## ISL9440BEVAL1Z

Evaluation Board: Triple PWM Step-Down Synchronous Buck Controller
and One LDO

The ISL9440BEVAL1Z evaluation board features the ISL9440B. The ISL9440B is quad-output controller that integrates three PWM synchronous buck controllers and one low-dropout linear regulator controller. Then ISL9440B offers programmable soft-start, independent enable functions and integrates OV/OC/OT protection. The current mode control architecture and internal compensation network keep peripheral components to a minimum. The strong gate drivers of the ISL9440B are capable of driving 20A current for PWM1 and PWM2 and 15A for PWM3.

Table 1 shows the difference in terms of ISL944xx family features.

**TABLE 1. FEATURES OF ISL944X FAMILY**

| PART NUMBER | EARLY WARNING | SWITCHING FREQUENCY (kHz) | SOFT-STARTING TIME (ms) |
|---|---|---|---|
| ISL9440 | YES | 300 | 1.7 |
| ISL9440A | YES | 600 | 1.7 |
| ISL9441 | NO | 300 | 1.7 |
| ISL9440B | YES | 300 | PROGRAMMABLE |
| ISL9440C | YES | 600 | PROGRAMMABLE |

The ISL9440BEVAL1Z is easy to set up to evaluate the performance of the ISL9440B. Please refer to the "Electrical Specifications" for typical performance summary.

## Electrical Specifications

Recommended operation conditions, unless otherwise noted. Refer to schematic and typical performance curves.

| PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNITS |
|---|---|---|---|---|---|
| $V_{IN}$ | All outputs are in regulation | 15 | 19 | 23 | V |
| $V_{OUT}1$ | | 4.85 | 5.0 | 5.15 | V |
| $V_{OUT}2$ | | 3.25 | 3.32 | 3.4 | V |
| $V_{OUT}3$ | | 11.64 | 12.0 | 12.36 | V |
| $V_{OUT}4$ | | 2.47 | 2.50 | 2.58 | V |
| PWM1 Rated Current | $V_{IN}$ = 19V, $T_A$ = +25°C, No forced airflow, All three PWM outputs are fully loaded | | 15 | 18 | A |
| PWM2 Rated Current | | | 15 | 18 | A |
| PWM3 Rated Current | | | 12 | 14 | A |
| LDO Rated Current | R7 = 0$\Omega$, R4 is not populated | | 0.8 | 1.0 | A |
| $V_{OUT}1$ Peak-to-Peak Ripple | $V_{IN}$ = 23V, All three PWM outputs are fully loaded, Oscilloscope is with full bandwidth. | | 83 | | $mV_{P-P}$ |
| $V_{OUT}2$ Peak-to-Peak Ripple | | | 61 | | $mV_{P-P}$ |
| $V_{OUT}3$ Peak-to-Peak Ripple | | | 109 | | $mV_{P-P}$ |

## *What's Insides*

The Evaluation Board Kit contains the following materials:

• The ISL9440BEVAL1Z

• The ISL9440B, ISL9440C datasheet

• This EVAL KIT document

## *Recommended Equipment*

The following materials are recommended to perform testing:

• 0V to 24V power supply with at least 20A source current capability

• Three electronics loads capable of sinking current up to 20A

• Digital multimeters (DMMs)

• 100MHz quad-trace Oscilloscope

• Signal generator (for load transient tests)

## *Quick Set-up Guide*

1. Ensure that the circuit is correctly connected to the supply and electronics loads prior to applying any power. Please refer to Figure 1 for proper set-up.

2. Connect Jumpers J3, J4 and J5 in the ENx positions.

3. Turn on the power supply

4. Adjust input voltage $V_{IN}$ within the specified range and observe output voltage. The output voltage variation should be within 3%.

5. Adjust load current within the specified range and observe output voltage. The output voltage variation should be within 3%.

6. Use oscilloscope to observe output voltage ripple and Phase node ringing. For accurate measurement, refer to Figure 2 for proper test set-up.
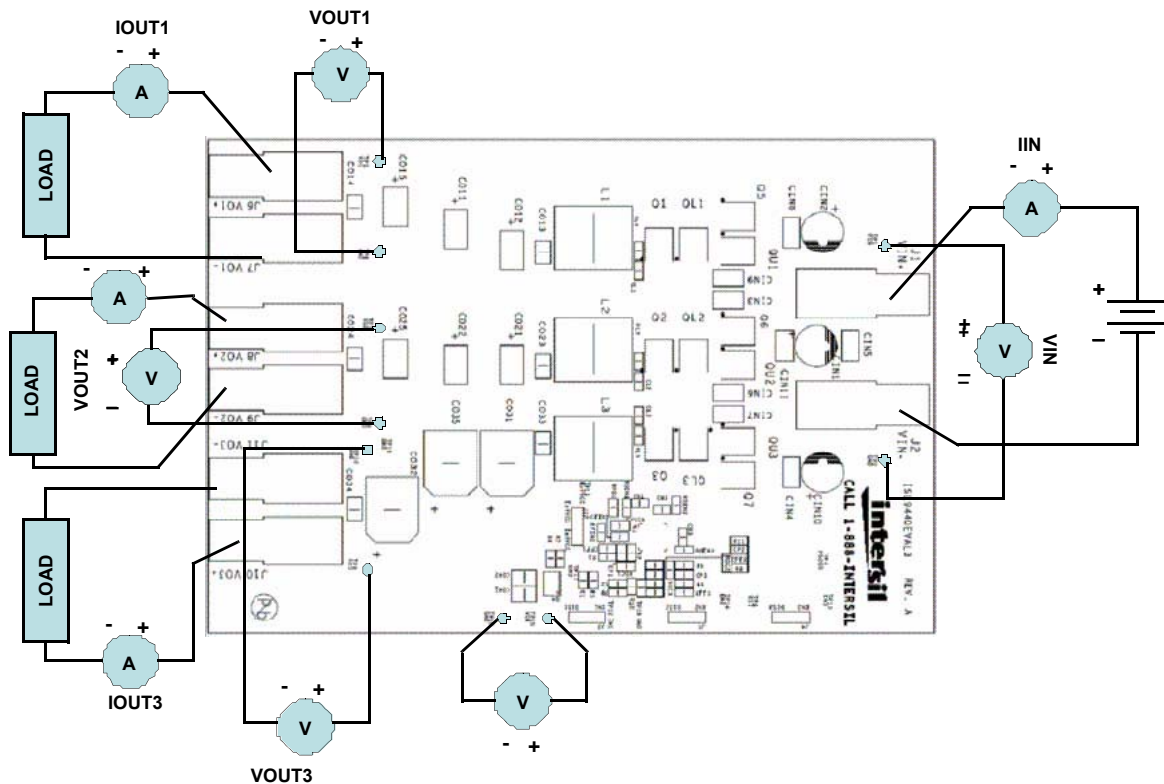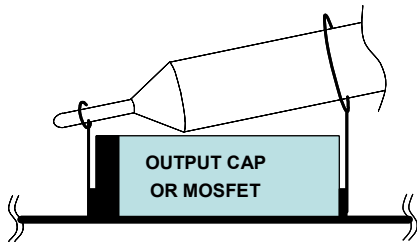


**FIGURE 1.  PROPER TEST SET-UP**

**FIGURE 2. PROPER PROBE SET-UP TO MEASURE OUTPUT RIPPLE AND PHASE NODE RINGING.**

## Load Transient Circuit Set-up

1. Select a DPAK N channel MOSFET with VDSS breakdown > 20V.

2. Install the load transient circuit as indicated on the schematic. Refer to Figure 3 for details.

3. R12, R14, R16 are 10kΩ resistors for discharging the MOSFET gates.

4. R13, R15 and R17 are current sensing resistors to monitor the load step. For accurate measurement, please use 5% tolerance sensing resistor or better. To alleviate thermal stress, use 0.1Ω or smaller resistance. The resistance of the sensing resistors sets the current scale on the oscilloscope.

