

How do I Install Structured Wiring

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WHY STRUCTURED WIRING?

Wire is cheap. Opening walls is expensive. It is best to put in ten times the amount of wire that you will use at any one time. This provides the capacity and flexibility for the future needs of your home.

If you buy into that concept, then structured wiring makes sense for you.

WHAT IS STRUCTURED WIRING?

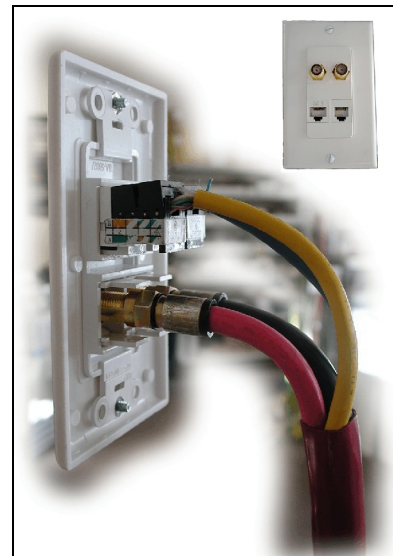
Structured wiring is a method of providing the communications infrastructure of your home in a well organized, easy to understand, and thorough way to provide a general solution to your present and future needs. Rather than run a coax here, and a Cat 5 there, and another coax somewhere else as you guess at the future needs, the structured approach is to consistently run a full bundle of wire to every significant room. The full structured bundle consists of two 4-pair Cat 5 cables and two coax cables (usually quad shield RG-6), and optionally two multi-mode optical fibers. There are other structures, but this is the configuration that has overwhelmingly become the standard.



WHY THE 2+2 STRUCTURE?

The two coax cables provide a down stream and an upstream signal path. You can get everything you want down a single coax including cable channels, satellite signals, and your own closed circuit channels for your front porch, front yard, and back yard cameras. The upstream cable is used to carry additional closed circuit channels, such as a baby crib camera, or a VCR feed to your video distribution hub so that any TV in the house can tune to these feeds.

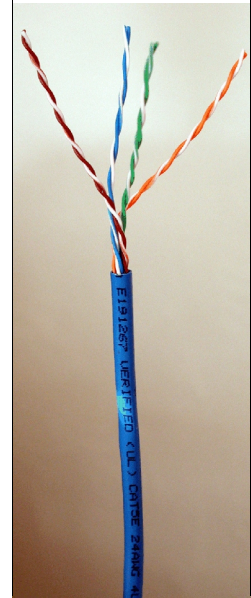
The two Cat 5e cables are for telecommunications and networking. The term Cat 5 refers to an industry standard for twisted pair cable construction which is capable of supporting data speeds of up to 100 Megabits per second (MB/S). This is the highest speed normally used in small office and residential applications. The most popular configuration for Cat 5 cables is four pairs, or a total of eight conductors. With two of these



cables in the 2+2 structured cable, there are a total of eight pairs available for carrying telecommunication or networking signals. This is way more than is normally needed, but since the cost of including extra pairs is low, the convenience in organization that is provided by this arrangement makes it the configuration of choice.

It takes more than just quality Cat 5 wire to make computer networks achieve speeds of 10 or 100 MB/S and beyond. The connectors must be rated at Cat 5, and the patch cables used to go from wall outlets to network equipment must also be Cat 5 rated. In addition, the connectors must be carefully attached to make sure the twist in the wire is maintained to within a half inch of where it is punched down into the connector. There can be no splits or Tees in the Cat 5 path between an active network hub and the terminal equipment.

Because of the strict rules that apply to Cat 5 network transmission lines, most installers will allocate one of the Cat 5 cables in a structured cable to network use, and allocate the other to telecommunications and control applications. Since telephones and network signals provided by your telephone company, including DSL, operate at frequencies much lower in the spectrum than Ethernet networks, you can bridge telephone lines, use Tees, and attach multiple extensions without a strict observance of the rules needed for high frequency data transmission. Installation and maintenance is greatly simplified by allocating one Cat 5 cable to networking and the other to everything else. With four pair in each cable, there are plenty of signal paths for either application.



Cat 5e Wire

IS THE 2+2+2 STRUCTURE BETTER

In addition to two Coax, and two Cat 5 cables, many home owners install two optical fiber runs. This is often referred to as the 2+2+2 structure.

