Test Summary

This test report outlines the performance of category 5e, category 6 and enhanced category 6 cabling when transmitting Gigabit Ethernet signals under conditions of elevated temperature.

Background

Structured cabling is often installed in plenum spaces above suspended ceilings, on the highest floor of a building, in portable classrooms and on factory floors. The temperature of these places can vary greatly depending on building design, location, HVAC efficiency, and time of day. They may experience extreme temperature fluctuations over a period of time. In some of these common applications, the temperatures can be as high as 70 C. It is not uncommon over the course of a day for the temperature in some industrial settings to rise and fall as much as 25 C (45^0 F).

To analyze the influence of temperature fluctuations on Gigabit Ethernet (1000BASE-T) performance, the competence center conducted a series of experiments where 1000BASE-T signals were transmitted over the cabling system as the temperature was varied from 20 C to 70 C in 10 degree increments. Bit Error Rate (BER) was measured while the cable temperature was rising (e.g. 40^0C to 50^0C) as well as during a "soak period."

Test Setup

Figure 1 shows the elevated temperature test setup.

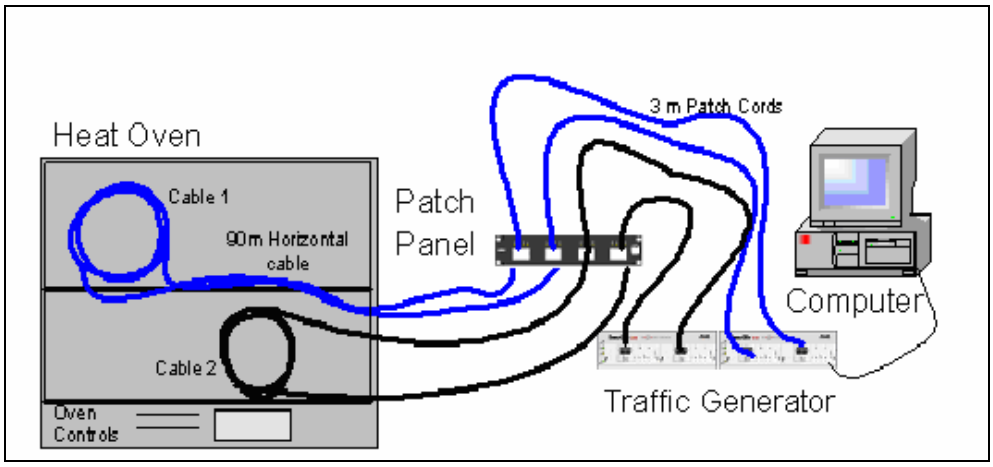

Figure 1: Elevated Temperature Test Setup

Test Hardware consisted of the following:

- Traffic Generator with Gigabit Ethernet (1000BASE-T) modules
  - 1518 bits, continuous, full duplex
- Handheld Tester, CHAN 5/5e/6 Adapter
- 90 meter, 2 connector cabling channel
  - CAT5e – Berk-Tek LANmark-350 and HyperPlus 5e cable with Ortronics CAT 5e connecting hardware
  - CAT6 - Berk-Tek LANmark-1000 cable with Ortronics GigaMo+ connecting hardware
  - CAT6e – Berk-Tek LANmark-2000 cable with Ortronics GigaMo+ connecting hardware

A 90 m sample of each cable was spooled onto a wooden reel. The capacity of the oven allowed for two cable reels to be tested concurrently. Both ends of each cable sample exited the oven through a 2" hole on the side. Each end of the horizontal cable was terminated to a patch panel port. Two patch cords were connected between the patch panel ports and the Traffic Generator.

The following temperatures were used during testing:

- Baseline settings under room-temperature conditions: 20-25 C
- Elevated settings: varied from 30 to 70 C

Tests were allowed to run for at least four hours until the temperature of the cable was considered stable. The number of dropped or erred frames was monitored during the investigation.

Test Results

Prior to active testing, the channels were tested for conformance to the requirements of ANSI/EIA/TIA-568-B.2 and ANSI/EIA/TIA-568-B.2-1 using a hand-held field tester at each temperature. The results were adjusted for temperature per the requirements of ANSI/EIA/TIA-568-B.2. All cables passed the applicable transmission requirements.

Detailed in Figure 2 are the resulting CRC errors at each temperature for all cable types.

