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טלדור
כבלים ומערכות בע"מ

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כנס יועצי מערכות תקשורת

22-24 אוקטובר - מלון דניאל ים המלח

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Testing and approval of cabling systems

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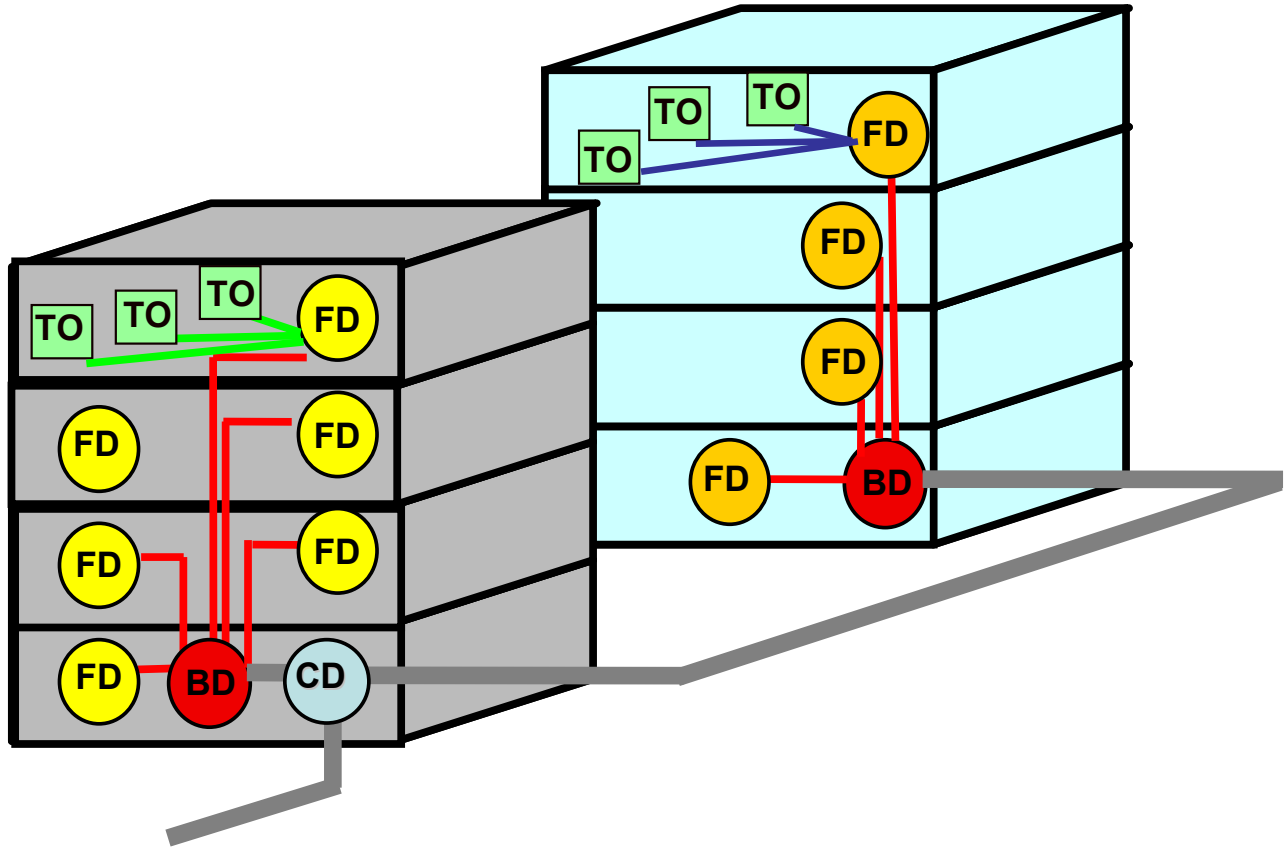
Agenda

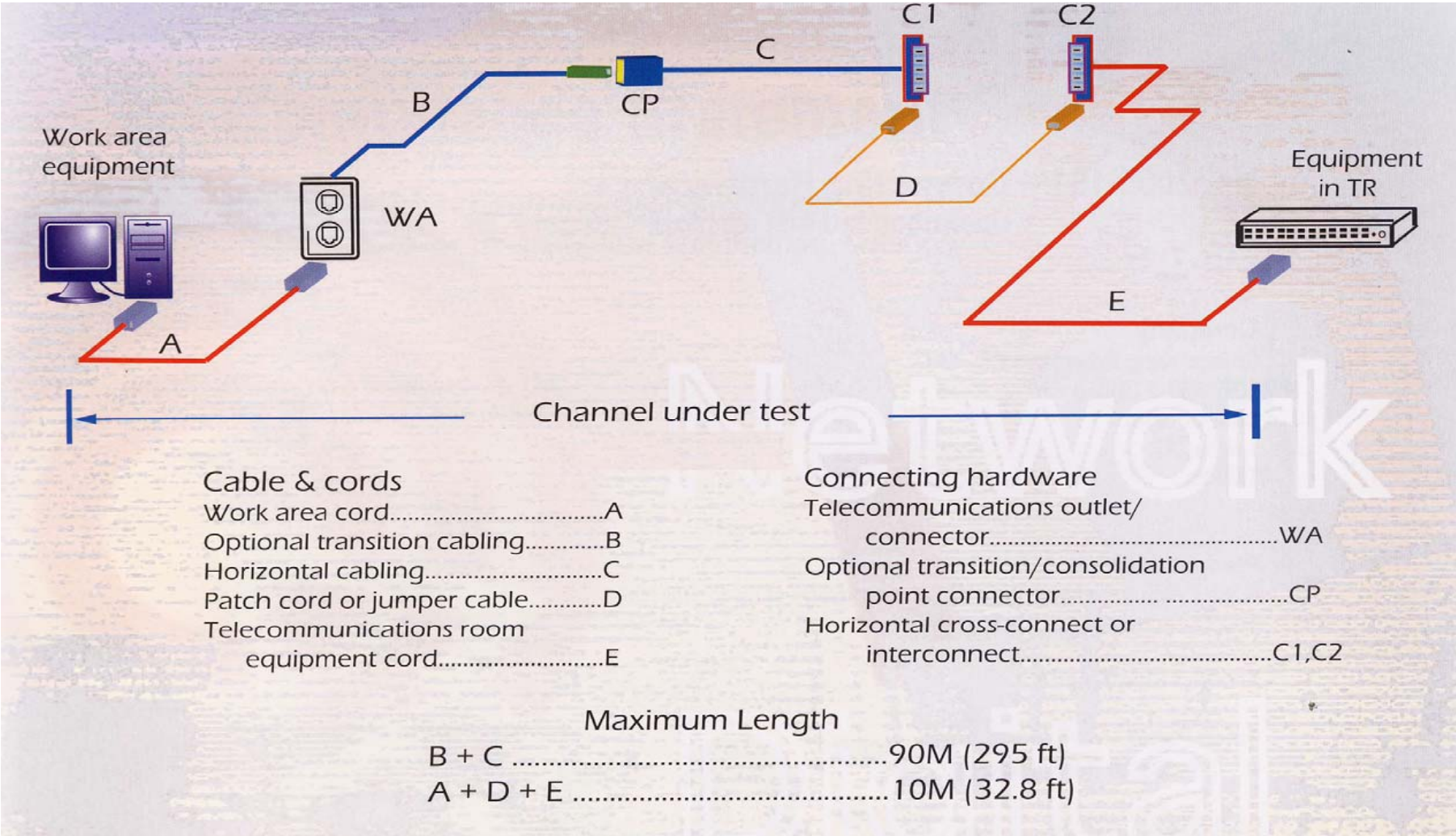
- Structure of typical cabling system
- Transmission parameters - Review
  - Individual cable (cabling) - Internal
  - Between Cables (cabling) - External
- Installation parameters
  - What should be measured and reported
  - What can’t be measured in practical installations
- Problems in high performance networking
- Recommendation

Elements of structured cabling

- Campus Distributor
- Backbone
- Building Distributor
- Vertical Cabling
- Floor Distributor
- Horizontal Cabling
- Transition Point
- Terminal Outlet



Channel Structure



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Some facts regarding networks and measurements

- The upgrading / changing of the installed cables is highly difficult, complicated and expensive task
- Experience shows that the optimal cables for installation are cables with the highest performance category)
- In many cases the installed cables have higher category (7, 7A) than the connecting hardware (6, 6A)
- High speed data communication systems are influenced by many characteristics (parameters) that just few of them can be measured and most of them are measured up to limited frequency.
- Those parameters can't be controlled during practical installation and should be determined by the quality of the network components

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Some facts regarding networks and measurements

- Practically, just the permanent link is tested but the transmission is done through the whole channel
- The measurement is determined and limited to the performance of the connecting hardware and test equipment. The performance of the fixed (permanent) part (cables) is not tested and unknown
- The actual communication speed (data rate) is lower than the bit rate

Many problems can be created in the high frequency zone and special attention should be given when choosing the cables

Shannon's Law

Channel Capacity = BandWidth * log2(1+SNR) Bit/s

Channel Capacity = BandWidth * log2(1+S/N) Bit/s

The maximum available error free bit rate in a limited bandwidth (BW) with presence of noise (N)

- Cannel capacity: the maximum theoretical bit rate (bit/s)
- BandWidth: The channel width (Hertz)
- SNR: Signal to noise ratio = S/N

Attenuation-Insertion Loss

- Reduction in signal strength = Attenuation is a measure of how much the signal (good signal – the data itself) is attenuated (reduced) when it transmitted from one end of the cable to the other end.
- The signal is reduced (attenuation is increased) when cable length is longer and the frequency is increased.
- The signal is reduced (attenuation is increased) when the frequency is increased.

