Engineering Standard

SAES-T-795 28 January, 2004

Communications Facility Grounding Systems

Saudi Aramco DeskTop Standards

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1 Scope

This standard covers mandatory requirements governing the design and installation of communications grounding systems for electronic, analog and digital telecommunications facilities and remote digital switching terminals and repeater sites. This includes upgrading existing facility when new equipment is being added.

2 Conflicts and Deviations

Any deviations, providing less than the mandatory requirements of this standard require written waiver approval as per Saudi Aramco Engineering Procedure SAEP-302.

3 References

Referenced standards and specifications shall be of the latest edition, revision or addendum, unless otherwise stated. Applicable references are listed below.

3.1 Saudi Aramco References

Saudi Aramco Engineering Procedure

SAEP-302	*Instructions for Obtaining a Waiver of a Mandatory Saudi Aramco Engineering Requirements*

Saudi Aramco Engineering Standards

SAES-P-111	*Grounding*
SAES-T-887	*Telecommunications Electrical Coordination - Protection at Power Plant and Radio Stations*
SAES-T-903	*Outside Plant Electrical Protection and Grounding*

Saudi Aramco Materials System Specification

09-SAMSS-106	*Epoxy Coating of Steel Reinforcing Bars*

Saudi Aramco Standard Drawing

AA-036391	*Communications Equipment Grounding for Telecommunication Facilities*

3.2 Industry Codes and Standards

General Telephone and Electronics

GTE 795-805-071	*Central Office, Grounding Systems - Engineering Applications*
GTE 795-805-072	*AC Service Grounding Engineering Applications*
GTE 795-805-073	*Telephone Central Office Grounding of Transmission Equipment*
GTE 795-805-074	*Inspecting Central Office Grounding and Electrical Protection*
GTE 795-805-075	*Remote Electronic Serving Area Grounding Systems - Engineering Considerations*

National Fire Protection Association

NFPA 70	*National Electrical Code (NEC)*
NFPA 780	*Standards for the Installation of Lightning Protection Systems*

4 Design Requirements

The GTE 795-805-071, Telephone Operations Practices "Central Office Grounding Systems Engineering Applications"; GTE 795-805-072, "AC Service Grounding Engineering Applications"; GTE 795-805-073, "Central Office Grounding Transmission Equipment"; GTE 795-805-074, "Inspecting Central Office Grounding and Electrical Protection"; and GTE 795-805-075, "Remote Electronic Serving Area Grounding Systems - Engineering Considerations" are hereby recognized as Saudi Aramco Engineering Standard SAES-T-795, "Communications Facility Grounding Systems". Mandatory items and modifications are listed herein.

4.1 Communications Facility Grounding

4.1.1 Each communications facility shall have one common grounding system.

4.1.2 Single-point Ground Systems (SPG)

All communications facility grounding shall include a Single-point Ground System (SPG), where the positive battery, circuit ground, or discharge ground do not contact other grounds except at a designated single point. (Reference: Standard Drawing AA-036391).

4.1.3 All ground conductors, straps and connections shall be installed in a manner to direct the fault current or lightning from its source to the grounding electrode system.

4.2 Grounding System Components

The major components of the grounding system are:

- Grounding Electrode System
- Master Ground Bar (MGB)
- Floor Ground Bar (FGB)
- Vertical Equalizer (VE)
- Horizontal Equalizer (HE)
- Noncoated Building Steel
- Computer Floor Grounding
- MDF/Entrance Cable Protector Ground Bar (ECPGB)
- Cable Shield/Cable Vault Ground Bar (CVGB)
- Waveguide Entrance Ground Bar (WEGB)
- Grounding Conductor (GC)

4.2.1 Grounding Electrode System

4.2.1.1 The communications facility grounding system shall be either or all of the following:

- Ground ring
- Rod electrodes
- Ground fields, etc.
- Noncoated Building Steel

4.2.1.2 Saudi Aramco Standard SAES-P-111 and the NFPA 70 (NEC) code requirements shall be complied with for all AC Power grounding, grounding electrodes and grounding electrode systems for communications facilities.

