International IOR Rectifier

# IRDC38060-P1V2

# Sup*IR*Buck™

## USER GUIDE FOR IR38060 EVALUATION BOARD

### DESCRIPTION

The IR38060 is a synchronous buck converter with a PMBus interface, providing a compact, high performance and flexible solution in a small 5mmx6mm PQFN package.
Key features offered by the IR38060 include I2C/PMBus configurability of output voltage, soft-start, input UVLO, input overvoltage protection, output overvoltage protection, output overcurrent protection, Power Good, thermal protection and switching frequency. Additionally, the IR38060 also features enhanced line/ load regulation with feed forward, external frequency synchronization with smooth clocking, internal LDO, true differential remote sensing and pre-bias start-up.

A temperature and bias compensated output over-current protection function is implemented by sensing the voltage developed across the on-resistance of the synchronous rectifier MOSFET for optimum cost and performance.

This user guide contains the schematic and bill of materials for the IR38060 evaluation board. The guide describes operation and use of the evaluation board itself. Detailed application information for IR38060 is available in the IR38060 data sheet.

### BOARD FEATURES

- PVin = +12V (+ 13.2V Max), ***No Vcc required.***
- $V_{out}$ = +1.2V @ 0-6A
- $F_s$= 600kHz
- L= 0.82uH
- $C_{in}$= 3x22uF (ceramic 1206) + 1x330uF (electrolytic, optional)
- $C_{out}$=7x22uF (ceramic 0805)

## CONNECTIONS and OPERATING INSTRUCTIONS

A well regulated +12V input supply should be connected to PVin+ and PVin-. A maximum of 6A load should be connected to VOUT+ and VOUT-. The inputs and output connections of the board are listed in Table I.

IR38060 needs only one input supply and internal LDO generates Vcc from PVin. Another internal LDO generates the 1.8V needed by the internal digital circuits. If operation with external Vcc is required, then R25 should be removed and external Vcc can be applied between Vcc+ and Vcc- pins. Vin pin and Vcc pins should be shorted together for external Vcc operation by installing R24. **For normal, non-tracking operation, R27 should not be populated and a 100 kOhm resistor should be connected from the Track_En pin to P1V8.**

The board is configured for remote sensing. If local sense is desired, R8 should be uninstalled and R16 should be installed instead.

I2C/PMBus communication is established through the 4 pin header which allows connection to the SCL/SDA/SALERT and GND lines from the host/dongle. For proper operation in digital communications mode, R35 must always be populated.

External Enable signal can be applied to the board via exposed Enable pad and *R18 should be removed for this purpose.*

