Off Grid Solar Power System for Public Safety Communications

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Importance of Public Safety Communications

- Basis of Emergency Services
- Police, Fire, Paramedics, Public Works
- Must Work During and After the “Perfect Storm”

Challenges for this Project

- Small Mountain Top Radio Building and Tower with NO Land for Solar Panels
- Utility Power 20 Miles Away
- Closest Location for Solar Panels About 2000 Feet Away
- Lots of Snow in the Winter and a Good Part of the Year

Off Grid Power Requirements

- Very Remote Site
- Located in a National Forest
- Inaccessible More Than 1/ 2 the Year
- Located in a Rural California County at 10,025 Feet
- Power Load of About 3000 Watts Continuous

View of Radio Site

Closer View

Even Closer View

Beginning of Winter

Other Alternative Energy Solutions

- Too Difficult for Fuel Cells – Unknown Maintenance Costs and Difficulty to Deliver Fuel
- Too Much Wind for Wind Power – High Maintenance.
- Remote Primary Generator – Difficult to Get Permits to Operate Continuously Diesel Not Allowed by US Forest Service.

Solar Power System

- Generation and Energy Storage in Meadow 2000 Feet from Radio Site
- Solar Array Sized at 7 Times Continuous Load
- Low Voltage Solar System for Reliability and Safety

