# ISL8202MEVAL1Z

Evaluation Board

UG071
Rev.0.00
May 3, 2016

The ISL8202M power module is a single-channel synchronous step-down complete power supply, capable of delivering up to 3A of continuous current. Operating from a single 2.6V to 5.5V input power rail and integrating a controller, power inductor and MOSFETs, the ISL8202M can achieve up to 95% conversion efficiency. It also provides fast transient response with excellent loop stability, and can deliver output voltage as low as 0.6V. Switching frequency is also adjustable from 680kHz to 3.5MHz with either external resistors or the SYNC clock option. The selectable PFM mode can also be enabled to boost up light-load efficiency to extend battery life. Other features include programmable soft-start, soft-stop, input undervoltage lockout, 100% duty cycle operation, over-temperature, overcurrent/short-circuit with hiccup mode, and overvoltage and negative overcurrent protection. The ISL8202M also has a dedicated enable pin and power-good flag that allows for easy system power rails sequencing.

The ISL8202MEVAL1Z evaluation board is designed to demonstrate the performance of the ISL8202M. By default, the board is set with a 1.2V output voltage with 1.5MHz switching frequency. Other output voltage values can be easily set by changing the jumper position. Switching frequency can be adjusted by changing the FS pin resistor.

## References

- ISL8202M datasheet

## Key Features

- 2.6V to 5.5V input voltage range
- Adjustable output voltage as low as 0.6V with ±1.6% accuracy over line/load/temperature
- Default 1.8MHz current mode control operations
  - 680kHz to 3.5MHz resistor adjustable
  - External synchronization up to 3.5MHz
  - Selectable light-load efficiency mode
  - 100% duty cycle LDO mode
- Programmable soft-start and soft-stop output discharge
- Dedicated enable pin and power-good flag
- UVLO, over-temperature, overcurrent, overvoltage and negative overcurrent protections

## Specifications/Default Set-Up

- $V_{IN}$ = 2.6V to 5.5V
- $V_{OUT}$ options (via jumper selection): 1V, 1.2V, 2.5V, 3.3V
- MAX $I_{OUT}$ up to 3A
- $f_{SW}$ = 1.5MHz by default
- Set to PWM mode by default
- 1ms soft-start time by default

## Ordering Information

| PART NUMBER | DESCRIPTION |
|---|---|
| ISL8202MEVAL1Z | ISL8202M single 3A power module evaluation board |

