UC1843B-SP evaluation module (EVM)

The UC1843BEVM-CVAL is the evaluation module (EVM) for the UC1843B-SP and provides a platform to electrically evaluate its features. This user's guide provides details about the EVM, its configuration, schematics, and BOM.

Contents

1 Introduction 3
2 System Design Theory 4
3 Test Setup and Results 8
4 Board Layout 21
5 Schematics and Bill of Materials 28

List of Figures

1 Test Setup 8
2 Efficiency Over Input Voltage 10
3 Load Regulation 10
4 20 V_{IN} Frequency Response 11
5 40 V_{IN} Frequency Response 12
6 Thermal Characteristics for 20 V_{IN} 13
7 Output Voltage Ripple 20 V_{IN} 14
8 Output Voltage Ripple 40 V_{IN} 14
9 Load Step Down With 20 V_{IN} 15
10 Load Step Up With 20 V_{IN} 15
11 Load Step Down With 40 V_{IN} 16
12 Load Step Up With 40 V_{IN} 16
13 Start-up 20 V_{IN} With Fully Loaded Output 17
14 Start-up 20 V_{IN} With No Load on Output 17
15 Start-up 40 V_{IN} With Fully Loaded Output 18
16 Start-up 40 V_{IN} With No Load on Output 18
17 Start-up 20 V_{IN} With Fully Loaded Output 19
18 Start-up 40 V_{IN} With Fully Loaded Output 19
19 Voltage Stress on Main Switching MOSFET (Q1) 20
20 Output Diode Stress (D2) 20
21 Top Overlay 21
22 Top Solder 22
23 Top Layer 22
24 Signal Layer 1 23
25 Signal Layer 2 23
26 Bottom Layer 24
27 Bottom Solder 24
28 Bottom Overlay 25
29 Drill Drawing 26
30 Board Dimensions 27

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31 UC1843BEVM-CVAL Schematic 01 29
32 UC1843BEVM-CVAL Schematic 02 30

List of Tables

1 Test Parameters 8
2 Efficiency for 20 V_{IN} 10
3 Efficiency for 40 V_{IN} 10
4 20 V_{IN} Load Regulation 10
5 40 V_{IN} Load Regulation 11
6 Frequency Response Characteristics for 20 V_{IN} 12
7 Frequency Response Characteristics for 40 V_{IN} 12
8 Notable Thermal Values for 20 V_{IN} 13
9 Bill of Materials 32

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1 Introduction

The UC1843B-SP EVM uses the UC1843B-SP, INA901-SP, LM139AQML-SP, and UC1901-SP to create an isolated feedback flyback with current sensing and overcurrent flags. The UC1843B-SP is used to switch the low side MOSFET of the flyback converter and provides voltage and current to the output. The system uses the UC1843B-SP to provide 5-V and 10-A outputs. These outputs are not dependent on the UC1843B-SP itself, and can be increased or decreased depending on the design. The INA901-SP senses the input current which is then provided to the LM139AQML-SP to create an overcurrent flag. In a full system, this flag could be used to shutdown the UC1843B-SP and turn off the converter.

1.1 Features

- Pulse-by-pulse current limiting using UC1843B-SP
- PWM control using UC1843B-SP
- Current sensing using INA901-SP
- Overcurrent comparison using LM139AQML-SP

1.2 Applications

- Space satellite isolated power supplies
- Radiation hardened applications
- Space satellite payloads

1.3 Description

CAUTION


Do not touch! Surface of EVM gets hot. Contact may cause burns.

The UC1843BEVM-SP uses the UC1843B-SP, INA901-SP, LM139AQML-SP, and UC1901-SP to create an isolated feedback flyback with current sensing and overcurrent flags. The UC1843B-SP is used to switch the low side MOSFET of the flyback converter and provides voltage and current to the output. The system uses the UC1843B-SP to provide 5-V and 10-A outputs. These outputs are not dependent on the UC1843B-SP itself, and can be increased or decreased depending on the design. The UC1901-SP senses the output voltage and provides isolated feedback to the UC1843B-SP to complete the control loop. The INA901-SP senses the input current which is then provided to the LM139AQML-SP to create an overcurrent flag. In a full system, this flag could be used to shutdown the UC1843B-SP and turn off the converter.

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2 System Design Theory

2.1 Switching Frequency

Choosing a switching frequency has a trade off between efficiency and bandwidth. Higher switching frequencies will have larger bandwidth, but a lower efficiency than lower switching frequencies. A switching frequency of 200 kHz was chosen as a trade off between bandwidth and efficiency. Using equations provided by the data sheet for the UC1843B-SP, R_T and C_T were chosen to be 7.15 kΩ and 1200 pF, respectively. The equation for the switching frequency used is Equation 1.

$$f_{osc} \approx \frac{1.72}{R_{osc} \times C_{osc}} \tag{1}$$

$$f_{osc} \approx \frac{1.72}{7.15\ k\Omega \times 1200\ pF} = 200\ \ kHz \tag{2}$$

2.2 Transformer

The transformer of the design consists of two major values, turns ratio, and primary side inductance. There is no minimum limit to the turns ratio of the transformer; only a maximum limit. The equation below gives the turns ratio as a function of duty cycle, which if put in the maximum duty cycle of the converter will give a maximum turns ratio. The UC1843B-SP design targeted a duty cycle of 50%, which is somewhat low for this controller. The suggested value would be around 70% duty cycle to take advantage of the fact the UC1843B-SP has full duty cycle range. The equation of the turns ratio of the transformer is Equation 3.

$$N_{psMAX} = \frac{V_{inMIN} \times D_{lim}}{(V_{out} + V_{Diode}) \times (1 - D_{lim})} \tag{3}$$

$$N_{psMAX} = \frac{20\ V \times 0.5}{(5\ V + 0.7\ V) \times (1 - 0.5)} = 3.5 \tag{4}$$

Often the turns ratio will slightly change in design due to how the transformer is manufactured. For the UC1843B-SP design a turns ratio of 3.33 was used. Another turns ratio that is important is the turns ratio of the auxiliary winding. The auxiliary winding is found by figuring out what positive voltage is needed from the auxiliary winding. Picking what voltage the auxiliary winding should have lets one pick the turns ratio from the secondary to the auxiliary winding, which in turn allows for the turns ratio from primary to auxiliary to be found. The equation for the turns ratio for the auxiliary winding is Equation 5.

$$N_{pa} = \frac{N_{ps} \times (V_{out} + V_{Diode})}{V_{aux}} \tag{5}$$

$$N_{pa} = \frac{3.33 \times (5\ V + 0.7\ V)}{13\ V} = 1.46 \tag{6}$$

An auxiliary winding of 1.43 was used for the UC1843B-SP design due to manufacturing constraints. The primary inductance of the transformer is found from picking an appropriate ripple current. A higher inductance will often mean reduced current ripple, thus lower EMI and noise, but a higher inductance will also increase physical size and limit the bandwidth of the design. A lower inductance will do the opposite, increasing current ripple, lowering EMI, lowering noise, decreasing physical size, and increasing the limited bandwidth of the design. The percent ripple current can be anywhere from 20% to 80% depending on the design. The equation for finding the primary inductance from the percentage ripple current is Equation 7.

$$L_{PRI} = \frac{V_{inMAX}^{\ 2} \times D_{MIN}^{\ 2}}{V_{out} \times I_{out} \times f_{osc} \times \%_{Ripple}} \tag{7}$$

$$\frac{(40\ V)^2 \times 0.25^2}{5\ V \times 10\ A \times 200\ kHz \times 0.4} = 25\ \ \mu H \tag{8}$$

There are quite a few physical limitations when making transformers and this inductance could vary slightly. For the UC1843B-SP, design a primary inductance of 21 µH. This corresponds to a percent ripple of around 0.475. The peak and primary currents of the transformer are also generally useful when designing the physical structure of the transformer. Use the following equations to calculate peak and primary currents.

$$I_{Ripple} = \frac{V_{out} \times I_{out} \times \%_{Ripple}}{V_{inMAX} \times D_{MIN}} \tag{9}$$

$$I_{Ripple} = \frac{5\ V \times 10\ A \times 0.475}{40\ V \times 0.25} = 2.375\ \ A \tag{10}$$

$$I_{PriPeak} = \frac{V_{out} \times I_{out}}{V_{inMIN} \times D_{MAX} \times \eta} + \frac{I_{Ripple}}{2} \tag{11}$$

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$$I_{PriPeak} = \frac{5\ V \times 10\ A}{20\ V \times 0.5 \times 0.8} + \frac{2.375}{2} = 7.44\ A \quad (12)$$

$$I_{PriRMS} = \sqrt{D \times \left(\frac{V_{out} \times I_{out}}{V_{in} \times D}\right)^2 + \frac{I_{Ripple}^2}{3}} \quad (13)$$

$$I_{PriRMS} = \sqrt{0.5 \times \left(\frac{5\ V \times 10\ A}{20\ V \times 0.5}\right)^2 + \frac{(2.375\ A)^2}{3}} = 3.79\ A \quad (14)$$

$$I_{SecRMS} = \sqrt{\left(1 - D\right) \times I_{out}^2 + \frac{(I_{Ripple} \times N_{ps})^2}{3}} \quad (15)$$

$$I_{SecRMS} = \sqrt{0.5 \times \left(10\ A\right)^2 + \frac{(2.375\ A \times 3.33)^2}{3}} = 8.42\ A \quad (16)$$

2.3 RCD and Diode Clamp

For the UC1843B-SP design a Zener diode was used, which will clamp (often called the snubber) the voltage to around the breakdown voltage of the Zener diode plus the input voltage of the design. Since Zener diodes take time to switch, the actual clamped voltage will often be above the Zener diode breakdown voltage plus the input voltage. Since a resistor and capacitor are commonly used for the clamp for flybacks, the design philosophy for how to pick resistor and capacitor values will be covered. The resistor and capacitor is generally a value that is found through testing, but starting values can be obtained. To choose the resistor and capacitor needed for the RCD clamp, first decide the limit the node is allowed to overshoot. The equation for finding the voltage of the clamp is Equation 17.

$$V_{clamp} = K_{clamp} \times N_{ps} \times (V_{out} + V_{Diode}) \quad (17)$$

Note that K_{clamp} is recommended to be 1.5 as this will allow for around 50% overshoot. The parasitic inductance of the transformer and how much the snubber voltage is allowed to change over the switching cycle helps to calculate starting values for the resistor and capacitor using Equation 18 and Equation 19.

$$R_{clamp} = \frac{V_{clamp}^2}{\frac{1}{2} \times L_{leakage} \times I_{PriPeak}^2 \times \frac{V_{clamp}}{V_{clamp} - N_{ps} \times (V_{out} + V_{Diode})} \times f_{osc}} \quad (18)$$

$$C_{clamp} = \frac{V_{clamp}}{\Delta V_{clamp} \times V_{clamp} \times R_{clamp} \times f_{osc}} \quad (19)$$

A starting value of 10% is generally used for ΔV_{clamp}.

2.4 Output Diode

The voltage stress by the converter on the diode can be found with the following equation:

$$V_{DiodeStress} = V_{out} + \frac{V_{inMAX}}{N_{ps}} \quad (20)$$

$$V_{DiodeStress} = 5\ V + \frac{40\ V}{3.33} = 17\ V \quad (21)$$

Note that any diode picked should have a voltage rating of well above this value, as it does not include parasitic spikes in the equation. The UC1843B-SP diode was picked to have a voltage rating of 60 V.

2.5 Output Filter and Capacitance

The output capacitance value is picked such that there is enough capacitance for the required voltage ripple and output current load step. The UC1843B-SP design uses equations Equation 22 and Equation 24 to find a minimum capacitance.

$$C_{out} > \frac{I_{out} \times D_{MAX}}{V_{Ripple} \times f_{osc}} \quad (22)$$

$$C_{out} > \frac{10\ A \times 0.5}{50\ mV \times 200\ kHz} = 500\ \mu F \quad (23)$$

$$C_{out} > \frac{\Delta I_{step}}{2\pi \times \Delta V_{out} \times f_{co}} \quad (24)$$

$$C_{out} > \frac{10\ A}{2\pi \times 0.7\ V \times 2.2\ kHz} = 1\ mF \quad (25)$$

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A value of around 1145 µF was chosen to keep output voltage ripple low. Note that the output voltage ripple in the design was further decreased by adding an output filter and by adding an inductor after a small portion of the output capacitance. Six ceramic capacitors were picked to be placed before the output filter and then the large tantalum capacitors with some small ceramics were added to be part of the output filter. The initial ceramics will help with the initial current ripple, but have a very large output voltage ripple. This voltage ripple will be attenuated by the inductor and capacitor combination placed between the ceramic capacitors and the output. The following equations are used to calculate the amount of attenuation that will come from a specific output filter inductance. An inductance of 500 nH was chosen to attenuate the output voltage ripple and the attenuation was sufficient for the design.

$$F_{resonant} = \frac{1}{2\pi \times \sqrt{L_{Filter} \times C_{oBulk}}} \tag{26}$$

$$F_{resonant} = \frac{1}{2\pi \times \sqrt{0.5\ nH \times 1127\ \mu F}} = 6.7\ \ kHz \tag{27}$$

$$F_{Zero} = \frac{1}{2\pi \times C_{oBulk} \times ESR_{oBulk}} \tag{28}$$

$$F_{Zero} = \frac{1}{2\pi \times 1127\ \mu F \times 0.009\ \Omega} = 15.69\ \ kHz \tag{29}$$

$$Attenuation_{fsw} = 40 \times \log_{10}\left(\frac{f_{osc}}{f_{resonant}}\right) - 20 \times \log_{10}\left(\frac{f_{osc}}{f_{zero}}\right) \tag{30}$$

$$Attenuation_{fsw} = 40 \times \log_{10}\left(\frac{200\ kHz}{6.7\ kHz}\right) - 20 \times \log_{10}\left(\frac{200\ kHz}{15.69\ kHz}\right) = 36.88\ \ dB \tag{31}$$

Sometimes the output filter can cause peaking at high frequencies. This can be damped by adding a resistor in parallel with the inductor. For the UC1843B-SP design, 0.5 Ω was used as a very conservative value. The resistance needed to dampen the peaking can be calculated using the following equations:

$$\omega_o = \sqrt{\frac{2(C_{oCerm} + C_{oBulk})}{L_{Filter} \times C_{oCerm} \times C_{oBulk}}} \tag{32}$$

$$\omega_o = \sqrt{\frac{2(19\ \mu F + 1127\ \mu F)}{500\ nH \times 19\ \mu F \times 1127\ \mu F}} = 463\ \ kHz \tag{33}$$

$$R_{Filter} = \frac{R_o \times L_{Filter} \times \left(C_{oCerm} + C_{oBulk}\right) - \frac{L_{Filter}}{\omega_o}}{\frac{R_o \times (C_{oCerm} + C_{oBulk})}{\omega_o} - L_{Filter} \times C_{oCerm}} \tag{34}$$

$$R_{Filter} = \frac{0.5 \times 500\ nH \times \left(19\ \mu F + 1127\ \mu F\right) - \frac{500\ nH}{463\ kHz}}{\frac{0.5 \times (19\ \mu F + 1127\ \mu F)}{463\ kHz} - 500\ nH \times 19\ \mu F} = 0.232\ \ \Omega \tag{35}$$

