ERICSSON REVIEW

MD 110/20 – "The Greatest Little System in the World"
MD 110/FS – A Communications System for the Banking and Finance World
BCS 150 – A Digital Business Communications System
Fibre Manufacture using Microwave Technique
Power in the Switch Room – A New Power Supply Alternative

4 1988

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Cover
A workstation for sales staff at the clothing manufacturer Esprit Sweden AB, employing the digital system BCS 150.
This business communication system was developed by Ericsson Business Communications AB in collaboration with the Swedish Telecommunications Administration.
The Administration markets the system in Sweden under the name FENIX DX/60.
The telephone set in the picture is the DIALOG 2752

MD 110/20 — "The Greatest Little System in the World"

Britt-Inger Eriksson and Sven-Åke Forssell

MD 110 is the common designation of a family of business PABXs which has been designed with the aim of facilitating flexible private communications networks for both voice and data communication. MD 110/20 is a new member of the family, intended for small offices that need sophisticated telephone services and data comunication facilities.
The authors describe the requirements on which MD 110/20 is based, its technical design and the characteristics that make the system unique among small PABXs.

design engineering
private telephone exchanges

Good communications to, from and within a company are a prerequisite for success and profitability, for small as well as large companies. Ever since its introduction MD 110 has very successfully been marketed and sold as a system that offers sophisticated, cost-effective solutions to communications problems, primarily for large companies and institutions.

Ericsson Business Communications AB has now developed MD 110/20 so as to be able to offer small and medium-sized companies and small offices within large enterprises the same advanced services that so far have been available to large companies only.

A prime requirement during the development was that customers should be able to preserve the value of previous investments, training etc. when extending the system. Savings are made if the same spare parts and operation and maintenance routines can be used for all PABXs – large and small – in a company. Ericsson would be able to take advantage of previous investments in development, training, marketing organization, aids etc.

MD 110 can be expanded from approximately 40 to over 10,000 extensions. Using the same basic technology for all exchange sizes means that the customer's initial investment is not affected by any need for extension. The system is optimized for digital terminals and exchange lines. All extensions can already be equipped for simultaneous voice and data communication and in the near future for ISDN services also. Customers who want to continue using their analog telephones when the system is installed can easily change to digital sets with a wider range of functions when the need arises. The system is designed so that such a conversion only requires a change of printed board assemblies in the PABX and the input of the relevant data.

Technical description

MD 110/20 is an independent PABX which can also serve as part of a large MD 110 system. Interconnection with

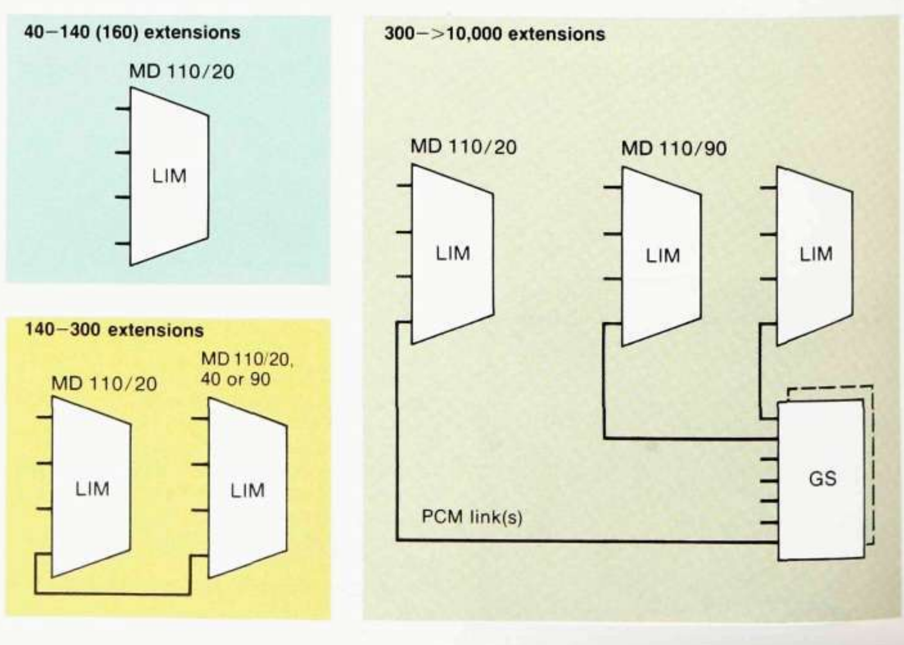

Fig 1
The structure of MD 110

LIM Line module
GS Group switch

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other units in the MD family is via 32-channel PCM links, fig. 1.

An MD 110 system is built up of modular blocks,[1] line interface modules, LIM, which in large systems are interconnected via a central group switch, GS.

MD 110/20 consists of one LIM, fig. 2. Its maximum capacity is 160 extensions and 2x30 channels for external calls. All extensions and exchange lines must be digital for maximum capacity to be obtained. The time switch in LIM has 512 inputs for voice and data. Each input has a capacity of 64 kbit/s. MD 110/20 can be equipped with any combination of interface circuits for analog and digital telephones,[4,5] data terminals[4] and lines to the public network.

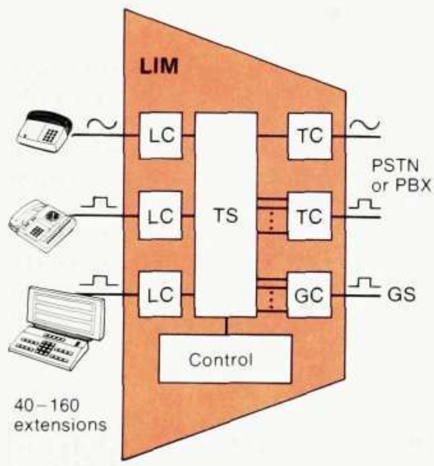


Fig 2
The structure and connection facilities of the line module, LIM

LIM	Line module
TS	Time switch
LC	Line circuit for extensions
TC	Line circuit for exchange lines
GC	Connection unit for the group switch
PSTN	Public switched telephone network
GS	Group switch

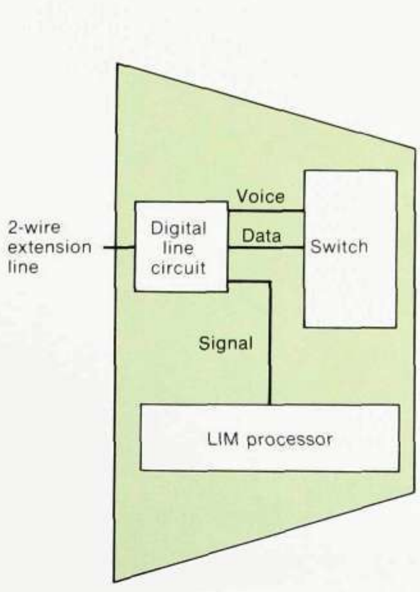


Fig 3
Voice and data channels in an LIM

Digital telephones, operators' sets and data terminals are connected to a digital line board, ELU-D, which contains eight line interface functions and occupies 8 or 16 multiple positions in the switch, fig. 3. Normally eight time slots are used for speech channels and eight for data channels.

Extensions and operators' sets are connected to the PBX via two-wire lines. Adapters for data terminals are connected to the same physical line as the telephone set for simultaneous voice and data commuication.

The digital system sets are common to all MD 110 PBXs and consist of the new DIALOG 2500 family. It comprises four types of telephone, from a basic set with five function buttons to a multi-facility set with 39 function buttons, loudspeaker and a 2x20-character alphanumerical display. The display provides support when using the many services available in MD 110, fig. 4.

The data communications services require a terminal adapter which is attached to the telephone. The adapter can also be used separately at a data terminal. A PC that is to be connected to the PBX can be equipped with a terminal adapter in the form of a printed board assembly.

The construction of MD 110 and the use of the system in business communications have been described in previous issues of Ericsson Review.[1–4,7] This article deals with the demands made on a small system in the MD 110 family and how they have been met in MD 110/20.

Design requirements

An analysis of demands from customers, subsidiaries and telecommunications administrations resulted in the following basic requirements for MD 110/20. It must:
- be capable of working as an independent PBX and also as an integral part of a large MD system
- cover the range 40–150 extensions and provide both voice and data communication facilities for all extensions

Fig 4
The digital telephone family DIALOG 2500

DIALOG 2501	(Top, right) Basic set with five programmable function buttons and volume control
DIALOG 2531	(Top, centre) This set contains 12 programmable function buttons, monitor loudspeaker and volume control
DIALOG 2561	(Top, left) This set contains an alphanumerical display, 12 programmable function buttons, loudspeaker and volume control
DIALOG 2562	(Right) This set contains an alphanumerical display, 39 programmable function buttons, loudspeaker and volume control. The set is suitable for executive-secretary and multiline applications

- use the same technology and have the same functions as the rest of the MD family
- fit into an office environment. One cabinet should accommodate all equipment
- have a low cost of installation.

Physical structure

MD 110/20 consists of a detached cabinet, fig. 5, which holds all hardware, including filters, power supply unit, main distribution frame and batteries. The latter can keep the PBX operating for up to 3 hours in case of a mains failure.

An extension unit is available, mounted on top of the cabinet and intended for customer-specific equipment, for example extra power equipment or terminating units for PCM links. The only connections that need to be made on site are external cables to the main distribution frame and to the mains.

Cabinet

Development in the component field is rapid and permits considerable reduction of hardware volume. This feature has been exploited in BYB 212, the packaging structure used for the MD family. BYB 212 meets current international requirements for mechnical and electrical environmental endurance during transport and operation. The cabinet is a mechanically self-supporting unit made of sectional metal with the top and base fixed to the sides. The sides are covered with plates. The main distribution frame is normally installed on the right-hand side of the cabinet, so the side cover on this side is extra deep. The front and rear of the cabinet are covered with removable plates with two locks. The electrical screening in the cabinet is provided by screening strips, and by screens at the top and bottom.

A cabinet contains three shelves for magazines with battery space below. Two of the shelves hold telephony magazines – basic and extension magazines. The third shelf holds two magazines with power supply unit, DC/DC converters, ringing generator and filter boards.

Magazine

The magazines are of single-unit height, i.e. six building modules, BM (one BM = 40.64 mm), and consist of a board frame with a wired back plane, which forms the connecting unit. The normal magazine width is 12 BM. The printed board assemblies are connected to the connectors on the back plane, usually two per board, and are held in place by a locking bar. The connectors and guides in the board frame are placed at standard intervals of six or eight modules (one module = 2.54 mm).

The basic magazine contains the control system, a switch for 256 time slots and device boards. An extension magazine contains only device boards and a switch for 256 time slots.

Fig 5
Cabinet BYB 212 0111

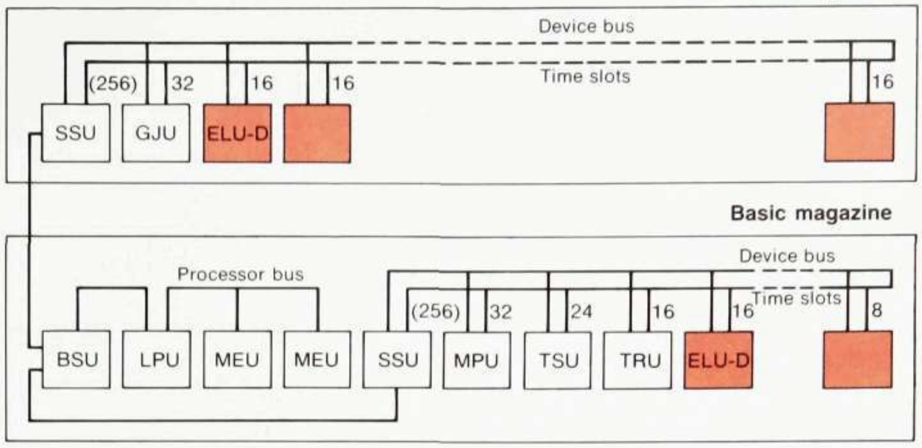


Fig 6
Diagram of the LIM structure and the allocation of switch time slots to the device boards

LPU	Processor
MEU	Memory
BSU	Time switch, basic unit
SSU	Time switch, extension unit
TSU	Tone sender
TRU	Tone receiver
MPU	Conference device
GJU	GS connection device

Optional device boards with a maximum of 8 devices, mainly internal and external line circuits

The interface between the magazine boards and the back plane is standardized for flexible positioning of device boards. The allocation of switch time slots to the board positions is shown in fig. 6. The basic magazine has 13 optional board positions, which are primarily used for internal and external line circuits. Nine of the positions have been allocated 16 time slots each, which allows simultaneous voice and data communication for eight extensions. The board spacing is eight modules. The extension magazine has 15 optional board positions, each of which is allocated 16 time slots. The board spacing in this magazine is 2x6 modules. The time slots are distributed in such a way that boards requiring 32 time slots can be used on condition that one of the positions next to such a board is empty or used for a device which does not need any time slots. In order to avoid empty board positions next to GJU, MPU, TSU and TRU these boards have been given fixed positions to which the necessary number of time slots have been allocated.

The third shelf contains two magazines, one for the DC/DC converters and ringing generator, three BM wide, and the other for filter boards and the power supply unit, nine BM wide. The filter boards, which contain secondary protection and filters to stop conducted interference, are placed outside the screened space. The screening of the switching equipment is obtained by mounting the magazine at the right-hand side and using screening strips. A screening plate is placed over the front of the filter magazine. At the rear, the magazine back plane – which is made of aluminium – prevents the propagation of interference, figs. 7 and 8.

