Expert System for Fault Diagnosis of Stand Alone PV Systems

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1. ABSTRACT

Faults in any components (modules, connection lines, converters, inverters, etc.) of photovoltaic (PV) systems (stand-alone, grid-connected or hybrid PV systems) can seriously affect the efficiency, energy yield as well as the security and reliability of the entire system, if not detected and corrected quickly. In addition, if some faults persist they can lead to risk of fire. Fault detection and diagnosis methods are indispensable for the system reliability, operation at high efficiency, and safety of the PV plant. In this project, the types and causes of failures in a Stand Alone PV system are examined and an Expert System is developed for Fault Diagnosis and Condition Monitoring of a Stand Alone PV system.

2. METHODOLOGY

- A Test Bench of a Stand Alone PV System is developed on Simulink/MATLAB as shown in Figure 2.
- An optimal sensor network is implemented on the simulation model of the PV system for data acquisition.
- An exhaustive Failure-Mode and Effect-Analysis (FMEA) is conducted on the system and Fault data is generated for all kinds of faults.
- Detailed analysis of all the types of electrical faults is done to identify the faults and their symptoms
- The various electrical parameters that are affected by the faults are determined
- An Expert System is Built using Logic and if-then-else decision structures for Fault Classification.
- The Fault Data is written from sensor modules onto a text file which will be read by the expert system tool to identify the fault.
- A User-Interactive Front-End is developed at the operator end for Fault Diagnosis and Condition Monitoring of various subsystems of the Stand Alone PV system. The inference engine runs at the back end of the diagnostic GUI.

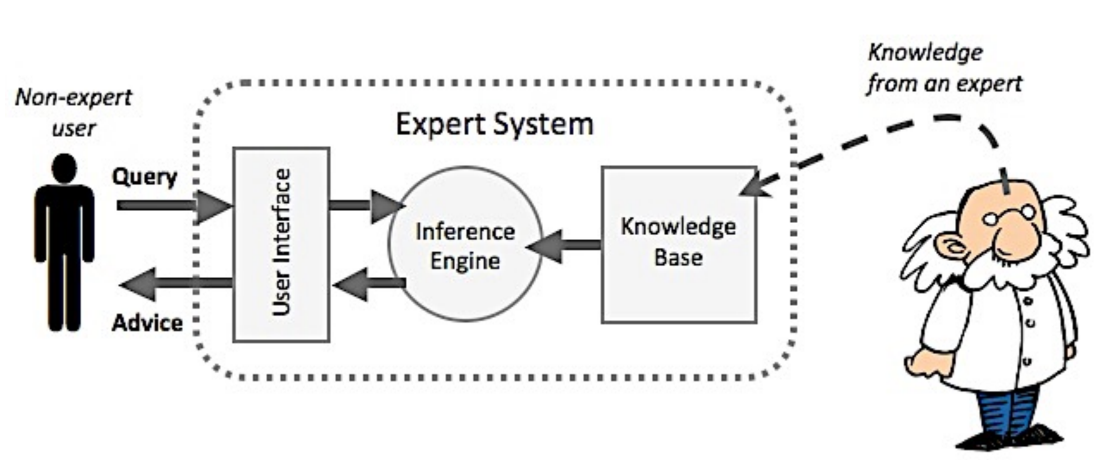

Figure 1: Expert System Model

3. TEST BENCH FOR FMEA OF STANDALONE PV SYSTEM

A Stand Alone PV System consists of: PV Panels, DC-DC Converter, Battery System, Inverter and Load. The system is modeled in Simulink/MATLAB. PV panel is modeled as a non-ideal current source, DC-DC converter is modeled as a conventional Closed loop Buck Converter, the inverter is modeled as the conventional H-Bridge Single Phase inverter and the load is a R-L branch. The battery model available in Simulink/MATLAB is used for developing the Test Bench.

For Failure Mode Effect Analysis (FMEA) of the system, the following faults are simulated.

