# ACT510xEVK1-102 User's Guide

## Description

This document describes the characteristic and operation of the Active Semi ACT5101EVK1-102 and ACT5102EVK1-102 evaluation kits (EVK). It provides setup and operation instructions, schematic, layout, BOM, and test data. The ACT5101EVK1-102 demonstrates the ACT5101QI102 power management IC. The ACT5102EVK1-102 demonstrates the ACT5102QI102 power management IC. Other ACT5101QIxxx and ACT5102QIxxx options can be evaluated on these EVKs by replacing the IC and any other necessary components.

The two EVKs are very similar. The difference is that the ACT5101 output voltage is set by internal registers and it has A/D functionality. The ACT5102 output voltage is set by external resistors and it does not have A/D functionality. The setup and operation of the two EVKs are identical, so this document only references the ACT5101.

## Features

The EVKs can be used as a standalone boards if desired. However, to access the internal registers and to take full advantage of the IC's capability, the user must connect the EVK kits to a PC with Active Semi's USB-TO-I2C interface dongle and use the GUI software. The EVK provides full access to the each converter's input and output voltage, as well as all the digital control signals. This gives the user the flexibility to configure the EVK to match their real world system.

**Figure 1 – EVK Picture**

## EVK Contents

The ACT5101EVK1-102 and ACT5102EVK1-102 evaluation kits come with the following items:

1. EVK assembly
2. USB-TO-I2C dongle
    a. Dongle
    b. Custom 4-pin connector that connects the USB-TO-I2C dongle to the EVK assembly

### Required Equipment

ACT5101EVK1-102

USB-TO-I2C Dongle

Power supply → 4~22V @ 6A for full power operation

Oscilloscope →100MHz, 4 channels

Digital Multi-meters (DMM)

Windows compatible PC with spare USB port.

### Hardware Setup

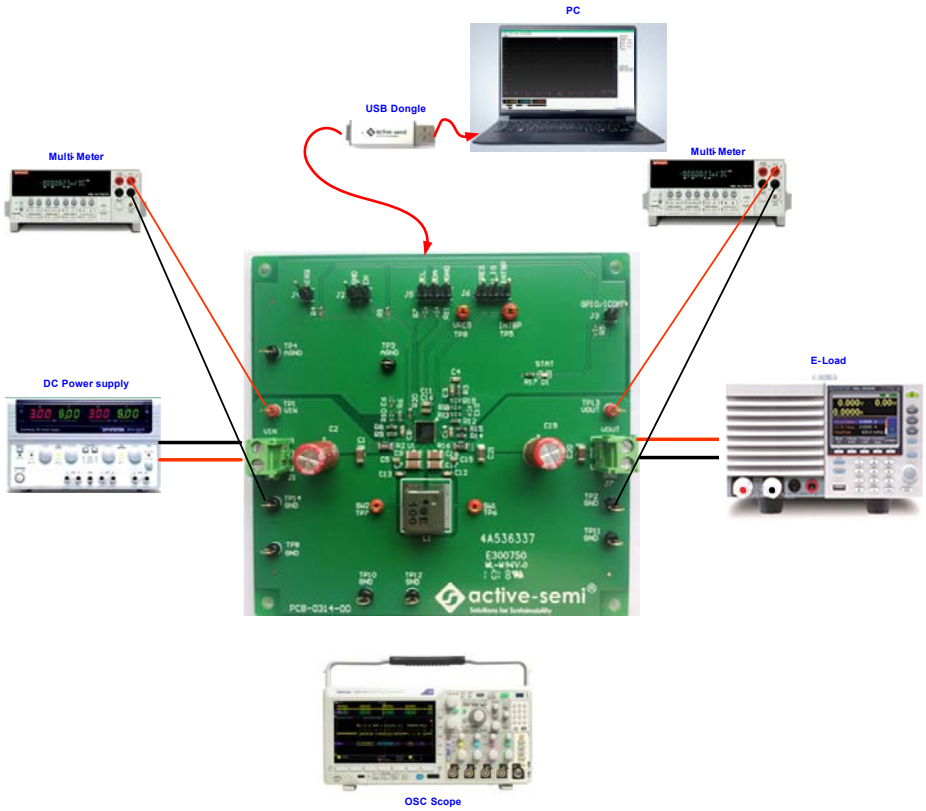



**Figure 2 – EVK Setup**

## Quick Start

### Hardware Connections

Refer to Figure 2 for hardware connections.

1. Connect a DC power supply to J1. Please ensure the correct power supply polarity.
2. Connect an E-Load to J7.
3. Connect Digital Multi-Meters to VIN and VOUT to monitor the input voltage and output voltages.
4. Add a digital Multi-Meter in series with VIN and VOUT if you want to observe input and output current.
5. Be careful to keep the input voltage and battery voltage within the specifications.
6. Add a jumper to J6 to connect INTBP to V_IO.
7. Optional – Connect the EVK to the PC with the USB dongle.
8. Apply input power. Note that the out

### GUI Setup (optional)

1. Refer to the end of this document for detailed instructions to install the ACT5101 GUI.
2. Connect the USB-TO-I2C dongle to the computer via a USB cable.
3. Connect the USB-TO-I2C dongle to the EVK J5 connector. Refer to Figure 3 to ensure the correct polarity of the connection. As a guide, use the “Active-Semi” logo on the top of the dongle so the black wire is connected to the Dongle GND pin.

