Nexans	**Performance Analysis of Berk-Tek's 25-Pair, Category 5e Cables**
Data Communications Competence Center	**DCCC03112202** June 29, 2007

Test Summary

Active testing was performed on Berk-Tek's 25-pair, Category 5e cables. The testing demonstrates the ability of this cable to reliably transmit Gigabit Ethernet (1000BASE-T) traffic over a 90-meter channel while multiple alien Gigabit Ethernet and Fast Ethernet (100BASE-TX) signals are simultaneously operating in the same cable. Results confirm the high reliability of this product when transmitting Gigabit Ethernet.

Background

The purpose of these tests was to investigate the operation of Berk-Tek 25-pair cables while concurrently running gigabit Ethernet (GbE) or combinations of GbE and Fast Ethernet (FE) signals under the same sheath.

ANSI/TIA/EIA 568-B specifies the transmission requirements for multi-pair category 5e cables. This standard limits crosstalk of pair-to-pair and between groups of pairs within the cable.

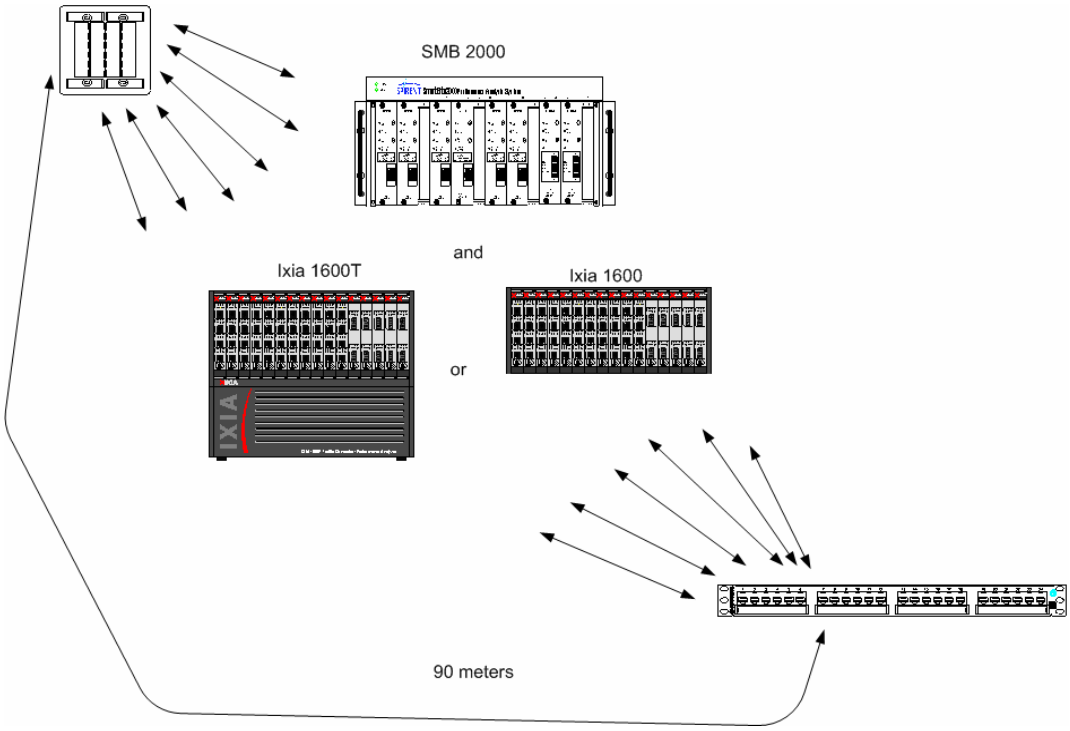
Crosstalk was evaluated by several methods: using active testing include stressing the transmission channel with different combinations of disturbing pairs, use of weak transmission cards and use of a distorted signal. Different scenarios of GbE and FE were simultaneously transmitted over the cable to confirm that with concurrent signals of different types, the network bit error rate would exceed that specified for in the IEEE objectives.

