CAS – *A Novice Guide*

Introduction

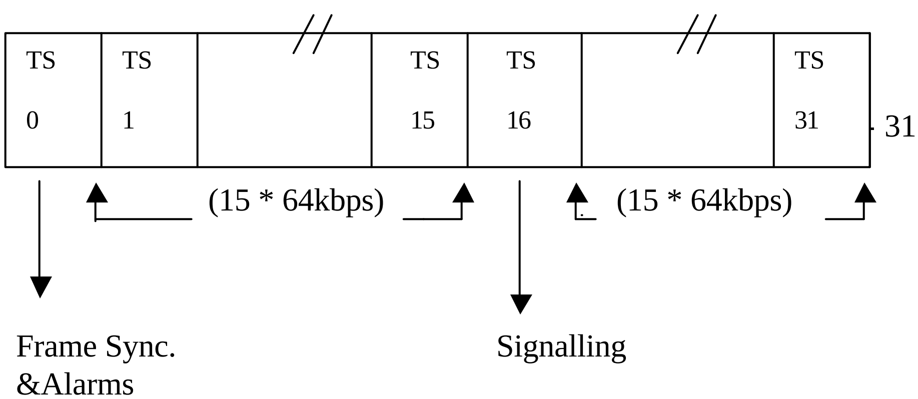
CAS stands for **Channel Associated Signalling**. With this method of signalling each traffic channel has a dedicated signalling channel. In other words the signalling for a particular traffic circuit is permanently associated with that circuit. This makes CAS inflexible and slow.

Channel-associated call-control is still widely used today mostly in South America, Africa, Australia and in Europe. However since 1979 other forms and applications of signalling have come about and can be generally referred to as Common-Channel signalling (CCS).

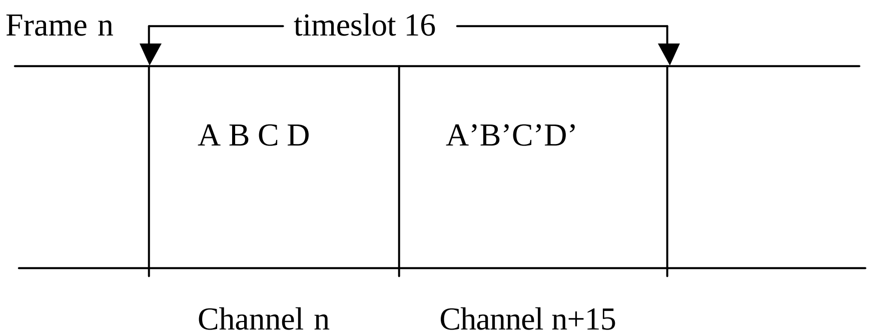
Common Channel Signalling (CCS) was introduced in 1976 and is where the common channel carries data messages which convey signalling for the circuits between two switches. CCS only requires one signalling channel for up to 1000 traffic channels. It is able to do this by only signalling when required, unlike CAS which signals even if nothing has happened. CCS is faster, more flexible and allow greater services

In Europe, timeslot 16 was designated as the signalling channel for all signalling associated with the 30 traffic time slots in the E1 (2.048 Mbps) bearer. Within timeslot 16, each traffic channel is allocated 4 bits once every 16 frame multiframe. It is not possible for all 30 channels to signal within the 8 bits in time slot 16. Therefore channels take turns using slot 16. Two channels send their ABCD signaling bits in each frame. The 340-user channel then takes 15 frames to cycle through all the signalling bits. One additional frame is needed to synchronize the received to the signalling channel. So the full multiframe has 16 frames.

Frame structure for a (E1) 30-channel connection.



<u>How timeslot 16 is used between the 30 channels</u>

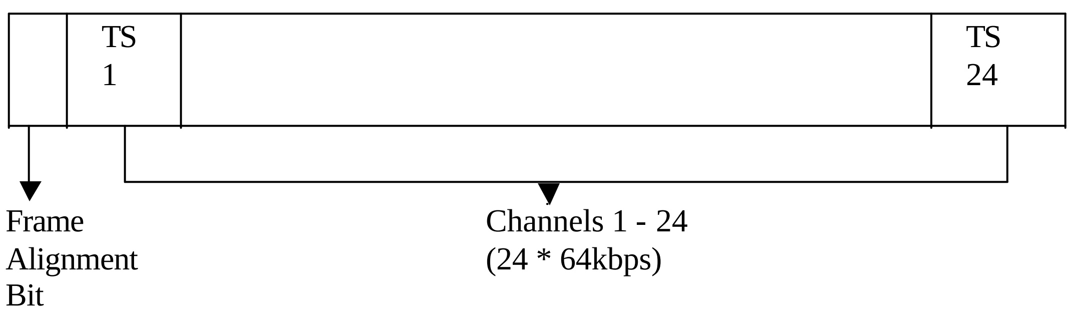


Effectively, every 2 ms a traffic channel will signal using 4 bits of information (2Kbps per traffic channel), whether there is any new information or not.

The term B-channel, meaning bearer channel describes a 64kbps channel for voice or date. It is a term taken from ISDN. A B-channel may also be used in a circuit switched, packet switched or leased line. A CAS timeslot could be described as a B-channel as it provides a 64kbps path used for speech.

