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Designing for Clean Power

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HDR Architecture, Inc.

BUILDINGS for ADVANCED TECHNOLOGY WORKSHOP

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Agenda



- What is Power Quality
- Types of Power Conditioners
- Power Distribution System Configurations
- Grounding

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What Is Power Quality?



POWER QUALITY is the concept of powering and grounding electronic equipment in a manner that is suitable to the operation of that equipment and compatible with the premise wiring system and other connected equipment.

Source: IEEE Std 1100-1999

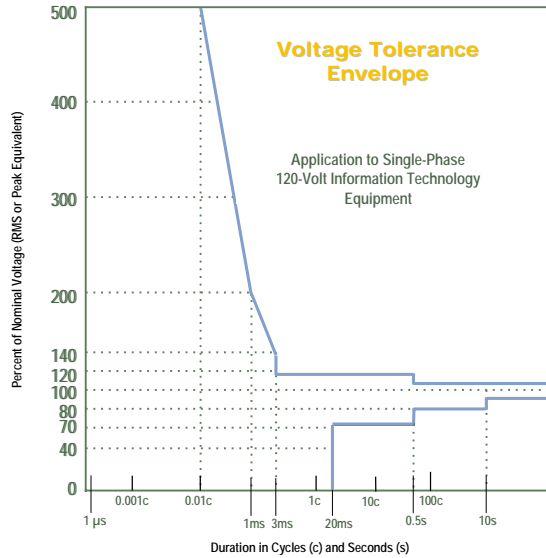
Typical Immunity of Electronic Equipment



Frequency parameter affecting loads	Typical range of power sources	Typical immunity of electronic loads	
		Normal	Critical
Line Frequency	±1%	±1%	±0.5%
Rate of frequency change	1.5 Hz/s	1.5 Hz/s	0.3 Hz/s
Voltage parameter affecting loads	Typical range of power sources	Typical immunity of electronic loads	
		Normal	Critical
Over and undervoltage	+6%, -13.3%	+10%, -15%	±5%
Swells/sags	+10%, -15%	+20%, -30%	±5%
Transients, impulsive and oscillatory, power lines	Varies: 100-6000 V	Varies: 500-1500 V	Varies: 200-500 V
Voltage distortion (from sine wave)	5-50% THD	5-10%	3-5%
Phase imbalance	2-10%	5%	3%

Source: IEEE Std 1100-1999

ITIC (CBEMA) Curve (1996)



Source: IEEE Std 1100-1999

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Sources of Power Disturbances



External:

- Lightning
- Faults
- Utility switching surges
 - ▲ Voltage Regulation
 - ▲ Power Factor Regulation
 - ▲ Line Maintenance

Internal:

- Mechanical equipment: chillers, fans, pumps
- Adjustable frequency drives
- Elevators
- Shop equipment
- Lighting fixture ballast
- Power supplies
- Laboratory equipment

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Power Conditioners



The Concept



The Reality



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Performance of Various Power Conditioning Equipment



Power Quality Condition	Power Conditioning Technology									
	Transient Voltage Surge Suppressor	EMIRFI Filler	Isolation Transformer	Voltage Regulator (Electronic)	Voltage Regulator (Ferrous)	Motor Generator	Standby Power System	Uninterruptible Power Supply	Standby Engine Generator	
Transient Voltage Surge	Common Mode	Yellow		Yellow	Yellow	Yellow	Yellow	Yellow		
	Normal Mode	Green						Yellow		
Noise	Common Mode		Yellow		Yellow	Yellow	Yellow	Yellow		
	Normal Mode							Yellow		
Notches								Yellow		
Voltage Distortion								Yellow		
Sag								Yellow		
Swell								Yellow		
Undervoltage				Yellow	Yellow					
Overvoltage				Yellow	Yellow					
Momentary Interruption							Yellow	Yellow		
Long-term Interruption									Yellow	
Frequency Variation								Yellow		

It is reasonable to expect that the indicated condition will be corrected by the indicated power conditioning technology.