2.6 Compensation

The poles and zeros of a flyback converter can be found with the following equations:

$$f_{ZESR} = \frac{1 + D}{2\pi \times C_{out} \times R_{ESR}} \tag{36}$$

$$f_{ZESR} = \frac{1 + 0.5}{2\pi \times 1146\ \mu F \times 0.009\ \Omega} = 23.15\ \ kHz \tag{37}$$

$$f_P = \frac{1}{2\pi \times C_{out} \times R_o} \tag{38}$$

$$f_P = \frac{1}{2\pi \times 1146\ \mu F \times 0.5} = 278\ \ Hz \tag{39}$$

$$f_{RHPZ} = \frac{R_{out} \times (1 - D_{MAX})^2}{2\pi \times \frac{L_{PRI}}{N_{ps}^2} \times D_{MAX}} \tag{40}$$

$$f_{RHPZ} = \frac{0.5 \times (1 - 0.5)^2}{2\pi \times \frac{21\ \mu H}{3.33^2} \times 0.5} = 21\ \ kHz \tag{41}$$

$$f_{Compensation\ \ Zero} = \frac{1}{2\pi \times R11 \times C32} = \frac{1}{2\pi \times 5.11\ k\Omega \times 0.22\ \mu F} = 142\ \ Hz \tag{42}$$

$$f_{Compensation\ \ Pole} = \frac{1}{2\pi \times R11 \times C28} = \frac{1}{2\pi \times 5.11\ k\Omega \times 1500\ pF} = 20.76\ \ kHz \tag{43}$$

Type IIB compensation was selected to compensate the poles and zeros of the flyback converter. Since the right half plane zero (RHPZ) of the flyback converter is unable to be compensated, the crossover frequency of the converter should be between one fourth to a whole decade below the RHPZ of the converter. Type IIB compensation has 1 pole and 1 zero to help compensate the converter. The pole from the compensation is suggested to be placed by the RHPZ of the converter and the zero from compensation is suggested to be placed a decade before the expected crossover frequency. The compensation values for the converter were using these guidelines. For the non-isolated portion of the

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board this means choosing the value of the compensation resistors and capacitors along these guidelines. For the UC1901-SP, the compensation was placed using the same guidelines, however the UC1901-SP adds a static gain of 12 to the feedback loop. This increase in gain can be compensated for by dividing the resistor from compensation down and increasing the values of the capacitors by the same amount. This allows for the gain to be controlled in the system without changing the poles and zeros of the system. Optimization is needed for compensation values and those values can be validated through testing.

2.7 Sense Resistor and Slope Compensation

The sense resistor is used to sense the ripple current from the transformer as well as shutdown the switching cycle if the peak current of the converter is allowed to get too high. The voltage threshold of the CS pin is around 1 V, thus the equation to find the sense resistor from the peak current is shown in Equation 44.

$$R_{cs} = \frac{V_{CS\ \ Threshold} - V_{Slope\ \ Comp\ \ Offset}}{I_{limit}} \tag{44}$$

$$R_{cs} = \frac{1\ V - 0.1\ V}{12\ A} = 0.075\ \ \Omega \tag{45}$$

Note that I_{limit} should be greater than $I_{PriPeak}$, and that the voltage offset from the slope compensation will be dependant on the amount of slope compensation in the design. The value of 0.075 Ω for the sense resistance was found to be the optimum value adding some headroom for slope compensation offset of 0.1 V. Slope compensation was implemented with a BJT being turned off and on by the RC pin of the device. The BJT was placed between the REF pin and a resistor divider to the CS pin. The optimum slope compensation value can be found from the following equations after picking a value for the top of the divider:

$$S_c = \frac{V_{out} \times R_{cs} \times G_{cs}}{L_{PRI} \times N_{ps}} \tag{46}$$

$$S_c = \frac{5\ V \times 0.075\ \Omega \times 3}{21\ \mu H \times 3.33} = 16088 \tag{47}$$

$$S_{osc} = \frac{f_{osc} \times V_{oscpp}}{D_{MIN}} \tag{48}$$

$$S_{osc} = \frac{200\ kHz \times 1.7\ V}{0.25} = 1360000 \tag{49}$$

$$R_{csf} = \frac{R_{top}}{\frac{S_{osc}}{S_c} - 1} \tag{50}$$

$$R_{csf} = \frac{11.8\ k\Omega}{\frac{1360000}{16088} - 1} = 141\ \ \Omega \tag{51}$$

The UC1843B-SP design uses a much higher resistor of 1.47 kΩ, but this is an attempt to be very conservative. Note that the bottom resistor can be used as part of a filter to the CS pin as well, which is implemented in the design using a capacitor near the CS pin. Care was taken such that the RC filter would not filter the switching frequency by having the RC time constant be a decade less than the switching frequency.

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3 Test Setup and Results

3.1 Test Setup

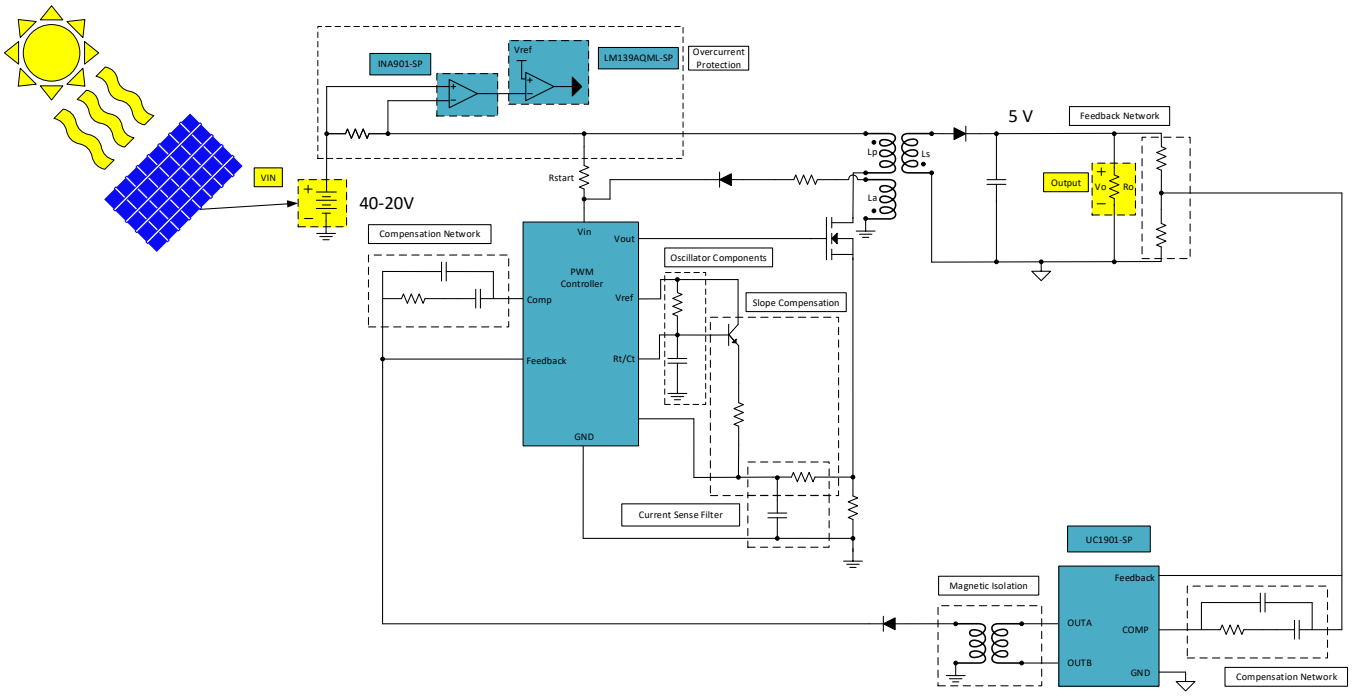


Figure 1. Test Setup

WARNING

The UC1843BEVM-CVAL (EVM) is intended only for the developer's evaluation of the UC1843B-SP Current Mode PWM Controller device.

This EVM is not designed nor intended to simulate actual end product or subassembly applications involving high voltages often found in isolated topologies exceeding specified electrical circuit ratings for the UC1843BEVM-CVAL.

To minimize potential risk of personal injury, death, or damage to the EVM itself, application of any differential voltages applied between the electrical grounds of each input and output side of the evaluation module is strictly prohibited.

Table 1. Test Parameters

PARAMETER	SPECIFICATIONS
Input Power Supply	20 to 40 VDC
Output Voltage	5 VDC
Output Current	0 to 10 A
Output Current Pre-load	100 mA
Operating Temperature	25°C

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Table 1. Test Parameters (continued)

PARAMETER	SPECIFICATIONS
Switching Frequency of UC1843B-SP	200 kHz
Peak Input Current Limit	12 A
Bandwidth	~4 kHz
Phase Margin	~80°

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3.2 Test Results

3.2.1 Efficiency

Efficiency measurement was taken after the board was run for 20 minutes at full output load. Values for input voltage, input current, output voltage, and output current were then taken starting at 10 A and decreasing the output load by 1 A down to no load. The output current does not include the 100-mA pre-load that is already included on the board.

Table 2. Efficiency for 20 V_{IN}

V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Efficiency
20.06	3.24	4.97	9.98	64.99	49.58	0.763
20.11	2.87	4.97	9.01	57.71	44.79	0.776
20.15	2.51	4.97	8.01	50.57	39.84	0.788
20.19	2.17	4.98	7.01	43.82	34.89	0.796
20.24	1.84	4.98	6.01	37.24	29.93	0.804
20.28	1.52	4.98	5.01	30.83	24.98	0.810
20.32	1.21	4.99	4.01	24.59	20.00	0.813
20.36	0.91	4.99	3.01	18.53	15.02	0.811
20.39	0.63	4.99	2.01	12.85	10.04	0.781
20.44	0.33	4.99	1.01	6.74	5.04	0.748
20.47	0.06	5.00	0	1.23	0	0

Table 3. Efficiency for 40 V_{IN}

V_{IN}	I_{IN}	V_{OUT}	I_{OUT}	P_{IN}	P_{OUT}	Efficiency
40.05	1.53	4.97	9.98	61.27	49.61	0.810
40.07	1.37	4.97	9	54.89	44.76	0.815
40.09	1.22	4.98	8.01	48.91	39.86	0.815
40.11	1.06	4.98	7.01	42.52	34.90	0.821
40.14	0.91	4.98	6.01	36.52	29.94	0.820
40.16	0.76	4.98	5.01	30.52	24.98	0.818
40.18	0.62	4.99	4.01	24.91	20.01	0.803
40.20	0.48	4.99	3.01	19.30	15.02	0.779
40.23	0.32	4.99	2.01	12.87	10.04	0.780
40.25	0.19	4.99	1.01	7.65	5.05	0.660
40.27	0.03	5.00	0	1.21	0	0

3.2.2 Load Regulation

Load regulation was taken after output voltage settled and after decreasing load in 1-A increments.

Table 4. 20 V_{IN} Load Regulation

V_{OUT}	I_{OUT}
4.968	9.98
4.9707	9.01
4.9736	8.01
4.9766	7.01
4.9795	6.01

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Table 4. 20 V_{IN} Load Regulation (continued)

V_{OUT}	I_{OUT}
4.9825	5.013
4.9853	4.012
4.9883	3.012
4.9911	2.011
4.9939	1.01
4.9962	0

Table 5. 40 V_{IN} Load Regulation

V_{OUT}	I_{OUT}
4.971	9.98
4.9735	9
4.9762	8.01
4.9788	7.01
4.9815	6.01
4.9841	5.012
4.9868	4.012
4.9894	3.011
4.992	2.011
4.9946	1.011
4.9959	0

3.2.3 Frequency Response

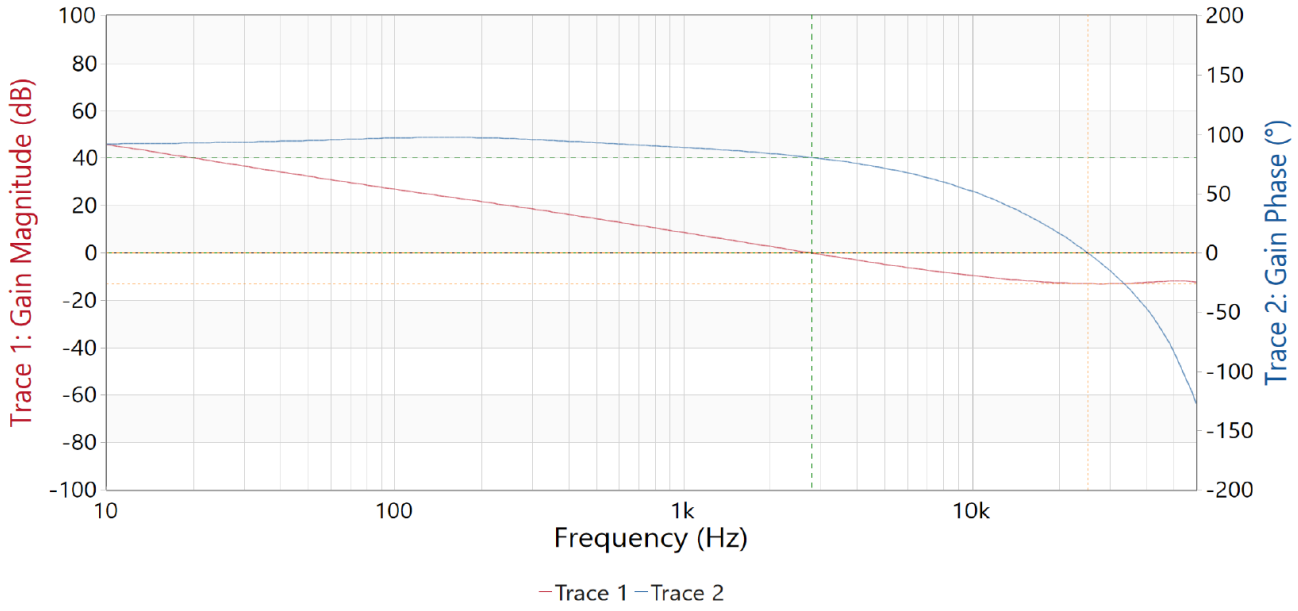


Figure 4. 20 V_{IN} Frequency Response

Frequency response was taken with 10-A output current and 20 V_{IN}.

