Lesson 4: Testing and Documentation

Hello and welcome to this lesson on Testing and Documentation

In this lesson we will learn to:

- Understand the importance of testing cabling plant installations
- Understand the application of testing standards.
- Understand how continuity and loop testing equipment is used
- Understand the correct methods of measuring key parameters
- Understand how telephone cabling is tested

Testing

Testing of the Structured Cabling system is the most important activity of the installation phase. It verifies the transmission quality of the system to approved standards.

Remember , it is not a Category 5E/6 system until it has passed the tests defined in the testing standards

Testing with a Cat 5E/6 certification tester ensures the following:

The installed cabling meets the required standard

The cabling was complete when the installer left the site
A full record of the original cabling is made

Future applications will be able to run over certified cable

Test Equipment

They consist of the following.

A display or master unit

A remote handset

Test leads for both Link and Channel tests

They usually have the following functions

Ability to carry out a full range of tests (i.e., tests required for Cat 5E/6)

Provide a selection of tests in a menu

Ability to carry out individual tests

Ability to save results

Ability to print or download results

Types of Testing

The most common installation fault is an error in the punch down or the incorrect sequence of wires to pin numbers.

The identification of this type of fault is easily achieved using an inexpensive cable checker without the need of a full certification tester.

It is recommended that the following two types of tests are used

Continuity / Wire map tester used by the installer at time of cable termination to ensure cables are in correct position and terminated correctly

Certification test, to be completed on all cables to ensure full compliance to the installed specification.

Continuity Testing

Simple wire map testing

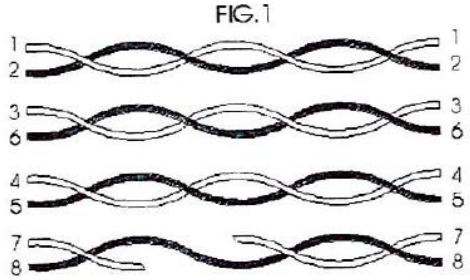
As with any wiring system structured cabling needs to be tested to see that there is continuity of the circuit. In addition, the cables need to be checked that the wires within the cable are terminated on the right pin numbers.

Typically, when testing twisted pair cable, wires are connected straight through. Straight through means that pin 1 of the connector at one end is connected to pin 1 of the connector at the other end, pin 2 is connected to pin 2, pin 3 to pin 3, and so on.

Wire Map checks for shorts, opens, crossed pairs, reversed pairs and other wiring errors. Wire Map also checks the continuity of a shield if one exits.

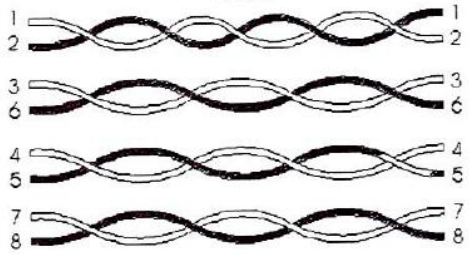
Continuity Wiring Errors

FIG.1



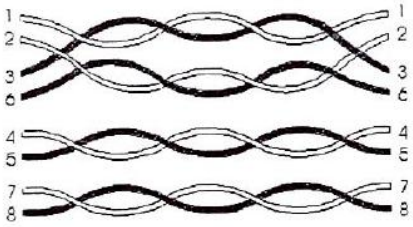
Open (7)

FIG.2



Reversed (1 & 2)

FIG.5



Split Pair

Certification Testing (100% testing)

