# Test Requirements for ISO Block, A5461883

# 1 Introduction

## 1.1 Scope

This document describes the procedures and equipment required to perform acceptance testing on the ISO Block.

# 2 Applicable Documents

**Drawings:**

- A5461883, Circuit Card Assembly, ISO Block
- A5461884, Printed Wiring Board, ISO Block
- A5461885, Schematic, ISO Block
- A5461886, Mechanical Interface Control Drawing, ISO Block
- A5522525, Pin, Transformer (Large pins)
- A5522526, Pin, Transformer (Small pins)

**Documents:**

- PICkit™ 3 In-Circuit Debugger/Programmer User's Guide
  http://ww1.microchip.com/downloads/en/DeviceDoc/52116A.pdf
- MCP19118/19 Digitally-Enhanced Power Analog Controller with Integrated Synchronous Driver Datasheet
  http://ww1.microchip.com/downloads/en/DeviceDoc/20005350A.pdf

# 3 Test Equipment and General Procedures

## 3.1 Test Setup

Refer to Figure 1 regarding the test setup required for testing of the ISO Block.

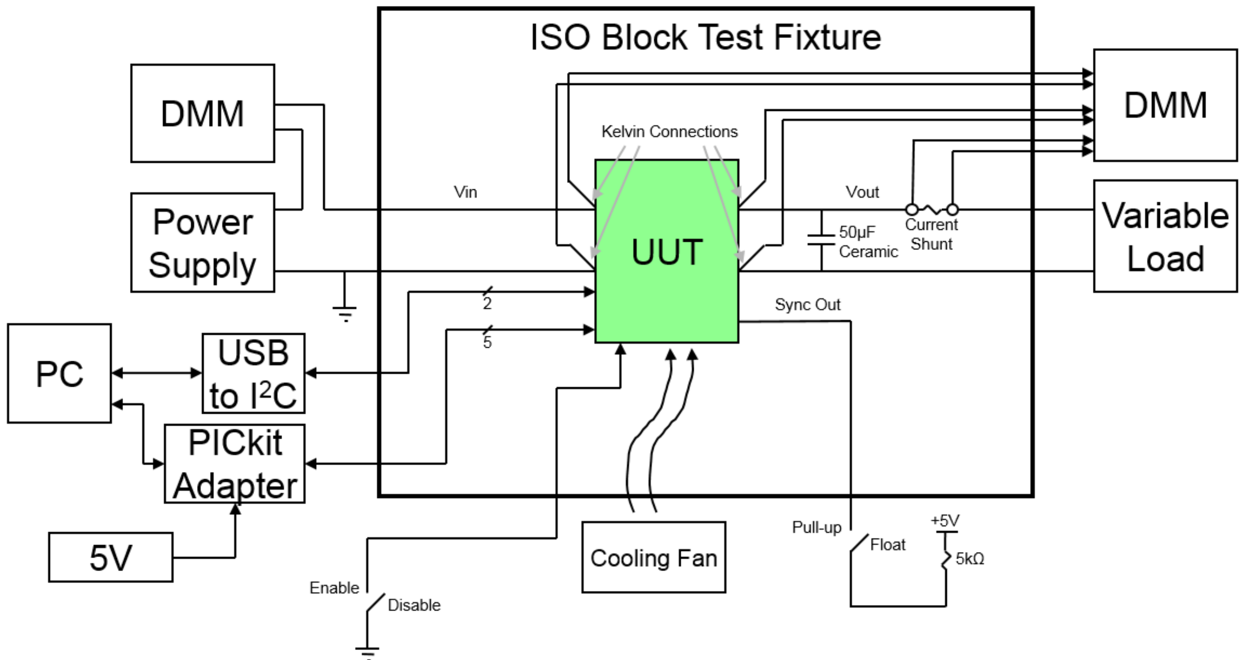


**Figure 1. Test Setup**

Note that due to high currents, DMM measurements of the input and output voltages of the UUT must be made with Kelvin connections to eliminate the effects of the contact resistances.

## 3.2 Equipment Requirements

**Table 1. Electrical Requirement Descriptions**

| Instrument | Capability Required |
|---|---|
| Power Supply | Output Voltage Range: 0V to 36VDC<br>Maximum Output Current: 6A<br>Adjustable Current Limit<br>Maximum Output Ripple: 100mVp-p |
| Electronic Load | Constant Current Range: 0A to 13A over voltage range of 9V to 11V<br>Constant Current Range: 0A to 11A over voltage range of 11V to 13V |
| DMM | |
| DMM / Current Shunt | For measurement of output current a DMM or current shunt capable of handling up to 12.5 Amperes is required. This requirement can be waived if the variable load is an electronic load with calibrated current measurement capability. If a shunt is used, an Ohmite TGHGCR0100FE, or similar, is recommended. The DMM, shunt, or electronic load readout is used for providing high accuracy DC current measurements to support calibration of the UUT's over-current protection circuit. |
| USB to I$^2$C Adapter | Texas Instruments USB Interface Adapter EVM USB-TO-GPIO |
| PICkit | Microchip PICkit 3 In-Circuit Debugger PG164130 |

### 3.3 Unit Under Test Interconnection

Refer to Figure 2 for the location of the Unit Under Test (UUT) pins, their numbers, and names. Table 2 provides a description of the pins.

**Table 2. ISO Block Pin Descriptions**

| Pin Number | Pin Name | Description |
|---|---|---|
| 1 | VIN | Input voltage with respect to VIN_RTN. Nominally 28V. |
| 2 | ENABLE_N / ICSPDAT | Active LOW enable signal. Short to VIN_RTN to enable the ISO Block output. Allow to float to disable the ISO Block. Pulled up to 5VDC through 20KOhms. Secondary function is the in-circuit serial programming data line. |
| 3 | SYNC | Dual use pin. It is an input at power-up. The level on this pin determines the $I^2C$ address of the unit. If the pin is held above 3.75V at startup the $I^2C$ address is 28 (0x1C), if held below 1.25V, the address is 29 (0x1D), if held between 2.5V and 3.75V, the address is 30 (0x1E) and if the pin is held between 1.25V and 2.5V at startup, the $I^2C$ address will be 31 (0x1F) (Pull-ups should be a minimum of 4.5KOhms). Once the unit is enabled, the pin becomes an output driving a synchronization clock. Pulled down to VIN_RTN through 20KOhms. Except where otherwise specified, assume this pin was LOW at startup and the UUT's $I^2C$ address is 28 (0x1C). |
| 4 | SCL / ICSPCLK | $I^2C$ clock. Referenced to VIN_RTN. Pulled up to 5VDC through 20KOhms. Secondary function is the in-circuit serial programming clock line. |
| 5 | SDA | $I^2C$ data. Referenced to VIN_RTN. Pulled up to 5VDC through 20KOhms. |
| 6 | VIN_RTN | Return for VIN |
| 7 | VOUT_RTN | Return for VOUT |
| 8 | VOUT_RTN | |
| 9 | VOUT | ISO Block power output. Nominally 10V, up to 10A output current. 50µF of ceramic capacitance must be connected between these pins and VOUT_RTN in the test fixture. |
| 10 | VOUT | |

