ISL73846MEV2Z

Single Switch Isolated Forward Converter Evaluation Board

Description

The ISL73846MEV2Z evaluation platform evaluates the ISL73846M in a single switch forward converter power supply topology. The circuit uses a power transformer for power transfer to secondary and includes a demagnetizing winding for core reset and an auxiliary winding to provide the power to the VDD pin of the device. The ISL73846M is a radiation tolerant dual output pulse width modulator that can be used in high frequency switching power supplies in either voltage mode or current mode control configurations. The board uses and input of 28V input and converts it to a regulated DC output of 5V at an output current of 10A.

Specifications

- Input Voltage, V_{IN}: 22V to 34V
- Output voltage, V_{OUT}: 5V
- Output Current, I_{OUT}: 0A to 10A
- Switching frequency: 400kHz
- Number of Board Layers: 8
- PCB Thickness: 2oz outer, 1oz PCB thickness

Features

- Programmable soft-start
- Off-line startup
- Programmable UVLO and EN threshold hysteresis
- Synchronous rectification
- Feedback isolation using ISLFBKISOEV2Z
- Tight line/load regulation of less than 1%
- Current Mode control with slope compensation
- Pulse-by-pulse current limiting for overcurrent protection

Board Contents

The following is shipped with the evaluation board.

- Feedback isolator board ISLFBKISOEV2Z

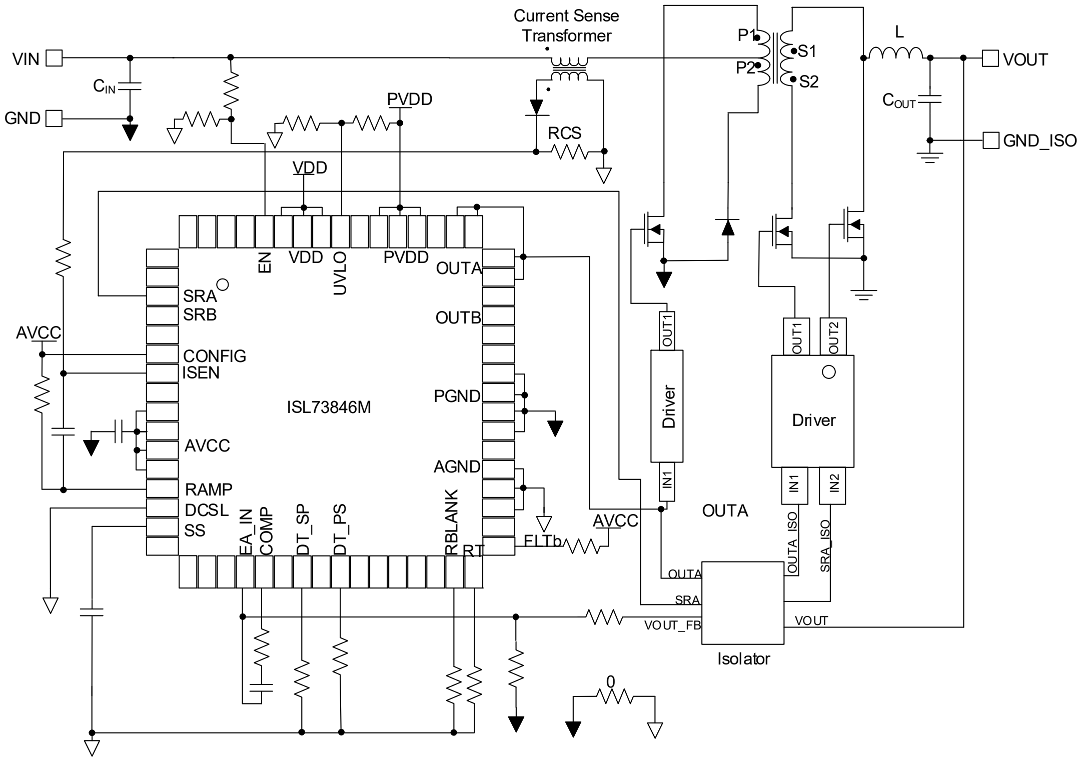

Figure 1. Block Diagram

Contents

1. Functional Description

ISL73846MEV2Z is a one-switch forward converter power supply that takes an input voltage between 22V and 34V and outputs 5V with a maximum load of 10A. The main switch on the primary side is driven by OUTA while main and freewheeling rectifiers on the secondary side are respectively driven by OUTA and SRA. The forward topology requires maximum duty cycle of 50% for this reason the DCSL pin is tied to AGND setting the frequency of OUTx to half of the oscillator frequency.

1.1 Design Specifications

The ISLI73846MEV2Z design specs are summarized in Table 1.

Table 1. Design Specifications

Description	Specification
Input Voltage	28V Nominal, Range 22V to 34V
Output Voltage	5V, ±1% over line and load
Maximum Load	10A
Output Current Ripple	20%, range 18% to 22%
Switching Frequency	400kHz
Load Transient Overshoot Undershoot	3%
Efficiency	85% at 6A load, 83% efficiency at 10A
Bandwidth	3kHz

1.2 Feedback Isolation

Because the forward converter topology can provide an isolated output, the output voltage feedback on the secondary side of the transformer (T1) to the controller on the primary side must be galvanically isolated. Also, synchronous rectifier drive signals OUTA and SRA must be isolated to be used by the ISL71040M drivers on the secondary side.

These two functions are provided with the ISLFBKISOEV2Z daughterboard which has a housekeeping flyback converter providing continuous power to circuits required for feedback isolation and GMR-based digital isolators (ISL71710M). On the secondary side of the daughterboard, output voltage is converted to PWM with the help of the ISL7119 dual comparator. One comparator is used to generate a relaxation oscillator ramp while the other is used for pulse-width modulation. This PWM signal is communicated through the digital isolator to the primary side of the daughterboard and then filtered near the EA_IN pin of the ISL73846M controller for voltage regulation.

Note: The input to the isolator (VOUT_ISO) must be greater than 1.22V for the isolator to generate PWM output (DRVIN_ISO). For this reason, there is no soft start at startup until the voltage presented at the input is 1.22V. The CONFIG pin of the controller must be tied to AGND with a 113.5k resistor for pulse-by-pulse current limiting.

1.3 Overvoltage Protection

Since the ISL73846M has an op-amp error amplifier (as opposed to a transconductance error amplifier), it is not capable of transient OV fault detection. For this reason, an external OV protection circuit is implemented on the ISL73846MEV2Z board, which pulls down FLTB of the controller and forces hiccup whenever output voltage increases above 5.5V.

1.4 Transformer

Given the input and output voltage specification of the forward converter (V_{IN} = 28V nominal, V_{OUT} = 5V), the transformer choice was PL300x2-101L coil craft transformer with two 5 turns primary windings: One winding is used for power conversion and one for transformer reset. The secondary side of the transformer has 4 windings with one turn each, all connected in series (ratio 5:4). One auxiliary winding with two turns is used for offline startups to deliver power to the VDD pin. The leakage inductance is 350nH while the magnetizing inductance is 224µH.

1.5 Inductor

The output inductor L1 (4.7µH) is selected so that nominally (V_{IN} = 28V) inductor current ripple is 20% of full load current (10A).

The following equations were used:

(EQ. 1) $$D = \frac{N_S \times V_{OUT}}{N_P \times V_{IN}}$$

(EQ. 2) $$L = \frac{V_{OUT} \times (1 - D)}{f_{SW} \times I_{RIPPLE}}$$

where:

- N_S is the number of turns of the secondary winding of T1 (5 turns)
- N_P is the number of turns of the primary winding of T1 (5 turns)
- f_{SW} is the switching frequency 400kHz.
- I_{RIPPLE} the output inductor current peak to peak ripple 2A based on the 20% design spec.
- V_{IN} is the input voltage 28V nominal.
- V_{OUT} is the output voltage 5V.
- D is the duty cycle.

1.6 Output Capacitance

To make the output stable, the converter bandwidth is set at 3kHz. To ensure output voltage overshoot and undershoot during a 0A to 10A load transient is below 150mV (3% of 5V) and set a 3kHz (f_C) converter bandwidth, output capacitance of 3.56mF is required.

The following equations were used to find R_{LL} = 15mΩ and COUT = 3.56mF.

(EQ. 3) $$R_{LL} = \frac{V_d}{I_{OUT}}$$

(EQ. 4) $$C_{OUT} = \frac{1}{2\pi \times R_{LL} \times f_C}$$

where:

- R_{LL} is the load line resistance.
- C_{OUT} is the output capacitance.
- f_C is the converter bandwidth (3kHz).
- V_d is the transient deviation (150mV).

1.7 Synchronous GaNFETs Switches

Typically, the primary-side switch in a forward converter is expected to block double the input voltage of the converter. Because the input voltage can be as high as 34V for a nominal 28V rail, the switches are expected to block 68V. However, the leakage inductance of the main transformer can cause the drain-to-source voltage of the primary GaN FETs to spike much higher. The maximum output load of 10A when reflected on the primary side would equal 8A. Two parallel GaN FETs (ISL70024) with 200V breakdown voltage and 7.5A current rating are selected for this purpose. RC snubber is also implemented on the primary side GaN FET to limit inductive voltage spikes on its drain voltage.

Synchronous rectification can significantly improve efficiency in isolated converter topologies, and the ISL73846M controller can generate outputs to control synchronous rectifiers. OUTA is used to drive the main rectifier while SRA is used to drive the freewheeling rectifier. Because the main transformer winding ratio is 5:4, the synchronous freewheeling rectifier is expected to block 27.2V when the input voltage is 34V, 100V GaNFETs (ISL70023) are chosen for the synchronous rectifier switches.

In isolated topologies with synchronous rectifiers, output inductor current is negative particularly at steady state with no load and during a load step-down transient. Because there is no path for negative currents to flow through the synchronous rectifiers or primary side switches when they are off (during dead time at no load condition or if the controller shuts down when the inductor current is negative), large negative currents can cause large drain-to-source voltage spikes on the freewheeling synchronous rectifier. To mitigate this, an RCD clamp circuit is implemented at the LX node of the converter (see Figure 8), allowing negative inductor current to flow into the clamp capacitor and discharge into the isolated ground. An RC snubber circuit is also implemented on the main rectifier GaNFET.

1.8 Frequency

A switching frequency of 400kHz is selected to optimize the converter overall performance. To program the switching frequency, connect a 2.87kΩ resistor (R36) between the RT pin and AGND.

1.9 Blanking Time

150ns of blanking time is sufficient to ensure that switching transients are ignored before the PWM comparator resets the output. A 2.2kΩ resistor (R37) is placed between the RBLANK pin and AGND. Consequently, the minimum on/off time is programmed to 210ns (blanking time is approximately 60ns lower than minimum on/off time).

Figure 2 shows the PWM outputs and voltages at the ISEN and RAMP pins. The cursors show approximately a 150ns delay between the rising edge of OUTA and the rising edge of ISEN/RAMP voltages. It was verified that 150ns is enough blanking time for the current sense waveforms to be free of switching transients.

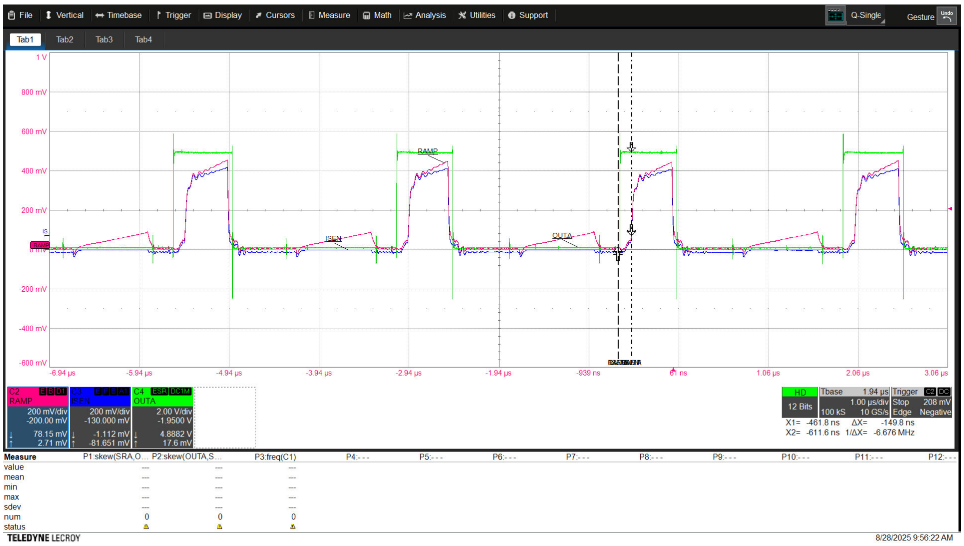

Figure 2. Blanking Time

1.10 Dead Time

OUTx falling to SRx rising dead time is programmed to 110ns and SRx falling to OUTx rising dead time is programmed to 60ns (see Figure 3). The primary switch is driven by a low side driver to mitigate the drive delay of the main rectifier which is also driven by a low side driver and the same applies for the freewheeling rectifier.

The dead times are programmed by placing R39 (30.1kΩ) and R40 (60.4kΩ) from the DT_SP and DT_PS pins of the controller.

