UTC REGION 2 MEETING

The Effect of Digital Frame Loss on Audio Teleprotection

Introduction

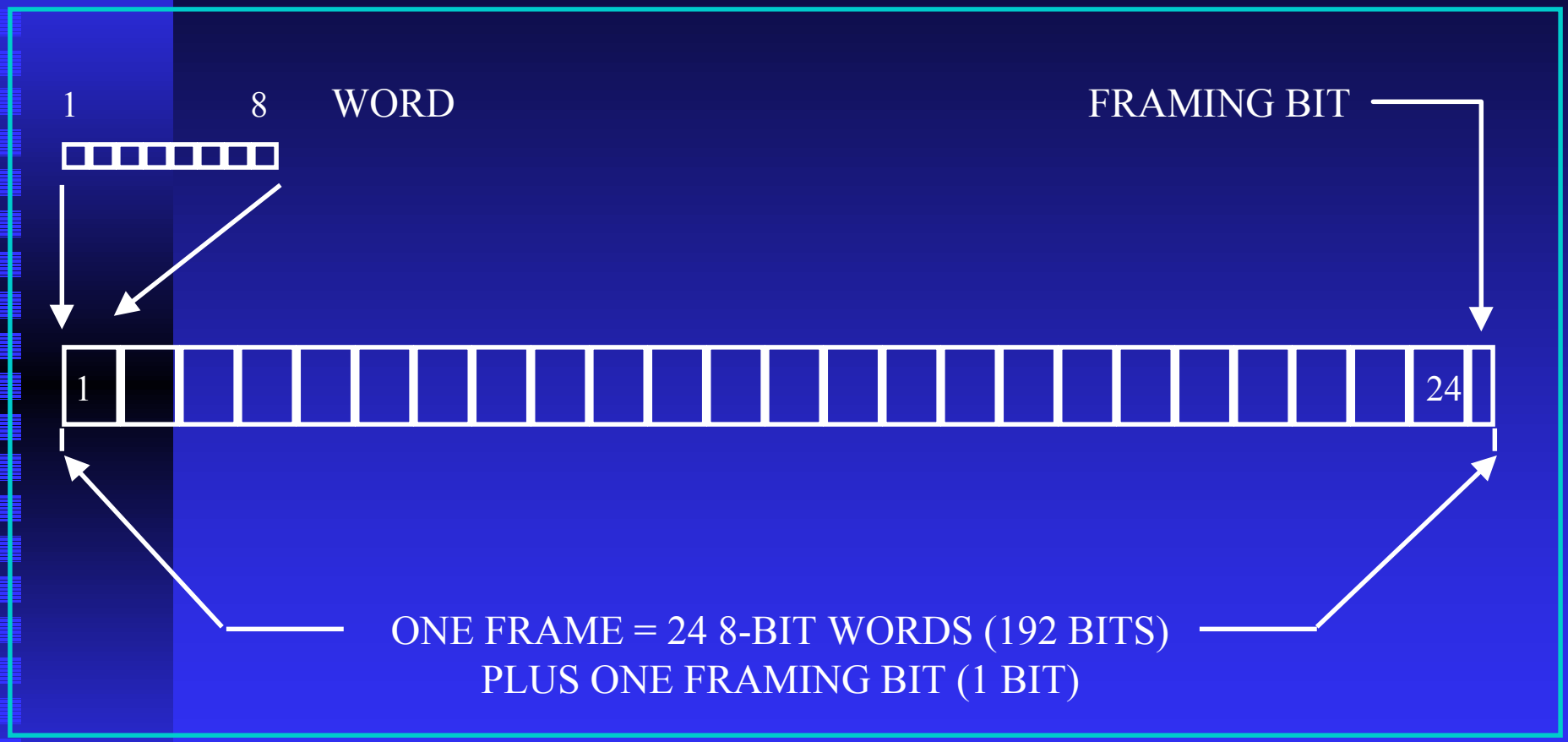
Audio Teleprotection was perfected over analog communications systems

Digital is different!!!

