High Voltage DC Power Plants for Telecommunications Facilities

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Challenges

- Reduce the investment in copper
- Reduce the infrastructure need to support the copper
- Reduce the labor to install that copper
- Retain the reliability of telecom power systems

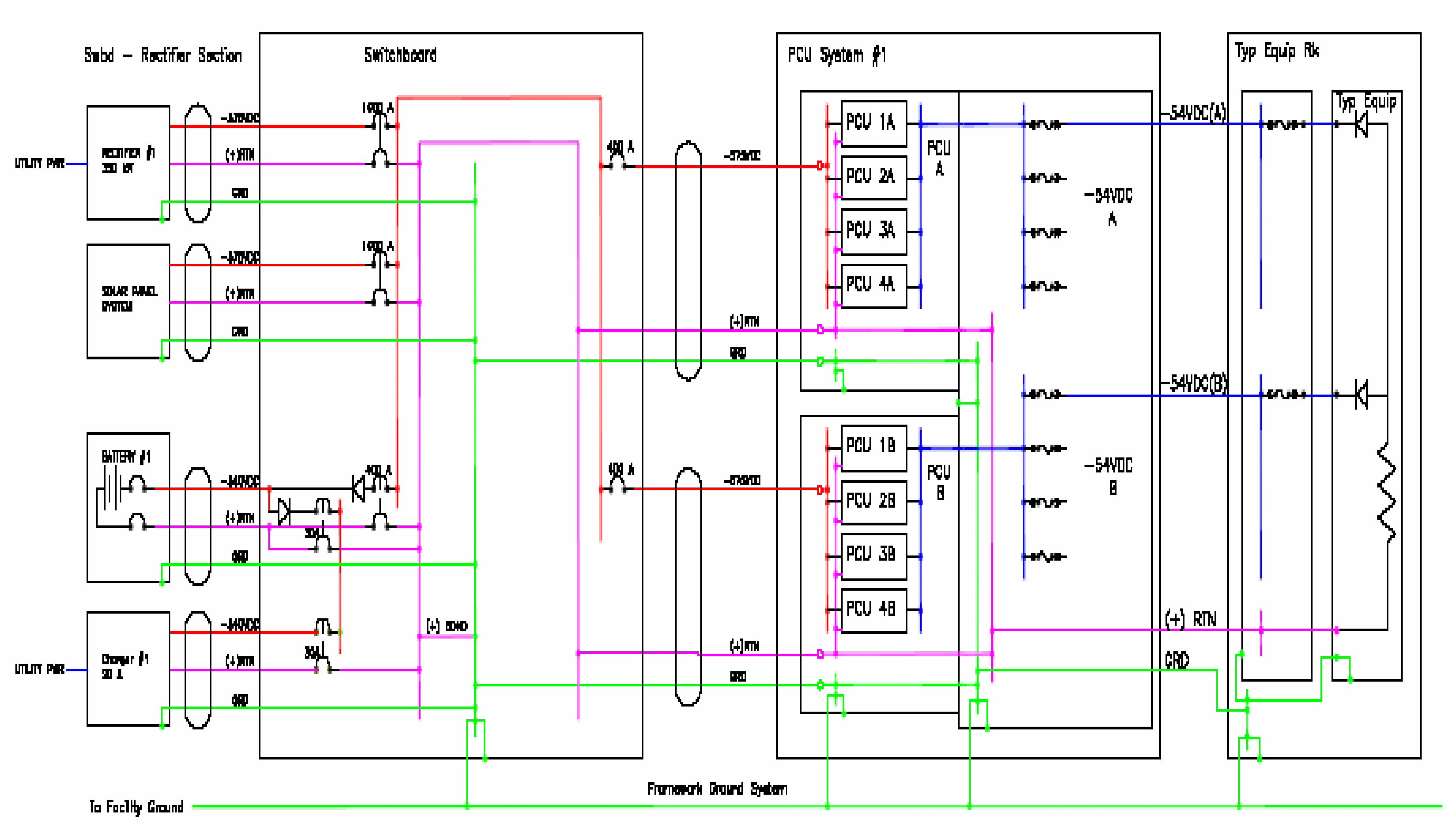
What’s Been Done So Far

- 4ESS was powered by a 140 VDC power plant
- Work has been started in 300 VDC, 350 VDC and 380 VDC systems

