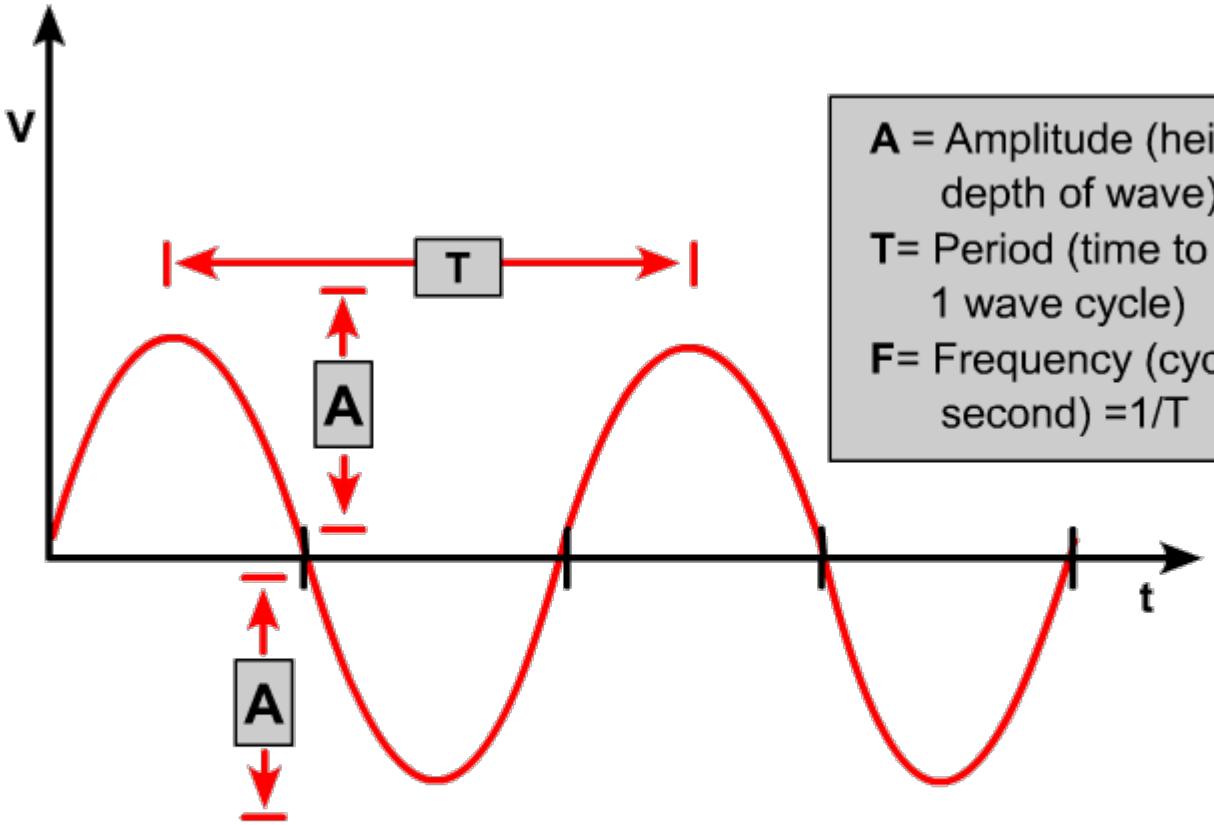
Cable Testing

TELECOMMUNICATIONS AND NETWORKING

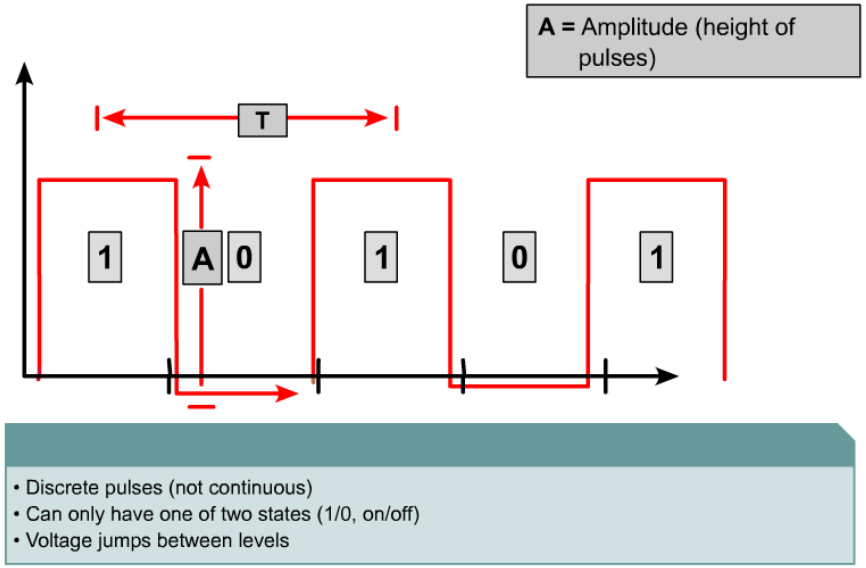
Analog Signals



A = Amplitude (height or depth of wave)
T= Period (time to complete 1 wave cycle)
F= Frequency (cycles per second) =1/T

- Continuous voltage
- Voltage varies as time progresses
- Many encodings possible

Digital Signals

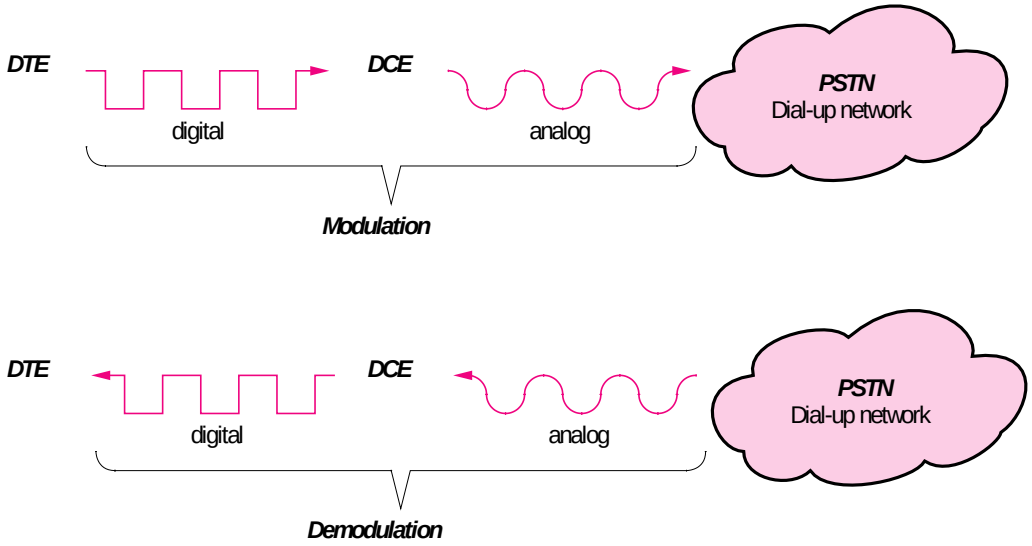


- Square waves, like sine waves, are periodic.
- However, square wave graphs do not continuously vary with time.
- The wave holds one value for some time, and then suddenly changes to a different value.
- This value is held for some time, and then quickly changes back to the original value.
- Square waves represent digital signals, or pulses. Like all waves, square waves can be described in terms of amplitude, period, and frequency.

