TPS2480 and TPS2481 Evaluation Module

This user's guide describes the evaluation modules (EVM) for the TPS2480 and TPS2481. TPS2480 and TPS2481 are positive-voltage, power-limiting, hot-swap controllers with a built-in I2C™ current monitor. The TPS2480 operates in a latched fault manner whereas the TPS2481 operates in an automatic retry manner.

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1 Description

The EVM design allows for several common application designs: a 12-V system with latched or automatic retry and a 48-V system with latched or automatic retry. The 12-V versions feature Texas Instruments new line of high-performance power MOSFETs. The EVM also provides a USB interface for the I2C™ current monitor when using the TPS2480/1 GUI on a PC.

1.1 Features

- General TPS2480/1 Device Features
  - Programmable current limiting and power limiting for complete SOA protection
  - Programmable fault timer to eliminate nuisance shutdowns
  - Programmable undervoltage lockout
  - Power good
  - Latched operation mode (TPS2480)
  - Automatic retry mode (TPS2481)
- EVM Configurable Options
  - TPS2481EVM-001 (12 V, 480 W, auto retry)
  - TPS2480EVM-002 (12 V, 480 W, latched)
  - High-voltage applications (48 V, 400 W, auto retry or latched)

NOTE: The high-voltage version is not orderable. For details, see the schematic and bill of materials.

1.2 Applications

- Any live backplane insertion application
  - Servers
  - Telecommunications

1.3 Electrical Specifications

Table 1. TPS2480/1EVM Electrical and Performance Specifications at 25°C

Characteristic	TPS2481EVM-001 TPS2480EVM-002	High-Voltage Application
Maximum input voltage	15 V	57 V
Input voltage (operating)	10 V 14 V	42 V to 54 V
Turnon voltage (maximum)	9 V	35.8 V
Turnoff voltage (minimum)	7.9 V	31.6 V
Nominal current	40 A	8.3 A
Trip point current	45 A to 55 A	9 A to 11 A
Operating temperature	–40ºC to 85°C	–40°C to 85°C
TPS2480 fault timer trip time (nominal)	528 µs	240 µs
TPS2481 fault timer period (nominal)	4.4 ms	2.0 ms
Program power limit (Vprog/2*R1)	200 W	400 W

2 General Configuration and Description

2.1 Physical Access

Table 2 lists the TPS2480/1EVM connector functionality, and Table 3 describes the test point availability.

Table 2. Connector Functionality

Connector	Label	Description
J1/J6	+IN/–IN	Power bus input (high-current, screw-down lugs). J1 is +IN and J6 is –IN. Apply bus input voltage between either J1/J6 or between J3/J8.
J3/J8	+IN/–IN	Power bus input (banana jack). J3 is +IN and J8 is –IN. Apply bus input voltage between either J1/J6 or between J3/J8.
J2/J5	+OUT/–OUT	Switched bus output (high-current, screw-down lugs). J2 is +OUT and J5 is –OUT. Apply the load between either J2/J5 or between J4/J7.
J4/J7	+OUT/–OUT	Switched bus output (banana jack). J4 is +OUT and J7 is –OUT. Apply the load between either J2/J5 or between J4/J7.
J13	USB	USB port. Connect furnished USB cable to PC when using the TPS2480/1 GUI
J9	A1	Allows selection of the A1 I2C address bit. The EVM default is set to address 1000000 by R13/R14. For other address options, remove R13/R14 and see the table on the schematic.
J10	A0	Allows selection of the A0 I2C address bit. The EVM default is set to address 1000000 by R13/R14. For other address options remove R13/R14 and see the table on the schematic.
S1	EN	Selecting the S1 EN position (toward TP15) allows the TPS2480/1 to enable the MOSFET if the power bus input is above the turn on voltage. Setting S1 away from the EN position disables the MOSFET.
J11, J12		For manufacturing use only. Shunts must remain installed in J11 and J12.

Table 3. Test Points

Test Point	Color	Label	Description
TP2	RED	+IN	Power bus input high.
TP5	BLK	–IN	Power bus input low.
TP3	ORG	+OUT	Switched bus output high.
TP4	BLK	–OUT	Switched bus output low.
TP1	WHT	SNS	SNS pin test point.
TP6	WHT	GATE	GATE pin test point.
TP10	WHT	PG	PG pin (power good) test point.
TP16	WHT	TMR	TMR pin (timer) test point.
TP18	WHT	PRG	PROG pin (power program) test point.
TP15	WHT	EN	EN pin (enable) test point.
TP14	WHT	SCL	SCL pin (serial clock) test point.
TP13	WHT	SDA	SDA pin (serial data) test point.
TP12	WHT	A1	A1 pin (upper address bit) test point. Level set by R14 and J9.
TP11	WHT	A0	A0 pin (lower address bit) test point. Level set by R13 and J10.
TP17	RED	3P3V_USB	VS pin (current monitor supply voltage) test point. The USB source applied at J13 powers the current monitor.
TP19	BLK	GND	GNDB pin (current monitor ground) test point. The USB source applied at J13 powers the current monitor.
TP7	WHT	HSNS	High-voltage (HV) sense test point. TPS2480/1EVM-001 provides a circuit to shift the current monitor input. This test point mirrors the voltage at TP1.
TP9	WHT	LSNS	Low-voltage (LV) sense test point. This test point represents the HV to LV mirrored current sense voltage.
TP8	RED	V–	Sense voltage mirror negative supply voltage. Normally ~5 V below the power bus high-input voltage.
D6	GRN	USB	USB active indicator LED. When a USB power source is presently connected to a PC, this LED illuminates.

3 Test Setup

Figure 1 shows a typical test setup for TPS2480/1EVM. Input voltage can be applied as described in Table 2.

