

Using the TPS650001/3/6 2.25 MHz Step-Down Converter with Dual LDO

The TPS650001/3/6 is a single chip Power Management ICs for portable applications. The device combines a single step-down converter with two low dropout regulators. The step-down converter enters a low power mode at light load for maximum efficiency across the widest possible range of load currents. For low noise applications the device can be forced into fixed frequency PWM mode. The step-down converter allows the use of a small inductor and capacitors to achieve a small solution size. The step-down converter has Power Good status output that can be used for sequencing. The LDOs are capable of supplying 300mA and can operate with an input voltage range between 1.6V and 6.0V, allowing them to be supplied from the step-down converter or directly from the main battery. The step-down converter and the LDOs have separate voltage inputs and enables, allowing for design and sequencing flexibility.

Contents

1	Introduction	2
1.1	Applications	2
1.2	Features	2
2	TPS650001/3/6 EVM Electrical Performance Specifications	3
3	Schematic	4
4	Connector and Test Point Description	5
4.1	JP1 – ENDCDC	5
4.2	JP2 – ENLDO1	5
4.3	JP3 – ENLDO2	5
4.4	JP4 – MODE	5
4.5	JP5 – VINLDO1	5
4.6	JP6 – VINLDO2	5
4.7	J1 – VIN/GND	5
4.8	J2 – VODCDC/GND	5
4.9	J3 – VLDO1/GND	6
4.10	J4 – VLDO2/GND	6
4.11	J5 – $\overline{PG}$	6
5	4 TPS650001/3/6 Typical Performance Data and Characteristic Curves	6
5.1	Efficiency	6
5.2	Line and Load Regulation	6
5.3	Output Voltage Ripple	9
5.4	Startup Timing	10
6	EVM Assembly Drawings and Layout	11
7	List of Materials	14

List of Figures

1	TPS650001/3/6 EVM Schematic.....	4
2	TPS650001/3/6 Efficiency vs Load Current	6
3	TPS650001/3/6 DCDC Converter Load Transient Response.....	7
4	TPS650001/3/6 LDOx Transient Response	7
5	TPS650001/3/6 DCDC Converter Line Transient Response.....	8
6	TPS650001/3/6 LDOx Line Transient Response	8

7	TPS650001/3/6 Output Voltage Ripple (MODE = low)	9
8	TPS650001/3/6 Output Voltage Ripple (MODE = high)	9
9	TPS650001/3/6 DCDC Converter Startup Timing.....	10
10	TPS650001/3/6 EVM Component Placement (Viewed from Top)	11
11	TPS650001/3/6 EVM Top Copper (Viewed from Top)	12
12	TPS650001/3/6 EVM Bottom Copper (Viewed from Bottom).....	13

List of Tables

1	TPS650001/3/6 Output Voltage Specifications	2
2	TPS650001/3/6EVM Electrical and Performance Specifications	3
3	TPS650001/3/6EVM Bill of Materials	14

1 Introduction

1.1 Applications

- Point of Load
- Embedded Processor Power
- Cell Phones, Smart-phones
- PDAs, Pocket PCs
- Portable Media Players

1.2 Features

- Input Voltage Rating : 2.3-V up to 6.0-V
- Output Voltages of DCDC converter and LDOs internally fixed (see [Table 1](#))
- Output Current Rating 600-mA (DCDC converter) / 300-mA (LDOs)
- Spread Spectrum Clock (SSC) for best EMI performance
- 2.25-MHz Switching Frequency
- 16 pin 3mm × 3mm QFN package