Digital and Analog Bandwidth

- **Bandwidth** = The width or carrying capacity of a communications circuit.
- **Analog bandwidth** = the range of frequencies the circuit can carry
  - used in analog communications such as voice (telephones)
  - measured in Hertz (Hz), cycles per second
  - voice-grade telephone lines have a 3,100 Hz bandwidth
- **Digital bandwidth** = the number of bits per second (bps) the circuit can carry
  - used in digital communications such as T-1 or DDS
  - measure in bps
  - T-1 -> 1.544 Mbps

Digital and Analog Bandwidth



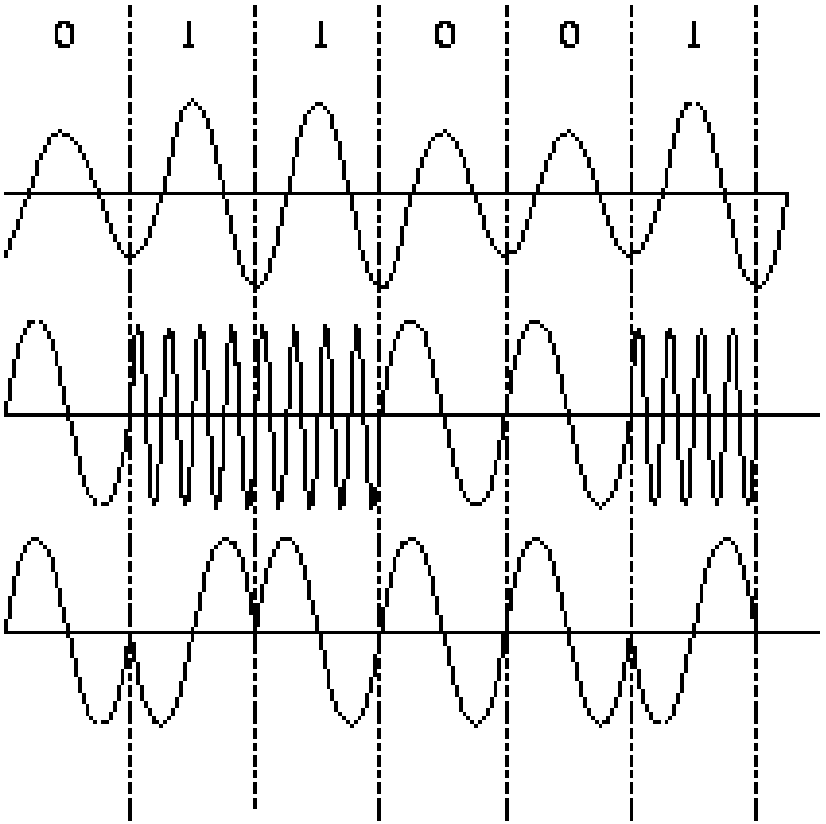
- **Digital Signals (square wave)**
  - digital signal = a signal whose state consists of discrete elements such as high or low, on or off
- **Analog Signals (sine wave)**
  - analog signal = a signal which is “analogous” to sound waves
  - telephone lines are designed to carry analog signals

Transmission Terminology

- **Broadband transmission**
  - In general, broadband refers to telecommunication in which a wide band of frequencies is available to transmit information.
  - Because a wide band of frequencies is available, information can be multiplexed and sent on many different frequencies or channels within the band concurrently, allowing more information to be transmitted in a given amount of time (much as more lanes on a highway allow more cars to travel on it at the same time).
- **Baseband transmission**
  - Describing a telecommunication system in which information is carried in digital (or analog) form on a single unmultiplexed signal channel on the transmission medium. This usage pertains to a baseband network such as Ethernet and token ring local area networks.
- **Narrowband transmission**
  - Generally, narrowband describes telecommunication that carries voice information in a narrow band of frequencies.
  - More specifically, the term has been used to describe a specific frequency range set aside by the U.S. FCC for mobile or radio services, including paging systems, from 50 cps to 64 Kbps.

