Mike Holt's Illustrated Guide To

# COMMUNICATIONS SYSTEMS

Extracted from Understanding NEC® Requirements for Limited Energy and Communications Systems



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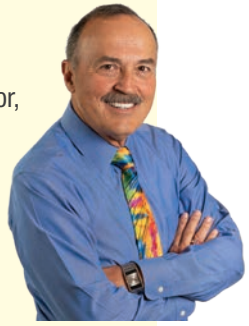


**Mike Holt** is an author, businessman, educator, speaker, publisher and *NEC®* expert. He has written hundreds of electrical training books and articles, founded three successful businesses, and has taught thousands of electrical *Code* seminars across the United States and internationally.

Mike's approach to electrical training is based on his own experience as an electrician, contractor, inspector and teacher. He's always felt a responsibility to his students and to the electrical industry to provide education beyond the scope of just passing an exam. This commitment, coupled with the lessons he learned at the University of Miami's MBA program, have helped him build one of the largest electrical training and publishing companies in the United States.

Mike's one-of-a-kind presentation style and his ability to simplify and clarify technical concepts explain his unique position as one of the premier educators and *Code* experts in the country. His passion for the electrical field drives his goal to increase electrical safety and improve lives.

Mike's commitment to pushing boundaries and setting high standards extends into his personal life. He's an eight-time Overall National Barefoot Waterski Champion with more than 20 gold medals, many national records, and he has competed in three World Barefoot Tournaments. In 2015, at the tender age of 64, he started a new adventure—competitive mountain bike racing. Every day he continues to find ways to motivate himself, both mentally and physically.

Mike and his wife, Linda, reside in New Mexico and Florida, and are the parents of seven children and six grandchildren. As his life has changed over the years, a few things have remained constant: his commitment to God, his love for his family, and doing what he can to change the lives of others through his products and seminars.

*I dedicate this book to the*
**Lord Jesus Christ,**
*my mentor and teacher.*
*Proverbs 16:3*

*Print Date: June 6, 2023*

ARTICLE

# 800

# GENERAL REQUIREMENTS FOR COMMUNICATIONS SYSTEMS

## Introduction to Article 800—General Requirements for Communications Systems

This article contains the general requirements applicable to all installations of coaxial cable [Article 800], hard-wired telephones [Article 805], and radio distribution systems [Article 820]. Many of these requirements mirror those contained in Article 722. Take special not that Article 810 is not included within the scope of this chapter. Many of these rules are outside of the scope of this material, however, some of the topics we cover include the following:

- Scope
- Access to Electrical Equipment Behind Panels Designed to Allow Access
- Abandoned Cable
- Spread of Fire or Products of Combustion
- Separation from Lightning Conductors
- Wiring
- Applications of Listed Communications Wires, Coaxial Cables, and Raceways

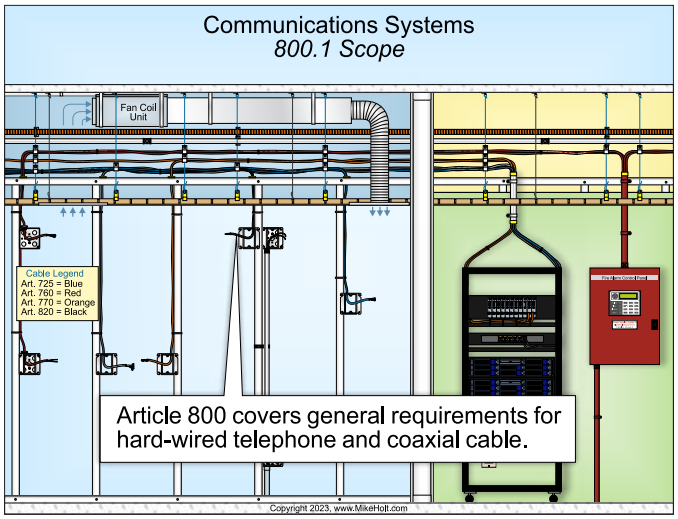
Article 800 consists of five parts:

- Part I. General
- Part II. Wires and Cables Outside and Entering Buildings
- Part III. Grounding Methods
- Part IV. Installation Methods Within Buildings
- Part V. Listing Requirements

# Part I. General

## 800.1 Scope

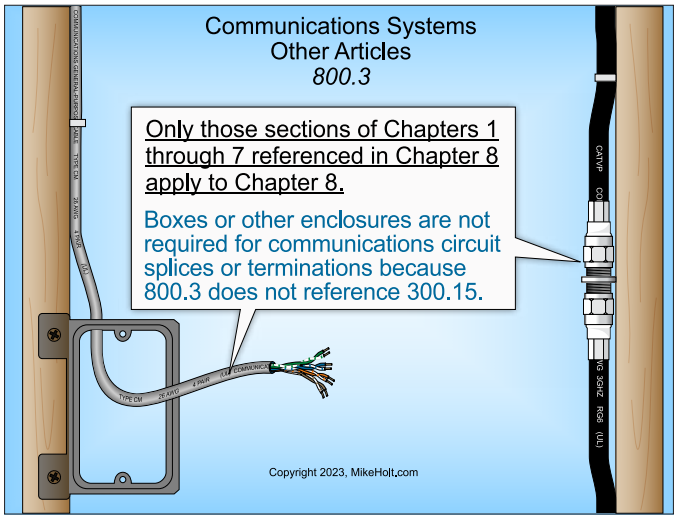
Article 800 covers general requirements for hard-wired telephones [Article 805] and Coaxial Cable [Article 820]. ▸Figure 800–1




▸Figure 800–1

## 800.3 Other Articles

Only those sections of Chapters 1 through 7 referenced in this article apply to Chapter 8. ▸Figure 800–2




▸Figure 800–2

**(A) Output Circuits.** As appropriate for the services provided, the output circuits derived from a network-powered broadband communications system's network interface unit (NIU) or from a premises-powered broadband communications system's network terminal must comply with the requirements of the following:

(1) Class 2 power-limited circuits—Part II of Article 725 and Parts I and II of Article 722

(2) Power-limited fire alarm circuits—Part III of Article 760

(3) Optical fiber cables—Part V of Article 770

**(B) Hazardous (Classified) Locations.** For circuits and equipment installed in a location classified in accordance with 500.5, the applicable requirements of Chapter 5 apply.

**(C) Wiring in Ducts for Dust or Vapor Removal.** The requirements of 300.22(A) apply.

**(D) Equipment in Plenum Spaces.** Equipment installed in plenum spaces must comply with 300.22(C)(3).

**Author's Comment:**

- According to 300.22(C)(3), electrical equipment with a metal enclosure, or a nonmetallic enclosure listed for use in an air-handling space, can be installed in a plenum space.

**(E) Installation and Use.** Communications equipment must be installed and used according to manufacturers' instructions in accordance with 110.3(B).

**(F) Optical Fiber Cable.** Where optical fiber cable is used to provide a communications circuit within a building, Article 770 applies.

