T07

Thermal Monitoring Unit

*System Test Plan*

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Rev 3.0

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*System Test Plan*

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**1.0 Introduction**

This device will monitor the temperature and current of a busbar and output the current and temperature of the busbar to a visual display.

This is the document that describes all the equipment in the system, as well as all the equipment used to test the system. This document describes the procedures that will be followed to test the system.

1. **Reference Documentation**
   1. *Design Documentation*

**System Specifications**

|  |  |  |
| --- | --- | --- |
| **Marketing Requirement** | **Engineering Requirements** | **Justification** |
| 1,2,3 | 1. System shall have two input sensors. | The output temperature should correspond with a current. |
| 3 | 1. PCB used board shall be no greater than 16 inches squared | This is a limitation given by the project requirements |
| 2,3,4 | 1. Voltage shall not exceed 5V for input. | To keep the system safe and cost effective the voltage should remain low. |
| 3,4 | 1. System should be able to function at temperatures greater than 10°C and less than 120°C | Busbars can be operated between these temperatures. Unit will be in close a closed structure. |
| 1,2,3 | 1. Unit should monitor temperature within the 10°C to 120°C range | This limitation will keep the cost of the temperature monitor low. |
| 2,3 | 1. The accuracy of the measured current should be within 5% | There are a wide variety of current monitoring devices that can accomplish this. |
| 1,2,3 | 1. The accuracy of the thermal sensor should be within 2°C | There are a wide variety of thermal sensors that can accomplish this. |
| 1,3 | 1. System should be able to take samples between 1 second to 10 minutes. | Range of time is feasible since unit will analog monitoring capabilities. |
| 2,3 | 1. System will be powered by a 9V battery. | For easy transportation and mobility. |
| **Marketing Requirements**   1. The system should monitor temperature and current simultaneously 2. The system should be easy to operate and install 3. The system should have low cost 4. The system should be as safe as possible | | |

1. **Thermal Monitoring System Overview**

*3.1 Operational Description*

This device will monitor the temperature and current of a busbar using an infrared temperature sensor and a current transformer. The System will be controlled by a microcontroller powered by a 9 Volt Battery. The power to the microcontroller will be brought to 5V through a voltage regulator. The microcontroller will take a digital input from the Infrared Sensor and output the temperature reading to a LCD screen. Concurrently the microcontroller will take an analog input from the rectified output of a Current transformer and output the current to the same LCD screen.

*3.2 Definition of Terminology*

Infrared Temperature Sensor – A device that uses infrared to measure temperature without contact. The temperature is inferred from an object by the thermal radiation of the object

Current Transformer – A transformer that uses the magnetic field of an AC current to induce a secondary current in the secondary windings of the transformer. The secondary current is proportional to the turns ratio between the primary and secondary windings.

Microcontroller – A small computer on a single integrated circuit containing a processor core, memory, and programmable input and output peripherals.

Voltage Regulator – A device which limits the voltage output to maintain a constant voltage level.

LCD screen – A digital display that uses liquid crystal cells that changes reflectivity in an applied electric field.

*3.3 Computational Method*

IR: The computational methods used to calculate the output of the temperature were taken from the internally stored data in the IR. The algorithm was taken from the bildr.org/2011/02/mlx90614-arduino/ .

CT: The computational methods for describing the current of the CT. Were derived using the 100:5 ratio of the CT. The voltage output of the CT was measured at different currents and a linear relationship was calculated using the y = mx + b formula.

1. **Testing**
   1. *Test Equipment*

Oscilloscope: TPS 2012B

The oscilloscope was used to test the output current of the SR-51A as well as the output voltage of the CT.

Multimeter: Extech Instruments 420

The (name) was used to verify the output voltage of the CT, as well as the current that would be output to the microcontroller.

Current Meter: Fluke 322

The current meter was used to measure the output current of the CT.

SR-51

The SR-51A was used to output current to the CT.

* 1. *Test Setup*

The System will be tested in the Power Lab at PSU since all the test equipment is located in the Lab. A prototype will be built using components on hand to reduce total cost of testing. This prototype will be used to complete tests 5.1 – 5.8. After the prototype has passed all these tests the System will be built on the PCB board and tests 5.1-5.9 will be ran.