There are differing opinions on the need for fiber in the house. The argument for adding fiber is that the potential bandwidth is much greater than twisted pair, and it is relatively inexpensive. People see fiber used at work and are convinced that it is just a matter of time before it is needed for residential networks. The most typical argument against installing fiber is that the market is quite void in residential products that use fiber – particularly the type of fiber that is standard for residential use. At the present time, the established standard for residential optical fiber is Multimode 65 micron with a 120 micron sheath. The connectors used are type ST. Some people in the industry believe that a different standard will evolve before fiber products for residential applications become readily available on the market.

To add to the confusion, people see fiber service being provided to the house by service providers in places like Palo Alto, California. There is even a standard acronym used in trade journals: FTTH for Fiber To The House. FTTH would appear as proof positive that fiber is needed in the house. It is not necessarily so. Where FTTH service is available, once the fiber enters the house

from the street, the first place it goes is into a fiber modem where the signal is converted to 10BaseT or 100BaseT Ethernet. It is then transported through the home network on twisted pair copper Cat 5 cables.

The argument has existed for a number of years where the proponents feel that copper will not provide enough bandwidth for future applications. During those same years, new designs of networking equipment have steadily pushed the upper limit of copper ahead of practical needs. The outcome so far has been that the much lower cost of twisted pair copper equipment continues to rule the market. You might say, "Why then is fiber used for networks at work?" A big reason is that twisted pair Ethernet solutions, 10BaseT and 100BaseT are by specification limited to a distance between terminal equipment of 90 meters (approximately 300 feet.) That distance limitation can be a problem in large buildings and industrial campuses, but is rarely a limitation at the residential level.

At HomeTech Solutions, around fifty percent of the structured cable sold contains fiber. When customers look at the added cost of including fiber in the cable, they often decide they don't want to worry about whether or not it will be needed, so they include it. It typically adds less than \$400 to an installation provided it is left dark and stowed in the wall with no connectors attached. Terminating fiber is a costly process that is labor and tool intensive. If fiber becomes needed, it can be terminated later if it is included in the cable.

ORGANIZATION IS THE KEY TO SUCCESS

If you are going to put in ten times the amount of wire that you will use at any one time, then it is important that you organize it so you can find and connect the ten percent that you need at any point in the life of the house. Structured cable is a big start in that direction. It provides uniformity and completeness. The next step is to have a central "Head End" panel where cables are terminated and organized in a patch panel where they are easy to identify and understand as the years roll on.

In recent years the market place has exploded with new offerings of structured wiring products. Most of the new companies are focusing on low cost and providing the perception of giving the best bang for the buck. All of the offerings that I have seen get the basic job done from a technical standpoint. The big difference between the best and the worst is the visual organization of the head end panel. At the top end is Future Smart Networks with a very easy to understand, visually well organized, and functionally complete line of Pro and SuperPro series of panels. At the bottom of the stack are cabinets with plywood backs where you can screw on your own collection of punch down blocks, video splitters, amplifiers, and the like. The difference in cost from the best to the worst is typically a few hundred dollars for a given level of functionality. In deciding what is best for you, we recommend you consider the ten year test. When you look at the panel you are considering, do you think that ten years after installation, you or the occupants of the house then will be able to easily figure out how to reconfigure or modify the panel? If your answer is yes, then you have selected a good panel. If it is "maybe" or "I'm not sure," then I suggest you seriously consider getting a better organized panel. The relatively small difference in cost up front will make a big difference in practical utility through the years in the future. A panel

that is difficult to understand is usually left alone in future years rather than being regularly reconfigured to keep up with the changing needs of the family.

