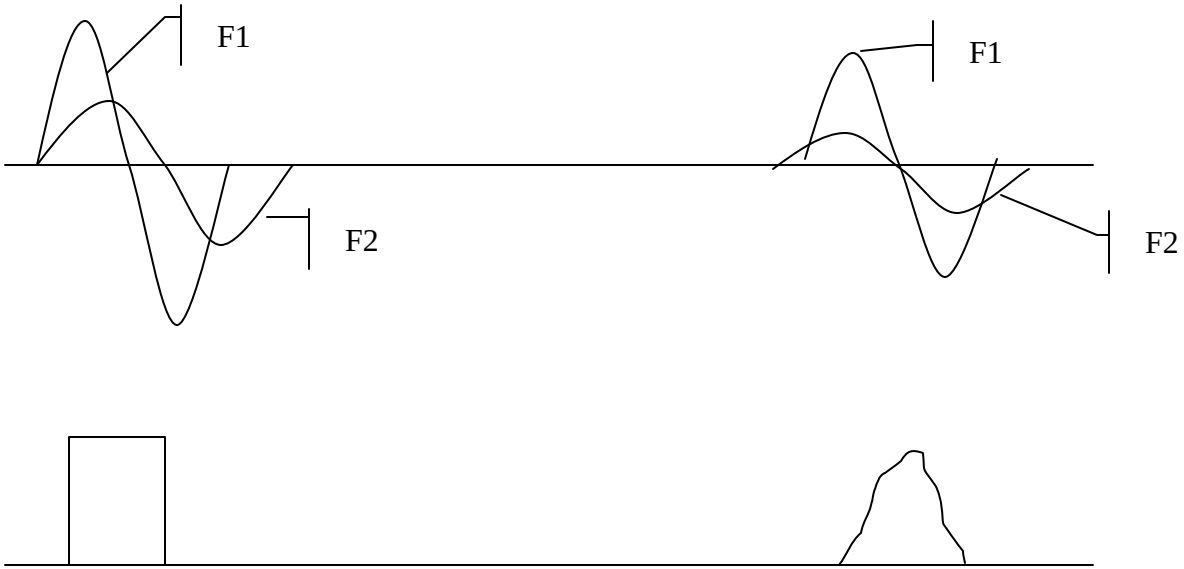
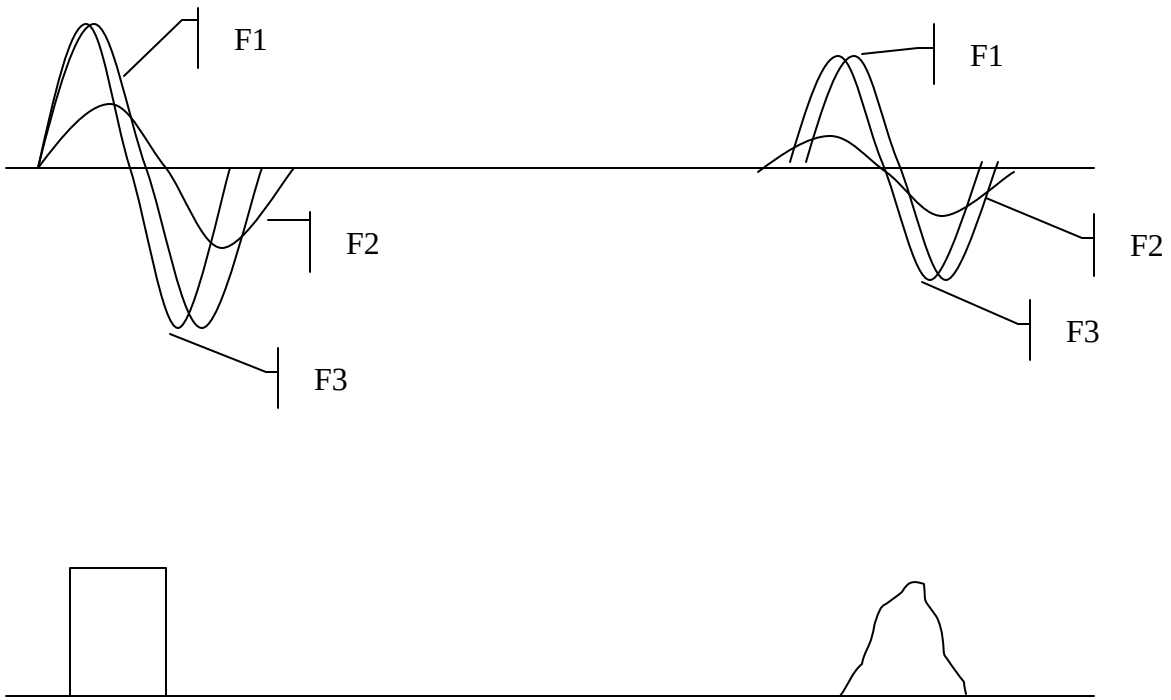
Line Errors