4.2.1.3 The design of the grounding electrode system, calculations of the earth resistance, and the grounding methods and measurements shall be according to SAES-T-887 and SAES-P-111.

4.2.1.4 The grounding electrode system shall be bonded to all the following facilities present at the premises:

- AC main service power neutral
- Metal underground water piping system and/or metal well casing within a distance of 3 meters
- Noncoated building steel

- Any other ground electrode system

Commentary Note:

Grounding electrodes and ground rings shall be constructed, bonded and shall provide access to lead connections for resistance measurements in accordance with SAES-P-111 (Section 4.1.3 through 4.1.8, Section 4.2 and Section 5).

4.2.1.5 The ground resistance of the grounding electrode system at the MGB shall not exceed:

- 3 ohms for communications facilities with Electronic Switching and Transmission Systems
- 2 ohms for communications facilities with a Communications Tower(s)

4.2.2 Master Ground Bar (MGB)

4.2.2.1 The MGB is a copper ground bar located within the communications equipment room. The minimum size shall be 6 mm x 102 mm x 500 mm. Make all grounding connections to the MGB using two-hole approved copper terminal lugs.

4.2.2.2 There shall be only one MGB for every communications facility. The MGB shall be located as close as possible to the AC service and outside plant main distribution frame, without interfering with cable structures and support. The location of the MGB must be identified on building drawings and equipment layout plans, and on the bar itself.

4.2.2.3 The MGB shall be bonded to the building ground grid (AC power ground) through two buried leads from opposite sides of the ground grid. The leads shall be a minimum of 4/0 AWG (120 mm^2) bare tinned-copper conductors. Unavoidable bends shall have a large radius (for minimum acceptable bending radius, refer to 4.2.11.5). The two leads shall be run in PVC conduit. When the PVC conduit is used in areas where it would be exposed to sunlight, it must be a type that is resistant to ultraviolet rays.

4.2.2.4 Direct bonding of communications equipment within the communications building to the building ground grid is not permissible. The communications equipment shall be

bonded to the building ground grid through a single point at the MGB. The MGB is the common point of grounding connection for the DC and communications equipment. The AC distribution system shall not be connected to the building ground grid through the MGB.

4.2.2.5 The MGB shall be divided to the following zones:

P surge producers (such as interior radio equipment including cable trays that are connected to radio equipment, Cable Shield/Cable Vault Ground Bar and MDF/Entrance Cable Protector Ground Bar)

A surge absorbers (both ground leads coming from the opposite sides of the ground grid)

N non-isolated equipment (DC Power system positive return bus, computer floor, communication racks and cable trays)

I isolated equipment (electronic switching equipment & transmission systems and terminal Equipment)

These zones shall be permanently labeled on the MGB and on the building drawings.

Commentary Notes:

1. The isolated equipment zone must be placed as far away as possible from the surge producer zone.

2. The MGB must not have leads (other than those specified in this practice) connected to it to complete an electrical path for any other purpose. The MGB shall not be placed in the cable vault.

4.2.2.6 The communications equipment located outside communications building (i.e., communication towers, waveguides, etc.) shall be bonded directly to the AC ground grid outside the building.

4.2.3 Floor Ground Bar (FGB)

4.2.3.1 One FGB shall be installed on each floor of the communications building for every 60 x 60 m^2 equipment area. Also, FGB shall be provided if the distance between

the MGB/FGB and the involved equipment exceeds 40 m or the equipment floor area exceeds the specified limit.

4.2.3.2 The location of the FGBs must be identified on the building drawings and on the equipment layout plans and shall not interfere with the cable support requirements. The minimum size shall be 6 mm x 102 mm x 500 mm. All connections shall be two holes.

