

# Standard and CRC-4 frame testing



## Application Note 1211-1

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APPLICATION [ 2Mb/s ]
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INTERFACE [ TERNARY ] LINECODE [ HDB3 ]
FRAME (6,704) [ CRC4 MFM ]
THROUGH MODE [ OFF ]
TX CLOCK SOURCE [ INTERNAL ]

PATTERN [ 2^11-1 ]

RECEIVE TIMESLOT [ AS PER TX ]
Tx [ F***..... ]
0 |-----| 31
Bandwidth 192kb/s

ALARM GENERATION [ OFF ]
ERROR ADD [ BIT ] [ SINGLE ]
STATUS:
OFF CAS MFM NO MFM CAS,CRC4 MFM
MFM
```

In-service testing of 2 Mb/s digital circuits and services is greatly enhanced when framing is added to the 2 Mb/s data.

CCITT recommendation G.703 which defines characteristics of hierarchical digital interfaces, states that for the 2 Mb/s hierarchy, transmission can be bit-sequence independent. In other words 2 Mb/s and 64 kb/s facilities are “clear channel”, and do not require any

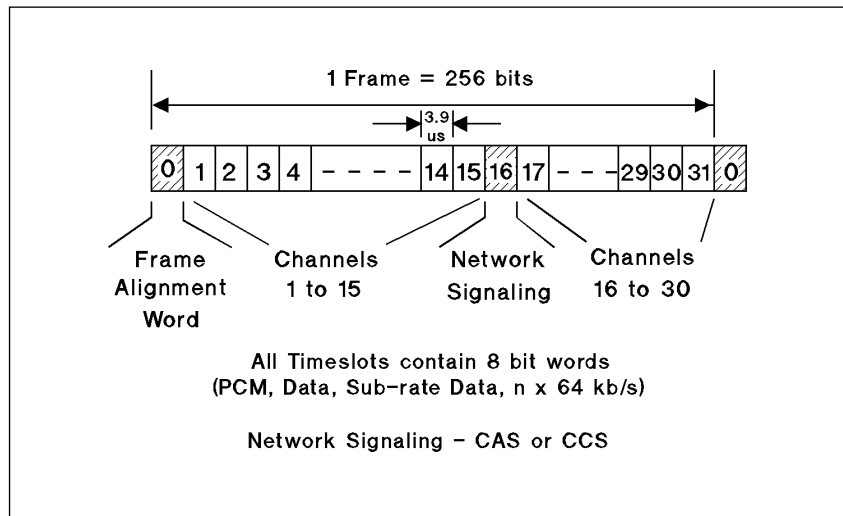
particular signal structure to pass through the network. Although this transparency can be useful for transmission of wideband signals, sending an unstructured signal into the network can have drawbacks.

An apparently random signal cannot be monitored in-service by the service provider for transmission errors, and it is impossible to provide bandwidth grooming or switching of channels.

It is likely that the PTT/service provider will not be able to guarantee network performance with unstructured 2 Mb/s traffic. In view of this, most private networks operate with the standard 2 Mb/s frame structure defined in CCITT recommendations G.704 and G.706.

