School of Engineering and Energy
ENG470 Engineering Thesis

Re-commissioning of a Battery Charge Controller Test Setup

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A report submitted to the School of Engineering and Energy, Murdoch University in partial fulfilment of the requirements for the degree of Bachelor of Engineering
“I hereby declare that this thesis document is submitted to the School of Engineering and Energy, Murdoch University in partial fulfillment of the requirements for the degree of Bachelor of Process Instrumentation and Control Engineering is my own work except the idea was referenced. The document has not been submitted to any other school or academic institution.”

Signature : ___________________________

Name : Muhamad Nurfifi Pauzi

Date : 19 JANUARY 2017
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Abstract

The School of Engineering and Technology at Murdoch University offers a major in Instrumentation and Control Engineering. Students who are enrolled in this major have an opportunity to choose a second major in Renewable Energy System Engineering. This second major helps students to expand their knowledge in Renewable Energy by conducting a research project in final year. Students are able to develop skill and knowledge in using the LabView, battery charge controller, solar array simulator, load bank, and battery simulator.

The main goal of this thesis is to re-commission a battery charge controller test setup. The test setup integrates the performance and functionality of battery charge controller following the standard IEC (International Electrotechnical Commission) 62509.

This thesis illustrates the main idea of the components involve in battery charge controller test setup and its working principle. The problem arising from the Research Institute for Sustainable Energy (RISE) and its Renewable Energy Systems Laboratory (RESLAB) were principally involved in developing battery charge controller test procedures documented in the IEC62509 International Standard. In this document, the performance and functioning of battery charge controller will be investigated and examined in a selected test.

This report first provides an introduction to battery charge controller following with the objectives of the project. Chapter 2 overviews the literature review of battery charge controller and types of battery charge controllers. Chapter 3 continues the methodology used to complete this test setup consists of standard test procedures. Chapter 4 presents an overview of the project, instruments involved in test setup and the user interface. Chapter 5 discussed the outcomes of the result, discussion and problem in chapter 6, and chapter 7 concludes outcome learning of this project with future work. The report also lists the reference list and appendices with contain related information to the project.
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Mrs. June Burnett
Abbreviation

BCC- Battery charge controller

IEC- International Electrotechnical Commission

MPPT- Maximum Power Point Tracking

VOC- Voltage Open Circuit

PWM- Pulse Width Modulate

PV- Photovoltaic

RISE- Research Institute for Sustainable Energy

RESLAB- Renewable Energy Systems Laboratory

SAS- Solar Array Simulator

VOC- Voltage Open Circuit
1 Introduction

1.1 Project Background

This chapter provides relevant background information for the thesis project. The reason of developing a battery charge controller test setup is to test and analyze the performance and functionality of Battery charge controllers. Besides, the battery charge controller gives an opportunity for end user to key in and adjust parameter value in testing the charge controller. In this project, LabView will be used as interface with the data logging ability. Previous used equipment will be used to perform the task by following the standard test procedures for every test setup from the given references.

The first section reviews the functionalities of Battery Charge Controller’s (BCC). The second section describes different types of BCC’s and provides details on the BCC used for testing this project. The third section shows the test setup of BCC and reviews the role of RISE and Reslab in developing BCC. The fourth section provides the overview of tests setup and integrated components. The fifth section provides and analyses results from selected BCC tests using the test setup. The sixth section discusses outcomes of the result with the arising problem. This report finished with the conclusion of the project outcomes and future work to be done.

1.2 Project Objective

The main objective of this project is to re-assemble and re-commission a previously existing battery charge controller test setup. Previous used equipment will be used to perform the task by following the standard test procedures for selected test setup according to the standard test procedure.

The second objective is, to perform selected performance and functionality tests of the PL40 Battery charge controller.
Re-commissioning of a Battery Charge Controller Test Setup

The third objective is, to create a user-friendly test setup with easy parameter adjustment capability. This will provide end user to key in and adjust parameter value in testing the charge controller. In this project, LabView will be used as an interface with the data logging ability.

Finally, the aim of this project is significantly for education purpose for an incoming engineering student. In addition, its purpose is to develop and upgrade the existing battery charge controller test setup in future.

2 Literature Review

2.1 Battery Charge Controller

The battery maintains its current and voltage level at certain stages by using battery charge controllers for regulating purpose. A battery charge controller is a device which has been designed to optimize the system performance by regulating power source into or from the battery at different stages. There are three different types of stages as shown in Figure 1 below which are bulk stage, absorption stage, and float stage. At the bulk stage, battery current is at its maximum charge current while an increase in a battery voltage. A constant voltage absorption while reducing the absorption of current is called as Absorption stage. Float stage is where a voltage and current is floating at a certain level and remain constant.[1]

![Figure 1: 3 different stages of battery charging [1]](image-url)
Basic setup of Battery Charge Controller system as shown in Figure 2.

There are 7 basics functions of a controller:

1) Blocking reverse current
2) Preventing overcharge
3) Control Set Points vs. Temperature
4) Control Set Points vs. Battery Type
5) Low Voltage Disconnect
6) Overload Protection
7) Display and Metering
2.2 Types of Battery Charge Controllers

There are four different types of solar charge controllers:

2.2.1 Shunt Controller

Shunt controller as illustrated in Figure 3 below, is most suitable for use in small systems (less than 20amps) and considered as a standard charge controller. The ability to shunt the power sources by bypassing the batteries when its fully charge resulting the battery from overcharging. A blocking diode is located series between array and battery. Shunt controller is cheap, simple design and a reliable charge controller for a small system. A one-way blocking diode serves as a single way which only allowed current to flow in a battery while prevent the current to withdraw back into the array during at night. S1 will shunt the circuit when the battery is fully charged while S2 will disconnect the load when voltage reaches below the minimum level of the discharge point. [2]

![Schematic diagram of Shunt Controller](image1)

Figure 3: Schematic diagram of Shunt Controller[3]
2.2.2 DC-DC Converter Type Charge Regulators

DC to DC converter used to convert the output of PV generator to a variable load. The concept of the converter is by step up or step down the voltage. Three types of DC to DC converters such as Buck (Step-down) converter, Boost (Step-up) converter, and Buck-Boost (Step-down/up) converter as shown in Figure 4, 5 and 6 below.\[4\]

![Figure 4: Buck Converter](image)

![Figure 5: Boost Converter](image)
2.2.3 Pulse Width Modulation (PWM) Controller

PWM stands for Pulse Width Modulation (PWM) which is often used in BCC’s for float charging. This type of controller will rapidly turn on and off the switch and send out a series of short charging pulses to the battery. The working principle of PWM depends on the battery status. If the battery is fully charged, it will send just a “tick” few seconds while if the battery is discharged, it will send a long pulse until the battery goes into fully charged mode again. It has an ability to check the status of the battery by analyzing the wide of the pulse and automatically adjust itself each time. However, PWM has a minimum level voltage where if the battery is drawn too low, power cannot be supply to the battery.