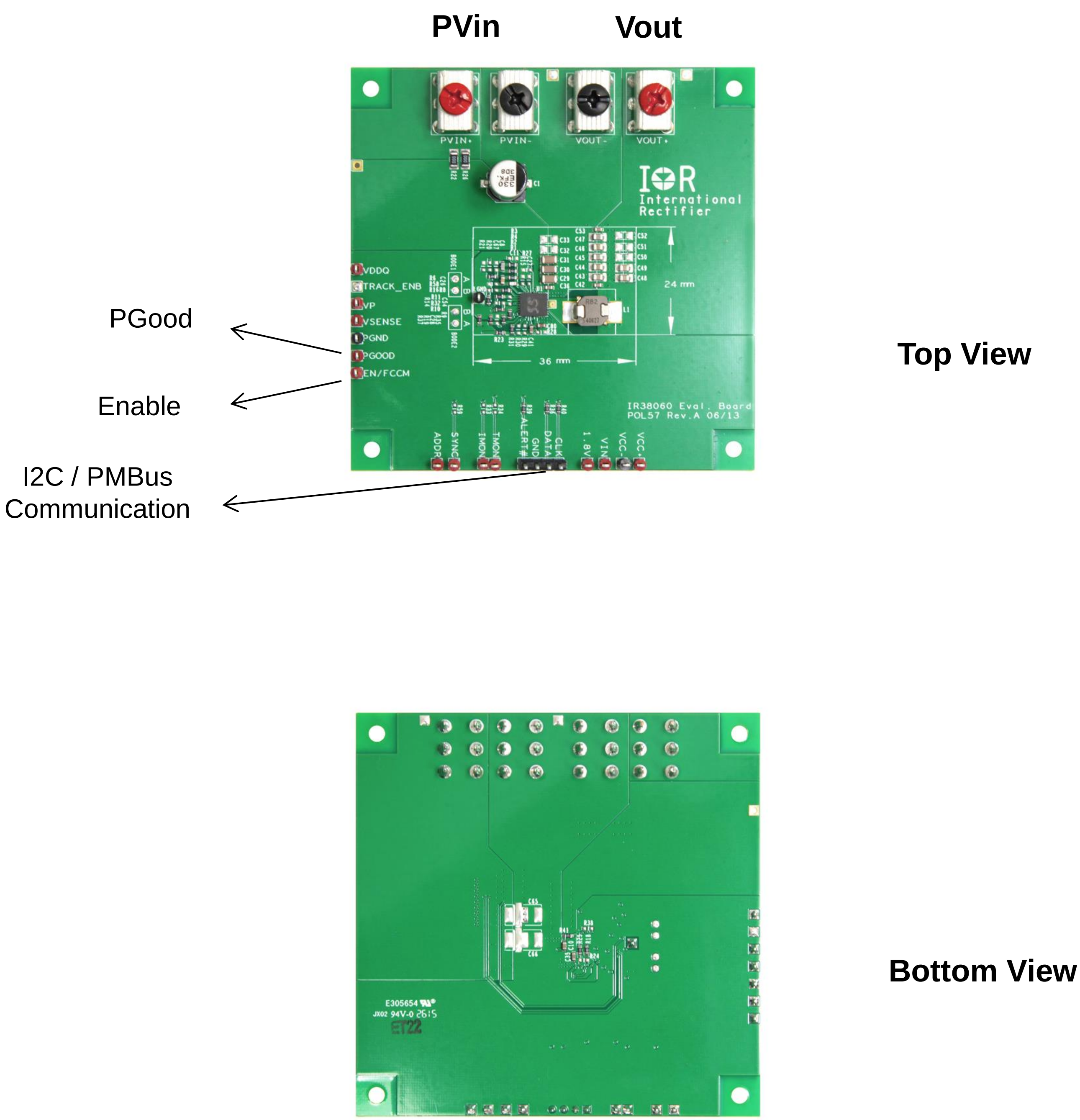
**Table I. Connections**

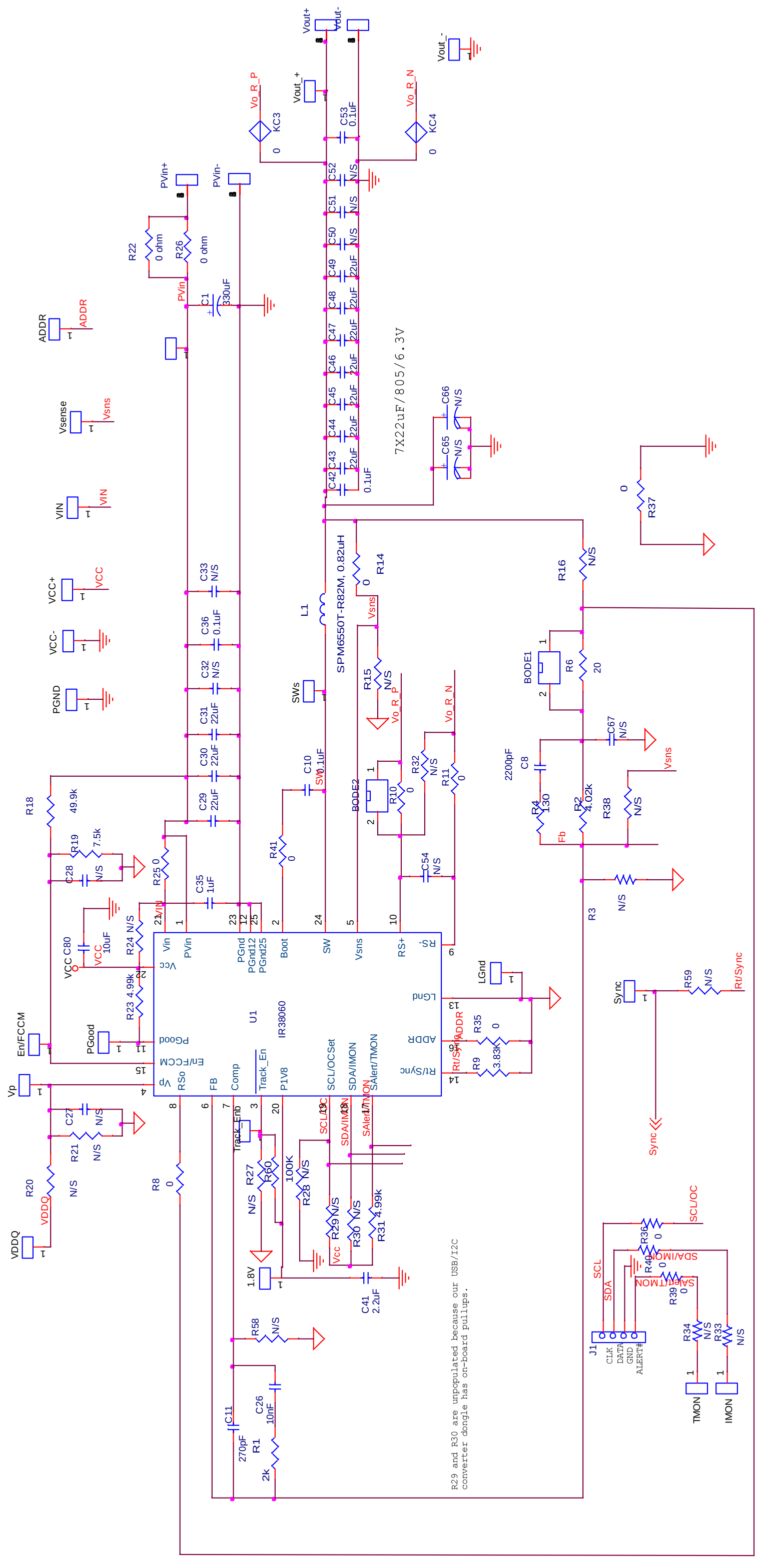
| Connection | Signal Name |
|---|---|
| PVin+ | PVin (+12V) |
| PVin- | Ground of Pvin |
| Vout+ | Vout(+1.2V) |
| Vout- | Ground for Vout |
| Vcc+ | Vcc Pin |
| Vcc- | Ground for Vcc input |
| Enable | Enable |
| PGood | Power Good Signal |

## LAYOUT

The PCB is a 4-layer board. All of layers are 2 Oz. copper. The IR38060 and most of the passive components are mounted on the top side of the board. Power supply decoupling capacitors and feedback components are located close to IR38060. The feedback resistors are connected to the output of the remote sense amplifier of the IR38060 and are located close to the IR38060. To improve efficiency, the circuit board is designed to minimize the length of the on-board power ground current path. Separate power ground and analog ground are used and may be connected together using a 0 ohm resistor.

## CONNECTION DIAGRAM






R60 =100K is not present in evaulaution boards older than Revision B

**Fig. 1: Schematic of the IR38060 evaluation board**

## Bill of Materials

| Item Number | Quantity | Part Reference | Value | Description | Manufacturer | Part Number |
|---|---|---|---|---|---|---|
| 1 | 1 | C1 | 330uF | SMD Electrolytic, F size, 25V, 20% | Panasonic | EEE-FK1E331P |
| 2 | 1 | C8 | 2200pF | 2200pF, 0603, 50V, NPO | TDK | C1608C0G1H222J |
| 3 | 1 | C11 | 270pF | 50V, 0603, NP0, 5% | Murata | GRM1885C1H271JA01D |
| 4 | 1 | C26 | 10nF | 0603, 50V, X7R, 10% | Murata | GRM188R71H103KA01D |
| 5 | 3 | C29 C30 C31 | 22uF | 22uF, 1206, 25V, X5R, 20% | TDK | C3216X5R1E226M160AB |
| 6 | 4 | C10 C36 C42 C53 | 0.1uF | 0603, 50V, X7R, 10% | Panasonic | ECJ-1VB1H104K |
| 7 | 1 | C35 | 1uF | 0603, X5R, 25V, 20% | TDK | C1608X5R1E105M |
| 8 | 7 | C43 C44 C45 C46 C47 C48 C49 | 22uF | 0805, 6.3V, X5R, 20% | Murata | GRM21BR60J226ME39 |
| 9 | 19 | LGND 1.8V ADDR EN/FCCM IMON PGND PGOOD SW SYNC TMON VCC+ VCC- VDDQ VIN VIN_+ VOUT_+ VOUT_- VP VSENSE | 0.075" SQ_SMT_TestPoint | | | TP-200-125 |
| 10 | 1 | J1 | Header-4P | | | |
| 11 | 1 | C41 | 2.2uF | 0603, 10V, X5R, 20% | TDK | C1608X5R1A225M080AC |
| 12 | 1 | R19 | 7.5k | 0603,1/10W,1% | Rohm | MCR03EZPFX7501 |
| 13 | 1 | L1 | 0.82uH | 0.82uH, DCR=4.3mohm | TDK | SPM6550T-R82M |
| 14 | 1 | R1 | 2k | 0603, 1/10W, 1% | Rohm | MCR03EZPFX2001 |
| 15 | 1 | R2 | 4.02k | 0603, 1/10W, 1% | Rohm | MCR03EZPFX4021 |
| 16 | 1 | R9 | 66.5k | 0603, 1/10W, 1% | Rohm | MCR03EZPFX6652 |
| 17 | 1 | R4 | 130 | 0603, 1/10W, 1% | Rohm | MCR03EZPFX1300 |
| 18 | 1 | R6 | 20 | 0603, 1/10W, 1% | Rohm | CRCW060320R0FKEA |
| 19 | 11 | R8 R10 R11 R14 R25 R35 R36 R37 R39 R40 R41 | 0 ohm | 0603, 1/10W | Rohm | CRCW06030000Z0EA |
| 20 | 1 | R18 | 49.9k | 0603, 1/10W, 1% | Rohm | MCR03EZPFX4992 |
| 21 | 2 | R22 R26 | 0 ohm | 1206, 1/4 W | Panasonic | ERJ-8GEY0R00V |
| 22 | 2 | R23 R31 | 4.99k | 0603, 1/10W, 1% | Rohm | MCR03EZPFX4991 |
| 23 | 1 | C80 | 10uF | 0603, 10V, X5R, 20% | Murata | GRM188R61A106ME69D |
| 24 | 1 | U1 | IR38060 | IR38060 5mm X 6mm | International Rectifier | IR38060 |

