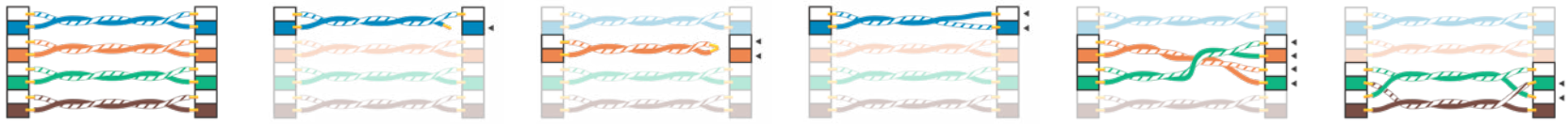
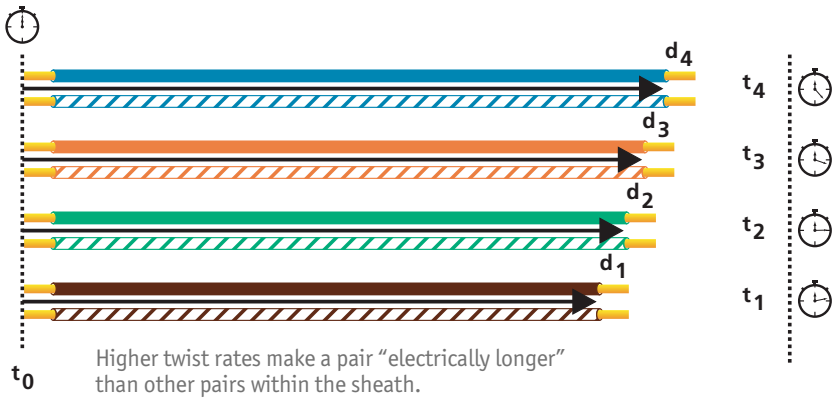
Twisted Pair Cabling Measurements

Wiremap

Pair 1
Pair 2
Pair 3
Pair 4



Delay/Skew



Higher twist rates make a pair "electrically longer" than other pairs within the sheath.

Propagation Delay: $t_4 - t_0$

Delay Skew: $t_4 - t_1$

Skew = Maximum difference in propagation delay between the fastest pair to the slowest pair.

Delay/Skew Failure: Excess length, poor cable design.

Resistance Unbalance



Resistance Unbalance within a pair is a measurement of the difference in resistance between the two conductors in a balanced wire pair.

$$\text{Resistance Unbalance}_{\text{within a pair}} = \left[\frac{|R_{C1} - R_{C2}|}{R_{C1} + R_{C2}}\right] 100\%$$

R_{C1} is the DC resistance of conductor 1.
R_{C2} is the DC resistance of conductor 2.
Where conductor 1 and conductor 2 are the two conductors of the same pair.



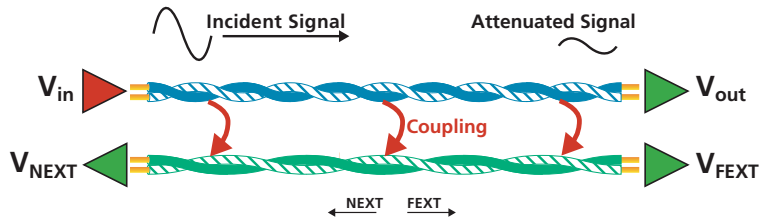
Resistance Unbalance between pairs is a measurement of the difference in parallel resistances between two balanced wire pairs

$$\text{Resistance Unbalance}_{\text{between pairs}} = \left[\frac{|R_{P1} - R_{P2}|}{R_{P1} + R_{P2}}\right] 100\%$$

R_{P1} is the DC parallel resistance of the conductors of a pair.
R_{P2} is the DC parallel resistance of the conductors of another pair.

Failure: Contact Resistance Issue or poor cable design. Testing is not required for field certification, but is essential to understand if a link will support higher levels of PoE.

Insertion Loss, NEXT, FEXT, ACR, ACRF



Insertion Loss: $\left[\frac{V_{in}}{V_{out}}\right]$

Failure: Excess length, high frequency or temperature, excess return loss, wire gauge too thin, poor cable design.