2.2.4 Maximum Power Point Tracking (MPPT) Controller

MPPT controller can be divided into two groups which are: [5]

1) Indirect MPPT

Used to estimate the voltage of MPP by making simple assumptions and measurements. Enable the voltage of solar generator to be adjusted seasonally without being affected by surrounding. However, it only estimates the optimum operating point because it is not able to regulate the characteristic of the solar generator.
2) Direct MPPT

An optimum operating point provides to PV generator from measured current, voltage, and power. Hence, in this system the generator able to regulate the changes and achieve optimum performance.

The MPPT controller able to work with higher voltages supply from a series of panels setup. This controller can extract the most current charge from the PV module during cold or sunny day. However, it produces a very little output to the batteries during low light levels.

3 Methodology

The development of a battery charge controller test setup is based on the standard test procedures according IEC 62509 Ed.1. The standard test procedures describe the requirement or basic setup for each kind of test setup. Three references method that been used in this project:

1) IEC 62509 Ed.1: Performance and functioning photovoltaic battery charge controllers

2) PV GAP PVRS 6A Charge controllers for photovoltaic (PV) stand-alone systems, with a nominal system voltage below 50V. Annex — Specification and testing procedure, to PVRS 6, 06/2000.

3) ResLab Document ref: TP-RESL-T-0016

3.1 RISE/Reslab activities on BCC Testing Standard Development

The research Institute for Sustainable Energy (RISE) and its Renewable Energy Systems Laboratory (RESLAB) were principally involved in developing battery charge controller test procedures documented in the IEC62509 International Standard. This document reports on the validation process and results for ResLab’s Battery Charge Controller (BCC) Test Procedures (TP-RESL-T-0016). These procedures are based on the draft standard “Performance and functioning requirements for
PV battery charge controllers” which is being developed under the IEC committee. It is also intended that these test procedures cover the requirements of PVGAP PVRS6A “Charge controllers for photovoltaic (PV) stand-alone systems, with nominal system voltage below 50V”. [6]

3.2 Selected Tests

There are four major tests available under IEC 62509 Ed.1 with minor sub test. Objective and condition for each of the test can be refer to clause 9.2: [7]

General Conditions for Tests

- Setup and Preconditioning for Tests
- DC Power Sources for Testing
- General Test Setup
- Charging Cycle Test Setup
- Efficiency, Thermal Performance and PV Over Current Test Setup

1) Battery Lifetime Protection Tests

- Battery to PV Array Leakage Current Test
- Charging Cycle Tests
- Load Disconnect / Load Reconnect Test

2) Energy Performance Tests

- Standby Self Consumption Test
- Efficiency Test
3) Protection and Fail-Safe Tests

- Thermal Performance Test
- PV Over Current Protection Test
- Load Over Current Protection Test
- Battery Reverse Polarity Test
- PV Array Reverse Polarity Test
- Battery Open Circuit Test

4) User Interface Tests

- General

These are a full list of option that can be test and analysis under given standard procedures. Every tests strategy will determine the efficiency, performance, and quality of a battery charge controller. Only selected highlight tests were performed and conduct.

4 Project Overview

4.1 Battery Charge Controller

Battery Charge Controllers are also called Battery Charge Regulators, Charge or Load Controller and Voltage Regulators. Based on IEC (International Electrotechnical Commission 2010) it is called as Battery Charge Controllers as a standard term. PL40, as shown in Figure 7 with the specifications shown in Table 1, will be used as BCC with its capability as a controller which capable to adjust the function. The most interesting part is it can display the performance of the system. PL40 integrated with a regulator which will disconnect the system when it detects a low battery. It also gives a freedom to operate the system according to user interest. As an example, the user might be able to set the power on and off by adjusting the controllers. It also will display a daily charge and discharge,
load, amp, and minimum or maximum battery voltages on the LCD display and hold the memory for a month in case user forgot what happened.

Figure 7: PL40 user guide. [8]

Table 1: Performance and Specifications of PL40. [8]

<table>
<thead>
<tr>
<th>Parameter</th>
<th>PL40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal System Voltages</td>
<td>12-48V</td>
</tr>
<tr>
<td>Solar Charge Current Maximum</td>
<td>40A</td>
</tr>
<tr>
<td>Load Switch Current Maximum</td>
<td>7A</td>
</tr>
<tr>
<td>Voltage Drop at Rated Current</td>
<td>0.4V</td>
</tr>
<tr>
<td>Supply Current</td>
<td>14mA</td>
</tr>
<tr>
<td>Battery Temperature Sensor Range</td>
<td>-5 to +50</td>
</tr>
<tr>
<td>Weight</td>
<td>320</td>
</tr>
</tbody>
</table>
Basically, charge controllers prevent battery form over charged and discharged, prolong battery lifetime, and avoid electrical overload. Battery charge controller will regulate the suitable level voltage to be stored automatically. Hence, it will run the appliances in a safe way and keep battery efficiency and capacity at its optimum. Some of the modern charge controllers has a low voltage disconnect (LVD) built in. The purpose is to automatically reconnect or disconnect the circuit when it recovers from low battery voltage or detecting to high current draw respectively.

4.2 PV simulator

A photovoltaic act as a source by supplies the current to the battery. However, there might be a reverse current in direction during the night. As a result, the battery will slightly discharge. Hence, the diodes may be implemented in the circuit either on positive or negative of the connection. Diodes will prevent the current from being drawn back to the PV array and maintain the battery voltage level. However, PV simulator as shown in Figure 8 will be used in this project as input for Battery Charge Controller. In another word, PV simulator will be used instead of real PV. This is due to best characteristic result to determine charging setpoint to those expected with a real PV. PV simulator has a better response and more stable which will provide better performance evaluation. It can provide an accurate I-V curve anytime with parameters such as open circuit voltage, and short circuit current.
Figure 8: Solar/PV array simulator

The simulated PV input approach is preferable because it does not rely on environmental conditions for testing. It also allows performing the tests under more controlled standard conditions. The use of a PV simulator has been identified as the best approach to be used as the PV input for testing of BCCs to determine charging setpoints. This method provides operation characteristics closest to those expected with a real PV input.

