ERICSSON REVIEW

DIAVOX Courier 605
Planning of Rural Networks with AXE 10
Passive Cooling of Premises for Electronic Equipment
Microprocessor-Controlled Equipment for Automatic Battery Charging
Microprocessor-Controlled Power Supply for Small Telecommunication Plants

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DIAVOX Courier 605, a new addition to Ericsson's DIAVOX family

DIAVOX Courier 605

Urban Jansson and Olle Larsson

Ericsson's DIAVOX family has received a new member, DIAVOX Courier 605. This new telephone set simplifies business calls through rational and efficient operation. The main functions include two-way loudspeaking function, up to 36 clearly arranged single-button access possibilities, nine abbreviated numbers, repetition of the most recently dialled number, clock, stopwatch and a reminder signal. The telephone set can be connected to analog PABXs, for example ASB 900, ASB 100 and ASB 20.
The authors describe the new telephone set, its properties, functions and handling, and also its technical construction.

UDC 621.395.6

Modern technology can simplify the telephone part of office work considerably. Most people are used to going through a fairly elaborate procedure in order to initiate a telephone call. The first step is to find the telephone number of the person to be called. The number is usually to be found in an address book, in a binder, on a calling card, or in an internal or public telephone directory. The second step comprises lifting the handset, waiting for the PABX dial tone, dialling the number for an external line, waiting for a new dial tone, dialling the number etc. In over half of the cases the caller cannot reach the called person and has to abandon the attempt. In most cases the whole procedure takes more than half a minute. Single-button access cuts this time down to a few seconds.

With single-button access the caller only presses one button. There is no need to take any further action until the called person has answered, and the conversation can then start immediately.

Surveys have shown that over 80% of business calls are made to a group of people with whom the caller is in regular contact. The number of people in such a group is often more than thirty.

Fig. 1
DIAVOX Courier 605

Loudspeaking function

The voice-controlled loudspeaking function makes it possible to carry out a telephone conversation without using the handset, thus ensuring full mobility. It is therefore possible to fetch binders, look up documents in files, make notes etc. during the call. The handset is not even required when dialling and waiting for an answer, so the caller can carry out other tasks during this time. The two-way loudspeaking function is voice switched and includes a volume control.

The sound reproduction in DIAVOX Courier 605 is of a very high quality. The set is therefore extremely suitable for conferences by telephone, in personal offices as well as in conference rooms. Several people can participate, thereby saving both time and money by means of DIAVOX Courier 605.

Other functions

- Normal (low-speaking) function using the handset
- Tone ringer with volume control and tone pitch switch
- Seven-segment numeric display for 16 character positions
- 36 single-button access facilities with clear labelling
- Nine abbreviated numbers
- Repetition of the last number dialled
- Storage of the last number dialled in a single-button access register
- Clock
- Stopwatch
- Reminder signal
- Dual tone multi-frequency and impulse dialling
- Dial tone receiver.

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Design of the telephone set

The set is shown in fig. 1. The functions of the various buttons are:

P PROG	Start/stop of a programming procedure
R	Register calling
M MUTE	Privacy in the loudspeaking mode
○ Red button □ with LED	On/off switch for the loudspeaking function
T TIMER	Start/stop of stopwatch
E ERASE	Erasing a character
I INT	Pause for second dial tone
S SEND	Abbreviated dialling
1–36	Twelve buttons for single-button access, with three choices per button

Operation and display functions

One button per function

The main aim has been to reduce considerably the time required for initiating a call. In mot cases it is only necessary to press one button, for example when using the single-button access facility. The set is automatically switched to the loudspeaking mode when one of the functions single-button access, abbreviated dialling, repetition of the last number dialled etc. is used.

In those cases where the PABX offers useful facilities the codes for these can be incorporated as single-button access with the label in clear text, for example call forwarding, reset call forwarding, conference etc. For this reason the characters *, # and R can be stored and transmitted.

Short search times

The time saved through single-button access must not be lost in searching for the correct name or through accidentally pressing the wrong button. The telephone set has therefore been designed as a clear and lucid telephone directory. The names entered are large and clear, like the buttons. The eye and finger do not have to be moved during the selection process. The whole procedure, including the searching, only takes a second or two.

Successive programming

Another time-saving feature is the possiblility of successively building up and altering the single-button access directory, i.e. the number that a caller uses can be stored when a call is made. This is more convenient than if programming has to be done separately. It can take up to ten minutes to program a single-button access directory of some thirty names.

Last number redial

The recurring numbers are programmed for single-button access. The last number dialled can be repeated several times. This is done by depressing buttons "Send" and "0".

Abbreviated dialling

Up to nine telephone numbers can be stored for abbreviated dialling. Such a number is transmitted by pressing button "Send" and one of the digit buttons 1 to 9.

Numeric display and time metering functions

The information is shown on a seven-segment liquid crystal display (LCD) for 16 characters. This means that long international numbers can be displayed in their entirety.

Fig. 2
Mechanical construction

Number display
The telephone number is shown to the right on the display during digit transmission and programming. This applies for normal dialling, single-button access, abbreviated dialling and transmission of the last number dialled. The digit being transmitted to the line flashes.

Clock function
The time, in hours and minutes, is always shown to the left on the display when this space is not used for any other purpose. The date is shown to the right on the display when the set is idle.

Stopwatch
Timing is started and stopped with a function button. The recorded hours, minutes and seconds are shown to the right on the indicator.

Reminder signal
A time can be programmed for a reminder signal. The signal is then given each day at that time.

Traffic functions

Incoming calls
Incoming calls are answered by depressing the red button or by lifting the handset.

Call state
The loudspeaking mode is indicated by slow flashing of the LED above the red button. A change to the normal (low speaking) mode is made by lifting the handset. The call is terminated by returning the handset or pressing the red button.

Outgoing calls
An outgoing call is initiated by single-button access, abbreviated dialling, normal dialling or number retransmission. The set is then automatically set to the loudspeaking mode. The digits can be dialled continuously without having to wait for the dial tone from the PABX. If the caller wants to make the call in the low speaking mode, the handset must be lifted before the desired function button is depressed.

Programmable functions
All programming is initiated by depressing the programming button. A P is then shown to the left on the display. When the programming has been completed the button is depressed again. This extinguishes the P.

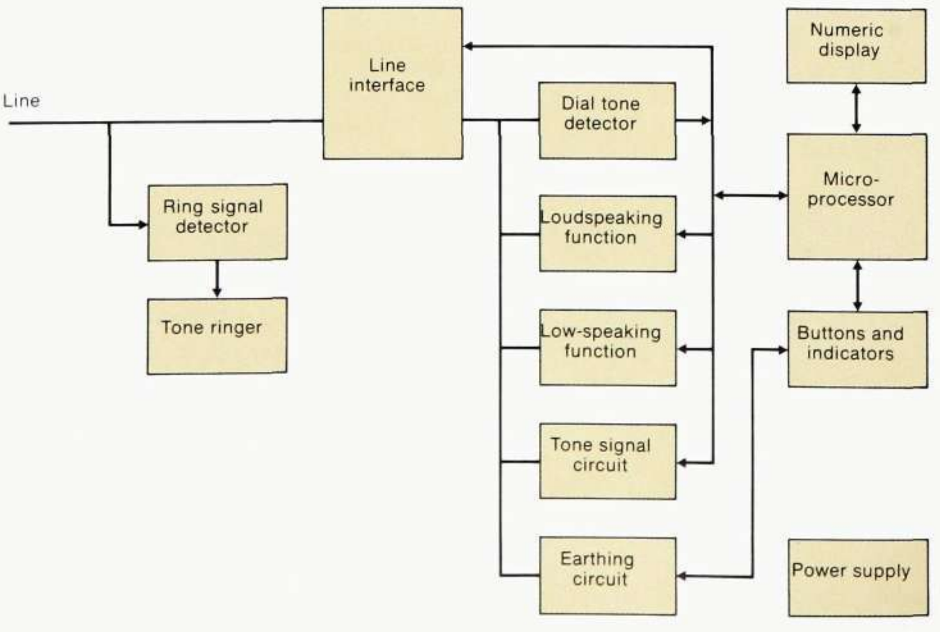
Any procedural errors made during the programming are indicated by "ERROR" being shown to the left on the display. The Erase button is used to remove the error. The programming is then resumed just before the point where the error was made. If the caller presses the wrong digit button he just erases the faulty figure with the Erase button and continues the programming.

Single-button access
There are 12 buttons available for this facility. Each button gives access to one of three different choices by depressing the button once, twice or three times respectively. The pause between repeated depressing of the button must not exceed 700 ms.

A telephone number is stored in the single-button access store by pressing the desired button the appropriate number of times and then dialling the number in question, or repeating the last number dialled.

The normal procedure is to store the number when a call has been made, by

Fig. 3
Block diagram of the telephone set. The line interface unit includes hook function, impulsing circuit and a circuit for timed break register calling



first depressing the programming button (P), then the access button (as many times as required) and finally the buttons for repeating the last number dialled. The number should then be written on the label.

Abbreviated dialling
Numbers for abbreviated dialling are input by pressing button P, one of the digit buttons 1 to 9, the digit buttons for the desired telephone number and then again button P.

Clock function
The time, and the time for a reminder signal, can easily be programmed using button P and digit buttons.

Signalling towards a superior system
Setting of pulse dialling, DTMF, PABX prefix, dial tone receiver etc. is carried out with the aid of button P and different procedures.

Technical design

Control system
Fig. 3 shows a block diagram of DIAVOX Courier 605.

The control system comprises a microprocessor with 4k 8-bit ROM and 128 8-bit RAM. The data store, which is not included in the processor, is a 1k 4-bit RAM and contains the programmed telephone numbers. The numbers are preserved by battery back-up in the event of a mains failure.

Line unit
The line unit contains three relays, which are used for line connection and dial impulsing. Adaptation to national requirements for line connection is made by means of straps on this printed board assembly.

Mechanical construction
An office telephone primarily requires a large number of programmable keys with space for labelling or a description of the function. A key spacing of 16.8 mm is used in all Ericsson's telephone sets with pushbutton dialling. The width and depth of the set are multiples of this spacing.

The telephone set contains one upper printed board assembly parallel with the cover and another in the base, fig. 2.

The electric functions have been divided so that the control system and line connection functions are placed on the upper board. The low-speaking and loudspeaking functions are placed on the lower board.

Tone ringer
The base of the telephone set contains a piezo-electric transmitter with a resonator to the tone ringer.

Power supply
The power supply from the PABX or public exchange to which the telephone is connected is not sufficient to drive all functions in the set. It is therefore connected to the mains via a small built-in rectifier. The battery back-up can be chosen to cover all functions or only the data store, depending on the reliability of the mains network.

Access to the batteries is via a lid in the base of the set.

Acoustic properties
Particular attention was paid to the loudspeaking function when designing DIAVOX Courier 605. As regards circuit engineering it is a further development of Ericsson's loudspeaking telephones of type ERICOVOX. The voice-switched part consists of a special CMOS circuit, which controls the switching digitally, fig. 4.

Since the telephone set requires separate power supply for the single-button

Fig. 4
Block diagram for the loudspeaking function

F_B	Noise-sensing circuit
F_{M1}, F_{M2}	Microphone amplifier
M	Muting button
AC	Comparison circuit
DCC	Digital voice control circuit
D_M	Attenuation
VC	Volume control

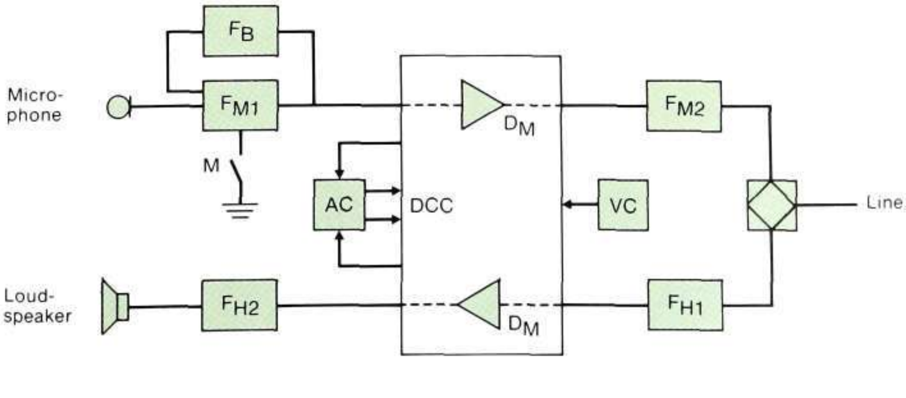


Fig. 5
DIAVOX Courier 605

access function, this type of feeding was also chosen for the loudspeaking function. This means that the voltage drop across the set can be kept low even in the loudspeaking mode, at the same time as the output level is kept high and free from distortion.

The loudspeaking function has been designed for the optimum acoustic quality. The necessary electronics are placed in the base of the set. The loudspeaker is placed on the upper board using a soft suspension.

The electret microphone in the telephone is suspended in a similar way. It is placed in the base, in a cover of conducting plastic that screens electrical radiation.

Summary

DIAVOX Courier 605 has been designed for easy handling and good sound quality. Easy handling is achieved by such functions as single-button access, whereby a call can be set up by depressing one button, and the simple procedures required for programming the desired telephone numbers. Good sound quality is provided by the continuously controlled voice switching and the carefully designed loudspeaker and microphone mounting. The telephone set is easily adaptable to different national requirements by strapping or adjustment of resistances.

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1. Larsson, O.: *Characteristics of Voice-Switched Loudspeaking Telephones.* Ericsson Rev. *52* (1975):3/4, pp. 148–156.

Planning of Rural Networks with AXE 10

Ingmar Andersson and Erling Olsson

New technology should be exploited to the full when planning rural telephone networks in order to meet present and future requirements. Ericsson has developed a system package for this purpose which includes both products and network planning aids.
The authors give a brief description of the system package concept, and also some examples of the planning of typical rural networks.

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621.395.34

Good telecommunications in rural areas are a prerequisite for the expansion of trade and industry outside urban regions. They also improve the possibilities of providing social services for the people in these areas. Extension of the telephone network in rural areas is a profitable investment from the point of view of national economy. This view is often opposed by more short-term business economy arguments, for example that the investment cost per subscriber is high and the income low. In many cases these arguments are correct, but they do not apply for the overall profitability over a long period of time.

The situation in rural networks is different in industrialized and developing countries.

In industrialized countries automatization has usually been completed. Today such countries have relatively well branched telephone networks consisting of small terminal exchanges of the step-by-step or crossbar type connected to a secondary centre. The size of the terminal exchanges is usually in the range 30–500 subscribers and the number of terminal exchanges per secondary centre is 5–20. The network structure is a combination of star and tree. The transmission media are mainly open wire and pair cable on pole lines. Small carrier systems with 12, 24 or 60 channels on pair cable or radio relay link can occur, but low frequency circuits over loaded pairs are the most common form of transmission.

Alterations in these networks often mean replacing old equipment, combined with a certain amount of growth. The reasons for the replacement are many. For example, the existing exchanges cannot handle new telephone facilities, such as services initiated from push-button sets, toll-ticketing charging or data services. Other reasons are high operating or maintenance costs, lack of spare parts etc. For practical and economical reasons the replacement often has to take place over a long period of time, sometimes several decades.

Developing countries and also many recently industrialized countries are faced with the task of automatizing the manual network and extending the network to new places where telephone services have not previously been available. In these countries the exploitation of new technology in the networks is therefore not tied to existing equipment to the same extent. It is then possible to skip a generation of technological development and let the new technology govern the network design.

