

A.C.E.32

Power Network Communication

Digital

Power Line Carrier

System Description
1551-QZAD 930 001, rev. C

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Introduction

Power line carrier (PLC) is used in almost all the countries of the world to transfer information via high-voltage transmission lines and has become an important instrument for the management and safety of power systems.

The A.C.E. 32 digital power line carrier terminal (PLC) is a multipurpose terminal that supports the main existing services:

- Telephony
- Data transmission
- Teleprotection

A digital PLC is defined as a PLC where the transmission scheme is digital and digital technology is used to realise the functions needed.

The equipment utilises 8 kHz (two contiguous bands of 4 kHz) to establish a full duplex connection. On the available bandwidth a data stream of 32 kbit/s is transferred (covering the telephony and data transmission) plus signals for teleprotection. The capacity for speech and data transmission can be utilised in a very flexible way and can accommodate up to 3 speech channels and 9 data channels. The total capacity is thus approximately the triple of a single channel analogue PLC that utilises the same bandwidth.

The A.C.E. 32 is basically defined as one version. However, based on the flexible architectural structure of the equipment a number of configurations can be implemented. This can be done by inserting different interface cards and by defining the configurations through the Man-Machine Interface (MMI).

The equipment meets International Standard IEC 60495 (1993-09) regarding the applicable parts: The line side requirements, the local side requirement and the environmental conditions. This means that the A.C.E. 32 is compatible with analogue PLCs on the line side and can coexist in a mixed analogue and digital PLC network. The integrated teleprotection subsystem meets the International Standard IEC 60834-1(1999-10).

This means that it is easy to include A.C.E. 32 in the existing PLC networks and gives for example the possibility of easy upgrade of capacity on "bottle-neck" connections by replacing existing terminals.

The Equipment

Basic structure

Figure 1 shows the block diagram of an A.C.E. 32 terminal, where the following subsystems are defined:

- SCC: Supervision, control, and configuration with access via the Man-Machine Interface
- ALT: Adaptive link transmission (the transmission part)
- TPS: Teleprotection subsystem
- SDC: Serial data communication (the data channels)
- TEL: Telephony (the speech channels with speech codecs)

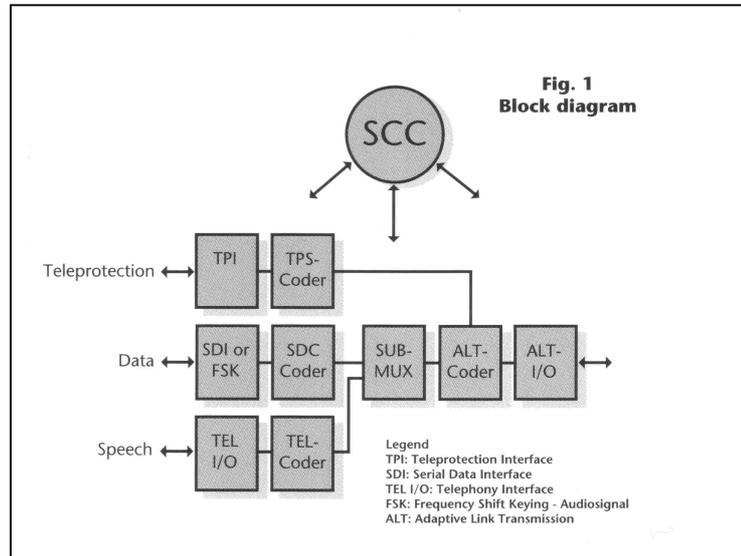


Figure 2 shows the structure of an A.C.E. 32 terminal. It is a bus-oriented type of equipment where most of the functionality is realised in SW. Each of the subsystems are accessed by interface modules. The ALT I/O is basically the equipment housed in the Power Shelf (Power Amplifier, Hybrid and Line Filter).

