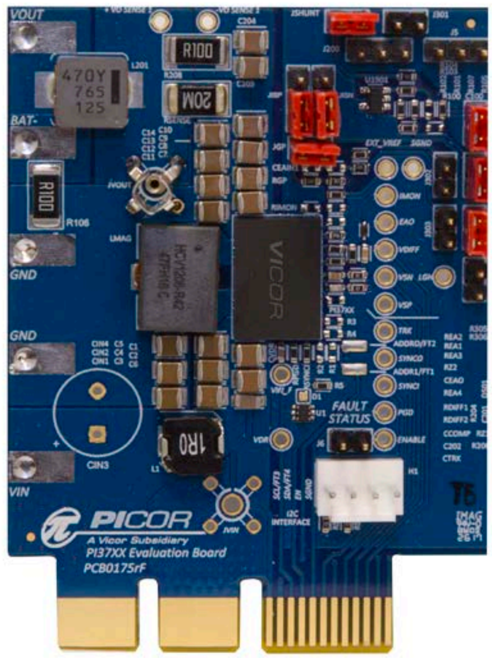
PI3740-00-EVAL1, -EVAL2

ZVS Regulators
Buck-Boost Evaluation Board User Guide

Contents **Page**



Introduction

The PI3740-00 evaluation board comes in two versions, EVAL1 and EVAL2. EVAL1 should be used to evaluate the PI3740 in constant-voltage or standard constant-current applications where V_{OUT} is above 8V. EVAL2 is designed for specialized constant-current applications using high-side current sense where V_{OUT} is below 8V. These boards have been designed to showcase various constant-voltage and constant-current applications and can be configured with a few selectable jumpers. This guide will walk the user through the various options.

The PI3740-00-LGIZ is a high-efficiency, wide-input-range DC-DC ZVS Buck-Boost regulator with integrated controller, power switches and support components all within a high-density 0.4 x 0.55in System-in-Package (SiP). The evaluation board measures 2.5 x 2.25in and contains all the components necessary for a variety of applications. Not all components will be needed for all applications.

Part Ordering Information

The customer evaluation boards can be ordered following the link to Vicor Cool-Power ZVS Buck-Boost Switching Regulators.

IMPORTANT NOTICE:

Be sure to read the precautions below entirely BEFORE using the evaluation board. Do not operate the evaluation board unless you have the appropriate safety precautions in place on your bench to ensure a successful experience.

The list below is not comprehensive and is not a substitute for common sense and good practice.

- When testing electronic products always use approved safety glasses. Follow good laboratory practice and procedures.
- During operation, insure the power devices and surrounding structures can be operated safely.
- Care should be taken to protect the user from accidental contact when under power.
- Provide a strain relief for wires and place the system on the bench in such a way as to prevent accidental displacement from bench top.
- Review thermal consideration and guideline associated with operating the evaluation board. Most notably use a bench top fan and use rubber feet to elevate the PCB as they allow air flow to the bottom.
- Remove power and use caution when connecting and disconnecting test probes and interface lines to avoid inadvertent short circuits and contact with hot surfaces.
- Verify power connections to avoid reversing applied voltage polarities.
- Avoid creating ground loops between the SGND and PGND pins when making measurements.
- The product evaluation board is designed for general laboratory evaluation. It is not recommended for installation in end user equipment.
- Refer to the specific regulator module data sheet for electrical rating of the device, thermal and mechanical product details. It is important to remain within the device rated range when testing.

The evaluation board is designed for user convenience to evaluate the performance of Vicors mounted ZVS Buck-Boost product. Sockets are provided to permit quick probing. The evaluation board provides lugs and top layer banana jack footprint for input and output connections, signal connectors allowing wire, signal test points for easy connection to standard test equipment, and Kelvin Johnson-Jack for accurate voltage measurements of power nodes.

Box Contents

The evaluation board ships with the following contents:

- 1 x PI3740-00-EVAL1 or PI3740-00-EVAL2 customer evaluation board
- 8 x jumpers

Features

1. Input and output lugs for source and load connections.
2. Location to place through-hole input aluminum-electrolytic capacitor. (CIN3)
3. Input source filter (L1, L200, RIN)
4. Oscilloscope probe jack for accurate, high-frequency output (JV_{OUT}) and input (JV_{IN}) voltage measurements.
5. Signal pins test points and wire connectors.
6. Kelvin voltage test points and sockets for all pins of PI3740.
7. Jumper selectable High-Side / Low-Side current sensing
8. Jumper selectable float voltage.