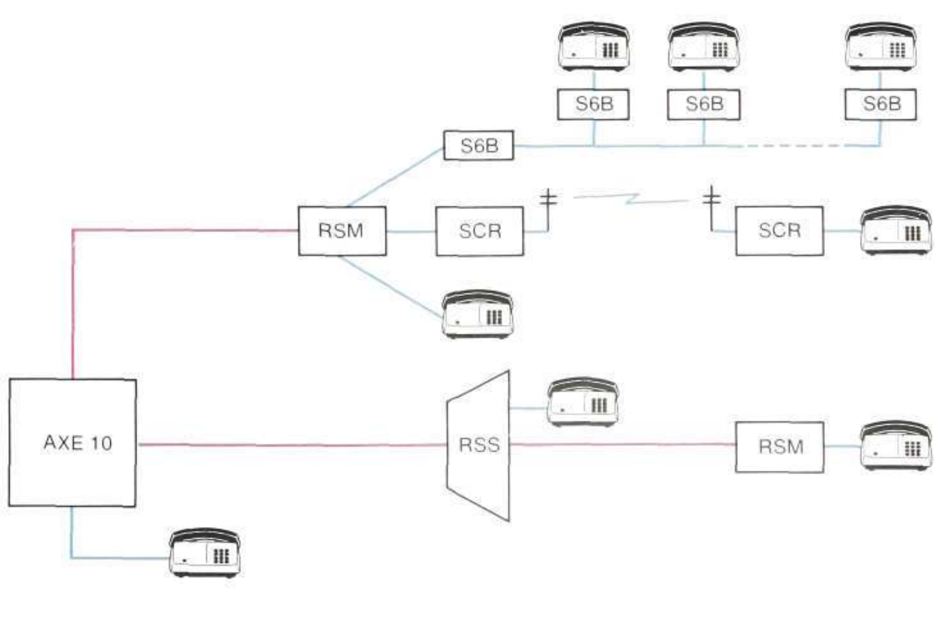

Fig. 1
Products in Ericsson's digital system package for rural networks

RSS Remote subscriber stage
RSM Remote subscriber multiplexer
SCR Single-channel radio relay link
S6B Eight-channel subscriber carrier system
(pink line) Digital line system, cabel or radio relay link
(blue line) Analog circuits

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Exchange equipment

	Container 40' AXE 10	Container 20' RSS	Container 10' RSS	Cabinet RSS	Cabinet RSM
Number of subscribers					
Maximum	4096	2048	768	128	30
Extension module	64	64	64	64	15
Number of 2 Mbit/s links					
Maximum	–	16	6	1	1
Extension module	–	1	1	1	1

Transmission equipment

Capacity	Cable system	Radio relay link
30 channels	ZAD 2 pair cable ZAM 2 fibre cable	MINILINK 10, 13, 15, 18 GHz TD 400, 900, 1500, 2000 MHz
60 channels	–	TD 400, 900, 1500, 2000 MHz
120 channels	ZAD 8 pair cable	MINILINK 13, 15, 18 GHz TD 900, 1500, 2000 MHz
240 channels	–	TD 900, 1500, 2000 MHz
480 channels	ZAM 34 fibre cable	NL 2, 13 GHz

Distribution equipment

Capacity	Cable system	Radio relay link
1 subscriber	–	RT 150, 400 MHz
8 subscribers	S6B pair cable – (branching for each subscriber)	

Table 1
The products in Ericsson's digital system package for rural networks consist of AXE 10 exchange equipment in containers and cabinets, transmission equipment and distribution equipment

In many developing countries the telephone service needs to be introduced in a large number of communities. Budget limitations often lead to expansion programs with one public telephone per community. This is then a coin box set or a set with a subscriber's call-fee meter, which is installed in, for example, a shop. More than one telephone is of course also required in many cases, but typically the telephone density will be low even in areas with a large number of inhabitants.

In many developing countries there is a lack of trained personnel, it is difficult to arrange a reliable power supply, and the climate and terrain pose problems. This leads to special demands on the equipment and the network design.

Product survey

Ericsson has developed an integrated digital system package for rural networks. It uses the possibilities offered by digital technology to integrate transmission and switching, and facilitates centralization of the operation and maintenance functions, fig. 1.

The system package comprises AXE 10[2] with remote switching stages, RSS[3], and remote subscriber multiplexers, RSM[4], connected together by means of digital transmission systems over cable[5] or radio relay links[6]. A special cable for rural networks, TUKA, has also been developed.[7] A system that utilizes solar and wind power, ERICSSON SUNWIND[8], has been developed for the power supply of small exchanges, figs. 2–6. The system has high operational reliability and requires little maintenance.

The distribution network, i.e. the network nearest to the telephone sets, is analog and can be designed in different ways. Fig. 1 shows connection via a physical line, a single channel radio relay link and an eight-channel subscriber carrier system. A summary of the products is given in table 1.

Together these products constitute a modern integrated system package for rural networks which gives good economy, high reliability, good expansion facilities, compatibility with existing networks and the ability to meet any future demands.

The use of remote units in the network contributes to good network economy. Such units are economically viable for very small numbers of subscribers (ten subscribers or more). They also make it possible to extend the catchment area for the exchange, thus reducing the cost per subscriber. In addition the technical development results in a gradual reduction of the volume of the hardware, fig. 7, which is very important for rural applications.

There are many advantages in using the same basic system in the rural network as in the rest of the national network, for example as regards training, operation and maintenance routines, the stocking of spare parts etc. Furthermore any new services and functions developed for the national network can quickly and easily be introduced in the rural network as the demand arises.

The centralized operation and maintenance functions in the AXE 10 system make it possible to supervise the subscriber lines, the remote units and the transmission systems from an AXE 10

Fig. 2
A remote subscriber switch, RSS, installed in a container

Fig. 3
A remote subscriber multiplexer, RSM, in a cabinet

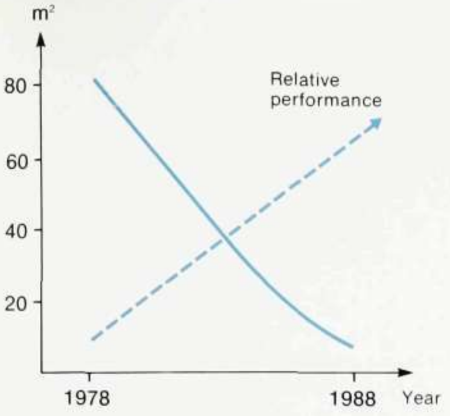


Fig. 7
The space requirements for an 8000-line AXE 10 local exchange

parent exchange. Any fault in these equipments results in an alarm printout, which is used to locate the faulty unit. Normal operating functions can also be handled from the parent exchange. In rural networks, which usually cover large areas, these features contribute greatly to the good overall economy of Ericsson's system package.

Network planning

Network planning is essential in order to achieve good network quality, high flexibility and a low cost. Planning is particularly important when new technology is to be introduced, since many basic conditions will then be altered. For example, the cost ratio between transmission and exchange equipment changes with digitalization, and will in its turn alter the optimum network structure. Old planning rules can then become obsolete.

Two important items in the network planning are the decisions regarding

- the type, quantity and time for installation of equipment in the network, with regard to certain predetermined conditions for growth and traffic volume, so that the cost is reduced to a minimum
- basic plans, so that the overall network quality is maintained or improved, and so that the different parts of the network can interwork.

The following is mainly devoted to the first item.

The second item is of a general nature and concerns the whole of the national network, not just the rural parts.[9] Ericsson's system package with remote units offers great advantage in two respects, both of considerable importance to rural networks.

Improved transmission quality is obtained because the transition from the amplified four-wire network to the two-wire network has been moved out to the remote units, and hence a larger part of the network has four-wire transmission. This means lower attenuation up to the transition point without any risk of singing.

Efficient number capacity management is achieved since a stock of spare numbers can be shared by several communities.

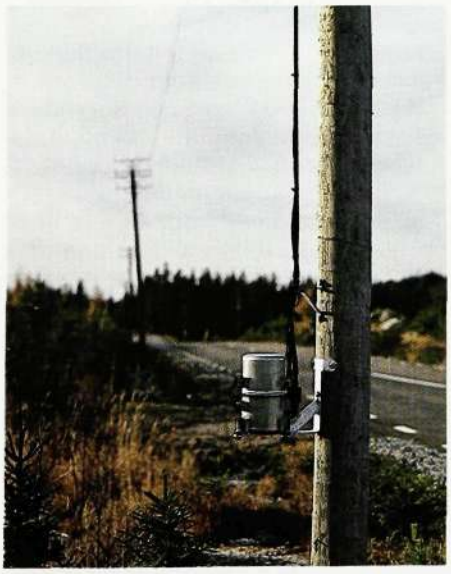
Planning aids

The economical assessment of different alternatives constitutes an extremely important part of the network planning. Of necessity it includes much calculation. Manual calculations would be very time-consuming even for a rural area, particularly if consideration is to be paid to the development of the network over a long period of time. A computer aid has therefore been developed in order

Fig. 4
Pole with a PCM repeater case for connection to TUKA cable

Fig. 5
MINILINK 15 mounted on a mast

Fig. 6
A mast with wind turbine and solar panels



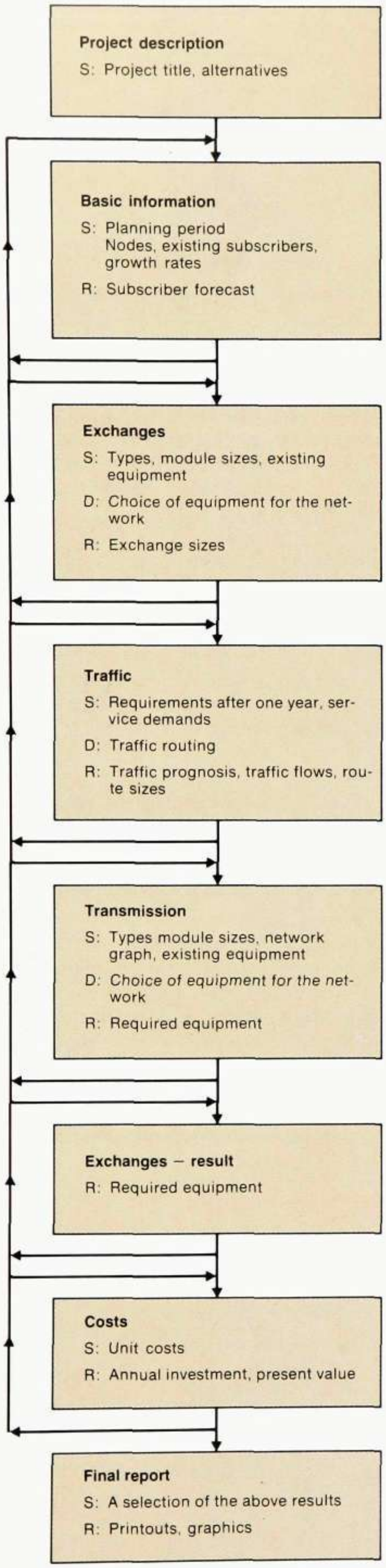


Fig. 8
A summary of the planning aid.
On the basis of a planning idea the planner builds up information regarding the network in the computer. The network plan is improved in an iterative process. When the plan has been completed a final report is prepared

S Specification
D Decision
R Result

to facilitate this stage of the planning work. The main features of this aid are that

- consideration is paid to existing equipment as well as fixed costs and the module size of the equipment
- the planner chooses the equipment
- the computer dimensions and calculates the cost of the network for the planning period
- the planning is carried out as a dialogue between the planner and the computer.

The aid enables the planner to evaluate more network alternatives than would otherwise be possible. This ensures a high quality level in the network planning, and in comparison with manual methotds the time required for the calculations is reduced considerably.

The exchanges and junction routes in rural areas are small. Fixed costs and the size of modules are therefore important factors in the calculation of costs. The aid has been designed with consideration paid to this fact. For example, the exchange equipment can be divided into three levels, which in system AXE 10 correspond to groups of magazines, individual magazines, and partly equipped magazines.

The transmission equipment is divided into terminals and intermediate repeaters for line systems or radiolinks, and multiplexers for the standardized hierarchic transmission levels. The necessary infrastructure, i.e. buildings, masts, roads and installation methods, can be specified individually for each network node or route. This gives the model greater conformity with actual network costs.

The input data consist of general information, such as the type of equipment used in the network and its cost, and information specific to each network, such as communities, the number of subscribers, distances, traffic requirements, growth rate and existing equipment.

Fig. 8 shows the structure of the planning aid and how it can be used when planning a network. The working method is similar to manual planning. The main difference is that the computer carries out the necessary calculations quickly and stores the alternatives that the planner wants to retain.

By testing different alternatives the planner arrives at the network plan that is most suitable in each individual case. The chosen plan can be the one that has the lowest present value as regards investments and operation and maintenance, or one with a combination of low present value and an even investment rate.

When the planner judges that the network planning has been completed the results have to be output and documented. For this purpose lists are printed which contain information concerning the network, equipment quantities and costs, divided into communities and routes or given in graphic form.

The interworking with the computer is carried out by means of menus, from which the planner selects the activity to work on. Data are fed in with the help of panels, fig. 10. The planning aid is extremely easy to use and requires only a minimum of computer knowledge.

Network examples

The use of the products and planning aid is described with the aid of two rural network examples. These networks are ficticious, but they have been defined on the basis of actual conditions.

The first area, network A, has been chosen to illustrate conditions that occur mainly in industrialized countries. In this case the existing equipment and the infrastructure govern the design of the future network.

The other area, network B, has been chosen to illustrate the planning of a new and more extensive network of the type found primarily in developing countries.

In both cases the cost of two alternatives is compared, one based on autonomous exchanges in each network node and one on Ericsson's digital system package. The comparison is made with present-value analysis over the period 1985–1994. The costs do not include

Fig. 9
A result list

5 20 Transmission – Listing of transmission equipment (summary)

System	Specification		Exist Capac	Year 1985	Year 1986	Year 1987	Year 1988	Final Capac
Equipment: Cable Line Systems								
ZAD 2	Line terminal		0	12	2	4	0	18
ZAD 2	Repeater		0	14	3	4	0	21
ZAD 2	Repeater box		0	11	0	3	0	14
Equipment: Radio links								
MINIL 8	Line terminal		0	0	0	4	0	4
Equipment: Multiplexers								
ZAK 0/1L	Multiplexer		0	1	0	1	0	2
ZAK 1/2	Multiplexer		0	0	0	4	0	4
Equipment: Cables								
.9	PL cable (km)	20p	8	0	0	0	0	8
OW	PL open wire	1p	55	−55	0	0	0	0
TUKA	PL cable	2p	0	16	0	2	0	18
Equipment: Cable construction (km)								
Normal	Pole line (PL)		19	3	0	2	0	24
Equipment: Radiolink construction								
MED	Mast, build etc		0	0	0	3	0	3

Basic conditions for the network examples

Parameters for economic calculations

Calculation method	PWAC
Planning period	1985–1994
Economic comparison period	1985–2024
Rate of interest	10%
Analog station equipment	
AUTO 100	
extension module	100 subscribers
basic cost	0.5 of AXE 10
extension cost	1.25 of AXE 10
maximum size	10 000 subscribers
AUTO 40	
extension module	40 subscribers
basic cost	0.25 of AXE 10
extension cost	1.25 of AXE 10
maximum size	200 subscribers
Digital station equipment	
AXE 10 with RSS and RSM	
Digital transmission equipment	
Pair cable system, ZAD	0.7, 2 Mbit/s
Radio relay link system, MINILINK	0.7, 2, 8 Mbit/s
Multiplexers, ZAK	
Cables	
PCM pair cable for rural networks	TUKA
Standard pair cable	0.9 mm, 42 nF/km
Cable installation method	
Buried in the ground	
Run on pole lines	
Buildings	
Existing buildings or containers for	AUTO 40, 100, RSS (>128)
Cabinets for	RSM, RSS (≤128)
Masts for radio relay links	
Height	25 m

the distribution network nearest to the subscribers, since this part of the network is assumed to be planned in the same way in all the alternatives.

However, it might be possible to reduce the cost of the distribution network in networks built with the digital system package compared with networks containing autonomous exchanges. The reason for this is that in certain cases the remote units can be placed closer to the subscribers than the exchanges. In the examples it has been assumed that this is not the case.

Common conditions for networks A and B

A number of conditions are common for the two areas studied. These include basic plans, the type of equipment and the basic data for the economic calculations, see the fact panel.

In the case of the network with autonomous exchanges in each network node, a small autonomous exchange, AUTO 40, and a medium one, AUTO 100, are used, see the fact panel. These analog exchanges are ficticious, but the assumptions concerning modules and costs are representative, and this is sufficient for the subsequent planning. The number of functions and services provided by these exchanges is of course smaller than in AXE 10, but it is assumed that the basic requirements are met. The analog exchanges are installed in containers or in existing buildings. The transmission network consists of physical circuits or, when economically justified, digital systems having a transmission rate of 0.7 Mbit/s or higher.

