

# ERICSSON REVIEW

RAILWAY SIGNALLING SYSTEMS  
CONSTRUCTION PRACTICE BYB FOR TRANSMISSION EQUIPMENTS  
FIRST-ORDER PCM MULTIPLEX IN THE BYB CONSTRUCTION PRACTICE  
AXE 10—A REVIEW  
OPERATION AND MAINTENANCE FUNCTIONS IN ASB 100 AND ASB 900  
ANTENNA SYSTEM FOR THE EXOSAT SATELLITE  
A TELEPHONE SYSTEM FOR FOREIGN EXCHANGE TRADING  
CUSTOM DESIGN CIRCUITS FOR TELECOMMUNICATIONS

4 1980





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## Contents

- 118 · Railway Signalling Systems
- 124 · Construction Practice BYB for Transmission Equipments
- 129 · First-Order PCM Multiplex in the BYB Construction Practice
- 138 · AXE 10—A Review
- 149 · Operation and Maintenance Functions in ASB 100 and ASB 900
- 156 · Antenna System for the EXOSAT Satellite
- 160 · A Telephone System for Foreign Exchange Trading
- 166 · Custom Design Circuits for Telecommunications



### COVER

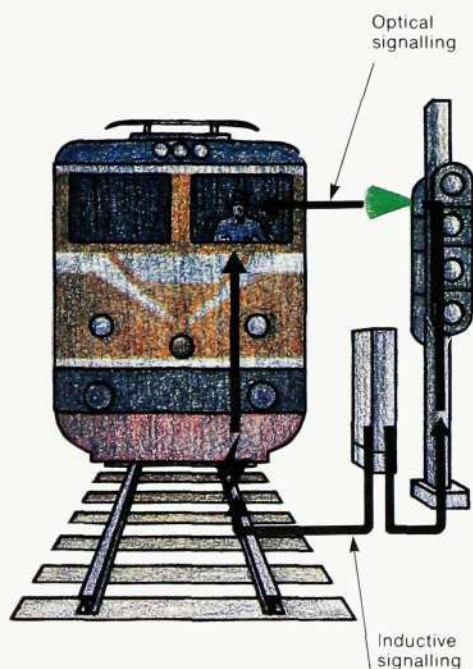
The signal to the left in the cover picture symbolizes modern railway signalling technology

# Railway Signalling Systems

Hans S. Andersson

*The Ericsson Group have designed, manufactured and marketed railway signalling equipment since 1915. The product range has included such systems as signalling equipment for the track, safety systems for the train routing, remote control systems and systems for supervising the speed. The product range has successively been renewed in step with the technical development. The development in the fields of electronics and computers has contributed greatly to this renewal. This article deals with the background and the present scope of this work. Some of the recently developed systems will be described in greater detail in subsequent issues of the magazine.*

UDC 656.25



**Fig. 1**  
Signalling to the train driver can be carried out either via signals beside the track or on a panel in the driver's cabin. In the latter case the message is transmitted inductively to the locomotive

The railway administrations are constantly seeking ways and means of utilizing the tracks, rolling stock and personnel more efficiently without any reduction in safety. Rail traffic poses very special safety problems. The high speed and high mass of the trains in combination with the low friction between steel wheels and rails give considerable braking distances. Rigorous rules must be set in order to safeguard against traffic accidents. The aid and devices that help to achieve this safety and efficiency are used to

- set up train routes, control points and signals, ensure that the track is free and safeguard the movements of trains
- transmit information to the train driver
- supervise the speed.

In modern signalling systems the operation of points in order to prepare train

routes and to provide protection against conflicting train movements is almost exclusively done with remotely controlled, electrical point machines, fig. 4. However, manual operation of hand-thrown points occurs on track sections that are seldom used.

A detection device, called a track circuit, is used to check that the track is free from trains and vehicles.

The established train route is protected against conflicting train movements by interlockings. The interlocking conditions state that points in the routes cannot be switched and that conflicting signals cannot be cleared.

The interlocking equipment, which is usually common for a whole station or yard, is normally placed fairly close to the objects, such as points, tracks and signals, that are to be supervised. The control equipment can be placed at a greater distance. Thus the control can be centralized to a few places, fig. 2. Such systems contribute to efficient traffic handling and low personnel requirement.

The information to the train driver is transmitted by means of fixed signs and light signals. Information to the locomotive can also be transmitted inductively from special transponders on the track or via radio, figs. 1 and 5.

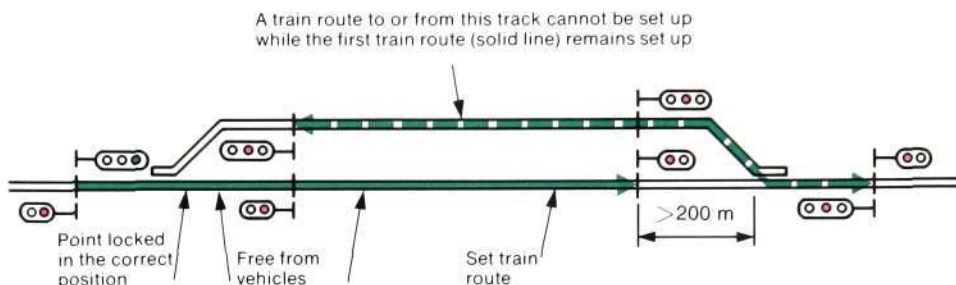
**Fig. 2**  
Train movements in stations can be controlled locally or centrally. In the latter case a large number of stations are controlled from the same place, i.e. centralized train control, CTC. The picture shows the local control office in Oslo central station, Norway





HANS S. ANDERSSON  
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Fig. 3  
Certain conditions have to be met to safeguard the movement of a train at a station



Supervisory equipment, which brakes the train if the driver keeps too high a speed, has long been used in underground systems and has also been introduced on certain railway sections, where trains run at a very high speed or where the traffic density is very high. On other sections with very little traffic it has previously not been possible to justify economically even the introduction of automatic braking if the train passes a stop signal. New technology now offers the possibility of speed supervision also on sections with low traffic density and in the long run it will be possible to relieve the train drivers of some of the responsibility they now bear, fig. 6.

### Safeguarding of train movements

Train movements must be protected against

- collision with other trains
- collision with vehicles on level crossings
- derailment because of point changes at the wrong time
- derailment because of too high speed.

In order to achieve this protection each moving train is allocated an area of the

track network, within which the train can move in accordance with certain rules. Speed limits, signals at stop and stop signs must be strictly observed. The area allocation means that no other trains may move in the area and that points in the area may not be switched as long as the area allocation remains. However, area allocations for shunting do not block point operation.

The track network is divided into geographical areas of different sizes. A moving train can be allocated one or several such areas, depending on such factors as the permitted speed of the train. When the entrance signal to a train route shows "clear", the train route is locked. All points and other devices that belong to the train route are locked in the correct positions, all protective signals show stop and the route is guaranteed free from obstacles, there are no other trains or vehicles in the area, fig. 3.

### Interlocking equipment

The conditions that apply for different train routes and train movements can be compiled in an interlocking table for each track area. Conventional signal boxes use safety relays to ensure that all conditions in the interlocking table are



Fig. 4  
Point machine for operating points

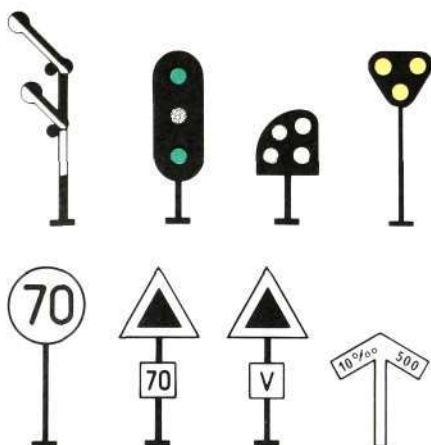
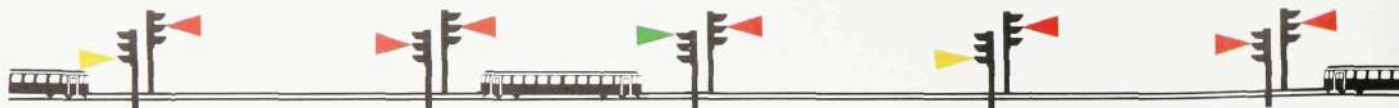


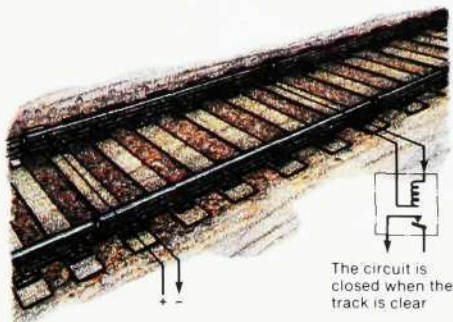
Fig. 5  
Some types of signals and signs that are placed along a track

Fig. 6  
The train driver must keep a lot of information in his mind in order to be able to drive the train in the best possible way

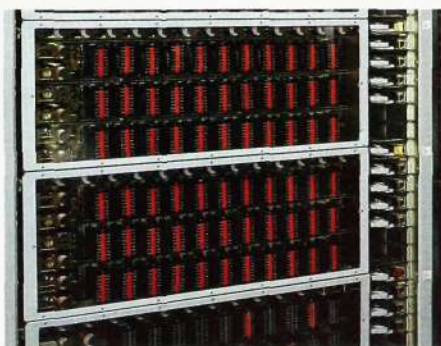




**Fig. 7**  
Automatic block signals, controlled by track circuits, are used between stations to inform the train driver of the position of the train in front of him

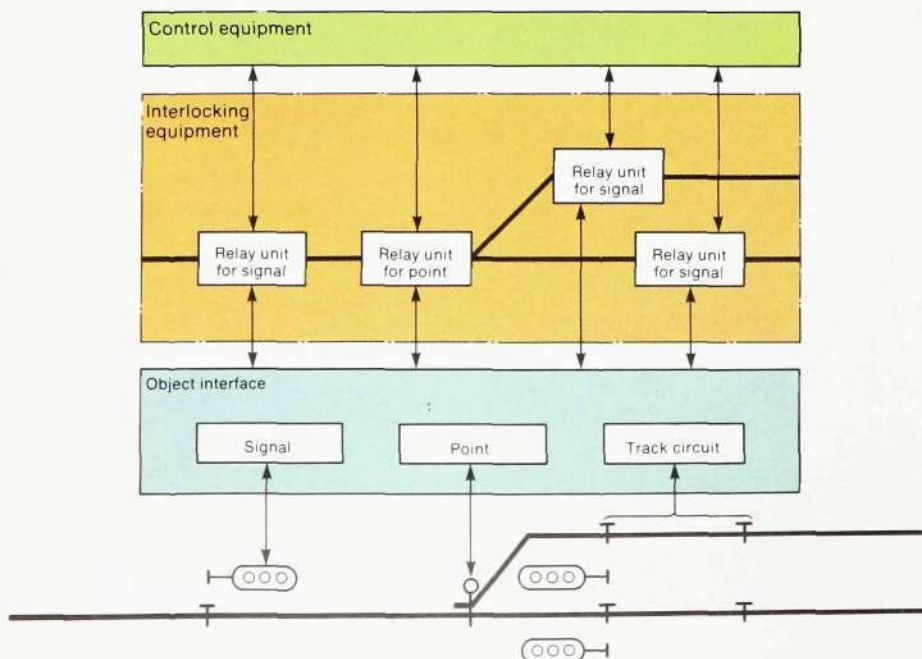


**Fig. 8**  
A track circuit comprises a battery, an insulated part of the track and a relay. The relay is normally operated but releases when a vehicle occupies the track circuit



**Fig. 9**  
A "geographical" relay unit for a main signal

**Fig. 10**  
The safety equipment at a station, arranged in accordance with the "geographical" method



met. The relay contacts are connected together to form current paths that correspond to the different conditions.

Another way of stating the conditions is by means of the "geographical" method. The conditions are related to different objects in the track area, points, signals, derailleurs etc. For each object the conditions are set for each possible state and each possible change of state. The relays that are needed for the interlocking of an object are brought together to a relay unit. One type of relay unit is used for points, another for signals etc., fig. 9. The relay sets, which are also called logic blocks, are connected to adjacent ones by means of multi-wire cables in a pattern that corresponds directly to the track system, fig. 10. The interface between the relay units is standardized.

The same geographical method of stating the interlocking conditions is used in LM Ericsson's computer-controlled interlocking system. In this case the conditions are stated in the computer program instead of in current paths via the relay contacts.

## Track circuits

Already at an early stage it was found necessary to be able to ensure, automatically and absolutely reliably, that a track section was free from trains. The

oldest and still most frequently used type of equipment is the track circuit. Its design is shown in fig. 8 in its simplest form. A track section is insulated from the adjoining parts of the track. The rails function as insulated conductors. The track circuit is fed with current from a battery at one end. The current through the circuit keeps a relay at the other end operated. The relay releases when a train short-circuits the track.

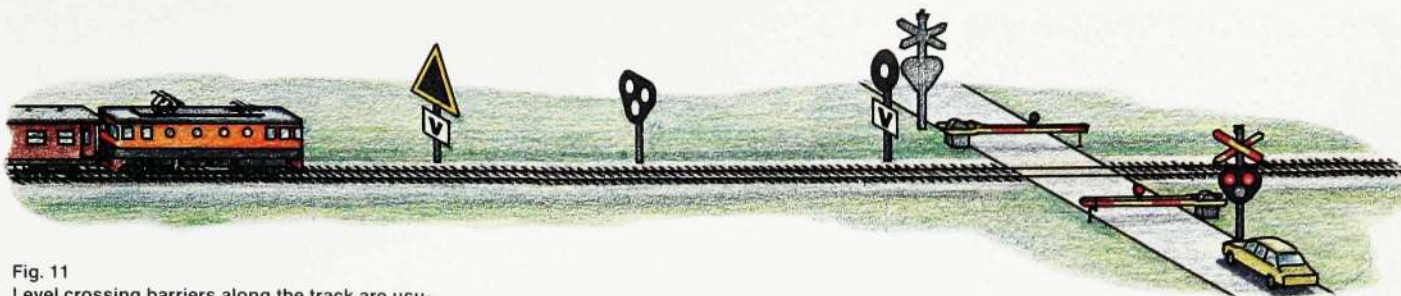
There are a number of types of track circuits, partly because there are different electrical traction systems for trains. For example, alternating current must be used for the track circuits when the trains are driven with direct current. In some cases the track circuit current is pulsed in order to obtain more reliable function or to combine the track circuit function with inductive transmission of information from the track to the locomotive by means of different pulse frequencies. Two prerequisites for such transmission of information are that the locomotive must be equipped with some form of antenna in front of the first pair of wheels, for receiving the pulses, and also that locomotives enter the track circuit from the relay end.

Track circuits are used to

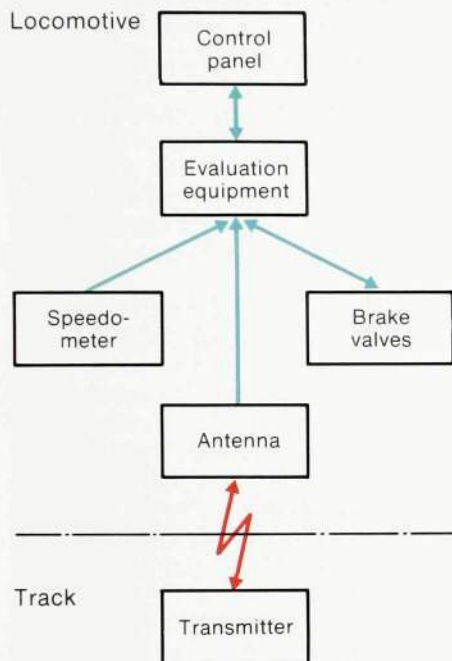
- check that train routes are free from obstacles
- block any switching of points
- automatically release traversed train routes
- control level crossing protection
- detect the approach of trains
- indicate the position of trains.

## Blocking equipment

The section above on interlocking equipment dealt with interlocking in stations. Similar interlocking must of course also be possible between stations. In its simplest form the latter type of interlocking is carried out by means of telephone calls and written routines. Agreements concerning states for train movements between two stations are noted on a form in each station. Sometimes the form routine is supplemented by a technical device that controls the exit signal to the line. With such manual blocking systems there is no need to equip the track sections between the



**Fig. 11**  
Level crossing barriers along the track are usually closed automatically when the train approaches the crossing. The distance from the crossing to the point where the barriers start closing is dependent on the speed limit for the track



**Fig. 12**  
The parts in an automatic train control system, ATC

**Fig. 13**  
The ATC system supervises that the train does not exceed the speed limits, which are depending on the train itself, the condition of the track and the traffic situation



Automatic blocking systems require track circuits along the whole route between stations. With long distances between stations it is possible to have several track circuit sections and signals, and more than one train can then be moving simultaneously along the track between two stations, fig. 7. When the whole route is free, the block can be turned for traffic in the opposite direction.

## Automatic train control

Systems for automatic train control, ATC, supervise the speed of the train and brake the train automatically if the speed limit is exceeded. The transmission of information between the track and the locomotive can be continuous or intermittent, i.e. at intervals along the track. The older systems that are still used in many underground railways have continuous transmission of information, but the number of different messages is limited to three or four speed limits, of which one corresponds to stop. Older intermittent systems usually only transmit stop messages if the train passes a stop signal. In certain cases such systems are supplemented by a function that gives advanced stop warning.

The requirement for safety and at the same time efficient utilization of the track network have led to the track

being equipped with a large number of signs and signals, which in good time inform the train driver of the characteristics of the track and the traffic situation. With the aid of this information the train driver is expected to optimize the speed of the train, figs. 5 and 6.

More recently ATC systems with a large transmission capacity have been constructed. Systems for both continuous and intermittent transmission are available. LM Ericsson have developed a system with intermittent transmission, fig. 12. A large amount of track data, such as signal messages, track slopes, curve radii and speed limits are collected, transmitted and processed together with train data, braking ability etc. The processed result is presented to the train driver on a panel, fig. 13. The equipment in the locomotive continuously supervises that the train driver observes the set restrictions, and the train is automatically braked if the speed should exceed the limit at any time.

## Level crossing protection

Level crossing protection can consist of

- visual and acoustic signals
- barriers.

The equipment can be operated manually or automatically. Manual operation, particularly of barriers, occurs in densely populated areas. However, protection equipment is usually made fully automatic, fig. 11.

When designing level crossing protection equipment it is assumed that road vehicles should give way to trains. The equipment is usually independent of other signals and interlockings on the track. However, at a station there may be interdependence between the signalling equipment at the station and level crossing protection equipment.

The signal towards the train in independent level crossing protection equipment is usually placed so that the train driver does not have time to stop a train which is running at full speed if he finds that the signal indicates that the protection equipment is not working. It is therefore essential that the signals and barriers for the road traffic are very reliable.



Fig. 14  
In stations with local interlocking control the signals may be set with keys in the track diagram

In Sweden an advanced warning signal to the train at level crossings has been introduced in certain places. Complete signalling towards the railway with absolute stop obligation for the trains would mean unacceptable waiting times for the road traffic.

The increasingly large differences in the speed of different types of trains justify the introduction of a control system for level crossing protection that takes the train speed into account. Such systems are already in use in some places. On sections with automatic train control it is possible to include data concerning the level crossing protection in the information that is automatically transmitted to the locomotives.

### Control and supervision systems

Basically the handling of railway traffic is carried out in accordance with a pre-determined timetable. Traffic controllers can cancel trains, put on extra trains, change train meeting places, change the order of trains and carry out any measures that are made necessary

by, for example, engineering work on the tracks within their district.

Station masters at manned stations, fig. 14, and dispatchers at remote control centres, fig. 15, control and supervise the train traffic via control panels. Certain of the tasks of traffic controllers, for example changing train meeting places and the order of trains, can be delegated to remote train dispatchers. The method of establishing a centre for the control and supervision of the traffic in a large geographical area with many stations is called centralized traffic control, CTC.

Centres that handle a large volume of traffic can be equipped with various aids, for example for the recording of train numbers and their display on track diagrams, for automatic route setting and for traffic recording. Traffic recording simplifies statistical follow-up of the train traffic.

LM Ericsson have developed an advanced control and supervision system for areas with high traffic. The system is computer-controlled, uses colour display screens for all indicating and constitutes a means for efficient and rational traffic handling, fig. 16.

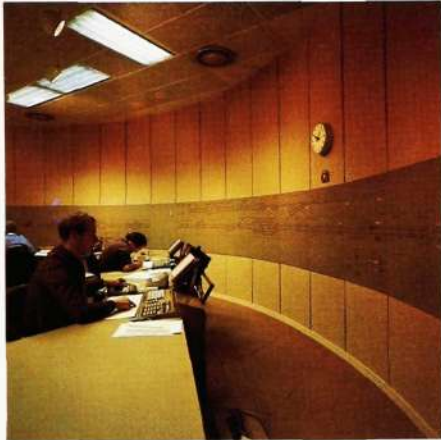


Fig. 15  
The CTC centre in Stockholm, Sweden, controls 60 stations and about 400 km of tracks

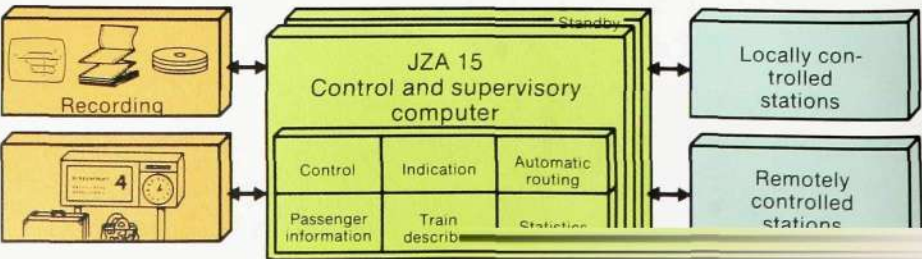


Fig. 16  
A computer-controlled control and supervisory system with colour display screens for large stations and for remote control of a large geographical area with many stations

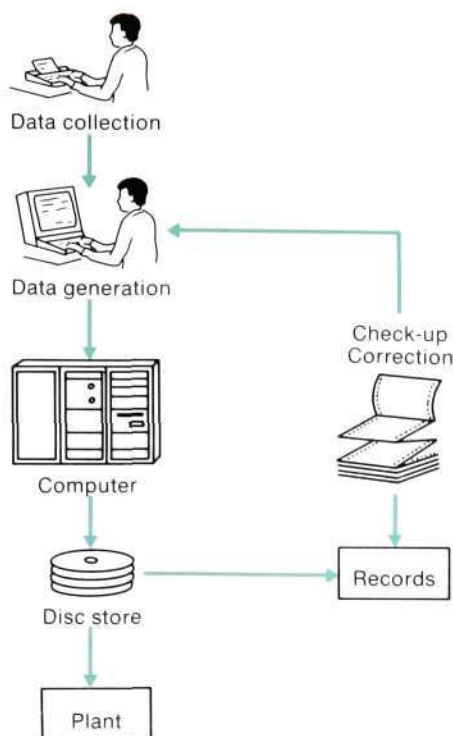
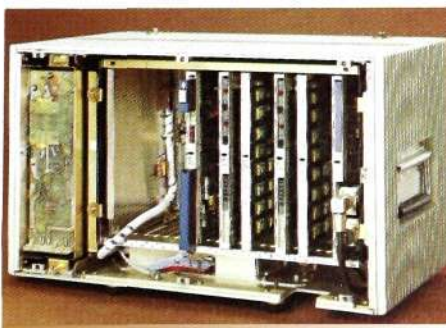


Fig. 17  
A computer aid is available that greatly simplifies the work of preparing the data and documentation that is individual to each installation



Fig. 18  
Plug-in safety relays are still predominant in interlocking systems not using "geographical" system as in fig. 9

Fig. 19  
The evaluation equipment for ATC is based on stored program controlled micro computer technology



## Product stipulations

Stringent safety requirements are made on many items in the product range in fault situations. A simple failure must not cause a dangerous situation. Moreover a failure must be detected and cleared fast enough to exclude the possibility that another failure appears which, combined with the first, endangers the safety. This affects the design and manufacture. Great precision is required in the production testing. In addition the equipment will be exposed to great stresses. The heavy railway traffic causes large mechanical vibrations. The traction current is returned partly through earth, and this gives rise to strong electrical disturbances. For example, the disturbances can be very troublesome when the traction current is taken from 16 kV single-phase 16 $\frac{2}{3}$  Hz a.c. voltage and the locomotive has thyristor control. Furthermore certain equipment must be able to withstand both arctic and tropical climatic conditions.

There are standards for the construction of railway signalling equipment, but the standards are not the same in all countries. However, most conventional equipment with essential safety functions is constructed in accordance with specifications issued by the Association of American Railroads, AAR, British Standards, BS, or the Office de Recherches et d'Essais, ORE, which is a working agency within the Union Internationale des Chemins de Fer, UIC. The construction standards are designed for contemporary technology and usually have to be altered when a changeover is made to new technology. The degree of safety that is obtained with robust relays and large insulation gaps between the circuit elements corresponds to what is obtained with high information and system redundancy in computer-controlled systems.

The traffic regulations also have many national characteristics. The position and meaning of visual signals are different in different countries, as are the conditions for the protection of train movements. Different experience and different assessments have led to different rules and regulations.

These rules and regulations are not greatly affected by a changeover to a new technology. However, in order to be able to apply them in connection with computer-control, it is necessary to give them a more stringent mathematical expression, so the rules and regulations must be rewritten in the form of a process algorithm. This has been done in the development work on LM Ericsson's new computer-controlled interlocking system.

## Development trends

Intensive development work is being carried out to utilize the facilities provided by new technology for better use of track and rolling stock, partly through higher speed and denser traffic. The railway administrations are also striving towards increased rationalization of the activities and increasing traffic safety. This requires

- efficient control of train traffic
- increased use of ATC systems
- more suitable level crossing protection, for example through the introduction of a control depending on the trains' speed
- equipment that is reliable and easy to service, and which needs only simple planning (fig. 17), short installation time with low manpower requirement and is easy to extend
- interworking of different administrative sections, for example through joint use of the transmission equipment for telecommunication, power and signalling purposes.

The technology based on relays, fig. 18, which is now predominant in equipment with safety requirements, will in the long run be replaced by stored program controlled computer technology where the microcomputer in particular is likely to become very important, fig. 19. One reason for this development is that the cost of relay-based technology increases successively relative the cost of electronics.

Data transmission is increasingly being used for the new systems. Fibre optics could with advantage be used for this purpose in order to overcome the difficult electrical interference problems. Data communication via radio from control centres to the locomotives may also come to be more widely used.

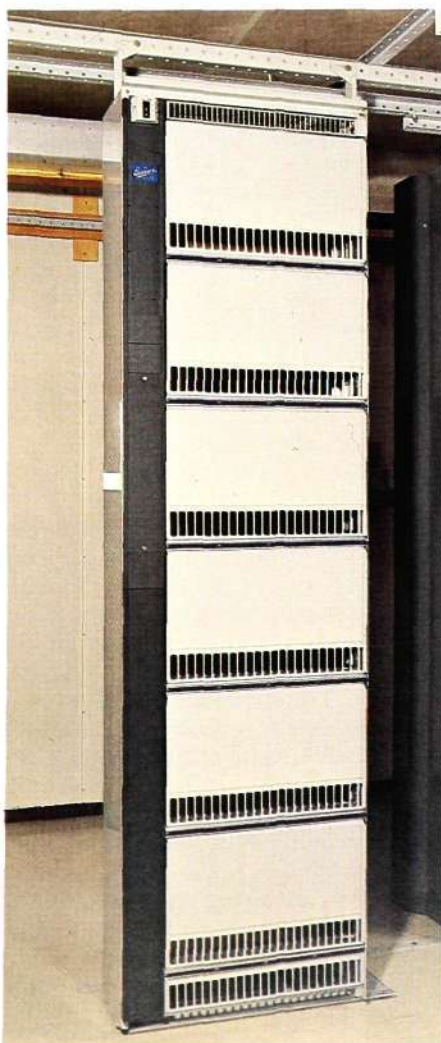
# Construction Practice BYB for Transmission Equipments

Per-Alrik Hallberg and Bo Viklund

*LM Ericsson's present transmission equipments have been designed using the M5 construction practice, but in future the BYB construction practice, which was developed for telephone exchange systems, will also be used when designing new digital transmission systems. The same printed board format is used in M5 and BYB. In the M5 construction practice the printed board assemblies are installed in shelves that cover the whole width of the rack, whereas in BYB they are plugged into magazines having different widths. A bay that can take both M5 shelves and BYB magazines has been constructed, since both types of equipment will be in use for a long time. In this article the authors give the reasons for the decision to use BYB, show how the construction practices for transmission equipments have successively been adapted to suit new component technology and finally describe the new M5/BYB bay.*

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Fig. 1  
An M5/BYB bay, equipped with BYB magazines



When LM Ericsson were ready to develop a new generation of digital transmission equipment the question arose as to which type of mechanical construction practice would be most suitable. Should the M5 construction practice be used also in future, or was a change necessary because of the changes in requirements and prerequisites? The argument that motivated the choice of construction practice BYB, which was originally intended for telephone exchange systems, are given below.

## Several sizes of magazine

The increased degree of integration and the complexity of the components have meant that the amount of space required for the various system functions has decreased. An M5 shelf is now often too large a mechanical unit for one system function. Several functions have therefore had to be combined in one shelf. It would be better to be able to use a mechanical unit of a size that is appropriate for the functional unit. This is possible with the BYB magazines, since they come in four different widths within the available bay width.

