



**THE DATASHEET OF  
ISL8210MEVAL1Z**



# ISL8210MEVAL1Z

User's Manual: Evaluation Board

Industrial Analog and Power

## 1. Overview

The ISL8210MEVAL1Z evaluation board (shown in [Figures 4](#) and [5](#)) is designed for evaluating the [ISL8210M](#). The ISL8210M is a single channel, synchronous step-down DC/DC power supply module that is capable of delivering up to 10A of continuous current. The proprietary Renesas [R4 Technology](#) control scheme has extremely fast transient performance, accurately regulated frequency control, and all internal compensation. The ISL8210M includes four setting up pins (SETx) for module configuration and allows for easy R4 loop optimization that results in fast transient performance across a wide range of applications, including all ceramic output filters. The ISL8210M integrates the controller, all power components, and most passive components. The device requires only a few external components to operate, which significantly reduces design complexity and board space, and it optimizes for high power density applications without the need for airflow or a heatsink.

The ISL8210MEVAL1Z evaluation board is a 3 x 3 inch six-layer FR4 board with 2oz. copper on all layers. The ISL8210MEVAL1Z operates from a single 4.5V to 15V wide input power rail and offers adjustable output voltages down to 0.5V and efficiencies of up to 95%. The ISL8210MEVAL1Z comes with placeholders for pin-strap resistors to set up output voltage, PFM/PWM mode, temperature compensation (TCOMP), switching frequency ( $f_{SW}$ ), AV gain, OCP retry/latch-off, ultrasonic PFM enable, soft-start ramp rate, RR impedance, and AV gain multiplier (1x or 2x).

By default, the ISL8210MEVAL1Z is set to a 1V output voltage with a 400kHz switching frequency, 49 AV gain, and 200k $\Omega$  RR.

### 1.1 Key Features

- Input voltage range: 4.5V to 15V, capable of delivering up to 10A of continuous current and up to 95% conversion efficiency
- Adjustable output voltage: 0.5V to 5V with  $\pm 1.5\%$  load/line/temperature regulation with remote sense
- Proprietary Renesas [R4 Technology](#)
- Programmable  $V_{OUT}$ , PFM/PWM mode, TCOMP,  $f_{SW}$ , AV gain, OCP retry/latchoff, ultrasonic PFM enable, soft-start ramp rate, RR, and AV gain multiplier
- Startup into precharged load
- Dedicated enable pin and PGOOD indicator
- Comprehensive fault protection for high system reliability: over-temperature protection, output overcurrent and short-circuit protection, output overvoltage and undervoltage protection, open remote sense protection, input UVLO and power sequence, and fault reset
- Thermally enhanced 12mmx11mmx5.3mm HDA package

### 1.2 Specifications

The ISL8210MEVAL1Z is configured and optimized for the following operating conditions:

- $V_{IN}$  = 4.5V to 15V
- $V_{OUT}$  = 1V
- $I_{OUT-MAX}$  = 10A
- $f_{SW}$  = 400kHz
- AV gain multiplier = 2x, AV gain = 49, RR = 200k $\Omega$
- TCOMP = +5 $^{\circ}$ C

### 1.3 Ordering Information

| Part Number    | Description   |
|----------------|---|
| ISL8210MEVAL1Z | 10A high efficiency step-down power module evaluation board |

### 1.4 Related Literature

For a full list of related documents, visit our website:

- [ISL8210M](#) device page

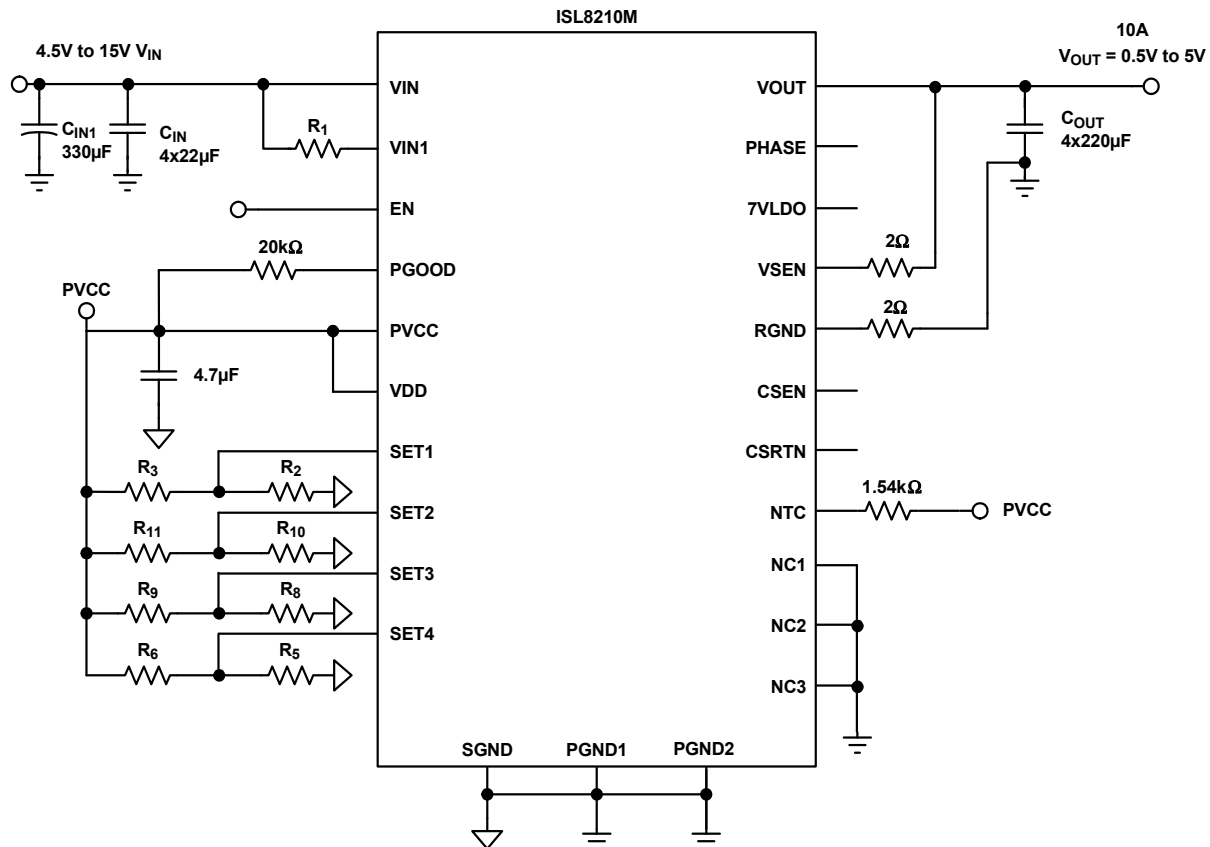


Figure 1. ISL8210MEVAL1Z Block Diagram

### 1.5 Recommended Testing Equipment

- DC power supply with minimum 15V/10A source current capability
- Electronic loads capable of sinking current up to 10A
- Digital Multimeters (DMMs)
- Oscilloscope with bandwidth greater than 100MHz

## 2. Functional Description

The ISL8210MEVAL1Z evaluation board provides the peripheral circuitry to evaluate the ISL8210M feature set. The ISL8210MEVAL1Z includes several connectors, test points, and external pin-strap resistors that simplify ISL8210M validation. [Figure 4 on page 23](#) shows the top of the ISL8210MEVAL1Z. [Figure 5 on page 23](#) shows the bottom of the ISL8210MEVAL1Z.

### 2.1 Quick Start Guide

- (1) Disable the module by toggling the mechanical switch SW<sub>1</sub> to **2-3** as shown in [Figure 4](#).
- (2) Connect the DC input power supply to banana sockets J<sub>4</sub> and J<sub>3</sub> and the electronic load to sockets J<sub>14</sub> and J<sub>15</sub>. Ensure that the polarity for the power leads is correct and the input voltage is within the ISL8210MEVAL1Z's operating range of 4.5V to 15V. Use test points TP<sub>1</sub> (VIN) and TP<sub>3</sub> (GND) to accurately measure the input voltage.
- (3) Toggle the mechanical switch SW<sub>1</sub> to **1-2** to enable the module.
- (4) Turn on the DC input power supply.
- (5) Probe test points TP<sub>3</sub> (VOUT) and TP<sub>4</sub> (PGND) to observe the output voltage. The output voltage should read 1V.
- (6) Adjust the input voltage, V<sub>IN</sub>, within the specified range and observe the output voltage. The output voltage variation should be within ±1.5%.
- (7) Adjust the load current to within the specified range of 0A to 10A and observe the output voltage. The output voltage variation should be within ±1.5%.
- (8) To change V<sub>OUT</sub>, disconnect the ISL8210MEVAL1Z from the setup and populate 1% standard 0402 resistors at the R<sub>2</sub> and R<sub>3</sub> placeholder locations on the bottom layer. Use [Table 1 on page 5](#) as a reference for programming different output voltages. See the “ISL8210M Design Guide Matrix of Typical Applications” table in the [ISL8210M](#) datasheet for recommended values in typical applications.
- (9) To change PFM/PWM mode and TCOMP, disconnect the ISL8210MEVAL1Z from the setup and populate 1% standard 0402 resistors at the R<sub>10</sub> and R<sub>11</sub> placeholder locations on the bottom layer. Use [Table 2 on page 11](#) as a reference for customizing module specifications. Renesas recommends using +5°C as the TCOMP.
- (10) To change OCP retry/latchoff, f<sub>SW</sub>, AV gain and ultrasonic PFM enable, disconnect the ISL8210MEVAL1Z from the setup and populate 1% standard 0402 resistors at the R<sub>8</sub> and R<sub>9</sub> placeholder locations on the bottom layer. Use [Table 3 on page 17](#) as a reference for customizing module specifications. See the “ISL8210M Design Guide Matrix of Typical Applications” table in the [ISL8210M](#) datasheet for recommended values in typical applications.
- (11) To change the soft-start ramp rate, RR, and AV gain multiplier, disconnect the ISL8210MEVAL1Z from the setup and populate 1% standard 0402 resistors at the R<sub>5</sub> and R<sub>6</sub> placeholder locations on the bottom layer. Use [Table 4 on page 20](#) as a reference for customizing module specifications. See the “ISL8210M Design Guide Matrix of Typical Applications” table in the [ISL8210M](#) datasheet for recommended values in typical applications.

## 2.2 Thermal Considerations and Current Derating

Proper board layout is critical so that the module can operate safely and deliver the maximum allowable power. For the board to operate properly at high ambient temperature environments and carry full load current, carefully design the board layout to maximize thermal performance. For best thermal performance, use enough trace width, copper weight, and proper connectors.

The ISL8210MEVAL1Z is capable of operating at 10A full load current at room temperature without the need for additional cooling systems. However, if the ISL8210MEVAL1Z needs to operate at elevated ambient temperatures, the available output current needs to be derated. See the derated current curves in the [ISL8210M](#) datasheet to determine the maximum output current that the ISL8210MEVAL1Z can supply.

## 2.3 Programming the Resistor Reader

This section contains information about operating the resistor reader with the ISL8210M's four setting up pins (SET1, SET2, SET3, and SET4) to customize module specifications. See the "Definition of SET Pins" table in the [ISL8210M](#) datasheet for detailed descriptions of each setting up pin.