Test Equipment

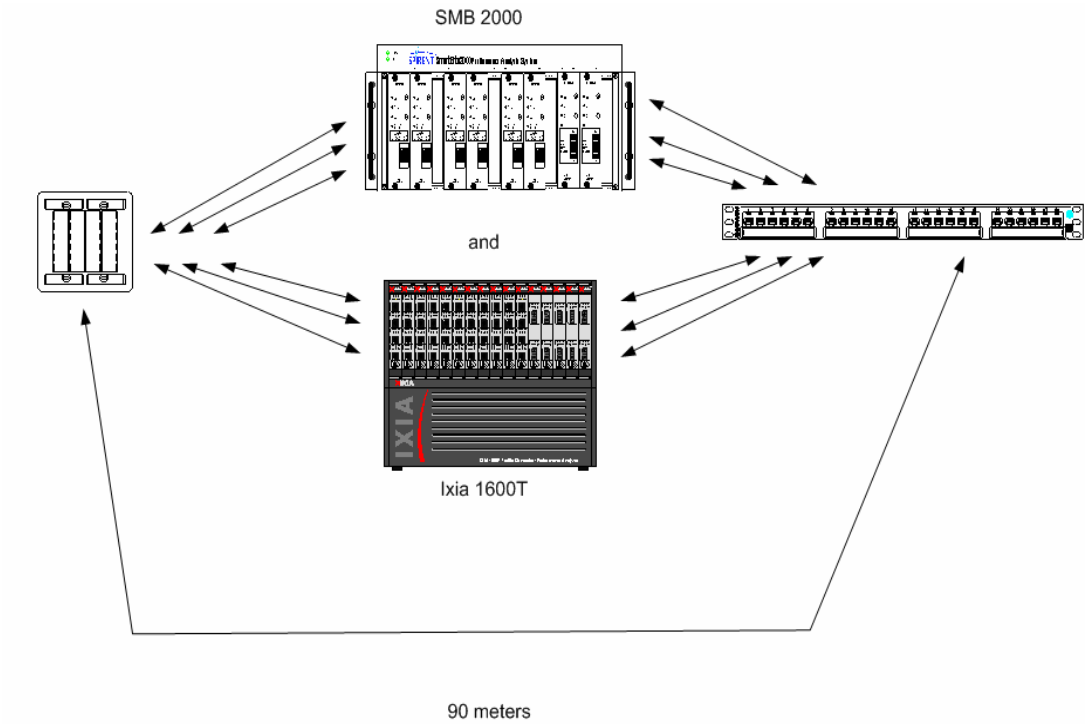
- Spirent SmartBits® 2000 Multi Performance Analysis System with Model GX-1420B Gigabit Ethernet modules and SX-7410B Fast Ethernet Modules.
  - 64 byte frames
- IXIA® 1600T Traffic Generator/ Performance Analyzer System with Model LM1000T-5 Gigabit Ethernet/ Fast Ethernet Modules.
  - 64 byte frames
- IXIA 1600 Traffic Generator/ Performance Analyzer System with Model LM100TX Fast Ethernet Modules.
  - 64 byte frames
  - Sony Tektronix Arbitrary Waveform Generator, AWG610
  - 2 Signals generated and uploaded using Nexans Signal Generator
    - Signal One: 1518 byte message length, 00000000FFFFFFFF message type, 2.0 V amplitude, random jitter type, rise time and fall time are steep.
    - Signal Two: 64 byte message length, 00000000 message type, 2.0 V amplitude, random jitter type, rise time is steep, fall time is invalid.
- 100 meter, 2 connector cabling channel
  - Cable: Berk-Tek 25-pair verified 5e
    - Part Number: 10059632 Plenum (CMP), 10061456 Non-Plenum (CMR)

- Connectivity
  - Patch Panel(s): Ortronics Clarity CAT 5e OR-PHD5E6024
  - Jack(s): Ortronics Clarity CAT 5e Tracjack OR-TJ5E00
  - Patch Cable(s): Ortronics Clarity CAT 5e

