

An Introduction to ISDN

TANDBERG

Application Notes

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1. ISDN

1.1. Overview

ISDN is a digital communications network providing transmission rates in multiples of 64kbits per second. Typically described as 2B + D, Basic Rate ISDN (BRI) logically uses 2 64 kbit/s data channels (B channels) and one 16 kbit/s signalling channel (D channel). ISDN has yet to become a single global standard although within Europe EURO-ISDN is used almost exclusively. Individual countries however, have their own flavours of ISDN all of which are based to a varying degree around the ITUs ISDN standard.

2. The D Channel

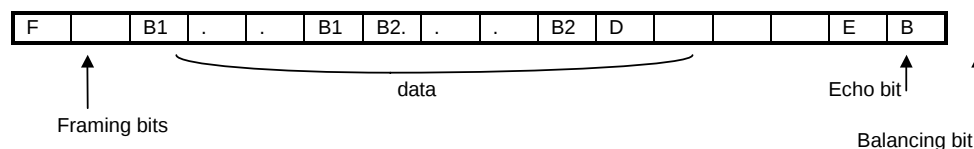
An ISDN *conversation* is controlled via the D channel, which supports a 3 layer protocol. The three layers are as follows:

Layer 1	Physical	Clock / Synchronisation
Layer 2	Basic Protocol Setup, Handshaking	
Layer 3	Signalling	Initiation, Progress (all call handling)

Basically the D channel controls the call. It is possible to analyse the D channel with an ISDN monitor which will provide a decoded display of the 3 layers. Such a monitor is an integral part of TANDBERG's products. It is also possible to send X.25 packet data via the D channel although TANDBERG do not use this facility.

2.1. Layer 1

Layer 1 is the physical layer and ensures that a connection exists between the network and the ISDN terminal (TE) e.g. TANDBERG products. Obviously as only 2 wires exist over which to transfer data the channels cannot be physically separate. Instead the channels are separated by time. Layer 1 uses frames to transport layer 2 and 3 information. A typical layer 1 frame might look like:



The Framing, Echo and Balancing information are used to help control the data on the line and help in the control of Framing, Collision Detection and to avoid DC levels on the line, respectively.

2.2. Layer 2

Layer 2 is used to control the handshaking between the network and the TE.

Establishing a layer 2 connection requires that a TE has what is known as a *tei* (terminal equipment identifier). This is assigned by the network and will be unique to that TE and is used by the network to identify the TE on layer 2 at all times.

Whilst the network is trying to assign a *tei*, communication with a TE still needs to be uniquely identified in some way. This is achieved by using a *Ri* or reference indicator. Once a *tei* is assigned the *Ri* is no longer used.

Once a *tei* has been established the TE sends out a SABME (set asynchronous balanced mode extended) this requests that the network be set for full duplex communication. The network response is a UA (user acknowledge) indicating it accepts the SABME.

From this point forward the layer 2 information is generally just an I or a RR. I is indicating that the TE or NT is sending an information frame (it is this frame that is the layer 3 information). RR (reciever ready) indicates that the NT or TE is ready to recieve information.

The TE and Network continue to handshake during an ISDN call and while the line is idle to ensure both parties are present and available.

A disconnection is issued at layer 2 as well in the form of DISC to which the receiving party responds with UA. If no layer 3 information is received after 10 seconds then the network will automatically issue a DISC.

2.3. Layer 3

Layer 3 consists of:

1. Messages.
2. Information elements.

An information element must always be tagged to a message. Layer 3 messages are used to control the content and progress of a call.

A typical Layer 3 conversation may look like that illustrated in figure 1 overleaf.

3. The B Channel

The transmission of data over ISDN is achieved via multiples of 64kbit/s B channels. The protocol used to achieve successful digital communication within the B channels (inband signalling) is up to the ISDN end user. TANDBERG use the ITU-T, H.320 standard. Whatever the inband signalling, the *bearer capability* requested by a TANDBERG system when setting up a video call will be Unrestricted Digital Information (UDI). Requesting UDI indicates to the network that it should provide a full 64kbit/s bandwidth per channel and must not apply any compression / decompression algorithm to the transmitted information.