Table 1. TPS650001/3/6 Output Voltage Specifications

	VOUTDCDC	VLDO1	VLDO2
TPS650001	1.2 V	1.8 V	2.8 V
TPS650003	1.5 V	3.3 V	1.8 V
TPS650006	1.2 V	1.8 V	3.3 V

2 TPS650001/3/6 EVM Electrical Performance Specifications

Table 2. TPS650001/3/6EVM Electrical and Performance Specifications

PARAMETER		NOTES AND CONDITIONS		MIN	NOM	MAX	UNITS	
INPUT CHARACTERISTICS								
V _{IN}	Input Voltage			2.3		6.0	V	
V _{IN_UVLO}	Input UVLO	VIN falling		1.72	1.77	1.82	V	
Hysteresis				160			mV	
OUTPUT CHARACTERISTICS								
V _{ODCDC}	Output Voltage DCDC	V _{IN} = Nom, I _{OUT} = Nom, TPS650001, TPS650006		1.2			V	
		V _{IN} = Nom, I _{OUT} = Nom, TPS650003		1.5				
	Accuracy DCDC1	VINDCDC 2.3V to 6V, With 1% tolerance resistors	PFM/PWM	–3.5%		3.5%		
			PWM	3%				
I _{OUTDC}	Output Current DCDC	V _{INDCDC} = 2.3 V to 2.5 V				300	mA	
		V _{INDCDC} = 2.5 V to 6 V				600		
VLDO1	Output Voltage LDO1	V _{IN} = Nom, I _{OUT} = Nom, TPS650001, TPS650006				1.8	V	
		V _{IN} = Nom, I _{OUT} = Nom, TPS650003				3.3		
I _{OUTLDO1}	Output Current LDO1	Continuous output current				300	mA	
VLDO2	Output Voltage LDO2	TPS650001				2.8	V	
		TPS650003				1.8		
		TPS650006				3.3		
I _{OUTLDO2}	Output Current LDO2	Continuous output current				300	mA	
	Accuracy LDOs	VINLDO = 1.6 V to 6 V, Iout = 1 mA to 175 mA, VLDOx = 1.2 V, With 1% tolerance resistors				–5.5%	5.5%	
		VINLDO = 1.5 V to 6 V, Iout = 1 mA to 300 mA, VLDOx = 1.2 V, With 1% tolerance resistors				–5.5%	5.5%	
SYSTEMS CHARACTERISTICS								
F _{SW}	Switching Frequency			1722	2250	2847	kHz	

4 Connector and Test Point Description

4.1 JP1 – ENDCDC

Placing a shorting bar between ENDCDC and ON ties the EN pin of the DCDC converter to VIN, thereby enabling the DCDC converter. Placing a shorting bar between ENDCDC and OFF ties the EN pin of the DCDC converter to GND, thereby disabling the DCDC converter.

4.2 JP2 – ENLDO1

Placing a shorting bar between ENLDO1 and ON ties the EN pin of LDO1 to VIN, thereby enabling LDO1. Placing a shorting bar between ENLDO1 and OFF ties the EN pin of LDO1 to GND, thereby disabling LDO1.

4.3 JP3 – ENLDO2

Placing a shorting bar between ENLDO2 and ON ties the EN pin of LDO2 to VIN, thereby enabling LDO2. Placing a shorting bar between ENLDO2 and OFF ties the EN pin of LDO2 to GND, thereby disabling LDO2.

4.4 JP4 – MODE

JP4 selects the forced PWM or Power Save Mode (PSM) operation for the DCDC converter. Placing a shorting bar between MODE and PWM ties the MODE pin of TPS650001/3/6 to VIN, thereby selecting forced PWM operating mode for the DCDC converter. Placing a shorting bar between MODE and PFM ties the MODE pin of TPS650001/3/6 to GND, thereby selecting Power Save Mode operating mode for the DCDC converter at light-load conditions. If Power Save Mode is selected the DCDC converter will automatically switch to PWM mode at heavier load conditions.

4.5 JP5 – VINLDO1

This header is the input supply for LDO1. Placing a shorting bar between VINLDO1 and VINDC/VODCDC supplies LDO1 from VIN with R2. It can be also supplied from the output of the converter VODCDC with R1 (not assembled). An external power supply can be connected between JP5 pin 2 (VINLDO1) and pin 3 (GND). Please note that the resistors R1 and R2 should be removed when supplying the LDO from an external power supply.

4.6 JP6 – VINLDO2

This header is the input supply for LDO2. Placing a shorting bar between VINLDO2 and VINDC/VODCDC supplies LDO2 from VIN with R4. It can be also supplied from the output of the converter VODCDC with R3 (not assembled). An external power supply can be connected between JP6 pin 2 (VINLDO2) and pin 3 (GND). Note that the resistors R3 and R4 should be removed when supplying the LDO from an external power supply.

4.7 J1 – VIN/GND

The input power supply has to be connected to this header. The power supply must be connected between J1 pins 1 and 2 (positive connection) and J1 pins 3 and 4 (GND). The leads to the input supply should be twisted and kept as short as possible. The input voltage has to be between 3.3-V and 6-V.

4.8 J2 – VODCDC/GND

This header is the output of the step-down converter. This output voltage is internally fixed for the TPS650001/3/6 (see [Table 1](#)). VODCDC is capable of sourcing up to 600-mA. A load can be connected between J2 pins 1 and 2 (positive connection) and J2 pins 3 and 4 (GND).

