Ethernet Performance of Network Isolators

White Paper

Information and definitions for the characterization of network isolators

Depending on the measurement parameter, the ethernet performance of a network component is not only dependent on the hardware component itself, but also on the transmission link in which it is installed. The measurement results of a network isolator (NI) alone are only of limited significance. The adjustment of the individual plugs to each other, the alignment of the NI and the use of different patch cable lengths will affect the performance of individual measured values differently.

That is why NIs are rated by the cable routes in which they are installed. Depending on the speed class and system, there are different limit values which are frequency dependent. These limit values for the cable routes include the values of the "Insertion Loss" (IL), "Return Loss" (RL) and the "Near-End-Crosstalk" (NEXT) and are in ISO/IEC 11801 and TIA/EIA-568 defined.

1 TEST SETUPS FOR CLASSIFICATION

Correctly measuring the NI, interpreting the parameters, and selecting the standards and limits can quickly become complex, but if you follow the two recommended setups for the NIs (see Figure 1), the specified classification of the NI can be ensured.

1.1 MEASUREMENT SETUPS

Usually an NI is placed into an existing Ethernet network, which consists of the following components: an end device to be protected, an NI, a patch cable to the wall outlet, the Permanent-Link (or horizontal floor distribution) and a connection to a network distributor such as a switch. Since the NI is to be attached as close as possible to the device which is supposed to be protected, setup 1 is recommended. Depending on local conditions, an installation according to setup 2 is also acceptable.

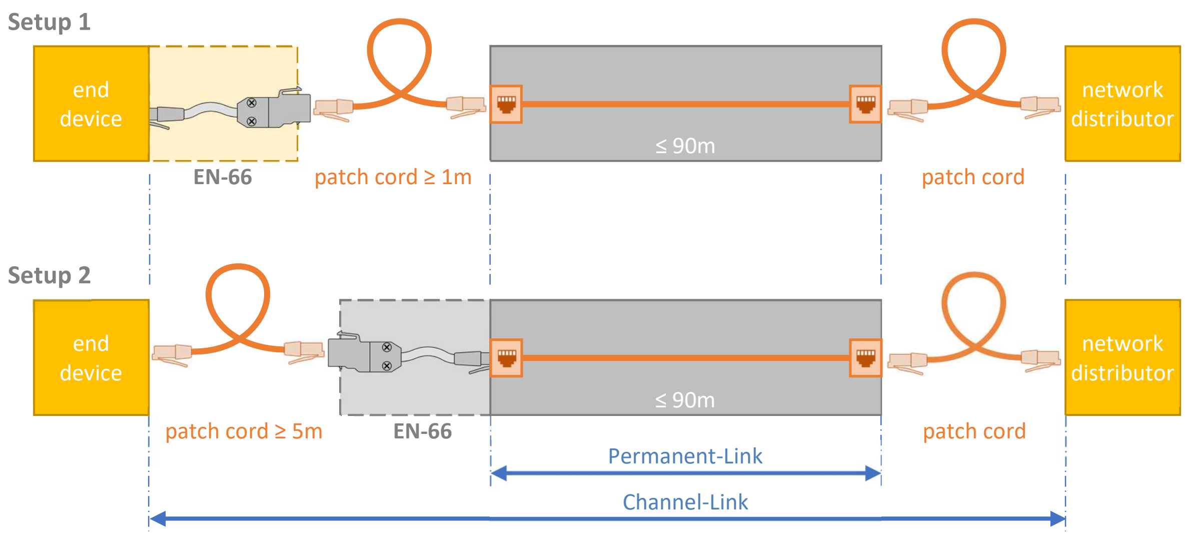

Figure 1 Setup with network isolators for certification according to ISO/IEC 11801 and TIA/EIA-568. The maximum Channel-Link length should not exceed 100m.

Of course, the NI can also be used in any other configuration. However, these may not be classified by ISO/IEC 11801 or TIA/EIA-568. Since every change leads to a shift in the measurement parameters, the specified speed of the NI may no longer exist. However, it should also be noted that even if the limits of

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the classification are slightly undercut, in most cases a stable data throughput with the specified classification speed is still possible.

