UPS CASE STUDY

SERVER INCOMPATIBILITY

PRESENTED AT IEEE / MCPQG MEETING
NOVEMBER 28, 2012

BY MIKE PUCKETT, PE

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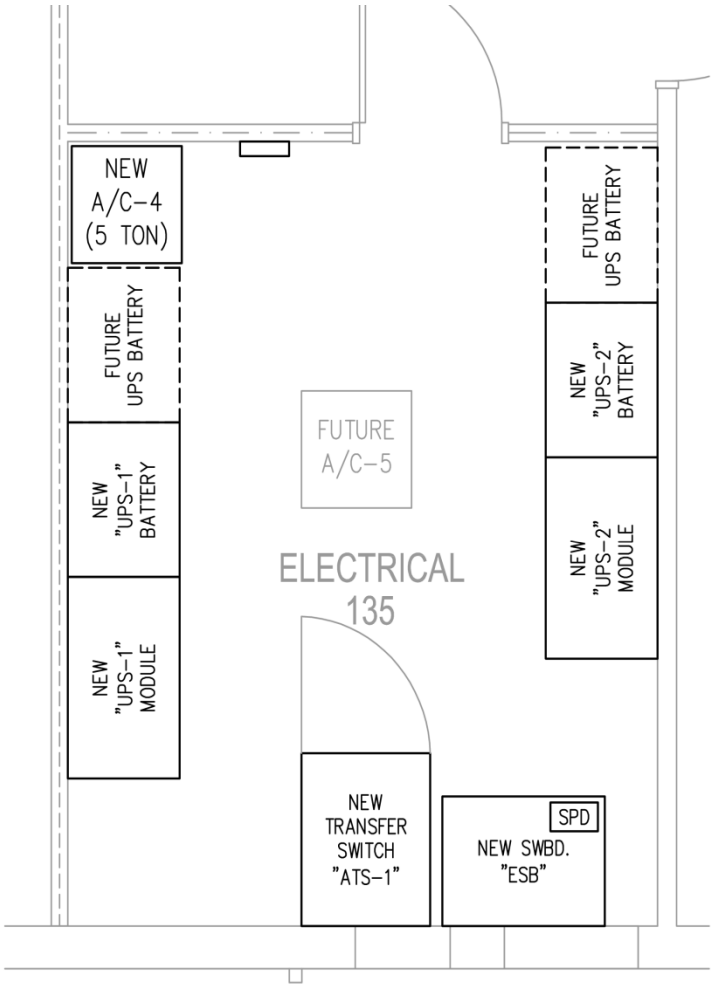
THE CRITICAL DIFFERENCE BETWEEN OFF AND ON

UPS ROOM LAYOUT



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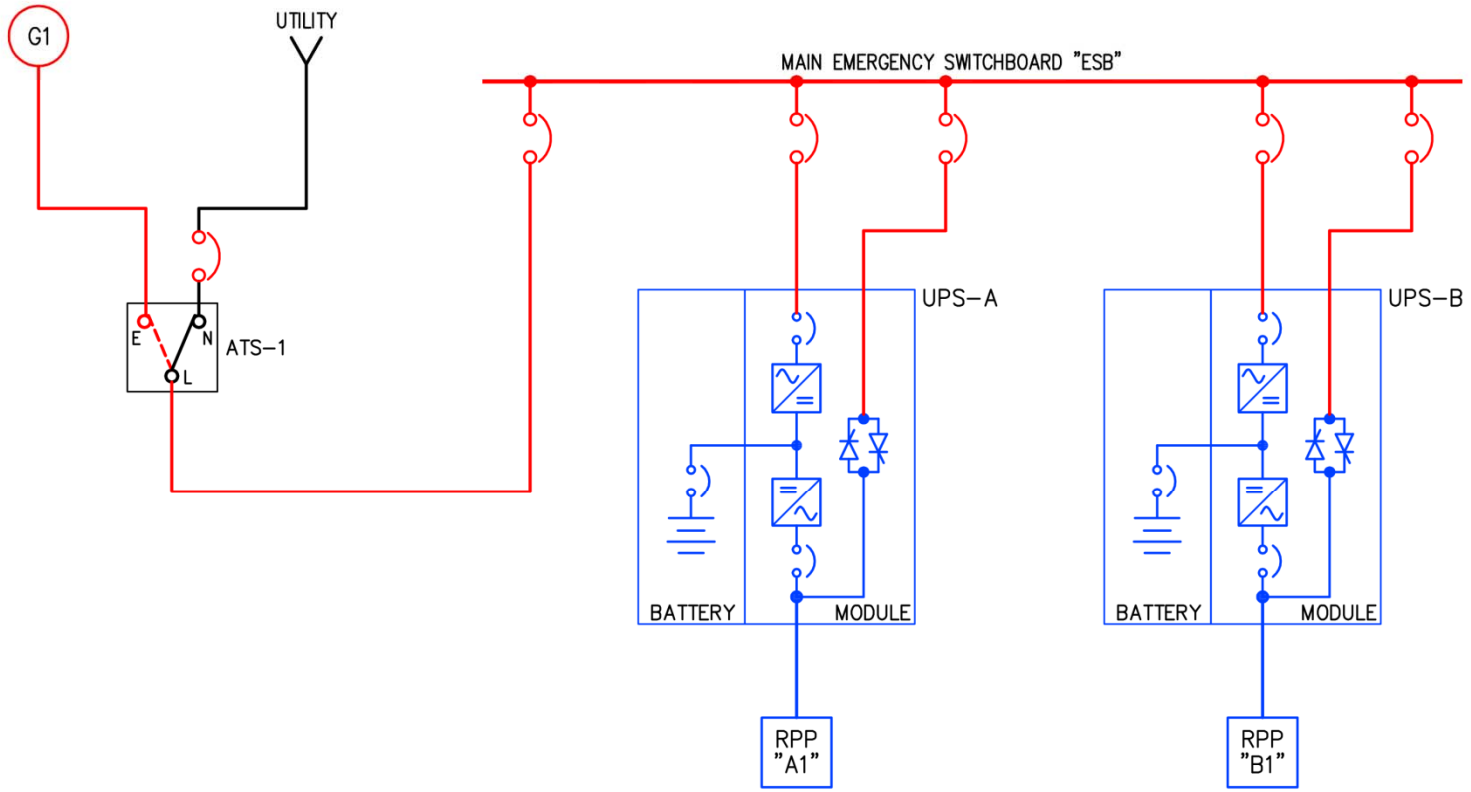
ONE-LINE DIAGRAM



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LOADS

- Initial Load on UPS Systems was about 13% each
- Initial Maximum Heat Gain in the UPS Room about 90% of the A/C rating based on each UPS being 25% loaded

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A/C PERFORMANCE

- A/C unit set-point was 68 and space temperature was running about 77
- When compressor cycled, space temperature climbed to low 80's during the compressor's 3 minute time delay

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INVESTIGATION

- A/C manufacturer checked-out the A/C unit's performance
- A/C was performing at or above spec
- Rechecked Heat Gain Calculations. They looked good.
- Largest Source of Heat Gain was from UPS Systems

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INVESTIGATION

- **Researched UPS Heat Loss**
- **Efficiency = Pin/Pout**
- **Heat Loss = Pin – Pout = Pout/Eff - Pout**
- **UPS Heat Losses Include:**
  - No-Load Losses: Transformer & Inductor core loss, capacitors, fans, controls
  - Load Proportional Losses: Switching
  - Load I^2R Losses: Transformer & Inductor coil loss, Conductors, Conduction

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INVESTIGATION

- Measured Input and Output kW of one UPS System to check Heat Loss (Efficiency)
- UPS was rejecting about same heat as if it was 50% loaded.
- Measured Heat Loss = 8.1kW.
- Published Heat Loss at 25% Load = 6.4kW
- Published Heat Loss at 50% Load = 8.2kW

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INVESTIGATION

- UPS Manufacturer decided to perform their own testing
- Measured Input and Output kWh and DC Link simultaneously for ~15 minutes.
- Difference of above divided by Time = Heat Loss
- Did this for normal 13% load and with all load on one UPS (22%)

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UPS HEAT LOSS MEASUREMENTS

Load	Heat Loss	Efficiency	Load PF
0	7.4kW		
13%	8.4kW	74%	-0.923
22%	8.7	82%	-0.963

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MEASUREMENTS VS. PUBLISHED SPECS

Load	Heat Loss	Efficiency	Load PF
Measured:			
0	7.4kW		
13%	8.4kW	74%	-0.923
22%	8.7kW	82%	-0.963
Published Specs:			
25%	6.4kW	87.60%	0.8 - 0.9
50%	8.2kW	91.65%	0.8 - 0.9
75%	11.4kW	92.20%	0.8 - 0.9
100%	15.7kW	92%	0.8 - 0.9

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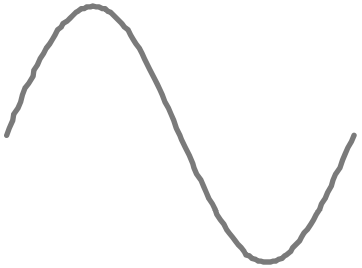
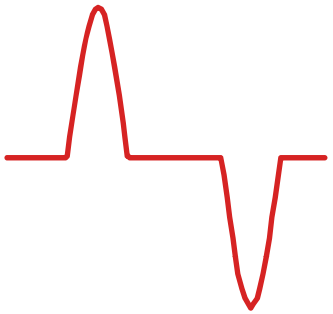
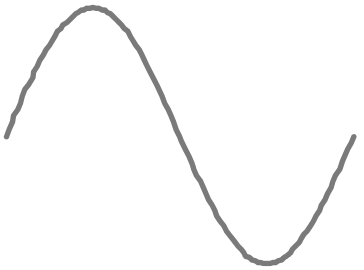
I.T. EQUIPMENT POWER SUPPLIES



