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Korte inhoud :

Om de bestaande niet-ISDN terminals te kunnen aansluiten op het ISDN, zijn Terminal Adaptors (TA's) nodig. De TA is een apparaat dat de transmissiesnelheid van de bestaande terminal (50 tot en met 64000 bps) converteert naar de snelheid van de ISDN terminal (64000 bps). Daarnaast verzorgt TA het ISDN D-kanaal signalerings-protocol. Vooral de TA's voor circuit geschakelde datatoepassingen (TA-csd's) komen hier aan de orde.

De onderwerpen zoals de functionele beschrijving van een TA-csd, de functionele architectuur van een TA-csd en de informatie uitwisselingsprocedures tussen de terminal en de TA-csd (nodig voor het opbouwen en verbreken van data-verbindingen, het instellen van parameters in de TA-csd en het uitvoeren van tests) zijn beschreven.

Samenvatting

Bij de introductie van het nieuwe digitale netwerk (ISDN), spelen terminal adaptors (TA's) spelen een belangrijke rol. TA's geven de mogelijkheid om de bestaande niet-ISDN terminals te kunnen aansluiten op het ISDN. De TA is een apparaat dat de originele transmissie snelheid van de bestaande terminal (50 tot en met 64000 bps) converteert naar de snelheid van de ISDN terminal (64 kbps) en dat het ISDN D-kanaal signalerings-protocol verzorgt. Dit verslag beschrijft het ontwerp van een TA voor circuit geschakelde data toepassingen (TA-csd). In het bijzonder zijn de functionele specificatie van een TA-csd , de informatie uitwisselings-procedures tussen de terminal en de TA-csd die nodig zijn voor het opbouwen en verbreken van data-verbindingen, het instellen van de parameters in de TA-csd en het uitvoeren van tests, beschreven.

Summary

By introducing the new digital network (ISDN), ISDN terminal adaptors (TA's) will play an important role. TA's give the possibility to connect the existing terminals to ISDN. A TA is in fact an equipment that converts the original transmission rate of the existing terminal (50 up to 64000 bps) into the rate of the ISDN terminal (64 kbps) and provides the ISDN D-channel signalling protocol. This paper deals with designing a TA for circuit switched data (TA-csd). In particular the functional specifications of a TA-csd and the information exchange procedures between the terminal and the TA-csd, that is necessary for establishing and clearing a call, for setting the parameters on the TA-csd and for executing tests will be described.

Preface

I would like to thank my tutors, ir. A.W. Doorduin and ir. M. Ven of Network and Systems of AT & T en Philips Telecommunicatie Bedrijven B.V. (APT), prof. ir. J.L. de Kroes and ir. R.A. Beukers of Delft University of Technology for their help and excellent guidance during their supervision of my graduation project.

In addition I want to thank the following people from APT, who have always been helpful and very kind to me in answering my questions:

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Bijlage

Voorstel afstudeeropdracht Mevr. M.L. Wenas

Het maken van een functionele beschrijving van een ISDN Terminal Adaptor (TA) t.b.v. circuitgeschakelde datatoepassingen en het ontwerpen van de informatie uitwisselingsprocedures tussen de Terminal en de Terminal Adaptor die nodig zijn voor:

a. het opbouwen en verbreken van dataverbindingen;

b. het instellen van parameters in de Terminal Adaptor en/of Terminal;

c. het uitvoeren van tests;

d. eventuele andere functies in de Terminal Adaptor, bijv. functies ter verhoging van de gebruikersvriendelijkheid.

Er dient rekening gehouden te worden met reeds bestaande procedures op dit gebied, bijv. procedures t.b.v. auto-dialling modems.

Glossary :

ANSI	American National Standards Institute
ASCII	American Standard Code for Information Interchange
AU	Adaptation Unit
bps	bits per second
CCITT	The International Telegraph and Telephone Consultative Committee
CEPT	European Conference of Post and Telecommunication Administrations
CSPDN	Circuit Switched Public Data Network
DEC	Digital Equipment Corporation
DIN	Deutsche Industrie Normen
DIS	Draft International Standard
EBCDIC	Extended binary coded Decimal Interchange Code
EIA	Electronic Industries Association
GSTN	General Switched Telephone Network
HDLC	High Level Data Link Control
IBCN	Integrated Broadband Communication Network
IBM	International Business Machines
ISO	International Standard Organization
IU	Interworking Unit
LAP	Link Access Protocol (=Data Link Layer from OSI)
LAP-B	Balanced Link Access Protocol (a subset of HDLC from ISO)
LAPD	D-channel Link Access Protocol
MODEM	Modulator - Demodulator
NT1	Network Termination 1
NT2	Network Termination 2
OSI	Open Systems Interconnection
PABX	Private Automatic Branch Exchange
PSPDN	Packet Switched Public Data Network
PSTN	Public Switched Telephone Network
SNA	Systems Network Architecture
SOPHO	Synergetic Open PHillips Office
TA	Terminal Adaptor
TA-csd	Terminal Adaptor for circuit switched data
TE1	Terminal Equipment type 1
TE2	Terminal Equipment type 2
UART	Universal Asynchronous Receiver/transmitter

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1. Introduction

At this moment the circuit switching networks used for data communications are among other things the public switched telephone network (PSTN) and the circuit switched public data network (CSPDN).

In the near future, a new kind of digital network will be provided, which provides circuit switching and the packet switching. It is called the Integrated Services Digital network (ISDN), which supports the integration of all telecommunication services into one worldwide standardized digital network. In the ISDN, text, voice, data and many other services will be transported digitally.

In case of circuit switching, one ISDN line grants two communication channels (B1 and B2) for transmitting user data and one channel (D) for transmitting signalling information. For basic access rate (2B + D), the rate of the B1 and B2 channels is 64 kbps; the rate of the D-channel is 16 kbps.

The terminal manufacturers have been developing for ISDN a new kind of terminals which rate is 64 kbps. At this moment different kind of terminals supplied with different interfaces (a/b, V.24/V.28 or RS-232-C, X.21 etc.) and with different rates (50 up to 64.000 bps) are still being used at universities, offices, companies, banks etc.

To connect these existing terminals to ISDN, a terminal adaptor (TA) is needed. The major functions of the TA is to convert the rate of the existing terminals to 64 kbps and to provide the ISDN D-channel signalling protocol. Thus a TA gives the alternative not to replace the already installed equipments to ISDN equipments, but only adapt it. In short, a TA provides a cost effective solution to connect existing communication equipments to the ISDN. In this report, a TA for circuit switching mode (TA-csd) will be described.

Chapter 2 describes the principles and the applications of circuit switched data on PSTN, CSPDN and ISDN.

Chapter 3 explains the kinds of existing terminals and the types of TA-csd's. Interviews with some people from universities and companies pointed out what is the most used type of terminals and interface. For that type of terminal and interface the TA-csd is designed.

Chapter 4 discusses the ISDN TA-csd functional specification. Also the possibilities of the physical layout for this TA will be reviewed. Based on the currently available IC-components, the hardware architecture of a TA-csd is designed.

Chapter 5 describes the principles of the standard Hayes command set used on auto dialing modems and the principles of the enhanced Hayes command set used to control the TA-csd. The information exchange procedures (protocol) between the terminal and the TA-csd and the mapping from the enhanced Hayes command set into the ISDN I.451 access layer 3 protocol are also discussed.

Appendix A is referred to the reader who is unfamiliar with ISDN. An introduction into ISDN is shortly described there.

In appendix B, a short article is reprinted about the development of the standard Hayes command set used on auto dialing modems (in Dutch).

Appendix C contains some example of smart modems which are available in the market.

Appendix D gives the list of the enhanced Hayes command set with short description about the meaning of every command.

2. Circuit Switched Data

2.1 Introduction

This chapter will describe the circuit switching networks for data communication purpose. At first, the principles of circuit switching will be explained. And then the application of the circuit switching in various types of networks (PSTN, CSPDN and ISDN) will be described.

Circuit Switching:

The idea of circuit switching will be illustrated using the telephone network as an example. Essentially this is a collection of electronic switches and various means of transmission. These elements allow every user (subscriber) on the network to be connected to every other user. The required connections are made by telephone exchanges; these could also be described as automatic switches. Figure 2.1 shows a telephone network consisting of two exchanges.

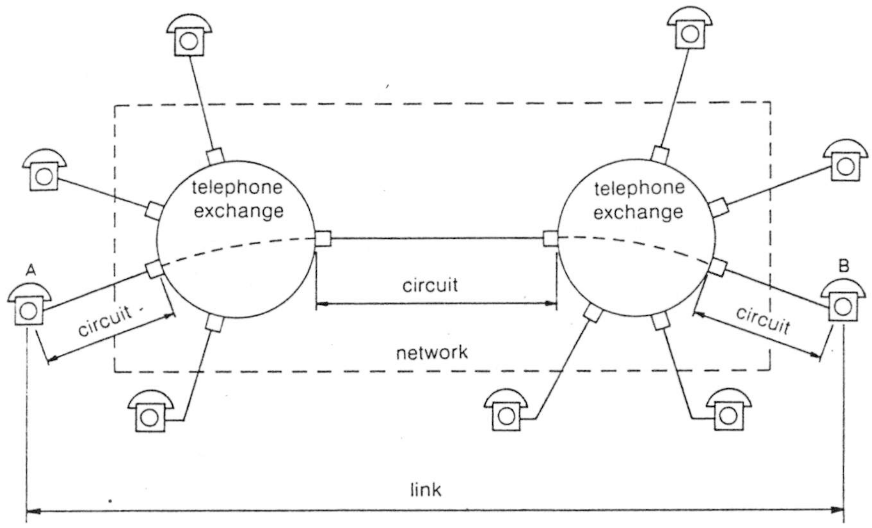


Figure 2.1
Circuit Switching Network

When subscriber A wishes to be connected to subscriber B, a number of circuits must be connected in sequence. This through connection of the circuits is one of the jobs carried out by the telephone exchange. The telephone network is therefore a circuit switching network.

The important point in switching is that all circuits which establish a given connection between source and destination (subscribers A and B) must be maintained as long as information is transmitted in other words as long as the subscribers require them. This means that a direct link is present all the time, independent of the actual transmission of information.

2.2 Circuit Switched Data on PSTN

The public switched telephone network (PSTN) has originally been set up for speech communication with 3100 Hz bandwidth (300 - 3400 Hz analogue signals).

To transmit digital data via the PSTN, it is necessary to place an equipment, called modem, between the user terminal and the telephone link (Figure 2.2).

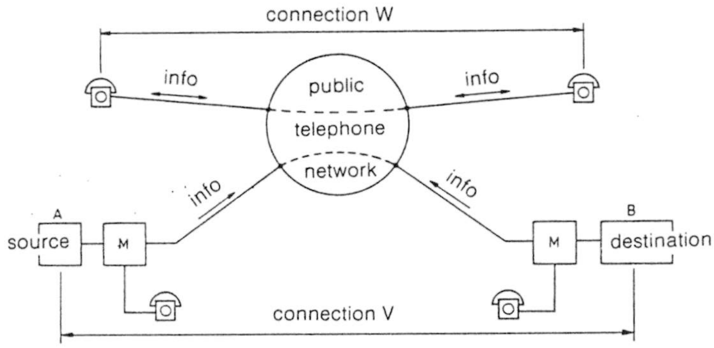


Figure 2.2
Speech/data communication via PSTN

It is possible to use modems with speeds of up to 19200 bps depending on the type of modulation and coding method that is used. The function of the modem in a data communication link is to convert serial digital signal information from a terminal station (PC, terminal, host) into an analogue signal that can be transmitted over great distances via the PSTN. In general the modem modulates the digital bit stream into a carrier and demodulates the analogue signals into the digital bit stream at the receiving side. The modem forms the link between data processing and telecommunication. This central position makes the modem a very important component in the data communication chain. Nowadays data communication via PSTN using modems is the most common case.

The PSTN is intended to offer every subscriber the facility of setting up a connection with any other subscriber. In figure 2.2 the calling subscriber is shown as subscriber A and the called subscriber as subscriber B. In the context of data communication, subscriber A may be a terminal user and subscriber B a computer system. To connect terminal or computer system to the telephone line the CCITT's V.24/V.28 or EIA's RS-232 interface will be used, which are specially designed for connection to analogue facilities. Switched lines (circuits) are used for the connection between the terminal and the computer system.

The PSTN, which is a circuit switching network, is made up of:
1. Telephone exchanges (automatic switches)
2. Telephone instruments
3. Transmission elements
See figure 2.3.

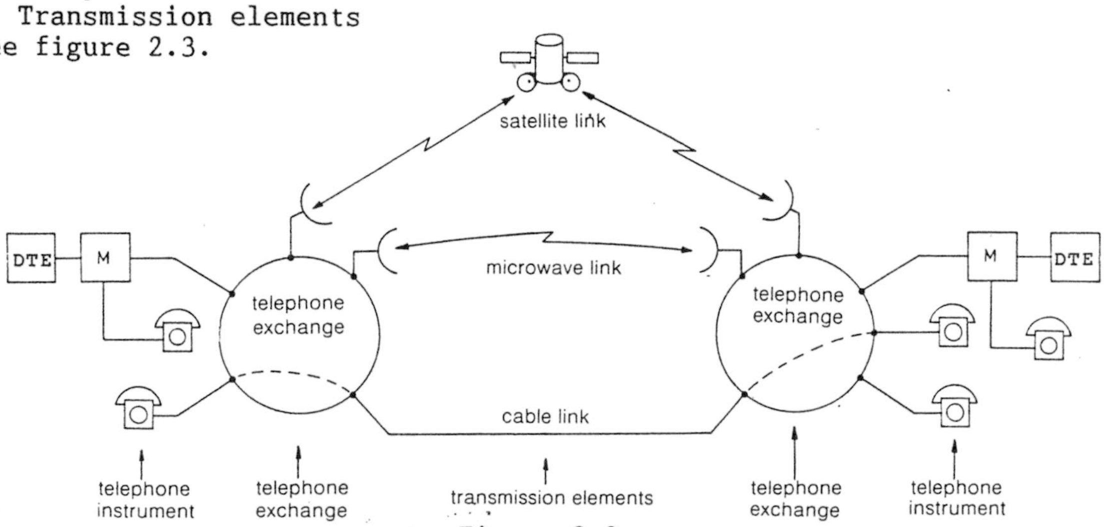


Figure 2.3
Elements in PSTN

The most important task of a telephone exchange are :
- To set up and clear connections, which are always between two subscribers (telephone instruments).
- To ensure that connections set up in this way are maintained as long as the subscribers require them.
- to record the costs of each call.
- to release the connections.

Modern, analog, telephone exchanges are usually computer controlled and fitted with two processors. The second one is used as a backup in case there is a failure in the first. The connections are made with the aid of reed relays in the exchange's switching network (Figure 2.4).

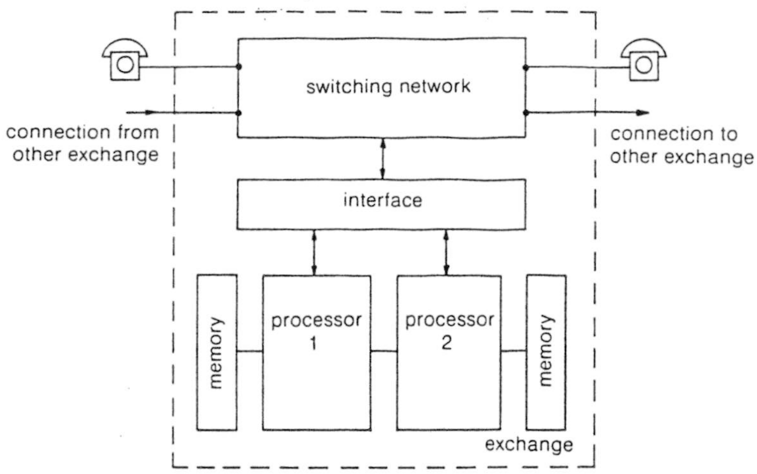


Figure 2.4
Telephone exchange

Telephone instruments:

From the subscriber's point of view, the most important element in the telephone network is the telephone instruments (telephone or terminal/modem), which is seen as a fast and inexpensive medium for speech/data communication.

Terminal/modem suitable for connection to a PSTN are :
- Start stop (asynchronous) mode terminals connected to asynchrone type modems
- Synchronous mode terminals connected to synchronous type modems

Start stop terminals are character oriented, and operate with a 7-bit code (ISO-7, ASCII or CCITT no 5) or and 8-bit code (V.4). Each character transmitted is regarded as a separate message which carries its own synchronization in the frame (start-,parity- and stop bit).

Synchronous terminals are block oriented. The characters that make up the messages are combined into one block of characters packed between control characters indicating the beginning and the ending of the message.

When a subscriber wants to set up a connection with another subscriber in the network, he has to start by transmitting the called subscriber telephone number, using rotary dial or a push-button dial (or 'Hayes' auto-dialing modem for data communication).

Using the number that has been dialed, the exchange(s) can set up the required connection. Once the connection is established, the subscribers can start to talk or communicate the data to each other. To make this possible the instrument is fitted with a transmitter and a receiver. At the end of the call, the connection can be cleared by replacing the handset (or by giving a command to the 'Hayes' smart-modem).

The transmission element of the PSTN:
- The circuits between the telephone instruments and the exchanges are usually formed by cables.
- The circuit between exchanges themselves:
  It may take place via cables, glass fibers (fiber optics), micro-wave links or satellites.

The digital transmission plays now an important role in the telecommunication. The great advantage is that the receiver can simply regenerate the received digital signals to the original signals. By digital transmission, the voice band signals have to be coded in bit streams and at the receiving side the received bit streams will be decoded to the original voice band signals. The technique used to code the analogue voice band signals to the digital bit streams is called Pulse Code Modulation (PCM).

In the modern digital telephone exchanges, the connections are made with the aid of the combination of the time switch and the space switch of the PCM channels.

2.3 Circuit Switched Public Data Network (CSPDN)

Using the existing telephone network (PSTN) for data communication is possible and modems are indispensable attachments. In fact to transfer digital information through the analogue telephone lines is a cumbrous method (first the digital data must be converted to the analogue signal and vice versa at the receiving side).

The ideal situation is that the digital information the user A sent will be transferred transparently through a circuit switching data network with a high speed rate to the user B without converting the digital data into analogue signals.

Circuit Switched Public Data Network (CSPDN) is a digital circuit switching network especially designed for data communication purposes. From user A to user B via CSPDN the data is kept digital. And establishing a call via CSPDN is much more faster than via PSTN (less than one second).

Terminals suitable for connection to a CSPDN can be divided into two groups:
- Start stop terminals (start/stop mode)
- Synchronous terminals (synchronous mode)

A CSPDN consists in most cases of a number of mesh connected Data Switching Exchanges (DSE) with multiplexers in the local networks (Figure 2.5).

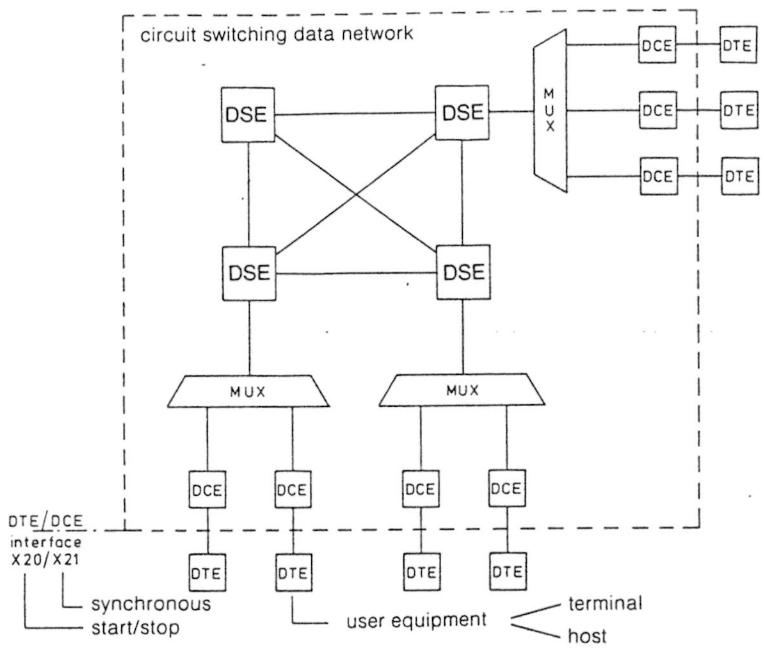


Figure 2.5
CSPDN

A clearly defined interface is fitted between the user equipment, the Data Terminal Equipment (DTE) and the Data Communication terminating Equipment (DCE).

For start/stop traffic the recommended interface is found in CCITT standard X.20 and for synchronous traffic in X.21. With a protocol described in X.20/X.21, a user can set up a data circuit to another user on the network, where the circuit begins and ends at a DTE/DCE interface.

The functions used for setting up, monitoring and clearing a connection are called signalling. It must be possible for signalling information to be exchanged between Data Switching Exchanges themselves but also between users and the network.

CSPDNs are bit sequence transparent; they are not capable of recognizing any structure in the bit stream exchanged between 2 terminal users, thus data from user A will be transparently sent to the user B. Character synchronization must therefore take place in the terminal itself. After the connection is established, every protocol the user wishes to use can be used. It does not matter whether an asynchronous character-oriented protocol or a synchronous block protocol is used. Of course both terminals must use the same type of protocol.

In the Skandinavian countries a modern CSPDN (Nordic Public Data Network) for synchronous traffic (X.21) has been installed.

Besides the Skandinavian countries, CSPDNs can also be found in the following countries :
- Austrian (Datex-L)
- Canada
- France (Transcom)
- Italy (Rete Telex-Dati)
- Japan
- USA
- West Germany (Datex-L)

Basic services offered are:
- Synchronous data transmission
- A number of standardised speed classes from 600 bps to 64 kbps

Additional service offered are:
- A user can subscribe to a number of optional user facilities,
  i.e. * rerouteing
  * abbreviated dialling
  * cost indication
  * closed user groups

In Sweden teletex service is offered via CSPDN (NPDN).

Teletex :
Teletex is a new service for text communication, currently being introduced by telecommunication authorities in several European countries. It provides text communication/processing and electronic mail facilities between terminals according to CCITT standardised protocols. These protocols ensure that equipment will not become obsolete too soon and that systems from different manufacturers can communicate with each other. Teletext, Viewdata or services with similar names provide database access capabilities.

The interface between terminal and network is the standard data network interface X.21 or X.21-bis (subset of V.24).

The kind of Teletex terminals :
1. Synchronous Terminal (X.21)
2. Start stop mode Terminal (X.21-bis)

The terminal here is able to perform more advanced functions with the aid of microprocessors: it may for instance have been designed as a word processor and equipped with floppy disk.
The local circuit between the terminal and the local DSE is 4-wire. The network offers synchronous full duplex data transmission via circuit switched connections. The user can take out a subscription allowing him to operate at 600, 2400, 4800 or 9600 bps.

For Teletex terminal required to interface with Circuit-Switched Public Data network (CSPDN) the three lowest layers of the OSI model can be summarised as follows :
1. The Physical layer describes the circuit ports as well as their electrical characteristics.
2. The data link layer carries out the frame oriented data structuring and enhances the data transmission capability in terms of error probability and synchronisation.
3. The network layer describes the call control procedures during the establishment and release of a call.

According to the OSI model, everything that happens at layer 4 (Transport Layer) and higher layer is independent of the service offered by the three bottom layers.

Teletex forms an important category of the total volume of traffic handled via CSPDNs.

The investments to set up a CSPDN is very high and for the time being such a network is not available in the Netherlands. The chance that a CSPDN will be installed in Netherlands is very little, because a new network called Integrated Services Digital Network (ISDN) is coming up.

2.4 Circuit Switched Data on ISDN

When the reader is not familiar with ISDN, please read appendix A first. The principles and the structures of ISDN will be described there.

ISDN defines a full network architecture (Figure 2.7). This architecture separates access functions (how to get into the network) from actual network functions (those internal to the network).

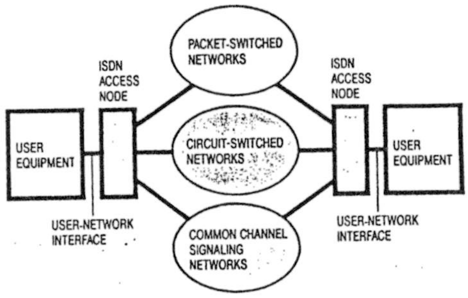


Figure 2.7
Network architecture of ISDN

The user-network interface is comprised of all the equipment between a user's customer-premises equipment and the network.

At ISDN reference points S and T, there are two access possibilities. They are (Figure 2.8):
1. Basic access: 2B + D; (B = 64 kbps; D = 16 kbps)
2. Primary rate access: 30B +D; (B = 64 kbps; D = 64 kbps)

The main characteristics of the circuit switched mode are:
The B-channel is purely used to transfer the user data and the D-channel handles the signalling information. 'User data' can consist of voice or data information. 'Signalling' refers to the passing of information for the establishment, maintenance and clearing of ISDN-channels.

Currently, signalling information in the PSTN such as ring, busy, and caller number is passed along in stream with the call (in-band signalling). The ISDN user network interface uses out of band signalling over the D-channel for more efficient transfer of data.

Thus establishing and clearing a call will be handled via the D-channel. When the call is established, the user data can be transferred transparently via the B-channel.

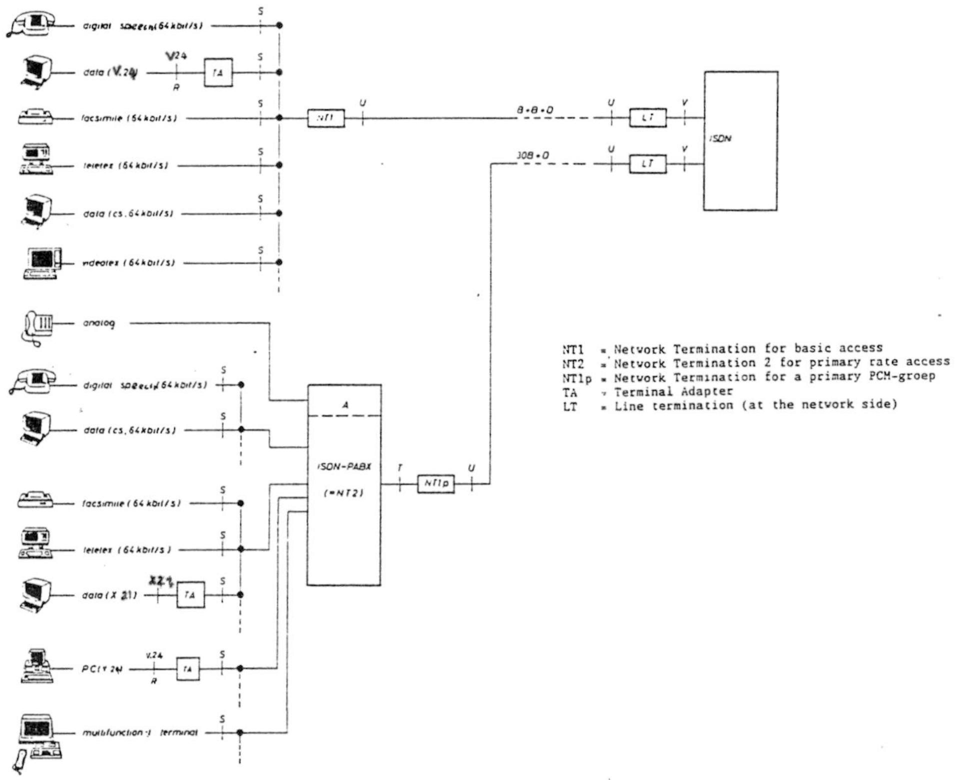


Figure 2.8
Basic and primary rate access

ISDN can interwork with the existing circuit switching networks described above (PSTN and CSPDN). The interworking is depicted on figures 2.9 and 2.10.

Interworking with PSTN:

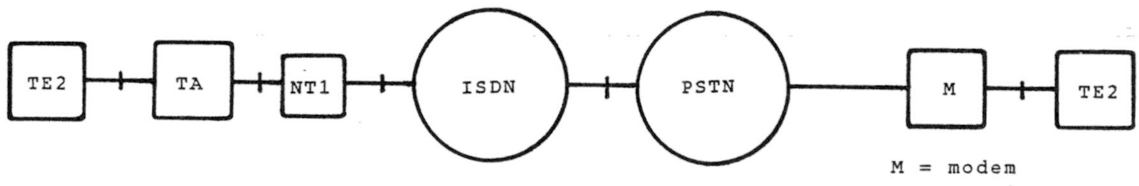


Figure 2.9
Interworking with PSTN

In this case, a terminal adaptor with modem connected to it is necessary.

Interworking with CSPDN:

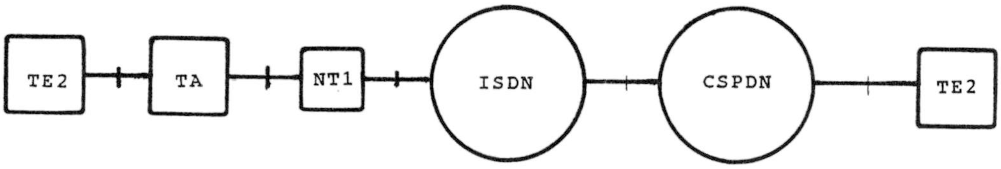


Figure 2.10
Interworking with CSPDN

The arrival of ISDN improves the data communication capabilities. The users can communicate with each other at the speed up to 64 kbps. Existing terminals can still be used using terminal adaptors.

England (British Telecommunication), Germany (Deutsche Bundespost), Japan, USA and Switzerland have started their first ISDN pilot services. The ISDN pilot project is not yet available in Netherlands, but PTT is now working hard to introduce ISDN services as soon as possible.

3. ISDN Terminal Adaptor for Circuit Switched Data (TA-csd)

3.1 Introduction

In view of the number and kind of terminals currently in use, the penetration of ISDN into the data processing and data communication community involves the necessity of a transitional step supporting communicating equipments and applications in use today.

It is also necessary to take account of interworking which will persist as long as the existing terminals of some remote users are connected to existing circuit switching networks such as the PSTN.

Thus for the first phase in the introduction of ISDN and for a number of years afterward, it will be necessary to adapt existing terminal devices to ISDN. Through this approach, a large, existing base of data terminal equipment will be able to use ISDN to access new and existing services via terminal adaptors. The configuration is depicted on figure 3.1.

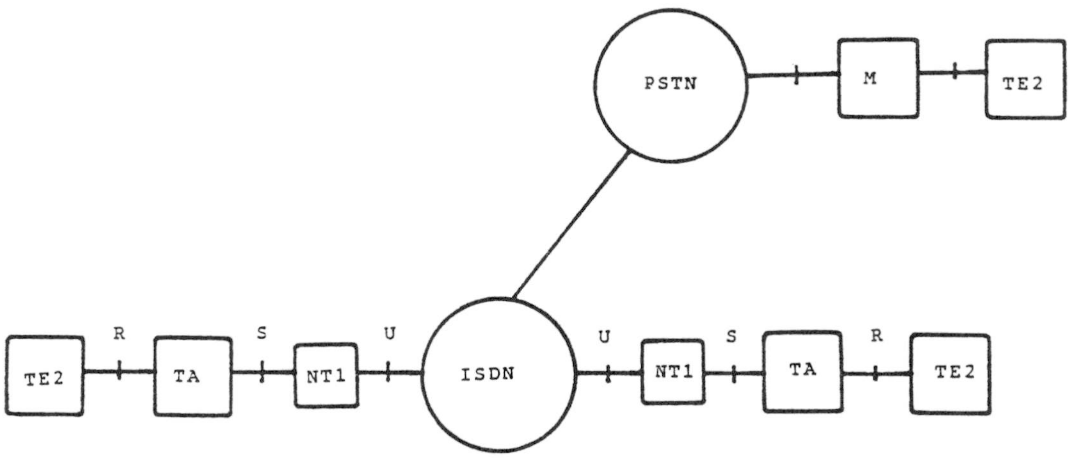


Figure 3.1
The configuration

In this chapter the kinds of the existing terminals, the possible types of TA-csd's and the choice of one of these types will be described.

3.2 Existing terminals on circuit switching networks

3.2.1 The principles of terminals

For data to be transferred using telecommunication techniques, a number of functional components are required. The most elementary functions of these components or units will be described.

The first unit in a link are the two stations that communicate with each other (Figure 3.2). The functions and facilities of these two stations may differ greatly. They could be two equivalent computer systems (CS) which interchange data or one station could be a computer system and the other a remote input device communicating with the computer system.

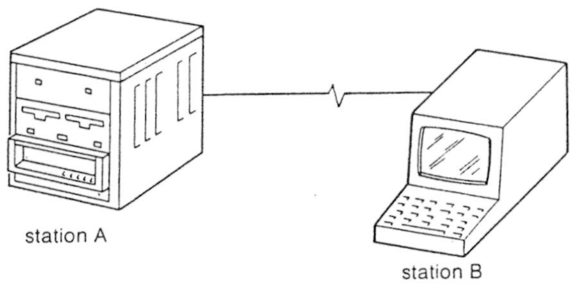


Figure 3.2
Stations

Stations in data communication links are generally referred to as terminal stations or terminals for short. The information transmitted over the link generally comprises text made up of characters (letters, figures, digits or signs).

In the computer system these characters are made up of a number of elements known as bits. As the link can transmit only one data-carrying element (bit) per unit time, the information to be transmitted must first be converted from parallel information (characters) to a string of serial elements (bits). On the receiving side, these serially received bits must again be converted into parallel information (characters). This conversion takes place in a control unit called Data Communication Controller (DCC) (Figure 3.3). Converting information from parallel to serial and vice versa is one of the most essential functions of the DCC.

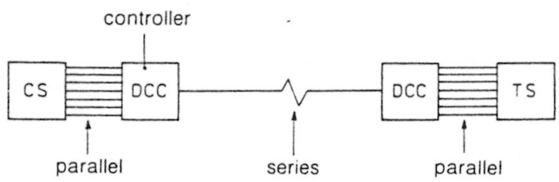


Figure 3.3
Data Communication Controller

The bit stream obtained in this way cannot be transmitted over long distances in this form, as the transmission medium is not suitable for the transport of DC signals. To avoid this problem, the information must first be placed on a carrying wave (AC) prior to transmission. This process is called modulation and takes place in a modem (Figure 3.4).

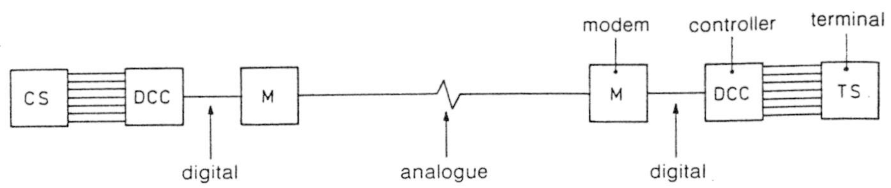


Figure 3.4
Long distance data transmission

Within the link between two stations there are various levels, each of which plays its own part in the total communication process (Figure 3.5).

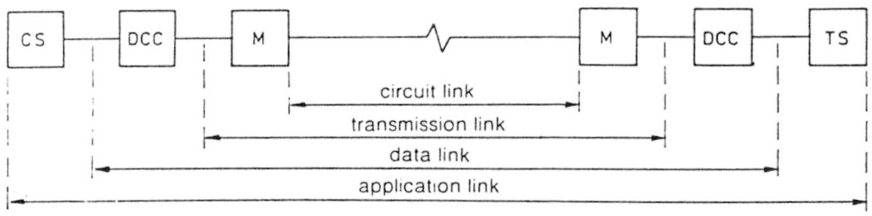


Figure 3.5
Communication levels

Circuit link (the lowest level) is responsible for the transport of serial, modulated information. There must be agreed signal levels and signal frequencies for this link.

The second level is called the transmission link (data circuit). The job of the transmission link is to deliver the serially arranged bits offered to the link at one end to the other end of the link in the same sequence. There must be agreements regarding the type of modems and the way in which bit transport (asynchronous or synchronous transmission) to and from the DCC is to be carried out.

The third level is the data link, which transmits coded information between two terminals. There must be agreement on the way in which a message is packed to enable it to be clearly read at the other end.

The highest level comprises the whole data communication link and is called the application link. It connects two terminals in such a way that both users are able to communicate with each other. There must be agreed methods to confirm a successful transmission, establish and clear a link etc.

Thus a terminal is an end station in a data communication link that gives users access to the communication network. In this context the 'users' can be either people entering information via terminals or programs being run on terminals. The combination of the processing unit and the DCC is referred as to as DTE (Data Terminal Equipment). The modem and the associated transmission equipment is referred to as Data Circuit termination Equipment (DCE) (Figure 3.6).

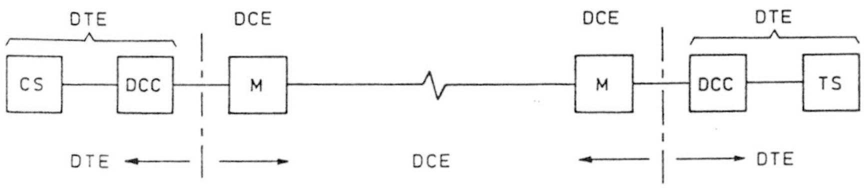


Figure 3.6
DTE and DCE

3.2.2 Types of Terminals

Globally speaking, there are two types of DTEs applied in circuit switching networks. The two standard types are:
1. Asynchronous (start/stop) mode DTE
2. Synchronous mode DTE

3.2.2.1 Asynchronous (start/stop) mode Terminals

For start/stop mode terminals, the message are made up of loose characters, at least as far as transmission is concerned. Each character is basically transmitted independently from any other. These characters may immediately follow one another, but it is also possible that for a given time between characters no transmission takes place. This time may be of any length (Figure 3.7).

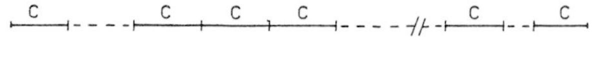


Figure 3.7
Character transport in the start/stop mode

For the purposes of transmission, each character in the start/stop mode is packed between synchronization bits. The character is therefore preceded by a start bit. After the start bit comes the character proper; this is formed from a number of data bits (varying between 5 and 8 depending on the code that is used) and a parity bit. The character is then followed by one or more stop bits. The bit pattern formed in this way is called a frame. A frame therefore consist of a character packed between start and stop bits. The start bit is added for synchronization purposes.

On reception, this start bit ensures both bit synchronization, the timing for the data bits to be received, and character synchronization, the correct reception of all the bits that make up the character (Figure 3.8).

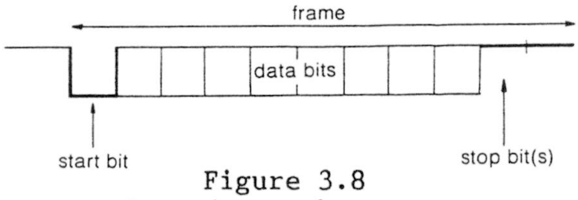


Figure 3.8
Start/stop character

Reception of the start bit's wave front starts a clock in the receiving DCC (Figure 3.9). Half bit rate later, i.e. in the middle of a start bit, a check is made to see whether it really was a start bit. This is to prevent any interference initiating the receipt of a character. One bit later, i.e. in the middle of each bit, the value of the bit is shifted into a receiving register. This continues until the whole character is received. After receipt of the character another check is made to ensure that the character is terminated with a stop bit.

