

ISL6446ADEMO1Z

Dual Channel Step Down Regulator Evaluation Board

AN1822
Rev 1.00
May 7, 2015

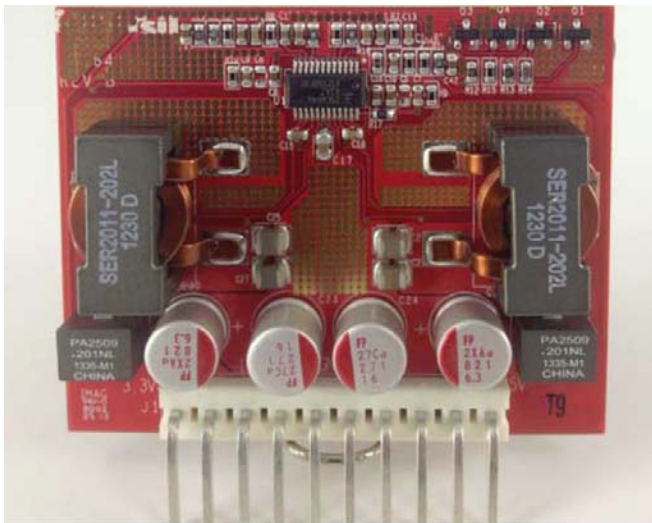


FIGURE 1. ISL6446ADEMO1Z REV B BOARD



FIGURE 2. ISL6446ADEMO1Z REV B BOARD BACKSIDE

Introduction

The [ISL6446A](#) is a high performance Dual PWM + Single Linear Controller. This device integrates complete control, monitoring and protection functions for two synchronous buck PWM controllers and one low power linear controller. Each PWM channel is switched 180° out-of-phase for reduced input ripple current and lower EMI.

The PWM controller uses voltage mode control for simple output regulation. The output can be regulated from $0.8 \cdot V_{IN}$ down to the 0.6V reference voltage. Switching frequency is programmable from 100kHz to 2.5MHz, providing either a cost optimized or compact power solution.

The ISL6446ADEMO1Z demo board is designed as an easy to use, dual output, non-isolated power module featuring synchronous buck function. It is well suited for any applications that require high performance, small space and low cost. The ISL6446ADEMO1Z output voltage is preset to 3.3V and 5V targeting ATX power supply applications. Each channel is designed for up to 20A of output current. Total power of the demo board is limited by thermal conditions.

Evaluation Board Features

- 12V input voltage
- Preset +5V and +3.3V output
- 20A output current each channel
- Two-in-1 PWM controller with out-of-phase operation
- Voltage-mode PWM control
- Efficiency up to 94.9%
- Prebias start-up
- Undervoltage lockout
- Output overcurrent protection
- Over-temperature protection
- f_{sw} set at 280kHz
- Simple dual layer board design

Evaluation Board Specifications

| SYMBOL | PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|------------|----------------|---------------------------|------|-----|------|------|
| V_{IN} | Input Range | Over I_O range | 10.8 | | 13.2 | V |
| V_{OUT1} | Output Range | Over I_O range | 4.8 | 5 | 5.2 | V |
| I_{OUT1} | Output Current | From no load to full load | 0 | | 20 | A |
| V_{OUT2} | Output Range | Over I_O range | 3.1 | 3.3 | 3.5 | V |
| I_{OUT2} | Output Current | From no load to full load | 0 | | 20 | A |

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Equipment Used for Validation

- 12V/200W input power source
- Dual channel electronic load

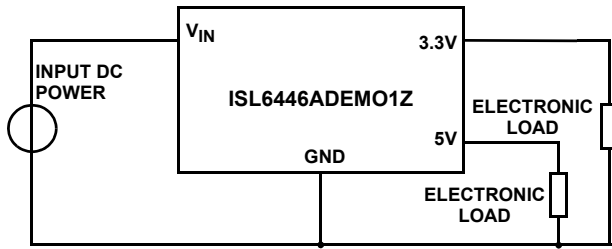


FIGURE 3. TYPICAL APPLICATION DIAGRAM

Terminal Functions

TABLE 1. TERMINAL FUNCTIONS

| TERMINAL NAME | DESCRIPTION |
|-----------------|---|
| V _{IN} | The positive input voltage node to the module, which is referenced to common GND. |
| GND | This is the common ground connection for the V _{IN} and V _{OUT} power connection. |
| 5V | The regulated positive 5V power output with respect to the GND node. |
| 3.3V | The regulated positive 3.3V power output with respect to the GND node. |

Getting Started

Using short twisted pair leads for any power connections and with all loads and power supplies off, refer to [Figure 4](#) for the proper measurement and equipment setup. The Power Supply (PS) should not be connected to the circuit until told to do so in the following procedure.

When measuring the input or output voltage ripple, care must be taken to avoid a long ground lead on the oscilloscope probe. Measure the input or output voltage ripple by touching the probe tip directly across V_{OUT} and GND terminals.

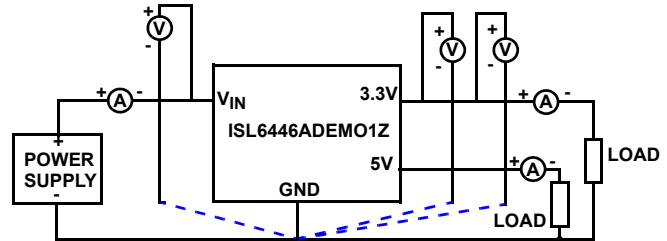


FIGURE 4. CONNECTION DIAGRAM

1. Keep the power supply and electronic load power off.
2. Connect the power supply; electronic load; voltage and current meters. [Figure 4](#) shows while keeping the power supply and load shut down.
3. Turn on the power supply and set the input voltage to 12V. Monitor input current. If input current exceeds 100mA, turn off power supply and look for shorts.
4. Confirm $V_{OUT1} = 3.3V$, $V_{OUT2} = 5V$
5. Slowly increase the load on V_{OUT} to 15A. Verify $V_{OUT1} = 3.3V$, $V_{OUT2} = 5V$

The board is now ready for operation.