Power Supply Waveform Prior to Mid 80's



Power Supply Waveform beginning around Mid 80's



Power Supply Waveform for Data Center I.T beginning around 2002

- **In 2001, the European Union put into effect IEC/EN61000-3-2, setting Limits on Harmonics for Equipment Above 75W**

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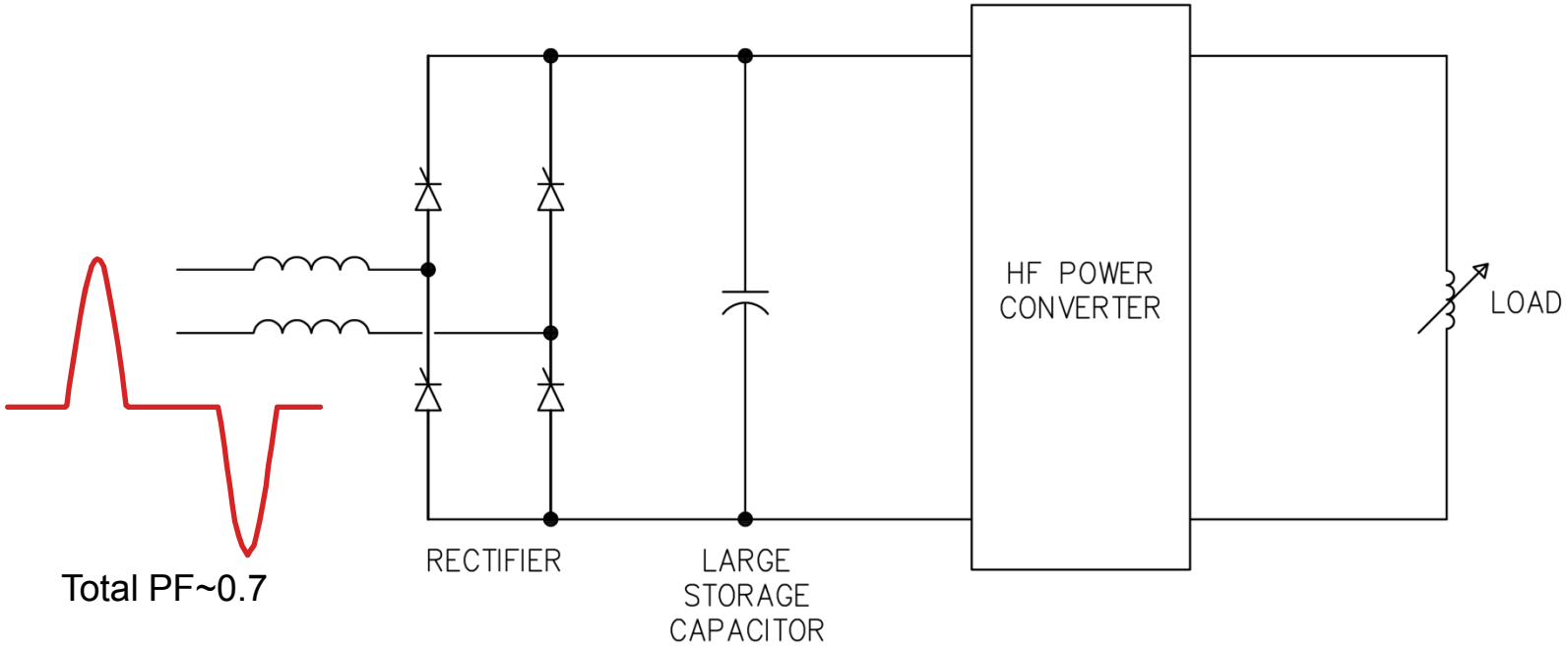
SWITCH-MODE POWER SUPPLY (SMPS)



- **SMPS prior to the European mandate and those currently not in compliance.**
- **It seems most non-Data Center equipment in U.S. does not comply with the European mandate and thus uses this SMPS**

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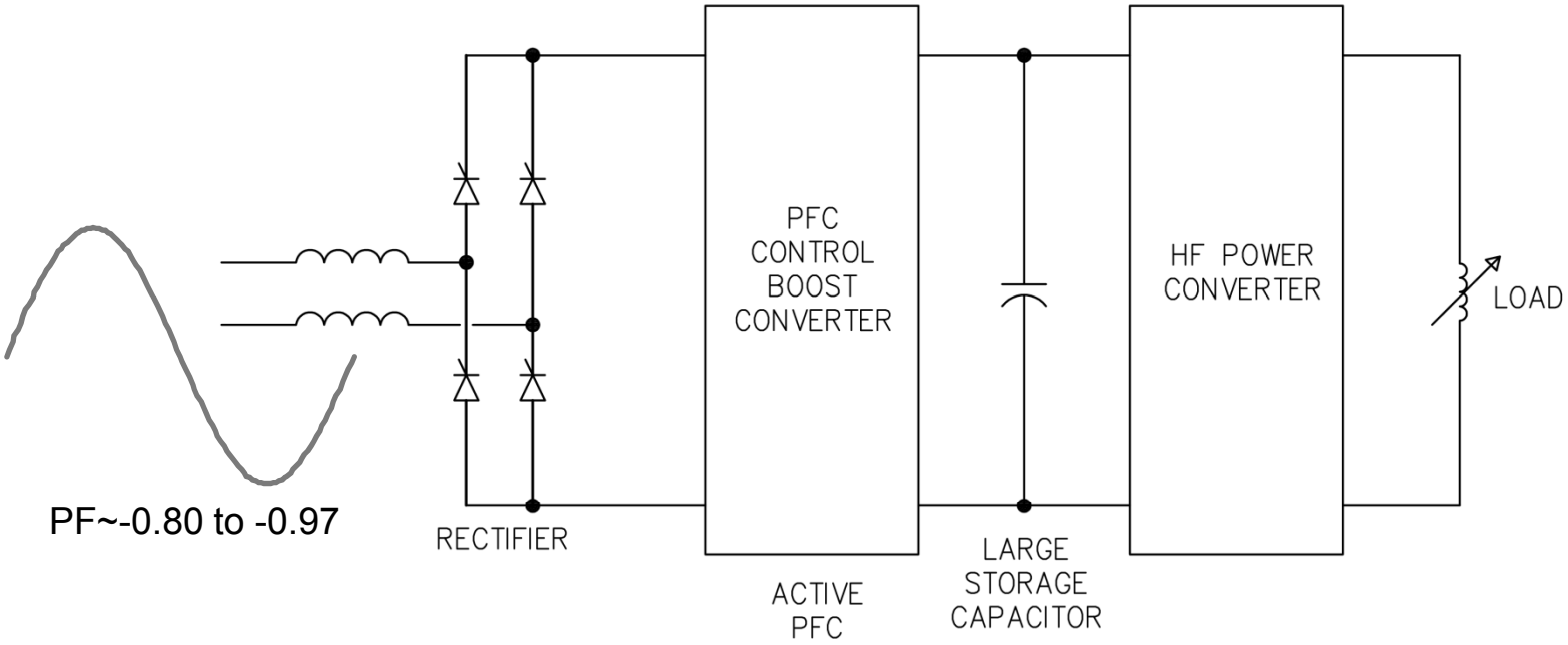
SWITCH-MODE POWER SUPPLY (SMPS)



- **Power Factor Corrected (PFC) SMPS after the 2001 European mandate.**
- **Includes leading PF at low loads.**