Summary of Modulations

- Amplitude Modulation (AM)
- Frequency Modulation (FM)
- Phase Shift Keying (PSK)



Decibels

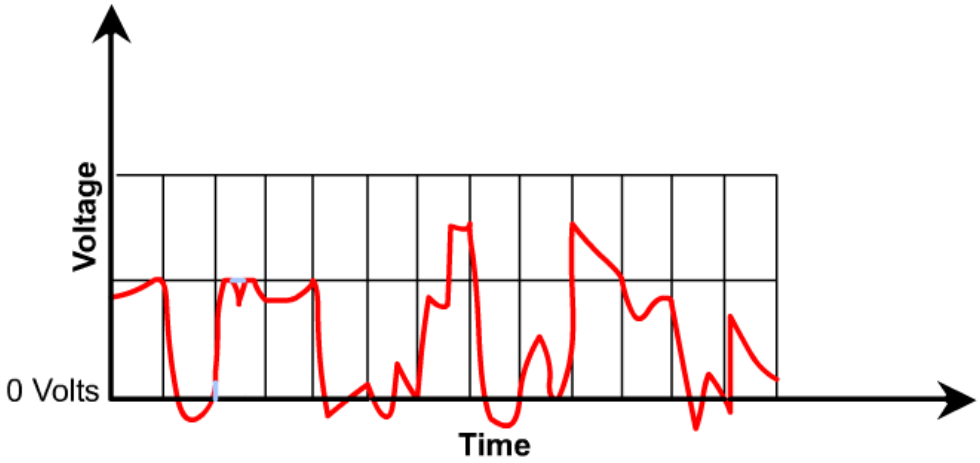
- There are two formulas for calculating decibels:

  $dB = 10 \log_{10} (P_{final} / P_{ref})$

  $dB = 20 \log_{10} (V_{final} / V_{reference})$

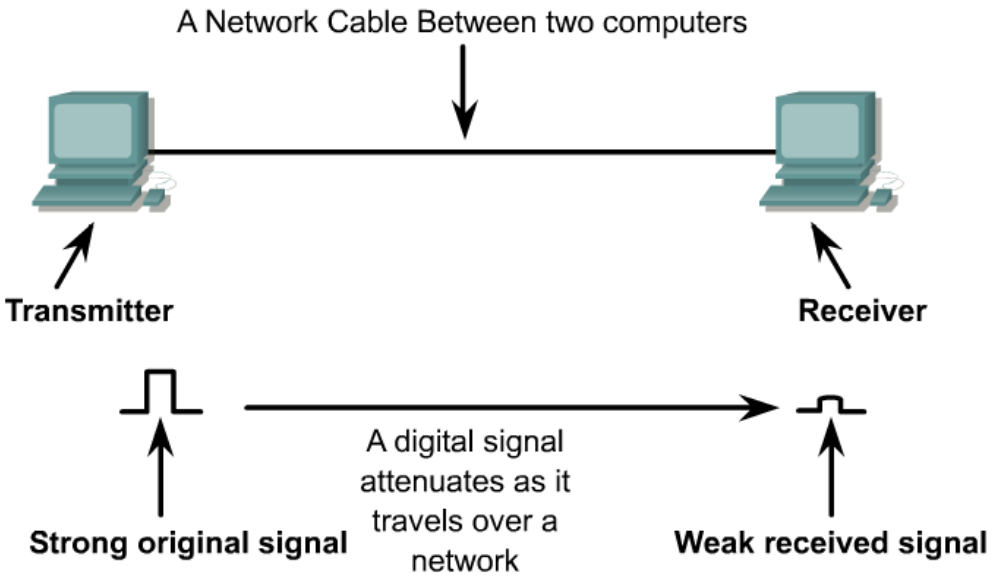
- The variables represent the following values:
  - **dB measures the loss or gain of the power of a wave**.
  - Decibels are usually negative numbers representing a loss in power as the wave travels, but can also be positive values representing a gain in power if the signal is amplified
  - **$\log_{10}$** implies that the number in parenthesis will be transformed using the base 10 logarithm rule
  - **P_{final}** is the delivered power measured in **Watts**
  - **P_{ref}** is the original power measured in **Watts**
  - **V_{final}** is the delivered voltage measured in **Volts**
  - **$V_{reference}$** is the original voltage measured in **Volts**