## 800.21 Access to Electrical Equipment Behind Panels Designed to Allow Access

Access to equipment must not be prohibited by an accumulation of coaxial cables that prevents the removal of suspended-ceiling panel.

## 800.24 Mechanical Execution of Work

**(A) General.** Equipment and cabling must be installed in a neat and workmanlike manner. ▸Figure 800–3

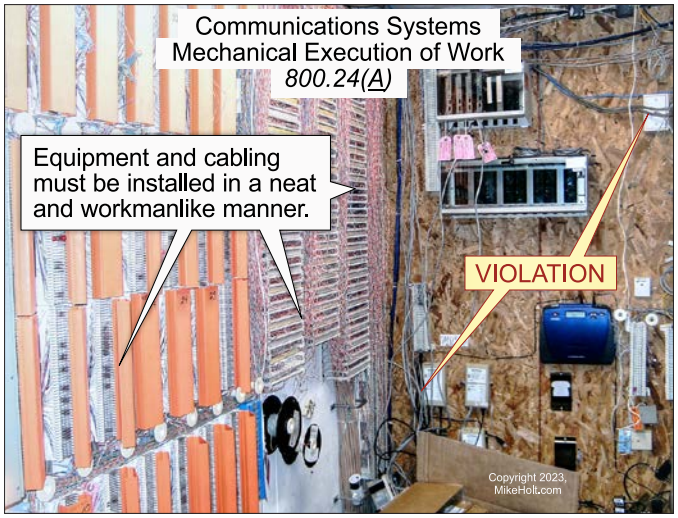



Figure 800–3

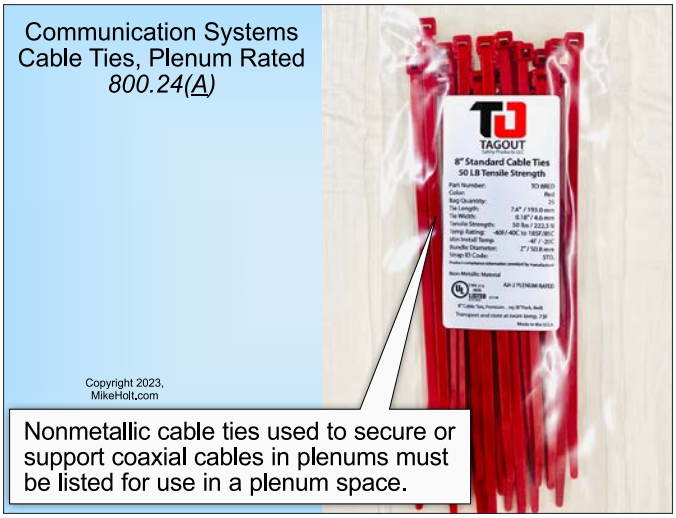



Figure 800–4

***Cable Support, Damage.*** Exposed coaxial cables must be supported by the structural components of the building so the cable will not be damaged by normal building use.

***Cable Securement, Fitting.*** Coaxial cables must be secured by straps, staples, hangers, cable ties listed and identified for securement and support, or similar fittings designed and installed in a manner that will not damage the cable.

***Protection From Physical Damage [300.4].*** Coaxial cables installed through or parallel to framing members or furring strips must be protected where they are likely to be penetrated by nails or screws by installing the wiring method so it is not less than 1¼ in. from the nearest edge of the framing member or furring strips, or by protecting it with a 1⁄16 in. thick steel plate or equivalent [300.4(A)(1) and (D)].

***Securing and Supporting [300.11].*** Communications raceways and coaxial cable assemblies must be securely fastened in place. The ceiling-support wires or the ceiling grid are not permitted to be used to support coaxial cables [300.11(B)].

***Cable Ties, Plenum Rated.*** Cable ties used to secure or support coaxial cables in plenums must be listed for use in a plenum space in accordance with 800.170. Figure 800–4

**Note 1:** Accepted industry practices are described in ANSI/TIA-568, *Commercial Building Telecommunications Infrastructure Standard*; ANSI/TIA-569-D, *Telecommunications Pathways and Spaces*; ANSI/TIA-570-C, *Residential Telecommunications Infrastructure Standard*; ANSI/TIA-1005-A, *Telecommunications Infrastructure Standard for Industrial Premises*; ANSI/TIA-1179, *Healthcare Facility Telecommunications Infrastructure Standard*; ANSI/TIA-4966, *Telecommunications Infrastructure Standard for Educational Facilities*; and other ANSI-approved installation standards.

**Note 3:** Paint, plaster, cleaners, abrasives, corrosive residues, or other contaminants may result in an undetermined alteration of wire and cable properties.

## 800.25 Abandoned Cable

To limit the spread of fire or products of combustion within a building, abandoned coaxial cables must be removed. Figure 800–5

According to Article 100, "Abandoned Cable" is defined as a cable that is not terminated at equipment other than a termination fitting or a connector and is not identified for future use with a tag.

Where cables are identified for future use with a tag, the tag must be able to withstand the environment involved.

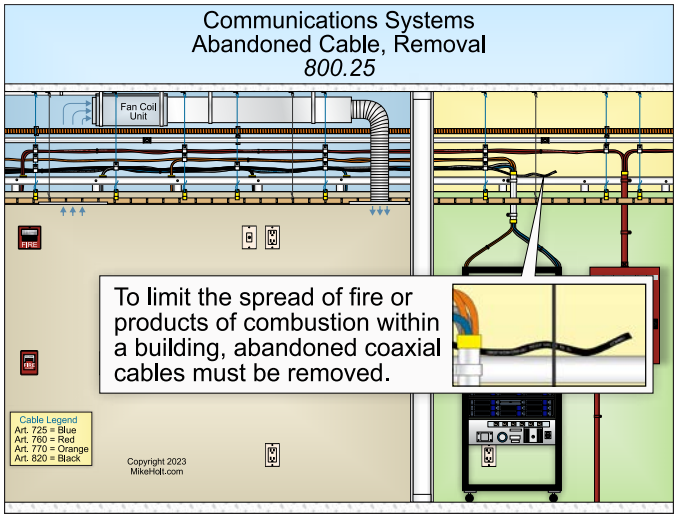



Figure 800–5

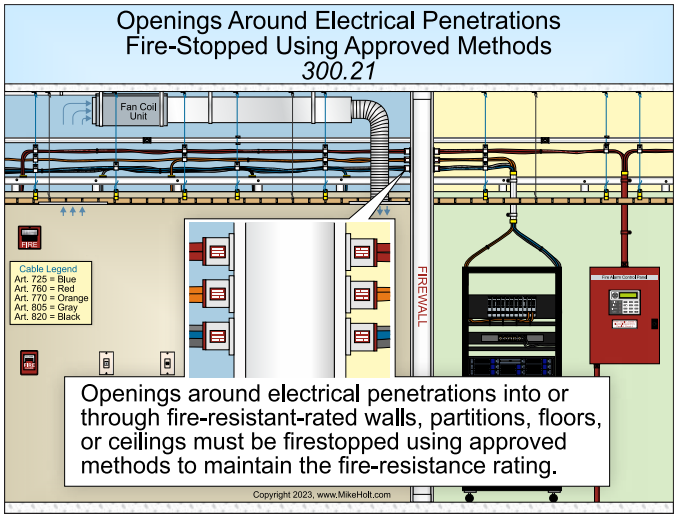



Figure 800–6

## 800.26 Spread of Fire or Products of Combustion

Coaxial cables must be installed in such a way that the spread of fire or products of combustion will not be substantially increased.