General Information

- V_{IN} Range: 8 – 60V_{DC}
- V_{OUT} Range: 10 – 50V_{DC} (for constant-voltage operation)
- Output Power: 50 – 140W [a]

[a] See PI3740-00 data sheet for maximum power rating at your particular input and output voltages.

Power Up Procedure

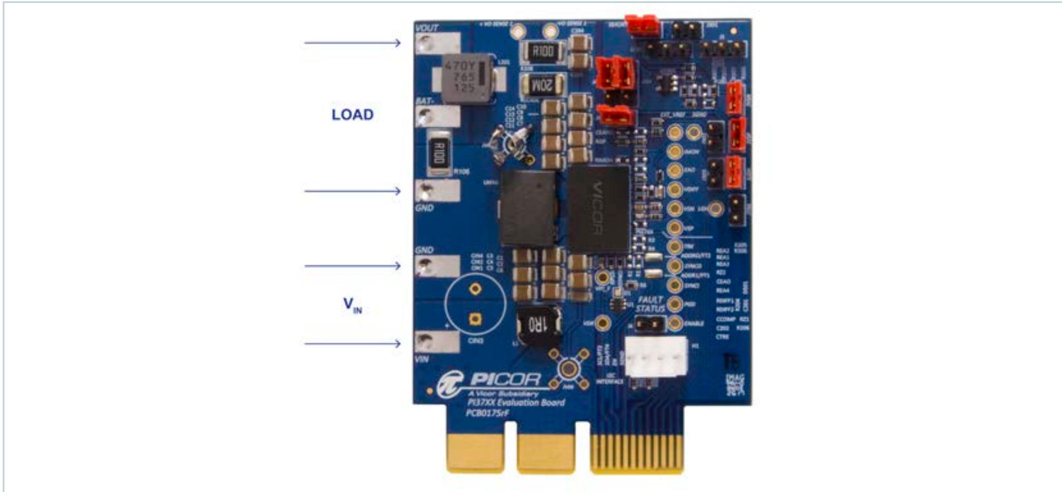
1. Ensure the jumpers are installed as shown in the following pictures depending on which configuration is chosen.
2. Connect the load as shown in the following pictures making sure of the polarity. (Positive to V_{OUT} and negative to GND or BAT–)
3. Connect the input source making sure of the polarity. (Positive to +V_{IN} and negative to GND)
4. Turn on input source ensuring it is within the range indicated in the general information section.

Constant-Voltage Operation (EVAL1)

For constant-voltage operation install JLGH, JPG, JISP, JISN, JVSP, JVSN, JSHUNT, as shown in Figure 1. The regulated output voltage can be adjusted by changing REA1 per the following equation.

V_{FLOAT} = (1.5887*REA1) + 1.7 where REA1 is in kΩ. With the present values, the output voltage is about 24V.

Figure 1
Jumper Placement for Constant-Voltage Operation (EVAL1)



Constant-Current Operation (EVAL1, EVAL2)

Constant-Current mode is required for battery and super capacitor charging applications. Both EVAL1 and EVAL2 can be configured for constant-current operation. EVAL1 should be the default board for all constant-current applications with the exception of high-side current sense applications where V_{OUT} can drop below 8V. Both evaluation boards can be configured to operate in a typical CC/CV charging scheme where the regulator output starts out in CC mode and then transitions to CV mode as soon as the battery voltage reached a predetermined float voltage.

