

# Using the TPS549A20: DCAP3 Mode, 15-A Synchronous Step-Down SWIFT™ Converter with PMBus PMBus™

## User's Guide



Literature Number: SLUUBE0  
November 2015

# **Using the TPS549A20: DCAP3 Mode, 15-A Synchronous Step-Down SWIFT™ Converter with PMBus PMBus™**

---

---

---

## **1 Introduction**

The TPS549A20EVM-737 evaluation module (EVM) uses the TPS549A20 device. The TPS549A20 device is a D-CAP3™ mode, 15-A synchronous buck-converter with integrated MOSFETs. The device provides a fixed 1.2-V output at up to 15 A from a 12-V input bus.

## **2 Description**

The TPS549A20EVM-737 is designed for a regulated 12-V bus to produce a regulated 1.2-V output at up to 15 A of load current. The TPS549A20EVM-737 is designed to demonstrate the TPS549A20 device in a typical low-voltage application while providing a number of test points to evaluate the performance of the TPS549A20 device.

### **2.1 Typical Applications**

- Servers and storage
- Workstations and desktops
- Telecommunication infrastructure

### **2.2 Features**

The TPS549A20EVM-737 features include the following:

- 15-A DC steady-state output current
- Support for a prebias-output voltage at startup
- Jumper, J2, for enable function
- Jumper, J5, for auto-skip and forced-continuous-conduction-mode (FCCM) selection
- Jumper, J7, for extra 5-V input for further power saving purpose
- Convenient test points for probing critical waveforms

### 3 Electrical Performance Specifications

**Table 1. TPS549A20EVM-737 Electrical Performance Specifications<sup>(1)</sup>**

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNITS
<b>INPUT CHARACTERISTICS</b>					
$V_{IN}$	Voltage range	5	12	18	V
$I_{IN(min)}$	Maximum input current	$V_{IN} = 5\text{ V}, I_{OUT} = 8\text{ A}$		2.5	A
$I_{IN(no\text{load})}$	No load input current	$V_{IN} = 12\text{ V}, I_O = 0\text{ A}$ with auto-skip mode		1	mA
<b>OUTPUT CHARACTERISTICS</b>					
$V_{OUT}$	Output voltage			1.2	V
	Line regulation	$(5\text{ V} < V_{IN} < 14\text{ V})$ with FCCM		0.2	%
	Load regulation	$(V_{IN} = 12\text{ V}, 0\text{ A} < I_{OUT} < 8\text{ A})$ with FCCM		0.5	%
$V_{RIPPLE}$	Output voltage ripple	$V_{IN} = 12\text{ V}, I_{OUT} = 8\text{ A}$ with FCCM		10	mVpp
	Output load current	0		15	A
	Output over current		15		A
$t_{SS}$	Soft-start time		1		ms
<b>SYSTEMS CHARACTERISTICS</b>					
$f_{SW}$	Switching frequency			1000	kHz
	Peak efficiency	$V_{IN} = 12\text{ V}, V_{OUT} = 1.2\text{ V}, I_{OUT} = 4\text{ A}$		91.0	%
	Full load efficiency	$V_{IN} = 12\text{ V}, V_{OUT} = 1.2\text{ V}, I_{OUT} = 8\text{ A}$		90.3	%
$T_A$	Ambient temperature			25	°C

<sup>(1)</sup> Jumpers set to default locations, See [Section 6](#).