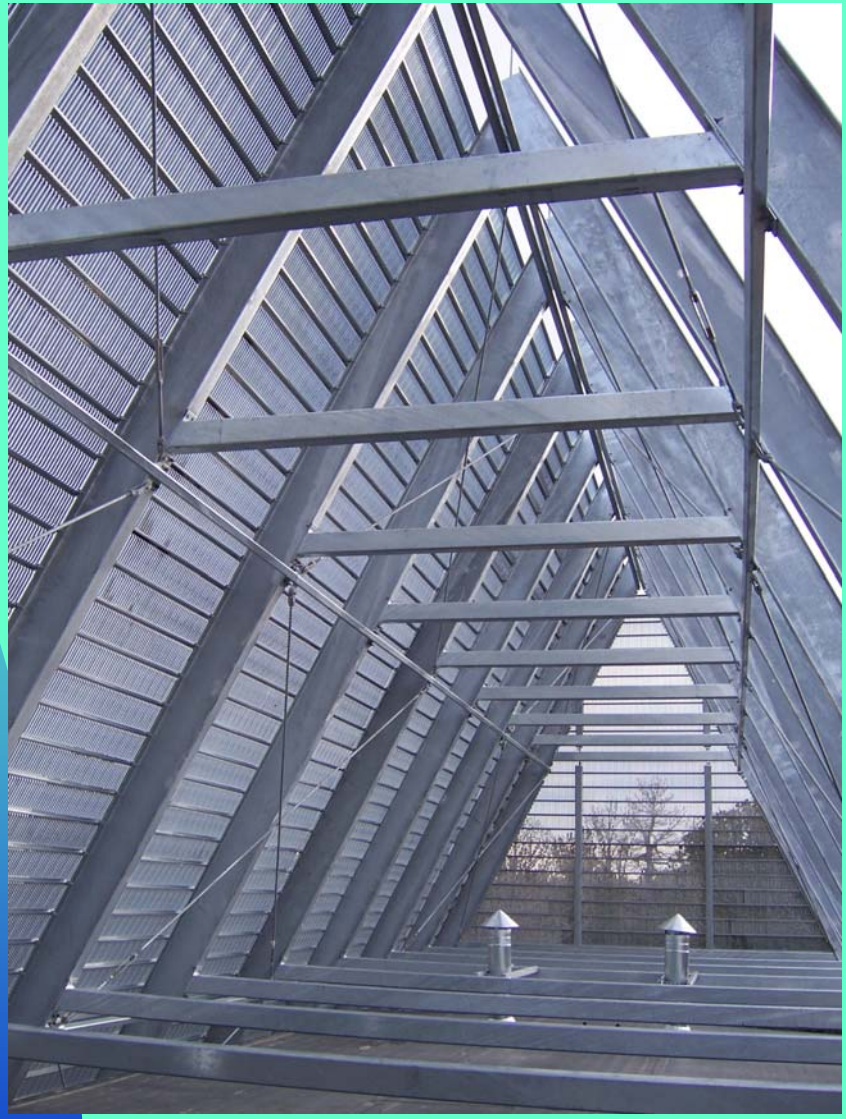
Artists Concept of Solar Array

Actual Array Under Construction

Rear View of Array

East End View of Array

View from West Inside Array Structure



Overall Array View from the South

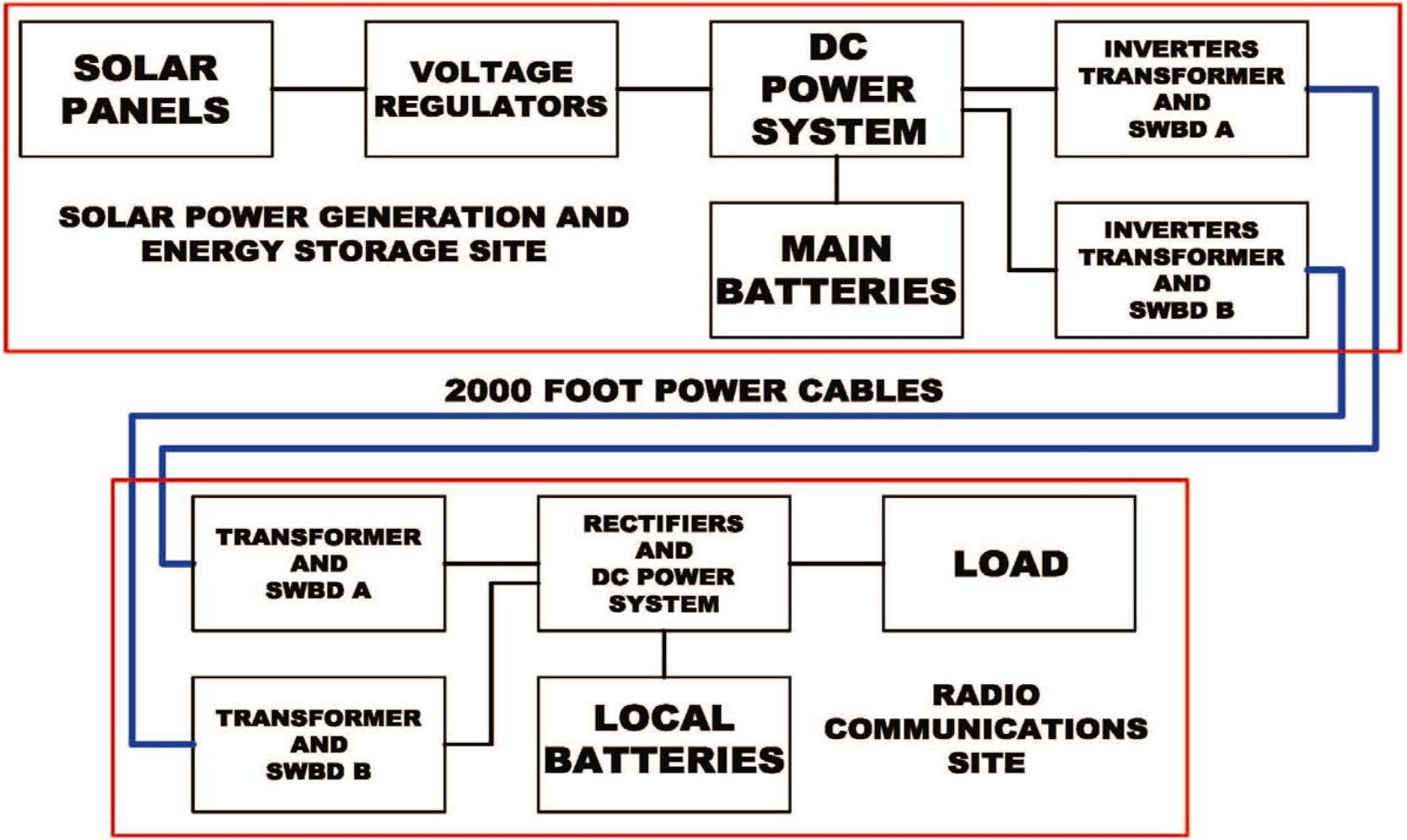
Array as Viewed from the Radio Site

First Solar Panels Installed

Close Up Of the First Panels

Partial Constructed Solar Array as of 09/08/2011

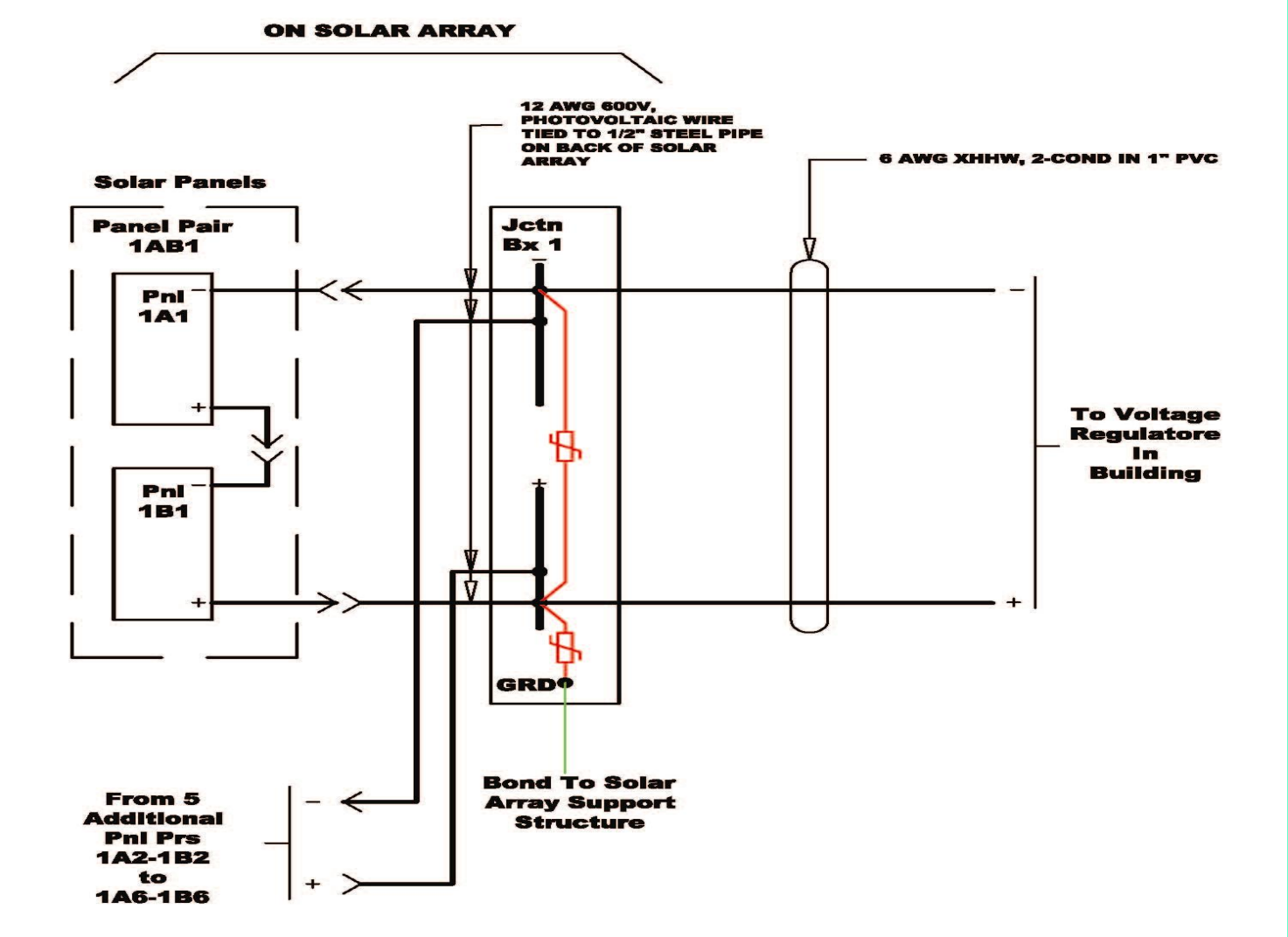
System Diagram



System Description

- System converts solar power to –48 VDC power.
- Energy is stored and converted to 550 VAC for transport to the remote Radio Site
- Power at remote Radio Site is converter from 550 VAC to –48 VDC to power communications equipment.

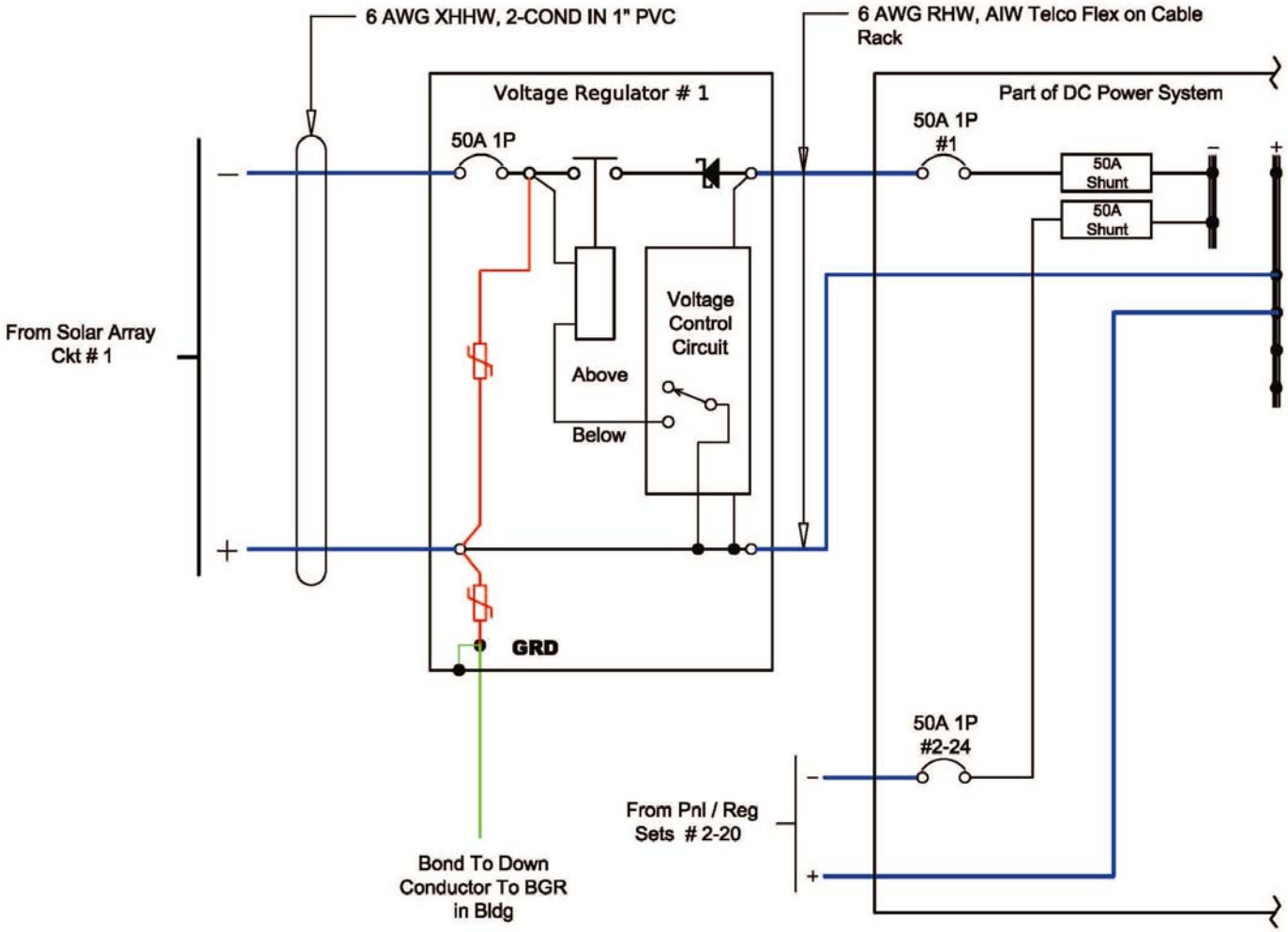
Solar Array


ON SOLAR ARRAY
12 AWG 600V, PHOTOVOLTAIC WIRE TIED TO 1/2" STEEL PIPE ON BACK OF SOLAR ARRAY
6 AWG XHHW, 2-COND IN 1" PVC
Solar Panels
Panel Pair 1AB1
Pnl 1A1
Pnl 1B1
Jctn Bx 1
To Voltage Regulatore In Building
GRD
Bond To Solar Array Support Structure
From 5 Additional Pnl Prs 1A2-1B2 to 1A6-1B6

Solar Array Circuit

- Consists of 6 series pairs of panels in parallel.
- Each circuit is pre-cabled with connectorized cables that plug into the panels.
- The 6 series-pairs of panels are paralleled in a pre-fabricated junction box for each circuit.