Overview of Digital Transmission

- Serial versus parallel data
- Framing patterns
- Loss of frame

T1 FRAME


1
8
WORD
FRAMING BIT
1
24
ONE FRAME = 24 8-BIT WORDS (192 BITS)
PLUS ONE FRAMING BIT (1 BIT)

CALCULATING THE 1.544 Mbps T-1 RATE

STEP	WHAT HAPPENS	CALCULATION
1.	The 8-bit digital samples created by PCM (voice channels only) are grouped into 24 discrete time slots created bt TDM. Each group of time slots is called a ***T1 frame.***	24 samples X 8 bits per sample 192 information bits per frame
2.	A framing bit is added to mark the end of one frame and the beginning of the next.	192 information bits + 1 framing bit 193 total bits per frame
3.	T1 frames are transmitted at the rate of 8000 per second.	8000 samples X 193 total bits 1,544,000 bits per second (1.544Mbps)

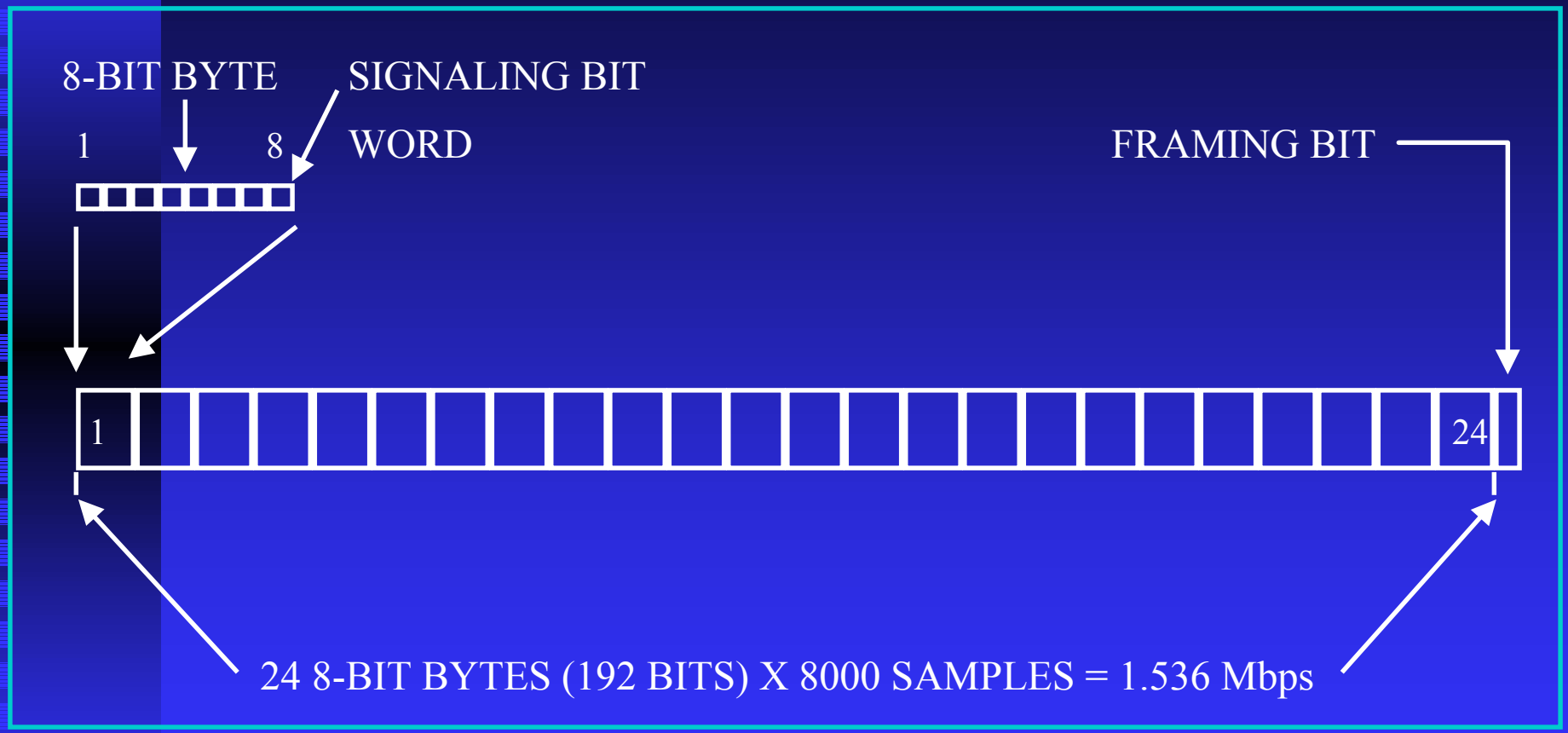
D1 Framing

- The 1.544Mb/s is organized in an orderly, understandable way. Framing provides this organization.

- A frame contains one sample(8-bits) from each of the DS-1's 24 time slots. A framing bit is used to separate the frames and indicate the order of information arriving at the receiving end.

- A **D1** frame contains 24 time slots, each carrying an eight bit word and a framing bit. Bit eight of each word is reserved for signaling information.

