

Traffic Signal Antenna Installations and NEC Rules For Antenna Installations Used For Traffic Signal Applications

Introduction

This article will review some of the National Electrical Code (NEC) rules on antenna installations as used for traffic signals and similar applications. Some of the NEC rules also apply to video monitoring and detection. The NEC is a minimum standard, and for optimal equipment protection additional recommendations (Application Note) will be made. Antenna installations are concerned with proper grounding and conductor separation. Improper grounding can result in fires and/or electrical shock.

Authors Comment: Most antennas are improperly grounded. Even the 18" diameter direct satellite dishes require antenna grounding. One common error is to install a ground rod at the antenna without bonding it to the building electrical grounding system.

Please refer to the illustration at the end of the article. This article is based on the 2002 NEC, and the literal text of the NEC is in *italics*.

NEC Articles

Most of the rules for antenna installations are in Chapter 800 – Communications, Articles 810 and 820. Several references are made to Article 250.

Article 810 Radio and Television Equipment - covers radio and television receiving equipment, for multi-element (yagi), vertical rod (omni), dish (satellite and direct satellite), and the support structure or mast.

Article 820 Community Antenna Television and Radio Distribution Systems – primarily covers the coaxial cable used to distribute the RF signals for community antenna television systems (CATV), but also covers the coaxial cabling used to connect antennas to equipment and for coaxial cable used for video systems, including detection and monitoring.

Article 250 Grounding - general requirements for the grounding and bonding of electrical systems, and is referenced by Article 820.

The key to understanding Articles 810 and 820 is given in NEC Section 90-3, Code Arrangement:

90.3 *General Requirements*¹ – Chapters 1 through 4 have the general requirements of the NEC.

Chapters 5, 6 and 7 are for special occupancies, equipment or conditions and the rules in these Chapters modify the general rules in Chapters 1 through 4.

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Chapter 8 covers Communications System and is not subject to the requirements of Chapters 1 through 7 except where the requirements are specifically referenced in Chapter 8.

For example, the burial depths for conductors and raceways in Chapter 3 do not apply to Chapter 8 – Communications applications.

Essentially, Article 810 covers the antenna mast and Article 820 covers the coaxial cable from the antenna or video cameras to the connected equipment. Both Article 810 and 820 reference Article 100 Definitions, so all the definitions apply.

For example: *Article 100 Location, Wet* states that any installation under ground is a wet location. [820.3 (C)] *Installation and Use* references [110.3] *Examination, Identification, Installation and Use of Equipment*. [110.3] requires that the coaxial cable used underground in a raceway to be of a type identified for a wet location.

In this article, the NEC rules are summarized and the reader needs to review appropriate sections to fully understand them.

Any reference to a building would also apply to a traffic signal cabinet, see the 2002 NEC definition of *Building* and the new definition of *Structure*.

Types of Antennas

There are two typical types of antennas used for traffic signal wireless applications – omni directional (omni), a single element antenna with a circular radiation pattern; and multi element type (yagi) that has a directional signal. Most are typically a DC grounded type in that the coaxial cable feed line is grounded at the antenna giving some lightning protection.

Support

The antenna must be securely supported. Antennas cannot be attached to poles with open electric light or trolley wires over 250 volts between conductors [810.12].

Antenna Masts

The antenna cannot be supported by an electric service mast [230.28 and 810.12]. Antenna masts and metal structures must be grounded [810.21]. Although a wooden pole could be used to support an antenna, it is not recommended as the wooden pole does not offer a low resistance path for lightning strikes, even if equipped with a grounding conductor from the antenna¹.

Other Articles

[810.3] requires coaxial cable used to connect antennas to other equipment to comply with Article 820.

Clearances

Per [820.10(A)], coaxial cables ahead of the Antenna Discharge Unit (ADU) or shield ground, are to be kept away and below electric light, power and non-power limited fire alarm conductors [820.10 (A) and (B)]. Cables between buildings either have to be acceptable for the purpose or can be attached to a messenger cable. Coaxial cable must have at least a 4 in. separation from conductors of electric light, power and non-power limited fire alarm or be permanently separated by a continuous fixed nonconductor. Separation of 6 ft from lightning conductors is required [820.10 (F)] .