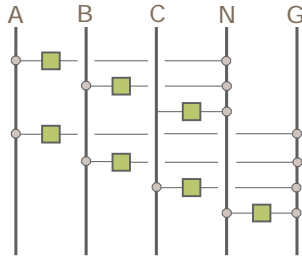
There is a significant variation in power conditioning product performance. The indicated condition may or may not be fully correctable by the indicated technology.

Source: IEEE Std 1100 - 1999

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Transient Voltage Surge Suppression (TVSS)

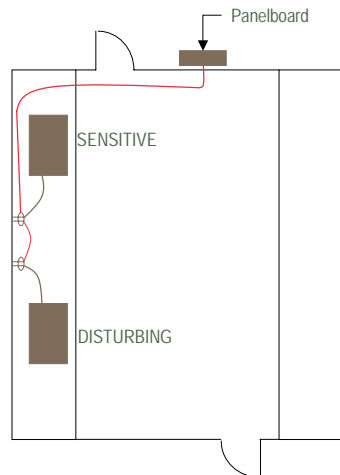


- Reduces common and normal mode transients and noise from line and load side sources
- The use of dedicated circuits improves the transients and noise reduction from one piece of lab equipment to another
- It is critical that the impedance between the protected bus and the TVSS be minimized
- Generally located within the panelboard enclosure

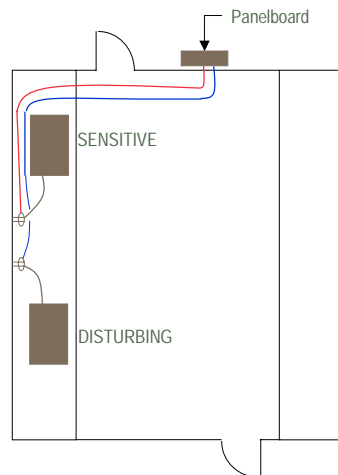
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Transient Voltage Surge Suppression (TVSS)



Multi-Outlet Circuits

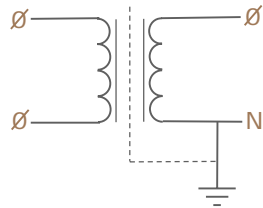


Dedicated Circuits

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Shielded/Isolation Transformers

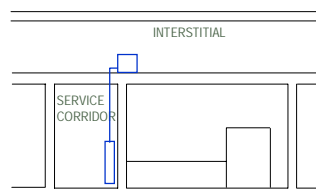


- Provides isolation from line side common mode transients and noise
- Provides local ground
- Reduces stray ground currents
- Locate as close to the lab as possible
- Source of ELF EMI
- Source of acoustic noise
- Source of vibration

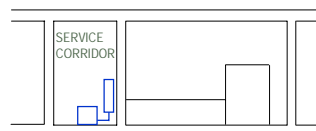
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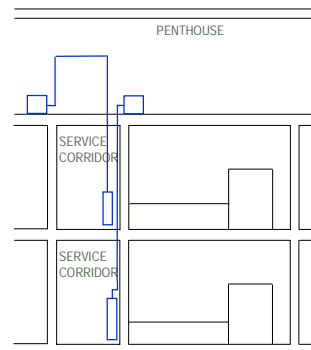
Shielded/Isolation Transformers



One Floor with Interstitial



One Floor

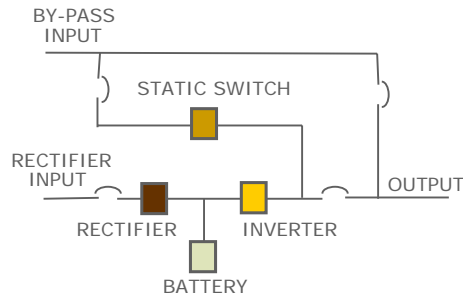


Two Floors with Penthouse

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Uninterruptible Power Supplies (UPS)