4.3 Battery Simulator

The role of the battery is to keep maintaining the suitable voltage level in the battery by keeping regulating a charging-discharging cycle. The minimum ratings for voltage should be greater than 1.4 nominal battery voltages and for current 1.25 greater than the rated battery charge controller battery charging current. Battery simulator is the most appropriate component to use since it will save a lot of time. The real battery might consume a lot of testing time because of the charging cycle without considering the battery size and efficiency. By using a simulator in Figure 9, the user can
easily change the battery voltage in a short time without the need to be waiting for hours for the battery to be charge or discharge. Hence, battery simulator is ideal for every single kind of test.

Figure 9: Agilent Battery Simulator

Battery simulator represents the properties of real batteries which supplies current, voltage and power to the load or device same as the actual battery. Working principle of battery simulator same as real battery, however, it provides high transition speed without facing any problem. Basic charging cycle for real battery from a dead battery to the full up to several hours depending on battery size and charging regime which is simulator only merely take a few seconds. This will ease user to monitoring, observing and analyzing the process or system behavior. Furthermore, it may not be practical to have a range of batteries to cater for all battery voltages and Ah ratings used in PV systems.
4.4 Project Test Setup

Findings from the topic, Photovoltaic simulator, controllable load banks and DC power supplies are an essential part to develop battery charge controller test setup. Each of the components plays an important role in the successful Battery Charger Controller system test setup as shown in Figure 10 and Figure 11. For other miscellaneous equipment can refer to appendix 9.1.

*Figure 10: General Test Setup[7]*

*Figure 11: Project Test Setup*
4.5 Program Interface

4.5.1 LabView

Computer has started to be used as a medium in the laboratory almost five decades ago. It is started with a very large physical machines and fit room-size. At the beginning, computers do not be used widely as it is only able to be used as calculating devices or display system. [9]

However, this machines massively used as collecting and displaying data in a real-time with exact results nowadays. How impressive it is from a room-size into very small size devices that are almost ten to fifteen times smaller. In this project, LabView software from National Instrument Corporation will be used as interface software companion with DAQ card hardware. LabView plays an important role in collecting, analyzing and controlling data in real time. [10] LabVIEW is a virtual interface engineering software used for basic to complex system. It is widely used in developing stand-alone configuration system with applications that require a test, measurement, and control with rapid access to hardware and data insights. [11]

Figure 12: DAQ card PCI 6220 m-series[12]

PCI 6220 m-series from National Instrument consists of 24 digital I/O, 16 analog inputs with 16 bits is used as data acquisition as shown in Figure 12 above. M-series offer enhanced functionality for cost-sensitive applications, high accuracy and faster speeds. National Instrument specifically design m-
series DAQ card to use with the driver software for application development in LabView. The LabVIEW programming environment makes things easier for hardware integration for engineering applications. Hence, it can have a consistent way to acquire data from NI and third-party hardware. LabVIEW reduces the complication of programming by provided immediately visualize results and focus more on an exceptional engineering problem. It had built-in, drag-and-drop engineering user interface creation and integrated data viewers. Standard parameters for this project include current, voltage, efficiency, power, temperature from Photovoltaic simulator, controllable load banks, DC power supplies and BCC. VI (Virtual Instrument) which is a built-in function in LabView used to measure the parameters besides from taken reading on the instrument screen. IV works as monitoring system which can be designed and customize into own preference. Data acquisition system is performed via digital I/O lines between microcontroller in DAQ card LabView software interface. VI has three main parts which are front panel as a user interface as shown in Figure 13 and Figure 14, block diagram as graphical programming, and an icon that is used within another VI.

4.5.2 Front Panel

![Figure 13: Left-Battery parameter Right-Acquired Data](image-url)
5 Results Analysis

This section of the report presents the results obtained from the selected tests according to section 3.2. These tests strategy will determine the efficiency, performance, and quality of a battery charge controller. The first section presents cycle test under Battery Lifetime Protection Tests. The second section presents efficiency test under Energy Performance Tests. The third section presents load over current test and battery open circuit test under Protection and Fail-Safe Tests.

5.1 Cycle Test (Set-Point Measurements)

The aim of this test is to measure the charging set-points it is necessary to monitor a complete charging cycle including all available charging stages of the BCC under test. Refer appendixes 9.3.2 for standard test procedure, parameter and result. Only first page of data collection be shown in appendix since it is a very long list of data. The PL40 has four main charging stages of set points:

- Bulk stage
- Absorption stage
- Float stage
The other characteristic of the PL40 that makes set point determination a bit less straightforward is that the unit measures the open circuit voltage of the PV array every 2 minutes. This causes the battery voltage and charging current to go through transient states as shown in Figure 15.

![Figure 15: Full Cycle Test](image)

At bulk stage, battery current is at its maximum charge current while an increasing in a battery voltage. Bulk stage sometimes called as boost stage. A constant voltage absorption while reducing the absorption of current is called as Absorption stage. Float stage is where a voltage and current are floating at certain level and remain constant. According to the PL series manual, the regulating stages start after the maximum boost voltage has been reached and sustained for 3 minutes. This needs to be taken into consideration to determine the maximum boost voltage. The BCC has limited control over the battery voltage in the regulating modes (absorption, float and bulk). This is because the power supply unit used to simulate the battery is an active system which is itself trying to control the battery voltage, therefore limiting the ability of the charge controller to perform this function.

Need to be aware of the mode changes of the BCC and adjust the power supply unit to a value which is close to the programmed set point, therefore some bias and uncertainties may arise due to this.

The ability of the BCC to regulate the battery voltage is limited because it depends on the transient behavior of the PV input source and the battery power supply along with other passive components of the system. [6]
5.2 Efficiency Test

The aim of this test is to determine the power efficiency of the BCC shall be evaluated from 10 % to 100 % of the rated charging current, at a battery voltage equivalent to 2.2 V/Cell ± 2 % and at an ambient temperature of 25 °C ± 2 °C. Refer appendixes 9.3.3 for the standard test procedure, parameter and result. Only first page of data collection is shown in appendix since it is a very long list of data.

![Efficiency VS Battery Current](image)

**Figure 16: Battery charge controller efficiency**

The outcomes from efficiency test, as the charging current increase, battery charge controller decrease in efficiency as shown in Figure 16 above. There is no load involved in this test. The assumption from the graph, if the current rated testing in high current, there will be a significant decreasing of efficiency. The decrease of efficiency low due to the applied current levels being significantly lower than rated current for this BCC.