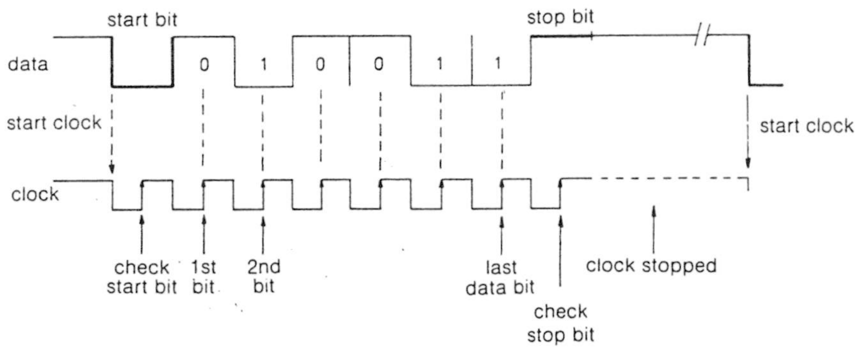


Figure 3.9
Synchronization start/stop character

The choice of the number of stop bits (1, 1.5 or 2) is mainly made on historical grounds. Mechanical terminals such as teleprinters need two stop bits to allow the mechanical parts enough time to return to their home position. A telex terminal needs only 1.5 stop bits. For most modern start/stop terminals, such as a Video Display Unit (VDU) terminal, 1 stop bit is enough. After the terminal is ready to receive the next character, the time between two characters must be at least 1 bit but it is not tied up to any standard. It would not even matter if a whole day passed between transmission of one character and the next.

In start/stop mode terminal each character transmitted is regarded as a separate message which carries its own synchronization in the frame, although in practice a number of characters is frequently combined into a message (or block) and transmitted in a single sequence.

The advantage of start/stop transmission is that no exact timing of transmitter and receiver is required. If the transmitter happens to transmit somewhat faster than the receiver is expecting, this will mean at most that the last few bits of the character are not clocked in exactly at the centre of the bit pulse. However, as the clock is restarted for each character, the first bit will always be clocked in exactly.

A disadvantage of this type of terminal is the comparatively large number of bits that has to be added to achieve synchronization: at least two bits per character.

3.2.2.2 Synchronous mode Terminals

In synchronous mode terminals the characters that make up the messages are combined into one block of characters. The block information formed in this way is packed between control characters indicating the beginning and end of the message (Figure 3.10).

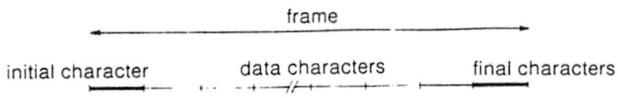


Figure 3.10
Character transmission in the synchronous mode

Because synchronous mode terminals do not add start/stop bits to the characters, synchronization with the receiving station has to be arranged differently. The following points need to be considered:
- the receiver must know when a bit is received from the transmitting station (bit synchronization). This is shown in figure 3.11.
- the receiver must know which bit of the character has been received (character synchronization). This is shown in figure 3.12.

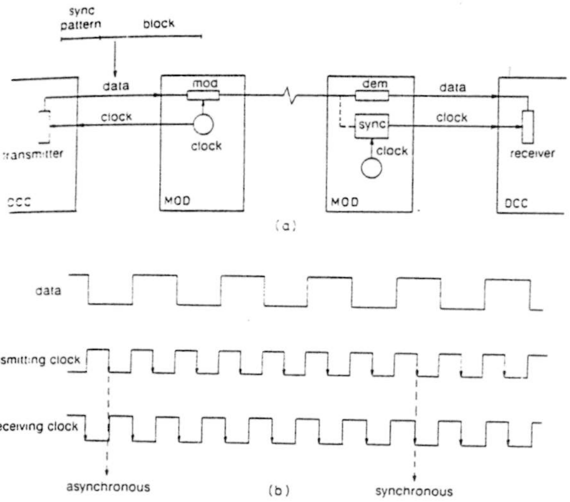


Figure 3.11
Bit synchronization

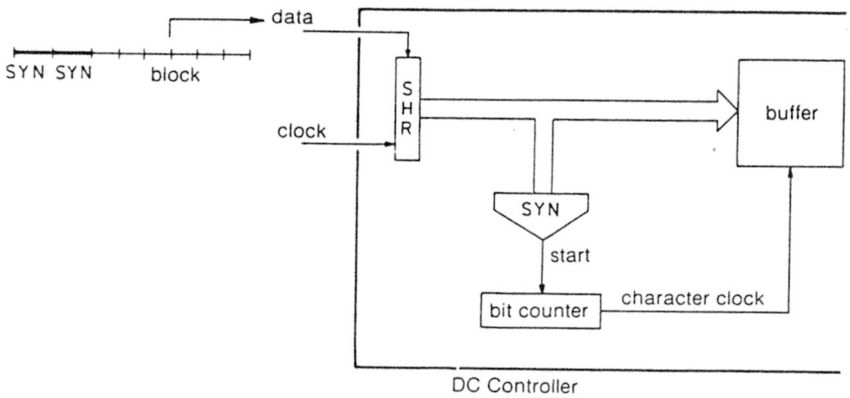


Figure 3.12
Character synchronization

One of the advantages that synchronous mode terminal have over start/stop terminal is that fewer synchronization elements must be added.

The disadvantage is that the equipment is more complicated and therefore more expensive.

3.2.3 DTE/DCE Interfaces

To connect terminals or computer systems (DTEs) to existing conventional networks (PSTN) via modem (DCE), the CCITT's V.24/V.28 (EIA's RS-232-C) interface are used, which are specially designed for connection to analogue facilities (Figure 3.13). The circuits in V.24 are practically identical to those in RS-232-C.

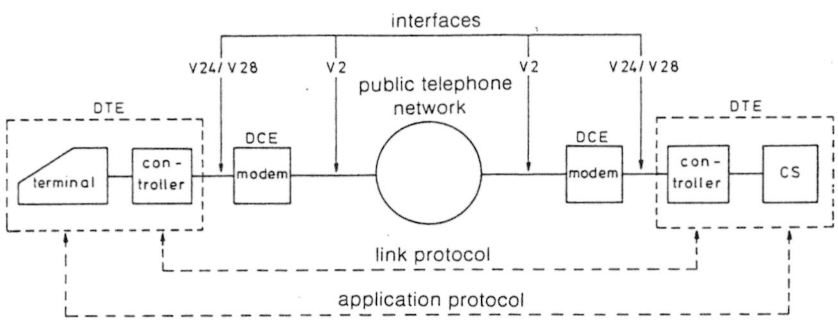


Figure 3.13
V.24 DTE/DCE interface on PSTN

V.24 is a serial communication interface used for asynchronous as well as synchronous data transmissions.

CCITT recommends the V.24 interface for the PSTN, but it is often used for leased and private links in data communication networks as well.

Apart from recommendation V.24, CCITT gives a number of other recommendations directly related to the V.24 interface. These recommendations contain information about:
- Power levels for data transmission over telephone lines (V.2)
- Electrical characteristics for unbalanced double current interchange circuits for general use with integrated circuit equipment in the field of data communication (V.10).
- Electrical characteristics for balanced double current interchange circuits for general use with integrated circuit equipment in the field of data communication (V.11).
- Electrical characteristics for unbalanced double current interchange circuits (V.28).
- Modem types (V.21, V.22, V.23, V.26, V.27, V.32, V.35)

To use the automatic calling facilities, CCITT recommended the V.25 and V.25-bis auto call interface to be added to the V.24 interface (Figure 3.14 and 3.15). V.25 corresponds to EIA's RS-366.

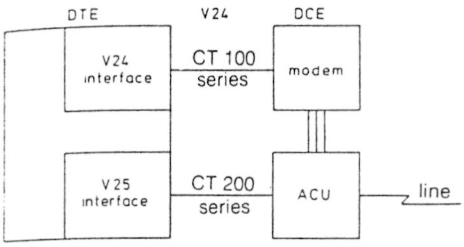


Figure 3.14
V.25 Automatic calling

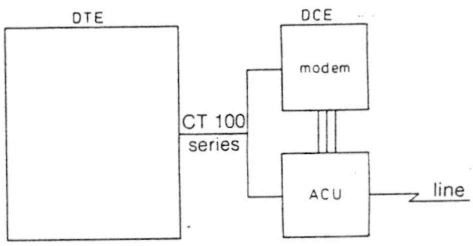


Figure 3.15
V.25-bis Automatic calling

During the development of the more modern public data networks there has been a gradual growth in demand for good interface standards between terminals or computer systems (DTEs) on the one hand and the network on the other hand. In other words, between DTE and DCE, CCITT has developed a number of standards known as the X-series, for public data networks. This series includes X.1, X.2, X.20, X.20-bis, X.21, X.21-bis, X.24, X.26, X.27 and X.29.

These standards contain recommendations for terminal connections, link control procedures, data transmission and the services required by leased circuits and for circuit switching networks.

One of the most important interfaces is defined in CCITT X.21. It is a universal interface for use between terminals or computer systems and the modern synchronous public data networks. The recommendation covers both circuit switching networks and leased circuits. From an operating point of view, interface X.21 replaces both the terminal-modem interface V.24 (RS-232) and the auto-call interface V.25 (RS-366).

CCITT recommended also two V.24 sub-sets known as X.20-bis and X.21-bis as interfaces for public data network (CSPDN).

X.21-bis interface provides a facility for connecting terminals with a V.24 interface to the new data networks. However, X.21-bis does not allow the use of many of the new functions available in X.21.

To connect start-stop mode terminal to public data networks, CCITT has developed X.20 interface. This makes it possible to achieve speeds up to 300 bps.

X.20-bis interface enabling start/stop mode terminal with a V.24 interface to be connected to the public data network.

Thus for start/stop (asynchronous) mode terminal the following interfaces are applied:
- V.24
- X.20
- X.20-bis

For synchronous mode terminal the following interfaces are applied:
- V.24
- X.21
- X.21-bis

3.3 ISDN Terminal Adaptors

For support of non-ISDN terminals to be connected to the ISDN, terminal adaptors (TAs) are required. The main function of the TA is to provide an access capability for non-ISDN terminals at the R-reference point to ISDN. The type of TA needed is determined by the communication mode and the interface of the terminal. Terminals can have an asynchronous (start/stop) or a synchronous communication mode. Terminals can also have the V.24, V.35, X.20, X.20bis, X.21, X.21-bis, a/b (analogue) interface etc.

Terminals Adaptors for circuit switched data connection (TA-csd's) is the main subject of this report. The types of TA-csd's, dependent on the terminal's interface, will be handled in this paragraph. TA-csd's for terminals with X.20 or X.20bis interfaces are not discussed in this report. This is because there is no standard defined by CCITT for supporting X.20 and X.20bis based terminals by an ISDN.

Possible types of TA-csd's are:
1. TA-csd a/b

2. TA-csd V.24
3. TA-csd V.35
4. TA-csd X.21
5. TA-csd X.21bis

In the following paragraphs each type of TA-csd will be explained.

3.3.1 TA-csd a/b

This equipment carries out the necessary conversions between the a/b two wire analog interface of the telephone equipments and the S/T interface (Figure 3.16).

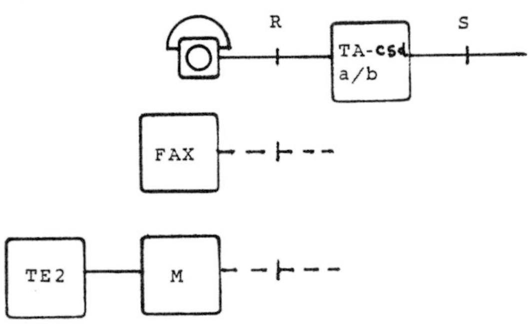


Figure 3.16
TA-csd a/b

Signalling conversion consists in ensuring the translation between the usual signals (make or break loop current, decimal dialing, transmission of tones, ringing signal, polarity reversal etc.) and the messages transmitted on the D-channel.

The user information is converted by encoding the audio frequency analog signal (300-3400 Hz band) into a digital string at 64 kbps according to the A law of CCITT recommendation G.711 and vice versa (decoding function).

This adaptor fits the telephone sets and all those terminals with a built-in modem (for e.g. facsimile/fax) or terminal with an external modem using the audio frequency band with either manual or automatic call set-up and answer facilities.

3.3.2 TA-csd V.24

The TA-csd V.24 is used to connect terminals with a V.24 interface to the ISDN S-interface (Figure 3.17).

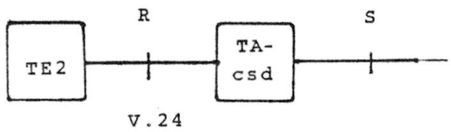


Figure 3.17
TA-csd V.24

The bit stream of the V.24 terminal (defined in X.1) is converted into 64 kbps by using the rate adaptation function in compliance with the following standards :

- CCITT V.110 :
  Support of DTEs with V-series Type Interfaces by an ISDN.
- ECMA 102 :
  Rate Adaptation for the support of synchronous and asynchronous equipment using the V-series type interface on a PTSN

Apart from the rate adaptation function, a TA also handles the ISDN D-channel signalling protocol to set up, answer and release a call.

TA-csd V.24 can be designed based on the following facilities:

a. TA-csd V.24 without automatic calling/answering facilities:
   In this case, the user can not set up or answer a call via his terminal or keyboard. A front panel comprising a keyboard with ten numerical keys and other function keys, as well as a display, built into the TA-csd V.24 is necessary to dial or answer a call. Optionally, the TA-csd V.24 may support hot-line connections.
b. TA-csd V.24 with automatic calling/answering facilities:
   When a TA-csd V.24 supports this facilities, the following standard interfaces can be used:
   * V.25 (Automatic answering equipment and/or parallel automatic calling equipment on the general switched telephone network). The automatic answering and calling procedures make use of the 200-series V.24 interchange circuits and are known as 'parallel' automatic calling (Figure 3.18).

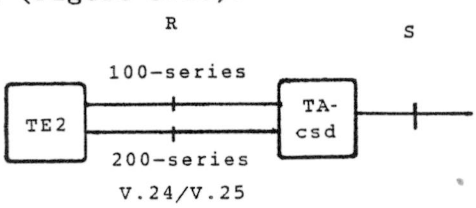


Figure 3.18
TA-csd V.24/V.25

   The TA-csd V.24/V.25 converts the V.25 protocol to D-channel signalling protocol.
   * V.25bis (Automatic calling and/or answering equipment on the general switched telephone network using the 100-series interchange circuits). The automatic calling and answering procedures make use of the 100-series V.24 interchange circuits and are known as 'serial' automatic calling (Figure 3.19).

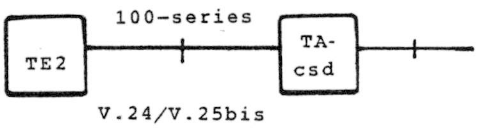


Figure 3.19
TA-csd V.24/V.25bis

The TA-csd V.24/V.25bis converts the V.25bis protocol to D-channel signalling protocol.

* Hayes command set
For asynchronous (start/stop) mode terminal, Hayes has defined a command set implemented on the auto dialing modems. The user can set up a call via his terminal or keyboard by giving a command to the modem. The modem dials the number and waits for the connection. If the connection is established, data can be exchanged between the users. When an incoming call arrives, the modem can also answer the call automatically. The same principle can be applied to the TA-csd V.24/Hayes supporting the auto calling/answering facilities (Figure 3.20).

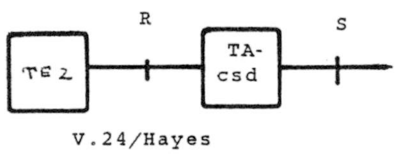


Figure 3.20
TA-csd V.24/Hayes

The user gives commands to the TA-csd V.24/Hayes to set up, answer or release a call. The TA-csd V.24/Hayes converts the Hayes command set into the D-channel signalling protocol.

3.3.3 TA-csd V.35

The TA-csd V.35 is used to connect terminals with a V.35 interface to the ISDN S-interface (Figure 3.21).

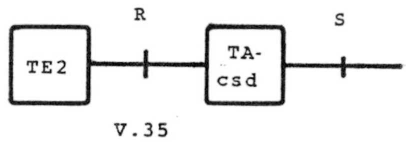


Figure 3.21
TA-csd V.35

The bit stream of the V.35 terminal (48 kbps) is converted into 64 kbps by using the rate adaptation function in compliance with the following standards :
- CCITT V.110 :
- ECMA 102 :

Apart from the rate adaptation function, the TA-csd V.35 also handles the ISDN D-channel signalling protocol to set up, answer and release a call.

A front panel, comprising a keyboard with ten numerical keys, and other function keys as well as a display, built in the TA-csd V.35 is necessary to set up or answer a call

3.3.4 TA-csd X.21

The TA-csd X.21 is used to connect a synchronous terminal with a X.21 interface to the ISDN S-interface (Figure 3.22).

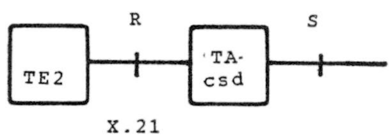


Figure 3.22
TA-csd X.21

The bit stream of the X.21 terminal (defined in X.1) is converted into 64 kbps by using the rate adaptation function in compliance with the CCITT X.30 recommendation. The rate adaptation method for the TA-csd X.21 is in line with the V.110/ECMA-102.

Apart from the rate adaptation function, this TA-csd X.21 also handles the signalling protocol of the X.21 interface and converts it into the ISDN D-channel signalling protocol to set up, answer and release a call.

3.3.5 TA-csd X.21bis

The TA-csd X.21bis is used to connect a synchronous terminal with a X.21bis interface to the ISDN S-interface (Figure 3.23).

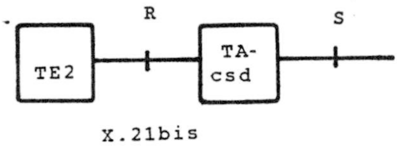


Figure 3.23
TA-csd X.21bis

The bit stream of the X.21bis terminal (defined in X.1) is converted into 64 kbps by using the rate adaptation function in compliance with the CCITT X.30 recommendation. TA-csd X.21bis also handles the signalling protocol of the X.21bis interface and converts it into the ISDN D-channel signalling protocol to set up, answer and release a call.

3.4 The choice of the TA-csd

In paragraphs 3.2.2 and 3.3 the types of terminals and TA-csd's are described. Before the functional descriptions of the TA-csd and the information exchange procedures between the terminal and TA-csd for circuit switched data applications can be designed, some decisions must be made relative to the following questions:
- Which type of the terminal interfaces (a/b, V.24, V.35, X.21, X.21bis etc.) forms the basis for the design of the TA-csd ? The interface must be available and used at present as well as for the following 5 up to 10 years. The RS-232-C interface is similar to the V.24/V.28 interface. RS-232 is defined by EIA and V.24/V.28 are defined by CCITT.
- For which type of terminals (asynchronous or synchronous mode) is the TA-csd intended ? The decision is depending on the type of terminals that are used most frequently in practice.

To answer the questions above, some people of the large and middle size businesses and some people of the Delft University of Technology have been interviewed. They are:
- Stikkel H.C, Department of Electrical Engineering of the TU Delft
- Spanjersberg H.A, computer centre of the TU Delft
- Heering, Ch.A, computer centre of the TU Delft
- Vink, Communication manager of Van Gend en Loos
- Hemmes, H.C.M., Services, systems and automation department of AEGON
- Werkhoven, S, EDP/A of APT
- Kardol J.A, Corporate communications of Philips Eindhoven

3.4.1 The summary of the interviews

University : TU Delft
Names : H.C. Stikkel
H.A. Spanjersberg
Ch.A. Heering

The interviews with the people from the TU Delft are summarized here.

The types of terminals used at the TU Delft are:
a. Asynchronous terminals, connected to the host via RS-232-C interface.
   for example: * VT200 mode terminals
   * VT100 mode terminals
   * Personal computers
   * Tektronix terminals (for graphical applications)
b. Synchronous terminals, connected to a cluster controller via coax interface.
   for example: * 3270 series IBM terminals
   * 3178, 3179, 3180, 3191, 3192 series IBM terminals

The number of asynchronous terminals is about 1700 and the number of synchronous terminals is about 300.

The advantages of the asynchronous terminals are:
- Cheaper, the difference is roughly 1000 to 2000 guilders compared with the synchronous terminals.
- Via IBM 7171 protocol converter or terminal emulators, asynchronous terminals can communicate with IBM mainframes.

RS-232-C interface is the most used interface at present.
H. Stikkel is very enthusiast about the use of the communication interface RS-232-C. The reasons therefore are:
- Good standardized interface
- It is a wide spread used interface at the universities as well as in companies.
- Voltage level is good
- High resistance to disturbances
- For short and long distance communication, the Kermit communication program will be used. The program has error checking facilities.
- This interface will be used for the next 5 to 10 years.

TU Delft also has a number of facsimiles to send and receive documents etc.

For data communication purposes, TU Delft has a local area network. It is called DUneT (Delft University of Technology Network). DUneT is a broadband-baseband network. The broadband network connects the TU buildings together and the baseband network (ethernet) connects for example the computers together within a building.

DUneT is connected with the following networks (Figure 3.24):
- Public telephone network from PTT via PSTN gateway
- SURFnet
  The old abbreviation of SURF is:
  Samenwerkende Universitaire Reken Faciliteiten
  The new one is:
  Samenwerkingsorganisatie computerdienstverlening voor hoger onderwijs en onderzoek
- EARN (european Academic Research Network)
- Datanet 1 via X.25 gateway
- DECnet
- Hewlett Packards Advancenet
- IBMnet/SNA network

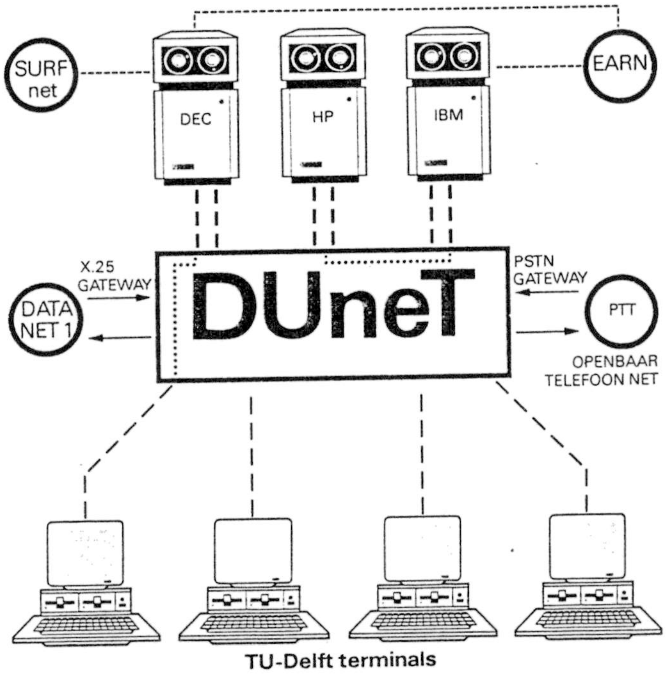


Figure 3.24
DUneT

Company : Van Gend en Loos
Name : Vink (Communication manager)

Van Gend en Loos is a big transport company.
It has a head office in Houten and 22 depots spread through Netherlands.

There are in total three mainframes, one IBM S/38 and two IBM S/37 (one system functions as a back up system) and one database system in the head office. In all depots there are in total 25 IBM S/36's.

The CC's are connected to FEP via modems. The CC's in the depots are connected in a star configuration via a leased lines and/or dial up lines to the head office. The network applied is the System Network Architecture (SNA) from IBM (Figure 3.25).

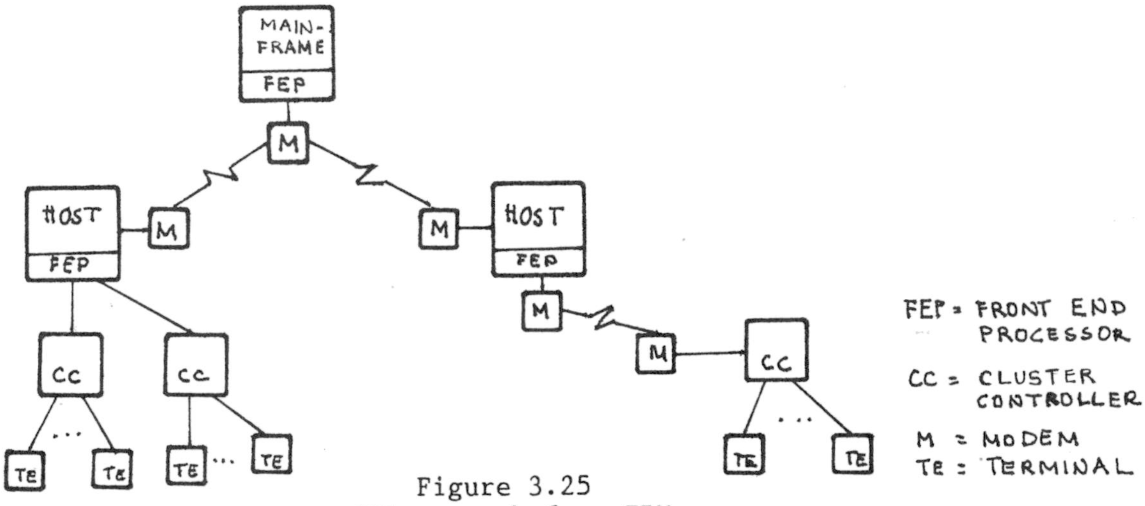


Figure 3.25
SNA network from IBM

For the communication via the depots to the head office, modems are used. The specification of the modems are:
- CCITT recommended type modems
- RS-232-C interface
- The rate for leased lines: 9600 bps
  The rate for dial up lines: 2400 bps
- synchronous transmission
- with automatic answering facility
- with test facilities
- full duplex

The total number of the IBM terminals are 600.
Besides synchronous IBM terminals, asynchronous IBM and compatible Personal Computers are also used. With the add-on card 3270 terminal emulations, the PC's can communicate with the mainframe. The number of PC's is 60 and they are usually used 'stand alone'. Van Gend en Loos has a number of facsimiles to send and receive the documents etc.

Company : AEGON
Name : Hemmes, H.C.M
(Services, systems and automatisation department)

AEGON is a big insurance company in Netherlands. It has 2 computer-centres in Leeuwaarden en s'Gravenhage. The configuration of the network is a starnetwork from IBM (SNA).

For the communication between the branches via leased or dial up lines modems are used. For the communications between cluster controller (CC) and front end processor (FEP) or between FEP's, baseband and/or normal modems are used.

The specification of the normal leased line modems are:
- CCITT recommended type modems
- RS-232-C interface
- 25-pin connector
- The rates are: 4800 or 9600 bps
- synchronous transmission
- with automatic answering facility
- with test facilities
- full duplex

The specification of the normal dial up modems are:
- CCITT recommended type modems
- RS-232 interface
- 25-pin connector
- The rate is 1200 bps
- asynchronous transmission
- Hayes compatible
- with test facilities
- full duplex

The specification of the basis band modems are:
- CCITT recommended type modems
- V.35 interface
- 34-pin connector
- The rate is 56 kbps
- synchronous transmission

The total number of IBM terminals is 2500. Besides the synchronous IBM terminals, the asynchronous IBM and compatible Personal Computers and facsimiles are also be used. With the add-on card 3270 terminal emulations, the PC's can communicate with the mainframes. The number of PC's is 250 and they are usually used 'stand alone'.

Company : AT & T and Philips Telecommunicatie Bedrijven B.V.
Name : S. Werkhoven (EDP/A)

The types of terminals used at APT are:

a. Asynchronous terminals, connected to the host via RS-232-C interface.
   for example: * VT200 mode terminals
   * VT100 mode terminals
   * Personal computers
   * Tektronix terminals (for graphical applications)
b. Synchronous terminals, connected to the cluster controller via coax interface.
   for example: * 3270 series IBM terminals
   * 3178, 3179, 3180, 3191, 3192 series IBM terminals

The number of asynchronous terminals is 700 and the number of synchronous terminals is 10.

APT has also a local area network, but it is not connected to the other public networks. It is fixed connected via modems to the local area networks at the other APT branch offices in England, Brussels etc.

Company : Philips Eindhoven
Name : J.A. Kardol (Corporate communications)

The communication can be divided into two great main classes:
1. Interhuman communication:
   - Interactive communication
     * Telephone
     * Videoconferencing
   - Messages communication
     * Voice mail
     * Facsimile
     * Telex
     * Teletex
     * Computer Based Messaging Systems (CBMS)
2. Datacommunication
   This is the communication between humans and computer applications and between computer applications.

The networks inside Philips:

I. Speech communication network
   International networks for telephony.
   It consists of PABXs. They are connected with each other via leased lines.

II. Data communication network
   - Local Area Network (LAN)
   - Corporate Data Network (CODAN)
   - SNA from IBM
   - DECnet
   - series network

III. Message communication network
   Philips Message Service (PMS)

The number of terminals at Philips in Turnhout:

	1987	1988	1989	1990	1991
DEC	150	200	240	265	275
IBM	70	100	115	120	125
PC	20	180	300	360	400

DEC terminals and PCs use the RS-232-C interfaces.
IBM terminals use the coax interface and are connected to the Cluster Controller. There are also facsimiles used to send and receive documents etc.

From the list given above, it is obvious that the number of PCs grows very fast. In the future, PCs will be used as terminal stations.

The modems used via dial up lines are of the following types:
* V.22   1200 bps
* V.22bis 2400 bps
* V.32   9600 bps

The modems used via leased lines are of the following types:
* V.27bis 4800 bps
* V.29   9600 bps
* V.33   14400 bps
* ----   19200 bps (not standard)
* Baseband modems (V.35)

The broadband modems used via the digital services from the PTT at the 64 kbps and 2 Mbps lines are of the following types:
* V.36   48 kbps
* V.37   128 kbps
  144 kbps
  156 kbps

Connectors:

V.24/V.28 (RS-232)	:	25-pin
V.35	:	34-pin
X.21	:	15-pin
RS-449	:	37-pin

3.4.2 The conclusions of the interviews

From the summary of the interviews given above, the following conclusions are made:

- For the companies, where the information processing, administration, logistics, business, invoices, settlements etc. are the main subjects, IBM terminals and IBM systems/network are used. In this case, they are the insurance company AEGON and the transport company Van Gend en Loos.

- For companies or universities, where development, manufacturing, mass databases, process control, computing facilities etc. are the main subjects, DEC terminals and the DEC systems/network are used. Beside it, they are also used the IBM terminals and the IBM mainframes, but the ratio between the IBM terminals and the DEC terminals is very small. In this case they are the telecommunication company APT, Philips and the Delft University of Technology.

- DEC terminals are connected to the host via the RS-232-C interface. PCs and modems are also using the RS-232-C interface. IBM terminals use the coaxial interface and coax cable to be connected to the Cluster Controller.

- On almost every middle size or large company, universities etc., the IBM and compatible Personal Computers (PCs) are available. PCs are used for advanced text editing capabilities (word processing), data bases, spreadsheet, writing programs in different kind of programming languages, data communications etc. They also use the PC as a DEC terminal (with a terminal emulation program running on it) or as an IBM terminal (with an add-on terminal emulation card built in the PC). In addition, not only the companies or universities use PCs, but also the home workers and the hobbyists.

3.4.3 The decisions

From the interviews, it is obvious that the X.21 or X.21bis terminals with X.21 or X.21bis interfaces and the V.35 terminals with V.35 interfaces are not applied. IBM terminals with the coaxial interfaces should be a candidate for the basis design of the TA-csd, as the universities as well as the companies have IBM terminals and mainframes. But the IBM terminals are not yet supported by the CCITT (Redbook, 1984). Thus for the reasons given above they are not chosen as the basic design of the TA-csd.

From the five candidates of the TA-csd's interfaces (a/b, V.24, V.35, X.21 and X.21bis) two kinds of TA-csd's remain. They are TA-csd a/b and TA-csd V.24.

To make a good decisions, which of the two types TA-csd's will be chosen, the following considerations are made:

- It seems from the interviews that the asynchronous (start-stop) mode interfaces used by DEC terminals and PCs, with RS-232-C interfaces are the most used type of terminals and interfaces.

- TU Delft has at least one facsimile and also the other companies interviewed. Facsimiles (up to group 3) have internal modems built in it and the interface to the PSTN-line is the a/b interface. However, the number of facsimiles are much less than the number of asynchronous terminals.

- Communication within ISDN:
  * To connect a terminal to the TA-csd a/b, modems at both user sides are necessary to make the communication possible (Figure 3.26).

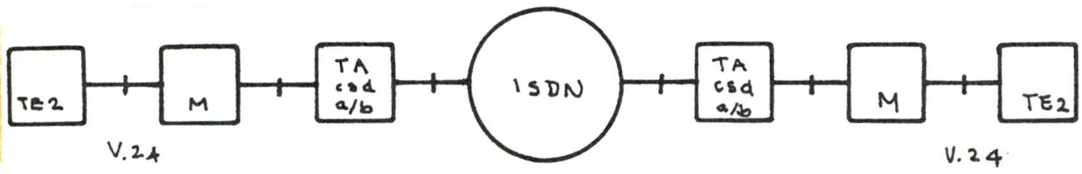


Figure 3.26
TA-csd a/b for communication within ISDN

In fact this is a disadvantage point. The digital data streams from the terminal must first be converted into analogue data signals (via modem) and then the analog data will be converted again to the digital data stream (64 kbps) via TA-csd a/b and vice versa at the other side.

* When a terminal is connected to the TA-csd V.24, modems are not necessary to make the communication possible (Figure 3.27).

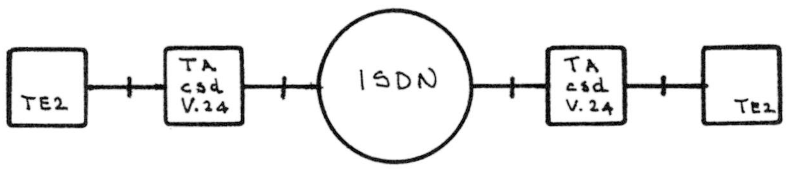


Figure 3.27
TA-csd V.24 for communication within ISDN

Via the rate adaptation method the digital data stream from the terminal will be directly converted to the other digital data stream (64 kbps) via TA-csd V.24.

- Communication via ISDN to the PSTN:
  * In this case a modem is also necessary to be connected to the TA-csd a/b (Figure 3.28).

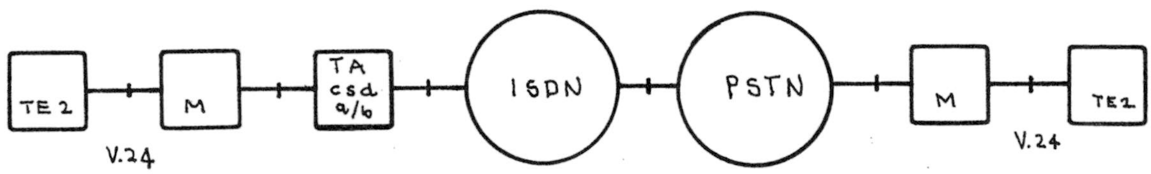


Figure 3.28
TA-csd a/b for communication via ISDN to PSTN

* A modem function in the TA-csd V.24 is necessary to make this kind of communication possible. This modem function can be realised by including an internal modem built in the TA-csd V.24 and/or by providing extra connectors to connect an external modem to it (Figure 3.29). It is handy for the case when the user already has an (expensive) high speed stand alone modem. He can always use it. It is worthy to make a consideration to implement this kind of configuration especially when the Integrated Circuits modems are getting cheaper and cheaper.

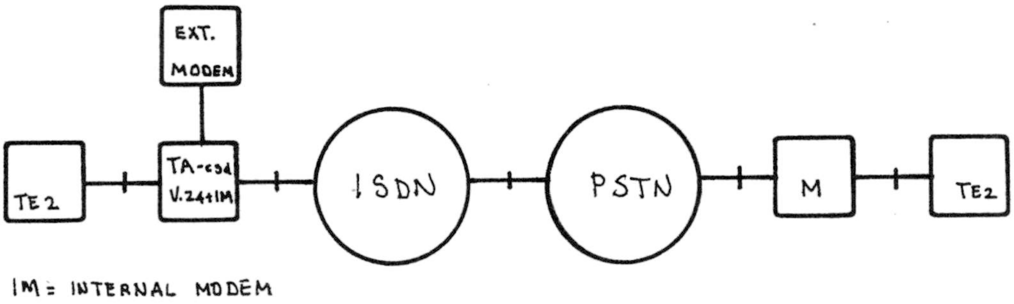


Figure 3.29
TA-csd V.24 for communication via ISDN to PSTN

From the reasons given above the asynchronous (start/stop) mode terminals used by DEC terminals and PCs in combined with RS-232-C interfaces are chosen for the basic design of the TA-csd.

To make the communication possible to the PSTN via ISDN, an internal modem will be built in the TA-csd V.24 and extra connectors are provided to connect an external modem to the TA-csd V.24.

At this moment the command language used to control the auto dialing modems are the 'de facto' standard Hayes command set. To provide the transparent replacement of modems and allow existing dial procedures and communication programs to work with ISDN is the Hayes command set chosen to control the TA-csd V.24.

In the next paragraphs, the TA-csd V.24 with built in internal modem and extra connectors is abbreviated with TA-csd. This TA-csd is controlled by using the Hayes command set.

4. The design of an TA-csd

4.1 Introduction

In the previous paragraphs the kinds of existing terminals and TA-csd's are described. A choice is also made for which type of terminals is TA-csd intended. In this chapter, the possibility of the hardware implementations of a TA-csd will be explained. Also the functional specifications of a TA-csd will be described. On the hand of the available ICs (S-interface ICs, rate adaptation ICs, modem ICs etc.), a hardware architecture of a TA-csd is designed.

In the last paragraph of this chapter, the test capabilities of the TA-csd will be handled. This feature is very helpful to the user, when something goes wrong.

4.2 The possibilities of the hardware implementations of a TA-csd

It seems from the market application studies that two separate hardware implementations of the TA-csd, one PC in-slot-based and the other stand alone are needed. This hardware design flexibility issue will be discussed separately for both of these implementations in the following paragraphs.

4.2.1 PC in-slot based TA-csd

With the open bus architecture of the IBM PC and compatible systems, it is possible to consider the integration of external TA-csd ISDN S-bus functions onto a PC I/O slot feature board. This approach has several obvious advantages in the PC environment:
- An in-slot approach can share the power and packaging of the PC.
- The TA-csd does not require a ROM or EPROM design since it can be loaded from the PC's diskette or disk. This allows significantly greater flexibility in tailoring the function of the adapter to meet new application requirements.
- The source of user data could be the PC bus or the output of one of the PC in-slot communication cards. By using the PC bus as the source of the data, the existing PC in-slot asynchronous communication card functions could be incorporated and replaced by the TA-csd in-slot board. This has the advantage of saving a PC slot.

This approach permits existing asynchronous data communications and networking applications to use the ISDN in a transparent way. Applications that now utilize asynchronous Hayes-compatible modems for access to the dial up or leased lines will be able to make use of the ISDN without modification. This is important because the initial use of the ISDN will be to support existing PC data communications applications.

4.2.2 Stand alone TA-csd

The basic application of a stand alone TA-csd is to permit the existing terminals with RS-232-C interfaces (asynchronous mode terminals, PCs, hosts etc.) to be connected to the S-reference point basic access of the ISDN network. It may be viewed as an ISDN-compatible modem.

Since the ISDN S-bus supports two 64 kbps B-channels and one 16 kbps D-channel, it is possible to attach multiple devices to the stand alone TA-csd. The 2B + D interface supports the simultaneous attachment of two devices, one device on each of the B-channels and for circuit switching mode the D-channel is purely used for signalling purposes.

The TA-csd (DCE) must interface with the existing terminal (DTE) by emulating a DCE interface, such that the attaching DTE is unaware that it is actually interfacing with the ISDN facility. This involves presenting a compatible electrical interface and proper timing and control of interface signalling leads between the DTE and the DCE.