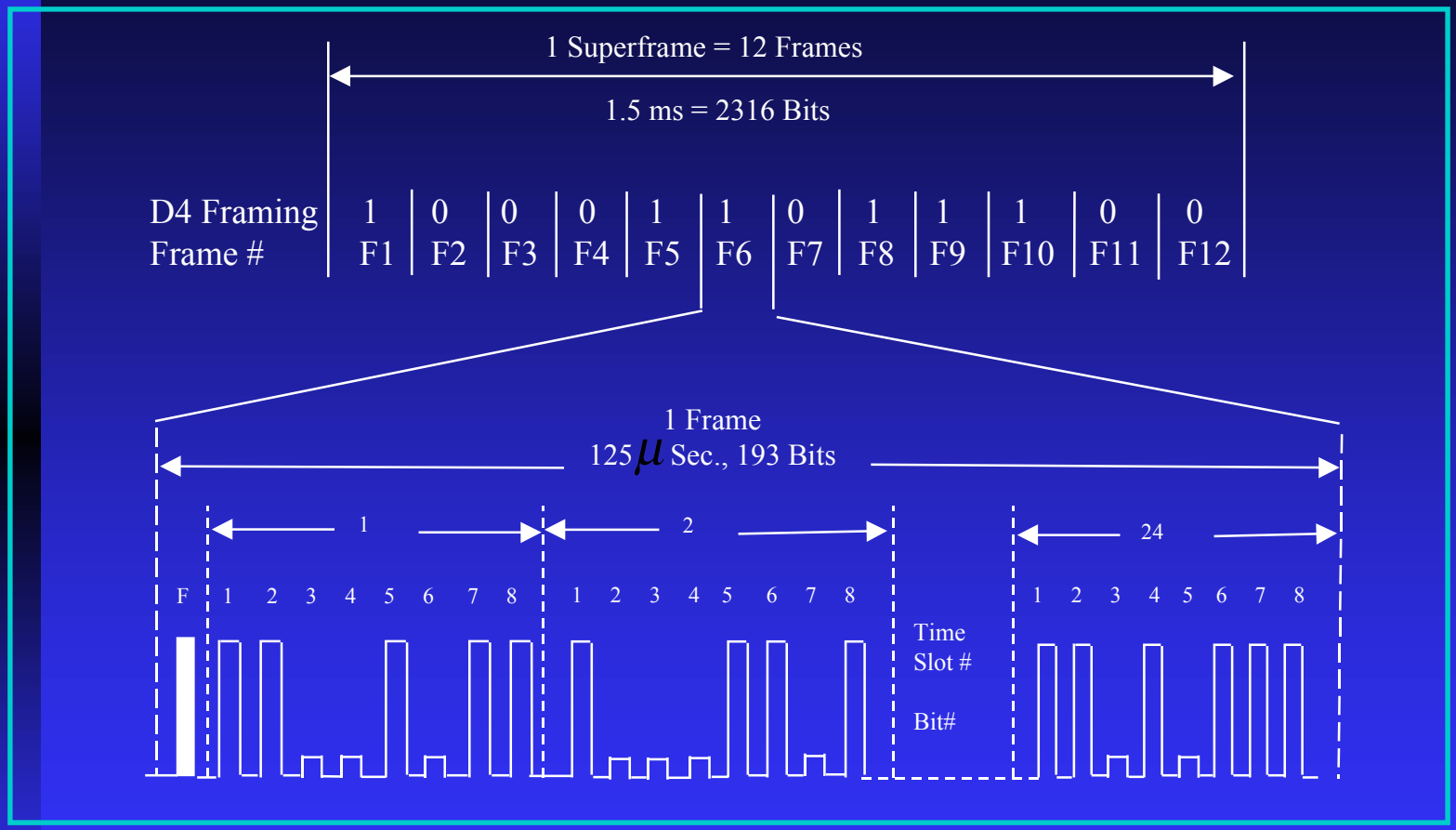
THE D1 FRAMING PATTERN



D4 FRAMING/SUPERFRAME(SF)

- 12 frames are grouped together to form a superframe. Each frame contains 8-bits of each of the 24 time slots and a framing bit(F-bit).
- The twelve framing bits are combined into a 12-digit word that provides frame and signal management.
