Low IDDQ PMIC for Battery Energy Harvesting Applications

The TPS65290 is an integrated PMIC for flow-meter system, low-power energy-harvesting, medical, consumer and commercial battery operation application. This EVM helps the evaluation of TPS65290 for your actual system. TPS65290 can be controlled by SPI using the USB2ANY kit.

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1 Introduction

1.1 I/O Description

Table 1. Power Connection

NUMBER	TYPE	LOCATION	SIGNAL	COMMENT
J1	I	N	Input supply	Connection to input supply
J2	I	N	SPI	Connection to SPI interface board
J3	O	S	LDO and MICRO outputs	Connection to MICRO and LDO output
J7	O	E	Buck-boost output	Connection to buck-boost output

Table 2. Header Descriptions

NUMBER	FUNCTION	LOCATION	PLACEMENT	COMMENT
JP1	Supply connect	NW	Connect analog VIN(pin #2) to the main power connector(J1)	Fit in most cases
JP4	LDO input connector	W	Connect VMAX to the joint of 1µF and LDO input	Fit in most cases
JP8	Buck mini connection	S	Connection to Buck mini inductor	Fit only when Buck mini is used
JP8A	PWR_LDO2 connector	S	Connection to PWR_LDO2 output If buck-mini option available leave open	Not connect in BUCKmini mode
JP10	Buck MINI output ESR	S	When not fitted adds a 1-Ω resistance to the output capacitor, allowing for a predictable ESR value for the BUCKmini mode. Fit for low IQQ LDO or zero leak circuit.	Fit according to test requirement
JP11	CE	S	Connect to VMICRO for enabling serial communication. Conect to GND for Vmicro only mode for lowest IDDQ consumption.	Fit according to test requirement
JP13	BB enable	SE	Connect to GND to disable BB (I2C can enable it). Connect to VMICRO to enable BB.	Fit according to test requirement

Table 3. Test Points

TP	NAME	LOCATION	SIGNAL
TP1	PWR_VIN	W	PWR_VIN input pin 1
TP2	GND	W	
TP3	PWR_VMAX	W	PWR_VMAX PIN 3
TP4	VMAX	W	VMAX PIN 4
TP5	LDO IN	W	LDO input pin 5
TP6	LDO_OUT	W	LDO output pin 6
TP7	PWR_LDO1	W	PWR_LDO1 switch output pin 7
TP8	GND	W	
TP9	GND	E	
TP12	PWR_BB2	E	PWR_BB2 switch pin 12
TP14	PWR_BB1	E	PWR_BB1 switch pin 13
TP15	BB_OUT	E	Buck boost output pin 15
TP16	BB_LX2	N	LX2 node BB (pin 16)
TP18	BB_LX1	N	LX1 node BB (pin 18)
TP20	INT	N	Interruption pin 20
TP21	MISO	N	MISO pin 21 SPI

2 Test Procedure

2.1 Hardware and Software Set Up

2.1.1 Power Supply

A power supply capable of supplying 2.2 V - 5 V, 3 A, is required. A short cable from the power supply to the EVM input is recommended. If long line is a must, a 2,200-µF capacitor is suggested at the input for better input supply stability.

2.1.2 Load

Use electronic load or other variable resistor to evaluate different load conditions.

2.1.3 Input Current Meters

The current meters must have low impedance when measuring the efficiency to decrease the voltage drop affect. Placing a 2,200-µF capacitor at the input side of the EVM will guarantee the low impedance.

2.1.4 USB2ANY Communication Kit

The USB2ANY serves as an interface adapter between a host PC and a TPS65290 EVM. The communication between the USB2ANY and the host PC is via USB, while the communication between the USB2ANY and the TPS56290 EVM is via an SPI. The USB2ANY hardware is based on the TI MSP430F5529 16bit Microcontroller with integrated USB 2.0.

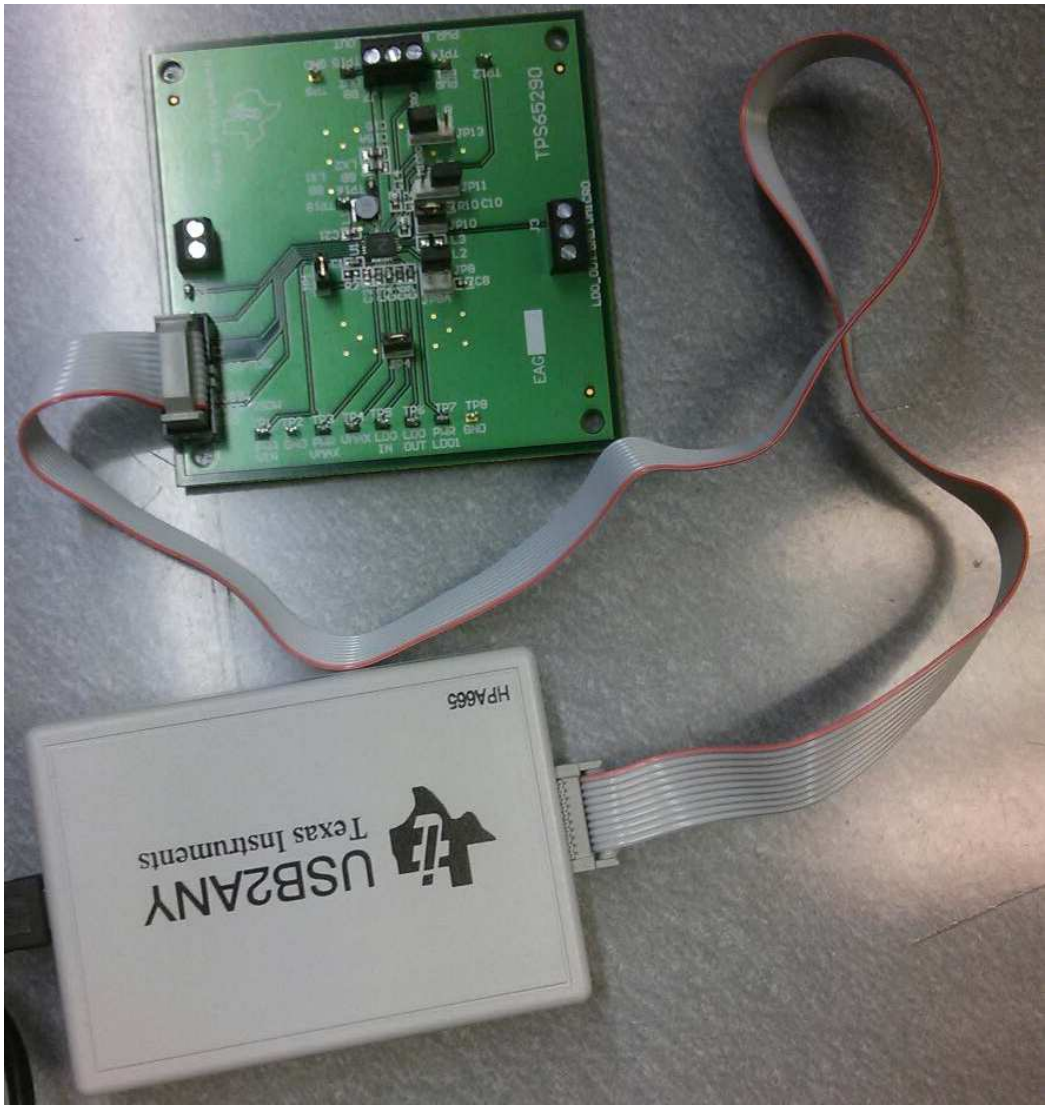

Figure 1. USB2ANY Interface

The center 10 pins of the USB2ANY is used to connect to JP2 in the EVM with the provided 10-pin flat cable. The pin definitions of the center 10-pin connectors of the USB2ANY box are shown in Figure 2.

