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Electric Power Quality Monitoring and Control of the SoE Clean Room

Bart Thompson

Virginia Commonwealth University

Gabriel Knight

Virginia Commonwealth University

Aubrey Buckner

Virginia Commonwealth University

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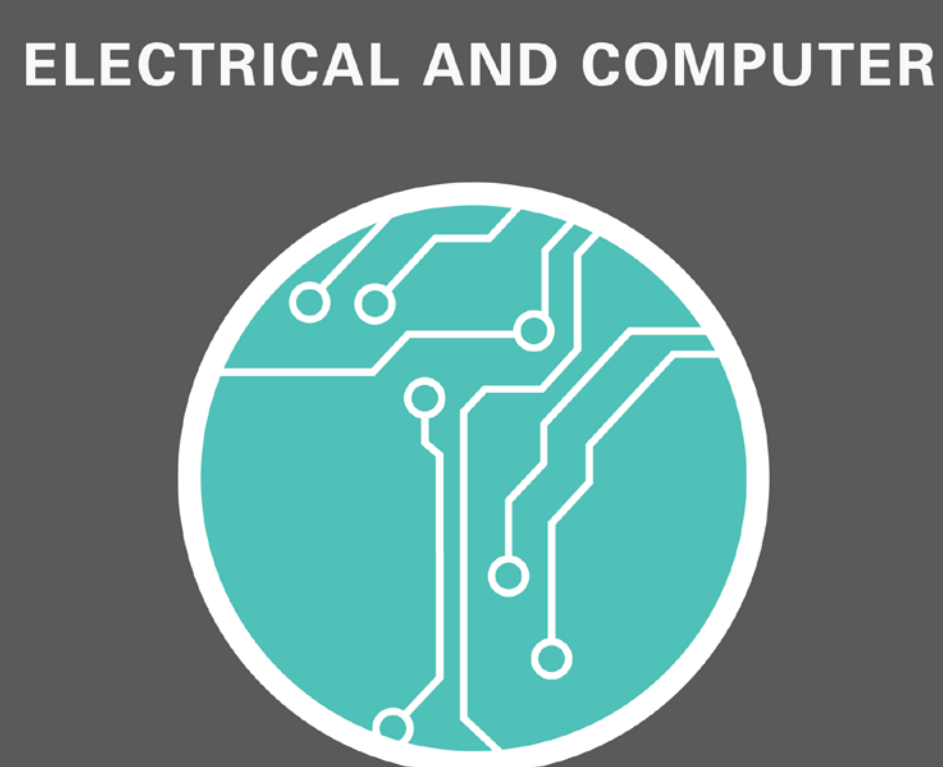
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Electric Power Quality Monitoring and Control of the SoE Clean Room

CAPSTONE DESIGN
EXPO 2016

Motivation

- Reported power quality issues in the SoE 3rd Floor Clean Room were costing the University time and money as these issues routinely damaged sensitive electronic equipment.
- The team used Eagle Power Quality Meters to monitor and record voltage waveforms on multiple 120 VAC phases for three months.
- A complete blackout of a single phase was recorded during this period, resulting in an 11 minute outage. Further investigation showed a neutral imbalance lead to this situation.