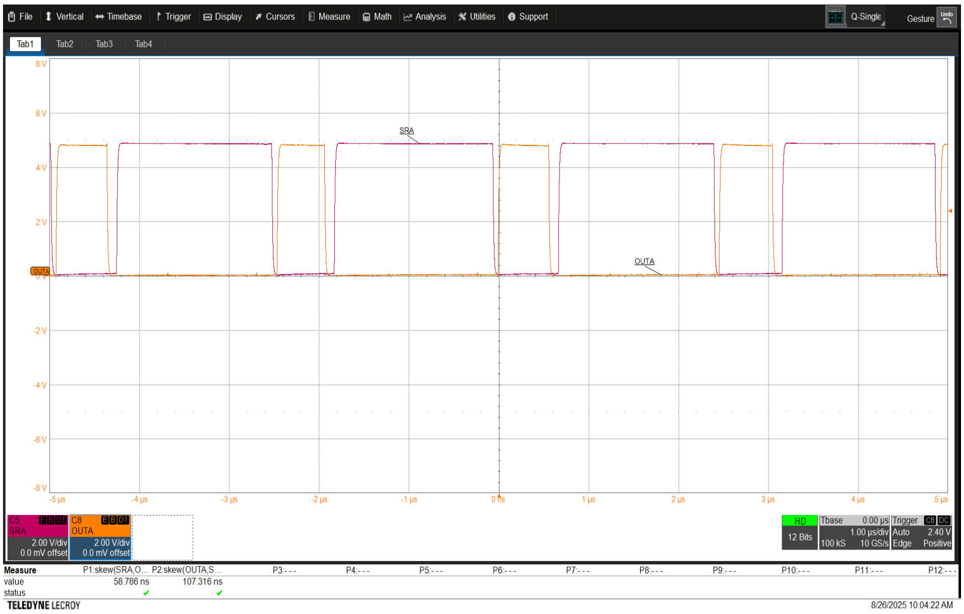

Figure 3. Dead Time

1.11 Current Sensing

Current sensing on the primary side is done by using a 1:50 transformer and a terminating resistor (RSENSE, R8 in schematics). At 10A output current (full load), the sensed voltage at the terminating resistor is designed to be 400mV.

(EQ. 5) $$R_{SENSE} = \frac{V_{ISEN}}{I_{OUT} \times n \times N}$$

where

- V_{ISEN} = 400mV
- N = 0.8 is the main transformer T1 turns ratio.
- n = 0.02 Current-sense transformer turns ratio.

Using Equation 5, the result is R8 = 2.5Ω.

1.12 Control Loop

The isolated feedback (ISLFBKISOEV2Z) circuit generates a 725kHz PWM output with 4V average when its input is presented with VOUT_ISO of 5V. This PWM output is referred to as DRIVIN_ISO in the schematic. To properly filter this signal, two poles at 20kHz are required. This is necessary to attenuate the ripple on the COMP output enough to ensure jitter on the OUTx outputs is acceptable. Note: One of the poles is canceled with ESR zero.

The voltage sensing network R9, R41, and R42 satisfies Equation 6 where V_{REF} is 600mV internal voltage reference and DRIVIN_ISO is 4V average isolated filtered PWM voltage.

(EQ. 6) $$\frac{R9}{R9 + (R42 + R41)} = \frac{V_{REF}}{VDRIVIN\_ISO}$$

For a 3% deviation during a full load transient, the PWM output of the feedback isolator should show a 150mV deviation. To match the sensed current, the gain of the error amplifier must be set as G = 2.67 or higher.

$$R_{COMP} > (R41 + R42) \times G$$

where R_{COMP} is the PI compensator resistor referred to as R42 in the schematics.

The result is R42 = 20.5k.

Use Equation 7 to calculate the pole capacitor, C9.

(EQ. 7) $$C_{pole} = \frac{1}{2\pi \times R_{COMP} \times f_p}$$

where R_{COMP} is R42 previously calculated (20.5k) and f_p is the pole frequency and set to 20kHz, C9 = 390pF.

Inverted zero of the integrators is set at 150Hz (1 out of 20 the bandwidth).

Use Equation 7 to calculate the compensation capacitor value, C24.

(EQ. 8) $$C_{COMP} = \frac{1}{2\pi \times R_{COMP} \times f_z}$$

where f_z is the inverted zero frequency set to150Hz and R_{COMP} is R42 value calculated earlier (20.5k), the result is C24 = 47nF.

1.13 Slope Compensation

Slope compensation is implemented to optimize jitter reduction. A resistor from AVCC, R12 and a capacitor C21 are used to generate a slope compensation. R12 and C21 are selected so that the slope of the ramp follows twice the falling Inductor current slope ($2 \times V_{OUT}$)/L. The ramp capacitor Cs (C21) is 1000pF (10x C5 ISEN filter capacitor as recommended in the datasheet).

Following Equations 11, 12, and 13 from the datasheet Rs (R12) in the schematics is 52.3K.

1.14 Offline Startup

The EN pin of the controller is programmed by resistors R3 and R4 such that the converter turns on at V_{IN} = 19V and turns off at V_{IN} = 17V. The controller sinks 6µA from the EN pin when it is not enabled. The EN threshold is 2V. The EN Hysteresis is programmed by R3 and the 6µA current (332kΩ × 6µA = 2V). The EN turn off threshold level (17V) is programmed by the R3/R4 ratio.

The VDD pin is powered by the AUX winding of the transformer (offline startup). UVLO is programmed by a resistor divider from VDD (R10 and R11). If the UVLO pin voltage is below the threshold (1.23V), the controller is in a low-power state, drawing less than 75µA of current. Use a startup resistor (R13) to slowly charge the VDD rail from VIN. When VDD reaches 8V, the UVLO threshold is met, the controller starts up, and the OUTx outputs start switching. When switching starts, the AUX winding output powers up and the operating current of the controller is supplied by the AUX winding. If VDD voltage falls below 6V after switching starts, the UVLO pin voltage falls below the threshold, and the converter shuts down and enters a low-power state. 68µF of capacitance on the VDD rail is required to ensure that VDD does not fall below the 6V UVLO falling threshold. The UVLO pin sources 5µA of current when the UVLO threshold is met. The upper resistor (R10) and the 5µA hysteresis current programs 2V UVLO hysteresis. The R10 and R11 resistor divider ratio programs the UVLO turn-on threshold.

1.15 Operational Characteristics

The ISL73846MEV2Z requires only one supply rail for VIN ranging from 22V to 34V to operate properly. The controller analog supply VDD input is provided through off-line start up at first then through the auxiliary winding of the PL300X2-101L transformer. The controller power circuitry supply PVDD input is tied to the internal LDO output AVCC(5V) for driving the GaN FET primary switch.

1.16 Setup and Configuration

Table 2 shows an overview of all the default jumper settings and their different configurations.

1. VDD_SEL is connected to position 2 and 3.
2. UVLO_SEL is connected to 2 and 3.
3. JP1 is connected to position 1 and 2.
4. Place ISLFBKISOEV2Z on J1 and J2 as shown in Figure 4.
5. Apply a 22V to 34V voltage to VIN banana plug connectors as shown in Figure 4.
6. A resistor or electronic load can be connected to the VOUT banana plug connectors as shown in Figure 4.
7. A minimum load of 400mA is required unless the modification to the board is applied as shown in the Board Modification for RCD Snubber section.

Table 2. Default Jumper Settings

Jumper	Function /Description	Default Configuration	Alternate Configuration
VDD_SEL	Select the supply rail for the VDD input	Jumper in 2-3 position connects VDD to the rectified signal coming from the auxiliary winding of the transformer.	Not Available
UVLO_SEL	Select the supply rail for the UVLO input	Jumper in 2-3 position connects UVLO to a VDD voltage divider network that sets the UVLO hysteresis.	Not Available

Table 2. Default Jumper Settings (Cont.)

Jumper	Function /Description	Default Configuration	Alternate Configuration
JP1	Select fault behavior	Jumper in 1-2 position connects the CONFIG pin to AGND using a 113k resistor. Overcurrent protection is set to pulse-by-pulse current limit at OC1 level or 1/1 Hiccup at OC2 level.	Jumper in 2-3 position connects CONFIG pin to AVCC: Overcurrent protection is set to 4/8 Hiccup at OC1 level and 1/1 Hiccup at OC2 level. This Configuration does not work with feedback isolation using ISLFBKISOEV2Z
J1/J2	Feed back Isolator connection	J1 and J2 are connected to ISLFBKISOEV2Z for feedback isolation.	J1 and J2 are not connected to the ISLFBKISOEV2Z (non isolated mode): in this case R-14, R19, and R43 must be populated with 0Ω resistors, R23 must be populated with a 3.47k resistor, R54 must be replaced with 15k resistor, and C51 must be DNP.

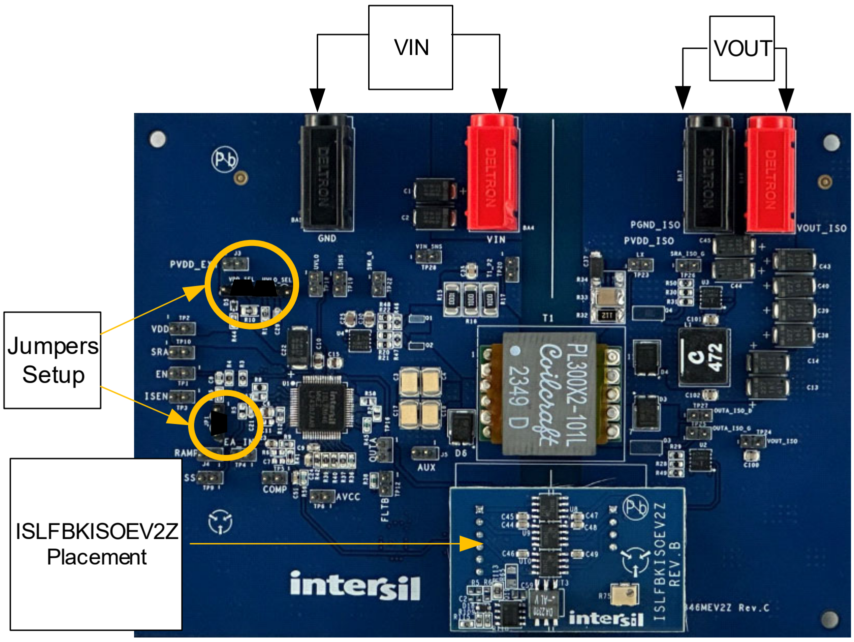

Figure 4. Setup Configuration

2. Board Design

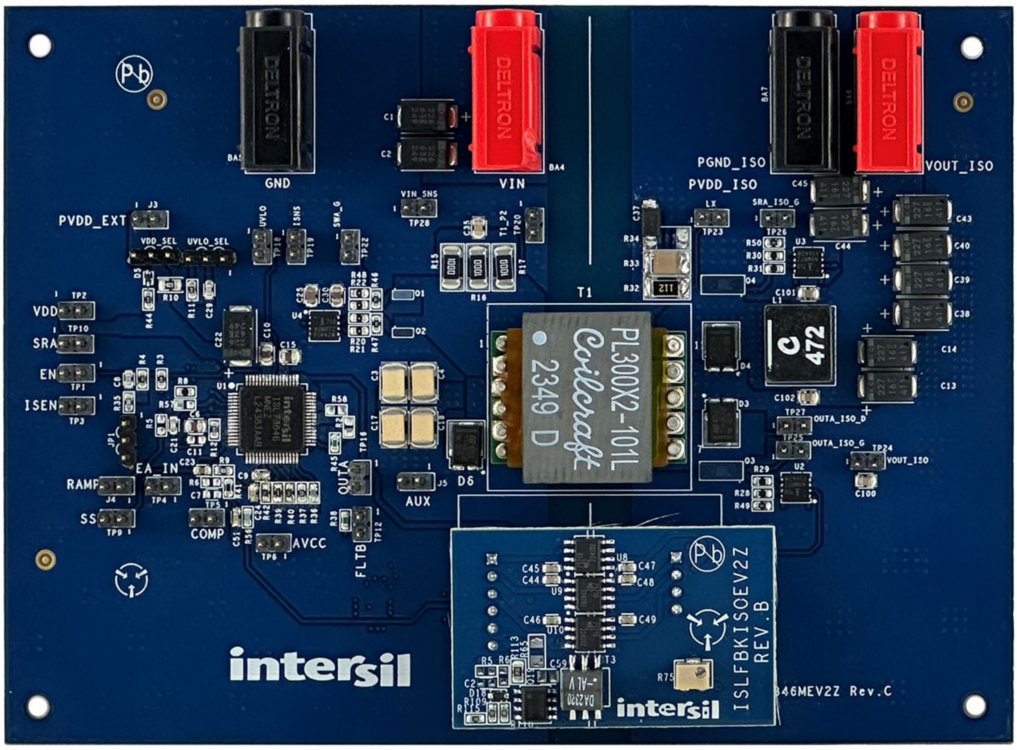

Figure 5. Top Board Photo

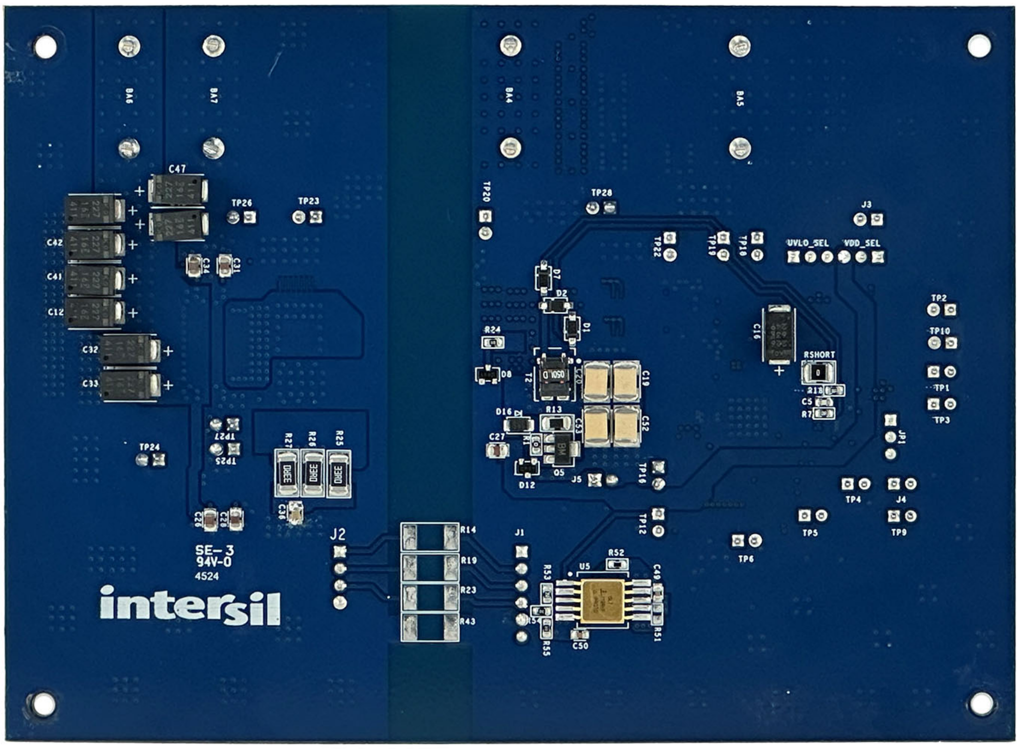

Figure 6. Bottom Board Photo

2.1 Layout Guidelines

For recommended layout guidelines for the forward converter, see the Board Layout details.