T1 Bearer
T1 describes a multi-channel system used in Northern America and Japan. This combines 24 input channels sampled at 8kHz, each carrying an 8 bit digital word, using mu-law encoding (similar to A-law used in Europe). An additional frame alignment bit is added per frame giving 1.544Mbps aggregate (the sum of the 24 channels) signal.

<u>The T1 frame structure</u>



Signalling is carried out by a technique that 'steals' a single bit per multiframe. Hence we get the term 'Robbed bit'.

Line Signalling
The 4 bits available in timeslot 16 for signaling allows for 16 possible signalling states, this much are seldom used or required. These signals are know as line signalling, supervision signals or ABDC bits. These signals are used to set up and clear down the call and represent events that occur on the trunk such as seizure, proceed-to-send, answer,

clear forward, etc. While the majority of supervision signals are used in all CAS systems, there are system-specific differences in the sets of supervision signals.

Below is the line signalling for a protocol called R2T1. This is documented in the Blue Books under Q.421.

TABLE 2/Q.421 as in the Blue book

State of the circuit	Signalling code			
	Forward		Backward	
	a_f	b_f	a_b	b_b
Idle/Released	1	0	1	0
Seized	0	0	1	0
Seizure acknowledged	0	0	1	1
Answered	0	0	0	1
Clear-back	0	0	1	1
Clear-forward	1	0	0	1
			or	
			1	1
Blocked	1	0	1	1

In **E&M** (Ear and Mouth) line signalling the speech circuit (or channel) has an associated E-wire and M-wire for signalling. In this type of line signalling only one bit of the signalling changes at any one time.

Register signalling
Register signalling also known as Address Signalling, selection signals and digits. The digits are used primarily to indicate the called number, but can also have other meanings. Examples of register signalling are DTMF, MFC R2, decadic (Loop disconnect) and MFR1.

Loop disconnect Signalling (or decadic) is associated with a DC analogue CAS system and was used in the early CAS systems. In this situation the local switch provides a DC voltage on all subscriber lines enough to power a telephone. When the telephone is on-hook (idle), the loop inside the instrument is broken, and no lines current is drawn. When the subscriber goes off hook, initiating a call, current is drawn. The sending of the dial digits causes the loop to be opened and closed at a rate of 10 pulses per seconds. Thus each number in the dial (0 to 9) can be represented by a series of pules and the digit 0 to equal to 10 pulses. The decadic pulsing can be seen via the line signalling by the toggling of one of the ABCD bits (usually the A-bit).

The two main disadvantages of Loop disconnect (LD) are; slow signalling speed and the requirement for a metallic path. Allowing for interdigit pauses LD signalling can transfer approximately 1 digit per second. LD is not suited to carried systems (FDM) or radio systems due to its' need for a metallic connect between the subscriber and the switch.

MF (Multi-frequency) signalling uses a two-tone combination to represent a dialed digit and is usually associated with push button phones. The tones are chosen from within the voice band (in-band) and transmitted as audio tones over the traffic circuit. A single tone is considered unsuitable due to possible voice imitations.

A chart showing the frequencies used in DTMF signalling

Digit	*Low frequency*	*High frequency*
1	697 Hz	1209 Hz
2	697	1336
3	697	1477
4	770	1209
5	770	1336
6	770	1477
7	852	1209
8	852	1336
9	852	1477
0	941	1336
*****	941	1209
#	941	1477

MF is much faster than LD as it is capable of transferring several digits per second. The ITU-T standard MF system is number 4, (MF4). This signalling technique is also referred to as Dual Tone Multi-frequency (DTMF).

One of the more familiar CAS protocols is **MFC R2**. This is a compelled sequence multi-frequency code signalling. The fundamental principles of compelled multi-frequency code register signalling were developed in 1954. In 1968 this signalling systems was recognized by CCITT as an international signalling system for regional use. MFC R2 can be used on international as well as national connections.

In MFC R2 signalling, the equipment units at the exchanges that send and received digits, and the signalling between these units, are usually referred to as register and interregister signalling.

The **compelled signalling operates as follows** :

?? On seizure of a link (or line), the outgoing R2 register automatically starts sending the first forward interregister signal;

?? as soon as the incoming R2 register recognizes this signal, it starts sending a backward interregister signal which has it's own meaning and at the same time serves as an acknowledgement signal;
?? as soon as the outgoing R2 register recognizes the acknowledging signal, it stops sending the forward interregister signal.
?? as soon as the incoming R2 register recognizes the cessation of the forward interregister signal, it stops sending the backward interregister signal;
?? as soon as the outgoing R2 register recognizes the cessation of the acknowledging backward interregister signal it may, if necessary, start sending the appropriate next forward interregister signal.