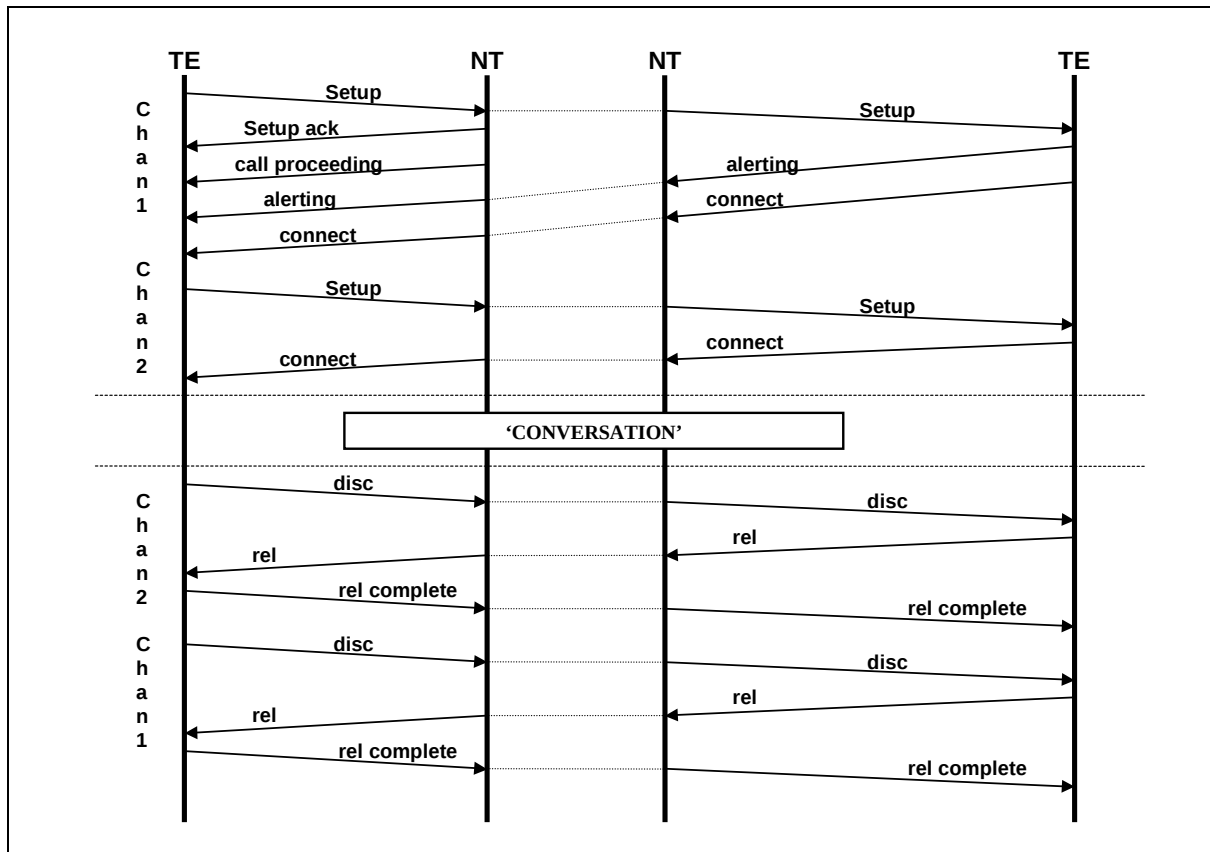


Figure 1

Speech is typically compressed before sending long distance, multiplexed with other speech channels and de-multiplexed and decompressed at the far end. To the human ear the effect is inaudible but for a network provider, this technique allows far more data to be transmitted using the same bandwidth. Such a technique is not suitable for the transmission of data, hence the request for UDI.

4. The Network & Connectivity

Diagrammatically the network can be illustrated as at Figure 2. The ISDN network is represented by a cloud from which individual lines (2 wire copper), via interface hardware, are run.

The 2 wires from the network are connected at the user site to a network terminating device known as an NT1. The connection between the network and the NT1 is known as the U Interface. Physically the U Interface is 2 wire copper and is known as '*local loop*'. Essentially it is the same as that used for analogue phones. The maximum length of a line for a U Interface is approximately 11km.

The NT1 links to the user's equipment (TE) via 8 wires, 2 Tx and 2 Rx as a balanced pair, 2 power supplies (for low current devices) and 2 Grounds. Up to 8 TEs may be connected to a single NT1 i.e each NT1 can support up to 8 separate MSNs with a TE on each. The connection between the NT1 and the TEs is known as the S/T Interface.

TANDBERG systems use a Co-incident S/T Interface. The cable between a TE and the NT1 is a *flat* cable i.e. there is no cross over of Rx/Tx pairs.