•The electrolytic input capacitor used on this demo board is to eliminate the impact of the parasitic inductance of a long input power cable. It may not be necessarily needed in real applications.

## TYPICAL OPERATING WAVEFORMS

**PVin=12.0V, Vout=1.2V, Iout=0A-6A, Fs=600kHz, Room Temperature, no airflow**

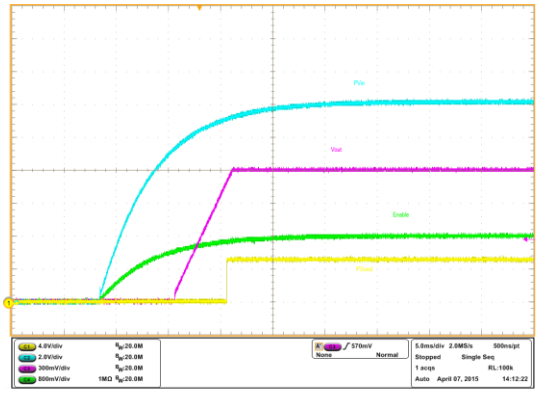


Fig. 2: $P_{Vin}$ Start up at 6A Load
$Ch_1$:$P_{Good}$, $Ch_2$:$P_{Vin}$, $Ch_3$:$V_{out}$, $Ch_4$:Enable

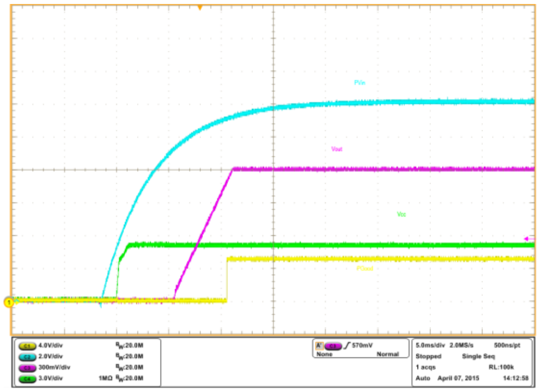


Fig. 3: $P_{Vin}$ Start up at 6A Load
$Ch_1$:$P_{Good}$, $Ch_2$:$P_{Vin}$, $Ch_3$:$V_{out}$, $Ch_4$:Vcc

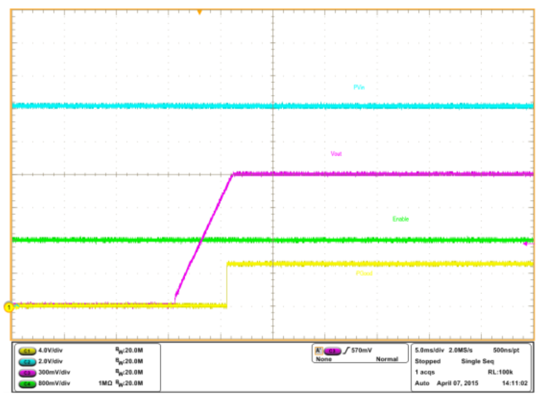


Fig. 4: Operation 80,Turn ON without margining, 6A load
$Ch_1$:$P_{Good}$, $Ch_2$:$P_{Vin}$, $Ch_3$:$V_{out}$, $Ch_4$:Enable

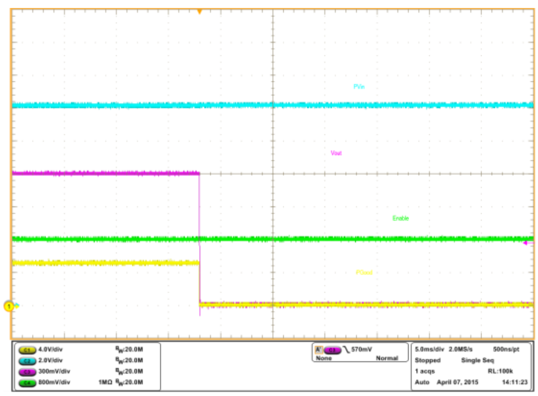


Fig. 5: Operation 00, Immediate OFF, 6A load
$Ch_1$:$P_{Good}$, $Ch_2$:$P_{Vin}$, $Ch_3$:$V_{out}$, $Ch_4$:Enable

