# AC System Monitoring Device

Design Review

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# Outline

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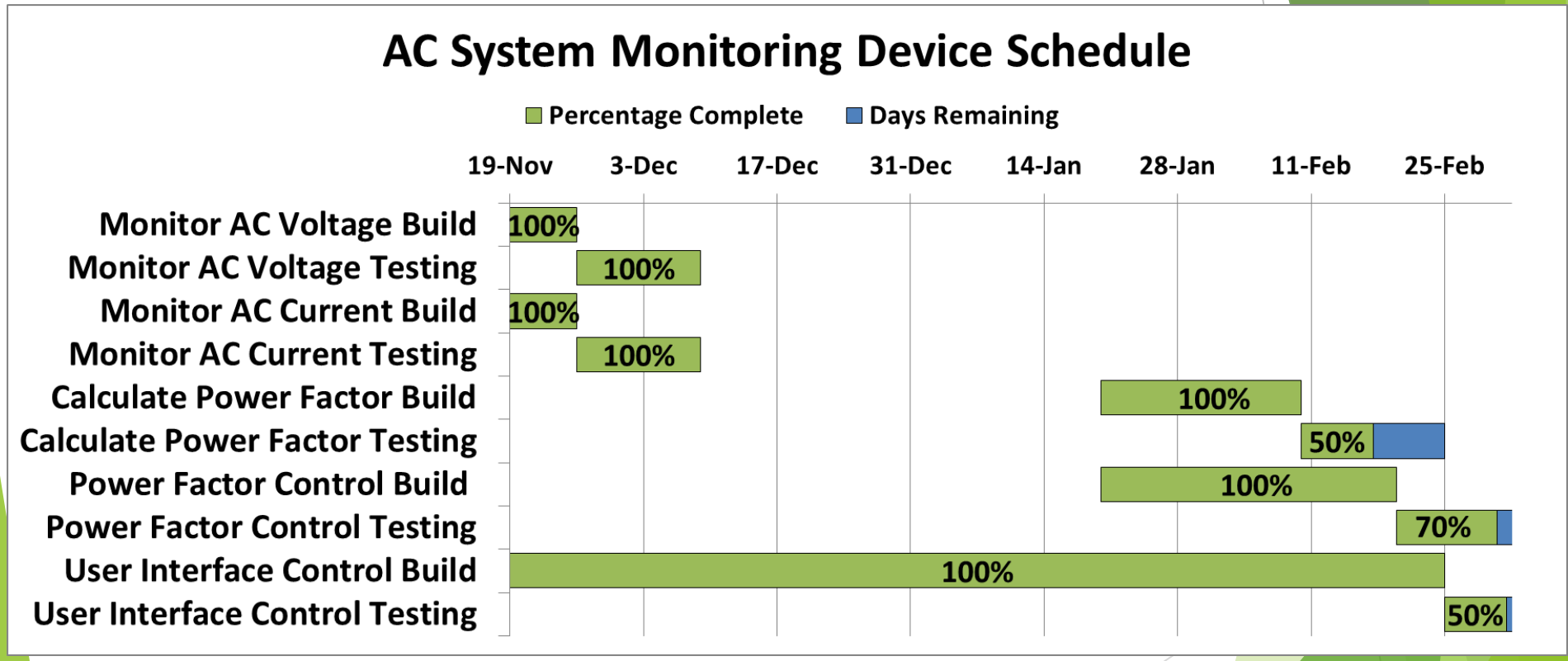
# Project Overview

- Project Description
  - Monitor alternating current (AC) system
  - Measure the efficiency of the AC system
  - Optimize the efficiency of the AC system through power factor correction
  - Implemented with a digital system
  - Displays AC system information on an LCD panel

# Project Overview

- Project Objectives
  - Monitor AC Voltage
  - Monitor AC Current
  - Monitor AC Power Factor
  - Power Factor Correction
- Proposed Solution
  - Schweitzer Engineering Laboratories (SEL)
  - SEL-2411 Automation Controller
    - AC power expansion card
    - Customizable logic programming

