COMMSCOPE®

Broadband applications and construction manual

Drop cable products

Contents

How to use this guide

The drop cable applications and construction guide is written for the cable installation professional who, due to the diverse services offered by CATV and telecommunication service providers, needs a quick and handy reference to practical installation information, especially in the case of retrofitting.

We've tried to simplify the decision-making process as to which cables to choose for what installation, taking into account factors such as performance over distance, preventing RF interference and fire/safety codes.

We also want to introduce you to some products that may ease some of your installation headaches, such as BrightWire® anti-corrosion treatment for braid shields, and QR® 320, an ultra-long-reach coaxial cable.

One of the big changes in our industry is the introduction of powered broadband services, which are addressed in the National Electrical Code's Article 830. This manual shows you when to use NEC 830 cables; pages 13 and 16 (aerial and buried installations) cover specific issues involving installation clearances; other chapters carry special callouts concerning NEC 830 issues.

Most attention is paid to residential installations (page 22) which has the most "practical" information, especially for trim-out. The MDU and commercial installations sections are more general, and will refer you back to page 22 for the specifics of finishing out the installation.

It is impossible to cover every single situation an installer may run into. These guidelines are no replacement for your good common sense and experience.

It's always good to know that you have backup should you run into a difficult installation. **If you find you need advice, call CommScope's BRC (Broadband Resource Center™) toll free at 866-333-3272 from 9 am to 5 pm ET Monday through Friday.** We're always glad to help out a fellow professional.

CommScope drop cable

During the last years of the 20th century, new words were added to the vocabulary of both installers and subscribers of cable and telecommunications providers; terms like digital, broadband, multimedia and smart homes entered our everyday language. Coaxial cable, formerly a one-way conduit for TV, is now a two-way conduit for specialty programming, HDTV, stereo radio, internet access, telephony and more. And, within the home and office, coaxial and UTP cables—even fiber optics—carry these services with a speed and clarity that were once thought impossible.

Here, in the 21st century, as providers of broadband services upgrade their plants to deliver the features demanded by millions of customers, we must keep in mind that the last mile—in fact the last few hundred feet of cable—is the essential component in the network. All of the digital high-speed gigahertz power promised by your company is nothing more than a dark screen if the cable that runs from the tap to the wall is poorly installed and connected.

Coaxial, UTP, fiber optic—CommScope makes all of the cables that make the broadband revolution possible. That's why we offer:

For the system buyer, a selection of cables that perform under extreme conditions, including sun, heat, cold, moisture and heavy RF interference. We also offer cables that resist corrosion and meet critical riser and plenum standards for indoor installation.

CommScope delivers on the promise of broadband services with a family of high-speed craft-friendly cables

For the craftsman, cables are available in convenient lengths with features that ease installation. We also offer toll-free technical assistance at 866-333-3272 if you need a fast answer on an installation issue.

CommScope is proud of our 30-plus-year relationship with the cable installer. We know you'll discover that CommScope cables deliver all the quality and features you need to make the digital revolution a success.

Cable descriptions—coaxial drop cable

The three types of cable used to carry broadband services to and within business and residences are coaxial, fiber optic and unshielded twisted pair (UTP). Coaxial cable is the most common; it is the "cable" in the term "cable TV." The vast majority of broadband networks are constructed using some type of coaxial cable. Coaxial is made up of these basic components:
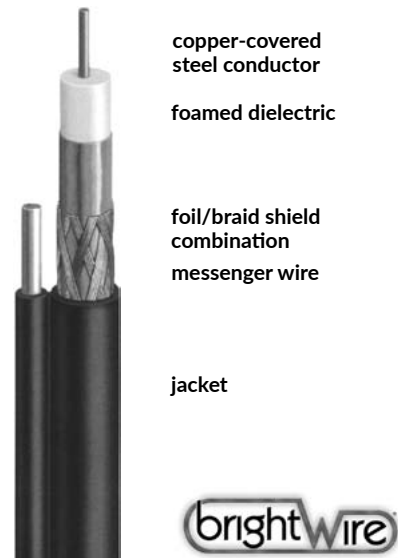
The center conductor carries a low-voltage RF or electronic digital signal and may also carry up to 150 volts of power (see Appendix/Safety Standards/NEC Articles 820 and 830). For optimum strength and performance, CommScope uses copper-clad steel for our coaxial cable—other types (solid copper, silver-coated copper-clad steel) are available;

The dielectric is a polymer insulation that supports the conductor. CommScope enhances the performance of its coaxial cable by using foamed (or cellular) dielectrics that offer lower loss;

The shield defends the signal from RF interference. CommScope uses a foil/aluminum wire braid combination for long-term protection and performance; our highest performance QR® 320 cables use a welded and bonded .013-inch (0.3-mm) thick strip of aluminum as a shield. Shielding corrosion can be prevented with CommScope's BrightWire® treatment, and a braid shield impregnated with Migra-Heal® flooding compound will resist moisture migration;

The jacket protects the entire assembly. Jacketing materials will vary depending on the application—tough polyethylene (PE) is used for buried installations; lower smoke-and-flame producing polyvinyl chloride (PVC) is used aerially and indoors, as are plenum-rated fluorinated ethylene propylene (FEP) and polyvinylidene fluoride (PVDF).

For aerial installations, a **messenger wire** is built into the cable for support. CommScope also offers Multi-Reach® cables that add up to six voice-grade UTPs for discrete phone service or powering.

copper-covered steel conductor

foamed dielectric

foil/braid shield combination

messenger wire

jacket

Braid shielding and coaxial cable performance

A coaxial cable must have, at minimum, a dual shield of aluminum foil tape overlaid with a woven braid of aluminum. **This braid shield greatly improves the electrical and mechanical performance** of the coaxial cable; in fact, a braid shield can vastly increase the installed life of the cable. All CommScope subscriber access coaxial cables use a combination of foil and braid shields.

Braid shielding provides low frequency protection
Foil shielding is usually a layer of aluminum bonded to a polyester tape. It provides 100 percent coverage over the dielectric and is best at preventing ingress and leakage of high-requency signals; however, it is not that effective with lower frequency signals. Aluminum braid shielding complements foil by containing and preventing interference from those lower frequencies.

Braid shields increase cable performance and can greatly extend the useful life of the cable

Braid shielding helps maintain dc resistance
Foil shielding is very flexible but lacking in mechanical strength. Stress caused by installation or by twisting and flexing over time (like in an aerial installation) will cause microscopic gaps to open in the foil. These "microcracks" degrade the electrical integrity of the foil and cause the dc resistance of the cable to rise. Resistivity gets worse as the cable twists.

Strong, flexible braid shielding supports the foil and helps fight the formation of microcracks. The braid wires do not microcrack; they bridge the gaps in the foil. Braid shielding keeps its integrity and delivers low and constant resistivity numbers even when twisting and flexing.

Braid shielding keeps attenuation low
Attenuation performance goes hand in hand with dc resistivity; high resistivity caused by microcracks in the foil will result in higher attenuation. A history of 15,000 flexures can degrade a foil shield to the point where the calculated attenuation could worsen by 400 percent or more. However, the robust nature of the additional braid shield keeps attenuation low.

Braid shielding keeps connectors connected
The additional strength provided by braid shielding gives connectors something to hold onto. In terms of pulloff force, both compression and crimp-fitted connectors hold much tighter to cables with braid shields.

UTP indoor cable

Unshielded twisted pair (UTP) cables consist of two insulated conductors twisted together in a very precise fashion; four of these pairs are then jacketed together into a cable. The angle and number of the twists acts like a shield and helps the digital signal stay robust over longer distances. UTP is used inside buildings to distribute voice and data signals over relatively short distances.

Through advances in construction and materials, UTP cables have a much higher bandwidth (information carrying capacity) than their telephone wire cousins. Most UTP cables are defined by a "category" or a performance designation. The categories are roughly determined by the bandwidth, or information-carrying capacity, of the cable. **Category 5** (a data cable rated at 100 MHz of bandwidth) is the most commonly used type in residences. For higher data speeds and increased bandwidth, CommScope also offers **Ultra II™** enhanced Category 5E (200 MHz) and **UltraMedia™ Category 6** (400 MHz) cables.

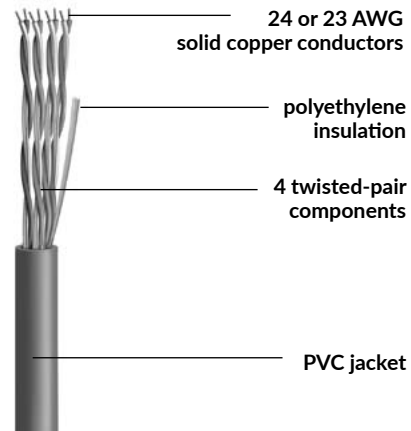**Maintaining the twist is essential, especially during connectorization** —the conductors must remain twisted right up to where they meet the jack. The loss of just one twist can degrade the performance of the cable so as to render it useless as a high-speed data cable.

UTP cables consist of three basic components:

The conductor is 23 or 24 AWG solid bare copper;

The insulation is usually a solid PE (foamed for UltraMedia) with FEP used in plenum cables; and

The jacket is a riser-rated PVC or plenum-rated FEP or PVDF. Because these cables are used indoors, pay special attention to the NEC rating of the application.

24 or 23 AWG solid copper conductors

polyethylene insulation

4 twisted-pair components

PVC jacket

Coaxial selection considerations—distance

Coaxial cable can be engineered for several levels of performance and cost-efficiency. For instance, a larger cable will carry a signal over a longer distance; additional shields provide more protection from interference. Your first consideration, however, is the overall distance of the drop. CommScope offers cables tailored for different distances:

QR® 320—these are our highest performance coaxial cables and are recommended for MDU usage (see Drop cable descriptions/specifications) or extremely long runs with their .071-inch (1.80-mm) copper-clad aluminum center conductor.

F11 series cables—excellent-performing coaxial cables with a 14 AWG (1.63 mm) copper-clad steel center conductor. They are recommended for use in runs of over 150 feet (45 meters).

F6 series cables—these are made for shorter runs, with an 18 AWG (1.02-mm) copper-clad steel center conductor. They are recommended for use in runs of 150 feet (45 meters) or less.

These cables are available in constructions for aerial and buried outdoor installations. They are also available for residential and commercial indoor (general, riser and plenum) usage.

Ask yourself three questions: what's the distance, what's the environment and how much shielding is needed?

	Maximum attenuation @ 68°F		
	QR® 320	**F11 series**	**F6 series**
MHz	**dB/100'**	**(dB/100m)**	
5	0.24 (0.79)	0.38 (1.25)	0.58 (1.90)
55	0.84 (2.76)	0.96 (3.15)	1.60 (5.25)
83	1.07 (3.51)	1.18 (3.87)	1.95 (6.40)
181 (F6 & F11 187)	1.60 (5.25)	1.75 (5.74)	2.85 (9.35)
211	1.73 (5.68)	1.90 (6.23)	3.05 (10.00)
250	1.86 (6.10)	2.05 (6.72)	3.30 (10.82)
300	2.04 (6.69)	2.25 (7.38)	3.55 (11.64)
350	2.25 (7.38)	2.42 (7.94)	3.85 (12.63)
400	2.38 (7.81)	2.60 (8.53)	4.15 (13.61)
450	2.52 (8.27)	2.75 (9.02)	4.40 (14.43)
500	2.72 (8.92)	2.90 (9.51)	4.66 (15.29)
550	2.85 (9.35)	3.04 (9.97)	4.90 (16.08)
600	2.98 (9.78)	3.18 (10.43)	5.10 (16.73)
750	3.34 (10.96)	3.65 (11.97)	5.65 (18.54)
865	3.62 (11.88)	3.98 (13.05)	6.10 (20.01)
1000	3.89 (12.76)	4.35 (14.27)	6.55 (21.49)

Coaxial selection considerations—shielding and environment

Once you've determined which cable answers your need for signal over distance, you need to determine the type of cable you'll need for the installation environment.

For areas of possible RF interference, (pager antennas or other visible problem as outlined on page 6 (Coaxial selection considerations—distance), or if there is a history of customer comments concerning interference from ham radios, etc.), consider using a tri-shielded cable (foil/60 percent braid/foil) shield. The extra layer of foil provides additional protection against high-frequency RF signals at little additional cost. Super-Shield (Quad) cables (foil/60 percent braid/foil/40 percent braid) provide optimum protection against RF interference.

Tri-shielded cables offer excellent RF protection at reasonable cost

For aerial installations, select a messengered cable (also called a figure-8 cable) with a polyvinyl chloride (PVC) jacket. The messenger wire is a steel wire that is webbed together with the coaxial cable. This wire supports the coaxial cable—under no circumstances should subscriber access coaxial be run without a messenger or lashed to a wire.

For buried installations, select a polyethylene-jacketed cable with MigraHeal® flooding compound to prevent moisture ingress in case of damage. Article 830 considerations (see pages 16 and 34) make the use of cable pre-installed in conduit **(CommScope's ConQuest®)** very attractive.
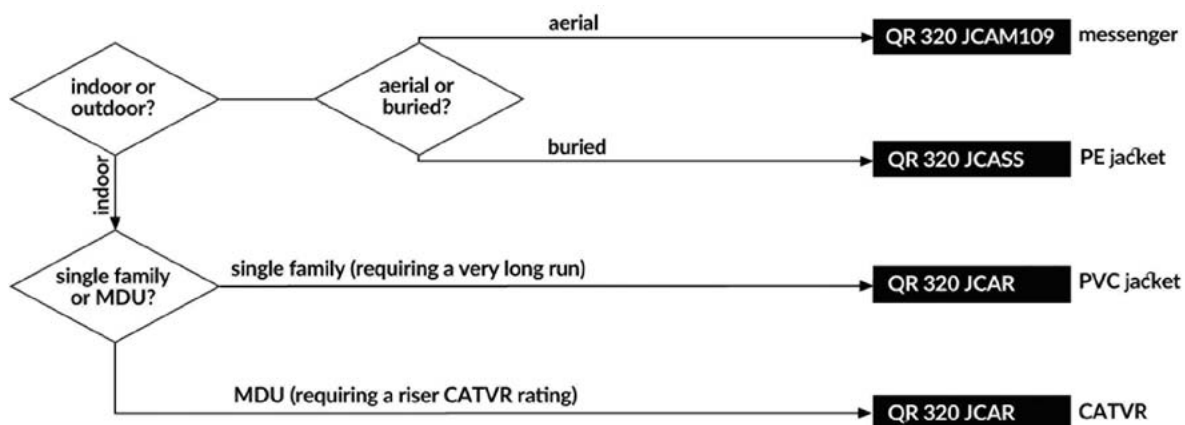
For cables that transition from outside to inside (from the ground block to the inside connection), select a CATV cable for residential use, or select a CATV or CATVR cable for commercial buildings.

For commercial installations, CATVR riser and CATVP plenum cables are required in certain circumstances. A riser-rated cable may be run vertically between floors; plenum cables are designed for use in air-handling spaces, such as the area above a hung ceiling. General-purpose cables (CATV) may be run horizontally within or along walls and in raceways—they cannot transition between floors.

For locations where salt or other aerial corrosives may be a problem, CommScope offers two aerial cable anti-corrosive treatments for braid shields: BrightWire®, a dry treatment that chemically combines with metal components to protect against corrosion (and improve dc loop resistance); and APD (amorphous polypropylene drop), a nonflowing polypropylene flooding compound.

