# ISL73846MEV1Z

Push-Pull Converter Evaluation Board

## Description

The ISL73846MEV1Z is an evaluation platform for a radiation-tolerant push-pull power supply, built around the ISL73846M PWM controller. It converts a nominal 28V input (20V-36V range) to a regulated 12V output, capable of delivering up to 12A continuous load current, and is optimized for space and high-reliability applications.

The design features synchronous rectification on the secondary side to improve efficiency and thermal performance. It operates at 200kHz per switch (effective 400kHz at the output filter), maintains ±2% output voltage regulation, and supports ±4% output voltage deviation during 0A to 12A load transients.

The included ISLFBKISOEV1Z feedback daughterboard enables signal-level isolation for both the output voltage feedback and synchronous rectifier PWM signals, while still allowing for accurate regulation during steady-state and fault detection.

Together, the ISL73846MEV1Z and ISLFBKISOEV1Z offer a comprehensive platform to evaluate the performance, control flexibility, and robustness of the ISL73846M in demanding isolated power supply applications.

## Features

- Synchronous push-pull converter
- Current-mode control
- Regulated isolated output
- Resistor programmable deadtime

## Specifications

- VIN range: 20V to 36V (nominal 28V)
- VDD_EXT range: 5V to 19V
- $V_{OUT}$ = 12V ±2%
- $I_{OUT}$ = 12A max (continuous, OCP level is 22A peak)
- Output voltage deviation from steady state value for 12A load transient less than ±4%.

Switching frequency = 200kHz per switch, 400kHz effective at output inductor and capacitors (ripple).

## Contents

- ISL73846MEV1Z board
- ISLFBKISOEV1Z daughterboard

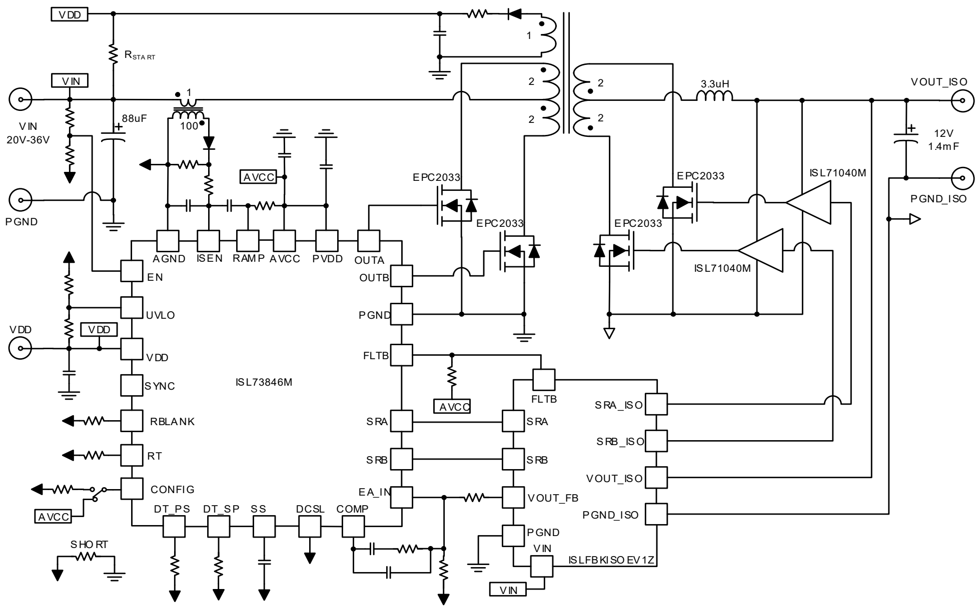


**Figure 1. Board Block Diagram**

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# 1. Functional Description

ISL73846MEV1Z features a single ISL73846M general-purpose PWM controller in a 50% duty ratio limited configuration. ISL73846M has integrated low-side drivers (OUTA/OUTB), which are used to directly drive the primary side switches (EPC2033 GaN FETs) of the converter. The secondary side synchronous rectifiers (EPC2033 GaN FETs) are driven by ISL71040MRTZ low-side drivers with SRA/SRB control signals generated by the ISL73846M controller. Deadtime between OUTx and SRx outputs of the controller are resistor programmable.

The PWM oscillator frequency is set to 400 kHz, and the DCSL pin is pulled to ground. This allows 50% duty ratio limited PWM outputs with alternate PWM pulses coming out of OUTA or OUTB. Switching frequency of each switch is 200kHz. Center-tapped synchronous rectifier configuration on the secondary side steps down the voltage across the inductor and doubles the switching frequency (effective 400kHz switching across output inductor L1, output capacitors and input capacitors).

Because the push-pull 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 generated by the controller must be isolated to be used by the ISL71040M drivers on the secondary side. The ISLFBKISOEV1Z daughterboard provides these two functions. The ISLFBKISOEV1Z daughterboard 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 one ISL7119 comparator. This PWM signal is communicated through the digital isolator to the primary side of the daughterboard and then filtered to be used by the error amplifier of the ISL73846M controller for voltage regulation.

Because 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 purpose, an external OV protection circuit is implemented on the feedback isolator daughterboard, which pulls down FLTB of the controller and forces hiccup whenever output voltage increases above 13.2V.

For current mode control, the pulsed input current is sensed with a current sense transformer (placed at the primary side center-tap of T1). Slope compensation is provided with a resistor from AVCC of the ISL73846M device and a capacitor from the ISEN pin to the RAMP pin to match the downslope of the inductor current referred to the primary side.

## 1.1 Push-Pull Converter Design with ISL73846M Controller

Given the input and output voltage specification of the push-pull converter ($V_{IN}$ = 28V nominal, $V_{OUT}$ = 12V), a transformer ratio of 1:1 ($G_{main}$ = 1, parameter used later) is deemed ideal. The push-pull converter topology also requires a center-tapped primary winding. A center-tapped secondary winding is also used in this application as it leads to reduced output inductor size, compared to a current doubler secondary rectifier configuration without center-tapped secondary windings. For this purpose, a custom planar transformer (ZF2931-AL) with 75µH magnetizing inductance (measured between pins 2 and 5 with 4 and 3 shorted and all other windings open) was developed. The leakage inductance of the transformer is 150nH (max, measured between pins 2 and 5 with 3 and 4 shorted and all other windings shorted).

Typically, the primary-side switches in a push-pull converter are expected to twice block the input voltage of the converter. Because the input voltage can be as high as 36V for a nominal 28V rail, the switches are expected to block 72V ideally. However, the leakage inductance of the main transformer can cause the drain-to-source voltage of the primary GaN FETs to spike much higher than 72V. GaN FETs with 150V breakdown ratings are chosen for this purpose. RCD clamps are also implemented on each primary side GaN FET to limit inductive voltage spikes on the drain of the GaN FETs.

Synchronous rectification can significantly improve efficiency in isolated converter topologies, and the ISL73846M controller can generate outputs to control synchronous rectifiers. Because the main transformer winding ratio is 1:1, the synchronous rectifiers are expected to block 72V when the input voltage is 36V. The same EPC2033 GaN FETs are chosen for the synchronous rectifier switches. In isolated topologies with synchronous rectifiers, output inductor current can be negative (for example, at steady state no load or 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 deadtime 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 synchronous rectifiers. To mitigate this, another RCD clamp circuit is implemented at the LX node of the converter (see schematics), allowing negative inductor current to flow into the clamp capacitor and discharge into the output capacitors.

A switching frequency of 400kHz (effective across the output LC filter) is chosen to optimize the converter efficiency because higher switching frequencies lead to additional switching and core losses. To program this switching frequency R36 = 5.9kΩ was chosen. 200ns of blanking time is required to ensure that switching transients are ignored before the PWM comparator resets the output. A 3.3kΩ resistor from the RBLANK pin to ground programs a minimum on/off time to 300ns. Blanking time is approximately 60ns lower than minimum on/off time.

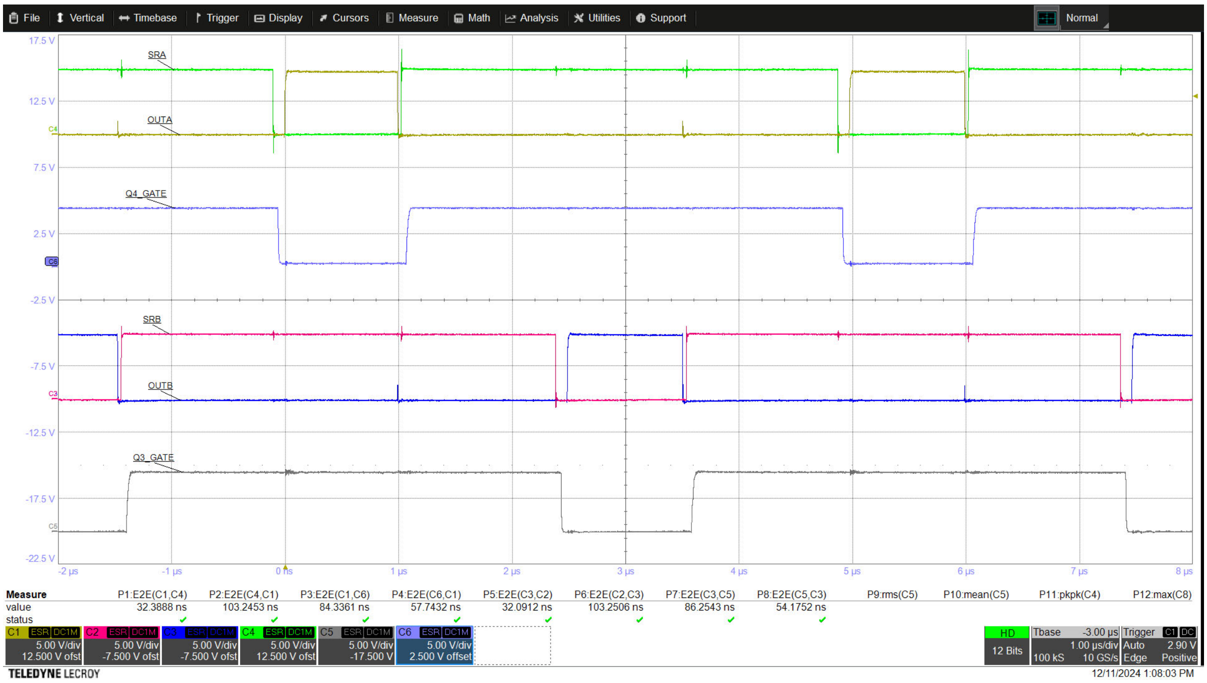


**Figure 2. PWM Outputs of ISL73846M and Synchronous Rectifier Gate Drive Signal, Measured Effective Deadtime**

OUTx falling to SRx rising deadtime is programmed to 30ns and SRx falling to OUTx rising deadtime is programmed to 100ns. The primary switches are directly driven by the ISL73846M controller, while the synchronous rectifiers are driven by the SRx outputs through digital isolators and additional low side drivers. Unequal deadtimes are programmed to compensate for the additional delay in the synchronous rectifier driving path. Figure 2 shows the controller outputs, the gate driver outputs, and the effective deadtimes. The deadtimes are programmed by selecting R39 (60.4kΩ) and R40 (10kΩ) from the DT_SP and DT_PS pins of the controller.