**Table 1. SET1 Resistor Reader**

| $R_{UP}$ (k $\Omega$ ) | $R_{DW}$ (k $\Omega$ ) | $V_{OUT}$ (V) |
|------------------------|------------------------|---------------|
| 49.9                   | 12.4                   | 0.500         |
| 45.3                   | 12.7                   | 0.508         |
| 42.2                   | 13.3                   | 0.516         |
| 38.3                   | 13.3                   | 0.523         |
| 35.7                   | 13.7                   | 0.531         |
| 34                     | 14.3                   | 0.539         |
| 31.6                   | 14.7                   | 0.547         |
| 29.4                   | 15                     | 0.555         |
| 28                     | 15.4                   | 0.562         |
| 26.7                   | 16.2                   | 0.570         |
| 25.5                   | 16.5                   | 0.578         |
| 24.3                   | 17.4                   | 0.586         |
| 23.2                   | 17.8                   | 0.594         |
| 22.1                   | 18.2                   | 0.602         |
| 21                     | 19.1                   | 0.609         |
| 20                     | 19.6                   | 0.617         |
| 19.6                   | 20.5                   | 0.625         |
| 18.7                   | 21.5                   | 0.633         |
| 18.2                   | 22.6                   | 0.641         |
| 17.4                   | 23.2                   | 0.648         |
| 16.9                   | 24.3                   | 0.656         |
| 16.5                   | 26.1                   | 0.664         |
| 15.8                   | 26.7                   | 0.672         |
| 15.4                   | 28.7                   | 0.680         |
| 15                     | 30.1                   | 0.688         |
| 14.7                   | 32.4                   | 0.695         |
| 14                     | 34                     | 0.703         |
| 13.7                   | 36.5                   | 0.711         |

Table 1. SET1 Resistor Reader (Continued)

| $R_{UP}$ (k $\Omega$ ) | $R_{DW}$ (k $\Omega$ ) | $V_{OUT}$ (V) |
|------------------------|------------------------|---------------|
| 13.3                   | 39.2                   | 0.719         |
| 13                     | 43.2                   | 0.727         |
| 107                    | 26.7                   | 0.734         |
| 97.6                   | 27.4                   | 0.742         |
| 90.9                   | 28.7                   | 0.750         |
| 82.5                   | 28.7                   | 0.758         |
| 76.8                   | 29.4                   | 0.766         |
| 71.5                   | 30.1                   | 0.773         |
| 68.1                   | 31.6                   | 0.781         |
| 63.4                   | 32.4                   | 0.789         |
| Open                   | 10                     | 0.797         |
| 57.6                   | 34.8                   | 0.805         |
| 54.9                   | 35.7                   | 0.812         |
| 52.3                   | 37.4                   | 0.820         |
| 49.9                   | 38.3                   | 0.828         |
| 47.5                   | 39.2                   | 0.836         |
| 45.3                   | 41.2                   | 0.844         |
| Open                   | 21.5                   | 0.852         |
| 42.2                   | 44.2                   | 0.859         |
| 40.2                   | 45.3                   | 0.867         |
| 39.2                   | 48.7                   | 0.875         |
| 37.4                   | 49.9                   | 0.883         |
| 36.5                   | 52.3                   | 0.891         |
| Open                   | 34.8                   | 0.898         |
| 34                     | 57.6                   | 0.906         |
| 33.2                   | 61.9                   | 0.914         |
| 32.4                   | 66.5                   | 0.922         |
| 30.9                   | 68.1                   | 0.930         |
| 30.1                   | 73.2                   | 0.938         |
| 29.4                   | 78.7                   | 0.945         |
| Open                   | 52.3                   | 0.953         |
| 28                     | 93.1                   | 0.961         |
| 174                    | 43.2                   | 0.969         |
| 158                    | 44.2                   | 0.977         |
| 147                    | 46.4                   | 0.984         |
| 133                    | 46.4                   | 0.992         |
| Open                   | 75                     | 1.000         |
| 118                    | 49.9                   | 1.008         |
| 110                    | 51.1                   | 1.016         |
| 102                    | 52.3                   | 1.023         |
| 97.6                   | 53.6                   | 1.031         |

Table 1. SET1 Resistor Reader (Continued)

| $R_{UP}$ (k $\Omega$ ) | $R_{DW}$ (k $\Omega$ ) | $V_{OUT}$ (V) |
|------------------------|------------------------|---------------|
| 93.1                   | 56.2                   | 1.039         |
| Open                   | 105                    | 1.047         |
| 84.5                   | 60.4                   | 1.055         |
| 80.6                   | 61.9                   | 1.062         |
| 76.8                   | 63.4                   | 1.070         |
| 73.2                   | 66.5                   | 1.078         |
| 69.8                   | 68.1                   | 1.086         |
| 68.1                   | 71.5                   | 1.094         |
| Open                   | 147                    | 1.102         |
| 63.4                   | 78.7                   | 1.109         |
| 60.4                   | 80.6                   | 1.117         |
| 59                     | 84.5                   | 1.125         |
| 57.6                   | 90.9                   | 1.133         |
| 54.9                   | 93.1                   | 1.141         |
| 53.6                   | 100                    | 1.148         |
| 52.3                   | 105                    | 1.156         |
| 49.9                   | 110                    | 1.164         |
| 48.7                   | 118                    | 1.172         |
| 47.5                   | 127                    | 1.180         |
| 46.4                   | 137                    | 1.188         |
| 45.3                   | 150                    | 1.195         |
| Open                   | 499                    | 1.203         |
| 237                    | 66.5                   | 1.211         |
| 221                    | 69.8                   | 1.219         |
| 200                    | 69.8                   | 1.227         |
| 187                    | 71.5                   | 1.234         |
| 178                    | 75                     | 1.242         |
| 165                    | 76.8                   | 1.250         |
| 154                    | 78.7                   | 1.258         |
| 147                    | 80.6                   | 1.266         |
| 140                    | 84.5                   | 1.273         |
| 133                    | 86.6                   | 1.281         |
| 127                    | 90.9                   | 1.289         |
| 121                    | 93.1                   | 1.297         |
| 115                    | 95.3                   | 1.305         |
| 110                    | 100                    | 1.312         |
| 105                    | 102                    | 1.320         |
| 102                    | 107                    | 1.328         |
| 97.6                   | 110                    | 1.336         |
| 95.3                   | 118                    | 1.344         |
| 10                     | Open                   | 1.352         |

Table 1. SET1 Resistor Reader (Continued)

| $R_{UP}$ (k $\Omega$ ) | $R_{DW}$ (k $\Omega$ ) | $V_{OUT}$ (V) |
|------------------------|------------------------|---------------|
| 88.7                   | 127                    | 1.359         |
| 86.6                   | 137                    | 1.367         |
| 82.5                   | 140                    | 1.375         |
| 80.6                   | 150                    | 1.383         |
| 78.7                   | 162                    | 1.391         |
| 75                     | 165                    | 1.398         |
| 73.2                   | 178                    | 1.406         |
| 71.5                   | 191                    | 1.414         |
| 69.8                   | 205                    | 1.422         |
| 68.1                   | 226                    | 1.430         |
| 374                    | 93.1                   | 1.438         |
| 340                    | 95.3                   | 1.445         |
| 316                    | 100                    | 1.453         |
| 287                    | 100                    | 1.461         |
| 267                    | 102                    | 1.469         |
| 255                    | 107                    | 1.477         |
| 237                    | 110                    | 1.484         |
| 221                    | 113                    | 1.492         |
| 21.5                   | Open                   | 1.500         |
| 200                    | 121                    | 1.508         |
| 191                    | 124                    | 1.516         |
| 182                    | 130                    | 1.523         |
| 174                    | 133                    | 1.531         |
| 165                    | 137                    | 1.539         |
| 158                    | 143                    | 1.547         |
| 150                    | 147                    | 1.555         |
| 147                    | 154                    | 1.562         |
| 140                    | 158                    | 1.570         |
| 137                    | 169                    | 1.578         |
| 130                    | 174                    | 1.586         |
| 127                    | 182                    | 1.594         |
| 124                    | 196                    | 1.602         |
| 118                    | 200                    | 1.609         |
| 115                    | 215                    | 1.617         |
| 113                    | 232                    | 1.625         |
| 110                    | 243                    | 1.633         |
| 105                    | 255                    | 1.641         |
| 102                    | 274                    | 1.648         |
| 100                    | 294                    | 1.656         |
| 97.6                   | 324                    | 1.664         |
| 523                    | 130                    | 1.672         |

Table 1. SET1 Resistor Reader (Continued)

| $R_{UP}$ (k $\Omega$ ) | $R_{DW}$ (k $\Omega$ ) | $V_{OUT}$ (V) |
|------------------------|------------------------|---------------|
| 475                    | 133                    | 1.680         |
| 442                    | 140                    | 1.688         |
| 402                    | 140                    | 1.695         |
| 374                    | 143                    | 1.703         |
| 357                    | 150                    | 1.711         |
| 332                    | 154                    | 1.719         |
| 309                    | 158                    | 1.727         |
| 294                    | 162                    | 1.734         |
| 280                    | 169                    | 1.742         |
| 267                    | 174                    | 1.750         |
| 255                    | 182                    | 1.758         |
| 243                    | 187                    | 1.766         |
| 232                    | 191                    | 1.773         |
| 221                    | 200                    | 1.781         |
| 210                    | 205                    | 1.789         |
| 34.8                   | Open                   | 1.797         |
| 196                    | 226                    | 1.805         |
| 191                    | 237                    | 1.812         |
| 182                    | 243                    | 1.820         |
| 178                    | 255                    | 1.828         |
| 174                    | 274                    | 1.836         |
| 165                    | 280                    | 1.914         |
| 162                    | 301                    | 1.992         |
| 158                    | 324                    | 2.070         |
| 154                    | 340                    | 2.148         |
| 147                    | 357                    | 2.227         |
| 143                    | 383                    | 2.305         |
| 140                    | 412                    | 2.383         |
| 137                    | 453                    | 2.461         |
| 732                    | 182                    | 2.469         |
| 665                    | 187                    | 2.477         |
| 619                    | 196                    | 2.484         |
| 576                    | 200                    | 2.492         |
| 52.3                   | Open                   | 2.500         |
| 499                    | 210                    | 2.508         |
| 464                    | 215                    | 2.516         |
| 432                    | 221                    | 2.523         |
| 412                    | 226                    | 2.602         |
| 392                    | 237                    | 2.68          |
| 374                    | 243                    | 2.758         |
| 357                    | 255                    | 2.836         |

Table 1. SET1 Resistor Reader (Continued)

| $R_{UP}$ (k $\Omega$ ) | $R_{DW}$ (k $\Omega$ ) | $V_{OUT}$ (V) |
|------------------------|------------------------|---------------|
| 340                    | 261                    | 2.914         |
| 324                    | 267                    | 2.992         |
| 75                     | Open                   | 3.000         |
| 309                    | 280                    | 3.070         |
| 301                    | 294                    | 3.148         |
| 287                    | 301                    | 3.227         |
| 274                    | 309                    | 3.281         |
| 267                    | 332                    | 3.289         |
| 105                    | Open                   | 3.297         |
| 249                    | 357                    | 3.305         |
| 243                    | 383                    | 3.312         |
| 232                    | 392                    | 3.320         |
| 226                    | 422                    | 3.328         |
| 221                    | 453                    | 3.406         |
| 215                    | 475                    | 3.484         |
| 205                    | 499                    | 3.562         |
| 200                    | 536                    | 3.641         |
| 196                    | 576                    | 3.719         |
| 191                    | 634                    | 3.797         |
| 1000                   | 249                    | 3.875         |
| 909                    | 255                    | 3.953         |
| 845                    | 267                    | 4.031         |
| 768                    | 267                    | 4.109         |
| 715                    | 274                    | 4.188         |
| 665                    | 280                    | 4.266         |
| 634                    | 294                    | 4.344         |
| 590                    | 301                    | 4.422         |
| 562                    | 309                    | 4.500         |
| 536                    | 324                    | 4.578         |
| 511                    | 332                    | 4.656         |
| 487                    | 348                    | 4.734         |
| 464                    | 357                    | 4.812         |
| 442                    | 365                    | 4.891         |
| 422                    | 383                    | 4.969         |
| 402                    | 392                    | 4.977         |
| 392                    | 412                    | 4.984         |
| 374                    | 422                    | 4.992         |
| 147                    | Open                   | 5.000         |
| 348                    | 464                    | 5.008         |
| 499                    | Open                   | 0.000         |