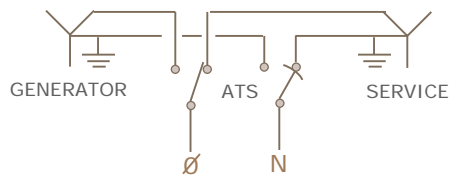


- Provides short term outage protection
- Provides regulated voltage and frequency without interruption
- Provides isolation from line side transients and noise
- Source of EMI
- Source of acoustic noise
- Source of vibration

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Standby Generators

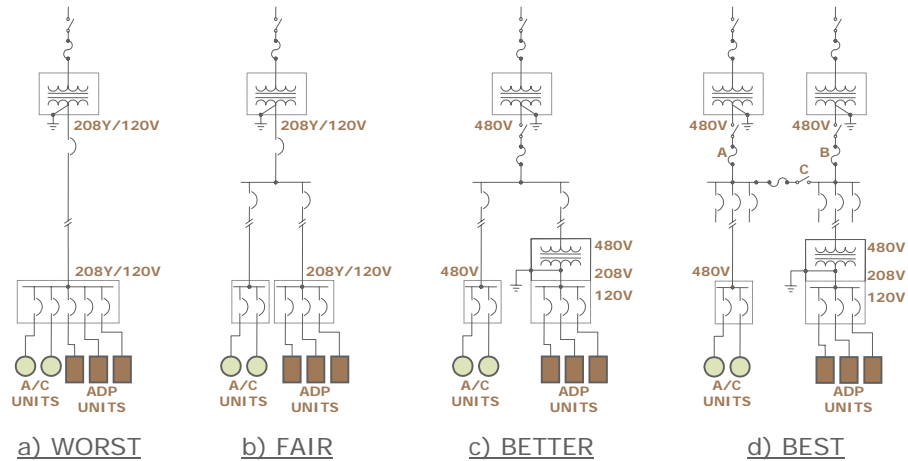


- Provides long term outage protection
- Source of EMI
- Source of acoustic noise
- Source of vibration

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System Configurations

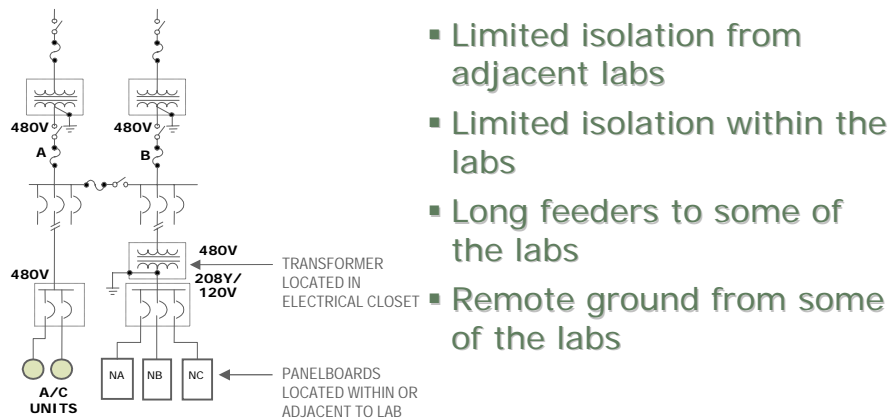


Source: IEEE Std 1100 - 1999

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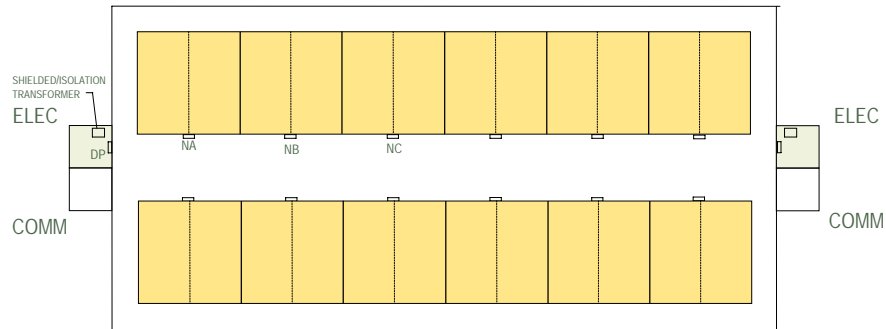