Line Error Problem	Corrected by
Attenuation Distortion	C Conditioning
Envelope Delay Distortion	C Conditioning
Signal-to-Noise Ratio	D Conditioning
Harmonic Distortion	D Conditioning
Jitter	Various Controls
Impulse Noise	Various Controls
Frequency Shift	Various Controls
Echo	Various Controls

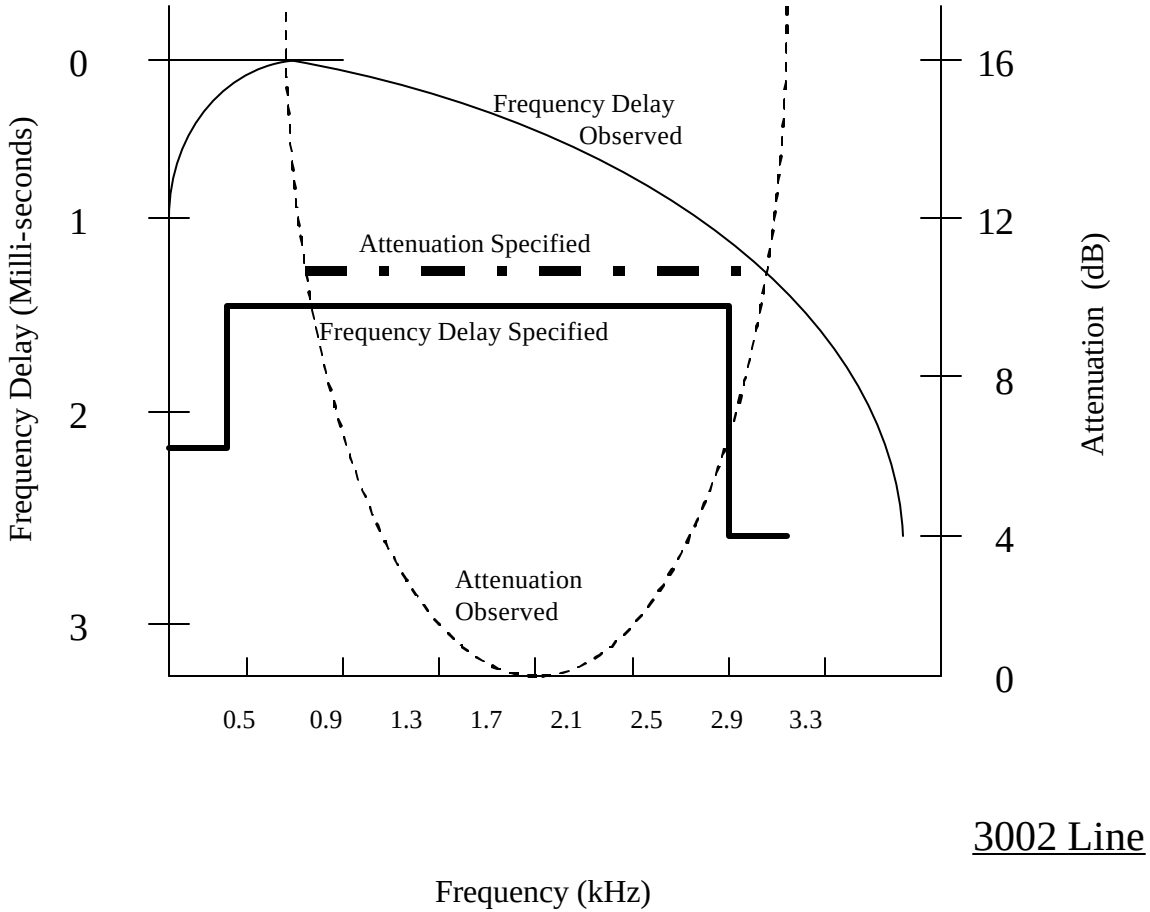
Attenuation Distortion



Envelope Delay Distortion

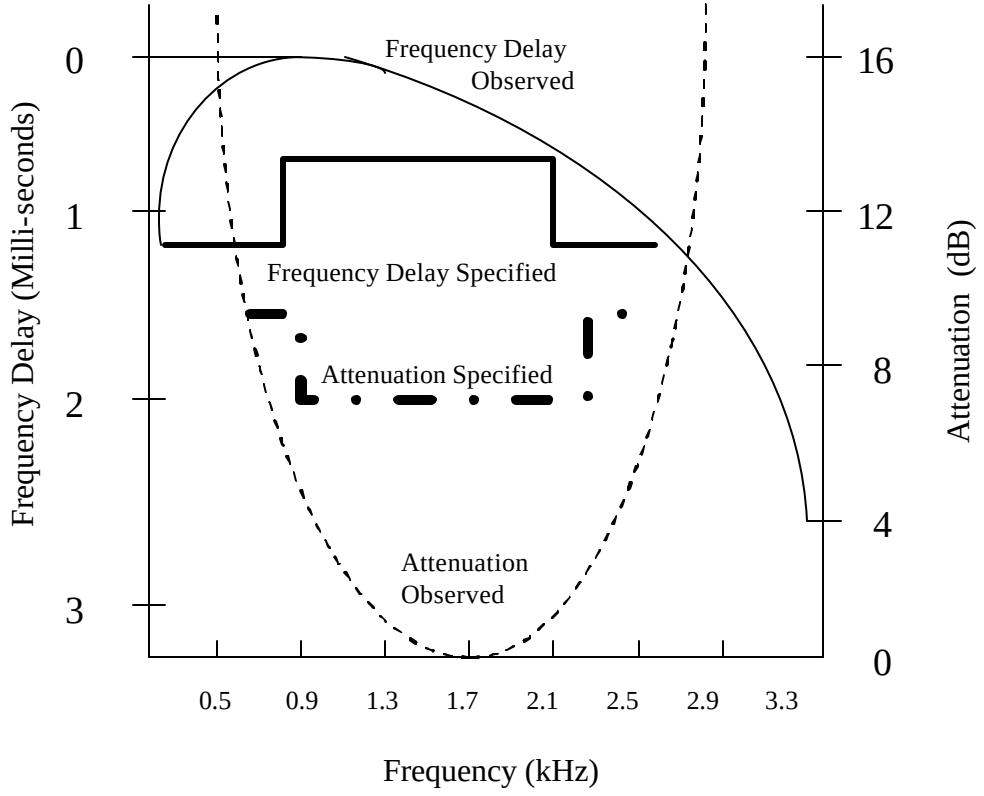


Non-Conditioned 3002 Line



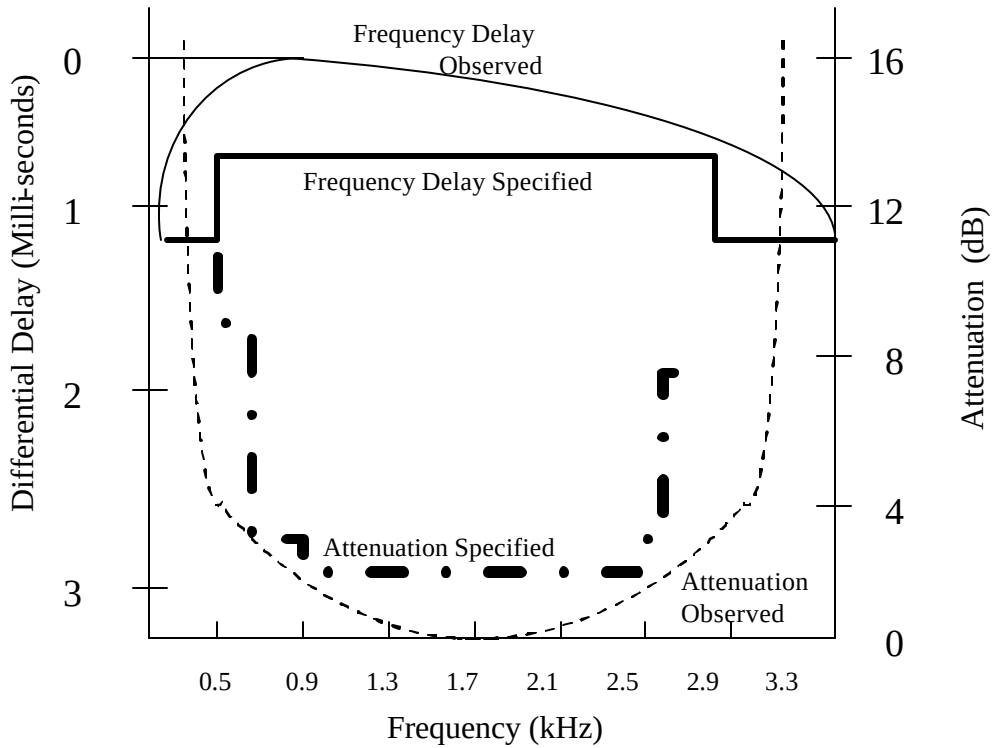
3002 Line