Table 2. SET2 Resistor Reader

| $R_{UP}$ (k $\Omega$ ) | $R_{DW}$ (k $\Omega$ ) | PFM     | Temperature Compensation ( $^{\circ}$ C) |
|------------------------|------------------------|---------|--|
| 29.4                   | 15                     | Enabled | +30                                      |
| 28                     | 15.4                   | Enabled | +30                                      |
| 26.7                   | 16.2                   | Enabled | +30                                      |
| 25.5                   | 16.5                   | Enabled | +30                                      |
| 24.3                   | 17.4                   | Enabled | +30                                      |
| 23.2                   | 17.8                   | Enabled | +30                                      |
| 22.1                   | 18.2                   | Enabled | +30                                      |
| 21                     | 19.1                   | Enabled | +30                                      |
| Open                   | 10                     | Enabled | +30                                      |
| Open                   | 10                     | Enabled | +30                                      |
| 45.3                   | 12.7                   | Enabled | +30                                      |
| 42.2                   | 13.3                   | Enabled | +30                                      |
| 38.3                   | 13.3                   | Enabled | +30                                      |
| 35.7                   | 13.7                   | Enabled | +30                                      |
| 34                     | 14.3                   | Enabled | +30                                      |
| 31.6                   | 14.7                   | Enabled | +30                                      |
| 20                     | 19.6                   | Enabled | +30                                      |
| 19.6                   | 20.5                   | Enabled | +30                                      |
| 18.7                   | 21.5                   | Enabled | +30                                      |
| 18.2                   | 22.6                   | Enabled | +30                                      |
| 17.4                   | 23.2                   | Enabled | +30                                      |
| 16.9                   | 24.3                   | Enabled | +30                                      |
| 16.5                   | 26.1                   | Enabled | +30                                      |
| 15.8                   | 26.7                   | Enabled | +30                                      |
| 15.4                   | 28.7                   | Enabled | +30                                      |
| 15                     | 30.1                   | Enabled | +30                                      |
| 14.7                   | 32.4                   | Enabled | +30                                      |
| 14                     | 34                     | Enabled | +30                                      |
| 13.7                   | 36.5                   | Enabled | +30                                      |
| 13.3                   | 39.2                   | Enabled | +30                                      |
| 13                     | 43.2                   | Enabled | +30                                      |
| 10                     | Open                   | Enabled | +30                                      |
| 63.4                   | 32.4                   | Enabled | +15                                      |
| 60.4                   | 33.2                   | Enabled | +15                                      |
| 57.6                   | 34.8                   | Enabled | +15                                      |
| 54.9                   | 35.7                   | Enabled | +15                                      |
| 52.3                   | 37.4                   | Enabled | +15                                      |
| 49.9                   | 38.3                   | Enabled | +15                                      |
| 47.5                   | 39.2                   | Enabled | +15                                      |
| 45.3                   | 41.2                   | Enabled | +15                                      |

Table 2. SET2 Resistor Reader (Continued)

| $R_{UP}$ (k $\Omega$ ) | $R_{DW}$ (k $\Omega$ ) | PFM     | Temperature Compensation ( $^{\circ}$ C) |
|------------------------|------------------------|---------|--|
| Open                   | 21.5                   | Enabled | +15                                      |
| 107                    | 26.7                   | Enabled | +15                                      |
| 97.6                   | 27.4                   | Enabled | +15                                      |
| 90.9                   | 28.7                   | Enabled | +15                                      |
| 82.5                   | 28.7                   | Enabled | +15                                      |
| 76.8                   | 29.4                   | Enabled | +15                                      |
| 71.5                   | 30.1                   | Enabled | +15                                      |
| 68.1                   | 31.6                   | Enabled | +15                                      |
| 43.2                   | 42.2                   | Enabled | +15                                      |
| 42.2                   | 44.2                   | Enabled | +15                                      |
| 40.2                   | 45.3                   | Enabled | +15                                      |
| 39.2                   | 48.7                   | Enabled | +15                                      |
| 37.4                   | 49.9                   | Enabled | +15                                      |
| 36.5                   | 52.3                   | Enabled | +15                                      |
| 34.8                   | 54.9                   | Enabled | +15                                      |
| 34                     | 57.6                   | Enabled | +15                                      |
| 33.2                   | 61.9                   | Enabled | +15                                      |
| 32.4                   | 66.5                   | Enabled | +15                                      |
| 30.9                   | 68.1                   | Enabled | +15                                      |
| 30.1                   | 73.2                   | Enabled | +15                                      |
| 29.4                   | 78.7                   | Enabled | +15                                      |
| 28.7                   | 84.5                   | Enabled | +15                                      |
| 28                     | 93.1                   | Enabled | +15                                      |
| 21.5                   | Open                   | Enabled | +15                                      |
| 102                    | 52.3                   | Enabled | +5                                       |
| 97.6                   | 53.6                   | Enabled | +5                                       |
| 93.1                   | 56.2                   | Enabled | +5                                       |
| 88.7                   | 57.6                   | Enabled | +5                                       |
| 84.5                   | 60.4                   | Enabled | +5                                       |
| 80.6                   | 61.9                   | Enabled | +5                                       |
| 76.8                   | 63.4                   | Enabled | +5                                       |
| 73.2                   | 66.5                   | Enabled | +5                                       |
| Open                   | 34.8                   | Enabled | +5                                       |
| 174                    | 43.2                   | Enabled | +5                                       |
| 158                    | 44.2                   | Enabled | +5                                       |
| 147                    | 46.4                   | Enabled | +5                                       |
| 133                    | 46.4                   | Enabled | +5                                       |
| 124                    | 47.5                   | Enabled | +5                                       |
| 118                    | 49.9                   | Enabled | +5                                       |
| 110                    | 51.1                   | Enabled | +5                                       |

Table 2. SET2 Resistor Reader (Continued)

| $R_{UP}$ (k $\Omega$ ) | $R_{DW}$ (k $\Omega$ ) | PFM     | Temperature Compensation ( $^{\circ}$ C) |
|------------------------|------------------------|---------|--|
| 69.8                   | 68.1                   | Enabled | +5                                       |
| 68.1                   | 71.5                   | Enabled | +5                                       |
| 64.9                   | 73.2                   | Enabled | +5                                       |
| 63.4                   | 78.7                   | Enabled | +5                                       |
| 60.4                   | 80.6                   | Enabled | +5                                       |
| 59                     | 84.5                   | Enabled | +5                                       |
| 57.6                   | 90.9                   | Enabled | +5                                       |
| 54.9                   | 93.1                   | Enabled | +5                                       |
| 53.6                   | 100                    | Enabled | +5                                       |
| 52.3                   | 105                    | Enabled | +5                                       |
| 49.9                   | 110                    | Enabled | +5                                       |
| 48.7                   | 118                    | Enabled | +5                                       |
| 47.5                   | 127                    | Enabled | +5                                       |
| 46.4                   | 137                    | Enabled | +5                                       |
| 45.3                   | 150                    | Enabled | +5                                       |
| 34.8                   | Open                   | Enabled | +5                                       |
| 154                    | 78.7                   | Enabled | Off                                      |
| 147                    | 80.6                   | Enabled | Off                                      |
| 140                    | 84.5                   | Enabled | Off                                      |
| 133                    | 86.6                   | Enabled | Off                                      |
| 127                    | 90.9                   | Enabled | Off                                      |
| 121                    | 93.1                   | Enabled | Off                                      |
| 115                    | 95.3                   | Enabled | Off                                      |
| 110                    | 100                    | Enabled | Off                                      |
| Open                   | 52.3                   | Enabled | Off                                      |
| 261                    | 64.9                   | Enabled | Off                                      |
| 237                    | 66.5                   | Enabled | Off                                      |
| 221                    | 69.8                   | Enabled | Off                                      |
| 200                    | 69.8                   | Enabled | Off                                      |
| 187                    | 71.5                   | Enabled | Off                                      |
| 178                    | 75                     | Enabled | Off                                      |
| 165                    | 76.8                   | Enabled | Off                                      |
| 105                    | 102                    | Enabled | Off                                      |
| 102                    | 107                    | Enabled | Off                                      |
| 97.6                   | 110                    | Enabled | Off                                      |
| 95.3                   | 118                    | Enabled | Off                                      |
| 90.9                   | 121                    | Enabled | Off                                      |
| 88.7                   | 127                    | Enabled | Off                                      |
| 86.6                   | 137                    | Enabled | Off                                      |
| 82.5                   | 140                    | Enabled | Off                                      |

Table 2. SET2 Resistor Reader (Continued)

| $R_{UP}$ (k $\Omega$ ) | $R_{DW}$ (k $\Omega$ ) | PFM      | Temperature Compensation ( $^{\circ}$ C) |
|------------------------|------------------------|----------|--|
| 80.6                   | 150                    | Enabled  | Off                                      |
| 78.7                   | 162                    | Enabled  | Off                                      |
| 75                     | 165                    | Enabled  | Off                                      |
| 73.2                   | 178                    | Enabled  | Off                                      |
| 71.5                   | 191                    | Enabled  | Off                                      |
| 69.8                   | 205                    | Enabled  | Off                                      |
| 68.1                   | 226                    | Enabled  | Off                                      |
| 52.3                   | Open                   | Enabled  | Off                                      |
| 221                    | 113                    | Disabled | +30                                      |
| 210                    | 115                    | Disabled | +30                                      |
| 200                    | 121                    | Disabled | +30                                      |
| 191                    | 124                    | Disabled | +30                                      |
| 182                    | 130                    | Disabled | +30                                      |
| 174                    | 133                    | Disabled | +30                                      |
| 165                    | 137                    | Disabled | +30                                      |
| 158                    | 143                    | Disabled | +30                                      |
| Open                   | 75                     | Disabled | +30                                      |
| 374                    | 93.1                   | Disabled | +30                                      |
| 340                    | 95.3                   | Disabled | +30                                      |
| 316                    | 100                    | Disabled | +30                                      |
| 287                    | 100                    | Disabled | +30                                      |
| 267                    | 102                    | Disabled | +30                                      |
| 255                    | 107                    | Disabled | +30                                      |
| 237                    | 110                    | Disabled | +30                                      |
| 150                    | 147                    | Disabled | +30                                      |
| 147                    | 154                    | Disabled | +30                                      |
| 140                    | 158                    | Disabled | +30                                      |
| 137                    | 169                    | Disabled | +30                                      |
| 130                    | 174                    | Disabled | +30                                      |
| 127                    | 182                    | Disabled | +30                                      |
| 124                    | 196                    | Disabled | +30                                      |
| 118                    | 200                    | Disabled | +30                                      |
| 115                    | 215                    | Disabled | +30                                      |
| 113                    | 232                    | Disabled | +30                                      |
| 110                    | 243                    | Disabled | +30                                      |
| 105                    | 255                    | Disabled | +30                                      |
| 102                    | 274                    | Disabled | +30                                      |
| 100                    | 294                    | Disabled | +30                                      |
| 97.6                   | 324                    | Disabled | +30                                      |
| 75                     | Open                   | Disabled | +30                                      |