5. Apply pulse square waveform to the ISTEP_CLK1, ISTEP_CLK2 and ISTEP_CLK3. The duty cycle of the pulse waveform should be small (<5%) to limit thermal stress on current sensing resistor and the MOSFETs (Q8, Q9 and Q10

6. The amplitude of the clock sets the current step amplitude. Adjust the clock amplitude and slew rate to set the current step and slew rate.

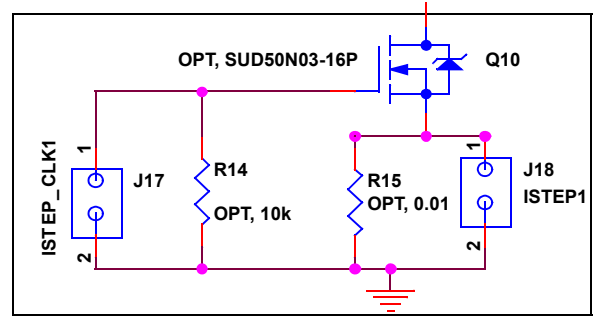7. Monitor overshoot and undershoot at corresponding output.



**FIGURE 3. LOAD TRANSIENT CIRCUIT FOR PWM1**

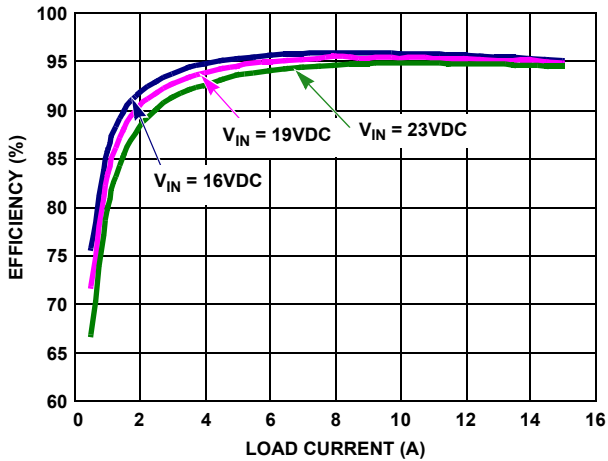## Typical Evaluation Board Performance Curves

$V_{IN}$ = 9V, unless otherwise specified.



**FIGURE 4. PWM1 EFFICIENCY vs LOAD ($V_O$ = 5.0V)**
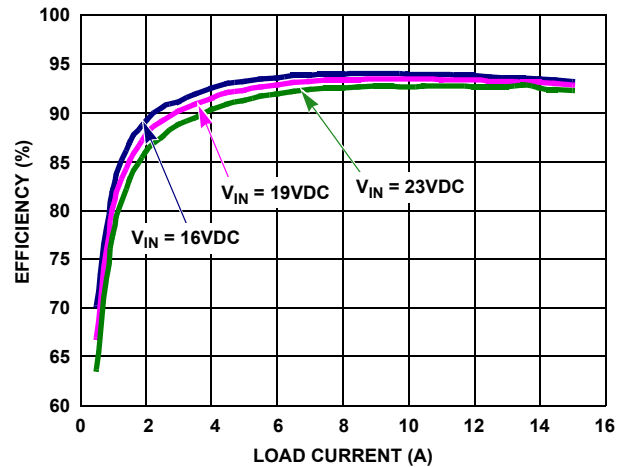


**FIGURE 5. PWM2 EFFICIENCY vs LOAD ($V_O$ = 3.3V)**

## *Typical Evaluation Board Performance Curves* $V_{IN}$ = 9V, unless otherwise specified. **(Continued)**
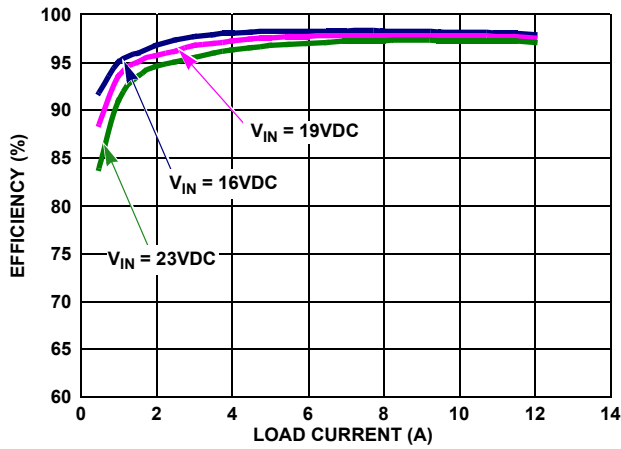


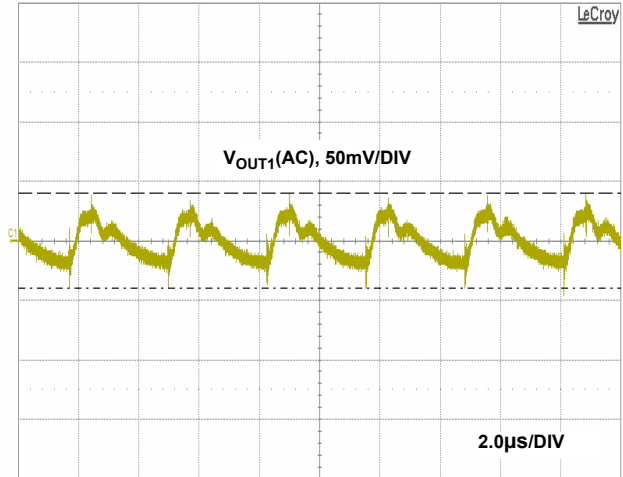FIGURE 6. PWM3 EFFICIENCY vs LOAD ($V_O$ = 12V)



FIGURE 7. PWM1 OUTPUT RIPPLE UNDER MAX LOAD
($V_{IN}$ = 23V, $I_{O1}$ = $I_{O2}$ = 15A, $I_{O3}$ = 12A, FULL
BANDWIDTH
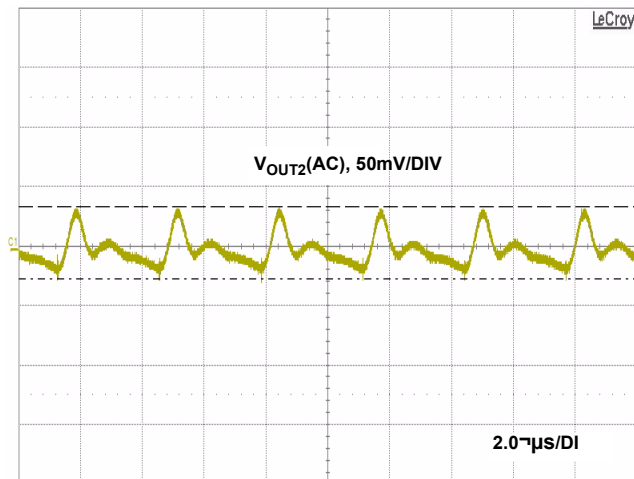