5.3 Load Over Current Protection Test

This test is carried out to evaluate the performance of the charge controller at 25° C and 125% of the rated load current. The maximum current load rating for PL40 equal to 7A. The test was set to 125%
of the rated load current which is equal to 8.25A. A circuit is overloaded when the current flowing in it is higher than it can safely handle. This can cause overheating and can even be a fire hazard. Refer appendixes 9.3.4 for standard test procedure, parameter and result. Only first page of data collection be shown in appendix since it is a very long list of data.

Figure 17: 125% overload maximum rated load current

Figure 17 presents the battery and load profile graph from load over current protection test. Load voltage and current, battery voltage significantly drops when there is overload current at the load terminal. This proved that PL40 has a protection against excessive current flows through the load to protect the charge controller and load itself. However, PL40 failed load over current protection test because it does not completely protect itself. The reason is after a few seconds, PL40 start to overheat and produce white smoke with a burnt smell refer to Figure 18. As an assumption, there might be a component inside the PL40 that had broken since the charge controller has not been used for a decade. According to the PL40 specification, the battery charge controller can protect overload current.
5.4 Battery Open Circuit Test

BCC with load terminals shall be protected from damage to itself and protect the load from the open circuit voltage of the PV array in the case of battery disconnection. Refer appendixes 9.3.5 for the standard test procedure, parameter and result. Only first page of data collection is shown in appendix since it is a very long list of data.
Re-commissioning of a Battery Charge Controller Test Setup

Figure 19 presents the voltage profile from battery open circuit test. Load voltage and PV array voltage significantly drop when there is an open circuit at the battery terminal. This proved that there is no direct voltage supply from PV into the load terminal. PL40 complete the battery open circuit test by protecting direct voltage contact between load and PV simulator.

6 Discussion

This section will provide the discussion and outcome from the previous result section.

1) Table 2 provides the result of four types of test, three of the test successfully tested while the other one fails.

<table>
<thead>
<tr>
<th>TYPES OF TEST</th>
<th>CONDITION</th>
<th>COMMENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>CYCLE TESTS (SET-POINT MEASUREMENTS)</td>
<td>COMPLETE</td>
<td>N/A</td>
</tr>
<tr>
<td>EFFICIENCY TEST</td>
<td>COMPLETE</td>
<td>N/A</td>
</tr>
<tr>
<td>LOAD OVERCURRENT PROTECTION TEST</td>
<td>FAIL</td>
<td>Produce white smoke and overheat the PL40. Due to overcurrent load.</td>
</tr>
<tr>
<td>BATTERY OPEN CIRCUIT</td>
<td>COMPLETE</td>
<td>N/A</td>
</tr>
</tbody>
</table>

2) It takes a very short time for the cycle test to complete all the stages (Bulk, Absorption, Float) by using battery simulator.[1]

3) The efficiency of the PL40 decreased when increasing the charge current. However, the decreasing of efficiency is low due to the applied current levels being significantly lower than rated current for this BCC.
4) Limit of 8 A maximum current for PV array simulator (PL 40 has a max. current of 40 A).

5) PL40 charge controllers able to protect the load from being directly supplied from PV Simulator through Battery Open Circuit test.

6) Laboratory temperature control is strongly recommended to achieve better measurement accuracies.

7) Current shunts should be used up to 2/3 of their rated capacity to avoid overheating and also to reduce the measurement uncertainty associated with temperature instability of the shunts.

### Table 3: Problem arising during the project

<table>
<thead>
<tr>
<th>Problem Encountered</th>
<th>Counter Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) An original instrument which is DC Power Supply (Battery Simulator) is broken.</td>
<td>Replace with another instrument by Technical Officer.</td>
</tr>
<tr>
<td>2) A lot of LabView program missing and had issues with compatibility software.</td>
<td>Outsource the previous version of LabView 8.2 and convert the file to the version of LabView 15.</td>
</tr>
</tbody>
</table>

### 7 Conclusion

As a conclusion from objective and result analysis, project successfully re-assemble and re-commission the existing battery charge controller test setup. It was a valuable experience to conduct the test up which had been left for a decade. However, not the installation was a problem, but the configuration each of instruments and the interface was the biggest problem during this thesis project.
In result section, proved that selected performance and functionality tests of the PL40 Battery charge controller has completely performed. Charging cycle test under battery lifetime protection able to complete charging cycle and all charging stages of the Battery charge controller. The efficiency of battery charge controller under energy performance test proved that PL40 was a good charge controller. However, the overload current under protection fail-self test failed because the controller did not cut-off the overload current terminal. PL40 should have the protection function, but it was due to the broken part inside the charge controller. Lastly, PL40 successfully protect the load from being directly connected to PV simulator voltage during the battery open circuit test.

End-user able to key in and adjust parameter value in testing the charge controller through LabView software following the clause 4.5.2. Battery charge controller PL40 can be performed by changing the parameter of Battery simulator, PV simulator, and load bank.

Apart from the view of the project, this project gives an easy understanding for educational purposes about the BCC roles. This test setup was a great opportunity to gain knowledge and ease incoming engineering students at Murdoch University.

7.1 Validation Process Summary

The validation process was carried out with the following steps:[6]

a) A continuous logging program logging programs verified testing of battery charge controllers. Both are intended to be used with testing systems of the isolation amplifier-DAQ card-logging program type.

b) Investigation of test configurations for PV input and battery for the types of tests required to be performed.

c) Analysis of factors affecting the measurement uncertainty for voltage, current, power and efficiency measurements.
d) Development of a calibration procedure for transducer-isolation amplifier-DAQ card-logging program measurement systems was developed for DC voltage and current measurements.

7.1 Future Work

Table 4: Project future to be performed

<table>
<thead>
<tr>
<th>Future Work/Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) Complete remaining test procedures on the PL40 to fully test the capabilities of the test setup.</td>
</tr>
<tr>
<td>2) Compile all the LabView program into a single program to ease a user.</td>
</tr>
<tr>
<td>3) Perform a test with different battery charge controller for different performance and functionality result.</td>
</tr>
</tbody>
</table>
8 References