# Progress – Work Accomplished From Nov. 19 to Mar. 3

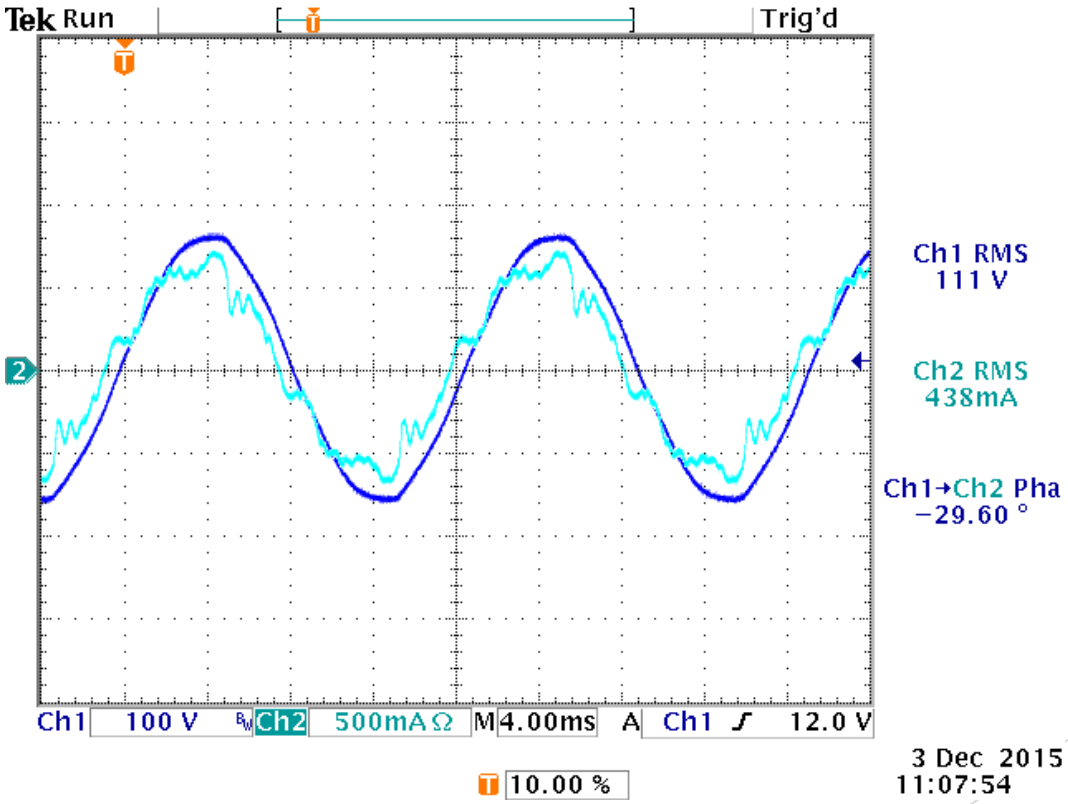


# Progress – Work Accomplished

- Achievements
  - Successful testing of AC voltage and current monitoring
    - Finished ahead of schedule last semester
  - Successful application of power factor calculation
    - Behind schedule on testing
  - Successful power factor correction circuit application
    - Sized the appropriate capacitance to correct power factor
    - Encountered current distortion when implementing power factor correction with the capacitor

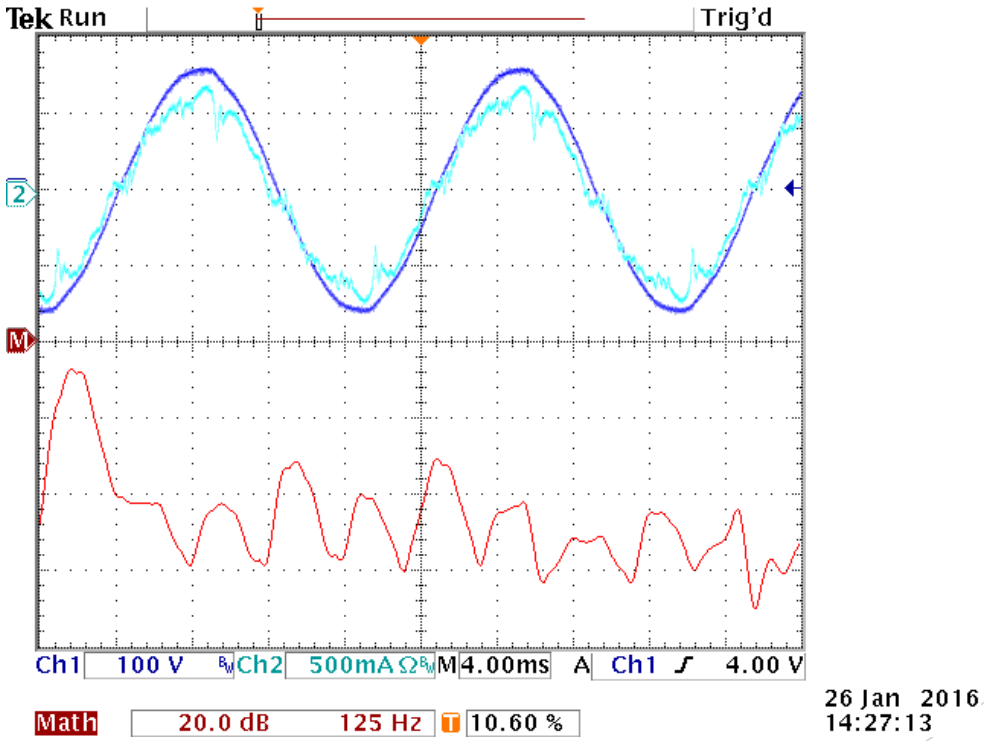
# Progress – Work Accomplished

- Problems faced - Encountering current distortion with only a capacitor used as the power factor correction device



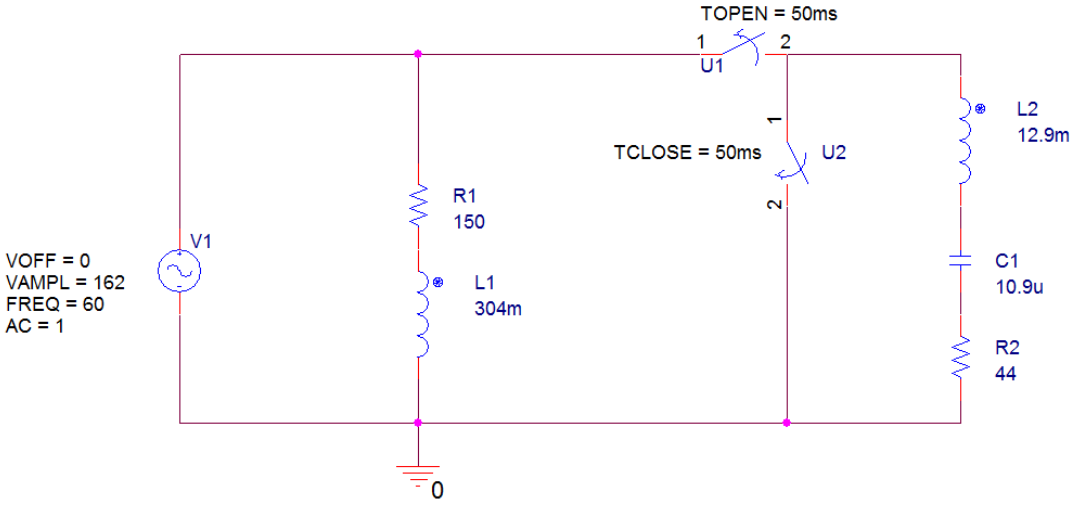
# Progress – Work Accomplished

- Analysis on the current distortion with FFT determined harmonics are being introduced by the power factor correction
  - Most prominent harmonics are the 7th and 11th



