

## **TPS650830EVM-095**

The TPS650830EVM-095 evaluation module is a fully assembled and tested circuit for evaluating the TPS650830 6-channel power management integrated circuit. The TPS650830EVM provides a platform for a user or designer to evaluate the TPS650830. It has the capabilities to experiment with the part in a holistic design approach for computing power and in a generic mode such as if the TPS650830 is placed into a new experimental application. This document includes instructions and results of typical electrical performance characteristics, connector and test point descriptions, setup instructions, schematics, printed-circuit-board (PCB) layouts and the bill of materials (BOM). Throughout this user's guide, the abbreviations *EVM*, TPS650830EVM, and the term *evaluation module* are synonymous with the TPS650830EVM-095, unless otherwise noted.

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## 1 Introduction

### 1.1 Features

- 4 DCAP2™ Controllers
- 1 Converter, 2-MHz Switching Frequency
- DDR Termination LDO,  $\pm 1$  A
- Wide Vin Range, 5.4 V – 21 V
- Dynamic Voltage Scaling, via I2C and/or Hardware Signal
- Output voltage adjustable via I2C interface
- Power Path Management for 2 Batteries and 1 Adaptor
- 8 Power Good Comparators and Sequence Logic for External DCDCs, LDOs and Load Switches.
- 2 Level Shifters
- Power-Button Logic Supported with Programmable Response Time and Counter Reporting
- RTC Backup Battery Selector with 3.1-V LDO Output
- Board Temperature Monitoring System
- 1-Hz Wake EC Clock

### 1.2 Applications

- Notebook Computing
- Tablets
- Human Machine Interface
- Infotainment Systems
- FPGA System Power

### 1.3 Requirements

To operate the EVM for basic evaluation purposes a PC, the EVM software, and power supply are needed in addition to basic a voltmeter or Digital Multimeter, DMM.

#### 1.3.1 Host Computer

A personal computer (PC) with a USB port is required to operate this EVM. The TPS65083x software runs on the PC and communicates with the EVM via the PC's USB port and the USB-to-GPIO interface.

PC Requirements :

- Microsoft® Windows® 7 operating system
- USB port
- Minimum of 30MB of free hard-disk space (100MB recommended)
- Minimum of 256MB of RAM

#### 1.3.2 Software

Download and install the TPS65083xEVM GUI on a PC to access the I2C registers.

#### 1.3.3 Power Supply Requirements

A DC power supply capable of delivering up to 21 V, 9 A, and 50 W is required to operate this EVM to its max power outputs.

## 2 TPS65083xEVM Electrical Performance Specifications

**Table 1. TPS650830EVM Electrical and Performance Specifications**

Parameter	Symbol	Notes and Conditions	Min	Typ	Max	Unit
<b>Input Characteristics</b>						
Input voltage	$V_{BATA}$	$V_{IN}$	5.4		21	V
Input Current	$I_{BATA}$		0		9	A
UVLO	$V_{UVLO}$	$V_{IN}$ falling	4.95	5.1	5.25	V
UVLO hysteresis	$V_{HYS-UVLO}$	$V_{IN}$ rising		200		mV
<b>Output Characteristics</b>						
<b>VR1</b>						
Output voltage VR1	VR1, V1.00A			1.0V		V
		I2C Programmable Range Margining	-5		+5	%
Output voltage accuracy VR1			-1		1	%
Load Regulation				0.5		%
Output Current VR1	$I_{OUT, VR1}$	$V_{IN}$ = Min to Max, Low Side $R_{ds_{ON}} = 7m\Omega$ , $R_{cs} = 9.53 k\Omega$ , $L = 1 \mu H$			6.8	A
Current Limit Low-Side MOSFET	$I_{LIMF}$	Low Side $R_{ds_{ON}} = 7m\Omega$ , $R_{cs} = 9.53 k\Omega$		8.5		A
Switching frequency	$F_{SW}$	NVDCZ = HIGH		500		kHz
<b>VR2</b>						
Output voltage VR2	VR2, V1.8A			1.8V		V
		I2C Programmable Range Margining	-4		+3	%
Output voltage accuracy VR2			-1		1	%
Load Regulation				0.5		%
Output Current VR2	$I_{OUT, VR2}$	$V_{IN}$ = Min to Max			1.8	A
Switching frequency	$F_{SW}$			2000		kHz
<b>VR3</b>						
Output voltage VR3	VR3, V3.3A_DSW			3.3V		V
		I2C Programmable Range Margining	-4		+3	%
Output voltage accuracy VR3			-1		1	%
Load Regulation				0.5		%
Output Current VR3	$I_{OUT, VR3}$	$V_{IN}$ = Min to Max, Low Side $R_{ds_{ON}} = 7m\Omega$ , High Side $R_{ds_{ON}} = 15.7m\Omega$ , $R_{cs} = 8.66 k\Omega$ , $L = 1.5 \mu H$			6.6	A
Current Limit High-Side MOSFET	$I_{LIMF}$	High Side $R_{ds_{ON}} = 15.7m\Omega$ , $R_{cs (HS)} = 22.6 k\Omega$ , $L = 1.5 \mu H$ , $V_{IN}$ up to 9V		13.15		A
Current Limit Low-Side MOSFET	$I_{LIMF}$	Low Side $R_{ds_{ON}} = 7m\Omega$ , $R_{cs} = 8.66 k\Omega$		7.73		A
Switching frequency	$F_{SW}$	NVDCZ = HIGH		800		kHz
<b>VR4</b>						
Output voltage VR4	VR4, VDDQ	DDRID shorted to GND		1.2V		V
		I2C Programmable Range Margining	-4		+3	%
Output voltage accuracy VR4			-1		1	%
Load Regulation				0.5		%
Switching frequency	$F_{SW}$			500		kHz
Output Current VR4	$I_{OUT, VR4}$	$V_{IN}$ = Min to Max, Low Side $R_{ds_{ON}} = 7m\Omega$ , $R_{cs} = 10.5 k\Omega$ , $L = 1 \mu H$			7.47	A
Current Limit Low-Side MOSFET	$I_{LIMF}$	Low Side $R_{ds_{ON}} = 7m\Omega$ , $R_{cs} = 10.5 k\Omega$		9.38		A
Switching frequency	$F_{SW}$	NVDCZ = HIGH		500		kHz

**Table 1. TPS650830EVM Electrical and Performance Specifications (continued)**

Parameter	Symbol	Notes and Conditions	Min	Typ	Max	Unit
<b>VR5</b>						
Output voltage VR5	VR5, V5A_DS3			5V		V
		I2C Programmable Range Margining	-4		+3	%
Output voltage accuracy VR5			-1		1	%
Load Regulation				0.5		%
Output Current VR5	$I_{OUT, VR5}$	$V_{IN}$ = Min to Max, Low Side $R_{ds_{ON}} = 7m\Omega$ , High Side $R_{ds_{ON}} = 15.7m\Omega$ , $R_{cs} = 4.87 k\Omega$ , $L = 3.3 \mu H$			3.55	A
Current Limit High-Side MOSFET	$I_{LIMF}$	High Side $R_{ds_{ON}} = 15.7m\Omega$ , $R_{cs (HS)} = 10.2 k\Omega$ , $L = 3.3 \mu H$ , $V_{IN}$ up to 9V		6.83		A
Current Limit Low-Side MOSFET	$I_{LIMF}$	Low Side $R_{ds_{ON}} = 7m\Omega$ , $R_{cs} = 4.87 k\Omega$		4.35		A
Switching frequency	$F_{SW}$	NVDCZ = HIGH		800		kHz
<b>LDO1</b>						
Output voltage LDO1	VLDO1, VTT	DDRID shorted to GND, VR4/VDDQ supplies $V_{INLDO1} = 1.2V$		0.6V		V
Output current of LDO1			-1		1	A
Source Current Limit of LDO1			2			A
Sink Current Limit of LDO1					-2	A