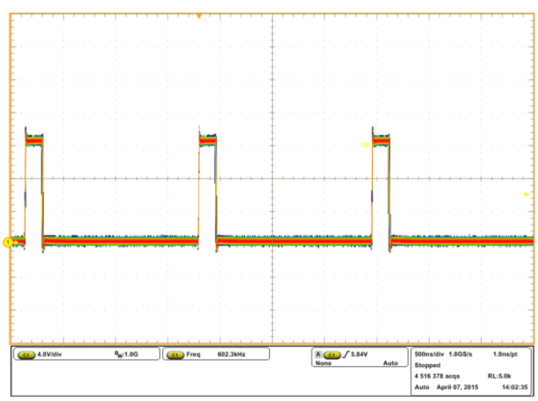


Fig. 6: Inductor node at 6A load
$Ch_1$:SW node

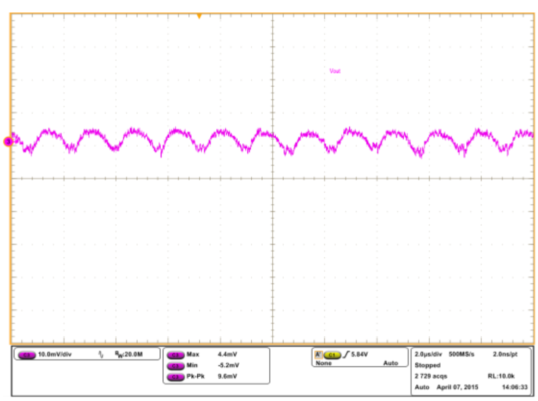


Fig. 7: Output voltage ripple at 6A load
$Ch_3$:$V_{out}$

**TYPICAL OPERATING WAVEFORMS**

**PVin=12.0V, Vout=1.2V, Iout=0A-6A, Fs=600kHz, Room Temperature, no airflow**

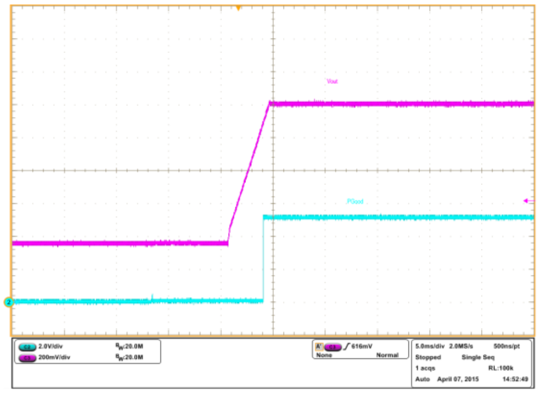


Fig. 8: 0.4V Prebias voltage startup at 0A load
$Ch_3$:$V_{out}$, $Ch_2$:$P_{Good}$

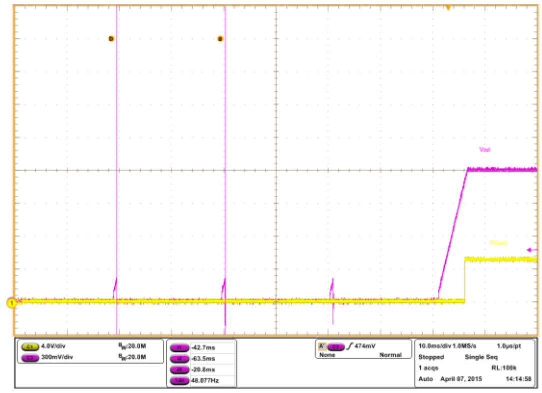


Fig. 9: Short-circuit recovery (Hiccup) at 6A load
$Ch_3$:$V_{out}$, $Ch_1$:$P_{Good}$

**TYPICAL OPERATING WAVEFORMS**

**PVin=12.0V, Vout=1.2V, Iout=0A-6A, Fs=600kHz, Room Temperature, no airflow**

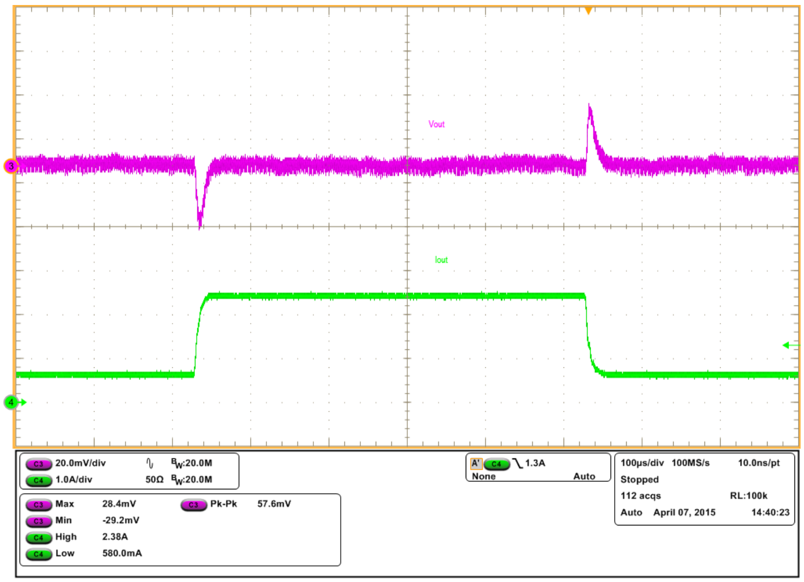



Fig. 10: Transient response, current step from 0.6A to 2.4A
$Ch_3$:$V_{out}$, $Ch_4$:$I_{out}$

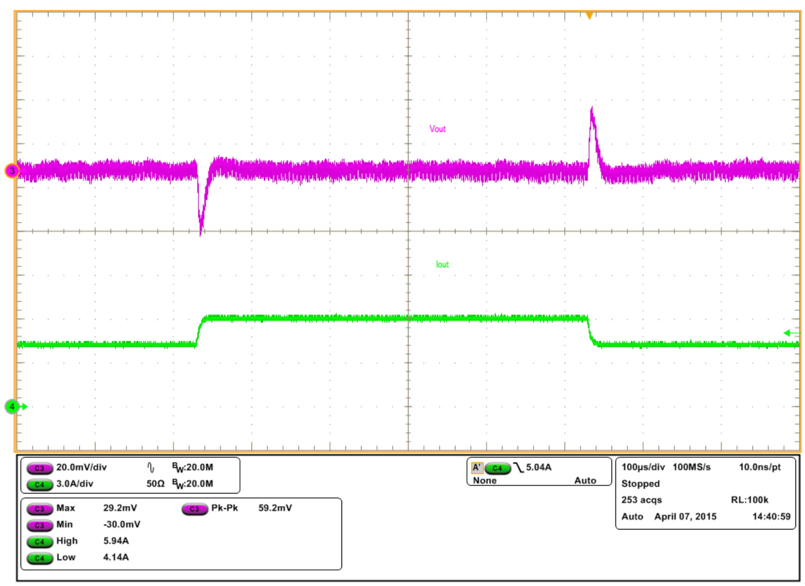



Fig. 11: Transient response, current step from 4.2A to 6A
$Ch_3$:$V_{out}$, $Ch_4$:$I_{out}$