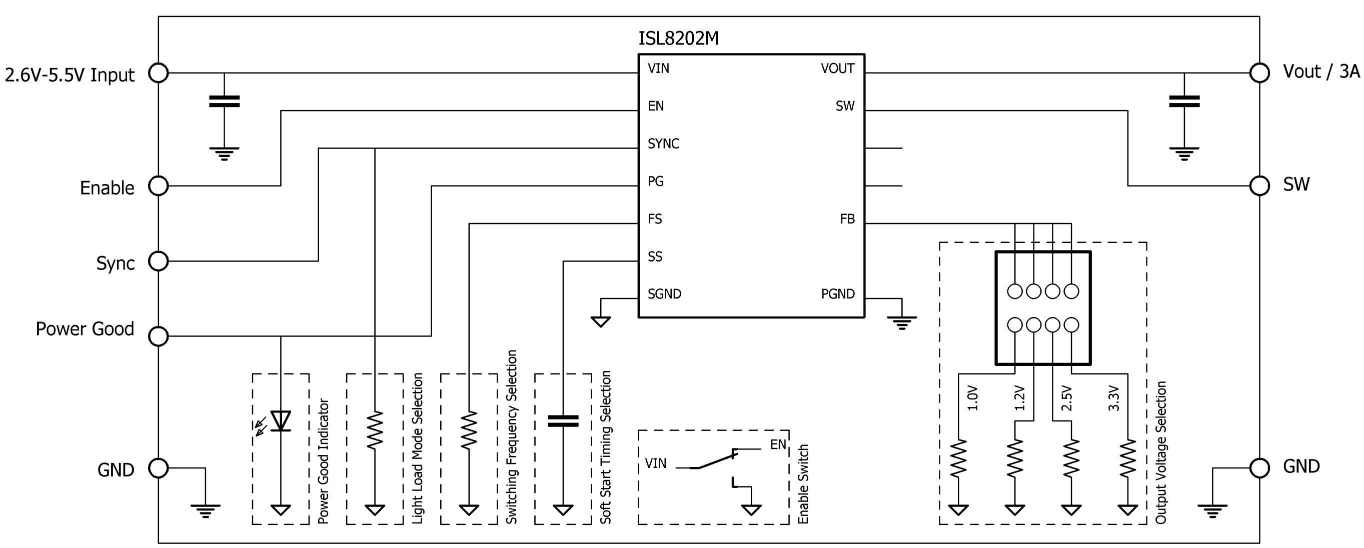


FIGURE 1. ISL8202MEVAL1Z BLOCK DIAGRAM

**TABLE 1. ISL8202M COMPONENT SELECTION GUIDE MATRIX**

| $V_{IN}$ (V) | $V_{OUT}$ (V) | $f_{SW}$ (MHz) | $C_{IN}$ (µF) | $C_{OUT}$ (µF) | $R_7$ (kΩ) | $R_{SET}$ (kΩ) | $C_{FF}$ (pF) |
|---|---|---|---|---|---|---|---|
| 5 | 0.6 | 0.8 | 2x22 | 3x22 | 261 | OPEN | 680 |
| 5 | 0.9 | 1.2 | 2x22 | 3x22 | 169 | 200 | 680 |
| 5 | 1 | 1.3 | 2x22 | 2x22 | 154 | 150 | 820 |
| 5 | 1.2 | 1.5 | 2x22 | 2x22 | 130 | 100 | 680 |
| 5 | 1.5 | 1.9 | 2x22 | 2x22 | 102 | 66.5 | 390 |
| 5 | 1.8 | 2 | 2x22 | 2x22 | 95.3 | 49.9 | 390 |
| 5 | 2.5 | 2 | 2x22 | 2x22 | 95.3 | 31.6 | 220 |
| 5 | 3.3 | 2 | 2x22 | 2x22 | 95.3 | 22.1 | 390 |
| 3.3 | 0.6 | 0.8 | 2x22 | 3x22 | 261 | OPEN | 680 |
| 3.3 | 0.9 | 1.2 | 2x22 | 3x22 | 169 | 200 | 680 |
| 3.3 | 1 | 1.3 | 2x22 | 2x22 | 154 | 150 | 820 |
| 3.3 | 1.2 | 1.5 | 2x22 | 2x22 | 130 | 100 | 680 |
| 3.3 | 1.5 | 1.9 | 2x22 | 2x22 | 102 | 66.5 | 390 |
| 3.3 | 1.8 | 2 | 2x22 | 2x22 | 95.3 | 49.9 | 390 |
| 3.3 | 2.5 | 2 | 2x22 | 2x22 | 95.3 | 31.6 | 220 |


FIGURE 2. TOP OF BOARD


FIGURE 3. BOTTOM OF BOARD

## Recommended Equipment

- 0V to 5.5V power supply with at least 5A source current capability
- Electronic load capable of sinking current up to 3A
- Digital Multimeters (DMMs)
- 100MHz quad-trace oscilloscope

## Functional Description

The ISL8202M is a single 3A step-down high efficiency power module optimized for FPGA, DSP, and Li-ion battery power devices. The module switches at 1.8MHz by default when the FS pin is shorted to $V_{IN}$. The switching frequency is also adjustable from 680kHz to 3.5MHz through a resistor from FS to SGND. To boost light-load efficiency, the ISL8202M can also be configured to operate in PFM mode by pulling the SYNC pin to SGND. The peak current mode control scheme is implemented for fast transient response. The module utilizes internal compensation to stabilize the system and optimize transient response, which greatly simplifies the application. Other excellent features include external synchronization, 100% duty cycle operation, and very low quiescent current. For more information, refer to the ISL8202M datasheet.

## Quick Start

The ISL8202MEVAL1Z is set to be $V_{OUT}$ = 1.2V, $f_{SW}$ = 1.5MHz by default. For other $V_{OUT}$ options, the recommended $f_{SW}$ needs to be adjusted by changing resistor ($R_7$) connected to the FS pin. Please refer to Table 1 for more information. The following operation procedure will be based on default settings.

1. Before applying power to input, ensure one shorting jumper on J1 across pins 5 and 6 is present. This selects the $V_{OUT}$ = 1.2V option.
2. Set the ENABLE switches SW1 to the “OFF” position.

3. Connect the positive of a power supply to the VIN connector and the negative of the power supply to the PGND connector. Make sure the power supply is not enabled when making connections and the input power supply voltage is set to a value between 2.6V and 5.5V.
4. Turn the power supply on.
5. Turn ENABLE switch SW1 to the “ON” position to enable module operation.
6. The power-good LED should illuminate in green if the module is operating properly.
7. Measure output voltage, $V_{OUT}$, at test points VOUT and PGND. The module output should be 1.2V.

## Programming the Output Voltage

The ISL8202MEVAL1Z evaluation board has several preset output voltages, 1.0V, 1.2V, 2.5V, and 3.3V, which can be selected in jumper J1. Other $V_{OUT}$ values other than on-board options can be set by proper selection of the resistor ($R_{SET}$) connecting from FB to SGND. In this case, $R_{SET}$ for default options ($R_9$, $R_{10}$, $R_{11}$, $R_{12}$) may need to be changed. The output voltage is governed by Equation 1.

$$V_{OUT} = V_{REF} \cdot \frac{R_{SET} + 100k\Omega}{R_{SET}} \quad \text{(EQ. 1)}$$

For the most common $V_{OUT}$ values and corresponding $R_{SET}$ values, please refer to Table 1 on page 2 for more information.

## Feed-Forward Capacitor Selection

In typical applications where the output capacitors are all ceramic, a feed-forward capacitor, $C_{FF}$ (as annotated as $C_{12}$, $C_{13}$, $C_{14}$, $C_{15}$ in schematic) is needed to be put in parallel with each $R_{SET}$ to insure loop stability in extreme operating conditions. With internal compensation mode enabled, the $C_{FF}$ values for typical operating conditions are optimized and listed in Table 1. This is how $C_{12}$, $C_{13}$, $C_{14}$ and $C_{15}$ default values are selected. Please note that, for system parameters that are different from Table 1 or external instead of internal compensation is used, the optimized value of $C_{FF}$ needs to be adjusted.