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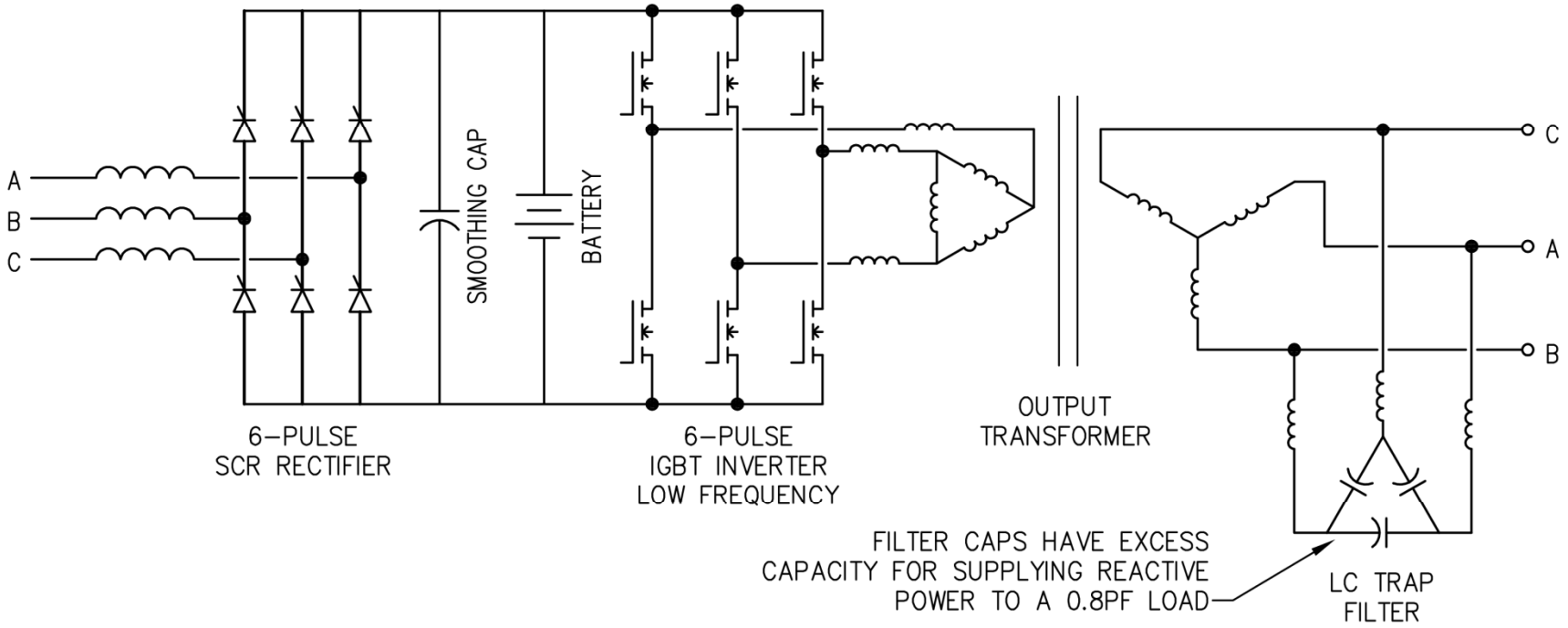
LEGACY UPS SYSTEMS



- **Legacy UPS systems were originally developed in the 80's for the original SMPSs with PF ~0.7 but are still being made**
- **Most built today are not legacy but there are plenty of existing**
- **They must be derated for leading PF loads like PFC SMPSs**

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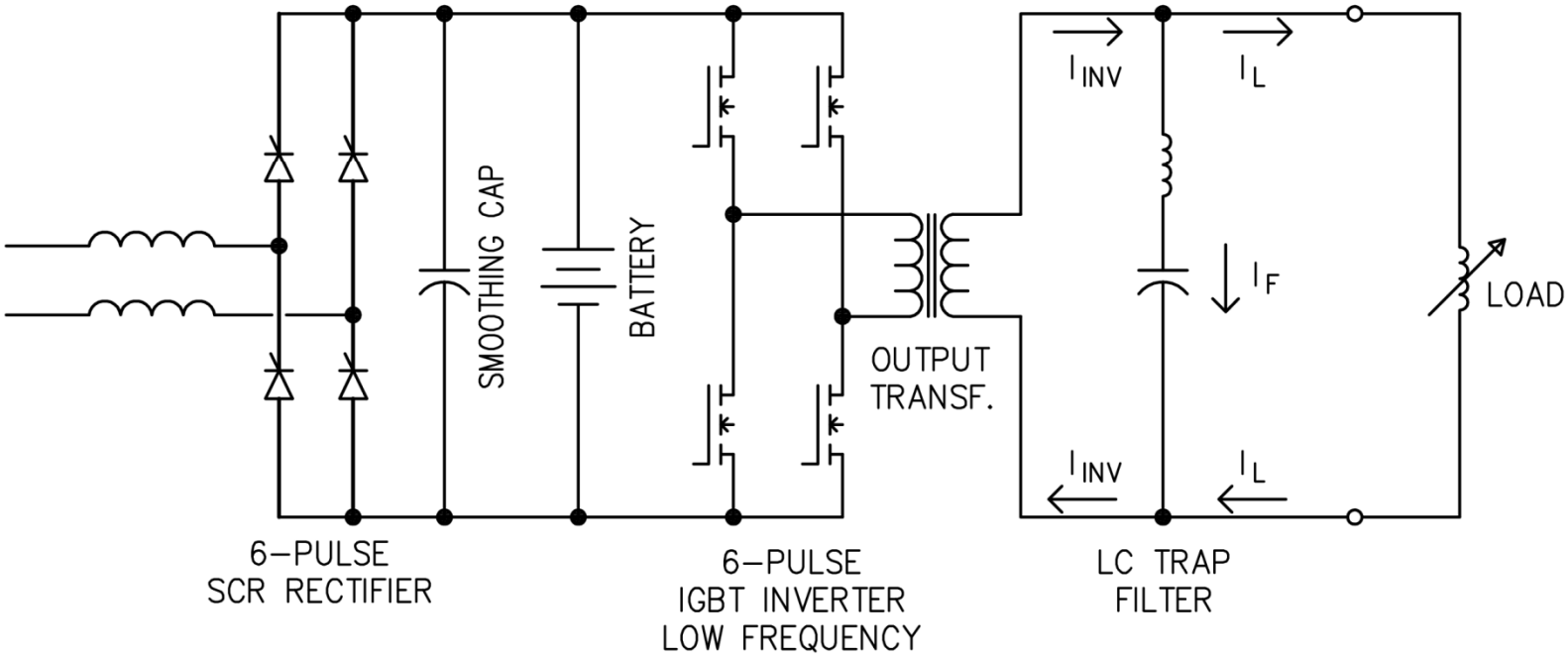
LEGACY UPS SINGLE PHASE EQUIVALENT CIRCUIT



- **$I_{INV} = I_F + I_L$. I_F net will be capacitive (-jX) and for a leading PF load, I_L will also be capacitive (-jX). Therefore, the net inverter and transformer current could exceed its designed rating and will also increase losses.**
- **Leading PF loads can also cause voltage (control) stability issues.**
- **Not as much potential for leading PF at UPS with 480V distribution**

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CONCLUSIONS

- **Know what you are specifying and getting.**
- **Know what the loads are.**
- **Get the most accurate heat loss data you can from the manufacturer**

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LIGHTNING CASE STUDY

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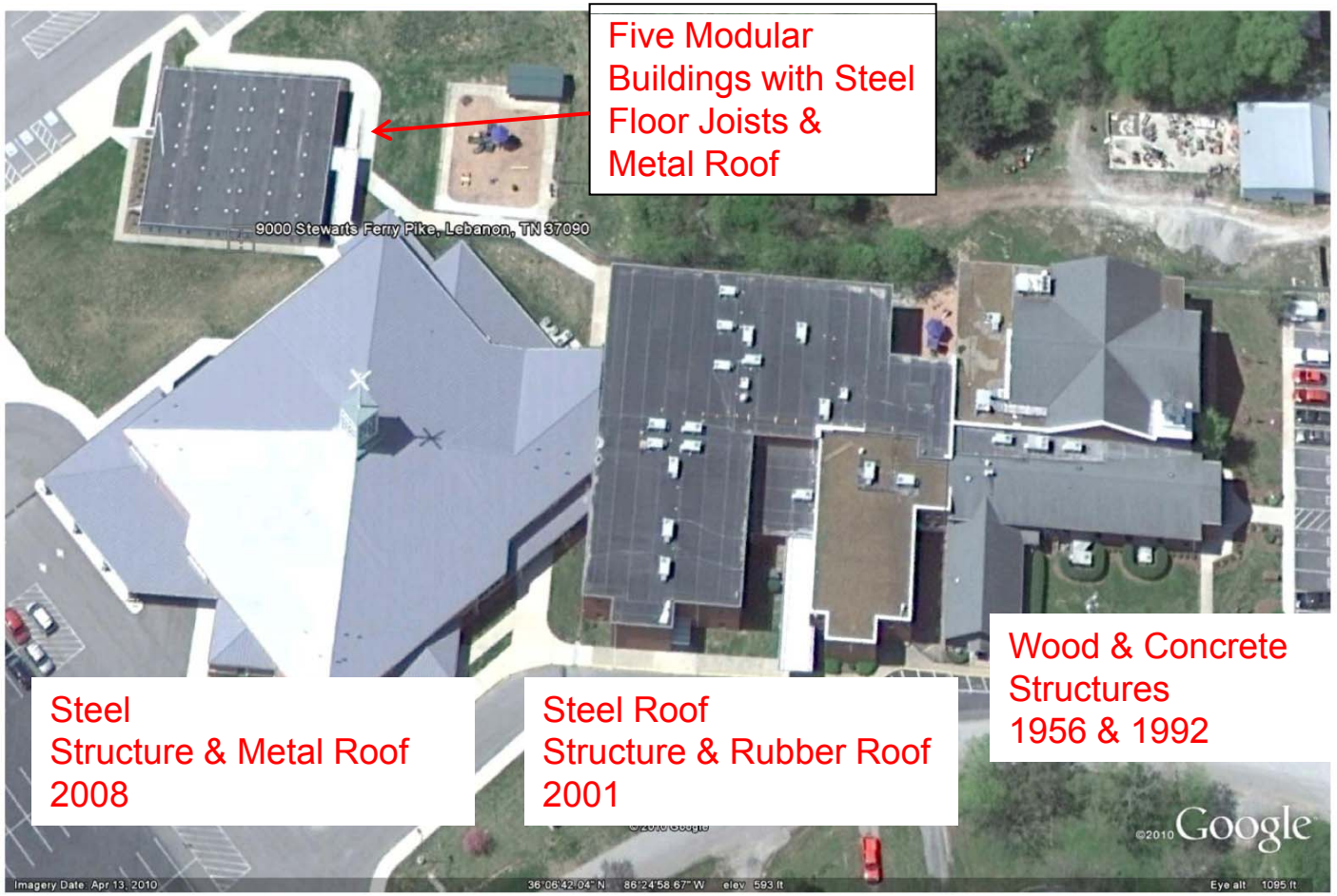
LARGE CHURCH