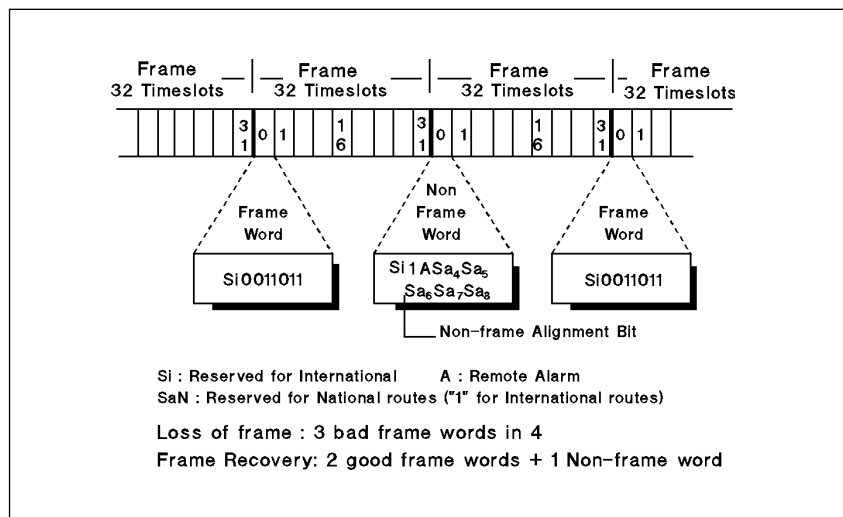
### Standard 2 Mb/s framing

Frame Format – G.704/G.706



Each 2 Mb/s frame contains 256 bits (32 timeslots, each of 8 bits) at a repetition rate of exactly 8 kb/s. The first timeslot (timeslot zero, TS0) is reserved for framing, error-checking and alarm signals, and the remaining 31 can be used for traffic. The individual channels can be used for 64 kb/s PCM, subdivided further for low-rate data or voice compression such as ADPCM (Adaptive Differential PCM) or aggregated for wideband signals such as videoconferencing or LAN interconnection. Sometimes a timeslot (such as TS16) is reserved for signaling - for example ISDN primary rate D-channel signaling such as Q.931 or Digital Private Network Signaling System (DPNSS), or channel associated ABCD signaling.

2.048 Mb/s PCM Frame Structure Frame Alignment (G.704, G.706)



The start of the 32 timeslot frame is signified by the frame alignment word (0011011) in TS0 of alternate frames. In the other frame, bit 2 is set to one and bit 3 contains the A-bit for sending an alarm to the far-end. The S-bits are all intended for international and national use and when unused are set to logic 1.

Once the demultiplexer has achieved frame alignment, it can separate the individual 64 kb/s channels in the frame. If three frame alignment words in four are received in error, the terminal declares loss of frame alignment and initiates a resynchronization process. The recovery criteria is one correct frame alignment word, one non-frame word bit 2 (logic 1), followed by one correct frame alignment word.

**Channel associated signaling**

Once the multiplexer has gained frame alignment, it searches in TS16 for the multi-frame alignment signal (0000) in bits 1 to 4. This marks frame 0 of the group of 16 frames called the multi-frame.

The multi-frame is only necessary when channel associated signaling (CAS) is used. Timeslot 16 then contains pairs of 4-bit ABCD signaling words. Over a complete multi-frame all 30 channels are serviced.

**Common channel signaling**

If common channel signaling (CCS) is used, then multi-frame alignment is unnecessary, and TS16 is simply used as a 64 kb/s data channel for CCS messages, or it can be turned over to revenue-earning traffic, giving a total of 31 channels for the payload.

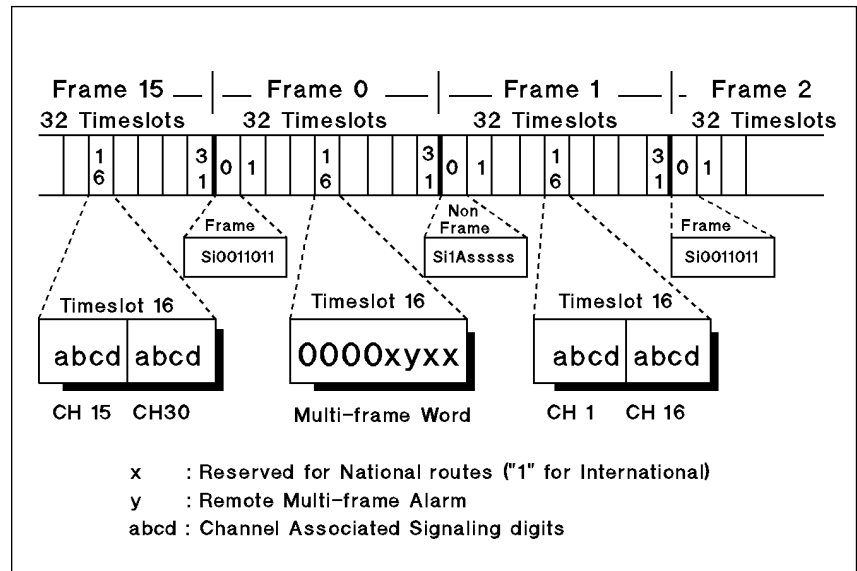
When the 2 Mb/s frame was used exclusively for PCM voice transmission, the frame alignment criteria was very reliable. However, it has some limitations particularly with increased data transmission and demand for on-line performance monitoring.

