

Module 10 - Copper Testing

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QUESTION BANKS

Preparation

- Cable and components should be visually inspected for proper installation, in accordance with Excel Installation Guidelines
- Once installed, the cabling system you are investing in must be thoroughly tested to ensure it meets both the requirements of the contract and that of the standards
- We insist that our integrators test every single point that is installed before we will issue the warranty
- The testers must have a valid calibration certificate
- The test head leads, whether specific leads in the case of Fluke or patch leads with other testers must be within usage limits. If they are the latter they should only be used for 750 tests

Acceptable Testers include:



Fluke DSX 5000



Lantek IV



Viavi Certifier 40G



Softing Wirexpert Pro

Approved Testers

For a full list of approved testers for certifying an Excel installation, visit the Excel website.

APPROVED TESTERS

 Fluke DTX1800 were made 'end of life' 3 years ago.

- The testers must have the save graph option turned on and all HDTDX/HDTDR selected for all *Pass/Fail results and plot data stored, with the latest firmware and software installed on the testers
 - *By selecting HDTDX/HDTDR for *Pass/Fail results it can help us to help you in certain troubleshooting situations*
- It is preferred that the EN 50173 standard is used to test all links, however you must test to the standard you want the warranty issued to
- All Class EA/Category 6A systems should be tested using the above standards (unless specifically mandated otherwise by the contract)
 - *When testing a Class EA link you must provide the correct test - if there is a consolidation point used, it must be EN50173 Class EA PL3. If there isn't a consolidation point in use, it is PL2*
- Results must be forwarded in the testers native format, e.g. Fluke LinkWare
 - *Forwarding the results in the testers native format means we can interrogate the results again providing useful feedback for troubleshooting*

Excel are willing to issue a warranty to whatever standard you require. However, the installer must test to that standard, i.e. we will issue the warranty to the standard you test to as we cannot issue at ISO11801 level when the test results are to TIA

 Please note there is a difference of 2.5db in the test limits of TIA and ISO/EN for Class EA/Category 6A systems, with TIA having the less stringent values

Pre-Testing Checklist

Before going into the field:

- 1 Charge and verify battery levels - there may not be power available on-site
- 2 Review performance testing specs for install (contracts)
- 3 Gather appropriate test adaptors and accessories
- 4 Inspect test adaptors and ensure there is no damage and they are within usage limits
- 5 Check test leads for damage, as damaged leads can lead to false failures
- 6 Set up unit with proper test and report identification of engineers involved
- 7 Check the calibration is valid
- 8 Reference test leads
- 9 Run Self-Test (as needed)



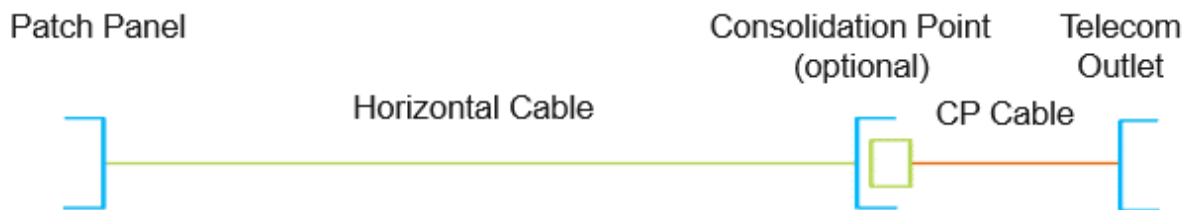
Excel require the ECP to identify the person carrying out the testing for each element

Installation Guidelines

If in doubt, visit the Excel website to double check the Excel Installation Guidelines.