## Better ventilation

The higher degree of integration of the components means more functions per unit of volume. However, the power requirement per function has not decreased at the same rate as the increase in function density per unit. The miniaturization has meant a concentration of power. The demand for better ventilation is now therefore greater than the previous demands for a compact construction.

## Simpler installation

Transmission equipment was previously used mainly in the trunk network and was concentrated to a few places. Today transmission equipment is used also in the local and subscriber networks. This wider application has led to increasing demands for easy installation. Station cabling that is plugged in on the front of the equipment gives good accessibility and simplifies the installation work. One disadvantage is that the front area available for maintenance functions is reduced. However, this is compensated by the reduced need of maintenance. Generally speaking there is practically no routine maintenance carried out in the bays nowadays, and the corrective maintenance consists mainly of the replacement of printed board assemblies.

## Simpler basic equipment

One aim when designing the bays has been to enable the basic transmission equipment required in the first stage to be as simple as possible. For this reason the converters for the power supply have been placed locally in the magazines. Such decentralization, which has been made possible through the use of new components and circuit designs, also gives high reliability throughout.

## Installing the units in different bays

The increasing degree of integration of switching and transmission technique, IST (Integrated Switching and Transmission), means that it must be possible to install transmission equipment not only in transmission stations but also in telephone exchanges. This applies, for example, for signal conversion and analog/digital conversion equipment. Thus it is essential that the same printed board assembly or magazine can be placed either in the transmission station bay or in the exchange bay row.

## History

In the M3 construction practice of 1959, fig. 2, the bay was a functionally separate system unit, for example a channel translating bay. Printed circuit boards for component mounting and connections were used for the first time. The transistor was coming into use. The

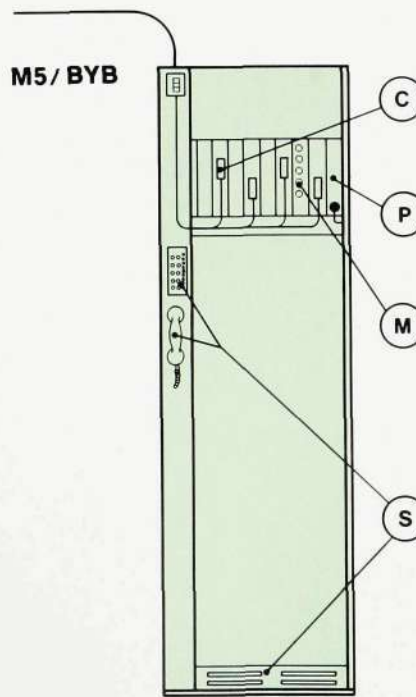
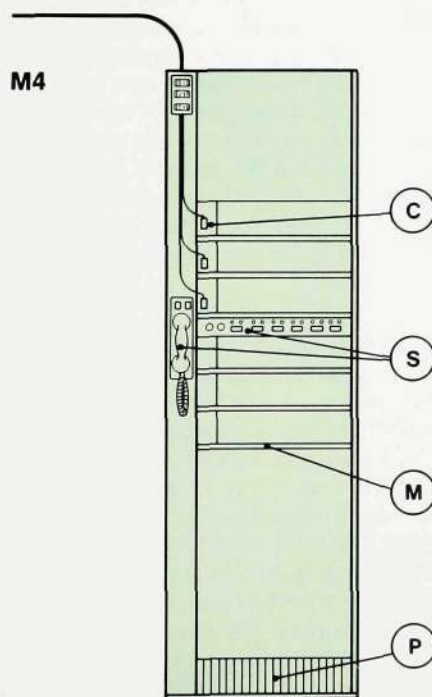
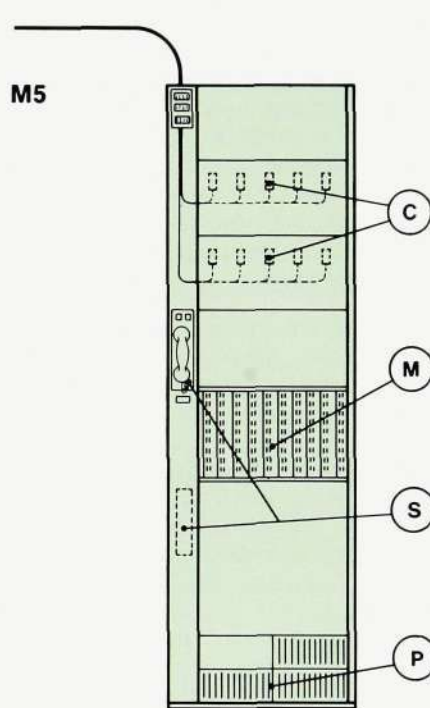
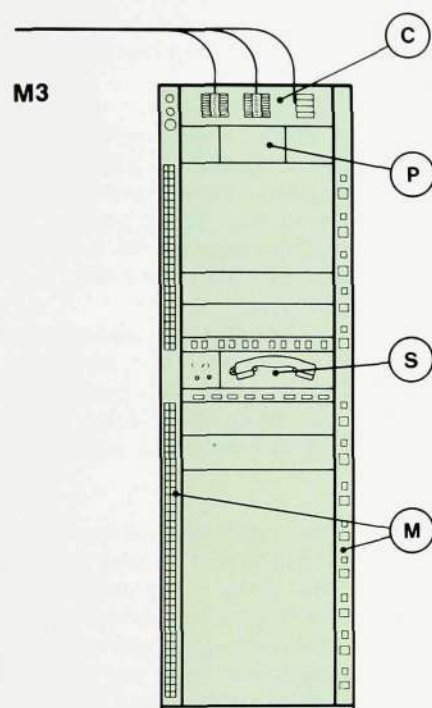


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Fig. 2  
The development of bays M3–M5/BYB for transmission equipment during the years 1959–1980

C Station cable connection  
P Power supply  
S Service line equipment  
M Maintenance equipment



made at the top of the bays. The power supply equipment was also placed there. The equipment for the maintenance functions was placed along the sides of the racks and the service equipment (telephone unit etc.) was situated in a panel in the middle of the bay.

The volume of the equipment could be reduced as the component technique was developed and the calculation methods were refined, and a bay became too large for a functional system unit.

The shelf construction practice, M4, was introduced in 1967. The station cabling was brought direct to the shelf. The power supply equipment was placed at the bottom of the bay to facilitate successive extension of the bay from the bottom. The equipment for maintenance functions was placed along the lower edges of the shelves and the telephone unit in the left hand upright. In the middle of the bay there was a narrow panel left for alarm lamps and service line jacks.

The continuing development of components led to even more efficient and smaller components. Hybrid circuits and integrated circuits were coming on the market. The format of the printed board was changed. A larger, almost square board was more suitable since it meant fewer connections between the printed board assemblies in the shelf and provided a longer edge for the large number of connectors. The printed boards for digital functions in particular require many connectors.

The M5 construction practice was introduced in 1976. The bay cabling was brought right in to the shelf connectors where the printed board connectors were plugged in. However, coaxial cables were still connected in at the left-hand shelf side. Equipment for maintenance functions was now only placed on the front edges of the printed board assemblies. The routine maintenance had been eliminated or considerably reduced. The telephone unit, alarm unit and service line jacks were placed in a bay upright in order to give maximum bay flexibility. The power supply equipment for up to three voltages was placed at the bottom of the bay.

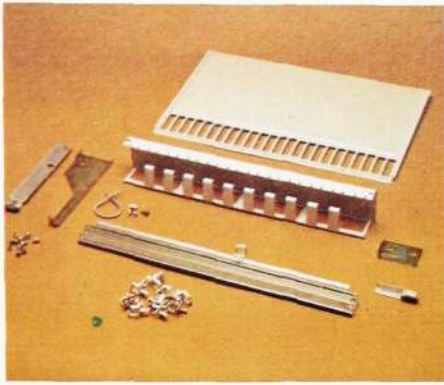


Fig. 4  
Assembly kit for a BYB shelf



Fig. 5  
Assembly kit for a BYB magazine

The M5/BYB bay is introduced on the market in 1981. In this construction the station cabling is taken direct to the front edge of the printed board. This gives good accessibility for installation, inspection and testing. The front edges also contain the equipment for certain maintenance functions. Power converters are provided in each magazine. The magazines have good electrical characteristics and can be used for high frequencies and bit rates without any special measures being required. The telephone unit and service line jacks are placed in the left-hand bay upright, but the associated electronic equipment and the alarm unit are normally placed at the bottom of the bay.

### The M5/BYB bay

The M5/BYB bay is very similar to the M5 bay. It is built up of a bay frame with a left-hand and a right-hand upright. The uprights have space for the station cabling and also for power distribution and alarm concentration bars. M5 shelves, or shelves for the BYB magazines, are mounted between the uprights. The shelves are designed to give good ventilation. Extra ventilation units can be installed next to equipment with high power consumption. The connection of the station cabling is designed so that

the cables can be prepared and equipped with connectors before the shelves and magazines have been delivered. A bay that is only partially equipped can thus be completely cabled at a moderate extra cost, which simplifies any extension work.

The dimensions of the bay are in accordance with recommendations from CEPT and CCITT. It is 600 mm wide, 260 mm deep and has a height of 2743, 2134 or 1160 mm.

The bays are divided vertically into building modules, BM, of 40.64 mm. The highest bay provides a space of 66 BM for the installation of equipment. The corresponding space for the two other bay heights is 51 BM and 27 BM.

The two bay uprights are connected by means of a base plate and, at the top, two horizontal angle iron bars. Fig. 3 shows a part of an M5/BYB bay equipped with BYB magazines and an M5 shelf.

The left-hand upright is wide enough for the station cables and its brackets. The front of the upright is provided with hinged cover strips. The narrower right-hand upright is designed with three vertical channels, two wide and one narrow, are formed on the inside. U-shaped copper bars for the power feeding and alarm concentration are mounted in the wide channels. In the spaces where no shelves are fitted the bars are protected against accidental contact by means of plastic covers. The narrow channel, to the rear of the upright, is intended for the incoming power cables. Vertical earth rails made of copper sheeting are mounted at the rear of each upright, on the inside.

### Installing and connecting BYB magazines and M5 shelves

Two assembly kits are needed to install a BYB magazine in the bay, one for the shelf and one for the magazine. The shelf kit consists of side members, rear and front rails, a cover plate and magnetic locks, fig. 4. The shelf takes up 8 BM vertically, provides good ventilation of the magazines and makes cable installation easy. The overall width of the shelf corresponds to 12 BM. The magazines are available in widths of 3, 6, 9

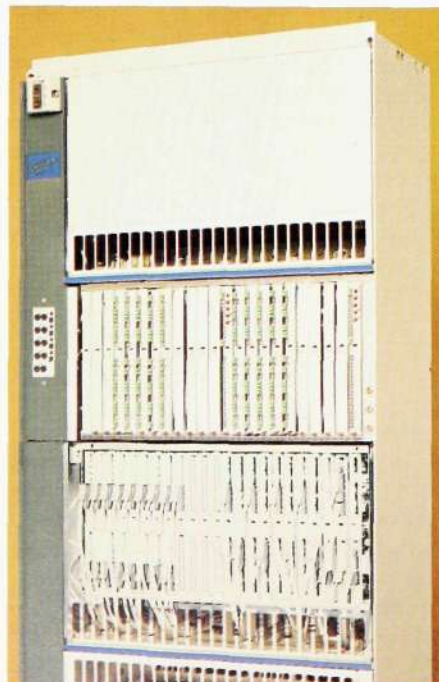


Fig. 3  
An M5/BYB bay with BYB magazines and an M5 shelf. The front cover of one magazine has been removed

Fig. 7  
Printed board holder for the alarm unit



and 12 BM, and they can be combined arbitrarily to form a full shelf.

The magazine kit consists of two supports and two connection cables, fig. 5. One cable is connected to the bars in the right-hand upright to provide power, and the other connects the alarm outputs of the magazine to the alarm concentration bars. The latter cable also contains a metal clip with a light emitting diode, which is clipped to the front rail. An alarm in the bay can thus easily be localized to the right magazine even with the cover plate in position. The supports are fixed between the front and rear rails of the shelf. The magazine is mounted on the supports and the station cables are connected to the connectors on the front edges of the printed boards.

The M5 shelf is connected to the earth bars when the shelf is installed and screwed to the bay uprights. The shelf is connected to the power feeding and alarm concentration bars by means of contact tabs, which terminate the shelf cabling, and which are pressed into the relevant copper bar in the right-hand upright and secured by screws, fig. 6. The M5 connectors for the station cab-

ling are inserted in connector mounts at the rear of the shelf before the shelf is fitted into the bay. The printed board assemblies are delivered separately and are the last to be plugged in.

### Power supply

Each magazine has its own d.c./d.c. converter. The M5 shelves are fed either from built-in or centrally placed d.c./d.c. converters. The two feeding methods have been described previously in this magazine<sup>2</sup>.

In the case of feeding from the mains the rack is equipped with mains rectifiers. The rectifier outputs are connected direct to the bay d.c./d.c. converter for central feeding, and to the feeding bars in the right-hand bay uprights for the power feeding of magazines and any M5 shelves with local converters.

### Alarm equipment

The alarm equipment for the rack is mounted in a printed board holder, fig. 7, at the bottom of the bay (figs. 1 and 2). It consists of an alarm concentrator with inputs for the alarms and also its own power feeding input. The unit has a number of separate outputs for different

Fig. 6  
Connectors for connecting an M5 shelf to the bay

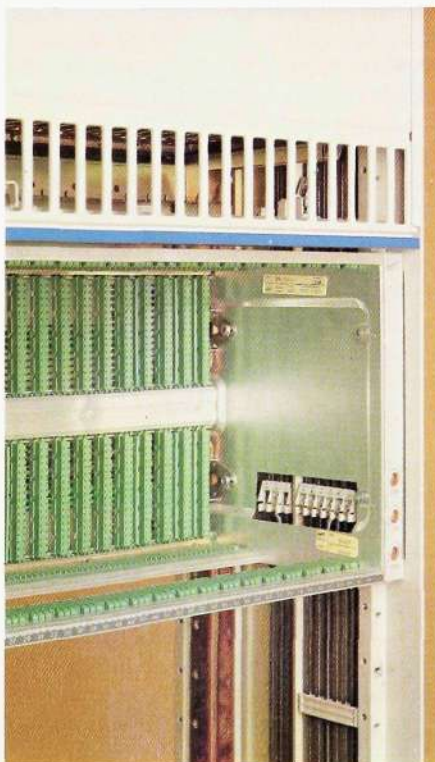


Fig. 8  
Alarm interface for printed board assemblies in BYB magazines



alarm categories, intended for different types of exchange alarm systems. The alarm function can be either a break or a closure. There is a choice between earth-free, separated alarm outputs and outputs with common earth. Exchange alarm bells can be connected. Facilities are also provided for alarm acknowledgements and for connecting bay alarm lamps. The printed board holder takes up two building modules vertically. The alarm concentrator is built up on a standard printed board, which is mounted horizontally in the holder. There is space for further printed board assemblies with supplementary functions.

The shelves and magazines are equipped with alarm circuits that provide fault indications. Some conditions that can cause an alarm are, for example, faulty secondary voltage, synchronization error and bit error.

One printed board assembly in each magazine has a connection panel for outgoing alarms and two light diodes for indicating alarm states, fig. 8. The alarm outputs are connected to the bay alarm unit via the alarm concentration bars. The other alarm outputs, which provide more detailed alarm information, can either be connected to a separate alarm system or they can be used direct for fault localization when a fault occurs.

#### Service telephone

The service telephone line is used in connection with the installation and maintenance of line systems. A printed board assembly for the service telephone is mounted in the printed board holder. The telephone is of the same type as those used along the line, and it is connected to a panel mounted in the left-hand upright cover, fig. 2.

#### Ventilation

The shelf assembly kit is designed so that air can enter the bay with very little flow resistance, disperse under the magazine, pass up through it and come out at the top. If further ventilation is required, ventilation units having a height of two building modules can be installed in the bay.

### Transmission equipment in BYB 101

The need to be able to install transmission equipment in the same premises as exchange equipment is increasing. It is therefore an advantage to be able to use the same mechanical construction. When the transmission equipment is mounted in magazines, these can be installed and connected in the same way as in the case of exchange equipment in row construction practice BYB 101<sup>3</sup>.

The alarm unit then consists of a magazine of three building modules in width, which holds an alarm concentrator and up to five alarm indicators, fig. 9. The alarms from up to eight magazines are collected via an alarm indicator. Thus a total of 40 magazines can be connected. An alarm from a magazine lights a diode lamp on the associated alarm indicator. A diode lamp that indicates the alarm category lights on the alarm concentrator.

Fig. 9  
The alarm concentrator and alarm indicators in a BYB magazine having a width of 3 BM



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3. Alexandersson, R. and Rörström, H.O.: *New Packaging Structure*. Ericsson Rev. 53 (1976):2, pp. 100–107.

# First-Order PCM Multiplex in the BYB Construction Practice

Hans-Henrik Hamacher and Göran Pettersson

LM Ericsson have developed a new generation of first-order PCM multiplex systems, ZAK 1/30-4, as a part of the modernization of their transmission equipments. The BYB construction practice was chosen for the new equipment, partly to make it compatible with existing telephone exchange equipment as well as other transmission equipment. In this article the use of this type of equipment is described, as well as its design and function, together with different equipment and connection alternatives.

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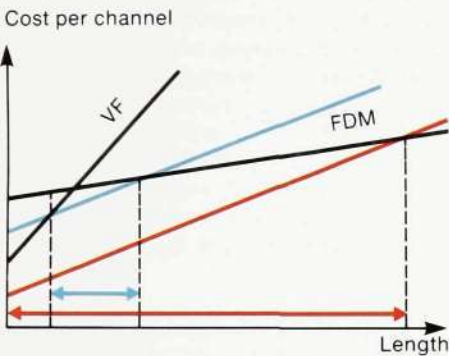


Fig. 3  
A cost diagram for different transmission and exchange alternatives

— PCM with analog exchanges  
— PCM with digital exchanges  
— FDM Frequency division multiplex systems with analog exchanges  
— VF Physical circuits with analog exchanges

The economical circuit length for digital transmission increases (from blue to red arrow) when digital exchanges are introduced

For many years digital transmission has been used on a large number of circuits between analog telephone exchanges, fig. 1. When the exchanges are also made digital it will be possible to connect the digital lines direct to the exchanges and the number of conversions between digital and analog signal per circuit will be reduced, fig. 2. Thus digital lines combined with digital exchanges provide a more economical network<sup>1</sup>, fig. 3.

The changeover to a fully digital network will take many years and will comprise many stages. The number of PCM converters will increase with the extension of the digital areas and the analog/digital conversion will be moved closer to the subscribers. During this expansion it will also be necessary to move PCM equipment, fig. 2.

The digital transmission channels obtained by the use of PCM are also suitable for data transmission. It must be assumed that the channels will be used for both telephony and data to an increasing extent as the digital areas grow.

LM Ericsson have developed a new first-order PCM multiplex system, ZAK 1/30-4, for such networks. One of the

aims of the development work has been to ensure that the equipment has the following general characteristics:

- easy to handle
- movable
- so flexible that it can be equipped for either telephony or digital data transmission, or both
- easily accessible interfaces for all functions.

ZAK 1/30-4 converts 30 analog telephony channels to one digital channel with a transmission speed of 2.048 Mbit/s. This is done by means of filtering, sampling, analog/digital conversion and digital multiplexing. These processes have been described in previous articles in this magazine<sup>2,3</sup>.

## Construction practice

The BYB construction practice was chosen for the new multiplex equipment. A general description of this construction practice has been published in an earlier issue<sup>4</sup>. The characteristics that motivated the choice of BYB for new digital transmission systems are discussed in the preceding article<sup>5</sup>. The following features are of particular advantage in a first-order multiplex system:

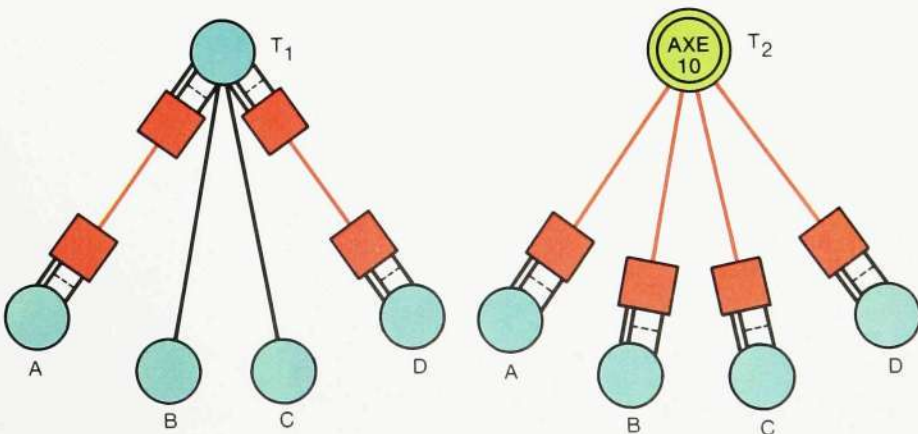
- the equipment is delivered with the magazines fully equipped, which simplifies the installation work
- each magazine is an independent unit with its own d.c./d.c. converter. It can be mounted in an M5/BYB bay, in a BYB 101 bay row or a BYB 201 cabinet. This gives great flexibility when planning new systems and when moving PCM equipment

Fig. 1  
PCM equipment in an otherwise analog network

Fig. 2  
PCM equipment in a mixed analog/digital network

● Analog exchange  
■ PCM equipment  
— Digital lines

Changing the analog exchange in fig. 1 to a digital exchange means fewer analog/digital conversions on the circuit A-D. The PCM converters at T<sub>1</sub> can be moved to exchange B and C.





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— all cabling is accessible from the front, which simplifies both installation and rearrangement.

## System characteristics

ZAK 1/30-4 is designed to be easy to install and maintain. It is equipped with efficient fault supervision, which quickly provides information regarding the type and location of any fault.

## Installation

The d.c./d.c. converter works with battery voltages between  $-20\text{ V}$  and  $-72\text{ V}$  without the operating range having to be adjusted.

The only adjustment that is required during the installation is the matching of the channel levels on the speech channel side. This is done with the aid of attenuators, which are common for eight channels. The attenuation is set by means of plug-in U-links, fig. 4. The attenuation can be changed just as easily, which simplifies any rearrangement of the equipment.

## Fault supervision and maintenance

The supervision on the digital side of the PCM multiplex (PCM-mux) is in accordance with recommendations of CCITT. If a fault occurs, diode lamps on the front edge of the printed board light and indicate the type of fault. Individual alarm outputs can be connected to the traditional type of alarm equipment, e.g. urgent and non-urgent alarms for each rack or row. This conforms to the alarm principles of previous generations of PCM-mux. In addition each individual alarm state, such as loss of frame alignment, bit error etc., can be indicated separately. These alarm outputs can be connected to central supervision equipment in the network, for example AOM 101 via LM Ericsson's computer-controlled transmission maintenance system ZAN 01. This gives an overall picture of faulty PCM equipments, fig. 5. The fault clearing time will be short, since the fault is quickly localized and the type of fault determined, and the repairman can be equipped with the correct spares and sent to the right place.

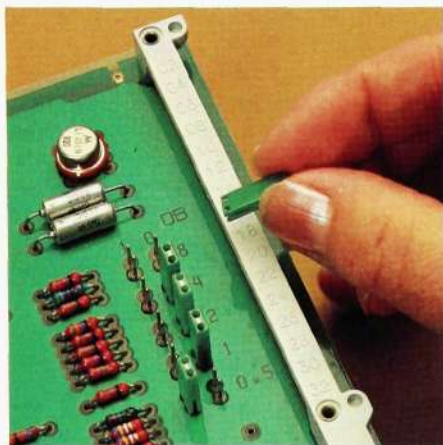


Fig. 4  
Adjusting the attenuation of a channel unit. The attenuator is common for eight channels and the steps are clearly marked

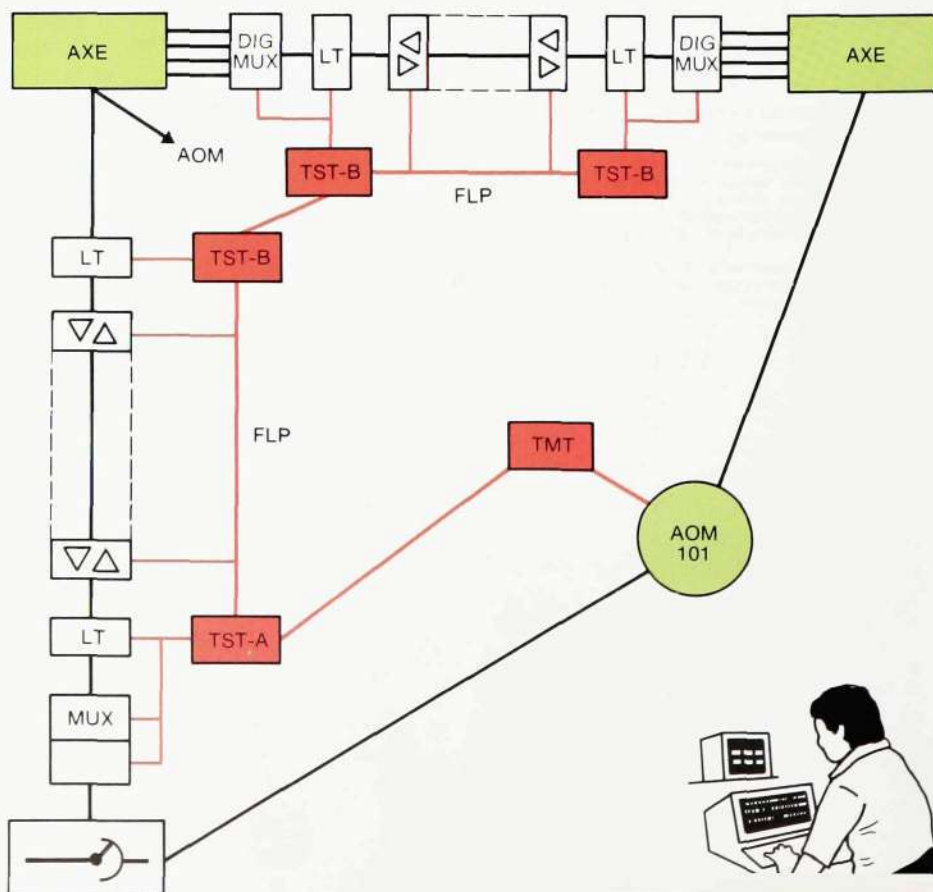
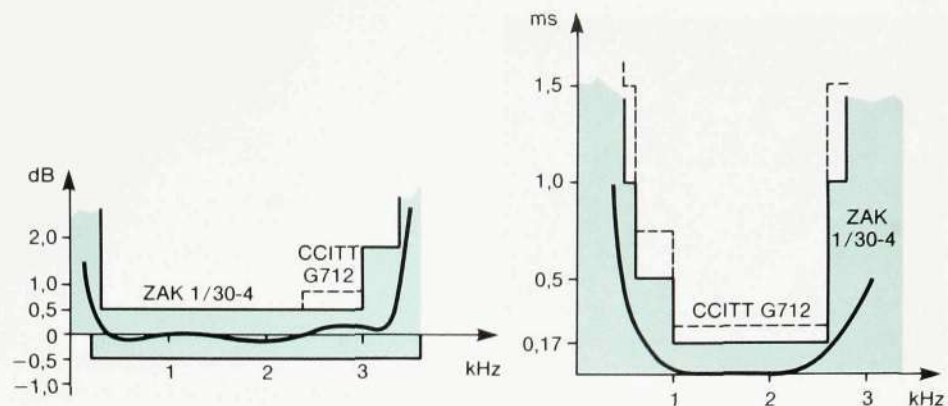


Fig. 5  
Operation and maintenance system AOM 101 with ZAN 01 for exchange and transmission equipments. The alarm information from the transmission equipments is collected in blocks TST. TST-A is superior and communicates with TST-B via FLP and with TMT. TMT can be connected to AOM 101

— Belongs to ZAN 01  
— Analog exchange

**Fig. 6**  
The pass band attenuation and group delay distortion in a PCM link. Curves for typical values are drawn



Preventive maintenance is not necessary. The changes in component characteristics that occur because of temperature variations and ageing have been taken into consideration in the electrical design. Well-tried components are used and the power consumption is kept low, which gives the equipment very high reliability.

It has been possible to reduce the number of types of printed board assemblies for standard PCM-mux to five, one of which is the d.c./d.c. converter. High reliability and few types of printed board assemblies mean that the necessary stock of spares is reduced. Central fault supervision, and stores that are common for several exchanges further reduce the number of printed board assemblies that have to be kept in stock<sup>6</sup>.

### External timing control

The PCM-mux timing can be controlled externally. External timing is used when the system is to work in a synchronous, digital network. The external timing is connected in at the front of the printed boards.