Noise In Time and Frequency



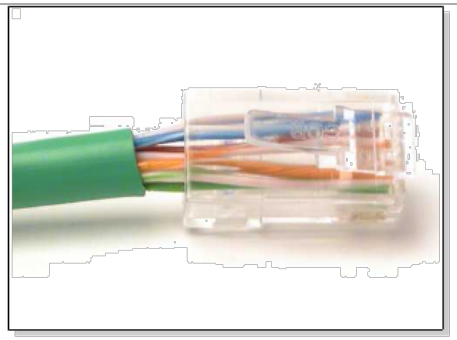
- Noise is an important concept in communications systems, including LANS.
- While noise usually refers to undesirable sounds, noise related to communications refers to undesirable signals.
- Noise can originate from natural and technological sources, and is added to the data signals in communications systems.
- All communications systems have some amount of noise.
- Even though noise cannot be eliminated, its effects can be minimized if the sources of the noise are understood. Laser noise at the transmitter or receiver of an optical signal

Attenuation and Insertion Loss on Copper Media

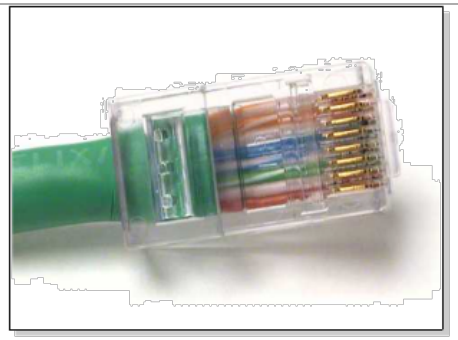


- Attenuation is the decrease in signal amplitude over the length of a link.
- Long cable lengths and high signal frequencies contribute to greater signal attenuation.

Sources of Noise on Copper Media



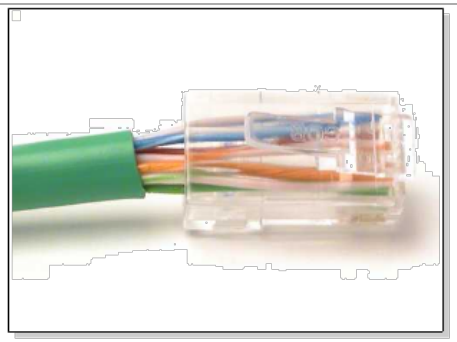
Bad Connector - Wires are untwisted for too great a length.



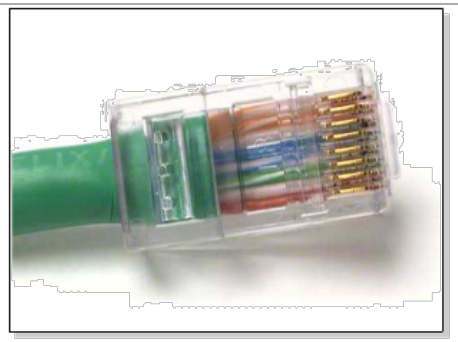
Good Connector - Wires are untwisted to the extent necessary to attach the connector.

- **Crosstalk** involves the ***transmission of signals from one wire to a nearby wire.***
- When voltages change on a wire, electromagnetic energy is generated.
- This energy radiates outward from the transmitting wire like a radio signal from a transmitter.
- Adjacent wires in the cable act like antennas, receiving the transmitted energy, which interferes with data on those wires.