4 Schematic

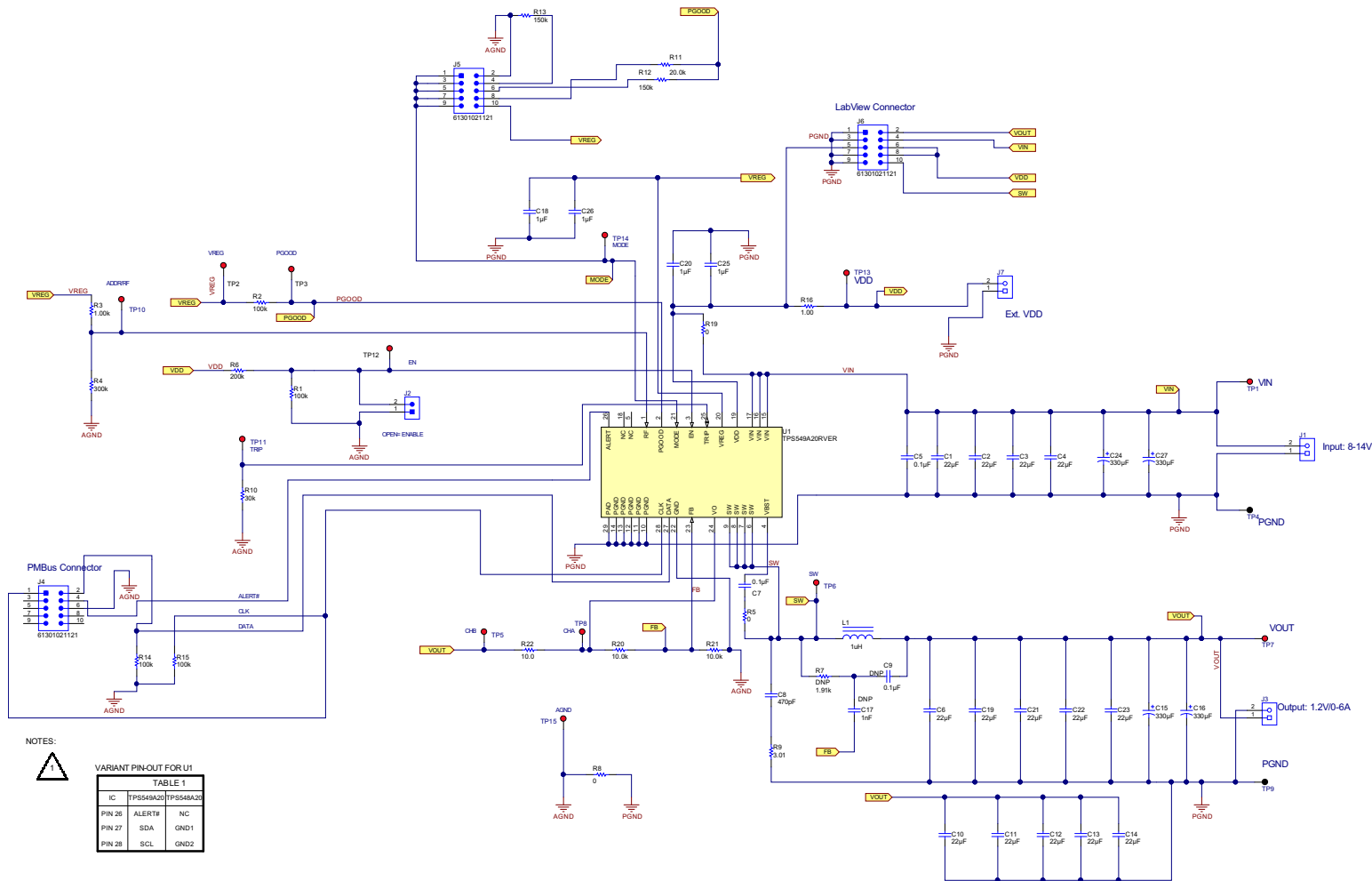


Figure 1. TPS549A20EVM-737 Schematic

## 5 Test Setup

### 5.1 Test Equipment

**Oscilloscope**— A digital or analog oscilloscope measures the output ripple. The oscilloscope must be set for the following: 1-M $\Omega$  impedance, 20-MHz bandwidth, AC coupling, 1- $\mu$ s / division horizontal resolution, 20-mV / division vertical resolution. Test points TP7 and TP9 measure the output ripple voltage by placing the oscilloscope probe tip through TP7 and holding the ground barrel on TP9 as shown in Figure 2. Using a leaded ground connection can induce additional noise due to the large ground loop.

**Voltage Source**—The input voltage source  $V_{IN}$  must be a 0 to 14-V variable-DC source capable of supplying 10 ADC. Connect  $V_{IN}$  to J1 as shown in Figure 3.

**Multimeters**— V1:  $V_{IN}$  at TP1 ( $V_{IN}$ ) and TP4 (GND).  
V2:  $V_{OUT}$  at TP7 ( $V_{OUT}$ ) and TP9 (GND).

**Output Load**—The output load must be an electronic constant-resistance-mode load capable of 0 to 15 ADC at 1.2 V.

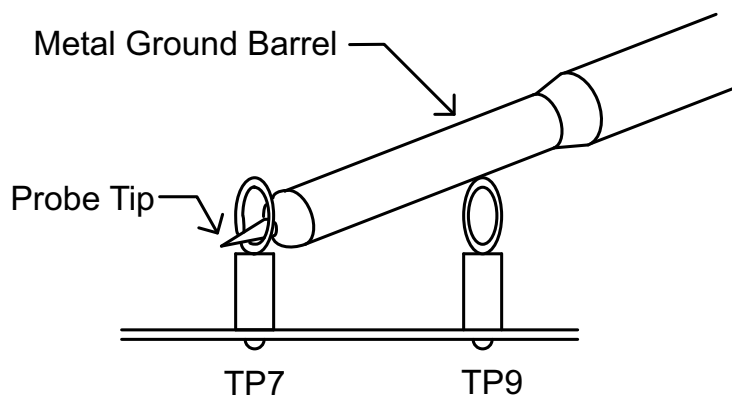
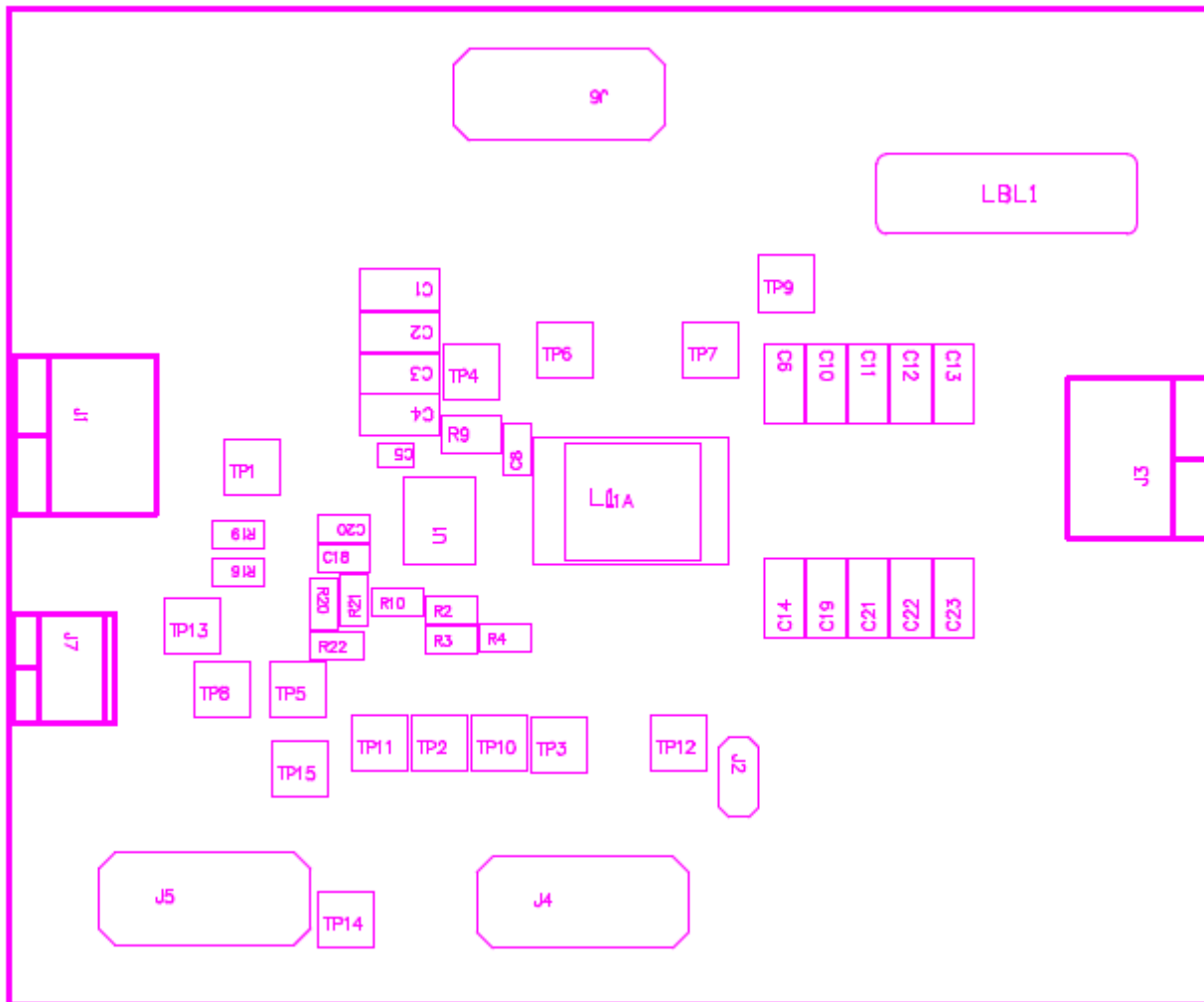


Figure 2. Tip and Barrel Measurement for  $V_{OUT}$  Ripple

#### Recommended Wire Gauge:

1.  $V_{IN}$  to J1 (12-V input)
  - The recommended wire size is 1 $\times$  AWG number 14 per input connection, with the total length of wire less than 4 feet (2 feet input, 2 feet return).
2. J3 to LOAD
  - The minimum recommended wire size is 2 $\times$  AWG number 14, with the total length of wire less than 4 feet (2 feet output, 2 feet return).

