

# Stressed Receiver Sensitivity (SRS) Test

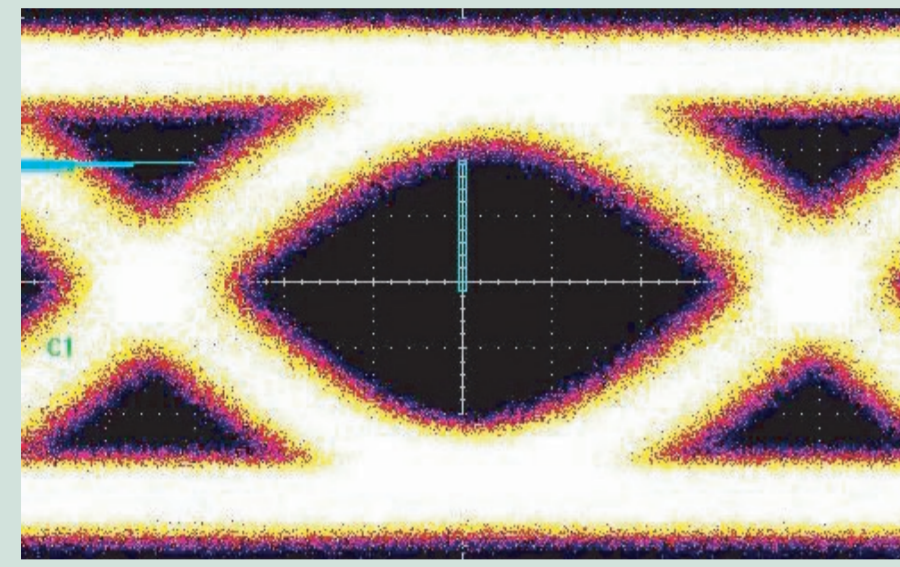
## 10 Gigabit Ethernet, 10G Fibre Channel

Stressed Receiver Sensitivity Testing (also known as stressed eye testing) applies to an optical receiver's stressed sensitivity. The 10 Gigabit Ethernet (GigE) standard requires that the specified stressed sensitivity must be met with bit error ratio (BER) of better than  $10^{-12}$  for the input optical signal that contains the specified amount of jitter and vertical eye closure. This test assures interoperability amongst vendors and plug-and-play performance for users by simulating the worst signal conditions a receiver can face in the field.

SRS must be able to generate the required signal and verify the DUT's compliance to the standard. 10 Gigabit Fibre Channel has the same transmitter and receiver requirements as 10 GigE.