The output inductor L1 (3.3µH) is selected so that nominally (VIN = 28V) inductor current ripple is 40% of full load current (12A). The isolated feedback generator (ISLFBKISOEV1Z) circuit generates a 1.7MHz PWM output with 4V average when VOUT_ISO is 12V. To filter this PWM output from the isolated feedback circuit, two poles at 40kHz are placed in the compensation network. This is necessary to attenuate the ripple on the COMP output enough to ensure jitter on the OUTx outputs is below 50ns. To make the output stable, the converter bandwidth is set at 3.5kHz.

To ensure output voltage overshoot and undershoot during a 0A-12A load transient is below 360mV (3% of 12V) and set a 3.5kHz converter bandwidth, output capacitance of 1.4mF is required.

Current sensing on the primary side is done using a 1:100 ($G_{sns}$ = 0.01, parameter used later) transformer and a 2.8Ω terminating resistor (RSENSE, R18 in schematics). At 12A output current (full load), the sensed voltage at the terminating resistor would be 336mV. For a 3% overshoot/undershoot during a full load transient, the PWM output of the feedback isolator should show a 120mV overshoot/undershoot. To match the sensed current, the gain of the error amplifier must be set to be 2.8 or higher. The PWM filter on the isolated feedback generation board and error amplifier components (R41, C21, R42, C9) on the eval board are designed to set two poles at 40kHz, an integrator with a zero set at 500Hz and a gain of 2.8.

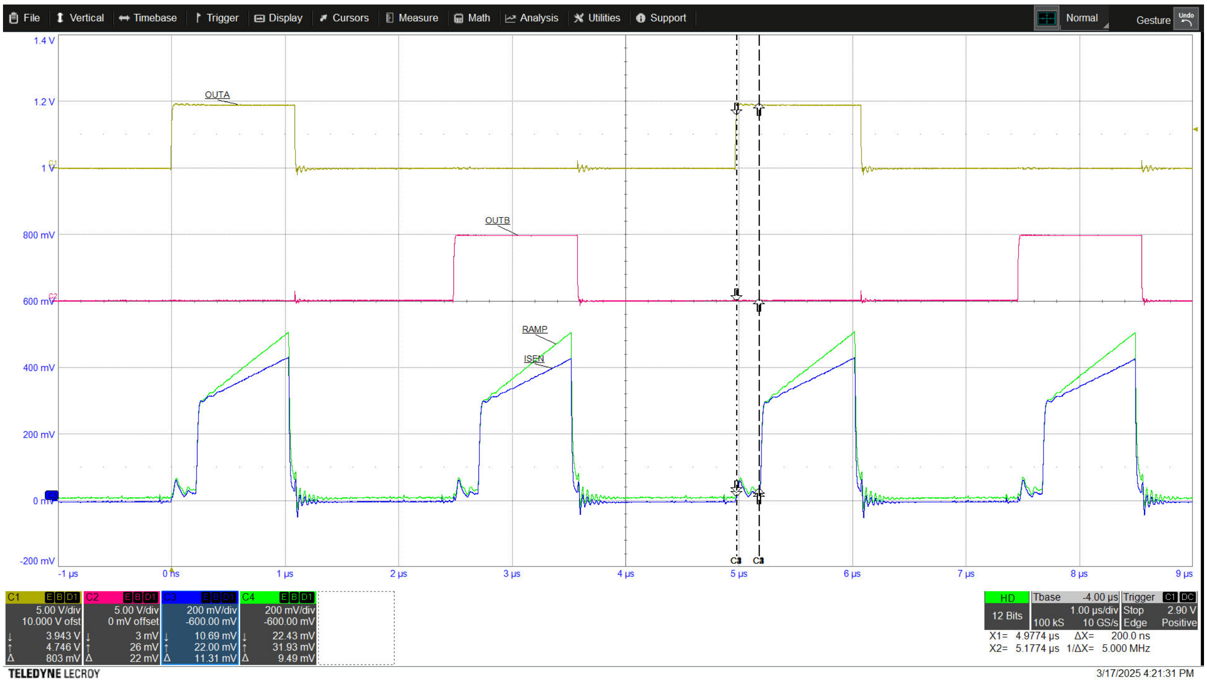


**Figure 3. PWM Outputs of ISL73846M, Current Sense and Slope Compensated Current Sense Inputs, Measured Effective Blanking Time = 200ns**

Because the duty ratio of the application is close to 50% (higher than 50% at the lowest input voltage which is 20V), slope compensation is required to mitigate sub-harmonic oscillations. A resistor from AVCC, R8 and a capacitor C21 are used to generate a slope compensated current sense signal. R8 and C21 are chosen such that the slope of the compensated current sense signal on the RAMP pin matches $\frac{V_{IN}}{L1} \times R_{SENSE} \times \frac{G_{sns}}{G_{main}}$. A current sense filter capacitor C5 was not necessary as the current sense input to the controller was verified to be free from high frequency noise. Figure 3 shows the PWM outputs and voltages at the ISEN and RAMP pins. The cursors show approximately a 200ns delay between the rising edge of OUTA and the rising edge of ISEN/RAMP voltage. It was verified that 200ns is enough blanking time for the current sense waveforms to be free of switching transients.

The EN pin of the controller is programmed by resistors R3 and R4 such that the converter turns on at VIN = 19V and turns off at VIN = 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). And the EN turn off threshold level (17V) is programmed by the R3/R4 ratio.

The UVLO pin of the controller can be directly connected to VDD if external VDD is used. If VDD is powered by the AUX winding of the transformer (offline startup) then UVLO must be programmed by a resistor divider from VDD (R10 and R11). If UVLO pin voltage is below the threshold (1.23V), the controller is in a low power state, drawing less than 100µA of current. A startup resistor R44 is used to slowly charge up the VDD rail from VIN. When VDD reaches 10V, 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 8V after switching starts, UVLO pin voltage falls below threshold, and the converter shuts down and enters a low power state. 44µF of capacitance on the VDD rail is required to ensure that VDD does not fall below the 8V UVLO falling threshold. The UVLO pin sources 5µA of current when

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.

## 1.2 Feedback Isolation

To maintain galvanic isolation between the primary and secondary sides of the converter, output voltage feedback and the synchronous rectifier control signals must be isolated. This is achieved with the ISLFBKISOEV1Z daughterboard. The daughterboard converts the output voltage of the converter, VOUT_ISO, to a pulse width modulated signal by using a hysteretic comparator (U5 on ISLFBKISOEV1Z schematics) on the secondary side. This signal is then passed through the isolation barrier with the help of an ISL71710 (GMR based) digital isolator. The average value of the PWM signal, VOUT_PWM, is 4V when output voltage is 12V and 500mV when the output voltage is 0V. The PWM output is then filtered with an RC filter (R14, C43 on ISLFBKISOEV1Z schematics). Figure 4 and Figure 5 show the PWM output of the digital isolator and the filtered version of the signal on the controller side, VOUT, and the behavior of the filtered feedback signal at startup.

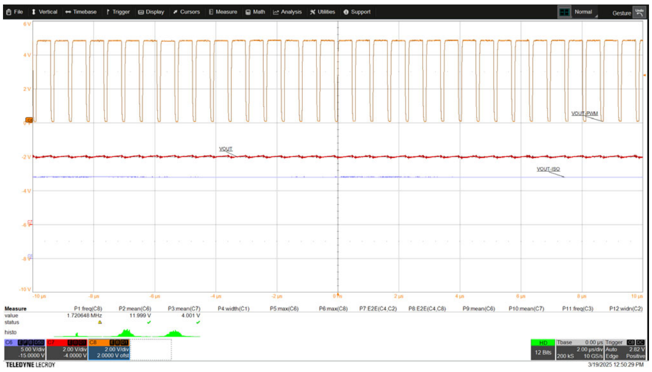


**Figure 4. PWM and filtered version of isolated feedback (VOUT_ISO = 12V)**

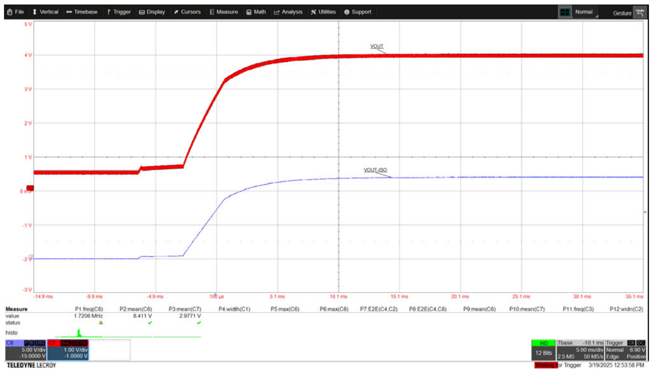


**Figure 5. Startup Response of Feedback Isolator Output (VOUT_ISO is Ramped Up to 12V)**

The synchronous rectifier driving PWM signals are similarly passed to the secondary side from the primary through two ISL71710M digital isolators. Additionally, a comparator is placed on the daughter card that pulls down FLTB when the output of the isolated feedback generator exceeds 4.5V (fast overvoltage protection) and puts the controller into hiccup mode. To power the circuits on the ISLFBKISOEV1Z, a housekeeping flyback is implemented using an ISL71041 controller. This generates ±9V output rails on the secondary side of the isolator and an 8V rail on the primary side (used for closed loop regulation of the flyback converter). Two ISL71090 5V reference ICs were used on the primary and secondary sides of the board to generate accurate 5V supplies required.

## 1.3 Operational Characteristics

The ISL73846MEV1Z push-pull converter is designed to operate from a 28V nominal input (VIN). The controller can be supplied from the VDD_EXT plug. VDD_EXT can range from 5V to 19V, which is the maximum operating voltage of the ISL73846M controller. Alternatively, the controller can also get its supply from the aux-winding of the main transformer. In this case stand-by current (to charge up VDD rail before the controller starts switching) is provided by a resistor (R44) from VIN. The following are the Jumper configurations for these two power-up methods:

- VDD_SEL jumper shorted between position 1 and 2, UVLO_SEL jumper shorted: controller powers up from VDD_EXT plug.
- VDD_SEL jumper shorted between position 2 and 3, UVLO_SEL jumper open: aux winding of main transformer supplies operating current of controller.

When powered up, the converter regulates VOUT_ISO to 12V. An electronic load can be used to test loaded operation and transient response of the converter. The maximum continuous load that the converter can support throughout its VIN range (20V – 36V) is 12A. A resistor divider from VIN is tied to the EN pin of the controller, which programs the controller to turn on when VIN is above 19V. When enabled, the controller turns off when VIN falls below 17V. Operating the converter at VIN less than 20V is not recommended as it might not be able to startup at full load without going into overcurrent protection mode.

The ISL73846MEV1Z board offers two overcurrent protection modes that are programmable by the CONFIG jumper:

- CONFIG jumper shorted – The CONFIG pin is connected to AVCC. The controller immediately goes into hiccup if OCP (sensed current is above 22A) is detected in 4 out of previous 8 switching periods of either OUTA or OUTB.
- CONFIG jumper open – The CONFIG pin is connected to ground with a 113kΩ resistor. In this mode, the controller limits the inductor current in a pulse-by-pulse manner when load is increased above 22A. As a result, the output voltage falls. When the EA_IN pin voltage falls below the undervoltage detection threshold, the controller goes into hiccup mode. Because the error amplifier of the ISL73846M is an operational amplifier (Op amp), EA_IN does not necessarily follow VOUT, if the output of the Op amp is not saturated.