FIGURE 8. PWM2 OUTPUT RIPPLE UNDER MAX LOAD
($V_{IN}$ = 23V, $I_{O1}$ = $I_{O2}$ = 15A, $I_{O3}$ = 12A, FULL
BANDWIDTH
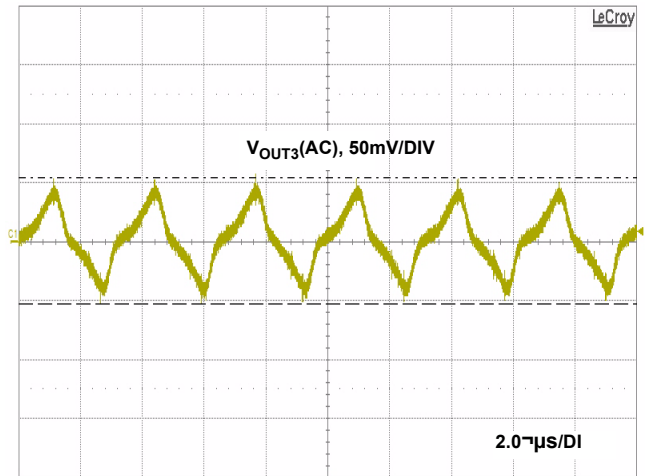


FIGURE 9. PWM3 OUTPUT RIPPLE UNDER MAX LOAD
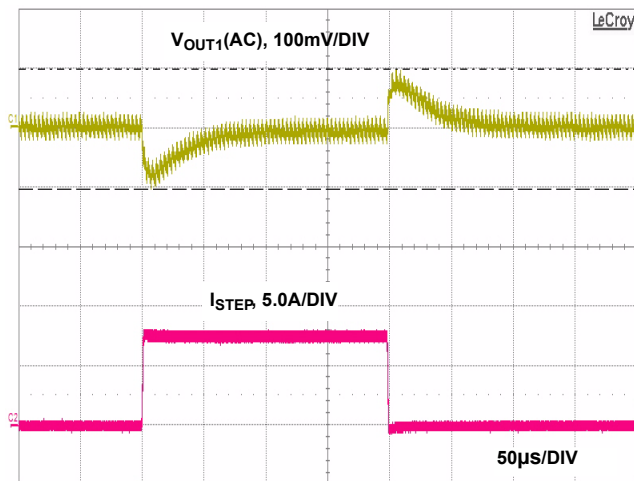($V_{IN}$ = 23V, $I_{O1}$ = $I_{O2}$ = 15A, $I_{O3}$ = 12A, FULL
BANDWIDTH



FIGURE 10. PWM1 LOAD TRANSIENT RESPONSE
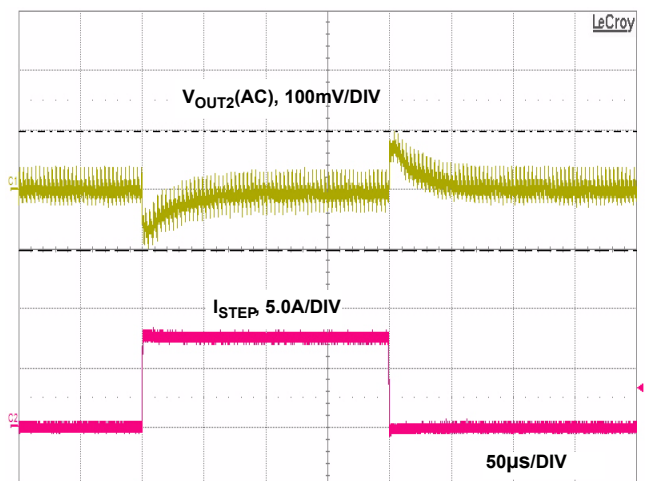(LOAD STEP FROM 3.75A TO 11.25A



FIGURE 11. PWM2 LOAD TRANSIENT RESPONSE
(LOAD STEP FROM 3.75A TO 11.25A

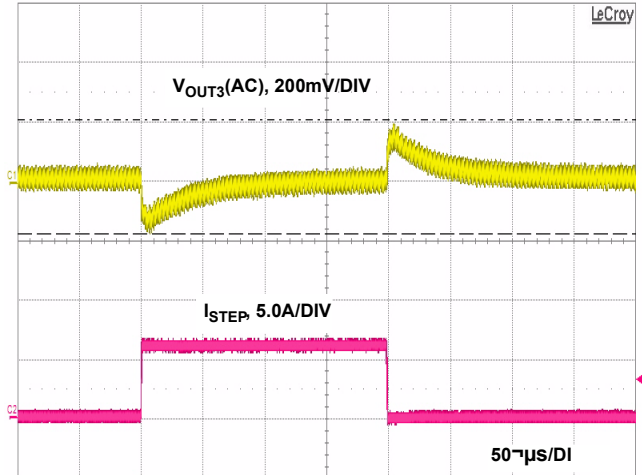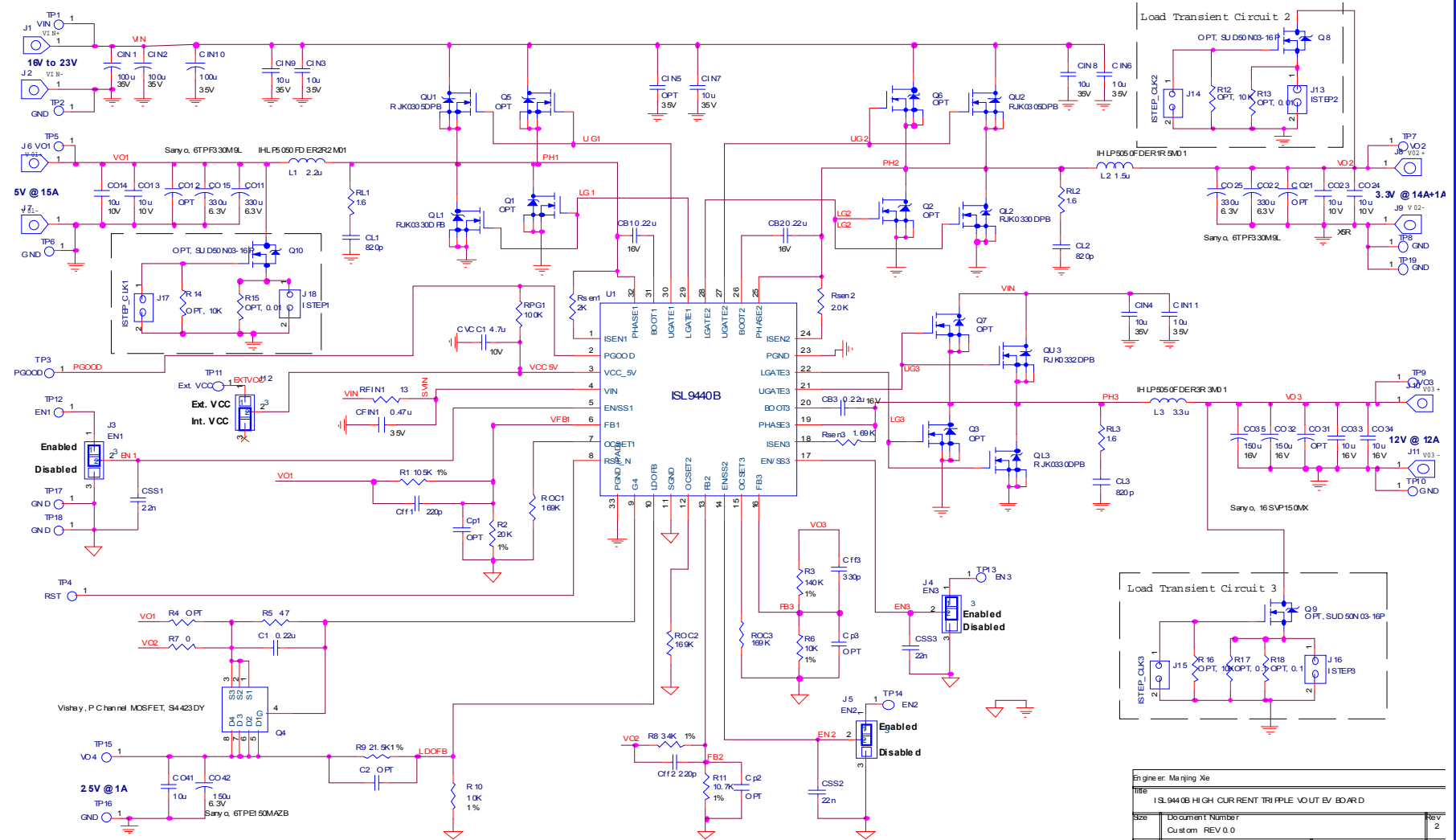## *Typical Evaluation Board Performance Curves* $V_{IN}$ = 9V, unless otherwise specified. **(Continued)**