### 3 TPS650830EVM Schematics

#### 3.1 TPS650830 Voltage Rails

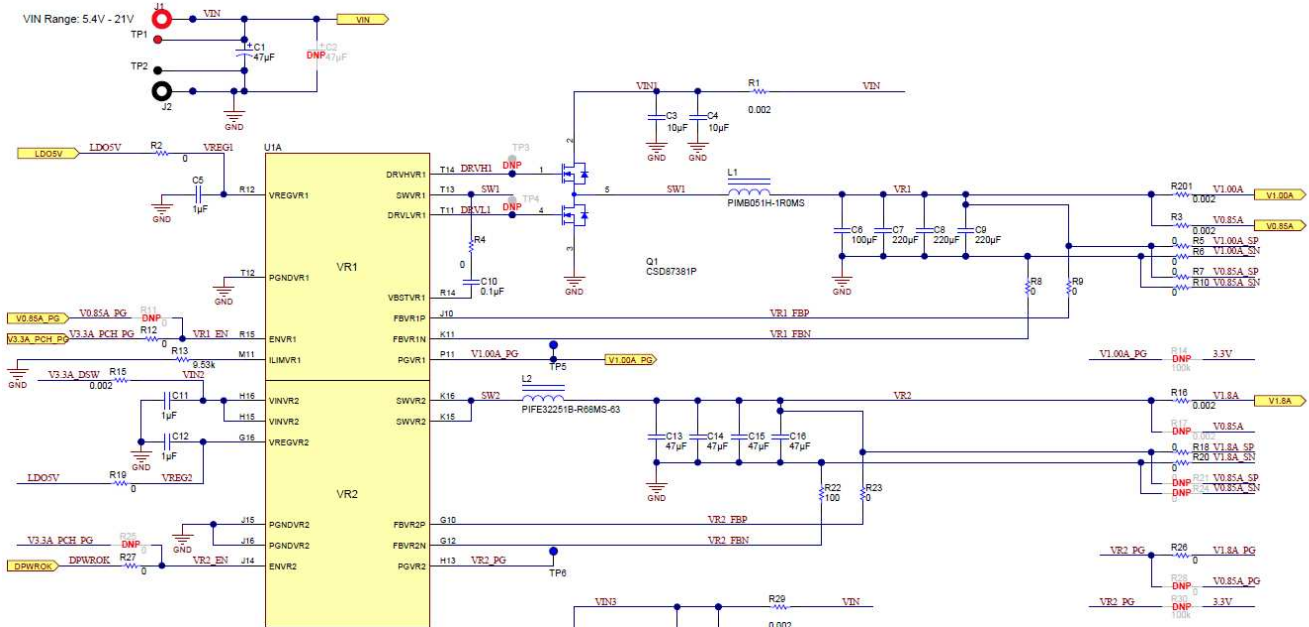


Figure 1. TPS650830EVM VR1 and VR2 Schematic

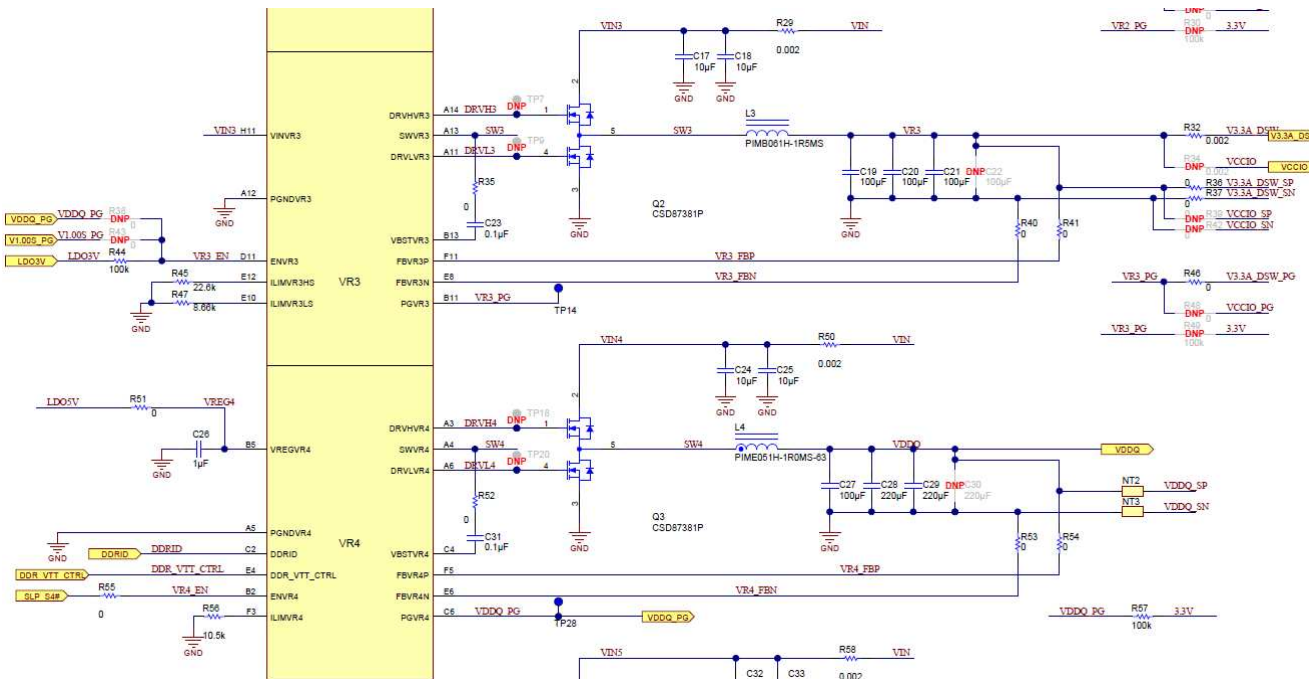


Figure 2. TPS650830EVM VR3 and VR4 Schematic

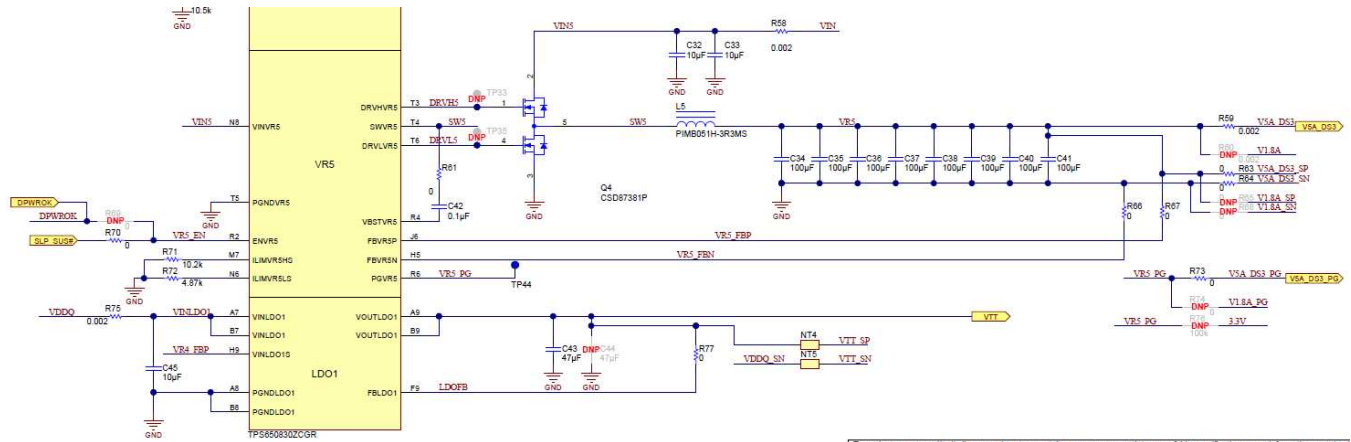


Figure 3. TPS650830EVM VR5 and LDO1 Schematic

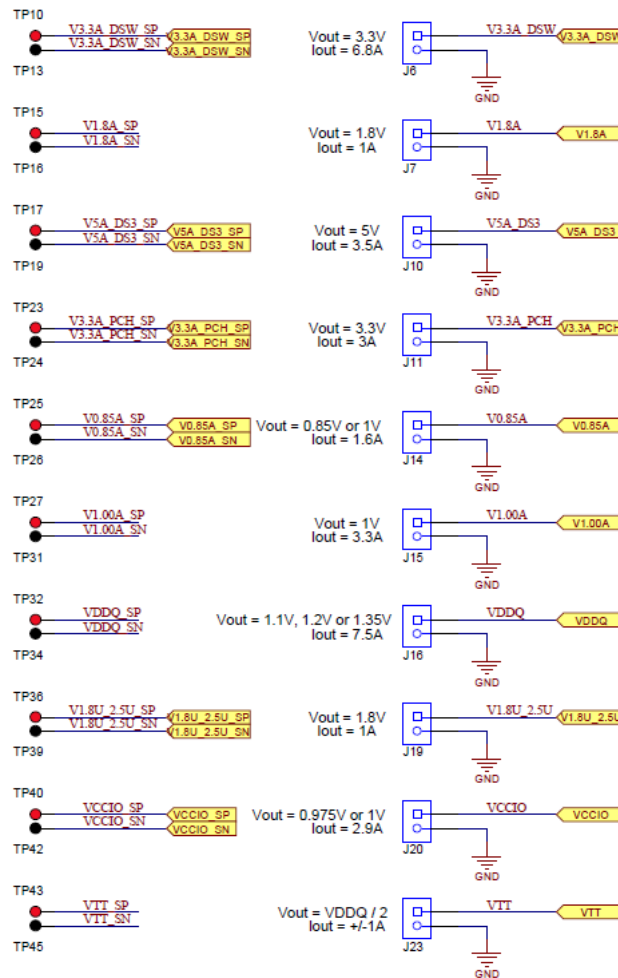


Figure 4. TPS650830EVM VR Outputs Schematic

### 3.2 TPS650830 Controls and TPS650830 Features

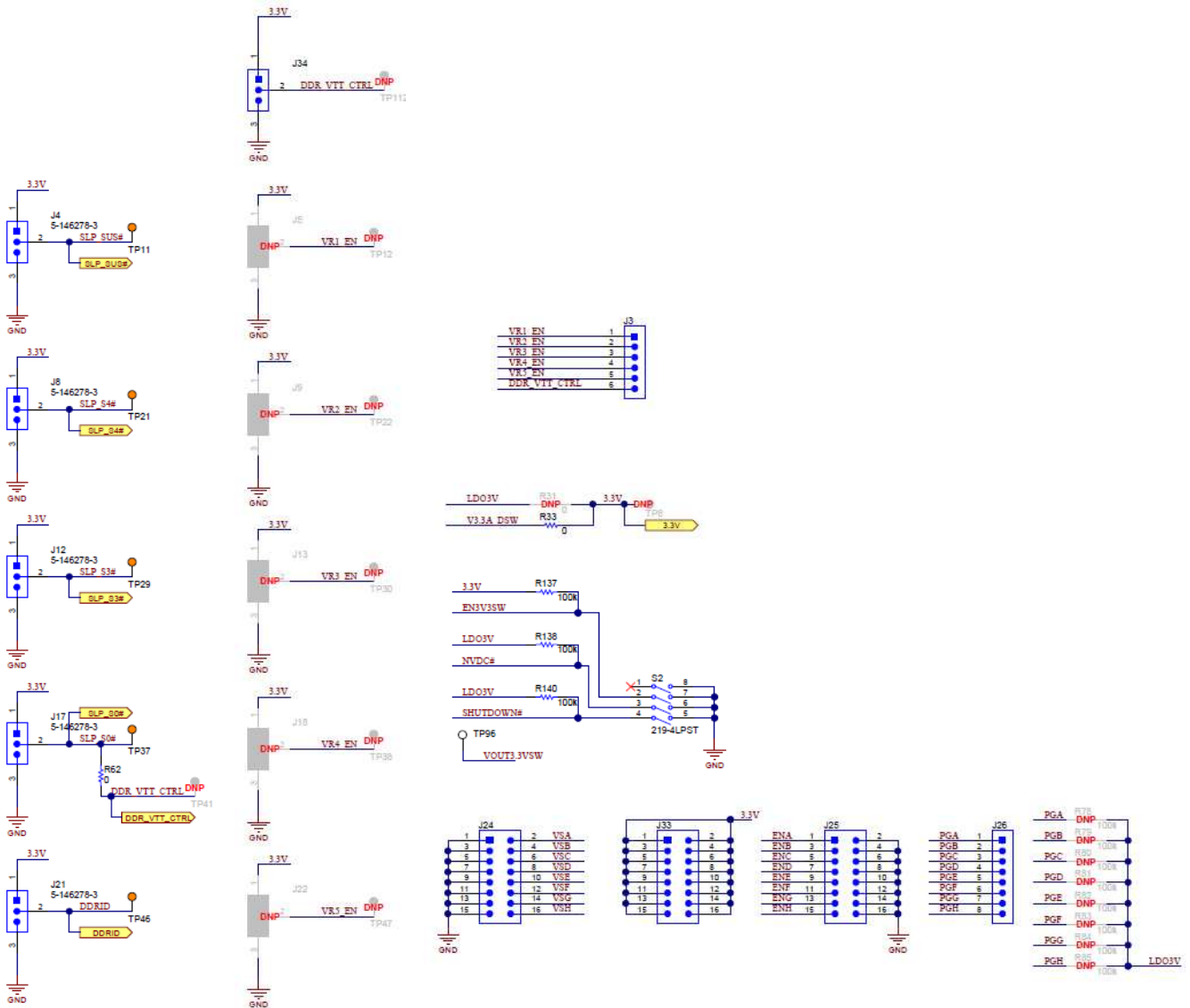


Figure 5. TPS650830EVM Controls Schematic

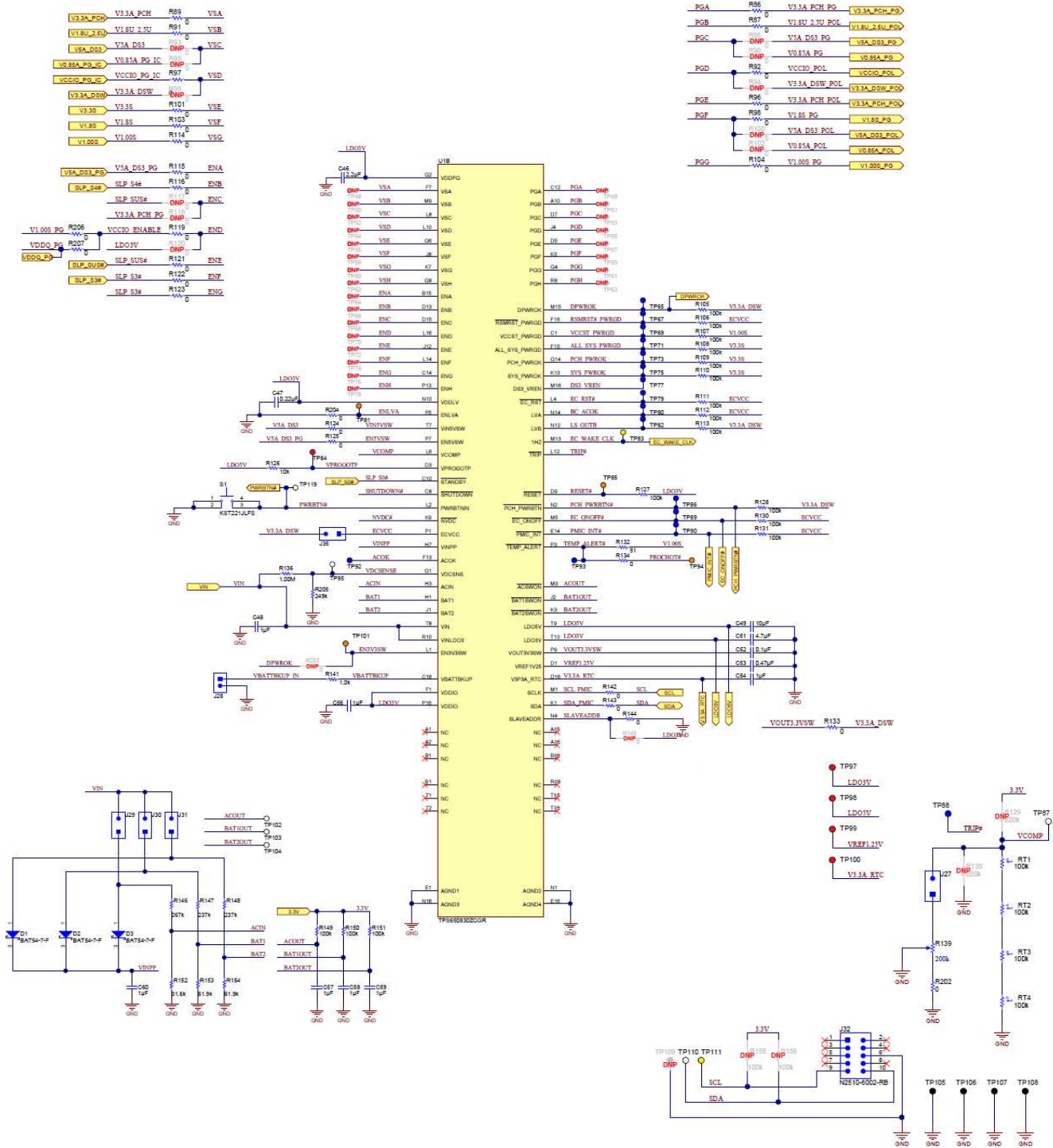


Figure 6. TPS650830EVM TPS650830 Schematic



### 3.3 Discretes and POLs

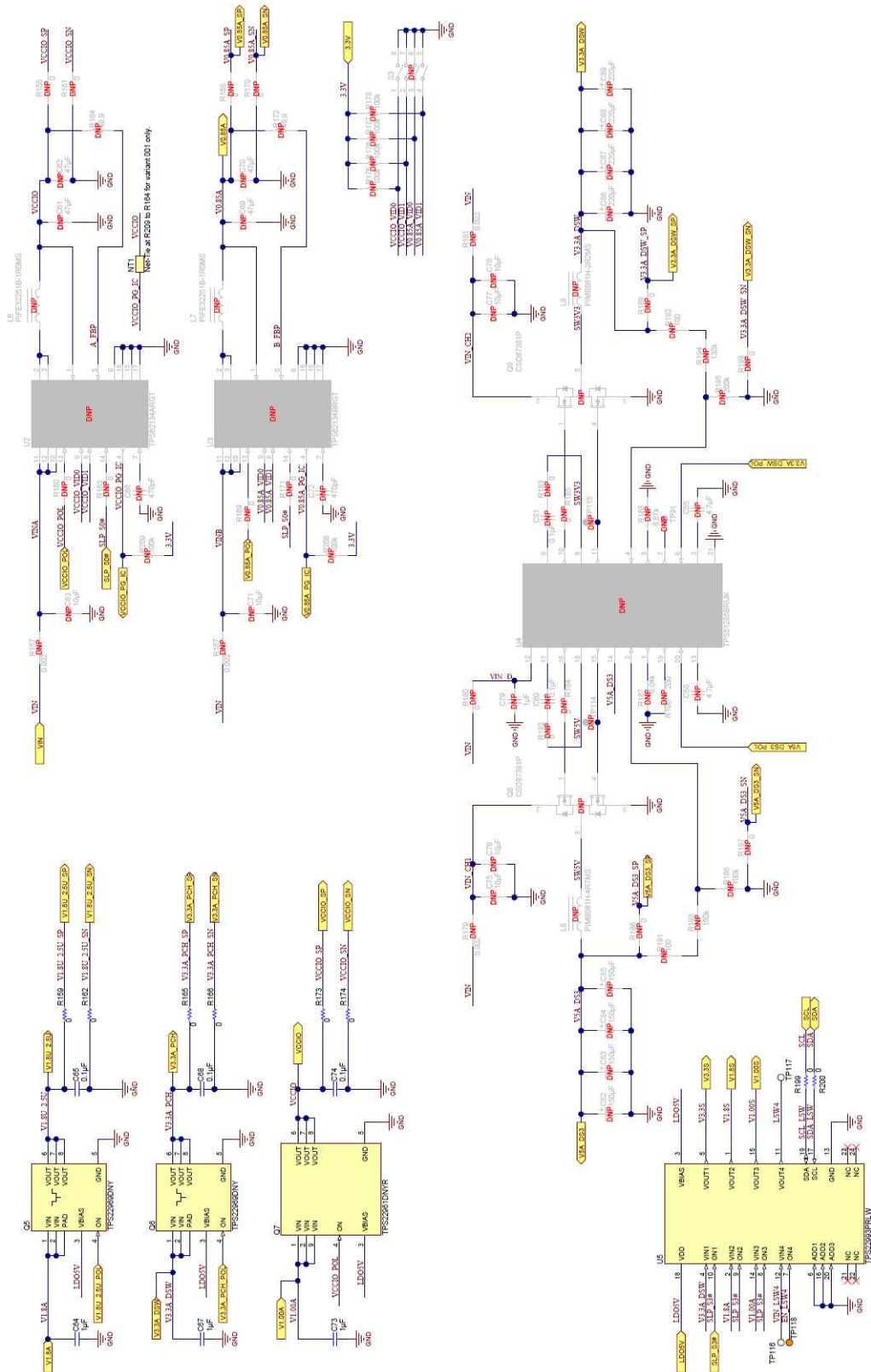


Figure 7. TPS650830EVM Discretes and POLs Schematic

## 4 Connectors, Switches and Test Point Descriptions

### 4.1 Power Connections

#### 4.1.1 J1 – VIN

This header is the positive connection to the input power supply. The power supply must be connected between J1 and J2 (GND). The leads to the input supply must be kept as short as possible. The input voltage has to be between 5.4 V and 21 V.