4.2.4 Vertical Equalizer (VE)

4.2.4.1 To equalize the ground potential in a vertical direction across the building, Vertical Equalizers (VE) shall be installed in buildings where the communications equipment (switching, transmission, DC equipment) is located on different floors.

4.2.4.2 The VE is an insulated copper conductor of minimum 750 MCM (thousands circular mils) (400 mm^2) size that shall be directly bonded to FGBs at each floor level. The VE shall be as straight as possible without offsets. Unavoidable bends shall be with a minimum turn radius of 900 mm.

4.2.5 Horizontal Equalizer (HE)

Horizontal Equalizers (HE) shall be used to equalize the ground potential from its appearance at the MGB/FGB to the FGBs (if installed) on the same floor. Multiple VEs shall be bonded by HEs of minimum 750 MCM (400 mm^2) insulated copper conductor. The HE must be as straight as possible. Unavoidable bends shall not exceed 90 degrees with a minimum turn radius of 900 mm.

4.2.6 Noncoated building Steel

All noncoated building structural steel and rebars shall be bonded to the building external ground ring accordance with SAES-P-111.

Commentary Note:

Coated rebars specified in this standard should be the epoxy-coated steel rebars as specified in 09-SAMSS-106.

4.2.7 Computer Flooring (N zone)

4.2.7.1 When computer flooring is used, form a loop around the perimeter of the floor area using a minimum of No. 6 AWG

(16 mm²) copper conductor and splice its ends together with a single splice. Bond the loop to the computer flooring metal support in intervals along the loop not to exceed 6 meters. Exposed connections shall be taped.

4.2.7.2 Bond the loop to the nearest MGB/FGB using a minimum of No. 2/0 AWG (70 mm²) insulated copper conductor.

4.2.7.3 Additional grounding and bonding of computer floors shall be applied according to the computer-flooring manufacturer's instructions.

4.2.8 MDF/Entrance Cable Protector Ground Bar (ECPGB) - P zone

The entrance cable protector ground bar (ECPGB) is a copper bar that is attached horizontally across the top or bottom of the Main Distribution Frame (MDF) or the Protector Distribution Frame (PDF). The ECPGB shall be grounded to the MGB/FGB using a minimum of No. 1/0 AWG (50 mm²) PVC insulated copper conductor at maximum intervals of 5 meters, so that no protector vertical is more than 2.5 meters from a ground lead to the MGB/FGB. The protectors (connectors) on each MDF or PDF vertical shall be interconnected (Interconnector Ground Strap) using a minimum of No. 6 AWG (16 mm²) insulated copper conductors and then connected to the ECPGB (Long Ground Strap) using a minimum of No. 6 AWG (16 mm²) insulated copper conductor (Figure-1, page 15).

4.2.9 Cable Shield/Cable Vault Ground Bar (CVGB) - P zone

Cable vaults shall have a copper Cable Vault Ground Bar (CVGB) which shall be bonded to the MGB using a minimum of No. 1/0 AWG (50 mm²) insulated copper conductor. No. 6 AWG insulated copper conductor or equivalent copper strap shall be used to bond cable shields to the (CVGB). The minimum size shall be 6 mm x 51 mm x 150 mm.

4.2.10 Waveguide Entrance Ground Bar

4.2.10.1 Waveguide Entrance Ground Bar (WEGB) is a copper ground bar located outside the communications building at or near the tower horizontal cable run entry.

4.2.10.2 The WEGB shall be bonded to the communications building grounding electrode system (building ground ring)

at a single point outside the building using a minimum of No. 4 AWG (25 mm²) bare tinned solid copper conductor.

4.2.11 Grounding Conductor (GC)

4.2.11.1 Grounding Conductors (GCs) are insulated green and yellow (or with yellow tape at visible locations) copper conductors that are used to connect the non-current carrying metal parts of DC communications equipment, raceways, and other enclosures to the inside building ground bars like MGB/FGB.