**FIGURE 12. PWM3 LOAD TRANSIENT RESPONSE (LOAD STEP FROM 3A TO 9A)**

ISL9440BEVAL1Z

## Schematic

Load Transient Circuit 2

OPT, SUD50N03-16P   Q8
ISTEP_CLK2
J14   R12 OPT, 10K   R13 OPT, 0.0   J13 ISTEP2

**16 to 23V**
J1 VIN   TP1 VIN   VIN+
J2   VIN-   GND   TP2

CIN1 100u 35V   CIN2 100u 35V   CIN10 100u 35V
CIN9 10u 35V   CIN3 10u 3.5V
CIN5 OPT 3.5V   CIN7 10u 35V
CIN8 10u 35V   CIN6 10u 35V

QU1 RJK0305DPB   Q5 OPT
Q6 OPT   QU2 RJK0305DPB

J6 VO1   TP5   VO1   Sanyo, 6TPF330M9L   IHLP5050FDER2R2M01   L1 2.2u   PH1   UG1   UG2   PH2   IHLP5050FDER1R5M01   L2 1.5u   VO2   TP7 VO2+
**5V @ 15A**
J7   VO1-   CO14 10u 10V   CO13 10u 10V   CO12 OPT   CO15 330u 6.3V   CO11 330u 6.3V   RL1 1.6   CL1 820p   QL1 RJK0330PB   Q1 OPT   LG1   CB1 0.22u 16V   Rsen1 2K   Rsen2 2.0K   CB2 0.22u 16V   LG2   Q2 OPT   QL2 RJK0330DPB   RL2 1.6   CL2 820p   CO25 330u 6.3V   CO22 330u 6.3V   CO21 OPT   CO23 10u 10V   CO24 10u 10V   **3.3V @ 14A+1A**   J8 VO2+
TP6 GND   OPT, SUD50N03-16P Q10   ISTEP_CLK1   J17   R14 OPT, 10K   R15 OPT, 0.0   J18 ISTEP1   Sanyo, 6TPF330M9L   X5R   J9 VO2-   TP8 GND   TP19 GND

U1 ISL9440B

PHASE1 32   BOOT1 31   UGATE1 30   LGATE1 29   LGATE2 28   UGATE2 27   BOOT2 26   PHASE2 25
1 ISEN1   ISEN2 24
2 PGOOD   PGND 23
3 VCC_5V   LGATE3 22
4 VIN   UGATE3 21
5 EN/SS1   BOOT3 20
6 FB1   PHASE3 19
7 COMP1   ISEN3 18
8 RSEL_N   EN/SS3 17
PGND 33   G4 9   LDOFB 10   SGND 11   OCSET2 12   FB2 13   ENSS2 14   OCSET3 15   FB3 16

CVCC1 4.7u 10V   RPG1 100K   VCC5V
TP3 PGOOD   PGOOD
TP11 EXTVCC J12   Ext. VCC   Int. VCC   VIN RFIN1 13   5VIN   CFIN1 0.47u 3.5V   VFB1
TP12 EN1   J3 EN1   **Enabled**   **Disabled**   EN1   CSS1 2.2n   VO1   R1 105K 1%   Cff1 220p   Cp1 OPT   R2 20K 1%   ROC1 169K
TP17 GND   TP18 GND
TP4 RST

VO1 R4 OPT   R5 47   C1 0.22u   VO2 R7 0   Vishay, P Channel MOSFET, Si4423DY   Q4   S3 S2 S1 D4 D3 D2 G
TP15 VO4   CO41 1u 6.3V   CO42 150u 6.3V   R9 21.5K 1%   LDOFB   C2 OPT   R10 10K 1%   **2.5V @ 1A**   Sanyo, 6TPE150MAZB   TP16 GND

VO3   Cff3 330p   R3 140K 1%   J4 EN3   TP13 EN3   **Enabled** **Disabled**
FB3   R6 10K 1%   Cp3 OPT   EN3   CSS3 2.2n
ROC2 169K   ROC3 169K
VO2   R8 3.4K 1%   FB2   Cff2 220p   R11 10.7K 1%   Cp2 OPT   J5 EN2   TP14 EN2   **Enabled** **Disabled**   EN2   CSS2 2.2n

VIN   Q7 OPT   QU3 RJK0332DPB   UG3   CB3 0.22u 16V   LG3   Q3 OPT   QL3 RJK0330DPB   CL3 820p   RL3 1.6   Rsen3 1.69K   PH3   IHLP5050FDER3R3M01   L3 3.3u   VO3   TP9 VO3+
CIN4 10u 35V   CIN11 10u 3.5V
CO35 150u 16V   CO32 150u 16V   CO31 OPT   CO33 10u 16V   CO34 10u 16V   **12V @ 12A**   J11 VO3-   TP10 GND
Sanyo, 16SVP150MX

Load Transient Circuit 3
OPT, SUD50N03-16P Q9
ISTEP_CLK3   J15   R16 OPT, 10K   R17 OPT, 0   R18 OPT, 0.1   J16 ISTEP3

Engineer: Manjing Xie
Title: ISL9440B HIGH CURRENT TRIPPLE VOUT EV BOARD
Size   Document Number   Rev
Custom REV 0.0   2
Date: Monday, January 26, 2009   Sheet 1 of 1