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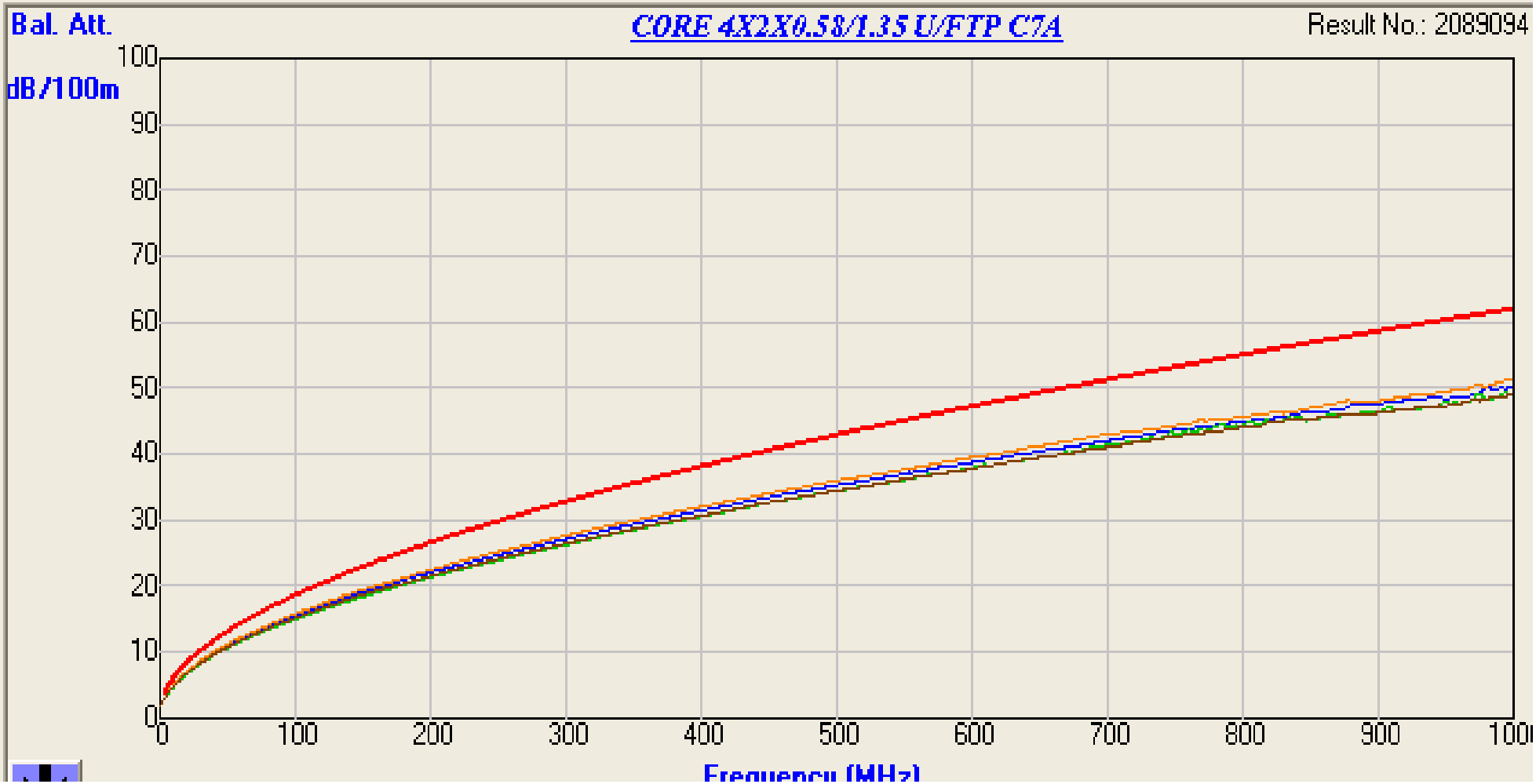
Attenuation (insertion Loss) Curve



Balancing: TCL & EL-TCTL

- Balanced cabling means that the signals at each wire of a pair are equal but opposite in direction.
- In well balanced systems (comparing to not well balanced systems):
  - The differential signals are high common mode signals are low.
  - The signal to noise ratio is high
  - The working points (in receiver and transmitter) are more in the middle and signals can be increased without causing to saturation.
  - The radiation is less and radiation interferences are lower.
  - The produced Cross-Talk is smaller and the influence from cross-talk is smaller.
- In order to have better protection from interferences (internal and external) the systems should be well balanced.
- The measurement methods are TCL and ELTCTL

TCL & ELTCTL – Measure how much the cabling system is balanced

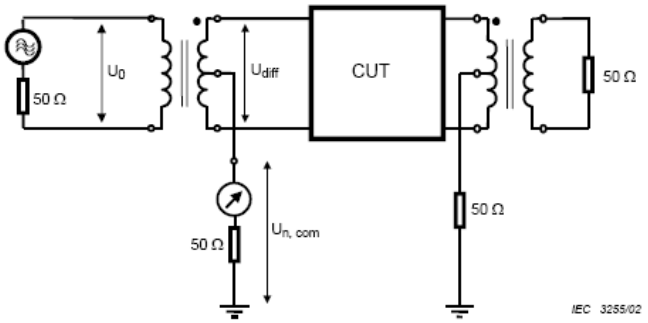


Figure 3 – Test set-up for unbalance attenuation at near end (TCL)

$$\alpha_{meas} = 20 \cdot \log_{10} \left| \frac{U_{n,com}}{U_0} \right|$$

The TCL (LCL) is influenced by the balance of each pair.

The measurement is done from one side.

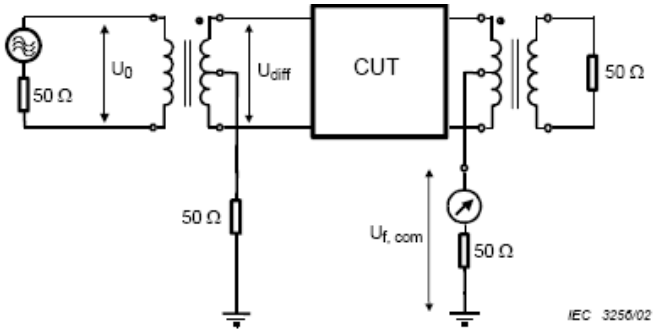


Figure 4 – Test set-up for unbalance attenuation at far end (TCTL)

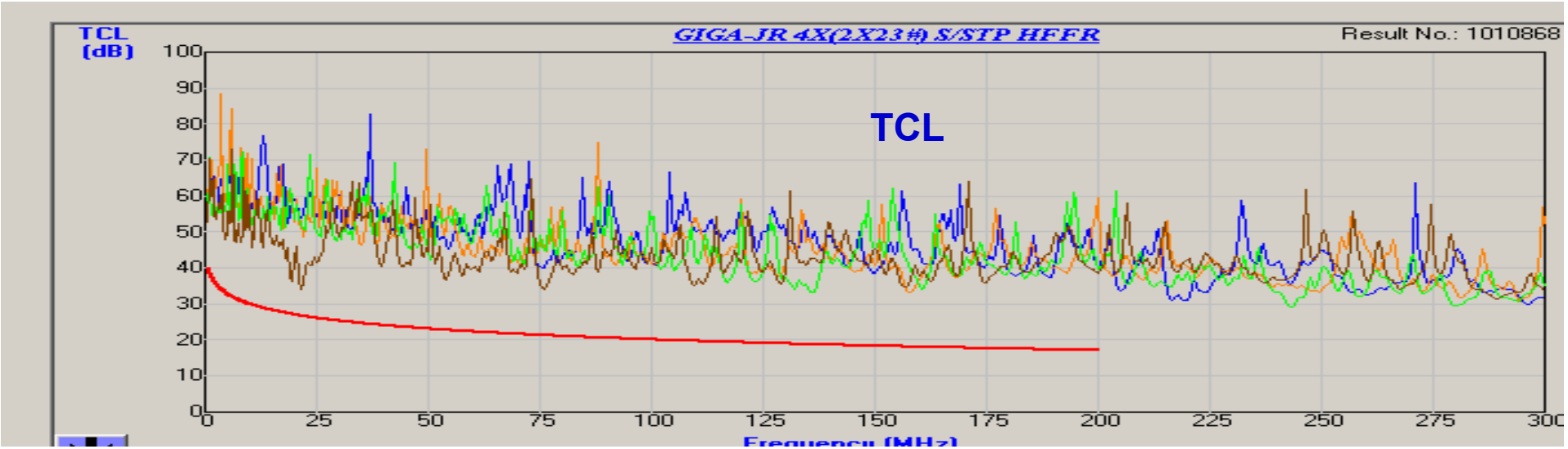
$$\alpha_{meas} = 20 \cdot \log_{10} \left| \frac{U_{f,com}}{U_0} \right|$$

The TCTL is influenced by the balance along the pair and the attenuation.

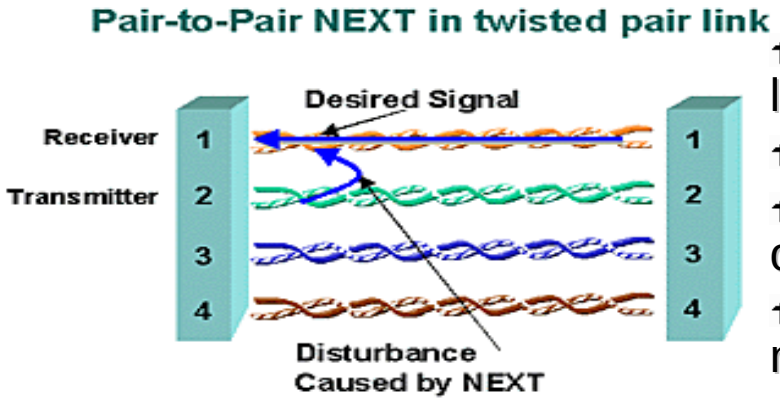
The measurement is done from two sides.