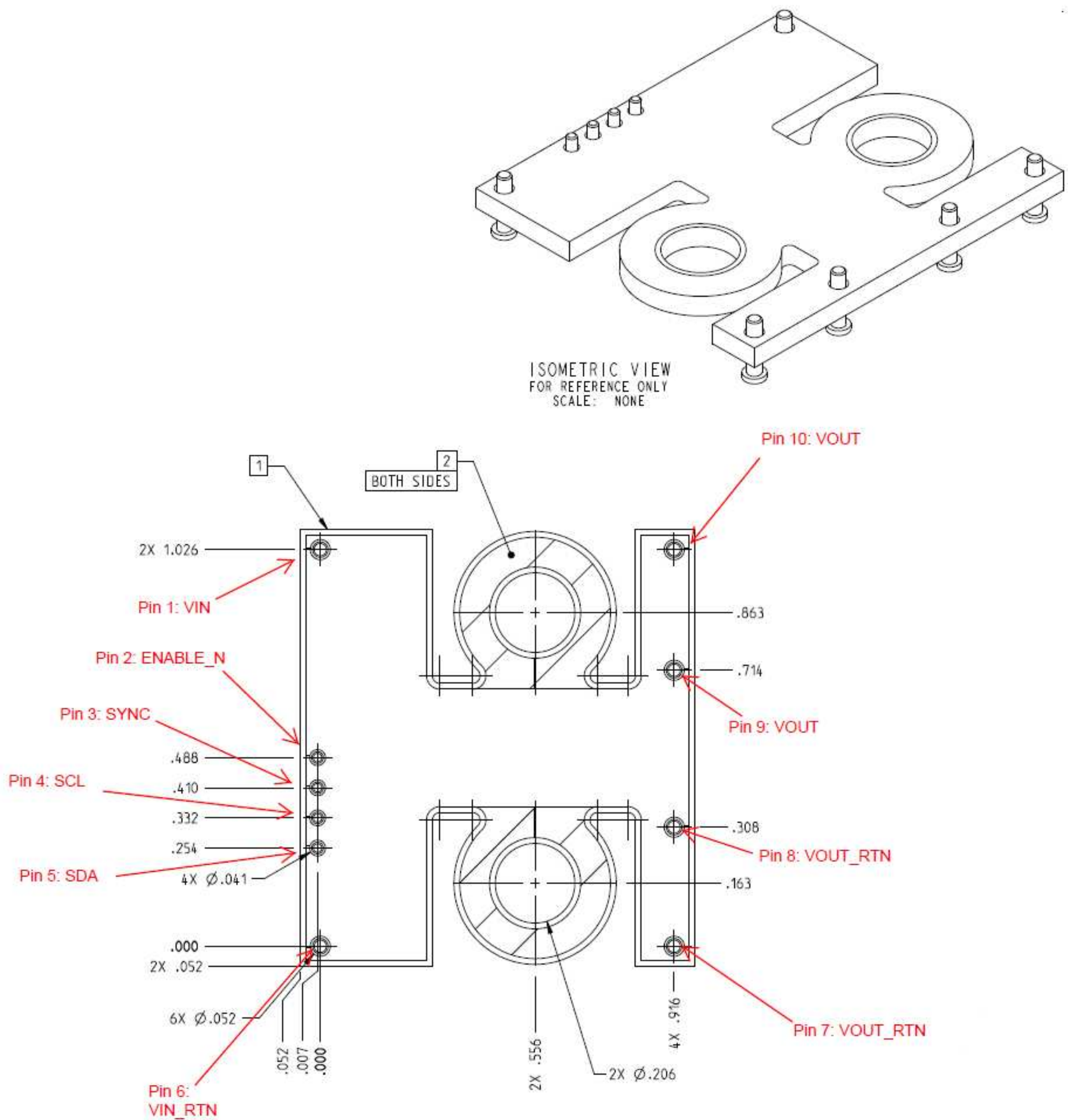


**Figure 2. UUT Pinout Definition (Top View)**

### 3.3.1 UUT Pins

The UUT is intended to be surface mounted to a host circuit card using the 10 pins shown in Figure 2. For test purposes, some method of connection is required that does not require soldering. Note that the pins come in two sizes with the large diameter pins intended for carrying high currents and the small diameter pins used for digital interfaces.

### 3.3.1.1 Large Pins

The large pins carry a significant amount of current and thus any interconnection scheme must be rated to handle this current.

**Table 3. Large Pin Current Carrying Requirements (per pin)**

| Pin Number(s) | Name | Maximum Continuous Current | Maximum Peak Current |
|---|---|---|---|
| 1, 6 | VIN, VIN_RTN | 3.9 Amperes | 4.9 Amperes |
| 10, 9, 8, 7 | VOUT, VOUT_RTN | 5.0 Amperes | 6.3 Amperes |

Notes:

1. Maximum peak current is the short term current drawn while calibrating and checking the over-current threshold.
2. Maximum continuous current is the current drawn by the unit at its maximum rated output power.

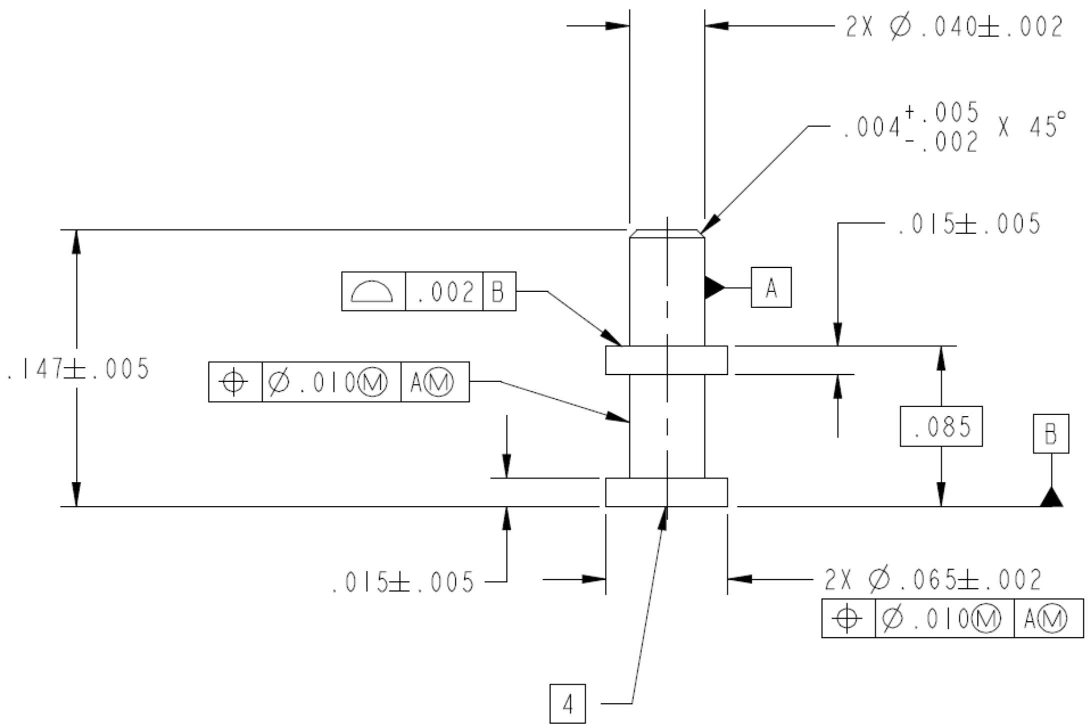


**Figure 3. Large Pin Dimensions**

Interface probes can be obtained from Everett Charles Technologies [http://ect-cpg.com/hc-probes](http://ect-cpg.com/hc-probes)

#### 3.3.1.2 Small Pins

The small pins are for digital input / output and thus current carrying capacity is not a consideration. They are, however, tightly spaced so any interconnect arrangement must be compatible with the 0.078" center to center spacing of these pins.