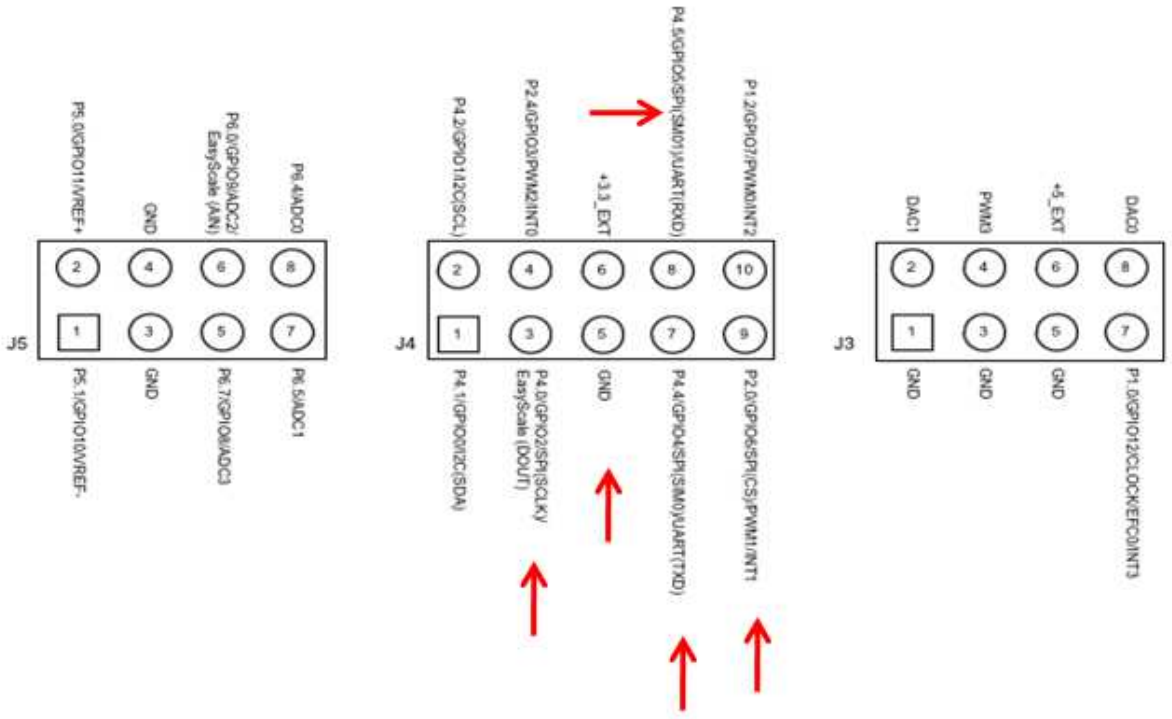

Figure 2. 10 Pins of USB2ANY Indication

Table 4. J4 10-PIN Connection of USB2ANY

TERMINAL		DESCRIPTION
NAME	NO.	
P4.1/GPIO0/I2C(SDA)	1	General-purpose digital I/O, I2C Data
P4.2/GPIO1/I2C(SCL)	2	General-purpose digital I/O, I2C Clock
P4.0/GPIO2/SPI(SCLK)/Easy Scale (DOUT)	3	General-purpose digital I/O, SPI Serial Clock, EasyScale DOUT
P2.4/GPIO3/PWM3/INT0	4	General-purpose digital I/O with port Interrupt, PWM up to 12 MHz
GND	5	Common Ground
+3.3_EXT	6	Provides a +3.3V output power supply at up to 100 mA. Switched, Limited, and Monitored
P4.4/GPIO4/SPI(MOSI)/UART(TXD)	7	General-purpose digital I/O, SPI Slave In Master Out, UART Transmit
P4.5/GPIO5/SPI(MISO)/UART(RXD)	8	General-purpose digital I/O, SPI Slave Out Master In, UART Receive
P2.0/GPIO6/SPI(CS)/PWM1/INT1	9	General-purpose digital I/O with port Interrupt, PWM up to 12 MHz
P1.2/GPIO7/PWM0/INT2	10	General-purpose digital I/O with port Interrupt, PWM up to 12 MHz

2.1.5 Software

Download the GUI and proper driver from the TI website: http://www.ti.com/product/tps65290 Refer to the name as: PC-Software_v1.14.0.3.zip. In order to operate the USB2ANY interface adapter, the following items are required:

- An assembled and programmed USB2ANY interface module
- Computer with Microsoft® XP SP2 (minimum) or Windows 7 operating system with .NET 2.0 frame work and available USB port
- Software zip: PC-Software_v1.14.0.3.zip
- Type-A to Mini-B (5-pin) USB cable (Included in an EVM kit)

- A 10-pin cable connector (Included in an EVM kit)

Then install the software step by step:

1. Extract the zip. The folder contains the USB2ANY_GUI.exe and support files. The USB interface adapter is recognized by a PC as a generic human interface device (HID), which is supported by the built-in USB/HID drivers of the Windows® operating system. Therefore, plug it and it will play automatically, no proprietary USB driver is required.
2. Plug in the USB cable to both the PC and the USB interface adapter. The status LED of the adapter will flash several times and then will illuminate steadily indicating that the USB2ANY is functioning properly and is ready to use.
   If the green LED fails to flash several times illuminating steadily, or fails to illuminate at all, check to ensure the USB cable is securely connected. If the connection is secure, try a different USB port and/or rebooting the computer. If that does not fix the issue then contact TI technical support.
3. Run the USB2ANY_GUI.exe software. The status bar on the bottom left should show USB2ANY: Detected. If it shows USB2ANY: NOT Detected, follow the procedure in step 2. above until the status bar indicates that the USB2ANY has been detected.

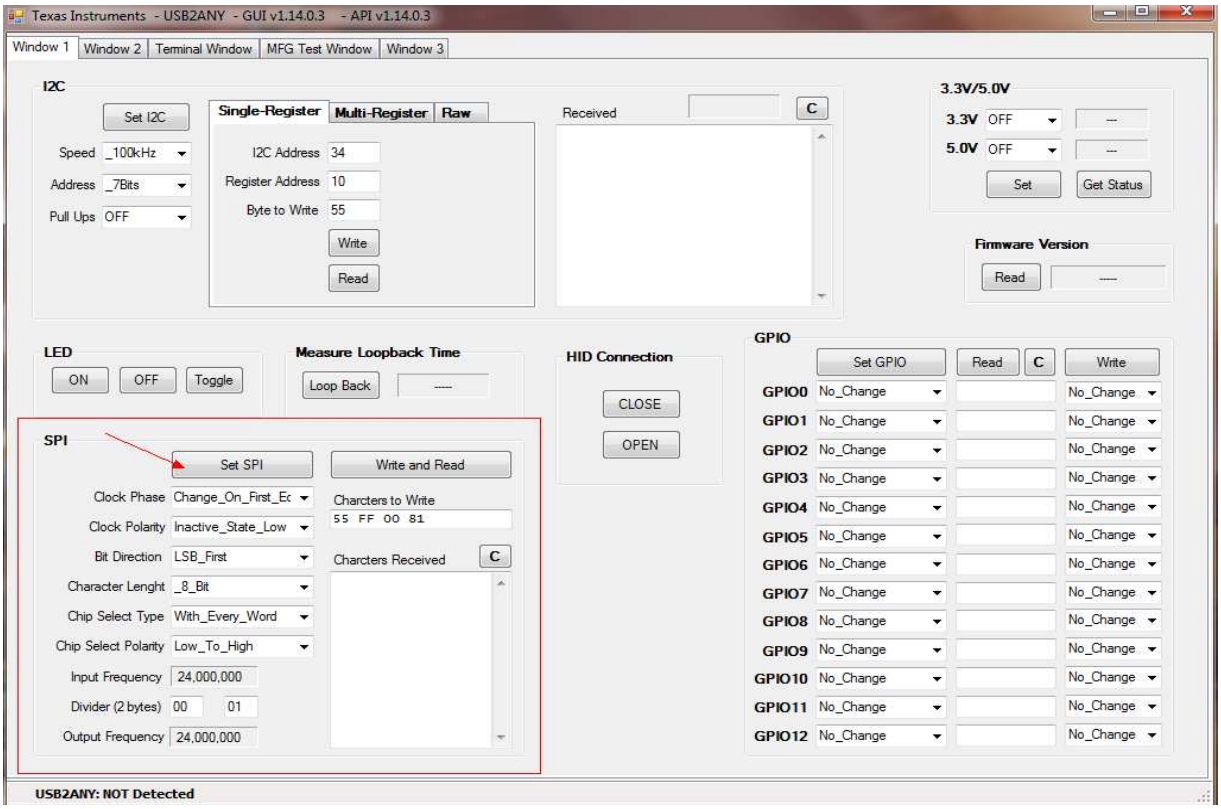

Figure 3. GUI Main Window

2.2 EVM Test

2.2.1 Power Up Sequence

1. Connect USB2ANY to a host computer by an USB cable
2. Launch USB2ANY GUI software as described in the following section
3. Connect a 10-pin flat cable between the USB2ANY and an EVM
4. Power up the input of EVM

2.2.2 USB2ANY GUI Launch

Change as the red box selection as shown figure Figure 4. Change the divider of the input frequency to the same as that in Figure 3 to make the communication speed 4 kHz. Start with low communication frequency for easier verification.

Make sure each red box is properly modified.

Then, clock “Set SPI” to make the change enabled.

“Set SPI” should be clicked everytime after any in the red boxes are changed.

Probe that voltages of CS, SCL, MOSI and MISO are all zero.

