ERICSSON

LBI-39067

Mobile Communications

STANDARD FOR SITE GROUNDING AND PROTECTION

Installation Manual

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1. OBJECTIVE

The fundamental objective is to provide a standard for site equipment grounding, with recommended methods that are essential to protect personnel, minimize components failure, and optimize performance by reducing electrical noise. Transient voltage introduced into a system often exceeds the operating parameters of electronic components and has destructive results. The fragile nature of semiconductors makes them even more susceptible to these externally induced transient voltages.

1.1. GROUNDING THEORY

In theory, a ground rod 1 inch in diameter driven into homogeneous 1000 ohm per meter (ohm/meter) soil for one meter would present only 765 ohms. Driving it another meter into the soil (two meters) would yield 437 ohms. Extending the depth to three meters would yield about 309 ohms.

By using three ground rods that are each one meter long, and driven into the same soil area one meter deep and one meter apart we could achieve a ground resistance of 230 ohms.

We quickly realize that we can get faster ohms reduction in ground resistance by installing multiple ground rods. If we also bury the interconnecting wire below the soil surface we are able to lower the ground resistance below 200 ohms.

With these conditions as a point of reference, the **ERICSSON** site installation should exhibit better than (below) five (5) ohms resistance between any connected point on the ground bus and earth ground. The exception to this requirement is noted at section **2.1.4. ANTENNA STRUCTURES ON TALL BUILDINGS**.

When making these measurements, an instrument similar to the **AEMC Model 3700HD** will be used to make these measurements. The measurements will be made using the instructions provided with the **AEMC 3700HD Ground Test Instrument**.

1.2. SCOPE

These specifications and requirements are prepared for both safety and damage prevention measures. The grounding, bonding, and shielding procedures are implemented to prevent damage to equipment, reduce Radio Frequency spectrum pollution and as a safety measure for maintenance and operating personnel.

The prime source of danger and damage is from lightning currents which are often conducted to the equipment by way of the coax transmission lines.

One of the better means to reduce the chance of damage from this source is to provide a low impedance path to ground for these currents without having the currents flow through the equipment.

1.3. GENERAL

The following needs constitutes a justification for grounding:

1) The need to control fast-rising electrical surges., which produce high voltage differences between the ends of single conductors such as heavy copper wires and bars.

2) The need to equalize surge potentials by controlled bonding of ***Ericsson*** Communication site ground elements.

   These elements include the following:

   a) Non **I**solated **G**round **Z**ones **(IGZ)** equipment grounds

   b) Surge Produces

   c) Surge Absorbers (provides path to ground)

   d) IGZ Grounds

3) The need to reduce voltage differences and control surge currents by using single-point grounding, which includes the following elements:

   a) A common or master ground bar configuration for establishing a common voltage reference plane (with respect to earth “true” ground) for the entire ***Ericsson*** communications site and for dispersing lightning and power surge activity rapidly to earth via the halo and ring ground system.

   b) A ground window bar, or equivalent, to establish a local point of reference potential for grounding sensitive electronic equipment. This is terminated on the master ground window as the single point ground and voltage reference for all equipment at the ***Ericsson*** communications installation.

   c) A single ground point in the isolated Ground Zone is at the master ground window. This again insures that potential equalization is true to any attached ground windows, and equipment.

d) The single point master ground bar will be cleaned to remove any oxidation to insure a low resistance connection. To establish sufficient metal to metal contact, an anti corrosion or antioxidant material is added at any connection points where grounding conductors are terminated.

1.4. RESPONSIBILITY

Throughout this document there will be references to ground rods and ground connections. In all cases mentioned there will be only one ground system allowed at each site, building, room, or communications shelter. **ALL GROUNDS ARE TIED TOGETHER**.

There should be no separately maintained ground rods or ground systems that are associated with the communications shelter, site, building, or equipment room.

Adherence to these requirements becomes the performance standard with respect **Ericsson** Mobile Communications shelters and communications systems.