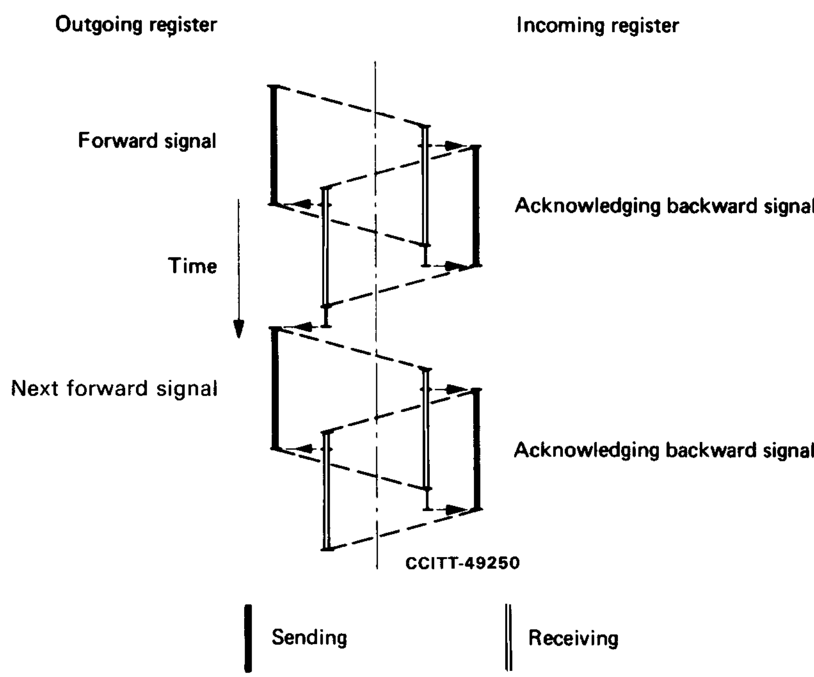


FIGURE 12/Q.440
Compelled signalling cycle

Each interregister signal consists of the simultaneous sending of 2 out of 6 in-band (within the audio band) frequencies (Multifrequency combinations). This 2 out of n code signal allows erroneous signals consisting of less or more than two frequencies to be detected and identified as faulty.

Multifrequency combinations

Combinations		Frequencies (Hz)						
No.	Numeral value = *x* + *y*	Forward direction (signals of Groups I and II)	1380	1500	1620	1740	1860	1980
		Backward direction (signals of Groups A and B)	1140	1020	900	780	660	540
		Index (*x*)	f_0	f_1	f_2	f_3	f_4	f_5
		Weight (*y*)	0	1	2	4	7	11
1	0 + 1		*x*	*y*				
2	0 + 2		*x*		*y*			
3	1 + 2			*x*	*y*			
4	0 + 4		*x*			*y*		
5	1 + 4			*x*		*y*		
6	2 + 4				*x*	*y*		
7	0 + 7		*x*				*y*	
8	1 + 7			*x*			*y*	
9	2 + 7				*x*		*y*	
10	3 + 7					*x*	*y*	
11	0 + 11		*x*					*y*
12	1 + 11			*x*				*y*
13	2 + 11				*x*			*y*
14	3 + 11					*x*		*y*
15	4 + 11						*x*	*y*

The forward as well as backward signals have primary and secondary meanings. The forward primary and secondary signals are usually described as group I and group II. The backward primary and secondary signals are described as Group A and group B.

TABLE 6/Q.441

Group I forward signals

Combination (a)	Designation of the signal (b)	Meaning of the signal (c)	Meaning of the signal (d)	Remarks (e)
1	I-1	Language digit: French	Digit 1	Col. (c) – These signals make up the first signal transmitted on an international link when it terminates in the country of destination of the call. When a link terminates in an international transit centre, however, these signals may be transmitted on the link after the country code indication and the country code. See also Recommendation Q.107.
2	I-2	Language digit: English	Digit 2	
3	I-3	Language digit: German	Digit 3	
4	I-4	Language digit: Russian	Digit 4	
5	I-5	Language digit: Spanish	Digit 5	
6	I-6	Spare (language digit)	Digit 6	
7	I-7	Spare (language digit)	Digit 7	
8	I-8	Spare (language digit)	Digit 8	
9	I-9	Spare (discriminating digit)	Digit 9	
10	I-10	Discriminating digit	Digit 0	
11	I-11	Country code indicator, outgoing half-echo suppressor required	Access to incoming operator (Code 11)	Col. (c) – First signal on an international link when it terminates in an international transit centre. Col. (d) – Other than the first signal on an international link.
12	I-12	Country code indicator, no echo suppressor required	i) Access to delay operator (Code 12) ii) Request not accepted	
13	I-13	Test call indicator (call by automatic test equipment)	i) Access to test equipment (Code 13) ii) Satellite link not included	
14	I-14	Country code indicator, outgoing half-echo suppressor inserted	i) Incoming half-echo suppressor required ii) Satellite link included	
15	I-15	Signal is not used	i) End-of-pulsing (Code 15) ii) End of identification	

TABLE 7/G.441

Group II forward signals

Combination (a)	Designation of the signal (b)	Meaning of the signal (c)	Remarks (d)
1	II-1	Subscriber without priority	These signals are solely used for national working
2	II-2	Subscriber with priority	
3	II-3	Maintenance equipment	
4	II-4	Spare	
5	II-5	Operator	
6	II-6	Data transmission	
7	II-7	Subscriber (or operator without forward transfer facility)	These signals are used for international working
8	II-8	Data transmission	
9	II-9	Subscriber with priority	
10	II-10	Operator with forward transfer facility	

11 12 13 14 15	II-11 II-12 II-13 II-14 II-15	} Spare for national use	

Group A backward signals

Combination (a)	Designation of the signal (b)	Meaning of the signal (c)
1	A-1	Send next digit (*n* + 1)
2	A-2	Send last but one digit (*n* -1)
3	A-3	Address-complete, changeover to reception of Group B signals
4	A-4	Congestion in the national network
5	A-5	Send calling party's category
6	A-6	Address-complete, charge, set-up speech conditions
7	A-7	Send last but two digit (*n* - 2)
8	A-8	Send last but three digit (*n* - 3)
9 10	A-9 A-10	} Spare for national use
11	A-11	Send country code indicator
12	A-12	Send language or discrimination digit
13	A-13	Send nature of circuit
14	A-14	Request for information on use of an echo suppressor (is an incoming half-echo suppressor required ?)
15	A-15	Congestion in an international exchange or at its output