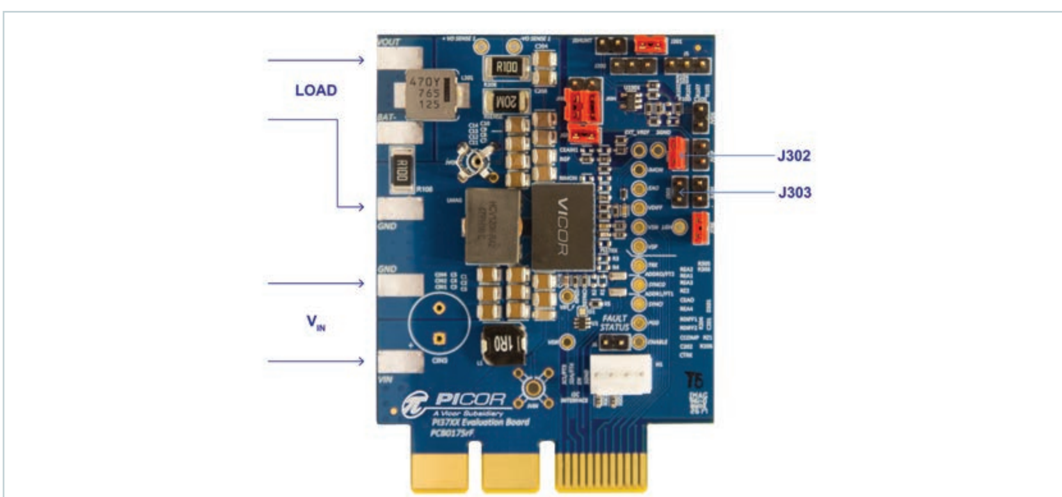
Constant-Current Float Voltage Adjustment

The float voltage or the voltage where the converter transitions to constant-voltage mode, can be adjusted by changing REA1 per the following equation.

V_{FLOAT} = (1.5887*REA1) + 1.7 where REA1 is in kΩ. The board is shipped with REA1 = 14kΩ which sets the float voltage to 24V. The board is also shipped for easy configuration for V_{OUT} values of 48V and 12V.

To configure for one of these preset values simply remove REA1 and place a jumper on J302 for $48V_{OUT}$ or J303 for $12V_{OUT}$.

Figure 2
Jumper Locations for Preset J302 $48V_{OUT}$ (shown) or J303 $12V_{OUT}$



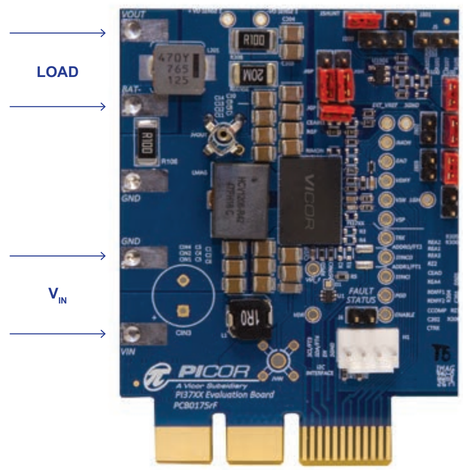
Constant-Current Configuration #1: (PI3740-00-EVAL1 Board)

Low-Side Current Sense Using PI3740 Internal Amplifier

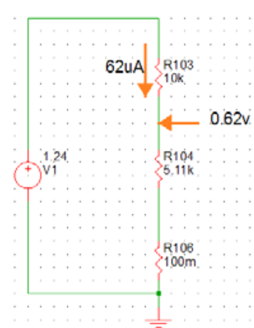
This configuration senses the current through R106 and uses the internal general purpose amplifier of the PI3740 to regulate the current. The jumpers need to be installed as shown. This configuration can be used for super-cap charging as well as battery charging. The benefit of this configuration is that you can use a standard value current sense resistor and adjust the current by changing a single 0603 resistor. It does require 6 resistors and a reference to implement the circuit. These components are contained within the evaluation board.

Install: JSHUNT, JVSN, JVSP, JLGH, JGP. Also install JISP & JISN between the 2 pins closest to JGP. This will short IS+ and IS– to ground.

Figure 3
Jumper Placement for Constant-Current Operation Configuration #1 (EVAL1)



Adjusting the Charging Current

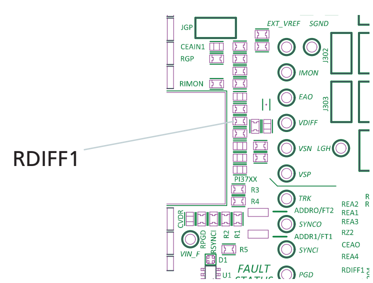


The charging current can be adjusted by changing R104 per the following equation.

I_{CHARGE} = (0.62 – (62µA*R104))/R106. In this example it would be: (0.62 – (62µA*5.11k)/0.1 or 3.03A.