1.4.1. Minimum Requirements

The purpose of the specification is to establish, minimum requirements for a grounding system which will provide a measure of personnel and equipment protection. In the event that any item specified within this document conflicts with the National Electrical code or local building-grounding related codes, those Codes may take precedence.

Protective measures to prevent equipment damage and personnel hazards against lightning will incorporate system grounding and bonding using good RF practices. While all conductors and connections have some associated resistance, the inductive reactance is normally much larger. All grounding and bonding conductors have low inductance interconnections to minimize the inductive voltage transients.

As stated in the general overview of this document, all elements of the system, and conducting elements in near proximity to the system are grounded and bonded together. This performs the function of maintaining any and all parts of the radio site at the same level of ground integrity as related to true ground.

1.5. PROCESS & DEFINITION

1.5.1. Coax and Transmission Line Grounding

At Ericsson repeater sites and antenna tower locations, our installers must attach three lightning protection grounding kits to each coaxial line used at the site.

Each coax run will have a gas tube type, or equivalent, lightning arrestor installed onto the coax near the cable entrance to the communications shelter or room. These are believed to be the best lightning arrestors available today.

These grounding kits will be terminated onto the master ground bar. All connections to the master ground bar window will be clean and free of any oxidation to insure a low resistance connection.

Each of these arrestors are effective in limiting the amount of lightning energy that can be transferred to the equipment via the inner conductor of the coax or transmission line.

1.5.2. Equipment Grounding

Each equipment rack, equipment cabinet, or equipment shelf will be grounded to a site ground via the inner building halo ground. In the case of communications shelters, the equipment enclosures will be attached in the same manner to this system “halo” ground.

1.6. GROUND WIRE COMPOSITION

No grounds will be run inside metal conduits because metal conduits increase the surge impedance of the grounding cables. The grounds which make up the “halo” ground will be of number 2 AWG or larger copper wire covered with a non-conductive approved plastic covering. This covering is light green. Where the halo ground is attached to exit ground wires, these wire(s) will be solid, tinned, bare copper, number 2 AWG or larger.

A complete grounding system for the antenna, towers, and buildings are provided. These include internal and external grounding systems for equipment in the communications building, grounding of the antenna towers and guys, transmission line, telephone line and AC power line grounding and grounding of the communications facility.

1.6.1. Ground Rods

Where an Ericsson ground system is installed, ground rods will be bare copper or copper-clad steel, 5/8 inch in diameter, and a minimum of 8 feet in length. As discussed in **"General"** (1.3) at the beginning of this document, multiple interconnected ground rods are normally provided.

To maintain the integrity of the ground system, where space permits, a minimum distance between ground rods will be 10 feet. Exothermic bond/weld connections will be made at all ground rod connections.

1.7. CONDUCTORS

Conductors that are employed below ground for the purpose of connecting ground rods will use:

a) Stranded copper wire, number **2 AWG** or larger.

b) Solid copper strap, with minimum of **18 AWG** and minimum width of two inches.

Conductors used above ground for interconnecting ground rings, halo's equipment (racks and cabinets), and other metal items will be:

a) Solid or stranded copper wire number **6 AWG** or larger.

b) Solid copper strap, with minimum thickness of **16 AWG** and a minimum width of one inch.

Precautions against the use of connections where dissimilar metals might cause deterioration of grounding surfaces are observed.

Below are lists of metals divided into groups. By avoiding the use of metals from one group attached to a metal of another group, we prevent ground contact surface deterioration.

Group A	Group B	Group C	Group D
Magnesium	Tin	Stainless Steel	Copper
Aluminum Zinc	Lead Steel Iron	Nickel	Silver

Metal surface contact of metals in the same group may be used with the following stipulations:

CONTACT SURFACES	**INSIDE**	**OUTSIDE** (Weather Exposed)
Within same group	OK	OK
Adjacent groups	OK*	Weatherproof coating must be applied after direct metal-to-metal contact.*

* No liquid should be allowed to come into contact with surface gaps of metal contacts from adjacent groups.