1. **System Tests**
   1. *Functional Tests*
      1. Power Supply and Voltage Regulator

This test will check to see if the power input pin is connected to the correct power jack stub. It will also verify that the ground pin will connect to the correct power jack stub. The output of the power pin shall be verified to connect to the voltage regulator input. The ground pin of the voltage regulator shall be verified to connect to the ground. The output of the voltage regulator shall be verified to connect to the power inputs of the smart cable, microcontroller, LCD, and IR.

* + 1. LCD

The LCD shall be tested to see if it receives power from the power supply and grounds to the ground on the PCB board. The pins that connect to the microcontroller shall be tested and verified.

* + 1. IR

The IR shall be tested to see if it receives power from the power supply and grounds to the ground. It shall also be tested to verify that the correct pins go to the microcontroller.

* + 1. CT

The CT shall be tested to see that it receives power from the output current of the SR-51A and grounds to the ground. It shall also be tested to see if the pins are set up for rectification and the out put of the CT will go to the microcontroller.

* 1. *Correct Power To Microcontroller*

This test will check to see if the 9V battery supply is reduced to 5V through the voltage regulator. The battery shall be connected to the power jack on the prototype board. The power jack shall be tested so that the ground pin goes to ground and the power pin goes to power.

The input on the voltage regulator will be tested to see if it receives 9V. The ground pin on the voltage regulator shall be tested to see if it goes to ground. The output of the voltage regulator shall be tested to see that it outputs 5V.

* 1. *Microcontroller Input and Output (Blinking Light Test)*

Once the power and voltage regulator have been verified to be in correct order, the smart cable pins shall be soldered onto the prototype board. The microcontroller and crystal shall also be soldered onto the prototype board. A simple LED and resistor shall be soldered onto the board as well. Once these components are soldered, a blinking light program will be loaded onto the microcontroller to test that microcontroller can be uploaded to. If the upload fails, check all connects for faults, and fix faults. Once upload is complete run program and verify that LED blinks. If LED doesn’t blink verify that connections are correct, and fix.

* 1. *LCD Input and Output (Hello World Test)*

Solder LCD pins on prototype with jumper wires. Connect jumper wires to LCD on breadboard. Load “Hello World” program onto microcontroller. Run program. Verify that program works. If program doesn’t work check connections and fix.

* 1. *IR Input and Output*

Solder jumper wires onto IR pins. Load IR program onto microcontroller. Using DC voltage source put small DC voltage across pin inputs (0.1-.05V). Verify that LCD is outputting a reading. If does not comply with expected output check connections and fix. Connect voltage supply through a voltage divider and verify that LCD is outputting a reading. If does not comply with expected output check connections and fix.

* 1. *Current Transformer Input and Output*

This test will verify that the measured 0-80A (input) will transform to the 0-4A and give an output of 0-1.2V across the 0.4ohm power resistor. The current transformer will be mounted onto the 0-80A current carrying wire and the rectified voltage across the power resistor will be measured for the full range of input amperage. The input amperage will be monitored via the oscilloscope using a current clamp. The corresponding dc output values will be measured by the oscilloscope as well.

* 1. *CT Output to LCD*

This test will verify that the measured analog value (0-1.2V) on the output of the current transformer is read by the microcontroller and the corresponding current value is displayed on the LCD screen. At this point both the LCD and the output on the current transformer have been tested to work correctly. This test is to make sure the integration of the separate modules is functional. The output voltage of the current transformer will go to analog input pin 26 on the microcontroller. The value displayed on LCD screen should correspond to the actual amperage value in the current carrying wire. A current clamp and an oscilloscope is to be used to monitor the actual current.

* 1. *IR Output to LCD*

At this point the microcontroller is working and the previous test programs have been successfully uploaded onto the board. It time to test the infrared temperature sensor. Test wires will be attached to the pins on the PCB board corresponding to the sensor’s inputs/outputs. The sensor will be connected to the test wires on a bread board. A test program consisting of code only for the IR sensor will be uploaded to the controller. If integration is successful and temperature values are being displayed on the computer, the LCD will be connected. Additional test code will be added to verify that the measured temperature value is displayed onto the LCD. Displayed temperature values will be compared to a heat gun measurement for an accuracy check.