MD 110/20 required a compact construction practice. The device boards are cabled direct to the rear of the filter boards via the magazine back plane, which eliminates the connection panel used in larger versions of MD 110. A new type of connector was also designed which eliminated wire wrapping at the back plane of the magazine. The new

Cabinet BYB 212 0111
Technical data

Height	1200 mm
Width	680 mm
Depth	340 mm
Weight	95 kg (fully equipped excl. battery)

The MDF installed in the cabinet
Able to withstand high levels of electromagnetic interference (EMI)
Meets the CISPR and FCC recommendations as regards radiated radio-frequency interference
Heat dissipation by means of self-convection

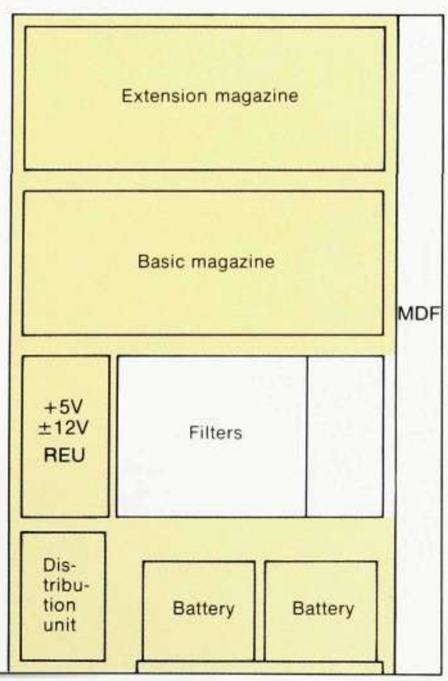


Fig 7, right
Diagram of cabinet for MD 110/20. Screened space indicated

MDF	Main distribution frame
AC/DC	Mains power unit
REU	Ringing equipment

Screened space

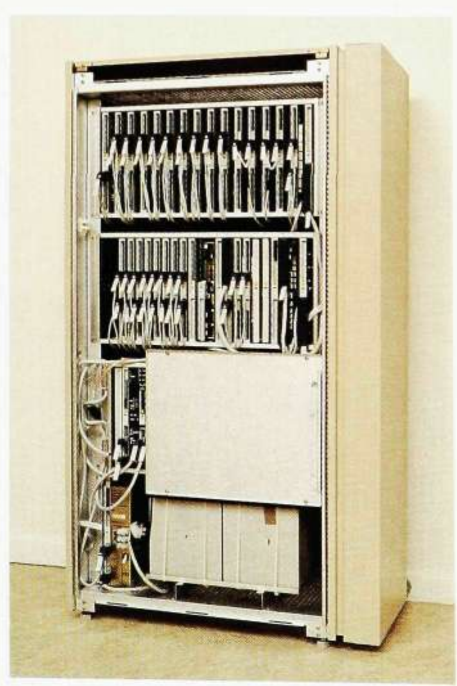


Fig 8, far right
The MD 110/20 cabinet with the front panel removed, showing the telephony magazines, batteries and the panel in front of the filter and power unit shelf

Fig 9a
Diagrams of the method of wiring the device boards in the telephony magazines to the back plane of the filter magazine. In reality the depth of the cabinet is only half the width.
Right: Side view of cabinet
Far right: Rear view of cabinet

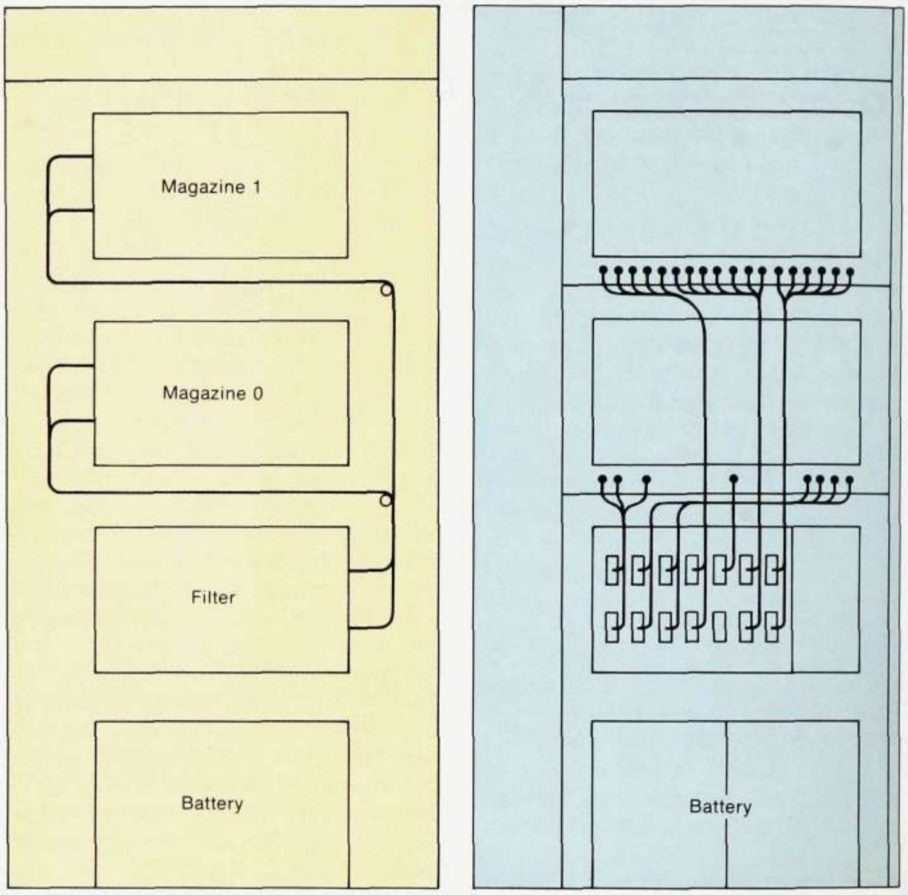
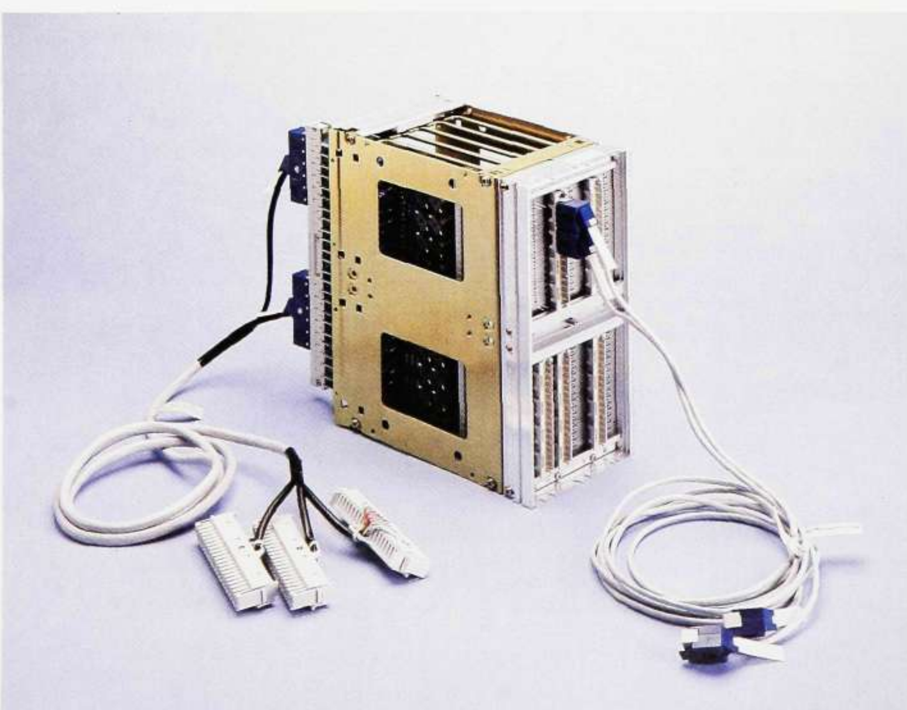


Fig 9b
Magazine with cables



connector simplifies manufacture, installation and extension.

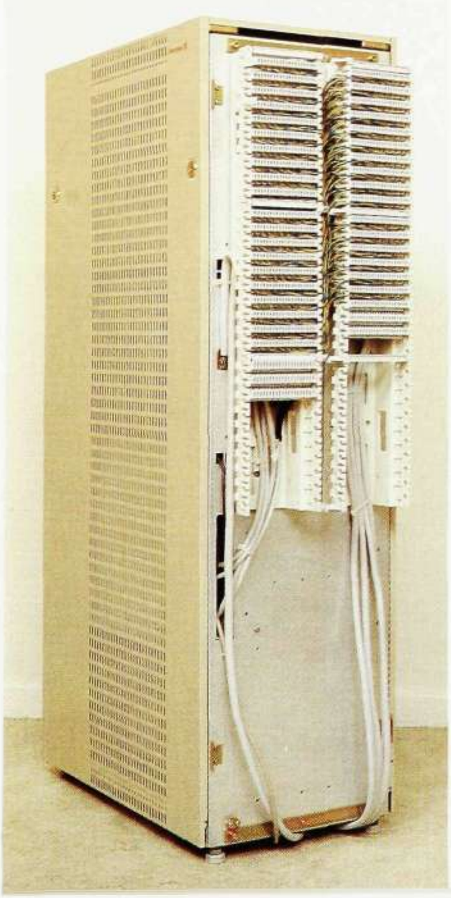
Cabling

All cabling to the printed board assemblies is connected at the front. Power for the logic circuits is also fed to the front of the telephony magazine. Further distribution is done at the back plane. However, as has been mentioned already, the device board cables are connected to the filter boards at the rear of the cabinet. All these cables have the same length.

With the cabling run direct from the boards to the rear of the cabinet there is no need for cable chutes below the magazines and inside the side plates. The method also simplifies the insertion and extraction of boards, fig. 9.

A DC voltage of −48 V is fed from the mains unit via a filter to two DC/DC converters, from which the internal logic

Fig 10
The right-hand side of the MD 110/20 cabinet with side cover removed, showing the main distribution frame



voltages are distributed to the telephony magazines.

Main distribution frame
The system is normally supplied with a built-in main distribution frame. It thus constitutes a complete unit with all equipment accommodated in the cabinet. The MDF is placed on the right-hand side of the cabinet and may consist of just one terminating panel for 300 wire pairs or two connection panels with 300 and 400 wire pairs for cross connection, fig. 10.

The standard MDF is Ericsson's Erinet,[6] but the variant KRONE can also be provided for markets where the telecommunications administration has standardized this type.

The MDF blocks have slot connectors for both the cable and the wire side and can take conductors having a diameter of between 0.4 and 0.65 mm. Each block is designed for 10 wire pairs and is mounted on a bracket. Two types of blocks are used, with or without breaking function. The latter makes it possible to carry out measurements of both the line and the exchange side. Cassettes with overvoltage protection for the lines can be installed if required.

Hardware
One of the prerequisites for MD 110/20 was that it should use the same printed board assemblies as the rest of the MD family. However, the boards in the system do not require the same space and use different numbers of time slots. In order to obtain a compact construction practice while making the optimum use of the switch time slots it was necessary to reduce the height of the analog device boards. New components and new technology meant that the height of both the extension and exchange line boards could be reduced. In addition the number of exchange lines connected to each board could be doubled.

Memory medium
MD 110 is normally equipped with dynamic RAMs having a capacity of 2 Mbyte per board. The memory contents are also stored on tape, for security reasons. However, it is space-consuming and costly to have a tape recorder continuously connected to a small system. System data is changed only rarely and then by service staff, who simultaneously record the changes. Protection against mains failures is primarily arranged by feeding the memory boards from the battery.

A new memory board with static RAMs was designed. The front of the board holds a NiCd battery, which preserves the memory contents for 65–100 hours in case of a mains failure. The battery is charged via a charging circuit on the board. The battery status can be checked by means of a non-locking switch. The time an LED remains lit indicates the level of the battery charge.

When the mains voltage to the system disappears, the battery takes over the feeding. The battery is disconnected when the system voltage returns and the input voltage to the memory unit reaches a predetermined minimum level. Normally the system restarts within a minute of the restoration of the mains voltage.

Having the memory fed by a battery on the board makes it possible to prepare new software at a maintenance centre. The pre-programmed memory boards are taken to the PBX and installed in the place of the old boards. The system can be started directly with the new software.

Installation

The mechanical design and cabling method of the system are based on the desire to reduce on-site installation costs. The working time should be as short as possible and one person should be able to carry out the work. The system is therefore tested and equipped with all internal cabling when delivered from the factory, which also minimizes the risk of faults.

Installation work has been simplified further through the development of a new type of cable with a connector at one end and a cross-connection block at the other. The cables are fitted in the system and tested before delivery.

During installation, customer data is also fed into the system. It is prepared in advance at a maintenance centre and

Technical data

Extensions, max.	160 }*
Exchange lines, max.	90 }*
Number of extensions/board	8
Number of analog exchange lines/board	4
Telephone operators	1–4
Ports	512
Optional board positions	28
Data storage	
SRAM with battery backup or DRAM with PC or tape recorder backup	
Ambient temperature, C°	+5 to 40
Relative humidity, %	20–80
Forced cooling is not required	
Power supply	
AC voltage, V	115/230 ± 15%
frequency, Hz	44–440
power cons. max., W	360

* Not at the same time

loaded directly into the memories or onto a floppy disc, which is then used to load the system.

Summary

With the launching of MD 110/20 Ericsson can offer cost-effective communications systems based on the MD 110 family to customers who need only a small PBX.

A customer who chooses an MD system can be certain that, although small initially, it can expand with the company. New line modules and new functions can be added without any software having to be replaced. It is only necessary to add hardware. This applies to the whole range from the smallest system, with around 40 extensions, to the largest, with more than 10,000.

This has several benefits for large companies with geographically scattered offices; for example good utilization of investments in training and spare parts and instant familiarity with the PBX wherever you move within the company.

Different MD 110 systems in a company can be interconnected by analog and/or digital tie lines to form advanced networks, either within a country or between countries.

MD 110/20 may be a small PBX, suitable for small companies, but it offers the same facilities as large PBX systems. In addition to its high functionality, it provides the company with the possibility of letting the staff share expensive equipment, such as laser printers, telex equipment and computer terminals. The latter feature constitutes an economical means of increasing the availability of expensive computers.

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MD 110/FS – A Communications System for the Banking and Finance World

Lars Nordström

Together with EB Netcom in Norway, Ericsson has developed a financial trading system based on Ericsson's PBX MD 110. The system meets all current requirements for an autonomous financial trading system. Significant synergy effects are gained by using MD 110 for administrative purposes as well. The author describes the structure of the system and the equipment and functions specific to this version of MD 110.

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Market requirements

The world of banking, stock exchange and securities dealings is a major market for Ericsson Business Communications AB, which is the largest individual supplier of private telecommunications equipment to this market in Western Europe. One of the product types successfully developed and marketed worldwide by Ericsson since the beginning of the 1970s is financial trading systems. Ericsson is therefore continually updating and improving its products and systems as market requirements change.

The demands made on a financial trading system are not quite the same as those made on an ordinary PABX. The system need not, in the first place, incorporate a multitude of functions, but very stringent requirements are imposed on it as regards the following five characteristics:
- availability
- connection facilities
- handling
- flexibility
- service and maintenance.