### 9.1 List of Equipment

#### Table 5: Equipment List

<table>
<thead>
<tr>
<th>No</th>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Desktop Computer</td>
<td>The user interface for display purposes.</td>
</tr>
<tr>
<td>2</td>
<td>DAQ Card PCI 6220 m-series</td>
<td>Hardware which consists of sensors for data acquisition by measuring basic measurement for current, voltage, temperature and power.</td>
</tr>
<tr>
<td>3</td>
<td>Agilent 34970A DMM DAQ</td>
<td>Switch unit purpose with capabilities of data logger and data acquisition features.</td>
</tr>
<tr>
<td>4</td>
<td>Power Supply, Agilent 6692A</td>
<td>Also called as DC power supply, consume little time with high power dc supply (low noise) and optimize the accuracy. [13]</td>
</tr>
<tr>
<td></td>
<td>Component Description</td>
<td>Description</td>
</tr>
<tr>
<td>---</td>
<td>---------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>5</td>
<td>Current Shunt (PV, Battery, Load)</td>
<td>Low resistance resistor used for measuring DC electrical voltage drop across the resistance.</td>
</tr>
<tr>
<td>6</td>
<td>Voltage Divider (PV, Battery, Load)</td>
<td>Simply used to reduce the output voltage into fraction of the given input across the component by using two or more resistors.</td>
</tr>
<tr>
<td>7</td>
<td>SCM5B 40/41 Dataforth Isolation Amplifier</td>
<td>A single channel of analog input from wide bandwidth voltage input module which amplified and converted to a high-level analog voltage output.[14] Consist of special input circuit that will protect power-line against any fault connection.</td>
</tr>
<tr>
<td>8</td>
<td>SC-2311 NI Signal Conditioning box</td>
<td>SC-2311 consist of 5B Series modules for an analog signal such as voltage, current, resistance, temperature. It also comes with SSR Series modules which are used for digital signal conditioning. [15]</td>
</tr>
</tbody>
</table>
### Electronic Load Bank

**Purpose:**
Perform a test and analyzing of DC power supplies and batteries. It has an input range from 0-60V voltage and 0-60A current with power contour of 300W.

---

### Oscilloscope

**Purpose:**
Laboratory equipment mostly used to display, adjusting and analyzing the oscillation or waveform of any kind of variables such as voltage vs. time, amplitude, frequency and varying input-output.

---

### 9.2 Type of Tests

Standard procedures are minimum requirements established by International Standard to test the functioning and performance of Battery Charge Controller system. This standard compliance with IEC 62509. The International Electrotechnical Commission describes the procedure test and requirements with basic installation application. [7]
Table 6: General Conditions for Existing Tests Setup

<table>
<thead>
<tr>
<th>Type of tests</th>
<th>Objective</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Setup and Precondi</td>
<td>Mounted and installed BCC according to the manual and basic configuration.</td>
<td>BCC shall be installed in a temperature-controlled chamber for all tests.</td>
</tr>
<tr>
<td>tion</td>
<td>Test procedure shall not commence until the chamber and BCC temperatures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>have reached thermal stability.</td>
<td></td>
</tr>
<tr>
<td>DC Power Sources</td>
<td>To measure the voltage at the BCC terminals as shown in Figure 2.</td>
<td>Minimum ratings:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• VOC &gt; 2*VBAT-NOM</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ISC &gt;1,25*IBCC-IN</td>
</tr>
<tr>
<td>Charging Cycle</td>
<td>Required voltage and/or current ratings at a certain value for testing</td>
<td>Preferred PV simulator.</td>
</tr>
<tr>
<td></td>
<td>and evaluation purpose.</td>
<td></td>
</tr>
<tr>
<td>Efficiency, Thermal</td>
<td>A battery simulator is most suitable as it can maintain a constant voltage</td>
<td>Battery terminals should remain constant during the test.</td>
</tr>
<tr>
<td>Performance, and PV</td>
<td>The use of voltage and current controlled power supply unit (PSU) is</td>
<td></td>
</tr>
<tr>
<td>Over Current</td>
<td>suitable for this test as long as it operates in voltage regulation mode</td>
<td></td>
</tr>
<tr>
<td></td>
<td>and supplies current to BCC at all times during the test.</td>
<td></td>
</tr>
</tbody>
</table>
### Table 7: Battery Lifetime Protection Tests

<table>
<thead>
<tr>
<th>Type of tests</th>
<th>Objective</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Battery to PV Simulator</td>
<td>To measure the reverse current through the BCC from the battery to the PV simulator.</td>
<td>Less than 0.1% reverse current on the PV side allowed when the battery voltage is equal to the nominal rated voltage.</td>
</tr>
<tr>
<td>Leakage Current</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charging Cycle</td>
<td>To measure the charging set-points of the BCC at 25 °C and 40 °C. To monitor a complete charging cycle and all charging stages of the BCC under test.</td>
<td>Suitable charging set-points and load disconnect set-points provided by BCC to be used for.</td>
</tr>
<tr>
<td>Load Disconnect / Load Reconnect</td>
<td>To protect the battery from over-discharge by validating the -low voltage set-points used for load disconnect (LVD) -load reconnect (LVR)</td>
<td>The BCC shall regulate the current from over-charging/discharging of the battery charge set-point by a used external piece of equipment to stop the current to the load, or an alarm.</td>
</tr>
</tbody>
</table>
### Table 8: Energy Performance Tests

<table>
<thead>
<tr>
<th>Type of tests</th>
<th>Objective</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standby Self Consumption</td>
<td>To determine the self-consumption of the battery charge controller.</td>
<td>BCC shall be in standby mode (no PV input or load).</td>
</tr>
<tr>
<td>Efficiency</td>
<td>To determine the efficiency of the BCC over the range of 10% to 100% charging current at an ambient temperature of 25 °C and 40 °C.</td>
<td>The power efficiency of the BCC shall be evaluated from 10 % to 100 % of the rated charging current.</td>
</tr>
</tbody>
</table>

### Table 9: Protection and Fail-Safe Tests

<table>
<thead>
<tr>
<th>Type of tests</th>
<th>Objective</th>
<th>Conditions</th>
</tr>
</thead>
</table>
| Thermal Performance | To evaluate the performance of BCC at -maximum rated temperature -rated charging current in bulk mode.  
<p>|                   | The effect of load switching device should be included in this test.       | The BCC shall be capable of handling rated input current/power from the simulator and, simultaneously, rated load current to load terminals (if provided) for at least 1 hour. |</p>
<table>
<thead>
<tr>
<th>PV Over Current Protection</th>
<th>To evaluate the performance of BCC under overload conditions.</th>
<th>The BCC shall not be damaged by excessive current from the PV simulator up to 125% of the full rated current and continue to operate normally after such an event and shall not require manual resetting.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Load Over Current Protection</td>
<td>To evaluate the performance of the BCC at 25 degrees and 125% of the rated load current.</td>
<td>If the BCC has a load terminal, this terminal shall be current protected to prevent overloads from causing damage to the operation of the essential PV BCC functions.</td>
</tr>
<tr>
<td>Battery and PV simulator Reverse Polarity</td>
<td>To verify the BCC tolerance to the connection of the -The battery in reverse polarity -PV simulator in reverse polarity and to verify the protection of the load from being</td>
<td>Protect BCC from reverse polarity connection of the PV simulator or the battery.</td>
</tr>
</tbody>
</table>
supplied with negative voltage.