* 1. *CT and IR Output to LCD*

So far all of the individual modules have been tested and are functional. The current transformer, microcontroller and LCD screen have been successfully integrated. The infrared sensor, microcontroller and LCD screen have been successfully integrated. The following test is to integrate all of them together and test the full combined code. If successful, both the current value and temperature values should be continuously displayed on the LCD at the same time. To make sure the values are correct, an oscilloscope will be used to monitor the measure current and a heat gun to monitor the temperature.

* 1. *Acceptance Test*

Mount System in enclose. Test temperature range from ambient to 200 degrees Fahrenheit. Test the current from 40A to 80A. System will be deemed acceptable if the outputs are correct.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test Writer:** Jose Aguilar | | | | | | | | | | |
| **Test Case Name:** | | | Current Transformer Confirm Test | | | | | | **Test ID:** | PSVS1 |
| **Description:** | | | Verify the current amount running through the busbar and confirming a =/-5percent correct voltage reading. Should jump by a ratio of .066 | | | | | | **Type:** | white box |
| **Test Information** | | | | | | | | | | |
| **Name of Tester:** | | | | Jose Aguilar | | | | | **Date:** | 11/21/14 |
| **Hardware Version:** | | | | - | | | | | **Time:** | 11:30 |
| **Setup:** | | | | Connect CT to Rectifier and connect to microprocessor | | | | | | |
| **Test** | **Vt** | **Expected Output** | | | **P** | **F** | **N/A** | **Comments** | | |
| **Vo** | | |
| 1 | 0 amps | 0.000 | | |  | X |  | Still some slight voltage but was concluded to a bad connection using a capacitor. Cap was not fully discharged | | |
| 2 | 20 amps | .1320 | | | X |  |  |  | | |
| 3 | 40 amps | .2640 | | | X |  |  |  | | |
| 4 | 60 amps | .3940 | | | X |  |  |  | | |
| 5 | 80 amps | .5280 | | |  | X |  | Some adjustment is needed to work on the saturation of the CT | | |
| 6 | 100 amps | 1.2 | | | X |  |  |  | | |
| **Overall Test Results:** | | | | | X |  |  |  | | |
| **Plan of Action** | | | Continue to double check the CT voltage output to properly read the amperage on the busbar. | | | | | | | |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Test Writer:** Rob Newcomb | | | | | | | | | | |
| **Test Case Name:** | | | Power Supply Test | | | | | | **Test ID:** | PSVS1 |
| **Description:** | | | Verify that voltage is 9V in and 9V out of Power jack. Verify that the Voltage into regulator is 9V and voltage out is 5V. | | | | | | **Type:** | White Box |
| **Test Information** | | | | | | | | | | |
| **Name of Tester:** | | | | Rob Newcomb | | | | | **Date:** | 11/21/14 |
| **Hardware Version:** | | | | - | | | | | **Time:** | 11:30 |
| **Setup:** | | | | Connect Battery to Pwr Jack and verify voltages with multimeter | | | | | | |
| **Test** | **Vt** | **Expected Output** | | | **P** | **F** | **N/A** | **Comments** | | |
| **Vo** | | |
| 3 | 9V | 9V | | | X |  |  | Had to add mod wire to connect Jack GND to board GND | | |
| 4 | 0V | 5V | | | X |  |  |  | | |
| **Overall Test Results:** | | | | | X |  |  |  | | |
| **Plan of Action** | | | Test Power to uC | | | | | | | |