In the alternative based on Ericsson's system package for rural networks, AXE 10 with remote units, RSS and RSM, is used. The equipment is installed in a container or a cabinet if it cannot be placed in existing premises. The transmission is based on digital systems with a transmission rate of 2 Mbit/s or higher, over pair cables or radio relay links in accordance with table 1. The pos-

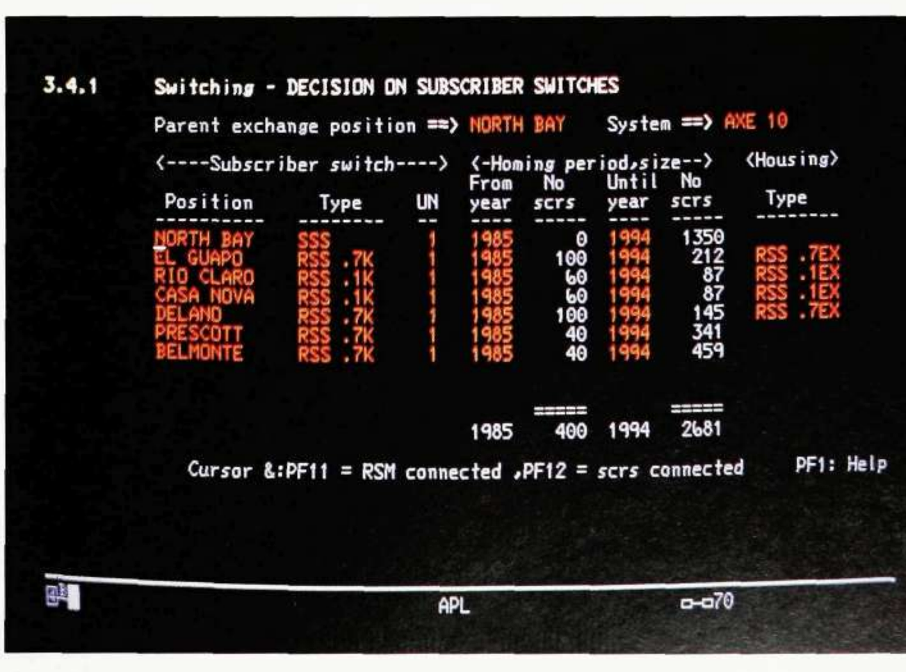
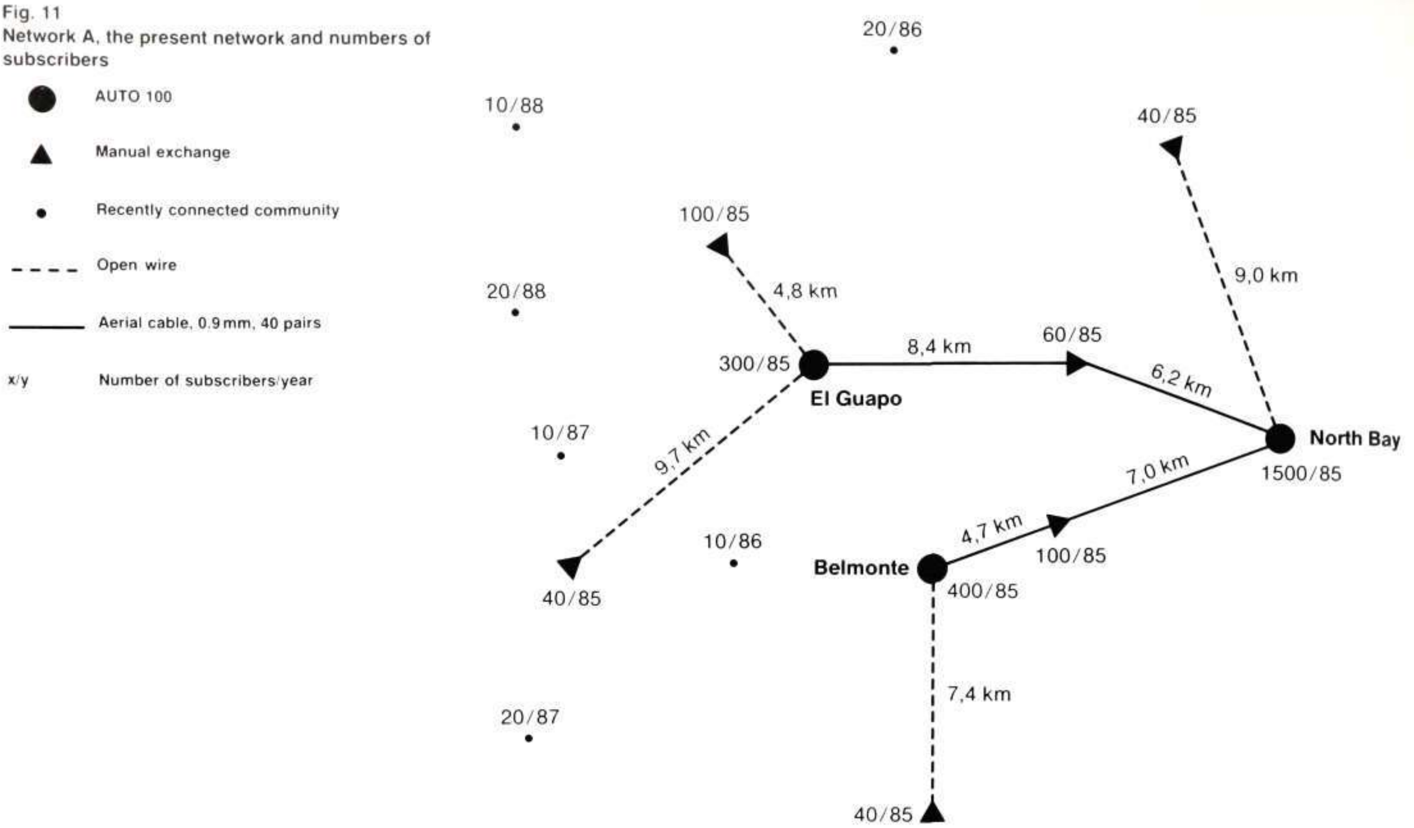


Fig. 10
A panel concerning remote subscriber stages

Fig. 11
Network A, the present network and numbers of subscribers



Data for network A

Area size	30×30 km
Number of subscribers	
1985	2 600
1994	4 900
Communities with automatic exchanges	3
Communities with manual exchanges	6
New communities	6
Subscriber growth rate	
North Bay, Belmonte, El Guapo	10% annually
Other communities	5% annually
Traffic	0.05 Erlang/subscr.

sibilities for centralized operation and maintenance offered by system AXE 10 are exploited.

Network A

The existing network and its specific conditions are shown in fig. 11 and the associated fact panel. The principal towns, Norht Bay, Belmonte and El Guapo, are equipped with automatic exchanges. They are surrounded by communities containing manual exchanges, but also some which at the start of the planning period have no telecommunications. The transmission network is largely built up of open wire or pair cables on pole lines.

The overall plans for the area are as follows. The manual exchanges are to be automatized at the beginning of the planning period. In new communities subscribers are put on a waiting list until the network can be extended. The open wires are to be replaced for maintenance reasons.

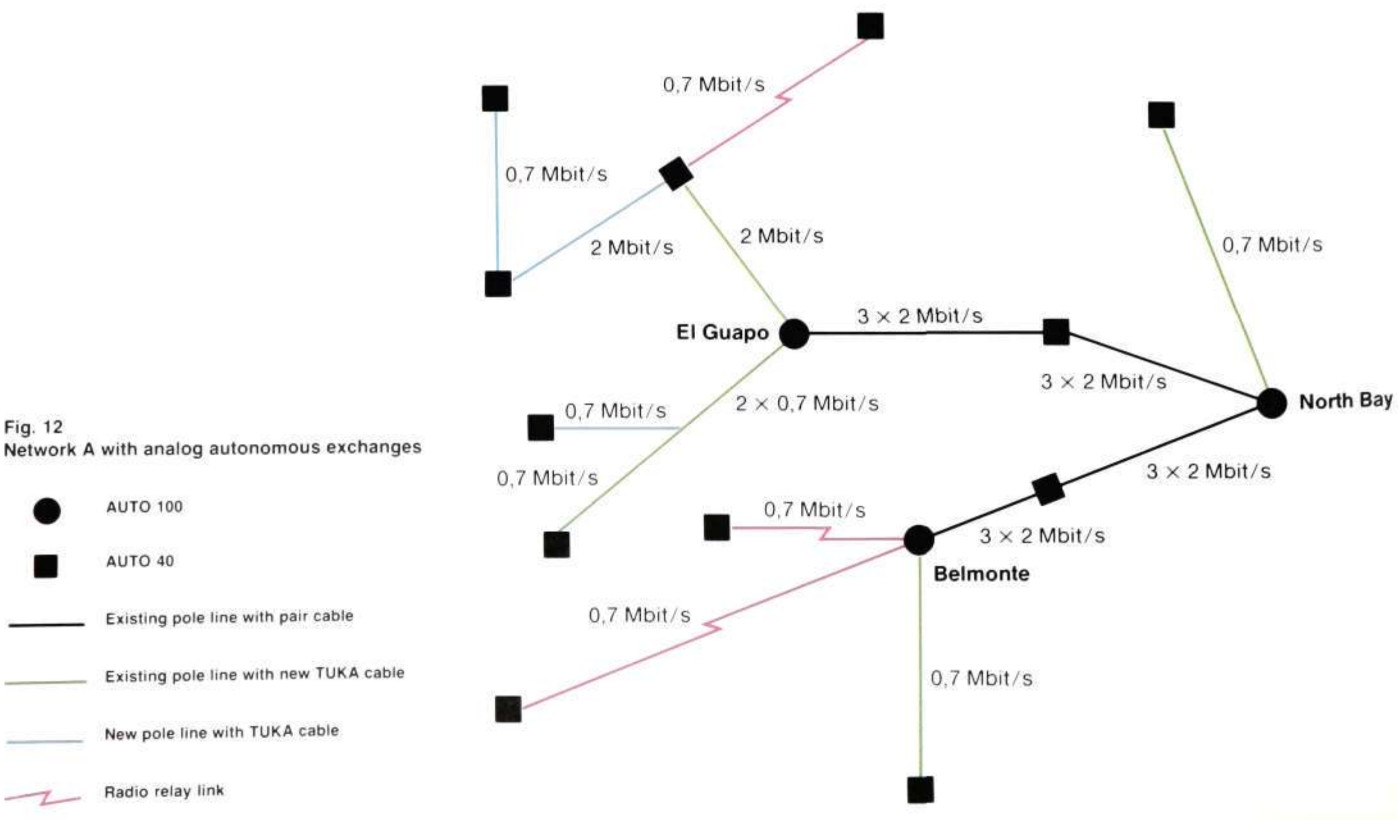


Fig. 12
Network A with analog autonomous exchanges

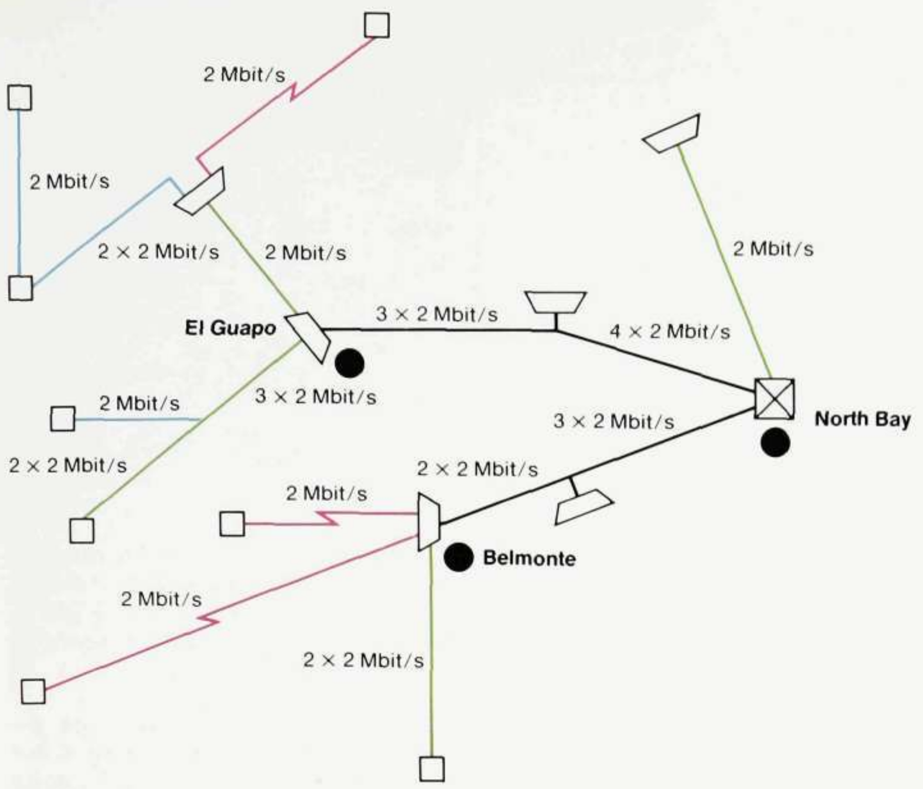
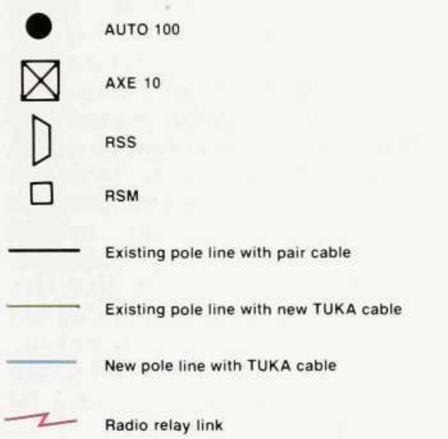


Fig. 13
Network A with Ericsson's system package for rural networks, with the analog exchange retained



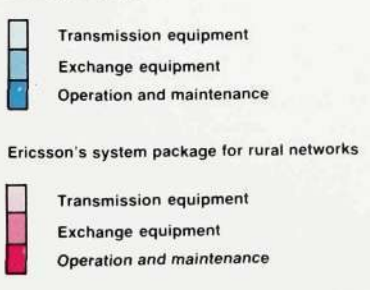
The alternative with autonomous exchanges means that the automatic exchanges in the principal towns will be extended as the need arises. In other communities new analog exchanges will be installed, whose traffic will be transited through the exchanges in the principal towns. Digital 2 Mbit/s line systems are to be installed on existing pair cables between the main towns, since the cable capacity on these routes is insufficient for physical circuits. On other routes digital line systems for 0.7 or 2 Mbit/s on TUKA cable of MINILINK will be installed depending on the capacity requirements, transmission conditions and infrastructure.

The alternative with Ericsson's system package for rural networks means that an AXE 10 exchange will be installed in the principal town North Bay. RSS or RSM will be installed in other places in order to minimize network costs. In all three principal towns the analog exchanges will retain their present subscribers, but new subscribers are to be connected to AXE 10 or RSS, i.e. the growth in subscriber numbers will be handled by digital equipment.

The analog exchanges are connected together via physical circuits over existing pair cables, whereas the new digital exchange equipment is connected by 2 Mbit/s systems over existing pair cables, TUKA cables or radio relay links, depending on local conditions.

The network structures for the two alternatives for the final year 1994 are shown in figs. 12 and 13. Fig. 14 and table 2 give the investments and present values. It should be noted that overall the integrated digital network plan with AXE 10 gives approximately 19% lower costs, present value, than the analog alternative. The reason for this is that the integration of transmission and switching reduces the cost of multiplexers and signalling equipment, and that the remote units (RSS, RSM) are more suitable for small subscriber numbers than the autonomous exchanges. Furthermore, with AXE 10 the opertion and maintenance costs are lower because of the centralization of these functions. Savings can also be made as regards buildings, since cabinets can be used for RSS and RSM, whereas the autonomous exchanges require containers.

Fig. 14
Network A, investments and present values



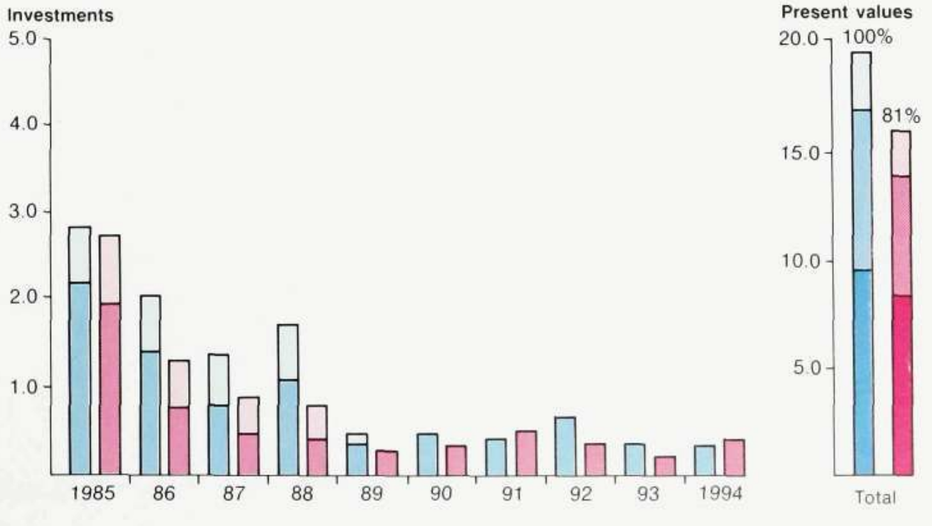
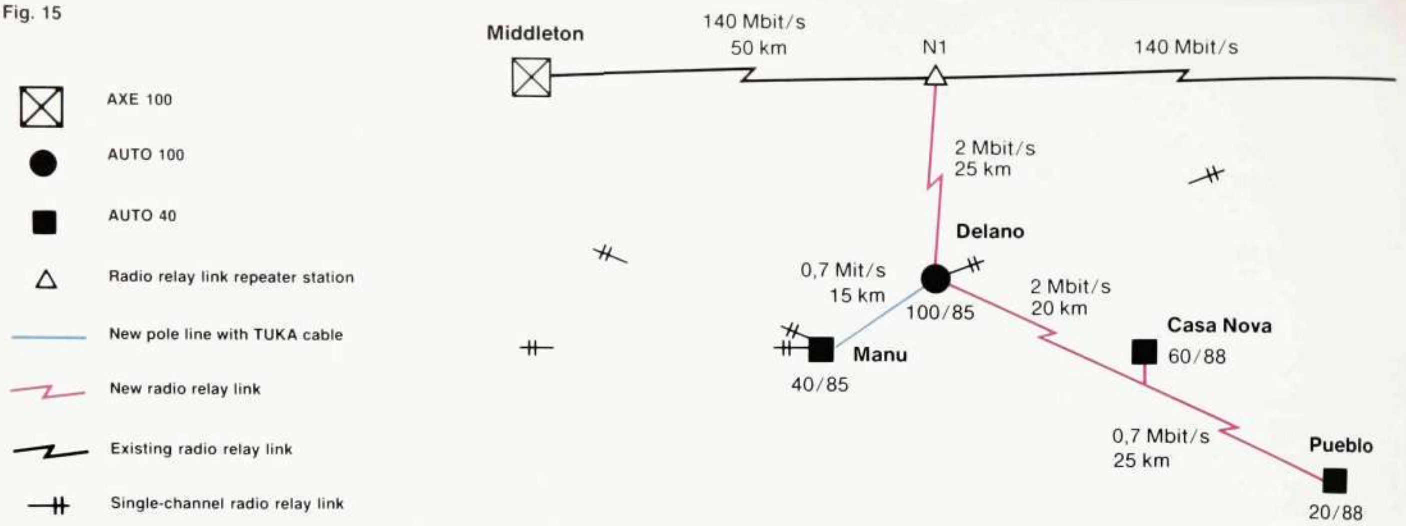


Fig. 15



It should also be noted that the difference in costs would have been larger if the planning period had been extended to the time when all analog exchanges had been taken out of service.