#### 4.1.2 J2 – GND

This header is the return connection to the input power supply for GND.

#### 4.1.3 Output Voltage Rails

See [Table 2](#) for header names, power source descriptions, and sequence.

**Table 2. Output Rail Headers**

Header	Name	Source			Turns On With
		TPS650830EVM	TPS650831EVM	TPS650832EVM	
J6	V3.3_DSW	VR3	POL, Discrete	VR3	Valid VIN
J7	V1.8A	VR2	VR5	VR2	Valid VIN
J10	V5A_DS3	VR5	POL, Discrete	VR5	SLP_SUS# Asserts High
J11	V3.3A_PCH	POL, Load Switch	POL, Load Switch	POL, Load Switch	SLP_SUS# Asserts High
J14	V0.85A	VR1	VR2	POL, Discrete	SLP_SUS# Asserts High
J15	V1.00A	VR1	VR1	VR1	SLP_SUS# Asserts High
J16	VDDQ	VR4	VR4	VR4	SLP_S4# Asserts High
J19	V1.8U_2.5U	POL, Load Switch	POL, Load Switch	POL, Load Switch	SLP_S4# Asserts High
J20	VCCIO	POL, Load Switch	VR3	POL, Discrete	SLP_S3# Asserts High
J23	VTT	VLDO1	VLDO1	VLDO1	SLP_S0# Asserts High

### 4.2 Switches

#### 4.2.1 S1 – PB\_IN

This is the pushbutton input. Pressing S1 pulls PWRBTNIN to GND. The power button can be used for many features such as turn on after a RESET or causing a RESET if configured correct via I2C. See the datasheet for more options and uses of the power button.

