FLUKE®

Putting residential cabling to the test

Application Note

In the workplace environment, we expect high-speed commercial cabling for data and voice-intensive applications. The growing adoption of broadband Internet access, telecommuting, and the emergence of high-speed home automation applications that control voice, audio/video, and security, are driving the residential market to demand data rate carrying capabilities and Quality of Service (QoS) equal, in many respects, to the commercial sector. The Telecommunications Industry Association (TIA) notes, "The trends of the past and the predictions for the future indicate that data rates have been doubling every 18 months." They observe as well that new applications such as streaming media will take advantage of these data rates, affording new capabilities for the residential homeowner. How do you take advantage of today's capabilities, and how do you ensure your home network will be able to take advantage of applications in the near future? For new residential construction, and most retrofit home networks, this means an Ethernet-based structured cabling system comparable to a medium-sized business installation of only a few years ago.

Structured cabling in the form of unshielded twisted pair (UTP) cabling is the preferred choice for 60 percent of home networks, according to InStat/MDR. Home networks may also mix structured cabling with other existing cabling such as phone lines (Home Phoneline Networking Alliance www.homepna.org) or power lines (Homeplug Powerline Alliance www.homeplug.org), using converters to move data from standard Ethernet to formats that fit the particular media. Wireless networks (which in fact take an extensive amount of wire!) constitute well over one-third of home network installations, and accommodate a laptop on the back patio, or link to a handheld tablet that might allow e-mail browsing and lighting control while sipping coffee in the kitchen.

Homeowners expect multiple pre-wired jacks for high-speed data networks, telephone, and cable TV. Commercial structured cabling manufacturers have jumped on the bandwagon to provide a comprehensive product line from cable to distribution equipment and now electrical contractors and installers of commercial cabling systems are in demand to specify, install, and test residential cabling systems to assure that they meet today's networking demands and comply with evolving standards.

Emergence of residential cabling standards

In discussing residential cabling, it is helpful to understand the recent historical actions that have resulted in today's standards. The best place to start is with the FCC's (Federal Communications Commission) Telecommunications Act of 1996. This Act was the first major overhaul of telecommunications law in almost 62 years. The goal of the Act was to deregulate telecommunications, increasing competition among telecommunications service providers to create a free market environment. With deregulation, it didn't matter who brought the cable from the street into your home, as the consumer had a choice of carriers. The same deregulated situation exists for interior wiring, as well. However, to carry data efficiently, there are now guidelines and regulations for wiring standards being set within the walls of the home.

In late 1999, the TIA/EIA published the ANSI/TIA/EIA-570-A Standards for Residential Telecommunications Cabling, which encompasses product performance specifications, installation practices, and testing. It is derived from the ANSI/TIA/EIA-568A Commercial Building Cabling Standard as well as the ANSI/TIA/EIA-569-A Standard for Commercial Building Pathways and ANSI/TIA/EIA-758 for Customer-Owned Outside Plant Cabling Standards. TIA/EIA-570-A attempts to standardize the requirements for new construction, additions, and remodeled single and multi-tenant residential buildings in the realm of telecommunication services. This includes more applications than the TIA/EIA-568A Standard for Commercial Buildings addresses, as the TIA/EIA-570-A Standard includes guidelines for installation of voice, data, video, multimedia, home automation, security, alarms, and home automation systems.

In December 1999, the FCC adopted the TIA/EIA-570-A and BICSI standards under their "Third Report and Order," which concentrates on the connection of residential inside wiring to the telephone network, establishing minimum inside wiring quality standards. Many industry watchers predict that these inside wiring quality standards will be included into local building codes, facilitating enforcement by causing simple inside wiring installations to be subject to the same inspection and approval process as electrical wiring.