The workplace, a dealer room, differs from an ordinary office environment both physically and mentally. In an ordinary office the aim is to create a quiet and pleasant environment with privacy for each individual. The personal space is often fairly large, and stress factors are avoided as far as possible. A dealer room is often quite different. High city rents and structural changes in companies – centralization into larger units – result in dealers having very limited working space. In addition the aim is

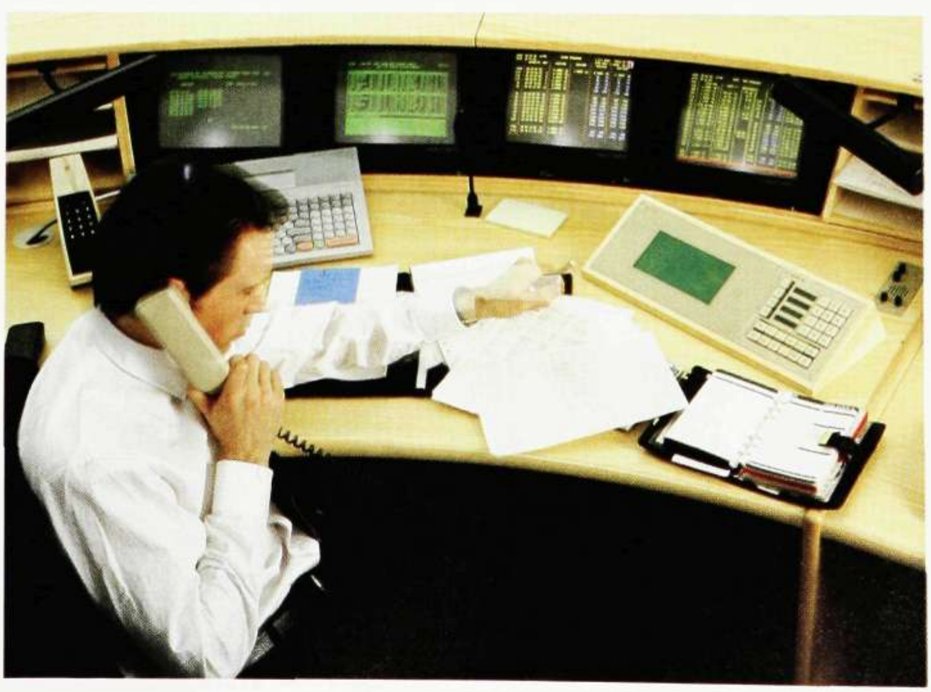


Fig. 1
Normal work place for a dealer. The picture was taken at the Cristiania Bank og Kreditkasse, Oslo, Norway

often to achieve excitement and a certain noise level in the room. Emotional, visual and auditory impressions can then give a fairly good picture of the level of activity in the market and the dealer can sense the degree of alertness required.

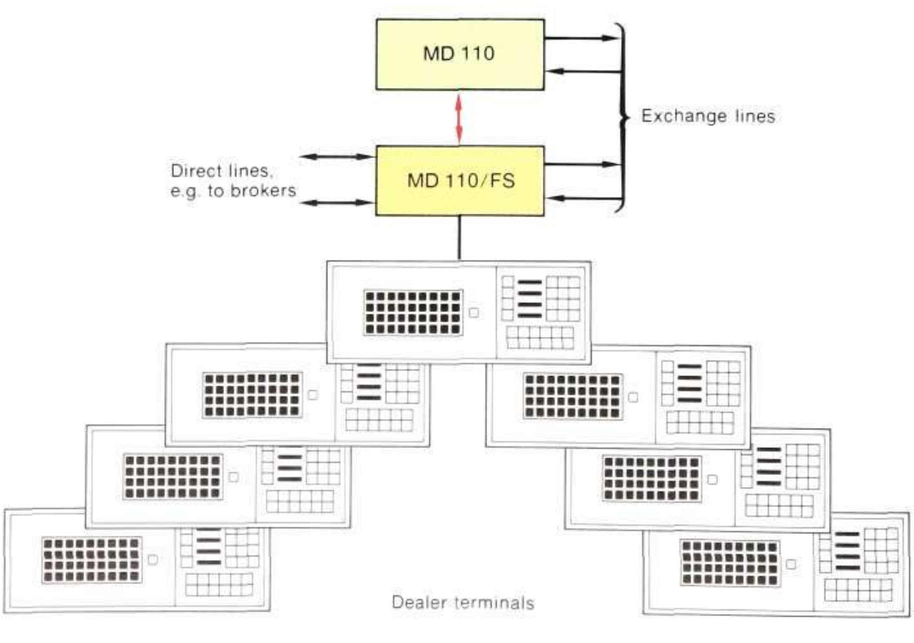
The methods of different categories of dealers are slightly different. Some listen continuously to a number of brokers via telephone lines and loudspeakers, *monitoring*. Many dealers at different banks and financial institutions may be monitoring the same broker. When he gives an acceptable offer for a currency or stock, the dealer has to try to be the first to reach the broker to make a transaction. Preferably it should be possible to obtain direct access to the broker just by pressing a button, *talk back*. Other dealers might have a number of large, steady customers who demand fast and efficient service. In such cases the dealer also requires means of rapid contact with these customers, who may be brokers or other banks and financial institutions.

The main requirements of a dealer system are:

- availability
  When the dealer wants to use the system it must be available. An unsuccessful attempt at setting up a call may result in the loss of large profits
- fast connection facilities
  It must be possible to establish the most frequently used connection paths by a single touch on a button. Leased lines are often used in order to reduce connection times and to ensure that the wanted line is not busy
- easy handling
  For several reasons the demand for easy handling is much stronger in the case of dealer systems than for ordinary PBXs. One reason is the need to establish contact rapidly. Naturally it is much quicker to activate a function by pressing a button once than by making a number of such movements. Another reason is that it is difficult to remember a number of code sequences for the desired functions. There is an express demand that learning to handle the terminal should be quick – a few hours. Easy handling also means easy learning
- flexibility
  The dealer must be able to change lines programmed for direct access buttons. Each dealer must also have a large number of such buttons available. Dealer terminals must be easy to move, so the cabling must not be complex. It must be easy to extend a system with more dealer positions but it is also desirable that large systems can be reconfigurated into several smaller ones. The reason is that the market is very dynamic. Swings can occur very quickly as October 17, 1987, will long remind us
- service and maintenance
  Service and maintenance must be easily available. The customer wants to ensure that the expected system availability will be met.

Fig. 2
MD 110/FS in a configuration suitable for banks etc.

Tie lines



Functions and structure

Normally the communications needs of a bank that is actively working with currencies and stocks can be met by a system in accordance with fig. 2. It consists of two subsystems: the general administrative PBX, an MD 110, and the special financial trading system, MD 110/FS, which provides the special functions required by the dealer. The main reason for not combining the two parts into one system is the dependability aspect. Two autonomous systems provide higher total availability than a single system. In addition the arrangement offers the possibility of using the exchange lines in MD 110, during heavy-traffic hours, to increase the traffic capacity of the dealer system.

The PABX, MD 110, can be equipped with analog standard telephones and different types of digital system sets. The public network is accessed via exchange lines and the financial trading system, MD 110/FS, via tie lines. MD 110/FS is connected to the public network, customers, brokers and other priority destinations via exclusive exchange lines; in many cases leased lines. There are also connections to dealer terminals, which can be of two types. One, the touch screen terminal, has a touch sensitive plasma display for instant connection to brokers etc., fig. 3, and the other, the key terminal, contains mechanical buttons and LCDs (Liquid Chrystal Displays) for the same purpose, fig. 4.

Fig. 3
The touch screen terminal contains a direct access panel, an indirect access panel, line buttons, function buttons, a push-button set and a control unit. Two handsets, two loudspeakers and a microphone can be connected to the terminal

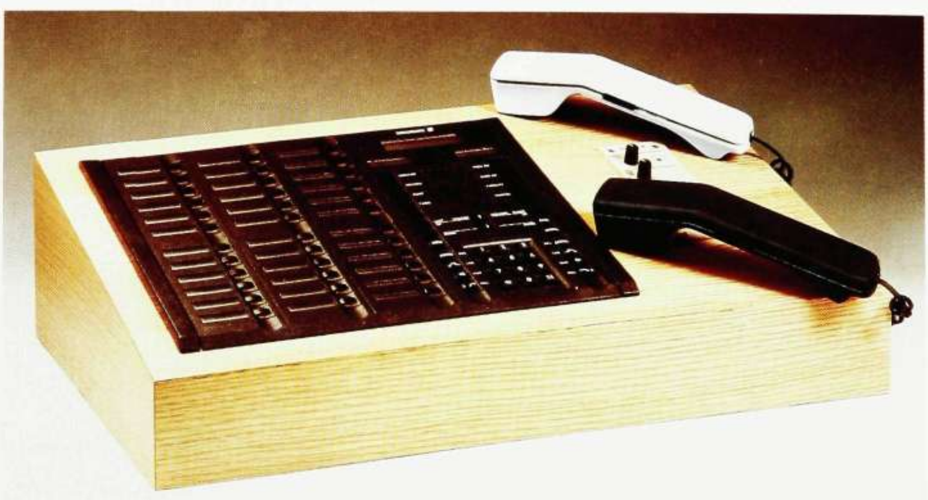


Fig. 4
The key terminal contains the same function units as the touch screen terminal but its direct access panel consists of mechanical buttons with LCDs instead of a pressure-sensitive plasma panel

TERMINALS

Both types of terminal can be used in MD 110/FS and can be combined as desired. The terminals are – and are used as – very sophisticated telephones. Two handsets, two loudspeakers and a microphone can be connected to each terminal, fig. 5, which has four voice channels to the PBX. One is used for each handset and one for each loudspeaker. The loudspeakers are used to monitor brokers and are often in operation for most of the day. Facilities are available for connecting up to seven brokers to each loudspeaker in a conference arrangement if the dealer so desires. In order to be able to speak to one of the brokers the dealer presses the button associated with the desired line. The microphone in the terminal is then connected to the line, talk back. It is also possible to switch one of the broker lines to one of the handsets.

The terminal contains function buttons for each of the two handsets. When a call is to be initiated or answered, the terminal automatically selects one of the handsets and the corresponding function button is illuminated. A call can be connected to a particular handset by pressing the relevant function button.

Parts of the hardware for the dealer terminals have been developed for the purpose, fig. 5. The interface unit, KDE, is common to both types of terminal. It consists of a 4-channel interface board for the PBX, a DC/DC converter and interface boards for the analog inputs and outputs – handsets, microphone, loudspeakers and tape recorder. KDE is mounted in a 19" shelf.

Touch screen terminal

Direct access panel

The central part of the touch screen terminal is the direct access panel, which consists of a plasma display of the type used in portable PCs, fig. 6. The display has a pressure-sensitive plastic coating wich gives electric contact when touched. On this display a pattern of 9x4 squares is programmed; each square representing a button function. Each square connects a direct access line, for example to a broker, to the terminal. The squares are used as direct access buttons for incoming as well as outgoing traffic and can be programmed with a label consisting of three lines of three characters each. Programming of a square takes about a minute and is done by an operator using an I/O terminal. When the panel is switched on, it shows

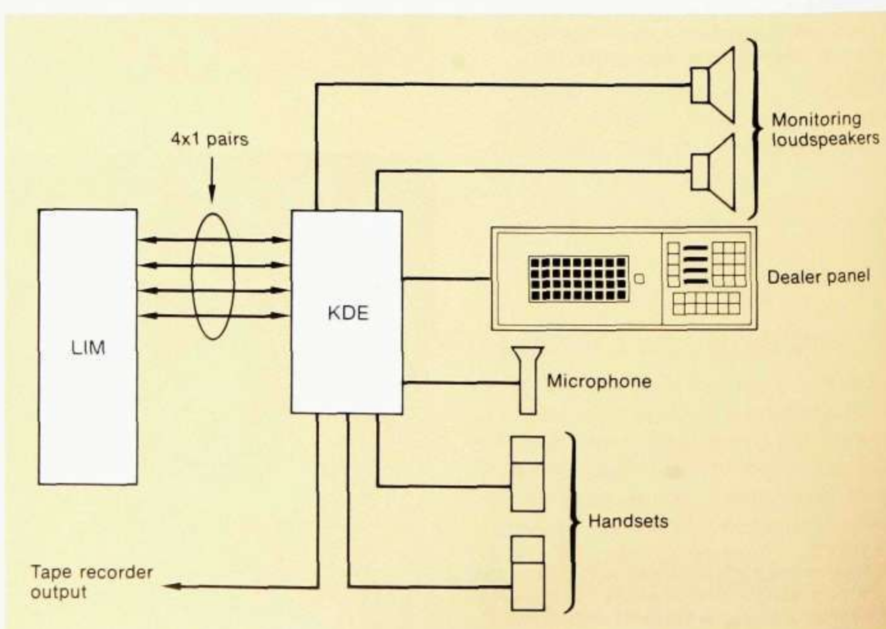


Fig. 5
The terminals are connected via a maximum of four pairs to the line module, LIM, in MD 110/FS. The interface unit, KDE, handles signal conversion and transmission. The handsets, loudspeakers, microphone and control panel are all connected to KDE

a menu of the available direct access lines. The menu can be changed via the terminal in question. The system allows programming of up to four whole menu pages per terminal. An incoming call that has not yet been answered is indicated by rapid flashing of the relevant button. A call in progress is indicated by slow flashing. Any calls coming in on one or more of the menu pages that are not being shown on the display are indicated by means of one of the buttons.

Indirect access panel
The touch screen terminal also includes an indirect access panel, which contains an ordinary push-button set with 12 buttons, four line buttons with associated alphanumerical displays and 12 function buttons. The panel is shown on the right in fig. 3.

The push-button set is used in the normal manner to dial full or abbreviated numbers.

The four line buttons are used to select lines for incoming or outgoing calls when the other party is not represented on the direct access panel. One of the lines is reserved for outgoing calls. Line no. four is reserved for group calls. An eight-character alphanumerical display provided for each line button shows the number dialled, digit by digit. When the number has been completed the display shows the identity of the called party in clear text if this information has been programmed into the PBX. When a call comes in, the display shows the identity of the caller if available. The display also shows to which handset the call has been routed or if it is parked, both for incoming and outgoing calls.

The twelve function buttons provide direct access to certain, frequently used facilities. Functions include choice of handset, choice of loudspeaker, call forwarding, repetition of last number dialled, transfer, parking and selection of menu page in the direct access panel.