- To share signaling bits by all 12 frames in the superframe, D4 framing uses a process called “robbed bit signaling.” The 8th bit of the DS-0’s in the 6th and 12th frames are reserved for signaling information.
- In summary, D4 framing improved signal quality by freeing more bits for customer information.

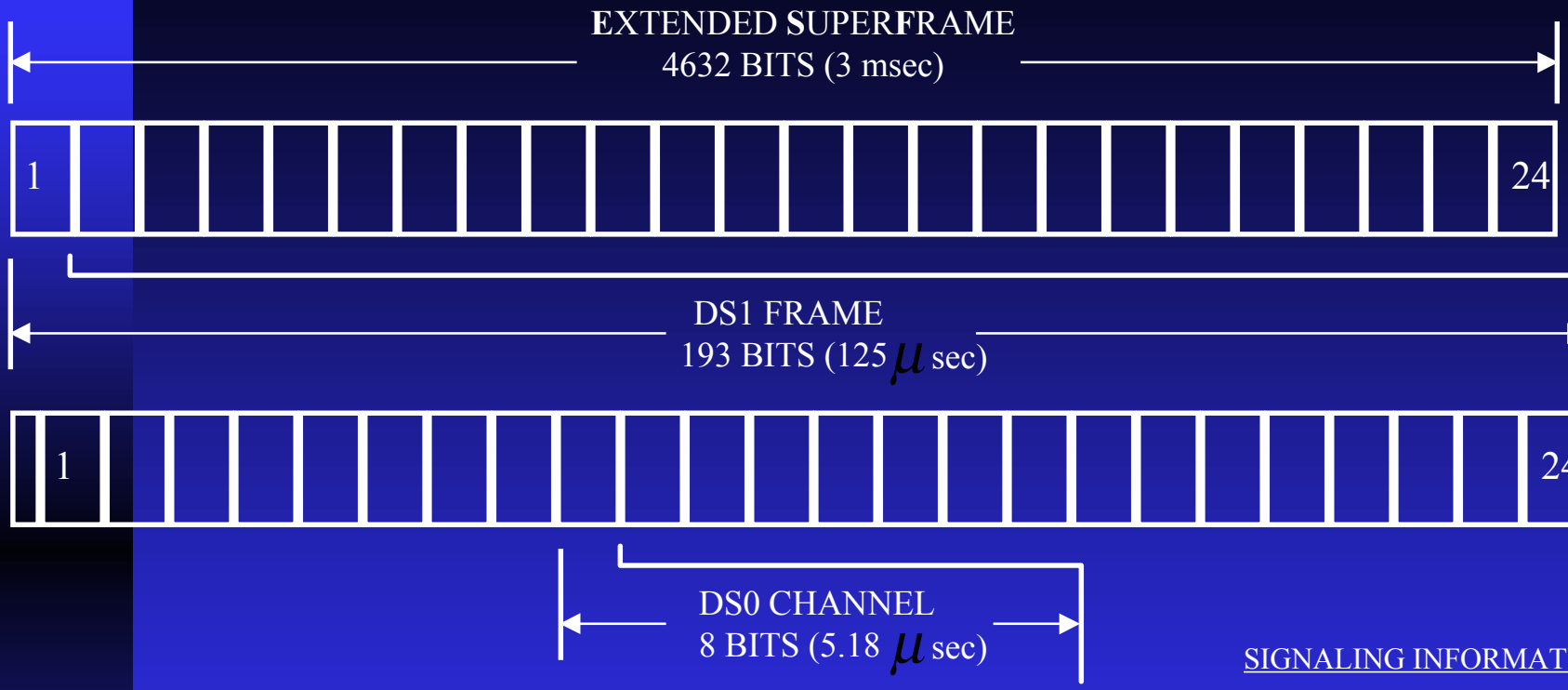
D4 SUPERFRAME (SF)