Undervoltage Lockout Circuit

The ISL6446ADEMO1Z demo board includes as part of its circuitry a UVLO (Undervoltage Lockout) circuit that prevents it from starting up with V_{IN} voltages less than about 7.8V. If you want to reduce the UVLO voltage, (resistor R₁₂ in the schematic of the board) it needs to be reduced in value.

Board Electrical Specifications $T_A = +25^\circ\text{C}$; $V_{IN} = 12\text{V}$; $V_{OUT1} = 3.3\text{V}$, $V_{OUT2} = 5\text{V}$, and $I_{OUT1} = 15\text{A}$, $I_{OUT2} = 15\text{A}$
 (unless otherwise noted).

| SYMBOL | PARAMETER | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|------------|----------------------------------|--|------------------------------------|-------|------|-------------------|
| V_{IN} | Input Range | Over I_O range | 10.8 | | 13.2 | V |
| V_{OUT1} | Output Range | Over I_O range | 4.8 | 5 | 5.2 | V |
| I_{O1} | Output Current | From no load to full load | 0 | | 20 | A |
| V_{OUT2} | Output Range | Over I_O range | 3.1 | 3.3 | 3.5 | V |
| I_{O2} | Output Current | From no load to full load | 0 | | 20 | A |
| η | Efficiency for DC/DC | $V_{IN} = 12\text{V}$ (Note 1) | $I_{OUT1} = I_{OUT2} = 2\text{A}$ | 93.39 | | % |
| | | | $I_{OUT1} = I_{OUT2} = 4\text{A}$ | 95.18 | | % |
| | | | $I_{OUT1} = I_{OUT2} = 8\text{A}$ | 95.87 | | % |
| | | | $I_{OUT1} = I_{OUT2} = 12\text{A}$ | 95.53 | | % |
| | | | $I_{OUT1} = I_{OUT2} = 16\text{A}$ | 94.88 | | % |
| | | | $I_{OUT1} = I_{OUT2} = 20\text{A}$ | 93.99 | | % |
| V_{r1} | V_{OUT1} Ripple (Peak-to-peak) | No load | | 30 | | mV _{p-p} |
| | | Full load | | 50 | | mV _{p-p} |
| V_{r2} | V_{OUT2} Ripple (Peak-to-peak) | No load | | 30 | | mV _{p-p} |
| | | Full Load | | 50 | | mV _{p-p} |
| V_{T1} | Transient (Peak-to-peak) | Output peak-to-peak voltage variation when output current changing from 5A to 10A with 2.5A/ μs slew rate | | 250 | | mV |
| V_{T2} | Transient (Peak-to-peak) | Output peak-to-peak voltage variation when output current changing from 5A to 10A with 2.5A/ μs slew rate | | 250 | | mV |
| F_s | Switching Frequency | Over V_{IN} and I_O range | | 280 | | kHz |

NOTE:

- For the efficiency test result please refer to [page 11](#).