In addition to the direct and indirect access panels the touch screen terminal contains two small units. One is a jack panel for connection of the handsets and the other a control unit. The control unit contains a buzzer that signals incoming calls. Five different tones are available so that terminals placed close together can be given distinctive signals. The unit also contains separate volume controls for the loudspeakers, a

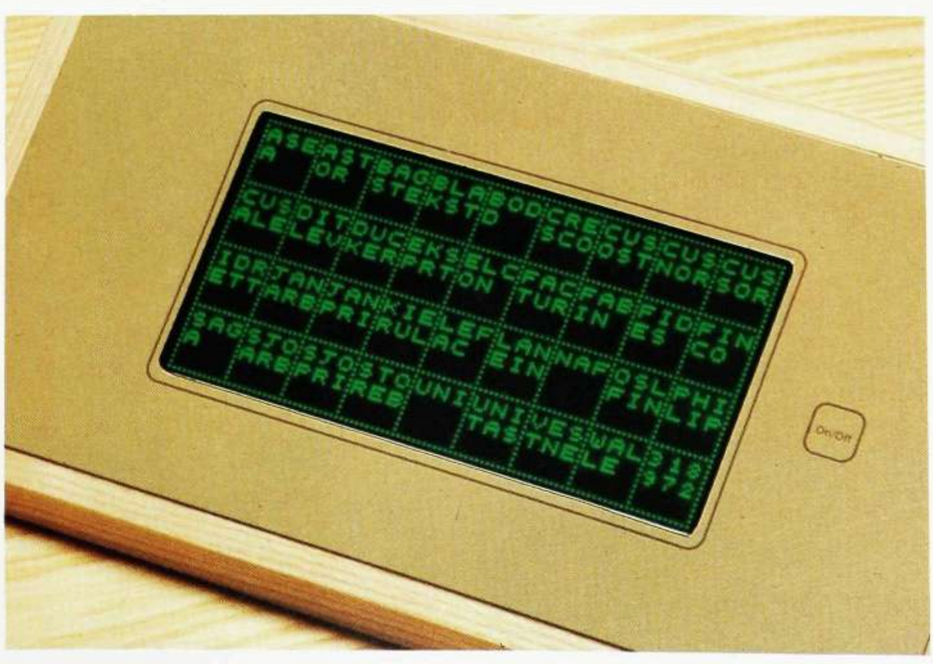


Fig. 6
The direct access panel consists of a plasma display with a pressure-sensitive plastic coating. An electrical connection is established at the spot where the coating is touched. The plasma display is switched on with a switch placed to the right of the screen

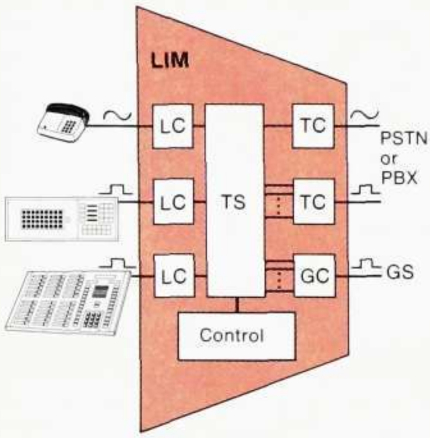


Fig. 7
Structure and connection facilities of the line module, LIM

LIM	Line module
TS	Time switch
LC	Connection unit for extension
TC	Connection unit for exchange line
GC	Connection unit for group switch
PSTN	Public switched telephone network
GS	Group switch

common volume control for the two handsets, a volume control for the buzzer and a "screwdriver" control for the buzzer frequency.

Key terminal
Functionally the terminal with buttons and LCDs is entirely equal to the touch screen terminal. There are good marketing reasons for providing both types. One is the price, which is considerably lower for the button type, and another is the fact that some customers prefer this type.

The direct access panel consists of mechanical buttons, each of which has an LCD that shows for which party the button is programmed. Two LEDs show the call status. The indirect access panel also works exactly as the one in the touch screen terminal. Handsets, loudspeakers and microphone are connected to the key terminal in the same way as in the touch screen terminal, and the same type of control unit is used in both terminals.

Structure of MD 110/FS

The structure of MD 110/FS is similar to that of MD 110, fig. 7, and the same modular hardware is used in both types. The main units in the system are line modules, LIM, and the group switch, GS, fig. 8. Up to 20 dealer terminals can be connected to an LIM, and an MD 110/FS can contain up to 50 LIMs. If the exchange system consists of only two LIMs they can be interconnected via PCM links. If more LIMs are required, the interconnection is made via the group switch, GS.

Transmission of information between the terminals and the exchange is in digital form. Analog standard telephones can be connected and used to supplement the terminals. The flexible structure of MD 110, and hence also MD 110/FS, makes it possible to place LIMs at a distance from the exchange, connected to it via PCM links, fig. 8.

Software

The software in MD 110/FS is also based on products developed for MD 110. It is divided into two main blocks. One, the operation and maintenance block, designated SES, is the same in both MD 110 and MD 110/FS. The other, the tele-

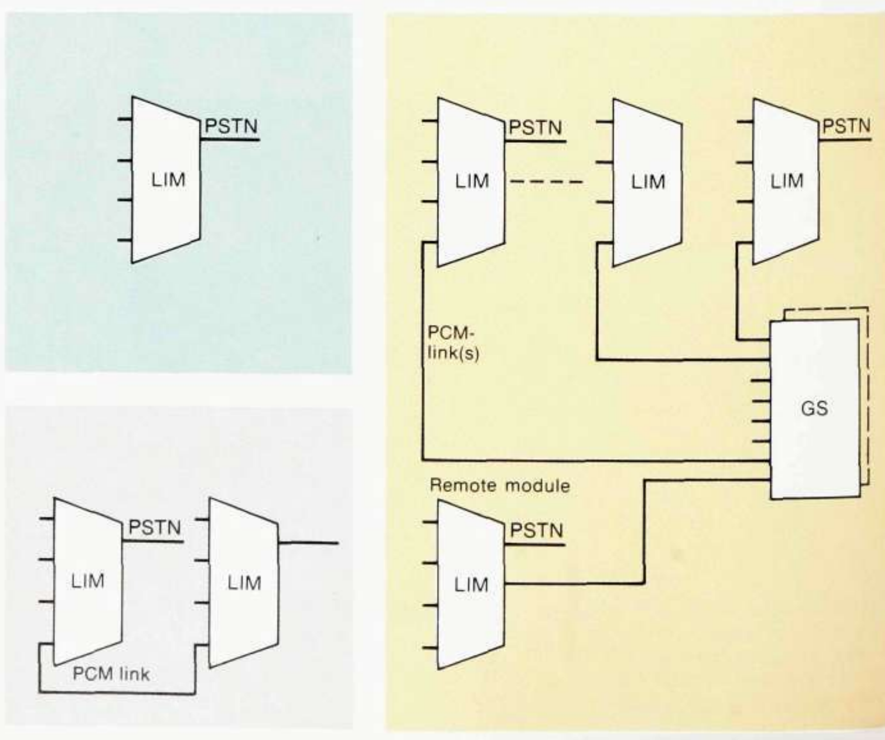


Fig. 8
Structure of MD 110/FS

LIM	Line module
GS	Group switch

Technical data

Loop resistance	
line to public exchange	1800 ohms
tie line	2000 ohms
Digit transmission	
decadic	10/16 Hz
break/make ratio	60/40 or 67/33
DTMF	In accordance with CCITT Q23
Transmission data	
encoding	A-law PCM in accordance with CCITT G.711
crosstalk attenuation	67 dB at 1100 Hz in accordance with CCITT Q517
Power supply	
power consumption, max.	approx. 340 W/cabinet
voltage	230 V +−15%,
frequency	45−65 Hz
Memory	
DRAM	
tape recorder for backup storage of memory contents	
Capacity	
terminals	<1000
exchange lines	<2000
Terminal wiring	
touch screen terminal	2−4 pairs
key terminal	2−4 pairs
line length	<1000 m (3280 ft)
Environmental requirements	
temperature	+5 to 40°C
relative humidity	20−80%
Fan cooling is not required.	

phony block, which contains the parts that determine the functions of the system, is designated ACS and has been developed especially for FS.

Summary

The modular design of the hardware and software, and the distributed structure, means that the system can easily be extended. It also means that a large system can be divided into a number of small autonomous units, a feature which ensures that the value of the investment is preserved even when the system has to be reconfigurated. This is particularly important in such a dynamic field as currency and securities dealings.

MD 110/FS is future-proof. Since FS is based on MD 110 it will benefit from all rationalization and improvements in MD 110. The services and functions unique to FS are also continually being developed and improved.

MD 110/FS has been developed to meet the needs and demands of the banking, stock exchange and finance world as regards telecommunications. The following requirements have been given priority:

- availability
  the system must never be out of service
- fast connection facilities
  makes the dealer more competitive
- easy handling
  reduces the risk of wrong numbers and shortens training time
- flexibility
  the highly dynamic line of business means frequent moves, merging of units, reconfigurations and changes in customer data. The communications system must not be an impediment
- service and maintenance
  any problems that may occur must be dealt with very quickly.

MD 110/FS meets these requirements. Representatives of various banks and financial institutions, telecommunications administrations in several countries and – in ergonomics and availability matters – authorities responsible for air traffic control were consulted when the requirements specification was prepared.

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BCS 150 — A Digital Business Communications System

Sven Kilander and Arne Svensson

Ericsson Business Communications AB, in collaboration with the Swedish Telecommunications Administration, has developed a digital business communications system. It covers the range 10–150 extensions, with up to 40 exchange lines. The system can easily be adapted to different markets and is suitable for production both in Sweden and abroad. The Swedish Telecommunications Administration has already introduced the system, which is marketed under the name FENIX DX/60. Some 1000 systems were taken into service during the first ten months and the experience has been very favourable.

private telephone exchanges
digital communication systems

The philosophy behind BCS 150

An important objective in the development of BCS 150 was to offer customers a user-friendly system which is of service to everyone in different types of enterprise. The system philosophy requires the telephones to form an integral part of the system and to be adapted to the services offered.

The system must be able to handle speech, text and data. Modern digital technology has been used to ensure cost-effective solutions and futureproofness.

BCS 150 gives all users access to digital telephones, and new services can thus be introduced – services that are easy to handle and are useful in the daily work. With BCS 150 the telephone has developed from a simple transmitter of speech into an efficient tool adapted to the individual needs of each user.

Adapting BCS 150 to the company

BCS 150 is intended to meet the communications requirements of both small

Fig. 1
Telephones and the central unit for BCS 150

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and medium-sized companies and therefore needs facilities for adapting its traffic pattern. A multiline system that enables several people to answer incoming calls may be suitable in a small company. A larger company may instead need one or more telephone operators to ensure an efficient communications system.

The traffic pattern in BCS 150 is flexible and can be adapted to suit different requirements. When the company grows, the system can be reconfigurated from a multiline system to a PBX system in which up to three operators can handle the incoming traffic. After such a conversion the system can still provide multiline functions for a number of groups. In addition, the incoming traffic to these groups can either be put through by the operator or routed direct to the extensions in question.

BCS 150 contains an ACD (Automatic Call Distribution) function in order to ensure better answering service to customers and evenly distributed work in busy work teams. This function is most appropriate for a group of people with a common task, for example order reception or booking offices. The incoming traffic to an ACD group can also be put through by the operators, if desired.

Adapting BCS 150 to the users
In most organizations, people work together in one way or another. BCS 150 can be adapted to a company's natural work teams so that people will not be tied to their telephones but can move freely within the area determined by team activities. This is described in the section "BCS 150 for work teams", and also how the telephone traffic is handled in a manner that is efficient for the team as well as the individual user.

BCS 150 always answers
When a caller cannot reach the called person, BCS 150 offers alternatives. The caller is given a message – verbal or text – stating when the called person will be available and, if desired, the reason for his or her absence.

The caller might want to leave a message. BCS 150 provides the appropriate facilities. A verbal message can be recorded from any type of digital telephone. If both parties have a telephone with a display they can exchange written messages. Alternatively the caller can send a simple *Call me* request. This facility is described in "Other messages in BCS 150".

Traffic patterns

BCS 150 – a multiline system
Multiline groups can be arranged within a BCS 150 system. The number of groups and the number of members of each group are both optional within the limits set by the maximum capacity of the system.

An incoming call to such a group can be answered by any participant. It is easy to transfer calls within the group and it is always possible to reach the other members of the group even during an external call.

One advantage of BCS 150 is that each member of a group can program his/her telephone to signal incoming external calls immediately or with a slight delay. This allows the group to appoint certain members to take care of incoming calls.

Conventionally a multiline telephone has individual buttons for the exclusive exchange lines. The choice of telephone set determines the number of exchange lines accessible from the set. DIALOG 2752 gives access to ten and DIALOG 2753 to 26 lines.

A common answer button for the exclusive exchange lines allows more such lines to the multiline system, regardless of the telephone model. All incoming calls are signalled at the common answer button, automatically put in a queue and answered in turn.

Individual line buttons give the members of the group an overview of the number of busy and free exchange lines. A common answer button gives an overview of the colleagues' telephone situation and also facilitates a mutual interception service. See "BCS 150 for work teams".

BCS 150 – an ACD system
The ACD function distributes the traffic evenly over one or more groups of extensions. Up to 40 extensions can be

allocated ACD and they can be divided into a maximum of four separate groups.

Dialog 2753 is a suitable telephone for ACD. It has programmable buttons and a display that continuously shows the queue state for each ACD group.

Each member reserves a programmable button as the answer button for each ACD group to be served. The answer buttons can be programmed *active* or *passive*, i.e. each member can individually decide which ACD groups are to be served at the moment. This feature increases the flexibility at fluctuating traffic load.

An incoming call is routed to the active member of the group who has been free the longest time. If a call cannot be answered immediately it is automatically put in a queue and then set up in proper order.

Vocal answer
It is important that callers placed in a queue are imformed about the situation. With an auxiliary board for digital speech storage, VMU (Voice Memory Unit), a message can be recorded and delivered, for example: "Welcome to ABC Airlines. We have a temporary queue. The waiting time is estimated to be 5 minutes."

The waiting time is calculated on the basis of the average queuing time for the last eight queuing calls. A new message with an updated waiting time is given every 30 seconds.

Statistics for the number of calls and the queue situation can be presented on the telephone display. The system can be equipped with printed board assemblies for call metering and separate equipment for processing which gives more detailed traffic statistics.

BCS 150 – a PBX system
When BCS 150 is programmed for the PABX function it can still serve as a multiline and ACD system.

Up to three operators' sets, DIALOG 2754, can be connected to the system. They are connected in the same way as other digital telephones.

DIALOG 2754 is built up of the same components as the ordinary display set but its display holds 160 characters. Its

Fig. 2
The telephone operator's position at Esprit Sweden AB. The telephone is a DIALOG 2754. The central unit is placed in the basement

701	ANSWER 202		
JOHANSSON & CO		ANDERSSON J	
C=00 I=00		LUNCH	
SEPT 18	14:32	BACK AT	1300

Fig. 3
An example of the type of information presented on the display of the operator's set

23 function buttons are modified for the special requirements of the telephone operators. In addition, the set contains 20 programmable buttons which the operator can use for direct access to the extensions with the heaviest traffic. Each such button is equipped with an LED that indicates whether the extension is free, busy or just called, which facilitates call handling.

Like all other digital telephones the operators' sets can be supplemented with headsets, providing easy switching between headset and handset.

Display on the operator's set
The display provides the operator with an overview of the traffic situation. Its top left-hand section shows incoming traffic and the top right-hand section indicates calls initiated by the operator, fig. 3. The bottom left-hand section shows queue information for incoming external traffic. The bottom right-hand section shows non-attendance information for the extensions in the system. The example in fig. 3 shows the information displayed when the operator at JOHANSSON & CO has answered an external call, dialled number 202 and is ready to connect the call to J ANDERSSON. The operator is immediately informed that Andersson is out to lunch and will be back at 13.00.