TABLE 9/Q.441

Group B backward signals

Combination (a)	Designation of the signal (b)	Meaning of the signal (c)
1	B-1	Spare for national use
2	B-2	Send special information tone
3	B-3	Subscriber line busy
4	B-4	Congestion (encountered after changeover from Group A signals to Group B signals)
5	B-5	Unallocated number
6	B-6	Subscriber's line free, charge
7	B-7	Subscriber's line free, no charge
8	B-8	Subscriber's line out of order
9	B-9	Spare for national use
10	B-10	Spare for national use
11	B-11	Spare for national use
12	B-12	Spare for national use
13	B-13	Spare for national use
14	B-14	Spare for national use
15	B-15	Spare for national use

MFR1 is another type of register signalling. It is mainly used with t1rb (which is on T1) and e1ls with E&M Register signalling. This last protocol is actually very similar to t1rb but it operates on an E1.

Part of the MFR1 register signalling is the sending of 'KP' before any digits are send and the sending of ST when all digits have been sent. The KP signal prepares the receiving equipment to accept subsequent register signals. Just like DTMF, MFR1 also sends in-band tone pairs.

Register signal code of System R1

Signals	Frequencies (compound) Hz
KP (start-of-pulsing)	1100 + 1700
Digit 1	700 + 900
Digit 2	700 + 1100
Digit 3	900 + 1100
Digit 4	700 + 1300
Digit 5	900 + 1300
Digit 6	1100 + 1300
Digit 7	700 + 1500
Digit 8	900 + 1500
Digit 9	1100 + 1500
Digit 0	1300 + 1500
ST (end-of-pulsing)	1500 + 1700
Spare	700 + 1700
Spare	900 + 1700
Spare	1300 + 1700

Aculab provide a number of CAS protocols. Below is a short description of each with a suggestion of switches that can be used to get the protocol up and running, or in a back to back test. All the CAS protocols mentioned below are for use on E1 trunks except the t1rb and sdlc protocols.

The majority of these CAS protocols require a DSP to enable tone based register signalling. In the cases where decadic register signalling is required or tone based register signalling is done using an external DSP resource, either the DSP daughter board should be removed from the E1 (or T1) card, or the switch –s98 should be added. Also to enable the transmission and receiving of decadic register signalling the switches –s17 and –s18 should be used. The switch –s98 stops any DSP code being downloaded to the DSP daughter board.

Alsn

This is a protocol used in Holland (M1ALSN.RAM). It is usually used in a use-net configuration. This particular part of the protocol is set up for the network end and is mainly used for development purposes.
General switches to use;
None

Alsu

This is a protocol used in Holland. It is usually used in a use-net configuration. This particular part of the protocol is set up for the user end. M1ALSU.RAM
General switches to use;

None

Belgu

This firmware is approved for use in Belgium (M1BELGU.RAM). It uses DTMF for outgoing calls, as is required for normal customer access lines in Belgium. However, within the network both way MFC is used. Also, similar results to the approved version (M1BELGU) may be obtained using M1R2T1 (see M1R2T1 release notes for more details on this).

General switches to use;

-s1 -s3,5 -s5,7 -s8,1 -s13,9 –s28,8 used in M1R2T1.RAM gives similar results to using M1BELGU.RAM

M1BELGU.RAM needs no specific switches to work.

In a test situation M1BELGU.RAM can be tested against M1R2T1.RAM using

-s1 -s3,9 -s5,7 -s8,1 -s16 -s29

Btcu

This is BT Callstream CAS protocol, which is usually used in a net-user configuration. Calls can only be received by the user end (M1BTCU.RAM).

General switches to use;

None

Btcn

This is BT Callstream CAS protocol that is usually used in a net-user configuration. Outgoing calls can only be made from the network end (M1BTCN.RAM). This is mainly used for development purposes.

General switches to use;

None

Btmc

This is BT to Mercury Interconnect CAS protocol using DTMF. It is an unbalanced protocol (it is not the same in both directions) and is usually used in one direction only.

General switches to use;

-s8 should be used to enable the outgoing side.

The incoming side needs no specific switches.

E1ls

This protocol is very similar to the T1RB protocol on T1, but E1 Line-Side (E1LS) is on E1. This firmware implements several versions of E&M and Loopstart line signalling with decadic (Dial Pulse), DTMF and MFR1 register signalling .

Feature Group B (FGB) and Feature Group D (FGD) is a functionality used mostly with E&M. FGB is when the incoming side sends a wink before digits are sent from the outgoing side indicating it is ready and able to receive digits. A wink here is a quick off hook. (FGD) is when the incoming side sends a wink before digits are received, it will then expect to receive the calling party number (CLI), then the called party number (DDI) and then a second wink to indicated all digits have been received, the call can then be answered.

The variants of line signalling implemented by this firmware are E&M 'immediate start', E&M 'delay dial', E&M 'wink start, Loop-start user side (LSU), and Loop-start Network (LSN). There is also optional support for the 'current feed open' far end disconnect scheme (pulse release).