4.9 J3 – VLDO1/GND

This header is the output of LDO1. This output voltage is internally fixed for the TPS650001/3/6 (see [Table 1](#)). VLDO2 is capable of sourcing up to 300-mA. A load can be connected between J3 pins 1 and 2 (positive connection) and J3 pins 3 and 4 (GND).

4.10 J4 – VLDO2/GND

This header is the output of LDO2. This output voltage is internally fixed for the TPS650001/3/6 (see [Table 1](#)). The default setting on the EVM is 2.8-V. VLDO2 is capable of sourcing up to 300-mA. A load can be connected between J4 pins 1 & 2 (positive connection) and J4 pins 3 & 4 (GND).

4.11 J5 – $\overline{PG}$

JP5 is pulled to GND if the output voltages of the DCDC converter and both LDOs are > 90% of their set point and all enable pins are pulled high.

JP5 pulled up to the selected pull-up voltage level if any of the output voltages VODCDC, VLDO1 or VLDO2 is <90% of its set point or all enable pins are pulled low

5 4 TPS650001/3/6 Typical Performance Data and Characteristic Curves

[Figure 2](#) through [Figure 9](#) present typical performance curves for the TPS650001/3/6. Since actual performance data can be affected by measurement techniques and environmental variables, these curves are presented for reference and may differ from actual field measurements.

5.1 Efficiency

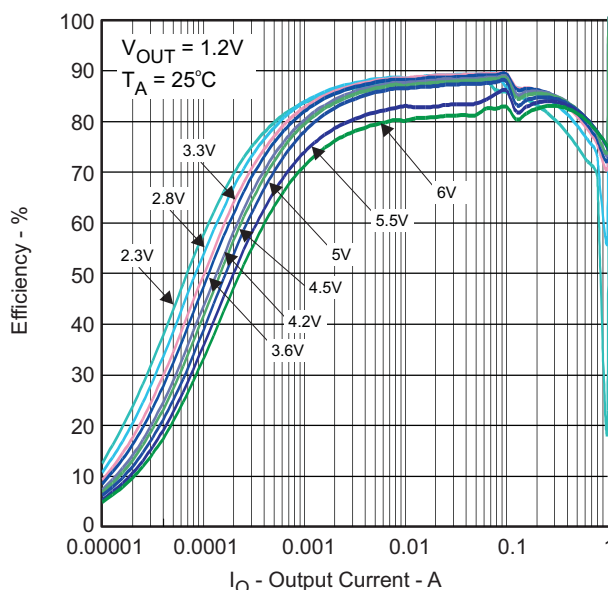


Figure 2. TPS650001/3/6 Efficiency vs Load Current

5.2 Line and Load Regulation

[Figure 3](#) and [Figure 4](#) show the load transient response of the DCDC converter and LDO, while [Figure 5](#) and [Figure 6](#) show the line transient response.

