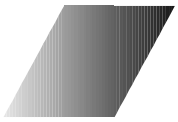

Worldwide Digital Connectivity

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Aculab plc

Q931 – An Overview

v 1.0

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Contents

1 Introduction

The relevant Q931 based specification or the ITU specifications are an essential purchase for anybody trying to design software to communicate along a Q931 based protocol link.

This document is not a replacement for the ITU specification, but may be used either as an introduction to the protocol, or by people who have occasional need to interpret Q931 protocol.

Consider a public telephone service provider that has a network available to customers so they can make calls from A to B.

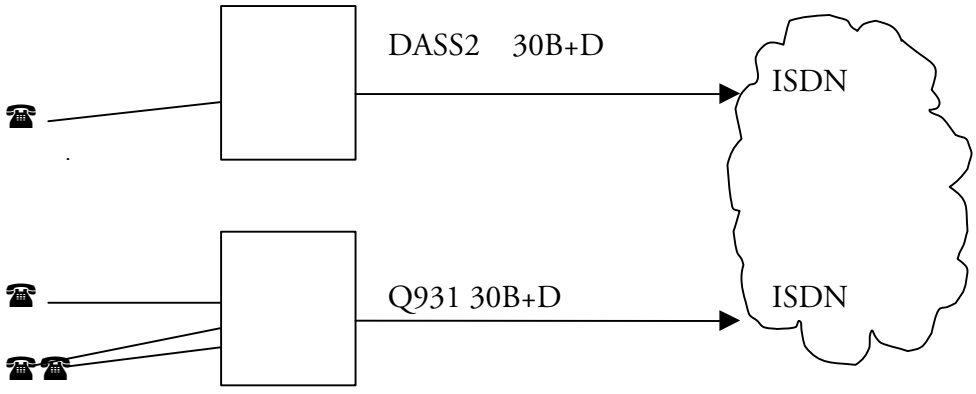
These calls were traditionally Voice orientated- If the customer wanted to send say a document- they would have to utilise a special machine that converted the hard document into a format that could be sent via a voice link. This is obviously a fax machine- which scans the paper and then makes a call to site B and sends the document as a series of voice band tones to the destination fax machine. In essence the nature of the DATA call is still voice band tones- like a voice call.

This method of sending data was extremely limiting if vast amounts of computer data needed to be sent from A to B, Therefore historically the PTO's would offer a totally separate Data network- for larger customers which utilised specific data lines offering wider bandwidth and thus higher transmission speeds. This was in essence a totally separate national network solely for DATA calls.

The concept of ISDN (Integrated Services Digital Network) was to amalgamate these networks – replacing them with one network capable of handling many different types of call. The main difference is that in the ISDN all speech is digitised and thus is no different from data.

The ISDN can handle Voice, Data and Fax calls using one common national/international network.

Both DASS2 and Q931 are signalling systems that are used to access the PTO's network.