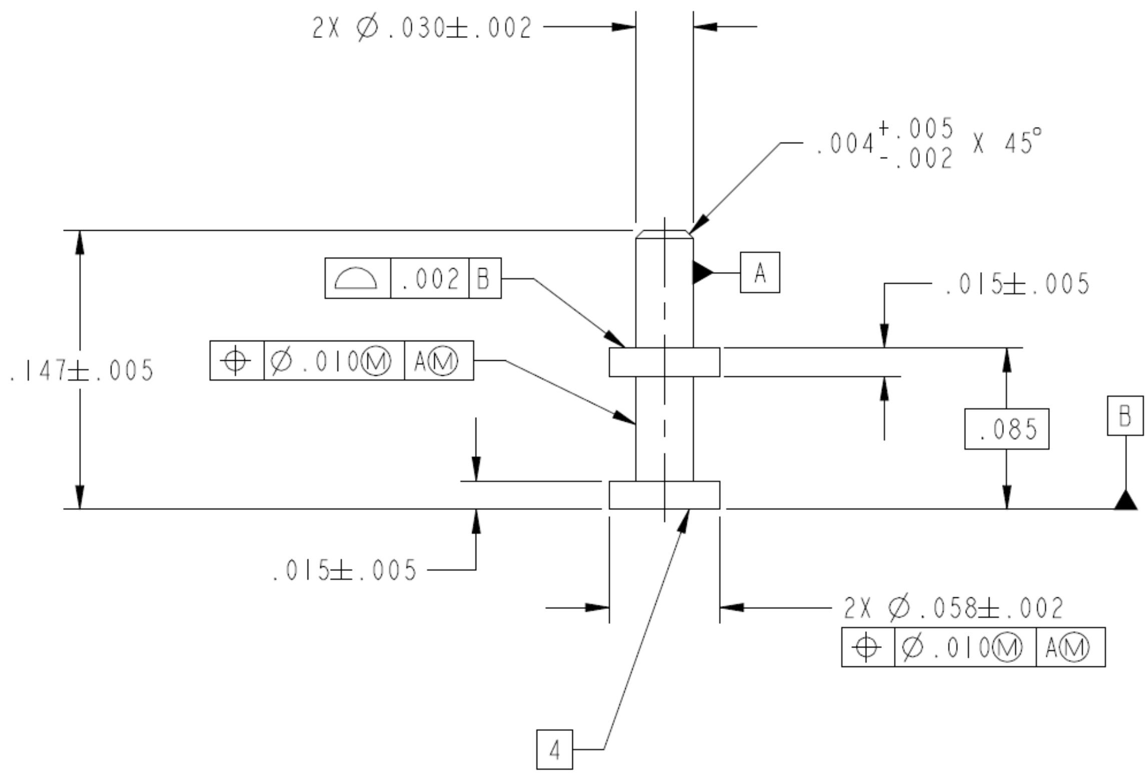


**Figure 4. Small Pin Dimensions**

Interface probes can be obtained from Everett Charles Technologies http://ect-cpg.com/ICT-FCT-probes

## 3.4 Unit Under Test Connections to PICKit and I$^2$C Adapter

### 3.4.1 PICKit Connections

When using the PICKit adapter to program the microprocessor, the following connections must be made:

**Table 4. PICKit Connections**

| PICKit Pin Name | PICKit Pin Number | UUT Pin Number | Comments |
|---|---|---|---|
| MCLR | 1 | N/A | Connect to pad shown in Figure 5 |
| VDD Target | 2 | N/A | Connect to external 5V supply. Connect supply return to pin 6 of UUT. |
| VSS (Ground) | 3 | 6 | |
| ICSPDAT | 4 | 2 | |
| ICSPCLK | 5 | 4 | |
| No Connect | 6 | N/A | |

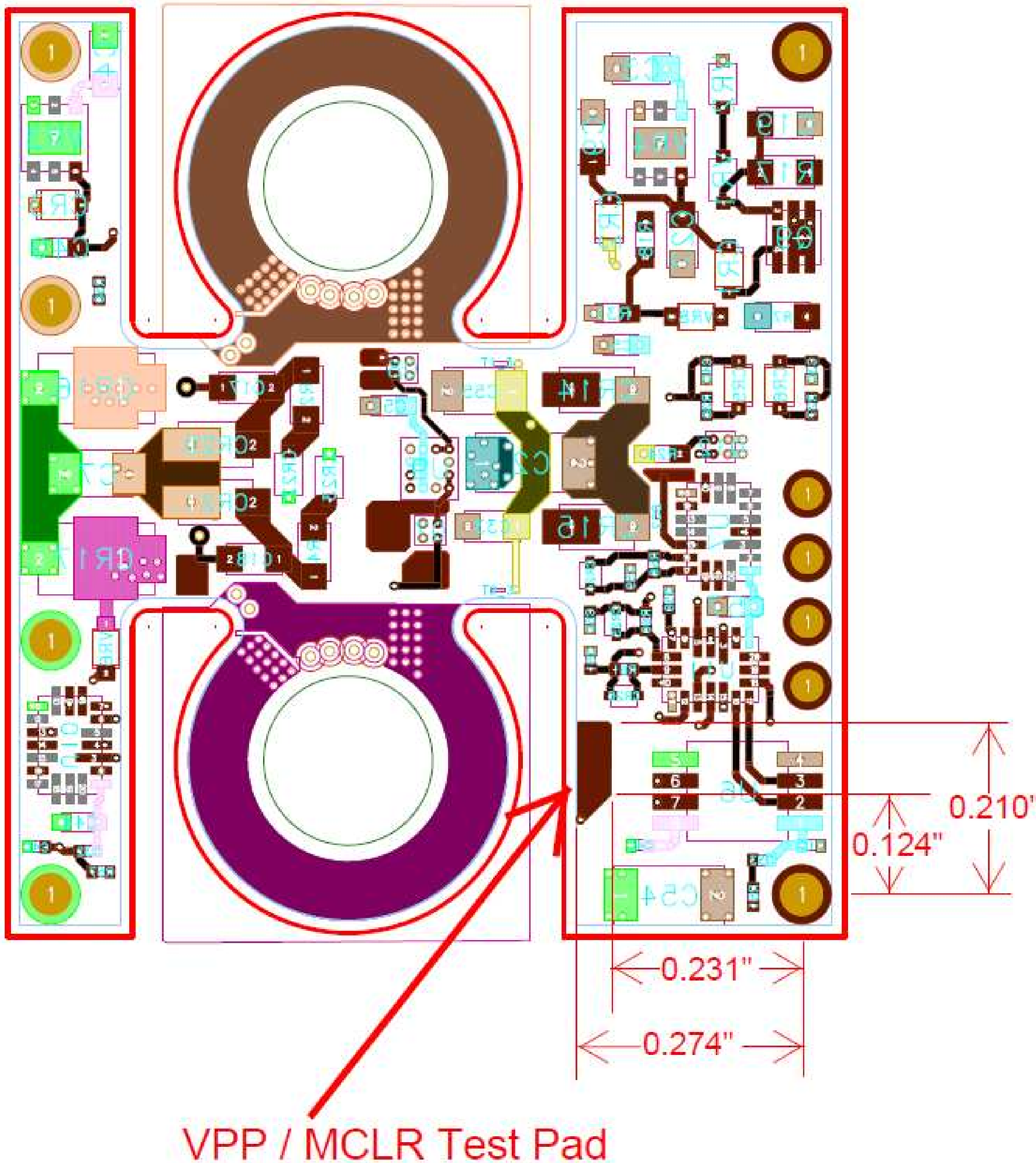


**Figure 5. PWB Bottom View Showing Location of VPP / MCLR Pad**

Interface probes can be obtained from Everett Charles Technologies [http://ect-cpg.com/ICT-FCT-probes](http://ect-cpg.com/ICT-FCT-probes)

### 3.4.2 I2C Adapter Connections

When using the TI $I^2C$ adapter to communicate with the UUT, the following connections must be made:

**Table 5. $I^2C$ Adapter Connections**

| $I^2C$ Adapter Pin Name | $I^2C$ Adapter Pin Number | UUT Pin Number |
|---|---|---|
| SCL | 9 | 4 |
| SDA | 10 | 5 |
| Ground | 6 | 6 |

### 3.5 Unit Under Test Communication

Communication with the ISO Block is facilitated by the $I^2C$ protocol. The firmware is configured to respond to specific *read* or *write* $I^2C$ command requests described in Section 5.2. Additional information can be requested from the device by writing an extension command to the READ_DEVICE_INFO (176 or 0xB0) command and then requesting a read from the READ_DEVICE_INFO command. These extensions are given in Table 10 of Section 5.3.

