

## ISL6841EVAL3Z

Evaluation Board for General Purpose Industrial Applications

AN1384  
Rev 0.00  
February 12, 2008

The ISL684x family of devices are superior performing pin compatible replacements for the industry standard 384x single-ended current mode PWM controllers. Also available in 8 Ld MSOP and 8 Ld SOIC, the ISL6841 in the space saving 2mmx3mm DFN package is used in the ISL6841EVAL3Z evaluation board.

The design requirements of this application require the superior performance characteristics of the ISL6841. Some key features of this part include:

- Tight internal voltage reference of 1%.
- 40ns peak current sensing.
- Internal 1A MOSFET driver.

The ISL6841 was selected for its UVLO threshold and its 50% maximum duty cycle limit. In addition, its low UVLO start threshold would help in easily modifying the design in catering to lower input voltage applications.

### Topology Selection

This evaluation board was designed to allow for maximum flexibility, targeting applications that use a typical battery input of 24V. Given the low input voltages for this application, a single-ended topology would be ideal. The flyback topology was selected for the low power levels targeted by this application with emphasis on low BOM cost. Continuous conduction mode of operation was chosen to achieve higher efficiencies at the expense of lower bandwidth of operation, a direct consequence of transition from continuous to discontinuous mode of operation.

For feature-rich applications that need short-circuit protection, over-temperature shutdown, etc., the ISL6841 may be substituted with the ISL6721. This evaluation board has been provided with placeholders for primary auxiliary winding feedback to save component cost in case of applications that can tolerate loose regulation requirements.

### Target Design Specifications

The following design requirements were targeted for evaluation purposes:

- Switching Frequency,  $f_{sw}$ : 200kHz.
- $V_{IN}$ : 18VDC to 30VDC.
- $V_{OUT}$ : 12V with 5% absolute regulation.
- $I_{OUT}$ : 2.5A.
- $P_{OUT}$ : 30W.
- Full Load Efficiency: 80% minimum under all line conditions, and loads of 20% and above.
- Ripple: 1% of output voltage.
- Form Factor: 2"x2".

The detailed design procedure for a continuous mode flyback topology has been discussed in the application note AN1192, available on Intersil's website:

<http://www.intersil.com/data/an/an1192.pdf>

### Typical Performance Characteristics

The major performance criterion for the converter are efficiency, load regulation and low output ripple. As can be observed from the following figures, the 20% load efficiency target of 80% has been comfortably met under all input voltage conditions. Tight load regulation has been achieved by using the opto-coupled feedback scheme.

### Waveforms

Typical waveforms can be found in the following Figures. Figure 1 shows the efficiency curves at different input voltages. Figure 2 shows the worst case output voltage ripple and noise.

Figures 3 through 6 show the drain and gate waveforms of the primary FET under different input and loading conditions.

Figures 7 through 10 show the secondary rectifier waveforms under different input and loading conditions.

A measure of the stability can be determined from the Bode plots shown in Figures 11 through 14. As shown, the gain and phase margins under the extreme conditions of line and load indicate a stable system under all operating conditions.