The programmed OCP mode is only detected when the controller powers up. To change the OCP mode of the controller, power cycling VDD of the controller is necessary after changing the CONFIG pin connection.

## 1.4 Setup and Configuration

Complete the following steps to power up the ISL73846MEV1Z evaluation board.

1. Ensure VDD and VIN are supplied to the board, VDD_SEL and UVLO_SEL jumpers are connected as discussed in the previous subsection.
2. Ensure CONFIG jumper is connected or open depending on required OCP mode.
3. Connect an electronic load or a multimeter to VOUT of the board (to monitor output voltage).
4. Ensure that the ISLFBKISOEV1Z daughter card is connected properly. (If not connected, the controller always detects output voltage as zero, output voltage keeps building up over multiple hiccup cycles if no load is applied. This might cause serious damage to the output capacitors and the eval board).
5. Set the electronic load to a value between 0A and 12A. Set the current limit of VIN supply to 9A or higher.
6. Turn on VIN and VDD supplies and monitor any probe points on oscilloscope as required. Output voltage observed should be within 2% of 12V. VDD_EXT supply current should be less than 10mA at steady state.

# 2. Board Design

## 2.1 ISL73846MEV1Z Board

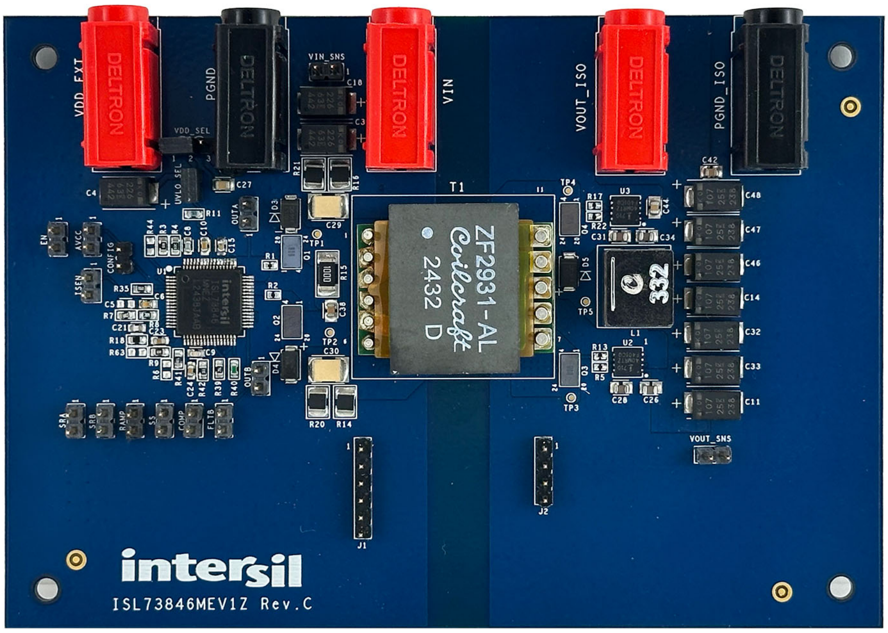


**Figure 6. ISL73846MEV1Z Evaluation Board (Top)**

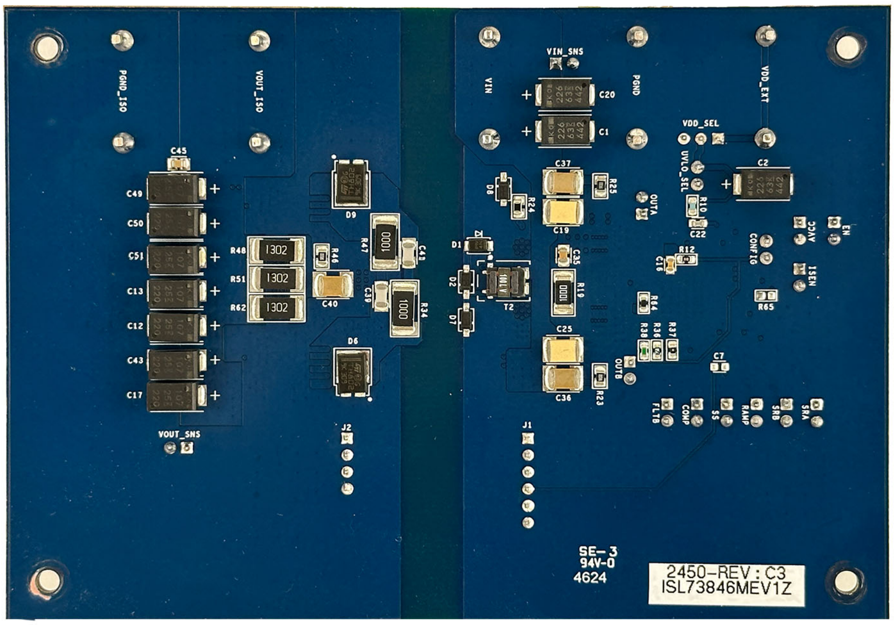


**Figure 7. ISL73846MEV1Z Evaluation Board (Bottom)**

### 2.1.1 Layout Guidelines

The push-pull converter topology uses two low-side switches on the primary side that can be driven directly with the low-side gate drivers in the ISL73846M controller. The PGND pin of the controller serves as the gate drive current return path. The PVDD pin of the controller is the supply of the gate drivers. Place low parasitic ceramic capacitors close to the PVDD pin to ensure proper decoupling of the gate drive currents. This evaluation board also supplies PVDD from AVCC of the chip because the average gate driver current required to drive EPC2033 GaNFETs at 200 kHz is lower than 5mA. A 10Ω resistor is also placed between AVCC and PVDD to ensure proper decoupling between AVCC and PVDD. Keep the physical area of the loop formed by the OUTx pins, the gate resistor the gate of the GaNFETs and PGND (gate drive path including return) as small as possible to minimize voltage overshoot on the gates of the GaNFETs.

The ISL78346M controller has a separate analog ground (AGND) pin which connects to sensitive nodes inside the chip. Renesas recommends connecting the analog ground to components that do not have switching current or higher than several tens of milliamperes of current going through them (for example, deadtime control, frequency control, blanking time control resistors). The AGND pin must be connected to the PGND pin (preferably with a 0Ω resistor to avoid ground loops) at a point on the board where high switching currents are not expected.

Do not route the current-sense resistor connection away from switching nodes. The loop formed by the current sense transformer outputs and the current sense resistor should be small in area so that it is not sensitive to di/dt coupling (routed differentially on this eval board). Place the output voltage feedback resistors close to the EA_IN pin of the controller as it is a sensitive node. Route the COMP and EA_IN traces (should the user want to put probe points to monitor those voltages) away from all switching traces.

Place the ceramic decoupling capacitors as close to the VDD, PVDD, and AVCC pins as possible. A 6-layer or higher layer count PCB is recommended for most applications. Renesas recommends connecting the closest inner layers to the top and bottom to PGND and not use them for routing any other signals. These ground layers should be uninterrupted (vias should not cause long continuous breaks on these ground planes). Additionally, Renesas recommends making the spacing between the top layer and layer 2 and the spacing between bottom layer and the closest inner layer 5mil to minimize parasitic loop inductances.

