Complete System-level Efficient and Interoperable Solution for Microgrid Integrated Controls

Michael Starke, Ben Ollis, Philip Irminger, Bailu Xiao, Guodong Liu, Dan King,
Andrew Herron, Mitchell Smith, Ishita Ray, Mark Buckner, Yaosuo Xue

OAK RIDGE National Laboratory

U.S. DEPARTMENT OF ENERGY

Under the Department of Energy (DOE) Smart Grid research program, Oak Ridge National Laboratory has developed a microgrid controller and device controls for microgrid operations. This system, the Complete System-level Efficient and Interoperable Solution for Microgrid Integrated Controls (CSEISMIC), consists of an Energy Management System (EMS), a Supervisory Control and Data Acquisition system (SCADA), and device controls including inverter and microgrid switch operations.

CSESIMIC 1.0

In the first version, the EMS has been coded in MATLAB while the SCADA system is coded in LabVIEW. Device controls have been developed on National Instruments hardware, coded in LabVIEW. The EMS receives and transfers information from the different interconnected apps including on and off grid optimizers, load and solar forecasters, visualizers, and energy price collectors and provides information to SCADA. All of these apps were developed in MATLAB and are run asynchronously in order to take advantage of parallel processing. The EMS functions were constructed as part of the main user interface (UI). The UI provides the user the ability to choose optimization settings, microgrid startup, blackstart, shutdown, islanding, and resynchronization. The EMS also performs all system configuration and system operation tasks and communicates directly with SCADA. A TCP-based messaging protocol was developed for this communication that allows communication with devices to be encapsulated within the SCADA application so the EMS application can deal with optimization and UI interactions. SCADA provides several necessary services to a microgrid, including logging, device communication, and emergency response. The SCADA application was programmed in LabVIEW with an Actor Framework implementation.
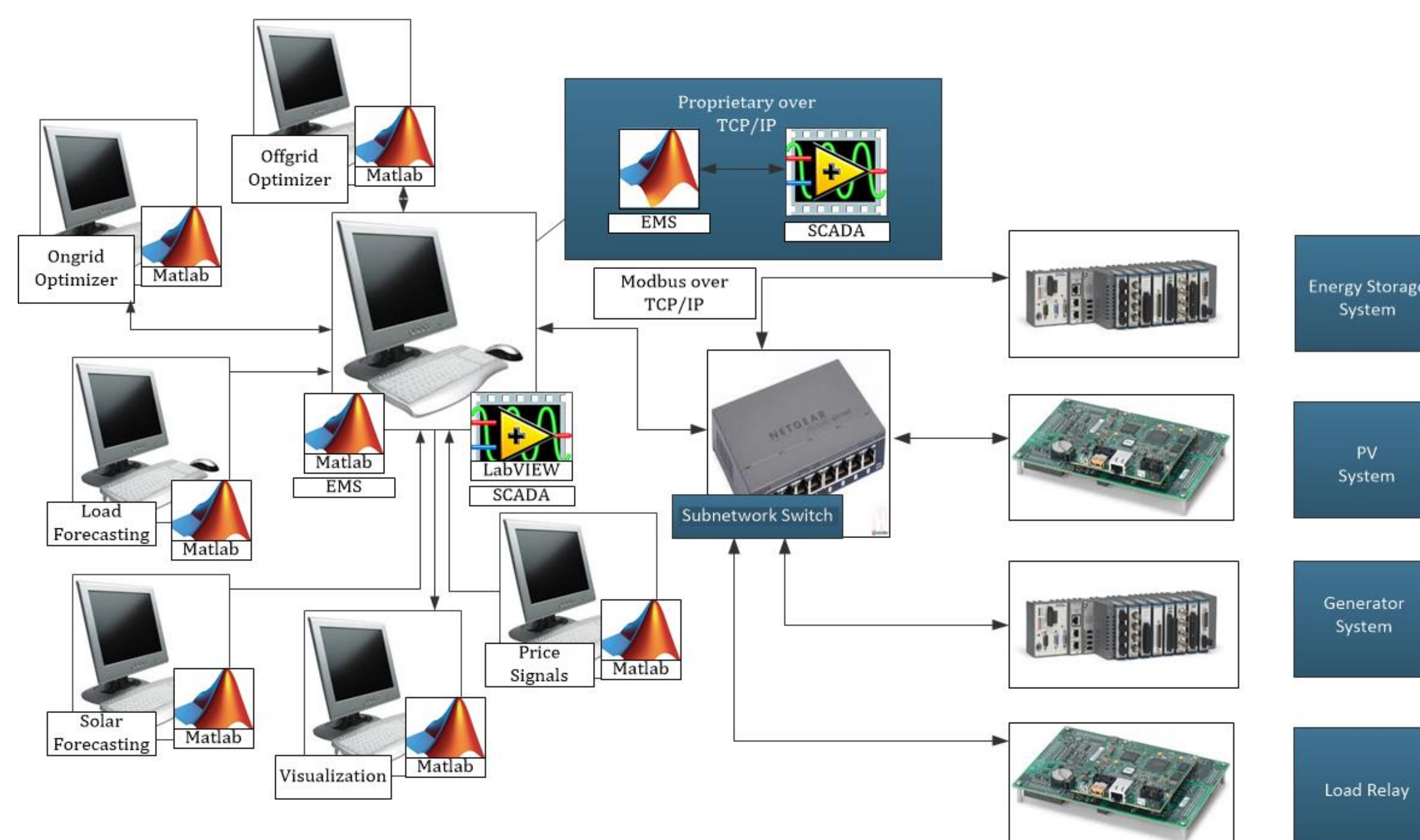

