

ERICSSON REVIEW

THE FIRST STAGE OF THE SAUDI ARABIA PROJECT COMPLETED
STORED PROGRAM CONTROLLED ELECTRONIC CALL DISTRIBUTION
INSTALLATION OF AXE EXCHANGES
ERICALL CONTACTOR – WITH MESSAGE TRANSMISSION
TRANSMISSION SYSTEMS FOR RURAL NETWORKS
UNINTERRUPTIBLE AC POWER SUPPLY SYSTEM, TYPE BZV 102
AUTOMATIC PROTECTION SWITCHING OF LINKS

1 1979





COVER
AXE exchange at Al Ulaya, Saudi Arabia

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EDITOR GUSTAF O. DOUGLAS

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Christian Jacobæus retires as the responsible publisher of Ericsson Review

With effect from this issue ERICSSON REVIEW has a new responsible publisher. Christian Jacobæus, D. Eng., the legally responsible publisher since 1967, retires from this post. The new responsible publisher is Gösta Lindberg, Technical Director of Telefonaktiebolaget LM Ericsson.

Christian Jacobæus has not only been the responsible publisher formally, he has also contributed a number of articles over a period of many years and has in various other ways taken an active part in the editorial work.

The editors

CHRISTIAN JACOBÆUS
Responsible Publisher 1967—1978

GÖSTA LINDBERG
Responsible Publisher 1979—

During his long career in LM Ericsson, Christian Jacobæus has been of great service to the company and has meant much for the development of telecommunication engineering throughout the world. His work for ERICSSON REVIEW has been equally valuable.

However, Christian Jacobæus' very considerable contribution to this journal has not been limited to the decade during which he was the responsible publisher. If any person can be said to have put his stamp on the journal during recent decades, this person is Christian Jacobæus. His first article was published as early as 1945 and since then he has often contributed articles of his own, always of great interest. The articles which ERICSSON REVIEW has had the privilege of publishing have usually been of a general nature with a very marked emphasis on future development. It would be no exaggeration to say that the content of his articles has been of utmost significance for the technical development within the Ericsson Group and, above all, of the greatest importance for spreading knowledge of LM Ericsson engineering all over the world. Through his contributions Christian Jacobæus' wide general knowledge of telecommunication engineering has made ERICSSON REVIEW the objective and informative technical journal it is today.

Björn Svedberg



The First Stage of the Saudi Arabia Project Completed

Knut Albertsson and Sten Henschen

Previously in this journal it has been described how the world's largest telecommunication contract was signed between the Ministry of Post, Telegraph and Telephone in Saudi Arabia and a consortium consisting of LM Ericsson, Philips and Bell Canada¹. As far as LM Ericsson and Philips are concerned the contract comprises delivery of telephone exchanges, buildings, cable, PCM equipment, network material etc., and its installation to form a complete, modern telephone network ready for service. The Bell Canada contract comprises the operation and maintenance of this network for a period of five years. This article deals mainly with the LM Ericsson AXE exchanges that have been installed during the first stage of the project.

UDC 621.395.34

The contract specifies that the first of the three stages in the project had to be completed by December 13, 1978, i.e. a year after the official announcement from the Ministry of Post, Telegraph and Telephone that the project had been awarded to the consortium. This stage has now been successfully completed and the exchanges were handed over to the Ministry at the specified time.

As regards the supply and installation of telephone exchanges LM Ericsson's commitment for stage 1 comprised:

a. two local exchanges type AXE in Riyadh, for 10 000 lines each, namely Al Malaz and Al Ulaya. The latter also handles local transit traffic.

b. three transit exchanges type AXE; one in Riyadh for 4 800 multiple positions, one in Buraydah for 3 600 and one in Abha for 2 400 multiple positions.

c. a new computer-controlled system for centralized operation and maintenance, AOM 101.

Philips' telephone exchange commitment for stage 1 comprised nine local exchanges, PRX, for a total of 62 500 lines.

Characteristics of the AXE system

The AXE system as supplied to Saudi Arabia has several outstanding characteristics and the most prominent of these will be discussed briefly here.

Digital group selector with integrated switching and transmission

The junction line network in multi-exchange areas is to a great extent built up of PCM lines and all AXE exchanges are equipped with digital group selectors. This has made it possible to integrate switching and transmission. Saudi Arabia is one of the first countries in the world to introduce such integration on a large scale.



Fig. 1
The Ministry of Post, Telegraph and Telephone in Riyadh



KNUT ALBERTSSON
STEN HENSCHEN
Telephone Exchange Division
Telefonaktiebolaget LM Ericsson



This means that the group selector through-connects digital lines without the speech signals having to be converted to analog form through the selector stage. This eliminates the need of equipment for analog/digital conversion and savings are made as regards signalling repeaters. In addition the transmission quality is improved. The advantages of this method have been described in more detail in a previous issue of the journal².

Savings are also made in the junction line network, thanks to the excellent traffic routing properties of system AXE and because the digital group selector works with full availability.

Optimization calculations have been made with the aid of a computer in order to make the best possible use of the economic advantages offered by the features described above. These calculations form the basis for the traffic rout-

ing in both the long-distance network and in the multi-exchange areas.

A new function is required in exchanges in integrated digital networks, namely network synchronization^{2,3}. This means that in practice the interworking exchanges work without any frequency deviation, which would otherwise cause transmission disturbances.

The exchange configuration in Riyadh with two local exchanges and one transit exchange represent the first AXE exchanges with network synchronization delivered by LM Ericsson.

Local call charging with data link transmission and toll ticketing for LD calls

The transit exchanges contain toll ticketing equipment, in which the charging information is recorded on tape. For local calls the charging data are transmitted via a data link to the computer-



Fig. 2
The 10 000-line AXE local exchange at Al Ulaya

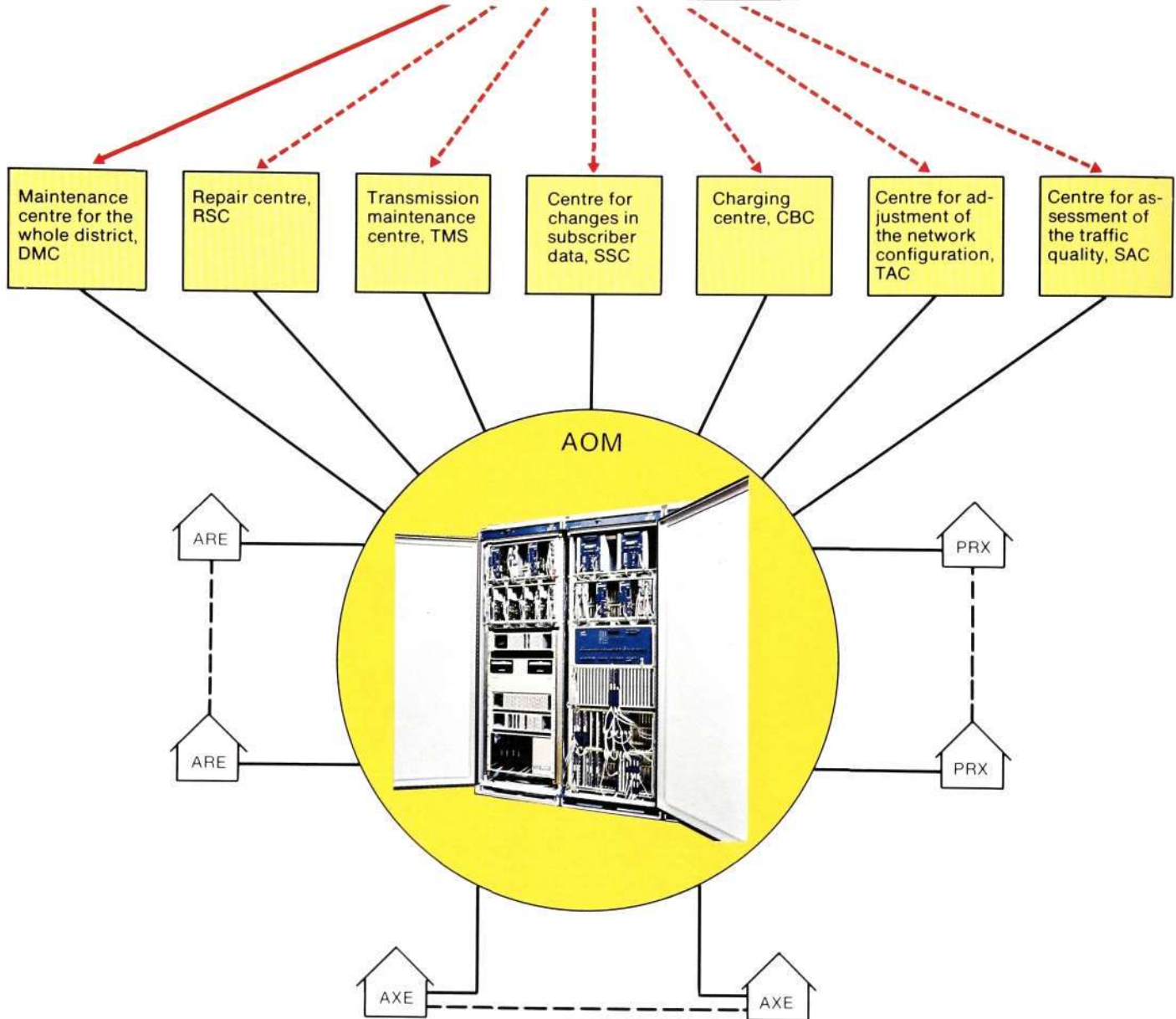


Fig. 3
The centralized operation and maintenance system AOM 101 with connected centres. Each centre is manned by operators provided with various aids

controlled operation and maintenance centre in the district in question.

New subscriber facilities

The subscribers will be offered new facilities, the most important ones being:

- push-button dialling
- subscriber programmable abbreviated dialling
- call waiting
- hot line

- automatic wake-up
- categories for priority allocation and barring.

Centralized operation and maintenance centre AOM 101

The centralized operation and maintenance system AOM 101 is used most efficiently when the connected exchanges are of the SPC type. This is the case in Saudi Arabia, where all new exchanges are of this type and all existing



Fig. 4
Inspection of a magazine in the transit exchange in Riyadh

Fig. 5
Block diagram of the AXE exchange in Al Ulaya

SSS Subscriber switching stage
GSS-D Digital group selector
TSS Trunk and signalling subsystem
LIC Subscriber line circuit
SSN Subscriber switching network
AJC A junctor circuit
BJC B junctor circuit
KRD Keypad code reception device
PCD PCM terminal device
T Time switch stage
S Space switch stage
ETC Exchange terminal circuit (for digital lines)
CSD Code sending device
CRD Code reception device
RP Regional processor
CP Central processor

ARF crossbar exchanges are modernized to computer-controlled ARE exchanges.

AOM makes it possible to adjust the network configuration in pace with temporary changes in the network, which gives the optimum network utilization on every occasion.

Other operation and maintenance activities are also centralized, with logically defined fields of activity, fig. 3.

Stage 1 includes AOM 101 in its basic version for the Riyadh district. Three more such systems and a superior operation and maintenance centre common for the whole of the national network are to be installed.

Interworking with other exchanges

With the completion of the first stage the capital, Riyadh, contains two AXE local exchanges, Al Ulaya and Al Malaz, and one AXE transit exchange, Riyadh Central. There are also several local exchanges ARF, one local exchange PRX, a national transit exchange ARE 13 and an international transit exchange ARM. Of these only the AXE exchanges are equipped with digital group selectors. The other exchanges have analog/digital conversion for traffic over PCM lines to and from the AXE exchanges. In the AXE exchanges the PCM lines are terminated direct in the digital group selector, which gives the optimum solution.

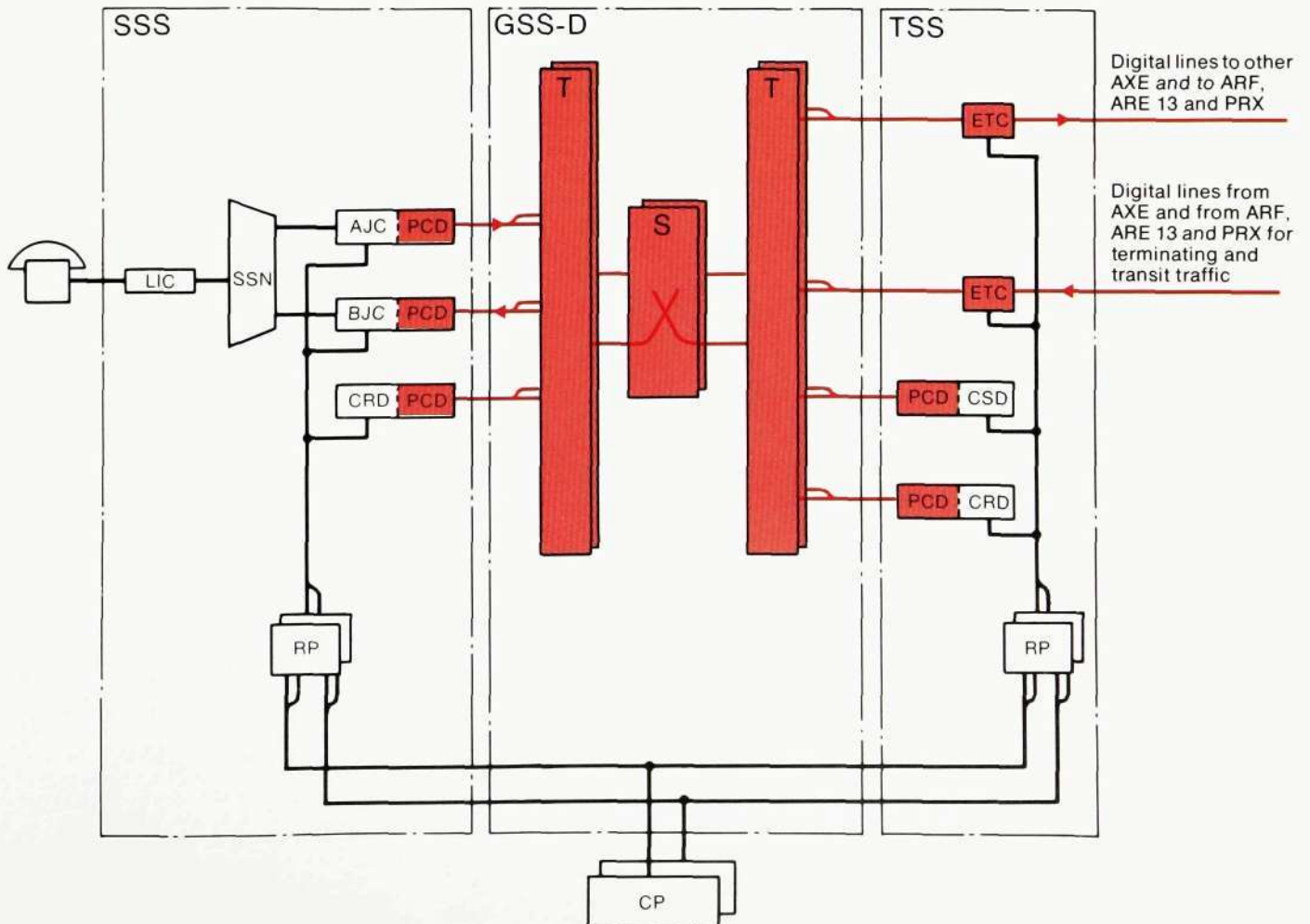


Fig. 5 shows a block diagram of the AXE exchange in Al Ulaya with a digital group selector for local traffic and local transit traffic. MFC signalling is used for register signalling between the AXE exchanges and also between AXE and other exchanges.

Completing the first stage

For this extensive project LM Ericsson built up a special organization in Saudi Arabia, and also formed a joint organization with Philips designated *Joint Venture*. In Sweden a special project section has been set up to handle and coordinate all activities.

New routines and methods have been introduced in order to meet the very short delivery times. For example, the electronic units, all of which have been tested individually in the factory, have also been thoroughly tested together under simulated operating conditions in a special AXE pre-test plant in Stockholm before being delivered, fig. 6. After completion of these tests the equipment was packed in containers and transported by air direct to the city where it was to be installed. Thanks to the effective assistance of the Ministry of PTT it

was possible to deliver the equipment to the site very quickly. The efficient delivery system and the fact that the units in system AXE are so easy to handle meant that the central processors – the most complicated units in the exchange – where working perfectly within five days of leaving the factory in Stockholm.

The direct air transport in containers also meant that there was no transport damage. In unfortunate cases such damage could delay the completion of an exchange considerably.

Work in progress

Installation of new equipment and extension in accordance with stage 2 was started before stage 1 was completed. On the part of LM Ericsson stage 2 comprises local exchanges for 50 000 lines, national transit exchanges for 24 500 multiple positions and international transit exchanges for 5 000 multiple positions.

Work is also in progress on the modernisation of the existing crossbar exchanges ARF by conversion to computer-controlled exchanges ARE 11, comprising approximately 200 000 lines. All traffic in the country will thus be handled by SPC exchanges, which means that all subscribers will be offered the same facilities and that the advanced administrative possibilities offered by the SPC technology will be utilized by the Ministry of PTT throughout the network.

Fig. 6
Pre-test plant for overall testing of complete exchanges before delivery



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Stored Program Controlled, Electronic Call Distribution System, ASDP 162

Hugo N. Garcia and Gösta Steimar

LM Ericsson's Australian subsidiary company has developed a system for automatic controlled distribution of telephone calls over a large number of trunks to a large number of operators.

The hardware and software of the system have the same structure as the well known AXE system.

The article describes briefly the possibilities and advantages of the system.

UDC 621.395.34

All companies and organizations are dependent on a good telephone service for their activities and in addition to an ordinary PBX certain enterprises need a special telephone exchange that can handle a large number of incoming calls. Such enterprises include:

- Airlines, railways, shipping lines etc.
- Travel agencies
- Department stores
- Banks
- Betting agencies
- Newspaper publishing companies
- Telephone operating companies
- General utilities.

Business like the above all have very heavy incoming telephone traffic that must be handled by a special group or groups of employees, for example booking clerks.

LM Ericsson's ASDP 162, Automatic Call Distribution (ACD) system, has been developed to eliminate many of the problems associated with this type of opera-

tion. The control of answering delays, the automatic distribution of calls, the recording of demand trends and the gearing of staffing levels to fluctuating traffic are merely some of the problems that a normal telephone system cannot resolve.

ASDP 162 has a flexible and modular structure and is available in three basic sizes:

ASDP 162/0 for up to approximately 500 trunks and approximately 500 operators.

ASDP 162/1 for up to approximately 90 trunks and approximately 90 operators.

ASDP 162/2 for up to approximately 60 trunks and approximately 60 operators.

Connection to ASDP 162 can be either via separate trunks for incoming and outgoing traffic or via two-way trunks.

ASDP 162 is a sophisticated call distribution system, fig. 2, with the following characteristics:

- The system handles a large number of calls simultaneously.
- A large number of queues are available. Each queue works on the "first in, first out" principle.
- The system is flexible and has a modular structure (building block principle). It is therefore easy to obtain systems of different sizes.



Fig. 1
Operators using the ASDP 162 call distribution exchange. Qantas Airways in Sydney, Australia



HUGO N. GARCIA
LM Ericsson Pty. Ltd. Australia
GOSTA STEIMAR
Subscriber Equipment Division
Telefonaktiebolaget LM Ericsson



- Numerous different traffic facilities are available to the operator and supervisory staff and also to the operation and maintenance organization.
- A complete system with traffic routing and supervision includes an operation and maintenance subsystem comprising teleprinters, display screens, tape recorders etc.

Distribution of calls

The basic structure of the ASDP 162 queue system is shown in fig. 3. The incoming trunks are divided into trunk groups which specify the origin of the calls and determine how they are to be handled. When a call enters a trunk group a search is first carried out in a distribution table to determine which groups of operators can handle the call.

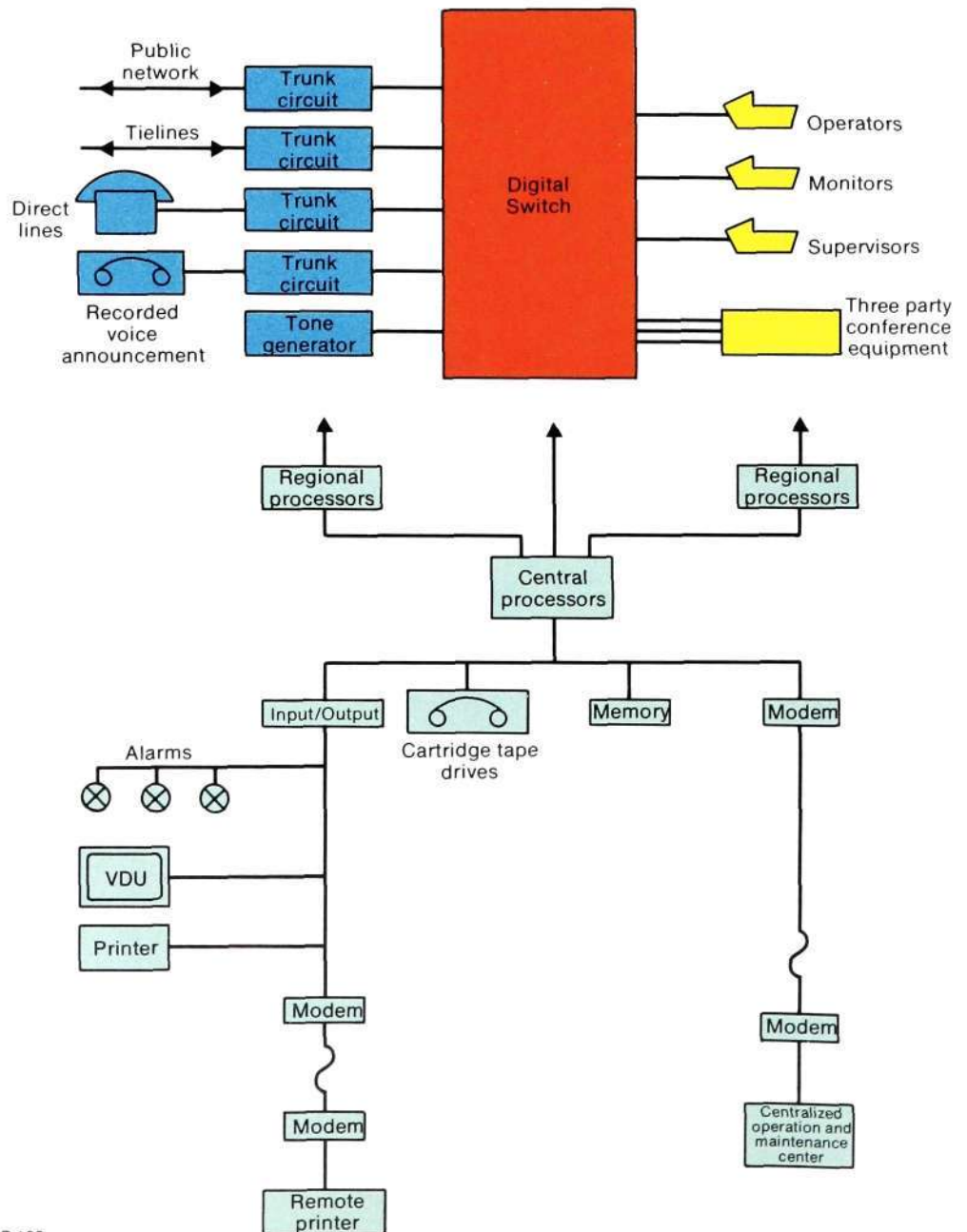


Fig. 2
The structure of call distribution system ASDP 162



Fig. 4
Operator console

The distribution table can choose between three alternative operator groups per trunk group. The selected operator group is then searched for free operators. If there are free operators in the group the call is routed to the one who has been free longest. If no operators in the group are free, the next group is searched in the same way and so on. If no operator is free the call is automatically queued. During the waiting period the ringing control tone is sent until one of the following three alternatives occurs.

1. An operator becomes free to answer the call.
2. After a certain time a recorded message is sent, saying that there is a queue and that the call will be answered as soon as possible.
3. The caller hangs up, and the call is then removed from the queue.

When an operator becomes free a priority table is used to determine which trunk group is in turn to have a call answered.

The priority table gives a "first choice" group and up to three alternative trunk groups. The first choice group is searched first, and if there are calls camped on to this group the call that has waited longest is connected to the operator. If there are no calls waiting in this group the three alternative groups are searched in turn. If no calls are waiting in these three groups either, the free operator is placed in a queue.

The operators are divided into groups, each with a monitor. There are also system supervisors, who normally are not in charge of operator groups and do not handle traffic. The system supervisors can restructure the queue order so that it suits different traffic conditions. The system supervisors can also obtain information continuously regarding the number of lost calls, the waiting times for answer, handling times etc. and can carry out measures to ensure that the call distribution system operates in an optimal way.

Fig. 3
The queue system in ASDP 162

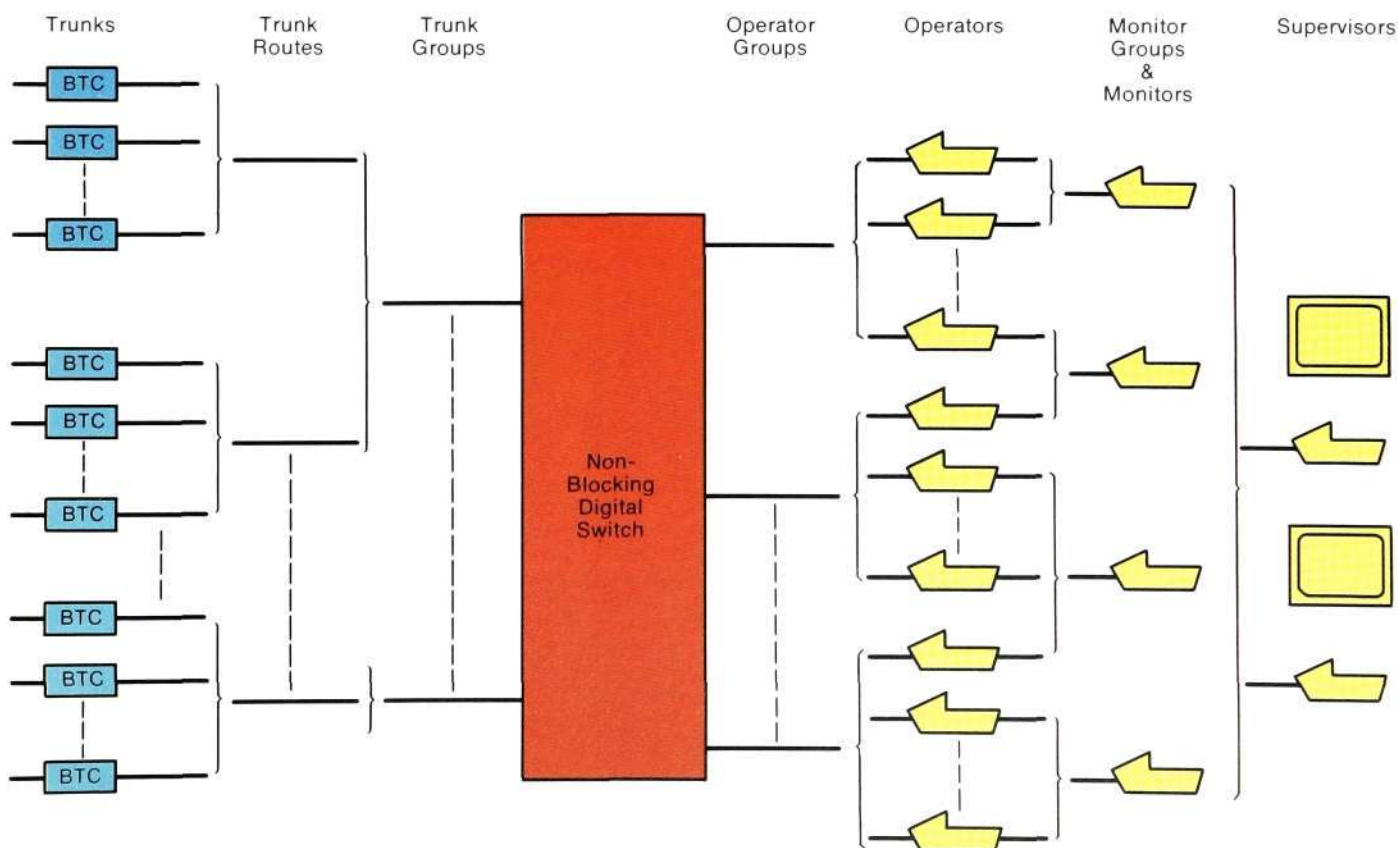




Fig. 5
A monitor at Qantas Airways in Sydney, Australia

Operator aids

The operator console

The operator console contains function buttons, a key set for dialling, information display with light-emitting diodes (LEDs) and alphanumerical indicators, fig. 4. It also contains a button for checking that the LEDs and indicators function correctly.

Each console can be allocated one of four categories for outgoing calls, with a three-digit analysis for control of long-distance calls, made by operators.

The operator console has three different operating states.

1. Immediately prepared to answer incoming calls. The call comes in without any button having to be depressed. A short tone notifies the operator that a call has been connected. If the public exchange signalling system permits, the calls can also be terminated automatically i.e. hands-free operation.
2. Non-service condition. After termination of a call the operator can prevent a new call being connected (to complete paperwork) by depressing a button. If a certain, preset time per operator group is exceeded, the monitor is alerted.
3. Unmanned, i.e. the headset is disconnected.

The operator console provides the operator with

- information regarding route and trunk numbers of incoming calls
- information that calls are waiting
- information regarding the status of parked and transferred calls
- the possibility of demanding recall of all displays including connected trunk route, trunk number, operator group and operator number
- the possibility of calling the monitor for assistance
- the possibility of choosing to answer only internal calls or all types of calls
- the possibility of transmitting music or recorded messages to parked or queuing subscribers.

The monitor

- has access to all operator facilities
- can monitor the calls of individual operators with or without a warning signal
- can enter operator calls and speak to the operator only or to both parties (three-party conference) and can also take over the call
- can obtain information on her display about each operator in the group as regards call state, category, allocated trunk groups, connected trunk group and type of connected or waiting call
- can check, via the display, whether any operator is unable to handle calls within preset time limits
- can program abbreviated dialling.



Fig. 6
Operator consoles with computer terminals in a tailor-made desk at Totalisator Agency Board, Melbourne



Fig. 7
ASDP 162 is built up in the same way as the AXE system

The system supervisor

- has access to all facilities available to a monitor
- is equipped with a monitor console a display terminal and in some cases also a printer
- supervises the system with the aid of periodically updated reports regarding the states of the trunk and operator groups
- supervises the statistically processed time reports and information provided by the system concerning individual operators, individual trunks, trunk groups and operator groups
- can change the following system data:
 - category of individual operators as regards the control of long-distance calls
 - operator grouping
 - monitor grouping
 - trunk route grouping
 - the distribution table for trunk groups towards operator groups
 - the priority table for operator groups towards trunk routes
 - the queue order of the direct dialling-in lines for calls to an operator group
 - recorded messages that are to be transmitted to trunk groups
- can change the following:
 - the preset of non-service time per operator group
 - the call time limit per operator group
- the answer delay time before a recorded message is sent to a waiting call, per trunk group
- the call time limit per trunk group
- the call time limit per outgoing trunk route
- the maximum permissible waiting time per trunk group
- the number of permissible lost or abandoned calls
- can connect special facilities, such as:
 - night service
 - spontaneous print-out
 - individual traffic recordings
- obtains indications of different types of alarms.

In addition to what has been stated above concerning the operator aids and the facilities provided for operators, monitors and system supervisors for distributing and monitoring incoming calls, the system also offers the following facilities:

- direct dialling to special facilities and/or individual operators
- enquiries and transfer between operators in the same group, other groups of operators, the monitor, the system supervisor, operators and extensions in other PABXs, special facilities (e.g. recorded messages) and enquiries to the public exchange

Scale 1:00

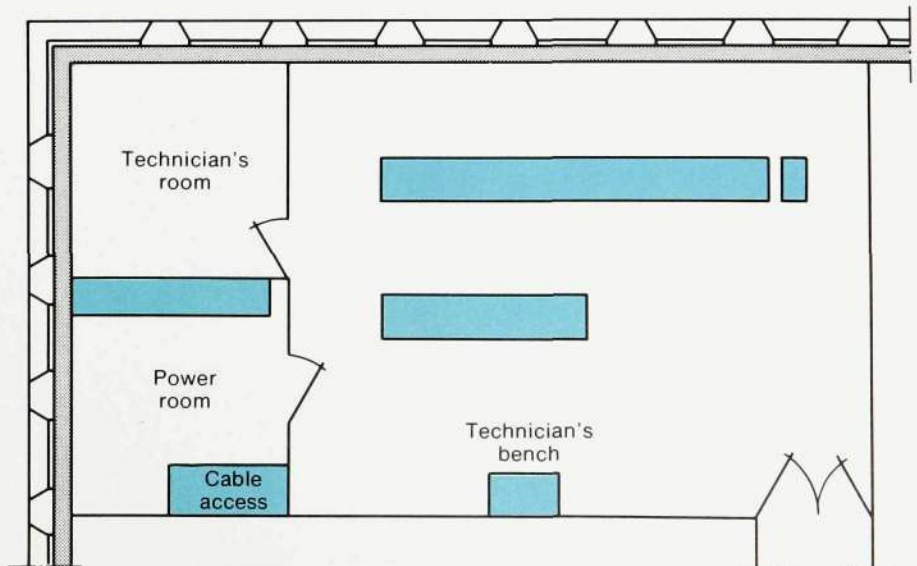


Fig. 8
A typical system for 150 trunks, 100 operators and 12 monitors

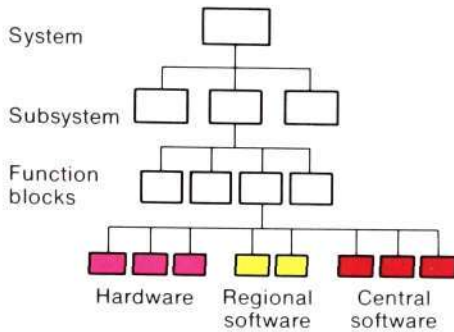


Fig. 9
The functional structure of ASDP 162

- separate transfer queues, with priority over normal queues, for transferring calls to other operator groups
- repeated enquiries of all types
- repeated transfers of calls
- three-party conferences controlled by a monitor
- automatic change of the system configuration during light traffic and low manning periods
- recorded messages
- external abbreviated dialling for the operators
- call recording.
- to connect or disconnect trunk and operator equipment in groups of 15 and 16 units respectively
- to connect or disconnect regional processors and to load a regional processor with the aid of a tape recorder while the system is in operation
- to set up test circuits through the digital switch
- to test the central processor buses, the regional processors and their buses. Certain of these test programs are recorded on a tape cassette and are included in the maintenance aids
- to read alarm buffers which record details concerning system alarms and which give references to the system maintenance manual as an aid for the maintenance staff
- to monitor faulty trunks, unused trunks and lost and abandoned calls.

Operation and maintenance

The principles for the operation and maintenance of ASDP 162 can be summarized as follows:

- the function of the exchange is continuously monitored by a built-in supervisory system
- if a disturbance should occur the system will automatically carry out measures to limit the effects of the disturbance
- preventive maintenance and routine testing when the exchange is in operation are avoided
- faults can be localized down to the printed board assembly level with simple aids.

For control and supervision of the exchange it is possible:

Mechanical construction

ASDP 162 is built up using the BYB 101 design practice, which was developed for LM Ericsson's well-known system AXE.

Fig. 9 shows the functional structure with the four levels: system, subsystem, function block and function unit. The mechanical side is built up in a corresponding way. The function block with its documentation thus cor-



Fig. 10
Exchange equipment and maintenance terminal

Data for ASDP 162

	ASDP 162/2	ASDP 162/1	ASDP 162/0
Maximum capacity trunks/operators	60/64	90/112	675/240
Maximum capacity operators/trunks (1 monitor/system supervisor equals 4 operators)	64/60	112/90	640/420
Central processors	1	2	2
Regional processors	0	0	5
Maximum number of trunk groups	16 (32)	16 (32)	16 (32)
Maximum number of trunk routes	60	64	64
Maximum number of operator groups	16 (32)	16 (32)	16 (32)
Maximum number of transfer queues	16 (32)	16 (32)	16 (32)
Maximum number of trunk groups per operator group	4	4	4
Maximum number of operator groups per trunk group	4	4	4
Switch terminations	128	256	1152
Number of trunks per trunk route	1-60	1-90	1-675
Number of trunks per trunk group	1-60	1-64	1-64
Number of operators per operator group	1-64	1-112	1-640
Number of operators per monitor	1-20 (50)	1-20 (50)	1-20 (50)
Number of operators per system supervisor	1-64	1-112	1-640
Maximum effect of a single fault:			
— switch terminations	64	64	64
— trunks	15	15	15
— operators	16	16	16
— processors	*)	0	0
*) Mean time before total system failure: 3 years			
Number of trunks per extension module	15		
Number of operators per extension module	16		
Number of switch terminations per extension module	64		
Row structure BYB 101:			
Height	2250 mm (6 shelves)		
Depth			
Single-side row	360 mm		
Double-side row	620 mm		
Width			
One shelf section	1097 mm		
One cable section	1097 mm		
Nominal operating voltage	48 V		
Environmental requirements:			
Ambient temperature	+5° to +45° C		
Relative humidity	20 %—80 %		
Traffic handling capacity	A non-blocking switch gives maximum traffic on connected trunks		

responds to the magazine with its documentation etc. This design permits the use of functional modules, direct cabling between the units with standard cables for front connection, good natural cooling and flexible placing of the power supply equipment.

All components are mounted on double-sided printed boards which are placed in magazines.

The circuits are of the integrated TTL type (low-power Schottky) with 4K dynamic MOS stores for most processor and control functions and miniature relays for interworking with the public network.

Fig. 8 shows a typical system for 150 trunks, 100 operators and 12 monitors.

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Installation of AXE Exchanges

Per-Olof Hagberg, Stig Hammarlund and Rune Östling

A new telephone exchange system should be easy to install, test and extend and the final product should have a high functional quality. This article describes how these requirements are fulfilled in the AXE system and also the aids and methods that are used when installing the system.

UDC 621.395.34.002

LM Ericsson's telephone exchanges are installed all over the world under varying conditions, and by a labour force that consists mainly of local employees. It is therefore important that the AXE system is well arranged from the point of view of installation. The far-reaching modularity of the system is an obvious advantage in this respect. For example, all function units are built up of magazines of varying size. These magazines/function units are equipped with printed board assemblies and tested at the factory before being delivered to the site. All the exchange cables are equipped with plugs and the majority are supplied from the factory as complete cable trunks.

The testing is mainly program-controlled and can therefore be carried out very quickly and without any risk of handling errors. Furthermore overall testing of the complete exchange can be carried out before delivery in order to reduce the work on site still further, and this was actually done in the case of the Saudi Arabia project¹. The installation of an

AXE exchange is carried out in two stages, construction and testing, and each stage comprises a number of activities, see fig. 3.

Construction

Material handling made easy

The installation work has been greatly simplified compared with earlier practice. The material handling at the installation site is now much easier. The material for an AXE exchange is delivered in two deliveries (A and B), one containing all the necessary mechanical items and cabling and the other the magazines, equipped with their printed board assemblies, and any other units. Each delivery is divided into a number of packages, each containing the material required for a limited part of the construction work. Thus no material need be unpacked until it is actually needed and the amount of handling required during the assembly is reduced to a minimum.

Rapid assembly of shelf rows

The traditional racks are not needed in an AXE exchange. The magazines (already assembled and factory tested) are instead mounted on shelves. Fig. 1 shows shelves being installed in a row section.



Fig. 1
Assembling shelves in an AXE exchange



PER-OLOF HAGBERG
STIG HAMMARLUND
RUNE ÖSTLING
Telephone Exchange Division
Telefonaktiebolaget LM Ericsson



A row section with magazine shelves and cable chutes is built up of a few simple parts. The hole spacing and the general structure are based on modules and the overall construction is in some respects similar to a meccano building set. The limited range of parts simplifies both the assembly work and the material handling. The assembly work can be carried out quickly and easily, without complicated measurements and checking of angles. Floor irregularities are easily compensated, fig. 5.

Plug-in cables

There is no laced, fixed cabling in the row construction. All connections between magazines are instead made with front cables, which are equipped with plugs at both ends. The number of cable types has been kept to a minimum. Furthermore all cables are made so that pin 01 at one end is connected to pin 01 at the other end, pin 02 to pin 02, and so on. This standardization simplifies cable handling, documentation and testing to a great extent.

All cables are connected at the front to

jacks along the front edges of the printed board assemblies or to special terminal strips, fig. 8. Existing cables can thus easily be changed or added to, which is particularly advantageous when extending an exchange. The cables can be fixed with a few clamps and there is no need for time consuming lacing.

All *internal cabling* in a group of magazines (e.g. a pair of regional processors and the magazines controlled by these) is usually carried out with prefabricated cable trunks equipped with plugs, and the cables are taken direct from the package as and when they are to be fitted, figs. 2 and 4.

A large part of the cabling work consists of the manufacture of such cable trunks, and hence the amount of work on site is very considerably reduced.

The *external cabling* between different groups of magazines is dependent on the layout of the premises, and consequently this is done by running cables in the conventional way.

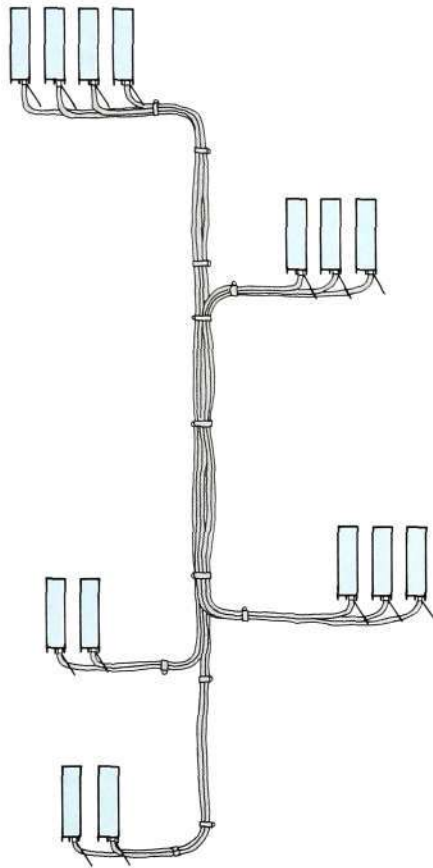


Fig. 2
A prefabricated cable trunk. The trunk consists of a number of cables held together by clamps. The cables are connected to plugs and then checked. The cable trunk is ready to be placed in the cable section and plugged in

Delivery A



Delivery B

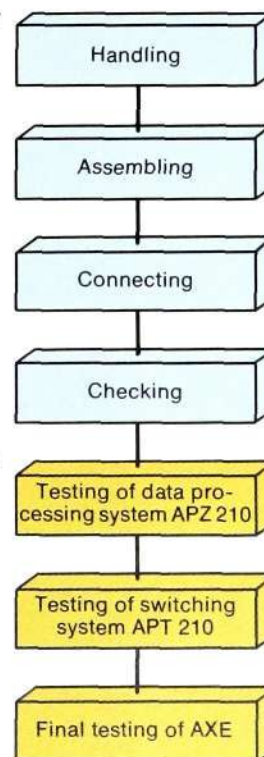


Fig. 3
The main activities during the installation work. The equipment is delivered at two times, A and B



Fig. 4
Installation of cable trunks straight from the package. The trunks are packed and marked in the order they are to be placed in the cable section, which eliminates much handling and identification work

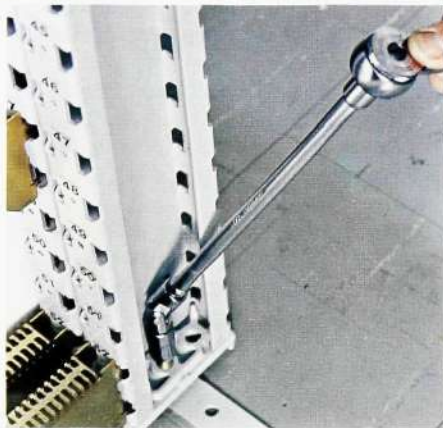


Fig. 5
Adjusting floor irregularities. Any such irregularities are compensated by means of an adjusting screw under each upright

Most of the cables are connected to plugs that have wire-wrap terminals. A wrapping method is used, which gives wiring of a high quality, fig. 6.

Checking

An important part of the construction work is the 100 % checking of all work carried out on the installation site. The prefabricated cables are checked before delivery.

In addition to a thorough inspection of all equipment an electronic cable tester is used to check all cables that have been prepared on site. The standardized connection of the two ends of the cable (pin 01 to pin 01 etc.) means that there is no need to program the cable tester for the different cable types, and thus the checking is very quick and simple.

Equipping

When the assembly described above is completed the shelves are equipped with the various types of magazines, fig. 7, after which the cables are plugged into the correct jacks and terminal strips, fig. 8. The equipment is then ready for the installation testing.



Fig. 6
External cables are connected to plugs by means of wire wrapping

Fig. 7
Equipping a row section. The central processor is
slid into position



Fig. 8
Cables are plugged into jacks and terminals strips

Fig. 9
The field version of testing system AVS

AVS-BAS	Aid for testing the hardware in the data processing system. AVS-BAS consists of software stored on cassette tapes and the printed board assemblies RAT and ROT
RAT	Random access (read and write) extra micro program store boards, which are inserted in the CPU magazines during the test. RAT is used for storing micro test programs, which are loaded from the AVS-BAS cassettes
ROT	Read-only extra micro program store boards, which are placed in the CPU magazines during the test. ROT contains permanently stored administrative test programs
CT	Cassette tape recorder, which belongs to the data processing system and via which the AVS-BAS programs are loaded into RAT and the program stores PS belonging to the data processing system
DL	Display unit, which belongs to the data processing system and which shows the test results. Fault localization is carried out down to the printed board assembly level
AVS-MIT	Fault tracing aid for tracing micro processes in the central processor and for the indication and setting of states in CPU. AVS-MIT consists of a panel unit MITO and the printed board assemblies MIT1 and MIT2
MITO	Control panel for the tracing equipment
MIT1 and 2	Printed board assemblies with tracing stores which are placed in the CPU magazines when the tracing equipment is to be used
AVS-RPT	Fault tracing aid for detailed fault tracing in regional processors. I/O devices and processor test unit PTU
PROM	Programmable read-only program store boards which are temporarily placed in the regional processors in which fault tracing is to take place, or in the case of fault tracing in I/O devices or PTU in the regional processors that control these. The boards contain permanently stored test programs
CPU-A, B	Central processor units
MAU	Maintenance unit
RP0, RP1 and RP	Regional processors
PS	Program store
DS	Data store
RS	Reference store
PTU	Processor test unit

Installation testing

Testing methods

The installation testing is carried out in accordance with well prepared methods which enable the work to be carried out efficiently and quickly.

The methods are based on the use of the exchange data processing system APZ 210 with its extensive maintenance functions for testing the switching system APT 210. Special installation test programs have been prepared for the work.

With the aid of these test programs a great number of tests can be carried out very quickly, utilizing the facilities for fault detection inherent in the data processing system. Handling errors are also avoided since the programs are automatized. Moreover, time consuming

programs can be performed during times when there is no staff at the exchange.

Efficient traffic generators, which are described later on in this article, are used in order to be able to generate a large number of test connections in the exchange within a short period of time.

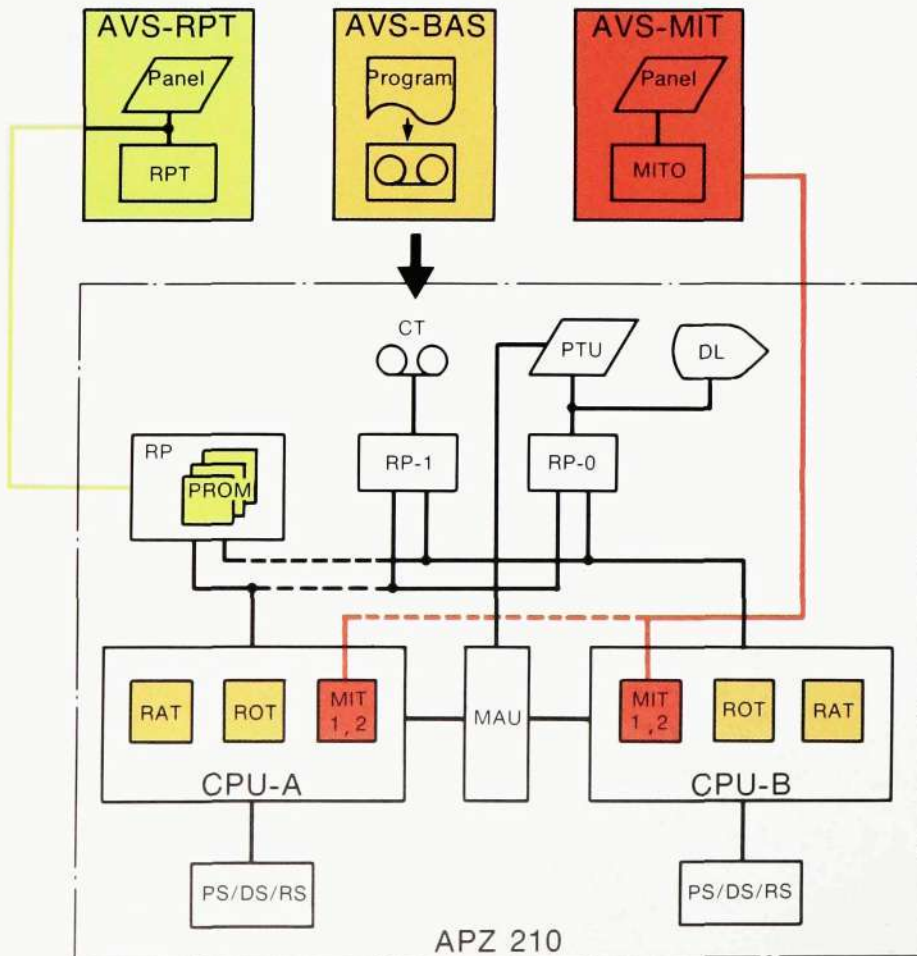
The flexible structure of the AXE system also offers the possibility of carrying out overall testing of a whole exchange before it is delivered to the installation site. This testing is carried out in special test exchanges and reduces further the amount of time required for testing on site.

Data processing system APZ 210

Data processing system APZ 210 is thoroughly tested in the factory at all levels from the components to a complete system in parallel operation. The data processing system can therefore be tested very quickly at the installation site and is then ready to be used for testing switching system APT 210. The testing of APZ 210 is carried out in two stages.

First the data processing system hardware is tested before its operating system is loaded. A field version, AVS, of the testing system that is used for factory testing of APZ 210 is utilized for this purpose. The testing system consists mainly of programs which are loaded in the central processor. Checking the hardware takes only a few hours. Fig. 9 shows the principles of the testing system and the functions of the various units that are included in the system.

The second stage consists of a functional check of the data processing system. The central processor is loaded with its operating system and started up in the parallel working mode. A number of essential functions are then tested by using certain of the control system's operation and maintenance commands from the exchange I/O devices. The results are checked by means of the printouts obtained from the system. This stage takes approximately a day, after which the testing of the data processing system is completed. The system is then dealt with as if it was in normal operation.



SSN

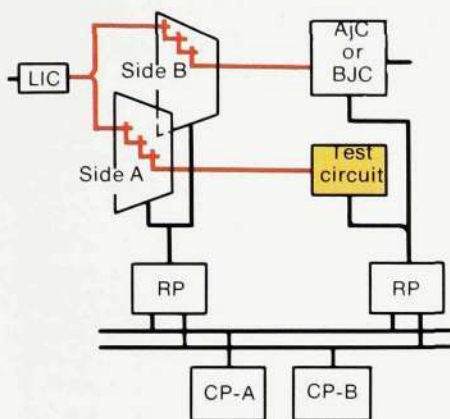


Fig. 10

Testing of an analog subscriber selector stage using a switch operation and link tester. The test aid comprises test programs, which are loaded into the central processor CP, and test circuits, which are temporarily installed in some of the A/JC positions.

The test programs control the setting up of connections from test circuits to LIC and from the same LIC to A/JC or B/JC. With the aid of A/JC/B/JC the test circuit then carries out continuity and leakage tests of the switching paths, which are chosen so that all switch matrices and links are tested.

LIC Subscriber line interface circuit
A/JC Junction circuit, A-subscriber
B/JC Junction circuit, B-subscriber
RP Regional processor
CP-A Central processor, side A
CP-B Central processor, side B

Switching system APT 210

The switching system is tested in three stages, which comprise (1) selector stages, junctor circuits, code senders and code receivers, (2) operation and maintenance functions and (3) traffic functions.

Selector stages, junctor circuits, code senders and code receivers

Subscriber selector stages, junctor circuits, code senders and code receivers are tested automatically with aids which are mainly realized in software. The regional processors to which the test objects are connected are also included in the tests, since the testing is controlled by the central processor.

Operating tests are carried out in the analog subscriber and group selector stages on each cross point relay, and continuity and leakage tests on each link. Fig. 10 shows the method used for testing subscriber selector stages.

In the digital group selector stage the digital switching paths are tested, with the speech and control stores being tested using different combinations of channels and time slots. Fig. 11 shows this test method.

Operation and maintenance functions

Most of the operation and maintenance functions in APZ 210 are realized entirely in software, which has been thoroughly tested before delivery and which is subjected to further testing in the operational testing described below. As a complement to this all operation and maintenance functions that contain hardware are tested separately. The functions to be tested are activated by commands or by the introduction of faults that affect the supervisory circuits.

Traffic functions

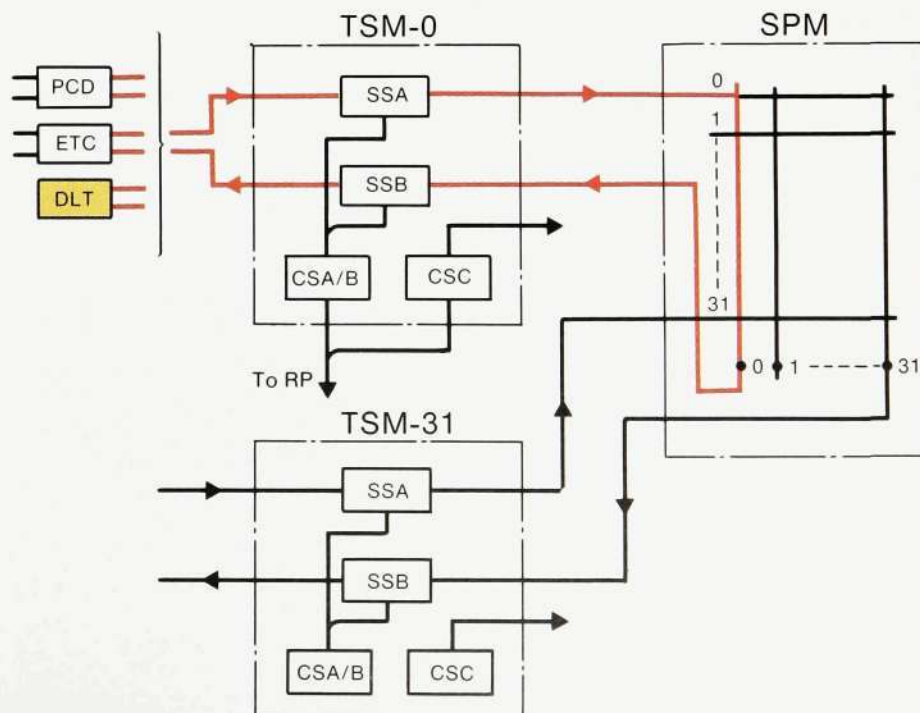
A systematic check of all traffic cases and special services is carried out. This check includes digit, route and tariff analysis, and is carried out with the aid of test connections. Every subscriber line multiple position and junction line equipment is also tested. Finally the functional quality is checked using a large number of test connections, which are set up in accordance with different patterns.

The traffic generators mentioned above, STG for connection to the subscriber line multiple, fig. 12, and TTG for connection to terminal circuits, are used for

Fig. 11

Testing of a digital group selector network. The tests are carried out by means of programs included in the operation and maintenance system for APT 210. The test programs control the setting up of test connections. The digital switching paths and the speech and control stores are tested with different combinations of channels and time slots.

TSM Time switch module
SPM Space switch module
PCD PCM terminal device
ETC Exchange terminal circuit for PCM
DLT Digital link tester. Is connected to the channels that are not connected to any device when the test is carried out
SSA Incoming speech store
SSB Outgoing speech store
CSA/B Control store for the speech store in TSM
CSC Control store for the cross points in SPM



these tests. They are independent of the AXE system and are controlled by their own minicomputers.

The traffic generators are operated from a panel and the test results are presented on a printer, and a large variety of fault types can be indicated on the printout. The software is standardized and need not be changed for TTG to suit different register or line signalling systems or for STG to suit different supervisory tone characters. TTG can also be connected to exchange terminal circuits for PCM lines with the aid of an adapter.

More data for the traffic generators are given on the adjoining page.

Final testing

The final testing comprises overall test of the complete exchange and consists mainly of operational testing, which is carried out in as realistic conditions as possible. It comprises a number of individual tests, which are performed in accordance with a detailed plan.

During the operational testing a large number of test connections are generated from STG and TTG as well as over the lines from interworking exchanges, and the supervisory and statistics functions of the exchange are activated. A number of operational routines are run through, and faults are introduced into the exchange so that supervisory and maintenance functions can be checked. The functional quality is supervised during the whole of the testing with the aid of result printouts from STG and TTG, and also the supervisory functions of the AXE system.

The operational testing provides a very efficient method of verifying quickly that the quality of the exchange is such that it can be taken into service. In most cases the customer's and the manufacturer's staff collaborate during the testing, in which case the operational testing will serve as the acceptance testing.

Extensions

The methods and aids for testing the AXE system described above are also used when testing exchange extensions. The modular structure of the AXE system makes such extension easy. Detailed instructions are available for each type of extension. These instructions describe how the new equipment is to be connected to the equipment already in operation, how new data are to be introduced, how the testing is to be carried out and how the new equipment is to be put into operation.

Conclusion

System AXE has a comprehensive modular structure and has been specially designed for quick and efficient installation. Effective aids and work methods have been prepared and developed. This means that an AXE exchange can be assembled and tested in only a third of the time required for a corresponding exchange of an earlier type.

Fig. 12
Work with the subscriber traffic generator STG



Traffic generators

LM Ericsson have developed two types of traffic generators which can be used for installation and acceptance testing of all types of telephone exchanges. The generators have a high capacity, which makes it possible to test the traffic functions of the exchange in question in a very short time in quite realistic conditions.

One type is a generator for subscriber traffic, STG, and the other a generator for trunk line traffic, TTG. Both are controlled by their own minicomputers, the one used in STG being the same as the AXE regional processor.

STG

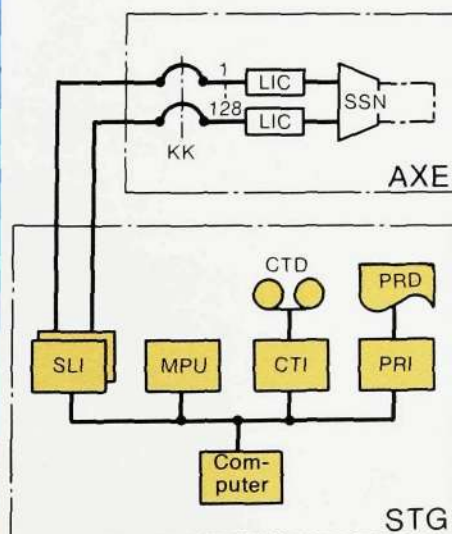
STG is connected to the subscriber line multiple in local exchanges and functions as the A-subscriber by generating test traffic and as the B-subscriber by receiving such traffic, fig. 13.

STG is used to

- determine the functional quality of the exchange during the final and acceptance testing
- test automatically every subscriber line multiple position
- carry out crosstalk tests
- generate up to 40 simultaneous calls
- generate test traffic to the code answering device in the interworking exchange.

Fig. 13
Block diagram of the subscriber traffic generator STG

SLI Interface towards subscriber line multiple inlets
MPU Operating panel
CTI Cassette tape interface
CTD Cassette tape device
PRI Printer interface
PRD Printer device

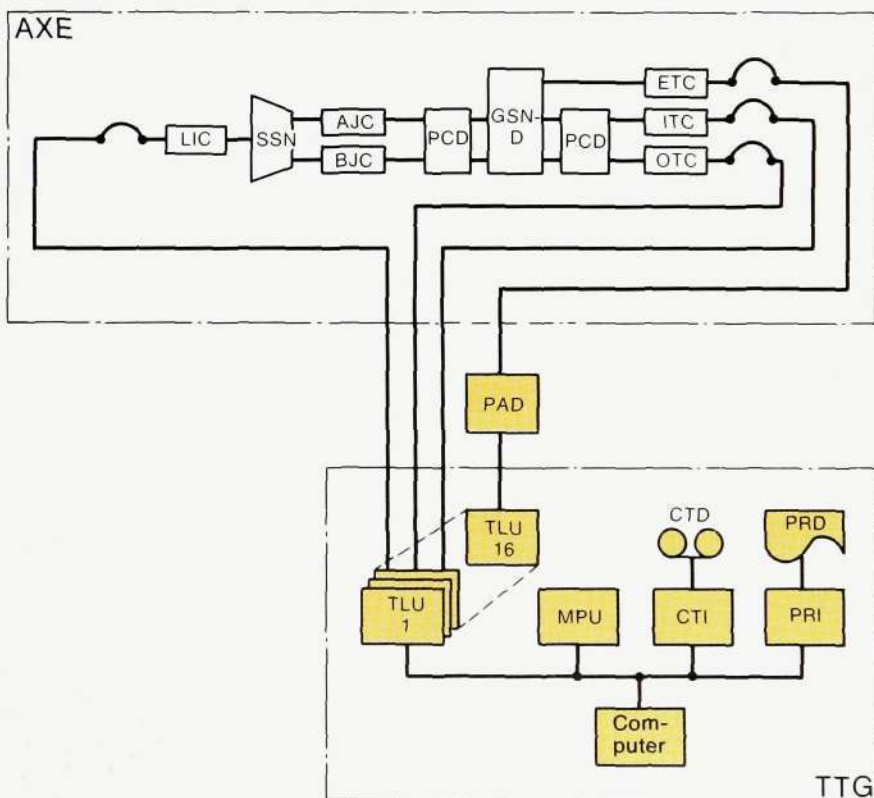


Technical data and functions

- Up to 128 multiple positions can be connected simultaneously. In addition to the traffic between these, test traffic can also be generated towards 16 code answers
- Up to 18000 test connections can be handled per hour
- Digit transfer can be carried out by means of both decadic impulsing and tone frequency key sending
- 20 fault types can be identified, for example faulty connection, missing or faulty tone and ringing signals
- The loading of subscriber data into STG can be done with a cassette tape recorder
- Statistics and fault printouts are obtained on a printer
- STG is operated from a panel with command and digit buttons and digit indicators.

Fig. 14
Example of how the generator TTG for trunk traffic can be connected to an AXE local exchange. The 16 outlets in TTG can be connected to any type of terminal circuit (ITC, OTC or ETC) and to subscriber line circuits (LIC) as desired. An external adapter is required for connection to digital terminal circuits

TLU Interface towards terminal circuits or subscriber line circuits
MPU Operating panel
CTI Cassette tape interface
CTD Cassette tape device
PRI Printer interface
PRD Printer device
PAD PCM adapter device



TTG

TTG is intended for use in transit and local exchanges. It is connected to the incoming terminal circuits for generating test traffic towards the exchange and to outgoing terminal circuits for terminating test traffic from the exchange. TTG can also be connected to the subscriber line multiple and thus covers all traffic cases in connection with traffic over trunk and junction lines, fig. 14.

TTG is used to

- determine the functional quality during final and acceptance testing
- test all traffic cases
- test the terminal circuits individually.

Technical data and functions

- Up to 16 terminal circuits or subscriber line multiple positions can be connected simultaneously
- TTG can be adapted to different analog line and register signalling systems and to PCM signalling with the aid of adapter devices. There is no need to change software
- Loading of data for the appropriate signalling processes between TTG and the exchange can be carried out by means of a cassette tape recorder
- Statistics and fault printouts are obtained on a printer
- TTG is operated from a panel with command and digit buttons and digit indicators.

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ERICALL CONTACTOR—a Paging System with Message Transmission

Dag Åkerberg

As a result of further development carried out by SRA Communications AB on their wireless paging system ERICALL CONTACTOR messages can now be transmitted and shown on a display in the receivers. Messages of up to 8 characters can be transmitted in each paging. Each character can consist of the digits 0–9, the letters a–e or a blank character. The message can consist of a telephone number to call, a room number, the code of a faulty machine etc.

This article describes briefly the new units that make it possible to transmit display messages, and gives some examples of system applications.

UDC 654.938

* There are two types of paging systems: *on-site systems* and *city-wide or country-wide systems*.

On-site paging systems form part of the internal communication system of a company or an administration. The systems vary in size from five to over 1000 receivers and cover areas that vary from small offices which need only one control unit with transmitter to large industrial plants, fire brigades and hospitals, with several transmitters and many simultaneous pagers. They can have several operators' positions, be connected to the PABX and/or intercom, have automatically released alarm calls, group calls, different characters for the various receiver alert signals, function supervision, charging rack, absence indication etc. Moreover it must be possible to provide local systems with facilities for sending speech messages to the pocket receiver with a transmitter for acknowledgement or talk back.

SRA Communications AB have marketed wireless local paging systems of their own manufacture since 1961.

ERICALL CONTACTOR is an advanced complete wireless on-site paging system*. The heart of the system is a specially developed digital decoder which is included in all pocket receivers. The digital decoder, together with the modular structure of the stationary equipment, gives ERICALL CONTACTOR many advantageous characteristics, and the system has been greatly appreciated by the customers ever since its introduction in 1975.

This article describes briefly the new units that enable display messages to be transmitted and gives some examples of system applications. For a detailed description of the system see "ERICALL CONTACTOR—a New Generation of Wireless Paging Systems" in *Ericsson Review* no. 3/4, 1975, pp. 136–147¹.

The new units, see figs. 1 and 2, are designed to match the previously developed units in the CONTACTOR system,

both as regards system design and mechanical construction.

System applications

In general it can be said that the display system provides a faster, simpler and more reliable means of transmitting information, which earlier could only be transmitted by means of speech.

Display paging, especially when combined with a vibrator, is very discreet compared with a spoken message.

Another advantage is that the transmission and presentation of the messages on a display is more reliable than a spoken message. Not only can the display message be received at a considerably lower field strength than speech but the display message is easier to distinguish in noisy surroundings. Furthermore the display message, unlike speech, remains in the receiver memory.

If the message consists of, for example, a telephone number to call, it can also comprise such information as "urgent" or "call when convenient". Thus the caller need not break off what he is doing just because he is being paged.

Connection to a PABX or an intercom system is very simple. An ordinary junction line or tie line in the PABX can be used for the transmission. Information

Fig. 1
Receiver variants, 25–45 MHz.
From the left: EC 400/410, EC 400/410 with vibrator, EC 401/411 with extra high audio output and the display receivers EC 405/415 (front) and EC 405/415 with vibrator





DAG ÅKERBERG
SRA Communications AB



Fig. 2
Control unit EC 115/125.

The installation-free control unit EC 115/125 has a built-in transmitter and a mains plug for direct connection to 110/220 V. The range of the unit is such that it covers small offices and buildings. If a large range is required the built-in transmitter (0.5 W and 1 W respectively) is replaced by separate 5 W transmitters and aerials

Fig. 3
Code format, standard code.

The code is of 300 ms duration. The code repetition time is 340 ms, which means a maximum of 177 codes per minute. The first 60 ms of the code are used for a start bit, which can have two different lengths. This is used to differentiate between two types of codes, the A and B codes. Each receiver is programmed for an arbitrary A and an arbitrary B code. The numbers of the codes are determined by 12 binary code number bits, each of 20 ms duration. The twelfth bit is the most significant. The binary code consists of what is called biphase code. The figure gives an example showing the call code A064 in the BCD coded version. The two rows at the bottom show the tone-carried code. High level corresponds to frequency f1 and low

regarding the source of the paging does not have to be stored in expensive, specially developed PABX equipment, but is instead transmitted to the display circuit in the paged receiver. The paged person then calls the number shown on the display. Thus the PABX connection interface is occupied for a very short time for each paging and consequently has a very high capacity. The seizure time is estimated to be 10–20 seconds per call. With 10 % congestion during the busy hour this permits 110–220 receivers in a system with one paging channel from the PABX, and 430–860 receivers in a system with two paging channels from the exchange.

The display system provides many different application possibilities for operation and process supervision and guard and alarm purposes. The message can consist of the number of a faulty machine, a measurement result, a room number for an acute case or a bed number in a hospital, part of a burning building or a building that has been subjected to illegal entry etc.

In the case of supervision it is often essential to obtain acknowledgement that a message has been received and understood. If not, it must then be possible to take rapid action. The receivers can

be fitted with a small acknowledgement transmitter for this purpose. CONTACTOR has a unique system (patented in Sweden, England, Germany and the USA) for synchronous tone acknowledgement. All paged receivers can acknowledge without delay or risk of confusion, even if paging is taking place from all terminals. The system also provides acknowledgement for the paged person, since the paging is repeated, but ceases when the central unit has received the acknowledgement. Details about different applications are also given in ref. 1.

Code format

The code and the digital decoder which were introduced with the CONTACTOR system in 1975 have worked very well and been very reliable. This standard code is shown in fig. 3.

The code consists of a start bit and 12 code number bits. The receiver contains a decoder which is able to receive two different codes, an A code and a B code. The difference between codes A and B lies in the length of the start bit. The code number bits consist of binary ones and zeros in what is known as biphase code. Both ones and zeros have an edge in the centre of the bit. The one has a

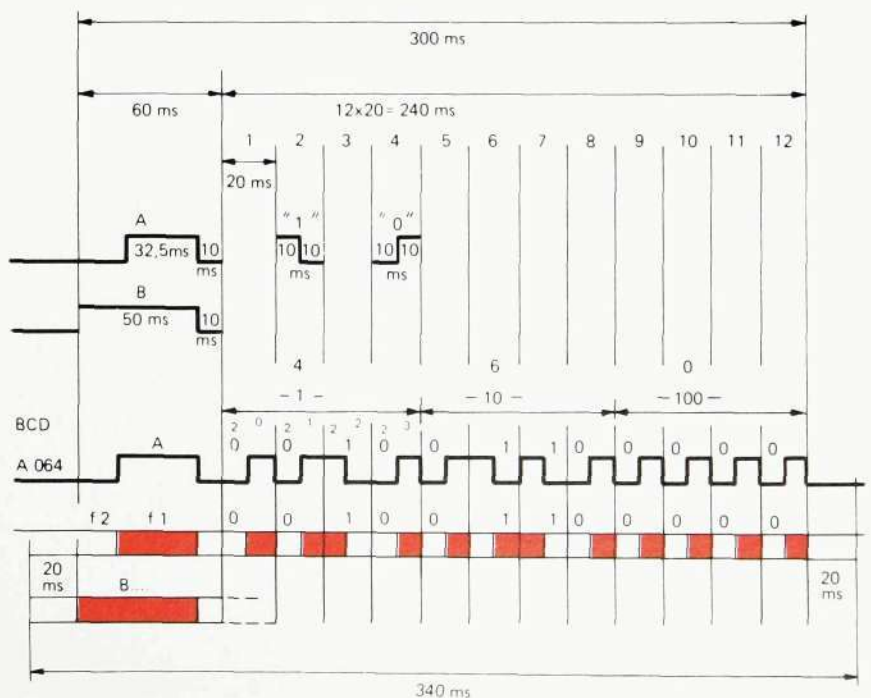


Fig. 4
Code format, display code.
The display code is a prolonged standard code. The 12 address bits are followed by 2 bits that give the code type, 2 bits that give the signal sequence and 16 or 32 bits for the message. The code type bits are always 2 ones for the display code (zero or no bit is interpreted as the standard code). The sequence bits indicate whether the audible indicator device is to transmit a repeated 1-bleep or 2, 3 or 4-bleep signal, see fig. 8. The number of message bits is 16 for 1–4 characters and 32 for 5–8 characters in the message. The example in the figure shows code A164, signal sequence 1-bleep and message 123

Fig. 5, right. Code format, special code.
The special code is a standard code that has been lengthened by 2 bits for code type and 2 bits for signal sequence. The code type bits for the special code are a one and a zero. The signal sequence bits indicate, as in the case of the display code, whether the audible indicator unit is to give a repeated 1, 2, 3 or 4-bleep signal. The special code transmits, in one code, the same information as is conveyed in the standard code repeated a number of times. Compare figs. 6 and 8

negative edge and the zero has a positive edge.

Fig. 3 shows the call code A064 in BCD coded form, which is standard. The 12 code number bits give 1000 combinations with BCD coding and 4096 combinations with binary coding. Before the code can modulate the transmitter carrier it is first converted into tone frequencies, which are indicated by the white and red strips in fig. 3. High level is represented by frequency f_1 and low level by frequency f_2 .

A further four frequency pairs f_1/f_2 can be obtained, giving a total of 5000 call codes of each type A and B with BCD coding, and 20480 with binary coding. The number of codes is so large that there is no need for adjacent systems to use the same call code.

The same code is used to transmit display messages, the only difference being that a number of bits have been added for the message part, fig. 4.

Safeguards against false calls

Test prove that mere noise cannot activate the decoder. No false calls have been obtained above and below the sensitivity limit. It is only just on the lower edge of the sensitivity limit, where about half of all correct calls are lost, that 0.16 % false calls were obtained (one of the four figures was wrong). The average risk is insignificant that the receiver in a local system will be exactly on

the lower edge of the sensitivity limit when a call comes in. A figure of 1 in 10^6 as the practical risk for false calls would be no exaggeration¹. This figure is reassuring.

Nevertheless attention should be paid to the risk of dialling the wrong number on the telephone or control unit. Tests indicate a fault risk in the order of 2 % when dialling 7-digit numbers on push-button telephones in public telephone networks. However, the display in the control unit makes it possible to check the dialled number before it is transmitted.

The decoder

The decoder has been redesigned to enable message transmission. The new decoder has been designed to receive both the standard code and the display code in order to obtain compatability with standard receiver systems without display. Thus the old decoder can be replaced by the new. A third code format, the special code shown in fig. 5, can also be received. The decoder determines whether it is a standard, display or special code on the basis of the number of bits in the code.

The decoder also contains logic circuits for automatic opening of the speech channel, synchronous acknowledgement via acknowledgement transmitters, current saving and generating the alert signal.

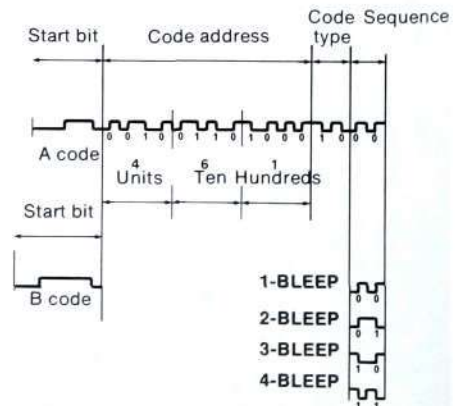
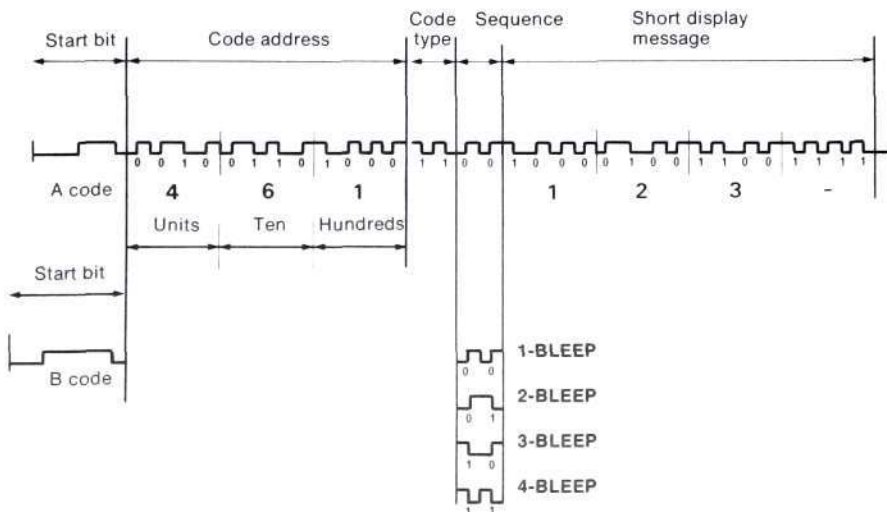
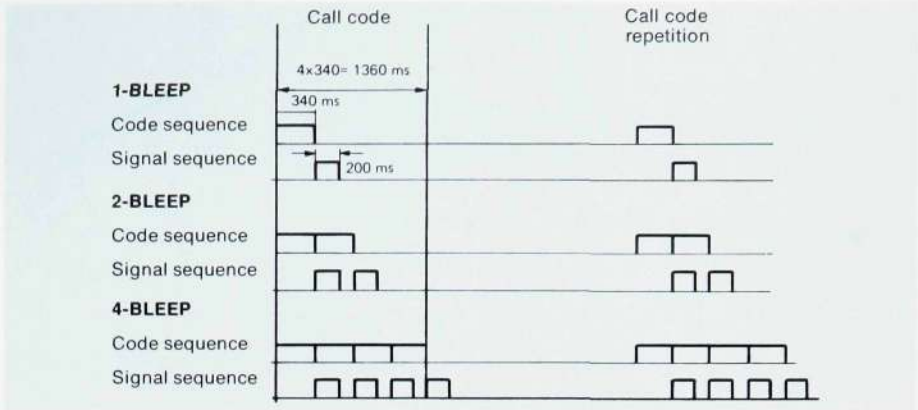


Fig. 6
The receiver signal characters, standard code. The signal sequence is controlled by the encoder, which means that a short 200 ms bleep is heard in the receiver each time the code is sent out. A call code can consist of 1, 2, 3 or 4 identical codes in succession, which gives a signal of 1, 2, 3 or 4 bleeps from the receiver. The call code is repeated a number of times, the number of repetitions being determined by the control unit. Each receiver can be coded for an arbitrary A code and an arbitrary B code. Which of the two codes has been received can be decided by optical indication, which makes possible a maximum of eight different signal characters, four for the A code and four for the B code



0 123456789
a b c d e

a 123
c 14
a250 e e 12
e 109 875



Fig. 7
Different types of display messages. The characters that can be transmitted are the lower case letters a–e, the digits 0–9 and blank character. If more than 4 characters have been received, characters no. 5–8 are obtained by depressing the listening button twice. Different bleep signals indicate whether the message contains more than 4 characters or not

In the case of the standard code the alert signalling is controlled by the encoder. The receiver gives a bleep each time its own code is received. The stationary equipment, the encoder, repeats the code in accordance with different preset patterns in order to provide different alert signal characters, see fig. 6.

In the case of the display code or special code the receiver provides signals in the same way as in the case of the standard code, but the signal sequence is controlled by the receiver on the basis of the signal sequence information (1, 2, 3 or 4-bleep) received with the code. When the code is received the decoder starts the signalling which lasts 5 seconds. During this time the sequence is repeated 4 times, fig. 8. The signalling can be cut short by depressing the listening button.

To receive and store messages the decoder must be equipped with a display drive circuit, which contains a store for the message, and also multiplex and drive stages for a 4-digit LED display.

The display lights up during the signalling time and for approximately 1.5 seconds after a manual recall from the store. The last message to be received remains in the memory until a new mes-

sage is received. If more than 4 characters are transmitted, characters 5–8 are obtained by depressing the listening button twice. The number of characters in the message (1–4 or 5–8) is automatically indicated by means of different signal characters, fig. 8.

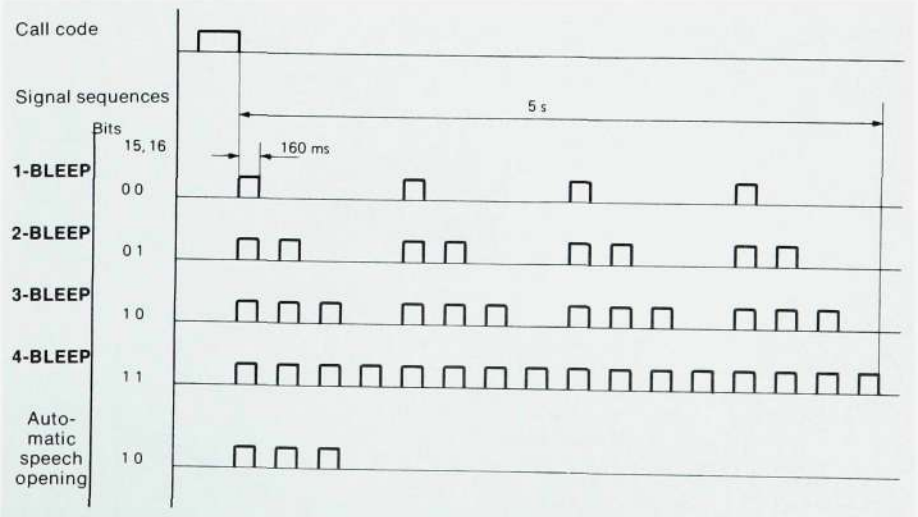
The receiver

The standard receivers (without display) for the frequency range 25–45 MHz are still designated EC 400 (superregenerative) and EC 410 (superheterodyne). The new decoder does not alter their function since it can receive the same standard code as the old decoder.

The display receivers, designated EC 405 and EC 415 respectively, are obtained by changing the top of the standard receivers to a raised top that contains a LED display and a display drive circuit with a message memory, fig. 1.

The display receivers can receive standard codes as well as special and display codes. This makes for a very flexible system structure. Standard and display receivers can be combined in one and the same system. Previously delivered systems with standard receivers can be extended using display receivers, since

Fig. 8
The receiver signal characters, display and special codes. The signal sequence is controlled by the receiver. Bits 15 and 16 indicate whether the receiver is to give a repeated 1,2,3, or 4-bleep signal. The bleep sequence is repeated 4 times during a period of 5 seconds before it is automatically cut off. The signal can be cut off earlier by means of a button on the receiver. As in the case of the standard code the A and B codes can be distinguished by means of optical indication, which gives 8 different signal characters. If the receiver is set for automatic listening, the receiver will automatically connect the speech channel to the audible indicator device after 3 bleeps



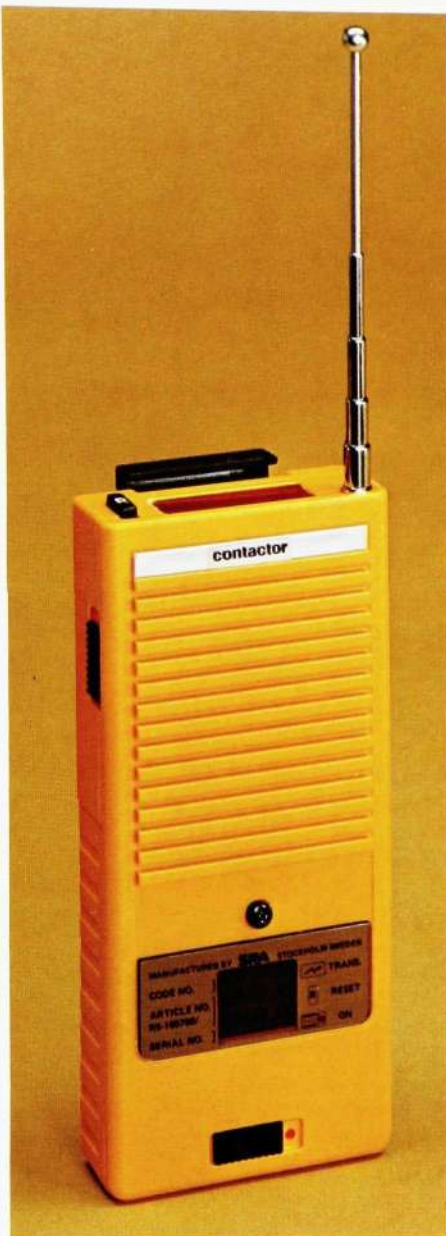


Fig. 9
Receiver EC 424, 420–470 MHz.
The receiver has a large loudspeaker for loud and clear speech transmission. The available attachments include display, vibrator and talk-back or acknowledgement transmitter

these also function as standard receivers.