QR® 320 series selection matrix (MDUs and very long runs)

This is a quick reference for QR 320 Series cables from CommScope. Answer the questions as you read along the diagram to arrive at the construction code for the cable required for your application.
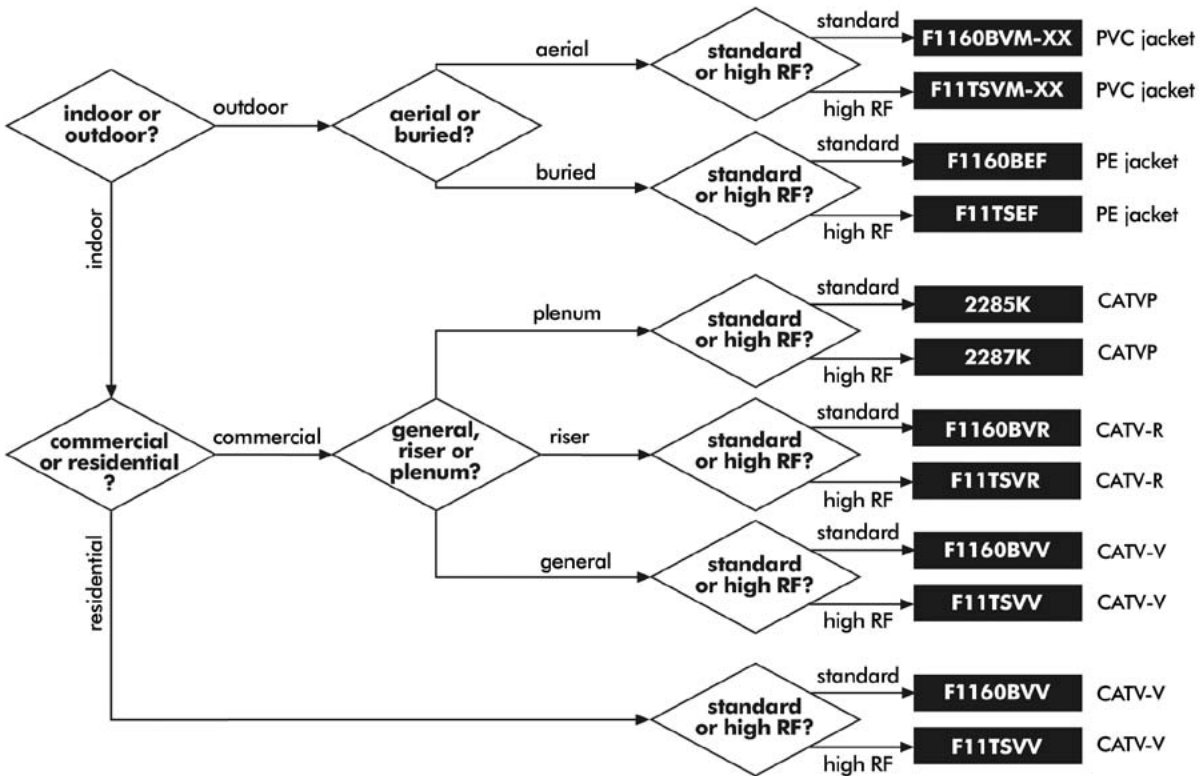

QR 320 cables have a unique welded aluminum strip shield for superior RF protection and a large center conductor for lower attenuation over longer distances. We recommend them for use in MDUs.

Underground QR 320 cables use MigraHeal® flooding compound, which is applied under the jacket, making it suitable for direct burial. MigraHeal floodant is designed to flow into damaged jacket areas, sealing this area and inhibiting corrosion.

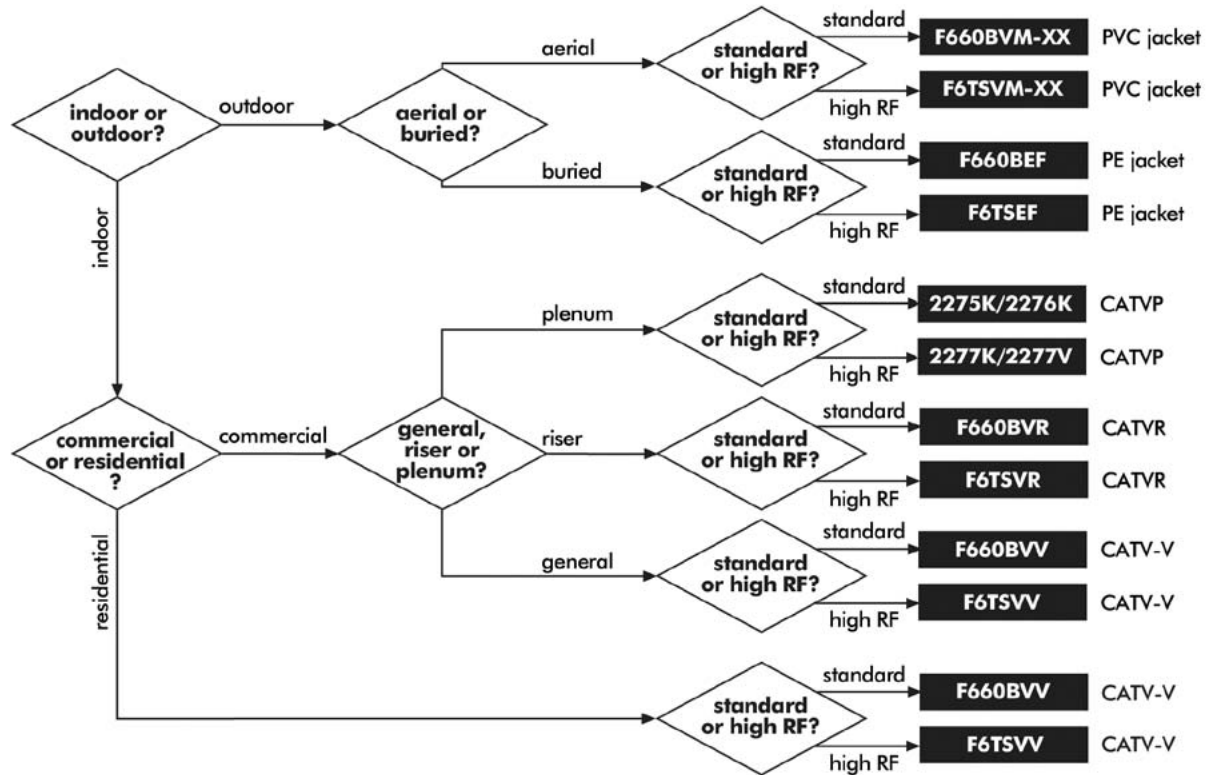# F11 Series selection matrix (runs over 150 feet/45 meters)

This is a quick reference for F11 Series cables from CommScope. Answer the questions as you read along the diagram to arrive at the construction code for the cable required for your application.

The XX in the part number should be filled with the code for the anti-corrosion agent you'd prefer as follows: **BW** for CommScope's dry BrightWire®, or **APD®** for the more traditional APD flooding compound. All nonplenum high RF cables are tri-shielded (foil/60 percent braid/foil); super-shield versions are available. Plenum cables are available only with super-shields.

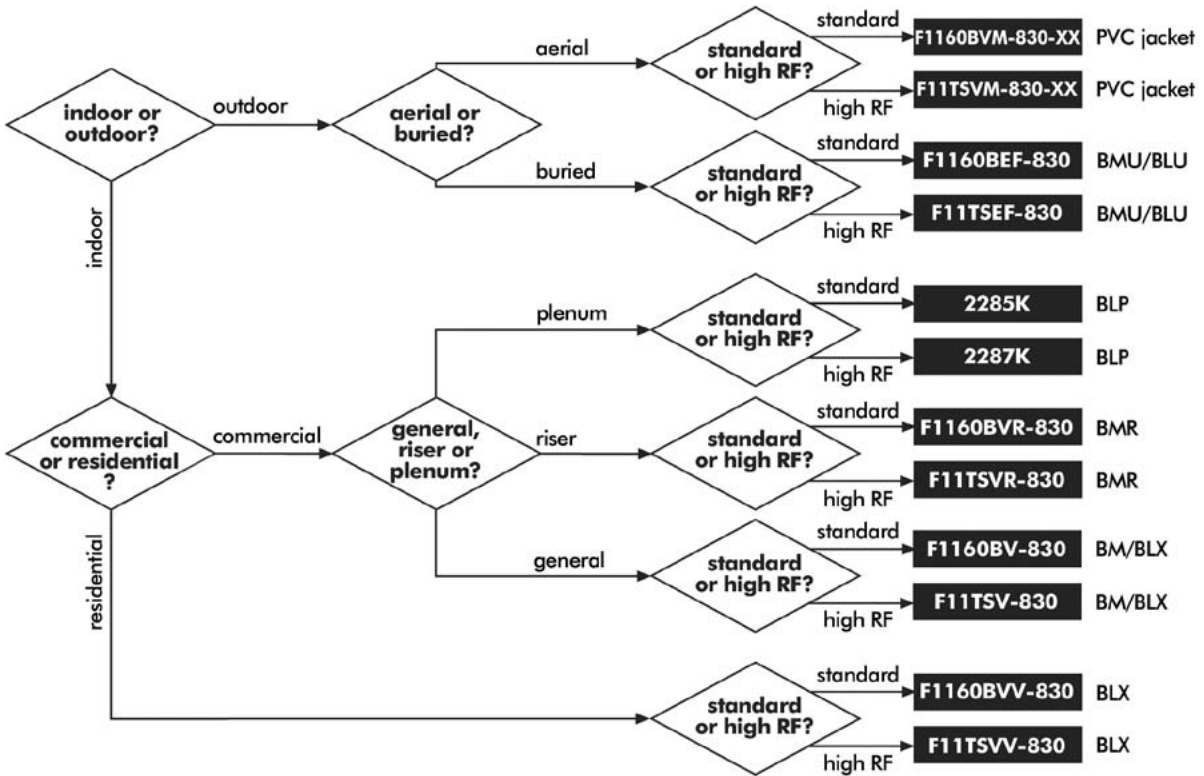# F6 Series selection matrix (runs 150 feet/45 meters or less)

This is a quick reference for F6 Series cables from CommScope. Answer the questions as you read along the diagram to arrive at the construction code for the cable required for your application: The XX in the part number should be filled with the code for the anti-corrosion agent you'd prefer:

BW for CommScope's dry BrightWire®, or **APD**® for the more traditional APD flooding compound. All nonplenum high RF cables are tri-shielded (foil/60 percent braid/foil); super-shield versions are available. Plenum cables are available only with super-shields. A 90 percent braid is available for 2276K.

F11 Series selection matrix for NEC 830 (runs over 150 feet/45 meters)
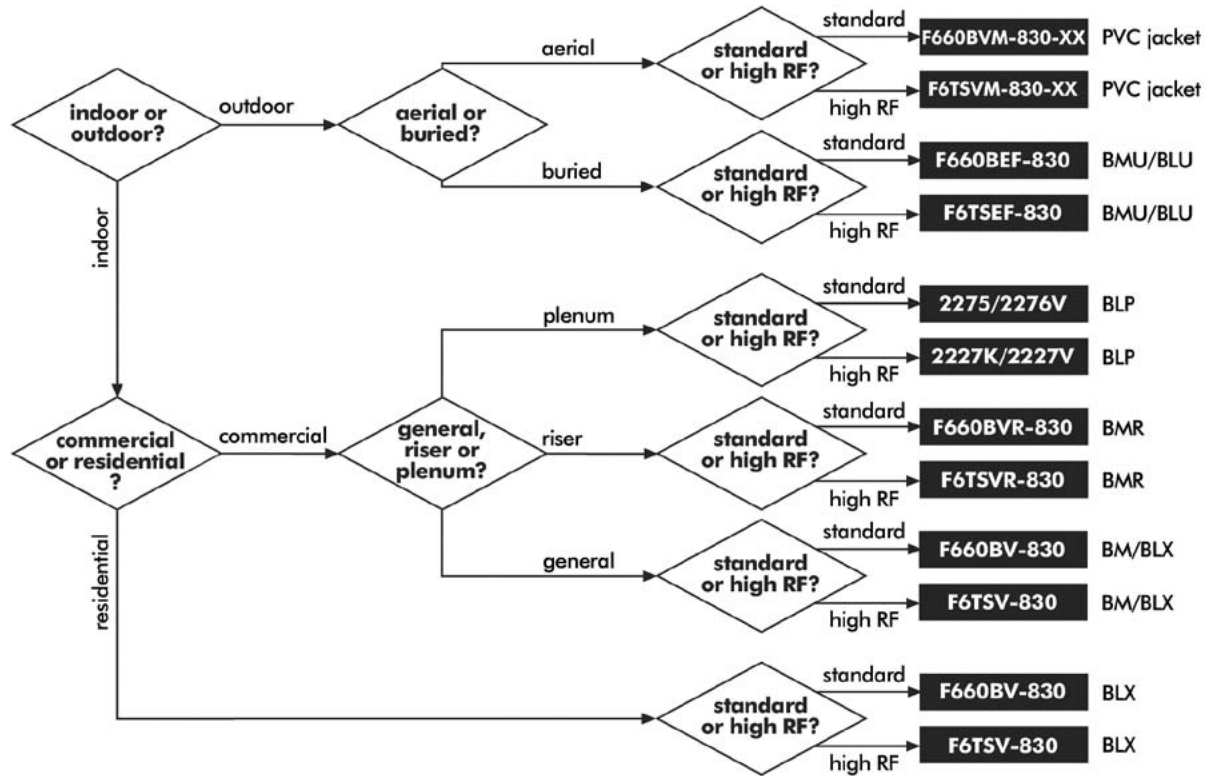
This is a quick reference for F11 Series cables that meet NEC 830. Answer the questions as you read along the diagram to arrive at the construction code for the cable required for your application: The XX in the part number should be filled with the code for the anti-corrosion agent you'd prefer:

BW for CommScope's dry BrightWire®, or **APD®** for the more traditional APD flooding compound. All nonplenum high RF cables are tri-shielded (foil/60 percent braid/foil); super-shield versions are available. Plenum cables are available only with super-shields.

F6 Series selection matrix for NEC 830 (runs 150 feet/45 meters or less)

This is a quick reference for F6 Series cables meeting NEC 830. Answer the questions as you read along the diagram to arrive at the construction code for the cable required for your application: The XX in the part number should be filled with the code for the anti-corrosion agent you'd prefer:
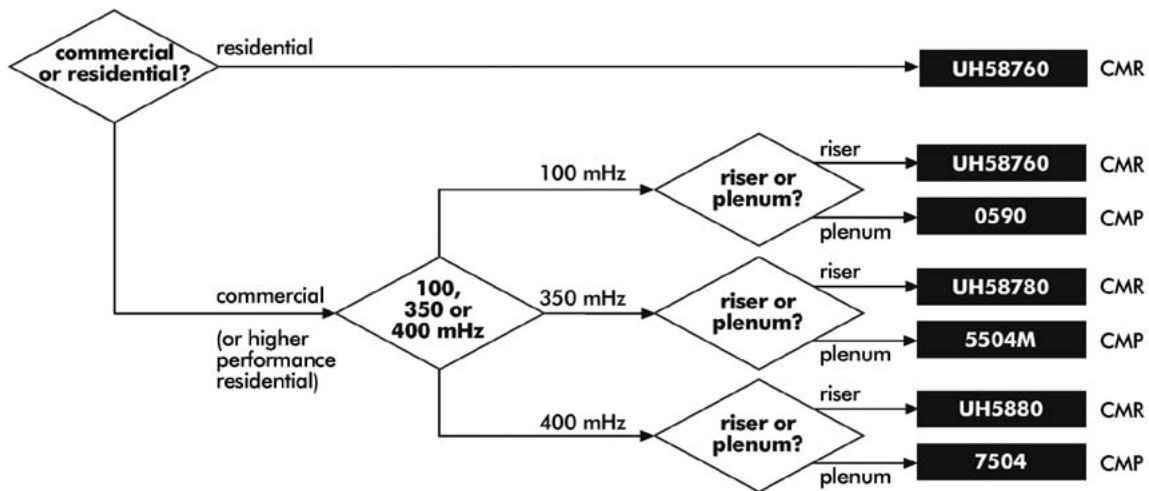

BW for CommScope's dry BrightWire®, or **APD®** for the more traditional APD flooding compound. All nonplenum high RF cables are tri-shielded (foil/60 percent braid/foil); super-shield versions are available. Plenum cables are available only with super-shields. A 90 percent braid is available for 2276K.

UTP and fiber-optic cables

Two factors control the selection for UTP and fiber-optic cables; the speed of the network they will support and the NEC rating required by the installation.

For UTP cables within the home, CommScope's Category 5E UTP (product code UH58760) offers more than enough bandwidth for most applications. These cables meet the NEC CMR (riser) designation.

If you are installing UTP in a commercial application (or require higher performance in a residential application), see the chart below:

For fiber-optic cables within the home, we recommend a two-fiber interconnect with a riser rating using multimode fibers (construction code R-002-IC-6F-FSDOR). A plenum version is available.

Planning the run

The time you take in examining the site prior to installation is well spent and can help you avoid problems later on. You need to be aware of issues such as right-of-way (ROW), where you will tap into the span, the distance of the run and where you will attach and bond the cable at the customer's structure. Refer to page 6 (cable selection) to determine what cable to use based on distance or NEC 830 considerations.