### 2.1.2 Schematic Diagrams

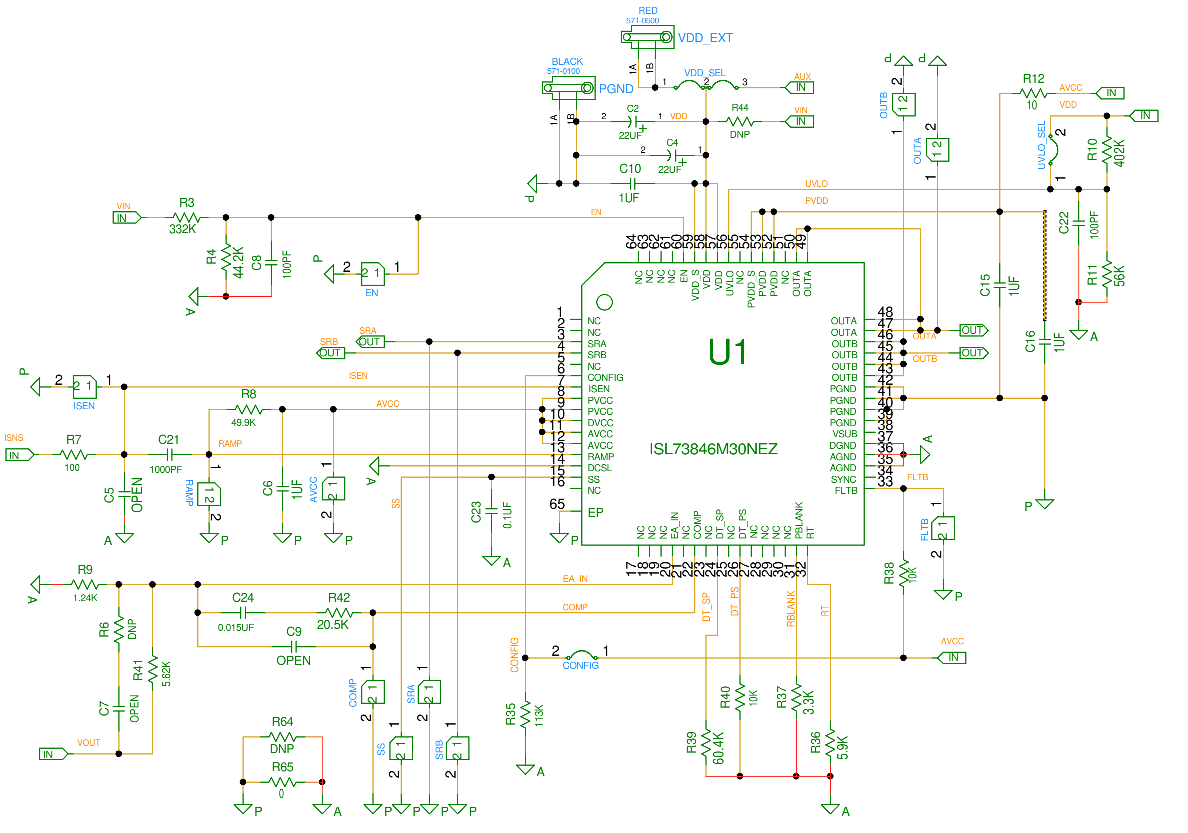


Figure 8. ISL73846MEV1Z Schematic Page 1

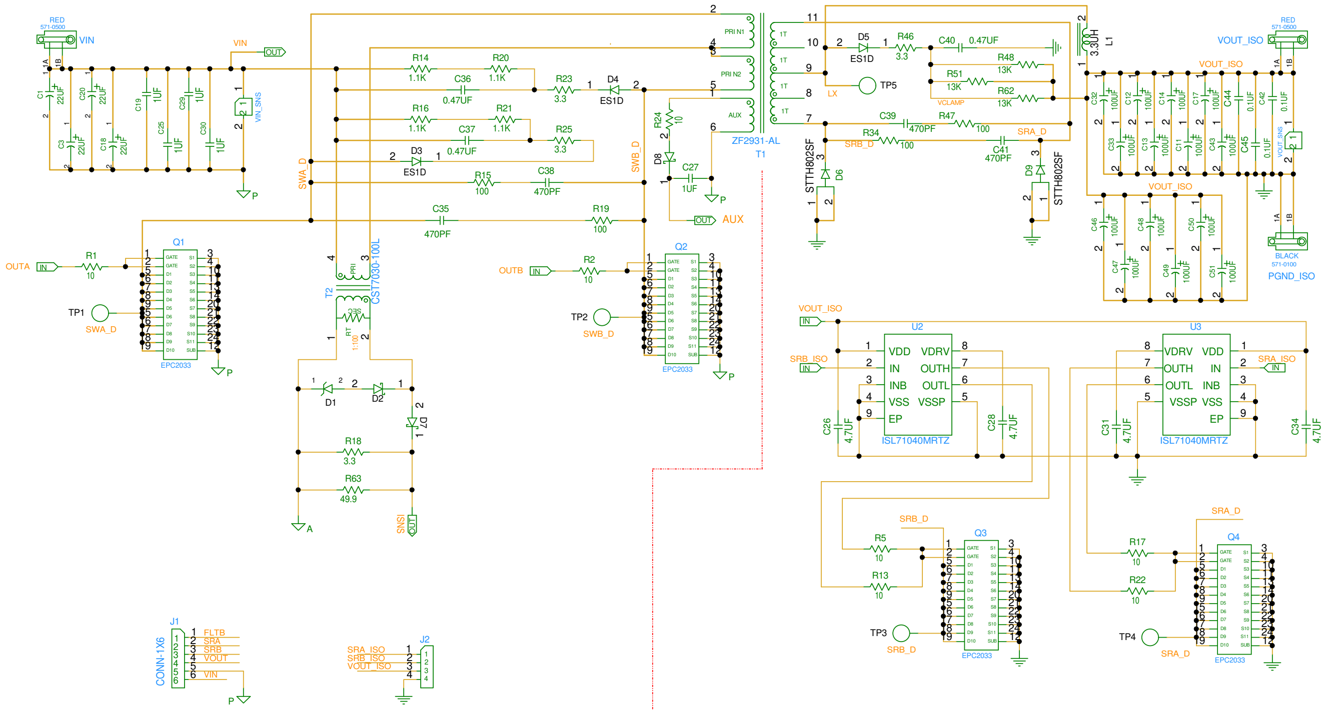


**Figure 9. ISL73846MEV1Z Schematic Page 2**

## 2.1.3 Bill of Materials

| Qty | Reference Designator | Description | Manufacturer | Manufacturer Part Number |
|---|---|---|---|---|
| 1 | C24 | CAP, SMD, 0603, 0.015µF, 25V, 10%, X7R, ROHS | KYOCERA | KGM15AR71E153KT-T |
| 1 | C23 | CAP, SMD, 0603, 0.33µF, 16V, 10%, X7R, ROHS | YAGEO | CC0603KRX7R7BB334-T |
| 1 | C21 | CAP, SMD, 0603, 1000pF, 25V, 10%, C0G/NP0, ROHS | KYOCERA | KGM15ACG1E102KT-T |
| 2 | C8, C22 | CAP, SMD, 0603, 100pF, 100V, 10%, C0G/NP0, ROHS | TDK | C1608C0G2A101K080AA-T |
| 3 | C42, C44, C45 | CAP, SMD, 0805, 0.1µF, 25V, 10%, X7R, ROHS | KYOCERA | KGM21NR71E104KT-T |
| 1 | C27 | CAP, SMD, 0805, 1µF, 50V, 10%, X7R, ROHS | YAGEO | CC0805KKX7R9BB105-T |
| 2 | C35, C38 | CAP, SMD, 0805, 470pF, 200V, 10%, X7R, ROHS | KEMET | C0805C471K2RAC7800-T |
| 3 | C36, C37, C40 | CAP, SMD, 1812, 0.47µF, 200V, 10%, X7R, ROHS | KEMET | C1812C474K2RAC7800-T |
| 4 | C19, C25, C29, C30 | CAP, SMD, 1812, 1µF, 100V, 10%, X7R, ROHS | Vishay | VJ1812Y105KBBAT4X-T |
| 4 | C6, C10, C15, C16 | CAP, SMD, 0603, 1µF, 25V, 10%, X7R, ROHS | MURATA | GCM188R71E105KA64D-T |
| 4 | C26, C28, C31, C34 | CAP, SMD, 0805, 4.7µF, 25V, 10%, X7R, ROHS | KEMET | C0805C475K3RACAUTO-T |
| 2 | C39, C41 | CAP, SMD, 1206, 470pF, 200V, 10%, C0G/NP0, ROHS | KYOCERA | KAM31BCG2D471KT-T |
| 14 | C11-C14, C17, C32, C33, C43, C46-C51 | CAP-TANT, SMD, 7.3×4.3mm, 100µF, 25V, 20%, ROHS | KEMET | T521X107M025ATE030-T |
| 6 | C1-C4, C18, C20 | CAP-TANT, SMD, 7.3×4.3mm, 22µF, 63V, 20%, ROHS | KEMET | T521X226M063ATE075-T |
| 1 | L1 | COIL-PWR IND, SMD, 3.3µH, 20%, 27.4A, ROHS | COILCRAFT | XAL1010-332MED-T |
| 3 | D3-D5 | DIODE-RECTIFIER, SMD, 2P, SMA, 200V, 1A, ROHS | DIODES Inc. | ES1D-13-F-T |
| 2 | D6, D9 | DIODE-RECTIFIER, SMD, TO-277A, 200V, 8A, ROHS | STM | STTH802SF-T |
| 3 | D2, D7, D8 | DIODE-SCHOTTKY, SMD, SOD-123, 100V, 0.15A, ROHS | Vishay | BAT46W-E3-08-T |

| Qty | Reference Designator | Description | Manufacturer | Manufacturer Part Number |
|---|---|---|---|---|
| 1 | D1 | DIODE-ZENER, 5.1V, 800mW, SMD, DO-219AB, ROHS | Vishay | BZD27B5V1P-M3-08-T |
| 1 | C9 | CAP, SMD, 0603, 200pF, 50V, 10%, NP0, ROHS | Vishay | VJ0603D201KXAAJ-T |
| 2 | U2, U3 | IC- GaNFET DRIVER, 8PTDFN, 4×4, ROHS | RENESAS | ISL71040MRTZ |
| 4 | Q1-Q4 | IC-GaNFET, SMD, DIE, N-CHAN, 150V, 48A, ROHS | EPC | EPC2033-T |
| 1 | U1 | IC-RH, DUAL OUTPUT PWM CONTROLLER, 30K, 19V, 1.5A, ROHS | RENESAS | ISL73846M30NEZ |
| 1 | R7 | RES, SMD, 0603, 100Ω, 1/10W, 1%, TKF, ROHS | YAGEO | RC0603FR-07100RL-T |
| 1 | R35 | RES, SMD, 0603, 113K, 1/10W, 0.1%, TNF, ROHS | YAGEO | RT0603BRD07113KL-T |
| 1 | R8 | RES, SMD, 0603, 49.9K, 1/10W, 1%, TKF, ROHS | YAGEO | RC0603FR-0749K9L-T |
| 1 | R36 | RES, SMD, 0603, 5.9K, 1/10, 1%, TKF, ROHS | YAGEO | RC0603FR-075K9L-T |
| 2 | R34, R47 | RES, SMD, 2512, 100Ω, 2W, 1%, TF, ROHS | TE Conn. | CRGP2512F100R-T |
| 6 | R1, R2, R5, R13, R17, R22 | RES, SMD, 0402, 2Ω, 1/10W, 1%, TF, ROHS | YAGEO | RC0402FR-072RL-T |
| 1 | R64 | RES, SMD, 0603, 0Ω, TKF, ROHS | Vishay | RCS06030000Z0EC-T |
| 1 | R9 | RES, SMD, 0603, 1.24K, 1/10W, 1%, TF, ROHS | Stackpole | RMCF0603FT1K24-T |
| 2 | R38, R40 | RES, SMD, 0603, 10K, 1/10W, 0.1%, TNF, ROHS | Vishay | TNPW060310K0BEEA-T |
| 1 | R12 | RES, SMD, 0603, 10Ω, 1/10W, 1%, TKF, ROHS | Stackpole | RMCF0603FT10R0-T |
| 1 | R42 | RES, SMD, 0603, 20.5K, 1/10W, 1%, TF, ROHS | Stackpole | RMCF0603FT20K5-T |
| 1 | R37 | RES, SMD, 0603, 3.3K, 1/10W, 1%, TKF, ROHS | Rohm Semi. | KTR03EZPF3301-T |
| 1 | R18 | RES, SMD, 0603, 2.8Ω, 1/10W, 1%, TKF, ROHS | Vishay | CRCW06032R80FKEA-T |
| 1 | R3 | RES, SMD, 0603, 332K, 1/10W, 1%, TKF, ROHS | Stackpole | RMCF0603FT332K-T |
| 1 | R10 | RES, SMD, 0603, 402K, 1/10W, 1%, TKF, ROHS | KOA Speer | RK73H1JTTD4023F-T |
| 1 | R4 | RES, SMD, 0603, 44.2K, 1/10W, 1%, TKF, ROHS | Stackpole | RMCF0603FT44K2-T |
| 1 | R41 | RES, SMD, 0603, 5.62K, 1/10W, 1%, TKF, ROHS | Stackpole | RMCF0603FT5K62-T |
| 1 | R39 | RES, SMD, 0603, 60.4K, 1/10W, 1%, TKF, ROHS | Stackpole | RMCF0603FT60K4-T |
| 1 | R24 | RES, SMD, 0805, 10Ω, 1/2W, 1%, TKF, ROHS | Panasonic | ERJ-P6WF10R0V-T |
| 3 | R23, R25, R46 | RES, SMD, 0805, 1Ω, 1/8W, 1%, TKF, ROHS | Stackpole | RMCF0805FT1R00-T |
| 4 | R14, R16, R20, R21 | RES, SMD, 1210, 1.1k, 1/2W, 1%, TKF, ROHS | Vishay | CRCW12101K10FKEA-T |
| 2 | R15, R19 | RES, SMD, 2010, 100Ω, 1W, 1%, TKF, ROHS | Stackpole | RMCP2010FT100R-T |
| 3 | R48, R51, R62 | RES, SMD, 2512, 13K, 3W, 1%, TKF, ROHS | TE Conn. | 352213KFT-T |
| 1 | R11 | RES, SMD, 56K, 1/10W, 1%, TKF, ROHS | KOA Speer | RK73H1JTTD5602F-T |
| 1 | T2 | TRANSFORMER-CURRSENS, 1:100 TURNS, 20A, ROHS | Coilcraft | CST7030-100LC |
| 1 | T1 | TRANSFORMER, CUSTOM, ROHS, 2:2:4CT, 150µH, ROHS | Coilcraft | ZF2931-AL |
| 1 | R44 | DO NOT POPULATE | - | - |
| 3 | R6, R63, R65 | DO NOT POPULATE | - | - |
| 2 | C5, C7 | DO NOT POPULATE | - | - |
| 2 | CONFIG, UVLO_SEL | CONN-HEADER, 1×2, RETENTIVE, 2.54mm, ROHS | Amphenol | 69190-202HLF |
| 1 | VDD_SEL | CONN-HEADER, 1×3, BRKAWY 1×36, 2.54mm, ROHS | Amphenol | 68000-236-1X3 |
| 1 | J2 | CONN-HEADER, 1×4, BRKAWY 1×36, 2.54mm, ROHS | Amphenol | 68000-236-1X4 |
| 1 | J1 | CONN-HEADER, 1×6, BRKAWY 1×36, 2.54mm, ROHS | Amphenol | 68000-236-1X6 |

| Qty | Reference Designator | Description | Manufacturer | Manufacturer Part Number |
|---|---|---|---|---|
| 13 | AVCC, COMP, EN, FLTB, ISEN, OUTA, OUTB, RAMP, SRA, SRB, SS, VIN_SNS, VOUT_SNS | CONN-HEADER, 1×2, 2.54mm PITCH, 5.5×3.3mm, ROHS | 3M | 961102-6404-AR |
| 2 | PGND, PGND_ISO | CONN-PLUG, TH, 4mm INSUL.SOCKET, BLK, R/A, ROHS | Deltron | 571-0100 |
| 3 | VDD_EXT, VIN, VOUT_ISO | CONN-PLUG, TH, 4mm INSUL.SOCKET, RED, R/A, ROHS | Deltron | 571-0500 |