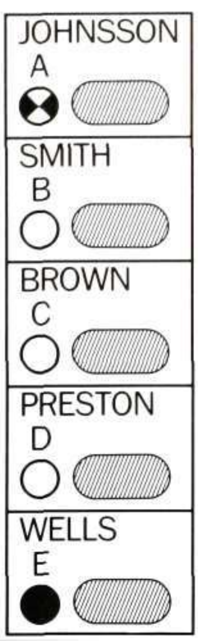


Fig. 4
The button panel of DIALOG 2752, with the names of the team members marked above the programmable buttons. Each button has an LED that shows whether the extension is free, busy or being called

The system incorporates all normal operator functions. One particular exclusive feature may be mentioned. When the operator is about to put a call on hold for a busy extension, function button *Identify* provides further information to help the operator decide whether the new call should be announced or not. The request *Identify* results in information on the display showing whether the call in progress at the busy extension is external or internal, and in the latter case the name of the other party is also indicated.

BCS 150 for work teams

Ringing telephones that have been left unattended are not only a nuisance to people around but also show bad telephone service. Adapting BCS 150 to the work teams of the company is one of the most important actions to ensure that the telephone traffic is handled efficiently and does not cause irritation.

Choice of telephone set
The telephones for a work team are chosen to suit the size of the team. The buttons on the telephone are programmed with the numbers of all the extensions used by the team. A call can then be answered anywhere on the team's premises and it is easy to get in touch with other members for inquiries, call transfer, etc.

DIALOG 2751 has one programmable button *(Pick up)*
DIALOG 2752 has ten programmable buttons
DIALOG 2753 has 26 programmable buttons.

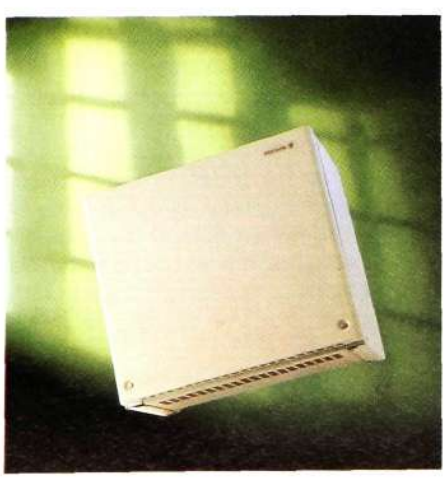
Fig. 4 shows the button panel of DIALOG 2752, having the programmable buttons labelled with the names of the team members. An LED associated with each button shows whether the extension is free, busy or being called. A flashing LED indicates an incoming call. The call is answered by pressing the associated button. Other members of the team are called using the relevant button; the system provides single-button calling within the team.

When using the interception function it is important that the acoustic signalling can be arranged to suit the users. Within a work team it is usually most suitable to

Display sets receive ritten information, e.g.	**1 TIME OF RETURN BACK AT 1430**
Other sets receive spoken information	**"I will return at two-thirty"**

Fig. 5
An example of the type of information that can be provided by BCS 150

Fig. 6
The central unit in BCS 150



have calls on the colleagues' lines indicated by a muted single signal after a delay of approximately 10 s.

Naturally BCS 150 includes a *manager-secretary* function. It provides direct connection between manager and secretary, a connection that is available regardless of any other telephone traffic in the system. One advantage of BCS 150 is that two or more secretaries jointly can answer the telephones of an optional number of managers and that the interception service can cover not only the ordinary extension numbers but also any private external lines, if desired.

Non-attendance information in BCS 150

Each extension can program non-attendance information which can be presented to any caller using a display telephone. If the system is supplemented with printed board assembly VMU for digital storage of speech, it provides the non-attendance information in verbal form to all other telephones in the system. An external caller is automatically routed to the telephone operator or the person handling the interception service.

The information consists of one of seven predetermimed alternatives. The system has the following six statements programmed when delivered:
- TIME OF RETURN, BACK AT
- DATE OF RETURN, BACK MONTH DAY
- LUNCH, BACK AT
- MEETING, BACK AT
- VACATION, BACK MONTH DAY
- ILLNESS, BACK MONTH DAY
  All these statements can be adapted to individual customer requirements and can be given in different languages.

The spoken information is recorded from a display telephone by a suitable person within the company, e.g. the telephone operator. A complete verbal message comprises the following parts:
- one of the seven statements mentioned above (Time of return, etc.)
- hour (0–23)
- minutes, in steps of 15 (00, 15, 30, 45)
- month (January, February, etc.)
- day (1–31)

The system combines three statements to form a complete non-attendance message.

For example, if a person programs the telephone with the information that he will return at 14.30, callers will receive the statements shown in fig. 5.

It is also possible to provide individual information for callers. The desired message can be recorded using any digital telephone. The information is then given to all internal callers. Alternatively a person with a display set can input a written message that will be presented on all calling display sets.

Other messages in BCS 150

A caller who does not receive an answer in system BCS 150 can leave a message. All digital telephones can leave a *Ring me* request and, if the system is equipped with VMU, a vocal message.

A *Ring me* request is similar to a signalling message. The LED in the called set starts flashing. On return, the called person presses the *Message* button and the system calls the originating telephone.

A spoken message is stored digitally in VMU. The called person uses the *Message* button to get the message replayed in the loudspeaker or handset.

Written messages can be exchanged between display sets. A text message can contain up to 40 characters.

If several messages are left for an extension they are automatically put in a queue and will be retrieved in proper order.

Paging

All digital telephones are equipped with a loudspeaker. It can be used for paging, which is the simplest and most efficient way of finding a person. The extensions in the system are divided into a maximum of eight groups with completely free allocation to the various groups. One of the groups can be used for general calls, which means that paging messages are sent out to all telephones. A list of the persons within the company who are allowed to initiate paging is made at the customer's request.

Data communications

Every extension in BCS 150 can reach a communications channel that can be used for speech or data. Using the communications channel for data does not mean that the telephone is blocked to incoming calls. The data call can be parked and the telephone call answered.

Simultaneous transmission of voice and data from an extension is possible with an extension line designed for data traffic, i.e. a four-wire line.

One system for several companies

Up to eight companies can share one BCS 150 system and have access to all its facilities. Each company can have its own exchange lines and individual telephone numbers. BCS 150 can handle up to three separate operator functions, i.e. three operators' sets, at the same time. Two or more companies can share an operator function.

Night service

The exclusive exchange lines can be divided into a maximum of eight groups, which can be connected individually for night service. It is also possible to connect each exchange line individually to one or more optional extensions, and also to appoint a second answering position, which is called after a delay of 30 seconds.

For night service it is most practical to switch incoming traffic to the *Pick up* buttons on the telephones. The calls can then be answered by any of the appointed extensions and the traffic situation is easily surveyed.

When the system is supplemented with VMU, the traffic can be routed to a prerecorded spoken message. Separate answering equipment is thus not needed in BCS 150.

System structure

BCS 150 consists of a central unit, to which the telephones are connected via a two-wire star-shaped network. The system is designed for digital telephones but analog terminals, for example telefax equipment, can be connected. However, the system is not suitable for customers who want to change their telephone system but retain their analog sets. With analog telephones it would be impossible to make the best use of the facilities provided by the system.

Central unit

The central unit can consist of one or two cabinets, each with 14 board spaces, fig. 6. One cabinet gives a capacity of 60 extensions and two cabinets 150 extensions.

The digital switch is built up around a PCM bus, fig. 7, to which all boards with traffic-handling devices are connected. Another bus is arranged in parallel with

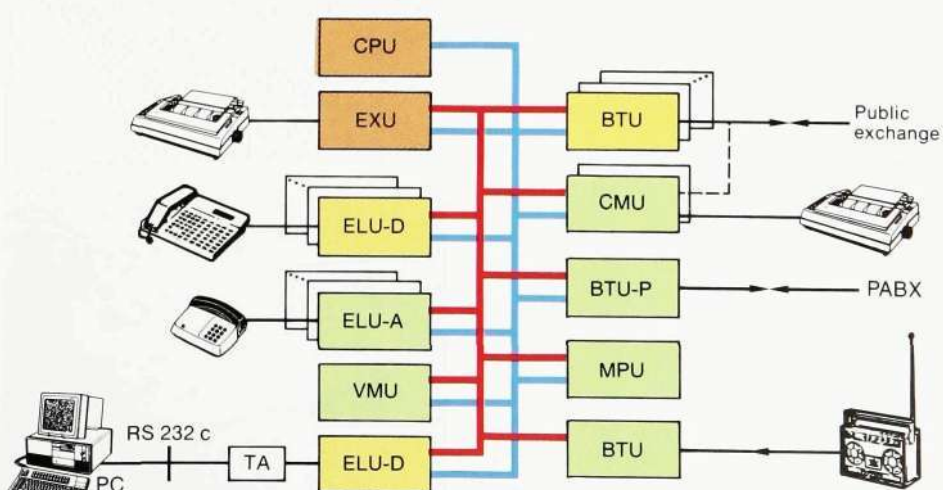


Fig. 7
Block diagram of BCS 150.
A fully built-out system has 26 board spaces, which can be allocated to the boards listed below as desired. The services *charging, speech storage* and *conference* require one board space each. Equipment for data communication (TA) and connection of PABX (BTU-P) will be introduced in 1989

CPU Central processing unit
ELU-D 10 digital extensions
ELU-A 4 analog extensions
BTU 4 exchange lines
BTU-P Tie lines
EXU Modem, V.24 port
CMU Charging
MPU Conference
VMU Digital speech storage (240 s)

PCM bus

Control bus

Optional equipment

the PCM bus, namely a control bus for the communication between the central software and regional software on the device boards in question. The system requires only two basic printed board assemblies, CPU and EXU.

Telephone sets

Telephones of three different sizes are available in order to meet the individual requirements of the users. DIALOG 2751 is the smallest variant and corresponds to an ordinary telephone. There is one important difference, though. In addition to its ordinary function as a two-line telephone (initiated by means of the Pick up button) it can be used for the handling of messages and non-attendance information. Loudspeaking calling, i.e. dialling with the handset in place, is of course possible, and also repetition of last number dialled.

DIALOG 2752 is the standard set for the system. It has ten programmable buttons, which can be used for external abbreviated dialling. Each button can also be used for single-button calling/interception service or for easy handling of the system services on the principle of one button = one service.

The telephone has two signal channels for its own line, which means that it is seldom marked busy. A new call coming in during a call in progress is presented

Fig. 8
DIALOG 2751

Fig. 9
DIALOG 2752

Fig. 10
DIALOG 2753

Fig. 11
DIALOG 2754

TECHNICAL DATA

Capacity	
Extensions	10–150
Exchange lines	<40
Line data	
Analog extension	
Two-wire circuit	
Line length, max.	10,000 m
Loop resistance	2100 ohms
Decadic or DTMF signalling	
Digital extension	
Two-wire circuit	
Line length, max.	800 m
with repeater	1600 m
Central unit	
Height	463 mm
Width	528 mm
Depth	305 mm
Weight	30 kg
Environment	
Ambient temperature	+5–40 °C
Relative humidity	10–85 %
Programming	
Locally via DIALOG 2754	
Centrally via V.23 modem	
Data communication	
V.24 (RS232C), asynchronous, serial, max 19.2 kbit/s	
Radiation	
EMI	FCC 15J, CISPR 22, VDE 0878, all class B
Electrostatic discharge	
– without faults	max. 6 kV
– only software errors	max. 10 kV
Power supply	
Mains voltage	110, 127, 220,240 V
Frequency	50/60 Hz

When idle, the display shows the date, time, own number and name	18 SEP ANDERSSON			14:30 200
When a call comes in the display shows the name and number of the caller	BROWN			234
When a called extension is busy the caller can ask for assistance using the *Menu* button. The display then shows the facilities available via the menu buttons	JONES	 wait F2	212 cbk F3	B intr F4

wait = call waiting
cbk = call back
intr = intrusion

Fig. 12
Some examples of the type of information shown on the display of DIALOG 2753

on "line 2". The existing call is automatically parked if the new call is answered. It is also easy to switch back and forth between the two calls.

DIALOG 2753 offers both loudspeaking and lowspeaking functions. It has 26 programmable buttons, of which 20 have the optional function *external abbreviated dialling*. The programmable buttons are marked with the letters of the alphabet and are used when sending written messages or transferring written information to other DIALOG 2753 sets in the system.

The display on the telephone informs the user about the telephone situation and instructs him how to use the menu buttons on the set to obtain access to the facilities provided by the system. Fig. 12 shows some types of information presented on the display.

Summary

In addition to the properties and functions described above, BCS 150 provides all facilities for a rational telephone service available in most modern telephone systems.

Ericsson BCS 150 facilitates contact between people. BCS 150 has been designed to enable its users to easily reach each other in different situations.

BCS 150 puts the user in the centre. A manageable system providing services that are useful to everybody in the company is a good description of system BCS 150. What is useful to the individual is also useful to the company. BCS 150 is not only a telephone system; it is a complete communications system for speech, text and data. Its flexibility makes for good adaptation to the varying traffic requirements of different companies. It can easily be modified to meet new demands and new traffic patterns.

A BCS 150 system adapted to the actual organization of the company ensures good telephone service and low telephone costs.

Fibre Manufacture using Microwave Technique

Leif Stensland and Peter Gustafsson

In cooperation with the Swedish Institute of Microelectronics, Ericsson Cables AB has developed a new fibre manufacturing method. In this method, IMCVD, a microwave cavity replaces the oxyhydrogen torch as the heat source. Microwaves give a homogeneous heating of the whole preform body in contrast to the torch, which is only capable of heating the surface. In IMCVD the thermal conductivity of the glass material will not limit the preform cross-sectional area and, consequently, much larger preforms can be manufactured. The manufacturing method may thus be much more economical. From the preforms, fibres are drawn in a conventional way.
The authors present the IMCVD method and give some results from a pilot production.

optical fibres
manufacturing processes
heating
microwaves

Optical fibres have more or less revolutionized telecommunications networks during the 1980s[1-3] because of their advantages as transmission media. They have very low attenuation and allow extremely high transmission rates but are nevertheless thin, light, flexible and strong; they are also insensitive to electrical interference and electrically isolating. Many industrial countries, including Sweden, have therefore switched from classical electrical cables to optical cables for new installations in the long-distance network. Consequently, large amounts of fibre are needed for cable manufacture. During the first half of the 1980s there was a general fibre shortage and fibre manufacturing facilities were quickly expanded on a large scale. From the middle of the 1980s, worldwide production of fibres has been on a level with demand, primarily because of the lower rate of expansion of the long-distance networks in the US. But the present general consensus is that, in future, optical cables will be used to an increasing extent in local telephone networks also, resulting in another rise in fibre demand. Nevertheless, in-house fibre production can only be economical if the manufacturing process is very efficient.

Manufacturing methods for optical fibres

Several different methods of manufacturing optical fibre have already been developed, and the work is continuing. All methods used to produce fibres for telecommunications require the manufacture of a quartz glass rod, a preform. Fibres are then drawn from this preform. At present prices, a profitable fibre production requires large-scale manufacture. Large scale in this case means not only large production volume but also a certain size of the individual preforms.