Unlike the PC in-slot TA-csd, which can provide for its functional flexibility via loads from the PC-disk, these selectable options and capabilities should be provided via replaceable ROM cartridge implementations, for e.g. asynchronous to X.25 protocol via X.3 PAD.

4.3 The functional specifications

The functional specifications of a TA-csd can be divided into the following parts:

1. The base parts
2. The man-machine interface parts
3. The additional parts

<u>The base parts:</u>

The base parts of a TA-csd has a number of service independent ISDN functions, they are:
- Access to the S-bus
  It is a 4-wire interface which provides the S-bus layer 1 functions.
- D-channel handling
  It handles the full layer 2 functionality (LAPD protocol) and layer 3 basic call handling signalling functions.
- B-channel preprocessing
  Adaptation of B-channels to carry continous 64 kbps data streams. The methods are:
  * Bit rate adaptation of V.24 interface data rates to the 64 kbps B-channel rate, defined in I.463.
  * Analog to digital conversion of modulated signals to 64 kbps B-channel rate.

- Conversion of electrical, mechanical, functional and procedural characteristics of the V.24/V.28 (RS-232-C) interface to those required by an ISDN at reference point S and/or T.
- The rate goes from 50 up to 19200 bps for asynchronous data transmission.
- End-to-end synchronization of entry to and/or exit from the data transfer phase.
- Call establishment and release (disestablishment) based on automatic calling and automatic/manual answering.

The man-machine interface parts:

For this purpose an enhanced Hayes command set is made based on the standard Hayes command set. The description of the Hayes command set will be described on chapter 5.

This part is an important part for the user to control the TA-csd, by typing the Hayes commands via the keyboard or via a communication program that is running on a PC.

The enhanced Hayes command set supports the following features:
- Compatible with the standard Hayes command set
- Auto dial
- Auto redial
- Auto answer
- Loop back testing
- Memories to store a number of telephone numbers
- The parameters on the TA-csd can be set up.

The additional parts:

- The mapping functions necessary to convert the enhanced Hayes command set to the D-channel protocol.
- It provides an automatic baud rate detector to conform its communication speed and character format (data-, parity-, stop-bits) to those settings in the terminal of communications software when it receives the Hayes command from the user.
- It supports the flow control mechanisms, defined in I.463. Flow control allows the connection of asynchronous DTEs operating at different user data rates by reducing the character output of the faster to the slower.
- An internal modem is built in the TA-csd to make the communication possible between the user connected to ISDN via TA-csd and the user connected to the PSTN via a modem.
- Extra connectors are also available to connect the external modem to the TA-csd.
- All functions are controlled by a microprocessor.
- It has a front panel status lights.
- Power supply
  For in-slot based TA-csd, the power is shared via the PC and for stand alone TA-csd the power supply comes from the main (220 V or 110 V).

4.4 Available IC components

4.4.1 S-interface ICs

The ISDN S interface will be the dominant standard interface for the connections of all types of user equipments to ISDN. The S interface is a 4-wire connection, two wires are used for transmit and two for receive.

The semiconductor manufacturers have developed ISDN's S interface ICs for two major reasons:
- Until 1987, the S-interface was the only ISDN physical layer standard that companies could develop products for; it was the only one defined adequately.
- Most of the user equipments (such as telephones, workstations, printers, facsimiles etc.) will attach to the S-bus.

Some examples of the S interface ICs from different manufactures are shortly described below. They are :

Advanced Micro Devices (AMD):

The Am79C30A Digital Subscriber Controller (DSC) and Am 79C32A ISDN Data Controller (IDN), shown in figure 4.4.1, provide the terminal equipment access to the ISDN.

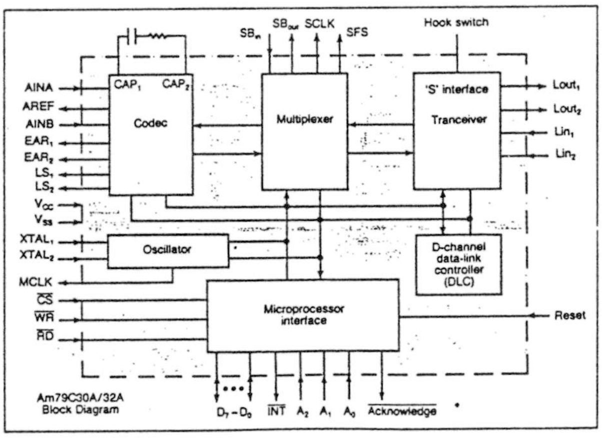


Figure 4.4.1
Am79C30A Block Diagram

The features are:
- The Am79C30A/32A is compatible with the CCITT I-series recommendations at the S reference point allowing the user of the device to design TEs which conform to the international ISDN standard.

- A serial port gives the user access to the B-channels of the Am79C30A/32A multiplexer. This serial port may be used by data terminals, and provides, with additional circuitry, access to the CCITT R reference point.
- The Am79C30A/32A provides a 192 kbps duplex digital path between the TE located in the subscriber's premises and the NT or PABX line card over 4-wires. The transmission rate of 192 kbps provides a 48 bit frame every 250 microsecond for framing and maintenance.
  The frame structure provides for frame synchronization and multiple terminal contention resolution as described in the CCITT I-series recommendations.
- The Am79C30A/32A separates the bit stream into the B1, B2 and D channels. The B channels are routed through to different sections of the Am79C30A under user control. The D channel is partially processed in the Am79C30A/32A and passed to the microprocessor for further processing.
- The Am79C30A/32A supports point to point and point to multipoint connections.
- The Am79C30A can be used as a voice telephone, a digital data terminal, or voice and data terminal. The Am79C32A can be used as a digital data terminal. The audio processor in the Am79C30A, shown in figure 4.4.1, uses Digital Signal Processing (DSP) to implement the codec and filter functions. The audio processor interfaces to a speaker, an earpiece, and two separate audio inputs. In the receive and transmit paths the user may program gain or alter the frequency response. The audio processor is not available in the Am79C32A.
- The Am79C30A/32A is controlled via an interrupt driven microprocessor bus interface by an external microprocessor. Using this interface, the microprocessor processes the D-channel information and programs the Am79C30A/32A accordingly. This includes programming a multiplexer within the Am79C30A/32A to route the B-channels as specified by the D-channel control information. The microprocessor can interrogate and program the Am79C30A/32A via its mode, status and error registers.

Intel:

The S interface transceiver allows the digital signals from the user equipment to be transmitted forth and back to the ISDN Central Office (CO) via the regular telephone lines. Intel's S transceiver is called the 29C53 and it is fully compatible with I.430 CCITT's standards, capable of connecting telephones, PCs, facsimiles and other types of user equipments to an ISDN network. The architectural Overview of the 29C53 is shown on figure 4.4.2.

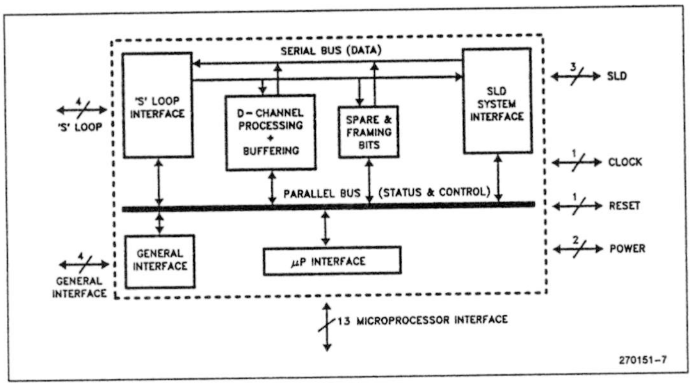


Figure 4.4.2
29C53 Architectural Overview

The functions that the 29C53 performs include:

- 4 wire full duplex digital point to point baseband transceiver that can be used in public or PABX digital subscriber or data communication applications
- Power down modes for lower power consumption when idling or not in use
- 144 kbps effective data transfer rate, exceeding 1 km supporting voice and data transfers.
- Master/slave modes of operation, same part can operate at both ends of subscriber loop.
- Microprocessor interface, direct interface to MCS iAPX microprocessor family (iAPX is an Intel Trademark)
- SLD interface, directly compatible with iATC Telecom product family
- Built-in HDLC packetizing/depacketizing for D-channel message handling

The 29C53 can be used whenever an S interface connection is needed, both in the user equipment and on the other end inside the NT (network termination).

Mitel:

The MT8930 Subscriber Network Interface Circuit (SNIC) is a device which implements the CCITT I.430 recommendation for the ISDN S and T reference points. Providing point to point and point to multipoint digital transmission, the SNIC may be used at either end of the subscriber line (NT or TE).

The functional block diagram is depicted on figure 4.4.3.

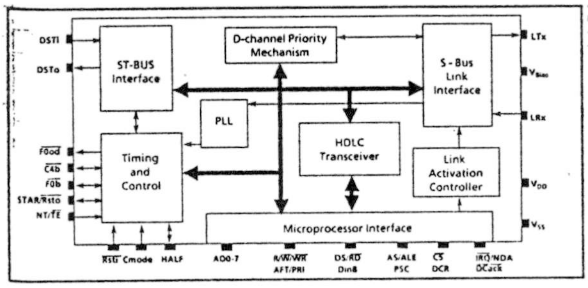


Figure 4.4.3
MT8930 functional block diagram

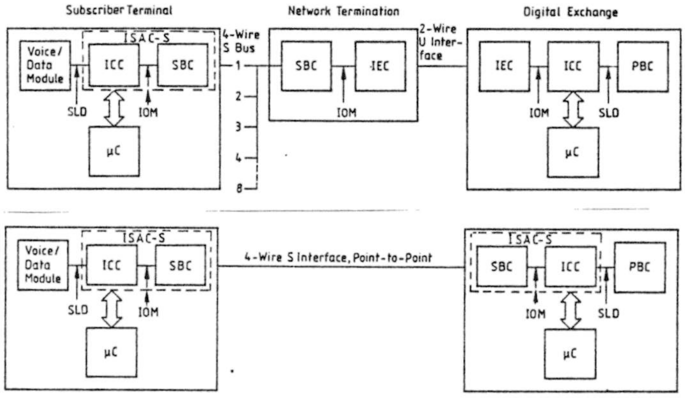
An HDLC D-channel protocol is included and controlled through a Motorola/Intel microprocessor port. It is fabricated in Mitel's ISO2-CMOS process.

The features are:
- Full duplex 2B + D, 192 kbps transmission
- Link activation/deactivation
- D-channel access contention resolution
- Point to point, point to multipoint and star configurations
- Master (NT)/Slave (TE) modes of operation
- Complete loopback testing capabilities
- Self contained timing extraction with on chip PLL/VCO (no crystal required)
- On chip HDLC D-channel protocoller
- Mitel ST-BUS interface
- Single 5 Volt power supply

Although no ISDN equipments have yet reached the market in volume, some semiconductor companies have already introduced second generation ISDN chips, for example:

Siemens:

Siemens first introduced its 2-chip PEB 2070/2080 set for S-interface applications. The two devices interconnect by means of Siemens proprietary IOM (ISDN Oriented Modular) serial bus, which operates at 512 kHz and has two unidirectional data lines, a clock line, and a data-direction line (Figure 4.4.4).



PEB 2070	ISDN Communication Controller	ICC
PEB 2080	S Bus Interface Circuit	SBC
PEB 2085	ISDN Subscriber Access Controller (S Interface)	ISAC-S
PEB 2090	ISDN Echo-Cancellation Circuit	IEC
PEB 2095	ISDN Burst Transceiver Circuit	IBC
PEB 20950	ISDN Subscriber Access Controller (S Bus), (PABX, U Interface)	ISAC-P

Figure 4.4.4
ISDN Oriented Modular (IOM) architecture

The PEB 2080 S-bus interface circuit (SBC), shown on figure 4.4.5 connects to the S-interface; the PEB 2070 ISDN communication controller (ICC) performs the LAPD processing and splits the two B-channels into separate data stream (Figure 4.4.6). The serial SLD bus uses three wires to transfer data between chips. The SLD bus has one bidirectional data line; otherwise, it resembles the IOM bus. Either of the S-interface's B-channels can be assigned to the SLD port through the chip's serial port control register.

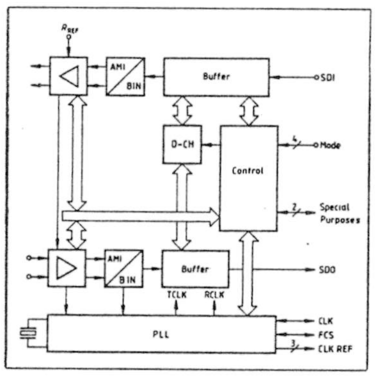


Figure 4.4.5
PEB 2080 S Bus Interface Circuit (SBC)

The features are:
- S bus transceiver according to CCITT I.430
- Recovery of clock and frame signals in different mode of application
- Frame alignment for trunk module application
- SLD and IOM compatible
- Handling of command/indicate information during the activation or deactivation procedure
- Level detect in power down mode
- Switching of test loops
- Control of bus access by echo bit handling
- 2 micron CMOS technology and low power

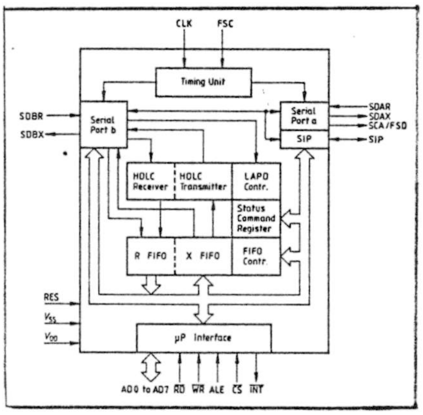


Figure 4.4.6
PEB 2070 ISDN Communication Controller (ICC)

The features are:
- High level support of LAPD protocol
- FIFO buffer (64 bytes per direction) for efficient transfer of D channel messages
- IOM interface to layer 1 (SBC, IBC, IEC)
- Serial interface to B-channel sources (SLD and SSI)
- Parallel microprocessor interface to MCS 48, 51, 85, 86, 88 family
- Expansion of applications by programming different data paths and data rates
- Support of activation/deactivation procedure
- Wide variety of operating modes
- 2 micron CMOS technology and low power

Siemens combines the functions of the PEB 2070 and PEB 2080 in its second generation device in one chip, the PEB 2085 ISDN subscriber controller (Figure 4.4.7).

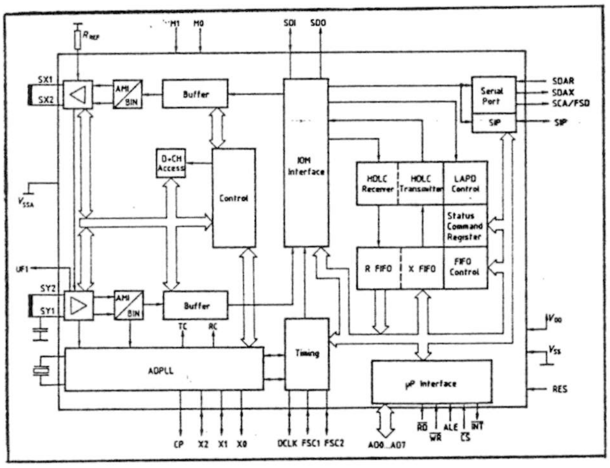


Figure 4.4.7
PEB 2085 ISDN Subscriber Access Controller (ISAC-S)

The PEB 2085 ISAC-S is a transceiver circuit able to interface voice/data communication equipment via the 4-wire CCITT S bus. It supports the LAPD protocol by hardware, for efficient transfer of D-channel packets FIFO structures are used.

Finally, several representative S-interface ICs from many semiconductor companies are listed on the following table:

REPRESENTATIVE ISDN S-INTERFACE ICs

MANUFACTURER	PART NUMBER	PART NAME	FUNCTION	PRICE
ADVANCED MICRO DEVICES	AM79C30A	DIGITAL SUBSCRIBER CONTROLLER	S-INTERFACE, D-CHANNEL PROCESSOR, CODEC, FILTER, DTMF DIALER, RINGER	$33.25 (100)
	AM79C31A	DIGITAL EXCHANGE CONTROLLER	S INTERFACE TO PCM HIGHWAY CONVERTER	$20 (100)
	AM79C312A	DIGITAL EXCHANGE CONTROLLER	79C31A WITHOUT DATA-LINK CONTROLLER	$18 (100)
	AM79C32	ISDN DATA CONTROLLER	DATA-ONLY VERSION OF 79C30	$20 (100)
	AM79C401	INTEGRATED DATA PROTOCOL CONTROLLER	LAPB/LAPD LOGICAL-LINK CONTROL	<$30 (100)
AT&T	T7250	UNITE	S-INTERFACE, D-CHANNEL PROCESSOR	$16 (1000)
INTEL	29C48	VOICE CONVERSION CHIP	CODEC, FILTER	$6 (10,000)
	2952	LINE CARD CONTROLLER	CONTROLS EIGHT 29C53s	$9.50 (10,000)
	29C53	DIGITAL LOOP CONTROLLER	S-INTERFACE, D-CHANNEL PROCESSOR	$12.70 (10,000)
	83C152	UNIVERSAL COMMUNICATIONS CONTROLLER	μC WITH HDLC CONTROLLER	$25 (10,000)
MITEL	MT8994	DIGITAL TELEPHONE CHIP	μ-LAW CODEC, FILTER, DTMF DIALER, RINGER	$17.15 (1000)
	MT8995	DIGITAL TELEPHONE CHIP	A-LAW CODEC, FILTER, DTMF DIALER, RINGER	$17.15 (1000)
	MT8930	SUBSCRIBER NETWORK INTERFACE	S-INTERFACE, D-CHANNEL PROCESSOR	$16 (1000)
	MT8952B	HDLC PROTOCOL CONTROLLER	HDLC CONTROLLER	$8 (1000)
MOTOROLA	MC145474	S/T INTERFACE TRANSCEIVER	S INTERFACE	$12 (10,000)
	MC145488	DUAL DATA-LINK CONTROLLER	DUAL HDLC CONTROLLER	$16 (10,000)
	MC145503	FILTERED CODEC	CODEC, FILTER	$4.50 (10,000)
SIEMENS	PEB 2060	SIGNAL PROCESSING CODEC FILTER	CODEC, FILTER	$12.80 (1000)
	PEB 2070	ISDN COMMUNICATIONS CONTROLLER	D-CHANNEL CONTROLLER	$13.60 (1000)
	PEB 2080	S-BUS INTERFACE CIRCUIT	S INTERFACE	$13.60 (1000)
	PEB 2085	ISDN SUBSCRIBER ACCESS CONTROLLER	COMBINES PEB 2070 AND PEB 2080	$24 (1000)
	SAB 82520	SERIAL COMMUNICATIONS CONTROLLER	DUAL HDLC CONTROLLER	$17.60 (1000)

4.4.2 Rate adaptation IC's

To make the communication possible between the existing terminals via ISDN TA-csd, is the rate adaptation function inevitable. In this paragraph two available rate adaptation IC's from two different manufacturers will be briefly described.

Philips:

The DRA-circuit (Data Rate Adapter) has been developed to adapt user data rates to the 64 kbps channel. It converts synchronous (600, 1200, 2400, 4800, 9600, 19200 and 38400 kbps) and asynchronous (0 up to 19200 kbps) data rates in two types of framing defined by CCITT (I.463).

The DRA can be divided into four main functional parts:

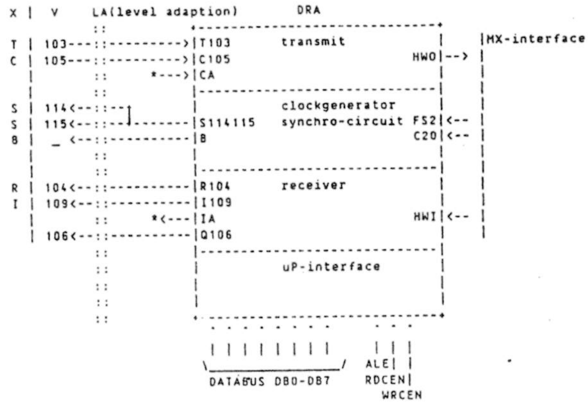


Figure 4.4.8
Data rate Adapter (DRA)

The transmitter part converts data on circuit T103 to 64 kbps, according to the CCITT X.30 and V.110 specification. The receiver must do the same in reverse including byte- and bit- synchronization, and delaying of circuits I109 and R104, to fit the Byte-timing for X-series of interfaces. The DRA must be initiated by the microprocessor with information about speed, testloops, set- or reset of interchange circuits, etc. It is possible to read information from the DRA about speed setting of the B-subscriber, read out of interchange circuits and synchronization of the DRA.

Mitel:

The MH89500 R-Interface Module (RIM) is a circuit which implements the rate adaptation function within a Terminal adapter (TA). It converts data between the interface formats of an ISDN B-channel and a terminal port, conforming to V.24 or X.21. The RIM provides bit rate adaptation conforming to recommendations ECMA. 102, CCITT I.461 and I.463. The addition of circuitry to control the state of the RIM and to provide ISDN D channel signalling allows conformance to the maximum integration scenario described in CCITT I.461. The RIM will function back-to-back with the MT8930 (S/T interface) to provide a complete terminal adaptation solution between V- or X-series ports and the ISDN S/T interface.

The functional block diagram is shown on figure 4.4.9

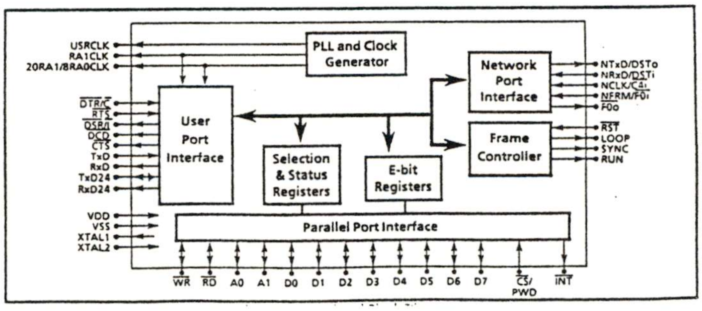


Figure 4.4.9
MH89500 Functional block diagram

The features are:
- Synchronous operation at 600, 1200, 2400, 4800, 9600, 19200 and 64000 kbps
- Asynchronous operation at 50 - 600, 1200, 2400, 4800, 9600, and 19200 bps
- User programmable network port interface
- Flexible format subrate multiplexing
- Frame synchronization monitoring and auto resynchronization
- Local and remote loopback modes
- Intermediate RA1CLK, 20RA1CLK and position of D24
- User access to E-bits
- Optional automatic user rate selection
- Stand alone or MPU peripheral mode operation
- Single +5V supply, low power CMOS

4.4.3 Single-IC Modems

Single IC-modems are eliminating board-level modems that transmit at 1200 bps or less. Indeed, even single-IC modems that operate at 2400 bps are available.

Essentially, by adding a single-IC modem (internal modem) and an codec circuit to the terminal adaptor (TA-csd), a virtual front end processor for communicating over the PSTN via ISDN is realised.

There is no standard definition of a single-IC modem. Some manufacturers place all of the modem functions in a single chip, others place multiple chips in a hybrid module, and still others place more than one chip on a single substrate and it called a single package modem.

Regardless of the configuration, all single IC-modems also require a microcontroller to execute the modem command set and handshake protocols; this being the case, some manufacturers have opted to transfer some of the modem functions to the external microcontroller.

Achieving a complete modem usually requires the addition of a 4- to 2-wire hybrid and a data access arrangement (DAA) for connection to the analogue a/b line. DAA is a protective circuitry that the user is protected from harsh telephone environment, and so that the network is protected from customer-equipment malfunction.

Single-IC modems must interface with a microcontroller; connecting an interrupt line on the microcontroller to the ring line on the DAA enables the detection of a ring signal.

Most today's single-IC modems provide the following functions:
- Modulation/demodulation
- Transmit and receive filtering
- Microcontroller interfacing
- Serial port interfacing
- Asynchronous-to-synchronous conversion circuitry
- Scrambling and descrambling (if required)
- Clock generation

Most also have Automatic Gain Control (AGC) to normalize the 45-dB dynamic range of received signals, and most have answer and call-progress tone detectors along with dial tone and multiple frequency (DTMF) generators.

In addition many includes:
- UARTS
- Loop-back test modes
- Audio outputs
- Answer- and guard-tone generators
- Line equalizers
- A/D and D/A converters
- Digital signal processors

The single IC-devices primarily support Bell 212A and 103 North American Standard and CCITT international standard such as V.21, V.22, and V.23, which govern 0 to 300 bps and 1200 bps communications. Single IC modems that support the CCITT V.22bis standard for 2400 bps communications are also emerging.

A hybrid modem may not be a single IC-modem because a hybrid module contains many chips. Because these modules contain the necessary 4- to 2- wire hybrid and DAA unit, the real estate required to build a complete modem is comparable to that of the single-IC modems described thus far. The initial cost of a hybrid module is considerably greater than that of a single-IC design.

The examples of the single modems from different manufacturers are described below.

The available single IC-modems:

Advanced Micro Devices (AMD):

The Am79C12 from AMD is a representative example of a single IC-modem that performs all modem functions on one chip. Because the Am79C12 contains an integral 4- to 2-wire hybrid, to configure a complete 300 to 1200 bps modem only a microcontroller and a DAA have to be added (Figure 4.4.10).

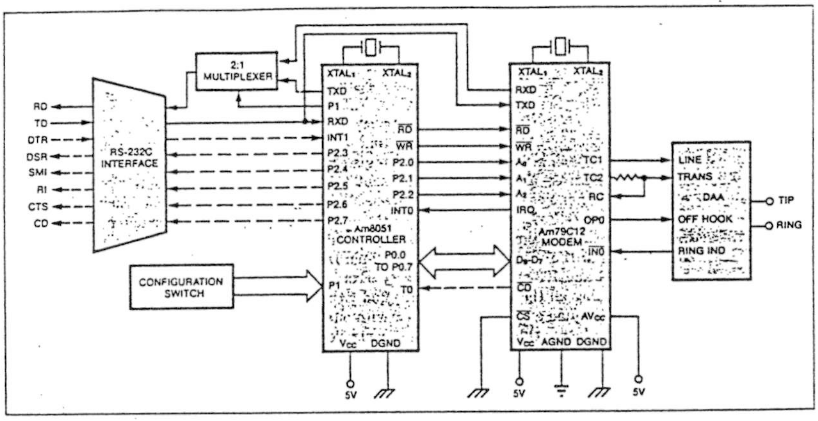


Figure 4.4.10
The Am79C12 modem has all its modem functions on one chip

It conforms to Bell 212A and 103 modem specifications, and it contains all the modulation, demodulation, digital filtering, and A/D and D/A functions for both the transmitter and receiver. The chip also has a DTMF tone generator, a UART, a call-progress tone detection circuit, and analog and remote digital loop-back test modes. The device comes in either a 44-pin PLCC (Plastic Leaded Chip Carrier) or a 40 pin plastic DI.

AMD has dubbed its AM79101 a World chip because it supports both the North American Bell 202 and 103 and the international CCITT V.21 and V.23 specifications. The Frequency Shift Keying (FSK) modem chip contains answer tone and DTMF generators for DTMF-tone auto-dialling. When operating in the V.23 mode, it can transfer data in the back channel at 150 bps. The unit contains a 4- to 2-wire hybrid and uses digital signal processing (DSP) for filtering and modulation and demodulation functions. The device is available in either a 28-pin PLCC or DIP.

Silicon Systems (SSI):

Silicon Systems also has a couple of single-chip modems that are in the world class family. The K222 combines Bell 212A and 103 and CCITT V.22 and V.21 capability, and the K224 provides 2400 bps CCITT V.22bis operation along with V.22 and V.21 and Bell 212 A and 103 modes. By incorporating these standards, each of the chips is able to provide worldwide communications capabilities at 1200 bps. And, the two K-series members are plug compatible and upgradeable with all other K-series devices. None of the K-series of single chip modems puts the 4- to 2-wire hybrid on chip. Figure 4.4.11 shows the typical circuitry necessary to build a complete modem with any of the devices in this family. The 2-operational amplifier duplexer performs the 4- to 2-wire hybrid function.

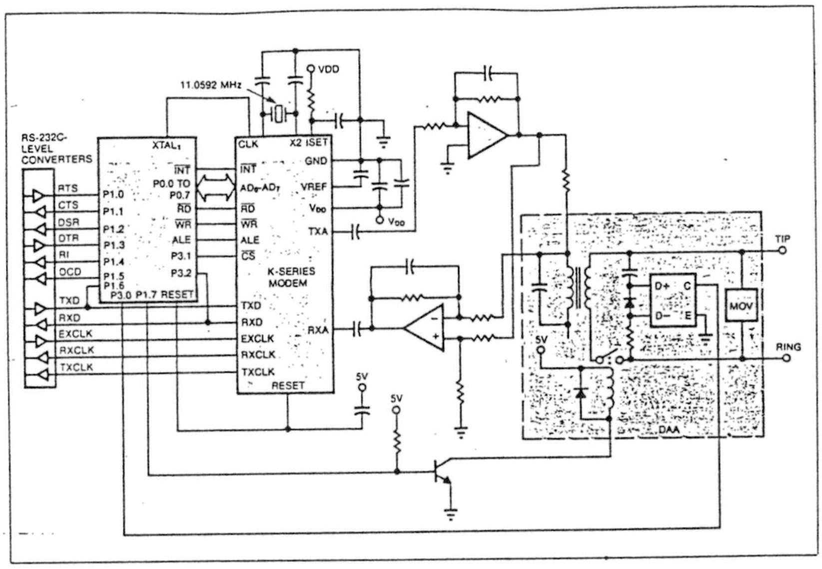


Figure 4.4.11
The K-series of single-IC modems from SSI

K222 integrates analog, digital and switched capacitor filtering on a single substrate. The chip includes a DTMF tone generator, 550 Hz and 1800 Hz guard tone generators, call progress tone detection circuitry, answer tone generators, and numerous test modes, including analog Loop back and remote digital loop back.

The K224 provides 2400 bps operation as defined by the CCITT V.22bis standard with fall back to the lower speeds of both the Bell 212A and 103 and CCITT V.22 and V.21 standards. Containing all the features of the K222 chip along with a QAM (Quad Amplitude Modulation) modulator and demodulator, the chip provides selectable compromise equalizers for 1200 bps operation and adaptive equalizers for 2400 bps operation. In addition to a serial data interface, it has an 8-bit multiplexed address/data bus for interfacing with an 8-bit microcontroller.

The available hybrid modems:

Cermetek:

The CH 1780 hybrid module from Cermetek conforms the CCITT V.22bis, V.22, Bell 212A and 103 specifications and therefore operates at 2400, 1200 and 0 to 300, respectively. It has 44 pins, which it can be directly soldered or placed in a socket. Like all hybrid modules, the CH1780 contains the 4- to 2- wire hybrid and built-in FCC part 68-registered DAA with an FCC registration number and Ringer Equivalence Number (REN). The module responds to the Hayes AT command set, allowing it to answer and initiate calls and execute diagnostic tests. Because the module is configured for serial communications, a UART is required to interface with a host. The host controls the modem by sending serial ASCII command sequences.

Xecom :

Another hybrid module is Xecom's XE2400, which has 40 pins (Figure 4.4.12).

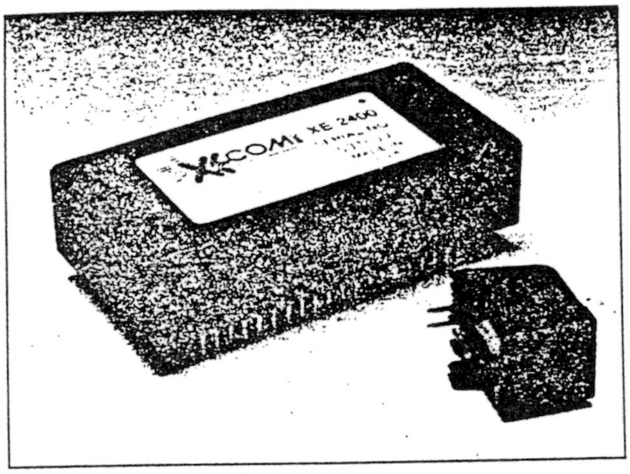


Figure 4.4.12
Hybrid modules, such as the XE2400

The device conforms to CCITT V.22bis, V.22 and V.21 and Bell 212A and 103 specifications. It uses the Hayes AT command set, interfacing with the host through a serial TTL interface, a series of ASCII commands provides control. The XE2400 supports analog and digital loopback tests.

The available single package modems:

Rockwell international:

This manufactory choose to put more than one chip on a single substrate and call it a single package modem. The R48MFX Monofax facsimile modem comprises two chips packaged is a 64-pin quad in-line packaged (Figure 4.4.13).

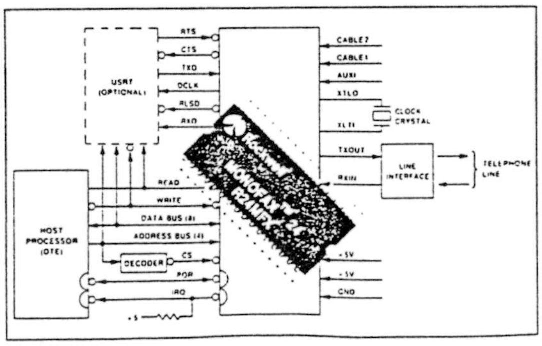


Figure 4.4.13
Single package modem, such as the R24MFX

Optimized for use in compact Group 3 facsimile machines, it supports CCITT V.27ter 4800 and 2400 bps half-duplex modes as well as the CCITT V.21 for 0 to 300 bps protocol communications. The unit includes adaptive equalization, can diagnostically determine line quality, and has two DTE interfaces (a parallel microprocessor bus and an RS-232-C serial port).

At last, the representative manufacturers of single modem ICs are displayed on the table of the following page.

REPRESENTATIVE MANUFACTURERS OF SINGLE-MODEM ICs

COMPANY	DEVICE	STANDARDS							POWER SUPPLIES	POWER DISSIPATION	UART	DTMF	DUPLEXER	DAA	FILTER TYPES	AGC	CALL-PROGRESS TONE DETECTION	TECHNOLOGY	TEST FEATURES	PACKAGE	COST	OTHER FEATURES
		BELL			CCITT																	
		103	202	212A	V.21	V.22	V.22BIS	V.23														
ADVANCED MICRO DEVICES	Am7910	•	•		•			•	5V −5V	500 mW					DIGITAL	•	•	NMOS	ALB	28-PIN CERAMIC DIP, PLASTIC DIP, PLCC	$13.35 (100)	ON-CHIP ADC AND DAC
	Am7911	•			•			•	5V −5V	500 mW					DIGITAL	•	•	NMOS	ALB	28-PIN PLASTIC DIP, CERAMIC DIP, PLCC	$12.80 (100)	ON-CHIP ADC AND DAC, 150-BPS BACK CHANNEL; LEASED LINE AND TELEX COMPATIBLE
	Am79C12	•		•					5V	300 mW	•	•	•		DIGITAL	•	•	CMOS	ALB DLB	44-PIN PLCC, PLASTIC DIP	$36 (100)	SELECTABLE ON-CHIP LINE EQUALIZER
	Am79101	•			•			•	5V −5V	500 mW		•	•		DIGITAL	•	•	NMOS	ALB	28-PIN CERAMIC DIP, PLASTIC DIP, PLCC	$17.60 (100)	150-BPS BACK CHANNEL
CERMETEK	CH1760A	•		•					5V −12V	650 mW		•	•	•	SCF	•	•	HYBRID	ALB DLB	2.54×3.74-IN. MODULE	$245 (100)	FCC REGISTERED
	CH1760E	•		•					12V −12V 5V	280 mW		•	•	•	SCF	•	•	HYBRID	ALB DLB	2.54×6.60-IN. MODULE	$395 (100)	MEMORY-EXPANSION PORT TO STORE 52 PHONE NUMBERS; FCC REGISTERED
	CH1770	•		•					5V −5V	600 mW		•	•	•	SCF	•		HYBRID	ALB DLB	2.54×3.74-IN. MODULE	$179 (100)	FCC REGISTERED
	CH1780	•		•	•	•	•		5V −12V	350 mW		•	•	•	DIGITAL AND SCF	•	•	HYBRID	ALB DLB	2.54×3.74-IN. MODULE	$390 (100)	FCC REGISTERED
	CH1765								12V 5V −12V	280 mW		•	•	•	SCF	•	•	HYBRID	ALB DLB	2.54×3.74-IN. MODULE	$265 (100)	FCC REGISTERED
EXAR	XR-2100				•				5V −5V	200 mW					SCF	•	•	CMOS	ALB	20-PIN CERAMIC DIP, PLASTIC DIP	$3.46 (100)	
	XR-2130	•		•		•			5V, −5V	200 mW		•			SCF	•	•	CMOS	ALB, DLB EYE PATTERN	28-PIN CERAMIC DIP, PLASTIC DIP	$11.44 (100)	DEDICATED MODEM CONTROLLER AVAILABLE (XR-2131); COST AS LOOP DEMODULATOR
GE SOLID STATE	CD22212E	•		•					12V	180 mW		•			SCF	•	•	CMOS	ALB DLB	22-PIN DIP, 28-PIN PLCC	$16.50 (100)	PIN AND SOFTWARE COMPATIBLE WITH SSI'S K221, K222, AND K224 MODEM ICs
	CD2223E	•						•	4.5 TO 13V	10 mW AT 5V 60 mW AT 12V					SCF			CMOS	INTERNAL LOOP-BACK TEST	16-PIN DIP	$6.19 (100)	DIGITAL DEMODULATOR
MICRO POWER SYSTEMS	MP8512	•		•	•	•			5V −5V	240 mW	•	•	•		DIGITAL AND SCF	•	•	CMOS	ALB DLB	40-PIN DIP	$15 (100)	
NATIONAL SEMICONDUCTOR	UA212AT			•					5V −5V	35 mW		•			DIGITAL		•	CMOS	ALB DLB	28-PIN DIP, SMD	$18 (100)	
	UAV22					•			5V −5V	40 mW		•			DIGITAL		•	CMOS	ALB DLB	28-PIN DIP, PLCC	$18 (100)	
ROCKWELL INTERNATIONAL	R24MFX MONOFAX				•				5V 12V −12V	1W					SCF AND DIGITAL	•	•	CMOS (ANALOG) NMOS (DIGITAL)	EQM (EYE QUALITY MODEM)	64-PIN QUAD-IN-LINE PACKAGE	$49 (1000)	DSP CHIP CONFORMS TO V.27TER 2400-BPS OPERATION; ADAPTIVE EQUALIZER
	R48MFX MONOFAX				•				5V 12V −12V	1W					SCF AND DIGITAL	•	•	CMOS (ANALOG) NMOS (DIGITAL)	EQM (EYE QUALITY MODEM)	64-PIN QUAD-IN-LINE PACKAGE	$60 (1000)	CONFORMS TO V.27TER 4800-BPS OPERATION; DSP CHIP
SGS-THOMSON MICRO-ELECTRONICS	TSG7515	•		•		•			5V −5V	50 mW					SCF	•	•	CMOS	ALB DLB	28-PIN DIP	$20 (100)	DIGITAL PLL DEMODULATOR GENERATES 1800-Hz GUARD TONE ONLY
SIERRA SEMICONDUCTOR	SC11004	•		•		•			5V −5V	150 mW		•	•		SCF	•	•	CMOS	ALB DLB	24-PIN DIP, 28-PIN PLCC	$18.20 (100)	OPERATES WITH SC11007/008/017 DEDICATED CONTROLLERS
	SC11006	•		•	•	•	•		5V −5V	175 mW		•	•		SCF	•	•	CMOS	ALB DLB	28-PIN DIP, PLCC	$35 (100)	ADAPTIVE EQUALIZATION AND DESCRAMBLING DONE IN SC11009/010/011 CONTROLLER
	SC11014	•		•	•	•			5V −5V	150 mW		•	•		SCF	•	•	CMOS	ALB DLB	24-PIN DIP, 28-PIN PLCC	$21 (100)	DEDICATED CONTROLLER; (SC11007/008/017)
	SC11015	•		•	•	•			5V −5V	150 mW		•	•		SCF	•	•	CMOS	ALB DLB	24-PIN DIP, 28-PIN PLCC	$23 (100)	PROGRAMMABLE GAIN AMPLIFIER, USES DEDICATED CONTROLLER
	SC11016	•		•	•	•			5V	70 mW		•	•		SCF	•	•	CMOS	ALB DLB	24-PIN DIP, 28-PIN PLCC	$25.90 (100)	STANDBY POWER MODE; DEDICATED CONTROLLER (SC11027/028)
SILICON SYSTEMS	K212	•		•					5V, 12V (2 VERSIONS)	30 mW AT 5V 180 mW AT 12V		•			SCF	•	•	CMOS	ALB, DLB TEST PATTERN	22-PIN DIP, 28-PIN DIP, 28-PIN PLCC	$21 TO $24 (100)	COMPROMISE EQUALIZER; PIN COMPATIBLE WITH K SERIES
	K221				•	•			5V, 12V (2 VERSIONS)	30 mW AT 5V 180 mW AT 12V		•			SCF	•	•	CMOS	ALB DLB	22-PIN DIP, 28-PIN DIP, 28-PIN PLCC	$24 TO $25 (100)	PIN COMPATIBLE WITH K SERIES
	K222	•		•	•	•			5V, 12V (2 VERSIONS)	30 mW AT 5V 180 mW AT 12V		•			SCF	•	•	CMOS	ALB DLB	22-PIN DIP, 28-PIN DIP, 28-PIN PLCC	$29 TO $34 (100)	PIN COMPATIBLE WITH K SERIES
	K224	•		•	•	•	•		5V, 12V (2 VERSIONS)	100 mW AT 5V 360 mW AT 12V		•			SCF	•	•	CMOS	ALB DLB	22-PIN DIP, 28-PIN DIP, 28-PIN PLCC	$65 TO $70 (100)	COMPROMISE AND ADAPTIVE EQUALIZER COMPATIBLE WITH K SERIES
	K322					•		•	5V, 12V (2 VERSIONS)	30 mW AT 5V 180 mW AT 12V		•			SCF	•	•	CMOS	ALB DLB	22-PIN DIP, 28-PIN DIP, 28-PIN PLCC	[illegible]	75-BPS BACK CHANNEL COMPATIBLE WITH K SERIES
	K324				•	•	•	•	5V, 12V (2 VERSIONS)	120 mW AT 5V		•			SCF	•	•	CMOS	ALB DLB	22-PIN DIP, 28-PIN DIP, 28-PIN PLCC	[illegible]	COMPROMISE AND ADAPTIVE EQUALIZERS; COMPATIBLE WITH K SERIES
VLSI TECHNOLOGY	VL7C412			•	•	•			5V	70 mW		•	•		SCF	•	•	CMOS	ALB DLB	24-PIN DIP, 28-PIN PLCC	$9 (100,000)	DIRECT REPLACEMENT FOR SIERRA SC11016; COMPROMISE EQUALIZER
	VL7C312			•	•	•			5V −5V	150 mW		•	•		SCF	•	•	CMOS	ALB DLB	24-PIN DIP, 28-PIN PLCC	$9.50 (100,000)	DIRECTLY REPLACES SC11015; PROGRAMMABLE GAIN RECEIVER
	VL7C212			•	•	•			5V −5V	150 mW		•	•		SCF	•	•	CMOS	ALB DLB	24-PIN DIP, 28-PIN PLCC	$9 (100,000)	DIRECTLY REPLACES SC11004 AND SC11014; AUDIO OUTPUT PORT
	VL7224A	•		•	•	•	•		5V −5V	—		•	•		SCF	•	•	CMOS	ALB DLB	28-PIN DIP, PLCC	$13 (100,000)	ADAPTIVE EQUALIZATION IS PERFORMED IN DEDICATED CONTROLLER (VL7C235/245)
XECOM	XE1212	•		•	•	•			5V −5V	400 mW	•	•	•	•	SCF	•	•	HYBRID	ALB DLB	40-PIN 2.28×1.00×0.50-IN. PACKAGE	$116 (100)	FCC REGISTERED
	XE1214	•		•	•	•			5V −5V	1W		•	•	•	SCF	•	•	HYBRID	ALB DLB	40-PIN 2.28×1.00×0.5-IN. PACKAGE	$116 (100)	FCC REGISTERED
	XE2400	•		•	•	•	•		5V −5V	1W		•	•	•	DIGITAL	•	•	HYBRID	ALB DLB	40-PIN 2.75×1.38×0.625-IN. PACKAGE	$269 (100)	FCC REGISTERED

NOTES: 1. ALB = ANALOG LOOP BACK; DLB = DIGITAL LOOP BACK.
2. PLCC = PLASTIC LEADED CHIP CARRIER.
3. SCF = SWITCHED CAPACITOR FILTER.