General Concepts

- Convert utility power to high voltage DC
- Store energy in a central system
- Distribute it to the “point of use”
- Convert to –54 VDC for powering load equipment
- Retain the basic system architecture of telecom power systems

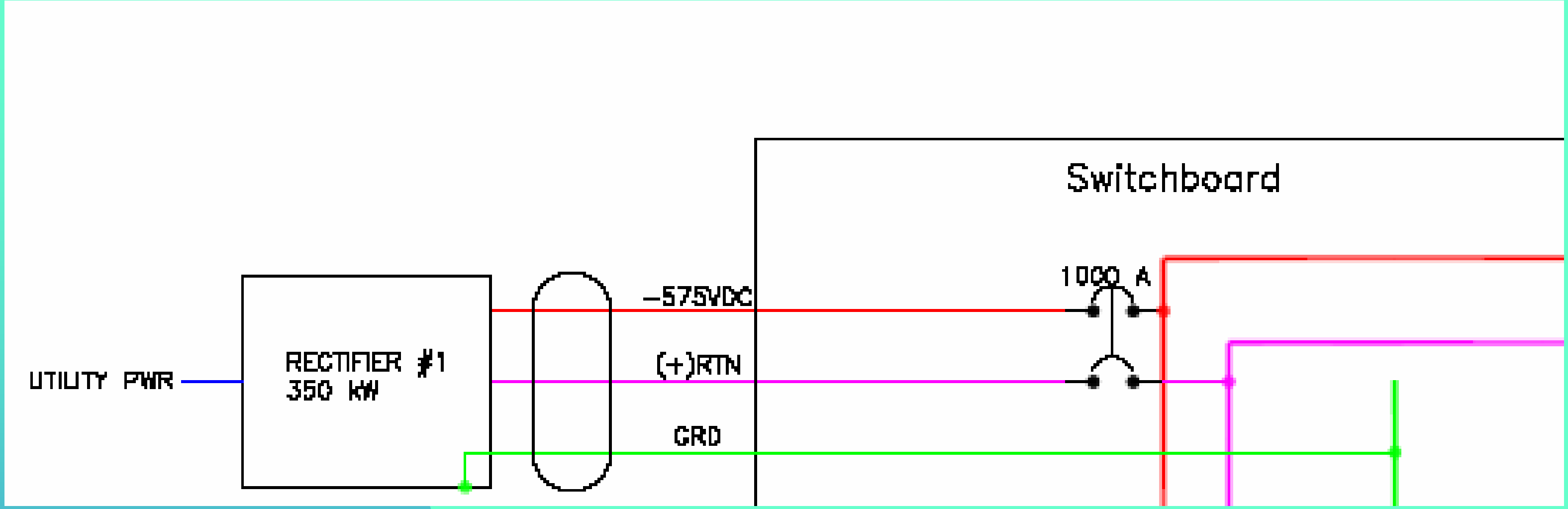
500KW-5MW DC Power Plant



Elements of the System