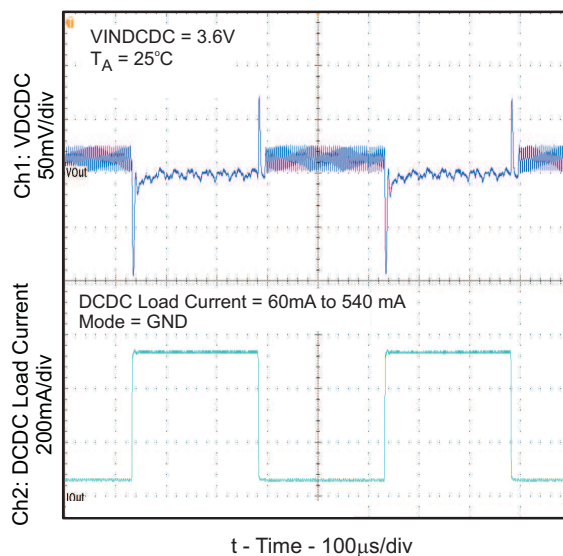


Figure 3. TPS650001/3/6 DCDC Converter Load Transient Response

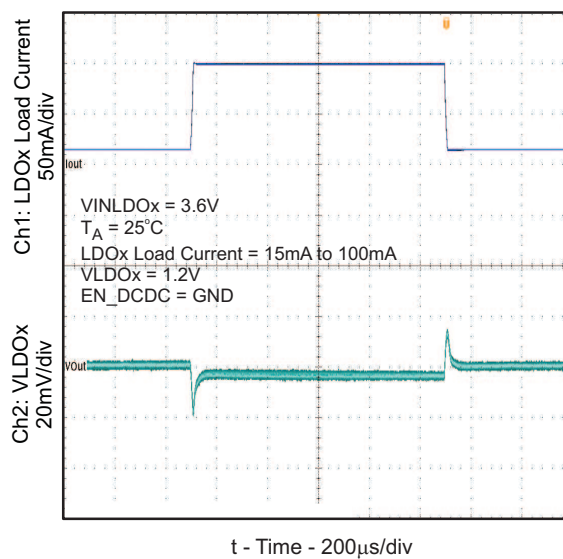


Figure 4. TPS650001/3/6 LDOx Transient Response

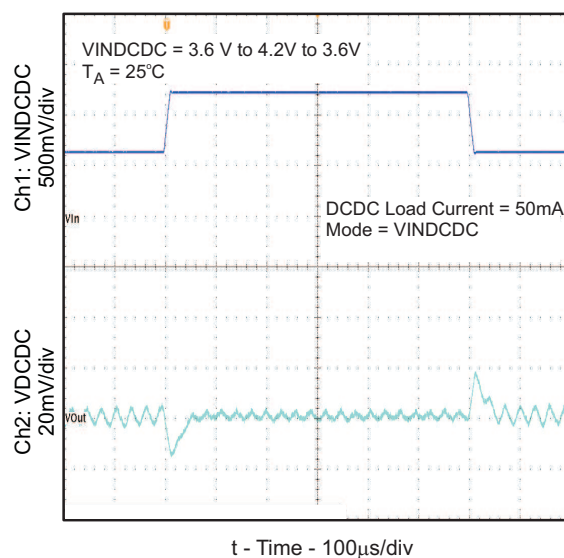


Figure 5. TPS650001/3/6 DCDC Converter Line Transient Response

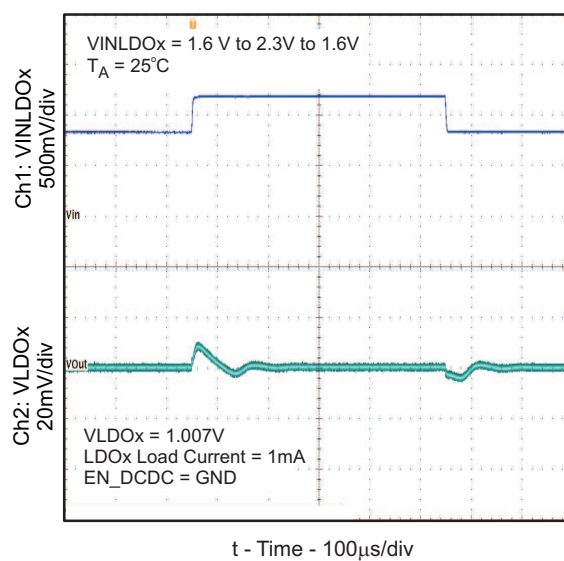


Figure 6. TPS650001/3/6 LDOx Line Transient Response

5.3 Output Voltage Ripple

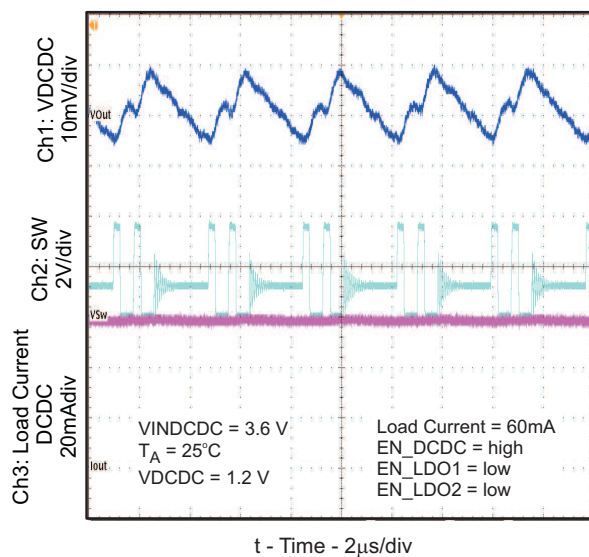


Figure 7. TPS650001/3/6 Output Voltage Ripple (MODE = low)