ONE shielded/isolation transformer per SUITE
ONE shielded/isolation panelboard per LAB

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System Configurations

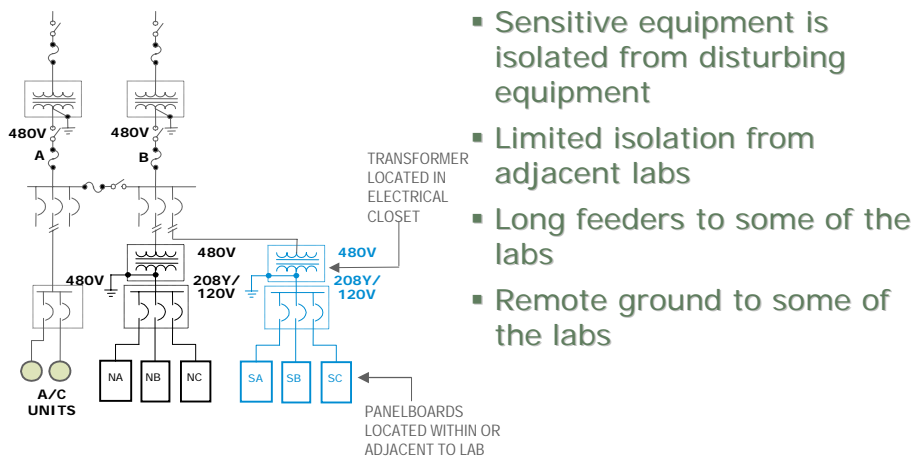


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System Configurations



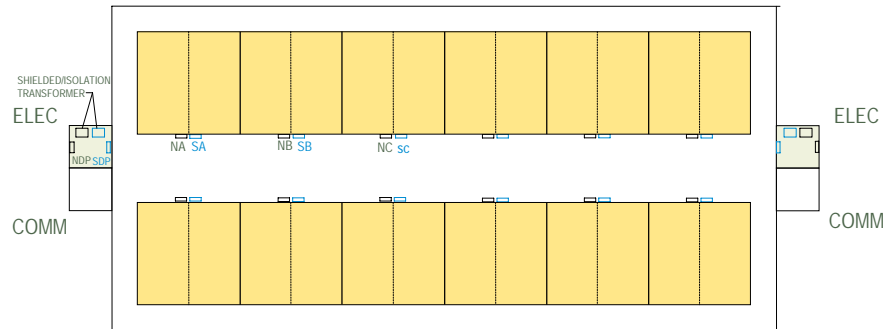
- Sensitive equipment is isolated from disturbing equipment
- Limited isolation from adjacent labs
- Long feeders to some of the labs
- Remote ground to some of the labs

TWO shielded/isolation transformers per SUITE
TWO shielded/isolation panelboards per LAB

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System Configurations

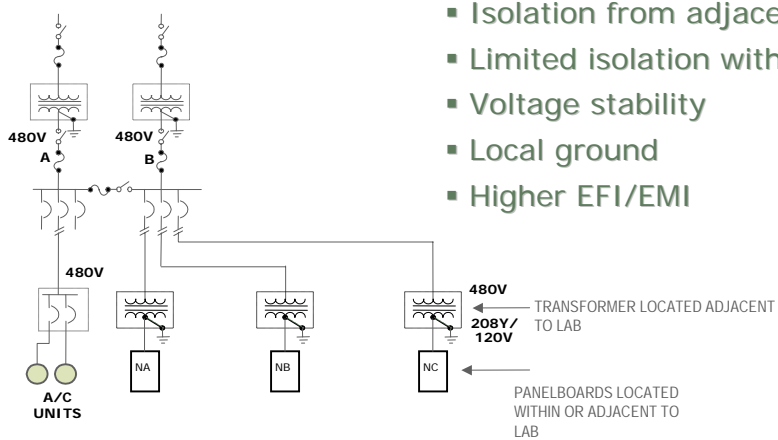


TWO shielded/isolation transformers per SUITE
TWO shielded/isolation panelboards per LAB