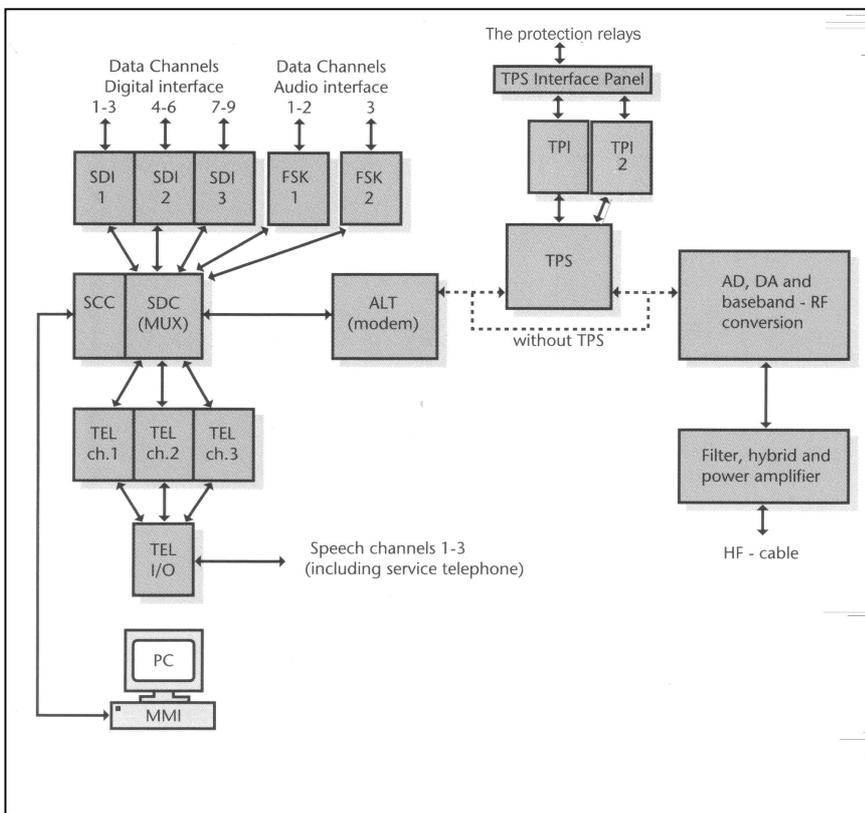


Figure 2.
Overview logical connections



Figure 3 shows the realisation of an A.C.E. 32 terminal consisting of a Power Shelf (upper shelf) and a Signal Shelf. To make the installation in a cabinet easier, the terminal is also equipped with an optional Cable Shelf as the lower shelf.

Figure 3.
The A.C.E.32 terminal

The shelves

Figure 4 shows how the Power Shelf is equipped. The shelf contains, from left to right, the DC Power Supply, the Power Amplifier, and the Hybrid and Line Filter.