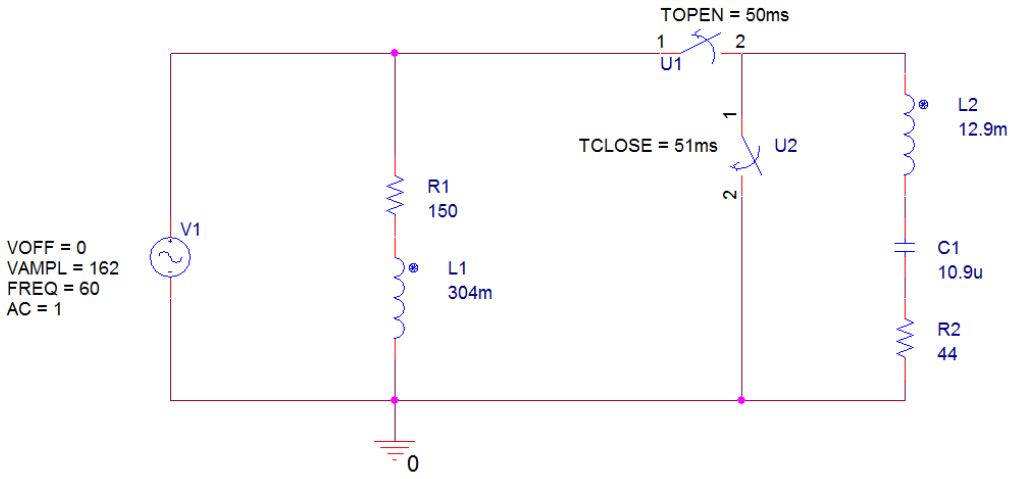
# Progress – Work Accomplished

- Proposed solution to harmonic distortion is the use of tuned harmonic filter to the 7th harmonic
- Problems faced – original RLC 7th harmonic tuned filter design
  - Testing this circuit revealed that overcurrent fault happens when turning off the power factor correction



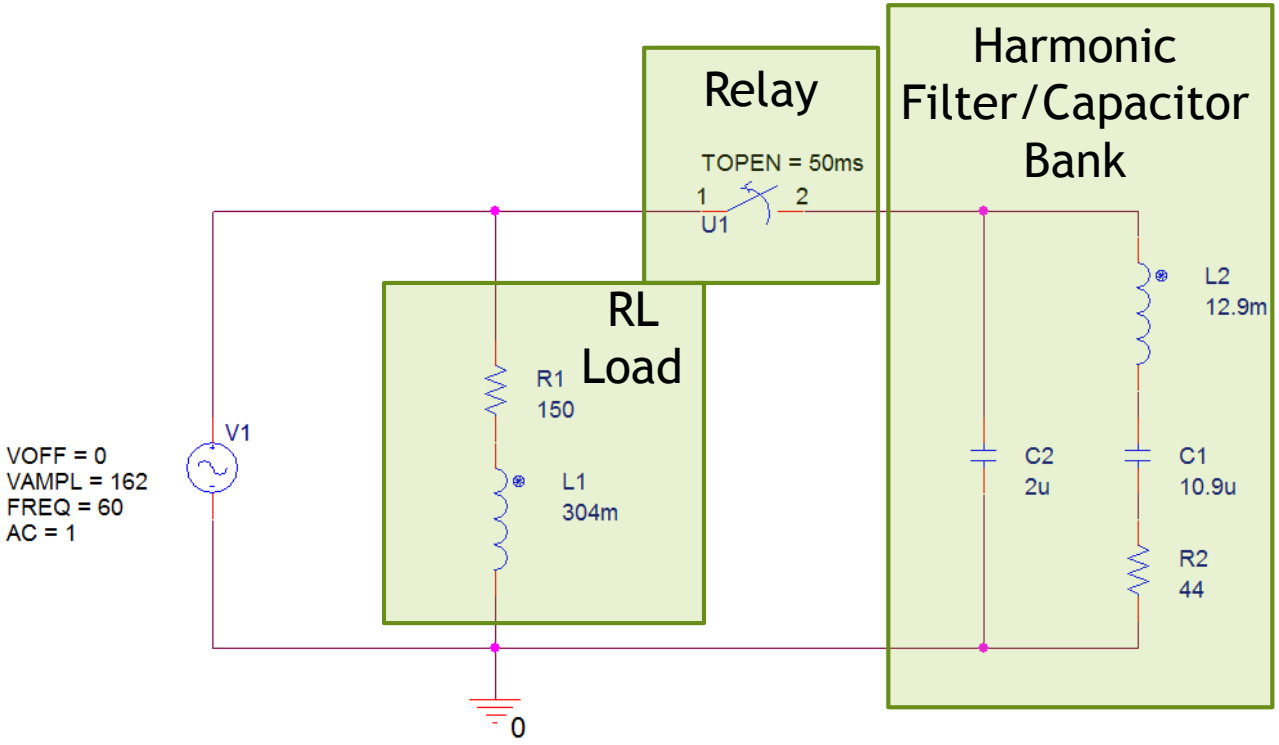
# Progress – Work Accomplished

- Using OrCAD model of the circuit
  - Changing the closing delay of the relay switch of 1ms later determined high voltage induced by the inductance of the RLC circuit.
  - Upwards to 20kV induced causing short to ground from the relay
  - Replaced the closing contact with a capacitor to dissipate energy from the circuit being opened