## 5.2 Recommended Test Setup



**Figure 3. TPS549A20EVM-587 Top Layer for Test Setup**

### Input Connections:

1. Prior to connecting the DC input-source, VIN, TI recommends to limit the source current from VIN to 10 A maximum. Ensure that VIN is initially set to 0 V and connected as shown in [Figure 3](#).
2. Connect the voltmeter V1 at TP1 (VIN) and TP4 (GND) to measure the input voltage.

### Output Connections:

1. Connect the load to J3 and set the load to constant-resistance-mode to sink 0 ADC before VIN is applied.
2. Connect the voltmeter V2 at TP7 (VOUT) and TP9 (GND) to measure the output voltage.

## 6 Configurations

All Jumper selections must be made prior to applying power to the EVM. Configure this EVM using the following configuration selections.

### 6.1 PMBus Address Selection

The PMBus address can be changed as shown in [Table 2](#).

**Table 2. PMBus Address Selection Settings**

PMBus ADDRESS	RESISTOR DIVIDER RATIO ( $\Omega$ )			$(R_{HIGH})$ (k $\Omega$ ) HIGH-SIDE RESISTOR	$(R_{LOW})$ (k $\Omega$ ) LOW-SIDE RESISTOR
	$(R_{LOW}/R_{LOW}+R_{HIGH})$	MIN	MAX		
00111111	> 0.557			1	300
00111110	0.5100	0.4958	0.5247	160	165
00111101	0.4625	0.4482	0.4772	180	154
00111100	0.4182	0.4073	0.4294	200	143
00111011	0.3772	0.3662	0.3886	200	120
00111010	0.3361	0.3249	0.3476	220	110
00111001	0.2985	0.2905	0.3067	249	105
00111000	0.2641	0.2560	0.2725	249	88.7
00101111	0.2298	0.2215	0.2385	240	71.5
00101110	0.1955	0.1870	0.2044	249	60.4
00101101	0.1611	0.1524	0.1703	249	47.5
00101100	0.1268	0.1179	0.1363	249	36.0
00100111	0.0960	0.0900	0.1024	255	27.0
00100110	0.0684	0.0622	0.0752	255	18.7
00100011	0.0404	0.0340	0.0480	270	11.5
00100000	< 0.013			300	1

For different switching frequency setting, please change R3 and R4 as shown in [Table 2](#).

### 6.2 Mode Selection

The MODE can be set by J5.

**Table 3. Mode Selection**

JUMPER SET TO:	MODE SELECTION
1 to 2 pin shorted	FCCM with 2x RC time constant
3 to 4 pin shorted <sup>(1)</sup>	FCCM <sup>(2)</sup> with 1x RC time constant <sup>(1)</sup>
5 to 6 pin shorted	FCCM <sup>(2)</sup> with 2x RC time constant
7 to 8 pin shorted	Auto-skip mode with 2x RC time constant
9 to 10 pin shorted	Auto-skip mode with 1x RC time constant

<sup>(1)</sup> Default setting.

<sup>(2)</sup> The device enters FCCM after PGOOD goes high.

### 6.3 VDD Pin Supply Selection

The controller can be enabled and disabled by J7.

**Table 4. Enable Selection**

SET ON CONNECTION	ENABLE SELECTION
R19 = 0 $\Omega$ <sup>(1)</sup>	VDD pin connected to VIN pins <sup>(1)</sup>
R19 = Open	VDD pin disconnected to VIN pins

<sup>(1)</sup> Default setting: the VDD pin connected to the VIN pins through R19.

For power-up, input J7 with proper voltage. The VDD pin input voltage range is from 4.5 V to 25 V.



## 7 Test Procedure

### 7.1 Line and Load Regulation and Efficiency Measurement Procedure

1. Set up the EVM as described in [Section 5](#) and [Figure 3](#).
2. Ensure the load is set to constant-resistance mode and to sink at 0 ADC.
3. Ensure all jumper settings are configured as shown in [Section 6](#).
4. Ensure the jumper provided in the EVM shorts on J2 before VIN is applied.
5. Increase VIN from 0 to 12 V. Use V1 to measure input voltage.
6. Remove the jumper on J2 to enable the controller.
7. Use V2 to measure the VOUT voltage.
8. Vary the load from 0 to 10 ADC, VOUT must remain in load regulation.
9. Vary VIN from 8 to 14 V, VOUT must remain in line regulation.
10. To disable the converter, place the jumper on J2.
11. Decrease the load to 0 A
12. Decrease VIN to 0 V.

### 7.2 PMBUS Setup and Verification

The TPS549A20EVM-737 contains a 10-Ω series resistor in the feedback loop for loop response analysis.

