A New Alien Crosstalk Testing Solution for 10GBASE-T Cabling System

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Abstract

IEEE is expected to release the standard for the next generation 10Gbps copper cable Ethernet network, termed 10GBASE-T, in 2006. For the deployment of 10GBASE-T on balanced copper cabling system, one key issue is the testing and mitigation of the noise coupled between the adjacent link segments, i.e. alien crosstalk. This paper discusses the issues and suggests a unique solution to the testing of alien crosstalk in a fast and effective way.

1 Introduction

The noise coupled between the adjacent cable segments illustrated in Figure 1 is referred to as alien crosstalk [1].

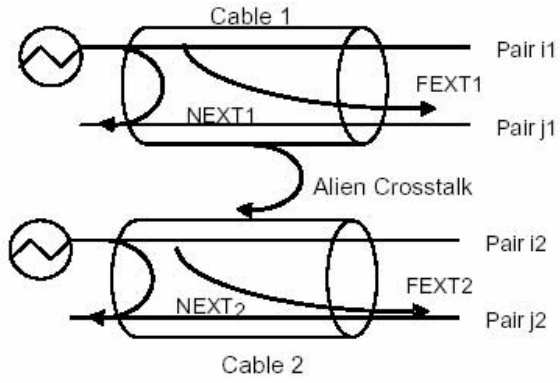

Figure 1. Alien crosstalk coupling between link segments

The alien crosstalk noise levels are dependent on the number and proximity of adjacent cables and connectors. Two metrics of alien cross-talk are PSANEXT (Power Sum Alien Near End Cross-talk) and PSAELFEXT (Power Sum Alien Far-end Cross-talk), which represent the cumulative effects of near end and far end alien cross-talk from all disturbing channels. Typically in a lab environment the measurement of PSANEXT and PSAELFEXT are based on cables configured in a six-around-one orientation, where the target cable is the central cable and adjacent to all of the other disturbing cables (Figure 2). The alien crosstalk coupling between a cable and 6 surrounding cables tightly bound in a six-around-one configuration exhibits a "worse case" [1]. Cable not in direct physical contact with the target cable generate much lower crosstalk and can be disregarded in comparison to the worst case scenario.

Alien cross-talk between cables reduces the operational bandwidth of a cabling channel because of an increased level of cross-talk noise decreasing the overall signal-to-noise ratio. For higher bandwidth applications like 10GBASE-T, its effects are much severe than for lower speed network applications.
Because of this, managing alien crosstalk becomes very critical in the deployment of 10GBASE-T and there is recently an increased interest in the technologies on this problem (e.g. [2], [3], [5]).

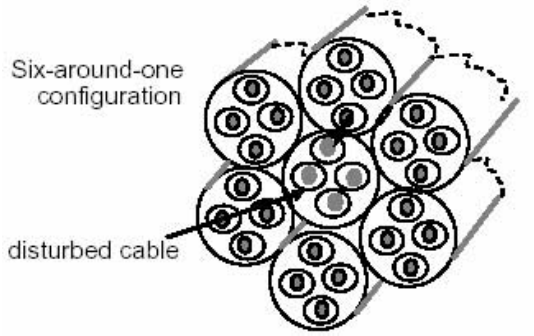

Figure 2. Six-around-one cable configuration

Since the alien crosstalk management depends on the alien crosstalk testing, the testing of the alien crosstalk is growing in attention from all corners of the industry.

The remainder of this paper is organized as follows: In Section 2, we give some background on the testing of alien crosstalk. Section 3 describes an effective solution to alien crosstalk testing. Finally, brief conclusions are drawn in Section 4.

2 Measurement of Alien Crosstalk

Before going into further details of alien cross-talk testing, we will have a look at the difference between alien crosstalk testing and in-channel crosstalk (NEXT) testing of cabling system:

a) Alien cross-talk testing is carried out between 1 disturbed (target) cable and >1 disturbing cables (typical is 6 as illuminated in Figure 2), while for in-channel crosstalk testing only one cable under test. Alien cross-talk testing therefore needs more than two cables to be connected to test equipment.
b) Testing should be executed for a bundle of cable, which may include >7 cables. Thus

- Before testing, the operator has to connect many cables, which may be located in different place.
- During testing, different cable combinations should be tested and recorded accordingly.
- Measurement combination will be complex with large number of cables. For n cables, even suppose every cable only measure one pair, then the ANEXT testing combination and results will be $n(n-1)/2$, and the AFEXT testing combination and results will be $n(n-1)$. For example, for a particular pair of 7 cables, there are 21 ANEXT and 42 AFEXT need to be acquired.

Basically, testing of Alien Crosstalk could be a complex and time-consuming task requiring a number of precious man-hours. A fast and convenient alien crosstalk testing solution would be dramatically increase productivity of crews testing installations.

