An Engineer’s Guide to Full Compliance for CAT 6A Connecting Hardware

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Introduction

The telecommunication industry recently achieved a huge step forward with the ratification of standards enabling 10 Gigabit per second over 4 twisted pairs of conductors, up to a maximal cabling length of 100m (10GBASE-T protocol). These efforts started within the Institute of Electrical and Electronics Engineers (IEEE) 802.3an Task Force, which established all of the physical layer requirements in order to support 10GBASE-T operation, published under the document IEEE 802.3an™–2006.

During the standards development, the Telecommunication Industry Association (TIA) worked closely with IEEE to establish systems, component requirements, and repeatable test procedures to ensure the end-users cabling installations meet the ANSI/TIA-568-B.2-10 industry specifications. Such system and component requirements allow the installed cabling to reliably support 10GBASE-T operation.

Due to the dominance of twisted-pair category cables (5e and better) in the market, the standards have focused on keeping the same user-friendly and well known RJ45 connector interface allowing for backward compatibility. The RJ45 connector was originally adopted as a standard interface in 1991 when the data transmission speeds were limited to 10Mb/s, and an operational frequency up to 16MHz.

Today, the 10GBASE-T protocol has an operational frequency up to 500MHz. Using the RJ45 connector at high frequencies leads to big challenges for the industry, such as reducing the amount of parasitic interferences. Any irregularity over the cabling length will adversely affect the signal transmission, unless the connectors are well designed to operate at such high frequencies.

In this whitepaper, you will be provided with expert insights into the testing of connecting hardware including:

- Definition of key parameters to ensure Augmented Category 6 compliance at the component level.
- Details on the test procedures, with illustrations of the specific test fixtures required for connecting hardware testing.
- Benefits and guarantees of compliant connecting hardware with examples of improvements.
Augmented Category 6 Connecting Hardware Testing

There are nine (9) important parameters that need to be tested in order to ensure full compliance of Augmented Category 6 connecting hardware.

1. **Insertion loss (attenuation)**

   Insertion loss limit values ensure that the signal will have sufficient strength at the other end. This parameter is normally met through the design of any connector, because they do not attenuate the signal significantly due to their very short length. Even though the length is short, additional losses at higher frequencies can result from connector impedance mismatch.

2. **Near-end crosstalk (NEXT)**

   The NEXT is the ratio of unwanted signal that is radiated on the same end of any of the three (3) other pairs, relative to the amount of signal that is injected on the disturbing pair, as shown in Figure 1. The NEXT test ensures that there will not be too much power interference on the other pairs.

![Figure 1: NEXT coupling illustration](image-url)
3. **Far-end crosstalk (FEXT)**

The FEXT is the ratio of unwanted signal that is radiated on the opposite end of any of the three (3) other pairs, relative to the amount of signal that is injected on the disturbing pair, as shown in Figure 2. The FEXT test also ensures that not too much power will be radiated on neighboring pairs.

![Figure 2: FEXT coupling illustration](image)

4. **Return loss**

The return loss is the ratio of reflected signal, relative to the signal that is injected on the same end of the same pair. The return loss testing is important because 10GBASE-T protocol uses bi-directional transmission on all four (4) pairs. Therefore, any reflection in the transmitted signal would come back in the receiver as an unwanted signal, as shown in the following figure.

![Figure 3: Return loss signal reflections illustration](image)
5. **Transverse conversion loss (TCL)**

The TCL is the measured ratio of common mode signal (adverse signal), relative to the amount of differential mode signal injected at the same end of the same pair (or vice-versa). The TCL test gives an indication of the connector’s electromagnetic immunity. Therefore, the common mode signals which may come from ambient electromagnetic noise, for instance, have a risk of being converted to differential mode and being added to the intelligible signal. On the other hand, a differential mode signal may be partially converted to common mode and some equipment is more sensitive to common mode signal.

![Figure 4: Mode conversion illustration](image)

6. **Transverse conversion transfer loss (TCTL)**

The TCTL is similar to the TCL, with the difference that the parasitic common mode voltage is measured at the opposite end than the injected differential mode signal. The TCTL, as well, is an indication of the connector’s electromagnetic immunity.