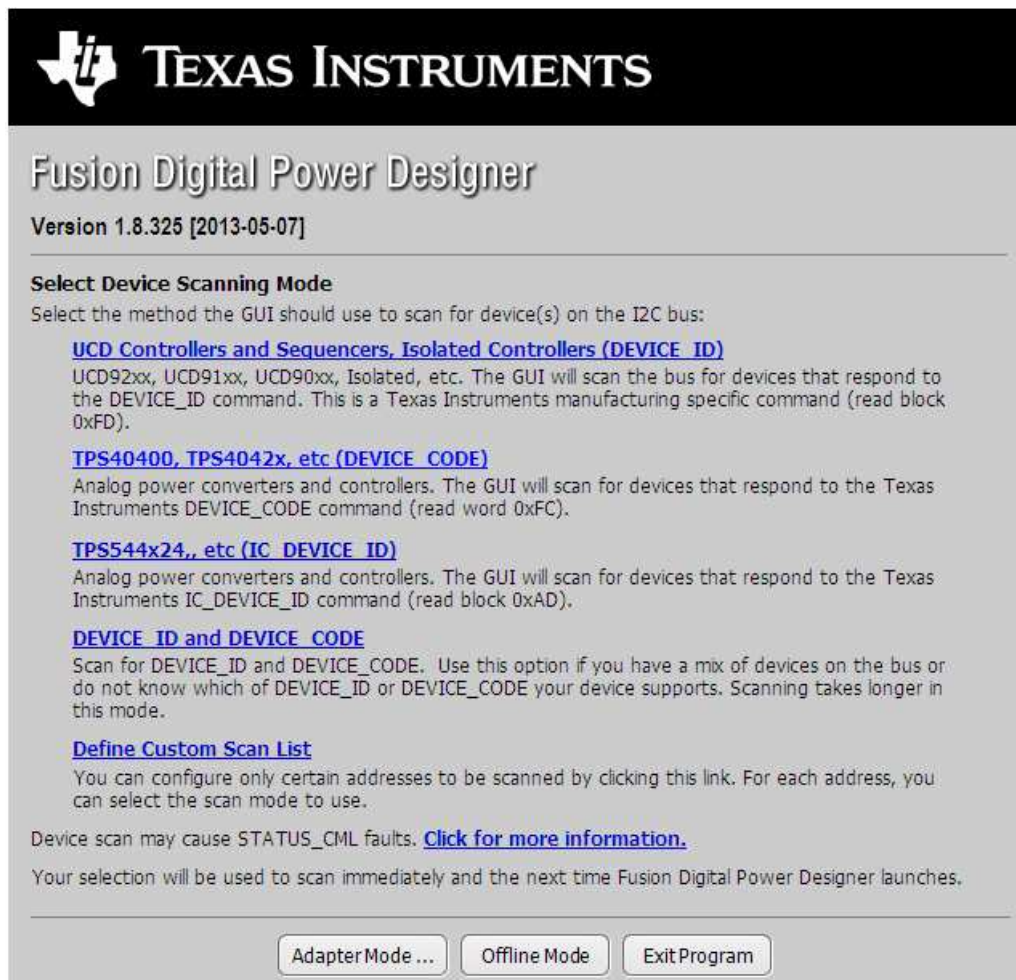
1. Download the Graphical User Interface (GUI) from [www.TI.com](http://www.TI.com).
2. Type *fusion* in the TI search bar.
3. Select *FUSION\_DIGITAL\_POWER\_DESIGNER* from the search result.
4. Download and install the latest release version of the software. The most current version to date is version 1.8.325 of the Fusion Digital Power Designer.
5. Connect the USB Interface Adaptor EVM (see [www.ti.com](http://www.ti.com) for more information) to J4 of the EVM. Ensure that Pin 1 of the USB interface adaptor (red wire) is connected correctly to Pin 1 of J4 on the EVM.
6. Connect the USB wire of the USB interface adaptor to one of the USB ports on the computer tower.
7. Ensure that the EVM is powered up and connected to the USB interface adaptor before opening the Fusion Designer GUI.
8. Double click the shortcut icon on the desktop for the Fusion Designer GUI. **Use the online version.**
9. Double click on the *TPS40400, TPS4042x, ect (DEVICE CODE)* from the *Select Device Scanning Mode* window as shown in [Figure 4](#).
10. When the GUI is loaded (see [Figure 5](#)), verify communication between the GUI and the EVM by changing the frequency of the EVM.

---

**NOTE:** The TPS549A20EVM is pre-set to a 400-KHz switching frequency.

---

11. Use the oscilloscope to monitor the switching frequency on the EVM on TP6.
12. Select a different frequency by clicking on the drop down box of the *FREQUENCY\_CONFIG:TPS53819 (TPS5391X)*.
13. Click on *Write to Hardware* and monitor the change of the switching frequency on the oscilloscope.
14. See the TPS549A20 datasheet ([SLUSAS9](#)) for more information regarding PMBUS registers.