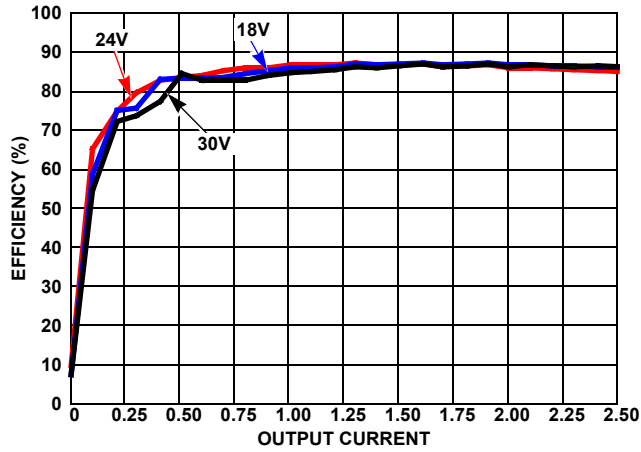


FIGURE 1. EFFICIENCY PLOTS

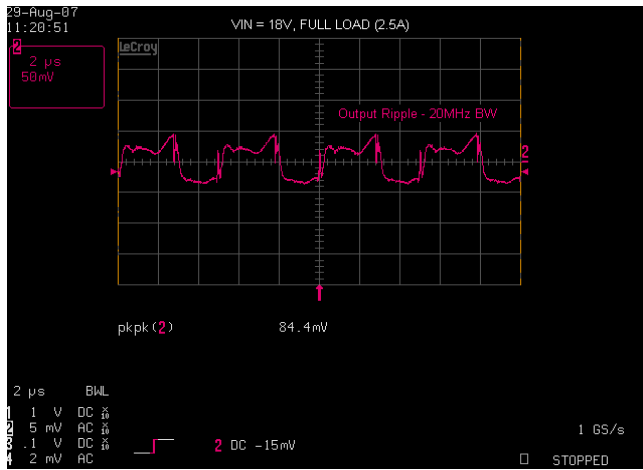


FIGURE 2. OUTPUT RIPPLE AND NOISE, 20MHz BW

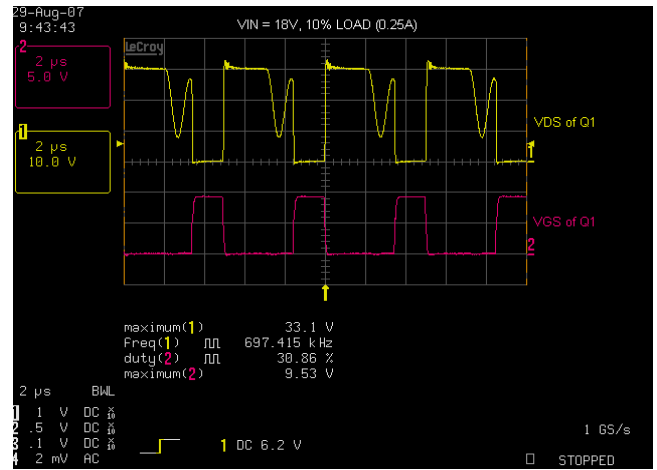


FIGURE 3. FET VOLTAGES,  $V_{IN} = 18V$ , LOAD = 250mA

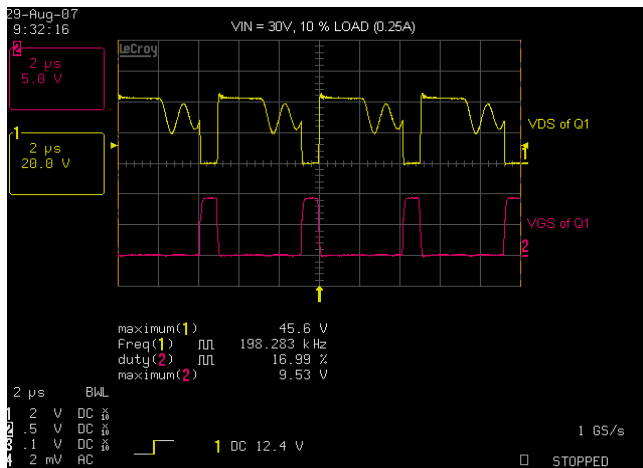


FIGURE 4. FET VOLTAGES,  $V_{IN} = 30V$ , LOAD = 250mA

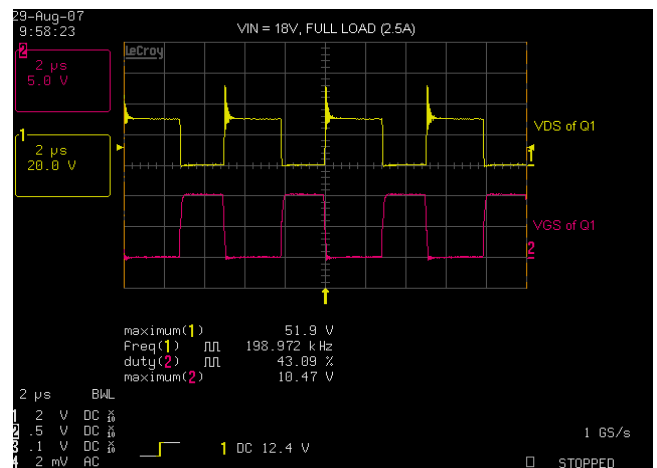


FIGURE 5. FET VOLTAGES,  $V_{IN} = 18V$ , LOAD = 2.5A

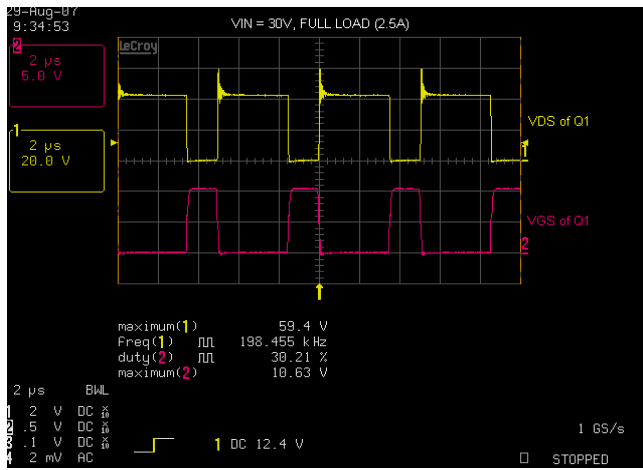


FIGURE 6. FET VOLTAGES,  $V_{IN} = 30V$ , LOAD = 2.5A

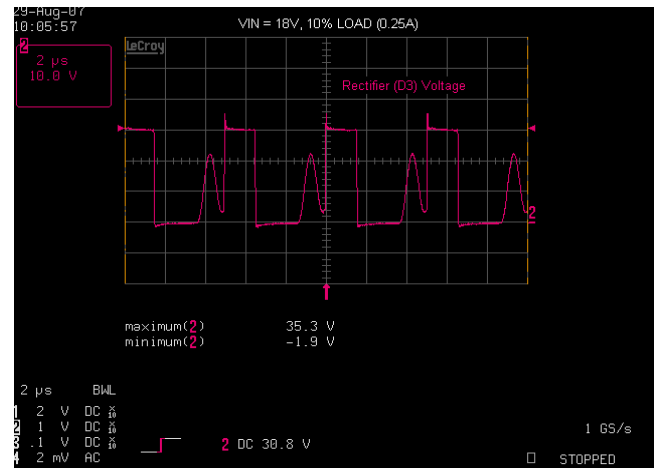


FIGURE 7. RECTIFIER WAVEFORM,  $V_{IN} = 18V$ , LOAD = 250mA

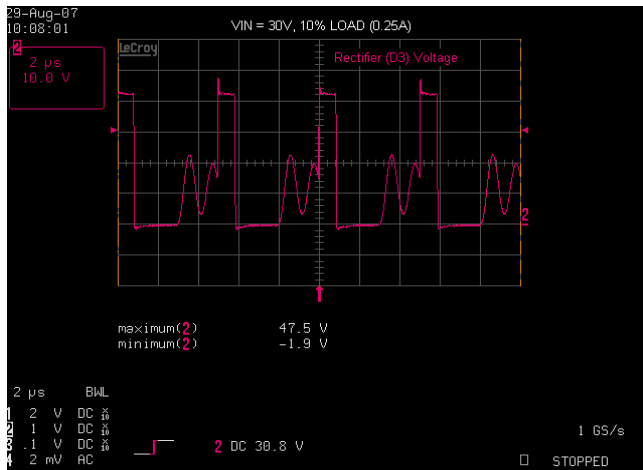


FIGURE 8. RECTIFIER WAVEFORM,  $V_{IN} = 30V$ , LOAD = 250mA

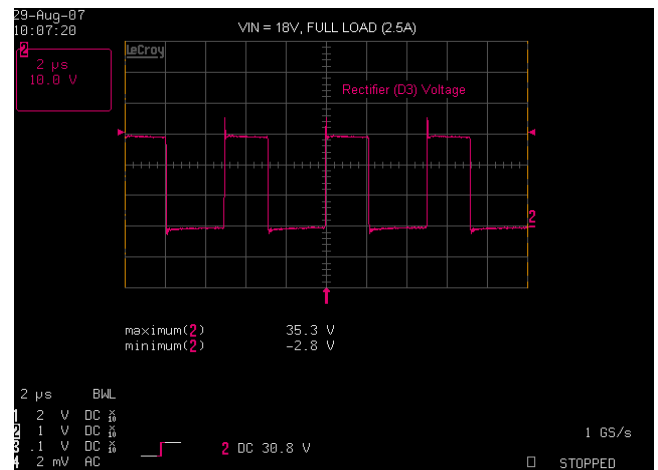