### Technical characteristics

In the foreseeable future PCM-mux will be used on circuits with several analog/digital conversions while the network is

gradually being digitalized. Particular attention has therefore been paid to the parameters that affect the signal quality when there are several conversions per circuit. The recommendations made by CCITT have been followed, but the limits set for the following characteristics have been made more stringent:

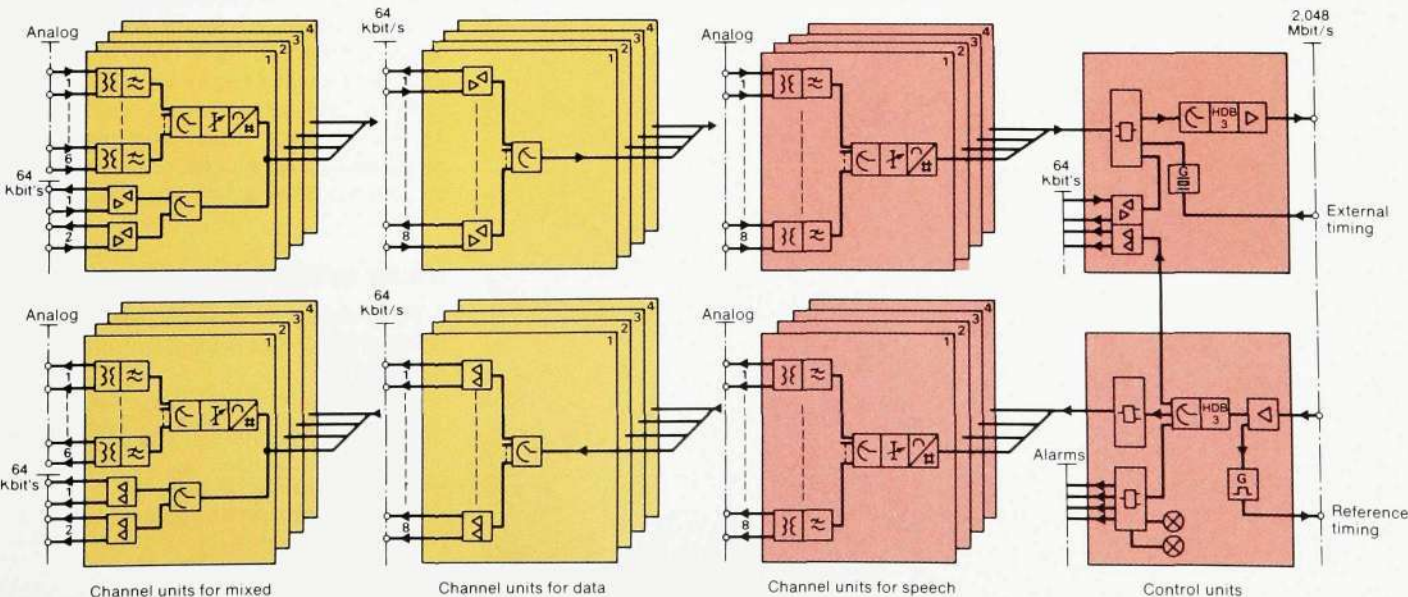
- pass band attenuation
- group delay/frequency distortion
- absolute delay
- noise in a silent channel
- crosstalk
- ripple attenuation
- out-band attenuation.

The pass band attenuation and group delay distortion requirements are shown in fig. 6. The stricter limits give transmission characteristics which make the circuit more suitable for data transmission via speech band modems.

The absolute delay of the system, i.e. the time it takes to transmit a signal from the analog input to the analog output on a PCM link, is of importance for circuits where several PCM links are connected in series. Troublesome echoes can occur and echo suppressors may be necessary if the delay is not kept small.

Low noise and low crosstalk in the PCM equipment is essential if a high trans-

**Fig. 7**  
Block diagram for ZAK 1/30-4.  
The basic equipment consists of control units and channel units for speech. Different combinations of data and speech can be obtained by replacing the speech channel units with channel units for data and/or channel units for mixed speech and data. The d.c./d.c. converter is not shown



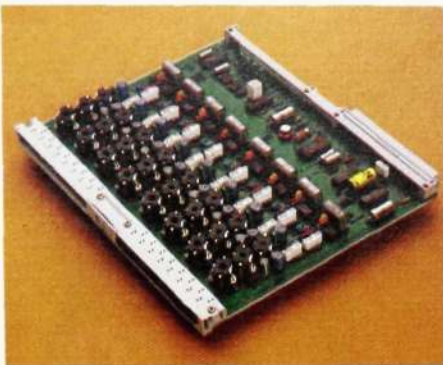


Fig. 9  
Send side channel unit

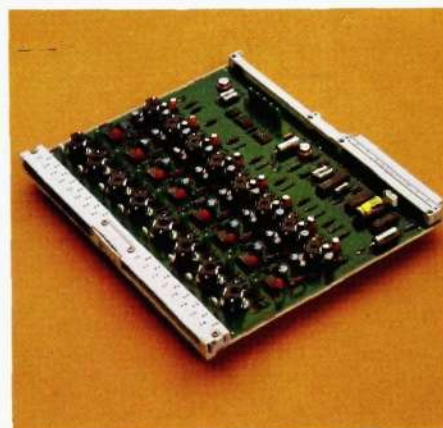


Fig. 10  
Receive side channel unit

Fig. 8  
ZAK 1/30-4, the PCM multiplexor equipped for 30 speech channels



mission quality is to be obtained. It is particularly important that there should be no crosstalk between subscribers connected to the same PCM terminal, as otherwise neighbours would be able to overhear each other. In this respect the design requirements are more stringent than the CCITT recommendations.

The requirements regarding ripple attenuation are also stricter than the CCITT recommendations. Large ripple voltages can in certain cases be induced into long analog two-wire circuits. It is essential that these ripple voltages are attenuated before the analog/digital conversion stage. Undesirable distortion occurs if the signal voltage is displaced by the ripple voltage.

The out-band attenuation is of importance when PCM-mux is connected to frequency division systems (FDM). With an attenuation level of 28 dB the new PCM-mux is suitable for any type of FDM connection.

## Development history

The development of ZAK 1/30-4 started with a study of possible methods for the three main functions: filtering, encoding and decoding, control.

The components that were available when the previous generations of PCM systems were designed had been developed for the computer industry<sup>3</sup>. Since then the manufacturers of microcircuits have extended their product ranges to cover the telephony field, but the available range of components is still rather limited.

LM Ericsson have studied the component market, conferred with manufacturers and assessed the development and future component performances. Extensive component investigations have been carried out and preliminary design studies defined and undertaken for the most interesting alternatives.

As regards filter functions the choice was between active filters, CCD filters (Charge Coupled Devices), digital filters and passive LC filters. The LC filter was chosen, and a further choice had to be made between the traditional iterative network structure and a special single-coil structure.

The codec function can be realized in many different ways. One design that was studied consisted of a central encoder which worked in the time division mode with 30 channels. Intensive studies of different types of single channel codecs have also been carried out. The design that was finally chosen contained an 8-channel encoder.

In the case of the control function there was a choice between standard logic circuits, standard PCM control circuits and more or less customer-tailored circuits for such functions as generation of the frame word, frame alignment and HDB3 encoding, and for the connection circuits for 64 kbit/s data transmission.

## Basic systems

A PCM-mux consists of five different types of printed board assemblies, fig. 7, namely:

- send side channel unit for 8 channels
- receive side channel unit for 8 channels
- send side control unit
- receive side control unit
- d.c./d.c. converter.

4 channel units of each type occupies a 240 mm wide magazine, fig. 8.

The filters, encoders and decoders are all placed on the channel unit boards, figs. 9 and 10. This has made it possible to keep the conductors for the sensitive analog signals very short.

The codec function is of the successively approximating type, fig. 11. The equipment consists of monolithic circuits for 8-channel multiplexors, sample and hold circuits, digital/analog converters and Successively Approximating Registers, SAR. This 8-channel codec is less complex and more reliable than the 1-channel and 30-channel codecs, and codec supervision is not justified in order to obtain reliable operation.

The attenuator on the channel unit covers a range of 15.5 dB. The attenuation is adjusted in steps of 0.5 dB by means of U-links, fig. 4.

Low delay distortion has been achieved by selecting the lowest possible grades of LC filters, fig. 6. The low pass filters are of grade 5 and the ripple filter is of grade 2. The band pass ripple value has been reduced to a level lower than that recommended by CCITT. The channel amplifier constitutes an active link in the ripple filter and is also used to provide the necessary limiting.

The low pass filters have the traditional iterative network structure with transformer-coupled coils. The receive side channel amplifier is also used as a second grade low pass filter. The filters are made with the lowest possible phase shift for the given grade in order to reduce the group delay.

The division of the channel unit into a send side and a receive side has certain advantages. For example, the crosstalk problems are reduced since there are no troublesome differences in speech level on the same printed board assembly. The analog/digital and digital/analog converters can work synchronously without complicated control and extra signal delay. Low delay helps the four-wire stability. In this respect the 8-channel encoding is also preferable to single channel encoding. The delay is only 1/8 of the sampling interval of 125  $\mu$ s.

The send side control unit contains logic circuits for controlling the encoding, for generating the frame word and for feeding the PCM signals into the 2 Mbit/s stream. The crystal oscillator can operate with either free oscillation or external timing. The PCM signal output and the external timing input are placed on the front of the unit. The connection is 75 ohms, coaxial.

The send side control unit also contains send and receive circuits for the signalling timeslot T16. The corresponding inputs and outputs for the 64 kbit/s signalling streams are placed on the front of the unit<sup>3</sup>. Fig. 13 shows the layout of the inputs and outputs on the fronts of the control units.

The receive side control unit contains logic circuits for controlling the decoding and channel distribution, for frame alignment and for recovering the signalling information. The input for the PCM-coded signal and the timing output consists of 75 ohm coaxial connectors on the front of the unit.

Circuits with a high degree of integra-

Fig. 11  
Monolithic circuits for codec functions.  
The same type of codec circuits is used on the send and receive side. On the send side all functions are utilized: multiplexor, sample and hold circuit, D/A converter, comparator and SAR. Only the D/A converter is used on the receive side

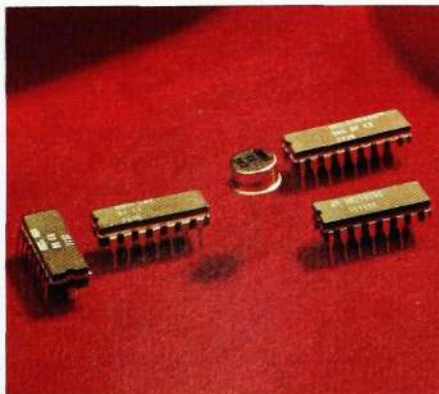
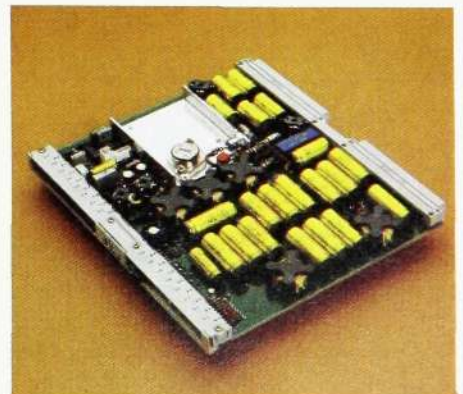


Fig. 12  
The D/A converter



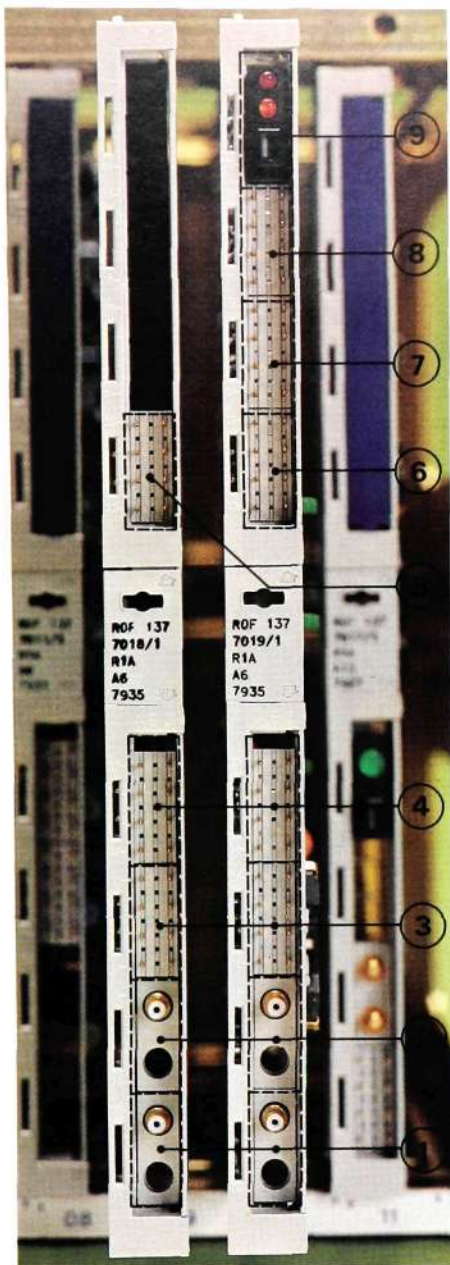


Fig. 13  
The layout of the channel unit fronts

1. 2 Mbit/s main flow
2. Input for external timing and output for reference timing
3. Free bits, no. 4-8. Input and output
4. Test points for certain digital signals
5. 64 kbit/s signalling interface
6. Outputs for urgent and non-urgent alarms and for reminder indication
7. Output for system alarms
8. Outputs for power alarm, alarm indication, loss of frame alignment, bit error rate and far-end alarms
9. Push-button for cancelling the bay alarm signal with diode lamps for near-end and far-end alarms

Fig. 14  
An example of the utilization of a 64 kbit/s timeslot for data. One 64 kbit/s timeslot corresponds to one speech channel. By means of multiplexing in a special data multiplexor it is then possible to transmit the amount of data shown in the table below instead of speech

Bit/s	Number of channels
600	63
2 400	20
4 800	10
9 600	5
48 000	1

tion have been used for the control units in order to save space on the printed boards. Special monolithic circuits have been used for frame alignment/frame word generation, signalling and HDB3 encoding.

The d.c./d.c. converter, fig. 12, is a three-voltage converter giving the secondary voltages +12, -12 and +5 V. It meets the stability requirements for primary voltages within the range 20-72 V. Chopper technique, careful choice of components and the best possible circuit design have contributed to give the converter 80% efficiency on full load. This unit, like all other units in the system, is only 20 mm wide. The front of the unit contains a breaker and indication Light Emitting Diode (LED) for the primary power supply.

The printed boards are of type ROF 137, with the dimensions 220x178 mm.

## Interfaces

The connection between the channels and the PCM-mux is four-wire. Any conversion to two-wire working is done in separate equipment. The channels are connected to the channel units via cables equipped with "half connectors" having 16 tags, which are plugged into one half of a connector on the printed board, fig. 8. The cables with their half connectors can be prefabricated, so that they can be plugged in quite simply during the installation. The half connectors are available with and without bus function. A half connector with bus function makes it possible to carry out parallel measurements on individual speech channels. If the half connector is replaced by a full connector with bus function it is also possible, with certain auxiliary equipment, to cut off individual channels.

The battery voltage is connected direct to the d.c./d.c. converter by means of a battery connector. Test points are provided for the secondary voltages. An alarm output for power unit faults is available on the unit itself and also among the other alarm outputs on the receive side control unit, fig. 13, item 8. Fig. 13 also shows the position of other interfaces and maintenance terminals.

Alarms are given by means of closure to earth via a transistor contact. The alarm outputs are combined into three different groups with common earth within each group. Each group is connected up via a "quarter connector" on the front of the unit, fig. 13.

Bay alarms can be cancelled by means of a push-button on the front of the send side control unit. The system can also be blocked to traffic via the signalling converter by depressing the button. An adjacent light emitting diode then lights as a reminder indication. This diode also indicates all near-end alarms. A second diode indicates far-end alarms.

If desired, detailed measurements can be carried out with the aid of test outputs for

- transmitted and received PCM bit streams
- sender and receiver bit timing
- half bit timing
- the frame timing, half frame timing and bit error counter.

The free bits in timeslot T0, bits no. 4-8, are available on the appropriate control unit for sending and receiving information. These bits can be used for such purposes as transmitting data and alarms.

Each quarter connector contains the necessary earth connections for all interfaces.

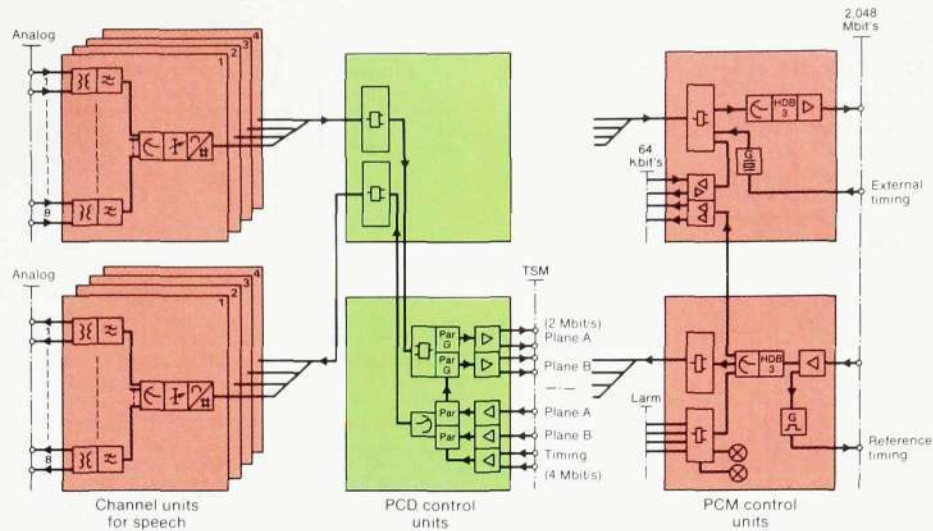
## Alternative equipment

### 64 kbit/s data channels

The PCM channels can be used for data instead of telephony. The data channels are then branched direct into the 2 Mbit/s stream without passing through the encoder. A digital channel is much more efficient for the transmission of digital information than an analog telephony channel. For example, a 64 kbit/s channel can transmit 20 data channels for 2400 bit/s, fig. 14. The multiplexing up to 64 kbit/s is then carried out in a separate equipment.

The equipment has been designed so that it can be adapted to different requirements as regards 64 kbit/s data channels. Each pair of channel units for

**Fig. 15**  
**Alternative equipping of PCM-mux/PCD.**  
 A PCD can be converted to a PCM-mux by changing the control units



by either printed board assemblies for six speech and two data channels or printed board assemblies for eight data channels. With different combinations of these types of printed board assemblies for the four pairs of channel units, the number of data channels can be increased from two to thirty in steps of two. With the system used entirely for data, a further data channel can be obtained by using the signalling timeslot T16 for this purpose, fig. 7.

**Analog/digital converter for AXE 10**  
 The analog/digital converter used in exchange system AXE 10 for connecting analog lines to the digital group selector is designated PCD (Pulse Code Modulation Device). This equipment converts speech signals into digital form in accordance with the same specification as for PCM-mux. The development of the two equipments was coordinated. The same types of magazine, channel units and d.c./d.c. converter are used in both equipments, but different printed board assemblies are used for the control units. The similarities help to simplify handling and the stocking of spares in networks where both PCM-mux and PCD are used, fig. 15.

**Fig. 16**  
**PCM-mux and PCD in a digital network.**  
 The figure shows the coupling between the transmission systems and their connection to AXE 10

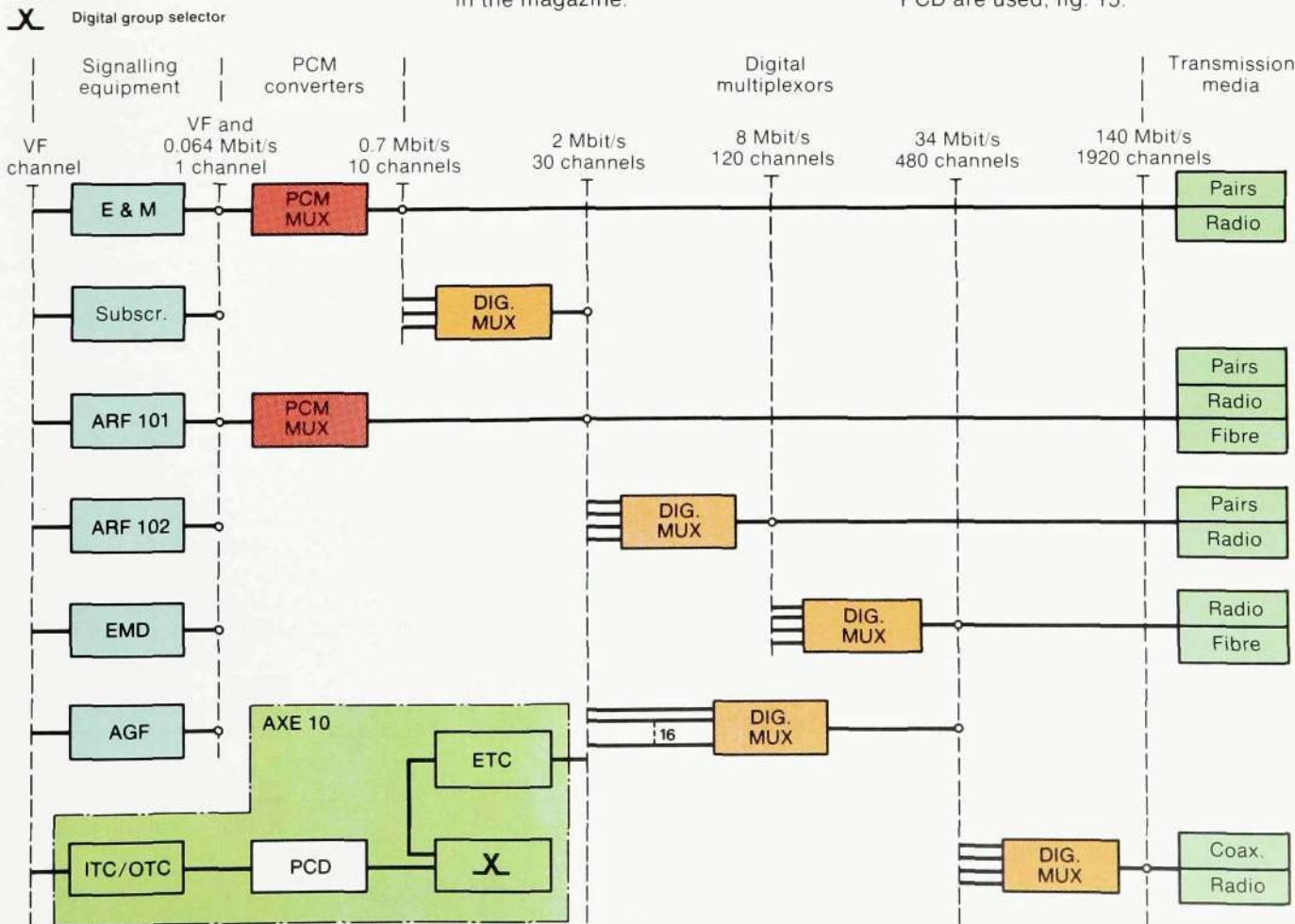
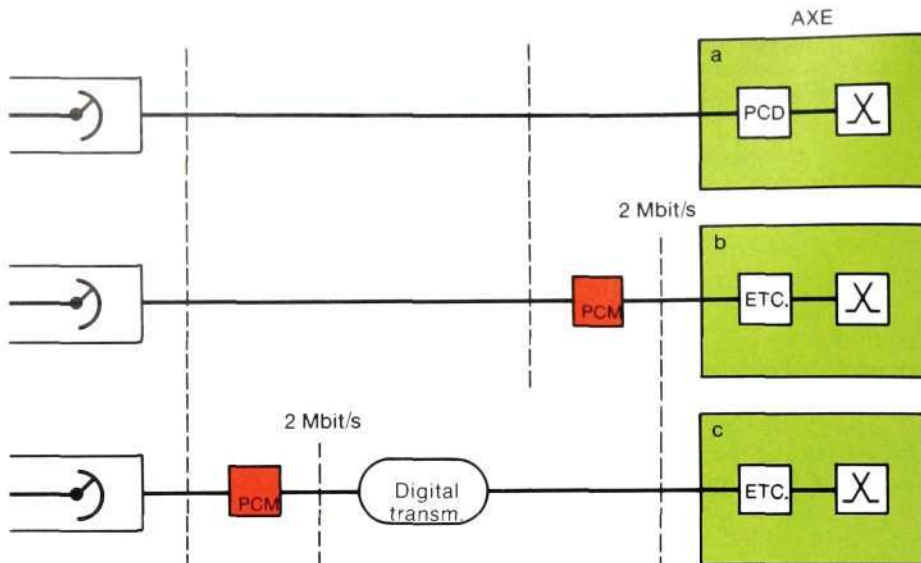


Fig. 17

Connection of analog telephone exchanges to AXE 10. (The signalling equipments are not shown)

- a. Analog transmission and PCM conversion in AXE 10
- b. Analog transmission and PCM conversion in the same exchange as AXE 10
- c. Digital transmission and PCM conversion in the analog exchange



## Connection alternatives

### Signalling equipment

It must be possible to connect the analog side of PCM-mux and PCD to telephone exchanges or lines of different types and with different signalling systems. All signalling matching is carried out in the signalling equipment, which is connected in between PCM-mux or PCD and the exchange or line concerned. The signalling equipment converts the signals from the analog side, for example digit pulses, charging information and seizure information, into digital form. In the case of two-wire connections the conversion to two-wire working is also carried out in the signalling equipment.

The great variety of signalling systems and connection conditions has necessitated extensive work on developing several types of signalling equipments. These equipments are generally placed in magazines of their own in order to provide greater flexibility for any rearranging, fig. 16.

### Connecting analog exchanges to AXE 10

Fig. 17 shows three alternatives for the connection of analog exchanges to AXE 10. Alternative a means that the conversion to the digital group selector in AXE 10 takes place in the signalling equipment and in PCD. This alternative can be chosen if the available cable capacity is sufficient and if the analog lines are to be used for a long time. If, in the future, a digital connection to AXE

10 is wanted, it will be possible to convert PCD to PCM-mux and connect in accordance with alternative b or c.

Alternative b gives digital connection to AXE 10 with signalling equipment and PCM-mux at the exchange AXE 10. Basically this alternative is the same as alternative a, but it requires matching equipment for the digital group selector, ETC (Exchange Terminal Circuit). However, this alternative may be preferable to alternative a if the route is to be replaced by a digital link (e.g. alternative c) in the near future. The ETC equipment is then already installed and the changeover is simplified.

Alternative c is more economical than alternative b if the wire pairs that are saved in the cable between the exchanges are required for other purposes, or if it would otherwise be necessary to lay a new cable. Alternative c can also be justified on the grounds that it gives better transmission characteristics if the attenuation on the analog circuit is high. Otherwise the argument favouring c will be the same as for b, namely that it prepares for future conversion to digital transmission.

### Connection to 10-channel PCM systems

The PCM-mux is also prepared for connection to LM Ericsson's 10-channel PCM system<sup>7</sup> via branching equipment, fig. 18. It is also possible to branch off less than 10 channels in each branching point. Up to seven branching points can

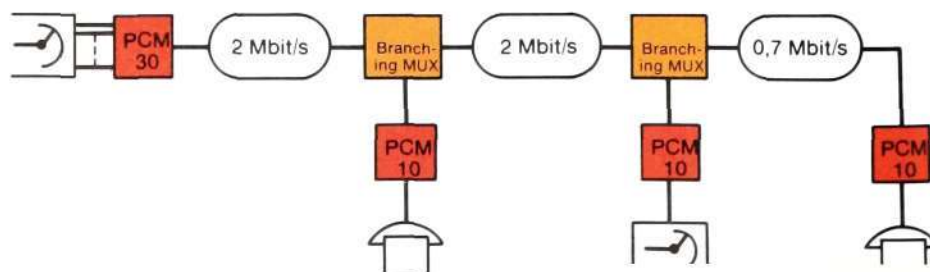


Fig. 18  
Branching from a 30-channel PCM-mux to a 10-channel system. The illustration shows three branching points for a mixture of analog exchanges and subscriber equipment. (The signalling equipment is not shown)

## TECHNICAL DATA

Number of channels	30
Coding	PCM, A-law in accordance with CCITT Rec. G.711
Frame structure	In accordance with CCITT Rec. G.732

### 4-wire analog interface

CCITT Rec. G.712 with the following additions:  
(The given values apply for loop-connected system)

Speech channel bandwidth	200–3400 Hz
Pass band attenuation	
50 Hz	>20 dB
200–300 Hz	0/+4 dB
300–3000 Hz	–0.5/+0.5 dB
3000–3400 Hz	–0.5/+1.8 dB
Group delay distortion	
500–600 Hz	<1.0 ms
600–1000 Hz	<0.5 ms
1000–2600 Hz	<0.17 ms
2600–2800 Hz	<1.0 ms
Absolute delay at about 1400 Hz	<0.45 ms
Nominal impedance input/output	600 ohms, balanced
Nominal levels	
input send level	–16 dB min.
output receive level	+8 dB max.
level adjustment	15.5 dB (in steps of 0.5 dB)
Crosstalk at 0 dBm0	
mean value	–75 dBm0
maximum	–65 dBm0
Idle channel noise	
mean value	–75 dBm0p
maximum	–65 dBm0p
Spurious out-band signals on the receive side	<–28 dBm0
Attenuation of out-of-band signals on the send side	>28 dB
Level stability during the life of the equipment with a maximum of one adjustment	±0.5 dB

### External timing

The internal oscillator can be controlled by external timing or by receiver timing with a frequency of

2048 kHz  
max. ±1.4 V  
75 ohms

### Alarms

In accordance with CCITT Rec. G.732

### 64 kbit/s signalling and data interface

In accordance with CCITT Rec. G.703

### 2.048 Mbit/s digital interface

In accordance with CCITT Rec. G.703

### Power

Consumption from battery (–20 to –72 V d.c.)	14 W
Mains rectifier 45–65 Hz	110, 127 or 220 V a.c. (+10 %/–10 %)

### Dimensions

Magazine (height x width x depth)	244x244x220 mm
Weight (fully equipped)	8 kg

be used. This means that PCM transmission can now be introduced on routes requiring only a small number of channels.