General switches to use;

For an E&M configuration making outgoing call –s6 is needed. For E&M receiving calls no switches are needed. The register signalling defaults to MFR1.

For the LSU/LSN; LSU can used switches -s8,9 -s6 –s11 –s12. LSN can use switches –s8,13 –s12. This gives DTMF register signalling.

Eema

The line signalling in this protocol is very configurable using –s switches detailed in the release notes. This E&M protocol only has 2 sets of line signalling; on-hook and off-hook. It is usually used on the Ericsson MD110 switch which uses E&M type A signalling, with decadic and DTMF Register signalling. It also can perform a wink start. A wink here is a quick off hook.

General switches to use;

None

El7

This firmware implements a version of signalling as implemented in Ericsson switches, and called "CAS Extension EL7, Interface to Voice mail systems". The spec suggests it works against an ASB 501 switch. This CAS protocol usually uses B,C and D bits, and not the A bits.

The implementation described here allows DTMF or decadic pulsing for register signalling, although normally only DTMF is available. The protocol is unbalanced, in that the signalling from the ASB end is different from the VM (Voice Mail system) end.

General switches to use;

The firmware defaults to the Voice mail end of this protocol. –s6 is needed to connect an outgoing call. On the ABS end the switch –s10 is required.

Esmn

This firmware implements several versions of E&M signalling, one having been taken from an L.M. Ericsson specification document called "Digital Channel Associated Signalling for Private Networks E/M Format", from Section 3 titled "Signalling Format 1 (A- Format)", which appears to be revision A, dated 07-Dec-1988. Other variants implemented by this firmware are E&M 'wink start, E&M 'immediate start' and DC5 protocols.

The implementation described here uses either DTMF or decadic pulsing for register signalling (although MFC is declared to be an optional alternative in the Ericsson documentation, it is not implemented here).

This protocol has a net and user configuration. Both configurations tend to be used for back-to-back testing, usually only the user end is used. This protocol tends to be used in Sweden.

General switches to use;

None

Esmu

This is the same as above, but is the network side of the protocol, usually used in back-to-back tests. This protocol tends to be used in Sweden.

General switches to use;

None

Fmfs

MF Socotel (French). MF Socotel is a compelled signalling system, where at each stage a single acknowledging signal is used to compel the forward or backward signal, providing information.
General switches to use;
-s9,2 should be used.
I701
Italian CAS.
General switches to use;
This uses switches –s32,255 –s33,255 -s34,255 –s35,255 to define a whole trunk as being outgoing. Hence calls can only be made in one direction. For more details see release notes.
Iem
Indonesian E&M SMFC R2 uses semi-compelled R2 register signalling. It is also known as discontinuous E&M.
General switches to use;
-s12,7 –s7,2 –s8,1 –s9,2
Ote2
Greek OTE 2-bit CAS. The OTE 2-bit CAS is specified in two variants, being:-
i) a DDI version (with digit signalling both inwards and outwards).
ii) a non-DDI version (with digit signalling outwards only)
The firmware 'OTE2' deals with both of these variants of 2-bit CAS, configured via '-s' switches on the device driver 'command' line. Note that neither of these versions is entirely symmetrical (balanced), this protocol has a user net configuration.
General switches to use;
For the user end; -s8 –s7 –s6,2. This enables the DDI version of the protocol and allows an outgoing call to connect. The net end should end should have -s7.
Ote4
Greek OTE 4 bit CAS.
General switches to use;
The switch –s30 is used to configure a trunk to be outgoing. The incoming needs no specific switches.
P8
Swedish CAS protocol driver. This is actually a combination of the P7 and the P8 protocol. (It has also been know to show attributes of an E&M protocol.) Within the P7 protocol calls from the network to the user do not use digits. Calls from the user end to the network will sends digits. With the P8 digits are sent from the network to the user end.
General switches to use;
If no switches are used it defaults to P8 both ways.
Pd1
The protocol is named after PD1, coming from the OFTEL document OTR001, which classifies this protocol group as 'port type PD1' for approvals purposes. They are also known variously as MCL (Mercury Communications Ltd.) CAS (MCL specification SS5002), and from various PBX suppliers as variants of DC5A.
The PD1 implementation provides three variants, as follows:-
DDI CAS, DTMF and decadic, balanced

Non-DDI CAS, DTMF and decadic, user end
Non-DDI CAS, DTMF and decadic, net end
On calls made from the network end to the user end using the non-DDI protocol, no destination digits are sent.
General switches to use;
-s8,2 will enable the DDI version of this protocol.
Or –s8,1 for a network configuration. With the user end –s8,0 (by default).

R2dk

This is an R2 based protocol for Denmark, with changes made to suit the specific issues of the Danish line signalling, which is quite different from Q421.
General switches to use;
User end, DDI -s1 -s9,1 -s34,50 -s28
Net end, DDI -s9,3 -s29

R2t1

This protocol does compelled R2 signalling, DTMF signalling and decadic signalling. It is highly configurable for different countries worldwide. See release notes for more country specific information
General switches to use;
-s1, default to MFC R2

Sdlc

This m1sdlc (Seiscor Digital Loop Carrier) usually used in Australia and is for use on T1 trunks. It has a net user configuration
General switches to use;
User end; -s8,0 –s6. This last switch is required for outgoing calls.
Net end; -s8,4

Smfs

A compelled multi-frequency line signalling for Socotel in Spanish, where at each stage a single acknowledging signal is used to compel the forward or backward signal providing information.
General switches to use;
-s9,4 can be used enabling a both way line. (Lines can in made incoming or outgoing only lines).