4.5 The functional architecture of a TA-csd

In this paragraph only the hardware architecture of the a stand alone TA-csd will be described. It comes, because a stand alone TA-csd can be connected to all asynchronous V.24 terminals (PC, dumb terminal, host etc.), while the PC in-slot based TA-csd can only be built in the PC.

The hardware architecture contains only the important parts of a TA-csd to perform the functions of a TA-csd (Figure 4.18). The parts are:

- S interface
  This part handles the access to the S-bus, D channel signalling etc. The S interface supports two 64 kbps B-channels. For the simplicity of the hardware architecture of the TA-csd, only one channel will be used. But depending on the need of the user, the hardware architecture can be extended so that two asynchronous terminals can operate simultaneously.
- Rate Adaptor
  This part performs the bit rate adaptation function of V.24 interface to the 64 kbps B channel rate as defined in I.463.
- Internal modem
  The main function of this internal modem is in fact to convert the incoming digital data streams that come from the RS-232-C link to the analogue voice band signals (300 - 3400 Hz). This is provided for the case that the user wants to communicate with a distant user which is connected to the analog PSTN.
- Connectors to be connected to the external modem.
- Codec, hybrid, filter
- Microcontroller (Microprocessor, PROM, RAM)
  This microcontroller is in fact the heart of the TA-csd. It controls all the activities in the TA-csd.
- Enhanced Hayes command interpreter
  In this part the complete enhanced Hayes command set will be stored.
- Baud rate detector
  This detector detects the speed and the character format coming from the terminal.
- Power supply from the main (220 V or 110 V).

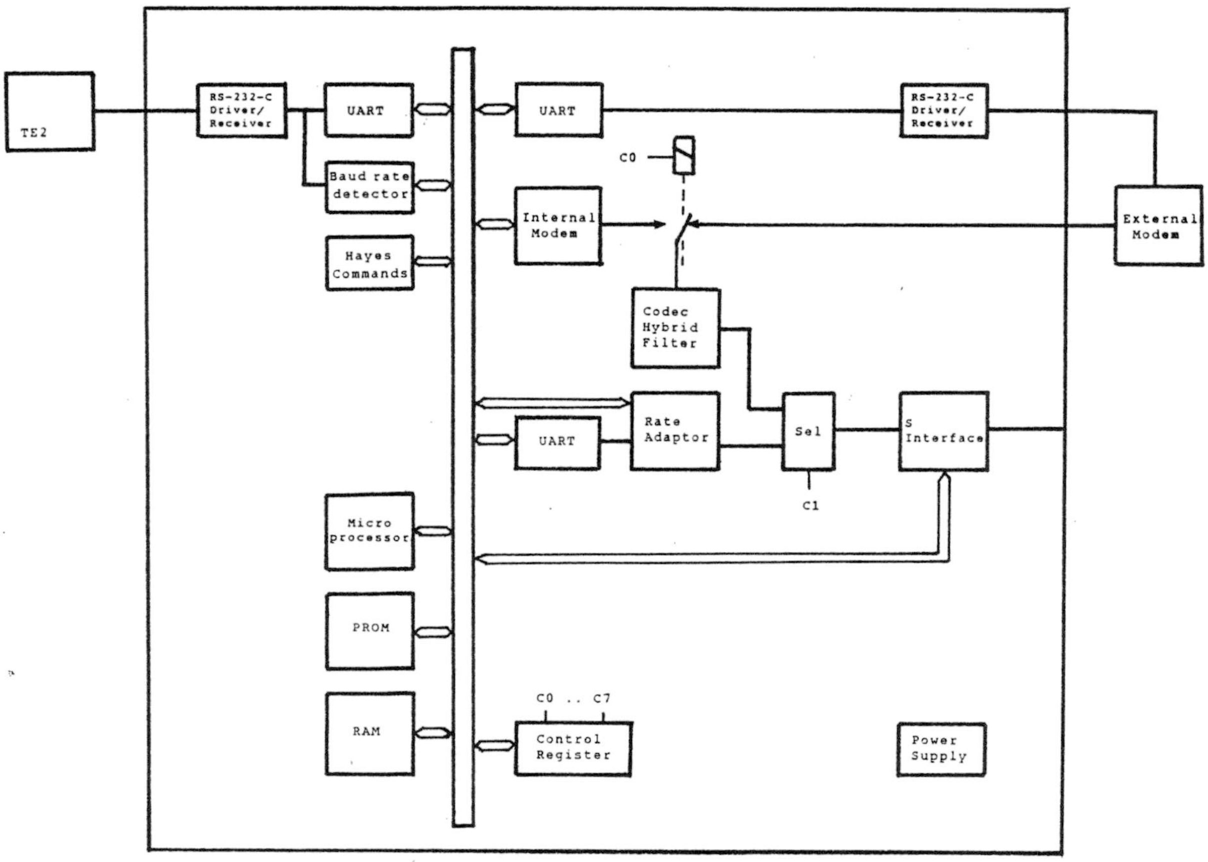


Figure 4.5
Hardware architecture of a TA-csd

Routine operation of the TA-csd:

Upon power up, the microprocessor in the TA-csd enters a reset routine stored in the PROM. This routine initializes among others the S-interface, the rate adaptor, the internal modem, the external modem (if it connected to the TA-csd) and the control registers.

The microprocessor continually scans the terminal via the UART for activity. The TA-csd is in principle now in an operational state and can start transmitting and receiving to and from the S-interface, RS-232-C link and internal modem/external modem/rate adaptor. It is now in de off-line command state (see chapter 5) and is ready to accept command sent by the user.

If the user enters a command via his keyboard to set up a call, the command will be first checked in the Hayes command interpreter part. If the command is valid, the microprocessor will transmit over the S interface a D-channel packet to the ISDN Central Office (CO) requesting that a B-channel be made available for data communication. At this point, the D-channel packet is processed by the ISDN CO. It will respond by transmitting a D-channel packet over the S-interface to the TA-csd indicating which B channels can be used for the data link. This packet is passed by the S interface to the microprocessor.

The microprocessor decodes the D channel packet and selects the rate adaptor or internal modem/codec or external modem/codec to connect to the designated B channel on the S interface. With the data link established the user can begin to transfer the data via the designated B channel.

In case the user wants to communicate within an ISDN network, the rate adaptor function will be selected by the microprocessor. The data will flow from the terminal via the RS-232-C link through the UARTs into the rate adaptor. The data will be adapted to the 64 kbps required for the B channel over the S interface, regardless of the rate at which it was originally received (50 up to 19200 bps). In the other direction, i.e. for incoming data from the S interface, the data is transmitted out of the S interface into the rate adaptor, then into the RS-232-C link via UARTs and finally to the user's terminal.

If the user wants to communicate with the distant user which is connected to the PSTN via ISDN network, the internal or external modem function should be selected. The internal or external modem converts the data streams from the RS-232-C link into an analogue voice band signals and the codec translates this data stream into a digital 64 kbps (PCM) pattern. This data will be transmitted via the designated B channel on the S interface to the ISDN CO.

When the TA-csd receives an incoming digital data via B-channel on the S interface, the data will be decoded by the codec to an analogue voice band signal and it will be converted by the internal or external modem into the original digital data stream of the user's terminal.

In this state the microprocessor monitors continously the data transfer and watch whether or not the escape command is sent by the user.

If the microprocessor detects the escape command, it will not transmit the received data from the terminal, because the following data comes is a command. In this on-line command state (see chapter 5) the user can release the call, set the paramater of the TA-csd etc.

If the user gives a command to release the call, the microprocessor will transmit a D channel packet over the S interface to the ISDN CO, requesting a call release. It will respond by transmitting a D-channel packet over the S-interface to the TA-csd indicating that the channel is released. The communication is terminated and the TA-csd goes back to the off-line command state, ready to accept the new commands.

It is very useful to make a TA-csd, that optionally can be combined with another type interface. For e.g. with a module card mainly for the signalling purpose, the basic design of the TA-csd can be extended, that it finally has two interfaces (RS-232-C and a/b). At the RS-232-C interface side, an asynchronous terminal can be connected to it and at the a/b interface side a conventional telephone can also be connected to it. In this case voice and data communication can be simultaneously used. At the a/b interface side, a facsimile or an external modem can also be connected to it.

4.6 The Test capabilities on the TA-csd

In this chapter the test capabilities on the TA-csd will be described; the procedures accessory to them are explained in paragraph 5.4.4 (Procedures for test capabilities).

Ta-csd has testing features to facilitate finding fault location when it does not operate properly or when transmission is not good enough and the causes are doubtful.

This testing features help the user to find out what is going wrong (his TA-csd is faulty or another reasons).

Globally the test capabilities on the TA-csd can be divided into the following divisions:

1. Initial check out TA-csd
   This test is used to check out the operation of the terminal and to determine if the connection between terminal and TA-csd is complete (Figure 4.6.1).
2. Local test loop TA-csd (Loop 3)
   This is a local test loop established as close as possible to the line to check the satisfactory working of the TA-csd including the rate adaptation function and the internal modem plus the codec functions built in the TA-csd. The functions shall be sequential tested by the TA-csd (first rate adaptation function and then the internal modem plus the codec functions). The situations are depicted on figure 4.6.2 and 4.6.3.

   The following test capability are applied when TA-csd is used in combination with the external modem.
3. Local test loop external modem
   This local test loop is established to check the satisfactory working of the TA-csd in combination with the external modem connected on it. This test is executed on three stages by the microprocessor of the TA-csd. The stages are:
   a. Initial check out
      This test is used to check out whether or not the connection of the TA-csd and the external modem (including the interconnecting cable) is all-right.(Figure 4.6.4).
   b. Analog loopback test
      This test is executed to test the integrity of the TA-csd and the external modem. During the test, external modem loops data internally sent from TA-csd back to the TA-csd and data looped inside the external modem is in analog form (Figure 4.6.5).
   c. Local line test loop
      This local line test loop is established as close as possible to the line to check the satisfactory working of the TA-csd including the external modem function and the codec function built in the TA-csd (Figure 4.6.6).

4. Remote test loop TA-csd (Loop 2)
   This test is used when unintelligible data is received at either TA-csd's. This loop allows user A to help the user B test the integrity of the TA-csd 2 and the ISDN-line if user A suspects either to be the cause of the transmission errors (Figure 4.6.7). Using this loop, user B can evaluate his TA-csd 2 and its ISDN-line connection to the TA-csd 1.
5. Remote test loop internal modem
   This loop will be set up by user A when user A wants user B to evaluate his modem and its PSTN-line connection to the TA-csd (including internal modem function), because either can be the cause of the transmission errors. This test is used when unintelligible data is received at TA-csd and remote modem (Figure 4.6.8).
6. Remote test loop external modem
   This loop will be set up by user A when user A wants user B to evaluate his modem and its PSTN-line connection to the TA-csd (including external modem function), because either can be the cause of the transmission errors (Figure 4.6.9). This test is used when unintelligible data is received at TA-csd and remote modem.

NOTE:
In fact executing the remote test loop is not useful while it makes no difference whether user B types the characters and they will be looped back by TA-csd (or TA-csd/modem) to user B or during the on-line communication state they communicate with each other. The remote test loop is a kind of a 'traditional test' that is implemented on every smart modem. The best manner is that both users test locally their TA-csd/modem and to check the line they can try to call another user.

The testing features given above will be explained in the following paragraphs.

4.6.1 Initial check out TA-csd

If the user has tried to establish a call, but he can not get the connection (no response), then he must first do this initial check out test. This test is used to check out the operation of the terminal, including the interconnecting cable and a part of the TA-csd, by returning response signals to the terminal for checking. (see figure 4.6.1).

To check out the TA-csd, the user will need to send command and receive responses between his terminal and the TA-csd. If he still can not receive responses from TA-csd, after he sent the command then he can assume that his TA-csd is faulty.

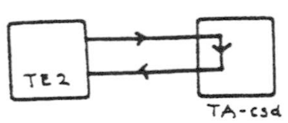


Figure 4.6.1
Initial check out TA-csd

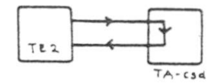


Figure 4.6.1
Initial check out TA-csd

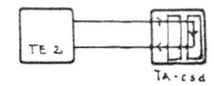


Figure 4.6.2
Local test loop TA-csd (Loop 3)
Rate adaptation function

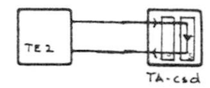


Figure 4.6.3
Local test loop TA-csd (Loop 3)
Internal modem function

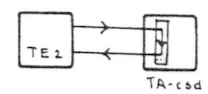


Figure 4.6.3a
Initial check out internal modem

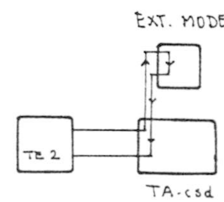


Figure 4.6.4
Initial check out

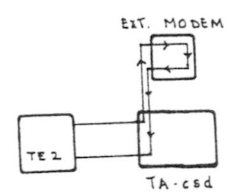


Figure 4.6.5
Analog loopback test

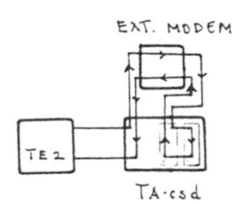


Figure 4.6.6
Local line test loop

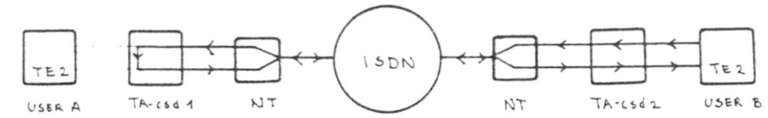


Figure 4.6.7
Remote test loop TA-csd (Loop 2)

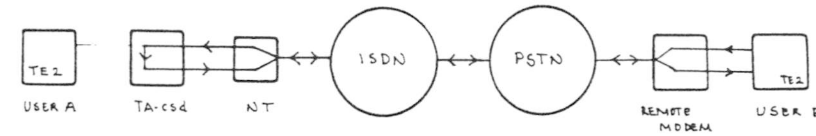


Figure 4.6.8
Remote test loop internal modem

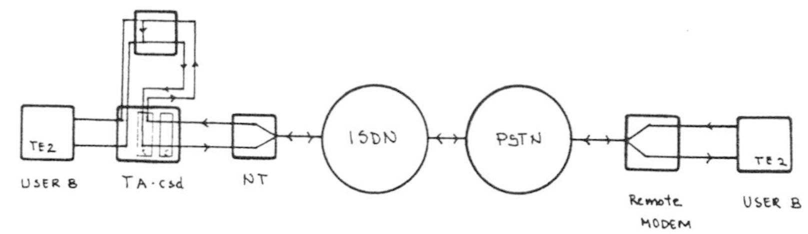


Figure 4.6.9
Remote test loop external modem

4.6.2 Local test loop TA-csd (Loop 3)

Suppose that the initial check out of the TA-csd did proceed successfully. This local test loop is established as close as possible to the line to check the satisfactory working of the TA-csd including the rate adaptation function and the internal modem plus the codec functions built in the TA-csd. The functions shall be sequential tested by the TA-csd (first rate adaptation function and then the internal modem plus the codec functions). This loop test can be executed whether or not the connection is present. To set up this local test loop TA-csd, the user shall give a command to the TA-csd.

Rate Adaptation function :
After TA-csd has received the command from the user to set up this loop, TA-csd generates a test pattern to the S-interface via rate adaptation part and at the S-interface the data will be internally looped back. At the receiver side of the TA-csd the test pattern will be compared. Therefore, the TA-csd can inspect the looped data having just been sent and check the correctness (Figure 4.6.2).

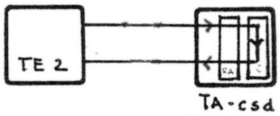


Figure 4.6.2
Local test loop TA-csd (Loop 3)
Rate adaptation function

If everything goes right, TA-csd sends message 'OK' to the user (both B-channels and D-channel are tested). The user can then judge that the rate adaptation part of his TA-csd and a part of his S-interface are all-right.

If the user receives the message 'ERROR', he can conclude that the rate adaptation part of his TA-csd is faulty.

Independent of the result of the first test, TA-csd goes on with the second test.

Internal modem function :
After TA-csd has tested the rate adaptation function, it begins to test the internal modem plus the codec functions. TA-csd generates a test pattern to the S-interface via internal modem and the codec parts. At the S-interface the data will be internally looped back and the test pattern will be compared at the receiver side of the TA-csd. Therefore, the TA-csd can inspect the looped data having just been sent and check the correctness (Figure 4.6.3).

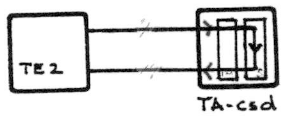


Figure 4.6.3
Local test loop TA-csd (Loop 3)
Internal modem function

If everything goes right, TA-csd sends the message 'OK' to the user (both B-channels and D-channel are also tested). The user can then judge that the internal modem, the codec and a part of his S-interface are all-right. If the user receives the message 'ERROR', he can not do anything more and concludes that his TA-csd is out of order.

If the local test loop TA-csd is successfully executed and the transmission errors still persist, the user may suspect the following reasons might be the cause of the transmission errors, depending on the function he at that moment uses.

- Rate adaptation function (Communication within ISDN):
  The user may suspect the interface of his TA-csd to the NT, the ISDN-line (incl. NT), the remote TA-csd or the remote ISDN-line to be the cause of errors.

  To check the interface of his TA-csd to the NT, the user can exchange the TA-csd with another TA-csd. If thereafter everything goes right, it means that the interface of his TA-csd to the NT is faulty.

  To check the ISDN-line, he can try to call another user. If by calling another user the transmission error has vanished, he can conclude that the remote TA-csd or the remote ISDN-line is the cause of the transmission error. He can request the remote user to test locally his TA-csd. At last if the transmission error is not vanished, after he called another user, the chance is great that his ISDN-line is not in order. He can contact the PTT to let them check his ISDN-line.

- Internal modem function (Communication to PSTN via ISDN):
  The user may suspect the interface of his TA-csd to the NT, the ISDN-line (incl. NT), the remote modem or the PSTN-line to be the cause of errors.

  To check the interface of his TA-csd to the NT, the user can exchange the TA-csd to another TA-csd. If thereafter everything goes right, it means that the interface of his TA-csd to the NT is faulty.

To check the ISDN-line, he can try to call another user. If by calling another user the transmission error has vanished, he can conclude that the remote modem or the PSTN-line is the cause of the transmission error. He can request the remote user to test locally his modem. At last if the transmission error is not vanished, after he called another user, the chance is great that his ISDN-line is not in order. He can contact the PTT to let them check his ISDN-line.

NOTE:
It would also be possible to make a test to check out the internal connection between TA-csd interface and the internal modem (Figure 4.6.3a). The user will need to send commands and receive responses between his terminal and the TA-csd. If the user can not receive responses from TA-csd, after he sent the command for several times then he can assume that his TA-csd is faulty.

In this case this test is superfluous, while if Local test loop TA-csd went right, the connection between TA-csd interface and the internal modem is automatically all-right.

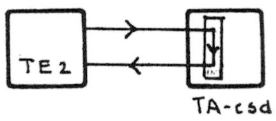


Figure 4.6.3a
Initial check out internal modem

4.6.3 Local test loop external modem

Suppose that the initial check out TA-csd did proceed successfully. This local test loop is established to check the satisfactory working of the TA-csd in combination with the external modem connected on it. This test is executed on three stages by the microprocessor of the TA-csd. The stages are:

a. Initial check out

This test is used to check out the connection of the TA-csd and the external modem, including the interconnecting cable, by returning response signals to the TA-csd for checking (Figure 4.6.4).

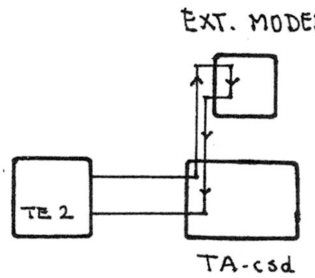


Figure 4.6.4
Initial check out

After TA-csd has received the command from the user to set up the test, the microprocessor of the TA-csd generates a test command (AT <CR>) several times to the external modem. External modem will automatically match the speed of the terminal. If the TA-csd receives a response 'OK' from the external modem within a limited time, it means that the connection to the external modem is all-right. TA-csd sends the message 'OK' to the user, otherwise 'ERROR'. The user shall check first the cable and exchange it. If it does not help, he shall connect the external modem directly to the terminal and give a command (AT <CR>). If the user receive the 'OK' response from the modem, it means that his modem is all-right and the TA-csd is faulty. Otherwise is his modem out of order.

If everything goes right, begins TA-csd to test the second stage of the local test loop external modem (Analog loopback test)

b. Analog loopback test

This test helps the user to test the integrity of the TA-csd and the external modem and the connection from TA-csd to the external modem if he suspects it to be the cause of transmission errors. This loop can be executed whether the connection is present or not.

TA-csd generates a test pattern to the external modem and the data sent from TA-csd will be internally looped back to TA-csd. Data looped inside the external modem is in analog form. At the receiver side of the TA-csd the test pattern will be compared. Therefore, the TA-csd can inspect the looped data having just been sent and check the correctness (Figure 4.6.5). During the test, data is not transmitted to the remote modem.

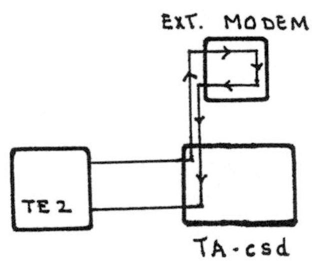


Figure 4.6.5
Analog loopback test

If everything goes right, TA-csd sends the message 'OK' to the user. If data are not looped back correctly during this test, the user gets the message 'ERROR' and concludes that his external modem is out of order.

If the second test loop goes right, begins the microprocessor of the TA-csd to test the third stage of the local test loop external modem.

c. Local line test loop

This local line test loop is established as close as possible to the line to check the satisfactory working of the TA-csd including the external modem and the codec functions built in the TA-csd. This loop can be executed whether or not the connection is present.

TA-csd generates a test pattern to the S-interface via external modem and the codec part of the TA-csd. At the S-interface the data will be looped back to the codec and the external modem. At the receiver side of the TA-csd the test pattern will be compared and TA-csd can inspect the looped data having just been sent and check the correctness (Figure 4.6.6).

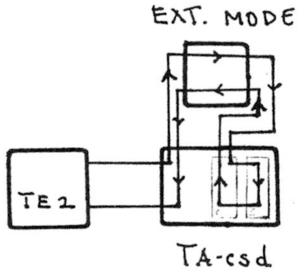


Figure 4.6.6
Local line test loop

If everything goes right, TA-csd sends the message 'OK' to user A (both B-channels and D-channel are tested).

If the user receives the message 'ERROR', he may suspect, that the interface of the external modem to the TA-csd, including the interconnecting cables or the input of his TA-csd might may be the cause of errors.

He can first check and exchange the cable. If it does not help, user A can conclude that the interface of his external modem to the TA-csd or the input of his TA-csd is defect.

If the test is executed successfully and the transmission errors are still persist, the user may suspect the interface of his TA-csd to the NT, the ISDN-line (incl. NT), the remote modem or the PSTN-line to be the cause of errors.

To check the interface of his TA-csd to the NT, the user can exchange the TA-csd to another TA-csd. If thereafter everything goes right, it means that the interface of his TA-csd to the NT is faulty.

To check the ISDN-line, he can try to call another user. If by calling another user, the transmission error has vanished, he can conclude that the remote modem or the PSTN-line is the cause of the transmission error. He can request the remote user to test locally his modem. At last if the transmission error is not vanished, after he called another user, the chance is great that his ISDN-line is not in order. He can contact the PTT to let them check his ISDN-line.

For this kind of transmission errors it is really difficult to find out where the fault is precisely located.

4.6.4 Remote test loop TA-csd (Loop 2)

Rate adaptation function:

This loop allows user A to help user B test the integrity of the TA-csd's and the ISDN-lines, if user A suspects the TA-csd 2 and the ISDN line either to be the cause of transmission errors.

User A to sets up the remote test loop TA-csd. During the test, user B types the characters and they are sent to the TA-csd. The TA-csd internally loops data sent from the TA-csd 2 back to the TA-csd 2 as shown in figure 4.6.7. Therefore, user B can inspect the looped data having just been sent and check the correctness. By user A, data is neither received nor displayed on the terminal.

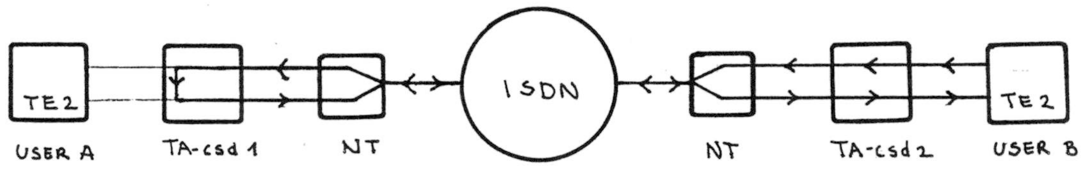


Figure 4.6.7
Remote test loop TA-csd (Loop 2)

If the characters are not looped back properly during this test, then user B shall locally test his own TA-csd (see paragraph 4.6.2).

4.6.5 Remote test loop internal modem

This loop will be executed when the remote modem and the PSTN-line could be the cause of the transmission error.

User A sets up the remote test loop internal modem. User B types the characters and they are sent to the TA-csd. The internal modem built in the TA-csd loops the characters back to the remote modem as shown on figure 4.6.8.

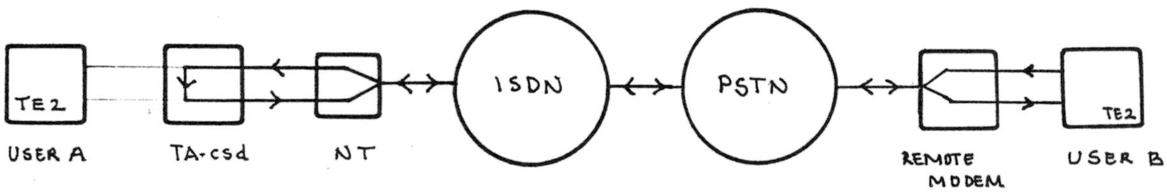


Figure 4.6.8
Remote test loop internal modem

If the characters are not looped back properly during this test, user B shall locally test his modem.

4.6.6 Remote test loop external modem

This loop will be executed when the remote modem and the PSTN-line could be the cause of the transmission error.

User A sets up the remote test loop external modem. User B types the characters and they are sent to the TA-csd/external modem. The external modem connected to the TA-csd loops the characters back to the remote modem as shown on figure 4.6.9.

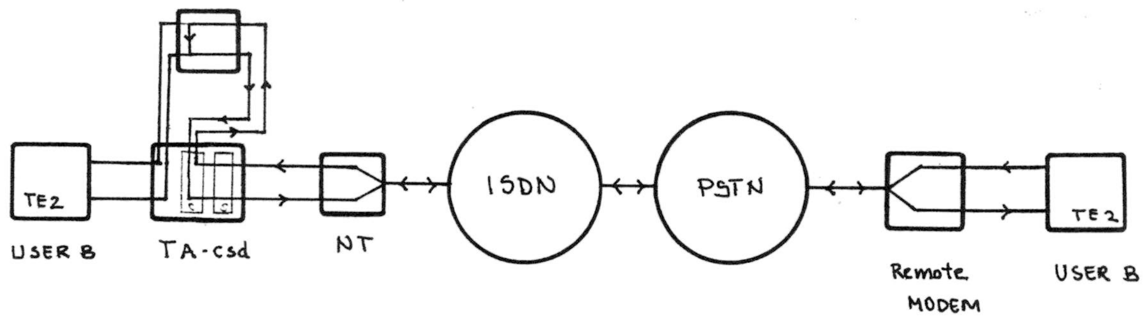


Figure 4.6.9
Remote test loop external modem

If the characters are not looped back properly during this test, user B shall locally test his remote modem.

5. Information exchange procedures

5.1 Introduction

Between terminal/PC/Host computer and TA-csd not only the user data, but also commands have to be exchanged in order to :
- set up calls
- release calls
- set parameters within the TA-csd
- read the status information from the TA-csd
- set up and execute tests

At this moment the 'de facto' standard Hayes command set, used to control auto dialling modems, is the most commonly used command language for this purpose.

For the reasons given above, it is decided to use the Hayes command set to give commands to the TA-csd. This will provide for the transparent replacement of modems and allow existing dial procedures and communication programs to work with ISDN. In fact, TA-csd is a kind of modem, who lets the user use the existing equipment (terminal etc.) to communicate (via the ISDN) with another existing equipment with the same interface.

The TA-csd implements the enhanced Hayes command set based on the standard Hayes command set (prefix **AT**). Not all commands from the standard Hayes command set are useful for the TA-csd. Those commands will not be used (e.g. AT T <CR> Touch Tone dial). There are also modified commands needed, that are not found in the standard command set. Therefore it is necessary to extend the standard Hayes command set (prefixes **AT**, **AT$** and **AT***). For e.g. **AT\\ A** Write a stored telephone number. Thus the enhanced Hayes command set has 4 prefixes, they are **AT**, **AT**, **AT$** and **AT***.

In the following paragraphs the standard and the enhanced Hayes command set, the information exchange procedures (between terminal and modem and between terminal and TA-csd) and the mapping from the enhanced Hayes command set into the ISDN I.451 access layer 3 protocol are described.

5.2 The principles of the Hayes command set

In the following paragraphs the principles of the standard Hayes command set used by the conventional auto-dialling modems and the principles of the enhanced Hayes command set for TA-csd will be described.

5.2.1 The principles of the standard Hayes command set

Nowadays, standard Hayes command set is implemented on almost every intelligent modem. The great advantage of such command set is that the user can control the modem by entering commands at a terminal keyboard or issue them through a communications program.

The main features of the intelligent modems (Hayes smart modems) are:
- It can dial a telephone number.
- It can answer automatically an incoming call.
- It will automatically match the speed of communication (baud rate) and the character format (data bits, parity bit and stop bits) between the terminal and itself.
- It sends a message to the user after a command has been executed.

Standard Hayes command set provides a set of commands that can change the modem's configuration (e.g. commands are echoed or not echoed), perform the modem's operations (e.g. dial a telephone number) etc.

The Hayes smart modem can be found in four different states:
State 1: Off-line command state
State 2: Wait for Carrier state
State 3: On-line communication state
State 4: On-line command state
The states are depicted on figure 5.2.1

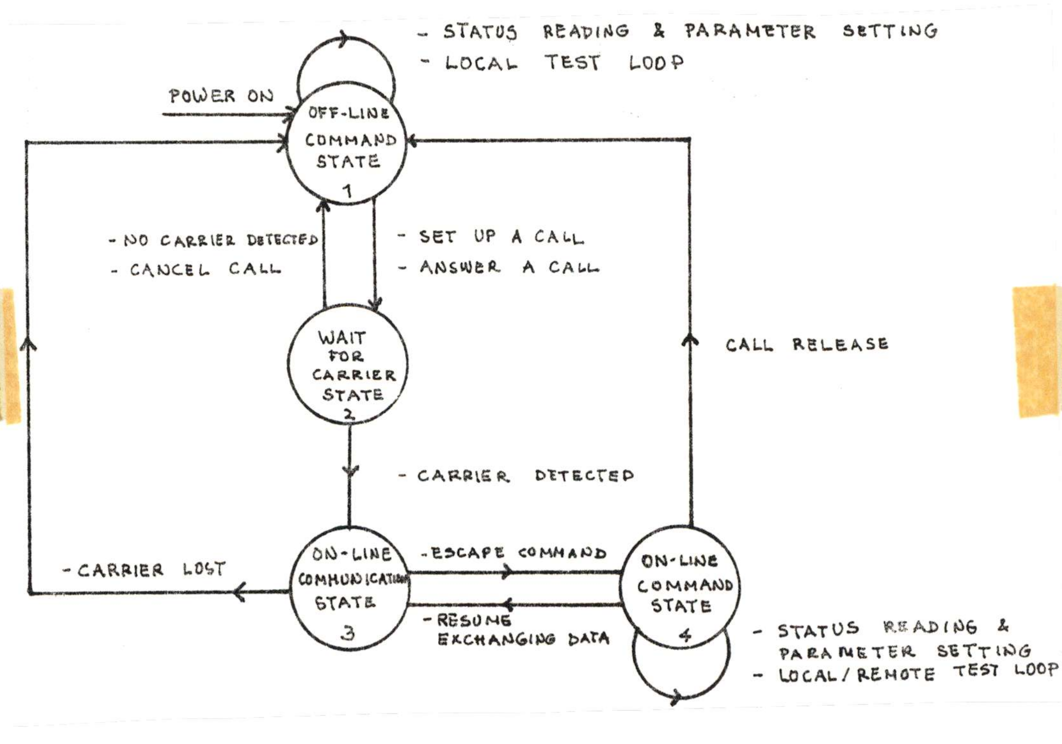


Figure 5.2.1
Hayes smart modem states

5.2.1.1 Off-line command state

When the power of the modem is turned on, the modem is initiated into its default values and enters to the off-line command state. In this state, characters sent to the modem from the terminal are interpreted as the standard Hayes commands. It is now ready to accept commands or an incoming call (no connection is yet established).

The user can send the standard Hayes commands to the modem to:
1. set up call.
2. answer manually an incoming call.
3. read the status information of the modem.
4. set parameters in the modem.
5. set up test loop.
   The test loop is called the analog loopback test (local test loop) This test loop allows the user to check the satisfactory working of the modem. He can set up an internal analog loop inside the modem by giving the specified commands. During the test, the modem internally loops data from terminal back to the terminal. Therefore the user can inspect the looped data having just been sent and check the correctness. Data looped inside the modem is in analog form, hence loopback in this form is named 'analog' loopback. During the test, data is not transmitted to the remote modem.

5.2.1.2 Wait for carrier state

After dialling all the digits of the phone number, the modem starts to wait for a carrier sent from the remote modem it is calling. It will come into the wait for carrier state.

Once a carrier is detected within a limited time, the modem goes on-line and sends the result message (CONNECT) to the terminal to indicate that the remote connection is established.

If no carrier is detected within a limited time, the modem releases the connection, returns to the off-line command state and sends the result message (NO CARRIER) to the terminal to indicate that the remote connection is not established.

During waiting for carrier, the user can cancel the call by pressing any key on the keyboard. The modem will release the connection, enter the off-line command state and send the 'NO CARRIER' result message to the screen. The user can also cancel the call during dialling.

5.2.1.3 On-line communication state

After a carrier has been detected, the modem establishes a connection to the remote modem. When establishing a remote connection, the modem also prepares to receive data sent from the remote modem. Once the modem established a connection to a remote modem it enters the on-line state.

When on-line, the modem transmits a carrier at the originate frequency to the remote modem all the time and the remote modem transmits a carrier at the answer frequency to the calling modem.

Once the carrier sent from the remote modem disappears and the disappearance is detected by modem, it releases the connection, returns to the off-line command state and sends the 'NO CARRIER' result message to the terminal to indicate that the remote connection is broken.