### Generation of Stressed Signal

Eye diagram of a stressed signal



Stressed signal condition as required by IEEE Std. 802.3-2005, section 4

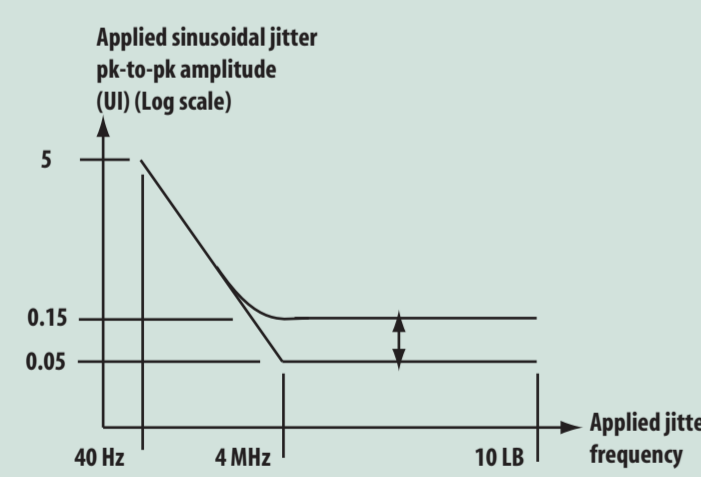
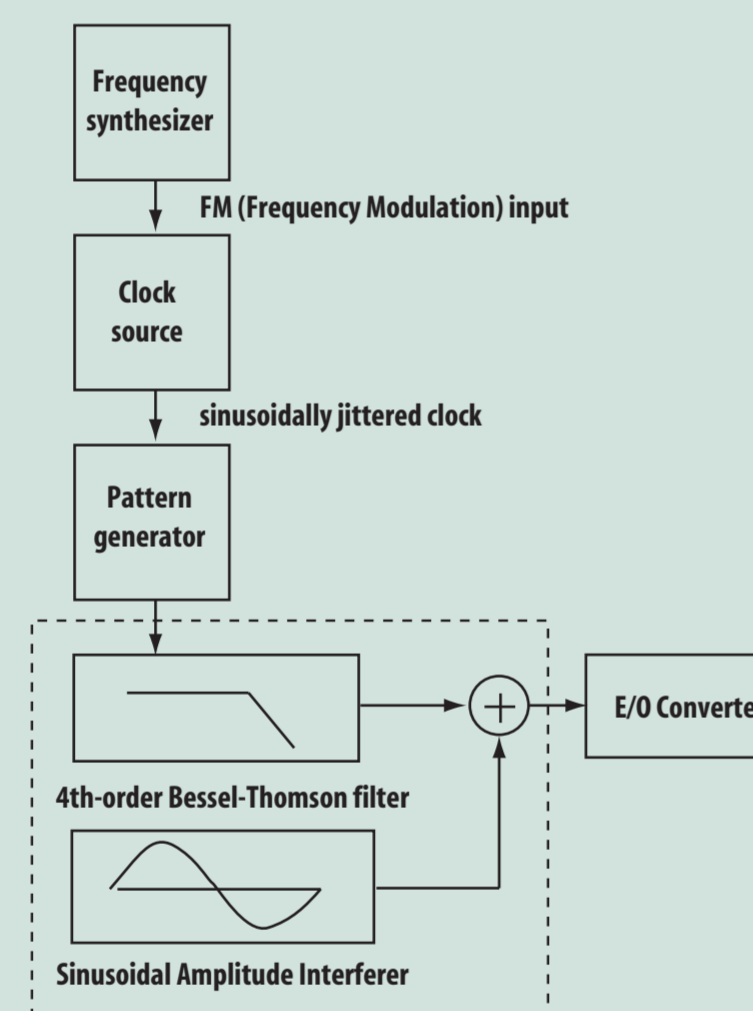
	Wavelength (nm)		
	850	1310	1550
Optical power in OMA (dBm) (P1 - P0)	-7.5	-10.3	-11.3
Vertical eye closure Penalty (dB) (VECP= $10 \times \log(\text{OMA}/\text{Ao})$ )	3.5	2.2	2.7
Stressed eye jitter (UI pk-pk) Measured at waveform average (P1-P0)/2	0.3	0.3	0.3
Extinction ratio ( $10 \log(P1/P0)$ ) (dB)	3	3.5	3

OMA, Extinction ratio and average optical power are interrelated. Once any two of them are known, the third can be calculated.

### Stressed waveform generation

- The 4th-order Bessel-Thomson filter emulates Inter-Symbol Interference (ISI)-induced Vertical Eye Closure Penalty (VECP).
- Sinusoidal amplitude interference causes additional VECP and emulates the effect of data dependent jitter (DDJ) which can not be created by phase modulation.
- Sinusoidal phase modulation represents other forms of jitter and can be used to test a receiver's ability to tolerate low frequency and high frequency jitter.
- The IEEE standard requires that a square wave pattern (a repeated pattern consisting of 4-11 consecutive 1s followed by an equal run of 0s) be used for the measurement of the Optical Modulation Amplitude (OMA) of an optical signal.
- Eye-diagram measuring instruments from different vendors may report different Extinction Ratio (ER) results to the same optical signal when the input power is low due to their treatment of the dark current. Since attenuation does not change the extinction ratio of an optical signal, it is advisable that the extinction ratio of an optical signal be measured at a higher power level where better accuracy can be achieved.