## 4 Test Procedure

### 4.1 Initial Checkout and Calibration

#### 4.1.1 Processor Programming

This section describes how the firmware is uploaded into the UUT.

**Setup:**

Connect a serial programmer to the UUT with the connections described in Table 4 of Section 3.4.1

Initially, allow ENABLE_N to float (HIGH, disabled state).

Disconnect any DC loads from the output.

Setup the input power supply to current limit at 0.1 Amperes.

**Procedure:**

1. Apply 15.0 ± 0.5 VDC to VIN with respect to VIN_RTN.
2. Ensure that the UUT doesn't draw over 100mA.
3. Transmit the firmware, provided as a Microchip .hex file, to the UUT through the serial programmer.
4. Once the UUT is successfully programmed, disable the input power and disconnect the serial programmer from the UUT.

#### 4.1.2 Initial Power-Up

Input power is applied to the UUT while it is in a disabled state and input current is measured. If the input current is reasonable, the UUT is enabled and the output voltage is verified. This test also confirms functionality of the ENABLE_N input pin.

**Setup:**

Disconnect any DC loads from the output.

Initially, allow ENABLE_N to float. (HIGH, disabled state.)

Setup the input power supply to current limit at 0.1 Amperes.

**Procedure:**

1. Apply 28.0 ± 0.5 VDC to VIN with respect to VIN_RTN.
2. Measure the input current with the UUT disabled. Verify the current is less than the value specified in Table 6. Disconnect input power and do not proceed if this test fails.
3. Verify that the UUT's output is off as indicated by the voltage indicated in the table. Note that the output voltage will not go to zero due to leakage paths connected to the UUT's output.
4. If the previous measurements meet the requirements in Table 6, increase the current limit of the input power supply to 1.0 Ampere.
5. Enable the UUT by shorting ENABLE_N to VIN_RTN and then transmitting the $I^2C$ command of a one-byte write of data with the value 128 (0x80) to the OPERATION command (1 or 0x01).
6. Measure the input current with the UUT enabled. Verify the current is less than the value specified in the table below. Disconnect input power and do not proceed if this test fails.
7. Measure the output voltage from VOUT to VOUT_RTN and verify it falls in the range specified in Table 6.

**Table 6. Initial Power-Up Current and Voltage Requirements**

| Parameter | Required Value | Tolerance |
|---|---|---|
| Input Current - Disabled | <20mA | N/A |
| Output Voltage - Disabled | <5.50V | N/A |
| Input Current - Enabled | <95mA | N/A |
| Output Voltage - Enabled | 10.00V | ±1.50V |

### 4.1.3 Output Voltage Calibration

The UUT's output voltage setting is adjusted to obtain the desired voltage at a particular load current. This will optimize the UUT's regulation band. Calibration of the UUT's voltage setpoint is performed by placing the UUT's firmware in a special calibration mode and then commanding the UUT's output to be increased or decreased until the required setpoint is obtained. The UUT will then program this setting to flash memory.

**Setup:**

A DC load will be applied during this test. Do not apply the load until the UUT is powered up.

Hold ENABLE_N LOW. (Enabled state.)

Setup the input power supply to current limit at 5.5 Amperes.

Using a fan, apply airflow to the UUT.

DMM sense ports shall measure the output voltage using Kelvin connections to reduce the effects of the contact resistances.

**Procedure:**

1. Apply 28.0 ± 0.5 VDC to VIN with respect to VIN_RTN, wait approximately 20 milliseconds, then reduce the input voltage to 12.5 ± 0.5 VDC. This lower voltage is required to allow entry into the calibration mode.
2. Command the UUT into calibration mode by requesting a read of 6 bytes from the CALIBRATION_ROUTINE command (189 or 0xBD).
3. The device will respond by transmitting 6 bytes of information containing the upper and lower bytes for the 3 words containing the board identification.
4. After receiving the 6 bytes of information, initiate a write command with the received 6 bytes of data to the CALIBRATION_ROUTINE command (189 or 0xBD).
5. The UUT will acknowledge each byte of data if it matches the same sequence and data that was initially transmitted during the read command.
6. After the 6$^{th}$ I$^2$C acknowledgment bit is received from the UUT and the I$^2$C stop bit is sent to the UUT, the device will enter the Calibration Mode.
7. Increase the VIN voltage to 28.0 ± 0.5 VDC with respect to VIN_RTN. The UUT output voltage should rise to 10.0 ± 1.5 VDC after transmitting the I$^2$C command of a one-byte write of data with the value 128 (0x80) to the OPERATION command (1 or 0x01).
8. Apply a load current of 5.0 ± 0.1 ADC to the UUT's output.
9. Externally, at the UUT pins, measure the output voltage VOUT with respect to VOUT_RTN with Kelvin connections to obtain a value of *VOUT*.
10. Calculate the required offset correction using the following equations

$$sign = \begin{cases} 0, & Vout < 10.0V \\ 1, & Vout \geq 10.0V \end{cases}$$

$$V_{offset_{coarse}} = Floor\left\{\frac{abs(10.0V - VOUT) * \frac{0.09823V}{V}}{\frac{0.0158V}{bit}}\right\}$$

$$V_{offset_{fine}} = 128 * sign + Round\left\{\frac{abs(10.0V - VOUT) * \frac{0.09823V}{V} - V_{offset_{coarse}} * \frac{0.0158V}{bit}}{\frac{0.0008V}{bit}}\right\}$$

11. If the value of $V_{offset_{coarse}}$ is larger than 9 then the calibration of output voltage failed.
12. Transmit the calibrated offset by writing two-bytes to the DELTA_OUTPUT_CHANGE command (179 or 0xB3). The first transmitted byte shall be the value computed above for $V_{offset_{fine}}$ and the second byte shall be the value calculated for $V_{offset_{coarse}}$.
13. The UUT will adjust the output voltage to the calibrated value.
14. After the stop bit is transmitted in the above step, the UUT will make the appropriate updates and turn the output off. The output will remain off until an I$^2$C command is sent to restart the output. A one-byte write of data with the value 128 (0x80) to the OPERATION command (1 or 0x01) will restore the output.
15. Externally, at the UUT pins, and with a load current of 5.0 ± 0.1 ADC, measure the output voltage VOUT with respect to VOUT_RTN with Kelvin connections to verify that

the calibrated UUT meets the required value and tolerance specified in **Error! Reference source not found.**; if the measurement lies outside the specified range, the output calibration failed.

**Table 7. Calibrated Output Voltage Tolerance Requirement**

| Parameter | Required Value | Tolerance |
|---|---|---|
| Calibrated Output Voltage at 5.0 Ampere Load | 10.0 | ±0.05V |

### 4.1.4 Current Limit Calibration

Calibration of the UUT's current limit function is performed by placing the UUT's firmware in a special calibration mode and then applying a load current equal to the desired over-current threshold. The UUT will then adjust its internal current limit threshold until an over-current fault is detected and store this value in its internal program memory.

**Setup:**

A DC load will be applied during this test. Do not apply the load until the UUT is powered up and the device has been instructed to be ready for the load.

Hold ENABLE_N LOW. (Enabled state.)

Setup the input power supply to current limit at 5.5 Amperes.

Using a fan, apply airflow to the UUT.

