User's Guide
SLVUA86–July 2014

Using the PWR594 EVM Dual Output DC/DC Analog with PMBus Interface

The PWR594EVM evaluation module (EVM) uses the TPS40425 or TPS40428 controller. Both TPS40425 and TPS40428 are dual output, 2-phase, stackable PMBus synchronous buck, driverless controllers that operate from a nominal 4.5-V to 20-V supply. The controllers allow programming and monitoring via the PMBus interface.

TPS40425 is in non smart-power mode (DCR mode) in factory default, it uses inductor DCR for current sense and external thermal transistor for temperature sense. TPS40428 is in smart-power mode in factory default, it obtains current and temperature signals from TI smart power stage.

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1 Description

The PWR594EVM is designed as a dual-output converter in default. It uses a nominal 12-V bus to produce a regulated 1.2-V output at up to 20 A of load current, and a regulated 1.8-V output at up to 20 A of load current. The PWR594EVM is designed to demonstrate the controllers in a typical low-voltage application while providing a number of test points to evaluate the performance of the controllers. The PWR594EVM can be configured as 2-phase by changing the bill of materials (BOM). Refer to the TPS40425 (SLUSBO6) and TPS40428 (SLUSBV0) datasheets for more information on multi-phase configuration.

To simplify the BOM, power stage CSD95378B is used for both TPS40425 EVM and TPS40428 EVM. In user's application, power stage CSD95372A can be considered for a TPS40425 design at non smart-power mode.

1.1 Typical Applications

- Wireless infrastructure
- Switcher/Router Network/Server/Storage

1.2 Features

- Regulated 1.2-V output up to 20-A DC steady-state output current
- Regulated 1.8-V output up to 20-A DC steady-state output current
- Both outputs are marginable and trimmable via the PMBus interface
  - Programmable UVLO, soft start, and enable via the PMBus interface
  - Programmable overcurrent warning and fault limits and programmable response to faults via the PMBus interface
  - Programmable overvoltage and undervoltage fault limit via the PMBus interface
  - Programmable high- and low-output margin voltages with a maximum range of +10%, –20% of nominal output voltage
- Convenient test points for probing critical waveforms

2 Electrical Performance Specifications

Table 1 lists the electrical performance specifications.

Table 1. PWR594 EVM-001 Electrical Performance Specifications

Parameter	Test Conditions	MIN	TYP	MAX	Unit
Input Characteristics					
Voltage range	V_{IN}	7	12	14	V
Maximum input current	V_{IN} = 7 V, I_{O1} = 20 A, I_{O2} = 20 A		10		A
No load input current	V_{IN} = 12 V, I_{O1} = 0 A, I_{O2} = 0 A		80		mA
Output Characteristics					
Output voltage, V_{OUT1}			1.2		V
Output voltage, V_{OUT2}			1.8		V
Output load current, I_{OUT1} (1)		0		20	A
Output load current, I_{OUT2} (1)		0		20	A
Output voltage regulation	Line Regulation: Input voltage = 7 V to 14 V			0.5%	
	Load Regulation: Output current = 0 A to 20 A, both outputs			0.5%	
Output voltage ripple, V_{OUT1}	V_{IN} = 12 V, I_{OUT} = 20 A		10		mVpp
Output voltage ripple, V_{OUT2}	V_{IN} = 12 V, I_{OUT} = 20 A		10		mVpp
Output overcurrent	Inductor peak current, TPS40425EVM		30		A
	Inductor peak current, TPS40428EVM		40		A
Systems Characteristics					
Switching frequency	V_{IN} = 12 V		500		kHz
Full load efficiency, V_{OUT1}	V_{IN} = 12 V, I_{O1} = 20 A, V_{OUT2} disabled		90%		
Full load efficiency, V_{OUT2}	V_{IN} = 12 V, I_{O2} = 20 A, V_{OUT1} disabled		92%		
Operating temperature	T_{oper}		25		°C

(1) The output current I_{OUT1} and I_{OUT2} can be up to 25 A, if the output overcurrent limit (IOUT_OC_FAULT_LIMIT) is set to 40 A.

3 Schematic

Figure 1 and Figure 2 illustrate the TPS40425 EVM and TPS40428 EVM schematics.

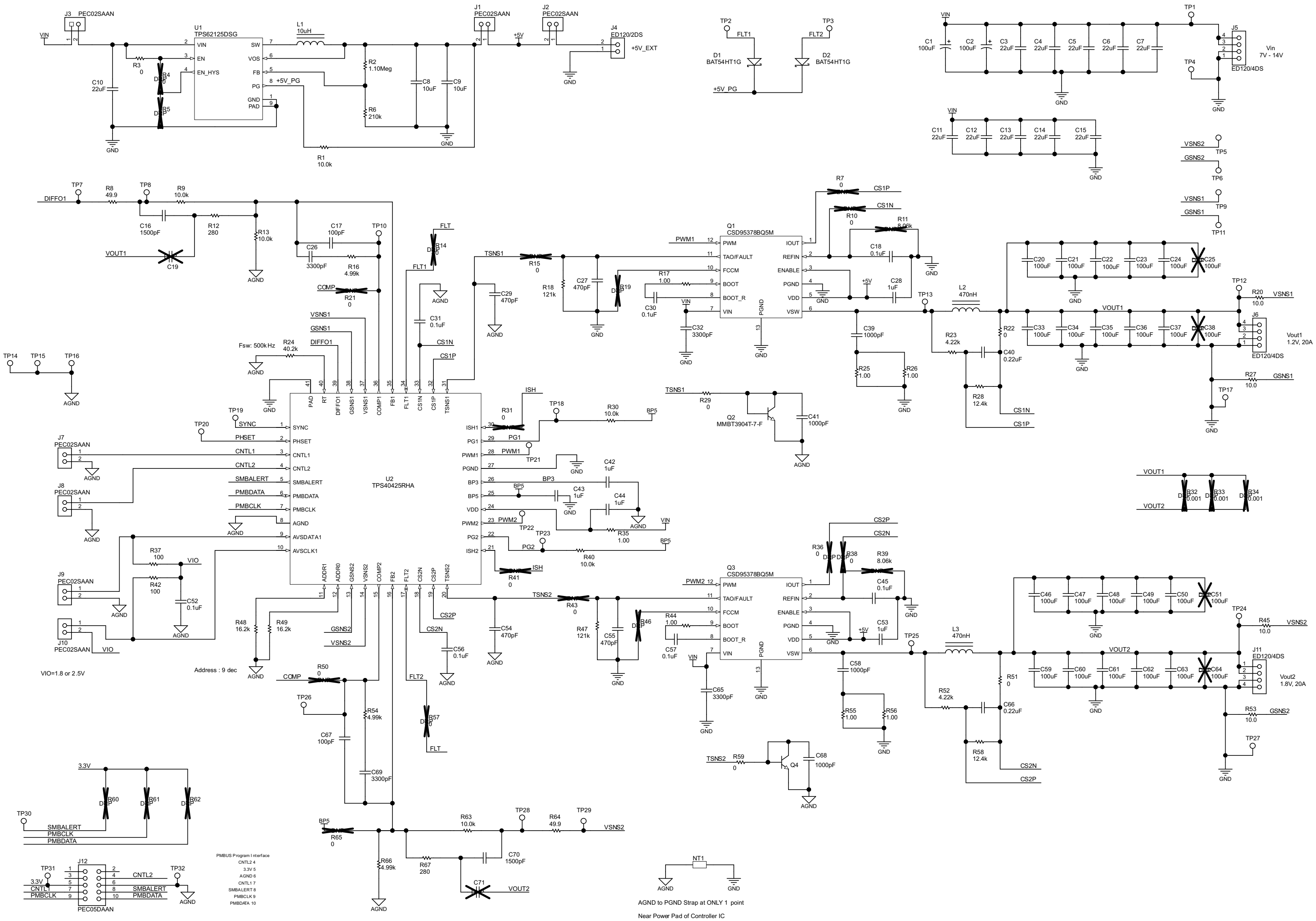

Figure 1. TPS40425EVM-PWR594 Schematic

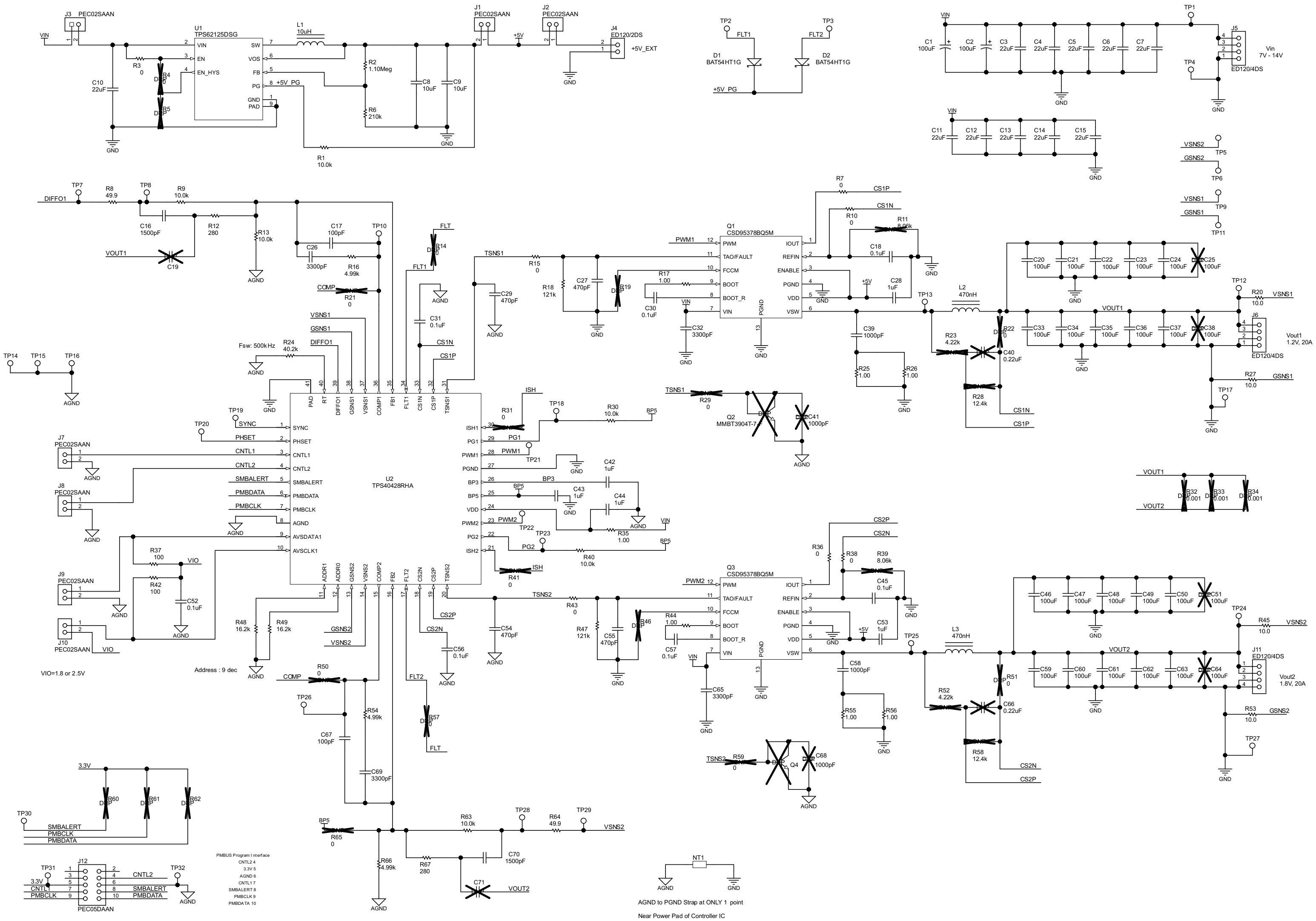

Figure 2. TPS40428EVM-PWR594 Schematic

4 Test Setup

4.1 Test and Configuration Software

In order to change any of the default configuration parameters on the EVM, it is necessary to obtain the TI Fusion Digital Power Designer software.

4.1.1 Description

Fusion Digital Power Designer is the Graphical User Interface (GUI) used to configure and monitor the controller on this EVM. The application uses the PMBus protocol to communicate with the controller over serial bus via TI USB adapter (see Figure 4).

4.1.2 Features

Some of the tasks you can perform with the GUI include:

- Turn on or off the power supply output, either through the hardware control line or the PMBus operation command.
- Monitor real-time data. Items such as output voltage, output current, temperature, warnings and faults which are continuously monitored and displayed by the GUI.
- Configure common operating characteristics such as V_{OUT} trim and margin, UVLO, soft-start time, warning and fault thresholds, fault response, and ON/OFF modes.

This software is available for download at this location:
http://www.ti.com/tool/fusion_digital_power_designer

4.2 Test Equipment

Voltage Source: The input voltage source V_{IN} should be a 0-V to 14-V variable DC source capable of supplying 15 ADC. Connect VIN to J5 as shown in Figure 3.

Multimeters: It is recommended to use three separate multimeters as shown in Figure 3. One meter to measure V_{IN}, the other two to measure V_{OUT1} and V_{OUT2}.

Output Load: Two variable electronic loads are recommended for the test setup as shown in Figure 3. Both Load 1 and Load 2 should be capable of 20 A.

Oscilloscope: An oscilloscope is recommended for measuring output noise and ripple. Output ripple should be measured using a *Tip-and-Barrel* method or better as shown in Figure 5.

Fan: During prolonged operation at high loads, it may be necessary to provide forced air cooling with a small fan aimed at the EVM. The temperature of the devices on the EVM should be maintained at less than 105°C.

USB-to-GPIO Interface Adapter: A communications adapter is required between the EVM and the host computer. This EVM was designed to use the Texas Instruments USB-to-GPIO Adapter, see Figure 4. This adapter can be purchased here: http://www.ti.com/tool/usb-to-gpio.

4.2.1 Recommended Wire Gauge

- VIN to J5 (12-V input) – The recommended wire size is 2xAWG #10, with the total length of wire less than 4 feet (2 feet input, 2 feet return).
- Load1 to J6 (1.2-V output) – The minimum recommended wire size is 2xAWG #10, with the total length of wire less than 4 feet (2 feet OUTPUT, 2 feet return).
- Load2 to J11 (1.8-V output) – The minimum recommended wire size is 2xAWG #10, with the total length of wire less than 4 feet (2 feet OUTPUT, 2 feet return).

4.3 Power Sequence Between Soft-Start and +5 V for Power Stage

A +5-V power supply is required by power stage CSD95378B and must be prepared before soft-start. Without preparation, the controller outputs the PWM signal at maximum duty cycle because the power stage is not working and output voltage is not regulated. The +5 V for power stage needs to be provided until the controller is turned off.

There is an onboard +5 V generated by the TPS62125 circuit. In default, a jumper is placed on J1 and the onboard +5 V is used for power stage. The FLT1 and FLT2 pins of the controller are connected to the PG pin of TPS62125 via diodes for power sequence between soft-start and onboard +5 V. Only when onboard +5 V is regulated, the FLT pins will be released to allow soft-start. Therefore, if onboard +5 V is selected, the power sequence is provided by the EVM design and no other procedure need to be conducted by user.

If an external +5 V is used for power stage, the external +5 V must be prepared before soft-start, and +5 V need to be provided until the controller is turned off.

The following list shows the jumper configurations for onboard and external +5 V:

- Onboard +5 V (In default): place jumpers on J1 and J3, remove jumper on J2
- External +5 V: place jumpers on J2 and J3, remove jumper on J1

4.4 Recommended Test Setup

Figure 3 shows the recommended test setup.

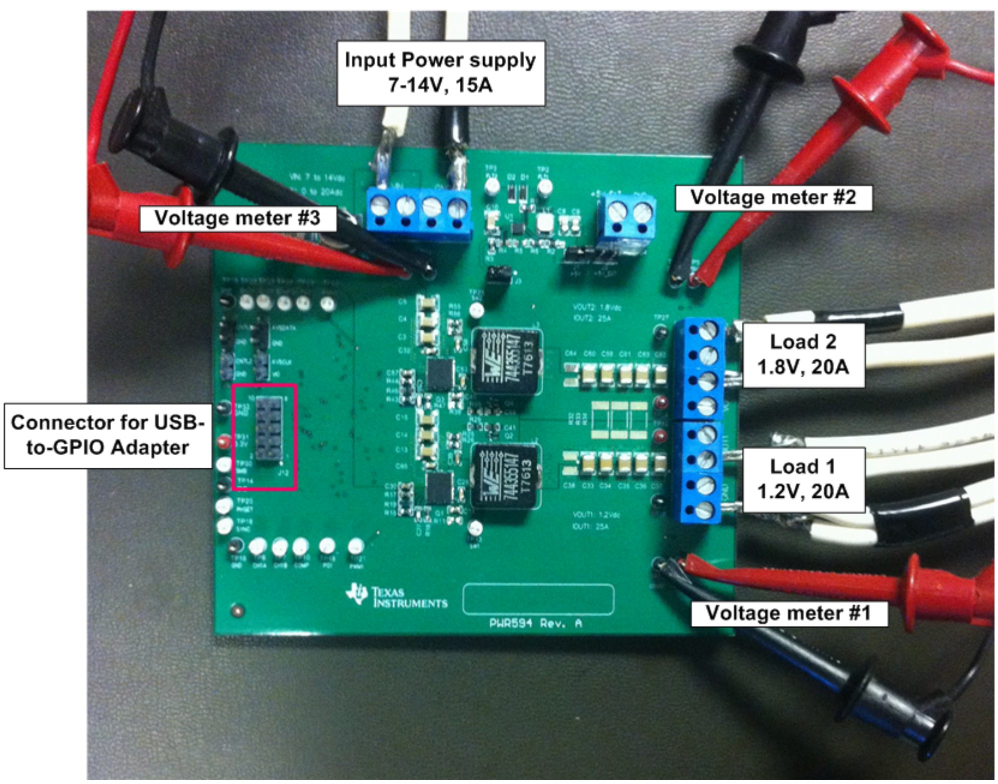

Figure 3. PWR594 EVM Recommended Test Set Up

4.5 USB Interface Adapter and Cable

Figure 4 illustrates the USB interface adapter and cable.

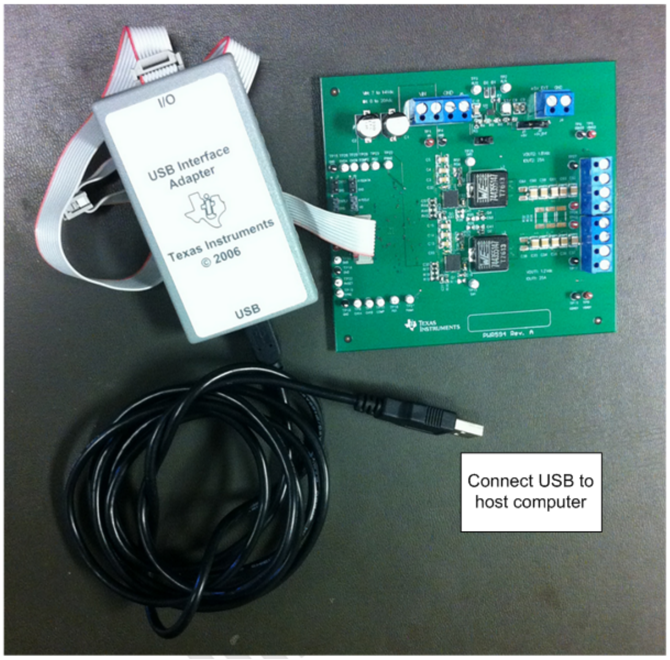

Figure 4. Texas Instruments USB-to-GPIO Adapter and Connections

Figure 5 illustrates the tip and barrel measurement.

