CENTRAL FLORIDA EXPRESSWAY AUTHORITY

CFX ITS Inspection Reference & Training Manual

Chapter 9

Grounding

9.0 Overview of Grounding

Grounding is required in electrical and ITS applications to ensure that unwanted electrical energy has a direct path to earth. Device or electrical grounding is achieved by physically connecting a designated busbar or equipment ground conductor to a ground electrode, driven into the earth. This path to ground must be kept as short as reasonably possible. Electrical surges can occur from a variety of sources with lightning, electrical equipment, and variations in electrical potential between elements being the most common. Ground connections protect equipment and technicians from unwanted electrical and lightning surges.

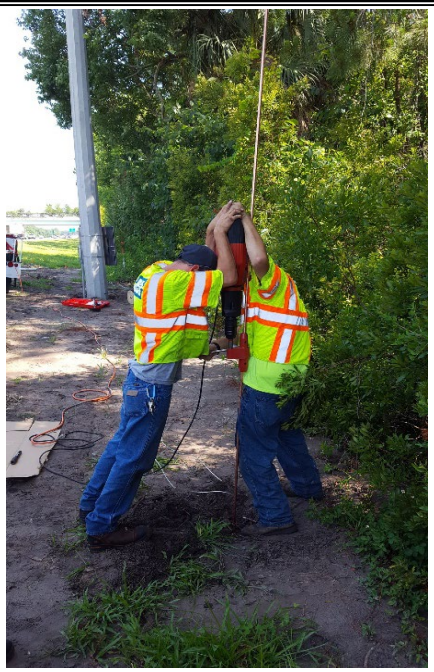
Due to the fact that Florida has a higher-than average amount of lightning strikes combined with the height of the ITS device poles, the ITS device locations are highly susceptible to induced voltage from nearby lightning strikes. These electromagnetic field disruptions from lightning cause surges of energy and can induce overhead or underground electrical conductors or directly impact the steel ITS poles. This induced voltage can then enter the ITS cabinet .and damage ITS equipment. Proper grounding installation, surge protection and routine inspection and maintenance is needed to ensure that equipment damages are minimized, and technicians are kept safe.

9.1 Grounding Components

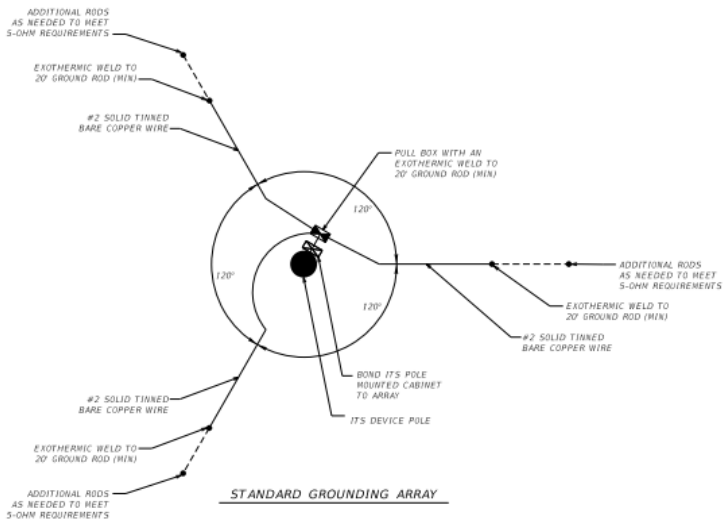
A grounding system is comprised of several parts. These parts all work together to create and provide a grounding system or grounding network that offers a robust and long-term solution for equipment and personnel. CFX has created multiple electrical grounding details for electrical service and safety disconnect sites as well as lightning protection grounding details for ITS device sites. These details are located within the latest edition of the ITS Design Standards.

9.1.1 Ground Electrodes – Ground electrodes, commonly referred to as “ground rods”, are copper coated steel rods that are driven into the earth. These rods must be a minimum of 10 feet in length and have a nominal diameter of 5/8”. Ground electrodes must meet the requirements of UL 467 as certified by an OSHA Nationally Recognized Testing Laboratory. Grounding electrodes must be configured in Grounding Electrode Assemblies and Grounding Electrode Arrays as detailed below. All ground rod assemblies and ground rod arrays must be bonded together with solid bare tinned copper conductor, unless otherwise shown in the plans.

