Adaptive Noise Cancellation in 30kA Power System

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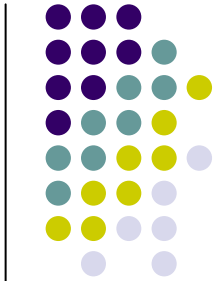
30kA Power System Specs



- 30kA, 30V dc Power System was designed and built at Fermilab for testing Superconducting High Field Magnets
- It is based on six commercial 150kW PEI power supply modules and following in-house modules: six 720Hz filters, two 15 kA /1kV dc solid-state dump switches, and a 3 MJ /30kA /1000V dc dump resistor
- Loads connected to the power system include resistive loads (HTS Power Leads) and superconducting magnets with an inductance range of 35 μH to 30 mH
- Maximum ramp speed is 300A/s

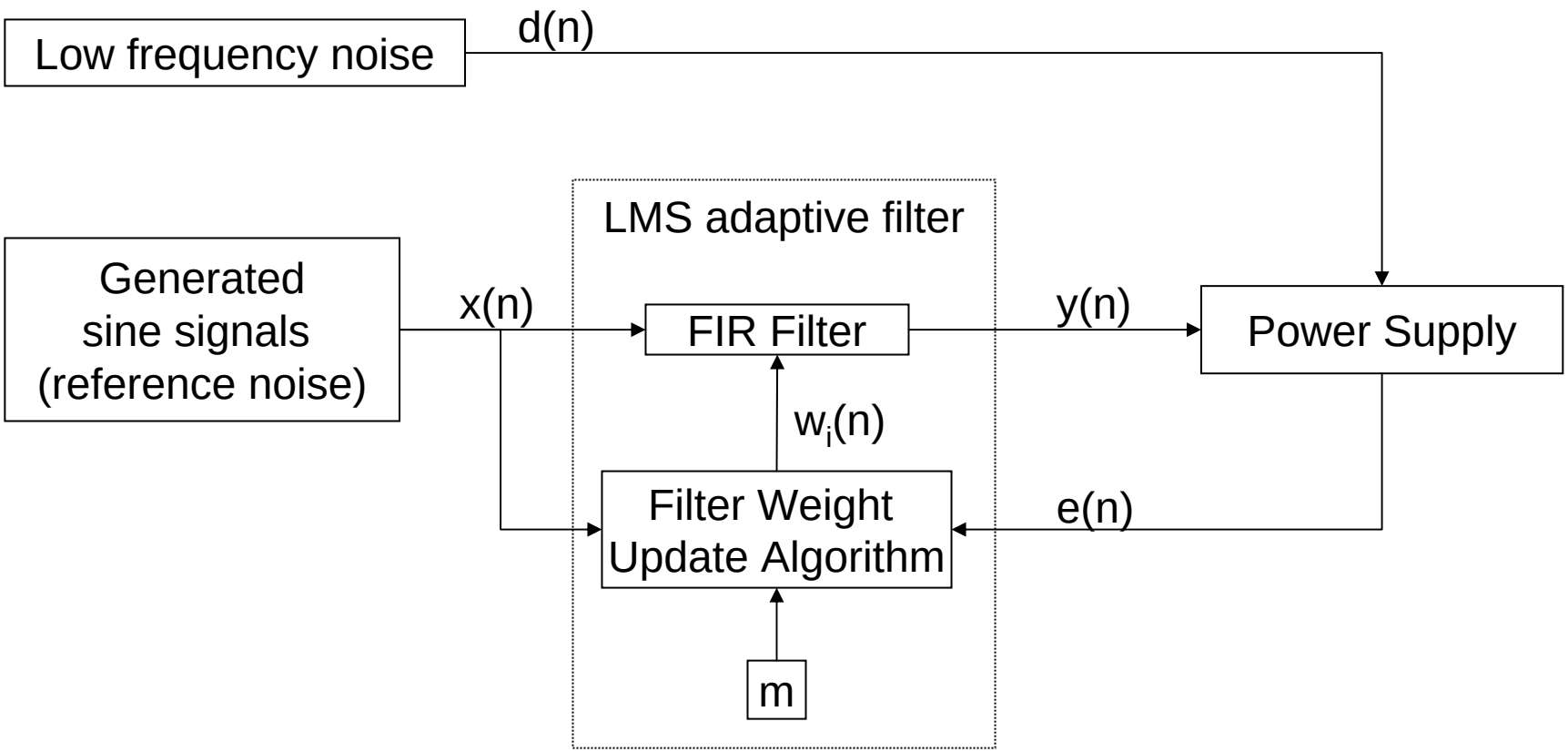
Low Frequency Noise

- It was noted that Power System has a low frequency (60Hz, 120Hz, 180Hz, etc) current noise due to imbalances in system elements.
- During quench studies the phenomenon of voltage spikes which precede magnet premature quenches was observed
- The ripple is almost equal in magnitude with generated voltage spikes
- Ripple should be cancelled for better voltage spikes study