The EL-TCTL is the amount of TCTL at the far end (calibrated with attenuation)

Typical measurement result of TCL & ELTCTL



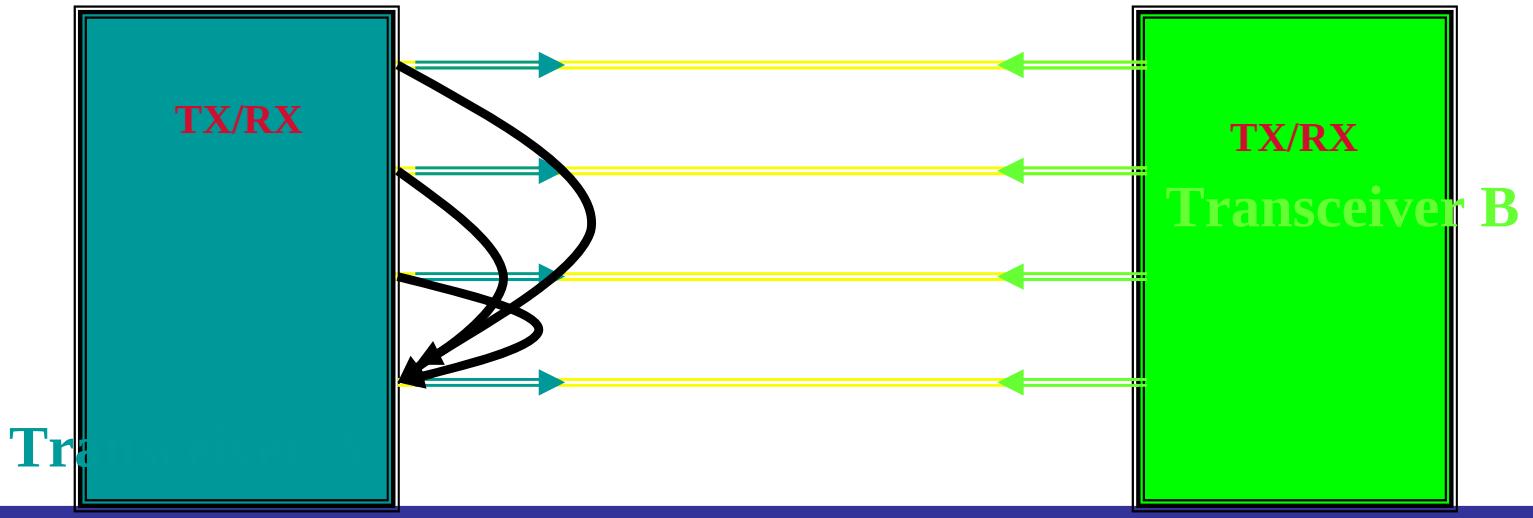
NEXT Loss + PowerSum NEXT Loss



- NEXT is the noise radiated into receiver from transmitter located in the same side (end) of the transceiver.
- In a 4 pair cable, 6 combinations of NEXT are exist.
- Each pair can be influenced by 3 NEXT sources (the other 3 pairs)
- NEXT is the noise, **Next Loss** is the attenuation of the noise

•Power Sum NEXT is the sum of the NEXT noises in one pair, generated by all other pairs together.

•PSNEXT is the worst case for NEXT influence.



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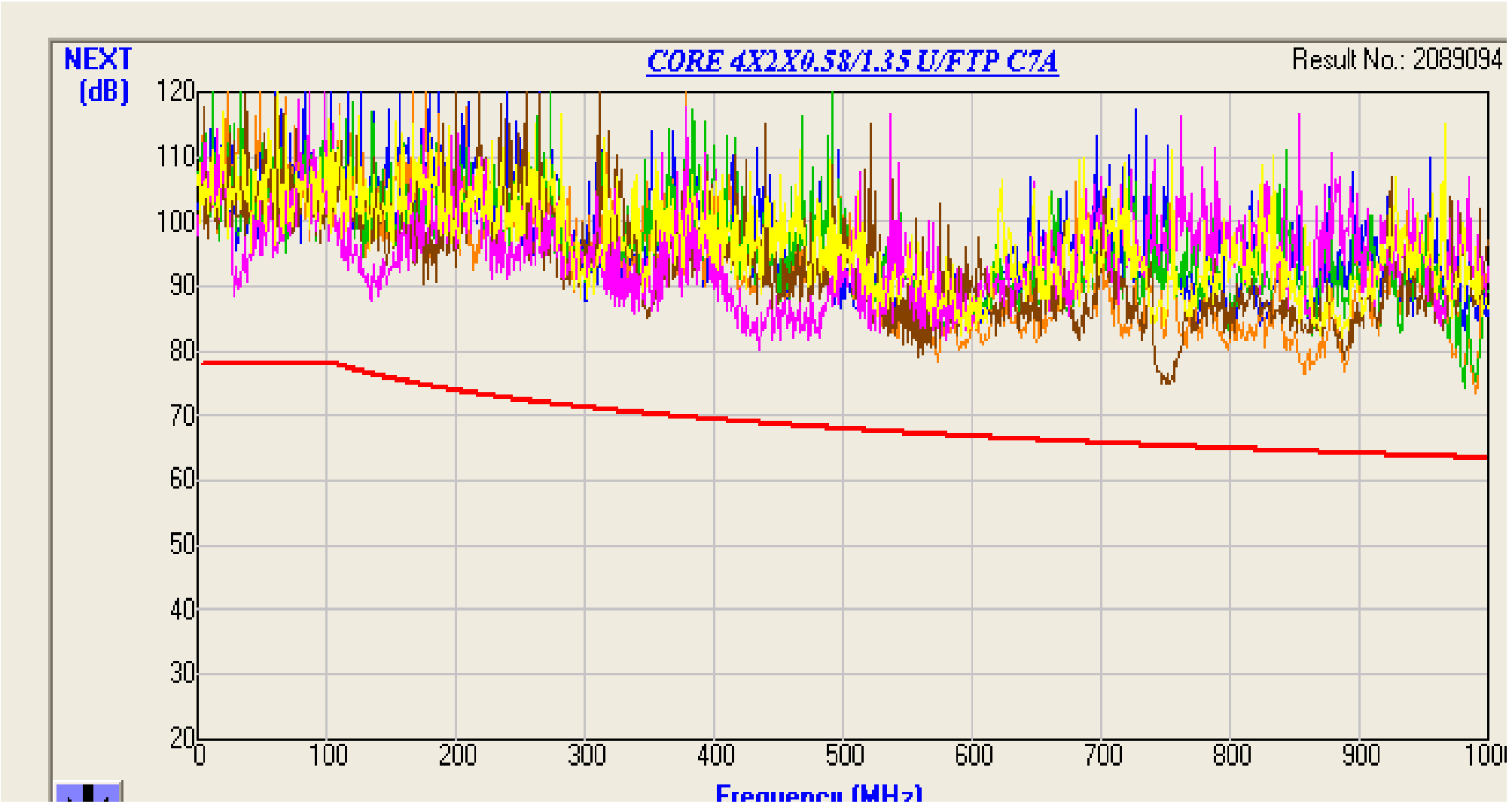
NEXT Loss Curve



ACR Attenuation to CrossTalk Ratio

- **The difference (in dB) between the NEXT loss of the induced signal and the remote signal attenuation at the near end.**
- **A measure of the cable contribution to the SNR (signal to noise ratio) at the receiver.**
- **Positive ACR indicates a capability of a cable to transfer a signal successfully**

ACR (dB) = Attenuation (dB) – NEXT (dB)

Higher ACR => higher margin of safety => lower BER

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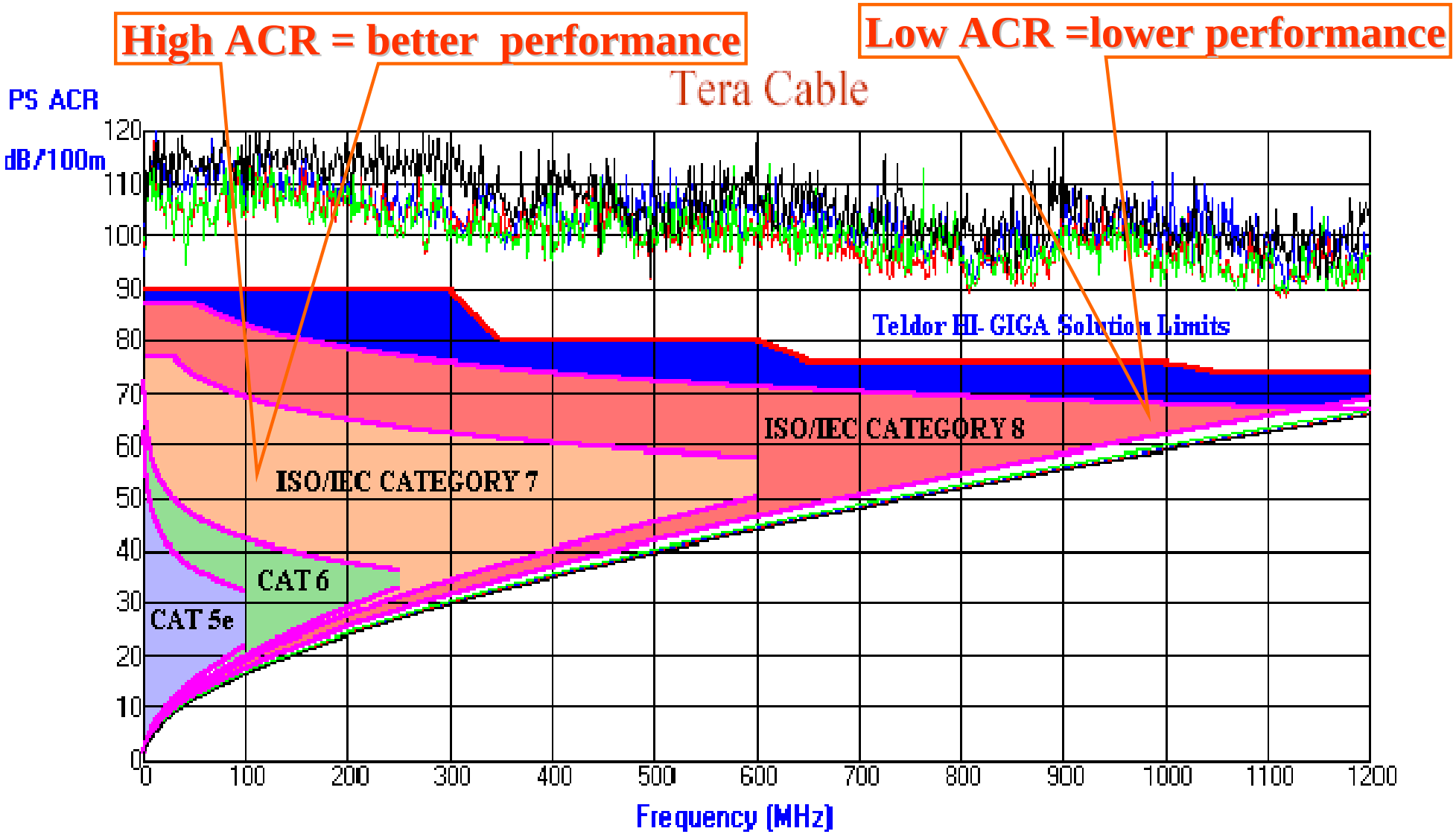
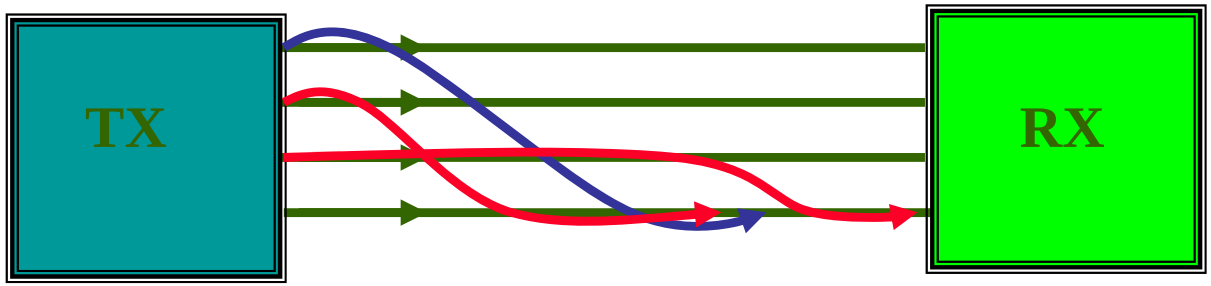
ACR of various Cables