#### 4.2.2 S2 – Multi-Switch Shutdown, NVDC, and 3.3-V Load Switch

This switch has 4 dip switches in it. Switch 1 is unused. Switch 2 is internal 3.3-V load switch enable. Set away from the ON position to enable the internal 3.3-V load switch. Switch 3 is NVDC selector. Set towards the ON position to put the device into NVDC mode. Switch 4 is Shutdown mode. Set towards the ON position to put the device into SHUTDOWN mode.

### 4.3 Enables

There are places for jumpers to enable the VRs directly on the board. However, the TPS650830EVM has other jumpers that set the Sleep States for the device. The sleep states indirectly enable the VRs.

VR2 and VR3 are already on before any enable switch asserting high. They are enabled by DPWROK and LDO3, respectively, with LDO3 enabled when VIN > UVLO.

### 4.3.1 J4 - SLP\_SUS#

SLP\_SUS# is active low and when set low will put the device into sleep state SUSPEND. When SLP\_SUS# asserts high, VR5 and VR1 turn on as well as the device enabling a load switch.

### 4.3.2 J4 - SLP\_S4#

SLP\_S4# is active low and when set low will put the device into sleep state 4. When SLP\_4# asserts high, VR4 turns on as well as the device enabling a load switch.

### 4.3.3 J4 - SLP\_S3#

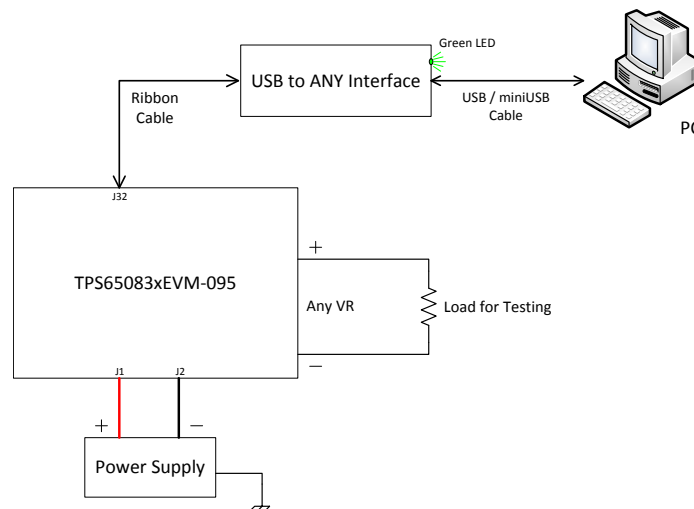
SLP\_S3# is active low and when set low will put the device into sleep state 3. When SLP\_3# asserts high, the device enables a load switch.

### 4.3.4 J4 - SLP\_S0#

SLP\_S0# is active low and when set low will put the device into sleep state 0. When SLP\_0# asserts high, VLDO1 turns on.

## 5 Setup

### 5.1 Hardware Setup



**Figure 8. Hardware Board Connection**

Before connecting the EVM, always remember to preset the power supply to correct voltages. Never "hot plug" or connect the power supply to the EVM with the power supply on. This can result in 2x input voltage overshoot that can damage the devices on the EVM.

Connect the EVM as shown in [Figure 8](#). Before turning on the power supply, set the SLP\_Sx# jumpers to LOW as they must be sequenced in the proper order for correct power up. The order for sequence is SLP\_SUS# → SLP\_S4# → SLP\_S3# → SLP\_S0#.

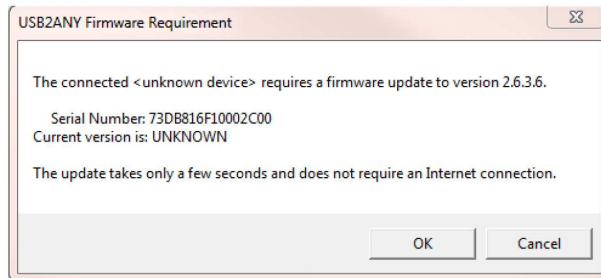
Once the power supply is on and providing a valid VIN voltage, the SLP\_Sx# signal can be set to HIGH in the listed sequence. After this, the EVM will have all power rails ON and regulating to their set voltage. ALL\_SYS\_PWRGD, TP71, should be HIGH signaling a valid power up of the system.

### 5.2 Software Setup

To install the GUI, first download the GUI from the Tools & Software folder at <http://www.ti.com/product/TPS650830/toolssoftware>. Once the zip file is open, simply double-click the Setup TPS65083xEVM.msi file. Follow the recommended prompts for installation.

Once installed, the GUI appears as seen in [Figure 10](#).

It is possible that first running the GUI and therefore the USB2GUI box, that the user will have to update the USB2ANY box's firmware. If this is the case, the user will receive a message similar to [Figure 9](#).

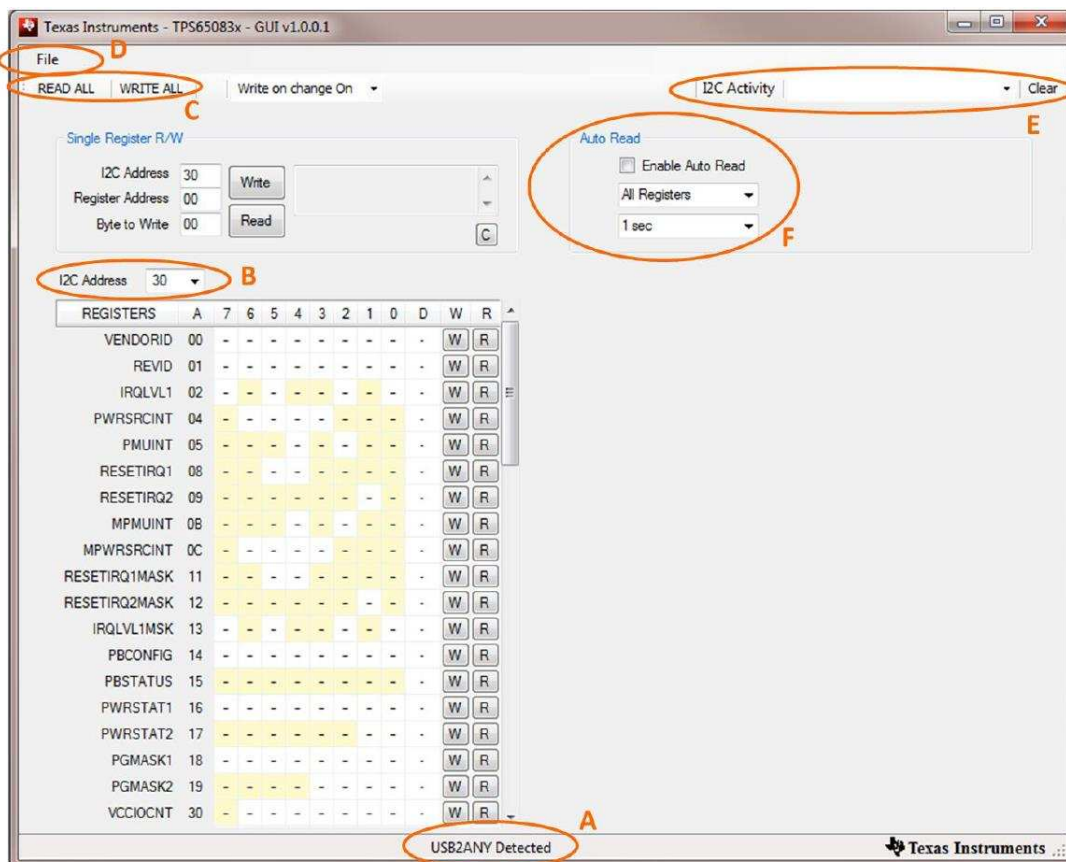


**Figure 9. Firmware Update Required Message**

### 5.3 Running the Software

Click on the TPS65083xEVM icon to start the software. If no icon appears on the host computer, then use the start button in the lower left corner of the screen to browse the program folders to find the software. The default directory for software installation is Program Files\Texas Instruments\TPS65083xEVM.

[Figure 10](#) is a diagram of the GUI and beneath the figure are descriptions of each feature that the GUI has to offer. The GUI has register and bit names. The register name is listed to the left of the data and I2C addresses. To see the bit names, hover the mouse over the data bit and the bit name will appear for as long as the mouse is positioned over the bit. See the TPS65083x data sheet for detailed description on these registers.



**Figure 10. Software Overview**

- (A) = USB2ANY Detection – If this message reads “USB2ANY Detected”, then the GUI and USB2ANY are operating correctly in that they are communicating to one another.
  - If this message reads “USB2ANY Not Detected” then the GUI and USB2ANY are not operating correctly and communication needs to be established. Try unplugging the USB cable, shutting down and restarting the GUI, followed by plugging in the USB cable.
- (B) = I2C Address Selection – Select the desired I2C address before attempting to communicate. The TPS65083x operates on 1 of 3 addresses: x30, x32, or x34, depending on the hardware configuration of SLAVEADDR pin.
- (C) = Read and Write All Commands – Use read and write all commands to read or write data on all the registers featured in the REGISTER List.
- (D) = File – User can select to save or load registers to or from a .txt file.
- (E) = I2C Activity – Logs all user activity over the I2C communication bus since opening the GUI or since last “Clear”. User can clear activity log by clicking on the “Clear” button.
- (F) = Auto Read – User can select to read all registers or just a single register every 1, 5, 10, or 20 seconds, as desired.

## 6 TPS65083xEVM Assembly Drawings and Layout

Figure 11 through Figure 18 show the design of the TPS65083xEVM printed-circuit board.