- Inverter Faults: IGBT Open Circuit/Short Circuit, IGBT Misfiring
- DC-DC Converter Faults: Switch Firing Failure
- Battery Faults: Battery Terminal Disconnect, Battery Terminal Short Circuit
- Panel Faults: Panel Terminal Disconnect

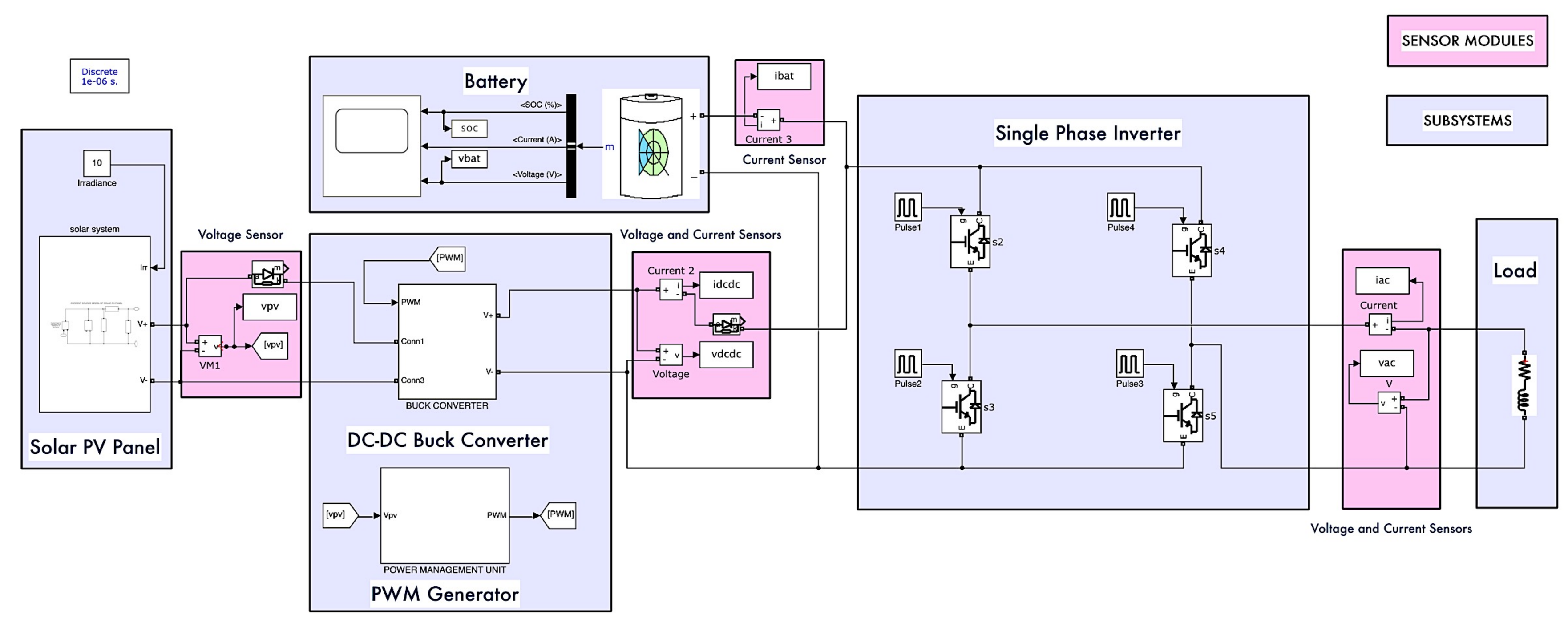

Figure 2: Test Bench Model of a Stand Alone PV System

KNOWLEDGE BASE OF THE EXPERT SYSTEM

4. FAULT CLASSIFICATION ALGORITHM

From the test bench model developed, various faults are simulated to generate the fault data for FMEA. From the fault data, an algorithm is developed to classify the faults. Fault labels F1-F9 are given for each fault type. Figure 3 shows the flowchart of the fault classification algorithm that runs at the back end of the expert system.