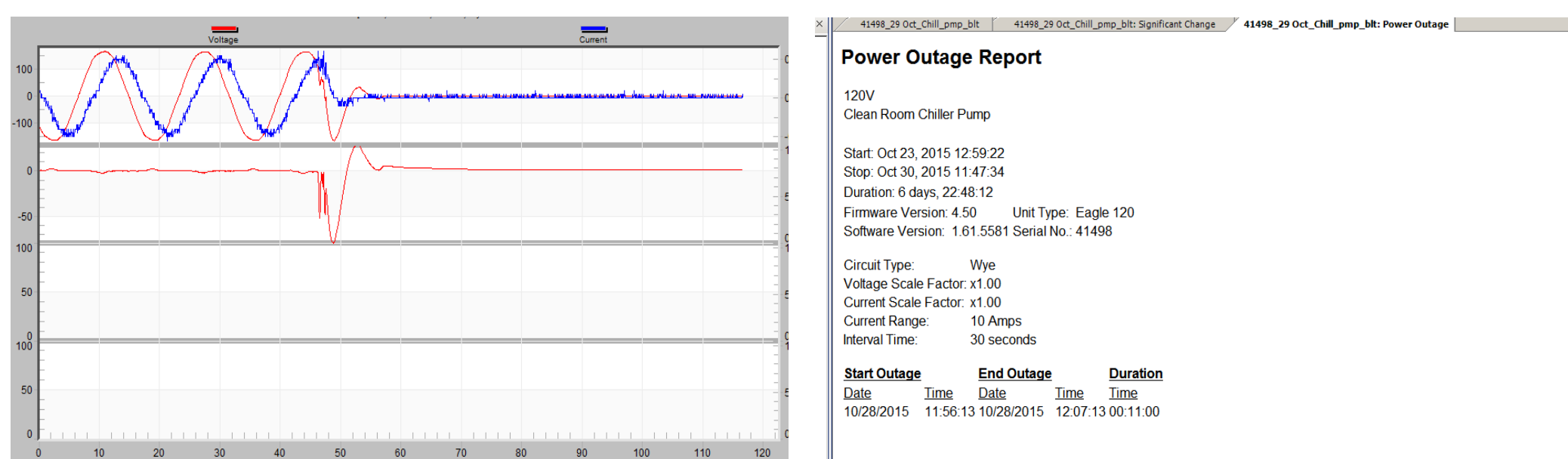


Figure 1: Waveform of neutral imbalance caused by Phase outage

Proposed Solution

- Isolation of equipment was the key to success.
 - small scale UPS backup devices had been implemented for this purpose.
- A large scale battery backed inverter would be the proper way to ensure utility level outages and building distribution issues no longer affect this equipment.
 - Disadvantage: such equipment is large and expensive,
 - Alternative solution: a method of using commonly available components was selected to create a demonstration platform to faculty and students.
 - This scalable technology can be used by future VCU engineering students to understand the impact of power quality.

Inverter design

- Single pulse three phase inverter
 - Simplistic design used in the residential sector for PV arrays will be adapted for use as an isolation inverter.
- Power MOSFETS
 - Discrete semiconductor devices Easy to size and control
- Precise control via Arduino
 - Readily programmable IED Reduces workflow
 - Precise control of pulse width modulation inversion.
- LC Series-Shunt filter
 - Filters harmonics from PWM waveform as well as unwanted harmonics from the loads.
- Battery Backed Inversion
 - A battery charger is used to provide a DC bus to the inverter while simultaneously keeping a backup battery charged. This ensures a constant source for the system