Like the standard receivers the display receivers can receive spoken messages. They can also be equipped for silent vibrator paging, fig. 1, and with a talk-back or acknowledgement transmitter in the frequency range 146–174 MHz.

A new receiver, EC 420, for the frequency range 420–470 MHz has also been designed. It is of the double superheterodyne type and has the same function as the other receivers. However, automatic opening of the speech channel and a loudspeaker are standard features. A variant, EC 424, with a built-in talk-back or acknowledgement transmitter in the range 146–174 MHz is also available, fig. 9.

Control equipment

The control equipment consists of an "all-in-one" control unit EC 105/115/125 and for large systems, also a new control unit EC 284 and a number of new printed board assemblies for the existing modular system EC 200.

System EC 100

EC 105 with a built-in transmitter is designated EC 115 for 25–45 MHz, and EC 125 for 420–470 MHz, fig. 2. The control unit is controlled by a micro computer. The choice of standard (or special) or display code is made on the control unit. Like in the previous version of system EC 100 flexible group call is the stan-

dard and one of eight signal characters can be chosen for each code. A message length of between 1 and 8 characters is chosen with the aid of the key set on the control unit. The control unit display shows the called number, signal character and message. Three pagings can be handled simultaneously.

Optional extras in the system are, as before, one-way speech, two-way speech, relay traffic, alarm board for automatic release of three preselected codes including message, absence indication via a charging rack and acknowledgement via the talk-back transmitter, fig. 10.

Indication is obtained on the control unit of transmission in progress, absence, acknowledgements from acknowledgement transmitters and when the speech channel is open. In the case of absence and acknowledgement the number of the receiver concerned is also shown. This is necessary since a total of 6 simultaneous pagings can be handled by the control unit.

System EC 200

System EC 200 is built up of module boards in a central unit. The boards are connected to different terminals, such as control units, PABXs and alarm contacts.

Fig. 11 shows schematically how the sequence giver cyclically scans different number givers. In the standard version 16 arbitrary number givers (channels) can be scanned by the sequence giver. The new module boards comprise the sequence giver and four number givers. Each number giver in its turn can then scan a number of subchannels. For example, the alarm number giver has 16 subchannels.

The control unit, EC 284, is the same as EC 105 but with a different control program. It has exactly the same function and features, except that the alarm board has been removed and that 4 pagings can be handled simultaneously. The unit is connected to a new number giver, EC 267, in the central unit, EC 201, via a 4-wire circuit.

The old sequence giver board, EC 251, has been replaced by a new one, EC

Fig. 10
System EC 100.
EC 105/115/125 can be supplemented with the functions one-way speech, two-way speech, relay traffic, alarm board for automatic release of 3 preselected codes with message, acknowledgement from a talk-back transmitter and absence indication via a charging rack. The figure shows an example with absence indication via a charging rack and release of a preselected alarm code

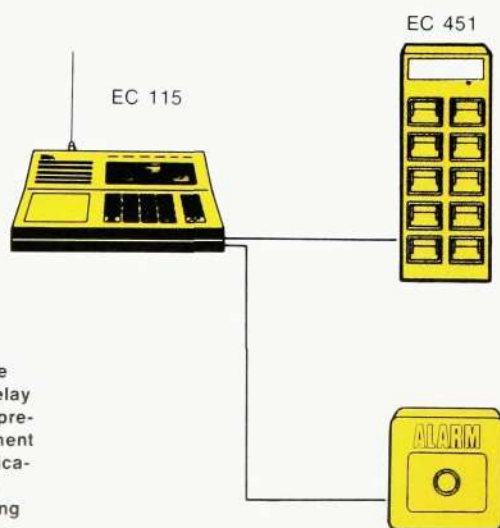
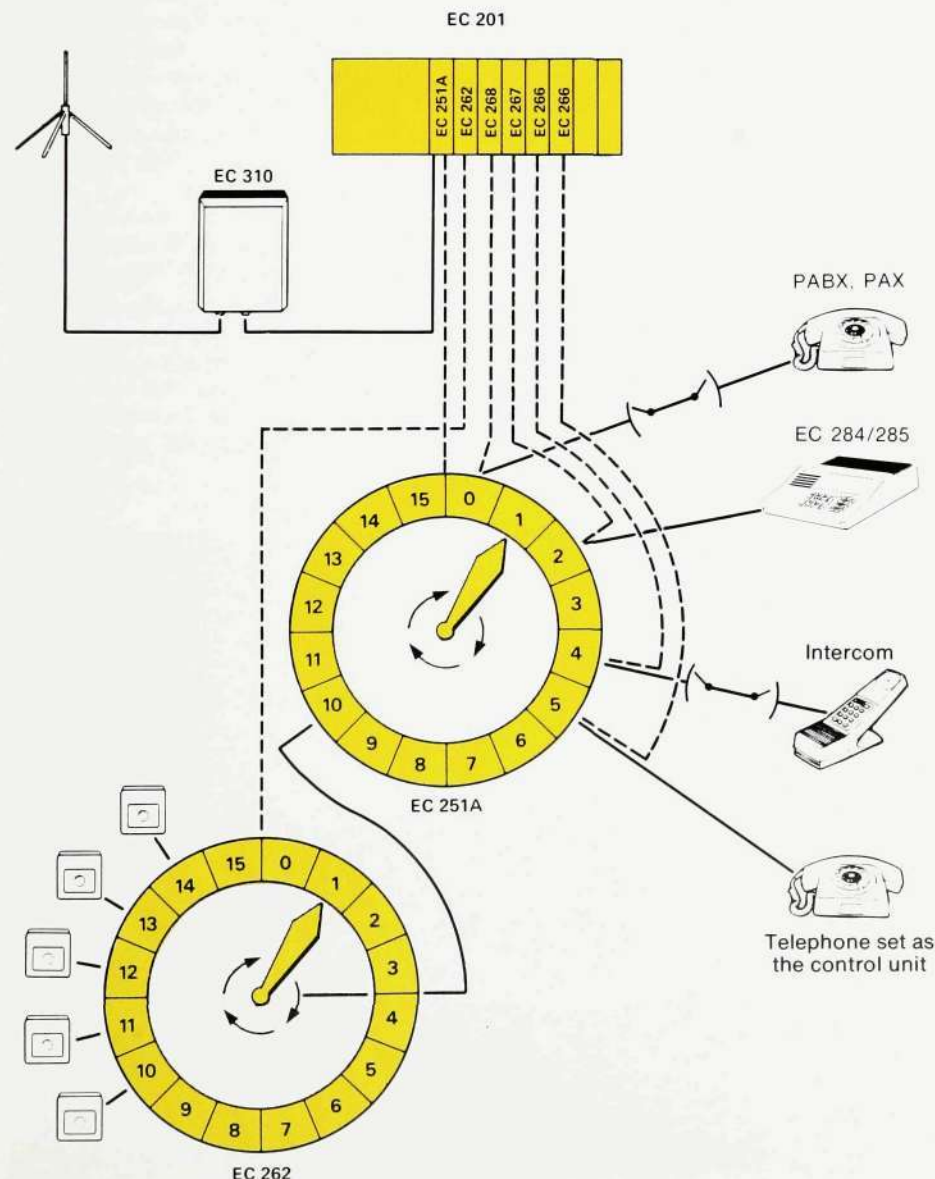


Fig. 11
Module system EC 200.
Sequence giver EC 251A scans the various number givers cyclically. 16 arbitrary number givers (channels) can be scanned in the standard version. Each number giver in its turn can scan a number of subchannels. For example, the alarm number giver EC 262 has 16 subchannels and EC 267/284 has 4. The figure shows a combination of the new modules. The board positions are unmarked and new and old number givers can be combined arbitrarily



251A, in order to be able to send the display (or special) code. The new board can generate either standard codes or display codes depending, in the information obtained from the various number givers.

EC 262 is a new alarm number giver which can be programmed with 16 different call codes with individual messages, signal characters and number of repetitions. Indications are obtained for no acknowledgement and/or absence. Transfer of calls is also possible in cases where acknowledgement is not received.

EC 266 and EC 268 are number givers for connection to PABXs when messages are to be transmitted. EC 268 also contains a "meet me" function. A telephone set with a line length of 10–20 km can also be connected to EC 266 as a control unit.

The new printed board assemblies can be placed in arbitrary positions in the central unit, as in the previous system. The sequence giver EC 251A can interwork with old units or new units or a mixture of both in the same system. Thus older systems with standard receivers can be extended to include a few or a large number of display receivers. The only changes that need to be made in system EC 200 are to change the sequence giver and to add one or more terminals for transmitting the display code.

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Transmission Systems for Rural Networks

Janne Blohm and Hans Liljeqvist

This article outlines the various problems encountered by Telecommunications Administrations when they undertake to provide rural areas and small communities with telecommunication service. In connection with this the article describes a number of transmission systems that have been specially developed for sparsely populated areas.

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621.395.3/5

In many countries the rural areas and small communities have been neglected as regards telecommunications. Telecommunications Administrations all over the world have concentrated primarily on building up their long distance networks and their transit and local exchanges and local networks in the cities. This development is only natural since from an economic point of view it is difficult for the Administration to justify the same investment in the rural networks as in the city telephone networks, mainly because business calls form the most important source of revenue for a Telecommunications Administration. Furthermore the investment per subscription is higher in rural networks, partly because of the greater distances. On the other hand it may be argued that the provision of good telecommunications in rural areas constitutes one of the most important prerequisites for expansion and extension of trade and industry outside the built-up areas, a development that most people would consider favourable.

The extension of rural networks has become a matter of considerable importance during recent years. The need to provide rural areas with a telecommunication service, with all its potentialities, has to an increasing extent been expounded at conferences and written about in journals and newspapers. The reasons for this may be that

- there is now a greater understanding of the importance of telecommunications for the consolidation of the national infrastructure
- there is a growing demand from the rural areas for a better telephone service—people living in rural areas should have the same facilities as those living in the cities
- there is a desire to create conditions that will encourage people to move out of the cities or at least will retard the movement into the cities
- through the use of new technology it is now possible to offer economical technical solutions that have not been possible hitherto.

By rural network is meant here the part of the network between the local exchange in a built-up area and small distribution points in the rural area, to which the subscribers are connected. If the number of subscribers is fairly large, greater than 30–50, such a distribution point can be equipped with a small local

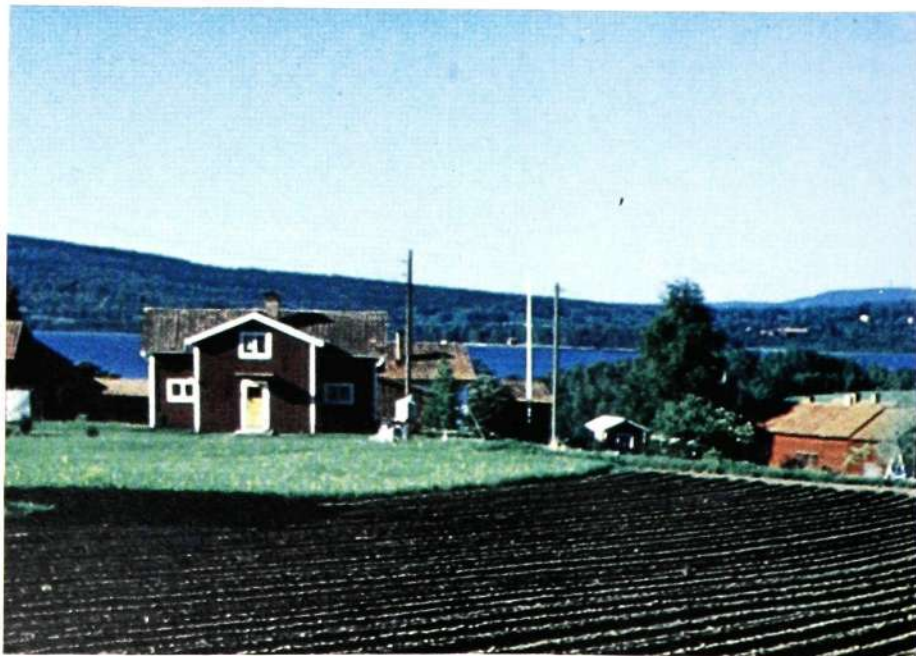


Fig. 1



JANNE BLOHM
HANS LILJEQVIST
Transmission Division
Telefonaktiebolaget LM Ericsson



exchange or a line concentrator in order to reduce the number of lines required to the parent exchange. This article deals primarily with systems for connecting groups of up to approximately 50 subscribers to each distribution point.

The problems that arise when extending rural networks are different in industrialized countries and developing countries. Industrialized countries, normally countries with high telephone density, have efficiently branched networks, and the distance from the subscribers to the nearest local exchange is usually fairly short. The telephone density in rural areas is only slightly lower than that in the cities.

Developing countries with low telephone density have widely dispersed local exchanges, not so well branched networks and often insufficient capacity in the trunk network. The telephone density in rural areas is only a fraction of that in the cities.

Fig. 2 gives a clear picture of the difference between typical industrialized countries and developing countries.

When the rural network is extended in a developing country, the primary aim is not to achieve a uniform telephone density throughout the country, but rather to get the rural communities connected to the national network at all. It is only at a later stage that the question of an even telephone density can be considered. This may often mean the connection of fairly large communities, with perhaps up to 10 000 inhabitants, which today are wholly without telephones.

A planned extension of the rural network shown in fig. 2a means a scarcely noticeable rise in the telephone density of the country. Nevertheless the number of communities that are not connected to the network must be reduced from approximately 97 % to 70 %, or, in other words, it is necessary to increase the number of connected communities by a factor of 10 (from 3 % to 30 %). This means a very great increase in the number of branches in the network.

Building up rural networks obviously presents considerable financial prob-

lems for many developing countries. The World Bank and other financing sources have realized this and for some years they have granted advantageous loans for rural network projects in different countries. These financing facilities should speed up the development.

LM Ericsson's transmission systems for rural networks

LM Ericsson have developed three different transmission systems suitable for use in

— *subscriber networks* as the link between small, geographically concentrated subscriber groups and the nearest local exchange. PBXs can be connected to the local exchange in the same way

— *junction networks* for connecting small local exchanges to the parent exchange or for direct routes between local exchanges.

The systems have the following designations:

ZAE 12 which comprises FDM (frequency division multiplex), terminating equipment and radio link equipment for 12 channels

ZAE 24 as above but for 24 channels

ZAE 30 which comprises PCM (pulse code modulation) multiplex, terminating equipment and radio link equipment for 30 channels. The system can also be used on pair cables.

A PCM system for 10 circuits will also be included in the product program.

SYSTEM STRUCTURE

One of the objectives of the design work was that the planning, ordering, delivery and installation of the equipment should be as simple as possible. Personnel who are not specialists in transmission engineering should be able to plan and install the systems and put them into op-

Fig. 2
Typical conditions in a developing country and an industrialized country

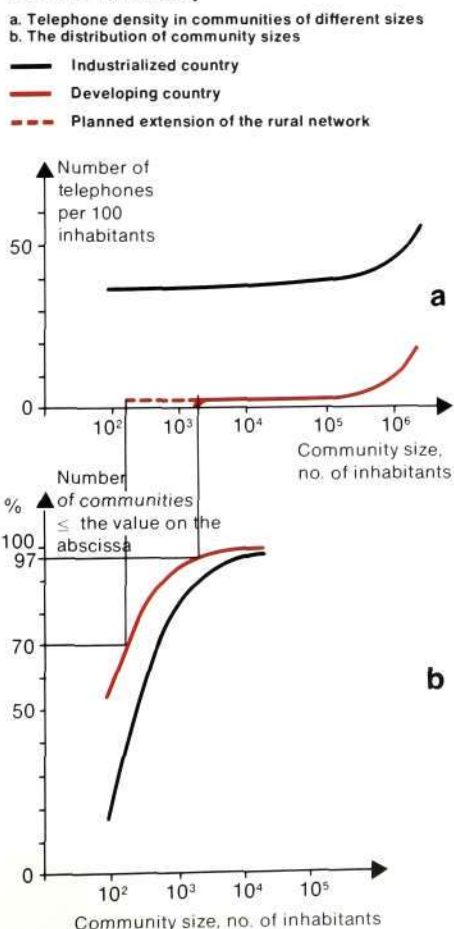




Fig. 3
The equipments are placed in lockable cabinets. External connections are made in a terminal panel at the top of the cabinet

eration. It must also be possible to install the equipment in premises that are also used for other purposes, such as office buildings etc.

In order to meet these demands the equipment is built into a lockable cabinet, type BYB 201. All equipment for multiplexing, terminations, current feeding and the generation of ringing current is placed in this cabinet, which is delivered wired for external connection to a terminal panel at the top of the cabinet, fig. 3.

As far as possible the different systems have been built up using the M5 construction practice¹ with the use of the same units as are found in LM Ericsson's other multiplex systems. Examples are the channel modem unit with out-band signalling for FDM systems² and the channel, modulator and demodulator units for PCM systems³. Special units have been designed for carrier generation and group translation.

Three "combination shelves" have been developed in order to make the equipment as compact as possible.

The 12-channel combination shelf contains

- four channel units with modems, filters and out-band signalling equipment, each of which converts three speech channels with the associated E&M signalling channels to a subgroup in the group band
- a group modem unit for translating the subgroups into the band 12–60 kHz or 60–108 kHz. When the system is equipped with only 6 channels the band used is 12–36 kHz or 60–84

kHz. The desired frequency band is selected simply by restrapping

- two units with a master oscillator and equipment for generating all carriers and signalling frequencies. The same units are used in the 24-channel combination shelf
- a d.c. converter for power feeding from a 24, 36, 48 or 60 V d.c. voltage source, for example the exchange battery
- four-wire/two-wire terminations or subscriber line relay sets including terminating units.

The 24-channel combination shelf is equipped with the same units as the 12-channel shelf and in addition

- modems for converting two groups into the frequency bands 12–60 and 60–108 kHz or 6–54 and 60–108 kHz. The desired bands are selected by means of straps. The standard version of the equipment is equipped for both alternatives
- four-wire/two-wire terminations for 24 channels or subscriber line relay sets (see the 12-channel combination shelf above), but in this system they are placed in separate shelves with a four-wire/E&M interface towards the multiplex equipment.

The fact that the units used in these systems are mainly the same as those used in the large M5 multiplex systems, which were designed for long-distance circuits, means that the small systems described here will have the same high transmission quality and reliability as the large ones. High reliability and few types of plug-in units are two important conditions for keeping the cost of maintenance and stocking of spares at a low level.

Local exchange

Parent exchange



Local exchange

Parent exchange



Fig. 4
E&M interfaces for junction networks



Fig. 5
MINI-LINK 13 with a parabolic antenna

The 30-channel PCM combination shelf contains

- channel units, for either a two-wire or four-wire output towards the low frequency side, with modulator and demodulator units, transmit and receive control units and a line interface unit for connection to a pair cable or 2 Mb/s radio relay link
- E&M signalling equipment
- alarm equipment.

When required, subscriber line relay sets are mounted in separate shelves, as in the case of the 24-channel terminal.

Signalling

On the low frequency side the multiplex equipment is terminated in a two-wire or four-wire standard type E&M interface. These interfaces are used in the junction network applications, fig. 4.

When the systems are used on subscriber lines, i.e. for connecting ordinary CB telephone sets, CB equipment in a manual switchboard or PABXs to a public telephone exchange, special relay sets are required for transmitting hook signals and digit pulses from the set to the exchange and transmitting ringing signals and microphone current from the exchange to the set. These functions are performed by two types of relay sets, one at the subscriber end and

one at the exchange end of the circuit. The relay sets also contain facilities for transmitting charging pulses during calls. Thus such circuits enable subscriber call-fee meters to be used either as an attachment to the ordinary telephone set or to coin-box sets, fig. 6.

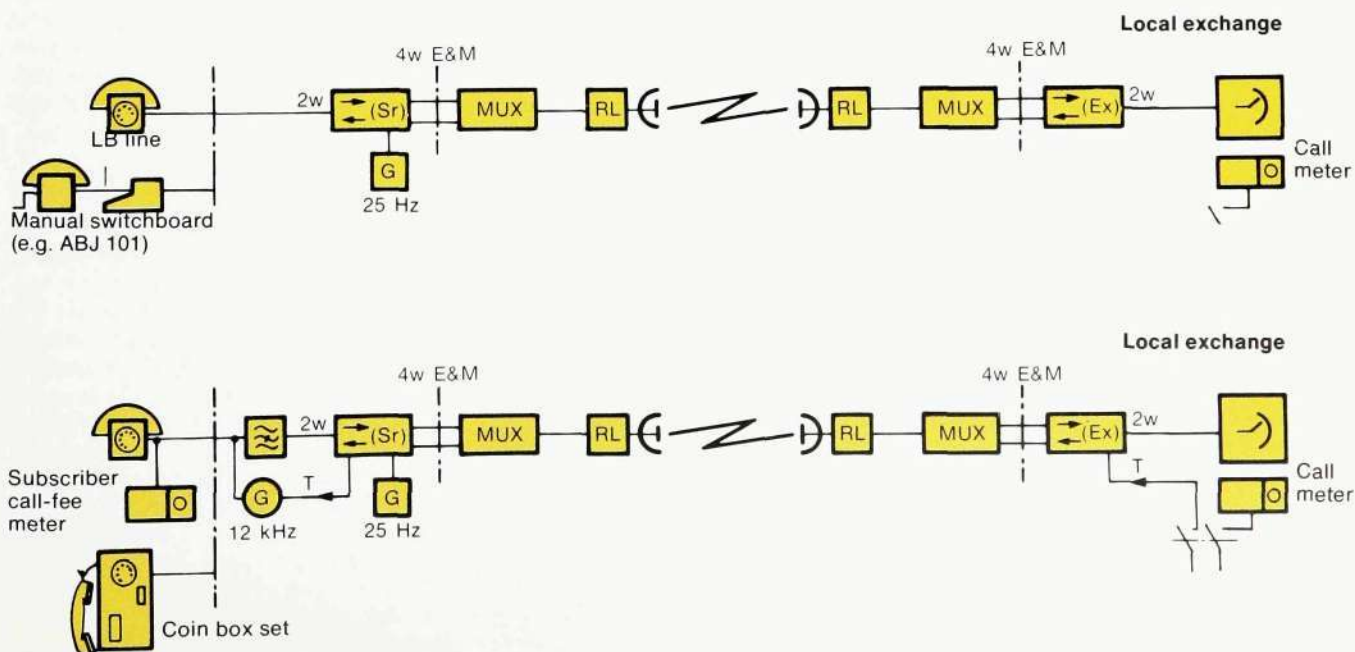
Automatic calling between two CB sets in a point-to-point circuit can easily be arranged by using the subscriber end relay set at both ends. The B subscriber will then receive a ringing signal when the A subscriber lifts the receiver.

The equipment for transmitting charging pulses and subscriber call-fee meters for installing together with the telephone set are optional equipment in the ZAE systems, and can be connected to any channel.

Power supply

The terminal installed at the exchange end is normally fed from the exchange battery, usually -48 V. The terminal at the subscriber end can be equipped with a rectifier unit and connected to the a.c. mains. The capacity of the rectifier unit is sufficient to feed the radio relay link terminal and charge a 48 V standby battery. A standby battery is recommended when the reliability of the a.c. mains is low. The ringing current for signalling to the subscriber equipment

Fig. 6
Interfaces for subscriber networks



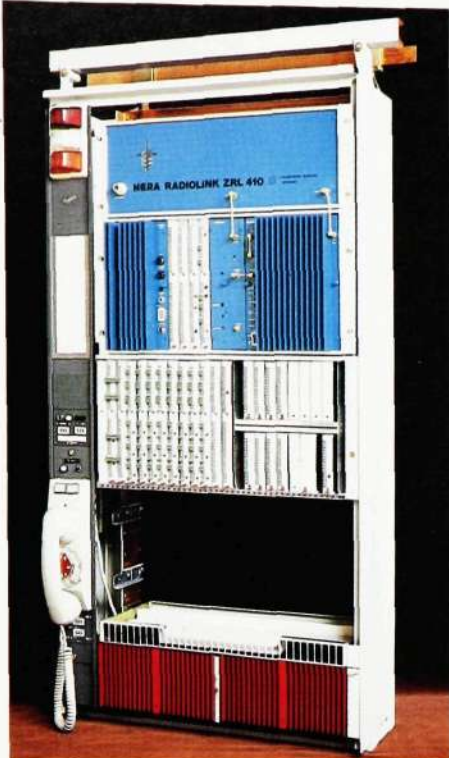


Fig. 7
ZRL 410 radio terminal mounted in a rack together
with a 24-channel multiplex terminal

is obtained from a ringing current generator, which is also fed from the battery in order to ensure continuous operation in the case of loss of the mains voltage.

Radio relay system

The choice of a suitable radio relay system is determined by local conditions, such as the type of terrain, distance, available frequency bands and frequencies within these, the need for expansion etc. These conditions vary considerably from country to country and in different parts of the networks, and in order to satisfy them LM Ericsson have developed a range of different types of low capacity relay systems, namely:

MINI-LINK 10 for 120 channels FDM or 30 channels PCM in the band 10.38–10.68 GHz. A complete terminal with transmitter/receiver and internal power unit and a flat antenna array is mounted in a sealed unit 30×30×17 cm for installation out of doors, for example on a mast. The equipment is also available with a 60 cm parabolic antenna, in which case the overall dimensions of the terminal are 67×63×52 cm. Up to 10 km can be bridged by a flat antenna array and up to 20 km with a parabolic anten-

na depending on the number of channels, the terrain, transmission availability requirements etc. Line of sight is always a prerequisite.

MINI-LINK 13 for 120 channels FDM or 30 channels PCM in the band 12.75–13.25 GHz. The standard version of this equipment includes a 60 cm parabolic antenna and has the same dimensions as the corresponding version of MINI-LINK 10. Typical hop lengths are 15–35 km depending on the conditions mentioned above for MINI-LINK 10.

MINI-LINK 10 and 13 were designed with a view to providing easily installed radio relay systems with low maintenance costs. The systems are of the "all inclusive" type with a high degree of integration of the microwave circuits.

ZRL 410 for 24 channels FDM in the band 270–470 MHz. This equipment is a recently developed successor to LM Ericsson's popular system ZRL 400. The band permits greater hop lengths than MINI-LINK 10 and 13, but it cannot be used in as many directions at each central point, since the directional effect of the antennas is lower in this frequency range.

Other material

Supplementary material, such as diversity equipment and installation kits for mounting MINI-LINK on a roof, a wall or in a mast can also be supplied, and also suitable terminating strips with overvoltage protection for connection of distribution cables. Petrol or diesel powered generators are also available.

PLANNING

The systems described above are particularly suitable for connecting groups of 6–30 subscribers direct to a local exchange. In many cases this will solve the telephone problem for a long time. In places with rapid expansion, however, the number of subscribers may have increased so much after only a few years that it will then be suitable to put up a local exchange at the subscriber concentration point.

The transmission systems described in this article are in accordance with the recommendations of CCITT and can therefore be used without restriction as

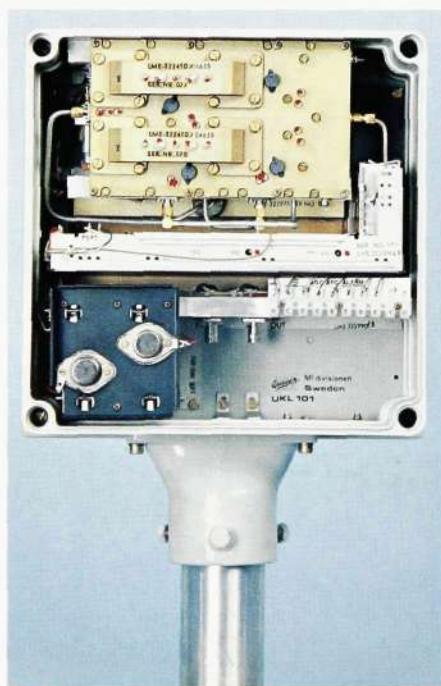


Fig. 8
MINI-LINK 10 with the rear cover removed

a link between the new exchange and the parent exchange without causing any reduction in the quality of the network.

When many small systems are to be ordered, kept in stock and installed it is advantageous to be able to work with units that are as large and easy to handle as possible. The system sizes and equipment variants have therefore been standardized, such as the type of power, type of circuits etc. Simple diagrams have also been prepared that simplify the choice of the right MINI-LINK with respect to distance, type of terrain and reliability requirements.

INSTALLATION

Equipment that is to be installed at many different places, often far from where the installation and maintenance staff are stationed, and often in very primitive premises, must be very simple and easy to install. The ZAE systems meet these requirements since

- all multiplex and power equipment has been combined to form one unit—the BYB cabinet—which can be installed even in buildings that are not specially adapted to telephone equipment, for example offices and similar premises, and there easily be connected to the power source, radio link and subscriber network
- the MINI-LINK terminal is an “all inclusive” unit, which can easily be mounted on a mast, a roof or a wall
- the equipment has been tested and its signal levels adjusted at the factory, so that the amount of lining up required on site is reduced to a minimum, comprising only checking of the feeding voltages and antenna direction for the maximum signal level in the receiver (AGC voltage) and function testing of the lines.

MAINTENANCE

High reliability is at least as important in equipment that is to work in rural networks as it is in equipment in long-distance networks, although the reasons are different: in long-distance networks a loss of traffic caused by failures is very expensive; in rural networks the amount of time used, and hence the cost of maintenance on site, calculated per subscriber line, can very easily become excessive. Very high reliability

and good stability, and thus the lowest possible maintenance costs, are achieved by using, as far as possible, the same units and components in the rural systems as are used in the systems for the long-distance network.

Alarms are provided for faults in the following functions: feeding voltages, carrier generation (FDM), bit faults, loss of frame alignment and codec faults (PCM), loss of receiver signal (radio relay link) etc.

Periodic maintenance is required only for any batteries included in the system. All other maintenance consists of fault clearing, which is done by changing faulty printed board assemblies and units. This method requires that a suitably dimensioned stock of spare parts is available.

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Uninterruptible AC Power Supply System, Type BZV 102

Anders Hansson

The input and output devices in computer-controlled telecommunication systems are usually fed with alternating current, and stringent requirements are imposed as regards the absence of interruptions and the quality of the AC voltage.

This article describes LM Ericsson's new system for uninterruptible AC power supply, a system which adequately fulfils these requirements. Solid-state inverters, which generate an uninterruptible sinusoidal AC voltage, form an essential part of the system.

UDC 621.311.4

Large electronic systems usually require uninterruptible and reliable power supply. In LM Ericsson's electronic telecommunication systems the greater part of the equipment is fed with direct current. However, there is an important equipment category that is fed with alternating current, namely the input and output devices that communicate with the exchange computer. Certain of these devices have such stringent requirements that feeding from the mains power supply is not acceptable in view of the risk of interruptions and other disturbances.

LM Ericsson have developed a new AC power system, BZV 102, in order to satisfy these requirements. It is based on

solid-state inverters as replacement for the mains power supply. It provides 220 V 50 or 60 Hz AC voltage and is fed from the normal DC supply of the telecommunication plant. The main features of BZV 102 are:

- simple and robust circuit design - high reliability
- a few basic units but nevertheless a high system flexibility
- easy to install, put into operation and maintain
- fully automatic operation
- special earthing system - a high degree of personnel safety.

Experience from ten years of AC supply of AKE telephone exchanges has been utilised in the design of system BZV 102. The work was carried out in close collaboration with, among others, the design groups responsible for the input and output devices in telecommunication plants. The special characteristics of the load, such as high start currents, have also affected the system design. The new equipment is particularly suitable for the modern AX systems, but can also be used in many other applications, not necessarily in the field of telephony.



Fig. 1
The development of AC system BZV 102 was carried out in LM Ericsson's modern power supply laboratory in Stockholm. Two inverters that form part of the system are being tested here



ANDERS HANSSON
Power Supply Department
Telefonaktiebolaget LM Ericsson

AC system

BZV 102 constitutes a complete system for AC feeding of particularly sensitive loads, such as the input and output devices in stored program controlled telephone exchanges. The main requirements of such loads, which have determined the design of BZV 102, are:

- voltage drops, however short, must not occur, since they can cause permanent disturbances, for example shutdown of connected devices
- high start currents, several times larger than the rated current, occur frequently
- during operation the feeding voltage must not deviate from the rated value of 220 V AC by more than 10 % even during the transient conditions described above.

These requirements can be satisfied in different ways. In the LM Ericsson AC system (BZV 101) used hitherto the problem was solved elegantly with the aid of an uninterruptible thyristor switch¹. However, this system is fairly complicated. When designing the new AC system BZV 102 the aim was to create a simple and flexible system.

Function

The main units in the system are a number of inverters type BMS 301, which give uninterruptible AC voltage. Each inverter normally feeds only one load item. In this way the requirements of the load are satisfied. The output voltage of the inverter may fall when a device is started (current limitation takes place in the inverter if the start current is high) but this does not cause disturbances in other devices already in operation.

A rack accommodates up to four inverters, I1-I4 in fig. 2. The inverters are fed from a rectifier/battery R, B. Each inverter feeds one critical load item, L1-L4, via a contactor switch, C1-C4 respectively. There are often also less critical devices, L5-L7, which are normally fed from the mains via transformers of 500 VA each, DS1-DS3. A similar transformer, SBY, constitutes the common standby for the inverters. In the case of a fault in an inverter, it is automatically replaced by the standby power source by means of a changeover in the relevant contactor switch.

The standby capacity is rated 500 VA. To avoid overloading the standby supply if more than one inverter fails, the standby is connected in accordance with a given order of priority, with I1 having the highest priority. However, the reliability of the inverters is high and in practice it is therefore unlikely that any load item will lose its feeding voltage.

System alternatives

The equipment described above with a fully equipped rack is the normal system alternative. Such an equipment is shown in fig. 3. Different system variants can be obtained by changing the number of units equipped. For example, if an inverter is removed there will be space for four more transformers for direct supply from the mains.

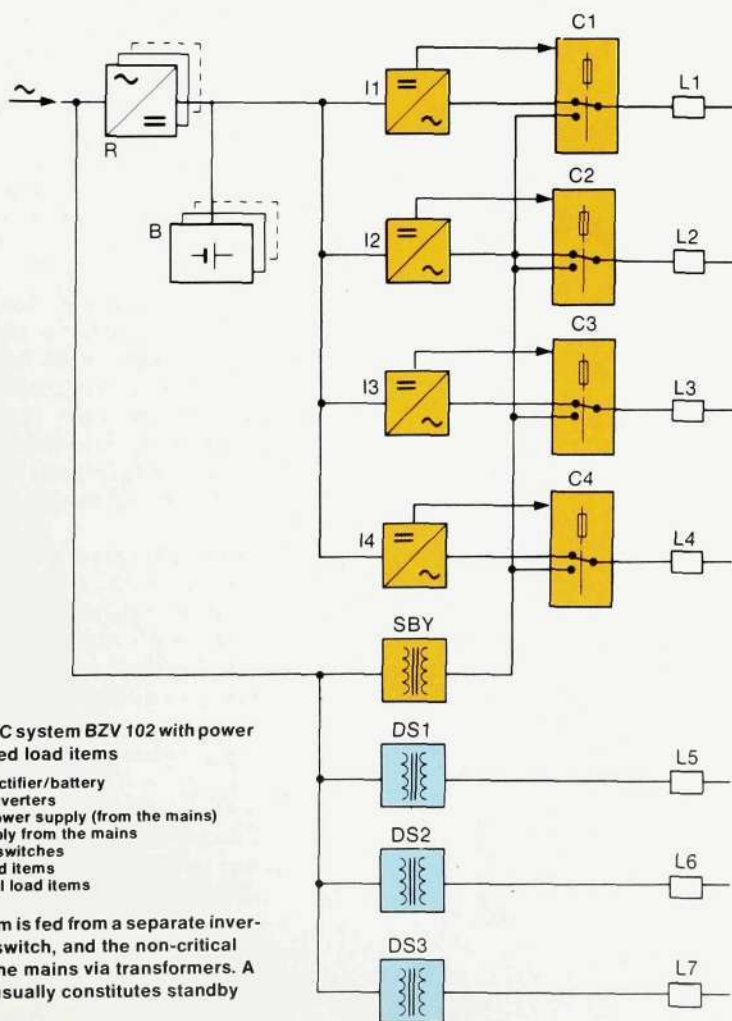


Fig. 2
A block diagram of AC system BZV 102 with power supply and connected load items

R, B Feeding rectifier/battery
I1-I4 Ordinary inverters
SBY Standby power supply (from the mains)
DS1-DS3 Direct supply from the mains
C1-C4 Contactor switches
L1-L4 Critical load items
L5-L7 Non-critical load items

Each critical load item is fed from a separate inverter, via a contactor switch, and the non-critical items are fed from the mains via transformers. A mains transformer usually constitutes standby for the inverters

Table 1
Possible system alternatives in BZV 102

SYSTEM ALTErna- tives	Ordinary inverters (I1...)	Standby (SBY) for ordinary inverters			Direct supply (DS1...)	
		From mains via transformer	From mains via stabilizer	From standby inverter	From mains via transformer	From mains via stabilizer
Inverters with standby	•	•				
	•	•			•	
	•		•			
	•		•			•
	•			•		
Inverters without standby	•					
	•				•	
	•					•
Only direct supply					•	
						•

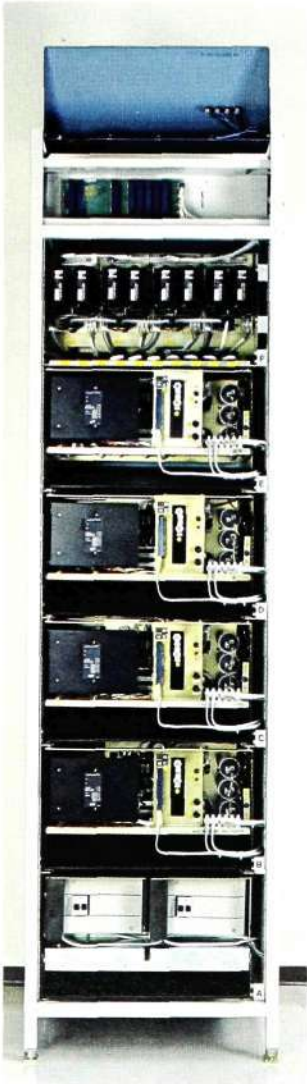


Fig. 3
A complete AC rack BZV 102 with the front plates removed. In this case the rack is equipped with 4 ordinary inverters, standby and direct supply from the mains via transformers and contactor switches for switching in the standby supply to the inverters. The top of the rack contains a connection panel with lamps for the outgoing alarm signals

If the quality of the mains is poor it is unsuitable to use direct supply from the mains via transformers. In cases where large transient voltages are encountered magnetic stabilizers, fed from the mains, are used instead so as to form an efficient transient filter. This alternative also gives a stabilized mains voltage.

In places where mains failures are frequent it would be unsuitable to use mains supply at all. An extra inverter is then used as the standby (SBY) for the ordinary inverters. It must then be decided in each individual case whether the non-critical load devices also are to be fed from inverters.

In certain cases it is not necessary to have a standby for the inverters, and the contactor switches are then not equipped. Direct supply from the mains is possible in accordance with the premises described above. Finally it is possible to equip a rack purely for direct supply from the mains.

Table 1 shows the possible system alternatives. Each alternative has different variants depending on the number and distribution of the units in question.

The blank squares are theoretically possible, but normally there is no practical use for such alternatives.

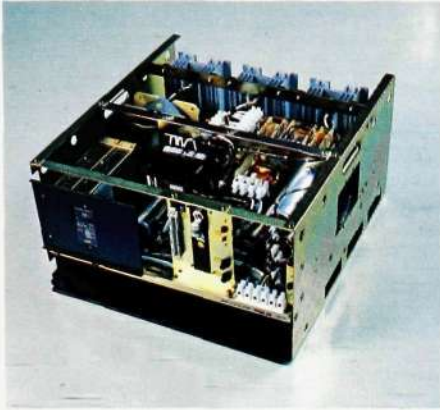


Fig. 4
Inverter BMS 301
48 V DC/220 V AC 500 VA
The principle of magnetic regulation gives simple circuit designs and high reliability

Inverter

The inverter BMS 301 converts 48 V DC voltage, which is usually obtained from the central DC power supply of a telephone exchange, into 220 V sine wave AC voltage with an output power of 500 VA. It is manufactured in two variants, for 50 Hz and 60 Hz respectively. The inverter is designed with a magnetic stabilizer, which gives the following advantages:

- simple and robust design
- good regulation with a large regulation range in spite of the low number of components
- low distortion
- short-circuit proof.

The inverter is designed for system BZV 102 but can also be used as an individual unit, fig. 4.

Function

The 48 V DC supply is connected via an input filter and input contactor to an inverter circuit INC as shown in fig. 5. The circuit contains two alternately conducting thyristors, providing a magnetic stabilizer MS with a rectangular AC voltage at a frequency of 50 or 60 Hz. The thyristors are triggered by pulses from a trigger device TD. These pulses also determine the frequency of the output voltage. The thyristors are turned off with the aid of special commutation components, L_c and C_c .

The magnetic stabilizer MS consists of a specially designed transformer with

very loose magnetic coupling between the primary side (P) and the secondary side (S), to which a resonance capacitor C_r is connected. The corresponding part of the transformer core works in the saturated area, and so-called ferroresonance is obtained. A constant voltage is then obtained across the resonance capacitor and also on the output. The output becomes sinusoidal through the resonance capacitor being connected in series with a special filter winding (F).

The task of the input filter IF is to attenuate the ripple components that are produced in the inverter circuit. In addition it protects the inverter from transients in the supply voltage. The input contactor IC is used to start and stop the unit.

Regulation and control

All regulation is carried out in the magnetic stabilizer MS. Thus the design of the trigger device circuit TD can be kept very simple. The output voltage is kept constant as long as the load current does not exceed the rated value. In the case of an overload the current limitation function starts operating and the output voltage is reduced. The inverter can also withstand a complete short-circuit on the output.

The unit is started and stopped with an operating device OD, which affects the input contactor and trigger device. It is essential that these are activated in the correct order.

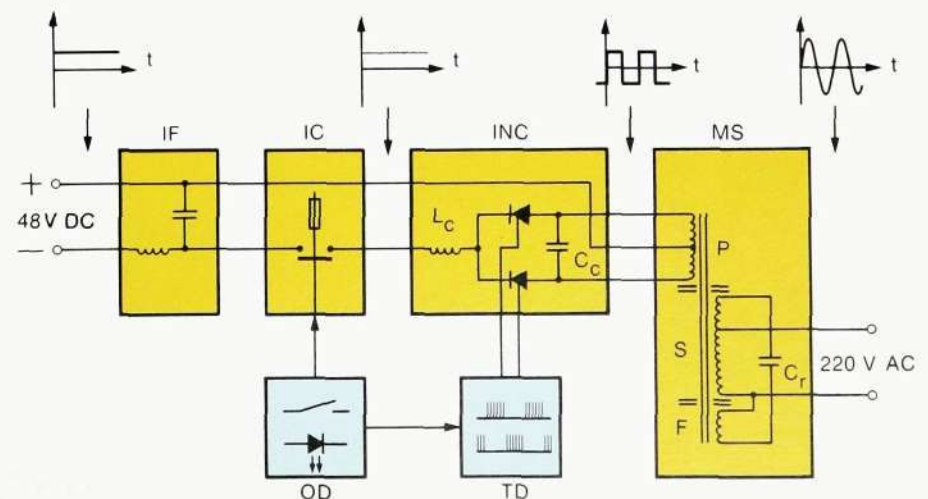


Fig. 5
A block diagram of inverter BMS 301 showing the functional signals

IF	Input filter
IC	Input contactor
INC	Inverter circuit
MC	Magnetic stabilizer
OD	Operating device
TD	Trigger device



Fig. 6
Inverter BMS 301, with its front plate removed, seen from the front when mounted in the rack. The inverter is operated by two push buttons, start and stop, mounted on one printed board assembly to the left in the unit

Protection and alarm

The inverter contains several protective functions and alarms for abnormal operating conditions:

- current limitation protects the unit against overload and short circuits
- a slow-acting output fuse blows in the case of a persistent short circuit on the output and causes an alarm
- a fast-acting input fuse protects the thyristors in the inverter circuit
- an earth fault indicator gives an alarm if any of the output terminals of the inverter is earthed.

The alarms are transmitted via the operating device OD.

Other characteristics

The inverter can also be provided with the following functions, which are not part of the standard equipment:

- remote start and stop
- parallel operation
- synchronization with another AC voltage source.

Mechanical design

The inverter consists of a plug-in unit, fig. 6. The operation and trigger devices each consist of a printed board assembly plugged into a cassette. When mounted in a rack the unit is equipped with a front plate. The control buttons and indication diodes are accessible through a hole in the plate. Fuses and connection points are easily accessible after removing the front plate.

Mechanical structure

AC system BZV 102 has the same mechanical design as LM Ericsson's new generation of power supply equipment type BZD 112. This packaging structure has been described in an

earlier issue of Ericsson Review², and hence only a few characteristics will be mentioned here. A complete rack is shown in fig. 7.

- Each unit is built up of standardized modules—great flexibility.
- The units are easy to mount—they are slid into the racks on rails.
- The units are cooled naturally (cooling through self-convection) in accordance with the parallel cooling method.
- The racks can be placed in single rows, double rows or against a wall.

Distribution

All alternating current is distributed from a central point, the contactor unit, placed in the top module unit in the rack, fig. 8, via plugs. This method makes it very easy to redistribute the load among the supply sources if necessary.

Earthing

Considerable thought was given to the earthing principle when designing system BZV 102, in order to ensure the greatest possible personnel safety. The latest Swedish electrical safety regulations are also met. The main characteristics of the earthing system are:

- The system is not directly earthed, i.e. the neutral is not earthed
- Mains feeding always takes place via separation transformers, which are equipped with class 2 insulation (Fi-marking) and encapsulated, fig. 9
- Earth fault relays on all 220 V outputs give an alarm if any of the outward distribution lines comes in contact with an earthed object; however, disconnection will not occur
- The short-circuit current to earth does not exceed 15 mA
- The voltage to earth is limited to 110 V.

Fig. 7
A complete AC rack BZV 102 with front plates attached



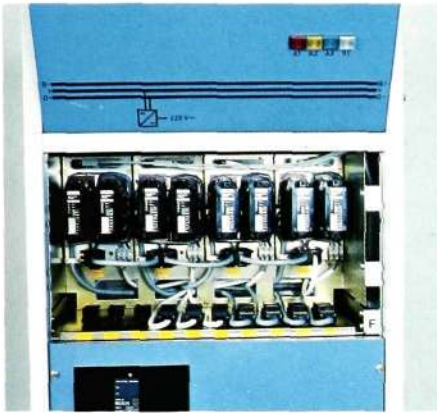


Fig. 8
A contactor unit containing 4 contactor switches. The load units can easily be connected to the various supply sources by means of plugs

Technical data for inverter BMS 301

Output data

Output voltage, nominal	220 V AC
Static regulation, with permissible variation of all parameters	$\pm 5\%$
Dynamic regulation with a load change of $\pm 30\%$ or a step-wise change of the input voltage of 6 V	$\pm 15\%$
Response time	Max. 100 ms
Frequency	50 or 60 Hz $\pm 1\%$
Waveform	Sinusoidal
Distortion	Max. 5 %
Output power with linear load	500 VA
Permissible power factor	0.6 – 1.0 ind.
Output current, peak value	Max. 3.1 A
Short-circuit proof	Yes
Short-circuit current (stationary)	5 – 10 A

Input data

Input voltage, nominal	48 V DC
Permissible variation technical data met	44 – 56 V DC
maximum	40 – 60 V DC
Input current with nominal input voltage and nominal load	Max. 16 A DC
Recommended input fuse	35 A DC
Efficiency with nominal input voltage and nominal load	Min. 67 %

General data

Psophometric noise level on the input, measured across 15 m Ω battery impedance	Max. 1 mV
Radio frequency interference on the input and output (In accordance with recommendations by C.I.S.P.R.)	
0.15 – 0.5 MHz	Max. 80 dB (10 mV)
0.5 – 30 MHz	Max. 74 dB (5 mV)
Ambient temperature	
Operation	0 to +45° C
Non-destructive	– 10° to +55° C
MTBF	44 years
Dimensions and weight	
Width	530 mm
Height	297 mm
Depth	565 mm
Weight	35 kg

Fig. 9
Two transformer units, with the front plates removed, seen from the front in the rack. All 220 V connections are efficiently encapsulated and protected from accidental contact. The units are FI marked (class 2 insulation)



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1. Wolpert, T.: *Uninterruptible Power Supply for Critical AC Loads – A New Approach*. IEEE Transactions on Industry Applications, Sept./ Oct. 1974.
2. Michelsen, S., Ekelund, F. and Rundkvist, K.: *A New Generation of Power Supply Equipment, Type BZD 112*. Ericsson Review 55 (1978):2, pp. 46–57.

Automatic Protection Switching of Transmission Links

Ulf Hedman, Torbjörn Johnson and Günther Ouvrier

The article describes a system for automatic protection switching of transmission links, which is intended to be put into operation when a fault occurs on a long-distance transmission system. The switching system has been developed by LM Ericsson in cooperation with the Norwegian and Swedish Telecommunications Administrations. The article also describes a field trial at present in progress in the Stockholm region.

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621.395.3/.5

In most countries the long-distance network is based on wideband coaxial cable and radio relay link systems. These communications systems operate with very high reliability thanks to modern electronic technology. However, in certain cases external occurrences can affect the operation of the system, and this can lead to serious traffic disturbances in the long-distance network. One example is a break in a coaxial cable section, which would occur if an excavator or the like happened to damage a buried cable. Experience shows that the number of disturbances caused by such and other external occurrences is considerably higher than the number of serious disturbances caused purely by equipment faults.

There are a number of possible methods of dealing with such disturbances. A common aim for all methods is that a total breakdown of one wideband transmission route shall not result in the failure of all circuits between any two places in the long-distance network.

The following alternative methods may be mentioned:

- spreading the traffic over several transmission paths that are independent of each other
- duplicating the transmission systems, i.e. transmitting the same traffic over two independent paths
- using a protection switching system that permits to form different standby links of the standby capacity in the network.

Spreading the traffic over several transmission paths is an old and well-tried method, which can easily be applied in most long-distance networks. However, the traffic routes are usually rather small, and it is therefore necessary to through-connect many small multiplex groups instead of a few large ones and almost without exception this is a costly business. Furthermore the method has its limitations as regards individually leased lines, since these are not connected through the switching stages of the telephone exchanges. A transmission breakdown on such lines will thus persist until the fault has been repaired.

The second method is advantageous for a few special traffic categories with a high degree of priority but requires far too great a transmission capacity to be used generally throughout a whole long-distance network.



Fig. 1
Accidents will happen — an excavator has damaged a telecommunications cable



ULF HEDMAN
Central Administration of Swedish
Telecommunications
TORBJÖRN JOHNSON
MI Division
Telefonaktiebolaget LM Ericsson
GÜNTHER OUVRIER
Transmission Division
Telefonaktiebolaget LM Ericsson



The third method is described in more detail in this article.

Protection switching system

PRINCIPLES

The basic structure of the protection switching system is described with reference to figs. 2 and 3, which show the traffic routes and traffic loads in a hypothetical long-distance network containing repeater stations A—F. (See the captions.)

Table 1

Equipment Type	Capacity per equipment	
	Standby sections	Working links
2	2	2
3	3	6
4	4	8

Fig. 2
A hypothetical long-distance telephone network
Protection switching equipments in repeater stations A to F inclusive

●—● Working link
○—○ Standby section

Fig. 3, right
A break between stations A and B.
Traffic via interconnected standby sections

○—○ Standby link
Protection switching of a normal working link at its terminating points
Standby sections connected together via the associated through-connection filter

Fig. 2 shows conditions during normal operation and fig. 3 how the protection switching can be made in the case of a break on the route between stations A and B. As can be seen, the two faulty working links have been connected to suitable standby links, which consist of individual standby sections that have been connected together. Similar standby switching is made when a fault occurs in any other part of the network.

One characteristic of the system is that there is only one standby section per line section. This in its turn means that the protection switching equipment required at each repeater station only has to handle a limited number of standby sections and terminating working links. Such a part of the standby network—which thus consists of a single standby section per line section and the neces-

sary switching equipment—is called a switching plane in the remainder of the article.

With only one switching plane it is of course only possible to arrange protection switching for a limited number of working links. However, there is nothing to prevent the installation of several switching planes in one and the same long-distance network. The different switching planes are then entirely independent of each other. Moreover they do not need to have the same capacity. By using this method the whole of the protection switching system can be adapted to the working link density of the particular network.

Three switching planes were used in the field trial described later in the article.

PROTECTION SWITCHING EQUIPMENT

The protection switching equipments used in the field trial are built up for varying maximum extension capacities in accordance with table 1.

All equipments have the following characteristics:

- they can be used for all CCITT standard carrier groups, from basic groups of 12 channels up to whole 12 MHz line bands
- they can be remotely controlled via an alarm and control system and also locally controlled via built-in push-buttons

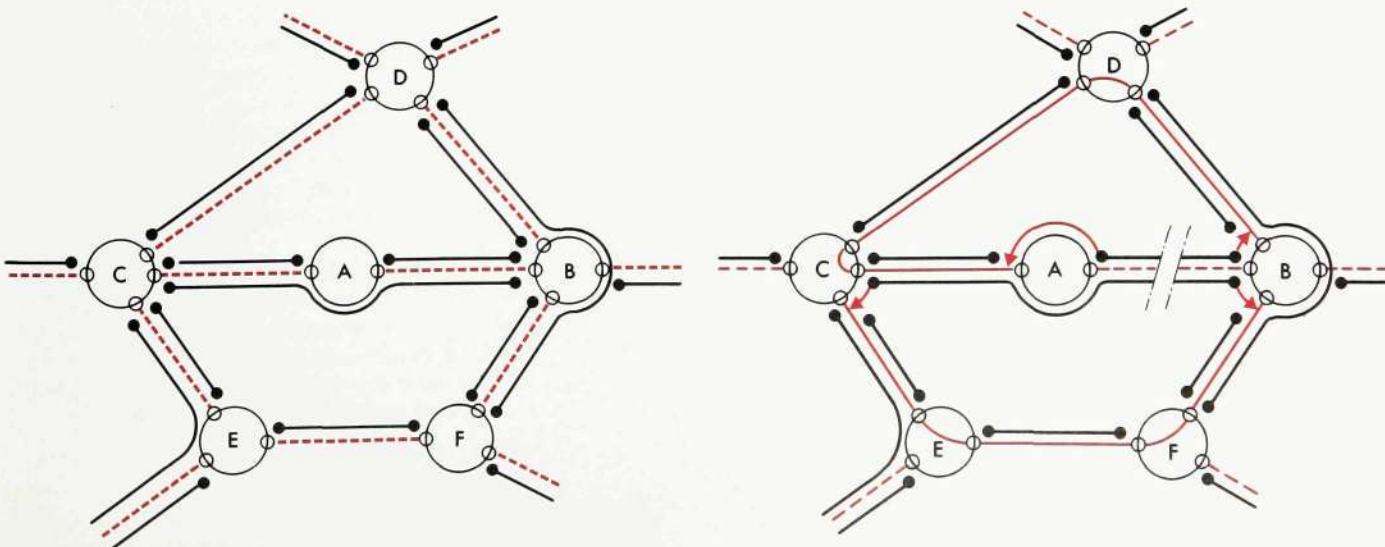
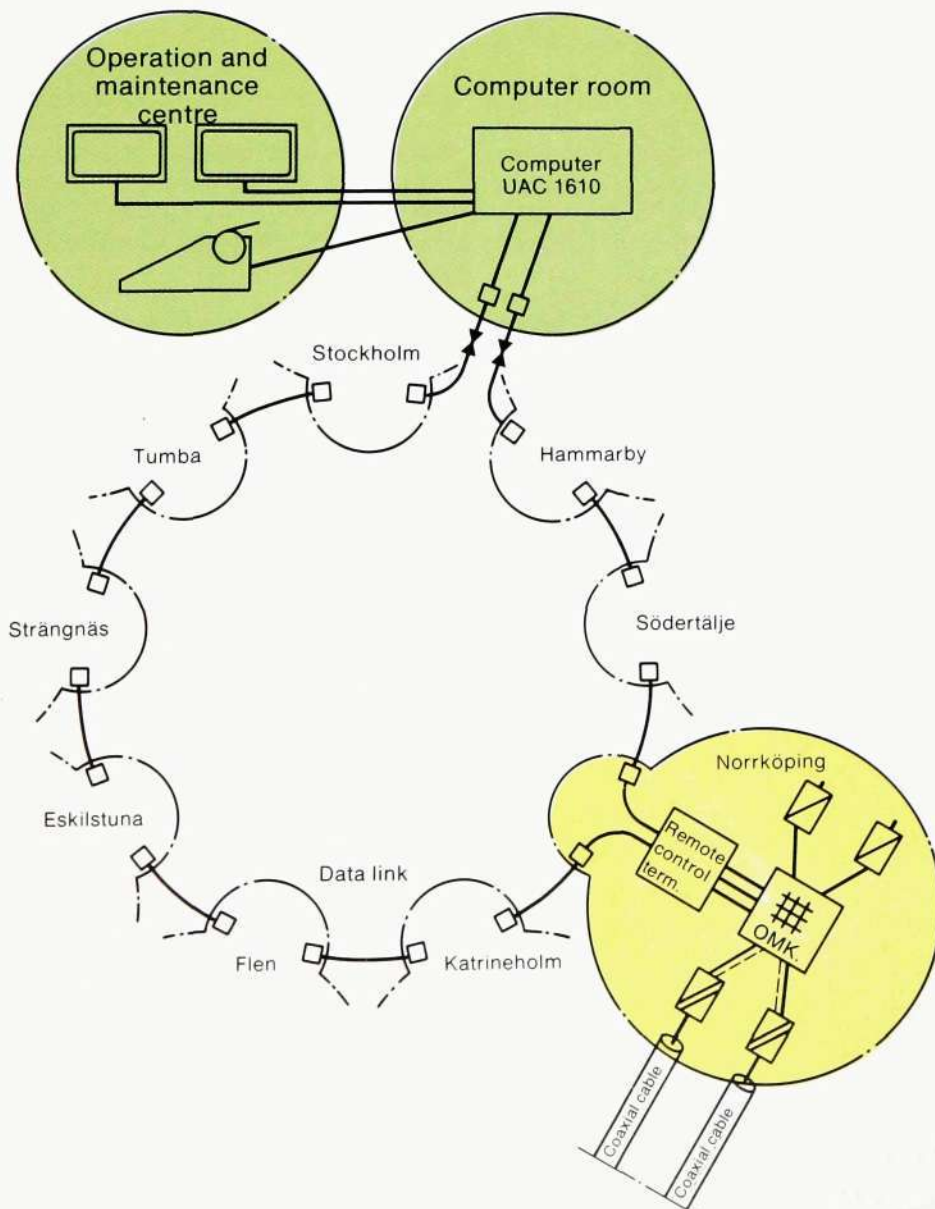


Fig. 4
The supervisory loop in the trial network

- Modem
- ▧ MG translating equipment 300/900
- ▨ SMG translating equipment 900/2700
- OMK Protection switching equipment



- the protection switching is always made for both transmission directions even if only one direction has been reported as faulty
- decentralized logic equipment prevents prohibited switching conditions
- standby pilots can be fed into all connected sections, i.e. the standby sections and also the released working links. The pilots are fed in automatically and can be inhibited by either remote or local control

- information regarding the operating state and the position of the change-over switches can be obtained electrically via output circuits and visually via built-in light-emitting diodes
- no repeaters are connected into the transmission paths of the protection switching equipments
- the switch contacts consist of mercury-wetted relay contacts
- the equipments are powered via decentralized power units
- the same types of units are used in all equipments with the exception of a few special units.

CONTROL SYSTEM

Central control equipment

The central control equipment consists of the LM Ericsson real time computer UAC 1610. It has two tasks:

- to communicate with the terminals in the remote control system
- to process all data associated with automatic protection switching in the supervised wideband network.

The computer is equipped with a real-time clock, alarm unit, console typewriter, transmission line interface units and cassette tape recorder.

The alarm unit is used to call a computer operator if a fault occurs in the computer system, since it normally works unmanned. The console typewriter is used for computer-dependent alarms and direct interventions in the program system during tests etc.

The transmission line interface units are used for connection to the remote control terminals and also for connection to the operator devices. The latter consist of two colour monitors with key-boards and a line printer, which can be placed in a suitable location, not necessarily adjacent to the computer room.

The cassette tape recorder, which is duplicated, is used for loading the program system when the system is started up, and for recording all incidents that occur in the system, including pilot alarms and state information.

Remote control system

LM Ericsson's terminal system JZA 700 is used as the remote control system.

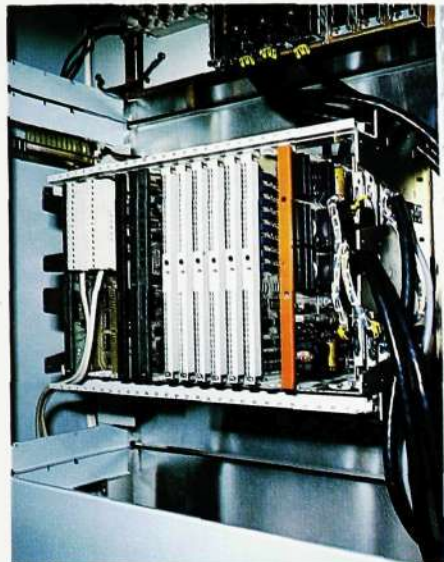


Fig. 5
Remote control terminal

In the field trial all terminals are connected to form a loop, and the ends of the loop are connected to the central computer UAC 1610, fig. 4. The transmission loop consists of physical lines which are completely separate from the coaxial cable routes of the wideband network. Standard modems with a transmission rate of 1200 bit/s are connected between each terminal and the transmission loop. The loop connection of the terminals increases the transmission reliability, since all terminals can be reached from the computer even if there is a one-way or a both-way break in the transmission loop.

Each terminal is equipped with an appropriate number of digital input and output boards, which have reed relays for earth separation and good protection against interference. The input and output boards are connected to the protection switching equipment via an intermediate distribution frame (IDF) with jacks. The IDF was introduced in order to simplify redistributions, which can be carried out easily and accurately with movable connectors without the need for soldering or other connection work (fig. 13). This is an important contribution to the operational reliability of the system, since an incorrect connection

during a redistribution could have serious consequences.

Reporting of pilot alarms and all state information from the terminals is controlled by the computer, which starts a cyclic process by requesting terminal no. 1 to transmit. If there has been a change in its input data since the last request, terminal no. 1 will then send all its information, otherwise it will just send its address. The message from terminal no. 1 then acts as a request to terminal no. 2 to transmit, and so on. The whole cycle continues in this way, and when the message from the last terminal has been received, the next cycle can be started.

In order to ensure that no information is lost the computer requests each of the terminals in turn—one terminal during each cycle—to send all its data, irrespective of whether any changes have occurred or not.

When the computer listens to the transmission loop during the cycles a supervision takes place which detects any break in the transmission of data. If no data are received from a terminal the computer sends a new request in the normal direction round the loop. If there still is no response the request is sent in the other direction round the loop.

When a persistent pilot alarm has been obtained the computer automatically sends out changeover orders. These are sent between the cycles since the computer cannot stop a report cycle once it has started.

Control program

The program system is based entirely on primary storage and comprises 32K 16-bit words, including data areas. It was specially developed for this project, with the exception of the operating system and certain handling routines, which were available as standard programs. The program language is assembler.

The main functions of the program system are:

- to analyze indications from the protection switching equipments in the repeater stations
- to convert operator commands to order telegrams that are transmitted to the terminals in the repeater stations

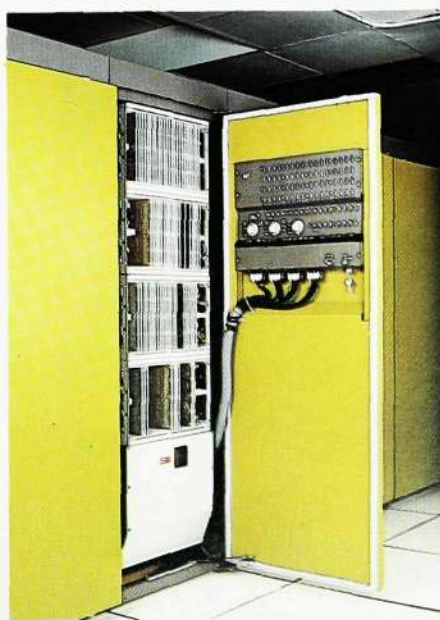


Fig. 6
UAC 1610. Central unit with control panel

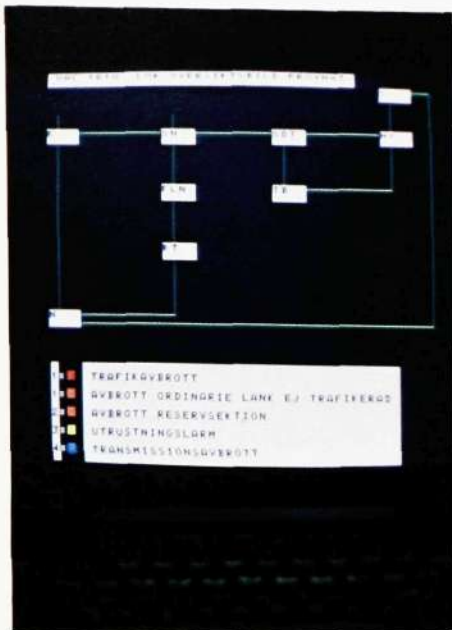


Fig. 7
Overall display picture of the trial network

This picture gives a concise version of the alarm information from all repeater stations

- to automatically carry out protection switching of links when persistent alarms are received from the associated pilot receivers
- to present the state of the supervised wideband network, the data transmission network and the protection switching equipments.

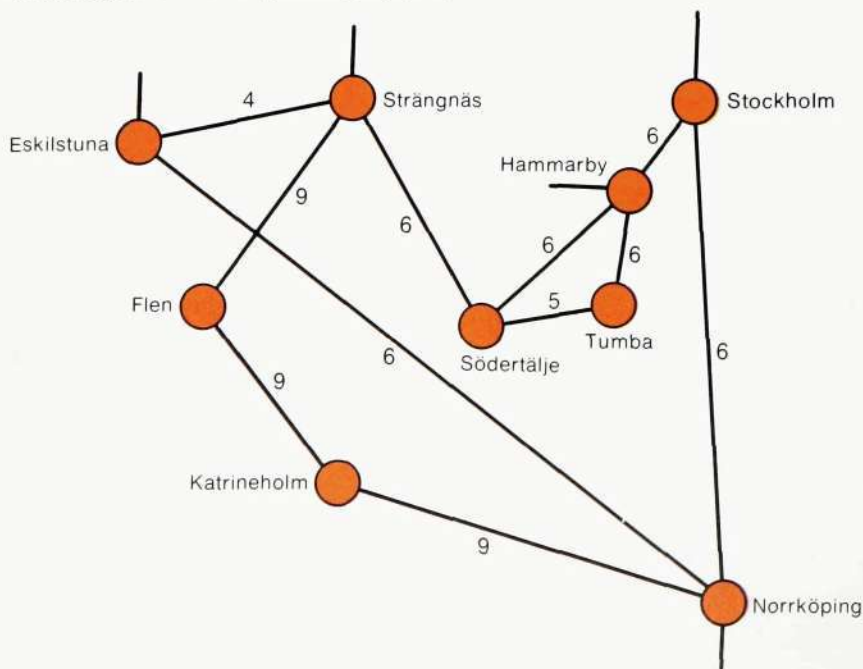
To enable the software to carry out these functions it has been designed as a number of function modules, which in their turn consist of individual programs with simple and well defined interfaces. Individual functions and programs can thus be modified quite simply without affecting adjacent programs.

Operator interface

The system carries out protection switching of links independently and without operator intervention when faults occur. All other functions, such as restoration to normal working links, are initiated by the operator.

The state of links, protection switching equipments and transmission lines is continuously indicated on the colour monitors. By means of commands the operators can choose whether to have an overall picture, which shows the most important information for the whole system, or a detail picture showing all available information for a limited number of stations.

Fig. 8
The coaxial cable routes in the trial network
The figures give the number of supermastergroups (SMG)



All incidents that occur in the network are printed on the line printer and recorded on the cassette tape. This record can be used for statistical processing.

Each command consist of a mnemonic code with a maximum of 6 characters and, when necessary, a number of parameters. The control system checks whether the code and parameters are correct and exist. If for any reason the command cannot be carried out correctly an error printout is obtained which gives the reason in text en clair. Apart from the various control commands there are also a number of commands that initiate various types of state reports.

Field trial

AIMS AND REQUIREMENTS

An extensive field trial was planned in order to obtain experience of automatic protection switching before deciding on its introduction on a larger scale in the Swedish telecommunication network. In addition to the recording and measurement of different reliability and quality parameters the man-machine aspects were considered to be of great interest, and great efforts were put into specifying means of presentation, printouts, commands etc.

To particularize, the field trial was to provide answers to the following problems:

- detection of and remedies for unforeseen problems when putting the system into operation, during the trial run and when carrying out alterations to the system
- assessment of the operational reliability
- data for transmission levels etc. during changeover, interruption times, changeover times and the sensitivity of the system to interference.

Some basic requirements that can be set for automatic protection switching, and which were consequently set for the trial system, are:

- in the case of persistent faults protection switching must take place before the call is disconnected (whether that is done automatically in the exchange or by the subscribers replacing the handsets). The limit was set to 10 seconds

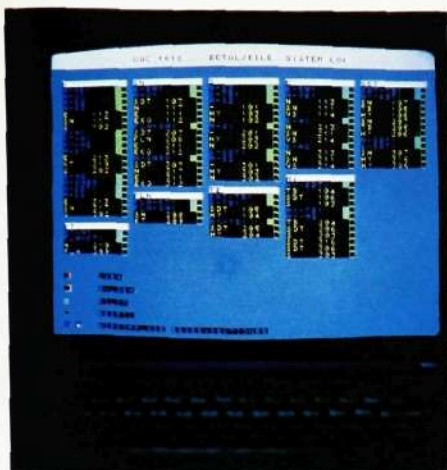


Fig. 9
A display picture with detailed information from some repeater stations

- single short interruptions (<1 second) must not cause protection switching
- there must be no substantial quality deterioration for traffic during normal operation
- only negligible disturbances between systems in operation when switching takes place
- return from the standby link to the normal working link must not take place automatically but must be controlled by the operator and carried out only when the link has been approved
- it must be possible to shift between automatically and manually controlled switching
- it must be possible to record important occurrences in the network in order to make possible follow-up and analysis
- it must be easy to adapt the system to changes in the network (new cable routes, groups and stations)
- breaks in the carrier network must not mean the loss of the control or supervisory function for any station.

TRIAL NETWORK

A part of the Swedish carrier network consisting of several meshes was chosen for the field trial. The trial network comprises 9 repeater stations and 11 coaxial cable routes between the sta-

tions, each of which includes two or three 12 MHz line links, fig. 8. The total cable length used for the trial is 560 km. The dimensioning of the standby capacity is such that each cable section contains three spare supermastergroups (SMG) which when connected up in suitable combinations provide adequate alternative routes for the 21 SMG links in traffic in the network.

The trial network provides a 100 % protection switching possibility for total breakdown, for example a cut cable, unless similar catastrophes occur in adjacent parts of the network at the same time.

Fig. 4 shows the structure of the trial system with protection switching equipment, remote control terminals, data lines, central computer and operator equipment.

Figs. 7, 9 and 10 shows the operator's position in the operation and maintenance centre in Stockholm with an overall picture and detailed information regarding alarms and switch states on the monitor screens. The operator can put questions and give orders to the system via the keyboard.

TRIAL OPERATION

Putting the system into operation

Careful preparations were made for putting the protection switching system into operation, which was carried out without a hitch. The computer, remote control terminals and changeover equipments were installed and tested separately. The system was then connected up (without any SMGs in service) and tested, first by means of manual orders from the operation and maintenance centre and then by means of automatic control. After the successful conclusion of these tests the system was put in the manual mode and the SMGs were connected in. The changeover to automatic control then took place without any problems.

Functional reliability

The functional reliability of the system was severely tested during the first five months of the field trial. A test link was connected up and breaks were simulated continually by generating pilot failures of varying length and periodicity.

Fig. 10
Operator's position with the two colour monitors and line printer (on the left)



ty. A fairly large number of real faults also occurred, namely no less than five total breakdowns on the cable sections involved and some ten SMG faults. In all cases the trial system carried out the protection switching according to plan.

It may also be mentioned that the operating staff consider the functional reliability of the system to be so good that when a transmission system has to be taken out of service temporarily, during periods of low traffic they simply disconnect the transmission route in question and leave it to the automatic control system to connect up a standby link. However, the recommended procedure is to order the system to connect up a standby link and not to initiate the actual changeover until this has been done.

Changeover times

The actual changeover times were measured in connection with the breaks generated on the test link.

Basically the system is designed so that the computer only accepts incoming pilot alarm information when the same information has been reported at least twice in succession. This makes the system more reliable although it increases the changeover time. Roughly speaking the changeover time can thus be considered as corresponding to at least three scanning cycles, two for alarm collection and one for order transmission. To this must be added the detection time in the pilot receiver, the processing time in the computer and the order transmission time.

The expected changeover time calculated on the basis of the conditions that exist in the trial network was approximately 3.5 seconds. The actual measurement results gave values between 3.2 and 4 seconds on condition that the data transmission loop was complete. With one data link disconnected the times were slightly over 5 seconds.

It is desirable that faults that last less than 2 scanning cycles should not cause changeover. During the testing of this function a large number of breaks of varying duration were generated intentionally.

The following results were obtained:
breaks <2 s: never any changeover
breaks 2–3 s: occasional changeovers
breaks >3 s: changeover every time

The above results apply for a complete data transmission loop. The times were approximately 2 seconds longer if any data link was disconnected. Thus the equipment meets the requirement that it must not carry out protection switching if the breaks are short.

Changeover took place when the SMG test link was subjected to bursts of short breaks (each less than 2 s), but the time between the start of the burst and the changeover varied considerably.

As has already been mentioned, the criterion for a changeover is that the same alarm must be obtained during two consecutive cycles, and this occurs sooner or later even in the case of bursts. This type of fault, a burst of short breaks, is fairly rare but causes considerable disturbance. Hence a changeover should take place but as ordinary calls are not disconnected in this case, as they would be with a complete break, there is no need to insist on the 10-second limit. Thus the system behaves satisfactorily in spite of the fact that no specifications for bursts of breaks had been drawn up in advance.

A changeover between two functioning links, for example when returning to the normal working link from a standby link or when changing over to a standby link in order to carry out maintenance work or similar work on the normal working link, causes a short interruption in service. The changeover time consists of the operate time (<2 ms) of the switch plus the difference in transmission time for the orders to the two terminal exchanges. The latter time has been found to be approximately 180 ms when the exchanges are next to each other in the alarm loop. The only effect on any calls in progress is that observant subscribers hear a "click".

Transmission level, attenuation, crosstalk

It is important to know what short-term changes in transmission level occur when protection switching are made,

Fig. 11
Part of a group distribution frame (GDF)

The coaxial connection panel in the centre belongs to a protection switching equipment placed back-to-back with the GDF rack

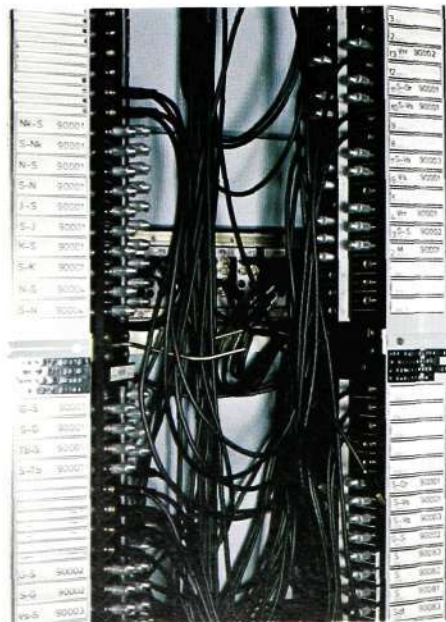




Fig. 12
Partially equipped protection switching equipment in a repeater station

mainly in order to decide how many SMG sections can be connected together without negative effects.

When an automatic protection switching is carried out the course of events is so rapid that the terminal repeaters in the individual standby sections do not have time to regulate the transmission level jumps that occur, partly as a result of systematic attenuation deviations in the individual switching points. This occurs in spite of the fact that the operations are not made synchronously but in the order as the telegrams arrive at the various stations. The size of the level jump is mainly dependent on

- the sum of the attenuations of the changeover switches concerned, including cabling
- the sum of the residual attenuation errors per standby section that remains after pilot regulation
- the sum of the systematic attenuation deviation of the SMG through-connection filters.

The measured attenuation through a protection switching was <0.1 dB, with variations of ± 0.05 dB. No frequency-dependent attenuation was found beyond what can be attributed to the necessary cabling between the equipments. Thus

the effect of the changeover switches on the attenuation is almost negligible.

The measurements carried out showed that under the conditions prevailing in the trial network it is perfectly possible to connect together more than 10 standby sections without any apparent disturbing effects. However, for planning purposes, a limit of 8 to 9 standby sections in cascade is recommended.

Some other quality parameters have been investigated. For example, the near-end and far-end crosstalk attenuation through the protection switching equipment was measured and it was found that in no case was it less than 112 dB, which is decidedly better than the specification for an ordinary group distribution frame (GDF). Furthermore the measurements did not show any other measurable noise contribution from the changeover switches, which is to be expected as they contain no electronically active components.

Man-machine interface

Interviews with the operating staff have indicated that the presentation means and commands were clear and easy to handle. It is possible that more information is presented in the trial network than is really necessary. For example, the overall display has proved to be of little value but in a larger network it is likely to facilitate a rapid understanding of the situation.

Reallocations in the network

On a few occasions checks have been made in order to determine how reallocations and extensions in the long-distance network affect the handling and function of the protection switching system. Generally speaking it can be said that more work has to be done in networks with protection switching equipments than in ordinary long-distance networks. This is because rearrangement work in the stations concerned has to be carried out not only in the existing GDFs, fig. 11, but also in the protection switching equipments (OMK), fig. 12, in the IDF, fig. 13, and sometimes also in the remote control terminals, fig. 5. Thus these networks require more extensive and above all more careful preparation than long-distance networks without OMK.

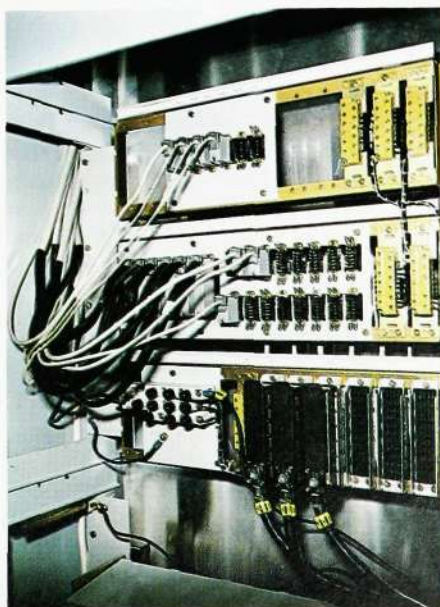


Fig. 13
Intermediate distribution frame (IDF)
The frame is built up with movable connectors which simplify rearrangement and extension

The rearrangement work has otherwise gone well and without problems. During the actual station work the system had to operate manually, that is to say the automatic protection switching was deactivated but not the supervision, and when everything had been connected in, the computer was taken out of circuit for a few minutes while the input of the new program module was carried out. In a fully developed system even such short breaks in the supervision can easily be avoided if the method of feeding in basic data from the operator's desk is used for minor changes.

Noticeable disturbances in the telephones channels

A number of test calls were recorded on tape for evaluation in order to get a better idea of the subscribers' reaction to the length of the transmission breaks during calls, i.e. the time between the fault's occurrence and the completion of the protection switching. These calls were transmitted via a test link on which breaks were generated. The participants were personnel who had previously been informed about the tests, but none of them knew exactly when the breaks were to occur.

The results of the investigation are not really surprising since they showed that usually only one of the two participants noticed the break, namely the one who was *not speaking*. However, what is perhaps more interesting is that the break was seldom considered to have a disturbing effect. The reason for this is probably that the listener often experiences a relatively large part of the break time as a natural pause in the speech of the other party. The participants reacted quite differently to breaks when music was being transmitted. The break was then much more noticeable.

It must be pointed out that the investigations are based entirely on breaks with a duration of between 3.2 and 4.0 seconds. They therefore provide no information about the degree of patience the subscribers can be expected to show, i.e. the time that elapses before the average subscriber decides to break a call by replacing the handset. However, there is no doubt that this time is longer than 4 seconds.

Conclusion

The field trial has shown clearly that it is possible to establish a system, which with satisfactory reliability can restore the service in the long-distance network within a few seconds when transmission breaks occur.

In the present situation the calls that are in progress are disconnected and traffic on the broken line cannot be expected to be restored for several hours. An automatic protection switching system improves the degree of service provided for the subscribers to such an extent that for instance a cable break on the route is experienced only as an insignificant disturbance.

The development now in progress, namely to operate an ever increasing number of stations in the network unmanned, is helped considerably if protection switching of transmission links can be done by remote control from operation and maintenance centres.

The future development of protection switching in the Swedish wideband network will mainly depend on the dimensioning of the standby capacity in the line systems. The target of 100 % protection switching facilities in all parts of the long-distance network is apparently too expensive. A standby capacity that can make up for 30–50 % of the line capacity that is lost as a result of a fault would probably be sufficient to achieve an acceptable congestion level in public networks and also permit protection switching for the more important leased lines.

The switching level in the trial network, i.e. the SMG level, seems to strike a good balance between on the one hand complexity and cost of the protection switching system and on the other hand efficient utilization of the line capacity.

The additional cost of automatic protection switching is in the order of 20 % of the cost of the standby capacity in the network. This extra cost is compensated by the reduction of the loss of revenue in the case of a fault, and the fact that a higher service level is achieved, which is an important goal for a telecommunications administration.