[VISIT WEBSITE](#)

Testing Specifications

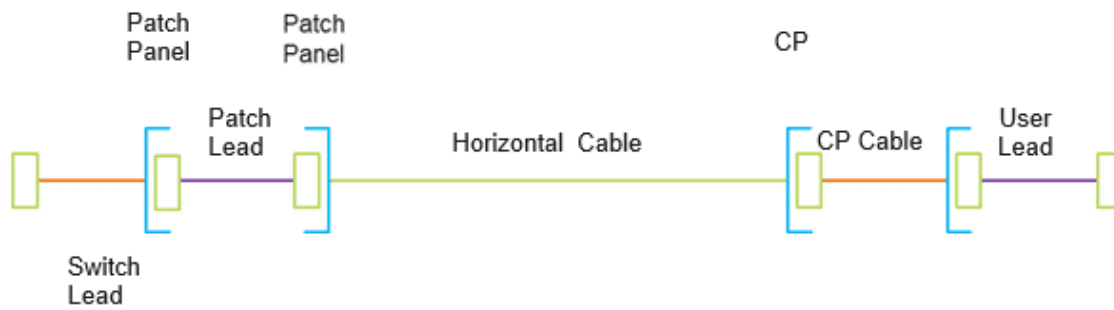


Permanent Link

The most common test called for within contracts

Permanent Link

- Consolidation Points cannot be closer than 15m to the Patch Panel
- There are two forms of test carried out and we insist on Permanent Link for Warranty purposes. It is the best test of what has actually been installed, as it doesn't move. It is also what is usually called for within the contract for the same reason
- The Permanent Link may also include a Consolidation Point and Cable
- If testing a Class EA or Category 6A solution, it should be tested to PL2 if there is not a consolidation point and PL3 if there is
- Finally if component compliant Patch Cords from Excel are used then the Channel Link test will be suitable

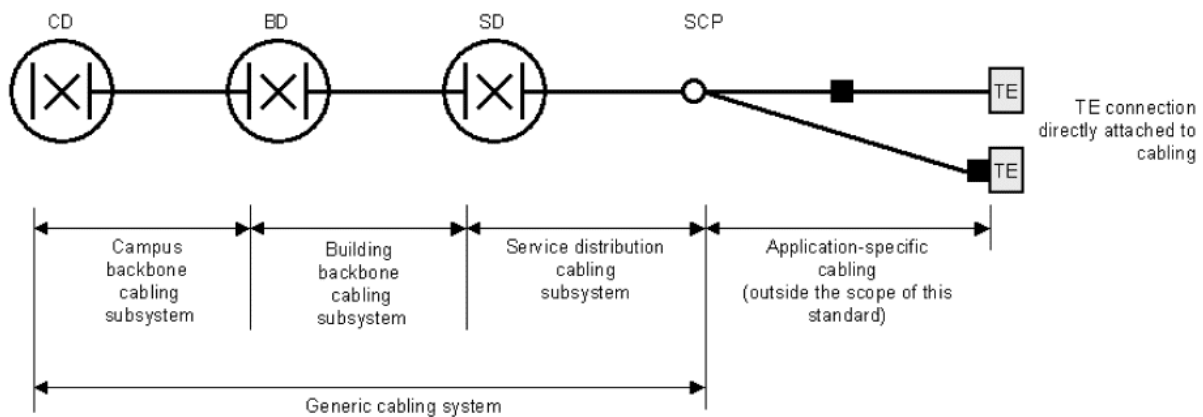


Channel

Channel testing should only really be done for troubleshooting

Channel

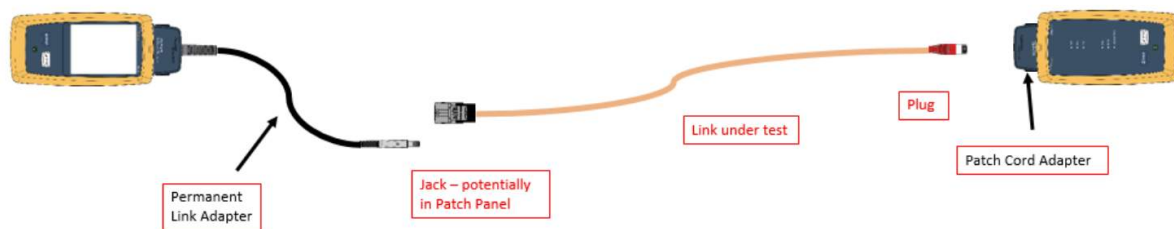
- There are two main Channel Models:
 - **Interconnect** is where the equipment in the main equipment room is connected to the permanent link using a patch cord
 - **Crossconnect** is when the switch/equipment is hardwired to a patch panel by way of a switch or harness link made up of the same solid core cable used for the horizontal cable. The two patch panels are connected by way of a patch lead to create a 'Patching Field'