## Frequency Adjust

The switching frequency of the ISL8202M is adjustable ranging from 680kHz to 3.5MHz via a simple resistor $R_{FS}$ (as shown in $R_7$ on ISL8202MEVAL1Z board) across FS to SGND. The switching frequency setting is based on Equation 2:

$$R_{FS}[k\Omega] = \frac{220 \cdot 10^3}{f_{OSC}[kHz]} - 14 \quad \text{(EQ. 2)}$$

When the FS pin is directly tied to VIN, the frequency of operation is fixed at 1.8MHz. For a recommended switching frequency with typical operation conditions, refer to Table 1. More detailed information on recommended switching frequency and $f_{SW}$ selection range is provided in “Recommended Switching Frequency” and “Operation Range”.

## Recommended Switching Frequency

The switching frequency for each $V_{IN}$ and $V_{OUT}$ combination needs to take into account a few trade-offs. Generally, a lower switching frequency will lead to higher efficiency. However, the switching frequency should not be decreased too low due to negative current protection limit. Moreover, when output voltage is relatively high, low switching frequency will result in more sub-harmonic oscillation. Therefore, the operating frequency needs to be kept relatively high under high $V_{OUT}$ conditions. However, switching frequency cannot be increased too much, or the minimum on-time limit could be violated. Based on these considerations, Figure 4 provides the recommended switching frequency under various typical $V_{IN}$ and across $V_{OUT}$ ranges.

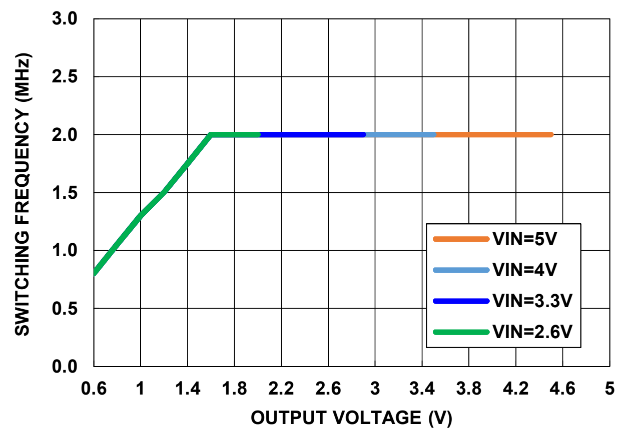


FIGURE 4. SWITCHING FREQUENCY RECOMMENDATION

## Operation Range

By default, the ISL8202MEVAL1Z is configured to operate at $V_{OUT}$ = 1.2V (J1 jumper position is at pins 5 and 6), $f_{SW}$ = 1.5MHz conditions. The $V_{IN}$ ranges from 2.6V to 5.5V. The board can also support a wider operating range to meet the requirement of specific applications. $V_{OUT}$ can be adjusted from 0.6V to 5V. Load current range is from 0A to 3A. Note that, for continuous operation at 3A, airflow across the board may be needed. The $f_{SW}$ can also be tuned. However, to ensure sufficient stability margins, switching frequency can only be adjusted within the safe operating regions represented with Figures 5 through 9. Operating outside of these areas may lead to system instability.