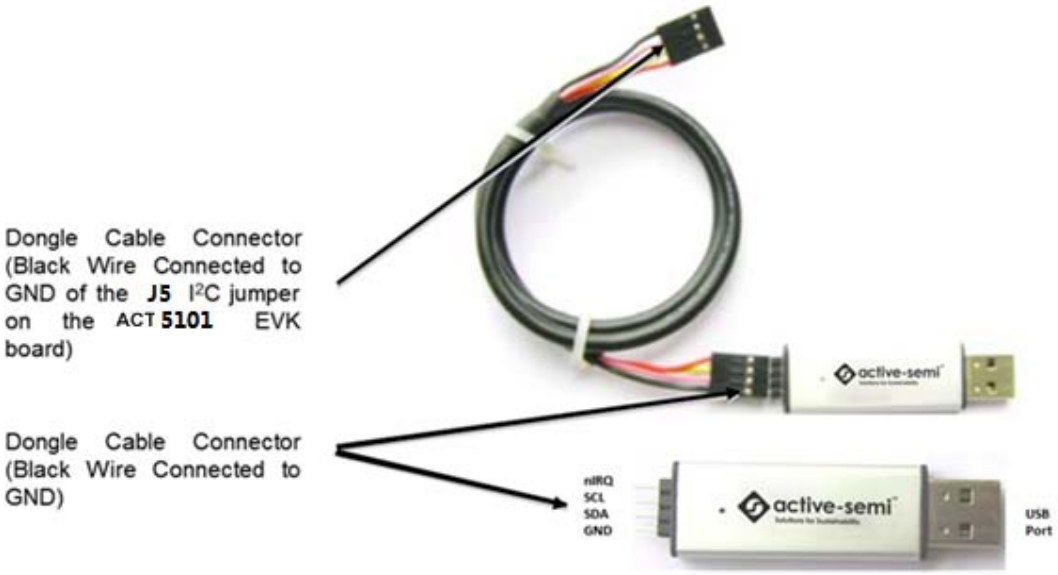



**Figure 3 – USB-TO-I2C Dongle Connection**

## Recommended Operating Conditions

The ACT5101EVK1-102 is designed for a 4V-22V input voltage. The maximum operating voltage is determined by the IC's maximum input voltage rating. The minimum operating voltages are determined by the buck-boost converter's minimum input voltage. Maximum currents are determined by the IC's CMI settings, which can be changed via I²C after startup. Operating currents are configured by CMI and external components.

**Table 1. Recommended Operating Conditions**

| Parameter | Description | Min | Typ | Max | Unit |
|---|---|---|---|---|---|
| VIN | Charger input voltage | 4 | - | 22 | V |
| VOUT | Charger output voltage | 3 | - | 20 | V |
| $I_{In\_max}$ | Maximum input current | | 5 | | A |
| $I_{out\_max}$ | Maximum output current | | 5 | | A |
| $I_{REG\_max}$ | Maximum LDO VREG load current | | 0.1 | | A |

## EVK Operation

### Turn On the Evaluation Board

Before applying the input voltage, please make sure the jumper (J6) is installed. Connect V_IO to INTBP or VREG. INTBP is the typical connection.

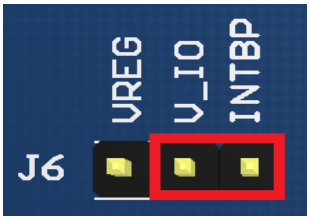



**Figure 4 – Hardware Configuration**

After the power source and E-Load are connected to the evaluation board per the required connections, the EVK can be powered for operation. Perform the following steps to turn on the board.

1. Ensure that the power supply connected to VIN (J1) is >4V and <22V.

3. Turn on power supply.

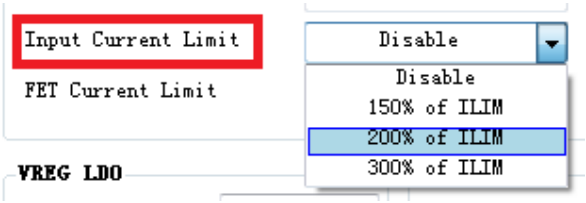
4. Apply the load.

### Input Current Limit Configuration

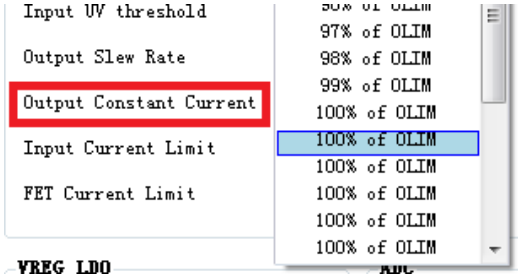
The ACT5101's ActivePath charger features configurable input and output current limit. These features are programmed with a combination of an external resistor and an internal I²C register. Refer to the ACT5101 datasheet for programming details.

**Input Current Limit** – The ACT5101EVK1-102 EVK input current limit is set to 11.11A. This is a function of the 5mΩ current sense resister, R2, the 36kΩ RILIM resistor, R6, and the I²C Input Current Limit bits, INLIMIT, which are set to 200% by default. The hardware current limit set by R2 and R6 is 5.56A. This current multiplied by the input current limit scaling factor of 200% gives a 11.11A input current limit. The input current limit is easily changed by modifying any of these three parameters. The easiest way to change the input current limit is with the Input Current Limit field in the GUI.


*ActiveSwitcher*™ is a trademark of Active-Semi.

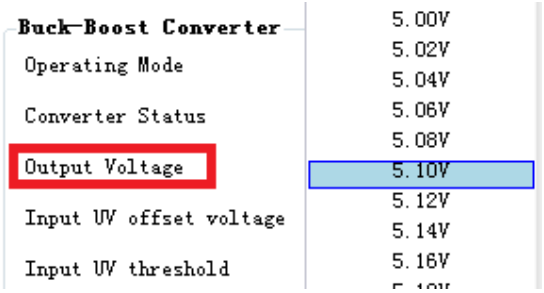



**Output Current Limit** – The ACT5101EVK1-102 EVK output current limit is set to 5A. This is a function of the 10mΩ current sense resister, R16, the 20kΩ RILIM resistor, R12, and the I²C Input Current Limit bits, CC, which are set to 100% by default. The hardware current limit set by R16 and R12 is 5A. This current multiplied by the input current limit scaling factor of 100% gives a 5A output current limit. The output current limit is easily changed by modifying any of these three parameters. The easiest way to change the output current limit is with the Output Constant Current field in the GUI.




## Output Voltage Setting

ACT5101 5.1V default output voltage can be changed I²C using the Output Voltage field GUI setting.

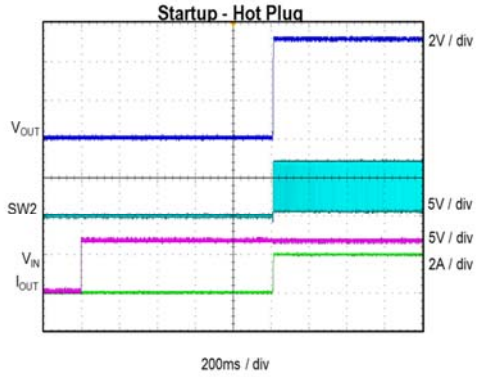



## Additional Programmable Functionality

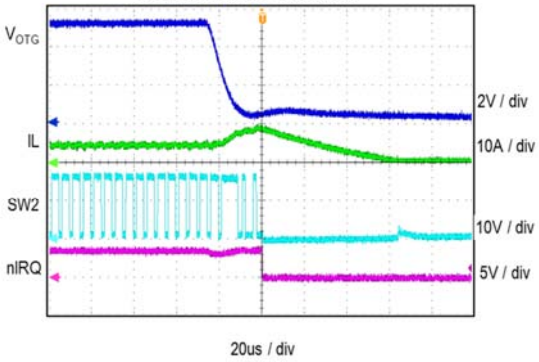
The ACT5101 contains many additional programmable parameters. Refer to the ACT5101 datasheet for additional functionality and default I²C register values.