Stressed signal generation block diagram



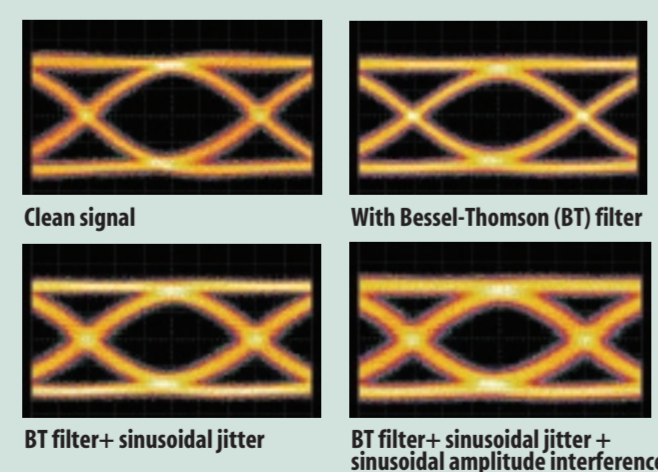
Frequency range	Sinusoidal jitter (UI peak-to-peak)
f < 40 kHz	NA
40 kHz < f ≤ 4MHz	$2 \times 10^{-7} / f + 5 \times 0.05$
4 MHz < f < 10 LB	$0.05 \leq S \leq 0.15$

S is the magnitude of sine jitter actually used in the calibration of the stressed eye. LB = Loop Bandwidth (of receiver being tested). Typical value for LB at 10G is 8 MHz.

Mask of the sinusoidal component of jitter tolerance

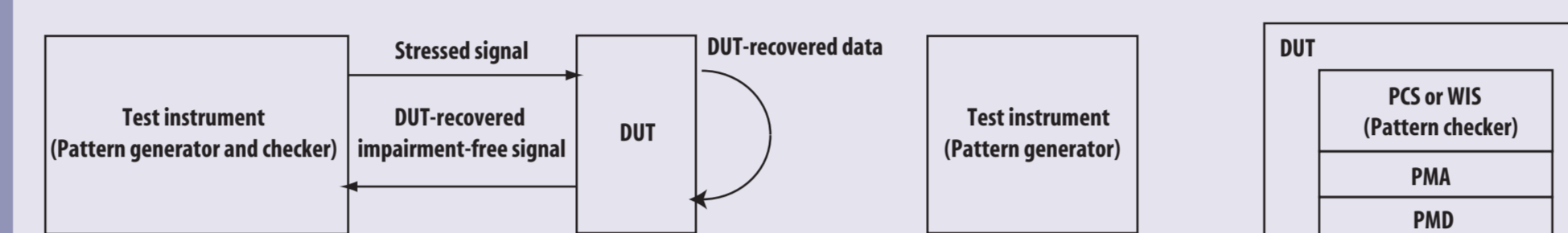
### Effects of physical impairments on eye diagram

- The 4th-order Bessel-Thomson filter closes the eye and is the major source for VECP.
- Sinusoidal amplitude interference causes additional eye closure. It also emulates bit shrinkage caused by data-dependent jitter.
- Changing sinusoidal jitter changes the thickness of the rising and falling edge of the trace.