It is also possible to obtain a 2MB link to the ISDN network. In this case the interface at the user site is usually made via an Inverse Multiplexer (IMUX) or a PBX. The connection between the ISDN network and the IMUX is known as a Primary Rate Interface.

Although referred to as 30B + D, a 2MB stream supports 32, 64kbit/s channels comprised of:

- 30 B channels
- 1 D channel
- 1 Sync. channel

Each connection to the network at the user end will have a unique MSN. This is a number allocated by the network provider to the user, which may be used to identify at least one TE.

In addition to an MSN it is possible to set a SUB. This is a sub-address and is sent as a suffix to an MSN. A SUB can be up to 4 digits long and enables separate TEs sharing the same MSN to be addressed individually.

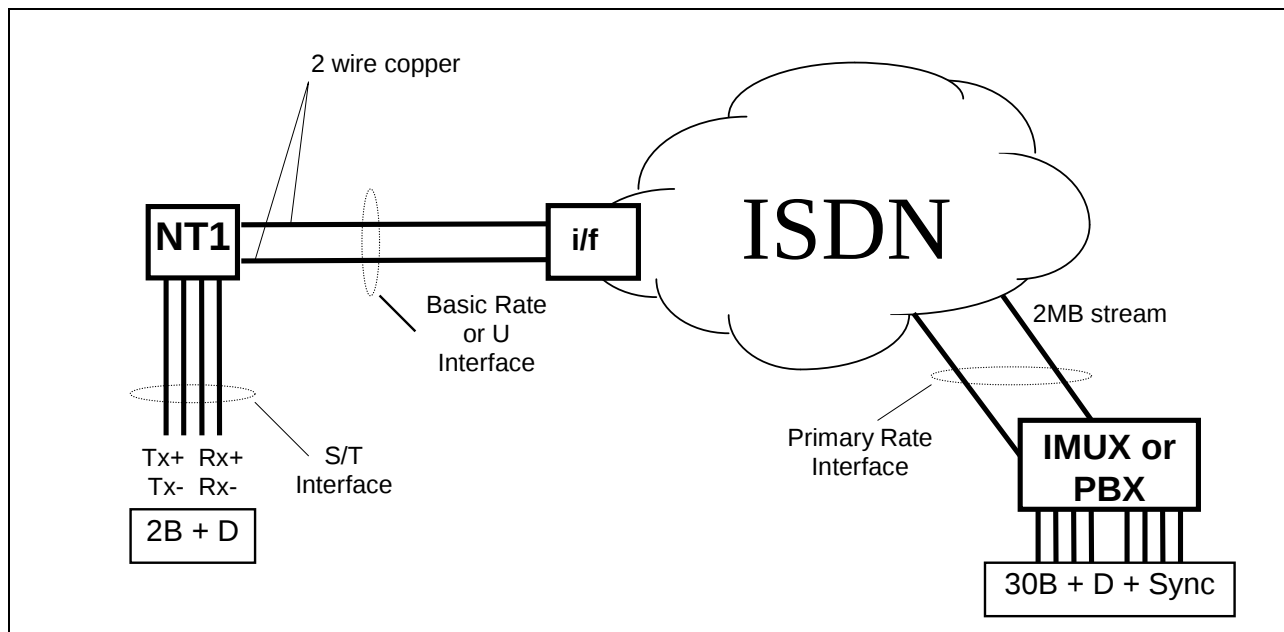


Figure 2.

Although all the 64kbit/s channels required may be provided by the same network for a single conversation there is no guarantee that they will travel simultaneously. This can result in significant delays between the separate channels. Usually these delays will never exceed 1 second, nevertheless TANDBERG systems have buffers to allow for delays of up to 1.2 seconds.

5. ISDN Cabling

As mentioned earlier TANDBERG Systems connect to the S/T interface using an 8 core straight through cable. Such a cable has the following properties:

- Each end is terminated with an RJ-45 jack.
- Pins 1,2,7 & 8 are not used by TANDBERG Systems as they are used by ISDN to provide a power source for low power consumption ISDN TEs such as ISDN telephones
- Pins 3,4,5 & 6 must be connected as they carry the Tx, Rx balanced pairs required for data communication.

The ISDN standard determines that a 100Ω resistive load be used to terminate both ends of the S/T interface, this is done to prevent reflections from the ends of the cable. Such a load is usually present in an NT1 and is often found in ISDN wall sockets.

5.1 How to connect the video system to the ISDN

Here are some examples on how the videoconference system can be connected to the ISDN line through the NT1.