### Connection to higher order systems

30 channels may not be sufficient for high traffic routes. This applies particularly when large digital areas are to be connected together using digital transmission. Multiplexing from 2.048 Mbit/s to higher transmission speeds is carried out in digital multiplexors<sup>8</sup>. Different transmission media are possible, fig. 16. Small digital areas that are situated close to such a large digital route are in a favourable position since they can be connected to the route by means of digital multiplexing equipment. Thus the further digitalization of small areas is intensified. The introduction of digital transmission in the long distance network is an important stage in the conversion of the whole national network to digital working.

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# AXE 10—A Review

Bo Å. Nilsson and Kjell Sörme

*AXE 10 is a telephone exchange system designed to cover the whole range from large international transit exchanges to small local exchanges and remotely connected subscriber stages. The system also comprises exchanges for mobile subscribers, equipment for traffic handled by operators and equipment for centralized operation and maintenance.*

*This article gives a review of AXE 10 and describes how the system can easily be adapted to suit different requirements by combining a number of standardized subsystems. These subsystems have well defined interfaces and can be further developed independently. Two such subsystems are the digital group selector and the digital subscriber stage, by means of which the AXE 10 system is adapted to a network with gradually increasing digitalization.*

UDC 621.395.34

- AXE 10 can be used to build:
- local exchanges
  - local tandem exchanges, separate or combined with local exchanges
  - transit exchanges for national and international traffic, separate or, in the national application, combined with local tandem exchanges and local exchanges
  - exchanges for automatic traffic to and from mobile subscribers, separate or combined with national transit exchanges
  - exchanges for rural areas, small towns and suburbs
  - remote subscriber stages for AXE 10 local exchanges.

Each of the above applications has a uniform set of functions, achieved by standardized subsystems and function blocks. Thus one and the same system covers all application areas, which means that the same methods, aids and procedures can be used throughout the network, for example for operation and maintenance.

AXE 10 has a clear and lucid structure and is easy to operate. Training course packages have been produced to suit different personnel categories and different qualifications. This means that operating staff with experience of conventional systems can learn to operate AXE 10 after a brief training period. The system is equipped with a complete range of built-in aids which relieve the staff of routine tasks. Each AXE 10 exchange can work as an independent unit as regards operation and maintenance, but it is also possible to coordinate and control these functions remotely, from special centres in the network. System AOM 101 has been developed for this purpose<sup>1</sup>.

The group switching subsystem, GSS, the trunk and signalling subsystem, TSS, the traffic routing and control subsystem, TCS, and the operation and maintenance subsystem, OMS, comprise the system nucleus that is necessary for all exchange versions. This nucleus is supplemented by the subscriber switching subsystem, SSS, for local traffic, the common channel signalling subsystem, CCS, for signalling to other stored program controlled exchanges and the operator position subsystem, OPS, for national and international traffic handled by operator, etc. in accordance with the requirements for the individual exchange, figs. 1a–d.

The structure of AXE 10 simplifies the introduction of new facilities and functions. The system can easily be adapted to suit new demands resulting from, for example, the rapid technical development.

Fig. 1a  
Some combinations of subsystems for common AXE 10 applications. GSS varies only as regards size and TCS as regards analysis and routing data. In the other subsystems the functions are selected according to the actual need

- TSS Trunk and signalling subsystem
- GSS Group switching subsystem
- OMS Operation and maintenance subsystem
- TCS Traffic routing and control subsystem (software)
- SSS Subscriber switching subsystem
- SUS Subscriber services subsystem (software)
- CHS Charging subsystem (software)
- OPS Operator position subsystem

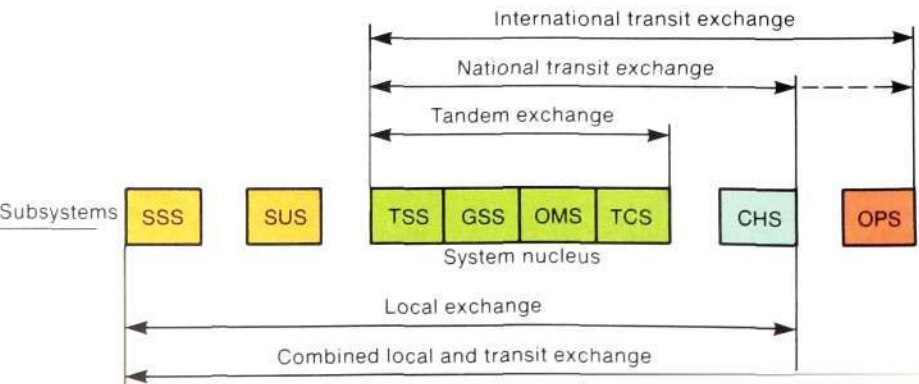
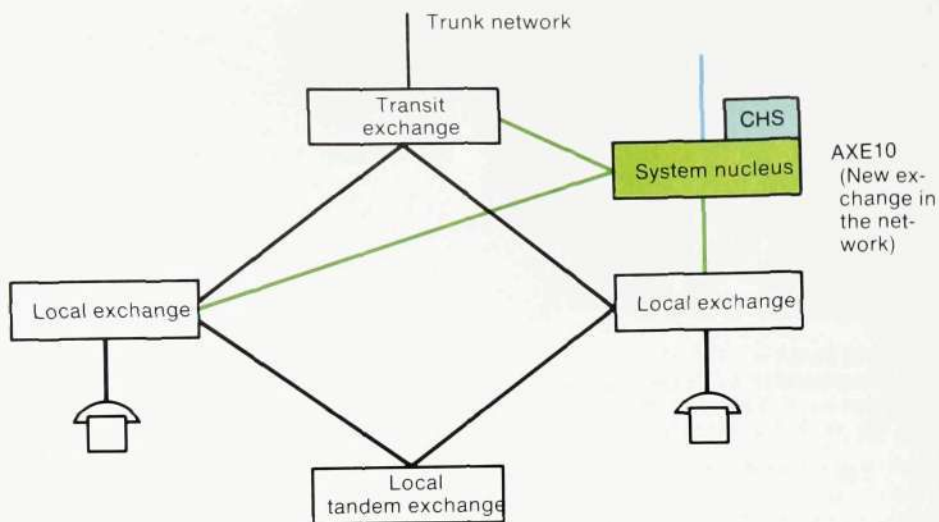




Fig. 1c

If an AXE 10 local tandem exchange is provided with a suitably equipped charging subsystem, CHS, and the traffic routing and control subsystem TCS is supplemented with data for outgoing trunk traffic, the tandem exchange can function as a national transit exchange. This reduces the load on existing transit exchanges in the network.

— Old lines  
— New junction lines  
— New trunk lines



that makes it possible to provide alternative versions with analog or digital group selectors. The differences between the two versions are mainly limited to the group selector subsystem, fig. 2.

New or alternative technical solutions can be introduced in other subsystems in a similar way. For example, the analog subscriber switching subsystem can be replaced by a digital subsystem without any major changes being necessary in the exchange. Fig. 2 shows different versions of an AXE 10 exchange, from a wholly analog to a fully digital exchange.

#### The digital group selector

The AXE 10 digital group selector<sup>2,3</sup> is a great help in the efforts to make the extension and further development of telephone networks economically viable.

The group selector can form part of local exchanges, tandem exchanges, national and international transit exchanges as well as exchanges for mobile subscribers. Remote subscriber stages can also be connected to the group selector.

The digital group selector offers the following advantages:

- PCM time slots can be through-connected without changes, the selector introducing no attenuation
- junction line relay sets and terminal equipments are simple and can be used at any network level. The equipments for switching and transmission can be integrated
- the selector works in the four-wire mode. The transmission properties are improved by the four-wire working being brought further down in the network hierarchy

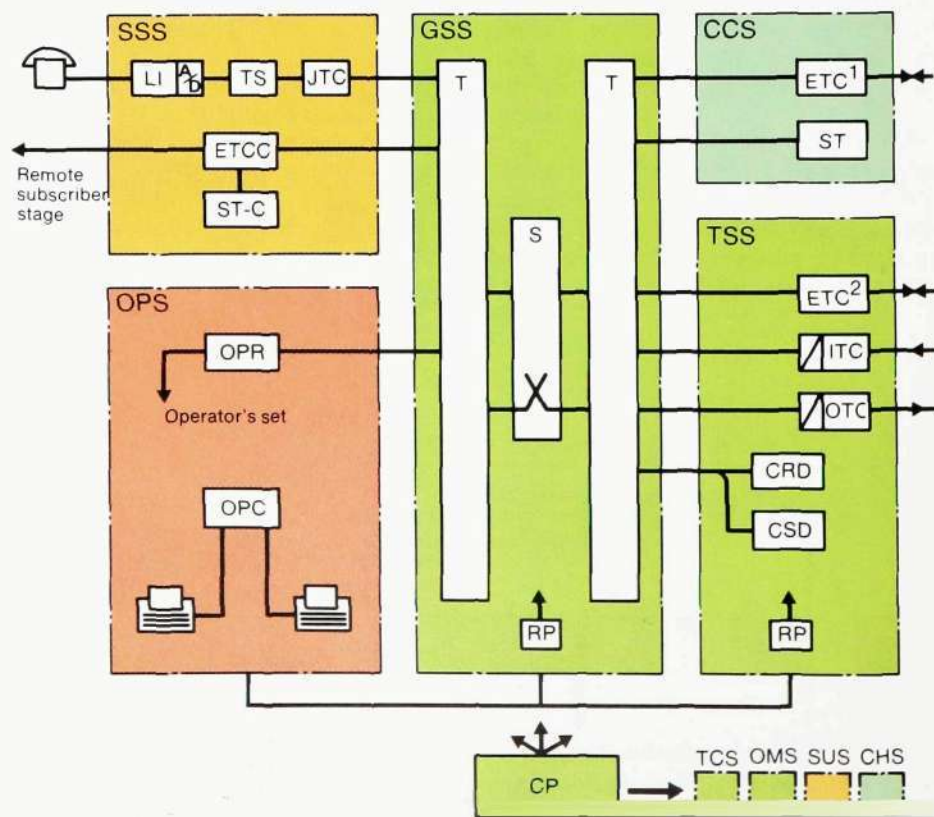


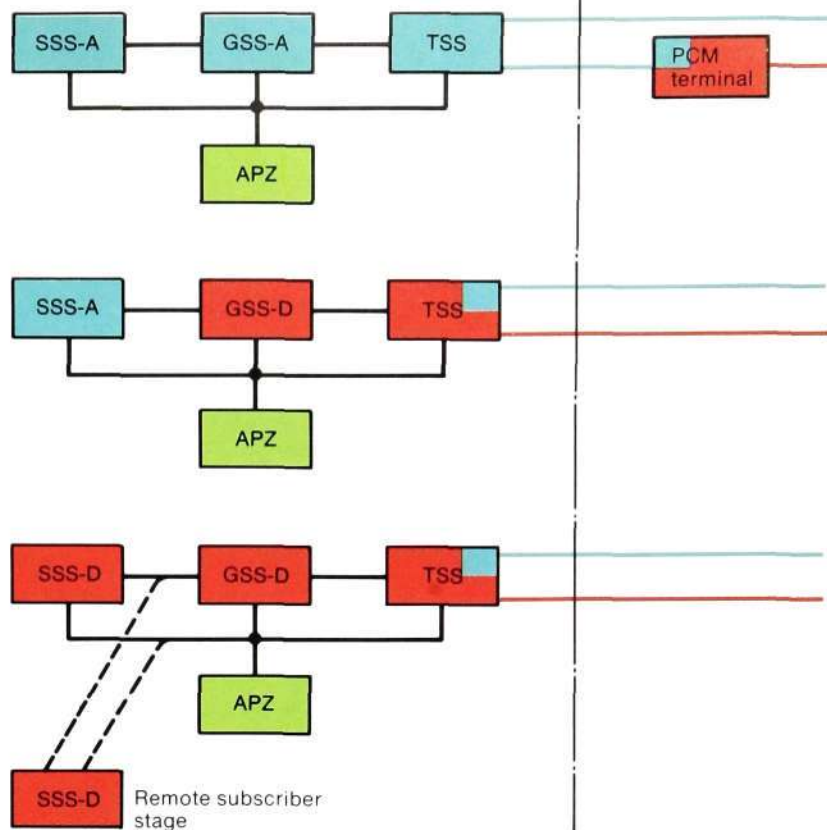
Fig. 1d

A simplified block diagram of an AXE 10 local exchange supplemented with OPS to make a combined exchange with operator service

LI Line interface  
TS Digital subscriber stage selector for 128 lines  
JTC Interface towards GSS  
ETCC Digital circuits to remote subscriber stage  
ST-C Signalling terminal  
ETC<sup>2</sup> Digital, junctions or trunk circuits with channel associated signalling  
OPC Operator position equipment  
OPR Connection of operator's set  
T Time switch module  
S Space switch module  
ETC<sup>1</sup> Digital, junctions or trunk circuits with common channel signalling  
ST Signalling terminal  
ITC Analog incoming junction or trunk circuit  
OTC Analog outgoing junction or trunk circuit  
CRD Code receiver  
CSD Code sender  
CP Central processor  
RP Regional processor

Fig. 2  
Successive changeover from analog to digital  
AXE 10 without any structural changes

GSS-A Analog group selector  
GSS-D Digital group selector  
SSS-A Analog subscriber stage  
SSS-D Digital subscriber stage  
TSS Trunk and signalling subsystem  
APZ Control system  
— Analog line  
— Digital line



- remote units are connected via PCM, which gives good transmission characteristics, good economy and high flexibility in the local network
- switching of a speech connection can be carried out without clicks or interruptions, for example when a connection is set up by an operator
- the internal congestion of the selector is negligible
- the junction lines can be connected arbitrarily. Lines belonging to the same route can be scattered within the group selector.

dition and digital/analog conversion. Intensive work on developing miniaturized circuits for these functions has been in progress for some years.

The AXE 10 digital subscriber stage is offered as an alternative to the analog stage in future deliveries of local exchange systems. It has the following general advantages:

- the amount of space required for the subscriber stage is reduced by almost half when a changeover is made to digital technology
- it makes possible future connection of digital subscriber lines and subscriber line multiples as well as terminals for different types of data services, fig. 3.

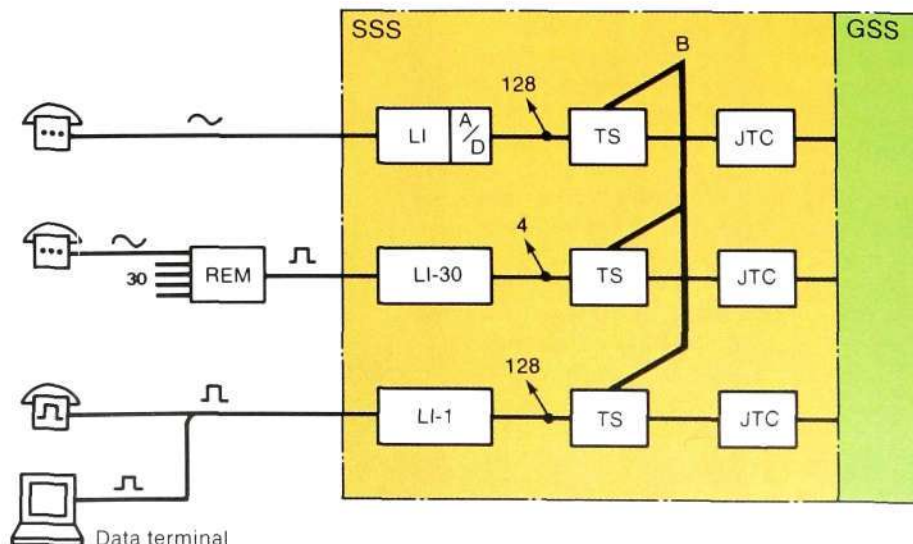
### The digital subscriber stage

A digital subscriber stage used in conjunction with analog telephone sets necessitates the use of individual circuits for each subscriber line for current feeding, ringing, sensing of hook con-

The digital subscriber stage in AXE 10 is built up with modules of 128 lines. 16

Fig. 3  
Some examples of connections to the AXE 10 digital subscriber stage. The figure shows the present and future basic equipment in the subscriber stage

REM Remote Exchange Multiplex—Equipment for connecting 30 analog subscriber lines to a 30-channel PCM system  
LI-A/D Line interface—analogue subscriber line  
LI-30 Line interface—30-channel PCM system  
LI-1 Line interface—digital subscriber line  
TS Time switch  
JTC Interface towards GSS  
B Internal bus  
— Analog transmission  
— Digital transmission



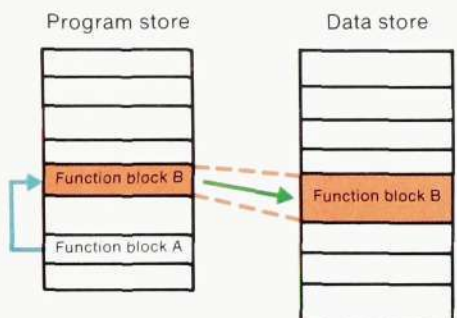


Fig. 4  
The structure of the software

Store area for a function block

Program signal between two function blocks

Access to data store. The function block has direct access only to its own data area

such modules form a fully built out stage of 2048 lines. The subscriber stage is connected to the group selector via a number of PCM links, each with 30 time slots per speech direction. The number of links is determined by the traffic, and the maximum number is 16. Each module of 128 lines is equipped with a time switch which connects the subscriber lines to time slots in the links towards the group selector. Full availability is obtained by means of an internal bus between the time switches.

The subscriber stage is connected to the group selector either direct via 30-channel links or remotely via one or more PCM systems. In the case of a remote subscriber stage the control information from the central processor in the parent exchange is transmitted in the signalling time slot of the PCM system. For this purpose common channel signalling with a transmission speed of 64 kbit/s is used. A pair of signalling links, with one working link and a standby, provide sufficient signalling capacity for a fully built out remote subscriber stage with 2048 subscribers.

The subscribers connected to such a remote stage have access to the same functions and facilities as the other subscribers.

### Software

The programs for AXE 10 are written in the high-level language PLEX<sup>4</sup>. The software is divided into function blocks with

clearly defined interfaces. A function block can contain both software and controlled hardware or only software. Within each function block the instructions are carried out in sequence, with facilities for jumps by means of jump instructions, fig. 4. The processors work with microprograms, which control that the jump possibilities are limited to within the block in question.

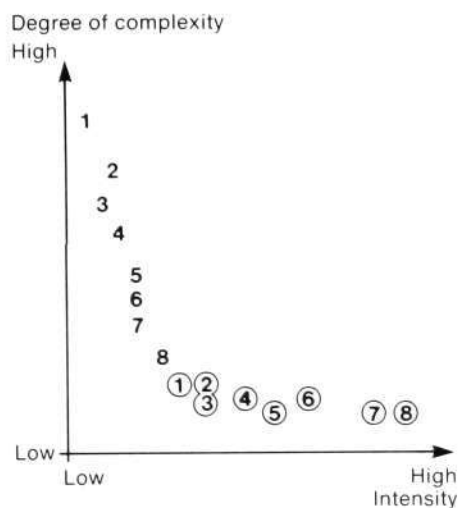
When the program handling for a switching sequence is to continue in another function block, the necessary information is transmitted between the blocks by means of program signals. A program signal contains the address and a number of data words. A supervisory function ensures that only correct signals are sent on.

The addressing of jump instructions and program signals is carried out with the aid of a reference store, where relative addresses are translated into absolute addresses. Program blocks and data blocks can be placed in arbitrary order and in arbitrary places in the stores concerned. When a block is written in or moved, the translation table in the reference store is updated. The possibility of arbitrary placing in the stores simplifies any reallocation that may be necessary in connection with extensions and function changes.

The structural, signalling and addressing principles of the system mean that when new or modified functions are to



Fig. 5  
Digital group selectors



**Fig. 6**  
The distribution of tasks among the central processor, CP, and the regional processors, RP, with regard to the degree of complexity and intensity of the tasks. Some examples:

**Functions implemented in central software:**

- 1 Fault analysis
- 2 Line testing
- 3 Monitoring of network synchronization
- 4 Change of subscriber data
- 5 Tariff analysis
- 6 Route analysis
- 7 Number analysis
- 8 Register signalling analysis

**Functions implemented in regional software:**

- ① Control of terminal equipment
- ② Control of signalling links
- ③ Control of data links
- ④ Sending and receiving register signals
- ⑤ Call supervision
- ⑥ Control of selectors
- ⑦ Sensing and control of subscriber line circuits
- ⑧ Sensing and control of junction line circuits

be introduced the function block concerned can be modified without the other function blocks being affected. In addition they provide good software reliability, since the effects of a software fault are effectively limited and fault localization is easy.

All signals between the various function blocks can be traced. The meaning of the signals and the signalling processes for different switching procedures are documented. If a functional fault occurs, the maintenance staff can pinpoint the faulty unit by studying the signalling sequence, without having to have detailed knowledge of the software.

### Control system

The control system in AXE 10 consists of the central processor and a number of regional processors. Fig. 6 shows the distribution of tasks among the various processors. The regional processors are placed together with the equipment that is to be controlled. The control and sensing functions carried out by the regional processors are usually simple, but require large computer capacity. When an exchange is extended, regional processors are added according to need. This way of distributing computer capacity gives good economy over a large range of exchange sizes. The central processor handles the more complicated functions and interworks with the regional processors via a bus system.

The control system is designed bearing in mind PLEX, the AXE 10 high-level language. There is good conformity between the PLEX phrases and the machine instructions. The control system is also adapted to the strict division of the software into modules and the formalized interworking between the modules. All these factors contribute to give system AXE 10 its good handling properties and high software reliability.

The control processor is duplicated and the two processor parts work in synchronism, one actively and the other in the standby mode ready to take over instantly if a fault occurs in the active part. There is continuous comparison of the results from the two processor parts, which makes it possible to detect faults immediately. A hardware fault in the active processor will not interfere with the

traffic handling, because the standby part will take over the control without any interruption of the work. The faulty processor part then changes over to automatic fault finding.

### AXE 10 in the network

Studies of the network structure and network economy when using PCM systems, digital group selectors and remote subscriber stages have been published previously<sup>3</sup>.

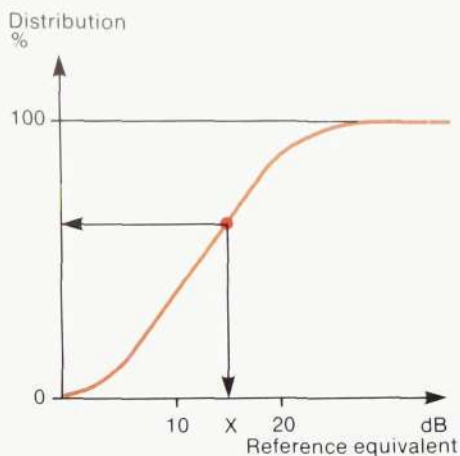
Digital transmission systems, PCM systems, make it possible to increase the number of circuits on existing cables and in existing ducts. Expensive digging operations can be avoided or postponed. Consequently for the distances that are common in urban and rural networks, namely 5–50 km, the investment costs of PCM are often lower than the corresponding costs of physical or carrier circuits.

If the interconnection of the transmission links is also made digital, by means of digital group selectors, the expense of modulation equipment in the connection point is avoided. This increases the economical distance range for PCM to 0–100 km.

The use of remote subscriber stages, connected to AXE 10 via PCM systems and placed between the primary and secondary networks, greatly reduces the need of cable in the primary network. The extra costs caused by the remote placing are small compared with the reduction in cable cost. Remote subscriber stages can also be used to extend old exchanges in urban networks and to replace parts of old exchanges which have to be dismantled.

The advantages of digital technology that have been discussed here apply not only for AXE 10 but also for other digital systems with similar facilities. The unique feature of AXE 10 is that the same system is used throughout the network and for all sizes of exchange.

Figs. 1a–d illustrate how AXE 10 is built up of a system nucleus to which different subsystems are added for different applications. There are only small differences between different types of



**Fig. 7a**  
Definition of the distribution of the reference equivalent.

● The percentage of calls having a reference equivalent  $\geq x$  dB

The reference equivalent is a subjective measure of the quality of a connection set up between two subscribers. It defines the sound level of the speech expressed in decibels (dB) relative to an international standard (NOSFER) set by CCITT in Geneva. The reference equivalent is affected by all attenuation and amplification on the connection and by the electrical and acoustic characteristics of the microphone and the receiver. It should be neither too high (= too low sound level in the called subscriber's receiver) nor too low (= too high sound level). The optimum value is about 10 dB.

The distribution of the reference equivalent for the calls set up during the busy hour gives a picture of the transmission quality of the network. The distribution takes into account the type of traffic and the traffic intensity, i.e. common types of connections have greater effect than rare types

exchanges and it has therefore proved useful to combine equipment for different applications in one and the same exchange. In the long run the number of different levels in the network hierarchy can be reduced in this way. The following examples illustrate the principle.

A local tandem exchange will have the same transmission properties as a transit exchange when the four-wire digital group selector is used in both exchanges. If certain function blocks in the charging subsystem, CHS, are added to the tandem exchange and its traffic routing and control subsystem, TCS, is supplemented by routing data for outgoing trunk traffic, the tandem exchange can work as a national transit exchange, fig. 1c. In this way the load on older transit exchanges in the network can be reduced.

A transit exchange can be supple-

mented with subscriber stages and subscriber services (subsystems SSS and SUS) and then becomes a primary centre with a combined local and transit function, fig. 1b. This is an economically attractive alternative for small towns and rural areas.

In order to further illustrate the possibilities of system AXE 10, some points regarding transmission, synchronization, signalling and charging are summarized below.

### Transmission

Telephone networks normally have four-wire long-distance connections and four-wire transit exchanges. The changeover from four-wire to two-wire working takes place on the lines to the local exchanges, either in the transit or the local exchange. When four-wire digital group selectors are introduced in the local exchange, the four-wire work-

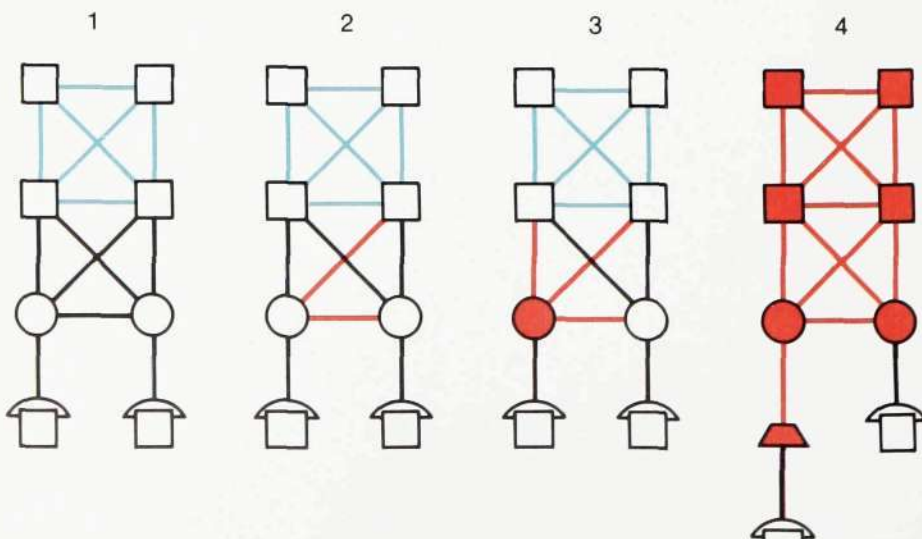
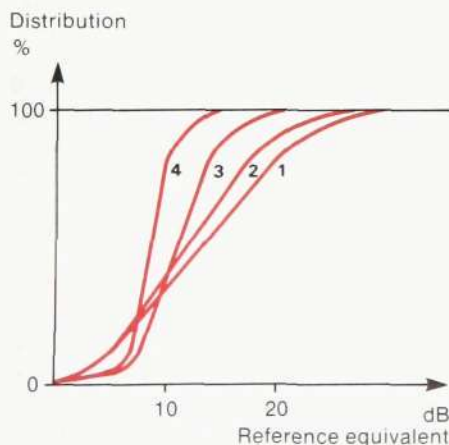
Diagram 7b shows the distribution of the reference equivalent for four different types of network shown in fig. 7c:

1. Analog network, four-wire transit exchanges, four-wire trunk lines, two-wire local exchanges, two-wire lines between the local exchanges and between local and transit exchanges.
2. As in 1), but with an occasional PCM line instead of long two-wire lines.
3. As in 2), but with digital local exchanges always connected to the other exchanges by means of PCM.
4. Digital network, remote subscriber stages, only the subscriber lines remain analog and two-wire.