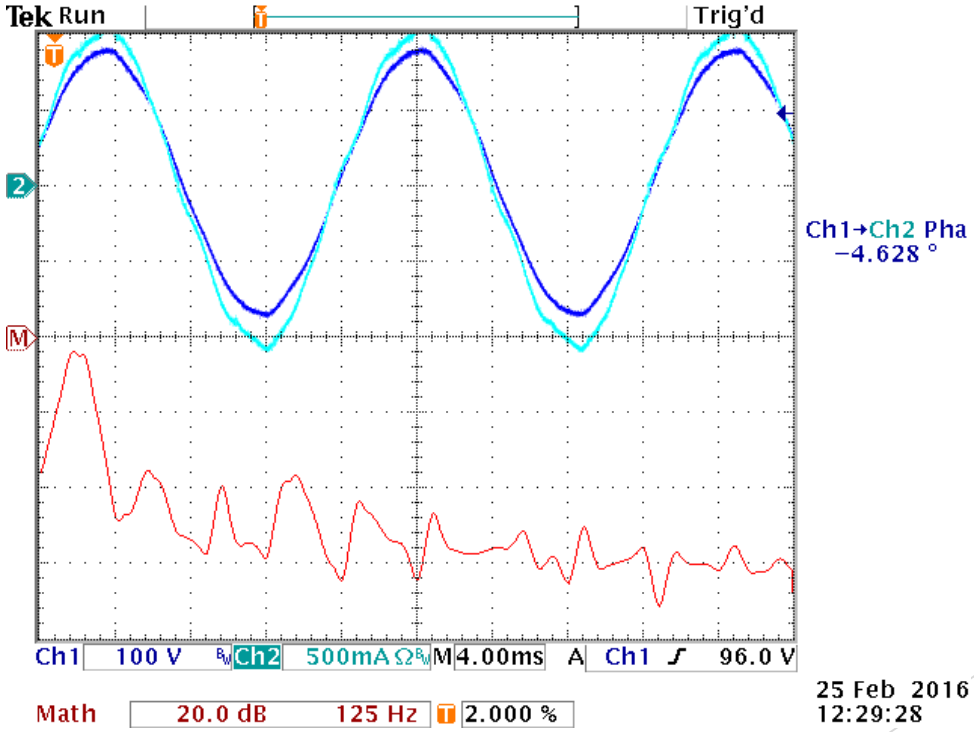
# Progress – Work Accomplished

- Final design for the tuned 7th harmonic filter using a RLC circuit



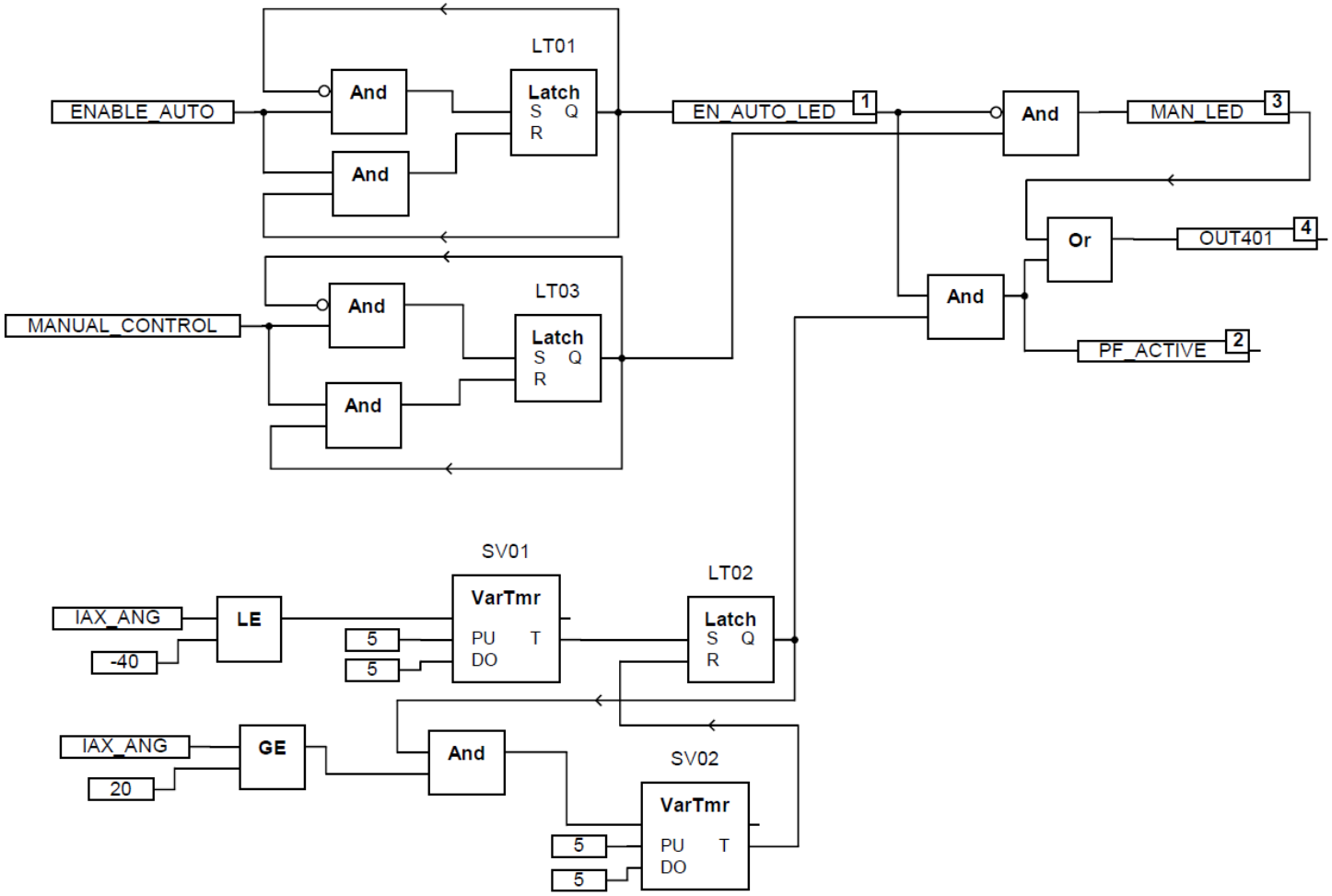
# Harmonic Filtering Testing

- Smoothing out of current distortion
  - 3rd, 5th, 7th, and 9th Harmonic still present
  - Overall current is increased due to the presence of the harmonic filter in parallel with the load

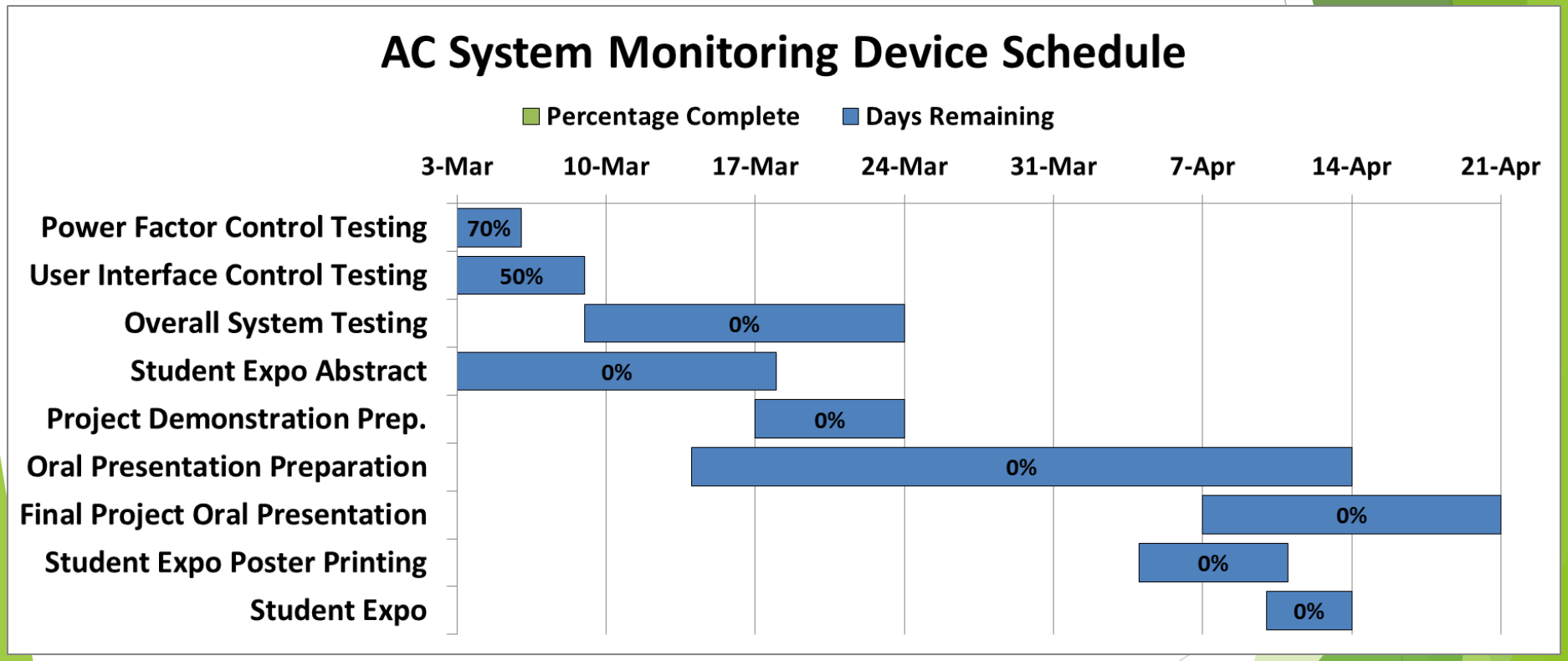


# Progress – Work Accomplished

- Successful work with user interface controls



# Progress – Work Remaining from Mar. 3 to Apr. 21



# Progress –Work Remaining

- Remaining tasks involve testing to verify the overall system operation
  - Finish testing power factor calculation
  - Finish testing power factor control
  - Finish user interface control testing
  - Final overall system testing
- Plan to complete the project before the demonstration date