4.2.11.2 GCs shall be insulated copper base material. They shall be run either in nonmetallic conduit only, or not in conduit at all, and run only through nonmetallic sleeves in ceilings, floors and walls.

4.2.11.3 GCs shall not be encircled with metal clamps. They shall not run through metal walls/plates/conduits or ducts. They shall be separated from the DC power, switchboards and high frequency cables etc. by at least 0.3 meter.

4.2.11.4 Ground conductors shall not be run within one meter of processors or memory frames.

4.2.11.5 All bends in ground conductors shall be kept to a minimum. Unavoidable bends shall have a large radius. The minimum acceptable bending radius shall be:

- 150 mm for sizes up to No. 6 AWG (16 mm²)
- 300 mm for sizes more than No. 6 AWG (16 mm²) and up to No. 4/0 AWG (120 mm²)
- 600 mm for sizes more than No. 4/0 AWG (120 mm²) and up to No.500 MCM (250 mm²)
- 900 mm for sizes greater than No. 500 MCM (250 mm²)

4.2.11.6 The grounding conductors shall be permanently marked at the MGB as well as at all other ground bars.

4.2.11.7 GCs connections to ground bars shall be only 2 holes connectors.

4.3 DC Power System Grounding

4.3.1 The DC Power system positive return bus shall be isolated from the framework and locate the return bus in or above the:

- Power control and distribution units
- Batteries and chargers/rectifiers

4.3.2 The positive return bus in the power distribution unit frame shall be connected to the nearest MGB or FGB on the same floor using an insulated copper conductor. The size of this conductor shall be a minimum of 2/0 AWG (70 mm^2), or designed to carry the maximum office drain current (whichever is larger).

4.3.3 The DC positive return cables shall be solid black color.

4.3.4 The DC negative supply cables and conductors shall be solid red color.

4.3.5 The chassis ground cables shall be solid green color.

4.4 AC Power System Grounding

4.4.1 AC Power services shall be grounded according to Saudi Aramco grounding standard SAES-P-111 and NFPA 70 (NEC) minimum requirements.

4.4.2 AC outlets grounding installed on communications equipment rack shall be isolated from equipment chassis.

4.4.3 AC-powered equipment, such as rectifiers and inverters and racks that they are mounted on, shall be isolated from the DC equipment racks, cable trays and DC grounding.

4.5 Entrance Cable Bonding

The metallic cable shield (including metallic armor, metallic central strength member, etc., if present) of each entrance cables (copper, co-axial and fiber optic) shall be bonded with a copper bonding ribbon of minimum 1.6 mm x 10 mm or a minimum of No. 6 AWG (16 mm^2) insulated copper. The bonding ribbon or the copper conductor shall be terminated and grounded on the cable vault ground bar.

4.6 Electronic Switching Equipment Grounding

4.6.1 Each electronic switching equipment frame shall be bonded to the grounding system through the MGB/FGB.

4.6.2 Run ground lead from MGB/FGB (I) zone along the main aisle, perpendicular to the equipment frame line-ups using a minimum of No. 2/0 AWG (70 mm²) insulated copper conductor. Install a lead down each aisle of electronic equipment, using a minimum of No. 2 AWG (35 mm²) insulated copper conductor, and bond it to the primary ground lead. Bond each equipment frame to the aisle ground lead using a minimum of No. 6 AWG (16 mm²) insulated copper conductor (Figure 2, page 16).

4.7 Transmission Systems and Terminal Equipment Grounding

(Refer to GTE Practice 795-805-073)

4.7.1 All transmission systems, equipment and terminal equipment shall be grounded using a Single-point Ground system.

4.7.2 The DC power cabling (feeder and distribution) to transmission system and terminal equipment shall be parallel paired conductors of equal size. The return buses of the Disconnect Switch Unit Frames and Power Distribution Unit Frames serving transmission equipment shall be insulated from the frames. All transmission equipment frames and the superstructure shall be grounded to the MGB/FGB.