Look for antennas to select cable shielding
A 60 percent braid/foil shield works for almost all CATV installations. If you are installing cable intended for a more active, two-way service (internet, high-speed data), you should consider a tri-shielded cable. Cellular and pager towers produce radiation that tends to raise havoc with CATV channels 19, 20 and 21. Ham radio aerials may also signify a problem. Urban zones (like southern California or metropolitan New York) have inherently high levels of RF pollution. We recommend tri-shielded cables with a minimum of 60 percent braid for areas with high RF concentrations.

Whether the installation is aerial or buried, a simple site survey now can prevent headaches later

Know your ROW (right-of-way)
The most direct route may not be the legal route. Make sure the route you're planning runs ONLY over the customer's property. Generally, you can follow a parallel path to power or phone lines. However, under no circumstances lash your drop to any other cable.

Locate the tap
While most spans have taps located next to the poles, you may occasionally find a tap in mid-span. This may be helpful in avoiding ROW issues.

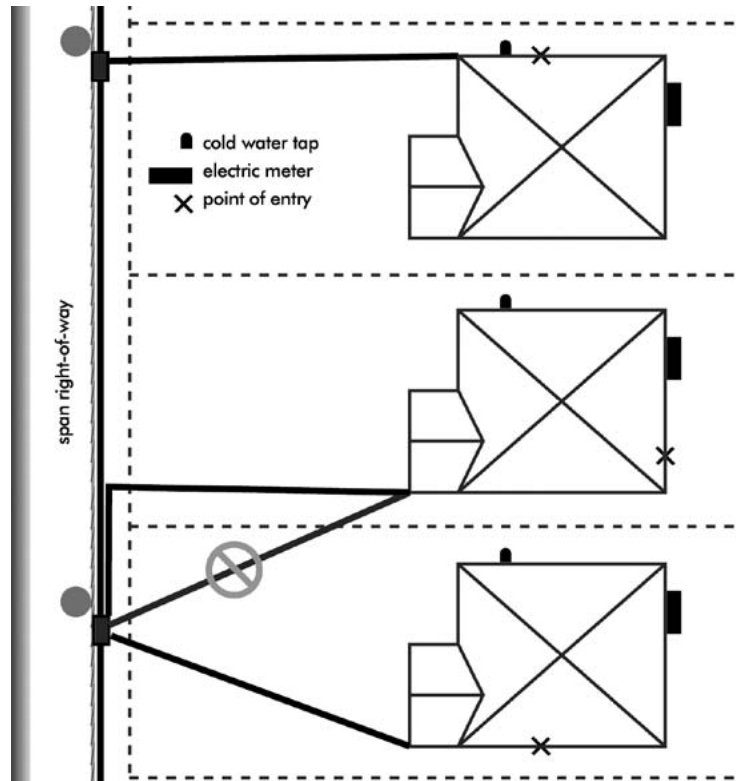**Select your attachment point for ease of bonding and access**
NEC 820 specifies that coaxial cable must be bonded, preferably with the electrical. Therefore, try to attach the cable to the wall or corner nearest the meter. If that can't be reached, an exterior cold water pipe (if the plumbing throughout the building and back to the main is entirely metal) or an existing ground rod will do. If these are impractical, you will have to hammer in a ground rod. In most cases, you will be selecting the cable entry point into the building; however, if the NIU is already in place, try to attach your cable as close to it as you can, keeping bonding considerations in mind.

Attachment examples for aerial installations

The top example shows a pretty straightforward installation. The electric meter is on the opposite side of the building from the span, so attachment near the the cold water tap is acceptable.

The middle example shows that the most direct route would trespass on neighboring property. Therefore, the drop should be run along the span and then angle to the building, eventually running toward the meter and then back to the point of entry. Be sure to check mid-span; it is possible that there may be a tap there because a pole was there at one time.

The bottom example is a tough call. It's marginally shorter to attach near the point of entry, run to the meter for bonding purposes and double back to the point of entry.

In all cases, check your local code requirements and system design specifications for your prescribed bonding requirements.

■ cold water tap
▬ electric meter
✕ point of entry

span right-of-way

Aerial installation/messenger (figure-8) cable

For best efficiency and lowest cost, aerial installation is generally preferred. However, local or subdivision codes sometimes require that utilities be installed underground. There are times the customer may want the cables hidden for aesthetic reasons. In these cases, see page 16 (buried installation) for instructions on buried installations.

A typical installation is shown below. A continuous length of cable runs from the tap to the attachment point and continues to the grounding point, called a ground/bond block. A second cable continues from the ground block through the point of entry to a termination point within the structure.
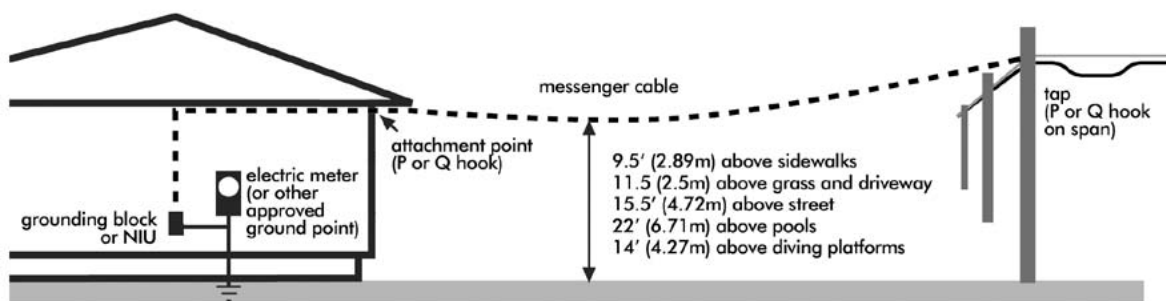
Article 830 considerations
Some systems use coaxial or UTP cable to carry power as well as signal to the NIU (network interface unit—sometimes called a NID/network interface device). When installing powered coaxial cable (carrying up to 150 volts), pay special attention to the cable-to-earth distance as shown in the diagram below.

> **Tech tip:** when pulling and hanging cable, avoid twisting, scraping, stepping on or crushing it

NEC 830 also requires that cable attached to the building within 8 feet (2.5 meters) of grade must be placed within conduit, raceway or some other approved cable guard.

NIUs and ground blocks
NEC 830 installations will terminate at an NIU. Most NIUs have built-in connections that must be grounded at the meter or other approved point. See page 20 (Attaching to the NIU—the 8 foot rule).

messenger cable

attachment point (P or Q hook)

electric meter (or other approved ground point)

grounding block or NIU

tap (P or Q hook on span)

9.5' (2.89m) above sidewalks
11.5 (2.5m) above grass and driveway
15.5' (4.72m) above street
22' (6.71m) above pools
14' (4.27m) above diving platforms

Pull the cable, separate the messenger

Set up your cable pack or A-frame beneath the tap. Take the cable end and walk toward the attachment point. Don't let the cable kink, scrape, tangle or get hung up as you walk - it may deform the cable and cause transmission problems later.

> **Tech tip:** always pull more cable than you think you'll need
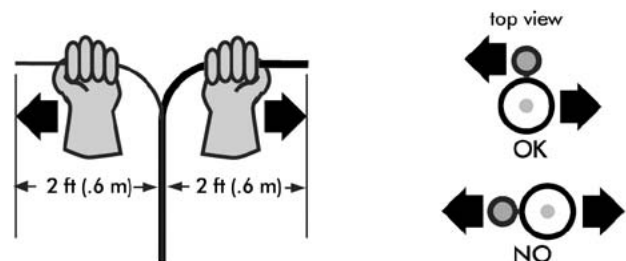
Keep pulling cable after you reach the attachment point. Remember, you need to have enough cable in hand to run along the soffit or foundation line of the building to reach the grounding point.

Go back to the reel and pull enough extra cable to reach the tap. Cut the cable at the reel.

Separate the messenger from the coaxial cable
Use your side cutters to start a split in the webbing between the messenger and the coaxial cable. Take the messenger in one hand and the coaxial in the other and smoothly pull your hands apart to split the webbing. Pull across the webbing (a scissors pull) instead of pulling the webbing directly apart.

Connectorize the cable
Attach the connector per the instructions on page 26 (connectorizing braid-shielded coaxial cable).

Attach the messenger to a drop clamp

1. Separate the messenger wire from the cable using the 90° (scissor) pull of the messenger and the cable, separating the length of messenger wire needed to make the wrap; about 15 to 18 inches.

> **Note:** Never use the drop clamp, a knife, or other sharp tool to separate messenger and cable.

2. Fit the cable and messenger wire into the drop clamp as shown, so the clamp bail is between the two.

3. Pull the messenger wire around the center of the bearing surface as shown, toward the rear or drop-side of the clamp.

4. Serve the messenger wire through the messenger wire slots and begin the wrap about the clamp body, as shown.

5. Continue the messenger wire wrap for two full turns.

6. Serve the messenger wire through the bottom messenger wire slot, as shown, to the drop-side of the clamp and cut the excess wire away, or ground it to the strand.

CommScope does not recommend the use of the 2-4-4 method or other methods of tying off the messenger around the cable. Studies have shown that the cable's impedance will change and worsen with loading.

Connect the coaxial to the tap

The cable should be connectorized per the instructions on page 26. Some systems like to protect the connection with a shield (a physical covering to protect against tampering). Place that over the connector now—you will require an F-connector tool to tighten the connection.

With the messenger secured to the span, screw the connectorized cable into the tap hand-tight. Using a torque wrench, tighten the connector to 30 lbs/in. If you don't have a torque wrench, twist the connector an extra 1/4 turn with your wrench or F-connector tool to seat it. Cover the connection with a boot.

You should have about 2 feet (60 cm) of cable between the tap and where the cable joins the messenger. Along with the ease of handling this provides, this extra cable will be very useful if you ever need to re-connectorize the cable.

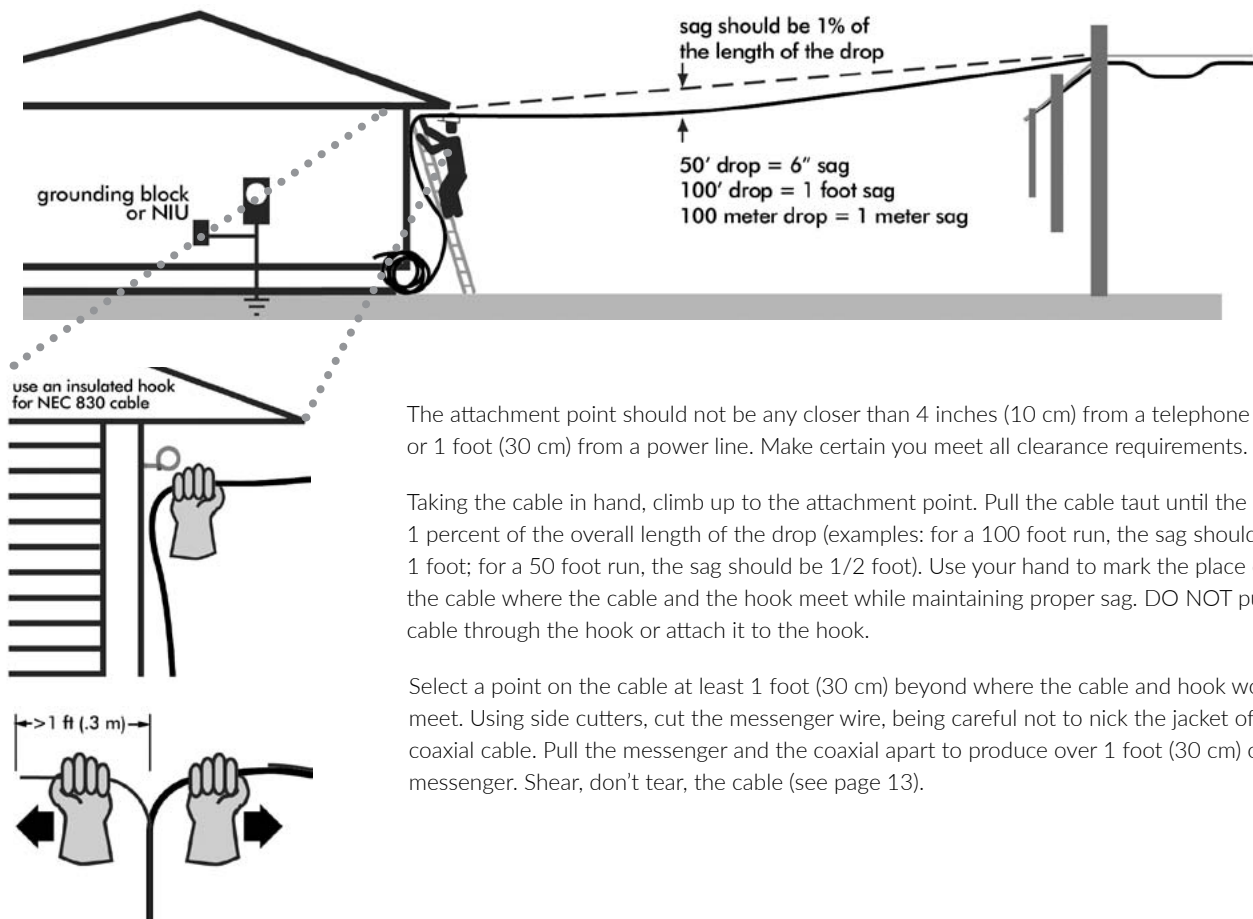use a cable tie to secure the cable loop

Store this cable by forming a loop of about 6 inches (15 cm) in diameter. Make sure the diameter of the loop is no smaller than 10 times the outer diameter of the cable. Use cable ties to form and secure the loop to the span.

Attach an identification tag to the cable.

Attach the cable to the residence

Using a ladder or a lift truck, climb up to the attachment point and screw or drive the P-hook or Q-hook into the residence. Use an insulated hook if you are bringing in powered service per NEC 830. A good attachment point is the corner of the house under the soffit. NEVER attach to an antenna, rain gutter, chimney, power mast or lightning rod. The hook should be parallel to the ground.

sag should be 1% of the length of the drop

50' drop = 6" sag
100' drop = 1 foot sag
100 meter drop = 1 meter sag

grounding block or NIU

use an insulated hook for NEC 830 cable

>1 ft (.3 m)

The attachment point should not be any closer than 4 inches (10 cm) from a telephone cable or 1 foot (30 cm) from a power line. Make certain you meet all clearance requirements.

Taking the cable in hand, climb up to the attachment point. Pull the cable taut until the sag is 1 percent of the overall length of the drop (examples: for a 100 foot run, the sag should be 1 foot; for a 50 foot run, the sag should be 1/2 foot). Use your hand to mark the place on the cable where the cable and the hook meet while maintaining proper sag. DO NOT pull the cable through the hook or attach it to the hook.

Select a point on the cable at least 1 foot (30 cm) beyond where the cable and hook would meet. Using side cutters, cut the messenger wire, being careful not to nick the jacket of the coaxial cable. Pull the messenger and the coaxial apart to produce over 1 foot (30 cm) of messenger. Shear, don't tear, the cable (see page 13).

Run the cable to the grounding block or NIU

Using the 2-4-4 method described on page 15, attach the messenger wire to the hook (or use a messenger wire clamp). Strip the remaining messenger wire from the coaxial.

Route the cable from the attachment point to the grounding block or the entry point for the NIU. The path should follow the architectural details of the residence, running down at the corners and across at beams and seams in the siding.
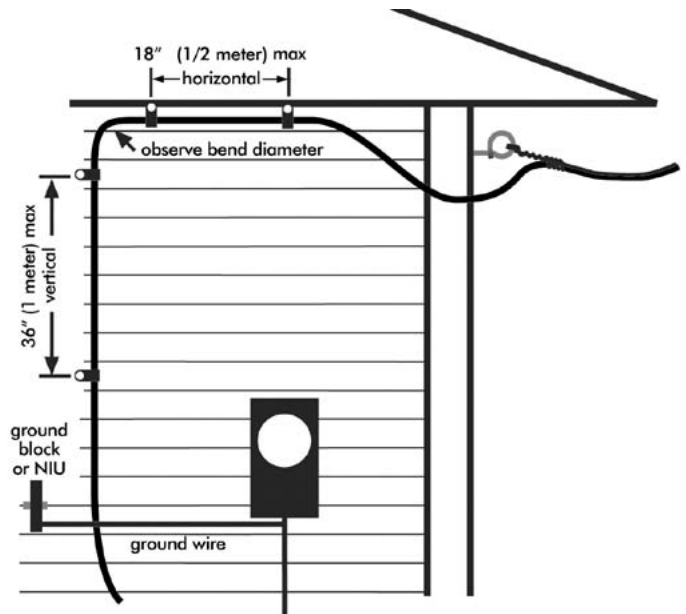
Use cable clips to attach the coaxial to the house. A variety of screw-in or nail-in clips are available for wood and masonry. Special snap-in clips are available for vinyl and aluminum siding. Never staple coaxial cable. Stapling will deform the dielectric and may damage the shield; in either case, a loss of performance will result and you will have to replace the cable.

