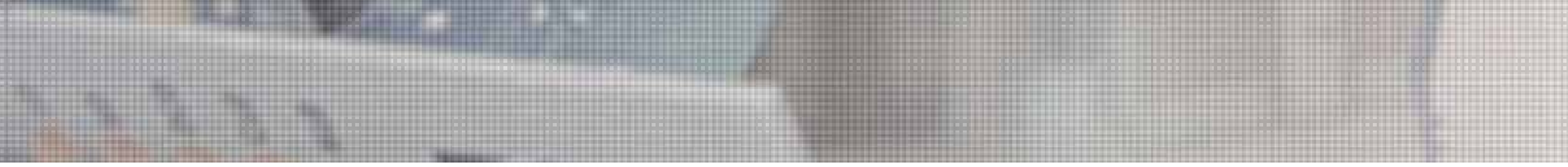


ISDN

What is ISDN

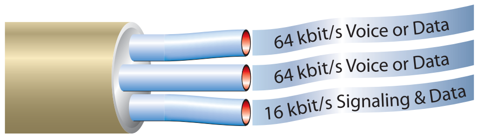
ISDN (**I**ntegrated **S**ervices **D**igital **N**etwork) is a digital equivalent to the standard PSTN telephone network (**P**ublic **S**witched **T**elephone **N**etwork). The ISDN technology is standardised according to the recommendations from the **I**nternational **T**elecommunications **U**nion (ITU).

Signalling

Instead of the telephone company activating the ring signal in your telephone ("In-Band signal"), a digital packet is sent on a separate channel ("Out-of-Band signal"). The Out-of-Band signal does not disturb the call in progress and has a short connection time. The signal contains information about who is calling, the type of call (data/voice), and number that is calling. Available ISDN equipment then determines how the call should be handled.

Connections

An ISDN-connection is built up of a number of B-channels that primarily carry data, and a D-channel mainly for control signals. The transfer rate for data on one B-channel is 64 kbit/s. Numerous channels can be interconnected to increase the speed. Customers are usually offered ISDN in the form of two different subscriptions: Basic access, that comprises of two B-channels and a 16 kbit/s D-channel (2B+D). This gives a maximum speed of two times 64 kbit/s, i.e. 128 kbit/s, suitable for users that require higher data transfer rates or wish to combine telephone, fax and data communication, or a small local-area network. It is possible to connect up to 8 ISDN devices on the same line. This is a big advantage if there are different types of devices on an ISDN connection.



The devices receive individual numbers exactly as if they had their own connection to the network. Primary access, comprises of 30 B-channels and a 64 kbit/s D-channel (30B+D). The maximum capacity will then be 2 Mbit/s, when all 30 channels are connected together. Primary access ISDN is suitable for connecting computers where there is a high data transfer rate requirement (for example, for video conferencing), large local networks, digital switches and bridges between large regional networks.

The greatest advantages of ISDN is the transfer rate (64–128 kbit/s), connection times of less than 2 seconds, connections that are more stable and less sensitive to interference as well as the flexibility of being able to connect multiple devices to the same line (for example, telephone, fax or computer).

ISDN components/interface

ISDN components include terminals, Terminal Adapters TA, Network-Termination devices NT, Line Termination equipment LT, and Exchange-Termination equipment CLA. Two terminal types are used in ISDN. Specialised ISDN-terminals with an ISDN-interface, Terminal equipment type 1 TE1, and terminals with an interface other than ISDN, units with a V.24 interface. These are referred to as Terminal Equipment type 2 TE2. TE1 is connected to ISDN with a 4-wire interface "twisted-pair" digital link, while TE2 is connected to the ISDN network via a TA. The terminal adapter can either be a freestanding device or an interface card mounted in the TE2 device. When TE2 and TA are freestanding units, a standardised interface such as RS-232/V.24 or V11/RS-485 is usually used.

The next interface up-stream is the Network terminal, this makes up the interface between the 4-wire interface in the customer installation and telecom operator's conventional 2-wire copper cables.

Network terminals are also available in two types, NT1 and NT2, where NT2 is a more complex device and which makes up layers 2 and 3, protocol functions and concentration. NT2s can, for example, be found in office switchboards. In most countries the network terminals belong to the telecom operator.