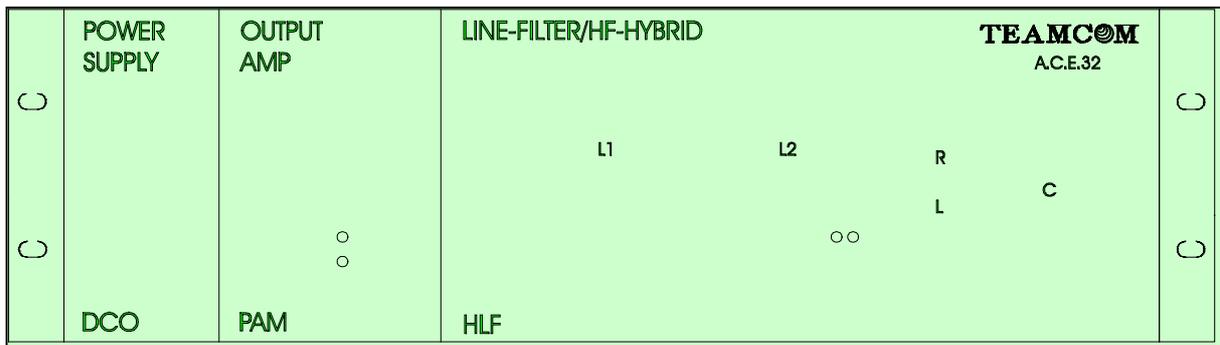


Figure 4.
The power shelf

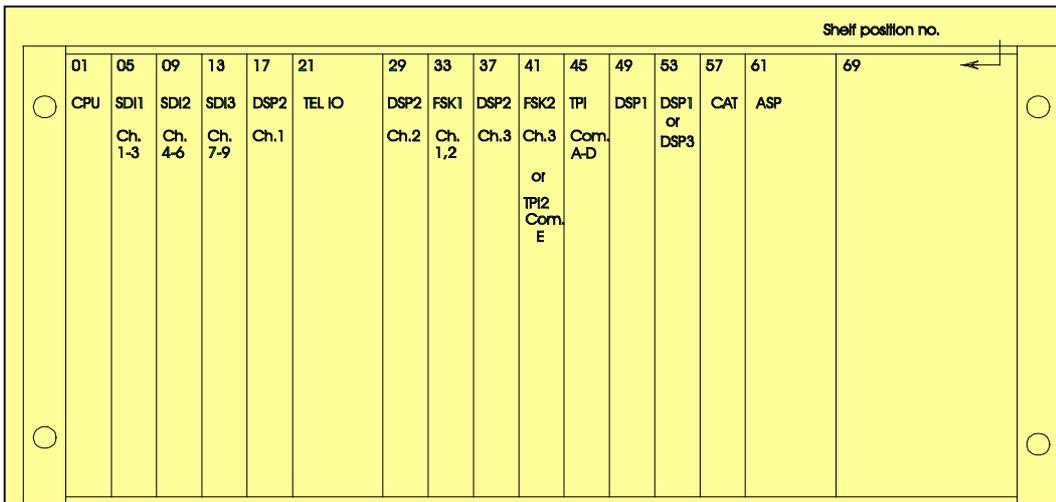


Figure 5.
The signal shelf

Figure 5 shows the position of the different cards in the Signal Shelf. Here we can identify the basic cards which are always present:

- The analogue signal processor, ASP
- The clock, alarm, and terminal interface, CAT
- The digital signal processor, DSP 1
- The central processor unit, CPU

In addition to the basic cards there will be a number of cards which depend on the configuration of the terminal.

The transmission

The equipment utilises 8 kHz for a full duplex connection. The duplex data stream of 32 kbit/s (net) is established in a 7 kHz bandwidth. This is achieved by using echo cancelling techniques and channel coding. The data stream is used for multiplexed speech and data. A teleprotection subsystem is integrated in the terminal. Guard-signals for teleprotection are inserted in the remaining 1 kHz at the band edges. When transmitting command-signals the combined speech/data-signal is blocked and tones are transmitted in the band made available (see Figure 6).