The components used for the measurements in this document are summarized in Table 1.

Table 1 Components of the measurement setup.

Netzwerkisolator	Emosafe; EN-66 (120mm)
Patch cord	R&M; 2* 5m; S-FTP Cat 6A; AWG26
Permanent Link cord	90m; S/FTP Cat 7A; AWG23/1, LSZH
Permanent Link jack	Roline; RJ45 Keystone Cat6A Jack, STP
Measuring instrument	Fluke Versiv; DSX-5000; 2* Cat 6A CH Adapter

1.2 CLASSIFICATION AND STANDARDS

The ISO/IEC 11801 and the TIA/EIA-568 sets the limit values for the speeds of various installation setups and define requirements for a wide variety of network components.

For example, the "Permanent-Link" (PL) is only the fixed (permanent) installation route between two communication partners. In comparison to that, the “Channel-Link” (CH) includes all network components that are located between two communication partners. This then also includes network isolators, patch cables or other components.

The limit values of ISO/IEC 11801 Class E_A and TIA/EIA-568 Cat 6A for a Channel-Link differ only in a few places by negligible sizes. Therefore, the limit values of ISO/IEC 11801 Class E_A are used below. Also note the easily mixed up notations of the two commonly used standards in Table 2.

Table 2 Comparison of the notation in the ISO/IEC und TIA/EIA standard for a 10GBase-T system.

	Link / Channel	Cabel / Jack
ISO/IEC 11801 *(international standard)*	Class E_A	Cat 6_A
TIA/EIA-568 *(american standard)*	Cat 6A	Cat 6A

2 CHARACTERISTICS

In the ISO/IEC 11801 and the TIA/EIA-568 standard, many characteristic values are mentioned, which defined values must not exceed or fall below the limit values. The three most important parameters are briefly explained below and relevant information for the use of the NI is discussed. If these three parameters meet the requirements, it can usually be assumed that all the other parameters will also meet the requirements.

2.1 INSERTION LOSS

The Insertion Loss (IL) indicates how much the signal is attenuated when passing through a test section. In contrast to the other two parameters, the IL is independent of the configuration of the setup and behaves additively with all other components of the setup. Figure 2 shows the IL of an EN-66 (IL_{NI}). This can simply be added to the other IL of the other components of the structure to get the total damping (IL_{Σ}). Only the limit value of the IL limits the maximum length of the setup.

$$IL_{\Sigma} = IL_{patchA} + IL_{NI} + IL_{PL} + IL_{patchB} \qquad \text{eq1}$$

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CABLE / MAXIMUM SYSTEM LENGTH

With regard to the IL, patch cables and horizontal cabling can be parameterized very well.

We would like to skip the deriving of the IL from the physical effects. In short, the cable resistance plays an important role, which depends on the frequency-dependent skin effect. But, by looking at the IL of a cable one can discover a rule of thumb for the IL of a cable:

$$IL_{cable}\,[dB] = \frac{l * \sqrt{f}}{d * 100} * \left[\frac{dB*mm}{\sqrt{MHz}\,m}\right] (\pm 5\%) \qquad \textit{eq2}$$

where d is the single wire diameter in mm, l is the length of the cable in *m* and f is the measuring frequency in *MHz*. Figure 3 shows how well the IL of a cable can be approximated using the given rule of thumb.

With a buffer of ≈46 dB at 500 MHz (see Figure 2, left), with an EN-66 a system length of 100m is possible from a single wire diameter of 0.48 mm.