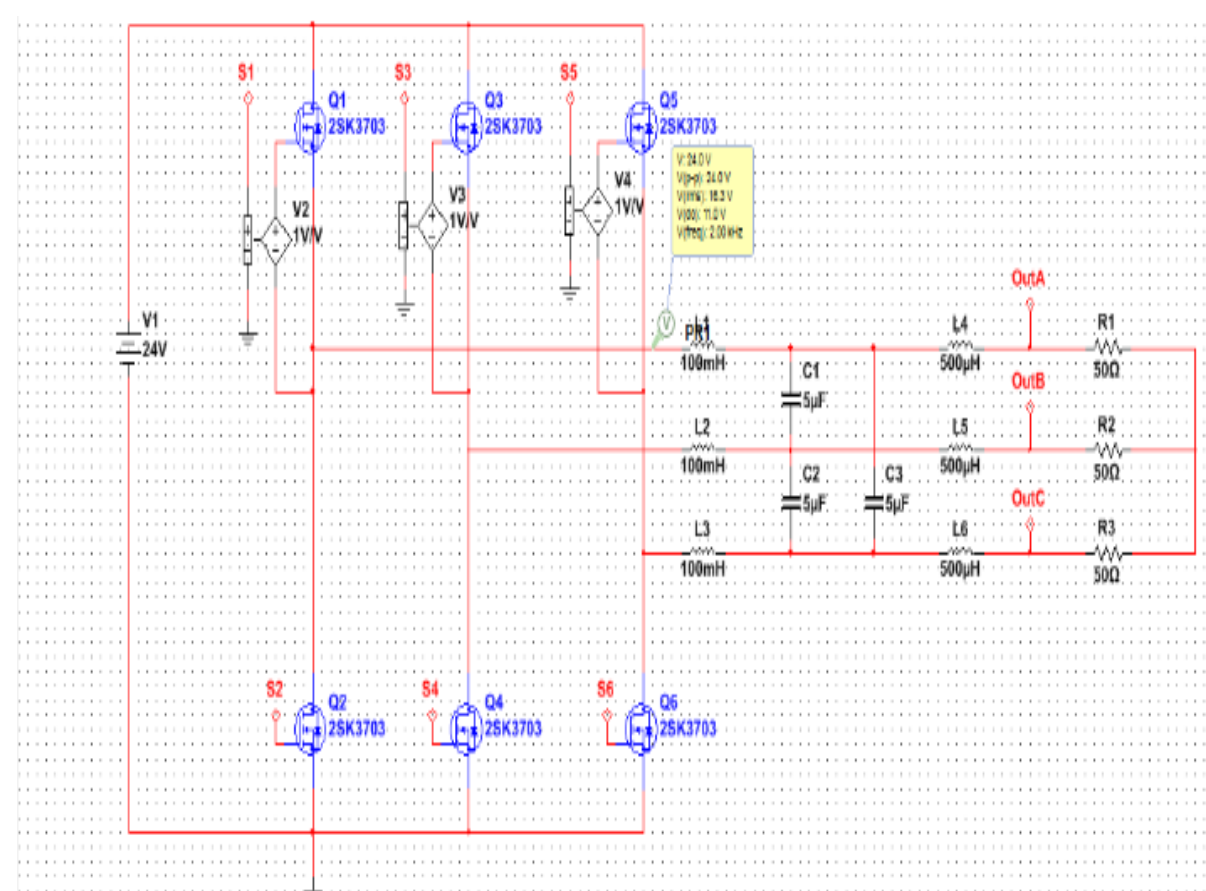


Figure 2: Inverter Circuit topology

Design Process

Arduino Programming Methodology

- A triangular PWM waveform is used to
 - switch the MOSFETS of the inverter. Arduino has a built in PWM generator, but cannot handle multiple PWM generators that are phase shifted.
- By writing a simple algorithm to pulse
 - pins in the proper sequence, multiple PWM signals can be used to generate crude sinusoids. With the LC filter in place, a clean sinusoid can be recaptured.