MAKING YOUR PLAN

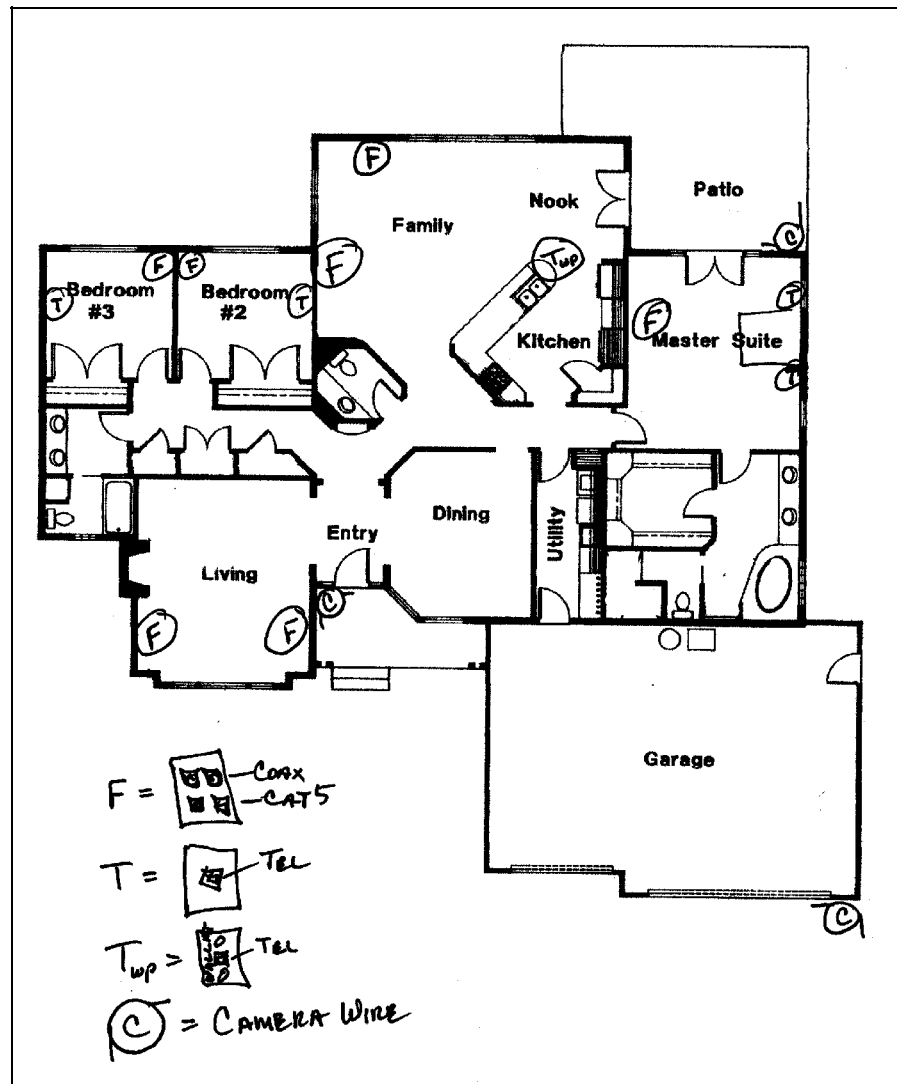
Making a plan is easy and usually takes about an hour. Here are step by step instructions.

1. Get a simple floor plan of your house which shows the walls, doors, windows, and names of the rooms. I like "A" size floor plans (8½ x 11 inch).
2. Get a soft lead pencil and a soft eraser so you can change your marks easily.
3. The symbols I use for marking the drawing are the following:
 "F" is for Full structure with two Cat 5, two Coax, and optionally two fibers.
 "T" is for a single run of Cat 5 cable.
 "C" is for a single Coax. With the subscript "Cam" it also includes two conductors for camera power.
4. Mark the positions of each type of wall outlet.
5. Make a list of the requirements to match the marks you put on the drawing.
6. Prepare the list of materials.

We will go through these steps one at a time.

Marking the Floor Plan

On the floor plan, mark the locations of each of the low voltage service locations. In the Master Bedroom, it is customary to place a full service plate where the entertainment equipment is to be located, and a telephone jack on each side of the bed headboard. The reason for the two telephone



Floor plan marked with low voltage service outlet locations.

jacks is to provide for separate phones or automation controls on each side of the bed. This can be particularly useful if an automated telephone switch (PBX) is installed at the head end.

In the other bedrooms, a full service plate is installed to support a study or entertainment center, and a telephone jack is located behind the headboard of the bed.

In the kitchen, if there is a bill paying desk or location where a computer or TV might be located, it is recommended that a full plate be provided.

Cameras are usually located at the front door, the parking area in front of the garage, and in the back yard. The cameras will be modulated on to private closed circuit channels that can be viewed by any TV in the house.

List of Requirements

The next step is to make a list of requirements.

In our example, seven zones are required. A zone is normally consists of a full structured cable plate and usually one or more related single runs of Cat 5 and coax.