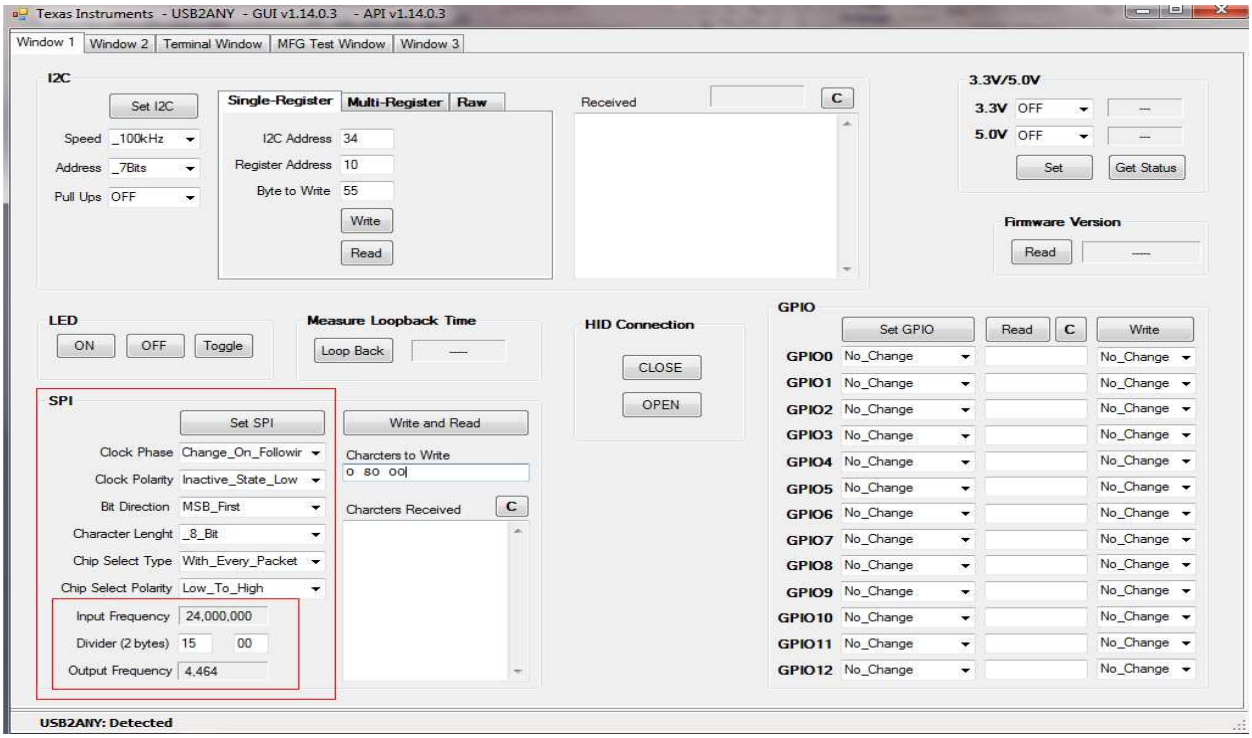

Figure 4. Set Up for the USB2ANY

2.2.3 Test With SPI Interface Buffer Disabled for Lowest IDDQ Mode

When JP11 is connected to GND, TPS65290 provides only Vmicro voltage and other blocks are disabled to maintain minimum power consupmtion. Therefore the SPI communication doesn’t work at Vmicro only. Use Table 5 for the proper jumper connection for Vmicro only mode.

Table 5. Jumper Connections for Low-IDDQ Measurement

Vmicro MODE	FIT THESE JUMPERS	DO NOT FIT THESE JUMPERS	JP11, JP13
TPS65290BM	JP1, JP4, JP8	JP8A, JP10	GND
TPS65290ZB	JP1, JP4, JP10, JP8A	JP8	GND
TPS65290LM	JP1, JP4, JP10, JP8A	JP8	GND

The default value of the micro and buck/boost are described in Table 6. The buck-boost can be enabled by connecting JP13 to Vmicro. Keep in mind that the loading of an oscilloscope probe or a multi-meter can increase the input current.

Table 6. Default Value of EVM

	DEFAULT OUTPUT VALUE			NOTES
	MIN	TYP	MAX	
Vmicro	1.98 V	2.2 V	2.42 V	
Vbb_out	3.977 V	4.1 V	4.223 V	To enable the buck/boost, JP13 should connect as ENBB-VMICRO

2.2.4 Test With the SPI illerface

Connect JP11 to Vmicro to enable SPI interface buffers and the digital block. Follow Section 2.3 for detailed GUI instruction.

2.3 GUI User's Guide

2.3.1 GUI User's Guide

Write "1 0 80" on the read box.

Click the "Write and Read" button.

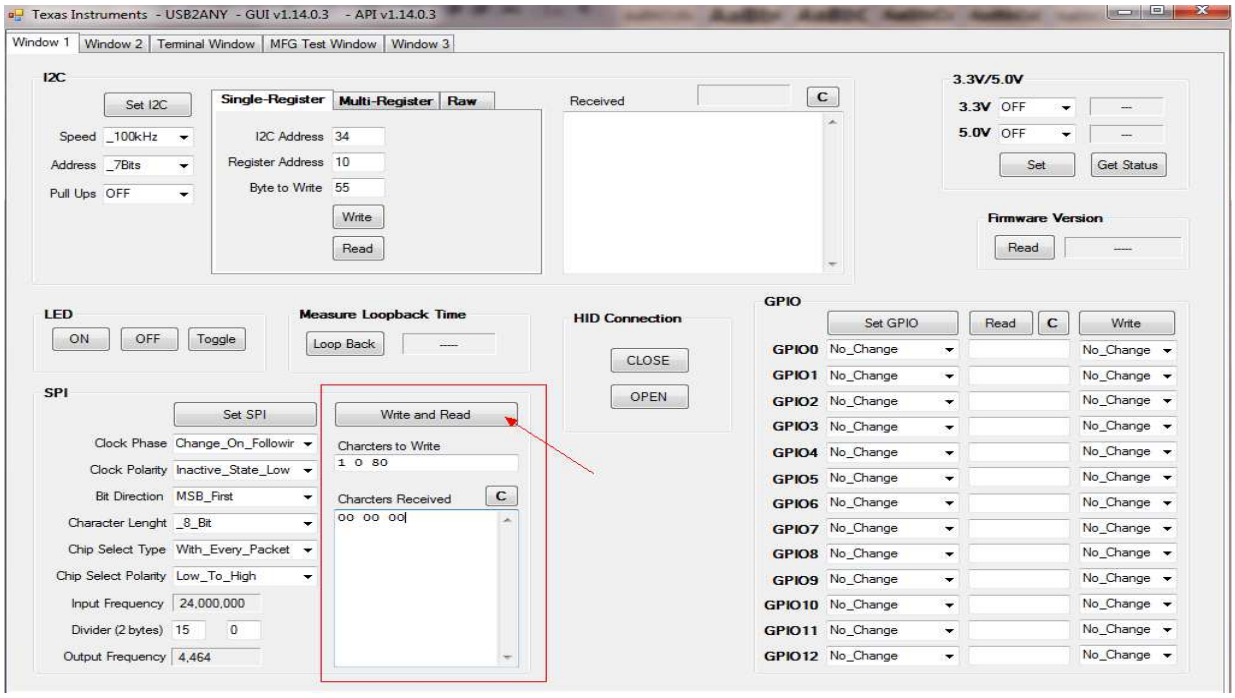

Figure 5. Unlock the USB2ANY

2.3.2 Read the Register

Fill in the red box then click the "Write and Read" button.

The first character is the register address to read. Keep the second and the third characters to be "80 00".

The figure below shows reading the address of 03, and then gets the data back as 08, which means that the buck/boost output voltage is 2.6V now.