**Procedure:**

1. Apply 28.0 ± 0.5 VDC to VIN with respect to VIN_RTN, wait approximately 20 milliseconds, then reduce the input voltage to 12.5 ± 0.5 VDC. This lower voltage is required to allow entry into the calibration mode.
2. Command the UUT into calibration mode by requesting a read of 6 bytes from the CALIBRATION_ROUTINE command (189 or 0xBD).
3. The device will respond by transmitting 6 bytes of information containing the upper and lower bytes for the 3 words containing the board identification.
4. After receiving the 6 bytes of information, initiate a write command with the received 6 bytes of data to the CALIBRATION_ROUTINE command (189 or 0xBD).
5. The UUT will acknowledge each byte of data if it matches the same sequence and data that was initially transmitted during the read command.
6. After the $6^{th}$ $I^2C$ acknowledgment bit is received from the UUT and the $I^2C$ stop bit is sent to the UUT, the device will enter the Calibration Mode.
7. Increase the VIN voltage to 28.0 ± 0.5 VDC with respect to VIN_RTN. The UUT output voltage should rise to 10.0 ± 1.5 VDC after transmitting the $I^2C$ command of a one-byte write of data with the value 128 (0x80) to the OPERATION command (1 or 0x01).
8. Wait 500 milliseconds before requesting the initialization of the output over-current calibration sequence.

9. Initiate calibration cycle by writing to the device with the READ_IOUT (140 or 0x8C) command with one byte of data with the value 85 (0x55). Verify start of calibration cycle as indicated by receipt of third acknowledgement bit. Immediately following the stop bit of this request, the device will then initialize the over-current trip point to allow calibration.
10. Wait at least 100uS before applying the load.
11. Apply a load current of 12.5 ± 0.1 ADC to the UUT's output.
12. Start the output calibration by writing a single byte to the READ_IOUT (140 or 0x8C) command. The byte shall be the value 85 (0x55). Upon receipt of the acknowledge bit, the UUT will begin to auto calibrate the over-current trip point.
13. Monitor the UUT output. Completion of the calibration cycle is indicated by the UUT output voltage shutting off (falling to less than 0.5VDC). Once complete, remove the load current from the UUT's output.
14. Request the trim value by writing the one byte command extension for TRIM_DAC_NUM (7 or 0x07) to the READ_DEVICE_INFO command (176 or 0xBO). Then read one byte from command READ_DEVICE_INFO. If the received value is either 1 (0x01) or 255 (0xFF) then the output current calibration failed.
15. Converter awaits an $I^2C$ command to restart the output. Write one byte of data with the value 128 (0x80) to the OPERATION command (1 or 0x01) to restore the output to 10.0 ± 1.5 VDC.

Caution:

The duration of the applied load current must be limited to prevent overheating of the UUT in the case of a calibration error. Note the time when load current is applied and the calibration routine is initiated and remove the load after 30.0 seconds.

### 4.1.5 Input Voltage Measurement Calibration

The UUT's input voltage measurement circuit is calibrated to ensure accurate undervoltage lockout (UVLO) thresholds. Calibration of the UUT's expected input voltage measurement is performed externally to the UUT. The UUT will sample its input voltage, compare this value to the supplied value and store the difference in its program memory.

**Setup:**

No load is applied to the UUT's output.

Hold ENABLE_N LOW. (Enabled state.)

Setup the input power supply to current limit at 1.5 Amperes.

**Procedure:**

1. Apply 28.0 ± 0.5 VDC to VIN with respect to VIN_RTN, wait approximately 20 milliseconds, then reduce the input voltage to 12.5 ± 0.5 VDC. This lower voltage is required to allow entry into the calibration mode.
2. Command the UUT into calibration mode by requesting a read of 6 bytes from the CALIBRATION_ROUTINE command (189 or 0xBD).

3. The device will respond by transmitting 6 bytes of information containing the upper and lower bytes for the 3 words containing the board identification.
4. After receiving the 6 bytes of information, initiate a write command with the received 6 bytes of data to the CALIBRATION_ROUTINE command (189 or 0xBD).
5. The UUT will acknowledge each byte of data if it matches the same sequence and data that was initially transmitted during the read command.
6. After the 6th $I^2C$ acknowledgment bit is received from the UUT and the $I^2C$ stop bit is sent to the UUT, the device will enter the Calibration Mode.
7. Increase the VIN voltage to 28.0 ± 0.1 VDC with respect to VIN_RTN. The UUT output voltage should rise to 10.0 ± 0.1 VDC after transmitting the $I^2C$ command of a one-byte write of data with the value 128 (0x80) to the OPERATION command (1 or 0x01).
8. Externally, at the UUT pins, measure the output voltage VIN with respect to VIN_RTN with Kelvin connections to obtain a value of *VIN*.
9. Calculate the expected input voltage as measured by the UUT per the following equation:

$$Vin_{exp} = Round\left\{\frac{VIN * \frac{0.04443V}{V}}{\frac{0.004883V}{bit}}\right\}$$

10. Write the expected value to the UUT with a two byte write to READ_VIN (136 or 0x88). The first byte to be transmitted shall be the lower byte of the integer $Vin_{exp}$. The second byte to be transmitted shall be the upper byte of the integer $Vin_{exp}$.
11. After the stop bit is transmitted in the above step. The UUT will automatically calibrate the ADC reading to the provided expected value. Once the device finishes its routine, the output voltage will turn off (falling to less than 0.5VDC). The output will remain off until an $I^2C$ command is sent to restart the output. A one-byte write of data with the value 128 (0x80) to the OPERATION command (1 or 0x01) will restore the output.
12. Read the value of the stored VINADCCOR by writing two-bytes to the READ_DEVICE_INFO command (176 or 0xB0) with the command extension ADC_CORRECTION (14 or 0x0E). The first byte received will be a two's complement signed char representing the input ADC offset. If the magnitude of the obtained signed char is greater than 6, then the output calibration failed.

### 4.1.6 Give the UUT a Unique Board Identification

This section will describe how to give the UUT a unique serial number.

**Setup:**

No load is applied to the UUT's output.

Hold ENABLE_N LOW. (Enabled state.)

Setup the input power supply to current limit at 1.5 Amperes.

**Procedure:**

1. Apply 28.0 ± 0.5 VDC to VIN with respect to VIN_RTN, wait approximately 20 milliseconds, then reduce the input voltage to 12.5 ± 0.5 VDC. This lower voltage is required to allow entry into the calibration mode.
2. Command the UUT into calibration mode by requesting a read of 6 bytes from the CALIBRATION_ROUTINE command (189 or 0xBD).
3. The device will respond by transmitting 6 bytes of information containing the upper and lower bytes for the 3 words containing the board identification.
4. After receiving the 6 bytes of information, initiate a write command with the received 6 bytes of data to the CALIBRATION_ROUTINE command (189 or 0xBD).
5. The UUT will acknowledge each byte of data if it matches the same sequence and data that was initially transmitted during the read command.
6. After the $6^{th}$ $I^2C$ acknowledgment bit is received from the UUT and the $I^2C$ stop bit is sent to the UUT, the device will enter the Calibration Mode.
7. Increase the VIN voltage to 28.0 ± 0.1 VDC with respect to VIN_RTN. The UUT output voltage should rise to 10.0 ± 0.1 VDC after transmitting the $I^2C$ command of a one-byte write of data with the value 128 (0x80) to the OPERATION command (1 or 0x01).
8. Write 7 bytes to the READ_DEVICE_INFO command (176 or 0xB0). The first byte shall be the command extension READ_BOARD_ID_1 (9 or 0x09). The remaining 6 bytes shall be composed of the BOARDID1LO, BOARDID1HI, BOARDID2LO, BOARDID2HI, BOARDID3LO, and BOARDID3HI; transmitted in the order given. A 20 bit work order and 14 bit serial number shall be generated for populating the bit-fields of the 3 board identification bytes shown in Table 11 of Section 5.4.
9. After the stop bit is transmitted in the above step. The UUT will store the new board identification in its program memory and then will turn the output off.
10. Monitor the UUT output. Completion of the calibration cycle is indicated by the UUT output voltage shutting off (falling to less than 0.5VDC). The output will remain off until an $I^2C$ command is sent to restart the output. Once the output falls below the specified value, write one-byte of data with the value 128 (0x80) to the OPERATION command (1 or 0x01) to restore the output.
11. Verify the board identification has been written to the device by initiating a one-byte write to the READ_DEVICE_INFO (176 or 0xB0) command with the extension codes for any of the three board identification words. READ_BOARD_ID_1 (9 or 0x09), READ_BOARD_ID_2 (10 or 0x0A), or READ_BOARD_ID_3 (11 or 0x0B) as given in Table 10. Then read two bytes from the READ_DEVICE_INFO command. The first byte received should match lower byte of the board identification and the second byte should match the upper byte of the data transmitted in step 7. An exception will be bits<7:0> (the lower byte of board identification word 2) which contain the flags for the calibration routines that have been run and the firmware version. If the received bytes don't match the intended board identification numbers that were sent (with the exception of the flag bits and firmware version for each of the calibration routines that have been run), then the board identification programming failed.