Channel

MPTL (Modular Plug Terminated Link)

- With the publication of ISO 14763-4 – Measurement of end-to-end (E2E) links, modular plug terminated links (MPTLs) and direct attach cabling, it outlines the use of the cabling directly terminated to equipment specific connectors such as field terminated RJ45 plugs
- The one problem was with the testing of these links, as the channel adapters ignore the value of the plug
- Now there is a way of testing this correctly EIA/TIA have published their test limits for this form of link and they are included within the Fluke DSX 5000
- ISO/IEC have also published a Technical Report ISO TR 11801-9910: 2020 with their limits but they have not been included yet
- Fluke Networks have introduced this as a formal test, however it requires a special set-up and the use of a Patch Lead Test Head - see image below



The Patch Lead Test head is required to ensure the value of the plug is included within the test.

If you do not have a Patch Lead Test head there is a way to carry out the test using a pair of Permanent Link Adapters and a Through Coupler, however this would also require re-certification of the results to ensure the result and it doesn't completely guarantee the same performance as the Patch Lead Test Head.

Technical Note

A Technical Note of how this is carried out can be found on the Excel website.

[VIEW DOCUMENT](#)

Copper Tests

WireMap —

- The first test to be performed
- This test also includes the Shield Integrity on Screened Systems
- Shows up common termination faults
- Testers give graphical display of faults

Probably the most common fault is wire map and it is both the first test as well as the most frustrating one for a link to fail on because it has nothing to do with the performance of the system but lack of attention to detail by the engineer doing the termination. It is also relatively simple to rectify before a lot of time is wasted testing all the parameters, hence most testers will stop at this stage.

Length Testing —

- Length of installed cable has strict limits. Or does it?
- Length is measured using Time Domain Reflectometry
- A signal is sent down cable and the time taken to be reflected from the far end determines the distance that it has travelled
- Each pair in a cable has a different length due to the difference in the twist ratios
- Test equipment must be set for the particular cable to be tested, specifically the NVP

All the standards BS/EN 50173, ISO/IEC 11801 & EIA/TIA 568.D stipulate a Permanent Link length of 90m and Channel length of 100m. However when testing to BS EN 50173 and ISO/IEC 11801 if you use good products installed to a high standard it is possible to get an overlength link to pass. It is only with TIA that it is a certain pass/fail at 90m.

It is important that the NVP is set correctly. The nominal value for Excel cables is contained, both on the specification sheets for each cable as well as in the manufacturers listing held within a Fluke tester.

Nominal Velocity of Propagation (NVP) —

- NVP is the speed a signal travels in a cable
- Expressed as a percentage of the speed of light in a vacuum (300,000 km/second) e.g. 76%
- For accurate measurements the NVP set in the tester must be the same as the cable under test
- NVP is NOT an indicator of a cables quality, it is just a nominal value to help measure the length. How tightly the pairs are twisted can have an impact of the NVP value.