RENESAS

**TABLE 2. BILL OF MATERIALS**

| ITEM | QTY | PART REFERENCE | VALUE | DESCRIPTION | PART NUMBER | MANUFACTURER |
|---|---|---|---|---|---|---|
| 1 | 1 | C1 | 0.22µF | | | |
| 2 | 3 | CB1, CB2, CB3 | 0.22µFF | CERAMIC CAPS, X5R, 16V | | AVX, TDK, Murata |
| 3 | 1 | CFIN1 | 0.47µF | CERAMIC CAPS, X5R, 35V | | AVX, TDK, Murata |
| 4 | 3 | CIN1, CIN2, CIN11 | 150µF | ALUM. ELEC. CAPS, 35V | | Panasonic |
| 5 | 6 | CIN3, CIN4, CIN6, CIN7, CIN8, CIN9 | 10µF | CERAMIC CAPS, X5R, 35V | | AVX, TDK, Murata |
| 6 | 2 | CO11, CO12, CO21, CO22 | 330µF | POSCAP, 6.3V, ESR 9m | 6TPF330M9L | Sanyo |
| 7 | 5 | CO13, CO14, CO23, CO24, CO41 | 10µF | CERAMIC CAPS, 0805, X5R, 6.3V | | AVX, TDK, Murata |
| 8 | 2 | CO31, CO32 | 150µF | SANYO, OSCON, 16V | | Sanyo |
| 9 | 2 | CO33, CO34 | 10µF | CERAMIC CAPS, X5R, 25V | | AVX, TDK, Murata |
| 10 | 1 | CO42 | 150µF | POSCAP, 6.3V | 4TPE100MZB | Sanyo |
| 11 | 1 | CVCC1 | 4.7µF | CERAMIC CAPS, X5R, 16V | | AVX, TDK, Murata |
| 12 | 2 | CFF1, CFF2 | 220pF | CERAMIC CAPS, NP0, 50V | | Generic |
| 13 | 1 | CFF3 | 330pF | CERAMIC CAPS, NP0, 50V | | Generic |
| 14 | 3 | CSS1, CSS2, CSS3 | 22nF | CERAMIC CAPS, NP0, 50V | | Generic |
| 15 | 1 | L1 | 2.2µH | POWER INDUCTOR | IHLP5050FDER2R2M01 | Vishay |
| 16 | 1 | L2 | 1.5µH | POWER INDUCTOR | IHLP5050FDER1R5M01 | Vishay |
| 17 | 1 | L3 | 3.3µH | POWER INDUCTOR | IHLP5050FDER3R3M01 | Vishay |
| 18 | 3 | QL1, QL2, QL3 | | N MOSFET, 30V | RJK0330DPB | Renesas |
| 19 | 2 | QU1, QU2 | | N MOSFET, 30V | RJK0305DPB | Renesas |
| 20 | 1 | QU3 | | N MOSFET, 30V | RJK0332DPB | Renesas |
| 21 | 1 | Q4 | | P MOSFET, 20V | Si4423DY | Vishay |
| 22 | 1 | R1 | 105kΩ | RESISTOR, 0603, 1/16W | | Generic |
| 23 | 1 | R2 | 20kΩ | RESISTOR, 0603, 1/16W | | Generic |
| 24 | 2 | R6, R10 | 10kΩ | RESISTOR, 0603, 1/16W | | Generic |
| 25 | 1 | R3 | 140kΩ | RESISTOR, 0603, 1/16W | | Generic |
| 26 | 1 | R5 | 47Ω | RESISTOR, 0603, 1/16W | | Generic |
| 27 | 1 | R8 | 34kΩ | RESISTOR, 0603, 1/16W | | Generic |
| 28 | 1 | R9 | 21.5kΩ | RESISTOR, 0603, 1/16W | | Generic |
| 29 | 1 | R11 | 10.7kΩ | RESISTOR, 0603, 1/16W | | Generic |
| 30 | 1 | RFIN1 | 4.7Ω | RESISTOR, 0603, 1/16W | | Generic |
| 31 | 3 | ROC1, ROC2, ROC3 | 169kΩ | RESISTOR, 0603, 1/16W | | Generic |
| 32 | 1 | RPG1 | 100kΩ | RESISTOR, 0603, 1/16W | | Generic |
| 33 | 2 | RSEN1, RSEN2 | 2.0kΩ | RESISTOR, 0603, 1/16W | | Generic |
| 34 | 1 | RSEN3 | 1.69kΩ | RESISTOR, 0603, 1/16W | | Generic |
| 35 | 1 | U1 | | QUAD OUTPUT CONTROLLER | ISL9440B | Intersil |
| **OPTIONAL COMPONENTS OR RESISTOR JUMPERS** | | | | | | |
| 1 | 1 | C2 | OPT | | | Generic |
| 2 | 3 | CL1, CL2, CL3 | 820pF | CERAMIC CAPS, 0805 | | Generic |
| 3 | 0 | CIN11,CIN5 | OPT | | | Generic |
| 4 | 0 | CO15, CO25, CO35 | OPT | | | Generic |

**TABLE 2. BILL OF MATERIALS (Continued)**

| ITEM | QTY | PART REFERENCE | VALUE | DESCRIPTION | PART NUMBER | MANUFACTURER |
|------|-----|----------------|-------|-------------|-------------|--------------|
| 5 | 0 | CP1, CP2, CP3 | OPT | | | Generic |
| 6 | 0 | Q1, Q2, Q3, Q5, Q6, Q7 | OPT | N MOSFET, 30V | | |
| 7 | 3 | RL1, RL2, RL3 | 1.6Ω | RESISTOR, 0805, 1/8W | | Generic |
| 8 | 0 | R4 | OPT | | | Generic |
| 9 | 1 | R7 | 0 | Resistor jumper | | Generic |
| **EVALUATION BOARD HARDWARE** | | | | | | |
| 1 | 8 | J1, J2, J6, J7, J8, J9, J10, J11 | | Big Lug | | |
| 2 | 1 | J3, J4,J5, J12 | | 3 HEAD JUMPER | | |
| 3 | 15 | TP1 ~ TP15 | | TEST POINT | | |
| 4 | 4 | | | STAND OFF | | |