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ERICSSON REVIEW

AKE 132 WITH SIGNALLING SYSTEM CCITT No. 6 IN LONDON
POWER SUPPLY SYSTEM FOR SMALL TELECOMMUNICATION PLANTS
STORED PROGRAM CONTROLLED PABX, ASB 900
10-CHANNEL PCM SYSTEM
POWER SUPPLY UNITS IN THE M5 CONSTRUCTION PRACTICE
COMPUTER-CONTROLLED, AUTOMATIC BATTERY CHARGING

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COVER

London/Thames International Switching Centre
(By courtesy of the British Post Office)

AKE 132 with Signalling System CCITT No. 6 in London/Thames ISC

Christopher Wright and Jan Swerup

This article describes LM Ericsson's new, advanced subsystem called CCITT6, which has been developed to implement signalling system CCITT No. 6 into AKE 132. It also deals with the signalling system No. 6 test traffic, which was successfully established between the AKE 132 exchange in London and an international gateway exchange in New York.

UDC 621.395.38

Signalling system No. 6 was originally implemented in AKE 131 for a field trial exchange delivered in 1970 to the Overseas Telecommunications Commission (Australia), OTC(A) in Sydney¹. After the field trial OTC(A) placed an order with LM Ericsson for another AKE 131 exchange with signalling system No. 6. This exchange was handed over in 1974. It was the first exchange in the world capable of using the new signalling system on a commercial basis. There were, however, no telecommunications administrations with which this potential could be exploited until July 1978, when signalling system No. 6 was inaugurated for traffic between Sydney, Tokyo and New York.

LM Ericsson's new implementation, CCITT6, which has now been developed to introduce signalling system No. 6 into AKE 132² takes full advantage of the APZ 150 processors. The first exchange with this new implementation has been delivered to the British Post Office for Mondial House, London, fig. 1. Today work is in progress for two other exchanges, namely a new international AKE 132 ex-

change being installed in Sydney and the extension of an exchange in Rotterdam.

It has been forecast that by 1985 as many as 18 countries will have introduced signalling system No. 6. This should benefit international telephone customers by providing faster and more reliable telephone service. Maintenance costs should also be reduced.

Important characteristics of signalling system No. 6

Signalling system No. 6 has been specified by the CCITT for international semi-automatic and automatic telephone traffic³ over unidirectional as well as bothway circuits. All types of transmission systems can be used including satellite, TASI and digital systems. The system has a large unused signal code capacity, which will allow for the addition of new signals. This spare capacity may be used for increasing the number of telephone signals as well as for introducing other types of signals, e.g. for network management and network maintenance.

All signalling information is carried over a separate data link, common to a number of speech circuits, fig. 2. On the data link information is organized in signal units of 28 bits each. To associate the information with the speech circuits,



Fig. 1
London/Thames International Switching Centre (ISC) is situated on the north bank of the River Thames



CHRISTOPHER WRIGHT
British Post Office
JAN SWERUP
Telephone Exchange Division
Telefonaktiebolaget LM Ericsson



a circuit identity (label) is contained in each signal message. Since this label requires a large number of bits, provision is made for sending multi-unit-messages consisting of several signal units under one label. Line signals (e.g. B-answer) are transferred as one-unit-messages while e.g. B-subscriber numbers are normally transferred as multi-unit-messages.

Detection of transmission errors is based on the decoding of check bits included in each signal unit and on a data channel failure detector. Errors are corrected by retransmission of the information and, in the event of an excessive error rate on the link, by transferring signalling to a reserve link. As the signalling in signalling system No. 6 takes place on a separate data link, a broken speech path would not in itself prevent the completion of a call. Therefore the speech path is tested with a continuity check tone, during the set-up phase of each call.

The signalling system may be used in the associated mode of operation or with signal transfer points (STP) in the non-associated mode, fig. 3. The associated mode is suited for large routes, while the non-associated mode is intended for small or medium size routes. With the non-associated mode several routes will share the capacity—and the cost—of the same signalling equipment.

Signalling system No. 6 in AKE 132

The third AKE 13-generation of signal-

ling system No. 6 now developed is based on extensive experience. Many fundamental concepts from earlier designs have been adopted, applying modern technology. The latest technique for structured software design has been used.

The new implementation offers several important features and fulfills the most exacting options specified by the CCITT, such as using speech circuits as reserve data links, applying parallel and serial STPs and rerouting upon receipt of a congestion signal from subsequent exchanges. It also has a fully developed man-machine interface, facilitating the operation of the system. Regional processors have been introduced in the signalling terminals to perform routine work, thus reducing the load on the central processors.

Subsystem CCITT6

Signalling system No. 6 is introduced into an AKE 132 exchange by the addition of the new subsystem CCITT6, which contains both hardware and software, fig. 4. The speech circuits and the signalling links are connected to the hardware, whereas the software performs the logic functions. The programs are executed in the central and regional processors.

The programs for subsystem CCITT6 contain 36 000 instructions, 18 000 belonging to central software, 5 000 to regional software and 13 000 to non-resident software.

Associated signalling



Non-associated signalling

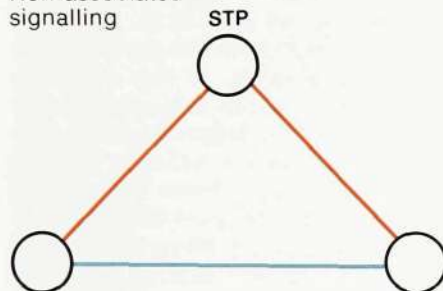


Fig. 3
Modes of operation
— Signalling links
— Speech circuits
STP Signal Transfer Point

Fig. 2
Signalling principles

① One-unit message

B-answer	Speech circuit No. 9	Checkbits
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② Multi-unit message

Seizure	Speech circuit No. 12	Checkbits
B-subscriber digits		Checkbits
B-subscriber digits		Checkbits
B-subscriber digits		Checkbits

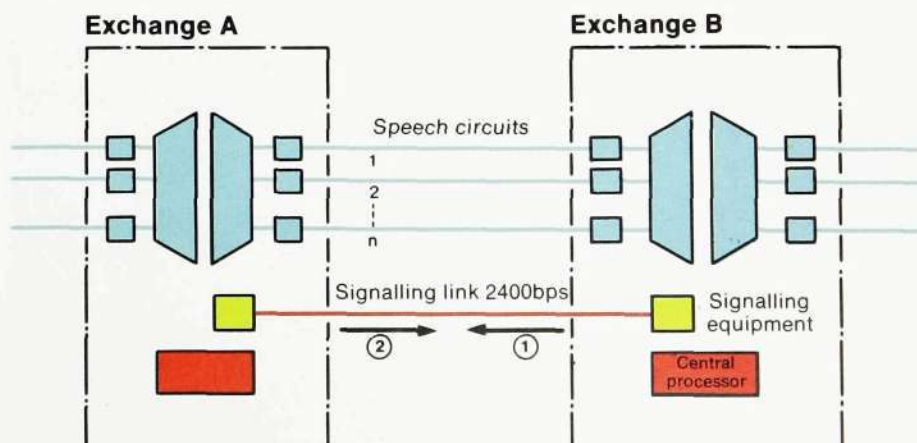
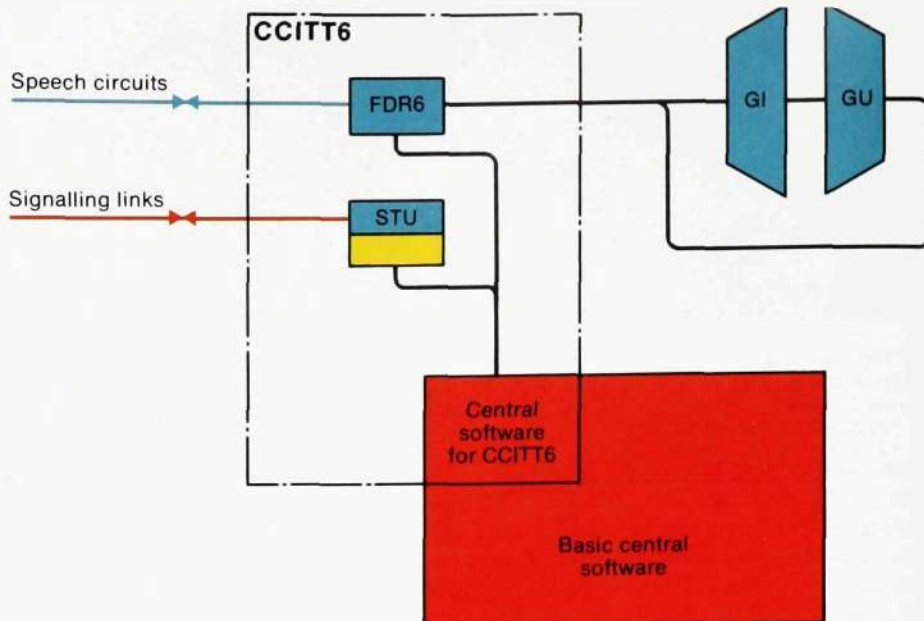
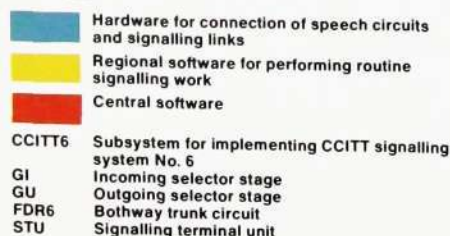


Fig. 4 Introduction of signalling system No. 6 into AKE 132



Design of subsystem CCITT6

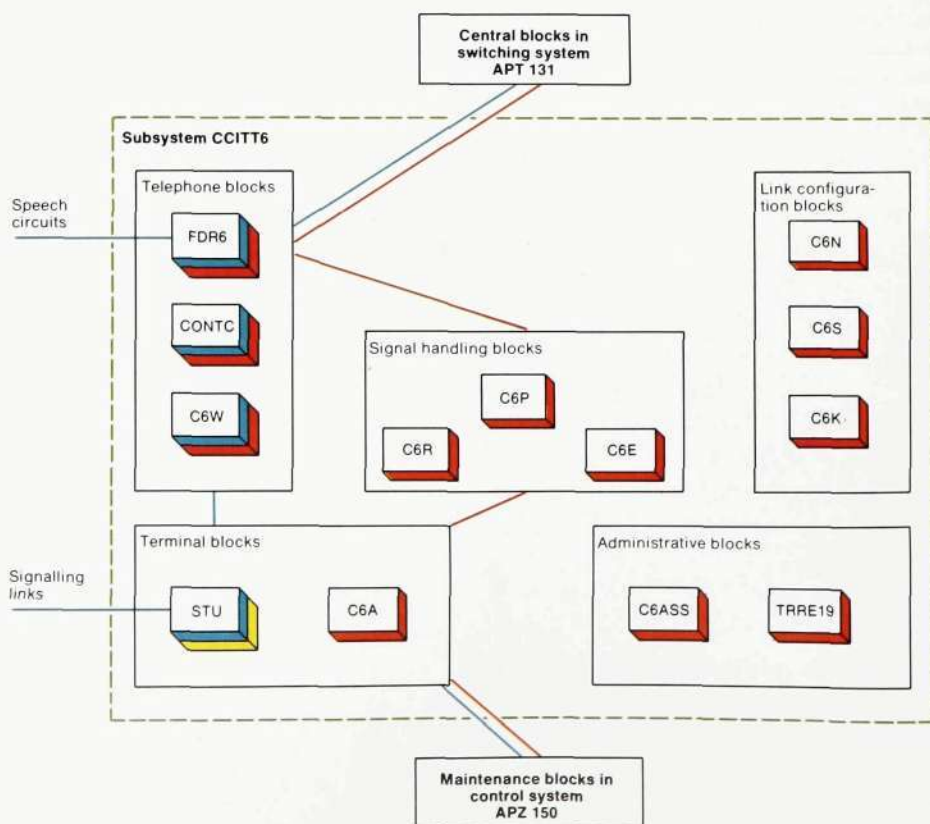
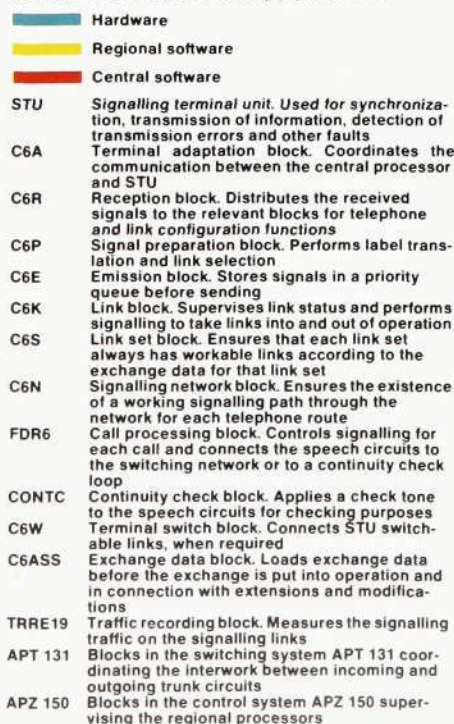
The subsystem CCITT6 consists of 13 functional blocks. They form five groups with different functions, i.e. terminal, signal handling, link configuration, telephone and administrative blocks. A short description of the blocks is given in the legend of fig. 5. Some additional information follows below.

The signalling terminal units STU contain regional processors of the APN 163 minicomputer type⁴, each controlling up to eight signalling links, fig. 6. The STU only performs routine work, leaving the qualified tasks to the central processor. In order to avoid loss of information

at STU-failure the retransmission stores are placed in the central processor.

Different types of information are transmitted over the signalling links, i.e. *telephone signals* concerning a particular call and speech circuit, *system control signals* not related to telephone signal information, but necessary for the proper functioning of the signalling system and *network management signals* used for the supervision and control of the speech network and the signalling network. There are different blocks in the subsystem CCITT6 handling these functions. Basic sending and reception functions, such as link selec-

Fig. 5 Functional structure of subsystem CCITT6



tion and label translation are performed by the common signal handling blocks.

If a link fails, signalling must be transferred to a reserve link. The configuration blocks then perform the necessary analysis to select such a reserve link. This may be initiated either when a link failure has been detected, or when there has been a service interruption in another part of the signalling network. Exchanges inform each other of such situations by means of system control and network management signals. In order to get the link configuration functions realized in a logical and easily understandable way, they have been structured into three levels; i.e. the link level, the link set level and the signalling network level.

The telephone blocks control signalling for each speech circuit and interwork with the central parts of the switching system APT 131, to establish call control and access to other equipment.

For administration of exchange data three types of commands are used, i.e. insert, delete and printout commands. Whenever the operator uses a command the system checks thoroughly the validity of the parameters before taking any action. The administrative functions also include means for measuring the signalling traffic on the links. This can be used to assess the dimensioning of

the signalling network and for calculating the amount of signal traffic transited through the exchange, when serving as STP.

Operation and maintenance

When new traffic requirements arise, exchange data can be modified by means of commands. New signalling routes, new reserve links etc. can thus be introduced without disturbing the traffic in progress.

The maintenance functions are designed in accordance with the LM Ericsson philosophy of Controlled Corrective Maintenance (CCM)⁵. Controlled Corrective Maintenance means that no manual actions shall be taken before the supervisory functions indicate that the service quality has fallen below a specified level. This level can be adjusted for each route individually, according to its importance. Thus the system provides the possibility of selecting at any time, by command, the optimum balance between service quality and maintenance activities.

In many fault situations the system corrects itself without manual intervention. Examples of such situations are sporadic transmission failures on speech circuits and signalling links, as well as service interruptions in interworking exchanges.

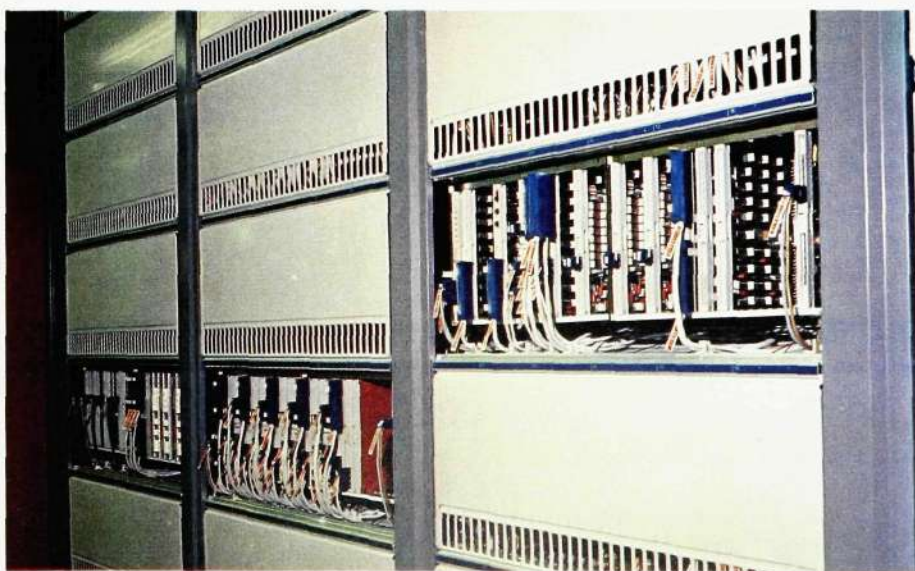


Fig. 6
Signalling terminal for subsystem CCITT6. Regional processor APN 163 in the foreground, link adaptors and modems in the background

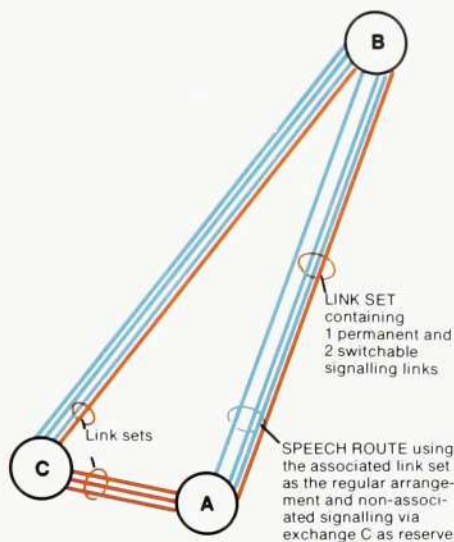


Fig. 8
Example of network configuration with
signalling system No. 6

— Speech circuit
— Signalling link

Commands are also provided so that maintenance staff may, at any time, question the system about the status of the exchange and about exchange data. The Automatic Transmission Measuring Equipment ATME 2⁶, and special link test equipment are available for measurements and tests specified by the CCITT. The International Transmission Maintenance Centre in London/Thames ISC is shown in fig. 7.

AKE 132 in the signalling network

AKE 132 with subsystem CCITT6 has been designed to permit full exploitation of the signalling network, which is of vital economic importance. Signalling networks can be designed in many ways, taking into account aspects of reliability, economy, availability, label allocation etc. Some of these aspects will be considered here, with reference to an intercontinental network.

In order to maintain service in the event of a link failure, it is desirable that there is more than one permanently synchronized signalling path to a distant exchange. The regular signalling arrangement between exchange A and B in fig. 8, could be an associated link, using a circuit from A to B. The reserve could be to a nearby exchange C, which can serve as STP. This implies that in-

stead of occupying an extra intercontinental circuit A—B, a low cost link A—C to the STP could be used. According to the same principles exchange A may serve as STP for traffic between C and B.

The cost of signalling arrangements could be substantially reduced, if the associated link could be eliminated. Administrations may however, be reluctant to rely on a third party for normal service of important routes. If more STP's could be connected, then the service might be considered sufficiently secure without the associated link. In AKE 132 it is possible to define up to five STP alternatives for each route.

In order to further improve reliability, the use of switchable links is recommended. These links are normally used as speech circuits, but are automatically switched over to signalling links when necessary. The cost of defining them as switchable links is negligible compared with the cost of a permanent link. In AKE 132 it is possible to define up to 11 switchable links in each route, in addition to the permanent links.

London/Thames international switching centre

Thames International Switching Centre (ISC) is situated in Mondial House, London on the north bank of the River



Fig. 7
The International Transmission Maintenance
Centre in London/Thames ISC with signalling
links for signalling system No. 6 on the left

Thames. It contains an AKE 132 exchange with an initial traffic capacity of 5000 Erlangs and it has presently the largest capacity in the world in respect of signalling system No. 6. The principal trunking of the exchange is shown in fig. 9.

Initially the exchange will switch traffic, not requiring international operator facilities, between the United Kingdom and major route countries. These comprise 12 continental and 4 intercontinental countries having the highest traffic level to and from the United Kingdom. International transit traffic is also possible. The catchment area for outgoing international traffic will be restricted to London only, whereas incoming international traffic will have full access to the national network.

Engineering tests with signalling system No. 6

Bilateral engineering tests with signalling system No. 6 were conducted between London/Thames and New York/Broadway international exchanges during November 1978. Previously functional testing of CCITT6 in AKE 132 had been done in a simulated environment at a testplant and on a back to back basis in the exchange. It was considered important however, to verify the design of the subsystem CCITT6 in a real environment and at the same time check the

interpretation of some of the CCITT recommendations. Notwithstanding the compliance to CCITT recommendations, it was important to ensure that the equipment was compatible with comparable equipment overseas.

Scope

The engineering tests were based on test schedules used for the earlier tests between USA, Japan and Australia. Functions for switchable reserves and non-associated working were not tested, as these optional functions were not available in the New York/Broadway exchange at the time.

A total of 110 tests were programmed over a four week period. Two data links and two speech circuits were used. They were fully interchangeable and spread over both cable and satellite routes. The tests covered five main test areas as detailed below:

Test of the data links

Preliminary tests were made of transmission characteristics of the circuits, which were lined up to data standard. Synchronization tests were then made to ensure that the AKE 132 and the New York system could synchronize under normal conditions.

Security arrangements

The data links were arranged in a configuration with one regular link and one

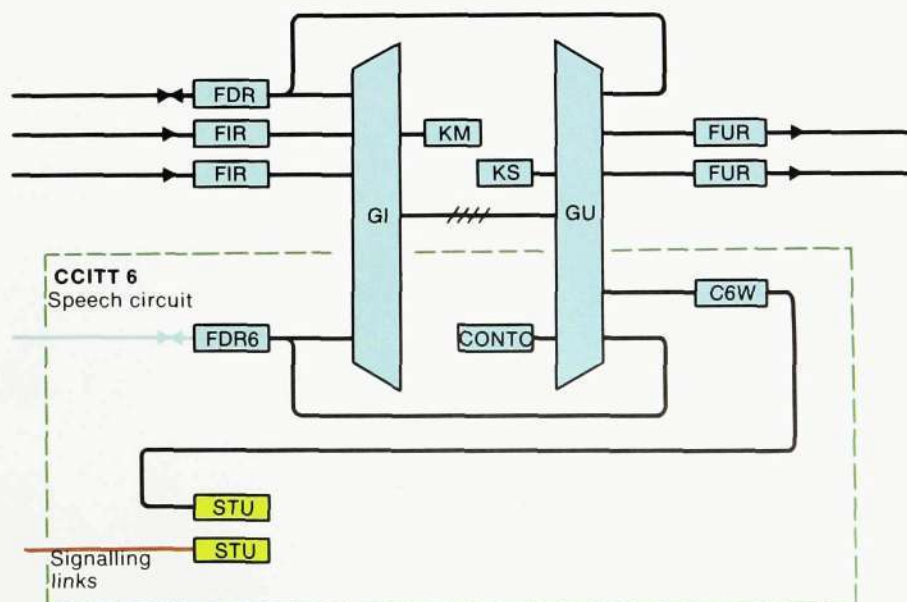


Fig. 9
Trunking diagram of AKE 132 with CCITT6

FDR	Bothway trunk circuit
FIR	Incoming trunk circuit
FUR	Outgoing trunk circuit
GI	Incoming selector stage
GU	Outgoing selector stage
KM	Code receiver
KS	Code sender
CCITT6	Subsystem for signalling system No. 6
FDR6	Bothway trunk circuit for system No. 6
STU	Signalling terminal unit
C6W	Unit for connection of STU to a switchable link (any speech circuit) after a signalling link failure
CONTC	Check tone transceiver

Fig. 10
AKE 132 with CCITT6 in the London/Thames ISC
will provide high quality international telephone
service



synchronized reserve. A short break was then made in the regular link to ensure that it was taken out of service and a changeover made to the reserve. Checks were also made to confirm that the regular link regained synchronization and was automatically put back into service when the link was restored.

Call processing, terminal traffic

Most of the normal and some abnormal call processing sequences were checked including the en-bloc mode (all digits transmitted in one message) and the overlap mode (split up digit transmission).

Call processing, transit traffic

Normal transit call sequences were tested in the en-bloc and overlap mode.

System failure conditions

Complete failure of the links was included to test the effects on devices that were idle, blocked, in register phase or in speech position. Similar tests were done with processor failures resulting in different types of restarts.

Test aids

The tests were conducted mostly with normal test aids available for AKE 132 systems in service. A link fail simulator was also used, which had been designed by the Telecommunications De-

velopment Department of the British Post Office. It enabled the transmit and receive directions of the links to be broken permanently or for approximately 100 ms.

Testing aids also included a data registration block used for the installation testing, a modem tester, call generating and terminating devices, a lamp display showing a part of the data store contents and a software trap.

The terminal equipment in New York was normally in service to Tokyo, but it was rearranged during the daily testing period with London.

Results

The tests were generally very successful and demonstrated that the AKE 132 and the New York system had compatible implementations of signalling system No. 6. Some minor faults were found and corrected in both London and New York. Some differences in design philosophy and interpretation of CCITT recommendations were also evident, but these points should have no influence on the proper operation of the system. It is thus evident that the AKE 132 with CCITT6 will provide high quality international telephone service to many customers.

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Power Supply System for Small Telecommunication Plants

Leif Hansson and Arne Strickert

The article describes a new generation of equipment for the power feeding of small telecommunication plants, such as remote subscriber stages and PBXs. The equipment consists of single-phase, thyristor-controlled rectifiers of different sizes together with distribution equipment.

The power supply equipment constitutes a complete system equipped with all necessary functions (automatic charging, protection, alarms). It is easy to install and requires no attention when in operation.

The mechanical design is extremely flexible, and as a result the equipment can be used in different ways. For example, the power supply equipment can be combined with the telecommunication equipment in the standard LM Ericsson packaging structure or it can be packaged as separate power racks (19"). Single units can also be supplied separately in their own cases for wall mounting.

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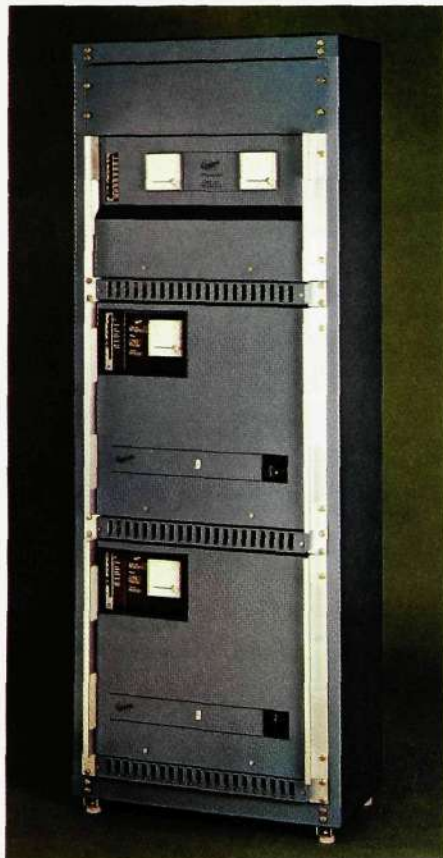
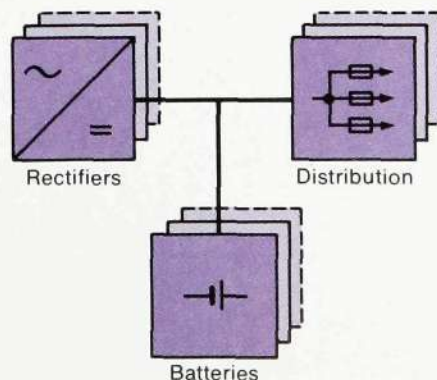


Fig. 1
Power supply equipment BZA 106 consisting of two rectifiers BMT 243 (25 A) and distribution unit BMG 661 mounted in a 19" rack. The equipment can be extended/supplemented by additional racks containing only rectifiers. The rectifiers work in parallel and can be used in systems with or without battery. A block diagram of the system is shown on the

The power supply equipment intended for small telecommunication plants, such as remote subscriber stages (concentrators), rural exchanges and PBXs, must satisfy stringent demands as regards flexibility in order that it shall be suitable for the different applications.

For example, the equipment must be able to work with or without batteries, i.e. it must be possible to use the rectifiers as battery chargers and also battery eliminators.

Mechanically the equipment must be adapted to different packaging structures. It must be possible to combine the power supply equipment with the telecommunication equipment in the LM Ericsson standard packaging structures BYB 101 and BYB 201 or to install it in a rack of its own (19"). Furthermore it must be possible to use separate units individually in their own cases for wall mounting.



Some other requirements are:

- The power supply equipment must be easy to install and must not require attention since usually no qualified operating staff is available on the site.
- Heat losses must be kept as low as possible. This is essential because the equipment may be installed in the same rack as the telecommunication equipment.
- The equipment must satisfy the requirements regarding power supply for an electronic load (ability to withstand incoming transients from the feeding network, low transient voltage deviation, low noise voltage).
- The equipment should be suitable for use in an office environment (low noise level, pleasant appearance).
- A high level of personnel safety (live parts protected against accidental contact etc.).

LM Ericsson have designed a new power supply system to meet the above-mentioned requirements. It consists of single-phase, thyristor-controlled rectifiers in three current sizes together with distribution equipment. The system and its units are described below.

Power supply system

Power supply system BZA 106 is built up of rectifiers, one or several working in parallel, together with a distribution unit and one or more batteries, fig. 1.

The rectifiers normally provide current for the telecommunication plant and a floating charge for the batteries. In the case of a mains failure the batteries supply the necessary current for the telecommunication equipment without interruption. When the mains voltage is restored the batteries are recharged by the rectifiers. The rectifiers also automatically charge the batteries at an increased voltage, so-called operating charge.

Rectifier

The new rectifiers, fig. 2, have been developed for three current values and two system voltages. The rectifiers are thyristor regulated in single-phase connection. They are adapted for feeding from standby power units and from



LEIF HANSSON
ARNE STRICKERT
Power Supply Department
Telefonaktiebolaget LM Ericsson



mains networks of poor quality. The rectifiers can therefore cope with large voltage and frequency variations, frequent mains failures and large distortion in the mains networks to which they are connected.

From a technical viewpoint an unlimited number of rectifiers can, in principle, work in parallel and they would then share the load equally. For the sake of operational reliability it is often better to choose several small rectifiers connected in parallel than one or a few large ones.

The rectifiers are provided with protection and control equipment which permits fully automatic operation and operation in unmanned exchanges.

Main circuit for 10 A and 25 A rectifier

The transformer is connected to the mains supply via a switch, fig. 3. The secondary side of the transformer is connected to a rectifier bridge consisting of two diodes and two thyristors. The thyristors receive trigger pulses from the control device. The current is measured by means of a current transformer, whose primary winding is connected on the anode side of each diode. The secondary winding is connected to the control device. The rectifier bridge

gives a pulsating DC voltage. Since current commutation takes place twice per cycle the basic ripple frequency will be 100 Hz. The voltage is smoothed by a filter consisting of two chokes and two capacitor banks. There is an ammeter and a fuse with alarm indication on the output of the rectifier. There is also a test terminal for checking the output voltage. In the 25 A rectifier the control device is fed via a transformer, connected to the secondary side of the main transformer, and in the 10 A rectifier it is fed via extra windings on the main transformer. Metal oxide varistors are connected across the secondary side of the transformer and protect the rectifier against the mains overvoltages.

Main circuit for the 4 A rectifier

The design of the 4 A rectifier is somewhat simplified but in principle it is the same as that described above. The printed board with the control device circuits also contains the rectifier bridge with thyristors and diodes, fig. 4.

Control circuit

The control circuit provides the thyristors of the bridge with two trigger pulses per cycle. The pulses have a mutual phase shift of 180° and a variable phase position with regard to the mains voltage (phase shift control). In this way



Fig. 2
The new line of single-phase rectifiers

BMT 241 rectifier 4 A
BMT 242 rectifier 10 A
BMT 243 rectifier 25 A
All for 24 and 48 V system voltage

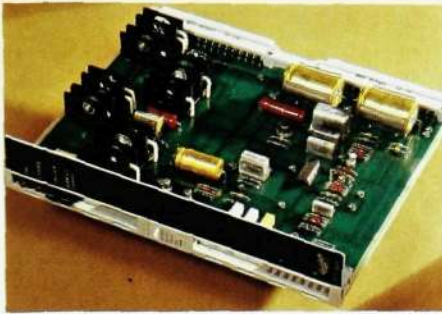


Fig. 4
Printed board assembly for rectifier. In addition to the control circuits BMT 241 (4 A) also contains a bridge with thyristors and diodes

the output voltage can be varied between zero and maximum. Regulation normally takes place at constant voltage. When the rated current is exceeded the control system changes over to constant current regulation (current limiting), which protects the rectifier against overload. The control circuit generates a linear sawtooth voltage, which is in synchronism with the mains voltage. The output voltage from the rectifier is sensed by an operational amplifier, which compares the actual value of the voltage with a reference voltage. Current sensing is carried out in a similar way, with the current signal being obtained from a current transformer. The output signal of the control amplifier in its turn is compared with the sawtooth voltage in a comparator. The output signal of the comparator consists of square wave pulses with a variable phase position, which after processing and amplification are used as the trigger pulses for the thyristors.

Operating charge is obtained when a signal affects the voltage regulation via a transistor coupling. This signal is obtained either from an external device (automatic charging, which is described below) or from a push-button on the control unit (manual charging).

Protective circuits

The rectifier contains circuits for protection against abnormal conditions.

- Current limiting, which protects the rectifier against overload and external short circuiting.
- Output fuse, which in case of an internal short circuit disconnects the rectifier and thus makes possible continued operation from battery or other rectifiers.
- Mains voltage monitor, which gives an alarm if the mains voltage disappears because of a fuse failure or any other fault.
- Internal voltage monitor which blocks the firing pulses if the mains voltage falls to a value that can jeopardise the function of the rectifier (disconnection at 60 % and reconnection at 70 % of the nominal mains voltage).

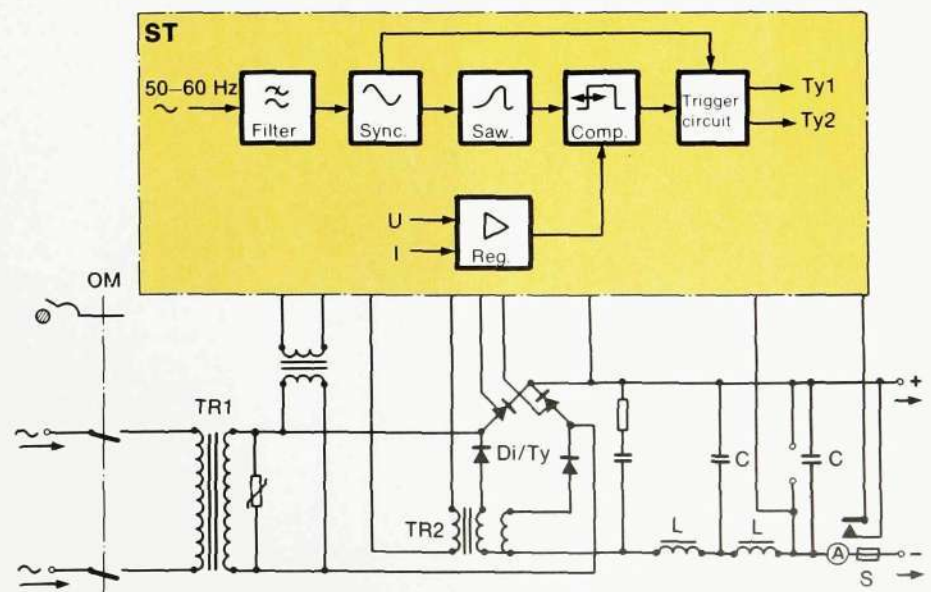
When the rectifier is started the current rises gradually to the required level. This also occurs in the case of a restart after any alarm condition that caused disconnection. This gradual start prevents unnecessary current surges and voltage overshoots.

The rectifier control unit contains the following adjustment devices:

- Two potentiometers for fine adjustment of voltage levels (normal operation, charging).
- A potentiometer for setting the current to between 0 and 110 % of the rated current (current limiting). This is also used for manual charging with a selected constant current value.

Fig. 3
The mains voltage is connected via the mains switch to the mains transformer. The voltage is rectified and regulated in the diode/thyristor bridge and smoothed in an LC filter. The control unit senses the output voltage and output current and gives trigger pulses to the thyristors so that a constant output voltage is obtained

OM	Mains switch
TR1	Mains transformer
TR2	Current transformer
Di/Ty	Diode/thyristor bridge
L	Filter choke
C	Filter capacitor
S	Output fuse
ST	Control device
A	Ammeter



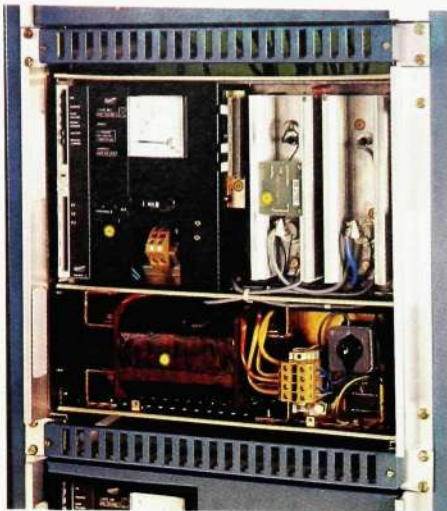


Fig. 5
Rectifier BMT 243 (25 A), with the front plate removed, seen from the front. The plug-in printed board assembly contains all control and monitoring functions. Light emitting diodes for the indication of the operating state and push-buttons for control are placed on the front of the control unit printed board. The rectifier bridge is placed to the right of the ammeter, with the thyristors and diodes easily accessible, which simplifies fault localization and service. Components with mains voltage (mains switch and mains transformer) are placed in the lower section of the rectifier case

Indication and signalling

The rectifiers have light emitting diodes for indication of the operating state and push-buttons for control, all of which are placed on the front of the control unit board, fig. 5.

The following signals can be sent from the rectifiers:

- Mains fault
- Fuse alarm

The following functions can be remotely controlled:

- Automatic charging
- Disconnection/restart (from the overvoltage monitor).

The rectifiers contain a plug connector, to which a cable can be connected for signalling between rectifier, distribution unit and any central unit.

Distribution unit

A separate unit, a distribution unit, for connecting distribution and battery cables, has been developed for this new series of single-phase rectifiers, see fig. 6. The advantage of a separate distribution unit is that the rectifiers can be changed without the operation being interrupted. Moreover custom-made dis-

tribution units can be used for different applications. The standard unit contains 3 fuses in values from 6.3 to 35 A and a fuse unit with 10 glass-tube fuses 1–6.3 A. A voltmeter and an ammeter are mounted in the front of the unit. The current is measured by a shunt.

The unit also contains printed board assemblies for supervision of the output voltage and automatic charging, which are described below.

Voltage supervision

The object of the voltage supervision is to protect the equipment and give an alarm in the case of abnormal operating conditions. If a fault occurs in the rectifier and its output voltage rises to an abnormal level, the overvoltage protection blocks the trigger pulses and gives an alarm. In the case of battery discharge the under-voltage monitor gives an alarm when the distribution voltage level becomes too low.

Automatic charging

The automatic charging operates on the principle of periodically charging the battery during a constant time, to full capacity. How often this periodic charging has to be carried out depends on the size and type of battery and how often

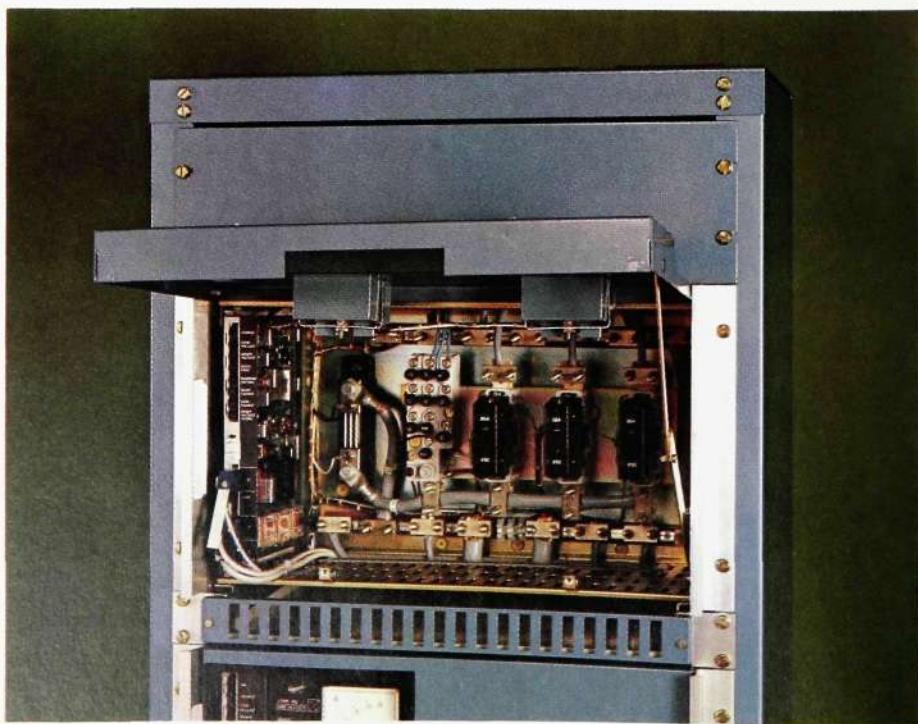


Fig. 6
Distribution unit BMG 661001, with the front plate open, seen from the front. The distribution unit contains three fuse sockets for fuses of values from 6.3 to 35 A and a fuse unit with 10 glass-tube fuses 1–6.3 A. The fuse holders are equipped with an alarm device. The printed board assembly contains circuits for supervising the distribution voltage and for automatic charging. The front of the printed board is equipped with light emitting diodes and push-buttons for indication and control

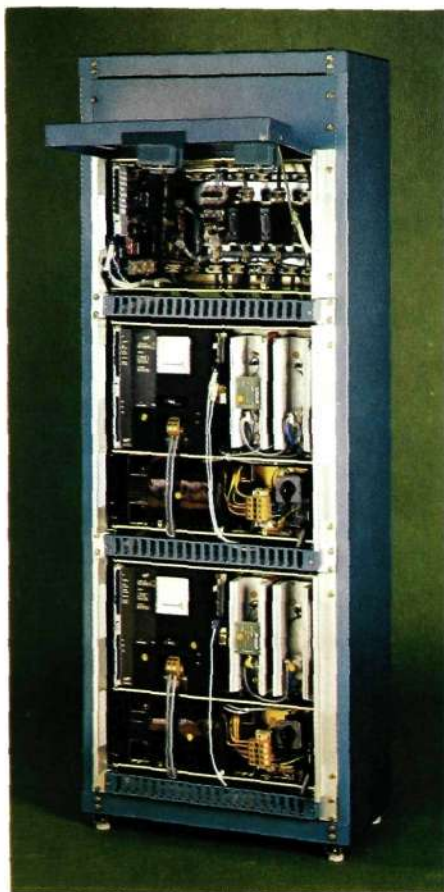


Fig. 7
Power supply system BZA 106 with the front plates removed. The rack is equipped with two rectifiers BMT 243 (25 A) and distribution unit. The rack is held to the wall by four spacing elements, which gives free cable paths along the wall behind the rack

Fig. 8
Rectifier BMT 243 (25 A) in PABX ASB 900. A distribution unit (BMG 660001), which is specially adapted for this PABX, is mounted at the top of the rack. The distribution unit contains automatic fuses, a printed board assembly for supervision of the distribution voltage and automatic charging and a special alarm collecting board



mains failures occur. The length of the period can be set to between 1 and 80 days with a charging time of between 22 minutes and 30 hours. The standard settings are adapted for ordinary lead-acid and Ni-Cd accumulators, i.e. a charging time of 7.5 hours every 20 days. If mains failures occur daily, with a consequent discharge of the batteries, the interval between charges should be reduced to 10 days. If sealed lead or Ni-Cd batteries are used, the times should be changed to charging for 1.5 hours every 24 hours. These recommendations apply for normal operating conditions. The floating and charging voltages of the rectifiers must be correctly adjusted in order to obtain maximum utilization of the batteries. The following voltage levels are recommended.

Type of battery	Floating voltage V/cell	Charging voltage V/cell
Lead-acid	2.18–2.20	2.30–2.35
Sealed lead	2.13	2.30
Ni-Cd	1.40–1.42	1.50–1.55
Sealed Ni-Cd	1.40	1.50

Power supply system BZA 106 can be supplemented with an equipment for automatic battery charging which works on the principle of current and time measurement (BMP 131)¹.

Mechanical construction of the units

The unit case is available in three sizes. The mechanical dimensions are given in the technical data.

A unit case consists of a rear plate, side members and top and bottom mounting plates (alike).

The rear plate is used for mounting heavy components, such as transformers and chokes. In order to achieve efficient ventilation of the units the top and bottom mounting plates are perforated with rectangular holes. These holes are also used for the mounting of the components and the construction gives good flexibility for different types of components. Printed board assemblies are installed with the aid of plastic guide strips, which are clipped into the top and bottom mounting plates. The units can be equipped with handles at

the front, which makes them easier to handle. In the packaging structure BYB 201 and in 19" version the handles are used as mounting brackets.

The unit case has a removable front plate, which is fastened with two captive screws. The necessary instruments, indication lamps and control devices are visible and accessible through cut-outs in the front plate.

The mechanical construction of the rectifiers is characterized by great flexibility, which makes it possible to place them in different types of racks and cabinets, for example

- in a separate rack
- in a rack with telecommunication equipment
- in a wall-mounted case.

Mounting in a separate rack

Power supply system BZA 106 is usually mounted in the newly developed 19" rack BAF 601 04 (530×260×1500 mm), fig. 7.

The load-bearing parts of the rack consist of four U-shaped steel plates, which also constitute the top, bottom and side plates. They are joined by means of standard screws.

Steel guide rails are mounted on the side plates at the heights required for the units concerned. A plate is mounted at an angle between the guide rails. It serves both as a cabling support and a guide for the air circulating through the rack. The units are cooled in accordance with the parallel cooling principle, which means that the rectifiers work under similar conditions, regardless of their positions in the rack.

The rack is delivered in parts in order to reduce the volume during transport. The final erection work on site then takes only a few minutes.

The front of the rack consists of the front plates of the units inserted. All visible steel surfaces are finished in blue hammer lacquer, which combines well with the anodized aluminium handles and the black fronts of the instrument panels. The rack is equipped with adjustable feet that compensate for any unevenness of the floor.



Fig. 9
Rectifier BMT 241 (4 A) in transmission equipment ZAE 12-1. The rectifier contains a separate distribution fuse.
The rectifier can be supplemented by a standard printed board assembly for automatic charging and will then function as a battery charger

The equipment is designed for installation against a wall. This, in combination with the fact that the units are of a very compact construction, means that the available space is utilized very efficiently.

Mounting in a rack for telecommunication equipment

The power supply equipment is often integrated with the other telecommunication equipment, and the standard packaging structures BYB 101 or BYB 201 are then used.

In certain cases the power supply equipment can occupy a whole rack in the exchange. One example of this is the PABX ASB 900, fig. 8. In other cases it constitutes a unit placed with the other telecommunication equipment in a common rack, such as in transmission system ZAE 12-1, fig. 9.

Mounting in a wall case

In small plants, where only one rectifier is needed, the rectifier can be placed in a wall-mounted case together with a simple distribution unit, fig. 10. The equipment is also arranged so that it can be equipped with a printed board assembly

for automatic charging if a battery is included.

The cases used for the 10 A and 25 A rectifiers are constructed of the same details as the floor rack.

Installation and maintenance

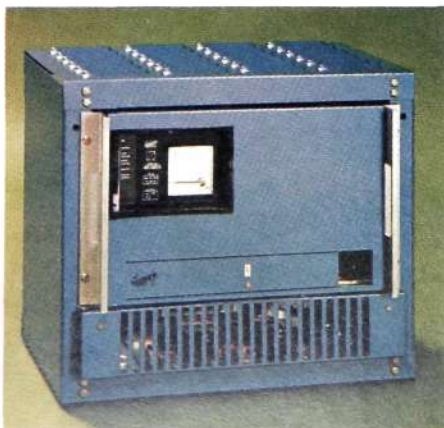
The units and racks are designed so that they can be installed very easily and put into operation quickly.

The units are delivered as complete factory-tested units. They are mounted with the aid of simple hand tools and the installation testing is limited to a visual inspection, a check for any transport damage, and a simple functional test.

The rectifiers are designed for high personnel safety. Even with the front plate removed any components and terminals with mains voltage are well protected against accidental contact.

Alarm and signal wires are run in a cable equipped with a plug (TSR cable), which is designed so that new units can be added very easily.

Fig. 10
Rectifier BMT 242 (10 A) for wall mounting. The lower part of the case contains two distribution fuses and terminals for measuring the distribution voltage and current.
A similar case is available for rectifier BMT 243 (25 A)



Technical data for rectifiers 48 V

Type		BMT 241 48/1	BMT 242 48/1	BMT 243 48/1
Output data				
Rated voltage	V=	48	48	48
Rated current	A=	4	10	25
Static regulation accuracy	mV=	200	80	80
Transient voltage deviation with the battery connected in parallel				
25-50-25 % current variation	V=	0.75	0.75	0.75
50-75-50 % current variation	V=	0.75	0.75	0.75
Transient voltage deviation without battery				
25-50-25 % current variation	V=	4	3	4
50-75-50 % current variation	V=	4	3	4
Noise voltage				
psophometric value	mV	<2	<2	<2
peak value	mV	<200	<200	<200
Input data				
Mains voltage, single-phase				
nominal value	V	220/110	220/110	220/110
permissible variations	%	± 10	± 10	± 10
permissible variations with slightly lower regulation accuracy	%	−30 − +20	−30 − +20	−30 − +20
Permissible frequency variation	Hz	47–63	47–63	47–63
Primary current with nom. 220 V and nom. output data	A	1.6	4.1	9.3
Power factor at 80 % I_{out}	$\cos \varphi$	0.7	0.68	0.7
Efficiency	%	80	85	88.5
Ability to withstand transients coming in from the mains				
amplitude	kV	1.5	2.5	2.5
rise time	μs	—	2	2
half value time	μs	—	500	500
Radio interference, mains side				
Requirement: CISPR recommendation		is met	is met with filter BMF	is met with filter BMF
0.15–0.5 MHz	≤66dB		101 036/2	101 036/2
0.5–30 MHz	≤60 dB			
Radio interference, DC side		is met	is met	is met
0.15–0.5 MHz	≤80 dB			
0.5–30 MHz	≤74 dB			
General data				
Permissible ambient temperature function	°C	0 – +45	0 – +45	0 – +45
non-destructive	°C	−10 – +55	−10 – +55	−10 – +55
Noise level	max dBA	—	50	50
Dimensions				
width	mm	243	485	485
height	mm	243	265	399
depth	mm	243	260	260
Weight	kg	14	30	52

References

1. Michelsen, S. et al.: *A New Generation of Power Supply Equipment, type BZD 112*. Ericsson Rev. 55 (1978);2, pp. 46–57.

Stored Program Controlled PABX, ASB 900

Robert Dietsch and Nils Pierre

The modernisation of LM Ericsson's range of PABX systems continues with the introduction of ASB 900, which is a stored program controlled PABX with electronic cross points in the switching network.

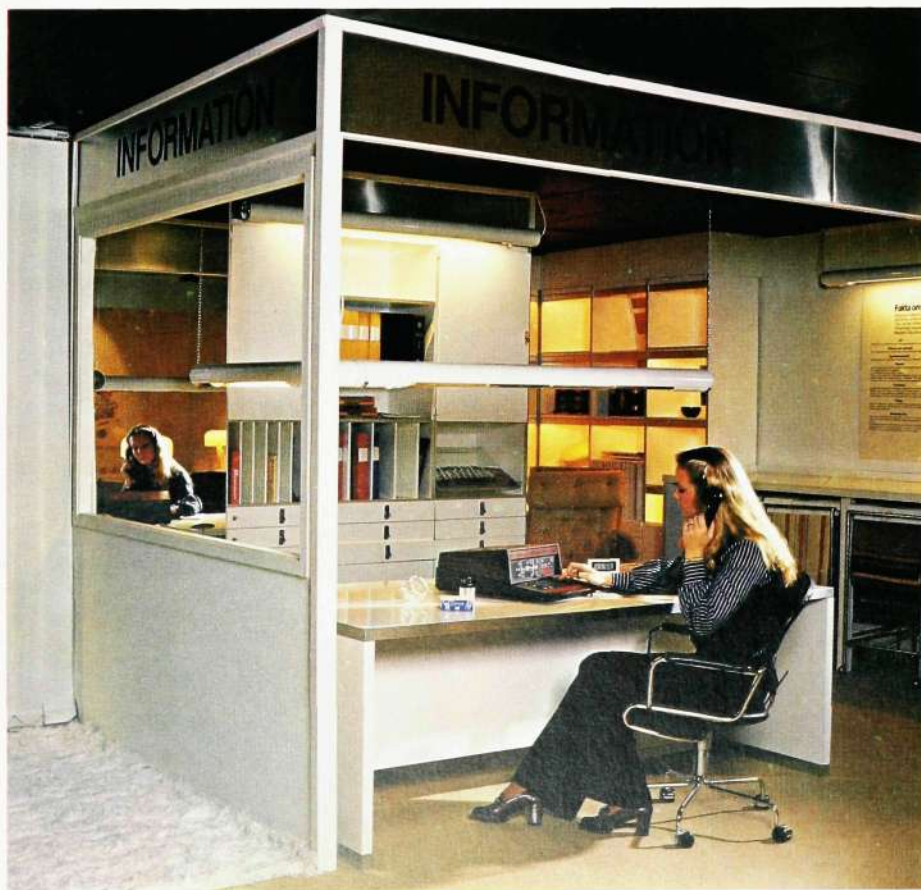
ASB 900 for 60–960 extensions satisfies the requirements of medium-sized companies and ASB 100 for 20–100 extensions, which has been described in a previous issue of Ericsson Review¹, is intended for small companies.

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ASB 900 offers a large number of traffic features and an efficient operation and maintenance system. The program structure with function modules, which has been developed for ASB 900, makes the exchange reliable and easy to administer.

ASB 900 is a modern, fully electronic, stored program controlled PABX. With its modern traffic features and well developed operation and maintenance system it is well able to satisfy all the present day requirements of an efficient PABX.

Fig. 1
PABX ASB 900



ASB 900 is built up in three levels, namely system, subsystems and function blocks, see fig. 2. Each function in the exchange has its own function block, which contains the hardware and software required for the entire function. This gives the exchange a simple structure and also makes it very flexible, since each function is then an independent unit, being completely independent of the other functions. This makes ASB 900 very easy to operate and administer.

The programs for ASB 900 are stored in a dynamic store of the RAM (Random Access Memory) type. This greatly simplifies the process of changing programs, for adaption to special markets and customers. Programs and data are loaded into the store from a cassette tape on the tape recorder that is built into the exchange. Changes in the store can then be carried out either via additional cassette tapes or via a typewriter terminal, which can be portable or permanently connected to the exchange.

ASB 900 is built up in the BYB 201 cabinet construction practice, which is a further development of the rack construction practice BYB 101, which was originally developed for exchange system AXE. ASB 900 is intended for 60–960 extensions. Two cabinets are required for an ASB 900 with 120 extensions, one for the control system and one for the extensions. Another cabinet is required for every additional group of 120 extensions until the maximum capacity of the exchange is reached, namely 960 extensions, which means a total of 9 cabinets. The cabinets can be equipped with a combination of single and double magazines or with power feeding or main distribution equipment if required.

The trunking diagram for ASB 900 is of the traditional type, with one extension and one device multiple, which are connected by an electronic three-stage switching network with thyristor cross points.

System design

ASB 900 is divided into two subsystems: THSS (Traffic Handling SubSystem) and OMSS (Operation and Maintenance SubSystem).



ROBERT DIETSCH
NILS PIERRE
Subscriber Equipment Division
Telefonaktiebolaget LM Ericsson



The subsystems in turn, consist of a number of function blocks, each of which handles one function in the exchange. A function block contains all the programs, data and hardware required for the function in question. The division into function blocks has made it possible to meet the demands as regards handling that are put on a modern PABX. ASB 900 satisfies the following requirements, see also fig. 3:

- Extensions can be made to the exchange hardware and software without interrupting the operation.
- Program changes can be carried out without interrupting the operation.
- Program and data changes that concern a specific function do not disturb other functions in the exchange.
- The programs stored in the exchange are identified by means of the article number and revision status of the individual program.
- Efficient fault localization and maintenance work can be performed during operation without interfering with the function of the exchange.
- Disturbances and faults are limited so that they do not affect other parts of the exchange.

Program system

The program system in ASB 900 has been designed to meet the demands made by different categories of users and other people concerned, for example service staff, administrators, salesmen and instructors.

The following requirements constituted the basic guidelines for the program design:

- a structure that permits changes both as regards function and size
- comprehensive testing and fault localization features
- a minimum amount of work to adapt the system for different telephony applications
- simple order routines
- high operational reliability.

In accordance with these guidelines, the program system has been optimized as regards the number of function blocks rather than the program volume.

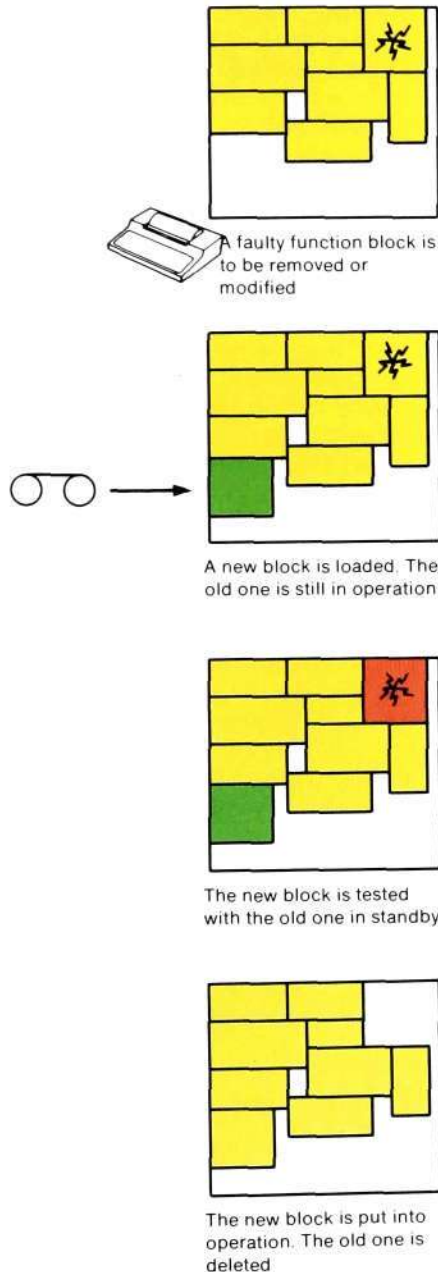
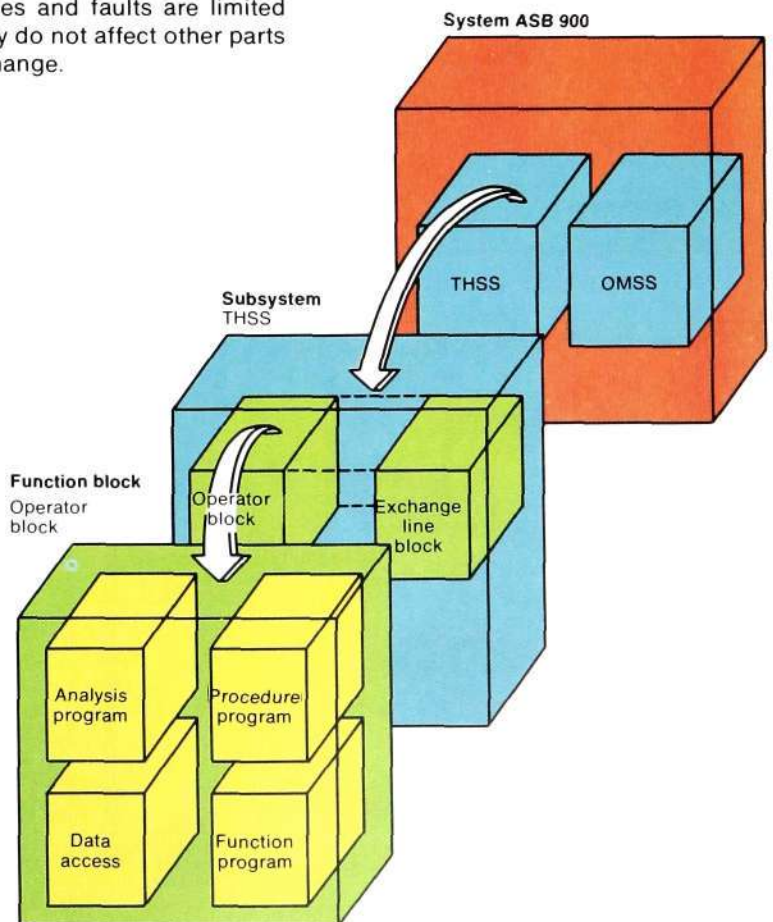


Fig. 3
The software can be modified or extended without disturbing the operation of the exchange

Fig. 2
The function block structure of ASB 900

THSS Traffic handling subsystem
OMSS Operation and maintenance subsystem



ASB 900 contains three different types of programs (fig. 2):
Analysis programs, which detect and analyze signals from the exchange hardware.

Procedure programs, i.e. programs with macro instructions for actions that are to be initiated as a result of the analyses.

The procedure programs are written in a high level language developed especially for ASB 900, where each switching function directly corresponds to one instruction.

Function programs, which are the tools the exchange uses for executing requested actions.

These types of programs are included in the various function blocks in different combinations, depending on the task of the block. The function blocks that are provided with data areas also contain special programs for administering the data.

Identification and the addressing of blocks and programs are carried out using the relevant block and program numbers. The relation between block/program number and address is stored at the beginning of the store in an address table. This addressing principle

contributes largely to the high flexibility of the software since it enables blocks and programs to be placed arbitrarily in the store.

In addition to the advantages already mentioned, building up the exchange in the form of function blocks also makes it easier to adapt the exchange to suit different markets. Only the function block that is particular for the market in question has to be modified, and it is also possible to test the function of this block separately since it contains all the programs required for the function.

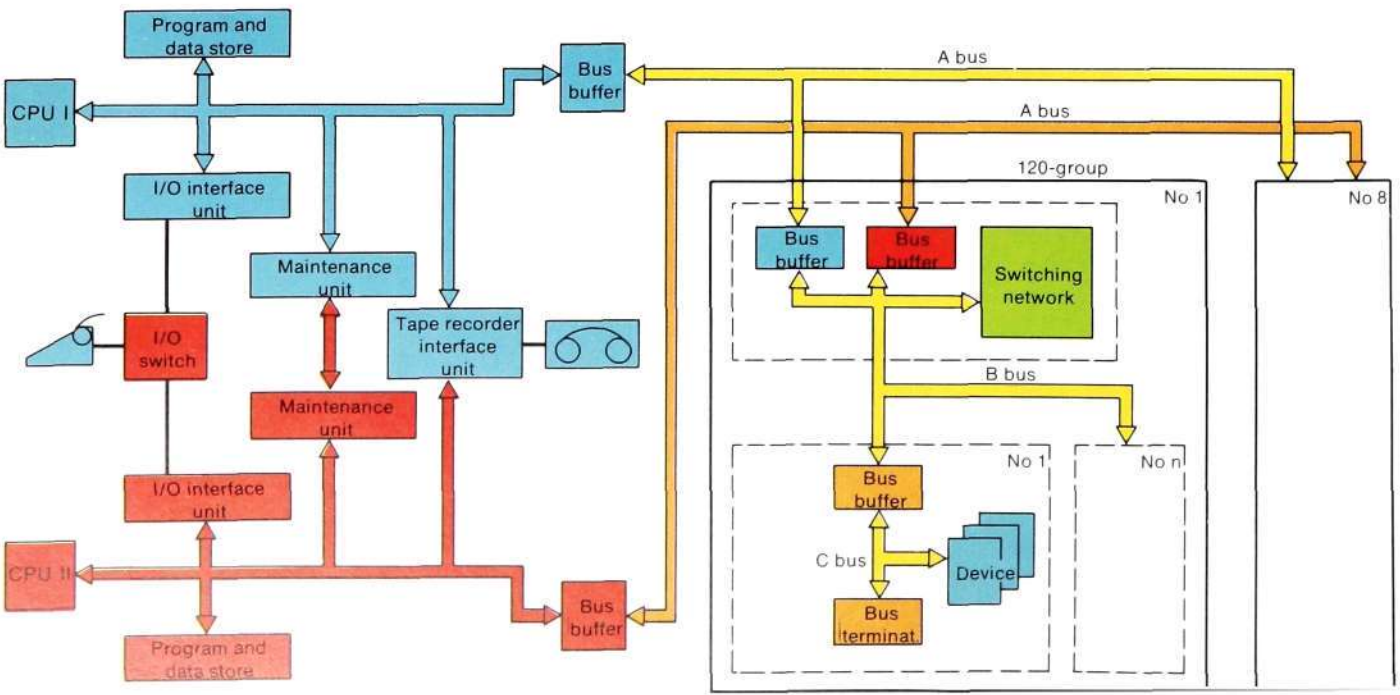
Control system

The control system in ASB 900 is built up around the processor APN 163 developed by LM Ericsson. The program and data store is the RAM type with a capacity of 128K words, with a word length of 17 bits.

The standard version of ASB 900 is equipped with one control system. It can be duplicated if even higher reliability is required. Duplication of the control system means duplication not only of the processor and store but also of the bus system between the control system and the switching equipment.

In an exchange with a duplicated control system the processors work in the

Fig. 4
The ASB 900 bus system



active-passive mode. This means that only the active control system handles the traffic while the passive control system is continuously carrying out internal routine tests in order to be ready all the time to take over control of the exchange. Communication between the two control systems takes place via an internal signalling channel over which information concerning the status of the control system is exchanged, fig. 4.

ASB 900 has been provided with two restart levels in case of faults: minor restart, which means only restart of the program concerned, and major restart, which means a reloading of the store and restart of the whole exchange.

The procedure for minor restart is the same irrespective of whether the exchange has a duplicated control system

or not, but in the case of a major restart in a duplicated control system a changeover is made to the passive system, the faulty system is then reloaded and restarted. No copying of the operating data takes place in connection with the changeover, which eliminates the risk of any fault in the working system affecting the passive system.

Alarm indications are obtained with both major and minor restarts, regardless of whether the control system is duplicated or not. These restarts are supervised internally. An alarm indication is obtained if the restart rate is too high.

Bus system

The exchange of information between the units in the exchange is carried out via a bus system. In ASB 900 the bus system has been divided into four levels in order to obtain greater reliability and flexibility (fig. 4).

The CPU bus, a high speed bus for information within the processor.

The A bus, for information between the control system and the various 120-groups. This bus is also duplicated if the exchange has a duplicated control system.

The B bus, for information between the magazines within each 120-group. This makes each 120-group independent of the other groups with respect to signalling.

The C bus, for information internally within a magazine.

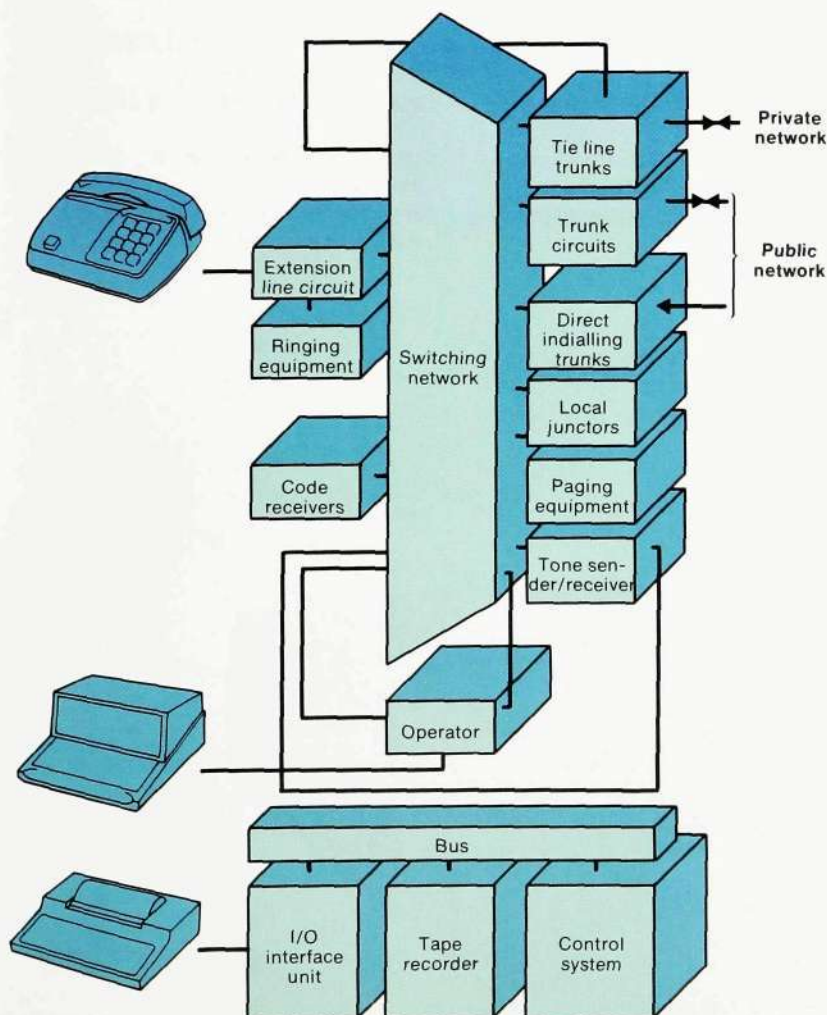
Switching network

The ASB 900 switching network is space divided and made of thyristor cross point matrices for symmetrical, two-wire through-connection. The switch is grouped in three stages with an extension multiple of 120 extensions and a device multiple which is common for all 120-groups. In this way all devices are fully accessible to all extensions, fig. 5.

Traffic features

The SPC (Stored Program Control) technique has made it possible to introduce a large number of new features

Fig. 5
Block diagram for ASB 900



and at the same time make old features more efficient. In ASB 900 many of these features are provided entirely by software. Thus there is no need for any changes in, for example, the cabling, which makes the exchange easy to administer.

The basic exchange has been prepared for the extra hardware required for the few features that require both additional software and hardware.

Different types of telephone sets can be connected to the exchange. This means that both push-button and dial telephones can be used in one and the same exchange without it being necessary to divide the extensions into categories.

Features

The traffic features offered by ASB 900 include:

- internal calls
- incoming calls via the operator
- outgoing calls, either direct or via the operator
- inquiry during both internal and external calls
- transfer of external calls
- priority
- common, universal or individual night service
- automatic call-back
- add-on conference
- flexible numbering and class-of-service allocation
- group hunting
- direct call diversion to an individual or common answering position
- direct in lines
- follow me
- group call pick up
- "call waiting" tone
- non-dialled connection to pre-selected extension or operator, ("hot lines")
- trunk call discrimination
- direct in-dialling
- tie-lines
- transit traffic
- common external abbreviated dialling
- individual external abbreviated dialling. The function is programmed by the operator and can be used by extensions equipped with push-button sets
- operator-controlled call metering
- individual call metering
- paging, visual or via radio (ERICALL CONTACTOR)
- busy indication panel for the operator
- MFC signalling for direct indialling and tie-line traffic.

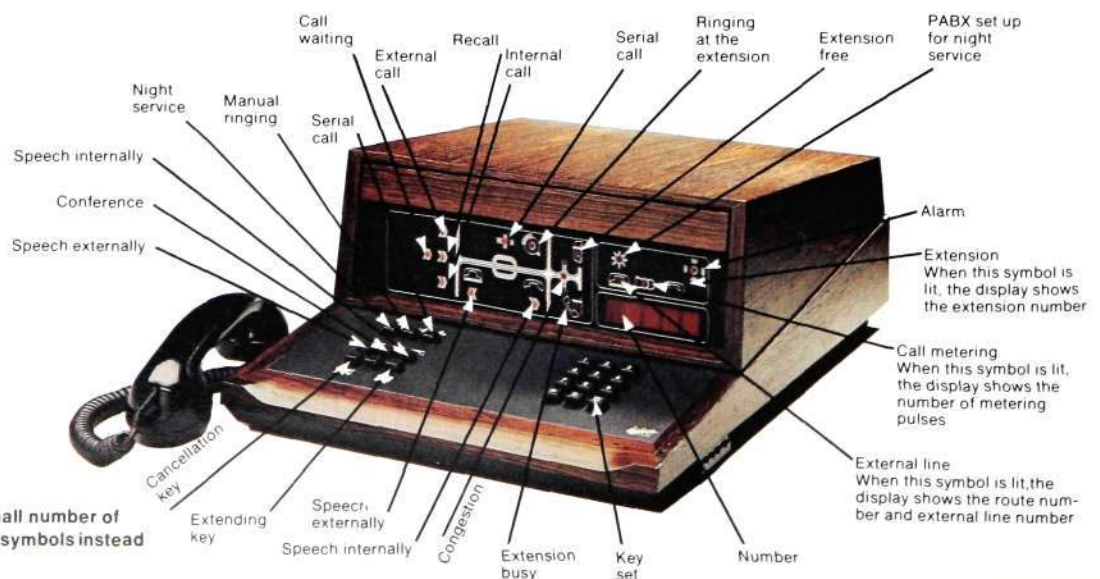


Fig. 6
The operator's set contains a small number of function buttons and explanatory symbols instead of text

Table 1
The capacity of ASB 900

Extensions	Operators	Trunk lines	Local junctors	Tone senders 'Registers'	Cabinets
120	2-3	24	12	6-8	2
240	4	40	18	11	3
360	5	56	24	14	4
480	6	72	30	17	5
600	7	88	36	20	6
720	8	104	42	23	7
840	9	120	48	26	8
960	10	136	54	29	9

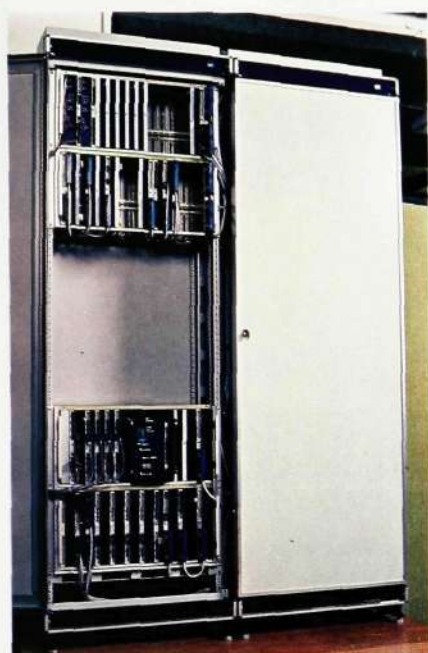


Fig. 7
Cabinet for ASB 900

Optional features

ASB 900 will also be adapted for use in several special fields. A number of optional features are now being studied for this purpose and the following may be mentioned:

- hotel features
- toll ticketing
- least cost routing
- multi-PABX function
- centralized attendant position.

Operator's equipment and functions

The operator is an important link between a business concern and the rest of the world. It is therefore essential that the operator's equipment is well designed. When developing the operator's set used in ASB 100 and 900, great attention has been paid to the simplification and improvement of the handling procedures, as well as the operator's set itself. The aim has been to obtain the best possible man-machine relationship, fig. 6.

The operator's set is equipped with a small number of function buttons, and explanatory symbols have been used instead of text. An information panel enables the operator to follow the setting-up of a call through the exchange.

Up to 10 operator's sets can be connected to ASB 900. This provides a good margin even in the case of an exchange built out to its maximum capacity.

In addition to the normal operator's functions the operator can receive in-

formation concerning different types of alarms. Furthermore the operator's set can be used as a terminal for the programming of features, for example number series, categories, abbreviated numbers and trunk call discrimination.

Traffic capacity

ASB 900 with 120 extensions offers a total traffic of 0.21 erlang per extension (7.56 ccs), and with the maximum number of extensions, 960, 0.18 erlang per extension (6.48 ccs), with a congestion of 0.01 and with 20-40 % internal traffic, see table 1.

The exchange can easily be adapted to different traffic environments, since all trunk line positions in the 120-groups can be equipped with direct indialling trunks (ITC-CD), tie-line trunks (BTC-P) or ordinary two way trunk lines (BTC-C) in the desired combination.

Mechanical construction

ASB 900 is built up of electronic components of the low power type. These are mounted on printed circuit boards with single or doublesided foil. The boards are mounted in magazines.

In the magazines all wiring between the printed circuit boards is carried out on the back wire-wrapped plane, which is equipped with board connectors. The magazines, which can be either single or double, are optimized for their function as regards extension modules, power consumption and the internal and external cabling.

The magazines are mounted in BYB 201 cabinets, which can be placed against a wall or back to back. The compact construction means that very little floor space is required, 0.18 m² per cabinet. The cabling between the magazines in a cabinet is carried out with prefabricated standardized cables. The cables are equipped with plugs and are plugged into front mounted connectors of the printed circuit boards, figs. 7 and 8.

The construction of the BYB 201 cabinets, in combination with the low power consumption of ASB 900, 0.5-2.5 kW depending on size, completely eliminates any need for forced cooling or air conditioning in ambient temperatures up to +40°C.



Fig. 8
A double magazine

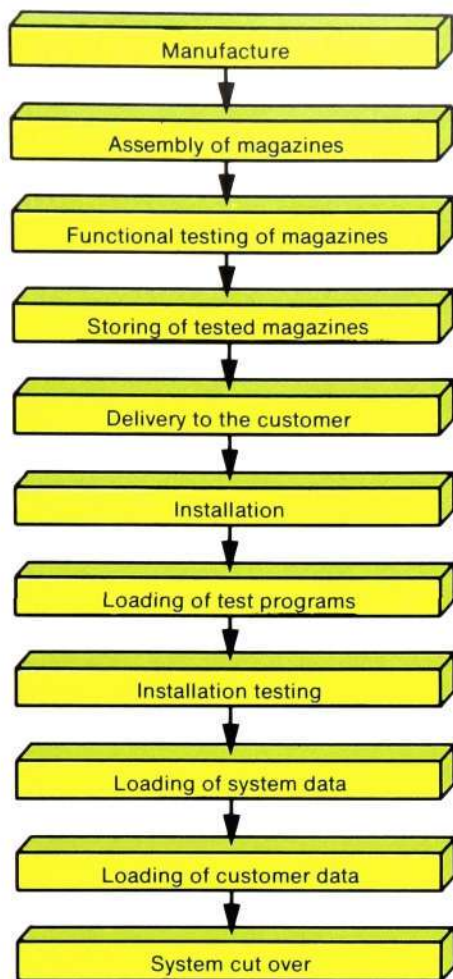


Fig. 9
The main stages from manufacture until the exchange is finally put into service

Power feeding

ASB 900 is powered from the mains via a rectifier which converts the mains voltage to 48 V D.C. The exchange is normally equipped with batteries in order to ensure uninterrupted service. The batteries are charged continuously from the rectifier.

The system voltage, 48 V, is distributed from rectifiers and batteries to the exchange cabinets. A distribution unit is built into each cabinet and the various magazines are fed from this unit via four separate power feeding cables. The internal power requirements of the magazines are met by local converters for 5, 12 and 20 V. This type of power distribution increases the reliability of the exchange, since the unit that is put out of action by the loss of a voltage, for example 5 or 12 V, can never be more than a magazine.

Installation and testing

ASB 900 undergoes functional testing at the factory before it is delivered, and this, in combination with prefabricated cables and special programs for installation testing, reduces the installation time considerably.

The installation is divided into the following stages, see fig. 9:

- assembly of the exchange and connection of the internal and external cabling
- loading of test programs. These are stored on cassette tape and loaded using the tape recorder built into the exchange
- installation testing
- loading of the system software (general system data are also stored on cassette tape). Additional data that is specific for the exchange in question can be loaded from a typewriter terminal
- system cut over.

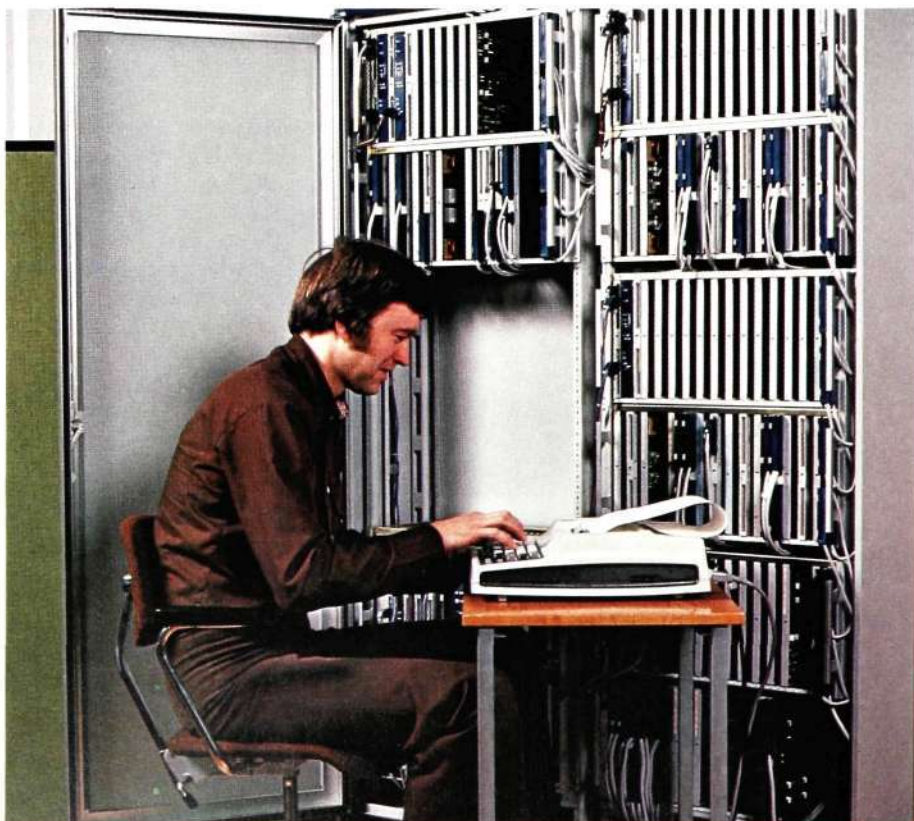


Fig. 10
Loading the system software

Technical data

Capacity			
Extensions	60	960	
Trunks incl. tie-lines	8	136	
Local junctors	6	54	
Tone senders	6	29	
Operators	2	10	
Traffic capacity	0.21–0.18 erlang with a congestion of 0.01 and with 20–40 % internal traffic		
Cabinet	Height	Width	Depth
	mm	mm	mm
	1800	600	300
Telephone sets	with a dial for 10 or 16 Hz and a pulse ratio of 30/70–50/50, or with push-buttons for tone frequency key sending in accordance with CCITT		
Current feeding	2×400 ohms, 48V		
Loop resistance	max. 1800 ohms for extension lines, including the telephone set		
Leakage resistance	min. 40 kohms		
Attenuation	external connection 0.8 dB internal connection 7 dB		} at 800 Hz
Crosstalk attenuation	min. 80 dB at 1100 Hz		
Number series	Three or four digits		
Control system	Single or duplicated processor and bus system		
Processor	APN 163 with 16-bit two-way data bus with one parity bit		
Store	128K words×17 bits dynamic RAM (Random Access Memory)		
Components	Thyristor crosspoints		
	Integrated circuits		
	TTL and LS-TTL		
	Transformers and miniature relays		
Power supply	110/127/220/230/240 V AC 50/60 Hz, alt. 42–54 DC		
Power consumption	0.5–2.5 kW depending on size		
Environmental requirements	+5°C–+40°C ambient temperature 20–80 % relative humidity		

Operation and maintenance

The operation and maintenance of ASB 900 take place through

- continuous functional supervision by a supervisory system built into the exchange
- automatic activation of functions for limiting the effect of disturbances on the operation of the exchange
- simple and efficient fault localization down to a faulty printed board assembly.

