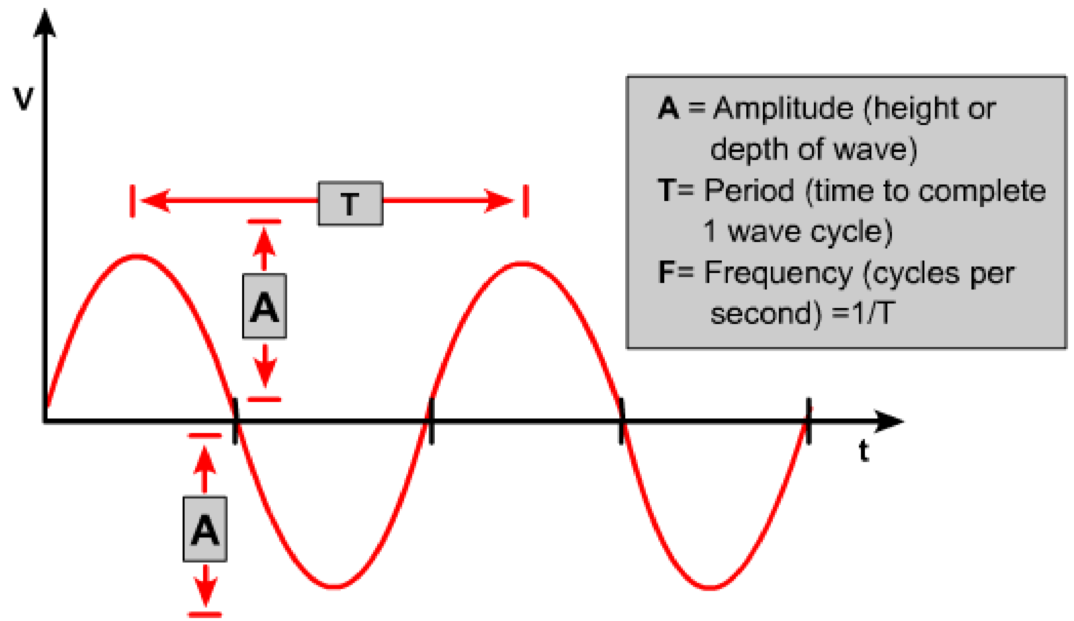
Cable Testing

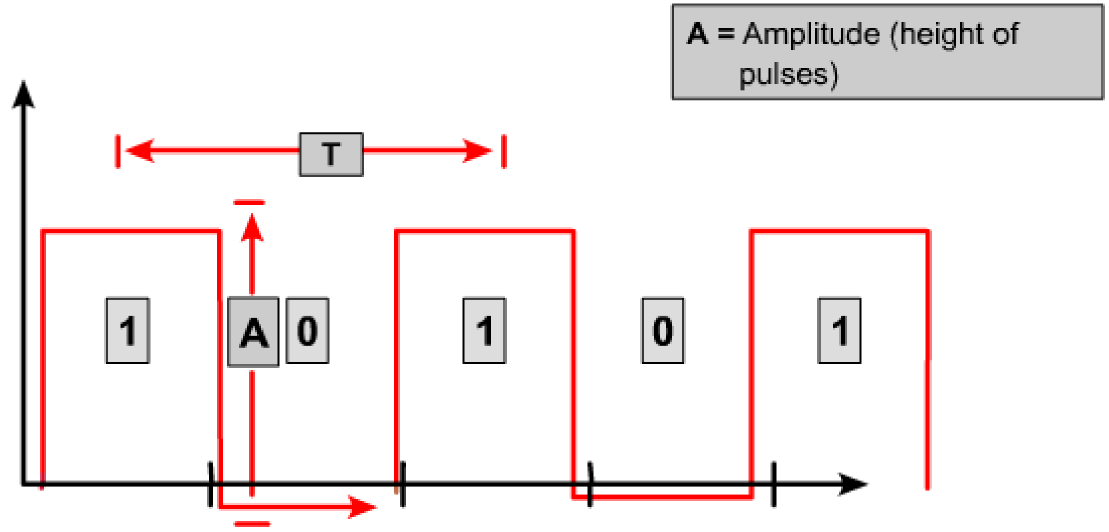
Sine Waves

- or sinusoids are graphs of mathematical functions
- are periodic (repeat the same pattern at regular intervals)
- are continuously varying (no two adjacent points on the graph have the same value)
- represent analog signal