The most commonly used preform manufacturing method is still the MCVD (Modified Chemical Vapour Deposition) method, fig. 1, which is also used by Ericsson Cables AB (ECA). In the MCVD method very pure, doped quartz glass is produced in a rotating thin quartz tube mounted in a glass lathe. Vapour from liquid silicon tetrachloride, $SiCl_4$, reacts with oxygen in a hot zone inside the quartz tube and silicon dioxide, SiO_2, quartz, is formed according to the reaction

$$SiCl_4(g) + O_2(g) + heat = SiO_2(s) + 2Cl_2(g)$$

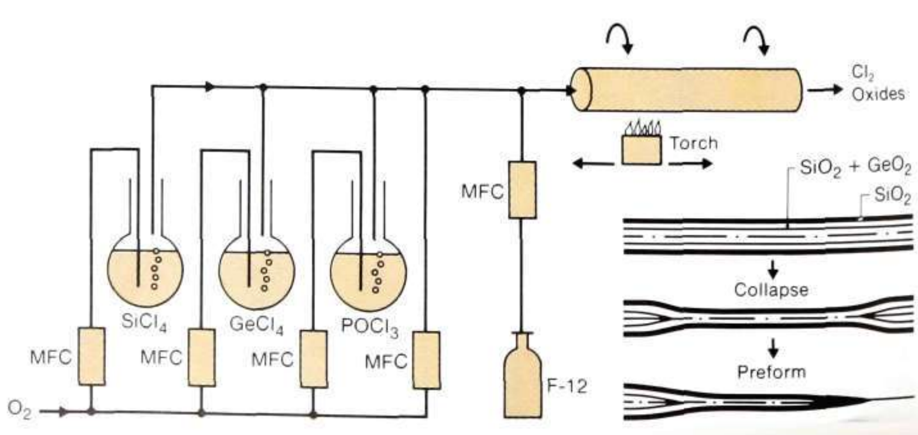


Fig 1
Basic diagram of preform manufacture using the MCVD method

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The quartz, which is amorphous and vitreous, is formed as a fine powder or soot and deposited on the wall of the tube beyond the hot zone. The hot zone is normally created by an oxyhydrogen torch that traverses the length of the tube. During passage it melts the previously deposited soot to a thin, homogeneous layer on the inside of the tube. After the torch has reached the end of the tube it is quickly returned to the starting point in order for a new layer to be deposited. The optical refractive index of each layer can be reduced or increased through the addition of fluorine or doping with germanium or phosphorous oxide. The doping is accomplished by adding small quantities of freon or germanium or phosphorous chloride vapour to the process gas. The dopants then form oxides in the same way as the silicon. Since liquid source chemicals can be obtained in a very pure form, they give extremely pure deposited layers. The deposited material must have a very high degree of purity – most impurities must be below the ppb level, i.e. less than 10^{-9}, in order to keep the fibre losses at the low level demanded. The number of layers deposited in the MCVD process is usually in the order of 20–40. When all layers have been deposited, the temperature of the torch is increased, which makes the tube hot enough for the surface tension to contract it to a solid rod, the preform. This process stage is called the collapse.

The preform is then drawn to a fibre in a separate drawing tower. In the tower the preform is heated to a very high temperature, approximately 2200°C, at which temperature it softens so that a thin fibre can be drawn from its tip. In the tower a thin plastic primary coating is also applied to the fibre.

The refractive index profile of the deposited central part of a single-mode preform may be as shown in fig. 2. The index profile of the drawn fibre is almost exactly that of the preform, only scaled down to the outer diameter of the fibre, 0.125 mm. The core – that part of the fibre in which the light propagates – constitutes only a small portion of the cross-section area, approximately 1%. The core is given a higher refractive index than its surround, the cladding, which is a prerequisite for the waveguide properties of the fibre. The difference is small, however, only approximately 0.3%, and is normally achieved by doping with DeO_2. The part of the cladding closest to the core also consists of deposited material.

There are two main reasons for this construction. In a single-mode fibre the fundamental mode is not completely confined to the core.[3] Hence specifications for single-mode fibres define the diameter of the mode field instead of that of the core, see box. If the fundamental mode would reach out to the part corresponding to the quartz tube in the preform, a part with high loss, it would be severely attenuated. A wide deposited cladding with low loss prevents such attenuation and also prevents diffusion of impurities from the tube into the core. The critical impurity is OH ions, which would cause a strong absorption peak at a wavelength of 1380 nm in the core. The total amount of deposited material has therefore been set to approximately 16% of the total cross-section area in

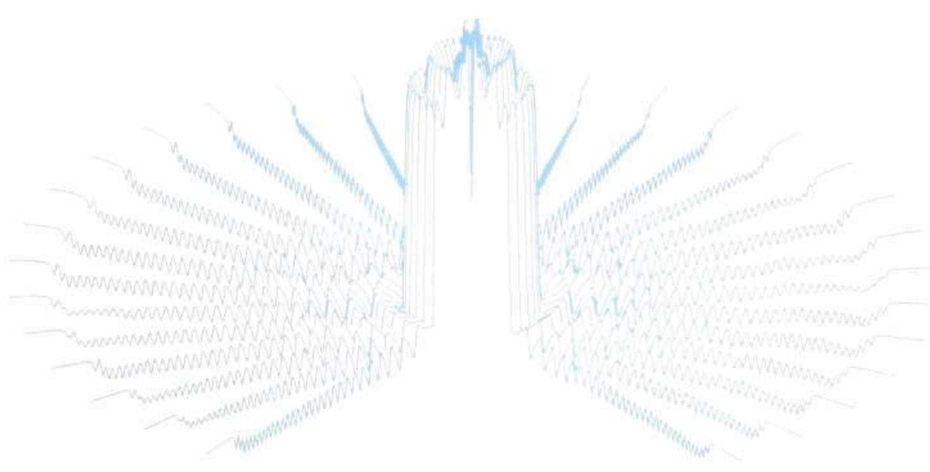

Fig 2
Refractive index profile of a preform for single-mode fibres

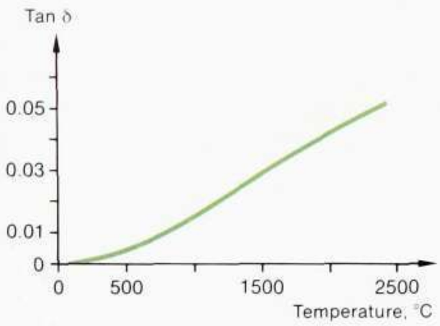

Fig 3
Loss factor of quartz as a function of temperature

ECA's previous preforms. Fig. 2 shows this deposited part of the collapsed preform.

The MCVD method, in its conventional version, gives relatively small preforms with an outer diameter of around 15 mm and a typical length of approximately 60 cm. Such a preform gives approximately 8 km of fibre. ECA has already used a method called jacketting as a means of obtaining larger preforms. In this process the collapsed preform tube with deposits is encased in an extra tube. ECA used jacketting tubes with outer and inner diameters of 25 and 19 mm respectively, 25/19. This more than doubled the equivalent fibre length per preform to approximately 18 km. Nevertheless, the preforms were somewhat too short to meet future requirements for economy.

The total process time is more important to the productivity of the preform process, calculated as equivalent kilometres of fibre per hour, than the length of the preform. The MCVD process time consists of the deposition time, the collapse time and possibly also jacketting time. However, in many cases the jacketting – and the collapse – can be performed in separate lathes and need not take up time in the deposition lathes.

The deposition time is reduced if the deposition rate is increased. This can be achieved by increasing the flow of chemicals, but it would require tubes with a larger inner diameter. Thin large-diameter tubes are mechanically weak structures and should preferably be avoided. Large tubes with thick walls are mechanically stable, but the torch will only heat the outside of the tube and there will be a considerable temperature drop over the thick wall. Since it is the temperature at the inner wall surface that determines the reaction temperature, it must be kept constant. Consequently, the external temperature may have to be so high that the tube becomes too soft and starts to vapourize at the outside. If the tube could be heated homogeneously over the whole cross-section the problem would be solved, since the outside of the tube would not need to be any hotter than the inside.

A stable collapse process for thin, large tubes would imply a slow collapse and, hence, reduced overall productivity. A thick tube would collapse in a more stable way than a thin one – even with a large inner diameter. With homogeneous heating, the temperature can be raised so that the collapse time is short, thus increasing the overall productivity considerably.

Microwave heating

One method for homogeneous heating of quartz glass which has been successfully tested is heating by means of microwaves. Quartz glass does not absorb microwaves at room temperature, but the absorption is increased substantially if the glass is heated to over 500°C, fig. 3. It has proved possible to further heat the glass from approximately 1000°C by placing it in a strong microwave field. The microwaves penetrate the whole glass body because the absorption is still comparatively low. The heating is therefore genuinely homogeneous. Microwave heating is thus suitable for thick quartz tubes.

The total amount of power developed in a material is given by the expression

$$P_{in} = 1/2\,\omega\,\varepsilon\,\varepsilon_o \int_V \tan\delta\, E^2\, dV$$

where

- ω is the angular frequency of the microwaves
- E the electrical field strength of the microwaves
- $\varepsilon\,\varepsilon_o$ the dielectric constant of the material

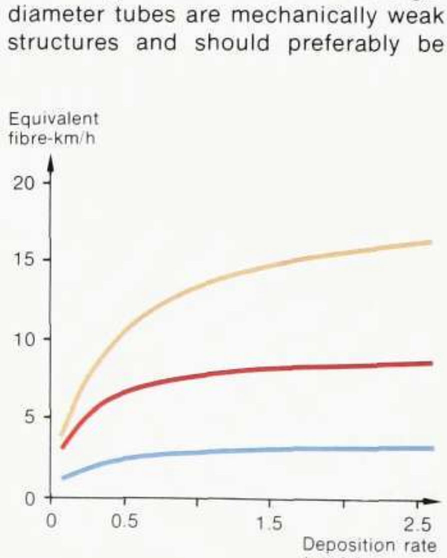

Fig 4
The total productivity, in equivalent fibre length per hour, as a function of the deposition rate in ECA's previous MCVD process compared with the productivity of the IMCVD method, using only the jacketting process, IMVCD M, or a process comprising jacketting of a deposited tube followed by simultaneous collapse of the deposition and jacketting tubes, IMCVD K

IMCVD K (90 cm)

IMCVD M (70 cm)

Previous ECA (60 cm)

tan δ the loss factor of the material
V the volume of the material.

When the material is heated it will lose energy in the form of radiation in accordance with the expression

$$P_{ut} = S\,e \int_A T^4 dA$$

where

S is the Stefan-Boltzmann constant
e the emission factor of the material, e = 1 for a black body
T the absolute temperature
A the outer surface area of the material.

Heating is possible only when P_{in} is larger than P_{out}. If this is the case T increases, and hence P_{out}, until P_{in} is exactly balanced by P_{out}. Thus, power is developed inside the material and lost at the surface. Consequently, the ratio volume/outer surface must be large if it is to be possible to reach high temperatures. This means that the conditions are favourable for the heating of thick tubes by means of microwaves.

The IMCVD method

Microwave heating of quartz tubes is used in the IMCVD (Intrinsic Microwave heated Chemical Vapour Deposition) method, a process developed by ECA together with IM (the Swedish Institute of Microelectronics, formerly the Institute for Microwave Technology). The project has also been given a grant from STU (the National Board for Technical Development). IMCVD increases the productivity considerably compared with a conventional MCVD process through the greater collapse speed, fig. 4.[4-5]

In IMCVD a thick quartz tube is first mounted in a glass lathe in the ordinary way. One end of the tube is then preheated to approximately 1000°C by a torch, fig. 5, after which the torch is switched off and a microwave cavity is slid over the hot area. The loss factor, tan δ, is then high enough for the microwave field in the cavity to be able to heat the tube further.

A system of cavity waveguides connect the microwave cavity to a microwave generator, a 5 kW magnetron operating at a frequency of 2.47 GHz. All equipment is mounted on a slide on the lathe base. For optimum heating of tubes the cavity has been designed so that only the circular mode TE-011 can exist. The TE-011 mode has a node at its centre and a maximum field strength at almost half the radius of the cavity; it is shaped somewhat like a doughnut. The cavity can now heat the tube further to over 2000°C. The cavity heats only a few centimetres of the tube, but the heat is conducted so that the hot zone extends axially over approximately 10 cm. The cav-

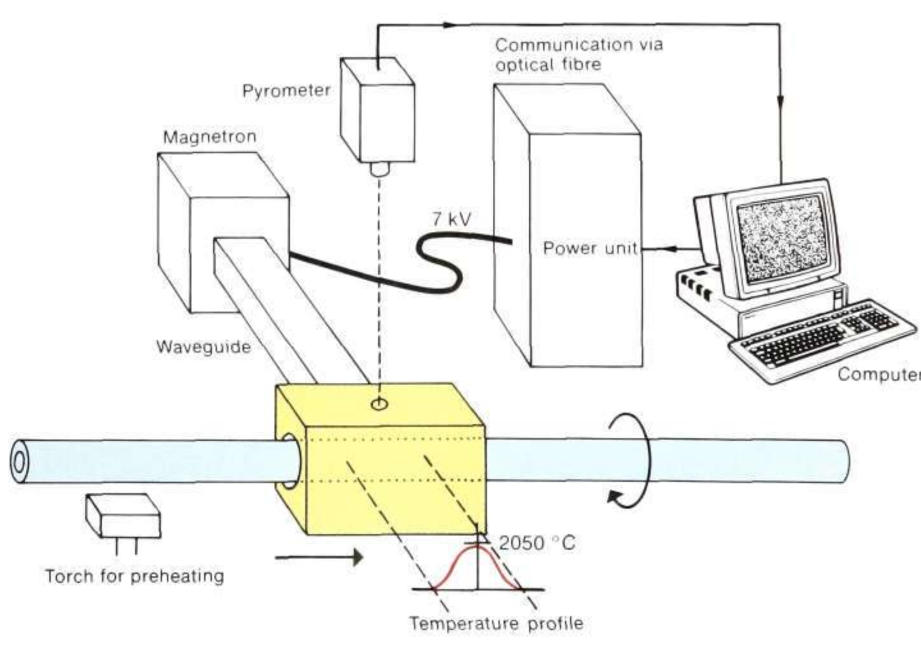

Fig 5
Diagram of the equipment for the IMCVD method

Cavity

Quartz tube

Fig 6
A preform being jacketted in an IMCVD lathe. The brass microwave cavity unit can be seen just to the right above the upper control panel. The heated quartz tube, which is strongly luminescent, is surrounded by flexible metallic screens whcih prevent leakage from the cavity

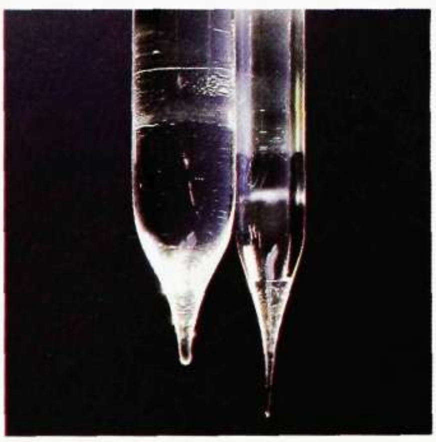

Fig 7
Preforms from the two processes, MCVD on the right and IMCVD on the left. An MCVD preform of 50 cm gives approximately 15 km of fibre and an IMCVD preform of the same length approximately 50 km

ity can then slowly be moved along so that the microwaves continuously heat new areas at the edge of the hot zone, which have already been preheated through the conduction. The traversing speed of the cavity is 0.5–1 mm/s.