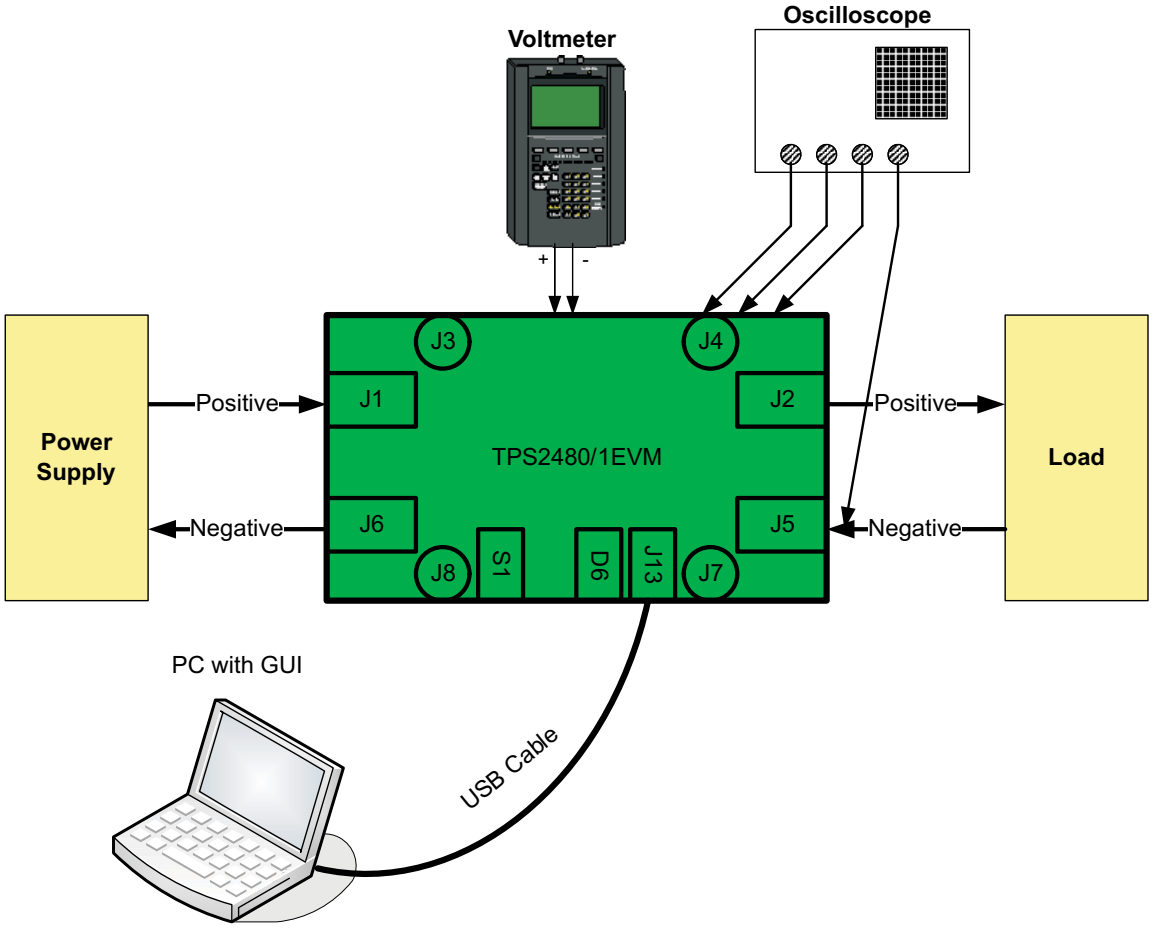

Figure 1. Typical TPS2480/1EVM Test Setup

4 TPS2480/1EVM GUI Setup

4.1 TPS2480/1EVM GUI Installation

If not already performed on the PC/laptop to be used for test, open the TPS2480/1 GUI (SLUC167) file, and extract it to a known folder.

4.2 TPS2480/1EVM GUI Operation

- Navigate to the TPS2480_1EVM.exe file, and double-click it. A GUI as shown in Figure 2 or Figure 4 appears. For a detailed example of the equations running behind the GUI, see the TPS2480/81 data sheet (SLUS939).
- Click the Calibrate tab of the GUI. A GUI form as shown in Figure 3 or Figure 5 appears.
- Type the appropriate Rshunt value into the text box (0.001 for TPS2480EVM-002/TPS2481EVM-001 or 0.005 for the High Voltage Application). Press the Enter Shunt Resistance GUI button.
- Type a value of 60 into Max Expected Current ± text box. Press the Enter Max Expected Current GUI button.
- Type a value of 0.002 into Enter LSB text box. Press the Enter Current LSB GUI button.
- At this time, the Read Initial Cal Current pushbutton activates (right side of Calibrate form under Second Calibration). Press the Read Initial Cal Current GUI button.
- Type the appropriate Measured Shunt Current value into the text box. Press the *Compute New Full Scale and Read Post Second Cal Current* GUI button.
- Press the Write all Edited and then the Read all Reg buttons in sequence.