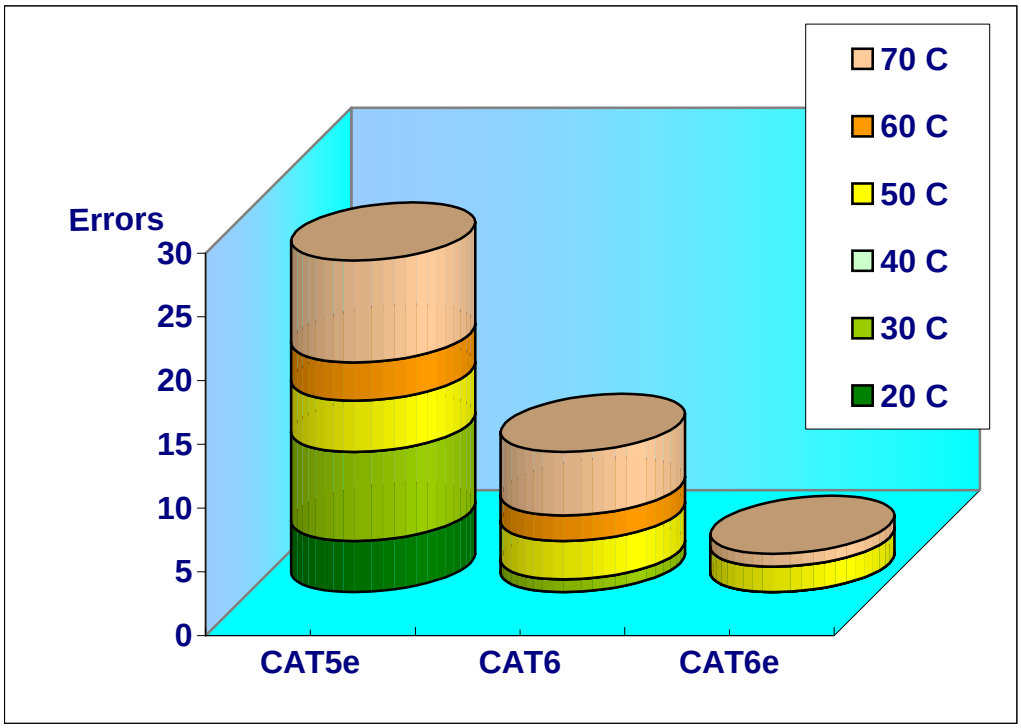

Figure 2: CRC Errors at Elevated Temperatures for CAT5e, CAT6 and CAT6e

The results of the tests show that there was a significantly higher occurrence of CRC errors at higher temperatures using category 5e cabling as compared to category 6. There was a further significant reduction in the number of errors when an enhanced category 6 cabling system was tested.

For category 5e cabling, 42% of the errors occurred below 50 C compared to 9% for category 6 and 0% for enhanced category 6. Above 50 C, there was an increase in errors for all cable types, with category 5e generating the greatest number.

Figure 3 shows the temperature and error progression over time.

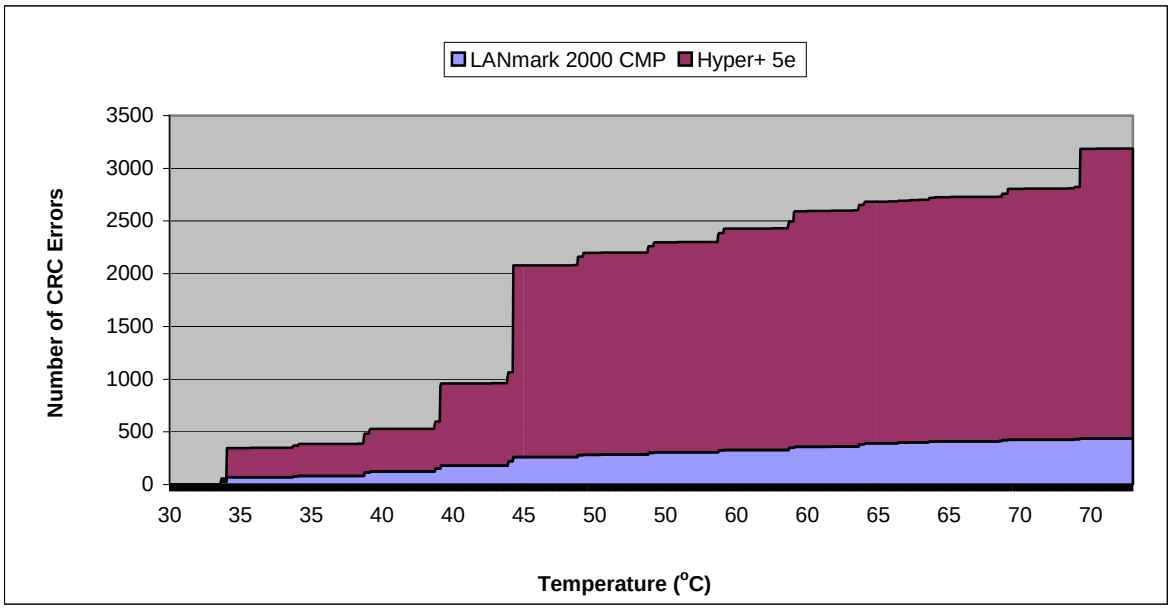

Figure 3: Progression of Errors as Temperature rises over a 24-hour Period

What is evident from Figure 3 is that as the temperature is changed, errors are created, but over a short period of time, the adaptive equalization of the Gigabit Ethernet transceivers allows the system to stabilize.

Observations & Conclusions

The performance of active network equipment, such as network interface cards (NICs) and switches is directly related to the signal-to-noise ratio of the data being transmitted over the network. These experiments illustrate the major influence temperature can have as a source of environmental disturbance on the system.

The data presented in this report shows that higher performance cabling systems such as category 6 and enhanced category 6 are less affected by temperature fluctuations. This allows for a stronger, less distorted signal to flow through the cable, regardless of the stress being exerted on it by the temperature variation.

A number of the CRC errors observed in these trials were a direct result of the inability of the Gigabit Ethernet transceivers to continue to maintain a link due to the increase in cable attenuation. The cards are forced to renegotiate through the adaptive equalization process to stabilize the network. Figure 3 clearly shows that enhanced category 6 cabling is vastly superior to category 5e cabling in regards to allowing the Gigabit Ethernet electronics to operate more reliably when temperature conditions are varying over time as is the case in many, real world situations.

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.