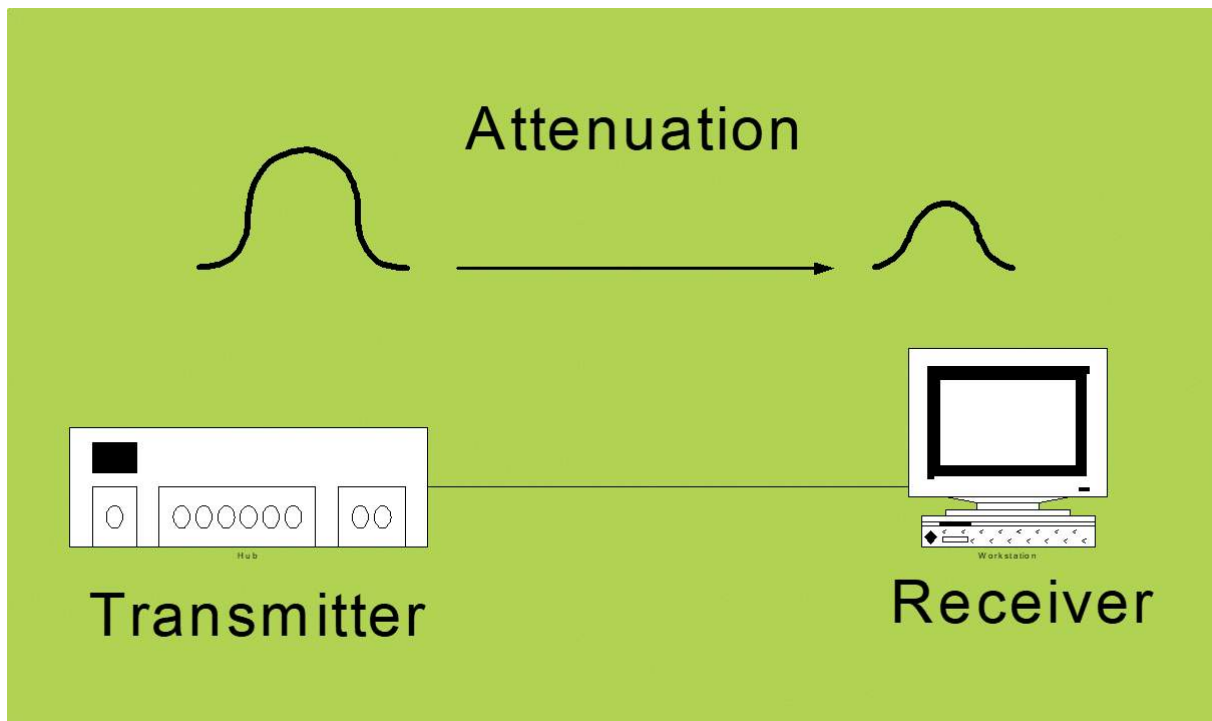
To get the most accurate results you need to ensure the NVP of the cable is set correctly. The manufacturers specification sheet for each cable will provide these details.

If you are still unsure or cannot get hold of these, there is a relatively simple way of establishing the NVP of a cable. By taking a very accurate length of cable, test it using permanent link and adjusting the NVP setting until it reads the exact length of cable.

Please note the NVP value quoted in specification sheets are nominal values, and may vary from batch to batch by a few decimal places due to variations in the twist ratios during production or changes in the batch of raw copper used. It is nothing to cause concern.

Attenuation (Insertion Loss) —

- The strength of a signal will reduce (attenuate) along the length of the cable
- Attenuation can also be referred to as Insertion Loss when testing



Attenuation

- Attenuation is measured in dB. The following table summarises dB loss and the equivalent value in terms of power remaining.
- Another way of looking at this is by describing one version of the 3dB rule. In its basic form it states that every 3dB is equivalent of a doubling or halving of power. On that basis if we start with 1 milliwatt, a loss of 9dB would result in a power level of 125 microwatts
- Attenuation can increase from several factors the main ones being:
 - Length
 - Increasing temperature
 - Increasing frequency
 - Bends and Kinks in the cables

One of the biggest hidden problems of PoE is the potential increase in heat within the bundles. This can be an issue as one of the major factors with attenuation is an increase in temperature. Whilst cabling is designed to operate at a wide range of temperatures, the optimum performance for 90m Permanent Link and 100m Channel is achieved at an ambient temp of 20°C. Any increase beyond that results in a reduction in the signal strength and therefore transmission distances.