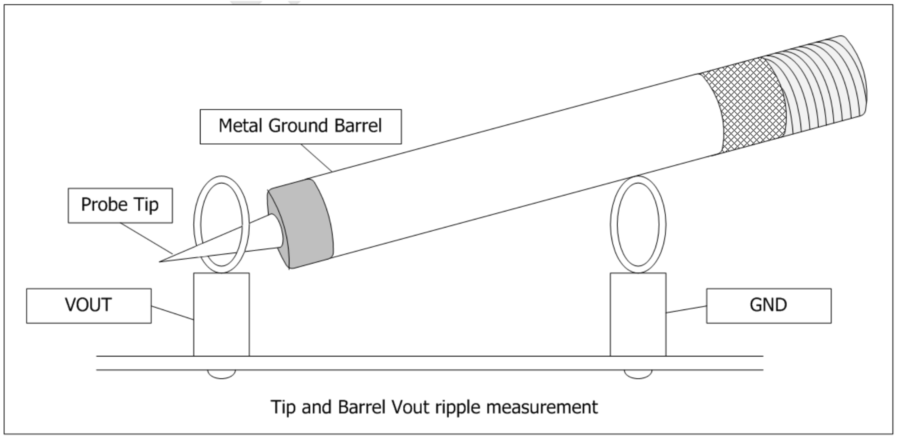

Figure 5. Tip and Barrel Measurement

4.6 List of Test Points and Connectors

Table 2 lists the test point functions.

Table 2. Test Point Functions

Test Point	Type	Name	Description
TP1	T-H Loop	VIN	V_{IN}+ measurement point
TP4	T-H Loop	GND	V_{IN}– measurement point
TP12	T-H Loop	VOUT1	V_{OUT1}+ measurement point

Table 2. Test Point Functions (continued)

Test Point	Type	Name	Description
TP17	T-H Loop	GND	V_{OUT1}– measurement point
TP9	T-H Loop	VSNS1	VSNS1 measurement point
TP11	T-H Loop	GSNS1	GSNS1 measurement point
TP13	T-H Loop	SW1	Switching point of Channel 1
TP21	T-H Loop	PWM1	PWM signal of Channel1
TP18	T-H Loop	PG1	PGOOD signal of Channel 1
TP10	T-H Loop	COMP1	COMP signal of Channel 1
TP2	T-H Loop	FLT1	FLT signal of Channel 1
TP8	T-H Loop	CH1A	Input for control loop measurements for Channel 1
TP7	T-H Loop	CH1B	OUTPUT for control loop measurements for Channel 1
TP24	T-H Loop	VOUT2	V_{OUT2}+ measurement point
TP27	T-H Loop	GND	V_{OUT2}– measurement point
TP5	T-H Loop	VSNS2	VSNS2 measurement point
TP6	T-H Loop	GSNS2	GSNS2 measurement point
TP25	T-H Loop	SW2	Switching point of Channel 2
TP22	T-H Loop	PWM2	PWM signal of Channel2
TP23	T-H Loop	PG2	PGOOD signal of Channel 2
TP26	T-H Loop	COMP2	COMP signal of Channel 2
TP3	T-H Loop	FLT2	FLT signal of Channel 2
TP28	T-H Loop	CH2A	Input for control loop measurements for Channel 2
TP29	T-H Loop	CH2B	OUTPUT for control loop measurements for Channel 2
TP19	T-H Loop	SYNC	SYNC signal
TP20	T-H Loop	PHSET	PHSET signal
TP30	T-H Loop	SMB	SMBALERT signal
TP31	T-H Loop	3.3V	3.3V pull-up voltage of PMBus

Table 3 lists the EVM connector functions.

Table 3. Connector Functions

Connector	Type	Description
J1	PEC02SAAN	Use onboard +5 V for power stage
J2	PEC02SAAN	Use external +5 V for power stage
J3	PEC02SAAN	Connect the input of onboard +5-V converter to VIN
J4	ED120/2DS	External +5-V connector
J5	ED120/2DS	VIN connector
J6	ED120/2DS	VOUT1 connector
J7	PEC02SAAN	CNTL1 connector
J8	PEC02SAAN	CNTL2 connector
J9	PEC02SAAN	AVSDATA connector
J10	PEC02SAAN	AVSCLK connector
J11	ED120/2DS	VOUT2 connector
J12	PEC05DAAN	PMBus connector

5 EVM Configuration Using the Fusion GUI

The controller on this EVM leaves the factory pre-configured. See Table 4 for a short list of key factory configuration parameters as obtained from the configuration file.

Table 4. Key Factory Configuration Parameters

Cmd NAME	CmdCodeHex	EncodedHex	Decoded	Comments
VIN_OFF	0x36	0xF014	4.0 V	Turn OFF voltage
VIN_ON	0x35	0xF01C	4.25 V	Turn ON voltage
IOUT_CAL_GAIN	0x38	0x8021	0.5 mΩ	Equivalent DCR value
IOUT_CAL_OFFSET	0x39	0xE000	0.0000 A	Current offset for GUI readout
IOUT_OC_FAULT_LIMIT	0x46	0xF83C	30.0 A	TPS40425EVM, OC fault level
		0xF850	40.0 A	TPS40428EVM, OC fault level
IOUT_OC_FAULT_RESPONSE	0x47	0x3C	Restart continuously	Response to OC fault
IOUT_OC_WARN_LIMIT	0x4A	0xF836	27.0 A	TPS40425EVM, OC warning level
		0xF84A	37.0 A	TPS40428EVM, OC warning level
MFR_04 (VREF_TRIM)	0xD4	0x0000	0.000 V	Trim voltage
ON_OFF_CONFIG	0x02	0x16	Control only, logic high	Control signal and OPERATION command not required
OT_FAULT_LIMIT	0x4F	0x007D	125 C	TPS40425 EVM, OT fault level
		0x0091	145 C	TPS40428 EVM, OT fault level
OT_WARN_LIMIT	0x51	0x0064	100 C	TPS40425 EVM, OT warn level
		0x007D	125 C	TPS40428 EVM, OT warn level
TON_RISE	0x61	0xE02B	2.7 ms	Soft-start time

If it is desired to configure the EVM to settings other than the factory settings shown above, the TI Fusion Digital Power Designer software can be used for reconfiguration. It is necessary to have input voltage applied to the EVM prior to launching the software so that the controller may respond to the GUI and the GUI can recognize the controller. In order to avoid any converter activity during configuration, an input voltage less than VIN_ON voltage should be applied. An input voltage of 4 V is recommended.

5.1 *Configuration Procedure*

1. Adjust the input supply to provide 4 VDC, current limited to 1 A.
2. Apply the input voltage to the EVM. Refer to Figure 3 and Figure 4 for connections and test setup.
3. Launch the Fusion GUI software. Refer to the screenshots in Section 10 for more information.
4. Configure the EVM operating parameters as desired.

NOTE: The *IOUT_CAL_GAIN* parameter is used by the controller in the calculation of output current level. In the TPS40425 EVM, the controller is at non smart-power mode in default, the IOUT_CAL_GAIN needs to be equal to the equivalent inductor DCR value for accurate current readout. In the TPS40428 EVM, the controller is at smart-power mode in default, IOUT_CAL_GAIN must be set to 0.5 mΩ for accurate current readout. The incorrect IOUT_CAL_GAIN value also affects OC Fault and OC Warn performance.

The *TON_RISE* parameter may affect proper startup if the rise time and output capacitance bank result in a current that exceeds the OC Fault level. The startup surge current in the output capacitance bank is added to the load current, so the sum of these two currents must be less than the OC Fault level for proper startup.

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6 Test Procedure

6.1 Line/Load Regulation and Efficiency Measurement Procedure

1. Set up the EVM as described in Figure 3.
2. Ensure both electronic loads are set to draw 0 Adc.
3. Increase V_{IN} from 0 V to 12 V using voltage meter #3 to measure input voltage.
4. Use voltage meter #1 to measure output voltage V_{OUT1}.
5. Vary the load from 0 to 20 Adc. V_{OUT1} should remain in regulation as defined in Table 1.
6. Vary V_{IN} from 7 V to 14 V. V_{OUT1} should remain in regulation as defined in Table 1.
7. Decrease the load to 0 A.
8. Use voltage meter #2 to measure output voltage V_{OUT2}.
9. Vary the load from 0 to 20 Adc. V_{OUT2} should remain in regulation as defined in Table 1.
10. Vary V_{IN} from 7 V to 14 V. V_{OUT2} should remain in regulation as defined in Table 1.
11. Decrease the load to 0 A.
12. Decrease V_{IN} to 0 V.

6.2 Control Loop Gain and Phase Measurement Procedure

The PWR594 EVM includes a 49.9-Ω series resistor in the feedback loop for both V_{OUT1} and V_{OUT2}. These resistors are used for loop response analysis, and are accessible at the test points TP7 and TP8 for V_{OUT1}, and TP28 and TP29 for V_{OUT2}. Those test points should be used during loop response measurements as the injection points for the loop perturbation. See the description in Table 5.

Table 5. List of Test Points for Loop Response Measurements

Test Point	Node Name	Description	Comment
TP8	INPUT1	Input to feedback divider of V_{OUT1}	The amplitude of the perturbation at this node should be limited to less than 100 mV
TP7	OUTPUT1	Resulting output of V_{OUT1}	Bode can be measured by a network analyzer as TP7/TP8
TP28	INPUT2	Input to feedback divider of V_{OUT2}	The amplitude of the perturbation at this node should be limited to less than 100 mV
TP29	VOUT2	Resulting output of V_{OUT2}	Bode can be measured by a network analyzer as TP29/TP28

Measure only one output at a time, with the following procedure:

1. Set up the EVM as described in Figure 3.
2. For V_{OUT1}, connect the network analyzer's isolation transformer from TP7 to TP8,
3. Connect the input signal measurement probe to TP8. Connect the output signal measurement probe to TP7.
4. Connect the ground leads of both probe channels to TP16.
5. On the network analyzer, measure the Bode as TP7/TP8 (Out/In).
6. For V_{OUT2}, connect the network analyzer's isolation transformer from TP29 to TP28.
7. Connect the input signal measurement probe to TP28. Connect output signal measurement probe to TP29.
8. Connect the ground leads of both probe channels to TP15.
9. On the network analyzer, measure the Bode as TP29/TP28 (Out/In).
10. Disconnect the isolation transformer from the bode plot test points before making other measurements, because the signal injection into the feedback loop may interfere with the accuracy of other measurements.

6.3 Efficiency

In order to measure the efficiency of the power train on the EVM, it is important to measure the voltages at the correct location. This is necessary because otherwise the measurements will include losses that are not related to the power train itself. Losses incurred by the voltage drop in the copper traces and in the input and output connectors are not related to the efficiency of the power train, and they should not be included in efficiency measurements.

When measuring the efficiency of V_{OUT1}, disable V_{OUT2} via the Fusion GUI. Likewise, when measuring the efficiency of V_{OUT2}, disable V_{OUT1}.

Input current can be measured at any point in the input wires, and output current can be measured anywhere in the output wires of the output being measured.

Figure 6 shows the measurement points for input voltage and output voltage. VIN1 and VOUT1 are measured to calculate the efficiency of channel 1, and VIN2 and VOUT2 are measured to calculate the efficiency of channel 2. Using these measurement points will result in efficiency measurements that do not include losses due to the connectors and PWB traces.

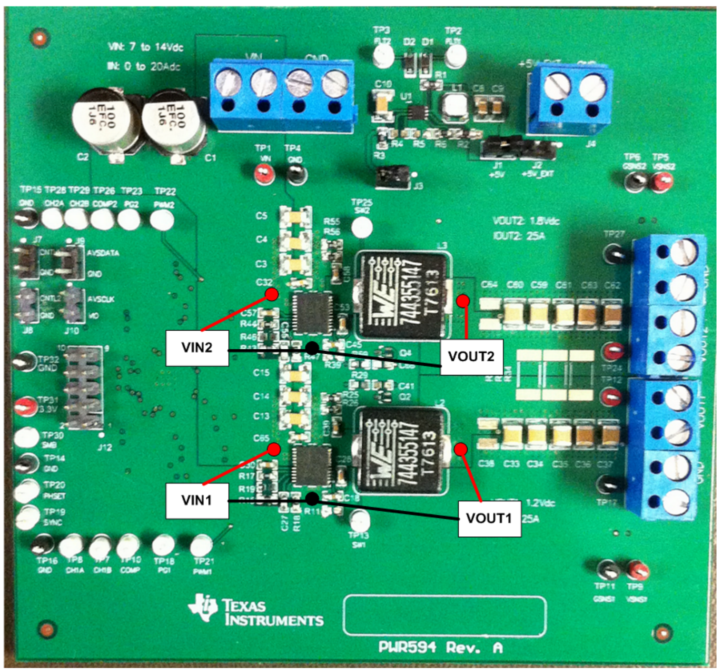


Figure 6. Test Setup for Efficiency Measurement

6.4 Equipment Turn On and Shutdown

- Turn on sequence:
  - Turn on external +5 V if in use. Skip this step if onboard +5 V is in use.
  - Turn on input power supply and increase V_{IN} above 7 V.
  - Turn on PWM.
  - Adjust load current on both outputs, as desired.
- Shutdown sequence:
  - Reduce the load current on both outputs to zero amperes.
  - Turn off PWM.
  - Reduce input voltage to zero volts.
  - Shut down external +5 V, if in use. Skip this step if onboard +5 V is in use.
  - Shut down the external FAN if in use.

7 Performance Data and Typical Characteristic Curves

Figure 7 to Figure 22 present typical performance curves and waveforms for the TPS40425EVM (TPS40425 EVM). Collect curves and waveforms on the TPS40428EVM with the test procedures in the previous section.