Note: In configuration #1 for constant-current operation, RDIFF1 should be removed. RDIFF1 is used in configurations where LGH is used to provide soft start.

Figure 4
RDIFF1 Location



Constant-Current Configuration #2: (PI3740-00-EVAL1 Board)

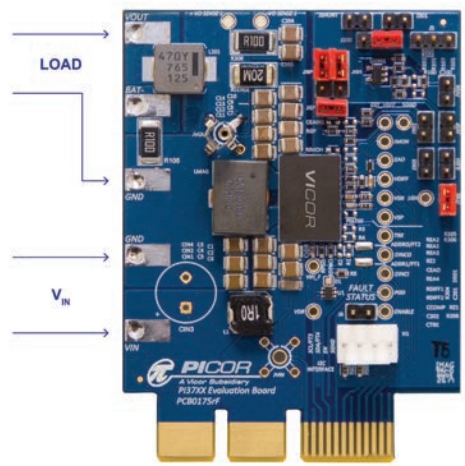
High-Side Current Sense Using R_{SENSE}

For customers who prefer high-side current sense, this configuration senses the current through R_{SENSE} and uses the internal Imon amplifier and the LGH pin of the PI3740. The LGH pin is the inverting input to an amplifier which has a 0.1V reference. Including R_{SENSE}, only 4 components are required for the current control loop. ***V_{OUT} minimum is 8V due to the common mode range of the IMON amplifier. This configuration cannot be used for super cap charging***.

Install jumpers as shown.

Figure 5

Jumper Placement for Constant-Current Operation Configuration #2 (EVAL1)



Install: JISP, JISN connecting RSENSE to IS+ and IS–, J200 connecting IMON to LGH, JTRK.

Charging Current: The LGH amplifier has a reference of 100mv nominally. The Imon amplifier has a gain of 20. So the voltage across R_{SENSE} will be 5mv when the circuit is active. Therefore, the current will be approximately 5mv/R_{SENSE}.

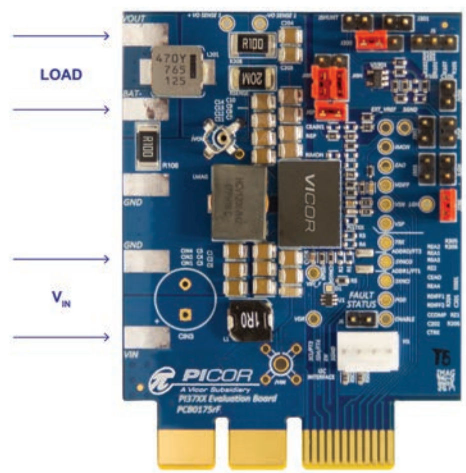
Constant-Current Configuration #3: (PI3740-00-EVAL1 Board)

Low-Side Current Sense and LGH

Current is sensed through R106 and, through a compensation network, fed into the LGH pin. This is a low-side current sense configuration which requires only 4 components including the current sense resistor.

Install jumpers as shown.

Figure 6
Jumper Placement for Constant-Current Operation Configuration #3 (EVAL1)



Install: J200 connecting R106 to R205/R206, JTRK, JISP and JISN shorting IS+ and IS– to ground.

Charging Current: The charging current will be approximately 100mv/R106. If a standard resistor value cannot be found that gives you the required current, use configuration #1.

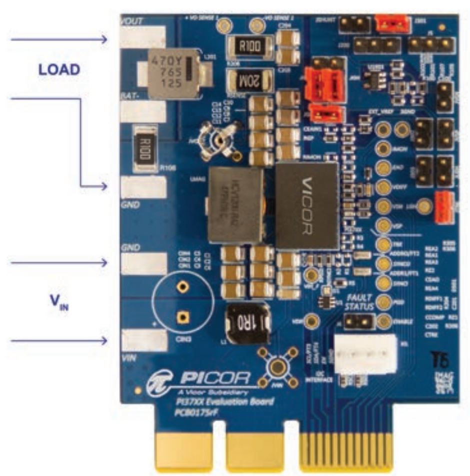
Constant-Current Configuration #4: (PI3740-00-EVAL2 Board)

High-Side Current Sense Using INA193 and LGH

For applications where V_{OUT} is below 8V and high-side current sense is preferred, this configuration must be used. This configuration senses current through R_{SENSE} and the output of the INA193 is fed into the LGH pin through a compensation network. The minimum recommended R_{SENSE} is 20mΩ. The maximum output voltage in this configuration remains $50V_{DC}$.