Built in 3 Phases between 1956 and 2008

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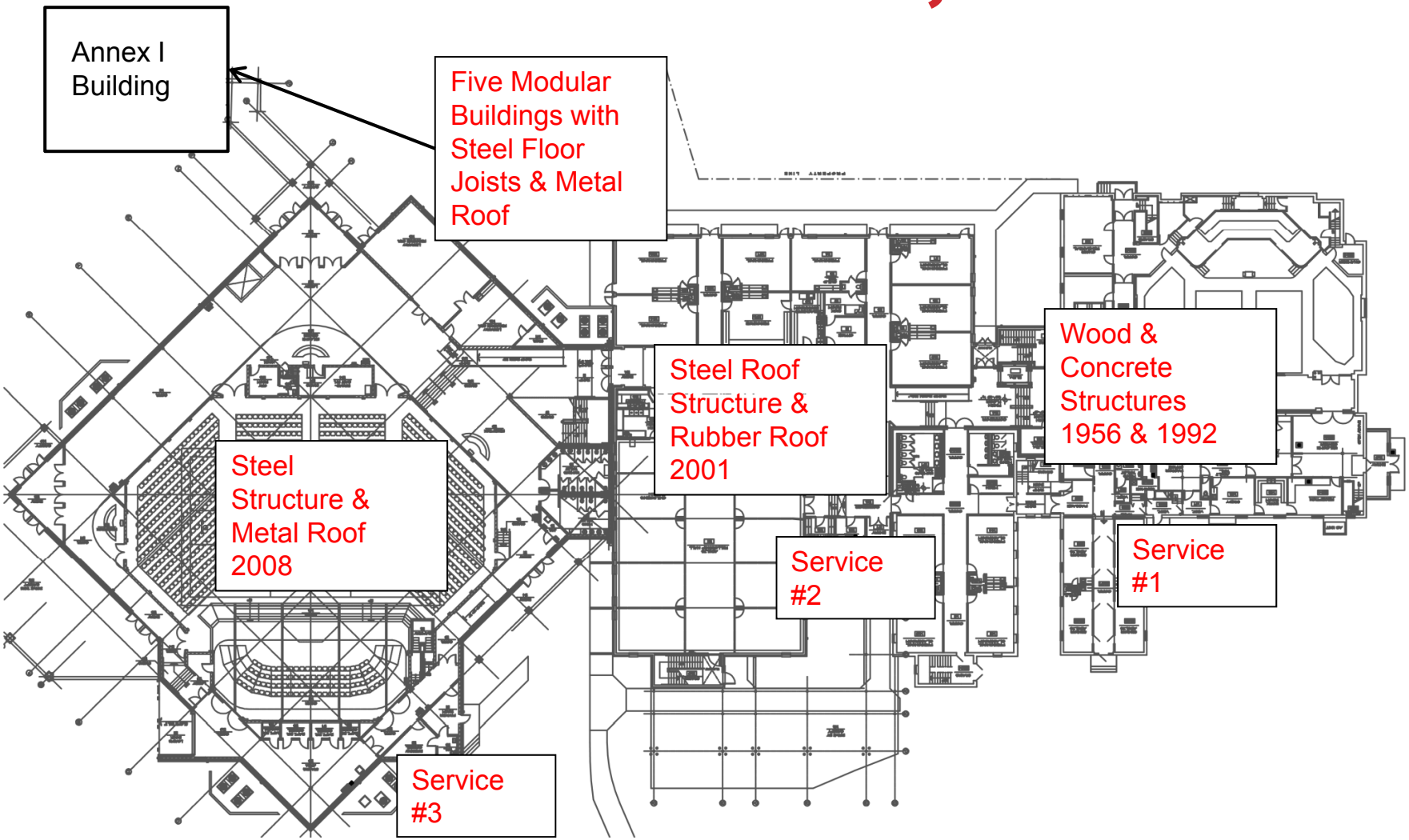
CHURCH CASE STUDY, CONT.



- **Built in 3 Phases between 1956 and 2008**

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CHURCH CASE STUDY, CONT.

Newest 2008 Sanctuary Addition

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CHURCH CASE STUDY, SYSTEMS

- **49 HVAC Units with 26 roof-mounted on 2001 section roof.**
- **HVAC DDC Control System.**
  - This system includes a data cable (RS-485 protocol) that daisy-chains through all HVAC unit controllers.
- **LAN that originates in 1992 section with fiber optic cables between 1992 section and 2008 section.**
- **A/V Control Room in 2008 section for Sanctuary.**
- **Video Transmitter in 2008 A/V Control Room with video Receiver in 2001 Café and in 2008 Library.**
- **Intercom at main front entrance for communicating with receptionist in front lobby.**
- **Access Control System with three card readers.**

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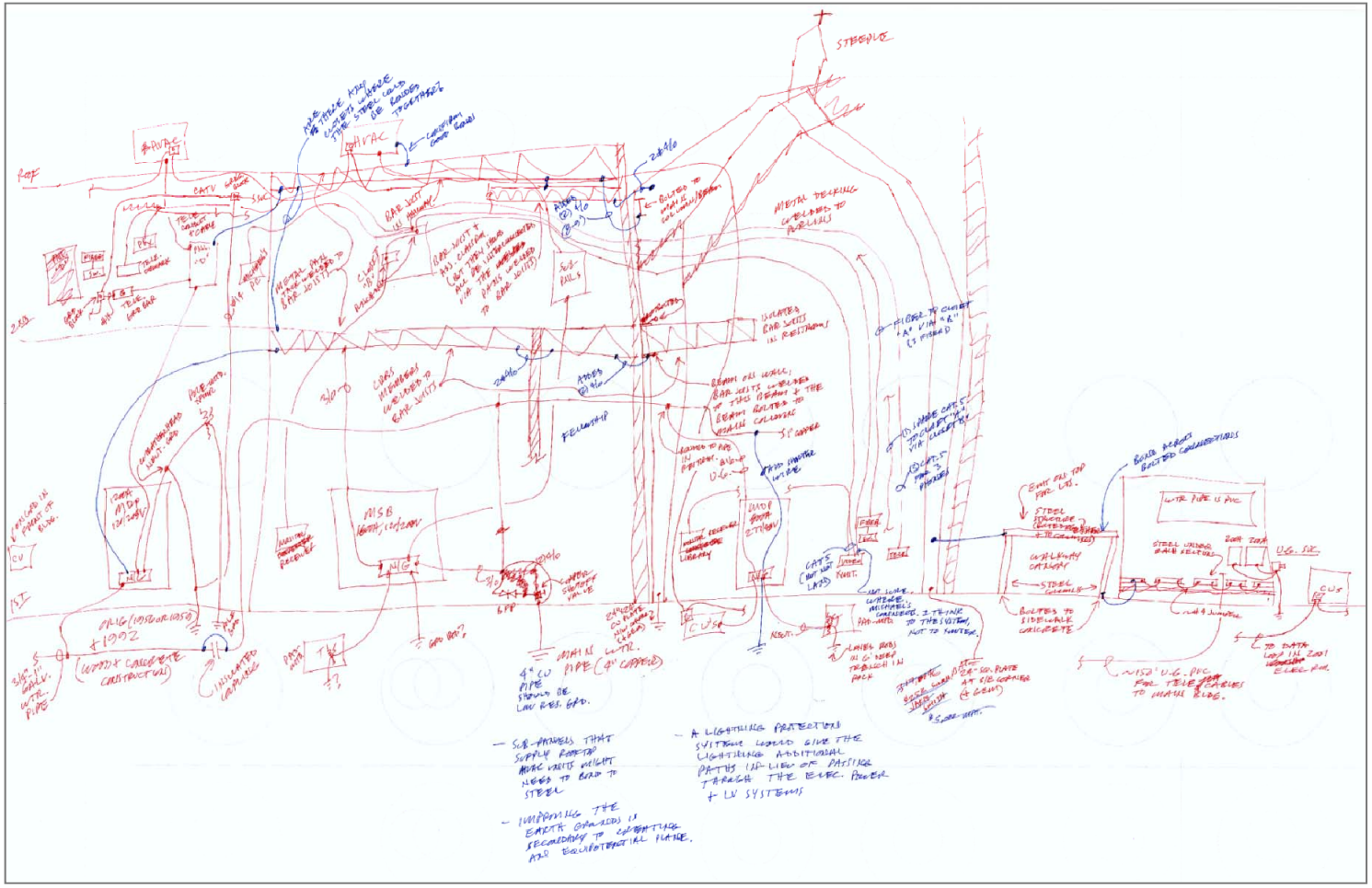

SITE SURVEY AND ANALYSIS

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- **HVAC DDC Control System.**
  - This was the main damage that occurred repeatedly.
  - It occurred occasionally before the 2008 section but escalated after the 2008 section.
  - This system includes a data cable (RS-485 protocol) that daisy-chains through all HVAC unit controllers.
- **Video Transmitter in 2008 A/V Control Room and video Receiver in 2001 Café. The café receiver had been damaged 2 to 3 times prior to 2010.**
- **Intercom and Card reader at main front entrance.**