ISL6446ADEMO1Z Schematic

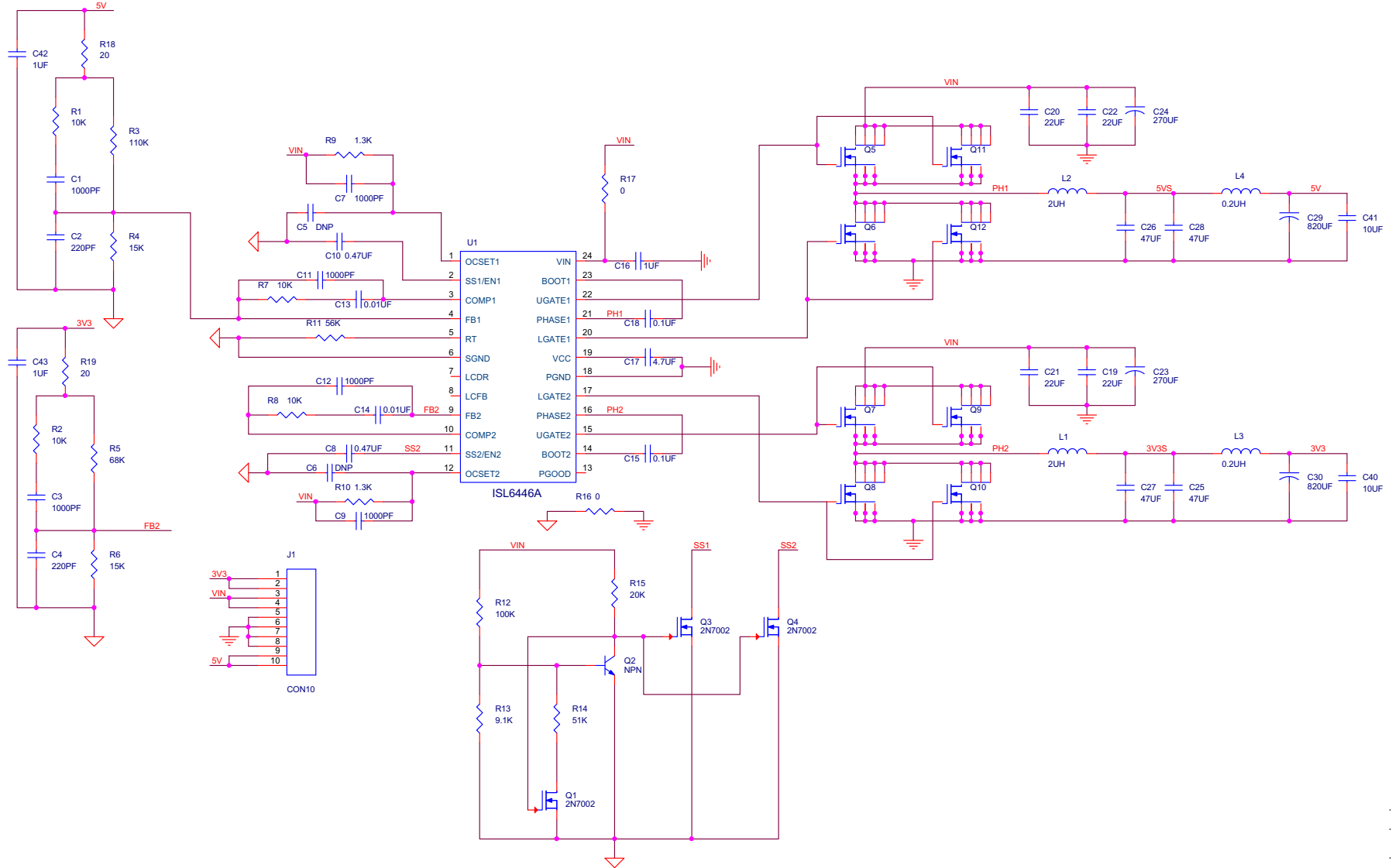


FIGURE 5. ISL6446ADEMO1Z SCHEMATIC

PCB Layout

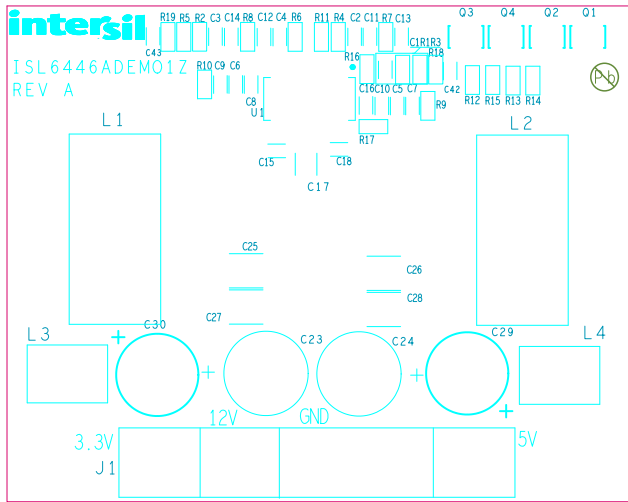


FIGURE 6. SILK SCREEN TOP

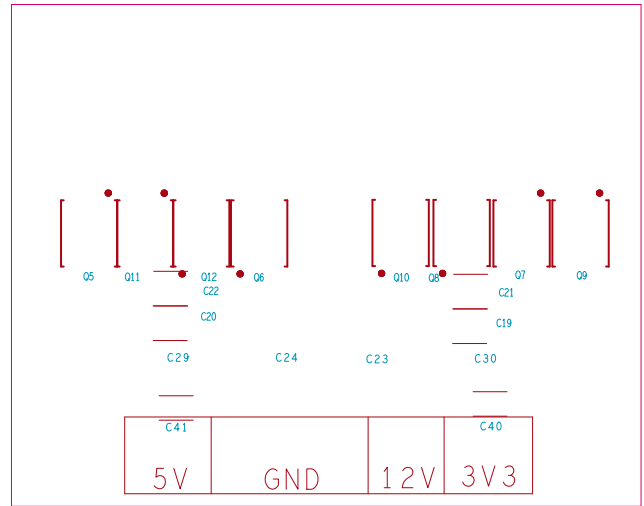


FIGURE 7. SILK SCREEN BOTTOM

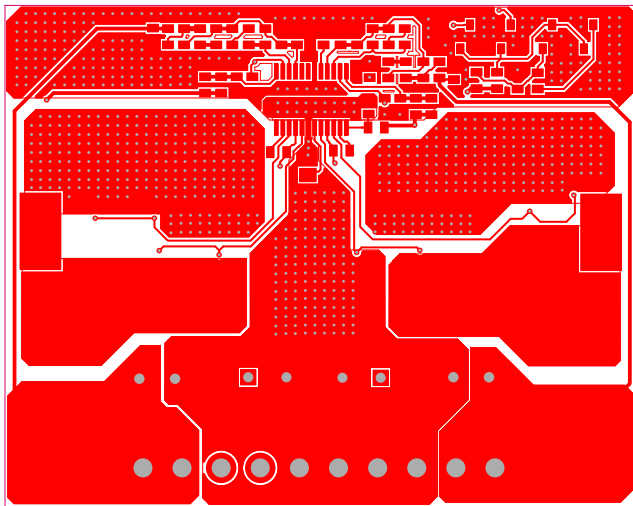


FIGURE 8. PCB TOP

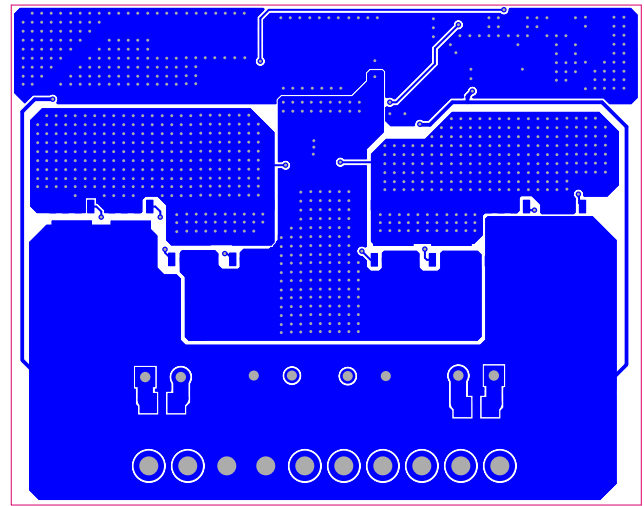


FIGURE 9. PCB BOTTOM

ISL6446ADEMO1Z Bill of Materials

| MANUFACTURER PART | QTY | UNIT S | REFERENCE DESIGNATOR | DESCRIPTION | MANUFACTURER |
|-----------------------|-----|--------|--------------------------|---|---------------------|
| ISL6446ADEMO1ZREVBPCB | 1 | ea. | | PWB-PCB, ISL6446ADEMO1Z, REVB, ROHS | IMAGINEERING INC |
| 06035C102KAT2A | 6 | ea. | C1, C3, C7, C9, C11, C12 | CAP, SMD, 0603, 1000pF, 50V, 10%, X7R, ROHS | AVX |
| GRM39X7R103K050 | 2 | ea. | C13, C14 | CAP, SMD, 0603, 0.01μF, 50V, 10%, X7R, ROHS | MURATA |
| GRM39X7R104K025AD | 2 | ea. | C15, C18 | CAP, SMD, 0603, 0.1μF, 25V, 10%, X7R, ROHS | MURATA |
| GRM188R61C105KA12D | 3 | ea. | C16, C42, C43 | CAP, SMD, 0603, 1μF, 16V, 10%, X5R, ROHS | MURATA |
| GRM188R71H221KA01D | 2 | ea. | C2, C4 | CAP, SMD, 0603, 220pF, 50V, 10%, X7R, ROHS | MURATA |
| C1608X7R1C474K | 2 | ea. | C8, C10 | CAP, SMD, 0603, 0.47μF, 16V, 10%, X7R, ROHS | TDK |
| ECJ-2FB1C475K | 1 | ea. | C17 | CAP, SMD, 0805, 4.7μF, 16V, 10%, X5R, ROHS | PANASONIC |
| C1206X7R100-106KNE | 2 | ea. | C40, C41 | CAP, SMD, 1206, 10μF, 10V, 10%, X7R, ROHS | VENKEL |
| GRM32ER71C226KE18L | 4 | ea. | C19, C20, C21, C22 | CAP, SMD, 1210, 22μF, 16V, 10%, X7R, ROHS | MURATA |
| ECJ-4YB0J476M | 4 | ea. | C25, C26, C27, C28 | CAP, SMD, 1210, 47μF, 6.3V, 20%, X5R, ROHS | PANASONIC |
| PA2509.201NL | 2 | ea. | L3, L4 | COIL-PWR INDUCTOR, SMD, 7X8.5, 0.2μH, 12%, 32A, 0.35mΩ, ROHS | PULSE |
| RL80J821MDN1KX | 2 | ea. | C29, C30 | CAP, TH, RADIAL, 820μF, 6.3V, 20%, ALUM.POLYMER, 3.5mmLS, ROHS | NICHICON |