Testing definitions

There are 3 types of tests that can be performed

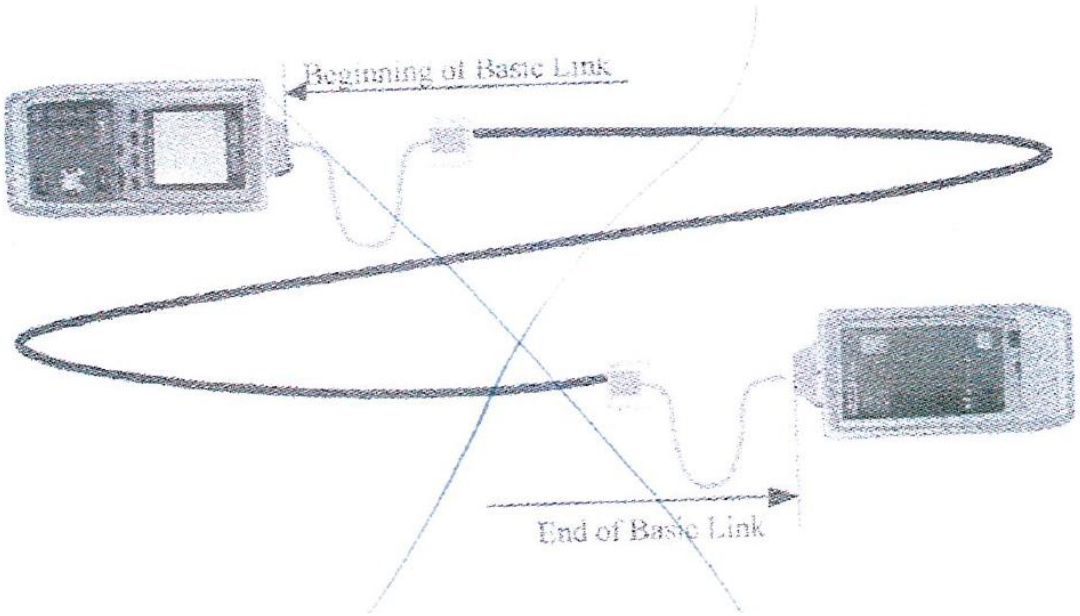
1. **Basic Link** (required for TIA certification Cat5E)
2. **Permanent Link** (required for ISO Class D&E and TIA Cat 6) certification
3. **TIA/ISO Channel** (includes the patch chords)

TIA Basic Link – Cat5E

The basic link has been defined in TIA TSB67, and includes all the permanently installed horizontal cable, the mated connection at the wiring closet end of the link, the telecommunications outlet at the far end of the link, an optional transition point (used for example in the case of modular furniture), and the two test cords necessary to connect the field tester to the end connectors. The basic link is used to verify the

performance of permanently installed cabling. It includes the field tester cord but not the mated connection at the field tester.

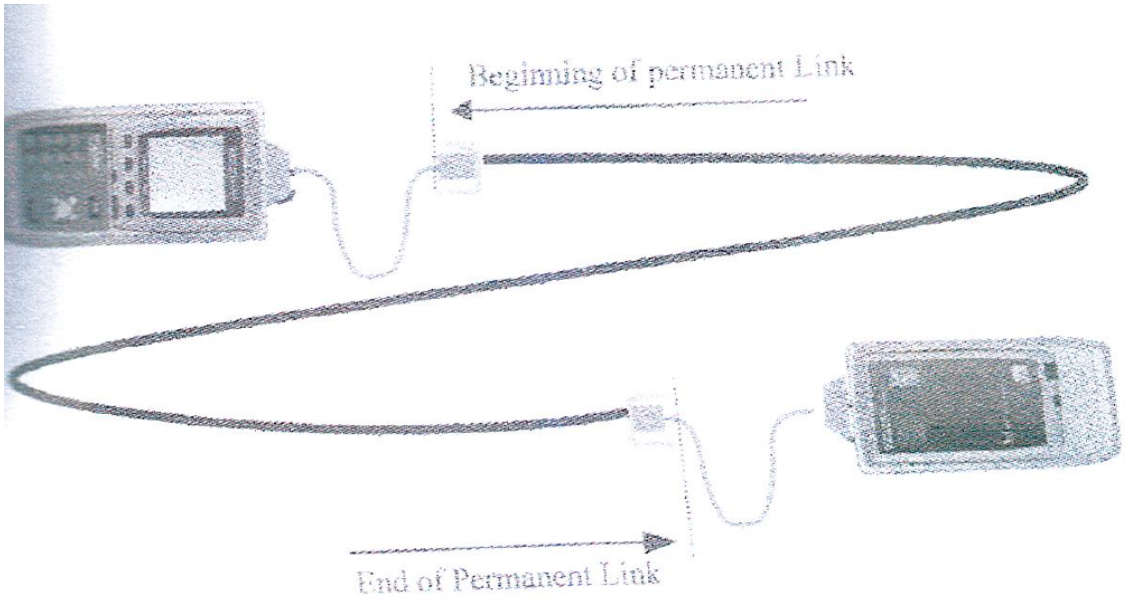
The Basic Link length of 94 metres includes 90 metres for the horizontal cabling and two metres for the test cords at both ends.