Place your first clip so as to allow for a small drip loop. Then place the clips about every 3 feet (1 meter) for vertical runs and no farther apart than 18 inches (.5 meters) on horizontal runs.

Make sure you do not kink or bend the coaxial cable tighter than the recommended bend diameter (usually 10x its outer diameter—check your cable specs to be certain). All coaxial connections to the grounding block or splitters must be horizontal.

If connecting to a ground block, proceed to page 19 (attach the cable to the ground block/aerial installation). If connecting to an NIU, proceed to page 20 (attaching to the NIU—the 8 foot rule).

For NEC 830, use an insulated hook for attaching the messenger wire
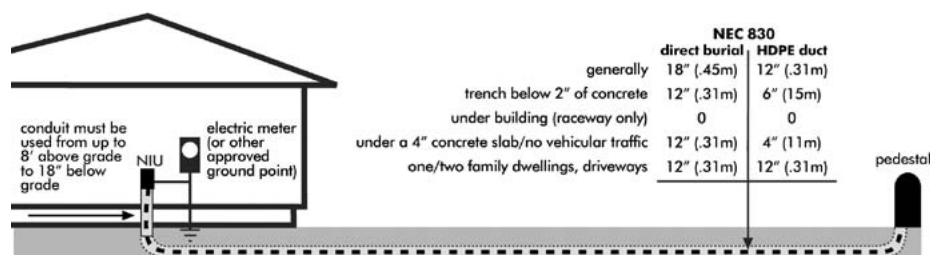

Buried installation

Underground service has become popular in many developments and subdivisions. Broadband services are brought in by buried cable, and accessed by pedestals which are usually at the property line.

While the easiest way to run the cable is to trench or plow in a burial-grade coaxial cable to a minimum depth of 12 inches (.3 m), **burying cable preinstalled in conduit is a far better method.** Cable in conduit (CIC) offers greater physical protection against environment, abrasion, rocks, etc., than direct burial, which can prolong the life of the cable. And, should the cable ever fail, it can be replaced without digging up the yard. CIC of 1/2 inch (13 mm) to 3/4 inch (21 mm) is recommended. If you are directly burying cable without using conduit, you should use an 18 inches (45 cm) length of it to protect the cable 6 inches (15 cm) below and 12 inches (30 cm) above grade where it emerges next to the residence.

Article 830 considerations

Systems that use coaxial cable to carry up to 150 volts of power (as well as signal) to an NIU fall under NEC 830 regulations. Pay special attention to the buried cable depth as shown in the diagram below. Note that CIC (HDPE conduit) doesn't need to be buried as deeply as direct burial installations.

Although NEC 830 permits the use of metal conduit, CommScope does not recommend its use. Problems with rust, water migration, and potential damage to the cable jacket due to cutting and scraping during installation are possible results of using metal conduit. Frozen water will crush cable in a metal conduit, but HDPE conduit will allow the ice to expand and save the cable.

NEC 830		
	direct burial	HDPE duct
generally	18" (.45m)	12" (.31m)
trench below 2" of concrete	12" (.31m)	6" (15m)
under building (raceway only)	0	0
under a 4" concrete slab/no vehicular traffic	12" (.31m)	4" (11m)
one/two family dwellings, driveways	12" (.31m)	12" (.31m)

Plowing installation notes

Direct burial cable and cable in conduit (CIC) may be installed by trenching or plowing. When plowing, select a plow chute with a bend radius no smaller (and preferably larger) than the minimum bend radius of the cable or CIC you are installing. The chute width should be at least 1/2 inch (1.25 cm) larger in diameter than the cable/CIC.

At the pedestal, dig a trench deep enough and at least twice the length of the plow blade/chute for the plow blade to enter it comfortably. A similar trench should be dug near the attachment point at the residence. The cable/CIC may pay-off from the front of the walk-behind plow or from a stationary reel along the route.

Carefully pull enough cable/CIC through the blade to comfortably allow for connectorization. Once the blade is completely in the ground, manually feed the cable/CIC into the plow blade.

In the walk-behind plow method, pay the cable/CIC over the top of the reel. Do not use reel brakes. In the stationary reel method, pull the cable/CIC end from the reel to the starting trench. With CIC, make sure both ends of the conduit are capped.
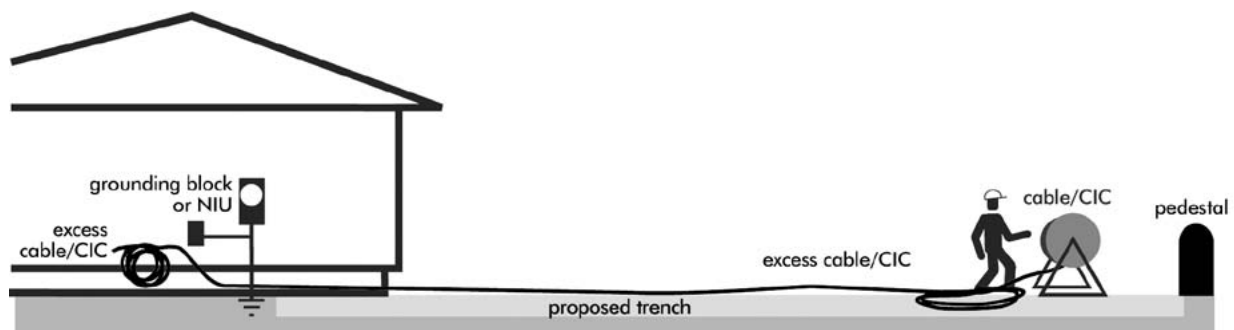

Trenching installation notes

The trench should be dug as straight, level and as rock-free as possible. Avoid tight curves. If there are rapid grade changes, and you are installing CIC, use back-fill to support the conduit. Taking into account NEC 820 and 830 considerations, dig the trench to correct depth.

Mount the reel so that pay-off is underneath toward the direction of the pull. If using CIC, make sure the conduit is capped.

Pull enough excess cable to permit easy installation at the attachment point and enough to reach a few feet beyond the pedestal. When in doubt of the exact length, always play out more than you think you will need.

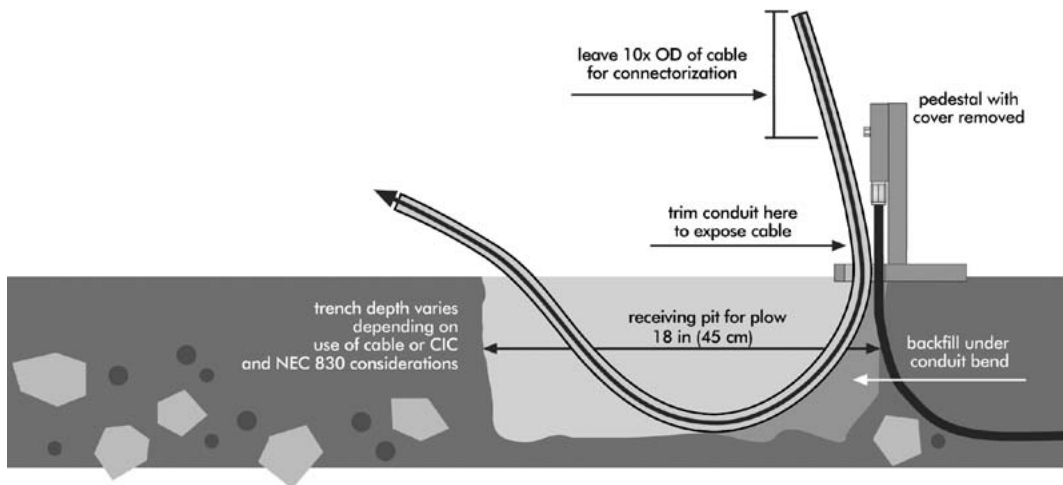# Pedestal preparation

Plowing

Dig a receiving pit to the depth required by either NEC 820 or 830, depending on your application (between 12 and 18 inches (30 and 45 cm) (see page 17). The pit should be about 6 inches (15 cm) wide and 18 inches (45 cm) long and run in the direction of planned line of the installation. The plow blade should be able to fit easily inside it.

Feed your cable or CIC through the plow blade and run it to the bottom of the pit and up through the pedestal base. The rule of thumb is to leave at least 10 times the outer diameter of the cable for easy connectorization and leaving some spare cable for connector replacement. If using CIC, tamp some dirt in as backfill support for the curve of the conduit.

If you are using CIC, keep the end capped until you've initially placed the cable. Use a ratchet shear (such as the Reed RS#1) to trim off the excess conduit. Fill the conduit end with a watertight sealing foam.

Trenching

If trenching, unreel your cable or conduit as shown on page 17. The only difference is that you will not need a receiving pit, as you will already have the trench dug.

Running the cable and connecting the drop at the pedestal

Plow to the residence

If you are plowing in the cable or CIC, make sure you have dug a receiving trench to the attachment point of the residence. Run the plow along your planned route to the attachment point. Remember that, for NEC 830 considerations, cable not in conduit must be buried at a depth of 18 inches (45 cm). You may not be able to run the tractor directly to the attachment point; if not, dig a larger receiving pit.
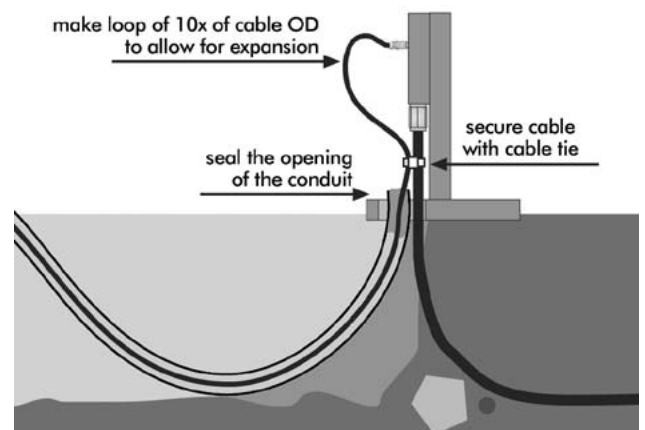
Trench to the residence

If you are trenching the installation, dig a trench of correct depth from the pedestal to the attachment point on the residence (see chart on buried installation overview).

Connectorize and attach the cable

After the cable has been placed, connectorize the cable per the instructions in the Coaxial connectorization section. Once the cable is connectorized, attach it firmly to the tap. Leave a loop of cable 10 times the outer diameter of the cable to allow for expansion and to leave extra cable should reconnectorization ever be required. Use the sealing sleeve to protect the connection from moisture.

Attach an identification tag to the cable. This is especially important if there are multiple taps at the pedestal. Use a cable tie to secure the lower part of the cable to the pedestal in order to keep the cable out of any dirt or water. If you are using conduit, seal the end of the conduit with either a waterproof expanding foam or with a duct cap. Once the cable is connected and the connections sealed, close the pedestal.
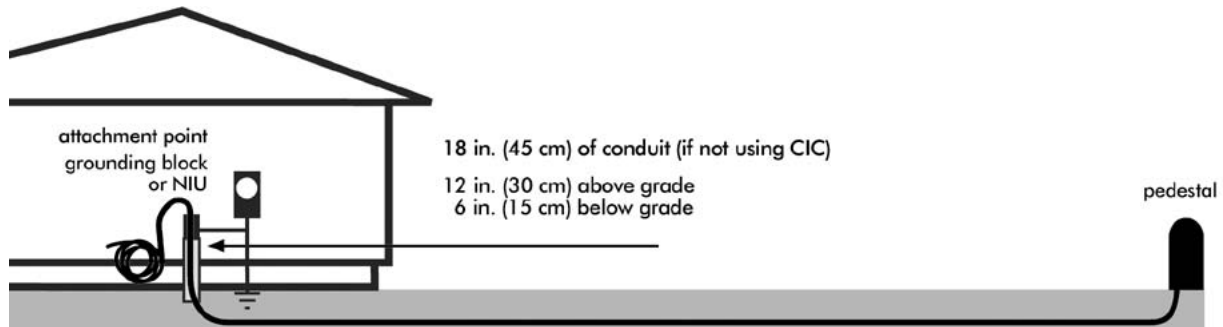
Attach the cable to the residence

Plow installation
Unreel the cable/CIC by hand until you have more than enough to reach the attachment point. Always err on the side of having too much cable.

If you have installed CIC, determine how much conduit you need to reach the attachment point. Using a ratchet shear, cut off the excess conduit to reveal the cable. Attach the conduit to the wall by using U-clamps. If you are not using CIC, use an 18-inch (45 cm) piece of HDPE or PVC conduit to protect the cable where it exits the earth. Place the conduit over the cable and run it down to the trench. Secure the

conduit to the wall with U-clamps so that 6 inches (15 cm) of cable is below grade and 12 inches (30 cm) is above grade. Seal the end of the conduit with either a waterproof expanding foam or with a duct cap.

Some installers favor an enclosure on the wall for the attachment point. If so, run enough conduit so as to touch the base of the enclosure, connecting the conduit using the enclosure manufacturer's instructions.

If connecting to a ground block, proceed to page 19 (Attach the cable to the ground block/aerial installation). If connecting to an NIU, proceed to page 20 (Attaching to the NIU—the 8 foot rule).

Attach the cable to the ground block/aerial installation

NEC Article 820 states that the ground block should be attached to the wall as close as possible to the electrical meter. Both the ground wire and the coaxial cable connections should run horizontally. The grounding wire should be as straight as possible.

The preferred bonding method is to attach the ground block's bonding wire to the electrical meter ground wire with a wire not less than 14 AWG in size. For recommendations regarding ground wires sizes, please refer to the National Electric Code (NEC 820-40) or your local building code. If bonding the

> **Tech tip:** test the bond with a voltmeter to ensure it's properly connected

ground block to the meter is not possible, you may bond to an exterior metal cold water pipe running into the earth. As a last resort, you may drive an 8-foot ground rod into the earth and attach the bonding wire to that, but you will need to ground ALL of the grounds of the residence to that rod.
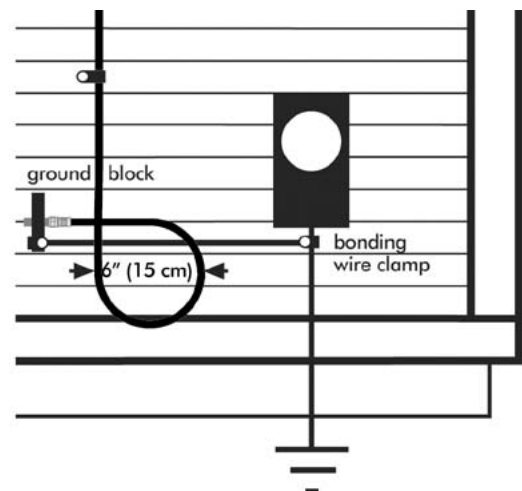
Special circumstances for mobile homes
Bond mobile homes at the electrical service tap. If there is no service tap, you may bond to the frame of the mobile home using a wire no smaller that 12 AWG. NEVER bond to the siding of a mobile home.

Connectorize the cable and form a loop
Once the bond is attached, cut the coaxial cable so you have a sufficient amount to reach the ground block comfortably plus about another 1 foot (30 cm). Connectorize the cable (see page 14) and attach it to the ground block. Then form a 6-inch (15 cm) diameter loop and secure it with a cable tie. This extra cable will be useful if you ever need to re-connectorize the cable.

Run and attach the cable to the ground block/buried installation

NEC Article 820 states that the ground block should be attached to the wall as close as possible to the electrical meter. Both the ground wire and the coaxial cable connections should run horizontally. The grounding wire should be as straight as possible.