In the on-line communication state, characters sent to the modem from the terminal are transmitted transparently to the remote modem and only an escape code surrounded by two escape guard times, sent to the modem from the terminal, is interpreted as a command (escape command).

5.2.1.4 On-line command state

The escape command brings the modem to the on-line command state (command state without breaking the established connection) from the on-line state.

In this state the user can send the standard Hayes command set to the modem to:

1. read the status information of the modem.
2. set parameters in the modem.
3. return to the on-line communication state and resume exchanging data.
4. release call.
   When the user has done in the on-line command state, he can :
   - release and end the data connection with the remote modem.
   - reset modem and break the connection with the remote modem.

   Thereafter the modem goes to the off-line command state and is ready to accept command(s).
5. set up test loop(s).
   - Analog loopback test (local test loop)
     The description of this test loop can be found on paragraph 5.2.1.1.
   - Digital loopback test (remote test loop)
     Digital loopback test allows the user to help the remote user test the integrity of the remote modem and the phone line. The user shall set up the an internal digital loop inside the modem by giving the specified commands. During the test, the modem internally loops data sent from the remote modem back to the remote modem. Therefore the remote user can inspect the looped data having just been sent and check the correctness. Data is neither received by terminal nor displayed on the screen. Data looped inside the modem is in digital form; hence loopback in this form named digital loopback.

NOTE:
The modem can be turned off in any state.
When this happens, the modem will be reset and any connection with the remote modem will be broken. If the user turns the modem on again, it will automatically come into the off-line command state.

5.2.2 The principles of the enhanced Hayes command set

Based on the principles of the standard Hayes command set used by the auto-dialling modem is the principle of the enhanced Hayes command set for TA-csd made.

Just like the modem,TA-csd can also be found in four different states:
State 1: Off-line command state
State 2: Wait for CONNECT state
State 3: On-line communication state
State 4: On-line command state

The states are depicted on the following figure:

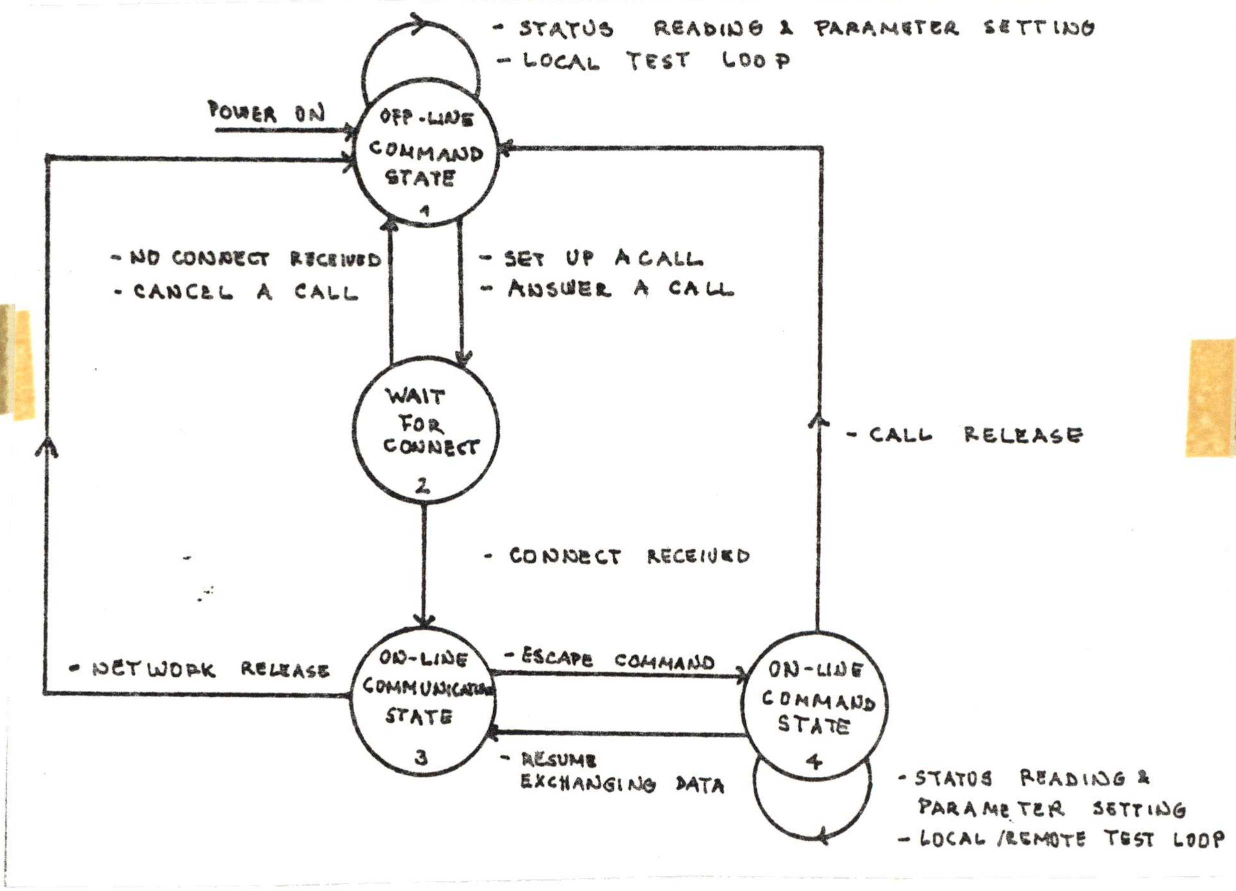


Figure 5.2.2
TA-csd states

5.2.2.1 Off-line command state

When TA-csd turns on, it will come in off-line command state. First is the TA-csd initiated into its default values (see appendix D). The internal modem, built in TA-csd is also initiated. When an external modem is connected to it, initiates TA-csd the external modem too into its default values (see also appendix D).

In this state TA-csd is ready to accept command(s) or an incoming call (the connection is not yet established).

The user can send the enhanced Hayes commands to the TA-csd to:
1. set up call.
2. answer manually an incoming call.
3. read the status information of the TA-csd.
4. set parameters in the TA-csd.
5. set up and execute the local test loop.
6. repeat the last command given by the user.
7. redial a call.
8. abbreviated dial.
9. write a stored number at the TA-csd's memories.

These descriptions are applied for general and rate adaptation functions.

For internal modem function, the user can send the commands to the TA-csd to:

10. let the TA-csd set up a call to PSTN and switch the internal modem on when the call is established.

And for external modem function, the user can send the commands to the TA-csd to:

11. let the TA-csd set up a call to PSTN and switch the external modem on when the call is established.
12. read the status information of the external modem.
13. set parameters in the external modem
14. set up a local test loop external modem.

TA-csd goes to the wait for CONNECT state after it has sent the SET UP message to the ISDN-network or received the SET UP message from the network.

5.2.2.2 Wait for CONNECT state

In this state TA-csd has set up or answered a call and it waits for the connection. If the user wants to cancel the call by pressing any terminal key or no 'CONNECT' message received from the network after the time out, TA-csd goes back to the off-line command state.

The transition from wait for CONNECT state to on-line communication state can occur under the following considerations :
- TA-csd established the call set up successfully

- TA-csd answered the incoming call successfully
Thus TA-csd has received the message CONNECT from the ISDN-network and the connection is established.

5.2.2.3 On-line communication state

TA-csd goes automatically to the on-line communication state, when the connection between two TA-csd's (or TA-csd/modem and remote modem) is established. In this state, the data received from terminal will be sent (transparently) to the remote TA-csd or remote modem.

If the terminal is a 'dumb' terminal, the on-line communication state lets the terminal communicate with a host computer.
Data entered at the keyboard is sent to the host computer.
Data received from the host computer is displayed on the terminal.

If terminal is a PC with terminal emulation and communication software running on it, the communication state lets the PC to communicate with a host computer (Terminal Emulation function) or another PC.

TA-csd can in this state only recognize one command:
the escape command. If an escape command is given from terminal, TA-csd goes to on-line command state, while maintaining the data connection.

5.2.2.4 On-line command state

When TA-csd is in the on-line communication state (data connection is already established) and the user wants to use command(s) to check or alter a parameter setting, release the call etc., he must first give the escape command to the TA-csd to go to the on-line command state. If the escape command is given to TA-csd, it goes to the on-line command state.

In this state the user can send the enhanced Hayes command set to the TA-csd to:

1. read the status information of the TA-csd.
2. set parameters in the TA-csd.
3. return to the on-line communication state and resume the exchange of data.
4. release calls.
   When the user has done in the on-line command state, he can :
   - release and end the data connection with the remote TA-csd or remote modem.
   - reset TA-csd and break the connection with the remote TA-csd or remote modem (internal and external modem shall also be reset).

   Thereafter the TA-csd goes to the off-line command state and is ready to accept command(s).
5. set up a local or remote test loop.
6. write a stored number at the TA-csd's memory.

These descriptions are applied for general and rate adaptation functions.

For external modem function, the user can send the commands to the TA-csd to:
7. read the status information of the external modem
8. set parameters in the external modem
9. set up a local or remote test loop external modem.

NOTE:

The TA-csd can be turned off in any state.
When it happens, TA-csd will be reset and any connection with the remote TA-csd or remote modem will be broken. If the user turns the TA-csd on again, it will automatically come into the off-line command state.

When TA-csd on state 3 or state 4, the ISDN-network can break the connection (Network release) and TA-csd goes back to the off-line command state.

5.2.3 Standard Hayes Command Set

In this paragraph the characteristics of the standard Hayes command set, implemented on the Hayes smart modem will be described.

Globally, the command set can be divided into two different parts :
1. Call control signalling commands to :
   - set up (dial) or answer a call
   - release a call
2. Local Control commands, to :
   - set the parameters on the modem.
   - set up the analog or digital loopback test
   - go to the on-line command state from the on-line communication state without breaking the data connection.

Every command the user gives to the modem shall precede by the command prefix **AT** (Attention Code). If several commands share a line, only one command prefix (**AT**) is required at the beginning of the line. All commands are terminated by pressing <CR> (suffix). Every time the **AT** string is received by the modem, it detects the baud rate and adapts automatically the communication speed and character format (parity, stopbit etc.) of the terminal.

For successful data connection, both modems shall have the same types (e.g. V.21 etc.).

Storing command line:
The command line entered is stored in the command buffer of the modem. The buffer is capable of storing up to 40 characters. The command

For successful data connection, both modems shall have the same types (e.g. V.21 etc.).

Storing command line:
The command line entered is stored in the command buffer of the modem. The buffer is capable of storing up to 40 characters. The command prefix, spaces and some symbols in the dial string (,),- do not occupy any space in the buffer.

The command line entered remains in the buffer and can be re-executed by the **A/** command until a new command line is entered or the power is turned off. Only **A/** command is not preceded by the **AT** prefix.

Hayes smart modem has a number of registers (S-registers) to store the timing parameters for controlling modem operations, ASCII values of some special characters, status bits of current conditions etc.
It also has the configuration switches that establishes the operating parameters for the modem whenever power is turned on or the modem is reset. The number of registers and the configuration switches are not always the same for every modem. It depends on how the modem's manufacturers implemented it.

The summary of commands, the result messages, the summary of registers and the summary of DIP switches of three kinds of smart modems can be found at appendix C.

Although the manufacturers of the smart modems implement the 'de facto' standard Hayes command set, there are a little bit differences between the command set implemented on the one modem and the other modem.

Please refer to appendix C to can see the differences of many kind of intelligent modems. (Some manufacturers do not want to use the term Hayes command set, but they call it the 'AT Command Set'. In fact AT the command set is the same as the Hayes command set.)

The differences are:
- One modem manufacturer may implement more command(s) than the other.
  For example:
  The command AT G- is implemented on modem B, but is not available on modem A.
- Command from the one modem has less parameter than the other modem.
  For example:
  The command AT H- of modem A has two (2) parameters, while the command AT H- of modem B has three (3) parameters
- By some modem manufactories is the AT command set not enough. They will extend the command set.
  For example:
  Modem C implements besides the standard AT command set also the extended AT command set. They have the prefixes (AT\, AT%, AT&).
- The same function is implemented on the different command.
  For example:
  Modem B: AT G0 (Guard tone disabled)
  Modem C: AT &G0 (Guard tone disabled)

Modem A = Smartlink 1200 S (Link Technology group)
Modem B = Lightspeed 1200 (Lightspeed Technology Inc.)
Modem C = AX/1200 and AX/2400 Series error correcting modems
(Microcom Inc.)

The most important commands for e.g. the commands to set up and answer a call ((AT D and AT A) are fortunately keeping the same.

5.2.4 Enhanced Hayes command set

The TA-csd implements the enhanced Hayes command set based on the standard Hayes command set (prefix **AT**). Not all commands from the standard Hayes command set are useful for the TA-csd. Those commands will not be used (e.g. AT T <CR> Touch Tone dial). There are also modified commands needed, that are not found in the standard command set. Therefore it is necessary to extend the standard command set (prefixes **AT**, **AT*** and **AT$**). For e.g. **AT\ A** Write a stored telephone number.

TA-csd stores configuration settings in a set of registers. These registers are similar to the Hayes smart modem registers although some have been extended and redefined for enhanced TA-csd features.

The command set can be divided into two different parts :
1. Call control signalling commands to :
   - establish a call
   - release a call
   - abbreviated dial a call

   These signalling commands are mapped into the ISDN D-channel signalling protocol (LAPD).
2. Local Control commands to :
   - set the parameters on TA-csd or external modem.
   - set the local or remote test loop
   - go to the on-line command state from the on-line communication state without breaking the data connection.

Command prefixes:

AT	Attention Code This prefix is used to give commands to TA-csd based on standard Hayes command set.
AT	Attention Code This prefix is used to give commands to the TA-csd.
AT*	Attention Code for internal modem function. This prefix is used to give commands to the TA-csd to select the internal modem function.

AT$ Attention Code for external modem
This prefix is used to give commands to the external modem via TA-csd.

The attention code precedes all command lines, except **A/**.
If several commands share a line, only one command prefix (**AT**) is required at the beginning of the line. All commands are terminated by pressing <CR> (suffix). The commands may be entered in either uppercase or lowercase letters.

Every time the **AT** string is received by the TA-csd, it detects the baud rate and adapts automatically the communication speed and character format (parity, stopbit etc.) of the terminal.

If the speed of the remote terminal does not match the speed of the local terminal, when an incoming call comes, then :

1. When both TA-csd's support the flow control mechanism, the incoming call can be normally accepted (automatically or manual answer).
2. If remote TA-csd does not support the flow control mechanism, the local TA-csd will give a warning bell to get the attention from the user. Then sends TA-csd a message to let the user change the speed of his terminal to the speed of the remote terminal.
   The message is : for e.g. 'Incoming call
   Speed : 19.200 bps'
   In this case the user must manually answer the call irrespective the setting (automatic answer).
   The procedures will be described in chapter 5.4.1.2.

By incoming call, when the character format of the local TA-csd does not match the character format of the remote TA-csd, the local TA-csd sends the message "FORMAT MISMATCH" to the local terminal. The user must change the format of the terminal to the right format available in the remote TA-csd.

When the external modem (Hayes smart modem) received **AT** commands from the TA-csd, it also detects the baud rate and conform automatically the communication speed and character format of the TA-csd.

For successful data connection between TA-csd/modem and the remote modem, both modems must have the same types and also speed (e.g. V.21 etc.).

Storing command line:
The command line entered is stored in the command buffer of the TA-csd. The buffer is capable of storing up to 40 characters (standard implemented on Hayes smart modem).

The command prefix (**AT**), spaces and some symbols in the dial string ((,),-) do not occupy any space in the buffer. The command line entered remains in the buffer and can be re-executed by the A/ command until a new command line is entered or the power is turned off.

The list of enhanced Hayes commands in off-line command state, on-line communication state and on-line command state can be found in appendix D.

5.3 Procedures between TE2 and modem

In paragraphs 5.2.1, 5.2.3 and appendix C, the principles and the contents of the standard Hayes command set are described. In this paragraph the global procedures associated with the standard Hayes command set for dialing, answering and testing will be explained. The detailed procedures shall be described in the modem user's manual

5.3.1 Dialing procedures

Successful dialing a call:

```
User                 TE2                Modem       Remote Modem   Remote User

  AT D P  0..9 <CR>
  ---------------->
                     AT D P 0..9 <CR>
                     ---------------->
                     CONNECT
                     <----------------
  'CONNECT'
  <----------------
                         CONNECTION
  <==============================================================>
```

Unsuccessful dialing a call:

```
User                 TE2                Modem       Remote Modem   Remote User

  AT D P  0..9 <CR>
  ---------------->
                     AT D P 0..9 <CR>
                     ---------------->
                     NO CARRIER
                     <----------------
  'NO CARRIER'
  <----------------
```

5.3.2 Answering procedures

Successful answering a call:

```
User                  TE2                Modem      Remote Modem    Remote User

                     RING
                     <-------------------
  'RING'
  <---------------              .
            .                   .
            .
                     RING
                     <-------------------
  'RING'
  <---------------
  AT A <CR>
  --------------->
                     AT A <CR>
                     ------------------->
                     CONNECT
                     <-------------------
  'CONNECT'
  <---------------
                           CONNECTION
  <=================================================================>
```

Unsuccessful answering a call:

```
User                  TE2                Modem      Remote Modem    Remote User

                     RING
                     <-------------------
  'RING'
  <---------------              .
            .                   .
            .
                     RING
                     <-------------------
  'RING'
  <---------------
  AT A <CR>
  --------------->
                     AT A <CR>
                     ------------------->
                     NO CARRIER
                     <-------------------
  'NO CARRIER'
  <---------------
```

5.3.3 Testing procedures

Starting analog loopback test

When the modem is on the on-line communication state, the following procedures will be used.

```
User                 TE2               Modem     Remote Modem   Remote User

                               CONNECTION
  <==============================================================>
  Pause at least at the given escape
  guard time (1 second)
  ---------------->---------------->
  +++
  ---------------->
                   +++
                   ---------------->
  Pause at least at the given escape
  guard time (1 second)
  ---------------->---------------->
                   OK
                   <----------------
  'OK'
  <----------------
  AT S16=1 <CR>
  ---------------->
                   AT S16=1 <CR>
                   ---------------->
                   OK
                   <----------------
  'OK'
  <----------------
  AT D <CR>
  ---------------->
                   AT D <CR>
                   ---------------->
                   CONNECT
                   <----------------
  'CONNECT'
  <----------------
             Character
  --------------------------------->
             Character
  <---------------------------------
```

Ending analog loopback test

If the user has finished the analog loopback test and thereafter he wants to break the connection and reset the modem, the following procedures is applied.

```
User                 TE2              Modem     Remote Modem   Remote User

  Pause at least at the given escape
  guard time (1 second)
  ---------------->---------------->
  +++
  ---------------->
                   +++
                   ---------------->
  Pause at least at the given escape
  guard time (1 second)
  ---------------->---------------->
                   OK
                   <----------------
  'OK'
  <----------------
  AT Z <CR>
  ---------------->
                   AT Z <CR>
                   ---------------->
                   OK
                   <----------------
  'OK'
  <----------------
```

Starting digital loopback test

If the user wants to help the remote user to set up the digital loopback test, then the following procedures will be used.

```
User                TE2                Modem     Remote Modem   Remote User

                              CONNECTION
  <================================================================>
  Pause at least at the given escape
  guard time (1 second)
  ---------------->---------------->
  +++
  ---------------->
                   +++
                   ---------------->
  Pause at least at the given escape
  guard time (1 second)
  ---------------->---------------->
                   OK
                   <----------------
  'OK'
  <----------------
  AT S16=4 <CR>
  ---------------->
                   AT S16=4 <CR>
                   ---------------->
                   OK
                   <----------------
  'OK'
  <----------------
  AT O <CR>
  ---------------->
                   AT O <CR>
                   ---------------->
                   CONNECT
                   <----------------
                                    CONNECT
                                    -------------->
  'CONNECT'
  <----------------
                                                     'CONNECT'
                                                   -------------->
                             CONNECTION
  <===============================================================>
                              Character
  <----------------------------------------------------------------
                              Character
  ---------------------------------------------------------------->
```

Ending digital loopback test

If the user wants to end the test (break the internal digital loop, release the connection and reset the modem) as he confirms that the remote user has already finished the test, he shall use the following procedures.

```
User                TE2               Modem      Remote Modem   Remote User

                           CONNECTION
  <================================================================>
  Pause at least at the given escape
  guard time (1 second)
  ---------------->---------------->
  +++
  ---------------->
                    +++
                    ---------------->
  Pause at least at the given escape
  guard time (1 second)
  ---------------->---------------->
                    OK
                    <----------------
  'OK'
  <----------------
  AT Z <CR>
  ---------------->
                    AT Z <CR>
                    ---------------->
                    OK
                    <----------------
  'OK'
  <----------------
```

5.4 Procedures between Terminal and TA-csd

5.4.1 Call establishment procedures

Terminals with RS-232-C interface are :
- Asynchrone Terminal
  Ex. DEC VT 220
- Personal Computer (PC)
  Ex. IBM PC and compatible with communication software

Depending on the terminal, the procedures for call establishment can be automatically set up or not.

The folowing procedures are specified for two essential destinations :
- ISDN Destination : rate adaptation function
  For rate adaptation function, the information exchange procedures occur between :
  - the user and the terminal

- the terminal and the TA-csd
Thereafter follows the mapping between the given Hayes command's at the R-reference point and the D-channel signalling messages.

- PSTN Destination : External Modem function
  Internal Modem function
  The information exchange procedures occur between :
  - the user and the terminal
  - the terminal and the TA-csd
  - TA-csd and the (external/internal) modem
  Thereafter follows the mapping between the given Hayes command's at the R-reference point and the D-channel signalling messages.

The following call establishment procedures are valid when the terminals are :
- Asynchrone terminal
- PC in the "Host mode"
The user enters the (Extended) Hayes commands via the keyboard.

<u>Call establishment at the originating interface :</u>

Successful originating call set up :
* Successful originating call set up for ISDN destination
* Successful originating call set up for PSTN destination

Unsuccessful originating call set up for ISDN and PSTN destination:
* Network congestion
* User busy
* No user answer
* Other reasons

Call cancellation for ISDN and PSTN destination

<u>Call establishment at the destination interface :</u>

Incoming call is accepted :
* Automatically answer an incoming call from ISDN
* Automatically answer an incoming call from PSTN
* Manually answer an incoming call from ISDN

Incoming call from PSTN is not succesful accepted

5.4.1.1 Call establishment at the originating interface

Before the following procedures are invoked, a reliable data link connection must be established between the user (TE/TA-csd/NT) and the network.

Successful originating call set up for ISDN destination :

Rate adaptation function :

If the user wants to communicate with another terminal connected via ISDN (communication within ISDN), the Hayes command with the **AT** prefix should be used.

```
User               TE2               TA-csd         Modem          Network

  AT D 0..9 <CR>
  ---------------->
                   AT D 0..9 <CR>
                   ---------------->
                                    'en-bloc' SET UP (unrestricted)
                                    ----------------------------->
                                    CALL PROCeeding
                                    <-----------------------------
                                    ALERTing
                                    <-----------------------------
                                    CONNect
                                    <-----------------------------
                                    CONNect ACKnowledged
                                    ----------------------------->
                   CONNECT
                   <----------------
  'CONNECT'
  <----------------
                       CONNECTION
  <==============================================================>
```

Successful Originating Call Set Up for PSTN destination :

Internal Modem :

In this case the user wants to use the internal modem function in the TA-csd to communicate with the remote user connected via modem to PSTN. The user shall give the extended Hayes command to the TA-csd with the **AT*** prefix.

```
User                TE2                 TA-csd          Modem           Network

  AT* D 0..9 <CR>
  ---------------->
                     AT* D 0..9 <CR>
                     ---------------->
                                        'en-bloc' SET UP (3.1 kHz)
                                        ----------------------------->
                                        CALL PROCeeding
                                        <-----------------------------
                                        ALERTing
                                        <-----------------------------
                                        CONNect
                                        <-----------------------------
                                        CONNect ACKnowledged
                                        ----------------------------->
                     CONNECT
                     <----------------
  'CONNECT'
  <----------------
                          CONNECTION
  <===============================================================>
```

External Modem :

When the user wants to use the external modem to communicate with the remote user connected via modem to PSTN, the user must give the extended Hayes command to the TA-csd with the **AT$** prefix.

```
User              TE2               TA-csd          Modem           Network

  AT$ D 0..9 <CR>
  ---------------->
                    AT$ D 0..9 <CR>
                    ---------------->
                                     'en-bloc' SET UP (3.1 kHz)
                                     ----------------------------->
                                     CALL PROCeeding
                                     <-----------------------------
                                     ALERTing
                                     <-----------------------------
                                     CONNect
                                     <-----------------------------
                                     AT H1 <CR>
                                     -------------->
                                     CONNECT
                                     <--------------
                                     CONNect ACKnowledged
                                     ----------------------------->
                    CONNECT
                    <----------------
  'CONNECT'
  <----------------
                        CONNECTION
  <===============================================================>
```

Unsuccessful originating call set up for ISDN destination :

Rate adaptation function :

The procedures, if the attempted call is unsuccessful should be hereafter described.

Network congestion :

The call cannot be handled by the network, because too many calls come in simultaneously (network congestion).

```
User              TE2               TA-csd        Modem          Network

  AT D 0..9 <CR>
  ---------------->
                    AT D 0..9 <CR>
                    ---------------->
                                     'en-bloc' SET UP (unrestricted)
                                     ----------------------------->
                                     DISConnect (Netw. Congestion)
                                     <-----------------------------
                                     RELease
                                     ----------------------------->
                                     RELease COMplete
                                     <-----------------------------
                    NO CARRIER
                    <----------------
  'NO CARRIER'
  <----------------
```

The called terminal is busy :

```
User              TE2               TA-csd        Modem          Network

  AT D 0..9 <CR>
  ---------------->
                    AT D 0..9 <CR>
                    ---------------->
                                     'en bloc' SET UP (unrestricted)
                                     ----------------------------->
                                     CALL PROCeeding
                                     <-----------------------------
                                     DISConnect (User Busy)
                                     <-----------------------------
                                     RELease
                                     ----------------------------->
                                     RELease COMplete
                                     <-----------------------------
                    BUSY
                    <----------------
  'BUSY'
  <----------------
```

If the called terminal gives no response to the call set up :

```
User             TE2             TA-csd        Modem         Network

  AT D 0..9 <CR>
  ---------------->
                   AT D 0..9 <CR>
                   ---------------->
                                    'en bloc' SET UP (unrestricted)
                                    ----------------------------->
                                    CALL PROCEEDING
                                    <-----------------------------
                                    DISConnect (No User Answer)
                                    <-----------------------------
                                    RELease
                                    ----------------------------->
                                    RELease COMplete
                                    <-----------------------------
                   NO ANSWER
                   <----------------
  'NO ANSWER'
  <----------------
```

When the call establishment is not successful for all other reasons than above :

```
User             TE2             TA-csd        Modem         Network

  AT D 0..9 <CR>
  ---------------->
                   AT D 0..9 <CR>
                   ---------------->
                                    'en bloc' SET UP (unrestricted)
                                    ----------------------------->
                                    CALL PROCEEDING
                                    <-----------------------------
                                    DISConnect (Cause, display)
                                    <-----------------------------
                                    RELease
                                    ----------------------------->
                                    RELease COMplete
                                    <-----------------------------
                   ERROR
                   <----------------
  'ERROR'
  <----------------
```

The network sends the DISConnect message with a cause and, if applicable, a display information element. The TA-csd sends the 'ERROR' message to the user screen to let the user know that the call is not successful.

Unsuccessful originating call set up for PSTN destination :

The procedures for the unsuccessful originating call set up for PSTN destination (external/internal modem function) is the same as for ISDN destination (data rate adaptation function) for same situations :
- Network Congestion
- User busy
- No user answer
- other reasons

Just replace the command prefix to the appropriate function (external/internal modem) and the bearer capability of the call set up
Thus replace :
* **AT** to **AT$** (external modem) or
  AT to **AT*** (internal modem)
* SET UP (unrestricted) to SET UP (3.1 kHz)

Call Cancellation :

If during the call set up the user wants to cancel the call, the only thing the user must do is pressing any key at the keyboard.
TA-csd recognize it and the call will be aborted.

Call Cancellation for ISDN destination :

For data rate adaptation function, the procedures are :

```
User               TE2                TA-csd         Modem          Network

  AT D 0..9 <CR>
  ---------------->
                    AT D 0..9 <CR>
                    ---------------->
                                     'en bloc' SET UP (unrestricted)
                                     ----------------------------->
                                     CALL PROCeeding/ALERTing
                                     <-----------------------------
  Press any char.
  ---------------->
                    any character
                    ---------------->
                                     DISConnect (Call Suspended)
                                     ----------------------------->
                                     RELease
                                     <-----------------------------
                                     RELease COMplete
                                     ------------------------------>
                    NO CARRIER
                    <----------------
  'NO CARRIER'
  <----------------
```

Call Cancellation for PSTN destination :

The same procedures would be used for the use of external/internal modem function.
Just replace :
* **AT** to **AT$** (external modem) or
  AT to **AT*** (internal modem)
* SET UP (unrestricted) to SET UP (3.1 kHz)

5.4.2.2 Call establishment at the destination interface

Incoming call:

Incoming call can come, while TA-csd is in one of the following situations :
- Non communication mode :
  * Off-line command state
  * On-line command state
- Communication mode

TA-csd can only answer an incoming call from a remote TA-csd/modem when it is in the non communication phase (off-line command state). The off-line command state is the command state without a remote connection or local loopback. In all other situations, the incoming call would be rejected.

TA-csd answers a call by two ways :
- Auto answer
  With auto-answer enabled, the user doesn't have to manually issue any command to answer a call when the call set up comes in.
  Once the call answered, TA-csd performs the answering operation to connect with the calling TA-csd/modem.
- Manual answer (only for rate adaptation function)
  If the TA-csd is in the off-line command state, it always monitor the incoming call set up. Once the call set up comes in, it immediately sends the 'RING' result codes one after another to the terminal screen and also a warning bell to take the attention of the user. The user has to manually issue the A command to have TA-csd answer the call. The command line **AT A <CR>** instructs the TA-csd to pick up the call at once and perform the answering operation for connecting with the calling TA-csd.

Depending on the contents of the register S0, TA-csd is unable (S0=0) or able (S0 > 0) to automatically answer an incoming call.

Incoming call is accepted :

<u>Automatically answer an incoming call from ISDN :</u>

Rate adaptation function :

```
User              TE2              TA-csd       Modem          Network

                                     SET UP (unrestricted)
                                     <-----------------------------
                                     ALERTing
                                     ----------------------------->
                                     CONNect
                                     ----------------------------->
                                     CONNect ACKnowledged
                                     <-----------------------------
                         CONNECT
                         <----------------
  'CONNECT'
  <----------------
                             CONNECTION
  <==============================================================>
```

<u>Automatically answer an incoming call from PSTN :</u>

If an incoming call comes from PSTN and an external (compatible Hayes smart) modem is connected into TA-csd, then put TA-csd the call first through external modem.

If the external modem can not detect carrier within 15 seconds, it shall send a 'NO CARRIER' message to TA-csd. It could be happened that the remote modem is not compatible with the external modem. In this case tries TA-csd to put the call through the internal modem. When internal modem detects carrier within 15 seconds, it will accept the call. TA-csd gives the message 'CONNECT' to the user to tell the remote connection is established. The conversation can then begin.

```
User              TE2               TA-csd        Modem         Network
                                       SET UP (3.1 kHz)
                                       <-----------------------------
                                       ALERTing
                                       ----------------------------->
                                       AT A <CR>
                                       (external modem)
                                       -------------->
                                       NO CARRIER
                                       <--------------

                                       Internal modem
                                       detects the carrier

                                       CONNect
                                       ----------------------------->
                                       CONNect ACKnowledged
                                       <-----------------------------
                         CONNECT
                         <-----------------
  'CONNECT'
  <-----------------
                             CONNECTION
  <==================================================================>
```

Manually answer an incoming call from ISDN:

Rate adaptation function :

```
User             TE2             TA-csd        Modem         Network

                                    SET UP (unrestricted)
                                    <-----------------------------
                                    ALERTing
                                    ----------------------------->
                   RING + beep
                   <----------------
  'RING' + "beep"
  <----------------          .
          .                  .
          .
                   RING + beep
                   <----------------
  'RING' + "beep"
  <----------------
  AT A <CR>
  ---------------->
                   AT A <CR>
                   ---------------->
                                    CONNect
                                    ----------------------------->
                                    CONNect ACKnowledged
                                    <-----------------------------
                   CONNECT
                   <----------------
  'CONNECT'
  <----------------
                       CONNECTION
  <=============================================================>
```

Incoming call from PSTN is not successful accepted :

If the external and internal modem can not accept the call because they can not detect a carrier within 15 seconds (by default) after going off hook to answer the incoming call, the next procedures will follow:

```
User             TE2                TA-csd         Modem          Network

                                       SET UP (3.1 kHz)
                                       <-----------------------------
                                       ALERTing
                                       ----------------------------->
                                       AT A <CR>
                                       (external modem)
                                       -------------->
                                       NO CARRIER
                                       <--------------

                                       internal modem
                                       does not detect
                                       carrier

                                       DISConnect (Cause)
                                       ----------------------------->
                                       RELease
                                       <-----------------------------
                                       RELease COMplete
                                       ------------------------------>
                        NO CARRIER
                        <----------------
  'NO CARRIER'
  <----------------
```

The external modem detects the lost of carrier during the on-line communication state:

```
User             TE2                TA-csd         Modem          Network

                            CONNECTION
  <============================================================>
                                       NO CARRIER
                                       <--------------
                                       DISConnect (Cause)
                                       ----------------------------->
                                       RELease
                                       <-----------------------------
                                       RELease COMplete
                                       ------------------------------>
                        NO CARRIER
                        <----------------
  'NO CARRIER'
  <----------------
```

The internal modem detects the lost of carrier during the on-line communication state:

```
User                TE2              TA-csd        Modem         Network

                         CONNECTION
  <==============================================================>
                                          internal modem
                                          detect the lost of
                                          carrier

                                          DISConnect (Cause)
                                          ----------------------------->
                                          RELease
                                          <-----------------------------
                                          RELease COMplete
                                          ------------------------------>
                              NO CARRIER
                              <-----------------
  'NO CARRIER'
  <-----------------
```

5.4.2 Call clearing procedures

Call clearing procedures for ISDN destination :

When the connection is available and the user has finished the data transfer, he can clear the data connection with the following procedures :

```
User                TE2                 TA-csd          Modem            Network


                             CONNECTION
  <==============================================================>
  Pause at least at the given escape
  guard time (1 second)
  ---------------->---------------->
  +++
  ---------------->
                    +++
                    ---------------->
  Pause at least at the given escape
  guard time (1 second)
  ---------------->---------------->
                    OK
                    <----------------
  'OK'
  <----------------
  AT H <CR>
  ---------------->
                    AT H <CR>
                    ---------------->
                                     DISCconnect
                                     ---------------------------->
                                     RELease
                                     <----------------------------
                                     RELease COMplete
                                     ---------------------------->
                    OK
                    <----------------
  'OK'
  <----------------
```

If the user wants to break the connection and thereafter reset the TA-csd into the default value, replace the command **AT H <CR>** into **AT Z <CR>**.

Call clearing procedures for PSTN destination :

External Modem :

```
User             TE2             TA-csd        Modem         Network


                       CONNECTION
  <==============================================================>
  Pause at least at the given escape guard time
  (1 second)
  ---------------->---------------->------------->
  +++
  ---------------->
                   +++
                   ---------------->
                                    +++
                                    ------------->
  Pause at least at the given escape guard time
  (1 second)
  ---------------->---------------->------------->
                                    OK
                                    <-------------
                   OK
                   <----------------
  'OK'
  <----------------
  AT H <CR>
  ---------------->
                   AT H <CR>
                   ---------------->
                                    AT H <CR>
                                    ------------->
                                    DISCconnect
                                    ----------------------------->
                                    RELease
                                    <-----------------------------
                                    RELease COMplete
                                    ----------------------------->
                   OK
                   <----------------
  'OK'
  <----------------
```

It is also possible to hang up the modem from the telephone line and then reset the modem into the value of the factory setting if the user wishes to do that, just replace **AT H <CR>** with **AT Z <CR>**

5.4.3 Procedures to set up parameters in the TA-csd

The procedures to set up the parameter on TA-csd :

Command is executed successfully :

```
User              TE2               TA-csd        Modem         Network

  AT S1=94 <CR>
  ---------------->
                    AT S1=94 <CR>
                    ---------------->
                    OK
                    <----------------
  'OK'
  <----------------
```

When an invalid command is given, then refuses TA-csd to execute the command and give the message 'ERROR' to the user.

```
User              TE2               TA-csd        Modem         Network

  AT\ Z1 <CR>
  ---------------->
                    AT\ Z1 <CR>
                    ---------------->
                    ERROR
                    <----------------
  'ERROR'
  <----------------
```

The list of commands to set up the parameter in TA-csd can be found in appendix D.

5.4.4 Procedures for test capabilities

TA-csd provides testing features to facilitate finding fault location when transmission quality is not good enough and the causes are doubtful.

Six difference test capabilities are defined and described on chapter 4.6 and in this chapter the procedures to execute a number of tests test will be explained.

The procedures to initial check out TA-csd:

```
User     TE2     TA-csd

AT <CR>
--------->
          AT <CR>
          -------->
          OK
          <--------
'OK'
<---------
```

The procedures for Local test loop TA-csd (Loop 3):

```
User     TE2     TA-csd     Modem     Network     Modem     TA-csd     TE2     User

                                    CONNECTION
<=============================================================================>
Pause (1 second)
---------------->
+++
-------->
         +++
         -------->
Pause (1 second)
---------------->
         OK
         <--------
'OK'
<--------
AT S9=1
-------->
         AT S9=1
         -------->
         OK
         <--------
'OK'                      (The rate adaptation part and the internal modem part
<--------                  are okay)
```

The procedures for Local test loop external modem:

```
User     TE2     TA-csd     Modem     Network     Modem     TA-csd     TE2     User

AT S9=2
-------->
         AT S9=2
         -------->
                  AT <CR>
                  -------->
                     .
                     .
                  AT <CR>
                  -------->
                  OK
                  <--------
         OK
         <--------
'OK'                (The local test loop external modem is successfully
<--------            executed en everything is allright)
```

The procedures for starting remote test loop TA-csd (Loop 2):

```
User    TE2     TA-csd     Modem    Network     Modem    TA-csd    TE2     User

                                 CONNECTION
   <=====================================================================>
Pause (1 second)
----------------->
+++
-------->
         +++
         -------->
Pause (1 second)
----------------->
         OK
         <--------
'OK'
<--------
AT S9=3
-------->
         AT S9=3
         -------->
         OK
         <--------
'OK'
<--------
AT O
-------->
         AT O
         -------->
         CONNECT
         <--------
                  CONNECT
                  --------------------------------------->
'CONNECT'                                                  CONNECT
<--------                                                  -------->
                                                                    'CONNECT'
                                                                    -------->
                                                                    Type
                                                                    Char.
                                                                    <--------
                                                           Char.
                                                           <--------
                  Char.
                  <---------------------------------------
                  Char.
                  --------------------------------------->
                                                           Char.
                                                           -------->
                                                                    'Char.'
                                                                    -------->
```

Procedures for ending remote test loop TA-csd (Loop 2):

```
User    TE2    TA-csd    Modem    Network    Modem    TA-csd    TE2    User

                                  CONNECTION
<=============================================================================>
Pause (1 second)
----------------->
+++
-------->
         +++
         -------->
Pause (1 second)
----------------->
         OK
         <--------
'OK'
<--------
AT S9=0
-------->
         AT S9=0
         -------->
         OK
         <--------
'OK'
<--------
```

The procedures for starting remote test loop external modem:

```
User     TE2     TA-csd     Modem     Network     Modem     TA-csd     TE2     User

                                 CONNECTION
   <=====================================================================>
Pause (1 second)
--------------------------->
+++
-------->
         +++
         -------->
                  +++
                  --------->

Pause (1 second)
---------------------------->
                  OK
                  --------->
         OK
         <--------
'OK'
<--------
AT$S9=5
-------->
         AT$S9=5
         -------->
                  AT S16=4
                  --------->
                  OK
                  <---------
         OK
         <--------
'OK'
<--------
AT$O
-------->
         AT$O
         -------->
                  AT O
                  --------->
                  CONNECT
                  <---------
         CONNECT
         <--------
                  CONNECT
                  --------------------------------------->
'CONNECT'                                                CONNECT
<--------                                                -------->
                                                                  'CONNECT'
                                                                  -------->
                                                                  Type
                                                                  Char.
                                                                  <--------
```

```
User     TE2    TA-csd    Modem    Network    Modem    TA-csd    TE2    User

                                                         Char.
                                                         <--------
                            Char.
                            <----------------------------
                            Char.
                            ----------------------------->
                                                         Char.
                                                         -------->
                                                                  'Char.'
                                                                  -------->
```

The procedures for ending the remote test loop external modem:

```
User     TE2    TA-csd    Modem    Network    Modem    TA-csd    TE2    User

                                CONNECTION
   <===================================================================>
Pause (1 second)
-------------------------->
+++
-------->
         +++
         -------->
                  +++
                  --------->

Pause (1 second)
---------------------------->
                  OK
                  --------->
         OK
         <--------
'OK'
<--------
AT$S9=5
-------->
         AT$S9=5
         -------->
                  AT S16=0
                  <---------
                  OK
                  <---------
         OK
         <--------
'OK'
<--------
```

5.4.5 Procedures for additional functions:

In this paragraph, a number of procedures for additional functions, like store a telephone number at memory n and dial a stored number at memory n will be described.