- **NT1 and videoconference system in the same room.** If the video system is the only equipment that is connected to the NT1 and the distance between the NT1 and the video system is less than 10 meters then the ISDN cable from the video system can be connected directly into the NT1. The NT1 then needs to be terminated with a 50Ω resistive load.
- **ISDN S0-bus use.** If there is a need for more than one ISDN wall socket on the particular ISDN line or if the distance between the video system and the NT1 is up to 100 meters then the NT1 must have a S0-bus. The 100-meter distance on the S0-bus is dependent on the quality on the cable used. It is possible to have up to 8 ISDN wall sockets connected to that particular NT1. The S0-bus must be terminated in both ends with a 100Ω resistive load.

Please note that each Tx pair and Rx pair must be terminated with a resistive load according to the above.

6. ISDN Cause Codes

Cause No. 1 - Unallocated (Unassigned) Number

This cause indicates that the destination requested by the calling user cannot be reached because, although the number is in a valid format, it is not currently assigned.

Cause No. 2 - No Route To Specified Transit Network

This cause indicates that the equipment sending this cause has received a request to route the call through a particular transit network, which it does not recognize. The equipment sending this cause does not recognize the transit network either because the transit network does not exist or because that particular transit network, while it does exist, does not serve the equipment, which is sending this cause.

Cause No. 3 - No Route To Destination

This cause indicates that the called party cannot be reached because the network through which the call has been routed does not serve the destination desired. This cause is supported on a network dependent basis.

Cause No. 4 - Send Special Information Tone (Five One Zero NT)

This cause indicates that the called party cannot be reached for reasons that are of a long term nature and that the special information tone should be returned to the calling party.

Cause No. 5 - Misdialed Trunk Prefix

This cause indicates the erroneous inclusion of a trunk prefix in the called party number. This number is supposed to be stripped from the dialed number being sent to the network by the customer premises equipment.

Cause No. 6 - Channel Unacceptable

This cause indicates that the channel most recently identified is not acceptable to the sending party for use in this call.

Cause No. 7 - call awarded, being delivered in an established channel

This cause indicates that the user has been awarded the incoming call, and that the incoming call is being connected to a channel already established to that user for similar calls (e.g. packet-mode x.25 virtual calls).

Cause No. 8 - Preemption

This cause indicates the call is being preempted.

Cause No. 9 - Preemption - Circuit Reserved For Reuse

This cause indicates that the call is being preempted and the circuit is reserved for reuse by the preempting exchange.

Cause No. 16 - Normal Call Clearing

This cause indicates that the call is being cleared because one of the users involved in the call has requested that the call be cleared.

Cause No. 16/4 or 17 - User Busy

This cause is used when the called user has indicated the inability to accept another call. This cause may code may be generated by the called user or by the network. Please note that the use equipment is compatible with the call.

Cause No. 16/3 or 18 - No User Responding

This cause is used when a called party does not respond to a call establishment message with either an alerting or connect indication within the prescribed period of time allocated (in Q.931 by the expiry of either time T303 or T310).

Cause No. 19 - No Answer From User (User Alerted)

This cause is used when a user has provided an alerting indication but has not provided a connect indication within a prescribed period of time. Note: This cause is not necessarily generated by the customer premise equipment, but may be generated by internal network timers.

Cause No. 20 - Subscriber Absent

This cause value is used when a mobile station has logged off, radio contact is not obtained with a mobile station or if a personal telecommunication user is temporarily not addressable at any user-network interface.

Cause No. 21 - Call Rejected

This cause indicates that the equipment sending this cause does not wish to accept this call, although it could have accepted the call because the equipment sending this cause is neither busy nor incompatible. This cause may also be generated by the network, indicating that the call was cleared due to a supplementary service constraint. The diagnostic field may contain additional information about the supplementary service and reason for rejection.

Cause No. 22 - Number Changed

This cause is returned to a calling party when the called party number indicated by the calling party is no longer assigned. The new called party number may optionally be included in the diagnostic field. If the network does not support this cause, cause no: 1, unallocated (unassigned) will be used instead.

Cause No. 26 - Non-Selected User Clearing

This cause indicates that the user has not been awarded the incoming call.

Cause No. 27 - Destination Out Of Order

This cause indicates that the destination cannot be reached because the interface to the destination is not functioning correctly. The signaling message was unable to be delivered due to a hardware failure.

Cause No. 28 - Invalid Number Format (Address Incomplete)

This cause indicates that the called party cannot be reached because the called party number is not in a valid format or is not complete.