ISO permanent Link – Class D&E, and Cat6 (TIA)

The permanent link has been defined in ISO 118011 and includes: all the permanently installed horizontal cable, the mated connection at the wiring closet end of the link, the telecommunications outlet at the far end of the link, and an optional transition point (used for example in the case of modular furniture).

The permanent link is used to verify the performance of permanently installed cabling. It differs from the TIA basic link in that it does not include the field tester cord. Of the course, the field tester cord is necessary 1 but this link definition requires the field tester to somehow compensate for all the characteristics of the cord so that as much as possible, the test cord is invisible to the measurement. Given the unpredictable performance of today's patch cord material, and the nature of measurements such as ELFEXT, this is neither possible nor practical. The permanent link definition does include the mated plug at the end of the field tester cord, but not the cord itself.

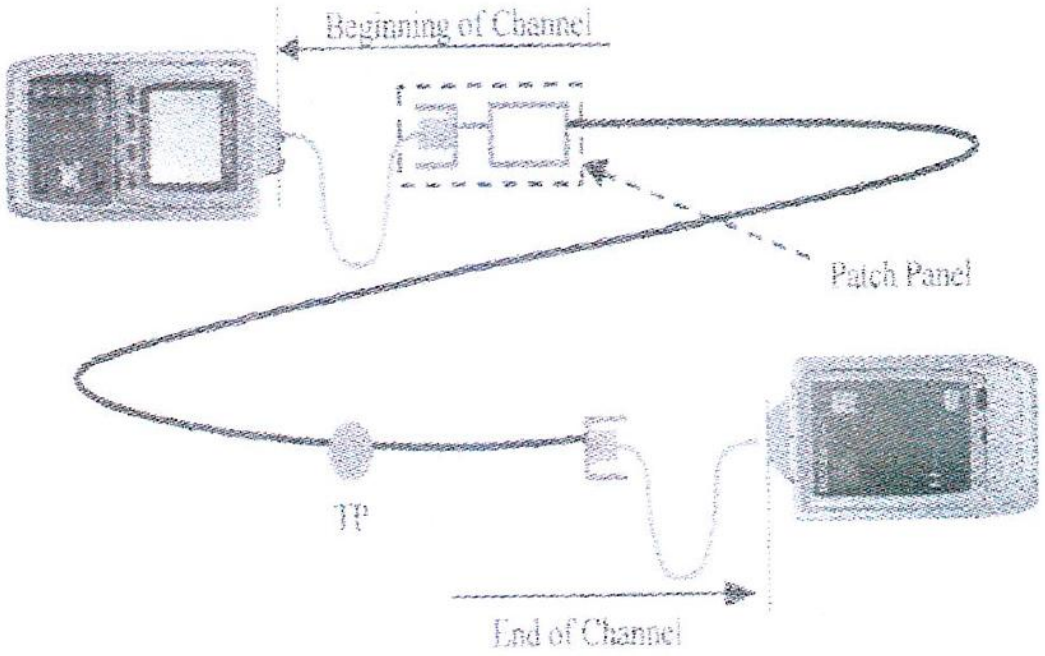


TIA IISO Channel

The channel, as described in TIA 568A and ISO 11801 AM2, includes up to 90 metres of horizontal cable, a work area equipment cord, an optional transition point, 2 cross-connections in the telecommunications closet, a patch jumper between these two connections, and a telecommunications closet equipment cord. In simple terms, the channel includes everything necessary to get data from a PC in an office to a hub in a wiring closet.

