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Chapter 7

Cable TV, Broadband, Telephone, and Security

Because of the increasingly widespread use of communications and security systems over the past two decades, electricians have been called upon to install many different types of wiring systems in homes. Although all these systems are composed of wires carrying electricity, the similarity to conventional wiring more or less ends there. Because of this distinction, this chapter will cover these systems:

1. Cable TV wiring
2. Telephone wiring
3. Broadband and home networks
4. Security wiring

Cable TV Wiring

Wiring for cable TV systems is covered by *Article 820* of the *NEC*. This article is specifically written for community antenna TV (CATV) systems but is applicable to common cable TV wiring. *Part A* of *Article 820* covers general requirements, which do not apply directly to the installer. *Part I* covers outdoor cables and the protection and grounding of cables. These requirements apply to the installers for the cable TV supplier rather than to the electrician who installs the wiring in the house.

For wiring within the residence, we refer to *Part V* of *Article 820 (Cables Within Buildings)*.

Section 820.50 specifies that the coaxial cables used for cable TV systems must be suitable for the purpose and resistant to the spread of fire. Usually Type RG59U cable is used.

Section 820.52 covers the installation of the coaxial cables. Generally, they may not be installed in the same raceway as power conductors or with Class 1 circuits. They may be run in the same raceway with Class 2 and 3 circuits. See *Article 725* for explanation of Class 1, 2, and 3 circuits. When installed as open wiring (as is common in homes), the coaxial cables must be kept at least 2 inches away from power or Class 1 circuits. When installed in plenums, these cables must be Type CATVP or meet the requirements of *Section 300.22*.

Although different cable TV suppliers may have different requirements (and you should verify the requirements *before* you begin any installation), the general installation procedure is as follows:

Usually the best method of installation is to bring a lead-in cable from the exterior of the home to a central accessible location, usually in an attic. From there, runs to individual outlets are brought out, like the tentacles of an octopus. The cables should be stapled to the framing members in the same manner as Type NM power cable (see Chapter 4 of this book). Care should be taken not to drive the staples in too far, because crimping the cable will harm its operation.

By arranging for all the cables to originate at one central location, the cable TV supplier can easily install the various amplifiers and splitters. This also makes the system far easier to service.

At the outlets, a plastic outlet box is attached to the wall stud, just as for a receptacle outlet, and the coaxial cable pulled into the box. Generally, it is recommended to leave 5 feet of extra cable at the outlets to facilitate connection to the television set. Remember, however, that this cable should be protected from damage until the construction is complete.

After the walls are finished, a trim plate having one hole is installed over the outlet, and the coaxial cable threaded through the hole. Typically, the installer's responsibility stops at this point.

Telephone Wiring

Generally, a four-wire telephone cable is looped from outlet to outlet, beginning at the location on the exterior of the house where the utility will connect the cable to its system, and ending at the final telephone outlet.

Like coaxial cable used for cable TV, the telephone cable should be installed in the same manner as Type NM power cable (see Chapter 4 of this book), and it should be terminated in plastic boxes, just as for cable TV outlets. Note, however, that wall phones and phones mounted over desks will need to be at special heights. Verify the heights of these outlets before installation.

Sometimes installers are required to put a trim plate over the box, and sometimes they may be required to install the jack. Again, verify these details with the local service supplier prior to installation.

A four-wire cable will handle two telephone lines (two separate phone numbers); if more lines are required, separate runs will be required.

Article 800 of the *NEC* covers communication circuits such as telephone systems. These circuits must be separated from power

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circuits and must be grounded. In addition, all such circuits that run outdoors (even if only partially) must be provided with circuit protectors (surge or voltage suppressors).

The sections below list the requirements for installation of communication circuits. Only one section applies to telephone wiring inside a house: *Interior Communications Conductors,* on page 139. Nonetheless, we are also including sections that deal with circuits outside a house. These would apply to conductors run to a garage or outbuilding and are good to have as a reference.

Conductors Entering Buildings

If communications and power conductors are supported by the same pole or run parallel in span, the following conditions must be met:

1. Wherever possible, communications conductors should be located below power conductors.
2. Communications conductors cannot be connected to cross-arms.
3. Power service drops must be separated from communications service drops by at least 12 inches.