## 4.2 Final Checkout

These tests are performed on a unit which has been calibrated per the prior section.

### 4.2.1 Output Load and Line Regulation

The UUT's output voltage as a function of output current and input voltage is measured to verify the calibration previously performed was effective and the UUT has no issues.

**Setup:**

A DC load will be applied during this test. Do not apply the load until the UUT is powered up.

Initially, allow ENABLE_N to float. (HIGH, disabled state.)

Setup the input power supply to current limit at 5.5 Amperes.

Using a fan, apply airflow to the UUT.

**Procedure:**

1. Apply 28.0 ± 0.1 VDC to VIN with respect to VIN_RTN.
2. Enable the UUT by shorting ENABLE_N to VIN_RTN
3. Verify and record the output voltage under the conditions specified in Table 8.

**Table 8. Calibrated UUT Input and Output Voltage Tolerance Requirements**

| Parameter | Input Voltage (±0.1V) | Load Current (±0.1A) | Required Value | Tolerance |
|---|---|---|---|---|
| Output Voltage, Nominal Line | 28.0V | 0.0A | 10.00V | ±0.30V |
| Output Voltage, Nominal Line | 28.0V | 5.0A | 10.00V | ±0.05V |
| Output Voltage, Nominal Line | 28.0V | 10.0A | 10.00V | ±0.30V |
| Output Voltage, Minimum Line | 24.0V | 10.0A | 10.00V | ±0.50V |
| Output Voltage, Maximum Line | 36.0V | 10.0A | 10.00V | ±0.50V |

### 4.2.2 Synchronization Pin Functionality

The UUT's synchronization pin functionality is confirmed by verifying that holding the pin HIGH during startup causes the UUT's $I^2C$ address to change.

**Setup:**

Disconnect any DC loads from the output.

Initially, allow ENABLE_N to float. (HIGH, disabled state.)

Setup the input power supply to current limit at 1.0 Amperes.

**Procedure:**

1. Pull the SYNC input pin HIGH (approx. 4.0V) through a 4.75KOhm series resistor. The pin has a 20KOhm pulldown resistor. The series resistor limits the input current to a safe value so that it can be applied before the UUT powers up. This ensures that the test equipment does not need to worry about timing of application of the HIGH value with respect to turn on of the 28V power supply.
2. Apply 28.0 ± 0.5 VDC to VIN with respect to VIN_RTN.
3. Verify $I^2C$ address has changed by sending a one-byte read query to $I^2C$ device address 28 (0x1C) and command code FREQUENCY_SWITCH (51 or 0x33). Verify that the received byte has value 0x06, if the request is not acknowledged, the synchronization pin test failed.
4. Disable the input power, the final checkout is now complete.