Cause No. 29 - Facilities Rejected

This cause is returned when a facility requested by the user cannot be provided by the network.

Cause No. 30 - Response To Status Inquiry

This cause is included in the STATUS message when the reason for generating the STATUS message was the prior receipt of a STATUS ENQUIRY.

Cause No. 31 - Normal, Unspecified

This cause is used to report a normal event only when no other cause in the normal class applies.

Cause No. 34 - No Circuit/Channel Available

This cause indicates that there is no appropriate circuit/channel presently available to handle the call.
Note: If you receive this call, try another data-service, such as dropping from a 64K to 56K data rate.

Cause No. 35 - Call Queued

This cause indicates that the call has been queued for service by the next available device.

Cause No. 38 - Network Out Of Order

This cause indicates that the network is not functioning correctly and that the conditions are likely to last a relatively long period of time. A call that is attempted soon afterwards will most likely not connect successfully.

Cause No. 39 - Permanent Frame Mode Connection Out-Of-Service

This cause is included in a STATUS message to indicate that a permanently established frame mode connection is out-of-service (e.g. due to equipment or section failure) [see Annex A/Q.933]

Cause No. 40 - Permanent Frame Mode Connection Operational

This cause is included in a STATUS message to indicate that a permanently established frame mode connection is operational and capable of carrying user information. [see Annex A/Q.933]

Cause No. 41 - Temporary Failure

This cause indicates that the network is not functioning correctly and that the condition is not likely to last a very long period of time. A call that is attempted almost immediately afterwards will most likely connect successfully.

Cause No. 42 - Switching Equipment Congestion

This cause indicates that the switching equipment generating this cause is experiencing a period of high traffic.

Cause No. 43 - Access Information Discarded

This cause indicates that the network could not deliver access information, low layer compatibility, high layer compatibility, or sub-address as indicated in the diagnostic.

Cause No. 44 - Requested Circuit/Channel Not Available

This cause is returned when the circuit or channel indicated by the requesting entity cannot be provided by the other side of the interface.

Cause No. 46 - Precedence Call Blocked

This cause indicates that there are no preemptable circuits or that the called user is busy with a call of equal or higher preemptable level.

Cause No. 47 - Resource Unavailable, Unspecified

This cause is used to report a resource unavailable event only when no other cause in the resource unavailable class applies.

Cause No. 49 - Quality Of Service Not Available

This cause is used to report that the requested Quality of Service cannot be provided (delay can't be supported).

Cause No. 50 - requested facility not subscribed

This cause indicates that the requested supplementary service could not be provided due to user oversight. This cause code is often caused by the CPE being configured for the wrong switch type.

Cause No. 52 - outgoing calls barred

This cause indicates that because of call screening provided by the network, the calling user is not permitted to make a call.

Cause No. 53 - Outgoing Calls Barred Within CUG

This cause indicates that although the calling party is a member of the CUG for the outgoing CUG call, outgoing calls are not allowed for this member of the CUG.

Cause No. 54 - incoming calls barred

This cause indicates that the called user will not accept the call delivered in the SETUP message.

Cause No. 55 - Incoming Calls Barred Within CUG

This cause indicates that although the calling party is a member of the CUG for the incoming CUG call, incoming calls are not allowed for this member of the CUG.

Cause No. 57 - Bearer Capability Not Authorized

This cause indicates that the user has requested a bearer capability, which is implemented by their equipment but the user is not authorized to use.

Cause No. 58 - Bearer Capability Not Presently Available

This cause indicates that the user has requested a bearer capability, which is implemented by the equipment which generated this cause but which is not available at this time.

Cause No. 62 - Inconsistency In Outgoing Information Element

This cause indicates an inconsistency in the designated outgoing access information and subscriber class

Cause No. 63 - Service Or Option Not Available, Unspecified

This cause is used to report a service or option not available event only when no other cause in the service or option not available class applies.

Cause No. 65 - Bearer Capability Not Implemented

This cause indicates that the equipment sending this cause does not support the bearer capability requested.

Cause No. 66 - Channel Type Not Implemented

This cause indicates that the equipment sending this cause does not support the channel type requested

Cause No. 69 - Requested Facility Not Implemented

This cause indicates that the equipment sending this cause does not support the requested supplemental service.

Cause No. 70 - Only Restricted Digital Information Bearer Capability Is Available

This cause indicates that on equipment has requested an unrestricted bearer service but that the equipment sending the cause only supports the restricted version of the requested bearer capability.