Ss5

CAS Signalling System #5. The line signalling here is based on a two tones, one in the forward direction the other in the backward direction. The register signalling is DTMF.
General switches to use;
-s6

T1rb

This protocol is very similar to the E1LS protocol on E1, but T1 Robbed Bit (T1RB) is on T1. This firmware implements several versions of E&M and Loopstart line signalling with decadic (Dial Pulse), DTMF and R1 register signalling. This protocol also has Feature Group B (FGB) and Feature Group D (FGD) functionality as explained the e1ls protocol.
The variants of line signalling implemented by this firmware are E&M 'immediate start', E&M 'delay dial', E&M 'wink start, Loop-start user side (LSU), and Loop-start Network

(LSN). Support for the 'current feed open' far end disconnect scheme (pulse release) and answer supervision is also available here.
A variety of different encoding framing methods are available with T1RB;

M1T1RB.RAM - D4 framing, AMI encoding, A-law DSP (Standard)
M1T1RBU.RAM - D4 framing, AMI encoding, u-law DSP (")

M1T1RB8Z.RAM - D4 framing, B8ZS encoding, A-law DSP
M1T1RB8U.RAM - D4 framing, B8ZS encoding, u-law DSP

M1T1RBES.RAM - ESF framing, B8ZS encoding, A-law DSP
M1T1RBEU.RAM - ESF framing, B8ZS encoding, u-law DSP

M1T1RBAM.RAM - ESF framing, AMI encoding, A-law DSP
M1T1RBAU.RAM - ESF framing, AMI encoding, u-law DSP

The mu-law variety is usually used in the States.
General switches to use;
For an E&M configuration making outgoing call –s6 is needed. For E&M receiving calls no switches are needed. The register signalling defaults to MFR1.
For the LSU/LSN; LSU can used switches -s8,9 -s6 –s11 –s12. LSN can use switches –s8,13 –s12. This gives DTMF register signalling.

Using the switch –s99,224
This switches enables protocol trace to be generated from the firmware on the card. An 8-bit parameter is used to vary what channel (or timeslots) is to be trace. To trace one particular channel the least significant 5 bits are used to give the correct channel reference.

To trace all 32 channels –s99,224 (128 + 64 + 32 = 128) is usually used. So the 8-bit word would be as follows.

128	64	32	16	8	4	2	1
1	1	1	0	0	0	0	0

For example –s99,193 is used to trace 1 channel. The 8-bit word would be;

128	64	32	16	8	4	2	1
1	1	0	0	0	0	0	1

To trace channel 10 you would need –s99, 202 ;

128	64	32	16	8	4	2	1
1	1	0	0	1	0	1	0

CAS protocol Trace
CAS protocol trace typically looks as below. It is taken from the compelled protocol R2T1;

```
00:00:48.535  Ch 01: 0 0 0 1  1 0 0 1
00:00:48.535  Ch 01: 0 0 0 1  1 0 0 1                 oseize
00:00:48.575  Ch 01: 0 0 0 1  1 1 0 1
```

```
00:00:48.590  Ch 01: 0 0 0 1  1 1 0 1                 odial
00:00:48.625  Ch 01: 0 0 0 1  1 1 0 1  ==>f1
00:00:48.625  Ch 01: 0 0 0 1  1 1 0 1                 odwbtone
00:00:48.720  Ch 01: 0 0 0 1  1 1 0 1        <==b1
00:00:48.720  Ch 01: 0 0 0 1  1 1 0 1  ==>
00:00:48.720  Ch 01: 0 0 0 1  1 1 0 1                 odwntone
00:00:48.815  Ch 01: 0 0 0 1  1 1 0 1        <==
00:00:48.815  Ch 01: 0 0 0 1  1 1 0 1                 odial
00:00:48.820  Ch 01: 0 0 0 1  1 1 0 1  ==>f2
00:00:48.820  Ch 01: 0 0 0 1  1 1 0 1                 odwbtone
```

Splitting up a line of trace;

00:00:48.535	**Ch 01:**	**0 0 0 1**	**1 0 0 1**	**oseize**
Timestamp Hr:Min:secs:milli secs	channel number	transmitted line Signalling	received line signalling	present state in the firmware

CAS trace may vary slightly depending on the tool used to collect the trace. For example Ptrace2 or TRACE.EXE. At times the time stamp will be in hexadecimal and will be in multiples of 5 ms (or 4ms in the case of P8).

`A B C D  A’B’C’D’`
`0 0 0 1  1 0 1 1` as mentioned before are the received and transmitted line signalling. They are also referred to as the ABCD bits (from left to right), i.e. the transmitted line signalling is AB=00. In most cases only bits A and B are changing. There are protocols where signalling is done on bits C and D.

Idle is the state the firmware state machine presently is in.