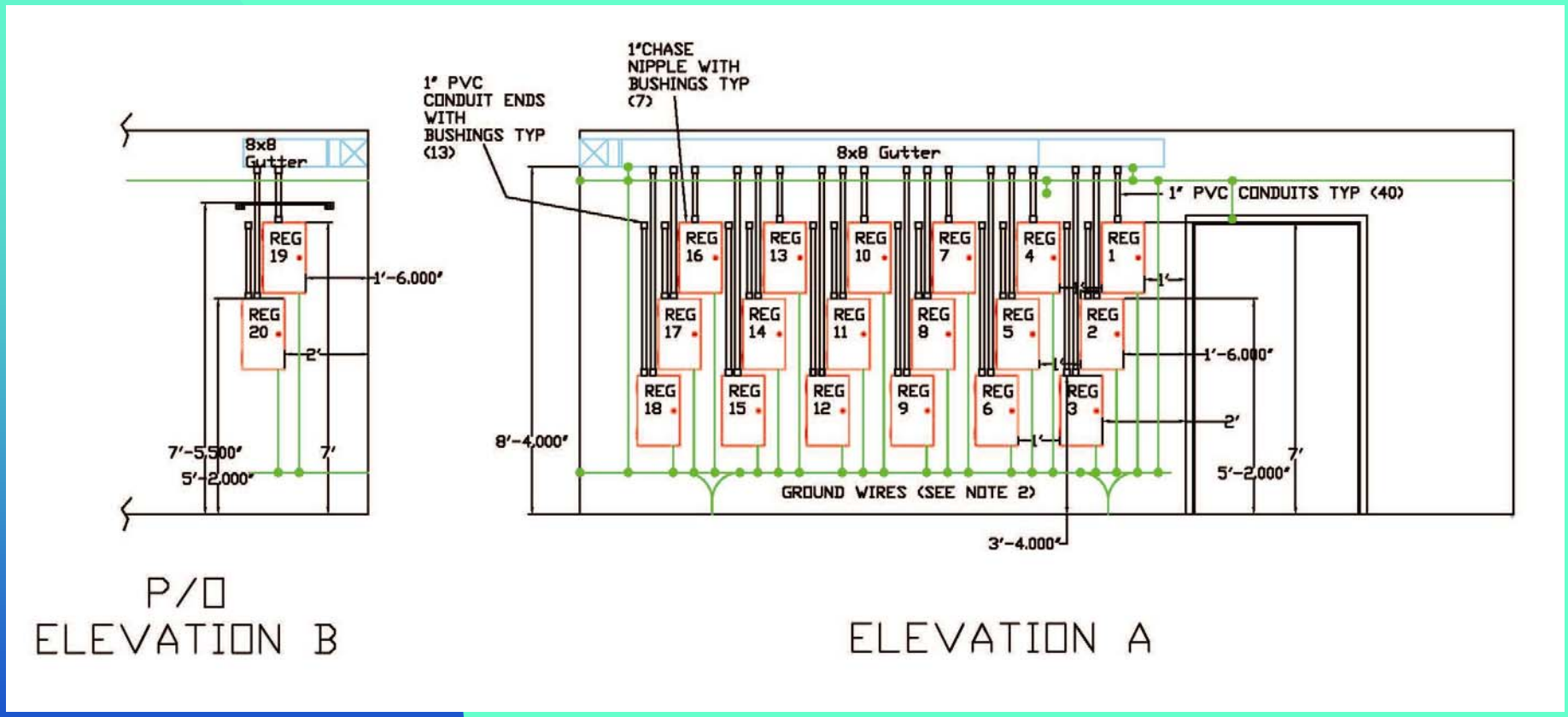
Voltage Regulator



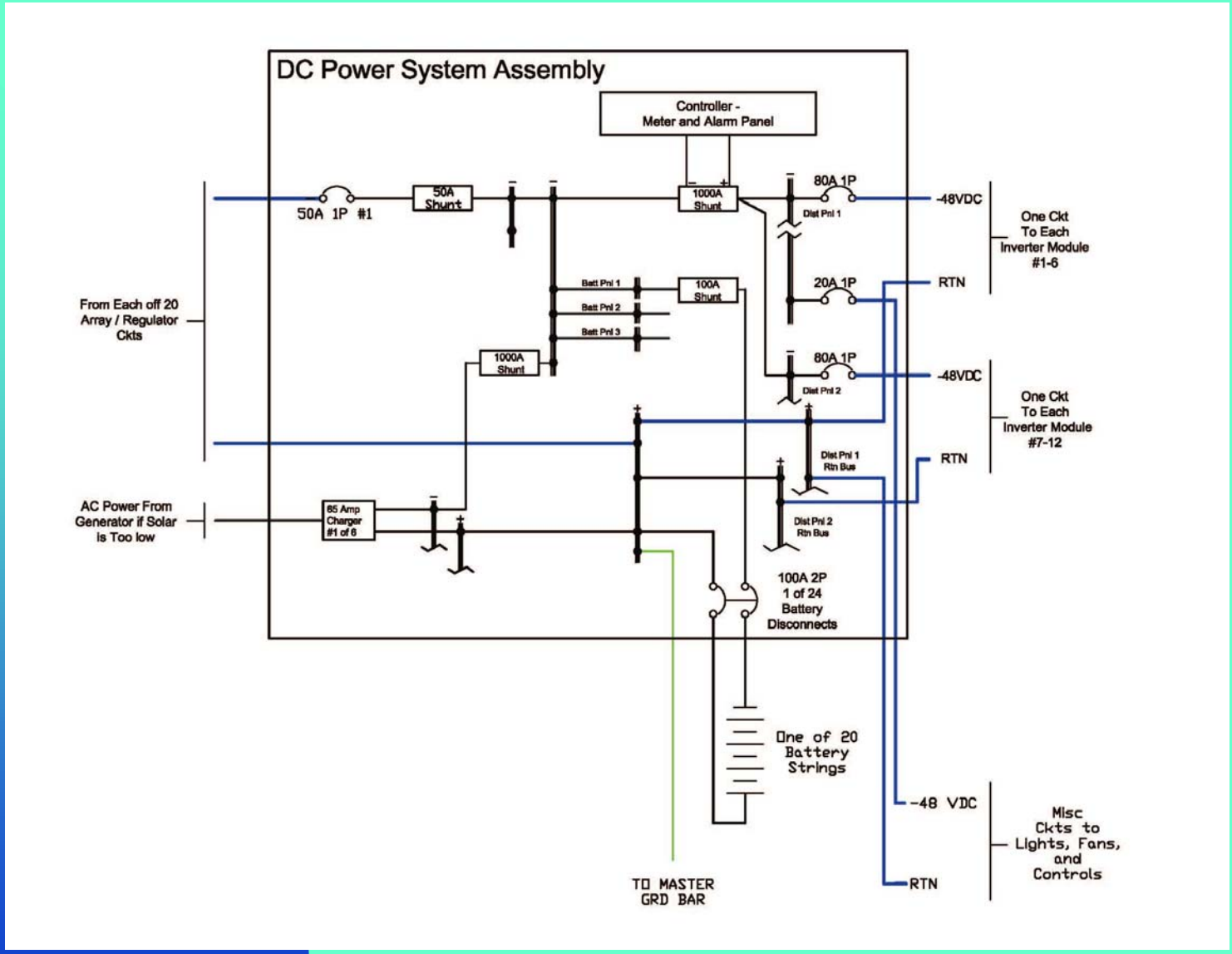
Voltage Regulator Description

- Voltage regulators located inside the building on an outside wall
- Each regulator is a simple ON-OFF device controlled by a voltage sensor circuit.
- If the bus voltage goes above 55.5 VDC, the regulator switches open the path from its associated solar panels.
- As the bus voltage drops below about 54.5 VDC the regulator clothes the path to its associated solar panels.
- MOVs provide protection from lightning induced surges.

Voltage Regulator Location and Grounding Details



DC Power System



Main Batteries

- C&D CPV 2500 cells
- 20 strings
- 23 cell strings
- Approximate reserve time of 9.5 days
- Seismic racks
- 1 tier to keep all cells at approximately the same temperature
- 2-pole battery disconnect breakers on each string
- Individual current shunts on each string

Batteries before installation

Battery Rack on Spill Containment

Back-up Chargers

- There are 6 ea 65 A chargers that are generator powered if required
- If the system voltage drops too low, the generator starts and the chargers run for a predetermined time to add energy to the main batteries.