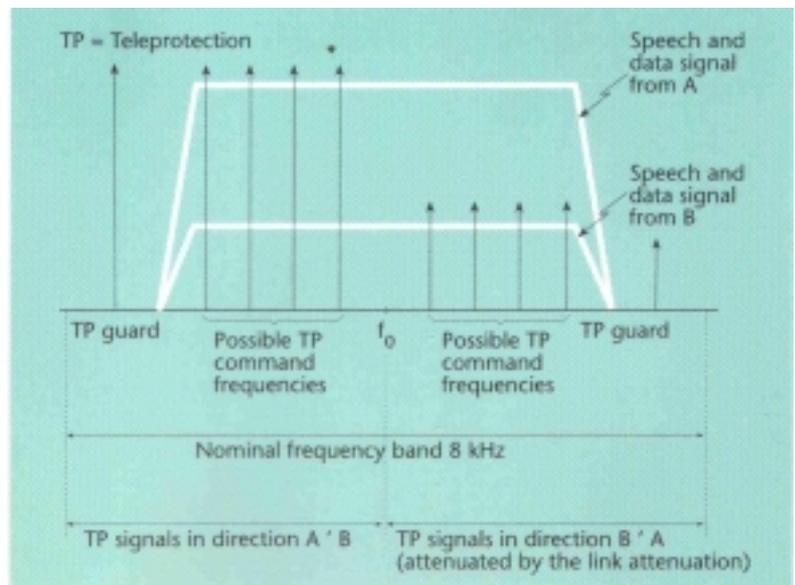
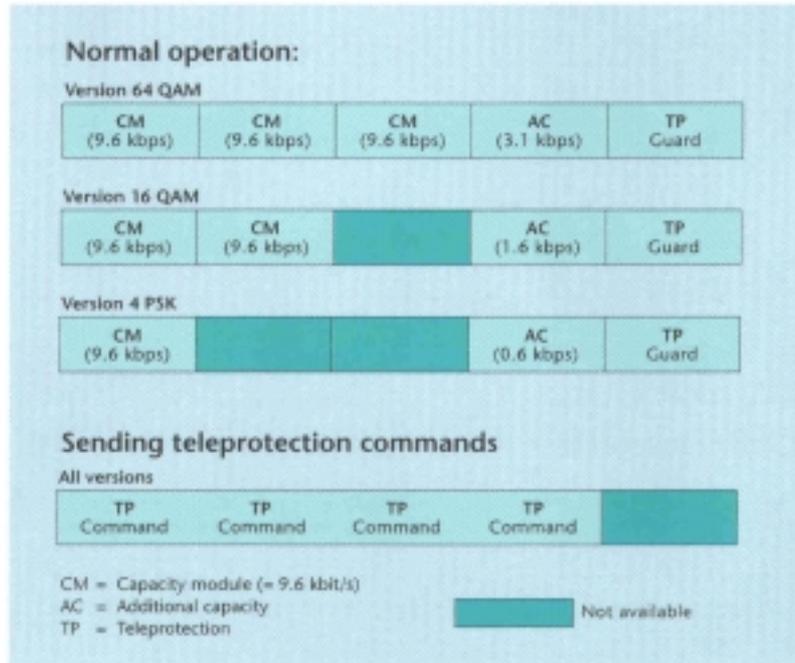


Figure 6.
Utilisation of the 8 kHz bandwidth

The capacity

The net capacity of the A.C.E.32 is 32 kbit/s plus capacity for teleprotection. In order to improve the transmission conditions at lines with high attenuation and/or high noise levels, it is possible to change the modulation scheme, with a resulting reduction in capacity. Table 1 shows the alternatives. For the same bandwidth (8 kHz) it is possible to choose capacity and the resulting required signal-to-noise ratio (SNR). All three alternatives can be configured from the PC.

Figure 7.
Utilisation of the capacity



The configured capacity can be utilised in a flexible way, see Fig. 7. The capacity can be regarded as split up in Capacity Modules (CM) plus the Additional Capacity (AC).

Each CM can be used for:

- One speech channel
- One or more anisochronous data channels
- One or more synchronous data channels. A synchronous data channel can alternatively use two CMs (19.2 kbit/s)
- Through-connection of audio signals from an FSK modem located outside the A.C.E. 32 terminal

The AC is utilised for asynchronous data channels. Those channels are dynamically multiplexed and will utilise all the current available capacity (i.e. in addition to the AC, the capacity for configured speech channels not in use, not configured CMs and not configured capacity within a CM).

The teleprotection channels are implemented in the terminal without influencing the capacity for speech and data.