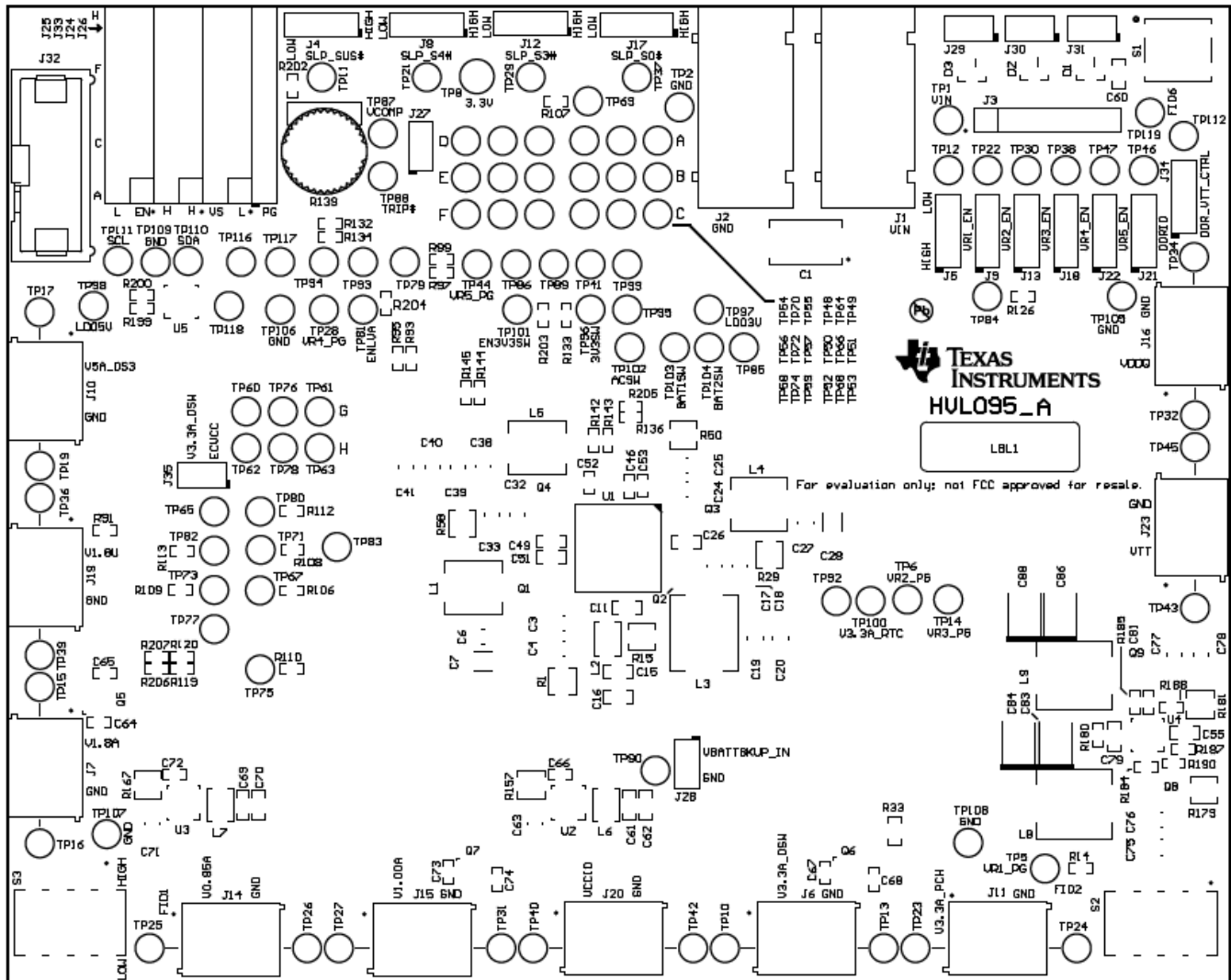


Figure 11. TPS65083xEVM Component Placement (Viewed From Top)

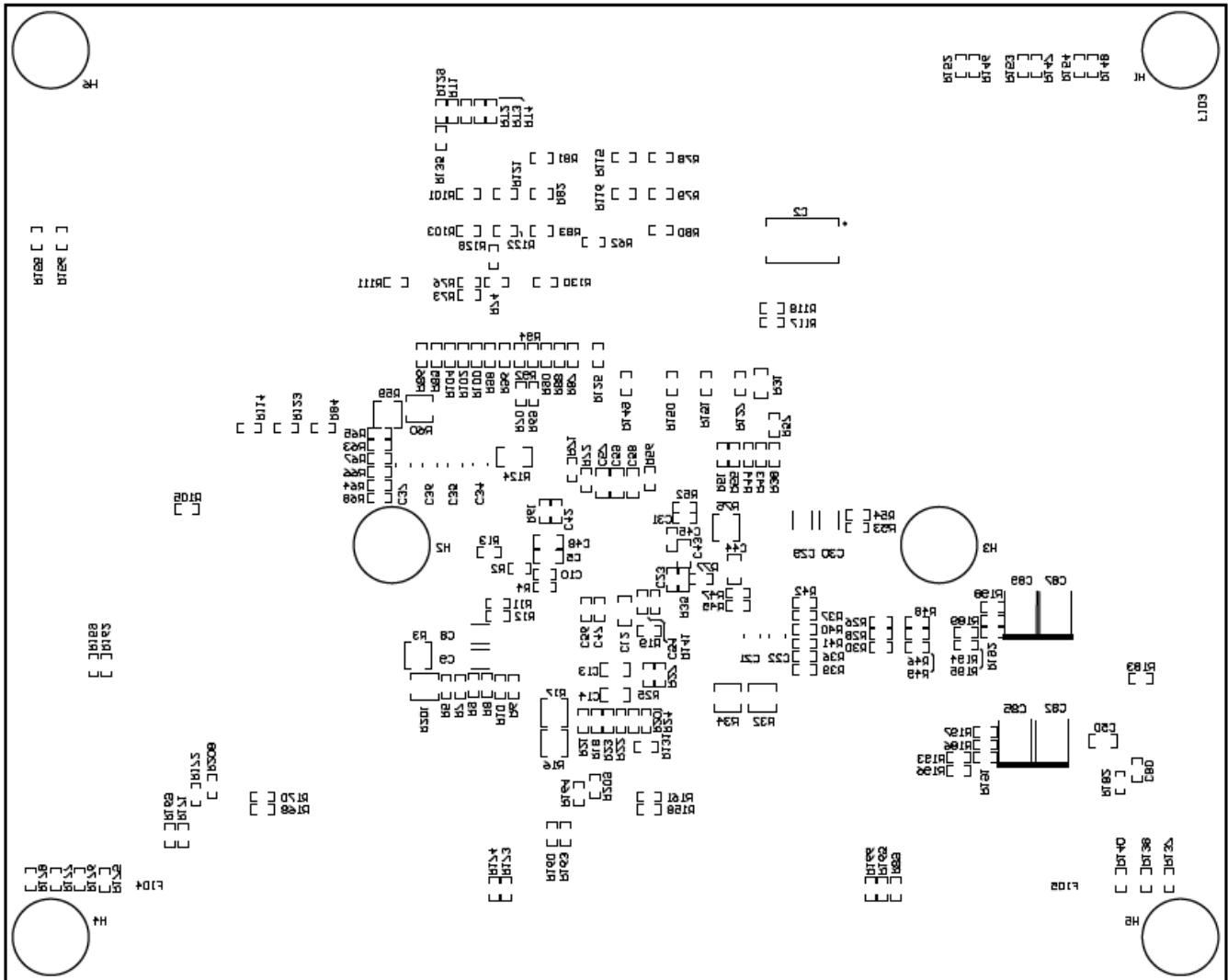
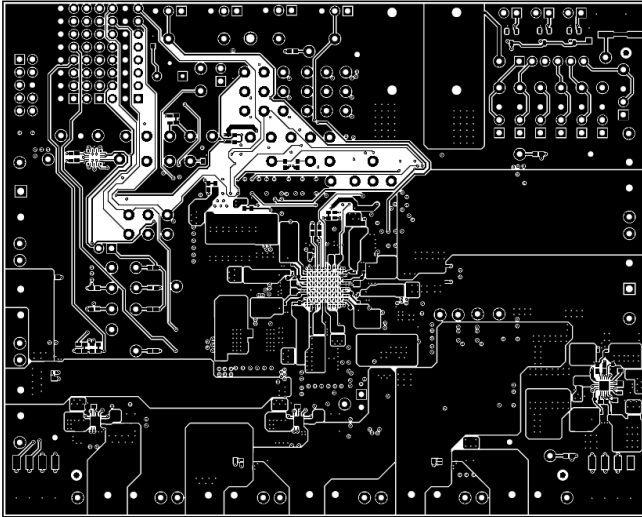
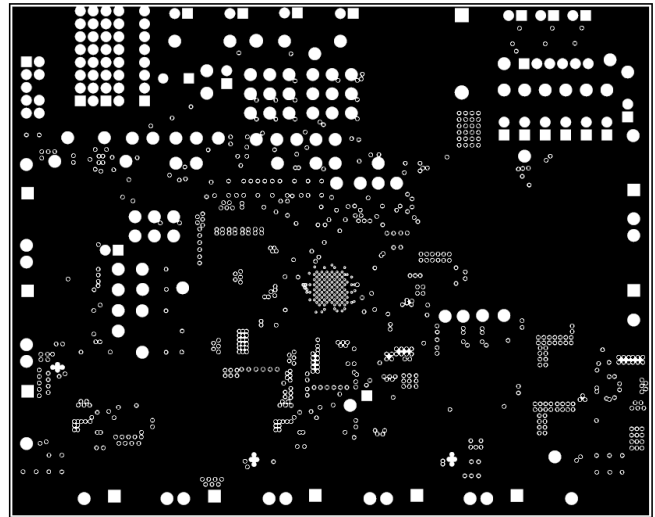


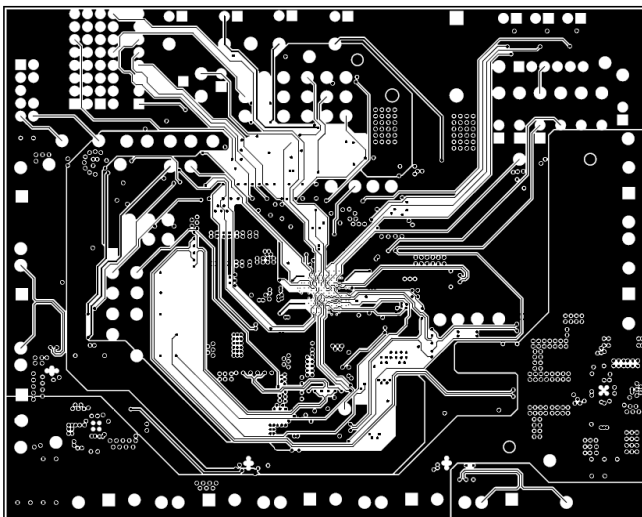
Figure 12. TPS65083xEVM Bottom Component Placement (X-Ray View)