### 2.1.4 Board Layout

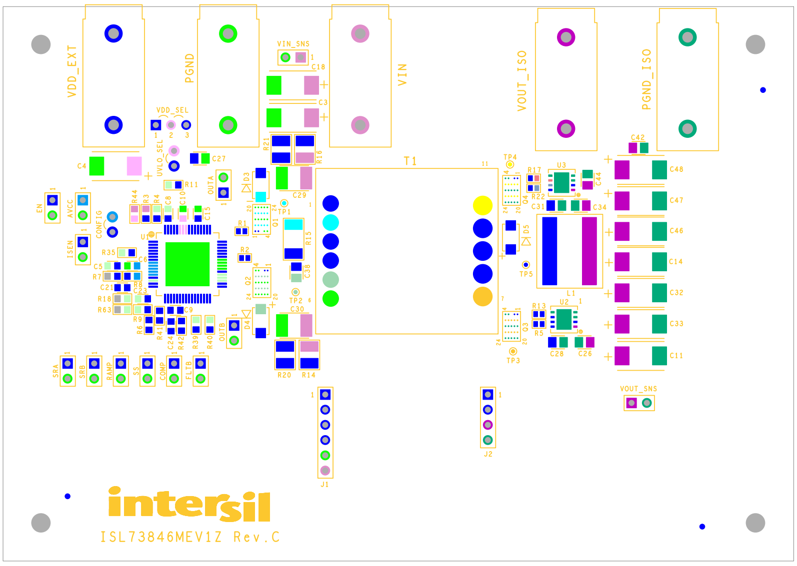


**Figure 10. Silkscreen Top**

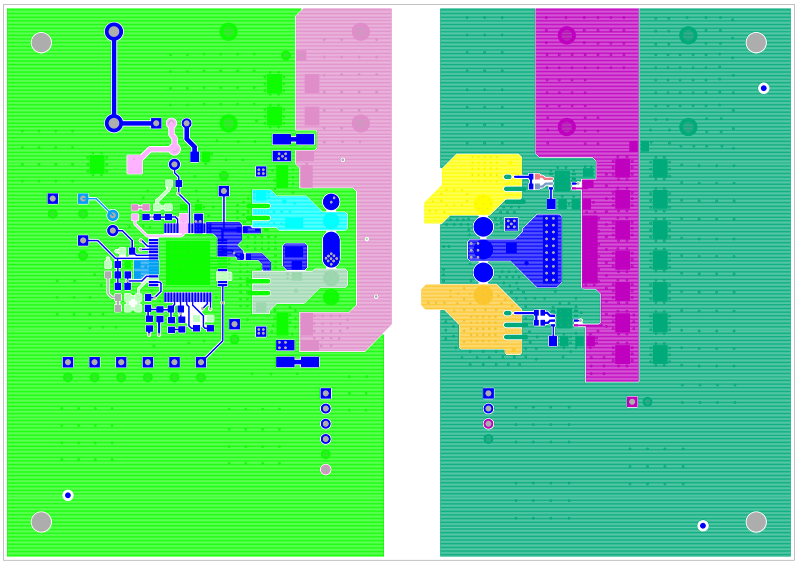

**Figure 11. Top Layer**

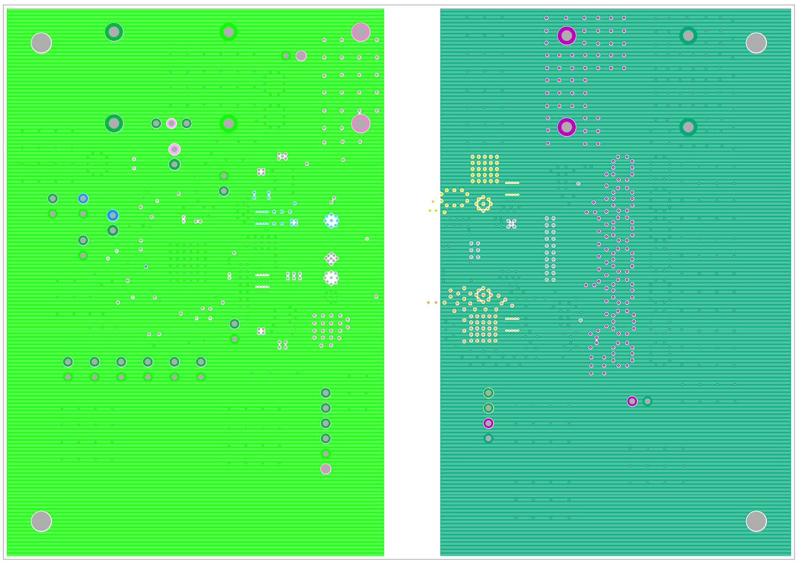

Figure 12. Layer 2

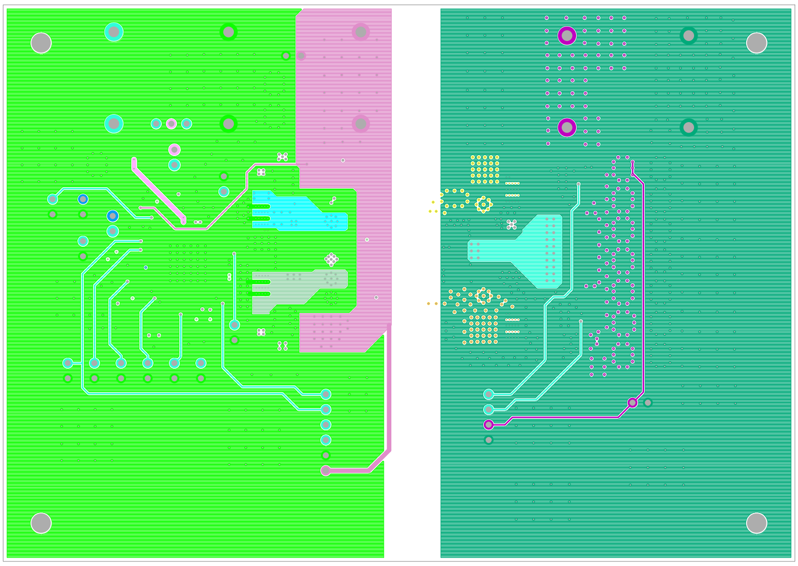

Figure 13. Layer 3

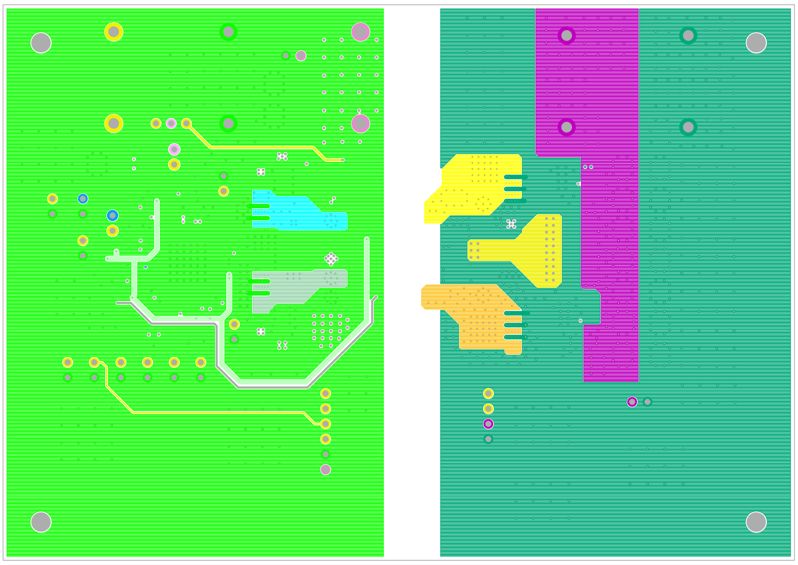

Figure 14. Layer 4

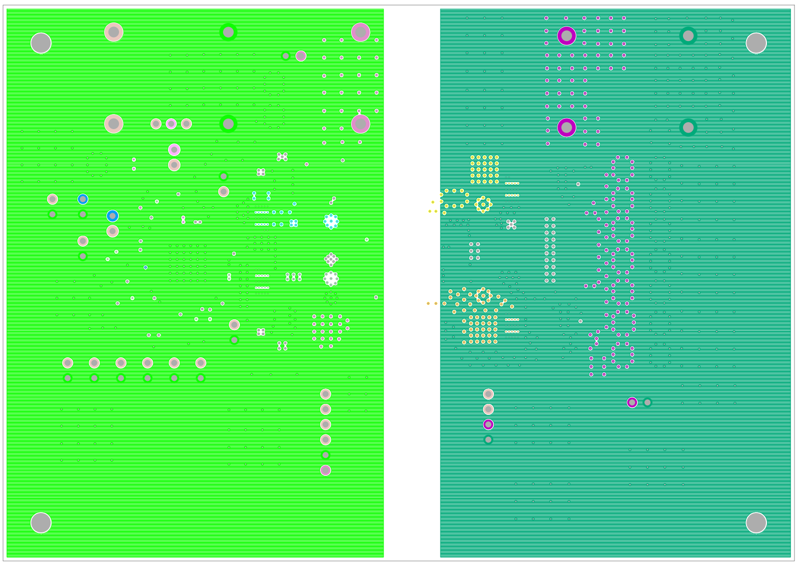

Figure 15. Layer 5

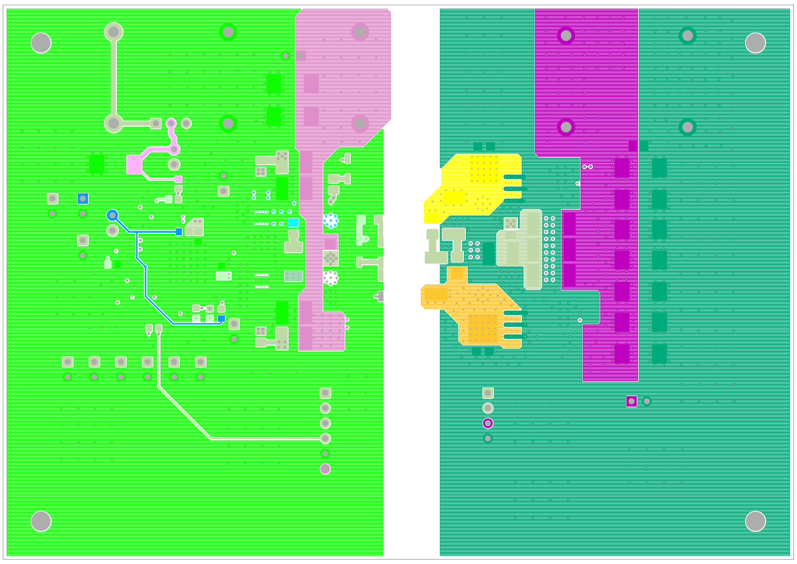

Figure 16. Bottom Layer

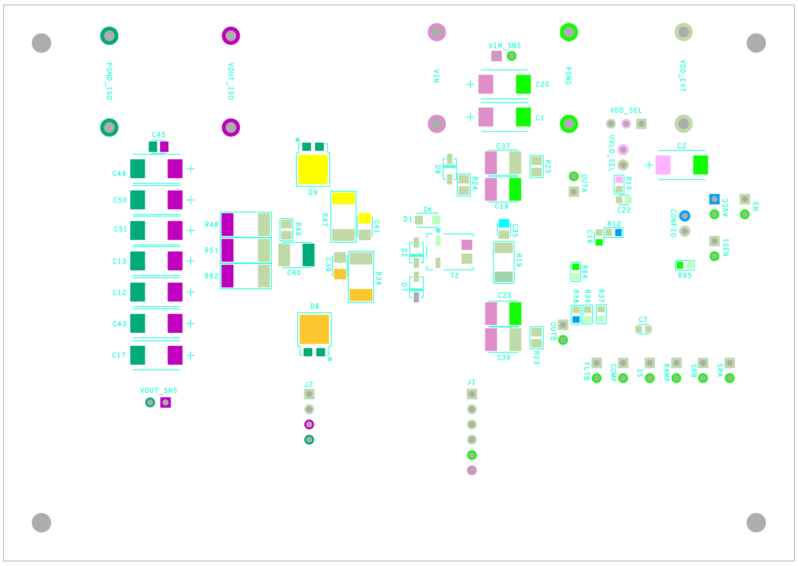

Figure 17. Silkscreen Bottom

## 2.2 ISLFBKISOEV1Z Daughterboard

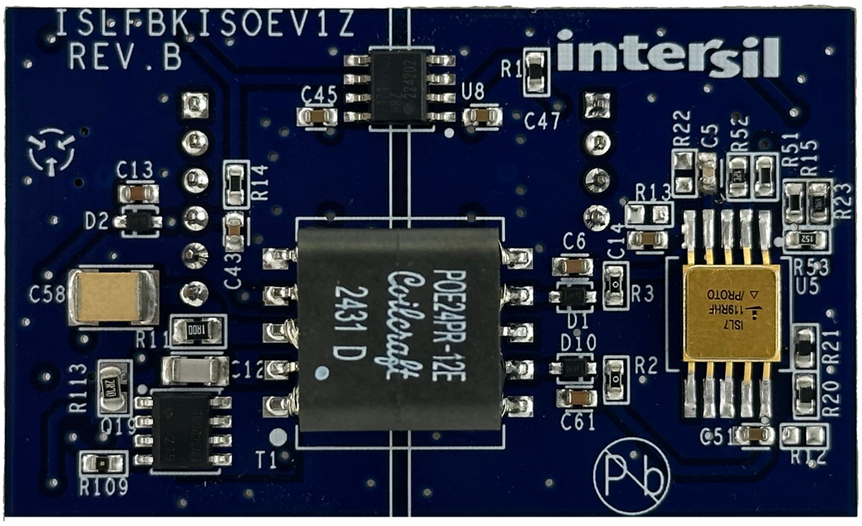


Figure 18. ISLFBKISOEV1Z (Top)

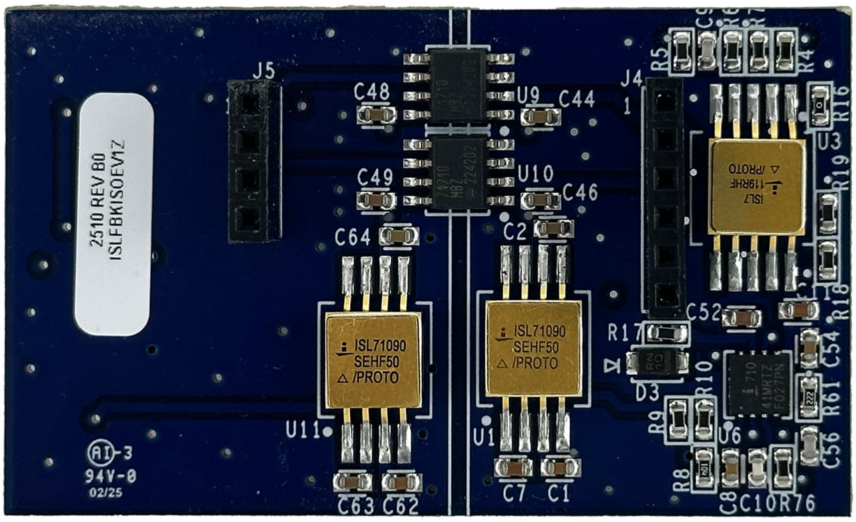


Figure 19. ISLFBKISOEV1Z (Bottom)

### 2.2.1 Schematic Diagrams

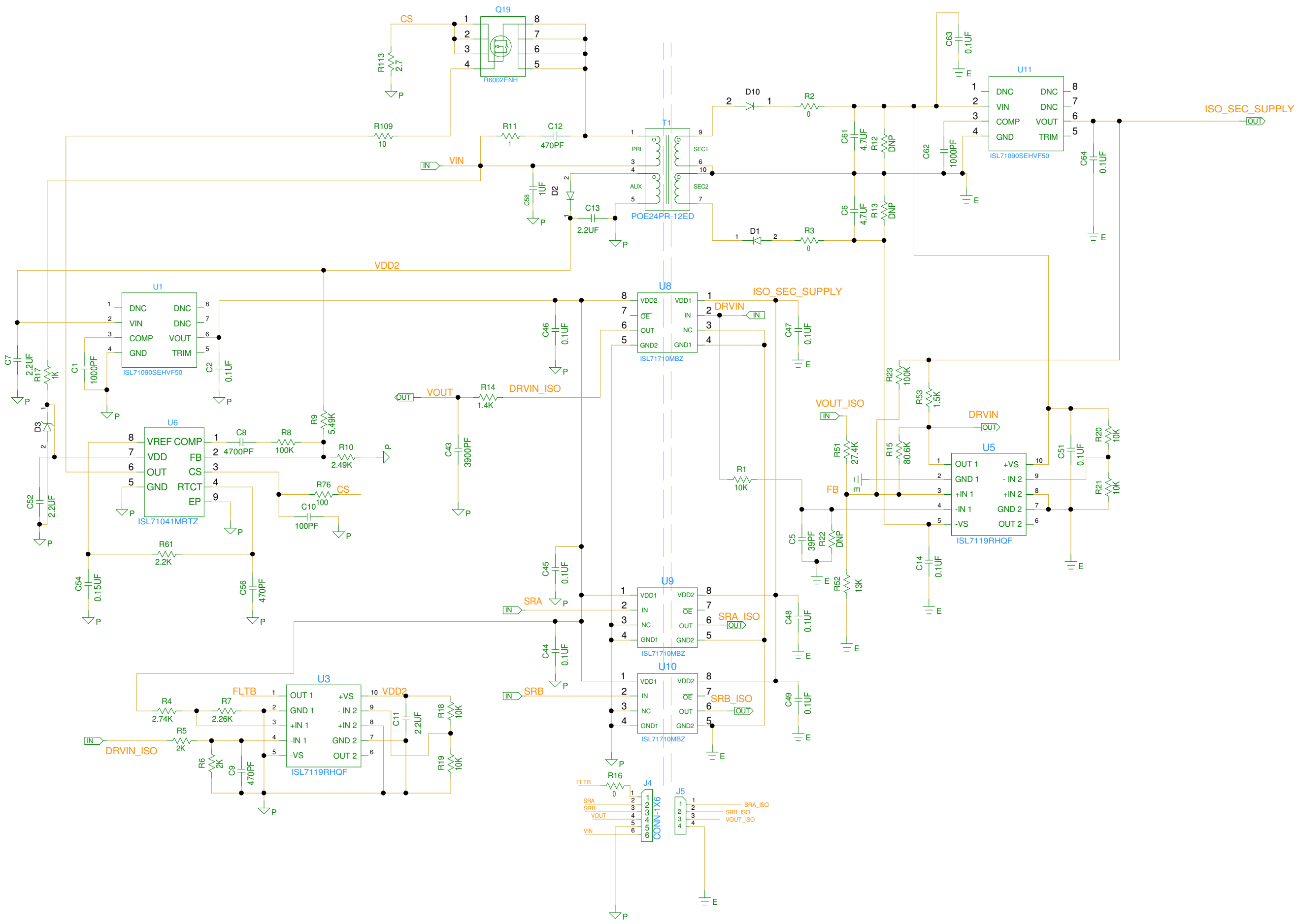


**Figure 20. ISLFBKISOEV1Z Schematic**

### 2.2.2 Bill of Materials

| Qty | Ref Des | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 1 | PCB | PWB-PCB, ISLFBKISOEV1Z, REVB, ROHS | Imagineering | ISLFBKISOEV1ZREVBPCB |