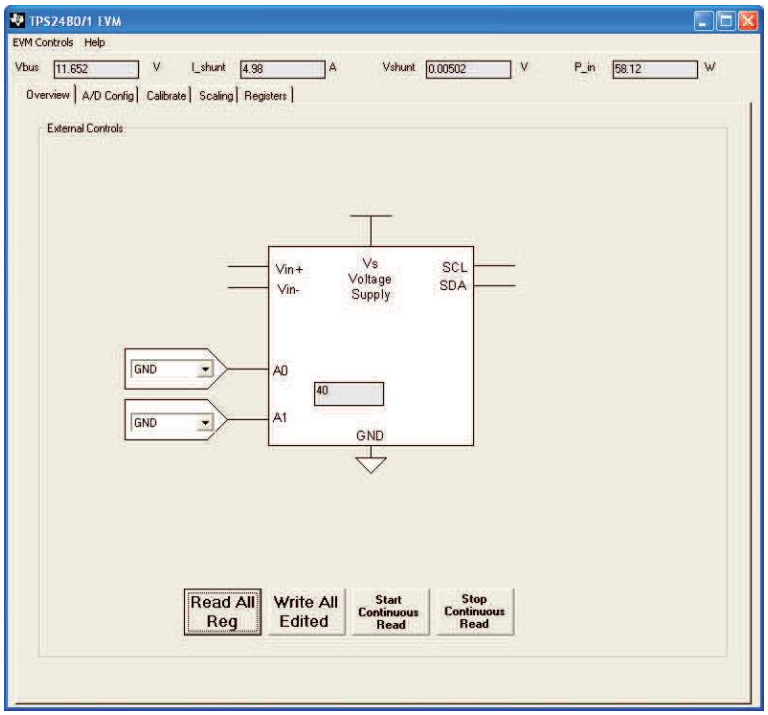

Figure 2. TPS2481EVM-001 and TPS2480EVM-002 GUI Overview Form

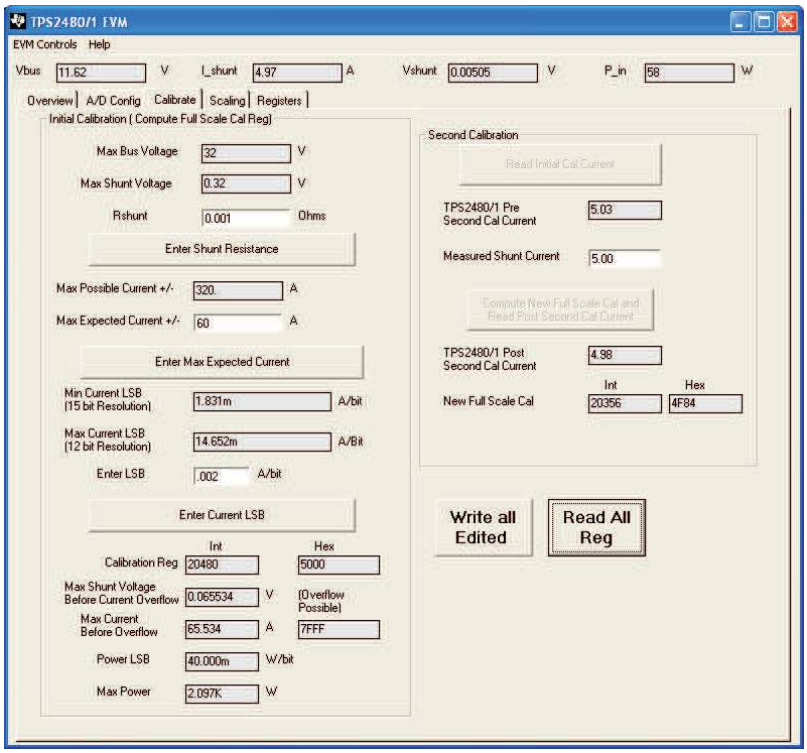

Figure 3. TPS2481EVM-001 and TPS2480EVM-002 GUI Calibrate Form

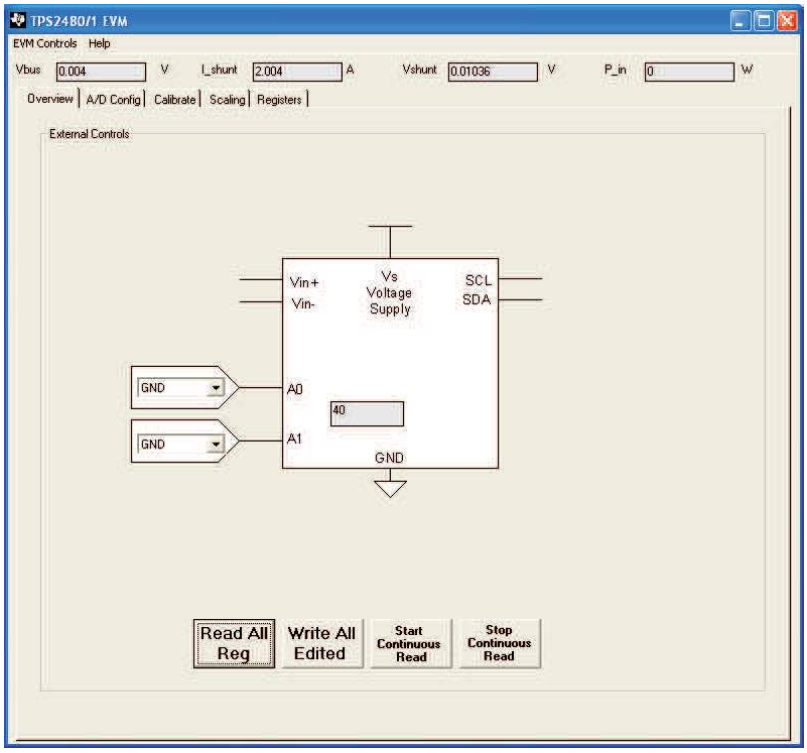

Figure 4. High-Voltage Application GUI Overview Form

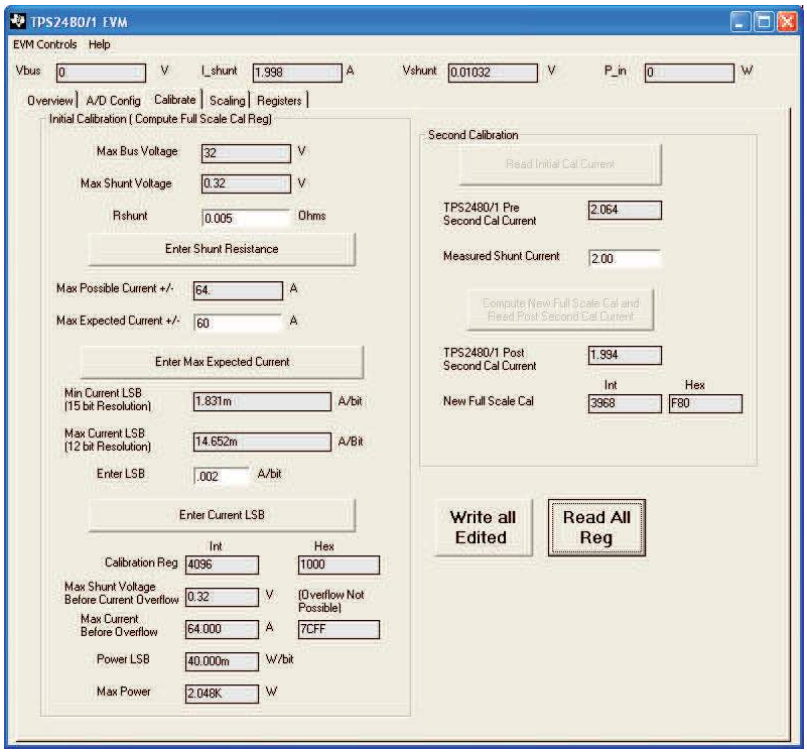

Figure 5. High-Voltage Application GUI Calibrate Form

5 TPS2480/1EVM Typical Performance Data

5.1 TPS2481EVM-001 and TPS2480EVM-002 Power Limit Curves

Figure 6 illustrates the current limit versus output voltage curve for TPS2481EVM-001 and TPS2480EVM-002.

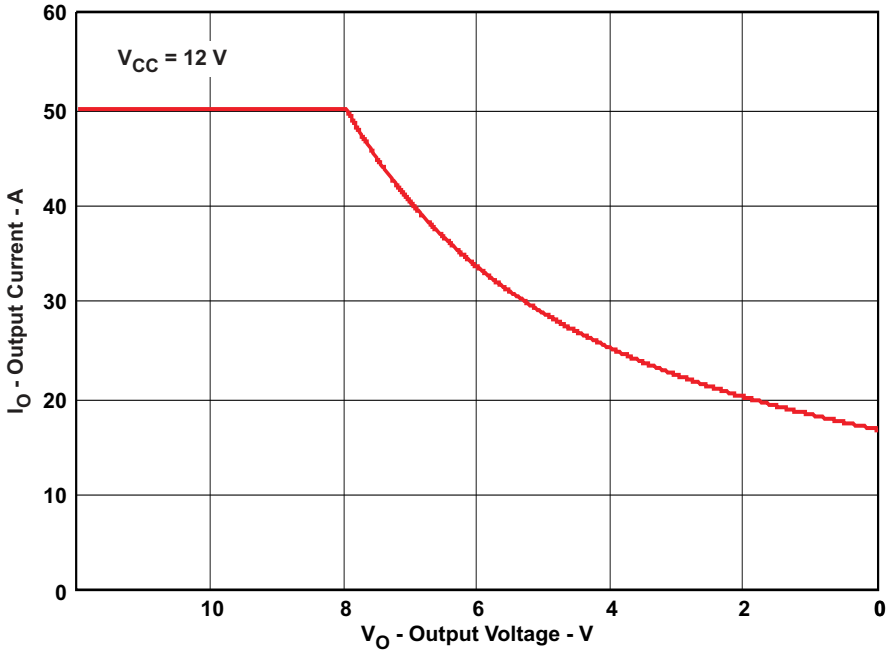

Figure 6. TPS2481EVM-001 and TPS2480EVM-002 Current and Power Limit Curve

5.2 High-Voltage Application Power Limit Curves

Figure 7 illustrates the current limit versus output voltage curve for the high-voltage application.