# ISL9440BEVAL1Z PCB Layout
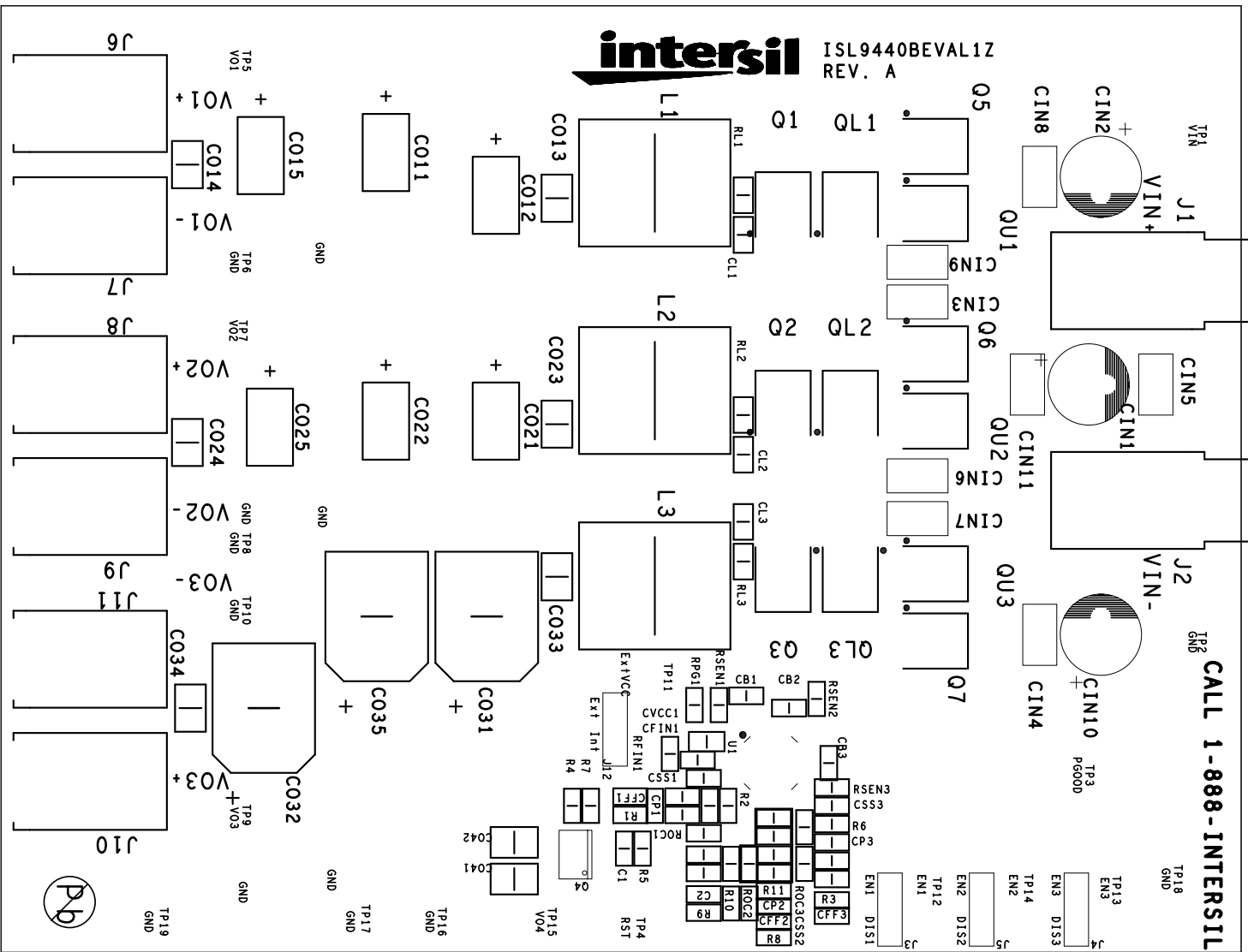


**FIGURE 13. TOP COMPONENTS**

FIGURE 14.  TOP LAYER ETCH
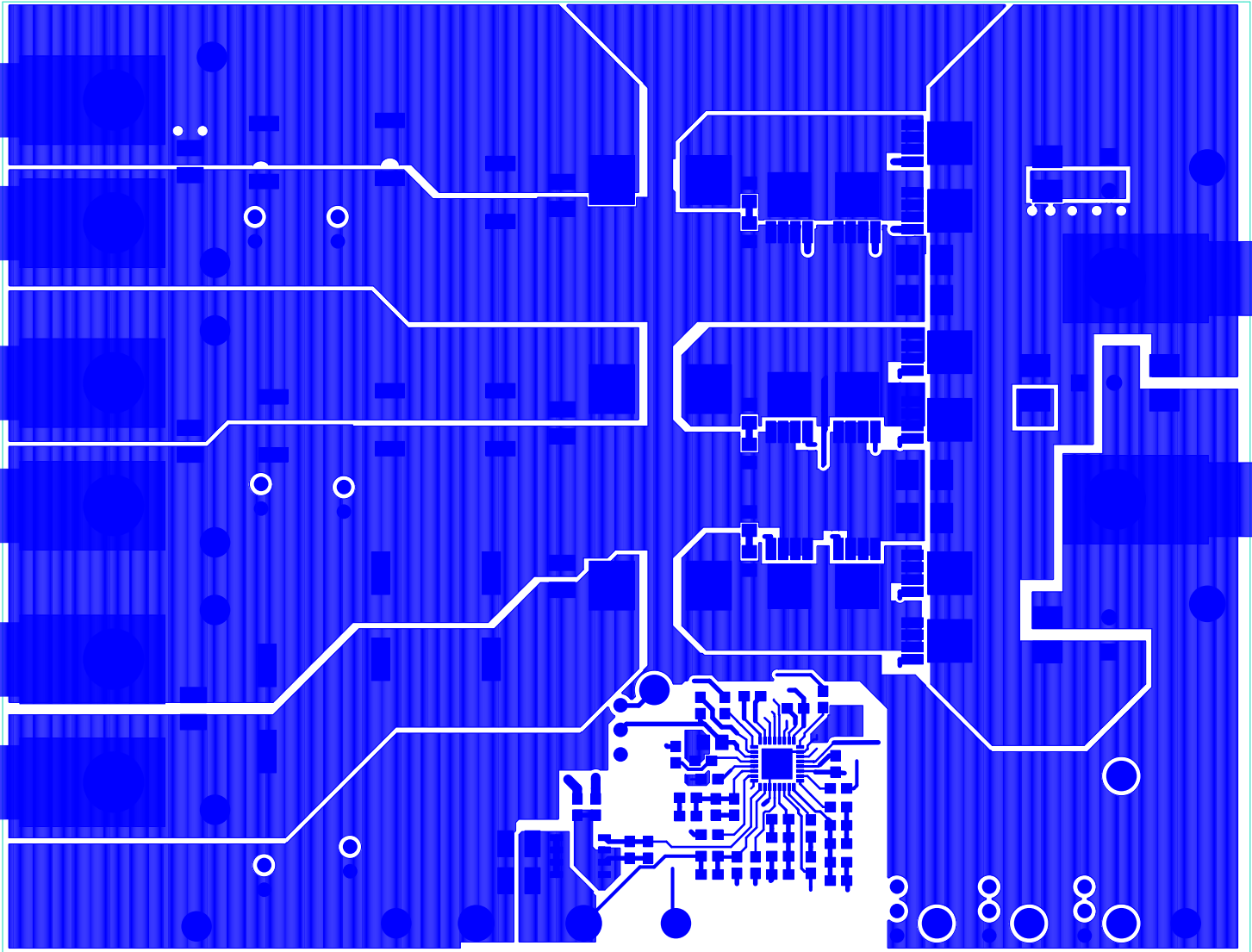
# ISL9440BEVAL1Z PCB Layout  (Continued)
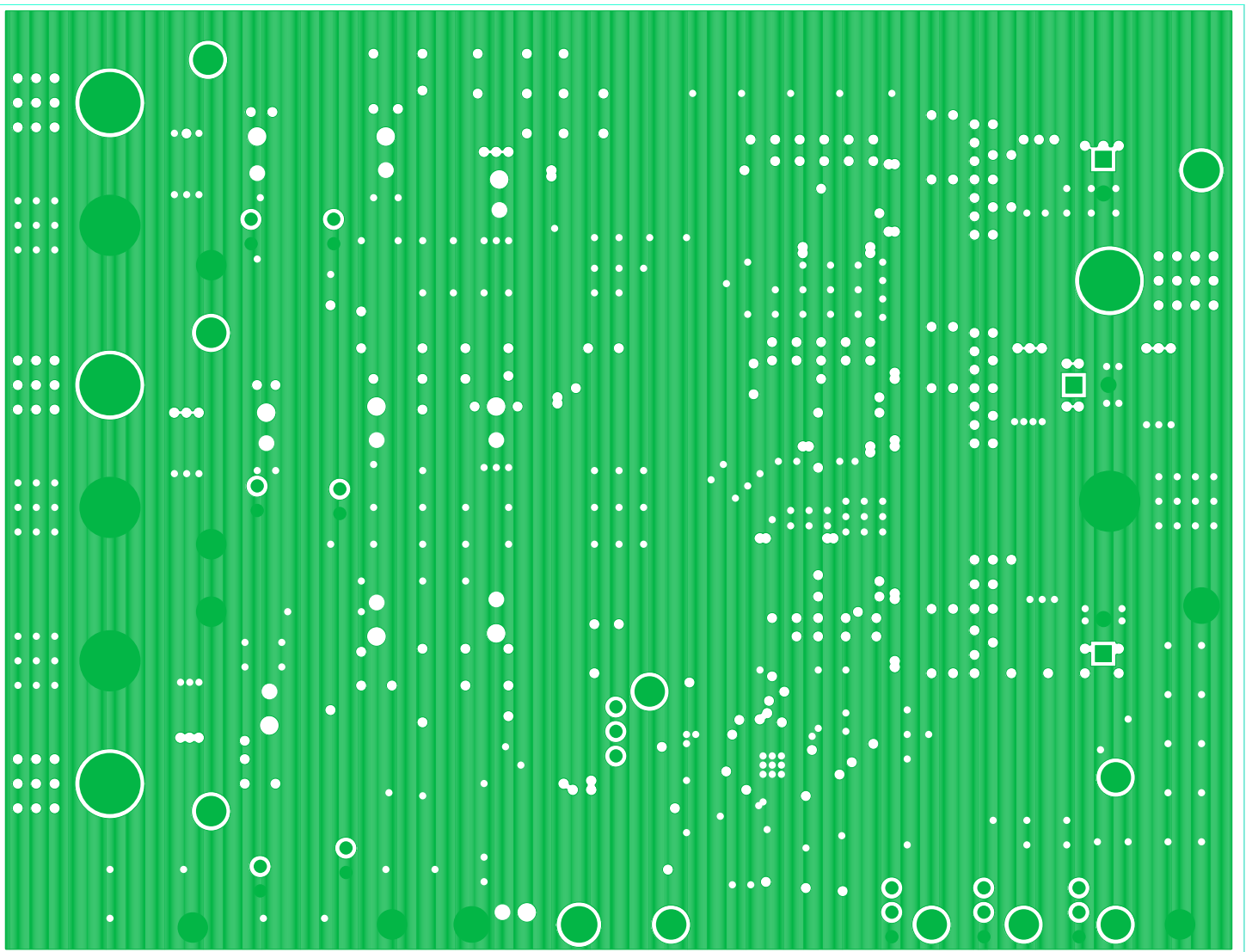
FIGURE 15.  SECOND LAYER ETCH