**Battery Open Circuit**
- To validate the BCC tolerance to the occurrence of an open circuit on the battery terminals. To protect the load from being connected directly to the PV simulator voltage.
- Protect BCC with load terminals from open circuit voltage in case any disconnection occurs.

<table>
<thead>
<tr>
<th>Type of tests</th>
<th>Objective</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td>To physically connected the BCC or operate via wireless communication for controlling, logging, or interface.</td>
<td>The interface can provide the user with valuable information about the system operation such as by LCD screen and LED indicator.</td>
</tr>
</tbody>
</table>

Table 10: User Interface Tests
9.3 Test Procedure and Parameter

9.3.1 Calibration

First, disconnect the signals to the DAQ card by unplugging the signal ribbon cable in the isolation amplifier backplane. Perform a self-calibration of the DAQ card from the National Instruments “Measurement and Automation Explorer” software as shown in Figure 20. After the self-calibration is finished, note down the date time and temperature in the test log book under the “TEST CONDITIONS” heading. Reconnect the signals to the DAQ card by plugging back the signal ribbon cable in the isolation amplifier backplane.[6]

![Figure 20: Perform self-calibration](image)

9.3.2 Cycle Test (Set-Point Measurements)

This test is to be performed at 10% charging current for IEC draft standard compliance.

a) Read the EUT manual to determine the following (note down any relevant
Re-commissioning of a Battery Charge Controller Test Setup

<table>
<thead>
<tr>
<th>Comments on the testing logbook):</th>
</tr>
</thead>
<tbody>
<tr>
<td>• EUT charging regime (charging stages and characteristics)</td>
</tr>
<tr>
<td>• Whether charging regime is optimised for a particular type of battery</td>
</tr>
<tr>
<td>• Whether the EUT is suitable for use with different types of batteries</td>
</tr>
<tr>
<td>• Default charging set-points</td>
</tr>
<tr>
<td>• Set-point adjustability</td>
</tr>
<tr>
<td>• Set-point adjustment procedure if applicable</td>
</tr>
<tr>
<td>• Set-point security mechanism if applicable</td>
</tr>
<tr>
<td>• Whether the set-points are temperature compensated and what is the temperature compensation factor or curve</td>
</tr>
<tr>
<td>• Whether the EUT includes or can be fitted with battery sensing wires</td>
</tr>
</tbody>
</table>

b) Connect test setup as specified in Figure 10.

c) Switch on the battery and set the voltage to nominal [5] 5% 

d) If the controller has the facility to change charging set-points and times, change the equalisation and absorption times to 30 minutes or the smallest allowable time, whichever is smaller. Also, if the BCC has any adjustable delay times for the transition from one stage to another, reduce these to 1 minute or the smallest allowable time, whichever is greater.

Note: Do not reduce delay times to less than one minute because this can cause undesirable mode changes while adjusting the battery voltage.

e) Ensure that ambient temperature is being logged by the lab’s temperature logging
Re-commissioning of a Battery Charge Controller Test Setup

system at 10-minute intervals or faster. Ensure that the ambient temperature in the lab is within 19°C to 27°C.

f) Precondition the EUT at 25 °C according to section 2.5.

g) Allow the instruments and power sources to warm up for at least 30 minutes.

h) Disconnect the signals to the DAQ card by unplugging the signal ribbon cable in the isolation amplifier backplane.

i) Perform a self-calibration of the DAQ card from the National Instruments “Measurement and Automation Explorer” software. After the self-calibration is finished, note down the date time and temperature in the test log book under the “TEST CONDITIONS” heading.

j) Reconnect the signals to the DAQ card by plugging back the signal ribbon cable in the isolation amplifier backplane.

k) Run the test program: K:\Source Code\LabVIEW\TopLevelTestPrograms\Charge Controller Testing\BCC Test Vis\_Top_Level_BCC Cycle Test and SetPoint Test.vi

l) Follow the program prompts and fill the information required. The logging parameters, scaling factors and offsets should be set as follows:

• Logging period = 1 Sec.

• DAQ Card Sampling Rate = 10,000 samples/s

• DAQ Card No. of Samples = 2,000

• Scaling factor of all voltages and currents = as per relevant calibration file

• Offset of all voltages and currents = as per relevant calibration file
Follow the program prompts until it asks you if you want to insert a comment for the test and click “Yes”. Insert a comment that describes the type of test and the type of PV input and battery setup used. Click yes to accept the comment.

Set the battery simulator resistor (RB) to produce a battery voltage of 2.1 V/cell at the test charging current (either 10%, 50% or 100%).

Set the battery backup PSU voltage to 1 V below the battery voltage (voltage across RB) and connect the simulated battery to the EUT.

If using the Agilent E4350A solar array simulator, set the operation mode to solar array simulator and the PV parameters to match an appropriate series combination of the following typical PV module (required software: _Top_Level_ManualOperation of HPSA4350B.vi), otherwise go to step (q):

- VOC = 21.5 V
- ISC = 5 to 10 % larger than IMP
- VMP = 17.5 V
- IMP = Adjust to produce 10% charging current

Note: If the controller is of the MPPT type, adjust the PV input current parameters to provide a 10% charging current \( \geq 2\% \), while operating within the MPPT window.

If using a power supply with a series resistor as the PV input, set the voltage limit to the maximum expected charging voltage plus 25%, plus the series diode voltage drop of 1 V. Set the current limit to produce 10% charging current.

Do not apply any load to the load terminals (if provided).
s) Click the “start logging” button in the test program prompt to start the logging.

t) Increase the battery voltage (by increasing RB) to the expected bulk or boost termination set-point minus 10%, and adjust the voltage of the battery power supply to:

Notes: 1. Take into account any temperature compensation when estimating the expected end of charge set-point.

2. In this and all subsequent steps adjust the voltage setting of the battery PSU after each battery voltage adjustment, in order to maintain the condition specified above.

u) Increase the battery voltage in 2% to 3% steps of the end of bulk (or boost) charge set-point, until the battery voltage is around 3% less than the programmed or expected cut off or regulation set-point. Wait 1 minute between voltage steps.

v) Increase the voltage in 0.1% to 0.2% steps of the end of bulk (or boost) charge set-point, until the BCC starts to regulate the charging current in case of regulating controllers (PWM or MPPT) or has cut out the current in case of ON-OFF controllers. Wait the specified delay time of the BCC + 1 minute between voltage steps. If the EUT manual does not specify a delay time, wait 2 minutes between voltage increments.