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System Configurations



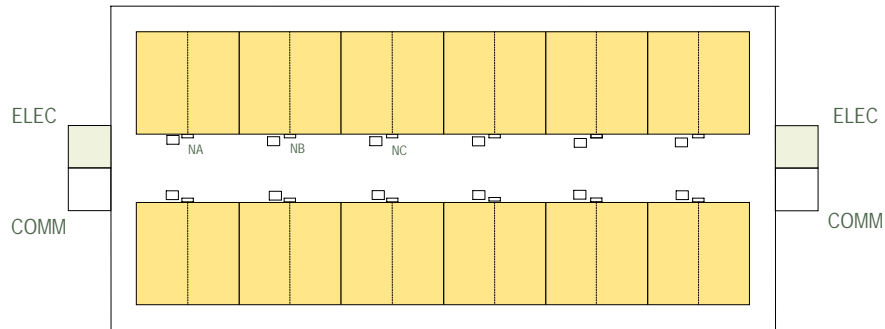
- Isolation from adjacent labs
- Limited isolation within lab
- Voltage stability
- Local ground
- Higher EFI/EMI

ONE shielded/isolation transformers per LAB
ONE shielded/isolation panelboards per LAB

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System Configurations

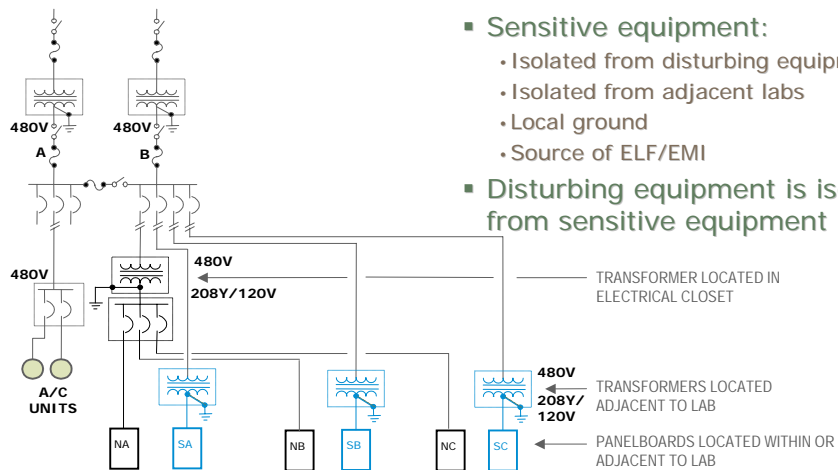


ONE shielded/isolation transformers per LAB
 ONE shielded/isolation panelboards per LAB

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System Configurations



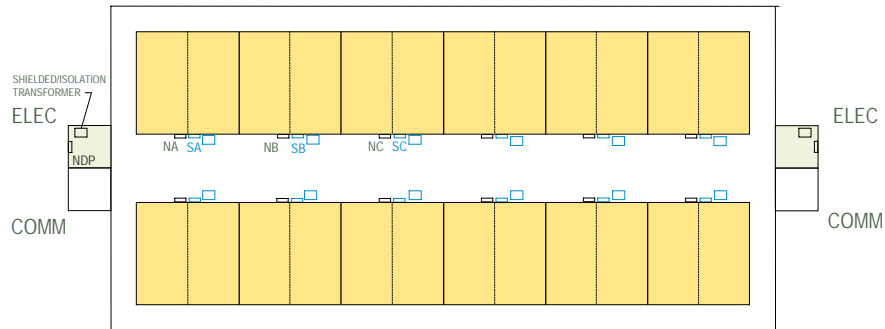
- Sensitive equipment:
 - Isolated from disturbing equipment
 - Isolated from adjacent labs
 - Local ground
 - Source of ELF/EMI
- Disturbing equipment is isolated from sensitive equipment