In the reference model for ISDN there are a number of reference points established that make up the interface between the reference model's devices/terminals according to the following:

- R --- Reference point that makes up the interface between non ISDN devices and terminal adapters TA standard RS-232/V.24.
- S --- Reference point that makes up the interface between TE/TA and NT1.
- T --- Reference point that makes up the interface between NT1 and NT2 devices.
- U --- Reference point that makes up the interface between NT and the LT line terminal.

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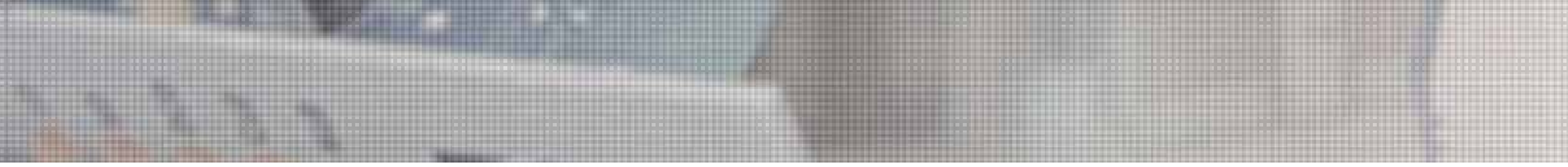
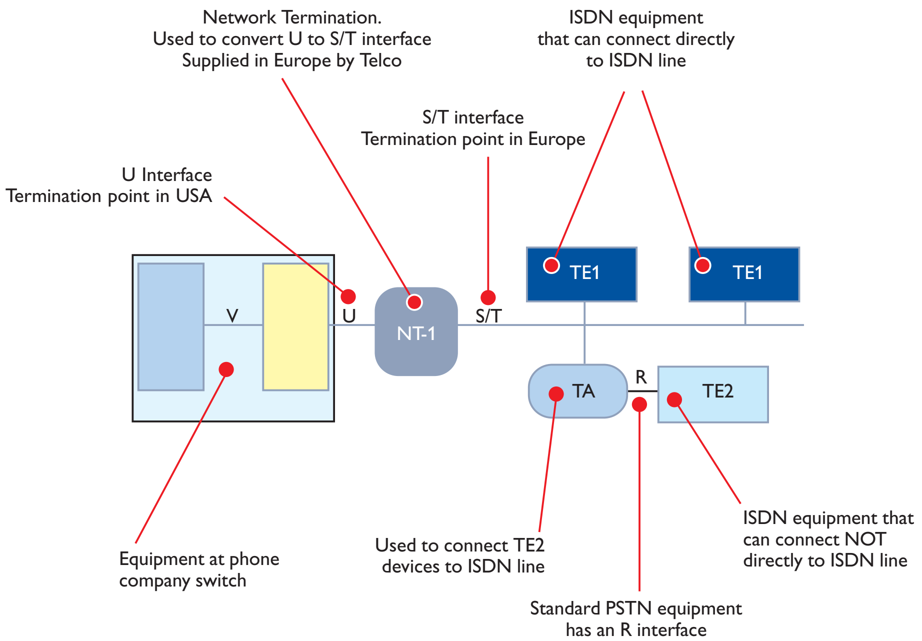
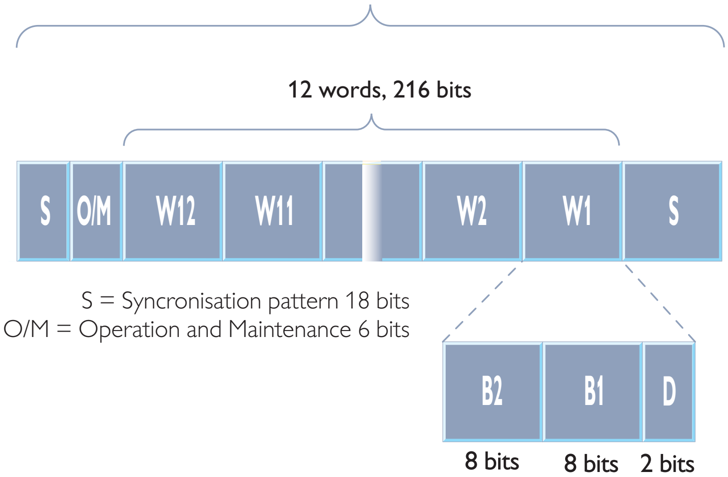




Physical layer

Signalling between the telecommunications exchange's line terminal (LT) and user's network terminal (NT) takes place over the U-interface while signalling at the user's premises, between NT and terminal adapter TA takes place over the S-interface. In the U-interface frames with a 240 bits length are used, these are transferred at a rate of 160 kbit/s. The U-interface's frames are structured as set out in the figure below.