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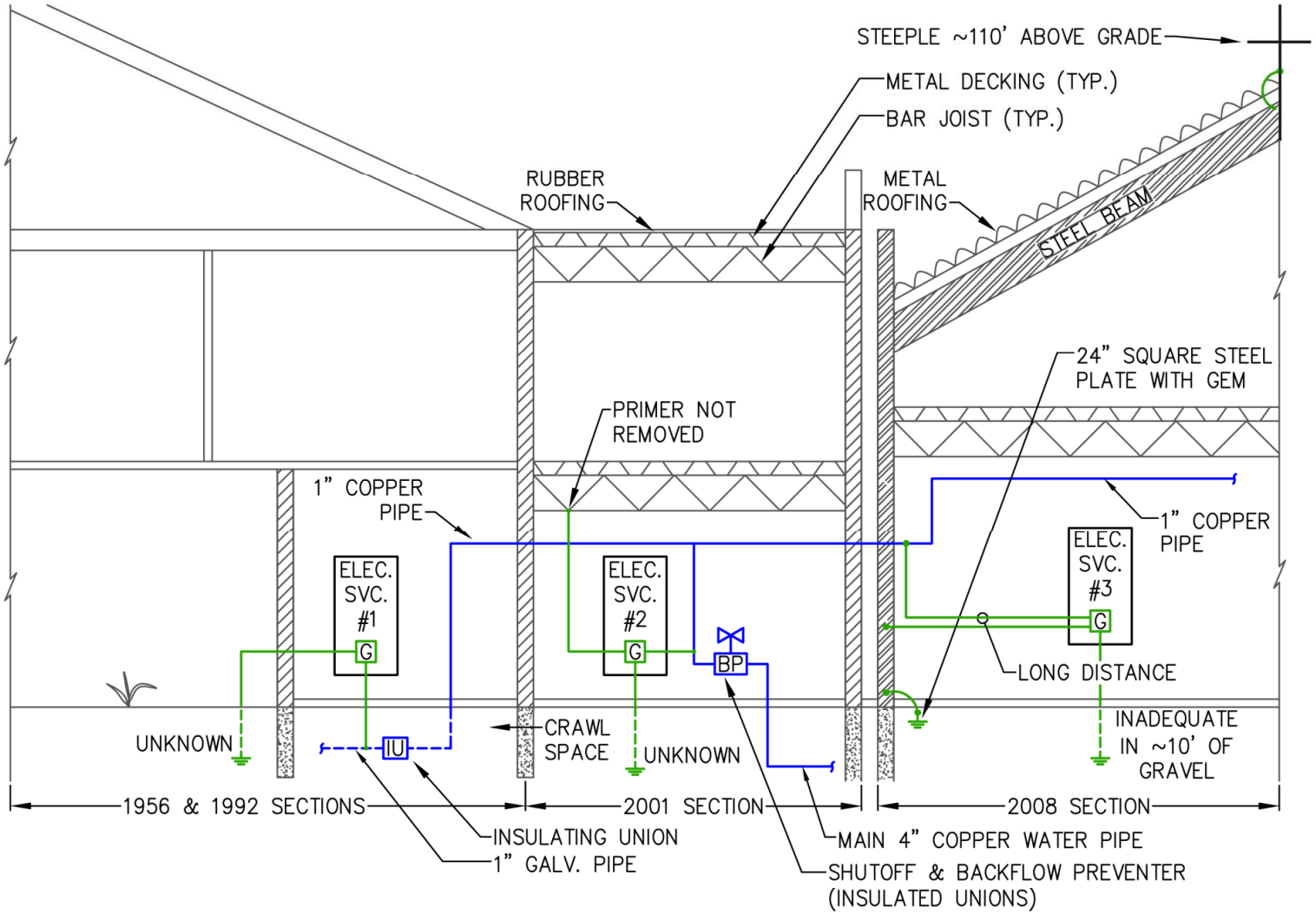

GROUNDING BEFORE

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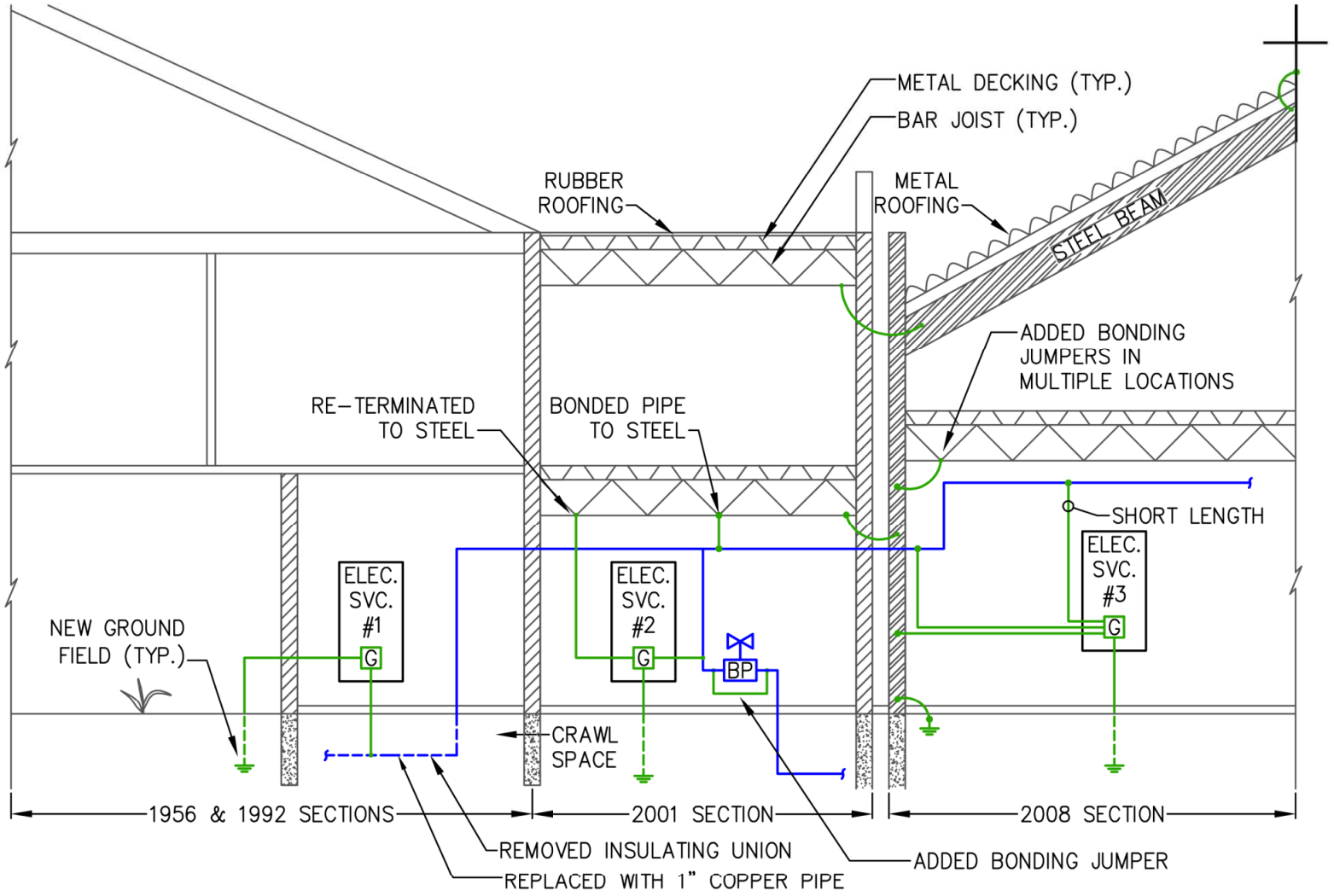