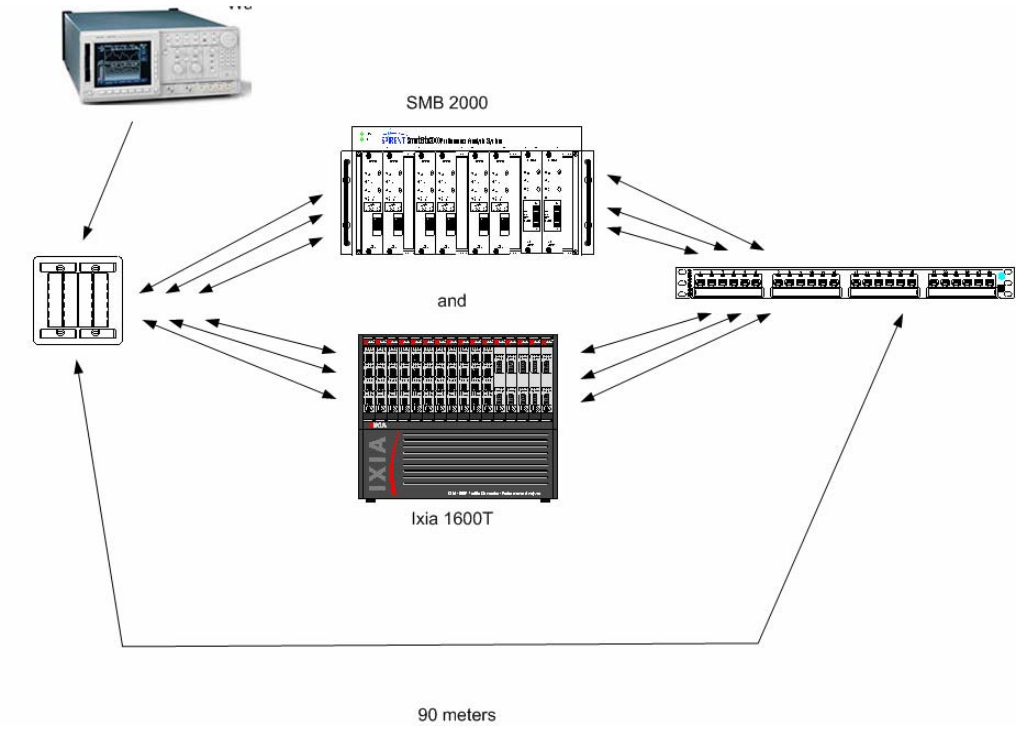
Tests 1-6 : Active Testing



Tests 7 & 8: Six Gigabit Ethernet, Weak Card Analysis



Tests 9-12: Three Gigabit Ethernet and Six Fast Ethernet, w/ Signal Generator.



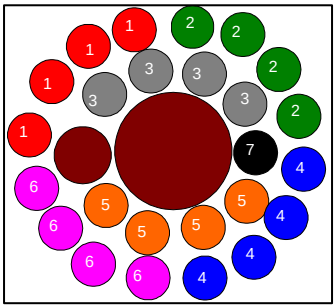
Tests Setup

The following tests were performed in this evaluation. The diagrams of the signal configurations and definitions of the method are defined further in this section. In all tests, twenty-four pairs in the cables were transmitting Ethernet traffic.

Table 1: 25 Twisted Pair Category 5e Tests Performed

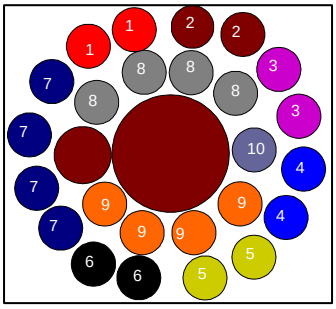
Test	Ethernet Signals		Cable	Method
	Gigabit	Fast Ethernet		
1	6	0	CMP	Active
2	3	6		
3	1	10		
4	6	0	CMR	
5	3	6		
6	1	10		
7	6	0	CMP	Weak Card
8	6	0	CMR	
9	3	6	CMP	Distorted Signal
10	3	6	CMR	
11	1	10	CMP	
12	1	10	CMR	

Figures 1-3 specify the placement of the GbE and FE connections for the tests in *Table 1*. A GbE signal is transmitted over 4 twisted pairs, while a FE signal is transmitted over two twisted pairs.



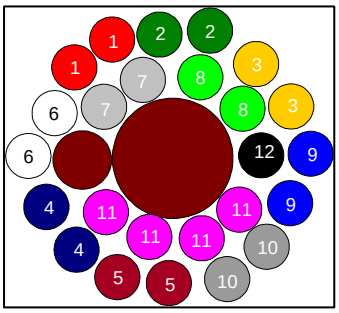
1-Gigabit Channel 1
2-Gigabit Channel 2
3-Gigabit Channel 3
4-Gigabit Channel 4
5-Gigabit Channel 5
6-Gigabit Channel 6
7-Unused Pair

Figure 1: 6 Gigabit Ethernet Configuration



1-Fast Ethernet Ch 1
2-Fast Ethernet Ch 2
3-Fast Ethernet Ch 3
4-Fast Ethernet Ch 4
5-Fast Ethernet Ch 5
6-Fast Ethernet Ch 6
7-Gigabit Channel 1
8-Gigabit Channel 2
9-Gigabit Channel 3
10-Unused twisted pair