EXTENDED SUPERFRAME (ESF)

- ESF expands the superframe from 12 to 24 193-bit frames. ESF was developed in order to be able to evaluate system performance without disrupting service by testing the t-1 link.
- Three fourths of the 24 control bits are reserved for evaluation of circuit performance.
- 6 control bits are reserved for cycle redundancy check (CRC), a method of detecting errors during transmittal (2kb/s);
- 12 control bits are reserved as a data link for communication between transmitting and receiving equipment at either side(4kb/s).
- 6 control bits are use to managed signaling and framing.

EXTENDED SUPERFRAME (ESF)



SIGNALING INFORMATION

8th BIT IN FRAME #	
6	A
12	B
18	C (A) DUPLICATE
24	D (B) DUPLICATE

FRAMING BIT SUMMARY

F1 ... F24

D	C1	D	0	D	C2	D	0	D	C3	D	1	D	C4	D	0	D	C5	D	1	D	C6	D	1

D - FORCED TO 1 BY USER, TBD BY ATT, 4 KBPS "EMBEDED OPERATIONS CHANNEL"
C1 - C6 = CRC6 POLYNOMIAL FOR ERROR DETECTION, 2KBPS, 98.4% OF SINGLE AND MULTIPLE ERRORS FOUND.
FRAMING PATTTERN = 2 KBPS.