GROUNDING AFTER

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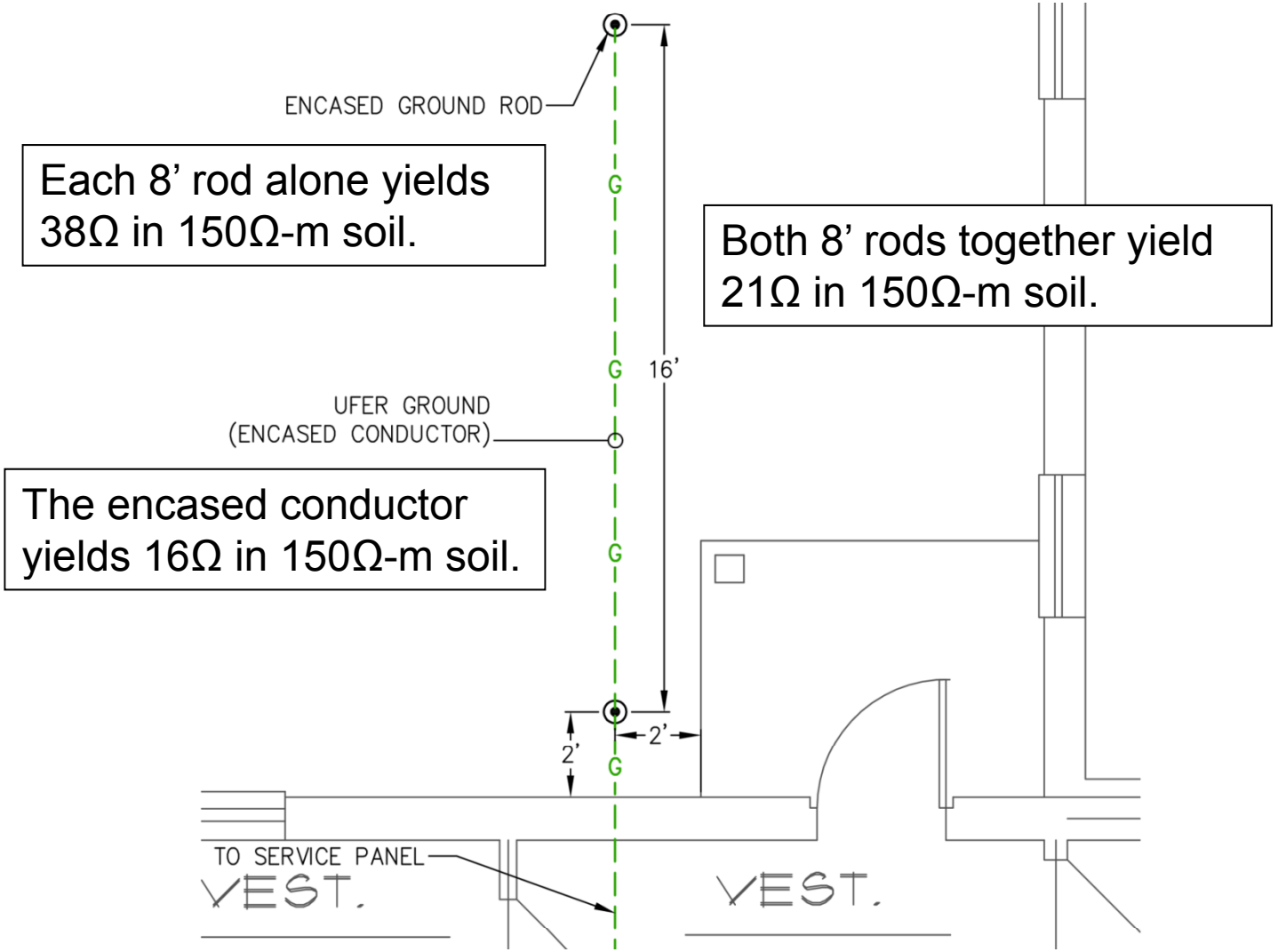

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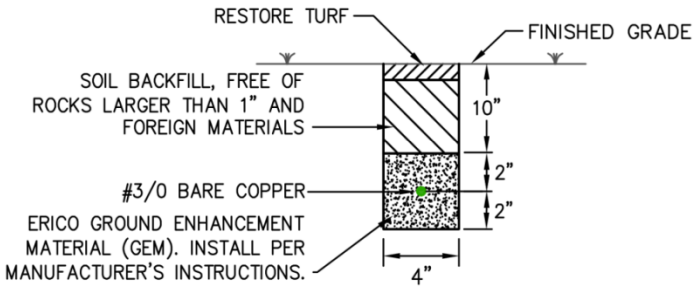

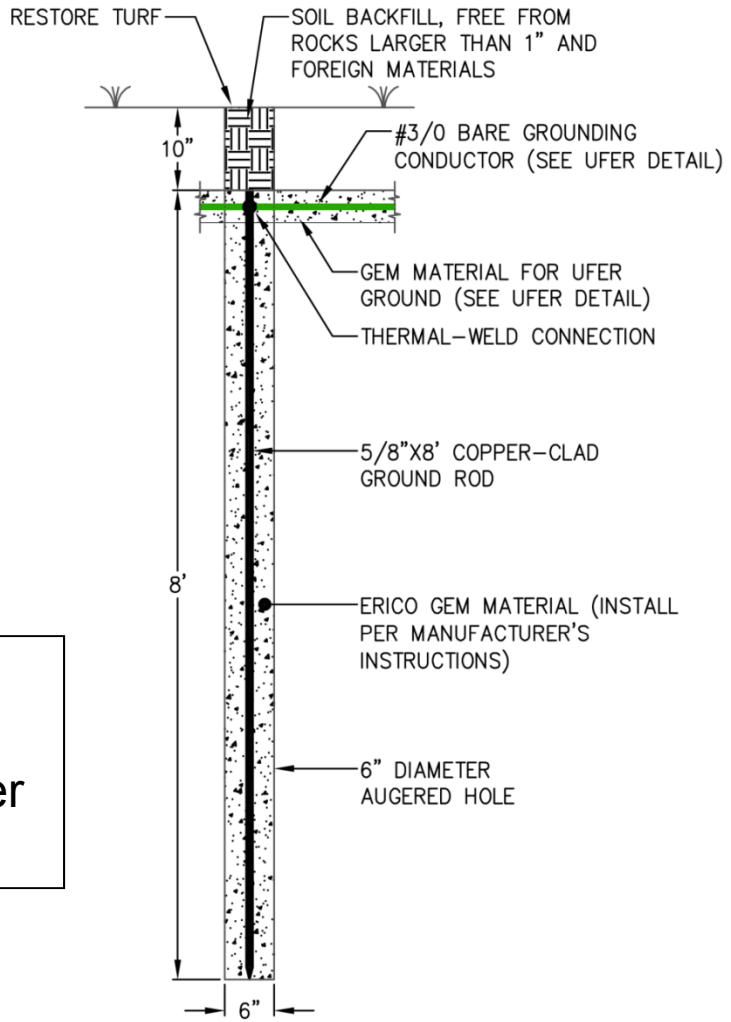

Can download Erico's Ground Resistance calculator from their website or calculate manually per IEEE Green book.

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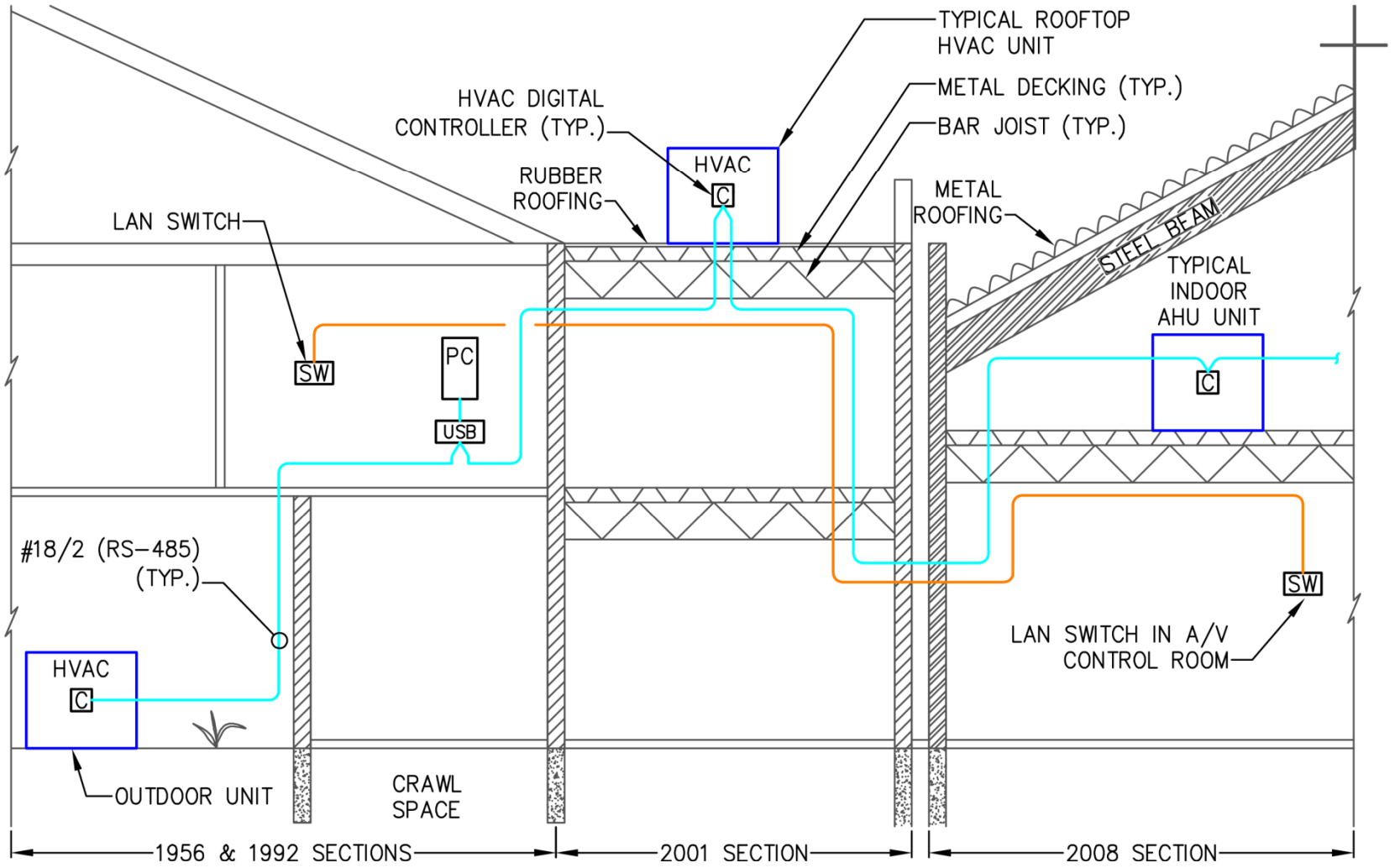