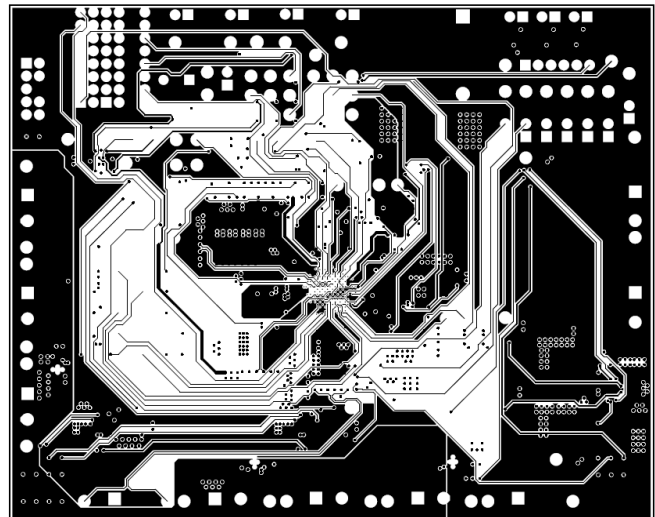
**Figure 13. TPS65083xEVM Top Copper  
(Viewed From Top)**



**Figure 14. TPS65083xEVM GND Layer  
(X-Ray View From Top)**



**Figure 15. TPS65083xEVM Signal 1  
(X-Ray View From Top)**



**Figure 16. TPS65083xEVM Multi 1  
(X-Ray View From Top)**



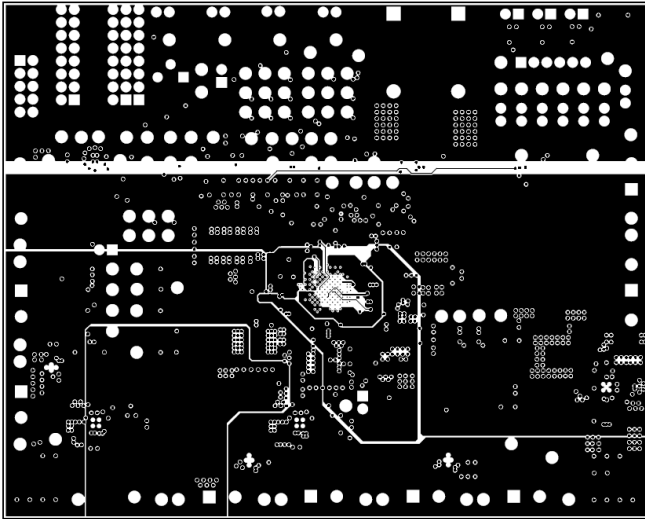


Figure 17. TPS65083xEVM Multi 2  
(X-Ray View From Top)

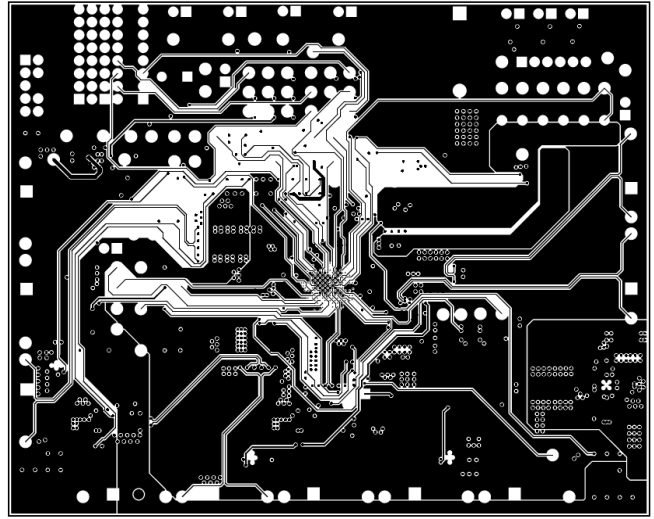


Figure 18. TPS65083xVM Signal 2  
(X-Ray View From Top)

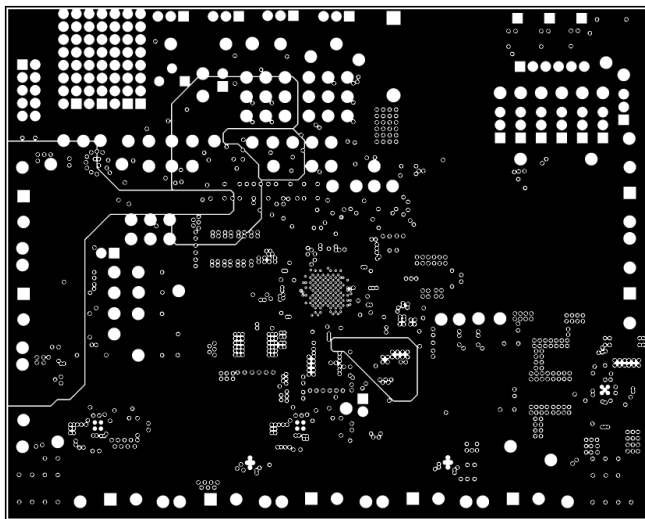


Figure 19. TPS65083xEVM Power Layer  
(X-Ray View From Top)

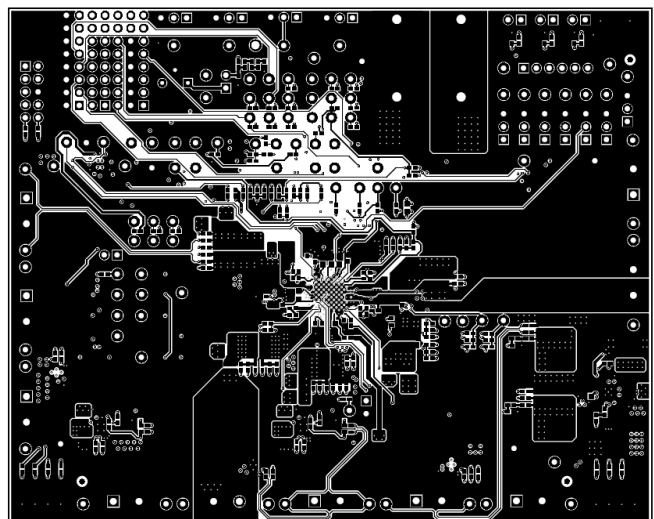


Figure 20. TPS65083xEVM Bottom Copper  
(X-Ray View)

## 7 Bill of Materials

Table 3 lists the BOM.

**Table 3. HPA515B Bill of Materials**

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1	1	47uF	CAP, TA, 47 µF, 35 V, +/- 10%, 0.3 ohm, SMD	7343-43	T495X476K035ATE300	Kemet
C3, C4, C17, C18, C24, C25, C32, C33	8	10uF	CAP, CERM, 10 µF, 25 V, +/- 10%, X5R, 0805_140	0805_140	GRM21BR61E106KA73L	MuRata
C5, C11, C12, C26	4	1uF	CAP, CERM, 1 µF, 10 V, +/- 10%, X5R, 0603	0603	GRM188R61A105KA61D	MuRata
C6, C19, C20, C21, C27, C34, C35, C36, C37, C38, C39, C40, C41	13	100uF	CAP, CERM, 100 µF, 6.3 V, +/- 20%, X5R, 0805_140	0805_140	GRM21BR60J107M	MuRata
C7	1	220uF	CAP, CERM, 220 µF, 4 V, +/- 20%, X5R, 1206_190	1206	GRM31CR60G227ME11	Murata
C8, C9, C28, C29	4	220uF	CAP, CERM, 220 µF, 4 V, +/- 20%, X5R, 1206_190	1206_190	GRM31CR60G227ME11L	MuRata
C10, C23, C31, C42	4	0.1uF	CAP, CERM, 0.1 µF, 10 V, +/- 10%, X5R, 0402	0402	C1005X5R1A104K	TDK
C13, C14, C15, C16, C43	5	47uF	CAP, CERM, 47 µF, 6.3 V, +/- 20%, X5R, 0603	0603	GRM188R60J476M	MuRata
C45	1	10uF	CAP, CERM, 10uF, 6.3V, +/-20%, X5R, 0402	0402	GRM155R60J106ME44	MuRata
C46	1	2.2uF	CAP, CERM, 2.2 µF, 6.3 V, +/- 20%, X5R, 0402	0402	GRM155R60J225ME15D	MuRata
C47	1	0.22uF	CAP, CERM, 0.22 µF, 6.3 V, +/- 20%, X5R, 0402	0402	C1005X5R0J224M	TDK
C48, C57, C58, C59, C60	5	1uF	CAP, CERM, 1 µF, 50 V, +/- 10%, X5R, 0603	0603	GRM188R61H105KAALD	MuRata
C49	1	10uF	CAP, CERM, 10 µF, 10 V, +/- 20%, X5R, 0603	0603	C1608X5R1A106M	TDK
C51	1	4.7uF	CAP, CERM, 4.7 µF, 10 V, +/- 10%, X5R, 0603	0603	CGB3B1X5R1A475K055AC	TDK
C52, C65, C68, C74	4	0.1uF	CAP, CERM, 0.1 µF, 6.3 V, +/- 10%, X5R, 0402	0402	C1005X5R0J104K	TDK
C53	1	0.47uF	CAP, CERM, 0.47 µF, 6.3 V, +/- 10%, X5R, 0402	0402	GRM155R60J474KE19D	MuRata
C54, C56, C64, C67, C73	5	1uF	CAP, CERM, 1 µF, 6.3 V, +/- 20%, X5R, 0402	0402	C1005X5R0J105M	TDK
D1, D2, D3	3	30V	Diode, Schottky, 30 V, 0.2 A, SOT-23	SOT-23	BAT54-7-F	Diodes Inc.
H1, H2, H3, H4, H5, H6	6		Bump, Cylindrical, 0.312 X 0.200, Black	Black Bump	SJ61A1	3M
J1	1	10A	Standard Banana Jack, insulated, 10A, red	571-0500	571-0500	DEM Manufacturing
J2	1	10A	Standard Banana Jack, insulated, 10A, black	571-0100	571-0100	DEM Manufacturing
J3	1		Header, 100mil, 6x1, Gold, TH	6x1 Header	TSW-106-07-G-S	Samtec
J4, J8, J12, J17, J21, J34	6		Header, 100mil, 3x1, Tin, TH	Header, 3x1, 100mil, TH	5-146278-3	TE Connectivity
J6, J7, J10, J11, J14, J15, J16, J19, J20, J23	10		Terminal Block, 2-pole, 200mil, TH	THD, 2-Leads, Body 10.16x7.6mm, Pitch 5.08mm	OSTTC022162	On-Shore Technology
J24, J25, J33	3		Header, 100mil, 8x2, Gold, TH	8x2 Header	TSW-108-07-G-D	Samtec
J26	1		Header, 100mil, 8x1, Tin, TH	Header, 8x1, 100mil, TH	5-146278-8	TE Connectivity
J27, J28, J29, J30, J31, J35	6		Header, 100mil, 2x1, Tin, TH	Header, 2x1, 100mil, TH	5-146278-2	TE Connectivity
J32	1		Header (shrouded), 100mil, 5x2, High-Temperature, Gold, TH	5x2 Shrouded header	N2510-6002-RB	3M
L1	1	1uH	Inductor, Drum Core, Powdered Iron, 1 µH, 8 A, 0.015 ohm, SMD	Inductor, 5.2x1.6x5.2mm	PIMB051H-1R0MS	Cyntec
L2	1	680nH	Inductor, Drum Core, Powdered Iron, 680 nH, 4.3 A, 0.027 ohm, SMD	Inductor, 3.2x1.2x2.5mm	PIFE32251B-R68MS-63	Cyntec
L3	1	1.5uH	Inductor, Drum Core, Powdered Iron, 1.5 µH, 6.5 A, 0.02 ohm, SMD	7.05 x 1.6 x 6.6mm	PIMB061H-1R5MS	Cyntec
L4	1	1uH	Inductor, Drum Core, Powdered Iron, 1 µH, 8.1 A, 0.014 ohm, SMD	Inductor, 5.2x1.6x5.2mm	PIME051H-1R0MS-63	Cyntec
L5	1	3.3uH	Inductor, Drum Core, Powdered Iron, 3.3 µH, 4.5 A, 0.052 ohm, SMD	Inductor, 5.2x1.6x5.2mm	PIMB051H-3R3MS	Cyntec
LBL1	1		Thermal Transfer Printable Labels, 0.650" W x 0.200" H - 10,000 per roll	PCB Label 0.650"H x 0.200"W	THT-14-423-10	Brady