Coaxial cables in a handhole or duct have to be separated from electric light, power and non-power limited fire alarm by a suitable barrier [820.11].

Note: The 1999 NEC in *Article [410-15 (B)] Metal Poles Supporting Lighting Fixtures* added the words “as a raceway” to metal poles used to support lighting fixtures, meaning the separation requirements of Chapter 3 would be required for low voltage cables/conductors and electric light/power conductors within the light pole.

Coaxial Cable

Article 810 refers to Article 820 for coaxial cables used to connect antennas to equipment. Article 820 again refers to Article 100 for definitions and adds definitions for Abandoned Cable (new), Exposed and Point of entrance. Per [820.3 (A)], accessible portions of abandoned cable must be removed, unless it is tagged for future use or has a connector attached. All coaxial cable must comply with [110.3] per [820.2(C)], which requires equipment to be installed according to its listing and labeling instructions.

Cable must be installed in a neat and workman like manner, supported by use of straps, hangers or fittings designed not to damage the cable [820.6].

For video detection and monitoring, the coaxial cable that extends outside of a building (or traffic signal cabinet) can be exposed to lightning and the outer conductive shield must be grounded [820.33].

Antenna Discharge Unit

A listed (see Article 100 Definition) antenna discharge unit (lighting arrestor) is required per [810.20 (A)]. An exception does not require a listed antenna discharge unit (ADU)

- If protected by an antenna discharge unit
- or the conductors are in a continuous metal shield, such as coax that is grounded [810.20 (A)].

The exception for a non-listed ADU refers to a “grounding block” that only breaks the coax shield and grounds it. The grounding block is what is commonly used, however it provides no protection on the center conductor of the coax.

Two Types of ADU



Polyphaser

Both of the units meet Section [810.20 (A)] by grounding the coax shield. Neither is listed. The ADU the left is typically used in residential applications and costs about \$3.00. The ADU's on the right are made by Polyphaser, are typically used for commercial radio sites, and costs about \$60.00 each. This shows a copper ground buss set up for a single point ground. The copper buss bar is bonded to the grounding electrode system outside with a 2 AWG bare copper conductor. If the Polyphaser is subject to a lighting surge, it conducts the energy to the copper ground buss and then outside.

Single ADU



This illustration shows a single ADU (Polyphaser). Instead of mounting on a copper buss bar, a 3 hole strut bracket and insulator was used. A 2 AWG 3/8" hole compression lug is fastened to the insulator with a 3/8-16 SS socket head cap screw. The 2 AWG copper conductor leads outside to the grounding electrode system.

The coax on the right is not a listed coax for use inside a building.

The coax on the left is a listed coax (per Section 820.50).

The ADU must be located outside or as close as possible to the entrance of the coax to the building [810.20 (B)]. The antenna discharge unit must be grounded [810.20 (C)]. The minimum size for the ADU grounding conductor is a 10 AWG copper conductor [810.21(H)], insulated, covered or bare, color not specified, run in a straight a line as possible, either inside or outside, to the nearest accessible grounding electrode per [810.20 (F)]:

- Building or structure grounding electrode system
- Grounded interior metal water pipe system
- Power service grounding means per [250.94]
- Metallic service raceway
- Service equipment enclosure
- Grounding electrode conductor or its metal enclosure

Application Note: An ADU is recommended even if coaxial cable is used.

If there is no grounding means per [810.20(F)], then an individual grounding electrode per [250.52] can be installed, or an effectively grounded metal structure can be used. An example of an effectively grounded metal structure could be a traffic signal mast arm foundation with reinforcing steel and a 4 AWG copper conductor bonded to the reinforcing steel and connected to the ADU. Article 810 does not have a reference to Article 250 for connection of grounding conductors, but all connections should be made per standard industry practice and section [110.3(B)]. If the ADU is mounted direct to the traffic signal cabinet, a grounding conductor is still required from the ADU to one of the electrodes listed above. Mechanical protection is required for the grounding conductor [810.21(D)] or the size can be increased. If the ADU grounding conductor is run through metallic conduit, then the conduit must be bonded at both ends to prevent a choke effect to lightning current [810.21(D)].