1.8. CONNECTIONS

All connections are made with minimum length conductors, with straight vertical (or horizontal) runs, if possible. Conductor bends, when required, will be greater than a 12-inch radius.

Connecting conductors will always transition in the direction of current flow or toward earth ground, and approach the main ground at an angle of roughly 45 degrees.

1.8.1. Below Ground

Connections made to ground rods, or to conductors below ground must be made using an exothermic (heat producing) process such as **Cadweld** or equivalent. This attachment procedure ensures firm, mechanically rigid, and maintenance free connections. Connecting and interconnecting conductors are placed at the same depth as the top of the ground rods.

CADWELD is a bonding process that provides a metallic bridge connection that exhibits virtually no resistance and its conductivity approximates that of the associated conductors.

1.8.2. Above Ground

Where possible, connections made above ground, in areas exposed to weather, the Cadweld or similar process will be employed. If environmental conditions prevent the use of the Cadweld process, the use of an appropriate pressure-type connection will be used.

Where above ground pressure type connections are employed, stranded wire will be used. Connections made above ground will be made with appropriate passivation of the mating surfaces, or use special transition clamps such as ***PolyPhasor Model J-1, J-2,*** or equivalent.

Connections to tower guy wires will use pressure connections.

1.9. SURGE SUPPRESSION DEVICES

Manufacturer Surge suppression device types referred to in this document are recommended and may be substituted as long as the substitution is of the same quality and performs the same function. Consideration must be given to voltage clamping level, response time, and energy rating for the intended application.

1.9.1. The Following Practices Are Avoided

a) Ground wire runs through metal conduit. If an occasion presents itself where the ground must be carried through a metal conduit, the ground wire must be bonded at each end of the conduit. The use of PVC conduit is preferred.

b) Reliance on the third wire (green wire) on ac power lines for lightning ground.

2. EXTERNAL GROUNDING SYSTEM

External grounding rings installed by Ericsson or approved contractors will individually encircle the antenna tower, the building, or equipment shelter.

Ground rods for the tower and building are installed so that the top of the rod(s) is minimum of 12 inches below soil surface. The ground rods for tower ground will be installed so that the bottom end of the rod is deeper than the lowest part of the tower footing.

Each ground ring listed above, such as the tower, building, fence, or other object will be interconnected with a minimum of two (2) stranded copper wires number 2 AWG or larger. Where possible, connections to the ground rings will be made using an exothermic (Cadweld process or equivalent) weld.

2.1. ANTENNA TOWER GROUNDS

Where monopole masts are employed, the ground system will consist of a minimum of three ground rods, connected together per the section on **“Conductor: Below Ground.”**

The mast connection to the ground system will be made with stranded wire number 2 AWG or larger. Connections to the mast will be in accordance with the manufacturer’s instructions. The connections will be short and direct with no sharp bends.

2.1.1. Wooden Antenna Poles

At installations where wooden antenna poles might be employed, the grounding system will consist of a minimum of two ground rods connected together and installed as per the paragraph **“Conductors**: **Below Ground.”**

Atop the pole, ground connections to the antenna or antenna mast are made per manufacturer recommendations. A number 2 AWG or larger stranded copper ground wire will be run down the pole, and away from all other conductors to avoid possible flashover.

2.1.2. Self Supporting Lattice Towers

The self supporting lattice tower grounding system consists of a ground rod at each tower leg. If necessary, additional ground rods may be used to decrease ground resistance where needed, or be used to reduce the distance between rods. Ground rods must be connected together per paragraph **“Conductors: Below Ground”**. Each tower leg is connected to the grounding system with number 2 AWG stranded wire or larger. Connections to the tower leg will be short and direct with no sharp bends.

