Senior Design
ENG EC 464

To: Future Senior Design Team, Users

From: Power Pooches, Team 14

Date: 5/3/2015

Subject: Read This First!

1.0 WELCOME

1.1 Welcome to the Smart Grid Test Facility! We hope you have fun with this project and that you learn about the power grid through its many features. This document outlines some important things to know about the system before building onto it. Refer to the User's Manual for more detailed information about operation of this system.

1.2 Professor Mark Horenstein (mnh@bu.edu) was the customer for this project, so he may also be able to assist with questions regarding the test facility.

1.3 The creators of this project are:

Name	Email	Primary Responsibility
Suleyman Kahyaoglu	kahyaogs@bu.edu	Generation: Motors & Alternators, Brackets, Safety Enclosures
Jeremy Kramer	jlkramer@bu.edu	Loads
Edward Leung	etl@bu.edu	Transmission Lines, Synchronization, Feedback Control, Transformers
Marissa Petersile	misspete@bu.edu	Transmission Lines, Synchronization, Feedback Control, Transformers
Christopher Powers	chrisp@bu.edu	Data Acquisition System, Sensor Suite

2.0 THINGS TO KNOW

2.1 MOTORS & ALTERNATORS

2.1.1 The grid is made up of three independent generation points. Two of these sources are made up of a motor, an alternator and a transformer, while the third source is a variable AC power source that serves as the reference (serves as the "infinite bus").

2.1.2 The two mechanical generation branches are identical to each other but function independently. A single branch is made up of a 24VDC motor, power by the DC power supply, driving an alternator through a belt-driven power transfer. The high output voltage of the alternator is then stepped down to 12Vpp using the transformer that feeds into synchronization switches [to the grid]. It is important to note there is a main cutoff switch installed for the DC power supply in order to cut power to the mechanical branches and that is must be switched ON in order to operate those generation points.

2.2 FEEDBACK LOOP

2.2.1 Refer to the software read-me file and the user's manual for operating the MSP430s and using the code.

2.2.2 The buck boards (motor drivers) are rated at 13A and should not experience any issues. Make sure to tie the "DIR" directional pin to ground so that the motor only spins in one direction (this should already be set up).

2.2.3 When powering up the system, power the 3V and 5V sockets. Wait 5 seconds before turning on the 24V switch, otherwise the generators will turn on automatically. After 5 seconds, the user chooses when the generators turn on by pressing the "reset" button on the MSP430s.

2.2.4 The up/down frequency buttons (next to the MSP430s) were included by customer request at the end of the year—although there is limited documentation of these buttons in our previous reports, the buttons are simple and easy to use. If you want the alternator frequency to be slightly higher or lower, press the buttons accordingly. To reset the frequency to 60Hz, simply press the MSP430's RESET button. However, do not do this while the generators are synchronized. These buttons are intended to slightly change frequency so that synchronization is easier (it can make the LED dim and brighten slower).

2.3 SYNCHRONIZATION CIRCUITS

2.3.1 The sync circuits are simply an LED, resistor, and two switches, and rarely lead to issues. Sometimes they get moved around and have trouble sticking back onto the cart; just stick them back on.

2.3.2 To visually watch synchronization, probe both sides of the sync circuits. To probe the generator side, place a probe on the exposed leg of the smaller switch (the side with the green tab). To probe the grid side, place another probe on the terminal block or breadboard wire coming from the closest transmission line (without a resistor/ Lego block between).

2.3.3 The big toggle switches are hot glued to the boards and should be treated gently. They're stuck well, but it is recommended to hold the switch while toggling the generator to the grid.

2.4 TRANSMISSION LINES

2.4.1 The delta configuration of 3 transmission line PCBs is connected in a loop. The loop includes 3 series power resistors encapsulated in LEGO housings that are strategically placed for limiting the current drawn from a generator. Each of the 3 generators connects to the grid out at a node between two different transmission boards. This triangular setup is designed to power all sections of the network when a single generator is energized and closed in.

2.4.2 The transmission PCBs carry 6 switches that may be turned on and off at any time whether or not there is power. If an overcurrent condition exists, turning off S1, S2, S4, and S5 (the 4 outside switches) quickly isolates the transmission lines from the source. There will be live open circuit voltage at the output of the generator, but no path for a short circuit. In addition, this protects any loads or current sensors that are hooked up to the load points. The primary emergency contact to open for motor-alternators remains the 24V switch located at the cart's top level. Since the transmission lines are made of power resistors, inductors, and capacitors rated for current below 2A, any trace of overheating should be dealt with immediately to preserve the integrity of the boards.

2.4.3 The transmission line PCBs have several RLC surface-mount components. The capacitors, in theory, are in parallel with the generators. As a safety precaution, each of the 4 capacitor components is placed in series with a basic resistor. The design is meant to control the AC short-circuiting that occurs when electrolytic capacitors see the constantly-reversing polarity from a sinusoidal source. It is important to handle the PCBs carefully. Although the inductors are firmly soldered into through-holes with applied tension, they still tend to shift when the boards are moved around. The Tamia connectors on the 4 sides of a transmission line can safely connect to any component with a female input header. There may be cases where the grid is energized, but the multi-meter/oscilloscope is not reading voltage. Look to troubleshoot the connectivity of the Tamia connectors. Excessive bending at acute angles will occasionally cause connection problems. If the PCB is misbehaving impedance-wise, please take the time to use an ohmmeter to assess the conductivity of the RLC components.

2.5 LOADS

2.5.1 The loads provided with the smart grid test facility are binary coded which means that the switches on the boards each correspond to the corresponding bit in an 8-bit number. The boards have been designed such that arranging the bits in any order from 0000 0000 to 1111 1111 will result in a different passive load value being seen by the loaded circuit. To "switch a load in" one must throw the adjacent switch to it's green setting. Taking it out is the reverse.

2.5.2 There are each resistive, inductive, and capacitive loads totaling three distinct PCB's. Due to cost and manufacturing constraints, the capacitor board is not perfectly operational, because the capacitors available were found to have a 20%-50% tolerance.

2.5.3 Included with the product is an Excel calculator that helps the user determine the phase angle of current after it flows through any given load board when it is hooked up to a transmission board. This can be used to calculate the results of other load values besides the values that are preset in the spreadsheet.

2.6 DATA ACQUISITION

2.6.1 The Data Acquisition system provided is not meant for precise measurement. Due to the nature of the components, their precision, the LABJACK, and the project overall, it is recommended that the DAQ only be used to acquire general conclusions regarding grid characteristics.

2.6.2 In addition, for high impedance loads where the current magnitude is in the tens of milliAmps, the software will plot a relatively noisy signal with noise of about +/- 5 milliAmps. This is completely normal, as the PCB was mainly designed for high current operations > 100 milliAmps.

2.6.3 Software wise, please refer to the users manual and the software readme before operation as they both contain very important information. In addition, do not feel limited to using our code/ MATLAB while using the project. MATLAB and LABJACK was specifically chosen, by us, to allow for easy and economical modification by BU students/faculty.