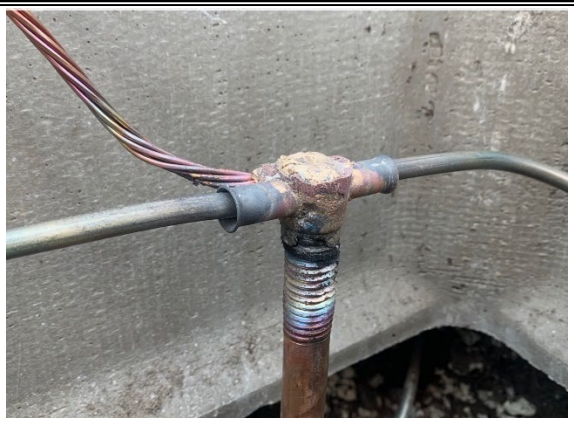
9.1.1.1 Grounding Electrode Assemblies – A ground electrode assembly consists of one or more ground electrodes coupled together, such that the total length of the assembly is a minimum of 20 feet, driven into the earth at a single point, without disrupting the electrical continuity of the assembly.



9.1.1.2 Grounding Electrode Arrays – A grounding electrode array must be installed in accordance with the plans for all ITS field equipment, poles, and structures to obtain the minimum required resistance. Grounding electrode arrays must consist of two or more grounding electrode assemblies, bonded together, separated by twice the length of the longer grounding electrode assembly, or 40 feet, whichever is greater. More information on the components of the grounding electrode array, as well as grounding electrode array configurations, can be found in CFX's ITS Design Standards. The standard grounding array layout is shown on the following page and is found on Sheet J-7 of CFX's ITS Design Standards.



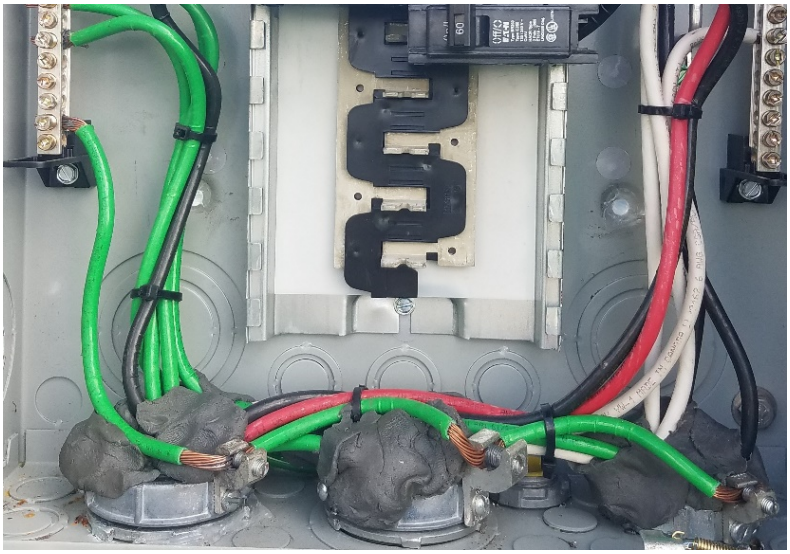
9.1.2 Exothermic Welds – All grounding connections between a ground rod must be exothermically welded together. If there are several conductors connecting to a ground rod, the exothermic weld must be designed for multiple conductors. The contractor must only use exothermic weld molds recommended by the manufacturer, specific to each weld application.



9.1.3 Grounding Pull Boxes – These pull boxes are installed directly next to an ITS cabinet and serve as an inspection point for the grounding system. These pull boxes house the "main" ground rod and allow technicians to test the same location during PMs to develop a long-term condition of the grounding system. These pull boxes have CFX GROUNDING stamped on the pull box lid and must not be used for any other application.