# 5 Appendix

## 5.1 ISO Block Dimensions

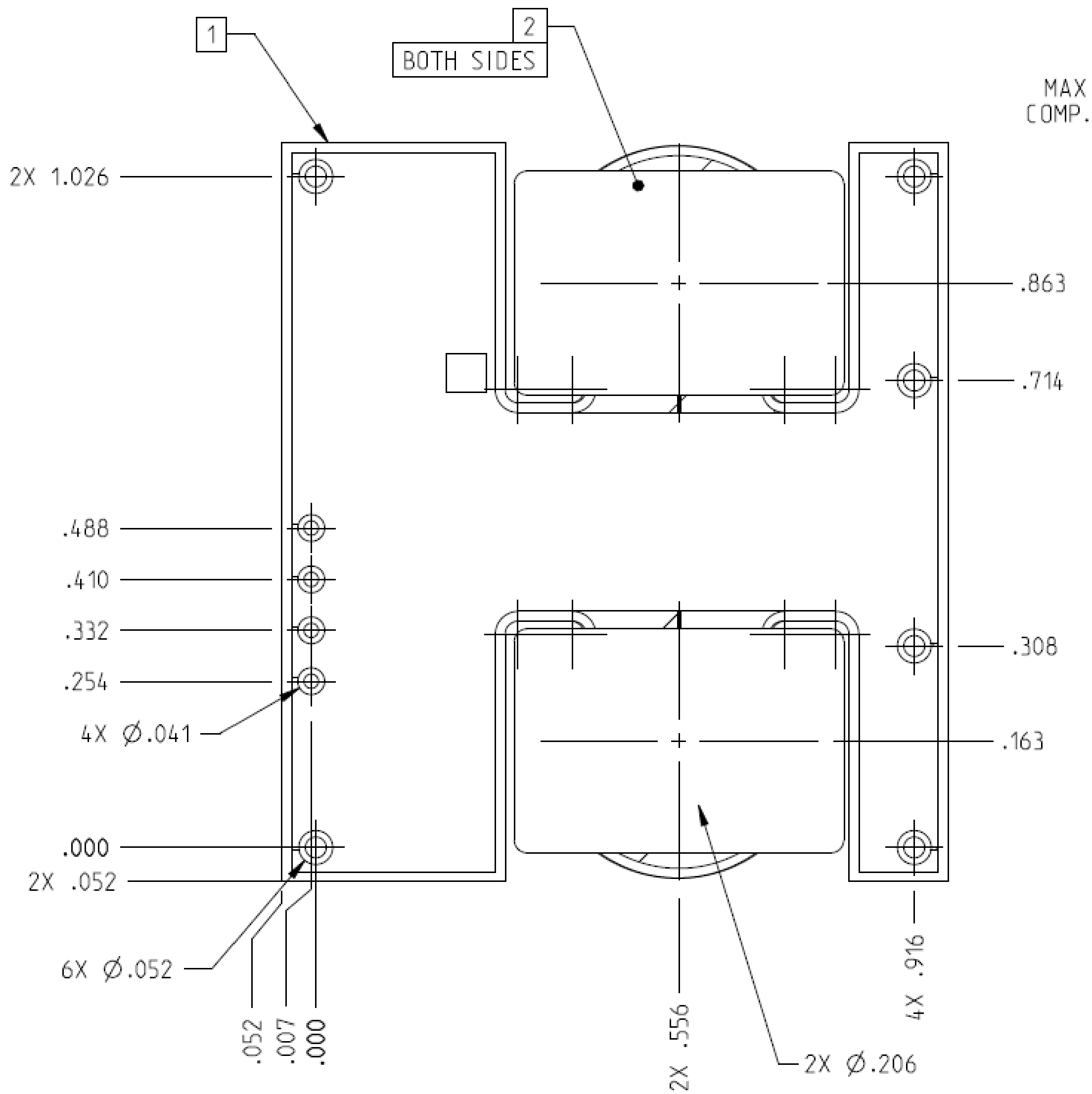


**Figure 6. Dimensions - Top View**

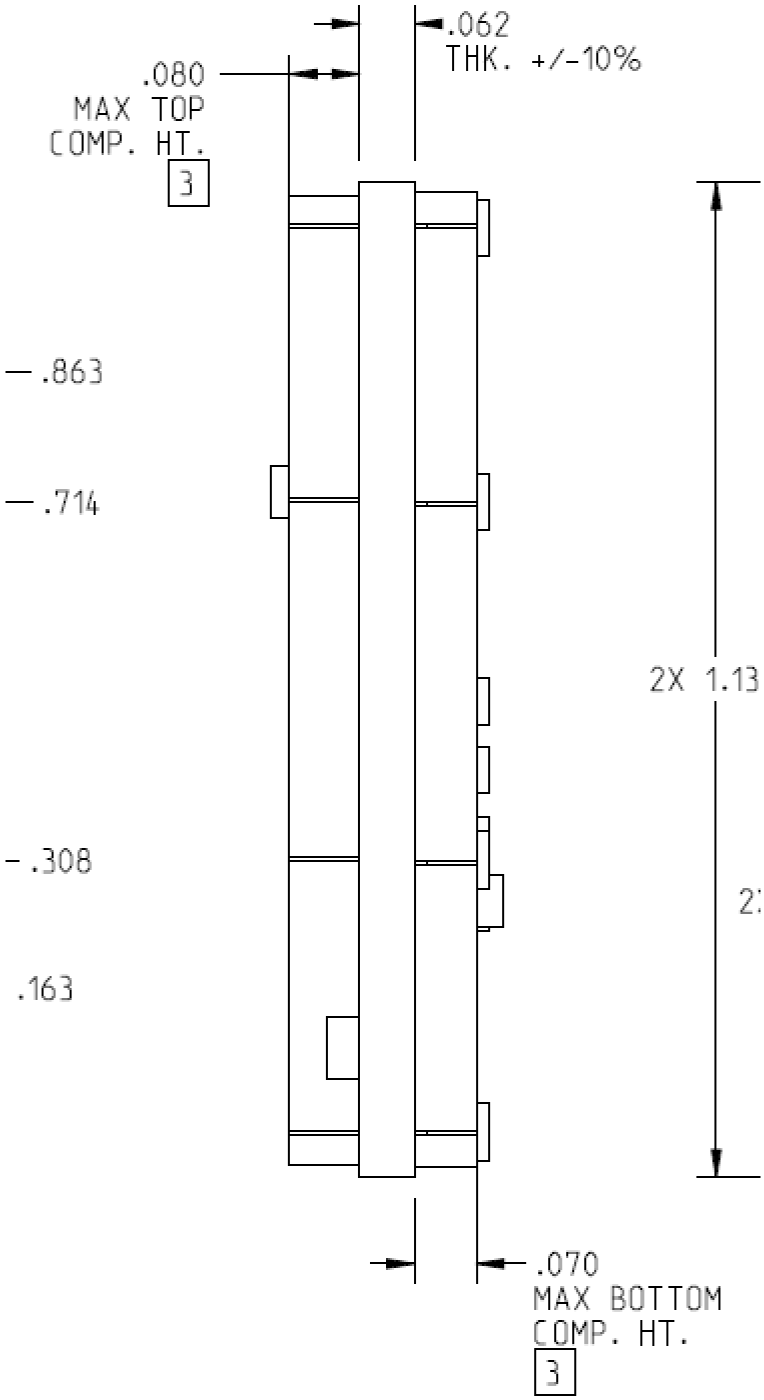


**Figure 7. Dimensions - Side View**

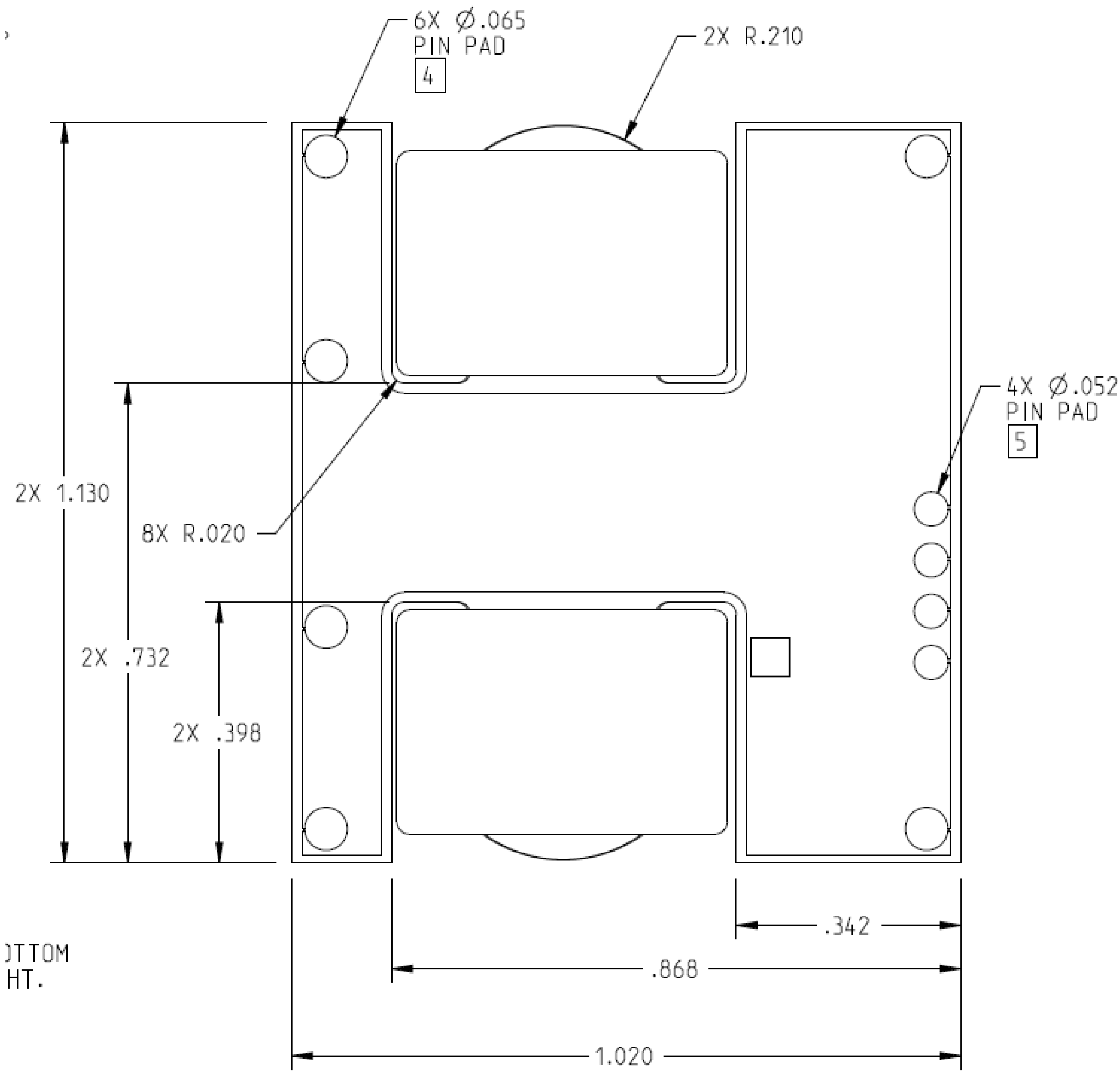


**Figure 8. Dimensions - Bottom View**

## 5.2 I²C Command Codes

**Table 9. I²C Command Codes**

| Command Code | Command Name | Decimal Value for Command | Description | R/W/Cal | # of Bytes Read | # of Bytes Written | # of Bytes Written in Calibration |
|---|---|---|---|---|---|---|---|