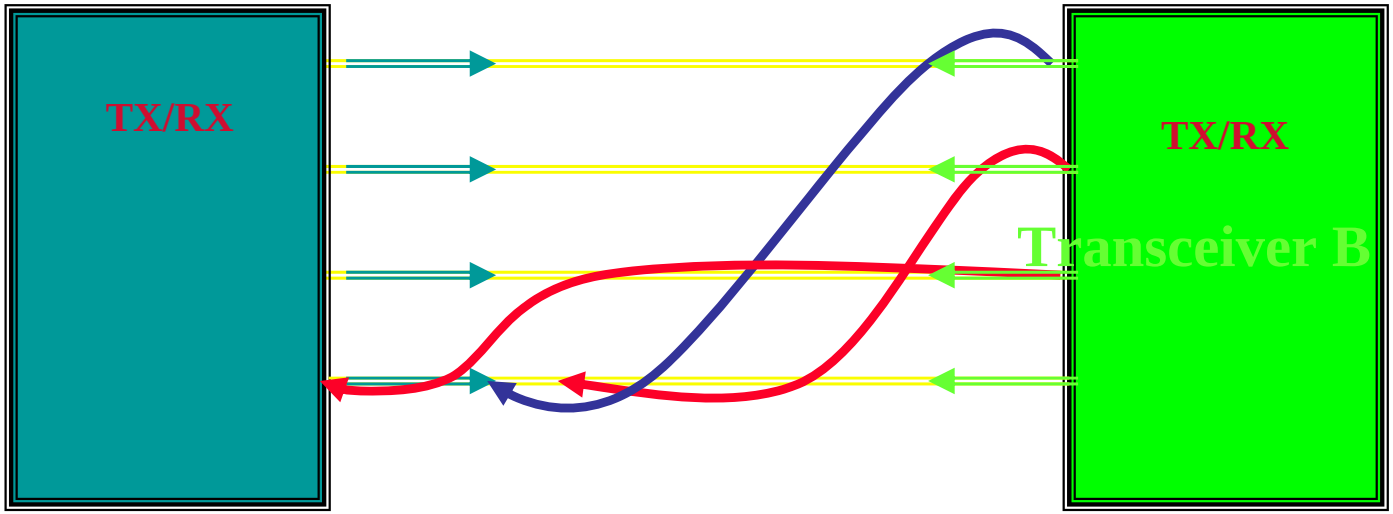
ELFEXT Loss + PowerSum Equal Level Far End Cross Talk Loss



ELFEXT is IOFEXT corrected for attenuation.

ELFEXT=IOFEXT-Attenuation (when measured with 100m length)

ELFEXT is the equivalent parameter to ACR at the far end



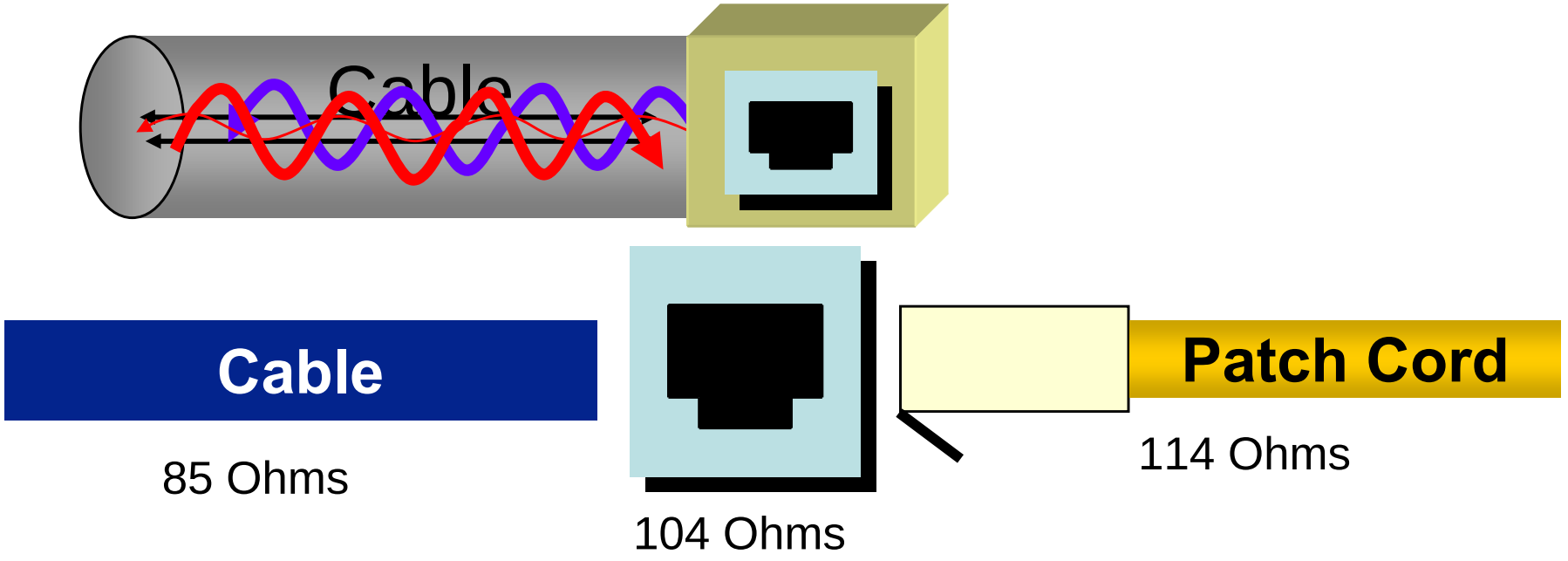
Transceiver A

•Power Sum ELFEXT is the sum of the FEXT noises in one pair, generated by all other pairs together.

•PSELFEXT is the worst case for FEXT influence.

Return Loss

- Is a measure of the reflected energy caused by impedance mismatches in the cabling system.
- Is controlled by closely matching the characteristic impedance values of the cables, connectors and patch cords
- More connectors = more Return Loss
- Poor terminations/untwisting = More Return Loss



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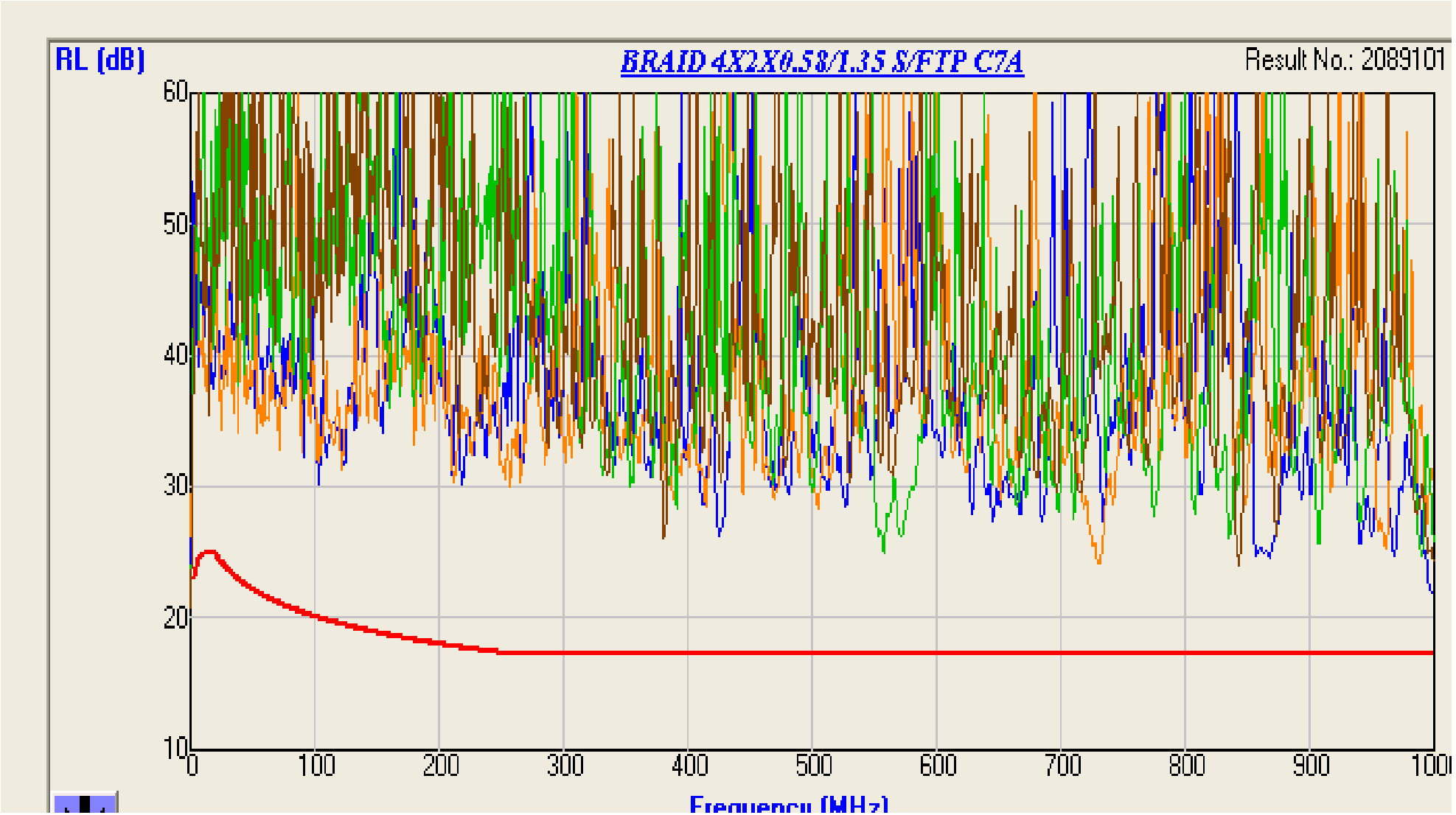
RL – Return Loss