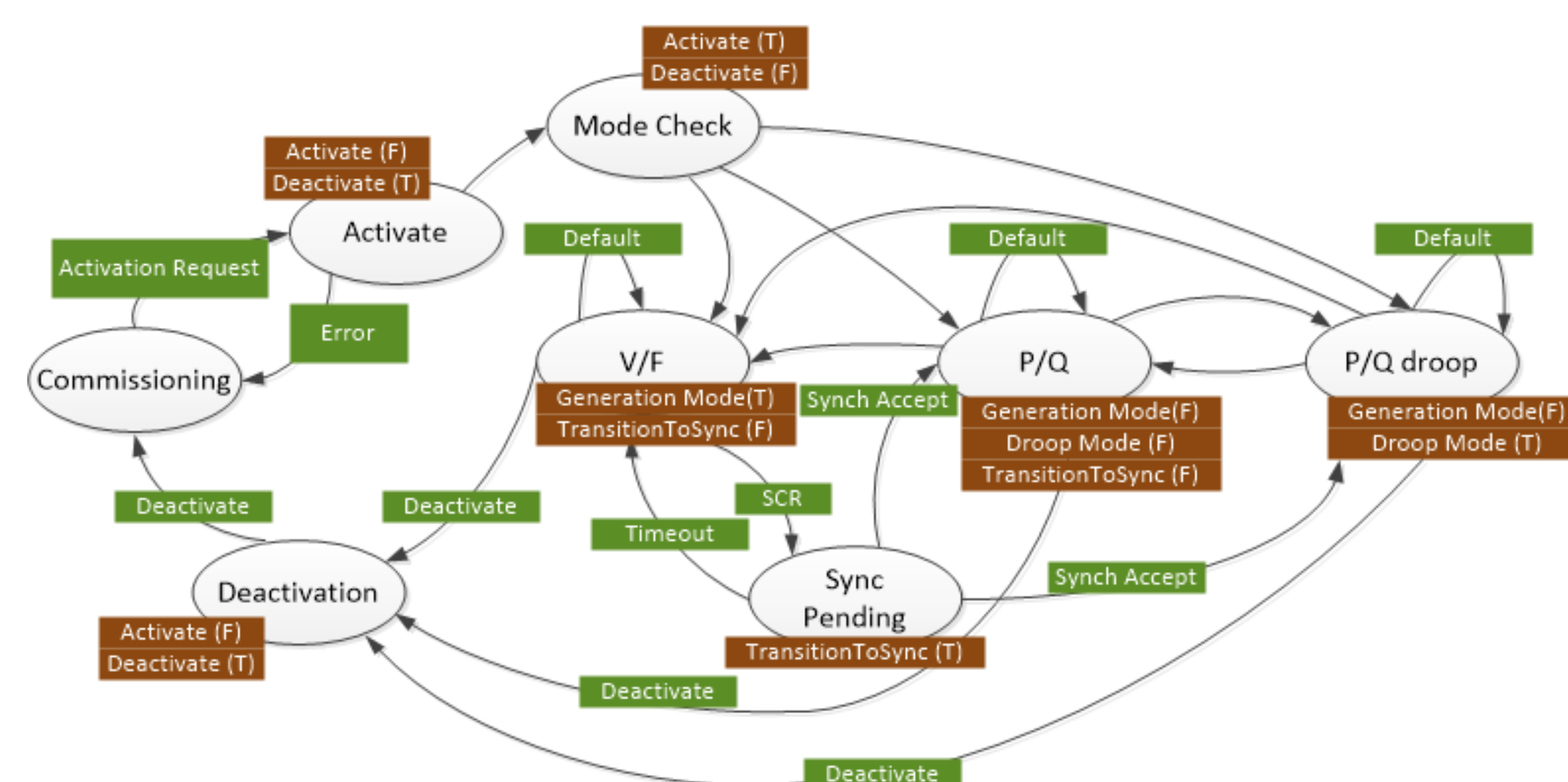Figure 1. Microgrid controller architecture.