Serial Versus Parallel

Parallel transmission gives one character at a time with hardware boundaries

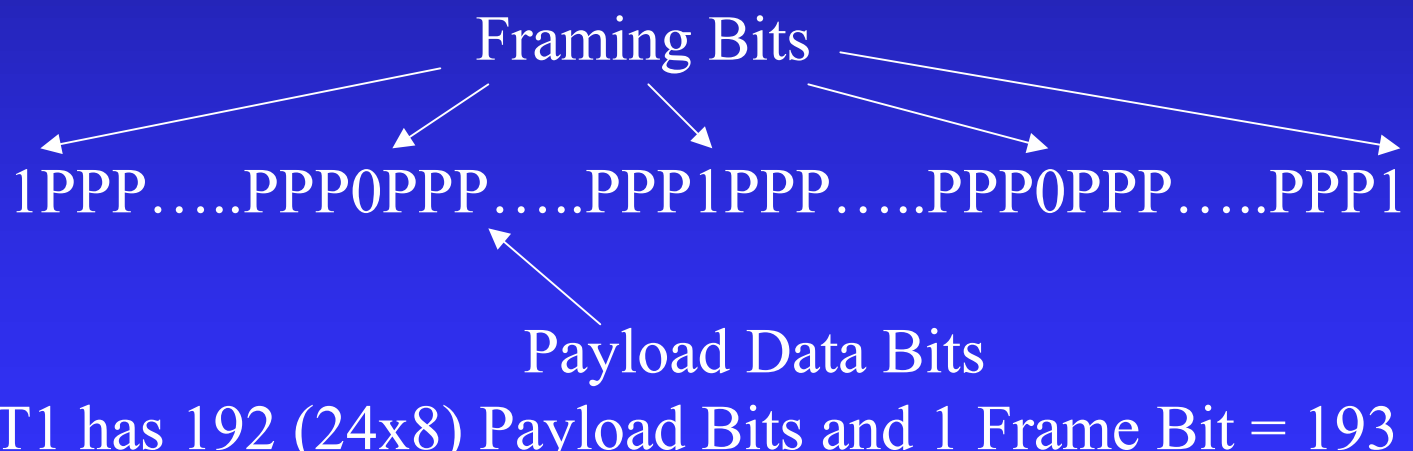
Serial transmission has no hard boundaries

10101010101011100011101101111

Channel 1

Framing Patterns

In order to find the boundaries a framing pattern is inserted



T1 has 192 (24x8) Payload Bits and 1 Frame Bit = 193 Bits

Framing Patterns

However, bits are bits.

Which ones are the frame bits?

1101100111000110110101110000101101110110111011101

It takes time for a receiver to find the framing pattern and it is easily lost when bits are corrupted

Loss of Frame

When a multiplexer is unframed the start of frame pointer is pointing to the wrong bit, shifting the channel pointers to the wrong bits

Description of Problem

- What causes loss of frame
- Media considerations
- Channel hopping
- Pink noise
- Teleprotection

What Causes Loss of Frame

- Corrupted framing bits
- Change in propagation time

Any disruption to the media of equipment can cause A loss of frame.

Media Considerations

Fiber – breaks, equipment failures

When it goes it usually fails completely or switches to a good path

Digital Microwave – path fades, multipath

Comes and goes continuously

Channel Hopping

- Caused by frame misalignment
- The frame misalignment is exactly a multiple of channel time or “words”. (5.18 uS for 1 word in typical TDM muxes)
- The channel faithfully outputs data intended for another channel or time slot

Pink Noise

- Caused by frame misalignment.
- The alignment is off by less than one channel or one “word” (5.18 us)
- Output circuits reproduce a complex noise pattern including various frequency components

Teleprotection – Channel Hop

- Designed to wait for trip frequencies after losing guard frequencies
- A channel hop to another teleprotection channel with correct trip frequencies for that channel

Teleprotection – Pink Noise

- Designed to pull trip and guard frequencies out of noisy channels
- Pink Noise can mimic a noisy trip condition
- AGC circuits help bring the noise to the proper level and a trip results

Possible Solutions

- Prevention
- Detection
- Addressing
- Frequency Diversity
- Squelching

Prevention

- Build a system which has
  - Robust framing during corruption
  - Rapid detection of “Loss Of Frame”
  - Takes action before a trip can occur

Detection

- Detection time is limited by the framing pattern
- At least two frames are required for minimum detection time
- Longer the frame – slower the detection
- Don’t want to be too sensitive

Channel Addressing

- Each protection pair has a unique TX/RX address transmitted with data
- Usually limited to digital teleprotection
- Can be done with audio but not quickly enough

Frequency Diversity

- Each protection pair has unique frequencies
- Can be a maintenance problem
- Does not protect against pink noise

Squelching

The Best Protection!