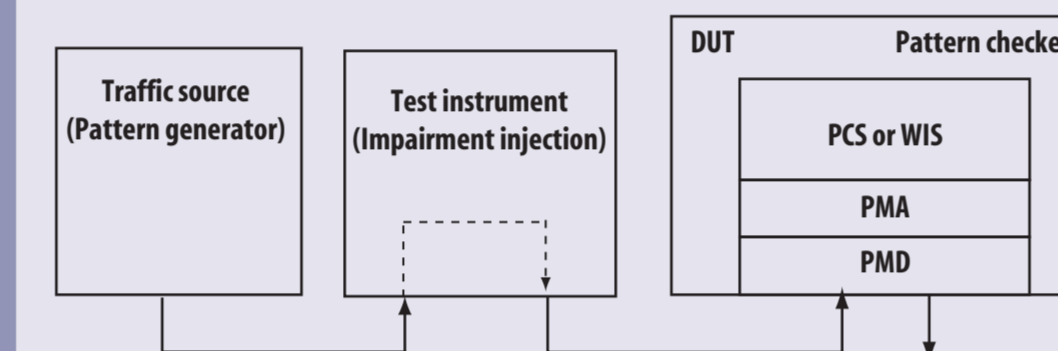
### Test Connection

Objective: Verify that the device under test (DUT) has BER performance better than  $10^{-12}$  when tested with stressed signal as required by IEEE Std. 802.3-2005, section 4.



Configuration 1: Terminal mode with error checker on test instrument

Configuration 2: Terminal mode with error checker on DUT



Configuration 3: Intrusive Monitor Mode (The tester only adds physical impairment to the user supplied test signal, the digital pattern of the test signal is not changed. This connection is used when non-standard special test patterns are required).

### Types of DUT, test patterns and configurations

DUT Types	What to check	Test Pattern	Applicable configurations
Transceivers	Bit errors	Unframed	1
Line cards	Bit errors, or CRC errors (Note 2)	Unframed (Note 1) or framed (Note 2)	1 (Note 3), 2, 3
Systems	Bit errors or upper layer errors (note 2)	Unframed (Note 1) or framed (Note 2)	1 (Note 3), 2, 3

Note 1: Supported only when the DUT has a built-in unframed pattern checker or it is capable of looping-back its recovered unframed pattern.  
 Note 2: For line cards and systems that have neither built-in unframed pattern checkers nor the ability to loop back the recovered unframed patterns, signals with valid data frames such as MAC frames or IP frames (framed patterns) are used instead. In such cases, bit errors within the payload areas of the frames or CRC errors are examined. This kind of test is not a standard test.  
 Note 3: Some line cards and systems are not capable of looping-back the received unframed test patterns.

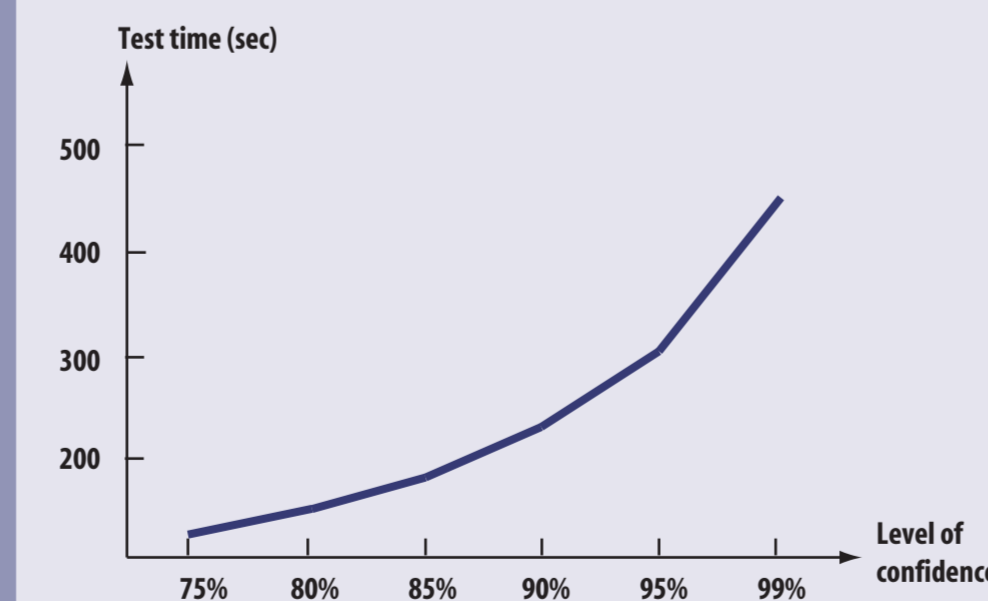
### BER, Test Time and Level of Confidence