For sensitive equipment - ONE transformer and panel per LAB
 For disturbing equipment - ONE transformer per SUITE, ONE panel per LAB

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System Configurations

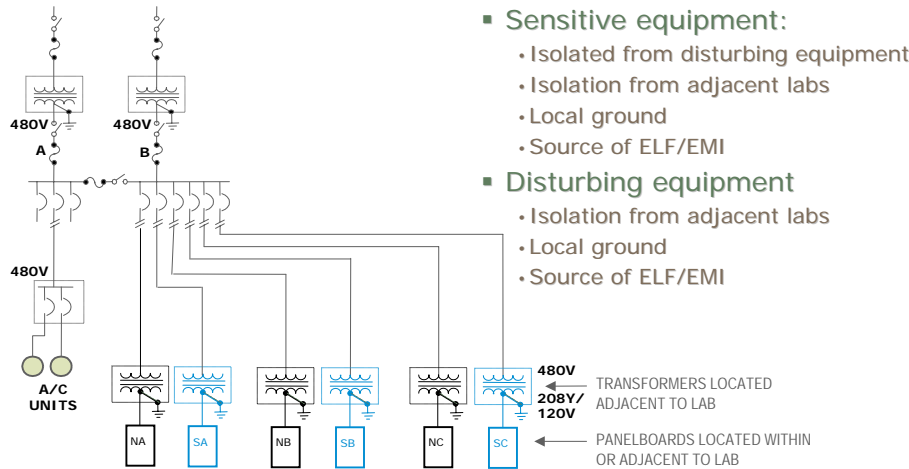


For sensitive equipment - ONE transformer and panel per LAB
 For disturbing equipment - ONE transformer per SUITE, ONE panel per LAB

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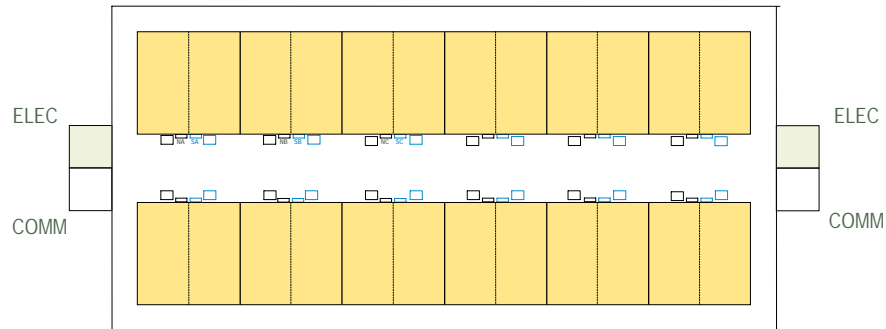
- Sensitive equipment:
 - Isolated from disturbing equipment
 - Isolation from adjacent labs
 - Local ground
 - Source of ELF/EMI
- Disturbing equipment
 - Isolation from adjacent labs
 - Local ground
 - Source of ELF/EMI

TWO transformers per LAB
 TWO panelboards per LAB

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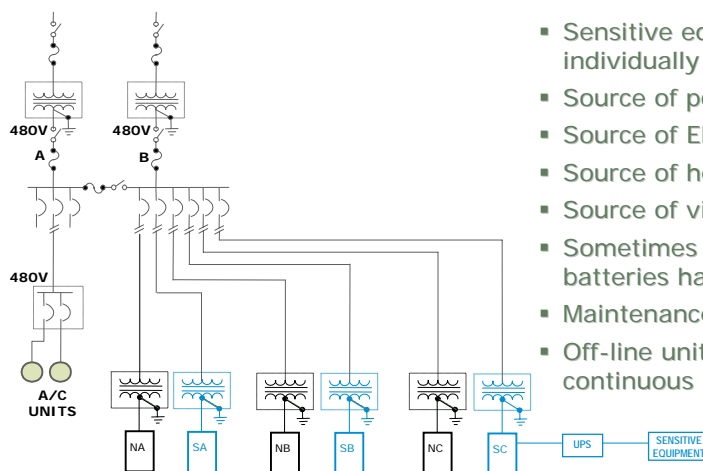