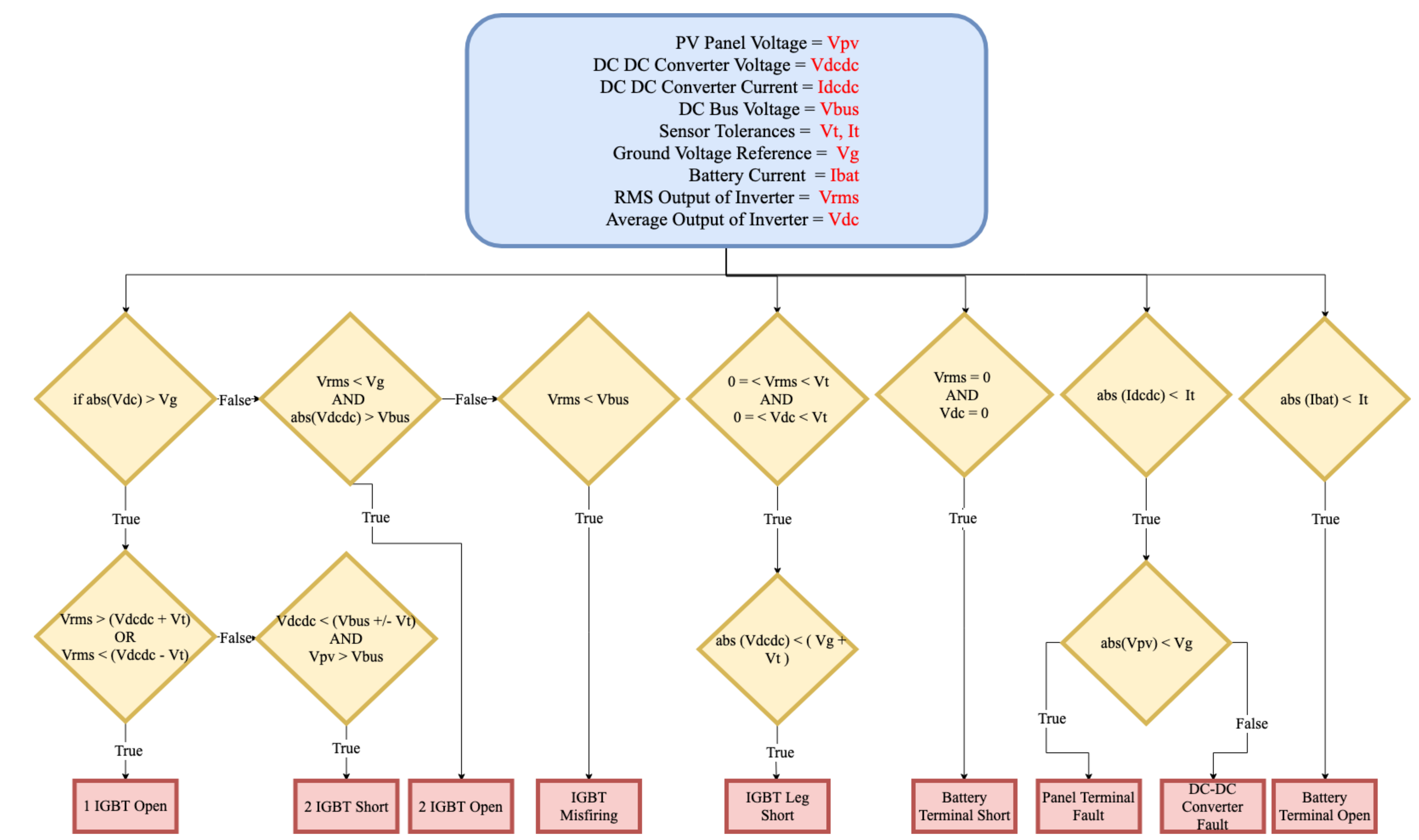

Figure 3: Flowchart of the Fault Classification Algorithm

INFERENCE ENGINE OF THE EXPERT SYSTEM

5. GRAPHICAL USER INTERFACE (GUI) FOR MONITORING & FAULT DIAGNOSTICS

The Fault diagnostic Tool is an Expert System with a Front End that gives the sensor data and fault type. At the back end, an if-else logic based inference engine is running which will analyse the senor data and diagnose the fault, The tool was run for i) A Healthy system without faults and ii) The system with fault in the inverter. Figures 4 and 5 show the Front-End of the GUI for these cases.