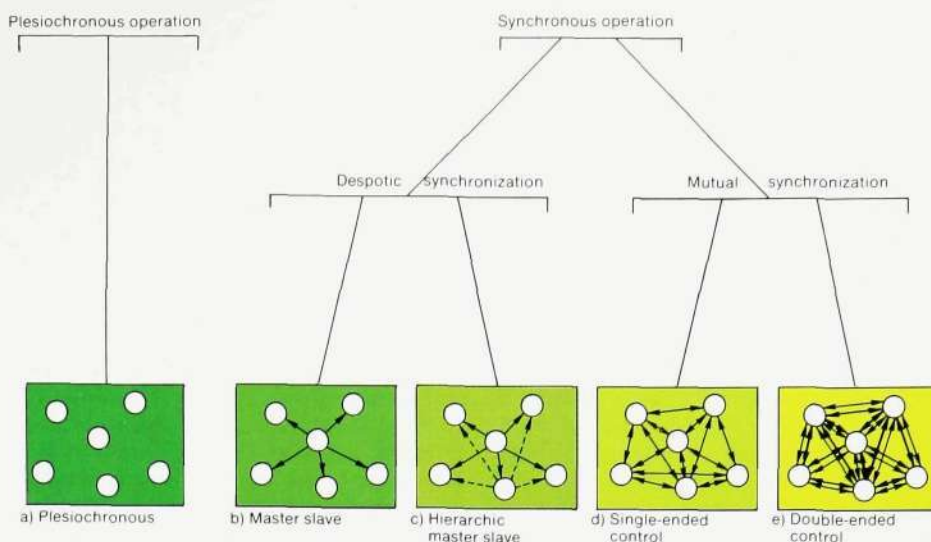
- Analog two-wire local exchange
- Analog four-wire transit exchange
- Digital local exchange
- Digital transit exchange
- ▲ Remote subscriber stage
- Analog four-wire trunk circuit
- Analog two-wire junction and subscriber line
- Digital circuits

**Fig. 7c**  
Four different types of network

**Fig. 7b**  
The distribution of the reference equivalent for four different types of network



**Fig. 8a**  
The most important network synchronization methods. Plesiochronous operation uses independently oscillating clocks with a high degree of accuracy. Automatic frequency control is used for the synchronous operation



ing can be extended so that only the subscriber lines remain two-wire. This result can be achieved early in parts of the network if digital exchanges and PCM systems are introduced at the same time, figs. 7a–c.

One advantage of the extended four-wire working is that different calls in the network will have similar attenuation, measured between the subscriber line inputs. Any differences in attenuation are caused by the fact that analog four-wire lines have a certain, low attenuation. Circuits containing only digital links, which are interconnected with digital equipment, will not give different attenuation for different calls.

The differences in attenuation that re-

main for different calls are mainly caused by the attenuation in the primary and secondary networks. The differences can be reduced by connecting remote groups of subscribers via remotely placed subscriber stages. The primary networks between the parent exchanges and the remote stages then consist of a number of PCM links without any attenuation.

If two-wire junction lines have to be connected to digital exchanges with four-wire through-connection, it is advisable to check the distribution of attenuation in the network and take the opportunity to balance the two-wire lines well. Stringent demands determine the permissible attenuation and delay/frequency distortion of each four-wire loop. The margin for singing caused by oscillation must be adequate, the contribution of the loop to echoes must be low and the attenuation distortion must also be kept within certain, narrow limits. In addition the permissible number of four-wire loops in the whole circuit is limited.

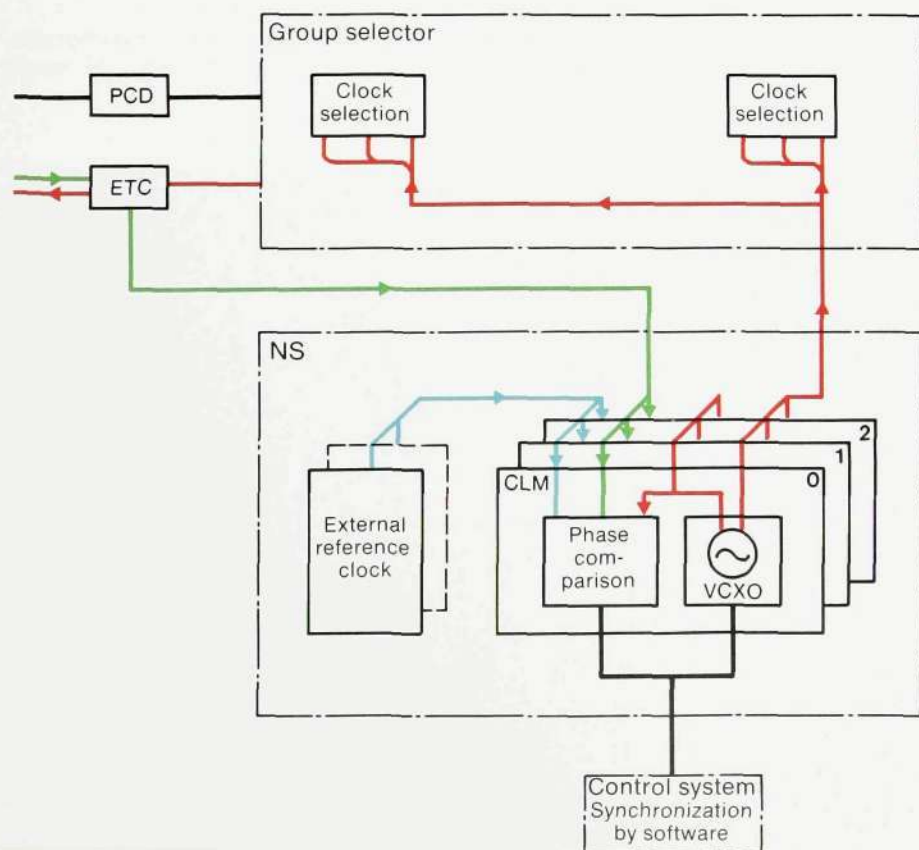
### Synchronization

Synchronism in a digital network means that all links in the network have the same bit rate. If the incoming rate on a circuit through the station is higher than the outgoing rate for the same speech direction there will not be time to send on all 8-bit words. A word will be lost at regular intervals and there is then a slip in the connection. The slip rate is dependent on the difference in speed between the two connected links.

The bit timing in AXE 10 is provided by a clock system, which for reasons of safety contains three clocks that work in parallel. The clock systems can be controlled in different ways by means of regulating circuits, depending on the synchronization plan used for the system<sup>2,3</sup>. The simplest way is the master-slave method, which means that one of the exchanges, for example a transit ex-

**Fig. 8b**  
Synchronization in AXE 10

- NS Function block for network synchronization
- PCD PCM terminal device, for analog lines
- ETC Exchange terminal circuit, for digital lines
- CLM Clock module
- VCXO Voltage controlled crystal oscillator
- Clock control, internally and over outgoing digital lines
- Plesiochronous and master synchronization
- Slave and mutual synchronization



change, provides the timing for the other exchanges through the bit flows to these exchanges. Other methods give different types of mutual synchronization. Control information is then transmitted between the clocks in the network so that they affect each other. Finally there is plesiochronous operation, which means that the exchanges work independently of each other, but with such a high degree of accuracy, for example  $10^{-11}$ , that slip occurs very seldom. Fig. 8a shows different synchronization methods and fig. 8b how they are implemented in AXE 10.

### Signalling

A new telephone exchange must be able to interwork smoothly with the existing exchanges in the surrounding network. AXE 10 is designed to suit all types of markets and meet the signalling conditions of the different networks, which can vary greatly from case to case. LM Ericsson systems are operating in networks all round the world, satisfying very different national requirements, and the experience thus gained has been drawn upon in the designing of AXE 10. The influence exerted by different signalling characteristics has been confined to a limited number of function blocks, assembled in a separate subsystem, TSS.

Common channel signalling is an alternative for stored program controlled exchanges. This type of signalling offers many advantages for both local and trunk networks. The signalling between two exchanges takes place over a data link, which is used jointly by many speech channels. There are two different methods, associated signalling and non-associated signalling, fig. 10. Associated signalling is used for routes with many lines, which can carry the cost of their own signalling links. Non-associated signalling is used for small routes, which jointly use signalling links via a signal transfer point, STP, which is placed centrally in the network.

Common channel signalling can be used in both analog and digital networks, but it is particularly attractive in digital networks, since

- the signalling takes place in PCM time slots, at a transmission speed of 64 kbit/s
- no special modem equipment is needed
- the high bit speed enables a large number of speech channels to use the same signalling link
- large amounts of signalling information can be transmitted for each speech channel.

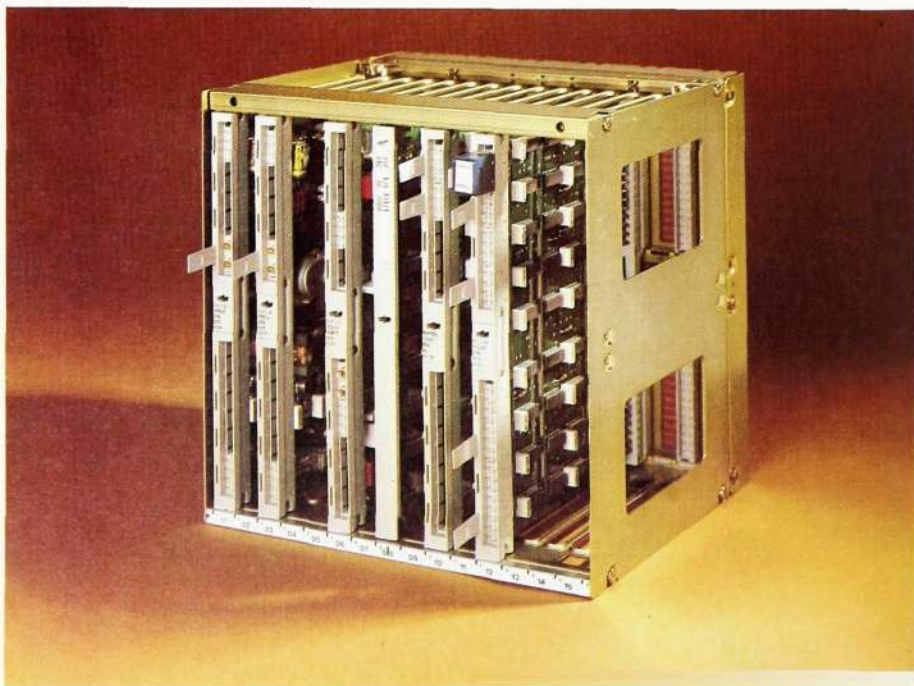


Fig. 9  
Magazine for ETC (Exchange Terminal Circuit)

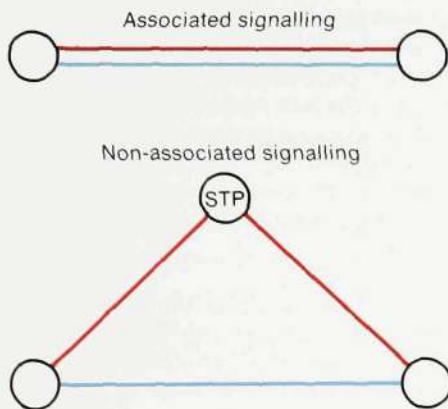


Fig. 10  
The methods for common channel signalling

— Signalling link  
— Speech path  
○ STP

Common channel signalling can of course be used for AXE 10. The system is primarily adapted to CCITT signalling system no. 7, for which a subsystem has been developed, designated CCS. The subsystem has all the functions that are required for sending and receiving over the signalling links, for example procedures for error supervision and requesting a repeat transmission if a fault occurs. If there is a break on a signalling link it will be detected by CCS and the traffic will be switched to a standby link. The signalling links can be reallocated on a routine basis, either locally from the terminal equipment in an exchange or centrally from an operation and maintenance centre.

### Charging

The charging subsystem, CHS, in AXE 10 is provided with full traffic analysis facilities. It can be used in all types of exchanges. For example, the choice of tariff for any outgoing call can be made in the local exchange. Alternatively the choice of tariff can take place in a superior transit exchange in the same way as in LM Ericsson's crossbar systems. The charging information is then transmitted to the local exchange by means of metering pulses, or is recorded centrally in the transit exchange, toll ticketing.

With pulse metering the pulses step the subscriber's counter in the data store. For reasons of security the contents of

the data store are copied regularly on to a cassette tape. With toll ticketing the A-number, B-number, date, time and duration of the call are recorded. The data are regularly output on to a magnetic tape or a cassette tape. The tape with the charging data is then transported to the administrative centre of the network for processing. Alternatively the charging data can be transmitted from the AXE 10 exchanges to the administrative centre over data links. The transmission is then remotely controlled from an operation and maintenance centre.

### Operation and maintenance

The operation and maintenance of telephone networks with AXE 10 exchanges has been described in detail in previous articles<sup>1,5</sup>.

The operation and maintenance of AXE 10 is simple. It is only in exceptional cases that staff with comprehensive knowledge of the system have to intervene. The basic concept is that the available, ordinary staff who are trained in the maintenance of crossbar systems, and who undergo a supplementary course in AXE 10, should be able to carry out the normal operation and maintenance of AXE 10 with the operational manual as the main aid.

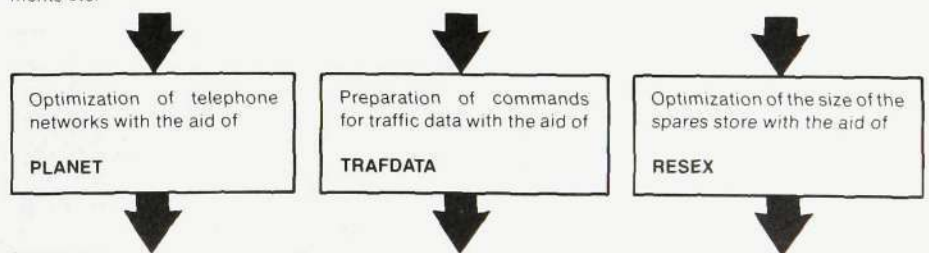
The quality of service is checked by means of supervision of all connections through the exchange. This provides

### Input data

Traffic from subscribers, traffic matrices, blocking and transmission conditions, traffic routing principles, the cost of exchanges, network and transmission equipments etc.

Linking the exchange to the network by specifying the name and destination of connected routes, the number of devices etc.

Fault rate and permissible shortage risk per unit. Total number of units of each type and the replacement time.



### Output data

Optimum number and position of exchanges and size of exchange areas, optimum cable types, cost accounting, number of subscribers in each exchange, detailed route and routing descriptions etc.

Cassette with commands ready for input in the exchange and check printouts.

The required number of replacement units of each of the 150-200 types that can occur.

Fig. 11  
Some ADP aids for administering networks and exchanges. These aids simplify the work and raise the quality

more complete information than the routine generation of test connections. It also provides information concerning subscriber behaviour. The equipment and software for routine testing have been reduced to a minimum. Thus the personnel are not burdened with routine tests and the subsequent analysis work.

The strict division of the system into function blocks with standardized signalling interfaces means that new functional blocks can be introduced and function blocks can be replaced without the other blocks being affected. Consequently functional changes can be carried out during operation without disturbing the traffic in progress.

The operation and maintenance subsystem OMS in AXE 10 is equipped with a wide range of functions and procedures for supervision, fault locating and clearing, collecting statistics and administration. In these respects the system is designed to work independently in the network and to be operated by the operation and maintenance staff in the exchange. AXE 10 also contains comprehensive functions for remote control of these activities.

LM Ericsson's operation and maintenance system AOM 101 is used for such remote control. It provides many facilities for organizing the activities of a number of centres specializing in different types of work, such as maintenance of subscriber lines, sales, traffic observation etc. These centres can be situated in different places to suit the activity in question.

### Auxiliary systems for AXE 10

A number of auxiliary systems have been developed for AXE 10. These make it easier for administrations to administer the networks and exchanges<sup>6</sup>. By means of these auxiliary systems, fig. 11, it is possible to

- optimize different types of telephone networks
- prepare floor plans, cabling information and other documentation for AXE 10 exchanges
- prepare commands in order to equip the exchanges with traffic data for the initial start and major operational changes

- provide operational support in cases of complicated faults, in the planning and introduction of new or modified functions and also in the administration of fault reports received from the network
- simplify the stocking of spares by optimizing the position and size of the stores.

Some other aids that should also be mentioned are training packages for AXE 10 and documentation for exchanges and work centres.

### Conclusion

The basic aim when developing system AXE 10 was to create a uniform and flexible system that was easy to operate and which remained up to date. As can be seen from this article this aim has been achieved, thanks partly to the clear and regular structure of the system.

The basic development work on AXE 10 has now been completed and the system has been adapted to suit several different markets. However, research and development work is proceeding in step with technical advances, so that new developments in the fields of components, processor technique, network structure and subscriber services can be utilized.

System AXE 10 has now been introduced or is being introduced in more than 20 countries.

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# Operation and Maintenance Functions in ASB 100 and ASB 900

Rolf Mörlinger

ASB 100 and ASB 900 are modern, stored program controlled PABXs for 20–108 and 60–960 extensions respectively. The stored program control, SPC, is utilized to provide the systems with advanced functions, not only for telephony but also for operation and maintenance. The basic principles are the same for the two systems, but certain functions that require large program volume are provided only in ASB 900.

This article gives a detailed description of the operation and maintenance functions in ASB 900, with comments on the features of ASB 100. General descriptions of ASB 100<sup>1</sup> and ASB 900<sup>2</sup> have previously been published in *Ericsson Review*.

Fig. 1 shows the block diagram for ASB 900, which, with a few exceptions, is the same as the diagram for ASB 100. The maximum number of devices is of course considerably higher for ASB 900 than for ASB 100. Moreover ASB 900 can be equipped with MFC receivers for direct in-dialling.

The memory technologies are different in the two systems. ASB 900 has random access memories for both programs and data. A cassette recorder is built into the exchange and provides memory back-up. ASB 100 has programmable read only memories for the programs and battery-protected random access memories for the data.

Both systems are normally equipped with a single control system, but when a very high degree of reliability is required, the control system, can be duplicated in ASB 900, using the active/passive method.

UDC 621.395.2

The PABXs ASB 100 and ASB 900 belong to the same system family. They are both built up using the cabinet construction practice BYB 201, are controlled by identical miniprocessors, an APN 163, and have identical operators' sets. There are also great similarities as regards the component ranges, circuit designs, programming methods and facilities.

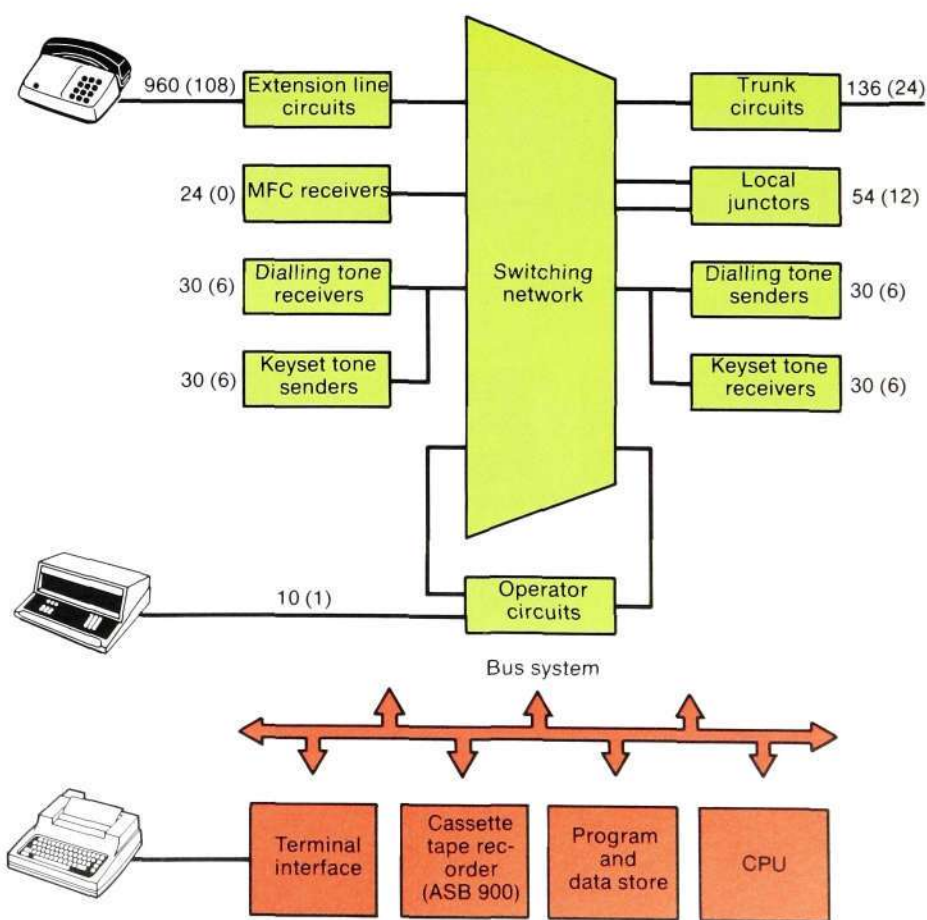


Fig. 1  
Block diagram of ASB 900 and ASB 100, giving the maximum number of devices of each type. Differences in brackets apply for ASB 100



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## Man-machine communication

Efficient man-machine communication is a prerequisite for rational execution of most operation and maintenance functions in an SPC exchange.

All communication between the operation and maintenance staff and the ASB systems takes place via standard type I/O terminals. Portable typewriter terminals are normally used. The man-machine language is based on English and is a subset of the CCITT MML (Man-Machine Language). The language consists of commands, acknowledgements and edited printouts.

Both systems have commands for

- the handling of exchange data
- fault localization
- the verification of repairs
- traffic recording.

In addition ASB 900 has commands for minor program changes.

A command consists of two parts, a command code and a parameter, see fig. 2. The command codes consists of five-letter mnemonics.

Each command in ASB 900 can be allocated to any one of six possible authorization classes, and each such class can be given an arbitrary pass word of up to 6 characters. Different personnel

categories can thus be given access to different parts of the total quantity of commands.

The standardized I/O interface of the ASB systems makes it possible to connect up to remote terminals via modem circuits. The most economical method, shown in fig. 3, is then to use switched connections. In this way changes in the exchange data, fault finding and traffic recording can be carried out from a distance, and operation and maintenance centres can be set up, each of which serves a large number of PAXBs.

As a matter of curiosity it may be mentioned that when the first ASB 100 exchange was installed in Belgium (1978), a fault in the exchange could be localized and the exchange data programmed from Stockholm, Sweden.

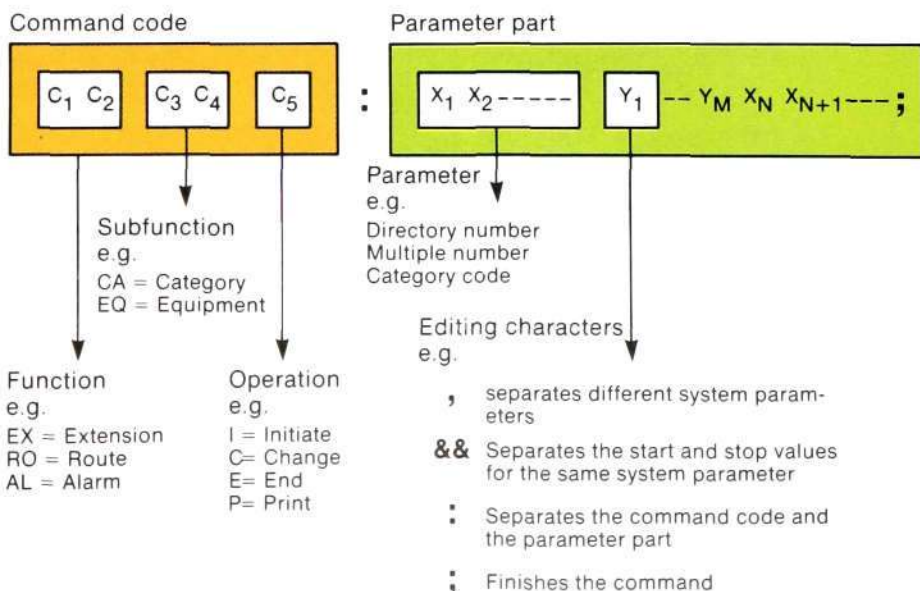
## Loading programs and data

The ASB 900 software is loaded into the exchange store from the built-in cassette tape recorder. The program tape does not contain any information regarding the store addresses of the various program units, only their numbers. The reason for this is that the system has automatic functions for store allocation, which makes it possible to load the various program units in any order, and in one or several batches.

The exchange data are loaded by means of commands from an I/O terminal, either on the spot or prepared in advance in order to reduce the amount of work needed on site. In the latter case either the PABX itself or a separate ASB 900 control system is used to prepare a loading tape, which contains both programs and data. It then takes only three to four minutes on site to load the system from such a tape.

In ASB 100 the programs are stored in permanent memories of the PROM type, and only the exchange data need be loaded on site. In the case of a mains failure the exchange data are preserved for up to 100 hours with the aid of batteries mounted on the memory boards. As an alternative the exchange data can therefore be programmed elsewhere if the transport to the installation site is

Fig. 2  
The structure of commands



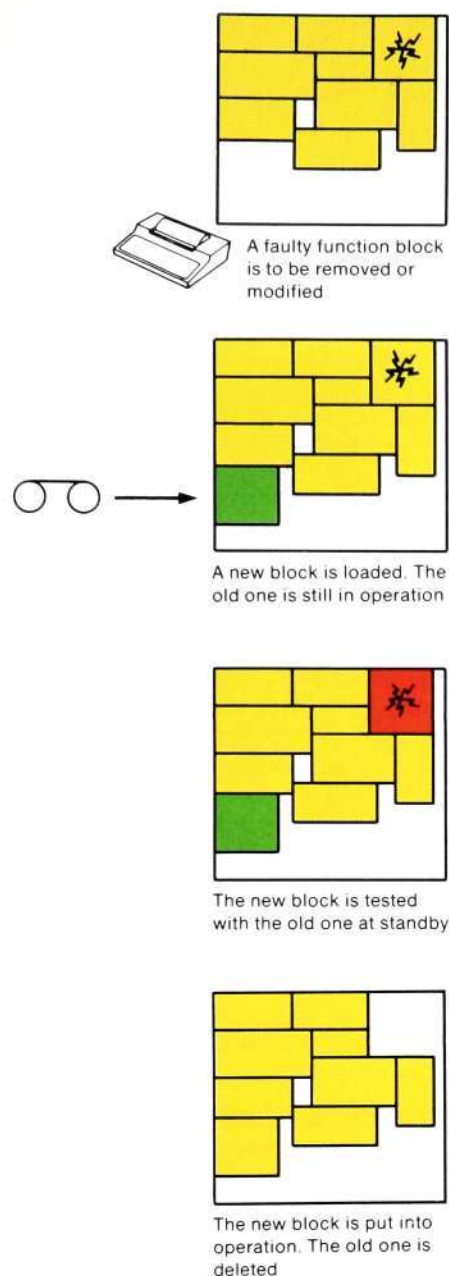


Fig. 4  
The software for ASB 900 can be modified or extended without disturbing the operation of the exchange

## Modifying and supplementing the software

A modified or new program unit can be loaded in ASB 900 without the other program units having to be reloaded. As can be seen from fig. 4, it is also possible to test the modified or new function on site before it is put into operation. This is done by marking the program unit in such a way that it is only accessible to test traffic. Small program changes can also be carried out from an I/O terminal by means of commands, so-called patching.

Up-to-date information regarding the state of the PABX software is useful after any change in the programs. Printout of the article number and revision code of all program units included in an ASB 900 is initiated with a command.

## Handling of exchange data from and I/O terminal

As has already been mentioned, commands are provided that make it very easy to handle data concerning, for example:

- extensions
- number analysis
- routes
- abbreviated dialling
- group hunting.

As far as possible, the commands used are identical for the two systems. A few commands for extension data are described below in order to illustrate the simplicity of handling.

If, for example, a new extension with the directory number 1234 and the category code 32010203 is to be connected to

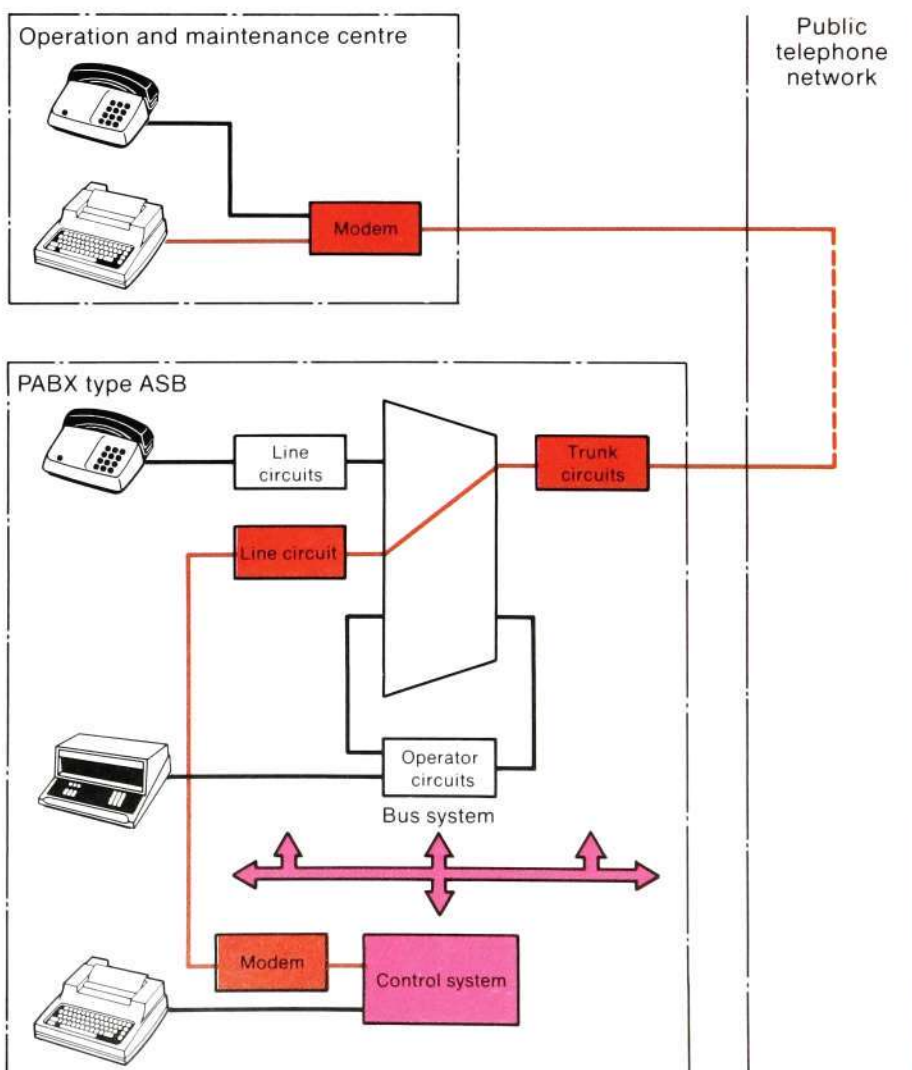


Fig. 3  
Centralized operation and maintenance. The handling of exchange data, fault localization and traffic recording for ASB 900 and ASB 100 can be carried out from an operation and maintenance centre



Fig. 5  
I/O terminals are used in the ASB systems, for example for programming the exchange data. The terminal in the picture is portable and weighs only 5 kg

multiple position 0001, the following command is given:

```
EXTEI:1234,0001,32010203;
```

The command code means EXTension Initiate.