Above roofs, communications conductors must have the following clearances:

1. Flat roofs: 8 feet
2. Garages and other auxiliary buildings: none required
3. Overhangs, where no more than 4 feet of communications cable will run over the area: 18 inches
4. Where the roof slope is at least 4 inches in rise for every 12 inches horizontally: 3 feet

Underground communications conductors must be separated from power conductors in manholes or hand holes by brick, concrete, or tile partitions.

Communications conductors should be kept at least 6 feet away from lightning protection system conductors.

Circuit Protection

Protectors are surge arresters designed for the specific requirements of communications circuits. They are required for all aerial circuits not confined within a city block. They must also be installed on all circuits within a block that could accidentally contact power circuits over 300 V to ground. They must also be listed for the type of installation.

Other requirements are as follows:

1. Metal sheaths of any communications cables must be grounded or interrupted with an insulating joint as close as practicable to the point where they enter any building (such point of entrance being the place where the communications cable emerges through an exterior wall or concrete floor slab or from a grounded rigid or intermediate metal conduit).
2. Grounding conductors for communications circuits must be copper or some other corrosion-resistant material and must have insulation suitable for the area in which the conductors are installed.
3. Communications grounding conductors may be no smaller than No. 14.
4. The grounding conductor must be run as directly as possible to the grounding electrode and must be protected if necessary.
5. If the grounding conductor is protected by metal raceway, the raceway must be bonded to the grounding conductor on both ends.

Grounding electrodes for communications ground may be any of the following:

1. The grounding electrode of an electrical power system.
2. A grounded, interior, metal piping system. (Avoid gas piping systems for obvious reasons.)
3. Metal power service raceway.
4. Power service equipment enclosures.
5. A separate grounding electrode.

If the building being served has no grounding electrode system, the following can be used as a grounding electrode:

1. Any acceptable power system grounding electrode (see *Section 250.52* of the *NEC*).
2. A grounded metal structure.
3. A ground rod or pipe at least 5 feet long and 1/2 inch in diameter. This rod should be driven into damp (if possible) earth and should be kept separate from any lightning protection system grounds or conductors.

Connections to grounding electrodes must be made with the *NEC* approved means. If the power and communications systems use

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separate grounding electrodes, they must be bonded together with a No. 6 copper conductor. Other electrodes may be bonded also. This is not required for mobile homes.

For mobile homes, if there is no service equipment or disconnect within 30 feet of the mobile home wall, the communications circuit must have its own grounding electrode. In this case, or if the mobile home is connected with cord and plug, the communications circuit protector must be bonded to the mobile home frame or grounding terminal with a copper conductor no smaller than No. 12.

Interior Communications Conductors

Communications conductors must be kept at least 2 inches away from power or Class 1 conductors, unless they are permanently separated from each other or unless the power or Class 1 conductors are enclosed in one of the following:

1. Raceway
2. Type AC, MC, UF, NM, or NM cable, or metal-sheathed cable

Communications cables are allowed in the same raceway, box, or cable with any of the following:

1. Class 2 and 3 remote-control, signaling, and power-limited circuits
2. Power-limited fire-protective signaling systems
3. Conductive or nonconductive optical fiber cables
4. Community antenna television and radio distribution systems

A few additional notes also apply:

- Communications conductors cannot be in the same raceway or fitting with power or Class 1 circuits.
- Communications conductors cannot be supported by a raceway unless the raceway runs directly to the piece of equipment the communications circuit serves.
- Openings through fire-resistant floors, walls, and so on, must be sealed with an appropriate fire-stopping material.
- Any communications cables used in plenums or environmental air-handling spaces must be listed for such use.
- Communications and multipurpose cables can be installed in cable trays.

- Any communications cables used in risers must be listed for such use.

Cable substitution types are shown in *Table 800.53* of the *NEC*.

Telephone Connections

The most common and simplest type of communication installation is the single-line telephone. The typical telephone cable contains four wires, colored green, red, black, and yellow. A one-line telephone requires only two wires to operate. In almost all circumstances, green and red are the two conductors used. In a common four-wire modular connector, the red and green conductors are found in the inside positions, with the yellow and black wires on the outer positions.