| RL81C271MDN1KX | 2 | ea. | C23, C24 | CAP, TH, RADIAL, 270μF, 16V, 20%, ALUM.POLYMER, 3.5mmLS, ROHS | NICHICON |
| SER2011-202MLB | 2 | ea. | L1, L2 | COIL-PWR INDUCTOR, SMD, 18.7X19.1, 2.0μH, 20%, 37A, 1.2mΩ, ROHS | COILCRAFT |
| 1-640385-0 | 1 | ea. | J1 | CONN-HEADER, TH, 1X10, NYLON, R/A, 0.156mmPITCH, ROHS | TE CONNECTIVITY |
| ISL6446AIAZ | 1 | ea. | U1 | IC-DUAL PWM/LINEAR CONTROLLER, 24P, QSOP, ROHS | INTERSIL |
| 2N7002-7-F | 3 | ea. | Q1, Q3, Q4 | TRANSISTOR, N-CHANNEL, 3LD, SOT-23, 60V, 115mA, ROHS | DIODES, INC. |
| BSC010NE2LS | 4 | ea. | Q7, Q8, Q11, Q12 | TRANSIST-MOS, N-CHANNEL, 8P, PG-TDSON-8, 25V, 100A, ROHS | INFINEON TECHNOLOGY |
| MMBT3904 | 1 | ea. | Q2 | TRANSISTOR-NPN, SMD, SOT-23, 40V, 200mA, 350mW, ROHS | FAIRCHILD |
| ERJ-3EKF20R0V | 2 | ea. | R18, R19 | RES, SMD, 0603, 20Ω, 1/10W, 1%, TF, ROHS | PANASONIC |
| CR0603-10W-000T | 2 | ea. | R16, R17 | RES, SMD, 0603, 0Ω, 1/10W, TF, ROHS | VENKEL |
| RK73H1JT1002F | 4 | ea. | R1, R2, R7, R8 | RES, SMD, 0603, 10k, 1/10W, 1%, TF, ROHS | KOA |
| CR0603-10W-1003FT | 1 | ea. | R12 | RES, SMD, 0603, 100k, 1/10W, 1%, TF, ROHS | VENKEL |
| ERJ-3EKF1103V | 1 | ea. | R3 | RES, SMD, 0603, 110k, 1/10W, 1%, TF, ROHS | PANASONIC |
| CRCW06031K30FKTA | 2 | ea. | R9, R10 | RES, SMD, 0603, 1.3k, 1/10W, 1%, TF, ROHS | VISHAY/DALE |
| ERJ-3EKF1502V | 2 | ea. | R4, R6 | RES, SMD, 0603, 15k, 1/10W, 1%, TF, ROHS | PANASONIC |
| CR0603-10W-2002FT | 1 | ea. | R15 | RES, SMD, 0603, 20k, 1/10W, 1%, TF, ROHS | VENKEL |
| RC0603FR-0751KL | 1 | ea. | R14 | RES, SMD, 0603, 51k, 1/10W, 1%, TF, ROHS | YAGEO |
| ERJ-3EKF5602V | 1 | ea. | R11 | RES, SMD, 0603, 56k, 1/10W, 1%, TF, ROHS | PANASONIC |
| RC0603FR-0768KL | 1 | ea. | R5 | RES, SMD, 0603, 68k, 1/10W, 1%, TF, ROHS | YAGEO |
| CR0603-10W-9101FT | 1 | ea. | R13 | RES, SMD, 0603, 9.1k, 1/10W, 1%, TF, ROHS | VENKEL |
| SJ-5003SPBL | 4 | ea. | Bottom four corners | BUMPONS, 0.44inW x 0.20inH, DOMETOP, BLACK | 3M |