The continuous operational supervision is carried out by a number of built-in functions, for example

- time monitoring of the program handling to avoid program loops
- monitoring of the restart rate
- monitoring of rectifiers and power feeding.

There are also automatic, periodic routine tests of

- the processor
- the program and data store
- the bus system
- the cassette tape recorder
- the changeover between the two control systems when the exchange is equipped with a duplicated control system
- the tone senders
- the ringing generators
- the switching network.

In the switching equipment a disturbance rate supervision is carried out on traffic carrying devices. Devices and data areas can be disturbance marked in order to limit the number of traffic disturbances caused by technical faults. The devices and areas that are thus marked will then not be selected until all those without disturbance markings are busy. The disturbance marking is automatically cancelled if the marked device or area is used in a successful connection.

The continuous system supervision automatically gives an alarm if a fault occurs in the exchange. The alarms, which are divided into four different urgency categories, are indicated on the operator's sets and on alarm displays.

The operator's set can also give supplementary information, for example which unit has caused the alarm.

Fault localization in ASB 900 is carried out partly by means of special test programs that are built into the system and partly with controlled test connections, which are initiated from the I/O device.

The procedure is simple and efficient and permits rapid localization of faults down to the printed circuit board level without interfering with the normal operation of the exchange.

Aids

All operation and maintenance information to and from ASB 900 is carried out via an I/O device, which can be a typewriter terminal, display terminal etc. For this purpose ASB 900 is equipped with a special input having a standardized interface in accordance with CCITT V24, fig. 10.

The operational supervision of ASB 900 is carried out locally from an I/O device that is permanently connected to the exchange, or remotely via a modem from a central supervision centre.

The system supervision includes

- programming of system data
- initiation of special test programs
- printouts of the result of test programs
- printouts of devices that are disturbance marked
- printouts of busy, blocked or test marked devices
- printouts of traffic recording data.

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10-Channel PCM System

Hans-Jörg Frizlen and Walter Widl

The increasing digitalization of telephone networks leads to demands for economical transmission also of small channel groups. Furthermore flexible connection facilities for different types of branching are required. LM Ericsson have therefore developed a 10-channel PCM system, which is mainly based on building elements that are used in the 30-channel PCM multiplex and 2 Mbit/s line systems. In this article the background and general design of the 10-channel systems are described and also a number of examples of different applications and their economy.

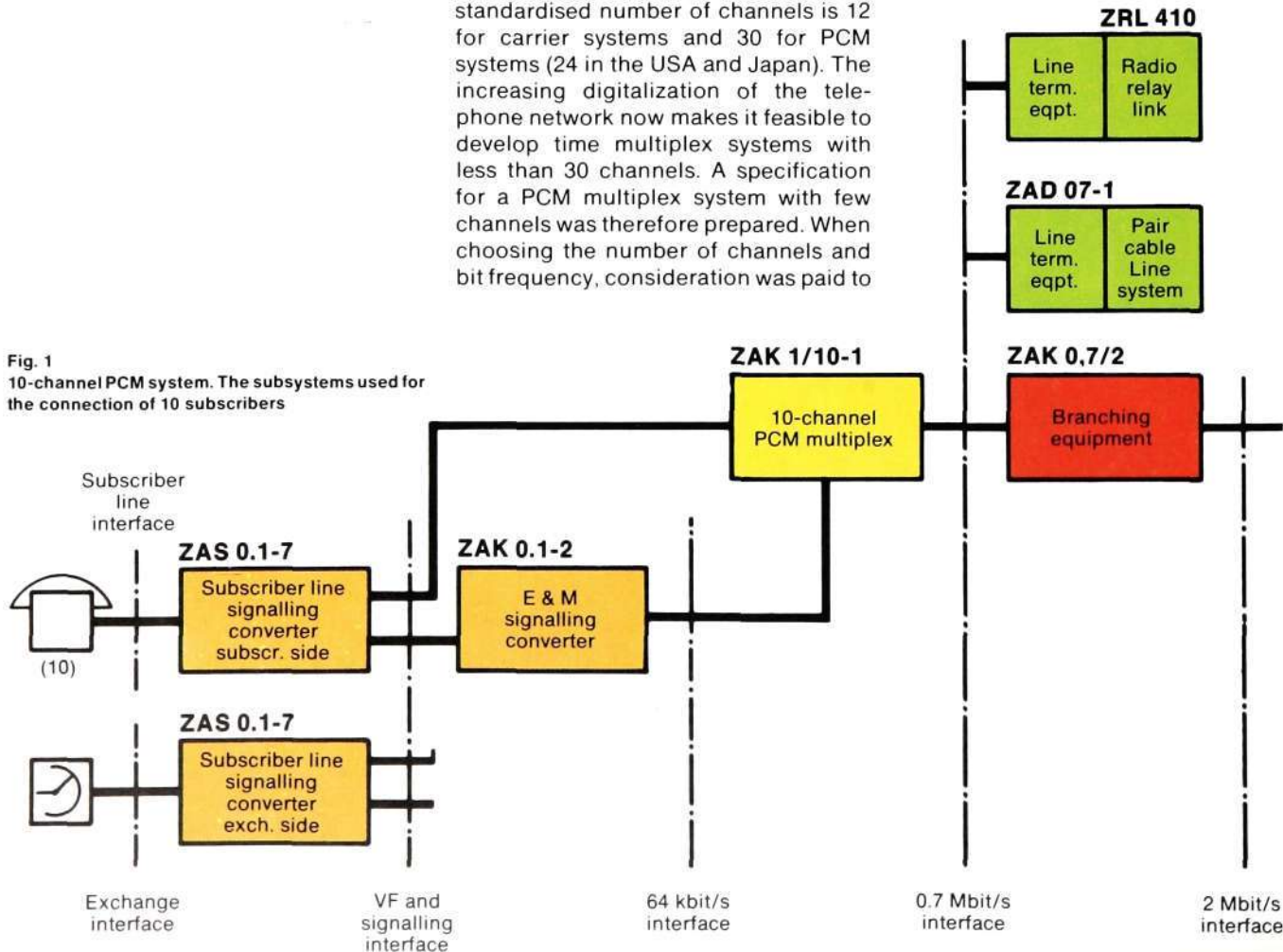
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Frequency and time multiplex systems (carrier and PCM systems) have been developed in order to be able to utilize transmission media efficiently. The development trend has been towards an increasing number of channels both in carrier and PCM systems, but at the same time systems with only a few channels have been developed, particularly in the carrier field, which are intended for the peripheral parts of the networks, particularly in fairly sparsely populated areas. Today the lowest standardised number of channels is 12 for carrier systems and 30 for PCM systems (24 in the USA and Japan). The increasing digitalization of the telephone network now makes it feasible to develop time multiplex systems with less than 30 channels. A specification for a PCM multiplex system with few channels was therefore prepared. When choosing the number of channels and bit frequency, consideration was paid to

the increase in the number of channels obtained by multiplexing, the need for synchronization and signalling information, the required repeater spacing and also the existing CCITT recommendations.

An evaluation¹ of these factors and the current network requirements have led to the design of a 10-channel PCM system with 704 kbit/s (i.e. 11 time slots of 64 kbit/s). The number of channels gives a simple multiplexing factor in relation to the 30-channel PCM system. The lower bit rate permits a regenerator spacing of almost twice that of the 2.048 Mbit/s line system. When 30-channel systems are installed on previously loaded cables it is usually necessary to include regenerators at each loading coil point. In the case of the 10-channel system it is sufficient to install a regenerator at every second loading coil point.

Fig. 1
10-channel PCM system. The subsystems used for the connection of 10 subscribers





HANS-JÖRG FRIZLEN
ELLEMTEL Development Company
WALTER WIDL
Transmission Division
Telefonaktiebolaget LM Ericsson



System structure

The 10-channel system consists of a number of subsystems, which can be combined so that a system configuration is obtained that is suitable for its position in the network and the type of connected exchanges. Fig. 1 shows the subsystems available for installation between subscribers and the terminal exchange.

Some of the subsystems are described in more detail below.

10-channel PCM multiplex equipment

The task of the 10-channel PCM multiplex equipment is to carry out analogue/digital conversion of 10 speech channels and to combine these digitally to form a 704 kbit/s bit stream. The system is thereby in conformity, both as regards construction and function, with LM Ericsson's 30-channel PCM multiplex² in accordance with CCITT Rec. G.732, but with only 10 time slots used for the transmission of speech, and one time slot used alternately for synchronization and signalling. This gives a frame structure consisting of 11

time slots. For signalling purposes there is also a multiframe structure which consists of 16 frames, see fig. 2. Frame and multiframe alignment and signalling information is placed in time slot T0. Frame alignment word 1 is found in frames 0, 4, 8 and 12, frame alignment word 2 in frames 2, 6, 10 and 14 (X indicates free bits). The multiframe alignment word is found in frame 1, and frames 3, 5, 7, 9 and 11 are used for the channel-associated signalling.

Signalling between the 10-channel PCM multiplex equipment and the signal converter is transmitted at a rate of 64 kbit/s and, as can be seen from the right-hand side of fig. 2, in the same frame structure that is used for the 30-channel system, but with signalling information in only the 10 first positions. Thus the signalling equipment developed for the 30-channel system can also be used for the 10-channel system.

The multiplex equipment consists of two channel boards for filtering and amplification of 10 channels, together with one modulator and one demodulator board for common A/D and D/A

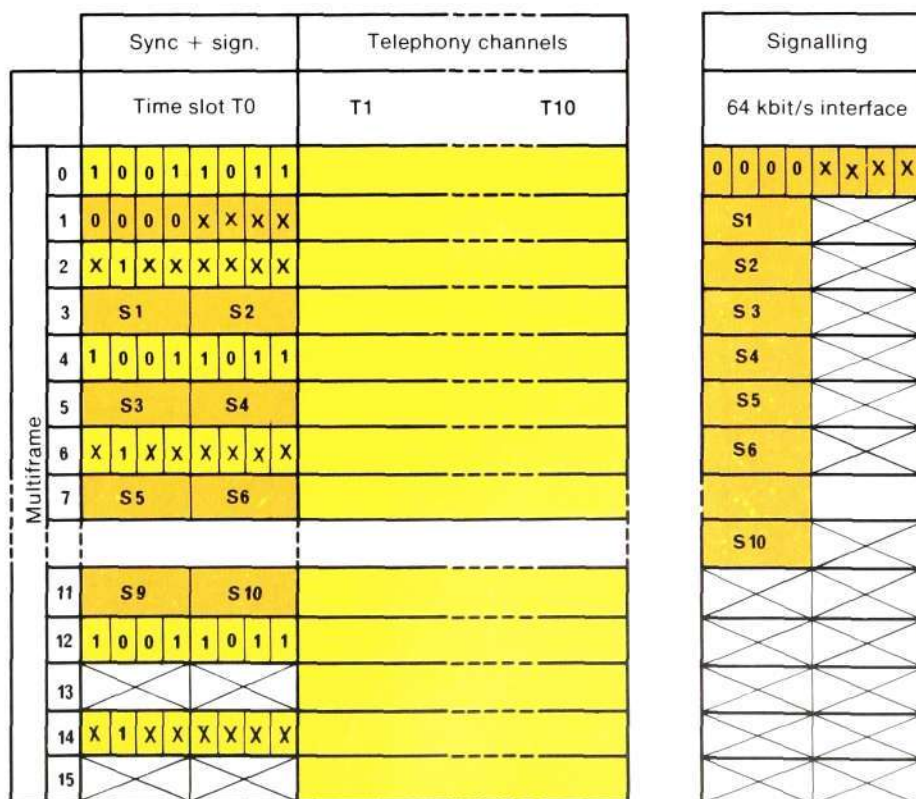


Fig. 2
10-channel PCM system, frame and multiframe structure. The signalling information is accessible via the 64 kbit/s interface. The chosen format permits the connection of different types of signalling converters

T Telephony channels
S Signalling channels
X Free bits

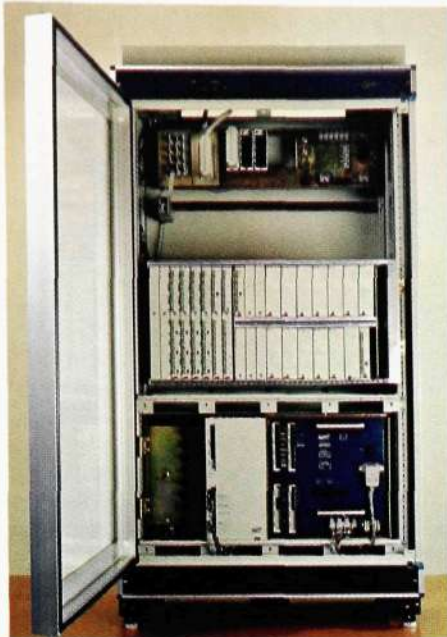
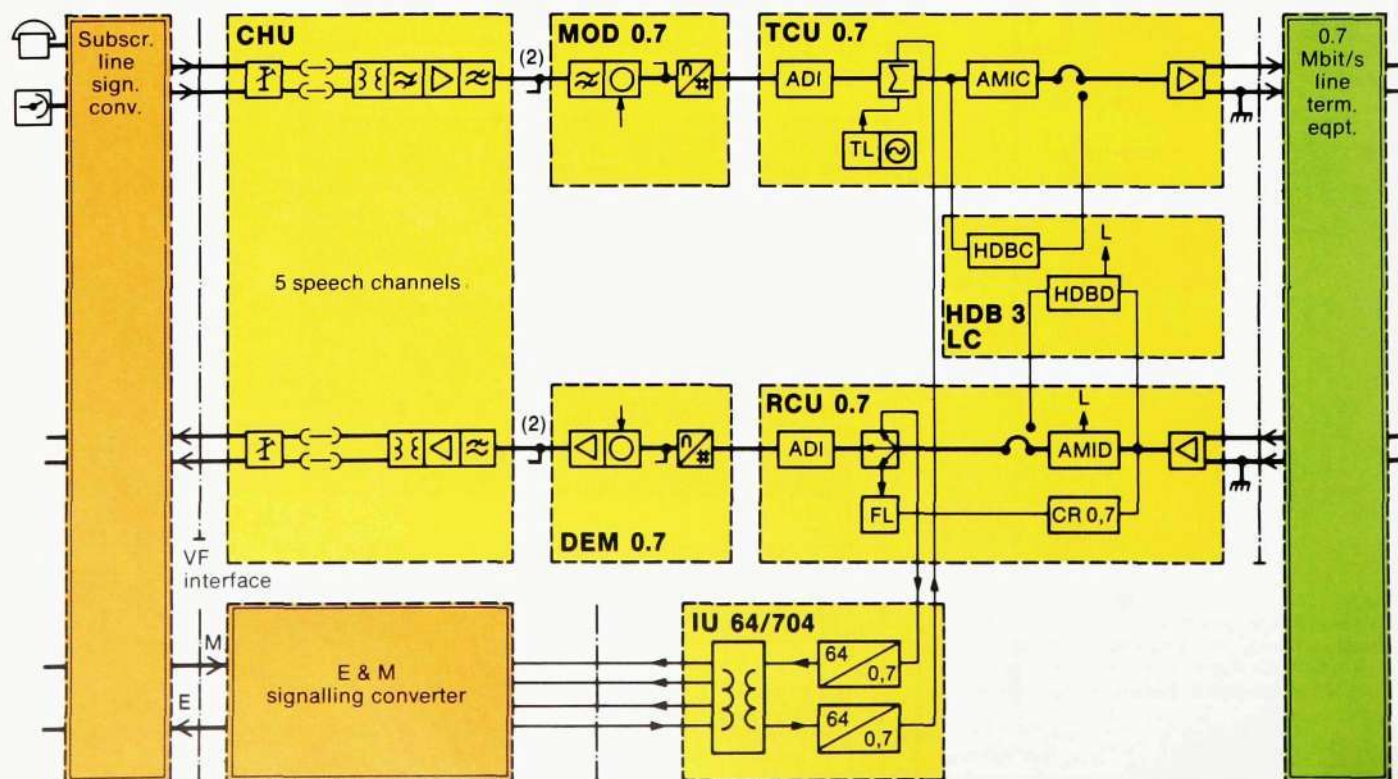


Fig. 4
10-channel PCM multiplex shelf in a BYB cabinet. The cabinet is equipped with power supply, ringing generator and connectors for the connection of 10 subscribers

Fig. 3
10-channel PCM multiplex shelf. In addition to the PCM multiplex equipment there is room for an E & M signalling converter, a subscriber line signalling converter (subscriber side or exchange side) and a 0.7 Mbit/s line terminal equipment

CHU Channel unit for 5 speech channels
MOD 0.7 Modulator unit
DEM 0.7 Demodulator unit
TCU 0.7 Control unit, transmitter
RCU 0.7 Control unit, receiver
IU Interface unit
HDB3 LC HDB3 codec unit (optional)



conversion, see fig. 3. Two logic units are required for the generation and regeneration of timing, frame and multiframe alignment, branching of signalling information and code conversion for line signals.

Normally the AMI (Alternate Mark Inversion) line code is used, but with the aid of an optional HDB3 code unit or HDB3 versions of the control units the HDB3 code can also be obtained.

The signalling information is taken through a rate converter for adaption to the 64 kbit/s interface.

A 10-channel PCM terminal shelf constructed in the LM Ericsson M5 construction practice for a 600 mm rack or BYB cabinet can accommodate the following subsystems:

- a 10-channel PCM multiplex equipment
- an E&M signalling converter
- subscriber line relay sets (the subscriber side or exchange side)
- a 0.7 Mbit/s line terminal
- a DC/DC converter for connection to the exchange battery.

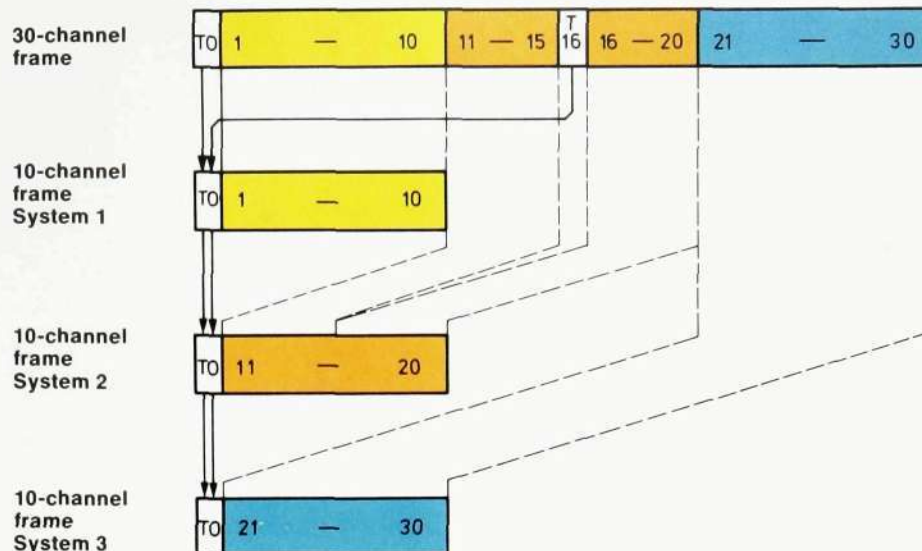
Fig. 4 shows a complete terminal for the connection of 10 subscribers.

Equipment for 0.7/2 Mbit/s digital branching

Multi-point networks with branches and connection of 10-channel systems to 30-channel systems creates a need for digital branching. A maximum of three 704 kbit/s bit streams then form a 2.048 Mbit/s bit stream with the frame structure of the 30-channel system in accordance with CCITT Rec. G.732. The interleaving of the three 10-channel frames, which is shown in fig. 5, is controlled by the incoming 2 Mbit/s timing.

The function of *leak branching* is illustrated in the block diagram of fig. 6. A 2 Mbit/s bit stream consisting of 30 channels is received from the terminal that determines the timing, i.e. terminal A, and from this bit stream 0.7 Mbit/s (10 channels) are leaked off and 2 Mbit/s with 20 channels continue to B. In the branching unit the bit, frame and multiframe positions are detected, the last mentioned in order to distribute the signalling information in time slot 16 to time slot 0 in the 10-channel system. In the branching unit 0.7 Mbit/s bit timing is generated synchronously through division by 32/11. A complete 10-channel frame is stored in a frame buffer, new 2

Fig. 5
The relation between the 10-channel and 30-channel PCM multiplex frames



Mbit/s and 0.7 Mbit/s frame alignment words are generated, and speech and signalling information is inserted in the new frames. In the opposite direction the 2 Mbit/s timing, which is looped in B, controls the interleaving of the 0.7 Mbit/s bit stream that is coming in from C via a frame buffer. It is necessary to loop the 0.7 Mbit/s timing in C in order to be able to synchronize the interleaving. After inserting new frame and multiframe alignment words the then complete 30-channel frames are sent back to A.

If a fault occurs in the terminals or the lines to C and B, an alarm indication is transmitted in the alarm bit X_3 in the frame alignment word two:

$$X_1 \ 1X_3X_4X_5X_6X_7X_8.$$

The national alarm bits $X_6X_7X_8$ can be used to transmit the alarm to the supervising exchange A.

Digital multiplexing, i.e. branching into three 0.7 Mbit/s subsystems, is carried

out in accordance with the same principles and using the same shelf as for leak branching. The shelf is then equipped for simultaneous branching of 3 bit streams at 0.7 Mbit/s by replacing one 2 Mbit/s interface equipment by two more branching equipments.

0.7 Mbit/s digital line systems over pair cable

The line system consists of line terminal equipment and remotely powered regenerators. The voltage values of the 0.7 Mbit/s interface correspond to CCITT Rec. G.703 for 2.048 Mbit/s with pulse times proportionally converted to 0.704 Mbit/s.

The reduced transmission speed permits larger regenerator spacing than in the case of a 2.048 Mbit/s line. Fig. 7a shows typical regenerator spacings for different cable types, calculated for 704 kbit/s and the fairly conservative amplification of 30 dB per section. For comparison purposes fig. 7b shows the regenerator spacings for 2.048 Mbit/s lines.

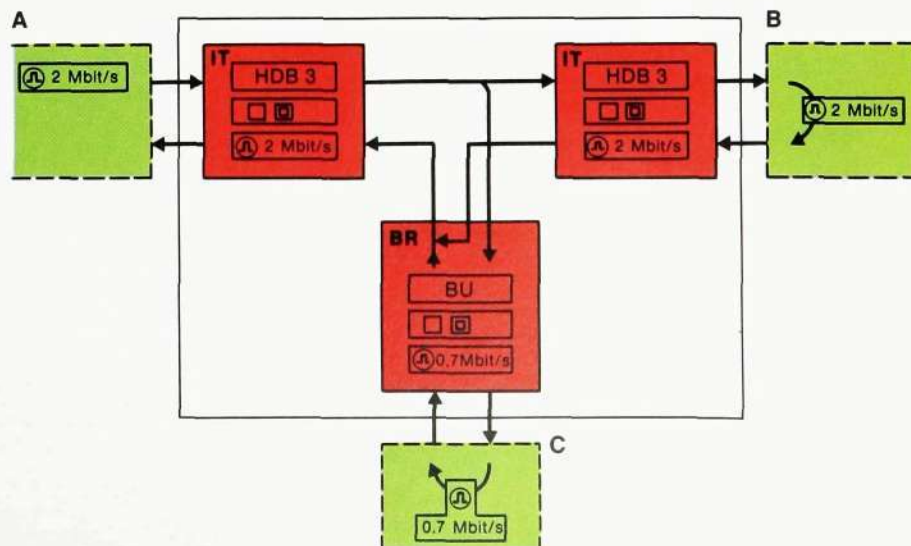


Fig. 6
Block diagram for branching equipment

- IT Interface unit
- BR Branching unit
- Frame alignment
- ⊠ Multiframe alignment
- ⊙ Timing
- HDB3 Coding/decoding

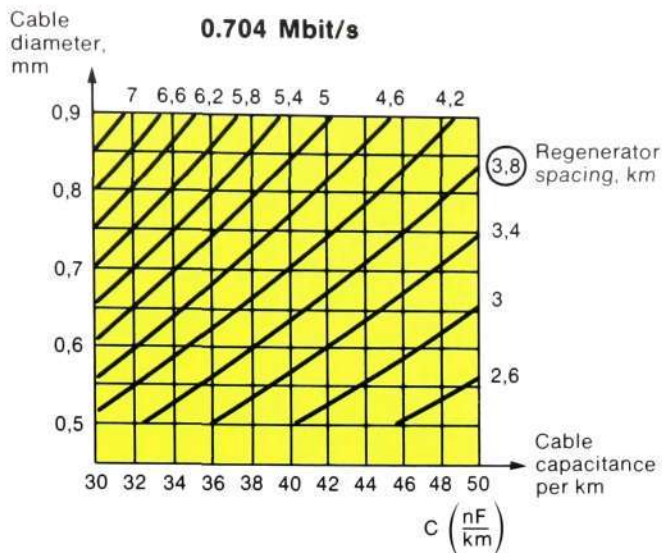
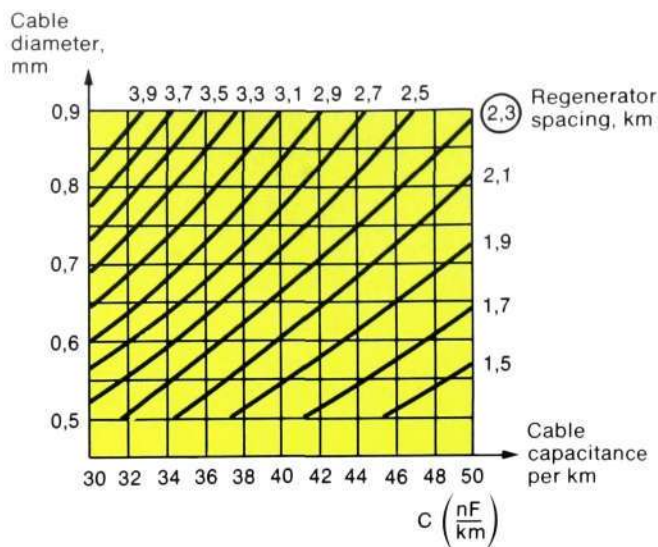


Fig. 7a
Repeater spacing in kilometres
PE cable
0.704 Mbit/s

Fig. 7b
Repeater spacing in kilometres
PE cable
2.048 Mbit/s



The line regenerator equipment for two directions of transmission is placed on one board. The basic regenerator functions, amplification, equalization and pulse regeneration, are carried out by a monolithic circuit that uses very little current. The regenerator is equipped with automatic gain control for adaptation to line attenuation values of between 5 and 35 dB, which simplifies the installation work. The regenerator is protected against overvoltages by vacuum lightning protectors, diodes and zener diodes.

Faulty regenerators are localized by means of a fault localization system based on controlled loop connection. Addresses, which with the aid of fault localizing instruments can be fed out via the 0.7 Mbit/s interface of the line terminal, are used to carry out the loop connection in the indicated two-way line regenerator, after which a test signal is sent out and then compared with the returning signal. The address code is designed so that a normal digital signal cannot cause a loop connection. This fault localizing method has the advantage that it does not require a separate *supervisory pair* and thus is particularly suitable for cables with only a few line pairs.

The line terminal consists of a connection board, terminal repeater, alarm unit and power units, and it can be placed in either a 10-channel PCM terminal shelf or a 0.7 Mbit/s branching shelf.

0.7 Mbit/s radio relay link terminal

The radio relay link terminal is connected via the 0.7 Mbit/s interface. The transmission normally requires a bandwidth of up to 700 kHz. The required band can be limited to 60–500 kHz when using band limiting with a vestigial sideband filter. Regeneration of the digital signal and timing recovery takes place at the output of the radio relay link receiver. Fairly simple radio relay links with a hop length of up to 50 km can be used because of the low bandwidth requirement.

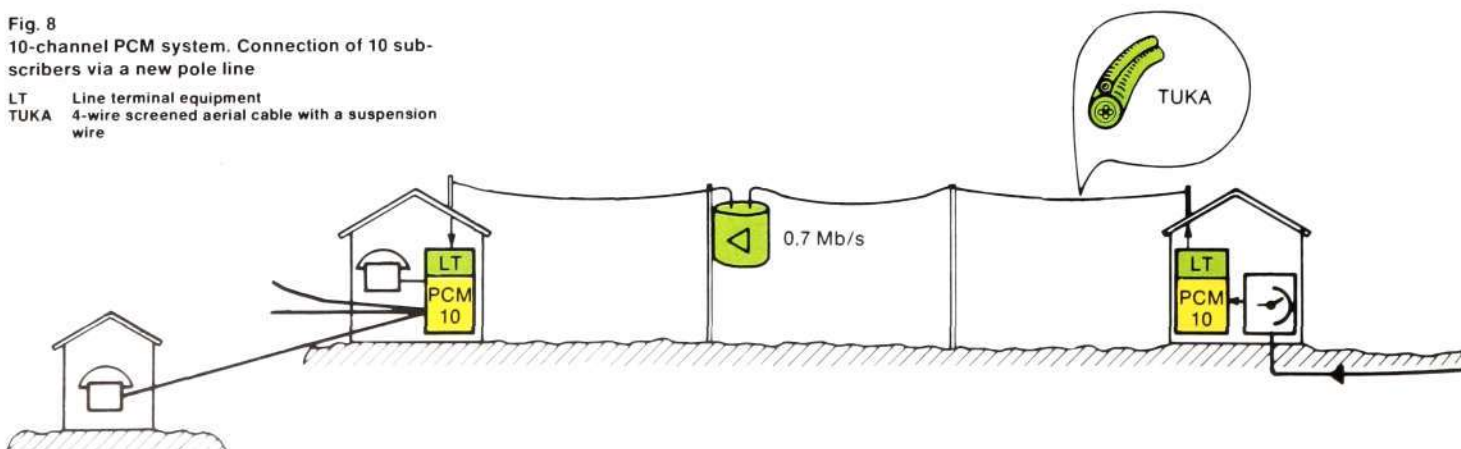
Applications

The 10-channel PCM system is used in the network in order to

- increase economically the number of circuits over small pair cables, e.g. the rural junction and subscriber networks in sparsely populated areas
- bring digital transmission out into the local networks when replacing electromechanical local exchanges by digital exchanges and concentrators.

Fig. 8
10-channel PCM system. Connection of 10 subscribers via a new pole line

LT Line terminal equipment
TUKA 4-wire screened aerial cable with a suspension wire



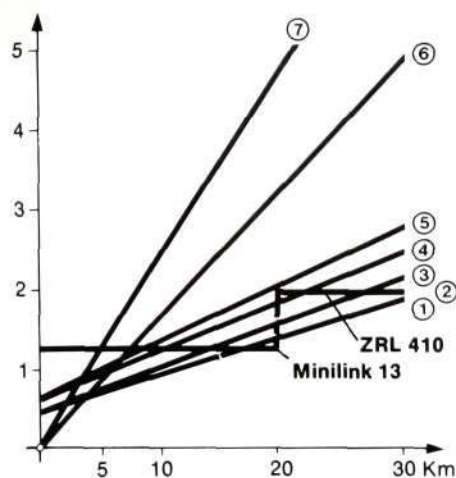


Fig. 10
The relative cost of different system alternatives.
Point-to-point connections

1. 10-channel PCM system, existing cable
2. 10-channel PCM system, radio relay link: 0–20 km type "MINI-LINK", 20–30 km type ZRL 410
3. 10-channel PCM system, TUKA on existing poles
4. 30-channel PCM system, TUKA on existing poles
5. 30-channel PCM system, existing cable
6. New 10-pair cable on existing poles
7. 10-pair cable on new pole line

— connect subscribers who require advanced digital facilities.

The range of applications of the 10-channel system is described below by means of a number of typical cases. The economy of the various cases is also discussed to some extent.

Point-to-point connections

Fig. 8 shows the connection of 10 subscribers to a terminal exchange and fig. 9 extension of the trunk lines between two exchanges. The number of circuits is increased by means of 10-channel PCM systems via aerial cable, along an existing or new pole line, or via existing buried cable. The need for modernisation can justify the introduction of 10-channel systems even if the amount of traffic does not increase. For example, open wire lines with high maintenance costs can be replaced by an aerial four-wire star quad cable with a suspension wire (so-called TUKA cable), using the existing poles.

The PCM equipment for subscriber connection is usually placed on existing premises or in outdoor cabinets with local power feeding. A suitable combination of the system parts shown in fig. 1 is required, depending on the application. The cost comparison in fig. 10 gives the relative total costs for different transmission alternatives and distances, based on Swedish conditions.

1. 10-channel PCM system, existing cable
2. 10-channel PCM system, radio relay link: 0–20 km type "MINI-LINK", 20–30 km type ZRL 410
3. 10-channel PCM system, TUKA on existing poles, a maximum of one system

4. 30-channel PCM system, TUKA on existing poles, a maximum of one system

5. 30-channel PCM system, existing cable

6. New 10-pair cable on existing poles

7. 10-pair cable on a new pole line.

The costs are calculated for the extension of trunk lines between two exchanges and include the purchase, installation and testing of the terminal and line equipment and the cables or radio relay links required.

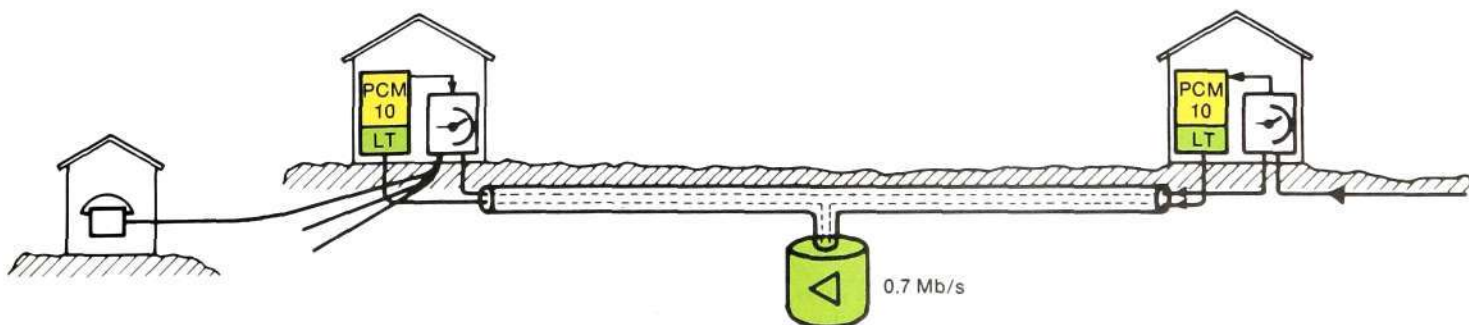
The cost comparison shows the 10-channel system to be superior for transmission over either deloaded or new four-wire screened cable with suspension wire (e.g. TUKA) and existing pole line or over radio relay links with a limited bandwidth and long hop length. For comparison purposes fig. 10 also shows the cost of physical circuits on loaded 10-pair trunk cable with plastic insulation and a 10-channel PCM system on the same type of cable.

The main factor that affects the costs is how much new installation work will be required, e.g. new cables, pole lines and houses. Radio relay links, which are connected to terminal equipment placed in a house, cabinet or buried container, therefore constitute interesting alternatives to cables.

Outdoor cabinets, similar to the distribution cabinets in the subscriber networks, can be used and the power supplied from the nearest mains fuse cabinet. AC/DC converters and standby batteries are dimensioned in accordance with the requirement as regards operating time in the case of a mains failure.

Fig. 9
10-channel PCM system. Extension of the trunk circuits in an existing cable

- PCM 10 Contains subsystems ZAK 1/10–1, ZAK 01–2 and ZAS 01–7
- LT Line terminal equipment ZAD 0.7–1
- ◁ 0.7 Mbit/s regenerator, ZAD 0.7–1
- ↻ Analogue exchange



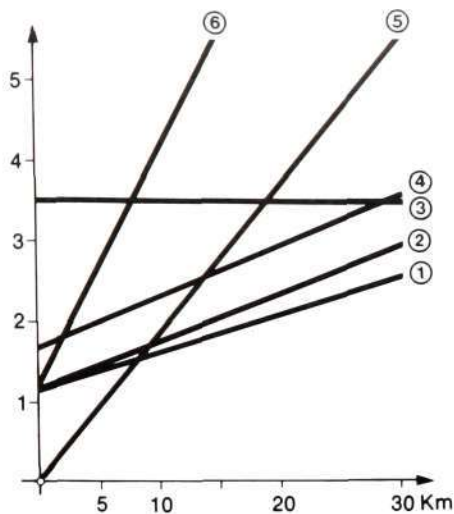


Fig. 11
The relative costs of several branchings along a route in accordance with fig. 12

1. Leak branching and 10-channel PCM multiplex. Existing cable, deloaded
2. Leak branching and 10-channel PCM multiplex. TUKA on existing poles
3. 30-channel system with demodulation and modulation (PCM 30 back-to-back) at each point instead of branching. TUKA on existing poles
4. Leak branching and 10-channel PCM multiplex. Radio relay link, type "MINI-LINK", 13 GHz
5. New 30-pair cable on existing poles
6. 30-pair cable on a new pole line

Branching

A number of communities are often connected by means of a telephone line that follows a road, river or valley and which connects the exchanges in the various communities. Fig. 12 shows a general example of such an application. Leak branching is carried out at several points along a 2 Mbit/s route. The subscribers are connected to the local exchanges via physical lines. An existing deloaded buried or aerial cable, a new 4-wire screened cable (TUKA) with a suspension wire or a small radio relay link can be used for the line system.

In the diagram of fig. 11 a comparison is made of the costs of the following system and line types as a function of the total distance:

1. Leak branching and 10-channel PCM multiplex. Existing cable, deloaded
2. Leak branching and 10-channel PCM multiplex. TUKA on existing poles
3. 30-channel system with demodulation and modulation (PCM 30 back-to-back) at each point instead of branching
4. Leak branching and 10-channel PCM multiplex, radio relay link type "MINI-LINK", 13 GHz
5. New 30-pair cable on existing poles
6. 30-pair cable on a new pole line.

The diagram shows that in this case also there are good reasons for replacing old open wire lines with PCM systems and leak branching.

The branching facility is economically advantageous compared with the method of demodulating and modulating with a 30-channel PCM multiplex at each point—a method that would have been used if the 10-channel system did not exist.

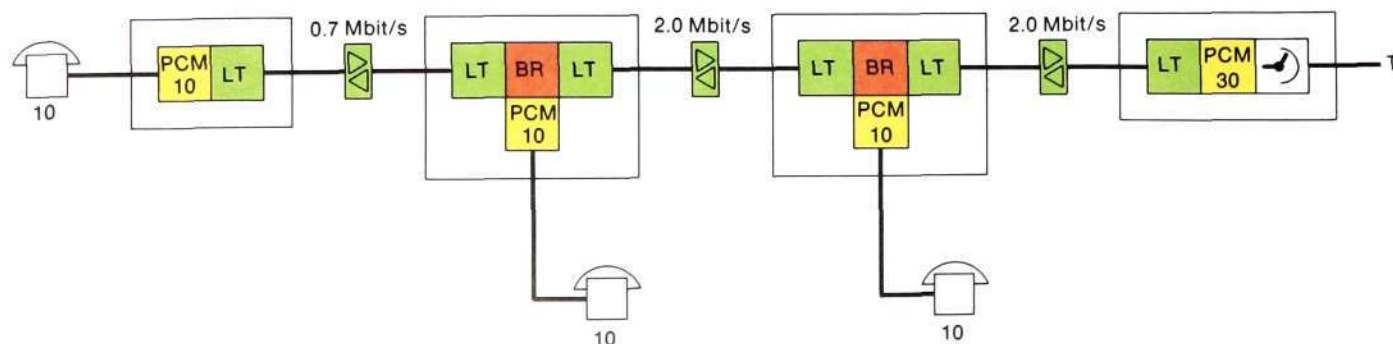
Another application of interest is the case of a new, small community, such as a tourist establishment in a sparsely populated area, where it would not be profitable to build a new exchange. Instead the new subscriber group is branched off from the nearest terminal exchange, if this already has incoming PCM systems or if PCM systems are installed to cope with the increase in traffic, see fig. 13a. In the new community the terminal equipment, which also contains subscriber line relay sets, can be placed in a building (e.g. shop) or alternatively in an outdoor cabinet.

The factors affecting the choice of line system are similar to those for point-to-point circuits if existing poles can be used. The more expensive subscriber line relay sets and outdoor cabinets, when these are used, reduce the profitability margin towards loaded aerial cable by a few kilometres compared with the case illustrated in fig. 10. Generally speaking the economic attractiveness of the 10-channel system is reduced by the high costs that will be incurred if it is necessary to build a new pole line or lay a new cable.

Future digitalization aspects

The present tendency to introduce digital transit exchanges and at the same time place digital PABXs or concentrators further out towards the subscriber makes digital transmission increasingly attractive. For example, when the rural exchange network is modernised, small terminal exchanges can be replaced by digital concentrators, which are controlled from the immediately superior exchange. Thus the case shown in fig. 13a can in future be realized as shown in fig. 13b.

Fig. 12
Several branchings along a route
Legend, see fig. 13



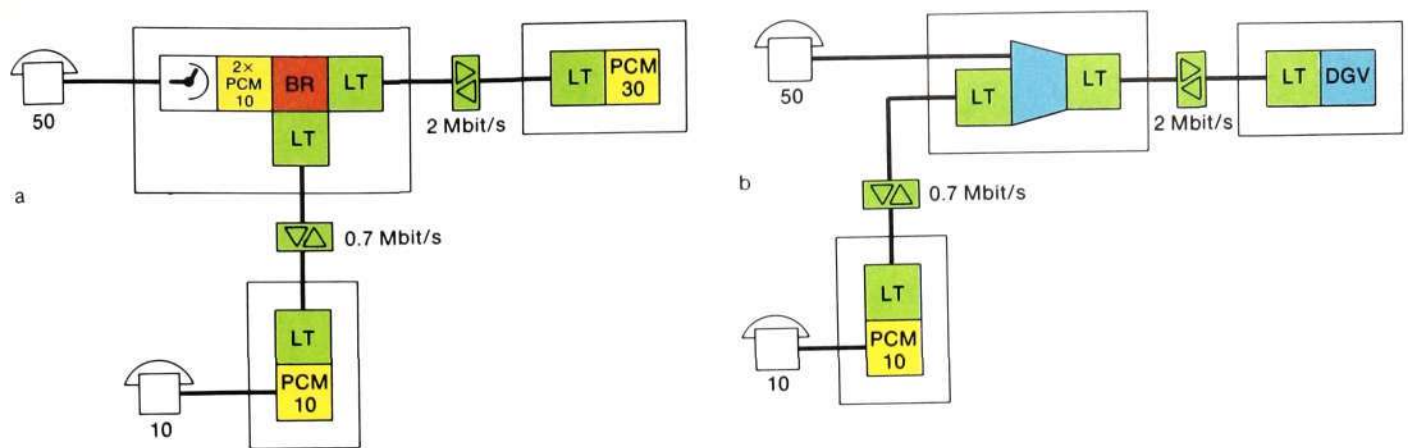


Fig. 13
Branching to a new community
a. With an analogue exchange in the terminal
b. With a digital concentrator in the terminal

PCM 10	Contains subsystems ZAK 1/10-1, ZAK 01-2 and ZAS 01-7
PCM 30	Contains subsystems ZAK 1/30-3, ZAK 01-2 and ZAS 01-7
LT	Line terminal equipment ZAD 0.7 or ZAD 2
→	Analogue exchange
↔	Two-way regenerator ZAD 0.7 or ZAD 2
BR	Branching equipment (IT + BR, see fig. 6)
DGV	Digital group selector

Digitalizing the subscriber network also opens up the possibility of using the network for digital services. For example, data terminals or equipment for crypto-telephony could then be connected. This would also create a demand for the transmission of digital signals over the long distance network. This demand could be met, particularly in an initial stage with a limited amount of digital traffic, using the equipment described above for 0.7 Mbit/s digital streams, which can be placed above the line frequency band of carrier systems (data over voice), or by using multi-level modems which place the streams in a supergroup band (data in voice), and thereby bridge the analogue carrier sections. With the aid of digital multiplexors that allow complete flexibility, the 0.7 Mbit/s signal streams can then be combined with 2 Mbit/s streams and transmitted over the digital lines of the PCM hierarchy.

Summary

LM Ericsson's 10-channel PCM system has been developed as a subsystem of the standardised PCM primary multiplex system. The system solution is very similar to that of the 30-channel system. Furthermore the mechanical construction and the maintenance and signalling principles of the two systems are similar and compatible.

Digital branching and multiplex equipment permits connection to 2 Mbit/s digital links.

The system is at present economically advantageous in sparsely populated areas compared with new cables or overdimensioned 30-channel systems. With the future successive digitalization of the rural network the system will enable the necessary digital circuits to be provided in a convenient and economic way.

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2. Lindquist, S. and Widl, W.: *30-Channel PCM Terminal Equipment*. Ericsson Rev. 53 (1976):1, pp. 38-49.

Power Supply Units in the M5 Construction Practice

Bo Viklund and Bengt Assow

A new type of power unit for the power feeding of transmission systems has been designed by LM Ericsson. The units are of what is called the triple output type and thus particularly suitable for systems utilizing PCM technology. The new power units are intended primarily for decentralized feeding, which means that each function unit (shelf) is supplied from its own converter. The article describes the advantages of the triple output unit, its design, operation and characteristics.

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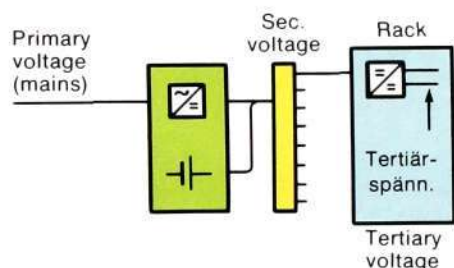


Fig. 1
Typical power supply system for telecommunication equipment

In principle a power supply system for telecommunication equipment comprises three voltage levels, fig. 1. The primary level consists of the voltage and the converters used for charging the exchange battery. This voltage is often obtained from a national network and has a standardized value between 110 and 240 V and is usually an AC voltage with a frequency of 50 or 60 Hz.

The second level, the secondary voltage, consists of the voltage from the battery. It is fused and distributed to the racks in which the electronic equipment is mounted. The battery voltage is 24, 36, 48 or 60 V.

The racks contain the converters that are required for generating the electronic voltages. The M5 construction practice contains converters for +5, +12 and -12 V and various types of converters for remote power feeding of different line equipments. These voltages constitute the tertiary voltages.

The converters are built into the equipments in accordance with one of two principles:

- Centralized power supply
- Decentralized power supply

Centralized power supply

The converters, which were described in Ericsson Review no. 3/4 1975¹, are mounted in power supply shelves, fig. 2. A summary of the input and output range and the output power from these different converters is given in table 1.

There are two types of shelves, with space for

- one AC/DC and one DC/AC converter
- two DC converters.

In the first case the rectifier powers the DC/DC converter in its own shelf. In the second case the converters are powered from a secondary voltage. The left-hand upright of the M5 rack contains a connection strip, from which the secondary voltage can be distributed to several power supply shelves.

The tertiary voltages from the shelves are connected to the bars in the right-hand upright of the rack via contact tabs. When the electronics shelves are mounted in the rack they are connected to the same bars via contact tabs and are thus connected to the same power unit, and a *centralized* power supply system is thereby obtained, fig. 4.

Racks for analogue equipment have six bars in the right-hand upright. Table 2 shows the function of these bars. The right-hand uprights are also used for distributing the carriers from the carrier shelf to the channel shelves.

Racks for digital equipment have a right-hand upright with nine bars. Their function is also shown in table 2.

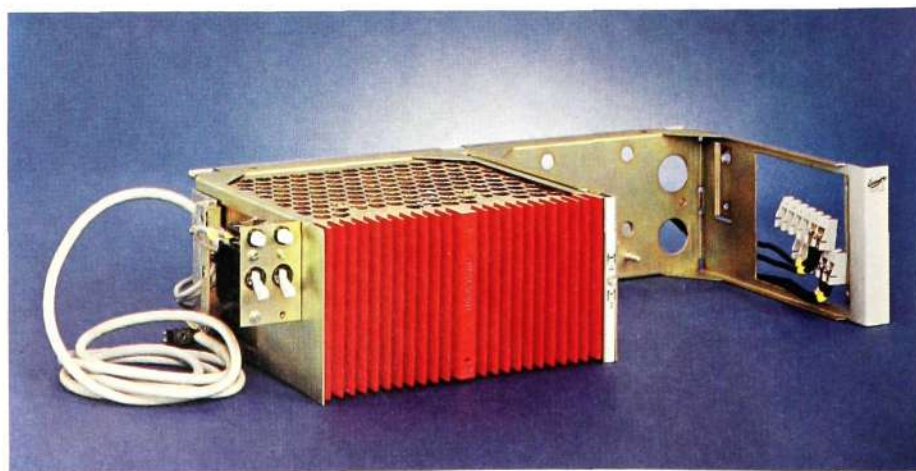
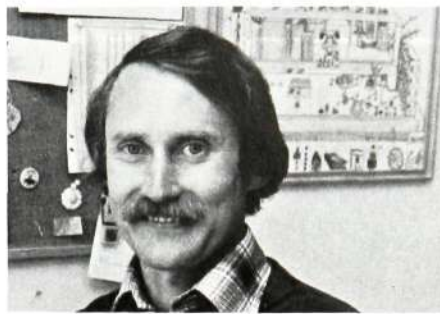


Fig. 2
Power shelf, equipped with a DC/DC converter. The shelf holds two converters.



BO VIKLUND
Transmission Division
BENG T ASSOW
Power Supply Department
Telefonaktiebolaget LM Ericsson



In the case of centralized power feeding it is possible to connect up the converters via diodes, so that a standby power supply is obtained.

Decentralized power supply

In a *decentralized* power supply system each function unit, which often consists of only one shelf, is fed from its own converter.

A decentralized system is preferred

- for small stations with only a few shelves in a rack. A decentralized unit is less expensive than a centralized unit since the output power is less
- for stations with a low rate of extension. The decentralized system gives a lower initial cost than centralized power supply
- in order to prevent the failure of a power unit from affecting more than a small section of the equipment

A triple output unit, in which the secondary voltage is converted to three tertiary voltages, has been developed for decentralized power feeding of shelves in PCM systems.

The converter units for power feeding of the various line equipments are decentralized: each power unit supplies only one system.

Triple output unit

Function

Fig. 3 shows a simplified circuit diagram of a triple output unit, type BMR 90704, BMR 90705 and BMR 90706.

The input voltage is fed to capacitor C1. L1 reduces transients from the input voltage and also noise from the unit towards the input voltage. C2 is large compared with C1 and is dimensioned primarily to handle the pulse currents obtained when transistor T1 opens and closes.

Transistor T1 controls transformer Tr1 in accordance with the fly-back principle. This means that energy is stored in Tr1 when T1 is conducting and when T1 ceases to conduct the voltage across Tr1 increases until the rectifier diodes D1, D2 and D3 start conducting. Energy is then transmitted to the outputs.

The output voltages +5 V and +12 V are added and compared with a reference voltage. The difference voltage then obtained is fed to the light emitting diode in an optical coupling unit, which transmits information to the primary side of the triple output unit. As a result the conducting time of transistor T1 is increased or decreased depending on whether the output voltages are too low or too high.

Table 1

V_{in} (V)	V_{out} (DC V)	P (W)
DC -20 to -72	+5	160
DC -20 to -72	+12	170
DC -20 to -72	-12	180
DC -30 to -72	-21	200
AC 110-240	-48	215

Table 2

Bar	Analogue systems	Digital systems
1	-12 V	-12 V
2	-12 V*)	+5 V
3	Spare (e.g. $-U_B$ **)	+12 V
4	"Urgent alarm"	"Urgent alarm"
5	"Non-urgent alarm"	"Non-urgent alarm"
6	Reminder indication	Reminder indication
7	The space is used for carrier distribution	Spare (e.g. $-U_B$)
8		$-U_B$
9		$+U_B$ (earth)

*) when the rack is divided between two DC/DC converters

**) U_B = exchange battery voltage

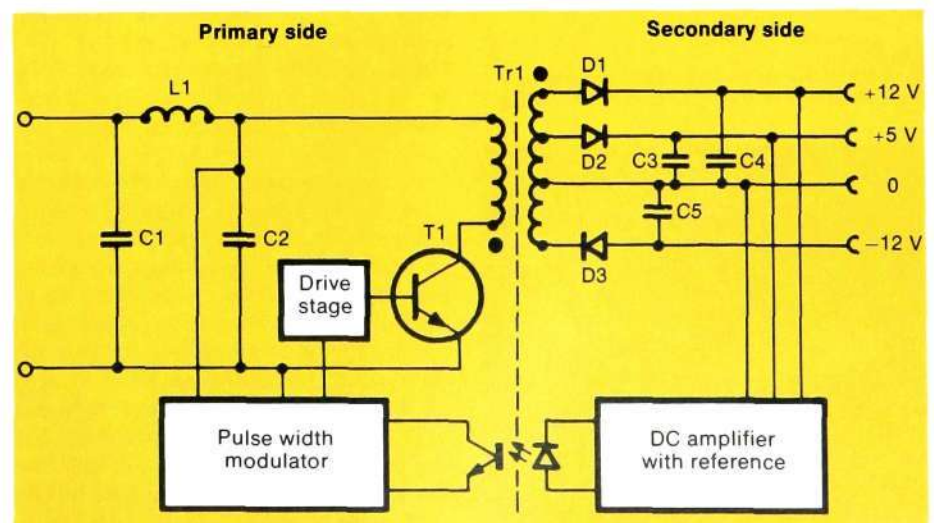


Fig. 3
Triple output unit, simplified circuit diagram

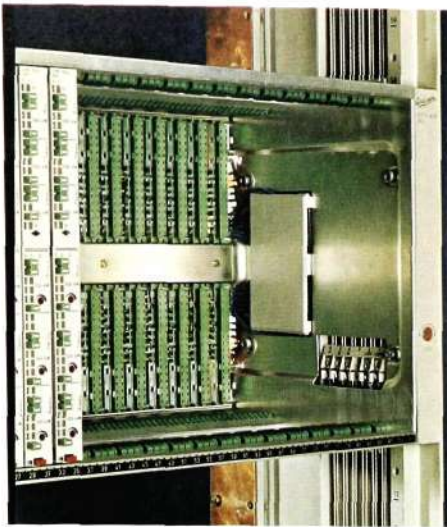


Fig. 4
Connection of a shelf to the bars in the right-hand rack upright

Ageing can affect the coupling factor of the optical coupling unit by 10–20 % – a realistic value after ten years of operation – but this does not affect the output voltages by more than 10 mV or so as the optical coupling unit comes after an amplifier. Ageing of the electrolytic capacitors during the same period will also give a change in the output voltage but in the opposite direction.

Characteristics

The switching method used (fly-back) means that the input voltage range of the unit can be made very large. The above-mentioned power units can work with any of the battery voltages 24, 36, 48 and 60 V without any restrapping being necessary.

The three output voltages can be loaded with a total maximum of 50 W and a maximum of 25 W on +12 V, 25 W on –12 V and 50 W on +5 V. However, the power unit should not be loaded continuously with more than 40 W on the +5 V output with an input voltage of 24 V, since otherwise its life will be reduced.

The limits for the output voltages are $\pm 4\%$ for +5 V and $\pm 5\%$ for +12 V and –12 V, provided that the loads are fairly evenly distributed on the output voltages. In the case of a very uneven load, for example 45 W on +5 V and only a few watts on +12 V and –12 V, the +12 V and –12 V voltages will not stay within the given limits because they cannot be regulated individually.

Under certain extreme loading conditions it may be necessary to adjust the output voltages. This can be done without dismantling the unit, by means of a trimming potentiometer which is accessible from the outside of the unit.

The outputs are made short-circuit proof by limiting the output currents. However, short-circuiting of, for example, the –12 V output gives a fairly high short-circuit current, corresponding to the full output power of the power unit, but the unit is dimensioned to take this for a period of several weeks. The ageing of the electrolytic capacitors sets a limit on the duration of the overload. The output current limiting level is approximately 30 % above the maximum output current on all outputs, so that occasion-

al load peaks, for example when connecting new units into the shelf, will not cause dips in the output voltages.

All outputs are equipped with over-voltage protection. The +5 V output protection consists of a completely duplicated regulation loop and the other outputs are protected by zener diodes.

The input and output are galvanically separated, and thus any output point can be earthed. For example, if a –5 V voltage is needed, the +5 V output is earthed and –5 V can then be obtained on the neutral. However, this will also change the other voltages, which then become +7 V and –17 V.

Figs. 6–8 show some interesting parameters of the triple output unit.

Mechanical construction

Triple output unit

- BMR 90704, is connected to M5 shelves
- BMR 90706, is placed in M5 shelves

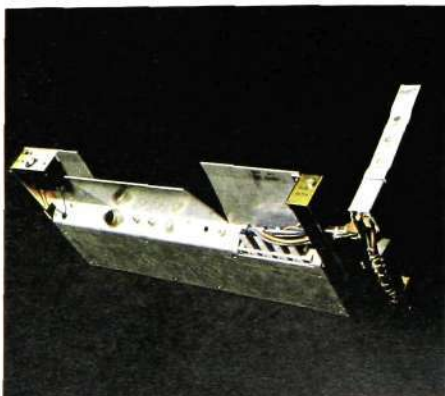
BMR 90704

BMR 90704 is constructed mechanically as a ventilation unit, so that the heat from the shelf below and that generated by the power unit itself is ventilated away from the shelf above the power unit, fig. 5. A circuit breaker that functions as a fuse is mounted to the left on the unit, for disconnecting the secondary voltage to the power unit. This voltage, the three tertiary voltages and the alarm function are accessible in a terminal block on the right-hand side of the power unit.

The power unit is connected to the bars (secondary voltage and alarm function) and to the shelf or shelves that are to be supplied via a guide with connectors. The connectors for the different voltages are not interchangeable. This eliminates the risk of faulty connection, fig. 5.

The tertiary voltages are connected to the shelf by means of the circuit breakers mounted on the front of the shelf side member. No changes have to be made in the rack when installing the shelf.

Fig. 5
BMR 90704. The power unit seen from below, showing the connector arrangement (to the right)



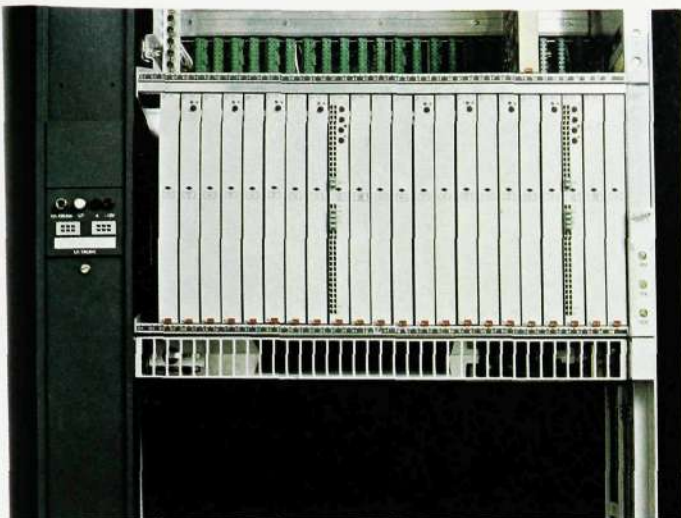


Fig. 9
A double shelf connected to BMR 90704. A protective grating is mounted in front of the power unit

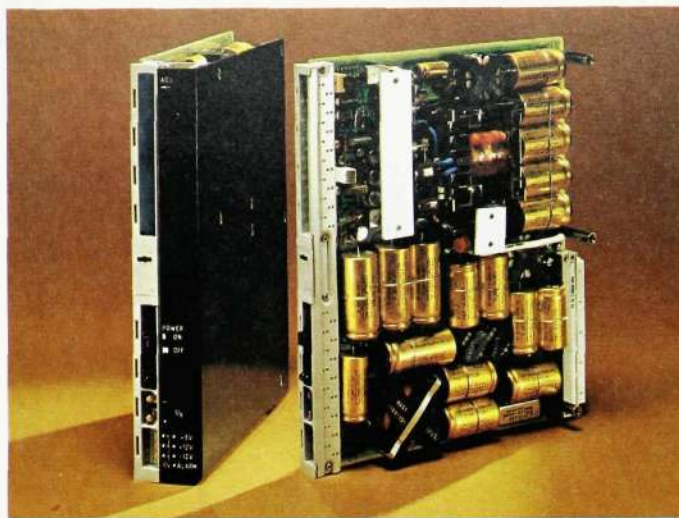


Fig. 10, right
Triple output unit BMR 90706

Efficiency

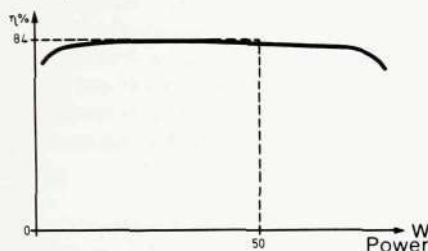


Fig. 6
The efficiency as a function of the load with an input voltage of 48 V. Half the output power is at +5 V and half at ± 12 V

Output voltage, V

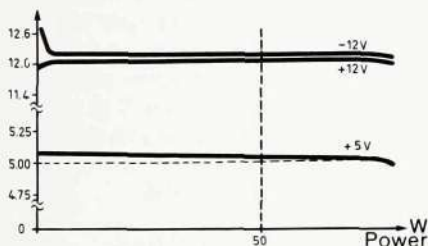


Fig. 7
The output voltage as a function of the load with uniform loading. Input voltage 48 V. Half the output power is at +5 V and half at ± 12 V

Output voltage, V

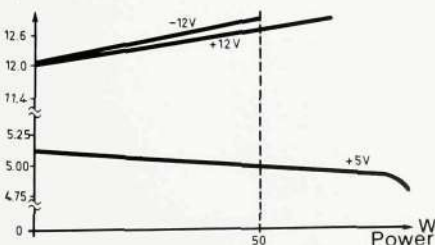


Fig. 8
The output voltage as a function of the load with uneven loading. Almost all the output power is at +5 V. The ± 12 V outputs have a constant load of 150 ohms (1 W) each.

When the right-hand guide has been installed, a simple guide is mounted on the left-hand rack upright. The power unit is inserted and connected and then locked in position. A protective grating is then fitted in front of the power unit, fig. 9.

The guide with the connector can be designed so that the shelf above and the shelf below are fed. It is also possible to arrange different voltage alternatives within the specification of the electrical possibilities of the power unit.

The power unit is also available in another version, BMR 90705. From a functional point of view this is identical to BMR 90704, but a few mechanical details have been changed to make it possible to install and connect the unit in 19" racks.

BMR 90706

Fig. 10 shows the triple output unit BMR 90706 constructed as an "ordinary" M5 unit. Shelves designed for this power

unit can be constructed so that they can also be connected to a centralized power supply.

Application

The triple output units have almost universal use and cover a very wide range of application, above all in PCM technology. One limitation is that if very little power is drawn from one or two of the output voltages it is necessary to check that these remain within their limits. The power unit is therefore specified with a minimum load for each output voltage, so that the output voltage limits are met with certainty.

The advantages of using one triple output unit instead of three one voltage power units are primarily greater reliability, lower cost and reduced space requirement, since the number of components in a triple output unit is only about a third of the number in three one voltage power units.

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Computer-Controlled, Automatic Battery Charging

Håkan Lind

Reliable equipment for automatic charging of storage batteries is of great importance for the life of the batteries.

The article describes an arrangement based on a new principle: Supervision of the change in the charging current as a function of time during the charging process. This arrangement gets round the difficulties caused by the changes in battery characteristics with temperature and age. The charging current is measured using a magnetic compensation method, with a Hall element as the detector. A data processing unit, a small computer, then controls the charging of the battery. The equipment also carries out periodic equalization charging and provides facilities for the recording of data so that the condition of the battery can be monitored.

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Storage batteries play an important role in uninterrupted power supply systems for telecommunication plants. An important function of such batteries is to provide the telecommunication equipment with the necessary power without interruption when a mains supply failure occurs, either during the whole of the failure time or until a standby power plant starts up.

One example of a battery operated DC power supply system is LM Ericsson's booster converter system, fig. 1, where a regulated DC/DC converter is placed between the battery and the load in order to successively compensate for the falling battery voltage during a discharge. In this way the load receives a constant voltage during the whole standby time^{1, 2}.

Batteries and battery charging

The cost of batteries in uninterrupted systems is considerable. In LM Ericsson's booster converter system for 48 V the batteries can constitute up to 30 % of the total cost of the system, in spite of the fact that saving in battery cost is one of the main features of this system.

The life of the batteries is therefore a factor of great importance when assessing the cost of a power supply system. Good maintenance of the batteries gives them a life of 10–15 years, whereas neglected maintenance can shorten their lives to less than 5 years.

One important part of the battery maintenance is the charging. Lead-acid accumulators must always be kept fully charged. Insufficient charging leads to sulphating of the negative plates with a consequent reduction in capacity. On the other hand, overcharging leads to increased water consumption, accelerated corrosion of the positive plates and an undesirable rise in temperature. In extreme cases the rise in temperature can develop in an avalanche manner so that the battery is ruined.

Manual charging of batteries requires well trained staff who follow the manufacturer's instructions carefully. Manual charging is also time consuming, which means high maintenance costs.

When the batteries have been discharged it is important to start the recharging immediately the mains power is restored, in order to regain the standby capacity as soon as possible. This gives rise to considerable problems in unmanned exchanges and in networks where mains failures are fairly frequent and where equipment for automatic charging is not available.

Equipment for automatic charging therefore has a wide range of application and various methods are used for starting and stopping the charging process. However, it has proved to be difficult to find a simple reliable function principle for detecting when the charg-

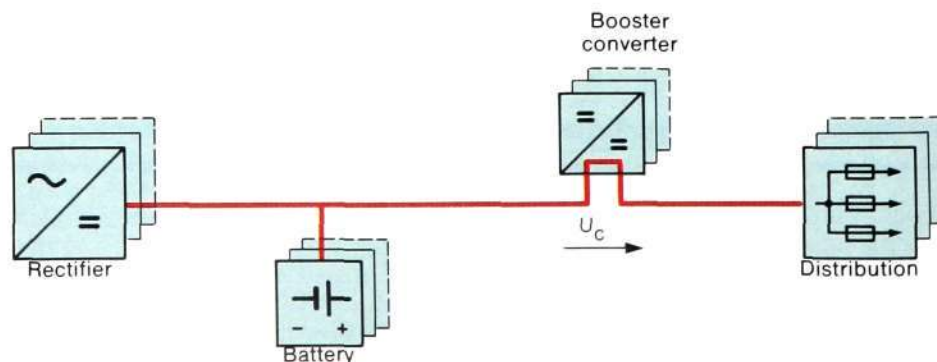


Fig. 1
Booster converter system BZD 112



HAKAN LIND
Power Supply Department
Telefonaktiebolaget LM Ericsson

ing is to be stopped, partly because the characteristics of a battery changes with temperature and its age.

LM Ericsson, who have been manufacturing and supplying automatic battery charging equipments for a very long time and who have thereby gained considerable experience of such equipments, have now developed an equipment for automatic charging in accordance with a completely new principle. The function of this equipment is based on the supervision and control of the charging current as a function of time. On the basis of this the equipment sends the rectifier either an operating charge signal, which results in the voltage level being raised to approximately 2.35 V/cell, or a floating charge signal, which results in the rectifier resuming normal floating charging, usually 2.20 V/cell for lead-acid accumulators.

An example of a charging process

An example of a charging process is shown in fig. 2. The mains power is restored at time "0" and at the same time an operating charge signal is sent to the rectifier.

During stage 1 the charging current is limited by the current limiting device of the rectifier. The charging voltage rises continuously in step with the increase in the charge in the battery and finally

reaches the nominal operating charge voltage of 2.35 V/cell.

How long stage 1 takes will depend mainly on

- the extent to which the battery was discharged at the commencement of the charge. The greater the extent of discharge the longer the time
- the amount of available charging current. The smaller the charging current the longer the time.

During stage 2 the battery is charged at a constant charging voltage. The charging current decreases successively in step with the growth of the charge in the battery. When the current decreases very slowly the degree of charging is approaching 100 %.

How long stage 2 will take depends primarily on the state of charge of the battery when it leaves stage 1 at a certain charging voltage.

During stage 3 the charging current levels out. The battery is not being charged any more (its counter e.m.f. does not increase). The current is now 2–10 mA/Ah. In order to avoid overcharging, the charging voltage must be reduced to the floating charge level as soon as the current ceases to fall, i.e. at the start of stage 3. Thus the task of the floating charge is to maintain the state of charge of the battery, i.e. to compensate for its self-discharge.

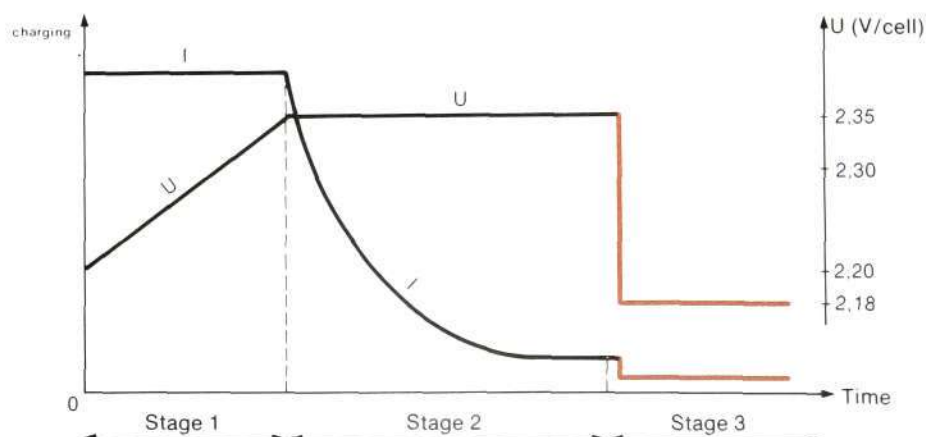


Fig. 2
An example of a charging process

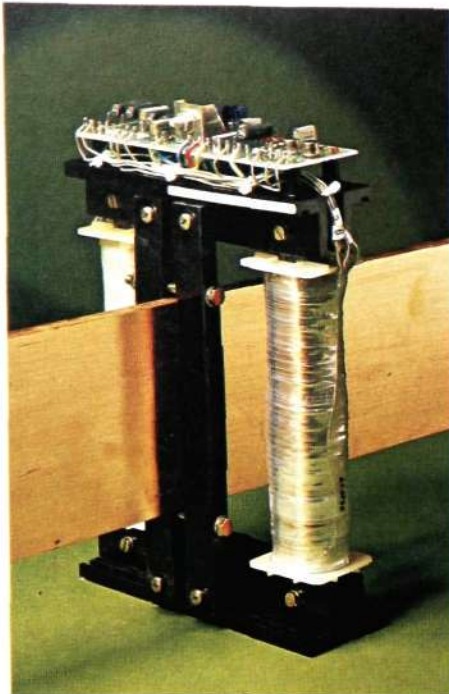


Fig. 3
Current measuring device.
The current measuring device is mounted round the charging bar. One end of the device is removable and hence the device can be installed during operation

The amount of the final charging current varies over a very large range (several 100 %) and is mainly dependent on

- the temperature of the battery; the final charging-current is doubled for approximately every 10° C increase in the temperature of the acid
- the age of the battery. The final charging current can be up to 3–5 times greater for, for example, an antimony-alloy lead-acid accumulator that is 5–6 years old than for a new accumulator.

Thus the charging process is dependent on several factors. Because of the changing characteristics of the battery it is very difficult to get charging equipment to operate well if it has to work with preset parameters. For example, there are charging equipments that break off the battery charging when the charging current falls below a preset value. The main problem in such cases is the above-mentioned variation in the final charging current.

BMP 130—new equipment for automatic battery charging

As has already been mentioned the charging current is stabilized at a constant value (steady state value) when the battery is fully charged, but this value varies within wide limits because of such factors as the age of the battery and the temperature of the acid. In order to eliminate the effect of all these factors LM Ericsson have developed a charging equipment that measures the change of the loading current with time. In this way it is possible to stop the charging at the correct time, i.e. when the current has become steady.

The advantages of the new method are as follows:

- a. Can be used for both lead-acid and alkaline batteries.
- b. Is independent of the size and age of the battery.
- c. Is independent of the temperature of the battery acid during the charging process.
- d. The charging can be interrupted if anything abnormal happens, for example a rise in the charging current, which is a sign of rising acid temperature.

The new method, which utilizes a universally applicable relationship between charging current and time, nevertheless poses considerable measuring problems of a technical nature. During the final stage of the charging the current change is very slow and sensitive measuring devices are required to detect the change with sufficient accuracy.

For example, in the case of a lead-acid accumulator of 1000 Ah the steady state value of the charging current is approximately 4 A with a cell voltage of 2.35 V. Moreover the change in charging current during the final stage of the charging is approximately 0.1 A per hour, which must be detected so that the charging is not stopped too early.

The measuring method used is based on magnetic measurement of the charging current, and digital technology for storing and comparing the different measurement values.

Function

The charging equipment includes a current measuring device with a high degree of measuring accuracy, fig. 3, and a data processing unit, which controls the charging on the basis of the charging current, fig. 4.

The function is described with the aid of the block diagram, fig. 5. The control unit gives a signal to the current measuring device to measure the charging to the battery.

The measured value from the current measuring device, in the form of an analogue signal, is then converted to a digital word in the data processing unit. This digital word corresponds to the mean value of the charging current during approximately 30 seconds. The measured value is then stored in store S1. A previous measured value (e.g. the preceding one) is stored in store S2. By comparing these two values the control unit can then detect whether the charging current falls, rises or levels out.

The measurements are carried out at intervals of 7½ minutes, and if the current has not fallen by more than for example 0.1 mA/Ah during 16 consecutive measurements (2 hours), the battery is fully charged and the charging is stopped.

Fig. 4
Data processing unit.
Up to 5 current measuring devices can be connected to the unit, where the measured values are added



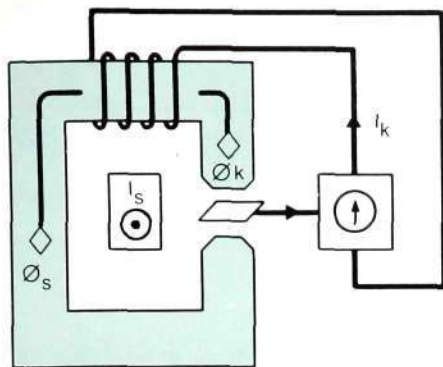


Fig. 6
The operation of the current measuring device. The Hall element controls the current I_s so that the flows I_s and I_k become equal. The current I_s is used as the measured value

Starting the charging

The battery charging is started in the following way.

- When the battery current exceeds a preset value (e.g. 30 mA/Ah) the charging starts without delay. This is what normally happens after a mains break
- When the battery current exceeds the steady state value of the previous charging (e.g. 5–10 mA/Ah), charging starts within 15 minutes (two measurements at an interval of 7½ minutes). This compensates for occasional short discharges.
- Periodic equalization charging every third week or three weeks after the previous charging. In this way the battery is kept equalized and the acid is agitated.
- Manual start of charging. This is used for example after the battery has been topped up with water.

Stopping the charging

The charging of the battery is stopped when any of the following conditions occurs:

- If the charging current levels out, i.e. has fallen by less than 0.1 mA/Ah during a period of 2 hours (16 measurements at an interval of 7½ minutes). This is the normal working.

- If the charging current increases, the charging is stopped within 15 minutes. The increase in charging current indicates an increase in acid temperature.

- If the charging has been going on for 32 hours.

Demands on current measurement, current measuring device ZTE 012 02

The utilization of the relationship between charging current and time makes great demands on the equipment that measures the current.

- The measuring device must be sensitive to direction. Discharge currents must be ignored.
- The measuring device must have a measuring range of 0–100 mA/Ah with a resolution of 0.1 mA/Ah, i.e. 0.1 % of the measuring range.
- The measuring device must withstand large currents, more than 1 A/Ah, i.e. more than 10 times the measuring range, without its function being jeopardized.
- The measuring device should be galvanically separated from the battery.

A magnetic measuring method is used which satisfies the above requirements, fig. 6. An iron core is placed around the

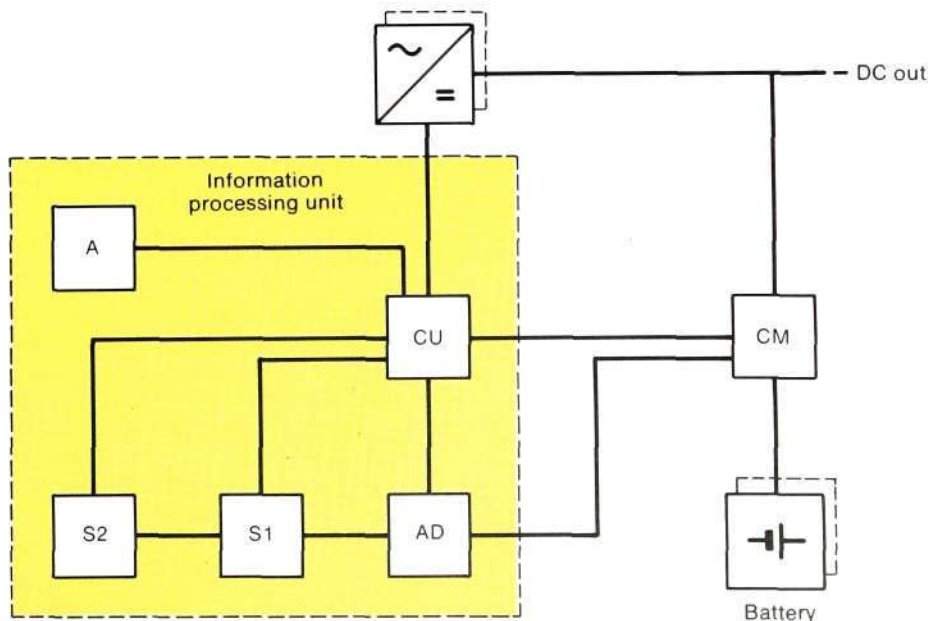


Fig. 5
The charging current to the battery is measured with the aid of the current measuring device. The measured value is stored in store S1 where it is compared with a previously stored measured value in store S2

AD	Analogue/digital converter
A	Alarm unit
CU	Control unit
CM	Current measuring device
S1	Store 1
S2	Store 2

charging bar. The current in the bar gives rise to a magnetic flow, Φ , in the iron. This flow is detected by a semiconductor that is sensitive to such flows, a Hall element.

The output signal of the Hall element is used to control a current in a compensation winding on the iron core, via a current generator. This current, I_k , gives rise to a flow Φ_k , in the core circuit which is in opposition to the flow caused by the charging current, Φ_s . The regulating system of the current measuring device attempts to keep Φ_s and Φ_k equal, so that the sum flow is zero. The value of the compensation current I_k is then used as the measured value for the charging current in the bar.

Choice of floating charge voltage for lead-acid accumulators

The main task of the floating charge voltage is to maintain the state of charge of the battery for a long period without overcharging. This means that the battery must not be "charged" by the floating charge voltage and the changeover from operating charge to floating charge must not take place until the battery has become fully charged.

Charging of the battery is a relatively rare occurrence and only takes place after mains breaks and when an occasional equalization charge is necessary, whereas floating charge is the normal condition. Consequently the floating charge voltage must be chosen with care, since it helps to determine the life of the battery.

In practical applications with conventional devices for automatic battery charging it has been necessary to choose a fairly high floating charge voltage, approximately 2.22 V/cell with an acidity of 1.24 g/cm³. As has been described above, the reason for this is that it has been difficult to stop the charging when and only when the battery has reached 100 % charging. The charging has instead been stopped at approximately 95 % charging level and the final charging has been carried out with the floating charge voltage.

BMP 130, on the other hand, stops the charging of the battery only when the state of charge has reached 100 %. The floating charge voltage can then be reduced to approximately 2.18 V/cell, which has the following advantages as regards the battery maintenance:

- the water consumption is reduced by 30–50 % compared with batteries with a floating charge voltage of 2.22 V/cell
- the corrosive current is reduced, which gives the battery longer life.

Periodic equalization charge

BMP 130 is equipped with a device that initiates recharging of the battery, i.e. increases the voltage to approximately 2.35 V/cell, three weeks after the last occasion the battery was charged. In this way the battery is kept in good condition and the acid agitated. The periodic equalization charging is useful to counteract any differences between the battery cells, for example the differences in self-discharging.

Recording of battery data with the aid of BMP 130

One important parameter for the assessment of the condition of a battery is the steady state value of the charging current. A low value (2–6 mA/Ah with a charging voltage of 2.35 V/cell) indicates that the battery is in good condition, whereas a high value (>10–15 mA/Ah) indicates that a check of the battery is necessary.

The steady state value of the charging current during the most recent charge is available at any time on a display panel with binary coded light emitting diodes, which is included on the BMP 130 data processing unit. This value is never more than three weeks old because of the device for periodic equalization charging.

A complete charging process can be recorded quite simply with BMP 130, so that a battery can be studied in detail. A simple printer is then connected to the data processing unit and a record of the charging current, with decimal presentation, is then obtained during the whole of the charging sequence.