As long as the two center conductors of the jack (again, always green and red) are connected to live phone lines, the telephone should operate.

Two-line phones generally use the same four-wire cables and jacks. In the case of two-line phones, however, the inside two wires (red and green) carry line 1, and the outside two wires (black and yellow) carry line 2.

Broadband and Home Networks

Broadband Internet connections are actually very easy to obtain in most places, and prewiring a home for them has become almost unnecessary. The most common broadband connects are either DSL connections, which come through a standard telephone line, or cable modem connections, which come through a cable television system. In both cases, all that is required is a small box and a few connecting cables. The only prewiring required is to make sure that there is a telephone cable or coaxial television cable where needed.

To take broadband service from the point of entrance to other locations in the home, however, requires additional work. There are two choices:

1. Distribution through the house via cable
2. Distribution through the house via wireless

Before we go through some of the basics, it is important to define a few terms:

A *repeater* is a device that receives and then immediately retransmits each bit. It has no memory and does not depend on any particular protocol. It duplicates everything.

A *bridge* receives an entire message into memory, analyzes it, and then retransmits it. If the message was damaged by a

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collision or noise, it is discarded. If the bridge knows that the message was being sent between two stations on the same cable, it discards it. Otherwise, the message is queued up and will be retransmitted on another cable. The bridge has no address. Its actions are transparent to the client and server workstations.

A *router* acts as an agent to receive and forward messages. The router has an address and is known to the client or server machines. Typically, machines directly send messages to each other when they are on the same cable, and they send the router messages addressed to another zone, department, or sub-network.

10Base5, 10BaseT, 10Broad36, and the like are the IEEE names for the different physical types of local area network often called Ethernet. The "10" stands for a signaling speed, of 10MHz. Base means baseband, and Broad means broadband. The last section indicates the cable type, where T means twisted pair and F (as in 10BaseF) means fiber.

An *access point* is a device that transports data between a wireless network and a wired network.

A *wireless node* is a user computer with a wireless network interface card (adapter).

Home Networks

Home networks are essentially light versions of commercial computer networks. They require a broadband connection to the Internet and a central panel. Depending on the complexity of the network, there may be connections to telephone and cable TV systems as well. From the panel, twisted-pair cables are run through the house, terminating in wall outlets in the same way as telephone cables. At the outlets, special plugs are installed, and short cords (called *patch cords*) connect computers to the outlets. If telephone and cable TV service is to be provided by the system, the process is the same, except that the cables and plugs vary.

ANSI/TIA/EIA-570-A Residential Telecommunications Cabling Standard covers home networking. This standard is derived from the usual EIA/TIA 568 standard for commercial structured cabling systems. Refer to Figures 7-1 and 7-2.

The *NEC* requirements for home networking are the same as for interior telephone conductors, which were covered earlier in this chapter. See *Article 800* of the *NEC* for telephone-type cables, and *Article 820* for coaxial cables, such as are used for cable TV circuits.

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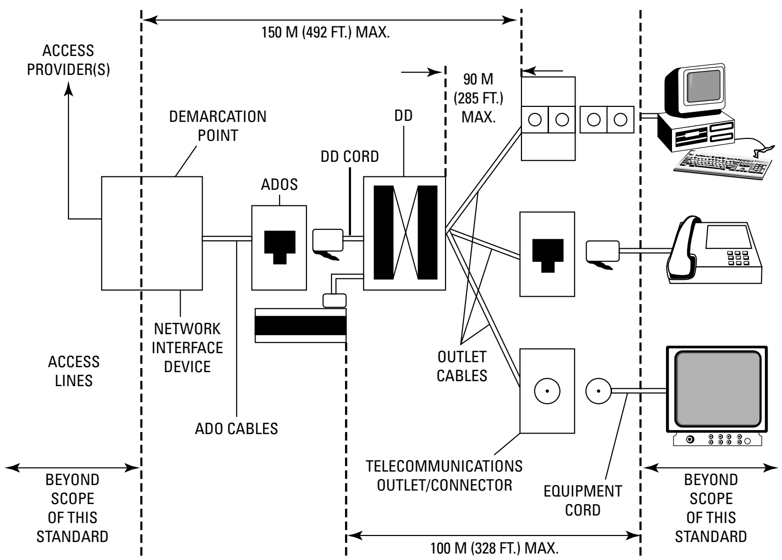