Table 2. SET2 Resistor Reader (Continued)

| $R_{UP}$ (k $\Omega$ ) | $R_{DW}$ (k $\Omega$ ) | PFM      | Temperature Compensation ( $^{\circ}$ C) |
|------------------------|------------------------|----------|--|
| 309                    | 158                    | Disabled | +15                                      |
| 294                    | 162                    | Disabled | +15                                      |
| 280                    | 169                    | Disabled | +15                                      |
| 267                    | 174                    | Disabled | +15                                      |
| 255                    | 182                    | Disabled | +15                                      |
| 243                    | 187                    | Disabled | +15                                      |
| 232                    | 191                    | Disabled | +15                                      |
| 221                    | 200                    | Disabled | +15                                      |
| Open                   | 105                    | Disabled | +15                                      |
| 523                    | 130                    | Disabled | +15                                      |
| 475                    | 133                    | Disabled | +15                                      |
| 442                    | 140                    | Disabled | +15                                      |
| 402                    | 140                    | Disabled | +15                                      |
| 374                    | 143                    | Disabled | +15                                      |
| 357                    | 150                    | Disabled | +15                                      |
| 332                    | 154                    | Disabled | +15                                      |
| 210                    | 205                    | Disabled | +15                                      |
| 205                    | 215                    | Disabled | +15                                      |
| 196                    | 226                    | Disabled | +15                                      |
| 191                    | 237                    | Disabled | +15                                      |
| 182                    | 243                    | Disabled | +15                                      |
| 178                    | 255                    | Disabled | +15                                      |
| 174                    | 274                    | Disabled | +15                                      |
| 165                    | 280                    | Disabled | +15                                      |
| 162                    | 301                    | Disabled | +15                                      |
| 158                    | 324                    | Disabled | +15                                      |
| 154                    | 340                    | Disabled | +15                                      |
| 147                    | 357                    | Disabled | +15                                      |
| 143                    | 383                    | Disabled | +15                                      |
| 140                    | 412                    | Disabled | +15                                      |
| 137                    | 453                    | Disabled | +15                                      |
| 105                    | Open                   | Disabled | +15                                      |
| 432                    | 221                    | Disabled | +5                                       |
| 412                    | 226                    | Disabled | +5                                       |
| 392                    | 237                    | Disabled | +5                                       |
| 374                    | 243                    | Disabled | +5                                       |
| 357                    | 255                    | Disabled | +5                                       |
| 340                    | 261                    | Disabled | +5                                       |
| 324                    | 267                    | Disabled | +5                                       |
| 309                    | 280                    | Disabled | +5                                       |

Table 2. SET2 Resistor Reader (Continued)

| $R_{UP}$ (k $\Omega$ ) | $R_{DW}$ (k $\Omega$ ) | PFM      | Temperature Compensation ( $^{\circ}$ C) |
|------------------------|------------------------|----------|--|
| Open                   | 147                    | Disabled | +5                                       |
| 732                    | 182                    | Disabled | +5                                       |
| 665                    | 187                    | Disabled | +5                                       |
| 619                    | 196                    | Disabled | +5                                       |
| 576                    | 200                    | Disabled | +5                                       |
| 523                    | 200                    | Disabled | +5                                       |
| 499                    | 210                    | Disabled | +5                                       |
| 464                    | 215                    | Disabled | +5                                       |
| 301                    | 294                    | Disabled | +5                                       |
| 287                    | 301                    | Disabled | +5                                       |
| 274                    | 309                    | Disabled | +5                                       |
| 267                    | 332                    | Disabled | +5                                       |
| 255                    | 340                    | Disabled | +5                                       |
| 249                    | 357                    | Disabled | +5                                       |
| 243                    | 383                    | Disabled | +5                                       |
| 232                    | 392                    | Disabled | +5                                       |
| 226                    | 422                    | Disabled | +5                                       |
| 221                    | 453                    | Disabled | +5                                       |
| 215                    | 475                    | Disabled | +5                                       |
| 205                    | 499                    | Disabled | +5                                       |
| 200                    | 536                    | Disabled | +5                                       |
| 196                    | 576                    | Disabled | +5                                       |
| 191                    | 634                    | Disabled | +5                                       |
| 147                    | Open                   | Disabled | +5                                       |
| 590                    | 301                    | Disabled | Off                                      |
| 562                    | 309                    | Disabled | Off                                      |
| 536                    | 324                    | Disabled | Off                                      |
| 511                    | 332                    | Disabled | Off                                      |
| 487                    | 348                    | Disabled | Off                                      |
| 464                    | 357                    | Disabled | Off                                      |
| 442                    | 365                    | Disabled | Off                                      |
| 422                    | 383                    | Disabled | Off                                      |
| Open                   | 499                    | Disabled | Off                                      |
| 1000                   | 249                    | Disabled | Off                                      |
| 909                    | 255                    | Disabled | Off                                      |
| 845                    | 267                    | Disabled | Off                                      |
| 768                    | 267                    | Disabled | Off                                      |
| 715                    | 274                    | Disabled | Off                                      |
| 665                    | 280                    | Disabled | Off                                      |
| 634                    | 294                    | Disabled | Off                                      |

Table 2. SET2 Resistor Reader (Continued)

| $R_{UP}$ (k $\Omega$ ) | $R_{DW}$ (k $\Omega$ ) | PFM      | Temperature Compensation ( $^{\circ}$ C) |
|------------------------|------------------------|----------|--|
| 402                    | 392                    | Disabled | Off                                      |
| 392                    | 412                    | Disabled | Off                                      |
| 374                    | 422                    | Disabled | Off                                      |
| 365                    | 453                    | Disabled | Off                                      |
| 348                    | 464                    | Disabled | Off                                      |
| 340                    | 487                    | Disabled | Off                                      |
| 324                    | 511                    | Disabled | Off                                      |
| 316                    | 536                    | Disabled | Off                                      |
| 309                    | 576                    | Disabled | Off                                      |
| 301                    | 604                    | Disabled | Off                                      |
| 287                    | 634                    | Disabled | Off                                      |
| 280                    | 681                    | Disabled | Off                                      |
| 274                    | 732                    | Disabled | Off                                      |
| 267                    | 787                    | Disabled | Off                                      |
| 261                    | 866                    | Disabled | Off                                      |
| 499                    | Open                   | Disabled | Off                                      |

Table 3. SET3 Resistor Reader

| $R_{UP}$ (k $\Omega$ ) | $R_{DW}$ (k $\Omega$ ) | Ultrasonic PFM | Fault Behavior | $f_{SW}$ (kHz) | AV Gain |    |
|------------------------|------------------------|----------------|----------------|----------------|---------|----|
|                        |                        |                |                |                | 1x      | 2x |
| Open                   | 10                     | Disabled       | Retry          | 300            | 42      | 84 |
| 49.9                   | 12.4                   | Disabled       | Retry          | 300            | 36.5    | 73 |
| 45.3                   | 12.7                   | Disabled       | Retry          | 300            | 30.5    | 61 |
| 42.2                   | 13.3                   | Disabled       | Retry          | 300            | 24.5    | 49 |
| 38.3                   | 13.3                   | Disabled       | Retry          | 300            | 19      | 38 |
| 35.7                   | 13.7                   | Disabled       | Retry          | 300            | 13      | 26 |
| 34                     | 14.3                   | Disabled       | Retry          | 300            | 7       | 14 |
| 31.6                   | 14.7                   | Disabled       | Retry          | 300            | 1       | 2  |
| 29.4                   | 15                     | Disabled       | Retry          | 400            | 42      | 84 |
| 28                     | 15.4                   | Disabled       | Retry          | 400            | 36.5    | 73 |
| 26.7                   | 16.2                   | Disabled       | Retry          | 400            | 30.5    | 61 |
| 25.5                   | 16.5                   | Disabled       | Retry          | 400            | 24.5    | 49 |
| 24.3                   | 17.4                   | Disabled       | Retry          | 400            | 19      | 38 |
| 23.2                   | 17.8                   | Disabled       | Retry          | 400            | 13      | 26 |
| 22.1                   | 18.2                   | Disabled       | Retry          | 400            | 7       | 14 |
| 21                     | 19.1                   | Disabled       | Retry          | 400            | 1       | 2  |
| 20                     | 19.6                   | Disabled       | Retry          | 500            | 42      | 84 |
| 19.6                   | 20.5                   | Disabled       | Retry          | 500            | 36.5    | 73 |
| 18.7                   | 21.5                   | Disabled       | Retry          | 500            | 30.5    | 61 |
| 18.2                   | 22.6                   | Disabled       | Retry          | 500            | 24.5    | 49 |

Table 3. SET3 Resistor Reader (Continued)

| R <sub>UP</sub> (kΩ) | R <sub>DW</sub> (kΩ) | Ultrasonic PFM | Fault Behavior | f <sub>SW</sub> (kHz) | AV Gain |    |
|----------------------|----------------------|----------------|----------------|-----------------------|---------|----|
|                      |                      |                |                |                       | 1x      | 2x |
| 17.4                 | 23.2                 | Disabled       | Retry          | 500                   | 19      | 38 |
| 16.9                 | 24.3                 | Disabled       | Retry          | 500                   | 13      | 26 |
| 16.5                 | 26.1                 | Disabled       | Retry          | 500                   | 7       | 14 |
| 15.8                 | 26.7                 | Disabled       | Retry          | 500                   | 1       | 2  |
| 15.4                 | 28.7                 | Disabled       | Retry          | 600                   | 42      | 84 |
| 15                   | 30.1                 | Disabled       | Retry          | 600                   | 36.5    | 73 |
| 14.7                 | 32.4                 | Disabled       | Retry          | 600                   | 30.5    | 61 |
| 14                   | 34                   | Disabled       | Retry          | 600                   | 24.5    | 49 |
| 13.7                 | 36.5                 | Disabled       | Retry          | 600                   | 19      | 38 |
| 13.3                 | 39.2                 | Disabled       | Retry          | 600                   | 13      | 26 |
| 13                   | 43.2                 | Disabled       | Retry          | 600                   | 7       | 14 |
| 10                   | Open                 | Disabled       | Retry          | 600                   | 1       | 2  |
| Open                 | 21.5                 | Disabled       | Retry          | 700                   | 42      | 84 |
| 107                  | 26.7                 | Disabled       | Retry          | 700                   | 36.5    | 73 |
| 97.6                 | 27.4                 | Disabled       | Retry          | 700                   | 30.5    | 61 |
| 90.9                 | 28.7                 | Disabled       | Retry          | 700                   | 24.5    | 49 |
| 82.5                 | 28.7                 | Disabled       | Retry          | 700                   | 19      | 38 |
| 76.8                 | 29.4                 | Disabled       | Retry          | 700                   | 13      | 26 |
| 71.5                 | 30.1                 | Disabled       | Retry          | 700                   | 7       | 14 |
| 68.1                 | 31.6                 | Disabled       | Retry          | 700                   | 1       | 2  |
| 63.4                 | 32.4                 | Disabled       | Retry          | 850                   | 42      | 84 |
| 60.4                 | 33.2                 | Disabled       | Retry          | 850                   | 36.5    | 73 |
| 57.6                 | 34.8                 | Disabled       | Retry          | 850                   | 30.5    | 61 |
| 54.9                 | 35.7                 | Disabled       | Retry          | 850                   | 24.5    | 49 |
| 52.3                 | 37.4                 | Disabled       | Retry          | 850                   | 19      | 38 |
| 49.9                 | 38.3                 | Disabled       | Retry          | 850                   | 13      | 26 |
| 47.5                 | 39.2                 | Disabled       | Retry          | 850                   | 7       | 14 |
| 45.3                 | 41.2                 | Disabled       | Retry          | 850                   | 1       | 2  |
| 43.2                 | 42.2                 | Disabled       | Retry          | 1000                  | 42      | 84 |
| 42.2                 | 44.2                 | Disabled       | Retry          | 1000                  | 36.5    | 73 |
| 40.2                 | 45.3                 | Disabled       | Retry          | 1000                  | 30.5    | 61 |
| 39.2                 | 48.7                 | Disabled       | Retry          | 1000                  | 24.5    | 49 |
| 37.4                 | 49.9                 | Disabled       | Retry          | 1000                  | 19      | 38 |
| 36.5                 | 52.3                 | Disabled       | Retry          | 1000                  | 13      | 26 |
| 34.8                 | 54.9                 | Disabled       | Retry          | 1000                  | 7       | 14 |
| 34                   | 57.6                 | Disabled       | Retry          | 1000                  | 1       | 2  |
| Open                 | 34.8                 | Disabled       | Latch          | 300                   | 42      | 84 |
| 174                  | 43.2                 | Disabled       | Latch          | 300                   | 36.5    | 73 |
| 158                  | 44.2                 | Disabled       | Latch          | 300                   | 30.5    | 61 |
| 147                  | 46.4                 | Disabled       | Latch          | 300                   | 24.5    | 49 |