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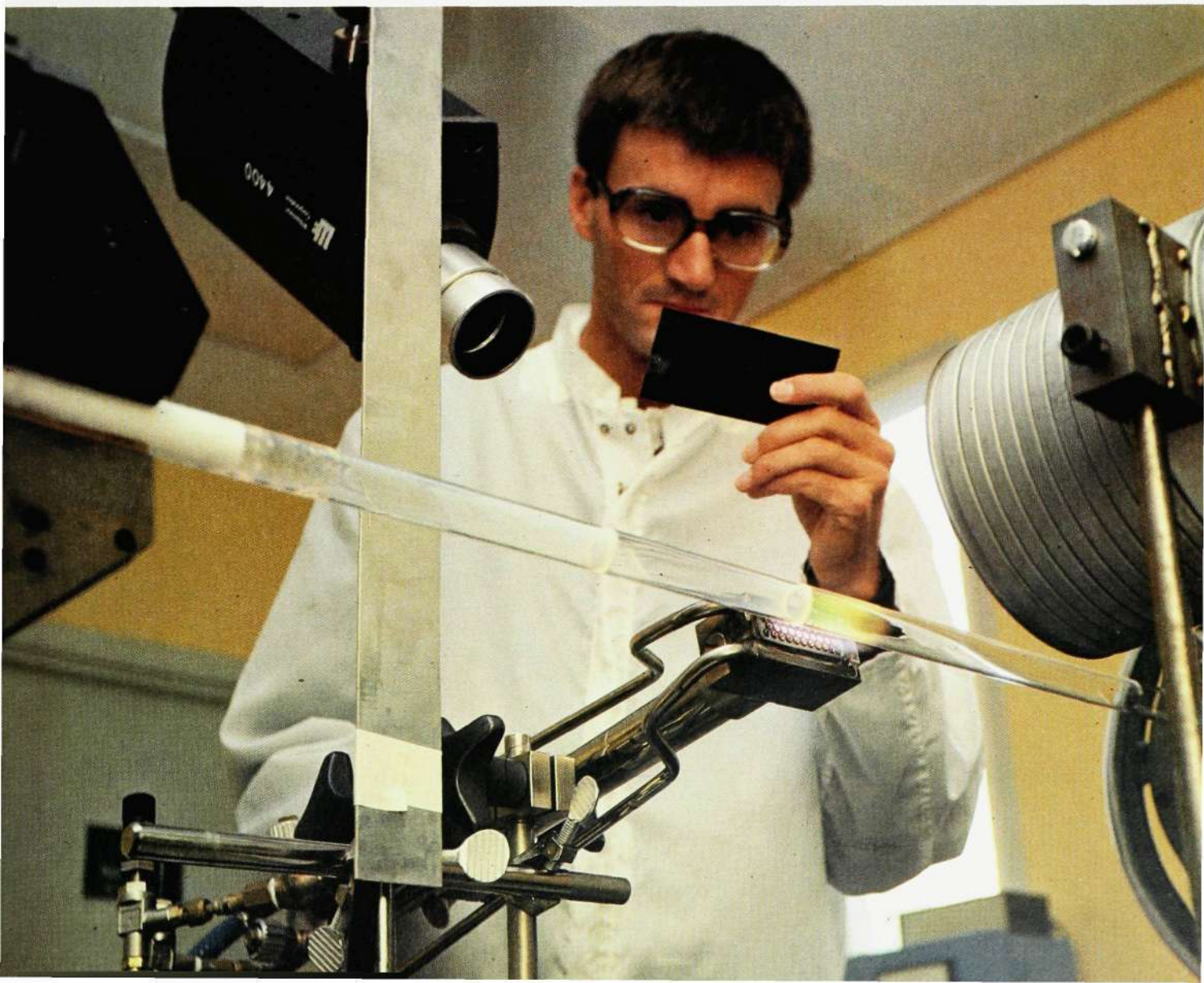


TELEFONAKTIEBOLAGET LM ERICSSON

ERICSSON REVIEW

THE LM ERICSSON PRIZE WINNERS 1979
THE SECOND STAGE OF THE SAUDI ARABIAN PROJECT COMPLETED
OPERATION AND MAINTENANCE OF NETWORKS WITH AXE 10
AOM 101, AN OPERATION AND MAINTENANCE SYSTEM
OFFICE COMMUNICATION SYSTEM DIAVOX 824
BOOSTER CONVERTER BMR 263 AS ACTIVE FILTER
FURTHER DEVELOPMENT OF THE ARE SYSTEMS

3 1979



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COVER
Optical fibre preform production by Chemical
Vapour Deposition in the LM Ericsson Materials
Laboratory

The LM Ericsson Prize Winners 1979

This article is an excerpt from the speech given by Dr. Håkan Sterky, chairman of the Ericsson Prize Committee, at the awards ceremony of the 1979 LM Ericsson Prize, May 7, 1979. The Prize, which consists of a gold medal and the sum of 100 000 Swedish Kronor, was first awarded at the LM Ericsson centennial in 1976, and according to the conditions governing the award of the Ericsson Prize it shall "be awarded to recognize an especially important scientific or technological contribution to telecommunications engineering made during the previous three-year period, or an earlier contribution whose significance has been acknowledged during the period".

By October 1st 1978, 40 proposals involving 44 candidates working in 12 different fields of activity had been submitted to the Ericsson Prize Committee. The Committee consists of three members and is completely independent of the LM Ericsson's Board of Directors and President. It has sole responsibility for selecting the prize winner among the candidates nominated. If an achievement has been shared by two or three persons, these persons may be awarded the prize jointly.

The Prize winners' presentations will be found on the following pages of this issue.

The 1979 Ericsson Prize is being shared by two men, both of whom, while working in separate fields, have made fundamental contributions to the long-distance transmission of information through optical fibres:

Dr. Charles Kuen Kao, who was born in Shanghai in 1933 and is now employed by the International Telephone and Telegraph Corporation in Roanoke, Virginia, and

Dr. Robert Distler Maurer, who was born in St. Louis in 1924 and now works at the Corning Glass Works in Corning, New York.

It would not be fair to all the other highly qualified candidates if I were to state that the Committee faced an easy task in selecting the 1979 Ericsson Prize winners. After extensive interviews with several experts in various fields, however, the Committee selected these two men. The decisive points which attracted the attention of the Committee, and which were influential in our final selection, were the imagination, the perseverance and the competence which Dr. Kao and Dr. Maurer exhibited in introducing the use of light waves as transmitters of information over long distance.

In their presentation the prize winners will describe in more detail how they began their work in the field of optonics, the potential they foresaw in their early visions

and discoveries, the current situation in optonics and the developments they foresee in the future.

As a supplement to their presentations, I would like to outline briefly the historical development of the art of transferring messages using light waves.

Transmission of messages by light waves—historical aspects

For thousands of years, beacons have been used to warn people of military actions. The message of Troy's fall was sent across the sea by the same means. Light from fires in lighthouses guided ships through perilous waters. Flares have long been used as danger signals. The content of information conveyed in this manner, however, was severely restricted. It was not until codes were established that these messages could contain more substantial information. About 150 years ago the Morse code alphabet was introduced in electrical telegraphy. In optical telegraphy, the same alphabet has been used from the 1800s up to modern times. One method used in this field was to tilt a mirror to reflect sunrays, the so-called Heliograph method, to convey messages from one point to another tens of kilometers away. In shipping, using the same basic method, signalling lamps have long been used to send Morse signals from one ship to another by keying a blind in front of the light source.

The Morse code, a forerunner to digital technology

As you all know, the Morse code consists of a number of combinations of dots and dashes which correspond to the letters of the alphabet, numbers and punctuation marks. Using this code translated into short and long electric impulses, messages could be cabled over long distances. Morse code was the forerunner of the digital techniques now used in the computer age, in which digital technologies are used on an increasing scale to transmit text, pictures, speech and music via electromagnetic waves. For these applications, however, the number of impulses, or "bits", must be increased from about ten to several millions per second. In other words, the bandwidth must be large enough to permit rapid and extensive transmission of information. This is made possible through optical telecommunication.

Prerequisites for optonics

Another prerequisite for the 1979 Ericsson Prize winners' achievements is the ability of light to be transmitted through a curved path. As you all know, light, like all other electromagnetic waves, is propagated in straight lines through space and the atmosphere. If light is conducted through a tube or a fibre, however, it can be propagated—under certain conditions—along paths other than straight lines. A basic condition for this phenomenon is that the tube must have a reflective inner surface or that the fibre must consist of a material with a higher refractive index than that of its surroundings, for example air. Another basic condition is that the attenuation of the light must be low enough to make it technically and economically feasible for optical methods to compete with other transmission systems.

In physics, it has been known for a long time that certain fibres can conduct light along curved lines. This phenomenon has been utilized for different technological, medical and decorative purposes. One such application has been used in medicine by inserting a glass fibre in the heart to study conditions of this vital organ. Normal optical glass, however, has a high absorption ratio, similar to that of the clouds in the atmosphere, and consequently the range of transmission was limited to ten or twenty metres. A radical change in this restricted capability was necessary if

optical systems were to meet the demands placed on today's commercial systems for transfer of information. Another prerequisite was access to suitable electro-optical converters for transmitting information and opto-electrical converters for receiving information. During the past decade, electronic components such as light-emitting diodes, diode lasers, photodetectors and avalanche diodes have been developed and are now produced commercially.

The Prize winners' contributions

In 1966, Dr. Kao, together with G.A. Hockham, published a paper on the possibilities of using glass fibres as conductors for optical transmission of information. His efforts at that time meant that he was proposing a special fibre design for optical transmission of information. He also foresaw that it would be possible to purify quartz glass to such a degree that the conductors' attenuation would be less than 20 decibels per kilometre. The first revolutionary proposal was based on fundamental theories. However, considering that Dr. Kao was not a specialist in various glass materials' optical properties, nor in the production of highly purified quartz

fibres, his second proposal on the development of optronics must be regarded as visionary. For the benefit of experts in this field, I would like to point out that optical glass available in the mid-1960s had an attenuation minimum of 1,000 decibels per kilometre and now, near the end of the 1970s, quartz fibres have been produced with an attenuation of less than one decibel per kilometre for certain light wavelengths. For laymen, these figures may be clearer if one considers that about ten years ago, the interior of the heart could be studied over a distance from one-half to one metre. Today, the transparency of an optical fibre is so high that the same observation could be made by a physician who is situated tens of kilometres away from the patient.

As the Director of Research at Corning Glass Works, Dr. Maurer realized, despite the doubts of many experts, that it would be worthwhile to attempt to develop a fibre made of such highly purified quartz that it could be used in telecommunications systems. Within an exceedingly short span of time, as early as 1970, the Corning research laboratory staff developed and produced several hundred metres of fibre, about 0.2 millimetres thick, with a core diameter of 3 to 4 μm and an attenuation of 20 decibels per kilometre at a light wavelength of 0.63 μm . At the same time, they also showed that fibres could be bent without significant radiation losses. Consequently, there would be no practical difficulties involved later on in laying fibre cables.

Dr. Kao and Dr. Maurer have through their theoretical research work and technical development of methods for the production of optical fibres opened promising new areas for telecommunications. Test installations for telephone traffic are now in operation and the world's telecommunications companies are convinced that optronics will make it possible for them to place better and less expensive transmission systems at the disposal of society and subscribers.

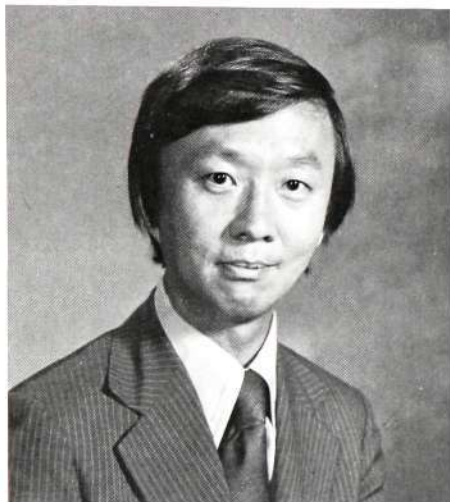
After many years of research and creativity the prize winners have given mankind access to new technical and economical methods of transferring information. In the true sense of the word, they have shed new light on a field which researchers and engineers will explore further in the fascinating future of telecommunications.

Fig. 1. Dr Robert Distler Maurer and Dr Charles Kuen Kao receive their prizes from His Majesty, Carl XVI Gustaf, King of Sweden. In the background Dr Håkan Sterky.



Optical Fibers and Systems: History and Future

Charles K. Kao



DR CHARLES K. KAO

Charles Kuen Kao, who was born in 1933 in Shanghai, China, received a B Sc degree in Electrical Engineering from the University of London in 1957 and a Ph D degree in Electrical Engineering, also from the University of London, in 1965.

He was the Chairman and Professor of Electronics of the Electronics Department of the Chinese University of Hong Kong from 1970 to 1974, and in 1974 he became associated with the ITT Electro-Optical Products Division as a Staff Scientist, which position he presently holds. Dr Kao is a pioneer in the field of optical fiber communications and has worked in this field since 1963. His experience includes theoretical studies and basic research in optical communication systems, fiber optic waveguide communications, circuits and systems design, and quasioptical techniques applicable to microwave systems.

He has been elected a Fellow of IEE (UK) and is a Senior Member of IEEE. He received the 1976 Morey Award from the American Ceramic Society for outstanding contributions to glass science and technology and in 1977 was awarded the Stewart Ballantine Medal by the Franklin Institute for his conceptual work on optical fiber communication systems. He was the recipient in March 1978 of the Sir Arthur Rank Prize of the Royal Society of England for his pioneering work in optical fiber communication. Recently he was honored with the 1978 Morris N Liebmann Memorial Award for making communication at optical frequencies practical by discovering, inventing and developing the material, techniques and configurations for glass fiber waveguides and in particular for recognizing and proving by careful measurement in bulk glasses that silicon glass could provide the requisite low optical loss needed for a practical communication system. He has written many technical papers and holds 11 patents.

In the 1950's the need for vastly improved communication facilities and services was recognized. This led to the search for a means to open up more of the electromagnetic energy spectrum for communication purposes. By late 1959 the laser was invented, heralding the entry of the equivalent of a radio frequency source at optical wavelengths. At last, the optical spectral region with its enormous potential for communication was opening up for exploitation. What was needed was a compatible set of a source, a detector, and a transmission medium. It soon transpired that the myriads of advantages of optical communication were not easily accrued in a practical and economic manner. The components simply did not come together to form a working system.

The early lasers were either bulky and power inefficient or must work at very low temperatures. Even the propagation paths offered unforeseen difficulties. There was the free space. Surely light should travel in a straight line through space. Not so, in our terrestrial domain. The inclement weather severely influences propagation conditions. Fog and snow can cause orders of magnitude change of the light intensity. In fact, even in clear weather, the density fluctuation of the atmosphere significantly alters the properties of the light propagation path. Over a kilometer a collimated beam could dance around in a disc with a diameter as large as a few meters at the destination due to the fluctuation of air density along the propagation path.

The matter of fiber material

The dielectric waveguide in the form of an optical fiber was a very attractive candidate as a transmission medium at optical wavelengths. However, optical fiber waveguide was not considered at that time to be a likely transmission medium since the optical loss was sufficiently high as to attenuate the light level to an unusable value over only several meters. Also at that time, semiconductor light sources and detectors, which matched well with the optical fiber to form the basic system, were in very early stages of development. The magnitude of problems appeared formidable. However, believing that a pro-

misging but difficult problem warranted special attention, we started work, in those days, in this area.

The principal tasks at that time were to establish theoretically the waveguide and material properties, and to demonstrate that the material and dimensional requirements were essentially realizable in practice.

While waveguide propagation was rather easily demonstrated by using specially prepared fiber samples, the material evaluation and dimensional tolerance studies presented a far greater challenge. The situation was almost as bad as attempting to measure an object which is less than a millimeter in diameter with a ruler whose smallest increment is one meter. Instruments to measure optical loss had sensitivities several orders less than what was required. Dimensional tolerance requirements had to be established on simulated fibers. In spite of these apparent drawbacks, the work proceeded successfully and encouragingly. The principal findings were published in a series of papers starting in 1966. In 1968 the existence of materials with sufficiently low loss was established experimentally. These events led to an increased interest and eventually to a world-wide activity. It is interesting to note how the fiber loss improved over the years, fig. 1. This is the result of the combined contribution of many talented people who have injected the necessary academic stimuli, management skill, professional talents, and societal concerns.

Today optical fiber systems technology has come of age. Optical fiber, source and detector characteristics have not only exceeded the target optical performances values in the research laboratories, but are also capable of meeting exacting physical and reliability requirements important in a real world environment. Other basic components, such as cable, connector and coupler, are at a similar stage of development. Fiber system technology is poised to step from the R&D phase into the production phase and is ready to vindicate its most important, but yet to be fulfilled promise, of cost effectiveness.

Type of Application	Advantage
Common Carrier	High Bandwidth, Long Repeater Spacing
Satellite Entrance Link	
CATV Trunking	No EM Interference
Power Utility	
Communication	High Bandwidth
Broadband Distribution	
Nuclear Power Station	
Control	No Fire Hazard & EM Interference
Computer System	
Interlinks	No EM Interference
Private Transmission	
Guided Weapons	No EM Radiation
Sensors (Pressure/Temperature)	
Intra Building	Light Weight, High Bandwidth
Communication	
Intra Vehicular	High Sensitivity
Communication	
	Improved Privacy
	No EM Interference
	Light Weight & Small Size

Table 1

Advantages of optical fiber systems

Let us relook at the major benefits of optical fiber. Those benefits can be grouped into three categories:

Its physical attributes include small size, light weight, high strength, and flexibility.

Its transmission benefits include wide bandwidth, low loss, and low cost.

Its special features are that it will not induce combustion, will not pick up R.F., will not radiate R.F., and will withstand very high temperature.

These advantages and special features can be exploited singularly or in combination to provide system performance and cost benefits to almost all types of applications across the entire modern industrial base. The roles and missions of optical fiber systems penetrate every aspect of communication and control.

A substantial number of systems have already been installed. It will be seen that the various systems installed, exploit in one way or another the main advantages of optical fiber systems, ta-

ble 1. One aspect is worth noting. The special features are being exploited early. This indicates that a new product is more easily introduced to fulfill a new function than an improved product to fulfill a replacement function. A more important aspect is that the advantages of optical fiber communication systems are opening up new system possibilities. These have far-reaching social and economic impacts beyond the better performance and low cost aspects.

Optical fiber systems give new features

Perhaps the most significant new service optical fiber systems can bring is the wide bandwidth information distribution network. If the cost of bringing services into each home via one or more fibers is not prohibitively high, it is possible to envisage such a network which permits voice, data, music, and TV to be available on an interactive basis.

The mode of introduction of such services is by no means defined. It is only possible to see that such services can have much sociological impact. For example, the remote surveillance of industrial sites or community thoroughfares can improve fire and security

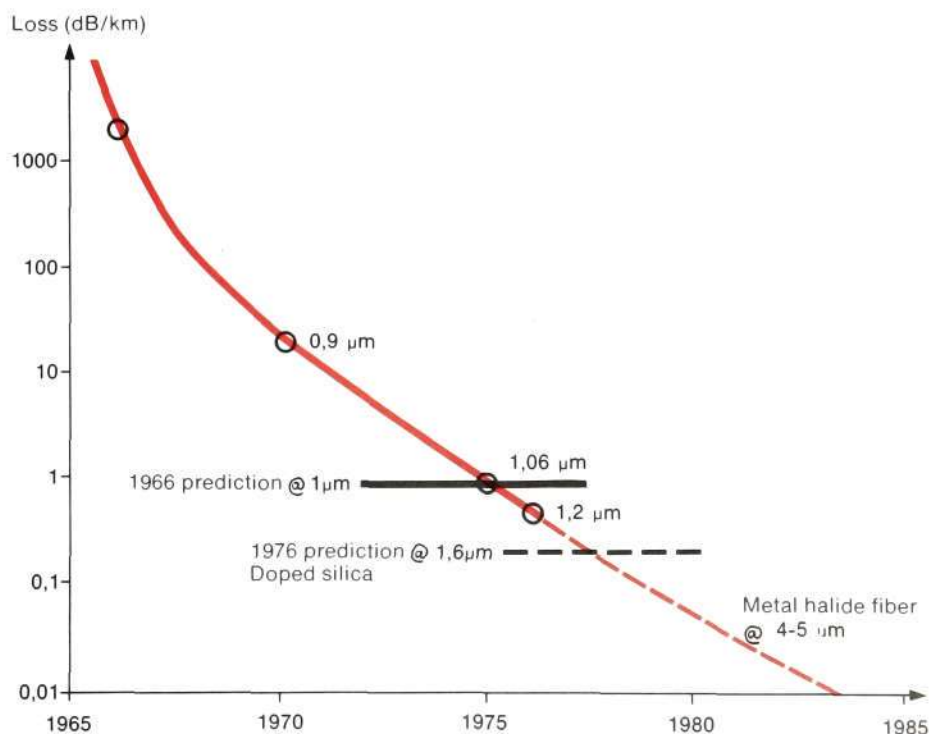


Fig. 1
Best fiber loss

services without the need of extra personnel; the video conferencing and shopping can save time and travel; low speed data services can be provided at reduced cost; and energy management such as preferential load shedding can become a reality. All in all, the existence of wideband distribution network enables the network provider to be the key operator in information distribution. The network is used not only for providing the interconnection of subscribers, but also for distributing the facilities offered by service vendors.

The network with its wide bandwidth capability is powerful enough to improve control and communication functions by leaps and bounds. Moreover, optical fiber, the wide bandwidth transmission medium, is emerging at the same time as VLSI technology which vastly increases the speed and functional capability of control circuits.

These two complementary key technologies are maturing at a crucial time

when communication and control are moving into an intensive man-machine interactive phase. It is not far-fetched to say that man-machine interrelationship is a new survival criterion for mankind and that the optical fiber multiservice distribution system will play a major role.

It is evident that the range of optical fiber system applications is broadening very rapidly. In fact, everything associated with optical fiber is growing. The different types of applications, the installed fiber length, fig. 2, the current sales, and the number of people involved are all growing at an exponential rate.

This is a good indication that optical fiber business, indeed, will grow exponentially and will generate the volume demand and result in the necessary cost reduction to sustain the growth and to enable economic introduction of new services, such as the broad band distribution network.

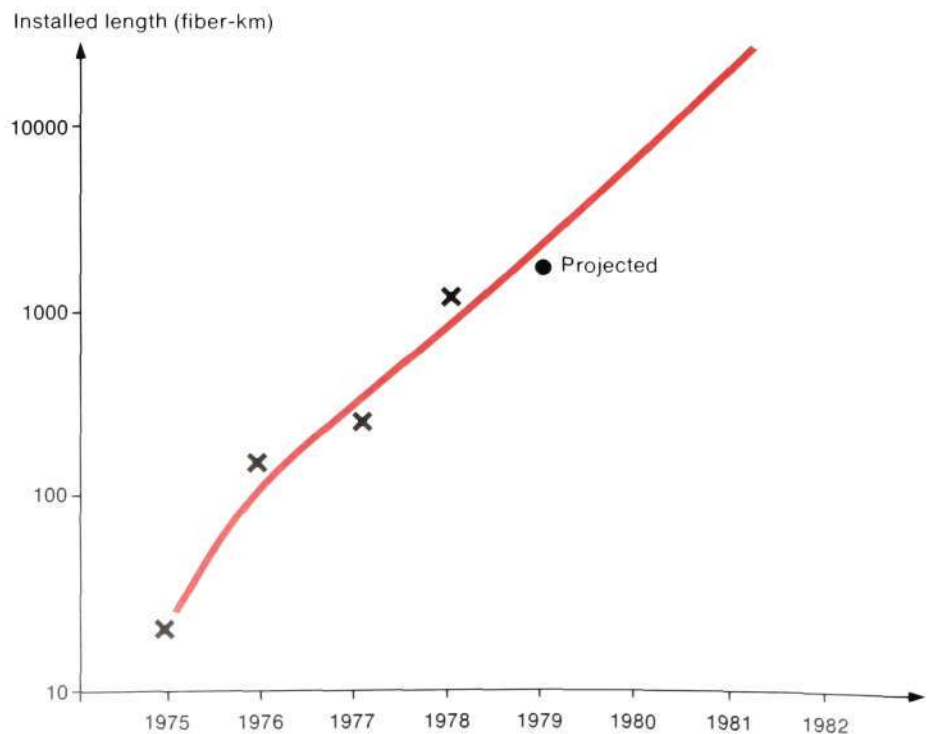


Fig. 2
Total worldwide yearly installed fiber-length

Optical Fibers and Components: History and Future

Robert D. Maurer



DR ROBERT D. MAURER

Robert Distler Maurer who was born in 1924 in St. Louis, Missouri, received his B.Sc. degree from the University of Arkansas in 1948 and the Ph.D. degree in Physics from MIT in 1951.

He spent a year at MIT in low temperature research and then joined Corning Glass Works to begin work on the physical properties of glasses. Since 1963 as Manager of Applied Physics Research, he was involved in a variety of materials research problems with glasses and crystallizing glasses for electronic and optoelectronic applications, such as photo-sensitive processes, lasers, and optical shutters. Presently Dr. Maurer is a Research Fellow at Corning Glass Works, Corning, New York, where his research activities aim at improving optical waveguide performance.

He has served several years in organizing the Optical Fiber Transmission Conference and is a member of the National Research Council Committee on Telecommunications. He has received the 1976 Morey Award of the American Ceramic Society. In 1978 he was chosen as the first recipient of the American Institute of Physics (AIP) Prize for Industrial Applications of Physics for contributions made to the practical application of optical communications through the understanding and discovery of materials and techniques for the fabrication of glass fiber waveguides. Recently he was honored with the 1978 Morris N. Lieberman Memorial Award for making communication at optical frequencies practical by discovering, inventing and developing the materials, techniques and configurations for glass fiber waveguides and in particular for giving an existence proof and demonstration that a vapor deposition process could be used to make guiding silicon fibers with the requisite losses. Dr. Maurer is a member of the American Physical Society, a Fellow of American Ceramic Society and former Chairman of its Glass Division, and a Senior Member of IEEE. He has written many technical papers and holds 4 patents.

Optical technology promises to provide our next major advance in telecommunications. In choosing light to carry the signal, technologists are breaking entirely from previous engineering practice. Until now, advances in telecommunications had occurred by gradually changing the electromagnetic wavelength that was used. This gradual evolution continued until wavelengths of about one centimeter were the shortest that were utilized. Now, by using light we have suddenly reduced the wavelength to one micrometer—10,000 times smaller—or one per cent of the diameter of a human hair. This great change has been the source of many benefits, as well as problems, for the new technology and for component construction in particular. For each major component, we can show how the change in wavelength has affected an important characteristic of that component and in this way illustrate the complexity and possibilities of this new technology. These few illustrations will provide less than a complete understanding. In a technical area as broad as optical communication components, a brief discussion can only hope to provide an acquaintance with the topic.

The components I will discuss are the primary ones: glass fibers, cables, connectors, signal sources and receivers. These exert a major influence on the system possibilities in both system architecture and performance. Indeed, no significant systems were feasible, or even considered, before satisfactory fibers had been made. As you know, the use of fibers in early optical systems was impossible because the attenuation was too high. The best fibers that existed at that time, the early 1960's, would transmit signals only about 20 meters. Practical considerations required transmission at least 100 times further—this requirement corresponds to one per cent of the incident light emerging after passing through one kilometer of fiber (20 dB/km). My personal work at that time was concentrated in achieving the large improvement in transmission that was required.

Two decisions were made near the beginning of this research that became the foundation of all that followed. One was to use glasses consisting primarily of

silica, with oxides added to the extent necessary to increase the refractive index. These glasses have provided the lowest attenuations yet achieved and have excellent physical properties. The other decision was to use vapor phase processes for manufacturing the glass preform, or rod, from which the fiber is drawn. Vapor phase processes have not only provided the necessary purity but, in addition, have turned out to be surprisingly flexible when adapted to new ways of making the preform. As a result, both ideas seem to have stood the test of time and remain at the heart of today's technology.

A major advantage of vapor phase glass-making is in eliminating the customary step of melting. By eliminating melting, the impurity dissolved in the glass from the melting container is avoided. Liquids, such as chlorine compounds of the glass ions, are vaporized and passed with oxygen gas through a hot region where the liquid vapor is oxidized to form a dust of small glass particles. These are collected and, when heated, consolidate to a dense bulk glass. An added advantage in this process is that the starting liquids can be purified by distillation.

This basic approach, with considerable elaboration, led to steady progress in reducing fiber waveguide attenuation. After some initial experimentation in 1966, the first high silica fibers were made in 1967. By 1970 Corning made the first fibers that met the transmission goal of one per cent through a kilometer (20 dB/km), fig. 1. This sparked a worldwide effort to develop the new technology and further advances have occurred in all aspects of this new area of telecommunications. By 1974, attenuation had been reduced another 20 fold, to one dB/km. It is even lower today.

The evolution of components for the new technology reflects major characteristics caused by the short wavelength of light, as mentioned earlier. Most notable is the small size of all the components. This is one of the major benefits because it conserves both equipment space and material. In accord with equipment size, information transmission with light now becomes more com-

Optical waveguide attenuation (dB/km)

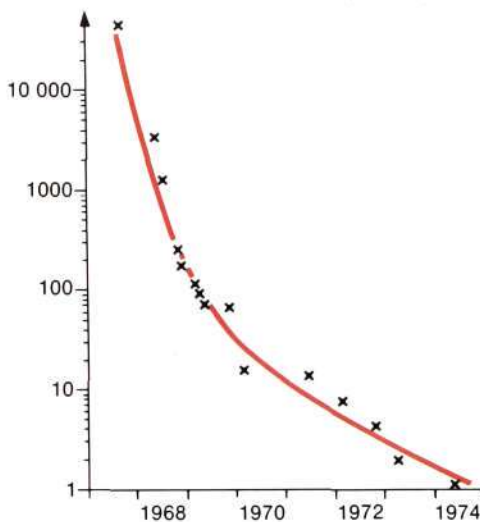


Fig. 1
Progress in reducing attenuation of high silica optical waveguides at Corning. The first waveguides ever to meet the practical goal of less than 20 dB/km were achieved in 1970

patible with information storage and processing which have also been greatly miniaturized.

Fiber Waveguides

Perhaps there is no better illustration of the dramatic change caused by the shift to light than in the search for new materials for fibers. Every research projects begins with considerable uncertainty about what factors have been overlooked or what unknown obstacles will be discovered. Fiber waveguides were no exception. Shortly after this research began, it became apparent that no one had considered some important optical effects. Two of these, absorption by atomic defects and intrinsic absorption, are discussed here.

The inherent transparency of many materials is masked by impurities and imperfections. Recall that windows appear transparent because they are thin; we are surprised when we can see the bottom of a river. The early optical waveguide research answered the question of what remains when these impurities and imperfections are removed. Only then are the fundamental roles of atomic defects and of intrinsic absorption revealed. Of these two, intrinsic absorption has proven of more practical interest.

Atomic defects occur in absolutely pure glass and absorb light to some degree.

They arise because of the fundamental tendency to increase entropy, or disorder. This force is pervasive in nature, and we face it every day as the tendency for things to go wrong. In glass-making, entropy is increased by the evolution of oxygen gas during the melting, since the gaseous form of matter is more disordered than the liquid or solid. When oxygen gas evolves in this way at high temperatures, the glass left behind is deficient in oxygen. Defects are thereby generated in the glass structure where oxygen atoms normally would be. In the early glasses, a single defect of this kind absorbed more light than the typical impurity atom. Glasses used today circumvent this problem because the defect absorptions are outside the wavelength region of the signal light.

However, it is of historical interest to realize that the first low loss fibers required finding an answer to the problem of atomic defect absorption. The solution was to utilize a chemical reaction within the glass that re-oxidized the defects. Various time-temperature treatments were required to control the reaction rate. As might be surmised, this was a complicated procedure and finding a workable method proved to be one of the obstacles in reaching the transparency goal. However, the effort was valuable in the end. The work showed that this fundamental absorption mechanism could be overcome to the degree necessary and the existence of high transparency was proved.

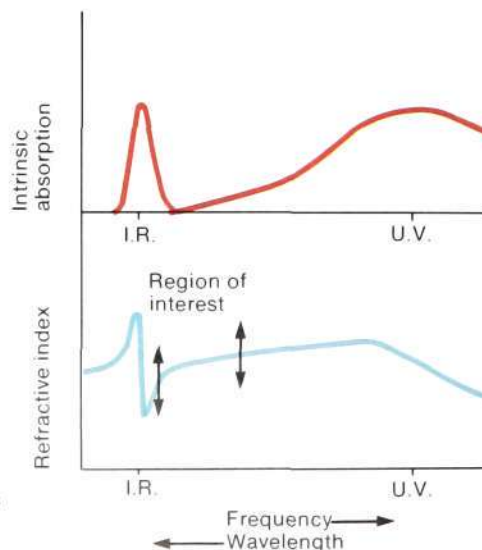


Fig. 2
Schematic diagram showing the intrinsic absorption for a transparent substance. The absorption is present in the transparent wavelength region of even an absolutely pure material

The second fundamental property of material transparency that is reached when impurities are removed is the intrinsic absorption. Glasses, and many "transparent" solids, are not transparent at short wavelengths of light (the ultraviolet) and are not transparent at very long wavelengths (the infrared). In these wavelength regions, the glass absorbs light and only in between them is the wavelength region called "transparent". However, these absorbing regions do not cease absorbing abruptly at the edge of the transparent region. Instead, they gradually decrease and it can even be shown theoretically (by the Kramers-Kronig relations) that their absorption extends entirely across the transparent region, fig. 2. In the transparent wavelength region, the absorp-

tion was not known because it was masked by impurities. This lack of knowledge about the magnitude of the absorption, plus the fact that there is no way to alter its magnitude, led to considerable concern. Should the intrinsic absorption prove too high to make a practical waveguide, the whole idea of the research could prove impossible. However, we now know that the intrinsic absorption is essentially negligible in the wavelength region of interest. By measuring the signal loss in the best fibers and subtracting the losses that are known, an upper estimate for the intrinsic absorption is obtained, fig. 3. The answer shows that there is a low minimum for this absorption somewhere in the near infrared (about 1.6 μm). Perhaps the most remarkable result of optical waveguide research has been the discovery of how small the absorption at this minimum is, or how transparent matter can be. We now know that light can pass through 20 kilometers of glass with more than half of it emerging. It has been remarked that if the deepest ocean were this transparent, we could easily see the bottom.

Partly because this minimum intrinsic absorption is at near infrared wavelengths, the best fibers today show their maximum transparency in this region.

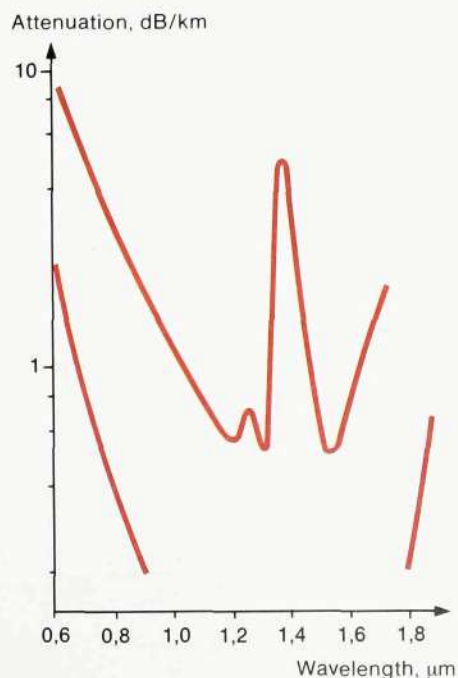


Fig. 3
Upper Curve: Data for a fiber of very low attenuation. Lower Curve: Residual attenuation remaining after subtracting known attenuation effects from upper curve. This residual attenuation is the best estimate of the intrinsic absorption

The highest transparency may be some ten times better than available today. Therefore there is still significant potential for increasing the transparency of fiber waveguides.

Sources and Detectors

The higher transparency region has encouraged research toward making components for the longer wavelengths, in the near infrared. The sources and detectors for the first generation of optical communication systems came from technology that existed prior to the fiber. Now, work is underway to provide new solid state sources and detectors for an optimum system that utilizes the best possible fiber characteristics.

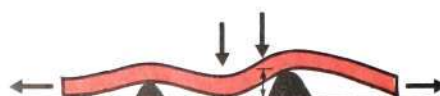
Lasers have been sought as a signal source for optical communications because of the increased signal power and concentration of this power within a narrow wavelength range. However, progress has been slow in achieving stability that endured over decades of use, so lasers are now only considered for short-lived situations. This degeneration in performance occurs because small defects (again, the order of a wavelength of light in size) develop with use. The new lasers designed for longer wavelengths exhibit much more promising durability than former lasers did at a comparable stage of development. This is attributed to the different materials that are being used. Thus, the shift to longer wavelength light may bring with it unforeseen benefits in the light source.

The signal receiver usually consists of a solid state detector and an amplifier. Present research on receiver amplifiers may also alleviate the problem of making detectors for the longer wavelength light. The present solid state detectors which have the highest sensitivity are complicated in their structure. Making these components from new materials involves considerable experimentation. If amplifiers can be perfected to the extent that simpler (p-i-n) detectors can be used with equivalent sensitivity, materials research would be greatly simplified. In general, it would then be possible to develop receivers for new wavelengths of light much more easily.

Cables

Optical cable technology has been able to utilize existing cabling techniques, materials and design knowledge, and this has been a major benefit. There is one important exception. New techniques have had to be devised to cope with the problem of microbending. The tiny fibers are flexible, and irregular displacements of their axis by as little as 1 % of the diameter can cause serious loss of light, fig. 4. It is no coincidence that 1 % of the diameter is our familiar quantity, the wavelength of light. These minute distortions are called microbends. The discovery of this effect is an interesting story of early optical waveguide research. At the time, experimental fibers were wrapped on cardboard drums. It was noticed that the light loss in travelling through the fiber seemed to vary erratically from day to day. With some searching, this variation was traced to the humidity. Cardboard is notorious for expanding and contracting with changing humidity, and as it expanded the fiber was pressed against the rough cardboard surface, causing microbends.

Microbends can arise from uneven application of the protecting plastic coating on fiber, from differential thermal contraction of the materials in the cable, or from external applied forces. As a result, a great deal of engineering effort is going into this practical problem. No immediate end to this effort is in sight. As the transparency of fibers is increased, especially by shifting technology to the longer wavelength of light, microbending losses must also be reduced in order not to sacrifice all the benefit gained. Thus, cabling technology can be expected to remain an area of active interest.



100 bumps per kilometer each 2.5 μm high give 64 dB/km

Fig. 4
Schematic showing the effect of microbends on a fiber waveguide. Microbends the wavelength of light in size cause measurable attenuation

Connectors

Connectors are mechanical devices for joining ends of fibers, or cables, with negligible loss of light. The wavelength of light leads to both disadvantages and advantages in making these components. The small size of the fiber, a result of the wavelength, makes mechanical control difficult. Again, the fiber position must be controlled to about one micrometer, an extremely difficult task to accomplish with inexpensive devices. As a result, connector development lags in this respect and there is considerable room for innovation. At the same time, crosstalk from one fiber to a neighboring fiber is extremely low in connectors for multiple fibers. This is partly because the short wavelength of the light results in scattering upon reflection within the connector which soon dissipates the power that leaks out of a fiber. Absorption of this leaked power is also stronger for light than for longer wavelength electromagnetic radiation.

Anticipated Progress

The components mentioned above are sufficient to provide simple links, defined as a signal source, transmission line and detector. This limited technology can be utilized in most of today's applications and many of tomorrow's. However, for widespread application, further reduction of costs through manufacturing efficiency is needed. This is a very large task but is so fragmented that it is almost impossible to pick a single point worthy of discussion here. On the other hand, the general importance of this effort cannot be overestimated. The future will see further innovation in manufacturing but it should be realized that as the technology becomes more definitive, the opportunity for innovation decreases. Further progress in this respect is assured only by the large effort now under way — the size of the effort compensating for the restricted opportunity.

Components of the future will include more than the simple types already mentioned. New system forms and functional requirements will suggest new types of devices. One example of this is the star coupler. No analogy of this device has been previously used on systems of high information capacity

(high bandwidth) because optical wavelengths are needed for the efficient construction of such devices. The invention of the star coupler came about because data bus structures using light were needed. As examples of possible new devices, we may see distributed amplifiers, holographic couplers, optical signal processors, etc. Whatever these future devices may be, and they will be more imaginative than the examples given here, we can only be sure they are largely unforeseen today. These new forms will permit future systems of greater complexity and capability. Here, as in the past, we expect new technologies like optical communications to open avenues and ideas not previously envisioned.

Telecommunication history shows a

steady increase over the last 100 years in information transmission capability for a single link. Quantitatively, this increase is represented by a series of gradual steps until the present. In the near future, optical technology will apparently generate a sharp discontinuity—the transmission capability will increase at least 100 times (to over 1 Gb/sec. for a single link). What does this mean? The invention of optical communications provided the means for this discontinuity. However, the increased capability can only arise if the technology is developed to a practical form by thousands of technologists. They are working because of a social need for vastly increased communication in an increasingly complex society. Optics will provide the means for entering this new era.

The Second Stage of the Saudi Arabian Project Completed

Bengt Johansson and Johan-Erik Månsson

A description of how the first stage of the large telephone extension project (TEP) in Saudi Arabia was carried out was the subject of an article in a previous issue of Ericsson Review¹. The second stage was successfully concluded on 13 June 1979 and this article contains further comments on this vast project.

UDC 621.395.34

Telephone exchanges

For LM Ericsson and Philips the second stage comprises 11 new local exchanges and 4 additions with a total of 95 900 lines. Thus stages 1 and 2 together have almost doubled the country's local network in a period of only 18 months. The number of lines has been increased from 198 800 to 377 300.

LM Ericsson's undertaking in stage 2 consists of two new AXE local exchanges in Mecca, each of 10 000 lines, a new AXE local exchange in Dammam of 8000 lines, the extension of an ARE 11 local exchange in Al Khobar by 2000 lines and the extension of the AXE local exchanges Al Malaz and Al Ulaya in Riyadh by 10 000 lines each. It also includes four new national transit exchanges of type AXE in Mecca, Medina, Jeddah and Dammam, with a total of 22 500 multiple positions, and three international transit exchanges of type ARE 13 in Riyadh, Jeddah and Dammam, with a total of 5000 multiple posi-

tions. In 18 months LM Ericsson have thereby supplied ten turn-key transit exchanges of a total of 38 100 multiple positions, which has considerably improved the country's long-distance and international traffic facilities.

A summary of the extent of the whole Saudi Arabian project and the size of the contracted extension stages for exchange lines is given in table 1 (page 103). According to the terms of the contract the agreed completion dates for the 476 000 local exchange lines meant that 75 000 lines had to be completed during the first 12 months, a further 100 000 lines by the end of 18 months and the remaining 301 000 lines by the end of 36 months, all periods reckoned from the date of the Letter of Intent, which was issued on 13 December 1977. As can be seen from the table the total number of lines for stages 1 and 2 is well above the stipulated number.

LM Ericsson's undertaking comprises both local and transit exchanges. All new local exchanges supplied by LM Ericsson are of type AXE. AXE exchanges for both local and national transit traffic are also being supplied.

Philips are providing only local exchanges of type PRX.



Fig. 1
Transit exchange AXE 10 in Riyadh



BENGT JOHANSSON
Telephone Exchange Division
JOHAN-ERIK MÅNSSON
Transmission Division
Telefonaktiebolaget LM Ericsson



LM Ericsson's share of the project also includes an extensive program for the conversion of all existing ARF exchanges to ARE 11. The four existing national transit exchanges in Riyadh, Taif, Jeddah and Damman have previously been converted from ARM to ARE 13 exchanges.

During the second stage of the project a number of AXE exchanges were put in operation in the cities of Mecca and Medina. Since only Muslims are allowed into these cities, the installation and testing of these exchanges were carried out by the Saudi Arabian installation company EPPCO. The work was very successfully carried out by staff who had been trained by LM Ericsson in Stockholm (Sweden) and in Saudi Arabia.

Buildings

In addition to the telephone exchange equipment the Saudi Arabian project includes the buildings to house the exchanges with the associated equipment for standby power and air conditioning. A total of 29 exchange buildings have been modernised and in some cases enlarged in order to adapt them to the new SPC systems.

Before the expiry of stage 2, work had also started on 11 of the stipulated 36 new exchange buildings.

Subscriber and junction line network

In addition to the installation of local exchanges the project comprises delivery and installation of large quantities of cable and network material for extending the subscriber and junction line networks in the cities. The latter networks are largely extended by means of PCM.

By the end of stage 2 the following work had been carried out and the required PCM equipment installed in the junction line network.

4 million	cable pair joints
700	cable cabinets
400 km	ducting
5000 km	ducts total
3600	manholes
600 km	cable running in ducts
800 km	cable trenches
1200 km	cable running direct in the ground
200 000	cable pairs terminated in main distribution frames
35 000	distribution points of 10 pairs

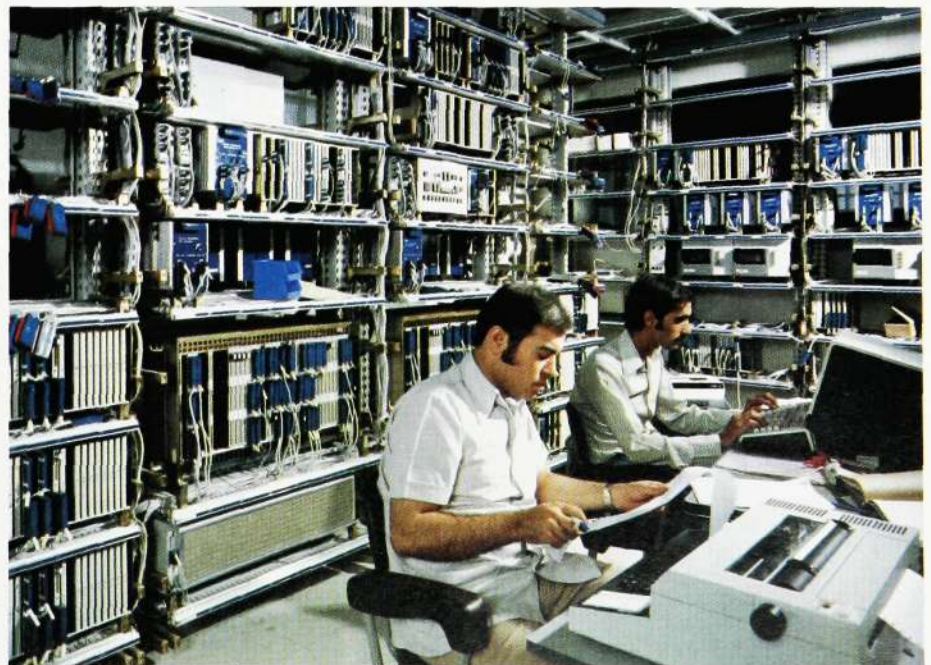


Fig. 2
Installation testing of the AXE 10 local exchange in Damman



Fig. 3
Building ducting in Riyadh

The networks have been planned so that the ducting will suffice until the year 2000.

Very considerable personnel resources had to be employed to ensure that this vast amount of work would be completed in the short time available. With full installation capacity the work force amounted to 6000 men. Approximately 300 of these belonged to the Joint Venture organization formed by LM Ericsson and Philips and the remainder were subcontractors for duct and cable installation work.

The project has necessitated the preparation of a very large number of drawings. Over 1000 design drawings have already been completed and many more will be required during the course of the work. Drawings are also made showing the various stages of the subscriber and junction line networks. By the end of the project the number of such drawings will be about 20 000.

Telephone sets

The Telephone Extension Project includes approximately 500 000 telephone

sets of the new type DIAVOX 100. This set forms part of a family of telephone sets which LM Ericsson are developing in close collaboration with the Swedish Telecommunications Administration. DIAVOX 100 is a push-button set that meets the very stringent requirements for transmission characteristics and stability imposed by the PTT Ministry. The telephone set has been adapted for local conditions. For example, the push-buttons have both Arabic and western numerals.

105 000 telephone sets were delivered during the second stage, and the total delivered is now 180 000 sets.

Traffic changes in the network

Any change made in an existing telephone network will affect all exchanges in that network, since new traffic routes are introduced and this changes the distribution of traffic between the various exchanges. This means that in all exchanges some of the equipment, for example registers and group selectors in ARF exchanges, must be adapted to the new traffic pattern in accordance



Fig. 4
Building ducts through the centre of Riyadh

Table 1
Telephone exchange lines included in the Saudi Arabian project

Exchange type	Stage 1 (12 months)	Stages 1+2 (18 months)	Stages 1+2+3 (36 months)
AXE local exchange lines	20 000	68 000	161 000
ARE 11 local exchange lines		2 000	3 000
PRX local exchange lines	62 600	108 500	312 000
AXE national transit exchange lines	10 600	33 100	52 800
ARE 13 international transit exchange lines		5 000	8 000
Total number of local exchange lines	82 600	178 500	476 000
Total number of transit exchange lines	10 600	38 100	60 800

The stipulated time for taking the lines into service is given in brackets for each stage above, counted in months from the issue of the Letter of Intent, 13 December 1977.

with a detailed time plan. Naturally this can only be done in well defined stages. Traffic matrices for both the long-distance network and the various multi-exchange areas were therefore prepared, not only for the final network plan after the completion of the TEP contract but also for important intermediate stages, using computerized network optimization calculations. Work plans were then drawn up for the different exchanges on the basis of these matrices.

It may be mentioned that, in conjunction with the radical structural change of the Saudi Arabian network resulting from the project, the charging, signalling and numbering systems will also be changed.

Coordinating the project

Such a rapid extension of a large national telephone network requires very considerable coordination at all stages of the project. A number of entirely different jobs must be completed in accordance with a carefully prepared time plan if it is to be possible to introduce a telephone exchange in the telephone network at the appointed time. If the time plan is not met there will be unnecessary loss of time and delays, which would mean serious financial consequences in a project of this magnitude. The coordination work is carried out by the Joint Venture organization, which has its headquarters in Riyadh.

Operation and maintenance

During the course of TEP the Ministry will gradually take over the responsibility for both the administrative and technical maintenance. Saudi Telephone, a company formed by Bell Canada, will then organize the maintenance on behalf of the Ministry.

LM Ericsson and Philips are building four different types of centres to facilitate the maintenance work:

1. AOM for centralized operation and maintenance activities².
2. Software centre, SWC, for handling the software.
3. Documentation centre for copying and distributing documents.

4. Repair centre, with the task of repairing faulty equipment in Saudi Arabia as far as possible.

The first AOM centre is already in operation in the Riyadh district. Three more district centres are to be built (Jeddah, Taif, Dammam), and also a superior national centre in Riyadh for the supervision of the whole of the national network.

The personnel of Saudi Telephone are undergoing instruction and training so that the company can take over the responsibility for operating these centres on behalf of the Ministry.

Experience of AXE exchanges

The positive experience obtained during the installation and cutting in of the five AXE exchanges of the first stage has been reinforced during the work on the seven new AXE exchanges and the two exchange extensions in the second stage.

The AXE system has come up to all expectations as regards installation³. The testing, including the final testing for "preliminary acceptance", was completed within the planned time without difficulty.

As regards operational reliability it is of course too early to be able to show any statistically processed material. However, it can already be stated that the general trend is very favourable. Statistics will be published as soon as sufficient information has been obtained.

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Operation and Maintenance of Telephone Networks with AXE 10

Lennart Söderberg

LM Ericsson have always attached great importance to the operation and maintenance characteristics of their telephone exchange systems. Thus methods for controlled, corrective maintenance were developed for the electromechanical systems AGF, ARF and ARM. For example, traffic route testers were used to determine the service quality. It was only when the quality level fell below a preset limit in any part of the equipment that corrective measures were applied.

The introduction of SPC technology meant that the supervision could be automatized and carried out on real traffic instead of test traffic and cover not only the exchange in question but also the surrounding network. The fault tracing could be developed to automatically isolate and indicate faulty functions. The many features of the AXE 10 operation and maintenance system are described in this article.

UDC 621.395.74-7

Telephone exchange system AXE 10, which has been described previously in a number of articles¹⁻⁸, is an SPC system intended for all levels in digital and analogue telephone networks. Other members of the AX family are the AXB systems for telex and data networks⁹⁻¹¹. Fig. 1 shows an AXE 10 local exchange and fig. 2 an AXB 20 telex exchange. Utilizing the extensive product range of the AX family means

great advantages for the administrations, primarily as regards uniformity in training, documentation, stocking of spares and software handling. The subsequent article describes how the operation and maintenance activities for these different types of telecommunication equipment can also be coordinated by connecting them to a common, computer-controlled operation and maintenance system, the AOM 101 system¹². In this article the following characteristics of system AXE 10 will be discussed in more detail:

- The automatic supervision of each connection through the exchange, combined with checking that the service quality remains within the set limits.
- The simple methods for changing and adding functions and data, which are made possible by the functional modular structure of the software and the standardized signalling interfaces between the function blocks.



Fig. 1
The AXE 10 local exchange for 10 000 lines at Al Ulaya, Saudi Arabia



LENNART SÖDERBERG
Telephone Exchange Division
Telefonaktiebolaget LM Ericsson

- The command-controlled collection of operational data, which are processed by the system before being presented in text en clair.
- The simple methods for clearing hardware and software faults.
- The integrated maintenance of the surrounding network and exchanges.
- Time-saving work methods which are adapted to the personnel.
- The possibilities of centralizing the operation and maintenance functions.

Supervisory functions concerned with the service quality

The system contains functions for supervising the hardware and software functions and the traffic load. The supervision is carried out on real traffic, not test traffic. Faults and overload are immediately detected and are dealt with in a suitable way depending on type and degree of urgency.

Table 1 shows some important supervisory functions.

Hardware supervision

Units that are common to more than 128 subscribers are duplicated. If a fault occurs in such a unit a changeover to the standby etc. is done automatically. For example, if a hardware fault were to lead to malfunction of one side of a processor pair, this side would automatically be stopped and the side that is free from faults would continue to process the traffic without any traffic disturbances. The operating staff would receive an alarm.

However, devices that are built up using analogue circuit technology, for example trunk and junction line units working into analogue networks, are supervised by means of statistical methods. Individual units with the associated lines will be blocked automatically if it is found that they are causing too many time forced releases, too poor transmission quality, unwanted disconnections etc. This normally keeps the service quality within predetermined limits that can be set by means of commands. Fault clearing is not necessary until so many devices have been blocked that there is a risk of too poor service quality during the busy hour. This is indicated by an alarm from the blocking supervision. Thus the principle used here is the same as in LM Ericsson's earlier systems, namely controlled corrective maintenance¹³.

Table 1
Important supervisory functions in AXE 10

Digital switching network	Control system APZ 210	Load supervision
Supervision of: Through-connection by means of parity inversion	Supervision of: The program handling by means of "watch dogs" in the processors	Supervision of: The central processor load by means of a call buffer
Speech paths by means of parity check	The hardware in the synchronously duplicated processors by means of side comparison	The load on the code sender and code receiver groups and the incoming and outgoing routes
Addressing paths by means of parity check	Stores by means of parity check	
Clock pulse paths by means of parity check	Data buses by means of parity check and time supervision of asynchronous signalling	
Clock frequency by means of majority choice	Power by means of voltage supervision in each magazine	
Plane selection by means of routine testing	Maintenance circuits and changeover functions by means of routine testing	
Address path supervision by means of routine testing	Software by means of addressing and signalling checks	
Speech path supervision by means of routine testing		
Clock pulse path supervision by means of routine testing		

In digital networks there is a bit flow regardless of whether the devices carry traffic or not. In the digital parts of system AXE there is therefore supervision at the PCM word level, not only during actual traffic but also during the idle and blocked condition, so that faults can be detected in all situations. The units in question are automatically blocked when a fault occurs and de-blocked when the fault disappears.

Automatic routine testing is carried out for some auxiliary functions that are seldom used, but which are nevertheless important, for example the plane selection functions in the digital group selector stage. In addition to the plane selection the supervisory and diagnostic functions concerned are checked.

The method utilized, with service quality supervision on *real* traffic, means that every connection set up through the exchange is supervised. This gives a much better picture of what effect the faults have on the service quality than when using *routinely generated test traffic*, which does not take the subscriber behaviour into consideration.

The method, in combination with automatic fault diagnosing and fault indication, means that the staff are not encumbered by large quantities of fault printouts and analyses of these. Nor is there any need for special test equipments with the associated test programs.

Software supervision

The fault rate in the AXE 10 programs is kept low by means of extensive testing and by using mainly standardized programs. The structure with function modules, in combination with the special addressing principles³, effectively limits the consequences of software faults, and these are also easy to locate with the aid of special tracing functions.

Nevertheless, automatic restart will take

place if implausible data or program derailment should be detected by the supervisory functions. This function maintains the operational reliability of the system by limiting the effects of serious faults. In connection with the restart an *informative printout* is obtained, which provides the basic data for the necessary corrections.

Load supervision

Automatic load supervision of both the control system and the individual routes is carried out in order to ensure optimum use of the equipment and the best possible handling of occasional load peaks.

If the control system gets overloaded, adjustments are automatically carried out, for example by giving preference to traffic from a transit exchange before locally initiated traffic.

An alarm is given if the sum of blocked and engaged lines on a route exceeds a preset level, since there is then a risk that calls are rejected or delayed. After detailed measurements the staff can decide which measures are to be taken.



Fig. 2
The AXB 20 telex exchange in Malmö, Sweden. AXB 20 contains the same processor, APZ 210, as AXE 10. Moreover the general design, the components and the mechanical construction are the same

Administration of subscriptions and charging
 Check of call metering
 Reading of call meters
 Toll ticketing
 Data collection for settling between administrations
 Tariff statistics per tariff rate
 Service observation for superior quality control

Traffic planning and administration
 Traffic measurement on routes
 Traffic measurement of different types of traffic, e.g. outgoing and incoming traffic
 Recording of traffic interest
 Recording of the load on the central processor system
 Recording of the call frequency to the central processor system
 Recording of the load on the regional processors

Maintenance
 Disturbance statistics
 Service quality statistics
 Transmission quality statistics (ATME)

Table 2
 An example of functions for the collection of operational data

For example, if a fault has occurred that results in large rejection, a temporary improvement can be obtained by changing the data. By this means the traffic can be rerouted for a short time and other traffic-limiting measures can also be carried out. More long-term changes, such as moving devices from one route to another, are performed by reallocating hardware or making the relevant data changes.

Supervision of certain subscriber facilities

Immediate operator intervention may be required for certain subscriber facilities, for example tracing of malicious calls and if the alarm call service fails because of a technical fault or lack of answer. In such cases the system supervisory function will give an alarm.

Alteration methods

A main advantage of AXE 10 is that alterations are easy to make. A distinction is made between data changes, where the characteristic in question is altered solely by means of changes in the data, and function changes, which always require the addition or change of programs but often also of data. In rare cases it is also necessary to add or change hardware.

Data changes

Data changes can concern the connection and disconnection of subscribers and facilities, changes in the characteristics of certain devices and routes, routing and tariff analyses, service quality levels, command authorization, printout routing etc. In the case of subscriber number changes the need of vacant multiple positions is reduced, since new subscribers can be allocated previously used multiple positions in accordance with the principle of free number group.

Small changes are preferably carried out from local or remote terminals, whereas extensive changes are best made with the aid of cassette or magnetic tapes, which have been loaded with the change commands in advance.

In order to prevent critical data changes from causing serious disturbances, a changeover to the old data can easily be made if necessary. Old, well-tried data are retained in the system until the new data have been tested.

Function changes

Function changes include for example the introduction of new or revision of existing subscriber facilities, operation and maintenance functions, signalling systems and I/O functions. These changes are made by introducing new function blocks or changing one or more blocks. The other function blocks are not affected.

The functional modular structure of AXE 10 and the standardized signalling interfaces of the function blocks towards interworking blocks³ make it easy to include new or revised function blocks in an AXE 10 exchange by means of special alteration functions. Fig. 3 shows the general method for such an alteration: introducing a new function block without causing traffic disturbances.

Operational performance information

The system conveniently provides the required operational information in the form of operational data and alarms.

Operational data

The operational data comprise information concerning charging, traffic,

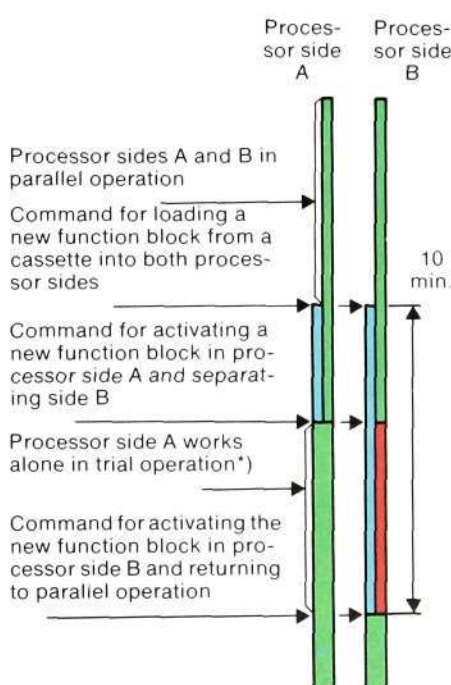


Fig. 3
 Adding a new function block in AXE 10.
 *) If the new software is faulty a changeover is made to side B and the original program package

Table 3
Examples of alarm classes, types and categories

Alarm class	Alarm type	Alarm category	Origin
Immediate action	Fault alarm	Switching system	Identity of the exchange of origin
Action the same day	Observation alarm	Control system	
Action during the week	which is released by a major manual intervention	Subscriber line network	
		Transmission network	
		Power	
		Overload	
		Subscriber facilities	

service quality etc. Table 2 shows the most important functions for the collection of such data.

The operational data are normally presented processed and edited, and are printed out in text en clair. However, when the data are to be processed further in an administrative computer, for example with toll ticketing, the output is in unprocessed form.

The collection of operational data is always initiated by a command from an operator. The output can either be made immediately or at predetermined times. The data are output to a printer, cassette or magnetic tape, either direct or via a data link.

Alarms

Abnormal conditions that affect the service quality direct are detected by the AXE 10 supervisory functions or, if applicable, are transmitted to the exchange in question from subordinate equipment and connected supervisory systems. The alarms are divided into alarm classes, types, categories and origins, see table 3. Each alarm can then be routed direct to the staff group concerned, i.e. the one responsible for exchanges, transmission, power etc.

In addition to local indication in exchanges, alarms can be given on re-

motely connected panels in the form of visual or audible signals or they can be handled by the computerized operation and maintenance system AOM 101, depending on the existing maintenance organization.

Detailed information concerning the alarm state of the exchange is given in its alarm list, which can be shown on a display by means of a command.

Spontaneous printouts are made only for alarms that require immediate action.

Fault clearing

The functional modular structure makes it easy to clear faults in the system, both in hardware and software.

Hardware

The hardware consists of printed board assemblies, I/O devices and power modules, placed in magazines in the BYB 101 construction practice. All units are easy to replace.

If a fault occurs, the unit in question is automatically blocked. The fault should be cleared within a certain period of time, depending on the alarm class. A printout guides the repairman to the correct magazine, where the unit is identified by its functional designation, which is given in the printout, fig. 5. The

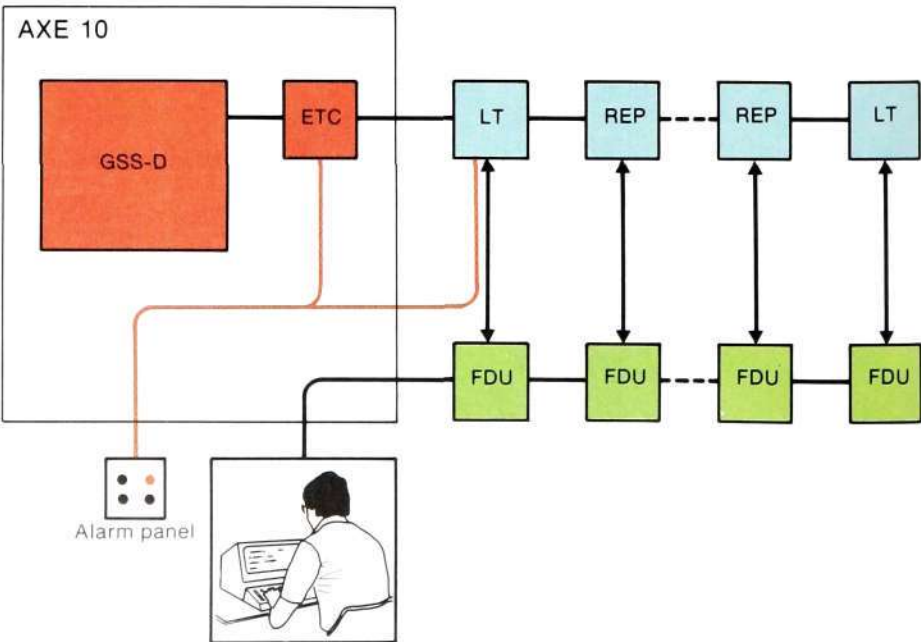


Fig. 4
Supervisory and fault localization functions for digital lines. The most important functions include:
Supervision of frame alignment
Supervision of multiframe alignment
Supervision of alarm indication signal
Supervision of the bit error rate
Alarm collection from the line terminal LT
Command-controlled localization of faulty line repeaters

GSS-D Digital group selector
ETC Exchange terminal
LT Line terminal
REP Line repeater
FDU Fault localization unit

Fig. 5
An example of an alarm printout

A1 Alarm class
APZ Alarm category
CP UNIT FAULT Headline in the operating manual
MAG The magazine that contains the indicated printed board assembly
CARD Printed board assembly designation, marked on the magazine
WEIGHT The probability, as a percentage, that the indicated printed board assembly is faulty

ORL-AXE-1
ALARM A1/APZ
CP UNIT FAULT

TIME 780224 1817

PAGE 1

MAG	CARD	WEIGHT
PS-B-09	STS-6	020
PS-B-09	STS-14	020
PS-B-09	BFU-1	060

END

faulty unit is replaced and the new unit is tested by means of the test functions built into the system. This gives a check that the fault has been cleared.

Software

A software fault in an exchange is cleared by replacing the program in the faulty function block by corrected and well tested software. This method is preferred to making changes in the programs by means of commands (patching). The designer corrects the fault himself, the program is correctly documented and the risk of introducing new faults is minimized.

Maintenance of surrounding networks and exchanges

AXE 10 contains efficient aids for localizing faults in the surrounding digital and analogue networks and in connected exchanges.

Digital networks

The incoming bit stream from digital

trunk lines is supervised by AXE 10 in accordance with CCITT recommendations, fig. 4. The supervision covers frame and multiframe alignment and bit error rate. When a fault is detected on such a line all affected devices are automatically blocked. The blocking is removed if the fault disappears. Persistent faults give rise to an alarm.

The trunk line terminal, LT, gives alarms for power faults, faults in transmitted and received digital signals and also for too high bit error rates.

Alarms from AXE 10 and LT are routed either to a position for integrated exchange and transmission maintenance or to a special transmission maintenance position.

When an alarm is obtained, fault localization can be ordered with a command. The distribution of the bit error rate along the trunk line is then measured via a separate pair of wires, which makes it possible to trace a fault to the line repeater REP in question.

Fig. 6
The most important supervisory functions in a network with common channel signalling in accordance with signalling system no. 7. The most important functions comprise:
Supervision of the bit error rate on the signalling links

Supervision of the load on the send buffers
Supervision of the signalling traffic accessibility towards different destinations
Blocking supervision of the speech channels

Exchange A can serve as the signal transfer point, STP, for traffic from AXE 10 to exchange B

--- Speech channel
- - - Signalling link
- - - Semi-permanent connection through the switching network
ST Signalling terminal for system no. 7
MUX Multiplexor
PCD Digital/analogue converter
ETC Exchange terminal

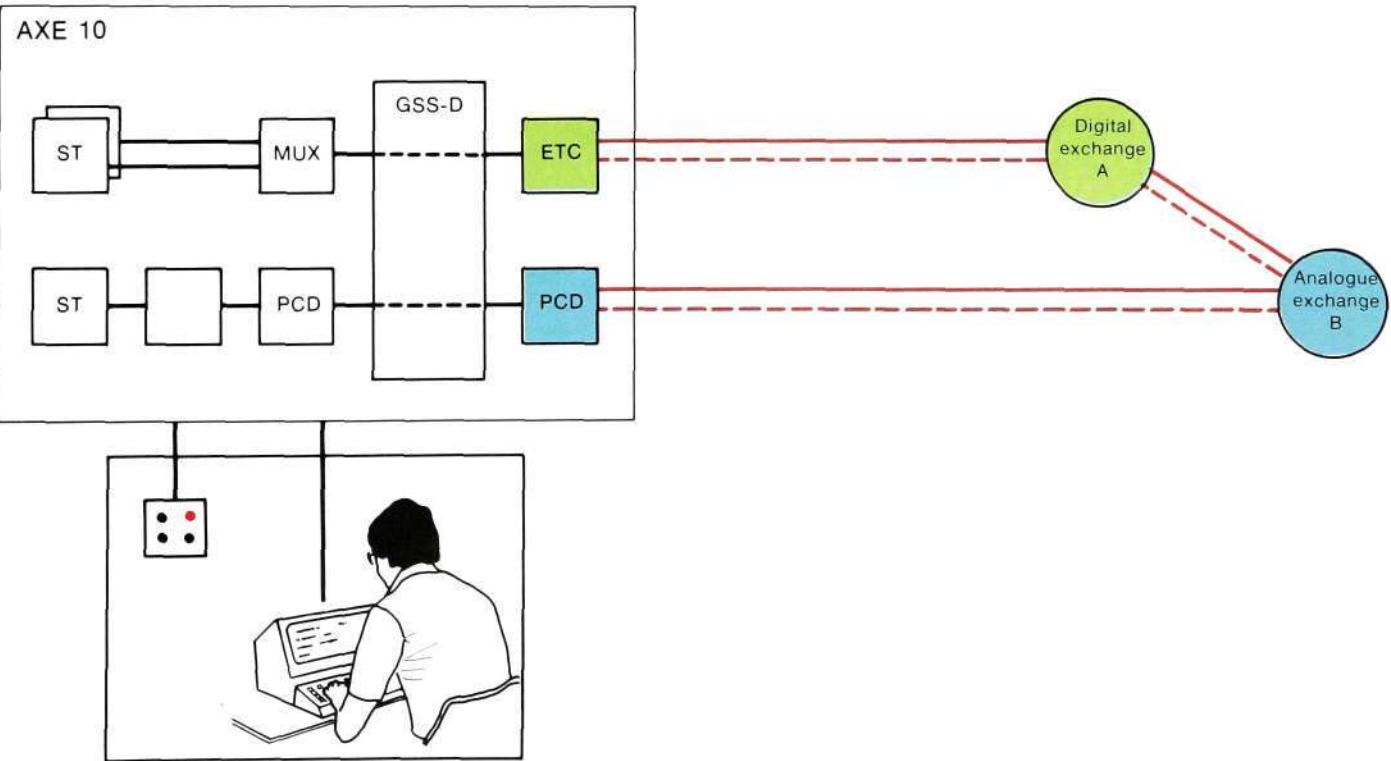
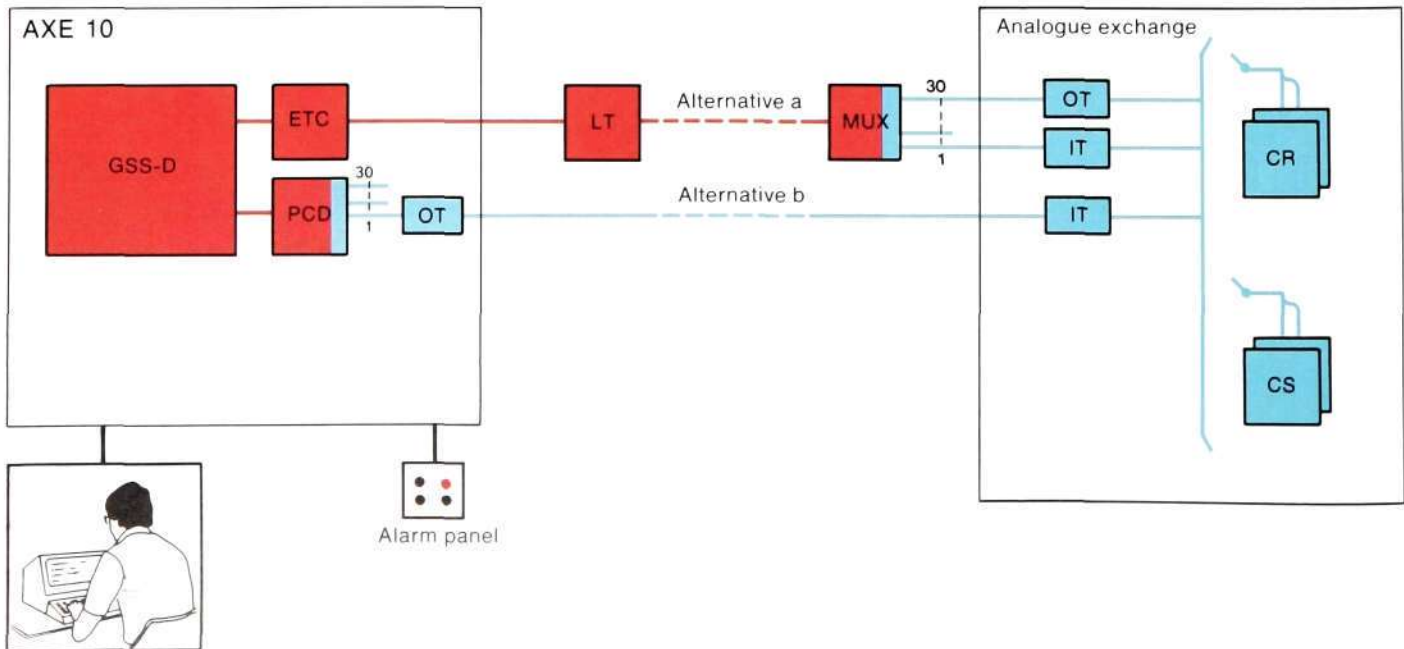


Fig. 7
The most important supervisory and fault localization functions for interworking with analogue exchanges comprise:

- Disturbance supervision of IT and OT routes
- Blocking supervision of IT and OT routes
- Seizure supervision of individual ITs and OTs
- Seizure quality supervision of individual ITs and OTs
- Signal course recording, by command
- Generation of test calls, by command
- Disturbance registration, by command
- Tracing of connection paths in the case of disturbances, by command
- Transmission measurement with the aid of ATME
- Transfer of pilot alarm

— Analogue equipment
— Digital equipment
GSS-D Digital group selector
ETC Exchange terminal for digital lines
PCD Integrated multiplexor with digital/analogue conversion
IT Relay set for incoming analogue lines
OT Relay set for outgoing analogue lines
MUX Multiplexor in the digital transmission system with digital/analogue conversion
LT Line terminal
CS Code sender
CR Code receiver



Equipment for common channel signalling

AXE 10 can supervise networks with common channel signalling in accordance with CCITT signalling systems no. 6 and no. 7. Only signalling system no. 7, which will be widely used, particularly at the national level, will be discussed here.

Signalling system no. 7 is primarily intended for digital networks, which are supervised in accordance with fig. 6. The signalling equipments for system no. 7 work much faster than traditional line and register signalling (64 kbit/s instead of 10 bit/s), and thus less equipment is needed and the fault rate is lower. However, the introduction of common channel signalling makes very high demands on functional reliability, since a fault in an equipment would affect a large part of the traffic. In AXE 10 the demands for functional reliability are met by means of automatic changeover to a standby channel when the monitoring of the bit stream indicates a fault. The standby channel can either be associated with the speech channel or routed via a signal transfer point. It is also possible to use speech channels as the standby, in which case they are automatically converted into signalling channels.

Carrier networks

Alarms from carrier terminals can be received by AXE 10 and distributed to the relevant staff. In the case of a pilot alarm the exchange devices concerned are automatically blocked. Automatic transmission recording is carried out and indicates groups or supergroups with unacceptable transmission quality. Supervision of individual circuits is carried out on real traffic.

Connected analogue exchanges

In the case of traffic from AXE 10 via digital lines to an analogue exchange it is possible for the system to indicate faulty devices in the latter, fig. 7, alternative a. The system supervises each individual channel and if a fault is detected in any one it must be caused by the connected device in the analogue exchange, since in the digital transmission system there can be no faults in single channels, only whole groups.

Analogue circuits to connected exchanges are also individually supervised by AXE 10, fig. 7, alternative b.

Faults and blockings in the analogue exchange that affect devices which are common to a route, such as code senders and receivers, can be detected by route supervision in AXE 10.

Fig. 7 shows the most important supervision and fault localization functions.

Analogue subscriber line network

The maintenance of the analogue subscriber line network is very labour-demanding and rationalization of maintenance can result in considerable savings.

The subscriber lines are therefore measured and supervised in connection with each call to and from a subscriber as shown in fig. 8. In addition the lines are supervised with regard to occupation, and if a line has not had any traffic for a certain period of time it is automatically tested.

Lines that deviate from the normal are marked as faulty or are blocked, depending on the amount of deviation. They are then automatically tested at regular intervals. When the fault on a blocked line ceases the line is automati-

cally taken back into service. An alarm is given if the number of deviating lines becomes excessive.

Individual lines can also be supervised as regards line lockout. An alarm is given for long blocking. Special supervision is provided for particular subscriber equipment, such as coin box sets. An alarm is obtained if no call of a preset minimum duration is carried out from such a set during a certain period.

System AXE 10 has integrated functions that enable a repairman to test an individual line from a subscriber set equipped with a dial or a push-button set. The line can also be tested by an operator from a terminal, for example when a complaint is received from a subscriber.

Time-saving methods that are adapted to the personnel

LM Ericsson continuously carries out ergonomic studies in collaboration with

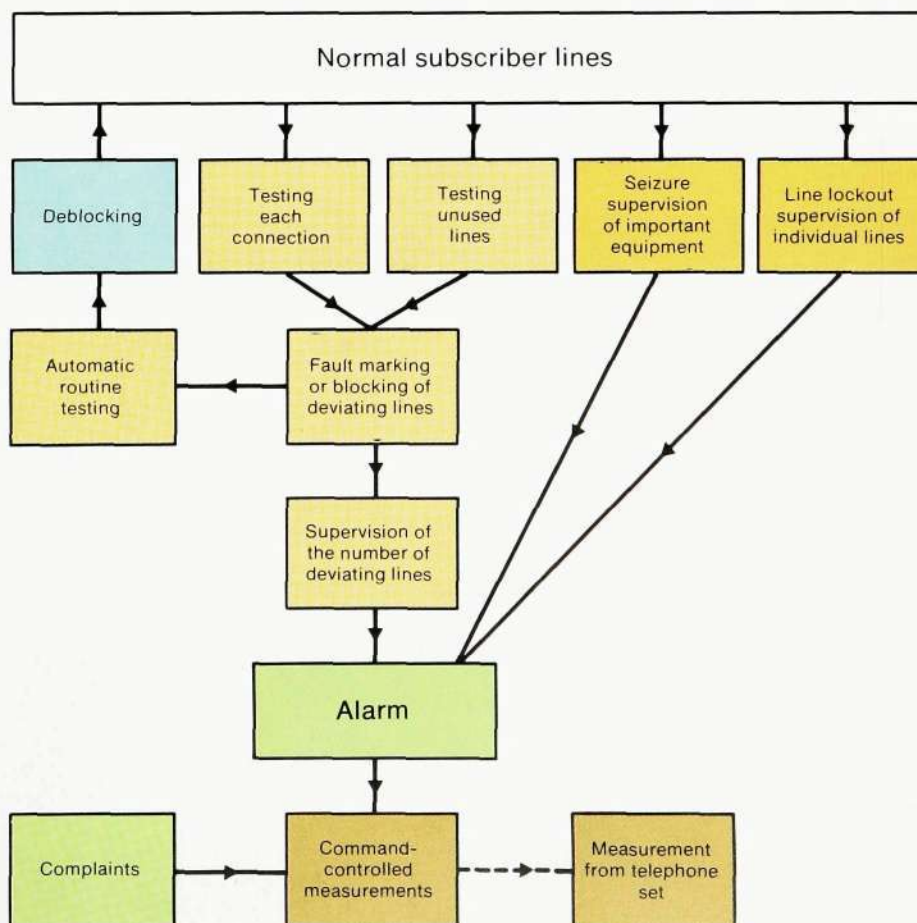


Fig. 8
Supervision and measurement of subscriber lines

experts in order to obtain data for the design of work positions and work methods to provide the best possible working conditions for the personnel. These data have also formed the basis for the design of operation and maintenance methods for telephone networks including AXE 10.

Simple tasks

The operation and maintenance of an AXE 10 exchange depends greatly on application, the surrounding network, the rate of alteration and the organization in question. The figures given below show the operation and maintenance characteristics of a normal AXE 10 exchange.

The operating work, which comprises collections of operational data and alterations, amounts to approximately 55 % of the total operation and maintenance activities, whereas the maintenance work accounts for only about 45 %.

Approximately 80 % of all operating work can normally be carried out by operators without system knowledge. They need to be able to operate the terminals and master the use of a number of commands. The task of these

operators consists of carrying out simple alterations and collect operational data. The major part of the work consists of subscription changes.

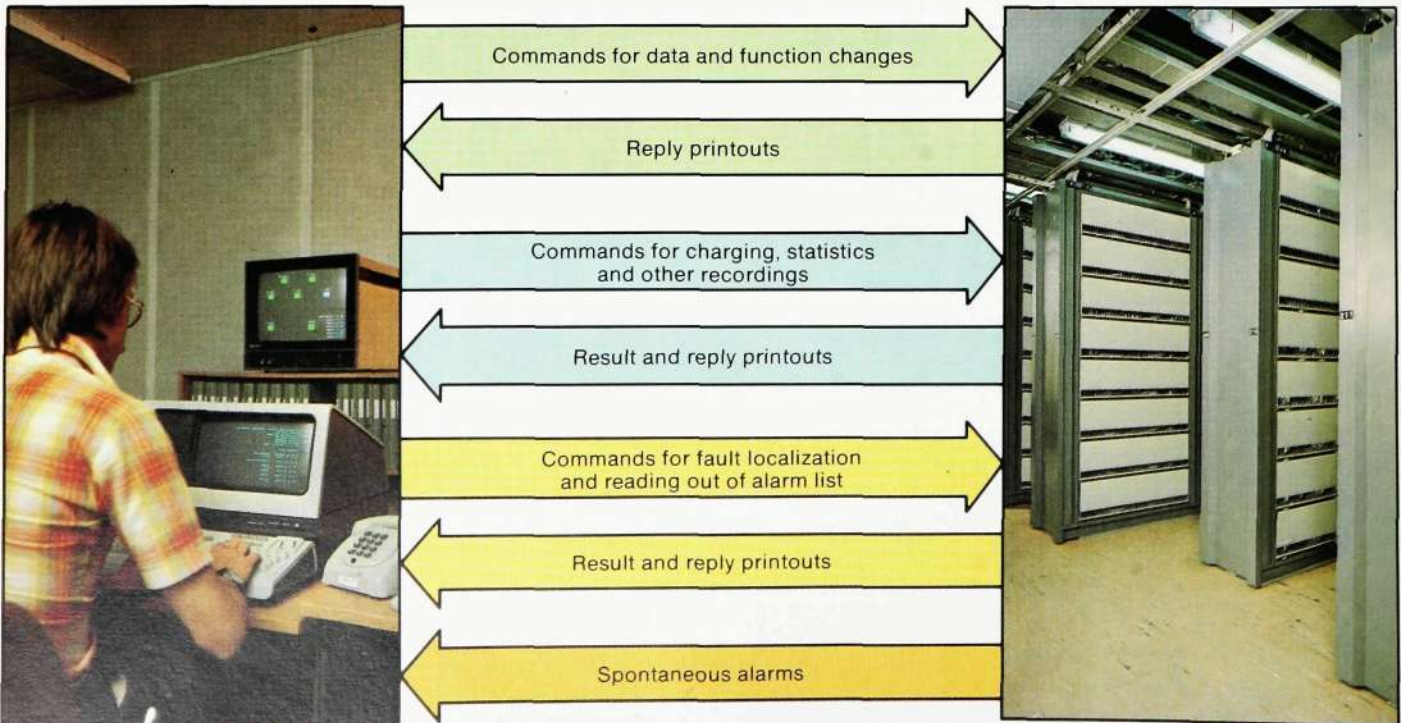
Investigations show that up to 98 % of the maintenance work can be handled by technicians with the operation and maintenance manual as the main aid. Only 2 % of the maintenance activities need be carried out by system experts with knowledge of AXE 10 hardware and software in accordance with the system documentation.