ISL6446ADEMO1Z Test Report

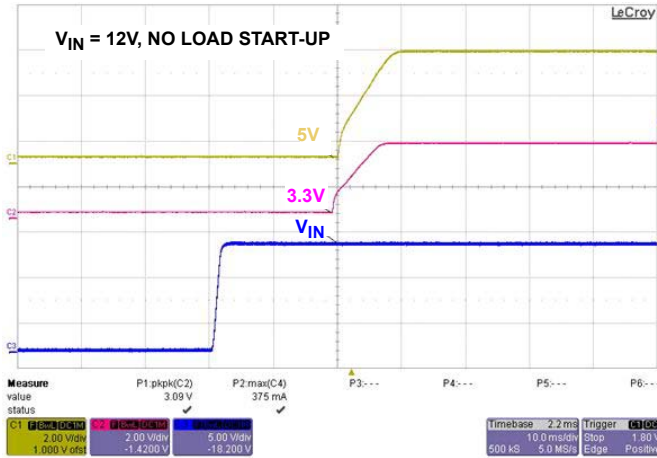


FIGURE 10. START-UP

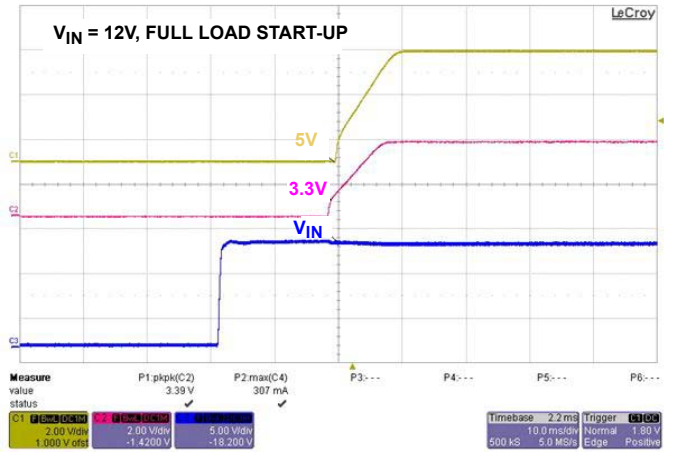


FIGURE 11. START-UP

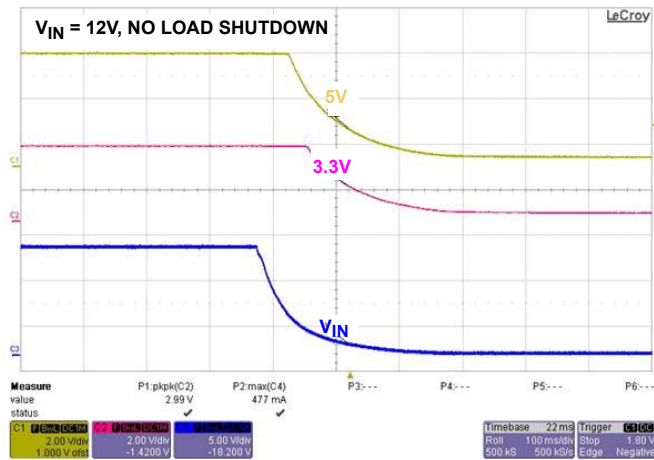


FIGURE 12. SHUTDOWN

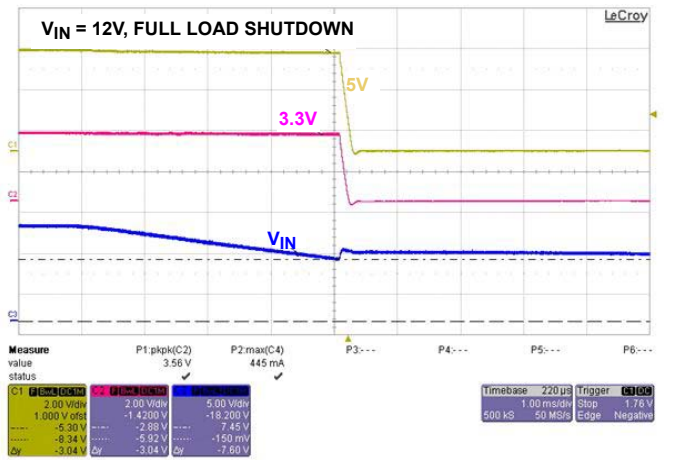


FIGURE 13. SHUTDOWN (UVLO VOLTAGE 7.4V)

Efficiency Curves Input = 12VDC, Output = 5V/20A, 3.3V/20A.