Table 3. SET3 Resistor Reader (Continued)

| R <sub>UP</sub> (kΩ) | R <sub>DW</sub> (kΩ) | Ultrasonic PFM | Fault Behavior | f <sub>SW</sub> (kHz) | AV Gain |    |
|----------------------|----------------------|----------------|----------------|-----------------------|---------|----|
|                      |                      |                |                |                       | 1x      | 2x |
| 133                  | 46.4                 | Disabled       | Latch          | 300                   | 19      | 38 |
| 124                  | 47.5                 | Disabled       | Latch          | 300                   | 13      | 26 |
| 118                  | 49.9                 | Disabled       | Latch          | 300                   | 7       | 14 |
| 110                  | 51.1                 | Disabled       | Latch          | 300                   | 1       | 2  |
| 102                  | 52.3                 | Disabled       | Latch          | 400                   | 42      | 84 |
| 97.6                 | 53.6                 | Disabled       | Latch          | 400                   | 36.5    | 73 |
| 93.1                 | 56.2                 | Disabled       | Latch          | 400                   | 30.5    | 61 |
| 88.7                 | 57.6                 | Disabled       | Latch          | 400                   | 24.5    | 49 |
| 84.5                 | 60.4                 | Disabled       | Latch          | 400                   | 19      | 38 |
| 80.6                 | 61.9                 | Disabled       | Latch          | 400                   | 13      | 26 |
| 76.8                 | 63.4                 | Disabled       | Latch          | 400                   | 7       | 14 |
| 73.2                 | 66.5                 | Disabled       | Latch          | 400                   | 1       | 2  |
| 69.8                 | 68.1                 | Disabled       | Latch          | 500                   | 42      | 84 |
| 68.1                 | 71.5                 | Disabled       | Latch          | 500                   | 36.5    | 73 |
| 64.9                 | 73.2                 | Disabled       | Latch          | 500                   | 30.5    | 61 |
| 63.4                 | 78.7                 | Disabled       | Latch          | 500                   | 24.5    | 49 |
| 60.4                 | 80.6                 | Disabled       | Latch          | 500                   | 19      | 38 |
| 59                   | 84.5                 | Disabled       | Latch          | 500                   | 13      | 26 |
| 57.6                 | 90.9                 | Disabled       | Latch          | 500                   | 7       | 14 |
| 54.9                 | 93.1                 | Disabled       | Latch          | 500                   | 1       | 2  |
| 53.6                 | 100                  | Disabled       | Latch          | 600                   | 42      | 84 |
| 52.3                 | 105                  | Disabled       | Latch          | 600                   | 36.5    | 73 |
| 49.9                 | 110                  | Disabled       | Latch          | 600                   | 30.5    | 61 |
| 48.7                 | 118                  | Disabled       | Latch          | 600                   | 24.5    | 49 |
| 47.5                 | 127                  | Disabled       | Latch          | 600                   | 19      | 38 |
| 46.4                 | 137                  | Disabled       | Latch          | 600                   | 13      | 26 |
| 45.3                 | 150                  | Disabled       | Latch          | 600                   | 7       | 14 |
| 34.8                 | Open                 | Disabled       | Latch          | 600                   | 1       | 2  |
| Open                 | 52.3                 | Disabled       | Latch          | 700                   | 42      | 84 |
| 261                  | 64.9                 | Disabled       | Latch          | 700                   | 36.5    | 73 |
| 237                  | 66.5                 | Disabled       | Latch          | 700                   | 30.5    | 61 |
| 221                  | 69.8                 | Disabled       | Latch          | 700                   | 24.5    | 49 |
| 200                  | 69.8                 | Disabled       | Latch          | 700                   | 19      | 38 |
| 187                  | 71.5                 | Disabled       | Latch          | 700                   | 13      | 26 |
| 178                  | 75                   | Disabled       | Latch          | 700                   | 7       | 14 |
| 165                  | 76.8                 | Disabled       | Latch          | 700                   | 1       | 2  |
| 154                  | 78.7                 | Disabled       | Latch          | 850                   | 42      | 84 |
| 147                  | 80.6                 | Disabled       | Latch          | 850                   | 36.5    | 73 |
| 140                  | 84.5                 | Disabled       | Latch          | 850                   | 30.5    | 61 |
| 133                  | 86.6                 | Disabled       | Latch          | 850                   | 24.5    | 49 |

Table 3. SET3 Resistor Reader (Continued)

| R <sub>UP</sub> (kΩ) | R <sub>DW</sub> (kΩ) | Ultrasonic PFM | Fault Behavior | f <sub>SW</sub> (kHz) | AV Gain |    |
|----------------------|----------------------|----------------|----------------|-----------------------|---------|----|
|                      |                      |                |                |                       | 1x      | 2x |
| 127                  | 90.9                 | Disabled       | Latch          | 850                   | 19      | 38 |
| 121                  | 93.1                 | Disabled       | Latch          | 850                   | 13      | 26 |
| 115                  | 95.3                 | Disabled       | Latch          | 850                   | 7       | 14 |
| 110                  | 100                  | Disabled       | Latch          | 850                   | 1       | 2  |
| 105                  | 102                  | Disabled       | Latch          | 1000                  | 42      | 84 |
| 102                  | 107                  | Disabled       | Latch          | 1000                  | 36.5    | 73 |
| 97.6                 | 110                  | Disabled       | Latch          | 1000                  | 30.5    | 61 |
| 95.3                 | 118                  | Disabled       | Latch          | 1000                  | 24.5    | 49 |
| 90.9                 | 121                  | Disabled       | Latch          | 1000                  | 19      | 38 |
| 88.7                 | 127                  | Disabled       | Latch          | 1000                  | 13      | 26 |
| 86.6                 | 137                  | Disabled       | Latch          | 1000                  | 7       | 14 |
| 82.5                 | 140                  | Disabled       | Latch          | 1000                  | 1       | 2  |

Table 4. SET4 Resistor Reader

| R <sub>UP</sub> (kΩ) | R <sub>DW</sub> (kΩ) | SS Rate (mV/μs) | RR (kΩ) | AVMLTI |
|----------------------|----------------------|-----------------|---------|--------|
| Open                 | 105                  | 0.157           | 200     | 1      |
| 332                  | 154                  | 0.157           | 200     | 2      |
| 309                  | 158                  | 0.157           | 400     | 1      |
| 221                  | 200                  | 0.157           | 400     | 2      |
| 210                  | 205                  | 0.157           | 600     | 1      |
| 165                  | 280                  | 0.157           | 600     | 2      |
| 162                  | 301                  | 0.157           | 800     | 1      |
| 105                  | Open                 | 0.157           | 800     | 2      |
| Open                 | 147                  | 0.315           | 200     | 1      |
| 464                  | 215                  | 0.315           | 200     | 2      |
| 432                  | 221                  | 0.315           | 400     | 1      |
| 309                  | 280                  | 0.315           | 400     | 2      |
| 301                  | 294                  | 0.315           | 600     | 1      |
| 232                  | 392                  | 0.315           | 600     | 2      |
| 226                  | 422                  | 0.315           | 800     | 1      |
| 147                  | Open                 | 0.315           | 800     | 2      |
| Open                 | 499                  | 0.625           | 200     | 1      |
| 634                  | 294                  | 0.625           | 200     | 2      |
| 590                  | 301                  | 0.625           | 400     | 1      |
| 422                  | 383                  | 0.625           | 400     | 2      |
| 402                  | 392                  | 0.625           | 600     | 1      |
| 316                  | 536                  | 0.625           | 600     | 2      |
| 309                  | 576                  | 0.625           | 800     | 1      |
| 499                  | Open                 | 0.625           | 800     | 2      |
| Open                 | 10                   | 1.25            | 200     | 1      |

Table 4. SET4 Resistor Reader (Continued)

| $R_{UP}$ (k $\Omega$ ) | $R_{DW}$ (k $\Omega$ ) | SS Rate (mV/ $\mu$ s) | RR (k $\Omega$ ) | AVMLTI |
|------------------------|------------------------|-----------------------|------------------|--------|
| 31.6                   | 14.7                   | 1.25                  | 200              | 2      |
| 29.4                   | 15                     | 1.25                  | 400              | 1      |
| 21                     | 19.1                   | 1.25                  | 400              | 2      |
| 20                     | 19.6                   | 1.25                  | 600              | 1      |
| 15.8                   | 26.7                   | 1.25                  | 600              | 2      |
| 15.4                   | 28.7                   | 1.25                  | 800              | 1      |
| 10                     | Open                   | 1.25                  | 800              | 2      |
| Open                   | 21.5                   | 2.5                   | 200              | 1      |
| 68.1                   | 31.6                   | 2.5                   | 200              | 2      |
| 63.4                   | 32.4                   | 2.5                   | 400              | 1      |
| 45.3                   | 41.2                   | 2.5                   | 400              | 2      |
| 43.2                   | 42.2                   | 2.5                   | 600              | 1      |
| 34                     | 57.6                   | 2.5                   | 600              | 2      |
| 33.2                   | 61.9                   | 2.5                   | 800              | 1      |
| 21.5                   | Open                   | 2.5                   | 800              | 2      |
| Open                   | 34.8                   | 5                     | 200              | 1      |
| 110                    | 51.1                   | 5                     | 200              | 2      |
| 102                    | 52.3                   | 5                     | 400              | 1      |
| 73.2                   | 66.5                   | 5                     | 400              | 2      |
| 69.8                   | 68.1                   | 5                     | 600              | 1      |
| 54.9                   | 93.1                   | 5                     | 600              | 2      |
| 53.6                   | 100                    | 5                     | 800              | 1      |
| 34.8                   | Open                   | 5                     | 800              | 2      |
| Open                   | 52.3                   | 10                    | 200              | 1      |
| 165                    | 76.8                   | 10                    | 200              | 2      |
| 154                    | 78.7                   | 10                    | 400              | 1      |
| 110                    | 100                    | 10                    | 400              | 2      |
| 105                    | 102                    | 10                    | 600              | 1      |
| 82.5                   | 140                    | 10                    | 600              | 2      |
| 80.6                   | 150                    | 10                    | 800              | 1      |
| 52.3                   | Open                   | 10                    | 800              | 2      |

### 3. PCB Layout Guidelines

The ISL8210MEVAL1Z is a 3x3 inch six-layer FR-4 board with 2oz. copper on all layers. The board can be used as a single 10A reference design. For board layout information, see [Figures 7](#) through [14](#) starting on page [27](#).