## Test Results

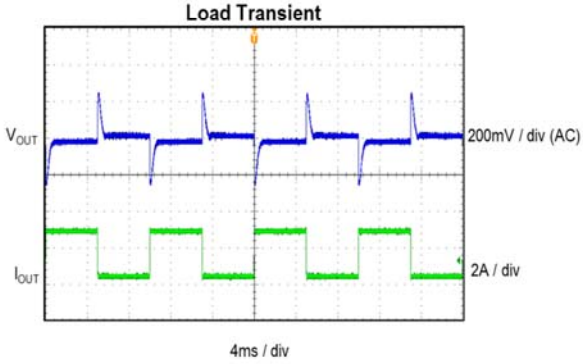
CMI 102
Startup - Hot Plug



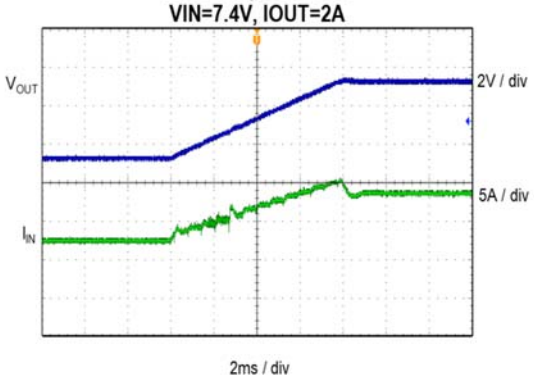

CMI 102
Short Circuit Protection



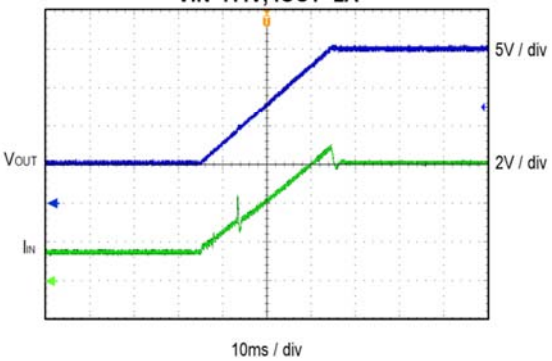

CMI 102
Load Transient



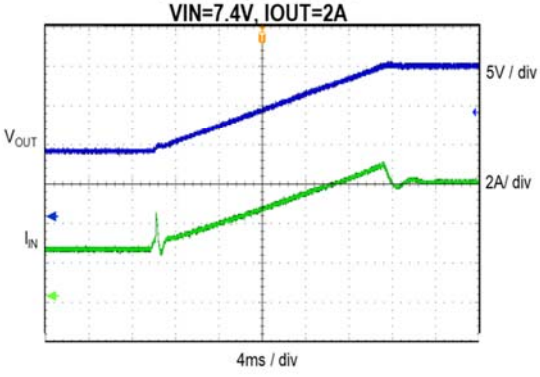

CMI 102
VOUT Step - 5V to 9V
VIN=7.4V, IOUT=2A



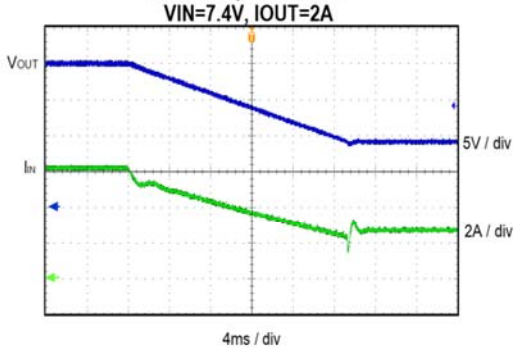

CMI 102
VOUT Step - 5V to 20V
VIN=7.4V, IOUT=2A



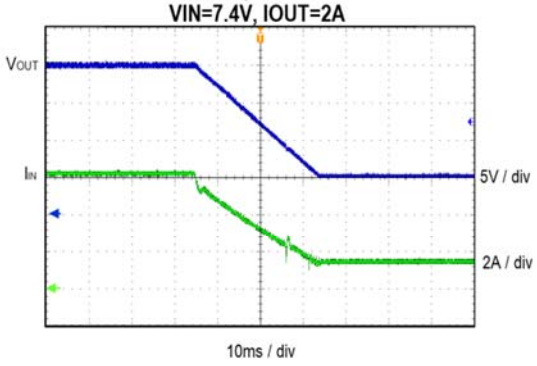

CMI 102
VOUT Step - 9V to 20V
VIN=7.4V, IOUT=2A



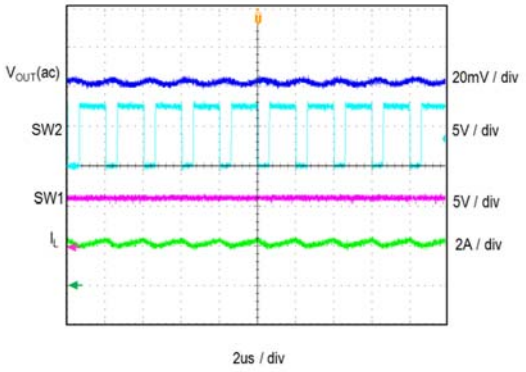
CMI 102
VOUT Step - 20V to 9V
VIN=7.4V, IOUT=2A