In addition to tower leg grounding, a ground rod must be installed at each guy anchor point approximately one foot from the anchor footing. The top of the ground rod will be a minimum of 12 inches below soil surface. The bottom of the ground rod will extend below the lowest point of the anchor footing. Number 2 AWG stranded copper wire is used to connect each of the guy wires to the ground rod at the guy anchor. Each ground rod is to be tied back to the tower **“ground ring”** below ground, using number 2 stranded copper wire.

2.1.3. Guyed Lattice Towers

The guyed lattice tower grounding system consists of three ground rods at the tower base. These ground rods must be connected together per paragraph **“Conductors: Below Ground”**. The ground conductors used to connect the grounding system will be number 2 stranded wire or larger. Connections to the tower will be short and direct with no sharp bends.

In addition to the tower leg grounding, a ground rod must be installed at each guy anchor point approximately one foot from the anchor footing. The top of the ground rod will be a minimum of 12 inches below soil surface. The bottom of the ground rod will extend below the lowest point of the anchor footing. Number 2 AWG stranded copper wire is used to connect each of the guy wires to the ground at the guy anchor. Each ground rod is to be tied back to the tower "ground ring" below ground, using number 2 stranded copper wire.

2.1.4. Antenna Support Structures On Buildings

Radio antenna installations atop building will have the tower, down conductors, transmission line shields, and other conducting objects within 6 feet of the tower or antenna base securely bonded together per paragraph **"Conductors: Above Ground" (1.7)** and **"Connections: Above Ground (1.8.-1.8.2.)."**

Atop steel-frame structures, where possible, the common bond point may be bonded to building steel with number 2 AWG or larger, copper wire. If available, the tower may also be bonded at roof level to a large metal, earth grounded, cold water pipe.

Atop reinforced concrete buildings, the common bond point should be connected via number 2 AWG or larger, stranded copper down conductors. These may be bonded to the earth grounded cold water main in the basement of the building or bonded to the building ground rod system. If available, the tower should also be bonded at roof level to a large metal, earth grounded, cold water pipe.

Guy wires associated with towers atop buildings should be grounded at their anchor points to a common bond point in the same manner as for grounding terrestrial towers. A dissimilar metal interconnect device will be used between the guy wire and the ground wire. Where the ground wire from multiple guys are daisy-chained, there will be at least a three inch "play" loop between guy-to-guy ground connections.

In the above case where tall building grounds are in use, the ground resistance should be maintained below (better than) ten (10) ohms between any equipment connected ground bus and earth ground.

> When making these measurements, an instrument similar to the AEMC Model 3700 HD will be used to make these measurements. The measurements will be made using the instructions provided with the **AEMC 3700HD Ground TEST Instrument**.

2.2. EQUIPMENT BUILDINGS

External **"halo"** ground is the grounding system around the exterior of the communications shelter or building. This ground system consists of a ground rod at each corner of the building. As necessary, additional ground rods will be added such that the distance between rods is less than 10 feet.

A ground rod is installed directly below the coax transmission line entrance to the building. Ground rods are spaced approximately 2 feet out from the perimeter of the building.

2.3. BULKHEAD PANEL

A weatherproof metal bulkhead panel should be installed on the building equipment wall. The panel will be comparable to the ***Andrew Type 204673*** or equivalent. The size should be determined by the number and size of transmission lines interconnecting through it. The appropriate Andrew cable boots, or equivalent, are used for the weatherproof connections.

The external panel must include a ground bar for transmission line shield ground connections and connections to the external ground system. The ground bar should be fabricated to avoid dissimilar metal connections as stated in this document (see paragraph **"Conductors: Above Ground."**)**.** The bar must be connected to the building external ground system by number 2 AWG (2 conductors may be employed to form a low inductance path to the system ground).

An internal sub panel, bolted directly to the bulkhead panel with multiple bolts may be used to mount the transmission line surge suppressor specified in paragraph **"Coaxial Suppressor."** The sub panel must be securely fastened with a low resistance, low inductance path to the bulkhead panel (stranded NO. 2 AWG or larger).