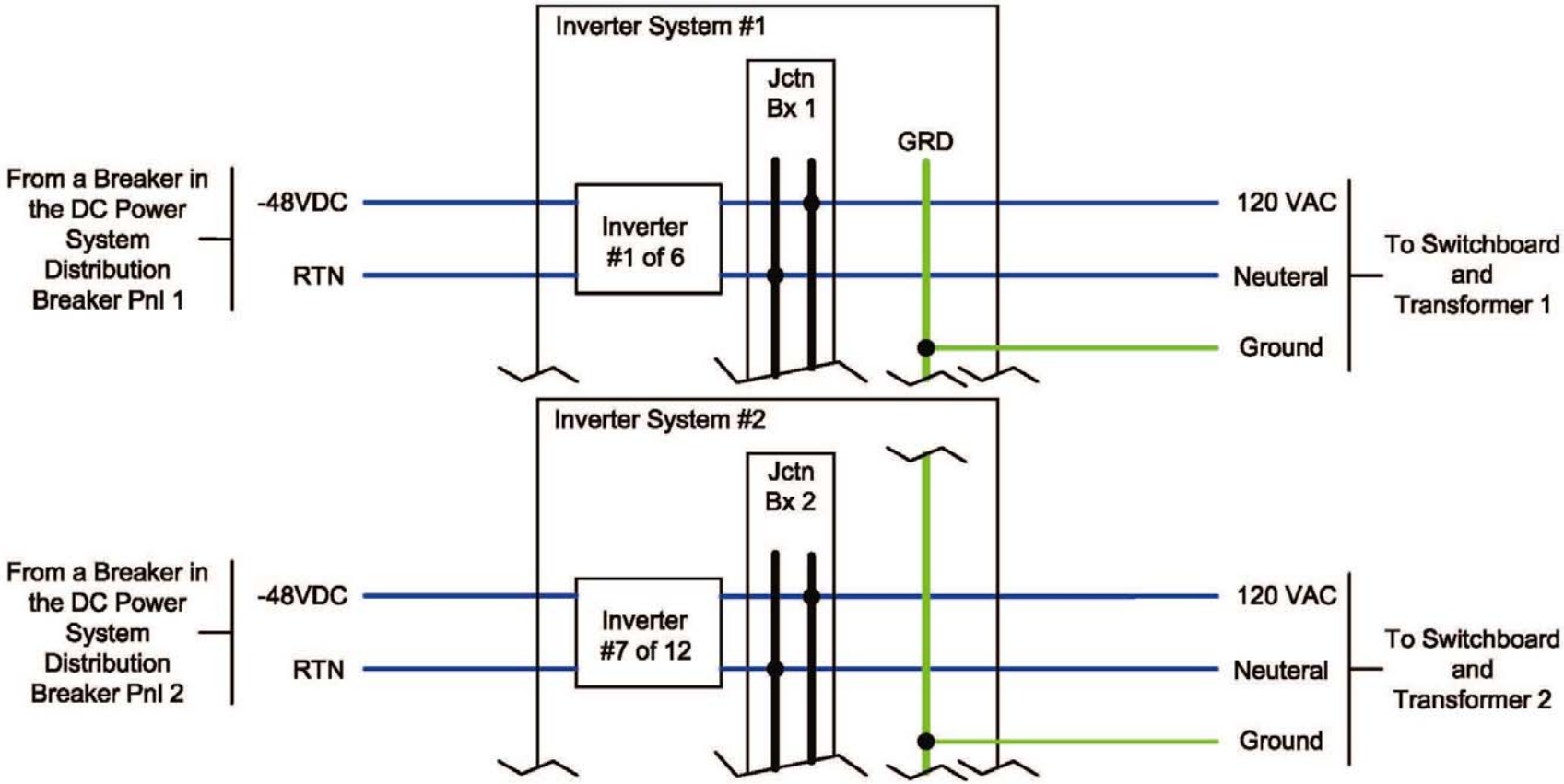
Generator

- The generator is a back-up if a major problem occurs with the solar system
- The generator starting battery is NiCAD.
- The generator also powers an electric heater to bring the site up to a minimum temperature

DC System Voltage

- Maximum voltage 55.5 VDC
- Approximately 2.413 Volts / cell
- Minimum voltage – 44.85 VDC at batteries (approximately 44 VDC at DC power plant bus.
- Approximately 1.95 Volts / cell
- At approximately 47 VDC the generator will start and run chargers to add charge to the batteries. Exact parameters still to be determined.

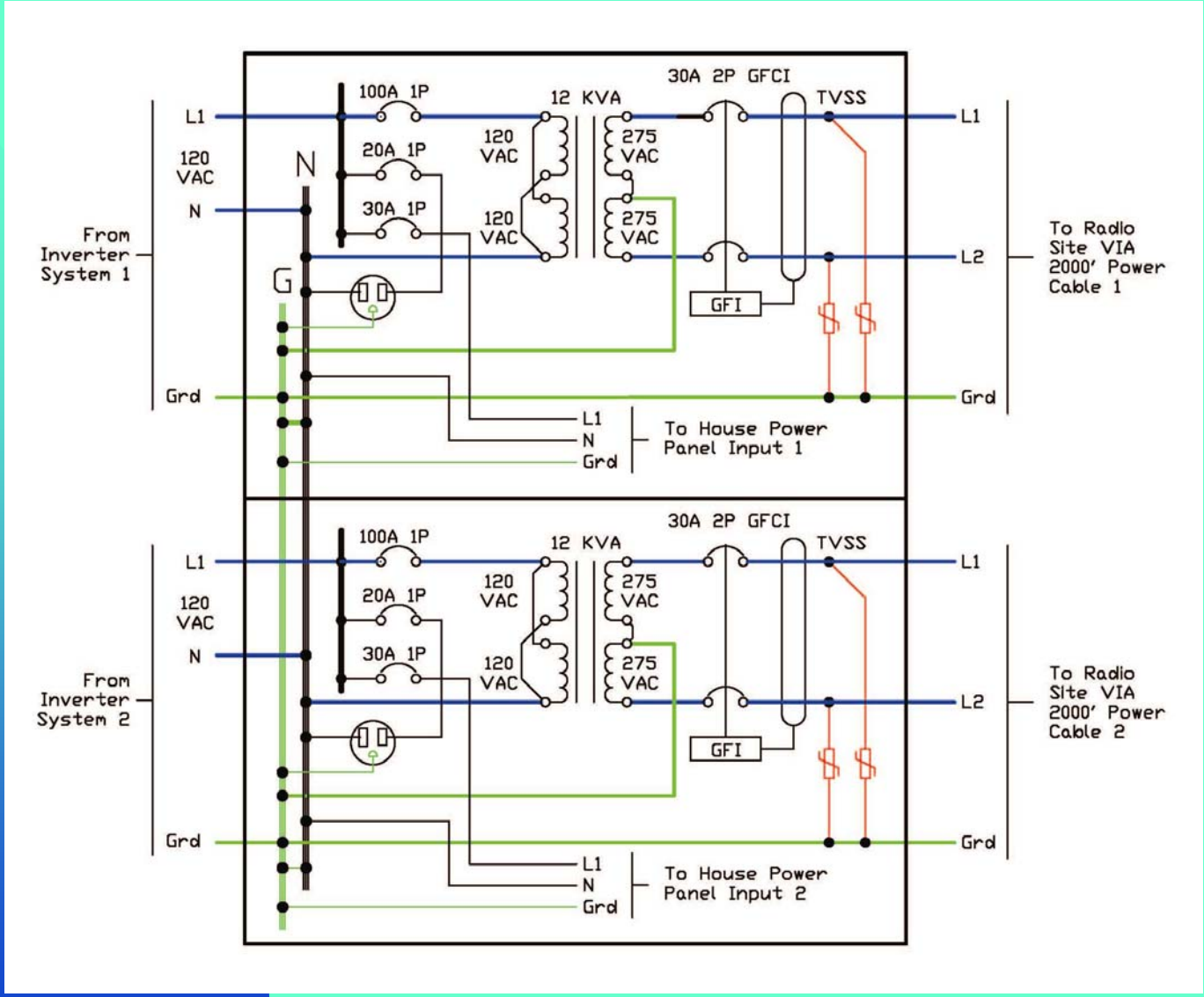
Inverter System



Inverter System

- Dual inverter systems
- Each system has 6 ea 2500 Watt inverter modules
- Inverters are hot swappable.
- Inverters are synchronized
- Inverters load share
- Each inverter system feeds a separate switchboard - transformer assembly.