The large part of the maintenance work that consists of localizing faults in the surrounding exchange and network with the aid of the AXE 10 fault localization functions can be handled by technicians with limited knowledge of the system.

Operation manual in flow chart form

Each chapter in the operation and maintenance manual contains instructions for a number of jobs. The alarm printouts refer direct to certain of these jobs. The instructions are given in the form of flow charts with supplementary text, which describes to the operator in detail, step by step, what to do until a fault has been located.

Fig. 9
The most usual command and printout functions in AXE 10



Psychological aspects must be considered.

For example, the system always replies within a short time after a command, so that the operator will not have doubts as to how the system has reacted to the command.

The operator must be in control of the system at any moment.

The operator can therefore interrupt a printout if he needs to send an important command. The input of commands cannot be interrupted by the system.

The operator should only receive the printouts he needs at the time.

This makes it easier for the operator to survey and plan his work. Spontaneous printouts are therefore given only in the case of alarms that require immediate action. All other printouts are the result of commands.

All these requirements, which are met by the AXE 10 man-machine communication, help to make the system simple and reliable as regards operation and maintenance.

Centralized operation

As can be seen from the above, the AXE 10 system contains complete functions for remote control of the operation and maintenance activities. Only 10–20 % of the work requires action out in the individual exchanges, and thus even large exchanges can be kept unmanned, fig. 10.

In areas with only a few AXE 10 exchanges the operation and maintenance of certain exchanges can be remotely controlled from a large, manned AXE 10 exchange or from another suitable centre. For this purpose lamp panels and terminals are used, which are connected to the remotely controlled exchanges via data links.

If a network contains many AXE 10 exchanges, or if the number of such exchanges is expected to grow rapidly, the computerized operation and maintenance system AOM 101 offers additional important advantages in connection with centralized operation, which is described in the following article¹². Since exchanges of other types in the network in question can also be connected to

AOM 101, a uniform operation and maintenance organization will be obtained in the network.

The connection to AOM 101 is made via a data link in accordance with CCITT Recommendation X25. In such a link 16 channels are used for simultaneous man-machine communication.

Summary

A summary of the most significant operation and maintenance characteristics of AXE 10 is given below.

- The system is part of a complete and uniform family, which also includes exchanges for telex and data networks, and thus the operation and maintenance activities for all these telecommunication branches can be coordinated.
- The supervision, which is based on real traffic, checks that the service quality stays within the permissible limits. It is an efficient method which reflects how well the system serves the subscribers.
- The surrounding digital networks, signalling networks for signalling system no. 7 and analogue networks and exchanges can also be integrated in the maintenance activities. Alarms can then be distributed to the personnel groups concerned.
- Function changes can easily be made without disturbing the traffic in progress.
- 98 % of the maintenance work can be carried out by technicians with the operation and maintenance manual as the main aid.
- Even very large exchanges can be run unmanned. The system is designed to facilitate centralized operation in conjunction with AOM 101.

To conclude, reference is made to fig. 11, which shows how automatic supervision, fault isolation and fault localization by replacing a faulty printed board assembly greatly simplify the maintenance work.

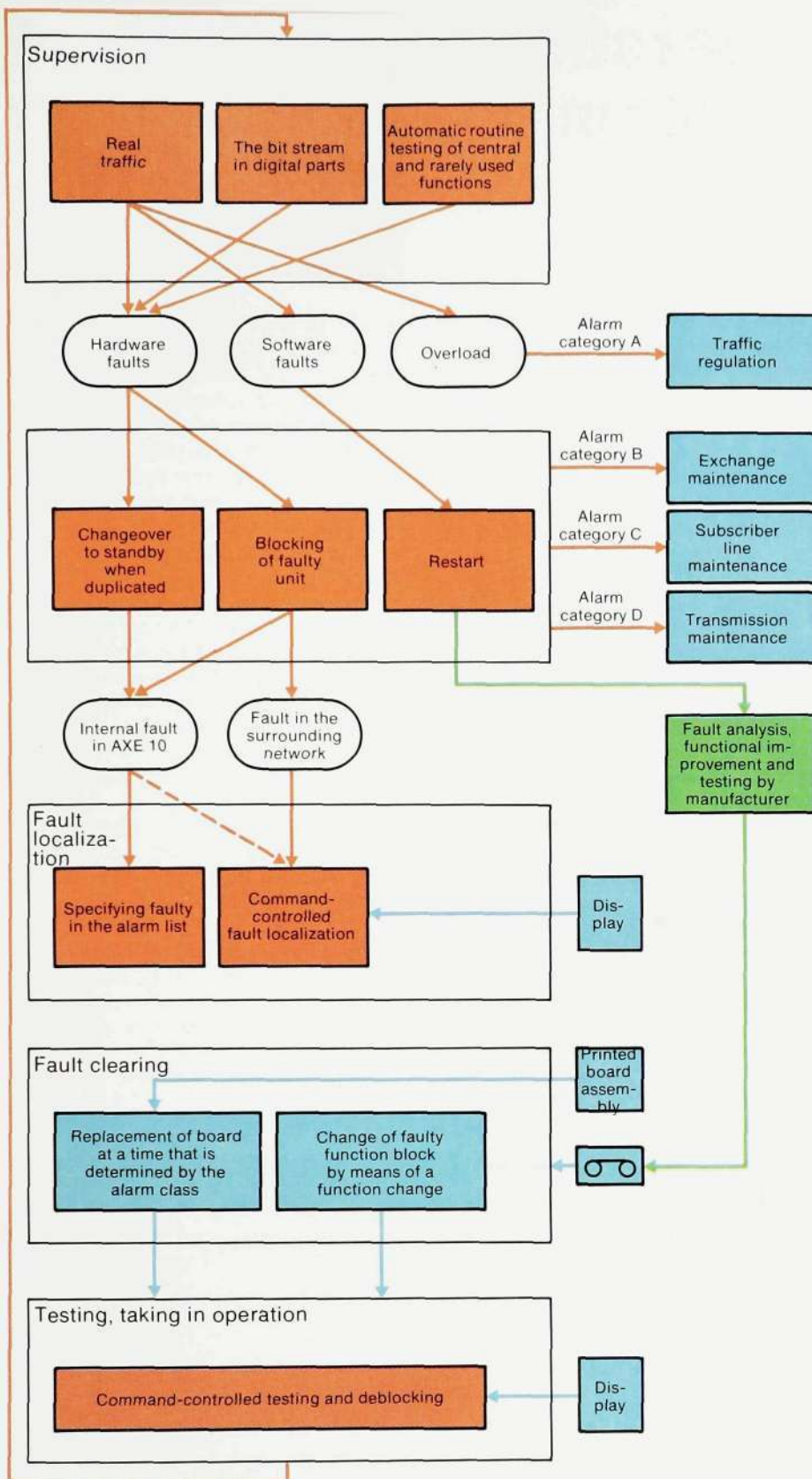


Fig. 11
Principles of the AXE 10 maintenance

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AOM 101, an Operation and Maintenance System

Göran Nordqvist

LM Ericsson have always devoted much effort to all aspects of the development of new telephone exchange systems. A well designed system and equipment of high quality mean that maintenance can be limited to automatic supervision and corrective measures^{1,2}. This has been shown at annual maintenance conferences, where experts from the participating administrations have put forward their views and compared notes.

A further step in the rationalization of the operation and maintenance activities is to centralize the supervisory and control functions to a few places. The computer-controlled operation and maintenance system AOM 101 has been designed for this purpose. The system is flexible and can be adapted to individual requirements. In this article the advantages of AOM 101 are presented, followed by a description of the structure and function of the system.

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In order to be able to manage a telecommunication network rationally and economically it is necessary to automatize the operation and maintenance activities further. This can be achieved by putting the operation and maintenance functions in the actual exchanges under computer control to a greater extent, which has been done in AXE and ARE. The advanced operation and maintenance characteristics of the AXE system have been described in the previous article³. Further rationalization can be achieved by centralizing the supervision and control of the operation and maintenance functions. The inde-

pendent, computer-controlled operation and maintenance system AOM 101 has been designed for this purpose. It provides the telephone administrations with additional facilities for economically maintaining the telephone equipment in such a condition that the subscribers' demands for fast and reliable connection, high transmission quality and accurate charging can be met.

It is not only SPC (Stored Program Control) exchanges that can be connected to system AOM 101. Exchanges of types ARF, ARM and ARK can also be connected via exchange terminals. The latter will also be used if transmission equipments, power plants etc. are to be supervised with the aid of AOM 101.

The computer-controlled operation and maintenance system AOM 101 provides many advantages, of which the following may be specially mentioned:

- Reduced operation and maintenance costs, since the work is simplified because the number of visits to exchanges is reduced: the right man can be sent to the right place and other resources will also be better utilized.



Fig. 1
Operation and maintenance system AOM 101. Exchange equipment AXE in the background



GÖRAN NORDQVIST
Telephone Exchange Division
Telefonaktiebolaget LM Ericsson

- Overall check at a glance. All telecommunication equipment can be controlled from a suitable place, fig. 2. By means of remote control the traffic flow can be distributed so that overloads and other network problems are reduced. Localization of complicated faults is also simplified.
- Instantaneous and reliable distribution of the required data to the personnel groups concerned, so that they can carry out their work efficiently.
- Coordination between the telecommunication network and existing computer systems for network planning, sales etc., which facilitates such work.
- Improved subscriber service because customer orders and complaints can be dealt with very quickly.

In the initial stage the existing organization is often retained, but the personnel are aided by the computer in their work. At a suitable time special work centres are then set up, each centre being responsible for a particular job, fig. 3. These centres should be placed in the most appropriate place with respect to organization, travelling distances and the need for contact with the personnel concerned.

Operation and maintenance centre

From an operation and maintenance centre the necessary commands are sent for altering exchange data and functions. A check is also made that ordered changes in the hardware and software are carried out. Finally the faults that occur in the supervised equipment are analyzed, decisions are made on measures to be taken and, if necessary, a repairman is sent to rectify the faulty item. Fig. 4 shows a work position in such a centre.

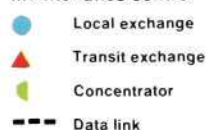
Separate work centres give a flexible organization

The personnel who work with AOM 101 carry out a large part of their work with the aid of terminals consisting of displays and typewriters, which can be located at any place in the network. The work can thus be organized in the best possible way for each individual case, since the terminals can be grouped according to individual requirements.

Centre for the maintenance of the subscriber line network

The staff at this centre receive subscriber complaints and carry out measurements on the subscriber lines in question. When necessary a repairman is sent out, and after the repair the staff check, by means of measurements, that the fault has been cleared.

Fig 2.
AOM 101 makes it possible to control the whole of the network in a large area from one operation and maintenance centre



Operation and maintenance centre

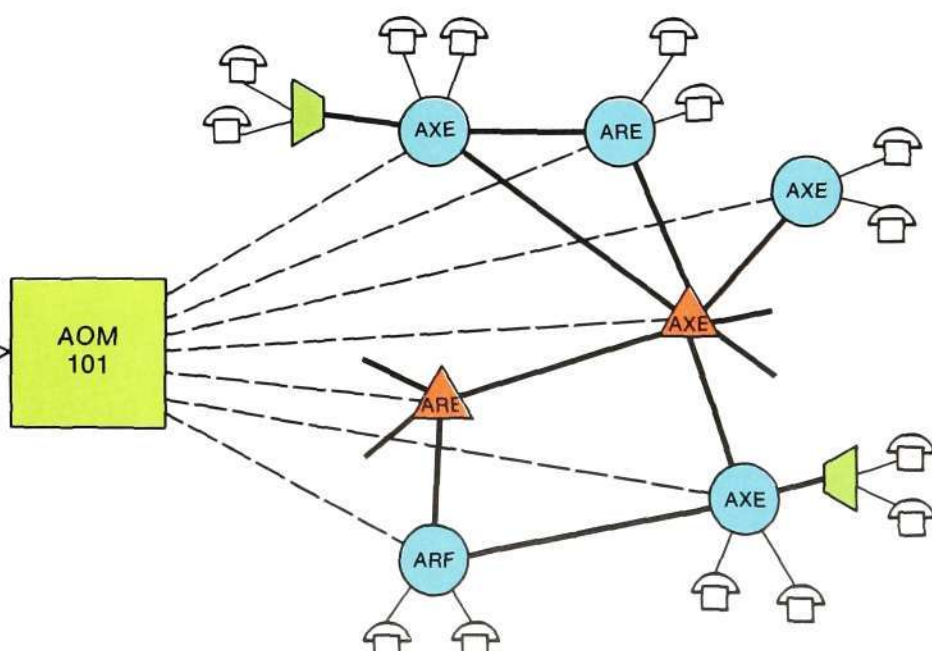
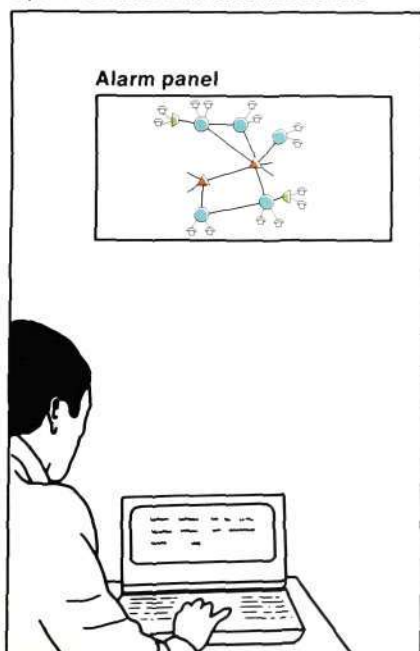




Fig. 4
A work position in an operation and maintenance centre

Sales centre

The staff at this centre receive orders for new subscriptions and request for category changes and also carry out the data changes for such subscribers. They also issue work orders for the personnel who perform the required installation work.

Traffic observation centre

The staff at this centre study the subscriber behaviour and collect and process data for statistics.

Network planning centre

On the basis of traffic recordings the staff at this centre compile information for short-term and long-term network planning. They are also responsible for the necessary action in the case of temporary overload, breakdowns etc.

System AOM 101 and its main parts

System AOM 101 consists of three main parts: work position terminals, a central processing system and exchange terminals, fig. 5.

The work position terminals are equipped with alphanumerical displays, different types of typewriter terminals and colour displays for network information, fig. 4.

The central processing system consists of processors with programs, communication units and external stores.

The exchange terminals, fig. 6, are used as interface and data collecting devices when exchange systems that are not based on SPC technology are to be connected to system AOM 101. These terminals can also be used for remote control of transmission systems, power equipment, buildings etc.

The work position terminals and the central processing system can be installed at different places if desired, since the various parts of system AOM 101 and the telecommunication equipment are connected together by means of data links. They can also be placed away from the telecommunication equipment.

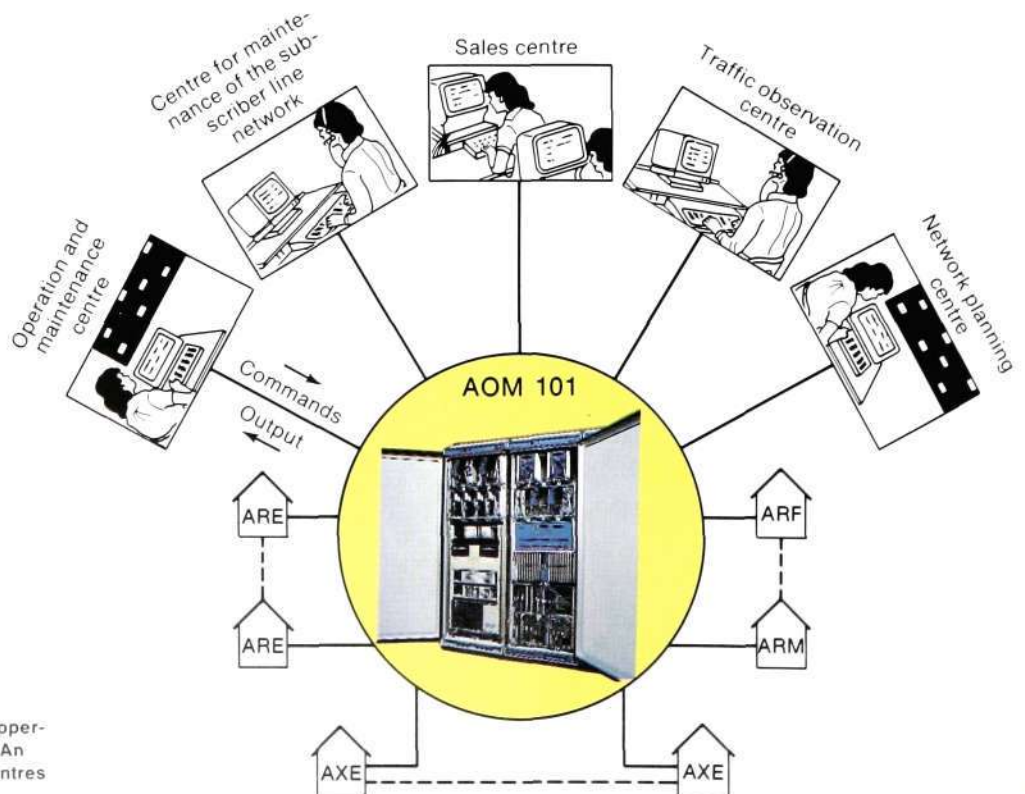


Fig. 3
Computer-controlled system for centralized operation and maintenance activities, AOM 101. An example showing some specialized work centres in the system

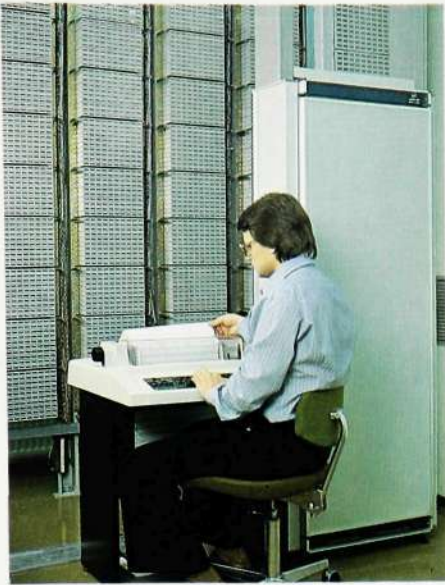


Fig. 6
Exchange terminal with OMT equipment (see fig. 5 below)

The central processing system

The central processing system has two main components: the application system APT and the control system APZ. Each of these consists of a number of modules or subsystems, whose main functions are described in fig. 7. The subsystems in their turn consist of function blocks, which are divided into function units, in accordance with the structural principles of system AXE.

The main characteristic of this structure is that both hardware and software are assembled in different modules according to different requirements. Each module constitutes a complete functional unit.

The system contains two types of processors: a central processor and up to fifteen regional processors.

The central processor is a medium-size processor specially adapted for real-

time applications. It processes the application programs, which are written in a high-level language (PASCAL).

The regional processors are of the mini type. Each such processor has a special job, for example data communication. The regional processors are often used to relieve the central processor of frequently recurring routine jobs.

The main function of the control part of system AOM 101 are described below.

Man-machine communication
AOM 101 contains the necessary functions for man-machine communication via the displays and typewriter terminals that are connected to the system.

AOM 101 checks each operator's authorization by means of his or her personal code, which prevents operators from utilizing unauthorized commands that could give them access

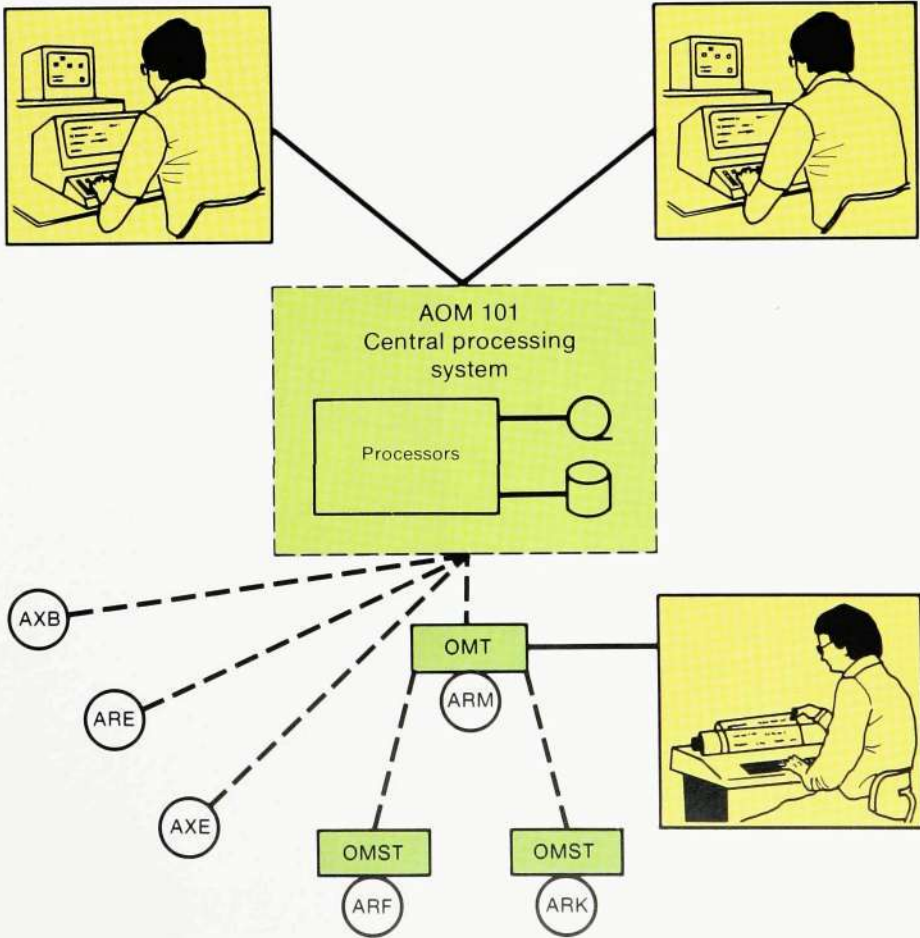


Fig. 5
The main components of system AOM 101
OMT } Terminals for exchanges
OMST } without SPC

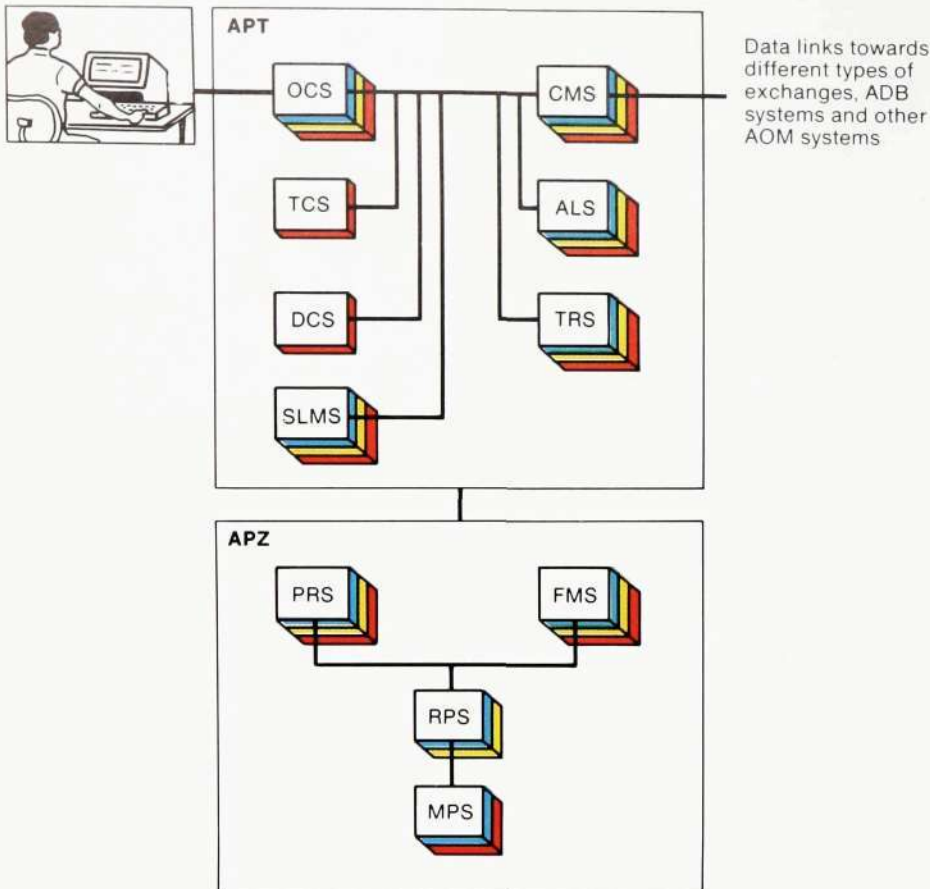


Fig. 7
Application system APT and control system APZ.
Division into subsystems

APT contains the following subsystems:

- OCS Permits man-machine communication via display and typewriter terminals
- TCS Permits recording of different types of data. The data are recorded in disk and magnetic tape stores
- DCS Permits collection of data from the telecommunication network, e.g. charging and statistics data
- SLMS Contains functions for the maintenance of subscriber line networks
- CMS Used by system AOM for data link communication with telephone exchanges, ADB systems and other AOM systems
- ALS Contains functions for receiving, analyzing and presenting alarm information
- TRS Permits traffic route testing in accordance with test programs specified by the operator

APZ contains the following subsystems:

- PRS Permits printout of information on a line printer
- FMS For the administration of data files, stored on disks or magnetic tapes
- RPS Regional hardware and software for controlling I/O devices and communications units
- MPS Central hardware and software for processing application programs

to functions which they are not permitted to use. In addition the system checks the format and partly also the contents of the information which the operator provides from his terminal, in order to prevent faulty commands from being sent out in the network. The system also contains facilities for routing the output to an optional terminal and to interrupt the output.

Up to 64 terminals can be connected to AOM 101, with any desired combination of displays and typewriters. These terminals are connected either individually or via concentrators. In the latter case four terminals can share one circuit, fig. 8.

Recording of data

Recording of data means that information concerning for example all changes that are ordered from work position terminals can be stored in data files. This information may prove useful in case of faults or subscriber complaints.

Alarm data processing

AOM 101 contains functions for receiving, analyzing, distributing and displaying alarm data from the telecommunication network, fig. 9.

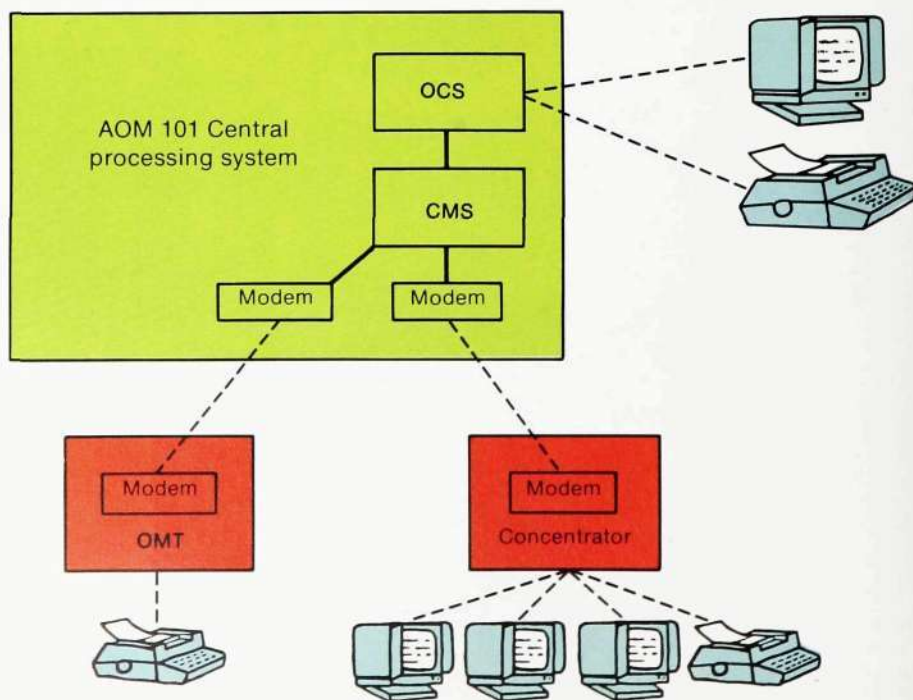


Fig. 8
The connection of operator terminals to AOM 101

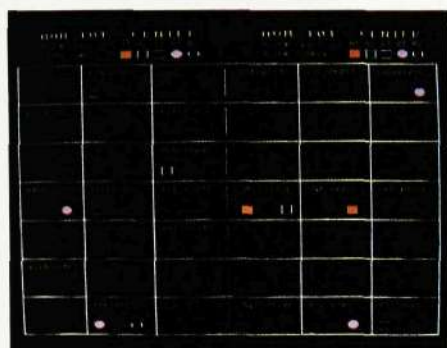


Fig. 9
Presentation of alarm information on a colour display

The alarm status is displayed in overall form on colour displays. The operator can then request detailed alarm information for presentation on his terminal.

Alarm data can be stored in different data files and information from these can be edited and presented to the staff in various ways.

Data collection

This function permits effective and rapid collection of data by means of simple order routines. The information from the network is fed in to AOM 101, where it can be printed out or stored on magnetic tape, which can then be used for processing in an administrative data processing system.

Data communication

System AOM 101 communicates with the connected systems, exchanges,

transmission equipment, power systems, administrative data processing systems and other AOM 101 systems via synchronous data communication circuits.

A maximum of 48 data links can be connected to an AOM 101 system. A data link can work at any of the transmission speeds 1200, 2400, 4800 or 9600 bit/s. The data links are in accordance with CCITT Recommendation X25.

Other functions

The central processing system also contains general functions for processing files and for printouts.

Terminals for the connection of exchanges without SPC

The terminals that are used when systems without SPC are to be connected to AOM 101 are designated OMT and OMST.

Fig. 10
Terminal equipment OMT for an ARF exchange in Tammerfors, Finland



The terminals consist of a number of hardware and software modules, which can be assembled to meet different requirements.

They collect information via test points. Information concerning states, the number of changes and the seizure times at these test points is stored in the terminal stores. A maximum of 10240 test points can be connected to an OMT, fig. 10, and 512 to an OMST.

In addition to test points, control points can also be connected to OMT and OMST. The control points are used for remote control of any function in a telecommunication system. A maximum of 320 control points can be connected to an OMT and 256 to an OMST.

The information that is collected and stored in the terminal stores can be of several different types and it is processed according to type. The results are either printed on a typewriter connected to OMT or transmitted via a data link to the central AOM 101 system.

A number of function blocks have been developed for systems ARF and ARM. However, there is nothing to prevent certain of these being used for the supervision of transmission and power equipments etc.

Among the functions available may be mentioned: supervision of devices and lines, traffic recording, statistics, alarm data processing, collection of charging data, remote measuring of subscriber lines and remote control.

Some applications

The modular structure makes system AOM 101 economical for a wide range of applications. Some examples of the usefulness of AOM 101 are given below.

Maintenance of AXE exchanges

System AXE contains functions that continuously monitor the traffic handling in the exchange and its own control system.

If anything abnormal occurs, for example the number of time forced releases exceeds a preset value, AXE generates an alarm message. This message is automatically and immediately sent via the data link to system AOM 101.

AOM 101 analyzes the message and updates the overall network information on the colour display concerned. If the alarm has high priority an audible alarm will also be given. This informs the

maintenance staff that something has happened which requires action. From his terminal the operator can then request detailed information concerning the fault. He usually obtains sufficient information to be able to decide on the appropriate maintenance action, for example to order a repairman to visit a certain exchange and replace one or more printed board assemblies.

System AXE also contains diagnostic programs which can be activated from the maintenance centre. These programs are used by the staff as an aid for fault localization when the alarm message does not contain sufficient information.

Maintenance of the subscriber line network

Maintenance of the subscriber line network forms a large part of the total maintenance work. However, experience shows that many of the complaints made by subscribers are caused by other things than faults in the subscriber line network, and it ought to be possible to verify this by simple means. It should therefore be possible to supervise the subscriber line network automatically and to carry out measurements by remote control.

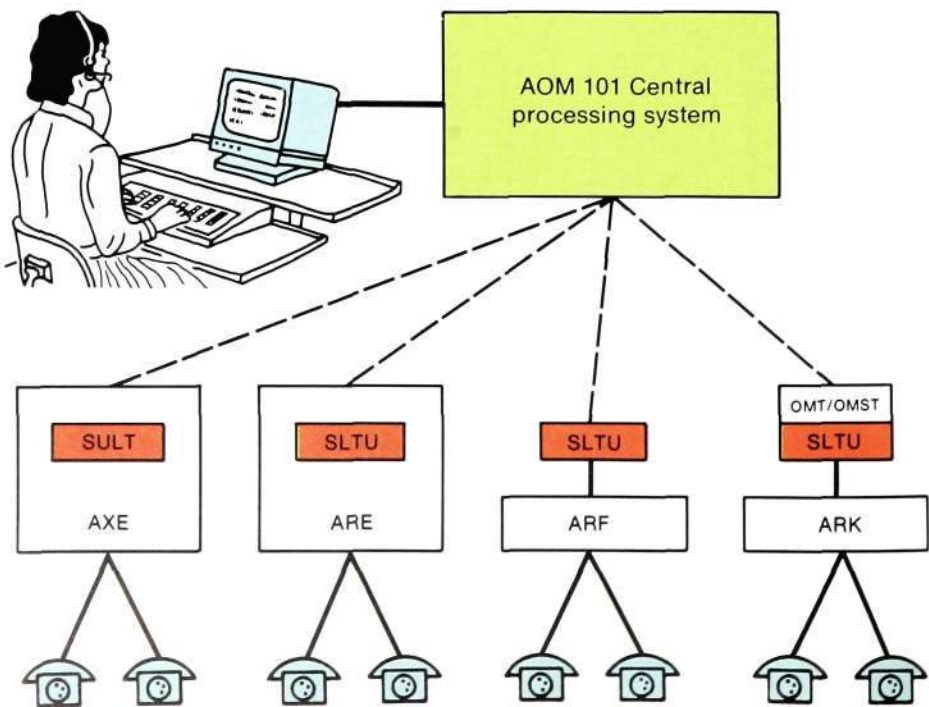


Fig. 11
Remote measuring of subscriber lines with the aid of AOM 101
SULT } Instruments for remote measuring of
SLTU } a large number of parameters

All LM Ericsson's local exchange systems can be equipped with a measuring instrument, which can be connected to any subscriber line by means of a selector. The instrument permits remote measuring of a large number of parameters, such as resistance, capacitance, unwanted voltages and the characteristics of the dial or push-button set.

This instrument is incorporated in exchanges of type AXE and ARE. In other exchange systems the instrument can be connected as a separate unit or as a part of OMT or OMST, fig. 11.

Routine tests of subscriber lines are arranged by the staff, who initiate test programs which automatically test a number of subscriber lines. The routine tests are generally carried out at night.

In addition system AXE carries out a quick test of the condition of the subscriber line whenever a call is made.

Changing subscriber data in AXE and ARE

In an SPC exchange the subscriber data are stored in data stores, and can quickly and easily be altered by means of commands. In AXE and ARE exchanges this can be done from work terminals that are connected to system AOM 101. This means that a special sales centre

could with advantage be set up for this purpose.

In system AOM 101 all ordered changes are recorded in special files, which can be used for fault localization and for updating subscriber data registers.

Alarm transmission from ARF and ARM

Exchange terminals OMT and OMST are used to transmit alarms from ARF and ARM exchanges. Each exchange is provided with a terminal of its own, preferably the smaller one, OMST. The exchange equipment is connected to the test point connectors in the terminal. Alarm information can be transmitted to an operation and maintenance centre via a data link. An OMT terminal, fig. 6, can form the central part in the transmission system.

Conclusion

The cost of the operation and maintenance of the telecommunication network constitutes a significant part of the expenditure of the telecommunications administration. Increased automatization and centralizing of these activities would therefore be a natural development. System AOM 101 is an important aid in this process, since it makes such automatization and centralization attainable.

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Office Communication System DIAVOX 824

Greger Jismalm and Sten Magnusson

DIAVOX 824, a new member of the DIAVOX family of instruments, is an electronic Office Communication System operating on three pairs of wires. The system has been developed by ELLEMTEL on a joint commission from the Swedish Telecommunications Administration and LM Ericsson.

Traditional multi-wire key telephones have long been used as line selectors, secretarial systems and as an alternative to small PABXs. A gradual changeover to electronic "few-wire" systems is now taking place. This not only means reduced installation and rearrangement costs, but also added flexibility and facilities.

UDC 621.395.2

DIAVOX 824 is an office communication system for a maximum of 8 trunk lines and 24 extensions. The system consists of a central control unit, to which extensions are connected in a star-shaped network, fig. 1. Each set is connected via three wire pairs, which makes installation and rearrangement easy and inexpensive. The trunk lines can be connected to a public exchange or a PABX or both.

DIAVOX 824 is used when it is desired to route traffic directly to one or a group of extensions without the aid of a special operator. DIAVOX 824 also offers convenience and ease of operation for call forwarding and attendance, inquiries, call transfers, priority calls, conference and switching between several calls in progress. The system is well suited for small offices, banks, travel agencies and airlines and for executive secretarial groups connected to PABXs.

System facilities

At present the system contains the following facilities:

- External and internal calls
- Privacy on all calls
- Call transfer
- Call pick-up
- Inquiry
- Automatic hold
- Call waiting
- Priority calls
- Private lines
- Call diversion
- Pooled lines
- Call queueing
- Flexible call routing
- Call restrictions

Extension instruments

The extension instruments have the same basic design and the same speech circuit as the new electronic push-button telephone DIAVOX 100.

In the DIAVOX 824 instruments the trunk lines are represented by a button and a lamp, fig. 2. The lamp flashes rapidly for incoming external calls, slowly for parked calls and glows steadily for an engaged line, i.e. a call in progress.

Parking is indicated at the extension placing the call on hold. At all other extensions the line is indicated as being engaged.

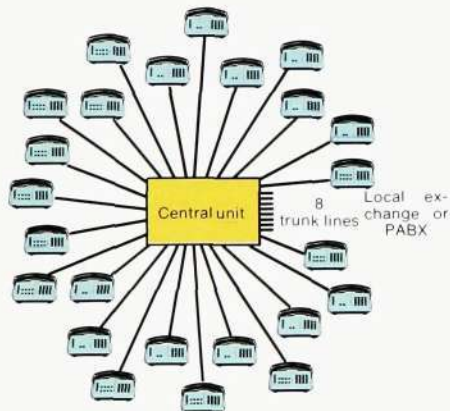


Fig. 1
Office Communication System DIAVOX 824 consists of a central unit and extensions connected in a star-shaped network

Fig 2
Telephones for DIAVOX 824. Types ALPHA (on the left) and BETA
The push-button set and function buttons in ALPHA and BETA are identical regarding both position and function.

D	Diversion	Diverting an incoming call to an attendance position
T	Transfer	Call transfer
C	Conference	Additional functions (Three-party conference and external abbreviated dialling)
R	Register	Service button for signalling to the local exchange or PABX
L1 — L8		Buttons for access to trunk lines
F G H		Prefixes for internal dialling
P	Priority	Signalling to a busy extension





GREGER JISMALM
Subscriber Equipment Division
Telefonaktiebolaget LM Ericsson
STEN MAGNUSSON
ELLEMTEL Utvecklings AB



DIAVOX 824 has one type of telephone (ALPHA) where each trunk line is represented by a button and a lamp. The ALPHA set shows the state of all trunk lines and gives free choice between all of them. An extension with an ALPHA set can thus be used as an attendance position for any of the trunk lines.

DIAVOX 824 also offers another type of telephone (BETA) with only two buttons with lamps for trunk lines. One button is used to answer calls in a call queue or transferred calls, depending on the type of traffic distribution chosen for the extension. The other button is used to get access to an outgoing private line or alternatively a pool of common lines. ALPHA and BETA sets can be used in any combination in the system.

Operation

The aim has been to make the operation easy and fast, since efficient traffic handling is particularly important in many applications, such as receiving and booking orders. The incoming *external calls* are indicated by double ring signals and a rapidly flashing lamp. These calls are answered by lifting the receiver and depressing the trunk line button.

When an external call has been completed, the extension receiver is replaced, which disconnects the call. If instead another trunk line is selected or an internal call is initiated, the original external call is automatically parked. A parked call is indicated by slow flashing of the lamp, and the call is resumed by

depressing the corresponding trunk line button.

An external call is initiated by depressing the button for a free trunk line. The extension then gets dialling tone from the local exchange or PABX, and is free to dial the desired number.

An incoming *internal call* is indicated by a single ring signal and is answered by lifting the receiver.

An internal call is initiated by depressing one of the three internal prefix buttons and one of the buttons in the 12-button set, i.e. F, G or H, followed by one digit. The caller gets the ringing tone if the extension is free and the busy tone if it is busy. In the latter case the caller can depress the priority button (P). The called extension then gets a ring signal even though he is engaged on a call. He must then decide whether he wants to accept the new call, in which case he also depresses the priority button.

All ring signals that arrive when the handset is lifted are reduced to a soft level in the telephone.

In order to make an *inquiry* during an external call it is only necessary to dial the number of the internal extension. The external call is automatically parked when dialling starts. The parked subscriber cannot hear the internal call. The external call is resumed by depressing the trunk line button with the parking indication. If the external call is to be transferred to the called extension, the *transfer* button (T) is depressed.

An external call can also be transferred by depressing the transfer button without dialling any internal number. The call can then be taken by any ALPHA extension, i.e. *call pick-up*. However, parking indication is obtained only on the extension that carried out the parking, and which is therefore responsible for the call. This form of call transfer is convenient when the transfer takes place in one and the same room or when loud-speaker paging is used: "Dave, please take five!"

Traffic distribution

The external traffic in DIAVOX 824 can be distributed over 1–3 routes and

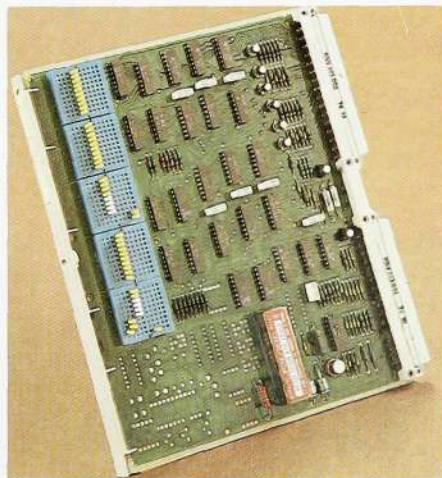


Fig. 3
Programmable exchange data store

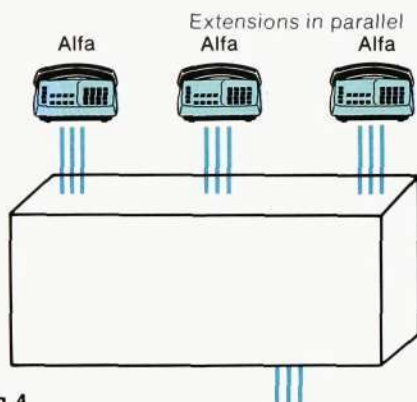


Fig. 4

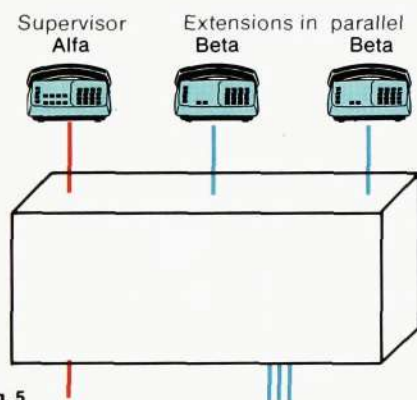


Fig. 5

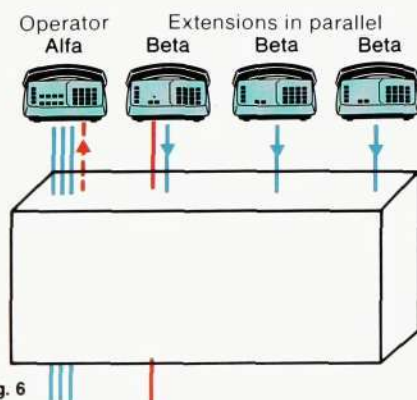


Fig. 6

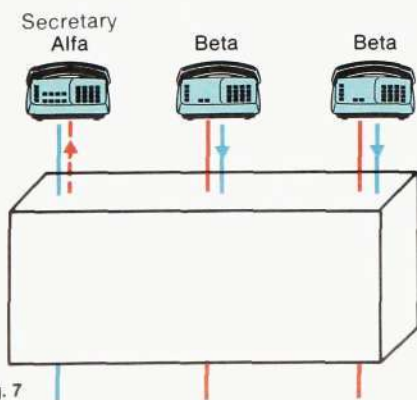


Fig. 7

routed in three ways, in any combination:

- on a trunk line route direct and in parallel to an associated group of extensions
- on another line route to one or several optional forwarding extensions
- On lines to specific extensions (private lines). These lines can be temporarily diverted to an attendance position, when the *diversion* button is depressed (D).

The outgoing external traffic can be arranged so that an extension has a free choice of line or is limited to a certain part of the trunk line route.

The following examples show the traffic distribution in some typical applications. The examples show only one of the three possible groups.

The traffic distribution is arranged by programming a plug board, fig. 3.

Line selector system

All free extensions are called in parallel when a call comes in, fig. 4. A muted signal is also sent to all busy extensions until the new call has been answered. The first extension to answer receives the call.

This traffic distribution has many advantages for small organizations without a special operator. All extensions have ALPHA sets.

Queue system

In this case, the extensions also receive the incoming traffic in parallel. The extensions have BETA sets, fig. 5. The incoming traffic now forms a queue. The first call in the queue is directed to all extensions. The first extension to answer receives the call, and the next call in the queue is presented to the remaining extensions.

A supervisor can be separated from the queue system and given an individual line.

This type of traffic distribution has great advantages for groups that work with order reception, ticket booking, fault complaint reception and similar applications.

Operator system

All incoming traffic on the common lines is directed to an operator, fig. 6. The operator then extends the calls to the other extensions. Outgoing calls can be made direct, without operator assistance.

One or a few of the extensions can be allocated a direct incoming line of their own. The calls can be diverted to the operator by depressing the diversion button.

Secretarial system

All extensions are allocated private lines, for example from a PABX, fig. 7. Private line calls can be diverted to the secretary by means of the diversion button. The secretarial position is equipped with an ALPHA set, and it is therefore possible for the secretary to see for whom the call was intended.

Adaptation to the telephone network

Adaptation to the over-riding system is carried out by programming the exchange data store and allows for the following:

- external dialling with VF signalling
- external dialling with decadic impulsing
- with impulsing: frequency, pulse/pause ratio, pause between digits and digit standard (corresponding to the order of the digits on the dial)
- type of register calling signal
- the length of the ringing signal pause
- any clear-forward signal on parked lines.

Central control unit, modularity

The central control unit can be placed in an ordinary office environment. It is a compact and quiet unit for wall mounting or table location, fig. 8.

The magazine in the central control unit holds a maximum of 24 printed board assemblies, two of which constitute the main distribution frame of the system. Eight of these board types form the basic equipment for all system sizes. The four remaining modular types of printed board assemblies allow a step by step system extension.



Fig. 8
The central equipment can be placed in an ordinary office environment

ELC	Extension Line Circuits	4 extensions per board
BTC	Bothway Trunk Circuits	4 trunk lines per board
LJC	Local Junction Circuits	2 internal links per board
SWN	Switching Network	8×8 cross points per board

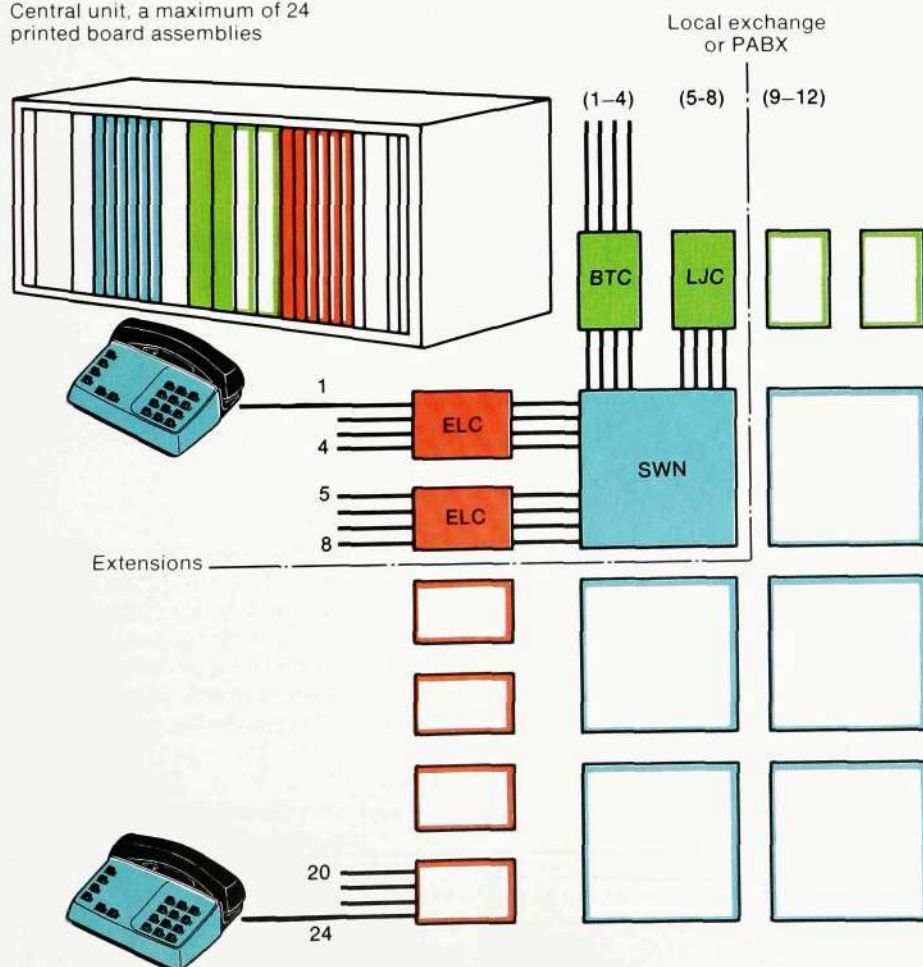
The modularity can be employed to obtain the following system sizes:

Extensions	Trunk lines	Internal links
8, 12, 16, 20, 24	4	2, 4, 6
8, 12, 16, 20, 24	8	2, 4
8, 12, 16, 20, 24	12	2

In the basic package the system is delivered equipped for 8 extensions, 4 trunk lines and 2 internal links. In fig. 9 the modular printed board assemblies that are included in the basic package are shown within the dashed line.

Fig. 9
The equipment in DIAVOX 824

Central unit, a maximum of 24 printed board assemblies



A trunk line board, which corresponds to four trunk line circuits, takes up one device board position. Alternatively the same position can accommodate two internal links. Within certain limits the device board space is available for trunk lines or alternatively internal links. The central control unit automatically senses which type of device board is installed in each position and reacts accordingly. At present the ALPHA sets can only handle 8 trunk lines, but a system with 12 trunk lines and only BETA sets is possible.

System structure

The system structure of DIAVOX 824 is shown in the block diagram of fig. 11. Each extension is connected to a common central unit via six wires. Two wires are used for analogue speech transmission and four for signalling. The central equipment consists of a switch and telephony devices for internal and external lines. The central unit also contains transmitters and receivers for the internal signalling, and a control system with processor, data and program stores. All units are connected to a system bus. The control system is designed for a maximum of 36 extensions and 28 trunk lines to cater for future applications.

Signalling system

All signalling between the extensions and the control unit is made via the four-wire digital signalling channel. The control unit does not perform any signalling detection on the analogue wire pair, since the key pad, the ringer and the cradle function also use the digital signalling channel.

The line signal is bi-phase modulated with a bit frequency of 62.5 kHz. This frequency is chosen so that a common receiver in the control unit can scan up to 36 extensions in approximately 30 ms, which corresponds to the shortest button depressing time that can occur.

The control unit continuously sends 32 information bits towards each extension, and these are updated at intervals of 2 ms. Each information bit can control a light emitting diode or tone ringer. The transmission timing is extracted from the continuously received signal.

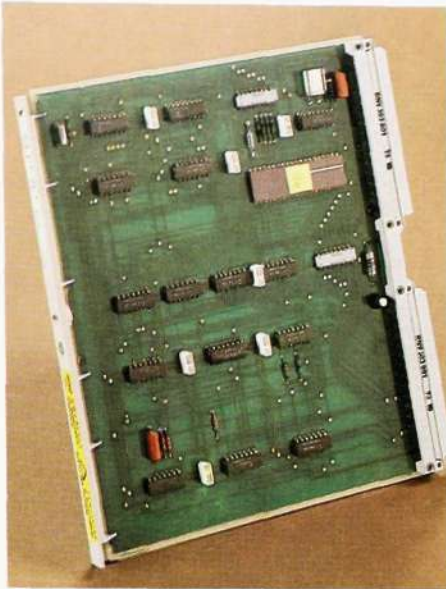


Fig. 10
Processor board, CPU

The state of all push-buttons and the cradle is continuously transmitted from the extensions by means of signal words of 7 information bits. The signalling from the extensions is periodically scanned by the common signalling receiver. The signalling receiver can scan up to 36 extensions in approximately 30 ms. During each scan the receiver compares two consecutive signal words for each extension. The signal is accepted and transmitted to the data store only if the two words are identical. In this way sporadic line interference is prevented from causing faulty connections.

Control system

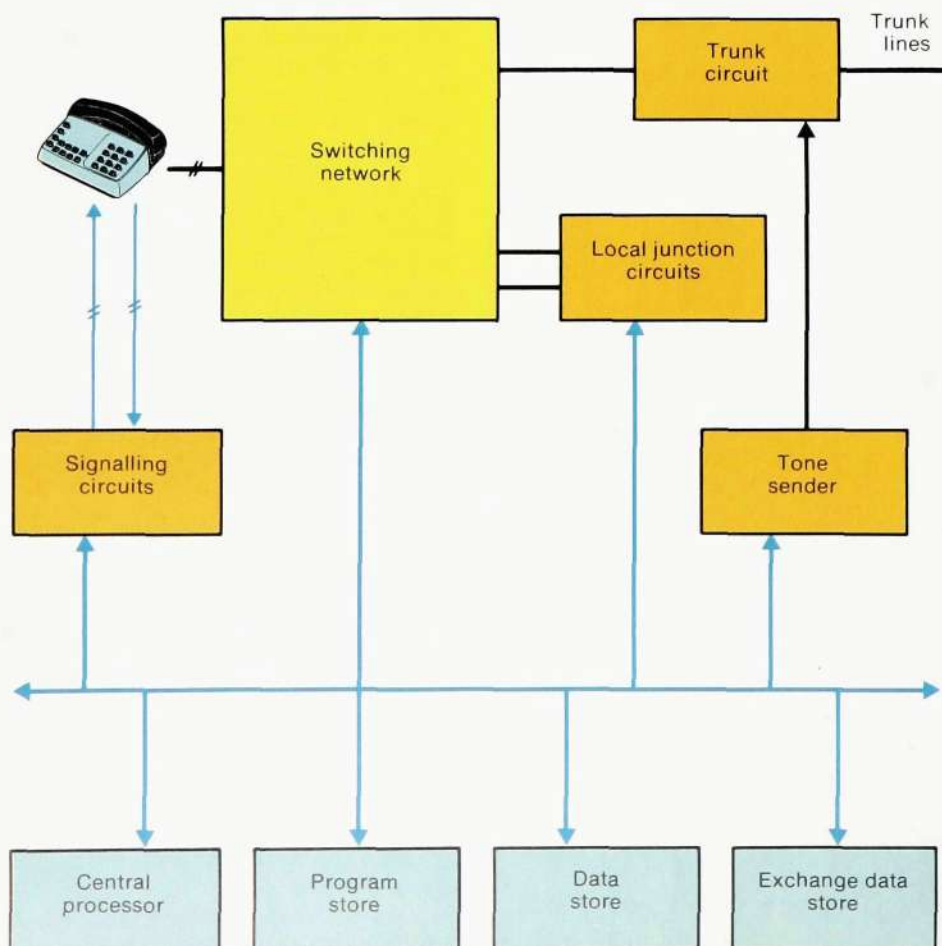
The control system consists of an 8-bit microprocessor (CPU), program and data store, clock and counters for generating timing signals, fig. 10. The program store is a mask programmed ROM store comprising 8 k bytes. The data store is a static RAM store of 2 k bytes. Adaptation to individual market

and customer requirements is done by means of programming in the exchange data store. The block diagram shows how the central control unit hardware is connected to the system bus. A 16-bit direct and inverted address is used on the address bus in view of the relatively large number of units that require individual addressing. This leads to simple circuits for address decoding.

A large number of hardware units must be controlled and scanned in real time. The data structure reflects the hardware structure since each unit has been allocated an individual area in the data store. The areas contain data words for signals, stages and link addresses to other units. The CPU provides real time control by addressing and processing the units cyclically and frequently enough to deal with all the desired functions in each unit.

The time limits for certain functions require exact timing. The timing is carried out by software with the aid of a break signal, which initiates the timing routines every 12.5 ms.

Fig. 11
Block diagram of DIAVOX 824



Trunk lines

The trunk circuits detect ringing signals, send loop signals and digit information (pulse or tone) to the over-riding system and connect the lines to hold. The tone signals are generated in a common tone oscillator.

During an external call the trunk line circuit is galvanically through-connected. The extension speech circuit is thus fed directly from the over-riding system.

Internal links

During internal calls the extension speech circuit is fed from an internal link. The internal link attenuates the speech level by 8 dB to provide levels similar to those of an ordinary external call, the internal link also sends the busy tone and ringing tone for internal calls.

Switch

The switch in DIAVOX 824 is a single-stage congestion-free reed switch with two-pole cross points. The relays are mounted in 8×8 cross points per board module and the switch is electronically controlled and supervised. This switch



Fig. 12
Reed switches for DIAVOX 824

was originally developed for the subscriber stage in system AXE, fig. 12.

The speech wire pairs from the extensions are connected to the rows of the switch matrix, and devices of the type trunk circuits or local junction circuits are connected to the columns.

Extensions

In addition to the conventional telephone function the extensions also have functions for receiving lamp and tone ringer information and for sending pushbutton and cradle switch information.

The transmission of speech between extension and central equipment is two-wire with conventional feeding. The speech circuit is electronic and located in the handset. The same components are used as in DIAVOX 100.

Light-emitting diodes, push-buttons and components for the transmission of information are mounted on two printed boards in the set. One wire pair is used for each signalling direction. The signalling electronic circuits are fed in phantom over the two signalling wire pairs. The power that can be transmitted in this way over a 2 km line is limited, and low current CMOS circuits are used in the telephone set. Later these will be combined into a custom design circuit. A low current connection method has also been used for the light-emitting diodes in order to save power.

Installation, operation and maintenance

Installation and rearrangement is greatly simplified, since the system uses a three-pair installation cable that is the same for all extensions and applications. No programmable functions are lost if a mains failure occurs. Thus the system is immediately available when the power returns. In the case of a mains failure line 1 is through-connected to an emergency telephone. The system can also be equipped with a back-up battery.

Installation testing and fault localization are carried out with the aid of a simple manual, an ALPHA and a BETA instru-

ment and a set of fault-free printed board assemblies.

Systematic test connections indicate the fault at the printed board assembly level. The voltage is disconnected and the faulty board is changed. The voltage is then switched on and the system is ready for use.

The central unit does not require cooling fans. The same high-quality components and the same system for quality audit are used for DIAVOX 824 as for other LM Ericsson telephone exchange systems.

During normal operation the system will supervise itself in order to limit the effects of electrical interference and component faults. The system also sends an alarm to the instruments if the programming of the exchange data store is clearly implausible.

Gas discharge tubes protect the system from overvoltage on the trunk lines. The extension line circuits are protected by automatic electronic fuses.

The instrument speech circuits are protected against radio interference. Each set contains a special thyristor diode across the speech wires as a protection against transient voltages on the line.

Upgraded version

Due to requests from various markets the system is under further development and will be equipped with more functions, among them the following:

- Abbreviated dialling with up to 30 common numbers
- Trunk discrimination control with up to 4 categories, comprising a maximum of 50 open or blocked directions
- Three-party conference
- Internal direct speech connection (with a loudspeaking telephone attachment)
- Night service and night blocking
- Cyclic call distribution for the queue function (ACD)
- Internal group hunting
- Call diversion if no answer
- Transfer before answer with recall
- Programming of exchange data and directory numbers from ALPHA sets.

Booster Converter BMR 263 as the Active Filter in Power Supply Systems

Folke Ekelund

In order to obtain high quality speech connections in a telecommunication network it is necessary to ensure that any noise voltages generated in the system do not exceed permissible levels. Such noise voltages can originate in for example the power supply equipment, but units that are powered from the equipment can also be noise sources.

LM Ericsson's power supply system type BZD 112 contains DC/DC booster converters with a high conversion frequency (20 kHz). The regulation characteristics of these converters make them suitable as noise suppressors (active filters). The booster converters effectively suppress low-frequency noise generated by the rectifiers in the power supply equipment and also noise from the connected telecommunication equipment.

The attenuation of the booster converters compensates for the lower attenuation of the power feeding circuits for subscriber lines in electronic exchanges, so that CCITT recommendations are satisfied.

Recommendation G123 refers to circuit noise in national networks. In section C, which deals with noise in a national, four-wire, automatic exchange, it is specified that the mean value of noise during a long period in the busy hour should not exceed the following values:

- Psophometrically weighted noise: -67 dBm0p (200 pW0p)
- Unweighted noise: -40 dBm0 (100 000 pW0) measured with a device with a uniform response curve throughout the band 30-20 000 Hz.

At a relative level of 0 dB

- -67 dBm0 = -67 dBm corresponds to 0.35 mV
- -40 dBm0 = -40 dBm corresponds to 7.9 mV

UDC 621.311.4

Power supply systems for telecommunications must satisfy a number of requirements so that the telecommunication equipment can operate reliably and the quality of the speech connections can be kept at the desired level¹⁻³. The requirements include not only absence of interruptions and limiting of voltage variations (both in the stationary condition and during transient processes) but also limiting of the levels of a.c. noise voltages that are caused by the power supply equipment. These requirements are based on CCITT Recommendations G123C and Q45, which concern transit exchanges but which have to a certain extent also been applied for local exchanges.

Recommendation Q45, which concerns the transmission characteristics of an international exchange, specifies the same limit values. The requirements are intended to maintain good transmission characteristics for both analogue and digital transmission (PCM). For example, in the case of digital transmission the noise voltage will affect the quantizing distortion.

The requirements given above apply for trunk and subscriber lines and must be converted into values that are applicable to the power supply equipment. The conversion must take into consideration both the attenuation in the power feeding circuits of the exchange and the

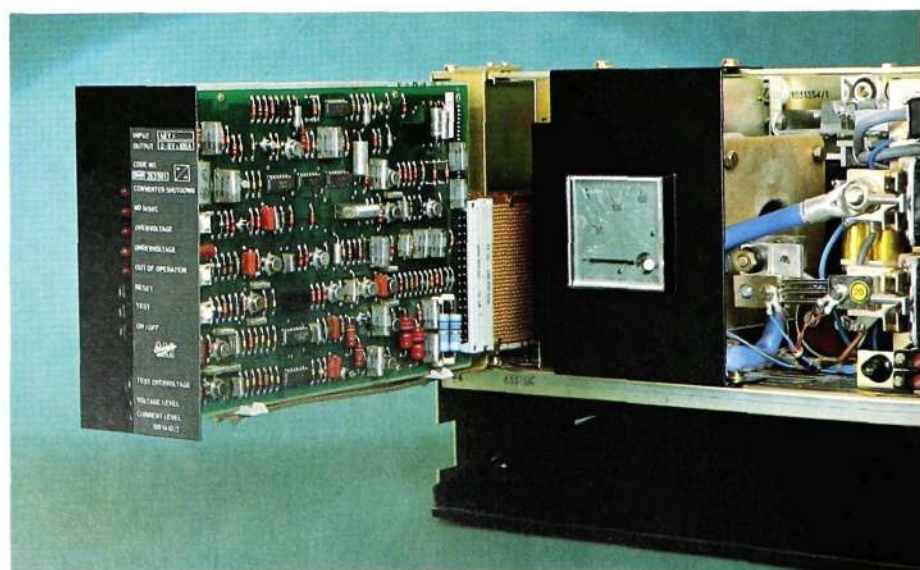


Fig. 1
Booster converter BMR 263, 100 A, 0-8 V.
The extended printed board assembly contains the control unit with regulation circuits for voltages and currents, including circuits for active filtering



FOLKE EKELUND
Power Supply Department
Telefonaktiebolaget LM Ericsson

need of margins for other noise sources in the exchange or transmission equipment.

In electronic telephone exchanges of type AXE the attenuation in the power feeding circuits is lower than in older exchange types. This has led to more stringent requirements for power supply equipment as regards a.c. noise.

The permissible noise on the 48 V distribution is as follows:

for transit exchanges

<5 mV (r.m.s.) in the frequency band 30–200 Hz

<2 mV (r.m.s.) in the frequency band 200–500 Hz

for local exchanges

<10 mV (r.m.s.) in the frequency band 30–200 Hz

<5 mV (r.m.s.) in the frequency band 200–500 Hz

These limits apply for an arbitrary part of the power distribution network, regardless of the current output up to full load.

Among the power supply units the rectifier constitutes a noise source in the above-mentioned frequency bands. A pulsating voltage is obtained when the mains voltage is rectified, i.e. there are a.c. voltage components superposed on the d.c. voltage, whose frequencies are whole multiples of the mains frequency⁴. The magnitude of the noise voltages is greatly dependent on the unbalance in the three-phase mains network. The greater the difference between the phase voltages, the greater the pulse voltage obtained. The above-mentioned requirements have therefore had to be

qualified to apply only when the network unbalance does not exceed 5 %.

The a.c. voltages generated by the rectifiers in an equipment are not only dependent on the unbalance of the network but also on the rectifier output current and the impedance in the battery circuit. High load and poor batteries give the highest noise levels. Table 1 shows some rectifier noise voltage values.

Booster converter BMR 263 as a filter

LM Ericsson's power supply system contains a booster converter, whose output voltage is added to the battery voltage¹, fig. 2.

The booster converter has to maintain the exchange voltage at the nominal level if the battery voltage falls, for example because of a mains failure. A system with booster converters ensures uninterrupted power supply and a high degree of utilization of the available battery capacity.

The booster converters in system BZD 112 work at a conversion frequency of 20 kHz. The advantages of a high conversion frequency are not only small volume, low weight and silent operation, but also very good regulation characteristics, which can be exploited to give the booster converter a function over and above those for which it was originally intended. Thanks to its high regulation speed the booster converter can neutralize noise voltages in the frequency band in question (0–600 Hz) and at the same time correct any deviations in the d.c. voltage value.

Type of rectifier	Noise	
	Frequency Hz	Level (full load) mV
Three-phase thyristor rectifier BMT 313, 100 A (6-pulse coupling)	50	25
	100	40
	300	2.5
Three-phase thyristor rectifier BMT 183, 630 A (12-pulse coupling)	50	110
	100	23
	200	5
	600	2.1

Table 1
Measured noise from two types of rectifiers

Fig. 2
LM Ericsson's standard booster converter system

- BR Rectifier, which feeds the exchange and also charges the battery
C Booster converter, which supports the battery, for example during a mains failure, and also acts as an active filter
 I_{BR} Alternating current from the rectifiers, which generates a noise voltage across the battery
 U_B^- Noise voltage across the battery
 U_B^+ The battery d.c. voltage
 U_C^- AC voltage generated by the booster converter to counteract U_B^-
 U_C^+ Noise voltage that reaches the load ($U_C^+ \ll U_B^+$)
 Z The impedance of the system

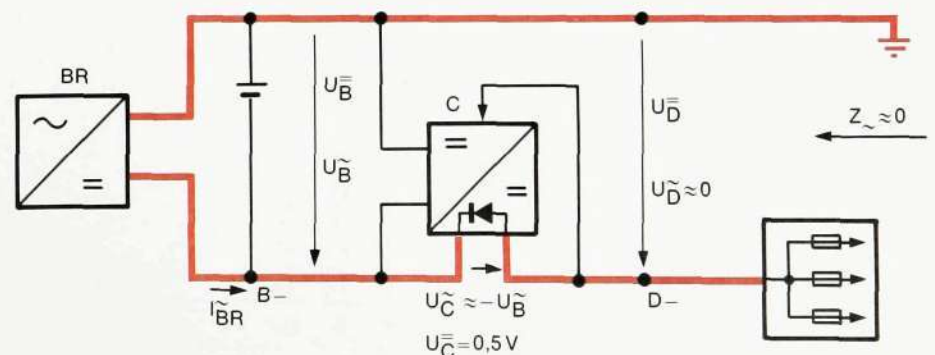
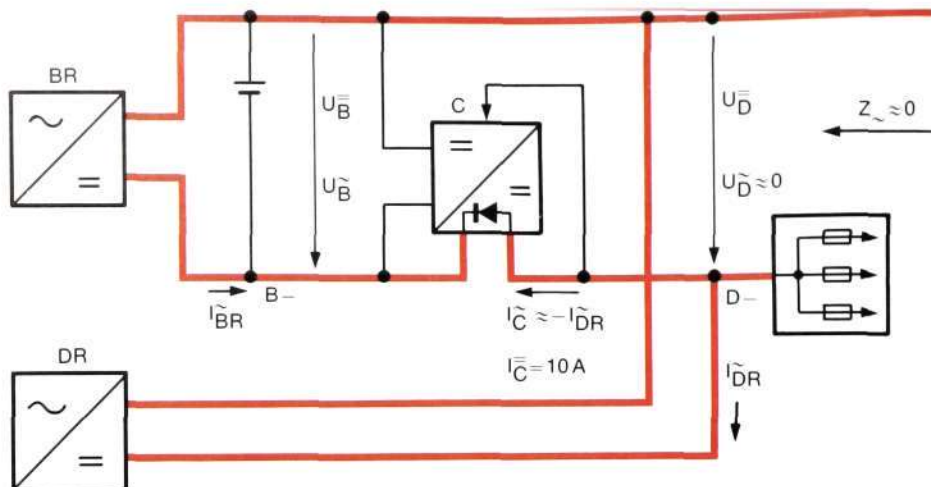


Fig. 3
Booster converter system with distribution rec-
tifiers

BR Rectifier that charges the battery (if necessary it can also feed the load via booster converters)
DR Rectifier that feeds the exchange direct via the distribution network D—
C Booster converter, which supports the battery and also acts as an active filter for all rectifiers (BR och DR)
 I_{DR} Alternating current from the charging rectifiers, fed to the battery
 U_B Noise voltage across the battery
 I_{DR} Alternating current generated by the distribution rectifiers
 I_C Alternating current which is absorbed by the converter and fed to the battery. I_C balances I_{DR} so that $I_{DR} + I_C = 0$. The alternating current that goes out to the load is almost zero.



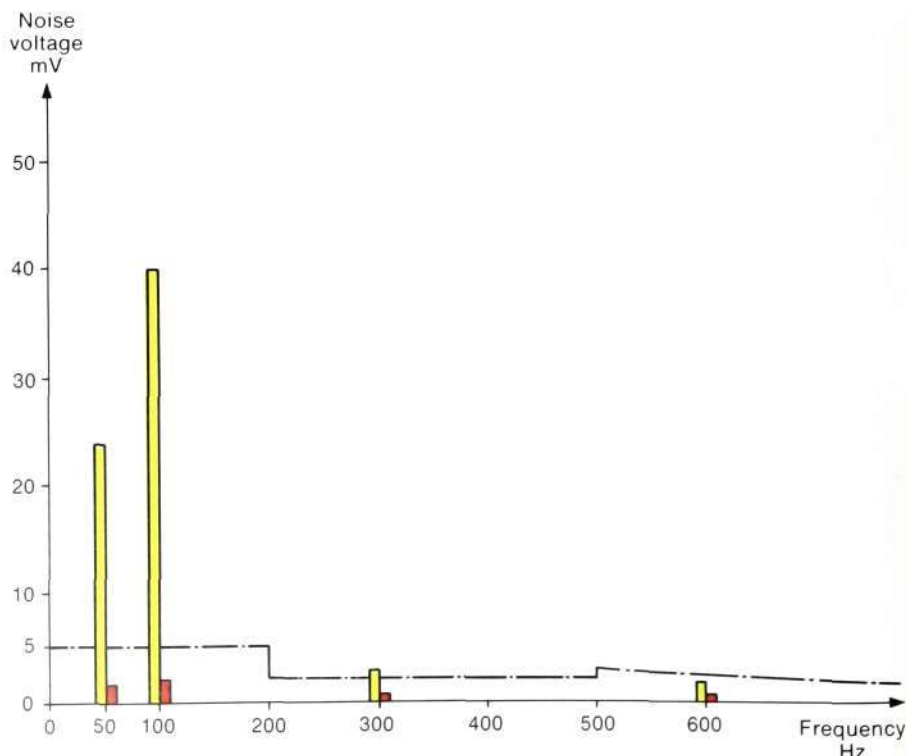
Operation in the system

Fig. 2 shows the position of the booster converter in the system. The a.c. voltage across the battery, U_B , constitutes a noise quantity in the regulation loop of the booster converter. The converter tries to regulate the distribution voltage, U_D , to a constant value. With a sufficiently high amplification in its regulation circuit the converter is able to limit the a.c. voltage, U_D , to a low level (in the order of 1 mV) by generating an a.c. voltage, U_C , on its output that is in opposition to U_B and of the same amplitude. The a.c. voltage U_C is superposed on the d.c. voltage, U_C . In principle U_C could be zero, but the best filter effect is obtained if it is at least half a volt. When the booster converter is used as a filter, a special regulator in its control unit ensures that $U_C \geq 0.5$ V. The filter function of the converter results in very low output impedance for frequencies in the band 0–600 Hz (tenths of a milliohm). Both the noise that originates

from the power supply equipment itself and the noise from other equipment is therefore effectively suppressed.

A system with booster converters can also be built up in accordance with fig. 3. Most rectifiers (DR) then work directly across the output of the equipment—giving the distribution voltage U_D . The branch formed by the battery and converters in series is then connected in parallel with these rectifiers. Charging rectifier BR keeps the battery charged. The alternating current I_{DR} generated by rectifiers DR is then absorbed by the battery and converters. This requires that the d.c. load on the converters is not less than the peak value of the alternating current I_{DR} . When the converter is used as a filter in this system a special regulator in the control unit ensures that the condition $I_C \geq I_{min}$ is met. The value of I_{min} has been set to 10 A in view of the magnitude of the alternating current per rectifier.

Fig. 4
Noise levels in BZD 112 with a network unbalance of 5 %
— Noise voltage across the battery
— Noise voltage across the load
--- Limit values according to LM Ericsson's requirements specification



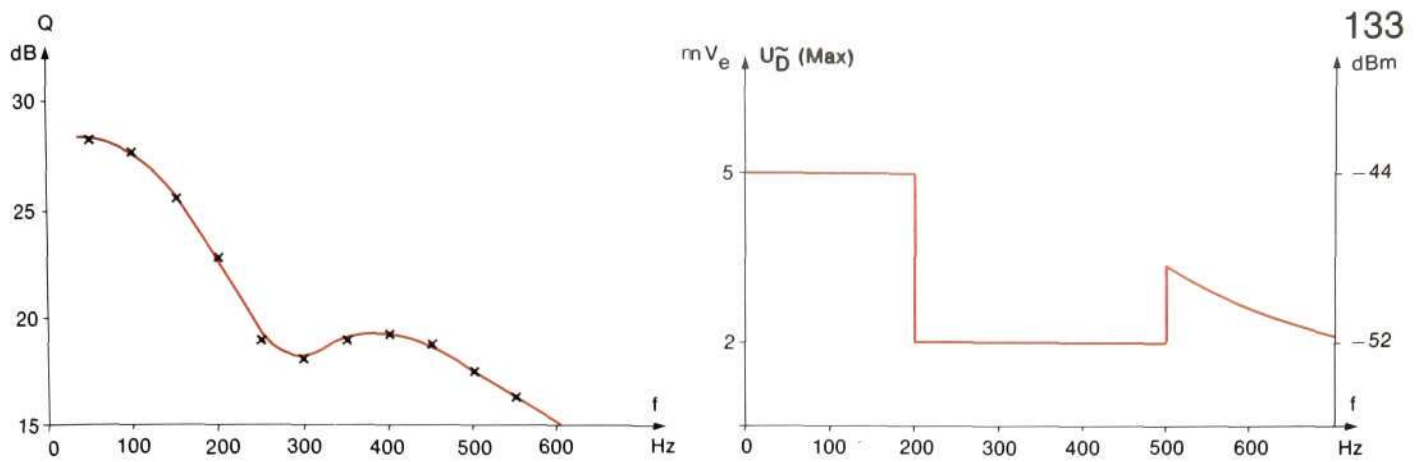


Fig. 5
The noise suppression capacity of the booster converter

The diagram on the left shows the noise suppression (Q) caused by the converter

$Q = 20 \cdot 10 \log (u_D / U_D)$
 U_D The noise voltage across the battery
 U_D The noise voltage across the distribution network
 f The frequency of the noise voltage

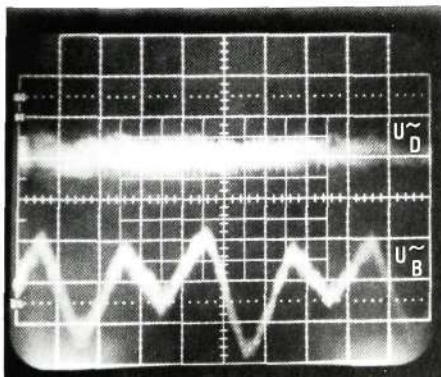
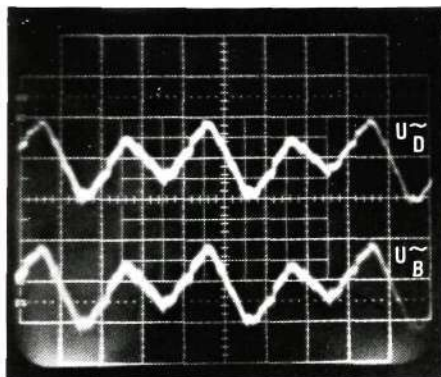
The diagram on the right shows the noise voltage across the distribution network (U_D). If these levels are reached (maximum permissible values for transit exchanges), the noise levels at the battery may be Q dB higher because of the noise suppression capacity of the converters

Fig. 6
Noise voltages, without and with active filtering

U_D AC voltage across the battery
 U_D AC voltage across the distribution network

The top oscillogram shows how the noise voltage across the battery reaches the distribution network without being attenuated when the converters are passive.
 The lower oscillogram shows how the low-frequency noise across the battery is prevented from reaching the distribution network when the converters work as active filters

Scale factors:
 Vertically 50 mV/cm
 Horizontally 5 ms/cm



Performance

Fig. 4 shows the noise levels that were obtained in a BZD 112 system with a network unbalance of 5%. The system contained four 100 A rectifiers and four 100 A booster converters with full load. (The noise levels are lower with smaller load.) The impedance in the battery circuit was $R = 20$ milliohms, $L = 17$ μ henry, values which are higher than is the case in actual installations.

The noise suppression capacity of the booster converter is shown in fig. 5, and the noise voltages, without and with filtering, in fig. 6. The diagram to the right (fig. 5) shows the permissible noise voltage levels on the output (distribution network) of a power plant for transit exchanges. From the diagram it is thus possible to read off the highest noise levels that the rectifiers are permitted to give across the batteries without exceeding the limits. For example, for a noise voltage at a frequency of 100 Hz

the level across the battery (before the converters) must not exceed -44 dBm $+28$ dB = -16 dBm, which corresponds to 120 mV.

Conclusion

The use of the booster converter as an active filter results in noise levels across the 48 V distribution network that are far below the limits given in the relevant CCITT recommendations. Low-frequency noise from the power unit rectifiers, which increases with increased unbalance in the mains network, is effectively suppressed and also noise from the connected telecommunication network.

The new function of the booster converter does not involve any additional costs and gives a power supply system that effectively utilizes all facilities offered by the equipment in order to meet the set requirements.

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Further Development of the ARE Systems

Jan Christensson and Håkan Jansson

Local exchange system ARE 11 and transit exchange system ARE 13 are continuously being improved in order to meet the advanced requirements of today and tomorrow. This article describes the main improvements introduced during the last two years. They comprise new subscriber facilities, rationalization of the control system, faster and more efficient testing, greatly increased storage capacity, a new advanced I/O system, magnetic tape units and common channel signalling.

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The situation at present

A large number of administrations introduced LM Ericsson's crossbar exchanges during the 1950s and 1960s. More than 50 per cent of these exchanges, which now comprise a total of approximately 23 million equivalent lines, are less than 10 years old. From the technical and economical viewpoint it is therefore advantageous to modernize these exchanges to SPC exchanges of ARE type, which is achieved by adding the control system ANA 30. The advantages of such modernization and the positive operational experience obtained have been described previously in a number of articles in this magazine. This applies primarily for the following three countries:

- *Denmark*, where the ARF exchanges in the Århus multi-exchange area were modernized into ARE 11¹. An account of the operational experience has also been given². The first national ARE 13 exchange was put into service in Nykøbing-Mors in October 1977, fig. 1.
- *Australia*, where the ARF exchanges are being modernized to ARE 11, and new ARE 11 exchanges are being installed throughout the country. It is estimated that the network will contain approximately 4.5 million ARE 11 lines when the work is completed^{3,4}.
- *Saudi Arabia*, where work is in progress on the modernizing of all ARF exchanges to ARE 11, comprising ca 200 000 lines⁵. Furthermore the country's four ARM exchanges have been modernized to ARE 13 and supplemented by the latest type of toll ticketing and operator system⁶.

The table on the last page of this article gives a survey of the number of installed and ordered ARE 11 and ARE 13 lines on 1st July 1979, divided into modernizations and new exchanges.



Fig. 1
The first national ARE 13 exchange was put into service in Nykøbing-Mors in Denmark on 5th October 1977



JAN CHRISTENSSON
HAKAN JANSSON
Telephone Exchange Division
Telefonaktiebolaget LM Ericsson



The first ARE 11 exchange of stage 2 design was handed over in Spain according to plan, fig. 2. In this design the switching system and control system are supervised in accordance with the same advanced method. Electronic charging has been integrated into the system and the processor capacity is larger than before. Thus the operation and maintenance processor OMP now has a more efficient operating system, and the central devices are routine tested to a greater extent than before. ARE 11, stage 2 design, has been described previously in this magazine⁷.

A few modifications have recently been carried out in order to improve further the interworking between control system ANA 30 and existing equipment.

Further development

The ARE systems are developed further in step with technological advances. For example, modern semiconductor memories are to replace the present ferrite core memories in the central store of the system and micro processors are to be introduced to control the stores. Moreover the system functions are being improved in accordance with the specifications of the administrations.

PUSH-BUTTON DIALLING AND SUBSCRIBER-CONTROLLED FACILITIES

Push-button sets are becoming more

and more common. They give faster dialling and are a prerequisite for most new subscriber facilities. Thus it is important to have a small and simple tone receiver that can be connected without selectors. The new tone receiver for ARE 11, which is designed in accordance with the new CEPT specification, satisfies these requirements. One receiver is required per signal transfer unit STU. A rack holds 135 receivers, which is quite sufficient for a normal exchange of 10 000 lines.