Capacity (kbit/s)	Modulation	Receiver dynamic range (dB)	Required SNR* (dB)
32	64 QAM	30	30
21	16 QAM	40	24
11	4 PSK	50	17

* For a bit error rate (BER) of 10^{-6}

Table 1. Capacity vs required SNR

Functionality

Speech channels

To be able to implement speech channels in a data stream of 32 kbit/s, speech coders are necessary. The A.C.E. 32 has a proprietary coder that uses approximately 8.3 kbit/s. Together with the associated signalling and error coding a speech channel needs 9.6 kbit/s.

The units involved when implementing up to 3 speech channels are (with reference to Fig. 5):

- The digital signal processor card, DSP 2 (one for each speech channel).
- The interface TEL I/O which covers all three speech channels, and the service telephone.

The interface TEL I/O covers the different applications of the speech channels and provides both 4-wire and 2-wire termination. If a telephone set is connected to TEL I/O a sub-board, R-SLIC, must be inserted at the interface, one for each telephone set to be connected. The R-SLIC contains circuits for ring signal generation, and power feed to the telephone set. The TEL I/O and R-SLIC cover also the subscriber line extension application.

TEL I/O accepts analogue speech channels with bandwidths of 0.3 to 2.0, 2.2, 2.4, or 3.4 kHz.

TEL I/O handles the following types of signalling:

- E&M (continuous or discontinuous)
- MFC-R2, tone transparent
- DTMF, tone transparent
- Decadic

Service telephone

Speech channel no. 1 can alternatively be used as a service telephone connection between two A.C.E. 32 terminals. An ordinary telephone set is used and will be connected to the front of the TEL I/O.

Data channels with digital interface

Capacity

The data channels can be configured as:

- Synchronous channels
- Asynchronous channels
- Anisochronous channels

Synchronous and anisochronous channels take capacity according to their defined transmission rate, while the asynchronous channels are defined according to the local interface transmission, but are dependent of the current available capacity. The asynchronous channels utilise the feature of dynamic multiplexing which means utilising the capacity of the speech channels when they are idle.

The data channels are interfaced via the SDI card. Each card can interface up to 3 data channels and a total of 9 channels can be configured on an A.C.E. 32 connection.

The data interfaces are subsets of V.24, according to Table 2 and meets V.28.

V.24	Signal name	From
CT 102	Signal ground	-
CT 103	Transmitted data	DTE
CT 104	Received data	DCE
CT 105	Request to send	DTE
CT 106	Ready for sending	DCE
CT 109	Data channel received line signal detector	DCE
CT 113*	Transmitter signal element timing	DTE
CT 114*	Transmitter signal element timing	DCE
CT 115*	Receiver timing	DCE

* Only one of the circuits will be available at any one time.

Table 2 . Data interface

Asynchronous channels

For asynchronous channels the following local transmission rates are available: 150, 200, 300, 600, 1200, 2400, 4800, 9600, and 19200 bit/s.

The A.C.E. 32 supports asynchronous channels transmitting words with 1 start bit, 1 or 2 stop bits and 7 or 8 data bits. The start/stop bits are stripped off the incoming words and regenerated at the receive end. The data bits may include one possible parity bit which is transmitted transparently across the link when the word comprises 7 data bits. For 8 data bits the parity bit is stripped off and regenerated at the receive end.

Each asynchronous channel contains deep buffers to handle the bursty traffic pattern. Handshake procedures are used to stop the traffic when the internal (or external) buffers overflow.

The remote handshake procedures between two DTEs connected to either side of an asynchronous channel is transmitted transparently. XON/XOFF is supported.

Synchronous channels

For synchronous channels the following transmission rates are available: 2400, 4800, 9600, 19200 and 32000 bits.

The transmit clock of CT 114 is used when the DTE is provided with the clock from an A.C.E. 32 link.

Anisochronous channels

An anisochronous channel is a "transparent" channel in the same way as an FSK channel in the analogue PLCs.