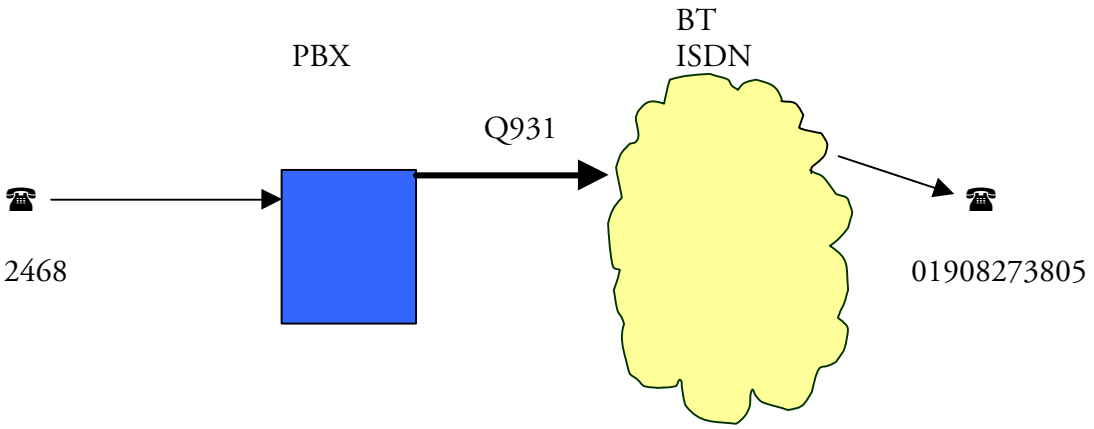
UK

In the UK the ISDN concept was first introduced to customers by BT with their DASS2 connections. Dass2 (Digital Access Signalling System) is a BT designed signalling standard. It was introduced before the Q931 standard was finalised by the International Community. British Telecom used the term ISDN when describing their DASS2 lines. DASS2 lines are provided to the customer on a 2Mb/s link and can handle 30 simultaneous calls (64Kb/s each). DASS2 is still offered by BT and other UK carriers. Q931 is the name of the CCITT document that describes the agreed signalling format for International ISDN. The CCITT used to be International Telegraph and telephone Consultative Committee. This is the organisation that set out the internationally agreed standards for telecommunications. This organisation has subsequently evolved into the ITU. In the United Kingdom the Q931 based protocol is ETS300 (also known ass Euro ISDN). This is a very close implementation of the original CCITT specification. This is a 2Mb/s service as with DASS2 but the feature capability is far greater. In the UK both DASS 2 and Euro ISDN (ETS300) lines are available to customers. Customers will normally choose the desired signalling system, as this will be dictated by their CPE equipment, usually a PABX.
(CPE- Customer Premises equipment)

Most modern PABXs can handle many different types of signalling system, however the trend seems to be away from the DASS2 which is no longer being developed by BT, and more towards the internationally recognised Q931 standard. The Q931 standard is an international standard utilised by many countries telephony service providers. The CCITT specify the standards for the Layer 1,2 and layer 3 signalling messages. The Layer 3 messages are the messages that actually control the call setup, cleardown, and routing. The Layer 3 messages or Call Control messages are the minimum messages that must be understood by the interfacing equipment. Individual service providers may publish their own documentation that details further messages that will be transported in addition to Q931 messages. There are a number of additional European documents that cover supplementary services. These cover features that may be instigated by exchanges via the ISDN and require a higher degree of Layer 3 implementation.

2 Establishing a Call

For the purpose of describing the layer 3 messaging it is easiest to illustrate the signalling using an example. If we consider a basic voice call, being dialled from extension 2468 on the Pabx, they dial a number 01980273805



In order for the PBX, in this case, to tell the public exchange that it wishes to establish a call, an exchange of messages is necessary. These messages will be sent on the D channel, which is a specific channel on the link dedicated for signalling use. It controls the signalling for all of the 30 voice B channels, hence 30B+D.

These messages will

1. Confirm the type of call and bearer capacity required
2. Confirm the availability of a channel between the PBX and the Service Provider
3. Pass the dialled number and caller number to the PTO
4. Tell the PBX the status of the dialled party- i.e. Busy, or ringing etc.

If we examined the layer 3 signalling on the Q931 link for the example call we would see messages as follows:

PBX→	ISDN (Public Exchange)←	
SETUP		This is a message sent from the PABX to the ISDN , It contains the dialled number, The callers number, the required bearer capacity and type of call (i.e. voice call)
	SETUP ACKNOWLEDGE	This is an acknowledgement form the PTO that they have received the request and have reserved the requested B channel on the link.
	CALL PROCEEDING	This message is sometimes sent whilst the PTO is processing the digits that

PBX→	ISDN (Public Exchange)←	
		it has been sent, usually when a change in status is encountered.
	ALERTING	This message is sent by the exchange to the PBX to tell the PBX that the destination extension is ringing, the Pabx will receive this message and generate a ringing tone to the originator earpiece. It is important to note that at this stage No b channel has been connected between the PTO and the PBX and that tones heard by the originator are generated locally.This prevents abuse of the system.
	CONNECT	This message indicates that the destination user has answered their ringing phone, It is required to tell the PBX that the far end user has answered and that the reserved B channel should be connected through, so that the users can establish a two way speech connection.
DISCONNECT		Because the disconnect message has been generated by the PABX, it is clear that the Originator has replaced the handset and cleared the call. The disconnect message will contain information about why the call has cleared (the Clear Cause)- in this case the cause would be 'Normal Clearing'
	RELEASE	The Public exchange acknowledges receipt of the disconnect message, and releases the b channel connection.
RELEASE COMPLETE		The PABX acknowledges receipt of the Release from the PTO and send a message confirming that the CALL is released completely.