# Conclusion

- Currently behind schedule because of current distortion from the power factor correction
  - Research of current distortion determined that is common issue with capacitor banks and transformers
  - Too much current distortion can cause instability for electronic equipment
- Power factor correction from initial testing shows power factor correction operation
- Harmonic filter design can be improved upon to reduce the power consumed from operations

# Q & A

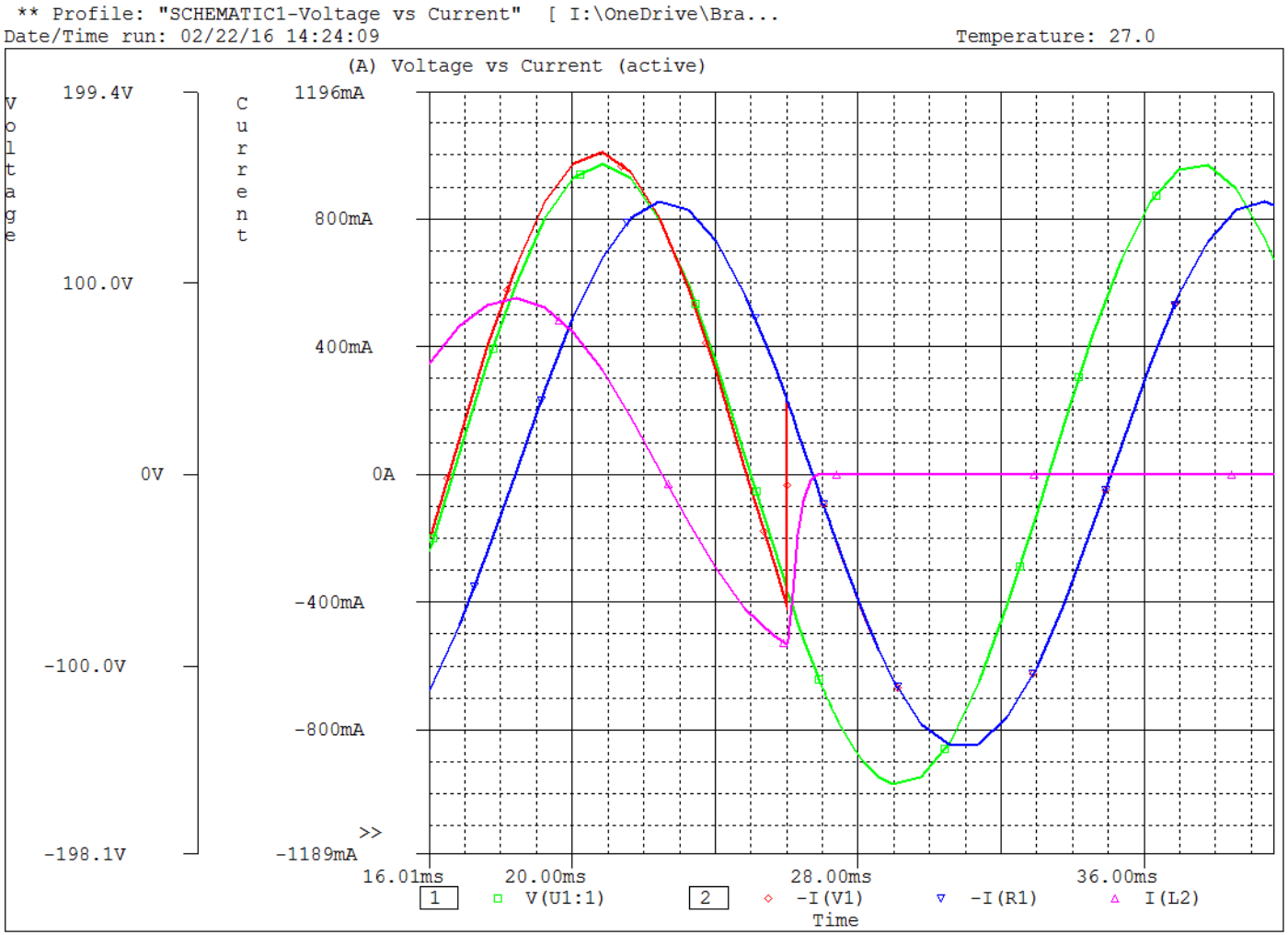
# List of Functional Requirements for the AC System Monitoring Device

| Specifications | Max | Min | Tolerance |
|---|---|---|---|
| Voltage Range | 250 Vac | 100 Vac | ±15% |
| Current Range | 5 A | 0 A | ±15% |
| Power Factor Calculation | 1.0 | 0.3 | ±15% |
| Refresh Rate | 1000 ms | 1 ms | N/A |
| Control Power Factor | N/A | 1 Switch | N/A |