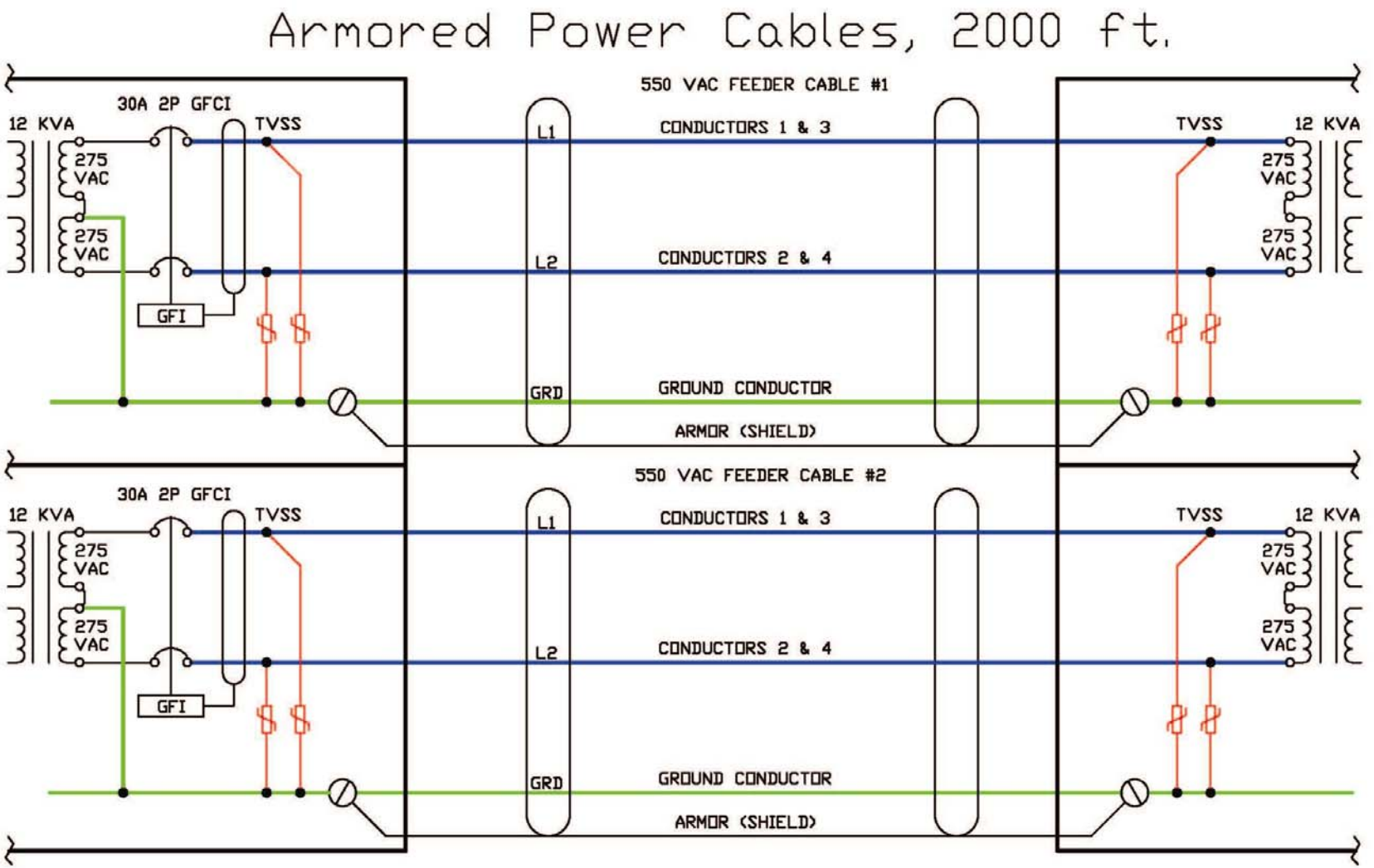
Switchboards and Transformers



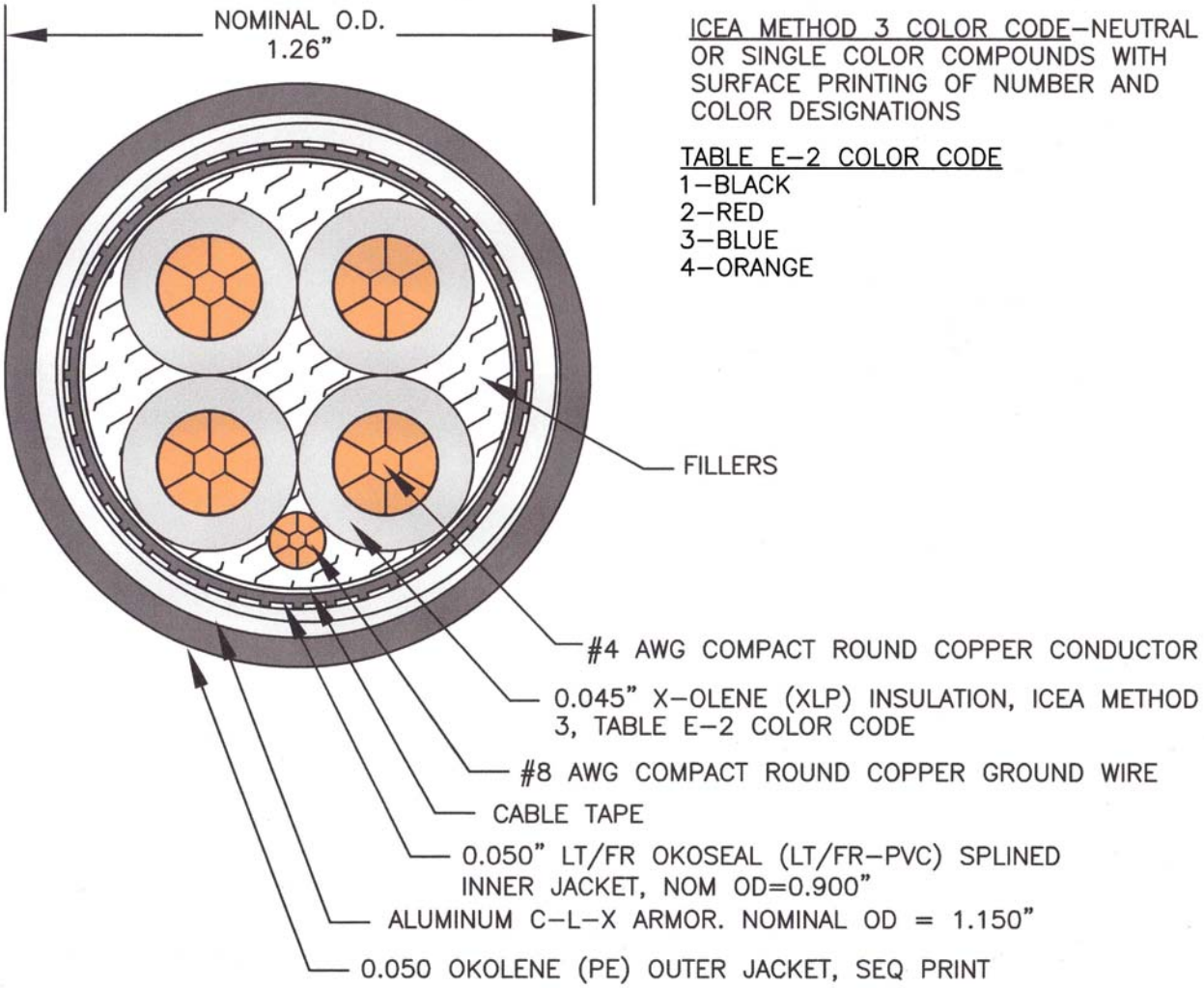
Switchboard – Transformer Assemblies

- There are two switchboard – transformer assemblies
- The switchboard feeds the transformer and local house power
- The transformer steps up the voltage to 550 VAC and feeds one of the power cables to the remote radio site
- The transformer center tap is grounded to minimize the voltage between the conductors and shield in the power cable