Transceiver Structure

- Modern NICs contain receiver and transmitter in the same port

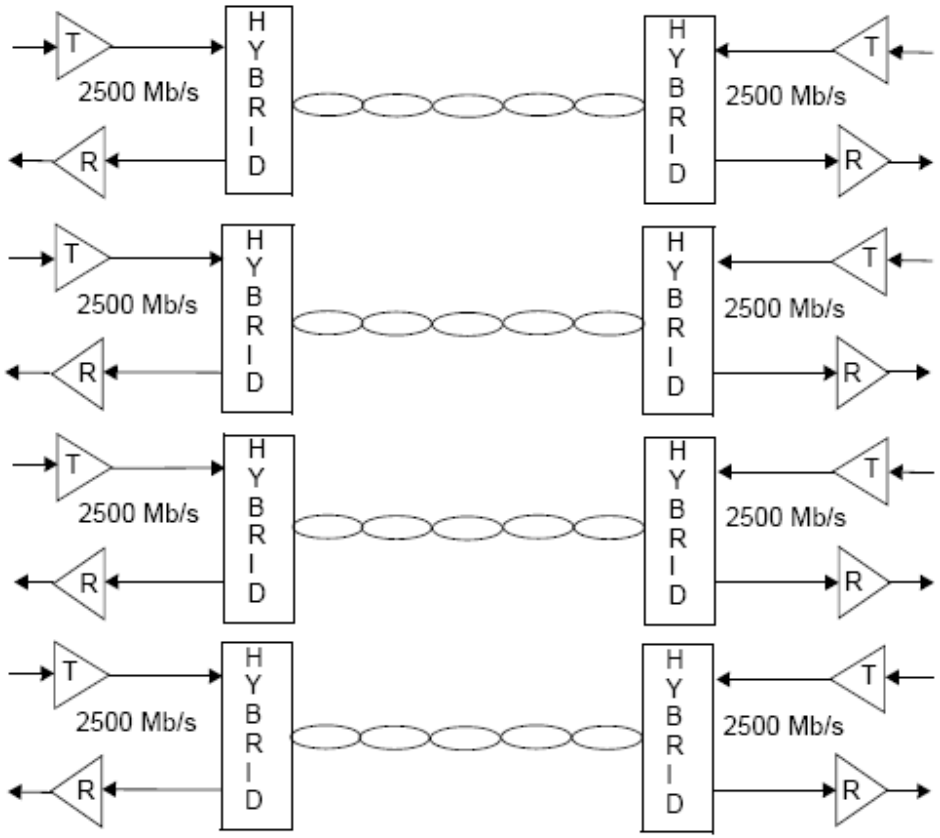
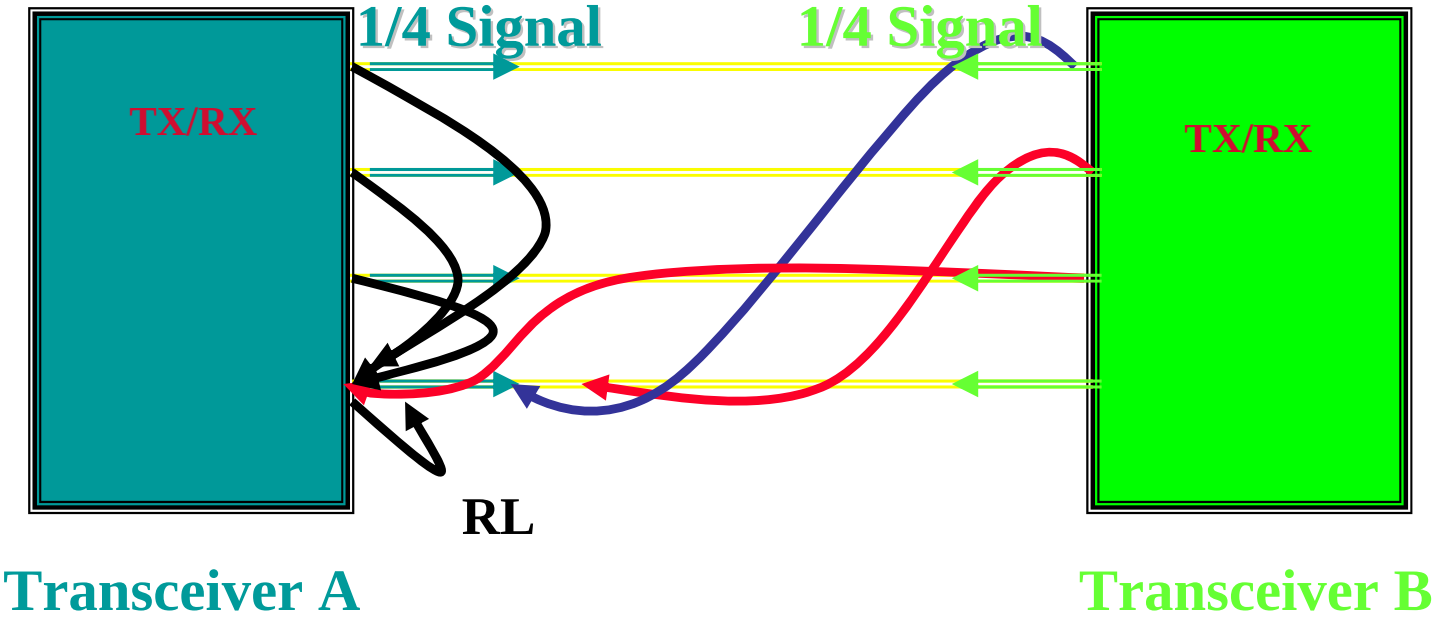


Figure 55–2—10GBASE-T topology

Internal Noise in the network

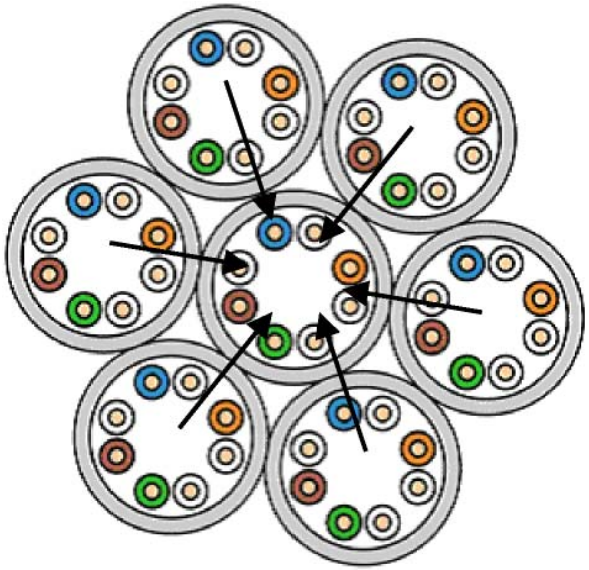
The crucial parameters in such systems are PS-ELFEXT, PS-ACR, Delay Skew, and Return Loss (RL).

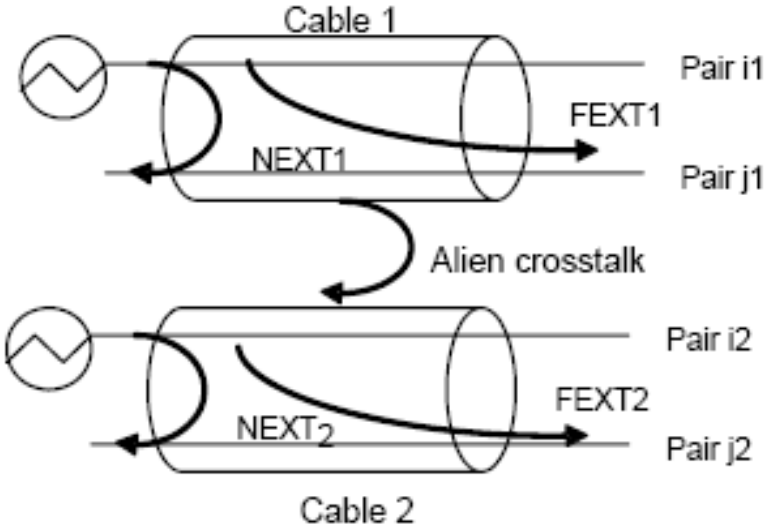


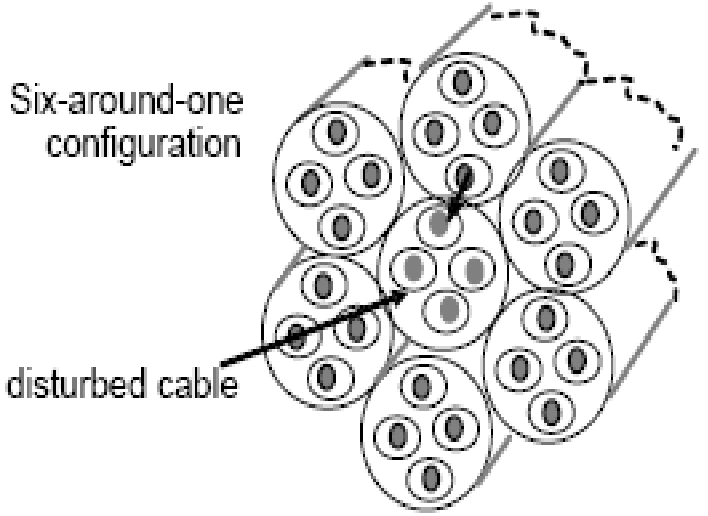
Alien CrossTalk

Alien Crosstalk is the noise coupled between the adjacent link segments

Alien crosstalk refer to Far end alien crosstalk as well as for near end alien crosstalk