| 2 | C1, C62 | CAP, SMD, 0402, 1000pF, 25V, 10%, X7R, ROHS | Kyocera | KGM05AR71H102JH-T |
| 1 | C10 | CAP, SMD, 0603, 100pF, 100V, 1%, C0G/NP0, ROHS | Kemet | C0603C101F1GACTU-T |
| 1 | C12 | CAP, SMD, 1206, 470pF, 100V, 10%, COG, ROHS | YAGEO | CC1206KRNPO0BN471-T |
| 11 | C2, C63, C64, C14, C44, C45, C46, C47, C48, C49, C51 | CAP-AEC-Q200, SMD, 0603, 0.1µF, 50V, 10%, X7R, ROHS | Murata | GCJ188R71H104KA12D-T |
| 1 | C43 | CAP, SMD, 0603, 3900pF, 50V, 10%, X7R, ROHS | KEMET | C0603C392K5RACTU-T |
| 1 | C5 | CAP, SMD, 0603, 39pF, 50V, 10%, C0G/NP0, X7R, ROHS | Kemet | C0603C390K5GACTU-T |
| 1 | C54 | CAP-AEC-Q200, SMD, 0603, 0.15µF, 25V, 10%, X7R, ROHS | TDK | CGA3E2X7R1E154K080AA -T |
| 1 | C58 | CAP, SMD, 1812, 1µF, 100V, 10%, X7R, ROHS | Vishay | VJ1812Y105KBBAT4X-T |
| 2 | C6, C61 | CAP, SMD, 0603, 4.7µF, 35V, 10%, X5R, ROHS | Murata | GRM188R6YA475KE15D-T |
| 4 | C7, C11, C13, C52 | CAP, SMD, 0603, 2.2µF, 25V, 10%, X7S, ROHS | Murata | GRM188C71E225KE11D-T |