Network B

This area is situated approximately 25 km from a trunk route, which is equipped with a 140 Mbit/s system over a radio relay link with spare capacity. The trunk route terminates 50 km further on in an AXE 10 combined local and transit exchange.

The area contains two manual exchanges which are to be automatized at the start of the planning period. Two communities are to be provided with telecommunications during the period. There are open wire lines, but these are in such a state that they cannot be used for future transmission systems.

Fig. 15 shows the final plan using autonomous exchanges. AUTO 100 is used in Delano and AUTO 40 in the other communities. The terrain is such that a radio relay link is most suitable for the route Delano – Casa Nova – Pueblo, while a cable on a pole line is preferable between Delano and Mano since a radio relay link would require an extra intermediate repeater station. A digital radio relay link is used for the route between the AUTO 100 in Delano and AXE 10 in Middleton, with the A/D conversion placed in Delano.

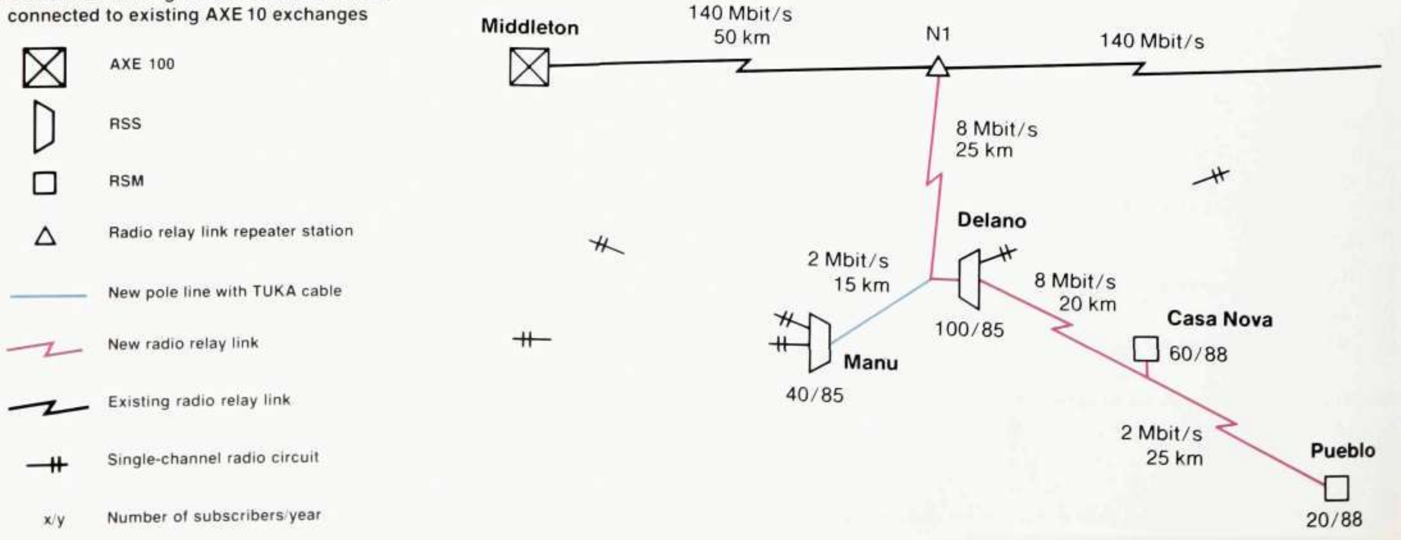
With Ericsson's system package for rural networks the existing AXE 10 exchange is used as the parent exchange for RSS and RSM, and the subscribers in the area are connected to the remote units, fig. 16. The 140 Mbit/s system is used for digital transmission between AXE 10 and the remote units in the area. RSM is preferable in Casa Nova and Pueblo, since the transmission costs are no higher than for an RSS, and the RSM requires less transmission capacity between Delano, N1 and Middleton. The conditions are different for Manu because cable is used for the transmission. RSS is preferable here, since an RSM would require two TUKA cables as against the one needed for the RSS. This is based on the assumption that the free capacity in the 140 Mbit/s system can be used free of charge. If this is not the case it might be more economical to use RSM also in Manu.

A comparison of present values shows that the cost of the digital alternative is approximately 34% lower than for the analog version, fig. 17 and table 2. The

Data for network B

Area size	75×50 km
Number of subscribers	
1986	140
1990	307
Communities with manual exchanges	2
New communities	2
Subscriber growth rate	
Middleton, Delano	10% annually
Other communities	5% annually
Traffic	0.03 Erlang/subscr.

Fig. 16
Network B with digital units, RSM and RSS, connected to existing AXE 10 exchanges



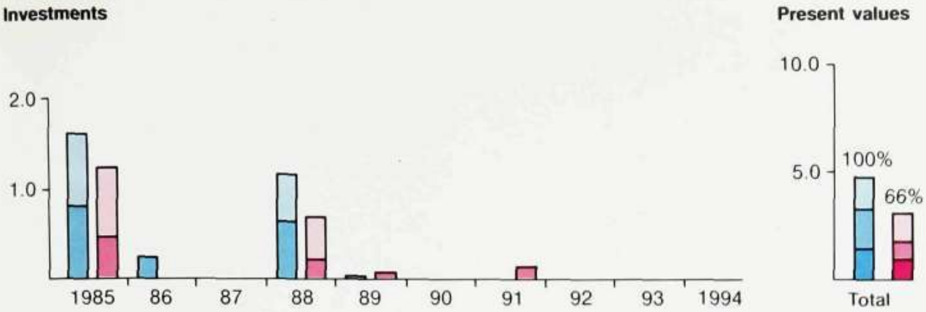


Fig. 17
Network B, investments and present value

Analog exchanges

- Transmission equipment
- Exchange equipment
- Operation and maintenance

Ericsson's system package for rural networks

- Transmission equipment
- Exchange equipment
- Operation and maintenance

reasons for this are partly the same as for network A, but another factor in network B is that the existing AXE 10 exchange can be used as the parent exchange for remote units in the rural area.

Conclusion

Ericsson's digital system package for rural networks gives integrated network designs with a high functional level, from the point of view of the subscriber as well as the administration, at a low overall network cost. Some of the features that contribute to this are:

- the use of stored program control and digital technology
- integration of transmission and switching
- the use of remote units, RSS and RSM, suited to small numbers of subscribers
- advanced operation and maintenance functions.

A computerized planning aid has been developed to facilitate efficient network planning. The aid makes it possible to quickly dimension and cost different network alternatives over a given planning period. The network model used in the aid is adapted to rural conditions. The planner works interactively with the computer by means of menus and panels. He needs only a minimum of computer knowledge in order to be able to operate the aid.

Two ficticious networks have been planned as examples. They show how a network can be planned with small, analog autonomous exchanges or with products in Ericsson's digital system package for rural networks. The economic evaluation shows that the network costs are 19% and 34% lower for the digital alternative than the analog plans respectively. The results show that Ericsson's products are well suited for a large range of applications also in rural areas.

Table 2
Distribution of costs, present value

	Network A		Network B	
	Small analog exchanges	Ericsson's system package	Small analog exchanges	Ericsson's system package
Electronics	6322	5143	1573	801
Buildings, power	1097	316	250	46
Total, exchanges	7419	5459	1823	847
Multiplexers	893	149	380	175
Line systems	355	485	30	53
Radio relay links				
Electronics	522	522	493	543
Mast and antenna	223	223	125	125
Cables	402	531	116	116
Installation	231	231	300	300
Total, transmission	2626	2141	1444	1312
Total network investment	10042	7760	3267	2159
Operation and maintenance	9468	8249	1534	1016
Total, present value	19510	15849	4801	3175

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Passive Cooling of Premises for Electronic Equipment

Rune Alexandersson, Anders Junborg and Hans-Jörgen Vesterberg

Ericsson has developed an extremely reliable cooling system for modern electronic equipment. The system works passively, which means that the heat is removed from the electronic equipment solely by means of spontaneous and natural processes. The system is driven by the heat produced by the electronics. The passive cooling equipment forms an important complement to Ericsson's active cooling equipment. The advantages of the passive method – no energy consumption and extremely high reliability at a low cost – are particularly evident in the case of small exchange units placed in cabinets or containers. The authors describe the background to the decision to develop passive cooling systems and the environmental requirements that have influenced the work. They also describe the main parts of the system, the overall economic aspects and the theoretical bases for the thermosyphon in the passive cooling system.

UDC 697.97:621.38

The passive cooling method has many advantages:
- Extremely high reliability, since the system is independent of external power sources and has no moving parts.
- Very good overall economy, since the investment cost is moderate, the equipment life long, the maintenance cost low and the energy cost non-existent.

The passive cooling method is most suitable for compact equipment installed in cabinets and for equipment in containers and small premises of conventional type.

Reliability

Equipment for public telecommunications requires high reliability. This is achieved by means of redundancy, careful selection of components and reliable power supplies. Reliable cooling equipment has also become very important in modern telecommunication engineering.

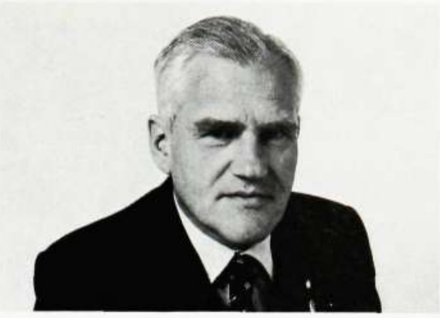
Modern component and system technology places great demands on efficient and reliable cooling. In the case of more decentralized network structures with remote, unmanned exchange units the need for reliable cooling is even greater.

Tradition of quality

Traditionally the operational reliability of Ericsson's telecommunication equipment has always been high. Great attention has been paid to all the links in the quality chain. This applies to everything from the overall system philosophy to the choice of components. Now that development has brought cooling technology into the picture the same high demands are made on the cooling equipment as on all other equipment.

The power density is seldom critical in conventional electromechanical systems, and hence the risk of operational

Fig. 1
A 20-foot container with passive cooling. The cooling modules are placed on the roof. The container can be used for different types of telecommunication equipment, such as remote subscriber stages, radio base equipment or PABX systems. The maximum permissible power loss in a warm climate is 3.5 kW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disturbances caused by too high temperatures is negligible. Modern electronic systems are more demanding in this respect.

A system which generates a high overall level of heat, with more concentrated heat generation in certain parts, requires special cooling mesures. Decentralized network structures and compact constructions lead the development towards unmanned exchange units that require reliable cooling systems with high capacity, particularly in hot climates.

Environmental requirements

The passive cooling system has been designed to provide an ambient temperature in accordance with Ericsson's environmental specification. The upper and lower temperature limits are +45°C and 0°C respectively. The limits are based on the permissible component temperature for system AXE 10.

The possible outdoor temperatures vary from −45°C to +50°C. The cooling system must be able to maintain the required indoor climate in spite of large temperature variations outdoors.

The dimensioning is based on the lower temperature limit. Instead of heating the premises the insulation is arranged so that the power loss in the electronic equipment gives the desired ambient temperature. The problem is then that the insulation increases the temperature indoors when the outdoor temperature rises. In a warm climate a destructive temperature level is soon reached. Traditionally this problem has been solved by means of conventional cooling equipment or some form of ventilation. In Ericsson's passive cooling system, the heat is transferred out of the room by means of a liquid circulation, a thermosyphon, which is dimensioned so as to maintain the indoor temperature within the permissible limits in spite of any external variations.

The passive method

The solar water heater is a common application of a thermosyphon. Water is heated by the sun in a collector, rises and is stored in a tank, fig. 4b.

The cooling application can be said to be a reversed water heater. The collector corresponds to a cooler which works at night. The environment cools water, which sinks. Thus the coolness is stored in the thermal mass of the system. The cool water is used to cool the electronics during the day, fig. 4c.

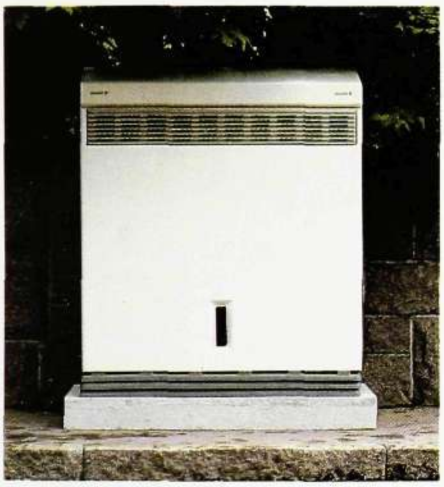
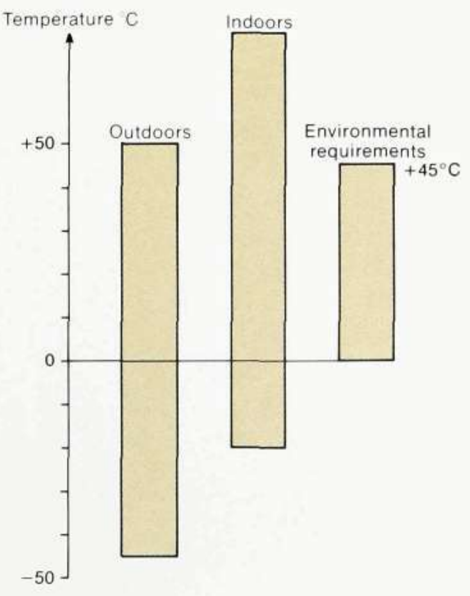


Fig. 2
An outdoor cabinet used for the remote subscriber stage, RSS, for 128 subscribers and the remote subscriber multiplexer, RSM, for 30 channels. The maximum permissible power loss is 320 W. The cabinet is sealed and passively cooled through self-convection of air



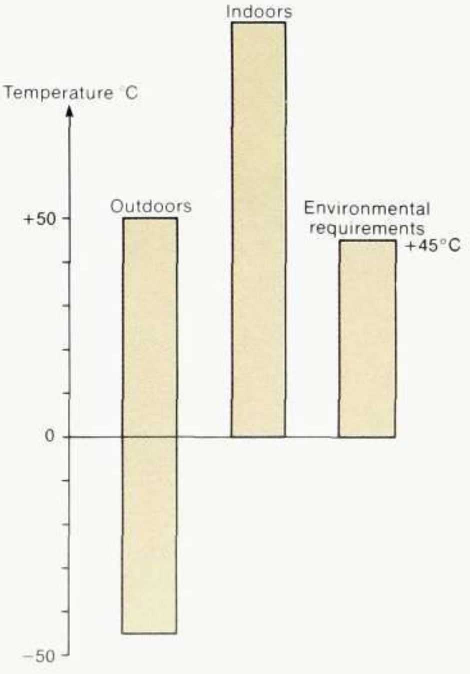
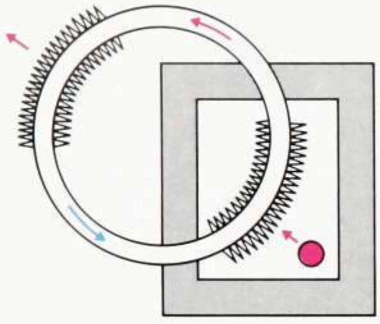
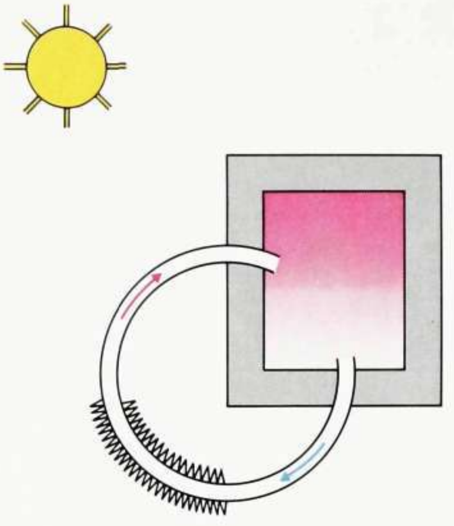


Fig. 3a
The problematic areas in passive cooling: outdoor and indoor temperature limits and environmental requirements

Fig. 3b
Shifting the problem area by insulating the room or premises in order to meet the lower temperature limit





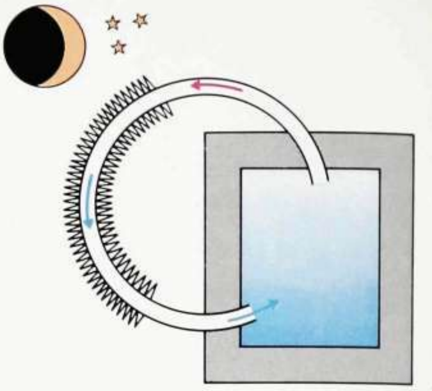


Fig. 4a
The basic principle of the thermosyphon

Fig. 4b
The thermosyphon used to heat liquids

Fig. 4c
The thermosyphon used to cool liquids

The four main parts of the passive cooling system

A fully buil-out system for passive cooling has four main parts: solar protection, insulation, thermal mass and thermosyphon.