- Quickly detect loss of frame and squelch output
- A relaying grade multiplexer should do this in less than 2 ms.
- Not available with channel banks

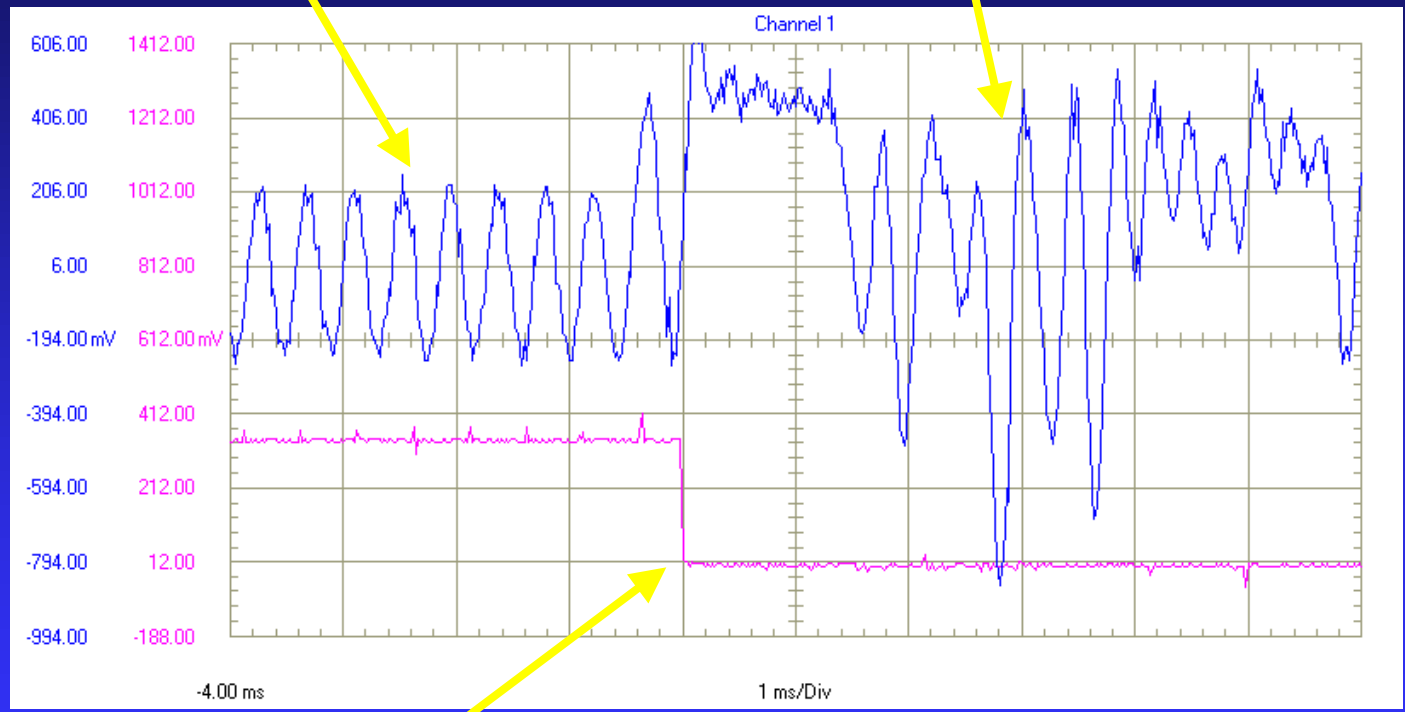
Test Results

- Pink Noise – No Squelch
- Pink Noise – With Squelch
- Channel Hopping – No Squelch
- Channel Hopping – With Squelch