| Qty | Ref Des | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 1 | C8 | CAP, SMD, 0603, 4700pF, 25V, 10%, X7R, ROHS | Kemet | C0603C472K3RAC7867-T |
| 2 | C9, C56 | CAP, SMD, 0603, 470pF, 50V, 5%, C0G/NP0, ROHS | Murata | GRM1885C1H471JA01D-T |
| 3 | D1, D2, D10 | DIODE-RECTIFIER, SMD, SOD-323, 2P, 100V, 250mA, ROHS | Diodes | 1N4148WSF-7-T |
| 1 | D3 | DIODE-ZENER, SMD, DO-219AB, 10V, 800mW, ROHS | Vishay | BZD27B10P-M3-08-T |
| 1 | J4 | CONN-RECEPTACLE, FEMALE, TH, 1X6, 2.54mmPITCH, ROHS | Sullins | PPTC061LFBN-RC |
| 1 | J5 | CONN-SOCKET, TH, 1X4, INSULATED, 2.54mm, ROHS | Sullins | PPTC041LFBN-RC |
| 1 | Q19 | TRANSISTOR, SMD, 8SOP, MOSFET, N-CHANNEL, 600V, 1.7A, 2W, ROHS | Rohm | R6002ENHTB1-T |
| 1 | R1 | RES-AEC-Q200, SMD, 0603, 10K, 1/10W, 1%, TKF, ROHS | Vishay | CRCW060310K0FKEB-T |
| 1 | R10 | RES-AEC-Q200, SMD, 0603, 2.49K, 1/10W, 1%, TF, ROHS | Panasonic | ERJ-3EKF2491V-T |
| 1 | R109 | RES-AEC-Q200, SMD, 0603, 10ohm, 1/10W, 1%, TKF, ROHS | Rohm | KTR03EZPF10R0-T |
| 1 | R11 | RES, SMD, 0805, 1ohm, 1/8W, 1%, TF, ROHS | Panasonic | RC0805FR-071RL-T |
| 1 | R113 | RES-AEC-Q200, SMD, 0805, 2.7ohm, 1/8W, 1%, TF, ROHS | Panasonic | RMCF0805FT2R70-T |
| 3 | R12, R13, R22 | DO NOT POPULATE OR PURCHASE | Various | Generic |
| 1 | R14 | RES-AEC-Q200, SMD, 0603, 1.4K, 1/10W, 1%, ROHS | Panasonic | ERJ-3EKF1401V-T |
| 1 | R15 | RES-AEC-Q200, SMD, 0603, 80.6K, 1/10W, 1%, TF, ROHS | Panasonic | ERJ-3EKF8062V-T |
| 1 | R2, R3, R16 | RES-AEC-Q200, SMD, 0603, 0ohm, 1/10W, TKF, ROHS | Panasonic | ERJ-3GEY0R00V-T |
| 1 | R17 | RES-AEC-Q200, SMD, 0603, 1K, 1/10W, 1%, TF, ROHS | Panasonic | ERJ-3EKF1001V-T |
| 4 | R18, R19, R20, R21 | RES-AEC-Q200, SMD, 0603, 10K, 1/10W, 1%, TKF, ROHS | Panasonic | ERJ-3EKF1002V-T |
| 1 | R23 | RES-AEC-Q200, SMD, 0603, 100K, 1/10W, 1%, TKF, ROHS | Stackpole | RMCF0603FT100K-T |
| 1 | R4 | RES-AEC-Q200, SMD, 0603, 2.747K, 1/10W, 0.1%, TNF, ROHS | Panasonic | ERA-3AEB2741V-T |
| 2 | R5, R6 | RES-AEC-Q200, SMD, 0603, 2K, 1/10W, 1%, ROHS | Panasonic | ERJ-3EKF2001V-T |
| 1 | R51 | RES-AEC-Q200, SMD, 0603, 27.4K, 1/10W, 1%, TF, ROHS | Panasonic | ERJ-3EKF2742V-T |
| 1 | R52 | RES-AEC-Q200, SMD, 0603, 13K, 1/10W, 1%, ROHS | Panasonic | RMCF0603FT13K0-T |
| 1 | R53 | RES-AEC-Q200, SMD, 0603, 1.5K, 1/10W, 0.1%, ROHS | Panasonic | ERA-3AEB152V-T |
| 1 | R61 | RES-AEC-Q200, SMD, 0603, 2.2K, 1/10W, 0.1%, ROHS | Panasonic | ERA-3AEB222V-T |
| 1 | R7 | RES-AEC-Q200, SMD, 0603, 2.26K, 1/10W, 1%, ROHS | Panasonic | ERJ-3EKF2261V-T |
| 1 | R76 | RES-AEC-Q200, SMD, 0603, 100ohm, 1/10W, 1%, TF, ROHS | Panasonic | ERJ-3EKF1000V-T |

| Qty | Ref Des | Description | Manufacturer | Part Number |
|---|---|---|---|---|
| 1 | R8 | RES-AEC-Q200, SMD, 0603, 100K, 1/10W, 0.1%, ROHS | Panasonic | ERA-3AEB104V-T |
| 1 | R9 | RES, SMD, 0603, 5.49K, 1/16W, 1%, TF, ROHS | Panasonic | ERJ-3EKF5491V-T |
| 1 | T1 | TRANSFORMER-FLYBACK, 24W, 12V, 1.0A, SMD, ROHS | CoilCraft | POE24PR-12ED-T |
| 2 | U1, U11 | IC-RH, ULTRALOW NOISE, 5.0V, ROHS | Renesas | ISL71090SEHVF50 |
| 2 | U3, U5 | IC-RH HIGH SPEED DUAL VOLTAGE COMPARATOR, ROHS | Renesas | ISL7119RHQF |
| 1 | U6 | IC-CURRENT MODE PWM, 50% DC, 7.0V UVLO, 8P, ROHS | Renesas | ISL71041MRTZ |
| 3 | U8, U9, U10 | IC-DIGITAL ACTIVE ISOLATOR, SMD, 8P, SOICN, ROHS | Renesas | ISL71710MBZ |
| 1 | PLACE ASSY IN BAG | BAG, STATIC, 3X5, ZIP LOC, ROHS | ULINE | 3X5-STATIC-BAG |
| 1 | AFFIX TO BOTTOM OF PCB | LABEL-DATE CODE=LINE 1:YRWK-REV#, LINE 2;BOM NAME | Renesas | LABEL-DATE CODE |

## 2.2.3 Board Layout

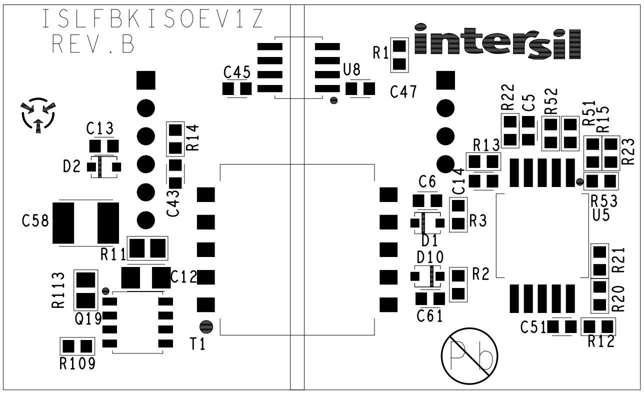


**Figure 21. Silkscreen Top**

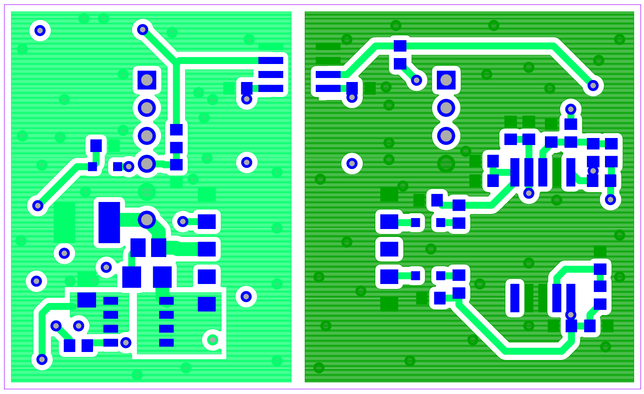

**Figure 22. Top Layer**

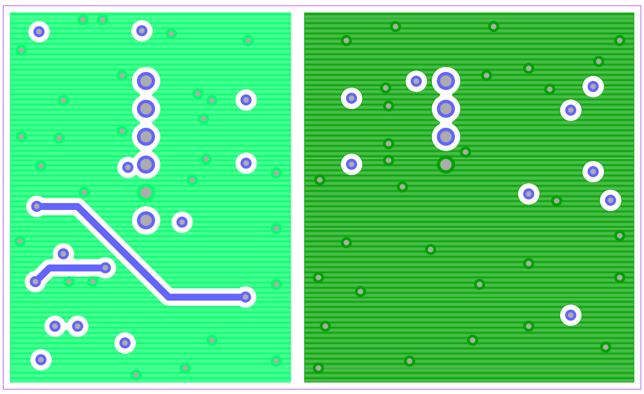

**Figure 23. Layer 2**

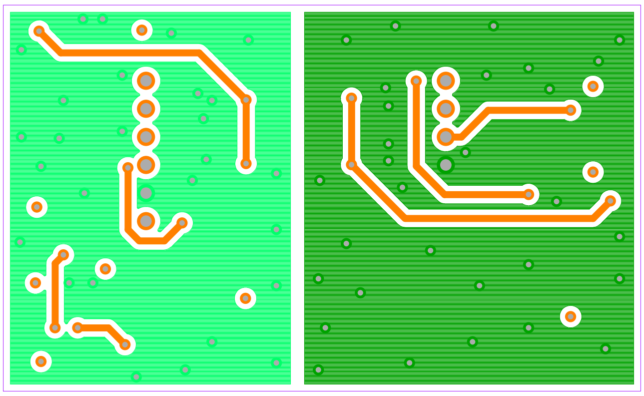

**Figure 24. Layer3**

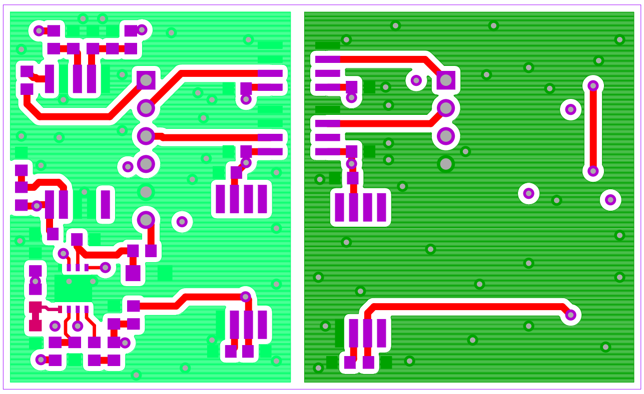

Figure 25. Bottom Layer

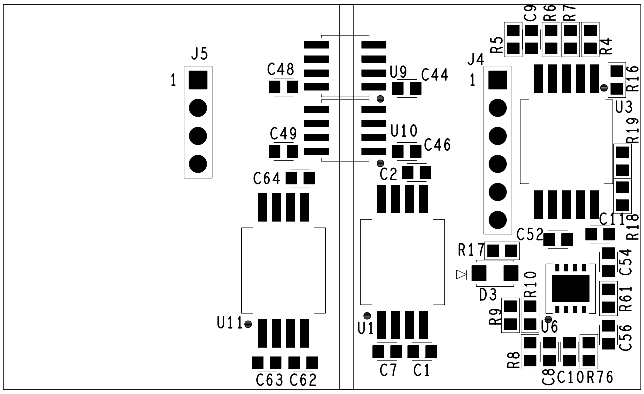


Figure 26. Silkscreen Bottom

# 3. Typical Performance Graphs

The following are the typical performance plots of the ISL73846MEV1Z push-pull converter evaluation board. For efficiency and load regulation plots, the controller is supplied from a 12V external power supply (VDD_EXT). Input power includes power consumption of the controller and ISLFBKISOEV1Z daughter card. Typical steady state switching waveforms, soft-start, and overcurrent protection operation waveforms are shown in Figure 27 to Figure 36.