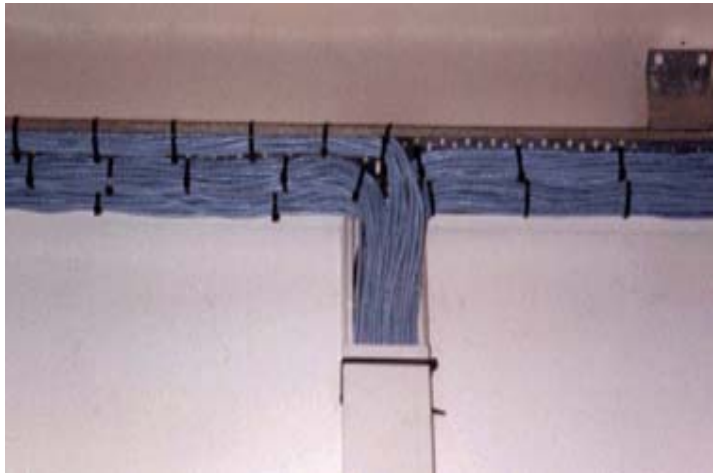


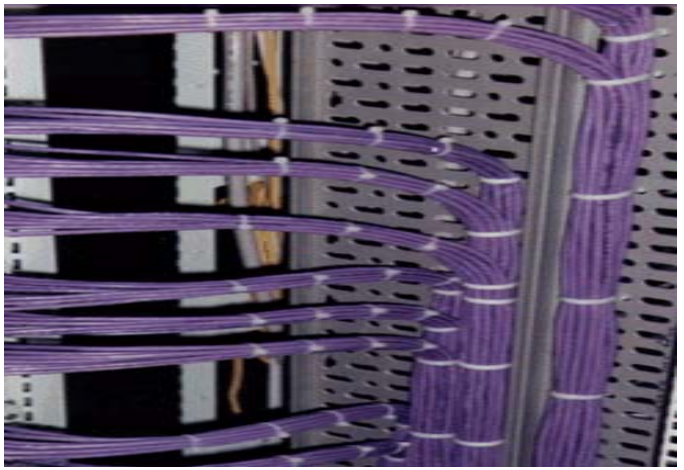




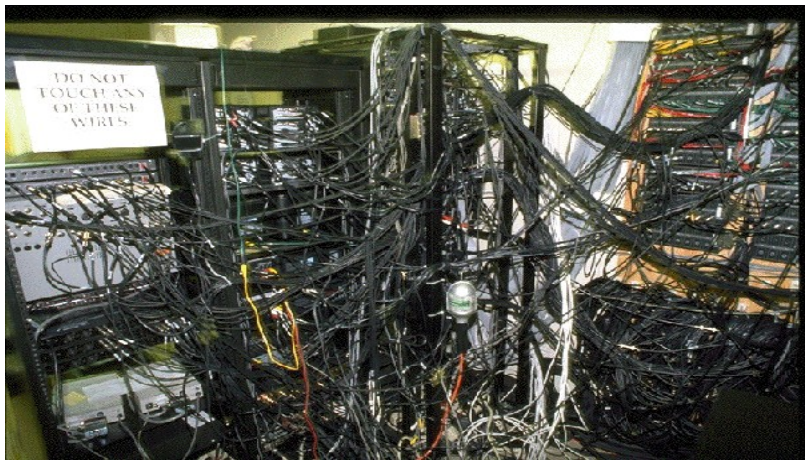
Alien CrossTalk – What is better?

Good Installation practice: Alien CrossTalk?

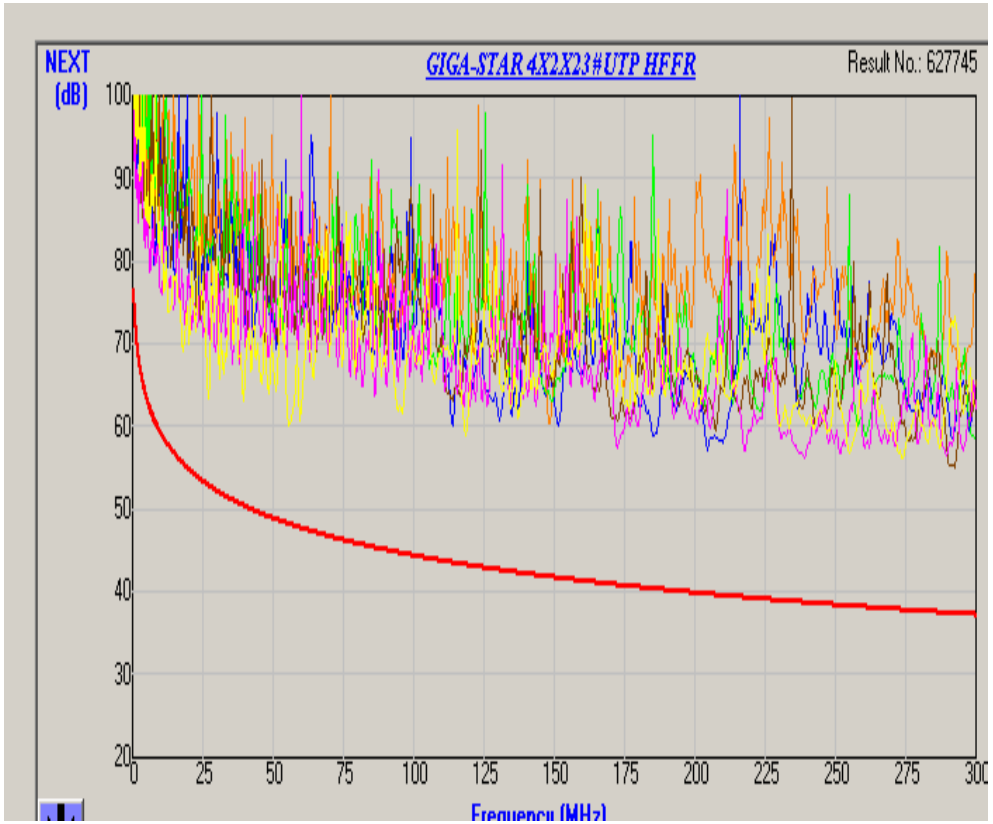




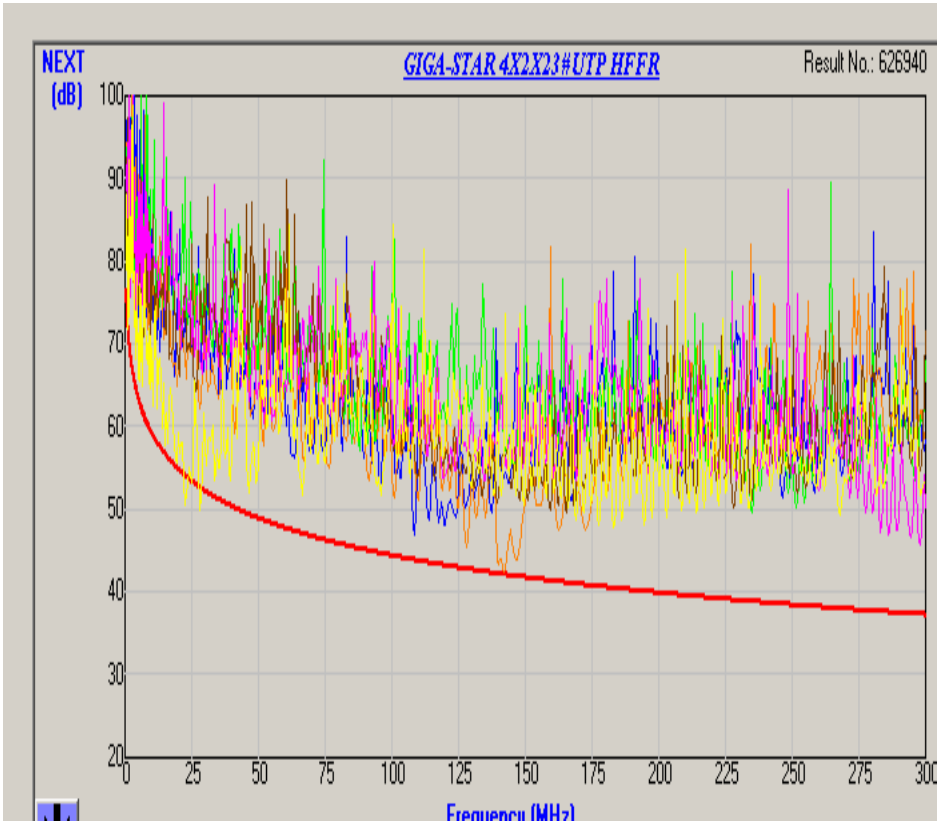
Wrong Installation practice: Alien CrossTalk?