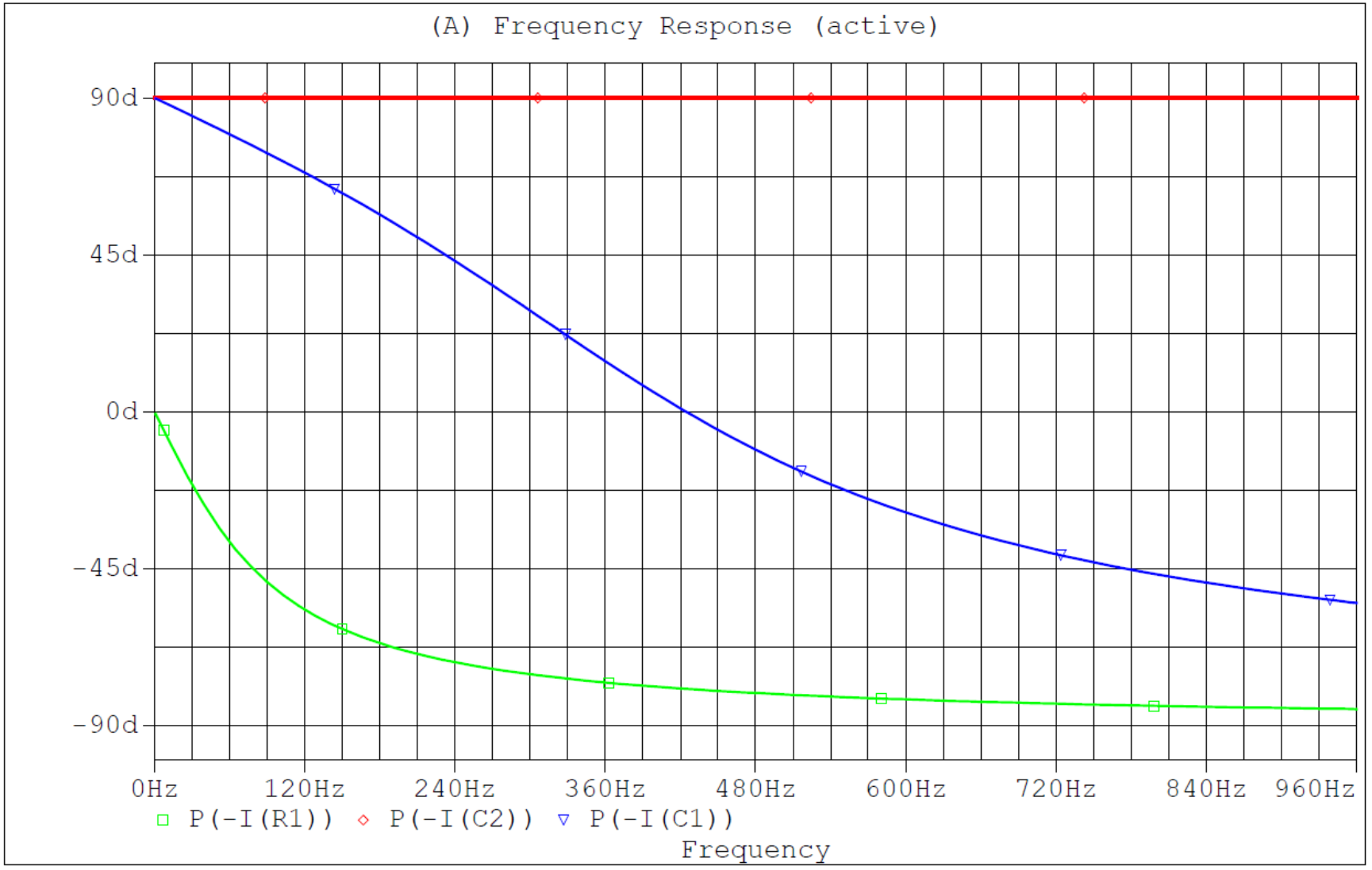
# Functional Specification of the SEL-2411 Automation controller

| Specification | Max | Min | Tolerance |
|---|---|---|---|
| Power Supply | 250 Vac | 125 Vac | N/A |
| AC Voltage Input Card (300V Model) | 250 Vac | 100 Vac | ±0.08% |
| AC Current Input Card (5A Model) | 10.0 A | 0.05A | ±0.5% |
| Power Factor Calculation | 1.0 | 0 | ±1% |
| Analog Output Refresh Rate | 100ms | N/A | N/A |
| Digital Electromechanical Contact Outputs | 8 | N/A | N/A |