## TYPICAL OPERATING WAVEFORMS

**PVin=12.0V, Vout=1.2V, Iout=0A-6A, Fs=600kHz, Room Temperature, no airflow**

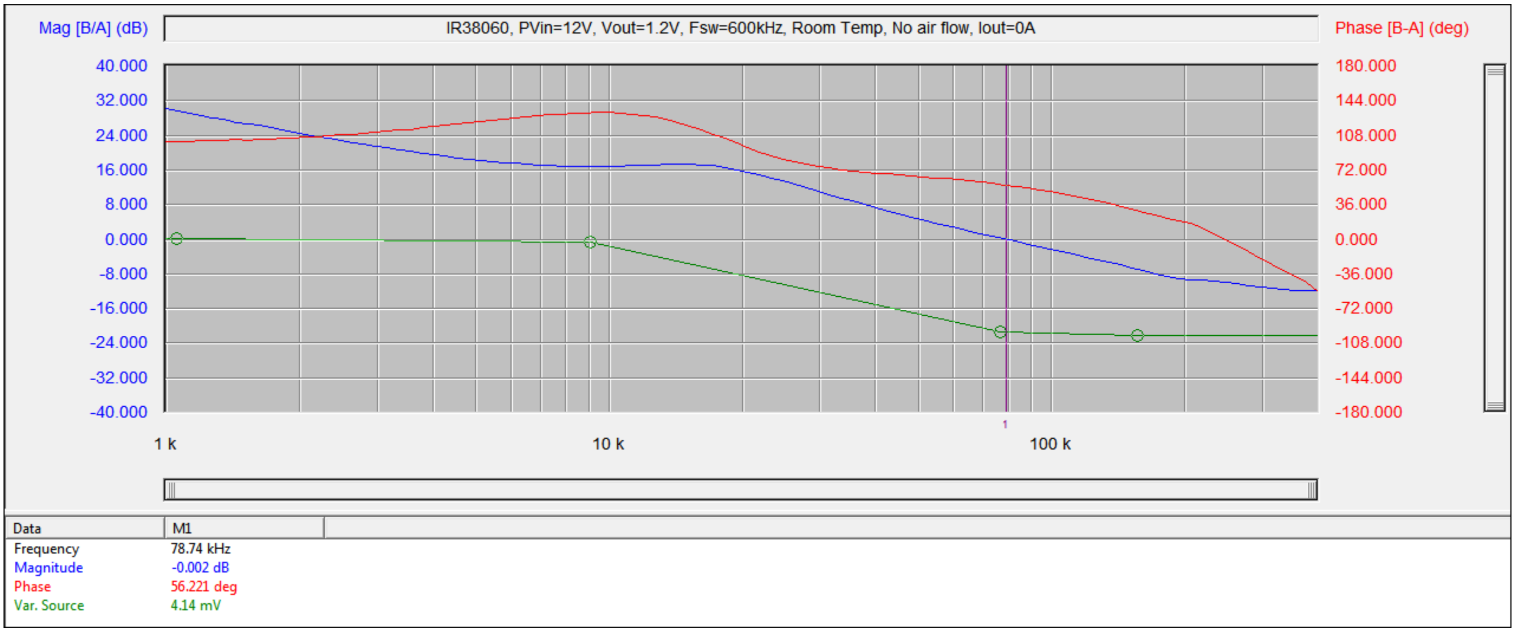



Fig. 12: Bode Plot at 0A load
Bandwidth = 78.7kHz, Phase Margin = 56.21 Degree

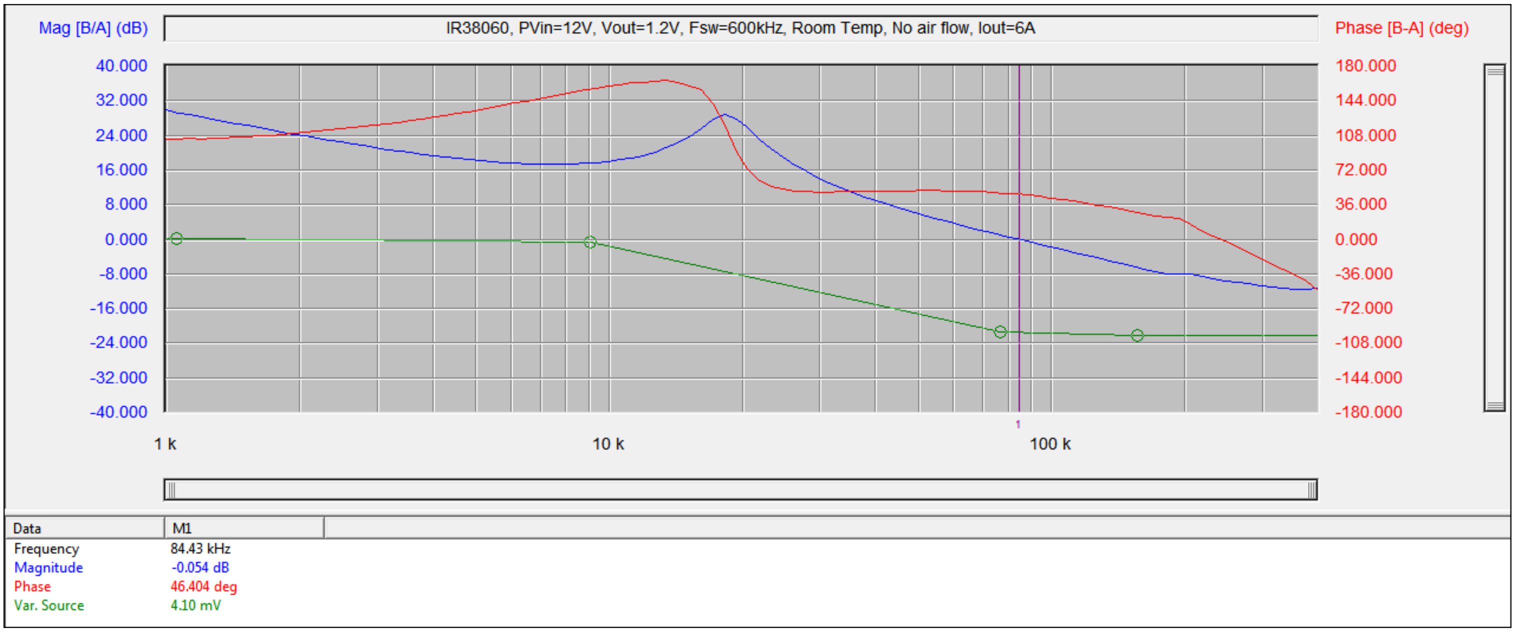



Fig.13: Bode Plot at 6A load
Bandwidth = 84.4kHz, Phase Margin = 46.6 Degree

**TYPICAL OPERATING WAVEFORMS**

**PVin=12.0V, Vout=1.2V, Iout=0A-6A, Fs=600kHz, Room Temperature, no airflow**

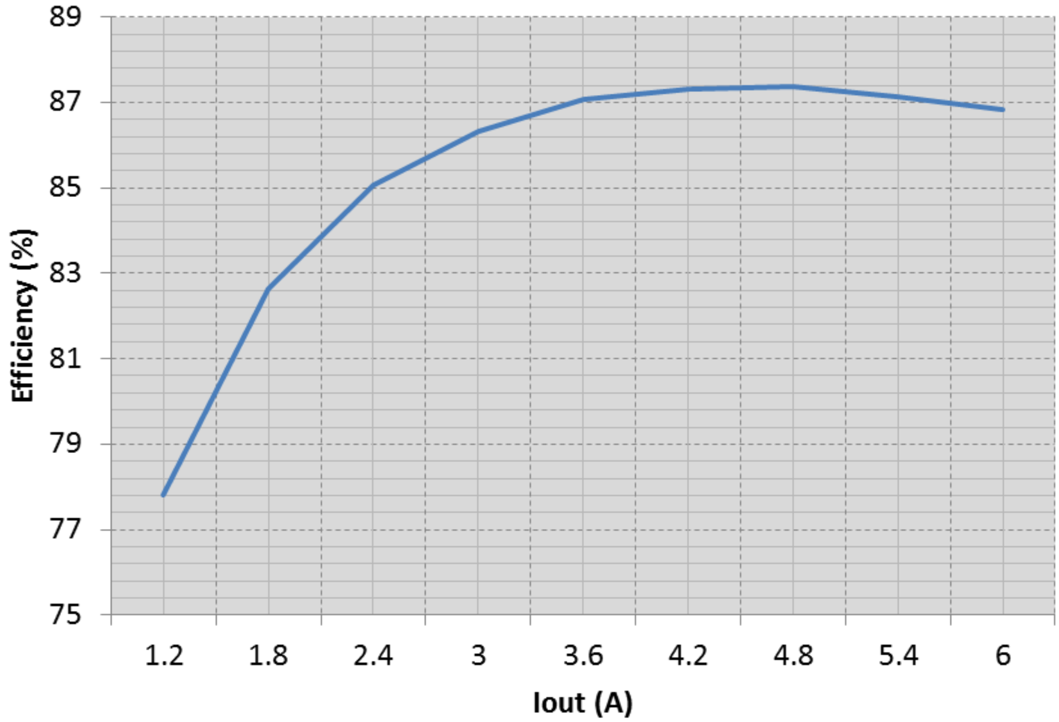