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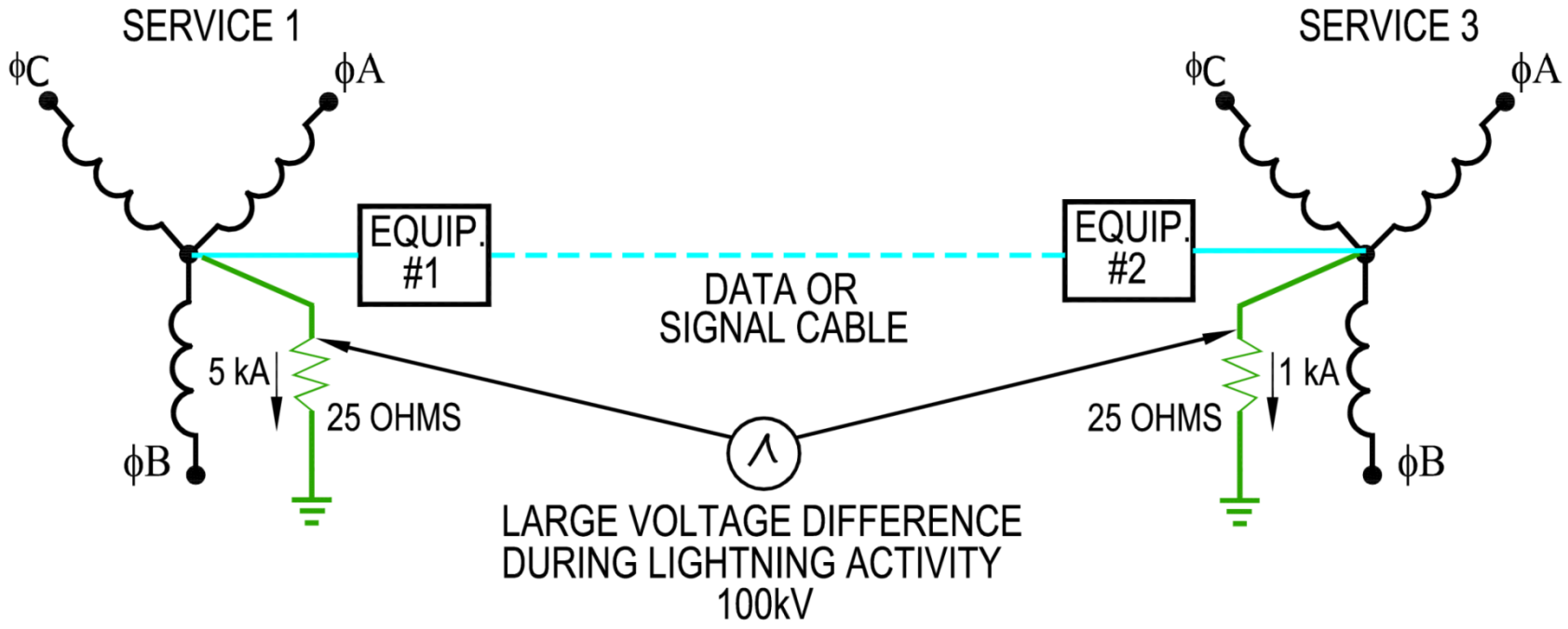

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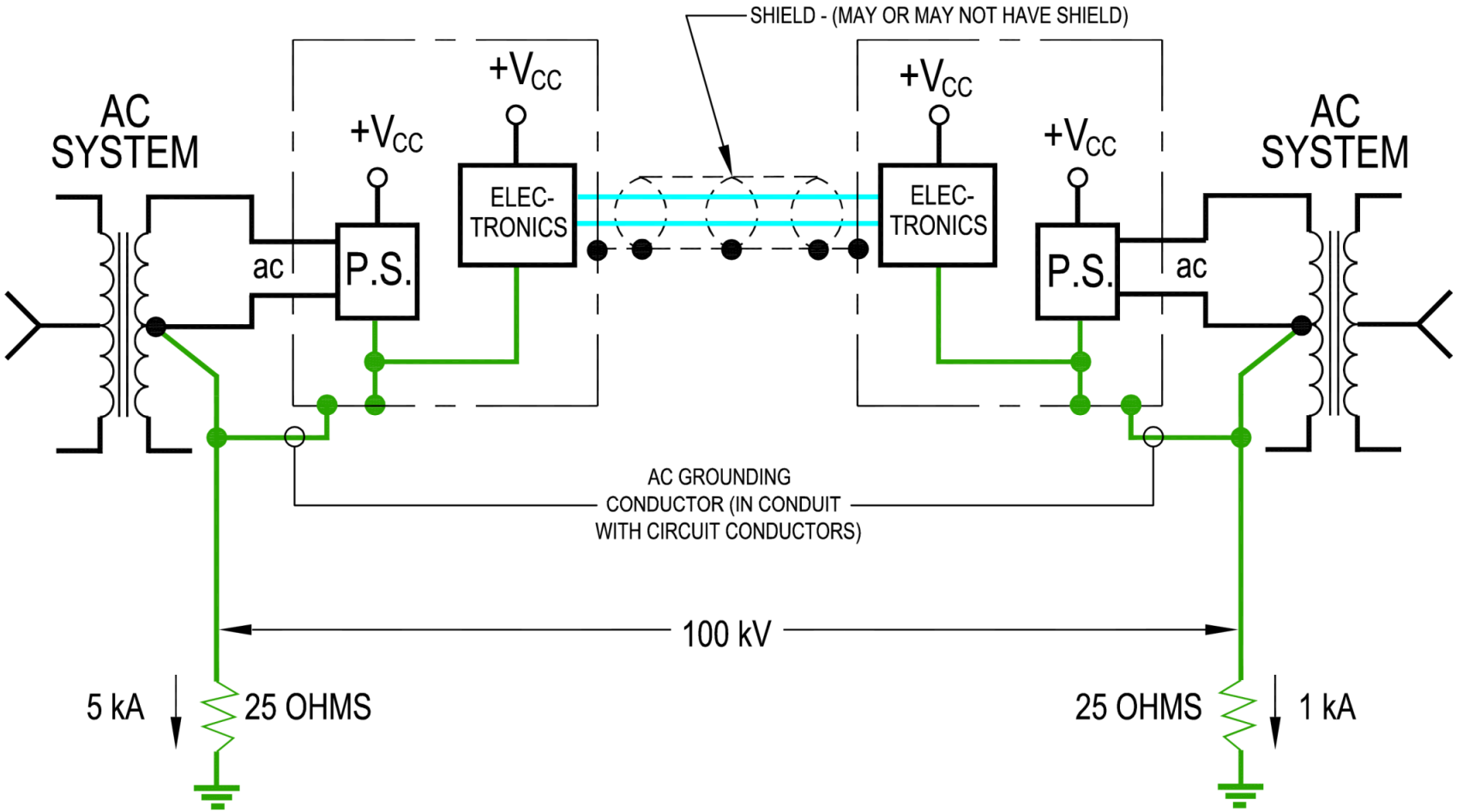

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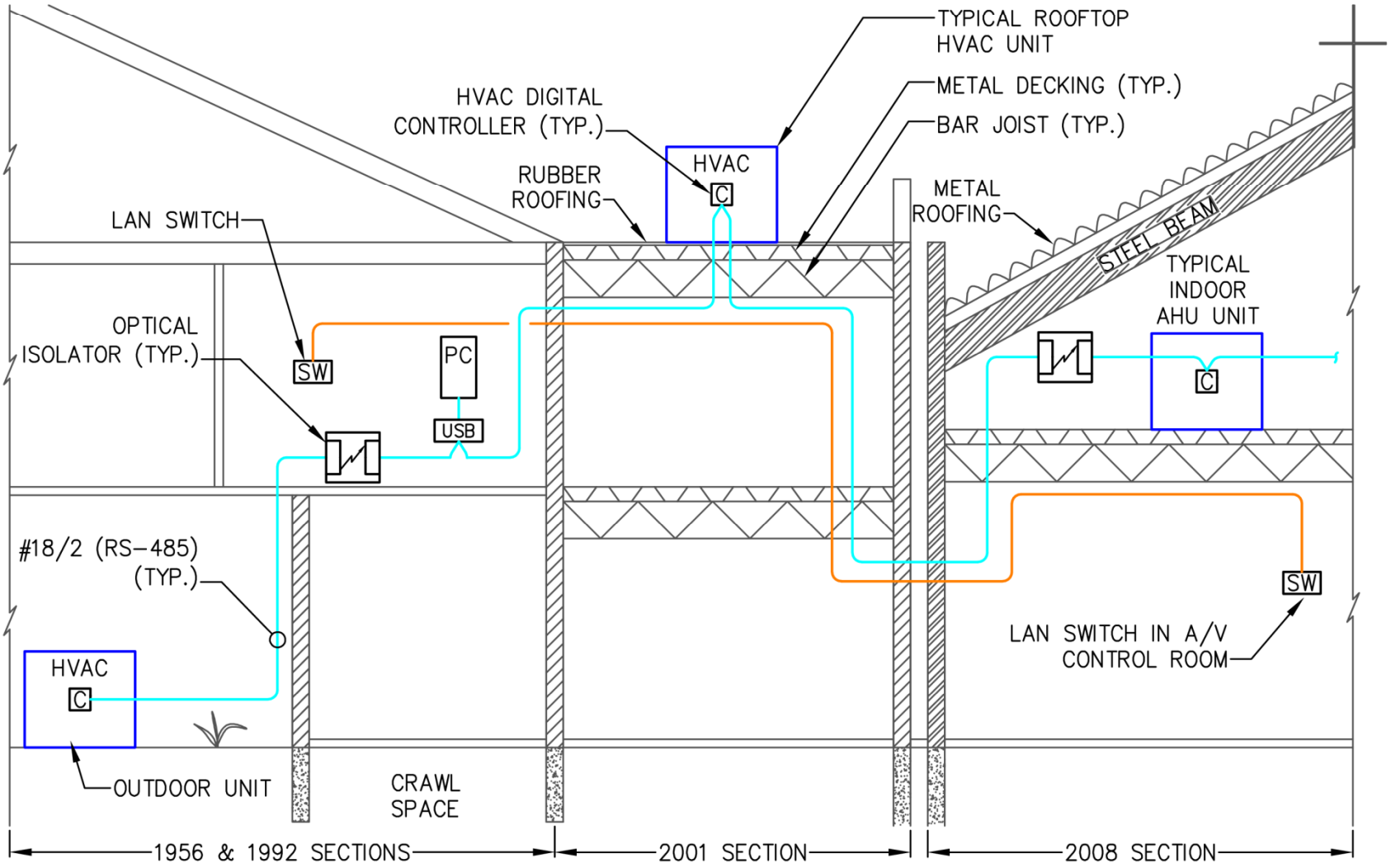