The preferred bonding method is to attach the ground block's bonding wire to the electrical meter ground wire with a wire not less than 14 AWG in size. For recommendations regarding ground wire sizes, please refer to the National Electric Code (NEC 820-40) or your local building code. If bonding the ground block to the meter is not possible, you may bond to an exterior metal cold water pipe running into the earth. As a last resort, you may drive an 8 foot ground rod into the earth and attach the bonding wire to that, but you will need to ground ALL of the grounds of the residence to that rod.
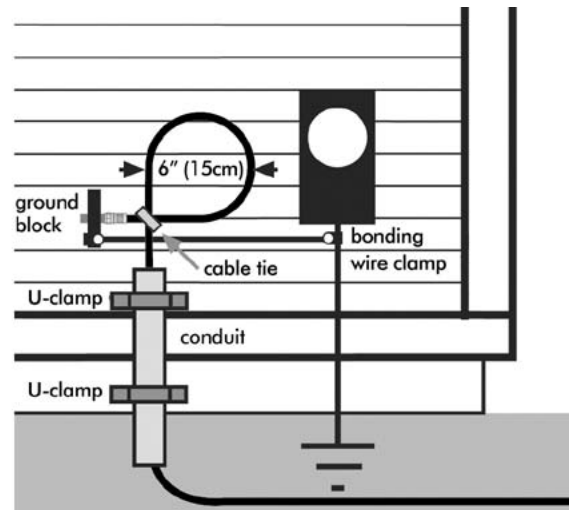
> **Tech tip:** test the ground with a voltmeter to ensure it's properly connected

Special circumstances for mobile homes
Bond mobile homes at the electrical service tap. If there is no service tap, you may bond to the frame of the mobile home using a wire no smaller that 12 AWG. NEVER bond to the siding of a mobile home.

Connectorize the cable and form a loop
Once the ground is attached, cut the coaxial cable so that you have a sufficient amount to reach the ground block comfortably plus about another 1 foot (30 cm). Connectorize the cable (see page 14) and attach it to the ground block, Then form a 6-inch (15 cm) diameter loop and secure it with a cable tie. This extra cable will be useful if you ever need to re-connectorize the cable.

Attaching to the NIU—the 8 foot rule

NEC Article 830 covers the installation of cable from the tap to the connection of the NIU. NEC 830-rated cables supply the voltage that powers the NIU. The NIU then distributes the various signals coming in over the drop (CATV, internet, telephone service, etc.) onto the preferred cable and connections that branch from the NIU throughout the residence. These interior cables (NEC 820 coaxial, NEC 800 twisted pair, NEC 770 fiber optic) carry very low, if any, voltage.
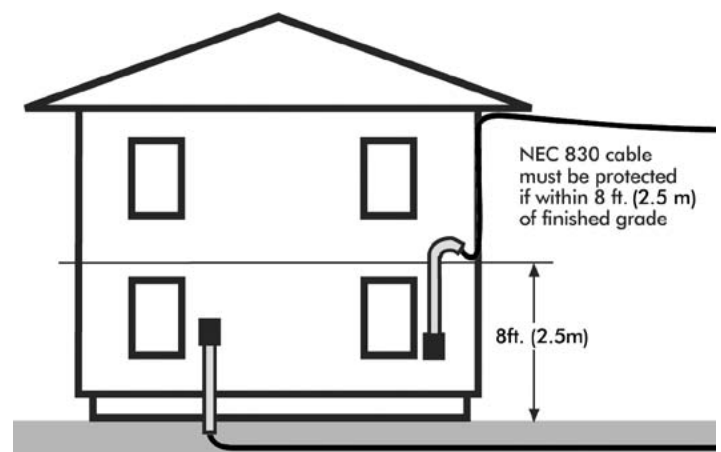
Page 13 (aerial installation) and page 15 (buried drop installation) discuss the distances required for a safe installation of NEC 830 cable and service to the residence.

The 8 foot rule
NEC 830 requires that powered broadband cables that are attached to a building within 8 feet (2.5 meters) of the finished grade **must be protected by molding or conduit.** If you are using CIC, this requirement is easily met by extending the conduit from the ground to the entry point.

If you are using direct burial cable without conduit, you must run the cable in conduit starting 18 inches (45 cm) below finished grade and finishing in contact with the NIU enclosure.

With an aerial installation, the cable should be placed in conduit with a J-joint at the top to prevent water from getting into the NIU, and then run to the top of the NIU enclosure.

NEC 830 cable must be protected if within 8 ft. (2.5 m) of finished grade

8ft. (2.5m)

Bonding the NIU

Bonding the NIU is similar to bonding a standard coaxial cable installation (see page 19/Attach the cable to the ground block/aerial installation). You should attach the NIU to the wall as closely as possible to the electrical meter. The bonding wire is attached to a point within the NIU enclosure. Specific bonding points will vary with each make of NIU, so please consult the manufacturer's instructions. In all cases, the bonding wire should be as straight as possible and run horizontally to the attachment point at the meter.
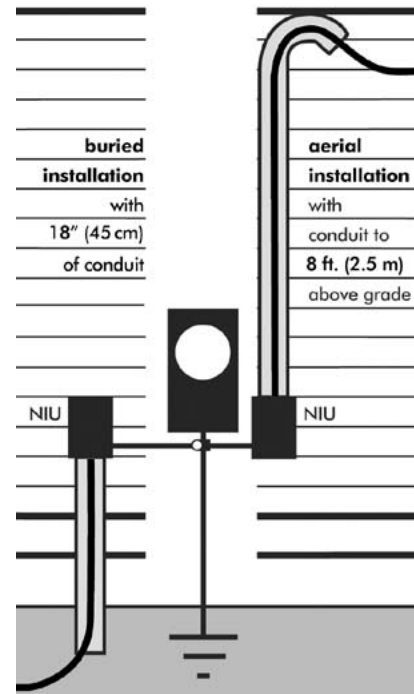
The preferred bonding method is to attach the NIU's bond to the electrical meter ground wire with a wire not less than 14 AWG in size. For recommendations regarding ground wire sizes, please refer to the National Electric Code (NEC 820-40) or your local building code.

If bonding the NIU to the meter is not possible, you may bond to an exterior metal cold water pipe running into the earth. As a last resort, you may drive an 8 foot ground rod into the earth and attach the bonding wire to that, but you will need to attach all of the grounds of the residence to that rod.

Connectorize the cable and attach it to the NIU
Once the ground is attached, cut the coaxial cable so you have a sufficient amount to comfortably reach the connection within the NIU plus about another 1 foot (30 cm), similar to the pedestal attachment (see page 18). Connectorize the cable (see page 26) and attach it to the NIU. If the cable is entering from above, form a small drip loop below the connection of the cable and the NIU. This loop will be useful if you have to re-connectorize the cable in the future.

The ability to recognize and avoid hazards is required of all construction personnel

buried installation with 18" (45 cm) of conduit

aerial installation with conduit to 8 ft. (2.5 m) above grade

NIU

NIU

Residential interior cabling—overview

By now, the drop has been run to the residence, attached and grounded at either the ground block or the NIU. How and where you enter the residence depends on the types of service that are going to be provided. If there is no NIU, you need to proceed from the ground block to the various locations around the residence, splitting the connections as you go. It may be to your advantage to use a ground block with a splitter so that two coaxial cables may be run in different directions. With an NIU, multiple and different cabling types may be used on the output side. A general rule is that CATV coaxial cable may be split, but phone and computer UTP should be home run to the NIU. Cable modems should be placed at the first split.
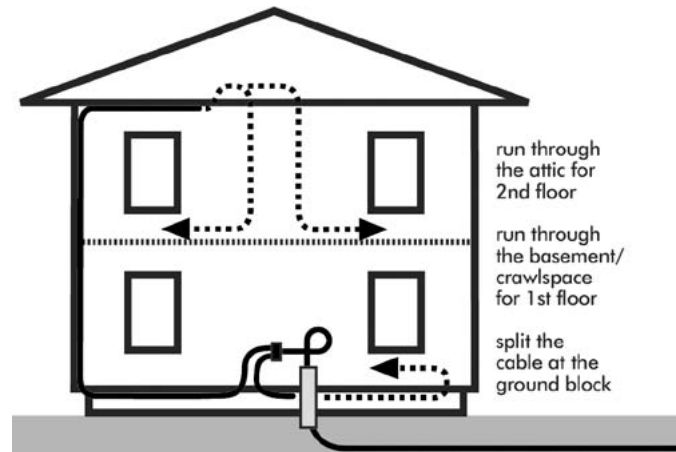
Article 830 considerations
Powered broadband cable must be terminated to a grounded location at an NIU (see page 20/Attaching to the NIU—the 8 foot rule for details). Except within the wall or in a conduit like commercial electrical cable, NEC 830 cable may not extend any farther than 50 feet (15.2 meters) within a residence.

Use the crawlspace, basement or attic to run cable
For the ground floor, plan your installation so the cable runs through the crawlspace or basement and then up through the floor or an interior wall to the outlets. For the upper floor, run up to and through the attic and then down through the walls to outlets.

If the crawlspace or basement present problems, another option is to run the cable around the outside of the residence. Be sure to use an outdoor-rated cable. Try to follow the architectural lines of the house and run the cable in places where the foundation meets the bottom of the exterior walls, or vertically along the corner trim, or under the soffit. You can bury cable next to the foundation (keeping in mind the burial depth per NEC 820). Avoid placing cable in direct sunlight, as that will accelerate cable aging. Consider a nonmetallic raceway to hide and protect the exterior cable.

run through the attic for 2nd floor

run through the basement/ crawlspace for 1st floor

split the cable at the ground block

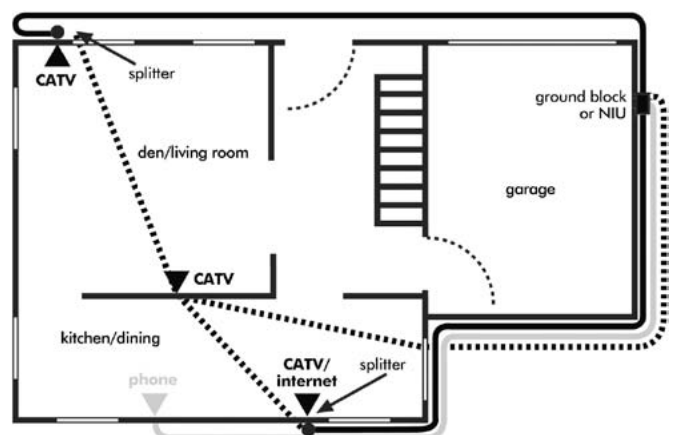# Planning the cable run/ground floor

Outlet locations are dictated by customer requirements—put them where they want them. Visually inspect every proposed outlet location. Be aware of the locations of electrical wires, plumbing, HVAC ductwork and other impediments. Use a stud finder to locate studs. As you plan your drops to specific locations within the residence, work within the interior walls whenever possible. This way, you avoid installation headaches like trying to push cable through insulation or around windows.

Tech tip: shorter cable runs produce clearer signals

In the example floor plan, the CATV and phone connections in the kitchen should be run beneath the house, but can just as easily be reached by running the appropriate cable (coaxial for CATV and internet, twisted pair from the NIU for phone and in-home data networks) along the foundation of the residence and entering through the exterior. In this case, the homeowner's concern for outside appearance should be your concern.

The CATV outlet in the corner of the living room can be reached by an exterior run up to the eaves above the garage door and back down at the corner of the house.

The CATV outlet on the interior wall is best reached by a home run back to the NIU through the crawlspace or basement. However, the coaxial cable could also be split from either of the two exterior connections. A splitter has one connection on the input side and two or more on the output side to evenly divide the signal between multiple cables.

CATV — splitter

den/living room

ground block or NIU

garage

CATV

kitchen/dining

phone

CATV/ internet — splitter

Locating and cutting outlet holes

Once outlet locations are determined, cut the holes as required. Carefully check the area for any possible obstructions, such as wall studs, plumbing or electrical wires. Be aware that obstructions like windows or interior openings like kitchen passthroughs may cause problems with dropping cables from above. Pocket doors are another concern; make sure the planned outlet is outside of their open range. Keep an eye open for creative routes to hide cable, such as running within closets.

Once you've settled on the precise locations, prepare to cut the holes.

(1) Mark the location
A communications outlet consists of the mounting bracket, the feet (which hold the bracket in the wall) and the faceplate. Using the mounting bracket as the template, trace a cutting pattern on the drywall, making sure there are no studs behind it. Match the orientation (vertical or horizontal) with the other outlets in the room and make sure your planned cut is level.
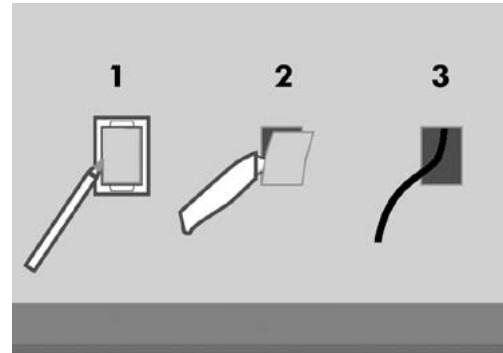
(2) Cut the opening
Using a drywall knife, utility knife or saw, cut the opening. Do not install the bracket yet; the metal edges may damage the cable during pulling and installation.

(3) Run the cable
Once the cable has been run, you may install the bracket and terminate the cable (see page 28).

Other wall surfaces
Older homes may have plaster and lath walls that will require a small rotary saw, or a cutout tool to cleanly penetrate and cut. Masonry walls will require a surface-mounted box screwed into the brick and a cable raceway to hide the cable.

Going through an exterior wall

Survey the interior of the residence for the outlet location. Using a point of reference that is common to both the inside and the outside (such as the lower corner of a window pane), measure the vertical and horizontal distances to the center of the outlet location (example: 1.5 feet over and 1 foot down from the lower corner of the window). Check again for obvious interference from electrical outlets, wall studs, plumbing, etc. **You may want to shut off any nearby electrical circuit, as accidental contact with live service may result in a fatal shock.**
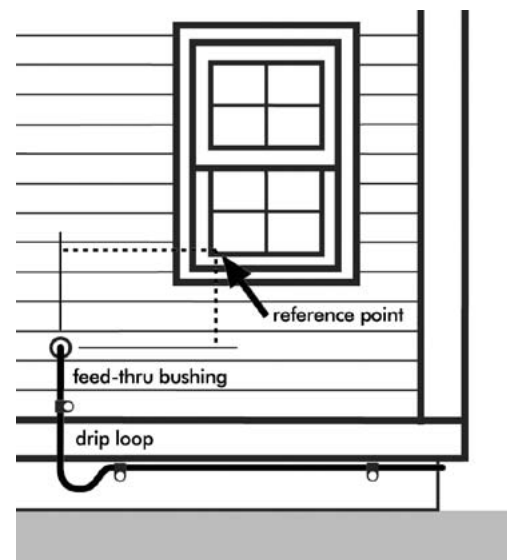
> **Tech tip:** use electrical outlet boxes to help find wall studs; they are attached to them

From the outside, measure from the reference point and **drill a thin pilot hole at a slight upward angle** to prevent water from later seeping in through the hole. If you are going through masonry, use a masonry bit and drill through the mortar, not the brick. If the pilot hole checks out, enlarge the hole with a larger bit. Insert a feed-through bushing.

On the inside, cut the outlet opening in the drywall. Do not install the bracket yet; the metal edges may damage the cable during installation.

Set your A-frame or cable box at the ground block/NIU and pull the cable with you to the entry point. Allow extra cable for running through the wall as well as forming a 5-inch (13-centemeter) drip loop. Use cable clips to attach the cable to the foundation of the residence.

Pass the cable through the bushing and through the hole in the drywall. Allow plenty of cable for termination. Form the drip loop and place your last fastener. Seal the bushing with RTV silicone or a similar weatherproof sealant.

reference point

feed-thru bushing

drip loop

Crawlspace and basement

Prior to entering a crawlspace or an unfinished basement, look and make sure that your planned entry point is not blocked by plumbing or unexpected obstructions like spoil left during construction. It may be possible to bring the cable through the crawlspace entrance. If not, use a masonry bit to drill through the foundation. Insert a feed-through bushing and pull the cable through; allow plenty of extra cable for reaching the outlet on the main floor.