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Table 6. Frequency Response Characteristics for 20 V_{IN}

PARAMETER	VALUE
Crossover Frequency	2.79 kHz
Phase Margin	80.66°
Phase Crossover	25.19 kHz
Gain Margin	–12.93 dB

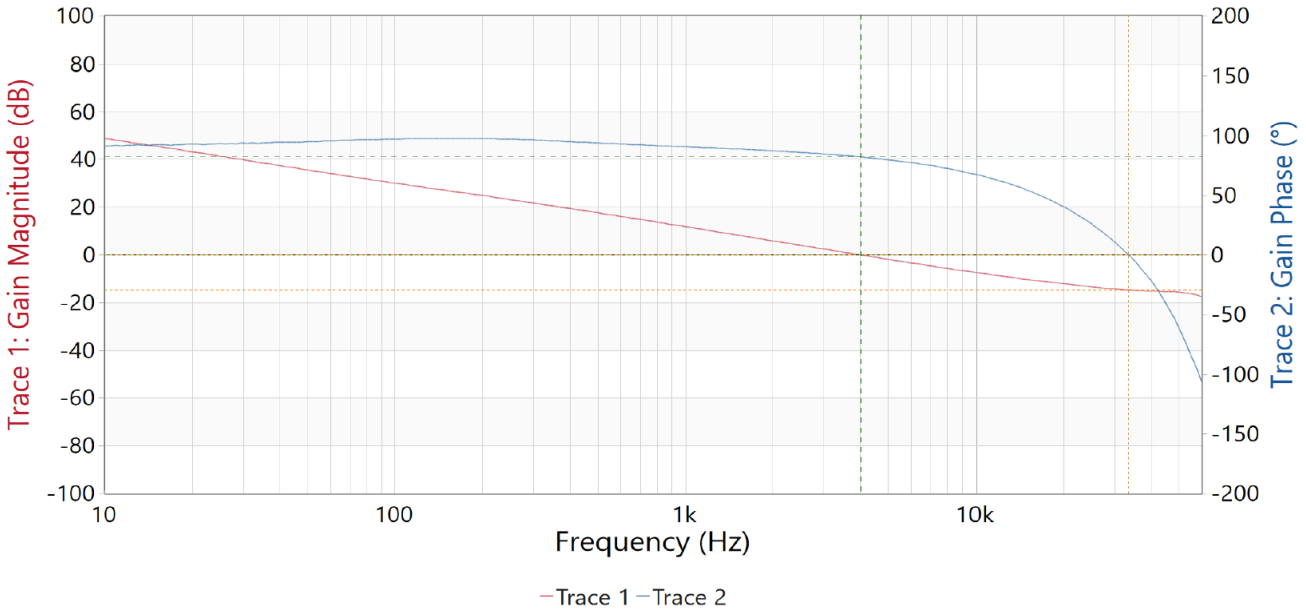


Figure 5. 40 V_{IN} Frequency Response

Frequency response was taken with 10-A output current and 40 V_{IN}.

Table 7. Frequency Response Characteristics for 40 V_{IN}

PARAMETER	VALUE
Crossover Frequency	4.04 kHz
Phase Margin	82.27°
Phase Crossover	33.59 kHz
Gain Margin	–14.68 dB

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3.2.4 Thermal Characteristics

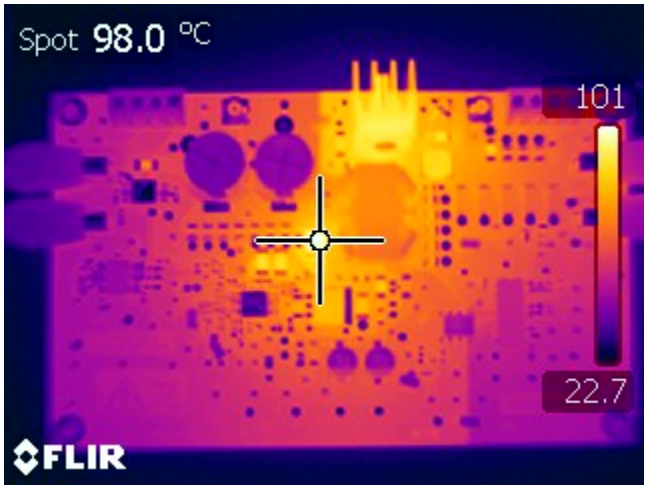


Figure 6. Thermal Characteristics for 20 V_{IN}

Thermal measurement was done with 20 V_{IN} after 20 minutes of running with full load on the output.

Table 8. Notable Thermal Values for 20 V_{IN}

Area	Temperature
Zener Diode Clamp (D4)	101°C
Output Diode (D2)	86.0°C
Output Filter Inductor (L1)	75.0°C
Main Switching MOSFET (Q1)	66.6°C
Sense Resistors (R17 and R18)	67.0°C
Transformer (T1)	56.0°C

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3.2.5 Output Voltage Ripple

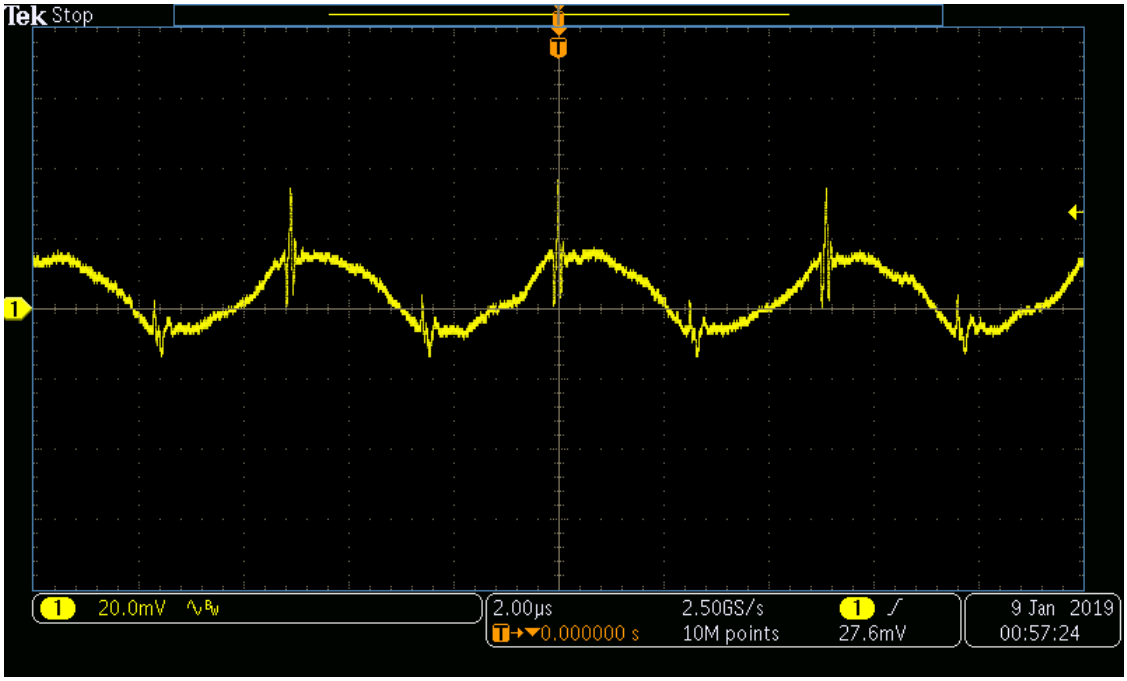


Figure 7. Output Voltage Ripple 20 V_{IN}

Output voltage ripple was taken with 20 V_{IN} and a fully loaded output.



Figure 8. Output Voltage Ripple 40 V_{IN}

Output voltage ripple was taken with 40 V_{IN} and a fully loaded output.

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3.2.6 Load Step

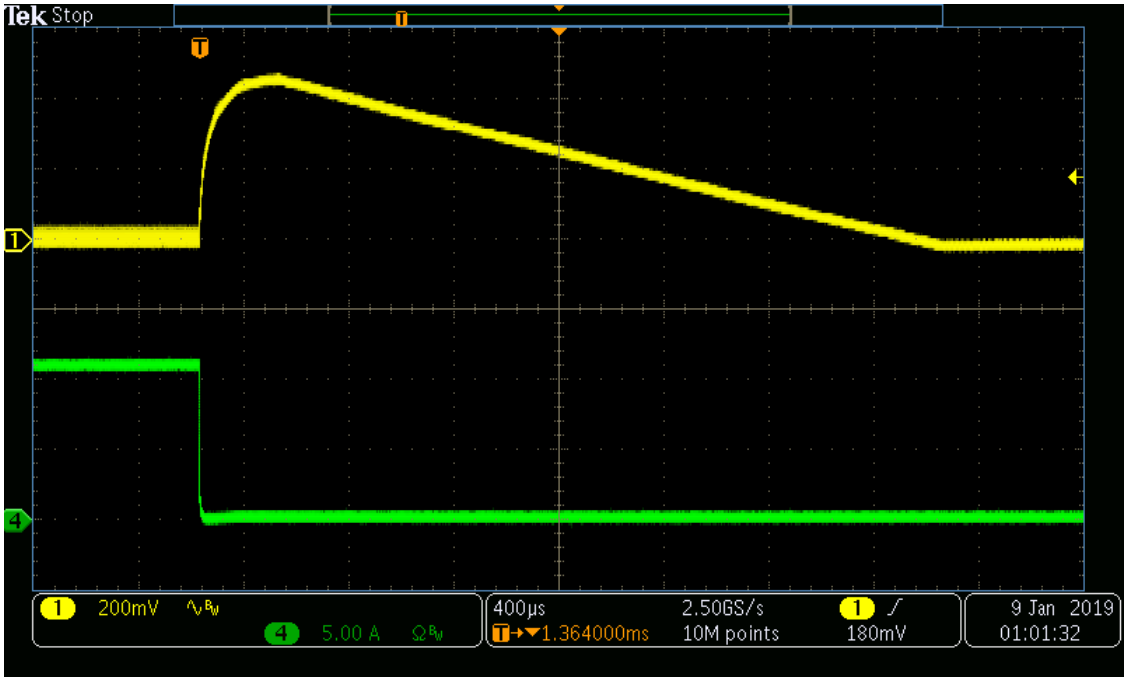


Figure 9. Load Step Down With 20 V_{IN}



Figure 10. Load Step Up With 20 V_{IN}

For tests shown in Figure 9 and Figure 10, 20 V was applied to the input and a load step was applied to the output. The load step applied was from 0 A to 10 A and 10 A to 0 A. Note that those currents do not include the 0.1-A pre-load.

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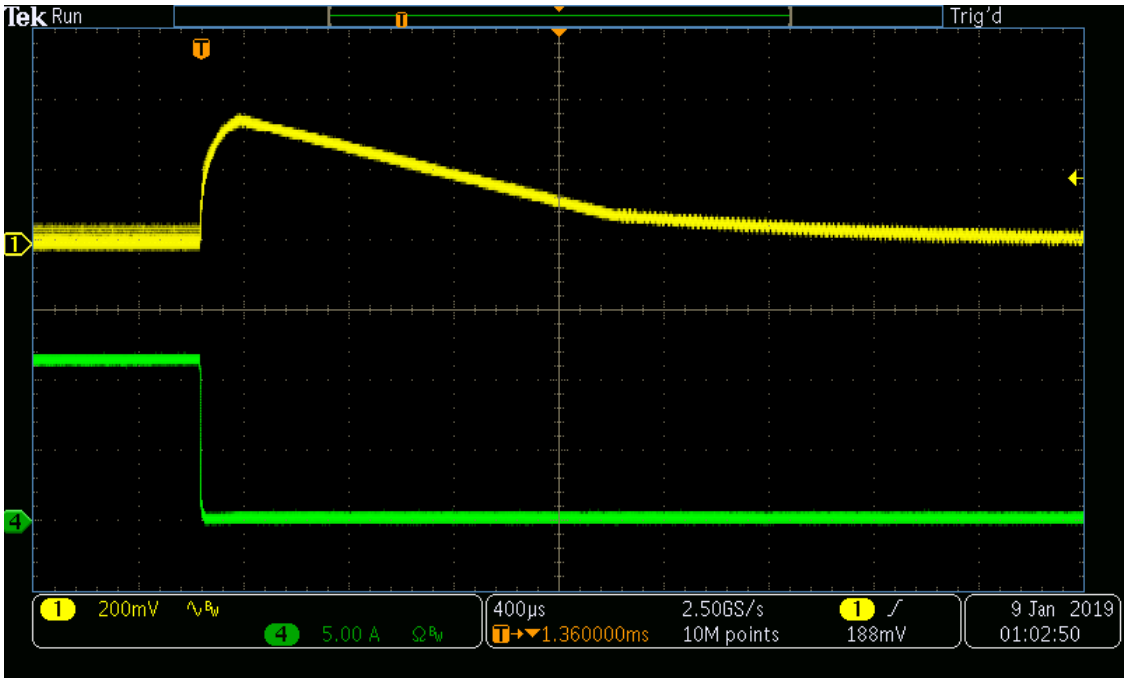


Figure 11. Load Step Down With 40 V_{IN}



Figure 12. Load Step Up With 40 V_{IN}

For tests shown in Figure 11 and Figure 12, 40 V was applied to the input and a load step was applied to the output. The load step applied was from 0 A to 10 A and 10 A to 0 A. Note that those currents do not include the 0.1-A pre-load.