Square Waves

- like sine waves, are periodic
- 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
- Square waves represent digital signals, or pulses

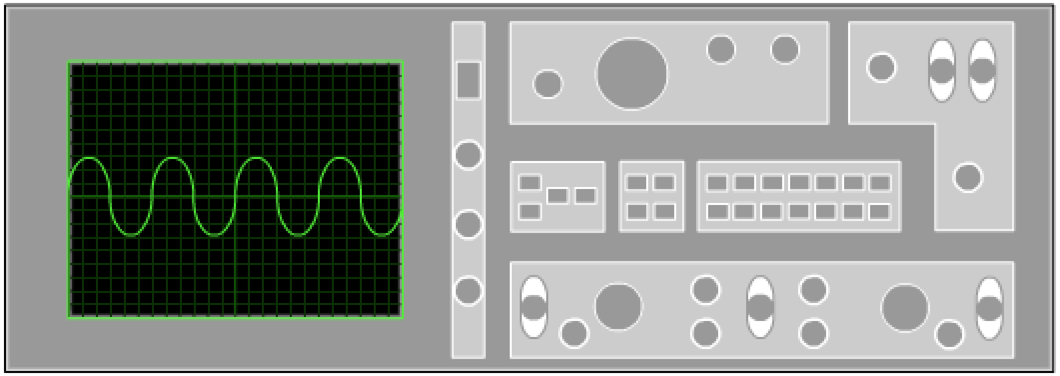


Decibels

- The decibel (dB) is a measurement unit important in describing networking signals
- 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 but can also be positive values representing a gain in power if the signal is amplified
  - 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
- light waves on optical fiber and radio waves in the air are measured using the power formula. Electromagnetic waves on copper cables are measured using the voltage formula

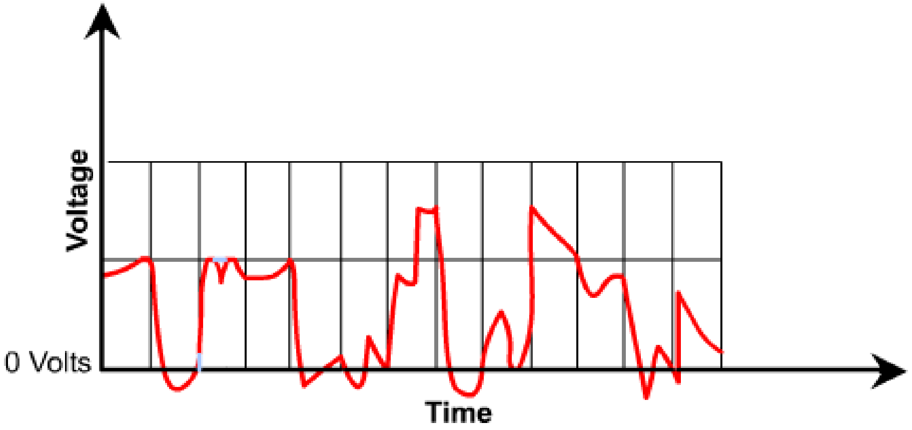
Viewing Signals in Time & Frequency

- Oscilloscope
  - Used to view electrical signals such as voltage waves and pulses
  - The x-axis on the display represents time, and the y-axis represents voltage or current
  - Analyzing signals using an oscilloscope is called time-domain analysis, because the x-axis or domain of the mathematical function represents time
- Spectrum analyzer
  - Creates graphs for frequency-domain analysis
  - Analyzing signals using spectrum analyzer is called frequency-domain analysis,
  - The x-axis represents frequency



Noise in Time & Frequency

- 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.
- There are many possible sources of noise:
  - Nearby cables which carry data signals
  - Radio frequency interference (RFI), which is noise from other signals being transmitted nearby
  - Electromagnetic interference (EMI), which is noise from nearby sources such as motors and lights
  - Laser noise at the transmitter or receiver of an optical signal