Install jumpers as shown.

Figure 7
Jumper Placement for Constant-Current Operation Configuration #4 (EVAL2)



Install: J301, JTRK, JISP and JISN to connect IS+ and IS– to ground.

Charging Current: The INA193 has a gain of 20. The output of the INA193 is divided down by R301 and R302. The LGH voltage is 100mv. Therefore the charge current is approximately (100mv*8/20)/R_{SENSE}, or 40mv/R_{SENSE}.

Paralleling Boards

Current-Sense Element in Each Board

If more current is required than can be supplied by one board, two boards may be used in parallel. Jumper the following pins together between boards; SGND, TRK, EAO, EN. Use short, low impedance jumpers especially on the SGND and EAO pins.

Only One Current-Sense Element

If only one board has a current-sense resistor, the LGH pins must also be connected together. Also, the connection to IMON, on the board which does not have the current-sense resistor, must be opened. (Remove J200).

Stability

The both evaluation boards are designed to be stable in a wide variety of applications. If instability is seen in your application, contact Vicor application support for assistance.

Test Points

Table 1
Test Point Descriptions

Reference Designator/ Functional Name	Description
VIN_F	Input voltage test point close to VIN of the PI3740.
+VOUT SENSE1 –VOUT SENSE 1	Output voltage test points.
VDR	A 5.1V auxiliary supply with max loading of 2mA. If used this pin must have a series resistance such as R103 = 1kΩ with a decoupling cap of 0.1µF such as C124.
PGD	Power good indicator. During a regulator fault this pin is pulled internally to signal ground.
EN	Input to the regulator. If left floating or driven high (VEN_MAX = 5.5V) regulator will be enabled.
SGND	Internal logic ground.
TRK	Soft-start and track input. An external capacitor may be connected between TRK pin and SGND to increase the rise time of the internal reference during soft start.
IMON	Output of the internal current sense amplifier.
EAO	Error Amp output. External connection for additional compensation and current sharing.
EXT_REF	Error Amp Inverting Input separated with REA3 = 10kΩ.
VSP	Non-inverting input to an independent amplifier.
VSN	Inverting input to an independent amplifier.
VDIFF	Output of the internal independent amplifier.
LGH	Input for constant-current amplifier.
SYNCO	Synchronization Output.
SYNCI	Synchronization Input.