# ISL9440BEVAL1Z PCB Layout (Continued)
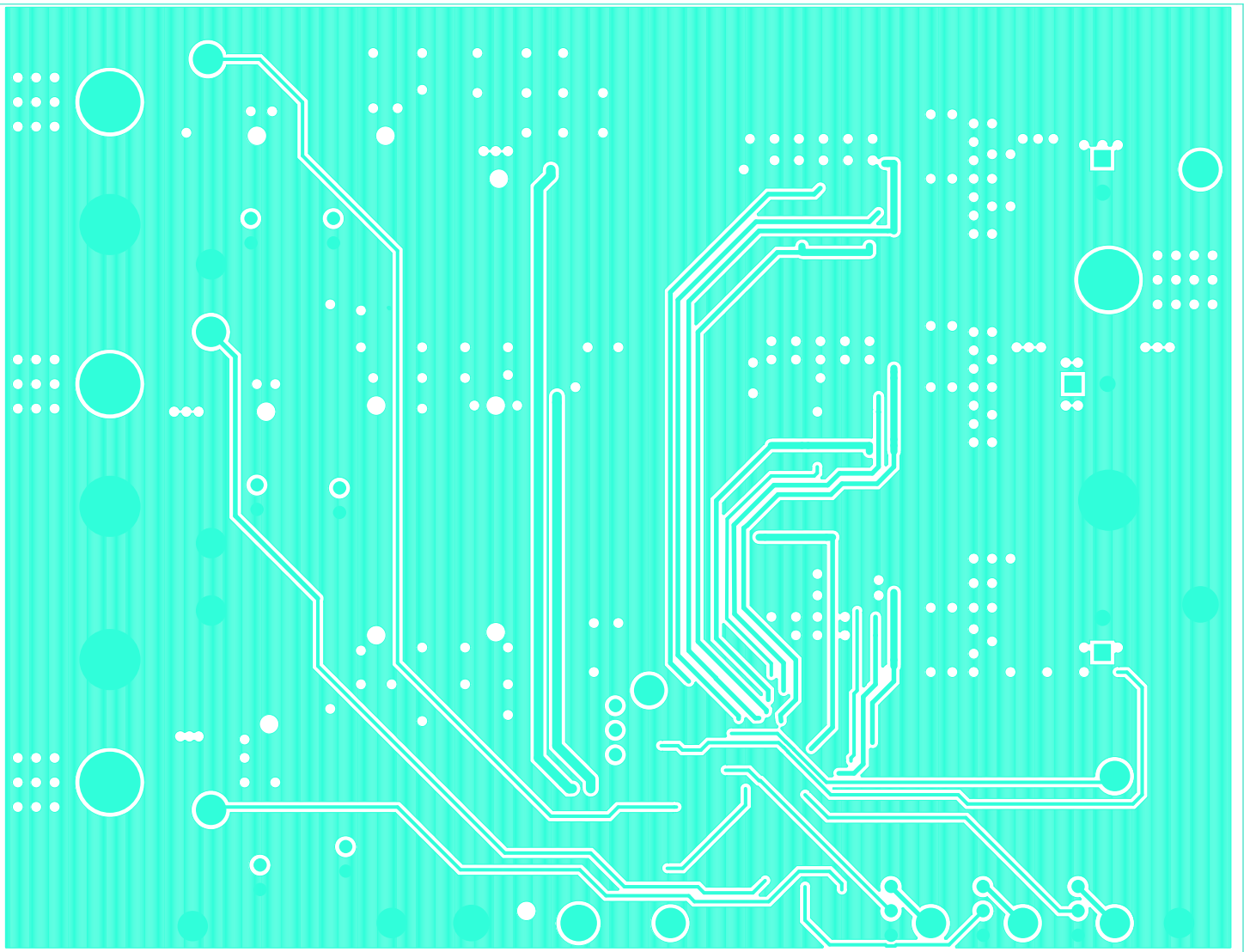


**FIGURE 16. THIRD LAYER ETCH**

*ISL9440BEVAL1Z PCB Layout* (Continued)
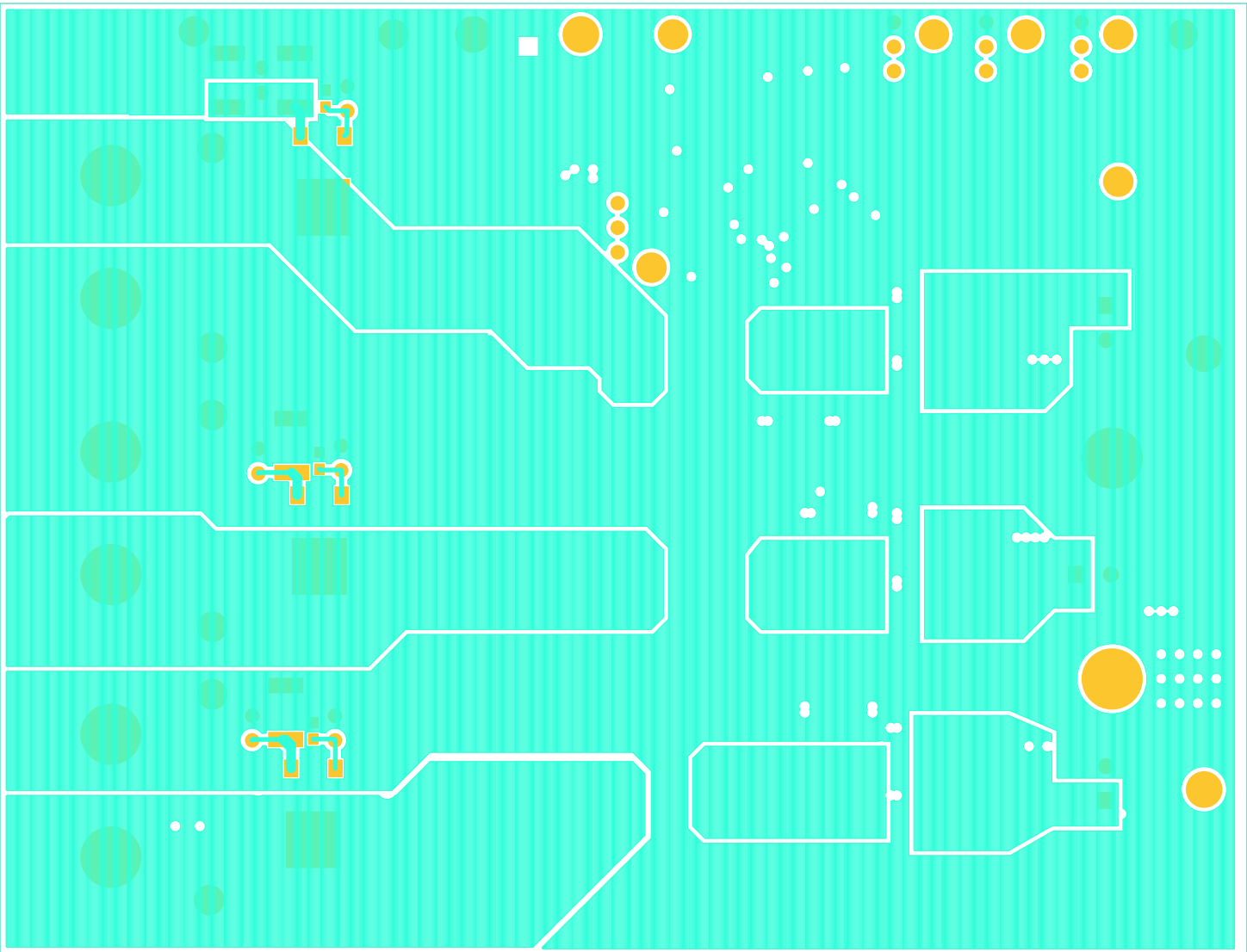