**Figure 4. Select Device Scanning Mode**

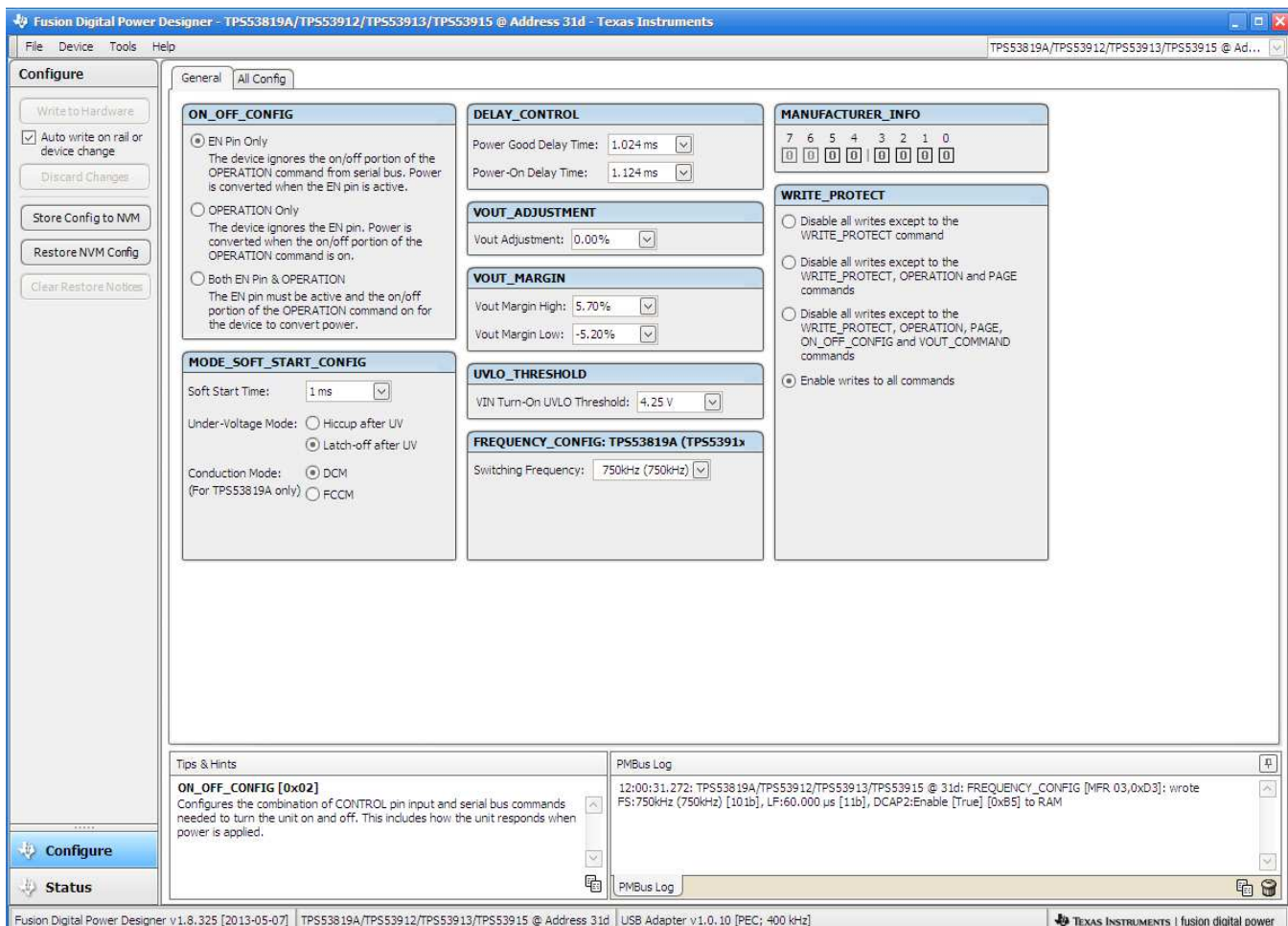


Figure 5. GUI for the Fusion Digital Power Designer

### 7.3 Control-Loop Gain and Phase-Measurement Procedure

The TPS549A20EVM-737 contains a 10-Ω series resistor in the feedback loop for loop response analysis.

1. Set up the EVM as described in [Section 5](#) and [Figure 3](#).
2. Connect the isolation transformer to the test points marked TP5 and TP8.
3. Connect the input-signal amplitude-measurement probe (channel A) to TP10. Connect the output-signal amplitude-measurement probe (channel B) to TP11.
4. Connect the ground lead of channel A and channel B to TP15.
5. Inject around 20 mV or less signal through the isolation transformer.
6. To measure control-loop gain and phase margin, change the frequency from 100 Hz to 1 MHz using a 10-Hz or less post filter.
7. Disconnect the isolation transformer from the bode-plot test points before making other measurements.
  - Signal injection into feedback can interfere with the accuracy of other measurements.

## 7.4 List of Test Points

**Table 5. Test Point Functions**

TEST POINTS	NAME	DESCRIPTION
TP1	VIN	Converter input supply voltage
TP2	VREG	LDO voltage
TP3	PGOOD	Power good output
TP4	PGND	Power ground
TP5	CHB	Input B for loop injection
TP6	SW	Switch Node
TP7	VOUT	VOUT terminal +
TP8	CHA	Input A for loop injection
TP9	PGND	Power ground
TP10	RF	RF pin
TP11	TRIP	TRIP pin
TP12	EN	Enable pin
TP13	VDD	VDD pin
TP14	MODE	MODE pin
TP15	AGND	Analog ground

## 7.5 Equipment Shutdown

Follow these steps when shutting down the equipment.

1. Shut down load
2. Shut down VIN

## 8 EVM Assembly Drawing and PCB Layout

The following figures show the design of the TPS549A20EVM-737 printed circuit board (see [Figure 6](#), [Figure 7](#), [Figure 8](#), [Figure 9](#), [Figure 10](#), [Figure 11](#), [Figure 12](#), and [Figure 13](#)). The EVM has been designed using a six-layer 2-oz copper-circuit board.