FIGURE 9. RECTIFIER WAVEFORM,  $V_{IN} = 18V$ , LOAD = 2.5A

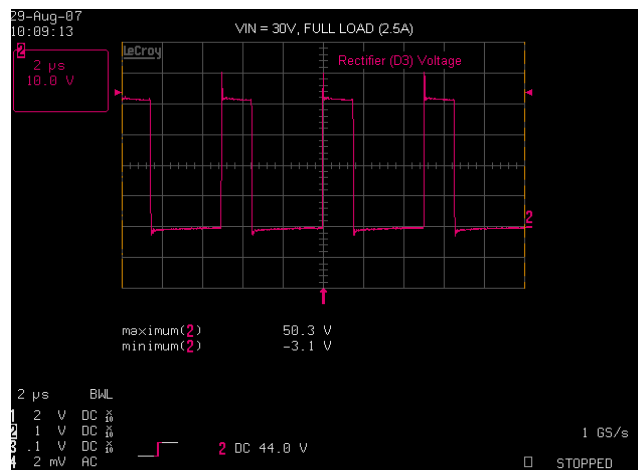


FIGURE 10. RECTIFIER WAVEFORM,  $V_{IN} = 30V$ , LOAD = 2.5A

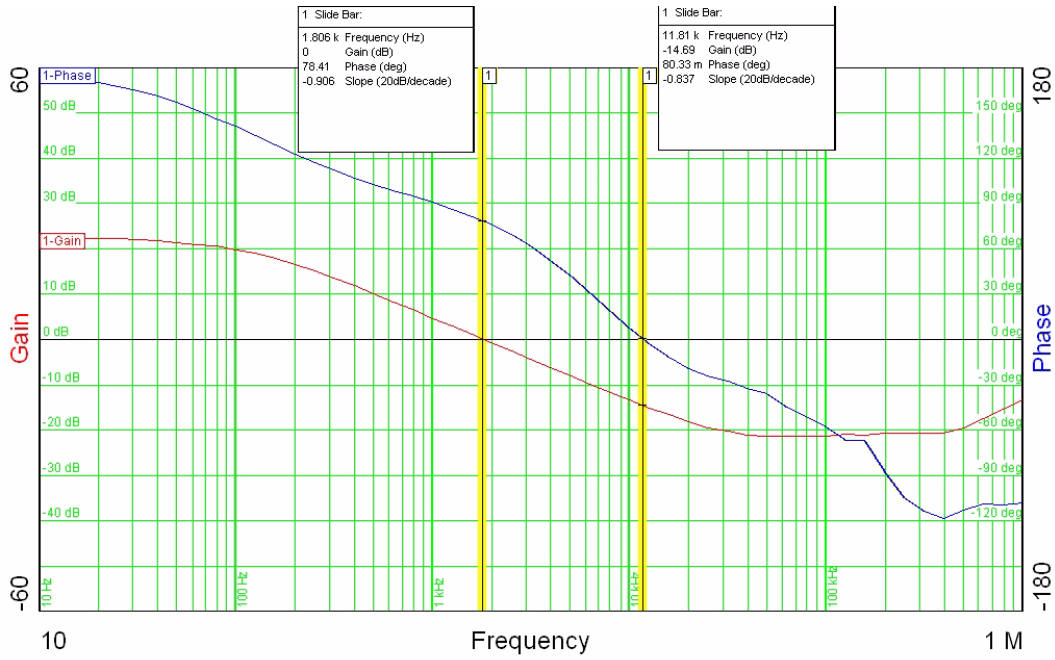


FIGURE 11. STABILITY ANALYSIS,  $V_{IN} = 18V$ , FULL LOAD

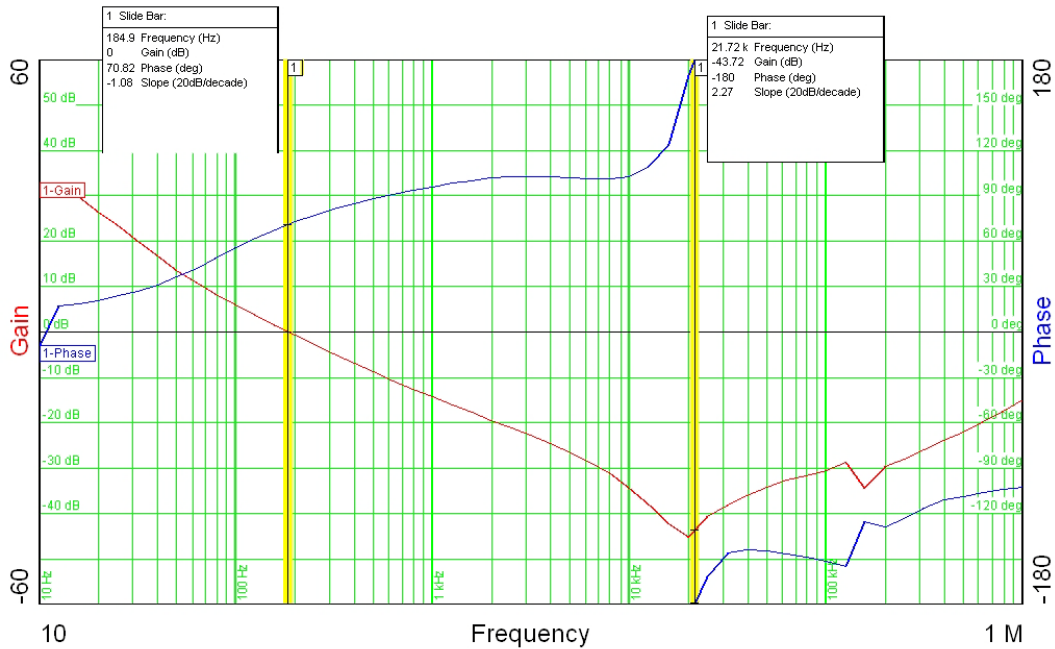


FIGURE 12. STABILITY ANALYSIS,  $V_{IN} = 18V$ , NO LOAD

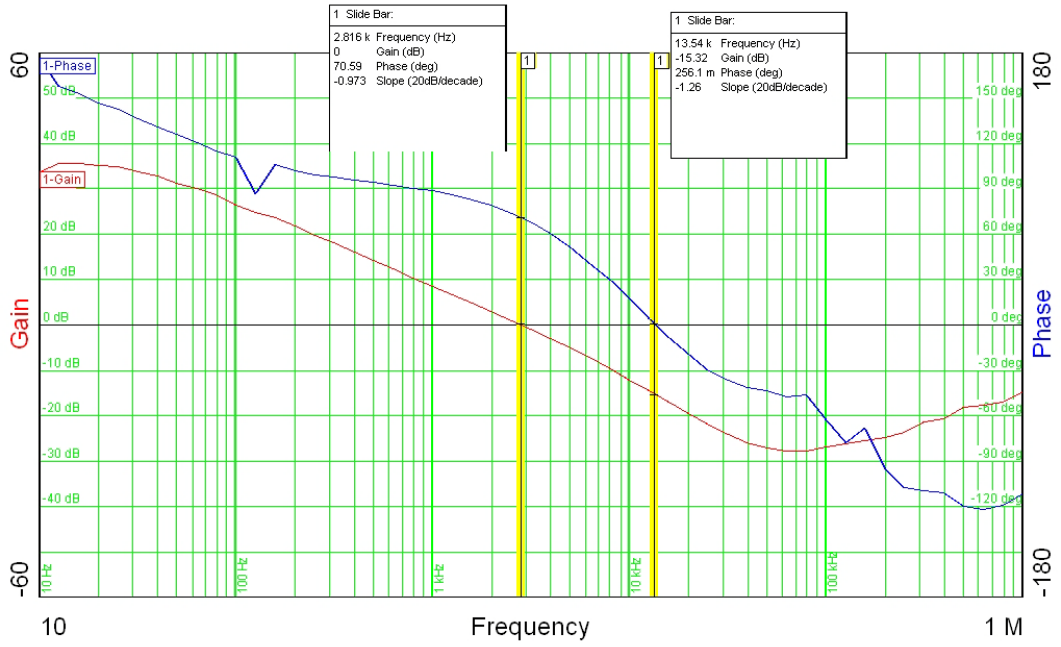


FIGURE 13. STABILITY ANALYSIS,  $V_{IN} = 30V$ , FULL LOAD

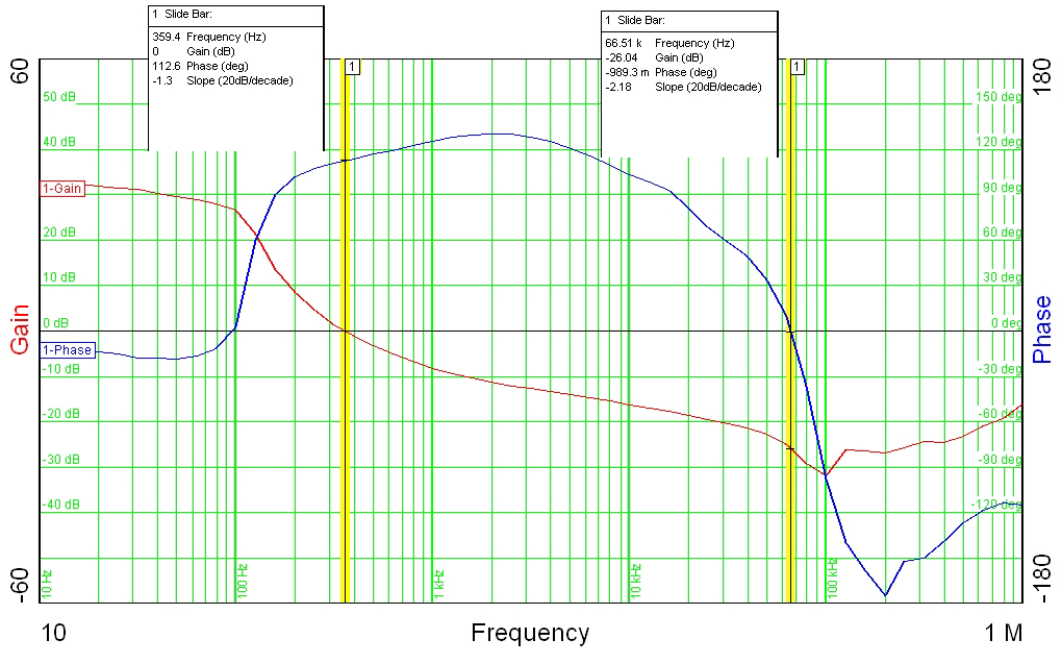


FIGURE 14. STABILITY ANALYSIS,  $V_{IN} = 30V$ , NO LOAD



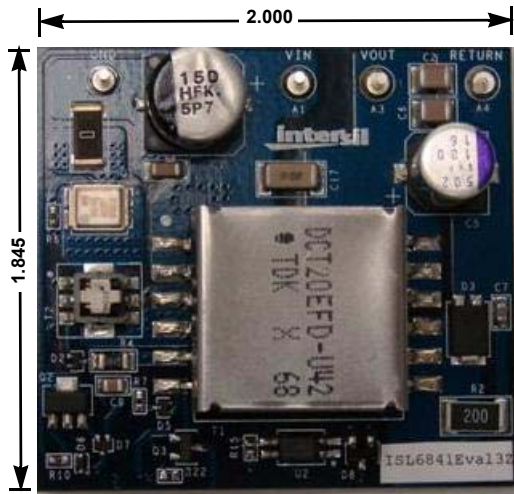


FIGURE 15. TOP VIEW - ISL6841EVAL3Z BOARD

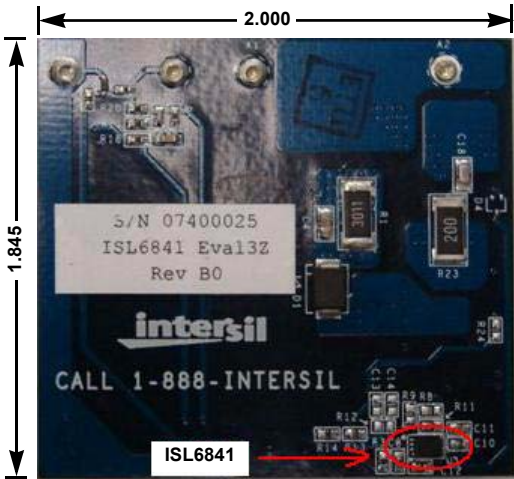


FIGURE 16. BOTTOM VIEW - ISL6841EVAL3Z BOARD

**Circuit Elements**

- Input Filtering Capacitance – C<sub>1</sub>, C<sub>3</sub>
- Isolation Transformer – T<sub>1</sub>