During the project, IMCVD has been used for deposition in and collapse and jacketting of thick quartz tubes. The improvement in productivity using IMCVD in the deposition stage is only marginal because of the low traversing speed, but the process time in the collapse stage is reduced considerably. In order to make the optimum use of the experience gained from deposition in the MCVD method together with the high collapse speed of IMCVD, ECA is at present using the new process to jacket MCVD preforms in thick tubes.

Pilot production at ECA

Up to the end of 1986 the experimental part of the IMCVD development was mainly carried out at IM. ECA contributed fibre drawing capacity, measurement engineering resources and project management. By the autumn of 1986 the project had advanced so far and shown such great potential that ECA decided to invest in development of equipment for the manufacturing of preforms using IMCVD. Early in 1987 ECA therefore started construction of an IMCVD unit for the jacketting of thick tubes. The unit was based on experience gained at IM but necessitated the development of entirely new equipment. The work was put out on commission to Hultronic Innovation AB. An MCVD lathe was rebuilt and equipped with a microwave cavity, a microwave generator, an advanced AT computer-controlled process system etc. The IMCVD unit was completed and tested during the spring of 1988 and is at present in pilot production, fig. 6.

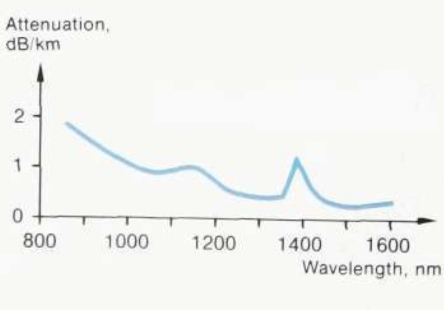

Fig 8
The attenuation of an IMCVD fibre

The method now used in the pilot production consists of deposition in accordance with the MCVD method in a thin tube, 27/24 mm. The tube is collapsed in the MCVD lathe and then jacketted in a thick tube, 40/24 mm, using the IMCVD method. The completed preform has a diameter of 35 mm, fig. 7. The greater mechanical stability has also made it possible to make the preform slightly longer, 70 cm. Consequently, an IMCVD preform gives approximately 50 km of fibre.

The deposition tube used in the IMCVD process has a low content of OH ions

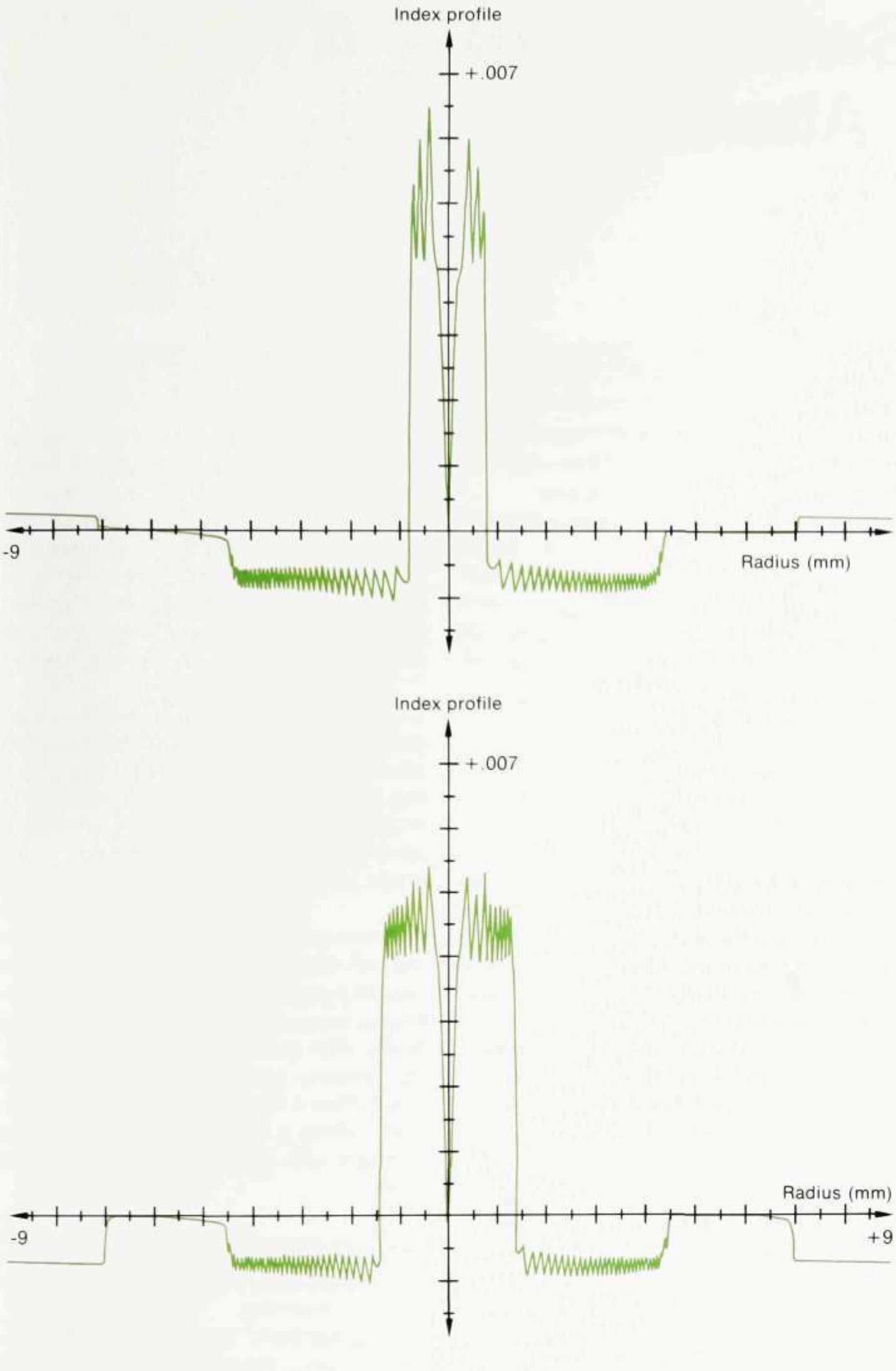

Fig 9
A cross-section of the refractive index profile in the core area for an IMCVD preform before jacketting (lower picture) compared with the corresponding section for an MCVD preform (upper picture). The core of the MCVD preform is built up of merely three layers, whereas the IMCVD core consists of nine layers

Technical data, standard single-mode fibre

Cladding diameter (quartz glass)	125 μm
Primary coating (plastic)	250 μm
Core diameter	8 μm
Mode field diameter	10 μm
Concentricity error (core/cladding)	< 1 μm
Cut-off wavelength for the LP11 mode	1150–1350 nm
Attenuation	
1300 nm	≤0.4 dB/km
1550 nm	≤0.3 dB/km
Chromatic dispersion	
1285–1330 nm	≤3.5 ps/nm km
1550 nm	≤20 ps/nm km

and the thickness of the deposited cladding can therefore be reduced without destroying the protection against ion diffusion. The deposited material now consists of only 6% of the preform cross-section, as against 16% in the earlier process. In spite of the much larger size of the preform the amount of deposited material is almost unchanged, and the preform production capacity at ECA has increased 2.5 times. The jacketting is so rapid that one IMCVD unit in two-shift use can process all preforms produced by three deposition lathes used in three shifts. By 1989 ECA will have a preform production capacity that corresponds to 40–50 000 km of fibre.

The fibres produced in this way have very good performance, fig. 8. The attenuation as well as other parameters, e.g. concentricity errors, are better than demanded by the specification. Certain properties, such as sensitivity to bending and fracture strength, even appear to be better than in previously produced fibres. As regards the sensitivity to bending, the improvement is a consequence of the fibre core being built up of several layers in the IM preforms, resulting in a more smooth refractive index profile with better propagation for the light waves, fig. 9. The fracture strength is probably higher because of the different treatment of the jacketting tube in the IMCVD and the MCVD processes. It is primarily the surface of the preform that determines the fracture strength.

Summary

A method for the manufacture of preforms has been developed. The method is based on microwave heating of quartz tubes and makes it possible to produce preforms with a large cross-sectional area. The method is now in use in pilot production at ECA and has increased the production capacity by a factor of 2.5.

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Power in the Switch Room – A New Power Supply Alternative

Inger Franzén

Since the early days of telephony, exchange power supply equipment has usually been placed in a special room, separated from the premises where switching equipment is installed. This separation was necessary because of the way in which conventional batteries affect the environment and because of the noise level of the power equipment. New technology for power components and batteries has made it possible to place power and switching equipment in the same room.
The author describes the properties of power supply equipment in different implementations of the new technology, the method chosen by Ericsson Components AB and some of the advantages of placing power equipment together with the equipment to be powered.

power supply to apparatus
telephone exchanges
economics

New technology for batteries and power components has lately made it possible to apply new principles for the planning and construction of power supply equipment. What is the new technology and what does it mean to the customer? In order to answer these questions it might be suitable to first recapitulate the conventional principles and how and why the various units look the way they do.

Conventional power supply equipment

Conventional power equipment from Ericsson consists of thyristor-controlled rectifiers, batteries, distribution equipment and possibly also regulated series converters, fig. 1.

Fig 1
BZA 122/2 is a conventional power supply system

The main circuits in the thyristor-controlled rectifiers operate at the mains frequency, 50 or 60 Hz. This gives thyristor rectifiers two of their main characteristics: the magnetic components – transformers and chokes – are large, and the noise level of the rectifiers would be considered annoying if they were placed where people have to work.

The batteries consist of ventilated lead-acid accumulators. They produce an explosive and corrosive gas during charging and the battery must therefore be installed in a separate room with good ventilation. The battery also consumes water, which must be replaced.

The noise level from the rectifiers and the risk of gassing from the battery has necessitated separation of the power supply equipment and the equipment it feeds. The great weight of the power equipment, including batteries, has meant that it is often placed in the basement, since a floor with the necessary strength can most easily be arranged there.

The consequences of conventional placement

Suboptimization
The placement has meant that the power supply equipment has often been considered as something separate and not as the natural part of the telephony equipment it certainly is. Ericsson Components has had a unique opportunity, through its close collaboration with designers at Ericsson Telecom, of developing the optimum combined solution for conventional power supply and switching. In the market-place, however, the power supply is often dealt with on its own, both by customers and suppliers. Power and switching equipment are often purchased separately, which makes it difficult to achieve the optimum overall result.

Operational disturbances
Power supply equipment installed in the basement often feeds all telephony equipment in a building. As a consequence operational disturbancies in one plant can cause trouble in another. For example, short circuits in some

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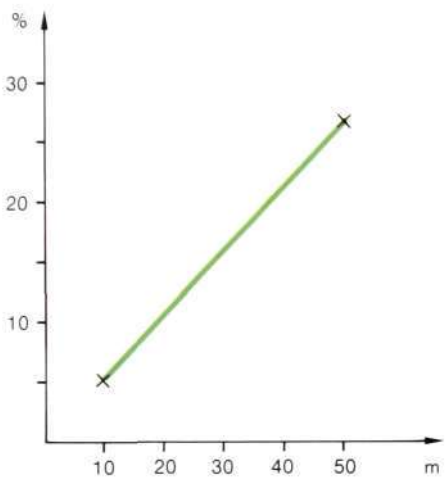


Fig 2
Cost of the distribution cable as a percentage of total distribution cost for conventional power supply equipment at different cabling distances

switching equipment can interfere with the operation of other devices. If the feeding equipments are of different manufacture there might be disputes concerning whose fault it was.

The cost of conventional power

Initial costs

The initial costs comprise not only the direct costs of power and batteries but also costs relating to the placement of the equipment.

The main disadvantage of having the power supply equipment in a separate room are the costs of transporting energy from the power room to the objects to be fed. These costs fall into two parts: cost of materials – distribution cables and mechanical structure – and cost of installation – making holes in walls and ceilings, installing the mechanical structure and running the cables. Ericsson Components has studied the costs of materials and installation for five exchanges having a power consumption of 5, 10, 15, 20 and 25 kW respectively. The cable distances concerned were between 10 and 50 m.

Fig. 2 shows the relative cost of the distribution cable as a percentage of the total materials cost for the power equipment with different cabling distances. The cost is mainly dependent on the distance between the switching and the power equipment and is basically independent of the power consumption. The cost rises from approximately 5% of the total materials cost to over 25% when the cabling distance increases from 10 to 50 m.

The distribution cable cost constitutes a large part of total installation costs for the power supply equipment. The percentage is dependent on both the power and the cabling distance, fig. 3, and is approximately 35% for a 5 kW exchange with a distance of 10 m and approximately 65% for a 25 kW exchange with a distance of 50 m.

The installation cost for conventional batteries may be high since they are often dry-charged when supplied and must then not only be installed but also filled with electrolyte and given the initial charge – a heavy and time-consuming job.

Operation and maintenance costs

The cost of checking the level and topping up the distilled water in the battery forms a major part of the maintenance costs. Other operation and maintenance costs specific to the conventional power equipment are the cost of the energy loss that occurs with long cable distances and the cost of special premises, such as battery rooms with special ventilation.

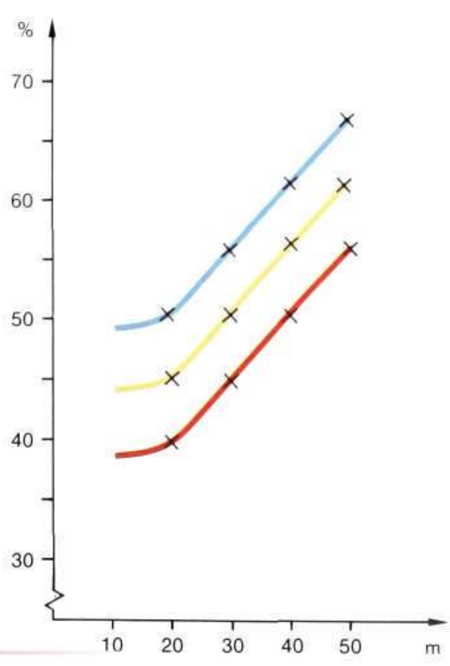


Fig 3
Cost of the distribution cable as a percentage of the total installation cost for conventional power supply equipment with different power consumption and cabling distances

20–25 kW
10–15 kW
5 kW

New technology – new opportunities

New rectifiers

New semiconductor components have made it possible to develop reliable high-frequency switched rectifiers, DOL-SMPS (Direct Off Line-Switch Mode Power Supply). These rectifiers operate at a high switch frequency, usually 20–40 kHz, which means that the magnetic components can be made much smaller than in the case of a conventional thyristor rectifier. Moverover, the switch frequency is not within the range of human hearing. The new technology has therefore made it possible to produce a completely noiseless, small and light rectifier.