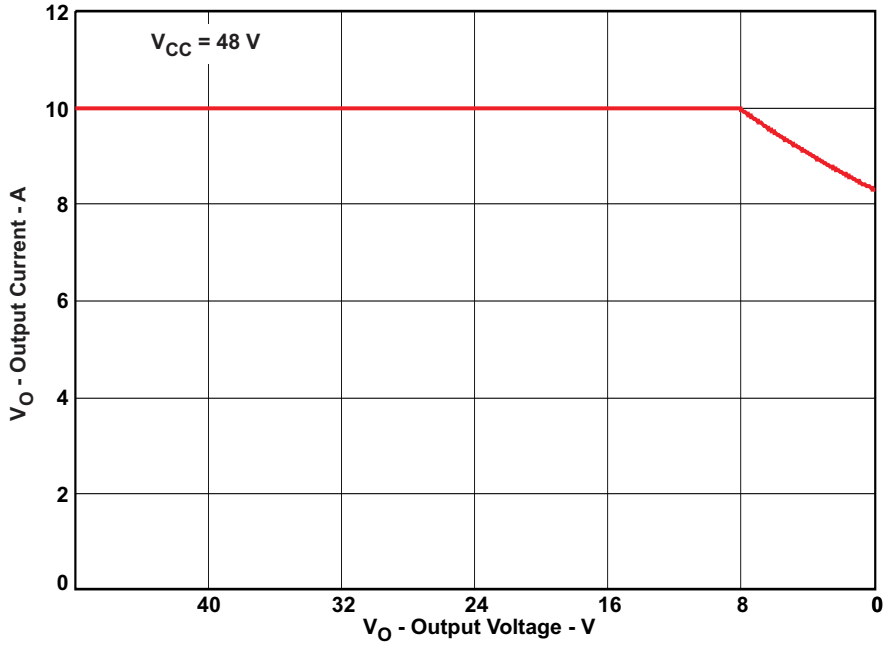

Figure 7. High-Voltage Application Current and Power Limit Curve

6 EVM Assembly Drawing and Layout Guidelines

6.1 PCB Drawings

Figure 8 through Figure 11 show component placement and layout of the EVM.