Sources of Noise on Copper Media



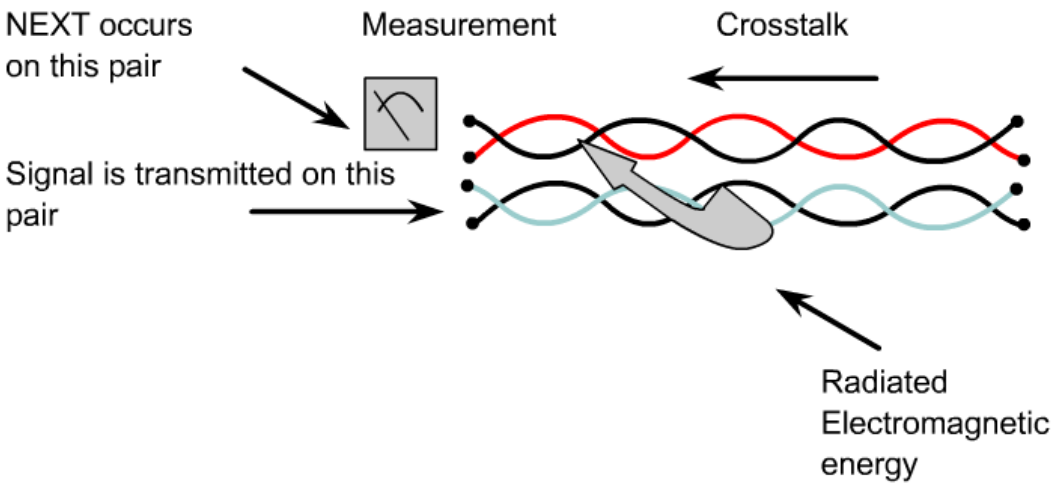
Bad Connector - Wires are untwisted for too great a length.



Good Connector - Wires are untwisted to the extent necessary to attach the connector.

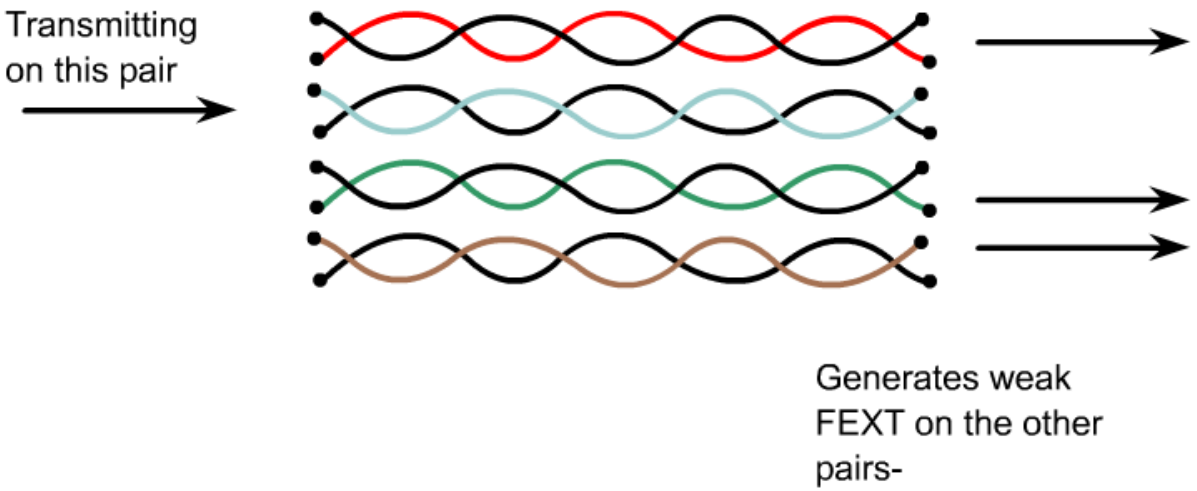
- Twisted-pair cable is designed to take advantage of the effects of crosstalk in order to minimize noise.
- In twisted-pair cable, a pair of wires is used to transmit one signal.
- The wire pair is twisted so that each wire experiences similar crosstalk.
- Because a noise signal on one wire will appear identically on the other wire, this noise be easily detected and filtered at the receiver.

Near-End Crosstalk (NEXT)