7.1 Efficiency

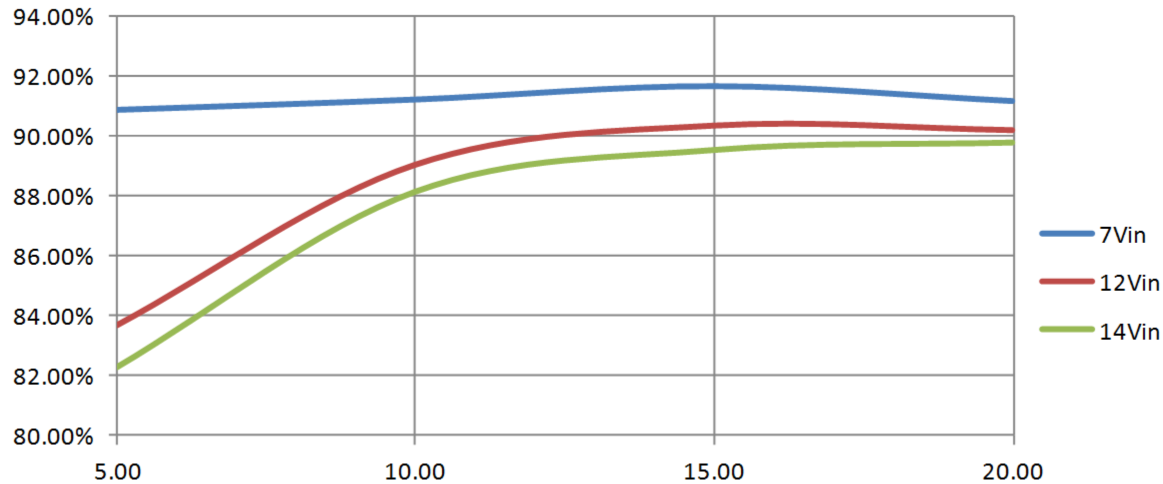


Figure 7. Efficiency of 1.2-V Output Versus Line and Load

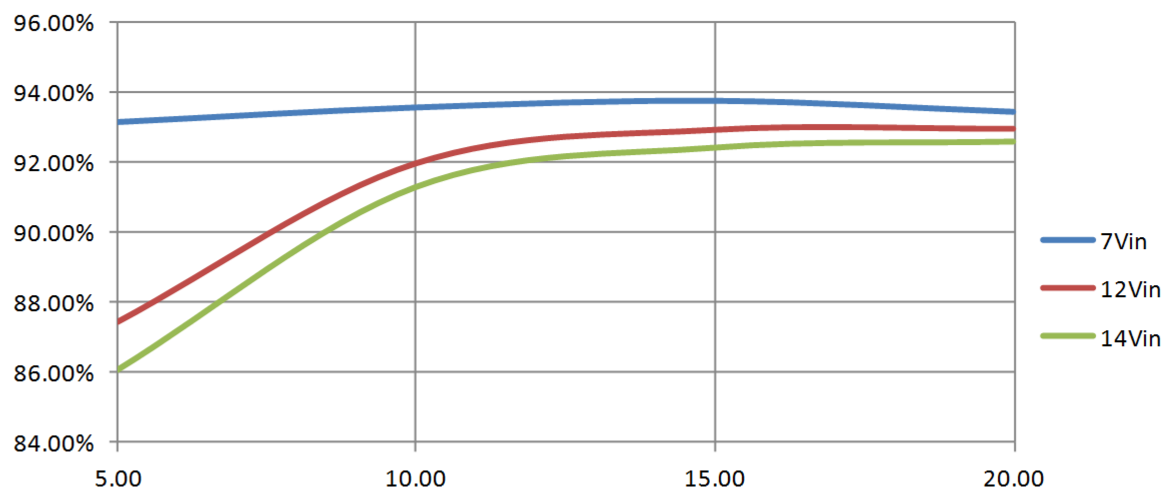


Figure 8. Efficiency of 1.8-V Output Versus Line and Load

7.2 Load Regulation

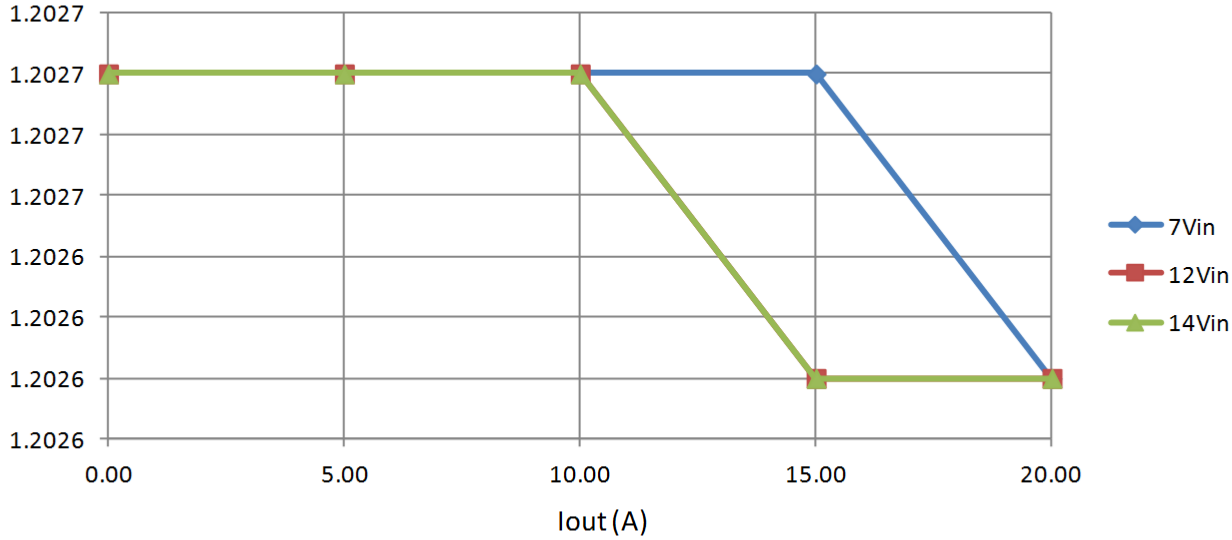


Figure 9. Load Regulation of 1.2-V Output

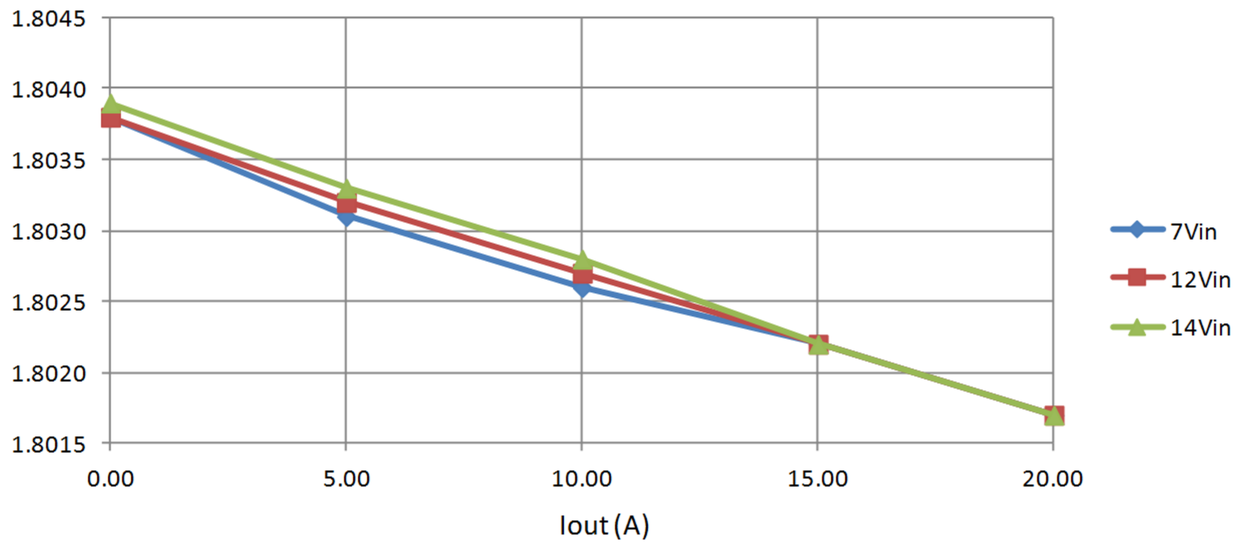


Figure 10. Load Regulation of 1.8-V Output

7.3 Bode Plot

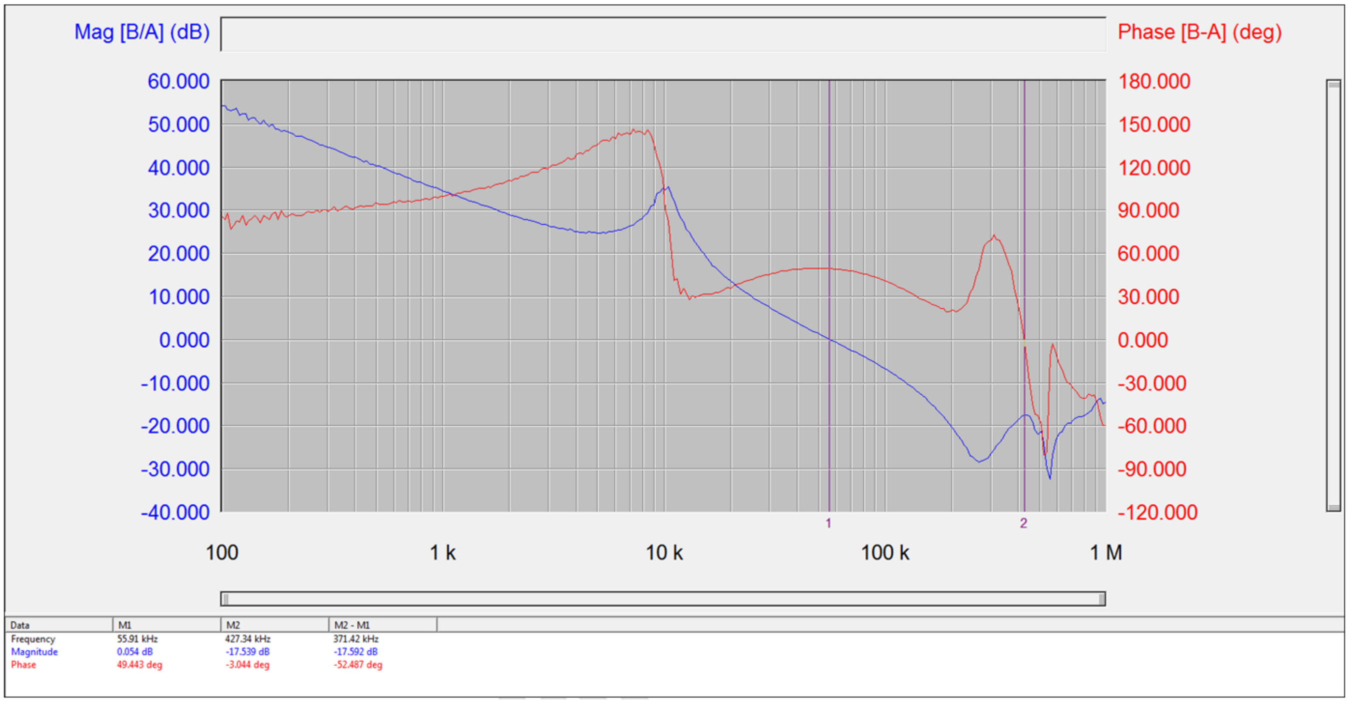


Figure 11. Bode Plot (12 V_{IN}, 1.2 V_{OUT}, 20 A)

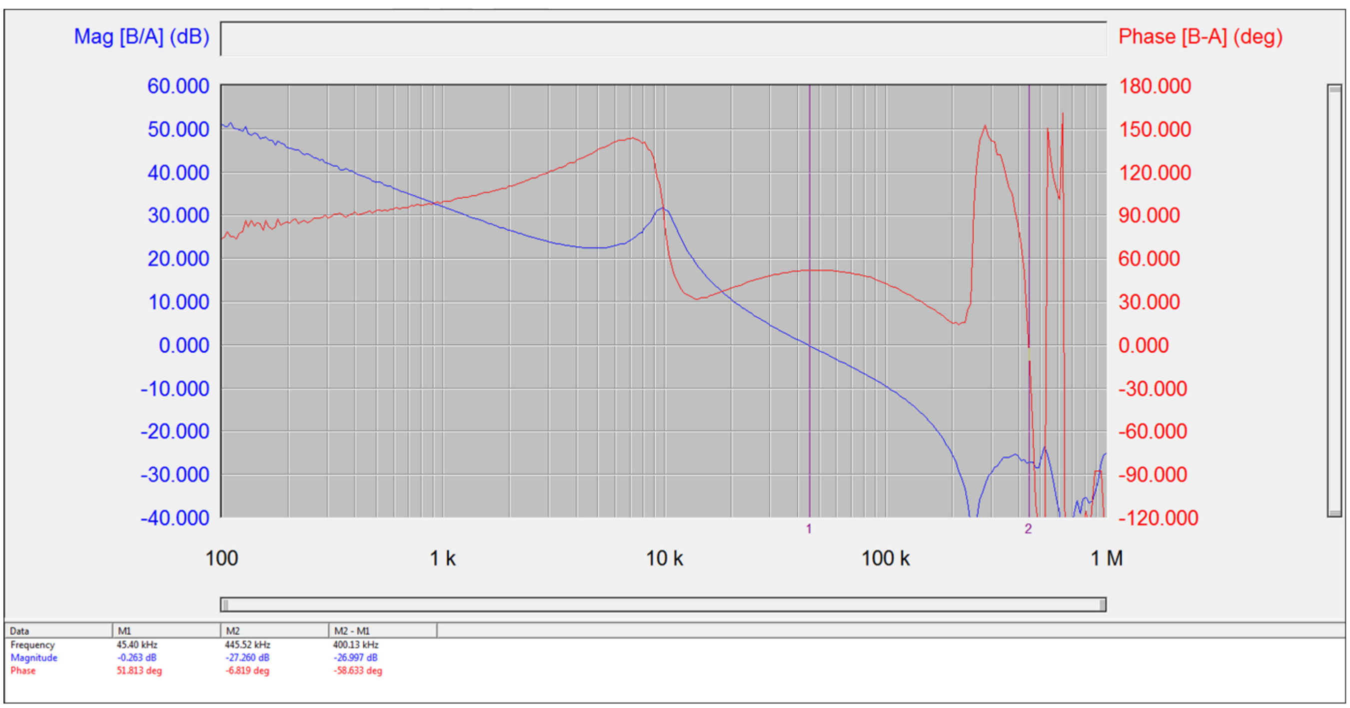
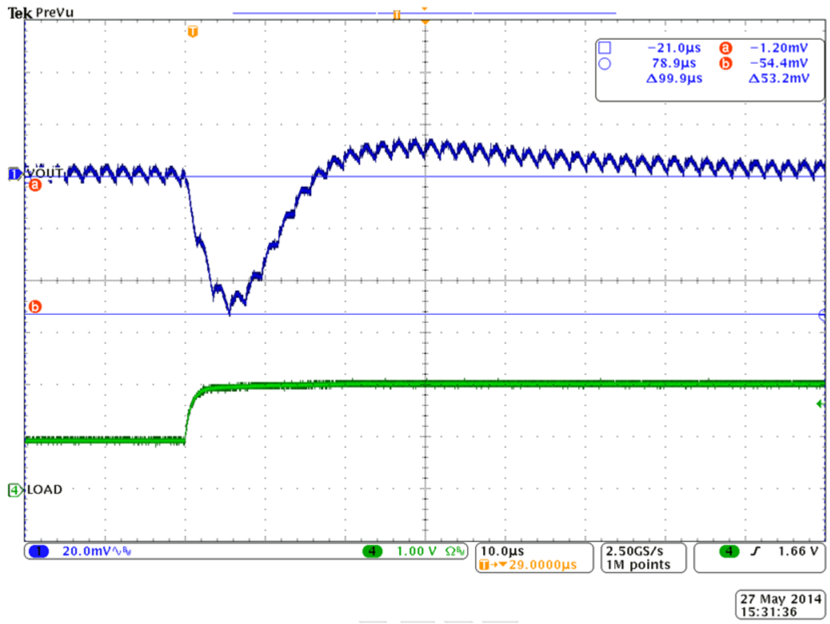


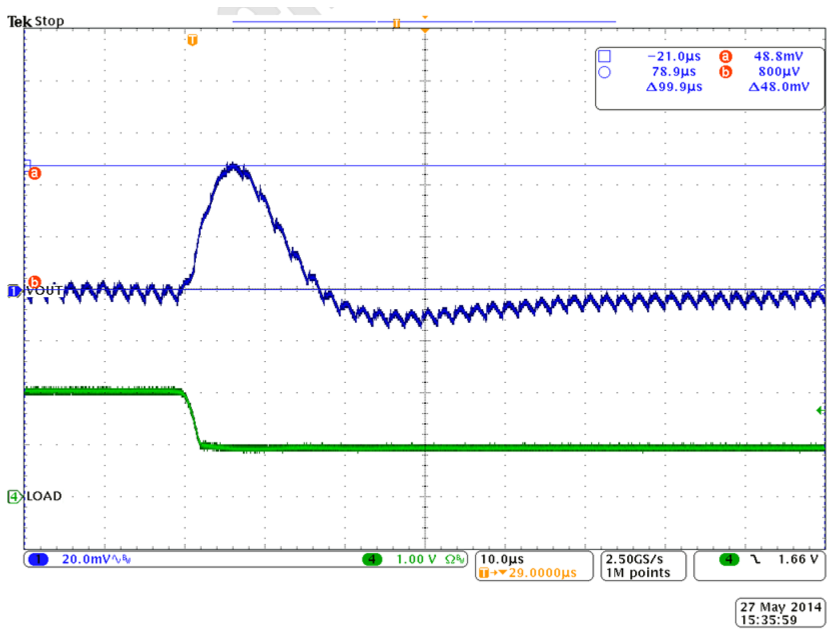
Figure 12. Bode Plot (12 V_{IN}, 1.8 V_{OUT}, 20 A)

7.4 Transient Response



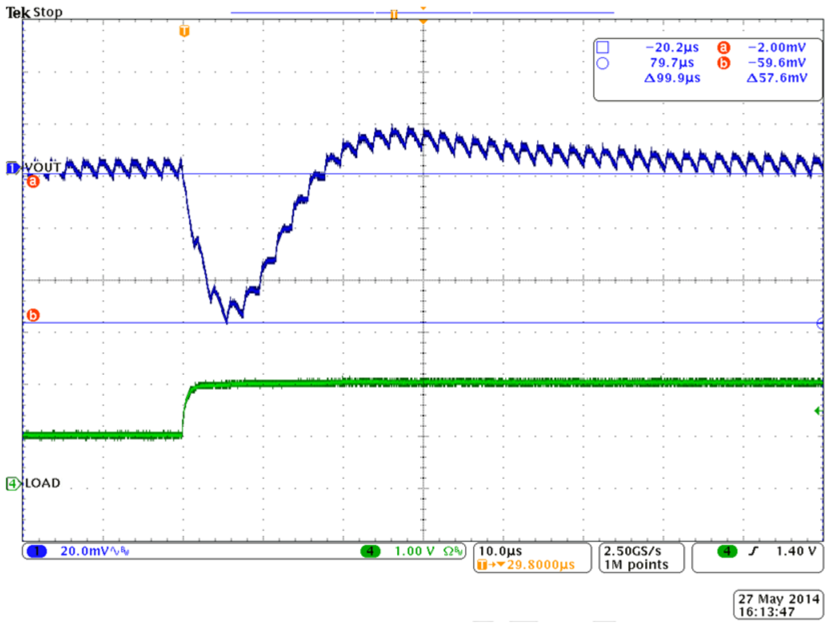
Ch1 = V_{OUT1} at 20 mV/division, Ch2 = Iout1 at 10 A/division

Figure 13. Transient Response (12 V_{IN}, 1.2 V_{OUT}, Load Step 10 A to 20 A, 5 A/µs)



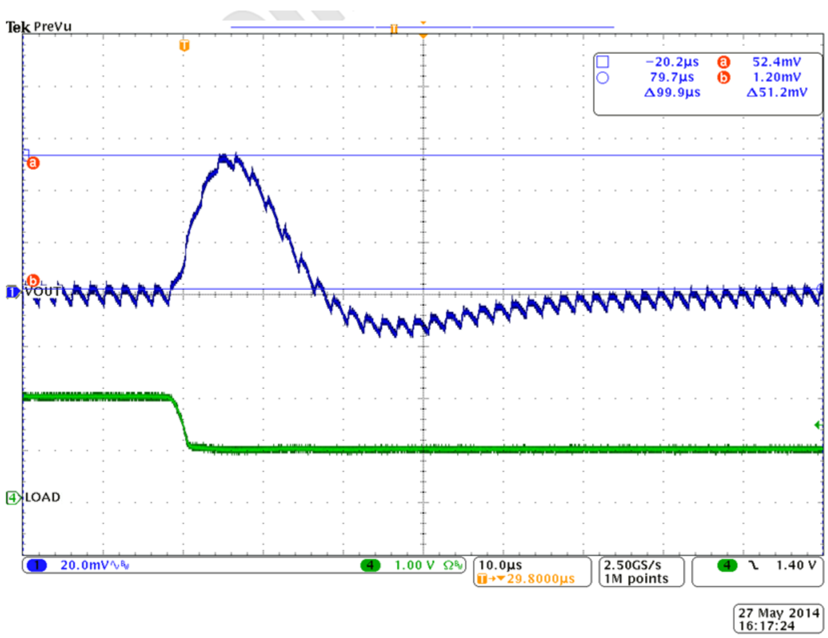
Ch1 = V_{OUT1} at 20 mV/division, Ch2 = Iout1 at 10 A/division

Figure 14. Transient Response (12 V_{IN}, 1.2 V_{OUT}, Load Step 20 A to 10 A, 5 A/µs)



Ch1 = V_{OUT2} at 20 mV/division, Ch2 = Iout2 at 10 A/division

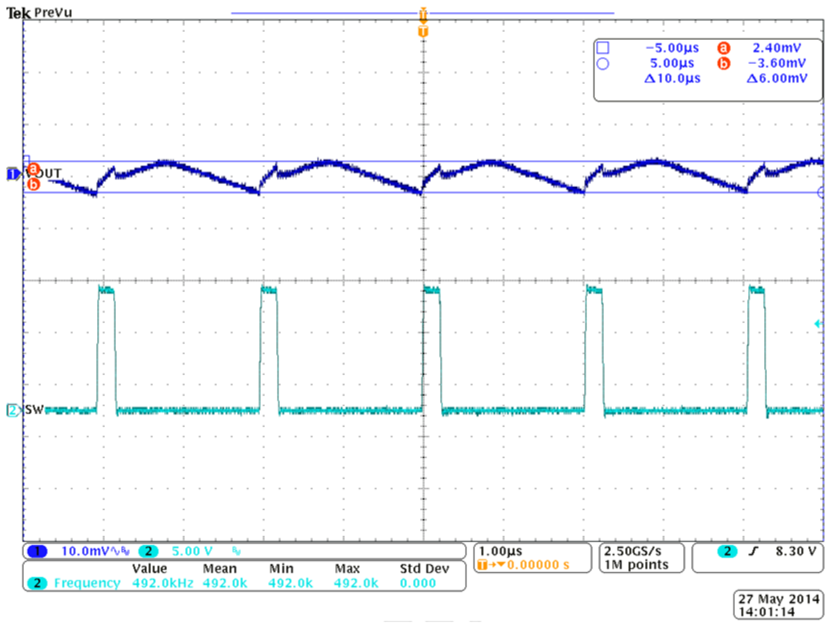
Figure 15. Transient Response (12 V_{IN}, 1.8 V_{OUT}, Load Step 10 A to 20 A, 5 A/µs)