The channel down not include the mated connection at the hub or PC. This means the plug at the end of the user's patch cord at both ends of the link is considered part of the data terminating equipment (DTE) and not part of the link. The reason for this is connectors must be considered as mated pairs of plugs and jacks, and since the jack is fixed in the DTE it was decided that connection would be part of the DTE.

In practice, the channel is rarely used in link certification, because user patch cords are almost never available when the permanent cabling is installed.



THE TESTS

All of the standards will require you to test some or all of the measurements below.

The following list the tests required by the different standards.

	ISO/IEC 11801:2002	EN50173-1: 2002	ANSI/TIA/EIA-568-B.2-1 2002
Wiremap	•	•	•
Length	①		•
Attenuation	•	•	•
NEXT	•	•	•
Power Sum NEXT	•	•	•
ELFEXT	•	•	•
Power Sum ELFEXT	•	•	•
Return Loss	•	•	•
ACR	•	•	②
Power Sum ACR	•	•	②
Propagation delay	•	•	•
Delay Skew	•	•	•
d.c. Loop Resistance	•	•	③

Test parameters

Wire Map

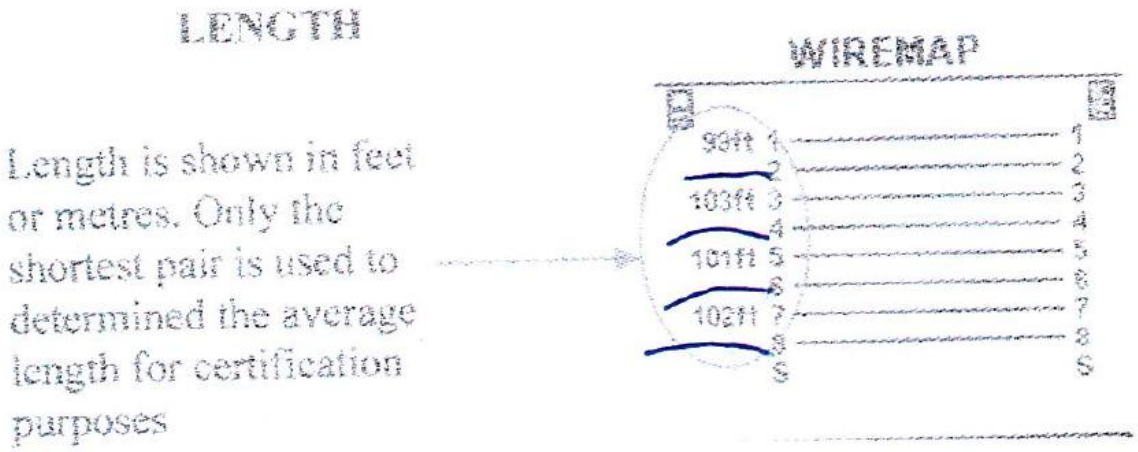
Wire Map shall report Pass if the wiring of each wire-pair from end to end is determined to be correct. The Wire Map results shall include the continuity of the shield connection if present.

Length

Length is defined as the physical or sheath length of the cable. It should correspond to the length derived from the length markings commonly found on the outside jacket of the cable. Physical length is in contrast to electrical or helical length, which is the length of the copper conductors. Physical length will always be slightly less than electrical length, due to the twisting of the conductors.