With data transmission, the traffic can simulate the frame alignment and non-frame alignment words and false framing is possible which would have serious effects on data.

Performance monitoring of the received signal is limited to checking for errors in the frame alignment signals. With only a total of 7 bits in 512 bits it gives a poor indication of errors in the payload. There is no way for the remote end to send back this rudimentary error performance data, so only one direction of transmission can be monitored at each location.

In the age of competitive digital leased live services, this is not very adequate!

**2.048 Mb/s PCM Frame Structure Channel Associated Signaling**



## CRC-4 framing

The new CRC-4 frame structure is defined in CCITT recommendation G.704. The CRC-4 remainder is calculated on complete blocks of data including all payload bits, and the 4-bit remainder is transmitted to the far-end for comparison with the recalculated CRC-4 remainder. If the two 4-bit words differ, then the receiving equipment knows that one or more errors are present in the payload. Every bit is checked so an accurate estimate of block error rate (or errored seconds) is made while the link is in-service. The CRC-4 framing algorithm is more complex and is extremely unlikely to be fooled by payload data patterns.

This table, from G.704, shows the sequence of bits in the frame alignment (TS0) position of successive frames. In frames not containing the frame alignment signal, the first bit is used to transmit the CRC multi-frame signal (001011) which defines the start of the sub-multi-frame. Alternate frames contain the frame alignment word (0011011) preceded by one of the Cyclic Redundancy Checksum - 4 (CRC-4) bits. The CRC-4 remainder is calculated on all the 2048 bits of the previous sub-multi-frame (SMF), and the 4-bit word sent as C<sub>1</sub>, C<sub>2</sub>, C<sub>3</sub>, C<sub>4</sub> of the current SMF. (Note that the CRC-4 bits of the previous SMF are set to zero before the calculation is made.)

At the receive end, the CRC remainder is recalculated for each SMF and the result compared with the CRC-4 bits received in the next SMF. If they differ, then it is assumed that the checked SMF is in error. What this tells us is that a block of 2048 bits had one or more errors. One thousand CRC-4 block error checks are made every second. Note that this in-service error detection process does not indicate bit error ratio (BER) unless you assume a certain error distribution (random or burst), to predict the average errors per block. Rather it provides a block error measurement.