The equipment to be cooled can for example be electronics in a container where

- the solar protection merely consists of the white exterior paint on the container
- the insulation in the walls eliminates the need for heating during the cold season and reduces the effect of the environment on the variations in the ambient temperature during the 24 hours of the day
- the thermal mass consists of walls and other parts of the room and the equipment, but above all the accumulator tank in the system. It stabilizes the daily cycle by accumulating heat during the warm part of the day. The heat is then removed from the container, mainly during the night
- the thermosyphon consists of a heat exchanger and pipes for the water flow.

The function of the thermosyphon is based on the fact that a warm liquid rises and a cool one sinks. The heat is therefore transferred upwards, and the circulation works like a thermal diode, fig. 4a. The thermosyphon is driven by the energy given off by the electronic equipment.

The physical properties of the liquid that govern the circulation are related to its temperature, and make the thermosyphon more eficient as it gets hotter. Low ambient temperatures are handled by choosing a mixture of liquids for the thermosyphon, for example water and glycol, that stops the circulation before the lower temperature limit is reached. The necessary automatic control is thus obtained by means of the choice of liquid.

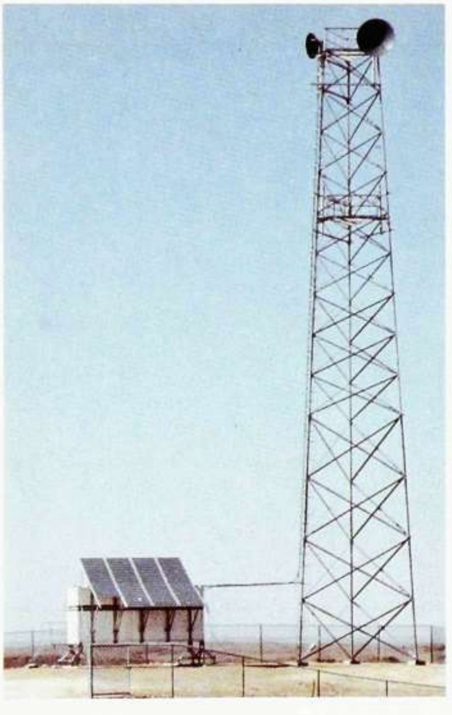


Fig. 5
This passively cooled container is used for a radio relay link. The power loss is 500 W. The radio equipment is powered by the solar panels on the roof. The passive cooling system is built into the walls

Economy

A comparison of economic calculations shows that the passive system is most economical, even when compared with a conventional air conditioning system. The long life of the passive system results in low depreciation costs.

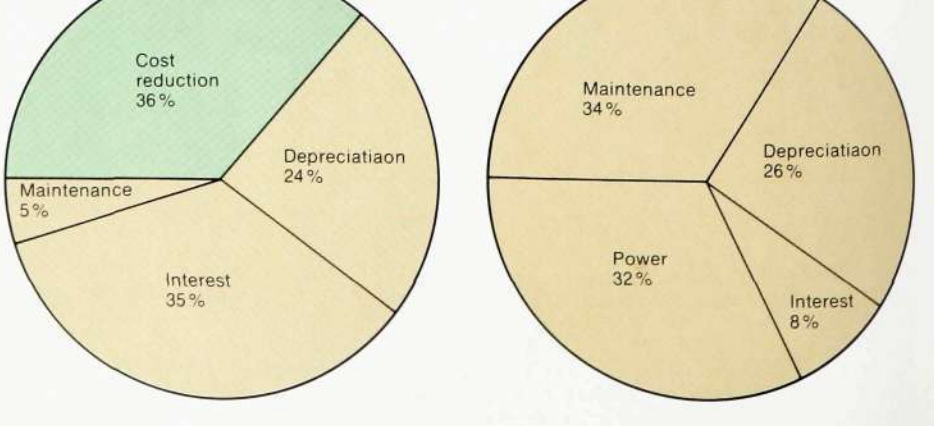


Fig. 6
Cost comparison of different cooling methods. The figure shows the life cycle costs for two systems, one with passive cooling and one with conventional air conditioning units. Other qualities, such as reliability and freedon from interruptions, have not been taken into account

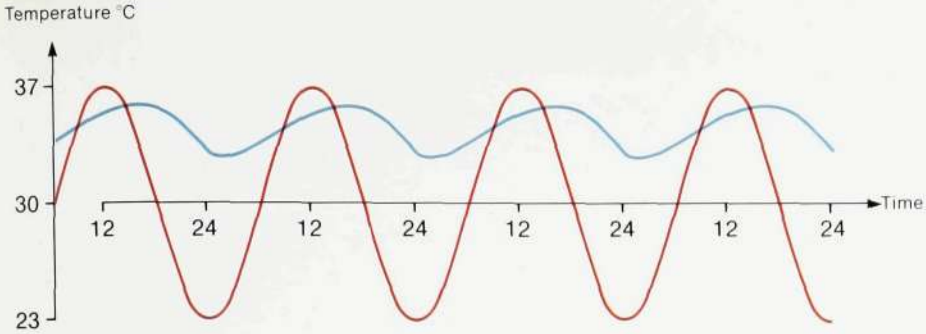


Fig. 7
Ambient temperature as a function of the outdoor temperature for typical climatic conditions

Ambient temperature

Outdoor temperature

The total power comsumption of a plant with passive cooling is approximately 30% lower than that of an equivalent plant with active cooling because the passive system does not require an external power source. The lower power requirement means that equipment with low power consumption, for example radio relay links, can be powered by primary power from solar cells and wind generators.

Maintenance costs are kept low because the passive cooling equipment has no moving parts. There are thus no problems caused by wear and ageing. The simple and robust construction is almost maintenance-free, and hence it is not necessary to make urgent service calls. Planned maintenance with preventive action is sufficient.

Small exchange units with conventional cooling have very little in the way of cooling reserves. A mains failure will quickly result in the temperature rising to a destructive level. In areas with uncertain power supplies there is therefore a real risk of interruptions in the telphone service. The administration then risks losing income and goodwill.

The theory of the thermosyphon

In applications that are similar to passive cooling, such as solar heaters or cooling systems for light water reactors, single phase thermosyphons are used, in which heat is transferred by means of natural convection.

Zvirin has compiled an excellent bibliography and summary of theoretical and experimental work on thermosyphons.[1]
With natural convection the flow is caused by temperature differences. The heat transfer and the flow are therefore coupled processes that cannot be considered separately as in forced convection.

Natural convection is governed by the basic conservation principles for mass and energy. A simplified one-dimensional model is normally used, with the spatial coordinates orientated around the thermosyphon and with non-compressible liquid. The continuity equation then states that the flow is constant along the circulation path, being a function only of time.

The momentum equation in the direction of circulation can be given as

$$\varrho \frac{\delta u}{\delta t} = -\frac{\delta p}{\delta s} + \varrho g \cos\varphi - F_s$$

F_s friction force per unit volume
g acceleration of gravity
p pressure
s spatial coordinate in the direction of flow
t time
u velocity
φ angle between the directions of flow and gravity
ϱ density

The pressure component is eliminated by integrating the momentum equation around the loop. At steady state the equation is reduced to

$$-g \oint \varrho \, dz = \text{constant} \times Q^2$$

where z is the vertical coordinate and where the friction has been taken as proportional to the square of the flow Q.

The left-hand side (the engine or chimney effect) is the difference in pressure between the cold and the warm parts of the circulation. The right-hand side (the break or friction) is dependent on both the type of flow (Reynolds' number) and the geometry of the thermosyphon.

The energy equation at steady state,

$$m c u \frac{dT}{ds} = P = h A \Delta T$$

A area
c *specific heat*
h heat transfer coefficiant
m mass
P power
T temperature

states that the increase in thermal energy is equal to the input power. This equation makes it possible to study the temperature change along the circulation path for a given flow. Since the heat transfer coefficient for a cooling unit is dependent on the actual temperature difference the calculations will have to be iterative.

In order to be able to use the thermal model over a large temperature range it is also necessary to take into consideration the temperature dependency of the physical properties of the liquid.

A numerical value for the flow is obtained from the coupled equations in an iterative process. Other quantities of interest, such as temperatures and power, can then be determined.

By studying the conservation of energy of the different thermal masses in the system in accordance with (thermal mass) x (temperature increase) = (input power) it is then possible to calculate the temperatures in the different parts of the system.

Summary
It is difficult to dimension passive cooling equipment merely with the aid of simple rules of thumb, because of the complexity of the basic relationships. It is very risky to generalize on the basis of inividual practical cases. However, computerized measurement and calculation methods, together with verification using full-scale models in climatic chambers, ensures the optimum dimensioning of cooling equipment for different applications.

Conclusion

Ericsson's passive cooling system offers extremely reliable temprature regulation for most electronics environments: compact cabinets, containers and more conventional exchange premises. The system can be installed in new plant, as well as when extending and modernizing existing plant.

In all cases the passive cooling method meets the demands for lower energy consuption that are being made by telecommunication administrations and other cost-conscious customers around the world.

Ericsson's passive cooling system is an economically competitive and attractive cooling method.

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Microprocessor-Controlled Equipment for Automatic Battery Charging

Peter Ahl

The cost of accumulator batteries in interruption-free power supply systems is considerable. Ericsson has therefore for a long time been developing equipment for automatic battery charging. It increases the battery life and thereby reduces the costs.
The author describes a new type of equipment which is controlled by a microprocessor. The battery current is monitored in order to determine whether the charging is to be started or stopped. The equipment can be used independently or be included in the recently developed system for computer-controlled power supply, ERICSSON ENERGYMASTER.[2]

UDC 621.355:681.31-181.4

Accumulator batteries constitute a very important part of interruption-free power supply systems for telecommunication plant. For example, in the case of a mains failure they have to supply the telecommunication equipment with energy as long as the failure lasts or until a standby power plant is started up. Ericsson's d.c./d.c. booster converter system BZD 412 for 400 A, fig. 1, is one power supply system that includes batteries.

The batteries are responsible for a large part of the cost of an interruption-free power system. The life of the batteries is therefore significant when assessing the cost of the whole power supply system. Good battery maintenance can give a life of 10–15 years, whereas neglected maintenance can reduce the life to less than five years.

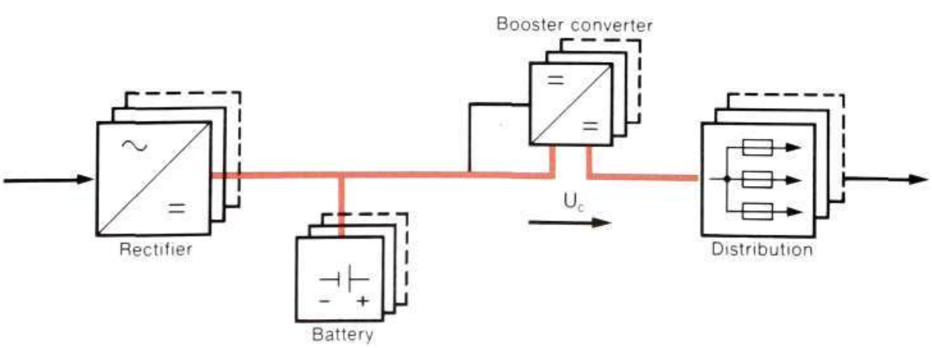
The charging is a major factor in battery maintenance. Lead accumulators must be kept fully charged. If the charge drops sulphation occurs in the battery, which reduces its capacity. On the other hand overcharging means increased water consumption, faster deterioration of the positive plates and an undesirable rise in temperature. In extreme cases the temperature can jump to a level that destroys the battery.

Manual charging of batteries in a plant is time consuming and requires well-trained staff who follow the manufacturer's instructions carefully. This means high maintenance costs.

Batteries that have been discharged must be charged again as soon as the mains power returns. This may be problematic in the case of unmanned equipment that is not provided with a system for automatic charging.

The correct maintenance of batteries can thus be both complicated and costly, and there is a large field open to equipment for automatic charging.

Fig. 1
Booster converter system BZD 412



Previous equipment

Ericsson has long been manufacturing and supplying equipment for automatic battery charging and has thereby acquired considerable know-how. In 1979, a completely new principle for automatic battery charging was introduced with equipment BMP 130. It was based on monitoring and constant control of the charging current with the aid of a special current measuring device, figs. 4 and 5. Current-controlled charging has proved to be the most suitable method for assessing the charging state of a battery and it has therefore been retained in the new equipment.

Time-controlled charging is another method for automatic battery charging. It is used in, for example, equipment BMP 131. The equipment monitors how long discharging has been going on. The batteries are then charged for a time that is proportional to the discharging time.

For more detailed information concerning these equipments reference should be made to previous articles in Ericsson Review.[1-4]

Battery charging

In Ericsson's power supply systems battery charging is normally carried out by increasing the voltage of the feeding

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rectifier to approximately 2.35 V per cell. This is done in order to increase the receptivity of the battery to energy and thus ensure quick and reliable full charging. When the battery is fully charged the voltage is reduced to a float charge level of approximately 2.20 V per cell. This may sound simple, but the difficulty lies in determining when the charging should be started and stopped.

The charging process can be divided into three stages, fig. 2a.

Stage 1 starts by a charging signal being sent to the rectifiers in the system. The charging current is limited by the current limiting device in the rectifier. The charging voltage increases continuously with the charge of the battery and finally reaches the nominal charging level. The time taken by stage 1 is determined primarily by how low the battery charge was and how high the available charging current is. Stage 1 is completed and stage 2 is entered when the charging voltage becomes constant.

During stage 2 the charging current decreases successively as the battery charge increases. When the charging current falls very slowly the charge of the battery is approaching 100%.