Power Cable System



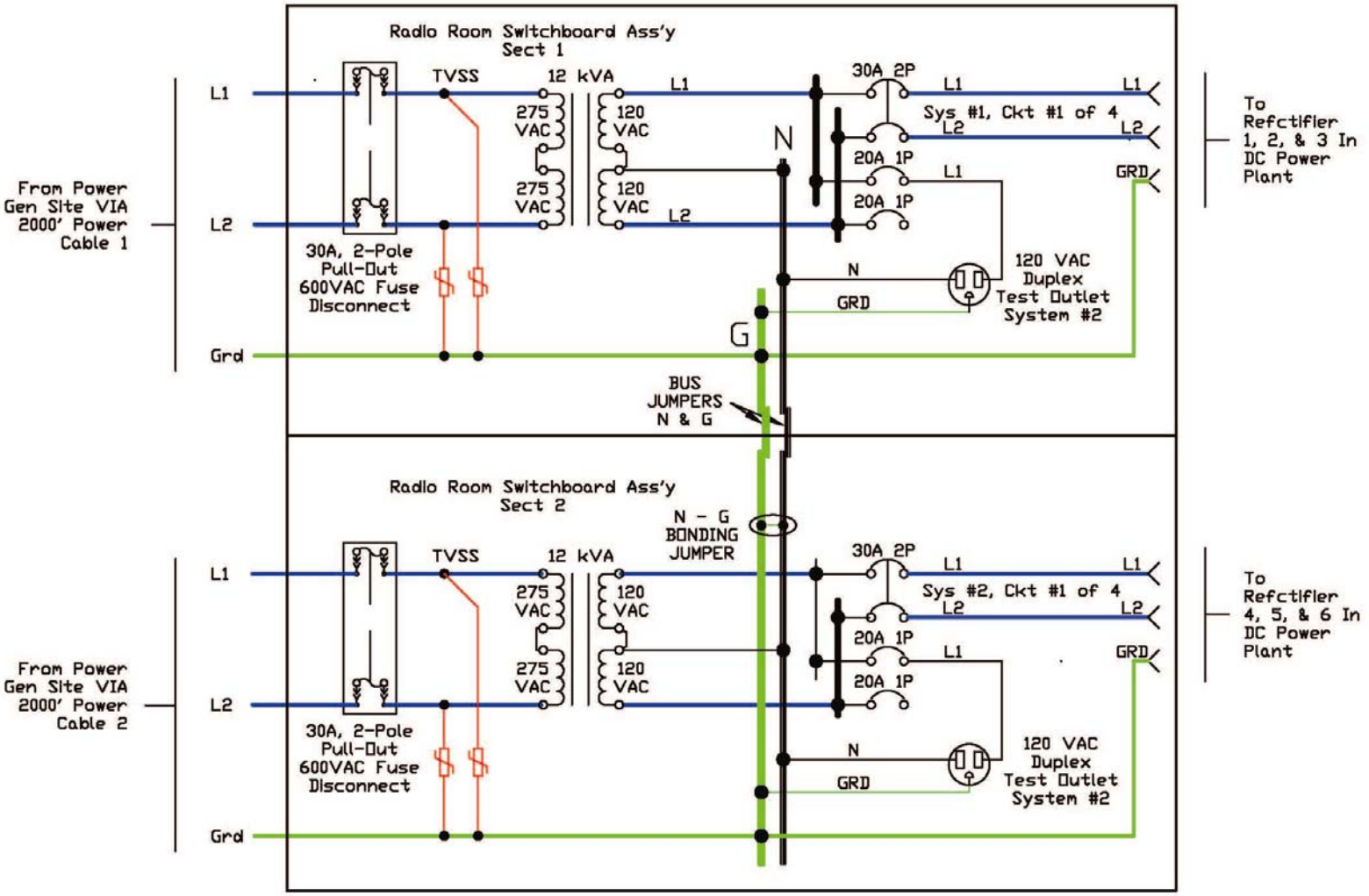
Power Cable Construction



Power Cable Protection

- Power cables connect the Radio Site on top of the mountain to the Power Generation and Energy Storage site in the meadow.
- Bonding the cables is very important to the protection plan.
- TVSS devices on each conductor to ground at each end.
- Conductors referenced to ground on the source end.
- Cable is balanced.
- Conductors 1 and 3 are used as L1 and 2 and 4 are used as line 2.
- TVSS devices keep the conductors within 1000 V of the armor (shield) and the ground conductor during a lightning strike.

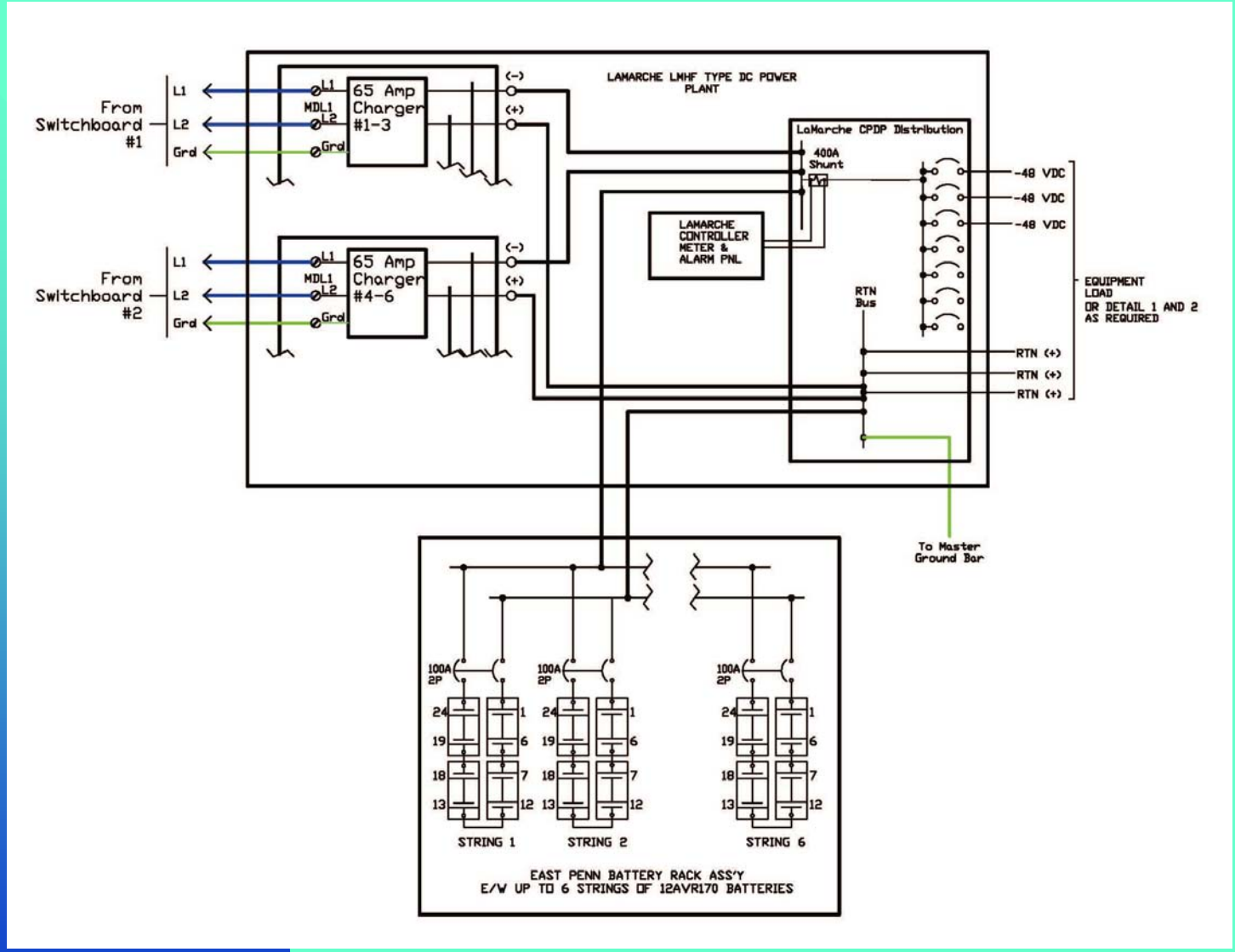
Radio Site Transformer and Switchboard



Radio Site Transformer and Switchboard Description

- Dual Transformer – Switchboard assemblies
- Transforms the 550 VAC to 120/240 VAC for powering the chargers.
- Each Transformer – Switchboard assembly powers 3 chargers and a 120 VAC service outlet and is associated with a power cable from the power generation and energy storage site
- Building lighting and fans are powered from the –48 VAC power plant.

Radio Site DC Power Plant



Typical Battery, Rack, and DC Power Plant for Radio Site

Radio Site DC Power Plant

- Consists of 2 sets of 3 chargers
- Each set of chargers is connected to a separate transformer – switchboard assembly.
- The site can operate with redundancy on a single set of 3 chargers.