C1 Conditioned 3002 Line



3002 Line
with C1 Conditioning

C4 Conditioned 3002 Line



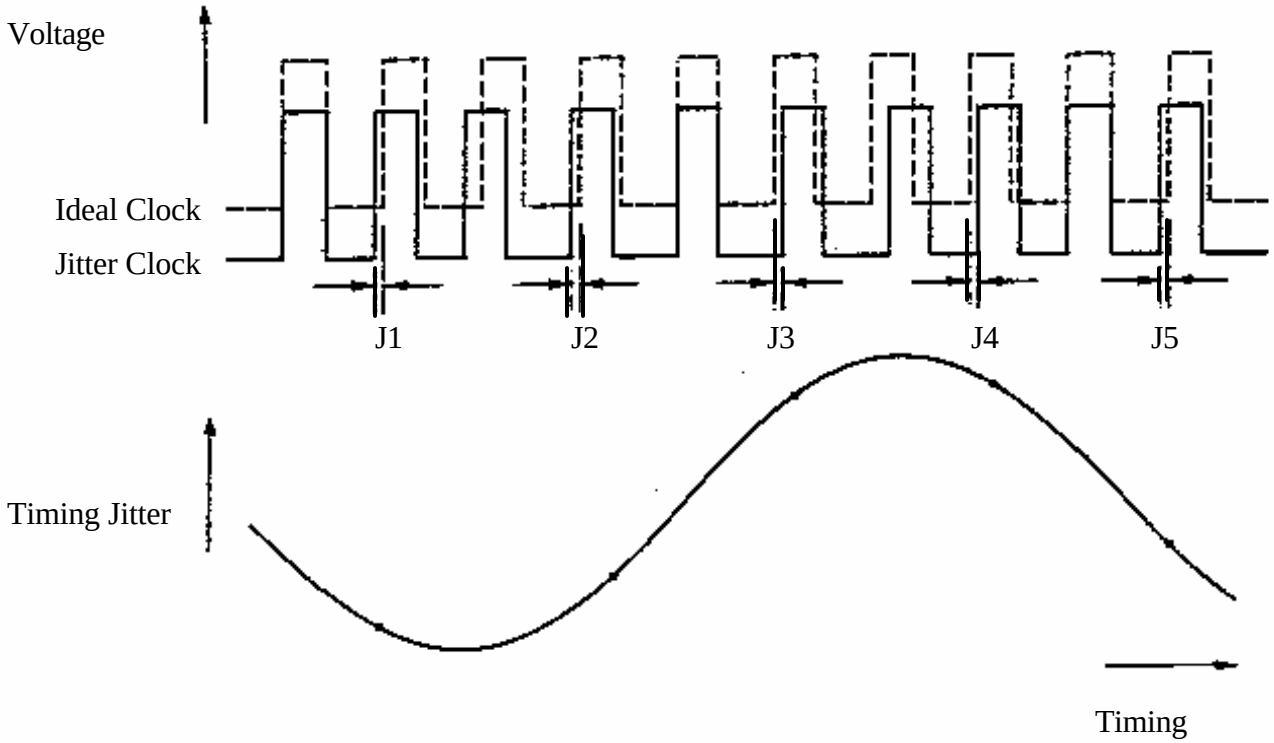
3002 Line
with C4 Conditioning

D Conditioning

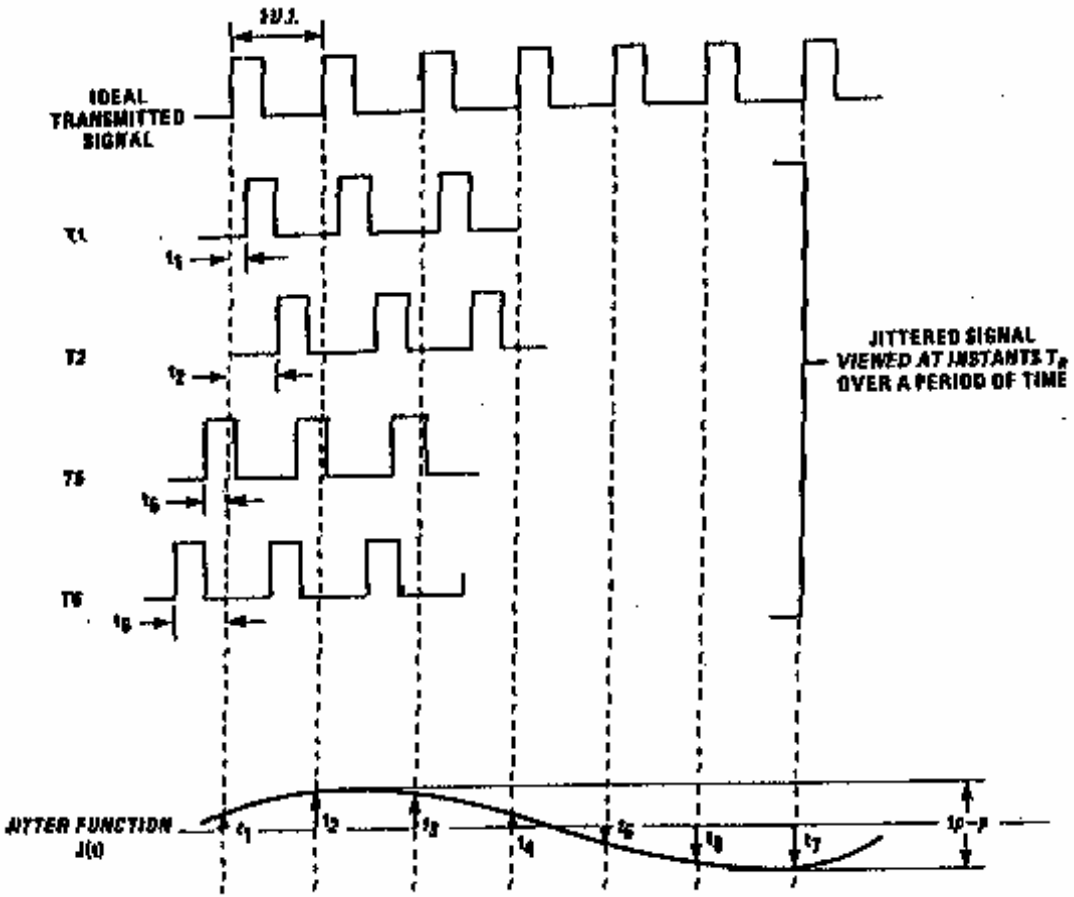
Used to control

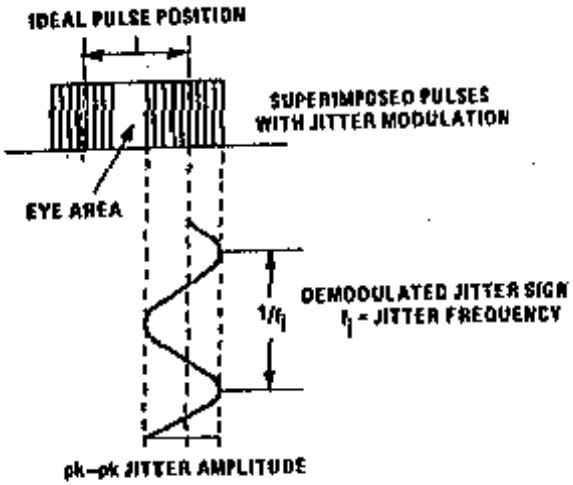
- **Harmonic Distortion**
  - ☛ Harmonic is an integer multiplier of original frequency
  - ☛ Caused by clipping sine wave or interference signal
  - ☛ Ingress, cross modulation, intermodulation
- **Signal to Noise Ratio**
  - ☛ 3002 Line has 2d Harmonic at -25 dB and 3rd at -30 dB
  - ☛ D Conditioned Line has 2nd Harmonic at -35 dB and 3rd Harmonic at -40 dB
- **D Conditioning types**
  - ☛ D1 is Point to Point
  - ☛ D2 is Multipoint with up to 3 remotes
  - ☛ D5 is Multipoint with up to 20 remotes

