Basics of DSL Bonded Physical Layer Testing

In the previous post, “DSL Physical Layer Testing,” we began to explore some of the background and requirements for DSL performance testing, including the simulation of the telephone network's local loop and noise conditions. In this entry, we'll explain the more detailed definitions of the simulated cross-talk noise and the implications for testing multi-pair systems.

Figure 1 below shows a simplified view of the cross-talk noise experienced by one CPE and one DSLAM port, when operating in the presence of a second pair of transceivers. In the figure, the red arrows depict the two types of cross-talk noise experienced by the CPE’s receiver, while the blue arrows depict the two noises experienced by the DSLAM’s receiver. The Far End Cross-talk (FEXT) is the noise signal that results from the signal of a transmitter located on the other end of the local loop cross coupling onto the wire pair used by the DSLAM and CPE 1. The Near End Cross-talk (NEXT) is the noise signal that results from the signal of a transmitter located on the same side of the local loop cross coupling onto the wire pair used by the DSLAM and CPE 1. The reference point for establishing a “near” or “far” location is always the receiver experiencing the noise.

Figure 1: Cross-talk definitions

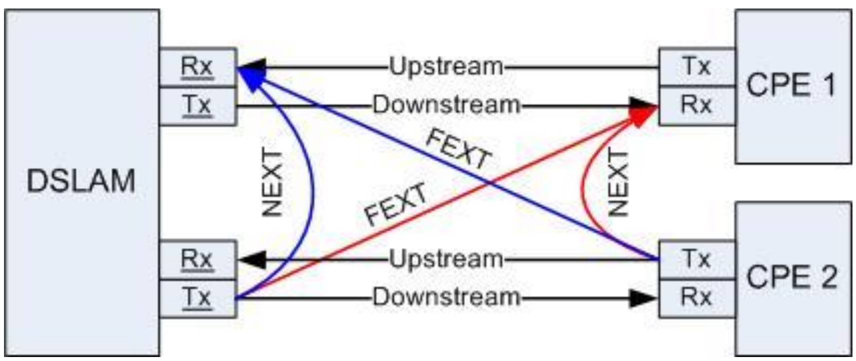
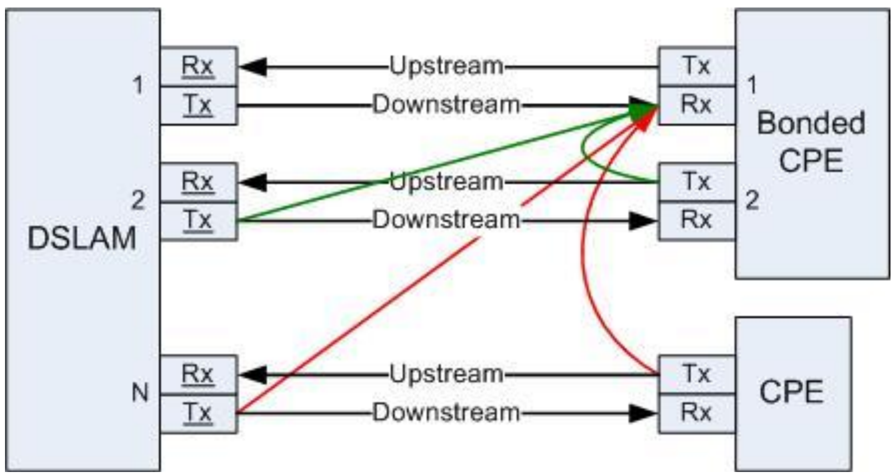


Figure 1 does not show all possible cross-talk paths, as the signals transmitted by the DSLAM and CPE 1 also impact the receivers used for the DSLAM and CPE 2 connection as well. Likewise, there are also noise sources not created by the DSL transceivers, such as switching power supplies or AM radio stations, where these noises are generally termed as external or ingress noises. As explained in the previous blog post, the telephone network’s local loops are usually organized into groups of pairs, typically 25 pairs per group, where the cross-talk noise experienced by one pair in the group can be expressed as a function of the number and type of DSL signals utilizing the other wire pairs. When the cross-talk noise is caused by DSL transceivers using the same technology or standard it is called self-cross-talk. Likewise, when the cross-talk noise is caused by different technologies or standards, it’s called alien-cross-talk. A performance test case may make use of different combinations of self, alien, and ingress noises to model a real deployment in a service provider’s network.

In general, most testing will also include the application a wide-band Additive White Gaussian Noise (AWGN), to the local loop being testing. The purpose of the AWGN noise is to establish an artificial noise floor experienced by the transceivers, which helps to eliminate some of the variability experienced between different test setups or test labs. Without the artificial noise floor, the transceivers would optimize the DMT modulation to the lowest noise floor between the test equipment, CPE, and DSLAM, where this condition is likely somewhere between -140 and -150 dBm/Hz, leading to non-repeatable testing.

As the technologies and media available from the Internet have increased the demands on connection speeds, DSL technologies have evolved to increase the available transmission bit rates. The DMT modulations have increased the number of sub-channels, increasing the transmission bit rate and bandwidth. Simultaneously, additional specifications have been developed to allow multiple DSL transceivers to be grouped in bonded groups, increasing the total aggregate bit rate available to the CPE. In Figure 2, the NEXT and FEXT cross-talk noises for one of the two receivers on the Bonded CPE are shown. A key point is the NEXT and FEXT self-cross-talk caused by the second transceiver in the CPE, shown as the green arrows.

Figure 2: Cross-talk in Bonded DSL Systems



This correctly implies the individual transceivers in the Bonded CPE never operate without the presence of at least a single self-cross-talk noise. While this constraint does not overly impact the operation of the Bonded CPE, it does require consideration if the performance of the individual transceivers is being compared to those of a single-line CPE. If we consider the case where the test setup only simulates the local loop and AWGN, the single-line CPE experiences the noise floor established by the AWGN. If the same test setup is applied to each of the lines of the bonded CPE, each transceiver operates in a noise environment that includes both the AWGN, as well as the self-cross-talk caused by the second transceiver in the Bonded CPE. If the number of pairs utilized by the Bonded CPE is increased, the self-cross-talk noise levels will likewise also increase.