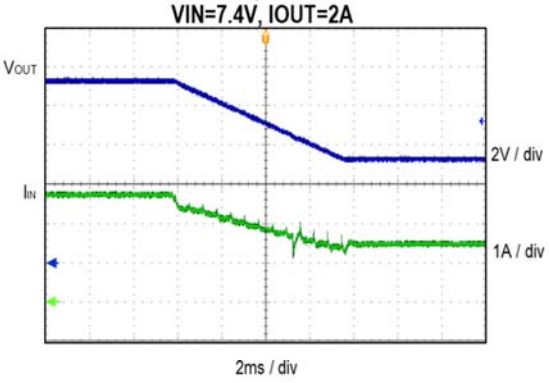

CMI 102
VOUT Step - 20V to 5V
VIN=7.4V, IOUT=2A



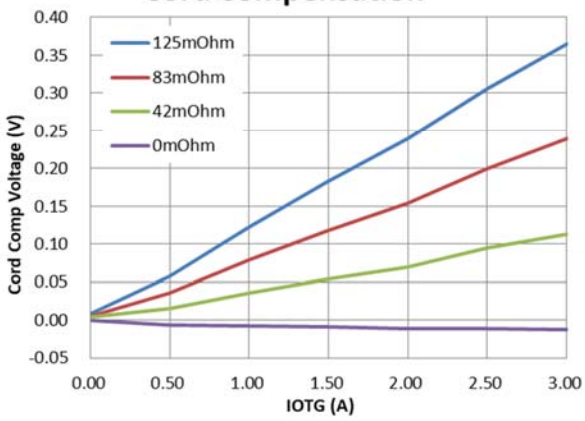

CMI 102
Switching Waveforms
Buck Mode



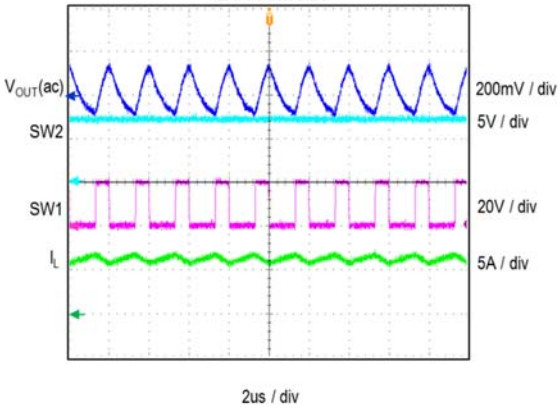

CMI 102
VOUT Step - 9V to 5V
VIN=7.4V, IOUT=2A

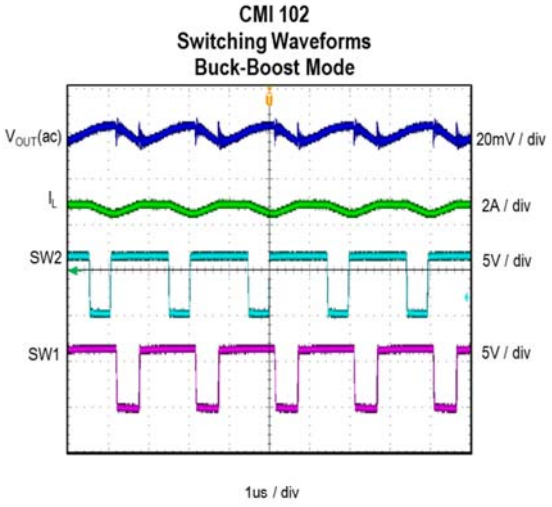


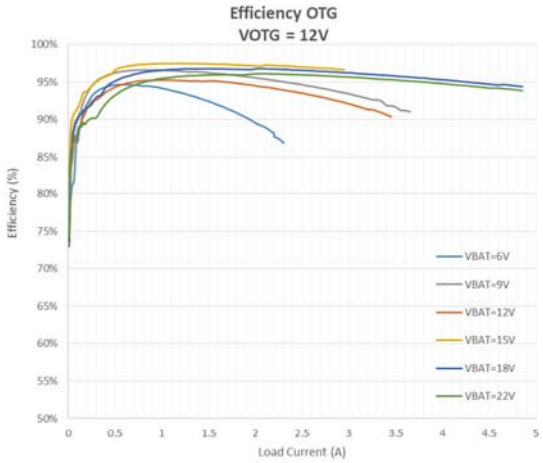

Cord Compensation

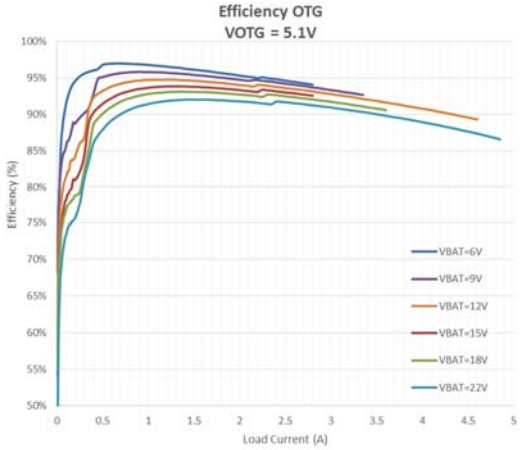



CMI 102
Switching Waveforms
Boost Mode

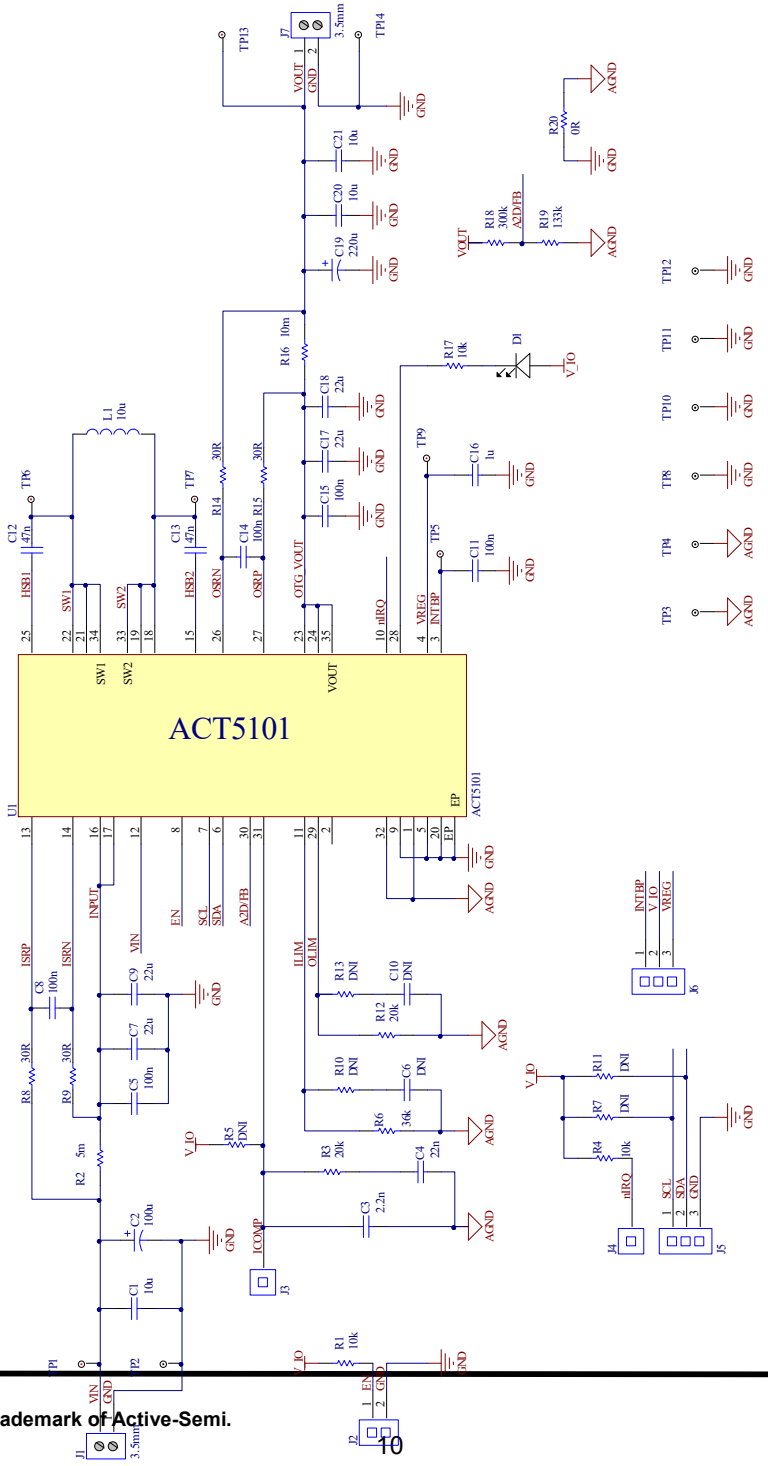



CMI 102
Switching Waveforms
Buck-Boost Mode
VOUT(ac)
IL
SW2
SW1
20mV / div
2A / div
5V / div
5V / div
1us / div


Efficiency OTG
VOTG = 12V
Efficiency (%)
Load Current (A)
VBAT=6V
VBAT=9V
VBAT=12V
VBAT=15V
VBAT=18V