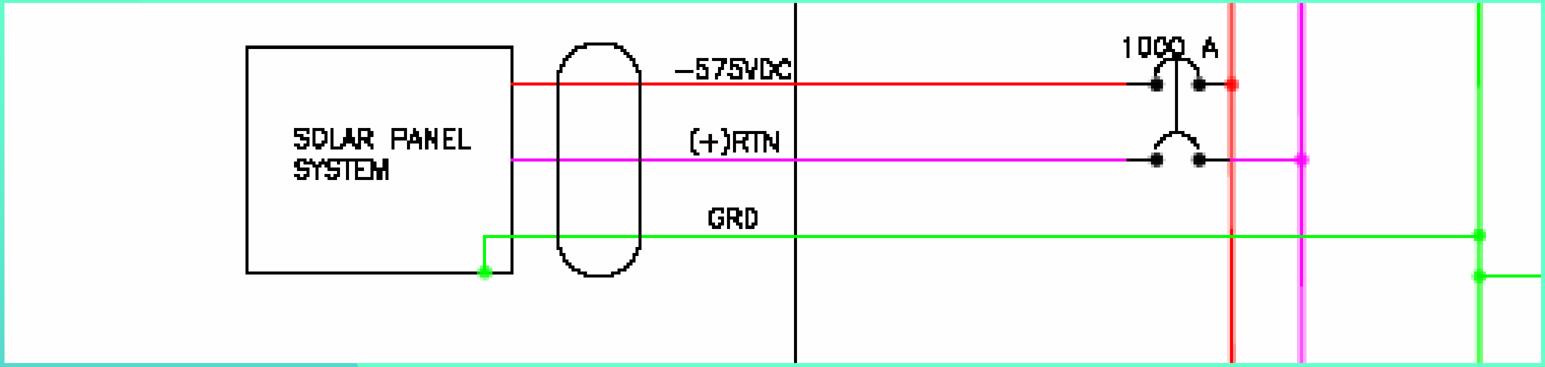
- Energy conversion to DC
- Energy storage
- Alternative energy input
- HV DC distribution
- Conversion to -54 VDC
- Distribution of –54 VDC

Utility Power to DC



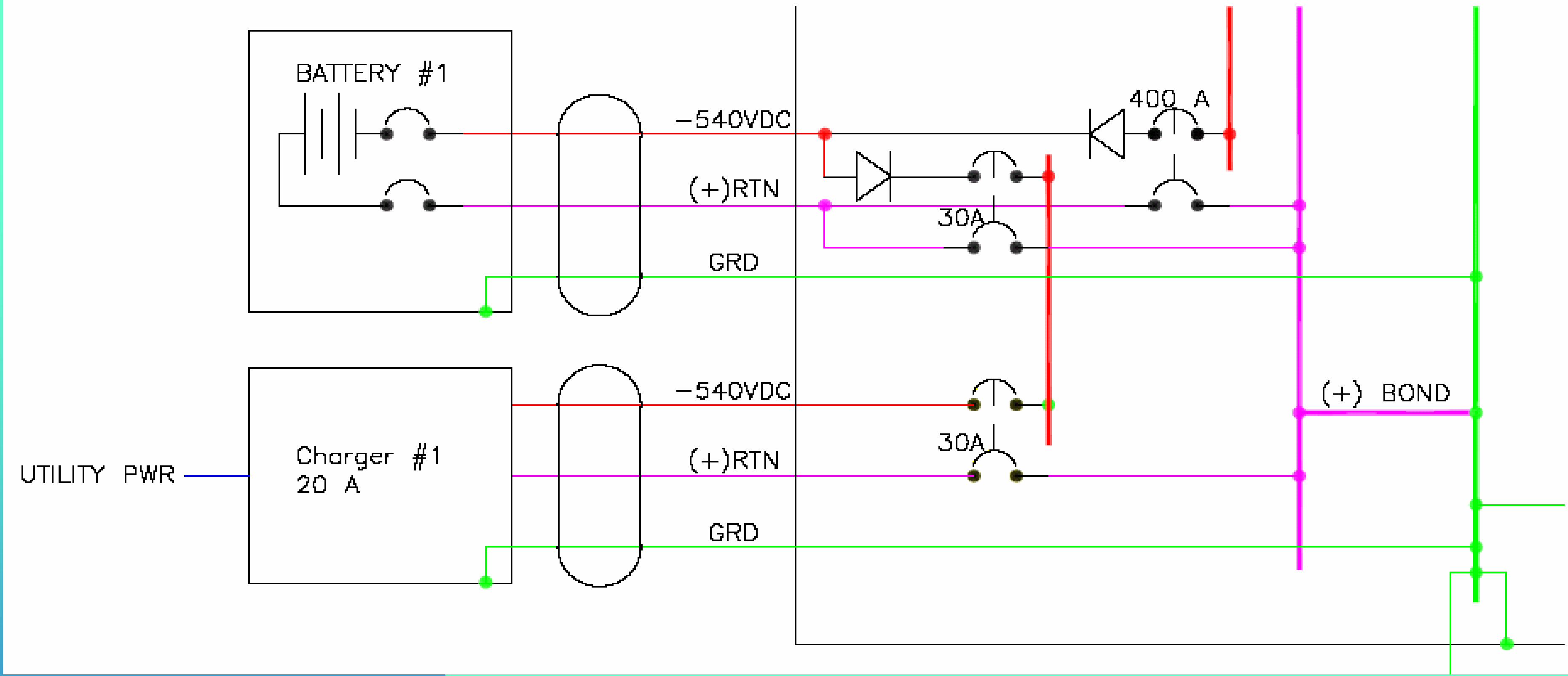
- The rectifiers convert the utility power to 575 VDC
- There are 3 or more in parallel to supply the load.