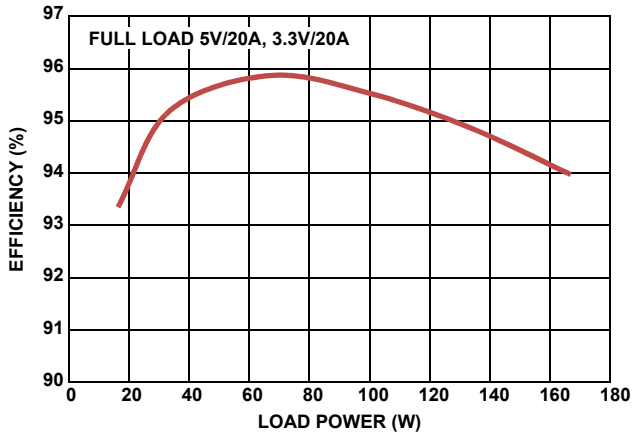


FIGURE 14. EFFICIENCY vs OUTPUT POWER

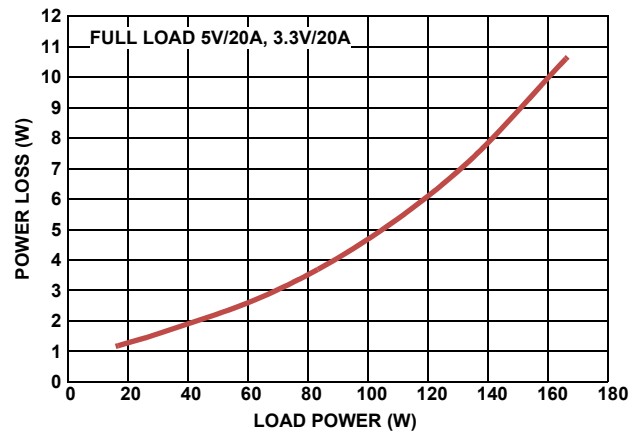


FIGURE 15. POWER LOSS vs OUTPUT POWER

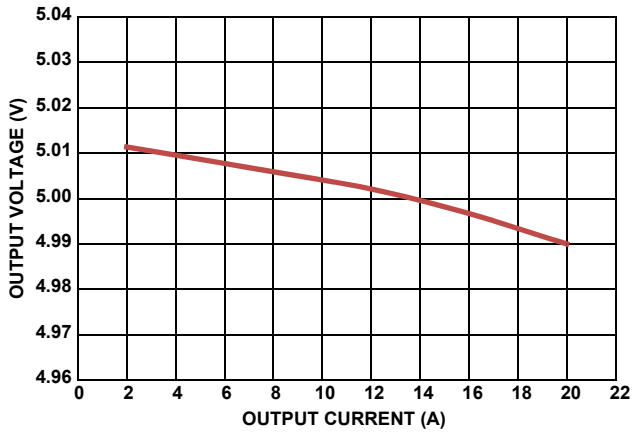


FIGURE 16. OUTPUT LOAD REGULATION 5V

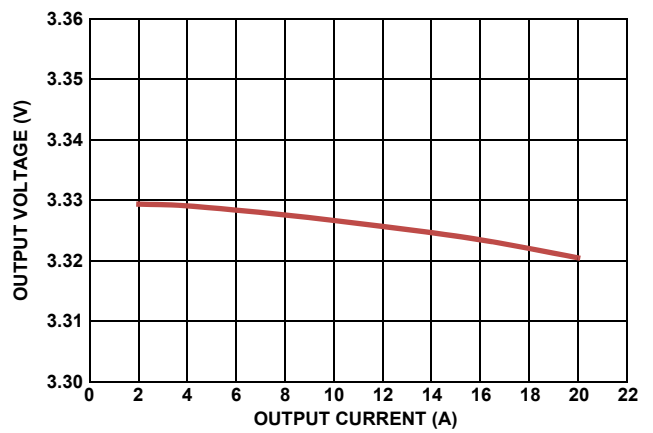


FIGURE 17. OUTPUT LOAD REGULATION 3.3V

Steady State Operation 1st stage LC (2μH + 2*47μF) + 2nd stage LC Output Filters (200nH + 820μF).

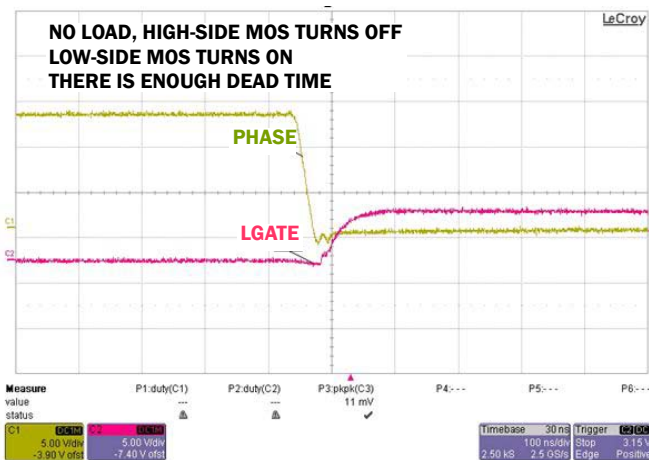


FIGURE 18. GATE DRIVER AND SWITCHING TRANSIENT

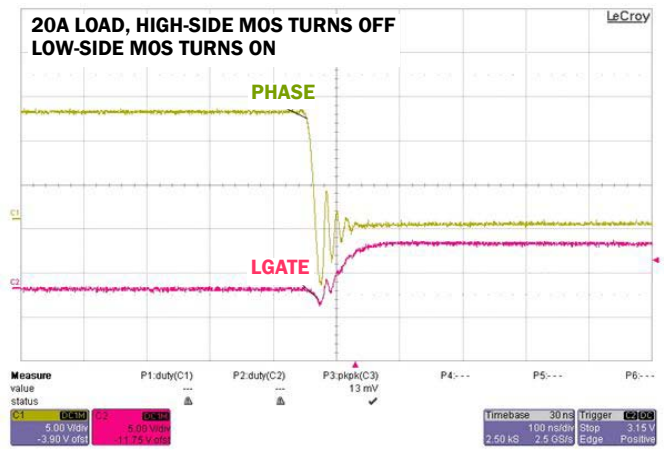


FIGURE 19. GATE DRIVER AND SWITCHING TRANSIENT

Steady State Operation

1st stage LC (2 μ H + 2*47 μ F) + 2nd stage LC Output Filters (200nH + 820 μ F). (Continued)