**Table 3. HPA515B Bill of Materials (continued)**

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
Q1, Q2, Q3, Q4	4		Synchronous Buck NexFET Power Block II, MPC0005A	MPC0005A	CSD87381P	Texas Instruments
Q5, Q6	2		5.5-V, 6-A, 4.4-mΩ On-Resistance Load Switch, DNY0008A	DNY0008A	TPS22969DNY	Texas Instruments
Q7	1		3.5-V, 6-A, Ultra-low Resistance Load Switch, DNY0008A	DNY0008A	TPS22961DNYR	Texas Instruments
R1, R3, R15, R16, R29, R32, R50, R58, R59, R75, R201	11	0.002	RES, 0.002, 2%, 1 W, 0508	0508	KRL2012E-M-R002-G-T5	Susumu Co Ltd
R2, R4, R5, R6, R7, R8, R9, R10, R12, R18, R19, R20, R23, R26, R27, R35, R36, R37, R40, R41, R46, R51, R52, R53, R54, R55, R61, R62, R63, R64, R66, R67, R70, R73, R77, R86, R87, R89, R91, R92, R96, R97, R98, R101, R103, R104, R114, R115, R116, R119, R121, R122, R123, R125, R133, R134, R142, R143, R144, R159, R162, R165, R166, R173, R174, R199, R200, R202, R204, R206, R207	71	0	RES, 0, 5%, 0.063 W, 0402	0402	CRCW04020000Z0ED	Vishay-Dale
R13	1	9.53k	RES, 9.53 k, 1%, 0.063 W, 0402	0402	CRCW04029K53FKED	Vishay-Dale
R22	1	100	RES, 100, 5%, 0.063 W, 0402	0402	CRCW0402100RJNED	Vishay-Dale
R33	1	0	RES, 0, 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R44, R57, R105, R106, R107, R108, R109, R110, R111, R112, R113, R127, R128, R130, R131, R137, R138, R140, R149, R150, R151	21	100k	RES, 100 k, 5%, 0.063 W, 0402	0402	CRCW0402100KJNED	Vishay-Dale
R45	1	22.6k	RES, 22.6 k, 1%, 0.063 W, 0402	0402	CRCW040222K6FKED	Vishay-Dale
R47	1	8.66k	RES, 8.66 k, 1%, 0.063 W, 0402	0402	CRCW04028K66FKED	Vishay-Dale
R56	1	10.5k	RES, 10.5 k, 1%, 0.063 W, 0402	0402	CRCW040210K5FKED	Vishay-Dale
R71	1	10.2k	RES, 10.2 k, 1%, 0.063 W, 0402	0402	CRCW040210K2FKED	Vishay-Dale
R72	1	4.87k	RES, 4.87 k, 1%, 0.063 W, 0402	0402	CRCW04024K87FKED	Vishay-Dale
R124	1	0	RES, 0, 5%, 0.125 W, 0805	0805	CRCW08050000Z0EA	Vishay-Dale
R126	1	10k	RES, 10 k, 5%, 0.063 W, 0402	0402	CRCW040210K0JNED	Vishay-Dale
R132	1	51	RES, 51, 5%, 0.063 W, 0402	0402	CRCW040251R0JNED	Vishay-Dale
R136	1	1.00Meg	RES, 1.00 M, 1%, 0.063 W, 0402	0402	CRCW04021M00FKED	Vishay-Dale
R139	1	200k	Trimmer, 200 K, 0.5 W, TH	Thumbwheel Trimmer	3352P-1-204LF	Bourns
R141	1	1.0k	RES, 1.0 k, 5%, 0.063 W, 0402	0402	CRCW04021K00JNED	Vishay-Dale
R146	1	267k	RES, 267 k, 1%, 0.063 W, 0402	0402	CRCW0402267KFKED	Vishay-Dale
R147, R148	2	237k	RES, 237 k, 1%, 0.063 W, 0402	0402	CRCW0402237KFKED	Vishay-Dale
R152	1	31.6k	RES, 31.6 k, 1%, 0.063 W, 0402	0402	CRCW040231K6FKED	Vishay-Dale
R153, R154	2	61.9k	RES, 61.9 k, 1%, 0.063 W, 0402	0402	CRCW040261K9FKED	Vishay-Dale
R205	1	249k	RES, 249 k, 1%, 0.063 W, 0402	0402	CRCW0402249KFKED	Vishay-Dale
RT1, RT2, RT3, RT4	4	100k	Thermistor PTC, 1k ohm @ 25C, 100k ohm @ 80C,+/- 3C, 0402	0402	PRF15BG102RB6RC	Murata
S1	1		Switch, Tactile, SPST-NO, SMT	Switch, 6.2X5X6.2 mm	KST221JLFS	C&K Components
S2	1		Switch, SPST 4 Pos, Top Actuated, SMT	SMD, 8-Leads, Body 11.93x6.95mm, Pitch 2.54mm	219-4LPST	CTS Electrocomponents
SH-J1, SH-J2, SH-J3, SH-J4, SH-J5, SH-J6, SH-J7, SH-J8, SH-J9	9		Shunt, 100mil, Gold plated, Black	Shunt 2 pos. 100 mil	881545-2	TE Connectivity

**Table 3. HPA515B Bill of Materials (continued)**

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
TP1, TP10, TP15, TP17, TP23, TP25, TP27, TP32, TP36, TP40, TP43, TP84, TP97, TP98, TP99, TP100	16	Red	Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone
TP2, TP13, TP16, TP19, TP24, TP26, TP31, TP34, TP39, TP42, TP45, TP105, TP106, TP107, TP108	15	Black	Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone
TP5, TP6, TP14, TP28, TP44, TP65, TP67, TP69, TP71, TP73, TP75, TP77, TP79, TP80, TP82, TP86, TP88, TP89, TP90, TP92, TP93	21	Blue	Test Point, Miniature, Blue, TH	Blue Miniature Testpoint	5117	Keystone
TP11, TP21, TP29, TP37, TP46, TP81, TP85, TP94, TP101, TP118	10	Orange	Test Point, Miniature, Orange, TH	Orange Miniature Testpoint	5003	Keystone
TP83, TP111	2	Yellow	Test Point, Miniature, Yellow, TH	Yellow Miniature Testpoint	5004	Keystone
TP87, TP95, TP96, TP102, TP103, TP104, TP110, TP116, TP117, TP119	10	White	Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone
U1	1		Simple and Flexible High Input Voltage PMU for Mobile Computers, ZCG0159A	ZCG0159A	TPS650830ZCGR	Texas Instruments
U5	1		Quad Channel Load Switch with GPIO and I2C Control, RLW0020A	RLW0020A	TPS22993PRLW	Texas Instruments