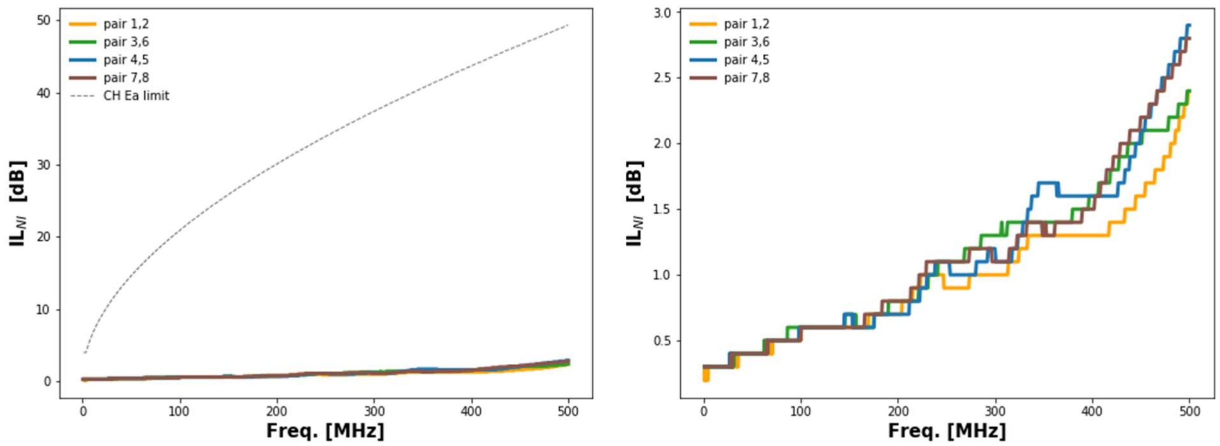

Figure 2 Insertion Loss of an EN-66 without other network components and splitting into the 4 wire pairs. (left: with limit of ISO/IEC 11801 Class E_A Channel; right: without any limit values).

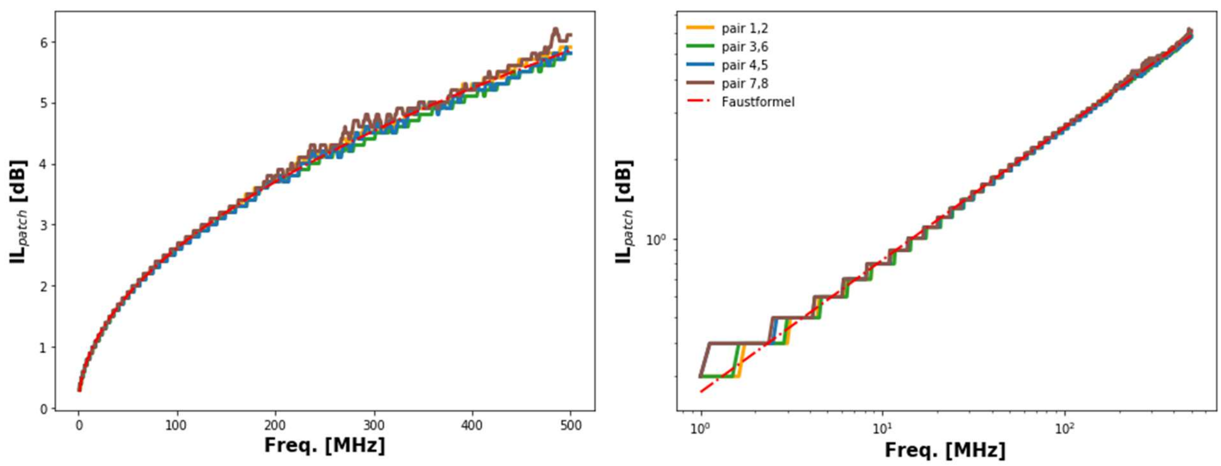

Figure 3 Insertion Loss of a patch cable (10m, 26AWG, SSTP) and rule of thumb (eq2) for cable runs (left: linear scaling; right: logarithmic scaling).

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2.2 RETURN LOSS

The return loss describes how well the wave resistances of the system components are matched to one another. The characteristic impedance of the 4 wire pairs should be 100 Ω and any deviation leads to a reflection of the signal, which is reproduced in the RL. The attenuation of the incoming signal to the reflected signal is specified in the RL. Accordingly, high RL attenuation is desirable for high signal quality.