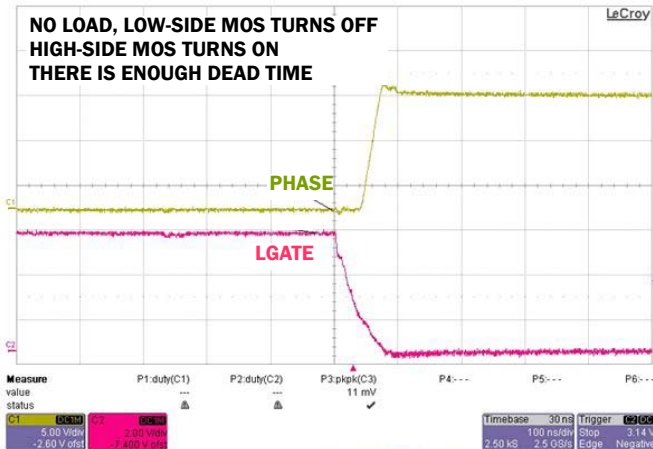


FIGURE 20. GATE DRIVER AND SWITCHING TRANSIENT

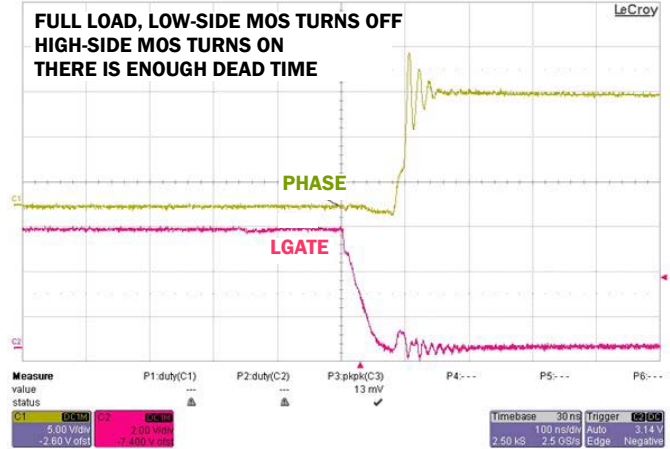


FIGURE 21. GATE DRIVER AND SWITCHING TRANSIENT

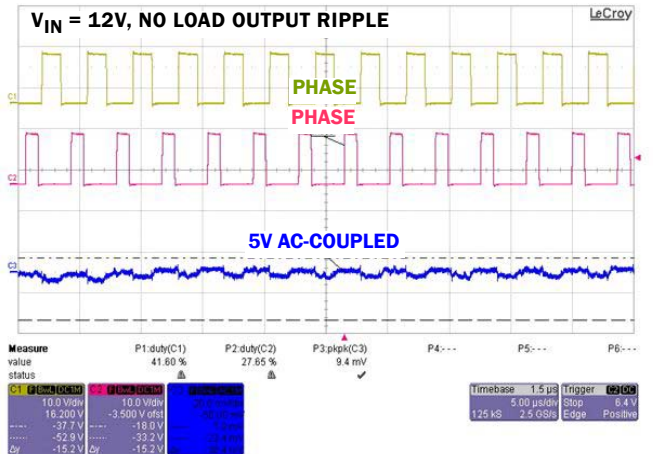


FIGURE 22. 5V NO LOAD OUTPUT RIPPLE 10mV

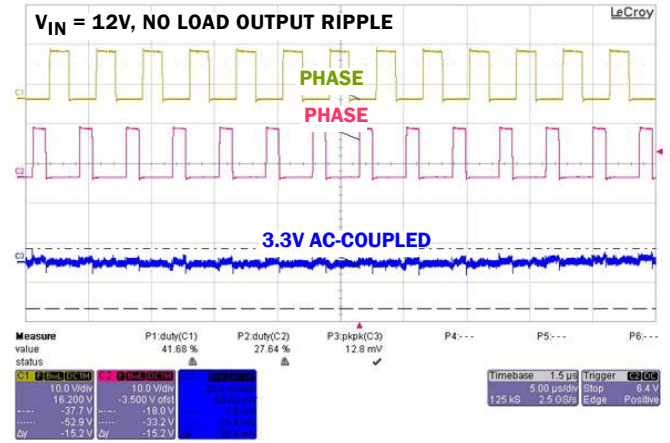


FIGURE 23. 3.3V NO LOAD OUTPUT RIPPLE 13mV

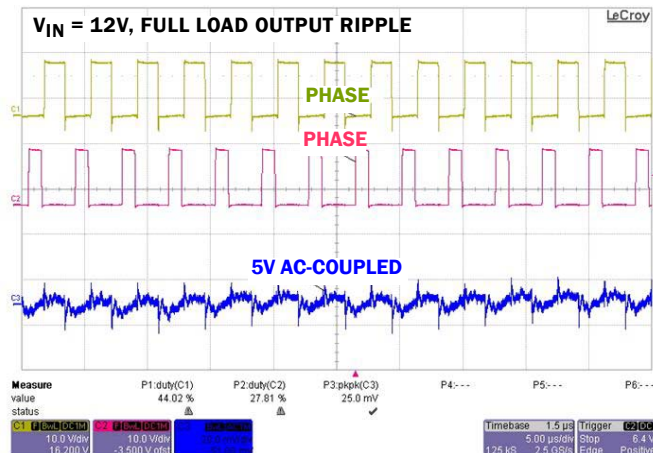


FIGURE 24. 5V FULL LOAD OUTPUT RIPPLE 25mV

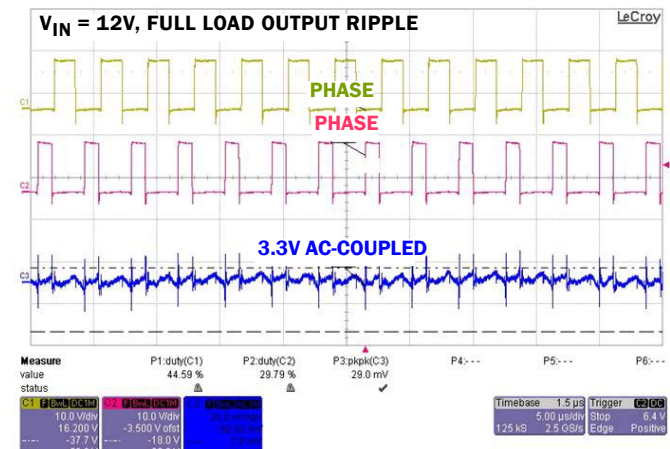


FIGURE 25. 3.3V FULL LOAD OUTPUT RIPPLE 29mV

Output Transient Responses

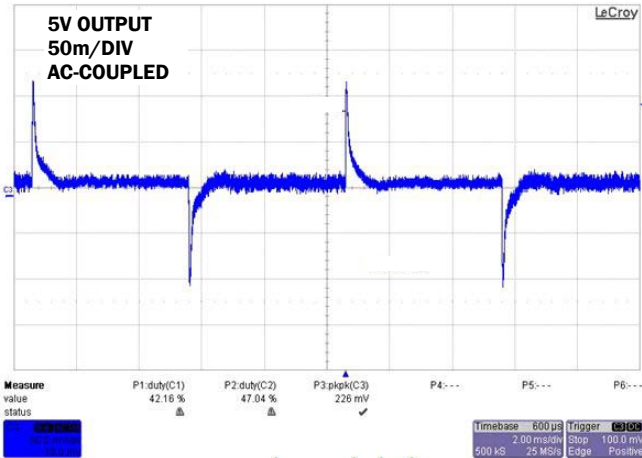