Why Adaptive Cancellation Was Chosen

- It was noticed that magnitude and phase of the ripple change during current ramping
- Cancelling algorithm should adapt to constantly changing magnitude and phase
- Adaptive filter should converge fast enough to follow those magnitude and phase changes

ANC System Block Diagram



Power Supply & Magnet Load Simulation Circuit

- Circuit has three inputs: dc/ramp, ripple, and compensation
- Two outputs: sum of three inputs and simulated magnet voltage
- Variable resistor to simulate different magnet inductances (to set output gain)

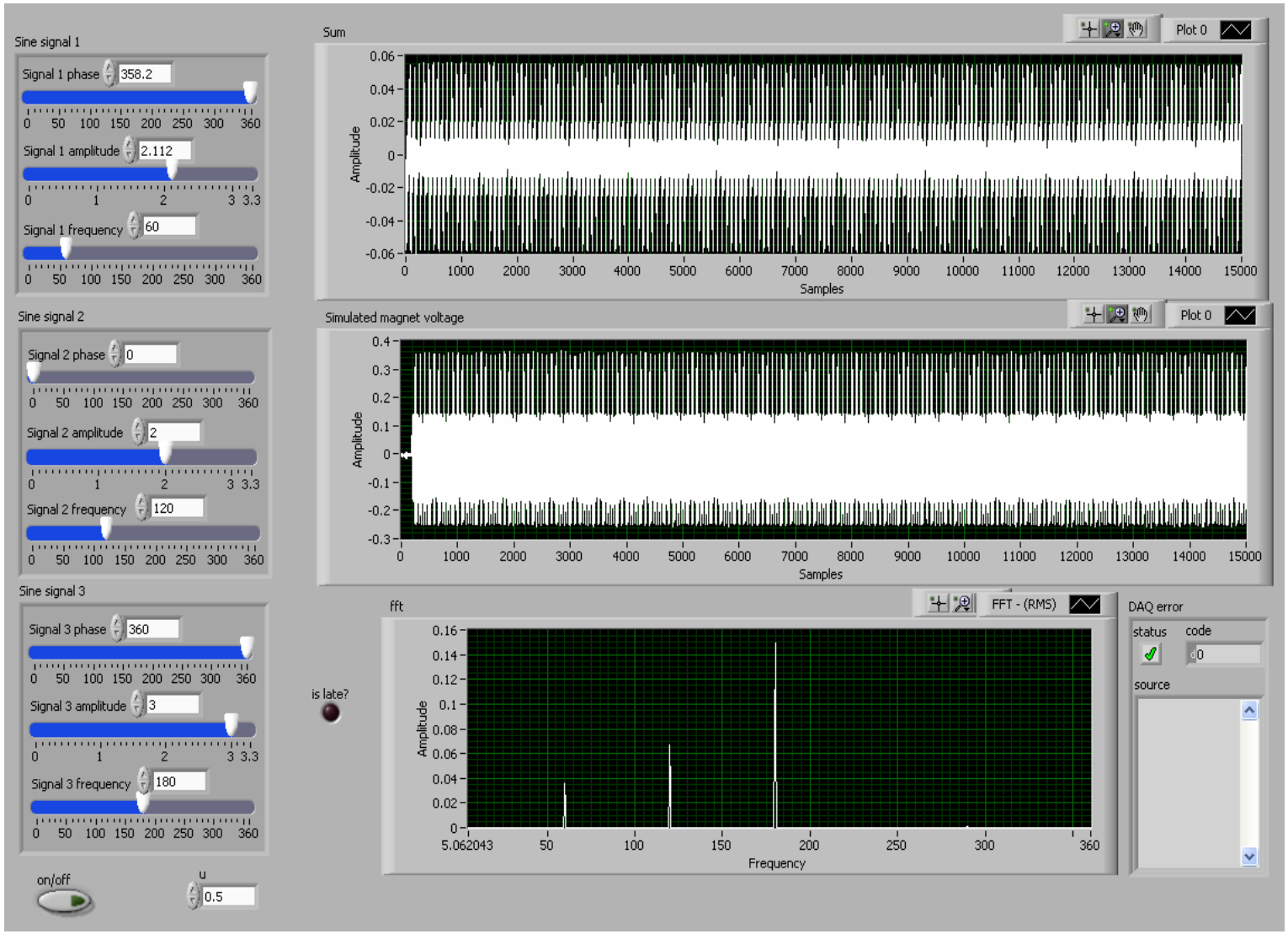
Diagram of Test With Simulation Circuit

Real-time system with I/O Device
LabView Real-time installed

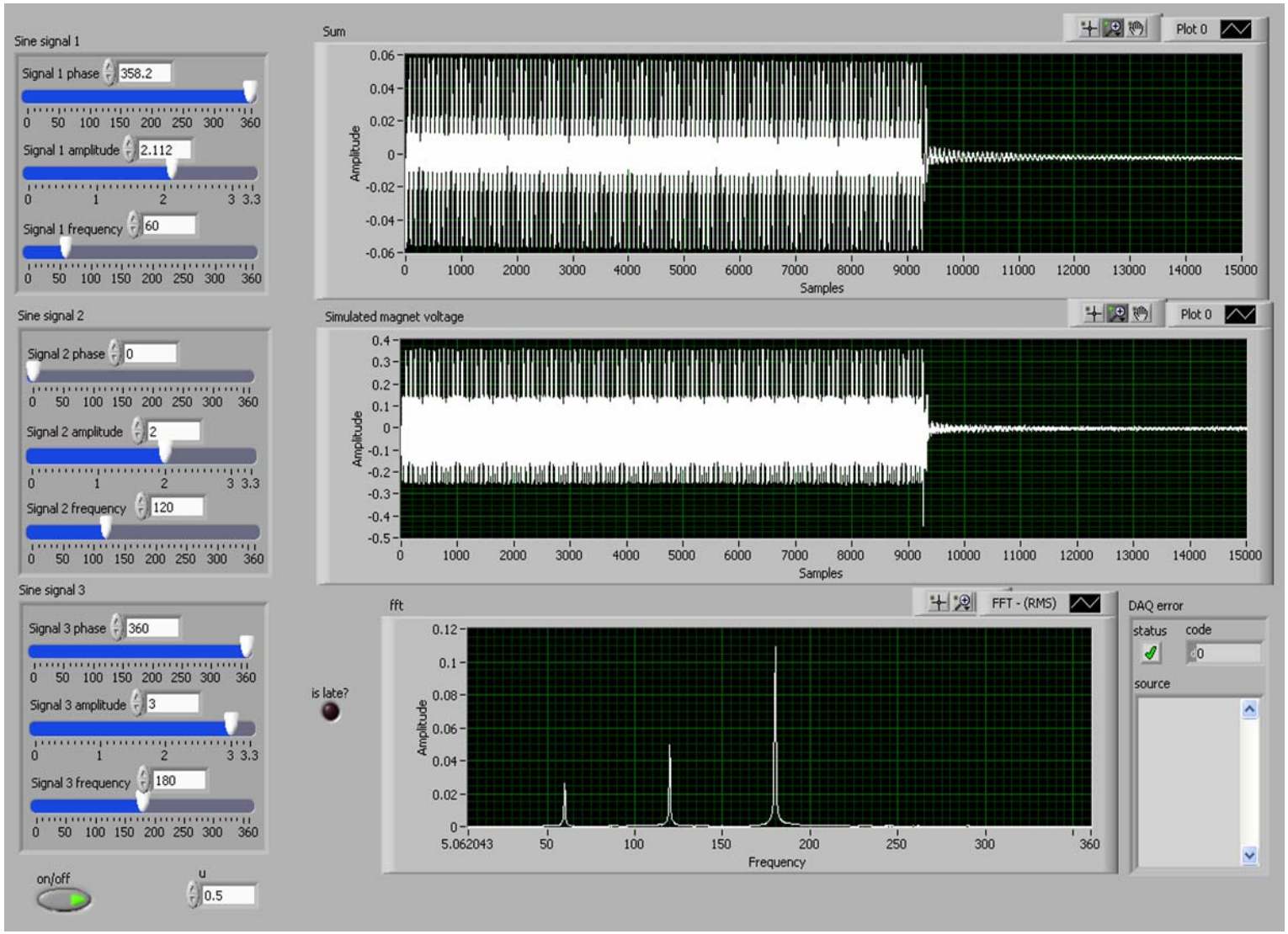
Computer with
NI LabView installed

Simulation circuit

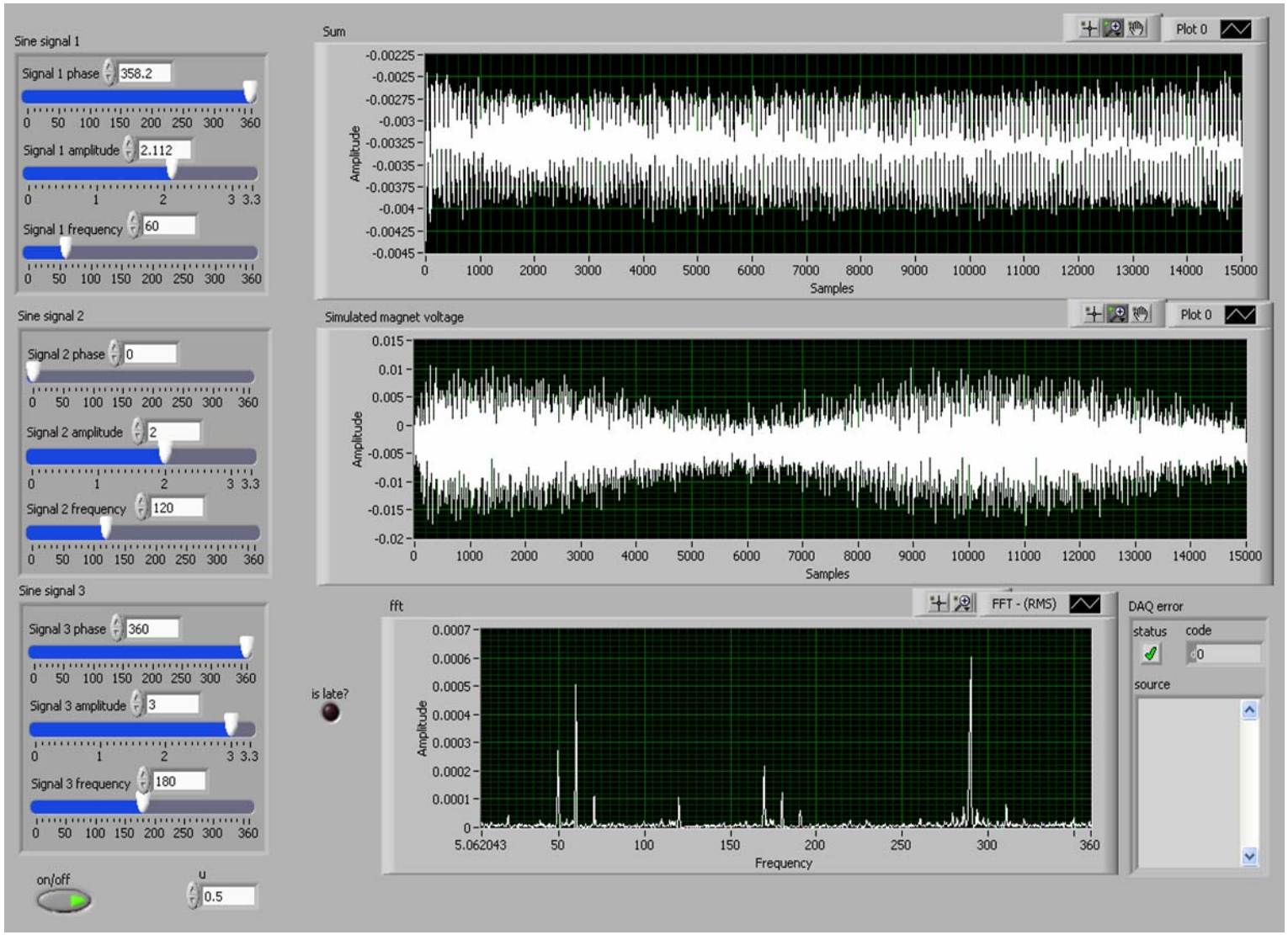
Test Results: LMS Turned Off



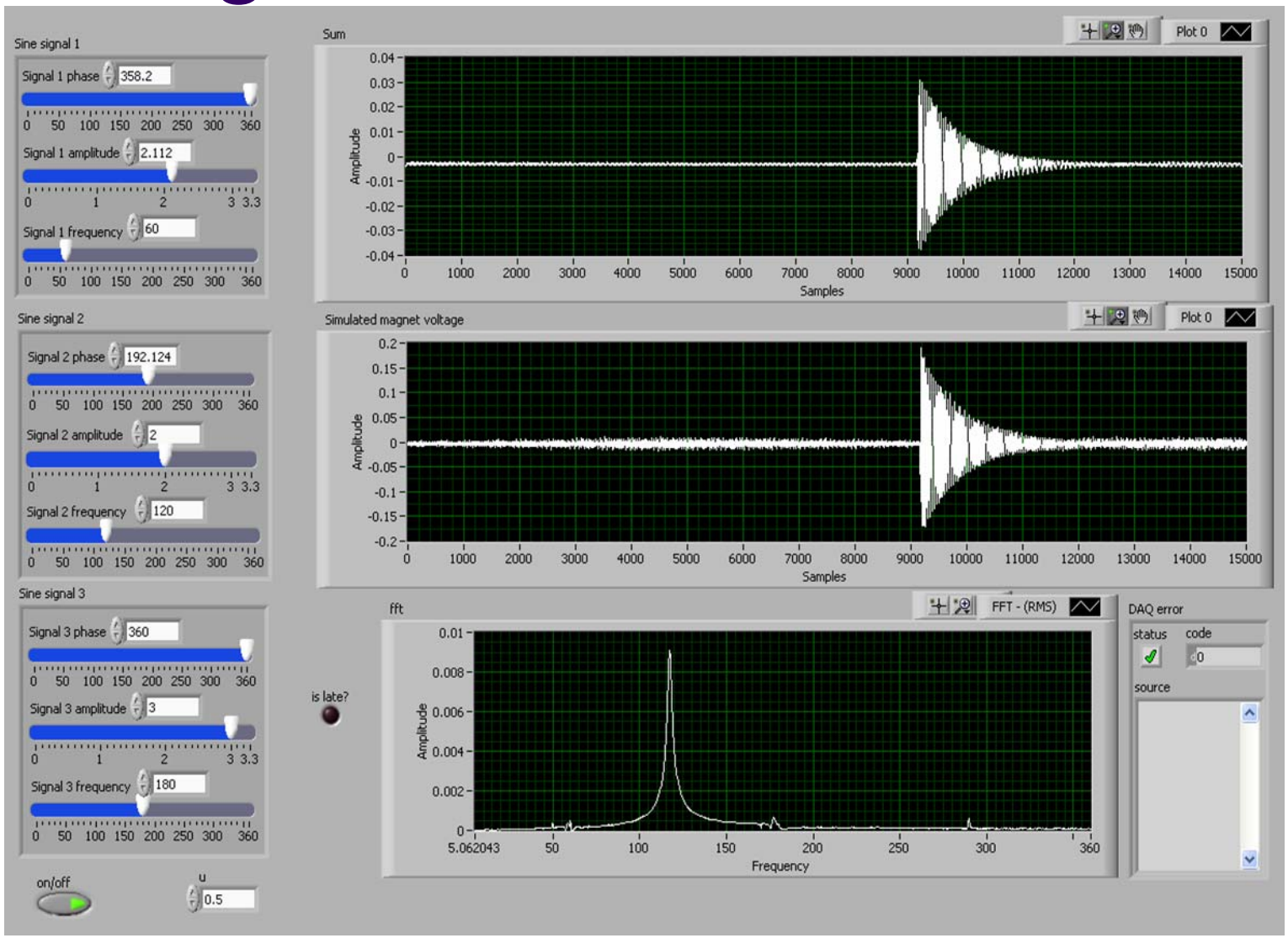
Test Results: LMS Turned On



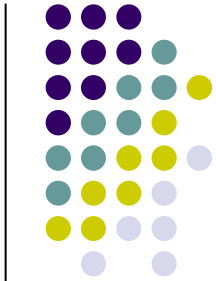
Test Results: Next 3 Seconds



Test Results: 120Hz Phase Changed



Test Results Summary



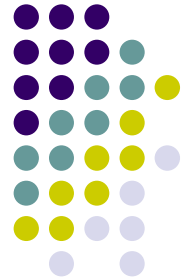
- It was proved that LMS adaptive filter can reduce ripple magnitude by the factor of 10 within 100-200 milliseconds (depending on ripple frequency)
- It was also noticed that higher m can provide higher convergence rate but make compensation output unstable, especially for higher gain. So some sort of compromise should be achieved in each particular situation.

Power Supply Tests Summary

- Algorithm works only with certain frequencies separately, but it doesn’t work with several frequencies simultaneously
- Algorithm parameters tweaking is needed
- Noise frequency shifting was observed

What Are The Next Steps

- Implement and try RLS algorithm which has higher convergence rates
- Improve program so it could detect the most significant noise frequencies and provide reference input according to them
- Study capabilities of filtered-x LMS algorithm
- Make more tests with the power system optimizing algorithm parameters



Thank you
for your attention