TWO transformers per LAB
TWO panelboards per LAB

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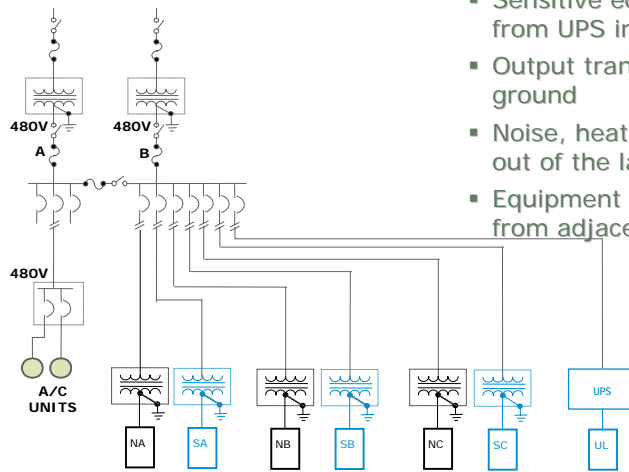
- Sensitive equipment is individually isolated
- Source of power disturbances
- Source of EMI
- Source of heat
- Source of vibration
- Sometimes unaware that the batteries have failed
- Maintenance can be an issue
- Off-line units do not provide continuous power conditioning

Point-of-use UPS

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System Configurations



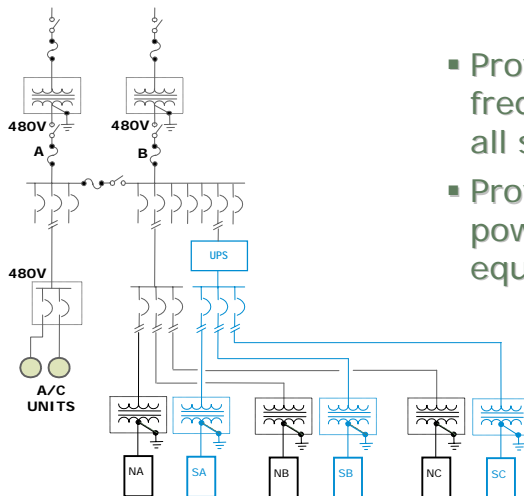
- Sensitive equipment is isolated from UPS input
- Output transformer provides local ground
- Noise, heat, EMI and vibration are out of the lab
- Equipment on UPS is not isolated from adjacent labs

ONE UPS per SUITE which all labs share

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System Configurations



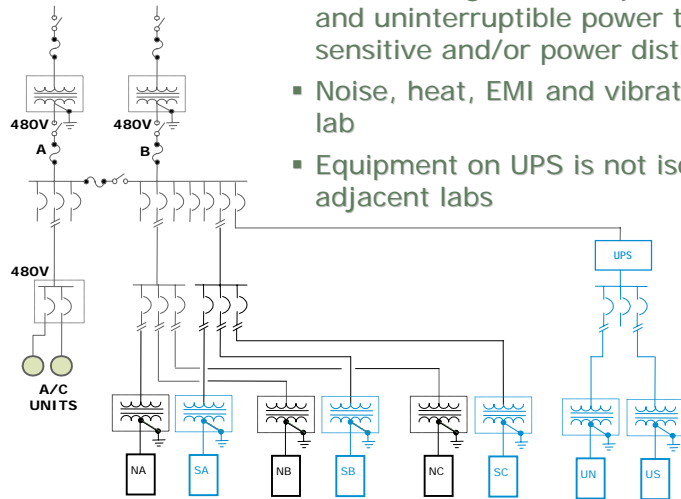
- Provides regulated frequency and voltage to all sensitive equipment
- Provides uninterruptible power to all sensitive equipment