Fig14: Efficiency versus load current

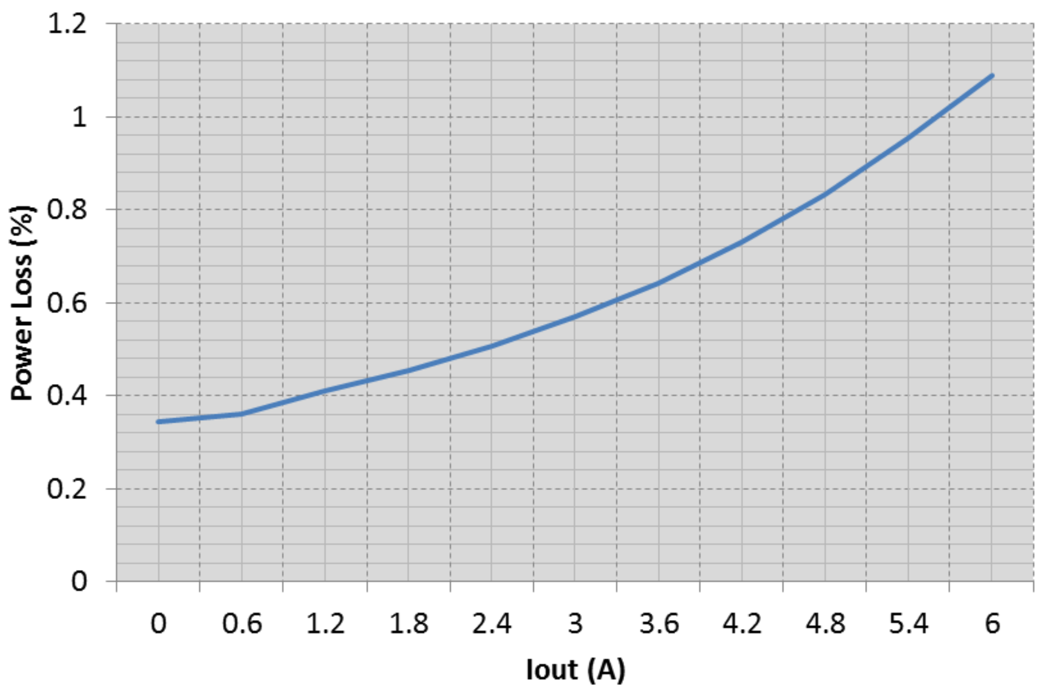



Fig.15: Power loss versus load current

**TYPICAL OPERATING WAVEFORMS**

**PVin=12.0V, Vout=1.2V, Iout=0A-6A, Fs=600kHz, Room Temperature, no airflow**

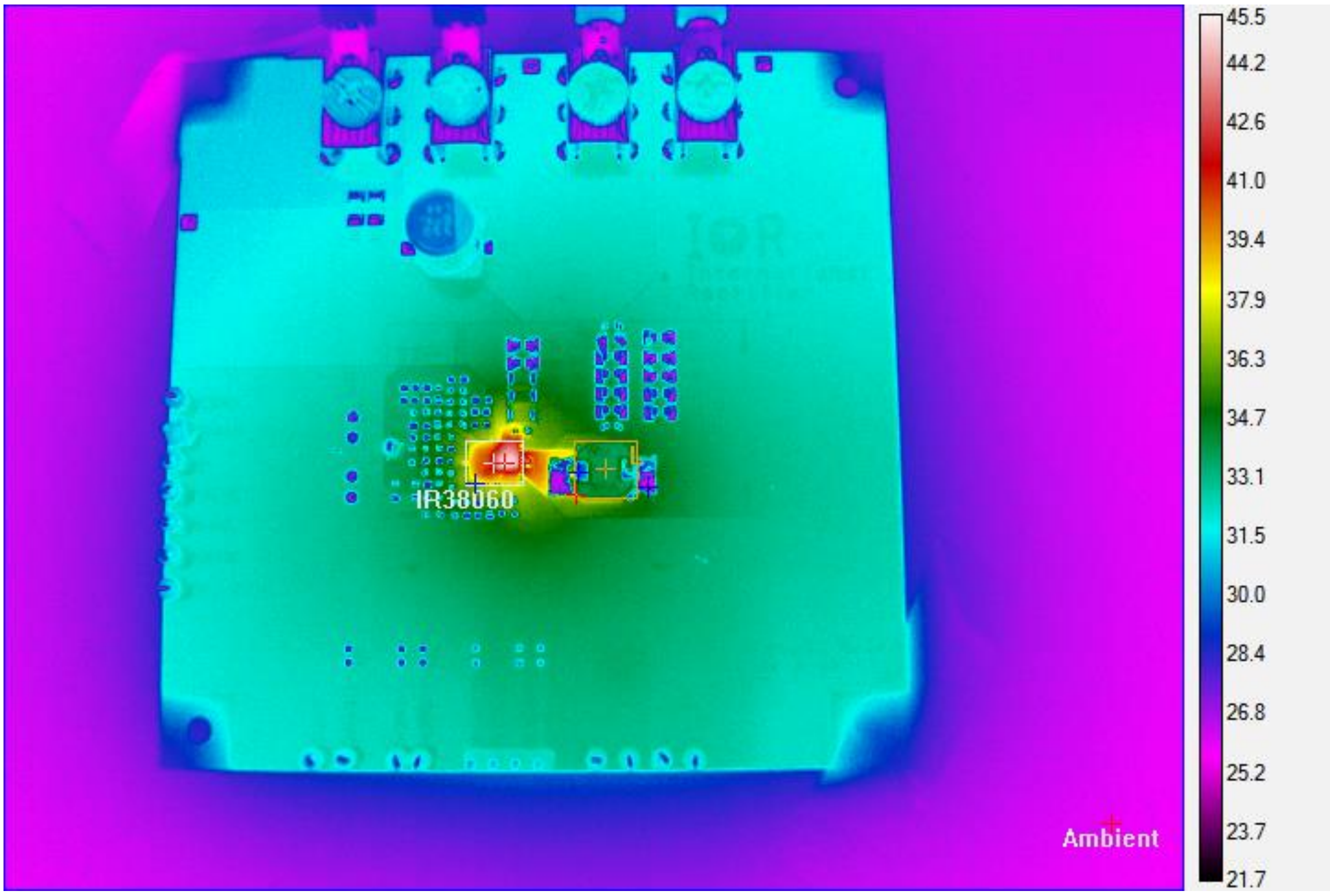



Fig. 16: Thermal Image of the board at 6A load
IR38060: 45.47°C, Inductor: 37.26°C, Ambient: 25.36°C