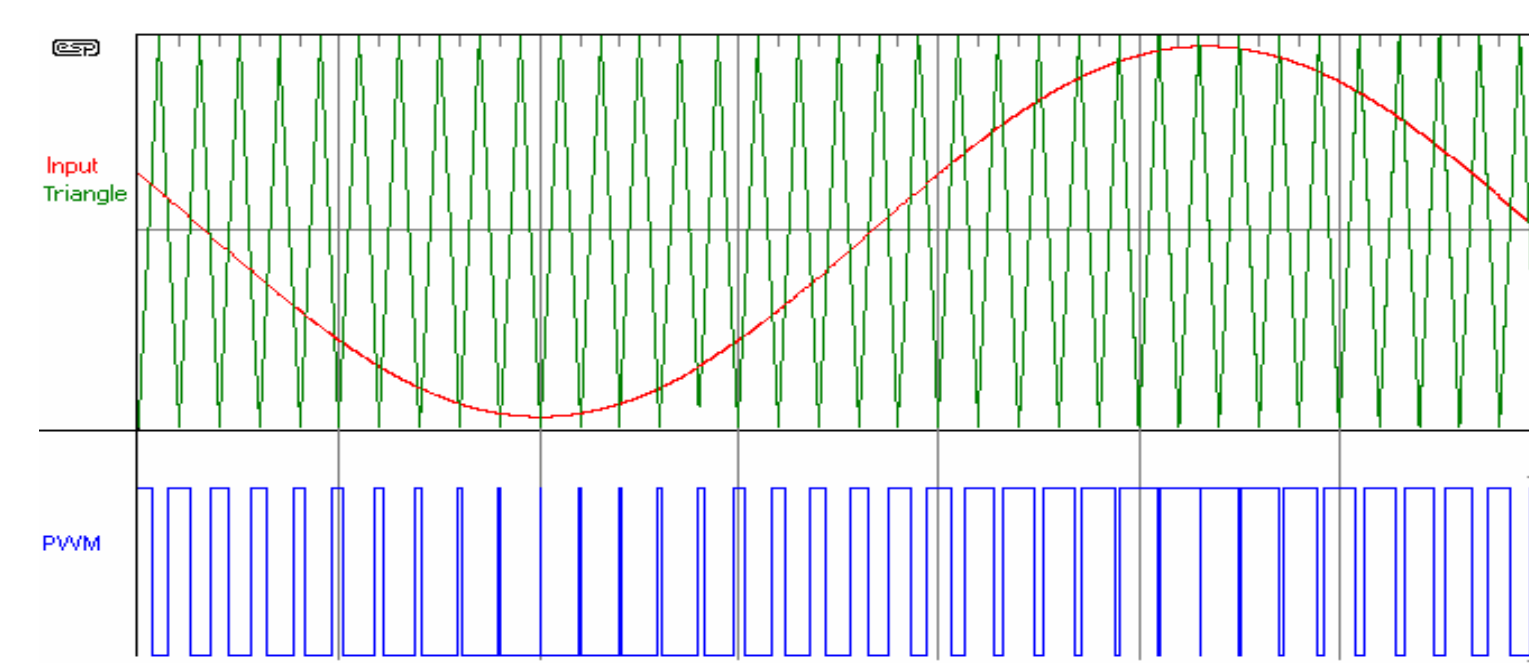


Figure 3: Waveform of Pulse Width Modulation producing ramp function

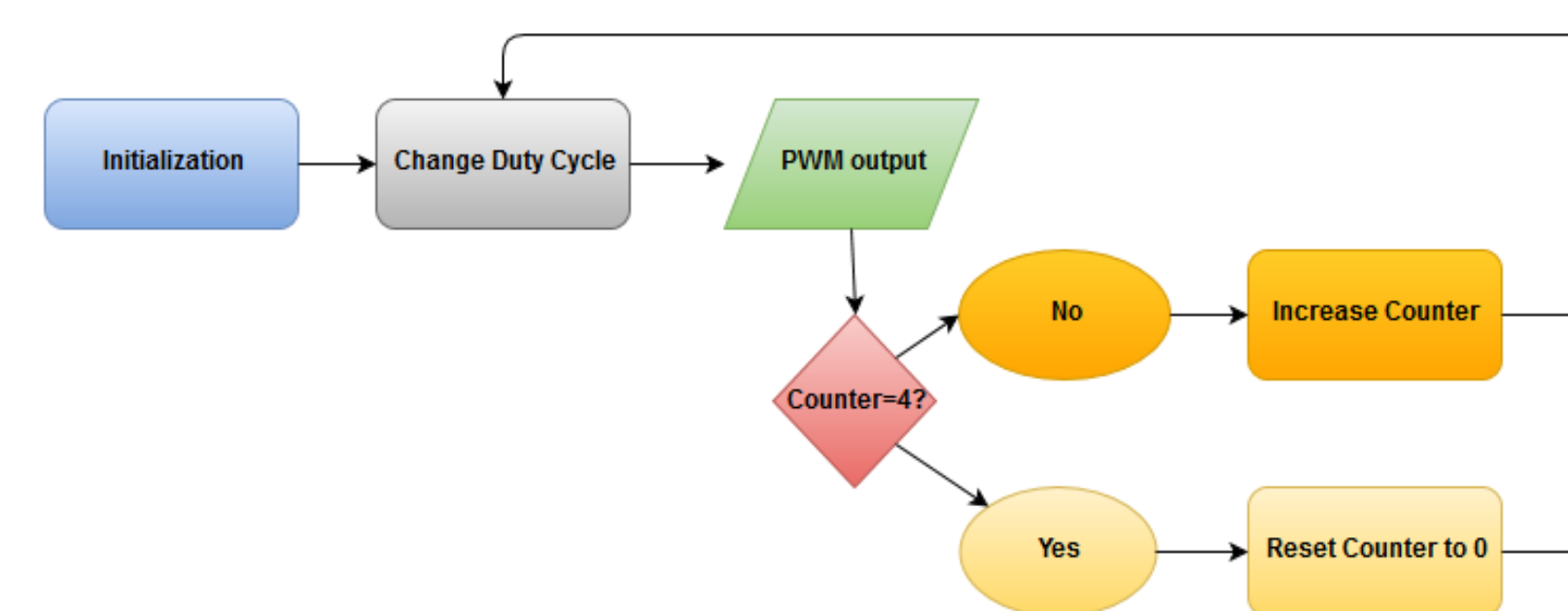


Figure 4: Logic Design Workflow Diagram

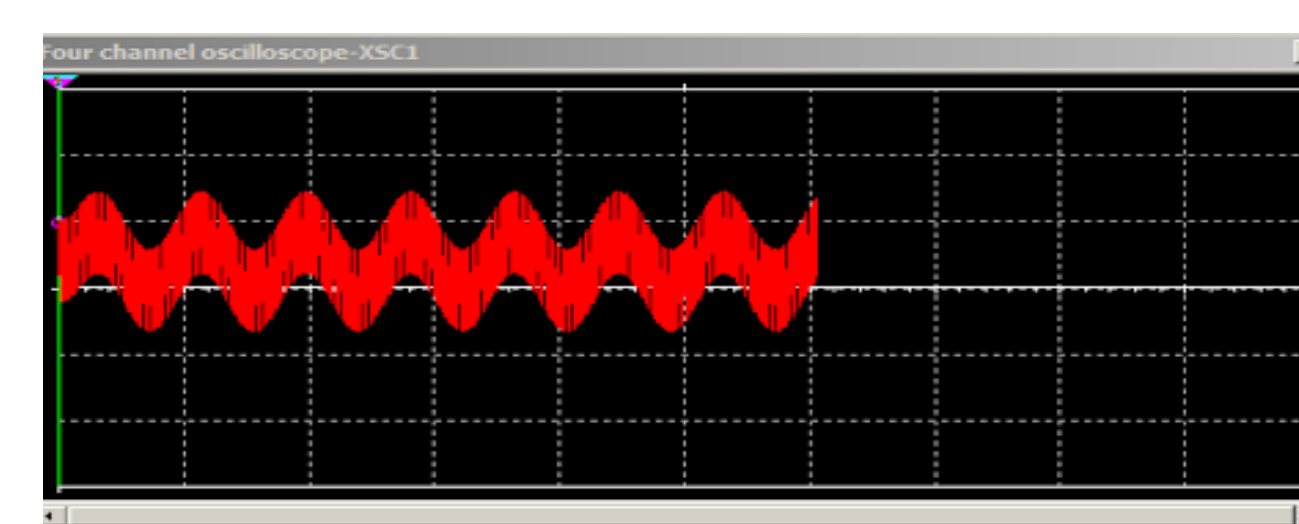


Figure 5: Output Voltage Waveform

Load Center

Why a load center?

- An inverter is only as good as its load. As part of the proof of concept, the team has designed and implemented a load distribution center to demonstrate the ability of the inverter to operate under varying conditions.
- This load center will have the ability to create line faults to demonstrate the inverter's ability to work despite issues that may arise in its isolated distribution network.
- To ensure safety of faculty and students, faults will be remotely created via switches and relays.