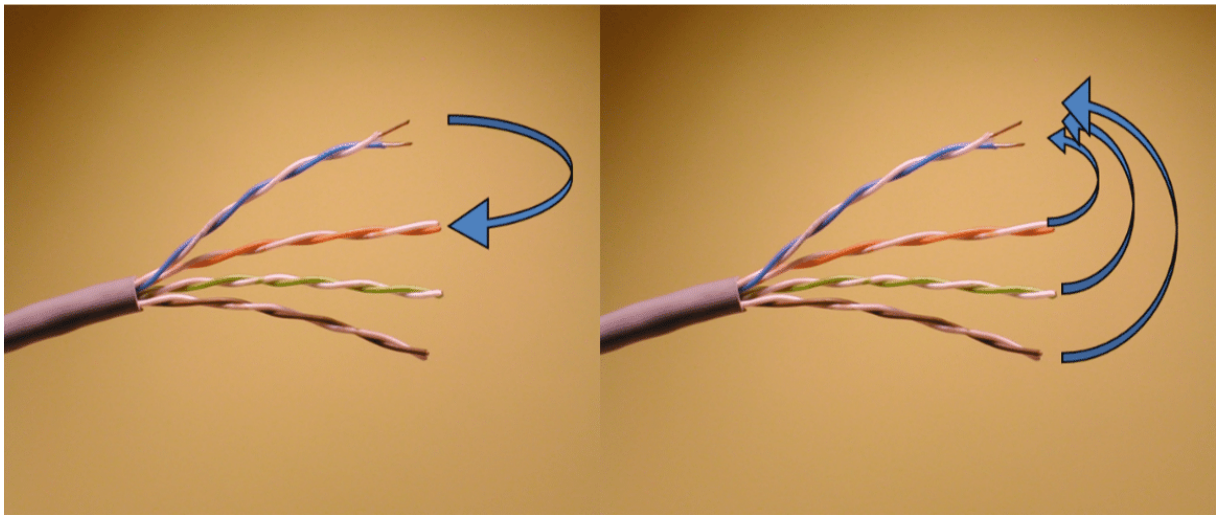
dB loss	Equivalent % Power
100	0
50	3
25	6
12.5	9
10	10
1	20
0.1	30
0.01	40
0.001	50
0.0001	60

Crosstalk —

- Variations in characteristic impedance allow ingress and egress of interference, meaning signals can leak from one pair to another
- This can be measured at the near end, NEXT or far end, FEXT
- If all pairs are carrying data then there can be a cumulative effect, POWERSUM NEXT
- Measured in dB and the higher the number the better, as that is your headroom, or safety margin.

This picture gives a clear understanding of what NEXT and PowerSum NEXT are:

The image on the left showing NEXT which is how one pair can affect its neighbour and PowerSum which is the cumulative effect of 3 pairs on one. This is one of the two test values directly influenced by the installer and typically reflects the quality of the termination.



10Gigabit and Category 6A —

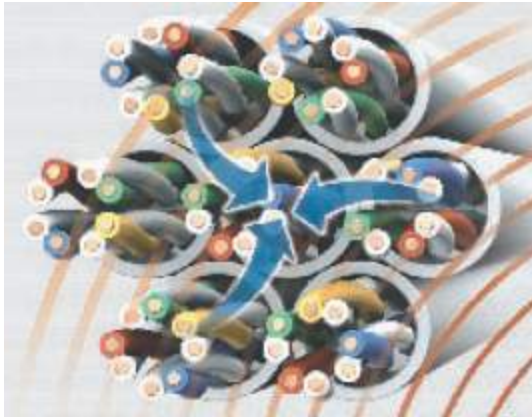
- With the introduction of 10GBase-T came bigger problems, the higher frequencies involved has meant the signal carrying cable has been more susceptible to outside influences. This is called Alien CrossTalk
- Alien CrossTalk is the noise source that limits the ability to transmit 10Gb Ethernet.
- The 10GBASE-T cards cannot compensate for the noise from adjacent channels.
- The cabling needs to do the cancelling wherever possible.
- Alien CrossTalk
 - Field Testing
 - Screened, NOT required
 - An unscreened solution may be 'Compliant by Design'
 - Unscreened approx. 3- 5% ANEXT Testing is typically recommended
 - This may be requested by the Client
 - This will lead to a huge number of individual tests, as it involves testing using a 6 around 1 method.