The ISL8210MEVAL1Z board layout is optimized for electrical performance, low loss, and good thermal performance. For similar performance in designs using the ISL8210M, use the following layout design tips:

#### 3.1 Layout Considerations

- (1) Renesas recommends using a six-layer PCB board. Use the top and bottom layer to route VIN and VOUT. Use a full ground plane in the internal layers (underneath the module) with shared SGND and PGND to simplify the layout design. Use another full ground plane directly above the bottom layer. Use the other internal layers to route the remote sense and PGOOD signals.
- (2) Place the input capacitors and high frequency decoupling ceramic capacitors between VIN and PGND as close to the module as possible. The loop formed by the input capacitors, VIN, and PGND must be as small as possible to minimize high frequency noise. Place the output ceramic capacitors close to VOUT. Use a copper plane to connect the output ceramic capacitors to the load to avoid any parasitic inductances and resistances. See [Figures 2](#) and [3](#) for an example layout.
- (3) Use large copper planes for power paths (VIN, VOUT, and PGND) to minimize conduction loss and thermal stress. Use multiple vias to connect the power planes in different layers.
- (4) Do not oversize the copper planes for the PHASE planes. Because the PHASE planes are subjected to very high dv/dt, the parasitic capacitor formed between these planes and the surrounding circuitry tends to couple the switching noise. Ensure that none of the sensitive signal traces are routed close to the PHASE plane.
- (5) Place the PVCC and VIN1 bypass capacitors underneath the PVCC and VIN1 pins and connect their grounds to the SGND. For the external pin-strap resistor dividers connected to SET1, SET2, SET3, and SET4, connect the low side dividers' ground to the SGND. If a local decoupling capacitor is used to bias these resistor dividers, place the decoupling capacitor close to the dividers and connect the capacitor's ground to the SGND. See [Figure 3](#) for an example layout.
- (6) Connect remote sensing traces to the regulation point to achieve a tight output voltage regulation. Route the remote sensing traces in parallel underneath the PGND layer and avoid routing the sensing trace near noisy planes such as PHASE. Place 2Ω resistors close to both VSEN and RGND to dampen the noise on the traces.

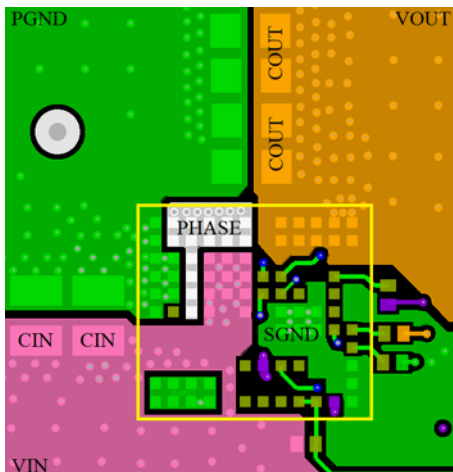


Figure 2. Layout Example - Top Layer

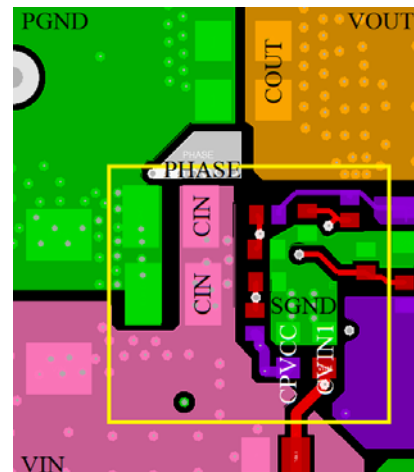


Figure 3. Layout Example - Bottom Layer



Figure 4. Top of Board

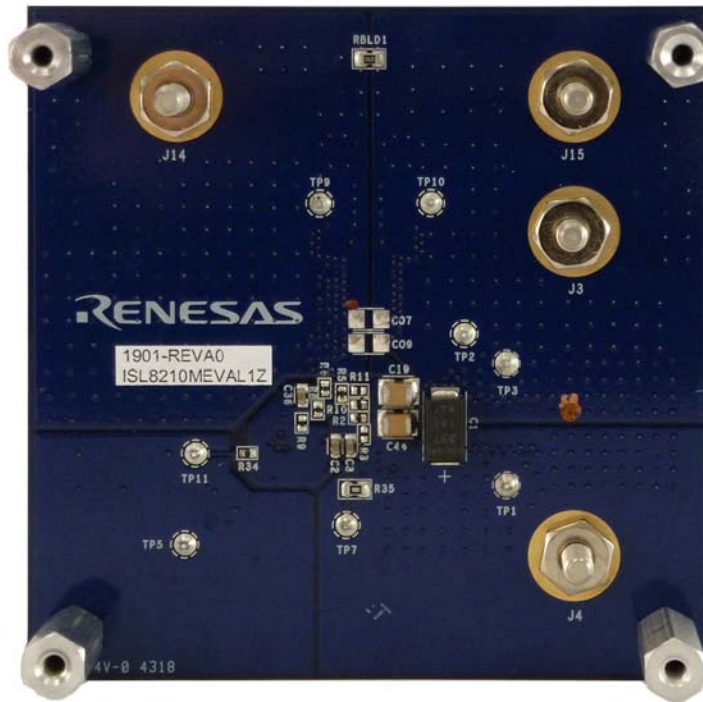


Figure 5. Bottom of Board



### 3.3 Bill of Materials

| Reference Designators    | Qty | Value          | Tol.      | Voltage | Power | Package Type | Manufacturer                 | Part Number        | Description              |
|--------------------------|-----|----------------|-----------|---------|-------|--------------|------------------------------|--------------------|--------------------------|
| C1                       | 1   | 330 $\mu$ F    | $\pm$ 20% | 16V     |       | 2917         | Kemet                        | T521X337M016ATE025 | POSCAP                   |
| C2, C36                  | 2   | 1 $\mu$ F      | $\pm$ 10% | 25V     |       | 0603         | Taiyo Yuden                  | TMK107BJ105KA-T    | Ceramic Capacitor        |
| C10, C11, C19, C44       | 4   | 22 $\mu$ F     | $\pm$ 10% | 25V     |       | 1210         | Murata                       | GRM32ER71E226KE15L | Ceramic Capacitor        |
| C3                       | 1   | 4.7 $\mu$ F    | $\pm$ 10% | 10V     |       | 0603         |                              |                    | Ceramic Capacitor        |
| C4                       | 1   | 1 $\mu$ F      | $\pm$ 10% | 16V     |       | 0603         | TDK                          | C1608X7R1C105K     | Ceramic Capacitor        |
| CO5, CO6, CO8, C10       | 4   | 220 $\mu$ F    | $\pm$ 20% | 6.3V    |       | 1206         | Murata                       | GRM31CR60J227ME11L | Ceramic Capacitor        |
| C37, C39, CO7, CO9, CO11 | 5   |                |           |         |       |              |                              |                    | DNP                      |
| J3, J15                  | 2   |                |           |         |       |              | Cinch Connectivity Solutions | 111-0703-001       | Binging Post (Black)     |
| J4, J14                  | 2   |                |           |         |       |              | Cinch Connectivity Solutions | 111-0702-001       | Binging Post (Red)       |
| RBLD1                    | 1   | 121 $\Omega$   | $\pm$ 1%  |         | 1/10W | 0805         |                              |                    | Thick Film Chip Resistor |
| RTM1                     | 1   | 1.54k $\Omega$ | $\pm$ 1%  |         | 1/16W | 0402         |                              |                    | Thick Film Chip Resistor |
| R2                       | 1   | 75k $\Omega$   | $\pm$ 1%  |         | 1/16W | 0402         |                              |                    | Thick Film Chip Resistor |
| R4                       | 1   | 100k $\Omega$  | $\pm$ 1%  |         | 1/16W | 0402         |                              |                    | Thick Film Chip Resistor |
| R5                       | 1   | 154k $\Omega$  | $\pm$ 1%  |         | 1/16W | 0402         |                              |                    | Thick Film Chip Resistor |
| R6                       | 1   | 332k $\Omega$  | $\pm$ 1%  |         | 1/16W | 0402         |                              |                    | Thick Film Chip Resistor |
| R8                       | 1   | 16.5k $\Omega$ | $\pm$ 1%  |         | 1/16W | 0402         |                              |                    | Thick Film Chip Resistor |
| R9                       | 1   | 25.5k $\Omega$ | $\pm$ 1%  |         | 1/16W | 0402         |                              |                    | Thick Film Chip Resistor |
| R10                      | 1   | 147k $\Omega$  | $\pm$ 1%  |         | 1/16W | 0402         |                              |                    | Thick Film Chip Resistor |
| R12                      | 1   | 24.9k $\Omega$ | $\pm$ 1%  |         | 1/16W | 0402         |                              |                    | Thick Film Chip Resistor |
| R30, R31                 | 2   | 2 $\Omega$     | $\pm$ 1%  |         | 1/16W | 0402         | Vishay                       | CRCW04022R00FKED   | Thick Film Chip Resistor |
| R34                      | 1   | 20k $\Omega$   | $\pm$ 1%  |         | 1/16W | 0402         |                              |                    | Thick Film Chip Resistor |
| R35                      | 1   | 0 $\Omega$     | $\pm$ 1%  |         | 1/10W | 0805         |                              |                    | Thick Film Chip Resistor |
| R3, R11                  | 2   |                |           |         |       |              |                              |                    | DNP                      |

| Reference Designators             | Qty | Value | Tol. | Voltage | Power | Package Type | Manufacturer | Part Number | Description   |
|-----------------------------------|-----|-------|------|---------|-------|--------------|--------------|-------------|---|
| SW1                               | 1   |       |      |         |       |              | C&K          | GT11MSCBE   | Switch Toggle<br>SPDT 0.4VA<br>20V  |
| TP1-TP3,<br>TP5, TP7,<br>TP9-TP11 | 8   |       |      |         |       | Through Hole | Keystone     | 5002        | Miniature PC<br>Test Point,<br>Silver Plating<br>0.040"<br>(1.02mm) Hole<br>Diameter<br>Mounting Type |
| U1                                | 1   |       |      |         |       | 12x11<br>HDA | Renesas      | ISL8210MFRZ | 10A Step-Down<br>Power Module   |