VBAT=22V


Efficiency OTG
VOTG = 5.1V
Efficiency (%)
Load Current (A)
VBAT=6V
VBAT=9V
VBAT=12V
VBAT=15V
VBAT=18V
VBAT=22V

## Schematic


ACT5101
U1
ACT5101
EP
VOUT
SW1
SW2
INPUT
VIN
EN
SCL
SDA
A2D/FB
ISRP
ISRN
ILIM
OLIM
OSRN
OSRP
OTG VOUT
nIRQ
VREG
INTBP
HSB1
HSB2
ICOMP
TP1
TP2
TP3
TP4
TP5
TP6
TP7
TP8
TP9
TP10
TP11
TP12
TP13
TP14
J1
J2
J3
J4
J5
J6
J7
L1
10u
R1
10k
R2
5m
R3
20k
R4
10k
R5
DNI
R6
36k
R7
DNI
R8
30R
R9
30R
R10
DNI
R11
DNI
R12
20k
R13
DNI
R14
30R
R15
30R
R16
10m
R17
10k
R18
300k
R19
133k
R20
0R
C1
10u
C2
100u
C3
2.2n
C4
22n
C5
100n
C6
DNI
C7
22u
C8
100n
C9
22u
C10
DNI
C11
100n
C12
47n
C13
47n
C14
100n
C15
100n
C16
1u
C17
22u
C18
22u
C19
220u
C20
10u
C21
10u
D1
V_IO
AGND
GND
VOUT
GND
3.5mm