2.2 Schematic Diagrams

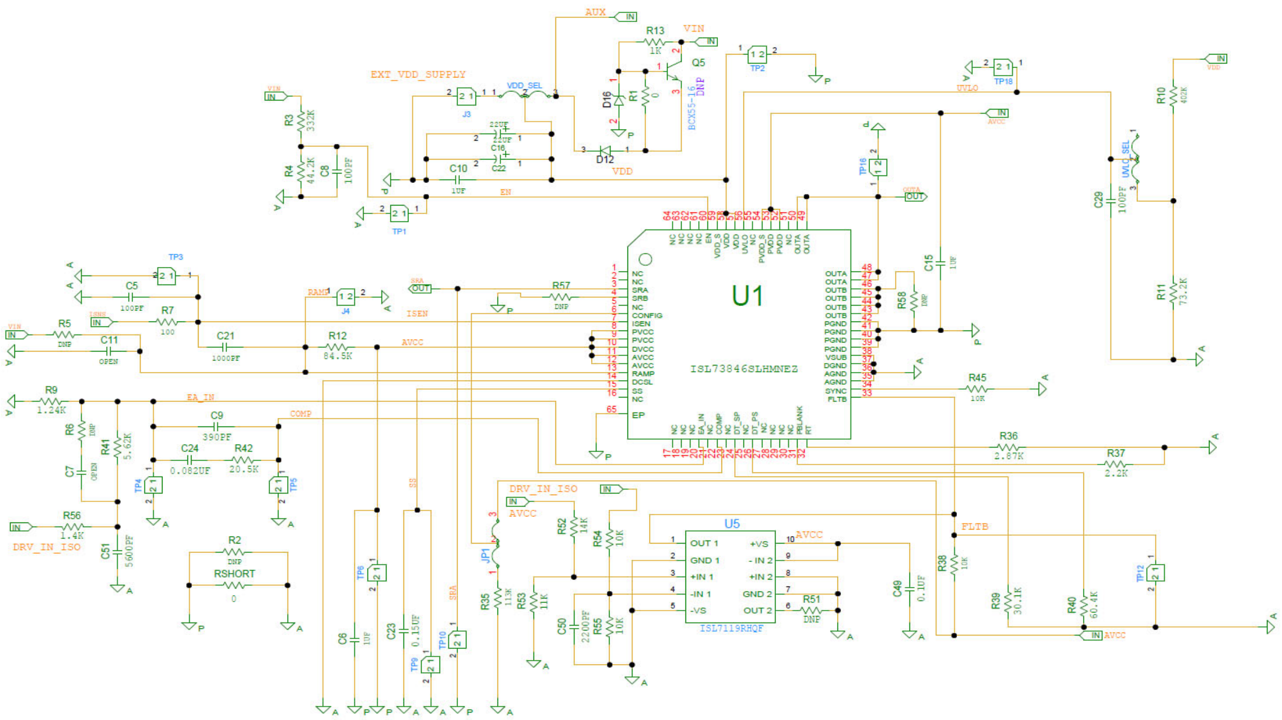

Figure 7. Control Stage Schematics

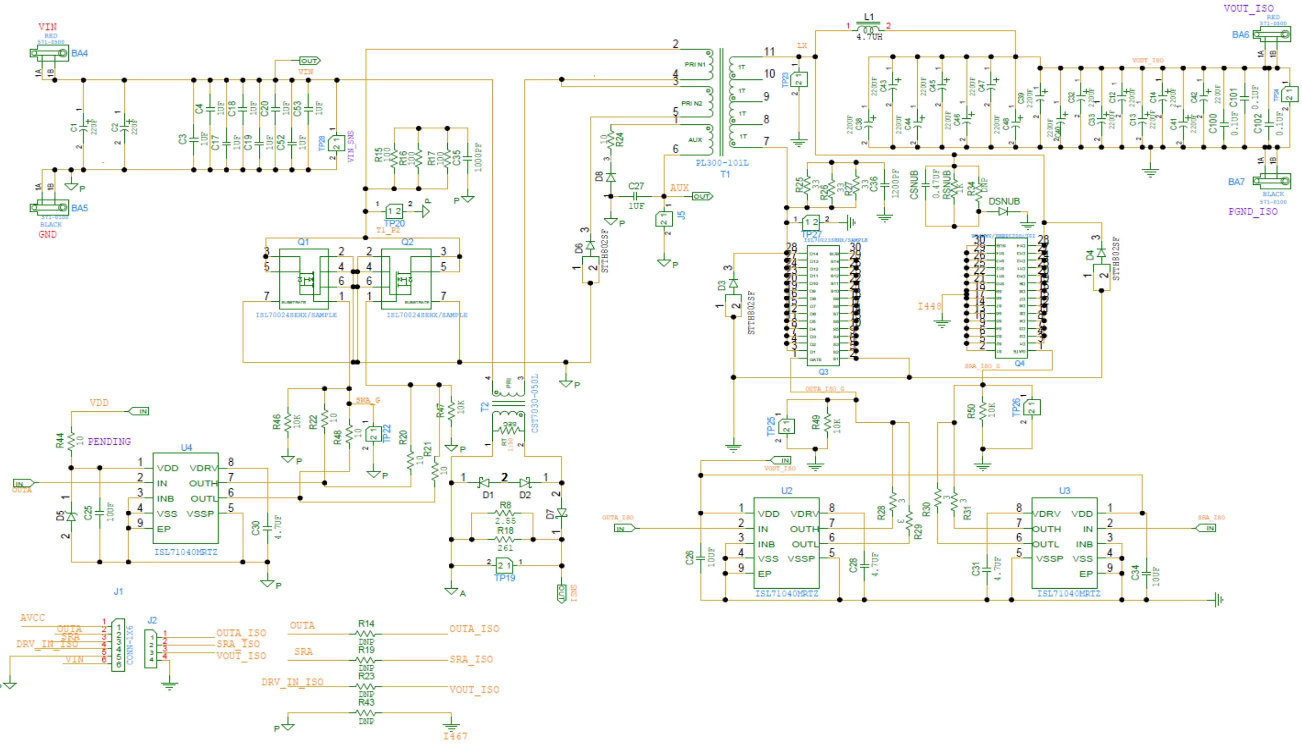

Figure 8. Power Stage Schematics

2.3 Bill of Materials

Qty	Ref Des	Description	Manufacturer	Part Number
2	BA5, BA7	CONN-PLUG, TH, 4mm INSUL.SOCKET, BLK, R/A, RoHS	Deltron	571-0100
2	BA4, BA6	CONN-PLUG, TH, 4mm INSUL.SOCKET, RED, R/A, RoHS	Deltron	571-0500
23	J3, J4, J5, TP1, TP2, TP3, TP4, TP5, TP6, TP9, TP10, TP12, TP16, TP18, TP19, TP20, TP22, TP23, TP24, TP25, TP26, TP27, TP28	CONN-HEADER, TH, 1×2, 2.54mmPITCH, 5.5×3.3mm, RoHS	3M	961102-6404-AR
1	C50	CAP, SMD, 0603, 2200pF, 50V, 10%, X7R, RoHS	Kemet	C0603C222K5RAC7867-T
3	C28, C30, C31	CAP-AEC-Q200, SMD, 0805, 4.7µF, 25V, 10%, X7R, RoHS	Kemet	C0805C475K3RACAUTO-T
2	C8, C29	CAP, SMD, 0603, 100pF, 100V, 10%, C0G/NP0, RoHS	TDK	C1608C0G2A101K080AA-T
1	C6	CAP, SMD, 0805, 1.0µF, 25V, 10%, X7R, RoHS	TDK	C2012X7R1E105K125AB-T
1	C23	CAP-AEC-Q200, SMD, 0603, 0.15µF, 25V, 10%, X7R, RoHS	TDK	CGA3E2X7R1E154K080AA-T
3	C10, C15, C27	CAP, SMD, 0805, 1µF, 50V, 10%, X7R, RoHS	Yageo	CC0805KKX7R9BB105-T
3	C25, C26, C34	CAP, SMD, 0805, 10µF, 25V, 10%, X7R, RoHS	Murata	GRM21BZ71E106KE15L-T
1	C49	CAP, SMD, 0603, 0.1µF, 16V, 10%, X7R, RoHS	YAGEO	CC0603KRX7R7BB104-T
1	C24	CAP, SMD, 0603, 0.047µF, 100V, 5%, RoHS	KEMET	C0603X473J3RACTU
1	C9	CAP, SMD, 0603, 390pF, 50V, 5%, C0G/NP0, RoHS	KEMET	GRM1885C1H391JA01D-T
1	C51	CAP, SMD, 0603, 5600pF, 50V, 10%, X7R, RoHS	KEMET	C0603C562K5RAC7867-T
1	C21	CAP, SMD, 0603, 1000pF, 25V, 10%, C0G/NP0, RoHS	AVX	KGM15ACG1E102KT-T
1	C5	CAP, SMD, 0603, 100pF, 50V, 5%, C0G/NP0, RoHS	AVX	KGM15ACG1H101J-T
0	C7, C11	DO NOT POPULATE OR PURCHASE	-	-
4	C1, C2, C16, C22	CAP-TANT, SMD, 7.3x4.3mm, 22µF, 63V, 20%, RoHS	Kemet	T521X226M063ATE075-T
16	C12, C13, C14, C32, C33, C38, C39, C40, C41, C42, C43, C44, C45, C46, C47, C48	CAP-TANT, SMD, 7.30mm x 4.30mm, 220µF, 16V, 20%, RoHS	Kemet	T521X227M016ATE035-T
1	C35	CAP, SMD, 0805, 1000pF, 200V, 10%, X7R, RoHS	Vishay	VJ0805Y102KXCAC-T
3	C100, C101, C102	CAP, SMD, 0805, 0.1µF, 25V, 10%, X7R, RoHS	Vishay	VJ0805Y104KXXAT-T
0	C37	Do Not Populate or Purchase	-	-
1	C36	CAP, SMD, 0805, 1200pF, 100V, 10%, X7R, RoHS	Vishay	VJ0805Y122KXBMC-T
8	C3, C4, C17, C18, C19, C20, C52, C53	CAP, SMD, 1812, 0.47µF, 100V, 10%, X7R, RoHS	Vishay	VJ1812Y105KBBAT4X-T
1	CSNUB	CAP, SMD, 1812, 0.47µF, 100V, 10%, X7R, RoHS	Vishay	VJ1812Y474KXBAT-T
2	D8, D12	Diode-Switching, SMD, SOT-23-3, 100V, 215mA, RoHS	Nexperia	BAS16-QR-T
3	D1, D2, D7	Diode-Schottky, SMD, SOD-123, 100V, 0.15A, RoHS	Vishay	BAT46W-E3-08-T