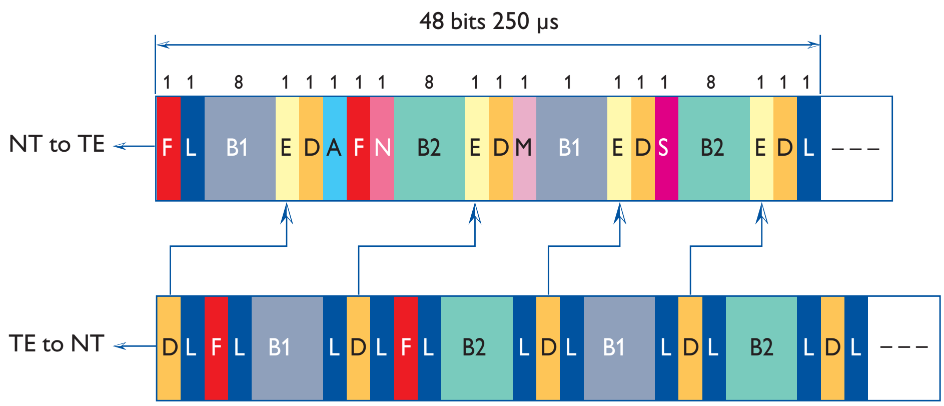
Frame structure
U-Frame when 2B1 Q coding
240 bits, 1.5 ms



Frame format of the S-interface

The S-interface's frames use 48 bits of which 36 are used for data transfer; the bit rate in the S-interface is 192 kbit/s. The internal structure of the frames differs slightly depending on in which direction the frames where sent. The figure below gives a picture of how the different bits are used.

A = Activation bit
B1 = B1 channel (2 x 8 bits / frame)
B2 = B2 channel (2 x 8 bits / frame)
D = D channel (4 x 1 bit / frame)
E = Echo of previous D bit
F = Framing bit
L = DC balancing
S = S-channel
N = Inverted F from NT to TE
M = Multiframing bit



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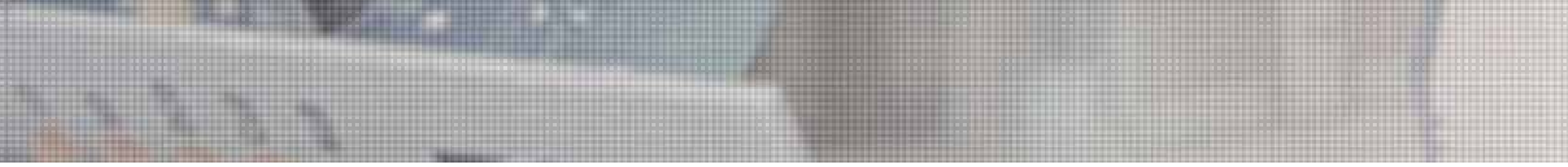


Layer 2 – Data link layer

The data link layer for ISDN is specified by ITU Q.920 to Q.923 standards. The D-channel's signalling is defined in Q.921. Link Access Procedure – D channel (LAP-D) is the protocol used in the data link layer. The LAP-D is nearly identical to X.25 LAP-B and both are based on HDLC. The structure of the frames used by LAP-D are shown below:

Flag	Address	Control	Information	CRC	Flag

Flag (1 octet)
Start flag always 7E16 (0111 11102).

Address (2 octets)

8	7	6	5	4	3	2	1
SAPI (6 bits)						C/R	EA0
TEI (7 bits)							EA1

SAPI (**S**ervice **A**ccess **P**oint **I**dentifier), 6-bits.
C/R (**C**ommand/**R**esponse) bit that indicates whether the frame is a command or answer.
EA0 (**A**ddress **E**xtension) Bit that is set to indicate the last byte in an address.
TEI (**T**erminal **E**ndpoint **I**dentifier) 7-bits device identifier (see page 102).
EA1 (Address Extension) bit, same functionality as EA0.