CRC-4 multiframe structure (G.704)

	Sub-multiframe (SMF)	Frame number	Bits 1 to 8 of the frame (TS0)								TS 1-31
			1	2	3	4	5	6	7	8	9-256
MULTIFRAME	I	0	C <sub>1</sub>	0	0	1	1	0	1	1	PAYLOAD
		1	0	1	A	S	S	S	S	S	
		2	C <sub>2</sub>	0	0	1	1	0	1	1	
		3	0	1	A	S	S	S	S	S	
		4	C <sub>3</sub>	0	0	1	1	0	1	1	
		5	0	1	A	S	S	S	S	S	
		6	C <sub>4</sub>	0	0	1	1	0	1	1	
	II	7	0	1	A	S	S	S	S	S	
		8	C <sub>1</sub>	0	0	1	1	0	1	1	
		9	1	1	A	S	S	S	S	S	
		10	C <sub>2</sub>	0	0	1	1	0	1	1	
		11	1	1	A	S	S	S	S	S	
		12	C <sub>3</sub>	0	0	1	1	0	1	1	
		13	E	1	A	S	S	S	S	S	
		14	C <sub>4</sub>	0	0	1	1	0	1	1	
15	E	1	A	S	S	S	S	S			

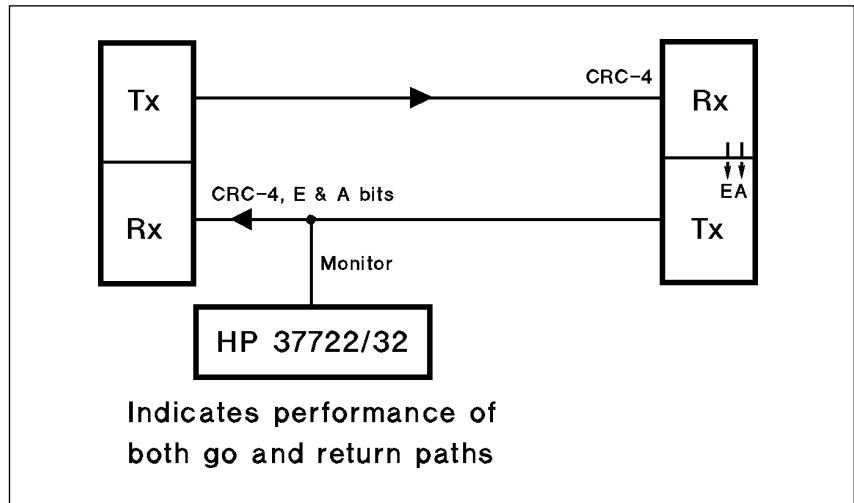
E = CRC-4 error indication bits; C<sub>1</sub> to C<sub>4</sub> = Cyclic Redundancy Check-4 (CRC-4) bits; S = Spare bits; A = Remote alarm indication; TS = Timeslot.

This is very useful for estimating percentage errored seconds (%ES) which is usually considered the best indication of quality for data transmission – itself a block transmission process. CRC-4 error checking is very reliable - at least 94% of errored blocks are detected even under high BER conditions, according to G.706.

Another powerful feature of CRC-4 framing provides a local indication of alarms and errors detected at the remote end. When an errored SMF is detected at the remote end, one of the E-bits is changed from 1 to 0 in the return path multi-frame. The local end therefore has exactly the same block error information as the far-end CRC-4 checker. Counting E-bit changes is equivalent to counting CRC-4 block errors. Thus the local end can monitor the performance of both go and return paths. This can be carried out by the network equipment itself, or by a test set like the Hewlett-Packard 37722A digital telecom analyzer or the HP 37732A telecom/datacom analyzer monitoring the received 2 Mb/s stream. In the same way, the A-bits return alarm signals for loss of frame or loss of signal from the remote end.

The CRC-4 frame structure described above is now gaining preference because of its error detection capability and immunity to false frame alignment (CCITT recommendation G.706). For systems without CRC framing, in-service testing is limited to checking for errors in the frame alignment word, which provides a poor indication of errors in the traffic payload. Monitoring code violations in HDB3 is another possibility; however, this measurement refers only to the nearest line section or the interface connection between equipment. It can be useful for troubleshooting, but has little application for monitoring overall system performance.