Openings into or through fire-resistant-rated walls, floors, and ceilings for electrical equipment must be firestopped using methods approved by the authority having jurisdiction to maintain the fire-resistance rating of the fire-rated assembly.

**Author's Comment:**

- Electrical circuits and equipment must be installed in such a way that the spread of fire or products of combustion will not be substantially increased. Openings into or through fire-resistive walls, floors, and ceilings for electrical equipment must be firestopped using methods approved by the authority having jurisdiction to maintain the fire-resistance rating of the fire-resistive assembly [300.21]. Figure 800–6
- Boxes installed in fire-resistive assemblies must be listed for the purpose. If steel boxes are used, they must be secured to the framing member, so cut-in type boxes are not permitted. "Putty pads" are typically installed on the exterior of the box, but many manufacturers have listed inserts for box interiors. Firestopping materials are listed for the specific types of wiring methods and the construction of the assembly they penetrate. Figure 800–7

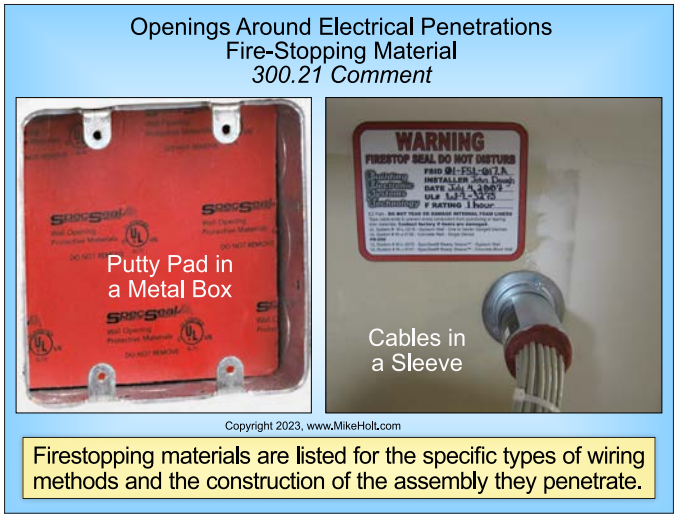



Figure 800–7

- Outlet boxes must have a horizontal separation of not less than 24 in. when installed on opposites sides in a fire-resistive assembly, unless an outlet box is listed for closer spacing or protected by fire-resistant "putty pads" in accordance with manufacturer's instructions. Building codes also have restrictions on penetrations on opposite sides of a fire-resistive wall. Figure 800–8 and Figure 800–9

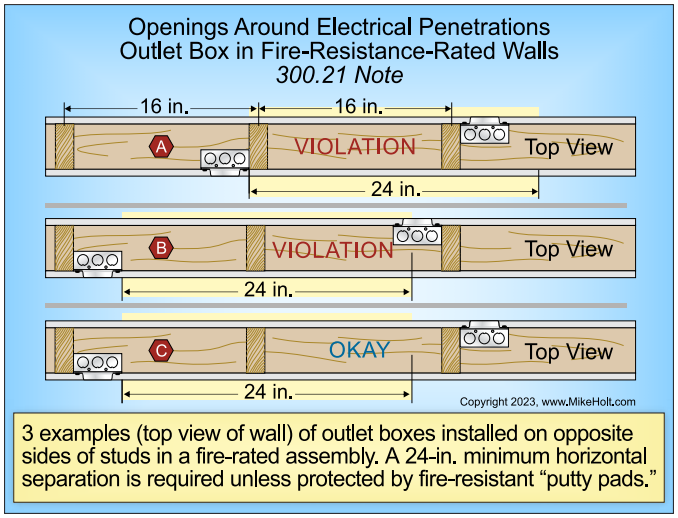



Figure 800–8

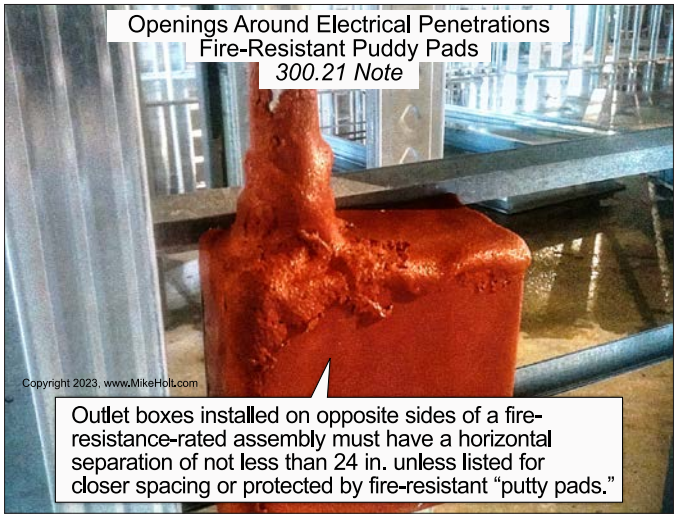



Figure 800–9

## Part II. Wires and Cables Outside and Entering Buildings

### 800.53 Separation from Lightning Conductors

Where practicable on buildings, a separation of not less than 6 ft must be maintained between communications circuits or coaxial cables and lightning protection conductors.

## Part IV. Installation Methods Within Buildings

### 800.110 Raceways

**(A) Types of Raceways.**

**(1) Chapter 3 Raceways.** Cables can be installed in any Chapter 3 raceway. Figure 800–10

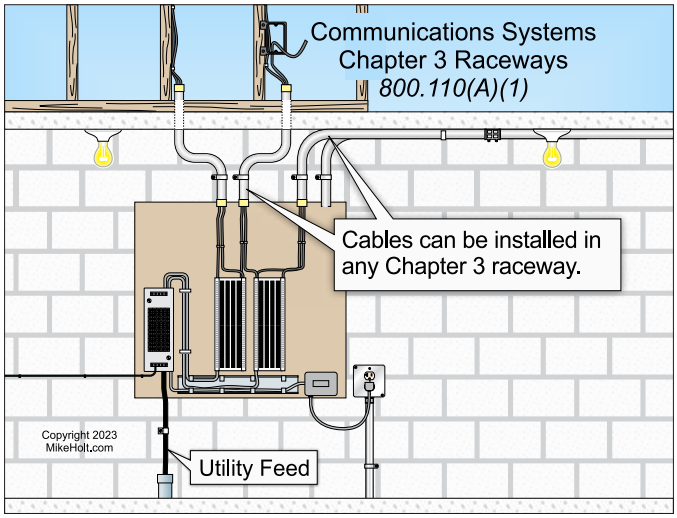



Figure 800–10

**Author's Comment:**

- Coaxial cable is not required to be installed in a Chapter 3 raceway, but when it is, it must be installed in accordance with the Chapter 3 requirements for that raceway.