- Power MOSFET – Q<sub>1</sub>
- Current Sense Network – T<sub>2</sub>, D<sub>2</sub>, R<sub>4</sub>, R<sub>3</sub>, C<sub>8</sub> (R<sub>5</sub> optional)
- Start-up Bias Circuit – R<sub>10</sub>, Q<sub>2</sub>, D<sub>6</sub>
- Operating Bias Circuit – D<sub>5</sub>, R<sub>7</sub>, C<sub>9</sub>, D<sub>7</sub>
- Control Circuit – U<sub>1</sub>, C<sub>10</sub>, C<sub>11</sub>, R<sub>11</sub>, C<sub>12</sub>, R<sub>6</sub>
- Conventional Rectification Diode – D<sub>3</sub>
- Output Filtering – C<sub>5</sub>, C<sub>6</sub>, C<sub>2</sub>
- Feedback Network – R<sub>13</sub>, R<sub>14</sub>, R<sub>15</sub>, R<sub>16</sub>, R<sub>17</sub>, R<sub>18</sub>, R<sub>19</sub>, R<sub>20</sub>, R<sub>21</sub>, D<sub>8</sub>, D<sub>9</sub>, C<sub>15</sub>, C<sub>16</sub>, U<sub>2</sub>
- Slope Compensation - Q<sub>3</sub>, R<sub>22</sub>
- Primary RCD Snubber - R<sub>1</sub>, D<sub>1</sub>, C<sub>4</sub>
- Primary FET Snubber - R<sub>23</sub>, C<sub>18</sub>
- Secondary Rectifier Snubber - R<sub>2</sub>, C<sub>7</sub>
- Safety Capacitor - C<sub>17</sub>
- Optional Circuit for Primary Auxiliary Feedback - R<sub>8</sub>, R<sub>9</sub>, R<sub>12</sub>, C<sub>13</sub>, C<sub>14</sub>

**Summary**

Using a high performance, low-cost PWM controller with a low pin-count, all the design targets have been achieved, while keeping the cost to a minimum. The ISL6841EVAL3Z schematic and BOM for the evaluation board are provided as follows. Please contact our Technical Support Center for custom output voltage requirements. They can be reached through Intersil's website at: <http://www.intersil.com/cda/home/> or via phone at 1-888-INTERSIL.