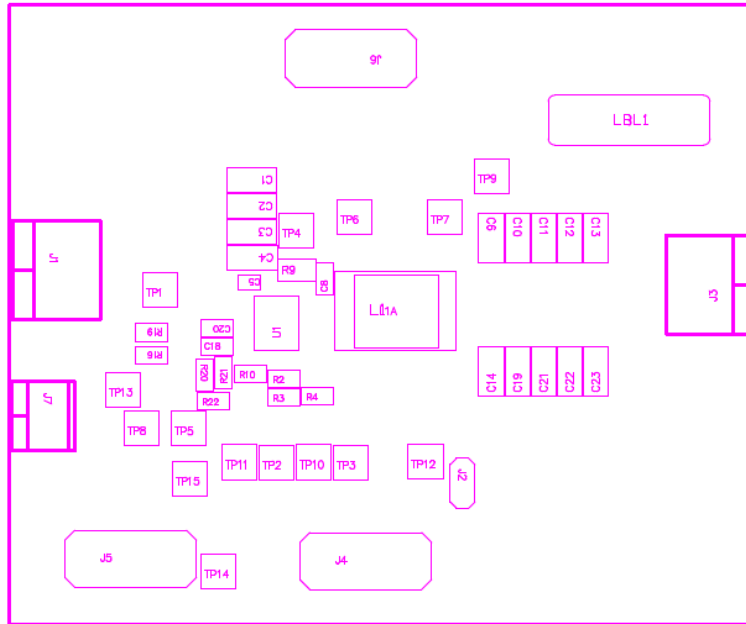


Figure 6. TPS549A20EVM-587 Top-Layer Assembly Drawing

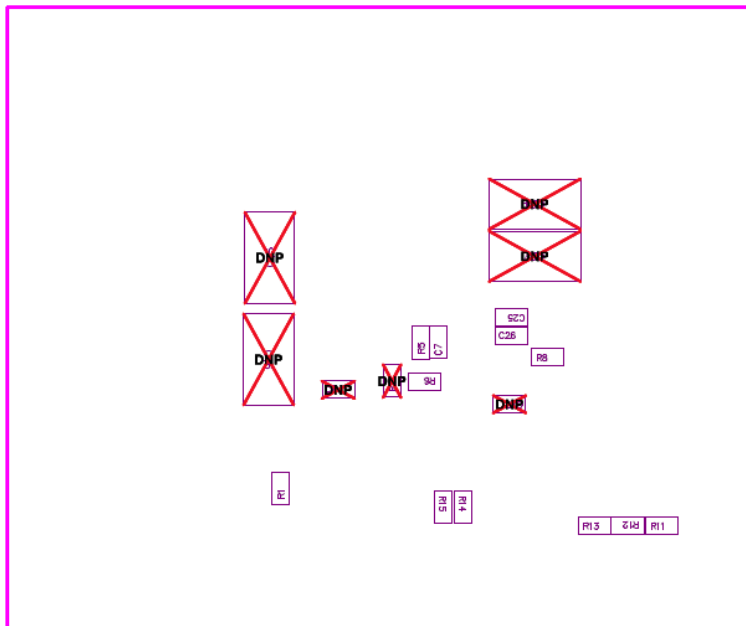
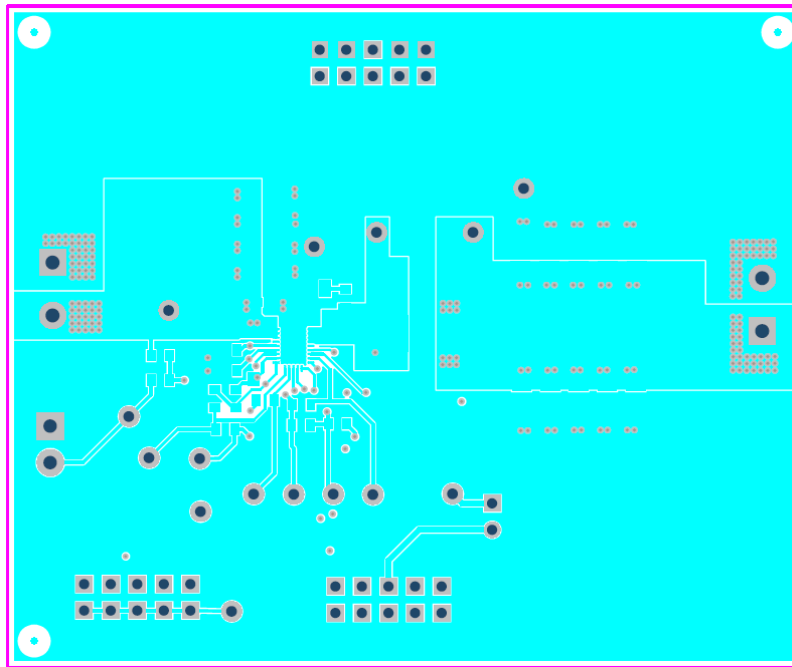
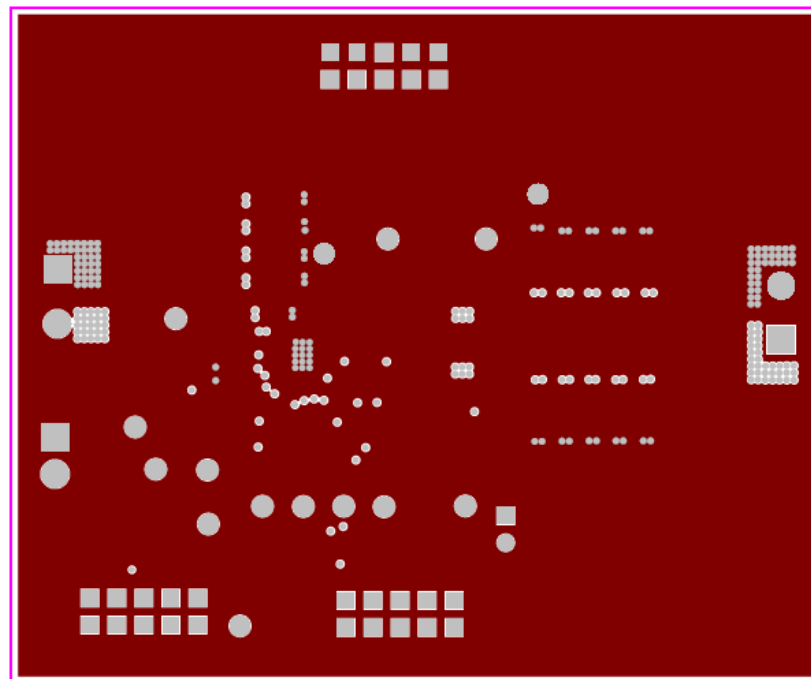