This is the complete line
```
00:00:48.535  Ch 01: 0 0 0 1  1 0 0 1                 oseize
```

```
00:03:45.445  Ch 01: 0 0 1 1  1 1 1 1                 odial
00:00:48.625  Ch 01: 0 0 0 1  1 1 0 1  ==>f1
```
In the above line the '==>f1' is the forward transmitted signal.

```
00:00:48.625  Ch 01: 0 0 0 1  1 1 0 1                 odwbtone
00:00:48.720  Ch 01: 0 0 0 1  1 1 0 1        <==b1
```
In the above line the '<==b1' is the backward received signal.

To fully understand trace and to use it to it’s full potential you also need to have the source code at hand. This is not available to our customers and not every one has an understanding for C code, so these people will always be at a disadvantage.

Hook flash (Call Transfer) signalling

There is a selection of CAS protocols such as t1rb, eema, e1ls can provide call transfer functionality via a hook flash. A hook flash is a quick off hook, which we implement via a meter pulse of a short duration. This duration is very much dependent on the switch that is being used. Any register signalling or dial tones needed after the hookflash will need to be produced by additional DSP resource. From the API prospective a call_put_charge API call is required.

Forced Release

The line signalling for a forced release is a,b = 00 in the backward direction. Before answer and after a predefined period (e.g. 60 – 120 secs) the incoming side will transmit a forced release. Also after the call is answered and the incoming side clears forward, if the calling subscriber does not clear the call within a predefined period, the incoming side will transmit a forced release.

The forced release itself has no releasing function, but it orders a release which thereafter is performed by normal clear forward. The signal is mainly used on circuits where metering signals exist.

For more information on forced release please see Blue book produced by ITU, recommendations Q.310 – Q.490, supplement 6, section 4.1.2.

Back Busy

Back busy (or blocking) is a signal that is available in some CAS (E1 and T1) protocols, that is sent over the ABCD bits, and is interpreted at the far end that the channel is not available for call placement (incoming to this end).

There is sometimes the concept of one-way working and both-way working lines, and back busy is typically only available against the direction of the call (in the backward direction). Back busy may even be illegal in the forward direction of lines that are configured for one-way use, but which are otherwise capable of both-way working (e.g. R2).

Without the 'auto back busy' functionality, when a channel is released to allow it to be used for another call, it returns immediately to the idle state, even though the application that would own it has not yet prepared to accept another call on that channel. Thus, it is possible for the channel to receive an incoming call before the application is ready to receive and process an incoming call.

With the 'auto back-busy' functionality activated, when a line is released to be used for another call it goes first into the back-busy state, which is interpreted by the far end as unavailable. When an application opens that channel (thus waiting for a call on that channel), the back-busy signal is removed, making the channel once again ready to accept a call.

In the case of R2 can exchange can block an idle trunk by changing its status from a,b = 1,0 to a, b = 1,1. As mentioned before exchanges will not seize these trunks. To end blocking, the exchange returns to a,b = 1,0 (idle).

Explanation of the state machine

When releasing a call the ‘goidle’ state is entered. If ‘auto back-busy’ is activated the STAT_OBUSY status detail is sent to the API and the ‘obusy’ state is entered. In this ‘obusy‘ state, the far end will not attempt to initiate an incoming call.

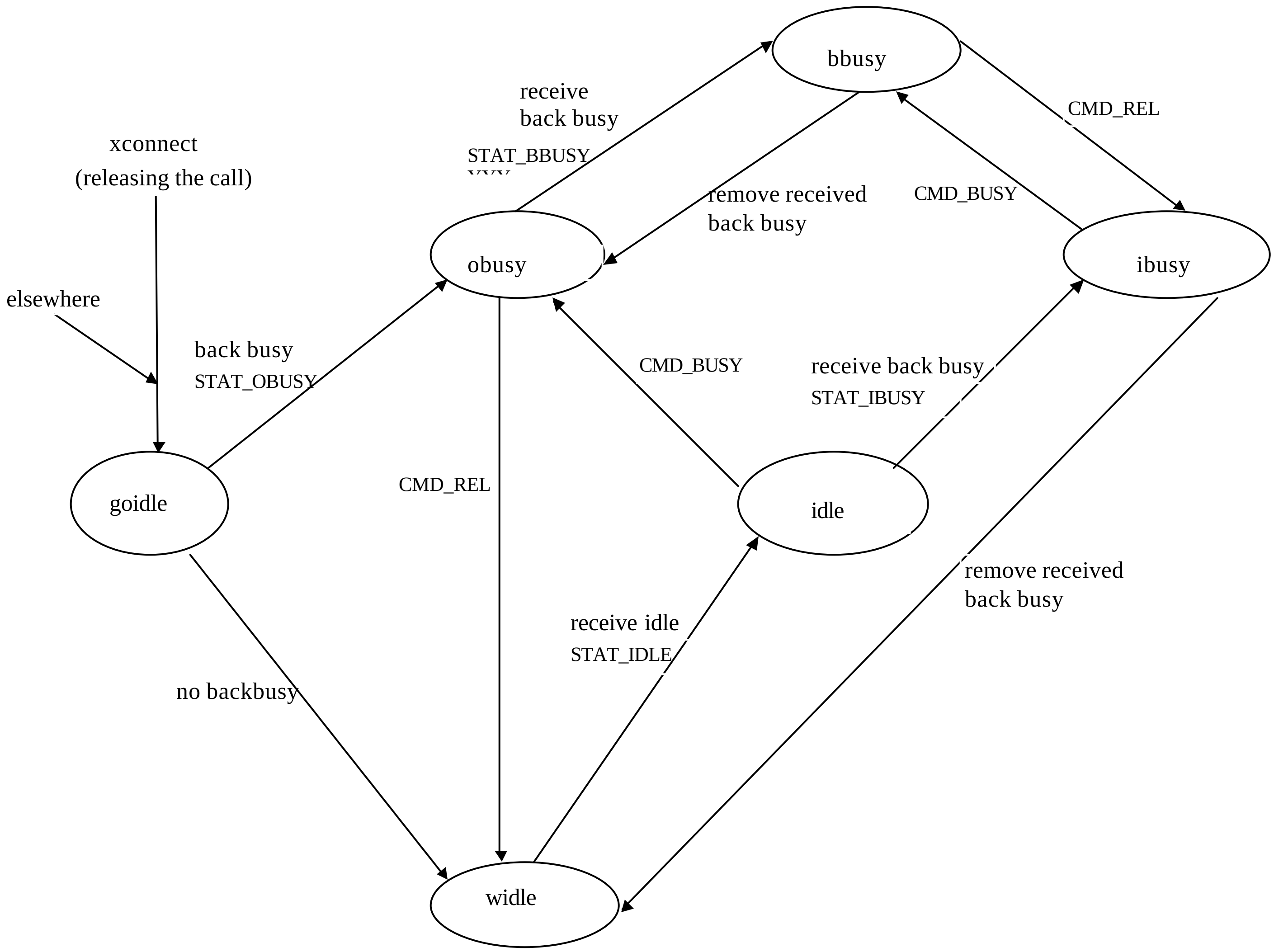
If while in this ‘obusy’ state, the far end also becomes back busied, the state ‘bbusy’ is entered. The status detail STAT_BBUSY is sent to the API. This state indicates that back-busy (blocking) is both being sent and received.