## Layout

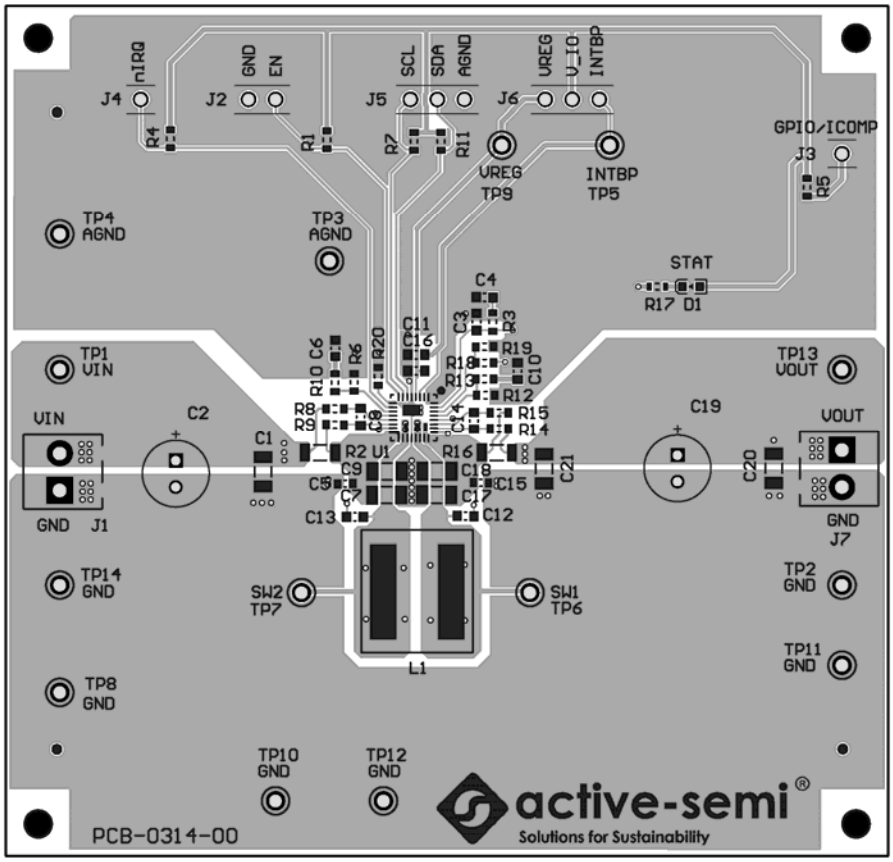



**Figure 5 – Layout Top Layer**

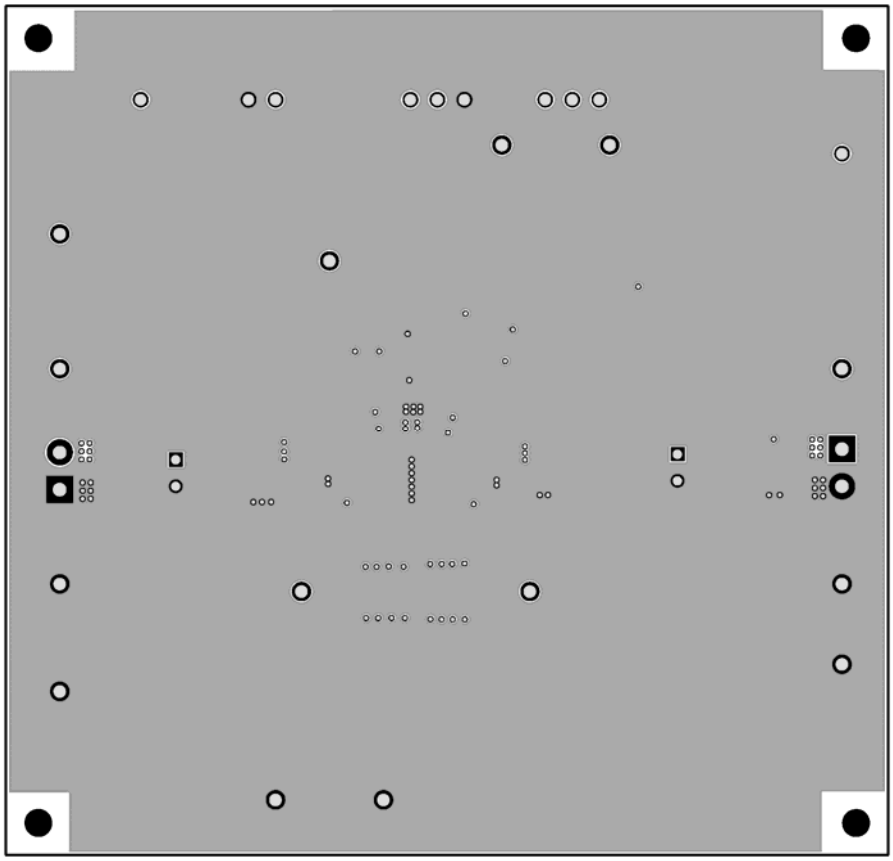


**Figure 6 – Layout Layer GND**

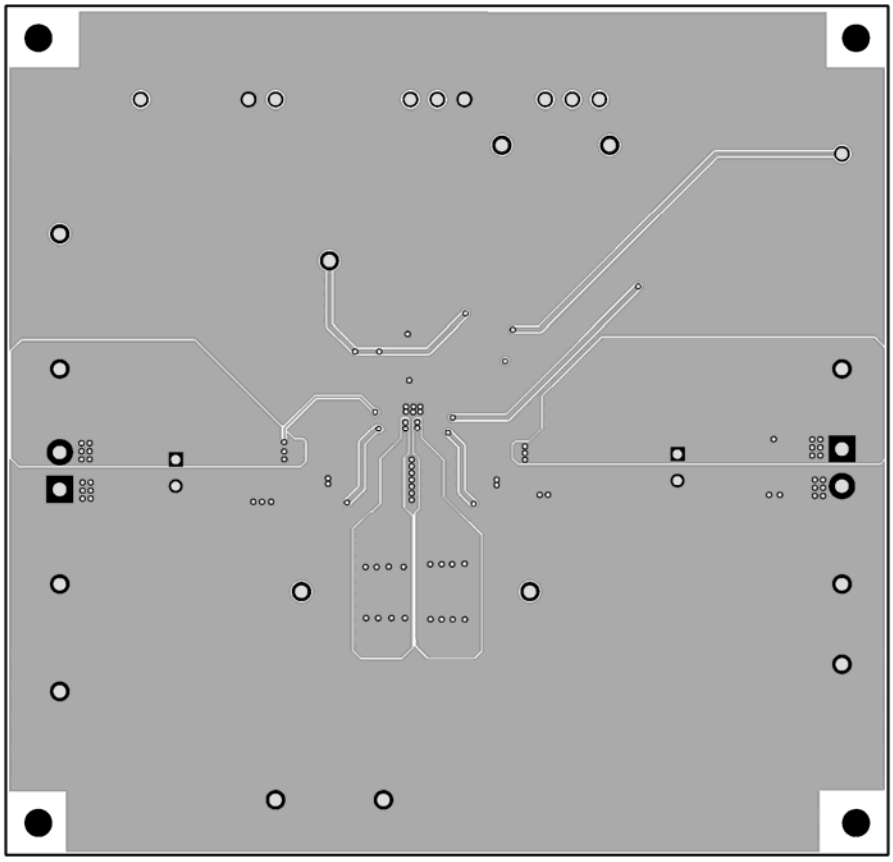


**Figure 7 – Layout Layer VCC**

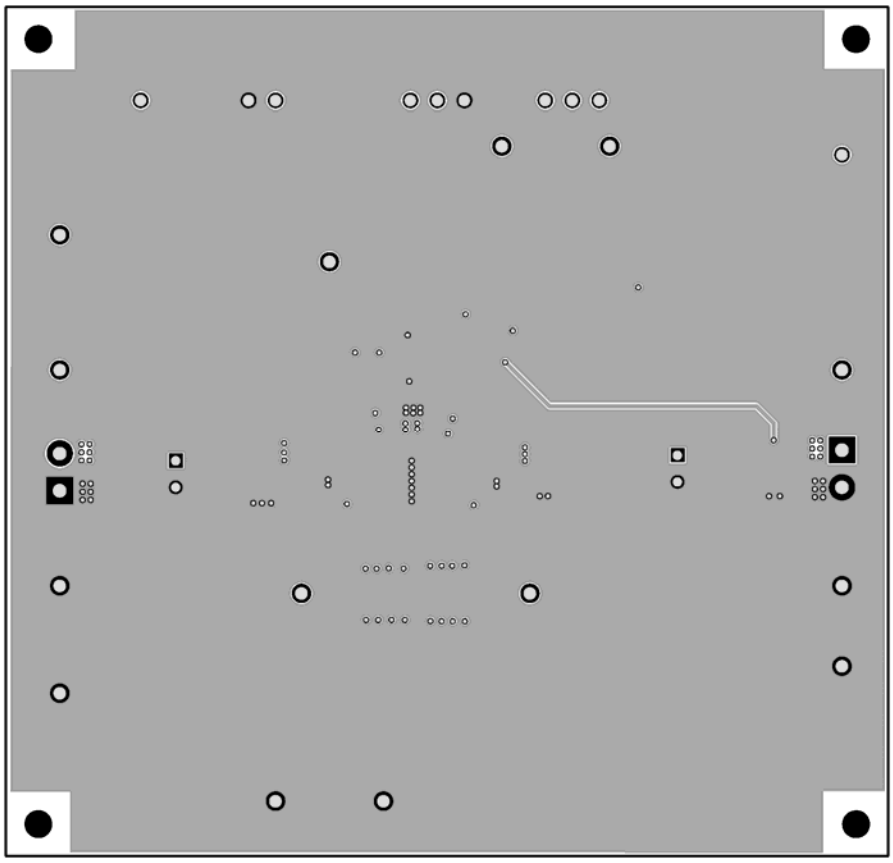


**Figure 8 – Layout Bottom Layer**

## Bill of Materials

**Table 2. ACT510x EVK BOM**

| | ASSY-0314-00-00 | ASSY-0314-00-01 | | | | | |
|---|---|---|---|---|---|---|---|
| Item | QTY | QTY | Ref Des | Description | Package | MFR | Part Number |
| 1 | 3 | 3 | C1, C20, C21 | Cap, Ceramic, 10uF, 35V, 10%, X5R | 1206 | Murata | GRM319R6YA106KA12 |
| 2 | 1 | 1 | C2 | ELCap, 100uF, 25V | 6.3mmx11mm | Wurth Elektronik | 865080445010 |
| 3 | 1 | 1 | C3 | Cap, Ceramic, 2.2nF, 25V, 10%, X7R | 0603 | Wurth Elektronik | 885012206061 |
| 4 | 1 | 1 | C4 | Cap, Ceramic, 22nF, 25V, 10%, X7R | 0603 | Wurth Elektronik | 885012206067 |
| 5 | 5 | 5 | C5, C8, C11, C14, C15 | Cap, Ceramic, 100nF, 50V, 10%, X7R | 0603 | Wurth Elektronik | 885012206095 |
| 6 | 0 | 0 | C6, C10 | DNI | 0603 | std | std |
| 7 | 4 | 4 | C7, C9, C17, C18 | Cap, Ceramic, 22uF, 35V, 10%, X5R | 1206 | TDK | C3216X5R1V226M160AC |
| 8 | 2 | 2 | C12, C13 | Cap, Ceramic, 47nF, 50V, 10%, X7R | 0603 | Wurth Elektronik | 885012206093 |
| 9 | 1 | 1 | C16 | Cap, Ceramic, 1uF, 10V, 10%, X7R | 0603 | Wurth Elektronik | 885012206026 |
| 10 | 1 | 1 | C19 | ELCap, 220uF, 25V | 6.3mmx11mm | Wurth Elektronik | 860010473011 |
| 11 | 1 | 1 | D1 | SMD LED blue | 0603 | Wurth Elektronik | 150060BS75000 |
| 12 | 2 | 2 | J1,J7 | Connector, 2 pin | 2141 S 3.50mm Horizontal Entry Modular | Wurth Elektronik | 691214110002S |