Figure 2: 3 Gigabit Ethernet and 6 Fast Ethernet Configuration



1-Fast Ethernet Ch 1
2-Fast Ethernet Ch 2
3-Fast Ethernet Ch 3
4-Fast Ethernet Ch 4
5-Fast Ethernet Ch 5
6-Fast Ethernet Ch 6
7- Fast Ethernet Ch 7
8- Fast Ethernet Ch 8
9- Fast Ethernet Ch 9
10-Fast Ethernet Ch 10
11-Gigabit Channel 1
12-Unused twisted pair

Figure 3: 1Gigabit Ethernet and 10 Fast Ethernet Configuration

Active testing is performed by sending Gigabit Ethernet (1000BASE-T) and/or Fast Ethernet (100BASE-TX) traffic along all channels simultaneously. The Weak Card testing used Ethernet transceivers that have been characterized as weak to test individual channels. The remaining channels are active with signals from strong cards. The Distorted Signal testing carries a marginal Fast Ethernet signal from an Arbitrary Wave Generator over a channel to a SmartBits card. All remaining channels are active with Ethernet traffic.

Test Results

Tests 1 (CMP) & Test 4 (CMR): Gigabit Ethernet

Table 2: Test 1 (CMP) & Test 4 (CMR), Gigabit signals

Cable	CH	Uplink			Downlink			CRC Errors	Frag-ment
		Frames Sent	Frames Received	Frames Lost	Frames Sent	Frames Received	Frames Lost		
CMP	1	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	2	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	3	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	4	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	5	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	6	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
CMR	1	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	2	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	3	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	4	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	5	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	6	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0

GbE signals were distributed in the 25-pair cable as shown in *Figure 1*. Ten billion frames were transmitted simultaneously down each channel in both directions with no lost frames and no errors. The test was performed twice, with each channel connected to SmartBits for one test and IXIA for the second test. The results were the same for both equipment configurations.

Tests 2 (CMP) & Test 5 (CMR): Three Gigabit Ethernet and Six Fast Ethernet

Table 3: Test 2 (CMP) & Test 5 (CMR), 3 Gigabit and 6 Fast Ethernet signals

Cable	CH	Uplink			Downlink			CRC Errors	Frag-ment
		Frames Sent	Frames Received	Frames Lost	Frames Sent	Frames Received	Frames Lost		
CMP	1	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	2	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	3	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	4	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	5	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	6	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	7	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	8	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	9	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
CMR	1	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	2	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	3	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	4	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	5	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	6	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	7	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	8	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	9	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0

GbE and FE channels were distributed through the cable shown in *Figure 2*. Exactly ten billion GbE frames were transmitted down each channel in both directions with no frames lost and no errors. One billion frames were sent through the FE channels as well with the same result.

Tests 3 (CMP) & Test 6 (CMR): One Gigabit Ethernet and Ten Fast Ethernet

Table 4: Test 3 (CMP) & Test 6 (CMR), 1 Gigabit and 10 Fast Ethernet signals

Cable	CH	Uplink			Downlink			CRC Errors	Frag-ment
		Frames Sent	Frames Received	Frames Lost	Frames Sent	Frames Received	Frames Lost		
CMP	1	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	2	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	3	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	4	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	5	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	6	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	7	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	8	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	9	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	10	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	11	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
CMR	1	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	2	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	3	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	4	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	5	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	6	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	7	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	8	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	9	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	10	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	11	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0

GbE and FE channels were distributed through the cable as shown in *Figure 3*. Exactly ten billion frames were transmitted simultaneously down the one GbE channel in both

directions without any frames being dropped or erred. In addition, exactly one billion frames were sent along the ten FE channels. These channels also had no dropped frames and no errors.

Tests 7 (CMP) & Test 8 (CMR): Six Gigabit Ethernet, Weak Card Analysis

Table 5: Testing Rotation, Gigabit Ethernet and Fast Ethernet, CMP & CMR

Cable	Test #	Cards 1&3	Cards 6&8	Cards 11&13	Frames Tx and Rx	Frames Dropped	CRC Errors	Fragmented
CMP	1	2	3	1	10,000,000,000	0	0	0
	2	3	1	2	10,000,000,000	0	0	0
	3	1	2	3	10,000,000,000	0	0	0
	4	6	5	4	10,000,000,000	0	0	0
	5	5	4	6	10,000,000,000	0	0	0
	6	4	6	5	10,000,000,000	0	0	0
CMR	1	3	4	2	10,000,000,000	0	0	0
	2	4	2	3	10,000,000,000	0	1	0
	3	2	3	4	10,000,000,000	0	0	0
	4	5	6	1	10,000,000,000	0	0	0
	5	6	1	5	10,000,000,000	0	0	0
	6	1	5	6	10,000,000,000	0	0	0

Note: Numbers in the Cards columns indicate the channel connected to it as seen in Figure 1.