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3.2.7 Start-up

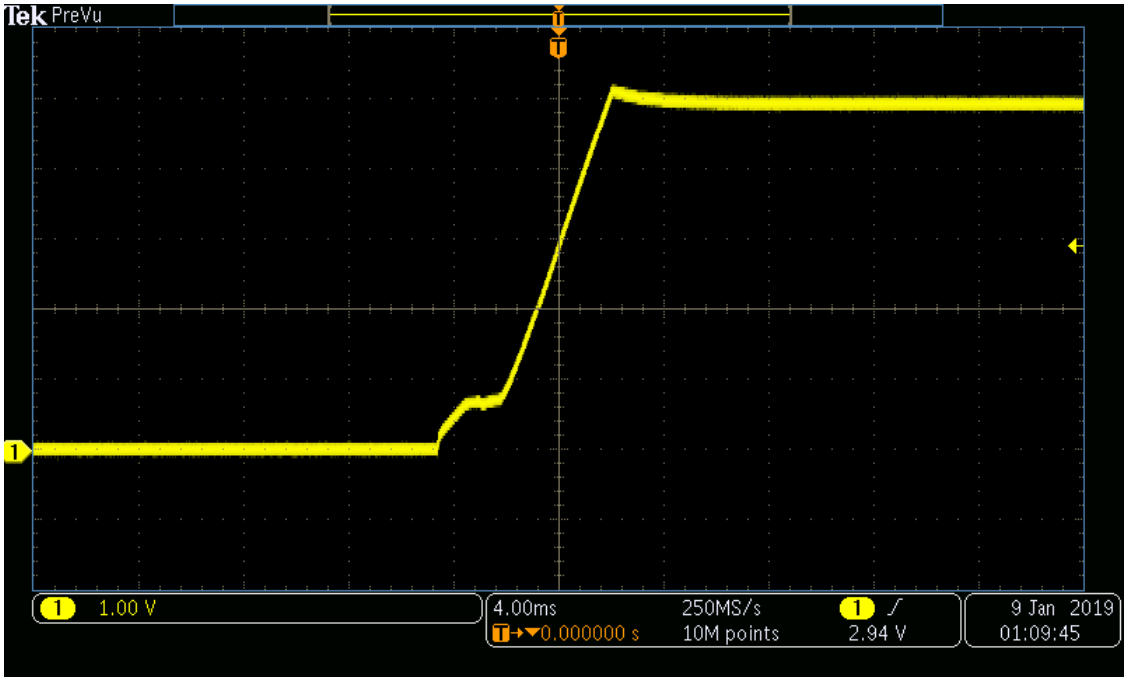


Figure 13. Start-up 20 V_{IN} With Fully Loaded Output

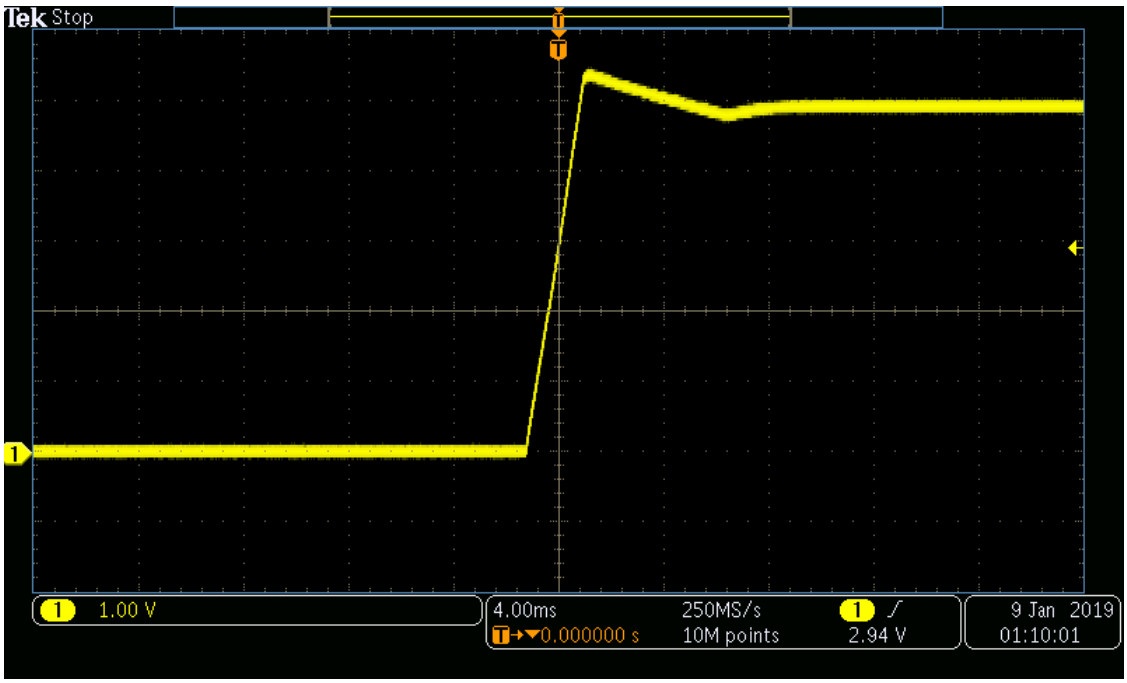


Figure 14. Start-up 20 V_{IN} With No Load on Output

For tests shown in Figure 13 and Figure 14, 20 V was applied to the input from 0 V initially. The output was either loaded with 0 A on the output or 10 A. Note that those currents do not include the 0.1-A pre-load.

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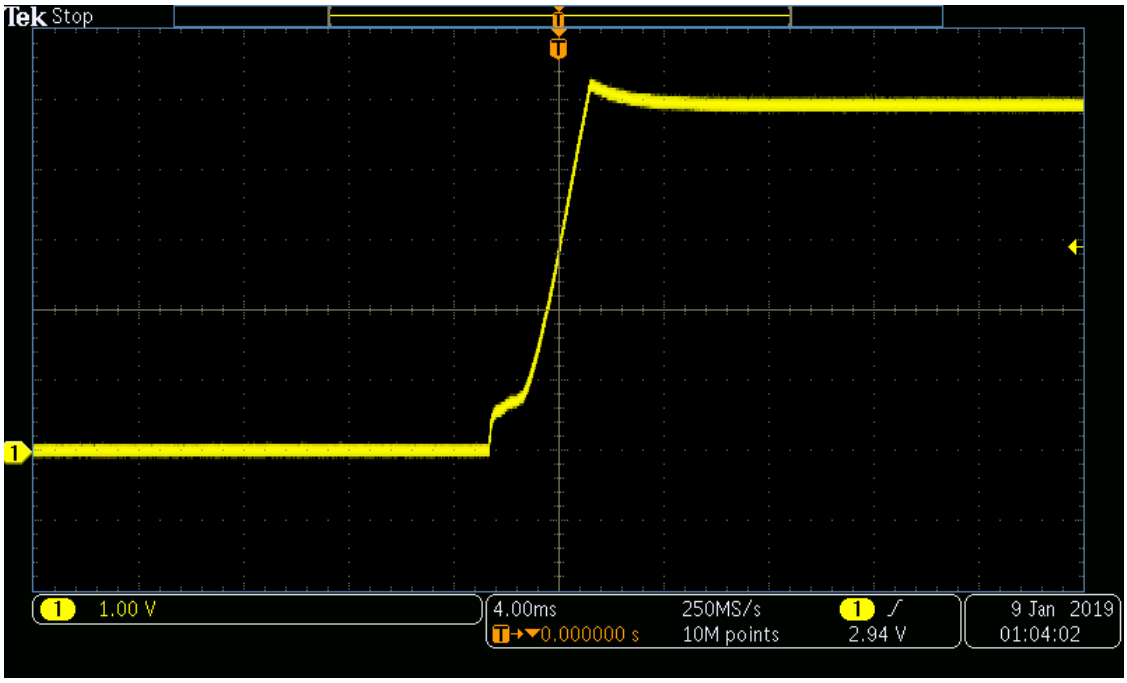


Figure 15. Start-up 40 V_{IN} With Fully Loaded Output

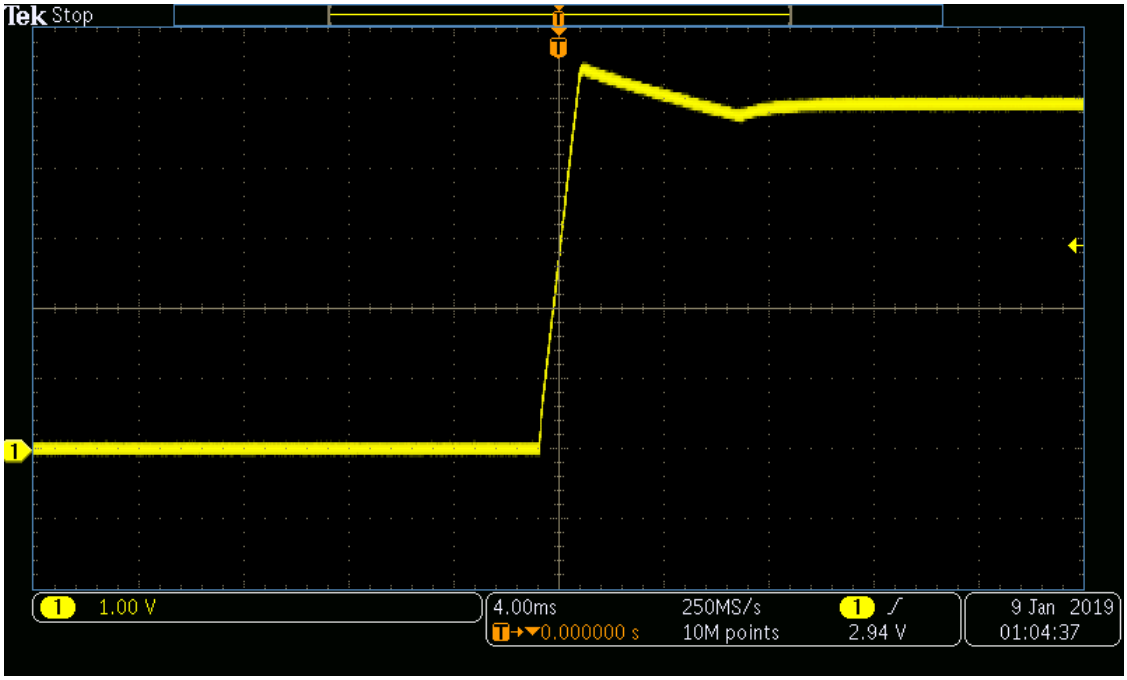


Figure 16. Start-up 40 V_{IN} With No Load on Output

For tests shown in Figure 15 and Figure 16, 40 V was applied to the input from 0 V, initially. The output was either loaded with 0 A on the output or 10 A. Note that those currents do not include the 0.1-A pre-load.

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3.2.8 Shutdown

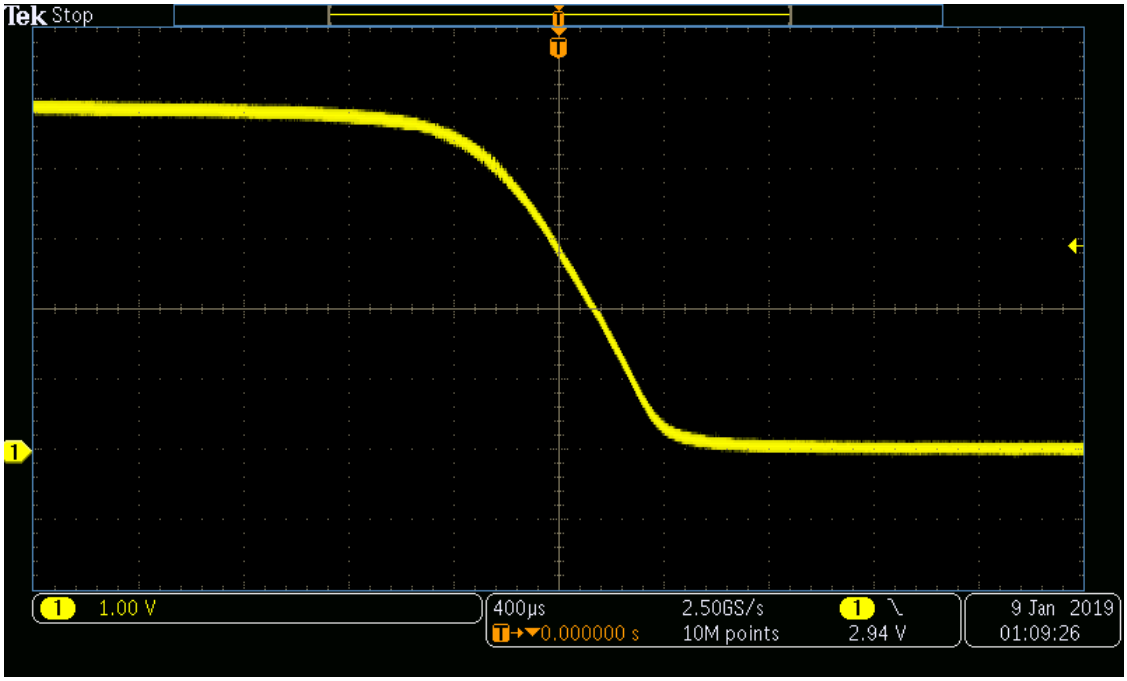


Figure 17. Start-up 20 V_{IN} With Fully Loaded Output

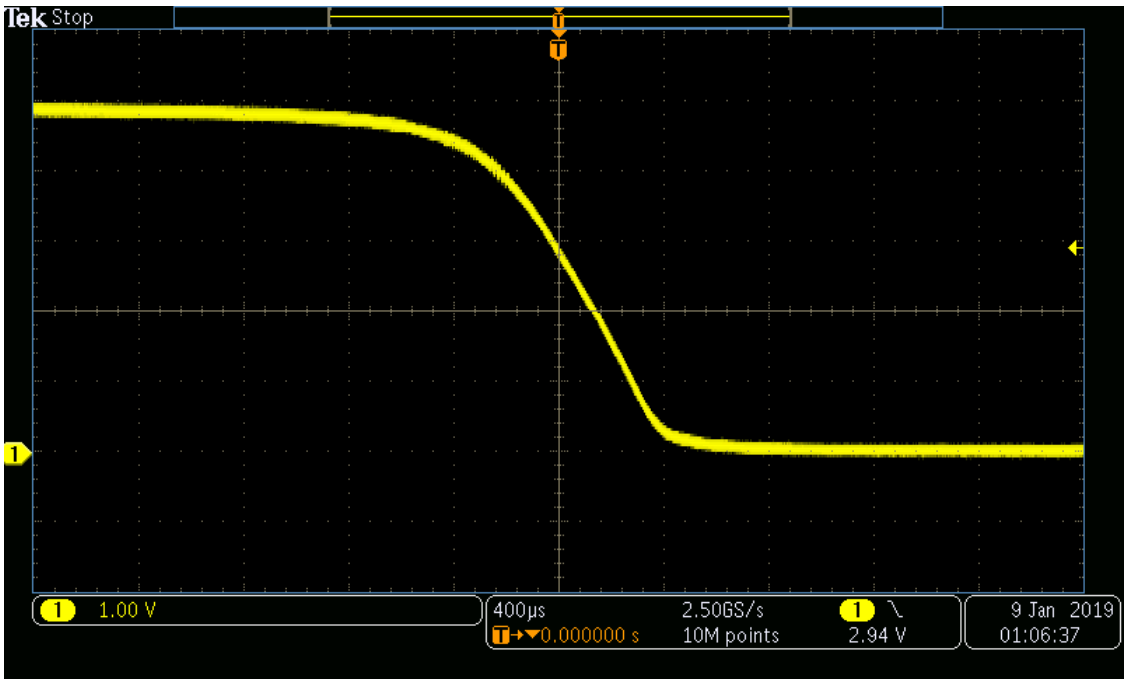


Figure 18. Start-up 40 V_{IN} With Fully Loaded Output

For tests shown in Figure 17 and Figure 18, 20 V or 40 V was applied to the input and then disconnected. The output was loaded with 10 A on the output. Note that those currents do not include the 0.1-A pre-load.