ARE 11 subscribers with push-button telephones can operate the following facilities:

- Connection and disconnection of barring categories
- Connection and disconnection of interception service from operator, machine announcement or a special tone
- Change of numbers for abbreviated dialling as shown in fig. 3. The common abbreviated dialling list for PABX extensions can be changed via an exchange line.

The CEPT recommendations for subscriber procedures are followed.

A four-figure personal code can be used to prevent unauthorized connection and disconnection of facilities. When the subscriber has completed the dialling the system carries out an authorization check before the change is made. The subscriber is then informed, by means



Fig. 3
Changing the number for abbreviated dialling. The subscriber dials *51*3*08182906# and receives tone information

*	Connection order and separator between different digit codes
51	The order for abbreviated dialling as recommended by CEPT
3	The abbreviated dialled number
08182906	New B-subscriber number, including the area code
#	End of message code
tone information	Inform the A-subscriber whether the change has been carried out or not

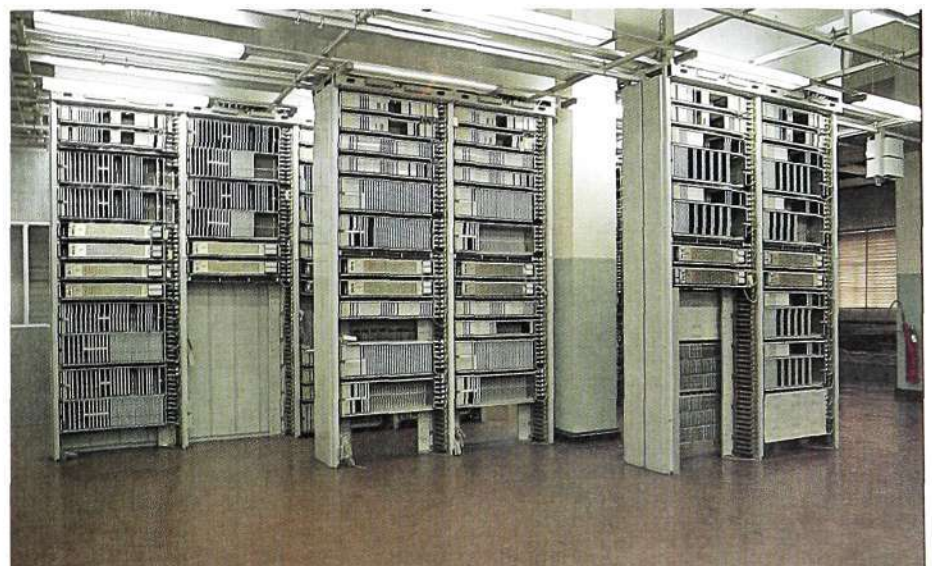
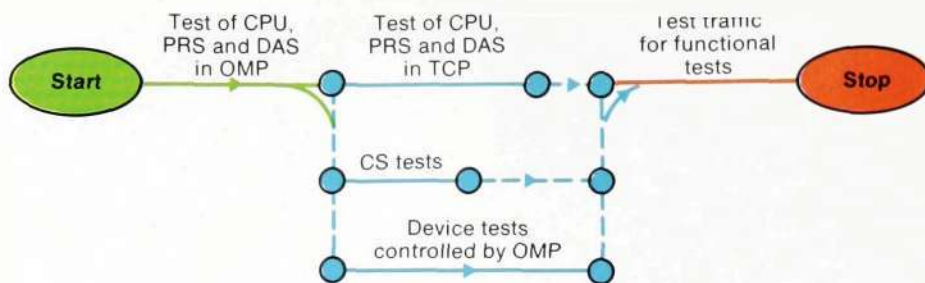


Fig. 2
The first ARE 11 stage 2 exchange design was handed over in Manoteras, Madrid, on 30th August 1978

Fig. 4
The various testing stages during the installation of ANA 30.

Test programs in OMP are used to test the associated CPU, PRS and DAS. Similar tests are then carried out in TCP, controlled by its test programs, and at the same time OMP initiates tests of CS and the other devices in the control system. The subsequent functional testing is carried out by means of test traffic from an ordinary exchange tester

OMP	Operation and maintenance processor
TCP	Traffic control processor
CPU	Central processing unit
PRS	Program store
DAS	Data store
CS	Central stores



of a tone or a message, whether the order has been executed or not. These functions have been realized by means of new programs in the processors TCP and OMP. Such examples show how SPC technology facilitates the introduction of new functions with no changes in the existing hardware.

RATIONALIZATION OF THE CONTROL SYSTEM

When a complete ARE 11 exchange is supplied, the MFC equipment is included as an integral part of the ANA 30 electronic equipment. When an ARF exchange is modernized to ARE 11 it has often proved profitable to design ANA 30 so that it can also control existing MFC code senders and the associated sender finders, which are also supervised by the same methods as other devices. This cuts down the material consumption considerably, and also reduces the installation and testing work.

A new multiplexor, MUX, has been introduced for both ARE 11 and ARE 13. This has been designed so that it can address both its own devices and those in the adjacent rack, which is particularly advantageous for the STU racks where only every second STU rack need be equipped with a MUX. This also re-

duces the material, and the addressing capacity is fully utilized, which is an advantage in large exchanges.

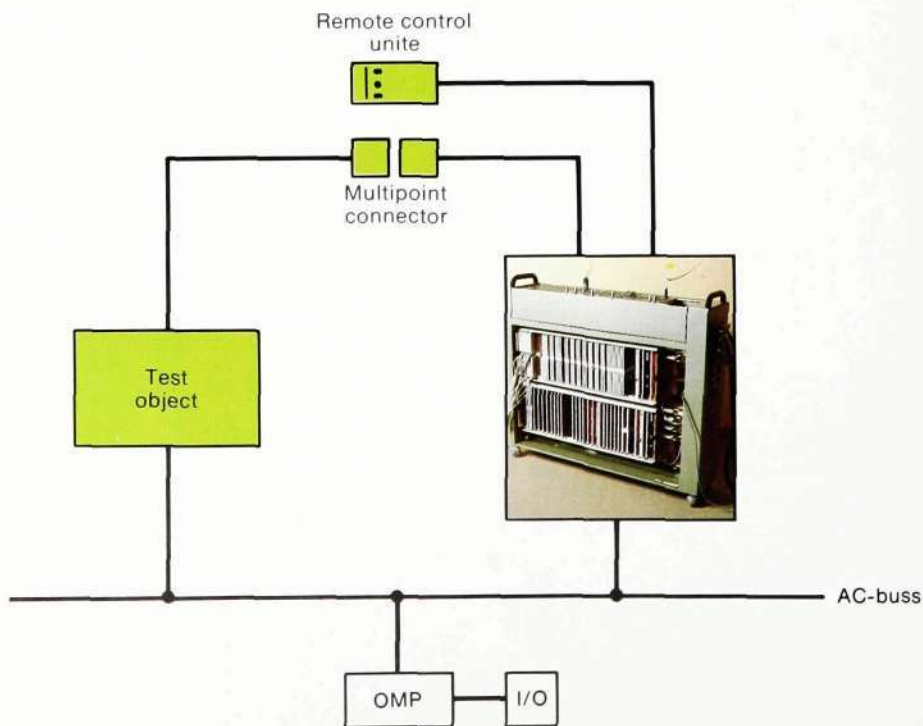
IMPROVED INSTALLATION TESTING Testing of ANA 30

Previously ANA 30 was mainly tested using manual methods. In ARE 11 and ARE 13 it has been possible to automatize the installation testing of ANA 30 by using its own processor, the operation and maintenance processor OMP. The time required for testing and fault finding has now been reduced by two thirds. The tests are initiated by means of commands from I/O devices, which also prints out the result. If a fault occurs, a fault printout code is obtained. The faulty printed board assembly can then be identified with the aid of a test manual and be replaced. The various test stages are shown in fig. 4.

Interworking devices and multiplexors, which constitute the major part of the hardware in ANA 30, are tested in accordance with fig. 5. In this case test equipment, mounted on two trolleys, is used, which interworks with special test programs in OMP. The trolleys are used for testing separate devices or for joint testing of various devices. In this way several types of devices can be tested

Fig. 5
Testing interworking devices and multiplexors using portable test equipment.

The test object is connected to the test equipment, which simulates a normal environment. OMP controls the test object and the test equipment via the AC bus, which is connected to both these units. The testing is started by means of a remote control unit RCU, which contains lamps that indicate whether the test has been successful or not



simultaneously and the fault indication can be improved. The automatic testing makes less demand on the technical and system knowledge of the staff.

The test trolleys with the associated documentation are delivered in special containers, which are re-used to send the trolleys on the next exchange.

Link testing in ARE 11

A new, electronic link tester LT 11 has been designed, which is used in new exchanges and extensions and in modernized ARF exchanges, fig. 6. It is used to test all links in each 1000-group and group selector, and tests loop resistance, leakage etc. This is done in a third of the time previously required, including the tracing and clearing of faults. It is also possible to carry out more extensive testing than before, and the test quality is higher.

INCREASED STORAGE CAPACITY

The storage capacity can now effectively and economically be increased as required, thanks to the use of modern semiconductor memories. Previously ARE 11 had ferrite core memories in three of the central stores in the exchange, namely the translation store TRS, subscriber store SCS and

abbreviated dialling store ADS. The fourth central store, charging data store CDS, has always been of the semiconductor type.

These four store units can now be replaced by a single storage unit, consisting of an electronic shelf, which has over twenty times the capacity of the previous shelf type using core memories (now 256 k words, previously 12 k words). The unit also contains a micro processor for controlling the store, so that the address functions of the large processors need not be changed. The store unit can be placed in an existing rack in an exchange that is already in operation. The increased storage capacity can for example be used to introduce abbreviated dialling and the number group function. The latter gives better multiple utilization and the number of multiple positions can be reduced.

An ARE 13 exchange to which no terminal exchanges without registers are connected, is equipped with only one central store, TRS. However, the amount of data in the exchange is so large that even in this case it is economical to change to semiconductor memories. For example, the amount of data in an international exchange is approximately 36 k words.

NEW I/O SYSTEM

It must be possible to connect ARE 11 and ARE 13 to the computerized operation and maintenance center AOM 101⁸. It is also desirable to simplify the loading of the central and processor stores in the exchanges. The new I/O system, associated with OMP, fulfills this desire, and is equipped as follows:

The number of local I/O inputs has been increased so that eight such devices can now be connected instead of four.

Cassette tape recorders will be used as an alternative to punched tape for the input and output of data and programs to the central and processor stores, if these are equipped with RAM instead of PROM. Cassette tape recorders will also be used for regular output of data regarding electronic charging.

ARE exchanges contain advanced operation and maintenance functions,

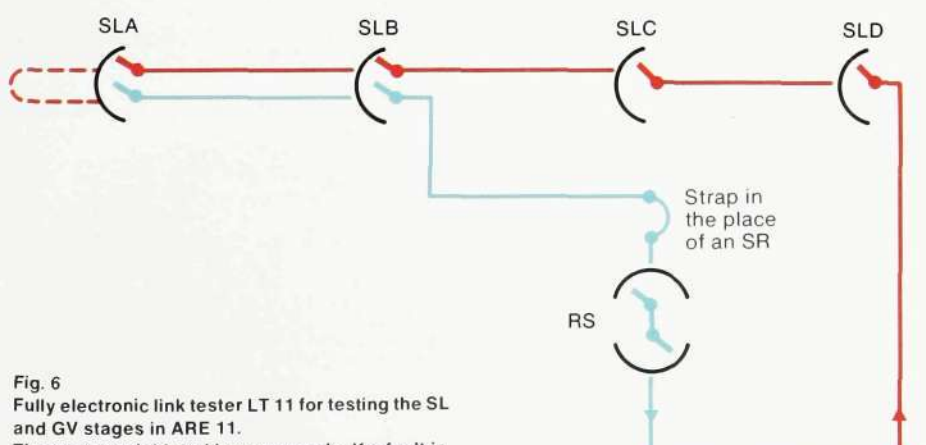


Fig. 6
Fully electronic link tester LT 11 for testing the SL and GV stages in ARE 11.

The tests are initiated by commands. If a fault is detected a detailed printout is obtained that specifies the position and cause of the fault. The link tester sets up 10 connections at a time through the SL or GV stage in accordance with a prepared combination pattern (the figure shows the SL stage), and loop resistance, leakage and extraneous potentials can be measured. The LR/BR function and the current through bars and verticals are also checked (not shown in the figure). The tester also checks its own function by means of diagnostic programs.

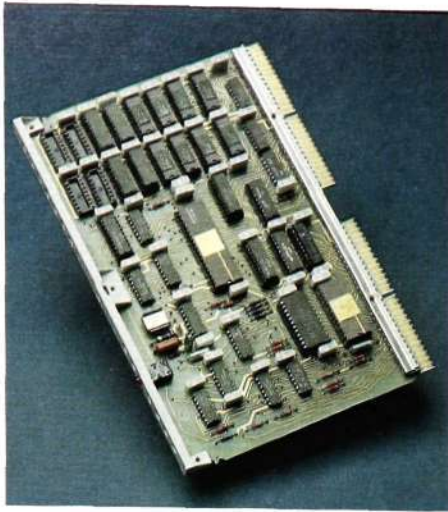


Fig. 7
Micro computer printed board assembly for the new I/O system

which can be controlled locally or from a special centre. When ARE 11 and ARE 13 are connected to AOM 101 the activities are concentrated into different specialized work centres according to the need, which means rationalization of the operation and maintenance work.

The interworking is carried out via data links, and the signalling interworking with AOM 101 satisfies the requirements of CCITT Recommendation X25.

Up to eight I/O processes can be exchanged simultaneously between an ARE exchange and an AOM 101 via each data link. Fig. 8 shows the general structure of the new I/O system.

MAGNETIC TAPE UNITS

When specified charging is required, magnetic tape units are used, which are connected to ANA 30 and can store the required data volume for further processing. The output function is dupli-

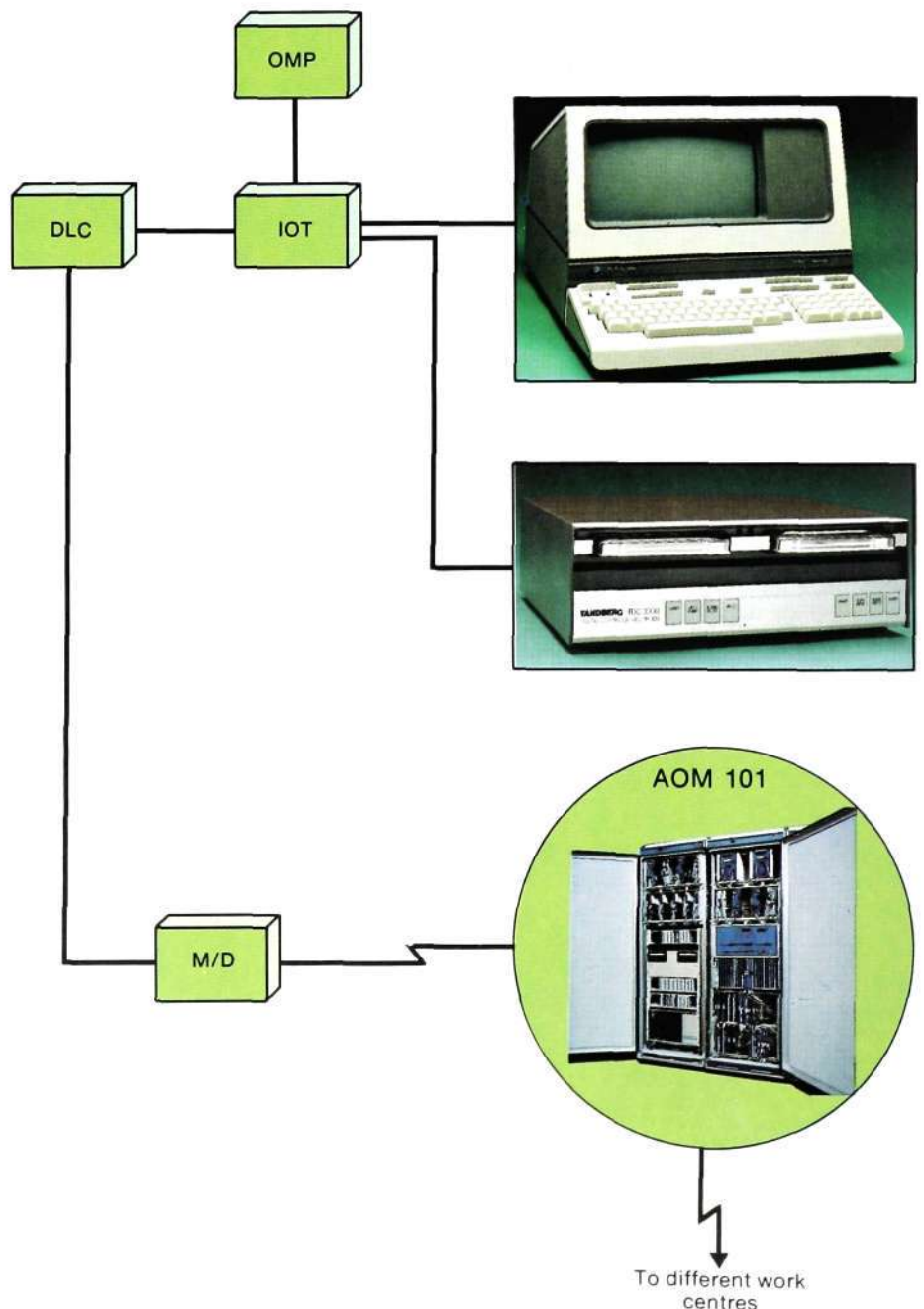


Fig. 8
The general structure of a new I/O system for ARE. Eight I/O devices can be connected and the system can interwork with AOM 101. It contains primarily:

- IOT Micro processor controlled unit for direct connection of display unit, printer and cassette tape recorder
- DLC Micro processor controlled unit for interworking with AOM 101 via a data link in accordance with CCITT Recommendation X25
- M/D Modem for remote connection of AOM 101 and I/O devices
- OMP Operation and maintenance processor in ANA 30, which is supplemented by certain programs for interworking with the new I/O system



Fig. 9
Magnetic tape unit for ARE exchanges

cated for reliability reasons. Magnetic tape is also used as an alternative to cassette tape for the output of data when electronic charging is used. Tape units as shown in fig. 9 will be used as output devices in ARE 11, for both specified and electronic charging. At a later stage these units will also be introduced in ARE for toll ticketing.

COMMON CHANNEL SIGNALLING

LM Ericsson have great experience of common channel signalling in accordance with CCITT signalling system no. 6. This has previously been described in this magazine⁹⁻¹¹, both in connection with local exchanges ARE 11 and transit exchanges AKE 13. The signalling system is now being introduced in ARE 13, which is well suited for common channel signalling. The first application will be the international exchange in Hong Kong, where the ARM 20 is modernized to ARE 13.

The new subsystem for signalling system no. 6 uses LM Ericsson's minicomputer APN 163, to which microcomputer-controlled units are connected, fig. 10. The use of this signal-

ling system will give faster and more reliable connection and will lower the operating costs.

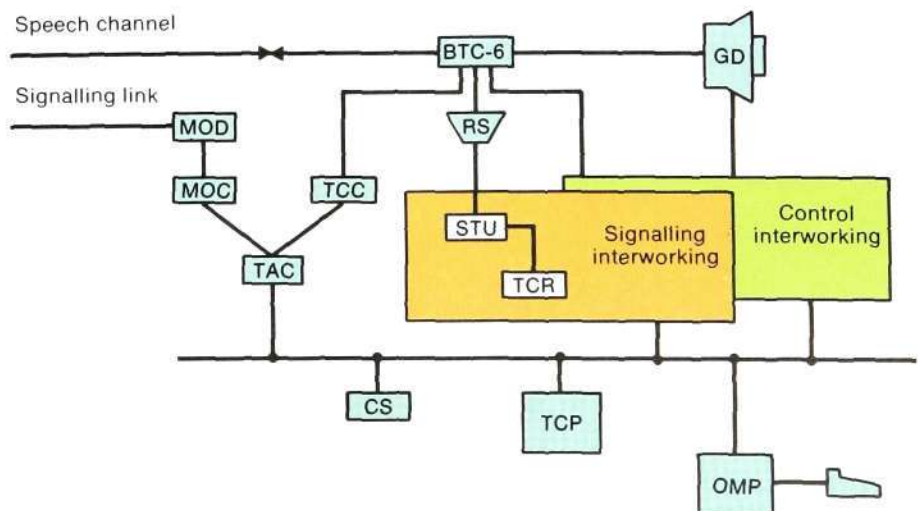
The control functions for signalling system no. 6 are included in the traffic handling processor TCP, and the operation and maintenance functions are included in the operation and maintenance processor OMP, which makes it necessary to extend the translation store.

Conclusion

The advantages of updating local and transit exchanges, ARF and ARM, have been described by several administrations, for example in Ericsson Review¹⁻⁴. Wishes have been expressed from various sources for the introduction of certain additional functions in the exchanges that have been evaluated in collaboration with the various administrations. This has led to the further development of the ARE system described above. The development work will continue when and as necessary so that the system is able to meet new demands and requirements.

Fig. 10
The basic structure of signalling system no. 6 in ARE 13

- MOD Modem for connecting a signalling link
- MOC Micro processor controlled unit for sending and receiving data via the signalling link, for generating and decoding check bits and for supervision, testing etc.
- BTC-6 Both-way international trunk circuit for signalling system no. 6
- TCC Micro processor controlled unit that is common for 32 BTC-6. The interface between TCC and BTC-6 consists of test and operate points, which are controlled by the micro processor. TCC also contains functions for supervision, settling of accounts and plausibility checks on received signals
- TAC Unit which is controlled by the miniprocessor APN 163 and intended for communication between the ANA 30 processors and the micro processor controlled units TCC or MOC as well as between TCC and MOC. TAC handles the transfer between external and internal addressing, selection of line, collection of statistics, supervision of routes and choice of international signalling code. TAC and the associated bus system are duplicated for greater reliability
- TCR Unit for checking the continuity in speech channels
- TCP Traffic control processor in ANA 30 which has been supplemented with particular programs for interlocking with signalling system no. 6
- OMP Operation and maintenance processor in ANA 30 which has been supplemented with particular programs for interworking with signalling system no. 6



ARE exchanges, the number of lines in operation and on order, July 1979

ARE 11

Country	New	Modernized to ARE 11	In operation	On order
Argentina	11 000			11 000
Argentina		2 000		2 000
Australia	74 000		10 000	64 000
Australia		526 400	155 200	371 200
Colombia	30 000		20 000	10 000
Denmark	37 000		28 000	9 000
Denmark		228 000	101 000	127 000
Egypt	20 000			20 000
Finland	33 000		9 000	24 000
Finland		61 200	26 400	34 800
Iceland	1 000			1 000
Kuwait	45 000			45 000
Saudi Arabia	3 000			3 000
Saudi Arabia		198 800		198 800
Spain	84 000		8 000	76 000
Jugoslavia*	79 000		10 000	69 000
Total	417 000	1 016 400	367 600	1 065 800

ARE 13

Country	New	Modernized to ARE 13	In operation	On order
Argentina	18 200		1 600	16 600
Curacao	700			700
Curacao		700		700
Denmark	1 000		1 000	
Egypt	2 400			2 400
Hong Kong	1 400			1 400
Hong Kong		2 000		2 000
Iceland	400			400
Ireland	18 000			18 000
Kuwait	4 400		3 600	800
Libya	3 200			3 200
Nigeria	2 600			2 600
Panama	800			800
Panama		2 000		2 000
Saudi Arabia	17 600		9 800	7 800
Saudi Arabia		6 000	6 000	
Sri Lanka	600			600
Total	71 300	10 700	22 000	60 000

*Via N. Tesla

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TELEFONAKTIEBOLAGET LM ERICSSON

ERICSSON REVIEW

ALARMCOM – A COMPUTER-CONTROLLED
ALARM COMMUNICATION SYSTEM
ERICSSON SLAR – AIRBORNE RADAR FOR MARITIME SURVEILLANCE
2 MBIT/S OPTICAL FIBRE LINE SYSTEM ZAM 2-1
LM ERICSSON'S POWER SUPPLY LABORATORY
AUXILIARY SYSTEMS FOR AXE 10 NETWORKS
TECHNICAL NEWS

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COVER

The alarm centre in the new head office of
Industriaktiebolaget Euroc in Malmö, Sweden.
The alarm system is manufactured by LM Ericsson
Telemateriel AB

ALARMCOM — a Computer-Controlled Alarm Communication System

Claes Hagland, Tor Isaksson and Björn Lengquist

One of the first products manufactured by Lars Magnus Ericsson was a fire telegraph equipment for the transmission of alarms. This was in 1876. Since then the Ericsson Group have developed and marketed several alarm systems. During the 1970s electronics and computer technology have provided new possibilities for developing systems to suit the needs of today.

LM Ericsson Telematerial AB, who develop and market different alarm systems, present their alarm communication system ALARMCOM. There has proved to be a market for it not only among the traditional customers, but also among telecommunication administrations who wish to offer their customers these new facilities. Thus the system has already been delivered to the Dutch Telecommunications Administration.

UDC 621.398: 654.9

ALARMCOM is the common designation for the whole family of alarm communication systems that is being marketed at present.

The concept "alarm communication" was originally created within LM Ericsson Telematerial AB about ten years ago, and it comprises not only the transmission of alarms but also the processing and display of incoming alarms and the triggering of certain actions in an alarm situation.

Buildings, installations and equipment that are to be protected against fire,

burglary or other damage or disturbances are equipped with suitable detectors which can detect damage or the risk of damage at the earliest possible stage.

Measures to prevent breakdown, theft, fire etc. must then be taken quickly so that the extent of the damage is limited. It is necessary to get service engineers, police or the fire brigade to the spot as soon as possible. However, if this is to be effective it is also necessary that these people bring the right type of equipment and that they know in advance what to do.

Present-day technology also makes it possible to supplement the human efforts by instant, remotely controlled measures, such as stopping machines, connecting of cameras, setting off sprinklers etc. These measures can be triggered automatically by the alarm communication system or manually, via the system, by an operator.

A comprehensive alarm communication system contains all these functions. Since the system is able to transmit a great amount of information to the



Fig. 1
Operator's position.
A control panel gives a survey of the alarm situation. The visual display screen shows the recommended action as regards incoming alarms. All measures are recorded on the printer



CLAES HAGLAND
TOR ISAKSSON
BJÖRN LENGQUIST
LM Ericsson Telemateriel AB



alarm centre, alarms can quickly be evaluated with the aid of the computer-controlled central equipment. The alarm computer prints out evaluations and proposals for measures in text en clair, and the operator in the alarm centre can immediately compile a list of measures to be taken and inform the personnel concerned, for example via telephone, radio or telex.

The various parts of the system can have different capacity. The system can thus easily be adapted to different plant sizes by means of choice of suitable equipment. All connections and system parts are continuously supervised. In systems with extremely high reliability requirements it is possible to transmit alarms over alternative connections in the case of a fault in the primary connection. Sabotage to the alarm transmission can always be detected if the messages that are sent over exposed routes are encrypted.

The central evaluation equipment is normally built up around a small computer, to which different types of display and storage equipment can be connected. The display equipment can consist of printers or visual display screens, and in certain cases special lamp panels. Extra large storage capacity is required when the display is to be supplemented with addresses and proposals for measures for different types of incoming alarms.

The required capacity of the alarm centre is determined by the number of connected alarm devices, their alarm rates and the maximum delay permitted for an alarm. Normally the alarm rate is

so low that thousands of alarm devices can be connected to a single display unit.

The alarms are usually transmitted via point-to-point connections. Alarm transmitters that automatically call the alarm centre can also be used.

The remainder of this article is devoted to the latest addition to the ALARMCOM family, HAZ 11101, a system specially suited for medium and large regional installations for the transmission of alarms from banks, industrial plants, offices, defence installations etc., with stringent requirements as regards security level and operational reliability.

System structure

The basic units of system HAZ 11101 are alarm transmitter, concentrator and central equipment. Multiplexors can also be included so that a single circuit can be used jointly by a number of alarm transmitters or concentrators.

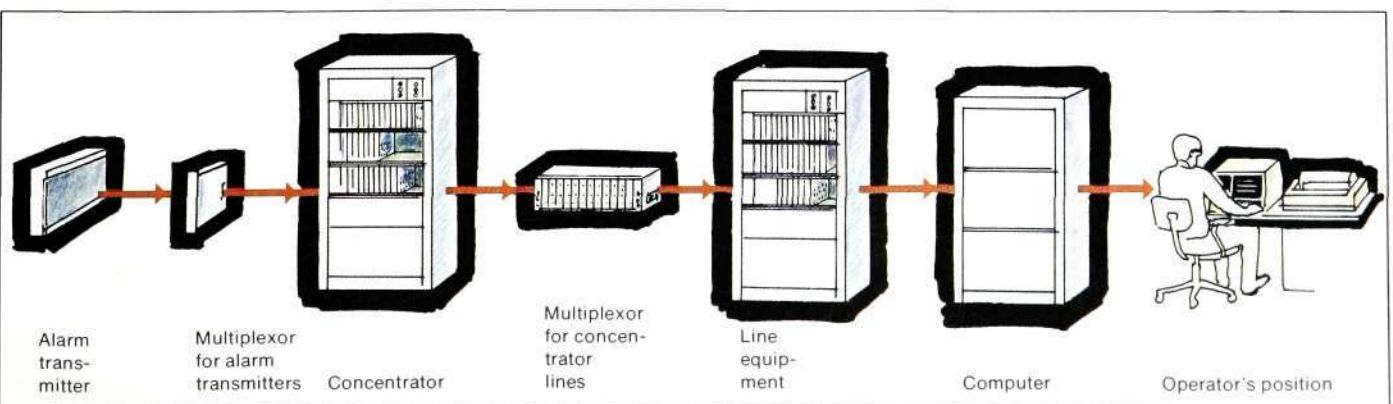
Alarm transmitter

The alarm transmitters connect the alarm devices and local alarm equipment to the system. The alarm transmitters receive control data from the concentrators and on demand send information regarding the existing states of the inputs.

Concentrator

The alarm transmitters in an area are connected to a concentrator. The concentrator continuously supervises the alarm transmitters and the connections to these, and transmits all changes of state to the alarm centre.

Fig. 2
System structure.
The transmission is concentrated in several stages to adapt it to the normal telecommunication network



The concentrator consists of a control unit and equipment for receiving the alarm transmissions. The control system is duplicated in systems where high reliability is required.

Alarm centre

The alarm centre equipment comprises line units for the connection of concentrators, computer equipment with the necessary stores and display equipment consisting of an operator panel, visual display screens and printers. The computer equipment can be duplicated.

Multiplexor

The system structure permits flexible utilization of the telecommunication network. The introduction of multiplexors at various system levels enables the customer to make optimum use of the available circuits. The system structure also makes it possible to use duplicated circuits at the system levels where high system availability is essential.

System characteristics

Basic principle

The alarm transmitters are scanned con-

tinuously by the concentrators. During each scan, any control orders are sent to the alarm transmitters.

The concentrator detects if any changes have occurred in the information from the alarm transmitters since the previous scan, and reports any such changes to the alarm centre. A line multiplexor can be installed between the alarm transmitter and the concentrator, which enables up to four alarm transmitters to use one and the same concentrator line in sequence.

In addition one or more line multiplexors can be installed between the concentrator and the alarm centre, for the purpose of interleaving, encryption and transmitting messages and also supervising the circuit.

Transmission

All transmission between units in the system takes part over two-wire circuits via synchronous modems with frequency shift modulation. Semiduplex with a transmission rate of 200 bauds is used between the alarm transmitters and the concentrators. Full duplex with a transmission speed of 300 bauds is used be-

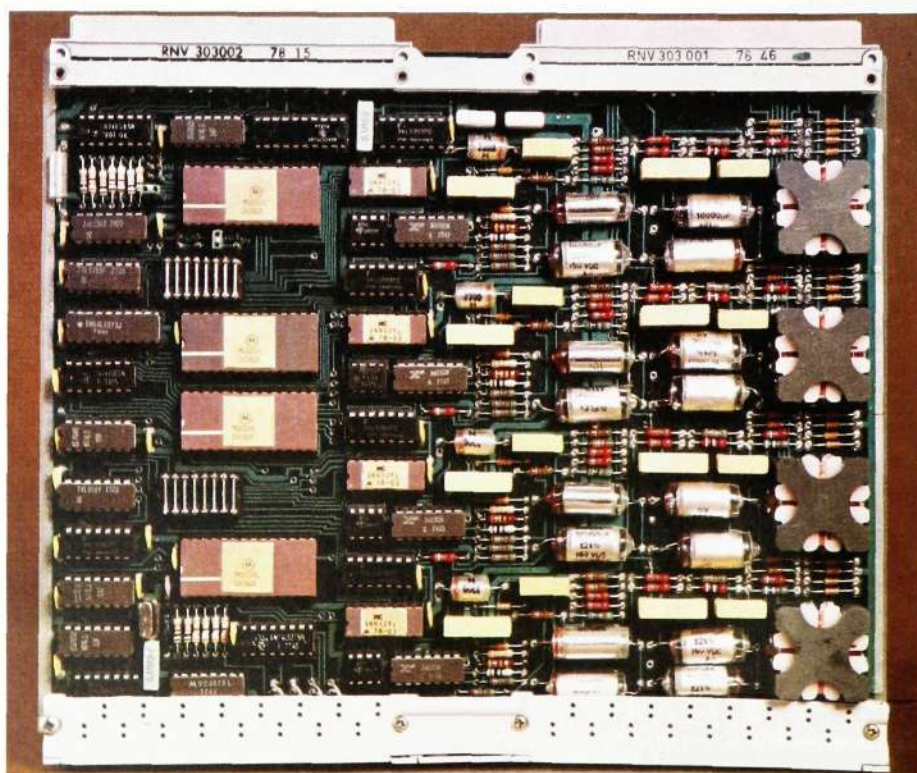


Fig. 3
A printed board assembly in the concentrator. LSI type micro circuits are used, making the units quite compact. The printed board assembly shown here is a connection unit for 4 lines with 4 modems and with line report circuits.

tween the concentrators and the alarm centre. All exchange of information between the various parts of the system is in the form of messages that contain sophisticated parity checking (HDLC format), which gives the system high immunity against interference and reduces the risk of false alarms.

Supervision

All system parts and all connections within the system are continuously monitored. Any faults are reported to the alarm centre by means of fault signals, which are treated in the same way as alarms.

Encryption

Alarm system circuits constitute a security risk when they go through unsupervised areas. Attempts may be made to put one or a group of alarm transmitters out of action by simulating the traffic that occurs when no alarms are being transmitted. Such sabotage can be prevented by providing every message with a signature that is changed with every transmission in a way which is known to the receiver. The message is encrypted and sent to the receiver, where it is decrypted and checked. The encryption eliminates any possibility of simulating the traffic, since the transmitted messages are always

changing in an apparently random manner. The encryption is carried out in accordance with the algorithm that has been accepted as the standard by the National Bureau of Standards in the USA.

Priorities

Fault signals have priority over alarms from individual alarm units, since faults in the system or its communication paths can prevent the transmission of alarms from several alarm transmitters. Alarms from alarm units in their turn are divided into eight priority groups as regards transmission. The purpose of the latter priority grouping is to prevent important alarms from being delayed by other alarms during occasional peak loads in the alarm network, for example in the case of large local power failures.

Operator's position

The incoming alarms are dealt with by a number of operators in the alarm centre. Each operator is provided with an operator panel, a display screen and a printer. The operator panel gives the operator an initial survey of the overall alarm state and is also used to order the desired information for display on the screen.

The printer records all received alarms and the measures taken by the operator.

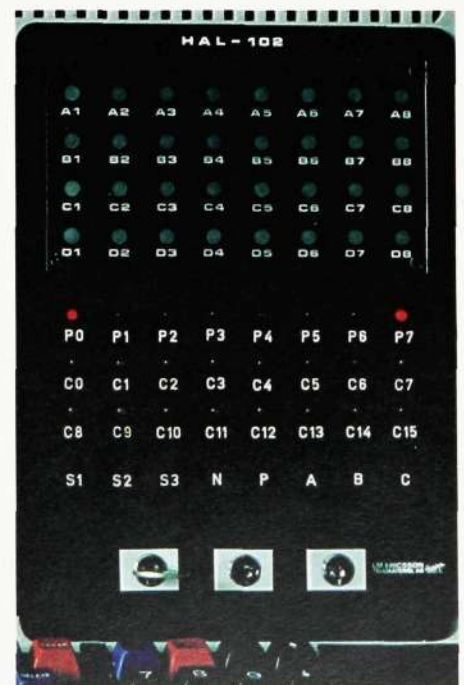


Fig. 4
Visual display screen and operator panel.
The information on the screen consists of section number, object address, object state and proposed measures

Functions of the alarm centre

The operators are supported by the functions of the alarm centre equipment. These functions are mainly realized in software and by data base processing in the computer equipment, and can vary in different installations. The functions described below may be considered as typical for a medium-sized alarm system.

Authorization

Several levels of authorization are used in order to prevent unauthorized interventions in the various parts and functions of the alarm system. Each operator in a centre has a personal code, which together with one of three keys in the operator panel defines his authority level.

The different levels used for the authorized staff at an alarm centre are normally as follows:

- Level 1 – (lowest) Alarm operators who are authorized to receive and acknowledge alarms and to read out information concerning the objects that give rise to alarms.
- Level 2 – Chief operators, who can change the stored information concerning the objects and also their current states.
- Level 3 – The person responsible for a centre, who can change the configuration of the installation by changing the parameters of the system.

Level 4 – The person responsible for the whole system, who can change the software of the system so that whole functions are changed.

Authorization at a higher level automatically gives access to all lower levels.

The evaluation of alarms from the objects is systematized by dividing them into categories. The system permits a number of categories, and the signals from and to the objects are treated in a similar way within each category.

Object states

The situation at an alarm object is described by means of the object state. This can be for example

- switched on or off
- alarm or no alarm
- undergoing testing.

When several alarm units are connected to one object, the object is divided into sections that can be disconnected separately.

Alarm display

When the system detects a change in the state of an object, the operator is informed by means of a buzzer and blinking light in a red light-emitting diode on the panel. The operator acknowledges and the alarm is shown on the display screen. The display contains information regarding

- the identity of the object
- the state of the object
- number of the section in question and type of alarm

Fig. 5
Alarm printout.
Occurrences are recorded on one or more printers

- 1 Type of alarm
- 2 State
- 3 Date
- 4 Time
- 5 Controllable objects
- 6 Sequence number
- 7 Address and times
- 8 Measures to be taken

```
-----1979-06-28 14:20-----ACKNOWLEDGE PICTURE-----
① ROBBERY      ② ALARM      ③ 06-09 ④ 11:15      ⑤ NO-RESET ⑥ 2345
⑦ POST-OFFICE  OXFORD STREET 14      OXFORD      C19 M-3456
OPENING-TIMES: MO-FR:0830-1700 TH:1900-2100 SA:0830-1200 XX:YYYY-ZZZZ
PERSONAL:      MO-FR:0000-2400 SA:0000-1600 SU:2330-2400 XX:YYYY-ZZZZ

***** ACTION INFORMATION *****
⑧ ALARM:      010-112233      010-667788
POLICE:      010-445566
OBJECT:      01234-23456      TSL 2345
              01234-34567      TSL 3456
RESPONSIBLE: MR. SMITH      010-654321
TELEPH. SERVICE: 010-445566
TECHN. SERVICE: 010-665544
```

- prerecorded instructions regarding action, with the relevant telephone numbers etc.
- instructions and descriptions that may simplify the operator's task of arranging the correct action to deal with the received alarm in the shortest possible time.
- one for alarms from objects that are being tested
- one for fault signals in the system (treated as ordinary alarms)
- one for messages concerning recovery from the alarm state.

Expected changes in the object state

Some changes of state are to be expected in a supervised plant. One example are the changes that occur when a bank opens in the morning and closes in the evening. Certain parts of the security arrangements in the bank are put out of action during the day, such as alarm contacts in the outer doors and often also protective devices for the bank vault.

The operator can request further summary and detailed information displays, which may be needed to be able to assess which measures are required.

When the operator has completed the measures required for an incoming alarm, he removes the alarm and is then ready to deal with another alarm.

Alarm priorities

Certain types of alarms require immediate action, whereas some delay can be accepted for other types. Thus the system provides for five different priority levels for groups of objects. Incoming alarms are processed by the central equipment in accordance with this order of priority. Each priority level is indicated and handled separately and the operator is thereby informed about the priority category of every incoming alarm.

There are three more priority levels in addition to the five mentioned above, namely

Such normal changes are automatically dealt with by the system, as long as they occur within a preset time interval for the object, in order not to overload the operator. In practice this means that 90–95 % of the incoming reports are automatically handled by the central equipment. This makes the system more efficient, since the operators are usually called only when real alarms occur.

Alarm handling

Alarms occur at random times and generate an alarm traffic that can be calculated statistically. The traffic calculation methods used in telecommunications engineering can give the probability of



Fig. 6
Alarm transmitter.
The alarm transmitter is mounted either in the same cabinet as the central unit or in a separate, similar cabinet

there being one, two, three etc. simultaneous alarms for processing in the centre. The system has an alarm queue for each priority category so that the alarms can be recorded and displayed in the right order.

The operator is informed if there are alarms waiting to be processed. The operator can also return alarms to the alarm queue after they have been displayed, so that he can work on several alarms at the same time.

Recording

All alarms that are received and processed by the central equipment are recorded, both on the printer at the operator's position and in the data storage equipment, for processing later. Actions by the operators that change the state of an object, the transmission system or the central equipment are also recorded. The records are used to follow up individual alarms and to assess other qualities in the operation of the system.

Statistics

One of the biggest problems as regards alarm systems is that of false alarms, i. e. alarms that have been released without there being an actual alarm situation. The greater the sensitivity of an alarm

unit, the greater the risk of false alarms. False alarms are also often caused by faulty handling of equipment or incorrect use of various alarm units.

Statistical evaluation, in an alarm centre, of received alarms and their causes provides the data for assessing and taking action regarding the number of false alarms. The centralization makes it possible to record all alarms and compare them with corresponding alarms from other, similar installations.

The statistical processing can also provide the basic data for a continual following up of the capacity and functional reliability of the system itself.

Control facilities

An alarm communication installation requires simple control facilities. For example, it must be possible to

- reset alarms by means of remote control
- switch fans, heating and lighting on and off
- unlock and lock doors
- acknowledge received alarms, for example from lifts
- send various test signals.

The system permits such control signals to be given either by manual interven-

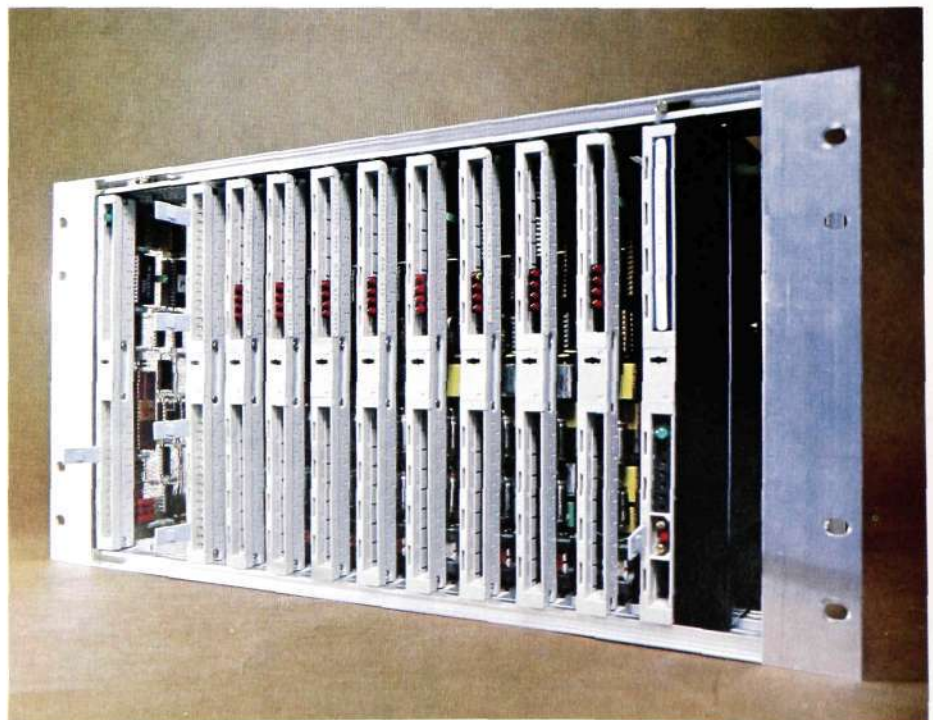


Fig. 7
Magazine with printed board assemblies.
Central units, such as concentrators and line equipments, are built up of 19" magazines and mounted in 19" cabinets. Each magazine is connected by means of plug and jack

tion by the operator, by time programs or by the occurrence of events that were postulated in the program.

Automatic testing

The central equipment contains functions that test the various system parts either automatically or on order from the operator. The purpose of the testing is to ensure that the installation is always ready to transmit and display alarms with the highest possible operational reliability.

Duplicated alarm centres

In cases where maximum security is required, the alarms can be transmitted from a concentrator to two alarm centres. Furthermore these two centres are connected to each other. When operational disturbances occur, alarms can also be transmitted over this connection. Alternatively the second centre can take over the responsibility for the alarm handling.

Data base

The data base in the alarm communication system comprises primarily the following information:

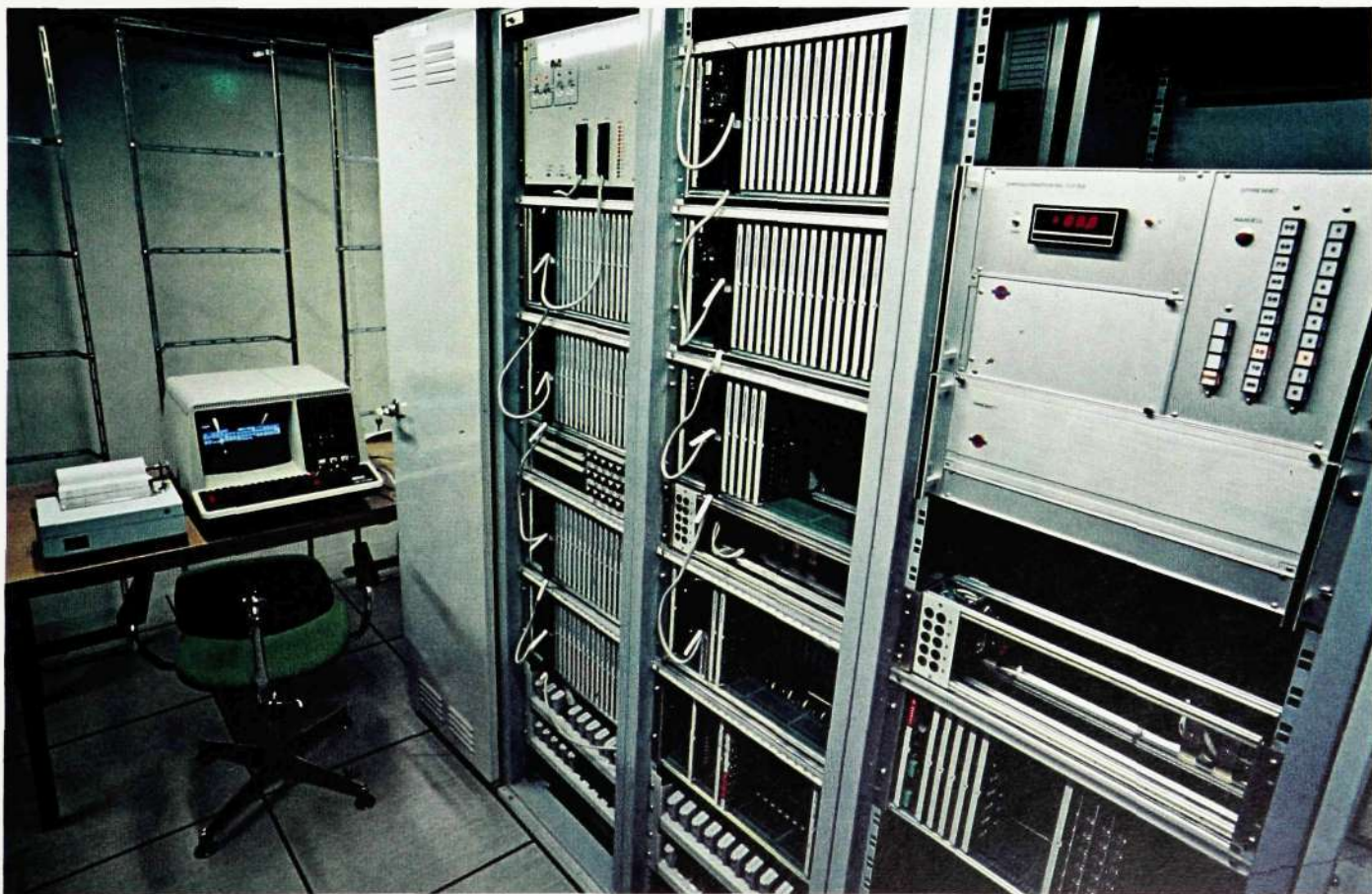
- objects descriptions with addresses and current telephone numbers
- registers with proposed measures for each alarm
- descriptions of the emergency services (police, fire brigade and various service organizations) with addresses, telephone numbers and other essential data.

Input of system parameters

Many functions that concern the communication between operator and system are carried out with the aid of dialogues between the operator and the system.

The system presents the operator with a number of possible alternative actions and the operator chooses one of them. The system then puts questions to the operator, who answers them either with

Fig. 8
Local computer-controlled alarm installation HAL
102



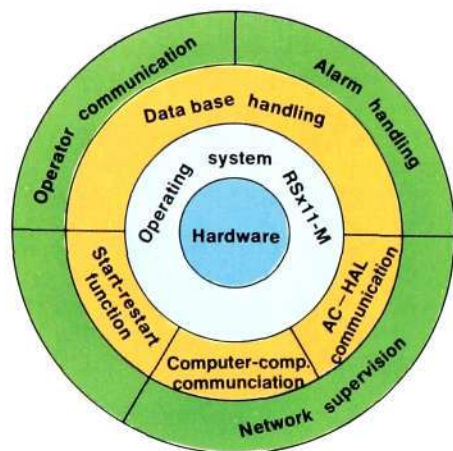


Fig. 9

Diagram of the software in HAZ 11101.

The purpose of the operating system RSx11-M is to distribute the work load on the various processors in the computers. An I/O processor is used to aid the central processor with the input and output of data to series-connected devices. The application programs are written in a high-level language to facilitate adaptation to different customer requirements.

a yes or no or with various data, texts, telephone numbers etc. In this way, even staff who are not data experts will quickly learn to alter and adjust the parameters of the installation. The input data are checked and are accepted only if they seem plausible.

Units in the system

The BYB construction practice, which is used for system AXE, is also used for the units in alarm communication system HAZ 11101. The magazines consist of 19" shelves of type BFL, and contain printed board assemblies of type ROF 13 (178×222 mm).

The alarm transmitters, which contain all the necessary electronic circuits, including a voltage regulator and circuits for eight inputs and outputs, are designed as printed board assemblies of type ROA 119 (344×222 mm).

The cabinets for the alarm magazines are equipped with locks and alarm contacts. Inputs and outputs are connected via an 80-pole RNV contact to each magazine. Certain signalling connections between the magazines utilize the front contacts on the units that handle the signalling between the shelves.

Each magazine contains a converter for the system voltages +12, +5 and -12 V. The magazines are equipped with different printed board assemblies depending on their function in the system. Each magazine also contains a micro computer of type APN 16501.

The system can be powered from standard rectifiers for voltages between 20 och 66 V.

Equipment

Units that are normally used

Magazines

BFL 304 – For connecting four concentrator lines to one or two computers in the central equipment

BFL 303 – Multiplexor for four concentrator lines

BFL 302 – Control unit for concentrator

BFL 301 – Receive equipment for 32 alarm transmitter lines

Other units

ZHZ 51501 – Multiplexor for four alarm transmitters

ROA 119 9302 – Alarm transmitter for the transmission of 8 alarms and 8 control signals. The capacity of the alarm transmitter can be increased in steps of 8 inputs and outputs to a maximum of 32 inputs and outputs

PDP 11 – Minicomputer in the alarm centre having an internal memory of 256k bytes and disk stores of at least 10M bytes

Special units and systems in operation in large numbers

HAL 101 – A simple transmission link with 1200 baud FSK modem and semiduplex asynchronous operation

HAL 102 – Local large computer-controlled alarm installation that supervises the security and operation of buildings and whole industries

– Regional system with simplified alarm display

HAL 106 – Transmission system which forms part of HAZ 11101 but which can also be connected to HAL 102 systems

HAL 107 – Transmission system with DC pulses that is connected to HAL 102 and which is used particularly for fire alarms

HAL 108 – Transmission system which forms part of HAZ 11101

HAL 11101 – VF transmission system that is connected to HAL 102 and can transmit up to 8 state indications for one object

The transmission systems in the ALARMCOM family can be combined to give the desired function in an alarm communication installation. For example, a HAL 102 concentrator with a standard cable and standard units can be connected to a concentrator in HAZ 11101. Alarm transmitters in HAL 106 can also be connected to a concentrator in HAL 102.

ERICSSON SLAR — Airborne Radar for Maritime Surveillance

Birger Ekengren

LM Ericsson's MI Division have developed a radar that is intended particularly for maritime surveillance from aircraft. It was developed on commission from the Swedish Space Corporation and in collaboration with the Swedish Coast Guard. System studies proved that a side looking radar would be best for the purpose. The radar system ERICSSON SLAR (Side Looking Airborne Radar) has been tested in the aircraft of the Swedish Coast Guard since 1977. It is now in series production and is being marketed in several countries.

In this article the background of ERICSSON SLAR and the radar itself are described. Calculated performance and test results are also given.

UDC 621.396.967:
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621.396.96.3

Since 1977 most coastal nations in the world claim an economic zone of 200 nautical miles off their coasts. The demand for the extension from 3 or 12 nautical miles, which was previously the usual limit, arose mainly because of the development in two fields. Firstly the traditional coastal industry, fishing, was threatened by depletion by increasingly efficient fishing fleets. Secondly offshore oil finds were of fundamental importance to the economy of many countries.

However, if an economic sea zone is to be upheld it must be possible to supervise it efficiently. Radar reconnaissance is an efficient means of detecting and tracing ships at any time of the day or night. The surveillance can be carried out from land-based radar stations, from ships or from aircraft. The choice of method must be made indi-



BIRGER EKENGREN
MI Division
Telefonaktiebolaget LM Ericsson

vidually, to suit the organization that is to carry out the reconnaissance.

Radar reconnaissance from aircraft

The supervision of Swedish waters is handled jointly by the Air Force, the Naval Forces and the Coast Guard. All these organizations utilize airborne radar. The Swedish Coast Guard have chosen to complement their coast supervision vessels with light aircraft. Two Cessna 337 Skymasters, fig. 1, have been in use since 1976, and in 1979 a Cessna 402 was added to the aircraft fleet. There are plans to purchase another plane in 1981.

The Coast Guard aircraft are used mainly to supervise fishing and check on oil discharges. Since aircraft have greater mobility and surveillance capacity than ships they can be used to direct a ship to the correct area quickly and thus contribute to good overall economy.

Radar is a necessary aid in air reconnaissance since the radar can locate ships as well as oil slicks at great distances regardless of the optical visibili-



Fig. 1
The Coast Guard Cessna 337 with an SLAR antenna pod

Type of ship	Gross tonnage	Mean cross section (m ²)
Dinghy	0.3	0.1 – 1
Small fishing vessel	5	5 – 10
Steel trawler	100	100 – 150
Small coastal vessel	200	500
Cargo ship	10 000	5 000
Tanker	40 000	100 000

Table 1
Typical radar cross sections for ship targets

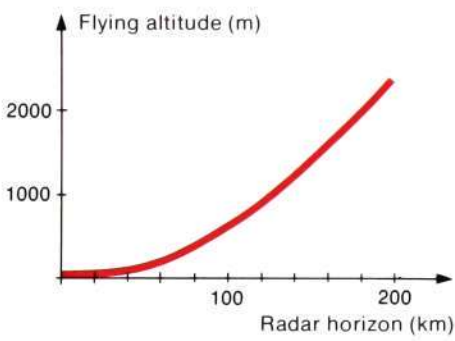


Fig 3
The relation between flying altitude and radar horizon in normal atmospheric conditions

ty. The radar pulses can also penetrate rain and fog, which makes the method relatively independent of the weather. This increases the number of hours during which air surveillance is possible. The surveillance can be carried out at irregular intervals. When sea-patrol aircraft are equipped with radar, intentional oil discharge and illegal fishing can therefore not take place under the protection of darkness or bad weather without the risk of discovery.

Radar surveillance does not normally allow identification of the target. However, when a suspect ship is discovered, it can be identified by flying to the spot or sending a ship there. The plane should be equipped with cameras to record the suspect ship, possibly supplemented by infrared sensors or low-light television for reconnaissance in the dark. The optical equipment usually necessitates flying at a low altitude.

Radar system for airborne maritime surveillance

Range for large targets

A steel trawler or a coastal vessel constitutes a large radar target, table 1. Even a fairly simple radar system with a moderate output power can detect such targets at a distance of 50–100 km. In the case of civil reconnaissance from a fairly

low altitude it is often not worth while investing in more powerful radar systems since the curvature of the earth means that the targets can only be detected out to the radar horizon, fig. 3. However, in the case of military reconnaissance it must be assumed that the radar system will be exposed to electronic countermeasures, which justifies more advanced and thus more expensive radar systems. When designing radar for maritime surveillance it is thus essential that the system requirements are thoroughly analyzed, so that one does not pay for performance characteristics that can never be utilized.

Range for small targets

If the normal tasks of the airborne reconnaissance include assistance in sea rescue operations and the pursuit of smugglers, it must be possible to detect very small radar targets. For these to be visible on the radar indicator it is not sufficient that the reflected signal is strong enough to be detected by the receiver. The target signal has to compete with reflections from the surface of the sea, sea clutter, which are characterized by their mean amplitude and their variations with time.

In order to reduce the mean level of the sea clutter the horizontal beam width

780717 3
165532 2
57299 142
17265029

Fig. 2
Illegal oil discharge in the Baltic Sea.
The photograph was taken from the Coast Guard Cessna 337. The data panel in the top right-hand corner shows that the photo was taken on July 17th, 1978, at 16.55.32, latitude 57°29.9' and longitude 17°26.5'. These data are also used in the SLAR display



must be small, the radar must have a short pulse length and the aircraft must fly low. The disadvantage of short pulse length and low flying is that they reduce the possibilities of seeing targets at great distances. A narrow antenna beam can be obtained by using a large antenna, which would obviously cause installation problems in the plane.

The effect of the sea clutter variations can be reduced by using the mean of a large number of readings (video integration). This can only be done if the antenna beam points at the target for a long time.

The conclusion is that the possibility of detecting small targets increases if the radar system is equipped with a large antenna, which slowly scans the relevant area. A simple way of achieving this is to use the principle of a side looking radar with a fixed antenna, fig. 4.

Radar for the Swedish Coast Guard

Choice of system

In 1976, on behalf of the Swedish Space

Corporation, LM Ericsson started work on the development of an airborne surveillance radar for the Swedish Coast Guard. At that time the new radar was mainly intended for oil spill reconnaissance.

Initial system studies showed that a side looking radar gives better possibilities of detecting oil on the water than a conventional forward looking radar. To be able to solve certain hitherto unsolved system choice problems it was decided to develop a prototype and install it in one of the Coast Guard planes. The Coast Guard were anxious to have continuous display of the radar picture in the plane during the flight. The radar system was therefore equipped with digital signal processing, so that a radar map could be displayed on an ordinary TV monitor without delay. A new antenna was developed that gave optimum coverage of the sea.

The prototype of ERICSSON SLAR was delivered in November 1977 and installed in the aircraft in January 1978. The system has been tested both in field trials and in practical operation for almost

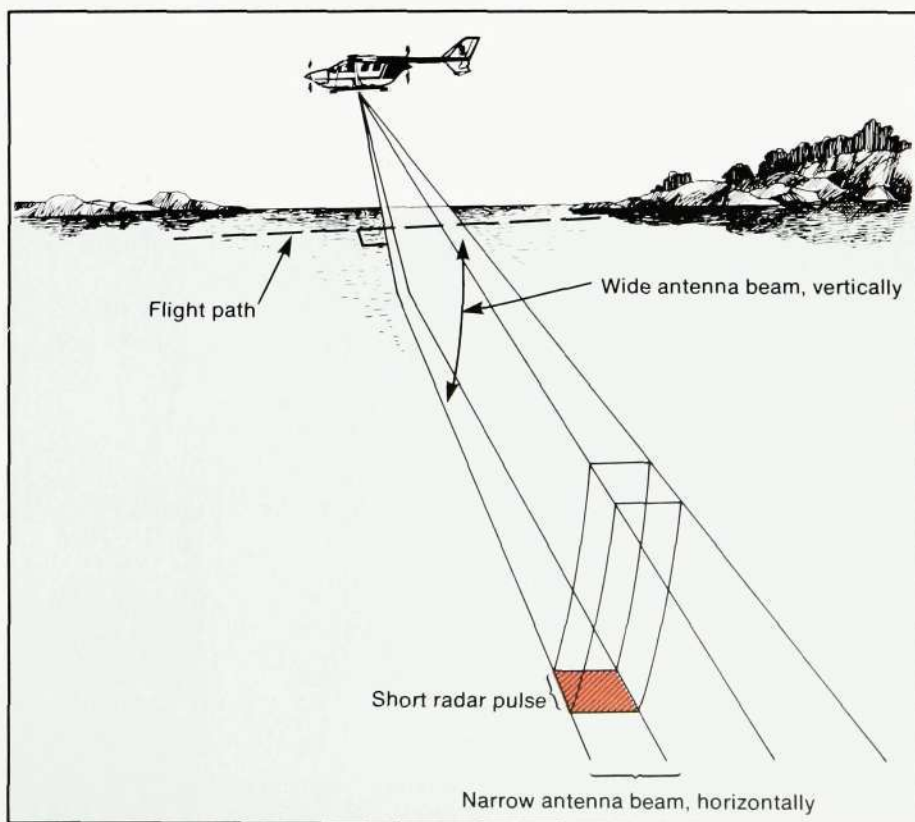


Fig. 4
Side looking radar (SLAR). Functional principle. A large antenna is mounted so that the antenna beam points perpendicularly to the flight direction. The antenna is mounted fixed, so scanning takes place by the plane moving forward

two years. It has functioned satisfactorily for supervision of ships as well as in the detection of oil slicks and small boats, and it was therefore possible to start series manufacture without any major changes being necessary. The series model of the radar is equipped with two antennas so that surveillance can be carried out simultaneously to both sides of the flight path if necessary. The tests have shown that it is not necessary to stabilize the antennas. Even a small plane as the Cessna 337 has such stable flight over the sea that fixed antennas can be used.

Description of ERICSSON SLAR

The radar system ERICSSON SLAR consists of five replaceable subunits, fig. 5.

The antenna unit consists of a three metre long fibre-glass pod, which contains two slotted waveguide antennas. The switching between antennas is done with the aid of a ferrite circulator. The antennas are designed with minimum horizontal beamwidth to give maximum angular resolution. Vertically the beam must be wide in order to provide sufficient illumination near the aircraft and insensitivity to variations in roll angle. The antenna gain in directions above the horizontal plane has been reduced

to a minimum in order to prevent interfering reflections from the wings and fuselage.

The transceiver unit is in all essential aspects identical to an ordinary pulse radar of the type used as weather radar in civil aircraft. The receiver has high instantaneous dynamic range to be able to receive signals of varying amplitude. It has a logarithmic characteristic in order to reduce the span between the weakest and the strongest signal.

A factor that was considered of great importance was that the gain of the radar receiver should be variable with time, so that near echoes are attenuated in relation to distant echoes. This reduces the difference between strong signals from nearby targets and weak signals from distant targets. Targets of a similar size are displayed with the same intensity on the radar indicator, regardless of their distance from the flight path.

The signal processing unit, fig. 6, carries out analogue-to-digital conversion of the video signals from the receiver, with an accuracy of 6 bits. Its main function is to add the signals from a large number of transmitted radar pulses and store the

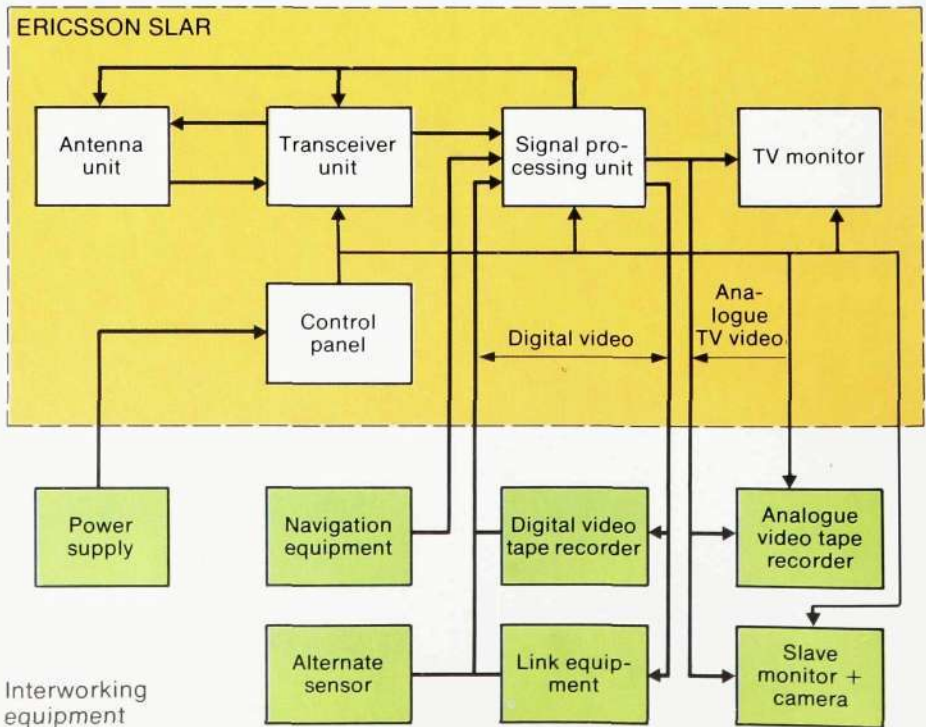


Fig. 5
System block diagram for ERICSSON SLAR and interworking equipment

Interworking equipment

Fig. 7
Control panel. All system functions are controlled from the panel except the luminance and contrast of the TV monitor



result in a TV refresh memory. From the memory the information is fed out to the TV indicator in the form of a map that moves down the screen as the plane moves.

The signal processing unit receives digital data from the navigation equipment in the aircraft. From these the speed of the aircraft is calculated, which is then used to control the speed of the rolling map movement. In this way the picture gets the same scale of distance in the flight direction as across it. (See the fact panel on page 157 for further information.) The operator can indicate a radar target on the screen with a light pen. A micro processor in the signal processing unit calculates the position of that target and gives the latitude and longitude in a text display area at the bottom of the screen. Navigation data, time etc, are also displayed in the same text-area.

The signal processing unit is interfaced to a digital tape recorder. Radar map pictures can be recorded for later

playback, either in the plane or, after landing, in a picture processing unit on the ground. The map picture can also be transmitted direct to a ground station or a ship via a communication radio channel. The signal processing unit generates test signals which can be used to locate any faults to the faulty subunit.

From the control panel, fig. 7, the operator can control the whole system with the exception of certain adjustments of the TV monitor, which must be done direct on the monitor.

The video signal is in accordance with current (CCIR) TV standards, and thus both the TV monitor and video tape recorder can be of standard types. The TV techniques make it possible to display stable radar map pictures, which can be viewed in full daylight.

The total weight of the radar system is less than 75 kg, of which the antenna pod accounts for 30 kg. However, in certain aircraft it is necessary to install an antenna on each side of the fuselage,

Fig. 6
Signal processing unit with built-in power supply

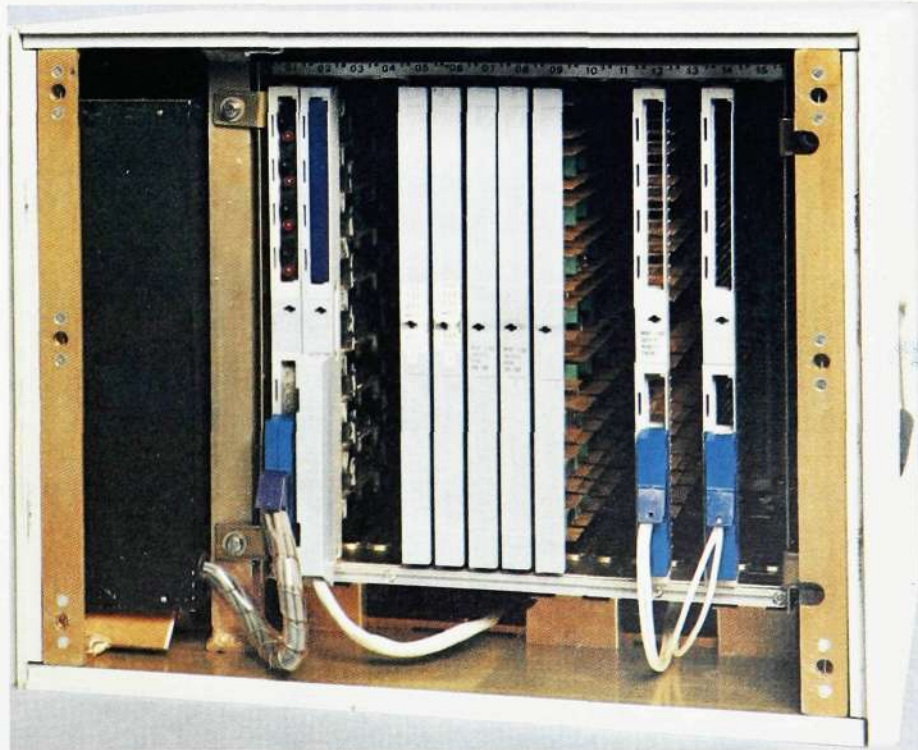




Fig. 10
Fibre-glass boat with an outboard motor. Gave the upper radar echo at C in fig. 8 below



Fig. 11
Coast Guard cutter. Gave the lower radar echo at C in fig. 8

Fig. 8, left
Oil discharge in the Baltic.
Picture area 20 × 20 km to the right of the flight path. The spot A is 400 l and B 50 l of diesel oil, which were discharged from the trial ship C approximately one hour before the flight. The large oil slick D is an illegal discharge of bilge water approximately 2 days earlier. Wind speed 8 m/s

Fig. 9, right
Oil discharge in the North Sea.
The recording shows 25 tonnes of crude oil (Ekofisk), which had expanded to 12 km × 2 km approximately 24 hours after the discharge. The spot E is a research ship and F a trawler. Wind speed 4 m/s

which increases the overall weight somewhat. The installation in the aircraft is very simple and only requires connection to 28 V DC and where appropriate also matching to the navigational equipment, tape recorder and radio.

Performance

ERICSSON SLAR has undergone fairly extensive trials in order to evaluate its performance as regards different targets. This applies particularly to controlled oil discharges. Figs. 8 and 9 show recordings from such trials. Experience indicates that discharges in excess of 100 litres show up very clearly within 20 km of the flight path. The contrast between oil and water is good regardless of the wind direction with wind forces of more than 1 m/s. Even very thin oil layers give good contrast relative the water. It is not possible to determine the quantity and type of oil via the radar. However, the surface area, position and drift of the oil slick can be mapped, and also its position relative any ships.

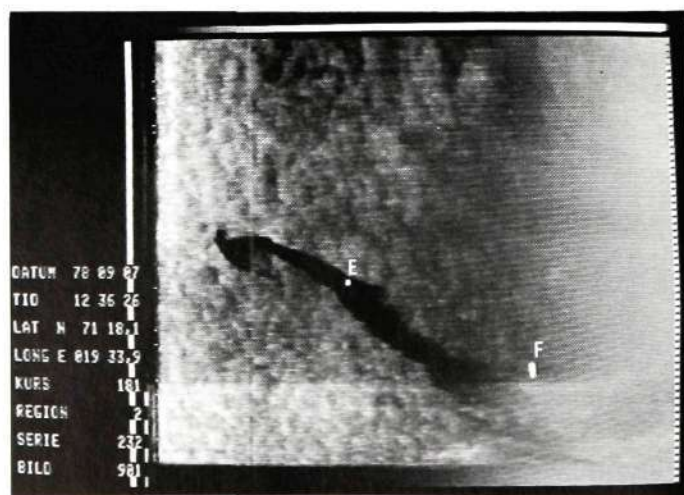
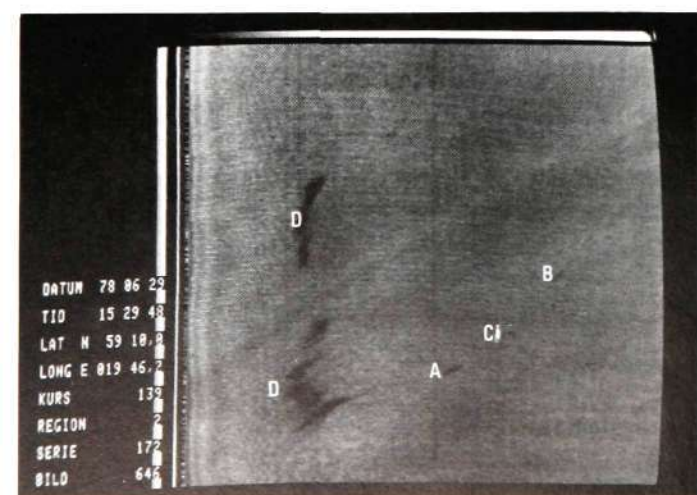
Theoretical calculations for surveillance from an altitude of 500 m, fig. 12, show that the possibility of discovering small radar targets is good up to approximately 20 km, after which it deteriorates. The smallest detectable target radar cross section is largely dependent on the flying altitude and sea state. Calm sea and low altitude give the best performance. Large ships can be seen right out to the radar horizon. The trial results agree with these calculation results, although

it has not been possible to make exact comparisons. Fig. 12 also shows that a side looking radar gives considerably better performance for small targets, and better surface coverage than a corresponding forward looking radar.

For ship reconnaissance the ability of the radar to distinguish between closely grouped targets is important, for example to determine the number of boats in a fishing fleet. A SLAR with its large antenna can distinguish between such targets better than a conventional forward looking radar. In a field trial a small glass fibre boat, fig. 10, was positioned approximately 300 m from a Coast Guard cutter, fig. 11. As can be seen from fig. 8 both boats could be distinguished on the radar screen when they were 13 km from the plane.

Conclusion

Airborne reconnaissance of Swedish territorial waters has proved to be an efficient way of deterring potential law breakers. The number of intentional oil discharges has successively decreased since this surveillance started. The reconnaissance capacity of the aircraft fleet will be radically improved in 1980 through the installation of SLAR. Any skipper who then decides to clean his oil tanks at sea or fish in Swedish waters can no longer count on avoiding disclosure. The Coast Guard also obtain an efficient surveillance aid that will stand them in good stead in sea rescue operations and oil catastrophes.



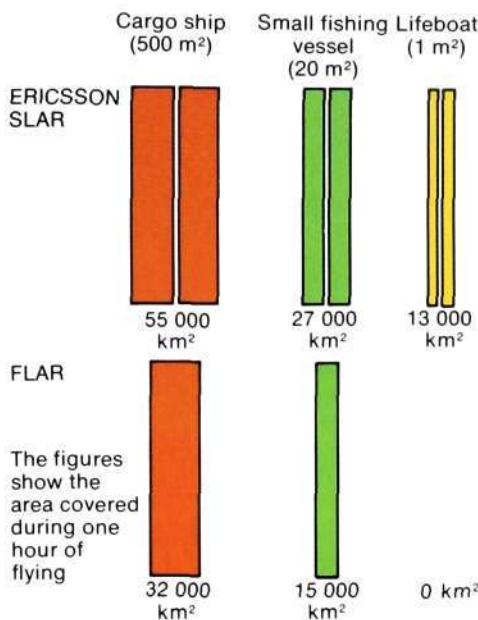


Fig. 12b
The sea surface scanned during one hour of flying. The diagram shows the difference in coverage between ERICSSON SLAR and an equivalent forward looking radar (FLAR).
Assumptions: Flying altitude 500 m
Flying speed 100 m/s
Sea state 2-4

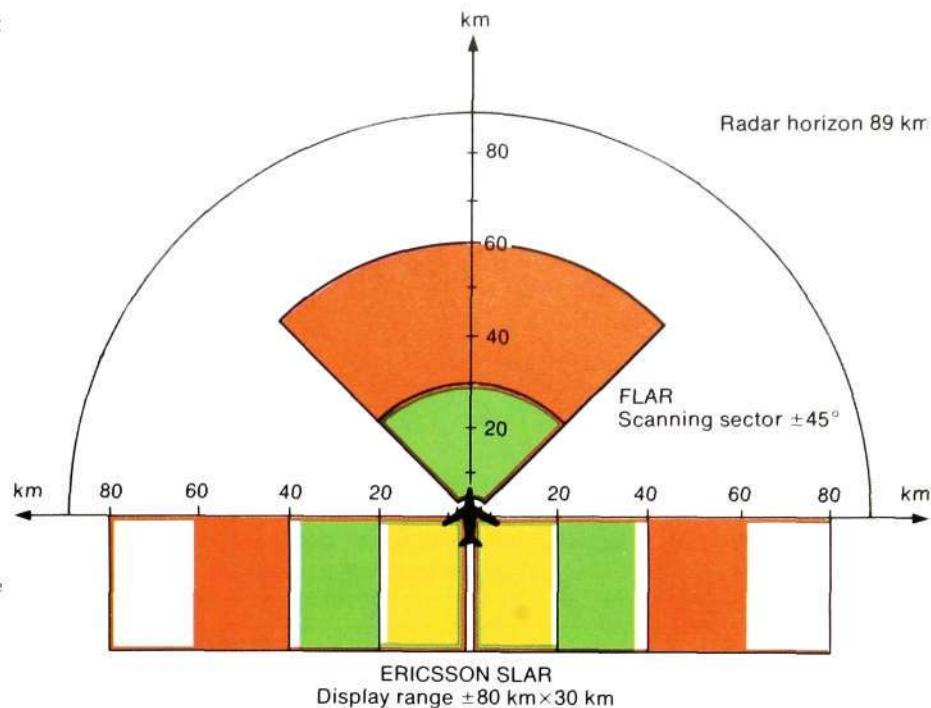


Fig. 12a shows calculated detection areas for ERICSSON SLAR with some typical radar targets: a lifeboat, a small fishing vessel and a cargo ship. As a comparison the corresponding detection area for a forward looking radar (FLAR) has been calculated. The two systems are assumed to have the same radar performance and to differ only as regards scanning system, display and beam width (0.5° for SLAR and 3° for FLAR). The calculations show that the less good angular resolution of such a FLAR makes it unable to detect targets of less than 20 m² with the given assumptions.

Detection range
SLAR (across) (radially)

Assumptions: Flying altitude 500 m
Flying speed 100 m/s
Sea state 2-4

TV display of SLAR pictures

The advantage of TV display compared with a conventional radar indicator (PPI) is that the radar map is shown continuously and with constant luminance. The TV picture is updated 25 times per second and is stored in a refresh memory in the radar signal processing unit.

The ERICSSON SLAR digital memory holds 512×512×6 bits. This is sufficient to show the radar map picture with 64 grey tones on 512 lines in the TV picture. Each line then consists of 512 picture spots. The definition of a standard TV monitor is limited to approximately the above 512×512 picture spots, and a larger store would therefore not give any advantage as regards display resolution.

The signal processing works with a resolution that corresponds to 78 m long sections of the sea across the flight path (sampling rate 2 MHz). When a processed radar video signal is fed out to the TV monitor, 512 such definition elements, pixels, can be shown on a line in the picture. The map picture width thus corresponds to 512×78 m, i.e. 40 km. This width is usually sufficient when surveilling for oil slicks. The area shown on the monitor then covers 20 km each side of the flight path and approximately 30 km in the flying direction, fig. A.

When searching for ships, a surveillance width of 40 km is often not enough. The picture can then be divided as shown in fig. B or fig. C, which increases the displayed width to 80 km. The position of the plane relative to the map picture is marked with an arrow. In both cases the signal processing unit adapts the video integration time to the flying speed so, that the TV map picture has the same distance scale along and across the flight path. Each picture element then corresponds to approximately 78 m × 60 m of the observed area.

The use of the digital memory and the disposition of the picture area are controlled by a microprocessor. Both the picture layout and the displayed areas can be change by means of a simple re-programming. It is also possible to enlarge parts of the map picture so that the monitor only shows an area of 20 km × 15 km. While this area is studied in detail, the memory is updated as usual with new information across the whole surveillance width.

If larger display width than 80 km is required, the signal processing unit can reduce the definition so that each picture element corresponds to approximately 156 m × 120 m of the sea surface. A map picture in accordance with fig. D can then be obtained.

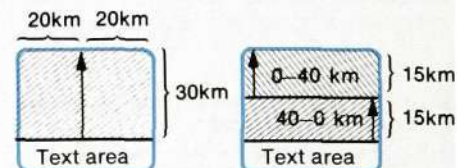


Fig. A
Displayed area:
20 km × 30 km,
both sides

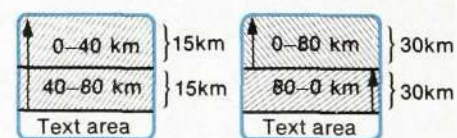


Fig. B
Displayed area:
40 km × 15 km,
both sides

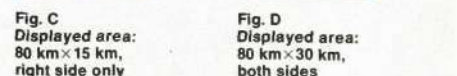


Fig. C
Displayed area:
80 km × 15 km,
right side only

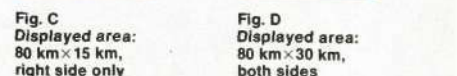


Fig. D
Displayed area:
80 km × 30 km,
both sides

Table 2
Technical data for ERICSSON SLAR

Antenna	
Beam width, horizontal	0.5°
vertical	33°
Antenna gain	31 dBi
Polarization	vertical
Surveillance direction	left, right or both sides
Transceiver unit	
Radar frequency	9.4 GHz
Output power	10 kW
Pulse width	0.5 μs
Pulse repetition frequency	1.0 kHz
Noise factor	8 dB
Automatic gain control	AGC
Manual gain control	MGC
Sensitivity time control	STC
Signal processing	
Digital memory	1.6 Mbit
Indicator	
Standard CCIR TV (625 lines)	
Range scales 20, 40, 80 km	

2 Mbit/s Optical Fibre Line System ZAM 2-1

Hans Giertz and Viesturs Vucins

LM Ericsson is carrying out development work on optical fibre components and systems. As a part of this work a line system for 2.048 Mbit/s, intended for a first-order PCM system, has been developed.

A number of line systems are now being tried by customers in the special applications for which the system is primarily intended, e. g. electrically disturbed environments, where conventional cable systems do not give satisfactory transmission quality, or where a system must be electrically isolated from the surroundings because of differences in potential.