The procedures to store a telephone number at memory n:

```
User     TE2     TA-csd

AT\En 0..9
--------->
          AT\En 0..9
          --------->
          OK
          <---------
'OK'
<---------
```

The procedures to dial a telephone number at memory n:

In this case is the rate adaptation function chosen.

```
User               TE2               TA-csd         Modem         Network

  AT\Cn
  ---------------->
                   AT\Cn>
                   ---------------->
                                    'en-bloc' SET UP (unrestricted)
                                    ----------------------------->
                                    CALL PROCeeding
                                    <-----------------------------
                                    ALERTing
                                    <-----------------------------
                                    CONNect
                                    <-----------------------------
                                    CONNect ACKnowledged
                                    ----------------------------->
                   CONNECT
                   <----------------
  'CONNECT'
  <----------------
                       CONNECTION
  <==============================================================>
```

6. Conclusions

Finally, the following conclusions can be made:

- It appeared from the interviews that the most used type of terminal interface is the asynchronous RS-232-C (V.24/V.28). RS-232-C is extensively used through out the computer industries. Almost all computers provide the RS-232-C serial ports, and the ones that do not, have that capability as an option. Almost every modem use RS-232-C interface too. Therefore for circuit switched data, the choice has been made to design a terminal adaptor for asynchronous terminals with RS-232-C interface (TA-csd).

- It is obvious that during the introduction of ISDN, TA-csd's will play an important role to make the transitions from PSTN into ISDN a success (the user still can use their non ISDN terminals) and to make the communication possible between digital ISDN and analogue PSTN (TA-csd has a built in modem and it can be connected to the external modem).

- As a matter of fact if the design of the TA-csd is extended with some extra hardware, the TA-csd could also be made suitable for connecting terminals which have analogue a/b interfaces to ISDN. The main difference between TA-csd (with RS-232-C interface) and the TA-a/b is that the latter also performs the signalling of the conventional telephone. When the TA-csd is provided with a signalling hardware module card, it is possible to transmit voice-band signals through the TA-csd. In this case, a conventional telephone device, external modem or facsimile (up to group 3) can be connected to the TA-csd and therefore to the ISDN. The TA-csd provided with this extention will become a 'multi purpose' TA-csd. As each ISDN connection provides two B-channels, both devices that are connected to such a TA-csd can operate simultaneously.

- It appeared that the command language used to control the auto dialing modems, the 'de facto' standard Hayes command set can also be used to control the TA-csd. For TA-csd is the enhanced Hayes command set made, that is compatible with the standard Hayes command set. It provides the transparent replacement of modems and allow existing dial procedures and communications programs to work with ISDN.

- The cost of a TA-csd is at this moment very difficult to determine. It comes because the development of a TA is now in the premature phase. Just a very preliminary estimation of the cost of a TA-csd can be made. The price of a TA is approximately the same as the price of a not very fast modem. It will lie between 1500 up to 3500 guilders.

7. The examination

Here follows the summary of the examination.

The examiners were:
- ir. J. Kommer
- ir. A.W. Doorduin
- ir. R.A. Beukers
- Prof. ir. J.L. de Kroes

The examination began at 3:18 p.m.
Hereafter follows the summary of the questions, that the examiners asked to the student and the answers that the student gave to the examiners.

Question 1 : How should the security functions be adjudged in this TA-csd?

Answer : With the auto call back function and the login password procedure can the security function be adjudged.

Alternative : In the Ta-csd is the list of the authorized users stored in the memory and if an incoming call comes, TA-csd checks first the identity of the called user. If the called user is a legal user, the call will be accepted, otherwise not. This is possible, while by an incoming call, the identification of the called user is also be sent to the TA-csd by ISDN.

Question 2 : Can the existing communication programs be used ?

Answer : Yes, especially when it is set up to the terminal mode.

Question 3 : Can a facsimile be connected to the TA-csd ?

Answer : Without the extention of the a/b interface in the TA-csd, a facsimile can not be connected to it.

Question 4 : It is possible to connect an external modem to the TA-csd, how it is possible ?

Answer : When the connection is already established, TA-csd sends a Hayes command to the external modem to let the modem go on-line. And thereafter, the communication can begin.

Question 5 : Is the usage of the X.25 interface in combination with V.24 interface already inquired ?

Answer : No, because the main subject in this paper is concentrated to the interfaces used by the circuit switching networks.

Question 6 : Hoe is the price of the TA-csd determined ?

Answer : From the interview with somebody from the commercial department, it appeared that the development of the Terminal Adaptor (TA) is in the very premature phase. It is strived for that finally the price of the TA's at the store will lie between fl. 1500,- and fl. 3500,- (approximately equal to the price of the middle speed modem now).

Question 7 : TA-csd has conversion functions, especially to convert the analogue voice signals to 64 kbps by codec. This conversion function can also be taken place in the PSTN. How do you think about this alternative?

Answer : In principle, this alternative gives the advantage point to the user of the TA-csd. It comes, because this function is not supported on every TA. Thus, when this function is implemented on PSTN, the user of a TA has not to worry, when he wants to communicate with PSTN-user.

Question 8 : Hoe do you think about the development of the TA's in the future. How long keep the TA's interesting?

Answer : First:

It will depend on the writing-off date of the existing terminals used. When the cost of the ISDN-terminals approximately equal to the cost of the new existing terminals, the ISDN terminals shall take the place of the existing terminals and in this case TA's are less interesting, but it will be still used as ISDN is not world wide available.

Second:

As long as ISDN is not available in the whole world, TA's are keeping interesting. The transition from PSTN into ISDN shall take place at least about 20 years.

Question 9 : Can you explain, what is the block Hayes commands on page 54 ?

Answer : This is not a hardware block (IC), it is a functional block that contains the legal enhanced Hayes command set. Every time when a command is accepted from the user, the command will be first checked for the validity via this enhanced Hayes command interpreter block.

Question 10 : Referring to page 72, under the NOTE consideration, when the TA-csd is turned off, how can ISDN know, that TA-csd has been turned off and how can the connection be cleared ?

Answer : If this TA-csd has a back up battery, it can detect that the power supply part from the main is turned off,

		and it can send a message 'DISCONNECT' to ISDN to let ISDN disconnect the connection.
Alternative	:	ISDN polled regularly every line. When there is no activity on the line, ISDN will release the connection.

Question 11	:	Referring to page 75, when is the message 'SPEED/FORMAT MISMATCH' applied ?
Answer	:	It is only applied when an incoming call comes.

The examination is closed at 4:20 p.m.

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Appendix A

An introduction into ISDN

The basic definition of ISDN that CCITT has defined is :

> 'An ISDN is a network, in general evolving from a telephony IDN, that provides end-to-end digital connectivity to support a wide range of services, including voice and non-voice services, to which users have access by a limited set of standard multi-purpose user network interfaces'

From the CCITT definition of ISDN it emerges that the basis is a network which in general evolves from the telephony IDN. The IDN here means the 'Integrated Digital Network' where the term integrated refers to the commonality of digital techniques used in transmission and switching systems in the main part of the network. In fact, the telephone IDN is a subset of the Public Switched Telephone Network (PSTN).

In particular the telephony IDN, based on 64 kbps adopted for the encoding of speech, has been considered since the 1970's to be a powerful means of conveying other services in addition to voice, such as data and video.

When access (i.e. the connection from the user's terminal to the local exchange) to this IDN is provided digitally to the user then ISDN is created, as shown in figure A.1.

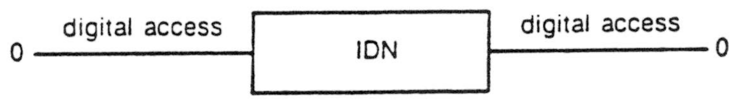


Figure A.1.
ISDN is the combination of IDN and digital access

The above principles applies to other types of IDN (e.g. a data network), and hence the 'in general evolving from a telephony ISDN...' in the CCITT definition. This means that ISDN includes all types of switching capabilities including circuit switching and packet switching within the concept.

The telephony IDN therefore consists of an interconnection of digital switching nodes, where circuits operating at 64 kbps are circuit-switched. These digital exchanges are linked together by a signalling network which is based on common channel signalling principles.
The currently evolving international standard for such a signalling system is known as 'CCITT signalling system No 7'.

This is a powerful message based system where the signalling control for many circuits is carried over a common channel.

Starting from the basic definition and principles of the ISDN, which were generally agreed in the 1976-1980 study period, the CCITT started in the 1980-1984 study period to do standardisation studies on the ISDN for the first time in a detailed manner. In order to standardise all necessary aspects of ISDN, the CCITT has divided the new I Series of Recommendations (Blue book/autumn 1989) into 7 differently parts (figure A.2):

1. I.100 family:
   General recommendations on definitions, vocabulary, attributes etc.
2. I.200 family:
   Service aspects of ISDN.
   Bearer services, teleservices and supplementary services.
3. I.300 family:
   Network aspects of ISDN.
   Network modelling, numbering, routeing etc.
4. I.400 family:
   ISDN user-network interfaces.
   (Reference configurations, layer 1 to 3 specifications, rate adaptation, and multiplexing etc. Some of this recommendations duplicate the Q.900 and X.30 Series of Recommendations).
5. I.500 family:
   Interworking
6. I.600 family:
   Maintenance

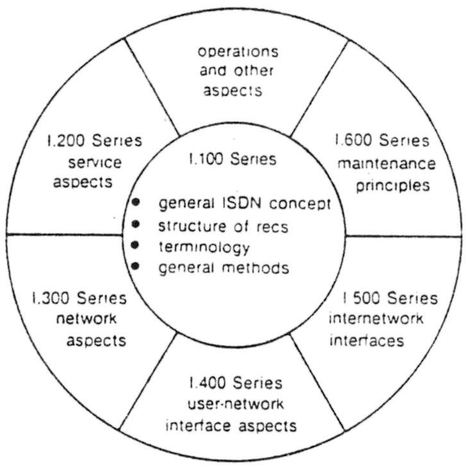


Figure A.2
Structure of the I-series of Recommendations

In the following paragraphs the important aspects, which related to the circuit switched mode are described.

A.1 Service aspects of ISDN

Telecommunication services are essentially the possibilities made available to users of a telecommunication network. The functional capabilities of the ISDN allow its user to be offered a much wider range of services than any previous network.

The services are divided into:
- Bearer services (I.211)
- Teleservices (I.212)
- Supplementary services (I.22Y)

An ISDN bearer services is defined as follows:
' A provision of such a service to the customer allows him the capability for information transfer between ISDN access points according to CCITT standards. The higher layer (i.e. above layer 3) terminal function is defined by the customer'

Thus bearer services correspond to the low layers 1 to 3 of the OSI model and are supplied at the terminal network interface.

The CCITT has identified 13 attributes to characterize bearer services. They are:

Information transfer attributes:
1. Information transfer mode (circuit, packet)
2. Information transfer rate (64, 384, 1536, 1920 kbps, ...)
3. Information transfer capability
   (unrestricted dig. inf., speech, 3.1 kHz audio, 7 kHz audio, 15 kHz audio, video, ...)
4. Structure
   (8 kHz integrity, Service data unit integrity, unstructured)
5. Establishment of communication (demand, reserved, permanent)
6. Communication configuration (point-to-point, multipoint, broadcast)
7. Symmetry
   (unidirectional, bidirectional symmetric, bidirectional asymmetric)

Access attributes:
8. Access channel and rate (D(16), D(64), E, B, HO, H11, H12)
9.1 Signalling access protocol (I.440, I.451, CCITT No 7, I.462 ...)
9.2 Information access protocol (G.711, G.721, I.460, I.451, X.25 ...)

General attributes:
10. Supplementary services provided
11. Quality of service
12. Interworking possibilities
13. Operational and commercial

An ISDN teleservices is defined as follows:
'The type of service provides the user with the complete capability, including defined terminal equipment functions, for communication with another user of the service according to protocols established by CCITT'

The teleservices attributes are:

1. Low layer attributes (see above)
   - information transfer attributes
   - access attributes
2. High layer attributes
   - Type of user information (speech, sound, text, facsimile, textfacsimile, videotext, video, others)
   - Layer 4 protocol functions (X.224, T.70, others)
   - Layer 5 protocol functions (X.225, T.62, others)
   - Layer 6 protocol functions (T.73, T.61, T.6, T.100, others)
     - resolution (200, 240, 300, 400, others)
     - graphic mode (alphamosaic, geometric, photographic, others)
   - Layer 7 protocol functions (T.60, T.5, T.72, others)
3. General attributes
   - supplementary low and high layer attributes (supplementary services)
   - user oriented quality of service
   - interworking possibilities
   - operational and commercial

Teleservices are offered to user rather than the terminal, and include functions in all seven layers (figure A.1.1).

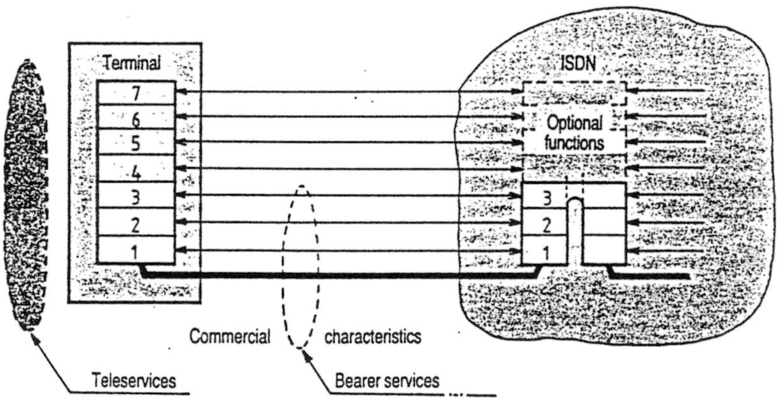


Figure A.1.1
Bearer services and teleservices

Supplementary services are sometimes referred to as user facilities. They correspond to optional functions associated with bearer services and teleservices. These are mainly low-layer functions which extend or modify a basic service to improve its ease-of-use and friendliness.

Although the CCITT has not finalized specifications for definition and implementation of supplementary services, many are the subject of draft recommendation (I.22y). The text that may be considered stable concern the following supplementary services are:

- Call forwarding; user-to-user signalling; closed user group; direct dialling in; call waiting; call completion to busy subscriber; calling line identification; inhibitation of calling line identification; add on conference call; three way conference call; call transfer; automatic credit card call.

Other supplementary services require further study, including:

- in-call modification, call screening by terminal, centrex, called line identification; call holding.

A.2 Network aspects of ISDN

The main aspects are:

- ISDN functional principles (I.310)
- Reference models (I.320)
- Numbering, routing and addressing (I.330/I.331)
- ISDN connection types (I.340)

The recommendations are devised to ensure international compatibility of services, terminal portability, and easier interworking between networks. Figure A.2.1 is the basic architecture model for an ISDN. User-network signalling is processed by the local exchange and user-to user signalling is transmitted over the no.7 common channel signalling network. The possibility of establishing circuit switched connections at less than 64 kbps is not yet defined (for further study).

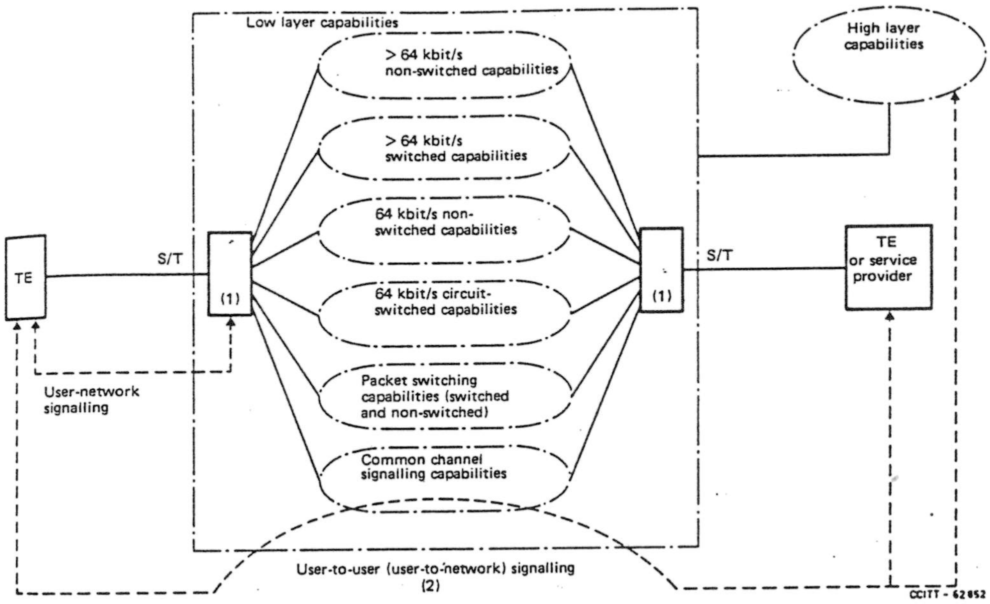


Figure A.2.1
ISDN architectural model

Note 1 – The ISDN local functional capabilities corresponds to functions provided by a local exchange and possibly other equipments such as electronic cross connect equipments muldexes, etc.

Note 2 – User-to-user signalling needs further study.

Note 3 – These functions may either be implemented within ISDN or be provided by separate networks.

Relations between the ISDN and other networks, or between two ISDNs are defined at the following reference points (Figure A.2.2):
K: for access to the telephone network or a dedicated network
M: for access to a specialized service provider
N: for access to another ISDN

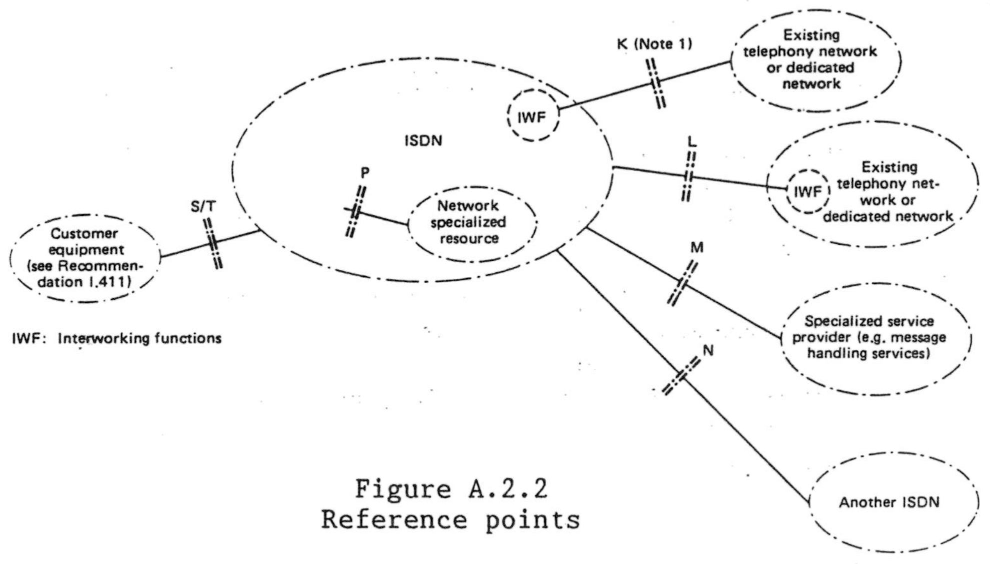


Figure A.2.2
Reference points

Numbering and addressing principles:
Each ISDN address consists of an international ISDN number and an optional subaddress. The ISDN numbers are consistent with the telephone numbering plan and an unambiguously identify a single subscriber terminal installation. A subaddress or complementary ISDN number may be used to select a specific terminal at the called end.

Types of connection:
ISDN connection types are the realization in the network of layer 1 to 3 functions, and are described by the attribute method. The connection types attributes are similar to those presented above for definition of services, but their values differ in several aspects. This is because the connection type attributes describe the technical capabilities of the network while the service attributes characterize telecommunication services. An ISDN connection is specified between two reference points at the boundary of the ISDN (S,T,K,L,M,N).

A.3 ISDN user-network interfaces

Connection of subscribers to the public ISDN involves resources from the subscriber's equipments to the local public exchange. The interface is a point where physical, electrical and logical characteristics can be defined. Examples of various possible user network interfaces are shown in figure A.3.1.

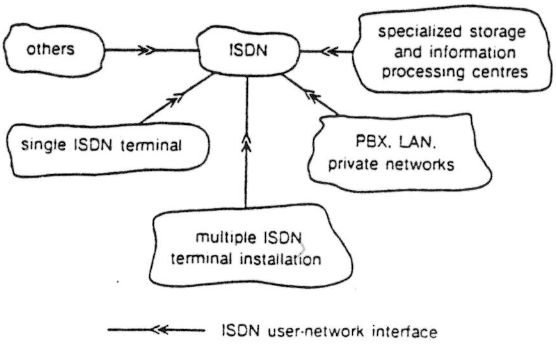


Figure A.3.1.
ISDN user-network interfaces

The figure illustrates that what is meant by a user-network interface is the point at which terminal equipment, PABXs, LANs or private networks are connected to the (public) ISDN.

The user-network interface covered the following aspects:
- Reference configuration (I.411)
- Channels, interface structures and access capabilities (I.412)
- Basic user-network interface
  (Layer 1/I.430; Layer 2/I.440, I.441; Layer 3/I.450, I.451)
- Primary rate user-network interface (Layer 1 up to 3)
  (Layer 1/I.431; Layer 2/I.440, I.441; Layer 3/I.450, I.451)
- Multiplexing, rate adaptation and support of existing interfaces.

Reference configuration:
Reference configurations are conceptual configurations useful in identifying various possible physical user access arrangements to an ISDN. Two concept are used in defining reference configurations:
- Reference points
- Functional groupings

See figure A.3.2.

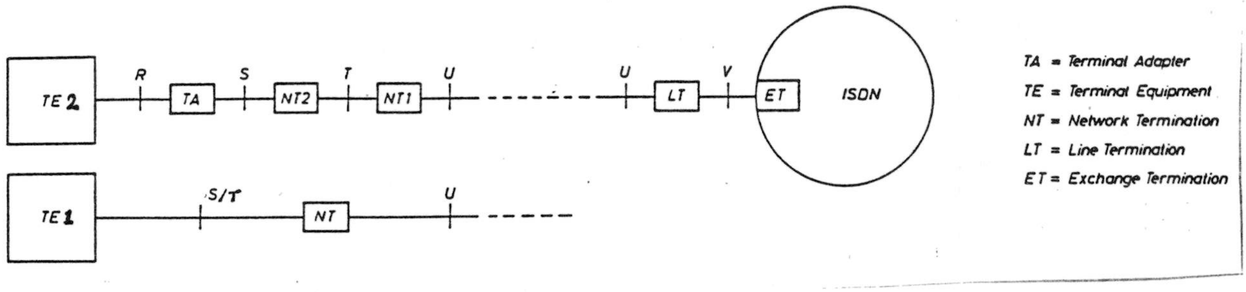


Figure A.3.2.
Reference configuration

Reference points:
A reference point is a conceptual point separating two functional groupings and may or may not correspond to a physical interface. The ISDN user-network interface is the physical interface corresponding to reference points S and T. Reference point R represents a terminal interface other than the ISDN interface. The transmission line is represented by reference point U and the input interface at the public exchange by V.

Functional groupings:
A functional grouping is a set of functions which may be needed in ISDN user access arrangement.

NT1, Network Termination 1:
Include functions broadly equivalent to layer 1 (Physical Layer) of the OSI model. These functions are associated with the proper physical and electromagnetic termination of the network.

NT1 functions are:
- Line transmission termination
- Layer 1 line maintenance functions and performance monitoring
- Timing
- Power transfer
- Layer 1 multiplexing
- Interface termination, include multidrop termination employing layer 1 contention resolution.

NT2, Network Termination 2:
Include functions broadly equivalent to layer 1 and higher layers (2,3) of the OSI model.

NT2 functions are:
- Layers 2 and 3 protocol handling
- Layers 2 and 3 multiplexing
- Switching
- Concentration
- Maintenance functions
- Interface termination and other layer 1 functions

Examples of equipment/combinations of equipment :
- A PABX can provide NT2 functions at layers 1, 2 and 3.
- A Terminal controller can provide NT2 functions at layers 1 and 2.
- A TDM (Time Division Multiplexer) can provide NT2 functions only at layer 1.
- In a specific access arrangement, the NT2 functional group may consist of only physical connections.

TE, Terminal Equipment :
Include functions broadly belonging to layer 1 and higher layers (2-7) of the OSI model.

The TE functions are :
- Protocol handling
- Maintenance functions
- Interface functions
- Connection functions to other equipments

Examples of equipment/combinations of equipment :
- Digital Telephones
- DTE (Data Terminal Equipment)
- Integrated work stations

TE1, Terminal Equipment type 1 :
Include functions belonging to the functional group TE with an interface that complies with the ISDN user-network interface recommendations.

TE2, Terminal equipment type 2 :
Include functions belonging to the functional group TE with an interface that complies with the following interface recommendations:
- other than the ISDN Interface Recommendation (e.g. the X. and the V.series interface recommendations, commonly used in equipment available nowadays)
- interfaces not included in CCITT Recommendations

TA, Terminal Adaptor :
Include functions broadly belonging to layer 1 and higher layers of the OSI model, that allow a TE2 terminal to be served by an ISDN user-network interface. One of the most important functions is the data rate adaptation required to package the traditional communication rates in 64 kbit/s. At the R-reference point are the X. and V.series interfaces applicable.

LT, Line terminal:
It has layer 1 functions between the transmission line (U) and the public exchange input(V): transmission, activation, over-the-line power feeding, maintenance, quality monitoring etc.

ET, Exchange Termination:
ET groups exchange functions assigned specifically to the access port in question: supervision, multiplexing, demultiplexing, D-channel processing, etc.

Channels, interface structures and access capabilities:
User interface specifications employ the concepts of the channel, interface structure and access capability.

A channel is a fixed portion of an interface's information carrying capabilities. there are four classes of channel:

1. B-channel:
   64 kbps channel, available to carry all types of information (voice , data information corresponding to circuit or packet switching, wide band voice etc).
2. D-channel:
   16 or 64 kbps channel operating in the message mode (Layer 2 and 3 protocols). It is primarily intended to carry signalling information for circuit switching by the ISDN. Additionally, a D-channel may also be used to carry telemetry information and packet switched data.
3. E-channel:
   64 kbps channel. It is primarily intended to carry signalling information for circuit switching by the ISDN. At the user network interface it is used only in the primary rate multiplexed channel structures as and alternate arrangement for multiple access interface configurations.
4. H-channels:
   H0 channel: 384 kbps
   H11 channel: 1536 kbps; H12 channel: 1920 kbps
   An H channel is intended to carry a variety of user information streams (fast fax, video, high speed data etc.). It does not carry signalling information.

Interface structure:

This is the way in which channels are organized in the useful part of the interface.
B-channel interface structures:

- Basic interface structure is composed of 2B + D channels.
  B= 64 kbps and D= 16 kbit/s.
- Primary rate B-channel interface structures.
  Europe: 30B + D
  USA : 23B + D
  B= 64 kbps and D= 64 kbit/s.

In the CCITT red-book the D-channel is already fully defined up to the layer 3 of the OSI model for basic access as well as primary rate access, while the B-channel is just only defined at layer 1 (see figure A.3.3).

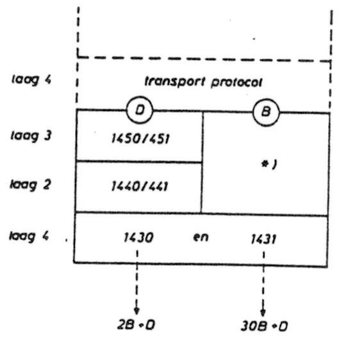


Figure A.3.3.
B- and D-channels standardization

* It is not yet defined.

The D-channel protocol:

User-network signalling must support the establishment of all types of connection required for transfer of information between users. It must also support supplementary services, including user-to-user signalling as an additional means of information transfer between users.

The D-channel protocol is structured into layers:
- The physical layer (layer 1) of the user-network interface is defined at the S or T interfaces.
- The data link layer (layer 2) provides of transmission of frames between two entities on each side of the S or T interfaces.
- The network layer (layer 3) assures control and supervision of calls.

Access capability:
It is the subset of the interface structure actually available for traffic. Thus, for the 2B + D structure, the access capabilities are D, B + D and 2B + D. Any shortfall between the access capability made available to a user and the maximum capability of the interface structure may be due to the commercial reasons (e.g. restrictions due to the line transmission system or to public switch design).

Basic user-network interface:

Located at the S and T reference points, the basic access interface (2B + D) is sometimes called the S terminal interface, the S/T interface and the passive bus interface (Figure A.3.4).

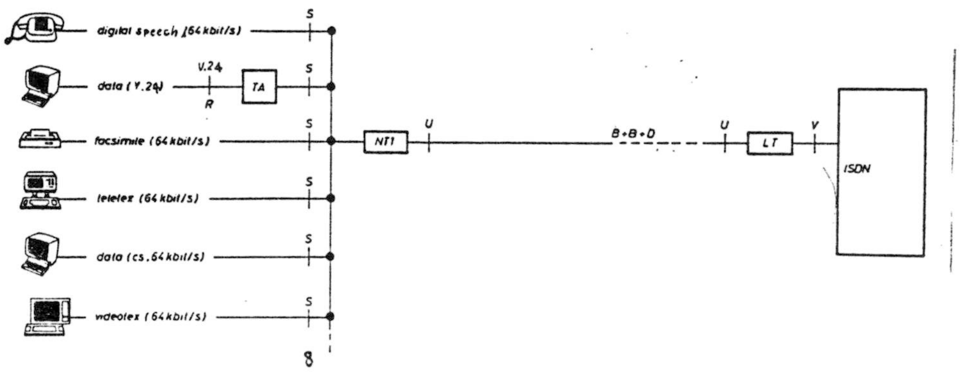


Figure A.3.4
Basic access interface

The physical level functions of the interface are defined in I.430 and is valid for B-channel as well as D-channel.
The main characteristics are :

- The interface has multipoint capability.
  It exists in a point-to-point configuration (Only one terminal is connected at the S/T interface) and in multidrop passive bus configurations involving up to 8 S-interface terminals.
- The physical transmission medium consists of a symmetrical pair for each of the two directions of transmission, plus two optional pairs for power feeding. each pair is terminated at each end by 100 (± 5%) ohms resistance. The phantom circuit of the two transmission pairs can be used to feed power to terminals from the NT2 or NT1 (40 V source with minimal output of 1 W).
- The line rate in each direction of transmission is 192 kbps, of which 144 kbps are assigned to the user channels (2B + D) and the remainder to interface management functions such as:
  * frame synchronization
  * activation and deactivation, so terminals can be placed in a low power- consumption mode when no calls are in progress.
  * use of the D-echo channel to resolve access conflicts on the D-channel (a shared resource for all terminals connected to the interface).
- Transmission employes a pseudoternary code in which binary 1 is represented by no signal and binary 0 by alternatively positive and negative pulses.
- Each terminal is connected to a bus by an ISO standard connector.

The data link layer for D-channel (I.440/I.441):
The Link Access Protocol on the D-channel (LAPD) provides for secure transmission of frames between equipment with layer 2 functions (TEs, TAs, NT2s and exchanges). These functions consist of:

- Link synchronization, for which frames are delimited by flags.

- Transparent transfer of information
- Detection of transmission errors by generation and analysis of a Frame Sequence Error (FCS)
- Error recovery by repeat transmission or errored frames
- Verification of frame formatting
- Numbering of information frames
- Flow control

These functions are specified in conformity with the principles of HDLC as defined by ISO.
The specific points to LAPD are:
- Supervision of data link status by periodic transmission of supervisory frames
- Use of a Service Access Point Identifier (SAPI) to identify the type of information carried by each frame (signalling, packet mode information or management information)
- Use of a Terminal Endpoint Identifier (TEI) to identify the terminal entity concerned by a frame

The network layer for D-channel (I.450/I.451):
The network layer functions for call control in the circuit mode involve:
- Layer 3 message handling
- Management of the resources assigned to a call
- Timer management
- Fault detection

Dialoguing between the user and network for call control purposes is by means of variable-length messages. For a circuit mode call in a B-channel these messages are exchanged before the B-channel connection is established. Several types of messages have been specified (table 1), each determining an action on the user or network side. Each message contains information elements, usually of variable lengths, that define the type of request, the resources to be reserved or the result of a processing operation.

NAME	DEFINITION
CALL ESTABLISHMENT MESSAGES	
ALERTING	RECEPTION OF A SETUP MESSAGE
CALL PROCEEDING (CALL PROC)	CALL ESTABLISHMENT HAS BEGUN AND NO MORE INFORMATION IS NEEDED
CONNECT (CONN)	CALL ACCEPTANCE BY CALLED USER
CONNECT ACKNOWLEDGE (CONN ACK)	RECEIPT OF CONNECT MESSAGE
SETUP	BEGIN CALL ESTABLISHMENT
CALL DISESTABLISHMENT MESSAGES	
DISCONNECT (DISC)	INVITATION TO RELEASE A CHANNEL AND ALL ASSOCIATED CALL-REFERENCE VALUES
RELEASE (REL)	SENDING SIDE HAS RELEASED A CHANNEL AND ALL ASSOCIATED CALL REFERENCE VALUES; SENDING SIDE SHOULD DO THE SAME IF IT HAS NOT ALREADY DONE SO
RELEASE COMPLETE (REL COM)	SENDING SIDE HAS RELEASED A CHANNEL AND CONSIDERS THAT CHANNEL TO BE READY FOR REUSE

Table 1
ISDN Network-layer messages

Control of circuit switched calls:

Figure A.3.5. is an example of procedures for setting up and releasing a circuit call between two ISDN terminals.

a. Outgoing call
   Terminal A sends a SET UP message, with en bloc addressing. Service indications and addresses in this message determine the functions to be performed in the network and allow the right terminal to be selected on the called subscriber premises.
b. Incoming call
   If the terminal B is free, it can answered the call and sends the necessary messages back to the network.

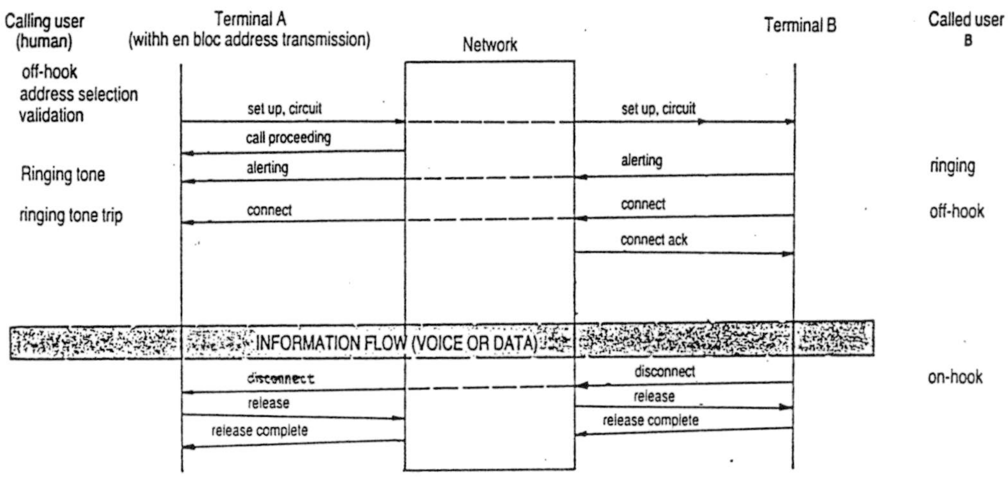


Figure A.3.5
Call control procedures for a circuit switched call

A.4 Maintenance principles

Maintenance of ISDN access line and of each subscriber installation (SI) is based on the subscriber connection reference configuration in figure A.3.2. This reference configuration is applicable to both basic and primary rate access lines. Maintenance relies on functions in the SI, network or supplied by a maintenance service provider (MSP).

Maintenance of access lines up to the T reference point is the responsibility of the network provider. MSPs may be public or private (when private they are connected to the network in the same way as other subscriber).

Maintenance of access line:

Subscriber access line maintenance uses fault detection, identification and localisation mechanism that supervise operation of the access line and facilitate fault elimination by maintenance staff.

Fault detection:
Faults affecting an ISDN access line are detected by supervisory mechanism in the line's various functional groupings. At layer 1, the quality of transmission can be permanently monitored while detected faults include power supply and power feeding faults, absence of signals, loss of synchronization and excessive error rates. At layer 2 and 3, faults are detected by the exchange termination (ET) through its mechanism for D-channel protocol supervision. In addition, the continuity of non-active basic access lines is periodically checked by the local exchange sending activation and deactivation signals.

Identification of faulted entity:
Detection of a fault starts a time delay or repeat transmission process. If the problem persists, the maintenance entity confirms the fault and makes the access line unavailable. When all call related resources have been released, the maintenance entity identifies the fault entity. Physical loopbacks in the ET, LT and NT1 determine whether the fault lies in the local exchange, the line or the SI.

Fault localization:
Once the faulted entity has been identified and the fault notified to maintenance personnel, additional tests are run to more precisely localize the fault. The purpose of this test is to identify a single plug-in element when the fault entity is the local exchange or the NT1, or to evaluate the distance between the local exchange and the fault when the faulted entity is the transmission line. The tests are usually initiated by maintenance personnel.

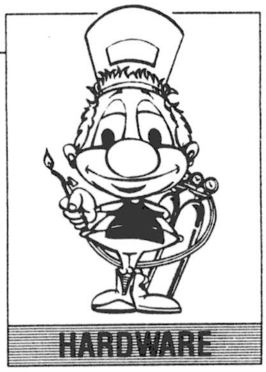
Maintenance of subscriber installation:

Maintenance is assured locally by supervisory and test devices in terminals, terminal adaptors, and NT2; and also by tests remotely controlled by a MSP responsible for maintenance of all or part of the SI.