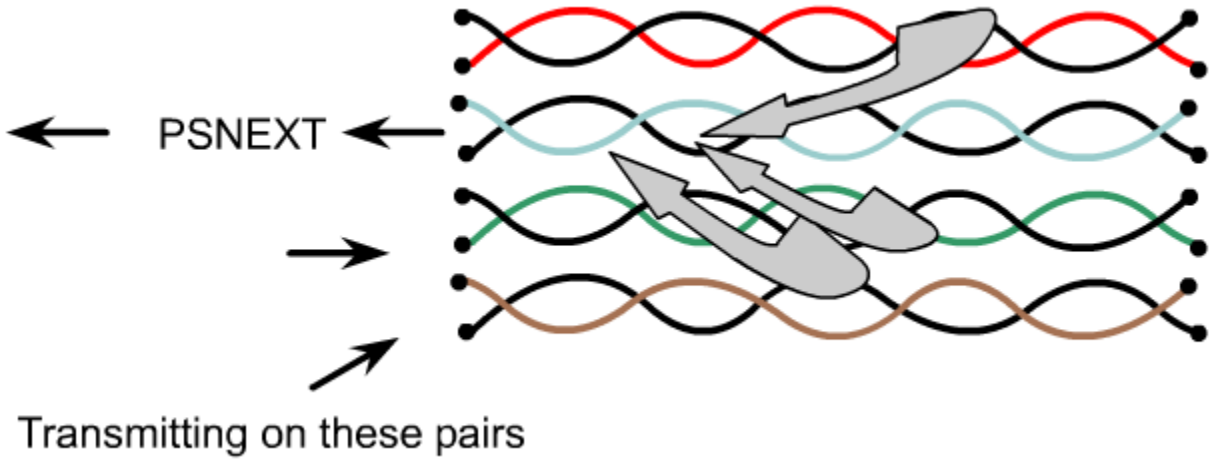
- **Near-end crosstalk (NEXT)** is computed as the ratio of voltage amplitude between the test signal and the crosstalk signal when measured from the same end of the link.

Far-End Crosstalk (FEXT)



- Due to attenuation, crosstalk occurring further away from the transmitter creates less noise on a cable than NEXT.
- This is called **far-end crosstalk, or FEXT.**
- The noise caused by FEXT still travels back to the source, but it is attenuated as it returns.
- Thus, FEXT is not as significant a problem as NEXT.

Power Sum Near-End Crosstalk (PSNEXT)

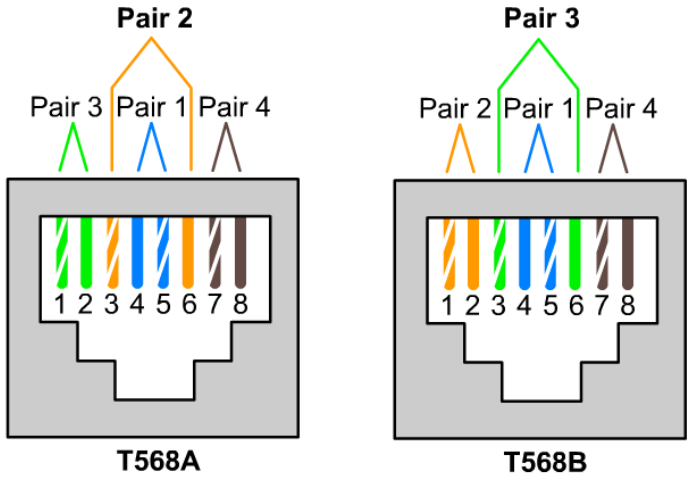


- **Power Sum NEXT (PSNEXT)** measures the cumulative effect of NEXT from all wire pairs in the cable.
- PSNEXT is computed for each wire pair based on the NEXT effects of the other three pairs.
- The combined effect of crosstalk from multiple simultaneous transmission sources can be very detrimental to the signal.