4.7.3 Single-point ground powered transmission frames shall not share a common remote power distribution unit frame or fuse panel bay. On transmission bays supported by a power distribution unit frame, connect the power distribution unit frame metal directly to the MGB/FGB using insulated copper conductor of the size described in 4.7.4.

4.7.4 If the largest fuse used at the Disconnect Switch Unit Frame or the fuse panel bay feeding transmission equipment bay is less than:

- 250 amperes, use no. 2/0 AWG (70 mm²) conductor
- 400 amperes, use 250 MCM (125 mm²) conductor
- 600 amperes, use 500 MCM (250 mm²) conductor
- 1000 amperes, use 750 MCM (400 mm²) conductor

4.7.5 Each individual transmission equipment frame shall be grounded using a ground lead from the MGB with No. 2/0 AWG (70 mm²) insulated copper. The ground lead shall run along the equipment bay and connect to the individual equipment, using branch leads of No. 6 AWG (16 mm²) insulated copper of no more than 1 meter in length.

4.7.6 The transmission equipment superstructure (cable rack) shall be joined to the grounding conductor connecting MGB and Disconnect Switch Unit Frames using No. 2/0 AWG (70 mm²) insulated copper conductor.

4.7.7 All transmission systems and terminal equipment with Stored Program Control, such as Digital Access Cross Connect Systems, shall be treated as separate electronic switching systems and shall be grounded according to electronic switching system grounding (Section 4.6).

4.7.8 Interior radio and microwave equipment (including cabinets and cable trays that are connected to the equipment) shall be connected directly to the MGB with No. 2/0 AWG (70 mm²) insulated copper conductors. The ground lead shall run along the equipment bay and connect to the individual equipment, using branch leads of No. 6 AWG (16 mm²) insulated copper.

4.8 Radio System Grounding

4.8.1 Antennas and towers associated with the Radio Systems shall be connected to the building ground electrode outside the building.

4.8.2 The grounding and bonding of the radio systems and towers shall be done according to SAES-T-887 and NFPA 780 guidelines.

4.9 Remote Electronic Serving Area Grounding

4.9.1 Remote Electronic Serving Areas as referenced, indicate a small communications installation like remote repeater/terminal site, microwave radio repeater, a radio/multiplexer, terminal, or a combination with or without telephone switches.

4.9.2 The grounding of the Remote Electronic Serving Areas shall comply with the requirements of this standard, as described in the previous sections.

4.9.3 For Remote Electronic Serving Areas, the ground resistance of the ground electrodes at the MGB shall not exceed:

- 3 ohms for a pad-mount over a total of 600 lines and for huts (enclosed walk-in structure that includes a vault with a controlled environment) without radio sites
- 5 ohms for pad-mount radio sites
- 2 ohms for radio sites with hut
- 25 ohms for pad-mount up to 600 total lines

- 5 ohms for communication sites that are part of other non-communication facilities or buildings without radio sites

4.10 Lightning Rod Systems

The need for installing a lightning protection system for buildings shall be determined according to the Risk Assessment Guide, Appendix 1 of the Lightning Protection Code, NFPA 780 and SAES-P-111.

4.11 Bonding Resistance

The resistance of grounding or bonding conductors between any two points shall not exceed 0.5 ohms.

5 Installation

Installation criteria such as planning, design, preparation, ground conductor sizing, routing and terminating shall be in accordance with Standard Drawing AA-036391 (Communications Equipment Grounding for Telecommunications Facilities), and other referenced and applicable standards and specifications.

6 Testing and Inspection

The ground resistance and single and multiple electrodes shall be measured and tested in accordance with SAES-T-887. Testing shall be witnessed by PID (Project Inspection Division). PID shall inspect all Communications facility grounding systems in accordance with this standard, SAES-T-887, SAES-T-903, SAES-P-111 and other applicable standards as listed in section 3.