| 13 | 1 | 1 | J2 | Header, 2pin, 100mil | | Wurth Elektronik | 61300211121 |
| 14 | 2 | 2 | J3,J4 | Header, 1pin, 100mil | | Wurth Elektronik | 61300111121 |
| 15 | 2 | 2 | J5,J6 | Header, 3pin, 100mil | | Wurth Elektronik | 61300311121 |
| 16 | 1 | 1 | L1 | Inductor 10uH, 5A, 26.5mohm | 6mmx6mmx6mm | Wurth Elektronik | 74439346100 |
| 17 | 3 | 3 | R1, R4, R17 | Res, 10kΩ, 1% | 0603 | std | std |
| 18 | 1 | 1 | R2 | Res, 5mΩ, 1% | 1206 | std | std |
| 19 | 2 | 2 | R3, R12 | Res, 20kΩ, 1% | 0603 | std | std |
| 20 | 0 | 0 | R5, R7, R10, R11, R13 | DNI | 0603 | std | std |
| 21 | 1 | 1 | R6 | Res, 36kΩ, 1% | 0603 | std | std |
| 22 | 4 | 4 | R8, R9, R14, R15 | Res, 30Ω, 1% | 0603 | std | std |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 23 | 1 | 1 | R16 | Res, 10mΩ, 1% | 1206 | std | std |
| 24 | 0 | 1 | R18 | Res, 200kΩ, 1% | 0603 | std | std |
| 25 | 0 | 1 | R19 | Res, 133kΩ, 1% | 0603 | std | std |
| 26 | 1 | 1 | R20 | Res, 0Ω, 1% | 0603 | std | std |
| 27 | 6 | 6 | TP1, TP5, TP6, TP7, TP9, TP13 | Test Point, Red, Through Hole, 1mm | 0.040" | Keystone | 5000 |
| 28 | 9 | 9 | TP2, TP3, TP4, TP6, TP8, TP10, TP11, TP12, TP14 | Test Point, Black, Through Hole, 1mm | 0.040" | Keystone | 5001 |
| 29 | 1 | 0 | U1 | IC, ACT5101, Integrated Buck-Boost | QFN32-4x4 | Active Semi | ACT5101QI102-T |
| | 0 | 1 | | IC, ACT5102, Integrated Buck-Boost | QFN32-4x4 | Active Semi | ACT5102QI102-T |
| 30 | 1 | 1 | -- | PCB, ACT5101/02 EVK1 REVB | n/a | n/a | PCB-0314-00 |
| 31 | 2 | 2 | -- | Shunt, 100mil, Black | n/a | n/a | 60900213421 |