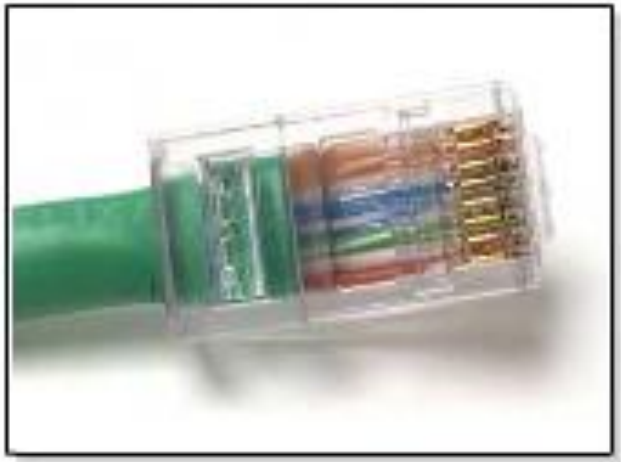


Attenuation and Insertion Loss on Copper Media

- Attenuation
  - is the decrease in signal amplitude over the length of a link
  - is expressed in decibels (dB) using negative numbers
- Impedance Discontinuity
  - Impedance is a measurement of the resistance of the cable is measured in ohms
  - If a connector is improperly installed on cable, it will have a different impedance value than the cable, called an impedance discontinuity or an impedance mismatch
  - Multiple discontinuities creating multiple echo effects
  - The echoes strike the receiver at different intervals making it difficult for the receiver to accurately detect data values on the signal, called jitter and results in data errors
- Insertion Loss
  - is the combination of the effects of signal attenuation and impedance discontinuities on a communications link

Source of Noise on Copper Media

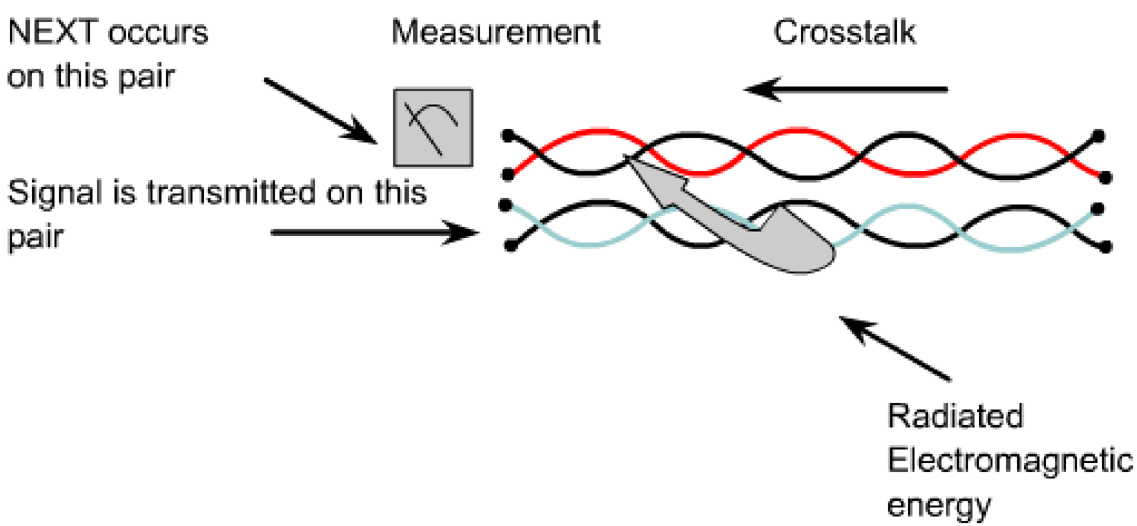
Bad Connector - Wires are untwisted for too great a length.