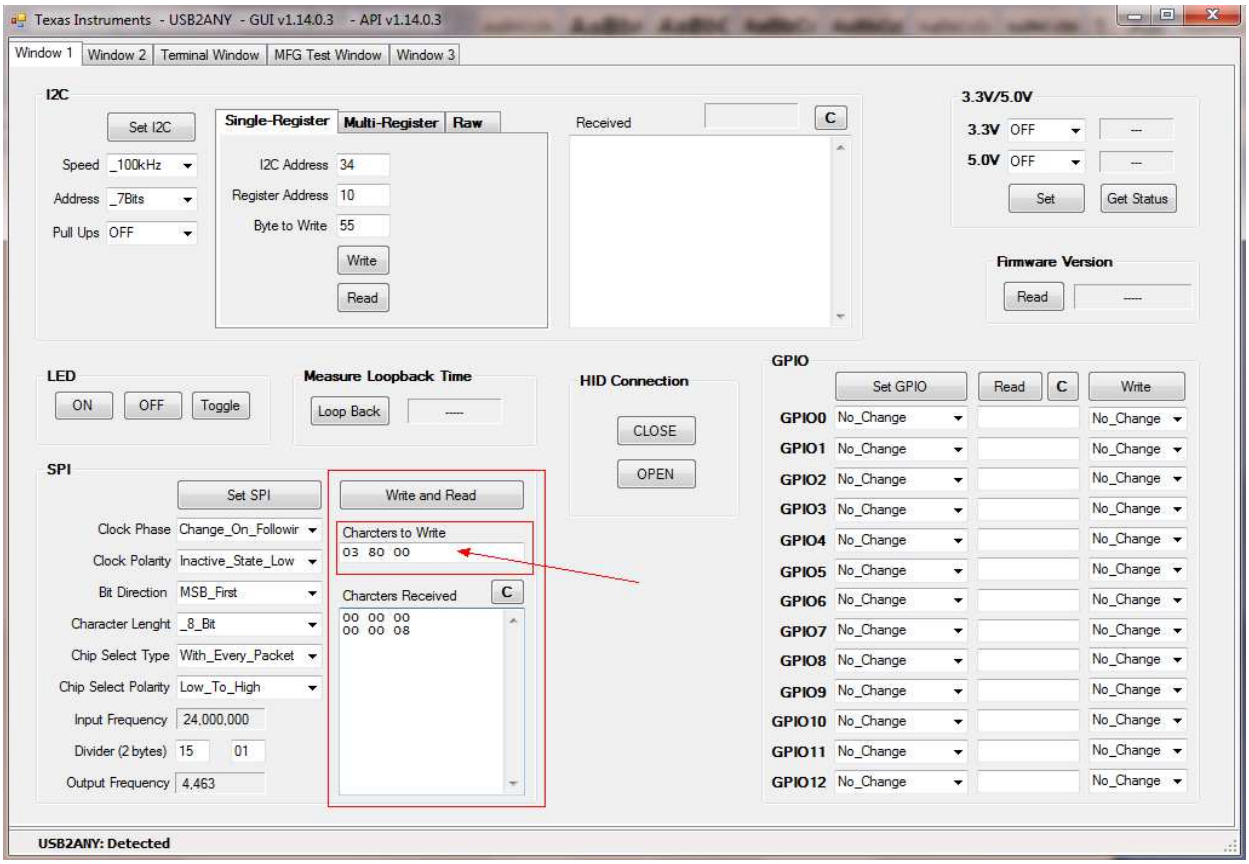

Figure 6. Read the Data

2.3.3 Write the Register

Fill in the red box then click the “Write and Read” button.

The first character is the register address to write, and the third character is the value to write in. Keep the second character to be “00”.

The figure below shows writing the HEX 12 to address 03, to change the output voltage to 4V, after setting the data you want to write, and click the “Write and Read”.

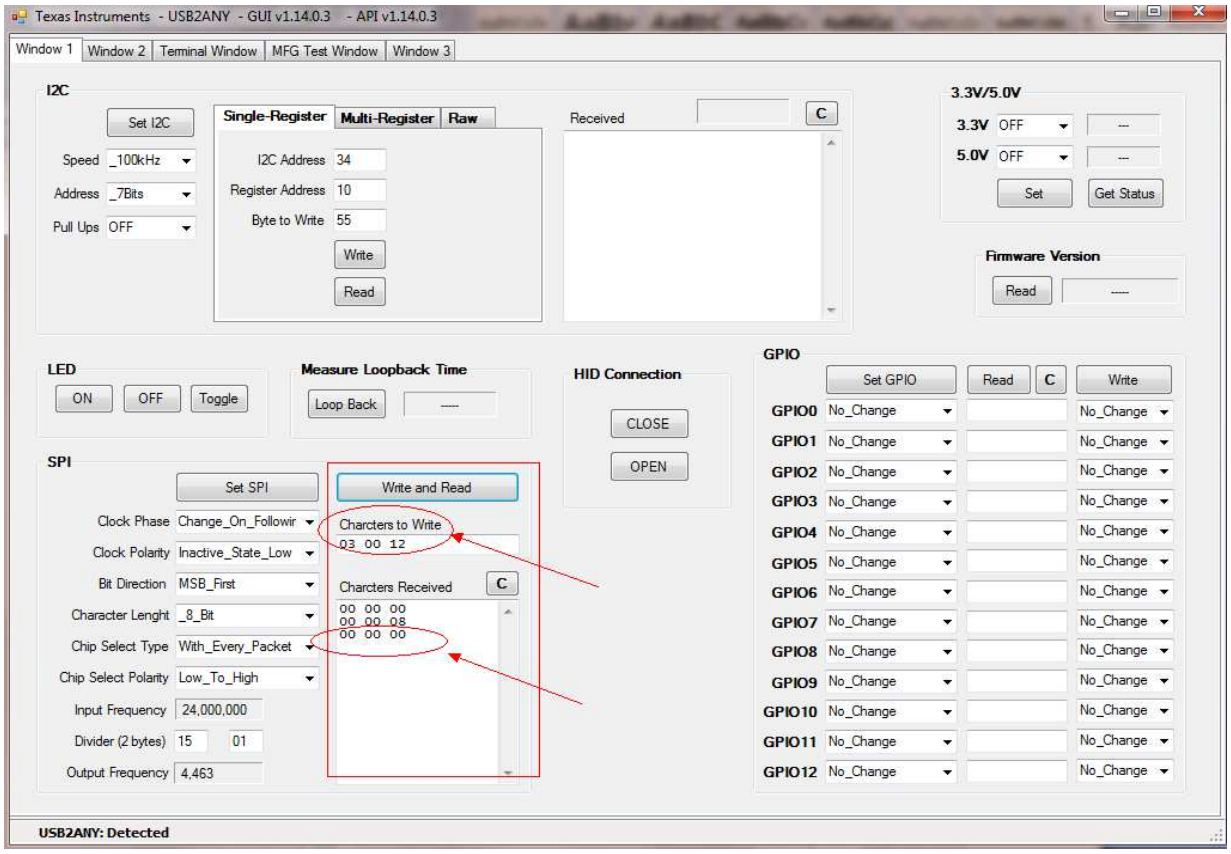

Figure 7. Write the Register

2.4 Simulation Model and Test Result

2.4.1 Spice Model

This device has one similar function spice model of buck/boost. Download at:
http://www.ti.com/product/tps63020

And it's convenient to use TINA-TI software to simulate under varying conditions. Download this tool at:
http://www.ti.com/tool/tina-ti