### 3.4 Board Layout

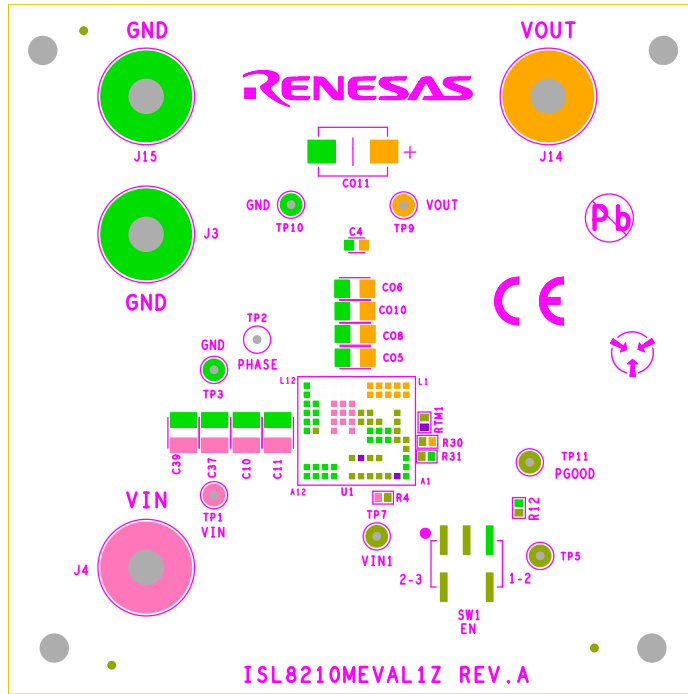


Figure 7. Silkscreen Top

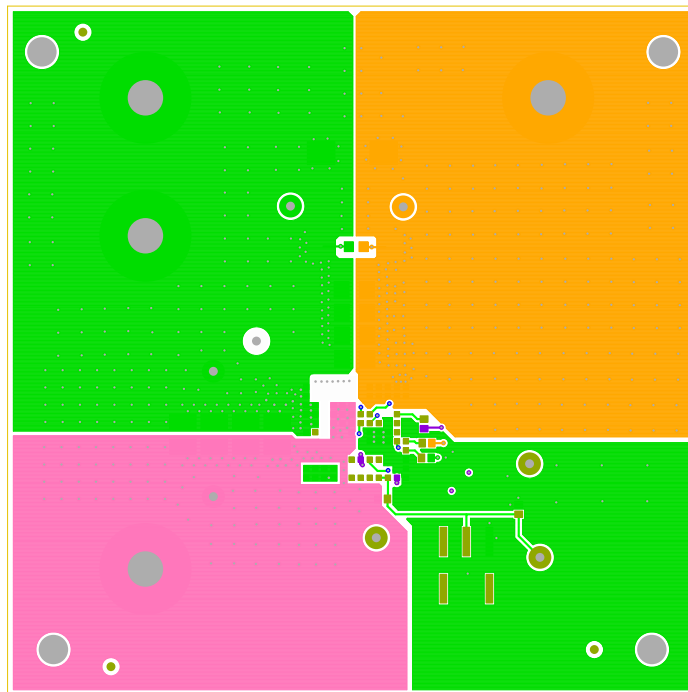


Figure 8. Top Layer Component Side

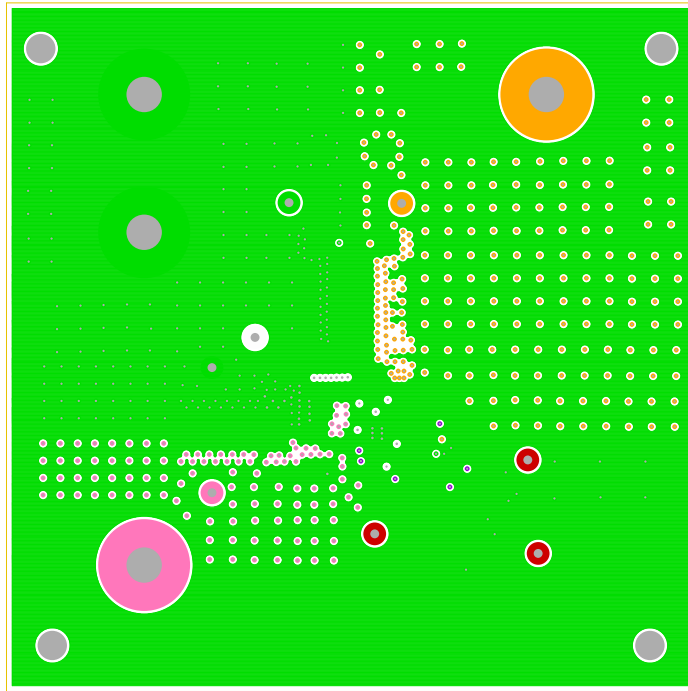


Figure 9. Inner Layer 2

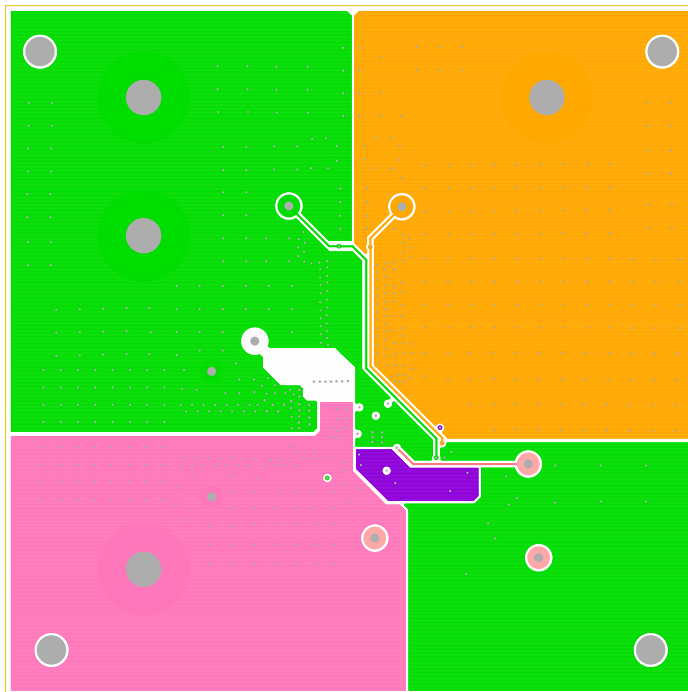


Figure 10. Inner Layer 3

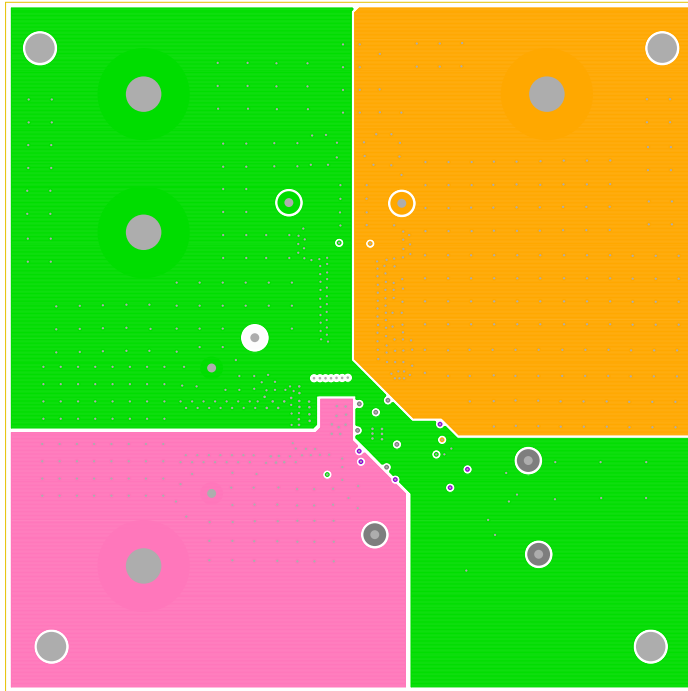


Figure 11. Inner Layer 4

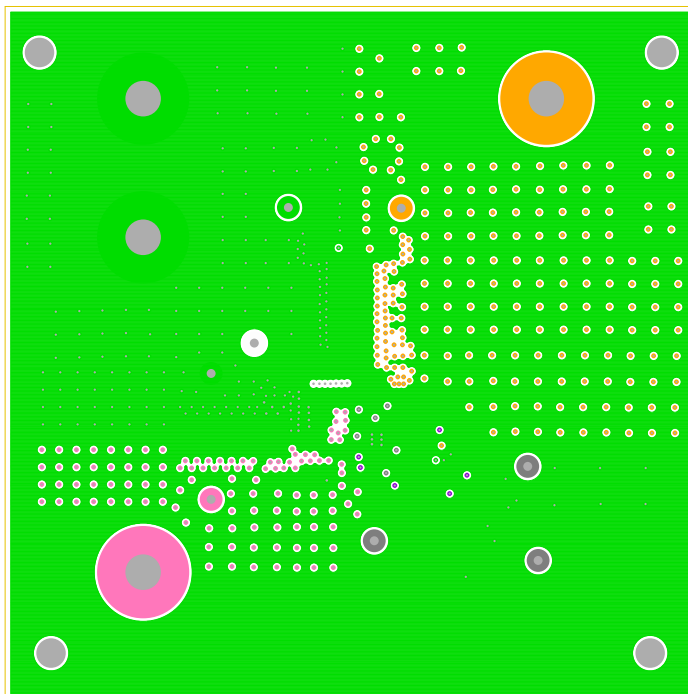


Figure 12. Inner Layer 5

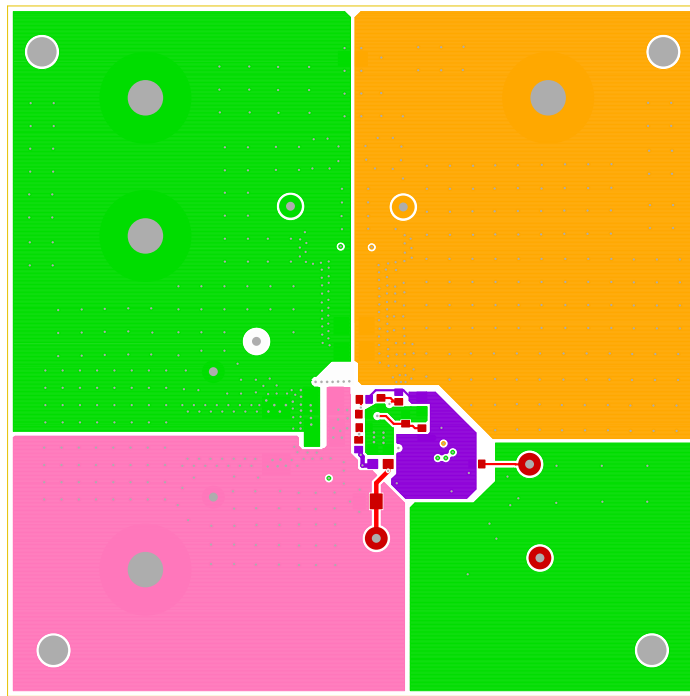


Figure 13. Bottom Layer Solder Side

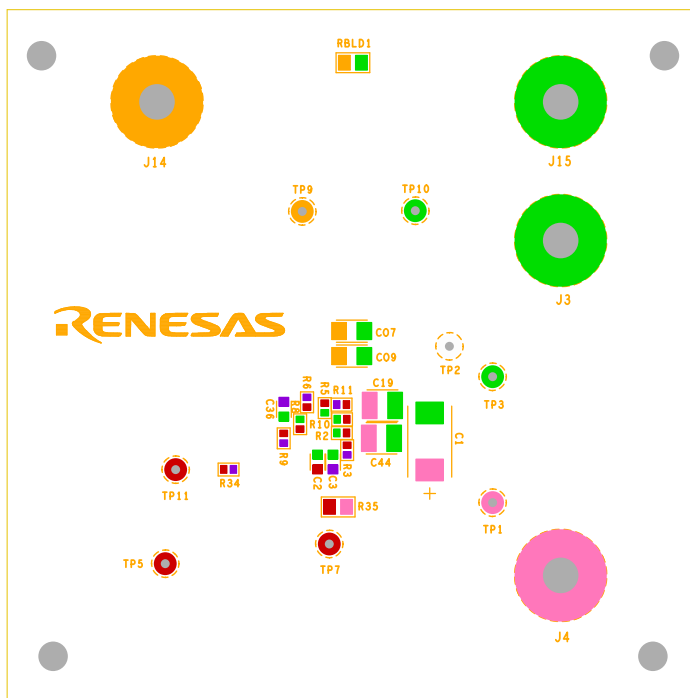


Figure 14. Silkscreen Bottom

### 4. Typical Performance Data

The following data was acquired using the ISL8210MEVAL1Z at +25°C ambient temperature and free air 0LFM. See the “ISL8210M Design Guide Matrix of Typical Applications” table in the [ISL8210M](#) datasheet for recommended configurations of different output voltages.