New batteries

Industrial research has resulted in the sealed or valve-regulated battery. It can

Fig 4
BZA 204 05
New power supply equipment with 50 A rectifiers, designed for installation together with AXE 10. The door of one of the power cabinets has been removed. The rear row contains a battery cabinet

be placed together with electronic equipment since the gassing is practically negligible. Maintenance is reduced considerably as the battery does not need topping up.

Power – an integral part of the exchange

What are the advantages of installing the power equipment in the switch room? Above all, the power becomes an integral and natural part of the telephony equipment. Who would have thought of separating the power supply units of the exchange and install them in a remote spot in the basement if the new technology had been available in the early days of telephony? The costs that are dependent on placement will also be reduced.

Choosing a new power supply system

When Ericsson introduced a new cabinet construction practice for AXE 10, Ericsson Components decided to develop a new power supply system for the new construction practice. It would exploit the advantages of new technology and be installed together with the switching equipment.

The decision regarding the placement of the power equipment was followed by the question of system design. Three alternatives were considered:

- to integrate the power supply fully with the various modules of the switching equipment
- to decentralize the power supply, using several, autonomous small units
- to keep the power equipment as a central unit.

Integrated power supply

Integrating the power equipment with each magazine module would result in very flexible power supply, optimized for the individual requirements of each module, and constitute the final stage in the integration of the power and switching equipment. The power equipment would consist of small AC/DC units that converted the incoming mains voltage to telephony voltages. The overall system efficiency would be increased since one conversion stage would be eliminated.

However, each unit must include redundancy and battery reserve. This would require many small batteries, which have a higher price per Ah than large batteries. Overall this would mean a higher cost for the exchange system. Distributing mains voltages to the telephony cabinets could cause disturbance. The risk, together with the requirements for human safety, would necessitate large modifications of the telephony equipment.

It was decided that the advantages of integrated power supply would not outweigh the disadvantages.

Several autonomous small power supply units

Dividing the power supply equipment into smaller, autonomous units, each

Fig 5
BZA 204 03/13
This system differs from BZA 204 05 in that the battery is placed in the same cabinet as the rectifiers and distribution units

Fig 6
Sealed battery with cell voltage equalizers, installed in a BYB cabinet

supplying a part of the switching equipment, for example a row, would have advantages as regards the load on the floor. Each power supply unit would contain a complete system with rectifiers, batteries and distribution and would have to include full redundancy. Such a solution would also mean an increase in the cost of the switching system due to the cost of this redundancy.

Distributed power supply as described here loses the advantages of the mutual backup effect in the dimensioning of the battery reserve. If some battery cells do not have full capacity because of too high self-discharge the battery, when discharging, will drop to the minimum permissible value earlier than expected. The effects can be limited if all battery cells in the exchange are connected in parallel.

However, if the battery is the sole supply for a part of the exchange this part will be cut out. At worst the consequences can be as serious as if all power equipment failed: the whole exchange would stop.

Decentralizing the power supply in this way was not considered suitable.

Centralized power supply
In centralized power supply equipment all rectifiers, distribution modules and batteries form one unit. A common battery bank reduces the consequences of battery cells being discharged too quickly because of reduced capacity. The overall impedance in the battery circuit can also be kept low. This means that any voltage transients caused by short circuits in the exchange can be kept within the permissible limits by means of transient-limiting distribution.[1]

In all alternatives the rectifier and battery capacity must be dimensioned for the power requirements of the units to be fed. The larger such units are, the better the utilization of the mutual backup effect, i.e. the fact that when one part of the exchange is consuming much power, other parts consume less. Centralized power equipment can be dimensioned for lower power than the sum of the power requirements for the different units in the other alternatives.

This effect can also be exploited in expansion. If the switching equipment is fed by several, distributed power units it might be necessary to extend several of these. With centralized power equipment it does not matter where in the switching equipment an extension is made. This makes it easier to optimize the dimensioning.

The analysis resulted in the choice of centralized power supply equipment.

Requirements for modern power supply equipment
Before Ericsson Components started developing the new centralized power system a market analysis was carried out in order to obtain an up-to-date picture of the demands made on the power supply equipment in a modern telecommunications network. The analysis showed that, basically, the demands remained the same as before: high reliability and good economy. However, there is a clear trend towards greater stringency. High reliability becomes even more important, partly because of the increasing amount of data traffic in the telecommunications network. A failure becomes more expensive the higher the proportion of data traffic. The probabiliy of a stoppage caused by a failure in the power equipment must be reduced to a minimum.

Good economy has always been important, of course, but in this case the requirements are becoming more stringent. However, there is a trend for customers to consider the total life cycle cost rather than just the investment cost when purchasing equipment.

New power supply equipment

Centralized power systems
On the basis of the above-mentioned analyses Ericsson Components has developed two centralized power supply systems designed for installation together with AXE 10. Both are of the ordinary full-float type. One system, BZA 204 05, fig. 4, has been described previously in Ericsson Review.[2] It contains 50 A rectifiers and the other system, BZA 204 03/13, fig. 5, 25 A rectifiers.

The new power supply systems can be supervised by Ericsson's supervision system ERICSSON ENERGYMASTER, EEM.[3] EEM allows remote control and supervision of power, batteries, diesel, cooling equipment, distribution panels, fire alarms etc. from a maintenance centre. Thus the new systems consist of centralized power supply equipment, adapted to EEM and designed for installation in the switch room.

Economy

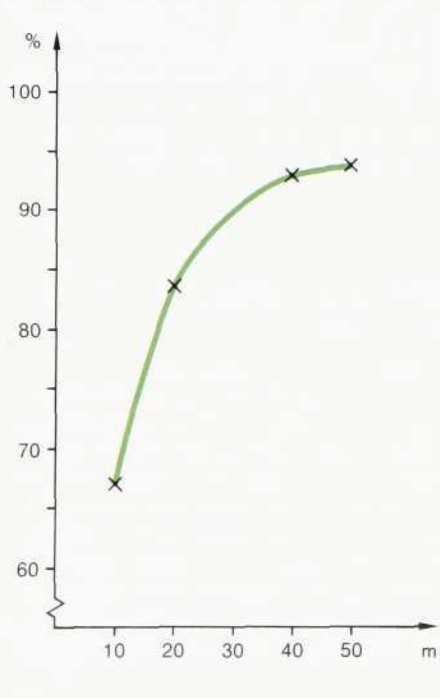
A study was made comparing the cost of placing the power supply equipment in the switch room and in a separate room. Five power levels were studied: 5, 10, 15, 20 and 25 kW. The cost was calculated for a battery reserve of one hour and distribution cabling distances of between 10 and 50 m for the conventional power system. The new power system in the study was BZA 204 05 with 50 A rectifiers and the conventional system was BZA 122/2 with 100 A rectifiers. It should be emphasized that the study was based on specific plants, and the figures should be considered as indicative of trends rather than exact results.

Initial costs

As has already been shown, one of the disadvantages of placing the power equipment in a distant room is the cost of the distribution cabling. When the power and switching equipment is placed in the same room the cable lengths are shorter, and smaller cables can be used. Fig. 7 shows the reduction in the materials cost for the distribution cable when the power equipment is placed in the switch room compared with installation in a separate room. The cost is reduced by 90 % when the power equipment is placed in the switch room instead of at a distance of 50 m.

Fig 7

Reduction of materials cost for distribution cable when the power supply equipment is placed in the switch room instead of a separate room. The cabling distance varies



As regards the actual power equipment the materials cost is higher for the new systems than for the conventional type. Basically there are three reasons for this increase:

- the cost of components in the new technology is still fairly high. The cost of new components tends to drop successively, whereas the cost of components used in the conventional technology remains constant. The price of the type of transistor module used in the new rectifiers, which constitutes a large part of the materials cost, is expected within two years to fall to a quarter of the present price
- the cost of sealed batteries is still much higher than the cost of ventilated batteries. In this case, too, the trend shows a reduction of the gap in the cost per ampere hour between ventilated and sealed batteries
- the new power supply systems are delivered as complete cabinets in order to reduce installation time. In system BZA 204 05 all units except the batteries and rectifiers are installed in the factory, in system BZA 204 03/13 also the rectifiers and, in certain cases, the batteries. Thus, parts of the installation work have been moved from the field to the factory, where this work can be performed more rationally. This optimization of the installation work appears as an increase in the materials cost.

Installation costs for the new power equipment have been reduced drastically. Fig. 8 shows a comparison of the total installation cost for the two generations. The cost has been reduced by between 45 and 70 % for the new systems, partly because of shorter installation times for power units as well as cable and batteries.

Diesel generator

The initial costs for power supply equipment include the cost of a standby diesel generator. It is normally dimensioned for a power factor of 0.8. Nevertheless, if thyristor-controlled rectifiers with cos $\varphi = 0.8$ are used, only a part, often 2/3, of the total capacity of the diesel generator can be utilized because of the distortion caused by the thyristors.

Even high-frequency switched rectifiers often cause severe distortion of the primary current, which gives the rectifier a very unfavourable power factor; values around 0.6 are not unusual. The low power factor means that the capacity of the diesel generator cannot be fully utilized. With a power factor of 0.6 only 75 % of the capacity can be used.

This fact was taken into consideration when the new power system was developed, and the rectifier was specially designed to draw sinusoidal current from the mains with a power factor that is very close to 1.0.[2] This was achieved by means of high-frequency switching. The primary current can be regulated several hundred times per cycle and can thus be given the desired waveform.

This type of rectifier behaves as a resistive load, which is ideal for the diesel generator. The latter will therefore only have to be dimensioned for the active power consumed by the rectifier. The diesel generator can then be made over 30% smaller than a generator in a conventional system for the same load which uses thyristor-controlled rectifiers. Compared with a system using high-frequency switched rectifiers having a power factor of 0.6 the new generator can be made 25% smaller. Theoretically it would be possible to achieve further reduction with overall optimization of the standby power plant for a power factor of close to 1.0. However, the diesel generator is often used for other loads with a power factor of 0.8, so such overall optimization is not suitable.

Operation and maintenance costs
The maintenance cost has been reduced primarily through the introduction of sealed batteries. However, many battery manufacturers recommend a battery check every three months. This time can be doubled if the batteries are equipped with Ericsson's patented cell voltage equalizer.[4]

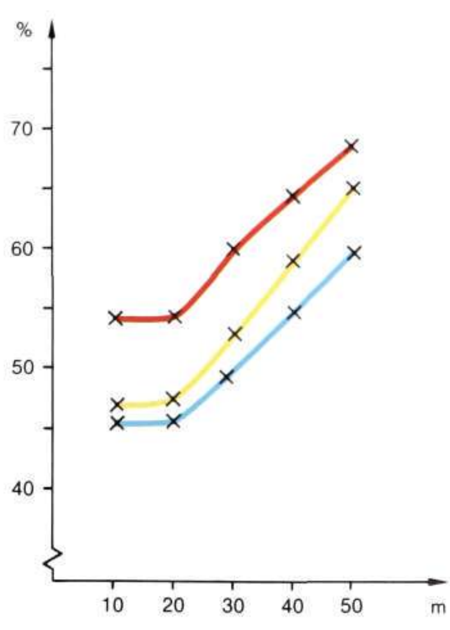


Fig 8
Reduction in total installation cost when the power supply equipment is placed in the switch room instead of a separate room. Cabling distance and power consumption vary

5 kW
10–15 kW
20–25 kW

EEM would reduce the maintenance cost further. The batteries and all auxiliary equipment can then be controlled from a maintenance centre. The reduction of the total maintenance cost achieved through the use of a sealed battery would be severely curtailed if staff still had to visit the place, say, once a month in order to test the standby power plant. The test can be made by remote control using EEM.

The spare parts philosophy for the new systems is to stock whole units, such as a rectifier. In the case of a failure, staff with no special training can change the faulty unit. The low weight and small volume of the spare units mean that they can be transported in ordinary cars.

The operating cost includes the fixed cost of premises. The new power systems require less space and above all no separate rooms with reinforced floors and special ventilation. This is particularly important in the case of radio base stations, whose power supply equipment is often installed on leased premises. It is not possible to give a general value of the savings in this case since the price per square metre varies considerably from one place to another around the world.

Capital costs
With the total installation time for the power equipment reduced by approximately 3/5, the time until the exchange is in service and generating income is also reduced, which lessens the cost of capital tied up in the exchange.

Reliability
Too low reliability costs money. An exchange failure is expensive, not only for the telecommunications administration but also for the companies that cannot use the telecommunications network to transfer information during the downtime. Too high reliability also costs money, in the form of unnecessary investment in redundant equipment and its maintenance. It is therefore essential that the optimum reliability level is found for the exchange, including the power supply equipment. A failure in the power equipment means a stoppage of the exchange. Reliability analyses for an exchange have shown that the reliability of the power equipment can be consid-

Fig 9
Great interest has been shown in the new power supply equipment. Presumptive customers study the equipment at Telecom 87 in Geneva

ered very good if its unavailability is ten times less than that of the whole exchange.[5]
The requirement for AXE 10 is that the unavailability is less than 5.7×10^{-6}. The reliability of the power supply equipment can be considered very good if its unavailability is 5×10^{-7}, which corresponds to a maximum of 12 minutes of system failure during 40 years of operation. The factors that affect the reliability of the power equipment have been described in detail in a previous issue of Ericsson Review.[5] They are mainly:
- the quality of the mains
- access to standby diesel generators
- system redundancy
- battery reserve time, which must be adapted to the quality of the mains
- the relationship between the devices in the system (e.g. if the function of one device is dependent on that of another)
- the MTBF (Mean Time Between Failures) for the devices in the system
- the MTTR (Mean Time To Repair) for the devices in the system.

For the calculated reliability to be obtained in practice, the equipment must be managed correctly. For example, the capacity of the battery is chosen on the basis of such factors as the quality of the mains and the required system reliability. The calculated reliability can be achieved only if the expected battery capacity is available when required. The battery must therefore be maintained correctly, and EEM can provide valuable assistance here. With EEM the power experts can easily check the condition of the power equipment, record any deviations in parameters etc. Deviations can then be corrected long before they affect the reliability of the system.

System reliability has always been an important parameter in the development of Ericsson's power supply systems. The new systems have been designed with the reliability aspect in mind and meet the requirement of the unavailability not exceeding 5×10^{-7}.

Summary

New power component and battery technologies has paved the way for the development of new systems for the power supply of telecommunications equipment. The systems consist of centralized power supply equipment, adapted for EEM and designed for installation in the switch room. The placement means lower cost of distribution cables, both as regards materials and installation. EEM provides the customers with an aid for optimization of maintenance, which means that they can be certain that the calculated reliability is achieved.

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