Cross Talk in Unshielded Twisted-Pair Cables

Cross talk in UTP cables is caused by capacitive coupling between pairs. Signals on pair A cause noise signals on pair B, and often the cross talk noise proves to be the limiting factor in the link performance. Cross talk occurs in two ways. Near-end cross talk (NEXT) happens when a signal from a transmitter at one end of a cable interferes with a receiver at the same end of the cable. Far-end cross talk (FEXT) occurs when a signal interferes with a receiver at the opposite end of the cable from the transmitter.

Near-End Cross Talk (NEXT)

Near-end cross talk loss is defined as:

$$\text{NEXT} = -20\log\left(V_n/V_i\right),$$

where V_n and V_i are shown in Fig. 1a. The minimum NEXT loss between pairs in a cable tends to follow a smooth curve, as shown in Fig. 1b, decreasing at a rate of 15 dB per decade. However, the actual NEXT between two particular pairs deviates significantly from this curve because of resonances in the twisted-pair. Typical measurements of the NEXT loss between some pairs in a 25-pair cable are also shown in Fig. 1b.

Far-End Cross Talk (FEXT)

Far-end cross talk loss is defined as:

$$\text{FEXT} = -20\log\left(V_f/V_i\right),$$

where V_f and V_i are shown in Fig. 2a. The minimum FEXT loss also decreases with frequency following a smooth curve, but at a rate of 20 dB per decade. As with NEXT loss, the actual FEXT loss between two particular pairs deviates from this curve. Typical measurements of the FEXT loss between some pairs in a 25-pair cable are shown in Fig. 2b.

Cross Talk Measurements

Our analysis of cross talk required a database of accurate and detailed measurements of cross talk between pairs in 25-pair cables. A measurement system was constructed to measure NEXT and FEXT losses of all pair combinations in 25-pair cables (see Fig. 3, next page).

Individual pairs were routed to the stimulus and response ports of a network analyzer via a computer-controlled switch. This allowed the automatic selection of 300 different pair combinations for NEXT measurements and 600 pair combinations for FEXT measurements. Any pair not being measured was terminated in 100 ohms via a balun and a 50-ohm termination internal to the switch. The network analyzer measured the cross talk loss (phase and magnitude) to 40 MHz, and this was downloaded to a computer database. Using this system, the NEXT and FEXT losses were measured for many thousands of pair combinations in a selection of 25-pair cables of varying manufacturer and age. The database was used to input NEXT and FEXT loss characteristics to the computation of cross talk noise described in "Cross Talk Analysis" on page 22.

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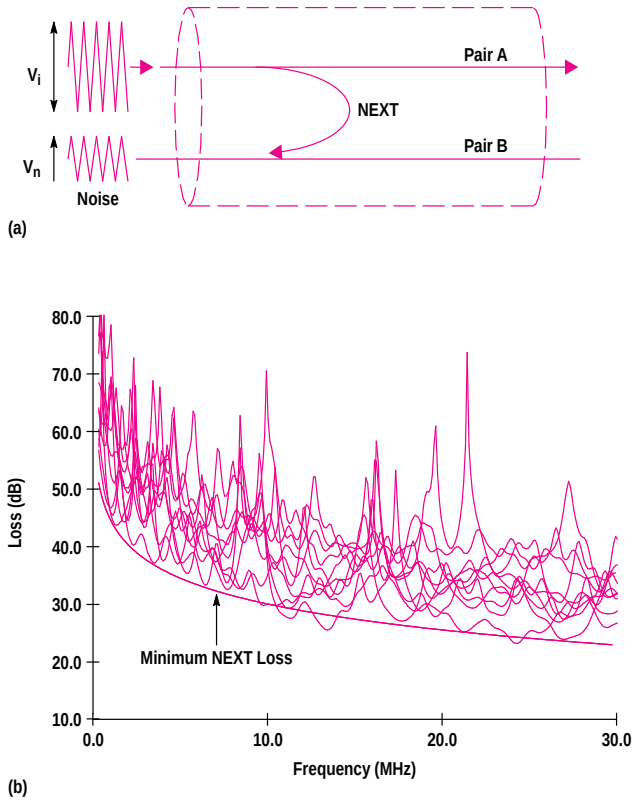

Fig. 1. (a) Near-end cross talk (NEXT). (b) Minimum theoretical NEXT loss and actual measurements.

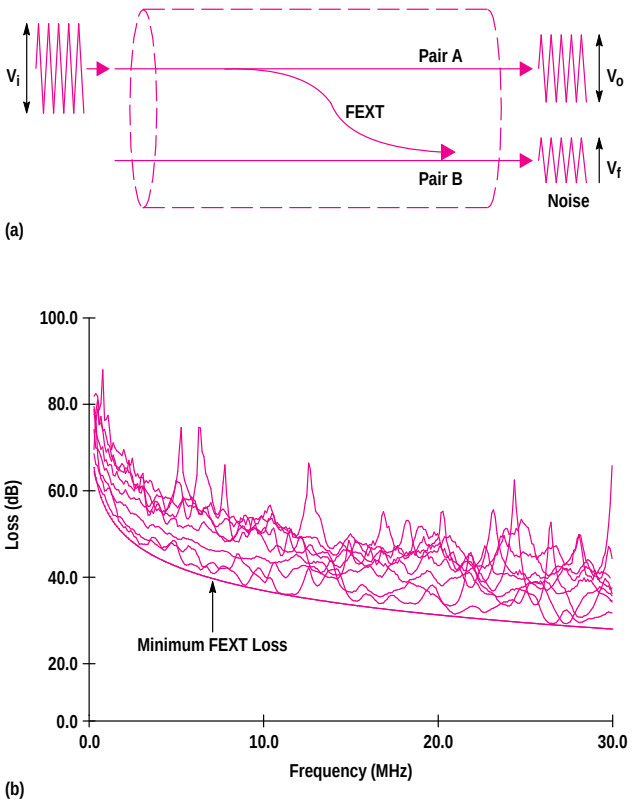

Fig. 2. (a) Far-end cross talk (FEXT). (b) Minimum theoretical FEXT loss and actual measurements.

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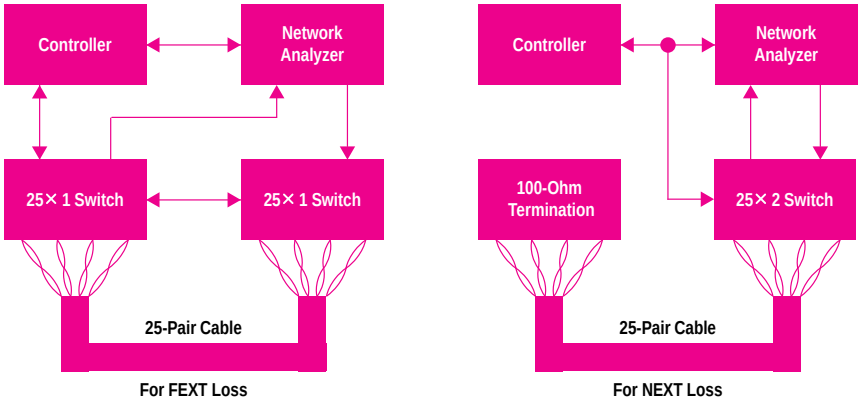

Fig. 3. Measurement system for NEXT and FEXT loss.