Figure 7. TPS549A20EVM-587 Bottom-Layer Assembly Drawing



**Figure 8. TPS549A20EVM-587 Top Layer, Copper**



**Figure 9. TPS549A20EVM-587 Layer Two, Copper**

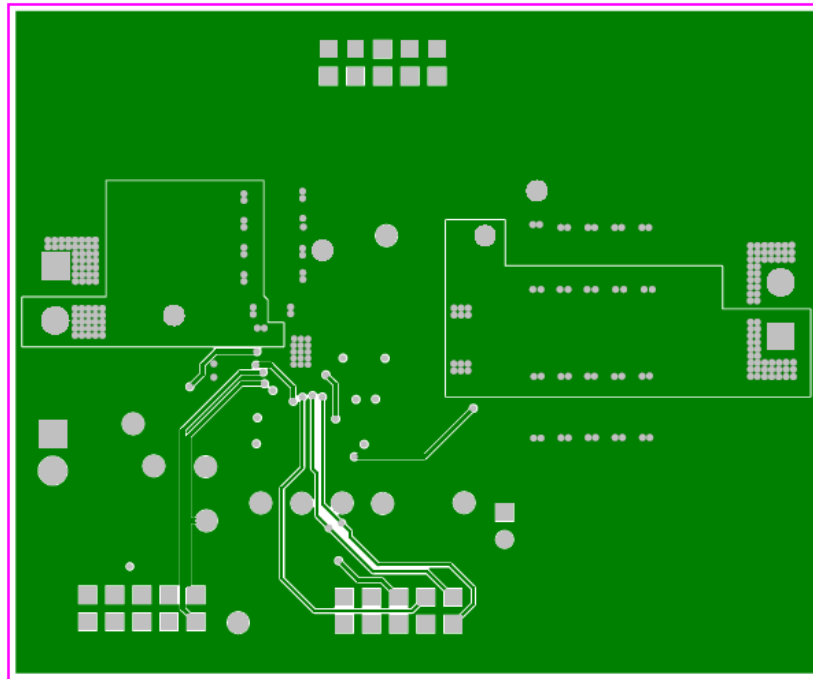


Figure 10. TPS549A20EVM-587 Layer Three, Copper

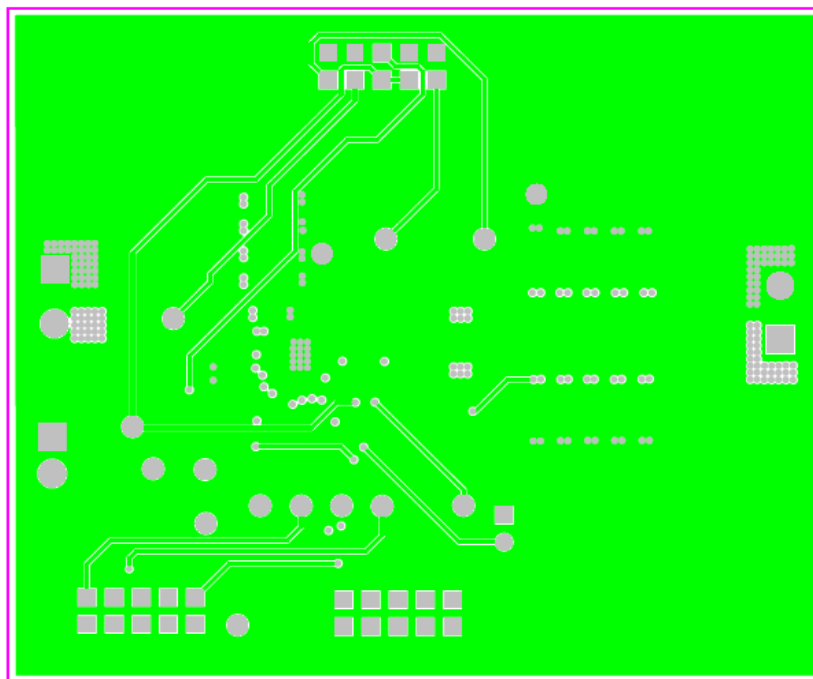


Figure 11. TPS549A20EVM-587 Layer Four, Copper

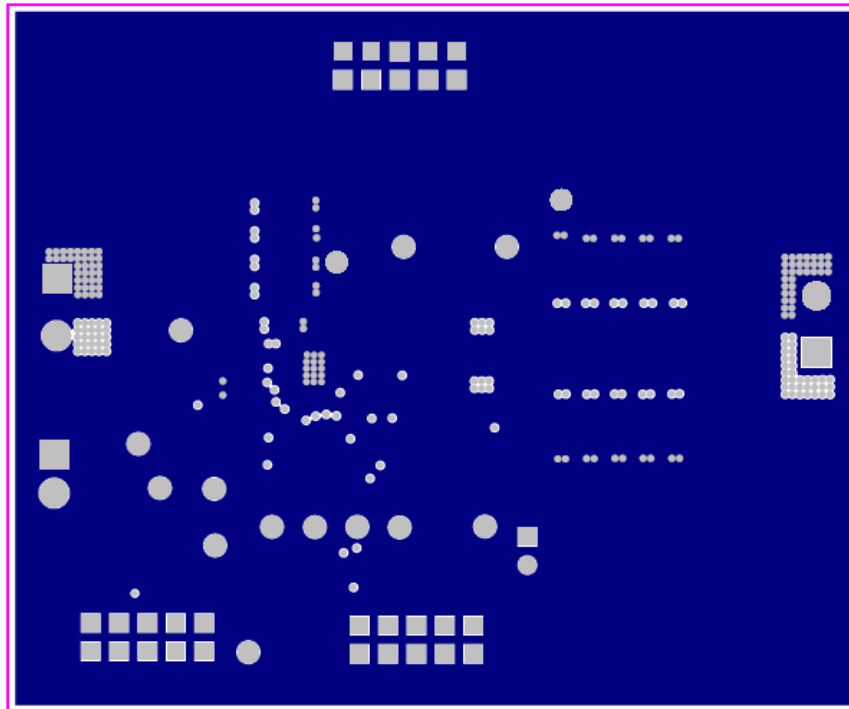


Figure 12. TPS549A20EVM-587 Layer Five, Copper

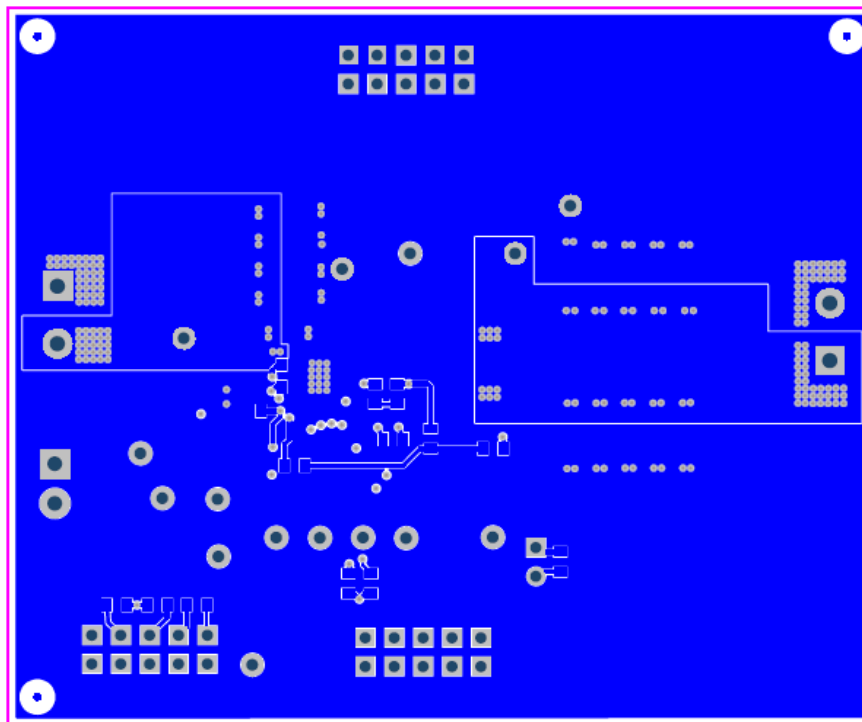


Figure 13. TPS549A20EVM-587 Bottom Layer, Copper



## 9 Bill of Materials

**Table 6. EVM Components List (Based on the Schematic, see Figure 1)**

Designator	Quantity	Value	Description	Package Reference	Part Number	Manufacturer
C1, C2, C3, C4	4	22 $\mu$ F	Capacitor, Ceramic, 25 V, X5R, 10%	1206	GRM31CR61E226KE15L	Murata
C5	1	0.1 $\mu$ F	CAP CER 0.1 $\mu$ F 25 V 10% X5R 0402	0402	GRM155R61E104KA87D	Murata
C6, C10, C11, C12, C13, C14, C19, C21, C22, C23	10	22 $\mu$ F	Capacitor, Ceramic, 6.3 V, X5R, 20%	1206	GRM31CR60J226KE19L	Murata
C7	1	0.1 $\mu$ F	CAP CER 0.1 $\mu$ F 50 V 10% X7R 0603	0603	GRM188R71H104KA93D	Murata
C8	1	470 pF	CAP CER 470 pF 50 V 10% X7R 0603	0603	GRM188R71H471KA01D	Murata
C9, C17	0	Open	Capacitor, Ceramic, 50 V, X7R, 10%	0603	Standard	Standard
C15, C16, C24, C27	0	Open	Capacitor, POSCAP, SMT, 2.5 V, 330 $\mu$ F, 8 m $\Omega$	7343(D)	2R5TPE330M9 or 6TPE330MIL	Sanyo
C18, C20, C25, C26	4	1 $\mu$ F	CAP CER 1 $\mu$ F 16 V 10% X7R 0603	0603	GRM188R71C105KA12J	Murata
FID1, FID2, FID3, FID4, FID5, FID6	0		Fiducial mark. There is nothing to buy or mount.	Fiducial	N/A	N/A
J1, J3	2	ED120/2DS	Terminal Block, 2-pin, 15-A, 5,1 mm	0.4 x 0.35 inch	ED120/2DS	OST
J2	1	PEC02SAAN	Header, Male 2-pin, 100-mil spacing,	0.1 x 2 inch	PEC02SAAN	Sullins
J4, J5, J6	3	PEC05DAAN	Header, Male 2x5-pin, 100-mil spacing	0.1 x 2 x 5 inch	PEC05DAAN	Sullins
J7	1	ED555/2DS	Terminal Block, 2-pin, 6-A, 3,5 mm	0.27 x 0.25 inch	ED555/2DS	OST
L1	1	1 $\mu$ H	Inductor, Power Chokes SMD	6,6 x 7,1 mm	PIMB065T-1R0MS	Cyntec
LBL1	1		Thermal Transfer Printable Labels, 0.650 (W) x 0.2 inch (H) — 10,000 per roll	PCB Label 0.65 (H) x 0.2 inch (W)	THT-14-423-10	Brady
R1, R2, R14, R15	4	100k	RES, 100 k $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW0603100KFKEA	Vishay-Dale
R3	1	1k	RES, 1 k $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW06031K00FKEA	Vishay-Dale
R4	1	300k	RES, 300 k $\Omega$ , 1%, 0.1 W, 0603	0603	RC0603FR-07300KL	Yageo America
R5, R8, R19	3	0	RES, 0 $\Omega$ , 5%, 0.1 W, 0603	0603	CRCW06030000Z0EA	Vishay-Dale
R6	1	200k	RES, 200 k $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW0603200KFKEA	Vishay-Dale
R7	0	Open	Resistor, Chip, 1/16 W, 1%	0603	Standard	Standard
R9	1	3.01	RES, 3.01 $\Omega$ , 1%, 0.125 W, 0805	0805	CRCW08053R01FKEA	Vishay-Dale
R10	1	57.6k	RES, 57.6 k $\Omega$ , 1%, 0.1 W, 0603	0603	RC0603FR-0757K6L	Yageo America
R11	1	20k	RES, 20.0 k $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW060320K0FKEA	Vishay-Dale
R12, R13	2	150k	RES, 150 k $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW0603150KFKEA	Vishay-Dale
R16	1	1	RES, 1 $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW06031R00FKEA	Vishay-Dale