Residential cable types specified in TIA/EIA-570-A include Category 3 UTP for voice, Category 5e UTP for data (and voice) and RG-6 coaxial cable for audio and video signals. Additional media, such as 2-wire 12-16 AWG, are also introduced in three addenda that were also published for whole-home audio, control systems and security. The standard refers to fiber optic cabling as an option for residential installations as well. Often these cables are co-bundled, to be pulled in tandem during installation.

Making the grade

TIA/EIA-570-A identifies two different types of residential cabling installation "pull" schemes to a faceplate outlet, Grade 1 and Grade 2. Grade 1 is a basic system that is adequate for telephone, television, and data. It includes one 4-pair UTP cable that meets Category 3 performance requirements and one RG-6, 75-ohm coaxial cable (also know as Series 6). The 570-A standard recommends Category 5 cable in place of Category 3 to facilitate upgrading to a Grade 2 installation.

Grade 2 residential installations accommodate bandwidth intensive multimedia applications. Grade 2 specifies two UTP cables, minimally Category 5, with Category 5e (a higher performance Category 5) cabling recommended. It also recommends two RG-6, 75-ohm coaxial cables, and references two fiber cables as an optional addition.

Residential/commercial similarities and differences

The difference between residential networks and large office networks include types of cables and applications, however this difference is narrowing. One of the highest performance UTP cabling types used commercially is Category 6 (Cat. 6). While the current TIA standard for residential cabling calls out lower bandwidth Category 5 or Category 5e cable, the TIA has most recently stated in a Q&A on their website (2002) that "Category 6 will be very effective in the residential market to support higher Internet access speeds while facilitating the more stringent Class B EMC requirements." You can anticipate seeing Category 6 cabling as a recommended alternative in the residential specifications sometime in the future.

Certain standards for commercial buildings may be appropriate for multi-dwelling housing, such as an apartment complex, but are overkill for single unit residential environments. Other commercial standards are directly applicable to residential installations. Maximum cable span lengths for commercial buildings are 90 meters for a link and 100 meters for a channel, but an average residential structured wiring network cable does not typically encompass that distance in a star configuration, possibly mitigating the need for some of the more esoteric tests for quality and performance as required in commercial testing. With that said, commercial standards that describe the testing procedures that evaluate the quality of a residential network installation are currently the only, and best, touchstone to measure the performance and reliability of installed cable and its connections.

Whether it is a home, office, or apartment, the common denominator for success is the quality of the pre-wiring and efficiency of the cabling infrastructure design. Today's cabling infrastructure designer must anticipate all the possible applications that could use the cable infrastructure, including applications not yet available, in order to future-proof the installation in the pre-wiring stage. Commercial cabling installation designers have been successful at creating flexible, future-proof cabling infrastructures. How future proof should you be? Some professional groups suggest designing for 15 years of service at increasing data rates. To accomplish this goal, professionally pre-wired residential installations emulate many of the practices of commercial structured cabling systems, such as utilizing patch panels versus punch-down wiring blocks for simple plug-and-play capability. Residential installations may also use in-home products that are derivations of a manufacturer's high-density, high-performance commercial products.

Testing — the key to residential system reliability

In commercial cabling, standards are solidly in place for performance testing of structured cabling systems. Business systems place high demands on installed cabling, and it is prudent to inspect the quality of the cable installation for proper performance. Such commercial networks are 'certified' to meet standards, whereas, in contrast, most residential cabling systems have been simply verified. Verification follows the basic cable procedures and installation practices, which include cable placement, cable stress, cable protection, and proper connections to ensure continuity.

With the convergence of residential and commercial requirements in bandwidth, QoS, materials, and components, today's high performance residential networks must now be installed with a commercial-like level of care, and many professional organizations recommend that they be performance tested and certified in the same manner envisioned for commercial installations. To meet TIA's installation recommendation of using Category 6 cabling in the residence, performance testing is highly recommended. Manufacturers of commercial field testers, such as Fluke Networks (www.flukenetworks.com), address the need to evaluate the performance of cable installations in both commercial and residential environments.