When data are first loaded into a new PABX, series of extensions with consecutive directory numbers and common category codes are often connected to consecutive multiple positions. The command above can then be used in a more powerful way:

```
EXTEI:1241&&1244,0002,32000103;
```

This command means that four extensions with the directory numbers 1241 up to and including 1244 and the category code 32000103 are connected to the multiple positions 0002 to 0005. This command can very well be used even if any of the extensions has a different category code, since this can easily be corrected afterwards with the command:

```
EXCAC:1242,36000103;
```

The command code means EXtension CAteory Change, and changes the category code of extension 1242 to 36000103.

If a printout of the data for the extensions connected to multiple positions 0001–0005 is desired, the following command is given:

```
EXEDP:0001&&0005;
```

The command means EXtension Equipment Data Print and the system gives the following printout:

EXTENSION DATA

EQ NO	DIR NO	CATEGORY
0001	1234	32010203
0002	1241	32000103
0003	1242	36000103
0004	1243	32000103
0005	1244	32000103
END		

There are also commands for

- moving an extension to a new multiple position

- printout of extension data in directory number order
- printout of free directory numbers and multiple positions
- erasing extension data.

The systems automatically control that the data that are being input are not contradicted by the data already in the store. For example, it is impossible to allocate the same directory number to two different multiple positions, or to give an extension a directory number that falls outside the extension number series that is defined in the number analysis data.

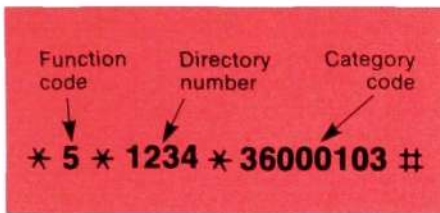
The data that describe the actual hardware equipment need not be programmed into the ASB systems. These data are input by automatic detection of the equipment and can also be output on command. This feature saves time both when taking the PABXs into service and when extending them.

Handling of exchange data from the operator's set

The ASB systems offer a number of sophisticated telephone functions. In order to be able to use them rationally it must be possible to change the corresponding exchange data easily and efficiently. It would not be rational to have operating staff visiting the PABX for this purpose. The systems are therefore designed so that the PABX operators are able to carry out the most common data changes from their sets. One or two-digit function codes are then used instead of command codes, fig. 6. In this way data for the following functions can be programmed:

- number group
- allocation of category to extensions
- common and individual abbreviated dialling
- trunk call discrimination
- group hunting
- call diversion
- night service connection.

However, the operation staff can, by means of a command from an I/O terminal, limit the facilities of the telephone operators to an optional part of the above-mentioned functions.



**Fig. 6**  
The operators can carry out the most common types of data changes from their sets. The illustration shows the changing of extension category

tion of frequent data changes in ASB 900, facilities have been provided for carrying out the programming of individual abbreviated dialling and the follow-me function from extensions with push-button dialling.

## Supervision

ASB 900 is equipped with a large number of automatic supervisory functions.

The control system is supervised in the following ways:

- time supervision of the program execution. This function, which is realized in hardware, detects if the program execution gets into a loop state or stops completely
- error rate supervision (parity faults, improbable program and hardware signals etc.)
- periodic, automatic function testing of:
  - processor
  - program and data store
  - cassette tape recorder
  - bus system
  - circuits for automatic changeover between the control systems.

In PABXs with a duplicated control system the above-mentioned supervisory functions are carried out by both the active and the passive control system in order to ensure, as far as possible, that the passive system is in full working order in case it becomes necessary to change over.

The switching system is supervised in the following ways:

- periodic, automatic function testing of
  - tone and ringing generators
  - senders and receivers for the dialling tone
  - senders and receivers for the key-sending tones
- error rate supervision per
  - trunk circuit
  - local junctor
  - link in the B stage of the switch
  - MFC receiver for direct in-dialling traffic.

The error rate supervision is carried out with the aid of data from the actual traffic. Each device that is being supervised is allocated a counter in the data store.

The counter is stepped down towards zero once for each seizure and stepped up an adjustable number of steps for each disturbance. By disturbance is meant, for example, time releases and very short holding times. The behaviour of the extensions will of course sometimes cause the counter to show greater quantities than the ideal value of zero, but the probability is very large that it is only real faults that will cause the counter to reach the alarm limit, which is set to 255.

Fuses and battery equipment are also supervised in ASB 900.

For obvious reasons the mean time between faults will be longer in ASB 100 than in the considerably larger ASB 900, and if a fault occurs it is usually soon discovered by the users. The automatic supervision in ASB 100 has therefore been limited to:

- time supervision of the program execution
- error rate supervision of the control system
- supervision of the battery charging equipment.

## Automatic action when a fault is detected

The standard action when a fault is detected is that the system gives an alarm in the way described in the next section.

If the fault concerns the control system an attempt at restart is made automatically. In ASB 900 this includes the re-loading of programs and data from the cassette tape recorder. In PABXs with a duplicated control system automatic changeover to the standby system will also take place.

If a fault is detected during the supervision of individual devices in ASB 900, the faulty device is marked as the last choice. This is done in order to limit the effect of the faulty device on the traffic.

## Alarm functions

Each of the supervisory functions in ASB 900 has been allocated an alarm code in the system. Thus the error rate supervision of trunk circuits has one code, the same function for local jun-

tors has another code etc. Each such alarm code can then be assigned to any one of three fault alarm classes, which can have the following significance:

- Class 1: Immediate action
- Class 2: Immediate action during day-time
- Class 3: Action at a suitable time

When a fault is detected the alarm class, alarm code and identity of the faulty unit are stored in an alarm table in the exchange data store. The alarm is indicated by means of a lamp on the operators' sets, but it can also be indicated on a separate alarm panel, which contains one lamp per alarm class.

The operator can order the system to indicate alarm class and alarm code when the alarm lamp is lit. These data are presented on the digit display on the operator's set. The operator passes on this information to the maintenance section, which is then able to send out a

man to the PABX with the necessary spare parts, at a time appropriate for the seriousness of the fault. The maintenance man is also able to obtain a printout of all the information in the alarm table via an I/O terminal, fig. 7.

ASB 100 has only a few alarm functions and the sources of the faults are indicated by means of the alarm lamp in the operator's set in the following way:

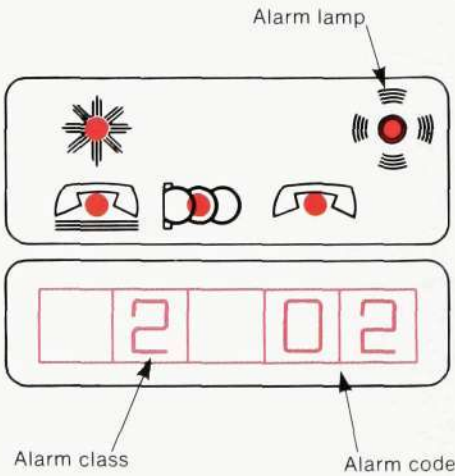
- Steady light      Program execution alarm
- Slow flickering      Error rate alarm
- Rapid flickering      Battery charging alarm

Fault localization and clearing

The alarm data provided by ASB 900 normally provide all the information that is required to pinpoint the faulty unit. In addition, both ASB 900 and ASB 100 are equipped with facilities for ordering



If the system detects a fault, an alarm lamp is lit in the operator's set. The operator can then order the system to indicate the alarm class and alarm code. The alarm code gives the type of device and type of fault



The maintenance man can, via an I/O terminal, request a printout giving the alarm class, alarm code and name and number of the faulty device

```
ALDAP ;
ALARM DATA
CLASS   CODE   DEV TYPE   DEV NO
2       02     TSC        001
END
```

Fig. 7  
Alarm functions in ASB 900

- program controlled function testing of
  - processor
  - program and data store
  - local junctors
  - tone senders
  - tone receivers
- controlled test connections
- printout of device states.

When a fault has been localized with the aid of alarm data or any of the above functions, the following repair routine is normally followed:

- blocking the device or devices on the faulty printed board assembly
- changing the faulty printed board assembly
- testing the new printed board assembly with the aid of program-controlled function tests or controlled test connections
- deblocking the device or devices on the new printed board assembly.

ASB 900 is also equipped with sophisticated functions for localizing program faults. For example, it is possible to set up break points at different levels in the program system by means of commands. When such a break point is passed in the program execution, a printout is obtained of the contents of the central processor registers and a number of previously specified data areas.

## Traffic recording

Both in ASB 900 and ASB 100 it is possible to order, by means of commands, the collection and printout of traffic recording data for all device groups that carry traffic, namely

- routes
- local junctors
- operators' sets
- tone senders and tone receivers.

The following data are collected in ASB 900 during 15 minutes long recording periods, the number of which is specified in the start command:

- the traffic, in erlangs
- the number of seizure attempts
- the number of cases of congestion towards outgoing routes and local junctors
- the number of calls queueing for access to operators, tone senders and tone receivers
- mean length of the queues to the operators.

The first printout takes place after an hour and contains the compiled data from the four first recording periods. After this a printout is made every 15 minutes with data for the last hour. Thus printout no. 2 contains data from recording periods nos. 2–5.

The traffic recording data can be stored on a cassette tape recorder for a later printout instead of an immediate one. It is also possible to order the system to start the traffic recording automatically at a certain time, for a number of consecutive days.

The need of traffic recording is considerably less in ASB 100. In this system the function is limited to the collection and printout of the amount of traffic per device group. In this case also, the data are collected in periods of 15 minutes, but the printout after each such period contains only the data for the latest period.

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# Antenna System for the EXOSAT Satellite

E. Roland Karlsson

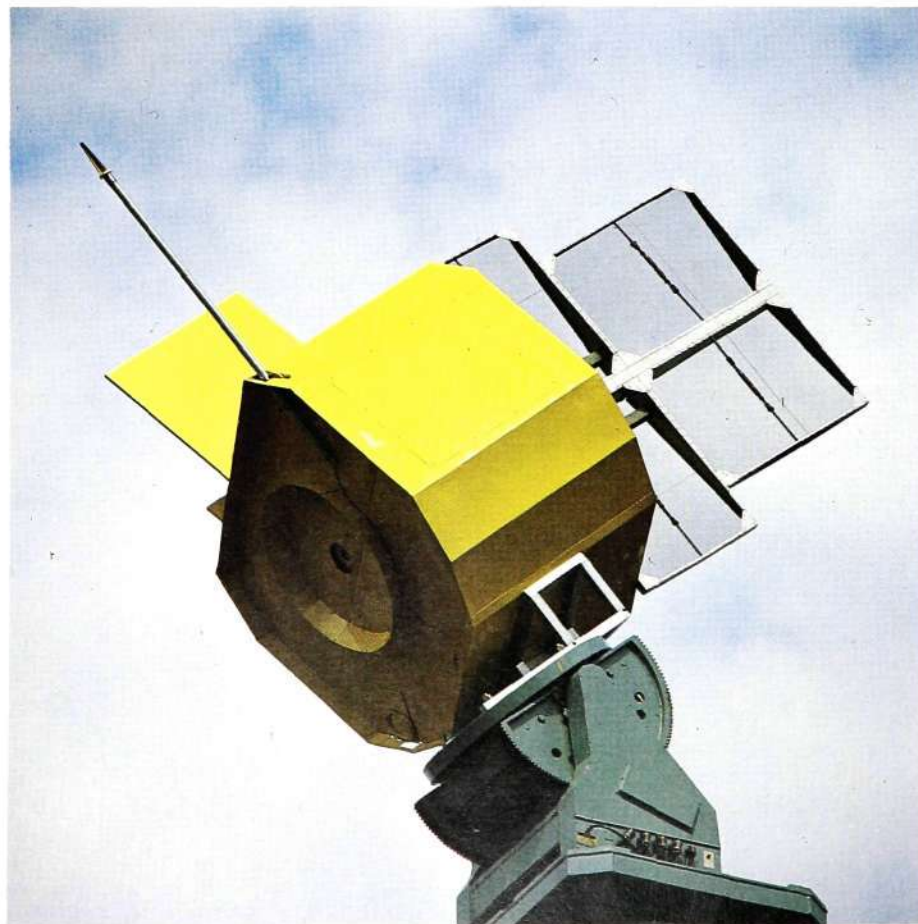
*EXOSAT is a satellite for scientific observations. It is equipped with instruments for measuring x-ray-radiation in space. The instruments will be aligned by orientating the whole satellite towards the x-ray source concerned. An omnidirectional antenna system is therefore essential for communication with earth.*

*The antenna system for EXOSAT has been developed and manufactured by LM Ericsson. The system consists of two antennas, each of which radiates over more than half a sphere. The antenna elements are cone-shaped spirals. Each antenna consists of four spirals with associated feeding device. In this article the design of the antenna elements and the optimizing of their position on the satellite are described, as well as the extensive measurements of performance that have been carried out using LM Ericsson's new automatic antenna measurement equipment.*

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621.371.36

EXOSAT is a triaxially stabilized satellite, which will orbit the earth in a strongly elliptical path. Its greatest distance from earth will be 200 000 km. The satellite is equipped with various instruments for measuring x-ray-radiation in space. The instruments will be aligned by orientating the whole satellite towards the actual x-ray source.

Fig. 1  
A model of the satellite with an antenna mounted on a 2 m long boom, top left



The satellite is being developed for the European Space Agency, with the West German company Messerschmitt-Bölkow-Blohm as main contractor. During the spring of 1977 LM Ericsson was given the task of designing the antenna system. The measurements of the performance of the completed units for the satellite were completed in January 1980. The launching is planned for the spring of 1981.

The antenna system will be used for two-way traffic. Control data for the satellite will be sent from earth, and measuring data and information regarding the different satellite subsystems are to be transmitted to earth.

## Requirements for the antenna system

The position of the satellite relative earth is determined by the direction to the x-ray source concerned and the orbit of the satellite. This means that the satellite can be aligned arbitrarily in space. The antenna system must therefore be omnidirectional. However, the satellite movements are slow, which means that the requirement for an omnidirectional antenna can be moderated slightly, and it is therefore possible to use two antennas, each of which radiates over more than half a sphere, if the switching between such antennas can be done quickly enough.

The antenna system must operate in the S-band, at a frequency of 2.1 GHz for the link up to the satellite and 2.3 GHz in the other direction. The polarization must be circular. The lowest power gain of the antenna in the critical downward direction is  $-3$  dBi and in the upward direction  $-8$  dBi. (The antenna gain is measured relative an ideal omnidirectional antenna;  $i$  = isotropic). These limits are to be met for all possible positions of the large panel of solar cells, which will always be turned towards the sun, fig. 1. This panel causes strong reflections which worsen the performance of the antenna system. Since the satellite will sometimes have to carry out measurements towards the same source for a long time, extreme temperatures will prevail. The lowest temperature for an antenna shadowed from the sun is cal-



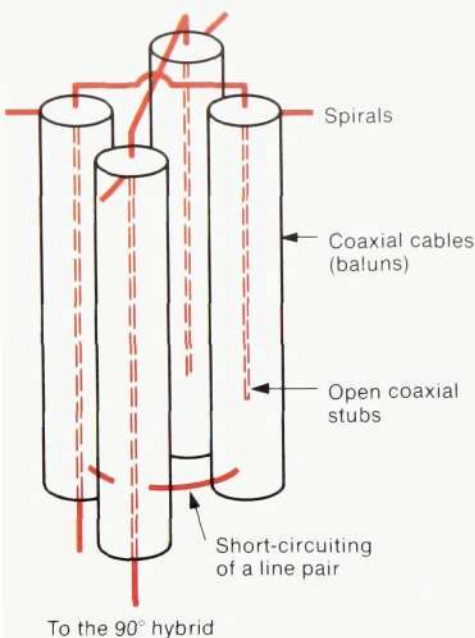


Fig. 4  
The coupling of the balun system, at the front end of the antenna, to the four spirals

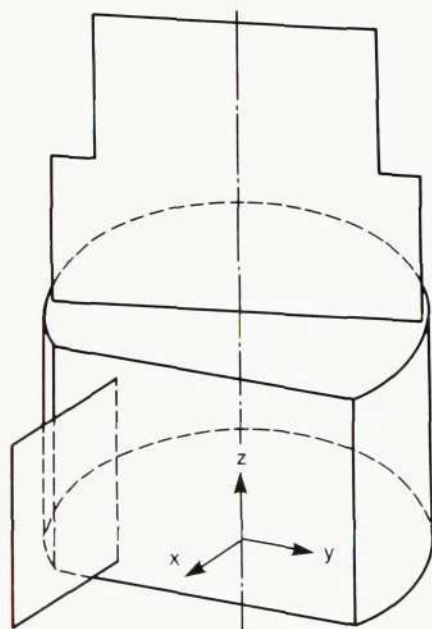


Fig. 5  
Schematic drawing of the mathematical satellite model that was used for the theoretical calculation of the optimum antenna location

tor and a conducting plane, and in the centre a thin insulator. The balun, fig. 3, consists of a coupling between a symmetrical and an unsymmetrical conductor, which gives the desired  $180^\circ$  phase shift for opposite spirals in the antenna. Fig. 4 shows how the two coaxial cables from the hybrid are connected to the antenna wires and to the coaxial cables in opposition. The centre conductors in the cables in opposition are only a few centimetres long. The screens of the coaxial cables are used as short-circuited pairs in order to obtain impedance matching between the feeding network and the antenna spirals.

#### Manufacture

The antenna spirals are formed of beryllium copper in a special tool, in which they are also heat treated in order to avoid deformation during assembly and handling. The spirals are mounted on a framework of glass fibre reinforced plastic, which in turn is placed on an aluminium base. This base also forms the housing for the stripline circuit in the feeding system. The part of the antenna which is exposed to space is to be coated with a special white paint in order to obtain optimum temperature conditions.

#### Antenna location

The antennas must be placed within certain limited areas so as not to interfere with other systems in the satellite. Computer calculations were carried out to determine the optimum location. The calculations were based on geometrical diffraction theory. Several different positions were tried, the main aim being to find the ones that gave the lowest

interference in areas with a low signal level. The satellite body was represented by the mathematical model shown in fig. 5 for calculation of the contributions due to direct, reflected, diffracted, doubly reflected and reflected and then diffracted radiation etc. A total of 61 radiation contributions were added. Furthermore the calculations had to be repeated for different positions of the solar panel. Fig. 6 shows an example of the results obtained, with only the reflected radiation shown for the sake of lucidity. The final antenna positions were determined by measurements with the antenna mounted on a model that was accurate from an electrical point of view, fig. 1. The measurement results conformed well with the calculation results.

#### Performance testing

Functional and environmental tests were carried out on the different parts of the antenna system in order to check the performance of the system. The tests were carried out in accordance with a previously prepared specification and in the following order:

- initial electrical functional testing of each unit
- checking of the mass, position of the centre of gravity and moment of inertia
- vibration testing with sinusoidal vibration and noise vibration (random)
- vacuum and temperature testing
- final electrical functional testing of each unit
- measuring of the radiation diagram with the antenna mounted on a model of the satellite.

Fig. 6  
Example of areas where reflected rays occur. The areas indicate different parts of the satellite which have caused reflections. The  $\alpha$  values are different angles of the solar panels

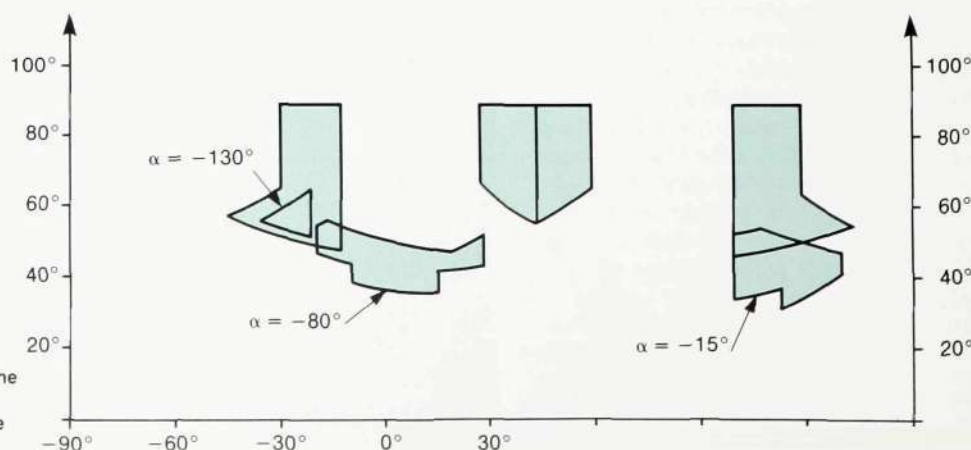
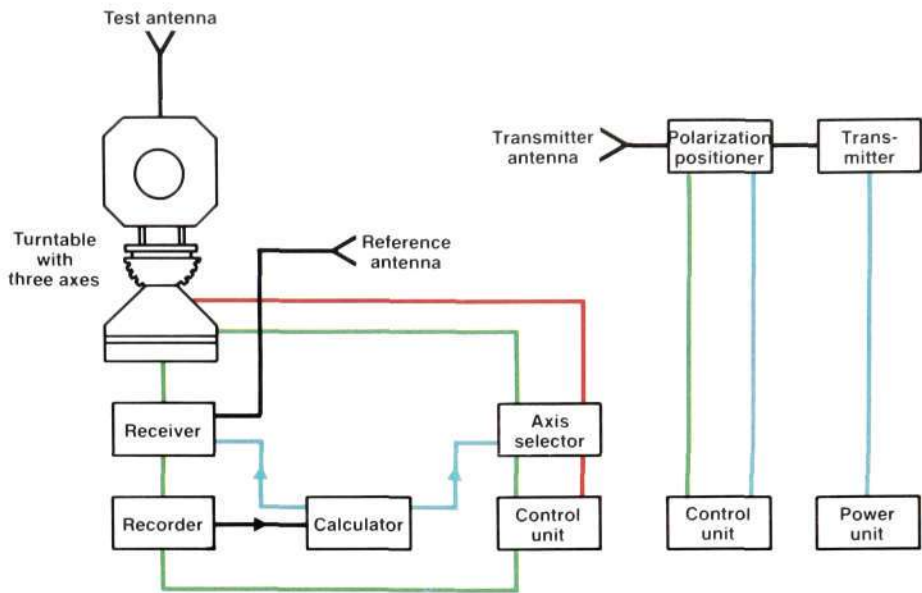


Fig. 7  
The connection for the radiation diagram measurements



The radiation diagram was measured with the antenna mounted on the same model as was used for the optimizing of the antenna position. The model was mounted on a turn table. Fig. 7 shows a block diagram of the measurement set-up.

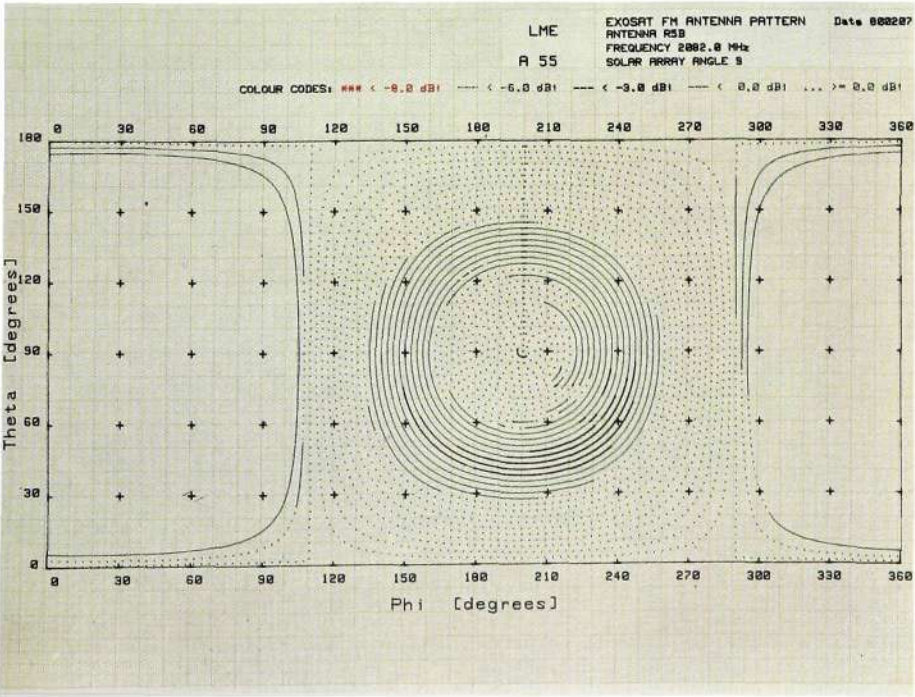
The power gain of the circularly polarized antenna was measured at one point using a linearly polarized rotating transmitter antenna. The measurements were then continued using a circularly polarized transmitter antenna, the first measurement value being used as a reference for the subsequent values.

The measurements were controlled by a computer, for which a measuring pro-

gram and an evaluation program had been compiled. The program stepped one angle in a spherical coordinate system in steps of 2.5° at a time. The satellite was rotated one turn for each step.

The measurements were continuous, and a recording was made for every second degree. The power levels and frequencies were checked before each measurement stage and were adjusted by the program when necessary. Each stage was also printed out in the traditional way by an antenna diagram printer, so that the measurements could be checked at any time. When a whole series of measurements had been completed for different solar panel angles and frequencies, all measurement data were presented, both in table form and as  $\Theta$ - $\Phi$  maps. The maps are in the form of level diagrams in order to give a comprehensive picture of the antenna performance. Fig. 8 shows a map that covers a whole sphere and shows the performance of one antenna.

Fig. 8  
A  $\Theta$ - $\Phi$  map which shows the radiation diagram for all space angles, with level contours



## Summary

The combination of technical and experimental work required for the development of the EXOSAT antenna system is typical of antennas with large coverage intended for spacecraft. For all such systems the performance measurements are extensive. LM Ericsson have carried out several similar projects. The staff are experienced, the methods are rational and the comprehensive measurements can therefore be performed quickly despite the quantity of measurements.

LM Ericsson is the first subcontractor to complete all the activities connected with their commitment. The antennas meet all requirements laid down in the specification. The time schedule has been met, and the cost limits have not been exceeded.

# A Telephone System for Foreign Exchange Trading

Karl-Gustav Carlsson and Arne Svensson

*LM Ericsson Telemateriel AB have developed a telephone system, AVE 100, for internal answering service or direct communication within a company. A touch on a button is all that is needed to answer a call or set up a speech connection. The system can also be used as a multiline telephone. The system was introduced at the beginning of the 1970s and has since been supplemented to be suitable also as a communication system for the foreign exchange departments in banks. In this article the new functions for this purpose are described, as well as the flexibility and rational operation of the system.*

UDC 621.395.22

Foreign exchange trading carried out by the foreign exchange departments in banks requires a reliable communication system that is fully adapted for this activity. The number of foreign exchange dealers can vary from a couple to several dozen depending on the size of the bank and the extent of its foreign exchange trading. Each dealer must be able to get in touch with trading centres all round the world, with colleagues in other banks and with other employees in his own bank, either via direct lines or via switched connections. He must be

able to have two calls connected up simultaneously to his control panel, since he often has to arrange a transaction between a seller and a buyer very quickly. The foreign exchange dealer must also be able to make conference calls and have access to special functions required for his work.

## AVE 100 for communication in foreign exchange trading

System AVE 100 provides a very suitable communication system for foreign exchange trading. In such applications it functions as a large multiline telephone system, where each dealer has access to many common external and internal lines from his control panel. Each panel, fig. 1, also contains two telephone units, each with a handset and a push-button set for dialling, and two loudspeakers with volume control. The loudspeakers are intended for two special supplementary functions, namely monitoring and camp-on listening.