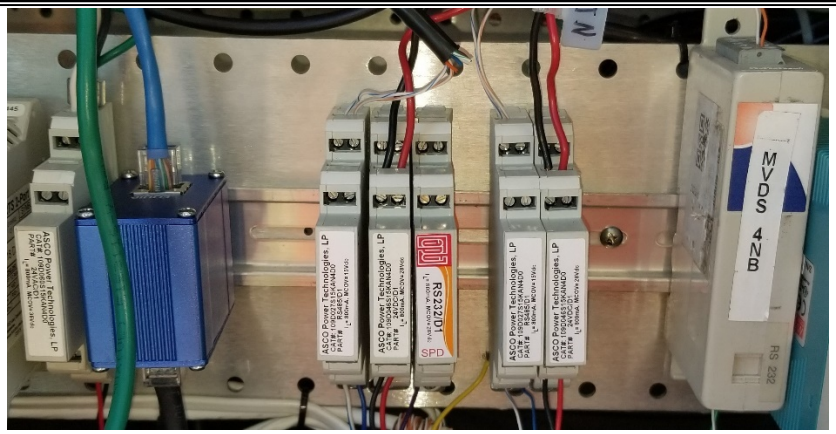
9.1.4 Direct-Buried Grounding Conductor – For underground connections between ground rods, CFX requires a #2 solid tin-plated copper conductor that is direct buried.

9.1.5 Internal Grounding Conductor – For grounding conductors that are used in electrical applications, connect busbar to busbar, or from the main cabinet busbar to the ITS device pole lug, the grounding conductor must be #6 stranded green insulated XHHW type conductor.



9.1.6 Busbars/Terminal Lugs – Busbars and terminal lugs are used to connect equipment ground conductors to designated grounding areas within equipment cabinets, or to connect a ground conductor to a metal component that carries electrical conductors.

9.1.7 Surge Protectors/Arrestors/Suppressors – Surge protectors are installed at electrical disconnects and within ITS cabinets. These devices protect the equipment, cabling and devices from overvoltage.



9.1.8 Grounding Bushing – Grounding bushings are installed on all rigid metal conduit that enters the ITS cabinet or electrical components. All grounding bushings are bonded together and are terminated on the ground busbar within the cabinet.

9.2 Grounding Requirements

CFX has several requirements listed within the Technical Specifications as well as the ITS Design Standards. These requirements are needed to be sure that unwanted electrical surges from different components of the ITS system do not inadvertently affect one another.

9.2.1 Electrical Ground – Isolating the electrical service ground from the ITS device grounding network ensures that unwanted surges that travel from nearby power lines or along the electrical service path are not directed onto the ITS device cabinet's grounding array. Within the ITS cabinets, care should be taken to ensure that the electrical equipment grounds do not connect to the main cabinet grounding busbar/terminal lug. This will ensure that any unwanted surge from the electrical equipment or conductors will travel back to the nearest electrical disconnect and dissipate at that site's grounding electrode.

9.2.2 Neutral-Ground Bonds – A neutral-to-ground bond must be made inside the first panel containing the secondary circuit from the utility transformer. This first neutral-to-ground bond is required by the power company and grounds out the utility's neutral conductor which eliminates unwanted return voltage from traveling on to the power company's system. Neutral-to-ground bonds must not be made beyond this first connection as this violates the NEC and can cause injury to technicians working between neutral to ground bonds. If a step-up **OR** a step-down transformer is installed in the electrical assembly, a new neutral-to-ground bond must be made inside the first panel that contains the secondary circuit of the transformer. If a step-up **AND** step-down transformer are installed in series, a neutral-to-ground bond must be made inside the step up-transformer. A neutral-to-ground bond must also be made inside of the first panel that utilizes the secondary circuit of the step-down transformer. No neutral-to-ground bonds, other than the ones described above, are permitted throughout the electrical system.

9.2.3 Physical vs. Chassis Connections – Physical connections to grounding busbars are required. Ensure that a direct path is used via a dedicated conductor and that points-of-failure are minimized. Connecting device grounds to the chassis is not approved. For cabinets and enclosures, the contractor must bond the cabinet ground busbar to the main grounding electrode. The grounding electrode conductor must be enclosed in galvanized rigid metal conduit.