The basic messages used on the Q931 link can be broke down into 2 separate types

1. Call establishment Messages
2. Call Clearing Messages

The messages available are as follows:

ALERTING
CALL PROCEEDING
CONNECT
CONNECT ACKNOWLEDGE
PROGRESS
SETUP
SETUP ACKNOWLEDGE

RESUME
RESUME ACKNOWLEDGE
RESUME REJECT
SUSPEND
SUSPEND ACKNOWLEDGE
SUSPEND REJECT
USER INFORMATION

DISCONNECT
RELEASE
RELEASE COMPLETE
RESTART
RESTART ACKNOWLEDGE

SEGMENT
CONGESTION CONTROL
INFORMATION
NOTIFY
STATUS
STATUS ENQUIRY

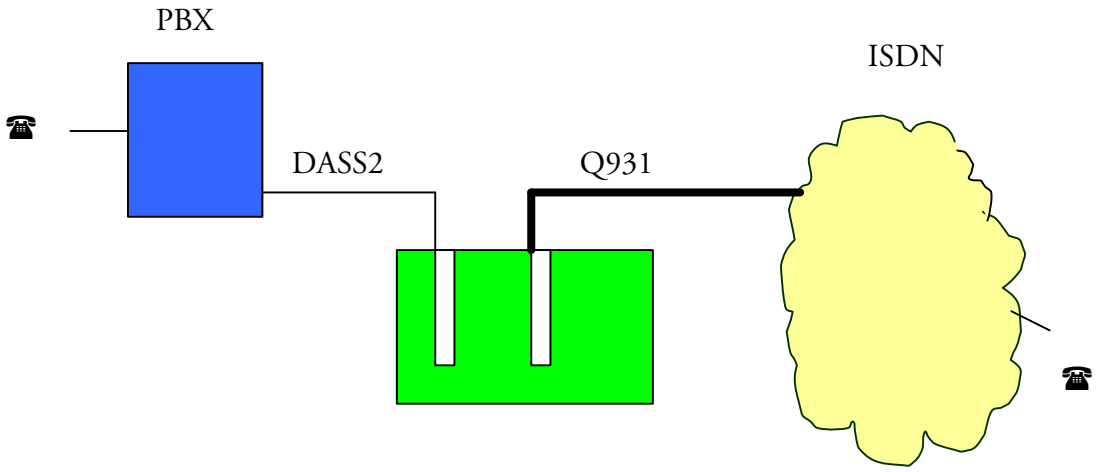
Within the Q931 Specification each of these messages is documented in full, and the circumstances under which the equipment should send the message. In the above example we have examined the Layer 3 signalling protocol messages which control the call throughout its duration. These are the digital messages that are passed between the PABX and the PTO exchange using the D channel.

The D channel contains all of the signalling for the 30 B channels

(D channel = data channel used for layer 3 signalling over Layer 2)
(B channel = bearer carries individual voice conversations calls)

If we take this example and apply it to the Aculab environment, then obviously our Interface cards are connected directly to the Service Providers ISDN line, in place of the customer PBX. A common use would be to use the Aculab cards as a signalling protocol converter if for instance the PBX only supported DASS2 but the customer had a Q931 ISDN line from the Service Provider.

Example below:



The Aculab card does not however directly decode the signalling messages into a readily readable format. In order to examine the Q931 messages we have to run a Trace utility. The Trace utility captures the raw data, which makes up the signalling protocol messages in exactly the same way as a proprietary protocol analyser does, the only difference is that the protocol analyser then automatically converts this raw hex data into a readable format. In the case of a call trace provided by the Aculab trace facility the signalling messages have to be manually decoded from the raw hex data. The format of the hex output can seem complex but with a little knowledge can be decoded relatively easily.

The following table shows the binary and hex values that are assigned in the blue book to the above call control messages.

Binary Bits 876 54321	Hex Value	Message	
000 00001	01	ALERTING	
000 00010	02	CALL PROCEEDING	
000 00111	07	CONNECT	
000 01111	0f	CONNNECT ACKNOWLEDGE	
000 00011	03	PROGRESS	
000 00101	05	SETUP	
000 01101	0D	SETUP ACKNOWLEDGE	
001 00110		RESUME	
001 01110		RESUME ACKNOWLEDGE	
001 00010		RESUME REJECT	
001 00101		SUSPEND	
001 01101		SUSPEND ACKNOWLEDGE	
001 00001		SUSPEND	

Binary Bits 876 54321	Hex Value	Message	
		REJECT	
001 00000		USER INFORMATION	
010 00101	45	DISCONNECT	
010 01101	4D	RELEASE	
010 11010	5A	RELEASE COMPLETE	
010 00110	46	RESTART	
010 01110	4E	RESTART ACKNOWLEDGE	
011 00000		SEGMENT	
011 11001		CONGESTION CONTROL	
011 11011	7B	INFORMATION	
011 01110	6E	NOTIFY	
011 11101	7D	STATUS	
011 10101	75	STATUS ENQUIRY	

The basic format of a Q931 Euro ISDN message is as follows

The Layer 3 signaling will be shown in the 5th hex number field. Field s1, 2, 3 and 4 are Layer1/2 information.