The major problem with Alien Crosstalk is the lack of an effective and simple way of field testing. It is a complex process of deciding the 'victim' and 'disturber' cables, ensuring they run in the same physical paths, then documenting your findings.

In theory you should calculate the number of tests based upon 1% of all your low risk 1% of Medium risk and 1% of long risk. This is decided by a combination of length and other surrounding cables.

It is then a matter of injecting a signal into a number of the 'disturber' cables that follow the same route as the selected 'victim'.

This has to be repeated for each of the cables within the selected group, therefore it is not a single test and can result in a massive increase of additional tests, on top of the Permanent Link testing that is already required. The one way around this is to install a screened solution, where this test is NOT required.



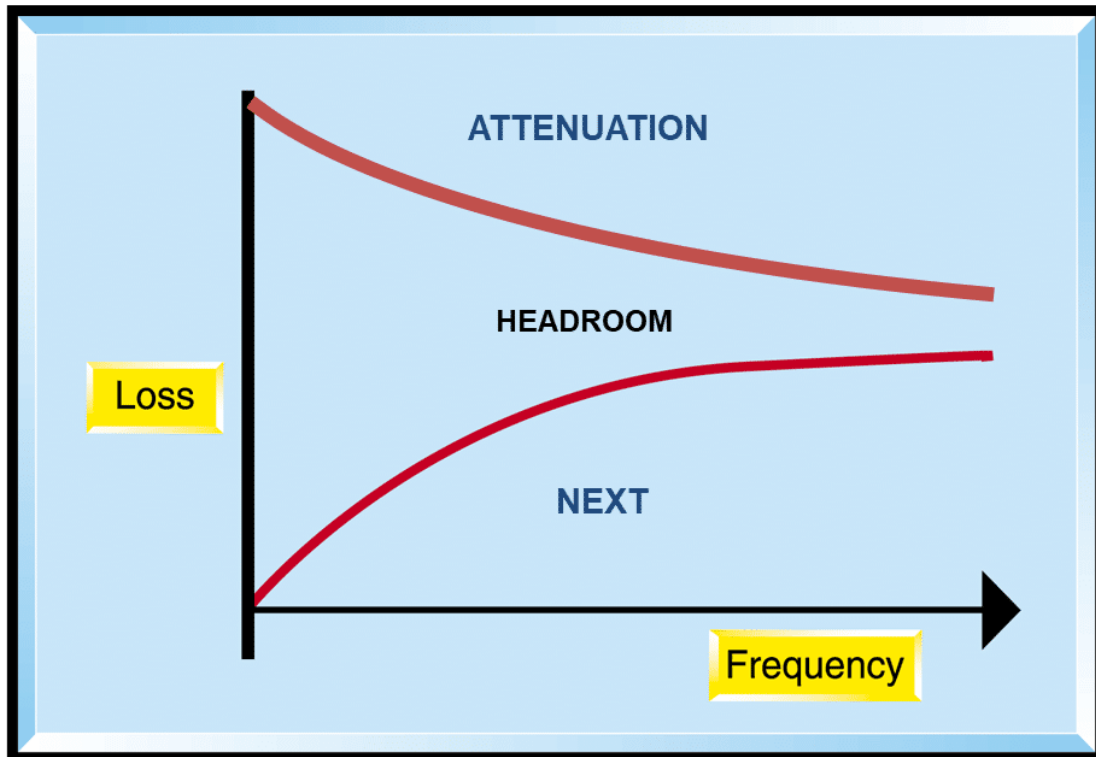
FEXT & ELFEXT —

- A lot of 'Cut and Paste' specifications still call for these tests
- FEXT is measured at the far end of the cable
- ELFEXT compares the levels of signal at the near end with attenuated levels at the far end, Normalized to the received signal level
- These are no longer valid field test measures and are only carried out in the Laboratory
- These have been replaced by ACR-F and Powersum ACR-F

If FEXT and ELFEXT are seen on the specification it is worthwhile challenging them as no field tester will test for these and they haven't and haven't done so for at least the last 20 years.