Qty	Ref Des	Description	Manufacturer	Part Number
1	D16	Diode-Zener, SMD, DO-219AB, 20V, 800mW, RoHS	Vishay	BZD27B20P-M3-08-T
1	D5	Diode-Zener, SMD, SOD-523, 13V, 300mW, RoHS	Diodes	BZT52C13T-7-T
3	D3, D4, D6	Diode-Rectifier, SMD, TO-277A, 200V, 8A, RoHS	STMicroelectronics	STTH802SF-T
1	DSNUB	Diode-Rectifier, SMD, DO214_AC, 200V, 1A, RoHS	Fairchild	ES1D
1	J2	CONN-HEADER, 1x4, BRKAWY 1×36, 2.54mm, RoHS	Various	Generic
1	J1	CONN-HEADER, 1x6, BRKAWY 1×36, 2.54mm, RoHS	Various	Generic
1	L1	COIL-PWR Inductor, SMD, 11.3×10mm, 4.7µH, 20%, RoHS	Coilcraft	XAL1010-472MED-T
1	Q5	Transistor, NPN, SMD, SOT-89, 4P, 60V, 1A, RoHS	Diodes Inc	BCX55-16-T
2	Q3, Q4	IC-Sample Die, Rad Hard, 100V GAN FET, RoHS	Renesas	ISL70023SEHX/SAMPLE
2	Q1, Q2	IC-Sample Die, Rad Hard, 200V GAN FET, RoHS	Renesas	ISL70024SEHX/SAMPLE
4	R46, R47, R49, R50	RES-AEC-Q200, SMD, 0603, 10K, 1/10W, 1%, TKF, RoHS	Vishay	CRCW060310K0FKEB-T
1	R18	RES, SMD, 0603, 243Ω, 1/10W, 1%, TKF, RoHS	Vishay	RC0603FR-07243RL-T
4	R28, R29, R30, R31	RES-AEC-Q200, SMD, 0603, 3Ω, 1/10W, 1%, TF, RoHS	Vishay	CRCW06033R00FKEA-T
1	R8	RES-AEC-Q200, SMD, 0603, 2.55Ω, 1/10W, 1%, TKF, RoHS	Vishay	CRCW06032R55FKEA-T
1	R52	RES-AEC-Q200, SMD, 0603, 14K, 1/10W, 0.1%, TNF, RoHS	Panasonic	ERA-3AEB1402V-T
1	R41	RES-AEC-Q200, SMD, 0603, 5.62K, 1/10W, 0.1%, TNF, RoHS	Panasonic	ERA-3AEB5621V-T
1	R39	RES-AEC-Q200, SMD, 0603, 30.1K, 1/5W, 1%, RoHS	Panasonic	ERJ-PB3B3012V-T
1	R40	RES-AEC-Q200, SMD, 0603, 60.4K, 1/10W, 0.1%, TKF, RoHS	Stackpole	RMCF0603FT60K4
0	R2, R5, R6, R51, R57, R58	DO NOT POPULATE OR PURCHASE	-	-
1	R53	RES, SMD, 0603, 11K, 1/10W, 1%, TF, RoHS	Yageo	AC0603FR-0711KL-T
1	R9	RES, SMD, 0603, 1.24K, 1/10W, 1%, TKF, RoHS	Yageo	RC0603FR-071K24L-T
1	R42	RES, SMD, 0603, 20.5K, 1/10W, 1%, TKF, RoHS	Yageo	RC0603FR-0720K5L-T
0	R14, R19, R23, R43	DO NOT POPULATE OR PURCHASE	-	-
4	R20, R21, R22, R48	RES-AEC-Q200, SMD, 0603, 10Ω, 1/10W, 1%, TKF, RoHS	Rohm	KTR03EZPF10R0-T
1	R36	RES-AEC-Q200, SMD, 0603, 2.87K, 1/10W, 1%, RoHS	Rohm	ERJ-3EKF2871V-T
1	R35	RES, SMD, 0603, 113K, 1/10W, 1%, TKF, RoHS	Yageo	RC0603FR-07113KL-T
1	R10	RES, SMD, 0805, 402K, 1/8W, 1%, TKF, RoHS	Yageo	RC0805FR-07402KL-T
1	RSHORT	RES, SMD, 1210, 0Ω, TKF, RoHS	Yageo	RC1210JR-070RL-T
1	R56	RES, SMD, 0603, 1.4K, 1/10W, 1%, TKF, RoHS	KOA Speer	RK73H1JTTD1401F-T
2	R54, R55	RES-AEC-Q200, SMD, 0603, 10K, 1/10W, 1%, TKF, RoHS	Stackpole	RMCF0603FT10K0-T
2	R24, R44	RES-AEC-Q200, SMD, 0603, 10Ω, 1/10W, 1%, TKF, RoHS	Stackpole	RMCF0603FT10R0-T
1	R37	RES-AEC-Q200, SMD, 0603, 2.2K, 1/10W, 1%, TKF, RoHS	Stackpole	RMCF0603FT2K20-T

Qty	Ref Des	Description	Manufacturer	Part Number
1	R3	RES-AEC-Q200, SMD, 0603, 332K, 1/10W, 1%, TKF, RoHS	Stackpole	RMCF0603FT332K-T
1	R4	RES-AEC-Q200, SMD, 0603, 44.2K, 1/10W, 1%, TKF, RoHS	Stackpole	RMCF0603FT44K2-T
1	R11	RES-AEC-Q200, SMD, 0603, 73.2K, 1/10W, 1%, TKF, RoHS	Stackpole	RMCF0603FT73K2-T
1	R12	RES-AEC-Q200, SMD, 0603, 52.3K, 1/10W, 1%, TKF, RoHS	Stackpole	RMCF0603FT52K3
3	R15, R16, R17	RES-AEC-Q200, SMD, 2010, 100Ω, 1W, 1%, TKF, RoHS	Stackpole	RMCP2010FT100R-T
3	R25, R26, R27,	RES-AEC-Q200, SMD, 2010, 33Ω, 1W, 1%, TKF, RoHS	Stackpole	RMCP2010FT33R0-T
0	R33, R34	DO NOT POPULATE OR PURCHASE	-	-
1	R13	RES-AEC-Q200, SMD, 1206, 1K, 1/4W, 0.1%, TNF, RoHS	KOA	RN73R2BTTD1001B25-T
1	R7	RES, SMD, 0603, 100Ω, 1/10W, 1%, TKF, RoHS	Yageo	RC0603FR-07100RL-T
2	R38, R45	RES-AEC-Q200, SMD, 0603, 10K, 1/10W, 0.1%, TNF, RoHS	Vishay	TNPW060310K0BEEA-T
1	R1	RES, SMD, 0603, 0Ω, W, TKF, RoHS	Yageo	RC0603JR-070RL-T
1	RSNUB (R32)	RES, SMD, 2010, 1k, 1W RoHS	Stackpole	RMCP2010FT1K00-T
1	T1	Transformer-Planar, 300W, Custom, AUX Winding 2TURN	Coilcraft	PL300X2-101L
1	T2	Transformer-Current, 1:50 Turns, 0.333mH, 20A, RoHS	Coilcraft	CST7030-050LC
3	U2, U3, U4	IC-GaN FET Driver, 8PTDFN, 4×4, RoHS	Renesas	ISL71040MRTZ
1	U5	IC-RH, Dual Comparator, CFP, 10P, RoHS	Renesas	ISL7119RHF/PROTO
1	U1	IC RT plastic, PWM Controller, 19V, 1.5A, RoHS	Renesas	ISL73846M30NEZ
3	JP1, UVLO_SEL, VDD_SEL	CONN-HEADER, 1×3, BRKAWY 1×36, 2.54mm, RoHS	FCI	68000-236HLF-1X3
1	NA	Feedback Isolator	Renesas	ISLFBKISOEV2Z