If transmission errors are caused predominantly by noise, the errors can be described by Poisson processes when the number of bits being tested (n) approaches infinity and the actual bit error ratio (p) approaches zero in such a way that  $np = \lambda$ . If p(k) is the probability of k errors being detected during a test, then:

$$p(k) = \frac{(\lambda)^k}{k!} e^{-\lambda}$$

Based on this, the number of bits (n) required to be tested to declare the actual BER is better than a preset BER objective  $BER_{obj}$  for a Confidence Level (CL) can be calculated as follows if no errors are detected during such test period:

$$n = \frac{\ln(1-CL)}{BER_{obj}}$$



Test time required for  $BER_{obj} = 10^{-12}$ , as a function of CL (10.3125Gbps)

Test time required as a function of confidence level (CL)

Bit rate (Gbps)	Test time (seconds) required for $BER < 10^{-12}$					
	CL=99%	CL=95%	CL=90%	CL=85%	CL=80%	CL=75%
9.953 (10GigE WAN)	463	301	232	193	164	140
10.312 (10GigE LAN)	447	291	224	184	156	135
10.518 (10GFC)	438	285	219	181	153	132
10.709 (OTU2)	430	280	215	178	151	130
11.049	417	271	209	172	146	126
11.095	415	270	206	171	145	125
11.270	407	266	205	169	142	123
11.310	407	265	204	168	142	123

Although SRS test is formally defined for 10 GigE and 10 Gigabit Fibre Channel, the same concept can be applied to other line rates such as 11.049G, 11.095G, 11.27G and 11.31G as listed in the Table above.

### Test Patterns

Pattern	Pattern for 10GBASE-R (10 GigE LAN) and 10 Gigabit Fibre Channel	Pattern for 10GBASE-W (10 GigE WAN)
1	BnBiBnBi	Mixed Frequency
2	AnAiAnAi	Frequency
3	PRBS31	PRBS31

PCS Scrambler Seed Values	
segment	Seed [57:0]
An	0x 3C8B4DCAB6804F
Bn	0x 34906BB85A38884

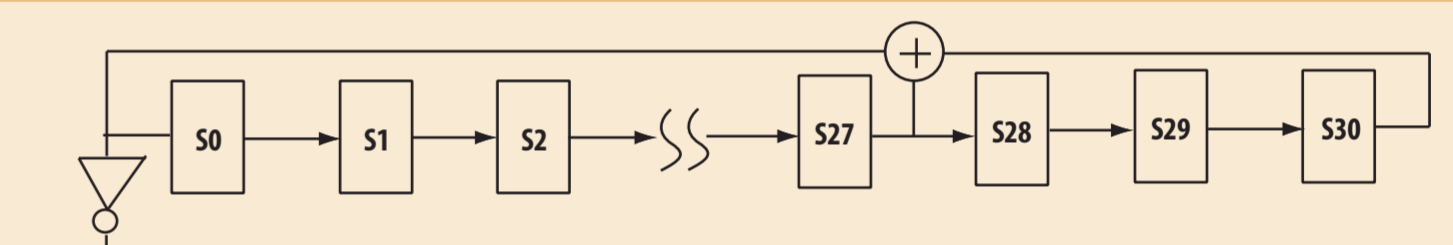
Note: Ai and Bi are the inverted seed for An and Bn respectively. Pattern 1 represents typical scrambled data. Pattern 2 is less typical but may occasionally happen and is thought to be more demanding of the transmission process including the clock recovery subsystem. Both patterns are balanced over their length of 33,792 bits.