USER INTERFACE OF THE EXPERT SYSTEM

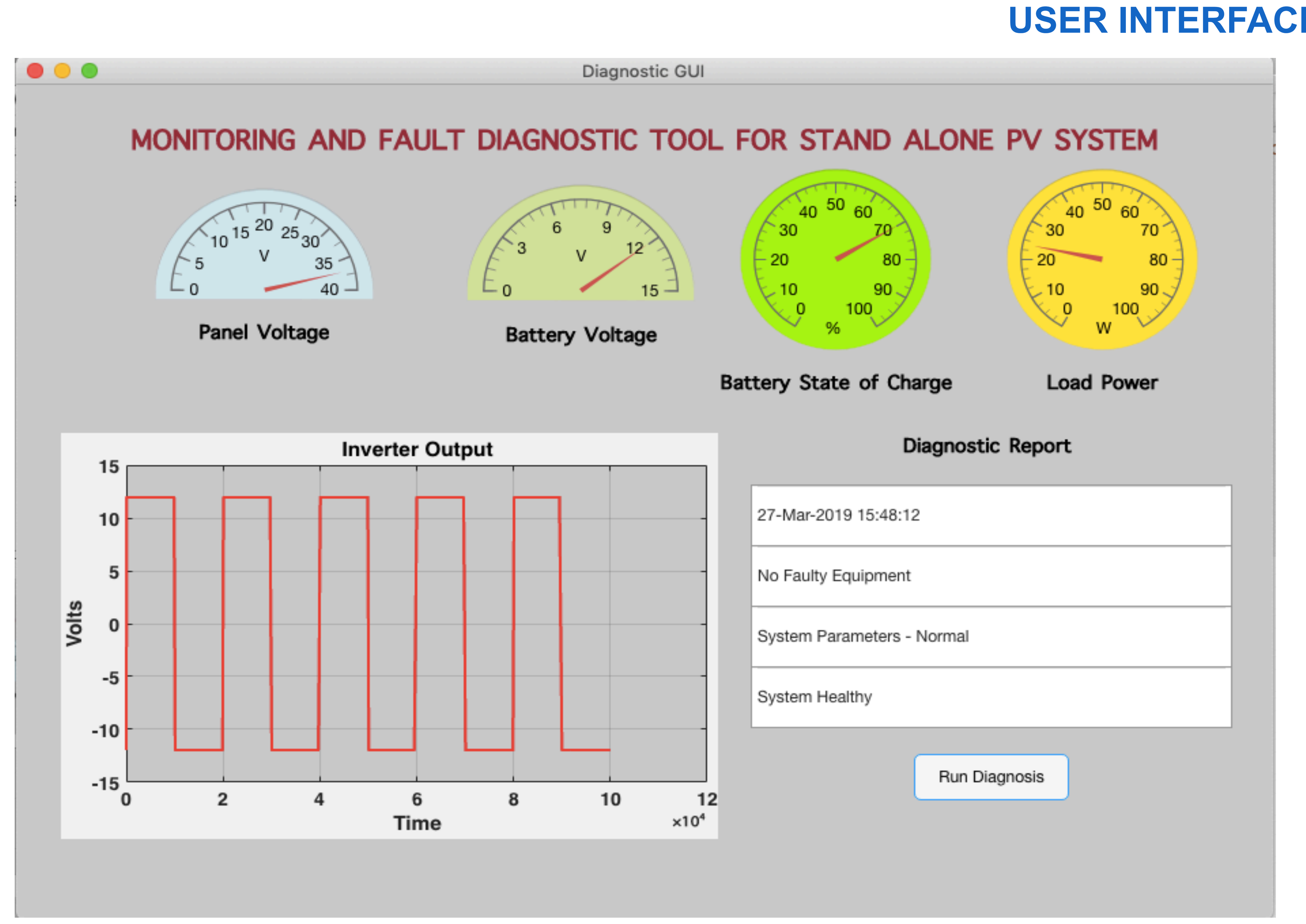

Figure 4: GUI Front End: No Fault in the system