2.4 Board Layout

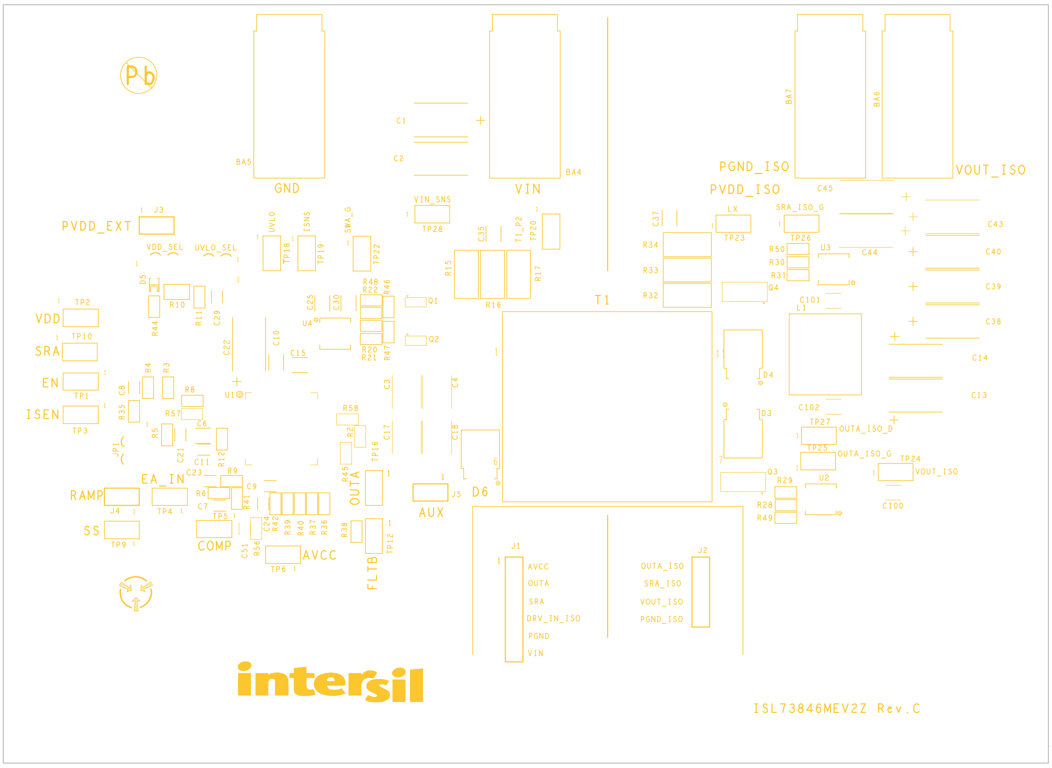

Figure 9. Top Silkscreen

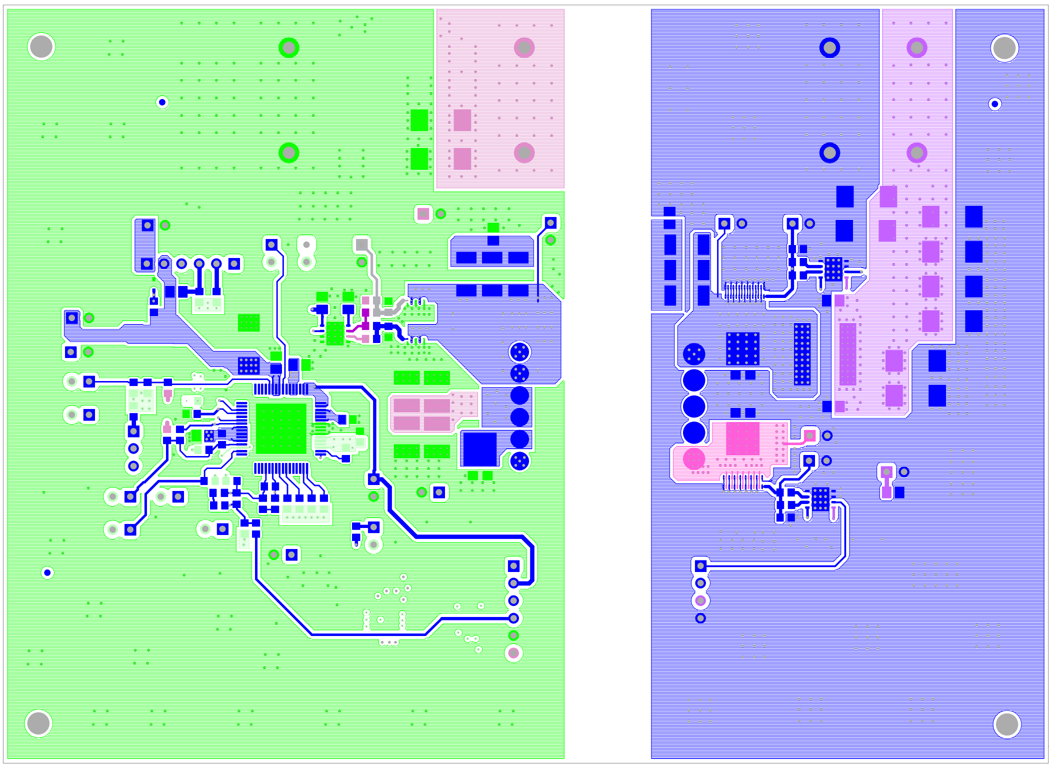

Figure 10. Top Layer

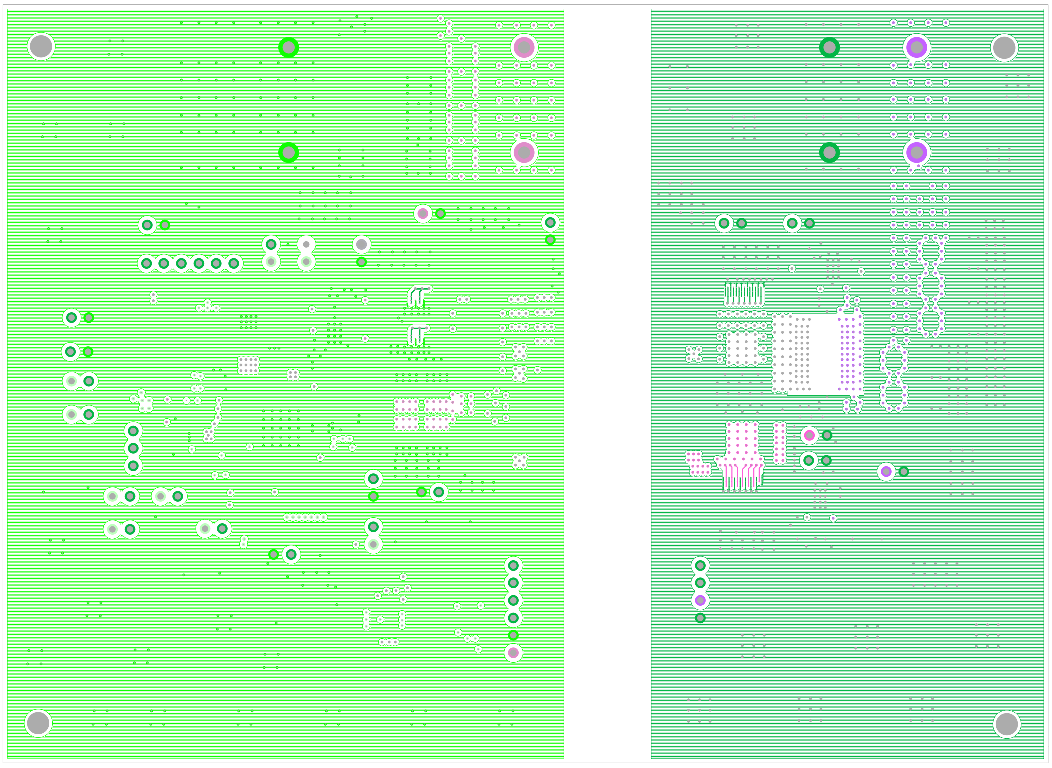

Figure 11. Layer 2

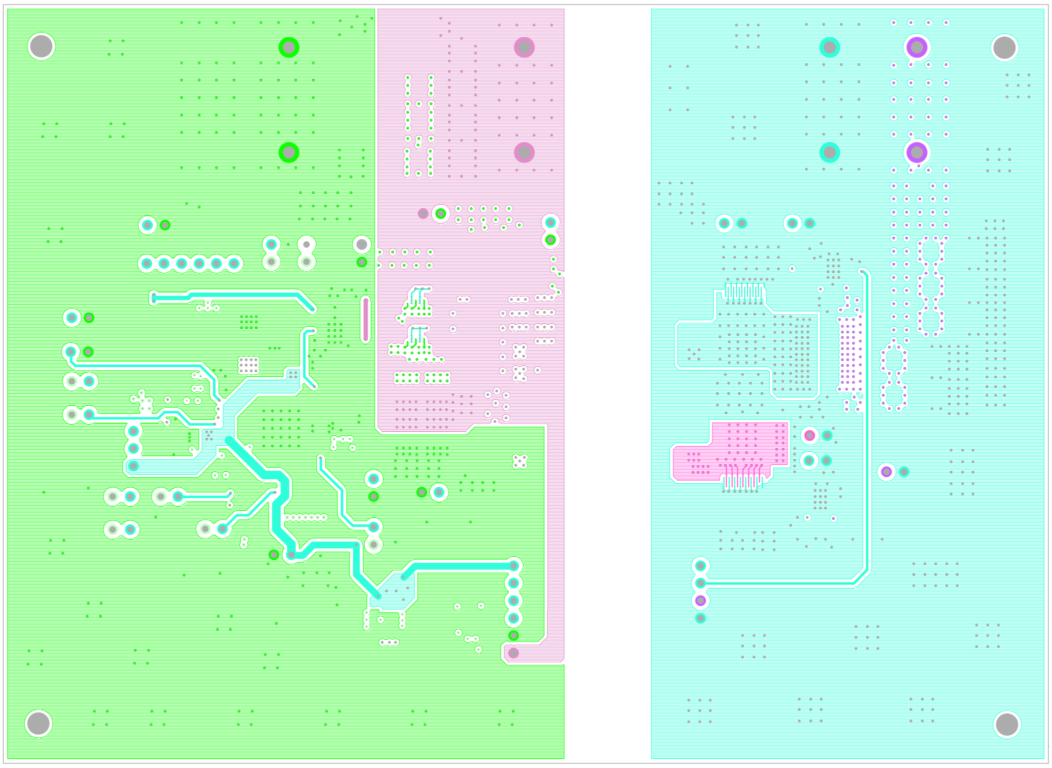

Figure 12. Layer 3

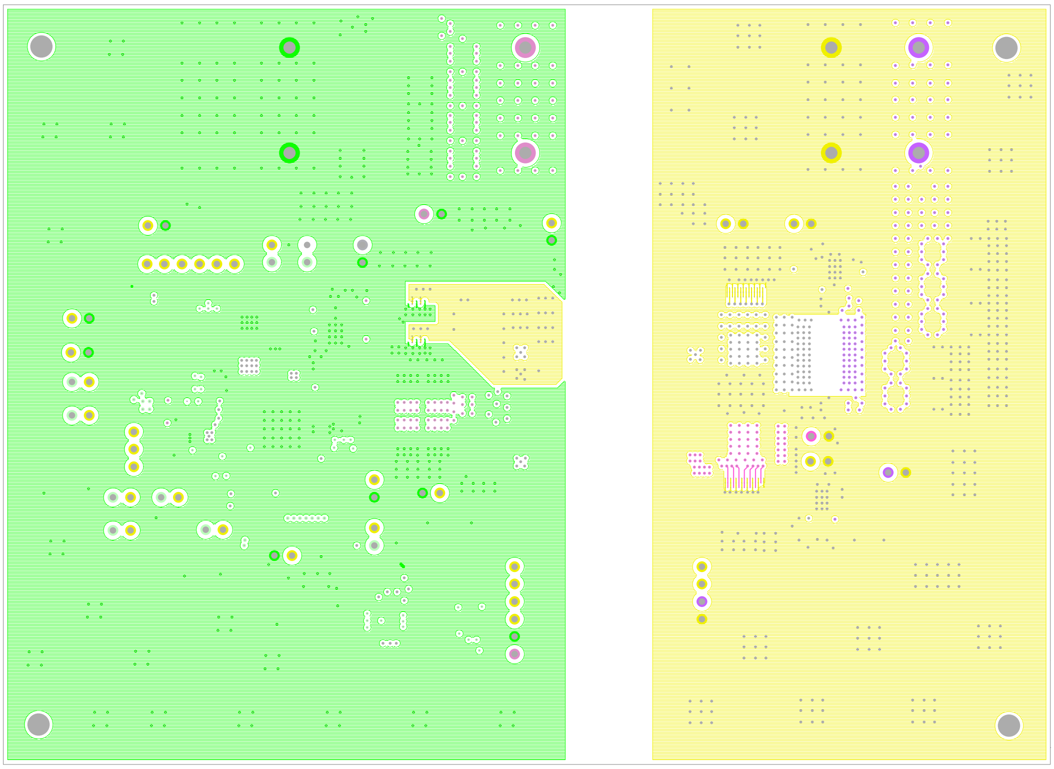

Figure 13. Layer 4

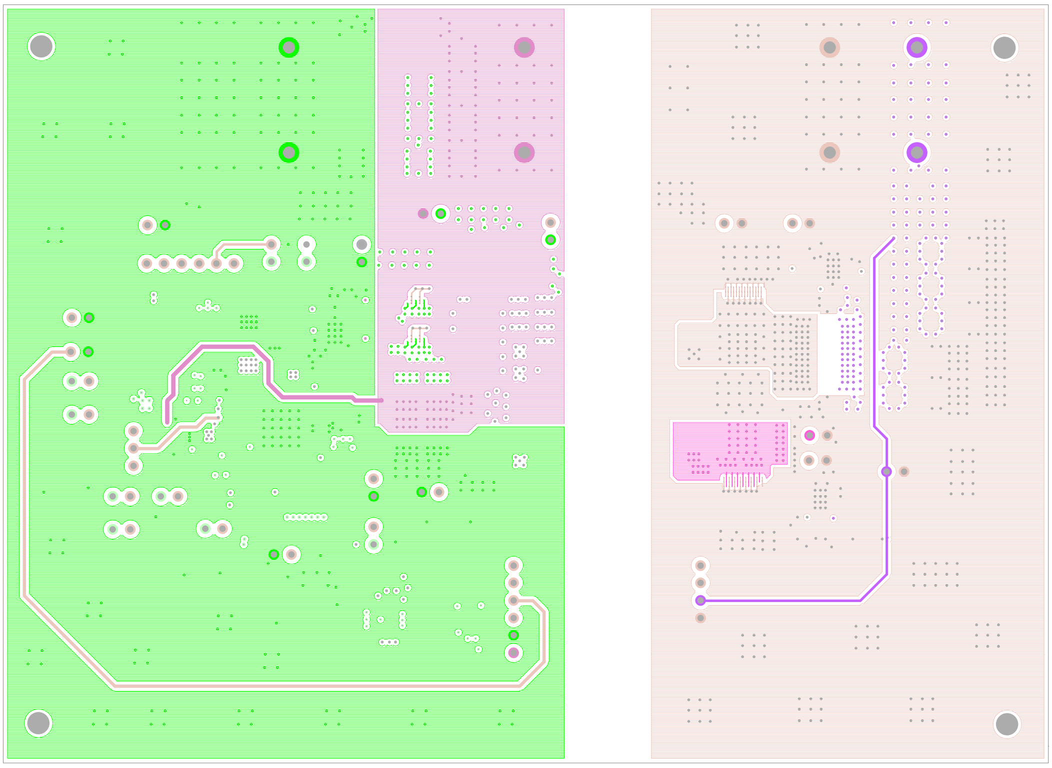

Figure 14. Layer 5

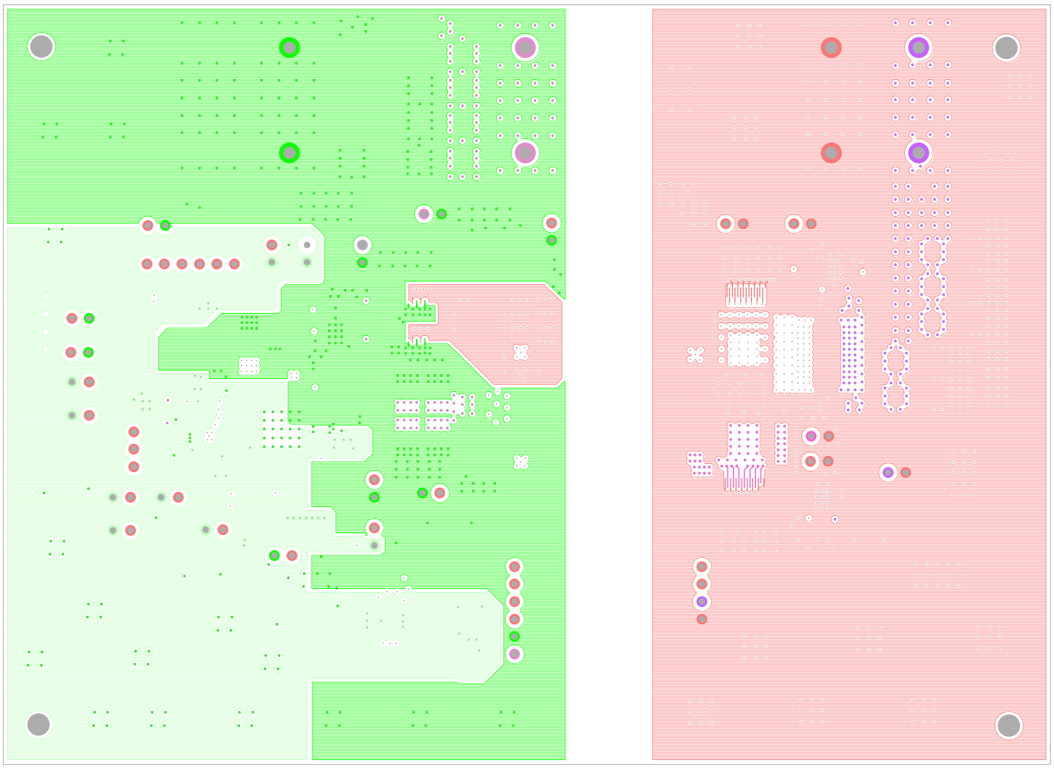

Figure 15. Layer 6

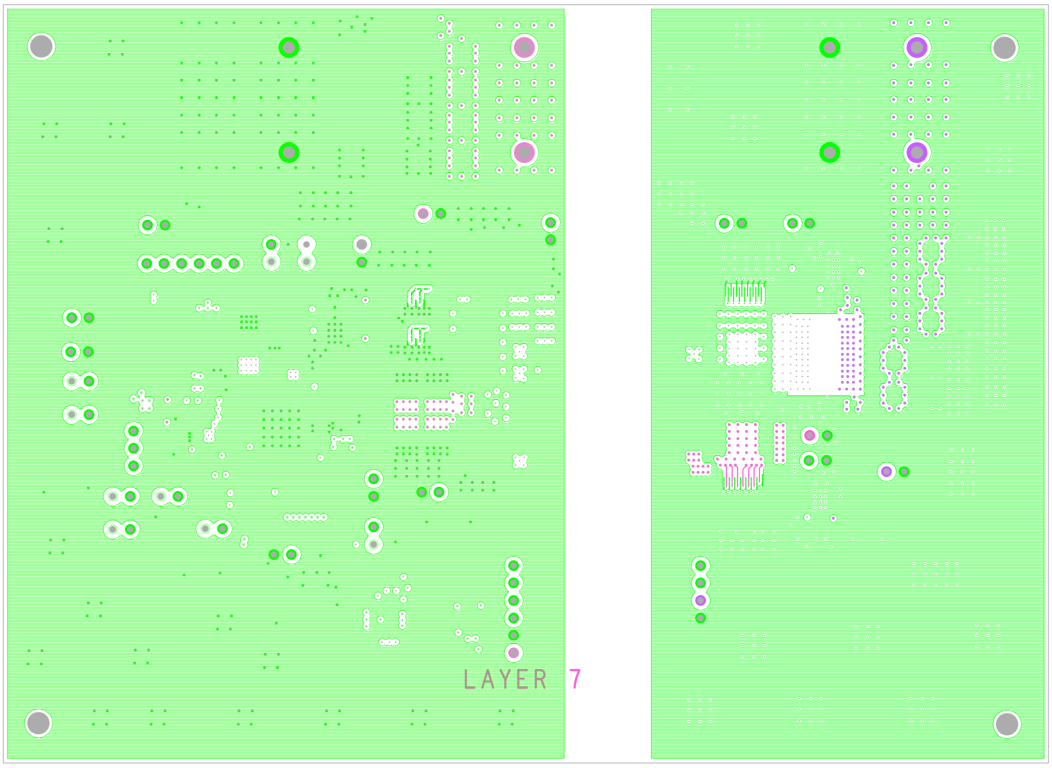

Figure 16. Layer 7

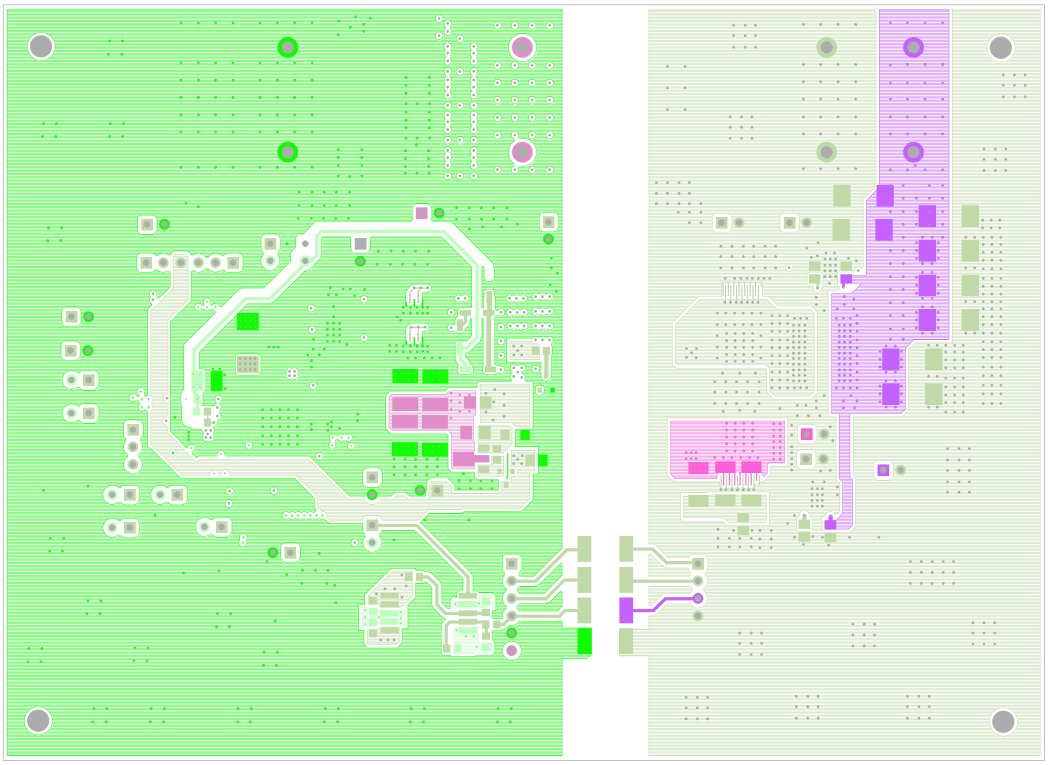

Figure 17. Bottom Layer

Figure 18. Bottom Silkscreen

3. Board Modification for RCD Snubber

The RC snubber for the LX node was modified to an RCD snubber by first removing R32, R33, R34, and C37 then proceeding to do the following steps:

1. Place an ES1D 200V diode between the left pad of R34 and C37 ground pad (diode cathode facing ground) as shown in Figure 19.
2. Place a 0.47µF 100V X7R capacitor across the R33 PCB pads as shown in Figure 19.
3. Place a 1k resistor across the R32 PCB pads as shown in Figure 19.

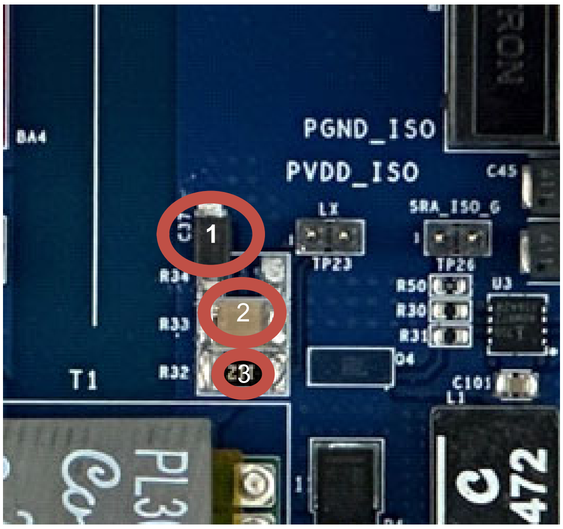

Figure 19. RC Snubber Modified to RCD Snubber

4. ISLFBKISOEV2Z (Isolation Board)

The ISLFBKISOEV2Z Board was developed specifically to provide feedback isolation to the ISL73846MEV2Z and ISL73846SLHEV2Z single-switch forward converters. It also provides isolation to the synchronous rectifiers PWM signals OUTA and SRA.

4.1 Features

- Closed Loop Fly back housekeeping supply.
- Feedback isolation.

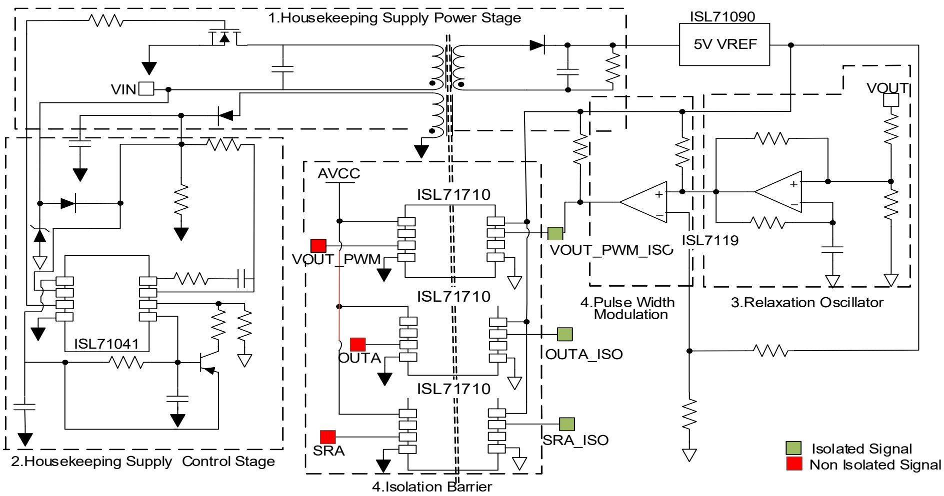

Figure 20. ISLFBKISOEV2Z Block Diagram

4.2 Functional Description

This board was developed specifically for radiation hardened PWM controller ISL73846M. To provide galvanic isolation for the V_{IN} = 28V to V_{OUT} = 5V forward converter evaluation boards, ISL73846MEV2Z and ISL73846SLHEV2Z.

The FB isolation circuit is divided into two main stages illustrated in Figure 21

- Converting the VOUT DC voltage into a Pulse Width Modulated signal (4V at 80% duty cycle).
- Transmitting the PWM Signal across an isolation barrier circuit

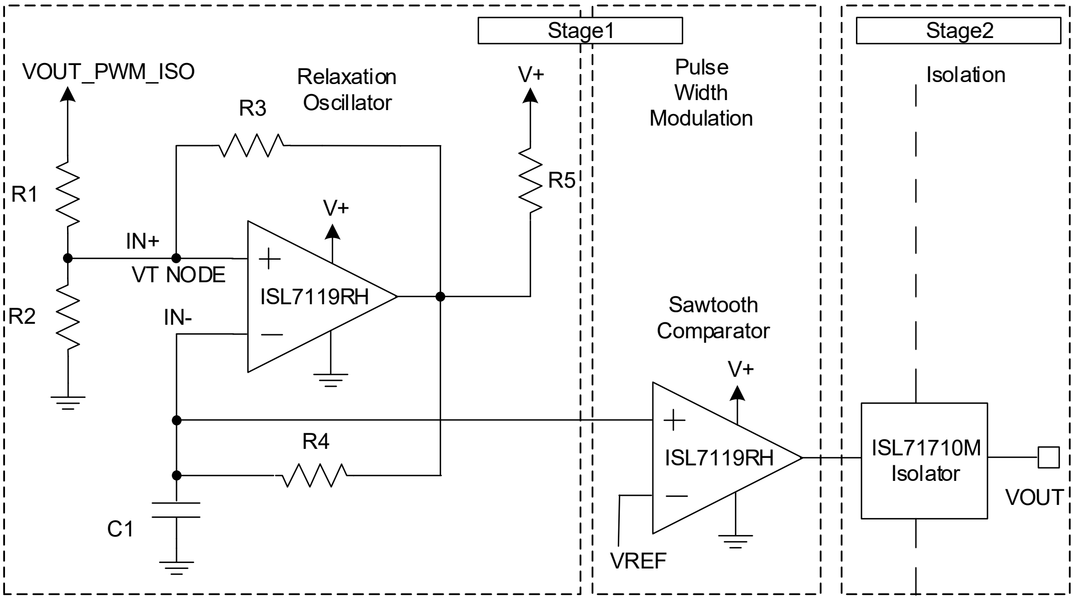

Figure 21. FB Isolation Circuit Main Stages

4.3 Schematic Diagrams

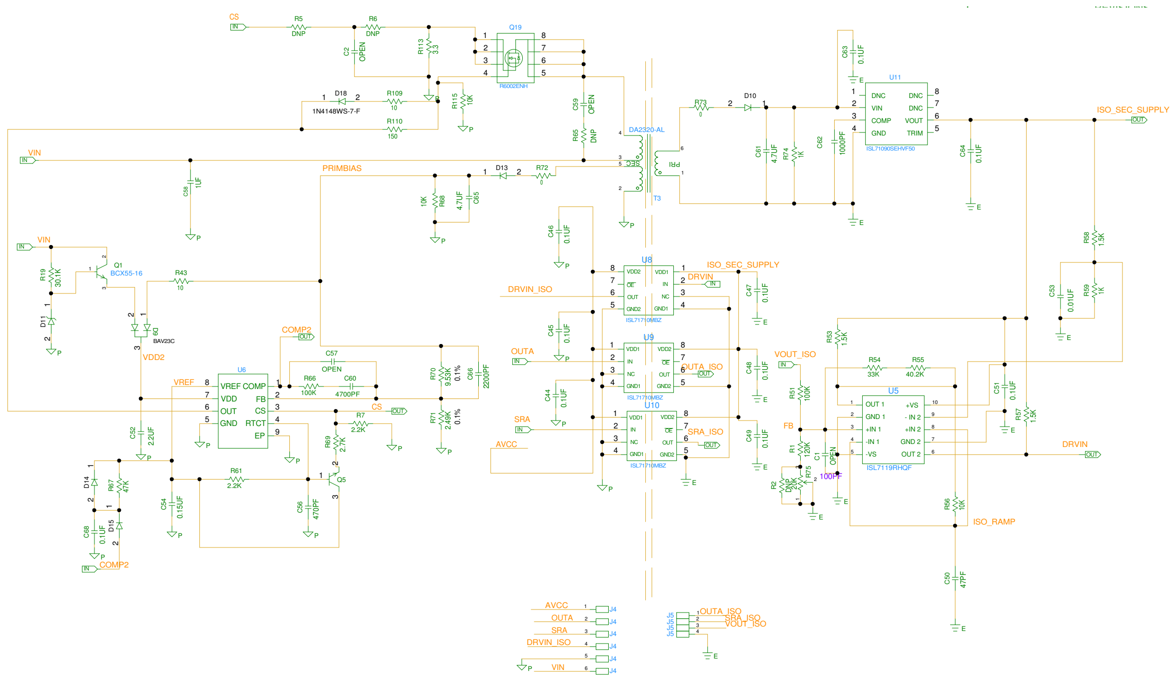

Figure 22. ISLFBKISOEV2Z Schematic

4.4 ISLFBKISOEV2Z Bill of Materials