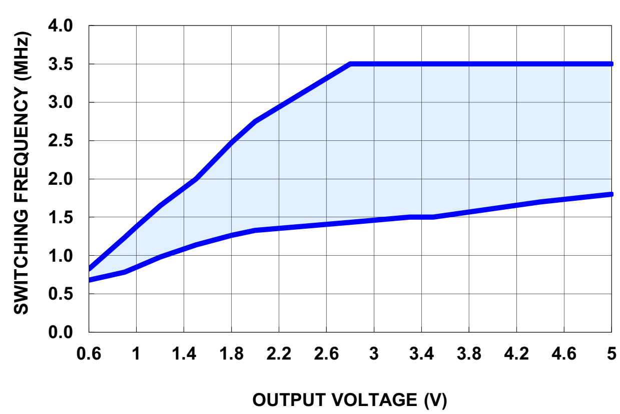


FIGURE 5. OPERATION REGION $V_{IN}$ = 5.5V

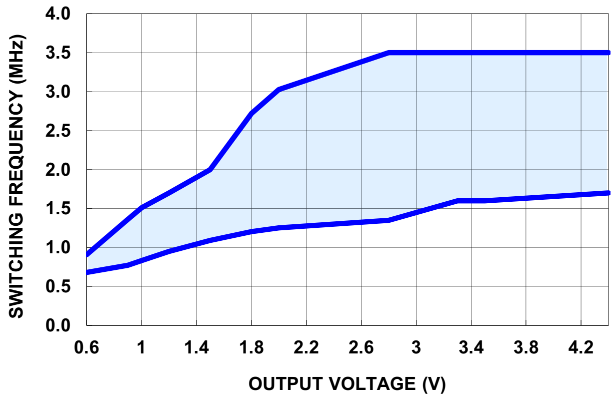


FIGURE 6. OPERATION REGION $V_{IN}$ = 5.0V

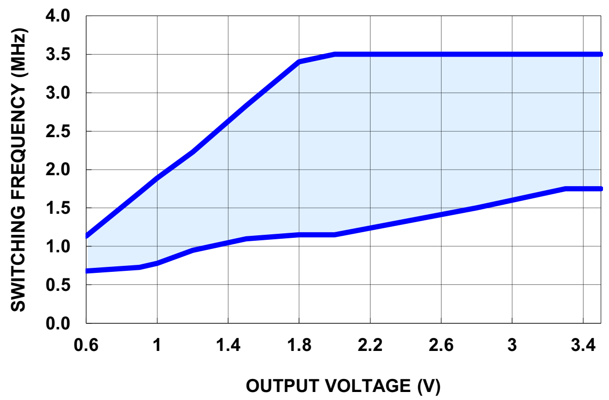


FIGURE 7. OPERATION REGION $V_{IN}$ = 4.0V

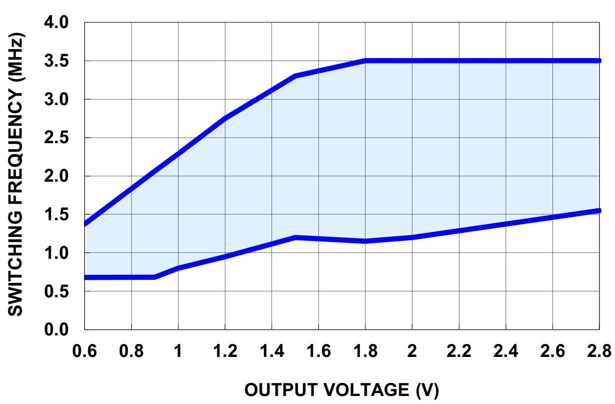


FIGURE 8. OPERATION REGION $V_{IN}$ = 3.3V

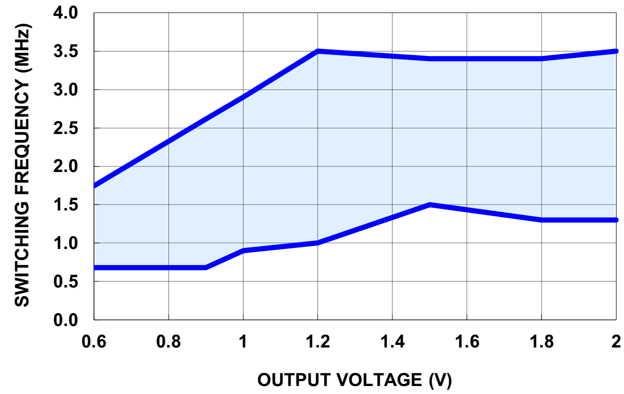


FIGURE 9. OPERATION REGION $V_{IN}$ = 2.6V

### PWM/PFM Selection

By default, the ISL8202MEVAL1Z is set to operate in PWM mode. This is achieved by connecting SYNC to VIN through $R_1$. Pulling the SYNC pin LOW forces the module into PFM mode, which enables pulse-skipping at light load to minimize the switching loss by reducing the switching frequency. Refer to the ISL8202M datasheet for more detailed information. PFM mode can be enabled by removing $R_1$ and shorting SYNC to SGND by putting a 0Ω resistor on $R_2$.

### Soft Start-Up

The soft start-up reduces the inrush current during start-up. The soft start-up time is set to 1ms by default through $C_6$. However, start-up time can be adjusted by tuning the $C_6$ value. Equation 3 can be used to determine the $C_6$ value for the target soft-start time $t_{SS}$.

$$C_6[\mu F] = 3.1 \times t_{SS}[S] \qquad \text{(EQ. 3)}$$

## Evaluation Board Information

The ISL8202MEVAL1Z evaluation board is a 2x2 in$^2$ four-layer FR-4 board with 2oz. copper on all the layers. The board can be used as a single 3A reference design. Refer to Figures 11 through 14 for board layout information. The board is designed with mechanical switches for ENABLE, power-good LED indicators, several connectors, test points and jumpers, which makes testing the board easy.

## Thermal Considerations and Current Derating

Proper board layout is critical in order to make the module operate safely and deliver maximum allowable power. In order for the board to operate properly in the high ambient temperature environments and carry full load currents, the board layout needs to be carefully designed to maximize thermal performance. To achieve this, select enough trace width, copper weight and proper connectors.

The ISL8202MEVAL1Z evaluation board is capable of operating at 3A full load current at room temperature with plenty of safety margin for junction temperature. However, if the board is to operate at elevated ambient temperatures, then the available output current may need to be derated. Refer to the derated current curves in the ISL8202M datasheet to determine the maximum output current the evaluation board can supply.