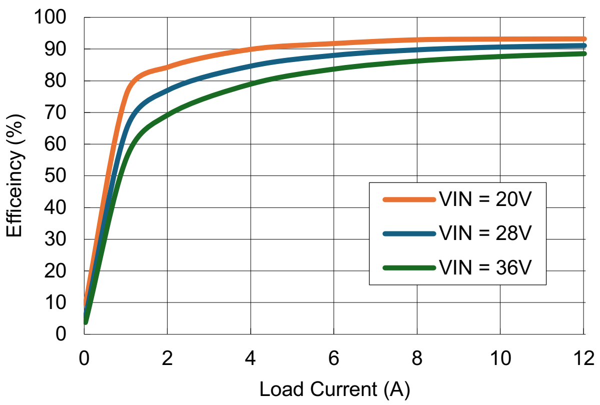


Figure 27. Efficiency

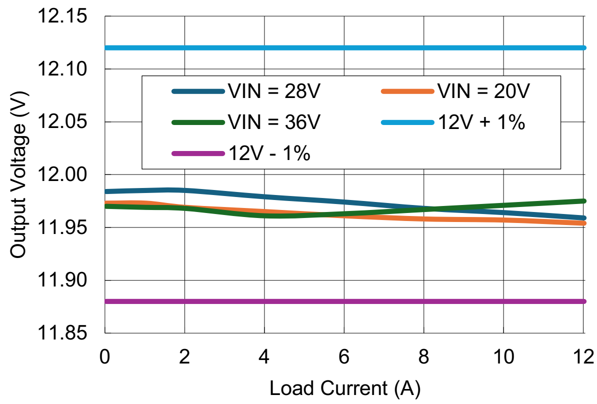


Figure 28. Load Regulation

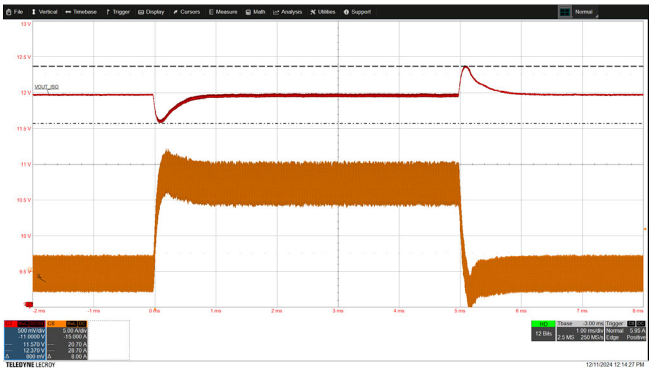

Figure 29. 0A to 12A Load Step Response ($V_{IN}$ = 28V)

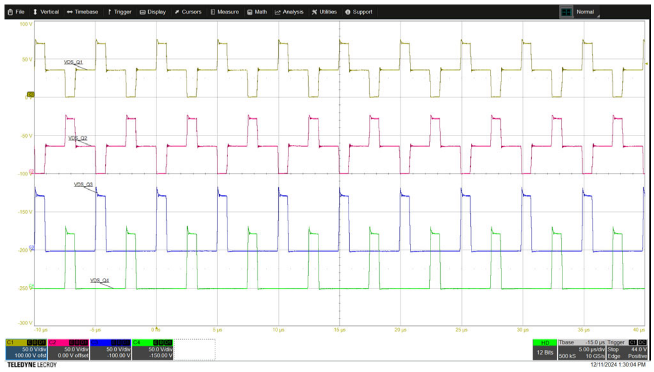

Figure 30. Drain-to-Source Voltages of GaNFETs, $V_{IN}$ = 36V, 0A Load

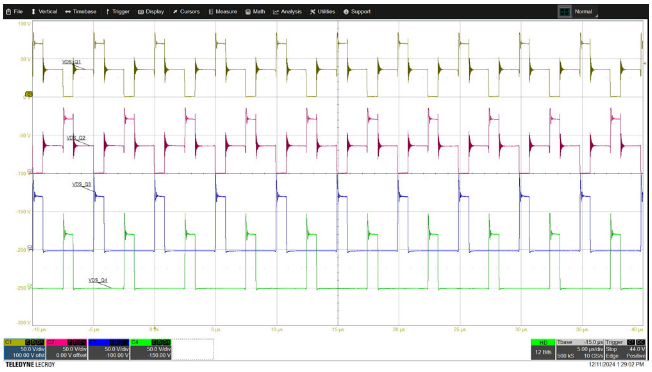

Figure 31. Drain-to-Source Voltages of GaNFETs, $V_{IN}$ = 36V, 12A Load

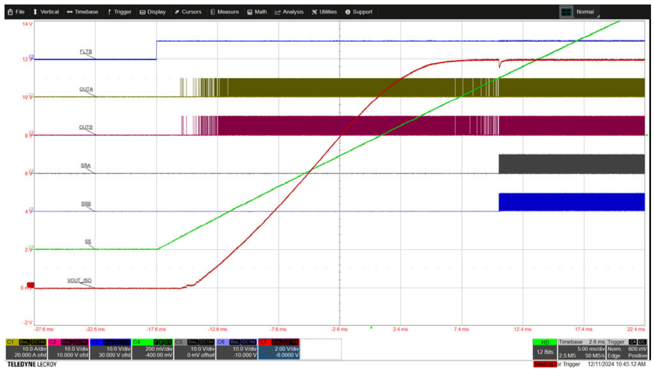

Figure 32. Soft Start (VIN Ramp Up to 28V, 0A Load)

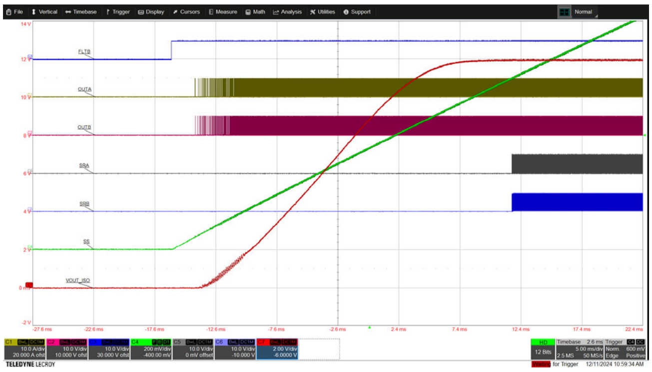

Figure 33. Soft Start (VIN Ramp Up to 28V, 12A load)

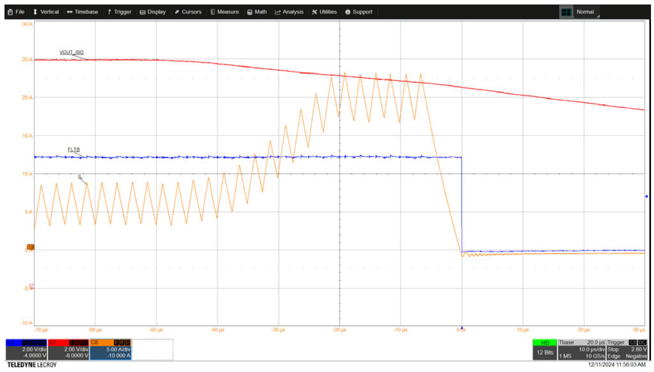

Figure 34. Overcurrent Protection (CONFIG Jumper Shorted, $V_{IN}$ = 28V)

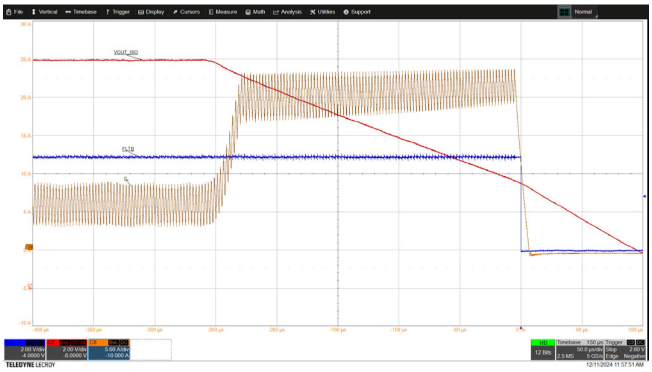

**Figure 35. Overcurrent Protection (CONFIG Jumper Open, $V_{IN}$ = 28V)**

*Note*: Part shuts down when an undervoltage fault is detected at the EA_IN pin.

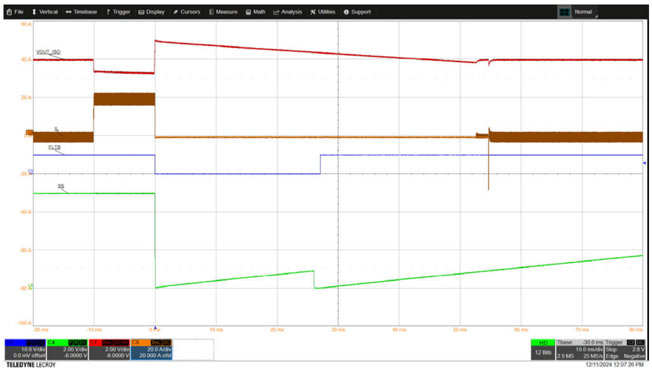

**Figure 36. Overcurrent Protection (CONFIG Jumper Open)**

*Note*: 19A load transient is applied and released after 10ms. The load release causes an overshoot on output voltage which is detected by the ISLFBKISOEV1Z board and causes the controller to go into hiccup.

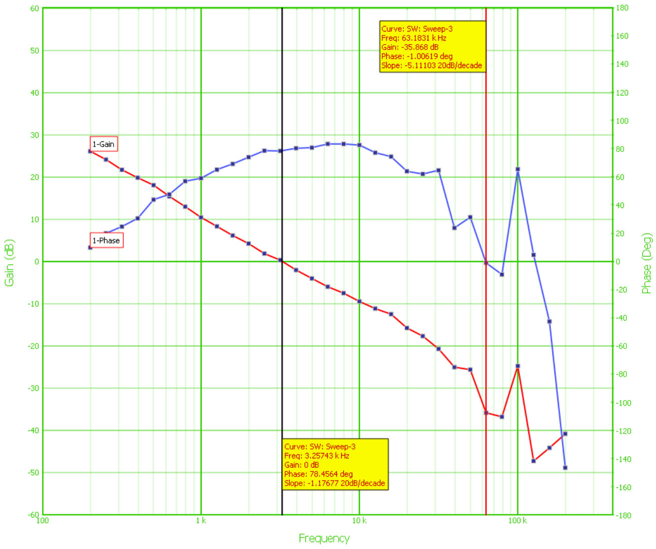


**Figure 37. Loop Gain/Phase Characteristics at $V_{IN}$ = 28V, $I_{OUT}$ = 6A**

# 4. Ordering Information

| Part Number | Description |
|---|---|
| ISL73846MEV1Z | ISL73846M Push-Pull Converter Evaluation Board |

# 5. Revision History

| Revision | Date | Description |
|---|---|---|
| 1.00 | May 15, 2025 | Initial release. |

### Corporate Headquarters

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### Contact Information

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