Ch1 = V_{OUT2} at 20 mV/division, Ch2 = Iout2 at 10 A/division

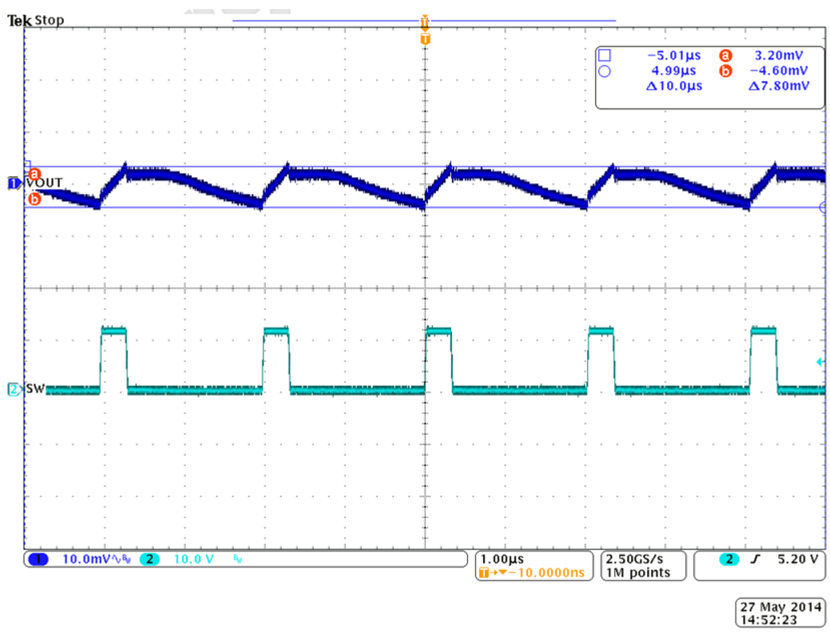
Figure 16. Transient Response (12 V_{IN}, 1.8 V_{OUT}, Load Step 20 A to 10 A, 5 A/µs)

7.5 Output Ripple



Ch1 = V_{OUT1} at 10 mV/division, Ch2 = SW node at 5 V/division

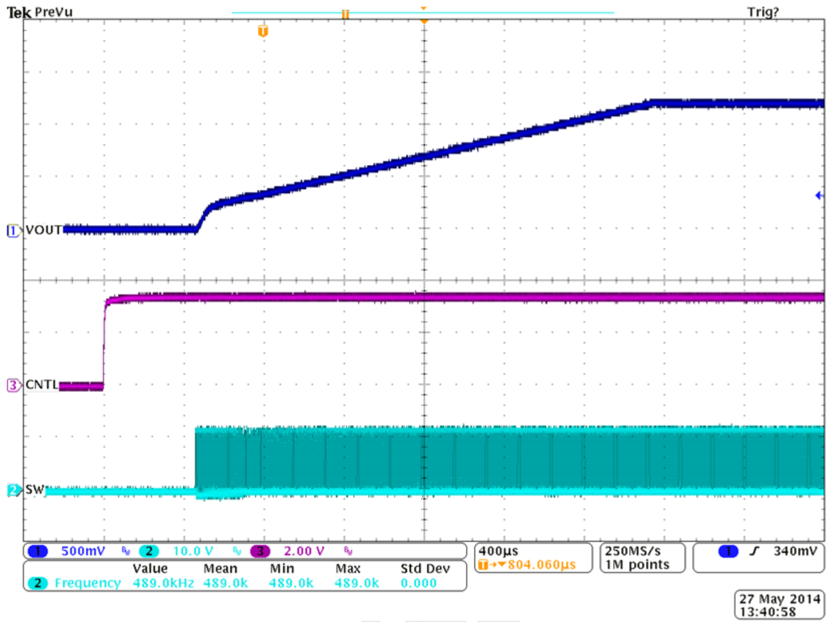
Figure 17. Output Ripple (12 V_{IN}, 1.2 V_{OUT}, 20 A)



Ch1 = V_{OUT2} at 10 mV/division, Ch2 = SW node at 10 V/division

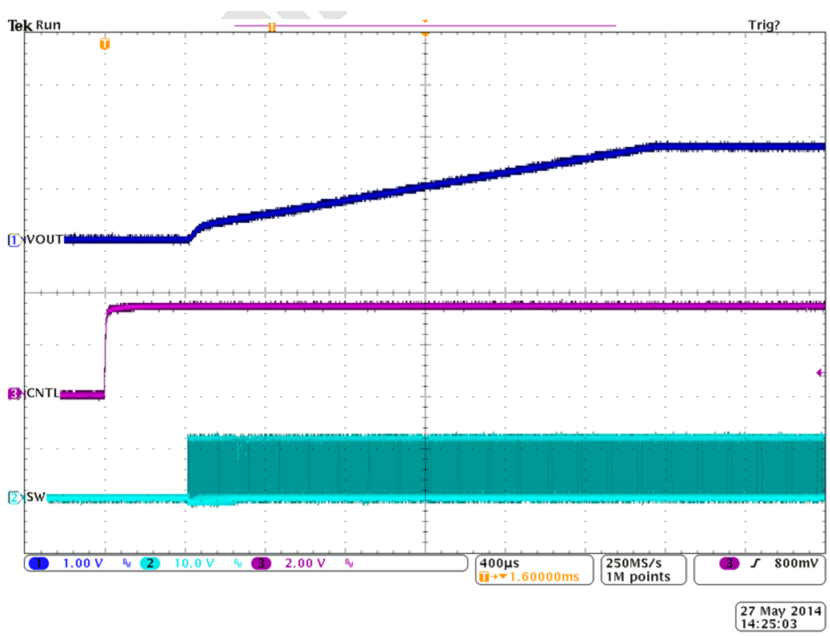
Figure 18. Output Ripple (12 V_{IN}, 1.8 V_{OUT}, 20 A)

7.6 Enable Turn On and Turn Off Waveforms



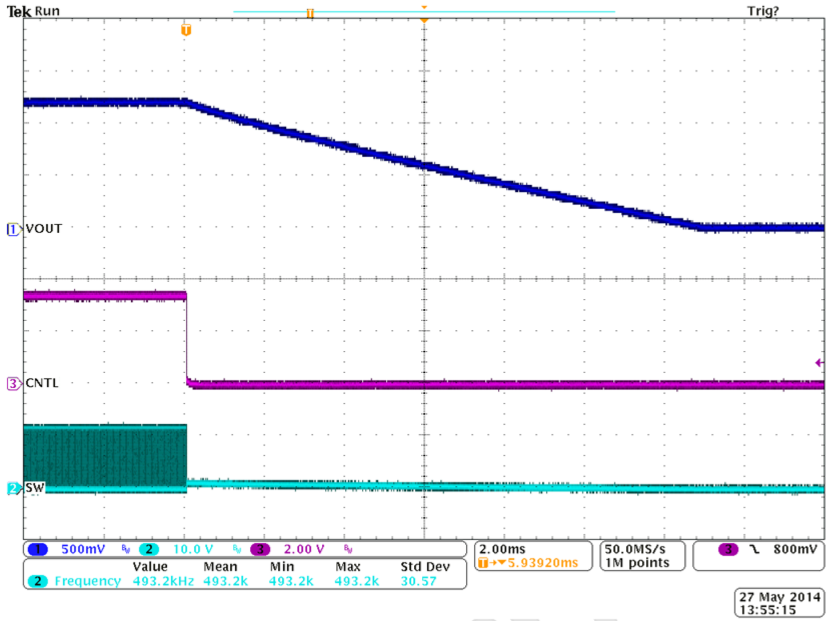
Ch1 = V_{OUT1} at 500 mV/division, Ch2 = SW node at 10 V/division, Ch3 = CNTL1 at 2 V/division

Figure 19. Enable Startup (12 V_{IN}, 1.2 V_{OUT}, 0 A)



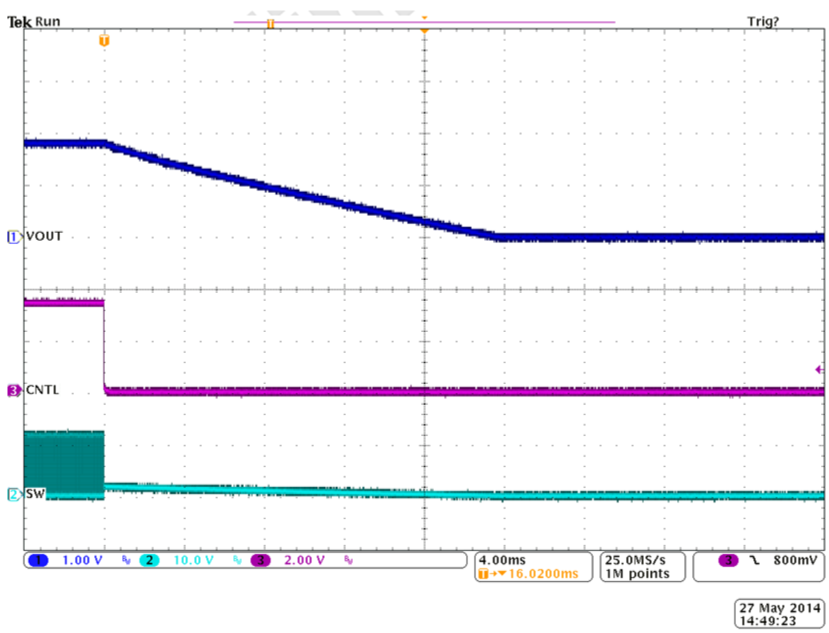
Ch1 = V_{OUT2} at 1 V/division, Ch2 = SW node at 10 V/division, Ch3 = CNTL2 at 2 V/division

Figure 20. Enable Startup (12 V_{IN}, 1.8 V_{OUT}, 0 A)



Ch1 = V_{OUT1} at 500 mV/division, Ch2 = SW node at 10 V/division, Ch3 = CNTL1 at 2 V/division

Figure 21. Enable Startup (12 V_{IN}, 1.2 V_{OUT}, 0.1 A)



Ch1 = V_{OUT2} at 1 V/division, Ch2 = SW node at 10 V/division, Ch3 = CNTL2 at 2 V/division

Figure 22. Enable Startup (12 V_{IN}, 1.8 V_{OUT}, 0.1 A)

8 EVM Assembly Drawing and PCB Layout

Figure 23 through Figure 30 show the design of the PWR594 EVM printed circuit board.

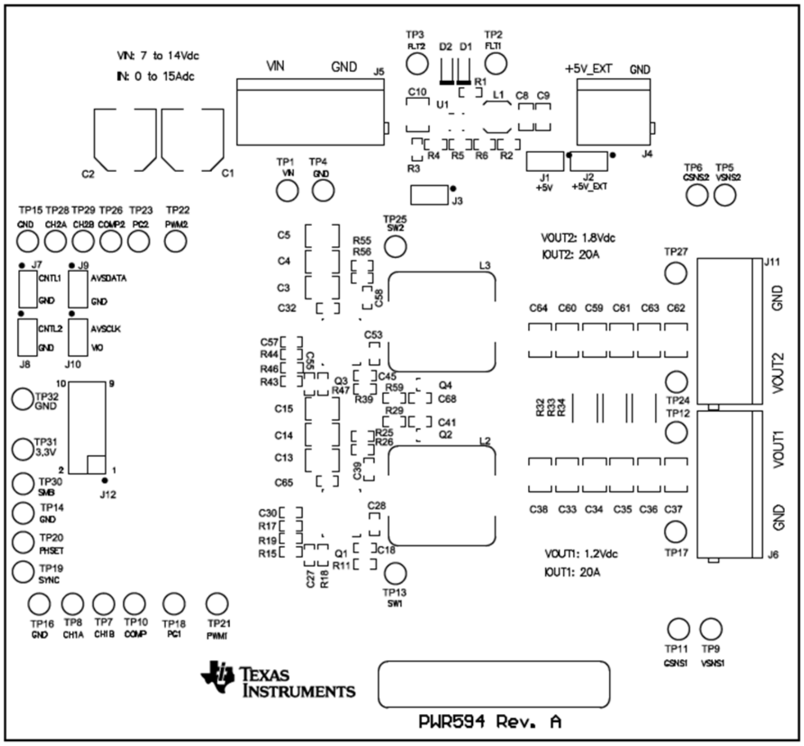


Figure 23. PWR594 EVM Top Layer Assembly Drawing (Top View)

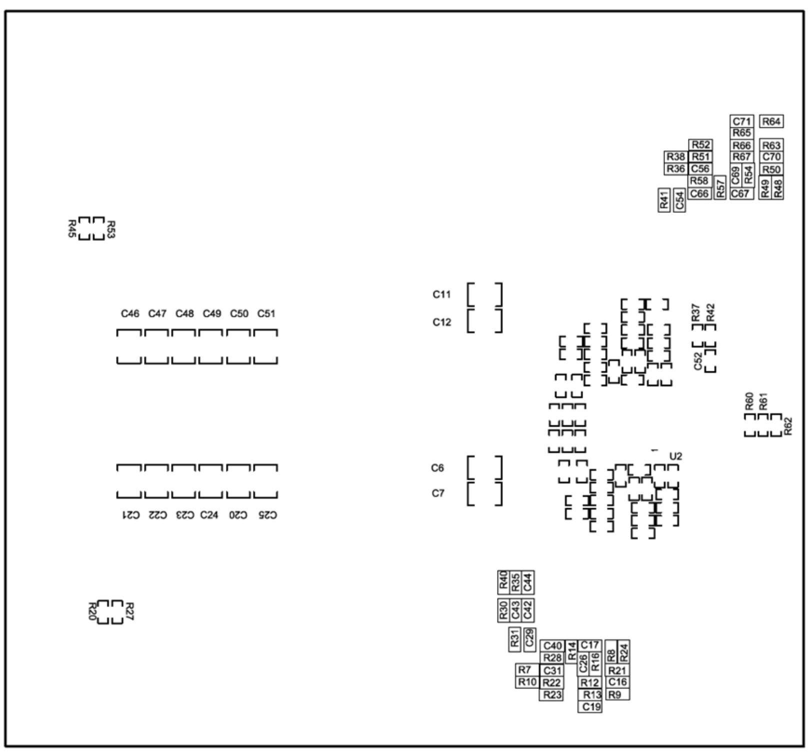


Figure 24. PWR594 EVM Bottom Assembly Drawing (Bottom View)

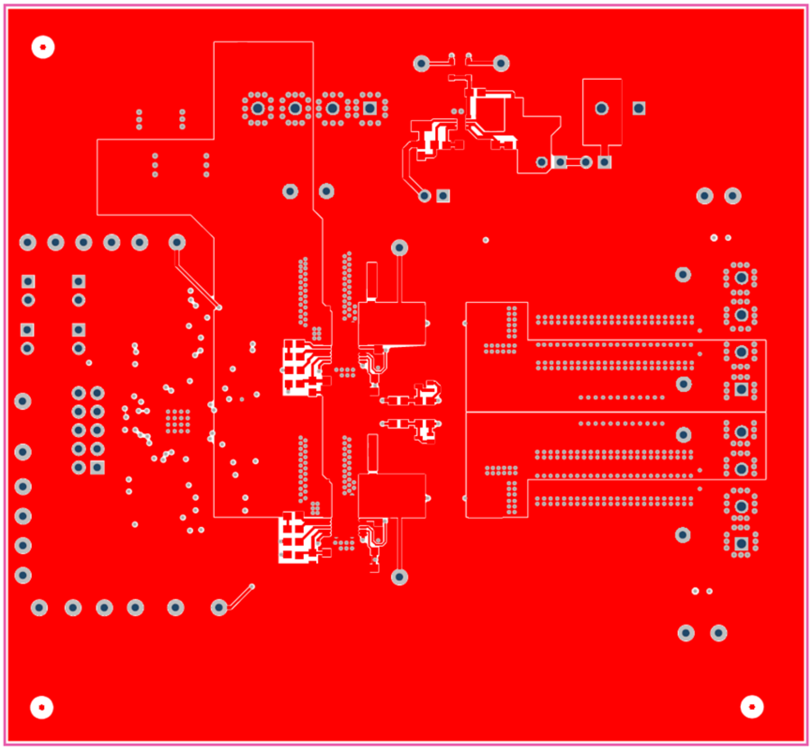


Figure 25. PWR594 EVM Top Copper (Top View)

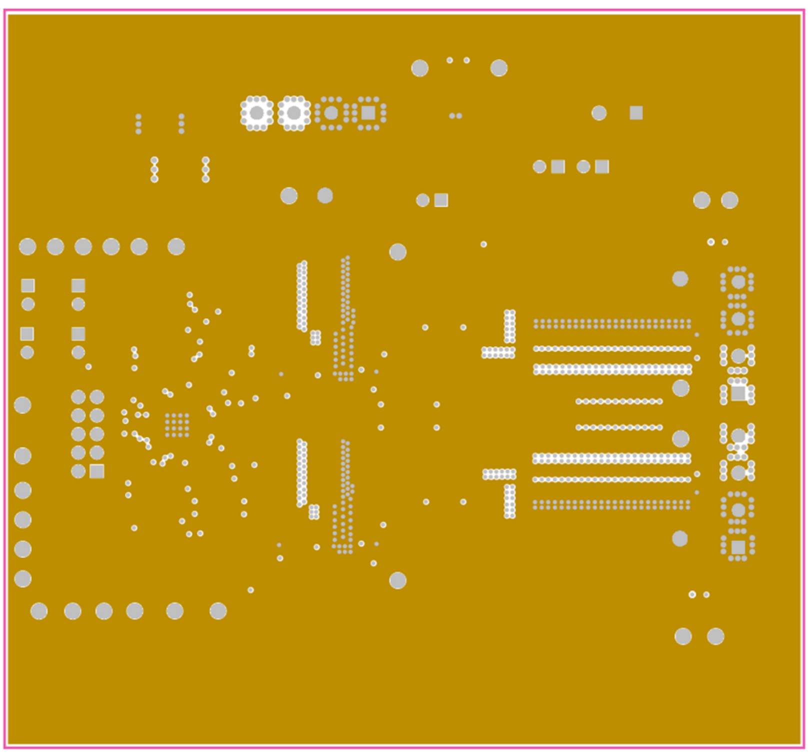


Figure 26. PWR594 EVM Internal Layer 1 (Top View)

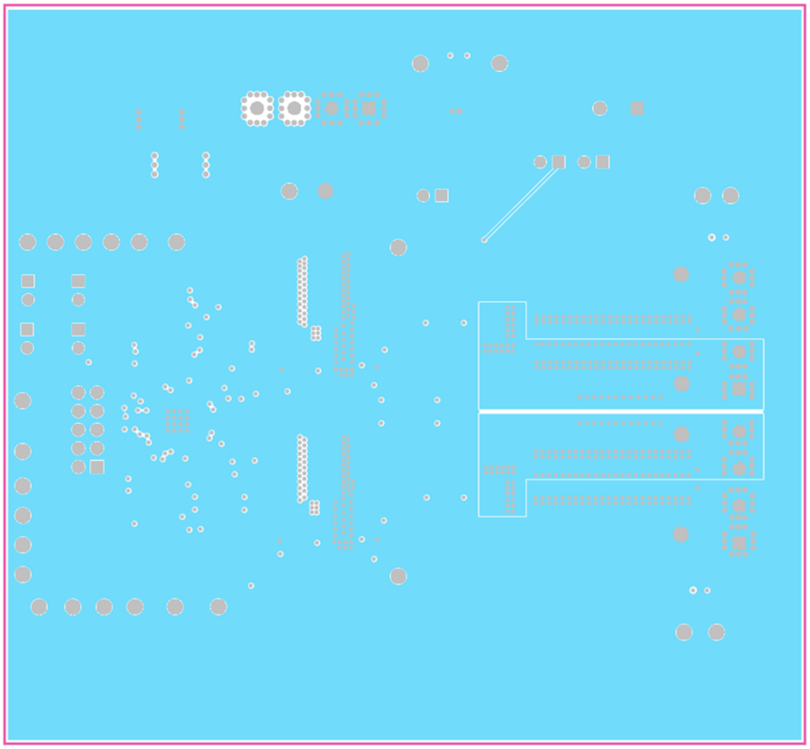


Figure 27. PWR594 EVM Internal Layer 2 (Top View)