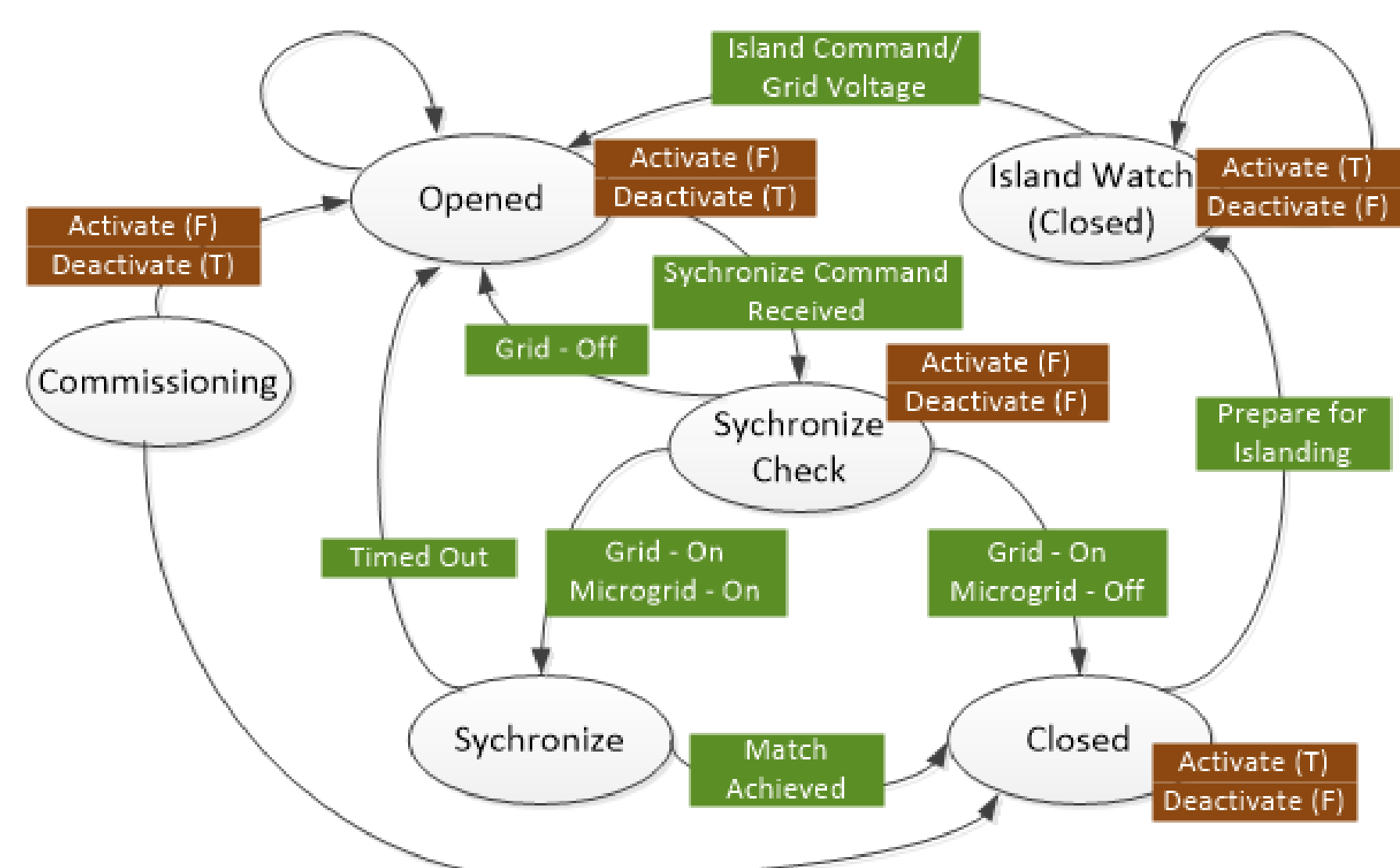Figure 2. CSESIMIC Energy Storage/Generator controller.