NEXT: Near-End Cross Talk $\left[\frac{V_{in}}{V_{NEXT}}\right]$

Failure: Poor twisting, common mode conversion, CP[1] too close to TO[2], poor cable or connector design, reflected FEXT.

FEXT: Far-End Cross Talk $\left[\frac{V_{in}}{V_{FEXT}}\right]$

Failure: Poor twisting, common mode conversion, poor cable or connector design.

ACR = NEXT - IL
Attenuation to Crosstalk Ratio

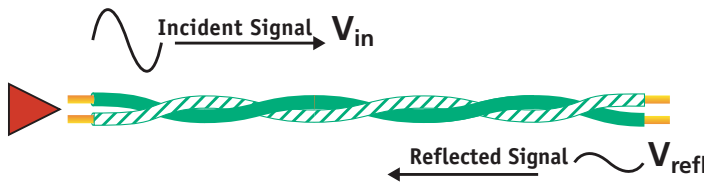
Failure: Excessive NEXT or Insertion Loss.

ACRF = FEXT - IL
Attenuation to Crosstalk Ratio Far-End

Failure: Excessive Insertion Loss or FEXT.

[1]CP = Consolidation Point
[2]TO = Telecommunications Outlet

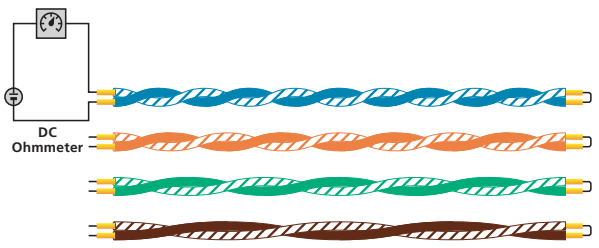
Return Loss



Return: Loss $\left[\frac{V_{in}}{V_{refl}}\right]$

Failure: Mismatched impedance of cable-connector, jack-plug, or cable-cable; untwisting at connector; closely placed connections; asymmetric twisting; high resistance contact; poor cable or connector design.

Loop Resistance





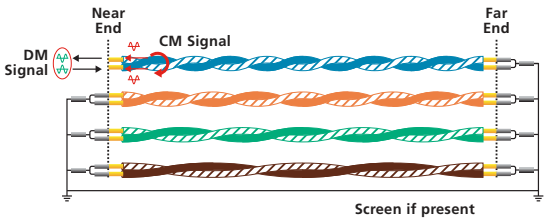
DC Loop Resistance

Measurement, in ohms, of the total DC resistance of the wires of a pair taken together.

Failure: Contact Resistance Issue or poor cable design.

Transverse Conversion Loss

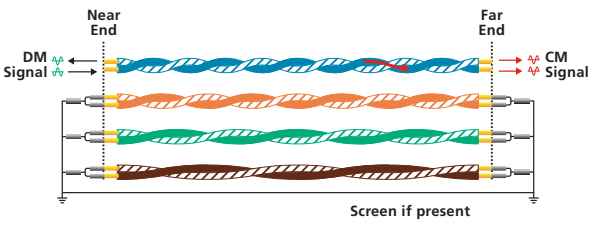
TCL



Transverse Conversion Loss

A ratio, expressed in dB, of the measured common mode voltage on a pair relative to the differential mode voltage on the same pair applied at the same end. TCL indicates if a pair is well balanced and with that has good immunity to external noise.

TCTL



Transverse Conversion Transfer Loss

A ratio, expressed in dB, of the measured common mode voltage on a pair relative to the differential mode voltage applied at the opposite end of the same pair, or on either end of another pair.

ELTCTL

$$ELTCTL = TCTL - IL_{dm}$$

Equal Level Transverse Conversion Transfer Loss

A calculation, expressed in dB, of the difference between measured TCTL and the differential mode Insertion Loss of the disturbed pair.

Failure (also for TCL): poor cable design of production.

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Formulas shown are conceptual representations of log scaled voltage ratios which are signed for loss where appropriate.

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