## STANDARD TERMS AND CONDITIONS FOR EVALUATION MODULES

1. *Delivery:* TI delivers TI evaluation boards, kits, or modules, including any accompanying demonstration software, components, or documentation (collectively, an "EVM" or "EVMs") to the User ("User") in accordance with the terms and conditions set forth herein. Acceptance of the EVM is expressly subject to the following terms and conditions.
  - 1.1 EVMs are intended solely for product or software developers for use in a research and development setting to facilitate feasibility evaluation, experimentation, or scientific analysis of TI semiconductor products. EVMs have no direct function and are not finished products. EVMs shall not be directly or indirectly assembled as a part or subassembly in any finished product. For clarification, any software or software tools provided with the EVM ("Software") shall not be subject to the terms and conditions set forth herein but rather shall be subject to the applicable terms and conditions that accompany such Software
  - 1.2 EVMs are not intended for consumer or household use. EVMs may not be sold, sublicensed, leased, rented, loaned, assigned, or otherwise distributed for commercial purposes by Users, in whole or in part, or used in any finished product or production system.
2. *Limited Warranty and Related Remedies/Disclaimers:*
  - 2.1 These terms and conditions do not apply to Software. The warranty, if any, for Software is covered in the applicable Software License Agreement.
  - 2.2 TI warrants that the TI EVM will conform to TI's published specifications for ninety (90) days after the date TI delivers such EVM to User. Notwithstanding the foregoing, TI shall not be liable for any defects that are caused by neglect, misuse or mistreatment by an entity other than TI, including improper installation or testing, or for any EVMs that have been altered or modified in any way by an entity other than TI. Moreover, TI shall not be liable for any defects that result from User's design, specifications or instructions for such EVMs. Testing and other quality control techniques are used to the extent TI deems necessary or as mandated by government requirements. TI does not test all parameters of each EVM.
  - 2.3 If any EVM fails to conform to the warranty set forth above, TI's sole liability shall be at its option to repair or replace such EVM, or credit User's account for such EVM. TI's liability under this warranty shall be limited to EVMs that are returned during the warranty period to the address designated by TI and that are determined by TI not to conform to such warranty. If TI elects to repair or replace such EVM, TI shall have a reasonable time to repair such EVM or provide replacements. Repaired EVMs shall be warranted for the remainder of the original warranty period. Replaced EVMs shall be warranted for a new full ninety (90) day warranty period.
3. *Regulatory Notices:*
  - 3.1 *United States*
    - 3.1.1 *Notice applicable to EVMs not FCC-Approved:*

This kit is designed to allow product developers to evaluate electronic components, circuitry, or software associated with the kit to determine whether to incorporate such items in a finished product and software developers to write software applications for use with the end product. This kit is not a finished product and when assembled may not be resold or otherwise marketed unless all required FCC equipment authorizations are first obtained. Operation is subject to the condition that this product not cause harmful interference to licensed radio stations and that this product accept harmful interference. Unless the assembled kit is designed to operate under part 15, part 18 or part 95 of this chapter, the operator of the kit must operate under the authority of an FCC license holder or must secure an experimental authorization under part 5 of this chapter.
    - 3.1.2 *For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant:*

### CAUTION

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

### FCC Interference Statement for Class A EVM devices

*NOTE: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.*

## FCC Interference Statement for Class B EVM devices

*NOTE: This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:*

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

### 3.2 Canada

3.2.1 For EVMs issued with an Industry Canada Certificate of Conformance to RSS-210

#### Concerning EVMs Including Radio Transmitters:

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

#### Concernant les EVMs avec appareils radio:

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes: (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

#### Concerning EVMs Including Detachable Antennas:

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication. This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

#### Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante. Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur

### 3.3 Japan

3.3.1 *Notice for EVMs delivered in Japan:* Please see [http://www.tij.co.jp/lstds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page) 日本国内に輸入される評価用キット、ボードについては、次のところをご覧ください。  
[http://www.tij.co.jp/lstds/ti\\_ja/general/eStore/notice\\_01.page](http://www.tij.co.jp/lstds/ti_ja/general/eStore/notice_01.page)

3.3.2 *Notice for Users of EVMs Considered "Radio Frequency Products" in Japan:* EVMs entering Japan are NOT certified by TI as conforming to Technical Regulations of Radio Law of Japan.

If User uses EVMs in Japan, User is required by Radio Law of Japan to follow the instructions below with respect to EVMs:

1. Use EVMs in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use EVMs only after User obtains the license of Test Radio Station as provided in Radio Law of Japan with respect to EVMs, or
3. Use of EVMs only after User obtains the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to EVMs. Also, do not transfer EVMs, unless User gives the same notice above to the transferee. Please note that if User does not follow the instructions above, User will be subject to penalties of Radio Law of Japan.

**【無線電波を送信する製品の開発キットをお使いになる際の注意事項】**

本開発キットは技術基準適合証明を受けておりません。

本製品のご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。

日本テキサス・インスツルメンツ株式会社

東京都新宿区西新宿 6 丁目 2 4 番 1 号

西新宿三井ビル

3.3.3 *Notice for EVMs for Power Line Communication:* Please see [http://www.tij.co.jp/llds/ti\\_ja/general/eStore/notice\\_02.page](http://www.tij.co.jp/llds/ti_ja/general/eStore/notice_02.page)

電力線搬送波通信についての開発キットをお使いになる際の注意事項については、次のところをご覧ください。[http://www.tij.co.jp/llds/ti\\_ja/general/eStore/notice\\_02.page](http://www.tij.co.jp/llds/ti_ja/general/eStore/notice_02.page)

4 *EVM Use Restrictions and Warnings:*

4.1 EVMS ARE NOT FOR USE IN FUNCTIONAL SAFETY AND/OR SAFETY CRITICAL EVALUATIONS, INCLUDING BUT NOT LIMITED TO EVALUATIONS OF LIFE SUPPORT APPLICATIONS.

4.2 User must read and apply the user guide and other available documentation provided by TI regarding the EVM prior to handling or using the EVM, including without limitation any warning or restriction notices. The notices contain important safety information related to, for example, temperatures and voltages.

4.3 *Safety-Related Warnings and Restrictions:*

4.3.1 User shall operate the EVM within TI's recommended specifications and environmental considerations stated in the user guide, other available documentation provided by TI, and any other applicable requirements and employ reasonable and customary safeguards. Exceeding the specified performance ratings and specifications (including but not limited to input and output voltage, current, power, and environmental ranges) for the EVM may cause personal injury or death, or property damage. If there are questions concerning performance ratings and specifications, User should contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may also result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM user guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, even with the inputs and outputs kept within the specified allowable ranges, some circuit components may have elevated case temperatures. These components include but are not limited to linear regulators, switching transistors, pass transistors, current sense resistors, and heat sinks, which can be identified using the information in the associated documentation. When working with the EVM, please be aware that the EVM may become very warm.

4.3.2 EVMs are intended solely for use by technically qualified, professional electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems, and subsystems. User assumes all responsibility and liability for proper and safe handling and use of the EVM by User or its employees, affiliates, contractors or designees. User assumes all responsibility and liability to ensure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard. User assumes all responsibility and liability for any improper or unsafe handling or use of the EVM by User or its employees, affiliates, contractors or designees.

4.4 User assumes all responsibility and liability to determine whether the EVM is subject to any applicable international, federal, state, or local laws and regulations related to User's handling and use of the EVM and, if applicable, User assumes all responsibility and liability for compliance in all respects with such laws and regulations. User assumes all responsibility and liability for proper disposal and recycling of the EVM consistent with all applicable international, federal, state, and local requirements.

5. *Accuracy of Information:* To the extent TI provides information on the availability and function of EVMs, TI attempts to be as accurate as possible. However, TI does not warrant the accuracy of EVM descriptions, EVM availability or other information on its websites as accurate, complete, reliable, current, or error-free.

6. *Disclaimers:*
- 6.1 EXCEPT AS SET FORTH ABOVE, EVMS AND ANY WRITTEN DESIGN MATERIALS PROVIDED WITH THE EVM (AND THE DESIGN OF THE EVM ITSELF) ARE PROVIDED "AS IS" AND "WITH ALL FAULTS." TI DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, REGARDING SUCH ITEMS, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR NON-INFRINGEMENT OF ANY THIRD PARTY PATENTS, COPYRIGHTS, TRADE SECRETS OR OTHER INTELLECTUAL PROPERTY RIGHTS.
- 6.2 EXCEPT FOR THE LIMITED RIGHT TO USE THE EVM SET FORTH HEREIN, NOTHING IN THESE TERMS AND CONDITIONS SHALL BE CONSTRUED AS GRANTING OR CONFERRING ANY RIGHTS BY LICENSE, PATENT, OR ANY OTHER INDUSTRIAL OR INTELLECTUAL PROPERTY RIGHT OF TI, ITS SUPPLIERS/LICENSORS OR ANY OTHER THIRD PARTY, TO USE THE EVM IN ANY FINISHED END-USER OR READY-TO-USE FINAL PRODUCT, OR FOR ANY INVENTION, DISCOVERY OR IMPROVEMENT MADE, CONCEIVED OR ACQUIRED PRIOR TO OR AFTER DELIVERY OF THE EVM.
7. *USER'S INDEMNITY OBLIGATIONS AND REPRESENTATIONS.* USER WILL DEFEND, INDEMNIFY AND HOLD TI, ITS LICENSORS AND THEIR REPRESENTATIVES HARMLESS FROM AND AGAINST ANY AND ALL CLAIMS, DAMAGES, LOSSES, EXPENSES, COSTS AND LIABILITIES (COLLECTIVELY, "CLAIMS") ARISING OUT OF OR IN CONNECTION WITH ANY HANDLING OR USE OF THE EVM THAT IS NOT IN ACCORDANCE WITH THESE TERMS AND CONDITIONS. THIS OBLIGATION SHALL APPLY WHETHER CLAIMS ARISE UNDER STATUTE, REGULATION, OR THE LAW OF TORT, CONTRACT OR ANY OTHER LEGAL THEORY, AND EVEN IF THE EVM FAILS TO PERFORM AS DESCRIBED OR EXPECTED.
8. *Limitations on Damages and Liability:*
- 8.1 *General Limitations.* IN NO EVENT SHALL TI BE LIABLE FOR ANY SPECIAL, COLLATERAL, INDIRECT, PUNITIVE, INCIDENTAL, CONSEQUENTIAL, OR EXEMPLARY DAMAGES IN CONNECTION WITH OR ARISING OUT OF THESE TERMS AND CONDITIONS OR THE USE OF THE EVMS PROVIDED HEREUNDER, REGARDLESS OF WHETHER TI HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES. EXCLUDED DAMAGES INCLUDE, BUT ARE NOT LIMITED TO, COST OF REMOVAL OR REINSTALLATION, ANCILLARY COSTS TO THE PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES, RETESTING, OUTSIDE COMPUTER TIME, LABOR COSTS, LOSS OF GOODWILL, LOSS OF PROFITS, LOSS OF SAVINGS, LOSS OF USE, LOSS OF DATA, OR BUSINESS INTERRUPTION. NO CLAIM, SUIT OR ACTION SHALL BE BROUGHT AGAINST TI MORE THAN ONE YEAR AFTER THE RELATED CAUSE OF ACTION HAS OCCURRED.
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