Level 1 supervision:
Supervision of SI level 1 functions in the SI mainly concerns power supply, distribution and level 1 conformity. Certain level 1 faults can be detected using the D-echo channel. The NT2 can verify level 1 continuity by sending activation and deactivation signals through the S-interfaces.

Internal tests:
Operation of terminals, terminal adaptors, and the NT2 can be partly or totally verified by internal self tests started automatically or on request by the user. These internal tests must not disturb the S-interfaces and may be interrupted by an incoming call. Testing by the NT2 must include test calls to a particular terminal. The NT2 must be able to control local loops at its output closed to the S interfaces.

These maintenance aspects are currently specified in principle only. These principles must be completed by the next CCITT recommendations (Blue book).



De Hayes Story deel 1

door Alexander Bausch

Nu de computer een beetje ingeburgerd lijkt te raken, komt er een nieuwe toepassing om de hoek kijken: datacommunicatie via de telefoonlijn. Om met een computer over de normale PTT-telefoonlijn te kunnen communiceren is een "MoDem" nodig. Modem staat voor Modulator- Demodulator. Een modem zet een signaal om van Digitaal naar Analoog en weer terug. Een computer verwerkt nl. alleen digitale informatie. Communicatie via telefoonlijnen kan echter alleen met analoge signalen, vandaar het MoDem.

Een stukje geschiedenis

Nu worden modems al langer toegepast, bijvoorbeeld het telex apparaat wat op 50 baud werkt, of het PTT viditel modem, wat op 1200/75 baud werkt. Dit zijn eenvoudige modems, dwz.: nummer met de hand draaien, wachten op connectie en dan het modem met een schakelaar inschakelen. In de V.S. is men echter al verder. Mede door het feit dat in de V.S. de PTT (Ma Bell, AT&T) geen monopolistische positie inneemt op het gebied van lijn telefonie hebben verschillende onafhankelijke bedrijven modems kunnen ontwikkelen die op de vrije markt verkocht konden worden. In deze omstandigheden is het zgn. "intelligente" modem ontwikkeld. Een intelligent modem kan zelf het nummer kiezen, telefoon aannemen, snelheid kiezen en nog veel meer. Het intelligente-modem werd geboren uit de behoefte om de produktiviteit van geleerden, ingenieurs en programmeurs bij grote zgn. "time-shared" computers op te voeren. Met de automatische kies- en herhalingsfuncties werd aan deze behoefte voldaan. Het eerste modem dat dit boodt was het Intellimodem van Bizcomp. Terwijl hij met zijn studie op Stanford University bezig was, begon Dr. Michael Eaton in 1978 het bedrijf "Bizcomp". Voor eigen gebruik vondt hij toen een apparaat uit, gebaseerd op een microprocessor bestuurd modem, dat automatisch een abonneenummer - ingevoerd van een terminal- koos. Als het nummer bezet was, hing dit apparaat automatisch de lijn op en koos het abonneenummer opnieuw, net zolang totdat de connectie tot stand kwam. Bij een geslaagde connectie liet het apparaat de gebruiker dit d.m.v. een boodschap weten. Uit dit eerste, in 1978 ontwikkelde prototype, kwam na een succesvolle introduktie het model 1030 Intelligent Modem in 1980 op de markt. Op dit model zijn meeste intelligente - of smart modems van vandaag gebaseerd. Het jaar 1983 was voor Bizcomp een belangrijk jaar; Bizcomp kreeg het patent over commandobestuurde modemtechnologie toegewezen. Dit levert het bedrijf een aanzienlijke bron van inkomsten op van de licentierechten van andere fabrikanten. In 1983 kon het dan ook gebeuren dat D.C. Hayes Microcomputer Products, Inc. en Bizcomp een licentie-overeenkomst tekenden, die Bizcomp maar liefst 2.5 miljoen U.S. dollars opleverden. Het Hayes Smartmodem is sindsdien snel uitgegroeid tot een pseudo standaard, de Hayes standaard.

De voordelen van intelligente modems

Allemaal heel mooi en aardig, maar wat zijn nu eigenlijk de voordelen van zo'n intelligent modem? Is het niet makkelijker met de hand een nummer te kiezen, en dan de verbinding tot stand te brengen? Om daar een adequaat antwoord op te geven, zullen we eerst naar een paar belangrijke commando's uit de AT commando-set kijken.

- AT - Elk commando begint met de AT string. Zodra het modem dit ziet, interpreteerd het modem dit als commando.
  AT staat voor ATtentie! commando.
- D - Dial. Kies het nummer.
- P - Gebruik Pulse (Kiesschijf) kiezen.
- T - Gebruik Tone (Toon) kiezen.
- W - Wacht op de kiestoon.
- , - of , - 2 seconde pause tijdens kiezen

Het commando dat nodig is om een modem een nummer te laten kiezen zou er dan als volgt uit moeten zien:

AT D P W 020-4220332

En zo zijn er nog een hele reeks commando's. De voordelen van zo'n intelligent modem zijn duidelijk. U kunt nu vanuit uw PC het modem zo aansturen zoals u dat wilt. Met behulp van de computer kan nu gebeld worden, net zolang totdat de connectie tot stand komt. Voor diegene de het pakket kennen: SideKick biedt deze mogelijkheid met haar dialer optie. Het modem kan tevens op eenvoudige wijze in auto answer mode worden gezet. Met de iets geavanceerdere modems zoals het CTS modem die biedt kan men zelfs telefoonnummers in het modem zelf bewaren. Het CTS 2424 adh modem beschikt nl. over een zgn. 'non volatile memory'. Non volatile memory is een Read/Write geheugen chip waar gegevens in weg geschreven kunnen worden, zonder dat deze verloren gaan wanneer het modem wordt uit gezet.
Midden- en kleinbedrijf kunnen met behulp van zo'n low cost intelligent modem en een personal computer hun eigen publiek of gesloten electronisch informatie systeem opzetten. De software die hiervoor gebruikt wordt is onder vele titels verkrijgbaar in de winkel, maar ook in de public domain softwarewereld zijn goede pakketten te vinden. Een electronisch informatie systeem kan 24 uur per dag via de telefoon bereikbaar zijn. Op eenvoudige wijze kunnen berichten aan het bedrijf worden toegespeeld, zonder al te veel kosten. Het enige wat men nodig heeft is een extra telefoonlijn, een modem, een computer en de software.
Bizcomp en INFO 80 BV. ontwierpen een nieuwe Europese AT commando set, die upwards compatible is met de oude set. Software problemen worden zo vermeden. De verschillen tussen de amerikaanse en de europese standaard zijn nl. zodanig, dat de originele AT commandoset voor de Europese PTT's niet acceptable is. Daarom is er een nieuwe set ontworpen die voldoet aan de CCITT en europese PTT normen. Natuurlijk staat de ontwikkeling niet stil. Zo heeft Bizcomp een unieke optie ontwikkeld: voice insert. Het wordt dan mogelijk om gelijktijdig te spreken en communiceren. Ook wordt hard gewerkt aan integratie van het nieuwe M.N.P. error correcting protocol. Met deze optie is 100% foutvrije communicatie en compressie mogelijk.
De AT commando set is in de VS al jaren de defacto standaard voor autodial modems. Hayes heeft hier voor gezorgd, vandaar de naam "Hayes compatible". Bizcomp staat, als kleine ontwikkelings BV. op de achtergrond en houdt het patent. Gezien het feit dat de meeste standaard software voor het Hayes compatible modem zijn geschreven, zal deze standaard ook in Europa wortel schieten, zij het dan in een gewijzigde vorm. Comnet/INFO 80 zal hier verandering in brengen. De Nieuwe modellen 4122 PC en 4122 SA (PC Card modem en Stand alone v.21, v.22 en v.22bis) zijn van het bewijs.

CCITT V-normen

Om op internationaal niveau tot een efficientere samenwerkingsvorm te komen, zijn de administraties van de gezamelijke nationale telecommunicatie-netwerken georganiseerd in de overkoepelende en coordinerende internationale organisatie voor telecommunicatie, de I.T.U. (International Telecommunication Union). De I.T.U., die verenigd is in de U.N.O. (United Nations Organisation), heeft haar zetel in Genève. De CCITT (International Consultative Committee for Telegraphy and Telephony) is een zeer belangrijke afdeling van de I.T.U. die zich bezighoudt met de verschillende facetten van internationale datacommunicatie zoals telegraaftechniek en datatransmissie, telefonie en schakelplantransmissie en laboratoria, onderhoud, bescherming en standaardisatie. De lijst van CCITT aanbevelingen voor open-

De Hayes Story

bare netwerken wordt aangeduid met de V-serie. Momenteel loopt deze serie van 2 t/m 56. We zullen de belangrijkste aanbevelingen nader bekijken.

V21

300 bps symmetrisch full duplex, enkelvoudige frequentiemodulatie. De lijn waarover de gegevens worden verstuurd, is verdeeld in twee gelijke delen van elk 300 baud breed. Doordat er meer dan voldoende reserveruimte in deze bandbreedte is, kan gebruik worden gemaakt van eenvoudige technieken en is dit soort modems zeer goedkoop. Een V21 modem is herkenbaar aan een 'fluittoon'.

V22

1200 bps symmetrisch full duplex, tweevoudige fasemodulatie. Hierbij worden per signaalwisseling twee bits tegelijk verstuurd. Daarmee wordt bereikt dat de splitsing van het 1200 baud kanaal (eigenlijk 1500) in twee gelijke delen van 600 baud toch in beide richtingen tegelijkertijd 1200 bps oplevert. Een V22 modem produceert een 'ruis'.

V22bis

2400 bps symmetrisch full duplex, een combinatie van fasemodulatie en amplitudemodulatie. Hierbij worden per signaalwisseling vier bits tegelijk verstuurd. Dus over een 600 baud kanaal gaan 2400 bps.

V23

1200 bps half duplex of 1200/75 asymmetrisch full duplex, enkelvoudige frequentiemodulatie. In deze CCITT aanbevelingen zijn enkele varianten opgenomen welke verschillen in de manier waarop het "onderste" deel van het kanaal wordt gebruikt. Dat wil zeggen dat bij de 1200 bps half-duplex variant deze in het geheel niet wordt gebruikt en bij de andere genoemde variant de ruimte "onder in" het kanaal wordt gebruikt voor de terminal input.

V24

Een lijst met definities van interchange-circuits tussen Data Terminal Equipment (DTE) en Data Communication Equipment (DCE). Samengevat ziet dat eruit als afgebeeld in figuur 1.

Pen nummers 25-pins connector	Beschrijving	van DCE	naar DCE	
1	Protective ground			Aarde
7	Signal ground			
2	Transmitted data (TXD)		x	Data
3	Received data (RXD)	x		
4	Request to Send (RTS)		x	Besturings en Status-signalen
5	Clear to Send (CTS)	x		
6	Dataset ready (DSR)	x		
8	Data Carrier (DCD)		x	
20	Data Terminal Ready (DTR)		x	
22	Ring Indicator (RI)	x		

afb1

V25 handshake procedure.

Definitie: automatisch oproepen en/of beantwoorden in het openbare telefoonnetwerk, inclusief het buiten werking stellen van echo onderdrukkers (2100 Hz) voor de met de hand tot stand gebrachte oproepen. Deze V25 handshake procedure is zeer belangrijk, met name voor de V22 modems. Het onderscheidt de CCITT V22 modems van de Amerikaanse Bell 212 modems. De werking van de V25 handshake is als volgt:

V25bis protocol is te vergelijken met de Hayes AT-commando-set voor de aansturing van automatische modems. Uit de aanduiding van de toegepaste modulatiemethoden voor de hierboven genoemde V-serie aanbevelingen, zal het U waarschijnlijk duidelijk zijn waarom een sneller modem ook (meestal) duurder is. Helaas is er in dit artikel geen ruimte voor een uitvoerige uitleg van de modulatiemethoden, maar daarvoor verwijs ik graag naar het boek Datacommunicatie met Local Area Network door P.C. de Heijer en R. Tolsma.

Duplex communicatie

De grote verwarring binnen deze aanbevelingen is toch wel de V23 norm. Een jaar of acht geleden kwam deze standaard in Europa sterk op als goedkope oplossing voor Viewtext databanken. V23 maakt gebruik van eenvoudiger modulatietechnieken dan V22 en was daarom goedkoper. Daar, zeker in het geval van bulletinboards en raadpleging van databanken, de output (naar de terminal) meestal veel groter is dan de input, was een asymmetrische verbinding zoals die bij V23 wordt gebruikt, inderdaad zo gek nog niet. V23 brengt echter tenminste drie praktische problemen met zich mee: 1. Populaire softwareprogramma's functioneerden in den beginne (en vaak nu nog) niet met de Europese V23 modems. De in de V.S. tot standaard verheven Hayes AT-commandoset werd namelijk pas zeer laat voor V23 geïmplementeerd. Waarschijnlijk omdat V23 en Viewdata systemen een typisch Europese aangelegenheid zijn. 2. De IBM PC met standaard 'aynchronous communications adapter' kan deze 'split-speed' niet aan. 3. Wanneer de aard van de applicatie anders is, zoals bij veel input in het geval van filetransfer, dan is 75 bps verre van ideaal.

In een 'half duplex' applicatie geschiedt de informatie-uitwisseling tussen twee stations niet tegelijkertijd. Dit houdt in dat op elk willekeurig tijdstip altijd maar 1 station bezig is met informatie over te dragen. De stations (A&B) bevinden zich dus afwisselend in de 'zend' (originate) en 'ontvang' (answer) toestand. Deze techniek leent zich uitstekend voor zgn. 'inquiry' systemen zoals Viditel. Immers, de output (naar de terminal) is meestal veel groter dan de input.

A* ←——————→ *B

Een respeeder in een modem levert de mogelijkheid om de PC een andere dan de werkelijke lijnsnelheid te laten 'voelen'. Deze faciliteit is met name interessant om het 75 bps kanaal voor de PC op te voeren tot 1200 bps, zodat de PC op 1200 bps full duplex kan werken. Wat er op de lijn gebeurt, blijft onveranderd, de effectieve transmissiesnelheid blijft 75 bps !!

Communicatie met een 1200 bps V22 full duplex modem aan de andere (host)zijde is niet mogelijk!

Het voordeel van full duplex-ommunicatie (V21, V22 en V22bis) is dat zenden en ontvangen tegelijkertijd kunnen plaatsvinden. De drie praktische problemen zoals die voor V23 gelden, zijn hier dan ook niet van toepassing. Bij full duplexsystemen is overdracht van informatie mogelijk in beide richtingen tegelijkertijd. Er behoeft in dit geval niet op elkaar te worden gewacht daar in beide richtingen tegelijkertijd gegevensoverdracht kan plaatsvinden. Deze techniek wordt steeds meer toegepast bij computersystemen en bulletinboardsystemen bij het uitwisselen van gegevens.

```
——————————————→
A              B
←——————————————
```

De wijze waarop de transportsnelheid wordt uitgedrukt, geeft nogal eens aanleiding tot misverstanden. Vandaar dat er precies moet worden gespecificeerd over welke sneldheid er gesproken wordt. Globaal kan worden gesteld dat er drie manieren zijn om snelheid uit te drukken, namelijk: - Baud (modulatiesnelheid aangeduid met Bd) - Bits per Seconde(signaleringssnelheid aangeduid met Bps) - Karakters per seconde (aangeduid met Kps) ■

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(wordt vervolgd).

```
   telefoonlijn          rs232              cpu
               +-------+         +----------+   +-------------+
-------/\/\----+ modem +---------+ computer +---+ toetsenbord :
               +-------+         +----------+   +-------------+

     Baud                 Bps                Kps
```

De Hayes Story *deel 2*

door Alexander Bausch

In de Hayes Story deel I zagen we wie het intelligente modem uitgevonden heeft, wat de voordelen van zo'n modem zijn en wat de CCITT V-normen voorstellen. In dit deel zullen we de commandoset en de registerinstellingen bekijken.

AT-commandostructuur

Elk commando wordt vooraf gegaan door de 'AT'-string. Iedere keer als de AT-string door het modem wordt ontvangen (als het modem in commandotoestand staat), detecteert het modem de baudsnelheid en past het zich automatisch aan de snelheid en pariteitsinstellingen van de computer aan. (DTE)
'AT' is de afkorting van ATtention.
Het modem is of in commandotoestand, of in onlinetoestand. Het modem gaat van commando- naar onlinetoestand na:
a) een geslaagde verbinding in zowel autodial- als autoanswertoestand.
b) geforceerd op de lijn te zijn gezet.
Het modem gaat van online- naar commandotoestand indien:
a) de verbinding verbroken wordt.
b) de 'escapestring' is gegeven.

De escapestring

Als u het modem een verbinding hebt laten leggen, dan zal het niet meer luisteren naar eventuele ingevoerde commando's.Het modem verkeert dan in on-linetoestand. Dat is maar goed ook, want als we in een over te seinen tekst de zin
WAT ZAG U OP MIJN SCHERM ?
zouden hebben staan, dan zouden de letters 2, 3, en 4 door het modem als het commando ATZ worden opgevat en dat zou betekenen dat het modem de verbinding meteen verbreekt ! Betekent dat dan dat we de verbinding alleen nog kunnen verbreken door het modem uit te schakelen? Gelukkig niet! Het modem reageert wel degelijk nog op een commando, maar dat is een commando dat uit een vrijwel niet voorkomende combinatie bestaat. Het is het enige commando waarop wordt gereageerd en bovendien, mocht het commando toch nog in bepaalde gevallen ongelukkig zijn gekozen, dan kunt U het zonder meer wijzigen! We noemen dit commando de escapestring. Na deze string luistert het modem weer naar de AT-commando's. Deze string ziet er als volgt uit:
˜ +++ ˜

Hierin geeft ˜ een seconde pauze aan. Wordt er dus gedurende minimaal 1 seconde geen signaal gedetecteerd en daarna drie plustekens ontvangen, waarna tenminste 1 seconde weer geen informatie wordt overgedragen, dangaat hetmodem weer naar de AT-commandoset luisteren.

Overzicht van de commando's

1. DIALING: Het kiezen van een nummer.

D cijfers 0-9
subcommando's:
P Pulse kiezen. (draaischijf)
T Touch Tone kiezen.
, Dialing pauze, 2 seconde.
; Terug naar COMMANDOTOESTAND na dialing
R Wordt gebruikt bij het bellen van originate-only modems.
W Wacht op kiestoon.
@ Wacht op 'stil antwoord'. (5 sec. stilte na ringdetect).
! 'Flash'. (1/2 sec. hoorn op de haak)
AT d p w 0 , 04750 , 15492 @
Het apestaartje @ wordt op plaatsen gebruikt waar het afscannen van de verschillende baudrates veel tijd in beslag neemt. Logt u in op een bulletinboard dat wel erg lang doet over hetscannen van de verschillende baudrates, dan kan het gebeuren dat het modem meldt dat het geen carrier kan ontdekken en de verbinding verbreekt voordat er van enige communicatie sprake kon zijn. Vooral de HCC FIDO-nodes hadden hier nogal eens last van. Met een apestaartje achter het nummer wacht het modem de stilte af, net zolang tot het de carrier tegenkomt.

A/ Voert het laatst uitgevoerde commando nogmaals uit.

2. ANSWERING: Automatisch beantwoorden van gesprekken.
A Handmatig een binnenkomend gesprek beantwoorden.

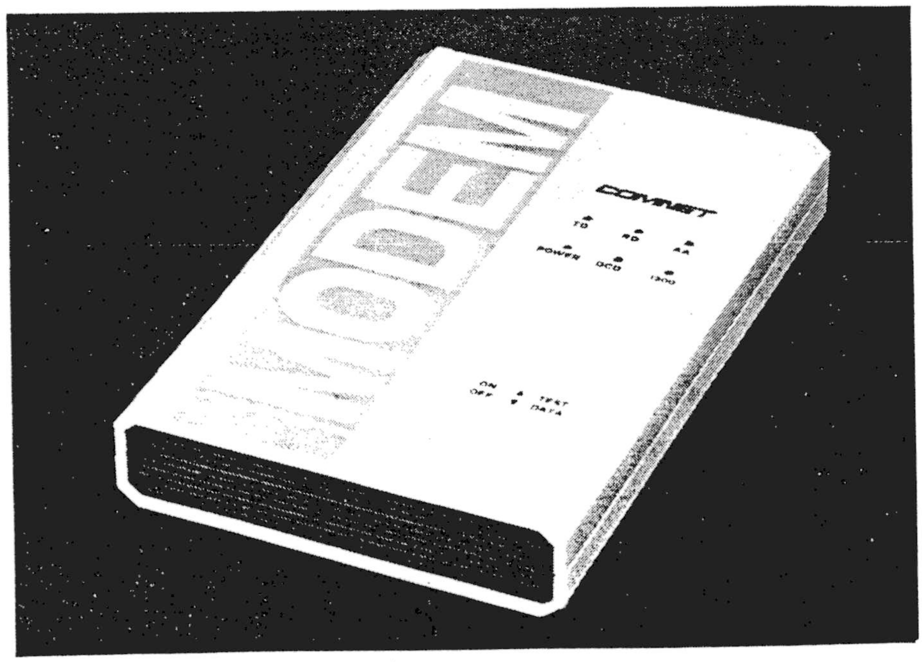
N.B. Het modem wordt niet met ATA in autoanswertoestand gezet. Er is het modem namelijk nog niet gezegd na hoeveel rings (S0) het de telefoon moet aannemen. Men kan dus stellen dat het modem met het commando AT S0 1 in autoanswer toestand wordt gezet.

3. Modemminstellingen:

-C	C0	Forceert het DCD signaal op V24 interface (PIN 8) UIT.
	C1	Forceert het DCD signaal op V24 interface (PIN 8) AAN.

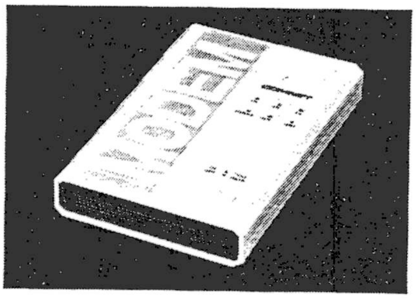
Sommige communicatie programma's zoals X-talk, Mirroren MITE (FRAMEWORK) werken nauw samen met het DCD-signaal op pin 8. Deze programma's kijken naar de status van pin 8. Als de carrier weg is en pin 8 laag, gaat het programma naar 'off-line' toestand. Zodra pin 8 hoog gaat, kan de gebruiker naar terminalmodus gaan, tenzij DCD wordt geforceerd met C1.

-E	E0	Alle commando's die U intikt worden NIET geecho'd.
	E1	Echo AAN.
-F	F0	Half duplex (Online lokale echo aan)
	F1	Full duplex
-H	H0	Modem op de haak. (ophangen)
	H1	Modem van de haak. (bezet)
-M	M0	Modem speaker uit.
	M1	Speaker aan totdat er een carrier wordt gedetecteerd.
	M2	Speaker altijd aan.



De Hayes Story

-I	0	Geeft produkt code door aan DTE
	1	Geeft produkt checksum aan DTE
	2	Geeft produkt checksum aan DTE
	3	Geeft produkt id code (bij-voor-beeld COMNET 3012 SA v.3.2)
-L	L0-L3	regelt het volume van de audiospeaker.
-O		Keert terug naar online-toestand.
-Q	Q0	Modem stuurt resultaatcodes naar de DTE.
	Q1	Modem stuurt geen restultaatcodes naar de DTE.
-Sr?		Leest de waarde van register r. (Zie registers)
-Sr=n		Zet register r gelijk aan de waarde n
-V	V0	Resultaatcodes zijn cijfers.
	V1	Resultaatcodes zijn Engelse woorden.
-Xn		Inschakelen uitgebreide resultaatcodeset.
X0		Het modem meldt "CONNECT" wanneer een carrier wordt ontdekt, ongeacht de snelheid: 300 of 1200 of 2400 baud.
X1		Het modem meldt "CONNECT" op 300 baud, "CONNECT 1200" op 1200 baud en "CONNECT 2400" op 2400 baud.
X2		als X1, bovendien wacht het modem op de kiestoon voordat het nummer wordt gekozen. Wordt binnen 4 seconden geen kiestoon gedetecteerd, dan wordt de melding "NO DIALTONE" gegeven. In gesprek wordt niet herkend.
X3		als X1, bovendien kiest het modem blind, dus zonder op een kiestoon te wachten. Wordt het in-gespreksignaal gedetecteerd, dan wordt "BUSY" gemeld.
X4		als X1, bovendien wacht het modem op de kiestoon voordat het nummer wordt gekozen. Wordt binnen 40 seconden geen kiestoon gedetecteerd, dan wordt "NO DIALTONE" gemeld. Wordt het in-gespreksignaal gedetecteerd, dan wordt "BUSY" gemeld. Indien de 'handshaking' (V25) niet succesvol verliep, komt het modem met de melding "NO CARRIER"



Het modem heeft ook een aantal registers. Deze kunt u voorzien van verschillende waarden. De registers worden voor het overgrote deel gebruikt om bepaalde waarden groter of kleiner te maken. Zo kan met de registerinstellingen het aantal belsignalen waarna een modem de telefoon moet opnemen (S0) worden ingesteld, de tijdsduur hoe lang een modem op kiestoon moet wachten, en nog veel meer. De nieuwe en meer geavanceerde modems beschikken over 'non volatile memory'. In deze modems kunnen registerinstellingen blijvend worden bewaard.Dit is ideaal, want op deze manier zijn dipswitches overbodig, en kunnen de modems op veel meer parameters vast worden ingesteld dan met een dipswitchblok (8-9). Het TS 2424 modem beschikt over zo'n non volatile memory.

Registers die te maken hebben met DIALING.

S6
Functie: Bepaalt hoe lang het modem op de kiestoon moet wachten. Parameters: 2-255 seconde Defaultwaarde: 2 Bereik: 1 t/m 255 Dit register bepaalt hoe lang het modem moet wachten op de kiestoon nadat de hoorn van de haak is genomen en voordat het abonneenummer wordt gedraaid. De minimumtijd is 1 seconde.

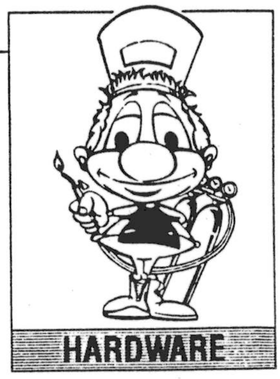
S8
Functie: Bepaalt de pauzeduur voor het pauzeteken ',' (komma) Parameters 0-255 seconde Defaultwaarde: 2 Bereik: 0 t/m 255 De komma wordt gebruikt als pauzeteken in het abonneenummer. (Bijvoorbeeld bij het kiezen van een nummer in een huiscentrale). Normaliter is een pauze van 2 seconden voldoende. Meerdere komma's achter elkaar kunnen worden gebruikt om de pauze te verlengen.

S11
Functie: Bepaalt de snelheid bij het toonkiezen. Parameters: 50-255 milliseconde Defaultwaarde: 70 Bereik: 50 t/m 255

Registers die te maken hebben met ANSWERING .

S0
Functie: Bepaalt het aantal belsignalen waarna moet worden opgenomen. Parameters: 0-255 rings Defaultwaarde: 0 Bereik: 0 t/m 255 Door een waarde van 1 t/m 255 toe te kennen aan dit register, wordt het modem in auto-answermodus geplaatst. S00 zet deze autoanswermodus uit. Het modem zal niet antwoorden op een binnenkomend belsignaal.

S1
Functie: Telt het aantal belsignalen. Parameters: 0-255 rings Defaultwaarde: 0 Bereik: 0 t/m 255 Register S1 wordt iedere keer wanneer er een belsignaal wordt geregistreerd, met 1 verhoogd. Voor de meeste applicaties zult U niets met dit register hoeven te doen, maar het kan gelezen of ingesteld worden.



Registers die te maken hebben met zowel DIALING als ANSWERING

S7
Functie: De tijd dat het modem wacht op een carrier nadat er gekozen of geantwoord is. Parameters: 1-255 seconde Defaultwaarde: 30 Bereik: 1 t/m 255 Nadat gekozen of geantwoord is, wacht het modem S7 seconden op de carrier. Als het modem het carriersignaal niet binnen S7 seconden detecteert, verbreekt het de verbinding en geeft de resultaatcode "NO CARRIER" waarna het terugkeert naar de commandomodus.

S9
nctie: Carrier detectie response tijd. rarameters: 1-255 (1/10 seconde) Defaultwaarde: 6 Bereik: 1 t/m 255 De carrierdetectie responsetijd is de duur dat een carrier aanwezig moet zijn, voordat het modem het als zodanig herkent.

S10
Functie: Bepaalt de tijd tussen het verlies van de carrier en het verbreken van de verbinding. Parameter: 1-255 (1/10 seconde) Defaultwaarde: 2 Bereik: 1 t/m 255

De vertragingstijd tussen het verlies van de carrier en het verbreken van de verbinding maakt het mogelijk een korte pauze in te voegen zonder dat de verbinding wordt verbroken. Wanneer S10 255, zal het modem de carrier negeren en zal het functioneren alsof de carrier doorlopend aanwezig is.

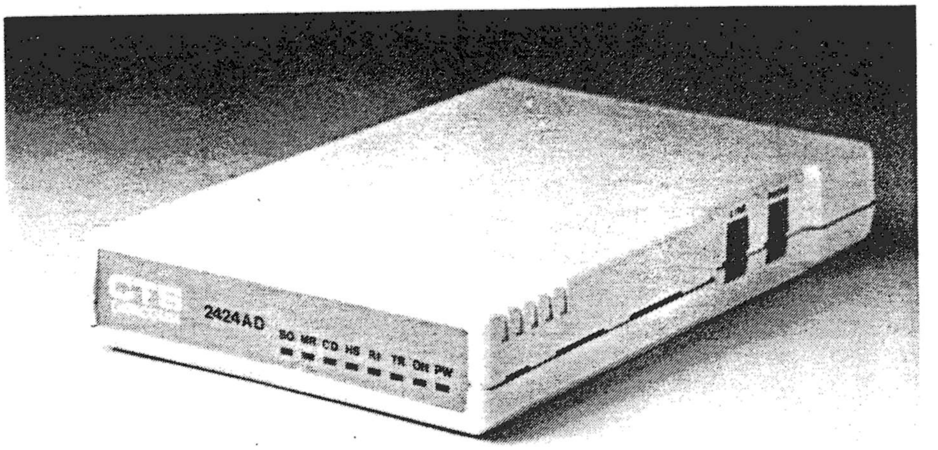
Registers die te maken hebben met KARAKTERDEFINITIE

S2
Functie: Bepaalt de waarde van de ESC-ode. Parameter: 0-127 (ASCII) Defaultwaarde: 43 Bereik: 1 t/m 127 S2 > 127 schakelt de ESC-code uit. De defaultwaarde voor S2 43. Dit is een ASCII "+". S2 kan op elke waarde van 0 t/m 255 worden ingesteld. Waarden groter dan ASCII 127 stellen de ESC-code buiten werking en garanderen een geheel transparante verzending van gegevens. Door de ESC-code buiten werking te stellen, wordt voorkomen dat de gebruiker per ongeluk het verzenden van gegevens afbreekt.

S3
Functie: Bepaalt de waarde van de Carriage Return. (CR) Parameter: 0-127 (ASCII) Defaultwaarde: 13 Bereik: 0 t/m 127 Normaliter is de ASCII waarde voor Carriage Return 13. Wanneer U apparatuur hebt waarbij dat niet standaard is, kunt U de waarde voor de Carriage Return code veranderen.

S4
Functie: Bepaalt de waarde van de line feed. (LF) Defaultwaarde: 10 Bereik: 1 t/m 127 Parameter: 0-127 (ASCII) De waarde voor de Linefeed wordt alleen in het Engels weergegeven. indien U geen linefeed wenst, kun U deze waarde veranderen in de "nul"-code.

S5
Functie: Bepaalt de waarde van de backspace. (BS) Parameter: 0-32 or 127 (ASCII) Defaultwaarde: 8 Bereik: 1 t/m 127 Dit is de terug-tik-toets, (backspace) die



gebruikt wordt om de cursor een positie terug te zetten en in de commandobuffer een positie te wissen. De backspacetoets wist niet de AT (attentie)-code. (Omdat AT geen ruimte in de commando buffer in beslag neemt)

Registers die SPECIALE FUNCTIES hebben.

S12
Functie:Bepaalt de tijd waarmee de escapekarakters omsloten worden. Parameters: 0-255 (1/50 seconde) Defaultwaarde: 50 Bereik: 20 t/m 255 Dit is de tijd tussen de laatste datakarakters en de eerste escapekarakters. Zie: XXXX ˜+++˜ XXXX. "˜ " is de escapecode wachttijd.

S13 - S15 (bit mapped)
S16 (bit mapped)

Functie: Testregister waarden.
Parameters:
- 0 normaal bedrijf
- 1 analoge online loopbacktest
- 2 dtmf toontest
- 4 digitale loopbacktest

S17 (bit mapped)
Functie: Testregister waarden.
Parameters:
- 0 volumebesturing bit 0 (ALCO)
- 1 volumebesturing bit 1 (ALC1)
- 2 0 - kiestoondetectie uitgeschakeld
  - 1 - kiestoondetectie ingeschakeld
- 3 0 - bezettoondetectie uitgeschakeld
  - 1 - bezettoondetectie ingeschakeld
- 4 0 - hoge transmissiesnelheid
  - 1 - lage transmissiesnelheid
- 5 0 - Pulsekiezen
  - 1 - Dubbeltoonkiezen
- 6 1 - Speaker ingeschakeld tot de carrier
- 7 1 - Speaker doorlopend ingeschakeld

-&C	0	Forceer het DCD signaal (Pin 8) hoog.
	1	Laat het DCD signaal alleen dan hoog gaan indien er daadwerkelijk een carrier wordt gedetecteerd.
-&D	0	Forceer het DTR signaal (Pin 20) hoog.
	1	Ga terug naar commando toestand na het verliezen van het DTR signaal.
	2	Ga terug naar commando toestand na het verliezen van het DTR signaal en geen autoanswer.
	3	Ga terug naar de fabrieks-instellingen na het verliezen van het DTR-signaal.
-&G	0	Geen guard toon
	1	550 Hz guard toon
	2	1800 Hz guard toon
-&L	0	Telefoon lijnen
	1	Gehuurde lijnen
-&W		Schrijf de instellingen weg naar non volatile memory.
-&F		Terug naar fabrieksinstellingen.
-&Zn		Schrijf telefoonnummer (n) naar non volatile memory.