Revision Summary

28 January, 2004	Revised the "Next Planned Update". Reaffirmed the contents of the document, and reissued with minor changes.

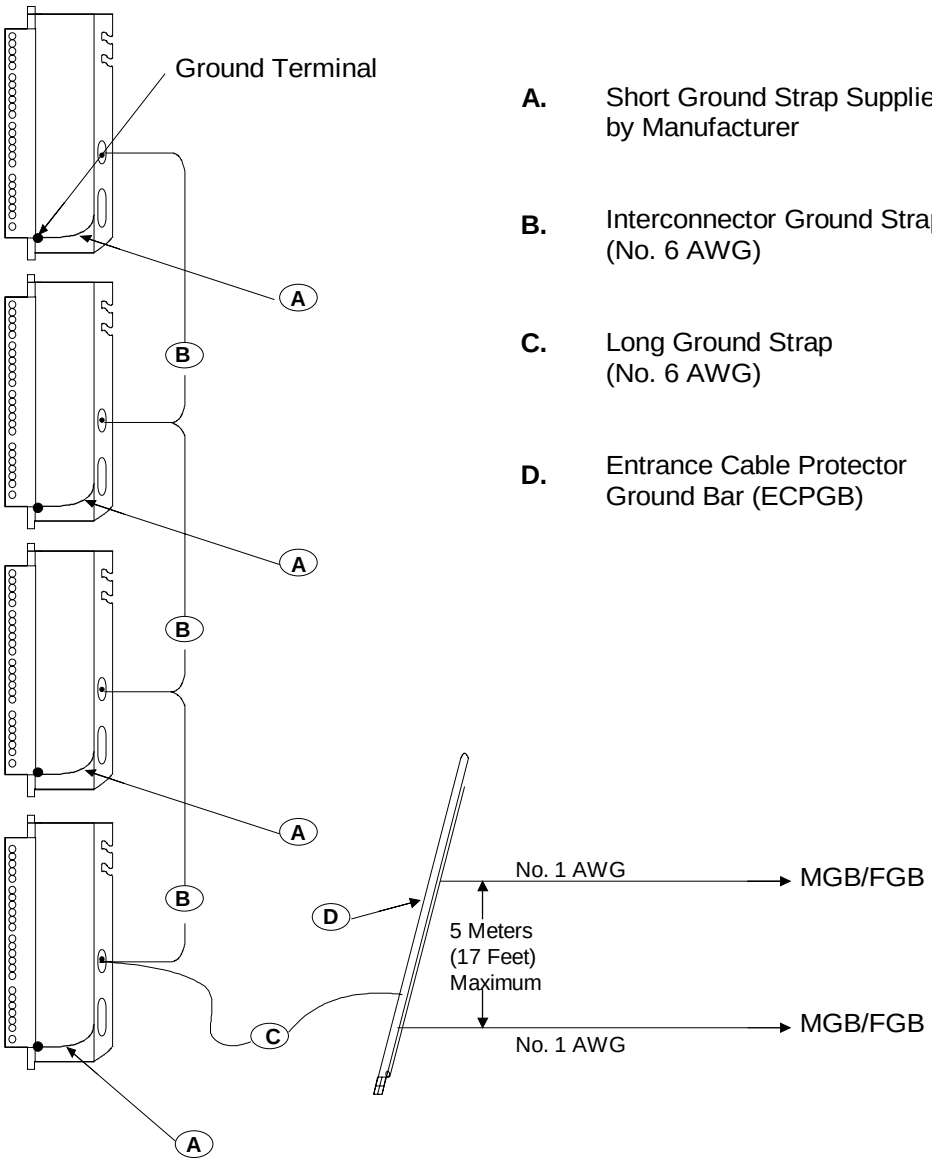

Figure 1 - Entrance Cable Protector Ground Bar (ECPGB)