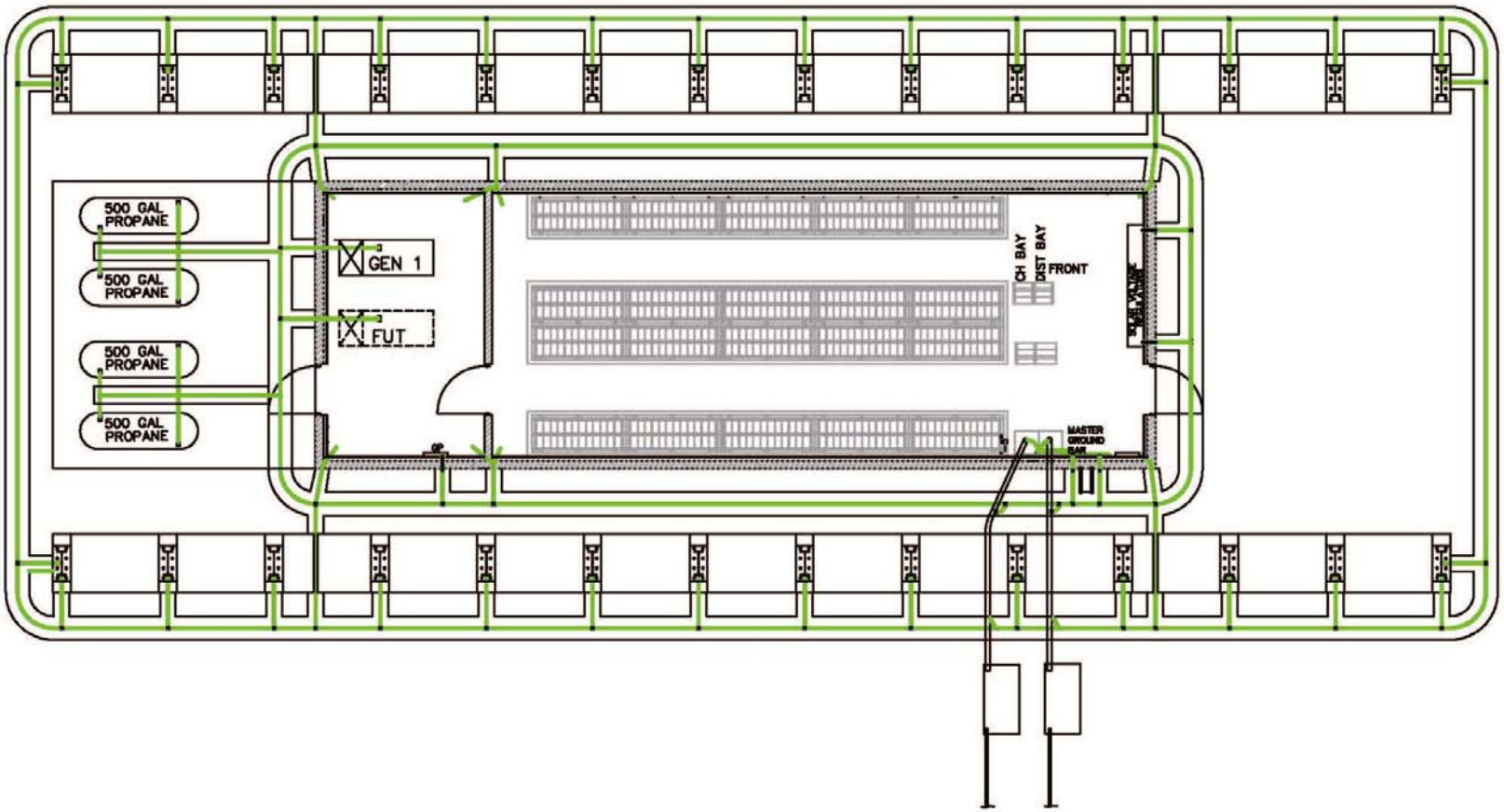
Radio Site Batteries

- There are 6 strings of East Penn - Deka Unigy 12AVR170 batteries.
- Each String has a 2-pole disconnect circuit breaker
- Batteries are mounted in a NEBS Level III certified battery rack assembly.
- These batteries provide fault clearing current and should run the site for 12 hrs if everything else fails.

Grounding

- Power Generation Grounding
- Radio Site Grounding
- Designed for long term reliability
- Designed to have a minimum of exposed copper to reduce “CREATIVE RECYCLING”

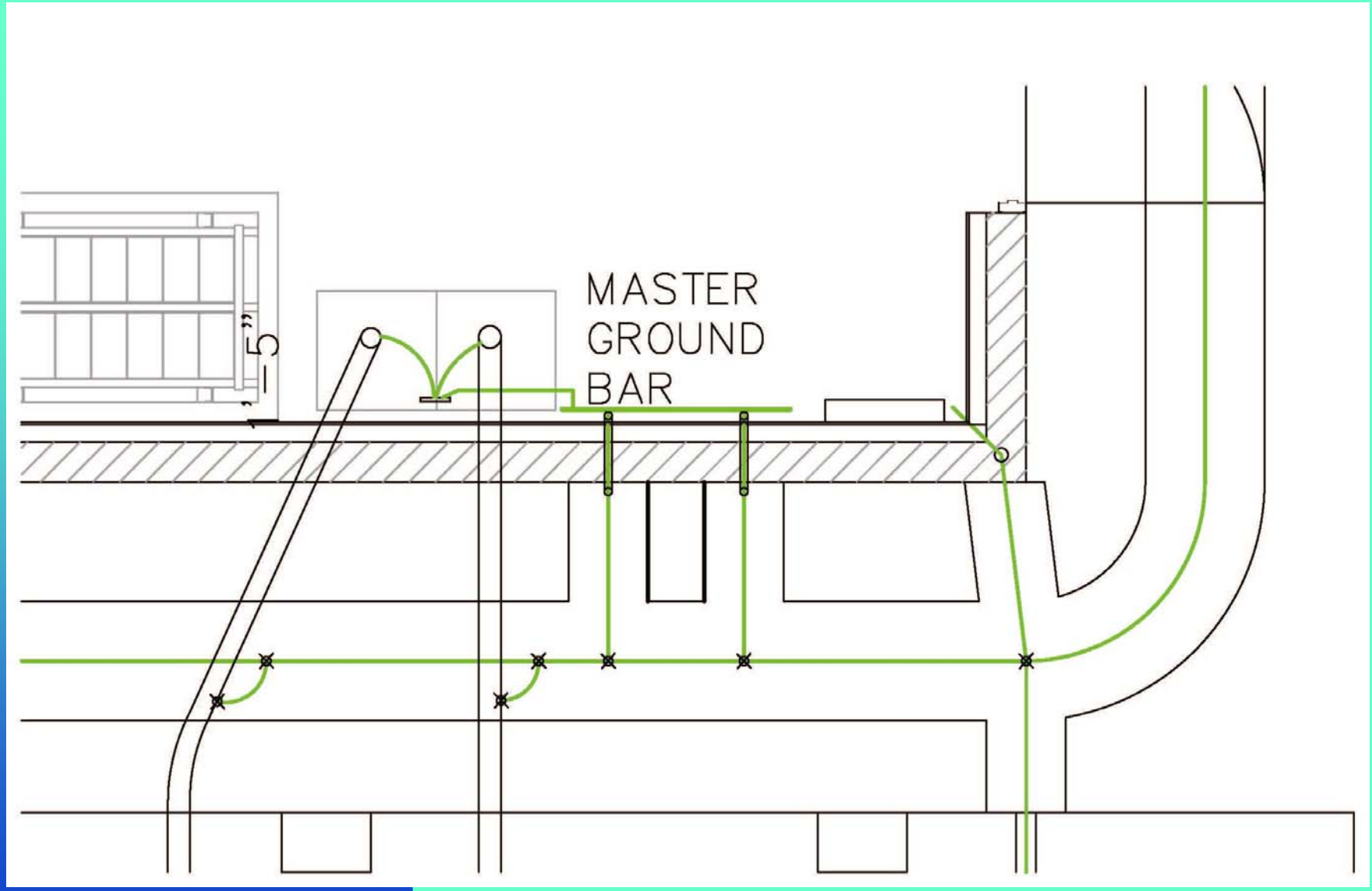
Power Generation Site Grounding Layout



Power Generation Site Grounding

- Ground ring is 2 AWG tinned solid copper wire
- Ground ring is imbedded in carbon concrete
- No ground rods due to rock base
- Array Anchor bolts grounded – no ground conductors to array
- Each frame is equipped with lightning rods
- 4” power conduits grounded
- Fuel tanks and generators have grounding pad imbedded in concrete under the equipment
- Solar regulators are grounded at entrance to site
- Power Cable is grounded at entrance to site.
- All site framework is plated and bonded to the halo at the walls.

Conduit Entrance and Master Ground Bar Area



Anchor Bolt Grounding

Anchor Bolt Grounding

- The solar array is supported by 14 “A” frames.
- Each “A” frame is grounded by bonding 2 bolts at each support point to the buried ground ring.