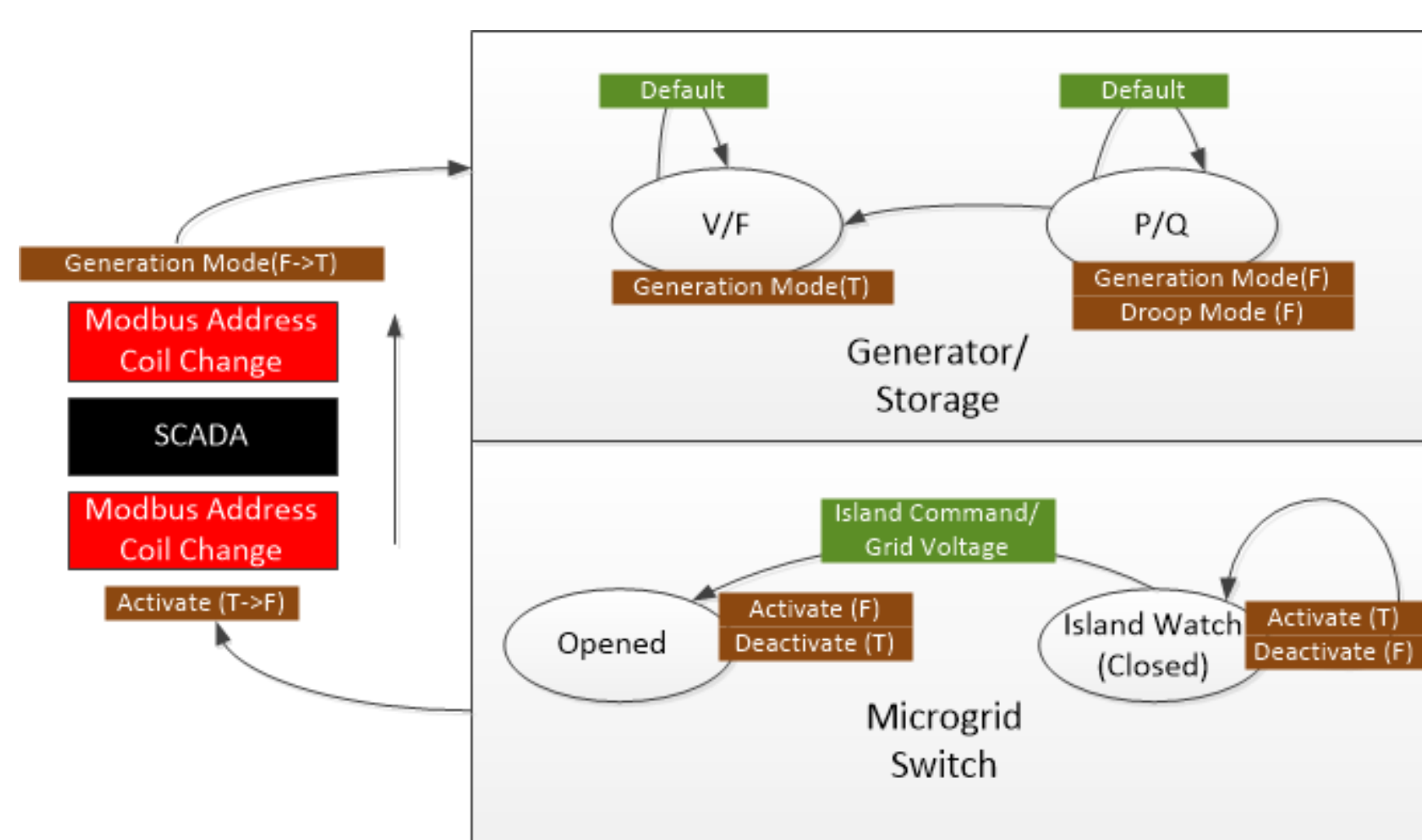Figure 3. CSESIMIC Microgrid Switch and Relay controllers.