Though these are the typical ITS grounding procedures for CFX ITS construction, it is important that the construction team verify the specific requirements in their contract. All required ITS grounding should be listed on the Contractor's CPM schedule as it is a pre-requisite to both Substantial Completion and Final Acceptance and it is vital that both the Contractor and CEI are aware of and meet these requirements.

9.3 Grounding Installation

A single-point grounding system must be installed. The primary ground electrode assembly is to be located in a grounding pull box with the top four inches above gravel so that it is easily accessible for inspection, resistance testing, and maintenance. The grounding pull box is to be installed between 12 and 36 inches from the element that is being grounded. All other ground electrode assemblies and their connecting conductors are to be direct buried a minimum of 18 inches below grade.

9.3.1 ITS Devices – Technical Specification 620A-2.1 requires a multi-point grounding array for all ITS device locations (including at existing sign structures where ITS devices are located) which attains a grounding resistance of 5 ohms or less as measured from the main ground rod located within the grounding pull box next to the ITS cabinet. ITS field equipment structures are to be exothermically bonded to the grounding array, as shown on the plans and as shown in CFX's ITS Design Standards. When erecting a new metal pole within 10 feet of existing metal poles or structures, the new pole or structure must be bonded to the existing array.

9.3.2 Power Services – Power service grounds are to be separated from the ITS cabinet and grounding array. The power service ground must not exceed a reading of 5 ohms. Per CFX Specification 639A-4, a continuous single XHHW, green insulated, #6 AWG stranded copper conductor will connect between the non-fused line-side disconnect, meter, transformer, and circuit breaker panel's ground busbar. Additional information related to the grounding of power services can be found in CFX's ITS Design Standards.

9.3.3 Electrical Disconnects – Technical Specification 620A-2.2 requires a single-point grounding electrode for all electrical disconnect locations (including safety disconnects) which attains a grounding resistance of 25 ohms or less as measured from the ground rod.

9.3.4 Fiber Optic Storage Locations – CFX Specification 620A-2.2 requires a single-point grounding electrode for all Fiber Optic Pull boxes, Splice Vaults and Manholes which attains a grounding resistance of 25 ohms or less as measured from the ground rod. This single point grounding electrode is specifically for connecting radio transmitters used for locating purposes and must never be connected to the ITS device grounding array as unwanted radio waves could flow onto the ITS device cabinet's sensitive low-voltage equipment.

9.3.5 Pull Boxes – Ground pull boxes as required by CFX Specification 635 and serve as the main inspection point of the lightning protection grounding system at each ITS device. These pull boxes are to be specifically for the lightning protection grounding system and must not contain any other electrical conductors or communication cabling. The pull box lid must be stamped with CFX GROUNDING.

9.4 Visual Inspections

Visual inspections of the grounding connections, surge protectors and other grounding elements is needed to ensure that grounding network is in good working order. This is performed during construction and prior to final acceptance as well as routinely performed by ITS Maintenance during PMs. The contractor is not to backfill below-grade grounding installations and connections until the inspector has inspected the ground rod and connections to ensure conformance to the plans. Contractors are required to notify the engineer at least five days prior to requiring a grounding inspection. All test results will be documented on a CFX standardized grounding form.

Please note that the following inspections must only occur when power is off and by a certified technician.

9.4.1 Ground Connections – Inspection of these terminal lugs, busbars and welds are performed by hand and with a screw driver. A check of tightness of all terminal lugs and busbars is needed to ensure the conductor connected is secure, and the lug is fully clamped down to provide a physical connection.

9.4.2 Continuity Test – A multi-meter with the continuity feature is required to test out both ends of a connection. This can be performed by placing one lead of the multi-meter to a conductor, terminal lug, or any other metal component and by touching the other lead to another conductor, terminal lug or any other metal component to see

if the two apparatuses are connected. This process is typically performed by touching one lead to the outside or inside of a device cabinet and touching the other lead to a ground rod.

9.4.3 Surge Protectors/Arrestors/Suppressors – A visual inspection of these surge devices is needed to be sure that any LED indicators are on and working in a "good" or "protected" state as well as looking for signs of physical damage on the surge protector.