Cause No. 79 - Service Or Option Not Implemented, Unspecified

This cause is used to report a service r option not implemented but only when no other cause in this class applies.

Cause No. 81 - Invalid Call Reference Value

This cause indicates that the equipment sending this cause has received a message with a call reference, which is not currently in use on the user-network interface.

Cause No. 82 - Identified Channel Does Not Exist

This cause indicates that the equipment sending this cause has received a request to use a channel not activated on the interface for a call. For example, if the user only subscribed to channels 1 to 12 and channel 13 through 23 is requested by either side, this cause is generated.

Cause No. 83 - A Suspended Call Exists, But This Call Identify Does Not

This cause indicates that a call resume has been attempted with a call identity, which differs from that in use for any presently suspended call(s).

Cause No. 84 - Call Identity In Use

This cause indicates that the network has received a call resume request. The call resume request contained a call identity information element, which presently does not indicate any suspended call within the domain of interfaces over which calls may be resumed.

Cause No. 85 - No Call Suspended

This cause indicates that the network has received a call resume request containing a Call identity information element, which presently does not indicate any suspended call within the domain of interfaces over which calls may be resumed.

Cause No. 86 - Call Having The Requested Call Identity Has Been Cleared

This cause indicates that the network has received a call resume request. The request contained a call identity information element which once indicated a suspended call, however, that the call was cleared while suspended (either a network time-out or remote user).

Cause No. 87 - User Not A Member Of CUG

This cause indicates that the called user for the incoming CUG call is not a member of the specified CUG or that the calling user is an ordinary subscriber calling a CUG subscriber.

Cause No. 88 - Incompatible Destination

This cause indicates that the equipment sending this cause has received a request to establish a call, which has low layer compatibility, high layer compatibility, or other compatibility attributes (e.g. data rate) which cannot be accommodated.

Cause No. 90 - Non-Existent CUG

This cause indicates that the specified CUG does not exist.

Cause No. 91 - Invalid Transit Network Selection

This cause indicates that a transit network identification was received which is of an incorrect format as defined in Annex C/Q.931

Cause No. 95 - Invalid Message, Unspecified

This cause is used to report an invalid message event only when no other cause in the invalid class applies.

Cause No. 96 - Mandatory Information Element Is Missing

This cause indicates that the equipment sending this cause has received a message, which is missing an information element which must be present in the message before that message can be processed.

Cause No. 97 - Message Type Non-Existent Or Not Implemented

This cause indicates that the equipment sending this cause has received a message with a message type it does not recognize either because this is a message not defined or defined but not implemented by the equipment sending this cause.

Cause No. 98 - Message Not Compatible With Call State Or Message Type Non-Existent Or Not Implemented

This cause indicates that the equipment sending this cause has received a message such that the procedures do not indicate that this is a permissible message to receive while in the call state, or a STATUS message was received indicating an incompatible call state.

Cause No. 99 - Information Element / Parameter Non-Existent Or Not Implemented

This cause indicates that the equipment sending this cause has received a message which includes information element(s)/parameter(s) not recognized because the information element(s)/parameter name(s) are not defined or are defined but not implemented by the equipment sending the cause. This cause indicates that the information element(s)/parameter(s) were discarded. However, the information element is not required to be present in the message in order for the equipment sending the cause to process the message.

Cause No. 100 - Invalid Information Element Contents

This cause indicates that the equipment sending this cause has received an information element which it has implemented; however, one or more fields in the information elements are coded in such a way which has not been implemented by the equipment sending this cause.

Cause No. 101 - Message Not Compatible With Call State

This cause indicates that a message has been received which is incompatible with the call state.

Cause No. 102 - Recovery On Timer Expiry

This cause indicates that a procedure has been initiated by the expiry of a timer in association with Q.931 error handling procedures.

Cause No. 103 - Parameter Non-Existent Or Not Implemented - Passed On

This cause indicates that the equipment sending this cause has received a message, which includes parameters not recognized because the parameters are not defined or are defined but not implemented by the equipment sending this cause.

Cause No. 110 - Message With Unrecognized Parameter Discarded

This cause indicates that the equipment sending this cause has discarded a received message, which includes a parameter that is not recognized.

Cause No. 111 - Protocol Error, Unspecified

This cause is used to report a protocol error event only when no other cause in the protocol error class applies.

Cause No. 127 – Interworking, Unspecified

This cause indicates that there has been interworking with a network which does not provide cause codes for its actions. The precise cause for a message being sent is not known.