Alternate Energy Input



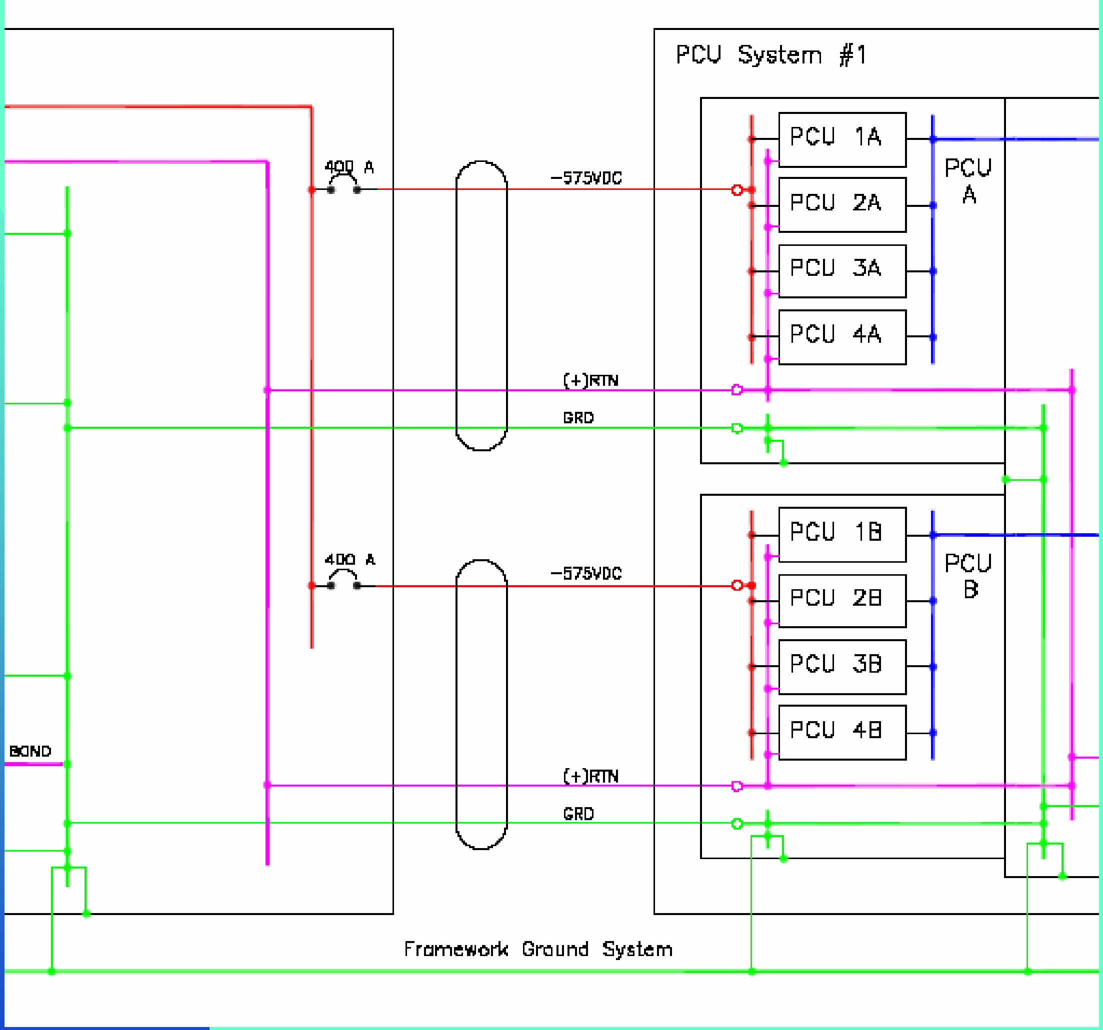
- **The solar panel system is a constant current device.**
- **As the sun comes out the solar panel system feeds more of the current to the load.**
- **The rectifiers reduce output because they are constant voltage devices.**
- **The system is self controlling.**