2.4. FENCES

Where possible to do so, metal fences within 6 feet of any ground ring or any grounded object will be grounded at twenty foot intervals along its length or at a minimum of each corner post and at each gate metal support post. This is to provide additional shock hazard protection from lightning.

A minimum 8-foot 5/8 inch copper or copper-clad ground rod shall be installed into the ground within one foot of the fence, near a fixed gate hinge post where appropriate. The top of the ground rod will be a minimum of 12 inches below the ground surface, or at the same level as the external ground ring to which it will be connected. Additional ground rods may be installed for each 20 feet of fence, at equal spacing.

Each ground rod will be connected underground by the most direct path to the nearest tower or building ground ring using a stranded copper wire, number 2 AWG or larger.

Above ground connection will be made by use of a pressure clamp near the bottom of the metal post. If below ground connections are used, it will be made by exothermic weld (Cadweld). Tinned copper ground strap (braid) is used to connect metal fence gate(s) to the main post. Pressure clamps are employed with these connections.

2.4.1. Nearby Metal Objects

The following components are connected to the external grounding system using a number 2 AWG (or larger) stranded copper wire.

a) The transmission line entry window into the building, as this is the entry point into the equipment area. All transmission lines are grounded to this window, and extra care is employed to ensure a very low inductance path to ground.

b) Ice shield and exterior cable tray between tower and building.

c) Emergency generator and any generator supporting platform or base.

d) Fuel tank(s), above or below ground.

e) other large metal or conductive objects within 6 feet of the communications shelter, tower, or the system ground.

f) To other ground systems provided by telephone company, or the electric utility provider(s). Local electric codes should be observed when making this attachment.

2.5. TRANSMISSION LINES

The following applies to the antenna and transmission lines outside the communications shelter or building where entry is made into the equipment shelter. These requirements do not apply to antenna and transmission lines that are contained entirely within the equipment room or communications shelter.

2.5.1. Shield Grounds

The outer conductor of coaxial transmission cables must be grounded with an appropriate coaxial cable grounding kit. These grounding kits are installed at three points on the cable. The grounding locations are as follows:

1) Immediately outside the cable entrance to the equipment room, shelter, or building. This ground is attached prior to the phaser type lightning suppressor.

2) At the bottom of the vertical run of cable, at a point near and above the bend onto the ice-bridge or support trestle. This grounding point should be as near the ground as possible.

3) The top end of the vertical cable run near the termination or antenna. This point is grounded or bonded to the tower by means of the clamp supplied as part of the grounding kit.

All three points should be grounded in accordance with the recommendations provided in the grounding kit instructions. These instructions are included in kits similar to the ***Andrew type 204989 or equivalent***.

2.6. COAXIAL SUPPRESSOR

Poly-Phaser type IS-B50 or equivalent lightning suppressor should be installed at the near the inside cable entrance of the building or communications shelter. This suppressor should be bonded to the nearby ground bus plate to remove surge currents from the center inductor of the cable.

2.7. TOWER-TOP PREAMPLIFIERS

PolyPhasor type IS-GF50 surge suppressor should be installed according the manufacturers instructions as an additional protective measure at the input ports of the tower-top amplifiers or preamplifiers. This protection is in addition to the Ericsson internal amplifier protective devices. All tower-top preamplifier chassis must be grounded to the tower.

Where possible, DC ground, shunt-fed antennas should be used as additional protection for the tower-top preamplifiers. Antenna cable attachments to the antennas are kept as short as possible.

In cases where tower-top amplifiers are employed that use DC supplied via the coaxial transmission line, Ericsson will ensure that an impulse suppressor similar to the ***PolyPhasor IS-GC50 DC*** injection type is used. Certain tower top amplifiers are already equipped with this type protection.