Here are some layer 2 messages that are ongoing on the link and can be ignored as they occur regardless of whether there is traffic on the link

001E0F36:RX:02,01,01,AD,
001E2040:RX:02,01,01,91,
001E0F36:TX:02,01,01,DD,
001E2040:TX:02,01,01,A9,
001E16FC:RX:02,01,01,AD,
001E2807:RX:02,01,01,91,
001E16FD:TX:02,01,01,DD,
001E2807:TX:02,01,01,A9,
001E1EC4:RX:02,01,01,AD,
001E2FCE:RX:02,01,01,91,
001E1EC4:TX:02,01,01,DD,

The first message in this Trace Occurs now and looks like this:

001E5A77:RX:02,01,DC,AC,08, 02,00,22,05,A1,04,03,90,90,A3,18,
03,A9,83,81,1E,02,8A,81,6C,0D,00,83,30,31,33,34,
34,33,30,34,33,34,34,70,05,80,30,39,35,30,

This may appear to be complete garbage but when broken down using the Q931 Specification it is clear that every Hex field has a meaning.

We will now break down the above message and decode what each part means.

001E5A77:RX:02,01,DC,AC – This is layer 2 message.

08,- This will always be seen as it signifies that the message conforms to 931

02,00,22- This is the call Reference number- Which is a number assigned to the call by the originating PABX so that when the far end sends a response then both systems know that there messages are referring to the same call. The call Reference number is used solely within the layer 3 messages to tie together the strings of messages that relate to a certain call. It is NOT the B channel number the call will be assigned to.

In this example the first field shows that the call ref. value is 2 fields long
The actual call reference for this call is 022

05,- Form the Table of Layer 3 messages we can see that the 05= SETUP This is a setup message.

In order to break down the following Hex fields within the Layer 3 message- we need to consult the CCITT Q931 specification which has a further table called INFORMATION ELEMENT Identifier Coding.

The Information elements are the sub elements within the main layer 3 message. An example of some key elements is shown below. For Further information please see the Q931 Specification.

Binary Bits 8 7954321	Hex Value	
0 0000000		
0 0001000	04	Bearer Capability
0 0001000	08	Cause
0 0010000	10	Call Identity
0 0010100	14	Call State
0 0011000	18	Channel Id
0 0011110	1E	Progress Indicator
0 0100000	20	Network Specific Facility
0 0100111	27	Notification Indicator
0 0101000	28	Display
0 0101001	29	Date/Time
0 0101100	2c	Keypad Facility
0 0110100	34	Signal
0 1000111	47	Closed User Group
0 1001010	4A	Reversed Charge Indication
0 1101100	6C	Calling Party Number
0 1101101	6B	Calling Party Subaddress
0 1110000	70	Called Party Number
0 1110001	71	Called Party Subaddress
0 1110100	74	Redirecting Number
0 1111000	78	Transit Network Selection
0 1111001	79	Restart Indicator
0 1111100	7C	Low Layer Compatibility
0 1111101	7D	High LAYER Compatibility
0 1111110	7E	User-User

As can be seen the information elements of the example message occur after the Layer 3 message- in the example message this is in the 6th field

```
001E5A77:RX:02,01,DC,AC,08,  02,00,22,05,A1,04,03,90,90,A3,18,
            03,A9,83,81,1E,02,8A,81,6C,0D,00,83,30,31,33,34,
            34,33,30,34,33,34,34,70,05,80,30,39,35,30,
```

The fields shown in bold type are the Information elements. Depending upon the element format shown in the CCITT specification, the element may have more than one field. If it does invariably the next field shows the number of fields following that apply to the particular information element.

Therefore the message reads as follows:
First Information element is **A1**= Sending Complete (Used to indicate there are no further destination digits to be sent)

Second Information Element= **04,**03,90,90 A3,= BEARER Capability- Length 3 fields

Third Information Element =**18**,03,A9,83,81.= Channel Identification- The call setup is requesting channel 81- in Binary this is 1000 0001 As the first bit has to be stripped then the channel requested is actually channel 1.

Fourth Information Element
6C,0D,00,83,30,31,33,34, 34,33,30,34,33,34,34
This is the 6C= Calling Party number , the CPI of the originating party that has been sent to the PTO. In this case the CPI is 01344304344 the digits are encoded in ASCII characters.