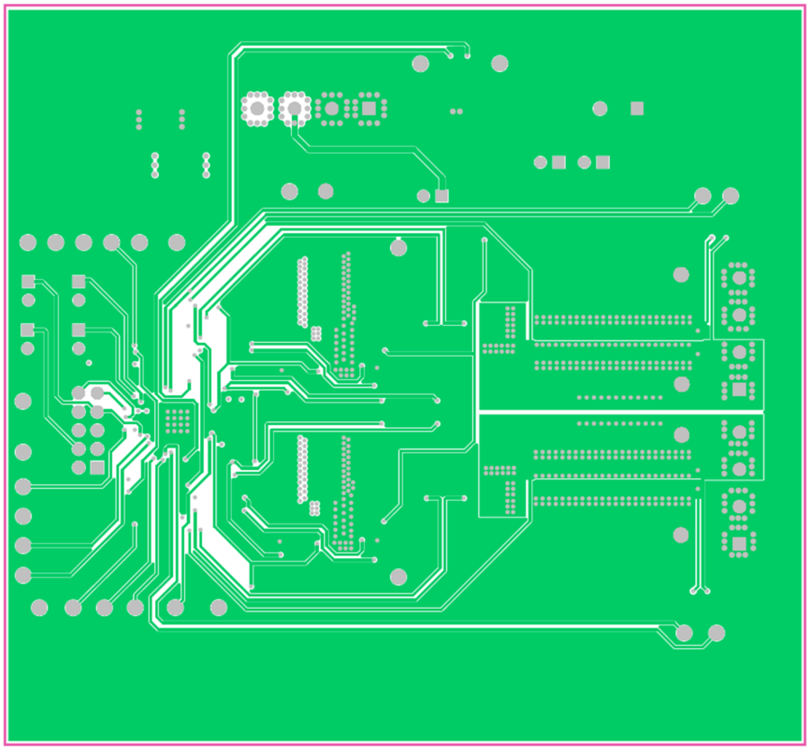


Figure 28. PWR594 EVM Internal Layer 3 (Top View)

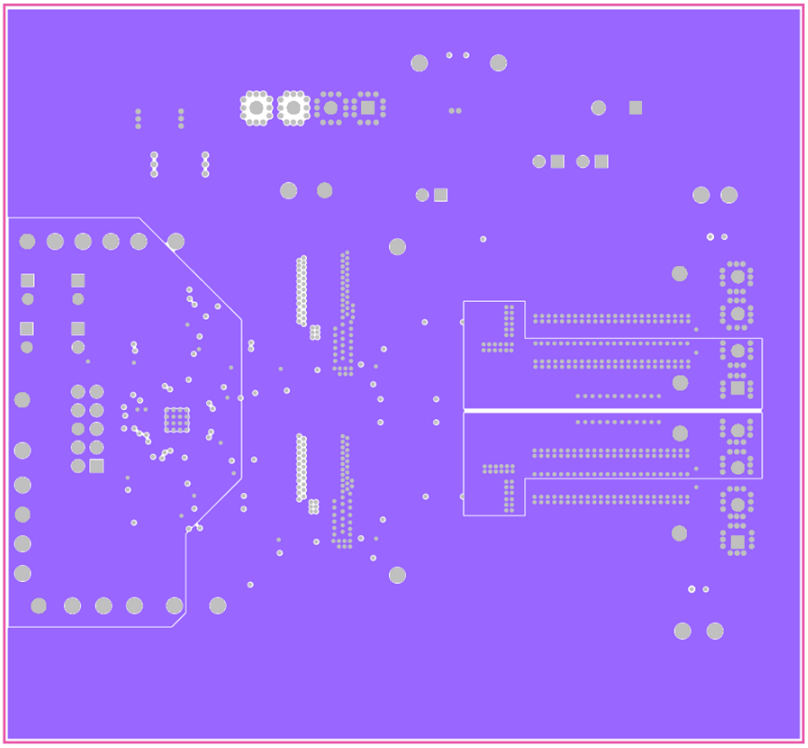


Figure 29. PWR594 EVM Internal Layer 4 (Top View)

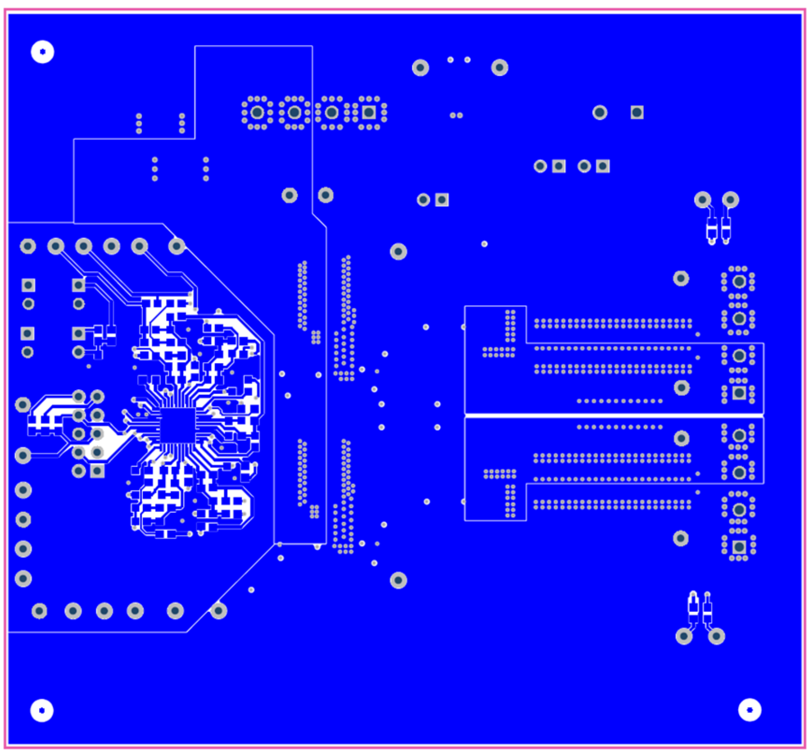


Figure 30. PWR594 EVM Bottom Copper (Top View)

9 Bill of Materials

Table 6 lists the BOM for the PWR594-001 (TPS40425 EVM). Table 7 lists the BOM for the PWR594-002 (TPS40428 EVM).

Table 6. TPS40425EVM-PWR594 Components List

Qty	Designator	Description	Part Number	Manufacturer
2	C1, C2	CAP, AL, 100 µF, 25 V, ±20%, 0.3 Ω, SMD	EEE-FC1E101P	Panasonic
11	C3–C7, C10– C15	CAP, CERM, 22 µF, 25 V, ±10%, X5R, 1210	STD	STD
2	C8, C9	CAP, CERM, 10 µF, 10 V, ±10%, X5R, 0805	STD	STD
2	C16, C70	CAP, CERM, 1500 pF, 25 V, ±10%, X7R, 0603	STD	STD
2	C17, C67	CAP, CERM, 100 pF, 50 V, ±5%, C0G/NP0, 0603	STD	STD
7	C18, C30, C31, C45, C52, C56, C57	CAP, CERM, 0.1 µF, 25 V, ±10%, X7R, 0603	STD	STD
20	C20–C24, C33–C37, C46–C50, C59–C63	CAP, CERM, 100 µF, 6.3 V, ±20%, X5R, 1210	STD	STD
2	C26, C69	CAP, CERM, 3300 pF, 25 V, ±10%, X7R, 0603	STD	STD
4	C27, C29, C54, C55	CAP, CERM, 470 pF, 50 V, ±10%, X7R, 0603	STD	STD
5	C28, C42–C44, C53	CAP, CERM, 1 µF, 25 V, ±10%, X5R, 0603	STD	STD
2	C32, C65	CAP, CERM, 3300 pF, 50 V, ±10%, X7R, 0603	STD	STD
4	C39, C41, C58, C68	CAP, CERM, 1000 pF, 50 V, ±10%, X7R, 0603	STD	STD
2	C40, C66	CAP, CERM, 0.22 µF, 25 V, ±10%, X7R, 0603	STD	STD
2	D1, D2	Diode, Schottky, 30 V, 0.2 A, SOD-323	BAT54HT1G	ON Semiconductor
7	J1–J3, J7–J10	Header, 100 mil, 2x1, Tin plated, TH	PEC02SAAN	Sullins Connector Solutions
1	J4	TERMINAL BLOCK 5.08 mm VERT 2POS, TH	ED120/2DS	On-Shore Technology
3	J5, J6, J11	TERMINAL BLOCK 5.08 mm VERT 4POS, TH	ED120/4DS	On-Shore Technology
1	J12	Header, 100 mil, 5x2, Tin plated, TH	PEC05DAAN	Sullins Connector Solutions
1	L1	Inductor, Shielded Drum Core, Ferrite, 10 µH, 0.7 A, 0.33 Ω, SMD	LPS3314-103MLB	Coilcraft
2	L2, L3	Inductor, Shielded Drum Core, WE-Perm, 470 nH, 30 A, 0.00067 Ω, SMD	744355147	Wurth Elektronik eiSos
2	Q1, Q3	Synchronous Buck NexFET Power Stage, DQP0012A	CSD95378BQ5M	Texas Instruments
2	Q2, Q4	Transistor, NPN, 20 V, 0.2 A, SOT-523	MMBT3904T-7-F	Diodes Inc.
1	R2	RES, 1.10 MΩ, 1%, 0.1 W, 0603	STD	STD
5	R3, R22, R29, R51, R59	RES, 0 Ω, 5%, 0.1 W, 0603	STD	STD
1	R6	RES, 210 kΩ, 1%, 0.1 W, 0603	STD	STD
2	R8, R64	RES, 49.9 Ω, 1%, 0.1 W, 0603	STD	STD
6	R1, R9, R13, R30, R40, R63	RES, 10.0 kΩ, 1%, 0.1 W, 0603	STD	STD
2	R12, R67	RES, 280 Ω, 1%, 0.1 W, 0603	STD	STD
3	R16, R54, R66	RES, 4.99 kΩ, 1%, 0.1 W, 0603	STD	STD
7	R17, R25, R26, R35, R44, R55, R56	RES, 1.00 Ω, 1%, 0.1 W, 0603	STD	STD
2	R18, R47	RES, 121 kΩ, 1%, 0.1 W, 0603	STD	STD
4	R20, R27, R45, R53	RES, 10.0 Ω, 1%, 0.1 W, 0603	STD	STD
2	R23, R52	RES, 4.22 kΩ, 1%, 0.1 W, 0603	STD	STD
1	R24	RES, 40.2 kΩ, 1%, 0.1 W, 0603	STD	STD
2	R28, R58	RES, 12.4 kΩ, 1%, 0.1 W, 0603	STD	STD
2	R37, R42	RES, 100 Ω, 1%, 0.1 W, 0603	STD	STD
2	R48, R49	RES, 16.2 kΩ, 1%, 0.1 W, 0603	STD	STD
2	SH-J1, SH-J3	Shunt, 100 mil, Gold plated, Black	969102-0000-DA	3M
6	TP1, TP5, TP9, TP12, TP24, TP31	Test Point, Miniature, Red, TH	5000	Keystone
17	TP2, TP3, TP7, TP8, TP10, TP13, TP18–TP23, TP25, TP26, TP28–TP30	Test Point, Miniature, White, TH	5002	Keystone

Table 6. TPS40425EVM-PWR594 Components List (continued)

Qty	Designator	Description	Part Number	Manufacturer
9	TP4, TP6, TP11, TP14–TP17, TP27, TP32	Test Point, Miniature, Black, TH	5001	Keystone
1	U1	IC, 3 V–17 V, 200 mA High Efficient Buck Converter	TPS62125DSG	TI
1	U2	IC, Dual output, 2-Phase, Stackable PMBUS Synchronous Buck Driverless Controller with AVS Bus	TPS40425RHA	TI

Table 7. TPS40428EVM-PWR594 Components List

Qty	Designator	Description	Part Number	Manufacturer
2	C1, C2	CAP, AL, 100 µF, 25 V, ±20%, 0.3 Ω, SMD	EEE-FC1E101P	Panasonic
11	C3–C7, C10–C15	CAP, CERM, 22 µF, 25 V, ±10%, X5R, 1210	STD	STD
2	C8, C9	CAP, CERM, 10 µF, 10 V, ±10%, X5R, 0805	STD	STD
2	C16, C70	CAP, CERM, 1500 pF, 25 V, ±10%, X7R, 0603	STD	STD
2	C17, C67	CAP, CERM, 100 pF, 50 V, ±5%, C0G/NP0, 0603	STD	STD
7	C18, C30, C31, C45, C52, C56, C57	CAP, CERM, 0.1 µF, 25 V, ±10%, X7R, 0603	STD	STD
20	C20–C24, C33–C37, C46–C50, C59–C63	CAP, CERM, 100 µF, 6.3 V, ±20%, X5R, 1210	STD	STD
2	C26, C69	CAP, CERM, 3300 pF, 25 V, ±10%, X7R, 0603	STD	STD
4	C27, C29, C54, C55	CAP, CERM, 470 pF, 50 V, ±10%, X7R, 0603	STD	STD
5	C28, C42–C44, C53	CAP, CERM, 1 µF, 25 V, ±10%, X5R, 0603	STD	STD
2	C32, C65	CAP, CERM, 3300 pF, 50 V, ±10%, X7R, 0603	STD	STD
2	C39, C58	CAP, CERM, 1000 pF, 50 V, ±10%, X7R, 0603	STD	STD
2	D1, D2	Diode, Schottky, 30 V, 0.2 A, SOD-323	BAT54HT1G	ON Semiconductor
7	J1–J3, J7–J10	Header, 100 mil, 2x1, Tin plated, TH	PEC02SAAN	Sullins Connector Solutions
1	J4	TERMINAL BLOCK 5.08 mm VERT 2POS, TH	ED120/2DS	On-Shore Technology
3	J5, J6, J11	TERMINAL BLOCK 5.08 mm VERT 4POS, TH	ED120/4DS	On-Shore Technology
1	J12	Header, 100 mil, 5x2, Tin plated, TH	PEC05DAAN	Sullins Connector Solutions
1	L1	Inductor, Shielded Drum Core, Ferrite, 10 µH, 0.7 A, 0.33 Ω, SMD	LPS3314-103MLB	Coilcraft
2	L2, L3	Inductor, Shielded Drum Core, WE-Perm, 470 nH, 30 A, 0.00067 Ω, SMD	744355147	Wurth Elektronik eiSos
1	LBL1	Thermal Transfer Printable Labels, 1.250" W x 0.250" H - 10,000 per roll	THT-13-457-10	Brady
2	Q1, Q3	Synchronous Buck NexFET Power Stage, DQP0012A	CSD95378BQ5M	Texas Instruments
1	R2	RES, 1.10 MΩ, 1%, 0.1 W, 0603	STD	STD
7	R3, R7, R10, R15, R36, R38, R43	RES, 0 Ω, 5%, 0.1 W, 0603	STD	STD
1	R6	RES, 210 kΩ, 1%, 0.1 W, 0603	STD	STD
2	R8, R64	RES, 49.9 Ω, 1%, 0.1 W, 0603	STD	STD
6	R1, R9, R13, R30, R40, R63	RES, 10.0 kΩ, 1%, 0.1 W, 0603	STD	STD
2	R12, R67	RES, 280 Ω, 1%, 0.1 W, 0603	STD	STD
3	R16, R54, R66	RES, 4.99 kΩ, 1%, 0.1 W, 0603	STD	STD
7	R17, R25, R26, R35, R44, R55, R56	RES, 1.00 Ω, 1%, 0.1 W, 0603	STD	STD
2	R18, R47	RES, 121 kΩ, 1%, 0.1 W, 0603	STD	STD
4	R20, R27, R45, R53	RES, 10.0 Ω, 1%, 0.1 W, 0603	STD	STD
1	R24	RES, 40.2 kΩ, 1%, 0.1 W, 0603	STD	STD
2	R37, R42	RES, 100 Ω, 1%, 0.1 W, 0603	STD	STD
2	R48, R49	RES, 16.2 kΩ, 1%, 0.1 W, 0603	STD	STD
2	SH-J1, SH-J3	Shunt, 100 mil, Gold plated, Black	969102-0000-DA	3M
6	TP1, TP5, TP9, TP12, TP24, TP31	Test Point, Miniature, Red, TH	5000	Keystone

Table 7. TPS40428EVM-PWR594 Components List (continued)

Qty	Designator	Description	Part Number	Manufacturer
17	TP2, TP3, TP7, TP8, TP10, TP13, TP18–TP23, TP25, TP26, TP28–TP30	Test Point, Miniature, White, TH	5002	Keystone
9	TP4, TP6, TP11, TP14–TP17, TP27, TP32	Test Point, Miniature, Black, TH	5001	Keystone
1	U1	IC, 3 V-17 V, 200-mA High Efficient Buck Converter	TPS62125DSG	TI
1	U2	IC, Dual output, 2-Phase, Stackable PMBUS Synchronous Buck Driverless Controller with AVS Bus	TPS40428RHA	TI

10 Screenshots

10.1 Fusion GUI Screenshots

When launching the Fusion GUI, select DEVICE_CODE as scanning mode to find TPS40425 or TPS40428.