Schematics

Figure 8
PI3740 Evaluation Board Schematic Page 1

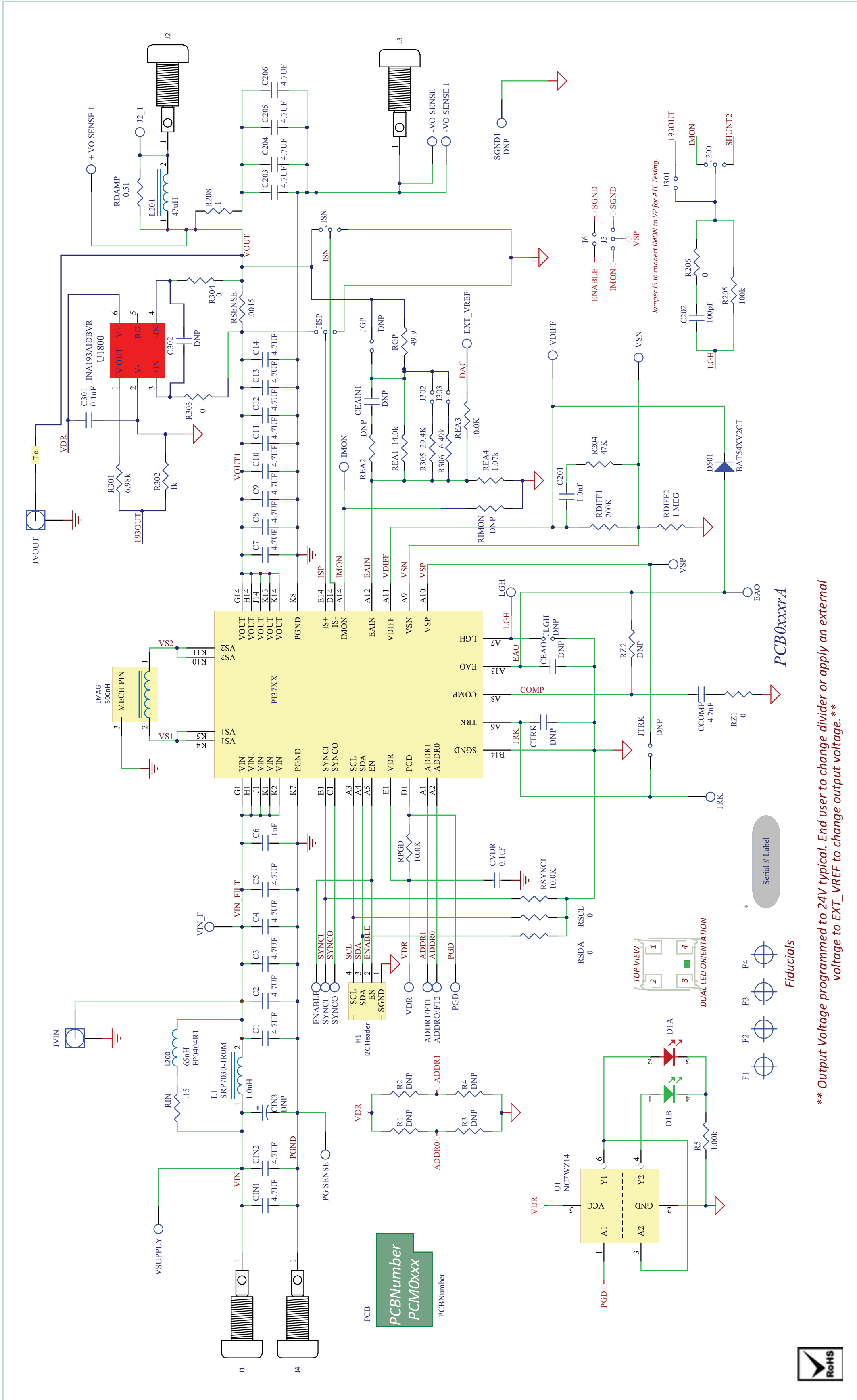
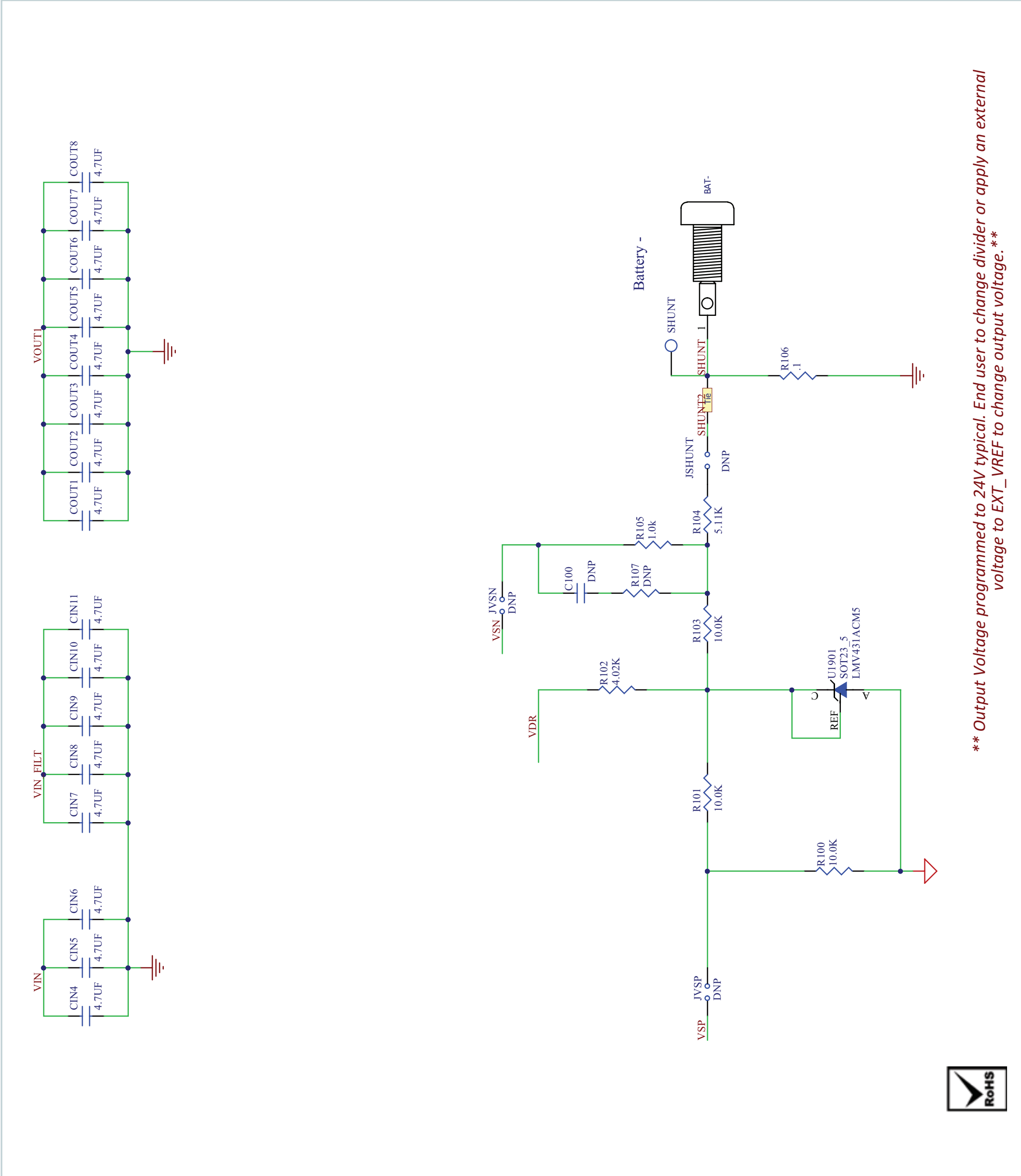