7. **DC resistance unbalance**

The DC resistance unbalance is the resistance difference between two conductors of the same pair. Any difference in DC resistance may have adverse effects on the Network Interface Cards (NICs) or active equipments when using Power over Ethernet (PoE) technology.
8. **Power sum alien near-end crosstalk (PSANEXT)**

   The PSANEXT is the summation of all radiated power from neighboring connectors, measured at the same end as the injected power. The PSANEXT is a new parameter that became important because 10GBASE-T operates at much higher frequencies radiating power farther to distant connectors.

9. **Power sum alien far-end crosstalk (PSAFEXT)**

   The PSAFEXT is the summation of all radiated power from neighboring connectors, measured at the opposite end than injected power. The PSAFEXT is a new important parameter that has been standardized since the Augmented Category 6 standard.

These are parameters that need to be tested for every component and system. For connecting hardware, there are many additional challenges in the test fixtures and test methods because it is not feasible to interface the RJ45 connecting hardware directly between the front of the connector and the network analyzers.

The TIA created a task group uniting the industry’s connecting hardware experts with the mandate to achieve reliable and repeatable connecting hardware test procedures. When testing connecting hardware, the starting point always includes a suitable test plug with known characteristics that represent the plugs that are meant to be mated with the connecting hardware. Therefore, a method of qualifying the test plug was established and proper fixtures were designed. The following two figures show an example of both a proposed test plug and a specially designed test fixture that enables the test plug qualification.

![Figure 5: Controlled test plug illustration](image-url)
The test plug shown in Figure 5, illustrates a test plug that has, by design, tightly controlled return loss and crosstalk characteristics. The printed circuit board plug enables control of the plug’s characteristics. However, plugs with twisted wire pairs may also be used to test connecting hardware if they meet the test plug standard requirements.

The test fixture shown in Figure 6 has been specially designed to measure the intrinsic characteristics of the plug. This test fixture has good return loss characteristics and no significant crosstalk, thereby enabling direct measurement of the test plugs.

The ANSI/TIA-568-B.2-10 standard defines very detailed test methods to determine the characteristics of the connecting hardware using the measured test plug data. Those new methods involve an extensive set of calculations that can determine the precise performance of the connecting hardware.

Benefits and guarantees of a compliant connecting hardware

The connecting hardware has to face various challenges in order to support data transmission to the desired speeds. For the most part, they come from the legacy of the RJ45 plug, which intrinsically has a significant amount of crosstalk coupling (NEXT and FEXT). This crosstalk is mainly due to the proximity of the wire pairs that are crimped with a blade contact, having a big enough area to behave like a transmitting and receiving antenna. This issue is worse for all combinations involving the wire pair positioned in contacts number 3 and 6, because it is split and adjacent to all three (3) other pairs, as shown in the following picture.
The connecting hardware has to compensate for the plug’s coupling by adding a coupling of the opposite polarity in order to cancel out most of the plug’s offending crosstalk. The following figure (not to scale) illustrates the plug’s intrinsic coupling, the jack’s compensation and the resultant reduced crosstalk.

A low NEXT coupling is a key to guaranteeing a good data transmission because the connectors are normally positioned at the extremities of the cabling channels. Any NEXT coupling will create additional parasitic noise over the signal on the neighboring pairs, which can be seen by the equipment. The following figure illustrates the minimal NEXT interferences reduction of wire pair combinations involving wire pair 3, 6 at the frequency of 100MHz.
Another improvement of Category 6A connecting hardware is on return loss limit lines. Compared to Category 6 connecting hardware, the limit line is 4dB higher, which means that 60% less power will be reflected back into the transmitter.

Ultimately, the compliance to all test parameters will guarantee a proper data transmission in order to transmit protocols up to 10GBASE-T.
Conclusion

Intertek is the leading provider of performance and safety testing in the cabling industry. We continue to move forward in our Category 6A testing capabilities with the recent creation of a state-of-the-art connecting hardware test setup.

Because of the recent ratification of the Category 6A standard by TIA, Intertek is now able to offer manufacturers the latest in testing for Category 6 and 6A connecting hardware transmission parameters testing. This will allow us to continue providing our customers with the flexibility and fast turnaround times they have come to expect from Intertek.

Additional Information

For more information on Intertek’s CAT 6A testing capabilities, please contact Intertek at 1-800-WORLDLAB, email icenter@intertek.com, or visit our website at www.intertek-etlsemko.com.