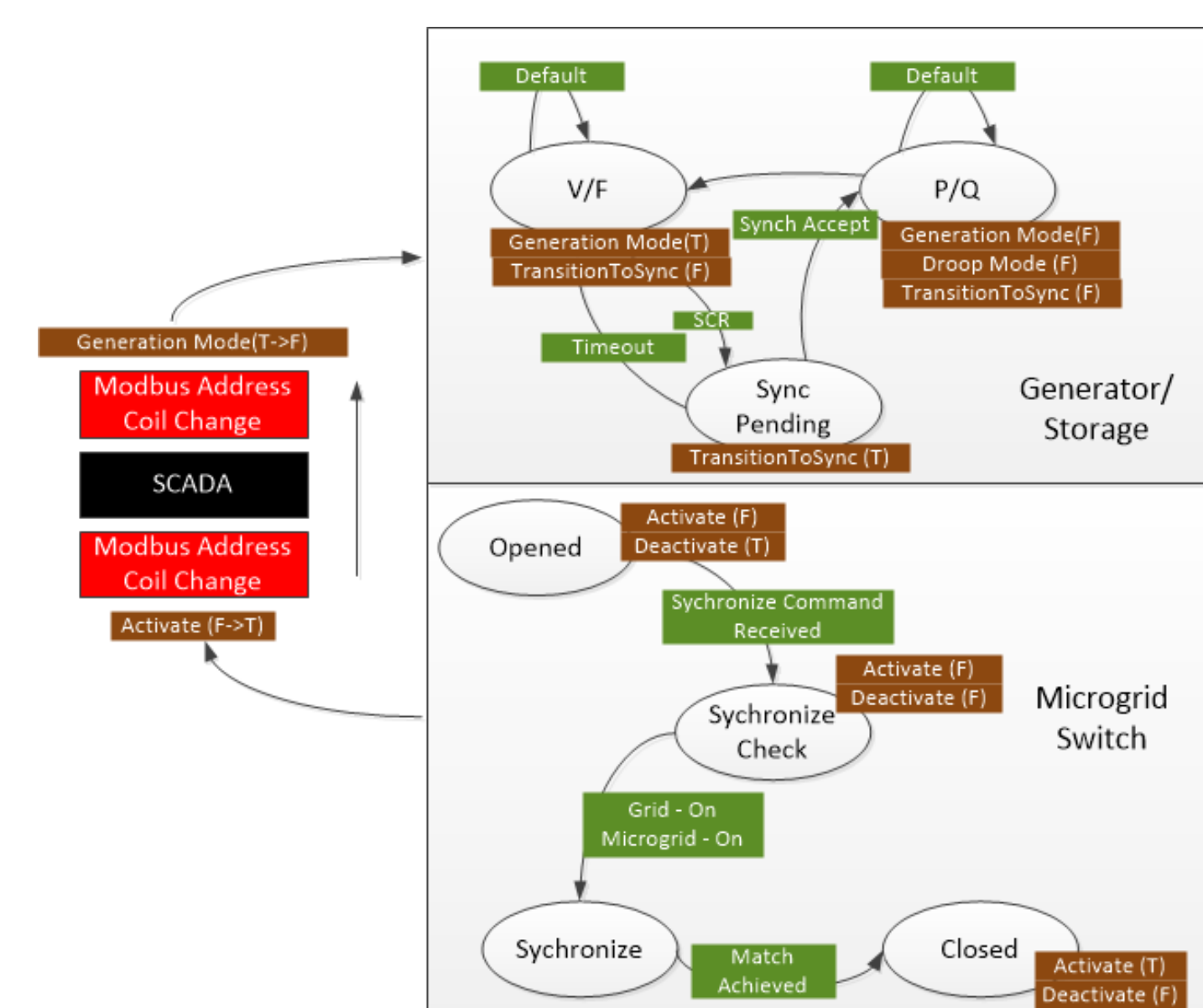Figure 4. Voltage/Frequency Control and Islanding.

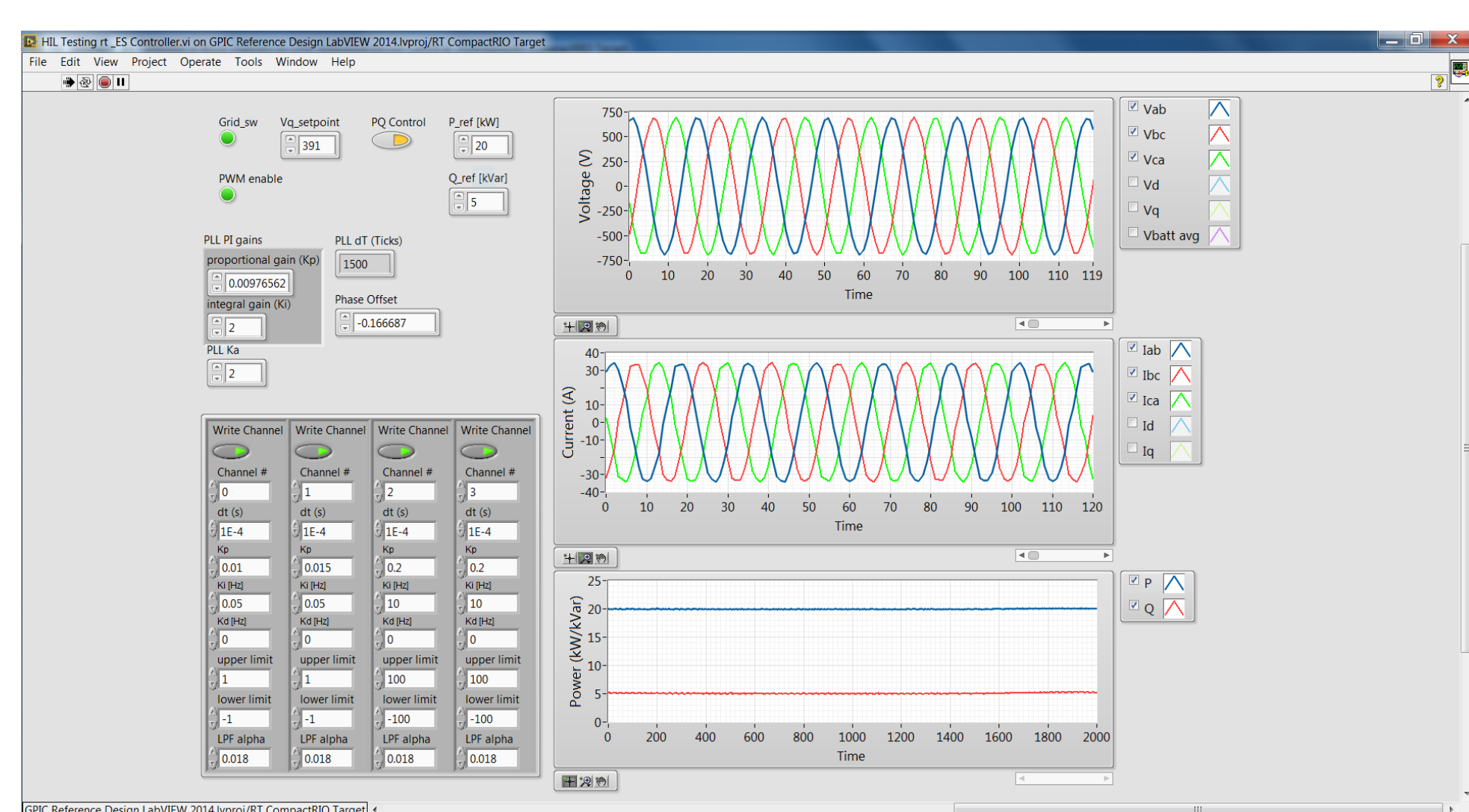Figure 5. Resynchronization.