**Component List**

REFERENCE DESIGNATOR	VENDOR	PART NUMBER	DESCRIPTION
C1	Panasonic	EEE-FK1H151P	CAP, SMD, 10.3mm, 150µF, 50V, 20%, ROHS, ALUM.ELEC.
C2, C6	TDK/Murata		CAP, SMD, 1210, 22µF, 16V, 20%, X7R, ROHS
C3	TDK/Murata		CAP, SMD, 1206, 1µF, 50V, 10%, X7R, ROHS
C4	TDK/Murata		CAP, SMD, 0805, 0.01µF, 100V, 10%, X7R, ROHS
C5	Sanyo	16SVP180M	CAP, SMD, E12, 180µF, 16V, 20%, OSCON, ROHS
C7, C18	TDK/Murata		CAP, SMD, 0805, 820pF, 100V, 5%, NPO, ROHS
C8, C12	TDK/Murata		CAP, SMD, 0402, 220pF, 50V, 5%, NPO, ROHS
C9	TDK/Murata		CAP, SMD, 0805, 1.0µF, 25V, 10%, X7R, ROHS
C10, C11	TDK/Murata		CAP, SMD, 0402, 0.1µF, 16V, 10%, X7R, ROHS
C15	TDK/Murata		CAP, SMD, 0402, 150pF, 50V, 5%, NPO, ROHS
C16	TDK/Murata		CAP, SMD, 0603, 0.22µF, 16V, 10%, X7R, ROHS
C17	Murata	GA352QR7GF152KW01L	CAP, SMD, 2220, 1500pF, 250V, 10%, X7R, ROHS
D1	Diodes	B340LB-13-F	DIODE-SCHOTTKY, SMD, SMB, 2P, 40V, 3A LOW VF, ROHS
D2, D5	Diodes	BAS70T-7-F	DIODE-SCHOTTKY, SMD, SOT-523, 70V, 70mA, ROHS
D3	Diodes	PDS560-13	DIODE-RECTIFIER, SMD, POWER DI5, 3P, 60V, 5A, ROHS
D6, D9	Diodes	BZT52C10T-7	DIODE-ZENER, SMD, SOD-523, 10V, 150mW, ROHS
D7	Diodes	BAT54CT-7-F	DIODE-SCHOTTKY, SMD, SOT-523, 30V, 200mA, DUAL DIODE, ROHS
D8	Sipex	SPX431LM-L	IC-ADJ. PREC.SHUNT REGULATOR, 3P, SOT-23, ROHS
Q1	International Rectifier	IRF6646	TRANSISTOR-MOS, N-CHANNEL, SMD, DIRECTFET-MN, 80V, 12A, ROHS
Q2	Diodes	BCX55-16	TRANSISTOR, NPN, SMD, SOT-89, 4P, 60V, 1A, ROHS
Q3	On Semi	MMBT2222ALT1G-T	TRANSISTOR, NPN, 3LD, SOT23, 40V, 600mA, ROHS
R1			RES, SMD, 2512, 3.01k, 1W, 1%, TF, ROHS
R2, R23			RES, SMD, 2512, 20Ω, 1W, 5%, TF, ROHS
R3			RES, SMD, 0402, 249Ω, 1/16W, 1%, TF, ROHS
R4			RES-CURR.SENSE, SMD, 1206, 6.49Ω, 1/4W, 1%, ROHS
R5			RES, SMD, 2512, 0Ω, 1W, TF, ROHS
R6			RES, SMD, 0402, 10Ω, 1/16W, 1%, TF, ROHS
R7			RES, SMD, 0402, 100Ω, 1/16W, 1%, TF, ROHS
R10			RES, SMD, 0402, 30k, 1/16W, 5%, TF, ROHS
R11			RES, SMD, 0402, 17.8k, 1/16W, 1%, TF, ROHS
R13, R14			RES, SMD, 0402, 100k, 1/16W, 1%, TF, ROHS
R15			RES, SMD, 0402, 5.11k, 1/16W, 1%, TF, ROHS
R16			RES, SMD, 0402, 499Ω, 1/16W, 1%, TF, ROHS
R17			RES, SMD, 0402, 4.64k, 1/16W, 1%, TF, ROHS
R18			RES, SMD, 0402, 1k, 1/16W, 1%, TF, ROHS



**Component List** (Continued)

REFERENCE DESIGNATOR	VENDOR	PART NUMBER	DESCRIPTION
R19, R22			RES, SMD, 0402, 10k, 1/16W, 1%, TF, ROHS
R20			RES, SMD, 0402, 6.34k, 1/16W, 1%, TF, ROHS
R21			RES, SMD, 0402, 3.83k, 1/16W, 1%, TF, ROHS
T1	TDK	DCT20EFD-U42S004	TRANSFORMER-FLYBACK, SMD, 20 $\mu$ H, CUSTOM, ROHS
T2	Pulse	P8205NL	TRANSFORMER-CURRENT SENSE, SMD, 8P, 500 $\mu$ H, 10A, ROHS
U1	Intersil	ISL6841IRZ	IC-CURRENT MODE PWM CONTROLLER, 8P, DFN, 2x3, ROHS
U2	California Eastern Laboratories	PS2801-1-A	IC-PHOTOCOUPLER, 4P, SSOP, ROHS

## Layout

The ISL6841EVAL3Z board met the form factor target with room to spare. Following are the layout pictures of the board. The gerber files are available upon request.