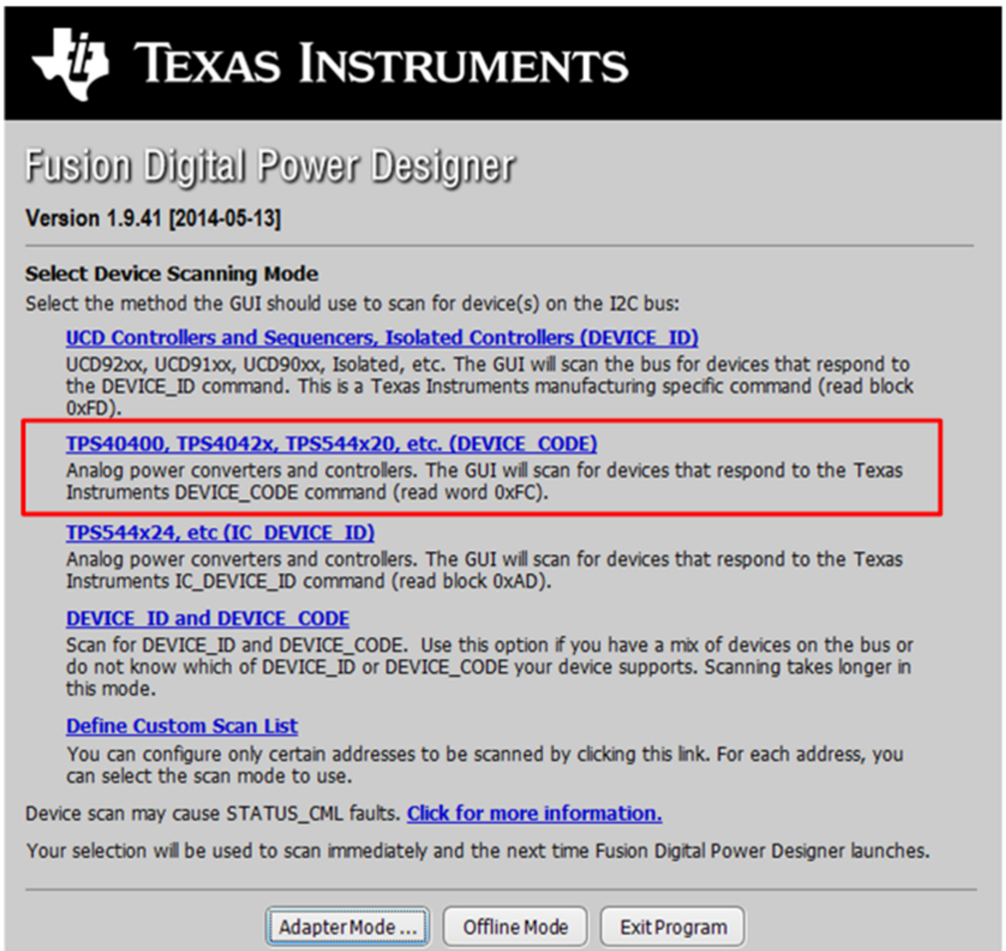


Figure 31. Select Device Scanning Mode

- Use the screen displayed in Figure 32 to configure the following:
  – OC Fault and OC Warn
  – OT Fault and OT Warn
  – Power Good Limits
  – Fault response
  – UVLO
  – On/Off Config
  – Soft Start time
  – Margin voltage

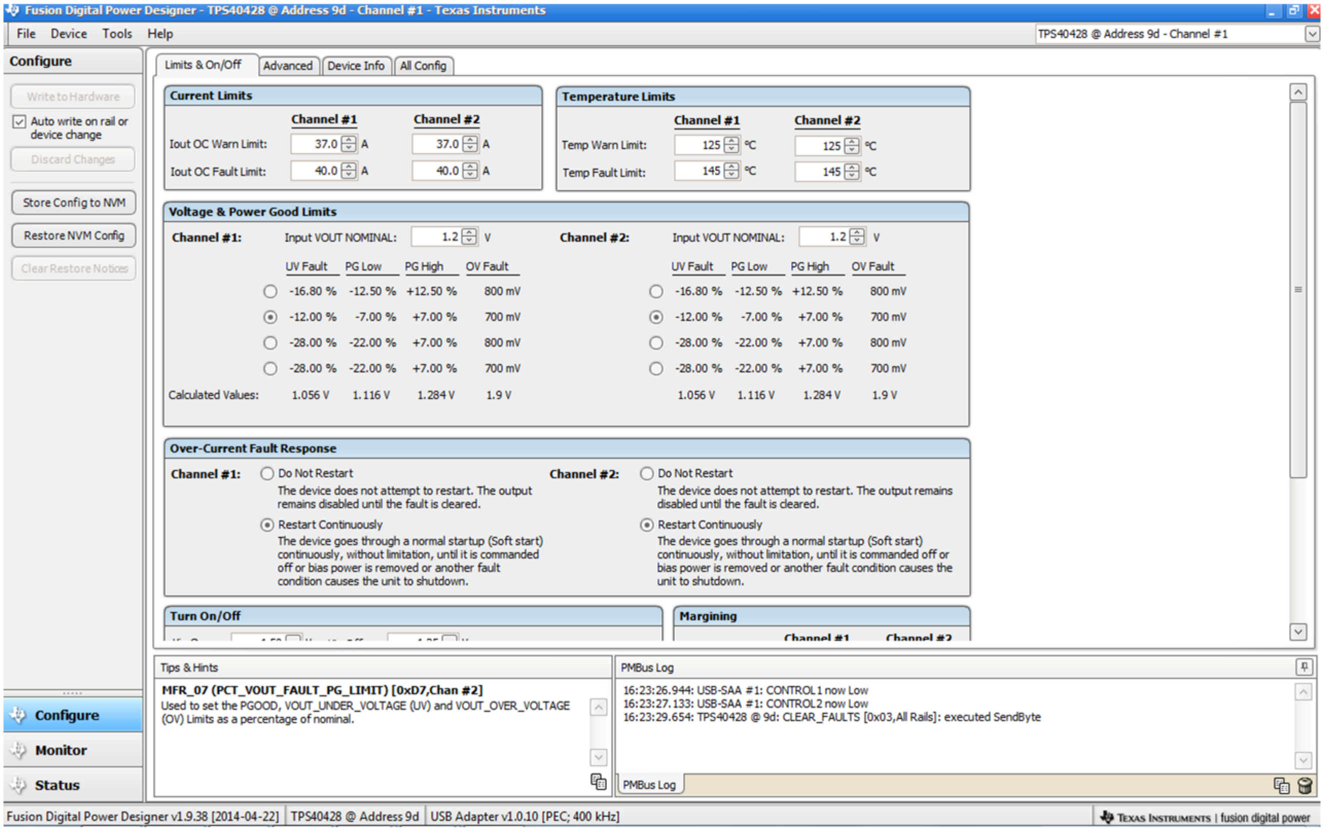


Figure 32. Configure- Limits and On/Off

- Use the screen in Figure 33 to configure:
  - Vref Trim
  - IOUT_CAL_GAIN
  - Write Protect
  - MFR_SPECIFIC_21 register

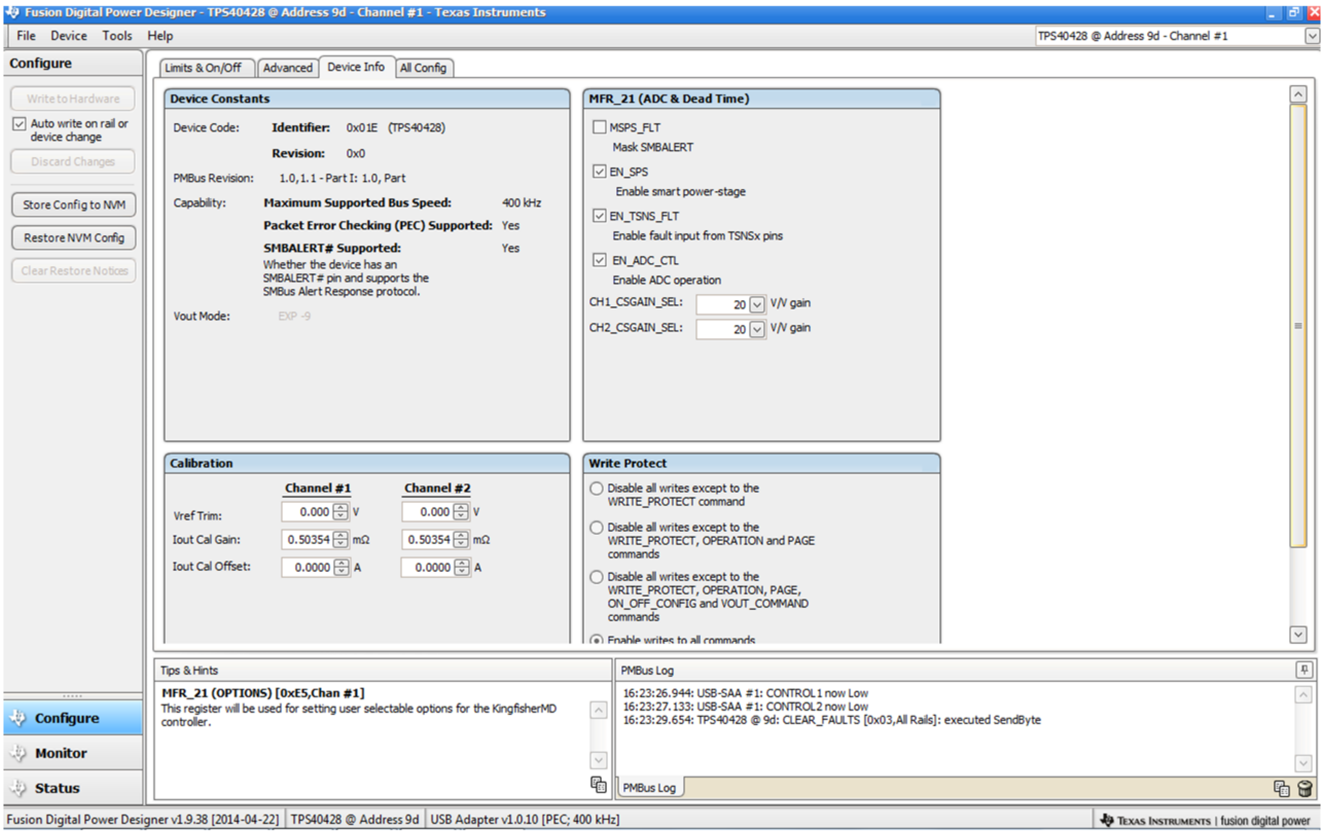


Figure 33. Configure - Device Information

Use this screen (Figure 34) to configure all of the configurable parameters, also shows other details like Hex encoding.

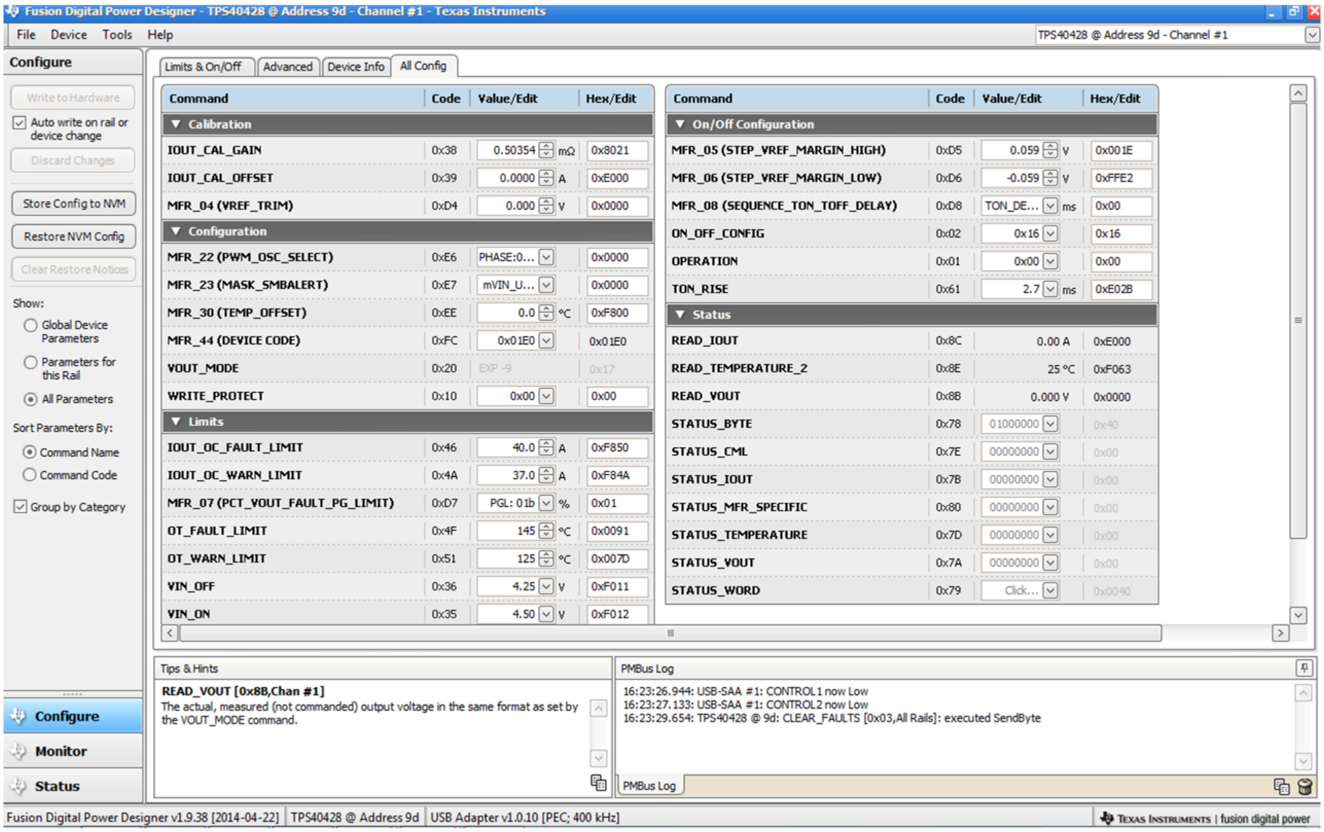


Figure 34. Configure - All Config

After a change is selected, an orange “U” icon is displayed, offering an *Undo Change* option. Change is not retained until either *Write to Hardware* or *Store User Defaults* is selected. When *Write to Hardware* is selected, the change is committed to volatile memory and defaults back to previous setting upon input power cycle. When *Store User Defaults* is selected, the change is committed to non-volatile memory and becomes the new default (Figure 35)

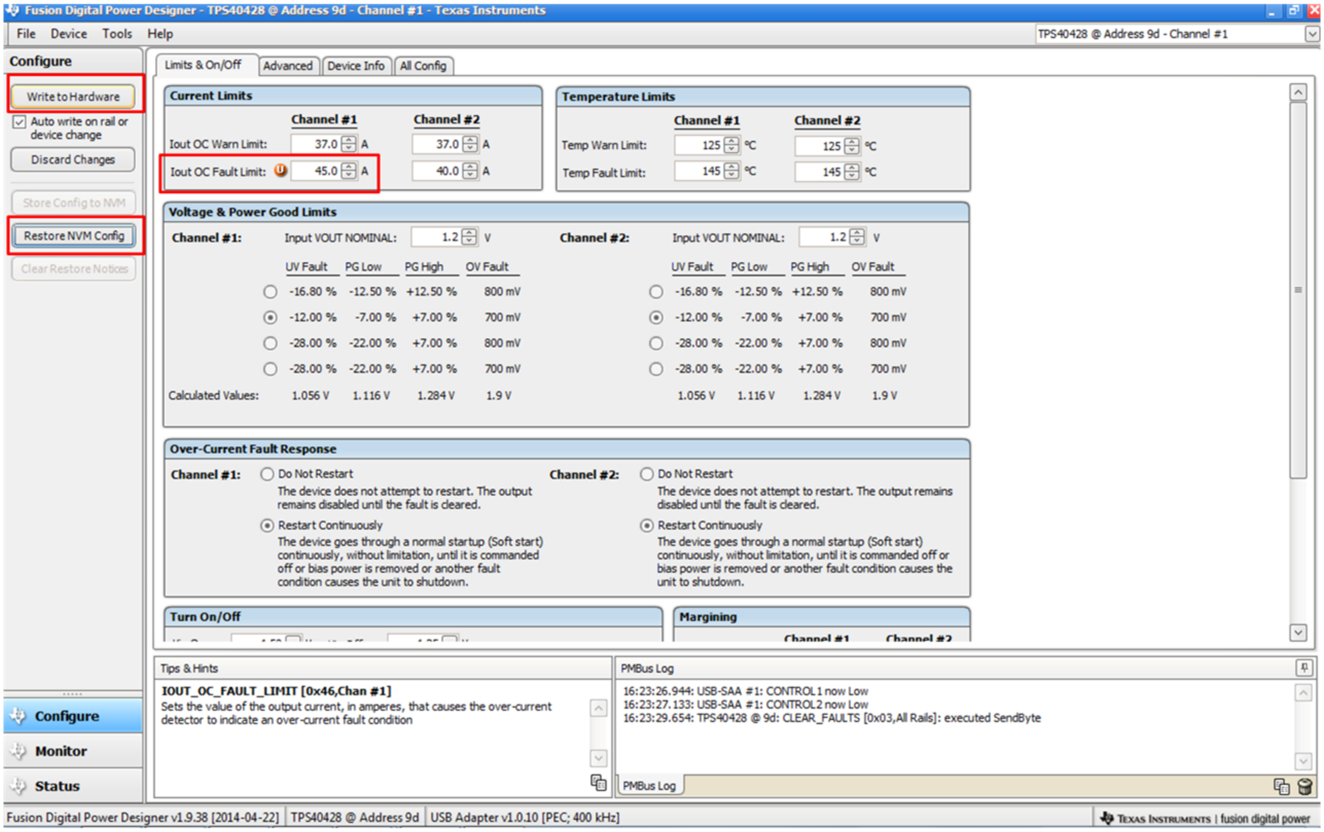


Figure 35. Configure - Limits and On/Off- On/Off Config Pop-up

A scroll-down menu in the upper right corner can be selected to change the view screens to one output rail or the other (Figure 36).

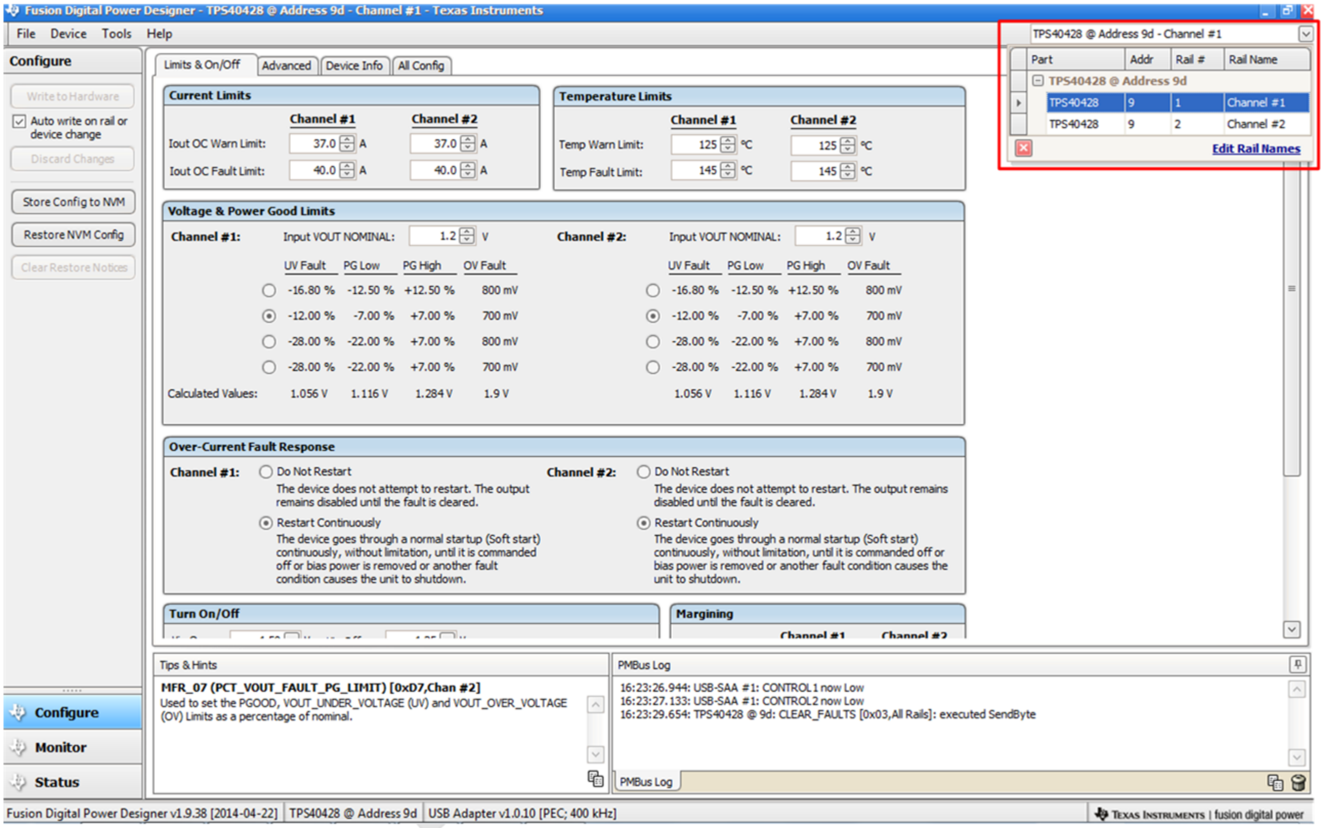


Figure 36. Change Screens to Other V_{OUT} Rail

When the *Monitor* screen is selected (Figure 37), the screen changes to display real-time data of the parameters that are measured by the controller. This screen provides access to:

- Graphs of V_{OUT}, *Iout*, *Temperature*, and *Pout*. As shown, the *Pout* display is turned OFF.
- *Start/Stop Polling* which turns ON or OFF the real-time display of data.
- Quick access to On/Off config
- Control pin activation, and OPERATION command.
- Margin control.
- Clear Fault. Selecting *Clear Faults* clears any prior fault flags.