# ISL8202MEVAL1Z Schematic

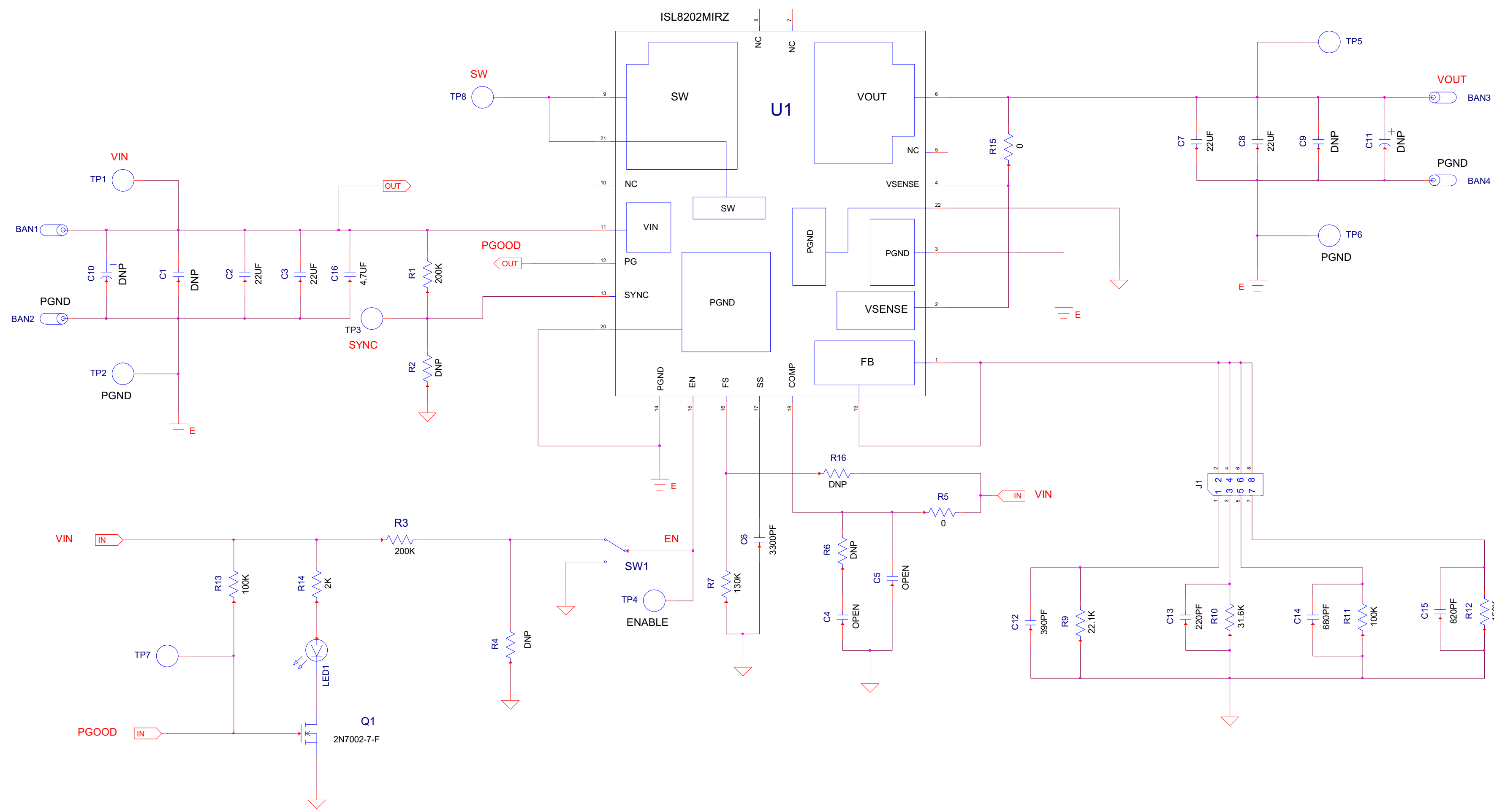


FIGURE 10. SCHEMATIC

# Bill of Materials

| REFERENCE DESIGNATOR | QTY | MANUFACTURER | PART NUMBER | DESCRIPTION |
|---|---|---|---|---|
| C16 | 1 | MURATA | GRM21BR71A475KA73L | CAP, SMD, 0805, 4.7µF, 10V, 10%, X7R, ROHS |
| C13 | 1 | PANASONIC | ECU-E1H221JCQ | CAP, SMD, 0402, 220pF, 50V, 5%, C0G, ROHS |
| C6 | 1 | PANASONIC | ECU-E1E332KBQ | CAP, SMD, 0402, 3300pF, 25V, 10%, X7R, ROHS |
| C12 | 1 | YAGEO | CC0402JRNPO9BN391 | CAP, SMD, 0402, 390pF, 50V, 5%, NP0, ROHS |
| C14 | 1 | YAGEO | CC0402JRNPO9BN681 | CAP, SMD, 0402, 680pF, 50V, 5%, NP0, ROHS |
| C15 | 1 | SAMSUNG | CL05C821JB5NNNC | CAP, SMD, 0402, 820pF, 50V, 5%, NP0, ROHS |
| C4, C5 | 0 | | | CAP, SMD, 0402, DNP-PLACE HOLDER, ROHS |
| C2, C3, C7, C8 | 4 | TAIYO YUDEN | LMK316AB7226KL-TR | CAP, SMD, 1206, 22µF, 10V, 10%, X7R, ROHS |
| C1, C9 | 2 | | | CAP, SMD, 1206, DNP-PLACE HOLDER, ROHS |
| TP1-TP8 | 8 | KEYSTONE | 5002 | CONN-MINI TEST POINT, VERTICAL, WHITE, ROHS |
| BAN1-BAN4 | 4 | KEYSTONE | 575-4 | CONN-JACK, MINI BANANA, 0.175 PLUG, NICKEL/BRASS, ROHS |
| J1 | 1 | BERG/FCI | 68000-236HLF | CONN-HEADER, 1x8, BRKAWY 1x36, 2.54mm, ROHS |
| J1-Pins 5-6 | 1 | SULLINS | SPC02SYAN | CONN-JUMPER, SHORTING, 2PIN, BLACK, GOLD, ROHS |
| LED1 | 1 | LITEON/VISHAY | LTST-C190KGKT | LED, SMD, 0603, GREEN CLEAR, 2V, 20mA, 571nm, 35mcd, ROHS |
| U1 | 1 | INTERSIL | ISL8202MIRZ | IC-3A PWR MODULE, ANALOG DC/DC, 22P, QFN, 4.5x7.5, ROHS |
| Q1 | 1 | DIODES, INC. | 2N7002-7-F | TRANSISTOR, N-CHANNEL, 3LD, SOT-23, 60V, 115mA, ROHS |
| R7 | 1 | TE CONNECTIVITY | 3-1879216-1 | RES, SMD, 0402, 130k, 1/16W, 0.1%, TF, ROHS |
| R12 | 1 | TE CONNECTIVITY | 3-1879216-2 | RES, SMD, 0402, 150k, 1/16W, 0.1%, TF, ROHS |
| R9 | 1 | TE CONNECTIVITY | 6-1879215-6 | RES, SMD, 0402, 22.1k, 1/16W, 0.1%, TF, ROHS |
| R11 | 1 | TE CONNECTIVITY | 9-1879208-7 | RES, SMD, 0402, 100k, 1/16W, 0.1%, TF, ROHS |
| R4 | 0 | | | RES, SMD, 0603, 0.1%, MF, DNP-PLACE HOLDER |
| R5, R15 | 2 | VENKEL | CR0402-16W-00T | RES, SMD, 0402, 0Ω, 1/16W, 5%, TF, ROHS |
| R1 | 1 | ROHM | MCR01MZPF2003 | RES, SMD, 0402, 200k, 1/16W, 1%, TF, ROHS |
| R2, R6, R16 | 0 | | | RES, SMD, 0402, DNP, DNP, DNP, TF, ROHS |
| R13 | 1 | VENKEL | CR0603-10W-1003FT | RES, SMD, 0603, 100k, 1/10W, 1%, TF, ROHS |
| R14 | 1 | KOA | RK73H1JTTD2001F | RES, SMD, 0603, 2k, 1/10W, 1%, TF, ROHS |
| R3 | 1 | VENKEL | CR0603-10W-2003FT | RES, SMD, 0603, 200k, 1/10W, 1%, TF, ROHS |
| R10 | 1 | YAGEO | RT0402BRD0731K6L | RES, SMD, 0402, 31.6k, 1/16W, 0.1%, TF, ROHS |
| SW1 | 1 | ITT INDUSTRIES/C&K DIVISION | GT11MSCBE | SWITCH-TOGGLE, SMD, 6PIN, SPDT, 2POS, ON-NONE-ON, ROHS |
| C10 | 0 | | | CAP, TANT, SMD, 2917, 10V, DNP-PLACE HOLDER |
| C11 | 0 | | | CAP, TANT POLY, SMD, 2917, 10V, DNP-PLACE HOLDER |