In order to measure length, a test set first measures delay, and then uses the cable's nominal velocity of propagation to calculate length. Nominal Velocity of Propagation (NVP) refers to the inherent speed of signal travel relative to the speed of light in a vacuum (designated as a lower case c). NVP is expressed as a percentage of c, for example, 69%, or 0.69c. All structured wiring cables will have NVP values in the range of 0.6c to 0.9c. Similarly, if you know the physical length and the delay of a cable, you can calculate the NVP.

By convention, length is derived from the shortest electrical length pair in the cable. Because of delay skew, the length of the four pairs often appears slightly different. This is normal and no cause for concern, unless significant (over 10%) variances are seen.

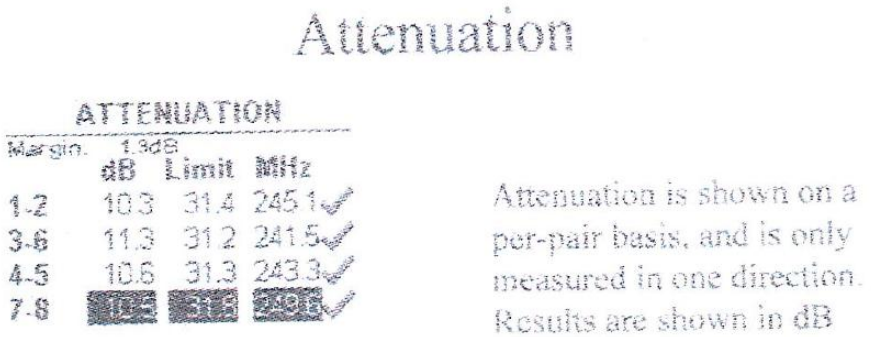


Insertion Loss (Attenuation)

All electromagnetic signals lose strength as they propagate away from their source, and LAN signals over cabling are no exception. The loss of signal strength in the

cable is attenuation. The more attenuation you have, the less signal is present at the receiver. **Attenuation increases with both frequency and length.**

Attenuation is measured in dB. Since it is a loss, it is usually expressed as a negative value. Thus, -10dB is a weaker signal than -8dB. Decibels are logarithmic, such that if any two signals are 3dB different, one is twice the power of the other. Thus, a -9dB signal has twice the power of a -12dB signal, and four times as much as a -15dB signal.



TSB 67 Attenuation Limits

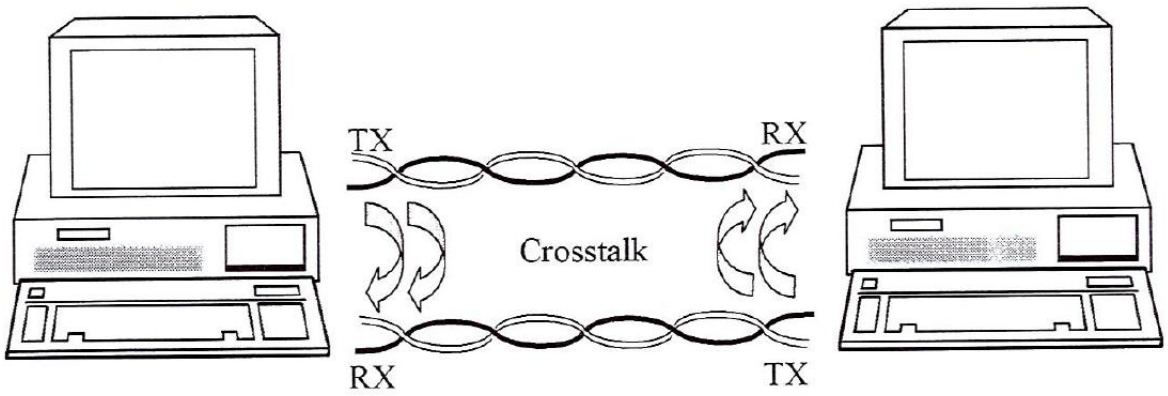
Frequency MHz	Category 3 (dB)		Category 5 (dB)		Category 5e(dB)	
	Channel	Link	Channel	Link	Channel	Link
1.00	<-4.2	<-3.2	<-2.5	<-2.1	<-2.2	<-2.0
4.00	<-7.3	<-6.1	<-4.5	<-4.0	<-4.5	<-4.0
8.00	<-10.2	<-8.8	<-6.3	<-5.7	<-6.3	<-5.7
10.00	<-11.5	<-10.0	<-7.0	<-6.3	<-7.1	<-6.4
16.00	<-14.9	<-13.2	<-9.2	<-8.2	<-9.1	<-8.1
20.00			<-10.3	<-9.2	<-10.2	<-9.1
25.00			<-11.4	<-10.3	<-11.4	<-10.3
31.35			<-12.8	<-11.5	<-12.9	<-11.6
62.50			<-18.5	<-16.7	<-18.6	<-16.7
100.00			<-24.0	<-21.6	<-24.0	<-21.6