2.4.2 Main Features

2.4.2.1 Efficiency

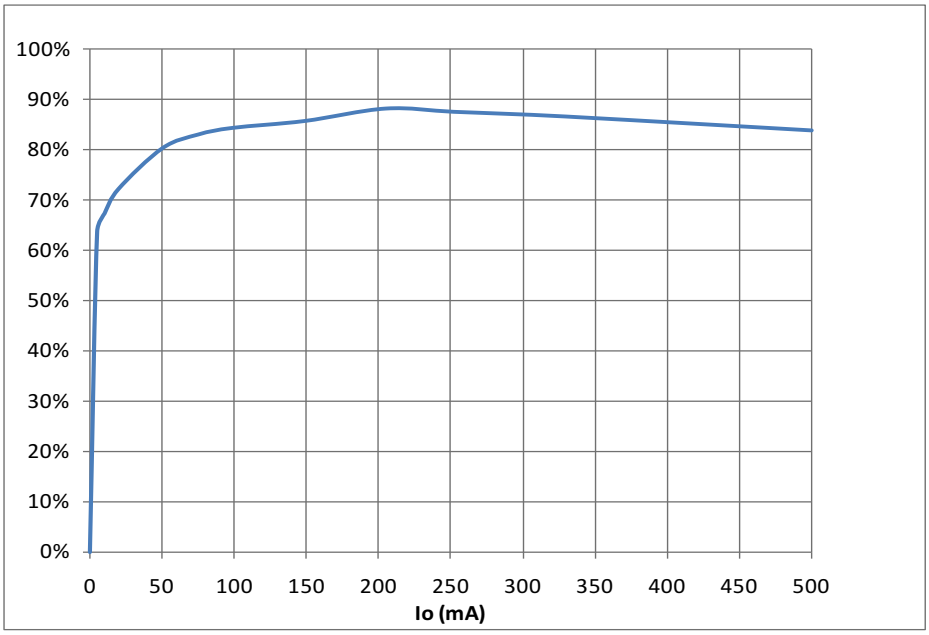

Figure 8. Buck Boost Efficiency, V_{IN} = 3.6 V, V_O = 4.5 V

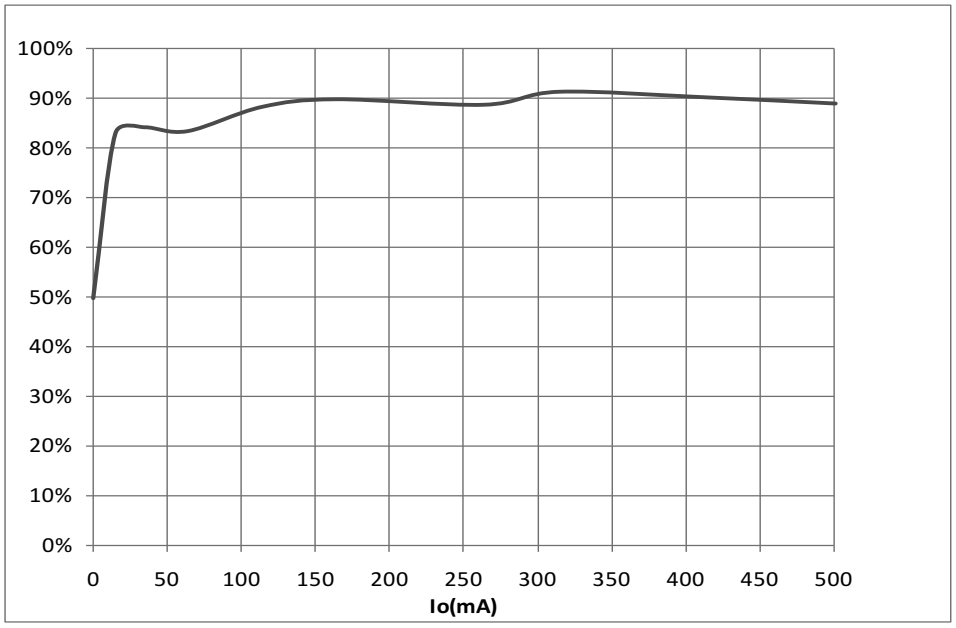

Figure 9. Buck Boost Efficiency, V_{IN} = 3.6 V, V_O = 2.8 V

2.4.2.2 Load Regulation

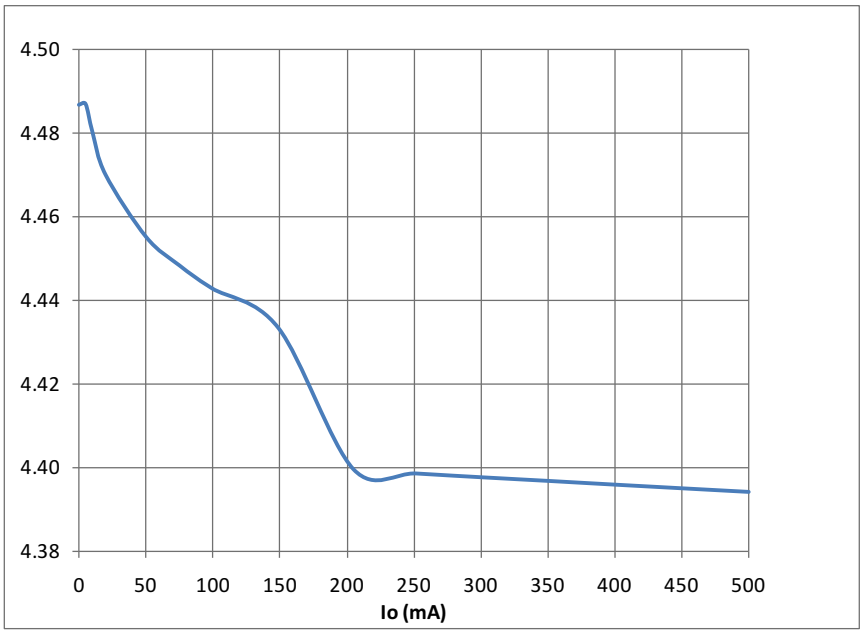

Figure 10. Buck Boost Load Regulation, V_{IN} = 3.6 V, V_O = 4.5 V, PFM Mode