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3.2.9 Component Stresses

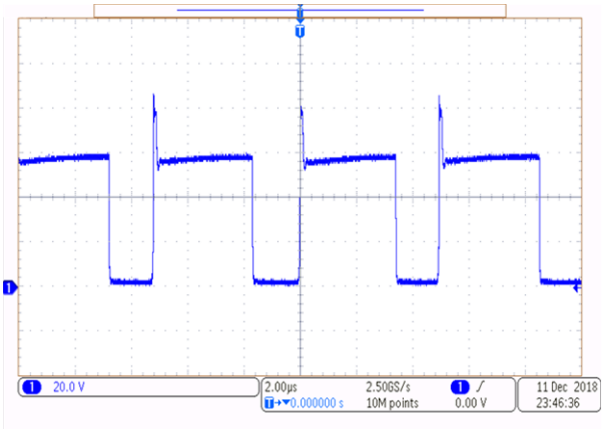


Figure 19. Voltage Stress on Main Switching MOSFET (Q1)

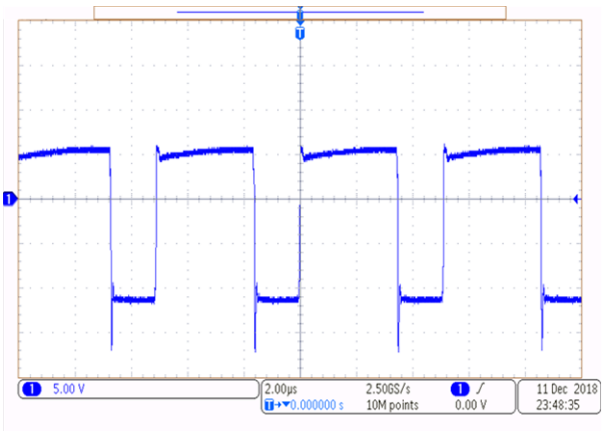


Figure 20. Output Diode Stress (D2)

For the test in Figure 19 and Figure 20, 40 V was applied to the input and 10 A was drawn from the output. For the output diode stress, the voltage was measured with respect to ground so the output voltage would have to be added to show the true stress on the output diode.

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4 Board Layout

Care was taken in the layout to ensure that high current path lengths were minimized as well as providing multiple layers for high current input/outputs. Signals were kept to the top layer, except when it was necessary to use the bottom layer. Internal layers were used for creating large planes for input/output current as well as the switch nodes of the topology. Areas that dissipate large amounts of power such as the RCD clamp and the sense resistors were placed on large copper planes in order to allow the thermal properties of the parts to keep the temperature down as much as possible. Care was also taken to have the high switching current path short. The switching current path starts at the input capacitors, through the transformer into the MOSFET, and then finally through the sense resistors and back into the input capacitors. On the secondary side the high switching current path is from the ground of the output capacitors, through the transformer, and then to the output.

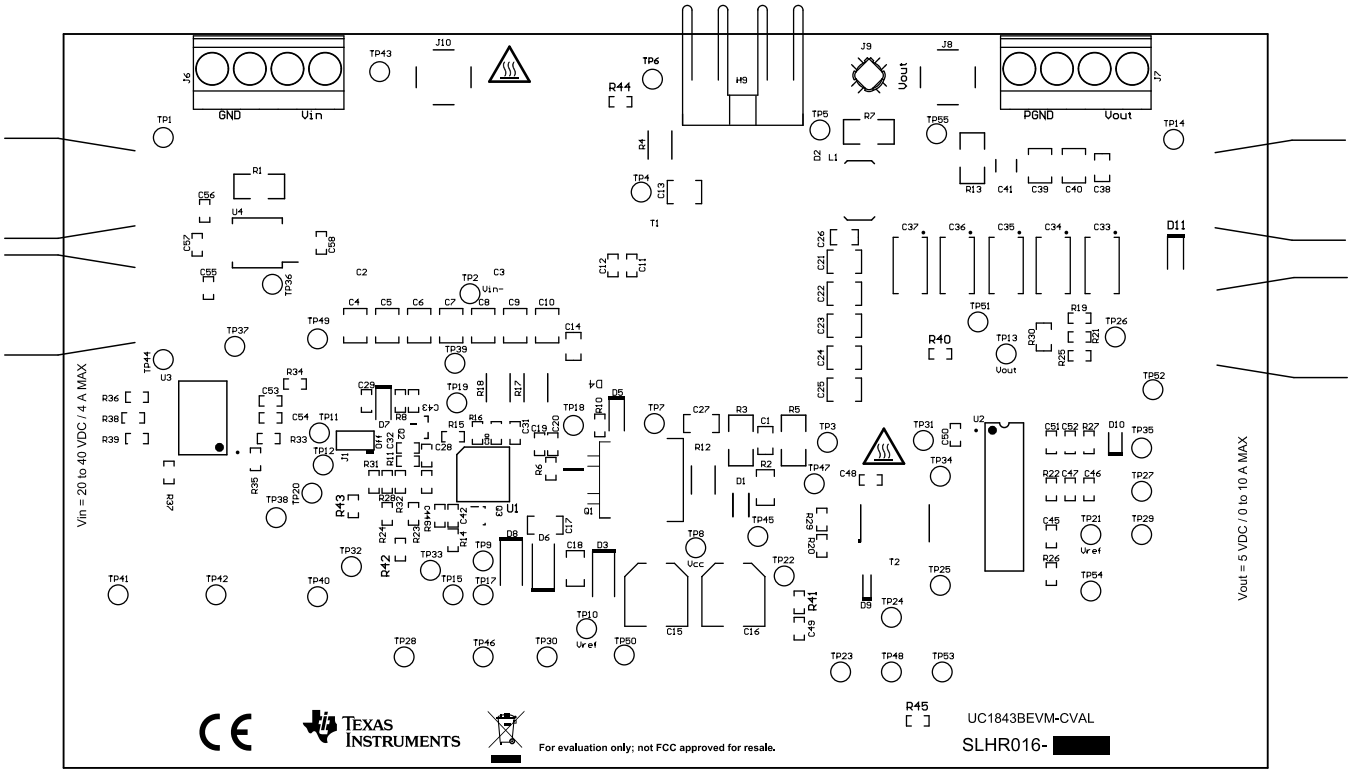


Figure 21. Top Overlay

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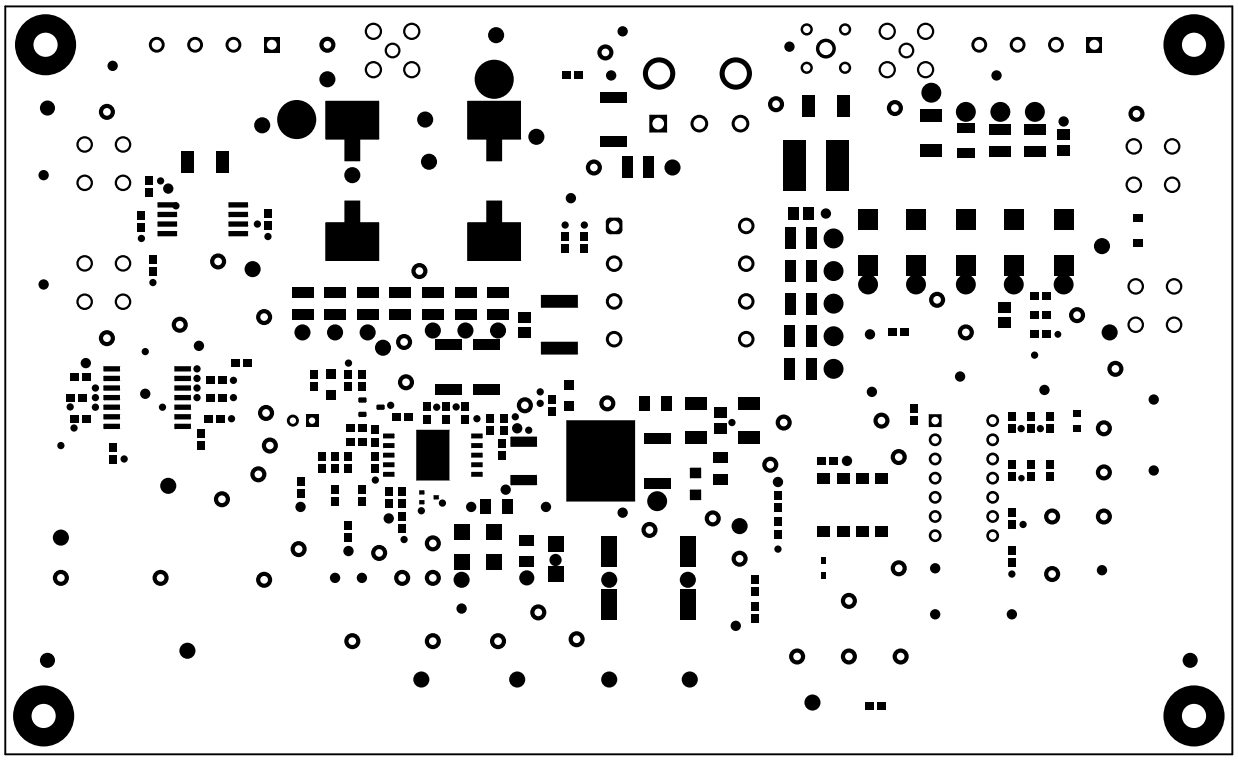


Figure 22. Top Solder

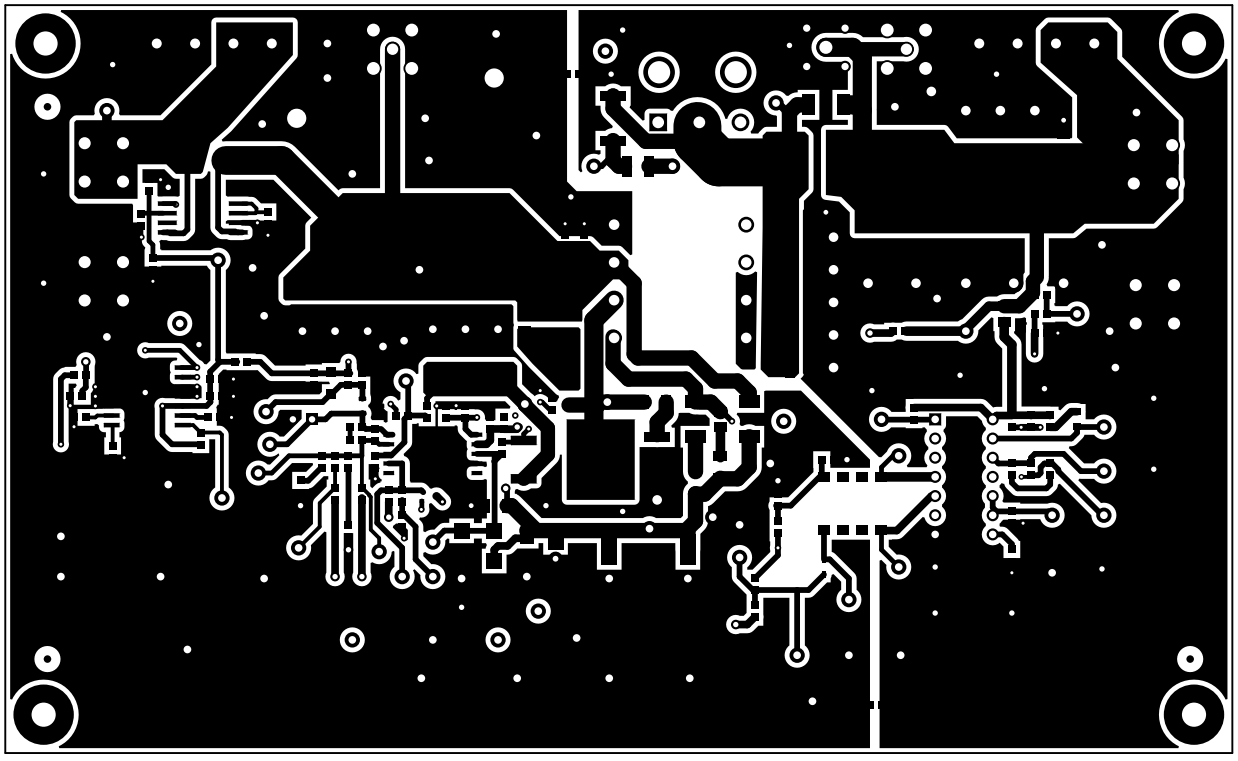


Figure 23. Top Layer

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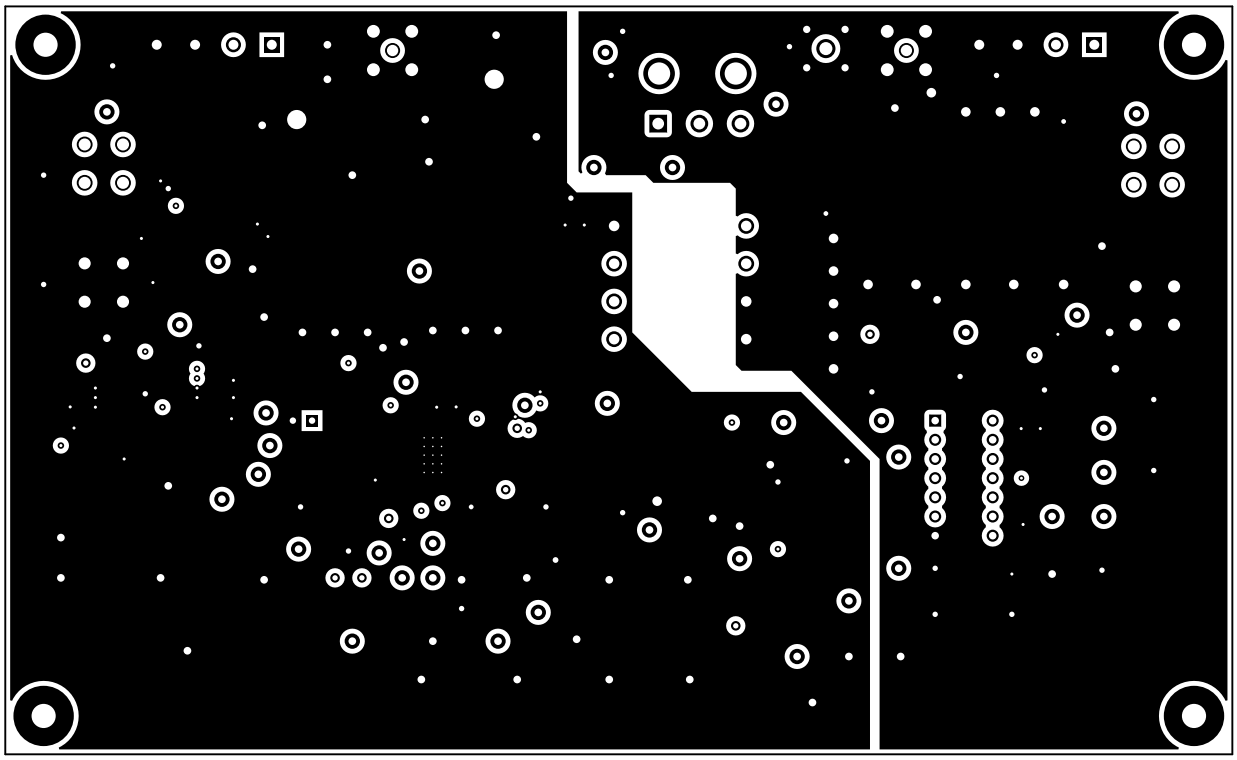