UDC 621.315:
621.391.63

In this article LM Ericsson's first optical fibre line system is presented. It is intended for digital transmission at 2.048 Mbit/s, corresponding to 30 PCM coded telephony channels, on optical fibre cable with a regenerator spacing of up to 6 km. The recommendations of CCITT have been followed when developing the equipment. From the system point of view the equipment is very like LM Ericsson's conventional digital systems in the M5 construction practice, which makes for easy adaption to other transmission equipment.

The equipment is characterized by high reliability, good transmission properties, great flexibility and a design that facilitates installation and maintenance. These characteristics were aimed at when choosing the system solution and the components.

System structure

In many respects the optical fibre digital line system ZAM 2-1 has the same mechanical and system structure as LM Ericsson's conventional digital line systems ZAD 2-4 and ZAD 8-2 in the M5 construction practice, for transmission on pair and quad cables.

The structure of the optical fibre digital line system is shown in fig. 1.

The connection to the line is made via the coaxial interface D1, which is standardized by CCITT. This means that the optical fibre link can be connected to all other standardized equipment for 2 Mbit/s.

The electrical signal is converted to an optical signal and vice versa in the line terminal repeater equipment. The optical interface F1 is designed to provide optimum adaption to fibre cables for long distance communication. ZAM 2-1 comprises only rack-mounted repeater equipment and in this respect it differs from LM Ericsson's systems for pair cables, which also include dependent intermediate repeaters. The optical fibre system is primarily intended for use in environments with electromagnetic interference, where conventional cable systems would not give satisfactory transmission quality, or in cases where the system must be electrically isolated from the surroundings. In such applications the transmission distances seldom exceed a few kilometres.

The transmission range of the link is dependent on the attenuation of the fibre cable. A fibre cable attenuation of 4 dB/km gives a transmission range of up to 6 km. If longer transmission distances than 6 km are required via the optical fibre link, several optical fibre line sections can be connected together in tandem, and pairs of terminal repeaters will then function as intermediate repeaters.

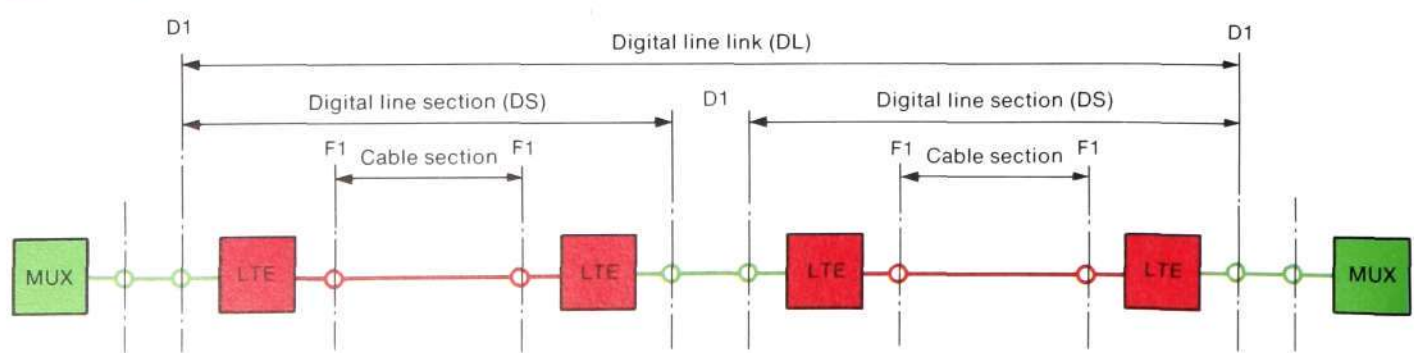
The electro-optical converter in the transmitter is a special light emitting diode that has been developed for optical fibre applications.

At present a light-emitting diode has the following advantages over a laser diode:

Fig. 1
Block diagram and interfaces for the 2Mbit/s optical fibre line system ZAM 2-1

MUX PCM multiplex equipment for 30 channels
LTE Optical fibre line terminal repeater equipment
D1 Digital link interface 75Ω (2 Mbit/s)
F1 Optical fibre interface (4 Mbaud)

— Interface cable (coaxial 75Ω)
— Line cable (fibre)





HANS GIERTZ
VIESTURS VUCINS
Transmission Division
Telefonaktiebolaget LM Ericsson



- longer life
- lower cost
- requires a considerably lower degree of complexity in the drive circuit.

- it is possible to detect faults
- the circuits have a low degree of complexity
- it is possible to transmit alarm signals (AIS).

The advantages of the laser diode become apparent only in systems for high transmission speeds, where the speed and narrow spectrum of the laser diode are important.

TERMINAL REPEATER EQUIPMENT

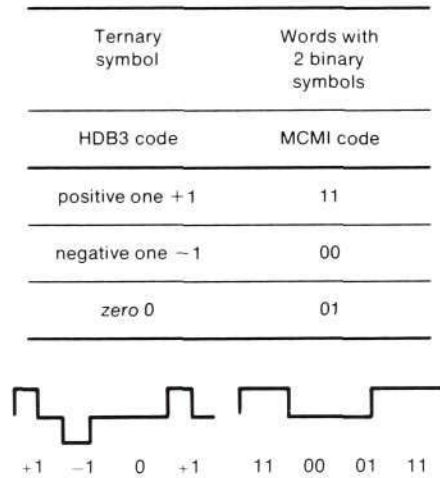
In the terminal repeater equipment the signals in the send and receive directions are converted between the electrical digital interface D1 and the optical fibre interface F1. The terminal repeater also includes equipment for detecting faults and indicating alarms. The terminal repeater equipment is mounted on three printed boards. The send and receive parts are shown in fig. 4.

The code chosen for this system is an 1T2B type code. It is also called MCMI because it can be considered as a modified CMI code. Every incoming ternary symbol is converted to two binary symbols. The optical fibre line will thus have a symbol rate of 4.096 Mbaud. The large bandwidth of the fibre permits this signal to be transmitted without any inter-symbol interference. The coding table is shown in fig. 2.

Because of the high degree of redundancy the chosen code permits very simple designs for the encoder, decoder and fault detection circuits. This is important in a system that is normally not equipped with intermediate repeaters, and where the terminal repeaters therefore represent a large part of the system cost. The code also makes the optical fibre link transparent to the D1 signal, and hence the bit error supervision can take place in the D1 interface.

In the drive circuit of the transmitter the binary signal from the encoder is converted to binary current pulses, which intensity modulate the light emitting diode. The light from the diode is connected to a fibre, which leads the light to an optical fibre connector, a plug, at the rear edge of the printed board assembly. The rear edge of the shelf is equipped

Fig. 2
Coding table for the MCMI code



Send side

Fig. 3 shows the block diagram of the terminal repeater equipment. The optical fibre transmitter contains an encoder, drive circuit and electro-optical converter.

The bipolar signal obtained from the digital interface is not suitable as a modulating signal in an optical system. In the encoder the signal is converted to a unipolar signal, where the relation between the incoming and the generated symbol follows a certain code. The code must be chosen so that:

- it is possible to carry out timing recovery in the receiver

Fig. 3
Block diagram of terminal repeater equipment in ZAM 2-1

HDB3/ MCMI signals to/from MCMI signals
OTX Optical fibre transmitter
ORX Optical fibre receiver
ACU Automatic changeover unit

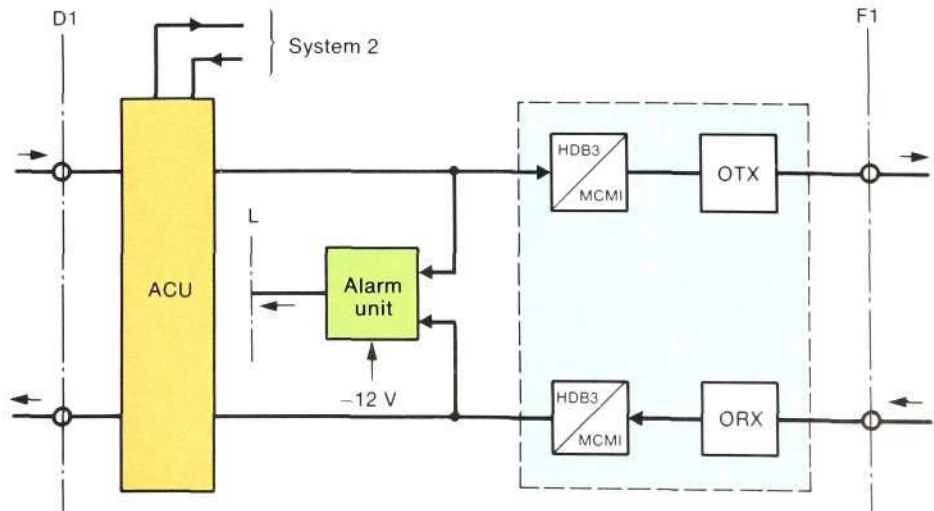
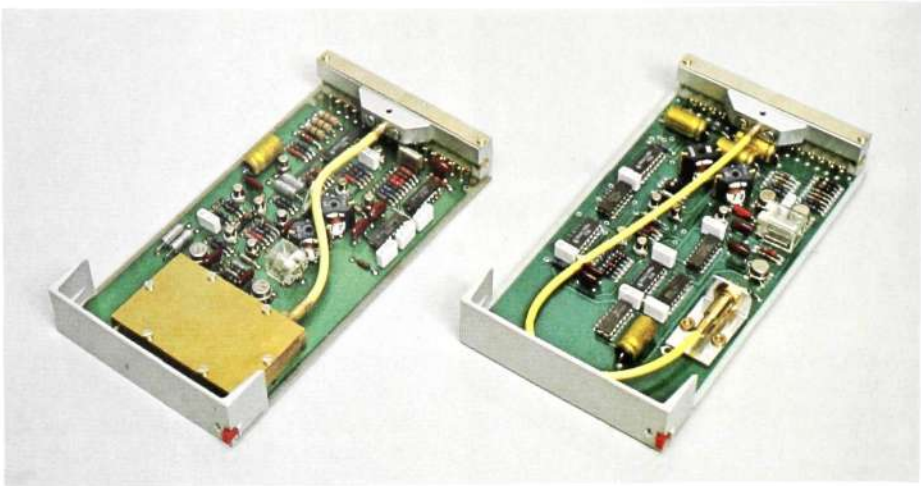


Fig. 4
Optical fibre receiver (left) and transmitter in the ZAM 2-1 terminal repeater equipment. The electrical and optical connectors are mounted at the rear edge of the boards. Fibre cables connect the optical connectors with the transmitter and receiver diode



with an optical fibre jack, and the light is led via a cable to the optical fibre interface F1 at the left edge of the shelf.

Receive side

In a corresponding way the received signal in the optical fibre interface F1 is led via a shelf cable, a board connector and a fibre on the receive printed board assembly to the opto-electrical converter. In this system the converter consists of a high efficiency PIN diode. The current generated by the light in the diode is amplified and filtered, and the signal is regenerated. After the 4.096 Mbaud uni-

polar signal has been regenerated it is converted back to the original bipolar D1 signal.

Because of the large bandwidth of the transmission medium, the sensitivity of the system will be dependent on the noise caused by the input amplifier and not on the inter-symbol interference caused by the transmission medium. Great efforts have been made to keep the noise low in the input amplifier. The signal current is only 2 nA, which means that the electronic equipment must have electromagnetic shielding from the surroundings. One basic aim has been to

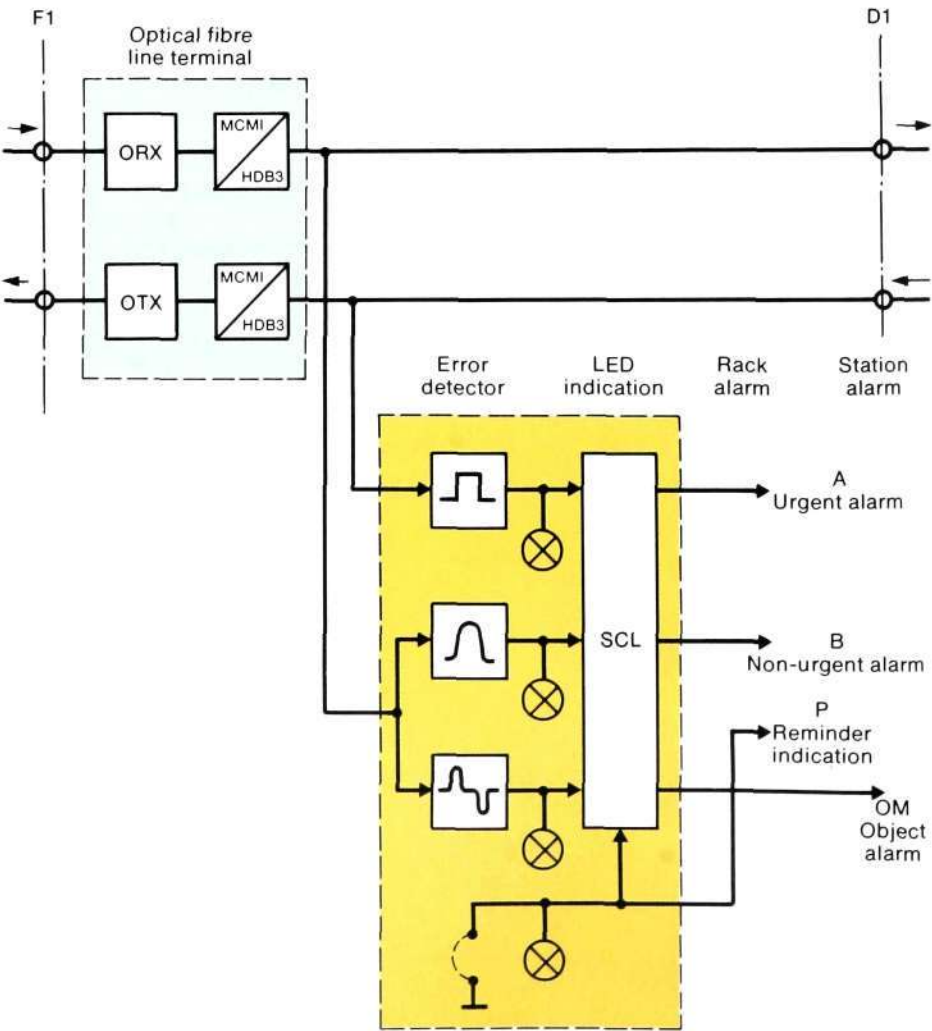


Fig. 5
Alarm functions in the terminal repeater equipment

-  Absence of pulses, send direction
-  Absence of pulses, receive direction
-  High error rate, receive direction
- SCL Strappable, combinatory logic circuit

obtain simple circuit solutions, and the large bandwidth of the fibre, in combination with the chosen line code, have made it possible to eliminate certain functions, such as adaptive equalization of the signal, automatic gain control and adaptive decision level.

Optical fibre connectors

Low attenuation in optical fibre connectors usually demands very high precision in the mechanical parts of the connector, in the order of a few μm . This makes the connectors very expensive. LM Ericsson have chosen a different solution.

In the optical fibre interface F1, to which it must be possible to connect a number of different fibre cables (the fibre parameters are not standardized yet), a unique, patented construction is used, which is based on connector elements with moderate tolerances, but where the precision is achieved by exact adjustment of the fibre ends. This ensures that the optimum adaption to the transmission fibre is always obtained. After the adjustment, which is normally only carried out once, when the system is installed, the fibre is locked in place. The connector can then be plugged in repeatedly without affecting the low attenuation and without readjustment being necessary.

Units are connected to the shelves by means of a non-adjustable board connector with low attenuation. The light emitting diode is connected via a fibre with larger diameter than the fibres in

the shelf and transmission cables. The difference in diameter between the two fibres counteracts tolerance errors in the connector.

The fact that the detector diode has a large area is exploited on the receive side. As on the send side, the connection between connector and diode can thus be made using a thick fibre. The loss in the two connectors thus becomes negligible. The connectors are designed to give an air gap of approximately $10\ \mu\text{m}$ between the two fibre ends. This makes the mechanical wear on these sensitive surfaces small.

Alarms, automatic changeover

The digital link interface D1 is monitored, and the alarm philosophy is the same as for the conventional systems for pair cable, ZAD 2-4 and ZAD 8-2, fig. 5. The supervision comprises the incoming and outgoing electrical signal (absence of signal gives an alarm) and the bit error rate in the receive direction. Light emitting diodes that are visible through the unit front indicate alarm states.

The terminal repeater shelf ZFM 23101 can be equipped with an automatic changeover unit which, in the case of an alarm in the receive direction, automatically switches over to another system, fig. 6.

OPTICAL FIBRE SHELVES

The system contains two types of shelves, which enable the optical fibre line to be connected to other line systems or to multiplex equipment.

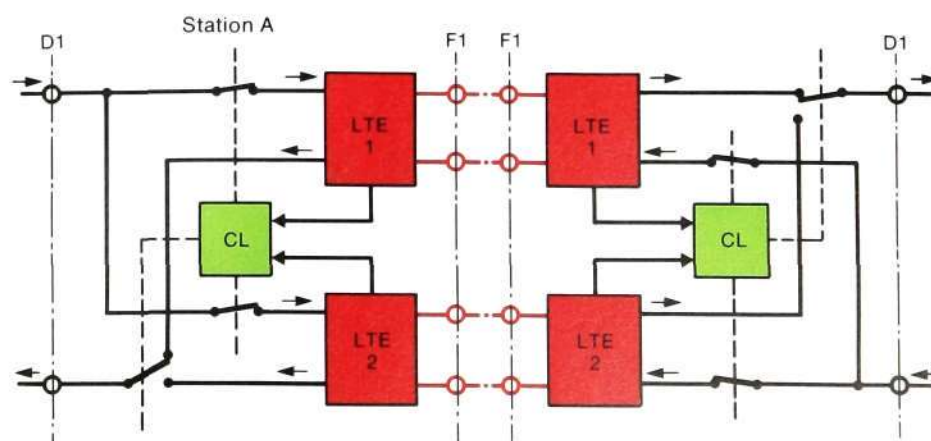


Fig. 6
Automatic changeover between a working and a standby system. The changeover is initiated by the absence of a signal in the receive direction or too high an error rate in the received signal

LTE 1 Optical fibre terminal repeater, system 1
CL Control logic for automatic changeover

The following equipment can be mounted in terminal repeater shelf ZFM 23101:

- two optical fibre terminals
- an automatic changeover unit
- a pseudo random generator.

The optical fibre terminals can be connected to multiplex equipment, a radio relay link or other external equipment via the coaxial interface D1. The automatic changeover unit permits switching to a standby consisting of the other optical fibre link or an external link.

The pseudo random generator sends a signal over an unoccupied line. The normal alarm circuits of the line can then be used for supervision. In cases where an optical fibre intermediate repeater is required, two terminals can be connected together via the D1 interface.

In the other shelf, ZFK 24211, fig. 7, the optical fibre link can be connected to speech channels and E & M signalling channels. In addition to the optical fibre line terminal the shelf contains LM Ericsson's multiplex equipment for 30 channels, E & M signalling equipment for 2×30 channels and a decentralized power unit. It can therefore be connected either to subscribers or to an exchange via external subscriber line relay sets.

Field trials

A number of systems are undergoing extensive trials by various customers, in applications where the environment is electrically disturbed, where there is risk of thunderstorms or where a system must be electrically isolated from the surroundings.

Various cable laying methods have been used, such as running in ducts, ploughing into the ground, suspension on poles and near high-voltage cables. The LM Ericsson subsidiary Sieverts Kabelverk provides cable types suitable for the various methods.

One system was installed in collaboration between LM Ericsson, Sieverts Kabelverk, Sydkraft AB (electricity suppliers) and Kabeldon AB (manufacturer of cable accessories) in October 1978. The optical fibre line system ZAM 2-1 was installed between two transformer stations in south Sweden. The line is approximately 1 km long and the fibre cable is integrated in a three-phase 24 kV power cable AXKJ $3 \times 95/25$ mm², fig. 8. Such composite cables are expected to reduce the installation costs in future power distribution networks. It is also expected that it will be possible to use the transmission line with its high capacity for other purposes than the transmission of data within the power

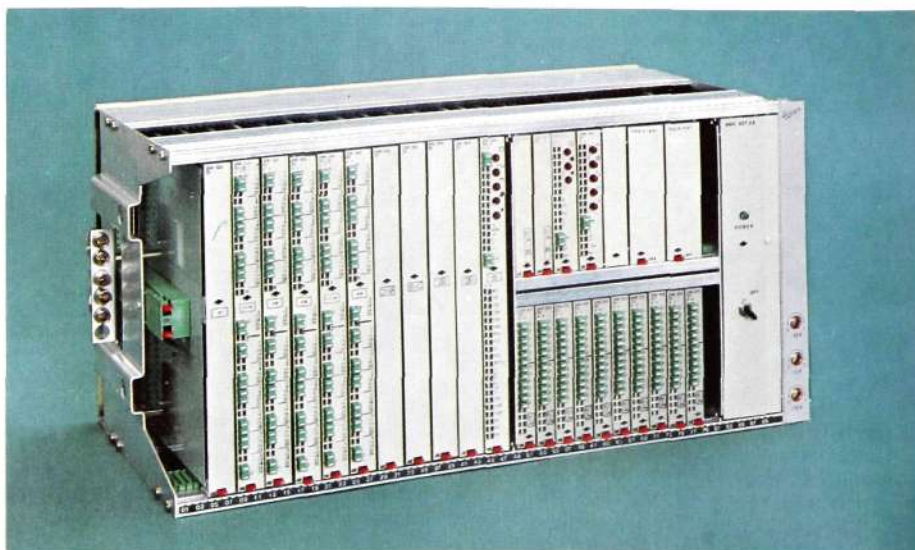


Fig. 7
Shelf for PCM multiplex terminal and optical fibre terminal, ZFK 24211

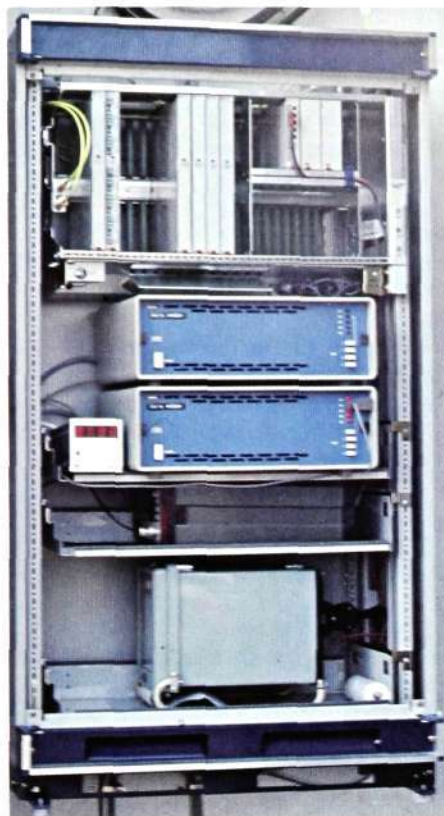


Fig. 9
Shelf for PCM multiplex terminals and optical fibre terminals installed in a transformer station. The shelf is mounted in a BYB cabinet together with equipment that monitors the performance of the link

network, for example for normal telephone services. The cable was installed by personnel from Sydkraft and Sieverts Kabelverk, the installation of the optical fibre connectors on site was carried out by Kabeldon AB and the installation of terminal repeaters and power supply equipment by Sydkraft and LM Ericsson, fig. 9.

Measurements carried out during the trial indicate that there has been no change in the performance of the fibre cable and no bit errors have occurred on the transmission line.

Technical data for optical fibre line system ZAM 2-1

Digital link interface D1

Bit rate	2048 kbit/s
Line code	HDB3
Pulse amplitude	± 2.37 V
Permissible cable attenuation	0–6 dB
Impedance	75 ohms unbalanced

Optical fibre interface F1

Symbol rate	4096 kbaud
Line code	MCM1
Fibre core diameter	50 μm^*
Numerical aperture (99 %)	0.21 μm^*
Output power	–17 dBm
Input sensitivity at an error rate of 5×10^{-10}	–50 dBm

*Transmission fibres with different core diameter and numerical aperture can be connected to this interface.

Repeater distance	Up to 6 km depending on the attenuation of the fibre cable
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Power supply

Centralized or decentralized converter for 24, 36, 48 or 60 V

Power consumption per optical fibre terminal 4 W

Ambient temperature

Normal operation	+10° C to +45° C
Limits for operation	0° C to +50° C
Limits for storage and transport	–40° C to +70° C

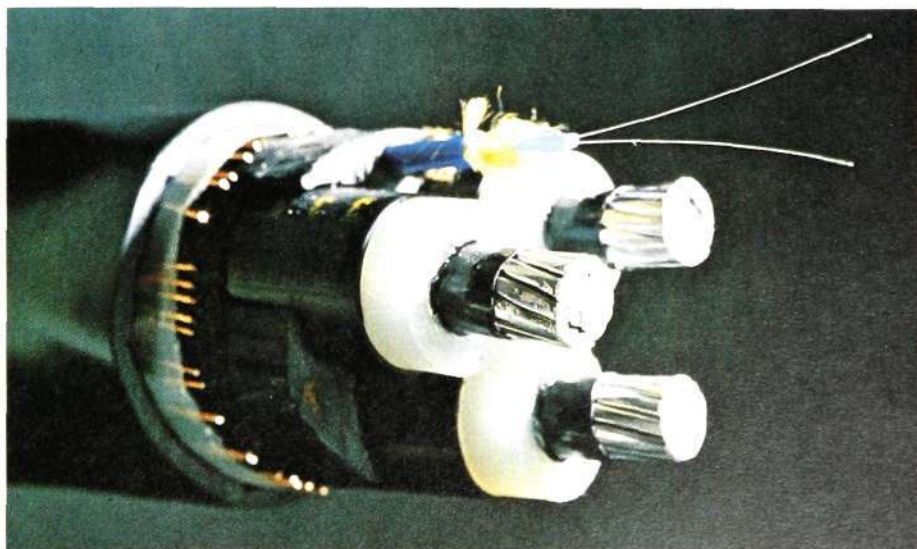


Fig. 8
Integrated fibre-power cable EKOF-AXKJ for laying direct in the ground (Sieverts Kabelverk)

LM Ericsson's Power Supply Laboratory

Ole Pavelsen

LM Ericsson's power supply department develops power supply systems and units with output power ranging from some watts up to tens of kilowatts. The development of large units requires a laboratory with large power sources and loads and also facilities for the distribution and control of high currents. The laboratory also needs an efficient electrical safety system.

In 1977, when LM Ericsson built new premises on the outskirts of Stockholm, a new house was also built for the power supply department, containing a modern and well-equipped power supply laboratory. In the new laboratory the activities have been extended to include decentralized power supply equipments ("rack power"), wind power and solar cell systems for telecommunication equipment. In this article the resources, and to some extent also the activities of the laboratory, are described and illustrated.

UDC 621.317.2

Power supply equipments constitute a considerable and economically important part of modern electronic telecommunication plants. Recent development of power supply equipment has been characterized by an increasing degree of complexity in both systems and units and also by the use of new components.

Previously the activities in the power supply laboratory concerned only central power supply and equipment for ringing and tone signalling. Decentralized power units, so-called rack power

units, have long been used in the transmission field. When SPC technology was introduced in public exchanges and PABXs, the need for rack power units arose in this field also. The development of such equipment was then carried out by the relevant system department.

When the new power supply laboratory near Stockholm was planned, the following reasons motivated the transfer to the new laboratory of all work on the power conversion for telecommunication:

- The possibility of overall optimization, both technically and economically, of the whole power supply for a telecommunication plant.
- Power conversion techniques for central power supply often use the same or similar methods as in the case of decentralized power supply.
- The work in the field of power components (power semiconductors, magnetic components etc.) can be carried out more efficiently.
- The problems concerning electrical safety, current distribution and other power supply matters can be handled more rationally.

Fig. 1
System test room. The panels to the left are used for AC distribution. The bars for high direct currents are run across the ceiling. A small selection of the power supply equipment developed and manufactured by LM Ericsson can be seen in the background





OLE PAVELSEN
Power Supply Department
Telefonaktiebolaget LM Ericsson

When designing the laboratory, consideration was also paid to the fact that the field of energy conversion is in a stage of intensive development. New components, such as fast power transistors and diodes and new magnetic materials, make possible conversion at increasingly higher frequencies (20–500 kHz). Sufficient resources were therefore assembled as regards staff, premises and equipment to meet the Group's total need of development in this new technical field.

The new laboratory also caters for some entirely new fields, such as the development of wind power and solar cell systems, and also central equipments for cooling telecommunication plants.

Layout of the laboratory

In the planning of the laboratory, regard was paid to the requirements and wishes of staff with long experience of laboratory work:

- The laboratory must permit all-round and realistic full-scale testing of large systems.
- It must include a flexible system for distribution and control of large direct and alternating currents.

- The equipment and installation must be designed for maximum personal safety and minimum fire risk.

Premises

The power supply laboratory comprises an area of 900 m². The space is used as follows:

- 2 system test rooms for large equipment, fig. 1
- 22 laboratory staff rooms, fig. 2
- 1 long-term test room
- 1 battery room
- 1 diesel room
- 1 control room with rectifiers and converters
- 1 load room
- 1 test room for components
- 1 test room for batteries
- 1 roof platform for testing outdoor equipment (wind generators, solar cells)
- 2 instrument and component stores

The system test rooms and laboratory staff rooms are air-conditioned. The air conditioning plant for the system test rooms is dimensioned to dissipate a total of 52 kW excess heat.

Laboratory equipment

Power supplies

The laboratory is supplied with both

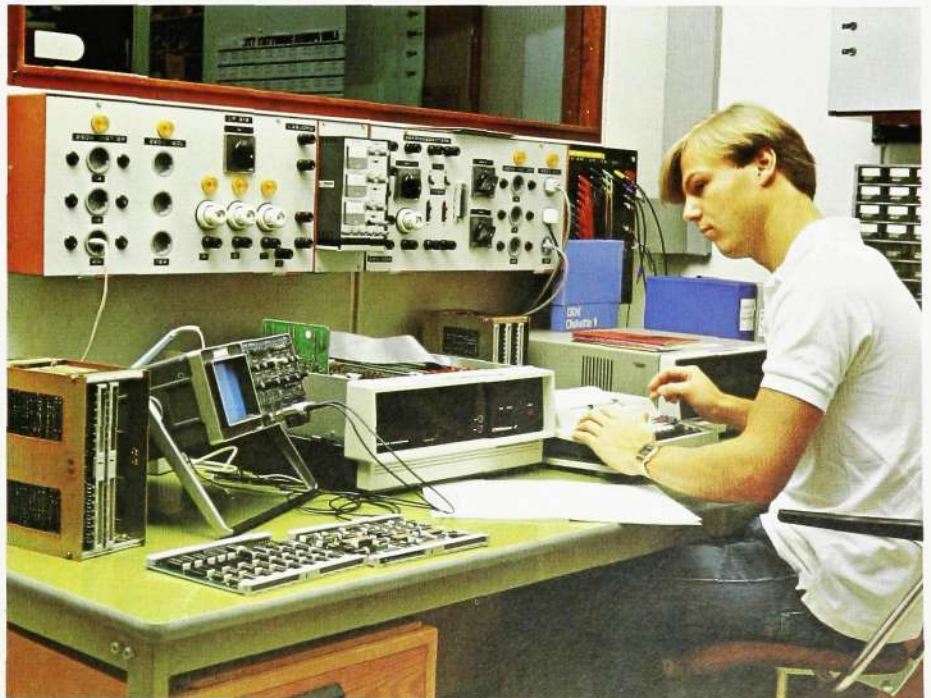


Fig. 2
Most laboratory staff rooms hold two work positions. The picture shows development work using a microcomputer system for power supply plant

alternating and direct current, fig. 3. The AC power comes from the public mains. The voltage can easily be varied from 0 to 450 V, three-phase, with the aid of a large, motor-driven variac (adjustable autotransformer).

Equipment can be tested according to active service conditions for example by varying the network frequency, using a medium-size diesel motor with an associated generator and a smaller motor generator consisting of a rectifier, DC motor and AC generator. With the aid of this apparatus the frequency can be varied within the range 45–65 Hz and the voltage 380/220 V $\pm 30\%$. A number of solid-state inverters provide uninterruptible AC voltage for sensitive loads (minicomputers etc.).

Thyristor rectifiers and lead acid batteries are used for the DC feeding. Five stationary exchange batteries of 800–1320 Ah each are all equipped with cell switches. In this way 21–24 cells (nomi-

nally 45–52 V) can be connected in. It is also possible to switch to 24, 36 and 60 V battery voltage. Five rectifiers with a total current capacity of 2000 A at 50 V provide support for the batteries during heavy loads. The rectifiers are also used for automatic charging and trickle charging of the batteries.

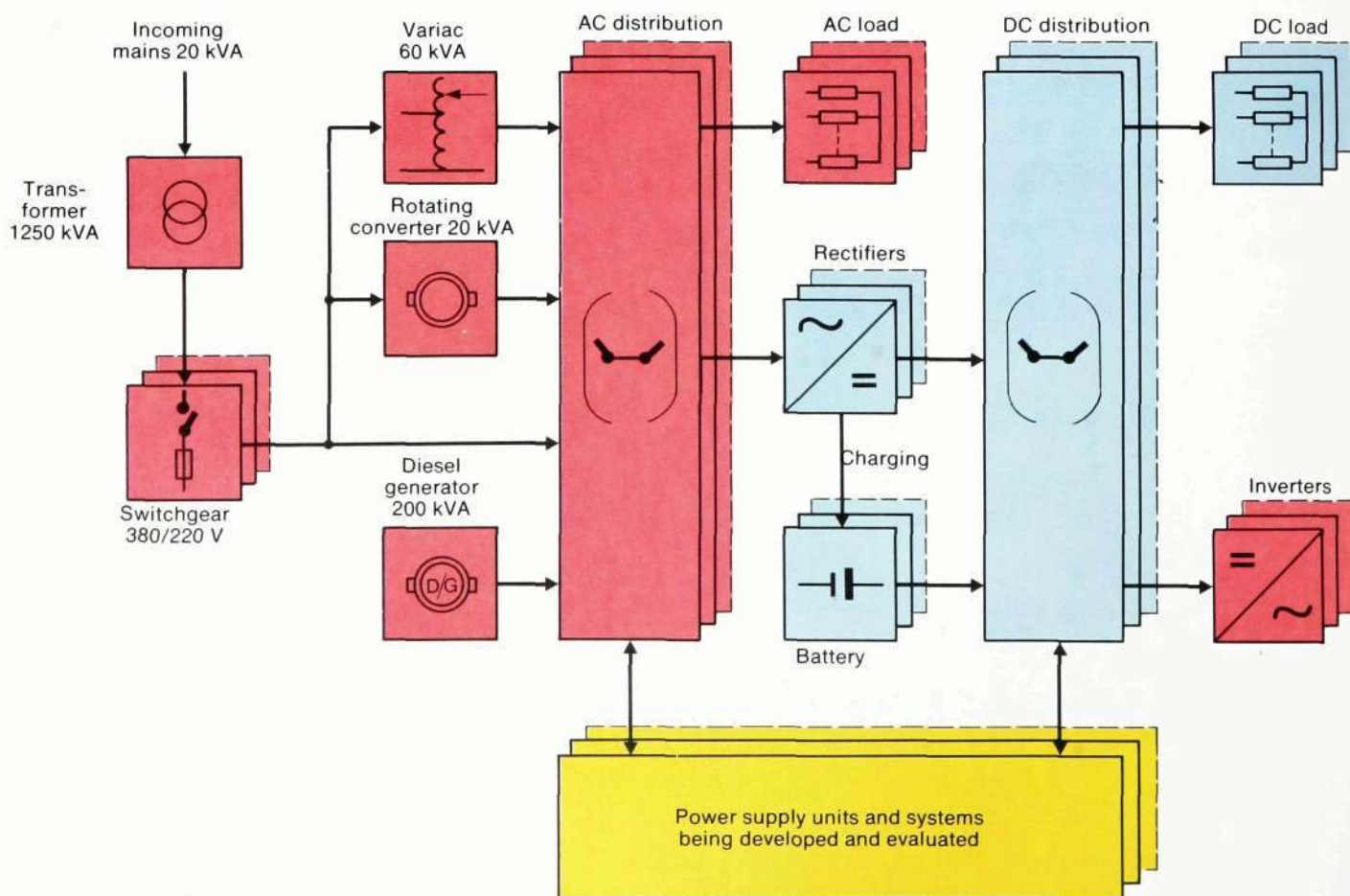
Distribution of alternating current

The AC distribution 380/220 V provides 8 power outputs of 80 kVA each and 36 outputs of 16 kVA. All these outputs can be fed from the mains, variac, diesel generator or motor generator. The type of power source is chosen by means of switches in the distribution panel, to the left in fig. 1.

A special transformer provides an isolated voltage 2 $\times$ 110 V which is distributed to all laboratory rooms.

The distribution system also includes 4-pole trunk lines to all laboratory staff rooms.

Fig. 3
A block diagram of the power sources, distribution and load of the laboratory



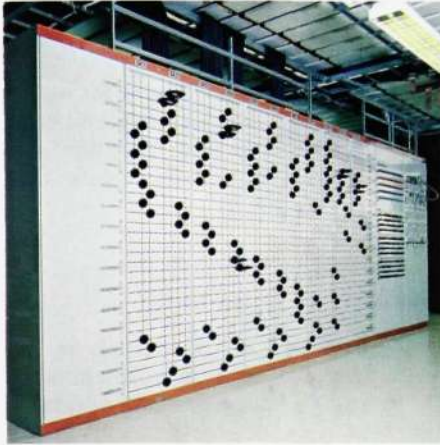


Fig. 4
Crossbar panels for the distribution of high direct currents and the remote control of these

Distribution of direct current

A distribution field of the crossbar type, with a cross point load of 1000 A, is used for the distribution of large direct currents, fig. 4. With the aid of this distribution field rectifiers, batteries, loads and units to be tested can be connected together in the desired combinations.

The following equipment is connected to the distribution field:

- to the horizontal bars: 5 exchange batteries, with the associated rectifiers, and 10 load units
- to the vertical bars: 8 distribution bar systems and 3 distribution cable systems.

1000 A can normally be used per laboratory work position in the system test room, utilizing the distribution bar systems. The bar systems can also be connected together to give up to 7500 A for system tests. The distribution cables to the laboratory staff rooms are dimensioned for 100 A and the cable to the long-term test room for 1000 A.

Load

When testing large power supply units and whole systems, the power to the load may amount to several hundreds of kilowatts. A considerable amount of heat is generated and water-cooled load units have been installed to dissipate the

heat. The units are placed in three stainless steel tanks of 800 litres each, fig. 5. Tank no. 1 contains load units for AC equipment (inverters, generators etc.). The load elements are wound for 220 V. Three elements form a Y-coupled three-phase stage for 380 V line voltage. The maximum effect is 200 kW, divided into 22 steps of between 1.5 and 15 kW each. Tanks no. 2 and 3 contain 10 load units for 40–60 V DC. The units are dimensioned for currents between 500 and 1000 A. Each unit can load the equipment on test stepwise from 5 A to 200 A. In the distribution field the load units can be connected in parallel to draw a maximum current of 7500 A (375 kW).

The temperature in each load tank is monitored by 3 thermostats. Two of these regulate the inflow of cooling water via motorised valves, and the third operates as a maximum thermostat and disconnects all load if the temperature reaches 90° C.

Control

The supply sources for both alternating and direct current and the load units are bulky, and are therefore placed in special rooms. However, a remote control system has been installed so that they can quickly and easily be operated from the laboratory positions.



Fig. 5
Water-cooled load units are placed in stainless steel tanks. The left tank is used for AC loads. Maximum load 200 kW. The other two tanks, which are used for DC loads can together be loaded with 7500 A at 50 V (375 kW)



Fig. 6
Control box for remote control of the supply sources (network, motor generator, variac, battery, cell switches and rectifiers) and for the control of different loads

The control wires for the battery contacts, cell switches, rectifiers, load units, network, diesel generator, variac and motor generator are run to 20-pole connectors in a distribution panel. Using distribution cables with 20-pole plugs, the control wires for a current source and a load are connected up to the two multipoint connectors in the distribution panel that are associated with the laboratory position concerned.

At the laboratory position a small control box, fig. 6, is connected in, from which remote control is carried out by means of micro switches, push-buttons and small potentiometers. It is possible to change for example the voltage, frequency, load and number of connected battery cells.

Laboratory staff rooms

All work positions in the laboratory staff rooms have access to the large laboratory power system for alternating and direct current, with remote control facilities as described above. In addition they are provided with special voltages, such as the isolated voltage 2×110 V for feeding test instruments and individually regulated DC voltages for feeding electronic circuits.

Outdoor testing

There is a 100 m² platform on the roof of the premises for testing outdoor equipment, such as wind turbines and solar cells. Nearby a small test room has been installed, to which certain trunk lines have been run.

Equipment for component testing

The laboratory activities include the testing and evaluation of power components, such as power semiconductors, magnetic components and capacitors. For this purpose special test equipment is often built, for example for measuring dynamic parameters of power transistors.

The evaluation program for important components often includes long-term testing, fig. 7.

Test instruments and ADP aids

In addition to normal laboratory instruments, such as current and power meters, curve tracers and memory oscilloscopes, the laboratory is equipped with a wide range of special instru-



Fig. 7
A long-term test room. Power transistors are undergoing cyclic load testing. The instrument on the right is a switch time tester for fast power transistors, designed by LM Ericsson

ments. Some examples are wave and spectrum analyzers, audio measuring instruments for signalling equipment, psophometers, equipment for measuring radio interference and surge voltage generators.

The laboratory has its own computer terminals that can be connected to LM Ericsson's large computers for calculating component values, static converter circuits etc. It also has its own minicomputers, which are used for example to supervise long-term tests of units and components.

Special equipment, such as the Exorciser, for the development of microcomputer programs, are also available in the laboratory.

Pilot workshop

In connection with the laboratory a workshop has been set up, where all prototypes of power supply equipments are manufactured. As far as possible the pilot workshop uses the same production methods as LM Ericsson's manufacturing units. Thus construction and documentation as well as convenience of manufacture are verified during the development of the prototype.

Electrical and personal safety

The laboratory staff are continually exposed to the dangers of electricity because of the relatively high AC voltages and large direct currents with which they have to work.

Great care has been spent on the preparation of a satisfactory electrical safety program, which comprises:

Earthing system

A special earthing system has been designed with the purpose of reducing the risk of dangerous differences in potential. This system is not the same as the conventional system of protective earthing. All metal objects within reach are connected to a special laboratory earth with floating potential.

When a live part is earthed or a person accidentally touches a live part and an earthed object simultaneously, a special protection unit is released that disconnects off all feeding voltages. The protection reacts at a current of 5 mA and the disconnection time is 10 ms. The system has been inspected and approved by the National Swedish Electrical Inspectorate.

Emergency break

All work positions are equipped with an emergency break push-button. The emergency break switch disconnects all supplies to the room in question and also to all other laboratory space on the same floor.

Instructions

Special instructions have been prepared which describe the principles of the electrical safety arrangements. They also include examples of possible dangerous situations. All staff at the laboratory (permanent and temporary) must confirm in writing that they understand the instructions.

Auxiliary Systems for AXE 10 Networks

Ingemar Svenle

LM Ericsson are continually engaged in developing methods and auxiliary systems intended to make the work on our telephone exchange systems easier for the customers. These auxiliary systems cover the whole range of activities, from the first planning of the telephone network to the operation and maintenance of the exchanges. Some of these auxiliary systems are associated with a certain exchange system, but others are independent of the system. The article describes the auxiliary systems that can be used with system AXE 10 and also discusses the documentation, personnel and training requirements for this system.

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The methods and auxiliary systems discussed here are (see also fig. 1):

- Methods and ADP aids (PLANET) for the optimization of all types of telephone networks.
- Methods and ADP aids (EXDATA) for preparing floor plans, cabling data etc. for AXE 10 exchanges.
- Methods and ADP aids (TRAFDATA) for preparing the commands needed in order to provide AXE 10 with traffic data.
- Methods for centralized operational aid in AXE 10 networks for the purpose of
 - assisting in the clearing of complicated and rare faults
 - planning when and how new and revised programs are to be introduced
 - administering fault reporting throughout the network.
- Methods for economical stocking of spares with district stores and a central buffer store, and ADP aids (RESEX) for optimizing the size of the store.

Network optimization

LM Ericsson have developed a calculation method for optimizing multi-exchange local networks and long distance (LD) networks.

The method is a further development of Yngve Rapp's calculation methods. The calculations take into consideration the alternative routes offered by the network, the desirable grade of service (congestion) and the permissible transmission attenuation. The calculations also include optimization of the number of exchanges and concentrators, as well as exchange sites,

exchange areas and intermediate exchange networks.

The calculations are carried out by a computer with the aid of the program system PLANET, which has been developed for this purpose. Networks containing several hundred exchanges can be studied. Hitherto this program system has been used to optimize some hundred complex telecommunication networks, which has resulted in large savings.

The program system is divided into a number of segments, each of which carries out one type of calculation. There are segments for optimum siting of a new exchange, for choosing the optimum routing in the network, for selecting the most economical transmission equipment for a route etc. Some segments are used in all calculations whereas others are solely for optimizing local networks or LD networks.

The input data to PLANET consist of, for example, information regarding the traffic generated by the subscribers, traffic matrices that give the traffic factors for different subscriber areas, congestion and transmission conditions, traffic routing principles and the cost of exchange, network and transmission equipment.

The output data include the optimum number of exchanges, exchange sites and exchange areas, and also the optimum cable types, cost statements, the number of subscribers in each exchange and detailed route and routing descriptions.

Preparation of basic installation data

The installation data are prepared individually for each exchange. They comprise mainly:

- floor plans that specify how the equipment is to be placed in the exchange building
- information regarding which magazines are to be included in the various magazine groups
- cabling information, which specifies how the various magazines and magazine groups are to be connected together



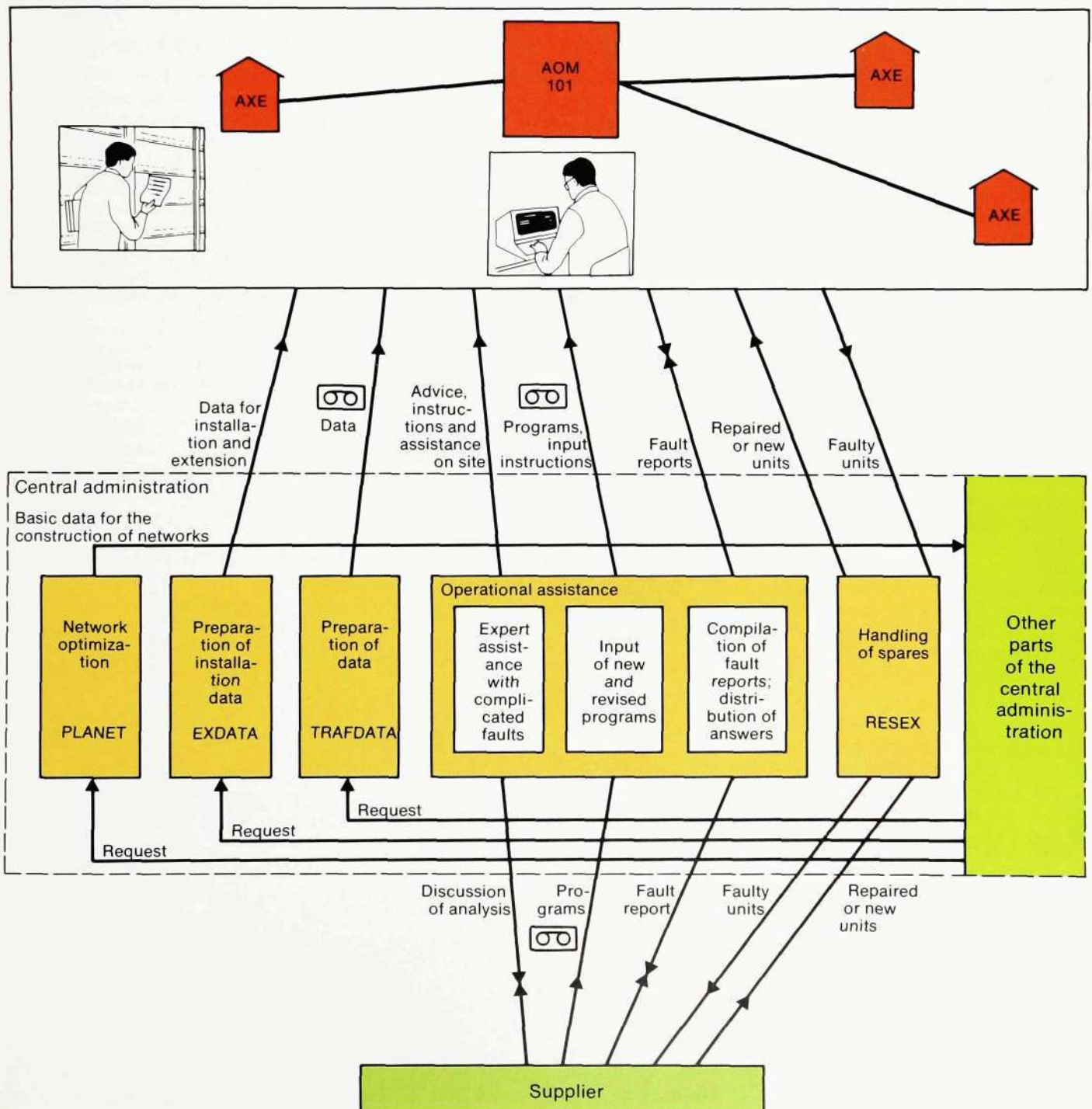
INGEMAR SVENLE
Telephone Exchange Division
Telefonaktiebolaget LM Ericsson

- commands that inform the control system about the placing and connection of the hardware in the switching system. Two examples are given in fig. 2.

Thus standard rules are used for the arrangement of magazines in magazine groups, for the connection of devices to selectors, for cabling within and between magazine groups and for the cable running. This makes it possible to automatize large parts of the preparation of installation data.

Fig. 1
Operational assistance and other auxiliary systems

The structure of the hardware in system AXE 10 is to a large extent standardized.



EXDGI: DEV = AJ - 03, MUP = GSD - 0 - 30;

EXPOI: RP = 32, POS = 203 - 17 - B;

Fig. 2

Two commands that describe the switching system hardware, its position and connections

Command code	EXDGI	Connection of a device to the group selector
	EXPOI	Definition of the position of an exchange device
Parameter names	DEV	Device
	MUP	Multiple position
	RP	Regional processor
	POS	Position
Parameter values	AJ-03	Local junctor no. 3
	GSD-0-30	Digital group selector, time switch module 0, multiple position 30
	32	The number of the regional processor
	203-17-B	Row 203, section 17, shelf B

SUSCC: SNB = 123456, SCL = TCL - 1;

Fig. 3

A command for changing the subscriber category

Command code	SUSCC	Change in subscriber category
Parameter names	SNB	Subscriber number
	SCL	Subscriber category
Parameter values	123456	Subscriber number
	TCL-1	Category: subscriber with priority

Fig. 4

TRAFDATA, the ADP aid for preparing commands

TRAFDATA	Program system comprising ca 15 000 statements in programming language PL 1
Register	Register in the computer store that contains the data required for the program system, such as command codes and permissible parameter values
TRAFFICINF	Punched cards with traffic information
ALPHA-TERMINAL	Alphanumerical terminal for controlling the process
Output of commands on a cassette tape	Output of commands on a cassette tape for loading the AXE 10 data store
Printout for checking the contents of the cassette tape	Printout for checking the contents of the cassette tape

The ADP aid EXDATA has been developed for this purpose and is now used to prepare most of the installation data. The EXDATA program is run on an IBM 3033 or a similar computer. The input data consist of information concerning the equipment in the exchange, including the number of devices, number of selector inputs etc.

Preparation of individual exchange data

Earlier systems, which were not computer-controlled, required extensive documentation that had to be prepared individually for each exchange. These individual exchange data then also had to be implemented by means of time-consuming connection and strapping work in the intermediate distribution frame for every new exchange, and also for all extensions and changes. In AXE 10 commands are used instead to provide the exchange with individual traffic data and to change these data. Such a command could be to change a subscriber category, fig. 3, or to route traffic from exchange A to exchange B via C.

Commands for small changes or for supplementing data are usually prepared and loaded manually.

However, the volume is sometimes too large to permit entirely manual handling. For example, approximately 12 000 commands are needed to load a new exchange of 10 000 lines. Changes in the data in an exchange that is already in operation can also be considerable. LM Ericsson have developed an ADP aid, TRAFDATA, to simplify the work of preparing commands. The input data to this aid consist of telephone oriented parameters that describe how the exchange is connected to the network, for example by giving the name and desti-

nation of the connected routes and the number of devices. On the basis of this TRAFDATA produces a cassette that contains the commands, ready for input to the exchange. TRAFDATA also carries out a number of checks, for example that the parameter values stay within the permissible limits. Fig. 4 shows the structure of this aid and fig. 5 shows an example of its use.

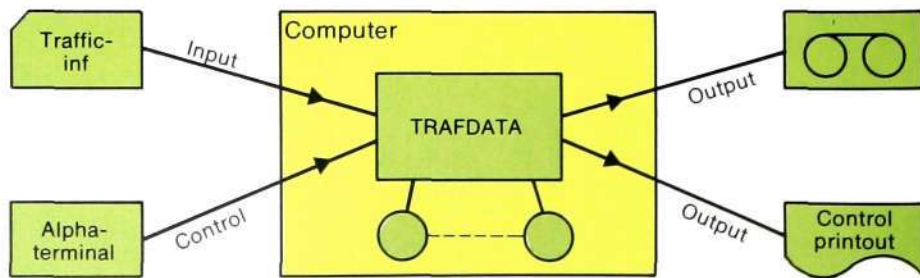
Operational back-up

The advanced functions for remote supervision and remote fault localization in AXE 10 have been described in a previous issue of Ericsson Review¹. The computer-controlled operation and maintenance system AOM 101, which provides further facilities for remote supervision and control, has also been described². The main purpose of this centralization has been to assemble at a few centres a number of similar tasks which occur frequently.

In the case of faults or disturbances that occur infrequently expert help may be necessary. This justifies further centralization to one unit that is common for the whole administration and to which the staff in operation and maintenance centres (OMC) can turn for assistance in difficult cases.

Central unit for assistance with complicated faults

The central unit should have access to experts with detailed knowledge of the system software and hardware, the available aids for fault localization etc. These experts must be able to localize complicated, rare faults unaided. This means that the total number of experts can be limited since they are used more efficiently. They can also more easily maintain their high level of knowledge and even improve it, since they will have



equally well qualified colleagues in the same unit, with whom they can discuss any problems.

Expert assistance is required, for example, if an OMC operator has followed the instructions in the operation and maintenance manual but has still not been able to locate a fault. Help can then be obtained via the telephone, fig. 6, or by the expert visiting OMC and perhaps also the exchange concerned. First the expert carries out an analysis to determine whether the fault is in a program, data, hardware or the documentation.

If the fault is in the hardware or data the expert will either correct the fault or give the OMC operator the necessary instructions.

If the fault is a design fault in a program the expert must give the supplier (LM Ericsson, Stockholm, or a subsidiary company) the information that is necessary to correct the program. This work is

simplified by the function in the exchange that on command gives print-outs of the loaded programs, with their revision codes. To have this information recorded externally has always proved to entail fault risks.

The expert must also investigate whether any special action can be taken to limit the effects of the fault. For example, there may be a fault in a traffic recording program. The fault results in a system restart if a special recording is initiated. The expert should then instruct the OMC operator not to initiate this recording until the faulty program has been replaced.

New and revised programs

It may be advisable to set up a central unit to plan when and how new program blocks are to be introduced in AXE 10.

On the basis of the operational disturbances that can be caused by the fault, this unit will decide whether a corrected program is to be loaded immediately in all exchanges concerned, or only in the exchange where the fault has been discovered. For example, if the fault has been triggered by a traffic case which does not occur in other exchanges, the loading of the corrected program in these exchanges can with advantage wait until the input of new or other revised programs becomes necessary. The unit also has to decide whether the loading should be carried out during normal working hours or during the night, and whether expert assistance is required.

Centralized fault reporting

When printed board assemblies have to be repaired, program faults rectified, operating instructions corrected etc., a fault report must be made out. A fault report form and instructions on how to fill it in have been prepared. The form makes it easier for the OMC staff to provide all essential information.

The staff at the central fault reporting section must check that the form is completed in accordance with the instructions. They then have to send the reports to the correct departments, ensure that answers arrive within the time promised and distribute the answers to the right sections in the operation and

Fig. 5

An example of the use of TRAFDATA.

The data that form the basis for the generating of commands in TRAFDATA are stored in an input data file. This file can be built up in two ways:

1. Data are specified on an input data form, are punched and read into the file.
2. Data are specified direct in the input file via a display screen, with the aid of a program called TRAFEDIT. This program generates a picture that is the same as the input data form used in method 1.

The TRAFEDIT program is also used to correct data in the input data file.

The picture shows an operator using method 2 to specify tariffs for an AXE 10 exchange



maintenance organization. For example, revised documents must be sent to the relevant document libraries.

The central section should also compile monthly reports and fault rate reports for the various exchanges etc. on the basis of the fault reports.

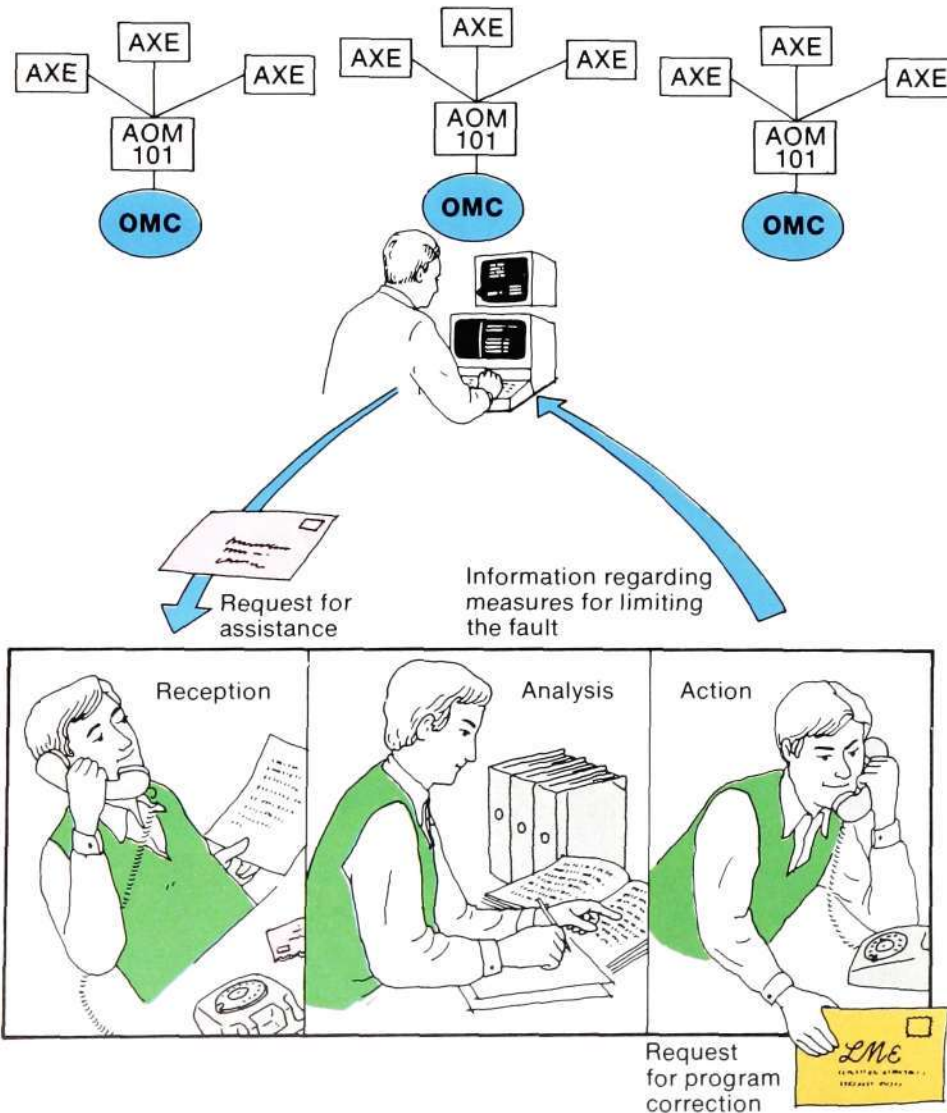
Handling of spares based on economical principles

The hardware faults in an AXE 10 exchange are repaired by replacing the indicated, faulty unit with a faultless unit. The types of units for which spares should be available as replacements are: printed board assemblies, I/O devices, and power units.

The need of immediately available spares is met by setting up stores for spares. When a hardware fault occurs in an exchange a replacement unit is taken out of the store. When the fault in the exchange has been cleared the stores organization ensures that the faulty unit is repaired or a new unit is purchased.

The repair of printed board assemblies and power units requires access to the same components, tools and test equipment as for the manufacture, and such repairs are therefore carried out by the supplier (the manufacturer of AXE 10 equipment within the country or LM Ericsson in Stockholm). I/O devices are usually repaired by the local representative of the manufacturer.

Fig. 6
The work of an expert in a central unit.
The illustration shows the method of working for one type of problem. With other types of problems the expert goes out to the OMC or the exchange to solve the problem on site



The size of a store depends on the following parameters:

- The fault rate of each unit, which is based on reliability data for the components in the unit.
- The permissible shortage risk for each unit, which is determined by the effect the unit has on the service quality of the exchange.
- The total number of units of each type in the exchanges that are served by the store.
- Replacement time, which is based on the spares organization of the administration and the delivery time of the repair department.

LM Ericsson have developed a calculation method, which gives the required size of the store on the basis of these parameters. The method has been compiled in a program system (RESEX), with the aid of which the required number of spare units (of the 150–200 types concerned) can be calculated quickly and correctly.

Number of exchanges per store

Calculations show that the store cost per exchange line is five times higher for a store serving one exchange with 5 000 lines than for a common store serving six exchanges with 10 000 lines each. If only the store cost were to be considered, substantial centralization would therefore be recommended. Against this is the need for quick delivery from store

to exchange. The grouping of exchanges into maintenance areas is a suitable basis for the stores organization, with a number of district stores, each serving a number of exchanges.

Replacement time

The time it takes to obtain replacement spare units influences the size of the store very considerably. On average the replacement time can be kept down to about seven days for the district stores if the administration has set up a central buffer store, but it can be in the order of four months if the unit is sent in for repair. Calculations show that a store which serves 60 000 AXE 10 lines must be doubled if it is going to take four months to get a replacement instead of seven days.

Fig. 7 shows the principles of a centralized stores organization, with a number of district stores and a central store that functions as a buffer between the district stores and the department that repairs the replaced units. As can be seen from the illustration the repairman fetches replacement units from the district store and afterwards returns the faulty units there. The faulty units are immediately sent to the central store, which without delay sends back replacement units and arranges for the repair of the faulty ones. If any unit is so badly damaged that it cannot be repaired, the central store orders a new unit. This centralized procedure gives short replacement time and very limited administrative work in the district stores.

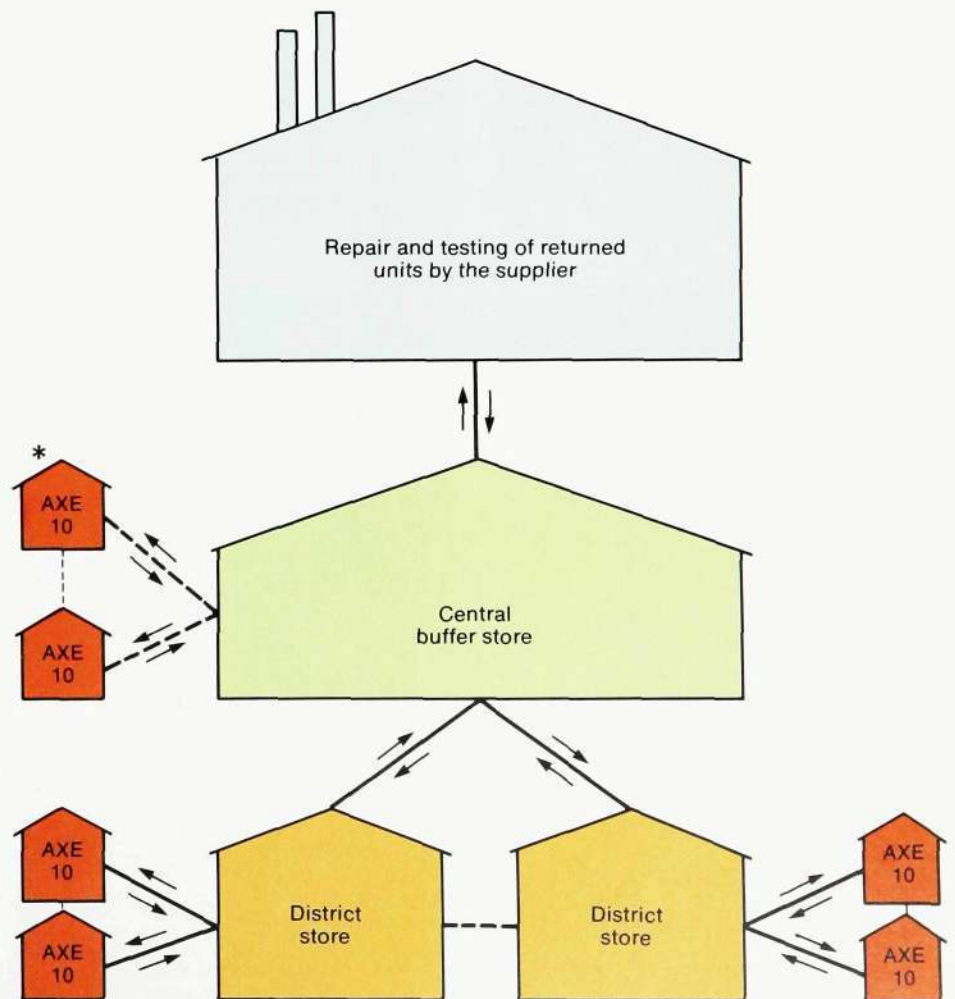


Fig. 7

An example of a centralized stores organization. The repairman is informed by means of printouts about faulty units. He brings faultless replacement units to the exchange and later returns the faulty ones to the district store.

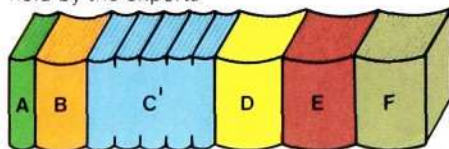
The faulty units are sent from the district store to the central store, which immediately sends back replacement units. From the central store the faulty units are sent to the relevant factory for repair. The repaired units are returned to this store for later distribution to the district stores.

* AXE 10 exchanges in the district where the central store is situated can be supplied with spares direct from this store.

Library	Main tasks	Required document modules
1. Unmanned exchange, centralized operation	Final localization of hardware faults and replacement of faulty printed board assemblies	B, C
2. Manned exchange, local operation and maintenance work	Fault analysis, operation and hardware activities	A, B, C
3. Operation and maintenance centre, OMC	Analysis of faults, operational activities such as changing and collecting charging data	A, B, C In certain circumstances there may be reason to add modules D, E and F
4. Other work centres, such as centres for maintenance of the subscriber line network SCC; traffic observation centres etc.	Receiving complaints from subscribers, measuring subscriber lines, observing subscriber behaviour etc.	Selected parts of module B
5. Central expert unit for operational assistance	Advanced fault analysis in the case of difficult and rare faults	A, B, C, D, E, F

Table 1

The Administration's central library held by the experts



Exchange library

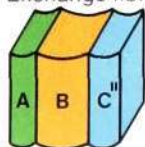


Fig. 8
The various libraries for local operation and maintenance work

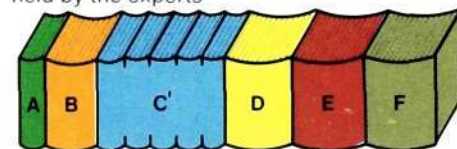
- C' Exchange documents for all exchanges served by the experts
C'' Exchange documents for the individual exchange

Documentation

Well planned documentation is necessary in order to be able to describe a system and its handling in a way that suits different users. It is essential that the documents are easy to understand. Much work has been put into the documentation of AXE 10 in order to meet these requirements. For example, the operation and maintenance manual is both easy to understand and instructive.

It is not only the formulation of the documents that is important but also the possibility of dividing the documents

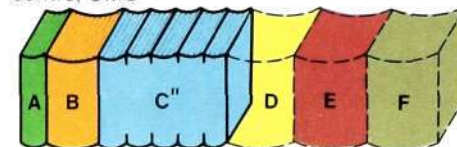
The Administration's central library held by the experts



Work centre library.
(For traffic observations, subscriber line maintenance etc.)



Library in the operation and maintenance centre, OMC



Exchange library

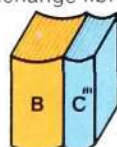


Fig. 9
The various libraries for centralized operation and maintenance work

- C' Exchange documents for all exchanges served by the experts
C'' Exchange documents for all exchanges served by the OMC
C''' Exchange documents for the individual exchange
The modules outlined by broken lines may sometimes be required in the OMC library

into units or modules, so that the documentation can be arranged in different libraries so suit the needs of every user. For AXE a module system is used, where each module contains information of similar type, such as system descriptions, or documents that deal with the same type of activities, for example operating instructions.

Document modules

The various modules are as follows.

Library summary, module A, which contains an overall list of contents of the whole library, a short description of the contents of the different modules and methods for easy identification of the various document categories.

Operation and maintenance manual, module B, which is the most important of all modules. It contains instructions in flow chart form, with supplementary text clearly stating, step by step, what the operator has to do to carry out a task, for example to locate and clear a fault. The manual also contains command and printout descriptions.

Exchange documents, module C, which contains the documents that are individual for each exchange, such as floor plans and cabling and assembly data.

System descriptions, module D, which contains functional descriptions at the system, subsystem and function block levels.

Software documents, module E, which is the largest module with 65 % of all documentation. It contains printouts that are obtained during the production of programs and comprises programs in source code (PLEX) and in target code, flow charts, signal distribution tables etc.

The software documents are rarely used, and as their volume is so large it may be suitable to use microfiches instead of ordinary paper copies. Each microcard holds 63 document pages. The microfiches are read using a viewer that enlarges the document to the normal size and projects it on a screen. With a combined viewer and copier a paper copy of the document can be obtained if necessary. Module E in the form of

microcards usually comprises five binders.

Hardware documents, module F, which mainly contains circuit diagrams and assembly drawings for printed board assemblies, and wiring information for magazines.

Libraries suited to different user groups

In order to be able to decide which modules are to be included in each library it is necessary to carry out a detailed analysis to determine which tasks are to be performed by the various centres etc. The result of such an analysis is naturally dependent on the operation and maintenance organization in question. Table 1 and figs. 8 and 9 give some guidelines for the allocation of modules to different libraries.

Personnel requirements and training principles

In addition to centralized operation, AXE 10 also offers great advantages as regards personnel requirement and training. The personnel requirement is low and good possibilities are provided for giving the various personnel

categories the training they require for carrying out their particular tasks.

Personnel requirement

The personnel requirement is determined by assessing how often a task has to be carried out and the average time it takes. The operation and maintenance work for an AXE 10 exchange covers not only the exchange itself but also maintenance work in the surrounding subscriber and trunk line network. This is because AXE 10 contains functions for network maintenance (supervision, tests). An analysis of the personnel requirement indicates that the total amount of operation and maintenance work for an AXE 10 local exchange with 10 000 lines is approximately 8.5 man hours per day. The work load varies from exchange to exchange, depending on such factors as the rate of change of subscriber data and the quality of the surrounding network.

The main part of this work can be carried out in various work centres. The analysis indicates that the amount of work that can be carried out in remotely located centers is about 80–90 % of the total volume, and the amount of local work that has to be done in the exchange constitutes about 10–20 %.



Fig. 10
Practical training in an AXE 10 exchange

The tasks that require most work are

- the connection and disconnection of subscribers and the changing of subscriber categories, which together account for about 40 % of the total number of working hours.
- the clearing of exchange and network faults detected by the exchange, i.e. alarm reception, analysis, fault localization, unit replacement and testing, which take up about 45 % of the total number of working hours.

Personnel categories

In a centralized operation and maintenance organization the tasks can be divided into four categories:

1. Expert assistance from a central section. This assistance is used when detailed knowledge of the system hardware and software is required.
2. Fault localization from operation and maintenance centres, OMC. The tasks include analysing incoming alarms in ordinary fault situations and localizing the faults to the faulty unit. They also include qualified correction work, such as changing the data for digit analyses in the exchanges. These tasks require knowledge of the system structure and function and also the operation of the system in accordance with the operation and maintenance manual.
3. Clearing the faults that have been localized in accordance with category 2. The tasks include travelling to the exchange in question, replacing faulty units with spares and then carrying out tests. The level of knowledge demanded by these tasks is slightly lower than that required for category 2.
4. Work in various centres, such as a central sales office or traffic analysis centre. The tasks include connecting and disconnecting subscribers, changing subscriber categories, collecting traffic recording data etc. These tasks demand only general system knowledge and knowledge of a limited number of commands and their use.

can be handled by operators with very little system knowledge.

Training principles

LM Ericsson offer a complete program for the training of operation and maintenance personnel. It includes both theoretical and practical training, the latter in an AXE 10 exchange, fig. 10. The program comprises courses that give basic education in telephony and SPC technology, system knowledge and training in operation and maintenance as well as installation engineering.

From these courses special course packages can be compiled which suit every personnel category. For example, a course package for maintenance technicians should comprise a four-week course on system knowledge and a five-week course on operation and maintenance, assuming that the pupils have basic training in telephone and SPC technology. All courses should be followed by practice in an exchange in operation.

Conclusion

Most administrations desire to handle all the operation and maintenance activities themselves. However, LM Ericsson are always prepared to supply expert assistance in accordance with principles which will be described in a later issue of Ericsson Review.

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1. Söderberg, L.: *Operation and Maintenance of Telephone Networks with AXE 10*. Ericsson Rev. 56 (1979):3, pp. 104–115.
2. Nordqvist, G.: *AOM 101, an Operation and Maintenance System*. Ericsson Rev. 56 (1979):3, pp. 116–123.

Category 1 requires system technicians with very good knowledge of the system. Categories 2 and 3 can be handled by maintenance technicians, with a slightly lower level of knowledge. Category 4

TECHNICAL NEWS

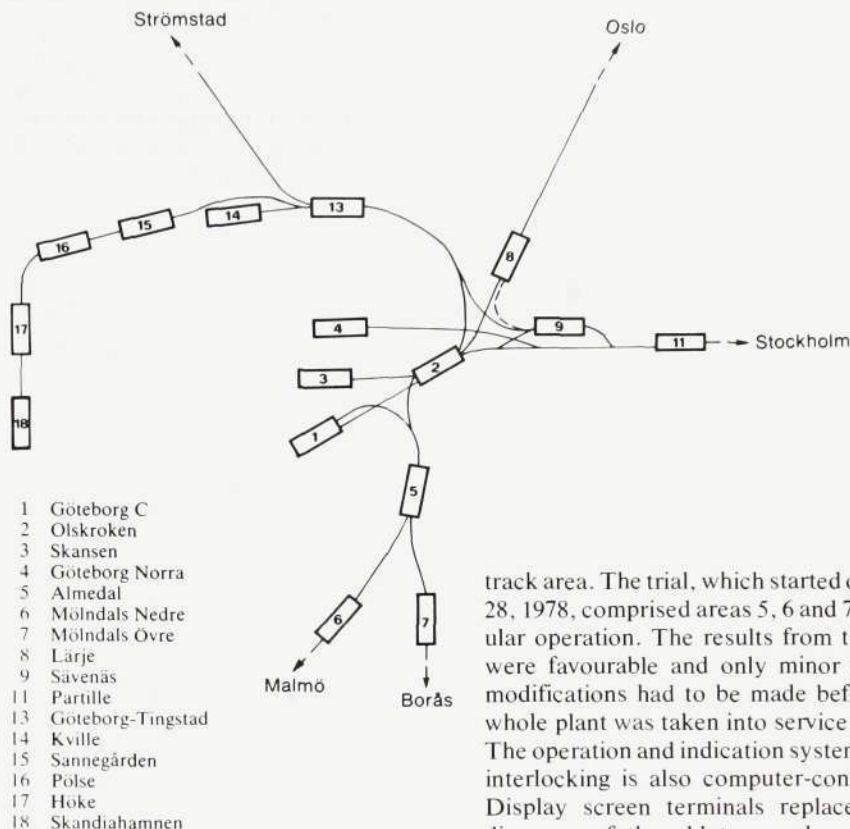
The first computer-controlled interlocking plant in the world

On November 19, 1979, a computer-controlled interlocking plant for railway traffic was taken into service in the Gothenburg area (west Sweden). The plant, which was manufactured by LM Ericsson, controls over 600 devices at present, including 115 points, 216 signals and 203 track circuits. When complete the plant will control about 1200 devices, corresponding to the track diagram to the right. At present areas 1, 5, 6 and 7 are in operation. The other areas will be incorporated successively.

The new and unique feature of the interlocking system is that all safety interlocking between the different devices in the railway yards is computer-controlled. In earlier, conventional plants safety relays have been used for interlocking. The interlocking conditions have depended on fixed interconnections of the relay contacts.

In the new system the rules for safe traffic handling have been given a stringent mathematical description. Both the mathematical description and the data transmission between the computer/interlocking system and the various devices in the railway yard have been designed to satisfy the demands for fully safeguarded function.

Before the plant for Gothenburg Central was put into operation the equipment underwent a field trial in a smaller part of the



Track diagram for the Gothenburg (Göteborg) area

track area. The trial, which started on May 28, 1978, comprised areas 5, 6 and 7 in regular operation. The results from the trial were favourable and only minor system modifications had to be made before the whole plant was taken into service.

The operation and indication system of the interlocking is also computer-controlled. Display screen terminals replace track diagrams of the old type, where lamps were used to indicate occupied tracks and the positions of signals and points.

The system design facilitates planning and installation. Changes in the track plan are also easier to carry out with this system. Moreover, the system provides facilities for coordination with the Swedish State Railways' other systems for traffic handling.

Another plant of the same type is now being installed in Malmö (south Sweden) and is expected to be put into operation by the middle of the 1980s.

Remotely powered branching

A remotely powered branching terminal has been developed by LM Ericsson, and is now being marketed for the coaxial cable systems ZAX 120 T and ZAX 480 T. The terminal is mounted in a sealed container for burying in the ground and is fed from the line power feeding.

The terminal can be equipped for branching up to 12 telephony channels with E & M signalling. The channels can be connected either 4-wire or 2-wire. Three of the channels can be provided with relay sets for subscriber signalling.

The required carriers are generated from the line pilot.

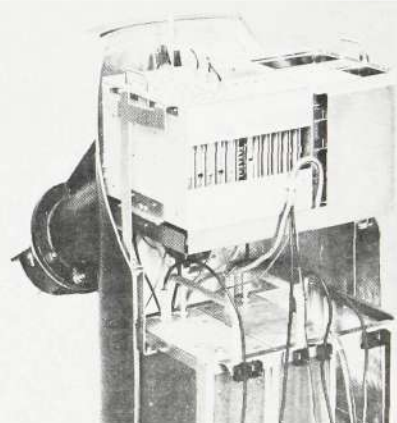
Since both power feeding and carrier control takes place over the line, the terminal can be installed at any suitable place along the line, and is completely independent of exchange buildings and local power feeding. This flexibility as regards placing, and the possibility of connecting subscriber lines makes the terminal particularly suitable

for such purposes as telecommunication along pipelines and railways.

Telecommunication along for example a pipeline normally requires a limited number of circuits between the base stations and a number of places along the line where often there are no exchange buildings. The circuits are required for telephony as well as remote supervision and data transmission.

The development of this type of terminal was made possible by the compact construction and low power consumption of modern carrier equipment.

The terminal equipment is mounted in a sealed container of the same type as is used for intermediate repeater stations in the coaxial cable systems ZAX 960 and ZAX 2700. The equipment consists of a repeater, a power unit and a shelf with multiplex units. The power unit contains a DC/DC converter, which uses the constant line current to give a constant voltage of 12 V. The power unit also contains hybrids for single or double branching. The multiplex shelf contains equipment for channel and group modulation, line termination and carrier generation.



Remotely powered branching terminal for coaxial cable systems

AXCE – a new power cable

The Swedish cable manufacturer Sieverts Kabelverk have developed a new power cable, AXCE, which was first put on the market in October 1979.

The new single-conductor cable is manufactured in versions with a rated voltage of 12 or 24 kV and with an aluminium conductor having an area of 50, 95, 150 or 240 mm². The cable is insulated with cross-bound polyethene, PEX, and a sheath of polyethene, PE. Up to this point the new cable is similar to its well-tried predecessor AXAL, which has for many years been used for the distribution of electricity both in the ground and in the air. AXAL has a screen consisting of a thin aluminium tape that is folded around the cable lengthwise and which requires a special adaptor for connecting the screen.

The new cable, AXCE, has a screen of undulating copper wires embedded in a semi-conducting layer. This layer also prevents water from penetrating into the cable and improves the mechanical characteristics of the cable. The screening wires are laid along the cable without twisting. The outer polyethene sheath has a smooth and even surface which is well suited for type and length marking. Fig. 1 shows the build-up of AXCE.

The cable can also be used as a self-supporting aerial cable if, in the cabling machine, the three phases are cabled round a suspension wire. The suspension wire is attached to special suspension devices on poles or brackets.

Fig. 2 shows how the outer sheath is stripped, thereby uncovering the individual screening wires when making a cable termination or joint. The undulating wires cut through the PE sheath and the material between the wires can then easily be removed.

AXCE is jointed and terminated using the material kits for PEX cables that are available in the market.

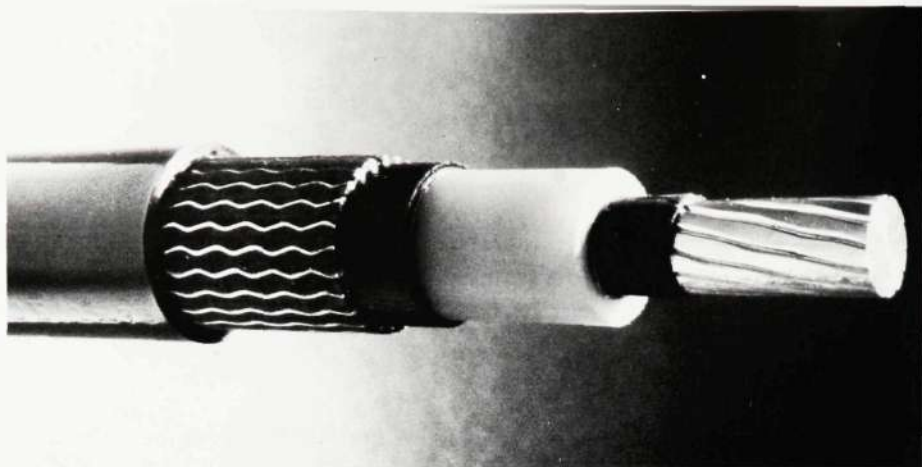


Fig. 1. The build-up of power cable AXCE



Fig. 2. Stripping the outer sheath and exposing the screening wires

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