Pink Noise – No Squelch

Valid Audio Tone

Pink Noise

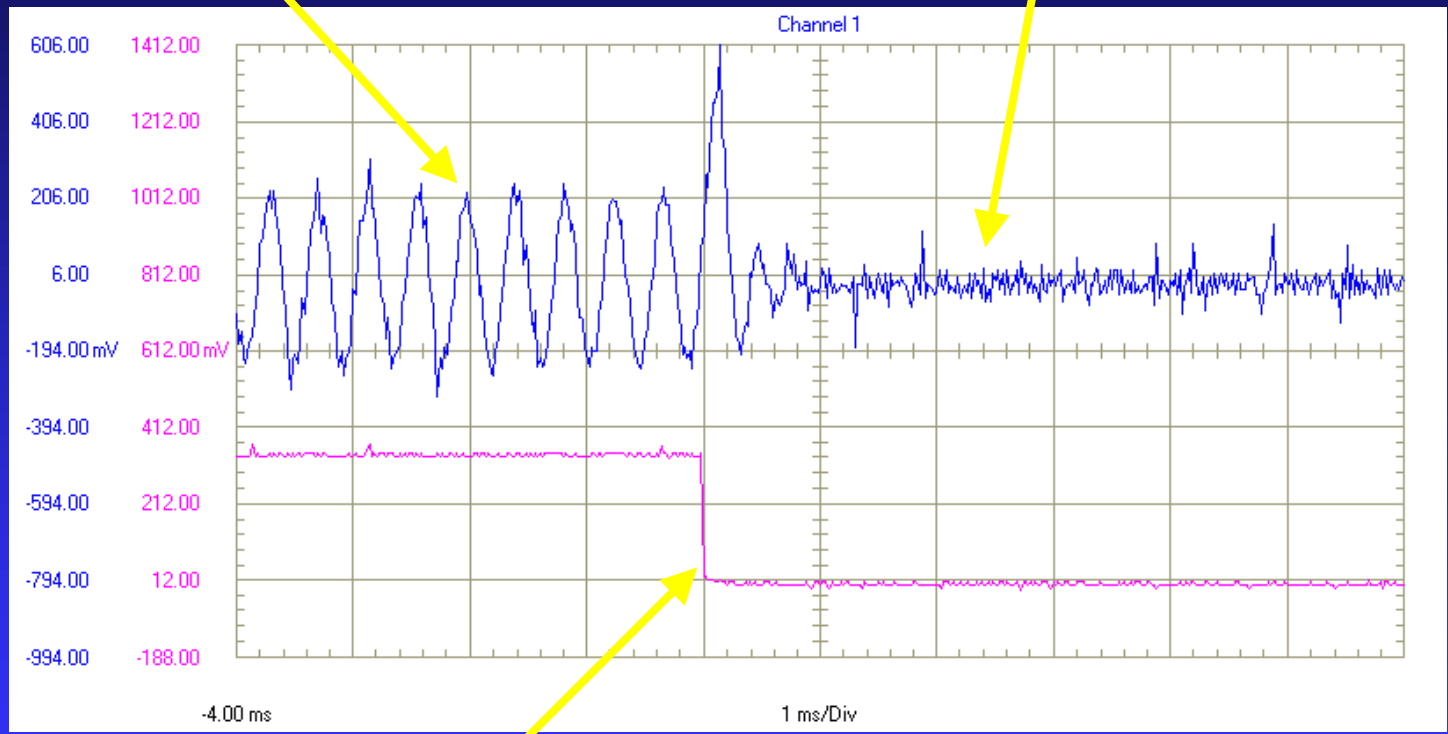


Loss of Frame

Pink Noise - with Squelch

Valid Audio Tone

Squelched Output



Loss of Frame

Channel Hopping – No Squelch

- Major utility sanctioned test
- Telecom grade T1 Mux – 24 PCM voice cards
- 23 channels at trip frequencies, 1 channel at guard with RFL 9745 teleprotection channel receiver
- Repetitive T1 breaks
- **One false trip output about every 20 minutes**

Channel Hopping – With Squelch

- Major utility sanctioned test
- RFL IMUX 2000 – T1 Multiplexer with DS0 squelching enabled
- Same setup and conditions as previous test
- **17 Hours – No False Trip Outputs**