**Remote End Performance Monitor**



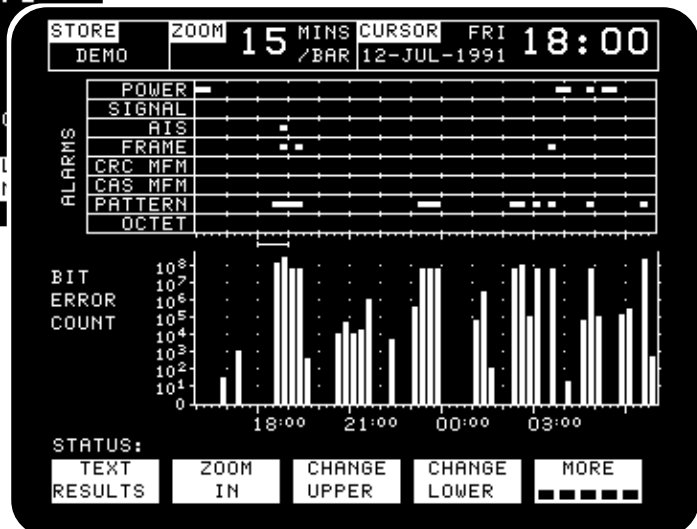
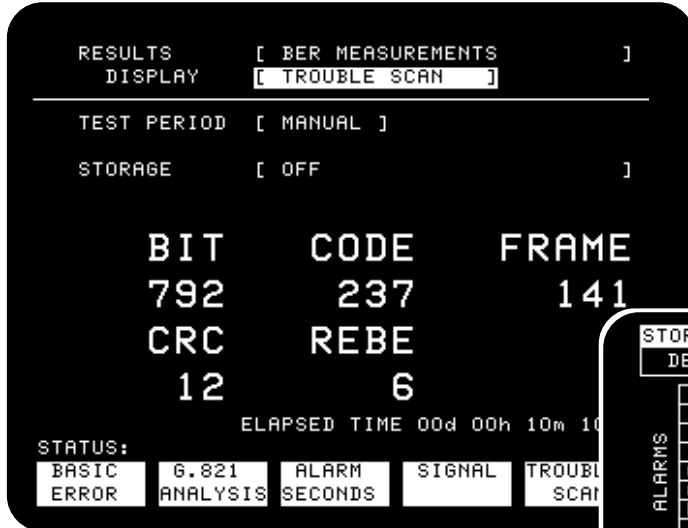
## In-service tests

The major benefit of in-service tests is that they allow the user's traffic to flow normally without interruption. This means that error performance statistics can be collected over a longer period, and with the storage available on modern test sets, weeks of data can be stored and time-stamped for multiple in-service parameters. These might include CRC-4 block errors, FAS errors, HDB3 code errors, E-bits (Remote End Block Errors – REBEs) and alarm history.

## Long-term monitoring

Long-term monitoring is useful for catching that elusive burst of errors which only seems to occur at the busiest time of the day! It also helps to confirm that the overall quality of the circuit meets specification.

The easiest way to analyze long-term measurements is the histogram. You can spot error bursts or periods of degraded performance almost instantly from a graphical display such as that shown below from the HP 37722A/32A.



## Timeslot monitoring

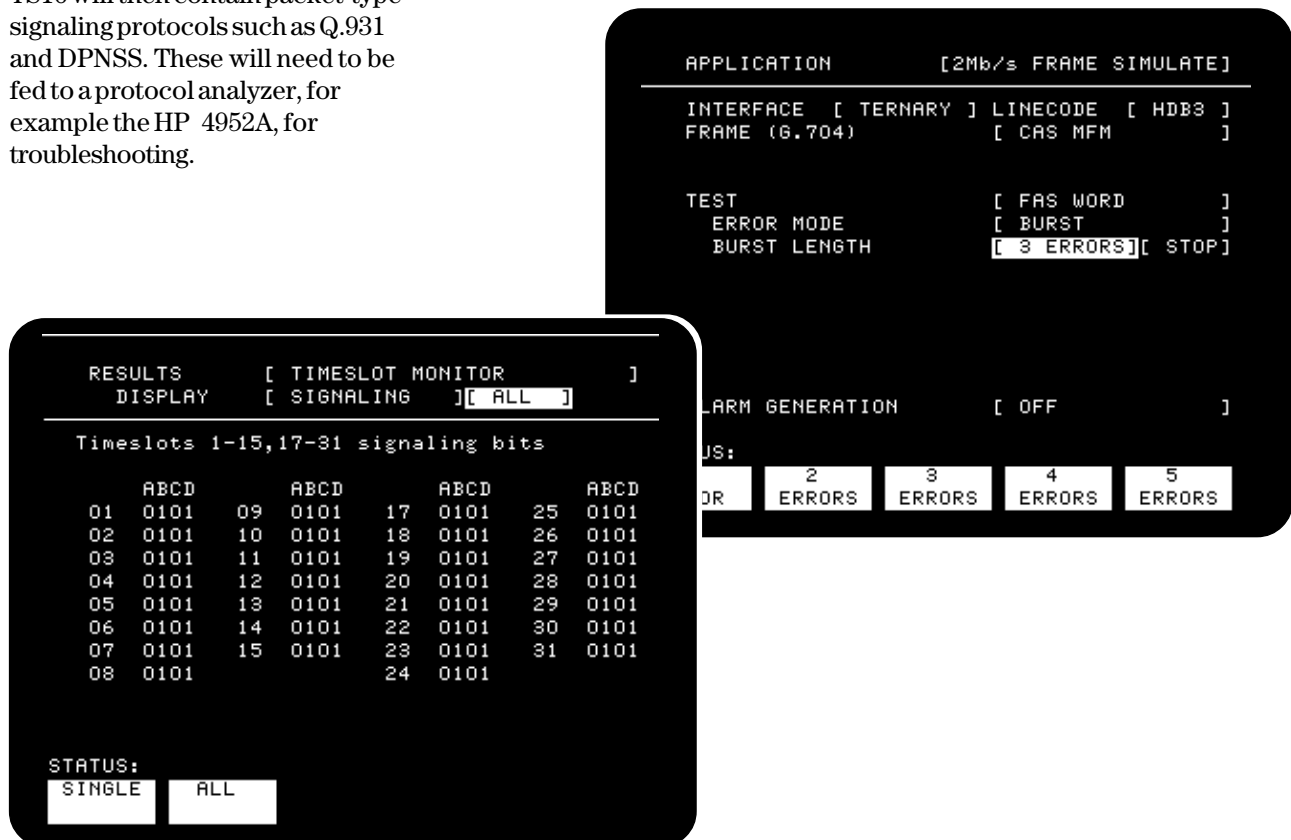
With a framed 2 Mb/s test set, there are other useful checks you can make. You can monitor the individual channels to check if they are carrying voice or data.

A demultiplexed channel at 64 kb/s can be fed to a protocol analyzer or decoded to provide a voice frequency output.