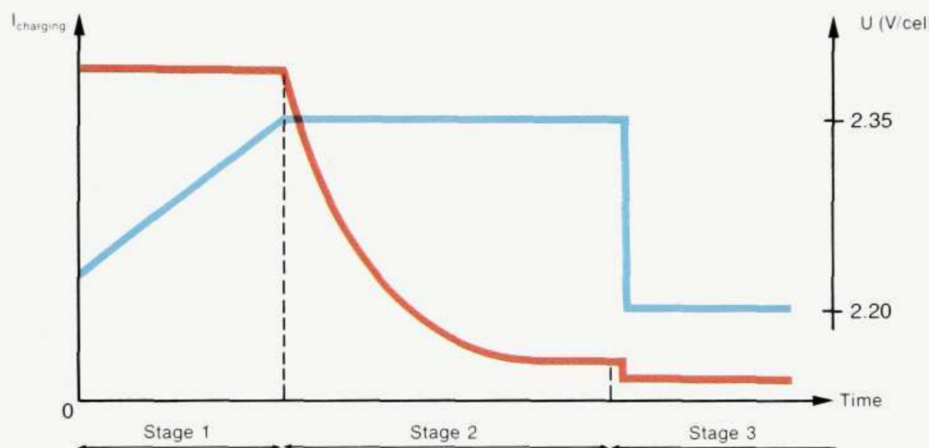

Fig. 2a
An example of the charging process

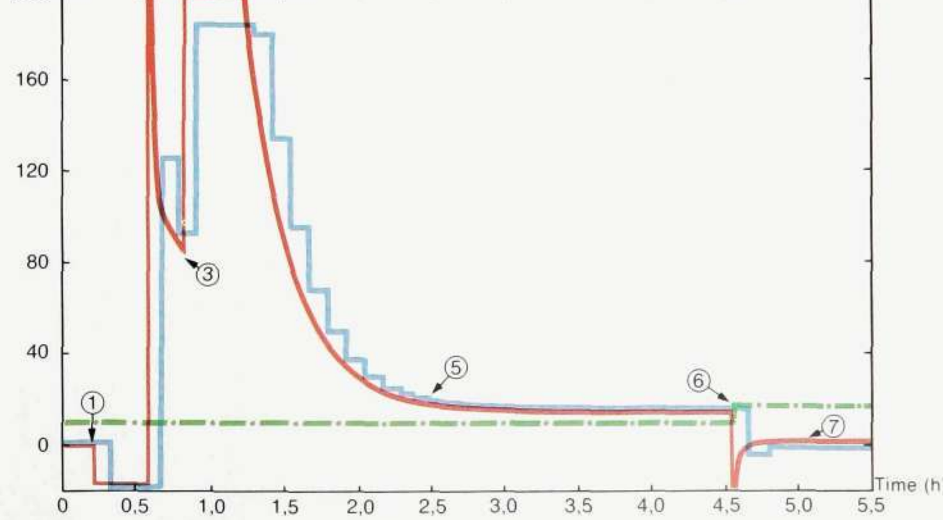

Fig. 2b
Charging with BMP 132 in booster converter system BZD 412.
Equipment: 1 accumulator battery (1320 Ah), 2 × 400 A rectifiers, 2 × 400 A converters

- 1 The mains voltage disappears. The battery is discharged. The current measuring device measures a maximum discharge current of 20 A.
- 2 The mains voltage returns. The rectifiers give float charge voltage and the battery starts charging.
- 3 The automatic battery charging unit sends a signal to the rectifiers to increase their output voltage to the charging level. The current to the battery increases further. The rectifiers limit the current, and hence the battery voltage does not reach the charging level immediately. The time required is dependent on the extent of the battery discharge, the load current and the number of available rectifiers.
- 3–4 If the current to the battery exceeds 200 A the measured values are limited to 200 A and approximately 180 A respectively.
- 5 The charging current starts to level off to a constant value.
- 6 The rectifier voltage is reduced to the float charge level. The last calculated mean current value is recorded as the final charging value.
- 7 The battery current has been stabilized at the self-discharge level.

Red line: Current values from the current measuring device
Blue line: Measured current from BMP 132
Green dash-dot line: Final charging current from BMP 132

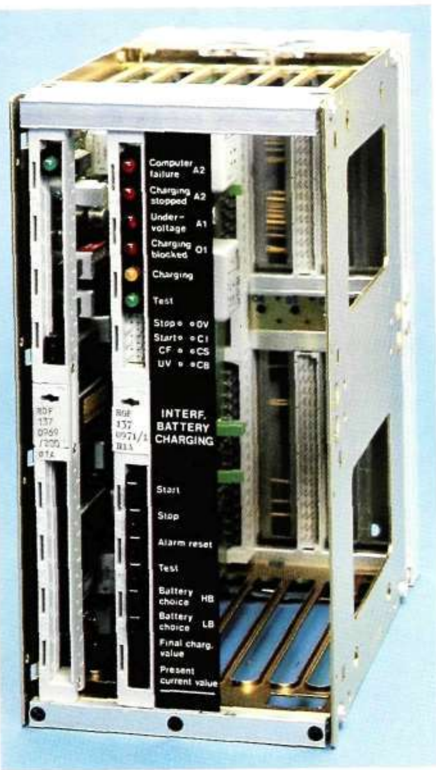

Fig. 3
Control unit for automatic battery charging

During stage 3 the charging current levels off and the battery is no longer being charged. In order to avoid overcharging the charging voltage must be reduced to the float charge level as soon as the current stops decreasing. The purpose of the float charge is to compensate for the self-discharge of the battery.

Final charging current

The battery current at the end of the charging is called the final charging current. Its value varies greatly (several 100%) and is mainly dependent on

- the temperature of the battery. An increase of approximately 10% in the temperature of the acid doubles the final charging current.
- the age of the battery. The final charging current can be 3–5 times larger for, for example, a 5–6 years old antimony alloy lead battery compared with a new one.

These characteristics make the final charging current a very useful tool for measuring the condition of the battery. In the new battery charging equipment it is recorded as the final charging value. The variations in the final charging current should also be considered when formulating the conditions for the cessation of the charging.

Fig. 2b shows an actual charging process using the new battery charging equipment.

BMP 132

The new, microprocessor-controlled equipment for automatic battery charging is designated BMP 132. It is based on the earlier equipment BMP 130, which it is intended to replace. BMP 132 is controlled by a program stored in the microprocessor.

The functional principle is current-controlled charging. With this method the batteries are always fully charged without any unnecessary overcharging. The equipment consists of a control unit and a number of current measuring devices of the same type as used in BMP 130. The equipment monitors the current to the battery. A high charging current means that the battery is discharged, so if the measuring devices detect a high current the control unit initiates charging in the way described above.

The greatest difference between BMP 132 and BMP 130 is in the circuit designs. Modern components, such as microprocessors, memory circuits, digital/analog converters and digital peripheral circuits, are used in the BMP 132 control unit. This has made the equipment cheaper and also more reliable and flexible.

The equipment can be used on its own or together with Ericsson's computer-controlled system ERICSSON ENERGYMASTER (EEM). EEM is a system for the control and supervision of power supply equipment. Each unit in the system has a built-in local computer which communicates with a common main frame computer. The main frame controls the local computers, which in their turn control the units. A terminal connected to the main frame allows an operator to control the units. In EEM the battery charging equipment also has other functions, such as monitoring the fuses.

The mechanical construction of BMP 132 differs from that of BMP 130 only in minor details, and BMP 132 can thus replace older equipment.

BMP 132 is primarily intended for Ericsson's 400 A system, but the microprocessor control means that it can easily be modified to suit other 48 V systems without having to change the hardware. This is the great advantage of the new equipment since it is thereby possible to meet individual customer demands.

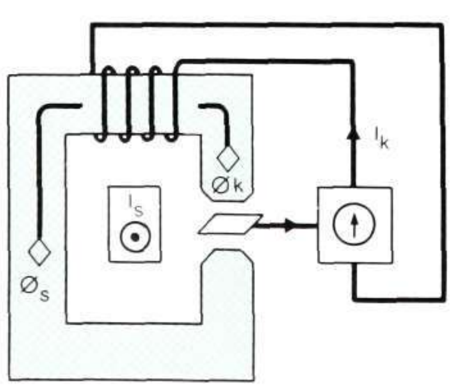

Fig. 4
Current measuring device ZTE 012 02
The current is measured using a magnetic compensation method, with a Hall element as the detector which controls the current I_k so that the flows Φ_s and Φ_k are equal. Flow Φ_s is caused by the battery current. The current I_k gives a voltage drop across a shunt resistor. The voltage is used as the measured value

Fig. 5
Current measuring device
The device is mounted around the charging current busbar. One end of the device is removable, so that installation can be carried out during operation

Construction

The equipment consists of a control unit, fig. 3, which contains a single-board local computer, LC, of the type used in EEM. When BMP 132 is used on its own it is supplemented with an interface board, IF. The control unit can be installed in the power distribution equipment. BMP 132 also includes 1–3 current measuring devices of type ZTE 012 02, fig. 4. These are mounted around the busbars that carry the battery currents, fig. 5, and they are connected via the power distribution to the board magazine connector. The same connector is also used for connecting in the −48 V feeding voltage, distribution alarms, EEM communication etc. The number of current measuring devices used is specified either by a command from EEM or by straps on IF. Fig. 6 shows a circuit diagram of the battery charging equipment.

LC is a measurement and control computer, fig. 7, built up around an 8-bit microprocessor with a 2 kbyte data store and an 8 kbyte program store. The printed board assembly also includes a digital/analog converter and digital interface circuits. The board is equipped with a communication connector of type RS 422. An internal d.c./d.c. converter provides the board with the necessary voltages.

When EEM is not used IF is needed to control the battery charging and to indicate alarm conditions. IF transmits the charging signal and alarm signals. The board also contains alarm circuits for monitoring the microcomputer and the −48 V power feeding. A connector on the front makes it possible to start and stop the charging by remote control.

Function

The equipment is stored program controlled, which means that the contents of the program store in the local computer controls the function of the equipment. The LC software is identical for all LCs in EEM, which means that any LC can be used in the battery charging equipment, a fact which simplifies the stocking of spares. The function of the board is changed by means of a switch, fig. 8.

LC monitors the state of the power distribution and communicates with EEM, or with IF if the equipment is autonomous. The communication with EEM is interruption controlled, resulting in short response times. If the equipment detects that a charging condition has been fulfilled it sends a signal to the system rectifiers, via EEM or IF, which raises the rectifier voltage to the charging level. Otherwise the voltage is normally kept at the float charge level.

The current is measured continuously, and every 7.5 minutes a mean value is calculated in LC. Here it is compared with the previous mean value or the final

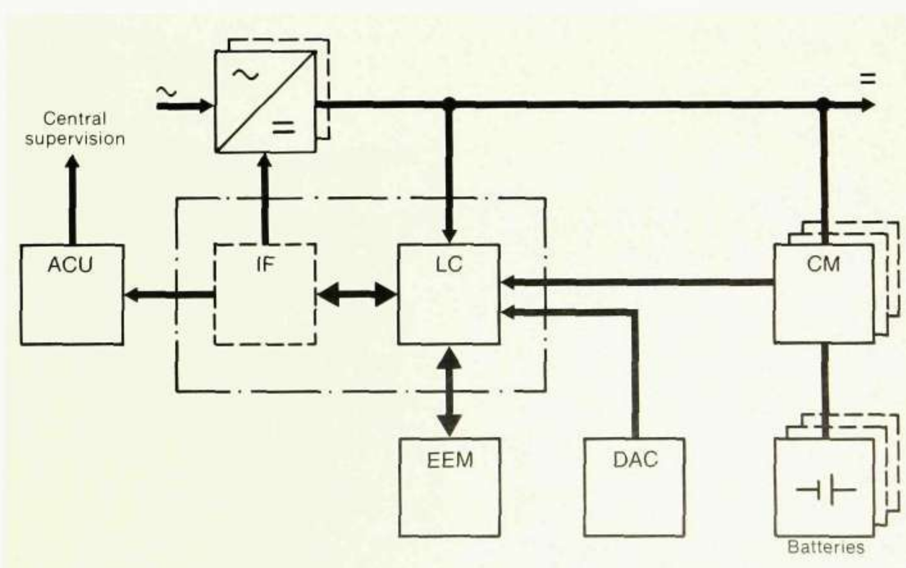

Fig. 6
Block diagram of the battery charging equipment

EEM ERICSSON ENERGYMASTER
LC Local computer
IF Interface board
CM Current measuring device
ACU Alarm concentrator
DAC Distribution alarm circuit

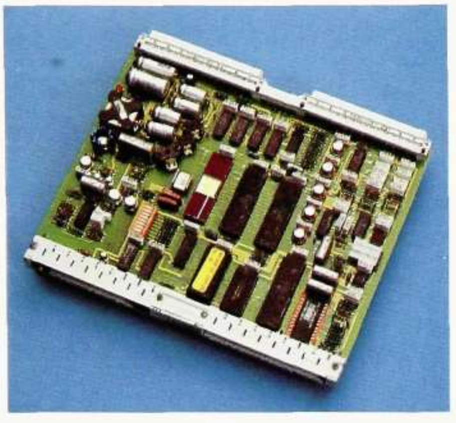

Fig. 7
The local computer
The printed board contains the MPU, memory, I/O circuits and a d.c./d.c. converter

charging value for a decision regarding any action to be taken. The battery voltage and a number of distribution alarms are also monitored. The alarms are transmitted to EEM, or to the power unit alarm concentrator if IF is used. The equipment can be controlled from EEM, or from IF if desired.

The different conditions for starting the charging are:
- The current to a battery exceeds the last final charging value by 10 A during two consecutive 7.5 minute periods. This is what normally happens after a mains failure.
- Three weeks have passed since the last complete charging. This compensates for the self-discharge of the battery and any differences between the battery cells are equalized.
- Manual start signal from EEM or IF. This is used, for example, when the battery has been topped up with water.
- Test signal from EEM or IF. The starting process is approximately 20 times faster than normal. This function is used for functional testing of the equipment.

The charging can finish in two ways: either the accumulator battery is fully charged or the charging has been faulty. The latter case results in an alarm.

Full charging is indicated by the fact that constant charging current has been obtained for a period of two hours from all batteries. The current is considered as constant if the difference between two 7.5-minute periods is less than or equal to 0.8 A. The condition that constant charging current must have been obtained helps to circumvent the problems caused by any changes in the battery characteristics resulting from temperature and ageing. The equipment stops the charging and records the last current measurement as the final charging value.

Faulty charging is indicated if
- the current exceeds 180 A for any battery for a period of ten hours.
- constant current has not been obtained within 24 hours.
- it is found during two subsequent 7.5-minute periods that the current has increased by 10 A or more above the minimum value for the charging period. If this should happen, the charging must be interrupted to protect the batteries from thermal avalanche, which would otherwise destroy them.

Any faulty charging condition results in the charging being stopped and the initiation of an alarm. The charging is blocked until a reset signal is obtained from EEM or IF. The charging can also be interrupted by a signal from EEM or IF.

A printout showing the present mean current values, final charging values, battery voltage and alarm states can be obtained via a terminal connected to the EEM system. Altenatively this information can be obtained from LEDs and signal outputs on IF. The front of the interface board contains two voltage outputs for measuring the latest mean current value and final charging value. These outputs give a voltage of 0–9 V, corresponding to a current of 0–180 A, fig. 9. This makes it possible to record the battery currents even when the equipment is used on its own. The selection of battery for recording is made by means of switches on the front of IF.

Adaptation to other 48 V systems

The new equipment is primarily intended for 400 A power supply systems. However, it can also be used in other

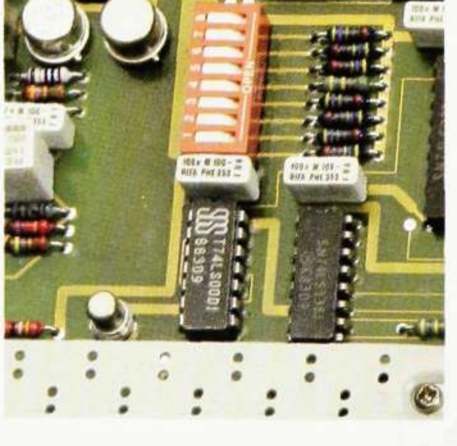

Fig. 8
Close-up of the switch on the local computer board

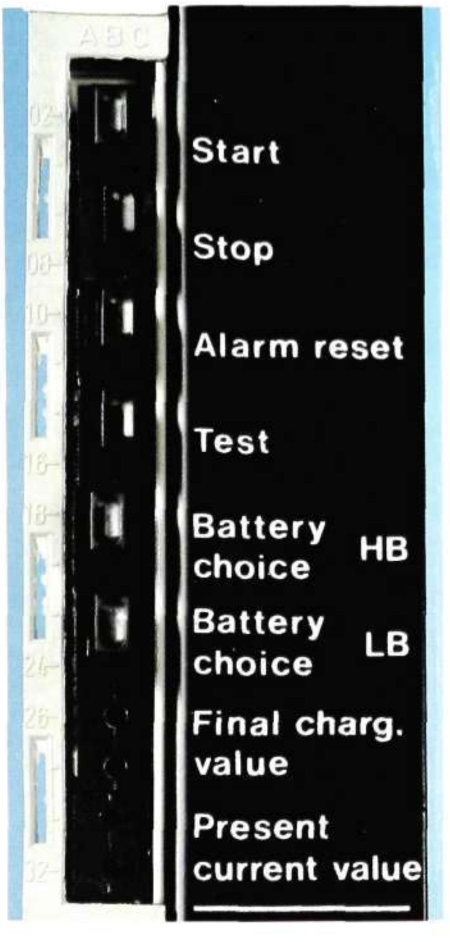

Fig. 9
Measurement outputs on the front of the interface board

48 V systems, for example the 100 A system.[4] This has been made possible by the microprocessor control and the great flexibility of the hardware. It is easy to change the supervision and control parameters in the program store, since it is contained in an EPROM capsule. It is also possible to introduce new routines in the battery charging program, using other principles, such as time-controlled charging, if desired. This increases the usefulness of the equipment even more.

Summary

BMP 132 has been developed on the basis of experience gained from earlier battery charging euipments. Modern electronic components, including a microprocessor, have been used in the circuit designs. Great importance has been attached to making the equipment reliable in all possible operating conditions.