Jitter


Voltage
Ideal Clock
Jitter Clock
J1
J2
J3
J4
J5
Timing Jitter
Timing

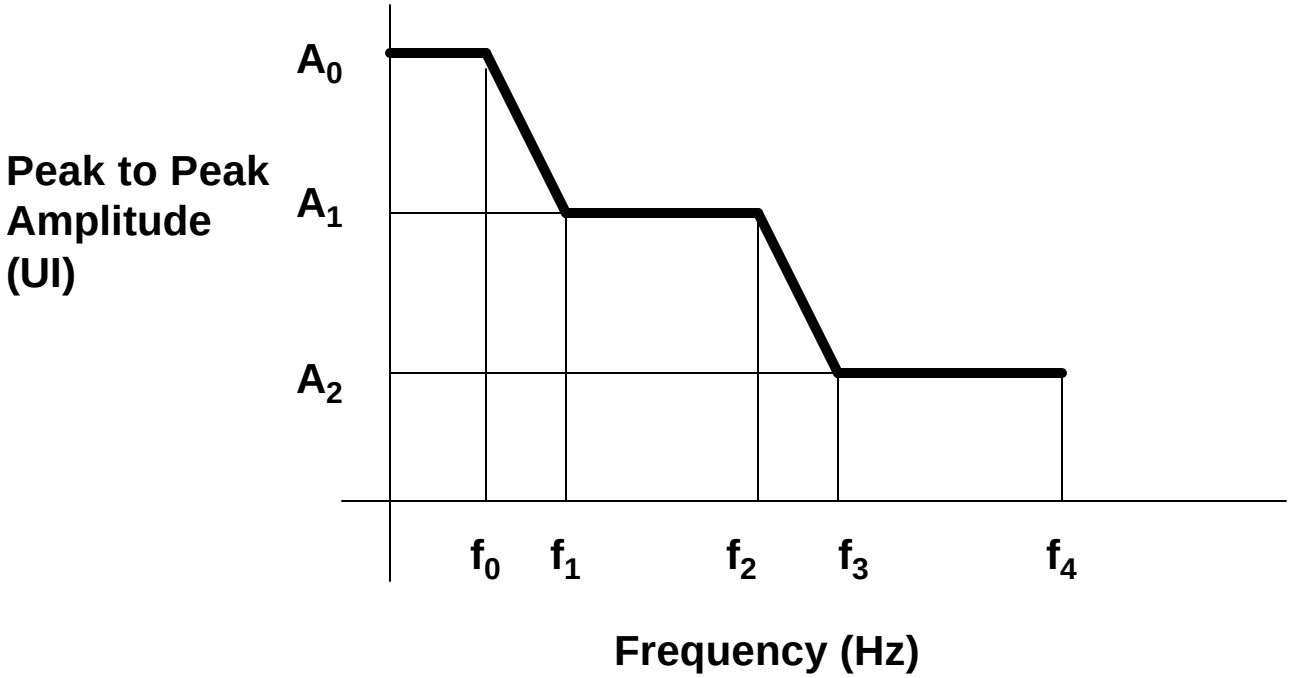
Timing jitter





CCITT G.824 Recommendation

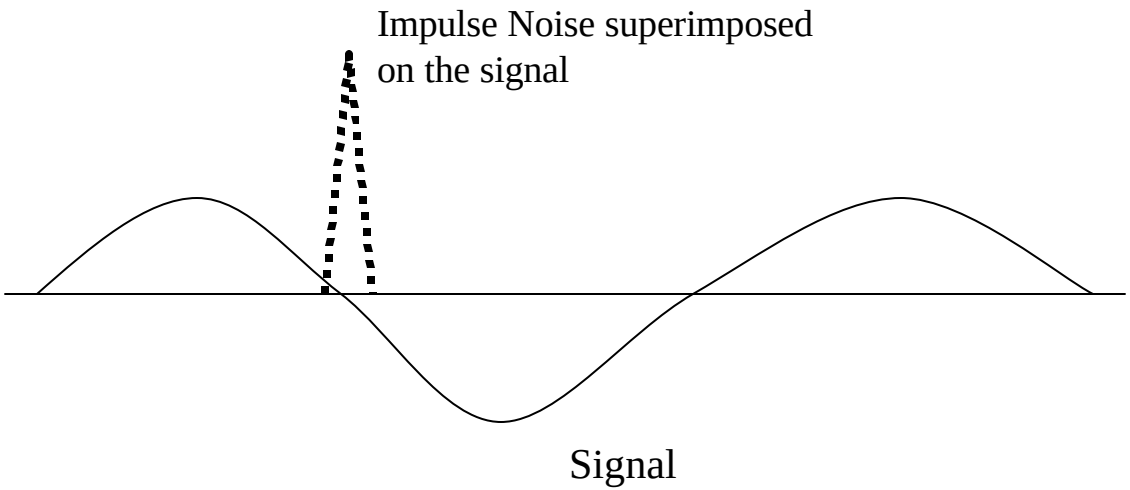
Mask of peak to peak jitter and wander that must be accommodated at the input of a digital network node