Alien CrossTalk In cat 6 UTP



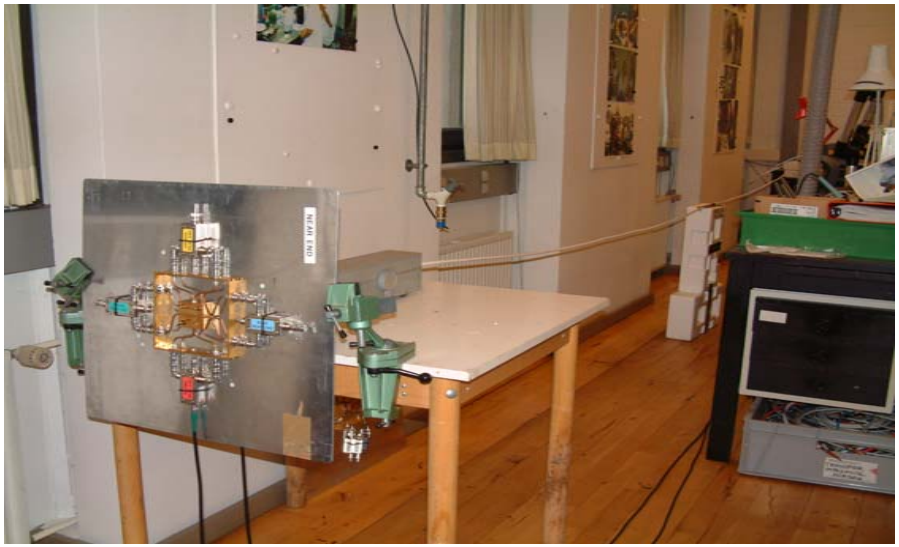
Single Cable



Bundle of Cables

Coupling Attenuation

- Coupling is the combined effect of Screening attenuation and unbalance attenuation



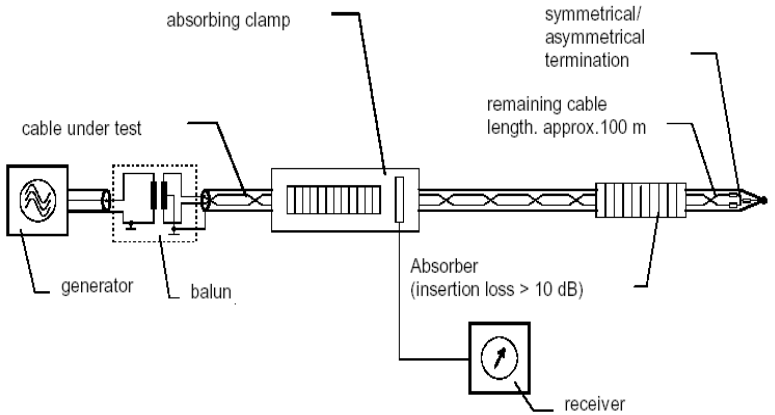
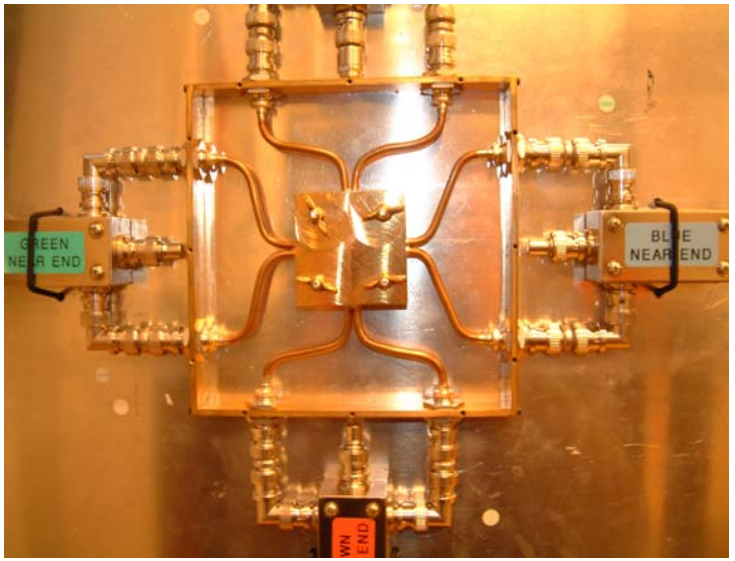


Figure 4: Principle measuring set up with absorbing clamps



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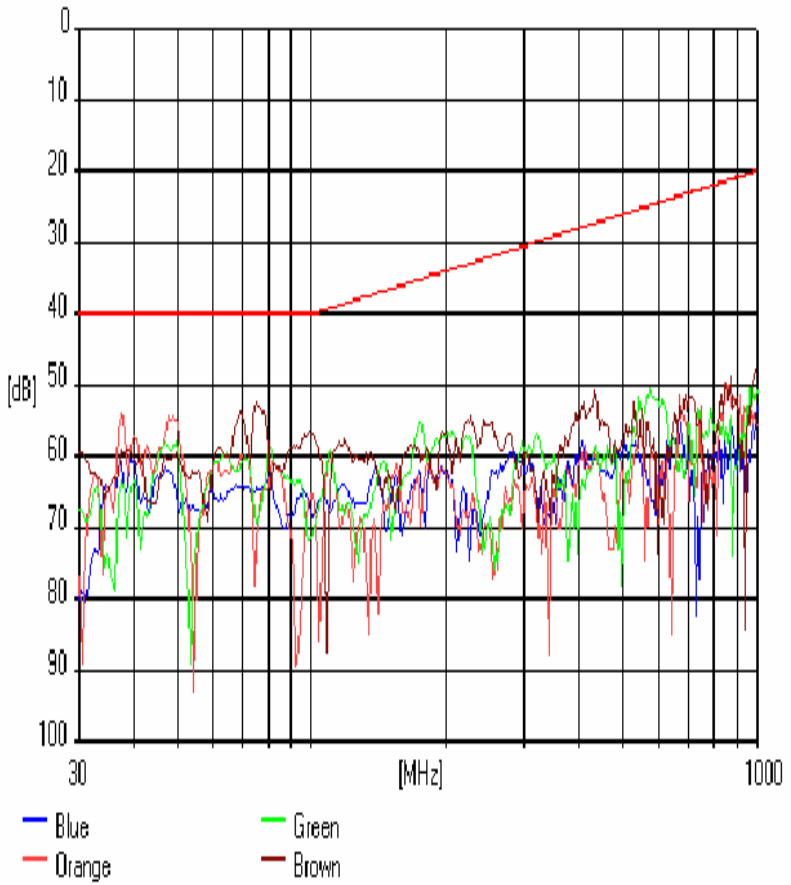
Coupling Attenuation types

Coupling attenuation type	Frequency range MHz	Coupling attenuation dB
Type I	30-100	85,0
	100-1 000	85,0 – 20 * log10 (*f*/100)
Type II	30-100	55,0
	100-1 000	55,0 – 20 * log10 (*f*/100)
Type III	30-100	40,0
	100-1 000	40,0 – 20 * log10 (*f*/100)

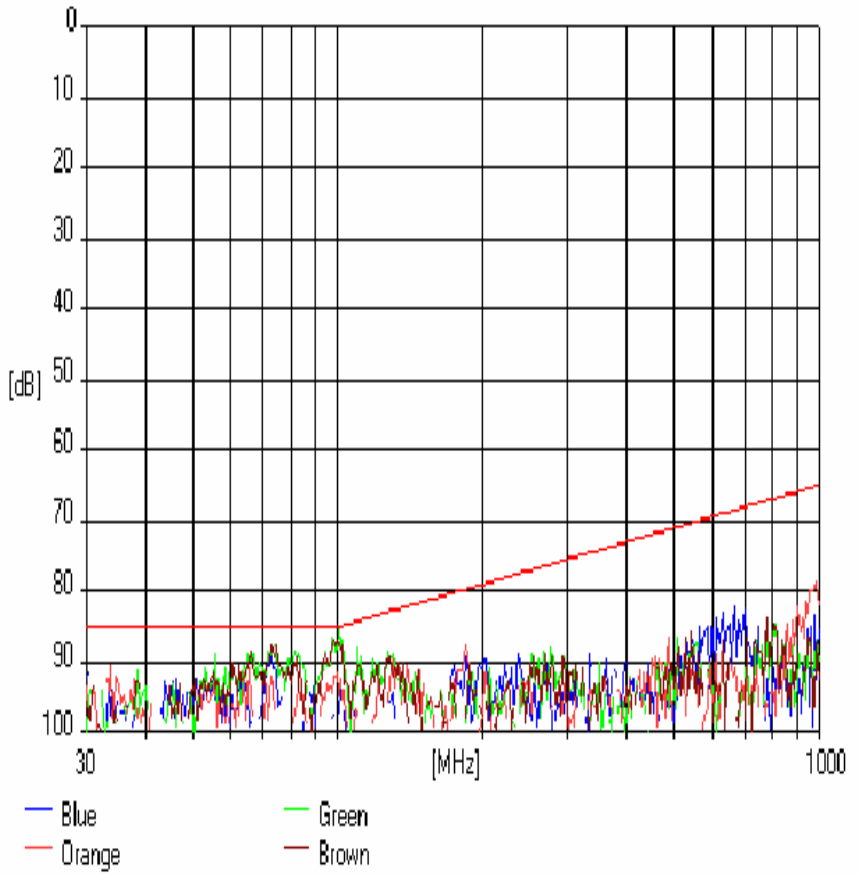
COUPLING ATTENUATION

Reel #6 Far end Type III, UTP Cat.6, PN750AZ04129



COUPLING ATTENUATION

Reel #4 Far end type I, S/STP Cat.7, PN:9928554103



10 GbE application

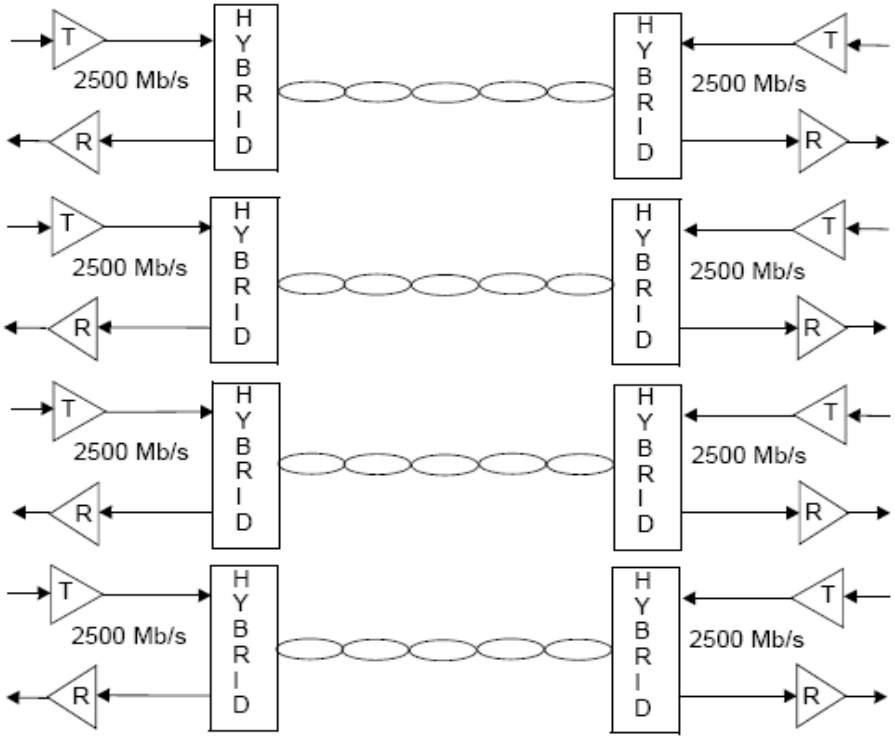


Figure 55–2—10GBASE-T topology

- 4 pairs, Full duplex
- 2.5Gbs per each pair
- PAM 12 is used
- Pam 8 is considered to be used in the future
- Advanced DSP is used with crosstalk canceletion