Attenuation to Crosstalk Ratio —

- ACR determines if a signal will still be readable after the effects of Attenuation and Crosstalk are taken into account
- In the case of ACR-F it determines whether the signal is still acceptable from the remote end of the cable
- Basically it compares the signal degradation with the increasing amount of NEXT at the higher frequencies, the gap between them is your headroom



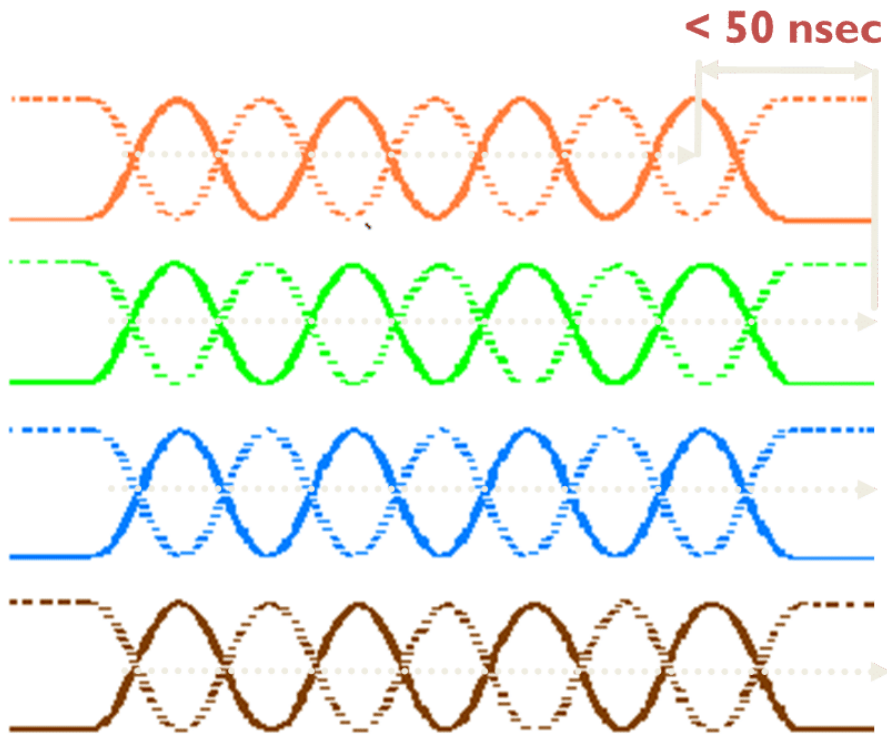
Delay Skew —

- A channel with more than 50 nanoseconds (ns) of delay skew cannot support Gigabit Ethernet successfully. Permanent Link limit is 44ns
- Each pair has a different twist ratio, which is intended to inhibit crosstalk, the difference on a 90m PL could be as much as 4-5m depending upon the tightness of the twists

The simple reason for the importance of this test is the end equipment (network interface card) does not have the error correcting capability to handle the information arriving over the four pairs with a large

time difference between each one. If the delay is too great it will just discard the information or 'drop packets'.

There is also Propagation Delay, which is the time taken for the complete signal to get from one of the links to the other, however this is rarely challenged by modern cabling unless there are other faults along the link.



Return Loss —

- Reflection of signal caused by Impedance mismatches along the cable
- Caused by poor installation
- Most commonly – damage along the cable
- Exceeding bend radius limits
- Occasionally – poor terminations
- Sometimes mismatches between cable, outlets and patch cables (when a mix & match solution is installed)

This is the other test value directly influenced by the installer. The most common cause is poorly installed cable, damage to the cable or pulling around too tight a bend.

Why test?