**(2) Communications Raceways.** Coaxial cables can be installed in communications raceways selected using Table 800.154(b), listed in accordance with 800.182, and installed in accordance with 800.113 and 362.24 through 362.56 where the requirements for electrical nonmetallic tubing (ENT) apply.

**(B) Raceway Fill for Communications Wires and Cables.** The raceway fill limitations of 300.17 do not apply to coaxial cables installed within a raceway.

### 800.113 Installation of Communications Wires, Cables, and Raceways

Types of cables used by this section are identified in Table 800.113.

| Table 800.113 Cables Used for Communications Circuits | |
|---|---|
| | Listed Cable Types |
| Plenum cables | CMP, CATVP, BLP, OFNP, OFCP |
| Riser cables | CMR, CATVR, BMR, BLR, OFNR, OFCR |
| General-purpose cables | CMG, CM, CATV, BM, BL, OFNG, OFN, OFCG, OFC |
| Limited-use cables | CMX, CATVX, BLX |
| Undercarpet | CMUC |
| Underground | BMU, BLU |

**(A) Listing.** Coaxial cables in buildings must be installed in accordance with the limitations of the listing.

**(B) Ducts Specifically Fabricated for Environmental Air.**

**(1) Uses Permitted.** The following coaxial cables are permitted in ducts specifically fabricated for environmental air as described in 300.22(B) if they are directly associated with the air distribution system:

(1) Plenum-rated cables up to 4 ft in length

(2) Any type of cable in a metal raceway in accordance with 300.22(B)

**(2) Uses Not Permitted.** The following coaxial cables are not permitted in ducts specifically fabricated for environmental air as described in 300.22(B):

(1) Plenum, riser, and general-purpose communications raceways

(3) Riser, general-purpose, and limited-use cables

(4) Type CMUC cables and wires

(5) Types BMU and BLU cables

(6) Communications wires

(7) Hybrid power and communications cables

**(C) Plenum Spaces.**

**(1) Uses Permitted.** The following coaxial cables are permitted to be installed in plenum spaces as described in 300.22(C):

(1) Plenum-rated cables

(2) Plenum-rated communications raceways

(4) Plenum-rated cables installed in plenum-rated communications raceways

(6) Plenum-rated cables and plenum-rated communications raceways supported by open metal cable tray systems

(7) Any type of cable installed in metal raceways in compliance with 300.22(C)

**(2) Uses Not Permitted.** The following coaxial cables, wires, and communications raceways are not permitted in other spaces used for environmental air as described in 300.22(C):

(1) Riser, general-purpose, and limited-use coaxial cables

(2) Riser and general-purpose communications raceways

(4) Type CMUC coaxial cables and wires

(5) Types BMR, BM, BMU, and BLU coaxial cables

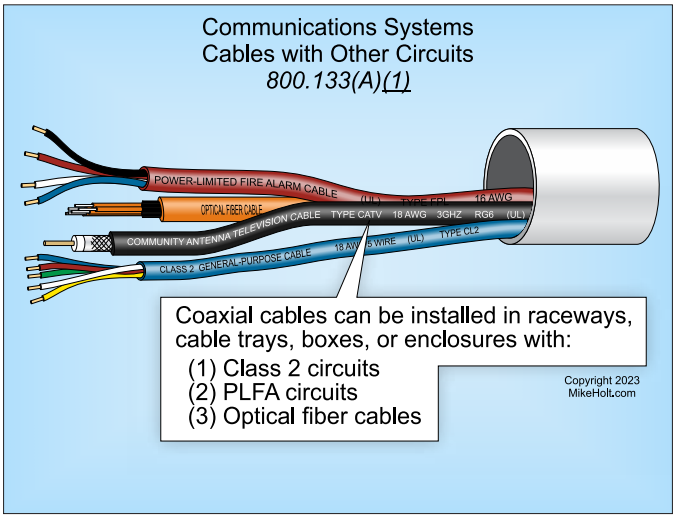
(6) Communications wires

(7) Hybrid power and coaxial cables

## 800.133 Installation of Coaxial Cables and Equipment

**(A) In Raceways, Cable Trays, Boxes, and Enclosures.**

**(1) Permitted with Other Circuits.** Coaxial cables are permitted in the same raceway, cable tray, box, or enclosure with jacketed coaxial cables of any of the following: ▸Figure 800–11




▸Figure 800–11

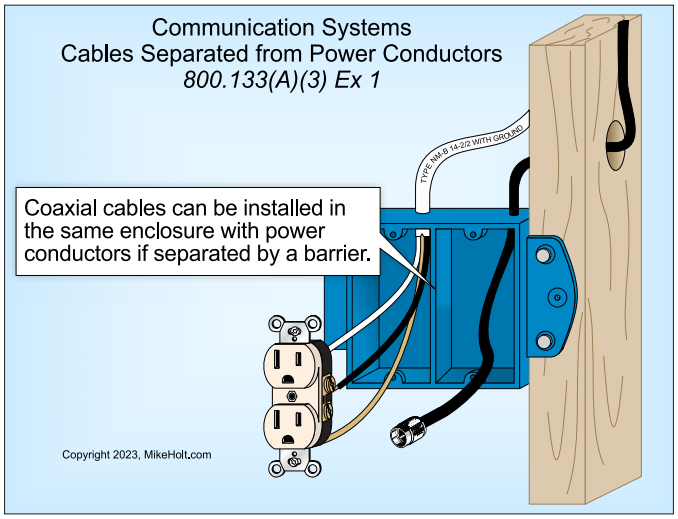
(1) Class 2 power-limited circuits in compliance with Article 725

(2) Power-limited fire alarm systems in compliance with Parts I and III of Article 760

(3) Nonconductive and conductive optical fiber cables in compliance with Parts I and V of Article 770

**(3) Separation from Power Conductors.** Coaxial cables are not permitted to be placed in any raceway, compartment, outlet box, junction box, or similar fitting with conductors of electric power or Class 1 power-limited circuits.

*Ex 1: Coaxial cables are permitted in the same enclosure with power conductors if separated by a barrier.* ▸Figure 800–12



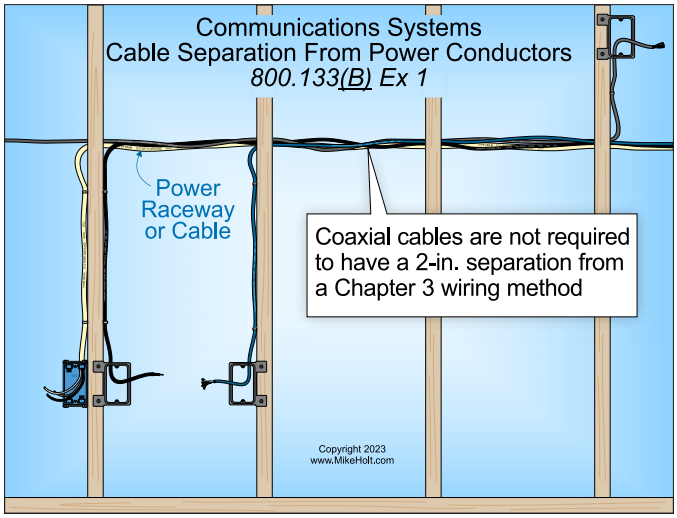

▸Figure 800–12

*Ex 2: Power conductors that supply coaxial cable distribution equipment must maintain ¼ in. of separation from coaxial cables within the enclosure.*

**(B) Separation from Power Conductors.** Coaxial cables must be separated by at least 2 in. from conductors of any electric light, power, and Class 1 power-limited circuits.