Cable Testing Standards

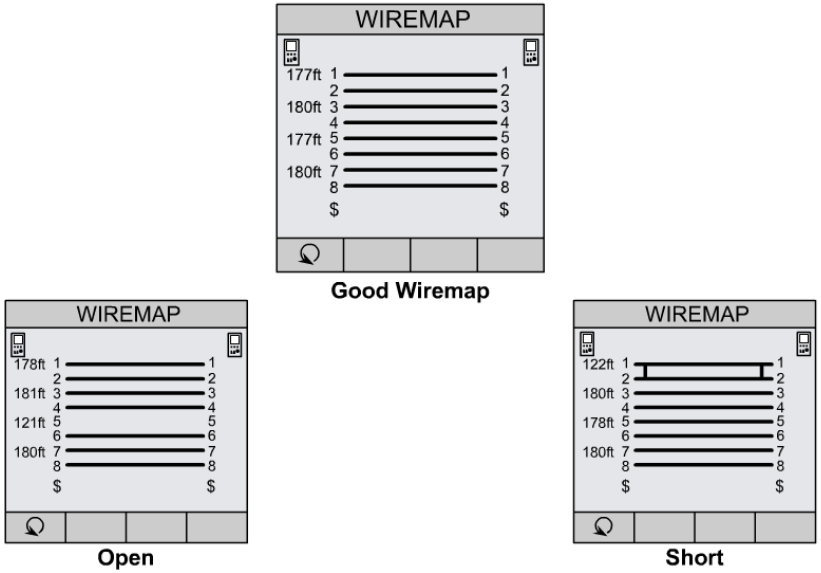
- The ten primary test parameters that must be verified for a cable link to meet TIA/EIA standards are:
  - Wire map
  - Insertion loss
  - Near-end crosstalk (NEXT)
  - Power sum near-end crosstalk (PSNEXT)
  - Equal-level far-end crosstalk (ELFEXT)
  - Power sum equal-level far-end crosstalk (PSELFEXT)
  - Return loss
  - Propagation delay
  - Cable length
  - Delay skew

Cable Testing Standards



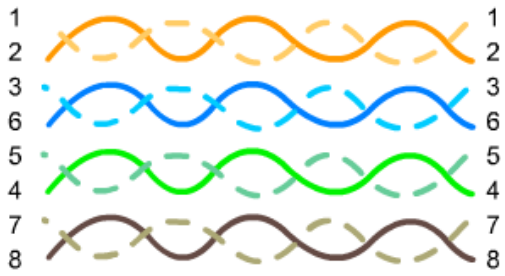
- The Ethernet standard specifies that each of the pins on an RJ-45 connector have a particular purpose.
- A NIC transmits signals on pins 1 and 2, and it receives signals on pins 3 and 6.
- The wires in UTP cable must be connected to the proper pins at each end of a cable.

Cable Testing Standards

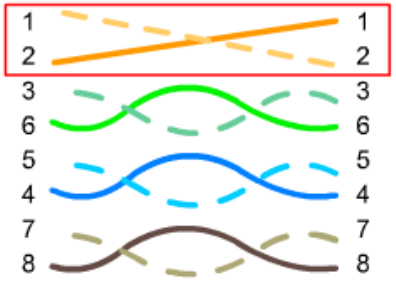


- The **wire map** test insures that no open or short circuits exist on the cable.
- An **open circuit** occurs if the wire does not attach properly at the connector.
- A **short circuit** occurs if two wires are connected to each other.

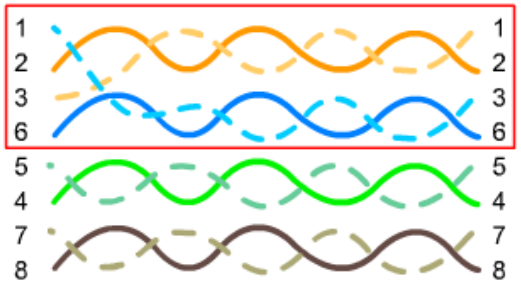
Cable Testing Standards



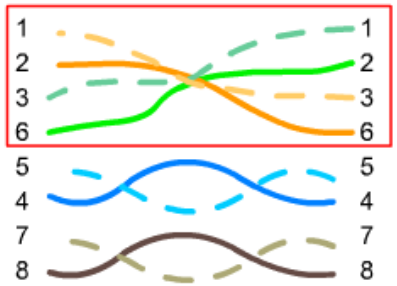
Correct T568B Wiring



Reversed-pair wiring fault



Split-pair Wiring Fault



Transposed-pair Wiring Fault

- The wire map test also verifies that all eight wires are connected to the correct pins on both ends of the cable.
- There are several different wiring faults that the wire map test can detect.