Qty	Ref Designator	Description	Manufacturer	Part Number
2	D10, D13	Diode -Rectifier, SMD, SOD-323, 2P, 100V, 250mA, ROHS	Diodes	1N4148WS
3	D14, D15, D18	Diode -Rectifier, SMD, SOD-323, 2P, 75V, 150mA, ROHS	Diodes	1N4148WS-7-F
1	D9	Diode-Array, SMD, SOT-23-3, 200V, 200mA, 1 PAIR Common CATH, ROHS	Diodes	BAV23C
1	D11	Diode-Zener, SMD, DO-219AB, 12V, 800mW, ROHS	Vishay	BZD27B12P-M
1	R75	POT-TRIM, TH, 20K, 0.25W, 10%, JLEAD, Sealed, TOP ADJ, ROHS	Bourns	3224W-1-203E-T
1	R19	RES-AEC-Q200, SMD, 0603, 30.1K, 1/10W, 1%, TKF, ROHS	Yageo	AC0603FR-0730K1L-T
2	R72, R73	RES-AEC-Q200, SMD, 0805, 0Ω, 1/2W, TF, ROHS	Vishay	CRCW08050000Z0EAHP-T
1	R56	RES-AEC-Q200, SMD, 0603, 10K, 1/10W, 0.1%, TNF, ROHS	Panasonic	ERA-3AEB103V-T
1	R55	RES-AEC-Q200, SMD, 0603, 40.2K, 1/10W, 0.1%, ROHS	Panasonic	ERA-3AEB4022V-T
1	R70	RES-AEC-Q200, SMD, 0603, 9.53K, 1/10W, 0.1%, TNF, ROHS	Panasonic	ERA-3AEB9531V-T
1	R69	RES-AEC-Q200, SMD, 0603, 2.7K, 1/10W, 1%, ROHS	Panasonic	ERJ3EKF2701V-T
0	R5, R6	DO NOT POPULATE OR PURCHASE	-	-
1	R59	RES-AEC-Q200, SMD, 0603, 1K, 1/10W, 0.1%, TNF, ROHS	Panasonic	ERA-3AEB102V-T
1	R1	RES, SMD, 0603, 120KΩ, 0.1%, 1/16W	TE	CPF0603B120KE1-T
2	R51, R66	RES, SMD, 0603, 100K, 1/16W, 0.1%, TF, ROHS	TE	CPF0603B100KE-T
3	R53, R57, R58	RES, SMD, 0603, 1.5K, 1/16W, 0.1%, TF, ROHS	TE	CPF0603B1K5E-T
1	R61	RES, SMD, 0603, 2.2K, 1/16W, 0.1%, ROHS	TE	CPF0603B2K2E1-T
1	R54	RES, SMD, 0603, 33K, 1/16W, 0.1%, ROHS	TE	CPF0603B33KE1-T
1	R67	RES, SMD, 0603, 47K, 1/10W, 1%, TKF, ROHS	Yageo	RC0603FR-0747KL-T
1	R74	RES, SMD, 1206, 1K, 1/4W, 1%, TF, ROHS	Panasonic	ERJ-8ENF1001V-T
0	R65	DO NOT POPULATE OR PURCHASE	-	-
0	R2	DO NOT POPULATE OR PURCHASE	-	-
2	R68, R115	RES-AEC-Q200, SMD, 0603, 10K, 1/10W, 1%, TKF, ROHS	Stackpole	RMCF0603FT10K0-T
1	R110	RES-AEC-Q200, SMD, 0603, 150Ω, 1/10W, 1%, TKF, ROHS	Stackpole	RMCF0603FT150R-T
1	R7	RES-AEC-Q200, SMD, 0603, 2.2K, 1/10W, 1%, TKF, ROHS	Stackpole	RMCF0603FT2K20-T
1	R71	RES, SMD, 0603, 2.49K, 1/10W, 0.1%, TNF, ROHS	Yageo	RT0603BRE072K49L-T
1	R113	RES-AEC-Q200, SMD, 0805, 3.3Ω, 1/2W, 1%, TKF, ROHS	KOA	SG73P2ATTD3R30F-T
2	R43, R109	RES-AEC-Q200, SMD, 0603, 10Ω, 1/10W, 1%, TKF, ROHS	Rohm	KTR03EZPF10R0-T
1	C53	CAP, SMD, 0603, 0.01µF, 25V, 10%, X7R, ROHS	Kemet	C0603C103K3RAC7411-T
1	C66	CAP, SMD, 0603, 2200pF, 25V, 10%, X7R, ROHS	Kemet	C0603C222K3RAC7867-T
1	C54	CAP-AEC-Q200, SMD, 0603, 0.15µF, 25V, 10%, X7R, ROHS	TDK	CGA3E2X7R1E154K080AA-T