*Ex 1: Coaxial cables are not required to have a 2-in. separation from a Chapter 3 wiring method.* ▸Figure 800–13

**(C) Support of Coaxial Cables.** Coaxial cables are not permitted to be strapped, taped, or attached by any means to the exterior of any raceway as a means of support.




▸Figure 800–13

## 800.154 Applications of Listed Communications Wires, Coaxial Cables, and Raceways

Permitted and nonpermitted applications of listed communications wires, coaxial cables, coaxial cables and raceways, must be in accordance with one of the following:

(1) Listed communications wires and coaxial cables as indicated in Table 800.154(a)

(2) Listed communications raceways as indicated in Table 800.154(b)

The permitted applications are subject to the installation requirements of 800.110 and 800.113.

## 800.170 Plenum Cable Ties

Cable ties intended for use in plenum space, in accordance with 300.22(C), must be listed as having low smoke and heat release properties.

ARTICLE

# 810 ANTENNA SYSTEMS

## Introduction to Article 810—Antenna Systems

This article covers antenna systems and the wiring and cabling associated with that equipment. Unlike other articles in this chapter, Article 810 is not covered by the general rules in Article 800. As a result, it stands completely alone in the *Code* unless a rule here references a specific rule elsewhere in the *NEC*. Many of these rules are outside of the scope of this material, however, some of the topics we cover include the following:

- Scope
- Avoid Contact with Conductors of Other Systems
- Metal Antenna Supports—Bonding
- Clearances
- Antenna Discharge Unit
- Bonding Conductors and Grounding Electrode Conductors

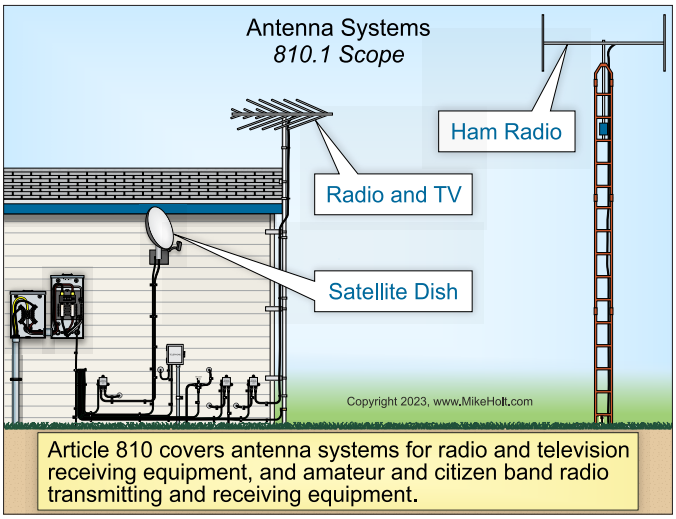
Article 810 consists of four parts:

- Part I. General
- Part II. Receiving Equipment—Antenna Systems
- Part III. Amateur and Citizen Band Transmitting and Receiving Stations
- Part IV. Interior Installation — Transmitting Stations

## Part I. General

### 810.1 Scope

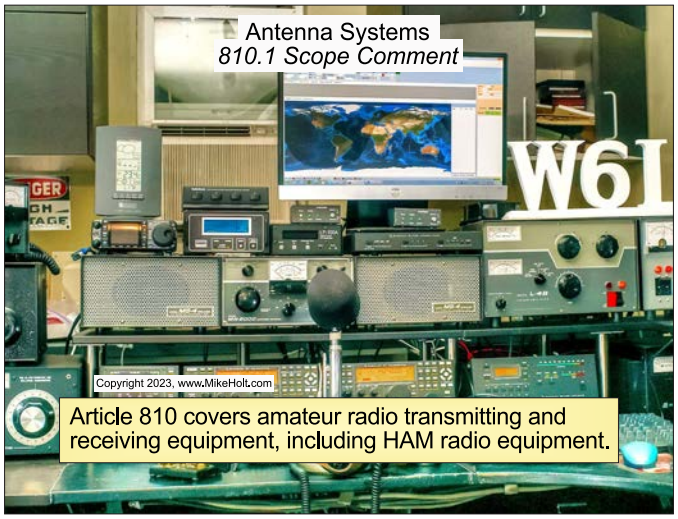
Article 810 covers antenna systems for radio and television receiving equipment, and amateur and citizen band radio transmitting and receiving equipment. It also covers antennas such as wire-strung type, multi-element, vertical rod, flat, or parabolic. ▸Figure 810–1




▸Figure 810–1

**Author's Comment:**

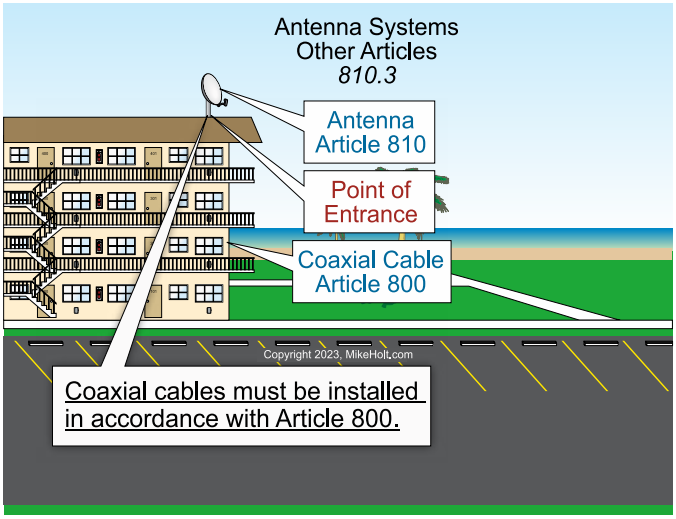
- Article 810 covers:
  - Antennas that receive local television signals.
  - Satellite antennas which are often referred to as satellite dishes.
  - Roof-mounted antennas for AM/FM/XM radio reception.
  - Amateur radio transmitting and receiving equipment, including HAM radio equipment (a noncommercial [amateur] communications system). ▸Figure 810–2




▸Figure 810–2

## 810.3 Other Articles

(2) Coaxial cables must be installed in accordance with Article 800. ▸Figure 810–3




▸Figure 810–3

**Author's Comment:**

- According to the *National Electrical Code Handbook*, "One of the leading causes of electrical shock and electrocution is the accidental contact of radio, television, and amateur radio transmitting and receiving antennas, and equipment with light or power conductors. Extreme caution should therefore be exercised during this type of installation, and periodic visual inspections should be conducted thereafter."