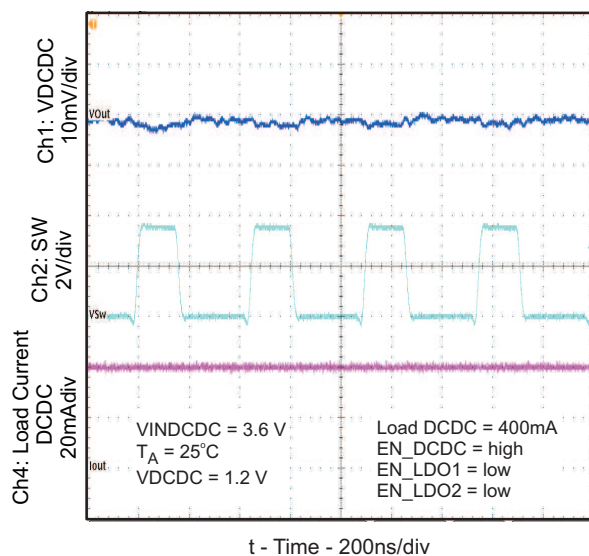


Figure 8. TPS650001/3/6 Output Voltage Ripple (MODE = high)

5.4 Startup Timing

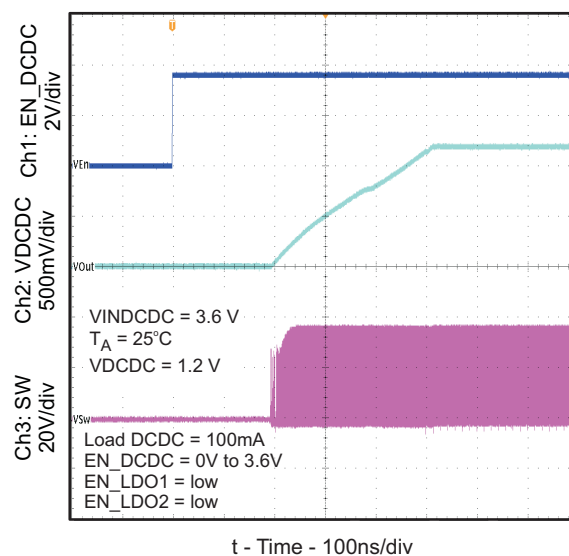


Figure 9. TPS650001/3/6 DCDC Converter Startup Timing

6 EVM Assembly Drawings and Layout

The following figures (Figure 10 through Figure 12) show the design of the TPS650001/3/6EVM printed circuit board. The EVM has been designed using a 2-Layer, 1oz copper-clad circuit board 2.0" x 2.4" (50.8mm x 61.09mm).