Certification is much more stringent than verification, as it refers to specified measurements that must be compared and meet pre-defined industry standards. As an example, to certify a Category 5e cable, thousands of measurements are taken and processed in complex formulas to derive a pass/fail result. Some of these measurements result in testing crosstalk, far end crosstalk, wire mapping, length, delay, skew, and return loss. These tests help determine the information carrying capacity of the cable installation. Most professional test equipment has the ability to log the test results for a specific cable, and print out a report that serves as proof of compliance. These certification reports should be provided by the installation professional to the customer prior to signing over a residential structured cabling installation.

The TIA/EIA-570-A standard for residential cabling installation includes normative field test requirements of the cabling. Backbone cabling testing includes a continuity test and testing for miswiring, such as shorts, crossed pairs, reversed pairs, and split pairs. The specific tests for the UTP cable and outlets include wire mapping, length, attenuation, and near-end crosstalk. Additional field tests where Category 5e is installed include power sum near-end crosstalk loss, power sum equal level far-end crosstalk and return loss.

Figure 2. New field testers have been developed to fit the price and work model of residential installers and electrical contractors.

In verifying residential cabling, the most important measurement or diagnostic function is wiremap. Wiremap ensures proper pin-to-pin connectivity between both ends of the link. In a home, a nail or staple could cut or short a cable, or the cable could be incorrectly terminated or miswired. A good wiremap tester will find the existence and location of any breaks, shorts, or miswires to help the installer identify and fix the problem quickly. For residential installations, a complete verification report to the customer, like a certification report, is the mark of a professional installation.

It is important to note that verification does not attempt to measure the information-carrying capacity of the link. In the past, verification was assumed to be solely adequate for residential cabling installations because residential cabling links are considerably shorter than commercial cabling links and therefore do not suffer nearly as much from attenuation losses. With larger residential

installations, high bandwidth guzzling audio/video entertainment applications on the horizon, and even higher ones envisioned in the future, this assumption is no longer safe. Certification is not a substitute for verification, either. Installation teams perform verification prior to certification testing. Defects are found in the cable installation at a far earlier point in the project, where they are less costly to repair than when the final certification testing occurs.

Trained professionals – the key to quality testing

While certification testing is now a highly automated process, the quality of training needed to install a high-performance residential structured cabling system is still extensive and not recommended for the weekend remodeler. Additionally, the interpretation of a certification failure, and the troubleshooting of the cable, connector, or punch down, requires experience and training. Fortunately, professional installers are taking advantage of extensive training opportunities through professional organizations such as IBEW, CEDIA, BICSI, and Cisco Learning Institute. After training, professionals will demonstrate their competency through passing a certifying exam such as COMPTIA's HTI+ certification.

Conclusion

Any investment should be judged by its quality and longevity to minimize risk of loss, and a residential structured cabling system is an investment. A residential structured cabling system solution should be chosen, installed and tested to minimize not just the installation cost, but the far greater replacement cost in the finished home. Using a trained, certified professional for installation, demanding the highest performance materials available, and testing the quality of the installation to the highest possible standards involve incremental costs over less expensive alternatives, but also pay big dividends over the life of the home network.

Note:

In the U.S., the FCC has published 99-405, effective July 2000. It says in part:

"For new installations and modifications to existing installations, copper conductors shall be, at a minimum, solid, 24 gauge or larger, twisted pairs that comply with the electrical specifications for Category 3, as defined in the ANSI EIA/TIA Building Wiring Standards.

All wire and connectors ... shall be marked, in a manner visible to the consumer, with the symbol "CAT 3" or a symbol consisting of a "C" with a "3" contained within the "C" character, at intervals not to exceed one foot (12 inches) along the length of the wire."

So in essence 99-405 says that all residential cabling must, at a minimum, meet Category 3 requirements. This is not a recommendation or a suggested practice. In the U.S., this is the law!

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