2.4.2.3 Line Regulation

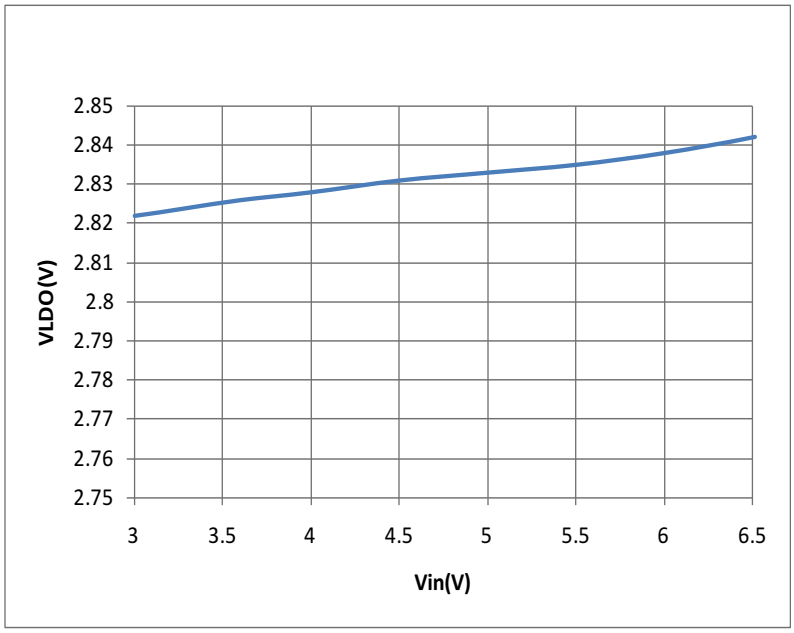

Figure 11. Buck Boost Line Regulation, V_O = 2.8 V, I_O = 5 mA

3 Schematic

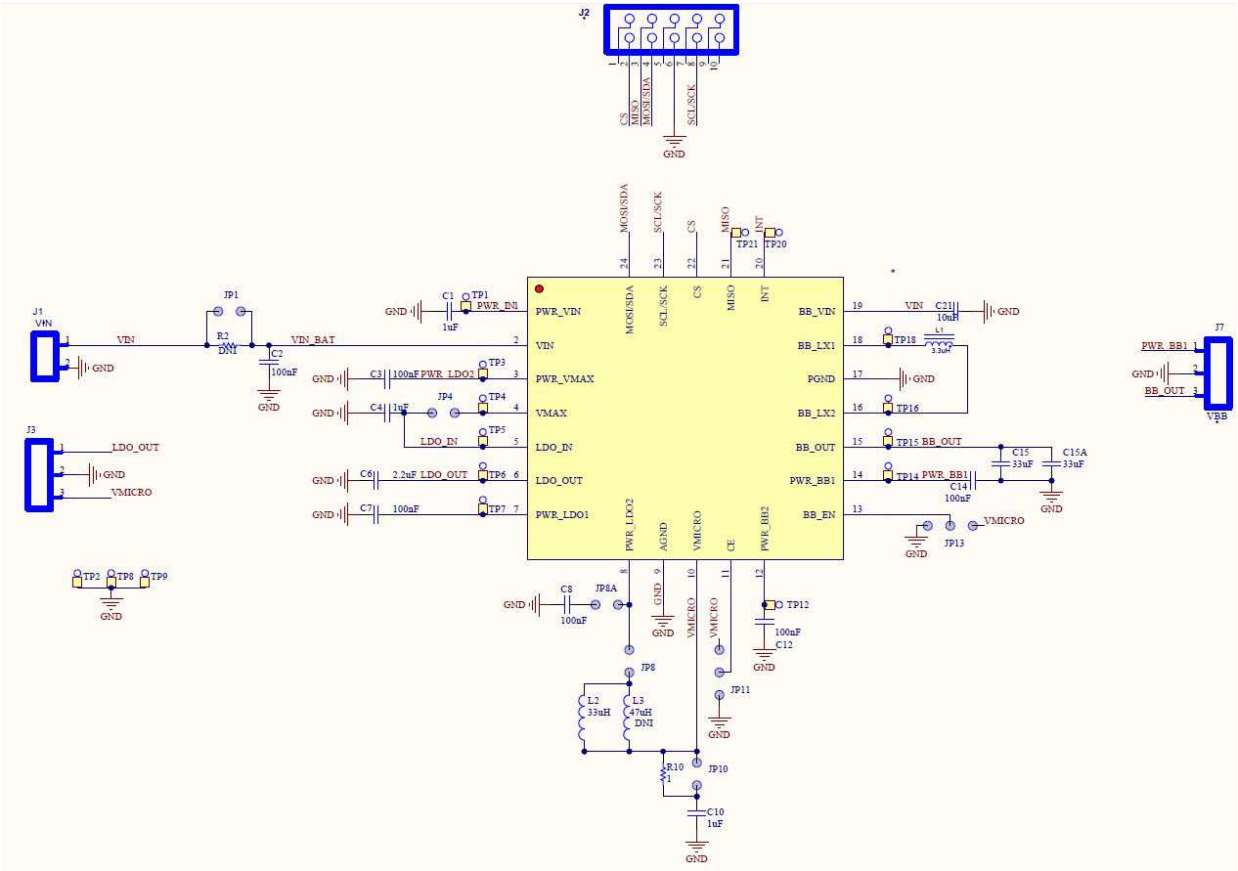

Figure 12. TPS65290 Schematic

4 Board Layout

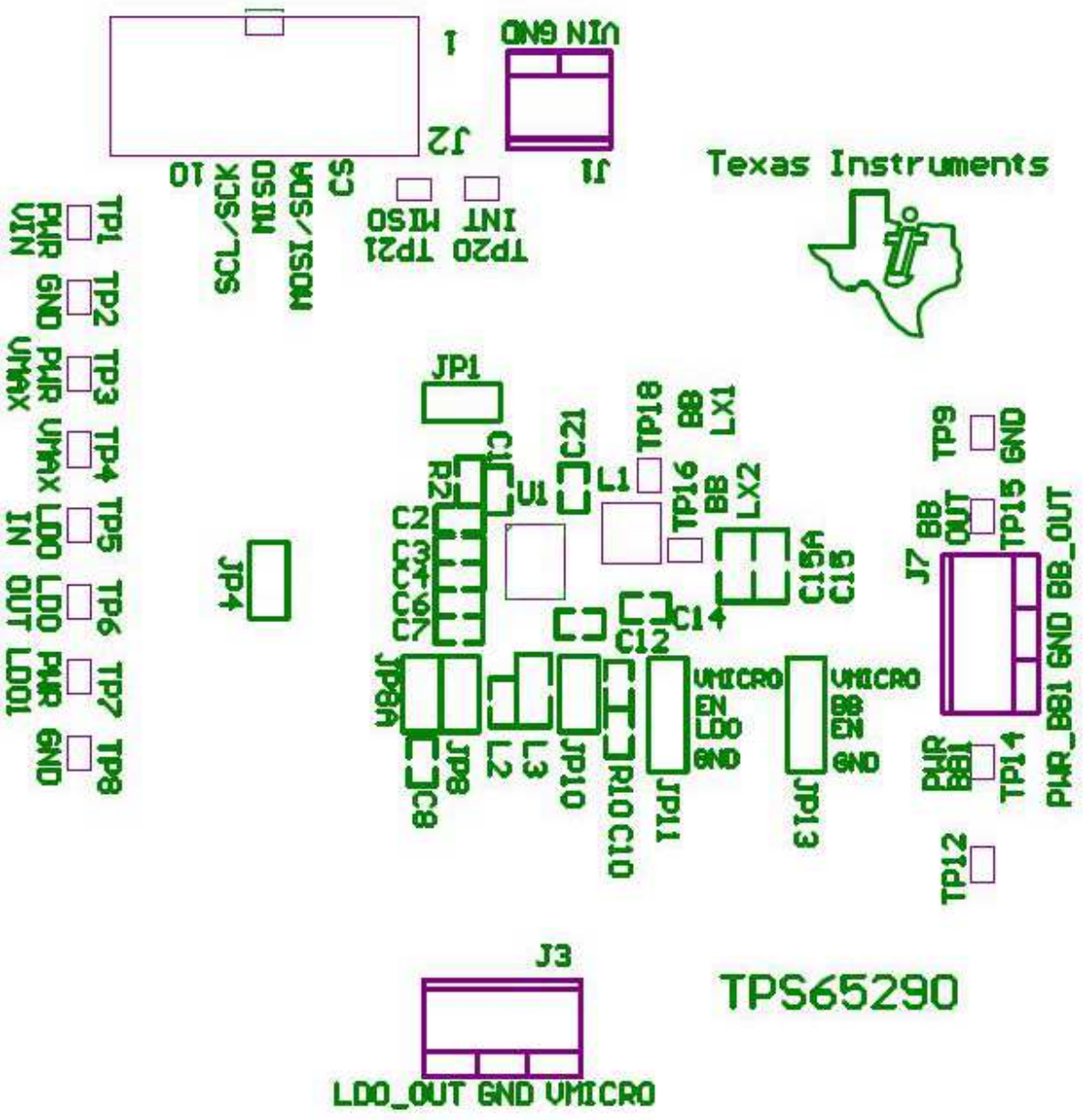

Figure 13. Placement

4.1 PCB Layout

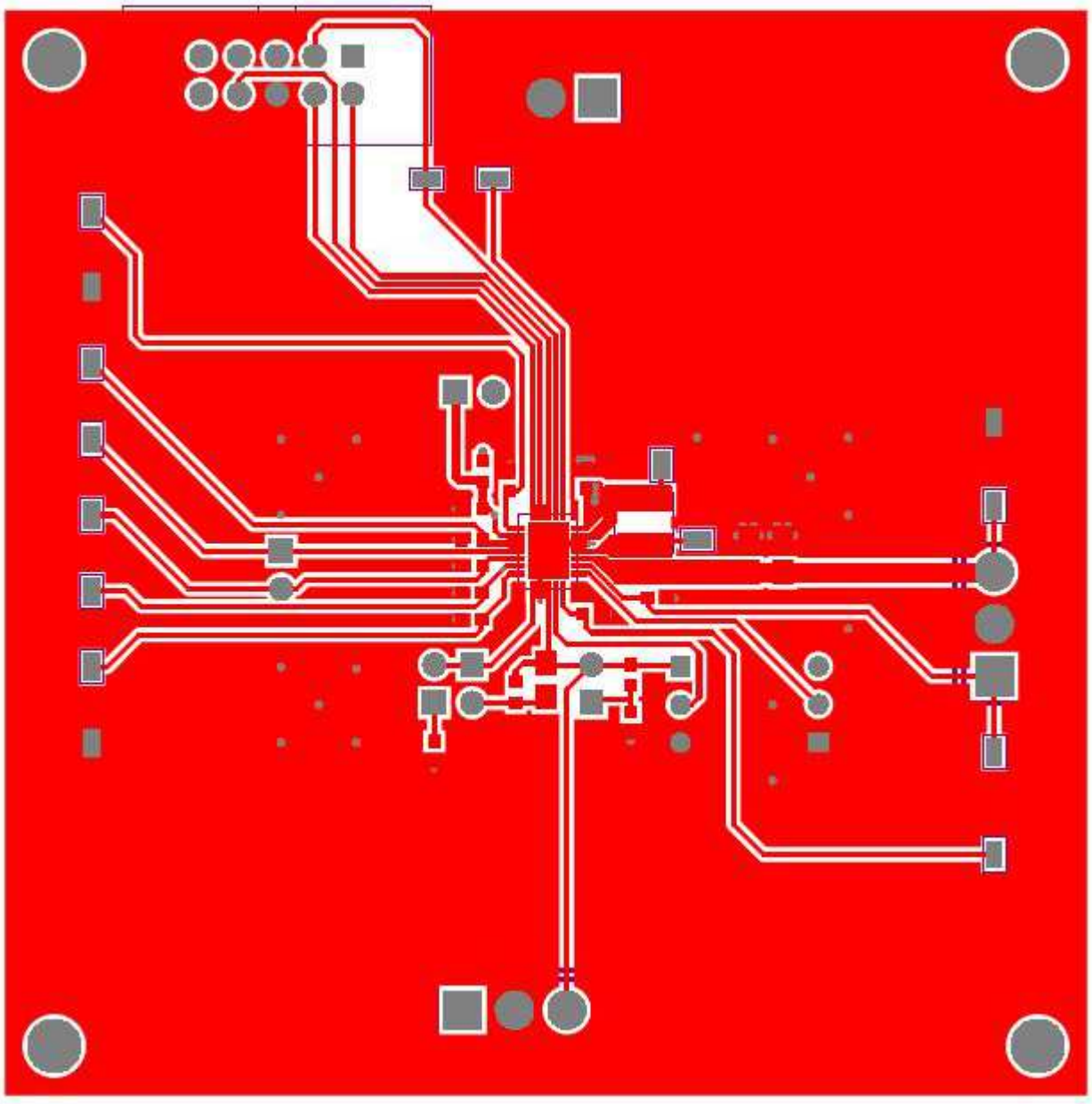

Figure 14. Board Layout (Top Layer)