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| **Test Writer:** Michael Meza | | | | | | | | | | |
| **Test Case Name:** | | | LCD Screen Test | | | | | | **Test ID:** | PSVS1 |
| **Description:** | | | Verify that LCD screen will receive voltage and displays desired text. | | | | | | **Type:** |  |
| **Test Information** | | | | | | | | | | |
| **Name of Tester:** | | | | Michael Meza | | | | | **Date:** | 11/22/14 |
| **Hardware Version:** | | | | - | | | | | **Time:** | 2:00 pm |
| **Setup:** | | | | Connect Battery to Power Jack and verify voltages with multimeter then write code for LCD to display text and receive range of numbers. | | | | | | |
| **Test** | **Vt** | **Expected Output** | | | **P** | **F** | **N/A** | **Comments** | | |
| **Vo** | | |
| 1 | 5V | Receive text “hello world ”and count | | | X |  |  |  | | |
| 2 | 5V | Variable text  “temp:” 0-80 | | | X |  |  | Was Able to see temperature change with minimal lag. | | |
| **Overall Test Results:** | | | | | X |  |  |  | | |
| **Plan of Action** | | | -connect to IR and test IR output to LCD | | | | | | | |

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| **Test Writer:** Rob Newcomb/Dmitry Leonchik | | | | | | | | | | |
| **Test Case Name:** | | | Board Connections Test | | | | | | **Test ID:** | BL1 |
| **Description:** | | | Verify that all connections are correct on PCB Board with schematic and multimeter | | | | | | **Type:** | White Box |
| **Test Information** | | | | | | | | | | |
| **Name of Tester:** | | | | Dmitry Leonchik | | | | | **Date:** | 11/21/14 |
| **Hardware Version:** | | | | - | | | | | **Time:** | 11:30 |
| **Setup:** | | | | Take PCD board and test connections with Multimeter | | | | | | |
| **Test** | **Vt** | **Expected Output** | | | **P** | **F** | **N/A** | **Comments** | | |
| **Ohms** | | |
| PS | 0V | PWR to VR PWR: 0  GND to PCB GND: 0 | | | X | X |  | Mod wire needed to connect power GND to board GND | | |
| VR | 0V | Pin to Pout: 0  Pin to GND: 0  Pout to GND: 0 | | | X  X  X |  |  |  | | |
| uC | 0V | Pin1 to Resistor to PWR: 0  Pin2 to TX: 0  Pin3 to RX:  Pin4 to D7: 0  Pin5 to D6: 0  Pin6 to D5: 0  Pin7 to PWR: 0  Pin8 to GND : 0  Pin9 to Crystal: 0  Pin10 to Crystal: 0  Pin11 to D4: 0  Pin12: N/A  Pin13: N/A  Pin14: N/A  Pin15: N/A  Pin16: N/A  Pin17 to E: 0  Pin18 to RS: 0  Pin19: N/A  Pin20 to PWR: 0  Pin21: N/A  Pin22 to GND: 0  Pin23: N/A  Pin24: N/A  Pin25: N/A  Pin26 to CT: 0  Pin27 to SDA: 0  Pin28 to SCL: 0 | | | X  X  X  X  X  X  X  X  X  X  X  X  X  X | X  X  X  X  X | X  X  X  X  X  X  X  X  X | Pin 17 was connected to IR  Pin 16 was connected to IR  Pin 26 had no connection  Pin 27 was connect to CT  Pin 28 was not connected | | |
| IR | 0V | Pin 27 to SDA: 0  Pin 28 to SCL: 0  PWR: 0  GND: 0 | | | X  X | X  X |  | Pin 27 was connect to CT  Pin 28 was not connected | | |
| CT | 0V | Pin 26 to +: 0  GND to -: 0 | | | X | X |  | Pin 26 had no connection  There are extra pins for this unit that are not used | | |
| LCD | 0V | Pin4 to D7: 0  Pin5 to D6: 0  Pin6 to D5: 0  Pin7 to PWR: 0  Pin8 to GND : 0  Pin17 to E: 0  Pin18 to RS: 0 | | | X  X  X  X  X  X | X |  | Pin 17 was connected to IR | | |
| CRY | 0V | Pin 9: 0  Pin 10: 0 | | | X  X |  |  |  | | |
| SC | 0V | TX: 0  RX: 0  PWR: 0  GND: 0  RESET to cap to uC Reset: 0 | | | X  X  X | X  X |  | Not connected to main power. No cap for reset. | | |
| **Plan of Action** | | | | | Apply Mod wires to noted points and retest | | | | | |