R20, R21	2	10k	RES, 10 k $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW060310K0FKEA	Vishay-Dale
R22	1	10	RES, 10 $\Omega$ , 1%, 0.1 W, 0603	0603	CRCW060310R0FKEA	Vishay-Dale
TP1, TP2, TP3, TP5, TP6, TP7, TP8, TP10, TP11, TP12, TP13, TP14, TP15	13	5000	Test Point, Red, Thru Hole Color Keyed	0.1 x 0.1 inch	5000	Keystone
TP4, TP9	2	5001	Test Point, Black, Thru Hole Color Keyed	0.1 x 0.1 inch	5001	Keystone
U1	1	TPS549A20RVE	IC, High Performance, 15-A Single Sync. Step-Down Converter with PMBus.		TPS549A20RVE	TI

## IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as “components”) are sold subject to TI’s terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI’s terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

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

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license 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 significant portions 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. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI’s goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or “enhanced plastic” are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer’s risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

**Products**

Audio	<a href="http://www.ti.com/audio">www.ti.com/audio</a>
Amplifiers	<a href="http://amplifier.ti.com">amplifier.ti.com</a>
Data Converters	<a href="http://dataconverter.ti.com">dataconverter.ti.com</a>
DLP® Products	<a href="http://www.dlp.com">www.dlp.com</a>
DSP	<a href="http://dsp.ti.com">dsp.ti.com</a>
Clocks and Timers	<a href="http://www.ti.com/clocks">www.ti.com/clocks</a>
Interface	<a href="http://interface.ti.com">interface.ti.com</a>
Logic	<a href="http://logic.ti.com">logic.ti.com</a>
Power Mgmt	<a href="http://power.ti.com">power.ti.com</a>
Microcontrollers	<a href="http://microcontroller.ti.com">microcontroller.ti.com</a>
RFID	<a href="http://www.ti-rfid.com">www.ti-rfid.com</a>
OMAP Applications Processors	<a href="http://www.ti.com/omap">www.ti.com/omap</a>
Wireless Connectivity	<a href="http://www.ti.com/wirelessconnectivity">www.ti.com/wirelessconnectivity</a>

**Applications**

Automotive and Transportation	<a href="http://www.ti.com/automotive">www.ti.com/automotive</a>
Communications and Telecom	<a href="http://www.ti.com/communications">www.ti.com/communications</a>
Computers and Peripherals	<a href="http://www.ti.com/computers">www.ti.com/computers</a>
Consumer Electronics	<a href="http://www.ti.com/consumer-apps">www.ti.com/consumer-apps</a>
Energy and Lighting	<a href="http://www.ti.com/energy">www.ti.com/energy</a>
Industrial	<a href="http://www.ti.com/industrial">www.ti.com/industrial</a>
Medical	<a href="http://www.ti.com/medical">www.ti.com/medical</a>
Security	<a href="http://www.ti.com/security">www.ti.com/security</a>
Space, Avionics and Defense	<a href="http://www.ti.com/space-avionics-defense">www.ti.com/space-avionics-defense</a>
Video and Imaging	<a href="http://www.ti.com/video">www.ti.com/video</a>

**TI E2E Community**
[e2e.ti.com](http://e2e.ti.com)

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265  
Copyright © 2015, Texas Instruments Incorporated