> **Tech tip:** when drilling, use the sharp, stiff wire used to hold floor insulation in place or a piece of coathanger—a drill bit will tear up carpet
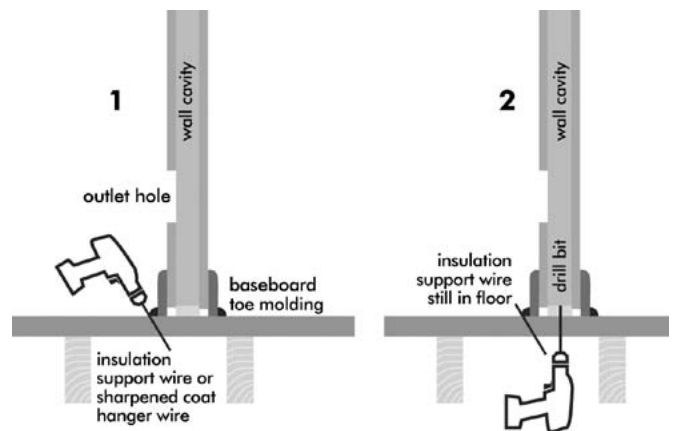
In a finished basement, plan your point of entry as close to the ceiling as possible and drill from the inside. Place your feed-through bushing and run the cable to the inside. With a hung ceiling, you may be able to run the cable on top of that, attaching the cable to floor joists. Otherwise, run the cable around the top edge of the room, and then cross to your ceiling entry parallel to the walls. Wire mold can be used to hide the cable.

Finding the wall from below
At the outlet location, trace and cut your outlet hole. Then use a stiff, sharp piece of wire to drill a pilot hole right at the base of the toe molding (to leave no sign of a pilot hole at all, remove the toe molding and drill from the base of the remaining molding or the drywall). When you feel you've broken through the floor, **detach the wire from the drill and leave it in the floor**.

Go under the floor and locate the wire. Measure in about 1 inch (2.5 cm) (more if you drilled in at a very steep angle) and, using a thin bit, drill a pilot hole straight up to make sure you're in the wall. Enlarge the hole to accommodate the cable and pull through enough for easy connectorization.

Use cable clips to attach cable to the floor joists.
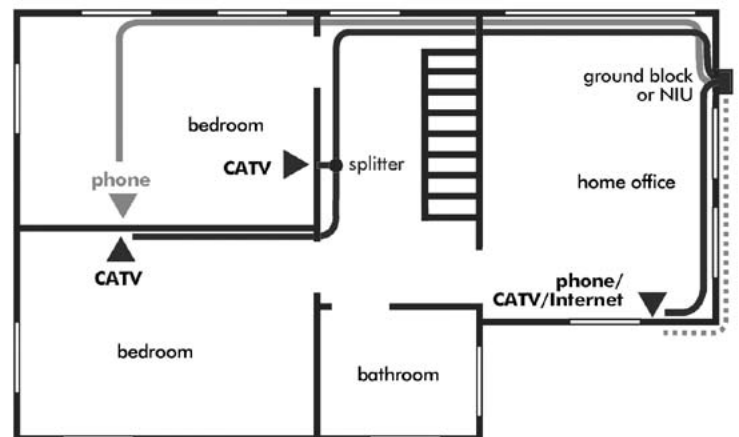

Planning the cable run/upper floor

Visually inspect the outlet locations for electrical wires, plumbing, HVAC ductwork, windows and other impediments. Use the interior walls whenever possible. This way, you avoid installation headaches like trying to push cable through insulation or around windows, or reaching under a roofline with a drill.

In the example below, all of the outlets can be reached from the attic. The phone outlet in the home office can also be reached from the exterior by running a cable up to the eaves and then across and down to the outlet location (consider a coaxial/UTP combination cable for this location). For the interior CATV outlets, a home run back to the NIU is preferred, but the CATV line can be split and continued.

Run the shortest distance possible, but avoid aisles and areas used for storage. You may need to run around the eaves, or even clip cable along the inside of the roof and come down a pillar.

The attic is usually accessed from outside by running the cable up the corner of an exterior wall. Before you drill, inspect the attic and check for any obstructions or clutter. Running cable up from the crawlspace or basement is a better and far less obtrusive method of getting to the attic. There may be an existing chase, but you may need to "fish" the cable up and alongside plumbing or HVAC ducting. See page 25 for instructions.

If entering from the outside, drill your entry hole at the roofline or slightly above it at a slightly upward angle. Use a feed-through bushing to prep the hole (see page 23). Feed the cable through the bushing and over to the drop; take more cable than you'll need. Remember to seal the bushing after the cable is pulled into place.

Using fish tape to run cable

Once cable is run to the attic, it can be fished through interior walls to the outlet location. Fishing cable usually requires two people: one at the top to feed the fish tape and a helper to receive the tape. A pair of walkie-talkies is a big help during this process. **Use a nonmetallic fish tape to avoid electrical shock.**

Locate the drop point
The top of the walls should be visible under the beams in the attic. You can locate the studs by looking for the nailheads on the cap, or top board, of the wall. Measuring from a common point, such as the exterior wall, will give you an approximate reference point. Drill through the wall cap.
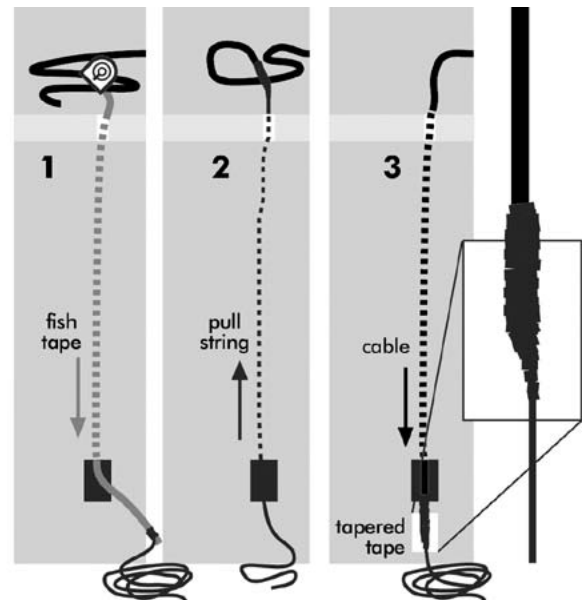
1) Fish the tape
Cut the opening for the outlet as in page 23. Run the fish tape through the hole and into the wall. The helper below should be able to hear the tape slide down the wall. It may be that you have entered the wrong wall cavity. If so, drill a new hole in the proper location. Once the tape has reached the outlet hole, have the helper tape a pull string to the tape. Retrieve the tape and the string.

2) Attach the cable to the string
Tie the pull string to the fish tape, then use several turns of electrician's tape to secure about 6 in (15 cm) of cable to the string. For easier pulling, build the tape up into a shape with tapered end.

3) Pull the cable down
While feeding the cable through the wall, have the helper gently but firmly pull the cable down to the outlet. If the cable snags, pull the cable back up and try again. Once the cable is at the outlet, untape it from the pull string and draw enough cable to make a connection.

Hiding cable

It is not always possible to run a cable to its planned location within the wall. If the locations cannot be changed, there are alternate methods of running and hiding cables.
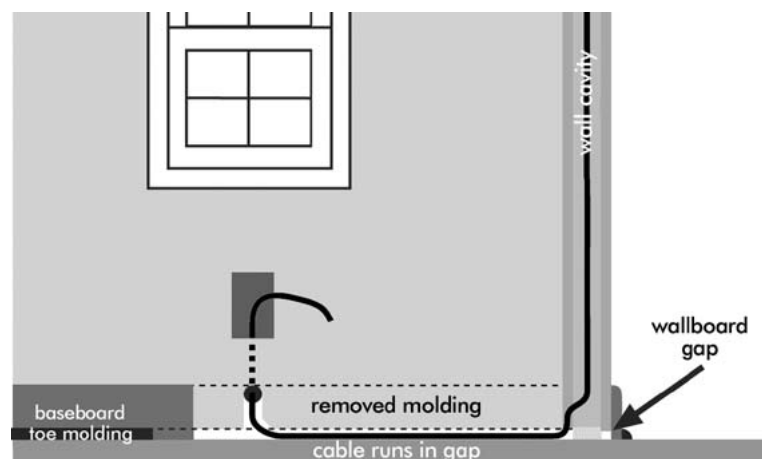
Under the wallboard
Many houses have a gap at the bottom of the wall that is covered by the floor molding. This gap is usually wide enough to provide a hidden cable path around a room. Floor molding usually consists of a toe molding and a baseboard. Both must be very gradually removed in sections. Toe molding is usually nailed in at an angle, so loosen it gently, prying about 18 inches (50 cm) apart, both up from the floor and out from the wall. Place a cloth behind your prying tool so as not to damage the floor or wall. Baseboards are usually nailed straight in to the wall studs. Gently pry them a very small bit at a time away from the wall so as to evenly remove the entire board.

Cable can now be run in the gap between the drywall and the floor. When you get to the outlet location, use a drywall knife to carve a vertical channel wide enough for the cable and about 2 inches (5 cm) in height. Make sure the molding is tall enough to cover the channel. Use a drill to enter the wall and pull the cable up to the outlet hole.

Using raceway
Cable entering from the floor can be clipped to the wall and hidden with a covering molding. There are several commercial brands of raceway; some are nailed on, some are glued, some are self-adhesive. Consult the individual manufacturer for installation instructions.

Connectorizing braid-shielded coaxial cable

These instructions refer to general practices. Exact instructions may vary with the maker of the tools and connectors you are using. Always refer to the manufacturer's specifications.

If you are going to use a boot to protect the connection at the tap, or if you are using a compression fitting with an independent sleeve, slide it over the cable end first. Strip the end of the coaxial cable by clamping your cable prep tool around the cable, making sure the end of the cable is flush against the stop. Rotate the tool 3x clockwise, then 2x counterclockwise until you've achieved a clean cut.
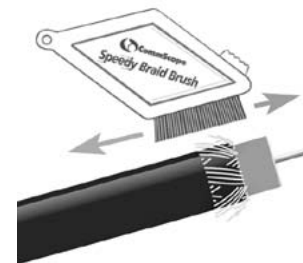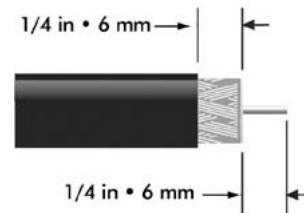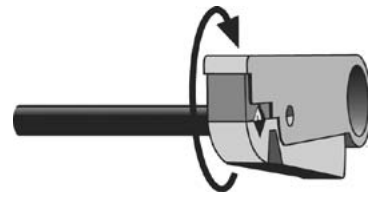
A clean cut will have a square end and the cable will have a round cross-section. The dimensions in the drawing are approximate; always check with your connector manufacturer for exact dimensions.

Carefully bend the braid back over the jacket. On tri- and super-shield cables, there is an outer layer of tape; carefully trim that away.

If you are using a crimp-style or one-piece compression connector, slide it over the cable end and use the crimping tool to firmly attach the connector. A good connection will have solid contact between the neck of the connector and the braid under it. The conductor should extend no more than 1/8 inch (3 mm) beyond the front edge of the connector.

If you are using a two-piece compression connector, slide the main boot over the cable. Then slide the compression sleeve up to the back of the connector. Use the proper compression tool to compress the connector to the manufacturer's specifications.

Tech tip: use a braid brush to brush back the braid. It makes connector insertion easier.

Connectorizing QR 320 solid shielded cable

QR 320 cables have a solid aluminum shield instead of a braid/foil shield combination. The dielectric needs to be cored out by the use of special tools. While the process is described below, you may wish to contact CommScope Digital Broadband Resource Center (866-333-3272) for more information.

A QR 320 coring tool, a file, a center conductor cleaning tool, wrenches sized for the connectors (adjustable wrenches are fine) and cable cutters are required. A high-torque, low-speed drill or a ratchet are optional, but will speed the process. Wearing safety glasses and gloves is recommended.

Prepare the cable by using the cable cutters to trim the cable to a smooth, round end.

Remove the proper amount of shield and dielectric with the QR 320 coring tool. Slide the cable into the tool until it stops. With slight forward pressure, twist the coring tool (either by hand or mechanically with the ratchet or drill) so the blade begins to strip and core the cable. Continue to turn the coring tool until it spins freely—the tool has a preset stop that requires no adjustment. Clean the dielectric and shield residue from the tool.

Clean the center conductor by using a nonmetallic cleaning tool. Score the coating on the center conductor at the shield and scrape it toward the end of the conductor. The conductor is clean if the copper is bright and shiny. DO NOT USE A KNIFE or other metal tool as it may damage the copper cladding.

Remove the correct amount of jacket with the QR 320 jacket removing tool. Slide the cable into the tool until the cable stops. Turn the tool clockwise to strip the jacket. Continue turning until it spins freely—the tool has a preset stop that requires no adjustment. **Remove any MigraHeal compound** that may be on the shield.

Slide the shrink tubing over the cable end, then attach the connector according to the manufacturer's instructions. Place and shrink the boot.

> **Note:** if you are using a heat-shrink boot (which is highly recommended), apply the flame carefully. Overuse of the torch may melt the jacket and dielectric.

Connectorizing UTP and telephone cable

These instructions refer to general practices. Exact instructions may vary with the maker of the tools and connectors you are using. Always refer to the manufacturer's specifications.

UTP—the twist is important
Twisted-pair cable twins its pairs together in a very precise lay, or frequency of twist. This lay provides a shielding effect that permits high-speed data signals to travel reasonably long distances with minimum interference. Maintaining that twist is essential to top performance, especially at the connector.
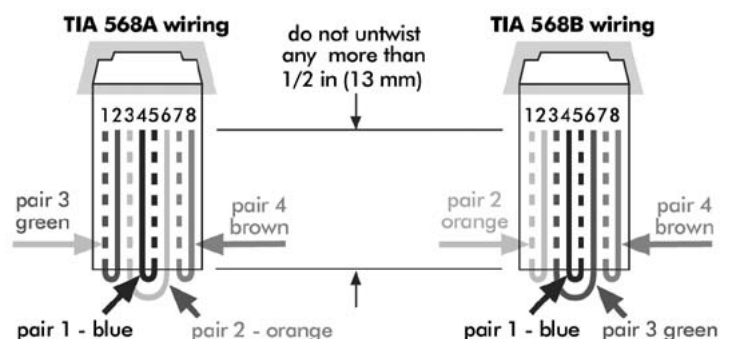
The majority of UTP data connectors are of the insulation displacement connector (IDC) type in an RJ45 size (eight-wire). As the wires are crimped into place, the insulation is automatically stripped away to permit clean conductor contact. Other proprietary tools and methods exist; consult your connector maker.

Use a ring tool to remove about 3 inches (7.5 cm) of jacketing. Electrician's snips can be used as long as you are careful not to nick or cut the insulation. This should expose four twisted pairs color-coded as pair 1/blue, pair 2/orange, pair 3/green and pair 4/brown. **When preparing the conductors for connectorization, do not untwist any more than 1/2 inch (1.3 cm) of the pair.**

The two most popular UTP wiring schemes are TIA 568A and TIA 568B. It doesn't matter which you choose as long as you are consistent throughout the installation. Place the conductors in the appropriate slots in the jack or the outlet (striped conductors in the odd slots, solid in the even) and crimp them into place with the appropriate crimping tool.

Phone wire
Follow the same rules as UTP; instead, use a standard four-wire RJ11 jack. The color of the conductors going across are 1/yellow, 2/green, 3/red and 4/black.

Trim-out and finish

With the cable run to the outlet, you can now trim out the installation.

1) Insert the bracket
Most brackets are meant to install directly to the drywall. Place the cable through the bracket and insert the bracket in the wall. Insert the "feet" at the bottom of the bracket so as to trap the drywall and the bracket. Tighten the attachment screw until the foot is firmly set. Repeat this process with the upper foot.

2) Attach the cable to the faceplate
Outlet faceplates will vary according to the cable type:

Coaxial faceplates require that you terminate the cable with a connector and then screw that connector to the female connection on the faceplate. To prevent cable twisting, turn the faceplate when attaching it to the connector, or just make sure you are turning only the hex nut of the connector and not the connector itself.