Energy Storage



- **There are 2 or more battery strings in parallel**
- **There are 2 or more separate chargers sized to recharge the batteries**
- **The batteries are diode isolated from the bus and floated at 540 VDC (lower than the 575 VDC bus)**

HV DC Distribution Diagram



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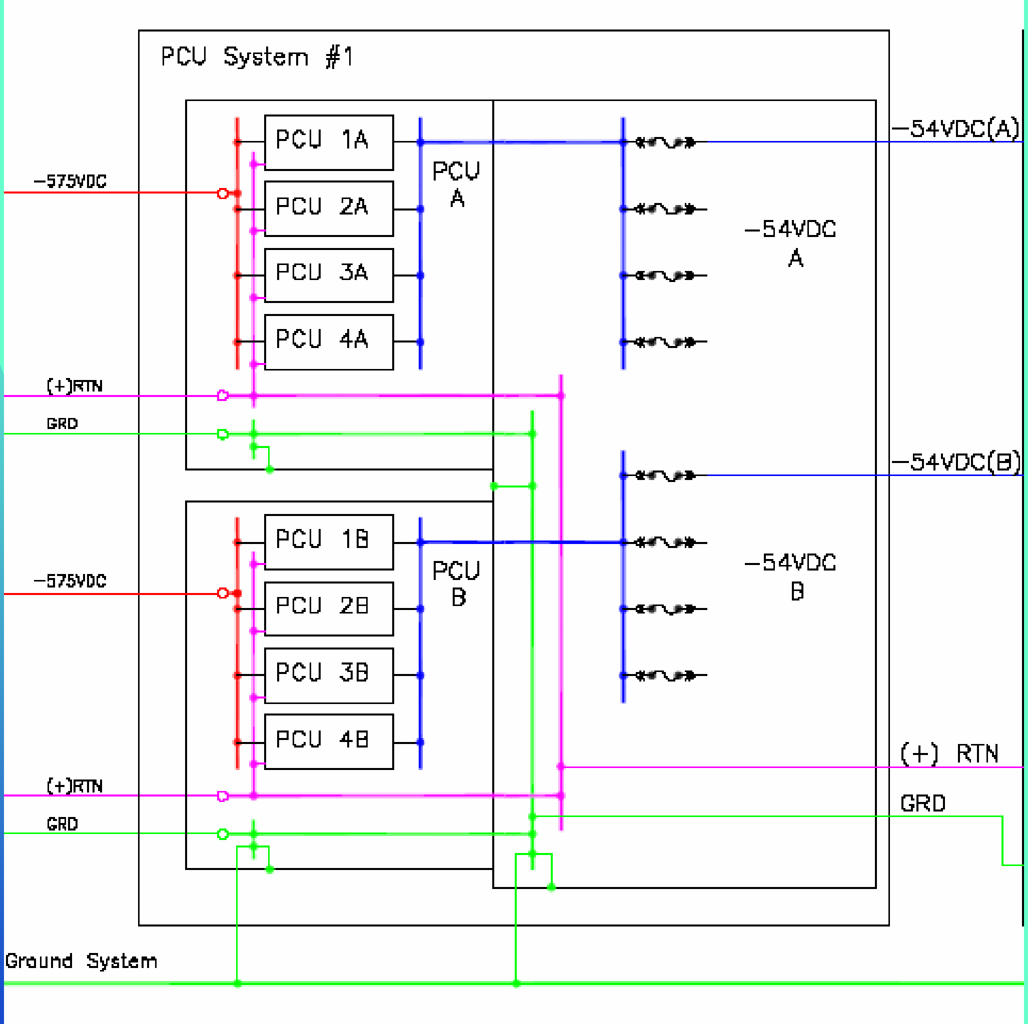
HV DC Distribution

- Personnel are protected from exposure to HV DC.
- It is contained in enclosed switchgear and conduit.
- HV DC side of the converters is enclosed in cabinets.
- Interlocks can be easily employed.