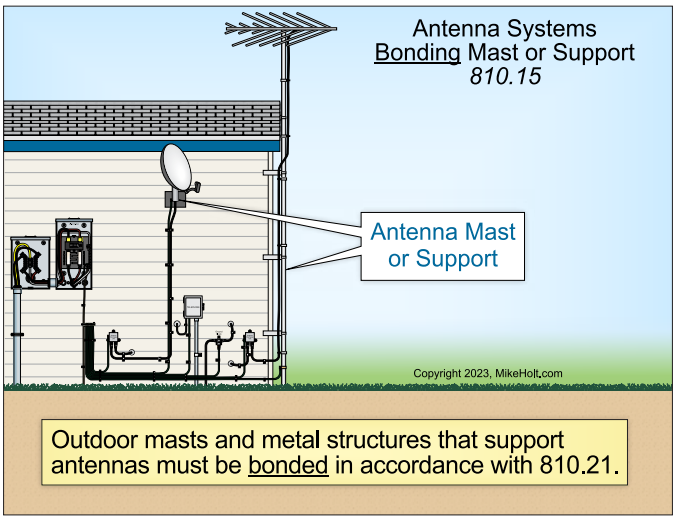
# Part II. Receiving Equipment—Antenna Systems

## 810.13 Avoid Contact with Conductors of Other Systems

Outdoor antennas and lead-in conductors must be kept at least 2 ft away from exposed electric power conductors to avoid the possibility of accidental contact.

## 810.15 Metal Antenna Supports—Bonding

Outdoor masts and metal structures that support antennas must be bonded in accordance with 810.21. ▸Figure 810–4




▸Figure 810–4

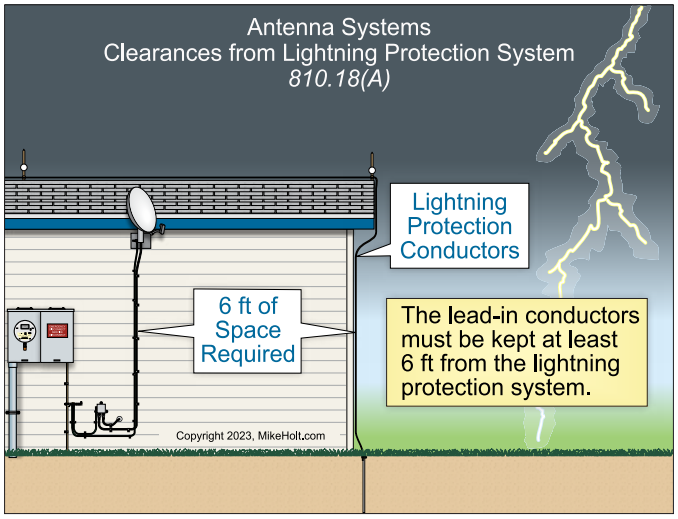
**Note:** See NFPA 780, *Standard for the Installation of Lightning Protection Systems*, for the application of the term "Rolling Sphere."

## 810.18 Clearances

**(A) Outside of Buildings.**

***Clearance From Power Conductors.*** Lead-in conductors attached to buildings must be installed so they cannot swing closer than 2 ft to the conductors of circuits of 250V or less, or closer than 10 ft to the conductors of circuits of over 250V.

***Clearance From Lightning Protection System.*** Lead-in conductors must be kept at least 6 ft away from the lightning protection system. ▸Figure 810–5




▸Figure 810–5

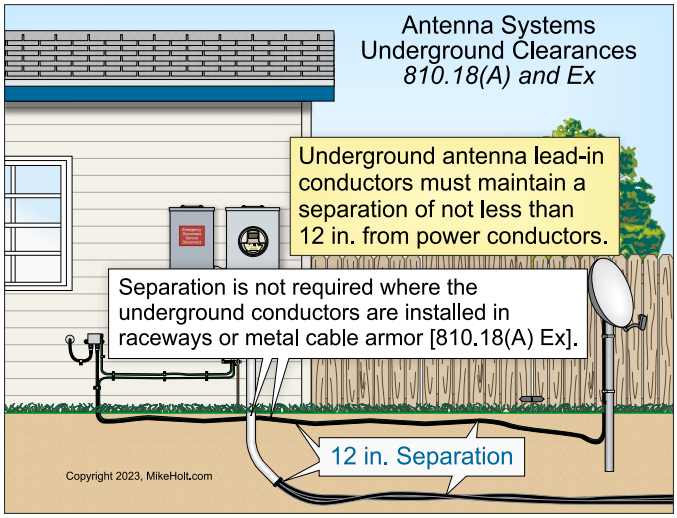
***Underground Clearances.*** Underground antenna lead-in conductors must maintain a separation of not less than 12 in. from electric power conductors.

*Ex: Separation of antenna cables from power conductors is not required where the underground antenna lead-in conductors or the electric power conductors are installed in raceways or metal cable armor.* ▸Figure 810–6

**(B) Indoors.** Indoor antenna and lead-in conductors are not permitted to be less than 2 in. from electric power conductors, unless one of the following applies:

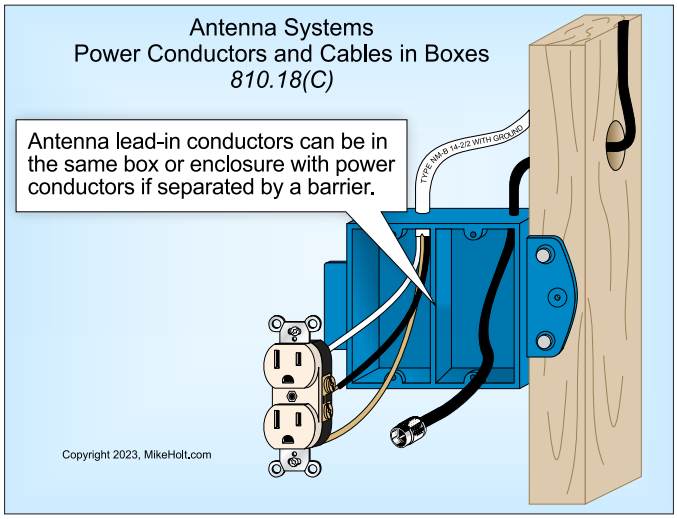
(1) The other conductors are in metal raceways or cable armor.

(2) The indoor antennas and indoor lead-ins are separated from other conductors by a firmly fixed nonconductor.




▸Figure 810–6

**(C) Boxes.** Antenna lead-in conductors can be in the same box or enclosure with power conductors if separated by a barrier. ▸Figure 810–7




▸Figure 810–7

## 810.20 Antenna Discharge Unit

**(A) Listed.** Each lead-in conductor from an outdoor antenna must be provided with a listed antenna discharge unit. ▸Figure 810–8

**(B) Location.** The antenna discharge unit must be outside or inside the building, nearest the point of entrance, but not near combustible material.