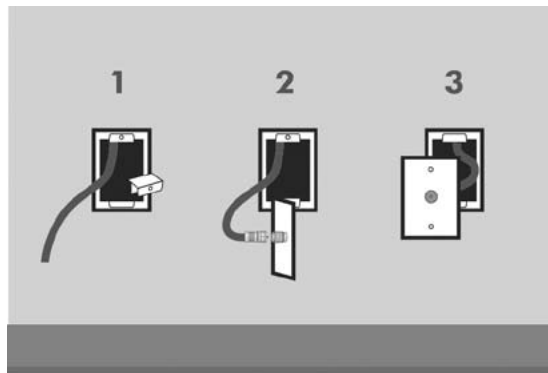**UTP data faceplates** require you to connectorize the cable to the jack. This is usually a separate component that snaps into the faceplate. Connectorize the cable like you did the jack on page 26, making sure you follow the same TIA568 pattern at all locations.

Telephone jacks usually require you to strip back the insulation and screw the wires into marked locations on the back of the faceplate.

3) Trim out the hole
Once the cable is connectorized and attached, carefully place the excess cable into the hole, making sure you do not exceed the bend radius or crimp the cable in any way.

Multidwelling units (MDUs)—overview

Multidwelling Units (MDUs) have a more strict set of rules for cable installation than single-family residences. Service is dropped from the tap to the building like a residential installation, either aerially (see page 16/Buried installation) or underground (see page 19/Attach the cable to the ground block/aerial installation). However, the cable is usually run to some sort of interconnect box, which allows the service provider to secure the connection and prevent tampering. This box may be inside or outside the building.

A building with two or more apartments or condominiums is not considered to be a single-family residence and is governed by commercial building and safety regulations. For instance, you may need to use riser-rated cables instead of CATV-rated residential cables. A general rule of thumb is if the cable penetrates the floor (if it runs vertically between floors), then you must use a riser-rated cable (CATVR for coaxial, CMR for UTP, OFNR for fiber). The riser cable is then run horizontally to the outlet (while you may use a lower rated cable for horizontal runs, the extra time and cost of termination outweigh the cost difference between the cables). You may use CATV cable inside metal conduit to pass between floors, though using a riser-rated cable is much easier.

> **Tech tip:** review page 22 (residential interior cabling) for complete advice on running cables inside a structure

Signal amplification
Another issue to consider is amplification. The signal being carried by the drop could be split literally dozens of times, thus decreasing its strength to the point where it is no longer viable. This is solved by installing a line amplifier before the cross connection. While most amplifiers are powered by the voltage in the cable, some require connection to 110/120V power. Consult the directions from the manufacturer for specific powering instructions.

The run from the cross connect to the apartment could be several hundred feet. You may wish to consider upgrading your cable (example: from F11 to QR 320) or installing another line amplifier along the route.

Article 830 considerations
The same rules apply concerning aerial distances (page 13), burial depth (page 16) and use of raceway or conduit within 8 feet (2.5 m) of the ground as residential installation. Article 830 also permits you to transition up to 50 feet (15.2 m) of cable to meet an interior-mounted NIU. Longer runs require that the cable be run in metal conduit or within the wall like electrical wiring.
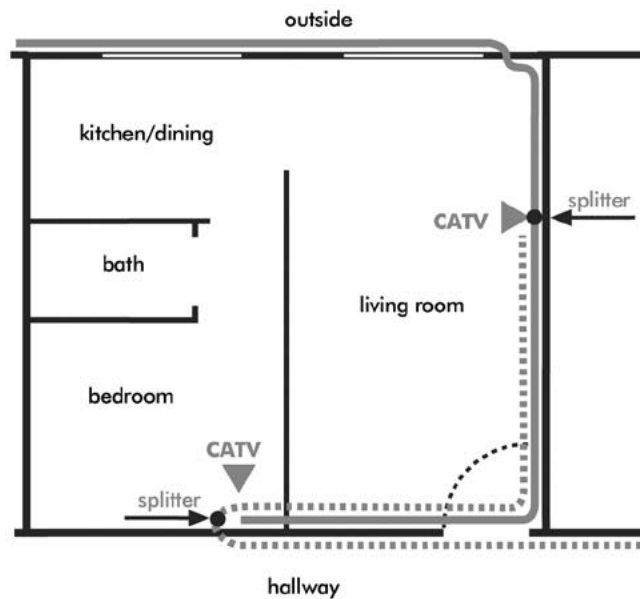
Planning the cable run in the apartment

Customer needs dictate where the outlets are located. Visually inspect every proposed outlet location. Be aware of potential problems like electrical outlets or HVAC ducting. You may not have the ability to drop cable from an attic or run up from a crawlspace, so your routing options may be limited. The preferred method would be to follow telecommunication conduit (if it exists) into the building. If not, consider the options shown below.

From the outside
In the example floor plan, there are two ways to bring the cable in. The solid line shows running the cable from the exterior, entering the wall and running to the two locations. A suggested routing would be to bring the outdoor cable in at the ceiling line, run the cable along the top of the wall and split it there. Use methods described on page 23 to position the entry point correctly. You can run nonrated cables a maximum of 50 feet (15 meters) into an MDU; any further distance requires a CATV-rated cable. A CATV-rated cable is then either fished through or attached to the wall and concealed with wiremold to reach the outlet location. The cable then continues along the top of the wall, over the door and through the interior wall to the second outlet, where it is either fished or attached to the wall and hidden with wiremold.

From the inside
The dotted line shows a possible route from an interior hallway. Cable from a riser is run along the top of the hall wall and enters the apartment at the ceiling. Use methods described on page 22 (residential interior cabling) to position the entry point correctly. The cable is split and either fished through the wall or attached to the outside of the wall. The cable continues along the top of the wall, over the door and around to the second outlet, where it is fished or run down to the outlet location.
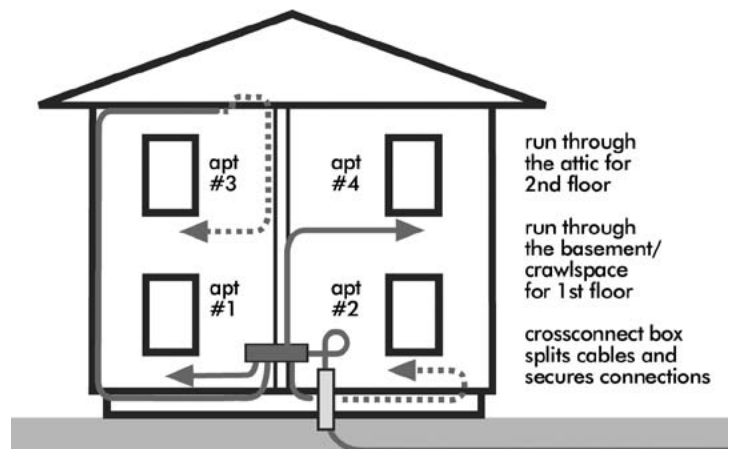

One- and two-story MDUs

For one- or two-story buildings, follow the same guidelines for running your cable on page 22 (residential interior cabling). A visual inspection of all proposed cable outlets is strongly recommended and will help you plan the best route for the cable.

Use the crawlspace, basement or attic to run cable
For the ground floor, plan your installation so that the cable runs through the crawlspace or basement and then up through the floor or an interior wall to the outlets. For the upper floor, run up to and through the attic and then down through the walls to outlets.

If the crawlspace or basement present problems, another option is to run the cable around the outside of the residence. Be sure to use an outdoor-rated cable. Try to follow the architectural lines of the house and run the cable in places like where the foundation meets the bottom of the exterior walls, or vertically along the corner trim, or under the soffit. You can even bury cable next to the foundation (keeping in mind the burial depth per NEC 820). Avoid placing cable in direct sunlight, as that will accelerate cable aging. Consider a nonmetallic raceway to hide and protect the exterior cable.

In this example, Apartment #1 is reached from the outside, running along the foundation and then upward to enter the wall. Apartment #2 is reached through the basement. Apartment #3 is reached through the attic. Apartment #4 is reached from the outside, with cable for #4 running up an architectural feature on the exterior wall. **Riser-rated cable is being used for Apartments 2 and 3 since a floor is being penetrated.**

run through the attic for 2nd floor

run through the basement/ crawlspace for 1st floor

crossconnect box splits cables and secures connections

Multiple-story MDUs/riser installation

Multiple apartments, multiple floors, and the extra distances involved all contribute to the complexity of an MDU installation. A helper is mandatory. A system designer will be required to specify whether and where line amplifiers are needed. As always, make a thorough visual inspection of the proposed route and all outlet locations. It may be that exterior installation is the only option; if so, see page 30.
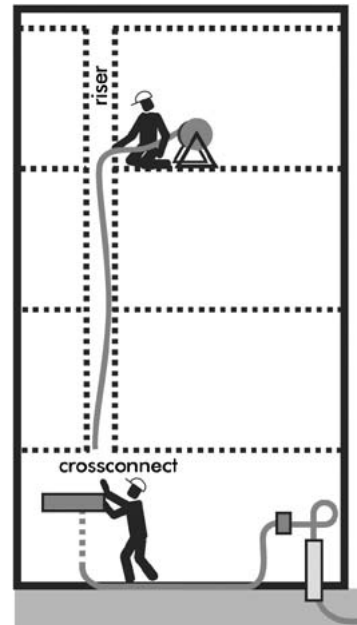
Reaching the cross connect
The drop should be grounded outside like a residential installation (see page 19/ Attach the cable to the ground block/aerial installation). From here, a cable may be run to an exterior cross connect or enter the building and attach to an internal cross connect that could be within a wiring or telecommunications closet. If you are using a powered cable (NEC 830) you may run 50 feet (15 meters) into the building without using conduit; any longer distance requires the use of metal conduit or placing cable within the wall.

Dropping cable to the closet
Check with the maintenance personnel of the building to locate any chases, risers, ductwork or conduit being used by electrical wiring. DO NOT place coaxial cable in the same conduit as electrical cable (unless it is a divided conduit). In a riser, coaxial cable must be run at least 12 inches (30 cm) from electrical wiring. Sometimes, elevator shafts can be used. The important thing is to use 1) riser-rated cable and 2) a cable with the performance required to carry the signal over the distance from closet to outlet. It could be that you will need a higher performance cable for the interior installation than you used for the drop because of the longer internal installation distance.

Set your cable reel or box near the riser entry point for the floor. Feed the cable down to a helper at the base of the riser. A congested telecommunications riser may require you to use fish tape to run the cable. See page 25 for specifics on using fish tape. Remember, you need to drop a cable for each apartment, so make sure the riser can accommodate the total number of cables you'll be using.

Multiple-story MDUs/exterior installation

It may be simpler to run the cable on the outside of the building up to each floor or each apartment. A separate cable will be needed for every unit. As always, make a thorough visual inspection of the proposed route and all outlet locations.

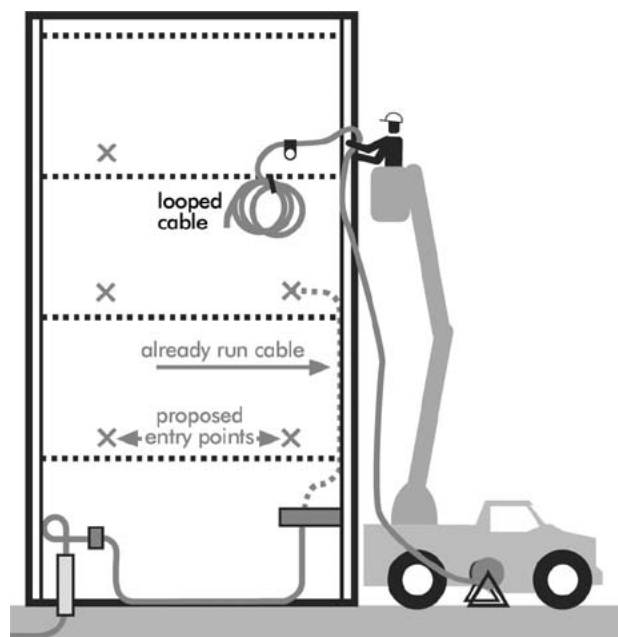Prior to installing the cable, read page 23 for the methods needed to locate and drill your entry hole.

Running cable to each unit
Use a ladder of greater height than required or a bucket truck to run the cable up the side of the building. Look for vertical and horizontal architectural elements that will help disguise the installation. Be sure you are using an outdoor-rated cable.

Take the cable end with you up to the entry point. Form more cable than you will need (you can never use too much) into a loose loop. Tie off the loop with a cable tie and attach the cable to the building wall with a cable clip. Don't let the loop hang free until you have at least two clips in the wall.

Continue to attach the cable to the wall using clips every 3 feet (1 meter) until you reach the point where you want to turn downward. Being careful not to exceed the bend radius, attach the cable to the wall as you descend.

Return to the entry point and enter the wall as described on page 23. Untie the cable loop and feed the cable through the hole.
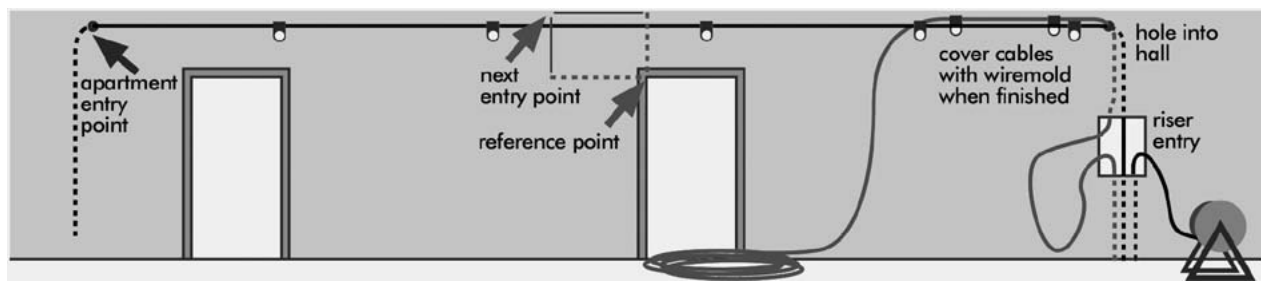
Multiple-story MDUs/inside the building

Unless you are able to share a conduit or routing with telecommunications wiring (you cannot run in the same conduit as electrical wiring unless the conduit is of the divided type), you may have to use a central hallway as your route. The challenge is to make the installation as unobtrusive as possible.

Hallway installation with raceway
The wall/ceiling joint offers a good route for interior installation. If there is a crown molding, carefully remove it (see page 25 for helpful hints). Starting from the riser, lay out the amount of cable needed to reach the apartment entry point. Calculate the amount of cable you'll need inside the apartment and double it; this will help prevent coming up short inside and the possible reinstallation of the whole cable length. Cut the cable. At the riser, drill a hole for the cable to enter the hallway. Bring the cable and run it through the hole into the hallway and then back to the apartment. Use methods described on page 23 to position the entry point correctly.

Use a stud finder to make sure you are drilling into a wall cavity. If possible, fish the cable down to the outlet location. Review page 22 (residential interior cabling) for details.

Once all the cables have been run, replace the crown molding or use wiremold to cover the cables.

Drop ceiling plenums
Cable can easily be laid on top of a suspended ceiling. However, the ceiling might be used as a plenum space (used for handling air for HVAC). If that is the case, you MUST either place the cable in metal conduit OR use a plenum-rated cable. See page 31 (Commercial installations—overview) for details.

Commercial installations—overview

Commercial installations differ from residential and MDU installations in several ways. Fire safety requirements are more strict. There may be cable raceways and ladders already in position to aid installation. The cable volume may be greater.

The general scheme of bonding to an exterior point such as the electrical meter still holds. The cable then will probably transition inside to a wiring closet with a cross-connect box for distribution within the facility. Depending on the size of the building, this main closet may connect to subclosets in other parts of the structure, or on different floors. Like MDU installations, you may need to consult a design engineer about using line amplification, or may wish to upgrade to a longer reach cable such as QR 320.

Wiring closets
Wiring closets (or telecommunication closets or TCs) can be rather complex. Literally hundreds of communication cables (phone, UTP, fiber) can be gathered here and interconnected through an array of patch panels and blocks. For specific instructions on connecting these types of cables, consult BICSI's excellent volume Residential Network Cabling published by McGraw-Hill.