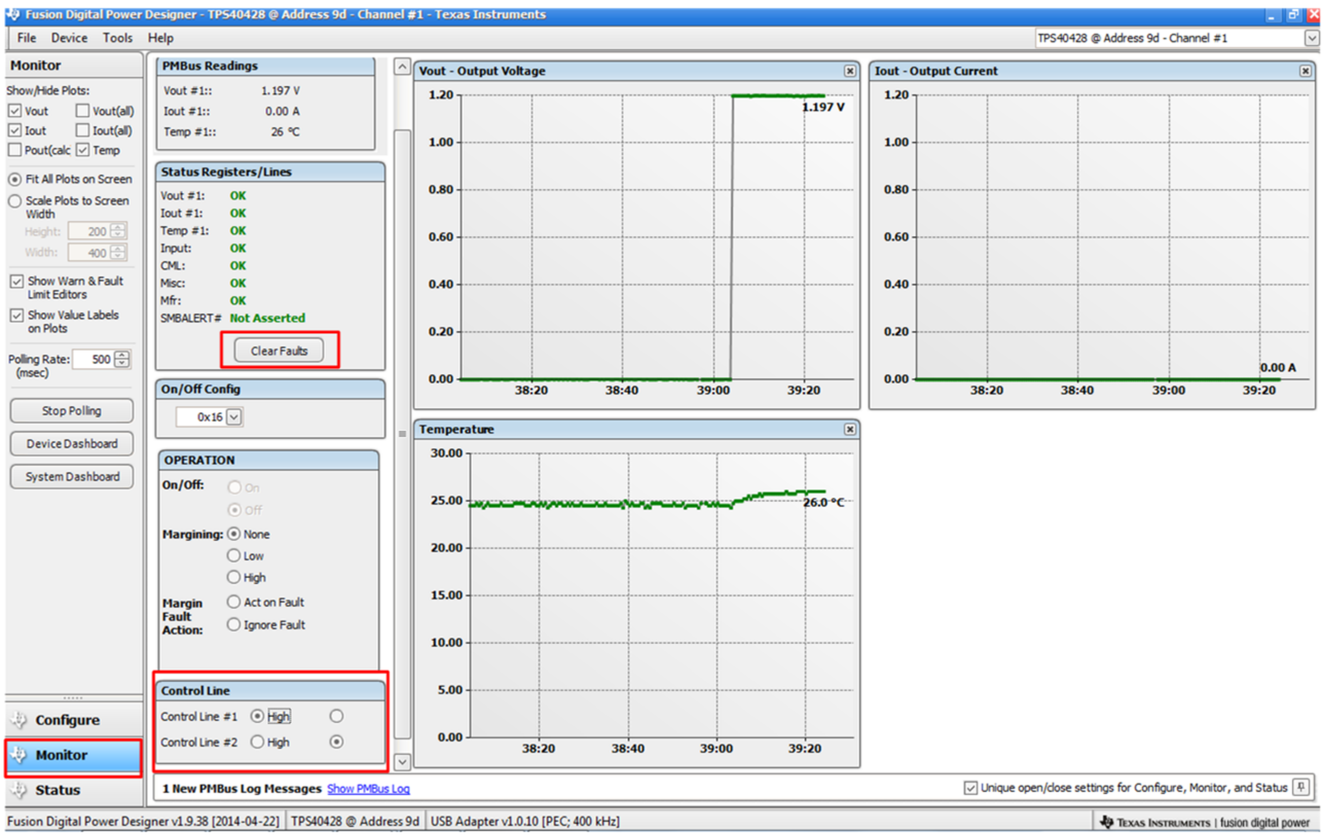


Figure 37. Monitor Screen

Selecting *System Dashboard* from mid-left screen adds a new window which displays system level information (Figure 38).

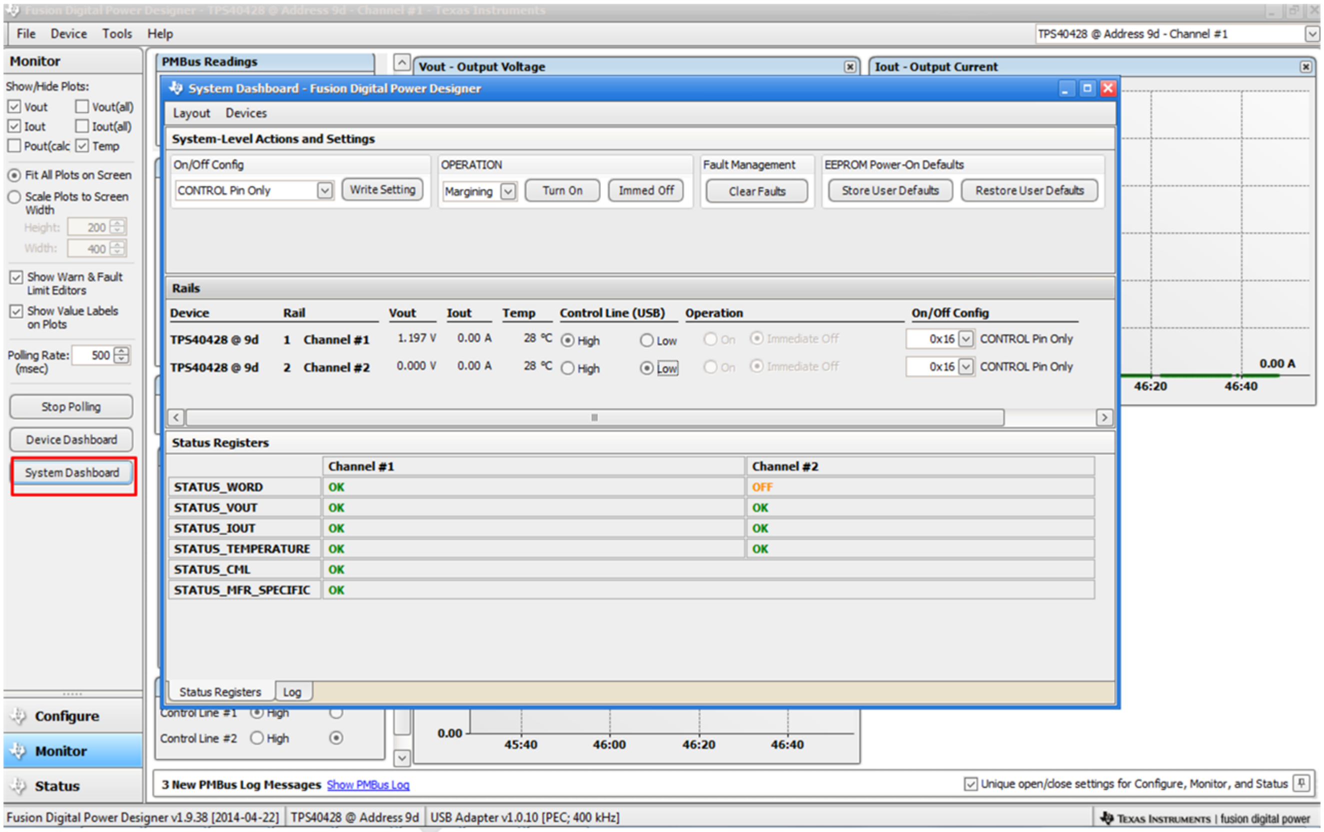


Figure 38. System Dashboard

Selecting *Status* from lower left corner shows the status of the controller (Figure 39).

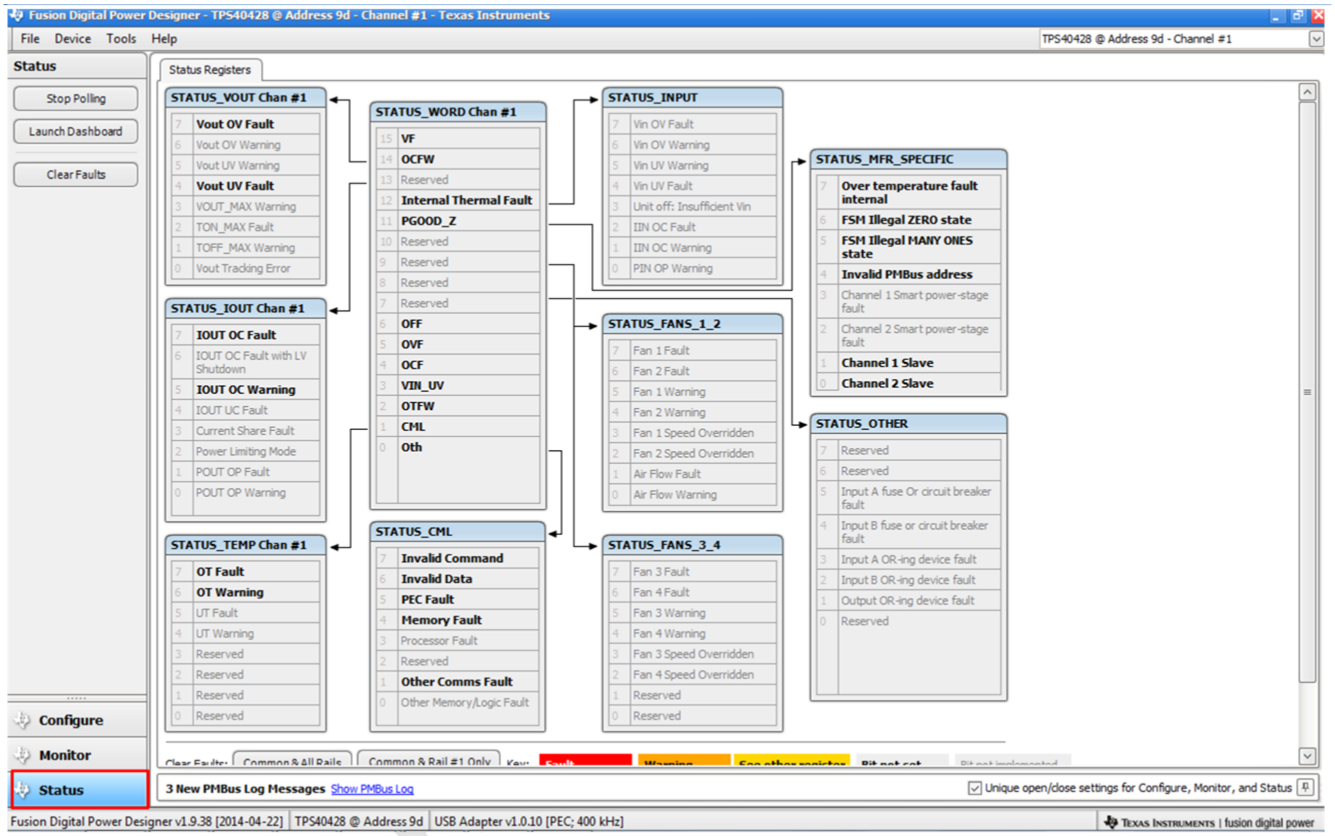


Figure 39. Status Screen

Selecting the pull down menu *File- Import Project* from the upper left menu bar can be used to configure all parameters in the device at once with a desired configuration, or even revert back to a *known-good* configuration (Figure 40). This action results in a browse-type sequence where the desired configure file can be located and loaded.

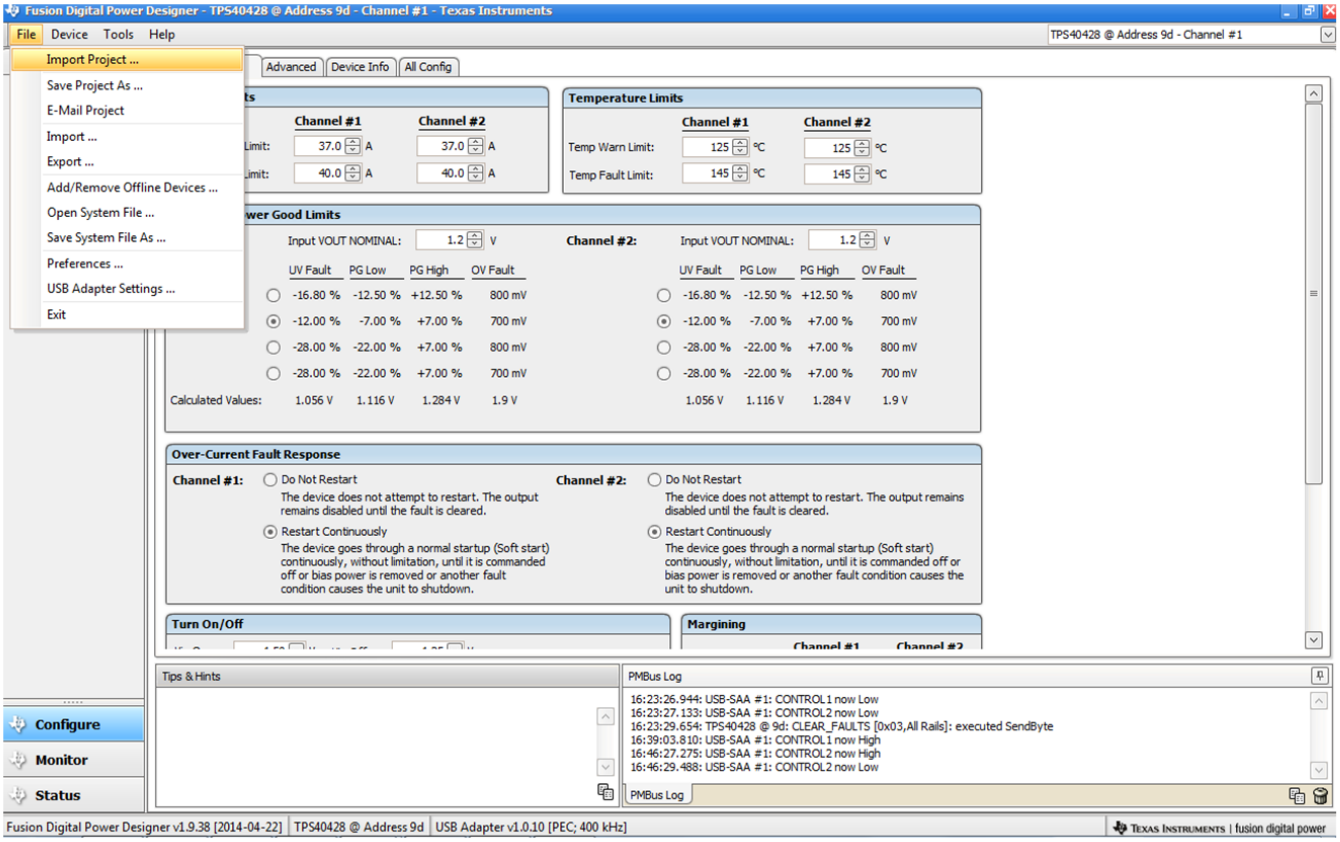


Figure 40. Import Configuration File

11 Two-Phase Configuration

The PWR594 EVM can be configured as 2-phase by changing the BOM. Figure 41 and Figure 42 show the schematics of 2-phase configuration. Table 8 and Table 9 are the components lists of 2-phase configuration.