**(C) Bonding.** The antenna discharge unit must be bonded in accordance with 810.21.

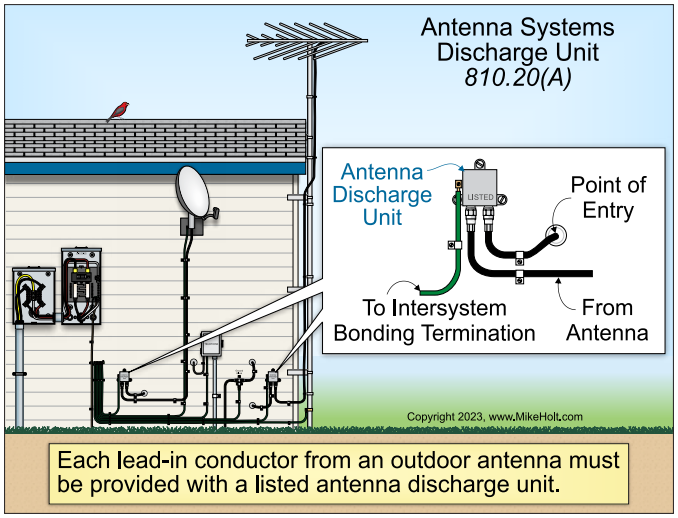



Figure 810–8

## 810.21 Bonding Conductors and Grounding Electrode Conductors

Bonding conductors must meet the following requirements:

**(A) Material.** The bonding conductor to the intersystem bonding termination must be copper, copper-clad aluminum, copper-clad steel, aluminum, bronze, or other corrosion-resistant conductive material. Figure 810–9

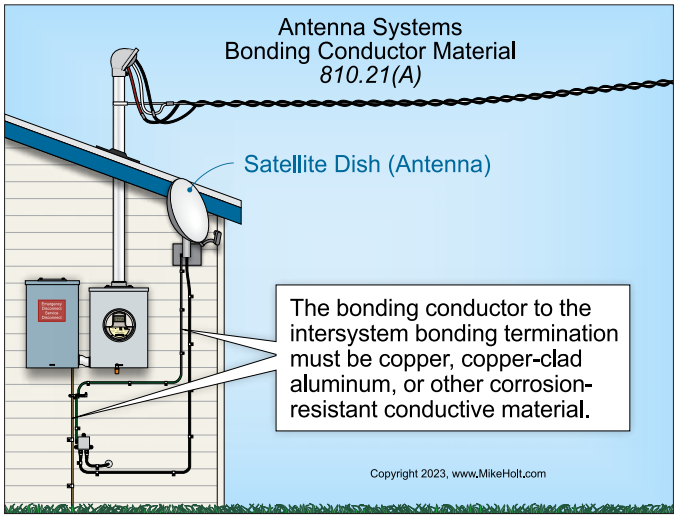



Figure 810–9

If aluminum or copper-clad aluminum is used, the bonding conductor must not be installed outside within 18 in. from the Earth, or if subject to corrosive conditions.

**(B) Insulation.** Insulation on bonding conductors is not required.

**(C) Supports.** The bonding conductor must be securely fastened in place.

**(D) Physical Protection.** Bonding conductors must be mechanically protected where subject to physical damage. Where installed in a metal raceway, both ends of the raceway must be bonded to the contained conductor.

**Author's Comment:**

- Installing the bonding conductor in PVC conduit is a better practice.

**(E) Run in Straight Line.** The bonding conductor must be run in as straight a line as practicable.

**Author's Comment:**

- Lightning does not like to travel around corners or through loops, which is why the bonding conductor must be run as straight as practicable.

**(F) Bonding Terminations.** The bonding conductor must terminate in accordance with the following:

**(1) Buildings or Structures with an Intersystem Bonding Termination.** The bonding conductor for the antenna mast and antenna discharge unit must terminate to the intersystem bonding termination [Article 100] as required by 250.94. Figure 810–10

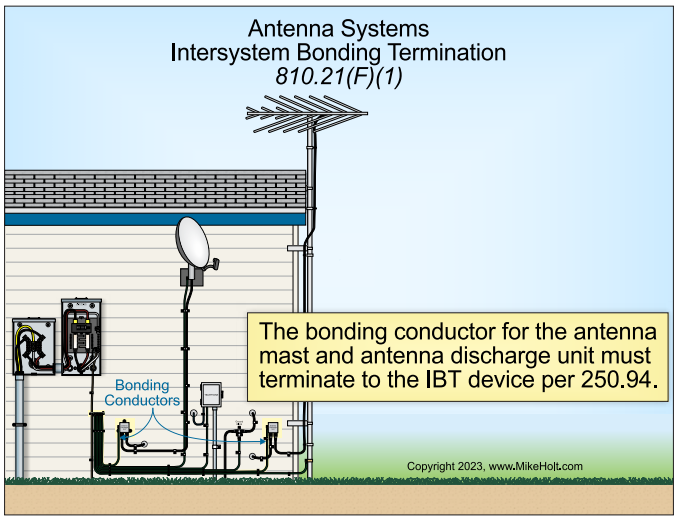


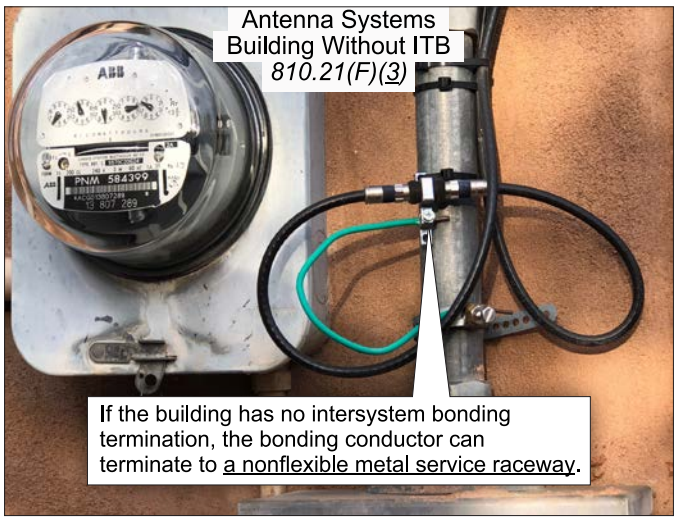

Figure 810–10

**(2) Buildings or Structures without an Intersystem Bonding Termination.** If the building or structure has no intersystem bonding termination, the bonding conductor must be connected to the nearest accessible grounding location on one of the following:

(1) The grounding electrode system as covered in 250.50

(2) The service accessible means external to the building as covered in 250.94

(3) The nonflexible metal service raceway. ▸Figure 810–11




▸Figure 810–11

(4) The service disconnect enclosure

(5) The grounding electrode conductor or the grounding electrode conductor metal enclosures of the service disconnect

(6) The grounded interior metal water piping systems, within 5 ft from its point of entrance to the building, as covered in 250.68(C)(1).