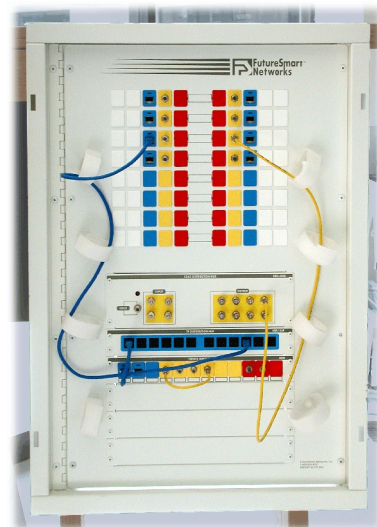
Besides the seven full 2+2 runs, there are there are four phone jacks, a wall phone mount, and three cameras. Individual Cat 5e cable and camera cable consisting of a coax and two stranded conductors will be run to those places.

Listing the Material

The next step is to select the material for the project. The Future Smart Pro 8 panel is a good fit for this application. It has eight zones, so there is adequate capacity. It also has space in each zone for the ancillary items like phone jacks and cameras.

The following is a list of materials that will fulfill this installation.

REQUIREMENTS			
	(F)	(T)	(C)
MASTER BR	1	2	
BR# 2	1	1	
BR# 3	1	1	
LIV RM	2		
FAMILY RM	2		
KITCHEN			1wp
ENTRY			1
GARAGE			1
PATIO			1
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Stock No	Item	Quantity	Notes
P08	P08 Futuresmart Pro Panel (Loaded to 4 zones)	1 each	The Future Smart Pro series comes standard only half of the zones filled with connectors. The additional MLCN and ML5N provide three additional zones plus connectors for additional phone and camera locations
MLCN	Panel Coax Inserts	9 each	
ML5N	Panel Cat 5e Inserts	11 each	
FT1RJ-5C	Structured Cable with 2 each Cat 5e and 2 each RG6 Quad Shield Coax (500 ft spool)	500 ft spool	
1583A	Cat 5e 4-Pair cable	1000 ft spool	
98132	Camera Cable. RG59 coax and 2 each 18AWG Stranded wire	500 ft spool	
MVQ	Satellite Grade RG6 Cable	500 ft spool	For dish antenna and UHF/VHF feeds from the roof.
MP1S	Mud Rings (single gang)	12 each	Mud rings are backless electrical boxes used to mount low voltage connector plates.
410804WP	4 port Quick Port wall plate	7 each	These parts will make up the following: 7 each Full plates (1 Cat 5 connector, 1 telephone connector, and two coax connectors. 4 each telephone jacks. 1 each phone wall mount jack
410801WP	1 port Quick Port wall plate	4 each	
41108RW5	Cat 5 QuickPort jacks	7 each	
41106RW	Voice grade QuickPort telephone jacks	11 each	
40831BW	Coax F Connectors - QuickPort	14 each	
40223	Phone wall mount jack	1 each	
SPL6Q	Compression Crimp Coax Connectors for RG6 Quad Shield	50 each	

Purchasing the Materials

My recommendation is buy only what you need for the next few days of installation work. The construction environment is hectic, and things that are not installed and secure have a way of disappearing. Small parts, bags, and partially filled boxes are often thrown out with the continuous straightening up and cleaning up that goes on when construction is taking place. Buying everything up front often ends up in buying much of it twice.

The only items needed during rough-in are the wire and the mud rings. The rest of the items are installed after the sheet rock is in place and painted.

All of the items in our list are normally in stock, but to be sure you won't be delayed, it is a good idea to place an order about a week before the items are needed.

PRE-WIRE INSTALLATION

Doing the Pre-Wire

Both Cat 5 wire and coaxial cable need special care during installation. Cat 5 wire is manufactured to very tight dimensional tolerances. So is coaxial cable. These cables are designed to work at very high frequencies. Take care to make sure they are not physically damaged during installation. Do not use metal staples or holding devices that will dent or deform the cable. Minimize the pulling tension to avoid physically damaging the shape of the cable.

Low voltage signal cables are normally installed after the electricians have finished roughing-in the power wiring. That is so the low voltage installer can avoid running signal wires next to power wires. Run the signal wires at least one stud cavity away from the power wires.