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0x01 | OPERATION | 1 | turn converter on/off and choose nominal output voltage mode reads/writes to the ON_OFF_I2C byte | R/W | 1 | 1 | -- |
| 0x03 | CLEAR_FAULTS | 3 | single byte write of any value clears any fault bits that have been set in the FAULT_STATUS register | W | -- | 1 | -- |
| 0x33 | FREQUENCY_SWITCH | 51 | single byte read command to obtain the value (PR2) controlling the switching frequency of the device | R | 1 | -- | -- |
| 0x78 | STATUS_BYTE | 120 | single byte read command to obtain the value in the FAULT_STATUS register indicating which faults have occurred | R | 1 | -- | -- |
| 0x88 | READ_VIN | 136 | 2 byte read command that obtains the most recent sample of the scaled input voltage. First the lower 8 bits (VINLSB), then the upper two bits (VINMSB) | R/Cal | 2 | -- | 2 |
| 0x8C | READ_IOUT | 140 | 2 byte read command that returns the approximated DC output current (IOUTLSB and IOUTMSB) | R | 2 | -- | 1 |
| 0xB0 | READ_DEVICE_INFO | 176 | write a one byte value between 1 and 16 to read a two byte device parameter specified | R/W/Cal | 2 | 1-3 | 7 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | | in the following table | | | | |
| 0xB3 | DELTA_OUTPUT_CHANGE | 179 | 2 byte read command to obtain first the fine control register (DELTA_FINE) then the coarse control register (DELTA_COARSE) controlling the offset from the output voltage setpoint | R/W/Cal | 2 | 2 | 2 |
| 0xBD | CALIBRATION_ROUTINE | 189 | 6 byte read or write command of bytes containing the device serial number for unlocking the calibration routines | R/W | 6 | 6 | -- |

## 5.3 I²C Command Extensions for READ_DEVICE_INFO

**Table 10. I²C Command Code Extensions for the READ_DEVICE_INFO Command Code**

| Command Extension Hex Code | READ_DEVICE_INFO command extensions | Decimal Value for Command Extension | Description | R/W/Cal | # of Bytes Read | # of Bytes Written | # of Bytes Written in Calibration |
|---|---|---|---|---|---|---|---|
| 0x07 | TRIM_DAC_NUM | 7 | single byte read to obtain the number of trim pulses (TRIMOC) sent to the output over-current DAC. Writeable once calibration has been unlocked for obtaining a tuned value for trimming the output over-current to a determined value | R | 1 | -- | -- |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0x09 | READ_ BOARD_ID _1 | 9 | 2 byte read command to obtain first the lower byte (BOARDID1LO) of the 1st board identification number then the upper byte (BOARDID1HI) | R/Cal | 2 | -- | 7 |
| 0x0A | READ_ BOARD_ID _2 | 10 | 2 byte read command to obtain first the lower byte (BOARDID2LO) of the 2nd board identification number then the upper byte (BOARDID2HI) | R | 2 | -- | -- |
| 0x0B | READ_ BOARD_ID _3 | 11 | 2 byte read command to obtain first the lower byte (BOARDID3LO) of the 3rd board identification number then the upper byte (BOARDID3HI) | R | 2 | -- | -- |
| 0x0E | ADC_CORRECTIONS | 14 | single byte read command to obtain the calibration values used to trim the microcontroller's ADC reading of Vin. The signed byte for the input voltage (VINADCCOR) | R | 1 | -- | -- |

## 5.4 Bytes and Bit-Fields for Readable and Writeable Data

**Table 11. Useful Bytes and Bitfields for data send and receivd from the UUT**

| Byte Name and Description | bit <7> | bit <6> | bit <5> | bit <4> | bit <3> | bit <2> | bit <1> | bit <0> |
|---|---|---|---|---|---|---|---|---|

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| ON_OFF_I2C - 8-bit field for reading/setting on or off status with i2c | I2C_ON - 1 if commanded to turn on via i2c, 0 if commanded to turn off (Note must be configured to respond to i2c in ON_OFF_OPERATION) | -- | -- | -- | -- | -- | -- | -- |
| FAULT_STATUS - 8-bit field for reading fault status | -- | -- | watchdog_timeout - 1 if microcontroller watchdog timer expired, 0 if it didn't expire | vout_uv_fault - 1 if the output voltage fell below the voltage specified by the output under-voltage threshold register, 0 if it remained above that specified value | vout_ov_fault - 1 if the output voltage rose above the voltage specified by the output over-voltage threshold register, 0 if it remained below that specified value | iout_oc_fault - 1 if the GreenPAK signaled an over-current event, 0 if it did not signal an over-current event | vin_uv_fault - 1 if input voltage fell below input threshold after a startup routine, 0 if the input voltage remained above the specified threshold | pwr_good_fault - 1 if power_good signal not received from GreenPAK after soft start routine, 0 if power_good didn't fault |
| VINLSB - 8-bit field for reading the input voltage | VINLSB<7:0> - Ten bit value formed with VINMSB for reading the input voltage using the equation: Vin_sampled = <VINMSB:VINLSB>*5/(1023*Vin_Voltage_Divider_Ratio) | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| VINMSB - 8-bit field for reading the input voltage | -- | -- | -- | -- | -- | -- | VINMSB<9:8> - Ten bit value formed with VINLSB for reading the input voltage using the equation: Vin_sampled = <VINMSB:VINLSB>*5/(1023*Vin_Voltage_Divider_Ratio) |
| IOUTLSB - 8-bit field for reading the output voltage | IOUTLSB<7:0> - Ten bit value formed with IOUTMSB for reading the input voltage using the equation: ??? | | | | | | |
| IOUTMSB - 8-bit field for reading the output voltage | -- | -- | -- | -- | -- | -- | IOUTMSB<9:8> - Ten bit value formed with IOUTLSB for reading the input voltage using the equation: ??? |
| DELTA_COARSE - 8-bit field for reading/settting the coarse offset voltage from the output voltage setpoint | DELTA_COARSE<7:0> - Eight bits field that in conjunction with DELTA_FINE represents the offset from the output setpoint using the equation: offset = -1^sign * (DELTA_COARSE*0x0158+DELTA_FINE*0.0008)/Vout_Voltage_Divider_Ratio | | | | | | |
| DELTA_FINE - 8-bit field for reading/settting the fine offset voltage from the output voltage setpoint | SIGN - 1 if offset should be negative, 0 if offset is positive | -- | -- | DELTA_FINE<4:0> - Five bits field that in conjunction with DELTA_COARSE represents the offset from the output setpoint using the equation: offset = -1^sign * (DELTA_COARSE*0x0158+DELTA_FINE*0.0008)/Vout_Voltage_Divider_Ratio | | | |
| TRIMOC - 8-bit field for reading the number of pulses sent to the GreenPAK over-current sensing circuit | TRIMOC<7:0>- Eight bit value between 1 and 255 indicating how many pulses are sent to the GreenPAK to trim the DAC for setting the over-current circuitry | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| BOARDID1HI - 8-bit field for reading the low byte of the upper byte of the first board identification number | -- | -- | WO<13:8>- portion of 20 bit field specifying board work order | | | | | |
| BOARDID1LO - 8-bit field for reading the low byte of the lower byte of the first board identification number | WO<7:0>- portion of 20 bit field specifying board work order | | | | | | | |
| BOARDID2HI - 8-bit field for reading the low byte of the upper byte of the second board identification number | -- | -- | WO<19:14>- portion of 20 bit field specifying board work order | | | | | |
| BOARDID2LO - 8-bit field for reading the low byte of the lower byte of the second board identification number | SER_NO_PROG - set by the controller if the serial number and calibration dates were programmed | IOUT_CAL - set by the controller if the output overcurrent trip point has been calibrated | VIN_CAL - set by the controller if the input voltage correction factor has been calibrated | VOUT_CAL - set by the controller if the output voltage setpoint has been calibrated | REV<3:0> - firmware revision | | | |
| BOARDID3HI - 8-bit field for reading the low byte of the upper byte of the third board identification number | -- | -- | SR_NO<13:8>- portion of 14 bit field specifying board serial number | | | | | |
| BOARDID3LO - 8-bit field for reading the low byte of the upper byte of the third board identification number | SR_NO<7:0>- portion of 14 bit field specifying board serial number | | | | | | | |

| | |
|---|---|
| VINADCCOR - 8-bit field for reading the 2's complement signed number for how many counts to adjust the ADC readings of the input voltage for accurate readings | VINADCCOR<7:0> - Eight bit, 2's complement value for specifying the number of counts to add/subtract from each ADC reading of the input voltage for accuracy (range of -128 to 127) |