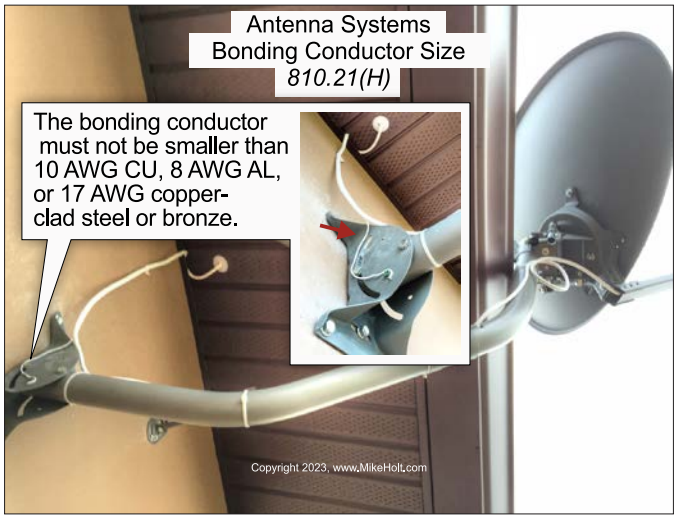
**Author's Comment:**

- Section 250.68(C)(1) permits interior metal water piping within 5 ft from the point of entrance to a building to extend or interconnect bonding jumpers to grounding electrodes.

An intersystem bonding termination device must not interfere with the opening of an equipment enclosure and must be mounted on nonremovable parts. An intersystem bonding termination device cannot be mounted on a door or cover even if the door or cover is nonremovable.

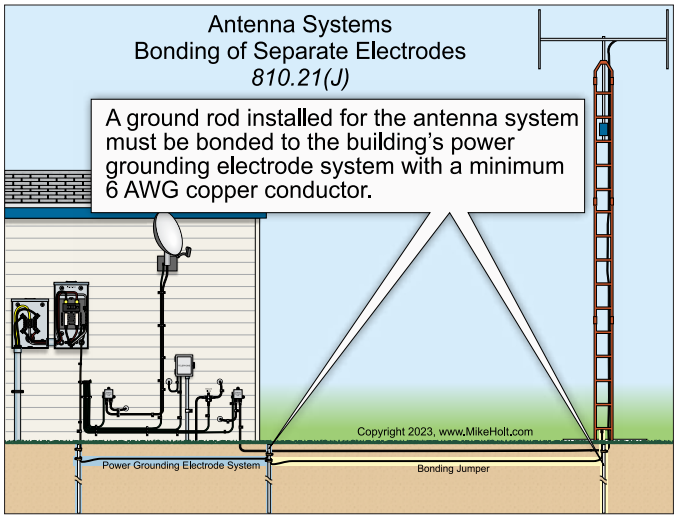
**(G) Inside or Outside Building.** The bonding conductor can be installed either inside or outside the building.

**(H) Size.** The bonding conductor is not permitted to be smaller than 10 AWG copper, 8 AWG aluminum, or 17 AWG copper-clad steel or bronze. ▸Figure 810–12




▸Figure 810–12

**(J) Bonding of Electrodes.** A ground rod installed for the antenna system must be bonded to the building's power grounding electrode system with a minimum 6 AWG copper conductor. ▸Figure 810–13



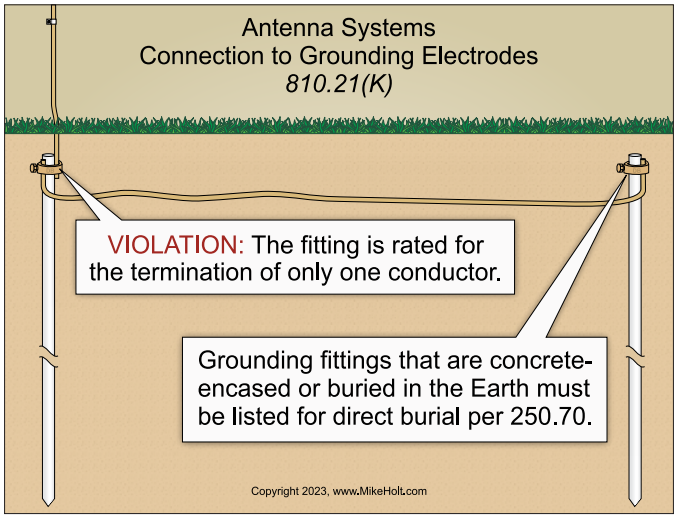

▸Figure 810–13

**Author's Comment:**

- A separate grounding electrode is not required for radio and TV equipment, but if it is installed, then it must be bonded to the building's power grounding electrode system with a minimum 6 AWG copper conductor.

- Bonding of electrodes helps reduce induced voltage differences between the power and communications systems during lightning events.

**(K) Electrode Connection.** Termination of the bonding conductor must be by exothermic welding, listed lugs, listed pressure connectors, or listed clamps. Grounding fittings that are concrete-encased or buried in the Earth must be listed for direct burial in accordance with 250.70. ▸Figure 810–14




▸Figure 810–14

**Author's Comment:**

- Grounding the lead-in antenna coaxial cables and the mast helps prevent voltage surges caused by static discharge or nearby lightning strikes from reaching the center conductor of the lead-in coaxial cable. Because the satellite dish sits outdoors, wind creates a static charge on the antenna as well as on the cable to which it is attached. This charge can build up on both the antenna and the cable until it jumps across an air space, often passing through the electronics inside the low noise block down converter feedhorn (LNBF) or receiver. Connecting the antenna and/or satellite dish to the building's grounding electrode system (grounding) helps dissipate this static charge.
- Nothing can prevent damage from a direct lightning strike, but grounding with proper surge protection can help reduce damage to the satellite dish and other equipment from nearby lightning strikes.

# Part III. Amateur and Citizen Band Transmitting and Receiving Stations—Antenna Systems

## 810.51 Other Sections

In addition to complying with Part III, antenna systems for amateur and citizen band transmitting and receiving stations must comply with 810.11 through 810.15.

## 810.57 Antenna Discharge Units—Transmitting Stations

Each lead-in conductor for outdoor antennas must be provided with an antenna discharge unit or other suitable means to drain static charges from the antenna system.

*Ex 1: If the lead-in conductor is protected by a continuous metallic shield that is bonded in accordance with 810.58, an antenna discharge unit or other suitable means is not required.*

*Ex 2: If the antenna is bonded in accordance with 810.58, an antenna discharge unit or other suitable means is not required.*

## 810.58 Bonding Conductors and Grounding Electrode Conductors—Amateur and Citizen Band Transmitting and Receiving Stations

Bonding conductors must comply with 810.58(A) through 810.58(C).

**(A) Other Sections.** Bonding conductors for amateur and citizen band transmitting and receiving stations must comply with 810.21(A) through 810.21(C).

**(B) Size of Protective Bonding Conductor.** The protective bonding conductor for transmitting stations must be as large as the lead-in but not smaller than 10 AWG copper, bronze, or copper-clad steel.

**(C) Size of Operating Bonding Conductor.** The operating bonding conductor for transmitting stations must be at least 14 AWG copper or its equivalent.

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