Since reflections can occur at both ends of a measurement setup, the RL is also measured at both ends of the setup. For the selected structures with an NI (Figure 1), the effects of the NI on the side of the network distributor are not visible. Therefore, only the measured values on the end device side are relevant and displayed here.

The wave resistance in a cable is maintained by an even and precisely determined twisting of the wire pairs with each other. However, this twisting cannot be maintained in the area of a plug connection. Therefore, it is necessary that the twisting of the wire pairs is maintained as long as possible. Because even short distances of a few millimeters in the connector and the contact surfaces can cause adjustment problems.

It should be noted that the RL is always a question of adaptation. A combination of one jack manufacturer can give very good results, but the connection with another manufacturer can lead to problems. But also, a low reflection can also be created with a plug-in combination in which both ends are far off from the target value of 100 Ω but have almost identical wave impedances.

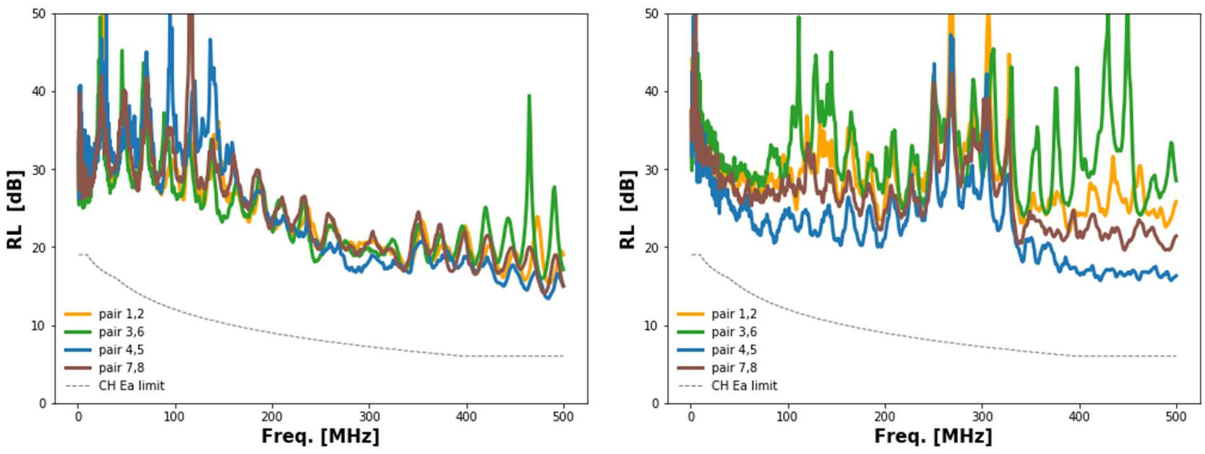

Figure 4 Return Loss of the end device sides and splitting of the 4 wire pairs (left: s 1; right structure 2).

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2.3 NEAR-END-CROSSTALK

For the Near-End-Crosstalk (NEXT), the crosstalk between the wire pairs between each other is quantified. With 4 wire pairs, 6 combinations follow, which can be viewed separately. In addition, this measurement can also be carried out at both ends of a measurement setup. As with the RL, the NEXT values on the network distribution side are independent of the NI. Figure 5 shows the typical NEXT results in setup 1 and setup 2. A comparison of the setups shown here, shows the strong effects the rearrangement of system components can have.

In order to reduce the crosstalk of the different pairs between each other, the wire pairs can be shielded from one another in cables with metal foils. Alternatively, on boards or in sockets, attempts are made to reduce the areas in which the different pairs must be close together.

Due to the structure of the RJ45 connectors and the layout on circuit boards, the individual NEXT channels may differ greatly.

It has to be noted that an increase of the NEXT performance is possible by increasing the length of the patch cable on the end device side.

Here, too, the NEXT performance of the individual components is not additive. However, all connected systems must have good NEXT performance.