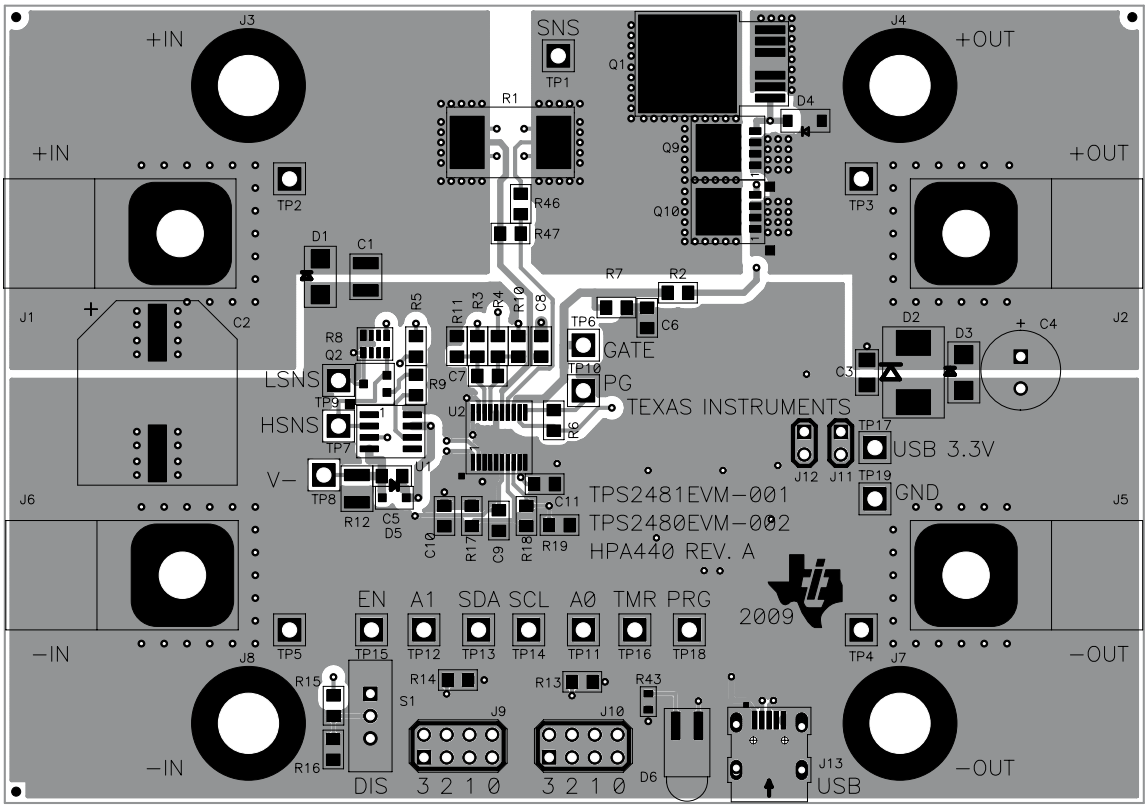

Figure 8. Top Side Layout/Routing

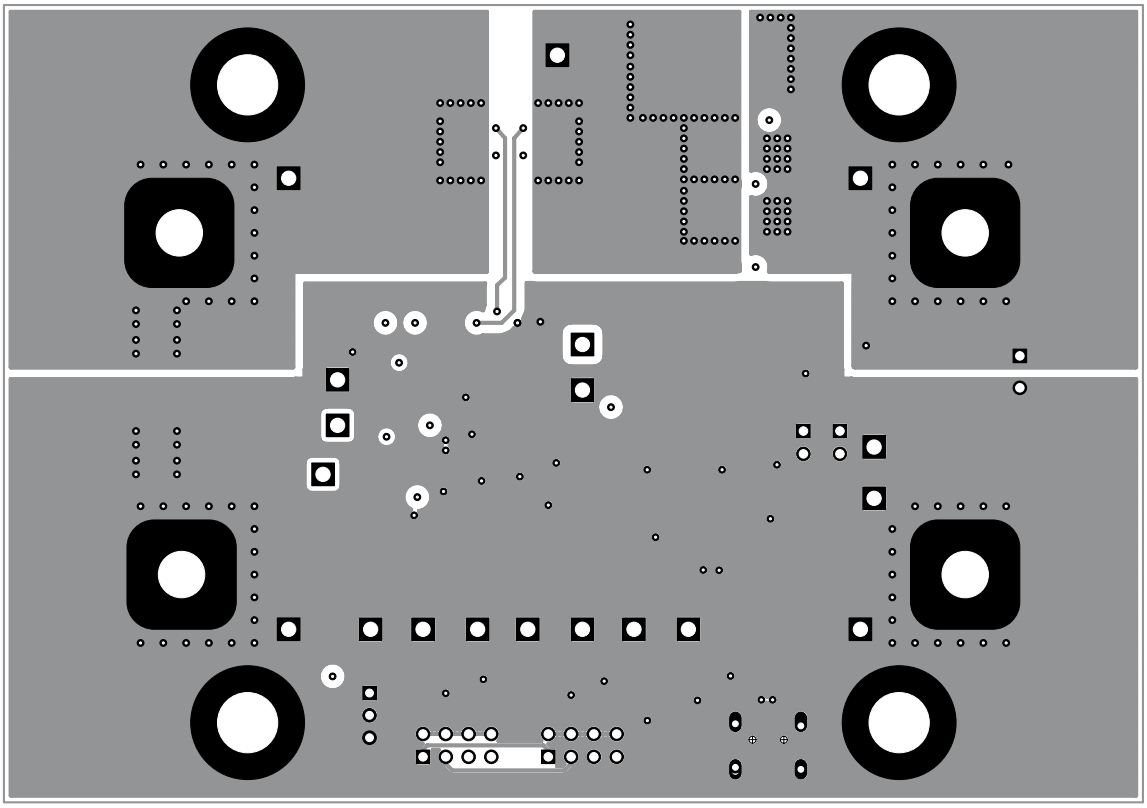

Figure 9. Layer Two Routing

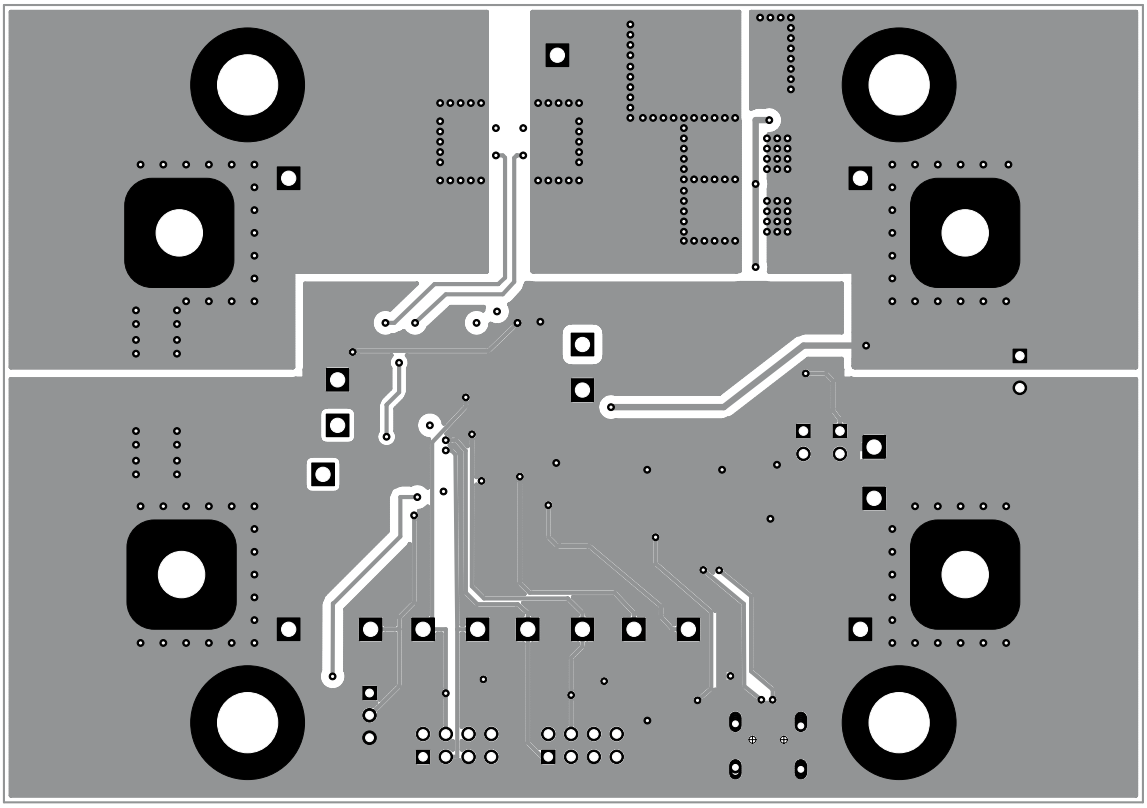

Figure 10. Layer Three Routing

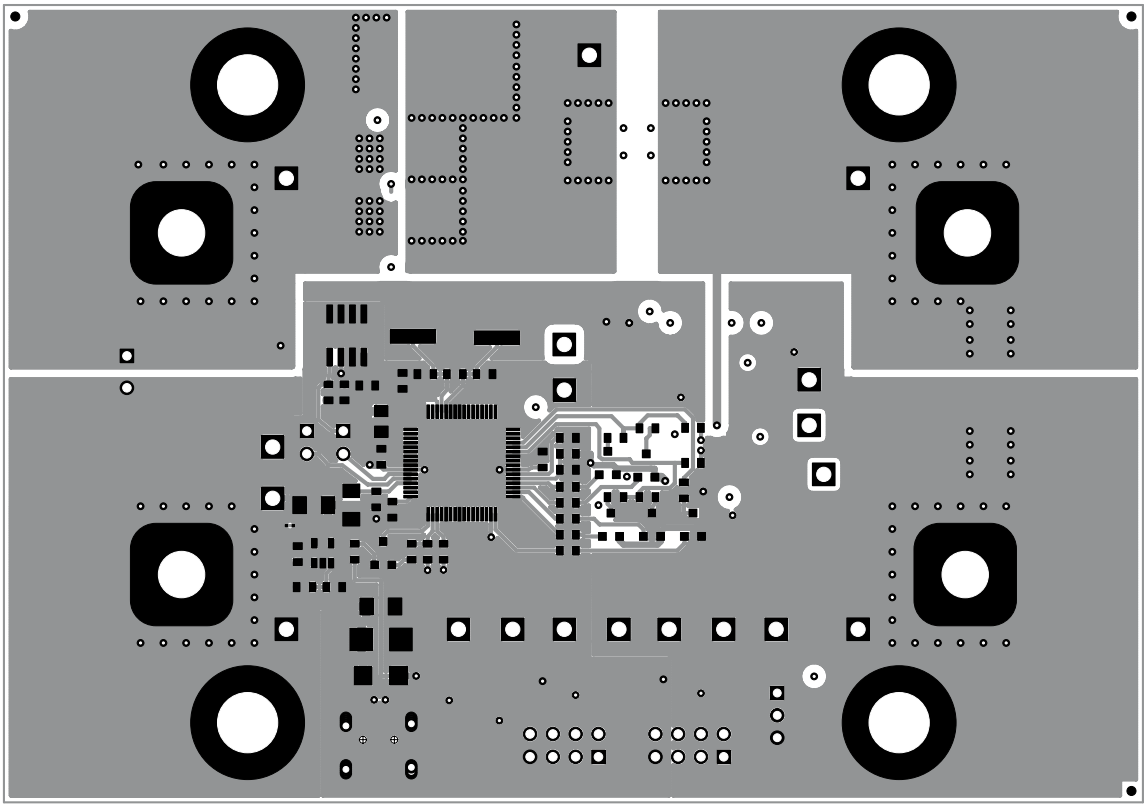

Figure 11. Bottom Side Placement/Routing

6.2 Layout Guidelines

The TPS2480/1 circuit layout must follow power and EMI/ESD best-practice guidelines. A basic set of recommendations include:

- Arrange the high-power devices so that current flows in a sequential, linear fashion.
- Place a good ground plane under the power planes and TPS2480/1.
- The TPS2480/81 must be placed close to the sense resistor and MOSFET using a Kelvin type connection to achieve accurate current sensing.
- A low-impedance GND connection is required because the TPS2480/81 can momentarily sink upwards of 100 mA from the gate of the MOSFET. The GATE amplifier has high bandwidth while active, so keep the GATE trace length short.
- Spacing consistent with safety standards like IEC60950 must be observed between the 48-V input voltage rails and between the input and an isolated converter output.
- Large copper fills and traces must be used on SMT power-dissipating devices, and wide traces or overlay copper fills must be used in the power path.
- The PROG, TIMER, and EN pins have high input impedances; therefore, their input lead length must be minimized.
- Oversize power traces and power device connections assuring low voltage drop and good thermal performance.

7 Bill of Materials and Schematics

7.1 Bill of Materials

Table 4. Bill of Materials

High Voltage Count		Count		RefDes	Value	Description	Size	Part Number	Supplier
TPS2480	TPS2481	TPS2480EVM -002	TPS2481EVM -001						
1	1	1	1	C1	1µF	Capacitor, Ceramic, 100V, X7R, 10%	1210	Std	Std
1	1	0	0	C11	1.5nF	Capacitor, Ceramic, 100V, X7R, 10%	0805	Std	Std
0	0	1	1	C11	3.3nF	Capacitor, Ceramic, 100V, X7R, 10%	0805	Std	Std
6	6	6	6	C12, C16–C18, C21, C23	0.1µF	Capacitor, Ceramic, X7R, 16V, 10%	0603	Std	Std
2	2	2	2	C13, C14	22pF	Capacitor, Ceramic, 50V, C0G, 10%	0603	Std.	Std.
1	1	1	1	C15	1000pF	Capacitor, Ceramic, 100V, C0G, 5%	0805	Std.	Std.
1	1	1	1	C19	1µF	Capacitor, Tantalum, 16V, 20%	3216	293D105X0016A2T	Vishay
1	1	0	0	C2	47µF	Capacitor, Aluminum, SM, 100V, 20%	0.670 × 0.750	EEVFK2A470Q	Panasonic
0	0	1	1	C2	1000µF	Capacitor, Aluminum, SM, 25V, 20%	0.670 × 0.750	EEVFK1E102Q	Panasonic
2	2	2	2	C20, C22	10µF	Capacitor, Tantalum, 10V, 20%	3216	293D106X0010A2T	Vishay
1	1	1	1	C3	0.1µF	Capacitor, Ceramic, 100V, X7R, 10%	1206	Std	Std
1	1	0	0	C4	47µF	Capacitor, Panasonic, 100V, 20%	0.315	ECA-2AM470	Panasonic
0	0	1	1	C4	330µF	Capacitor, Panasonic, 25-V, 20%	0.315	ECA-1EM331	Panasonic
1	1	0	0	C5	0.1µF	Capacitor, Ceramic, 100V, X7R, 10%	0805	Std	Std
3	3	3	3	C8, C9, C10	0.1µF	Capacitor, Ceramic, 100V, X7R, 10%	0805	Std	Std
0	0	0	0	C6, C7	0.1µF	Capacitor, Ceramic, 100V, X7R, 10%	0805	Std	Std
2	2	0	0	D1, D3	SMAJ58A	Diode, TVS, 58V, 1W	SMA	SMAJ58A	Diodes Inc.
0	0	2	2	D1, D3	SMAJ16A	Diode, TVS, 16V, 1W	SMA	SMAJ16A	Diodes Inc.
1	1	1	1	D2	MBRS3100T3	Diode, Schottky 3-A 100-V	SMC	MBRS3100T3	On Semi
0	0	0	0	D4	BZT52C8V2	Diode, Zener, Planar Power, 500mW, 8.2V	SOD-123	BZT52C8V2-7	Diodes Inc.
1	1	0	0	D5	BZT52C5V1	Diode, Zener, 200mW, 5.1V	SOD-323	BZT52C5V1S	Diodes Inc.
1	1	1	1	D7	MBRA130	Diode, Schottky, 1A, 30V	SMA	MBRA130	IR
1	1	1	1	D8	7.5V	Diode, Zener, 7.5V, 3W	SMB	1SMB5922BT3	On Semi
4	4	4	4	J1, J2, J5, J6	CX35-36-CY	Lug, Copper, 35A,	0.380 × 1.020 inch	CX35-36-CY	Panduit
2	2	2	2	J11, J12	PEC02SAAN	Header, Male 2pin, 100mil spacing,	0.100 inch × 2	PEC02SAAN	Sullins
1	1	1	1	J13	UX60-MB-5ST	Connector, Recpt, USB-B, Mini, 5pins, SMT	0.354in. × 0.303in.	UX60-MB-5S8	Hirose
4	4	4	4	J3, J4, J7, J8	3267	Connector, Banana Jack, Uninsulated	0.500 dia. inch	3267	Pomona
2	2	2	2	J9, J10	PEC04DAAN	Header, Male 2×4-pin, 100mil spacing	0.20 × 0.40 inch	PEC04DAAN	Sullins
1	1	0	0	Q1	IRFS3107-7PPBF	Transistor, MOSFET, 75V, 190A, 2.1 mΩ	TO-263-7	IRFS3107-7PPBF	International Rectifier
1	1	0	0	Q2	Si2325DS	MOSFET, P-ch, -150 V, 690-mA, 1.2 Ω	SOT-23	Si2325DS	Vishay
5	5	5	5	Q3–Q7	BSS84	Transistor, PFET, -50 V, 130 mA, Rds(ON) < 10 Ω at V(gs) = 5 V	SOT-23	BSS84	Fairchild
1	1	1	1	Q8	MMBT2222A	Transistor, NPN, 40 V, 500 mA	SOT-23	MMBT2222A	Fairchild
0	0	2	2	Q9, Q10	CSD16401Q5A-R	MOSFET, NChan, 25V, 37A, 1.3milliOhm	QFN5×6mm	CSD16401Q5A-R	TI
1	1	0	0	R1	0.005	Res, Power Metal Strip, 5W, ±1%	4527	WSR55L000FEA	Vishay Dale

Table 4. Bill of Materials (continued)