Notes: The EUT has started to regulate current when the average input current displayed in the test program screen is less than the adjusted value and its standard deviation has increased significantly.

If the delay time is programmable, set it to 1 minute to reduce test time.

w) If the controller is of the regulating type go to step (bb).

x) If the controller is of the ON-OFF type, reduce the battery voltage in 2% to 3% steps of the end of bulk (or boost) charge set-point, until the battery voltage is around 5% higher
than the programmed or expected reconnect set-point. Wait 1 minute between voltage steps.

Note: Take into account any temperature compensation when estimating the expected end of charge set-point.

y) Decrease the voltage in 0.1% to 0.2% steps of the end of bulk (or boost) charge set-point, until the BCC reconnects the PV current. Wait the specified delay time of the BCC + 1 minute between voltage steps. If the EUT manual does not specify a delay time, wait 2 minutes between voltage decrements.

Note: If the delay time is programmable, set it to 1 minute to reduce test time.

z) Repeat steps (v) to (y) two more times to verify the ON-OFF setpoints.

aa) Go to step (ff).

bb) If the controller is of the regulating type (PWM or MPPT) force an equalization charge if this facility is available; otherwise go to step (cc).

cc) Connect the oscilloscope via the high voltage differential probe (HVDP) to the PV input side and adjust RB so the duty cycle of the controller is 90% ± 5%. Once this has been done, disconnect the HVDP from the circuit.

Note: The HVDP can introduce significant noise to the measured signal, thus the need to remove it from the circuit once the duty cycle has been adjusted.

dd) Allow the charge controller to continue the charging cycle automatically (i.e. no further RB adjustments should be necessary) until it has reached and stayed in float mode for at least half an hour to obtain stable readings and any possible drift behaviour.
Re-commissioning of a Battery Charge Controller Test Setup

ee) Stop the logging program

ii) End of test

Note: To end the test first switch off the PV input power supply, then the battery power supply and finally by stop the logging program.

Figure 21: Cycle Test Parameter Part 1

Figure 22: Cycle Test Parameter Part 2
9.3.3 Efficiency Test

The efficiency test should be performed with the charge controller in the bulk/boost charging mode only, in order to avoid the situation where EUT is regulating the current, as efficiency is more important when maximum energy transfer is required.

Tests will be conducted at 10% to 100% charging current in steps of 10%.

a) Connect test setup as specified in Figure 10.

b) Ensure that ambient temperature is being logged by the lab’s temperature logging system at 10-minute intervals or faster. Ensure that the ambient temperature in the lab is within 19°C to 27°C.

<table>
<thead>
<tr>
<th>Table 12: Efficiency Test Standard Procedures [6]</th>
</tr>
</thead>
<tbody>
<tr>
<td>The efficiency test should be performed with the charge controller in the bulk/boost charging mode only, in order to avoid the situation where EUT is regulating the current, as efficiency is more important when maximum energy transfer is required.</td>
</tr>
<tr>
<td>Tests will be conducted at 10% to 100% charging current in steps of 10%.</td>
</tr>
<tr>
<td>a) Connect test setup as specified in Figure 10.</td>
</tr>
<tr>
<td>b) Ensure that ambient temperature is being logged by the lab’s temperature logging system at 10-minute intervals or faster. Ensure that the ambient temperature in the lab is within 19°C to 27°C.</td>
</tr>
</tbody>
</table>
Re-commissioning of a Battery Charge Controller Test Setup

c) Precondition the EUT at 25 °C according to section 2.5.

d) Allow the instruments and power sources to warm up for at least 30 minutes.

e) Disconnect the signals to the DAQ card by unplugging the signal ribbon cable in the isolation amplifier backplane.

f) Perform a self-calibration of the DAQ card from the National Instruments “Measurement and Automation Explorer” software. After the self-calibration is finished, note down the date time and DAQ card temperature in the test log book under the “TEST CONDITIONS” heading.

g) Reconnect the signals to the DAQ card by plugging back the signal ribbon cable in the isolation amplifier backplane.

h) Run the test program: K:\Source Code\LabVIEW\TopLevelTestPrograms\Charge Controller Testing\BCC Test Vis\_Top_Level_BCC Test Setup Calibration.vi

i) Follow the program prompts and fill the information required. The logging parameters, scaling factors and offsets should be set as follows:

- DAQ Card Sampling Rate = 10,000 samples/s
- DAQ Card No. of Samples = 10,000
- Scaling factor of all voltages and currents = as per relevant calibration file
- Offset of all voltages and currents = as per relevant calibration file

j) Follow the program prompts until it asks you if you want to insert a comment for that reading and click “Record Comment”

k) In the comment box specify the test point (e.g. 10%) and click OK.
I) Adjust the battery voltage to 2.2 V/Cell ± 2% by adjusting the battery PSU while keeping RB constant. Adjust the PV input current to provide 10% of rated charging current ± 2%.

Notes:

1. Make sure that the battery PSU is always operating in constant voltage mode

2. Note down the PSU settings in the log book at each current level.

3. Make sure that the load terminals are enabled (i.e. normal load voltage is present)

m) Click OK to take the readings whenever the EUT is operating in stable steady state mode. When the program prompts you if you want to make another reading click “Yes”. When the program prompts you if you want to insert a comment for that reading click “Record Comment”. In the comment box specify the test point (e.g. 10%) and click OK.

Note: Some charge controllers perform open circuit measurements or full I-V curve scans periodically. Care must be taken to avoid measurements just before or during such events as transient operation data is not useful to calculate efficiency.

n) The LabView program will take 5 readings at the same current level.

o) End of test

Note: To end the test, first switch off the PV input power supply, then the battery power supply and finally stop the logging program.
Re-commissioning of a Battery Charge Controller Test Setup

Figure 24: Efficiency Test Parameter Part 1

Figure 25: Efficiency Test Parameter Part 2
9.3.4 Load Over Current Protection Test

Table 13: Load Over Current Test Standard Procedures [6]

Load over current performance test should be performed with no PV input to the charge controller.

a) Connect test setup as specified in Figure 10.

b) Ensure that ambient temperature is being logged by the lab’s temperature logging system at 10-minute intervals or faster. Ensure that the ambient temperature in the lab is within 19°C to 27°C.