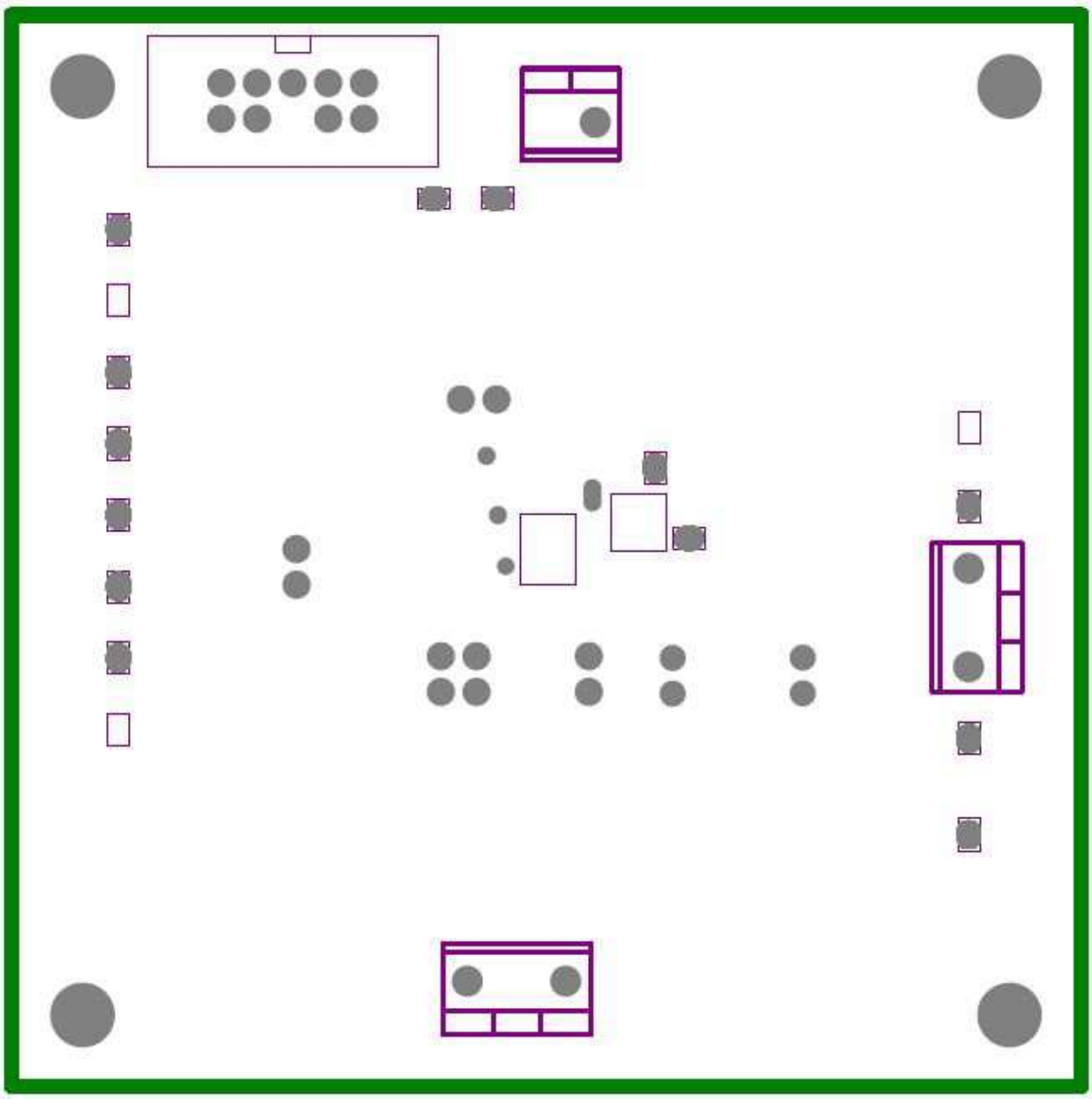

Figure 15. Board Layout (Middle 2nd) Layer

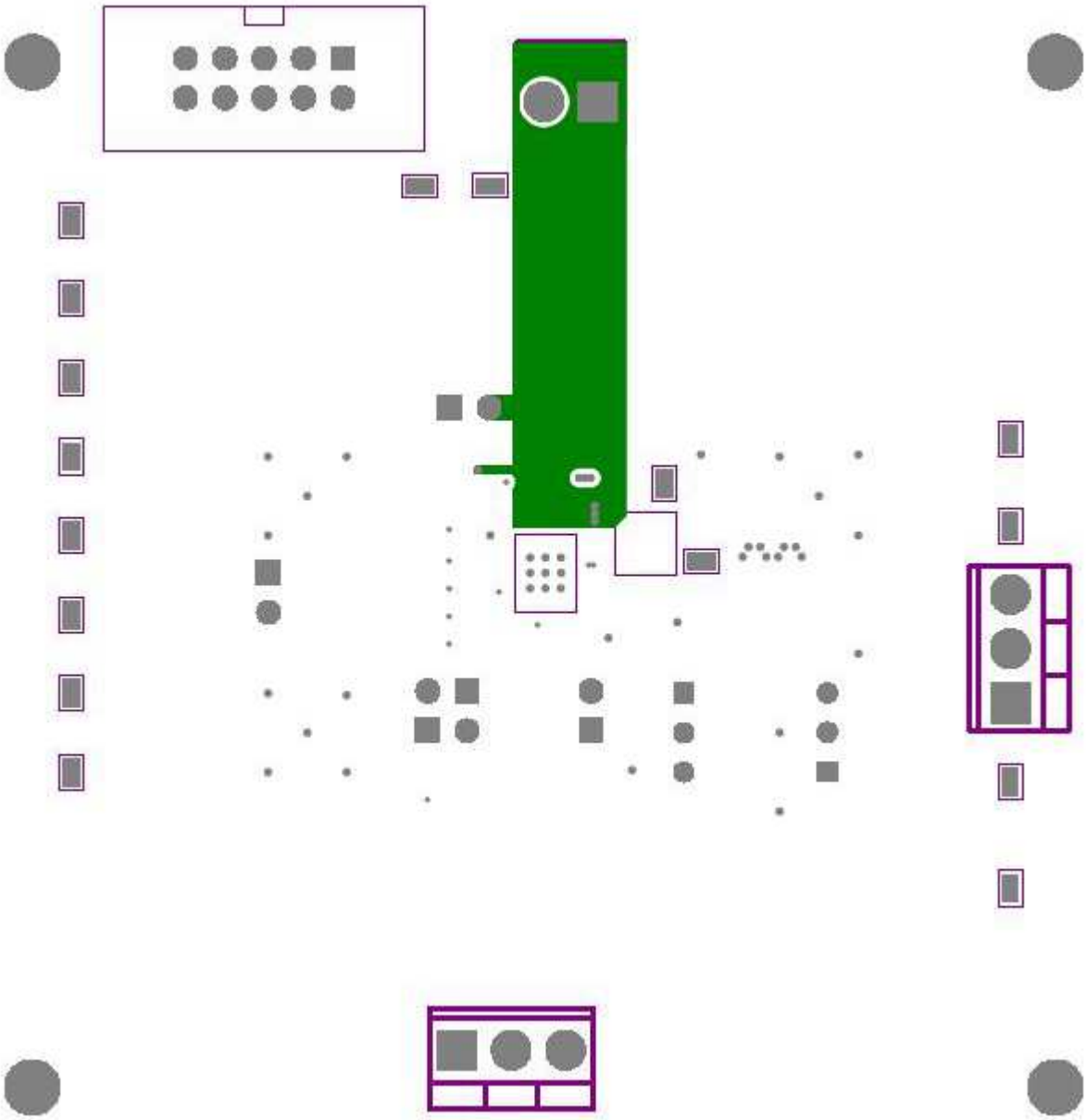

Figure 16. Board Layout (Middle 3rd) Layer

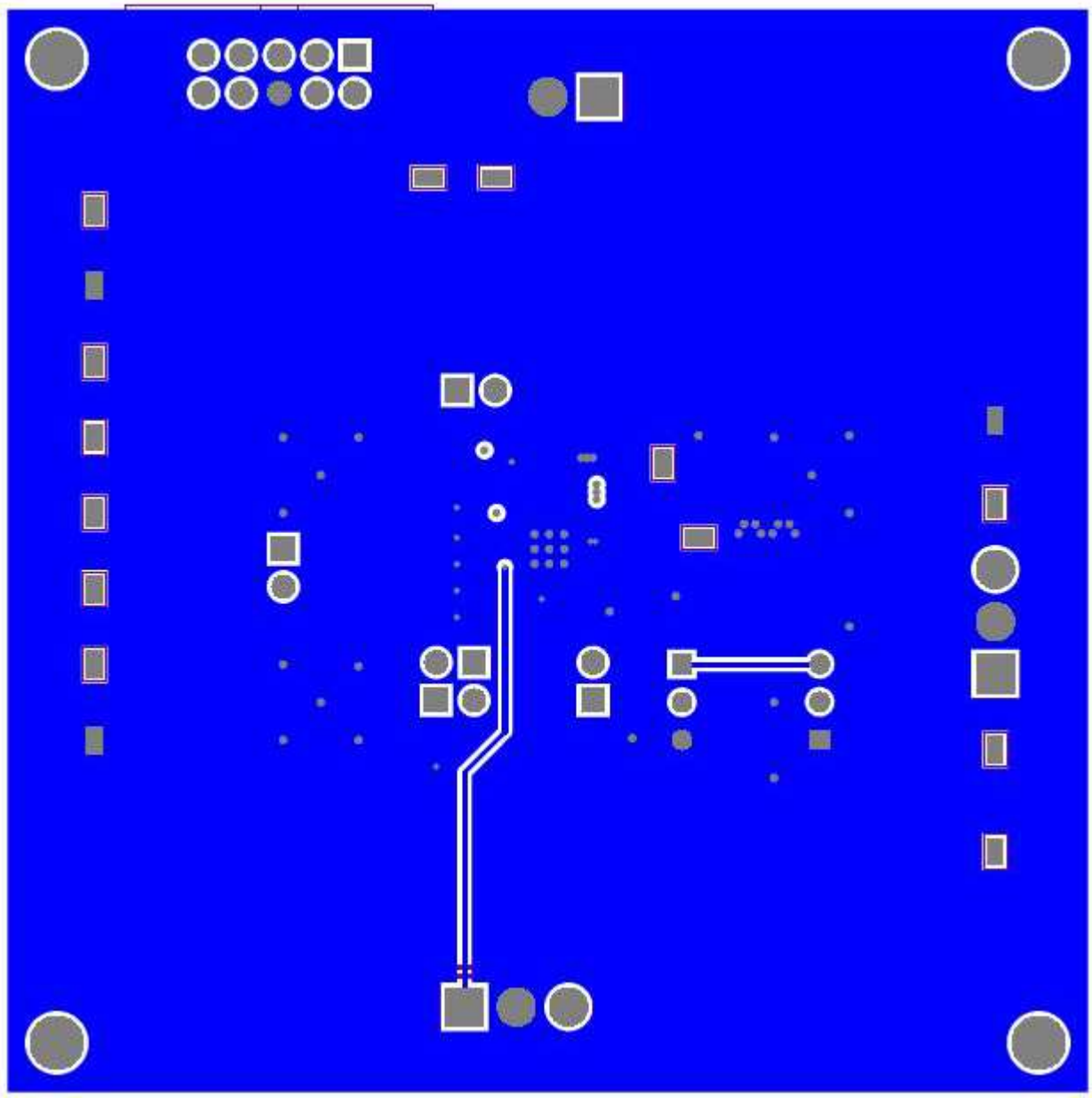

Figure 17. Board Layout (Bottom Layer)

5 Bench Test Setup Conditions

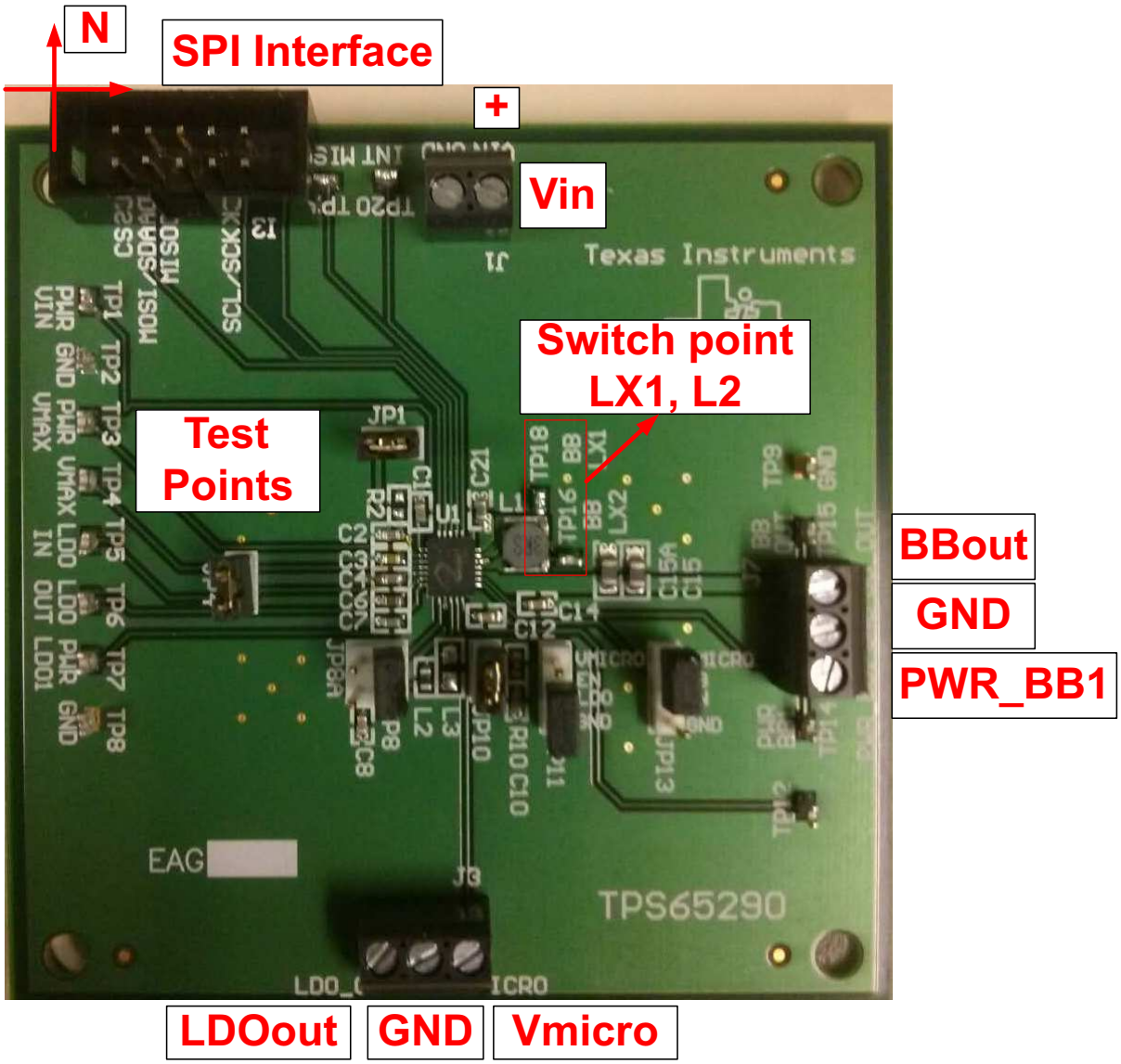

Figure 18. Headers Description and Jumper Placement

6 Bill of Materials

Qty	Designator	Value	Footprint	Manufacturer	Part Number	Description
4	C1, C7, C10, C4	1uF	0603	TDK Corporation	C1608X7R1A105K	CAP CER 1.0UF 10V X7R 0603
6	C2, C3, C8, C12, C14	100nF	0603	Kemet	C0603C104K8RACTU	CAP .10UF 10V CERAMIC X7R 0603
1	C6	2.2uF	0603	Kemet	C1608X7R1A225M	CAP CER 2.2UF 10V X7R 20% 0603
2	C15, C15A	33uF	0805	TDK Corporation	C2012X5R336M125AC	CAP CER 33UF 10V X5R 20% 0805
1	J1	ED1514	TB_2X3.5MM	On Shore Technology Inc	ED555/2DS	TERMINAL BLOCK 3.5MM 2POS PCB
2	J3,J7	ED555/3DS	TB_3X3.5MM	On Shore Technology Inc	ED555/3DS	TERMINAL BLOCK 3.5MM 3POS PCB