Six GbE channels were distributed through the cable as shown in *Figure 1*. Gigabit channels were tested, with 3 channels at a time connected to 3 pairs of SmartBits cards that have been characterized as weak cards. The other three channels were connected to IXIA. The channels were rotated on the SmartBits and IXIA cards. Exactly ten billion frames were transmitted simultaneously down the GbE channels in both directions with only one error. This error occurred on one of the stronger SmartBits cards.

Tests 9 (CMP) & Test 10 (CMR): Three Gigabit Ethernet and Six Fast Ethernet, with Signal Generator

Table 6: Test 9 (CMP) & Test 10 (CMR), Signal Generation, 3 GbE and 5 FE

Signal	CH	Uplink			Downlink			CRC Errors	Frag-ment
		Frames Sent	Frames Received	Frames Lost	Frames Sent	Frames Received	Frames Lost		
1	1	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	2	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	3	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	4	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	5	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	6	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	7	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	8	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	9	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
2	1	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	2	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	3	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	4	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	5	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	6	1,000,000,000	1,000,000,000	0	1,000,000,000	1,000,000,000	0	0	0
	7	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	8	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0
	9	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0

GbE and FE channels were distributed through the cable depicted in *Figure 2*. Exactly ten billion GbE frames were transmitted down each channel in both directions with no

frames being lost or erred. One billion frames were sent through the FE channels as well. Five FE channels had IXIA generated traffic on them. The sixth channel was connected to the waveform generator sending a controlled weak or distorting valid Ethernet signal on one end of the channel and a SmartBits card on the other end. No errors could be generated even though many different weak or distorting signals were used. The results of the two most distorted signals are in the following table.

Note: Descriptions of signals are located with test equipment.

Tests 11 (CMP) & Test 12 (CMR): One Gigabit Ethernet and Ten Fast Ethernet, with Signal Generator

Table 7: Test 11 (CMP) & Test 12 (CMR), Signal Generation, 1 GbE & 10 FE

Signal	CH	Uplink			Downlink			CRC Errors	Frag-ment
		Frames Sent	Frames Received	Frames Lost	Frames Sent	Frames Received	Frames Lost		
1	1	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	2	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	1	0
	3	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	4	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	5	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	6	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	7	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	8	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	9	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	10	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	11	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	1	0
2	1	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	2	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	3	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	4	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	5	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	6	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	7	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	8	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	9	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	10	1,000,000,000	1,000,000,000	0	10,000,000,000	1,000,000,000	0	0	0
	11	10,000,000,000	10,000,000,000	0	10,000,000,000	10,000,000,000	0	0	0

This tests is the same as the above three Giagabit Ethernet and six FE tests, with the channels of nine FE, one Gigabit, and one channel with a generated signal. One error was detected, a CRC error. This error is most likely a random error and has nothing to do with the generated signal.

Conclusion

It is clear from the data presented in this report, that the Berk-Tek 25-pair 5e cable is capable of reliable Gigabit Ethernet transmission, while other Gigabit Ethernet or Fast Ethernet applications are operating on other pairs within the same cable. Even when the cable is used with a weak transceiver or a stressed transmit signal, the performance of Gigabit Ethernet is better than IEEE 802.3 1000BASE-T BER objectives.

Table 8: Definitions of Acronyms	
Abbreviation	**Description**
CMP	Communications Plenum
CMR	Communications Riser
GbE	Gigabit Ethernet
FE	Fast Ethernet

Data Communications Competence Center

Nexans' Data Communications Competence Center, located at the Berk-Tek Headquarters in New Holland, Pennsylvania, focuses on advanced product design, applications and materials development for networking and data communication cabling solutions. The Advanced Design and Applications team uses state-of-the-art, proprietary testing and modeling tools to translate emerging network requirements into new cabling solutions. The Advanced Materials Development and Advanced Manufacturing Processes teams utilize sophisticated analytical capabilities that facilitate the design of superior materials and processes. The Standardization and Technology group analyzes leading edge and emerging technologies and coordinates data communication standardization efforts to continuously refine Nexans' Technology Roadmap. An international team of experts in the fields of cable, connectors, materials, networking, standards, communications and testing supports the competence center. The competence center laboratories are a part of an extensive global R&D network that includes eight competence centers, four application centers and two research centers dedicated to advanced technologies and materials research.