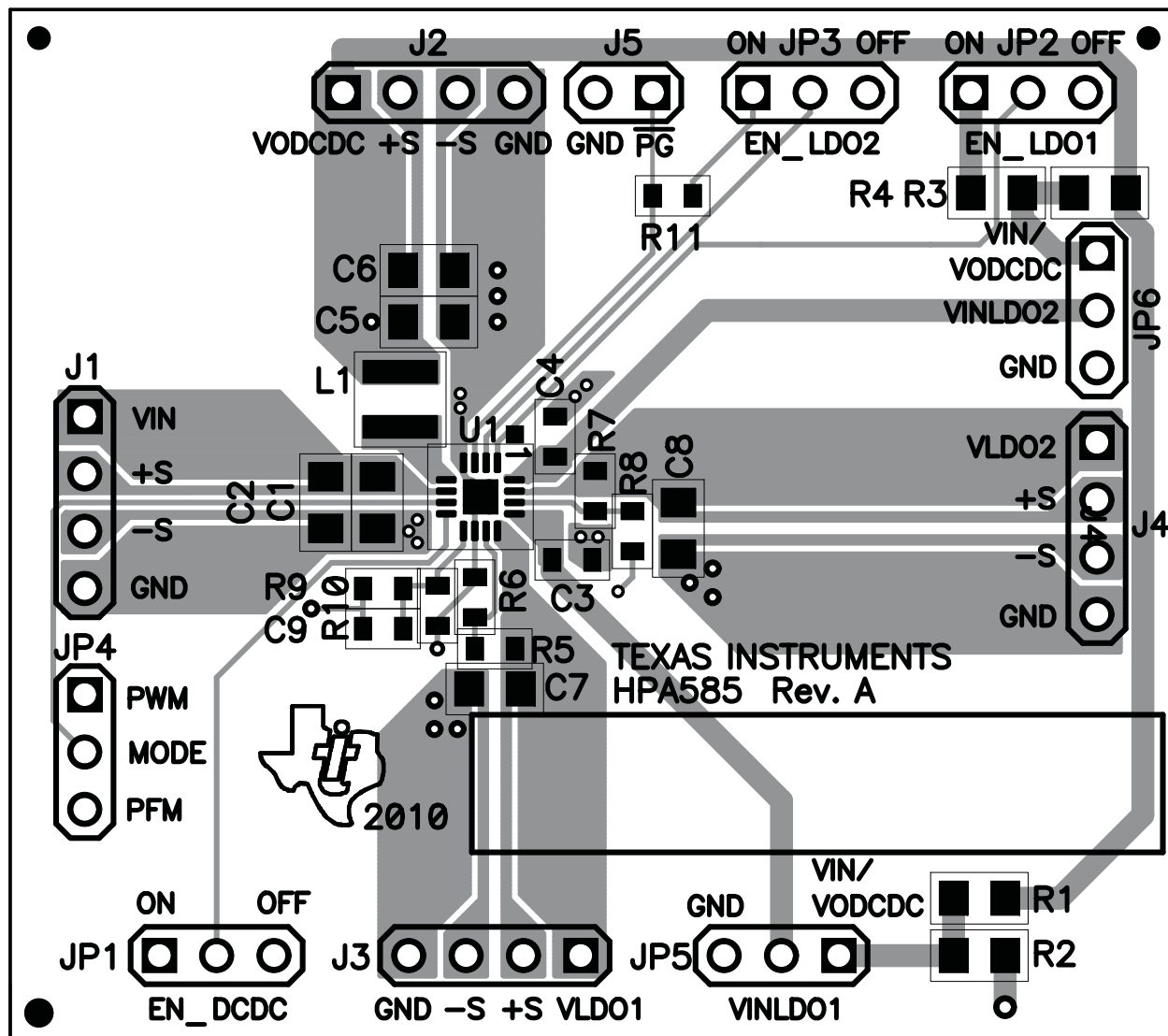


Figure 10. TPS650001/3/6 EVM Component Placement (Viewed from Top)