Met dank aan: Rob Hamerling, Sysop PC Square, Ruud Paap, INFO 80 BV, DATA-COMMUNICATIE met Local Area Network door P.C. de Heijer en R. Tolsma. ■

Alexander Bausch

Appendix C

The examples of the Hayes smart modems

C.1 Smartlink 1200S (Modem A)

C.1.1 Summary of Commands

COMMAND	DESCRIPTION
AT	Command line prefix
A/	Automatically re-execute the last command. Neither preceded by AT nor followed by RETURN
A	Manually answer incoming call
B	B0 CCITT V.21/V.22 protocol B1 BELL 103/212A protocol
C	C0 = Transmitter off C1 = Transmitter on (default)
D	Digits: 0–9 Symbols: Meaningful: # and * Meaningless: ( ) – and . Dial Modifiers: P Pulse Dialing T Touch-Tone Dialing / Pause 1/8 sec , Pause when dialing (2 second by default) ; Return to command state after dialing R Calling an originate—only modem ! Initiate a flash W Wait for dial Tone @ Wait for quiet answer Default: DP
E	E0 = Do not echo command E1 = Echo command (default)
F	F0 = Half-duplex – echo data F1 = Full-duplex – do not echo data (default)
H	H0 = Modem on-hook (hang up) H1 = Modem off-hook
I	I0 = Request product ID Code (130) I1 = Request firmware revision number
L	L1 = Speaker Volume low L2 = Speaker Volume medium (default) L3 = Speaker Volume high
M	M0 = Speaker off M1 = Speaker on until carrier detected (default) M2 = Speaker always on
O	O0 = Go to on-line state O1 = Remote digital loopback off (default) O2 = Remote digital loopback request
Q	Q0 = Send result codes (default) Q1 = Do not send result codes
Sr?	Read value in Register r (r=0....16)
Sr=n	Set Register r to value n (r=0....16; n=0....255)
V	V0 = Send single digit result codes V1 = Send word result codes (default)
X	X0 = Basic result code set (default) X1 = First extended result code set X2 = Second extended result code set(NO DIALTONE) X3 = Third extended result code set (BUSY) X4 = Fourth extended result code set (NO DIALTONE & BUSY)
Y	Y0 = Long space disconnect disabled (default) Y1 = Long space disconnect enabled
Z	Reset SmartLink Modem to default configuration
+++	Go from on-line state to command state

C.1.2 Result codes

DIGIT CODE	WORD CODE	DESCRIPTION
0	OK	Command line executed without errors
1	CONNECT	Carrier detected at 300 or 1200 bps
2	RING	Ringing signal detected
3	NO CARRIER	Carrier lost or never detected
4	ERROR	Error in command line Invalid command (not recognized by the SmartLink) Invalid character format at 1200 bps
5	CONNECT 1200	Carrier detected at 1200 bps
6	NO DIALTONE	The W dial modifier is issued and a dial tone is not detected within the period specified by S7 (30 seconds by default), or the X2 or X4 condition is selected and a dial tone is not detected within 5 seconds after going off-hook.
7	BUSY	Busy signal detected
8	NO ANSWER	The "wait for quiet answer" dial modifier @ issued and silence not detected

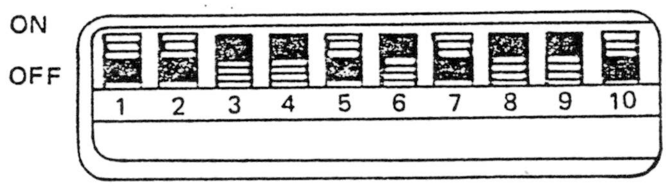
C.1.3 Summary of S Registers

REGISTER	PARAMETERS	FUNCTION	DEFAULT
S0	0-255 (rings)	Number of rings before auto-answer	0 rings
S1	0-255 (rings)	Count number of incoming rings	0 rings
S2	0-127 (ASCII)	Value of escape character	43 ASCII(+)
S3	0-127 (ASCII)	Value of carriage return character	13 ASCII (CTRL M)
S4	0-127 (ASCII)	Value of line feed character	10 ASCII (CTRL J)
S5	0-32 or 127 (ASCII)	Value of backspace character	8 ASCII (CTRL H)
S6	2-255 (seconds)	Wait for dial tone	2 seconds
S7	1-255 (seconds)	Wait time for remote carrier after dialing or answering	30 seconds
S8	0-255 (seconds)	Pause time for comma	2 seconds
S9	1-255 (1/10 second)	Carrier Detect response time	6 (600 milliseconds or 0.6 seconds)
S10	1-255 (1/10 second)	Delay time between loss of remote carrier and hang up	7 (700 milliseconds or 0.7 seconds)
S11	50-255 (milliseconds)	Duration and spacing of touch-tones	70 milli-seconds
S12	20-255 (1/50 second)	Guard time for escape characters	50 (1 second)
S13		UART Status register	
S14		Option register	
S15		Flag register	
S16		Put modem in self-test mode	0
	0	(normal operation)	
	1	(analog loopback test)	
	2	(touch-tone test)	
	4	(digital loopback test)	

C.1.4 Summary of DIP Switches

SmartLink 1200S™ Quick Reference Card

SWITCH	POSITION	FUNCTIONS
SW1	ON	DCD status is always On
	OFF	Sends actual DCD status (factory setting)
SW2	ON	Ignores DTR status
	OFF	Monitors DTR status (factory setting)
SW3	ON	Disables auto answer (factory setting)
	OFF	Enables auto answer
SW4	ON	CCITT V.21/V.22 (factory setting)
	OFF	BELL 103/212A
SW5	ON	Result codes sent as digits
	OFF	Result codes sent as words (factory setting)
SW6	ON	Result codes sent (factory setting)
	OFF	Result codes not sent
SW7	ON	Modem does not echo characters in command state
	OFF	Modem echoes characters (factory setting)
SW8	ON	Enables command recognition (factory setting)
	OFF	Disables command recognition
SW9	ON	Selects 33/67 make/break ratio (factory setting)
	OFF	Selects 39/61 make/break ratio
SW10	OFF	Not used



SmartLink 1200S Configuration Switches in their Factory Settings

C.1.5 ASCII Character Table

ASCII VALUE	CONTROL CHARACTER	KEY	ASCII VALUE	KEY	ASCII VALUE	KEY
000	NUL	CTRL-@	043	+	086	V
001	SOH	CTRL-A	044	,	087	W
002	STX	CTRL-B	045	-	088	X
003	ETX	CTRL-C	046	.	089	Y
004	EOT	CTRL-D	047	/	090	Z
005	ENQ	CTRL-E	048	0	091	[
006	ACK	CTRL-F	049	1	092	\
007	BEL	CTRL-G	050	2	093	]
008	BS	CTRL-H	051	3	094	^
009	HT	CTRL-I	052	4	095	_
010	LF	CTRL-J	053	5	096	`
011	VT	CTRL-K	054	6	097	a
012	FF	CTRL-L	055	7	098	b
013	CR	CTRL-M	056	8	099	c
014	SO	CTRL-N	057	9	100	d
015	SI	CTRL-O	058	:	101	e
016	DLE	CTRL-P	059	;	102	f
017	DC1	CTRL-Q	060	<	103	g
018	DC2	CTRL-R	061	=	104	h
019	DC3	CTRL-S	062	>	105	i
020	DC4	CTRL-T	063	?	106	j
021	NAK	CTRL-U	064	@	107	k
022	SYN	CTRL-V	065	A	108	l
023	ETB	CTRL-W	066	B	109	m
024	CAN	CTRL-X	067	C	110	n
025	EM	CTRL-Y	068	D	111	o
026	SUB	CTRL-Z	069	E	112	p
027	ESC	CTRL-[	070	F	113	q
028	FS	CTRL-\	071	G	114	r
029	GS	CTRL-]	072	H	115	s
030	RS	CTRL-↑	073	I	116	t
031	US	CTRL-_	074	J	117	u
032		spacebar	075	K	118	v
033		!	076	L	119	w
034		"	077	M	120	x
035		#	078	N	121	y
036		$	079	O	122	z
037		%	080	P	123	{
038		&	081	Q	124	|
039		'	082	R	125	}
040		(	083	S	126	~
041		)	084	T	127	Delete
042		*	085	U		

C.2 Lightspeed 1200S (Modem B)

C.2.1 Summary of Commands

LIGHTSPEED 1200 Commands

Command	Function
A	Manually answer incoming call.
A/	Repeat last command executed. Do not precede A/ with AT or follow with RETURN.
AT	Appear at the beginning of every command line.
B–	B0 = CCITT V.21/V.22 compatibility B1 = Bell 103/212A compatibility
C–	C0 = Turn off transmitter carrier C1 = Turn on transmitter carrier
D–	0 through 9 # and * P (pulse dialing) R (include at end of Dial command line to call originate-only modem) T (Touch-Tone dialing) W (wait for second dial tone) @ (wait for 5 seconds of silence) , (pause) ! (flash) % (adaptive dialing) ; (return to Command Mode after dialing) / (wait 1/8 of a second)
E–	E0 = Commands are not echoed E1 = Commands are echoed
+++	Switch from Data Mode to Command Mode; pause one second before typing; do not follow with carriage return (see Registers S2 and S12).
F–	F0 = Half-duplex –– echo data F1 = Full-duplex –– do not echo data
G–	G0 = Guard tone disabled G1 = 550 Hz guard tone G2 = 1800 Hz guard tone
H–	H0 = LIGHTSPEED 1200 is on-hook (hung up) H1 = LIGHTSPEED 1200 is off-hook, line and auxiliary relay H2 = LIGHTSPEED 1200 is off-hook, line relay only
I–	I0 = Display product-identification code I1 = Factory test I2 = Internal memory test
L–	L1 = Low speaker volume L2 = Medium speaker volume L3 = Loud speaker volume
M–	M0 = Internal speaker off M1 = Internal speaker on until carrier M2 = Internal speaker always on
O–	O0 = Return to Data Mode O1 = Turn off Remote Digital Loopback Test O2 = Request Remote Digital Loopback
Q–	Q0 = LIGHTSPEED 1200 sends responses Q1 = LIGHTSPEED 1200 does not send responses
?	?0 = Display menu for dialing commands and A to H commands ?1 = Display all commands
Sr?	Read value in register r (r = 0–16)
Sr=n	Set register r to value n (r=0–16; n=0–255)
U–	U0 = Disable data-to-voice detection U1 = Enable data-to-voice detection
V–	V0 = Single digit responses V1 = Word responses
X–	X0 = Hayes Smartmodem 300 compatibility and 600 bps X1 = Include CONNECT 1200 response X2 = Include dial tone detection response X3 = Include busy signal detection response X4 = Include both dial tone and busy signal detection responses
Y–	Y0 = LIGHTSPEED 1200 does not send or response to break signals Y1 = LIGHTSPEED 1200 sends break signal for four seconds before disconnecting
Z	Reset LIGHTSPEED 1200; return to default settings; required after changing switches

C.2.2 Result responses

LIGHTSPEED 1200 Responses

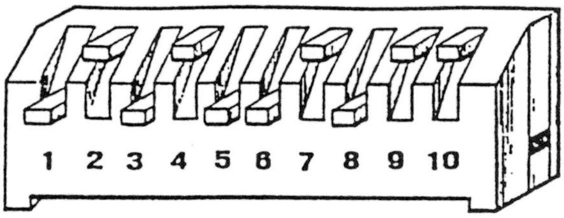
Word Responses	Digit Response	Meaing
OK	0	LIGHTSPEED 1200 executed your command line.
CONNECT	1	– For the X0 response set, the LIGHTSPEED 1200 has made a connection to another modem at 0-300, 600 or 1200 bps. – For the X1, X2, X3, and X4 response set, the LIGHTSPEED 1200 has made a connection to another modem at 0-300 bps or 600 bps.
RING	2	LIGHTSPEED 1200 is detecting a ring signal.
NO CARRIER	3	– LIGHTSPEED 1200 lost the remote carrier signal after making a connection. – LIGHTSPEED 1200 did not detect the remote carrier signal.
ERROR	4	– Your command line contains one or more errors. – You typed more than 40 characters on the command line. – Your LIGHTSPEED 1200 is set up for Bell operation while in the CCITT V.21/V.22 mode. – You are using an invalid character format while operating at 1200 bps. – There is an invalid check sum.
CONNECT 1200	5	If you sent the X1, X2, X3 or X4 command, the LIGHTSPEED 1200 sends this response after making a connection to another modem at 1200 bps.
NO DIALTONE	6	If you sent the X2 or X4 command, the LIGHTSPEED 1200 sends this response when it does not detect a dial tone and, as a result, stops acting on the command line you sent.
BUSY	7	If you sent the X3 or X4 command, the LIGHTSPEED 1200 sends this response after dialing a number and detecting a busy signal.
NO ANSWER	8	If you sent the @ command, the LIGHTSPEED 1200 sends this response after dialing a number and waiting for silence that it did not detect.

C.2.3 Summary of S Registers

S Registers

Register	Range	Preset Value	Function
S0	0–255 rings	0	Rings to auto-answer calls (also see Switch 5)
S1	0–255 rings	0	Count number of incoming rings/Signal quality
S2	0–127 ASCII	43	Escape character
S3	0–127 ASCII	13	Carriage return character
S4	0–127 ASCII	10	Line feed character
S5	0–32, 127 ASCII	8	Backspace character
S6	2–255 seconds	2	Dial tone wait time
S7	1–60 seconds	30	Wait time for remote carrier
S8	0–255 seconds	2	Comma pause time
S9	1–255 1/10 second	6	Carrier detect response time
S10	1–255 1/10 second	7	Delay time between loss of remote carrier and hang up
S11	50–255 milliseconds	70	Duration and spacing of Touch-Tones
S12	20–255 1/50 second	50	Escape characters guard time
S13	Bit-mapped register		UART status register
S14	Bit-mapped register		Option register
S15	Bit-mapped register		Flag register
S16	0, 1, 2, 4	0	Modem tests

C.2.4 Summary of Switches



Location of the Configuration Switches

Switch Settings

Switch	Preset Setting	Function
1	DOWN	LIGHTSPEED 1200 assumes the Data Terminal Ready (DTR) RS–232–C signal is always provided from your computer or terminal.
2	UP	LIGHTSPEED 1200 sends word responses.
3	DOWN	LIGHTSPEED 1200 sends responses to your computer's or terminal's screen.
4	UP	LIGHTSPEED 1200 echoes commands to your computer's or terminal's screen during the Command Mode.
5	DOWN	LIGHTSPEED 1200 does not automatically answer incoming calls.
6	DOWN	LIGHTSPEED 1200 assumes the Carrier Detect RS–232–C signal is provided continuously.
7	UP	LIGHTSPEED 1200 is connected to a single-line RJ–11 telephone jack.
8	DOWN	LIGHTSPEED 1200 recognizes commands.
9	UP	LIGHTSPEED 1200 is compatible with Bell 103/212A standards.
10	UP	LIGHTSPEED 1200 hangs up and returns to the Command Mode when DTR goes low.

C.3.1 The functional group tables of the AT command set

The table below shows the symbol and its meaning or the functional group it represents.

symbol	functional group
A	answering
D	dialing
M	MNP
O	online
P	port control
R	registers
S	synchronous only
T	test
V	visual display
Z	default operation
&	asynchronous RS-232C control
symbol	**what it means**
!	caution, for advanced use only
I	switches, commands also set by switches

Functional Group Tables

The following tables list AT commands and registers included in each functional group. Some commands and registers apply to more than one group.

A Answering

Answer	ATA
Auto Answer	ATS0 = n
Ring to Auto-Answer On	ATS0 = n
Carrier Detect Response Time	ATS9 = n
Delay for Hang Up After Carrier Loss	ATS10 = n
Set Guard Tone	AT&G
Hang Up	ATH
Set CCITT/Bell Mode	ATB
Set Leased Line Mode	AT&L

D Dialing

Dial	ATD
Redial the Last Telephone Number Dialed	ATDL
Dial a Stored Telephone Number	ATD/n
Read Stored Phone Numbers	AT\F
Write Stored Telephone Number	AT\P
Write Stored Telephone Entry 1	AT&Z
Set Pulse Dial	ATP
Set Tone Dial	ATT
Set Dial Pulse Ratio	AT&P
Hang Up	ATH
Pause Time for Dial Delay	ATS8 = n
Wait Before Dialing	ATS6 = n
Wait Carrier after Dial	ATS7 = n
Carrier Detect Response Time	ATS9 = n
Delay to Hang Up After Carrier Loss	ATS10 = n
Set Guard Tone	AT&G
Set Leased Line Mode	AT&L
Set CCITT/Bell Mode	ATB

Dial Modifiers

Pulse Dial	P
Tone Dial	T
Dial a Number in Answer Mode	R
Wait for Dial Tone Before Dialing	W
Pause During Dial	,(comma)
Wait for Quiet Answer Before Dialing	@
Flash	!
Return to Command State After Dialing	;(semicolon)
Dial First Stored Telephone Number	S
Dial Stored Telephone Number n	/n
Dial an Alternate Stored Number	Nn
Redial Last Number	L
Comment	:(colon)

M MNP

Set Operating Mode	AT\N
Maximum MNP Block Size	AT\A
Set Auto-Reliable Buffer	AT\C
Set Auto-Reliable Fallback Character	AT%A
Accept Reliable Link	AT\U
Originate Reliable Link	AT\O
Switch to Reliable Mode	AT\Y
Switch to Normal Mode	AT\Z
Block MNP Link	AT\L
Interface Protocol	AT\I

O Online

Set Escape Code Character	ATS2 = n
Hang Up	ATH
Enter Connect State	ATO
Perform Retrain Sequence	ATO1
Carrier Detect Response Time	ATS9 = n
Delay for Hangup After Carrier Loss	ATS10 = n
Set Inactivity Timer	AT\T
Set Speaker Control	ATM
Transmit Break	AT\B
Set Break Control	AT\K
Accept Reliable Link	AT\U
Originate Reliable Link	AT\O
Switch to Reliable Mode	AT\Y
Switch to Normal Mode	AT\Z
Set Leased Line Mode	AT&L
Auto-retrain	AT%E

P Port Control

Bps Rate Adjust	AT\J
Set Serial Port Flow Control	AT\Q
Set Modem Port Flow Control	AT\G
Set XON/XOFF Pass Through	AT\X
Clear Serial Port Speed	AT%U

R Registers

Write to Register	ATSn = x
Read Configuration Register	ATSn?
Read All Registers	AT%R
Display Value of Last Referenced Register	AT?
Point to New Register	ATSx
Change Value of Last Referenced Register	AT = n
Ring to Auto-Answer On	ATS0 = n
Ring Counter	ATS1 = n
Escape Code Character	ATS2 = n
Carriage Return Character	ATS3 = n
Line Feed Character	ATS4 = n
Back Space Character	ATS5 = n
Wait Before Dialing	ATS6 = n
Wait for Carrier After Dial	ATS7 = n
Pause Time for Dial Delay	ATS8 = n
Carrier Detect Response Time	ATS9 = n
Delay for Hangup After Carrier Loss	ATS10 = n
Escape Code Guard Time	ATS12 = n
Bit Mapped Register	ATS14 = n
Bit Mapped Register	ATS16 = n
Test Timer	ATS18 = n
Bit Mapped Register	ATS21 = n
Bit Mapped Register	ATS22 = n
Bit Mapped Register	ATS23 = n
Delay to DTR	ATS25 = n
RTS to CTS Delay Interval	ATS26 = n
Bit Mapped Register	ATS27 = n

S Synchronous Only

Synchronous Mode Selection	AT&M
RTS/CTS Options	AT&R
Delay to DTR	ATS25 = n
RTS to CTS Delay	ATS26 = n

Test

End Test in Progress	AT&T0
Local Analog Loopback	AT&T1
Local Digital Loopback	AT&T3
Respond to Remote Digital Loopback	AT&T4
Do Not Respond to Remote Digital Loopback	AT&T5
Initiate Remote Digital Loopback	AT&T6
Initiate Remote Digital Loopback with Self-Test	AT&T7
Local Analog Loopback with Self-Test	AT&T8
Test Timer	ATS18
Identification	ATI

Visual Display

Command Echo	ATE
Quiet	ATQ
Result Code Form	ATV
Modify Result Code Form	AT\V
Set Data Echo	AT\E
Extended Result Codes	ATX
Identification	ATI
Read Online Status, Help	AT\S
Read Configuration Registers	ATSn?
Read All Registers	AT%R
Display Value of Last Referenced Register	AT?
Read Stored Phone Numbers	AT\F

Default Operation

Restore Factory Defaults	AT&F
Reset	ATZ
Save Current Configuration	AT&W
Switch from AT to SX Mode	AT\M

Asynchronous RS-232C Control

Set Serial Port Ring Indicator	AT\R
Set Serial Port CD Control	AT&C
Set Serial Port DSR/CTS Control	AT\D
Set DTR Control	AT&D
RTS/CTS Options	AT&R
Carrier Detect Response Time	ATS9 = n
Delay For Hangup After Carrier Loss	ATS10 = n
RTS to CTS Delay Interval	ATS26 = n
Delay to DTR	ATS25 = n

C.3.2 Result codes AT mode

Short Form result codes are in decimal form. Short or long form display is controlled by the ATV command. /REL means an MNP reliable link is established.

Short Form	Long Form	Meaning
0	OK	Command line was executed
1		Not used
2	RING	Ring detected
3	NO CARRIER	No connection established or loss of carrier
4	ERROR	Command incorrectly issued
5	CONNECT 1200	1200 bps connection established Bell 212A or CCITT V.22 bis
6	NO DIALTONE	Dialtone not detected within specified time period*
7	BUSY	Busy signal detected*
8	NO ANSWER	Quiet answer not detected*
9	CONNECT 0600	CCITT V.22 600 bps connection established
10	CONNECT 2400	CCITT V.22 bis 2400 bps connection established (AX/2410 only)
20		Not used
21**	CONNECT 0600/REL	CCITT V.22 600 bps connection established MNP reliable link active
22**	CONNECT 1200/REL	1200 bps connection established Bell 212A or CCITT V.22 MNP reliable link active
23**	CONNECT 2400/REL	CCITT V.22 bis 2400 bps connection established MNP reliable link active (AX/2410 only)

*The display of this result code depends on the setting of the Extended Result Codes command.

**Only displayed when AT\V1 is in effect.

C.3.3 AT Configuration switches and buttons

Front Configuration Switches

REAR SWITCH 7 MUST BE DOWN FOR MOST SWITCHES TO TAKE EFFECT.

Switch	Position	Function
1	UP	Respond to DTR (AT&D2) Goes off hook in originate mode when T/D button is pressed
	DOWN	Affected by AT&W when reset. AT&D0 is restored by AT&F Goes off hook in answer mode when T/D button is pressed
2	UP	SX mode
	DOWN	AT mode
3	UP	No result codes (ATQ1)
	DOWN	Result codes (ATQ0)
4	UP	Command echo on (ATE1)
	DOWN	Command echo off (ATE0)
5	UP	Auto-answer enabled (S0 = 1)
	DOWN	Auto-answer disabled (S0 = 0)
6	UP	Carrier follows remote system (AT&C1)
	DOWN	Affected by AT&W when reset. AT&C0 is restored by AT&F
7	UP	Long form result codes (ATV1)
	DOWN	Short form result codes (ATV0)
8	UP	Dumb mode
	DOWN	Smart mode
T/D		Alternates between talk and data mode each time button is pressed OH indicator comes ON when the AX goes off hook in data mode OH indicator turns OFF when the AX goes on hook in talk mode
A/S	OUT	Asynchronous
	IN	Synchronous

Note: On rack-mount modems, the T/D (talk/data) and A/S (asynchronous/synchronous) push-buttons are replaced by two additional front configuration switches. The T/D button is replaced by front switch 9, and the A/S button is replaced by front switch 10.

Rear Configuration Switches

Switch	Position		Function
1,2	UP	UP	No flow control (AT\Q0, AT\G0)
	UP	DOWN	XON/XOFF for serial port, XON/XOFF for modem port (AT\Q1, AT\G1)
	DOWN	UP	Bidirectional hardware flow control for serial port, XON/XOFF for modem port (AT\Q3, AT\G1)
	DOWN	DOWN	Affected by AT&W when reset. AT\Q0 and AT\G0 are restored by AT&F
3,4	UP	UP	Normal mode (AT\N0)
	UP	DOWN	Reliable mode (AT\N2)
	DOWN	UP	Auto-reliable mode (AT\N3)
	DOWN	DOWN	Affected by AT&W when reset. AT\N1 is restored by AT&F
5	UP		Don't use MNP extended result codes (AT\V0)
	DOWN		Use MNP extended result codes (AT\V1)
6	UP		Don't restore factory defaults on reset, ATZ, or power up when front switch 2 is DOWN
	DOWN		Restore factory defaults on reset, ATZ, or power up when front switch 2 is DOWN
7	UP		Don't read switches on reset, ATZ, AT&F, or power up*
	DOWN		Read switches on reset, ATZ, AT&F, or power up
8			Not Used

*Front switch 2 and the A/S button are always read on reset or power up, regardless of the setting of rear switch 7. In addition, if front switch 2 is DOWN, rear switch 6 is always read on reset or power up, regardless of the setting of rear switch 7.

Installation Checklist

Why Should You Change Configuration Switch Settings?

Always set the AX serial port settings to match those used by your computer. Whenever possible, set the AX modem port to match the modem it's connected to on the other end of the line. Before you place a call or begin to accept incoming calls, review the following checklist to make sure your modem is set up the way you want. If it isn't, change the appropriate switch or switches. Refer to the switch setting tables in the previous section of this chapter to find out exactly which settings to use.

Be sure to set rear switch 7 DOWN and press the Reset button on the rear panel of your AX after you have finished setting the following switches.

Appendix D

The list of the enhanced Hayes command set

D.1 Commands in the off line command state

The commands, when TA-csd is on state 1 (off-line command state) are:
(Underlined parameter values are the default values.)

Command:	Parameters :	Description
General and rate adaptation function:		
		1. Command to let the TA-csd set up call:
AT D dial string		Dial a number Dial string is a combination of numbers and/or symbols.
	0..9	Numbers
		Symbols :
	( ) -	Dial digit separators to make a string of dial digits clear to the eye. They are displayed on the screen but ignored by TA-csd, thus they do not occupy any space in the command buffer.
		2. Command to let the user answer an incoming call:
AT A		Answer the call coming from ISDN manually
		3. Commands to read the status information from the TA-csd:
		- Read the identification code of the TA-csd:
AT In	n=0,1	0: I0 requests the TA-csd to report its identification code to the screen. 1: I1 requests the TA-csd to report the ROM check sum of the firmware on the screen.
		- Read the value stored in register Sr: With this command, TA-csd reads the content of register "r" and sends its value to the terminal as a decimal number.

Command:	Parameters :	Description
AT S0?	**n=0,1**	Read the value of register S0. 0: manually answer an incoming call 1: automatically answer an incoming call
AT S1?	**n=0..127 (ASCII)**	Read the value of register S1 (Escape character) Default: 43 (+)
AT S2?	**n=0..127 (ASCII)**	Read the value of register S2 (Carriage Return Character) Default: 13 (Ctrl M)
AT S3?	**n=0..127 (ASCII)**	Read the value of the register S3 (Line Feed character) Default: 10 (Ctrl J)
AT S4?	**n=0..127 (ASCII)**	Read the value of the register S4 (Backspace character) Default: 8 (Ctrl H)
AT S5?	**n=0..255 (second)**	Read the value of the register S5 (Wait time for 'CONNect' from the ISDN network after dialling by en bloc call SETUP and wait time for 'Connect Acknow ledge' from the network after accepting the incoming call.) Default: 30 second
AT S6?	**n=20..255 (* 1/50 second)**	Read the value of the register S6 (Guard Time for escape character) Default: 50 (1 second)
AT S7?	**bit mapped**	Read the value of the register S7 Register S7 is an 8-bit mapped register which reflects the status of the UART line control register from the TA-csd. The user can not change the contents of this register.

bit 0 & 1 : Number of stop bits

0	0	Not used
0	1	1 bit
1	0	1.5 bits
1	1	2 bits

bit 2 & 3 : Number of data bits including parity bit is present

0	0	Not used
0	1	5 bits
1	0	7 bits
1	1	8 bits

Command:	Parameters :	Description
		bit 4 & 5 & 6 : Parity information 0 0 0 Odd 0 0 1 Even 0 1 0 None 0 1 1 Forced to 0 1 0 0 Forced to 1
		bit 7 : Buffer flag 1 buffer overflow flag ERROR result code will be sent.
AT S8?	**bit mapped**	Read the value of the register S8 Register S8 is an 8-bit mapped register which reflects the user selected options bit (1-3) and the user rate (bit 4-7). The user can not change the contents of this register.

bit 0 : 0 Local echo disabled
1 Local echo enabled

bit 1 : 0 Result code enabled
1 Result code disabled

bit 2 : 0 Digit result code
1 Word result code

bit 3 : 0 Break signal disabled
1 Break signal enabled

bit 4 & 5 & 6 & 7 : User rate

4	5	6	7	User rate
0	0	0	0	0.050 kbit/s
0	0	0	1	0.075 kbit/s
0	0	1	0	0.110 kbit/s
0	0	1	1	0.150 kbit/s
0	1	0	0	0.200 kbit/s
0	1	0	1	0.300 kbit/s
0	1	1	0	0.6 kbit/s
0	1	1	1	1.2 kbit/s
1	0	0	0	2.4 kbit/s
1	0	0	1	3.6 kbit/s
1	0	1	0	4.8 kbit/s
1	0	1	1	7.2 kbit/s
1	1	0	0	9.6 kbit/s
1	1	0	1	12 kbit/s
1	1	1	0	14.4 kbit/s
1	1	1	1	19.2 kbit/s

Command:	Parameters :	Description
AT S9?	n=0..5	Read the value of the register S9 0: Normal Operation 1: Local test loop TA-csd (Loop 3) 2: Local test loop external modem 3: Remote test loop TA-csd (Loop 2) 4: Remote test loop internal modem 5: Remote test loop external modem
		4. Commands to set parameter in the TA-csd:
		- Local Echo command:
AT En	n=0,1	0: Any character entered to the TA-csd is not echoed back to the terminal (disabled). 1: Any character entered to the TA-csd is echoed back to the terminal (enabled). The echo feature is useful only when the terminal is configured for the full duplex mode.
		- Send responses to terminal or not:
AT Qn	n=0,1	0: TA-csd sends result codes to the terminal when it executes commands 1: TA-csd does not send result codes to the terminal when it executes commands
		- Set register Sr to the value "n":
AT S0=n	n=0,1	0: manually answer an incoming call 1: automatically answer an incoming call
AT S1=n	n=0..127 (ASCII)	Value of the Escape character Default: 43 (+)
AT S2=n	n=0..127 (ASCII)	Value of the Carriage Return Character Default: 13 (Ctrl M)
AT S3=n	n=0..127 (ASCII)	Value of Line Feed character Default: 10 (Ctrl J)
AT S4=n	n=0..127 (ASCII)	Value of Backspace Character Default: 8 (Ctrl H)

Command:	Parameters :	Description
AT S5=n	**n=0..255 (second)**	Wait time for 'CONNect' from the ISDN network after dialling by en bloc call SETUP and wait time for 'Connect Acknow ledge' from the network after accepting the incoming call. Default: 30 second
AT S6=n	**n=20..255 (* 1/50 second)**	Guard Time for escape character Default: 50 (1 second)
		- Send result codes as digits or words
AT Vn	**n=0,1**	0: TA-csd sends result codes as digits to the terminal's screen. (When the software package doesn't handle character strings efficiently) 1: TA-csd sends result codes as words to the terminal's screen.
		- Break signal:
AT Yn	**n=0,1**	0: TA-csd does not send or respond to break signals. 1: TA-csd sends break signal and discon- nects when it receives a break signal.
		5. Command to let TA-csd set up and execute the local test loop:
		- Put TA-csd in the test loop mode:
AT S9=n	**n=0..2**	0: Normal operation 1: Local test loop TA-csd (Loop 3) 2: Local test loop external modem
		6. Repeat last command:
A/		Repeat last command line Replaces AT, no <CR> required
		7. Redial a call:
AT\A		Redial last number

Command:	Parameters :	Description
		<u>8. Abbreviated dial:</u>
AT\B		Dial first stored telephone number
AT\Cn	n=1..16	Dial stored telephone number at memory n
AT\Dn	n=1..16	Dial an alternate stored number If TA-csd fails to make a connection, it will dial an alternate telephone number at memory n given here. If n is not explicitly given here by the user, TA-csd will dial the next stored number.
		<u>9. Write a stored number at memory n:</u>
AT\En dial string	n=0..15	Stores a number in the TA-csd directory. The user can store up to sixteen number. Dial string is a combination of numbers and/or symbols and/or dial modifier/command
	0..9	Numbers
		Symbols :
	( ) -	Dial digit separators to make a string of dial digits clear to the eye. They are displayed on the screen but ignored by TA-csd, thus do not occupy any space in the command buffer.
		Dial Modifier/command:
	:	Comment
	AT	Choose the rate adaptation function
	AT*	Choose the internal modem function
	AT$	Choose the external modem function
	<CR>	Carriage return
AT\F		Show the contents of the directory
Internal modem function:		
		<u>10. Command to let the TA-csd set up call to PSTN and switch the internal modem on when the call is established:</u>
AT* D dial string		Dial a telephone number Dial string is a combination of numbers and/or symbols.
	0..9	Numbers
		Symbols :
	( ) -	Dial digit separators to make a string of dial digits clear to the eye. They are displayed on the screen but ignored by TA-csd, thus do not occupy any space in the command buffer.

External modem function:

The commands with prefix **AT$** are applied when the user wants to communicate with the remote modem and his external modem is connected to the TA-csd. When the TA-csd turns on, it will automatically initiate the external modem to its default values. The default values for the external modem will be described below and are underlined.

Although every Hayes and (compatibles) smart modems are de facto standard, the factories may implement the Hayes command set a little bit different than the Hayes microcomputer product does.

When it happens, after the TA-csd initiated the external modem the default values the TA-csd gave to the external modem could be different interpreted by the external modem.

For the reasons given above, the user must have the possibility to set up the external modem values. The commands will be described below and the default conditions are underlined. To set up the external modem to the value n, please refer to the user's manual accessory to the modem. The commands precede with '(optional)' message will not be initiated by the TA-csd, while not every Hayes smart modem has the provision. But the user can send the command to set up the function(s).

In principle every Hayes and (compatible) smartmodem can be connected into the TA-csd. The communication is possible if both modems have the same type.

Command:	Parameters :	Description
		11. Command to let the TA-csd set up call to PSTN and switch the external modem on when the call is established:
AT$ D dial string		Dial a telephone number Dial string is a combination of numbers and/or symbols.
	0..9	Numbers
		Symbols :
	(**)** -	Dial digit separators to make a string of dial digits clear to the eye. They are displayed on the screen but ignored by TA-csd, thus do not occupy any space in the command buffer.

Command:	Parameters :	Description
		12. Commands to read the status information of the external modem:
		- Read the modem's identification code:
AT$ In	**n=...**	.: Requests the modem to report its identification code to the terminal. .: Requests the modem to report the ROM check sum of the firmware to the terminal.
		- Read the value of register Sr:
AT$ S0?	**n=0..255**	not applied
AT$ S1?	**n=0..255**	not applied
AT$ S2?	**n=0..127 (ASCII)**	Value of the Escape character Default: 43 (+)
AT$ S3?	**n=0..127 (ASCII)**	Value of the Carriage Return Character Default: 13 (Ctrl M)
AT$ S4?	**n=0..127 (ASCII)**	Value of Line Feed character Default: 10 (Ctrl J)
AT$ S5?	**n=0..127 (ASCII)**	Value of Backspace Character Default: 8 (Ctrl H)
AT$ S6?	**n=0..255**	not applied
AT$ S7?	**n=0..255 (second)**	Wait time for remote carrier after TA-csd dialling or answering a call. Default: 30 second
AT$ S8?	**n=0..255**	not applied
AT$ S9?	**n=0..255 (* 1/10 second)**	Carrier detect response time Default: 0.6 second
AT$ S11?	**n=0..255**	not applied

Command:	Parameters :	Description
AT$ S12?	**n=20..255 (* 1/50 second)**	Guard Time for escape character Default: 50 (1 second)
AT$ S13?	**bit mapped**	UART status register (see modem's manual)
AT$ S14?	**bit mapped**	Option register (see modem's manual)
AT$ S15?	**bit mapped**	Flag register (see modem's manual)
		13. Commands to set up the parameter in the external modem:
		- CCITT/Bell mode (optional): (The choice depends on remote modem)
AT$ Bn	**n=...**	.: Set the external modem to CCITT mode. .: Set the external modem to Bell mode.
		- Carrier transmitter (optional):
AT$ Cn	**n=...**	.: Disable carrier transmitter .: Enable carrier transmitter
		- Echo command:
AT$ En	**n=...**	.: Any character entered to the modem in the off-line command state do not echoed back to the terminal. .: Any character entered to the modem in the off-line command state do echoed back to the terminal. The echo feature is useful only when the terminal is configured for the full duplex mode.
		- Duplex (optional):
AT$ Fn	**n=...**	.: Half duplex .: Full duplex
		- Guard tone (optional):
AT$ Gn	**n=...**	.: Guard tone disabled (USA) .: 550 Hz guard tone .: 1800 Hz guard tone

Command:	Parameters :	Description
		- Control the speaker volume (optional):
AT$ Ln	n=...	.: Select low volume .: Select medium volume .: Select high volume
		- Turn the speaker on/off:
AT$ Mn	n=...	.: Speaker off all the time .: Speaker on until carrier detected .: Speaker on always
		- Result codes sent or not:
AT$ Qn	n=...	.: Modem sent result codes to the terminal (TA-csd), when it executes commands. .: Modem does not send result codes to the terminal when it executes commands.
		- Set register Sr to the value n:
AT$ S0=n	n=0..255	not applied
AT$ S1=n	n=0..255	not applied
AT$ S2=n	n=0..127 (ASCII)	Value of the Escape character Default: 43 (+)
AT$ S3=n	n=0..127 (ASCII)	Value of the Carriage Return Character Default: 13 (Ctrl M)
AT$ S4=n	n=0..127 (ASCII)	Value of Line Feed character Default: 10 (Ctrl J)
AT$ S5=n	n=0..127 (ASCII)	Value of Backspace Character Default: 8 (Ctrl H)
AT$ S6=n	n=0..255	not applied
AT$ S7=n	n=0..255 (second)	Wait time for remote carrier after TA-csd dialling or answering a call. Default: 30 second
AT$ S8=n	n=0..255	not applied
AT$ S9=n	n=0..255 (* 1/10 second)	Carrier detect response time Default: 0.6 second
AT$ S11=n	n=0..255	not applied

Command:	Parameters :	Description
AT$ S12=n	**n=20..255 (* 1/50 second)**	Guard Time for escape character Default: 50 (1 second)
		- Result codes:
AT$ Vn	**n=...**	.: Modem sends result codes as digits to the terminal (TA-csd). .: Modem sends result codes as words to the terminal (TA-csd).
		- Select some result code set:
AT$ Xn	**n=...**	.: Basic result code set .: Extended result codes set
		- Break signal (optional):
AT$ Yn	**n=...**	.: Modem does not send or respond to break signals. .: Modem sends break signal and disconnects when it receives a break signal.
		14. Command to let TA-csd set up the local test external modem:
AT$ S16=n	**n=...**	Modem test mode (see modem's manual): .: Normal mode .: Analog loopback test mode

D.2 Commands in the on line communication state

The command, when TA-csd is on state 3 (on-line communication state) is the escape command:

Command:	Parameters :	Description
Pause for at least one second		The value of the escape guard time (one second) is variable and can be set up on register S6.
+++		The value of the escape character (+) is also changeable and can be set up on register S1.
Pause for at least one second		The value of the escape guard time (one second) is variable and can be set up on register S6.

The user can also give the escape command to the external modem via TA-csd, when the modem is on the on-line state.

	Escape Command:
Pause for at least one second	The value of the escape guard time (one second) is variable and can be set up on register S12.
+++	The value of the escape character (+) is also changeable and can be set up on register S2.
Pause for at least one second	The value of the escape guard time (one second) is variable and can be set up on register S12.

D.3 Commands in the on line command state

The commands, when TA-csd is on state 4 (on-line command state).

Command:	Parameters :	Description
		1. Commands to read the status information from the TA-csd:
		These commands can be found in state 1. Please refer to state 1.
		2. Commands to set parameter in the TA-csd:
		These commands can be found in state 1. Please refer to state 1.
		3. Command to resume the exchange of data:
AT O		The O command returns the TA-csd to the on-line communication state after the escape characters is used to switched to the on-line command state.

Command:	Parameters :	Description
		4. Commands to release the call:
AT H		**H**ang Up command The command instructs the TA-csd to disconnect the connection. It is usually used to return to the off-line command state from the on-line command state.
AT Z		Reset the TA-csd It means that TA-csd will: - Disconnect the connection (if it exist) - Returns all registers to default values - Deletes from memory the last executed command, making the **A/** command inactive until the first command is executed - If an external modem is connected to it, TA-csd will also reset the external modem too. - Sends an **OK** response
		5. Command to set up the local or remote test loop:
AT S9=n	**n=0..5**	0: Normal Operation 1: Local test loop TA-csd (Loop 3) 2: Local test loop external modem 3: Remote test loop TA-csd (Loop 2) 4: Remote test loop internal modem 5: Remote test loop external modem
		6. Write a stored number at memory n:
		These commands can be found in state 1. Please refer to state 1.

External modem function:

		7. Commands to read the status information of the external modem:
		These commands can be found in state 1. Please refer to state 1.

Command:	Parameters :	Description
		8. Commands to set up the parameters in the external modem:
		These commands can be found in state 1. Please refer to state 1.
		9. Command to let TA-csd set up the local or remote test modem:
AT$ S16=n	**n=...**	Modem test mode (see modem's manual): .: Normal mode .: Analog loopback test mode (local) .: Digital loopback test mode (remote)

The following commands with unbold characters are not applied for ISDN purpose, but these commands could be sent by the communication program running on PC. They are known by TA-csd. But it have no special meanings. The communication program expected a result message after a command is given. Thus TA-csd must give the result message to the communication program.

Command:	Parameters :	Description
AT P		Pulse Dial the phone number Result message : OK
AT T		Touch-Tone Dial the phone number Result message : OK
		Dial modifiers:
	P	Pulse Dial
	T	Touch Tone Dial
	R	Dial a number in answer mode
	W	Wait for dial tone before dialling
	,	Pause during Dial
	@	Wait for quiet answer before dialling
	!	Flash (Call transference)
	;	Return to command state after dialling
	/	Pause 0.125 second (na)
	%	Adaptive dialling (na)

Ex. The following dial commands have the same meanings :

ATD 123456 <CR>

ATD P W / **123456 <CR>**

D.4 Result messages

The following result codes will be sent to the terminal by TA-csd.

Word Response	Digit Response	Meaning
OK	0	- TA-csd executes the command line stored in the command buffer without error. - TA-csd has canceled a call during the calling or answering operation. It is now ready to accept new command(s). - Initial check out TA-csd, Local test loop TA-csd (Loop 3),local test loop TA-csd external modem, remote test loop TA-csd (Loop 2), remote test loop internal modem or remote test loop external modem is successfully executed.
CONNECT	1	- TA-csd is connected to the remote TA-csd ('CONNECT' message is received from the ISDN-network) - TA-csd completes a local line test loop or local test loop. After this message displays on the screen, the character types by the user would be looped back. - TA-csd/modem is connected to the remote modem (the call is established).
RING	2	TA-csd receives the incoming call (SET UP message) from the ISDN- or PSTN-network. RING are displayed on the screen one after another once SET UP message is received until the user answers the call.
NO CARRIER	3	'CONNECT' message is never received from the ISDN-network and the call set up will be aborted.
ERROR	4	- TA-csd encounters an invalid command (not recognized) in executing the command line stored in the command buffer. - The user typed more than 40 characters on the command line. - If the call is rejected by the ISDN-network (network congestion, user busy, no user answer, other reasons) - The call establishment is not successful - Initial check out TA-csd, Local test loop TA-csd (Loop 3),local test loop TA-csd external modem, remote test loop

		TA-csd (Loop 2), remote test loop internal modem or remote test loop external modem is not successfully executed.
INCOMING CALL SPEED:..BPS	5	When an incoming call comes from ISDN and the speed of the remote TA-csd does not match the speed of the local TA-csd, then sends local TA-csd this message to let the called user change the speed of his terminal to the speed of the remote terminal, for the case that the remote TA-csd does not support flow control mechanism.
FORMAT MISMATCH	6	When the character format of the local TA-csd does not match the character format available in the remote TA-csd, this message will be sent to the local terminal. The user must change the format of his terminal to the right format available in the remote TA-csd.
BUSY	7	The call is rejected by the ISDN-network, because the remote user is busy,
NO ANSWER	8	The call is rejected by the ISDN-network, because the remote user does not answer the call.