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

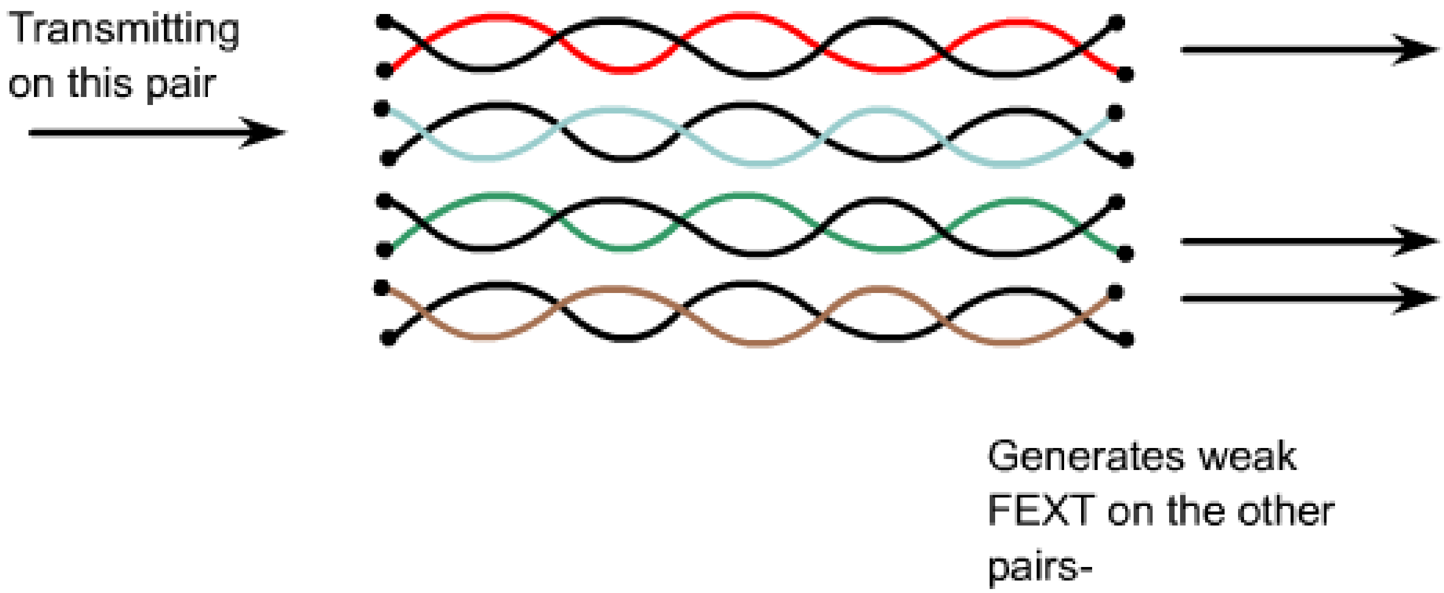
Types of Crosstalk

- Near-end Crosstalk (NEXT) - interference from adjacent wire or separate nearby cable measured from the same end
- expressing in a negative value of decibels (dB), low negative numbers indicate more noise
- by tradition, cable testers do not show the minus sign indicating the negative value, for example a NEXT reading of 30 dB (really -30) indicates less NEXT noise than does a NEXT reading of 10 dB (really -10)