Fifth Information Element=7**0**,05,80,30,39,35,30, This is the Called Party Number, i.e. the number that is being dialed by the PABX. The dialed number is sometimes referred to as the DA (Destination address) In the example the Called party number is 3950

As can be appreciated the above decode is only one message of a whole call setup messaging exchange.The remainder of the trace is shown below,

```
001E5A7C:TX:02,01,01,DE,
 Layer 2 Message received acknowledgment

001E5AA9:TX:00,01,AC,DE,08,02,80,22,02,18,03,A9,83,81,
Call Proceeding

001E5AAB:RX:00,01,01,AE,
Layer 2 Message received acknowledgment


001E77D8:RX:02,01,E0,B0,08,02,00,22,45,08,02,82,90,28,0C,2A,
            41,41,2A,43,4C,45,41,52,45,44,23,
DISCONNECT,CAUSE =90 = Normal call clear, Display 'AA
*CLEARED#'

001E780F:TX:00,01,B0,E2,08,02,80,22,4D,
RELEASE

001E7812:RX:02,01,E2,B2,08,02,00,22,5A,08,02,82,90,
Release Complete-Clear Cause Normal
```

3 Clearing Down a Call

Although the concept of layer 3 messaging may appear to be complicated, in reality the basic functionality is that of the basic POT (Plain Ordinary Telephone) phone line, like the standard analogue copper line we would encounter at home.

We are all familiar with the tones received when making a telephony call (Busy Tone, Ring Tone, and Number Unobtainable Tone). With Q931 the reason for a call failing is signaled using the clearing cause in a disconnect or release message.

For a PBX the code will be interpreted and an appropriate tone put on the line.

In the case of failed calls, there are numerous reasons why a call can fail

The table below shows the listing of Call Clear codes.

Message Pattern Binary 765 4321	Clear Cause Number	Reason for the Call Clear
000 0001	1	Unallocated(Unassigned) number
000 0010	2	No route to specified transit network
000 0011	3	No route to destination
000 0110	6	Channel Unacceptable
000 0111	7	Call Awarded and being delivered in an established channel
001 0000	16	Normal Call clear
001 0001	17	User Busy
001 0010	18	No user responding
001 0011	19	No answer from User (User alerted)
001 0101	21	Call reject
001 0110	22	Number Unspecified
001 1010	26	Non –selected user clearing
001 1011	27	Destination out of order
001 1100	28	Invalid number format
001 1101	29	Facility Rejected
001 1110	30	Response to Status enquiry
001 1111	31	Normal Unspecified
010 0010	34	No circuit / Channel available
010 0110	38	Network out of order
010 1001	41	Temporary failure
010 1010	42	Switching equipment congestion
010 1011	43	Access information discarded
010 1100	44	Requested circuit/Channel not available

Message Pattern Binary 765 4321	Clear Cause Number	Reason for the Call Clear
010 1111	47	Resources unavailable, unspecified
011 0001	49	Quality of service unavailable
011 0010	50	Requested facility not subscribed
011 1001	57	Bearer capability not authorised
011 1010	58	Bearer capability not presently available
011 1111	63	Service or option not available,unspecified
100 0001	65	Bearer capability not implemented
100 0010	66	Channel type not implemented
100 0101	69	Requested facility not implemented
100 0110	70	Only restricted digital information bearer capability is available
100 1111	79	Service or option not implemented unspecified
101 0001	81	Invalid call reference value
101 0010	82	Identified channel does not exist
101 0011	83	A suspended call exists, but
101 0100	84	Call Identity in use
101 0101	85	No Call suspended
101 0110	86	Call having the requested call identity has been cleared
101 1000	88	Incomplete Destination
101 1011	91	Invalid transit network selection
101 1111	95	Invalid message, unspecified
110 0000	96	Mandatory information element is missing
110 0001	97	Message type non existent or not implemented
110 0010	98	Message not compatible with call state or message type non existent or not implemented
110 0011	99	Information element non existent or not implemented
110 0100	100	Invalid information element contents
110 0101	101	Message not compatible with call state
110 0110	102	Recovery on Timer expiry
110 1111	111	Protocol error-unspecified
111 1111	127	Interworking, unspecified

Here is an example of a call clear message as seen on the Aculab Trace

```
001E77D8:RX:02,01,E0,B0,08,02,00,22,45,
08,02,82,90,28,0C,2A,
             41,41,2A,43,4C,45,41,52,45,44,23,
```

In the example we can see that the layer 3 message is 45 which is 'Disconnect'

The 08 Is the Information element meaning 'CAUSE'
In this case the information element is broken down as follows using the Q931 Specification.