Figure 24. Signal Layer 1

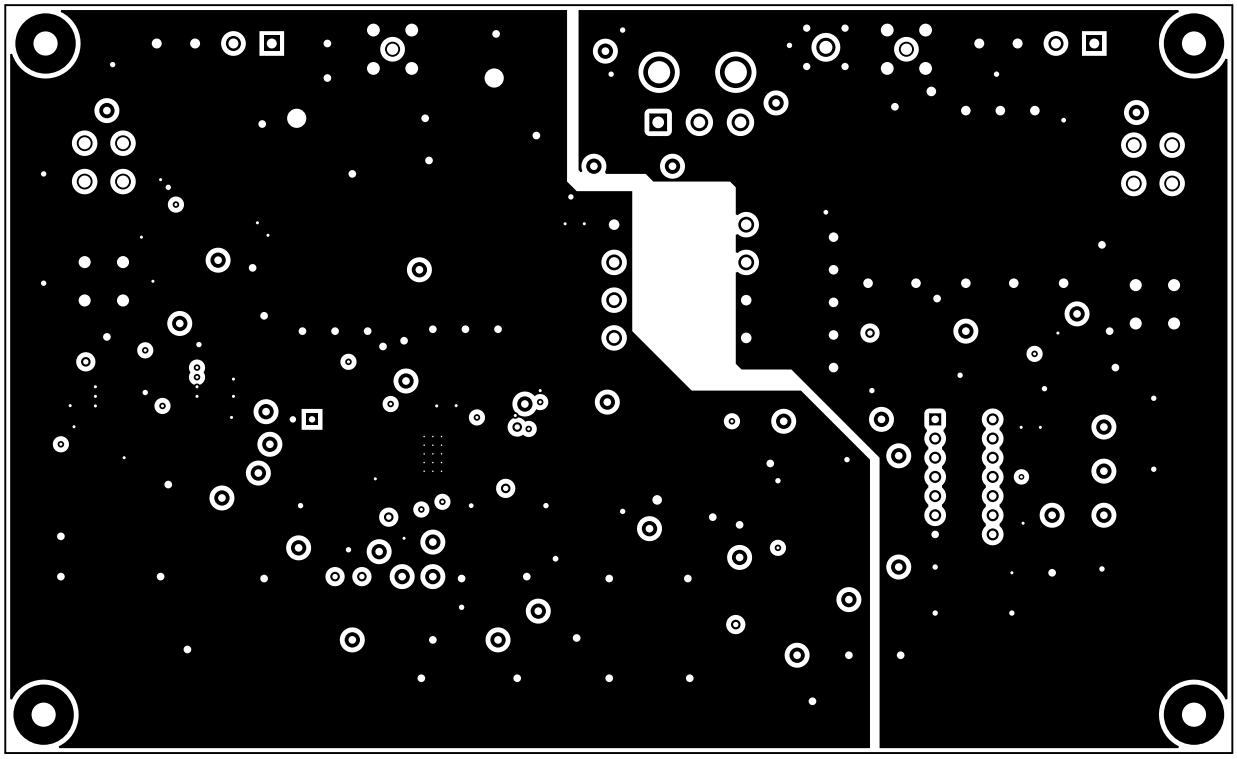


Figure 25. Signal Layer 2

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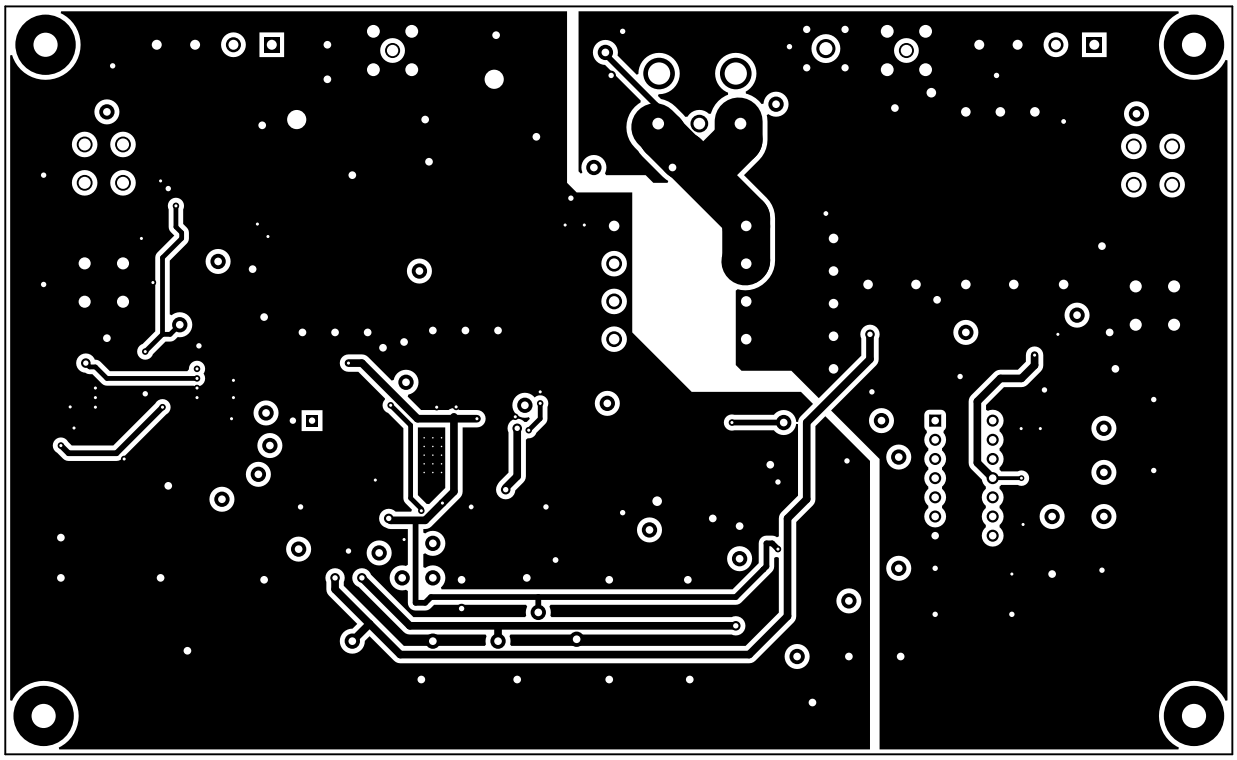


Figure 26. Bottom Layer

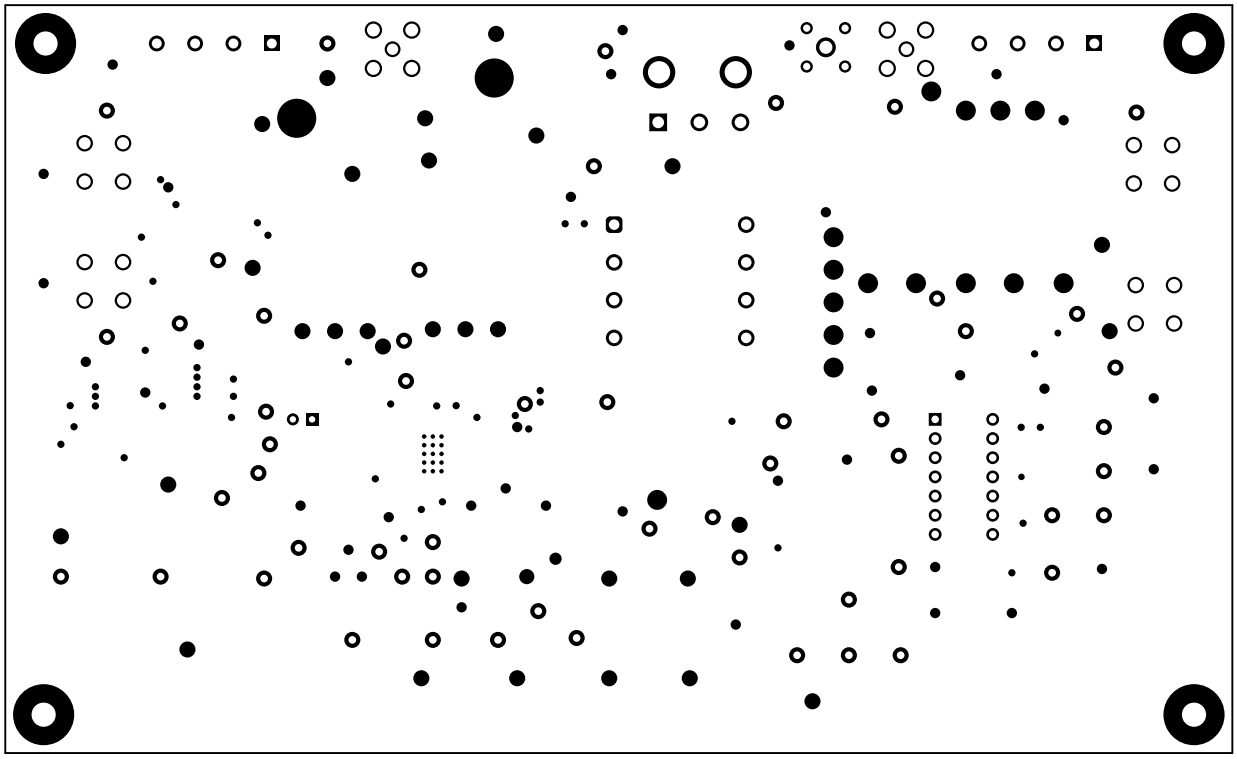


Figure 27. Bottom Solder

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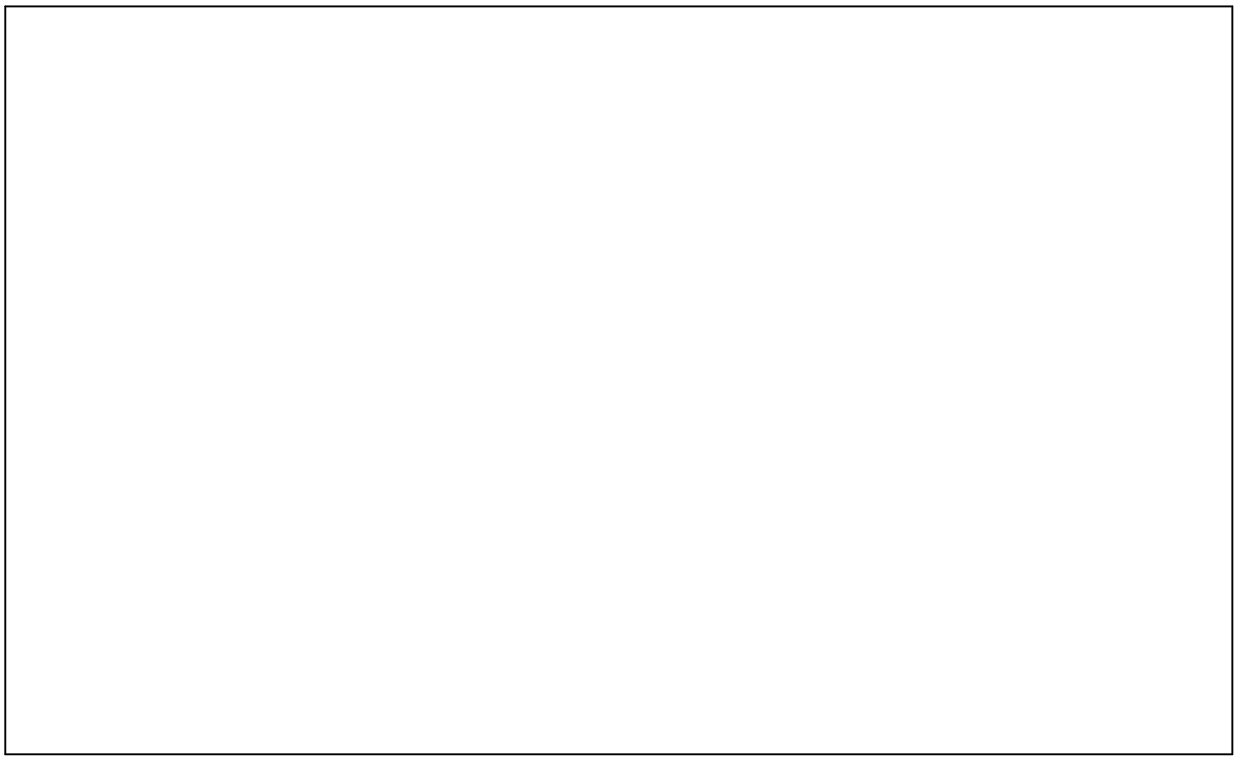
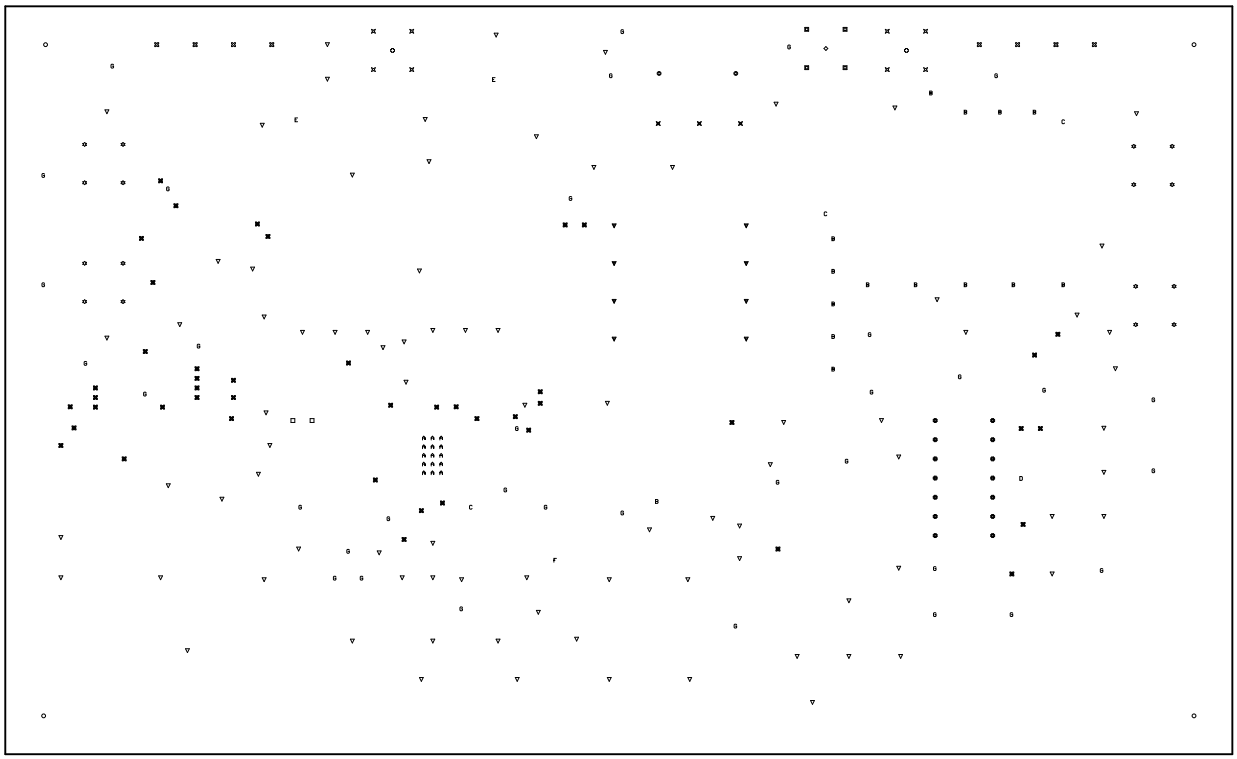