NEXT (Near End Cross Talk)

When current flows in a wire, an electromagnetic field is created which can interfere with signals on adjacent wires. As frequency increases, this effect becomes stronger. Each pair is twisted because this allows opposing fields in the wire pair to cancel each other. The tighter the twist, the more effective the cancellation, and the higher the data rate supported by the cable**. Maintaining this twist ratio is the single most important factor in any successful UTP installation.**

If wires are not tightly twisted, the result is near end cross talk (NEXT). If you have ever had a telephone call where you could hear another conversation faintly in the background, you have experienced cross talk. In fact, the name cross talk derives from telephony applications where 'talk' came 'across'. In LANs, NEXT occurs when a strong signal on one pair of wires is picked up by an adjacent pair of wires. NEXT is the portion of the transmitted signal that is electromagnetically coupled back into the received signal.

Because Cross talk is measured at the same end of the cable as the signal source, the term Near End Cross Talk (NEXT) is used to describe this measurement. It is desirable to have minimum amounts of Cross talk. Cross talk is also measured in dB. However, as minimum signal is required, the higher the dB value, the less signal interference, the better the installation.



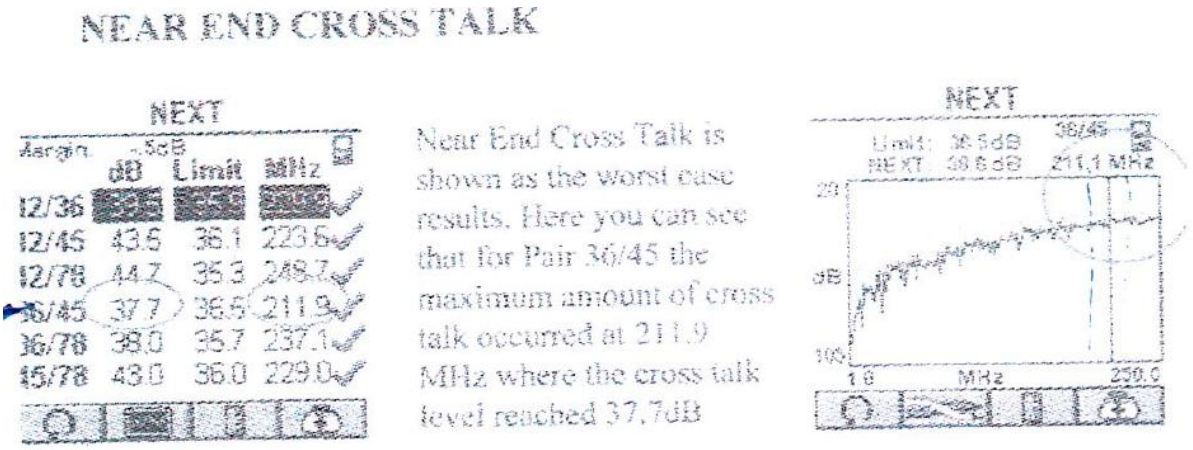
Crosstalk between stations

NEXT (Continued)

Results Interpretation

Since NEXT is a measure of difference in signal strength between a disturbing pair and a disturbed pair, a larger number (less cross talk) is more desirable than a smaller number (more cross talk). Because NEXT varies significantly with frequency, it is important to measure it across a range of frequencies.