Field testing procedure for Alien XT

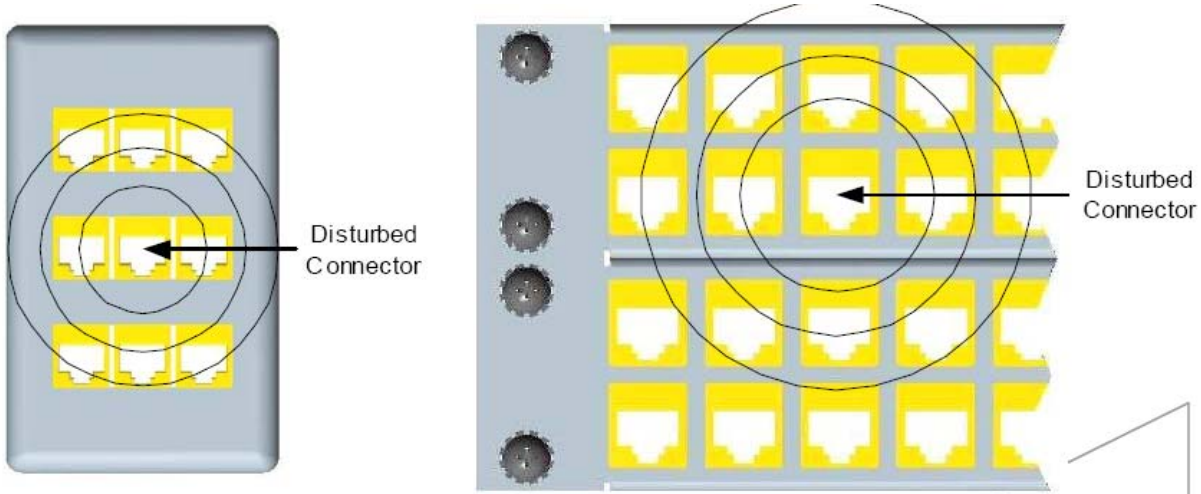
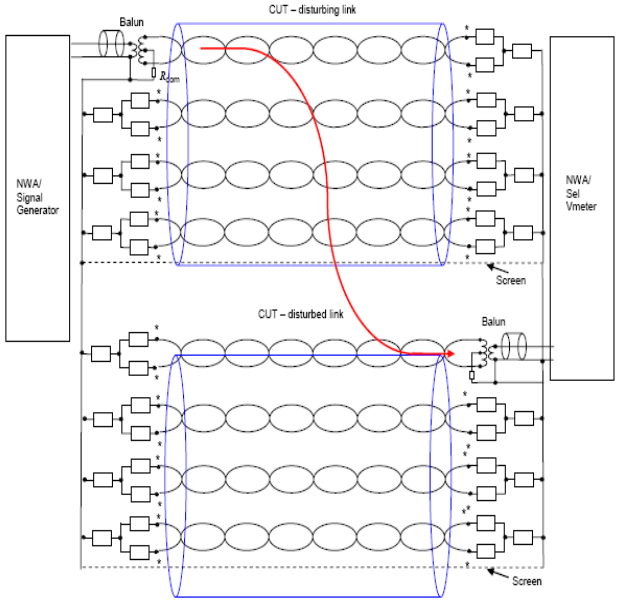


Figure C.18 - Example connector configurations for alien crosstalk



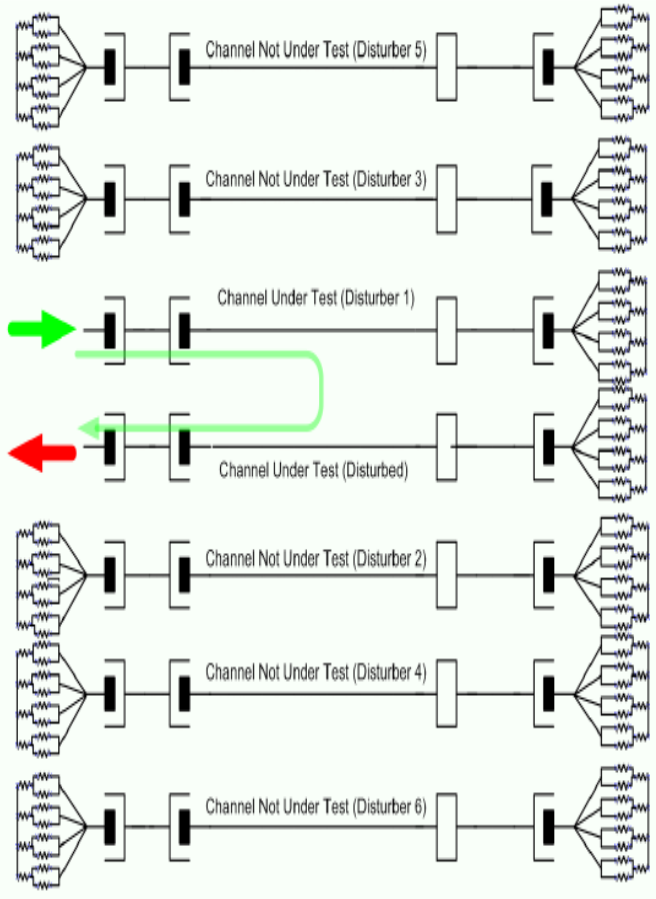


Figure C.5 - Schematic diagram of cabling ANEXT loss measurements

Field testers

- Level IIe. This level of performance is suitable to test up to and including category 5e
- Level III. This level of performance is suitable to test up to and including category 6
- Level IIIe. This level of performance is suitable to test up to and including category 6A

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Field Testing abilities

Parameter	Required By Channel	Required by Link	Measured with Field tester
Administration	Yes	Yes	**No**
Quality of Installation	Yes	Yes	**No**
Length	Yes	Yes	Yes
Wire Map	Yes	Yes	Yes
DC Loop Resistance	Yes	Yes	Yes
DC Resistance unbalance	Yes	Yes	**No**
Return Loss	Yes	Yes	Yes
Insertion Loss + ILD	Yes	Yes	Yes
NEXT	Yes	Yes	Yes
POWER SUM NEXT	Yes	Yes	Yes
ACRF	Yes	Yes	Yes
PSACRF	Yes	Yes	Yes

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Field Testing abilities

Parameter	Required By Channel	Required by Link	Measured with Field tester
TCL	Yes	No	**No**
ELTCTL	Yes	No	**No**
COUPLING Attenuation	Yes	No	**No**
Propagation Delay	Yes	Yes	Yes
Delay SKEW	Yes	Yes	Yes
PSANEXT	Yes	Yes	**No**
Average PSANEXT	Yes	Yes	**No**
PSAACRF	Yes	Yes	**No**
Average PSAACRF	Yes	Yes	**No**

Summary & Conclusions - A

- In high frequency region the sensitivity of the system and the potential for problems is increased:
  - The data (required signal) is attenuated.
  - The internal noise becomes stronger.
  - The external noise becomes stronger.
  - The S/N becomes smaller
- Critic parameters cannot be tested by field testers
- “PASS” is not sufficient because the future applications will required the maximum performance from the cabling and the testing is done with current connecting hardware category and do not give any information about the cables performance.

Conclusion - B

- Practically – just permanent link is tested while the transmission is done through the channel
- Field testing is limited to/due the following:
  - The upper frequency of the testers
  - The chosen category (mainly 6 or 6A) is lower than the performance of the cables (that good for future applications)
  - The testers cannot measure all the parameters as required by the standards
- Third party certifications show single succeed only and do not guaranty constant and stable high quality production and performance.

Conclusion - C

- The upgrading of a network is the most expensive and complicated task so smart decision (and proof) is to choose high category (7A at least). Those cables cannot be tested with the field tester.
- High frequency is totally different story than low frequency (cat 5e and cat 6). Failures, that have minor influence in cat 6) will be reflected in high frequency
- Using high quality and high level (category) cables made by first class producer with stable, constant and controlled production can guaranty that the cabling will meet the near & far future of the communication cabling and will recover the high frequency problems created during installation

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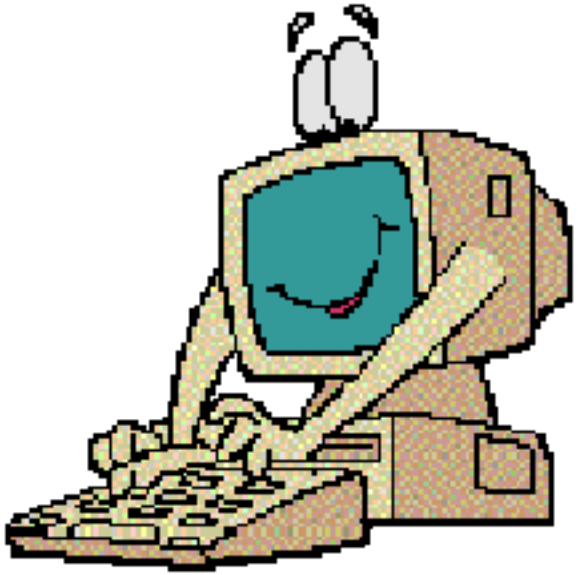
Thank you for your attention



and now the Q&A