High Voltage Count		Count		RefDes	Value	Description	Size	Part Number	Supplier
TPS2480	TPS2481	TPS2480EVM -002	TPS2481EVM -001						
0	0	1	1	R1	0.001	Res, Power Metal Strip, 5W, ±1%	4527	WSR51L000FEA	Vishay Dale
1	1	0	0	R12	24.0K	Resistor, Chip, 1/2W, 5%	1210	STD	STD
1	1	0	0	R15	249K	Resistor, Chip, 1/10W, 1%	0805	Std	Std
0	0	1	1	R15	54.9K	Resistor, Chip, 1/10W, 1%	0805	Std	Std
1	1	0	0	R18	47.5k	Resistor, Chip, 1/10W, 1%	0805	Std	Std
0	0	1	1	R18	178k	Resistor, Chip, 1/10W, 1%	0805	Std	Std
0	0	1	1	R19	20K	Resistor, Chip, 1/10W, 1%	0805	Std	Std
1	1	1	1	R2	10	Resistor, Chip, 1/10W, 1%	0805	Std	Std
1	1	1	1	R20	1.00M	Resistor, Chip, 1/16 W, 1%	0603	Std.	Std.
3	3	3	3	R21, R22, R39	1.5K	Resistor, Chip, 1/16 W, 5%	0603	Std	Std
9	9	9	9	R23, R24, R35–R38, R40–R42	33	Resistor, Chip, 1/16W, 5%	0603	Std	Std
5	5	5	5	R25, R27, R28, R29, R45	100K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
2	2	2	2	R26, R44	15K	Resistor, Chip, 1/16 W, 5%	0603	Std.	Std
0	0	2	2	R3, R4	0	Resistor, Chip, 1/10W, 5%	0805	Std	Std
2	2	0	0	R10, R11	0	Resistor, Chip, 1/10W, 5%	0805	Std	Std
0	0	0	0	R17	0	Resistor, Chip, 1/10W, 5%	0805	Std	Std
1	1	1	1	R46	0	Resistor, Chip, 1/10W, 5%	0805	Std	Std
3	3	3	3	R30, R31, R33	2.2K	Resistor, Chip, 1/16 W, 5%	0603	Std.	Std.
2	2	2	2	R32, R34	1K	Resistor, Chip, 1/16W, 1%	0603	Std	Std
1	1	1	1	R43	200	Resistor, Chip, 1/16W, 5%	0603	Std	Std
0	0	0	0	R47	100	Resistor, Chip, 1/10W, 1%	0805	Std	Std
1	1	0	0	R5	10K	Resistor, Chip, 1/10W, 1%	0805	Std	Std
1	1	1	1	R16	10K	Resistor, Chip, 1/10W, 1%	0805	Std	Std
1	1	1	1	R6	100K	Resistor, Chip, 1/10W, 1%	0805	Std	Std
2	2	2	2	R13, R14	1K	Resistor, Chip, 1/10W, 1%	0805	Std	Std
0	0	0	0	R7	1K	Resistor, Chip, 1/10W, 1%	0805	Std	Std
1	1	0	0	R8	100 × 4	Resistor, Chip Array, 100mW ± 0.1%	612	ACASA1000E1000P100	Vishay
1	1	0	0	R9	100	Resistor, Chip, 1/10W, 1%	0805	Std	Std
1	1	1	1	S1	EG1218	Switch, SPDT, Slide, PC-mount,	0.457 × 0.157 inch	EG1218	E_Switch
10	10	10	10	TP1, TP6, TP10–TP16, TP18	5012	Test Point, White, Thru Hole	0.125 × 0.125 inch	5012	Keystone
2	2	0	0	TP7, TP9	5012	Test Point, White, Thru Hole	0.125 × 0.125 inch	5012	Keystone
2	2	2	2	TP2, TP17	5010	Test Point, Red, Thru Hole	0.125 × 0.125 inch	5010	Keystone
1	1	0	0	TP8	5010	Test Point, Red, Thru Hole	0.125 × 0.125 inch	5010	Keystone
1	1	1	1	TP3	5013	Test Point, Orange, Thru Hole	0.125 × 0.125 inch	5013	Keystone
3	3	3	3	TP4, TP5, TP19	5011	Test Point, Black, Thru Hole	0.125 × 0.125 inch	5011	Keystone
1	1	0	0	U1	OPA333AID	IC, CMOS Op Amp, 1.8V micro-Power, Zero-Drift Series	SO-8	OPA333AID	TI
1	0	1	0	U2	TPS2480PW	IC, Positive Latching Hot Swap Controller and I2C Current Monitor	TSSOP-20	TPS2480PW	TI
0	1	0	1	U2	TPS2481PW	IC, Positive Auto-retry Hot Swap Controller and I2C Current Monitor	TSSOP-20	TPS2481PW	TI
1	1	1	1	U3	24LC64-I/SN	IC, Serial EEPROM, 64K, 2.5-5.5V, 400 kHz Max.	SO-8	24LC64I-SN	Microchip
1	1	1	1	U4	TUSB3210PM	IC, USB, General Purpose Device Controller	PQFP-64	TUSB3210PM**	Texas Instruments

Table 4. Bill of Materials (continued)

High Voltage Count		Count		RefDes	Value	Description	Size	Part Number	Supplier
TPS2480	TPS2481	TPS2480EVM -002	TPS2481EVM -001						
1	1	1	1	U5	TPS76333DBV	IC, Micro-Power 100 mA LDO Regulator	SOT23-5	TPS76333DBV	TI
1	1	1	1	Y1	12MHZ	Crystal, 12-MHz, 20 pF, ±50 PPM at 25°C	0.185 × 0.532	CY12BPSMD	Crystek
4	4	4	4			Screw, panhead, #10-32, 0.500 inch		PMS 102 0050 PH	Building Fasteners
4	4	4	4			Washer, flat, #10		#10FWZ	Building Fasteners
4	4	4	4			Washer, split, M5		MLWZ 005	Building Fasteners
4	4	4	4			Nut, hex, #10-32		HNZ102	Building Fasteners
2	2	2	2	—		Shunt, Black	100-mil	929950-00	3M
4	4	4	4		SJ5514-0	Bumpons, cylindrical, black		SJ5514-0	3M
1	1	1	1	—		PCB, 5 In × 3.5 In × 0.062 In		HPA440	Any
1	1	1	1	N/A		USB Cable, 5-pin, B-Mini Male to Type A Male, 2m		AK672M/2-2-R	Assman