The field tester should compare successive readings across the frequency range. If the NEXT curve crosses the pass/fail line at any point, then the link does not meet the stated requirement. Since NEXT characteristics are unique to each end of the link, six NEXT results should be obtained at each end.



TSB – 67 NEXT Limits

Frequency MHz	Category 3 (dB)		Category 5 (dB)		Category 5e (dB)	
	Channel	Link	Channel	Link	Channel	Link
1.00	>-39.1	>-40.1	>-60.0	>-60.0	>-63.3	>-64.2
4.00	>-29.3	>-30.7	>-50.6	>-51.8	>-53.6	>-54.8
8.00	>-24.3	>-25.9	>-45.6	>-47.1	>-48.6	>-50.0
10.00	>-22.7	>-24.3	>-44.0	>-45.5	>-47.0	>-48.5
16.00	>-19.3	>-21.0	>-40.6	>-42.3	>-43.6	>-45.2
20.00			>-39.0	>-40.7	>-42.0	>-43.7
25.00			>-37.4	>-39.1	>-40.4	>-42.1
31.35			>-35.7	>-37.6	>-38.7	>-40.6
62.50			>-30.6	>-32.7	>-33.6	>-35.7
100.00			>-27.1	>-29.3	>-30.1	>-32.3

PSNEXT (Power Sum Near End Cross talk) Loss

PSNEXT Loss captures the combined near-end crosstalk effect (statistical) on a wire pair when all other pairs actively transmit signals.

Power Sum NEXT Loss shall be evaluated and reported for each wire pair from both ends of the link-under-test (a total of 8 results, 4 from each end).

FEXT (Far End Cross Talk)

FEXT Loss shall be measured for each wire-pair combination from both ends of the link-under-test. FEXT Loss measures the unwanted signal coupling (crosstalk disturbance) on a wire pair at the opposite end (far-end) from which the transmitter emits the disturbing signal on the disturbing pair.

ELFEXT (Equal Level Far End Cross Talk) Loss

FEXT is measured to compute ELFEXT Loss that must be evaluated and reported in the test results. ELFEXT measures the relative strength of the far-end crosstalk disturbance relative to the attenuated signal that arrives at the end of the link. Minimum test results documentation (summary results): Identify the wire pair combination that exhibits the worst-case margin and the wire pair combination that exhibits the worst value for ELFEXT. These wire pairs must be identified for the tests performed from each end. Each reported case shall include the frequency at which it occurs as well as the test limit value at this frequency.

PSELFEXT (Power Sum Equal Level Far End Cross Talk) Loss

Power Sum ELFEXT is a calculated parameter than combines the effect of the FEXT disturbance from three wire pairs on the fourth one. This test yields 8wire-pair combinations. Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst-case margin and the wire pair that exhibits the worst value for PSELFEXT. These wire pairs must be identified for tehh tests performed from each end. Each reported case shall include the frequency at which it occurs as well as the test limit value at this frequency.

Return Loss

Return loss is a measure of the reflections caused by the impedance mismatches at all locations along a link. It is measured in dBs.

Small return losses are due to variations in the characteristic impedance along the length of the cable. The main source of return loss is caused by reflections from connectors. This change in impedance at the connector is known as an impedance mismatch.

The main impact of return loss is not the loss of signal amplitude but the introduction of ‘jitter’. Reflections of the signal need to be kept to a minimum if they are not to

interfere with the transmitted signal. Jitter can alter the shape of the transmitted pulse and cause errors in the received signal.