TESTING RESULTS

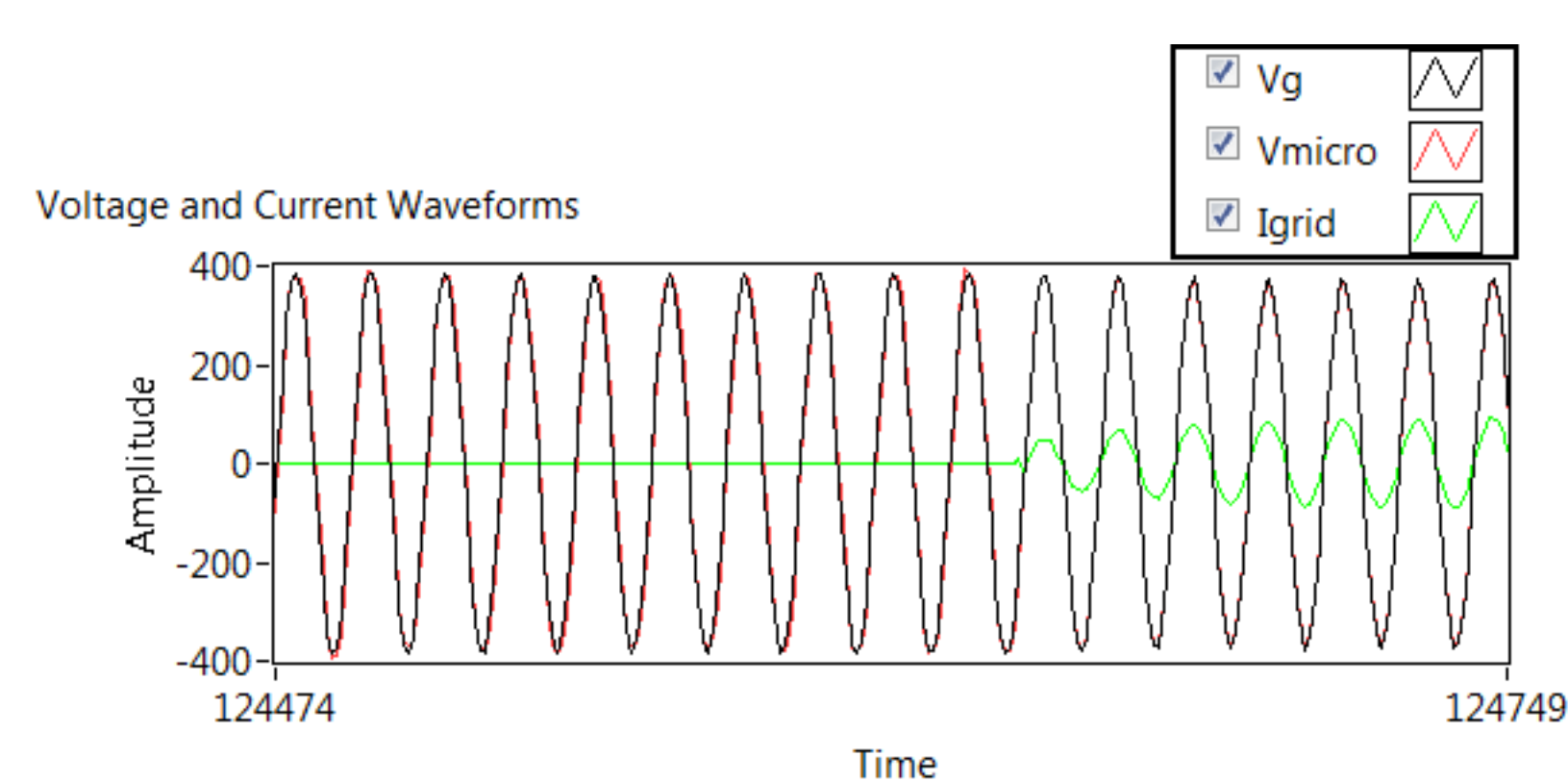Figure 6. User Interface of ES Controller.