Power Conversion & Distribution Diagram



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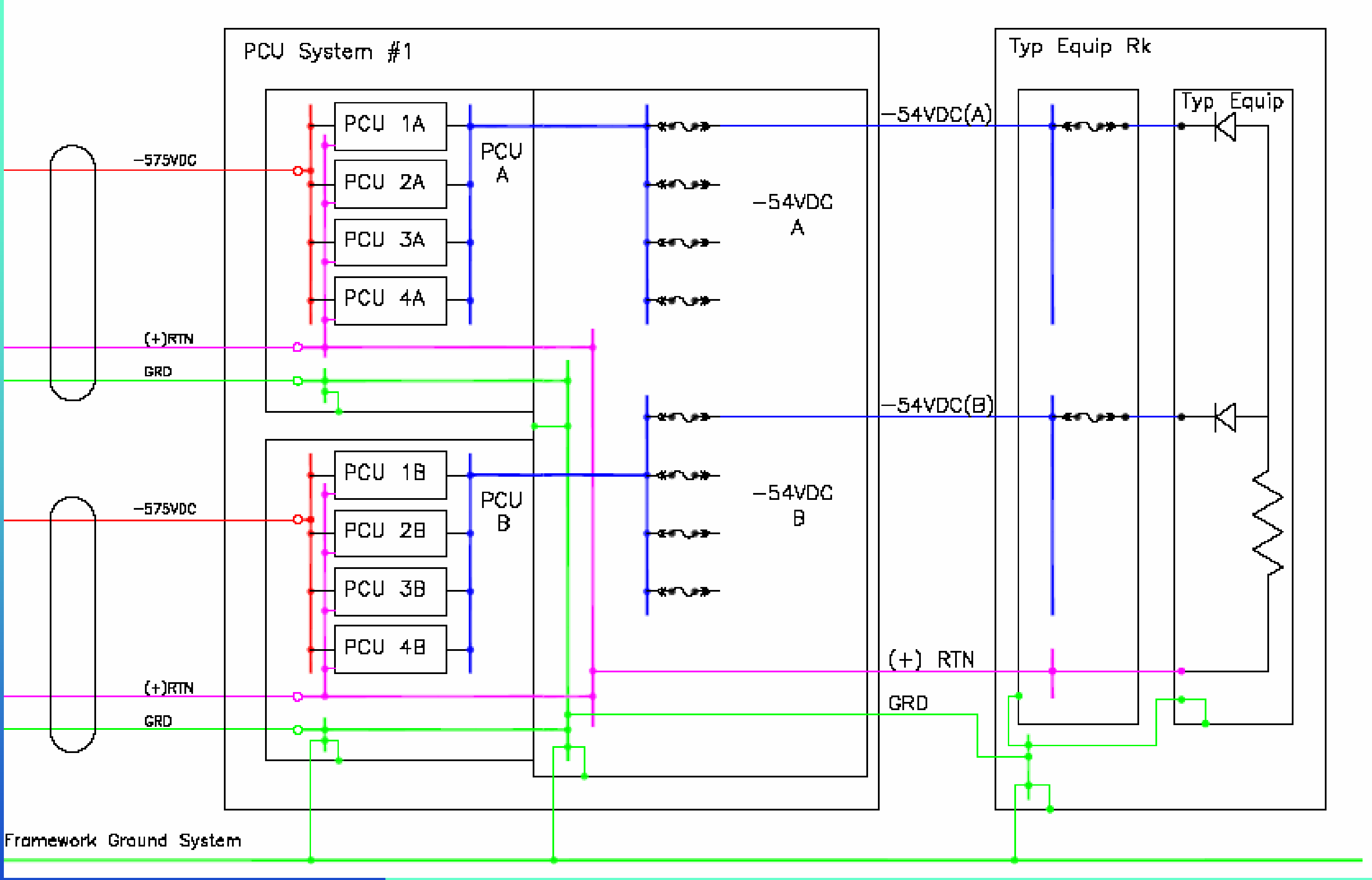
Power Conversion & Distribution