Control (2 bytes)
The control field is used to show the type of frame and command. There are three different types of frames: Information, Control/Monitoring and Unnumbered frames where the two first-mentioned also contain the sequence numbers (N[r] and N[s]).

Information
Information to the overlying network layer and user data.

CRC (2 bytes)
Cyclic Redundancy 16-bits checksum to detect bit errors in the transfer.

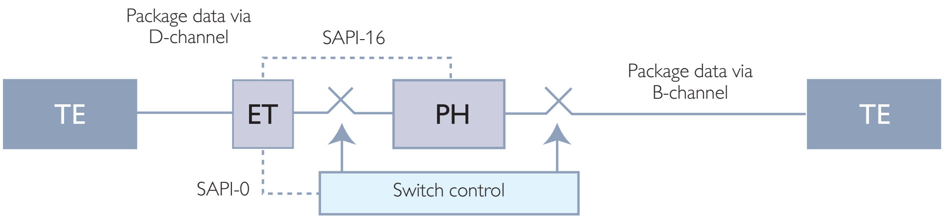
Flag (1 octet)
Final flag always 7E16 (0111 11102).

SAPI

The Service Access Point Identifier (SAPI) is a 6-bits field that allows the specification of up to 64 different service functions that layer 2 supplies to layer 3.

SAPI value	Related layer 3 or management entity
0	Call control procedures
1–11	Reserved for future standardization
12	Teleaction communication
13–15	Reserved for future standardization
16	Packet communication conforming to X.25 level 3 procedures
17–31	Reserved for future standardization
63	Layer 2 management procedures
All others	Not available for Q.921 procedures

The figure above gives a view of usage of the SAPI field, where SAPI = 0 is used for switch control and SAPI = 16 is used for package routing when X.31, X.25 over D-channel is used.



TEI

Terminal Endpoint Identifiers (TEI) is a unique ID that is allocated to each TA/TE on the ISDN S/T bus. The identifier can be allocated dynamically when the device is activated or statically during installation.

TEI Value	User Type
0–63	Non-automatic TEI assignment user equipment
64–126	Automatic TEI assignment user equipment
127	Broadcast to all devices

Layer 3 – Network layer

The network layer for ISDN is specified by ITU in Q.930 to Q.939. Layer 3 has functions to establish, maintain, and terminate a logical connection between two devices. The structure of the information field on layer 3 has a variable length and the different fields are specified by Q.931:

Information Field							
8	7	6	5	4	3	2	1
Protocol Discriminator							
0	0	0	0	Length of CRV			
Call Reference Value (1 or 2 octets)							
0	Message Type						
Mandatory & Optional Information Elements (variable)							

The information field's message header has the following appearance:

Protocol Discriminator (1 octet)

The field identifies the protocol type used to handle layer 3 messages. When Q.931 is used this field is 0816.

Length (1 octet)

Length of the subsequent field.

Call Reference Value (CRV) (1 or 2 bytes)

The field is used to identify the call/connection that the signal message belongs to. The value is used in all signalling as long as the current call is in progress.

Message Type (1 octet)

The field states the type of message sent. Four groups of messages can be discerned: connection, information, disconnection and other messages. SETUP and CONNECT belong to the first group. Information Elements (variable length)

The contents of this field consist of a number of information elements. The type of information element sent depends on the previous field Message Type. Elements for B-number information, additional services and transmission requirements on the network, etc. are found here.

CAPI

COMMON-ISDN-API (CAPI) provides a standardised interface to design software applications that utilises ISDN Signing up to the CAPI-standard gives applications that can communicate over ISDN without the need of considering manufacturer specific implementations of ISDN.

At present, work with the standard has virtually stopped and most telephone operators provide ISDN based on Q931/**ETSI 300 102**, CAPI version 2.0 developed to support the protocol based on Q 931. CAPI has been developed to form the basis of many different protocol stacks for networks, telephony and file transfer.

CAPI has currently been taken up as the European standard ETS 300 838 "**I**ntegrated **S**ervice **D**igital **N**etwork (ISDN); Harmonized Programmable Communication Interface (HPCI) for ISDN".

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