Figure 28. Bottom Overlay

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Symbol	Quantity	Finished Hole Size	Plated	Hole Type	Drill Layer Pair	Hole Tolerance
A	15	7.87mil (0.200mm)	PTH	Round	Top Layer - Bottom Layer	
D	1	15.00mil (0.381mm)	PTH	Round	Top Layer - Bottom Layer	
✖	45	16.00mil (0.406mm)	PTH	Round	Top Layer - Bottom Layer	
C	3	25.00mil (0.635mm)	PTH	Round	Top Layer - Bottom Layer	
G	35	28.00mil (0.711mm)	PTH	Round	Top Layer - Bottom Layer	
F	1	30.00mil (0.762mm)	PTH	Round	Top Layer - Bottom Layer	
□	2	33.47mil (0.850mm)	PTH	Round	Top Layer - Bottom Layer	
▣	4	38.00mil (0.965mm)	PTH	Round	Top Layer - Bottom Layer	
◘	14	39.37mil (1.000mm)	PTH	Round	Top Layer - Bottom Layer	
▽	85	40.00mil (1.016mm)	PTH	Round	Top Layer - Bottom Layer	
B	15	50.00mil (1.270mm)	PTH	Round	Top Layer - Bottom Layer	
⊠	8	52.00mil (1.321mm)	PTH	Round	Top Layer - Bottom Layer	
▼	8	55.12mil (1.400mm)	PTH	Round	Top Layer - Bottom Layer	+/-1.18mil
✪	2	59.06mil (1.500mm)	PTH	Round	Top Layer - Bottom Layer	
✖	3	61.02mil (1.550mm)	PTH	Round	Top Layer - Bottom Layer	
✡	16	62.99mil (1.600mm)	PTH	Round	Top Layer - Bottom Layer	+3.94mil/-0.00mil
⊠	8	66.93mil (1.700mm)	PTH	Round	Top Layer - Bottom Layer	
◇	1	68.00mil (1.727mm)	PTH	Round	Top Layer - Bottom Layer	
E	2	100.00mil (2.540mm)	PTH	Round	Top Layer - Bottom Layer	
◎	2	116.00mil (2.946mm)	PTH	Round	Top Layer - Bottom Layer	
○	4	125.98mil (3.200mm)	PTH	Round	Top Layer - Bottom Layer	
	274 Total					

Figure 29. Drill Drawing

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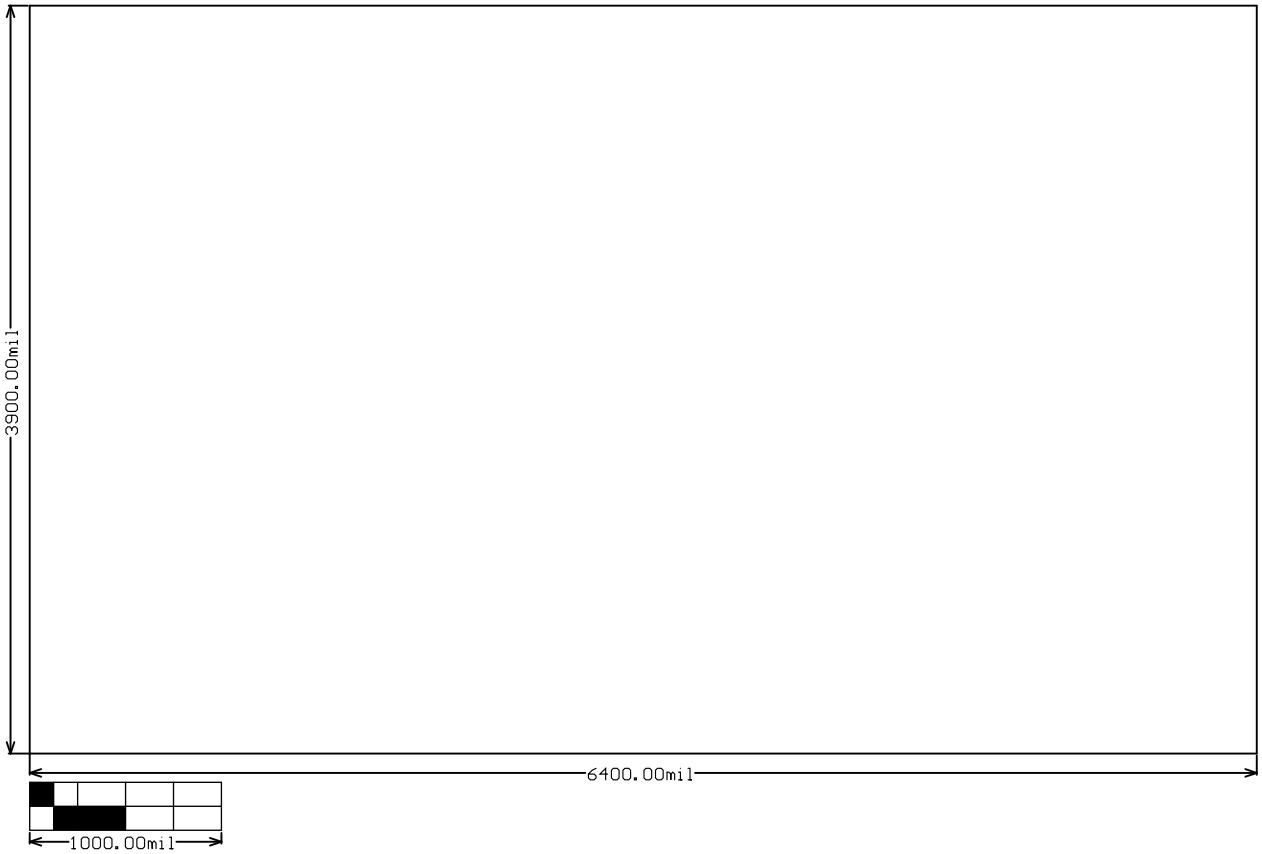


Figure 30. Board Dimensions

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5 Schematics and Bill of Materials

This section presents the UC1843BEVM-CVAL schematics and bill of materials.

5.1 Schematics

The following figures show the UC1843BEVM-CVAL schematic.

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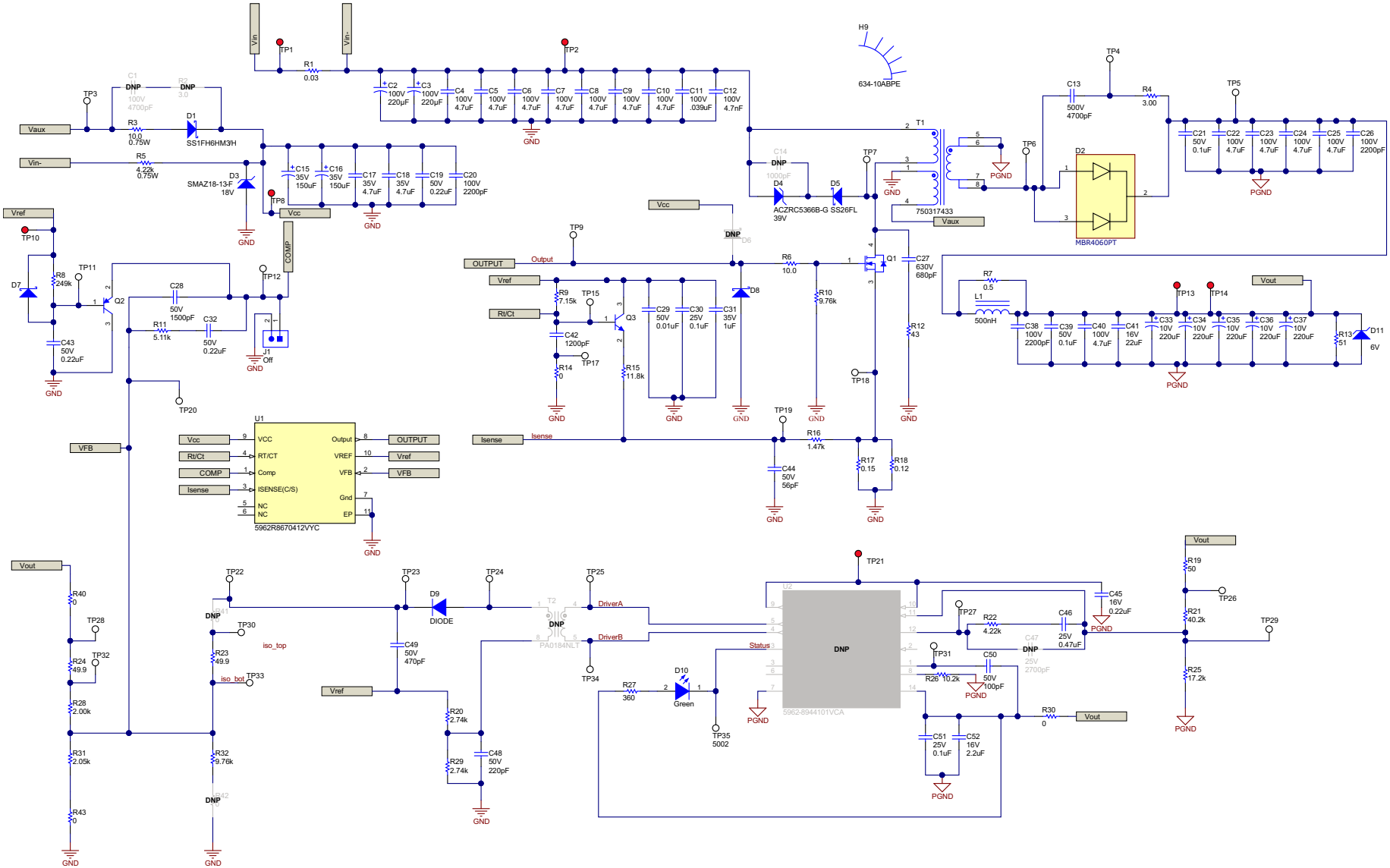


Figure 31. UC1843BEVM-CVAL Schematic 01

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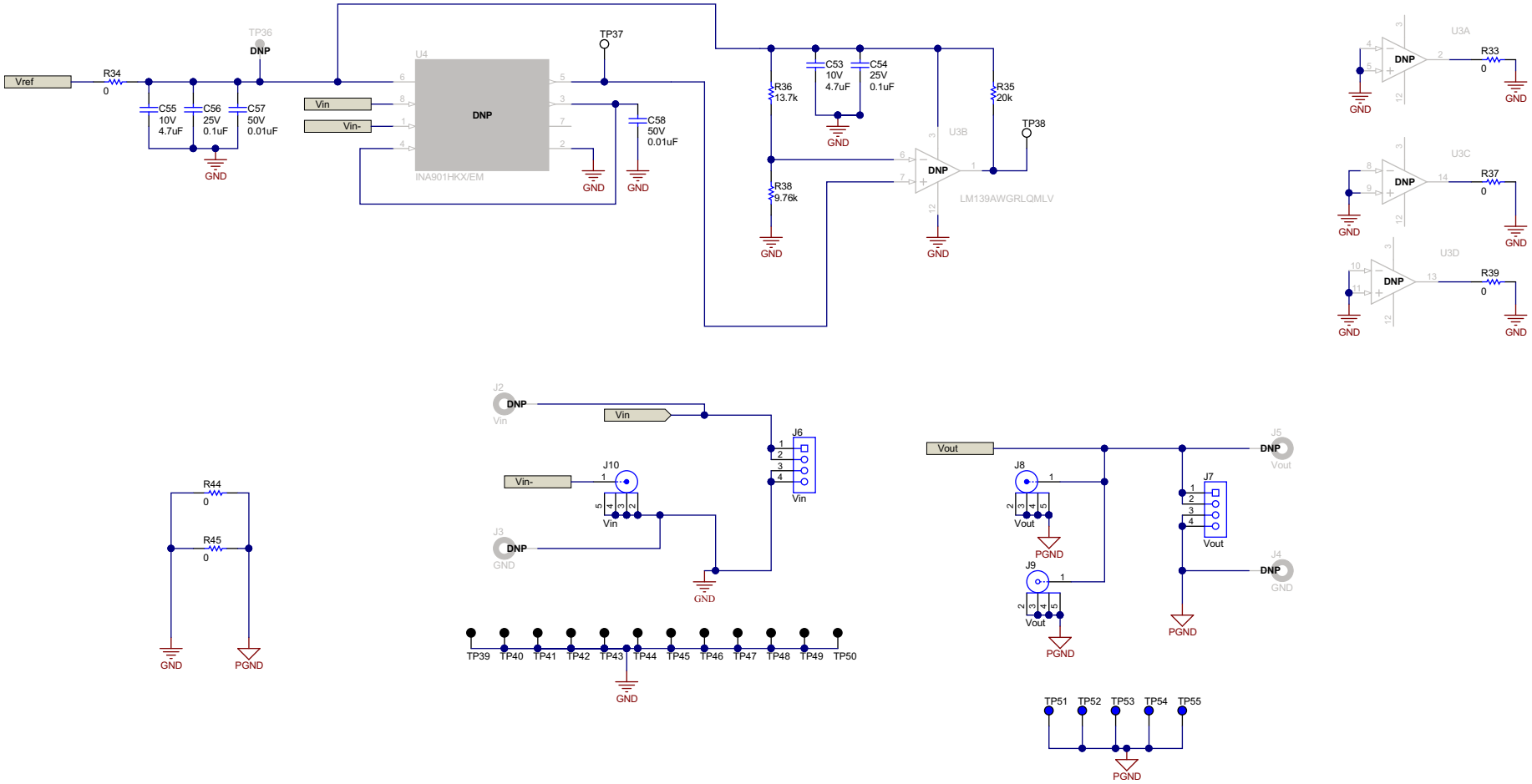