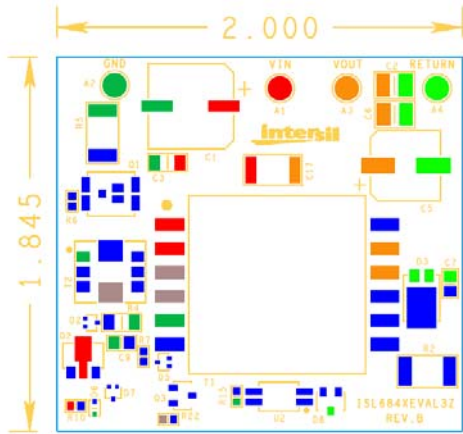


FIGURE 17. SILKSCREEN - TOP LAYER

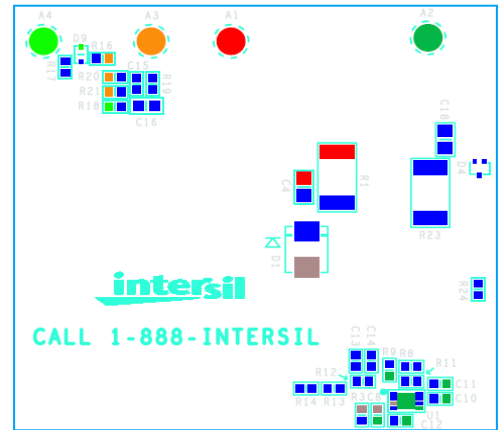


FIGURE 18. SILKSCREEN - BOTTOM LAYER

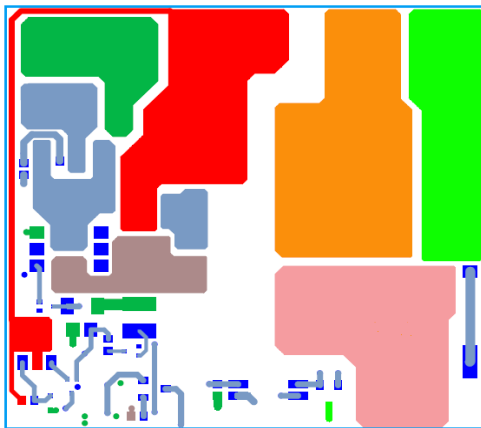


FIGURE 19. ETCH - TOP LAYER

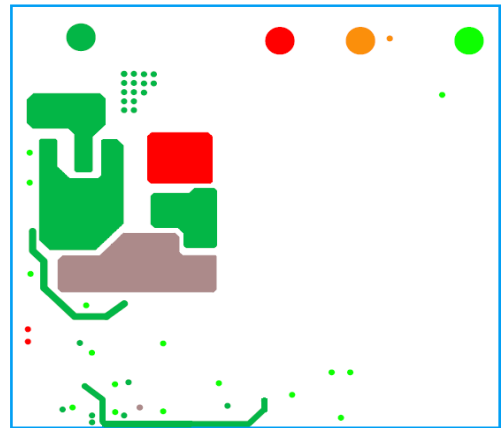


FIGURE 20. ETCH - LAYER 2

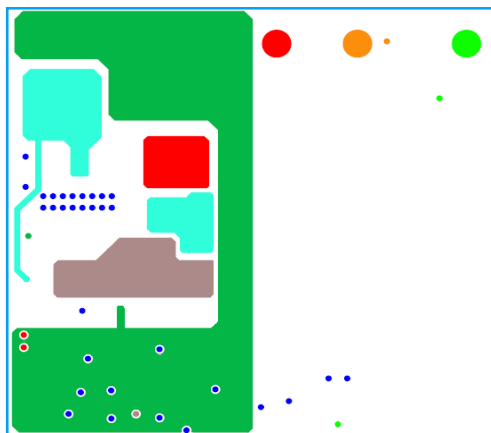


FIGURE 21. ETCH - LAYER 3

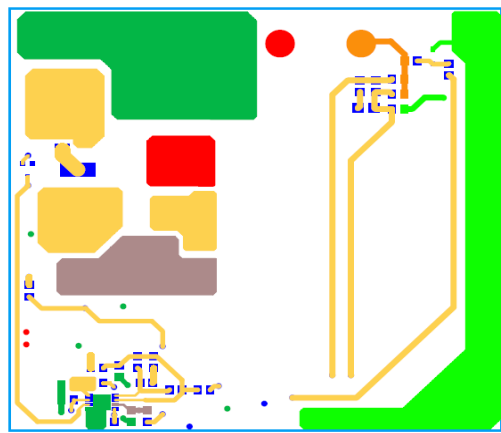


FIGURE 22. ETCH - BOTTOM LAYER

## Notice

1. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation or any other use of the circuits, software, and information in the design of your product or system. Renesas Electronics disclaims any and all liability for any losses and damages incurred by you or third parties arising from the use of these circuits, software, or information.
2. Renesas Electronics hereby expressly disclaims any warranties against and liability for infringement or any other claims involving patents, copyrights, or other intellectual property rights of third parties, by or arising from the use of Renesas Electronics products or technical information described in this document, including but not limited to, the product data, drawings, charts, programs, algorithms, and application examples.
3. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
4. You shall not alter, modify, copy, or reverse engineer any Renesas Electronics product, whether in whole or in part. Renesas Electronics disclaims any and all liability for any losses or damages incurred by you or third parties arising from such alteration, modification, copying or reverse engineering.
5. Renesas Electronics products are classified according to the following two quality grades: "Standard" and "High Quality". The intended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below.  
"Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; industrial robots; etc.  
"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control (traffic lights); large-scale communication equipment; key financial terminal systems; safety control equipment; etc.  
Unless expressly designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not intended or authorized for use in products or systems that may pose a direct threat to human life or bodily injury (artificial life support devices or systems; surgical implantations; etc.), or may cause serious property damage (space system; undersea repeaters; nuclear power control systems; aircraft control systems; key plant systems; military equipment; etc.). Renesas Electronics disclaims any and all liability for any damages or losses incurred by you or any third parties arising from the use of any Renesas Electronics product that is inconsistent with any Renesas Electronics data sheet, user's manual or other Renesas Electronics document.
6. When using Renesas Electronics products, refer to the latest product information (data sheets, user's manuals, application notes, "General Notes for Handling and Using Semiconductor Devices" in the reliability handbook, etc.), and ensure that usage conditions are within the ranges specified by Renesas Electronics with respect to maximum ratings, operating power supply voltage range, heat dissipation characteristics, installation, etc. Renesas Electronics disclaims any and all liability for any malfunctions, failure or accident arising out of the use of Renesas Electronics products outside of such specified ranges.
7. Although Renesas Electronics endeavors to improve the quality and reliability of Renesas Electronics products, semiconductor products have specific characteristics, such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Unless designated as a high reliability product or a product for harsh environments in a Renesas Electronics data sheet or other Renesas Electronics document, Renesas Electronics products are not subject to radiation resistance design. You are responsible for implementing safety measures to guard against the possibility of bodily injury, injury or damage caused by fire, and/or danger to the public in the event of a failure or malfunction of Renesas Electronics products, such as safety design for hardware and software, including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult and impractical, you are responsible for evaluating the safety of the final products or systems manufactured by you.
8. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. You are responsible for carefully and sufficiently investigating applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive, and using Renesas Electronics products in compliance with all these applicable laws and regulations. Renesas Electronics disclaims any and all liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
9. Renesas Electronics products and technologies shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations. You shall comply with any applicable export control laws and regulations promulgated and administered by the governments of any countries asserting jurisdiction over the parties or transactions.
10. It is the responsibility of the buyer or distributor of Renesas Electronics products, or any other party who distributes, disposes of, or otherwise sells or transfers the product to a third party, to notify such third party in advance of the contents and conditions set forth in this document.
11. This document shall not be reprinted, reproduced or duplicated in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products.  
(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its directly or indirectly controlled subsidiaries.  
(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.

(Rev.4.0-1 November 2017)



### SALES OFFICES

### Renesas Electronics Corporation

<http://www.renesas.com>

Refer to "<http://www.renesas.com/>" for the latest and detailed information.

#### **Renesas Electronics America Inc.**

1001 Murphy Ranch Road, Milpitas, CA 95035, U.S.A.  
Tel: +1-408-432-8888, Fax: +1-408-434-5351

#### **Renesas Electronics Canada Limited**

9251 Yonge Street, Suite 8309 Richmond Hill, Ontario Canada L4C 9T3  
Tel: +1-905-237-2004

#### **Renesas Electronics Europe Limited**

Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K  
Tel: +44-1628-651-700, Fax: +44-1628-651-804

#### **Renesas Electronics Europe GmbH**

Arcadiastrasse 10, 40472 Düsseldorf, Germany  
Tel: +49-211-6503-0, Fax: +49-211-6503-1327

#### **Renesas Electronics (China) Co., Ltd.**

Room 1709 Quantum Plaza, No.27 ZhichunLu, Haidian District, Beijing, 100191 P. R. China  
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

#### **Renesas Electronics (Shanghai) Co., Ltd.**

Unit 301, Tower A, Central Towers, 555 Langao Road, Putuo District, Shanghai, 200333 P. R. China  
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

#### **Renesas Electronics Hong Kong Limited**

Unit 1601-1611, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong  
Tel: +852-2265-6688, Fax: +852 2886-9022

#### **Renesas Electronics Taiwan Co., Ltd.**

13F, No. 363, Fu Shing North Road, Taipei 10543, Taiwan  
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

#### **Renesas Electronics Singapore Pte. Ltd.**

80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre, Singapore 339949  
Tel: +65-6213-0200, Fax: +65-6213-0300

#### **Renesas Electronics Malaysia Sdn.Bhd.**

Unit 1207, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia  
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

#### **Renesas Electronics India Pvt. Ltd.**

No.777C, 100 Feet Road, HAL 2nd Stage, Indiranagar, Bangalore 560 038, India  
Tel: +91-80-67208700, Fax: +91-80-67208777

#### **Renesas Electronics Korea Co., Ltd.**

17F, KAMCO Yangjae Tower, 262, Gangnam-daero, Gangnam-gu, Seoul, 06265 Korea  
Tel: +82-2-558-3737, Fax: +82-2-558-5338