2.8. TOWER-MOUNTED MICROWAVE AND REPEATER EQUIPMENT

For tower top repeaters, the input and output points are the most important to protect. Tower, telephone or control lines are often overlooked. Coax line protectors are employed in the Ericsson repeater inputs and outputs, and the preamplifier front end.

Power line protectors must be local and single point grounded at the top with the equipment. The need for power protection is doubled for tower top repeater and preamplifier installations where 120 or 240 VAC is being fed up the tower.

Above 18 GHz, microwave equipment usually has a Gunn down converter located on the back of the dish, being powered through one or two coaxial lines. These lines also handle the uplink and down link frequencies as well as **A**utomatic **F**requency **C**ontrol **(AFC)** error information.

Protectors similar to the Poly-Phaser IS-MD50LNZ should be employed at the top and bottom to properly protect the equipment. A device similar to the PolyPhasor IS-DC50LNZ is another type of protection used in these applications and is fully transparent to all existing voltages and signals from microwave equipment.

2.9. COMMUNICATIONS EQUIPMENT ROOM INTERNAL GROUNDING

A Halo ground should be employed inside the communications shelter. This Halo ground must be installed in the form of a "ring" in such a manner as to enable the use of short length conductors attached from the equipment racks, cabinet, cable trays, and equipment shelves to the ground ring (Halo).

This Halo is made of number 2 AWG stranded copper wire attached to standoffs at approximately eight (8) feet above the equipment room floor.

Where the room or communications shelter has less than 100 feet of perimeter, a minimum of four (4) ground risers are used. In any case, where possible, a ground riser is used at each corner of the perimeter. In installations where the perimeter of the equipment room exceeds 100 feet perimeter, a ground riser will be attached at every twenty (20) feet of perimeter. These ground risers are made of number **2 AWG SOLID** copper which exit the room, or building via poly-vinyl conduits (PVC).

2.9.1. Grounding Of Equipment Cabinets, Racks, And Shelves

Each equipment cabinet or rack shall be equipped with a ground bus that is attached to the halo ground and the external system ground. Each equipment chassis secured in a cabinet or rack is connected to the cabinet or rack ground bus. Equipment mounting rails are the preferred ground connection points within the cabinet or racks.

Attachment from the equipment cabinets and enclosures to the internal ground halo are made using number 6 (or larger) stranded copper wire. Connections from these enclosures to the halo ground will be made using the shortest path length to diminish inductance.

2.9.2. Cable Trays

Cable trays will be attached to the internal ground halo via number 2 AWG or larger stranded copper wire. Where mechanical connections (lugs, bolts) are made to interconnect cable tray section an additional connection will be employed between cable tray sections to ensure a good electrical ground connection. Number 6 or larger, stranded copper wire will be used.

Grounds between cable trays, equipment cabinets, equipment racks, and AC utility power enclosures will be via number 2 AWG or larger stranded copper wire.

When compression type connectors are employed at an ***Ericsson*** installed site or system, the Burndy compression system should be used. This system consist of connectors for taps, splices, cable to ground rod, and structural termination. These connectors may be used in some ***Ericsson*** sites ground applications. The Burndy system connectors are listed with ***Underwriters Laboratories Under Standard UL467***. Most connectors have been successfully tested according to the requirements of ***IEEE Standards 837***.

3.PLANS AND DOCUMENTATION

Drawing and Ground reference documentation will reflect the following items:

a) Grounding and bonding plan

b) Ground rod

c) Surge suppression devices

d) Bulkhead panel types

e) Coaxial cable grounding kits(s)

A prepared plan for lightning and surge protection measures implemented into ***Ericsson*** communications system is submitted as a part of the overall system specifications. This plan takes into account such items as the radio installation and equipment to be protected and local conditions. This plan must meet all requirements covered in this specification, unless a specified written waiver is provided by the customer and agreed by ***Ericsson***.

Ericsson GE Mobile Communications Inc.
Mountain View Road • Lynchburg Virginia 24502

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