Figure 9
PI3740 Evaluation Board Schematic Page 2



Bill of Materials

Table 1
Bill of Materials
Populated Components

Reference Designator	Description	QTY	Manufacturer	Manufacturer Part Number
C1, C2, C3, C4, C5, C7, C8, C9, C10, C11, C12, C13, C14, C203, C204, C205, C206, CIN1, CIN2, CIN4, CIN5, CIN6, CIN7, CIN8, CIN9, CIN10, CIN11, COUT1, COUT2, COUT3, COUT4, COUT5, COUT6, COUT7, COUT8	Capacitor, X5R, Ceramic, 4.7µF, 80V, 1206	35	MURATA	GRM32ER71K475KE14L
CCOMP	Capacitor, X7R, 4700pF, 50V, 0603	1	MURATA	GRM188R71H472KA01D
C201	Capacitor, X7R, 1nF, 50V, 0603	1	MURATA	GRM188R71H102KA01D
C202	Capacitor, X7R, 100pF, 50V, 0603	1	MURATA	GRM188R71H101KA01D
D1	Diode, LED, Red/Green, 1mm x 1mm	1	ROHM	SML-P24MUWT86
D501	Diode, Schottky, 30V, 200ma, BAT54XV2CT	1	FAIRCHILD	BAT54XV2
J5, J200, JISN, JISP	Connector Header 3 Position 0.1" Pitch	4	3M	961103-6404-AR
L200	Inductor, 65nH, 20A, FP0404	1	EATON	FP0404R1-R065-R
L201	Inductor, 48µH, 3.4A	1	PANASONIC	ETQP5M470YFK
L1	Inductor, 1µH, 11A, SRP7030-1R0M	1	BOURNS	SRP7030-1R0M
R5, R105	Resistor, 1.00k,1%,0.1W, 0603	2	ROHM	MCR03EZPFX1001
RSYNCI, RPGD, REA3, R100, R101, R103	Resistor, 10.0k, 1%, 0.1W, 0603	6	ROHM	MCR03EZPFX1002
R205	Resistor, 100k, 1%, 0.1W, 0603	1	ROHM	MCR03EZPFX1003
R305	Resistor, 29.4k, 1%, 0.1W, 0603	1	ROHM	MCR03EZHFL2942R
R306	Resistor, 6.49k, 1%, 0.1W, 0603	1	ROHM	MCR03EZHFL6491
REA1	Resistor, 14.0k, 1%, 0.1W, 0603	1		MCR03EZHFL1402
RSENSE	Resistor, .0015, 1%, 1W	1	PANASONIC	ERJ-M1WTJ1M5U
R106, R208	Resistor, 0.10, 1%, 2W	2	BOURNS	CRM2512-FX-R100ELF
RSCL, RSDA, RZ1, R206	Resistor, 0Ω, 1%, 0.1W, 0603	4	ROHM	MCR03EZPJ000
U1	Dual Schmitt Trigger Inverter, NC7WZ14,SC70-6	1	FAIRCHILD	NC7WZ14EP6X
U1901	Adjustable shunt regulator, 1.24V	1	TI	LMV431ACM5