## Board Layout

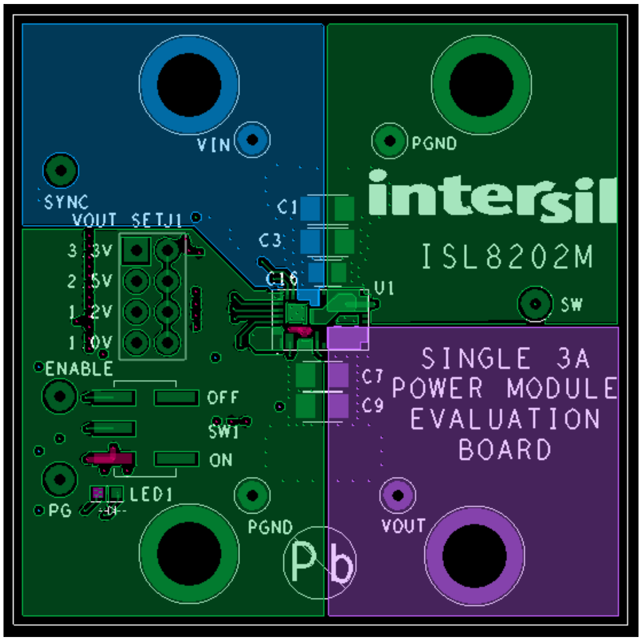


FIGURE 11. TOP LAYER (TOP VIEW)

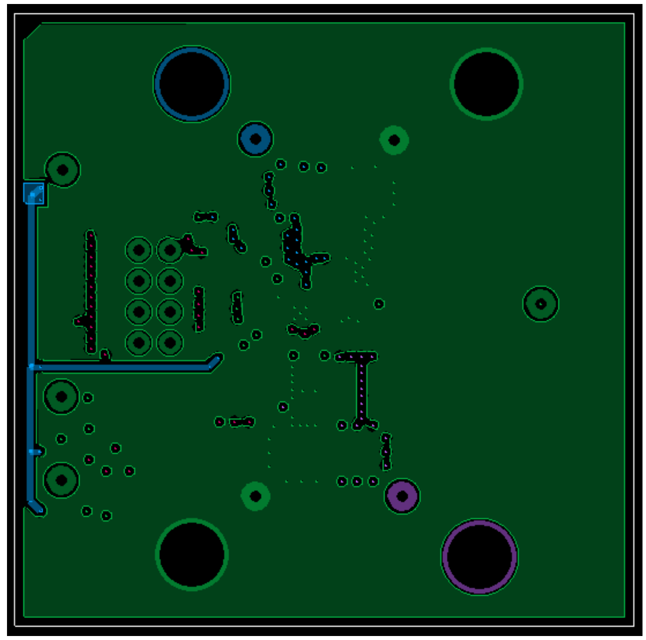

FIGURE 12. INNER LAYER 1 (TOP VIEW)