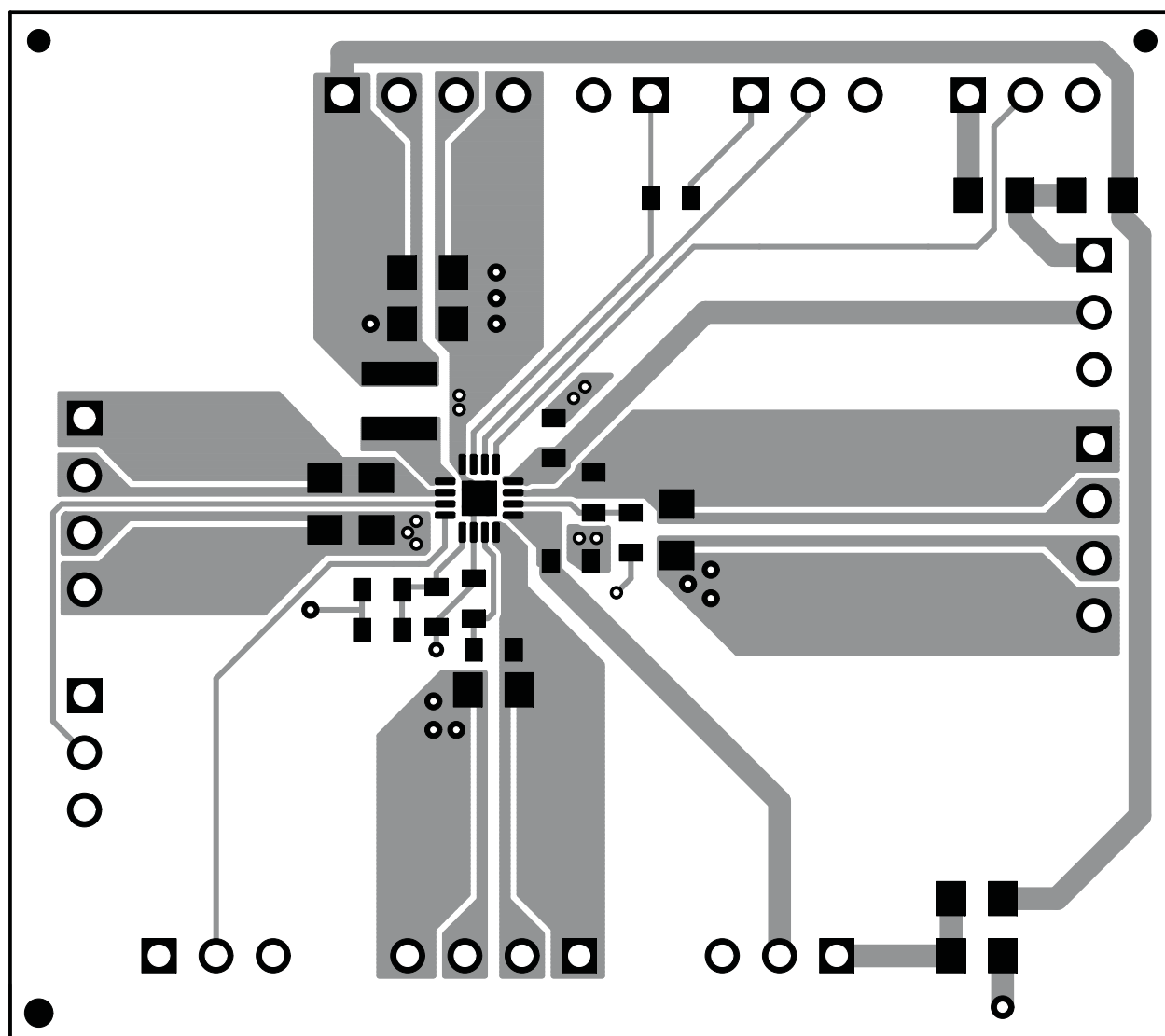


Figure 11. TPS650001/3/6 EVM Top Copper (Viewed from Top)