Fig. 1  
A telephone system for foreign exchange trading in full operation



KARL-GUSTAV CARLSSON  
ARNE SVENSSON  
LM Ericsson Telemateriel AB



Monitoring means that a speech circuit, often between the foreign exchange departments of two banks, is connected up to a loudspeaker. Any number of people can take part in a monitored call. During such a call both parties will normally have a loudspeaker connected in. A foreign exchange dealer who wishes to transmit a message uses his handset. The message is broadcast through the loudspeakers to the other participants. Only one dealer at a time in each group can transmit a message.

Camp-on listening means that the foreign exchange dealer is able to connect in a special loudspeaker when he is waiting for a message to come in on an established circuit, and wants to have his hands free in the meantime. He then takes the call on his handset when the message comes.

A complete system comprises control panels and a central unit that is dimensioned for the relevant number of lines and participants. The central unit is controlled from the control panels for connecting a certain line to a certain telephone unit.

### Control panel lines

The line operating wires between the control panel and the central unit are connected to push-button strips in one of the two fields in the control panel, fig.

2. The lines in the left-hand field are connected to the left-hand telephone unit when the relevant push-button is pressed, and the lines in the right-hand panel field are connected to the right-hand telephone unit. It is essential that the control panel lay-out is rational and the operation simple if this demanding work is to proceed smoothly even during very busy periods. The push-button strips can therefore be arranged in the order that is most suitable for each individual case. They are equipped with label strips which show clearly which line is obtained with each button. There is also a light emitting diode for each button, which shows the state of the line: free, busy, call attempt etc.

Fig. 3 shows an example of a line layout in the control panels of a system with 100 lines. The lines are grouped as follows:

#### *Left-hand panel field*

10 monitoring lines  
20 lines to the public exchange  
10 lines to the PABX

#### *Right-hand panel field*

10 direct lines ("hot lines") for long-distance connections  
30 direct lines ("hot lines") for short-distance connections  
10 lines that are individual to each participant  
10 spare lines

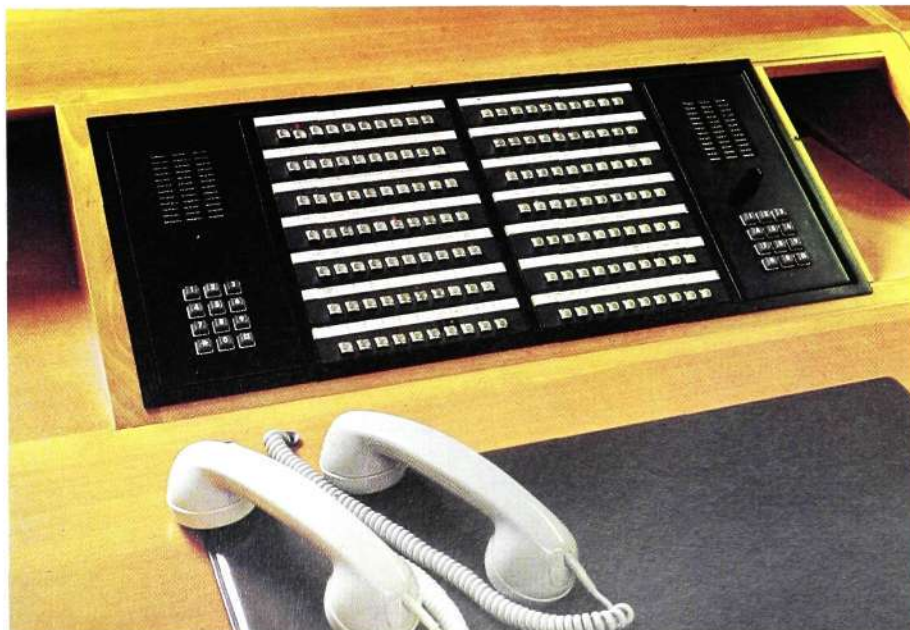


Fig. 2  
The control panel in a telephone system for foreign exchange trading

The monitoring lines can be point-to-point or switched circuits to foreign exchange brokers or banks within the country or abroad. The point-to-point circuits are established on permanently connected, leased lines or speech channels. The switched circuits are set up using ordinary exchange lines, possibly via the PABX, and are connected up with the aid of the push-button set in the telephone unit. The 10 monitoring lines can consist of any desired combination of point-to-point and switched circuits.

The connection to the public network is made via 20 exchange lines and 10 PABX lines. The combination of exchange lines and PABX lines is optional. The exchange lines are mainly used for outgoing traffic and reduce the load on the PABX. This is important, since the volume of traffic from foreign exchange departments into the public network is usually quite high. PABX lines are provided primarily to enable the PABX operators to set up calls to the foreign exchange dealers. All lines can of course be used for both incoming and outgoing traffic. A group number is usually used for the foreign exchange dealers both in the public exchange and the PABX in order to facilitate inward calling.

By direct lines are meant lines direct to a predetermined person or group of people. They can be divided into lines for long distance and lines for short distance depending on the technical equipment.

By long-distance lines are meant connections outside the local area in ques-

tion, via leased two-way speech channels to other places or other countries.

The short-distance lines are intended for local traffic, to local bank offices as well as within the dealers' own bank premises.

The individual lines are adapted to the requirements in each individual case. It is usually an advantage for the dealers to have their own extension numbers in the PABX and intercom system. Direct lines are also provided to close colleagues outside the foreign exchange trading group as an aid in the practical work.

Traffic facilities

The functions and properties of the various lines are described here using the numbering of the push-button strips shown in fig. 3.

Monitoring

One of the foreign exchange dealers decides which lines are to be available to the other participants in the system at a certain time. The lines are connected up by means of push-button strip no. 3. This strip is therefore usually only fitted in the control panel of one dealer (the others have dummy strips).

The push-buttons in strip no. 1 are used by the dealer to connect in an optional monitoring line to the loudspeaker above the left telephone unit. A volume control knob is mounted under the loudspeaker.

When the dealer wants to deliver a message he depresses the corresponding

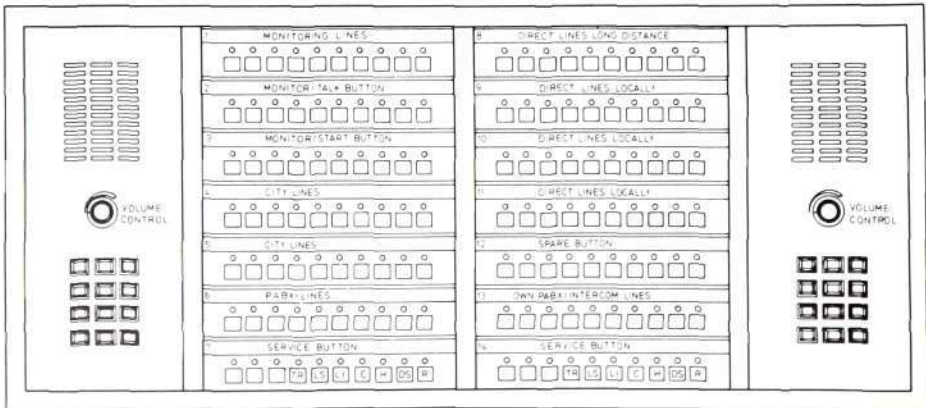


Fig. 3  
An example of the layout of the push-buttons in the control panel

speech button in strip no. 2 and speaks via the handset. The loudspeaker in his own panel is then disconnected in order to avoid acoustic feedback, but the other loudspeakers broadcast the message. During the message the speech buttons for the monitoring line in question in the other participants' panels are blocked, and a light diode above each button indicates that the speech facility is being used by another dealer. When the message is finished a return to the listening state is made by pressing button R in strip no. 7.

#### **Traffic via the public network**

The push-buttons in strips no. 4–6 represent the lines to the public network, either direct or via the PABX. Outgoing calls are dialled using the push-button set in the left-hand telephone unit.

A call in progress can be put on hold and another call initiated or answered. There is no limit as regards the number of calls that can be kept on hold. A call is automatically put on hold when another line is connected in to the control panel.

A call on hold can be taken over by anybody in the foreign exchange trading group by pressing the line button for the call in question. The call is disconnected with button R in strip no. 7.

#### **Traffic via the direct lines**

Push-button strips no. 8–11 are used for direct lines to prearranged persons and groups. A call is set up by pressing the relevant line button and is disconnected with button R in strip no. 14.

#### **Individual traffic**

Calls via the dealer's own extension line in the PABX or intercom are connected up using strip no. 13. Outgoing calls are dialled using the push-button set in the right-hand telephone unit.

Strip no. 13 can also be equipped with 8 direct lines to provide the dealer with rapid connection to close colleagues outside the foreign exchange department. Internal conferences with several participants can be set up using these lines.

#### **Camp-on listening**

Camp-on listening can take place on all lines except the monitoring lines, and means that an established call can be switched from the handset to the loudspeaker in the right-hand telephone unit. This is convenient for a dealer who is waiting for a message to be delivered over an established connection. He has his hands free during the waiting period and the message comes via the loudspeaker.



Fig. 4  
The foreign exchange department of the Christiania Bank og Kreditkasse in Oslo, Norway

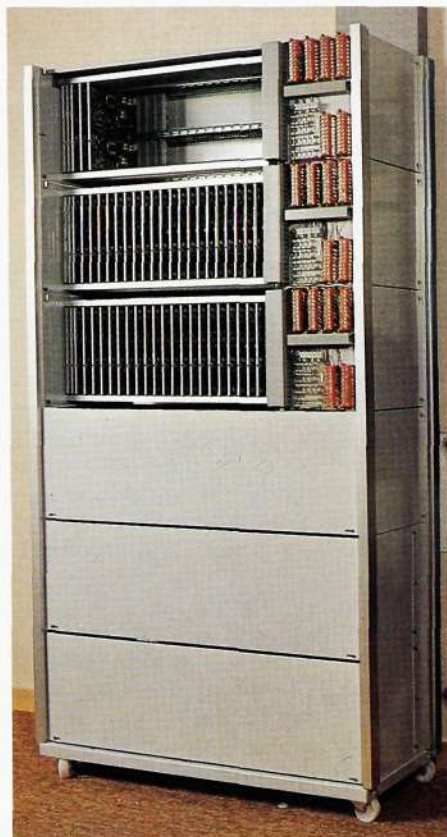


Fig. 5  
The central unit in AVE 100 for foreign exchange trading

The line is connected up to the loud-speaker or the handset by button LS in push-button strip no. 7 or 14. Two-way speech communication via the handset can be resumed at any time by pressing button LS again. The handset in question is thus not free for other calls during the waiting period.

#### Joint call

By a joint call is meant a call where two dealers are simultaneously connected in to the same end of a line. The speech units of the two dealers are connected in parallel to the line, giving a slightly lower transmission level. During such a call the light diode for the line in question will give a special signal in all control panels, indicating that the joint call facility is being used and no third person can be connect up to the line. To set up a joint call one participant must press the joint call button (LI in strip no. 7 or 14) while the other connects up the line. This avoids the possibility of accidental joint calls.

#### Conference

The conference facility enables a dealer to call two different people via two optional lines, for example in strip no. 6. After this individual notification of a conference the dealer can connect up a three-party conference by pressing button C in push-button strip no. 7.

#### Manual holding

Although the system is equipped with automatic holding of established calls when another line is selected, manual holding can be necessary in certain cases. Push-button H in strip no. 7 or 14

is pressed for temporary holding of a call, or if another dealer is to take over the call.

#### Recording of calls

Each telephone unit is equipped for the connection of a tape recorder for the recording of calls. The recording is controlled with button TR in push-button strip no. 7 or 14. Most tape recorders with remote control can be used.

#### Automatic number transmitter

An automatic number transmitter can be connected to the system as a separate unit. It can then be used on any line on which the push-button set is used for dialling.

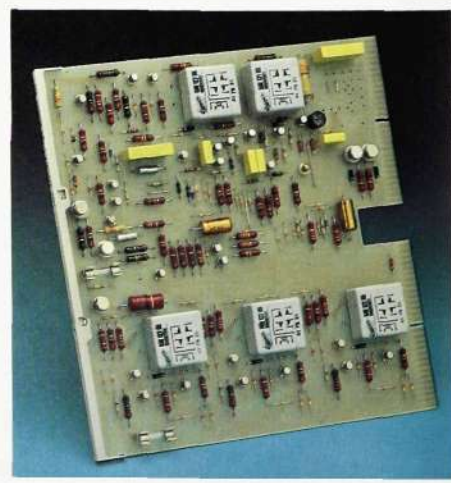
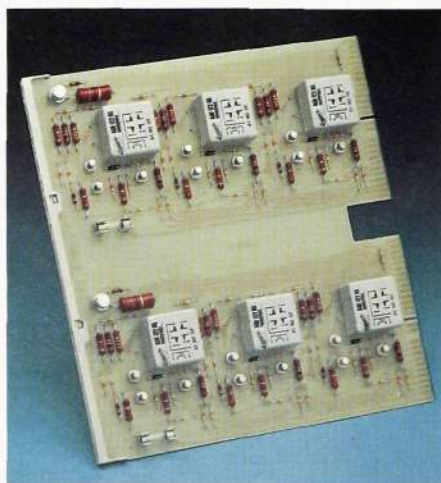
A number transmitter is not included as a standard part of the equipment because the requirements regarding capacity and construction vary greatly. However, the majority of the foreign exchange telephone systems are equipped with some type of automatic calling device in order to ease the work.

#### Indications on the control panel

A diode lamp is provided for each line and is placed above the line button in the control panel. It can indicate the following line states:

Line free	Extinguished
Call in progress	Lit
Incoming call	Rapid flashing, 1 Hz
Call on hold	Slow flashing, 0.5 Hz
Joint call	Flickering, 3 Hz

Fig. 6  
Printed board assemblies for the connection of three control panels, right, and for another six control panels, left



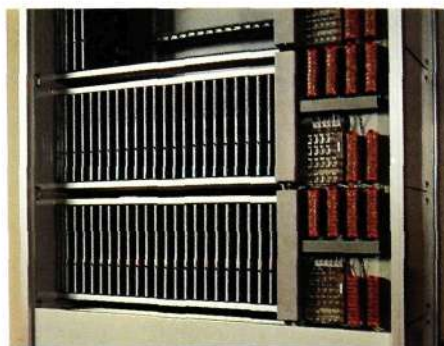


Fig. 7  
Shelves for the printed board assemblies

## Central equipment

The central equipment, fig. 5, consists of printed board shelves, which are placed in a rack or cabinet. Each shelf holds 20 printed board assemblies. The printed board assemblies for normal lines, fig. 6, consist of two main types. One type holds interface circuits for one line and three control panels. The other type holds the interface circuits for two times three control panels. The two types of printed board assembly can be combined in different ways so that the number of foreign exchange dealers who can reach the same line is increased from 3 to 6, 9, 12 etc. The shelves, fig. 7, can be equipped in different ways, for example with 20 lines to three dealers, or with 10 lines to nine dealers. The number of dealers per line can be increased in steps of 3 or 6 by means of additional shelves.

Thus the size of the system is determined by the number of shelves and printed board assemblies and can easily be adapted to meet individual requirements. The shelves are complete units, wired in the factory, which are interconnected by means of plug-in cables. The

control cables to the dealer's panels are also equipped with plugs, for simple and easy installation and servicing.

Ordinary telephone cable can be used for the connection of the control panels to the central equipment.

The system is powered by two separate 24 V batteries, each with automatic charging rectifiers. A signal generator is provided for the direct lines.

## Operational experience

The system described here is built up of the basic units that form part of ordinary AVE 100 systems, with the addition of the following special functions: monitoring, camp-on listening and external conference. AVE 100 systems have been marketed since the beginning of the 1970s. The operational experience has been very good and the fault rate has been low. The special functions that are included in the system for foreign exchange trading have also functioned very well in the more than 50 systems that have so far been taken into service.

# Custom Design Circuits for Telecommunications

Gunnar Björklund and Jan Johansson

*This article is one of a series devoted to the activities of RIFA and deals with integrated circuits for telecommunications. The use of electronic circuits that are custom designed for a certain function can provide the space saving or technical advantage that makes a new design profitable. Furthermore the performance is often improved at a low cost through small additions to the circuit. This is illustrated here by some examples of circuits that have been designed and manufactured by RIFA.*

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It has often been necessary to resort to special techniques in order to meet the stringent requirements imposed on electronic components for telecommunications. As early as the 1920s the Ericsson Group manufactured filter capacitors adapted for carrier systems on aerial lines<sup>1</sup>. At the beginning of the 1970s custom design components, such as hybrid circuits, resistance networks and precision capacitors, were developed for LM Ericsson's new M5 construction practice<sup>2</sup>. The availability of special components has also proved to be a prerequisite for many recent projects in the field of telecommunications.

The monolithic and thick film techniques are predominant in the manufacture of modern integrated circuits for telecommunications.

## Monolithic technique

The monolithic technique has been the driving force in the development that has led to the custom design circuits of today. The circuits are almost ex-

clusively built up on silicon substrates. The degree of integration is high, digital monolithic circuits with 3000 gate functions are not unusual. It is more difficult to give a figure for the possible degree of integration of analog functions, but it may be mentioned that today it is possible to integrate on a single silicon chip all the analog functions for the line interface circuit in a fully electronic subscriber stage. Of particular interest in telecommunications is the possibility of integrating both analog and digital functions on the same silicon chip.

Monolithic circuits for telecommunications must usually be hermetically encapsulated. Fig. 1 shows standard hermetic packages for mounting on printed boards. There are special packages for surface soldering, for example to ceramic substrates, see fig. 2.

## Thick film technique

During recent years the use of thick film technique has become widespread in the field of telecommunications, for simple resistance networks as well as for more complex hybrid circuits. The hybrid technique makes it possible to build a complete electrical functional unit on a single piece of ceramic substrate with conductor layers and precision-trimmed thick film resistors. To the substrate it is then possible to connect special monolithic circuits, high and low power transistors or chip capacitors. The electrical characteristics of the

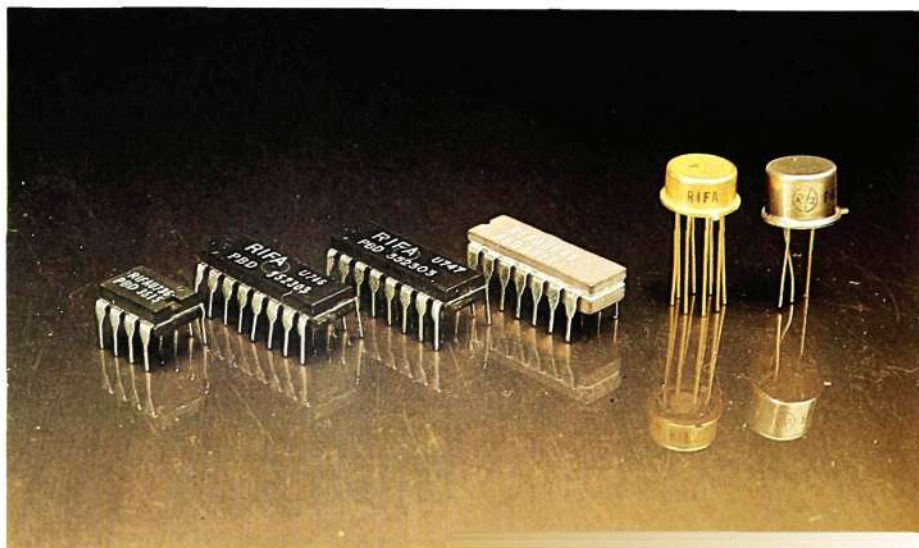


Fig. 1  
Standard hermetically sealed packages for mounting on printed boards



GUNNAR BJÖRKLUND  
JAN JOHANSSON  
AB RIFA



hybrid circuit can be adjusted to meet stringent requirements by means of functional trimming, i.e. laser trimming of resistors with simultaneous measuring of the circuit.

The high heat conductivity of the ceramic and the small dimensions of the add-on components facilitate very compact construction. The M5 construction practice for transmission equipment<sup>2</sup> is one example, and more recent component designs, which are described below, are other examples of the high packing density made possible by the use of hybrid technique.

### Standard circuits versus custom design circuits

Components for modern telecommunication equipment must be of high quality and be able to perform complicated technical functions. The development towards more complex functions also means that an increasingly larger part of the system is built into a few components. Varying system requirements make it difficult for manufacturers of standard components to design a component that meets the needs of several customers. Since the component designer usually has only a limited knowledge of telecommunication systems, he must base his work on specifications from an established manufacturer of telecommunication equipment.

The user of standard circuits must choose between passing on his knowledge of system requirements etc. to the manufacturer or waiting until a new standard circuit, based on the specifications of a competitor, is available on the market for general use.

Another alternative is the custom design circuit. It can be optimized for the user's own system requirements, and can be kept exclusive as long as desired.

### Custom design circuits

An efficient circuit design presupposes that modern techniques, i.e. monolithic and thick film techniques, are exploited to the full. This often means an overall optimization that reaches far beyond the function which was originally intended to be integrated in the circuit. A design that provides the best overall economy usually means that the largest possible number of functions are included in the circuit. The number of additional components is reduced to a minimum, the circuit reduces the required printed board surface, the heat dissipation is facilitated by the mechanical design of the circuit etc.

One prerequisite for a good circuit design is that the requirement specification utilizes the advantages offered by a special technique. This requires close collaboration between the customer

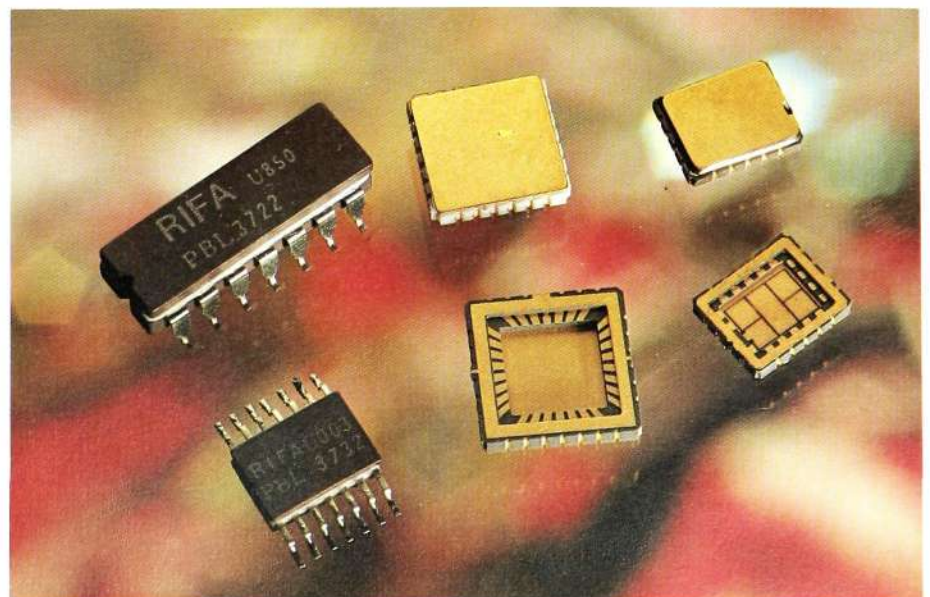


Fig. 2  
Monolithic packages for surface soldering

and the manufacturer. The customer must have a fundamental knowledge of how components are designed. The manufacturer in his turn must be able to state the technical and economic consequences of different specification requirements.

Today the development and manufacture of monolithic and thick film circuits is a mature and well established technique. Advanced computer aids and considerable, well tried production resources are available. The factor that now restricts the spreading of the use of custom design circuits to other fields of use is insufficient design resources among customers and manufacturers rather than lack of applications for the circuits.

### Full-custom or semi-custom design?

The high fixed costs that are normally inherent in the development of a new circuit restrict the use of monolithic technique. Not only must the cost of designing the electronic circuit be covered, but also the cost of generating photo masks and developing prototypes and test programs. This has led to efforts on the part of several manufacturers of custom design circuits to simplify the design work.

One method of manufacturing small series of monolithic circuits at a reasonable cost is to use a standard pattern of components and to vary only one or two of the last mask layers, containing the connections between the transistors

and the outputs. Several customer orders can be combined to give economical production runs with an identical production flow up to the last stages of the process. This semi-custom method for digital MSI and LSI circuits makes series of a few thousand circuits per year economically feasible.

Full custom design is usually profitable in cases where the annual circuit requirement exceeds 10 000. Original patterns are then usually generated for all the mask layers (7–9) on the silicon wafer. In spite of this the design times and the cost of producing masks can be kept reasonable, particularly for digital monolithic circuits, by using computer-aided design, with cell structures and layout rules stored in the design computer memory. The main advantage of designing circuits individually right from the start is of course that the chip surface is utilized better, which has a considerable effect on the manufacturing cost of large series. Moreover, if analog functions are required in addition to digital, the monolithic circuits must be equipped with very special function blocks so that the semi-custom method is not feasible.

For thick film circuits the full custom method is predominant, since the time and money spent on developing a new hybrid circuit, from the completed circuit diagram to the prototype, is considerably less than for a monolithic circuit.

### Circuit exemplifications

This section describes some custom design circuits developed in different techniques for customers within LM Ericsson by the RIFA design departments for monolithic and thick film circuits.

#### Two-tone generator

In modern telephone exchange systems the transmission of digits between the telephone set and the exchange is carried out by means of tone frequency key sending. Seven frequencies are used, four that correspond to the rows of the

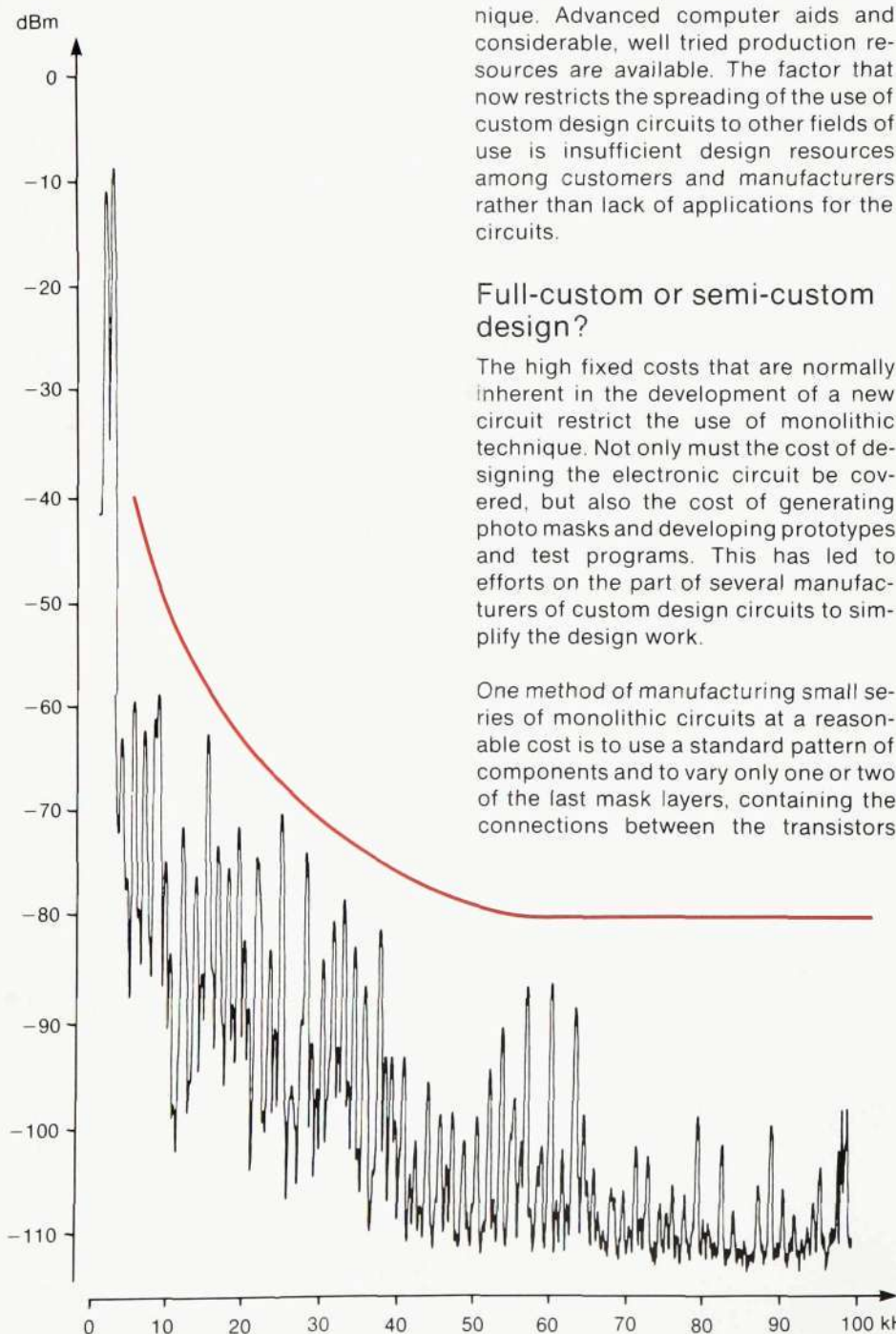
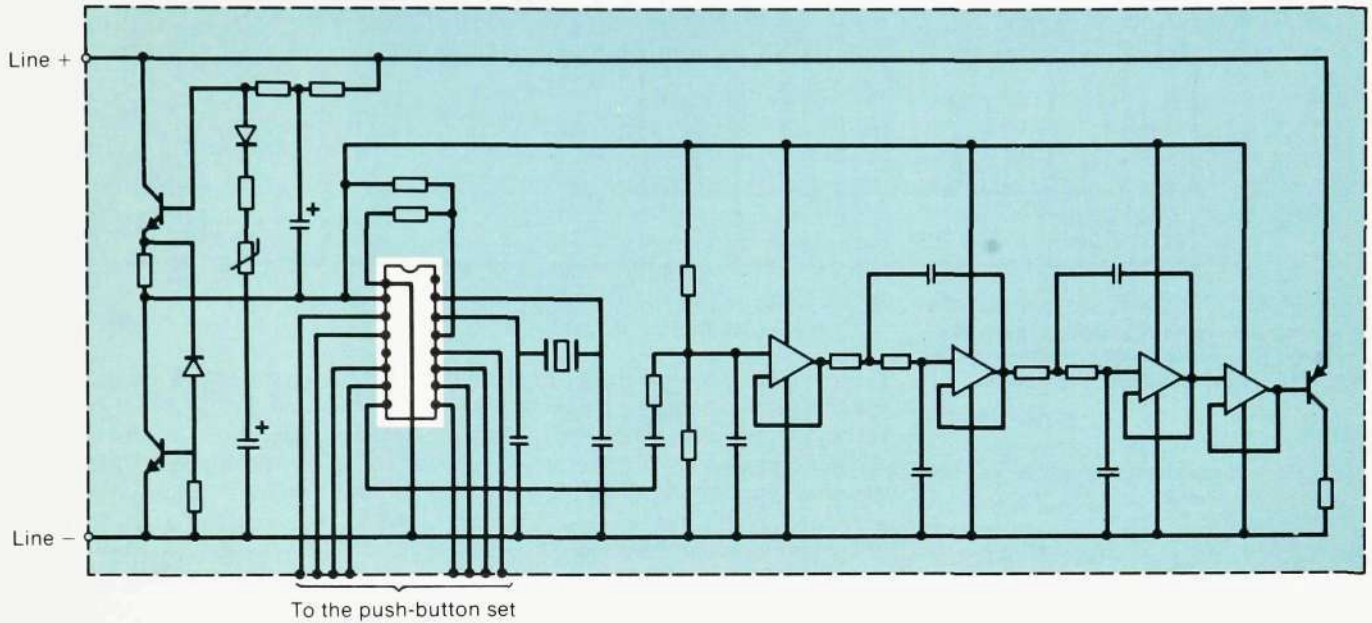


Fig. 3  
The harmonics spectrum from a two-tone circuit



**Fig. 4**  
A standard type of digital two-tone circuit with external components for filtering and line matching

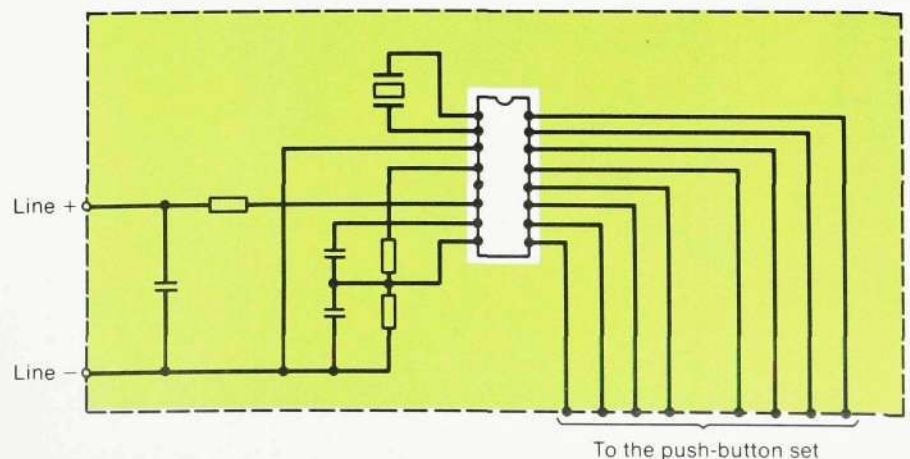
push-button set and three that correspond to its columns. Previously two-tone generators in telephone sets were manufactured using LC or RC technique.