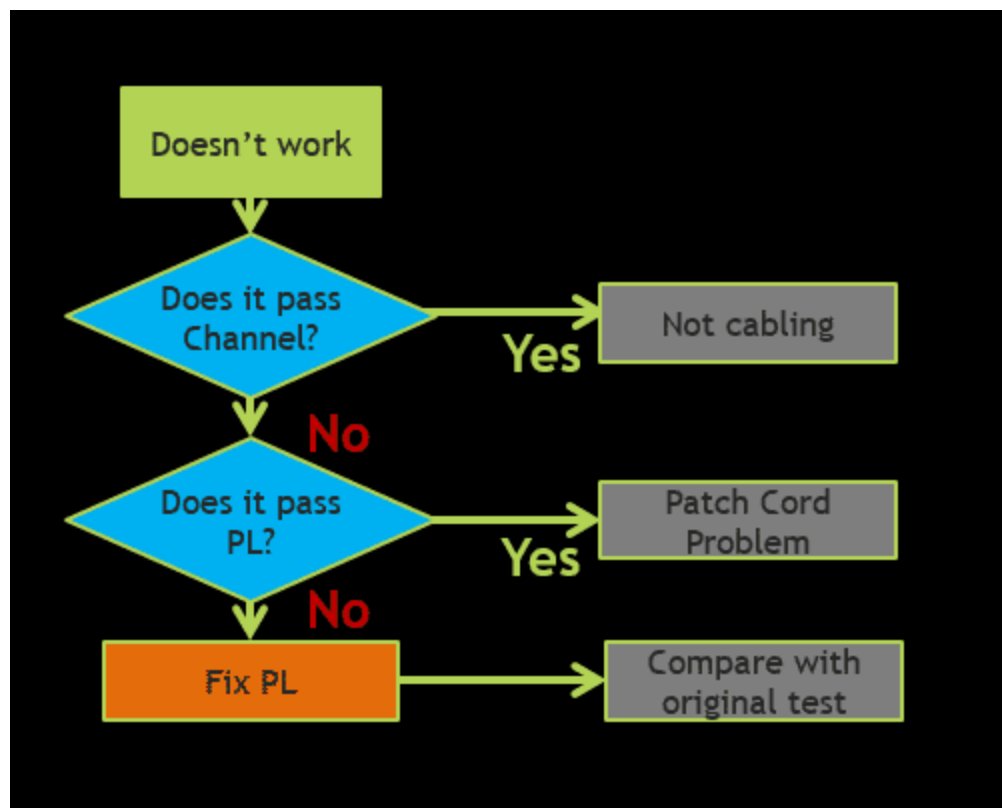
Carefully recording and storing your test results may pay benefits in the years to come. You never know whether you will be called back to site to 'investigate a failure' when in reality it is a user induced problem. If you have good records you will be able to prove the latter. Other reasons to test include:

- 1 It is required by the contract
- 2 It is required for the warranty application
- 3 It ensures you comply with industry standards, which are also a part of the contract
- 4 Troubleshooting support

This flow chart provides a simple overview for troubleshooting.

If you have followed all the steps outlined in this module, you will have gathered sufficient information to identify and rectify the fault.

If you are struggling to find it yourselves contact Excel Technical Support who will be able help you.



Test Results

The results for all warranty applications MUST be provided in an electronic format. For your own safety and good practice you should always keep an electronic copy of all results in a secure location for a reasonable period. Most contracts call for the installer to warrant/guarantee their own work for at least 12 months irrespective of the warranty.

All test results must be saved and downloaded:

- Printed or soft copies
- Copy for customer
- Copy for warranty
 - For a warranty they must be submitted in the tester's native format e.g. Fluke Linkware or Ideal Data Centre etc. *Submissions with .pdf files will be rejected.*
- Copy for your own records

Summary: Dos and Don'ts

Dos

- 1 Save test results in manufacturer format (e.g. Fluke Linkware)
- 2 Make sure tester is calibrated
- 3 Fill in the online application if you want a warranty
- 4 Test to the correct standard
- 5 Use an approved tester

Don'ts

- 1 Send test results as PDF
 - 2 Include results from other projects
 - 3 'Double Test' or Double Tap
-

 Double Tap relates to a lazy practice of testing the same link twice without moving the tester and recording two links with the same value. Excel Technical Staff are very experienced at identifying this practice and it may result in a future Warranty claim to be turned down.