- In this system 2 converter assemblies are employed.
- Each converter assembly is made up of 4 converters.
- 3 converters will support 100% of the load of both converter assemblies.
- Failure of a 575 VDC feeder will not cause an outage with dual input equipment.

-54 VDC Distribution Diagram



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-54 VDC Distribution

- The –54 VDC distribution is in a BDFB/SPDU that is in a separate cabinet from the converters.
- Buses from each converter assembly enter through feed through assemblies into the BDFB/SPDU cabinet.
- The “Return” (+) is a common bus for both converter assemblies.
- The equipment combines both –54 VDC feeds to the actual load.

HV DC Operating Voltages

- -575 VDC normal voltage from rectifier
- -540 VDC battery float voltage
- Batteries are behind diodes
- Minimize ripple current
- Reduce complexity of rectifiers
- Allow higher efficiency of rectifiers
- Better manage battery float voltage

Equipment Operating Voltage

- -54 VDC at converter outputs
- -53.5 VDC or above at equipment
- Resulting equipment operating current is lower

Features of Converted Power

- Short secondary distribution circuit lengths (30-40 ft max)
- No low voltage limit issues for equipment
- Minimum current due to the constant high end voltage
- Minimize copper size in primary and secondary distribution

Short Secondary Distribution Circuit Lengths

- Converter/BDFBs are located close to load equipment
- Typical distances of 25-40 ft
- Small conductor size to feed equipment with normal voltage drop (0.5 V loop)

Equipment Low Voltage Limits

- Converter output is regulated
- Power is either there or not

-54 VDC Current Minimized

- Since the converter output is regulated at –54 VDC, the load equipment current is minimized for a given load.
- Example:

I for 1000 W load @ -54 V = 18.52 a

I for 1000 W load @ -40 V = 25 A

Reductions in Copper

- Higher voltage results in lower current thus less copper

Current vs. Voltage For 500 KW System

- -54 VDC = 9560 A
- -40 VDC = 12500 A
- -575 VDC = 870 A
- -540 VDC = 926 A
- -425 VDC = 1176 A

Copper vs. System Voltage

Assumptions for Feeder Circuits

- For a 54 KW Circuit at 54 VDC, it would require 1000 A.
- For the same 54 KW Circuit at 540 VDC, it would only require 100 A.
- Assume the same power loss at each voltage.
- For the 54 VDC circuit, a 1 volt drop in the wire would result in a 1000 W loss.
- For the 540 VDC circuit, it would take a 10 V drop to loose the same 1000 W.

Copper vs. System Voltage

Voltage Drop Considerations Only

- For a 1 V drop in a 1000A circuit of 200 ft loop length it would take the following wire:

  A = 11.1 x 200' x 1000A / 1V

  A = 2,080,000 Circular Mill Cable

  The cable would be about 4 ea 500 kcmil cables.

- For a 10 V drop in a 100A circuit of 200 ft loop length, it would take the following wire:

  A = 11.1 x 200' x 100A / 10V

  A = 21,600 Circular Mill Cable

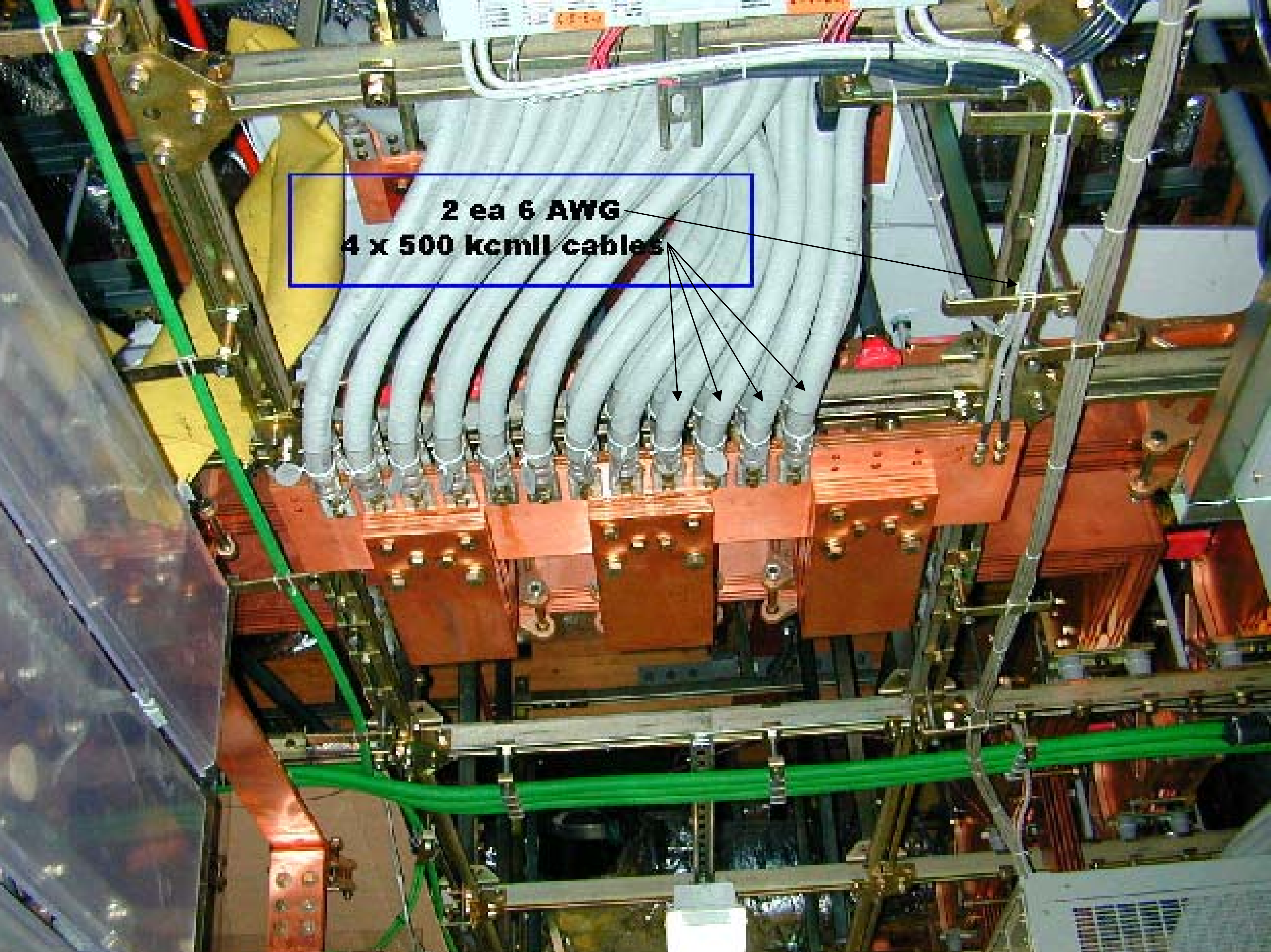
  The cable would be slight smaller than a 6 AWG (26,240 cmil) :

- Apparent reduction in size would be about 2,080,000 to 21,600 or about **96:1**

Copper vs. System Voltage

Current Carrying Capacity Considerations

- For a 1 V drop in a 1000A circuit of 200’ we used the 4 ea 500 kcmil cable, their current carrying capacity would be more than sufficient for the 1000 A.
- For a 10 V drop in a 100A circuit of 100’ we would need at least a 2 AWG cable to carry the current due to the current carrying capacity of the cables.
- The **actual ratio** of copper reduction would be about 2,000,000 to 66,360 or about **30:1**


2 ea 6 AWG
4 x 500 kcmil cables

System Grounding

- Single point ground for the HV DC system.
- That point is the Return bus (+) in the primary switchboard.

Questions?