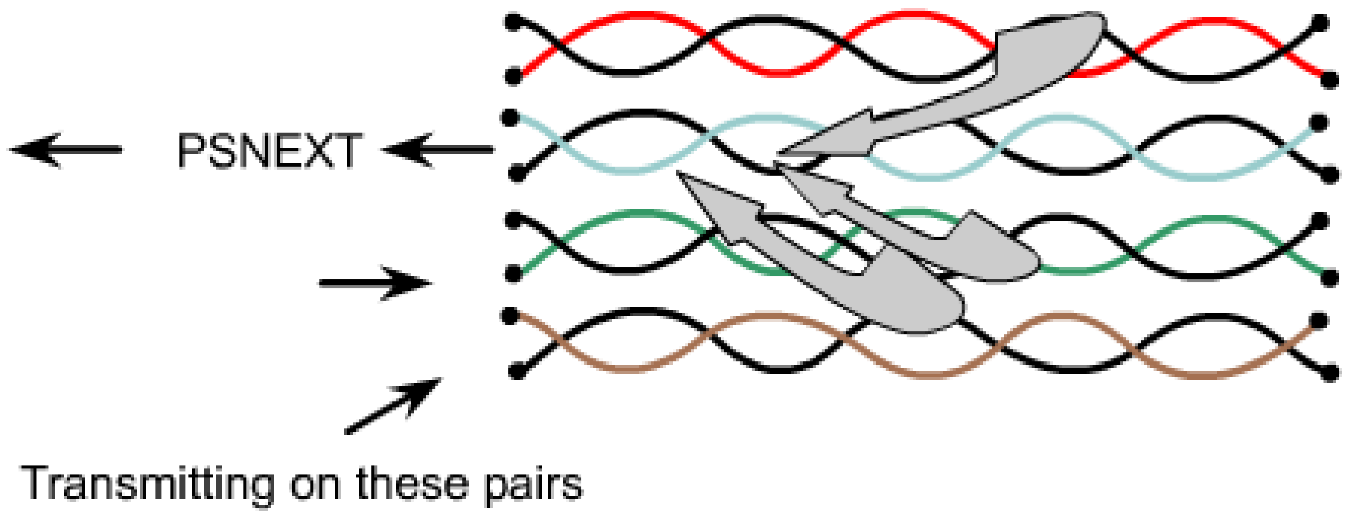
Types of Crosstalk

- Far-end Crosstalk (FEXT) - crosstalk occurring further away from the transmitter creates less noise on a cable than NEXT
- because of attenuation, FEXT creates less noise on a cable than NEXT



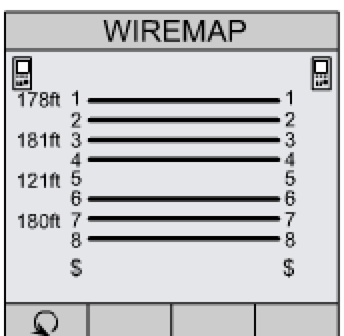
Types of Crosstalk

- Power Sum Near-end Crosstalk (PSNEXT) - measures the cumulative effect of NEXT from all wire pairs in the cable

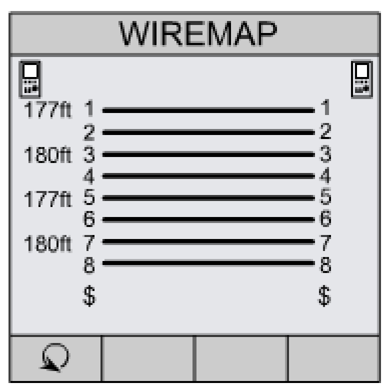


Cable Testing Standard

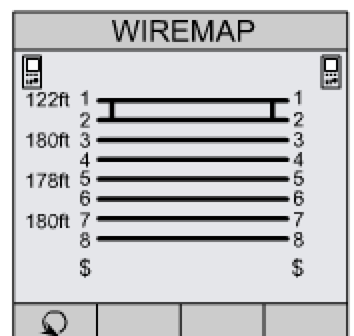
- The TIA/EIA-568-B standard specifies ten tests that a copper cable must pass
- The ten primary test parameters that must be verified for a cable link to meet TIA/EIA standards are: Wire map, Insertion loss, Near-end crosstalk (NEXT), Power sum near-end crosstalk (PSNEXT), Equal-level far-end crosstalk (ELFEXT), Power sum equal-level far-end crosstalk (PSELFEXT), Return loss, Propagation delay, Cable length, Delay skew
- **The wire map** - test insures that no open or short circuits exist on the cable and also verifies that all eight wires are connected to the correct pins on both ends of the cable



Open



Good Wiremap



Short

Other Test Parameters

- **Insertion loss** - combination of signal attenuation and impedance discontinuities
- **Near-end crosstalk (NEXT)** - interference from adjacent wire
- **Power sum near-end crosstalk (PSNEXT)** - measures the cumulative effect of NEXT
- **Equal-level far-end crosstalk (ELFEXT)** - crosstalk occurring further away from the transmitter
- **Power sum equal-level far-end crosstalk (PSELFEXT)** - measures the cumulative effect of FEXT
- **Return loss** - is a measure in decibels of reflections that are caused by the impedance discontinuities
- **Propagation delay** - measurement of how long it takes for a signal to travel along the cable being tested
- **Cable length**
- **Delay skew** - The delay difference between pairs

Testing Optical Fiber

- Because noise, crosstalk, Electromagnetic Interference (EMI) or Radio Frequency Interference (RFI) has no effect on fiber optic cable, so the primarily test involves shining a light down the fiber and measuring whether a sufficient amount of light reaches the receiver

Summary

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- Cabling testing involves certain electrical and mathematical concepts and terms, such as signal, wave, frequency, and noise. Understanding those terms is helpful when learning about networking, cabling, and cable testing.
- Attenuation (signal deterioration) and noise (signal interference) cause problems in networks because the data is not recognizable when it is received. Proper attachment of cable connectors and proper cable installation are important.