A coding function is implemented for the anisochronous channels to allow the receive side CT 104 to track the transmit side CT 103 with an accuracy better than 8%. This requires a transmission capacity of 3 to 4 times the maximum baud rate of the anisochronous channel.

Table 3 shows the available transmission rates.

Transmission rate (bit/s)	Required capacity (bit/s)
0 to 300	1200
0 to 600	2400
0 to 1200	4800
0 to 2400	9600

Table 3.
Anisochronous
transmission rate

Dynamic multiplexing

Data from all synchronous and anisochronous channels are multiplexed statically through the A.C.E. 32. Data from asynchronous channels are multiplexed through a dynamic multiplexer. This multiplexer will use the remaining link capacity when speech and the other data channels have been allocated their required link resources.

Data channels with audio interface

Capacity

Up to 3 audio signals from external FSK modems with transmission rate of 0 to 1200 baud can be through-connected. The signals are interfaced via an FSK card which accommodates interface circuits for two signals. The signal from one external FSK modem occupies one Capacity Module.

Teleprotection

Configurations

Three configurations can be implemented:

- 4 commands in 2 independent pairs. Within each pair one command is given priority over the other. The application can be 2 commands for line protection and 2 commands for direct tripping.
- 3 independent commands plus 1 overruling command. One application can be 3 commands for triple phase line protection and 1 command for direct tripping. (This configuration can also be used when 1 or 2 channels are needed).
- 3 independent commands plus 2 priority commands.

Teleprotection interface

The teleprotection functions are interfaced to the terminal via the card TPI (TPI2) in the Signal Shelf, and the teleprotection interface module located outside the shelf. The interface module provides a flexible arrangement of input relays, output solid-state relays and change-over relays. An optional panel with command counters can also be provided.

Operating principles

The guard signal, one for each direction, is located near the edges of the frequency band utilised. When commands are transmitted the guard signal and the speech/data stream are blocked, and tones are sent in the frequency band made available. The principal utilisation of the frequency band is shown in Figure 6.

Application

The parameters for blocking, permissive and direct transfer schemes are shown in Table 4.

Permissive	T_0 (ms) SNR ≥ 30 dB	T_{ac} (ms) SNR ≥ 6 dB	P_{mc} SNR ≥ 6 dB	P_{uc} SNR = any
	≤ 17	≤ 18	$\leq 10^{-4}$	$\leq 10^{-4}$

Blocking	T_0 (ms) SNR ≥ 30 dB	T_{ac} (ms) SNR ≥ 10 dB	P_{mc} SNR ≥ 10 dB	P_{uc} SNR = any
	≤ 17	≤ 18	$\leq 10^{-4}$	$\leq 10^{-4}$

Direct	T_0 (ms) SNR ≥ 30 dB	T_{ac} (ms) SNR ≥ 6 dB	P_{mc} SNR ≥ 6 dB	P_{uc} SNR = any
	≤ 27	≤ 27	$\leq 10^{-4}$	$\ll 10^{-6}$

Table 4.
Teleprotection
parameters
(4-command
concept)

- T_0 :** Nominal transmission time
 T_{ac} : Maximum actual transmission time (referred to P_{mc} for the same application)
 P_{mc} : Probability of missing command
 P_{uc} : Probability of unwanted command

(Noise bandwidth 4 kHz)

Protection commands are usually of short duration, typically less than 100 ms. Since data and speech transmission is blocked during command transmission, commands with a duration of up to 2 seconds are permitted. If a command longer than 2 seconds is applied, an alarm will be initiated and lasts as long as the command persists. An option can be utilised to interrupt the command after 2 seconds and resume data and speech transmission.

An in-service loop-test is included in the equipment. The loop-test will block the transmission of speech and data.

Service functions

The SCC subsystem

The SCC (supervision, control and configuration) subsystem is the basis for the Man-Machine Interface (MMI). The number of speech channels together with the number and type of data and teleprotection channels can be configured by a PC connected to the front of the CAT card. Each of these channels can be configured for the desired operation.