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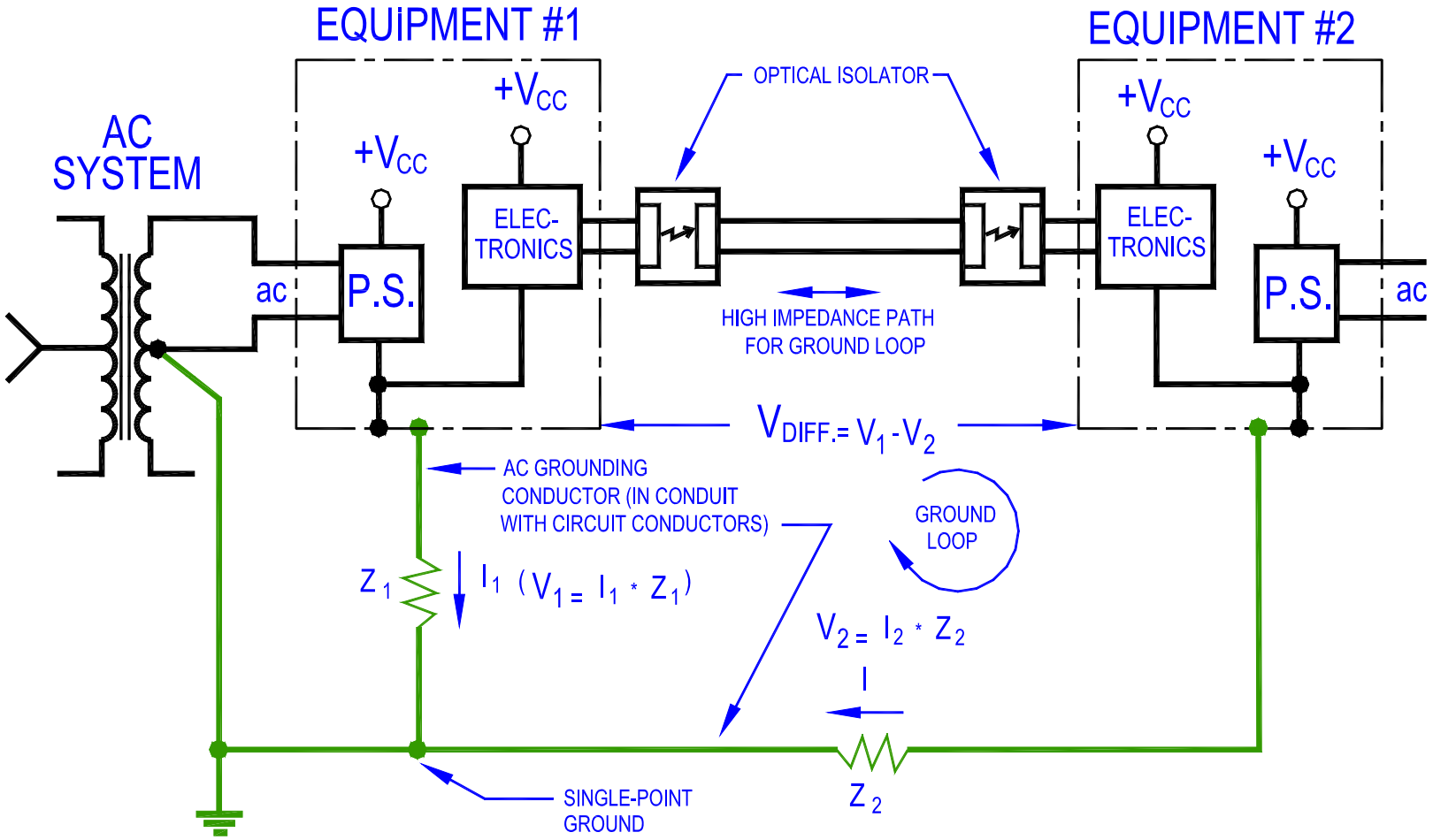

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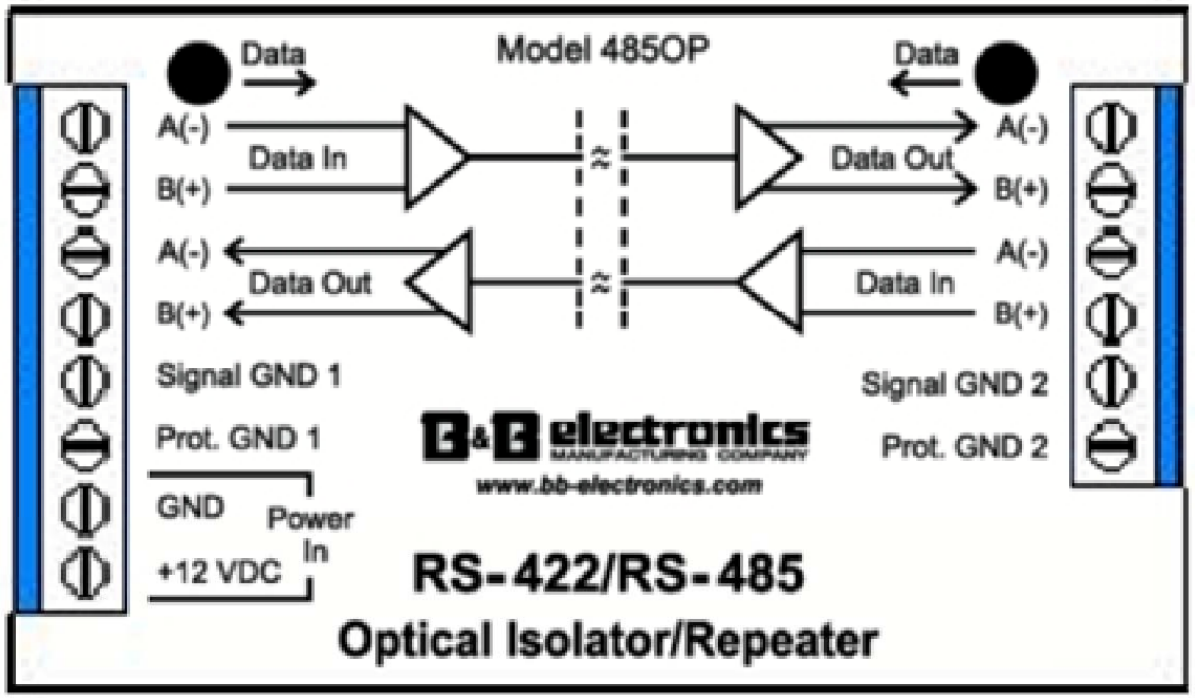

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- SPD for all Electrical Services.
- SPD for all sub-panels that supply rooftop equipment.
- Bonded the same sub-panels to the building steel.
- Monitoring system for SPDs to send alarms via the LAN.
- Improved installation of ac supply SPDs for fire alarm control panels and for low-voltage SPD for fire alarm outdoor circuit to PIV.
- Installed outdoor exposed DDC data cables in steel conduit.
- Intercom and Card reader at main front entrance.

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•As of December 2010, bonding of steel and water pipes were completed.

•2/24/11 thunderstorm, no damage.

•2/28/11 thunderstorm, three DDC controllers failed. Several had to be reset.

•3/23/11 and 4/4/11, Thunderstorms, no damage.

•Earth Grounding work completed 4/4/11.

•Optical Isolators installed 4/5/11.

•Most other work completed by 4/22/11.

•In summer of 2011, a severe storm damaged a circuit board and contactor in rooftop HVAC unit.
•No issues with any thunderstorms since summer 2011 event.

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EFFECVTIVE LIGHTNING PROTECTION

- Look at THE BIG PICTURE.
- Consider all Systems and Equipment Involved.
- For Personal Safety, Respect Lightning

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