c) Precondition the EUT at 25°C according to section 2.5.
<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>d)</td>
<td>Allow the instruments and power sources to warm up for at least 30 minutes.</td>
</tr>
<tr>
<td>e)</td>
<td>Disconnect the signals to the DAQ card by unplugging the signal ribbon cable in the isolation amplifier backplane.</td>
</tr>
<tr>
<td>f)</td>
<td>Perform a self-calibration of the DAQ card from the National Instruments “Measurement and Automation Explorer” software. After the self-calibration is finished, note down the date time and DAQ card temperature in the test log book under the “TEST CONDITIONS” heading.</td>
</tr>
<tr>
<td>g)</td>
<td>Reconnect the signals to the DAQ card by plugging back the signal ribbon cable in the isolation amplifier backplane.</td>
</tr>
<tr>
<td>h)</td>
<td>Run the test program: K:\Source Code\LabVIEW\TopLevelTestPrograms\Charge Controller Testing\BCC Test Vis_Top_Level_BCC Cycle Test and SetPoint Test.vi</td>
</tr>
</tbody>
</table>
| i)   | Follow the program prompts and fill the information required. The logging parameters, scaling factors and offsets should be set as follows:  
- Logging period 1 second  
- DAQ Card Sampling Rate = 10,000 samples/s  
- DAQ Card No. of Samples = 2,000  
- Scaling factor of all voltages and currents = as per relevant calibration file  
- Offset of all voltages and currents = as per relevant calibration file  

| j)   | Follow the program prompts until it asks you if you want to insert a comment for the test and click “Record Comment”. Insert a comment that describes the type of test and the type of battery setup used. Click yes to accept the comment. |
Re-commissioning of a Battery Charge Controller Test Setup

k) Click the “start logging” button in the test program prompt to start the logging.

l) Switch off SW1 to ensure no PV input is supplied and set RB=0.

m) Adjust the battery voltage to the nominal value ± 2% by adjusting the battery PSU, and the load current to 125% of rated by adjusting the load resistance.

Note: Note down the PSU settings in the log book.

n) Allow the EUT to operate under these conditions for one hour or until any thermal protection is triggered within the EUT (current regulation, shut down, etc.)

o) End of test

Note: To end the test, first switch off the battery power supply and finally stop the logging program.

---

Figure 27: Load Over Current Test Parameter Part 1
Re-commissioning of a Battery Charge Controller Test Setup

Figure 28: Load Over Current Test Parameter Part 2

Figure 29: Table of data for Load Over Current Test
9.3.5 Battery Open Circuit Test

This test is to be carried at ambient temperature (i.e. no temperature conditioning required).

Tests are also to be conducted under rated PV input current conditions and 50% load current conditions if load terminals are provided.

a) Revise the EUT documentation and the unit itself to verify whether it is capable of withstanding open circuit conditions on the battery terminals, or if there is a specific warning not to do so. If a warning is given in the unit or its documentation, do not go ahead with the test.

b) Connect test setup as specified in Figure 10.

c) Ensure that ambient temperature is being logged by the lab’s temperature logging system at 10-minute intervals or faster. Ensure that the ambient temperature in the lab is within 19°C to 27°C.

d) Allow the instruments and power sources to warm up for at least 30 minutes.

e) Disconnect the signals to the DAQ card by unplugging the signal ribbon cable in the isolation amplifier backplane.

f) Perform a self-calibration of the DAQ card from the National Instruments “Measurement and Automation Explorer” software. After the self-calibration is finished, note down the date time and DAQ card temperature in the test log book under the “TEST CONDITIONS” heading.

g) Reconnect the signals to the DAQ card by plugging back the signal ribbon cable in...
Re-commissioning of a Battery Charge Controller Test Setup

the isolation amplifier backplane.

h) Run the test program: K:\Source Code\LabVIEW\TopLevelTestPrograms\ Charge Controller Testing\BCC Test Vis\_Top_Level_BCC Cycle Test and SetPoint Test.vi

i) Follow the program prompts and fill the information required. The logging parameters, scaling factors and offsets should be set as follows:

- Logging period 1 second
- DAQ Card Sampling Rate = 10,000 samples/s
- DAQ Card No. of Samples = 2,000
- Scaling factor of all voltages and currents = as per relevant calibration file
- Offset of all voltages and currents = as per relevant calibration file

j) Follow the program prompts until it asks you if you want to insert a comment for the test and click “Yes”. Insert a comment that describes the type of test and the type of battery setup used. Click yes to accept the comment.

k) Click the “start logging” button in the test program prompt to start the logging.

l) Set the battery PSU voltage and current.

m) If using a PV simulator, set the PV parameters to match an appropriate series combination of the following typical PV module, and set ISC and IMP to produce rated charging current ± 5% and enable the PV PSU output, otherwise go to the next step.

- VMP = 17.5 V
- VOC = 21.5 V
### Re-commissioning of a Battery Charge Controller Test Setup

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>n)</td>
<td>If using a power supply with a series resistor as the PV input, set the voltage limit to the maximum expected charging voltage plus 25%, plus the series diode voltage drop (1 V); set the current limit to produce rated charging current ± 5% and enable the PV PSU output. Note: For MPPT type controllers, the input voltage needs to be adjusted to comply with the MPPT window of the EUT.</td>
</tr>
<tr>
<td>o)</td>
<td>Set the load to 50% of the rated load terminal current at nominal battery voltage.</td>
</tr>
<tr>
<td>p)</td>
<td>Connect the battery, load, and PV source in that sequence.</td>
</tr>
<tr>
<td>q)</td>
<td>Re-adjust the battery voltage to the nominal value by adjusting VPV-PSU, and allow the EUT to stay in this condition for 5 minutes.</td>
</tr>
<tr>
<td>r)</td>
<td>Disconnect the battery by opening SW2. Allow the unit to stay in this condition for 5 minutes.</td>
</tr>
<tr>
<td>s)</td>
<td>Reconnect the battery and verify if the unit is operating normally by reading any signals on the display. Note down any relevant observations in the logbook.</td>
</tr>
<tr>
<td>t)</td>
<td>Connect the setup as specified in Figure 10, and verify that the BCC regulation or switch off voltage is as expected according to the EUT set-points and any temperature compensation factor. Note: This can be achieved by following the general procedure for setpoint determination up to the first regulation stage of the BCC.</td>
</tr>
<tr>
<td>u)</td>
<td>End of test</td>
</tr>
</tbody>
</table>

Note: To end the test first switch off all power supplies and finally stop the logging program.
Re-commissioning of a Battery Charge Controller Test Setup

Figure 30: Battery Open Circuit Current Test Parameter Part 1

Figure 31: Battery Open Circuit Current Test Parameter Part 2
### Figure 32: Table of data for Battery Open Circuit

| A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z |
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 |