FIGURE 26. 5A~10A, 2.5A/µs, PEAK-TO-PEAK RIPPLE 226mV

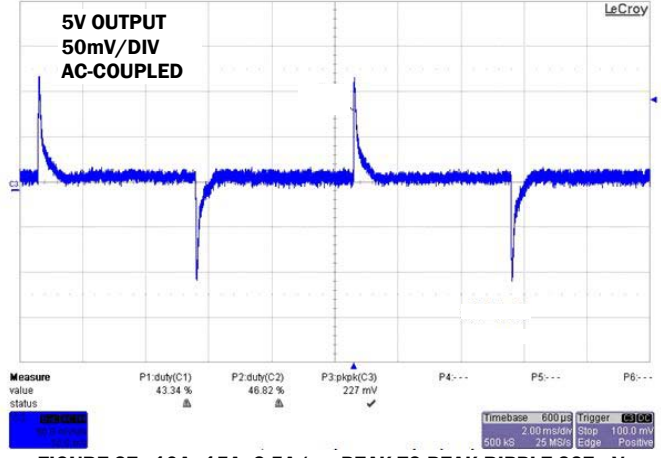


FIGURE 27. 10A~15A, 2.5A/µs, PEAK-TO-PEAK RIPPLE 227mV

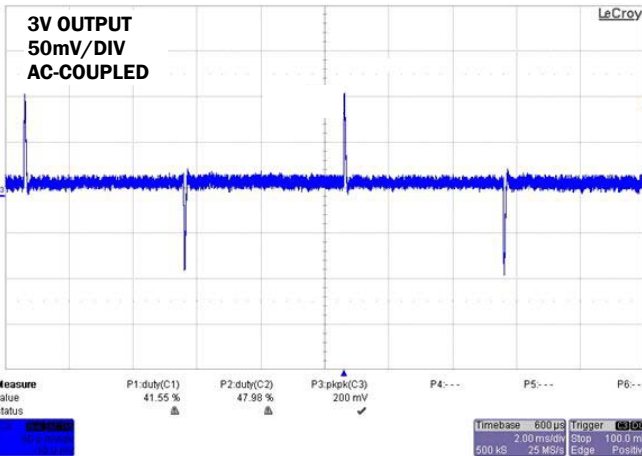


FIGURE 28. 5A~10A, 2.5A/µs, PEAK-TO-PEAK RIPPLE 200mV

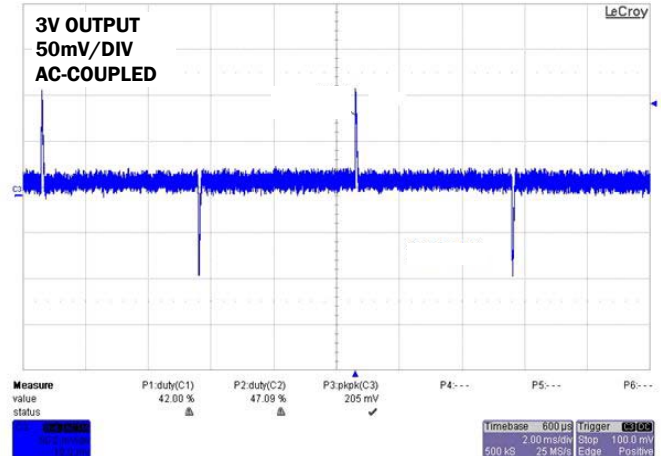


FIGURE 29. 10A~15A, 2.5A/µs, PEAK-TO-PEAK RIPPLE 205mV

Protection

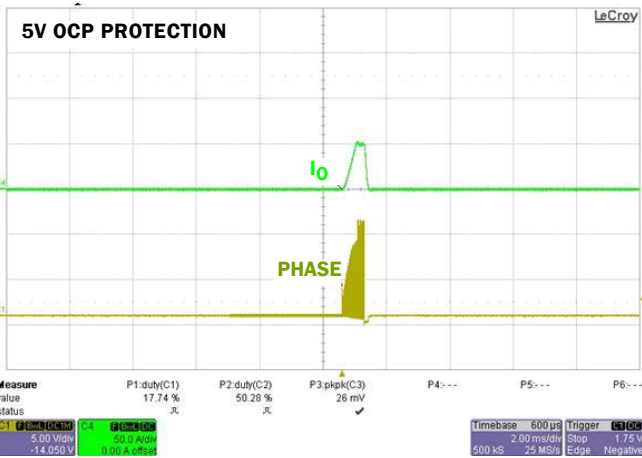


FIGURE 30. OVERCURRENT PROTECTION

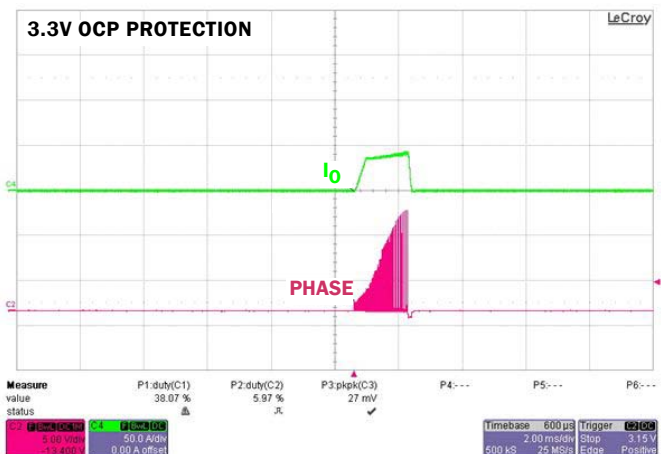


FIGURE 31. OVERCURRENT PROTECTION

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(Rev.4.0-1 November 2017)



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