Figure 7. Voltage and Current in Phase *a* during Resynchronization in RTDS Testbed.
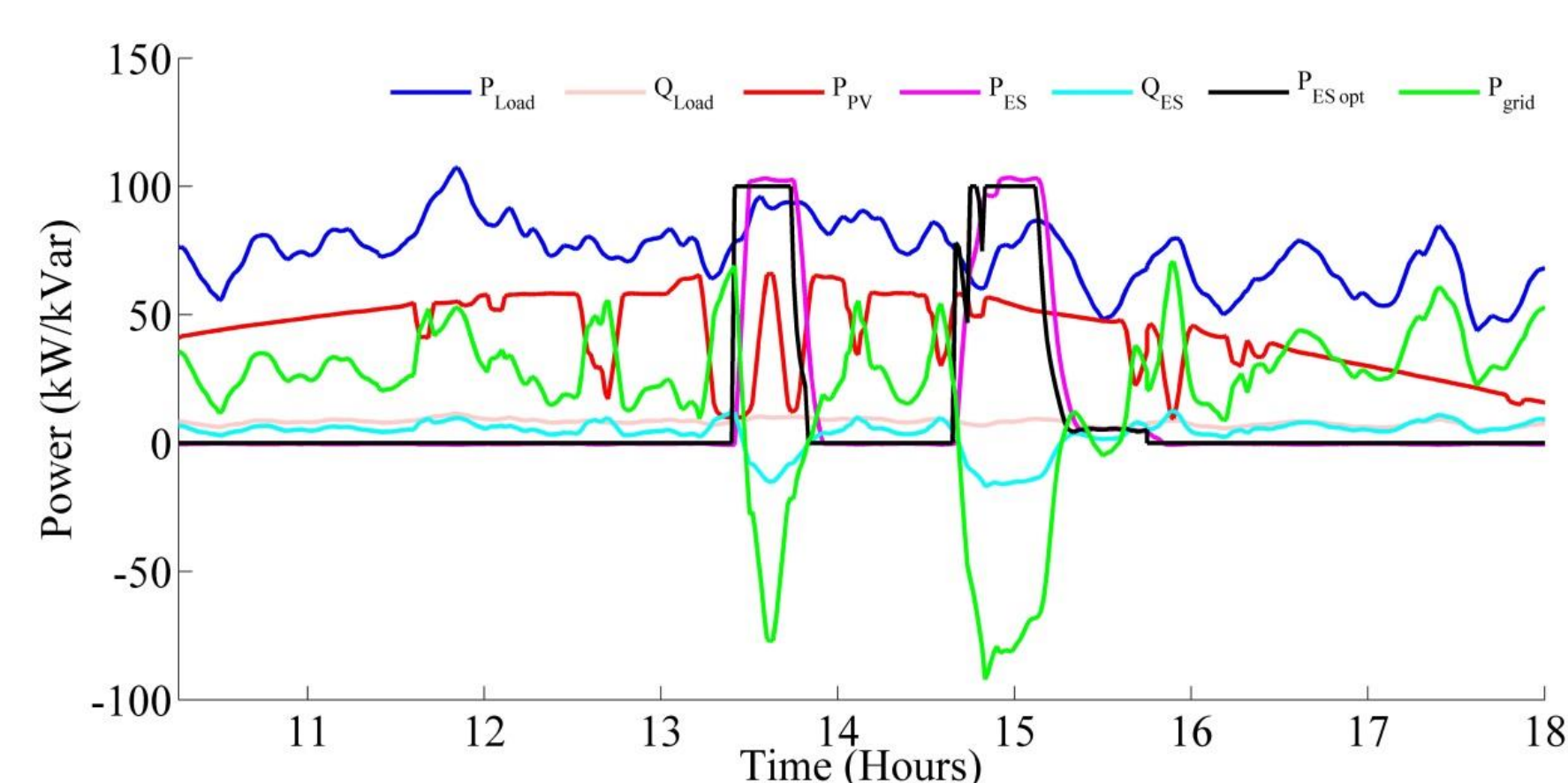