Figure 32. UC1843BEVM-CVAL Schematic 02

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5.2 Bill of Materials

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Table 9. Bill of Materials

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
!PCB1	1		Printed Circuit Board		SLHR016	Any		
C2, C3	2	220uF	CAP, AL, 220 µF, 100 V, +/- 20%, 0.12 ohm, SMD	D16xL21.5mm	UCZ2A221MNQ1MS	Nichicon		
C4, C5, C6, C7, C8, C9, C10, C22, C23, C24, C25, C40	12	4.7uF	CAP, CERM, 4.7 uF, 100 V, +/- 10%, X7S, AEC-Q200 Grade 1, 1210	1210	CGA6M3X7S2A475K200AB	TDK		
C11	1	0.039uF	CAP, CERM, 0.039 uF, 100 V, +/- 10%, X7R, 0603	0603	C0603C393K1RACTU	Kemet		
C12	1	4700pF	CAP, CERM, 4700 pF, 100 V, +/- 10%, X7R, 0603	0603	06031C472KAT2A	AVX		
C13	1	4700pF	CAP, CERM, 4700 pF, 500 V, +/- 10%, X7R, 1210	1210	VJ1210Y472KXEAT5Z	Vishay-Vitramon		
C15, C16	2	150uF	CAP, AL, 150 uF, 35 V, +/- 20%, 0.16 ohm, AEC-Q200 Grade 2, SMD	SMT Radial F	EEE-FK1V151P	Panasonic		
C17, C18	2	4.7uF	CAP, CERM, 4.7 uF, 35 V, +/- 10%, X7R, 1206	1206	C3216X7R1V475K085AC	TDK		
C19, C32, C43	3	0.22uF	CAP, CERM, 0.22 uF, 50 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E3X7R1H224K080AB	TDK		
C20	1	2200pF	CAP, CERM, 2200 pF, 100 V, +/- 5%, X7R, 0603	0603	06031C222JAT2A	AVX		
C21, C39	2	0.1uF	CAP, CERM, 0.1 uF, 50 V, +/- 10%, X7R, 1210	1210	C1210C104K5RACTU	Kemet		
C26, C38	2	2200pF	CAP, CERM, 2200 pF, 100 V, +/- 10%, X7R, 0805	0805	08051C222KAT2A	AVX		
C27	1	680pF	CAP, CERM, 680 pF, 630 V, +/- 5%, C0G/NP0, 1206	1206	GRM31B5C2J681JW01L	MuRata		
C28	1	1500pF	CAP, CERM, 1500 pF, 50 V, +/- 10%, X7R, 0603	0603	GRM188R71H152KA01D	MuRata		
C29, C57, C58	3	0.01uF	CAP, CERM, 0.01 uF, 50 V, +/- 5%, X7R, 0603	0603	C0603C103J5RACTU	Kemet		
C30, C51, C54, C56	4	0.1uF	CAP, CERM, 0.1 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E2X7R1E104K080AA	TDK		
C31	1	1uF	CAP, CERM, 1 uF, 35 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E1X7R1V105K080AC	TDK		
C33, C34, C35, C36, C37	5	220uF	CAP, TA, 220 uF, 10 V, +/- 10%, 0.045 ohm, SMD	7343-43	T495X227K010ATE045	Kemet		
C41	1	22uF	CAP, CERM, 22 uF, 16 V, +/- 20%, X7R, AEC-Q200 Grade 1, 1210	1210	CGA6P1X7R1C226M250AC	TDK		
C42	1	1200pF	CAP, CERM, 1200 pF, 100 V, +/- 5%, X7R, 0603	0603	06031C122JAT2A	AVX		
C44	1	56pF	CAP, CERM, 56 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	06035A560JAT2A	AVX		
C45	1	0.22uF	CAP, CERM, 0.22 uF, 16 V, +/- 10%, X7R, 0603	0603	885012206048	Wurth Elektronik		
C46	1	0.47uF	CAP, CERM, 0.47 uF, 25 V, +/- 10%, X7R, AEC-Q200 Grade 1, 0603	0603	CGA3E3X7R1E474K080AB	TDK		
C48	1	220pF	CAP, CERM, 220 pF, 50 V, +/- 10%, X7R, 0603	0603	C0603C221K5RACTU	Kemet		
C49	1	470pF	CAP, CERM, 470 pF, 50 V, +/- 10%, X7R, 0603	0603	885012206081	Wurth Elektronik		
C50	1	100pF	CAP, CERM, 100 pF, 50 V, +/- 5%, C0G/NP0, 0603	0603	885012006057	Wurth Elektronik		

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Table 9. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
C52	1	2.2uF	CAP, CERM, 2.2 uF, 16 V,+/- 10%, X7R, 0603	0603	EMK107BB7225MA-T	Taiyo Yuden		
C53, C55	2	4.7uF	CAP, CERM, 4.7 uF, 10 V, +/- 10%, X7S, 0603	0603	C1608X7S1A475K080AC	TDK		
D1	1	60V	Diode, Schottky, 60 V, 1 A, AEC-Q101, DO-219AB	DO-219AB	SS1FH6HM3/H	Vishay-Semiconductor		
D2	1		Diode Array 1 Pair Common Cathode Schottky 60V 40A Through Hole TO-247-3	TO-247	MBR4060PT	ON Semiconductor		
D3	1	18V	Diode, Zener, 18 V, 1 W, AEC-Q101, SMA	SMA	SMAZ18-13-F	Diodes Inc.		
D4	1	39V	Diode, Zener, 39 V, 5 W, AEC-Q101, DO-214AB	DO-214AB	ACZRC5366B-G	Comchip Technology		
D5	1	60V	Diode, Schottky, 60 V, 2 A, AEC-Q101, SOD-123F	SOD-123F	SS26FL	Fairchild Semiconductor		
D7	1	20V	Diode, Schottky, 20 V, 1 A, SOD-123F	SOD-123F	MBR1020VL	Fairchild Semiconductor		
D8	1	30V	Diode, Schottky, 30 V, 1 A, SMA	SMA	B130-13-F	Diodes Inc.		
D9	1	75V	Diode, Switching, 75 V, 0.3 A, SOD-523F	SOD-523F	1N4148WT	Fairchild Semiconductor		
D10	1	Green	LED, Green, SMD	2x1.4mm	LG M67K-G1J2-24-Z	OSRAM		
D11	1	6V	Diode, Zener, 6 V, 500 mW, SOD-123	SOD-123	MMSZ5233B-7-F	Diodes Inc.		
H1, H2, H3, H4	4		Machine Screw, Round, #4-40 x 1/4, Nylon, Philips panhead	Screw	NY PMS 440 0025 PH	B&F Fastener Supply		
H5, H6, H7, H8	4		Standoff, Hex, 0.5"L #4-40 Nylon	Standoff	1902C	Keystone		
H9	1			16.26x25.4x16.26 mm	634-10ABPE	Wakefield-Vette		
J1	1		Header, 100mil, 2x1, TH	Header, 2x1, 100mil, TH	800-10-002-10-001000	Mill-Max		
J6, J7	2		Terminal Block, 4x1, 5.08mm, TH	4x1 Terminal Block	39544-3004	Molex		
J8, J10	2		SMA Straight Jack, Gold, 50 Ohm, TH	SMA Straight Jack, TH	901-144-8RFX	Amphenol RF		
J9	1		Compact Probe Tip Circuit Board Test Points, TH, 25 per	TH Scope Probe	131-5031-00	Tektronix		
L1	1	500nH	Inductor, Shielded, Ferrite, 500 nH, 12 A, 0.0066 ohm, AEC-Q200 Grade 1, SMD	8x8x4.5 mm	SRN8040TA-R50Y	Bourns		
Q1	1	150V	MOSFET, N-CH, 150 V, 128 A, DDPAK	DDPAK	SUM80090E-GE3	Vishay-Siliconix		None
Q2	1	40 V	Transistor, PNP, 40 V, 0.2 A, SOT-23	SOT-23	MMBT3906	Fairchild Semiconductor		
Q3	1	40 V	Transistor, NPN, 40 V, 0.2 A, SOT-323	SOT-323	MMBT3904WT1G	ON Semiconductor		
R1	1	0.03	RES, 0.03, 1%, 1 W, 2010	2010	CSRN2010FK30L0	Stackpole Electronics Inc		
R3	1	10.0	RES, 10.0, 1%, 0.75 W, AEC-Q200 Grade 0, 2010	2010	CRCW201010R0FKEF	Vishay-Dale		
R4	1	3.00	RES, 3.00, 1%, 1 W, 2512	2512	ERJ-1TRQF3R0U	Panasonic		
R5	1	4.22k	RES, 4.22 k, 1%, 0.75 W, AEC-Q200 Grade 0, 2010	2010	CRCW20104K22FKEF	Vishay-Dale		
R6	1	10.0	RES, 10.0, 1%, 0.1 W, 0603	0603	RC0603FR-0710RL	Yageo America		
R7	1	0.5	RES, 0.5, 1%, 1 W, 2010	2010	CSRN2010FKR500	Stackpole Electronics Inc		

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Table 9. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
R8	1	249k	RES, 249 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603249KFKEA	Vishay-Dale		
R9	1	7.15k	RES, 7.15 k, 0.1%, 0.1 W, 0603	0603	RG1608P-7151-B-T5	Susumu Co Ltd		
R10	1	9.76k	RES, 9.76 k, 1%, 0.1 W, 0603	0603	RC0603FR-079K76L	Yageo America		
R11	1	5.11k	RES, 5.11 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06035K11FKEA	Vishay-Dale		
R12	1	43	RES, 43, 5%, 1 W, AEC-Q200 Grade 0, 2512	2512	CRCW251243R0JNEG	Vishay-Dale		
R13	1	51	RES, 51, 5%, 0.75 W, AEC-Q200 Grade 0, 2010	2010	CRCW201051R0JNEF	Vishay-Dale		
R14, R34, R40, R43, R44, R45	6	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603ZT0R00	Stackpole Electronics Inc		
R15	1	11.8k	RES, 11.8 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060311K8FKEA	Vishay-Dale		
R16	1	1.47k	RES, 1.47 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06031K47FKEA	Vishay-Dale		
R17	1	0.15	RES, 0.15, 1%, 2 W, 2512	2512	CRM2512-FX-R150ELF	Bourns		
R18	1	0.12	RES, 0.12, 1%, 2 W, 2512	2512	2-2176057-7	TE Connectivity		
R19	1	50	RES, 50, 0.1%, 0.125 W, 0603	0603	FC0603E50R0BTBST1	Vishay Thin Film		
R20, R29	2	2.74k	RES, 2.74 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06032K74FKEA	Vishay-Dale		
R21	1	40.2k	RES, 40.2 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW060340K2FKEA	Vishay-Dale		
R22	1	4.22k	RES, 4.22 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06034K22FKEA	Vishay-Dale		
R23, R24	2	49.9	RES, 49.9, 1%, 0.1 W, 0603	0603	RC0603FR-0749R9L	Yageo America		
R25	1	17.2k	RES, 17.2 k, 0.1%, 0.1 W, 0603	0603	RT0603BRD0717K2L	Yageo America		
R26	1	10.2k	RES, 10.2 k, 1%, 0.1 W, 0603	0603	RC0603FR-0710K2L	Yageo		
R27	1	360	RES, 360, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW0603360RJNEA	Vishay-Dale		
R28	1	2.00k	RES, 2.00 k, 1%, 0.1 W, 0603	0603	RC0603FR-072KL	Yageo America		
R30	1	0	RES, 0, 0%, W, AEC-Q200 Grade 0, 0805	0805	PMR10EZPJ000	Rohm		
R31	1	2.05k	RES, 2.05 k, 1%, 0.1 W, 0603	0603	RC0603FR-072K05L	Yageo		
R32	1	9.76k	RES, 9.76 k, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	CRCW06039K76FKEA	Vishay-Dale		
R33, R37, R39	3	0	RES, 0, 5%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	ERJ-3GEY0R00V	Panasonic		
R35	1	20k	RES, 20 k, 5%, 0.1 W, 0603	0603	RC0603JR-0720KL	Yageo		
R36	1	13.7k	RES, 13.7 k, 0.1%, 0.1 W, 0603	0603	RG1608P-1372-B-T5	Susumu Co Ltd		
R38	1	9.76k	RES, 9.76 k, 0.1%, 0.1 W, 0603	0603	RG1608P-9761-B-T5	Susumu Co Ltd		
T1	1	21uH	Transformer, 21 uH, TH	26x23.5mm	750317433	Wurth Elektronik		

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Table 9. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
TP1, TP2, TP8, TP10, TP13, TP14, TP21	7		Test Point, Miniature, Red, TH	Red Miniature Testpoint	5000	Keystone		
TP3, TP4, TP5, TP6, TP7, TP9, TP11, TP12, TP15, TP17, TP18, TP19, TP20, TP22, TP23, TP24, TP25, TP26, TP27, TP28, TP29, TP30, TP31, TP32, TP33, TP34, TP35, TP37, TP38	29		Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone		
TP39, TP40, TP41, TP42, TP43, TP44, TP45, TP46, TP47, TP48, TP49, TP50	12		Test Point, Miniature, Black, TH	Black Miniature Testpoint	5001	Keystone		
TP51, TP52, TP53, TP54, TP55	5		Test Point, Miniature, Blue, TH	Blue Miniature Testpoint	5117	Keystone		
U1	1		UC1843A-SP QML class V, radiation hardened current-mode PWM controller, HKU0010A (CFP-10)	HKU0010A	5962R8670412VYC	Texas Instruments		Texas Instruments
C1	0	4700pF	CAP, CERM, 4700 pF, 100 V, +/- 10%, X7R, 0805	0805	08051C472KAT2A	AVX		
C14	0	1000pF	CAP, CERM, 1000 pF, 100 V, +/- 10%, X7R, 0805	0805	08051C102KAT2A	AVX		
C47	0	2700pF	CAP, CERM, 2700 pF, 25 V, +/- 10%, X7R, 0603	0603	GRM188R71E272KA01D	MuRata		
D6	0	30V	Diode, Schottky, 30 V, 1 A, SMA	SMA	B130-13-F	Diodes Inc.		
FID1, FID2, FID3	0		Fiducial mark. There is nothing to buy or mount.	N/A	N/A	N/A		
J2, J5	0		Banana Jack Insul Nylon Red, R/A, TH	CTE_CT3151SP-2	CT3151SP-2	Cal Test Electronics		
J3, J4	0		Banana Jack Insul Nylon Black, R/A, TH	CTE_CT3151SP-0	CT3151SP-0	Cal Test Electronics		
R2	0	3.0	RES, 3.0, 5%, 0.25 W, AEC-Q200 Grade 0, 1206	1206	CRCW12063R00JNEA	Vishay-Dale		
R41, R42	0	0	RES, 0, 1%, 0.1 W, AEC-Q200 Grade 0, 0603	0603	RMCF0603ZT0R00	Stackpole Electronics Inc		
T2	0	1.2mH	Transformer, Gate Drive, 1.2mH, SMT	9.02x7.62x8.64mm	PA0184NLT	Pulse Engineering		
TP36	0		Test Point, Miniature, White, TH	White Miniature Testpoint	5002	Keystone		

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Table 9. Bill of Materials (continued)

Designator	Quantity	Value	Description	PackageReference	PartNumber	Manufacturer	Alternate PartNumber	Alternate Manufacturer
U2	0		Isolated Feedback Generator, -55 to 125 degC, 14-pin CDIP (J)	J0014A	5962-8944101VCA	Texas Instruments		
U3	0		Low Power Low Offset Voltage Quad Comparator, 14-pin CerPACK			Texas Instruments		
U4	0		Voltage Output, Unidirectional Measurement Current-Shunt Monitor, HKX0008A (CFP-8)	HKX0008A	INA901HKX/EM	Texas Instruments		Texas Instruments

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