**PMBus Command Summary**
**PVin=12.0V, Vout=1.2V, Iout=0A-6A, Fs=600kHz,**

| | | |
|---|---|---|
| 01 | OPERATION | On |
| 02 | ON_OFF_CONFIG | 0x1F |
| 10 | WRITE_PROTECT | 0x00 |
| 19 | CAPABILITY | 0xB0 |
| 1B | SMBALERT_MASK | |
| | STATUS_VOUT | 00 |
| | STATUS_IOUT | 00 |
| | STATUS_INPUT | 00 |
| | STATUS_TEMPERATURE | 00 |
| | STATUS_CML | 00 |
| 21 | VOUT_COMMAND | 1.199 V |
| 22 | VOUT_TRIM | 0.000 V |
| 24 | VOUT_MAX | 6.000 V |
| 25 | VOUT_MARGIN_HIGH | 1.262 V |
| 26 | VOUT_MARGIN_LOW | 1.141 V |
| 27 | VOUT_TRANSITION_RATE | 0.125 mV/us |
| 29 | VOUT_SCALE_LOOP | 1.000 |
| 33 | FREQUENCY_SWITCH | 600 KHz |
| 35 | VIN_ON | 1.000 V |
| 36 | VIN_OFF | 0.500 V |
| 39 | IOUT_CAL_OFFSET | 0.000 A |
| 40 | VOUT_OV_FAULT_LIMIT | 1.500 V |
| 41 | VOUT_OV_FAULT_RESPONSE | Shutdown |
| 42 | VOUT_OV_WARN_LIMIT | 1.379 V |
| 43 | VOUT_UV_WARN_LIMIT | 1.020 V |
| 44 | VOUT_UV_FAULT_LIMIT | 0.961 V |

| | | |
|---|---|---|
| 45 | VOUT_UV_FAULT_RESPONSE | Ignore |
| 46 | IOUT_OC_FAULT_LIMIT | 9.000 A |
| 47 | IOUT_OC_FAULT_RESPONSE | Immediate off, retry after 20ms |
| 4A | IOUT_OC_WARN_LIMIT | 7.500 A |
| 4F | OT_FAULT_LIMIT | 145 ℃ |
| 50 | OT_FAULT_RESPONSE | Inhibit |
| 51 | OT_WARN_LIMIT | 125 ℃ |
| 55 | VIN_OV_FAULT_LIMIT | 24.000 V |
| 56 | VIN_OV_FAULT_RESPONSE | Ignore |
| 58 | VIN_UV_WARN_LIMIT | 0.50 V |
| 5E | POWER_GOOD_ON | 1.074 V |
| 5F | POWER_GOOD_OFF | 1.000 V |
| 60 | TON_DELAY | 0.0 ms |
| 61 | TON_RISE | 6.0 ms |
| 62 | TON_MAX_FAULT_LIMIT | 0.000 ms |
| 63 | TON_MAX_FAULT_RESPONSE | Ignore |
| 64 | TOFF_DELAY | 0.0 ms |
| 65 | TOFF_FALL | 6.0 ms |
| 78 | STATUS_BYTE | 0x00 |
| 79 | STATUS_WORD | 0x0000 |
| 7A | STATUS_VOUT | 0x00 |
| 7B | STATUS_IOUT | 0x00 |
| 7C | STATUS_INPUT | 0x00 |
| 7D | STATUS_TEMPERATURE | 0x00 |
| 7E | STATUS_CML | 0x00 |
| 88 | READ_VIN | 11.969 V |

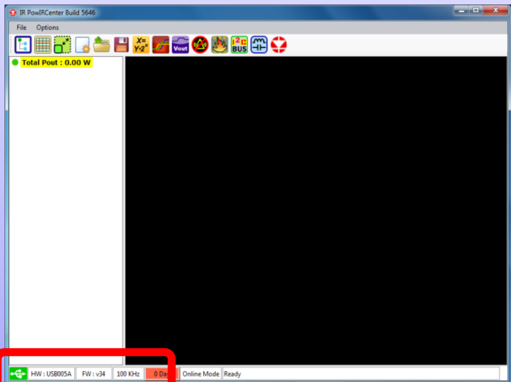
| | | |
|---|---|---|
| 64 | TOFF_DELAY | 0.0 ms |
| 65 | TOFF_FALL | 6.0 ms |
| 78 | STATUS_BYTE | 0x00 |
| 79 | STATUS_WORD | 0x0000 |
| 7A | STATUS_VOUT | 0x00 |
| 7B | STATUS_IOUT | 0x00 |
| 7C | STATUS_INPUT | 0x00 |
| 7D | STATUS_TEMPERATURE | 0x00 |
| 7E | STATUS_CML | 0x00 |
| 88 | READ_VIN | 12.156 V |
| 8B | READ_VOUT | 1.191 V |
| 8C | READ_IOUT | 0.000 A |
| 8D | READ_TEMPERATURE_1 | 26 ℃ |
| 96 | READ_POUT | 0.000 W |
| 98 | PMBUS_REVISION | 0x22 |
| 99 | MFR_ID | IR |
| 9A | MFR_MODEL | 0x30 |
| 9B | MFR_REVISION | 0x04 |
| AD | IC_DEVICE_ID | 0x30 |
| AE | IC_DEVICE_REV | 0x04 |
| D6 | MFR_I2C_ADDRESS | 0x10 |
| D8 | MFR_TPGDLY | 0 ms |
| D9 | MFR_FCCM | Forced Cont. Conduction M... |
| DB | MFR_VOUT_PEAK | 1.191 V |
| DC | MFR_IOUT_PEAK | 0.0 A |
| DD | MFR_TEMP_PEAK | 26 ℃ |