The many advantages provided by the equipment include:
- It can replace previous battery charging equipment.
- It increases the battery life.
- It is adapted to ERICSSON ENERGYMASTER.
- It can be used independently.
- It is easy to use.
- It protects the battery against charging faults.
- It is stored program controlled.
- When required it records the charging process and the battery state.
- It has a current measurement system that is galvanically separated from the battery.
- It gives maintenance charging every third week.

Ericsson's new battery charging equipment is thus flexible and can be used in many applications, with or without the ERICSSON ENERGYMASTER.

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Microprocessor-Controlled Power Supply for Small Telecommunication Plants

Per-Edward Samsioe and Renzo Santi

For many years electronic telephone exchanges have been computer controlled, and also supervised by computer-controlled systems, for example the maintenance system AOM 101. However, up to now the supervision of power supply equipment has not been computer controlled. This trend has now been broken by Ericsson Power Systems with the recent introduction of their two newly developed power supply systems with stored program control of the operation as well as the supervision. The first system, BZD 412 for large plants[4], includes the control system ERICSSON ENERGYMASTER[5].
In this article a version of the power systm BZA 106 with microprocessor control for small plants is described.[3] The new system is particularly suitable for unmanned exchanges, whose maintenance costs can be drastically reduced with the aid of computer control and centralized supervision.

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Fig. 2
The system is mounted in a 19" rack. The units are readily accessible behind their doors

BZA 106 is intended to supply small, modern telecommunication equipment, such as remote subscriber stages and PABXs, with interruption-free power, fig. 1. The system consists of two 25 A rectifiers, batteries, a battery fuse unit, a control unit, a contactor unit and distribution equipment, fig. 2. The accumulator battery can contain either 23 or 24 cells. (Voltages given in the remainder of the article mostly related to the cell voltage. The real voltage is obtained by multiplying the cell voltage by the number of cells.) The equipment contains sufficient protection and supervision circuits to enable it to operate wholly automatically. The distribution voltage is kept within the limits set for electronic exchanges in all working conditions. The accumulator battery is charged in a manner that gives the longest possible life and which ensures that the batteries always hold the required standby power. The system voltage is 48 V and the distribution current a maximum of 25 A. The system is built up of components that require very little maintenance. For example, the MTBF for the rectifiers is calculated to be 62 years.

Centralized supervision

Supervision by microprocessor makes it possible to centralize the supervision and testing of a large variety of equipment. The communication between the power supply equipment and the central supervision equipment can take place over a leased or switched telephone line or a data network, fig. 3. This means that information concerning currents, voltages and alarm states can be obtained continuously. Computer-controlled test functions and detailed alarm information facilitate central analysis of any fault, which makes it easier to choose the right serviceman and spare parts for the repair. Central fault analysis also makes it possible to arrange the repairs in the best order if faults should occur simultaneously in several exchanges. For example, in the case of abnormally long mains failures it is easy to determine which batteries most urgently require extra charging from a mobile diesel generator. The microprocessor system is designed for supervision of the exchange batteries. Today these are checked by means of service visits at an interval of between three and six months. Central supervision and new battery types (low antimony batteries) enable the intervals between service visits to be extended to up to 2 years. Hence the introduction of microprocessors in the power supply equipment for telephone exchanges opens wide possibilities for simplified maintenance, resulting in greatly improved economy.

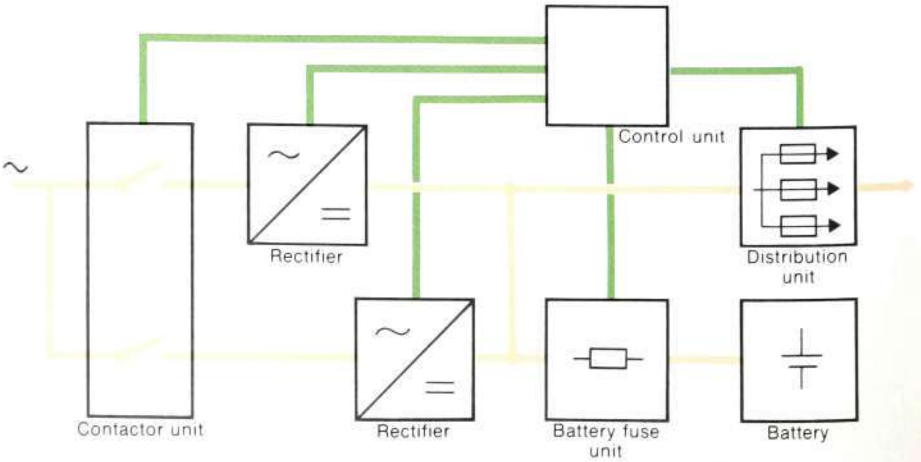

Fig. 1
Block diagram of the power supply system

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Function

The system is controlled and supervised by a control unit consisting of a processor board and an interface board, fig. 4. The unit carries out the following functions:

- automatic connection and disconnection of the rectifiers
- automatic battery charging
- alarm processing and supervision.

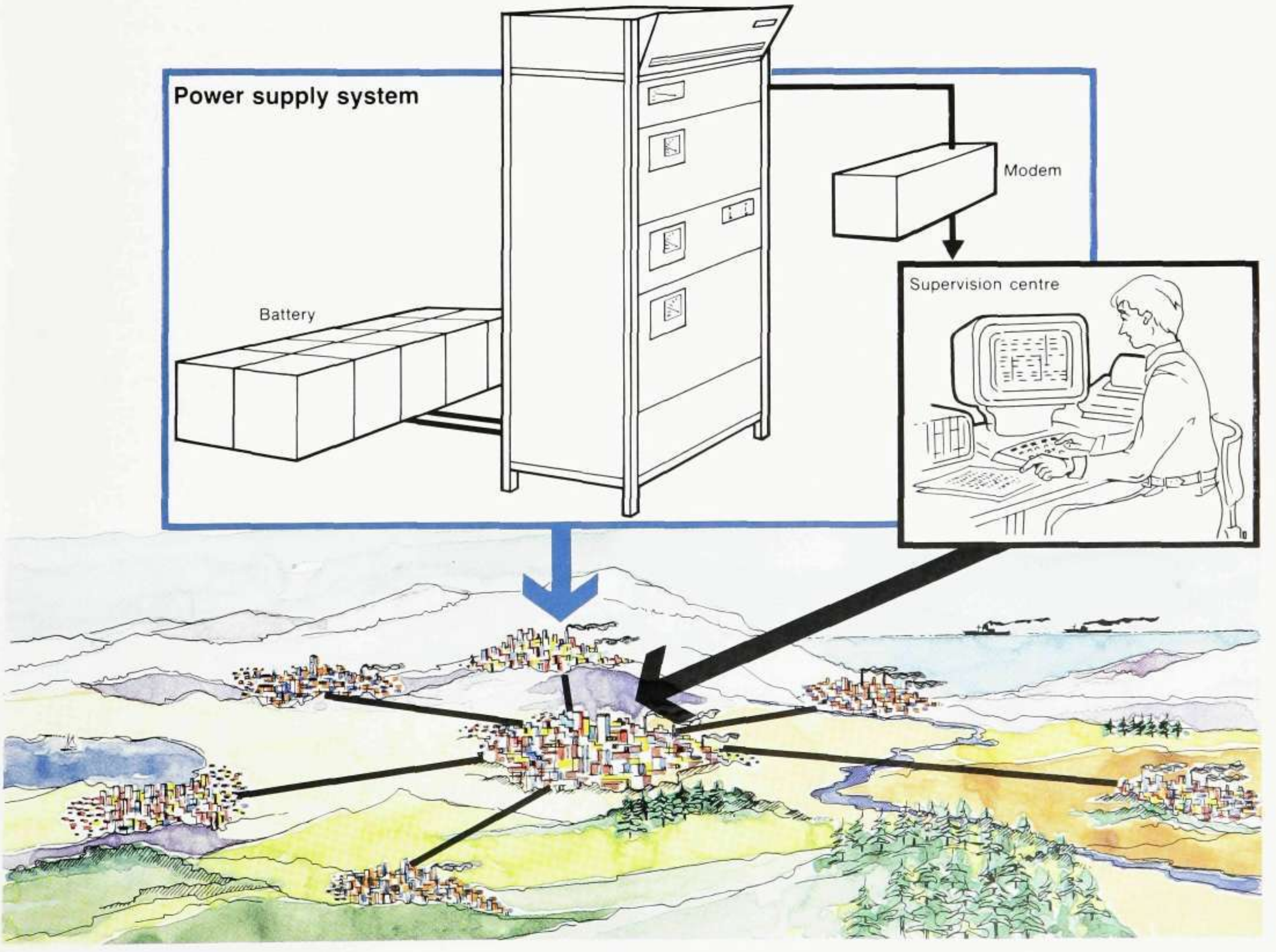
Connection and disconnection of rectifiers

One of the two rectifiers is always connected in and works as the regular unit, while the second serves as a standby. Contactors are used for connecting and disconnecting the rectifiers in each case. Hence the standby rectifier is always separated from the network, which prevents it from being affected by large network transients, such as those caused by lightning strokes. The changeover between the working and standby rectifier can be carried out by means of a switch on the contactor unit.

If a fault should occur in the working rectifier it is immediately disconnected and the standby is connected in. The types of faults that can occur are, for example:

- the combined input and output fuse of the rectifier is tripped (can also be done manually)
- the mains voltage disappears
- the rectifier cannot keep the battery voltage at the desired level (>2.20 V/cell)
- the mains circuit breaker is switched off.

Fig. 3
Centralized supervision



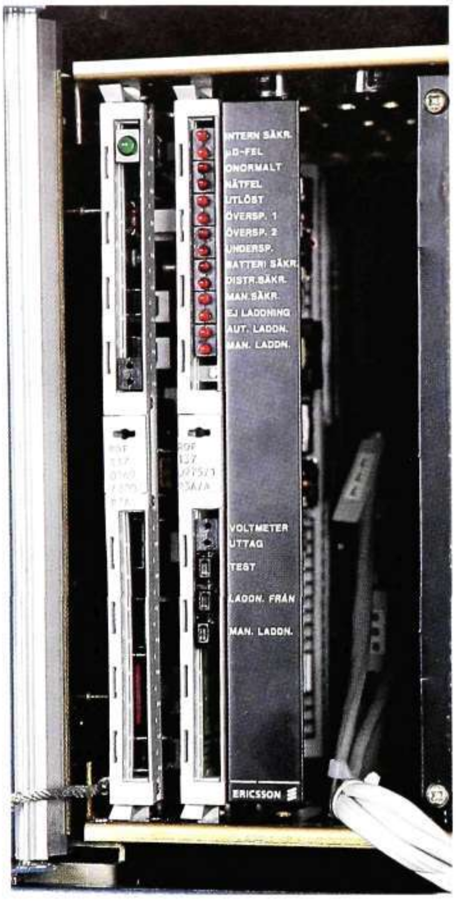


Fig. 4
The control unit is mounted in the same magazine as the contactor unit. Alarms in the system are indicated by LEDs on the fronts of the units

In all these cases an alarm is initiated and a LED is lit on the front of the control unit. In the case of too high battery voltage (>2.48 V/cell) the rectifier is disconnected by the overvoltage protection, and is then quickly restarted. If the voltage becomes too high again, the rectifier is disconnected for good and an alarm is initiated. This procedure eliminates the risk of the rectifiers being disconnected unduly because of external transients.

Automatic battery charging

During normal operation the operating voltage of the system is kept at the level that is most suitable for the battery. For a battery at normal room temperature the level is 2.20 V/cell, which compensates for its self-discharge and avoids dangerous overcharging. The function and life of the battery are greatly dependent on it being kept fully charged. After a discharge (e.g. after a mains failure) the charging should be rapid. The charging must then be stopped at the correct time, i.e. when the battery is fully charged. In the long term overcharging can damage the battery, and moreover the water comsumption will be abnormally high.

The charging function in the system, fig. 5, is as follows. During a mains failure (T1–T3) the battery voltage drops as the battery takes over the whole energy supply. When the voltage has fallen to 2.05 V/cell (T2) measurement of the discharging time starts and continues until the mains voltage returns (T3). Both rectifiers are then connected in and start charging the batteries (T3–T4) with full power. The battery voltage increases slowly since the rectifier current is limited. The rectifiers receive a signal from the control unit that the output voltage is to be increased to the charging level, 2.35 V/cell.

Measurement of the charging time does not start until the voltage has reached 2.25 V/cell (T4). From this time the charging (T4–T5) lasts a factor K longer than the measured discharge time, but no more than 24 hours. K is set to between 1 and 16 by means of four switches on the interface board.

The standby rectifier is always started up when charging is taking place so that the power of both rectifiers is utilized.

Periodic equalization charging

The computer carries out equalization charging at regular intervals. The period between chargings can be set to 3, 6, 9

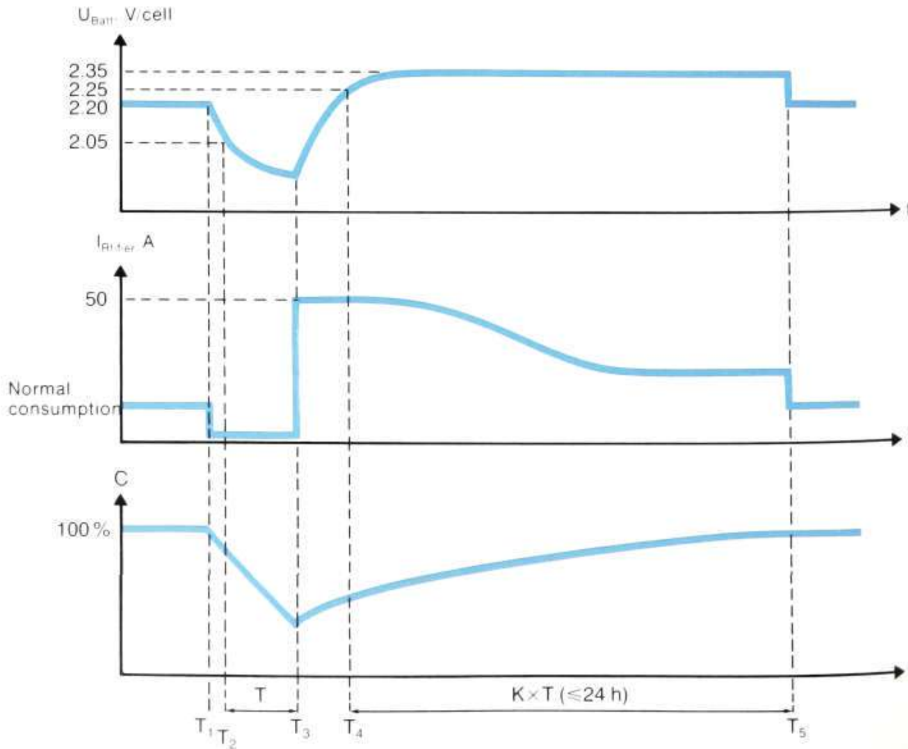


Fig. 5
Charging and discharging curves during a mains failure, controlled by voltage and time measurements. The upper curve shows the battery voltage, the middle curve the rectifier current to the battery and the lower curve the degree of battery charging

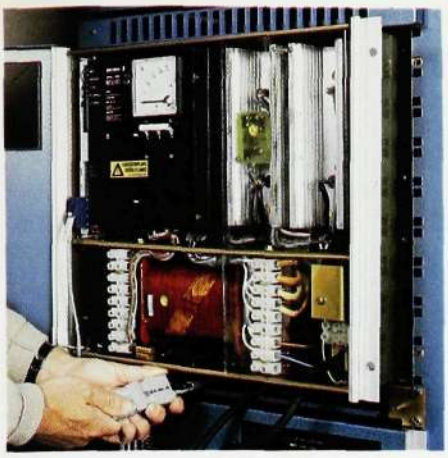


Fig. 6
The rectifiers are delivered separately. They are connected up to the system simply by inserting the unit into the rack. All electrical connections are made with plug-in cables

or 12 weeks by means of a switch on the interface board. The charging time can be set to between one and 16 hours, independently of other preset times.

Charging can also be initiated manually by means of a push-button switch. The manual charging time can be set to between 1 and 16 hours. The system automatically returns to normal operation after completion of charging, but if necessary the charging can also be interrupted at any time by means of another push-button switch.

Mechanical construction

The system is built up using the standard 19" construction practice BAF 601. All units except the rectifiers are mounted in standard magazines. The units are installed in racks and connected up before delivery. The rectifiers, which are mounted in the rack during the system installation, are delivered as complete, factory-tested units. The installation consists of inserting them into the rack and completing the plug-in type electrical connections, both d.c. and a.c., fig. 6. The installation is very simple and can be carried out by personnel who are not trained electricians. All units are equipped with doors, which simplifies maintenance. The current and voltage meters and the LEDs that indicate alarms are clearly visible even with the doors closed. The devices for manual control of the system are also accessible with the doors closed.