ACR (Attenuation to Cross Talk Ratio)

Due to the effect of attenuation, signals are at their weakest at the receiver end of the link, but this is where Cross talk is at its strongest.

In UTP cable, attenuation determines the strength of the received signal, while the noise in the cable is primarily the “NEXT” from the receiver / transmitter.

ACR is the difference between the Crosstalk and the Attenuation for the pair being tested. This is expressed as a ratio. ACT is considered to be a figure of merit. The better the Cross talk figure and the lower the Attenuation figure, the higher is the ACR figure.

PSACR (Power Sum Attenuation to Cross Talk Ratio)

The Power Sum version of ACR is based on PSNEXT and takes into account the combined NEXT disturbance of all adjacent wire pairs on each individual pair. This calculation yields 8 combinations – one for each wire pair from both ends of the link. Minimum test results documentation (summary results): Identify the wire pair that exhibits the worst-case margin and the wire pair that exhibits the worst value for PSACR.

Propagation Delay

Propagation delay is measured using the same technique as for length measurement. A signal is transmitted along the wire and the length of time for it to return is timed.

Propagation delay is half the round trip time used in length measurement. Most network standards specify a maximum time for propagation delay to ensure there are no data collisions on the cable.

Delay Skew

The measurement of the difference between the signal travelling in each pair is delay skew. The speed of the fastest signal is measured as propagation delay; the speed of the signal in the other pairs is compared to the fastest one and the difference recorded as delay skew.

Delay Skew

Pair	Prop. Delay	Delay Skew
1,2	245ns	0
3,6	250ns	5ns
4,5	252ns	7ns
7,8	249ns	4ns

For example, if the propagation delay in pair two is 245ns and the delay in pair one is 252ns, then the delay skew of pair one is 7ns.

DC Loop Resistance

The loop resistance should be no more the 40Ω.

Test Result Documentation

The test results information for each link shall be recorded in the memory of the field tester upon completion of the test. The test results records saved by the tester shall be transferred into a Windows TM-based database utility that allows for the maintenance, inspection and archiving of these test records. A guarantee must be made that the measurement results are transferred to the PC unaltered, i.e., “as saved in the tester” at the end of each test and that these results cannot be modified at a later time. Testers that transfer the numeric measurement data from the tester to the PC in a non-printable format offer superior protection. The database for the completed job shall be stored and delivered on CD_ROM including the software tools required to view, inspect, and print any selection of test reports. A paper copy of the test results shall be provided that lists all the links that have been tested with the following summary information:

The identification of the link in accordance with the naming convention defined in the overall system documentation.

The overall Pass/Fail evaluation of the link-under-test including the NEXT Headroom (overall worst case) number

The date and time the test results were saved in the memory of the tester.

Test Result Documentation should include the following:

- The identification of the customer site as specified by the end-user
- The identification of the link in accordance with the naming convention defined in the overall system documentation
- The overall Pass / Fail evaluation of the link-under-test
- The name of the standard selected to execute the stored test results
- The cable type and the value of NVP used for length calculations
- The date and time the test results were saved in the memory of the tester
- The brand name, model and serial number of the tester

- The identification of the tester interface
- The revision of the tester software and the revision of the test standards database in the tester
-

The test results information must contain information on each of the required test parameters.

The detailed test results data to be provided in the electronic database for each tested link must contain the following information for each of the frequency-dependent test parameters; the value measured at every frequency during the test is stored. In this case, the PC-resident database program must be able to process the stored results to display and print a colour graph of the measured parameters. The PC-resident software must also provide and print the summary numeric information for each test parameter.

Summary

In this lesson we learnt to:

- Understand the importance of testing cabling plant installations
- Understand the application of testing standards.
- Understand how continuity and loop testing equipment is used
- Understand the correct methods of measuring key parameters
- Understand how telephone cabling is tested