Bill of Materials (Cont.)

Table 1 (Cont.)
Bill of Materials Populated Components

Reference Designator	Description	QTY	Manufacturer	Manufacturer Part Number
RIN	Resistor, 0.15, 1%, 0.25W, 1206	1	ROHM	MCR18EZHFLR150
H1	4 Position, I^2C Header	1	MOLEX	22-23-2041
PI3740	Wide Input Range BB 10X14 SiP	1	VICOR	PI3740-00
JGP, J6, J301, J302, J303, JTRK, JVSN, JVSP, JSHUNT, JLGH	Connector Header 2 Position 0.1" Pitch	10	3M	961102-6404-AR
R204	Resistor, 47K, 5%, 0.1W, 0603	1	ROHM	MCR03EZPFX4702
CVDR	Capacitor, X7R Ceramic, 0.1µF, 50V, 0603	1	TDK	CGA3E3X7S2A104K-080AB
LMAG	Inductor, 0.42µH, 42A, HCV1206	1	EATON	HCV1206-R42-R
RIMON, REA2, RZ2, R1, R2, R3, R4, C6, C100, C301, C302, CEAIN1, CEAO, CIN3, CTRK, EAO, ENABLE, EXT_VREF, JVIN, LGH, PGD, IMON, R107, R301 R302,R303, R304, SGND, TRK, U1800, SYNCI, SYNCO, VDIFF, VDR, VIN_F, VOUT, VSN, VSP, + VO SENSE 1, – VO SENSE 1	Do Not Populate	38		
REA4	Resistor, 1.07k, 1%, 0.1W, 0603	1	ROHM	MCR03EZHFL1071
RDIFF1	Resistor, 200k, 1%, 0.1W, 0603	1	ROHM	MCR03EZHFL2003
RDIFF2	Resistor, 1 MEG, 1%, 0.1W, 0603	1	ROHM	MCR03EZHFL1004
RGP	Resistor, 49.9, 1%, 0.1W, 0603	1	ROHM	MCR03ERTF49R9
R102	Resistor, 4.02k, 1%, 0.1W, 0603	1	ROHM	MCR03EZHFL4021
JVOUT, JVIN	Connector, Johnson Jack	2	TEKTRONIX	131503100
R104	Resistor, 5.11k, 1%, 0.1W, 0603	1	ROHM	MCR03EZHFL5113
RDAMP	Resistor, 0.51, 1%, 0.25W, 1206	1	ROHM	MCR18ZEHFLR510

Bill of Materials (Cont.)

Additional or Changed Components for PI3740-00-EVAL2 Board

Table 2
Bill of Materials for Additional or Changed Components

Reference Designator	Description	QTY	Manufacturer	Manufacturer Part Number
C301	Capacitor, X7R Ceramic, 0.1µF, 50V, 0603	1	TDK	CGA3E3X7S2A104K080AB
RSENSE (Value Changed)	Resistor, 0.020, 1%, 1W	1	PANASONIC	ERJ-M1WSF20MU
R301	Resistor, 6.98k, 1%, 0.1W, 0603	1	ROHM	MCR03EZPFX6981
R302	Resistor,1.00k,1%, 0.1W, 0603	1	ROHM	MCR03EZPFX1001
R303,R304	Resistor, 0Ω, 1%, 0.1W, 0603	2	ROHM	MCR03EZPJ000
U1800	Current Shunt Monitor, INA193A	1	TI	INA193AIDBVR

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