Rectifiers

The system contains two 25 A rectifiers BMT 243 48. These single-phase thyristor rectifiers are intended for small power supply systems. The signalling diagrams of the rectifiers are designed for interworking with computer-controlled systems. The rectifiers are equipped with constant voltage regulation with built-in current regulation, slow start and a mains guard. The current and voltage levels are adjustable. The rectifiers are also equipped with protection and control devices for unmanned operation. They are designed for feeding from a standby power plant and from mains with high distortion, and they can accept large variations in frequency and input voltage. The main rectifier circuit, fig. 7, consists of a network transformer, a rectifying bridge with thyristors and diodes, a current transformer for current measurements and an output filter with chokes and capacitors. The output voltage regulation takes place in the thy-

Technical data for rectifier BMT 243 48

Input data		
Mains voltage, single-phase	V	220/110
Permissible variations with lower regulation accuracy	%	±10 −30 − +20
Frequency	Hz	47−63
Primary current with full load and 220 V input voltage	A	10
Power factor with 80% load	cos φ	0.77
Efficiency with 100% load	%	> 87
Ability to withstand incoming mains transients		
amplitude	kV	2.5
rise time	μs	2.0
time to half value	μs	500
CISPR recommendations are met		
Output data		
Rated voltage	V	48
normal voltage, adjustable	V	47−54
charging voltage	V	52−58
Rated current	A	25
current limiting, adjustable	A	0−25
Static regulation accuracy	mV	100
Dynamic regulation accuracy with load changes of ±25% with a battery > 100 Ah	V	1
Noise voltage		
psophometric value	mV	< 2
peak value	mV	200

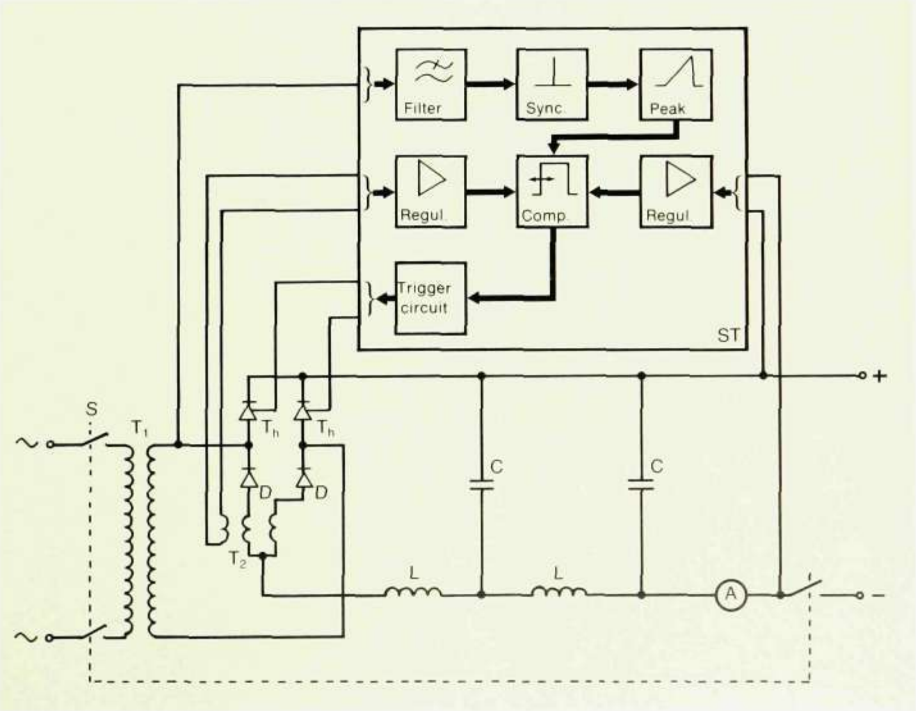


Fig. 7
The mains voltage is connected via the fused circuit breaker to the mains transformer. The voltage is rectified in the diode/thyristor bridge and then smoothed in an LC filter. The control device senses the output voltage and current and provides trigger pulses for the thyristors so that constant voltage is obtained

S	*Fused circuit breaker*
T1	Mains transformer
T2	Current transformer
Th	Thyristors
Di	Diodes
L	Filter coil
C	Filter capacitor
A	Ammeter
ST	Control device

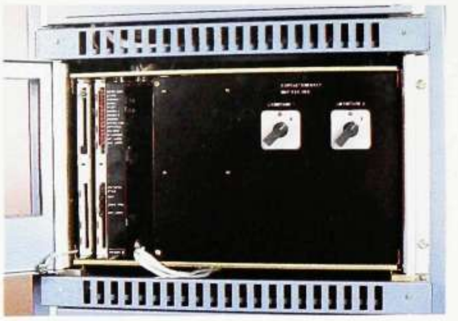


Fig. 8
The contactor unit contains contactors and mains switches. The control unit is mounted in the same magazine to the left of the contactor unit

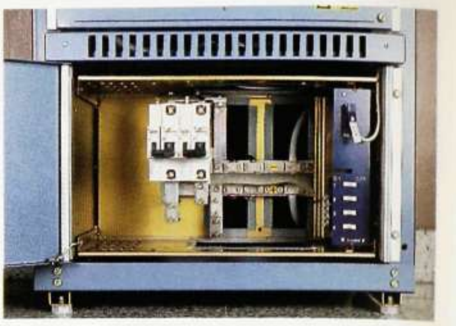


Fig. 9
Battery cables having a cross-sectional area of up to 70 mm² can be connected to the battery fuse unit. A control fuse set, which can be seen to the left in the unit, provides the control and alarm circuits with fuse-protected power supplies

ristors, which obtain trigger pulses from the control unit. The trigger pulses are time shifted relative to the zero transitions of the feeding mains voltage. The output voltage and current can be regulated by adjusting the time shift by means of phase shift control. Constant voltage regulation is normally used, but if the set current limit is exceeded, the regulating system switches over to constant current regulation (current limiting). The rectifier is equipped with a fused circuit breaker for two-pole disconnection of the mains voltage and single-pole disconnection of the rectifier output. This simplifies work on the rectifier. The trigger pulses to the thyristor can be blocked by an external signal or the internal voltage guard. Internal blocking occurs if the mains voltage falls to less than 60% of the nominal value. The rectifiers start up again automatically at approximately 70% of the nominal input voltage. The front of the rectifier contains LEDs for the following signals: in operation, charging in progress, rectifier fuse triggered, and loss of mains voltage. The following signals are sent to the control unit: current signal, mains failure and fuse alarm. The signals received from the control unit are the charging and disconnection signals.

Fig. 10
Distribution unit

Contactor unit

This unit, fig. 8, contains relay switches for disconnecting the rectifiers from the mains. The front of the unit contains switches for manual control of the relay switches and for selecting the working and standby rectifiers. The relay switches are normally controlled automatically by signals from the control unit.

Battery fuse unit

This unit, fig. 9, contains two 100 A battery fuses of the automatic type with electromagnetic tripping and four 3 A automatic fuses for feeding the control unit and alarm circuits. All fuses are equipped with alarms. When a fuse is tripped an alarm is sent to the control unit for forwarding externally. Batteries can be connected to the unit using cables with a maximum cross-sectional area of up to 70 mm².

Distribution unit

The distribution of current to telephone exchanges can be in either a low or high resistance mode. Low resistance distribution of energy from the power equipment to the telephone equipment takes place over a few cables having a large cross-sectional area and low resistance. However, in the case of a short circuit this type of distribution gives rise to very high currents, which means that the battery voltage first drops to a very low value, after which, when the fuse is released a high inductive voltage transient occurs.

Modern electronic telephone exchanges must be protected against large voltage drops as well as high inductive transients. High resistance distribution is therefore preferable. Each unit, which may be affected by a single fault, is then fed via a separate cable. The main characteristics of this distribution method are that the distribution cables have a fairly high resistance (>45 mohms), hence the name, and the battery has a low internal resistance.[4] The total resistance of the cables and the battery prevent the short-circuit current from exceeding 1000 A, compared with the 5000 A which is possible with low resistance distribution. These high resistance distribution properties in their turn mean that the voltage drop during a short circuit is limited to a maximum of 7 V in the distribution part of the power supply system. Other knock-out units that are not short-circuited can then continue to work without interruption. The inductive transients are limited

Fig. 11
There are two different types of distribution fuses. One is an ordinary low-resistance automatic fuse and the other a recently developed high-resistance electronic fuse in hybrid technology

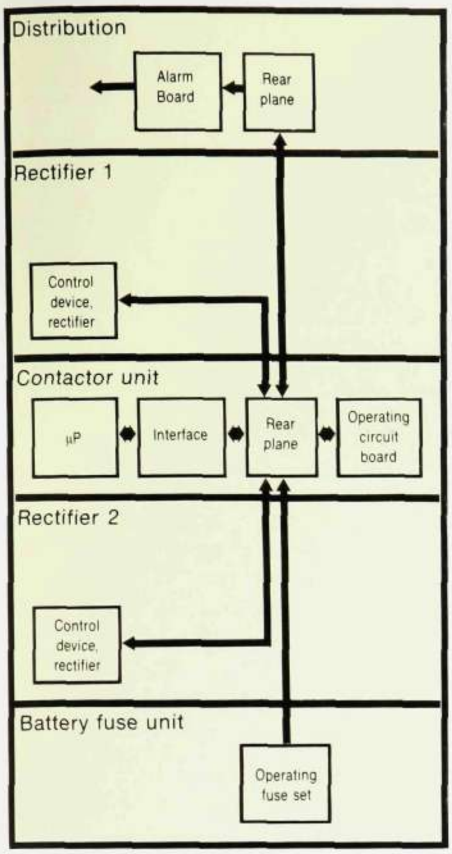
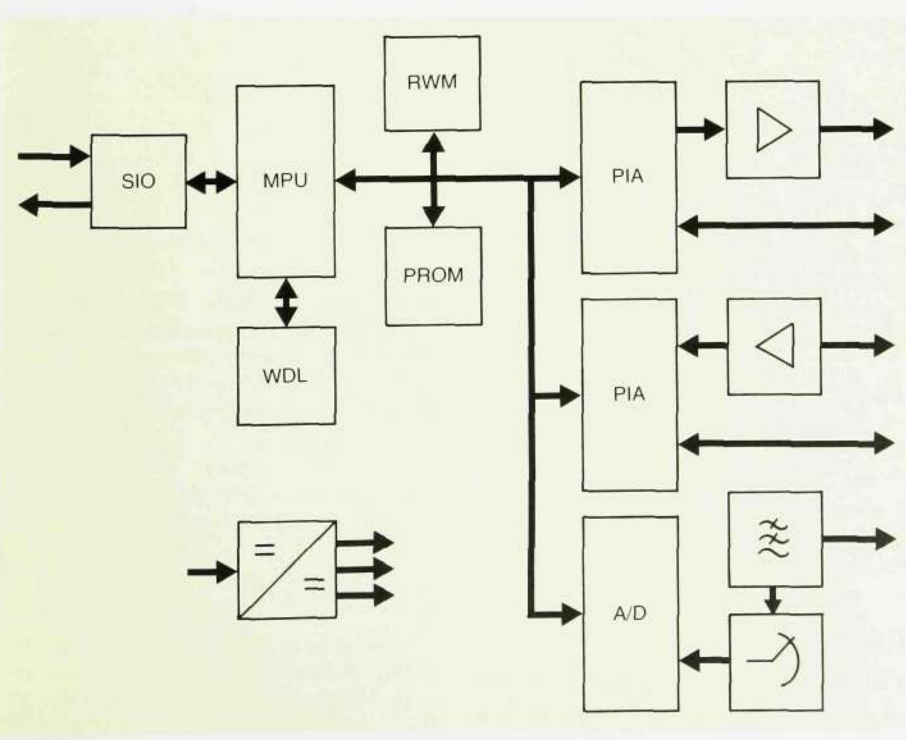


Fig. 12
The processor collects and sends data to the whole plant over standard plug-in cables connected to the rear plane of the control unit

Fig. 13
Block diagram of the control board
The printed board assembly is built up around a microprocessor which collects data via a number of interface circuits

MPU	Microprocessor
PROM	Program store
RWM	Working store
PIA	Digital interface circuit
A/D	Analog/digital converter
WDL	Watchdog logic
SIO	Drive circuit for serial communication



by the relatively low short-circuit current and by special low-inductance distribution cables.

In small exchanges the transient limiting method described above is usually not possible because the batteries are too small and have too high internal resistance. High resistance distribution can then be arranged by means of large capacitors or electronic fuses, the latter being preferable for reasons of space and economy.

Electronic fuse
The electronic fuse is an electronic unit which functions as a current limiter. If a short circuit should occur in a distribution branch the electronic fuse prevents the short-circuit current from rising to more than an ampère or so above the nominal value of the fuse. This should be compared with a low-resistance short circuit, where the current can amount to several thousand ampères. The current limiting performed by the electronic fuse prevents the battery voltage from falling to a level that is unsuitable for the operation of the exchange. This applies even for very small batteries.

The distribution unit, fig. 10, can be equipped with electronic or automatic fuses, fig. 11. Automatic fuses are used for exchange types that do not require transient limiting. Cables having a cross-sectional area of 10–16 mm^2 can be connected to the distribution. The terminal blocks are designed so that cables can be connected in during operation without any risk of short-circuiting. Alarms can be transmitted via modems and telephone lines. Nine alarm outputs are also available at screw terminals. A potential-free relay changeover is allocated to each alarm and can be used for signalling to the exchange, to give an acoustic alarm or to light a lamp in a lamp panel.

Control unit
The control unit is placed in the same mechanical unit as the relay switches. It communicates with the other parts of the system via plug-in cables that are connected to its rear plane. The control unit, fig. 12, includes:
- a control board with a microprocessor
- an interface board.

The control system obtains data from and sends information to the control devices for the rectifiers, the operating circuit board and the operating fuse unit.

Control bord
Both analog and digital data are fed to the control board to provide the basic information for decisions regarding measures to be taken. The control board, fig. 13, contains
- MPU, an 8-bit microprocessing unit, which carries out the programmed instructions that are required to ensure that the system works in accordance with the above functinal description.
- PROM, a programmable read only memory, which is a non-volatile memory for storing the program for the control system and also certain constants.
- RWM, a read/write memory, which is a volatile memory for storing measurements, internal variables etc.
- PA, a peripheral interface adapter, with input/output (I/O) circuits for digital sending of alarms etc. Certain wires pass through interface amplifiers.

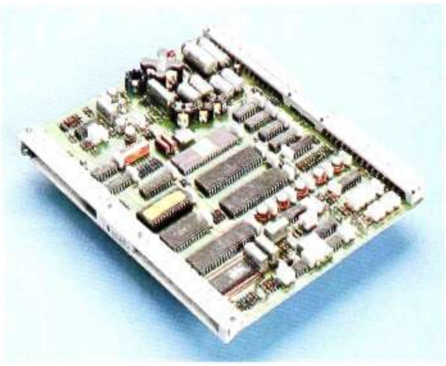


Fig. 14
The system control board contains a single-board processor with an internal voltage converter for its own power supply. The processor is also equipped with circuits that enable it to receive both analog and digital signals

- A/D, an analog/digital converter, with analog input circuits for sensing voltage levels. The signals are transmitted via an input filter and an analog multiplexer, so that several voltages can be measured by the same converter.
- WDL, watchdog logic, which supervises the operation of the computer. A failure results in an automatic computer restart.
- SIO, a serial I/O circuit for the communication function that makes remote supervision of the system possible.

The control board also contains a d.c./d.c. converter, which generates all the required logic voltages from the 48 V system voltage.

Remainder of the control system
The function of the interface board is to adapt the voltage levels of the system to the control board. The interface board contains push-button switches for manual control of the system and LEDs for alarm indications. A d.c./d.c. converter on the board provides internal logical voltages.

The alarm board, which is placed in the distribution unit, contains a number of relays which, when an alarm is received transmit a signal to a superior system via potential-free relay changeover contacts.

The interface and alarm boards are connected to the rest of the system via connectors in the rear plane. All the units in the system are connected to the rear planes of these boards via plug-in cables. Only the outgoing alarms are connected direct to the front of the alarm board, and screw-type teminals are used for these connections.

The watchdog logic initiates an alarm if a fault occurs in the processor, and at the same time it connects in both rectifiers. The operation can therefore continue, with reduced control and supervision functions until the microprocessor has been repaired.

Summary

The maintenance and service costs for power supply equipment constitute a relatively large part of the total budget, especially for small, unmanned exchanges. The introduction of processor-controlled functions makes it possible to centralize the supervision, resulting in considerable simplification of the maintenance routines. The microprocessor also has other major advantages, for example:

- Individual customer requirements as regards alarm printouts and supervision parameters can easily be met.
- New program blocks for additional control and supervision parameters can easily be introduced (e.g. for sophisticated supervision of batteries and for operational statistics).
- Savings can be made as regards hardware, particularly control and supervision logic.
- More sophisticated charging functions and monitoring of the battery charging can be introduced.

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