Riser and plenum cables
Any time a cable penetrates a floor (goes vertically between one or several floors), you must either use a riser-rated cable (CATVR) or install your cable in metal conduit. You can also use the plenum (air-handling) space above a drop ceiling to run plenum-rated cables (CATVP) without using conduit. These cables are more flame retardant and produce less smoke during a fire. Many office cubicle systems have built-in raceways that allow you to drop cables from the plenum ceiling directly to the desktop.
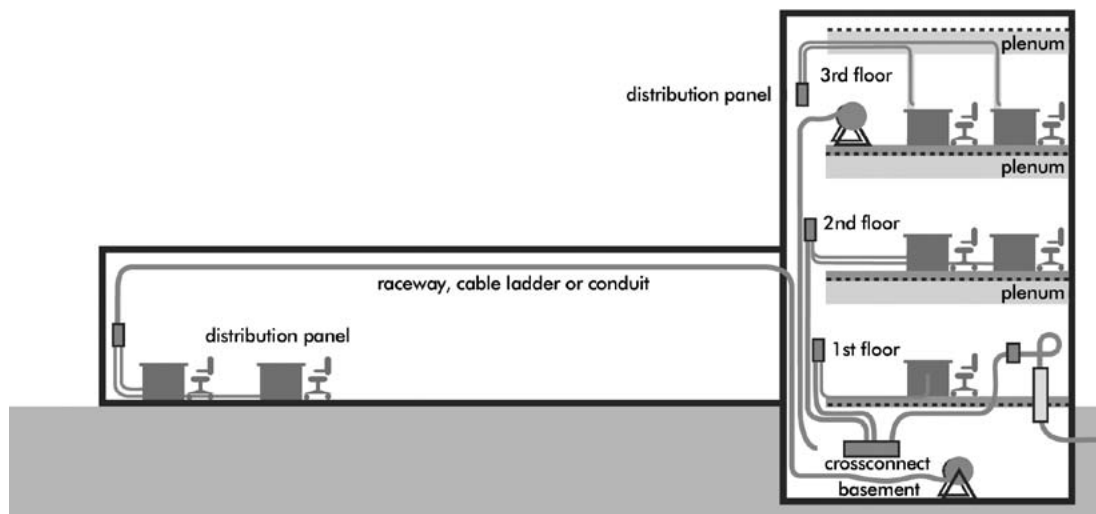
Article 830 considerations
The same rules apply concerning aerial distances (page 13), burial depth (page 16) and use of raceway or conduit within 8 feett (2.5 m) of the ground as residential installation. Article 830 also permits you to transition up to 50 feet (15.2 meters) of cable to meet an interior-mounted NIU. Longer runs require that the cable be run in metal conduit or within the wall like electrical wiring.

Wiring schemes

A typical schematic for wiring a commercial installation is shown below. Coaxial cable transitions from the bonding point into the basement of the building and is attached to a cross connect, probably in a wiring closet. Taking advantage of existing raceways and risers, riser-rated coaxial cable is pulled down the riser (or through the telecommunications conduit) from the higher floors. There, it is connected to a distribution panel and the horizontal cable runs are made.

On the third floor, plenum-rated cable is run through the ceiling spaces and dropped to the desktops through custom raceways. It can also be dropped in the walls to outlets. On the second floor, CATV coaxial cable can be used to run along the walls to outlets. It can be concealed with wiremold. On the first floor, a short run of CATV cable is run behind the floor molding and carried across the floor, protected by a tread raceway.

Due to the length of the long run to the far end of the building, a high-performance cable such as riser-rated QR 320, is run up and over from the wiring closet and across the building via raceway or cable ladder. If it is in a metal conduit, a cable with a lower fire rating may be used. Avoid using plenum cables for longer runs as they tend to attenuate faster.

Drop cable descriptions

On page 34 (Drop cable descriptions), the various types of subscriber access cables were generally discussed. This section details the differences in the varieties of coaxial cable used outside and inside the residence.

The construction examples given in the previous chapters deal with the most helpful types of coaxial cable; QR 320, 11 Series (RG 11) and 6 Series (RG 6). Commscope offers other types of coaxial cable as well, tuned to various uses within the residence. The full listing of our offerings includes:

QR 320 for longest reach and highest performance applications. The large 0.071 inch (1.80 mm) copper-covered solid aluminum conductor is coupled with a welded aluminum shield for maximum performance;

F11 series, recommended for use in runs of over 150 feet (45 meters), with a 14 AWG/1.63 mm copper-clad steel center conductor and a standard foil/60% braid construction. Tri-shield (foil/60 percent braid/foil) and Super-Shield (foil/60 percent braid/foil/40 percent braid) versions are available;

F6 series, recommended for use in runs of 150 feet (45 meters) or less, with an 18 AWG/1.02 mm copper-clad steel center conductor and a standard foil/60 percent braid construction. A foil/90 percent braid, Tri-Shield (foil/60 percent braid/foil) and Super-Shield (foil/60 percent braid/foil/40 percent braid) versions are available;

F59 series, recommended for very short runs, has an 0.032 inch (0.81 mm) copper-clad steel center conductor and a standard foil/67 percent braid construction. A foil/95 percent braid, Tri-Shield (foil/67 percent braid/foil) and Super-Shield (foil/53 percent braid/foil/35 percent braid) versions are available.

For further information on any of these cables, go to our website at www.commscope.com and download spec sheets, or call us at 1-800-982-1708 (1-828-324-2200 outside the U.S.).

Drop cable safety issues

Construction of a broadband cable system requires a substantial amount of manpower, tools and equipment. Underground and aerial construction will expose the manpower, tools and equipment to hazards, dependent on field conditions and circumstances.

The Occupational Safety and Health Administration (OSHA) defines a qualified employee as "any worker who, by reason of training and experience, has demonstrated his ability to safely perform his duties." Only a qualified employee should be assigned duties that could cause harm or potential harm to the construction crew, general public, cable plant, and other utilities.

This manual cannot identify the many hazards that exist in the construction environment, nor can it dictate the caution required with all of the tools, equipment and field conditions. CommScope continues this manual with the assumption that the construction personnel performing the work are qualified employees.

Three sets of national codes and standards apply to the construction of cable systems. Section 1910.268 of the OSHA Safety and Health Standards applies to work in telecommunications centers and field installations. The National Electric Code (NEC) applies to building utilization wiring, i.e., inside plant construction. The NEC applies specifically, but is not limited to, plant that is within or on public and private buildings or other structures. The National Electric Safety Code (NESC) generally applies to outside plant construction.

Municipal, state, county, and local codes are often applied to the construction of cable systems or work that involves their respective properties and right-of-ways. Pole lease agreements often stipulate specific practices related to safety.

The ability to recognize and avoid hazards is required of all construction personnel

These codes, regulations, and specified practices should be investigated, interpreted, communicated and observed.

Occupational Safety and Health Administration (OSHA) Standards

OSHA Standards were established in 1970 to help ensure workplace safety. The Standards are federal regulations that are intended to enable employers and employees to recognize, understand, and control hazards in the workplace. Standards have been established for general industry while some sections of the Standards are dedicated to specific industries such as telecommunications.

The generally applicable OSHA standards are found in:
Title 29 CFR Parts 1901.1 to 1910.441 General Industry, (OSHA), Order No. 869-019-00111-5
Excavations (OSHA 2226), Order No. 029-01600125-5
Underground Construction (Tunneling) (OSHA 3115)
Stairways and Ladders (OSHA 3124)

Copies of OSHA Standards can be obtained from:
Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402
(202) 783-3238

National Electric Code (NEC) Standards

The NEC typically identifies the construction techniques and materials necessary in building wiring requirements (i.e., inside plant construction) of fiber-optic or coaxial cable systems. The NEC has been developed by the National Fire Protection Association's (NFPA's) National Electric Code committee. Committee members are professionals from the electrical industry. The NEC addresses safety from fire and electrocution. The NEC has been adopted by the American National Standards Institute (ANSI).

Copies of NEC Standards can be obtained from:
National Fire Protection Association
1 Batterymarch Park/P.O. Box 9146
Quincy, MA 02269-3555
(800) 344-3555

NEC Articles 820 and 830

NEC Articles 820 and 830 both deal with broadband coaxial cable. Traditional coaxial networks carry a low-voltage radio frequency (RF) signal. The voltage is so low that it is not considered dangerous. NEC Article 820 is written with fire safety, not voltage, in mind.

However, with the advent of multiple services available over coaxial systems, the need for powered coaxial cable or UTP has risen. Some of these newer services require that a network interface unit (NIU) be installed at the subscriber's residence with the NIU being powered via the cable. Generally, if there is an NIU involved, the cable will have to be rated for NEC 830.

Basically, higher voltage NEC 830 cables need to be installed to provide greater protection for people than NEC 820 cables. Refer to the charts in Planning the run/Aerial installation or Aerial installation/buried installation for specific distances.

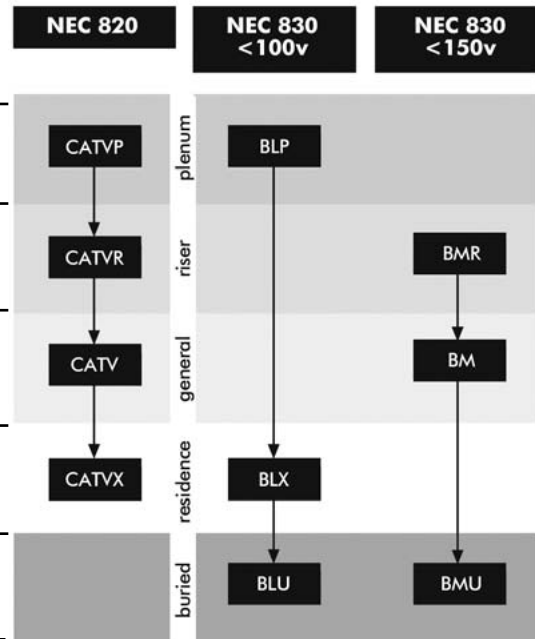Look for the cable rating on the jacket. The cable ratings are:

Plenum-rated cables, designed for use in plenums, ducts and air handling spaces, carry the strictest NEC rating.

Riser-rated cables are used in vertical shafts that penetrate more than one floor.

General purpose-rated cables may be used in locations other than plenums or risers.

Residential-rated cables are for use in one-, two-, and multifamily dwellings and in raceways.

Buried cables are for use underground alone or in conduit. This rating only concerns NEC 830 applications.

National Electric Safety Code (NESC) Standards and construction grades

The NESC defines grades of construction on the basis of strength requirements for reasons of safety. Section 24 of the NESC identifies construction grades B (the highest), C, D and N (the lowest).

Grade D construction typically applies to broadband coaxial cable and fiber-optic cable. Construction grades B or C may be applicable dependent on the situations that exist. If more than one grade of construction applies to a situation, the higher grade will apply. A qualified engineer should evaluate required construction and dictate the grade of construction. The strength requirements for the various grades of construction are defined within Section 26 of the NESC.

The NESC typically identifies the construction techniques and materials necessary in outside plant construction of electric supply or communication cable systems.The NESC is an American National Standard that has been written by a group of professionals that are concerned about the Standard's scope and provisions. The NESC has been adopted by the American National Standards Institute (ANSI). All references to the NESC in this manual are from the 2002 edition.

Special attention should be given to NESC Table 232-1, Vertical Clearance of Wires, Conductors, and Cables Above Ground, Roadway, Rail, or Water Surfaces, which is reproduced in part on the next page.

Copies of NESC Standards can be obtained from:
IEEE Service Center
445 Hoes Lane/P.O. Box 1331
Piscataway, NJ 08855-1331
(800) 678-4333

NESC table 232-1/vertical clearance of wires

This chart shows the clearances required for a coaxial cable, isolated communication conductors and cable, messengers and surge-protected wire meeting NESC Rule 230C1, depending on the type of surface it is above. For a complete listing, please contact the NESC at the address on page 34.

Surface	Minimum distance feet (meters)
Railroad tracks (except electrified railroads using overhead trolley conductors	23.5 (7.2)
Roads, streets, and other areas subject to truck traffic	15.5 (4.7)
Driveways, parking lots and alleys	15.5 (4.7)
Other land traversed by vehicles, such as cultivated, grazing, forest, orchard, etc.	15.5 (4.7)
Spaces and ways subject to pedestrians or restricted traffic only	9.5 (2.9)
Water areas not suitable for sailboating or where sailboating is prohibited	14.0 (4.0)
Water areas suitable for sailboating with an unobstructed surface area of: Less than 20 acres / Over 20 to 200 acres / Over 200 to 2000 acres / Over 2000 acres	17.5 (5.3) / 25.5 (7.8) / 31.5 (9.6) / 37.5 (11.4)
Land adjoining water areas posted for rigging or launching sailboats with an unobstructed surface area of: Less than 20 acres / Over 20 to 200 acres / Over 200 to 2000 acres / Over 2000 acres	22.5 (6.8) / 30.5 (9.3) / 36.5 (11.1) / 42.5 (12.9)

Pole lease agreements and other codes and regulations

Pole lease agreements
Cable system operators often enter into contractual agreements with the owners of utility poles. The pole owners are municipalities, telephone companies, and power companies. There are often specific safety practices that are specified in the contract. These safety practices may be more restrictive than other codes and standards. The contractual agreements should be investigated for safety requirements. The requirements should be interpreted, communicated and accordingly observed.

State, local, and municipal codes
State, local and municipal codes may also apply to the construction of the cable system. These codes will vary by location. These codes will have to be identified and applied as required on a location-specific basis.

Governing code or regulation
The more restrictive code or regulation must always be practiced.

The most restrictive code or regulation is the one that must be practiced

Broadband resource center—Your one-stop source for cable information

Responsive support and literally years of deployment experience make CommScope a unique build-out partner capable of walking you through broadband logistics each step of the way. To design and maintain high-speed, complex networks you'll need advanced levels of expertise. We realize that getting your technical personnel prepared to ascertain system requirements, understand engineering issues and select and install cable is not an insignificant hurdle. CommScope's Broadband Resource Center exists to help you overcome these obstacles. Our staff has skill sets from the RF, telephony, optical and internet worlds. We have a menu of services to help you develop technical competence and leadership within your own staff.

Building a reliable, future-proof broadband network requires not only the best technology, but also experience and assistance in deploying that technology. CommScope's Broadband Resource Center stands ready to assist you in your goal—the timely and cost-effective deployment of state-of-the-art broadband services.

Our management and technical staff represents over a century of combined experience in coaxial, fiber-optic and copper cable engineering and deployment. Members of CommScope's Broadband Resource Center team hold several patents and have been published in a variety of industry publications.

Active in your industry

Our employees are involved in industry trade groups such as Society of Cable Telecommunications Engineers (SCTE), National Cable Television Association (NCTA), Women In Cable and Telecommunications (WICT), Custom Electronics Design and Installation Association (CEDIA) and Home Builders Association of America (HBA).

Technical services & tools

Access to the Broadband Resource Center affords access to the a wide array of services and tools:

On-site custom training
Includes courses such as:

- Installation and splicing
- Construction logistics
- Broadband concepts

Call center support
Get advice such as:

- What products to order
- How to plan for construction
- What to expect along the way

**Training collateral—all available FREE;
just call customer service and request!**

- Comprehensive product catalogs
- Industry standard construction manuals (now available in English and Spanish!)
- Training videos available in DVD format (now available in English and Spanish!)
- Published articles
- White papers
- Internet website access to all product specification sheets
- Attenuation slide rules
- Specification assistance/review
- International experience
- Multilingual services available

Engineering services

- Laboratory analysis
- Standards committee support
- Field trials and troubleshooting support
- Sag and tension analysis

For more information about our Broadband Resource Center or for information on products, please contact us by phone at 1-866-333-3272 or send us an email at brc@commscope.com.

Everyone communicates. It's the essence of the human experience. *How* we communicate is evolving. Technology is reshaping the way we live, learn and thrive. The epicenter of this transformation is the network—our passion. Our experts are rethinking the purpose, role and usage of networks to help our customers increase bandwidth, expand capacity, enhance efficiency, speed deployment and simplify migration. From remote cell sites to massive sports arenas, from busy airports to state-of-the-art data centers—we provide the essential expertise and vital infrastructure your business needs to succeed. The world's most advanced networks rely on CommScope connectivity.

COMMSCOPE®

commscope.com

Visit our website or contact your local CommScope representative for more information.

CO-107145.1-EN (01/17)