Alarm functions

Three alarm outputs are available:

- Common alarm (COM)
- Receive alarm (RX)
- Transmit alarm (TX)

The alarms are also visible as red LEDs at the front of the CAT card together with a Teleprotection (TPS) alarm.

Separate Teleprotection Alarm is also available from the TPS Interface Panel.

Monitoring

The status of the terminal is monitored and presented at the front of the CAT card by green LEDs:

- System OK (SYST)
- Teleprotection OK (TPS)

Alarms and transmission parameters are also displayed on the PC via the Man-Machine Interface.

System data

General

Environmental conditions

Operating

IEC 60495 (1993-09), 3.1

Storage

IEC 60495 (1993-09), 4.1

Voltage withstand and EMC

IEC 60495 (1993-09), 5.3.1.11

Power supply

Voltage

48 VDC, +20%, -15%

DC Power consumption

Normal operation: Max. 200 W

With teleprotection command (or loop-test):

Max. 250 W

Transmission

Modulation

Speech and data

See Table 1

Teleprotection

Double On-Off Keying ("FSK")

Synchronisation

One source, internal or external

Master-slave concept

Transmission capacity

See Table 1 (plus capacity for teleprotection)

Utilisation of the capacity

See Figure 7

Carrier frequency range

40 to 500 kHz

Nominal bandwidth for a duplex connection

8 kHz

Frequency spacing for parallel connections

Between A.C.E. 32 terminals

≥ 8 kHz

Between an A.C.E. 32 terminal and analogue PLC terminals meeting IEC 60495 (1993-9)

≥ 8 kHz

Additional attenuation due to parallel equipment with 8 kHz gap

≤ 1.5dB

Output power

40 W (PEP): +46 dBm

Spurious emissions

IEC 60495 (1993-09), Figure A.2 (n=2)

Receiver dynamic range

See Table 1

Required SNR

See Table 1

Line side nominal output impedance

75 or 125 ohms unbal. or 140 ohms bal.

Return loss

≥ 10 dB

Services

Speech channels

Number of speech channels

0-3

Transmission rate per speech channel (including signalling)

9.6 kbit/s

Speech codec used

LASVQ

Speech delay per link

<50 ms

Speech channel interface (TEL I/O)

Number of speech channels per. interface

3

Nominal impedance

600 ohms non-complex

600 ohms complex

Return loss

≥14 dB

Signalling

DTMF, MFC-R2, continuous and discontinuous E&M, decadic

Service telephone

Speech channel no.1 can alternatively be used as service channel

Data channels

Number of data channels

0-9

Up to 3 signals from external FSK modems can be through-connected.

Transmission rates

Asynchronous channels

150, 200, 300, 600, 1200, 2400, 4800, 9600 and 19200 bits

Synchronous channels

2400, 4800, 9600, 19200 and 32000 bit/s

Anisochronous channels

0 to 300, 0 to 600, 0 to 1200 and 0 to 2400 bit/s

FSK through-connection

0 to 1200 Baud

Data channel interface (SDI)

Number of data channels per interface

3

Electrical

V.28

Functions

Subset of V.24 according to Table 2

Data channels interface (FSK)

Number of data channels per interface

2

Electrical

600 Ohms

Teleprotection

Number of commands

4 in 2 independent pairs with internal priority

or

3 independent with 1 overruling.

or

3 independent commands plus 2 priority commands

Characteristics of the commands

See Table 4

Mechanical construction

Shelves

Number

2

Optional

Cable Support Shelf

Teleprotection Counter Panel

Width

19"

Height

Power Shelf (upper shelf): 3 ASA-units (133.3mm)

Signal Shelf: 6 ASA-units (266.7 mm)

Cable Support Shelf: 3 ASA-units (133.3 mm)

Depth

Max. 300 mm

Weight

Power Shelf: 6.5 kg. Signal Shelf: 9.0 kg

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