TS16 is usually assigned to signaling. It is possible to demultiplex TS16 and display the 30 ABCD words for channel associated signaling to investigate permanently idle channels or “stuck bits”. Before taking a channel out of service, you can check that it is idle and so avoid unnecessary outage. Most private networks use common channel signaling for interconnecting PBXs. TS16 will then contain packet-type signaling protocols such as Q.931 and DPNSS. These will need to be fed to a protocol analyzer, for example the HP 4952A, for troubleshooting.

## Multiplexer performance monitoring

A fully framed 2 Mb/s test signal also allows you to check the proper operation of alarms and performance monitoring within the multiplexer. Send errors in the frame alignment signal either continuously or in burst-mode and check the loss of frame criteria and resynchronization in the multiplexer. You can simulate CRC block errors and alarms and check how the multiplexer responds locally and through E and A bits on the outgoing stream.





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**Latin America:**

Hewlett-Packard  
Latin American Region Headquarters  
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USA  
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**Australia/New Zealand:**

Hewlett-Packard Australia Ltd.  
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Australia  
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**Asia Pacific:**

Hewlett-Packard Asia Pacific Ltd.  
17-21/F Shell Tower, Times Square  
1 Matheson Street, Causeway Bay  
Hong Kong  
Fax: (852) 2506 9285

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