Figure 8. Long-term Testing Results in RTDS Testbed.
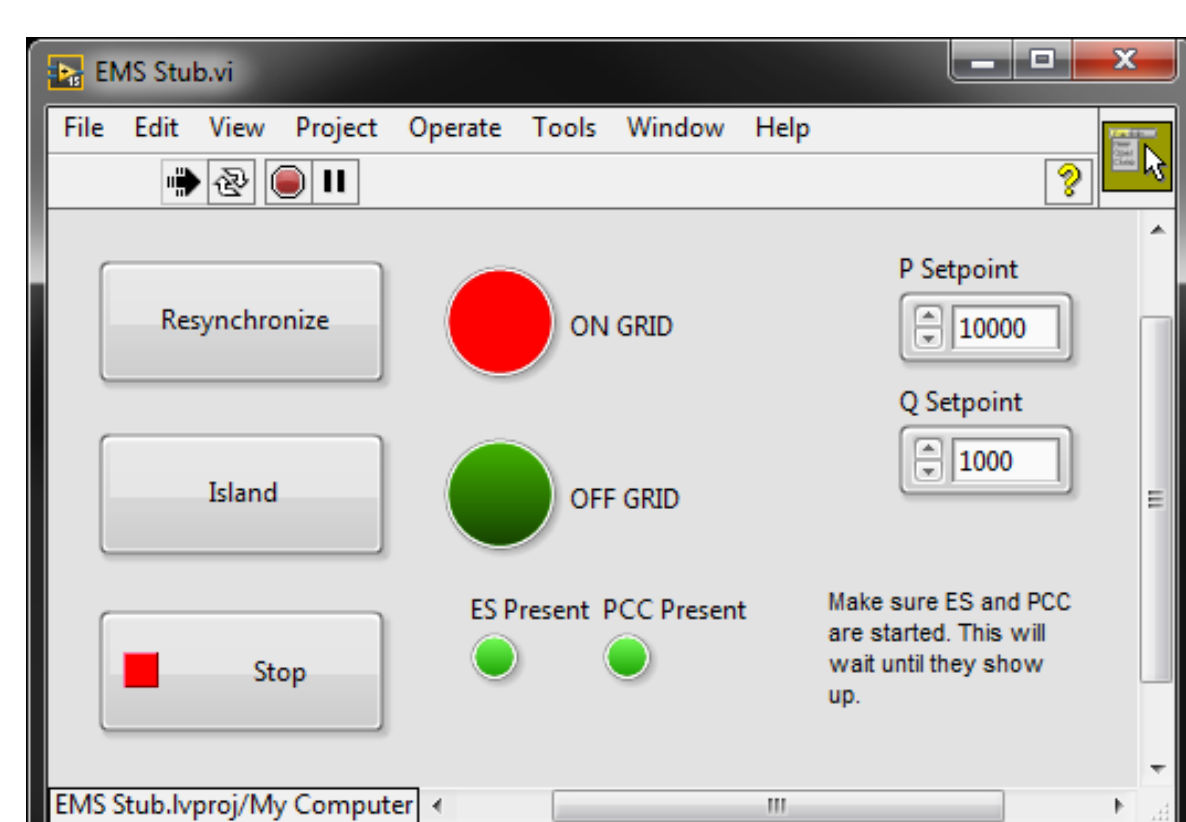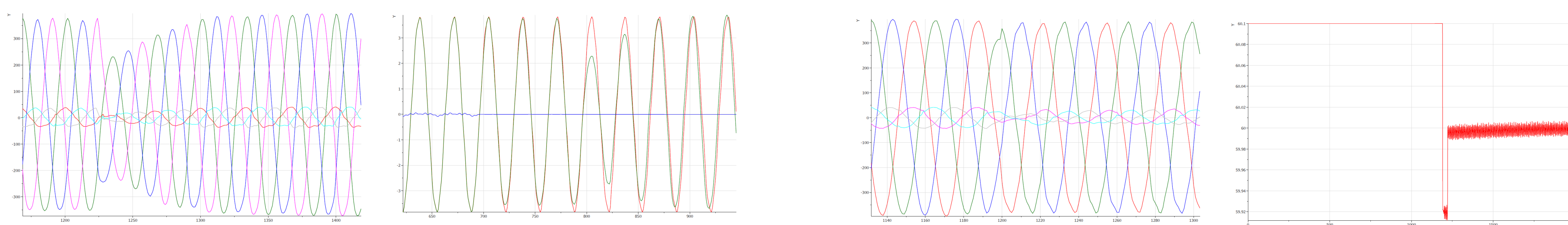

Figure 9. EMS Stub.

Figure 10. Islanding Testing Results in DECC Microgrid.

Figure 11. Resynchronization Testing Results in DECC Microgrid.