ADO = Auxiliary Disconnect Outlet **DD = Distribution Device**

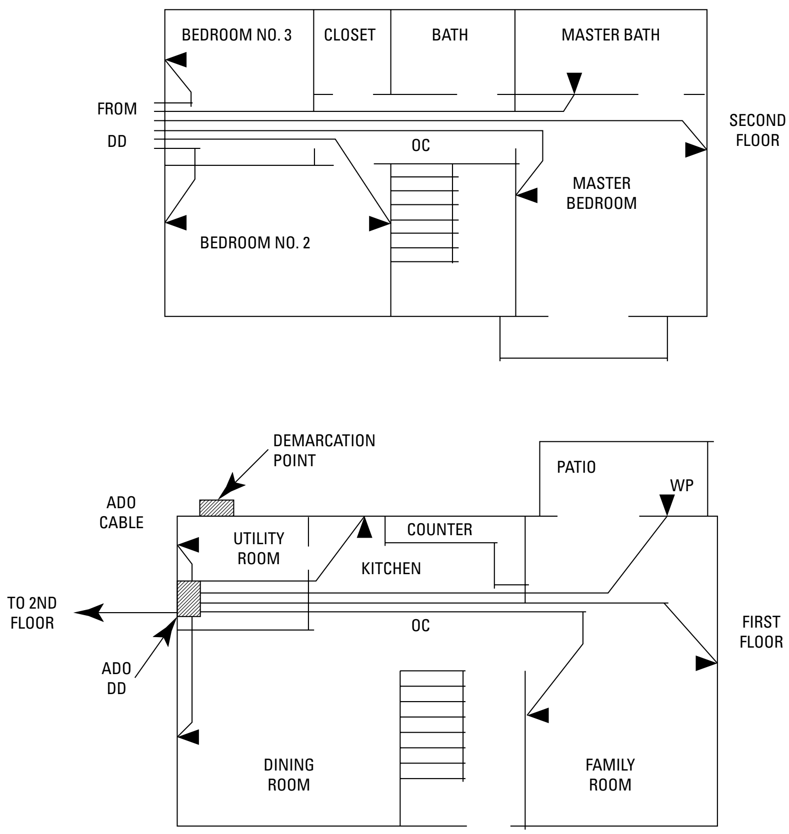
Figure 7-1 Typical home network layout.

Wireless

Wireless networks are a very effective and affordable method of connecting multiple home computers to the Internet. The signal transmission capacities and distance limits are not as great with wireless systems as they are for hard-wired systems, but they are generally more than sufficient.

When a wireless system is to be installed in a home, the main wireless panel will be installed next to or near the main telecommunications entrance to the home and will connect directly to the broadband device—a cable modem or DSL hub. From there, the signal will be distributed electromagnetically, with each connected device being fitted with a receiver and connecting hardware.

The simplest wireless network configuration is an independent (or peer-to-peer) network that connects a set of personal computers (PCs) with wireless adapters. Any time two or more wireless adapters are within range of each other, they can set up an



NOTE – Some code bodies limit placing telecommunications outlet/connectors in bathrooms.

Legend:

▲ – Telecommunications Outlet/Connector
ADO – Auxiliary Disconnect Outlet
DD – Distribution Device
OC – Outlet Cable
WP – Waterproof Outlet Box

Figure 7-2 Typical cabling system for a single residential unit.

independent network. These on-demand networks typically require no administration or preconfiguration. Access points can extend the range of independent networks by acting as a repeater, effectively doubling the distance between wireless PCs.

The distance over which radio signals can be used to communicate is a function of product design (including transmitted power and receiver design) and the propagation path, especially in indoor environments. Interactions with typical building objects, such as walls, metal, and even people, can affect how the magnetic energy propagates, and thus the range and coverage that a system achieves. Radio waves can penetrate many indoor walls and surfaces. The range (or radius of coverage) for typical wireless network systems varies from under 100 feet to more than 500 feet. Coverage can be extended.