9.5 Grounding Testing Requirements

Ground testing is required after the installation and replacement, when adding additional ground rods to an existing grounding network or as required during ITS Maintenance PMs. Additionally, a visual inspection is required to ensure all other components of the grounding system are in good and working order. This Section outlines the standard testing procedures that CFX requires for acceptance of the ITS and electrical grounding system on their construction projects.

9.5.1 Ground Electrode(s) Testing – CFX Specification 620A requires that all ground rods be tested by a three-point earth ground megger. The specifications also require that a grounding resistance as shown in Section 9.3 above is achieved. As shown in Figure 9.12, this device has three leads, one of which is connected to the ground electrode and the other two connect to metal stakes offset from the grounding electrode in a straight line. This testing method provides a more accurate reading of resistance when compared to a clamp-on unit.

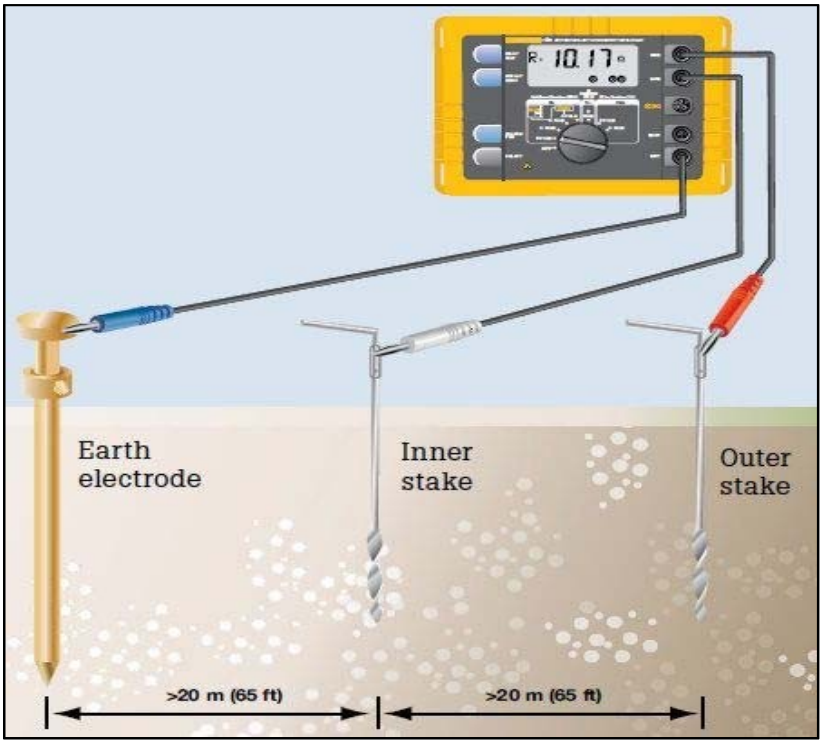


Figure 9.12: 3-Point Earth Ground Megger

9.6 Pre-Activity Considerations

1) Prior to the Contractor beginning any grounding installations, the Senior Inspector should meet with the lead for the Contractor, who will be in charge of the installation of the grounding components. The meeting topics should include all items as outlined within this chapter, so as to provide the Contractor with the CEI's expectations and criteria, by which the installation will be inspected. Additionally, the CEI will go over all of the submitted materials for

the grounding installation to make the Contractor aware that these are the only materials that are to be used on the project, unless they wish to submit additional materials.

2) The inspector must be diligent when inspecting the grounding installation to verify that only approved materials are being used, the installation is being performed per the plans, specifications and applicable Standard Plans, and that exothermic welds and all ground connections are solid and will not loosen over time.

3) Verify that the grounding arrays are being constructed as shown in Figure 9.3. Exceptions to this configuration can be made if the available Right of Way is not large enough to accommodate this configuration. If a different array configuration is required, ensure that appropriate distance is maintained between grounding electrode assemblies.

4) When overseeing grounding testing, be sure that environmental factors, such as soil condition are noted. Oversaturated soil conditions can often cause a test reading to be lower than it would be in dryer soil conditions. Therefore, if a grounding issue is found at a later date, the test record can be referenced to determine if the soil conditions may have played a role in passing the grounding system at the site.