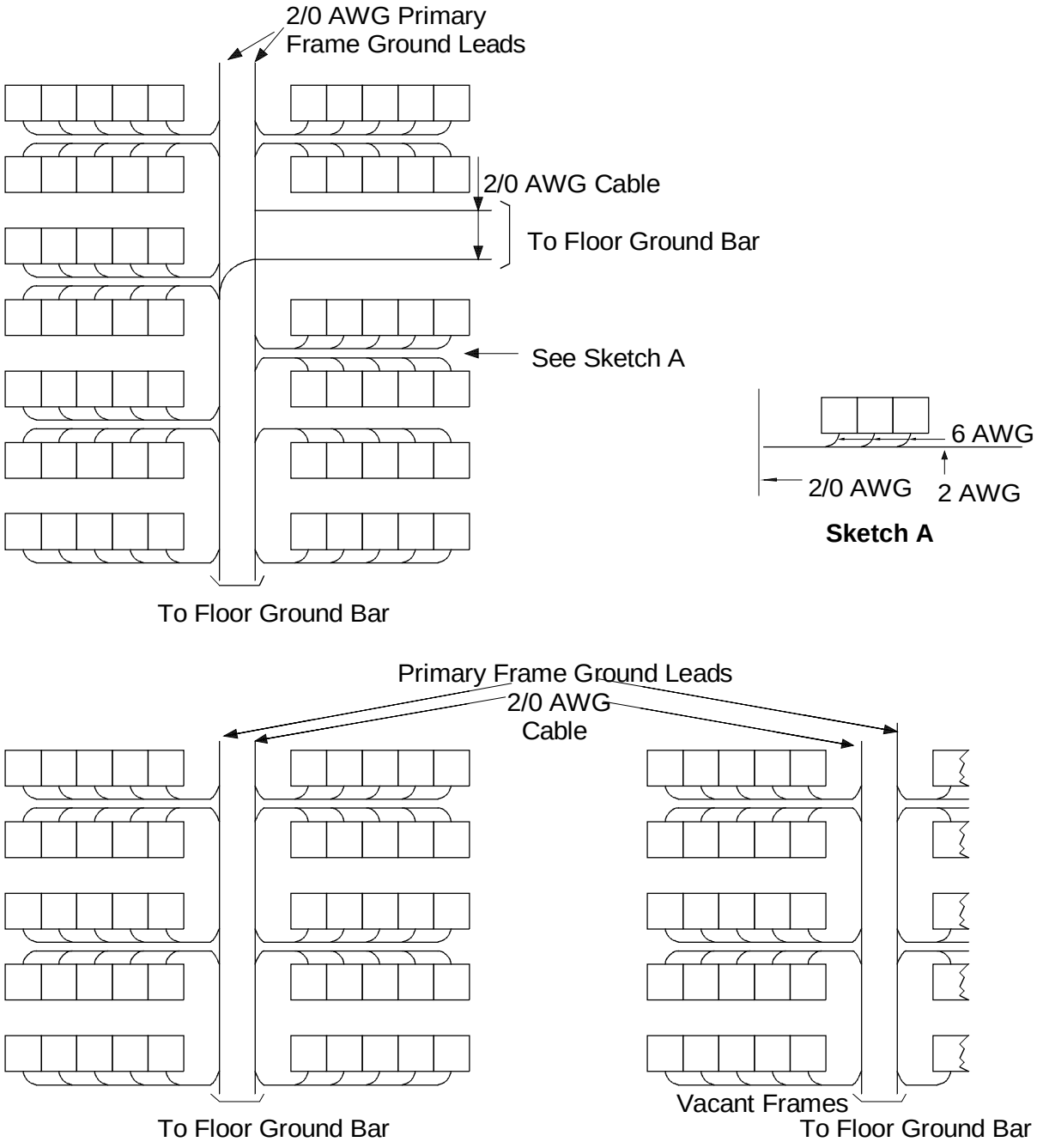

Figure 2 - Electronic Switching Equipment Frame Grounding