### Applications of Test Patterns

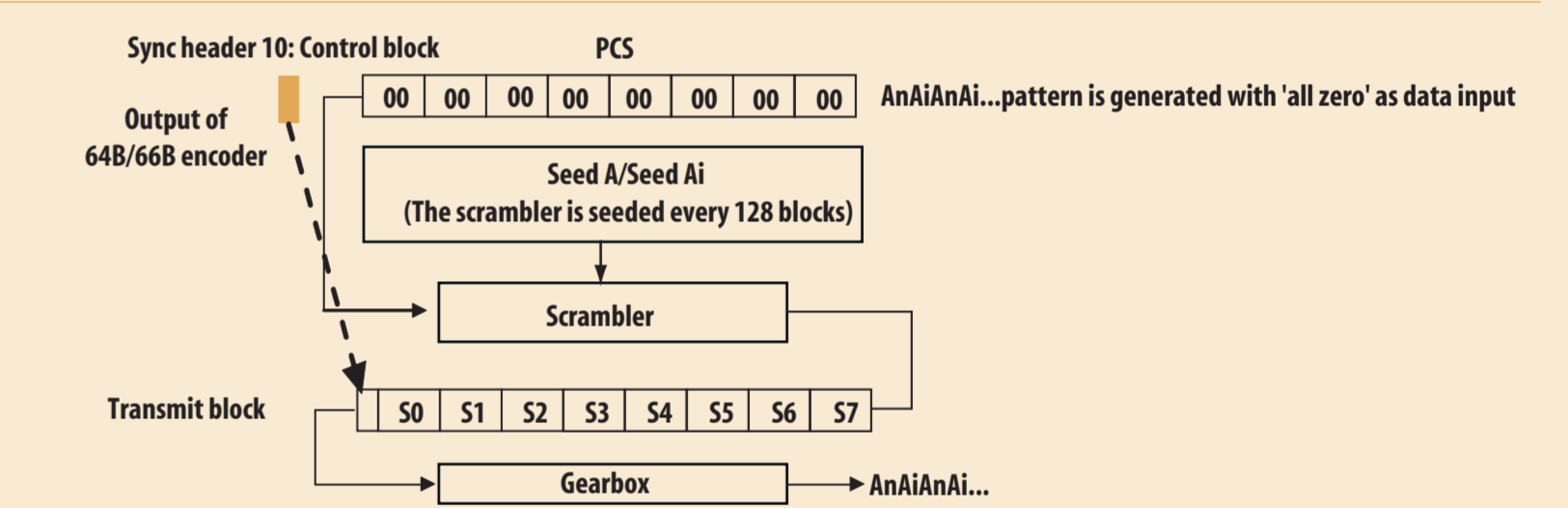
Test	Pattern
Average optical power	1 or 3
OMA (modulated optical power)	Square
Extinction ratio	1 or 3
Transmit eye	1 or 3
Receiver upper cutoff frequency	1 or 3
RINxOMA	Square
Wavelength, spectral width	1 or 3
Side mode suppression ratio	1 or 3
Vertical eye closure penalty calibration	2 or 3
Receiver sensitivity	1 or 3
Receiver overload	1 or 3
Stressed receive conformance	2 or 3
Transmitter and dispersion penalty	2 or 3