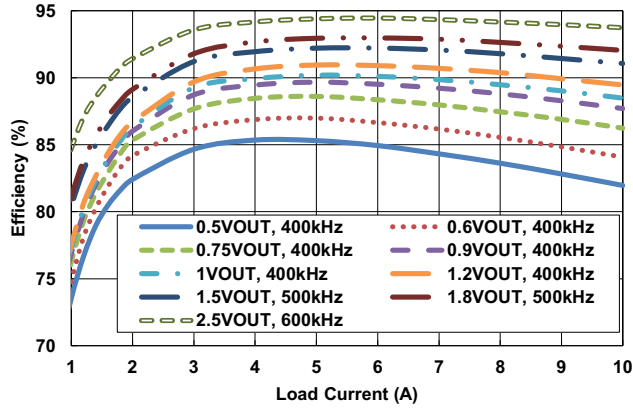


Figure 15. Efficiency vs Load Current at 5V<sub>IN</sub> (PWM)

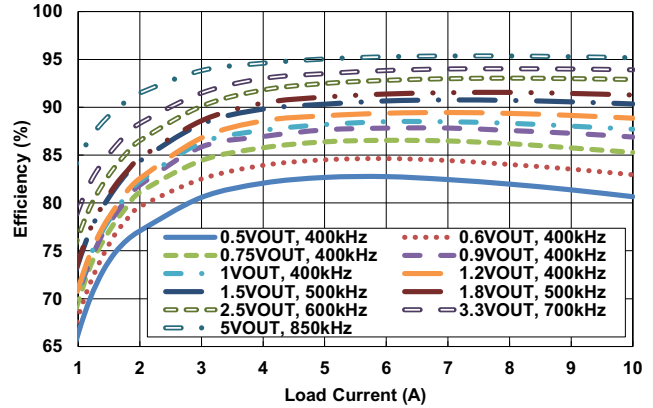


Figure 16. Efficiency vs Load Current at 8V<sub>IN</sub> (PWM)

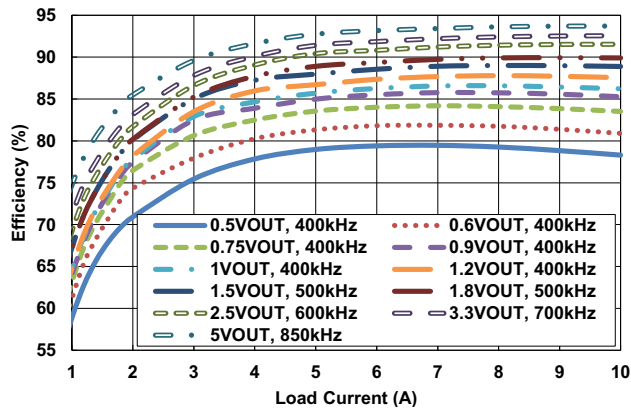


Figure 17. Efficiency vs Load Current at 12V<sub>IN</sub> (PWM)

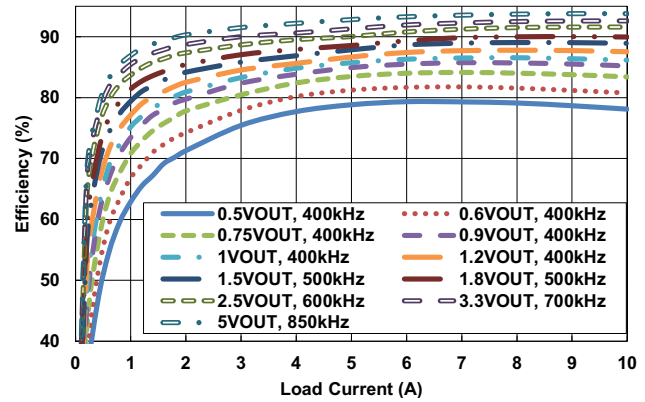


Figure 18. Efficiency vs Load Current at 12V<sub>IN</sub> (PFM)

### 5. Typical Performance Curves

Operating conditions:  $V_{IN} = 12V$ ,  $f_{SW} = 400kHz$ , AV gain = 49, RR = 200k $\Omega$ ,  $C_{OUT} = 4 \times 220\mu F$  Ceramic, PWM mode, unless otherwise noted.

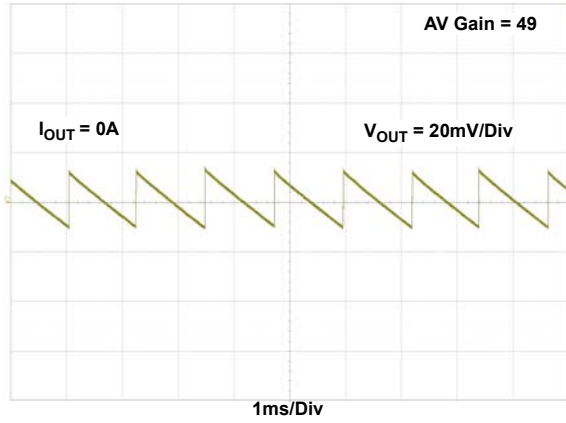


Figure 19. Output Ripple,  $V_{IN} = 12V$ ,  $V_{OUT} = 1V$ , PFM Mode

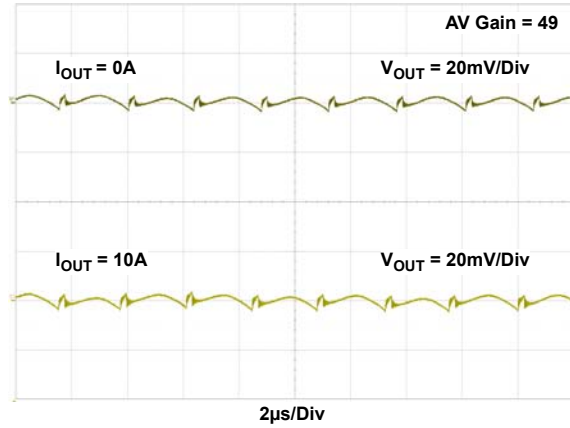


Figure 20. Output Ripple at  $12V_{IN}$  and  $1V_{OUT}$ , 400kHz

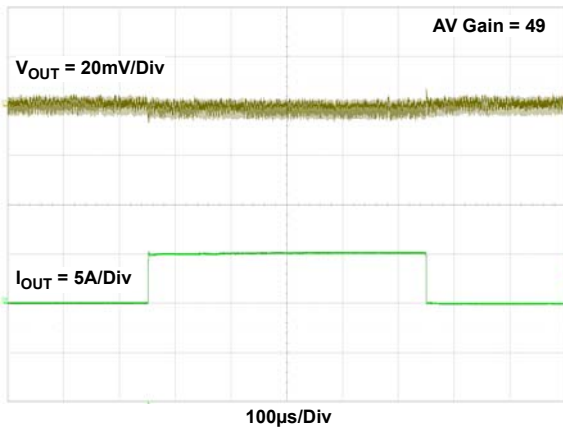


Figure 21. Load Transient Response at  $1V_{OUT}$ , 400kHz

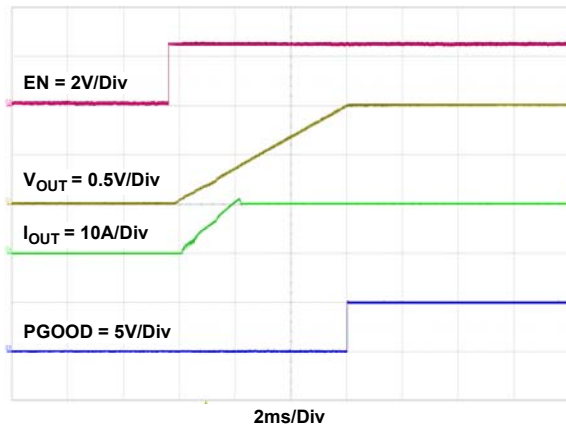


Figure 22. Start-Up Waveform,  $I_{OUT} = 10A$

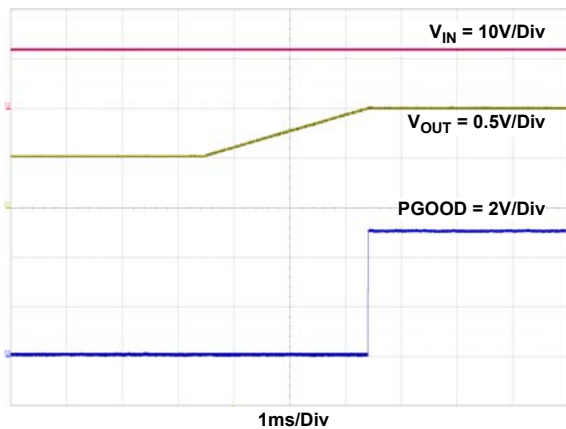


Figure 23. Prebiased Power-Up Waveform, Prebiased Voltage = 0.5V,  $V_{OUT} = 1V$ ,  $I_{OUT} = \text{No Load}$

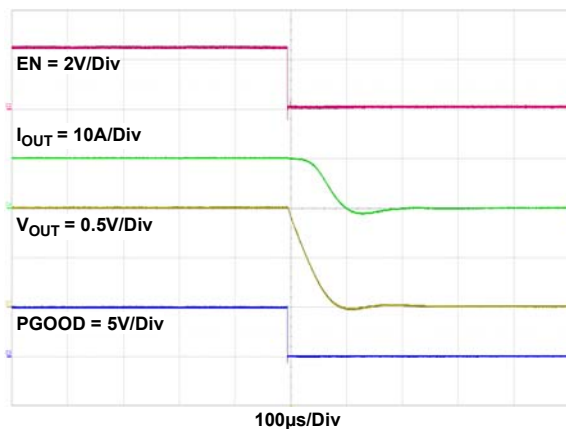


Figure 24. Shutdown Waveform,  $I_{OUT} = 10A$

Operating conditions:  $V_{IN} = 12V$ ,  $f_{SW} = 400kHz$ , AV gain = 49, RR = 200k $\Omega$ ,  $C_{OUT} = 4 \times 220\mu F$  Ceramic, PWM mode, unless otherwise noted. **(Continued)**

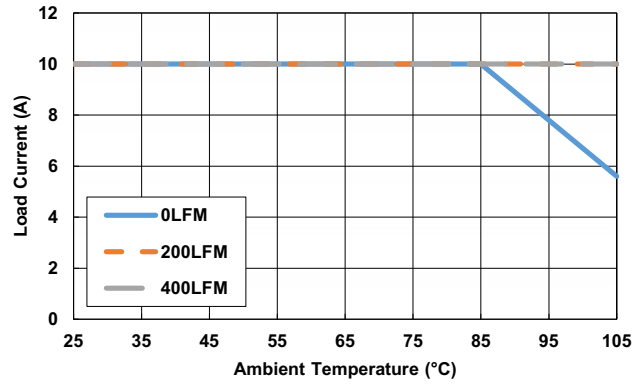


Figure 25. Derating Curve,  $V_{OUT} = 1V$

## 6. Revision History

| Rev. | Date         | Description                  |
|------|--------------|------------------------------|
| 1.01 | Feb 13, 2019 | Updated Figures 1, 2, and 3. |
| 1.00 | Feb 12, 2019 | Initial release              |

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