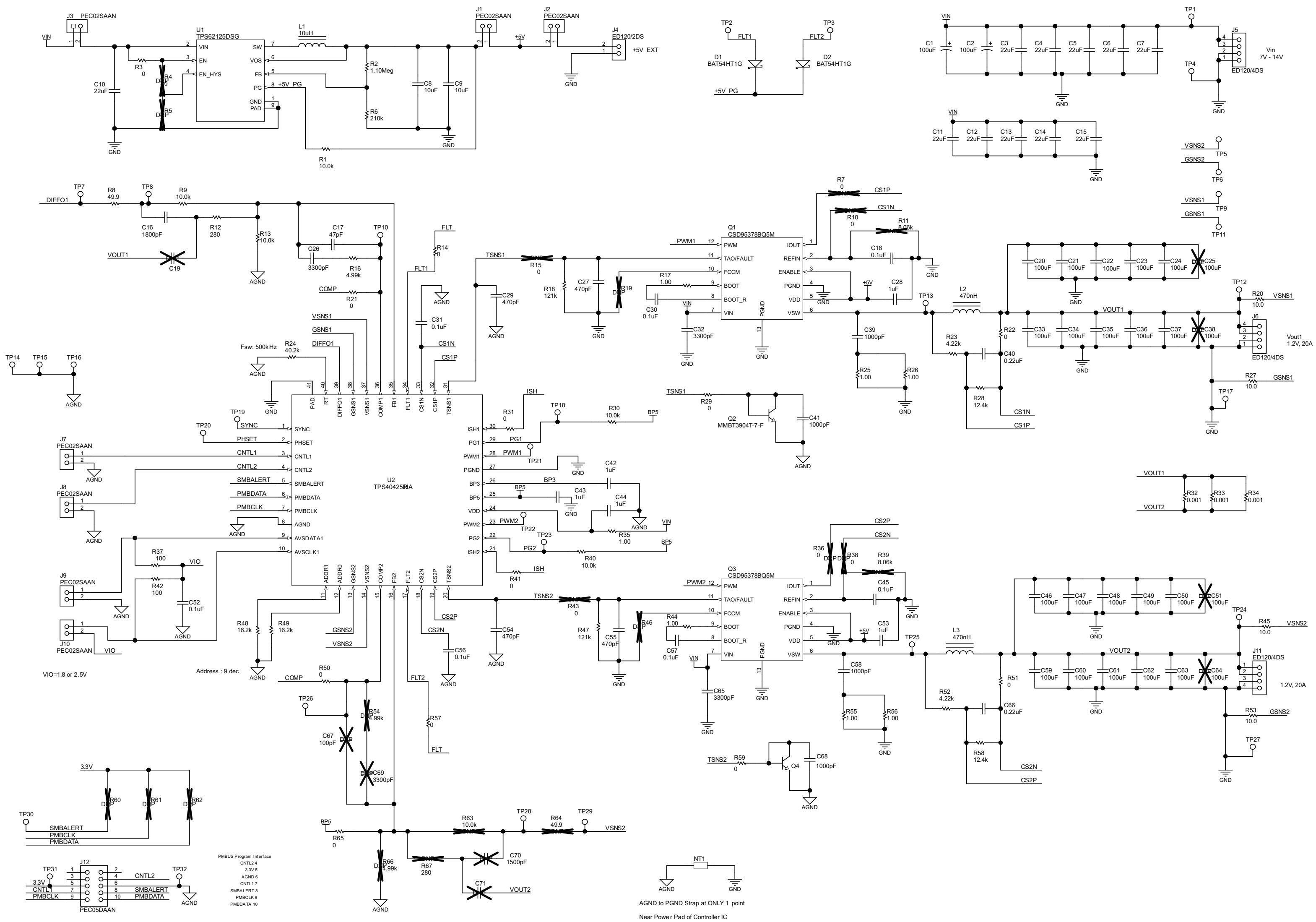


Figure 41. TPS40425EVM 2-Phase Schematic

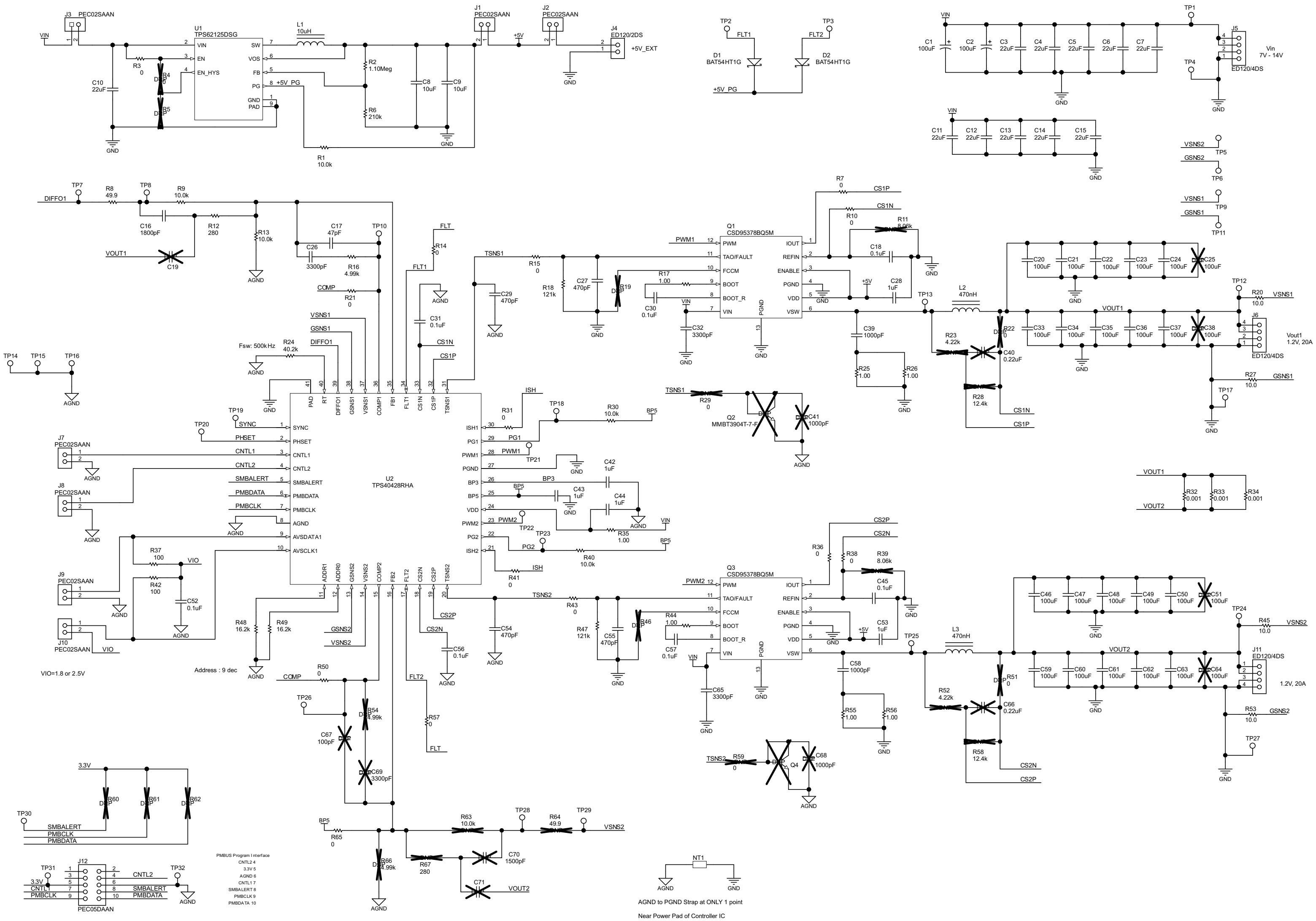


Figure 42. TPS40428EVM 2-Phase Schematic

Table 8. TPS40425EVM 2-Phase Components List

Qty	Designator	Description	Part Number	Manufacturer
2	C1, C2	CAP, AL, 100 µF, 25 V, ±20%, 0.3 Ω, SMD	EEE-FC1E101P	Panasonic
11	C3–C7, C10–C15	CAP, CERM, 22 µF, 25 V, ±10%, X5R, 1210	STD	STD
2	C8, C9	CAP, CERM, 10 µF, 10 V, ±10%, X5R, 0805	STD	STD
1	C16	CAP, CERM, 1500 pF, 25 V, ±10%, X7R, 0603	STD	STD
1	C17	CAP, CERM, 100 pF, 50 V, ±5%, C0G/NP0, 0603	STD	STD
7	C18, C30, C31, C45, C52, C56, C57	CAP, CERM, 0.1 µF, 25 V, ±10%, X7R, 0603	STD	STD
20	C20–C24, C33–C37, C46–C50, C59–C63	CAP, CERM, 100 µF, 6.3 V, ±20%, X5R, 1210	STD	STD
1	C26	CAP, CERM, 3300 pF, 25 V, ±10%, X7R, 0603	STD	STD
4	C27, C29, C54, C55	CAP, CERM, 470 pF, 50 V, ±10%, X7R, 0603	STD	STD
5	C28, C42–C44, C53	CAP, CERM, 1 µF, 25 V, ±10%, X5R, 0603	STD	STD
2	C32, C65	CAP, CERM, 3300 pF, 50 V, ±10%, X7R, 0603	STD	STD
4	C39, C41, C58, C68	CAP, CERM, 1000 pF, 50 V, ±10%, X7R, 0603	STD	STD
2	C40, C66	CAP, CERM, 0.22µFF, 25 V, ±10%, X7R, 0603	STD	STD
2	D1, D2	Diode, Schottky, 30 V, 0.2 A, SOD-323	BAT54HT1G	ON Semiconductor
7	J1– J3, J7–J10	Header, 100 mil, 2x1, Tin plated, TH	PEC02SAAN	Sullins Connector Solutions
1	J4	TERMINAL BLOCK 5.08 mm VERT 2POS, TH	ED120/2DS	On-Shore Technology
3	J5, J6, J11	TERMINAL BLOCK 5.08 mm VERT 4POS, TH	ED120/4DS	On-Shore Technology
1	J12	Header, 100 mil, 5x2, Tin plated, TH	PEC05DAAN	Sullins Connector Solutions
1	L1	Inductor, Shielded Drum Core, Ferrite, 10 µH, 0.7 A, 0.33 Ω, SMD	LPS3314-103MLB	Coilcraft
2	L2, L3	Inductor, Shielded Drum Core, WE-Perm, 470 nH, 30 A, 0.00067 Ω, SMD	744355147	Wurth Elektronik eiSos
1	LBL1	Thermal Transfer Printable Labels, 1.250" W x 0.250" H - 10,000 per roll	THT-13-457-10	Brady
2	Q1, Q3	Synchronous Buck NexFET Power Stage, DQP0012A	CSD95378BQ5M	Texas Instruments
2	Q2, Q4	Transistor, NPN, 20 V, 0.2 A, SOT-523	MMBT3904T-7-F	Diodes Inc.
1	R2	RES, 1.10 MΩ, 1%, 0.1 W, 0603	STD	STD
12	R3, R14, R21, R22, R29, R31, R41, R50, R51, R57, R59, R65	RES, 0 Ω, 5%, 0.1 W, 0603	STD	STD
1	R6	RES, 210 kΩ, 1%, 0.1 W, 0603	STD	STD
1	R8	RES, 49.9 Ω, 1%, 0.1 W, 0603	STD	STD
5	R1, R9, R13, R30, R40	RES, 10.0 kΩ, 1%, 0.1 W, 0603	STD	STD
1	R12	RES, 280 Ω, 1%, 0.1 W, 0603	STD	STD
1	R16	RES, 4.99 kΩ, 1%, 0.1 W, 0603	STD	STD
7	R17, R25, R26, R35, R44, R55, R56	RES, 1.00 Ω, 1%, 0.1 W, 0603	STD	STD
2	R18, R47	RES, 121 kΩ, 1%, 0.1 W, 0603	STD	STD
4	R20, R27, R45, R53	RES, 10.0 Ω, 1%, 0.1 W, 0603	STD	STD
2	R23, R52	RES, 4.22 kΩ, 1%, 0.1 W, 0603	STD	STD
1	R24	RES, 40.2 kΩ, 1%, 0.1 W, 0603	STD	STD
2	R28, R58	RES, 12.4 kΩ, 1%, 0.1 W, 0603	STD	STD
3	R32, R33, R34	RES, 0.001 Ω, 1%, 1W, 2512	STD	STD
2	R37, R42	RES, 100 Ω, 1%, 0.1 W, 0603	STD	STD
2	R48, R49	RES, 16.2 kΩ, 1%, 0.1 W, 0603	STD	STD
2	SH-J1, SH-J3	Shunt, 100 mil, Gold plated, Black	969102-0000-DA	3M
6	TP1, TP5, TP9, TP12, TP24, TP31	Test Point, Miniature, Red, TH	5000	Keystone
17	TP2, TP3, TP7, TP8, TP10, TP13, TP18–TP23, TP25, TP26, TP28–TP30	Test Point, Miniature, White, TH	5002	Keystone
9	TP4, TP6, TP11, TP14–TP17, TP27, TP32	Test Point, Miniature, Black, TH	5001	Keystone

Table 8. TPS40425EVM 2-Phase Components List (continued)

Qty	Designator	Description	Part Number	Manufacturer
1	U1	IC, 3 V-17 V, 200-mA High Efficient Buck Converter	TPS62125DSG	TI
1	U2	IC, Dual output, 2-Phase, Stackable PMBUS Synchronous Buck Driverless Controller with AVS Bus	TPS40425RHA	TI

Table 9. TPS40428EVM 2-Phase Components List

Qty	Designator	Description	Part Number	Manufacturer
2	C1, C2	CAP, AL, 100 µF, 25 V, ±20%, 0.3 Ω, SMD	EEE-FC1E101P	Panasonic
11	C–C7, C10–C15	CAP, CERM, 22 µF, 25 V, ±10%, X5R, 1210	STD	STD
2	C8, C9	CAP, CERM, 10 µF, 10 V, ±10%, X5R, 0805	STD	STD
2	C16, C70	CAP, CERM, 1500 pF, 25 V, ±10%, X7R, 0603	STD	STD
2	C17, C67	CAP, CERM, 100 pF, 50 V, ±5%, C0G/NP0, 0603	STD	STD
7	C18, C30, C31, C45, C52, C56, C57	CAP, CERM, 0.1 µF, 25 V, ±10%, X7R, 0603	STD	STD
20	C20–C24, C33–C37, C46–C50, C59–C63	CAP, CERM, 100 µF, 6.3 V, ±20%, X5R, 1210	STD	STD
2	C26, C69	CAP, CERM, 3300 pF, 25 V, ±10%, X7R, 0603	STD	STD
4	C27, C29, C54, C55	CAP, CERM, 470 pF, 50 V, ±10%, X7R, 0603	STD	STD
5	C28, C42–C44, C53	CAP, CERM, 1 µF, 25 V, ±10%, X5R, 0603	STD	STD
2	C32, C65	CAP, CERM, 3300 pF, 50 V, ±10%, X7R, 0603	STD	STD
2	C39, C58	CAP, CERM, 1000 pF, 50 V, ±10%, X7R, 0603	STD	STD
2	D1, D2	Diode, Schottky, 30 V, 0.2 A, SOD-323	BAT54HT1G	ON Semiconductor
7	J1–J3, J7–J10	Header, 100 mil, 2x1, Tin plated, TH	PEC02SAAN	Sullins Connector Solutions
1	J4	TERMINAL BLOCK 5.08 mm VERT 2POS, TH	ED120/2DS	On-Shore Technology
3	J5, J6, J11	TERMINAL BLOCK 5.08 mm VERT 4POS, TH	ED120/4DS	On-Shore Technology
1	J12	Header, 100 mil, 5x2, Tin plated, TH	PEC05DAAN	Sullins Connector Solutions
1	L1	Inductor, Shielded Drum Core, Ferrite, 10 µH, 0.7 A, 0.33 Ω, SMD	LPS3314-103MLB	Coilcraft
2	L2, L3	Inductor, Shielded Drum Core, WE-Perm, 470 nH, 30 A, 0.00067 Ω, SMD	744355147	Wurth Elektronik eiSos
1	LBL1	Thermal Transfer Printable Labels, 1.250" W x 0.250" H - 10,000 per roll	THT-13-457-10	Brady
2	Q1, Q3	Synchronous Buck NexFET Power Stage, DQP0012A	CSD95378BQ5M	Texas Instruments
1	R2	RES, 1.10 MΩ, 1%, 0.1 W, 0603	STD	STD
14	R3, R7, R10, R14, R15, R21, R31, R36, R38, R41, R43, R50, R57, R65	RES, 0 Ω, 5%, 0.1 W, 0603	STD	STD
1	R6	RES, 210 kΩ, 1%, 0.1 W, 0603	STD	STD
2	R8, R64	RES, 49.9 Ω, 1%, 0.1 W, 0603	STD	STD
5	R1, R9, R13, R30, R40	RES, 10.0 kΩ, 1%, 0.1 W, 0603	STD	STD
2	R12, R67	RES, 280 Ω, 1%, 0.1 W, 0603	STD	STD
3	R16, R54, R66	RES, 4.99 kΩ, 1%, 0.1 W, 0603	STD	STD
7	R17, R25, R26, R35, R44, R55, R56	RES, 1.00 Ω, 1%, 0.1 W, 0603	STD	STD
2	R18, R47	RES, 121 kΩ, 1%, 0.1 W, 0603	STD	STD
4	R20, R27, R45, R53	RES, 10.0 Ω, 1%, 0.1 W, 0603	STD	STD
1	R24	RES, 40.2 kΩ, 1%, 0.1 W, 0603	STD	STD
3	R32, R33, R34	RES, 0.001 Ω, 1%, 1W, 2512	STD	STD
2	R37, R42	RES, 100 Ω, 1%, 0.1 W, 0603	STD	STD
2	R48, R49	RES, 16.2 kΩ, 1%, 0.1 W, 0603	STD	STD
2	SH-J1, SH-J3	Shunt, 100 mil, Gold plated, Black	969102-0000-DA	3M
6	TP1, TP5, TP9, TP12, TP24, TP31	Test Point, Miniature, Red, TH	5000	Keystone

Table 9. TPS40428EVM 2-Phase Components List (continued)

Qty	Designator	Description	Part Number	Manufacturer
17	TP2, TP3, TP7, TP8, TP10, TP13, TP18–TP23, TP25, TP26, TP28–TP30	Test Point, Miniature, White, TH	5002	Keystone
9	TP4, TP6, TP11, TP14–TP17, TP27, TP32	Test Point, Miniature, Black, TH	5001	Keystone
1	U1	IC, 3 V-17 V, 200-mA High Efficient Buck Converter	TPS62125DSG	TI
1	U2	IC, Dual output, 2-Phase, Stackable PMBUS Synchronous Buck Driverless Controller with AVS Bus	TPS40428RHA	TI

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10. User has sole responsibility to ensure the safety of any activities to be conducted by it and its employees, affiliates, contractors or designees, with respect to handling and using EVMs. Further, user is responsible to ensure that any interfaces (electronic and/or mechanical) between EVMs 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.
11. User shall employ reasonable safeguards to ensure that user’s use of EVMs will not result in any property damage, injury or death, even if EVMs should fail to perform as described or expected.
12. User shall be solely responsible for proper disposal and recycling of EVMs consistent with all applicable federal, state, and local requirements.

Certain Instructions. User shall operate EVMs within TI’s recommended specifications and environmental considerations per the user’s guide, accompanying documentation, and any other applicable requirements. Exceeding the specified ratings (including but not limited to input and output voltage, current, power, and environmental ranges) for EVMs may cause property damage, personal injury or death. If there are questions concerning these ratings, 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 result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the applicable EVM user's 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, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using EVMs’ schematics located in the applicable EVM user's guide. When placing measurement probes near EVMs during normal operation, please be aware that EVMs may become very warm. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use EVMs.

Agreement to Defend, Indemnify and Hold Harmless. User agrees to defend, indemnify, and hold TI, its directors, officers, employees, agents, representatives, affiliates, 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 and/or use of EVMs. User’s indemnity shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if EVMs fail to perform as described or expected.

Safety-Critical or Life-Critical Applications. If user intends to use EVMs in evaluations of safety critical applications (such as life support), and a failure of a TI product considered for purchase by user for use in user’s product would reasonably be expected to cause severe personal injury or death such as devices which are classified as FDA Class III or similar classification, then user must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

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General Statement for EVMs Not Including a Radio

For EVMs not including a radio and not subject to the U.S. Federal Communications Commission (FCC) or Industry Canada (IC) regulations, TI intends EVMs to be used only for engineering development, demonstration, or evaluation purposes. EVMs are not finished products typically fit for general consumer use. EVMs may nonetheless generate, use, or radiate radio frequency energy, but have not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or the ICES-003 rules. Operation of such EVMs may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: For EVMs including a radio, the radio included in such EVMs is intended for development and/or professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability in such EVMs and their development application(s) must comply with local laws governing radio spectrum allocation and power limits for such EVMs. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by TI unless user has obtained appropriate experimental and/or development licenses from local regulatory authorities, which is the sole responsibility of the user, including its acceptable authorization.

U.S. Federal Communications Commission Compliance

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 could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

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 its own expense.

FCC Interference Statement for Class B EVM devices

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.

Industry Canada Compliance (English)

For EVMs Annotated as IC – INDUSTRY CANADA Compliant:

This Class A or B digital apparatus complies with Canadian ICES-003.

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

Concerning EVMs Including Radio Transmitters

This device complies with Industry Canada licence-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.

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.

Canada Industry Canada Compliance (French)

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

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.

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.

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Important 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.

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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２４番１号

西新宿三井ビル

http://www.tij.co.jp

Texas Instruments Japan Limited

(address) 24-1, Nishi-Shinjuku 6 chome, Shinjuku-ku, Tokyo, Japan

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