Fig. 17: PMBus Command Summary

# Quick Start: PowIRCenter GUI

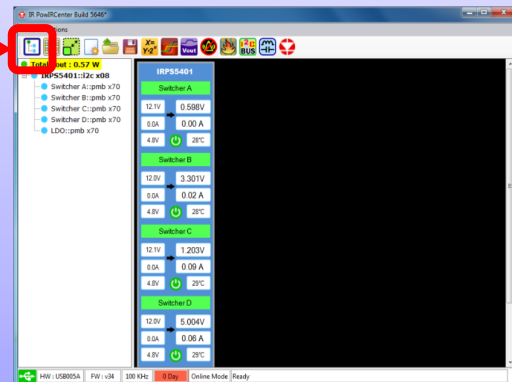
## Connecting devices

**Step 1** Start PowIRCenter & Connect USB Dongle



| | | | |
|---|---|---|---|
| HW : USB005A | FW : v34 | 100 KHz | USB Dongle connected |
| HW : USBxxx | FW : v | 100 KHz | USB Dongle NOT detected |

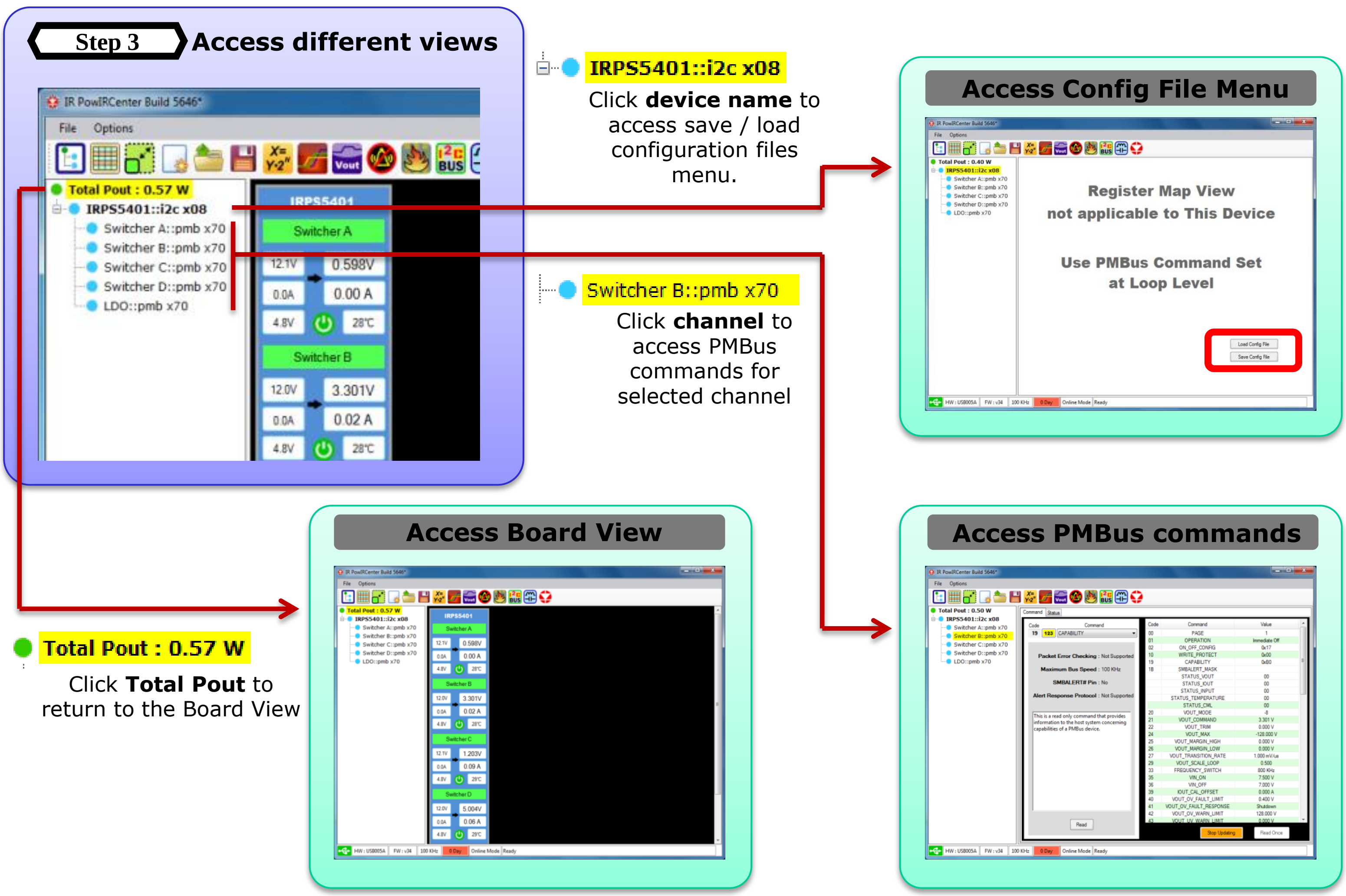
**Step 2** Detect attached demoboards



Press "Auto Populate Devices" button to detect boards connected to USB dongle

# Quick Start: PowIRCenter GUI

**Navigation: Accessing Different Views**



# Quick Start: PowIRCenter GUI

## PMBus Commands

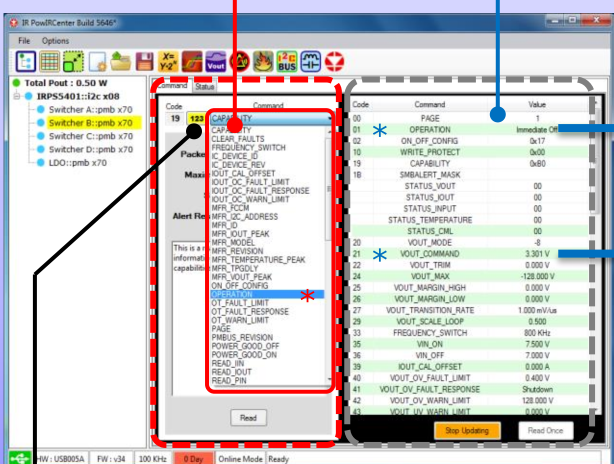
### Select Command for Selected Channel

Select command from pull down List

or

Click the command in right panel.

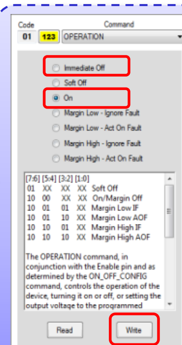
### PMBus Command Screen



### View Basic or All PMBus Commands

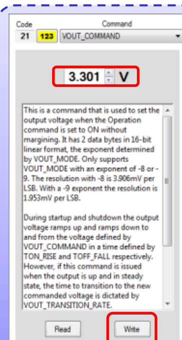
Click **A-Z** to sort the PMBus commands by name

Click **123** to sort PMBus commands by operation code



### Enable / Disable Channel (Command: OPERATION)

1. Ensure the channel enable is set high on board.
2. Click "On" or "Immediate Off" to turn on or off the channel.
3. Click "Write" button to send the command.



### Change Vout (Command: VOUT_COMMAND)

1. Enter Vout voltage.
2. Press enter after entering value.
3. Click "Write" button to send the command.