Locate the Mud Rings

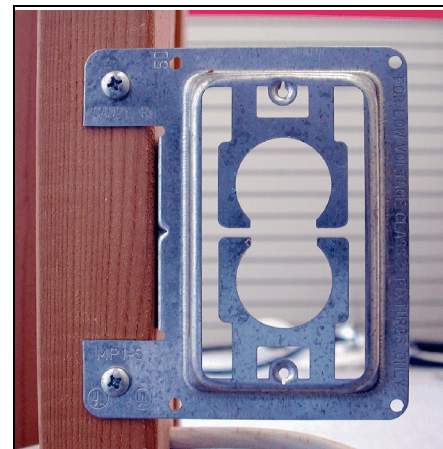
The first pre-wire step is to locate the mud rings. The mud rings are used for new construction when the framing is complete. Mud rings are essentially backless boxes that provide a mounting for the connector plates. When the sheet rock goes up, the installers fill in the small space between the mud ring and the sheet rock with joint compound. This compound is often referred to as mud, hence the name "mud ring."

Position the mud rings in locations that will be convenient for their use. They are normally mounted at the same level as the power outlets serving the same equipment. It is wise to locate them a minimum of several inches away from power outlets and power wires to avoid any electrical noise coupling.

The mud rings can be attached with nails or screws. Although they appear to be flimsy at this point, once the sheet rock is installed and mudded in, they will be quite secure.

Route the Wire

Once the mud rings are all installed, you can now select the routing for your structured cable and other communication wires. Find routes that avoid close parallel runs next to power wires. When



Mud Ring Installed On Stud

your structured cable must cross a power cable, route it at right angles where it crosses. Avoid kinking the wire or in any way deforming its shape. The wire is designed to be installed in normal residential constructions, so turn radiuses needed to go into standard stud cavities are fine. Most of the guidelines and standards written on installing Category 5 cable and coaxial cable place emphasis on maintaining large separations from power wires. You may see guidelines that state minimums of 16 inches. I have found that these guidelines are based on very worst case conditions. It makes sense to take advantage of space when it is available. If you find you are stuck with having to run parallel to power lines for several feet, don't lose sleep over it. It is very doubtful that the combination of the power line noise along with the sensitivity of the communications equipment attached to your structured cable will result in any coupling effect you will be able to detect. When you are forced into a parallel run, do your best to separate the low voltage cables from the power cables. When running in close proximity, every inch of separation makes a significant difference in the likelihood of electrical noise coupling.

It is usually easiest to route your cables from the mud ring straight up or down into either the attic space or the crawl space, and then secure them to joists or rafters with "J" hooks or other wire supports that gently hold the wire. When drilling through studs, for structured wire, use a 3/4 inch drill and center the hole in the stud. This will provide one inch of wood on between the edge of a two-by-four and the cable. If the sheet rock installer uses right type of screws, they will penetrate the wood less than one inch, so your wire is safe. If you want an extra margin of safety, install nail plates on the two-by-fours where the wire is located. These are hard metal plates that prevent the penetration of screws or nails into the area where your wire is routed.

In attic spaces, many professional installers follow the practice of hanging the cables high in the rafter space rather than routing them along ceiling joists. This is to avoid the possibility of workmen stepping on the cables or otherwise damaging them during installation or maintenance work in the attic.

Service Loops

At the mud ring, provide a service loop of at least two feet. Tuck the loop in the stud cavity so that after the sheet rock has been installed you can pull out the service loop. You will find that a generous service loop will make attaching the specialized connectors and trimming out the wall plate much easier than if you are working with short wires. It also gives you a second chance if you make a mistake while applying a connector.



Mud Ring with Structured Cable. (Note that the cable needs yet to be secured.)

At the head end panel, allow a very generous service loop. I recommend allowing enough wire to provide a full "U" from the entry into the panel around the inside of the panel and back to panel entry point. This will facilitate good organization of your wire when you are trimming out your panel. It is good to arrange the entry of the wire into the head end panel in such a way that you

can push excess wire back into a storage location such as the crawl space or the attic area where it is out of sight and protected. This allows you to dress the cables in the panel in a neat and tidy way, and yet still have an extra service loop tucked away out of sight to allow for reconfiguring at a later point in time if ever needed.

Completing the Pre-Wire

Before you leave the pre-wire job, do the following.

1. Place a cable identification tag on both ends of each wire so you can identify the cables at trim out time.
2. Check your original plan one last time to make sure you installed everything you intended.
3. If you like to work with clean cables at trim-out time, cover the ends of the cables with a stretch wrap material. A roll of plastic sandwich wrap works fine. When the sheet rock installers and painters have finished their work, you can pull off the protective stretch wrap and have clean cables to trim out with connectors.
4. Check each cable run to make sure it is out of the way of work people that will be around before trim-out time.
5. Make sure the ends of the cable are attached securely to the mud rings so they won't slip out of sight when the sheet rock is installed.
6. Make one last check for any spots that got damaged during installation.