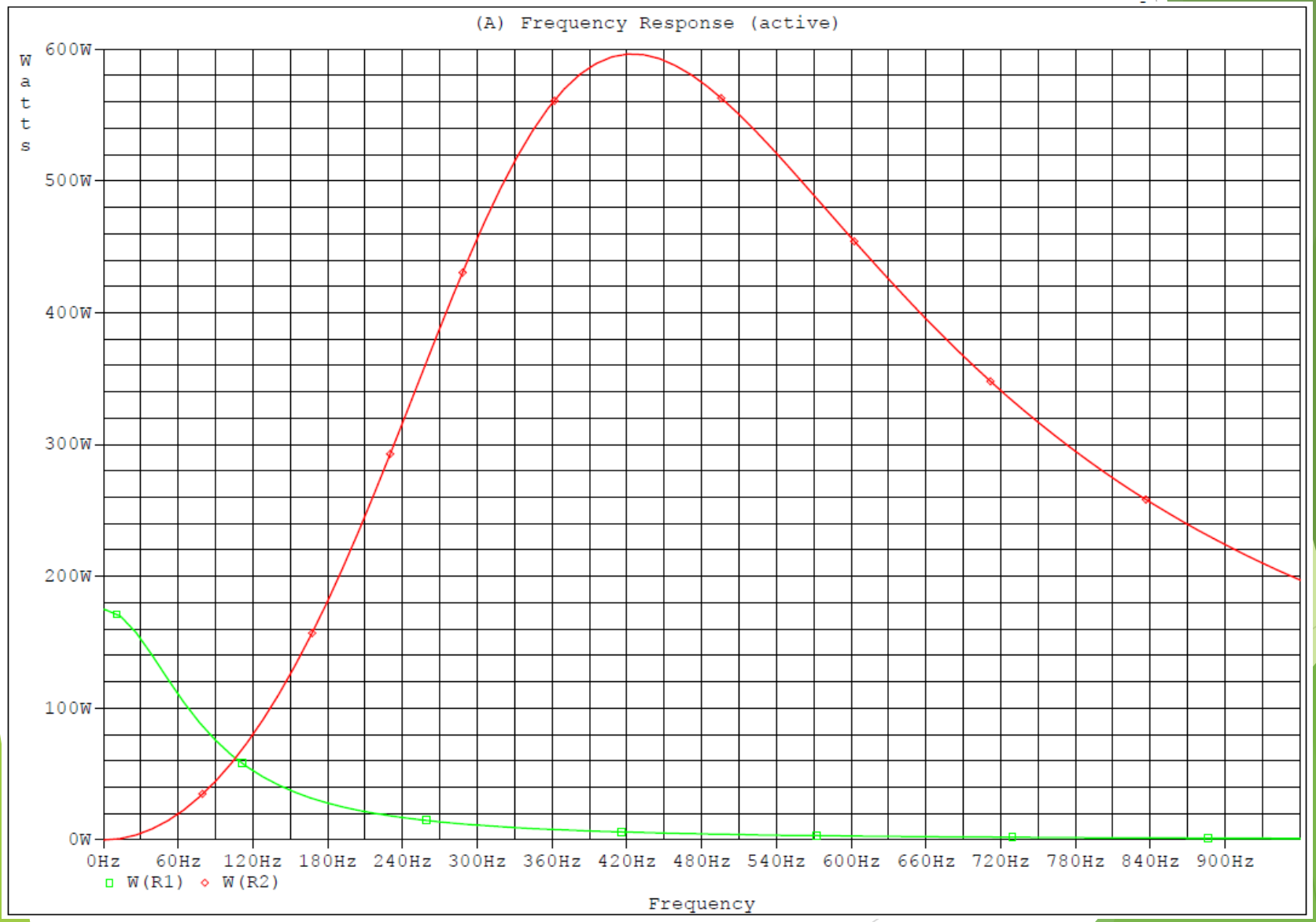
# Simulation in OrCAD adding 2µF capacitor



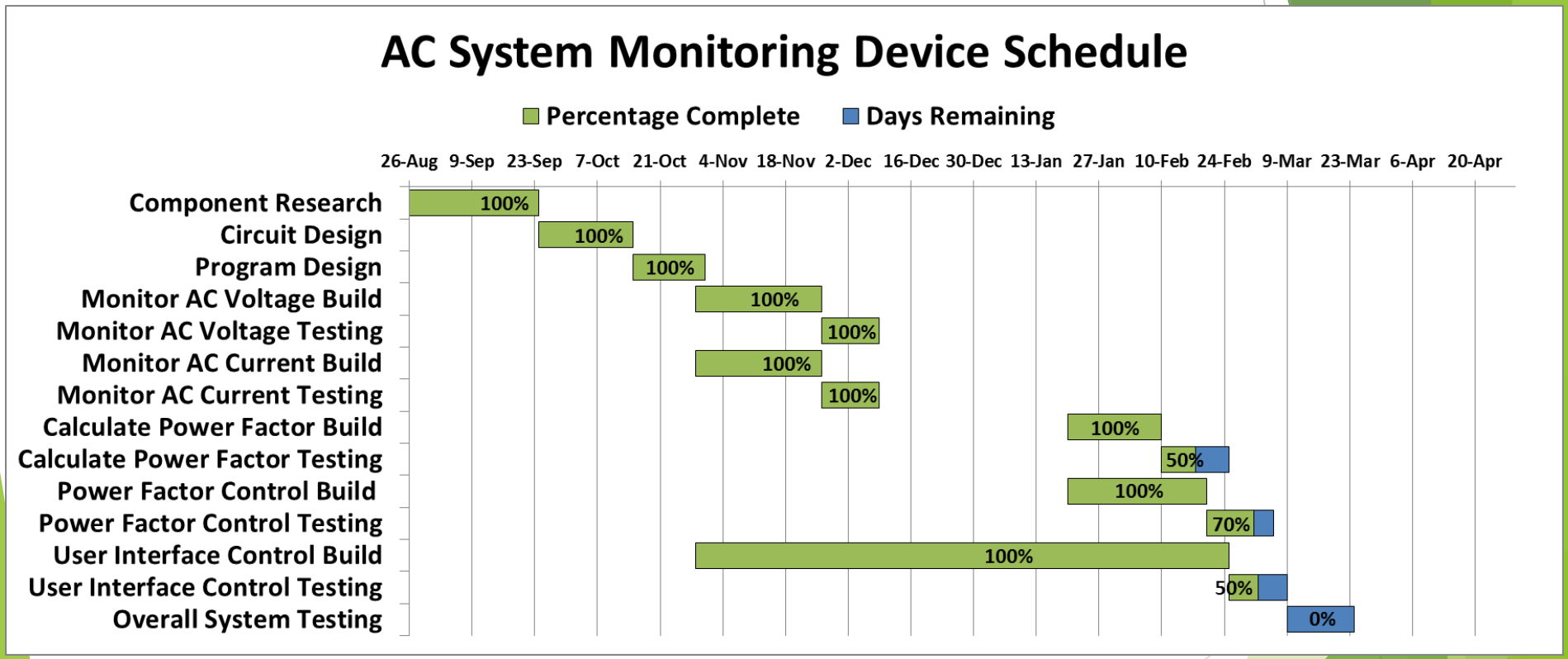
# Simulation Phase Shift



# Simulation Response



# Detailed Gantt Chart



# Detailed Gantt Chart Other Activities