The solutions proposed for alien crosstalk testing until now are mostly based on the existing solution for the normal crosstalk measurement. The basic configuration of one normal solution is illuminated as in the following Figure 3 [4].

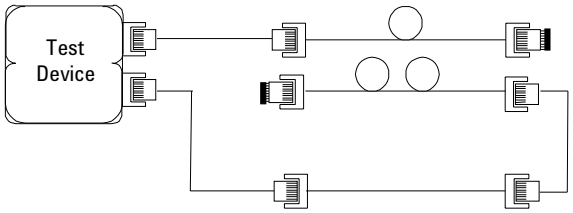

Figure 3. Alien crosstalk testing configuration in [4]

The solution in Figure 3 is based on a test device with 2 jacks connecting the target and disturbing cables under test, respectively. Such a solution has some disadvantages, such as not be able to provide a convenient and fast way for users to execute alien crosstalk testing for more than one disturbing cable, which is very common in practice.

3 Unique Methodology for Alien Crosstalk Measurement

A new patent pending solution described below is based on a new test tool called a AxTalk Stimulator.

3.1 Testing System Configuration

The cabling link testing configuration of this unique solution is shown in the Figure 4.

The disturbed cable (#1) is connected with the Local Spectrum Analyzer (e.g. Agilent WireScope) at the local end and the Remote Spectrum Analyzer (e.g. Agilent DualRemote) at the remote end. All disturbing cables (#2—#n) are connected with the AxTalk Stimulators at the both end.

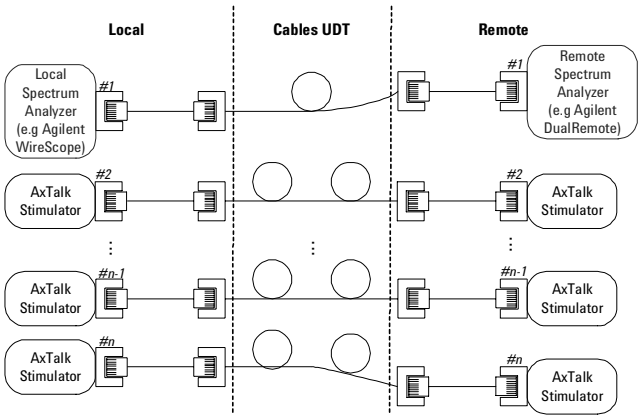

Figure 4. System configuration of AxTalk Stimulator based alien crosstalk testing

The AxTalk Stimulators is a palm size device, which has following three working modes:

- Transmit Mode: transmitting RF signal with specific pattern which will be described later when the remote unit is in Listen Mode.
- Termination Mode: both units switching to terminations, which is the default state supporting communication between local and remote AxTalk Stimulators.
- Listen Mode: switching to termination when the remote unit is in Transmit Mode.

The testing of alien crosstalk (e.g. Power Sum Alien NEXT) with AxTalk Stimulators is illuminated in Figure 5. For the Power Sum Alien FEXT testing, the roles of local and remote AxTalk Stimulators are reversed.

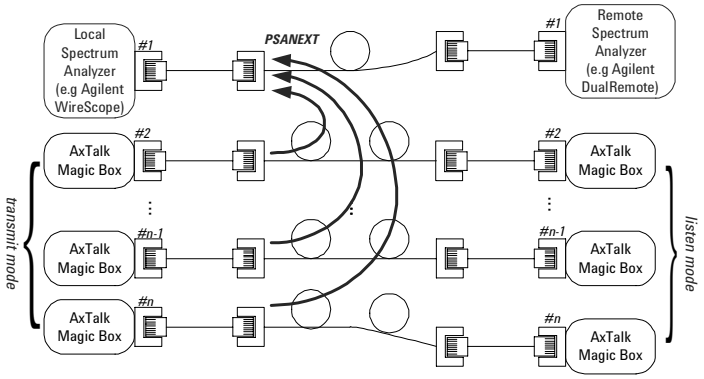

Figure 5. Power Sum Alien NEXT testing

3.2 Testing Principle

Alien cross-talk testing described here works on frequency domain principle. Frequency sweep is fundamental to a frequency domain measurement, which means a transmitter producing a sinusoidal test signal at each frequency of interest for a specific duration. The frequencies of interest are defined by the governing standard (e.g. TIA 568B.2 [4]). The test signal is then applied to a device under test (e.g. a cable pair) and received by a narrow-band receiver that is tuned to the same frequency.

The RF transmitting and receiving frequency sweep of AxTalk Stimulators and the spectrum analyzer, respectively, should be working in a specific pattern to achieve alien cross-talk measurement. This pattern consists of the AxTalk Stimulators performing a frequency sweep at a rate much faster than the spectrum analyser (Agilent WireScope).