Lightning Rods at Top of the Array

Ground Ring In Carbon Concrete

Buried Ground Ring Earth Connection

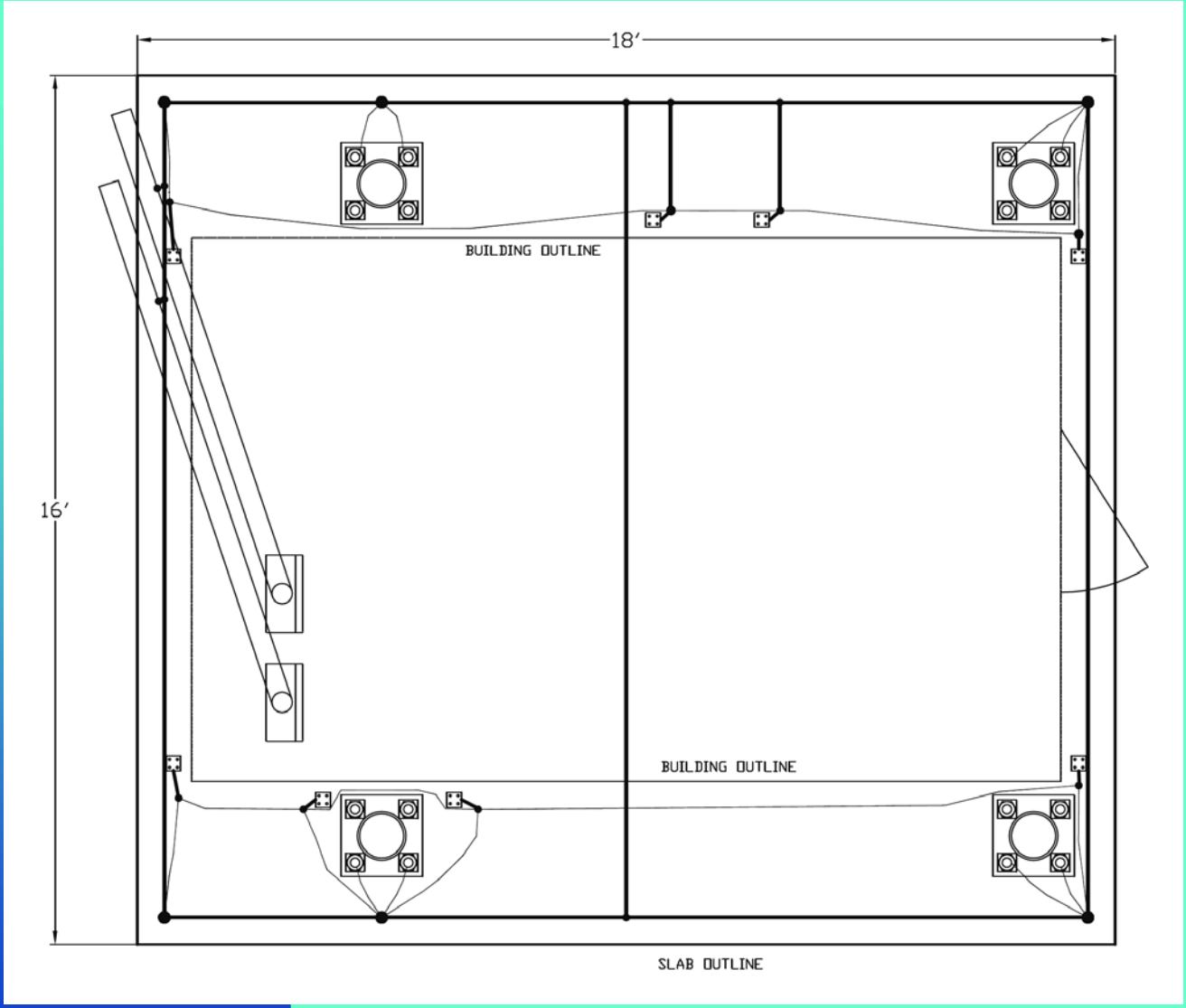
- The Buried Ground Ring is a 2 AWG tinned solid copper wire encased in conductive carbon bearing concrete.
- The conductive concrete enlarges the ground conductor surface by about 15 times.

Power Cable Conduit Grounding

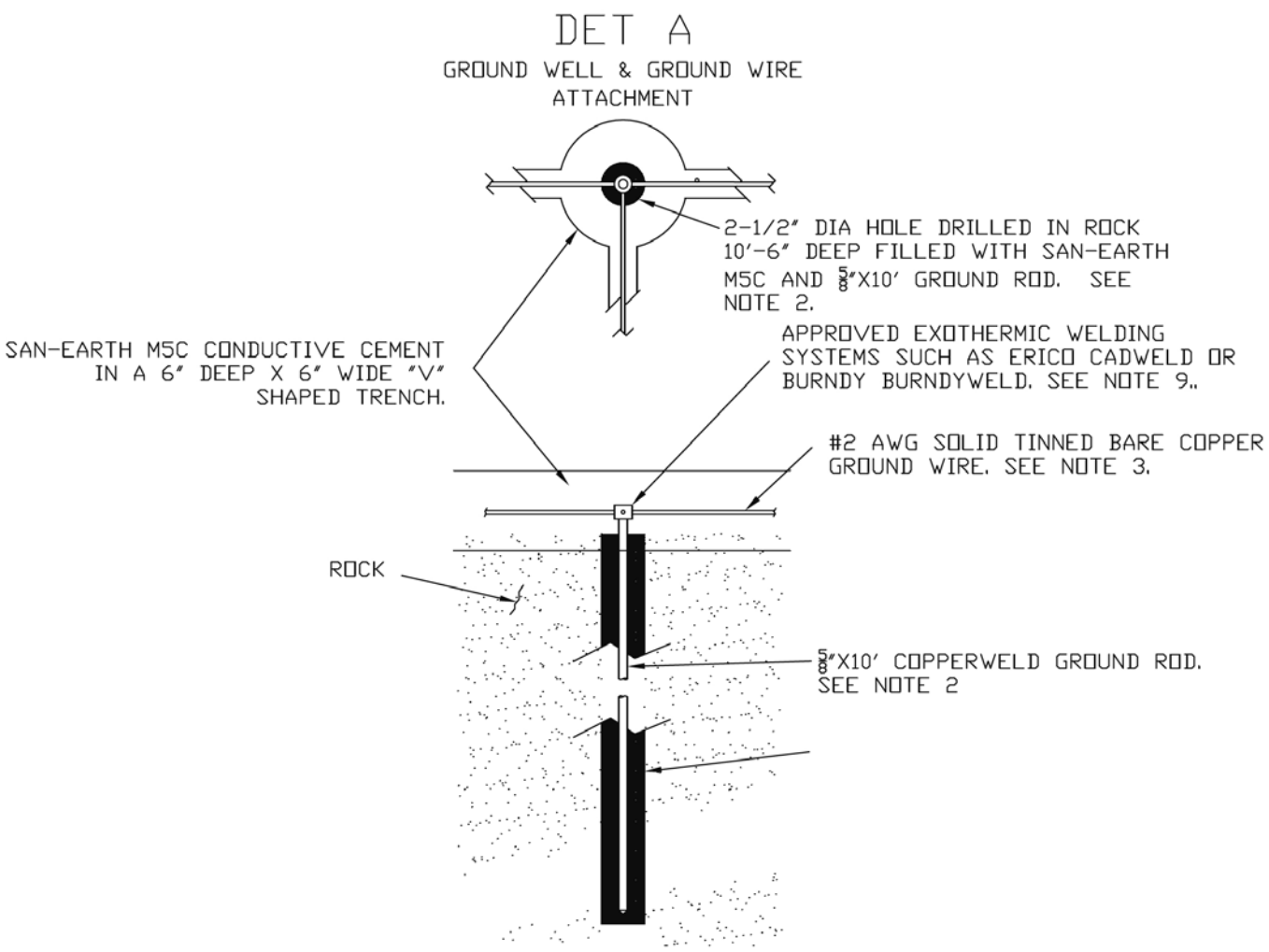
Power Cable Conduit Grounding

- Adds to earth connectivity.
- Terminated to the Switchboard ground and the Master Ground Bar.
- Terminated to both buried ground rings as they cross them.

Radio Site Grounding



Radio Site Ground Rods In Rock



Radio Site Grounding

- Room contains a halo ground.
- Power cables enter trough rigid steel conduit to bottom of switchboards.
- Building is steel skin sitting on a concrete slab and bonded to the imbedded ground plates.
- All building down conductors bond to imbedded ground plates set in the slab at specific locations to line up with elements in the building.
- Master Ground Bar next to switchboards.
- 6 drilled ground wells filled with conductive concrete and a ground rod.
- Ground ring connecting the drilled ground rods is set in a trough cut in the rock filled with conductive concrete.
- Rock is fairly conductive - iron bearing.

Partially Constructed Radio Tower

Construction still is in Progress

- Construction should be completed this summer.

Questions????

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