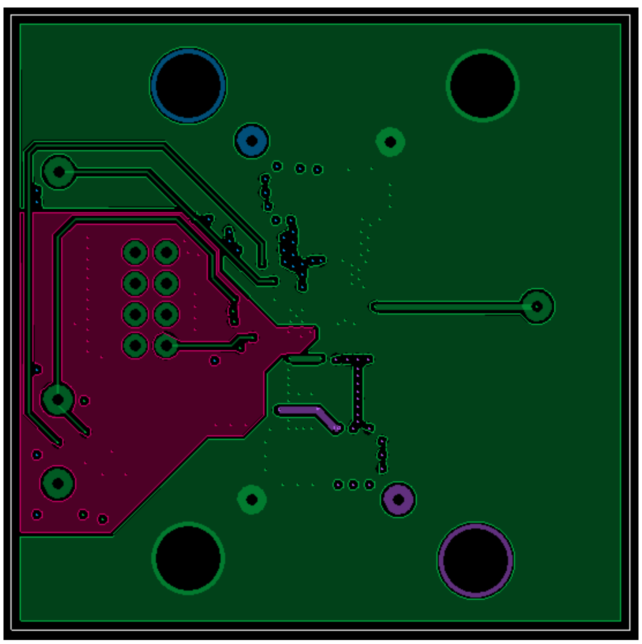

FIGURE 13. INNER LAYER 2 (TOP VIEW)

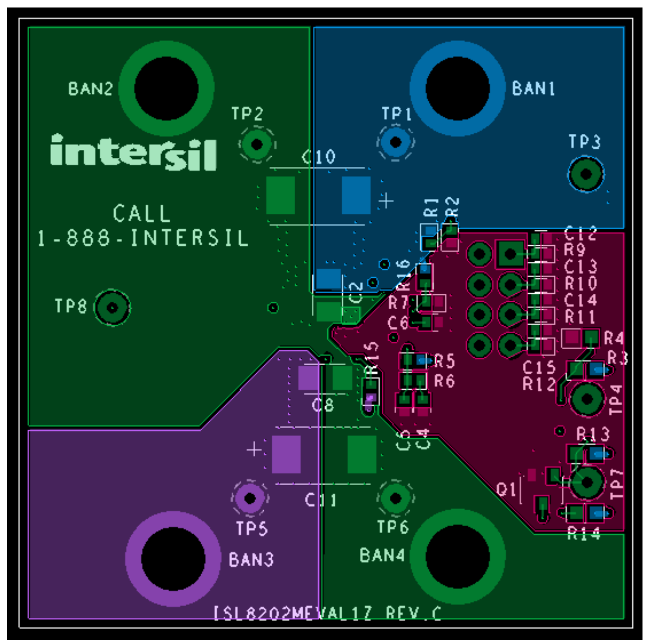


FIGURE 14. BOTTOM LAYER (BOTTOM VIEW)

## ISL8202MEVAL1Z Performance Data

The following data was acquired using a ISL8202MEVAL1Z evaluation board at +25°C ambient and free air 0LFM.