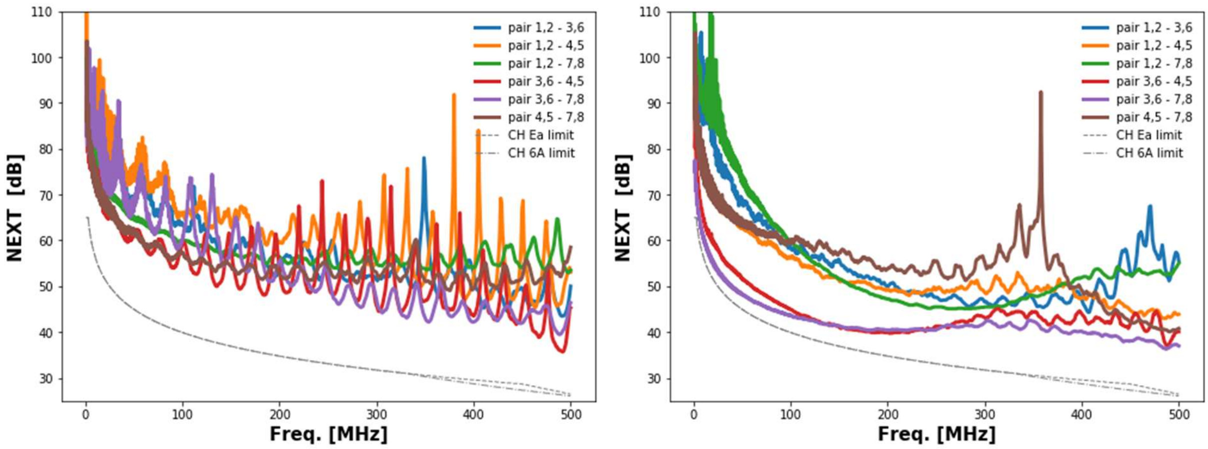

Figure 5 NEXT performance of the end device sides of the 6 groups (left: setup 1; right: setup 2).

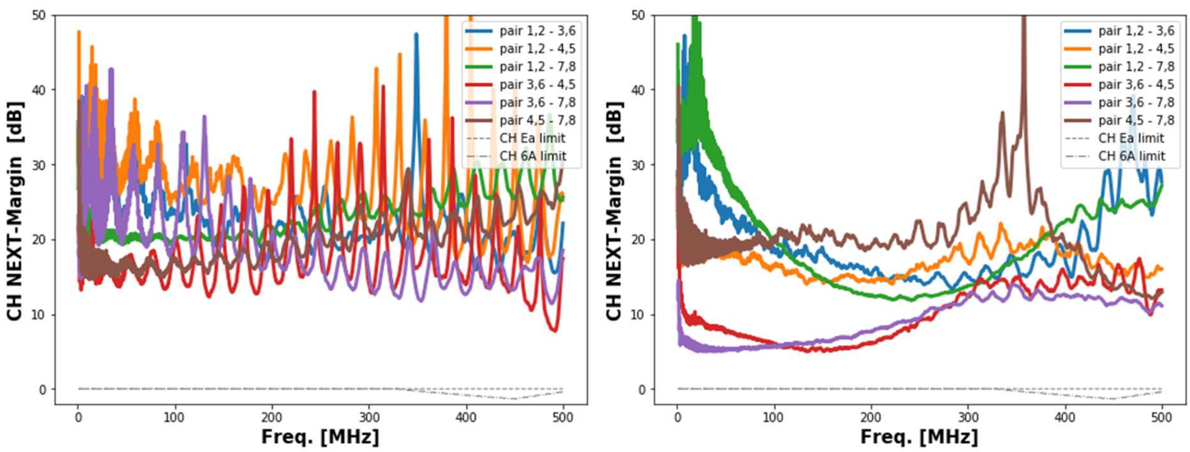

Figure 6 NEXT margin of the device pages of the 6 groups
(left: setup 1; right: setup 2) (identical values with Figure 5, only different representation)

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