Peak Cell Rate Jitter

- Packet network
- Cells travel to distant end over different paths
- During peak busy hours problems can occur
  - ☛ Cells lost
  - ☛ Cells excessively delayed
  - ☛ Results in signal degradation
- To avoid this need either larger buffers OR greater committed bandwidth for the service

Impulse Noise



ERROR DETECTION
&
CORRECTION METHODS

Error Detection

- Checksum Techniques
  - ☛ Block Parity Check
  - ☛ XMODEM Checksum
- Cyclic Redundancy Checks (CRC)

Error Correction

- Automatic Repeat Request (ARQ)
- Forward Error Correction (FEQ)

Block Parity Check

Bit Position									Block Parity Character
1	0	1	0	0	1	1	0	1	**1**
2	1	1	1	0	0	1	0	0	**1**
3	0	0	0	1	0	0	1	1	**0**
4	1	1	0	1	0	1	1	0	**0**
5	0	1	0	1	1	0	0	1	**1**
6	1	1	0	1	0	1	1	1	**1**
7	0	0	0	1	0	1	1	0	**0**
Character Parity	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**1**	**0**

XMODEM Checksum

Checksum	128 Characters of Data	Block Number	SOH

Cyclic Redundancy Check - CRC

CRC Result	**Data**	SOH
4 Octets	1500 Octets	22 Octets

Automatic Repeat Request (ARQ)

Works in conjunction with an error detection method

Two ARQ techniques:

- Stop and Wait
- Continuous

Forward Error Correction (FEC)

Much more complex

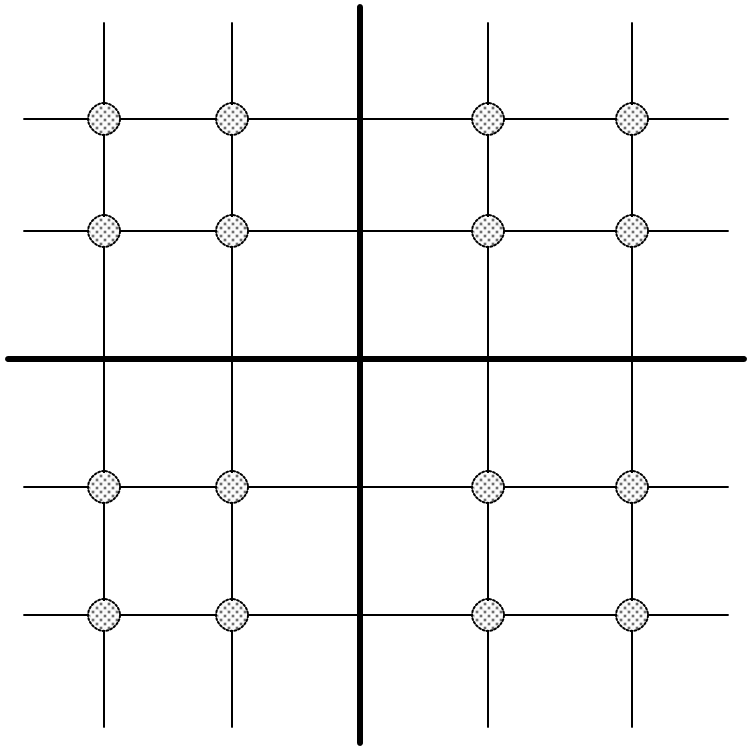
Data is not retransmitted

Requires check bits, parity bits, and
other information

Military communications
Critical information
Simplex system

$$$$$

Digital Error Measurements

- Bit Error Rate (BER)
- Block Error Rate (BLER)
- Erred Seconds & Severely Erred Seconds
- Phase Jitter
- Constellation & Eye Diagrams
- Digital Power Levels

Constellation Diagram