5	JP1, JP4, JP8, JP8A, JP10		JMP0.2	Molex Inc	22-10-2021	CONN HEADER 2POS .100 VERT GOLD
2	JP11, JP13		JMP0.3	Molex Inc	22-10-2031	CONN HEADER 3POS .100 VERT GOLD
1	L1	3.3uH	4mmx4mm	Abracon Corporation	ASPI-0418FS-3R3M-T3	INDUCTOR SHLD POWER 3.3UH SMD
1	L2	33uH	0603	TDK Corporation	GLFR1608T330M-LR	INDUCTOR 33UH 60MA 20% 0603
1	L3	47uH (DNI)	0805	TDK Corporation	GLFR2012T470M-LR	INDUCTOR 47UH 60MA 20% 0805
1	R10	1	0603	Panasonic ECG	ERJ-3GEYJ1R0V	RESISTOR 1.0 OHM 1/10W 5% 0603
16	TP1, TP2, TP3, TP4, TP5, TP6, TP7, TP8, TP9, TP12, TP14, TP15, TP16, TP18, TP20, TP21		TP_1030	Keystone	1030	TEST POINT SLOTTED
1	U1		RHF (PQFP-24)	Texas Instruments	TPS65290	
1	R2	0 Ohm (DNI)	0603			
1	J2	NA	5x2 header	Sullins Connector Solutions	SBH11-PBPC-D05-ST-BK	CONN HEADER 2.54mm 10POS GOLD
1	C21	10uF	0603	Taiyo Yuden	EMK107BBJ106MA-T	CAP CER 10UF 16V 20% X5R 0603

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