When a CMD_REL is received by the outgoing side it returns from the ’bbusy’ state to the ‘obusy’ state. The incoming side sending the CMD_REL returns from the ‘bbusy’ state to the ‘ibusy' state. No status detail is sent to the API when returning to the ‘ibusy’ state as it is effectively STAT_IBUSY, as IBUSY has the same numerical value as BBUSY, so no STAT change is sent.

In the ‘obusy’ state if a CMD_REL is received, the ’widle’ state is entered and then goes to the ‘idle’ state.

From the ‘idle’ state the channel may go either incoming or outgoing back busy. For received back busy it goes into the ‘ibusy’ state. For transmitted back busy it goes into the ’obusy’ state.

<u>Back Busy State Machine</u>



Terms and Acronyms
DDI Direct dial in
An **outgoing trunk** seizes an outgoing line, sends forward signals, and receives backward signals. An **Incoming trunk** receives forward signals, and sends backward signals.
In-band tones are audible tones, between 300 and 3400Hz.
Out-of-band tones. This is a narrow band of tones used as signalling tones centered at the signalling frequency f=3825 Hz.
ANI. The sending of the calling numbers is known as Automatic Number Identification.
The **Originating exchange** in a call is the local exchange serving the calling subscriber, and the **terminating (or destination) exchange** is the local exchange of the called subscriber.
Overlap address signalling. This is when the called number is not received all at once, so the called digits will be forwarded on to another exchange one at a time.
En-bloc address signalling. This is when the complete called number is sent out in one uninterrupted stream. ISDN protocols usually send their digits in this way.
Link-by-link signalling. This is signalling by two exchanges at the two ends of a trunk.
End-to-end signalling. In the end-to-end address signalling, the digit sender in the originating exchange sends address signals successively to digit receivers in the second, and later exchanges in the connection.
Malicious call holding is another name for last party release
A **Time Slot** is the same as a channel. A timeslot consists of 8 bits containing PCM encoded speech.
A **Frame** consists of all 30 timeslots (in the case of E1, 24 in the case of T1). Each frame contains a sample from each timeslot.
A **Multiframe.** It is not possible for all 30 channels to signal within the 8 bits in time slot 16. Therefore channels take turns using slot 16. Two channels send their ABCD signaling bits in each frame. The 340-user channel then takes 15 frames to cycle through all the signalling bits. One additional frame is needed to synchronize the received to the signalling channel. So the full multiframe has 16 frames.
Tone and Announcements. These include ring tones, busy tones, etc.
A **Register.** In R2 signalling, the equipment units at the exchanges that send and receive digits, and the signalling between these units, are usually referred to as register and interregister signalling.
Meter; Metering signals are pulsed type signals transmitted backwards during the conversation from the call charging point to the subscriber's call meter in the originating exchange. The are used to advise the originating exchange of the estimated cost for a particular dialed call.

Reference:
Wray Castle course notes Signalling Systems in Modern Telecoms Networks.
130 4 13 Ue March 1974, compelled sequence multi-frequency code signalling, Telefonaktiebolaget LM Ericssson, Telephone Exchange Division, S-126 25 Stockholm, Sweden.

Blue book Recommendation Q.440, Q.441 Q.421 Q.422

The Blue book produced by ITU (International Telecommunication Union) and CCITT (The International Telegraph and telephone Consultative Committee) Volume VI – Fascicle V1.4 Specification of signalling systems R1 and R2 Recommendations Q.310 – Q.490.

Signalling Telecommunication Networks by John G. Van Bosse. Published by Wiley – Interscience. ISBN number 0-471-57377-9