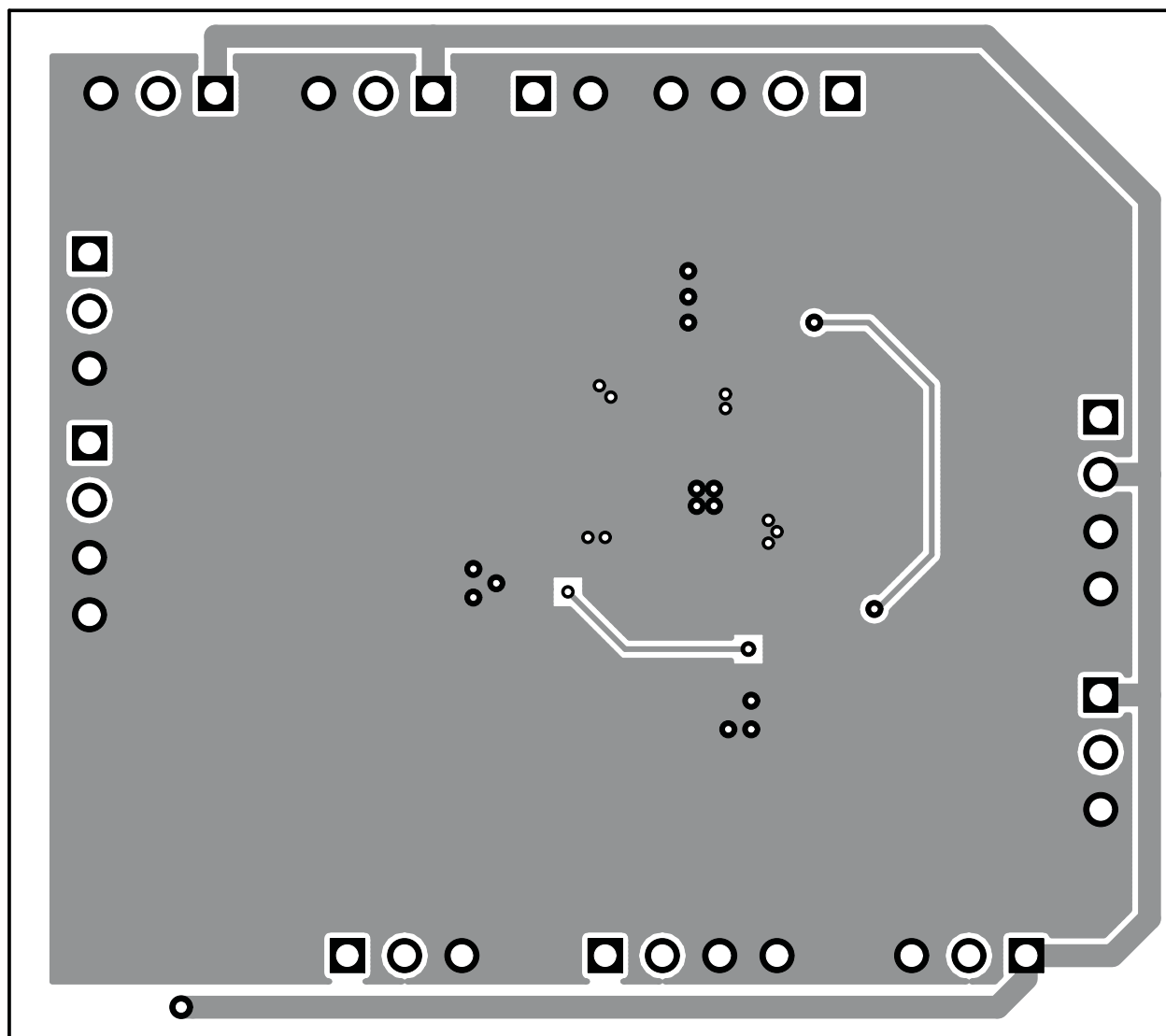


Figure 12. TPS650001/3/6 EVM Bottom Copper (Viewed from Bottom)

7 List of Materials

Table 3 lists the EVM components as configured according to the schematic shown in Figure 1.

Table 3. TPS650001/3/6EVM Bill of Materials

Count	RefDes	Value	Description	Size	Part Number	MFR
0	C1, C6	open	Capacitor, Ceramic, 10V, X5R, 10%, I	0805	Std	Std
4	C2, C5, C7, C8	10µF	Capacitor, Ceramic, 10V, X5R, 10%, e	0805	Std	Std
2	C3, C4	2.2µF	Capacitor, Ceramic, 16V, X5R, 10%,	0603	Std	Std
0	C9	open	Capacitor, Ceramic, 50V, C0G, 5%	0603	Std	Std
4	J1, J2, J3, J4	PEC04SAAN	Header, Male 4-pin, 100mil spacing	0.100 inch x 4	PEC04SAAN	Sullins
1	J5	PEC02SAAN	Header, Male 2-pin, 100mil spacing	0.100 inch x 2	PEC02SAAN	Sullins
6	JP1 - JP6	PEC03SAAN	Header, Male 3-pin, 100mil spacing	0.100 inch x 3	PEC03SAAN	Sullins
1	L1	2.2µH	Inductor, SMT, 2.0A, 110milliohm	0.118 x 0.118 inch	LPS3015-222ML	Coilcraft
0	R1, R3	open	Resistor, Chip, 1/10W, 1%	0805	Std	Std
2	R2, R4	0	Resistor, Chip, 1/10W, 1%	0805	Std	Std
3	R5, R7, R9	0	Resistor, Chip, 1/16W, 1%	0603	Std	Std
0	R6, R8, R10	open	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	R11	17.5k	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	U1 (HPA585-001)	TPS650001RTE	IC, 2.25 MHz Step Down Converter with Dual LDOs and SVS	QFN	TPS650001RTE	TI
0	U1 (HPA585-002)	TPS650003RTE	IC, 2.25 MHz Step Down Converter with Dual LDOs and SVS	QFN	TPS650003RTE	TI
0	U1 (HPA585-003)	TPS650006RTE	IC, 2.25 MHz Step Down Converter with Dual LDOs and SVS	QFN	TPS650006RTE	TI
1	--		PCB, 1.8 In x 2.04 In x 0.062 In		HPA585	Any
6	--		Shunt, 100 mil, Black	0.100	929950-00	3M
1	--		Label	1.25 x 0.25 inch	THT-13-457-10	Brady
Notes: 1. These assemblies are ESD sensitive, ESD precautions shall be observed. 2. These assemblies must be clean and free from flux and all contaminants. Use of no clean flux is not acceptable. 3. These assemblies must comply with workmanship standards IPC-A-610 Class 2. 4. Ref designators marked with an asterisk (***) cannot be substituted. All other components can be substituted with equivalent MFG's components.						

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		Applications	
Amplifiers	amplifier.ti.com	Audio	www.ti.com/audio
Data Converters	dataconverter.ti.com	Automotive	www.ti.com/automotive
DLP® Products	www.dlp.com	Communications and Telecom	www.ti.com/communications
DSP	dsp.ti.com	Computers and Peripherals	www.ti.com/computers
Clocks and Timers	www.ti.com/clocks	Consumer Electronics	www.ti.com/consumer-apps
Interface	interface.ti.com	Energy	www.ti.com/energy
Logic	logic.ti.com	Industrial	www.ti.com/industrial
Power Mgmt	power.ti.com	Medical	www.ti.com/medical
Microcontrollers	microcontroller.ti.com	Security	www.ti.com/security
RFID	www.ti-rfid.com	Space, Avionics & Defense	www.ti.com/space-avionics-defense
RF/IF and ZigBee® Solutions	www.ti.com/lprf	Video and Imaging	www.ti.com/video
		Wireless	www.ti.com/wireless-apps