ONE UPS per SUITE for all sensitive equipment

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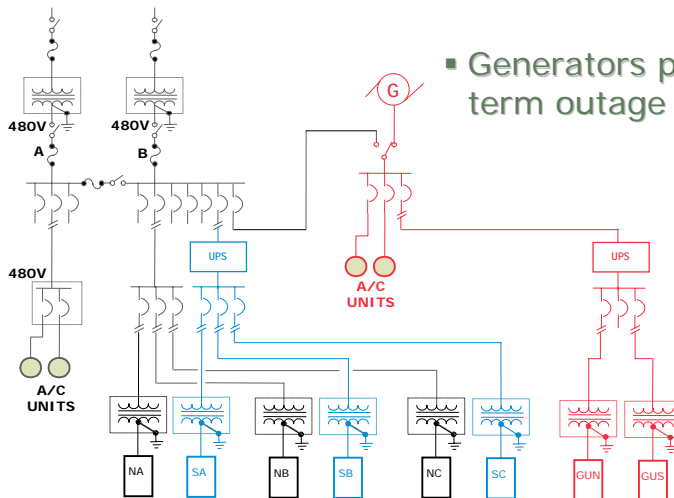


- Provides regulated frequency and voltage, and uninterruptible power to selected sensitive and/or power disturbing equipment
- Noise, heat, EMI and vibration are out of the lab
- Equipment on UPS is not isolated from adjacent labs

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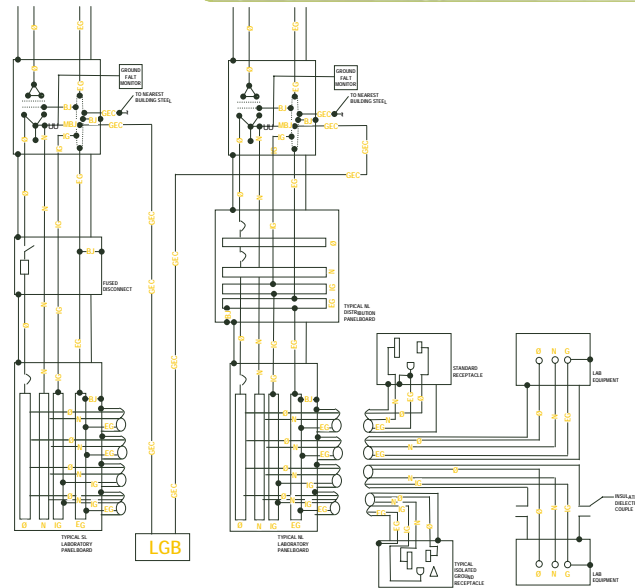


- Generators provide long term outage protection

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Grounding



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References



- IEEE Standard 1100-1999, IEEE Recommended Practice for Powering and Grounding Electronic Equipment (IEEE Emerald Book)
- FIPS PUB 94-1983 Guideline on Electrical Power for ADP Installations
- Ralph Morrison and Warren H. Lewis, Grounding and Shielding in Facilities, John Wiley & Sons, 1990

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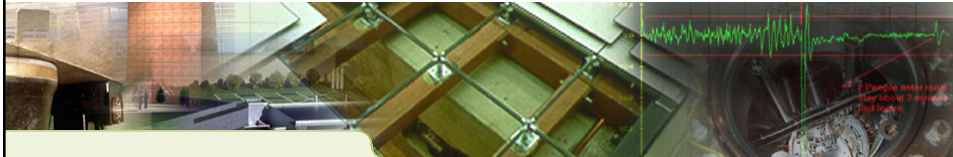
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