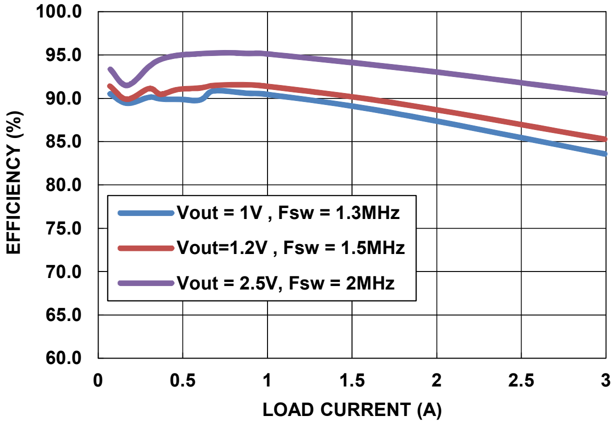


FIGURE 15. EFFICIENCY $T_A$ = +25°C, $V_{IN}$ = 3.3V PFM MODE

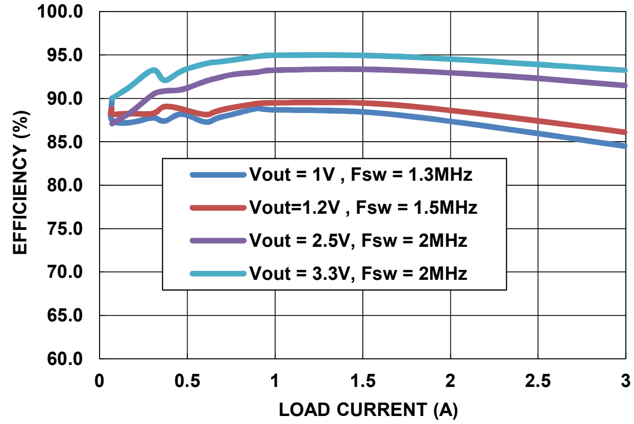


FIGURE 16. EFFICIENCY $T_A$ = +25°C, $V_{IN}$ = 5V PFM MODE

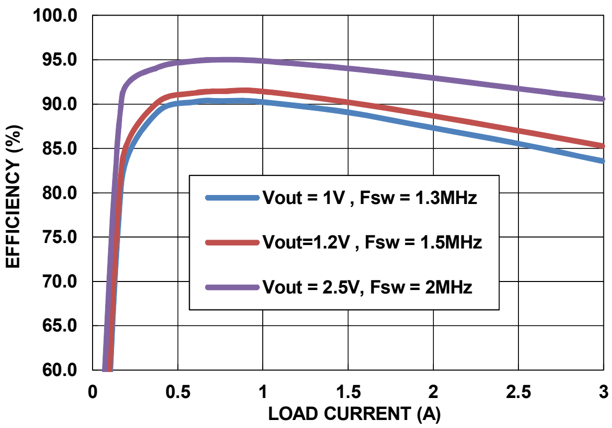


FIGURE 17. EFFICIENCY $T_A$ = +25°C, $V_{IN}$ = 3.3V PWM MODE

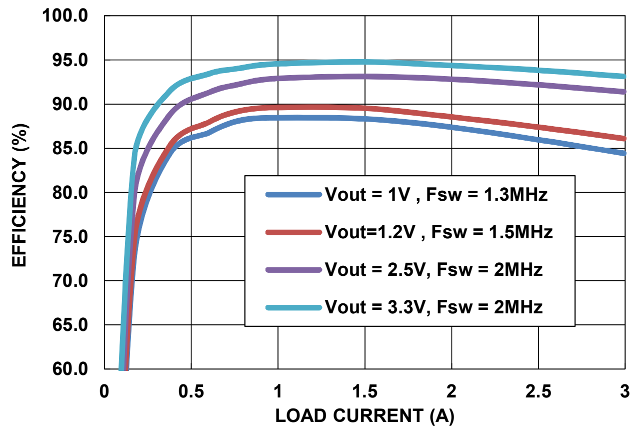


FIGURE 18. EFFICIENCY $T_A$ = +25°C, $V_{IN}$ = 5V PWM MODE

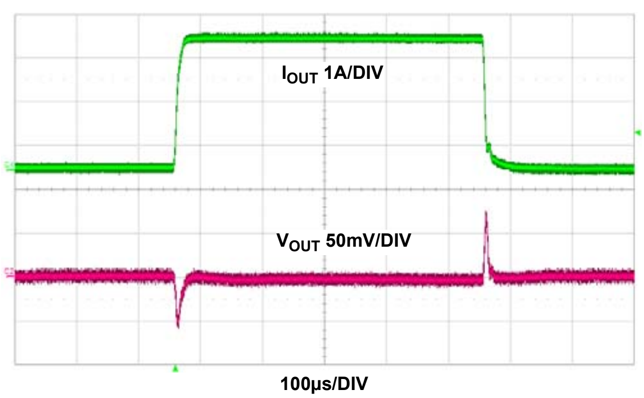


FIGURE 19. LOAD TRANSIENT $V_{IN}$ = 5V, $V_{OUT}$ = 1.2V, $I_{OUT}$ = 0 TO 3A, $f_{SW}$ = 1.5MHz, $C_{OUT}$ = 2 x 22µF CERAMIC CAPACITORS LOAD CURRENT SLEW RATE: 1A/µs

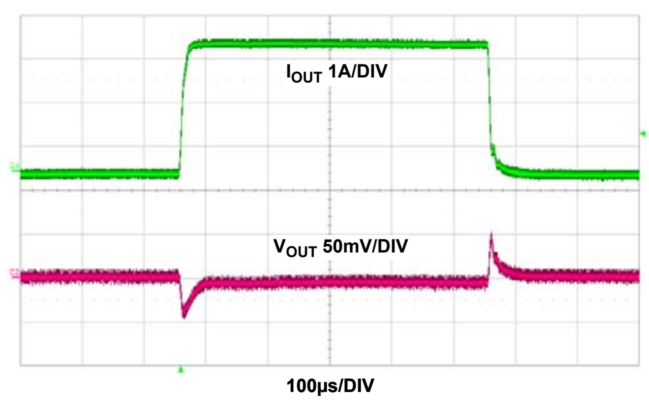


FIGURE 20. LOAD TRANSIENT $V_{IN}$ = 5V, $V_{OUT}$ = 3.3V, $I_{OUT}$ = 0 TO 3A, $f_{SW}$ = 2MHz, $C_{OUT}$ = 2 x 22µF CERAMIC CAPACITORS, LOAD CURRENT SLEW RATE: 1A/µs

## ISL8202MEVAL1Z Performance Data

The following data was acquired using a ISL8202MEVAL1Z evaluation board at +25°C ambient and free air 0LFM. **(Continued)**

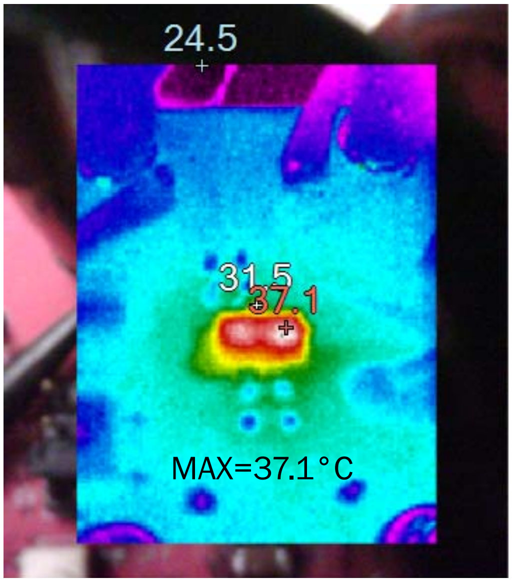


**FIGURE 21. THERMAL IMAGE AT $V_{IN}$ = 5V, $V_{OUT}$ = 1.2V, $I_{OUT}$ = 3A, $f_{SW}$ = 1.5MHz, $T_A$ = +25°C, FREE AIR 0 LFM**

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