Qty	Ref Designator	Description	Manufacturer	Part Number
7	C44, C45, C46, C47, C48, C49, C51	CAP-AEC-Q200, SMD, 0603, 0.1µF, 50V, 10%, X7R, ROHS	Murata	GCJ188R71H104KA12D-T
1	C52	CAP, SMD, 0603, 2.2µF, 25V, 10%, X7S, ROHS	Murata	GRM188C71E225KE11D-T
2	C61, C65	CAP, SMD, 0603, 4.7µF, 35V, 10%, X5R, ROHS	Murata	GRM188R6YA475KE15D-T
1	C62	CAP, SMD, 0805, 1000pF, 25V, 10%, X7R, ROHS	Kyocera	KGM21NR71E102KT-T
1	C68	CAP, SMD, 0603, 0.1µF, 16V, 10%, X7R, ROHS	Kemet	GCJ188R71H104KA12D-T
2	C63, C64	CAP, SMD, 0603, 0.1µF, 16V, 20%, X7R, ROHS	Kemet	GCJ188R71H104KA12D-T
1	C50	CAP, SMD, 0603, 47pF, 50V, 5%, C0G/NP0, ROHS	Yageo	CC0603JRNP09BN470-T
1	C56	CAP, SMD, 0603, 470pF, 50V, 5%, C0G/NP0, ROHS	Murata	GRM1885C1H471JA01D-T
1	C60	CAP, SMD, 0603, 4700pF, 50V, 5%, C0G/NP0, ROHS	TDK	C1608C0G1H472J080AA-T
0	C1, C2, C57	DO NOT POPULATE OR PURCHASE	-	-
1	C58	CAP, SMD, 1812, 1µF, 100V, 10%, X7R, ROHS	Vishay	VJ1812Y105KBBAT4X-T
1	Q1	Transistor, NPN, SMD, SOT-89, 4P, 60V, 1A, ROHS	Diodes Inc	BCX55-16-T
1	Q5	Transistor, NPN, 3P, SOT23, 30V, 600mA, ROHS	Motorola	MMBT2222LT1G-T
1	Q19	Transistor, SMD, 8SOP, MOSFET, N-CHANNEL, 600V, 1.7A, 2W, ROHS	Rohm	R6002ENHTB1-T
1	U6	IC-Current Mode PWM, 50% DC, 7.0V UVLO, 8P, RoHS	Renesas	ISL71041MRTZ
1	U11	IC-RH, Ultralow Noise, 5.0V, ROHS	Renesas	ISL71090SEHVF50
1	U5	IC-RH High Speed Dual Voltage Comparator, ROHS	Renesas	ISL7119RHQF
3	U8, U9, U10	IC-Digital Active Isolator, SMD, 8P, SOICN, ROHS	Renesas	ISL71710MBZ
1	J5	CONN-Socket, TH, 1×4, Insulated, 2.54mm, ROHS	Sullins	PPTC041LFBN-RC
1	J4	CONN-Receptacle, Female, TH, 1×6, 2.54mm Pitch, ROHS	Sullins	PPTC061LFBN-RC
1	T3	Transformer, SMD, 6.6mm, 264µH, MAX 95pF, ROHS	Coilcraft	DA2320-AL

4.5 Board Layout

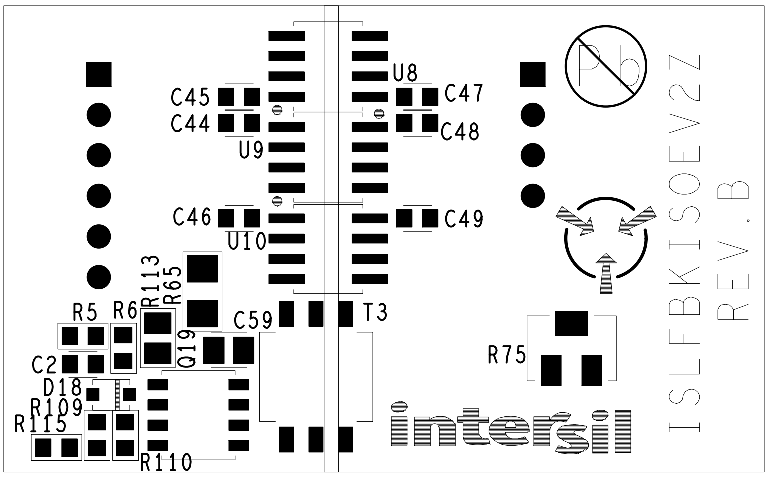

Figure 23. Top Silk Screen

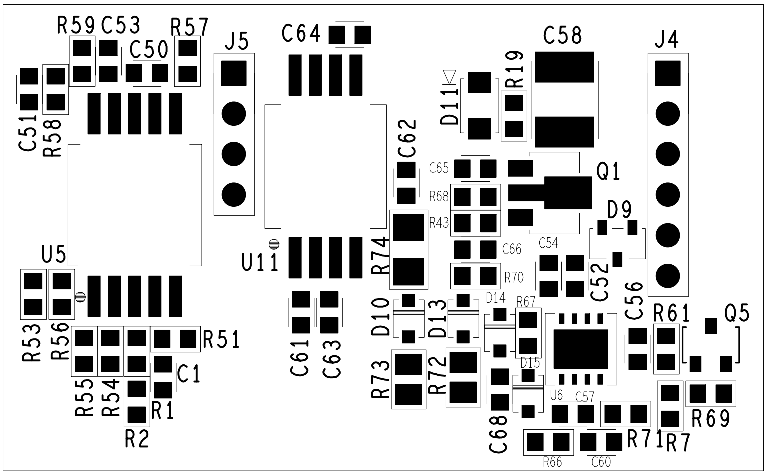

Figure 24. Bottom Silk Screen

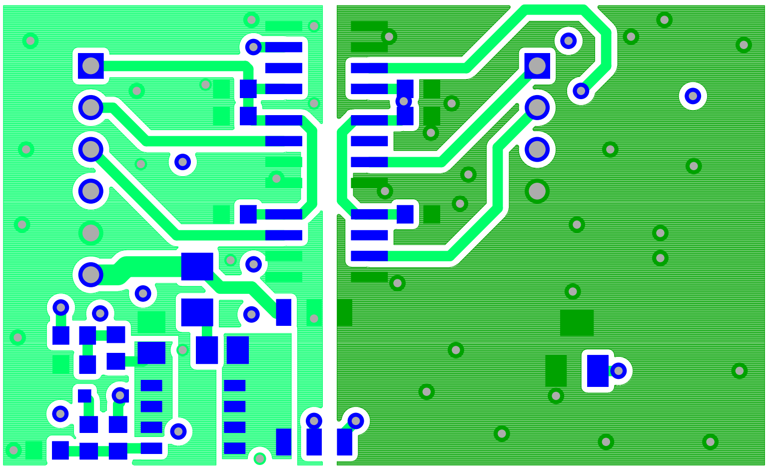

Figure 25. Top Layer

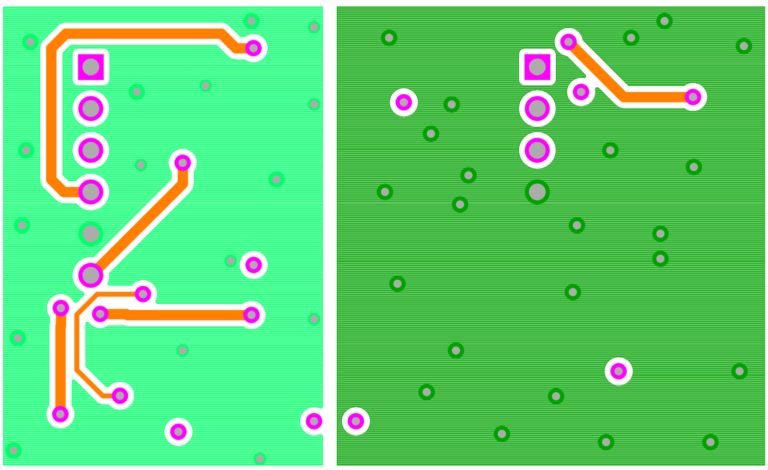

Figure 26. Layer 2

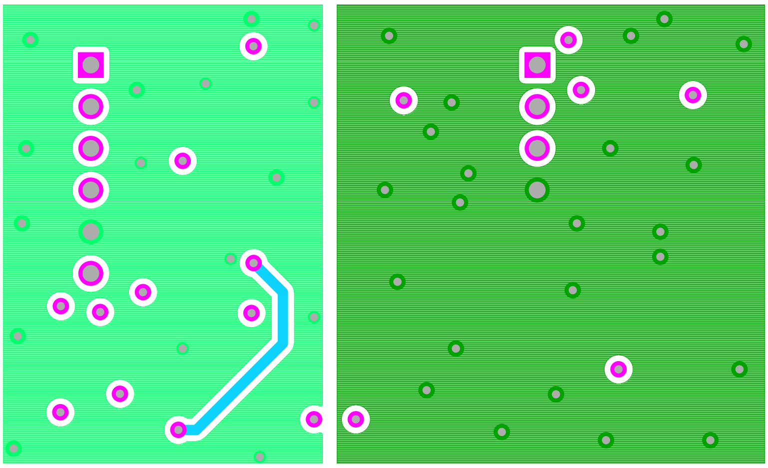

Figure 27. Layer 3

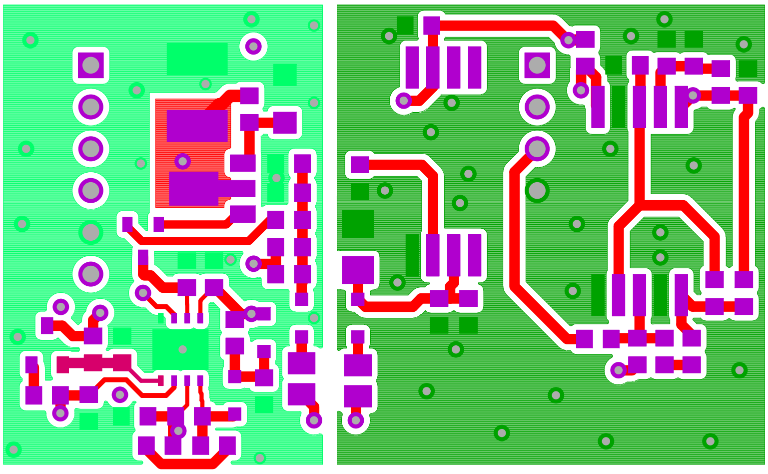

Figure 28. Bottom Layer 3

5. Overvoltage Protection Circuit

To protect the forward converter from a negative overcurrent, a comparator, ISL7119RHQF (U5 in the schematics shown in Figure 8) was added. This comparator pulls the FLTB pin of the ISL73846M low, forcing the converter to restart every time a feedback higher than 4.8V is detected from the isolator output.