The AxTalk Stimulators in the setup of Figure 5 produce repeated frequency sweeps on each pair of the cable connected to it. Let T be the period of time required for the AxTalk Stimulators to complete one frequency sweep. This means, during any period T, the transmitted RF signal will be swept at all required frequencies from $f_{\_low}$ to $f_{\_high}$.

The spectrum analyzer, e.g. Agilent WireScope Pro or DualRemote, connected to the disturbed cable, also performs a stepped frequency sweep. However, it completes the frequency sweep in a duration nT, where n is the number of steps from $f_{\_low}$ to $f_{\_high}$. This timing arrangement allows the spectrum analyser to receive the cross-talk from each disturbing cable pair for each frequency step required in the governing standard.

The AxTalk Stimulators work asynchronously with each other and the spectrum analyser. In other words, there is no secondary communication link among these devices, making the setup simple, reliable and lower cost.

3.3 Experiments and Testing Results

With the implementation of the solution proposed in this paper, experiments have been carried out to compare results of this new method to reference measurements using a RF Network Analyzer

Figure 6 shows the acquired alien NEXT from three disturbing cables #A—#C.

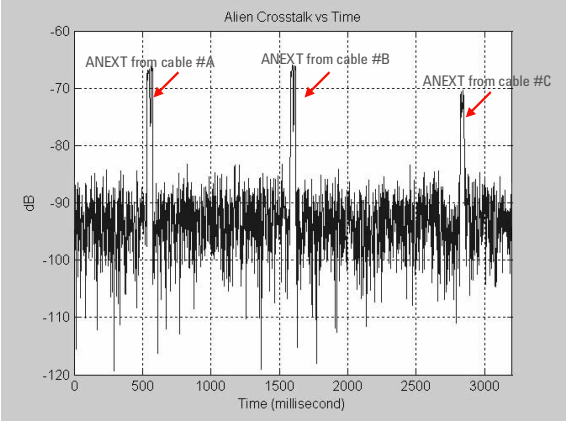

Figure 6. Acquired alien crosstalk coupled from three different cables at a particular frequency

Figure 7 shows the alien NEXT obtained with AxTalk Stimulators (red line with dot) is almost the same as the benchmark value obtained with Network Analyzer (blue line).

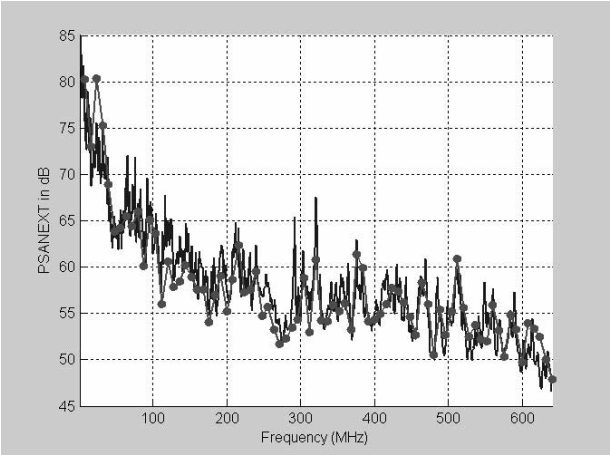

Figure 7. Comparison of acquired alien crosstalk with benchmark value.

3.4 Advantages of the Solution

The solution is quick, convenient, and accurate.
The method eliminates the tedious task of connecting and disconnecting the disturbing cables one at a time. Further, the AxTalk Stimulator is a small size device which could be placed anywhere. Even if a disturbing cable has end-point located in a different room, this solution makes alien cross-talk testing possible.

After connecting all cables to the corresponding AxTalk Stimulators, the alien crosstalk can be obtained in the time nT for any possible number of disturbing cables. The typical T is about 0.5 seconds and n is around 1000, thus total testing time is less than 10 minutes. Advanced methods to reduce the testing time even

further are under study. This is a significant advantage over existing methods that could take close to an hour to complete one test.

Last, it gives a way to quickly identify the disturbing cables with large coupled alien crosstalk noise, greatly helping the management process.

4 Conclusions

In this paper, a description of and a unique solution for alien crosstalk testing of cabling system for 10GBASE-T is proposed. This method gives a quick and convenient way for alien crosstalk with multiple disturbing cables. Experiments with prototype implementation verify the feasibility of the solution.

References

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[4] TIA TR-42.7, "Draft on TIA/EIA-568-B.2: Transmission Performance Specifications for 4-Pair 100 Ω Augmented CAT 6 Cabling", 2005.

[5] IEEE P802.3an (10GBASE-T) Task Force, http://www.ieee802.org/3/an/index.html.