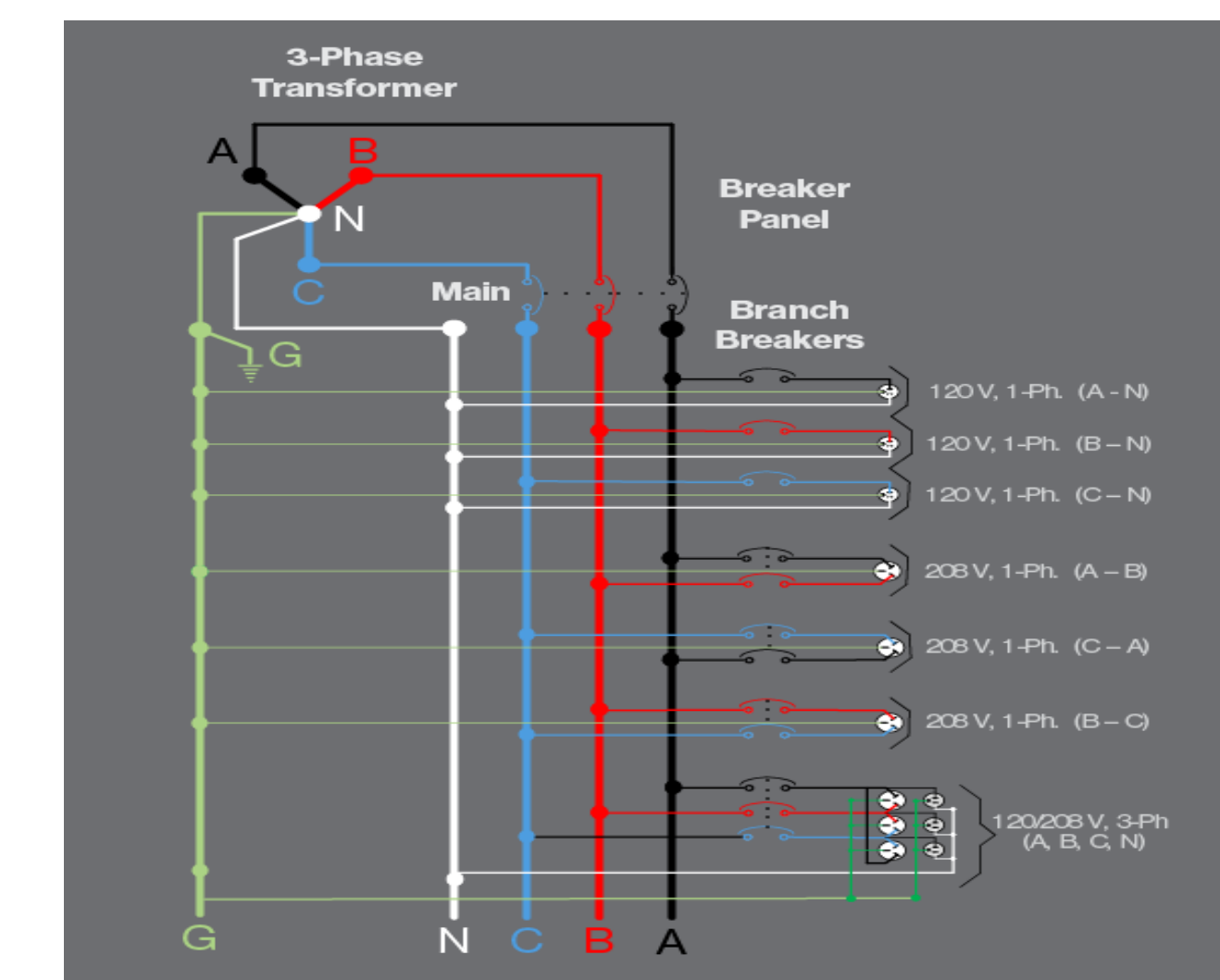


Figure 6: Load Center Design

Conclusion

What we have learned:

While single pulse inverters are an achievable design, adding extra MOSFETS to each phase would increase the cleanliness of the waveform. This added accuracy comes with the price of added complexity and cost.

Future works:

Multi-pulse inverter design would be desired, and obtainable with multiplexing the Arduino platform.



VCU School of Engineering

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