6. Typical Performance Graphs

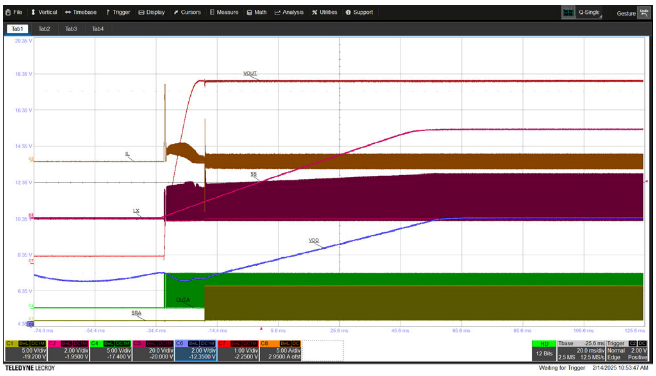

Figure 29. Startup with VIN 28V and No Load

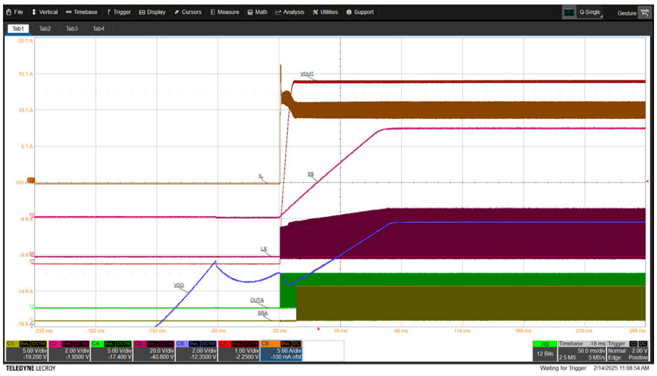

Figure 30. Startup with VIN 28V and 10A Load

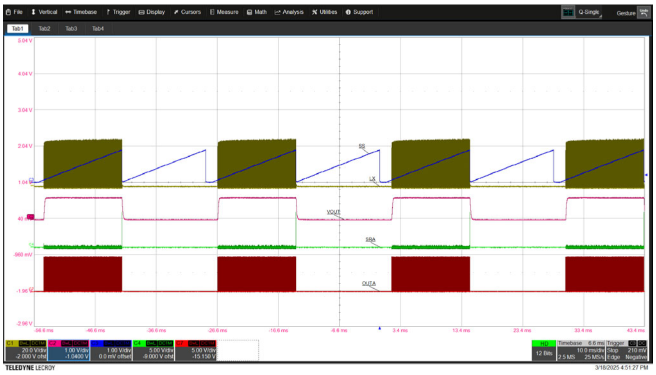

Figure 31. Startup with Output Short OCP Response, V_{IN} = 28V

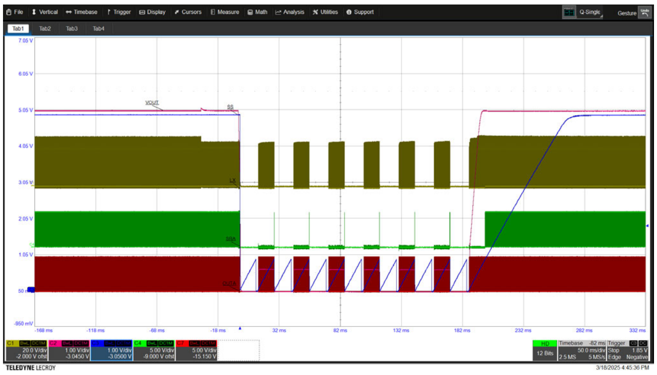

Figure 32. OCP Response Short at Steady State, V_{IN} = 28V

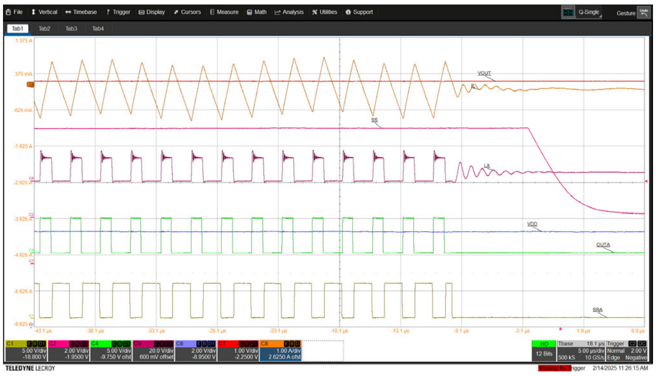

Figure 33. Shutdown with VIN 28V and No Load

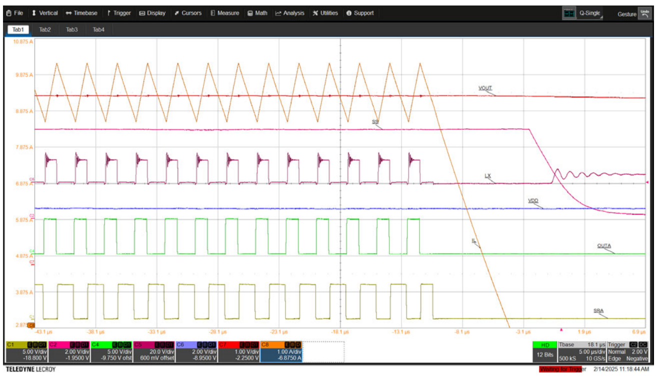

Figure 34. Shutdown VIN 28V and 10A Load

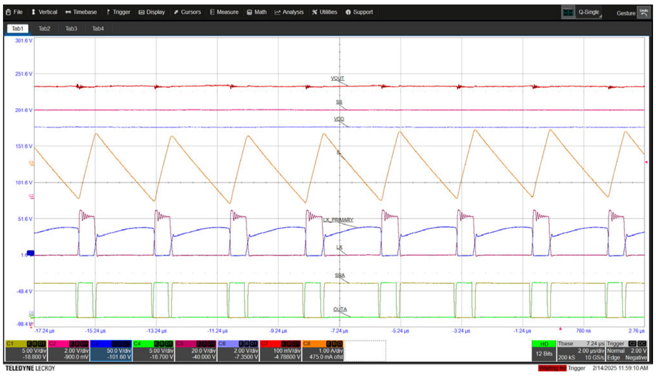

Figure 35. Waveforms with VIN 28V and No Load

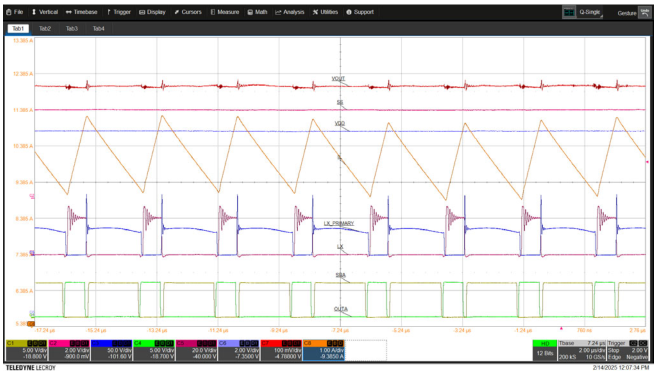

Figure 36. Waveforms with VIN 28V and 10A Load

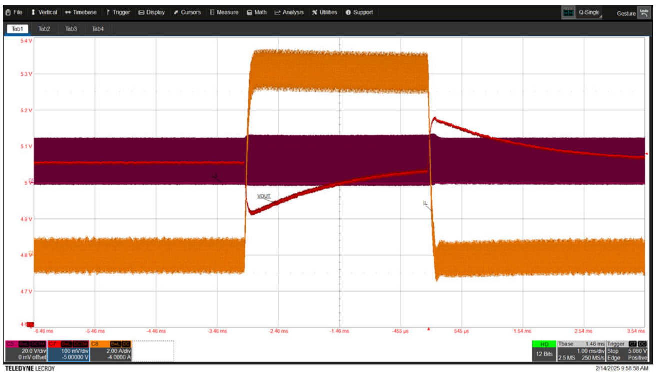

Figure 37. Load Transient with VIN 28V and Step Load from 0 to 10A at Room Temperature

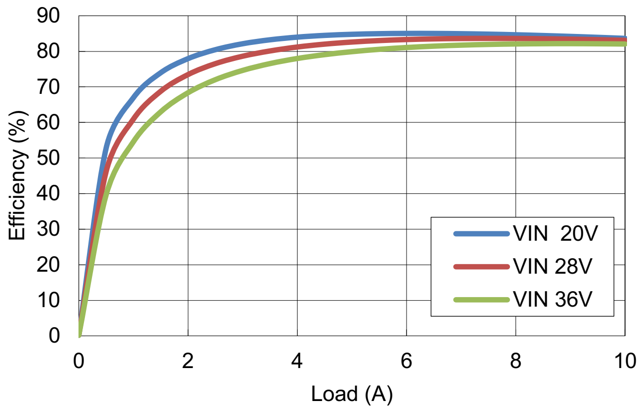

Figure 38. Efficiency with Various VIN at Room Temperature

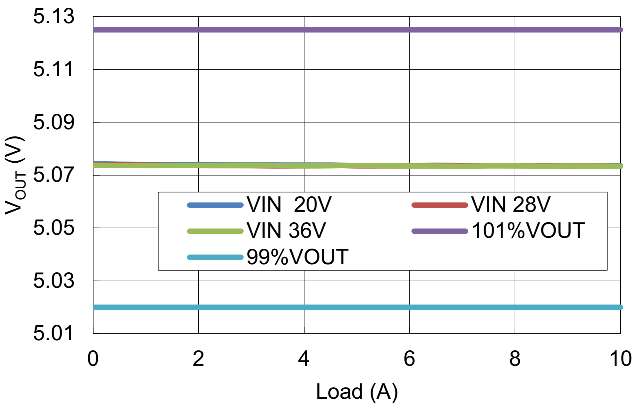

Figure 39. Load Regulation with 50mA Load at Room Temperature

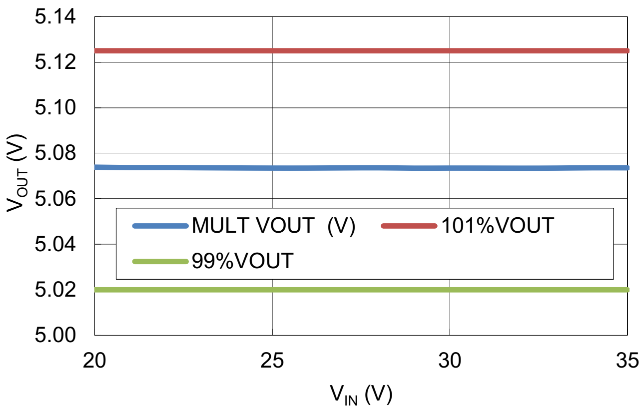

Figure 40. Line Regulation with Various VIN at Room Temperature

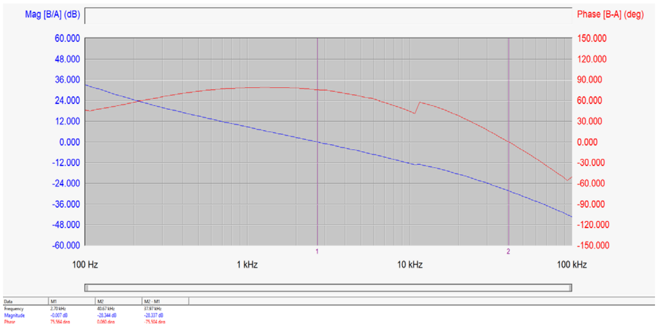

Figure 41. Gain and Phase vs Frequency (V_{IN} = 22V, Load = 10A)

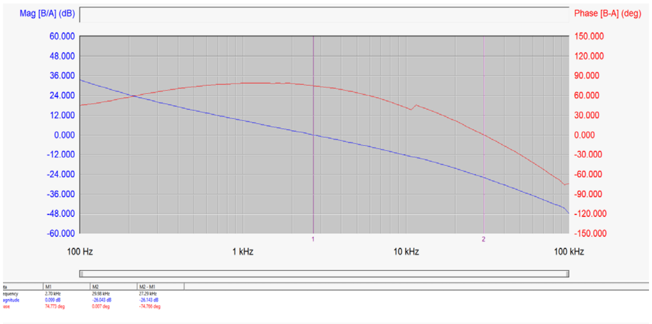

Figure 42. Gain and Phase vs Frequency (V_{IN} = 28V, Load = 10A)

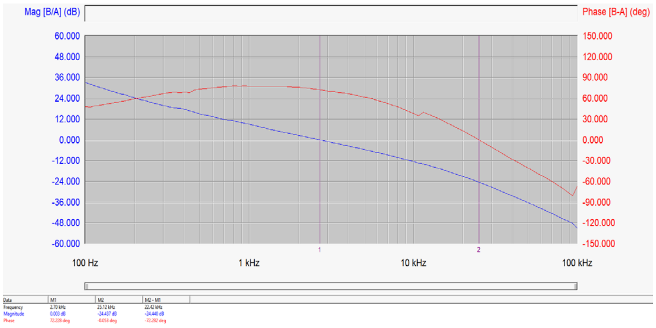

Figure 43. Gain and Phase vs Frequency (V_{IN} = 34V, Load = 10A)

7. Ordering Information

Part Number	Description
ISL73846MEV2Z	ISL73846M Single Switch Isolated Forward Converter Evaluation Board

8. Revision History

Revision	Date	Description
1.03	Oct 1, 2025	Updated Features bullets. Updated Input Voltage throughout. Corrected Titles for Figures 7 and 8 Updated Figures 41-43. Updated BOM for C24 and R12. Updated Functional description section. Added the following sections: ▪ Design Specifications ▪ Feedback Isolation ▪ Overvoltage Protection ▪ Transformer ▪ Inductor ▪ Output Capacitance ▪ Synchronous GaNFETs Switches ▪ Frequency ▪ Blanking Time ▪ Dead Time ▪ Current Sensing ▪ Control Loop ▪ Slope Compensation ▪ Offline Startup
1.02	Jul 18, 2025	Updated BOMs.
1.01	May 28, 2025	Corrected typo in the BOM and Figure 20 title.
1.00	Apr 15, 2025	Initial release

IMPORTANT NOTICE AND DISCLAIMER

Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,
Koto-ku, Tokyo 135-0061, Japan
www.renesas.com

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Contact Information

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