# Introduction

The ideal diode board is a battery management PCB that parallels the batteries together and provides reverse polarity protection and reverse current protection without the large voltage drop and power loss experienced by a real diode. The PCB is known as the Device Under Test (DUT).

# Estimated Time

30 minutes per board

# Prerequisites

Attend the Badgerloop Soldering and PCB workshop or receive approval from an electrical lead. Some experience with solder paste dispensing or hand soldering SMD components is preferred.

# Required Equipment

* P4\_LV\_IdealDiode\_001\_REVA PCBs (Qty up to 2) (DUT)
* Soldering iron (this can be done with the Hanko Station in MEHQ)
* Solder
* Side cutters (snips)
* PCB BOM (Qty per board)
  + SMD Components
    - SMAJ24A Diode (QTY 4)
    - SMAT7 Diode (QTY 4)
    - STL90N6F7 (QTY 4)
    - LTC4359 Ideal Diode Controller (QTY 4)
    - INA240x Amplifier (QTY 1)
    - 4700pF CAP (QTY 12)
    - 10mOhm RES (QTY2)
  + Through-hole Components
    - 2-pin screw terminal (QTY 8)
    - 3-pin screw terminal (QTY 1)
    - 2-pin 0.1” Header (QTY 4)
  + Other
    - 0.1” 2-pin Jumper (QTY 4)
* Microscope / Magnifying Glass / Calipers (optional)

# Visual Inspection

A simple visual inspection of the DUT includes:

1. Board thickness Design \_\_\_\_\_\_ Measured: \_\_\_\_\_
2. Board dimensions Design \_\_\_\_\_\_ Measured: \_\_\_\_\_
3. Warpage: Verified \_\_\_\_\_
4. Short circuit, bridge, open circuit, voids Verified \_\_\_\_\_
5. Surface quality (scratches, scrapes, burrs, etc.) Verified \_\_\_\_\_
6. Holes and Vias hole drilled, plating present Verified \_\_\_\_\_
7. Add a serial number to the DUT with permanent marker. Boards should be numbered with this format: <Abbreviated Name>-<Number>-<Revision> for example the first board would be labeled ID-001-A for Breakout Board, 001-006 for the unique identifier and A for the revision.

# Fit Check

Not required for the Ideal Diode PCB

# Soldering

## SMD Soldering

1. Apply solder paste to all SMD pads
   1. Note, if a component won’t be populated for whatever reason, do not apply solder paste. Bake boards soon after placement.
2. Place all SMD resistors (R1, R2), capacitors (C1 – C13) and ICs (U1-U5)
   1. I find it helpful to have a printout of the schematic and mark off when a component is placed on the board. This prevents DNP (Do Not Place) components from getting populated.
3. Bake boards following instructions for the specific oven.

### Soldering Inspection 1

1. Verify there are no shorts between adjacent solder joints. Using a magnifying glass or microscope is useful. Adjacent pins on the controllers need to be inspected carefully
2. Verify all solder joints have the appropriate amount of solder.
3. Heat up any un-melted solder paste with an iron if necessary.
4. Touch up any solder joints with an iron if necessary. Use hot air if you are trained with that tool.

## Through Hole Soldering

1. Insert the screw terminals P1-P9 and solder one pin on each component. Ensure that the component is flush to the PCB. Reheat the solder joint and adjust the component if it is not flush. Then solder the other pins.
2. Insert the 0.1” headers in P10-P13 and solder. Ensure that the component is flush to the PCB. Reheat the solder joint and adjust the component if it is not flush. Then solder the other pins.

### Soldering Inspection 2

1. Repeat the same steps as soldering Inspection 1

# Testing

This board is relatively simple, so the electrical testing is relatively short. For other PCBs, the electrical testing section will be more in-depth.

## Electrical Testing

### Continuity / Short Circuit Testing

1. Using a digital multimeter set to continuity mode, verify there are no shorts between pins. It’s useful to be on “beep mode”.
   1. My strategy is to hold the red multimeter lead on pin one, then contact all other pins. Then move the red multimeter lead to pin 2, then contact all other pins.
   2. Verified \_\_\_\_\_

### Ideal Diode Operation

#### Single Input Voltage Range Testing

1. Populate P10-P13 with a 0.1” 2-pin jumper to enable Shutdown Mode on each controller
2. Connect a bench power supply to terminals P1 with the correct polarity. Set the current limit to 300mA. Set the supply to 10V, but do not enable the supply
3. Use a DMM to measure the output voltage. Verify output voltage on P5-P8
4. Enable the Bench Power Supply
5. Remove the Shutdown Jumper on P10.
6. Record the output voltage Voltage \_\_\_\_\_
7. Disable the Bench Power Supply and set it to 14V
8. Enable the Bench Power Supply and record the output voltage Voltage \_\_\_\_\_
9. Repeat Steps 1-8 for P1-P4

#### Multiple Input Voltage Range Testing

1. Connect the power supply to P1 and P2 set to 10V. Set the current limit to 300mA. Keep the supply disabled.
2. Populate the shutdown jumpers on P10-P13
3. Probe the output on P5-P8
4. Enable the bench power supply
5. Remove the shutdown jumper on P10 and P11
6. Record the output voltage Voltage \_\_\_\_\_
7. Carefully, probe the Gate Voltage on Pin 1 of U2 and U3 Voltage \_\_\_\_\_
   1. Ensure that both are operating
8. Disable the Bench Power Supply and set it to 14V
9. Enable the Bench Power Supply and record the output voltage Voltage \_\_\_\_\_
10. Repeat Steps 1-9 for P2 and P3, P3 and P4, P1 and P4, P2 and P4 (as time allows)

#### Multiple Supplies Voltage Range Testing

1. Connect the primary bench power supply to P1 and the secondary to P2. Set the current limit to 300mA.
2. Populate the shutdown jumpers
3. Set P1 to 11V, set P2 to 11V
4. Remove the shutdown jumper P10.
5. Record the output voltage Voltage \_\_\_\_\_
6. Remove the shutdown jumper P11
7. Record the output voltage Voltage \_\_\_\_\_

#### Battery Integration

1. Repeat the Ideal Diode Operational Tests with a real LiFePO4 batteries

### Current Sense Amplification Testing

1. Configure the Badgerloop mini-load bank to 6Ohms. (Adjust the series-parallel configuration, see Brandon Hahn for details) to draw ~2A. Connect to P5
2. Populate the shutdown jumpers
3. Use a secondary power supply to provide 5V to P9. Tie grounds of both power supplies together. Set the current limit of the secondary supply to 30mA.
4. Connect a bench power supply to P1. Set the current limit to 2.5A.
5. Remove the shutdown jumper and enable the power supply
6. Record the current output from the supply (Either the digital readout or use a clamp meter) Voltage \_\_\_\_\_ Current \_\_\_\_\_
7. Record the output voltage across pins 2 and 3 of P9 Voltage \_\_\_\_\_
8. Verify the amplified output voltage corresponds to changes in current by adjusting the power supply output voltage.

## Integration Testing

Integration testing involves testing the interfaces between the DUT and any other PCB, connector and mechanical enclosure the DUT will nominally interact with.

1. Verify the PCB mounts properly in the enclosure. Verified \_\_\_\_\_

## Thermal and Vacuum Testing

1. As time allows, perform thermal and vacuum testing. This test could be combined with current sense amplification testing. Use a thermal camera, focusing on the FETs and shunt resistors