## GUI Installation

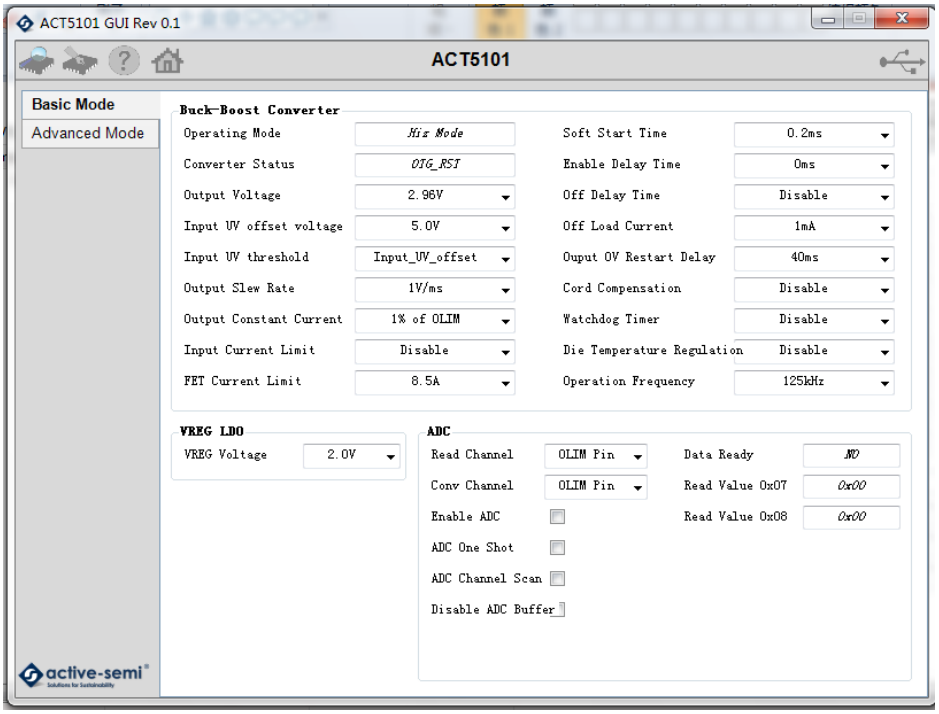
1. Get GUI files from the Active Semi website
2. Plug the USB-TO-I2C dongle into a free USB port.
3. Follow the instructions in the “How to install driver for dongle” folder.
4. Double click on the ACT5101 GUI.exe to start the ACT5101 GUI.

## GUI Overview

The GUI has 2 basic function buttons allocated in top-left of the Tool Bar which are Read and Write I²C. The GUI contains 2 setting modes: Basic Mode and Advanced Mode. In Basic Mode screen it displays basic user programmable configuration options are programmed using the drop-down boxes or check boxes. Advanced Mode contain the button text for changing setting for every single bit.

### Basic Mode

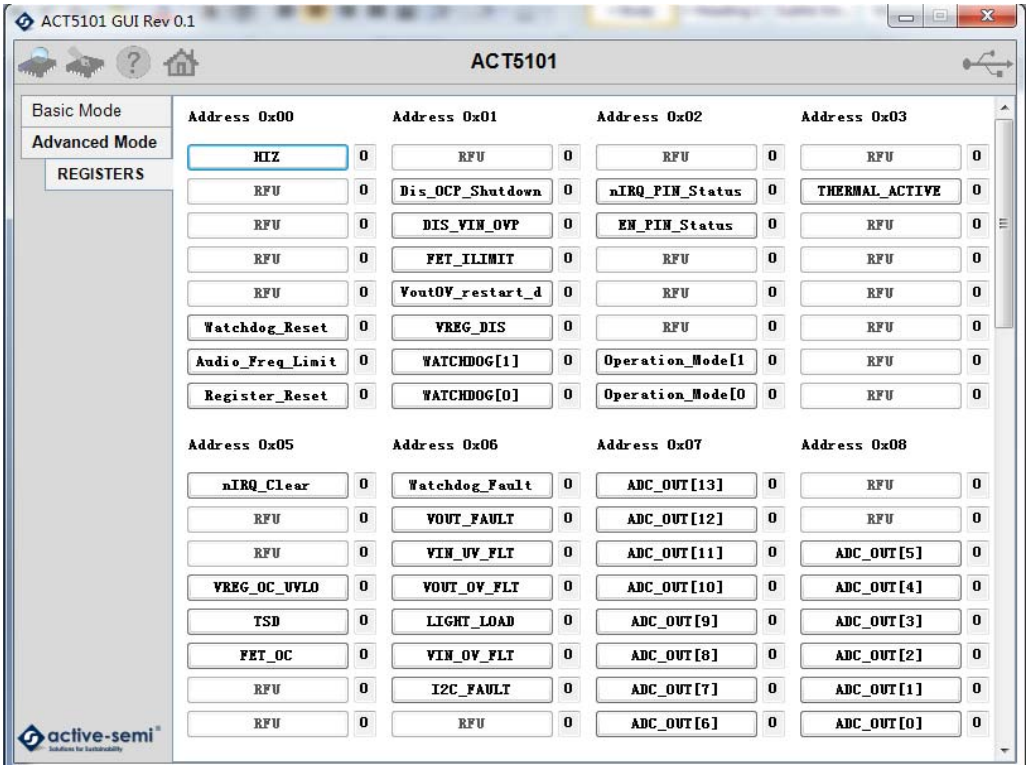
The following figure show the GUI in basic mode. This mode allows the user to easily change one or more IC settings.



### Advanced Mode

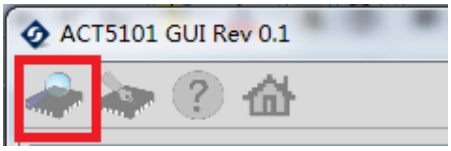
Click the “Advanced Mode” button in the left of the GUI screen to see all available user programmable options. With Advanced Mode, additional user programmable features can be selected using the button text. In the left side of the Advanced Mode Screen, click on the Tiles Selector to display the register to view or change. Then change a register one bit at a time by clicking on the desired bit. The value of the bit is display right next to the bit-name button.

Note that the far right side of the screen contains a scroll down button to scroll down to additional registers since the Tile Screen can only display up to 8 bytes at once.



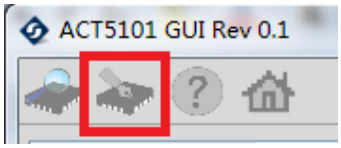
**Button Descriptions**

**Read:** Clicking on this button reads the ACT2861 registers and displays them in the GUI. Note that this reads all registers. Active-Semi recommends reading registers each time the ACT2861 powers-up to acquire the initial register settings. Active-semi also recommends reading registers after making changes to them. Immediately reading the registers after a write confirms the changes were properly stored.



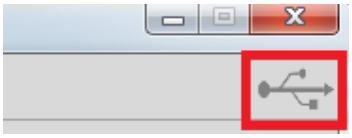

Read Button

**Write:** Clicking on this button writes the GUI settings to the ACT2861's registers. All registers are written, regardless of whether or not they were changed.

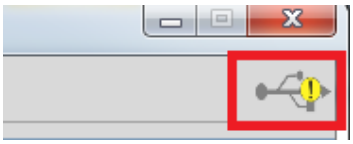



Write Button

**Dongle Connection Status:** The GUI also contains a dongle connection status that indicates Active-Semi's USB-TO-I2C dongle is connected to the USB port. The figure below shows the two possible indication status graphics.



**Dongle connected**



**Dongle Disconnected**

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