**FIGURE 17. BOTTOM LAYER ETCH (MIRRORED)**
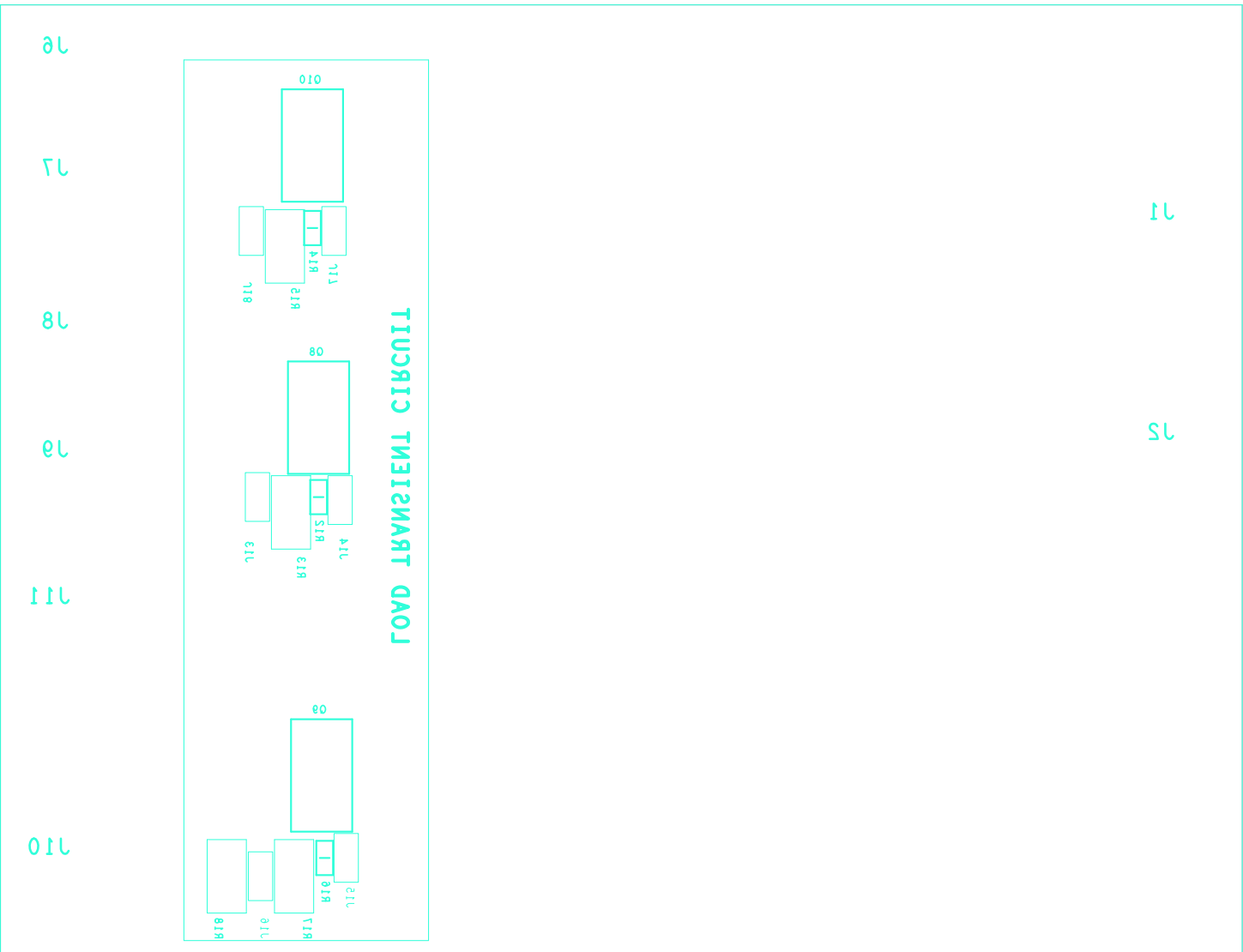
**FIGURE 18.  BOTTOM COMPONENTS (MIRRORED)**

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(Rev.4.0-1 November 2017)

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