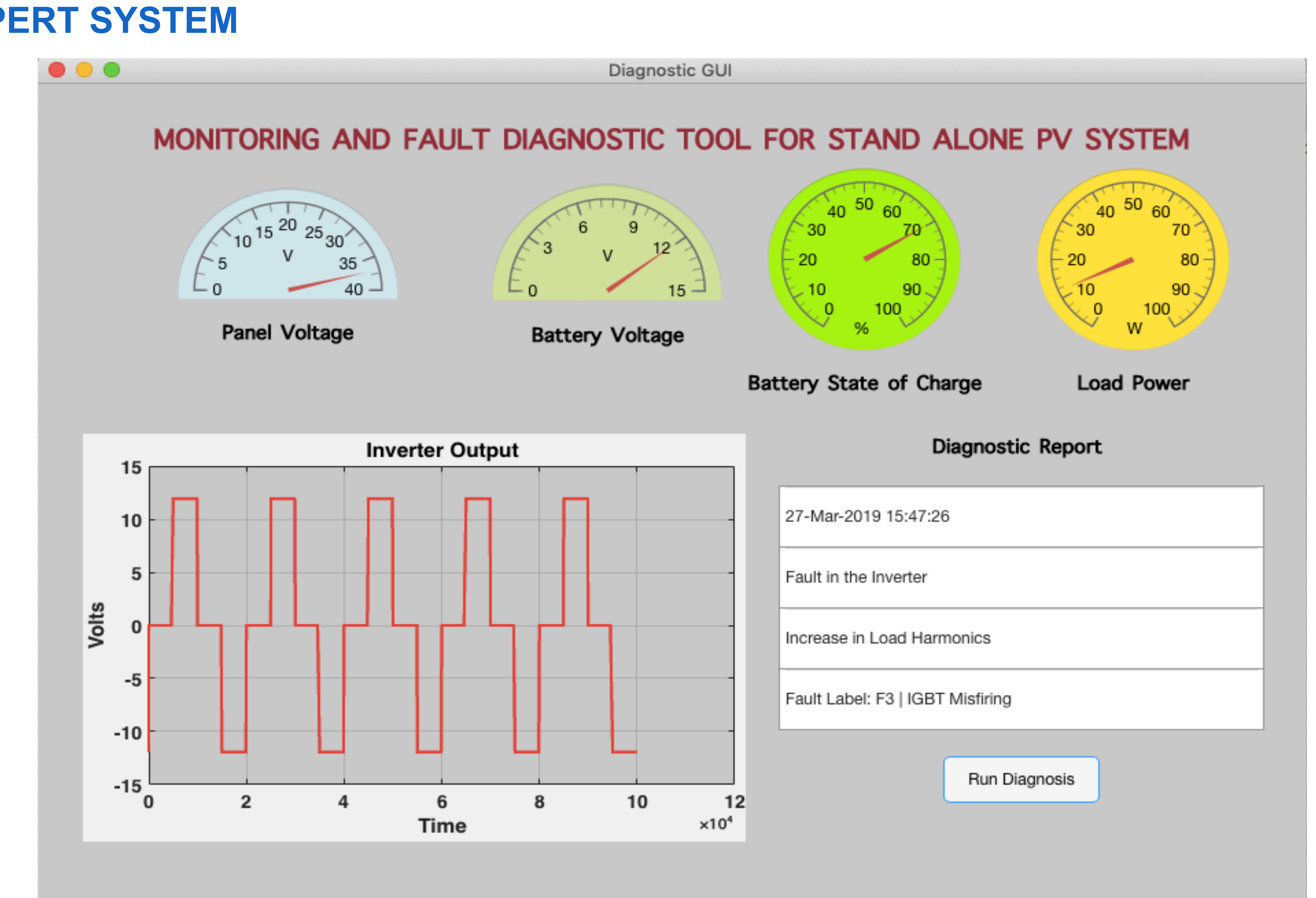

Figure 5: GUI Front End: Inverter Fault (IGBT Misfiring)