7.2 Schematics

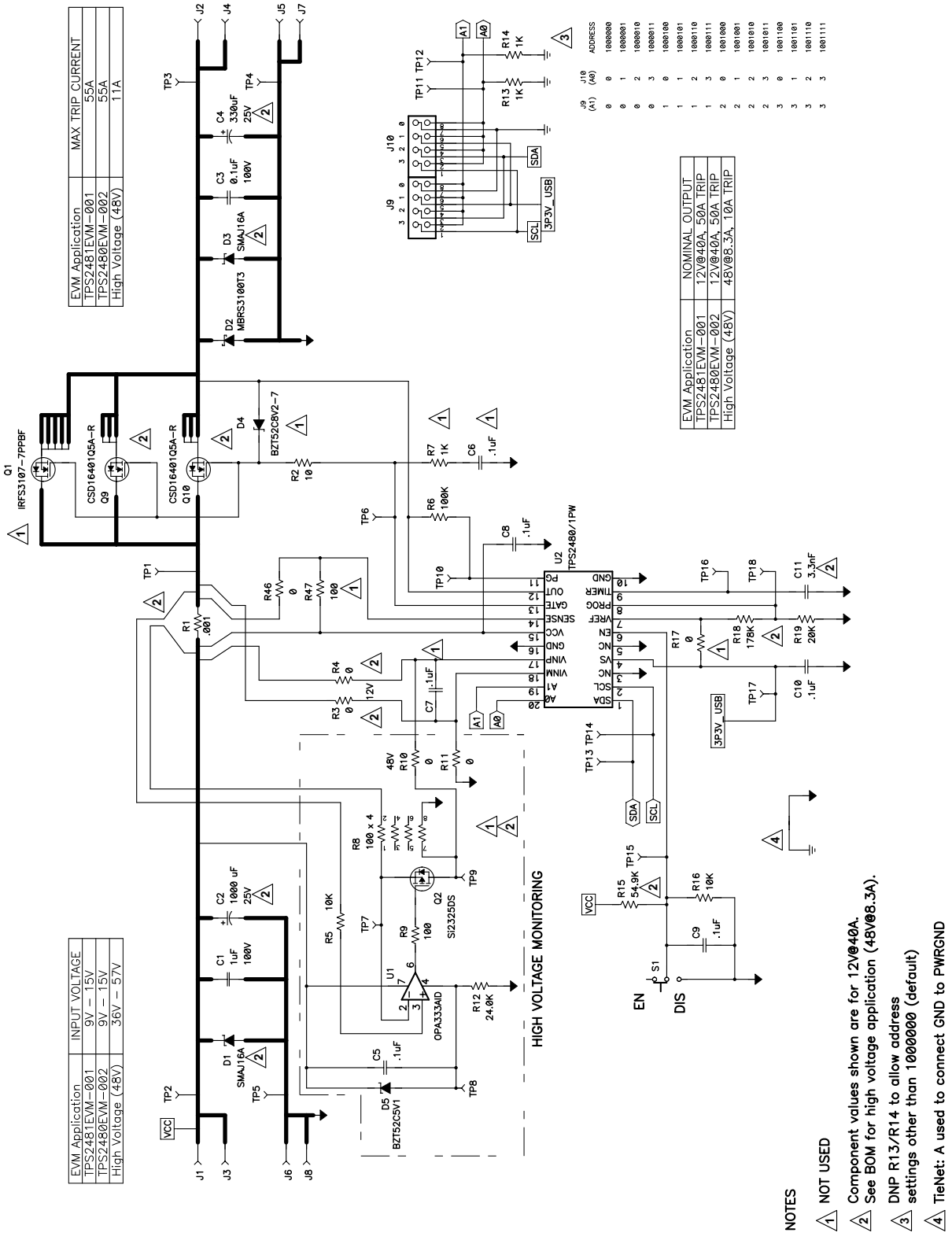

Figure 12. TPS2480/1 EVM Schematic

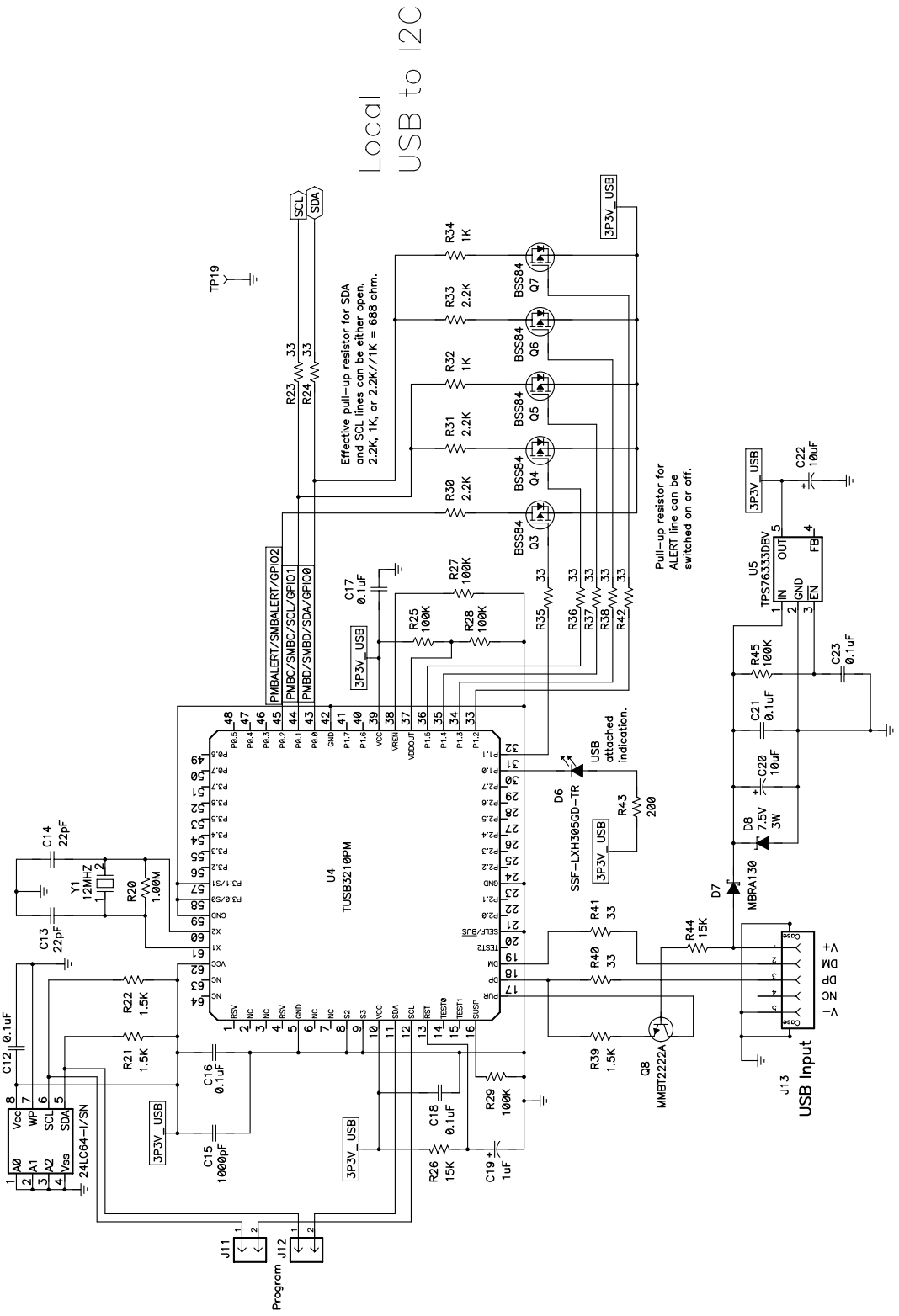

Figure 13. TPS2480/1 EVM Schematic – USB-I2C

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Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

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During normal operation, some circuit components may have case temperatures greater than 85° C. The EVM is designed to operate properly with certain components above 85° C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

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