Network Speed

As with wired networks, the actual rate of signal transfer (also called throughput) in wireless LANs is dependent on the product and the setup. Factors that affect throughput include the number of users, the type of system used, and bottlenecks on the wired portions of the system. Typical data rates range from 1 to 10 megabits per second (Mbps). Users of traditional Ethernet networks generally experience little difference in performance when using a wireless network. Wireless networks provide throughput sufficient for the most common office applications, including e-mail, shared peripherals, and multiuser databases and applications.

Security

One of the root technologies for wireless networks is military communications. Because of this, security has long been designed into most systems. These security provisions frequently make wireless networks more secure than most wired networks. Complex encryption techniques make it impossible for all but the most sophisticated to gain unauthorized access to network traffic. In general, individual nodes must be security-enabled before they are allowed to participate in network traffic. Nonetheless, unless security is taken seriously by the user, it can be an issue. And it must be said that Microsoft products are especially susceptible to security breaches.

The unlicensed nature of radio-based wireless networks means that other products that transmit energy in the same frequency spectrum can cause interference with a wireless network. Microwave ovens are a potential concern, but most manufacturers design their products to account for microwave interference.

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Security Systems

All security systems, regardless of how simple or complex, can be divided into three basic parts:

- **Sensors.** These are the devices that sense or respond to certain conditions in and around the protected area. (There are many types of sensors for many different applications.)
- **Controls.** The brains of the system are these controls that respond to the input from the sensors according to the desires of whoever set the system up.
- **Signaling devices.** These devices give out some type of signal (most typically a siren or buzzer) when an alarm condition is reached.

The critical factors in applying these devices to a home are that:

- All devices must be compatible.
- All the devices must be connected properly.
- The system must be properly designed to cover all vulnerable areas of the home and to provide effective responses.

Wired or Wireless

The primary choice in security systems is between wired systems, which have cables running to every device, and wireless systems, which transfer signals via radio waves (but which require regular battery changes).

Wired components are less expensive than wireless systems, but wired systems involve higher installation expenses.

The benefit gained by going wireless in that the system is less labor-intensive to install. In particular, it is the cost of installing cables that makes a wired system expensive, especially in existing homes. By sending signals via radio waves, this cost is completely avoided.

Yet, although a good deal of money is saved by avoiding the costly installation of wires, the wireless devices themselves cost quite a bit more than do the corresponding conventional devices. The reason is that each device must have two parts: a sensor and a transmitter. Additionally, they must have some type of built-in power source. Because of these requirements, the wireless devices are not only more expensive but also physically larger than the standard components.

Wireless window switches are made to be wired directly into a transmitter, which then sends a signal to the receiver when necessary. Most systems have the receiver built right into the control unit, although some use a separate receiver. Sometimes separate receivers are required for outdoor or special transmitters. A typical transmitter has a range of about 200 feet. If the transmitter is farther from the main receiver than this distance, a separate receiver must be installed within the transmitter's range.

Security Installations

Security wiring is covered by *Article 725* of the *NEC*, and security circuits are generally classified as Class 2 or 3. The installation requirements are similar to those for coaxial cable.

When installing security circuits, remember that there are two basic types of security circuits:

- Detection circuits, which run to the various devices that are used to detect an intrusion
- Signaling circuits, which run to the various devices (horns, lights, sirens, and the like) that signal an intrusion

These circuits cannot be joined at any time. Each type must have its own path to the control panel. For most systems, a small resistor will have to be installed at the end of each circuit. These are called end-of-the-line (EOL) resistors. These are required for monitoring the system.

For the installation of security wiring, it is critical that you follow the system manufacturer's instructions to the letter. To fail to do so will almost always result in problems. These are sensitive systems and must be installed exactly as designed. If you encounter a problem during the installation, you should call the supplier of the system rather than trying to figure out the easiest answer. Security wiring is installed in the same manner as telephone wiring and is terminated in plastic boxes in the same manner. Again, verify the mounting heights of all devices prior to roughing them in.

If you are required to install the various security devices and/or make the final connections to the control panel, make sure that the manufacturer's instructions are followed exactly. Again, don't try to find an easy answer to problems that may occur; call an engineer who is thoroughly familiar with the system.