### Generation of Test Patterns

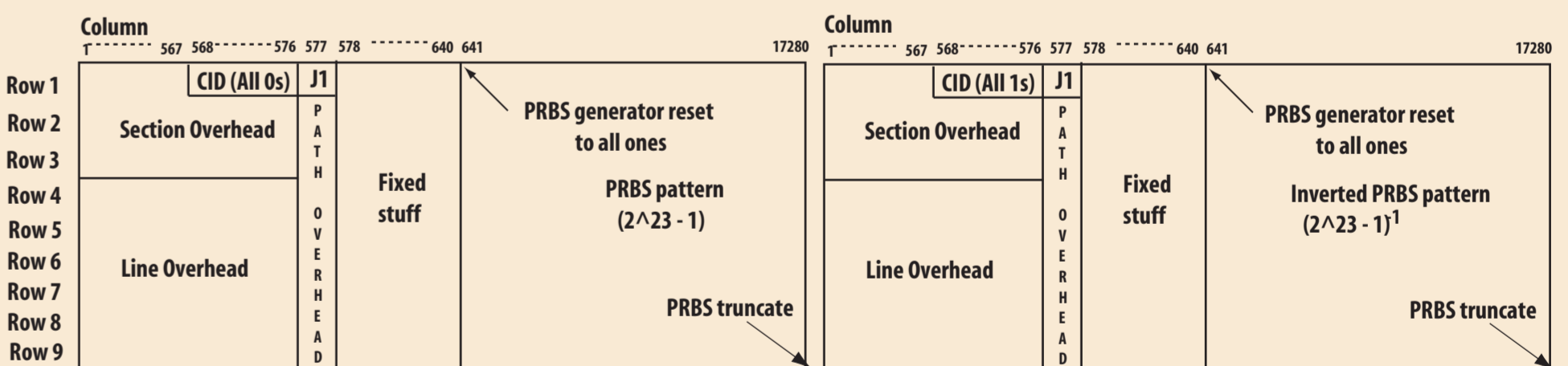
PRBS31 Pattern



AnAiAnAi...

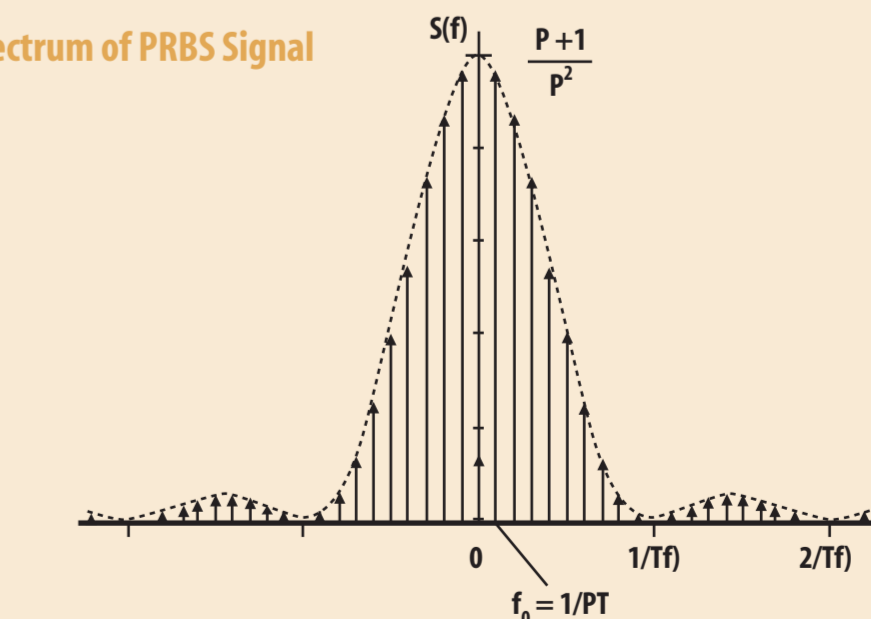


### Mixed frequency Pattern for the Case of SONET



Note: 1. The CID is selected to stress the lock range of the receiver circuitry. 2. Errors detected during mixed frequency testing are reported via B1, B2 and B3.

### Normalized Power Spectrum of PRBS Signal



$$S(f) = \frac{P+1}{P^2} \left\{ \frac{\sin(\frac{\pi f P}{P})}{\frac{\pi f}{P}} \right\}^2 \delta(f - n f_0), f \neq 0$$

$$S(0) = 1/P^2$$

P: Length of PRBS in number of bits  
 T: Period of a bit for 1/PT  
 There is no spectral content at frequency of line rate. The longer the PRBS, the denser the impulses are spaced.