Application Note: Often a 4 AWG or 2 AWG bare copper conductor will be used to ground the ADU. One suitable method would be to route the ADU grounding conductor directly out of the traffic signal cabinet through a PVC conduit and then connect it to the grounding electrode system, avoiding sharp bends. Note use of a metallic conduit requires bonding the conduit at both ends per [250.40(A)(6)].

The antenna mast must be grounded to one of the grounding electrodes listed above. Often the ADU and the antenna mast will use the same grounding electrode. If a separate grounding electrode is installed for the antenna mast, then this grounding electrode must be bonded to the building electrical grounding electrode system with a 6 AWG (minimum) copper conductor. This will help to keep all equipment at the same potential in the event of a lightning strike or contact with a higher voltage line [810.21(J)].

Authors Comment: Failure to bond the antenna grounding electrode to the building electrical grounding electrode system is one of the most common errors in antenna installations. Another common error is the

antenna is simply not grounded. Without an ADU and proper grounding, a nearby lightning strike can result in a difference in potential between the two systems of thousands of volts, resulting in arcing or a shock hazard.

Coaxial Cable Shield Grounding

The outer shield of a coaxial cable must be grounded as close as possible to the point of entrance, or if overhead, point of attachment. If the outer shield is grounded with a grounding block, then no other device, such as an ADU is required. [820.33].

Application Note: An ADU is still recommended.

The shield is grounded with a solid or stranded copper conductor, as short as possible. [820.40] allows the use of 14 AWG minimum grounding conductor, but it must nearly equal to the current carrying capacity of the coaxial cable shield, with the largest size required 6 AWG. Otherwise the grounding installation is nearly the same as described above for an ADU, except connections to the grounding electrode are per [250.70] and the grounding conductor must be as short as possible.

Coaxial cable inside a building must be listed as suitable for the purpose, such as CATV or CATVR [820.50]. See the UL Cable and Wire Marking Guideⁱⁱ for more information on cable markings. Listing is not required for the coaxial cable entering the building from outside, terminating at a grounding block (ADU), and not exceeding 50 ft into the building.

Application Note: A recommended practice would be to use a smaller coaxial cable downstream of the ADU, such as RG-59 or RG-6. This cable is required to be listed, but the coaxial cable ahead of the ADU does not have to be listed.

On the protected side of the ADU, coaxial cable is not permitted to occupy the same raceway, compartment, junction box as electric light, power and non-power limited fire alarm circuits unless separated by a barrier. An exception allows ¼" spacing from power conductors where these circuits are introduced to power the coaxial system equipment [820.52(A)(1)]. Generally 2 in. separation from electric light, power and non-power limited fire alarm circuits is required, or fixed nonconductive tubing can be used. While this separation is to keep the power circuit from energizing the low-voltage circuit in the event of a short, it is also important for noise reduction by induction into the low-voltage circuit from the power circuit.

Changes for the 2002 NEC

Some of the changes relating to this article for the 2002 NEC are:

- [90.3] *Chapter 8 covers communications systems and is ~~independent of~~ not subject to the requirements of Chapters 1 through 7.* This is to make it clear that the NEC covers communications systems
- Article 810 - no significant changes related to traffic signal applications.

- Article 820 added a new definition of Abandoned Coaxial Cable - *Installed coaxial cable that is not terminated at equipment other than a coaxial connector and not identified for future use with a tag.*
- Accessible portions of abandoned coaxial are to be removed [820.3(A)]. The intent is for all unused cables to be removed in buildings to reduce the spread of fire. This requirement has been added to all the low voltage wiring articles – 640, 725, 800, 820 and 830.
- The grounding conductor for the coaxial cable ground must now be as *short as practicable*. [820.40(A)(4)]. This change is to limit the distance between the power and communications circuits to minimize the difference in potential. In a residential application there is a 20 ft maximum distance.

Additional Resources

Low Voltage and Limited Energy, by Mike Holt. This excellent text on low voltage installations including Articles 810 and 820 is available as a free download from Mike Holt Enterprises, Inc., at www.mikeholt.com/low/low.htm

Lighting Protection and Grounding Solutions for Communications Sites, Polyphaser Corporation, Minden, NV, 800-325-7170, www.polyphaser.com

Practical Guide to Grounding, Erico, Solon OH, 1-440-248-0100, www.erico.com

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