You are now finished until the sheet rock installers and the painters have completed their work.

TRIM-OUT

After the walls are closed up and the walls have been painted, it is time to complete the trim-out phase of the installation. This consists of two parts. One is to attach the connectors and the wall plates to the mud rings. The other is to configure and connect up the head-end panel. In most jurisdictions the building inspector will require that all holes in the wall be covered with a UL approved closure. If for some reason you want to postpone trimming out your system until after final inspection, you will need to place a UL approved blank cover over each mud ring before final inspection. You will also need to properly close up the wall at the panel area.

In most cases the full trim-out is done before final inspection.

Installing Wall Plates

You will need the following tools for installing wall plates:

- Wire Cutter
- Coax Cable Stripper
- Compressor or Crimper for Coax Cable Connectors
- Cat 5 cable stripper for jacket
- Punch down tool for Cat 5 connectors (110 style)
- Spludger (optional)
- Screw driver

Start by pulling the cable out of the mud ring. This is the point in time when you will be happy you put a generous service loop behind the mud ring.

For structured cable, strip back the outer sheath approximately seven inches. Cut the coaxial cables to be three inches shorter than the Cat 5 cables.

Attach Coax “F” connectors to each of the coaxial cables, and attach Category 5 connectors to the Cat 5 cables. Some people prefer to attach a voice grade telecommunications connector (commonly called an RJ-11) to one of the Cat 5 cables to distinguish it from the connector used for computer networking. Others use Category 5 connectors for both application. A standard telephone plug will fit into a Category 5 jack. Provided you use the TIA 568A standard for wiring, a two line telephone plug will align correctly in a Category 5 jack.

A word on color codes and Category 5 connectors. Most Category 5 connectors show wire colors for connecting cables for two standards. They are TIA/EIA 568A and 568B. For residential wiring, use the colors for 568A. This will provide compatibility for two line phones.

Once you have the connectors attached to the cables, snap them into the holes on the cover plate. At this time carefully inspect all of your connections to make sure the wire colors are correctly positioned and every wire is fully seated in its connector. Slide the service loop back into the mud ring, and screw the cover plate in place. You may be wondering why you cut the coaxial cable three inches shorter than the Cat 5 cable. This is to provide an extra service radius for the Cat 5 wire to avoid strain on the connectors. If you did it right, there should not be a strain on the wires when the plate is attached to the mud ring.



Trimming out the Head End Panel

Attaching the cables to the connectors in the head end panel requires the same tools as the wall plates. Each model of panel has its own organization scheme. Acquaint yourself with the scheme recommended for your panel. Then use the same techniques for staggering the lengths of the wires to provide a neat and tidy installation. To bundle large numbers of wires together, use hook and loop type wire wraps that do not exert concentrated pressure on the wires. Push excess cable

lengths back into the wall, attic, or crawl space that you organized during the pre-wire installation for service loop storage.

Testing

The first step in testing should be a good visual inspection. Most of the problems that occur are visually detectable. If you are one who is good at paying attention to details when you do installation work, you probably have a defect free installation. If you want to test the installation just to make sure, several levels of testers are available.

The most common type of test is the standard continuity test. A tester that will find standard miswires for category 5 and voice grade jacks costs around \$80. These testers have a series of lights that indicate if each pair of wires is working. If the pair is okay, the light is green. If it is reversed, the light is red. If the pair is not connected, the light remains dark.

The next level of tester performs some dynamic tests and costs around \$400. This level of tester will detect pair violations and will indicate the distance to a break in the wire.

The next level up is a Time Domain Reflection meter. These costs around \$2500. They will test for full compliance with Category 5 performance. They are rarely used in residential installations.

If you used good quality materials and were careful during the installation, it is very doubtful that a problem exists that could not be detected with the simplest of the testers.

AFTER THE INSTALLATION

The whole purpose of installing a structured wire system is to have the flexibility to accommodate a wide variety of changing needs during the life of the house. The organization you put into your installation will show its benefit as you start installing the entertainment, communications, and computer equipment that attaches to these wires. You will undoubtedly be very happy you put this infrastructure into your house as the years go on.