A crystal-controlled oscillator can be used instead. The desired frequencies are then generated from the crystal frequency by means of digital synthesis. Circuits for this function can be made very small and give very well defined frequencies. However, with the digital method harmonics of the desired frequencies occur. These harmonics must be suppressed to an acceptable level.

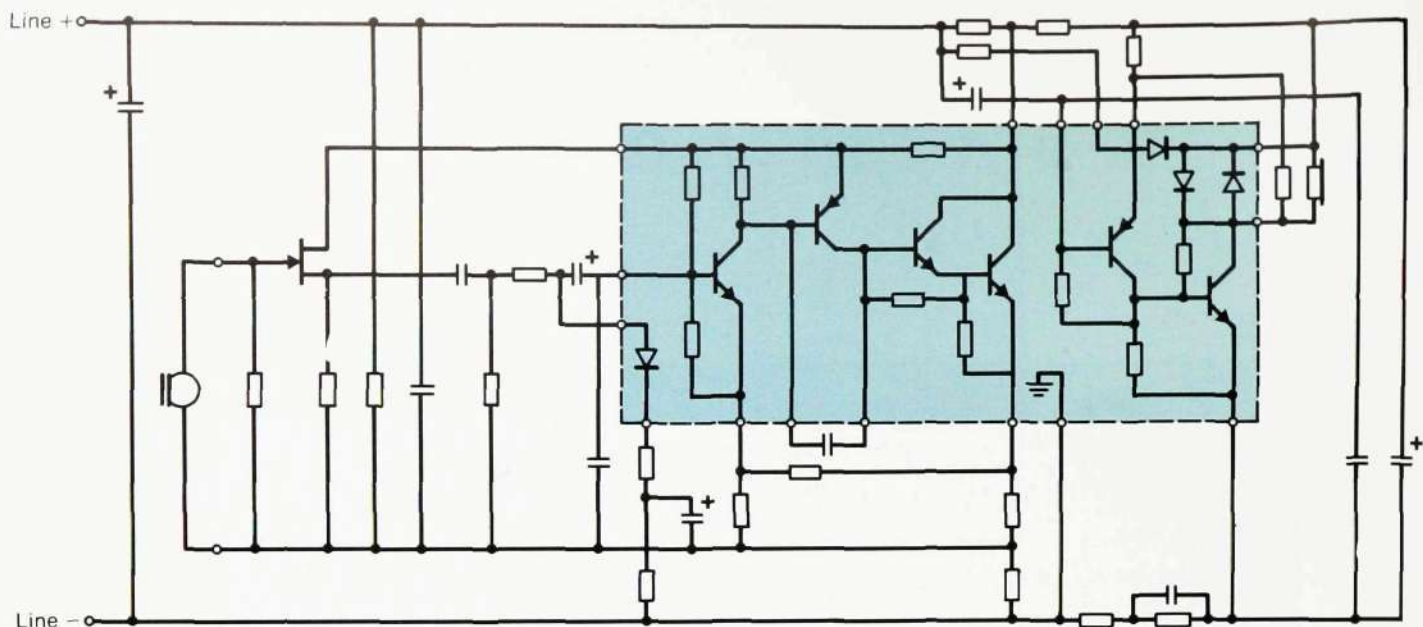
Fig. 3 shows a typical harmonics spec-

trum for the signal from such a tone generator. The CEPT requirement has been included for comparison. Harmonics in the upper frequency range must be attenuated to about 70 dB below the level of the basic frequencies by means of a lowpass filter, which may require a large number of components.

The technical development has been very rapid since the introduction of digital two-tone generators. The first two-tone generators comprised a digital circuit with external amplification and passive components for filtering and single matching to the telephone line, fig. 4. Today the complete function can be integrated on a single silicon chip, fig. 5.



**Fig. 5**  
The RIFA digital two-tone circuit with a minimum number of external components



**Fig. 6**  
A speech circuit for an electret microphone. The first generation, with a simple monolithic circuit and a large number of external components

This reduction in size was achieved when it became possible to combine linear functions with fast and densely packed, low-current logic circuits on one and the same silicon chip.

As can be seen from fig. 5 the circuit has also been designed so that the number of external passive components is reduced to a minimum apart from those needed for adaptation to the various markets.

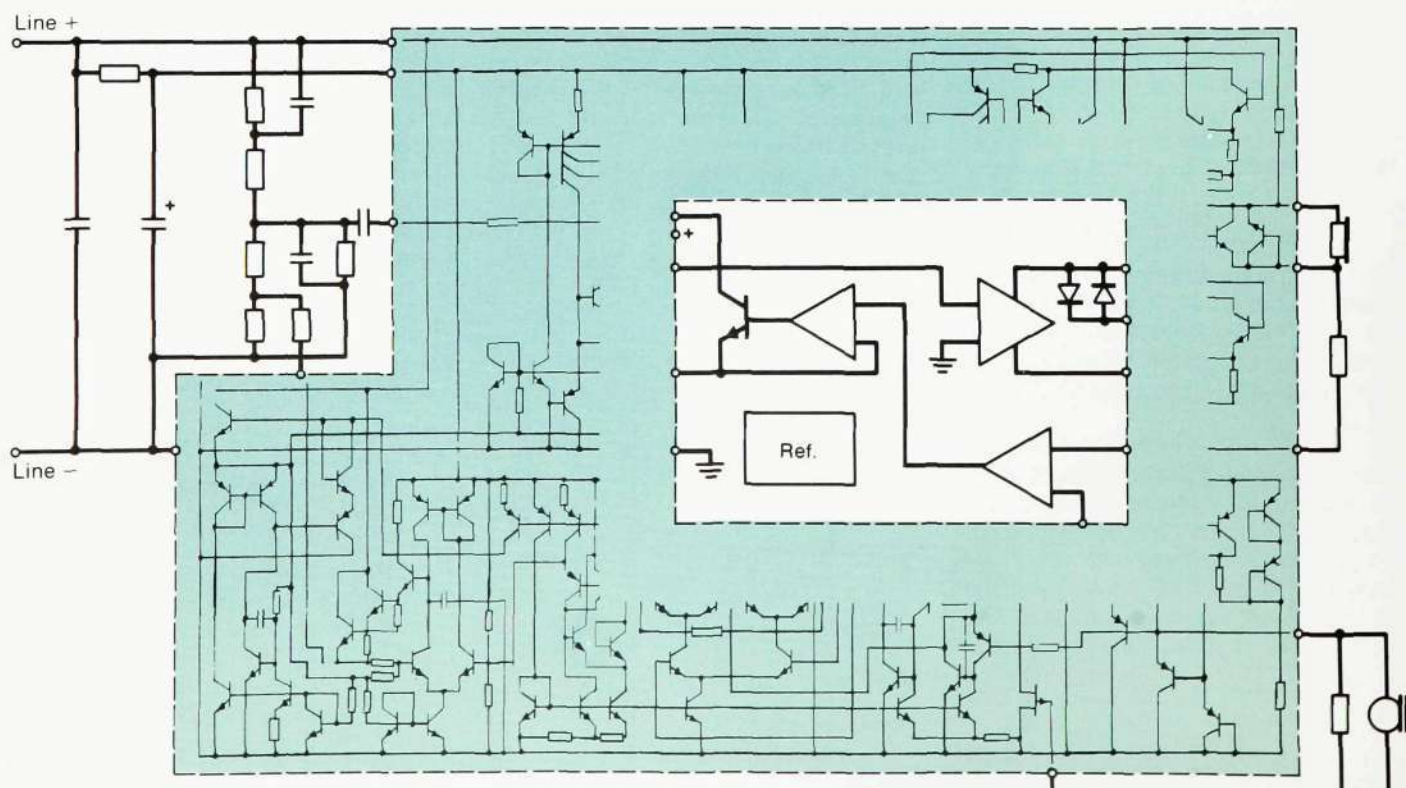
#### Speech circuit

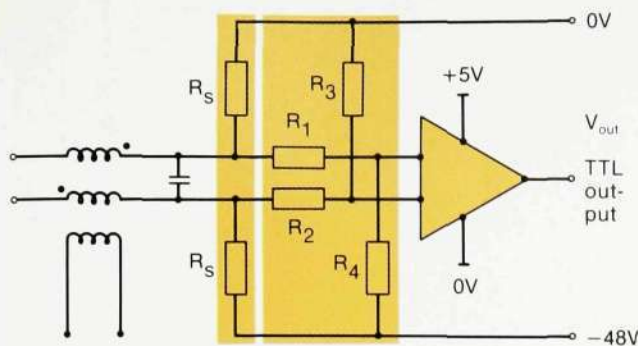
Figs. 6 and 7 show two electronic speech circuits. Externally they are

identical, and they are intended for use in a telephone set together with an electret microphone and an electromagnetic receiver, for example in ERICOFON 700 and DIAVOX 100. The circuit in fig. 6 is a forerunner to that in fig. 7. Both circuits have been constructed as mechanically identical hybrid circuits, fig. 8.

The first circuit consists of a simple monolithic circuit and a number of active and passive components on a thick film substrate. Function trimming of the complete hybrid circuit was accepted in order to make it possible to use a sim-

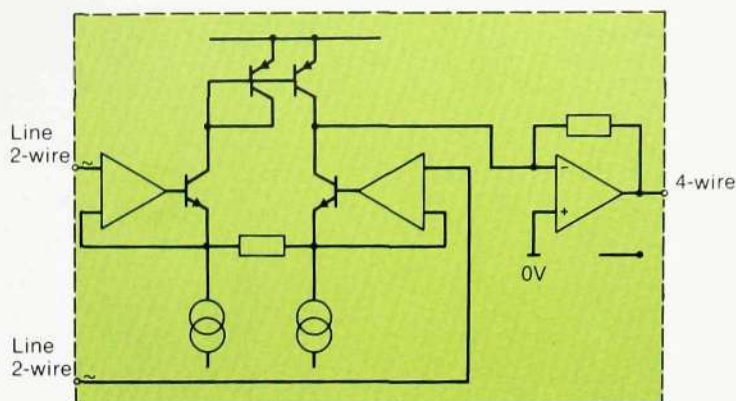
**Fig. 7**  
A speech circuit for an electret microphone. The second generation, with a complex monolithic circuit and a minimum of external components





**Fig. 9**  
A loop sensing circuit consisting of a monolithic circuit in high-voltage monolithic technique and a precision resistance network

**Fig. 10**  
Differential voltage amplifier in monolithic technique for an SLIC



plified circuit design. In the second circuit the monolithic technique has been exploited in full and the number of external components on the thick film substrate has been reduced to a minimum. The monolithic technique offers very good relative tolerances. This fact has been utilized in the design, and hence no function trimming is necessary.

The integrated circuit for the input amplifier in fig. 7 contains a field effect transistor, J-FET, in order to obtain good matching to the electret microphone. The amplification is controlled by the direct current on the line. This current in its turn is dependent on the length of the line. In this way it is possible to compensate for the attenuation, which is proportional to the line length.

The output amplifier transmits the amplified microphone signal to the telephone line and regulates the voltage between the line branches to a suitable level.

A part of the circuit, which replaces the transformer and line balance, separates

the signals in the two directions of transmission. The received signal is amplified in the circuit. In this case also, the amplification is dependent on the line length and the output is adapted for driving the receiver inset.

### Loop sensing on the line circuit board

In modern exchanges the sensing of the line state, i.e. on-hook, off-hook, is done electronically. Fig. 9 shows a circuit for loop sensing.

The line state is registered as a change of the voltage  $V_{out}$  from low to high level, or vice versa, with the aid of a resistance bridge  $R_1$ - $R_4$  and a comparator circuit in monolithic technique. The loop sensing circuit is equipped with high-ohmic thick film resistors which have been laser trimmed to low relative tolerances,  $\pm 0.1\%$ . It has low-level input current and low bias. This gives the circuit the following properties:

- correct loop sensing even with high values of line resistance  $R_L$
- effective protection of the comparator inputs against ringing signals and voltage transients
- loop sensing easily adapted to the demands of different administrations (e.g. different values of  $R_S$ ) by laser trimming of the resistors to the desired resistances
- high packing density on the printed board
- high stability of the changeover levels of the loop sensing, thanks to the encapsulation and the choice of basic technique for the bipolar monolithic circuit as well as the thick film resistors.

### Line interface circuit

The subscriber line interface circuit, SLIC, requires a large number of components if standard components are used. Fig. 10 shows an example of a differential voltage amplifier in monolithic technique. The use of this type of integration gives an SLIC with very good performance, for example as regards the attenuation of longitudinal noise. The packing density is high. This part of the circuit occupies approximately  $0.5 \text{ mm}^2$  on the chip, or about 2% of the

**Fig. 8**  
A complete speech circuit hybrid, mechanically, electrically and acoustically integrated with the electret microphone

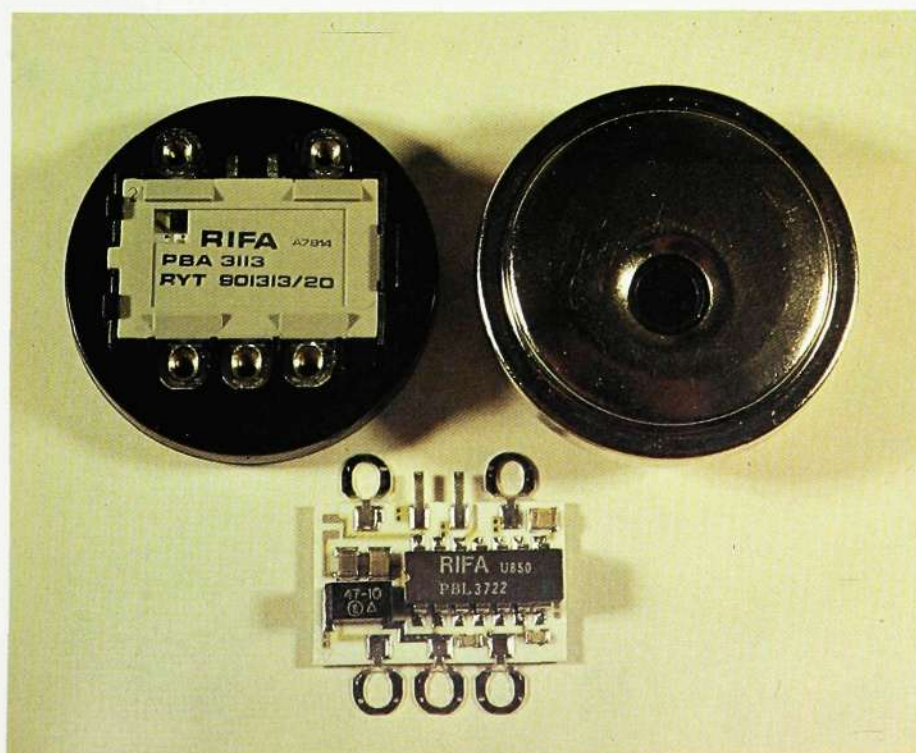
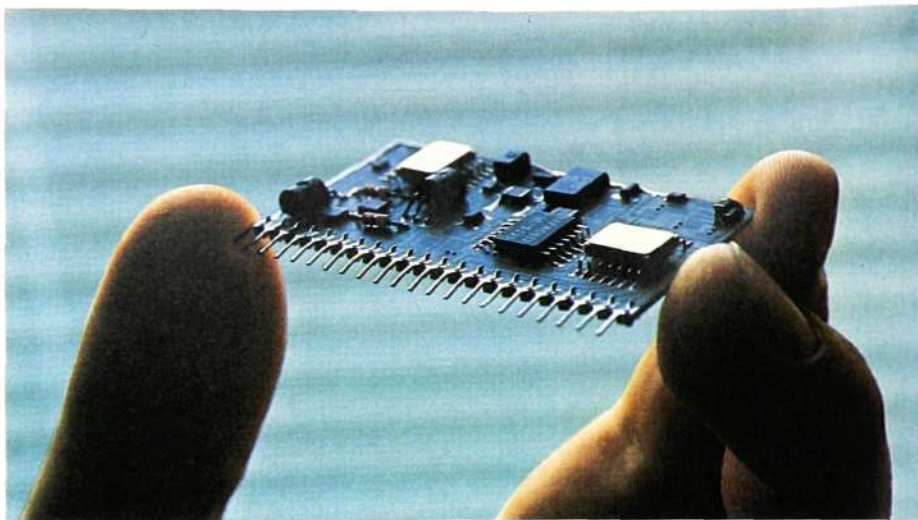


Fig. 11  
An SLIC hybrid



total silicon chip surface for the whole SLIC.

Fig. 11 shows a hybrid circuit for the complete line interface. The circuit contains three special monolithic circuits in miniature packages. The hybrid circuit contains all SLIC functions, interrupter-controlled current feeding, ringing, loop sensing, ring tripping, pulse receiving, earth button sensing, hybrid, balance and digital interface to a micro computer.

### Summary

The design examples described here show in different ways how custom design circuits have provided the most economical solutions to problems in the telecommunications field.

The two-tone generator shows how re-

quirement specifications can be met with sophisticated monolithic technique and how far the number of external components can be reduced.

The speech circuit shows how a combination of a monolithic circuit and a hybrid circuit can give complete mechanical and electrical integration.

The loop sensing shows how a satisfactory circuit has been obtained by using a monolithic circuit and a thick film resistance network, mounted as separate components on a printed circuit board.

Finally the line interface circuit shows how a combination of sophisticated monolithic and hybrid techniques gives an economical and efficient design for one of the most demanding functions in the field of telecommunications.

### References

1. Jacobæus, C. et al.: *LM Ericsson 100 Years*, 1976, pp. 344–353.
2. Axelsson, K. et al.: *M5 Construction Practice for Transmission Equipment*, Ericsson Rev. 52 (1975): 3/4, pp. 94–105.

<p>UDC 621.391.3.002 Hallberg, P.-A. and Viklund, B.: <i>Construction Practice BYB for Transmission Equipments</i>. Ericsson Rev. 57 (1980):4, pp. 124-128.</p> <p>LM Ericsson's present transmission equipments have been designed using the M5 construction practice, but in future the BYB construction practice, which was developed for telephone exchange systems, will also be used when designing new digital transmission systems. The same printed board format is used in M5 and BYB. In the M5 construction practice the printed board assemblies are installed in shelves that cover the whole width of the rack, whereas in BYB they are plugged into magazines having different widths. A bay that can take both M5 shelves and BYB magazines has been constructed, since both types of equipment will be in use for a long time. In this article the authors give the reasons for the decision to use BYB, show how the construction practices for transmission equipments have successively been adapted to suit new component technology and finally describe the new M5/BYB bay.</p>	<p>UDC 621.395.4: 621.376.56</p> <p>Hamacher, H.-H. and Pettersson, G.: <i>First-Order PCM Multiplex in the BYB Construction Practice</i>. Ericsson Rev. 57 (1980):4, pp. 129-137.</p> <p>LM Ericsson have developed a new generation of first-order PCM multiplex systems, ZAK 1/30-4, as a part of the modernization of their transmission equipments. The BYB construction practice was chosen for the new equipment, partly to make it compatible with existing telephone exchange equipment as well as other transmission equipment. In this article the use of this type of equipment is described, as well as its design and function, together with different equipment and connection alternatives.</p>	<p>UDC 621.396.67 621.371.36</p> <p>Karlsson, E. R.: <i>Antenna System for the EXOSAT Satellite</i>. Ericsson Rev. 57 (1980):4, pp. 156-159.</p> <p>EXOSAT is a satellite for scientific observations. It is equipped with instruments for measuring x-ray-radiation in space. The instruments will be aligned by orientating the whole satellite towards the x-ray source concerned. An omnidirectional antenna system is therefore essential for communication with earth.</p> <p>The antenna system for EXOSAT has been developed and manufactured by LM Ericsson. The system consists of two antennas, each of which radiates over more than half a sphere. The antenna elements are cone-shaped spirals. Each antenna consists of four spirals with associated feeding device. In this article the design of the antenna elements and the optimizing of their position on the satellite are described, as well as the extensive measurements of performance that have been carried out using LM Ericsson's new automatic antenna measurement equipment.</p>
<p>UDC 656.25 Andersson, H. S.: <i>Railway Signalling Systems</i>. Ericsson Rev. 57 (1980): 4, pp. 118-123.</p> <p>The Ericsson Group have designed, manufactured and marketed railway signalling equipment since 1915. The product range has included such systems as signalling equipment for the track, safety systems for the train routing, remote control systems and systems for supervising the speed. The product range has successively been renewed in step with the technical development. The development in the fields of electronics and computers has contributed greatly to this renewal. This article deals with the background and the present scope of this work. Some of the recently developed systems will be described in greater detail in subsequent issues of the magazine.</p>	<p>UDC 621.395.34</p> <p>Nilsson, B. Å. and Sörme, K.: <i>AXE10 - A Review</i>. Ericsson Rev. 57 (1980):4, pp. 138-148.</p> <p>AXE 10 is a telephone exchange system designed to cover the whole range from large international transit exchanges to small local exchanges and remotely connected subscriber stages. The system also comprises exchanges for mobile subscribers, equipment for traffic handled by operators and equipment for centralized operation and maintenance.</p> <p>This article gives a review of AXE 10 and describes how the system can easily be adapted to suit different requirements by combining a number of standardized subsystems. These subsystems have well defined interfaces and can be further developed independently. Two such subsystems are the digital group selector and the digital subscriber stage, by means of which the AXE 10 system is adapted to a network with gradually increasing digitalization.</p>	<p>UDC 621.395.22</p> <p>Carlsson, K.-G. and Svensson, A.: <i>A Telephone System for Foreign Exchange Trading</i>. Ericsson Rev. 57 (1980):4, pp. 160-165.</p> <p>LM Ericsson Telemateriel AB have developed a telephone system, AVE 100, for internal answering service or direct communication within a company. A touch on a button is all that is needed to answer a call or set up a speech connection. The system can also be used as a multiline telephone. The system was introduced at the beginning of the 1970s and has since been supplemented to be suitable also as a communication system for the foreign exchange departments in banks. In this article the new functions for this purpose are described, as well as the flexibility and rational operation of the system.</p>
	<p>UDC 621.395.2</p> <p>Mörlinger, R.: <i>Operation and Maintenance Functions in ASB 100 and ASB 900</i>. Ericsson Rev. 57 (1980):4, pp. 149-155.</p> <p>ASB 100 and ASB 900 are modern, stored program controlled PABXs for 20-108 and 60-960 extensions respectively. The stored program control, SPC, is utilized to provide the systems with advanced functions, not only for telephony but also for operation and maintenance. The basic principles are the same for the two systems, but certain functions that require large program volume are provided only in ASB 900.</p> <p>This article gives a detailed description of the operation and maintenance functions in ASB 900, with comments on the features of ASB 100. General descriptions of ASB 100 and ASB 900 have previously been published in Ericsson Review.</p>	<p>UDC 621.3.049: 621.39</p> <p>Björklund, G. and Johansson, J.: <i>Custom Design Circuits for Telecommunications</i>. Ericsson Rev. 57 (1980):4, pp. 166-172.</p> <p>This article is one of a series devoted to the activities of RIFA and deals with integrated circuits for telecommunications. The use of electronic circuits that are custom designed for a certain function can provide the space saving or technical advantage that makes a new design profitable. Furthermore the performance is often improved at a low cost through small additions to the circuit. This is illustrated here by some examples of circuits that have been designed and manufactured by RIFA.</p>

UDC 621.391.3.002

Hallberg, P.-A. and Viklund, B.: *Construction Practice BYB for Transmission Equipments*. Ericsson Rev. 57 (1980):4, pp. 124–128.

LM Ericsson's present transmission equipments have been designed using the M5 construction practice, but in future the BYB construction practice, which was developed for telephone exchange systems, will also be used when designing new digital transmission systems. The same printed board format is used in M5 and BYB. In the M5 construction practice the printed board assemblies are installed in shelves that cover the whole width of the rack, whereas in BYB they are plugged into magazines having different widths. A bay that can take both M5 shelves and BYB magazines has been constructed, since both types of equipment will be in use for a long time. In this article the authors give the reasons for the decision to use BYB, show how the construction practices for transmission equipments have successively been adapted to suit new component technology and finally describe the new M5/BYB bay.

UDC 656.25

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UDC 621.395.4:  
621.376.56

Hamacher, H.-H. and Pettersson, G.: *First-Order PCM Multiplex in the BYB Construction Practice*. Ericsson Rev. 57 (1980):4, pp. 129–137.

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UDC 621.395.34

Nilsson, B. Å. and Sörme, K.: *AXE10— A Review*. Ericsson Rev. 57 (1980):4, pp. 138–148.

AXE 10 is a telephone exchange system designed to cover the whole range from large international transit exchanges to small local exchanges and remotely connected subscriber stages. The system also comprises exchanges for mobile subscribers, equipment for traffic handled by operators and equipment for centralized operation and maintenance.

This article gives a review of AXE 10 and describes how the system can easily be adapted to suit different requirements by combining a number of standardized subsystems. These subsystems have well defined interfaces and can be further developed independently. Two such subsystems are the digital group selector and the digital subscriber stage, by means of which the AXE 10 system is adapted to a network with gradually increasing digitalization.

UDC 621.395.2

Mörlinger, R.: *Operation and Maintenance Functions in ASB 100 and ASB 900*. Ericsson Rev. 57 (1980):4, pp. 149–155.

ASB 100 and ASB 900 are modern, stored program controlled PABXs for 20–108 and 60–960 extensions respectively. The stored program control, SPC, is utilized to provide the systems with advanced functions, not only for telephony but also for operation and maintenance. The basic principles are the same for the two systems, but certain functions that require large program volume are provided only in ASB 900.

This article gives a detailed description of the operation and maintenance functions in ASB 900, with comments on the features of ASB 100. General descriptions of ASB 100 and ASB 900 have previously been published in Ericsson Review.







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