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ISL8130EV1Z - Boost Converter

Introduction

ISL8130EV1Z is a standard boost converter, which features the universal PWM controller, ISL8130. The evaluation board delivers 32V output at 1.25A. All the necessary components are within the 1.425" x 1.15" PCB area.

The ISL8130 is a universal PWMcontroller. It is designed to drive N-Channel MOSFETs in a synchronous rectified buck topology for up to 25A instant MOSFET current and can be configured for boost, buck/boost and sepic converters as well. The ISL8130 integrates control, output adjustment, monitoring and protection functions into a single package. The ISL8130 provides simple, voltage mode control with fast transient response.

ISL8130 Key Features

- Operates From:
  - - 4.5V to 5.5V Input for 5V Input
  - - 5.5V to 16V Input
- Resistor-Selectable Switching Frequency from 100kHz to 1.4MHz
- Voltage Margining and External Reference Tracking Modes
- Kelvin Current Sensing
  - Upper MOSFET $r_{DS(ON)}$ for Current Sensing for Buck and Buck/Boost Converter
  - Precision Resistor for Boost and Sepic Converter
- Extensive Protection Functions:
  - Overvoltage, Overcurrent, Undervoltage
- Power-Good Indicator

Evaluation Board Specifications

TABLE 1. EVALUATION BOARD ELECTRICAL SPECIFICATIONS

SPEC	DESCRIPTION	MIN	TYP	MAX	UNIT
VIN	Board Input Range	6	12	16	V
IOC	Input Current	8			A
VOUT		30.5	32	33.5	V
IOUT	V_{IN} = 6V	1.25			A
IOUT	V_{IN} = 12V	2.5			A
η	V_{IN} = 6V, I_{OUT} = 1.25A		90		%
η	V_{IN} = 12V, I_{OUT} = 2.5A		93.5		%

FIGURE 1. ISL8130EV1Z TOP VIEW

TABLE 2. RECOMMENDED COMPONENT SELECTION FOR QUICK EVALUATION

V_{OUT} (V)	R22 (kΩ)	V_{IN} (MIN) (V)	I_{OUT} (A)	F_{SW}(KHz)/R_T(KΩ)	MOSFET	FORWARD DIODE	INDUCTOR (L, ISAT)
32	174	6	1.25	330kHz/43.2kΩ	BSC100N06LS G	SS5P6	10µH, 10A
24	130	9	2	500kHz/28.7kΩ	BSC059N04 LS	SS3P4L	10µH, 7A
12	63.4	4.5	3	500kHz/28.7kΩ	BSC057N03 LS	SS5P3	2.2µH, 15A

NOTES:

1. Please select the output capacitor with a voltage rating higher than the output.
2. Please contact Intersil Sales for assistance.

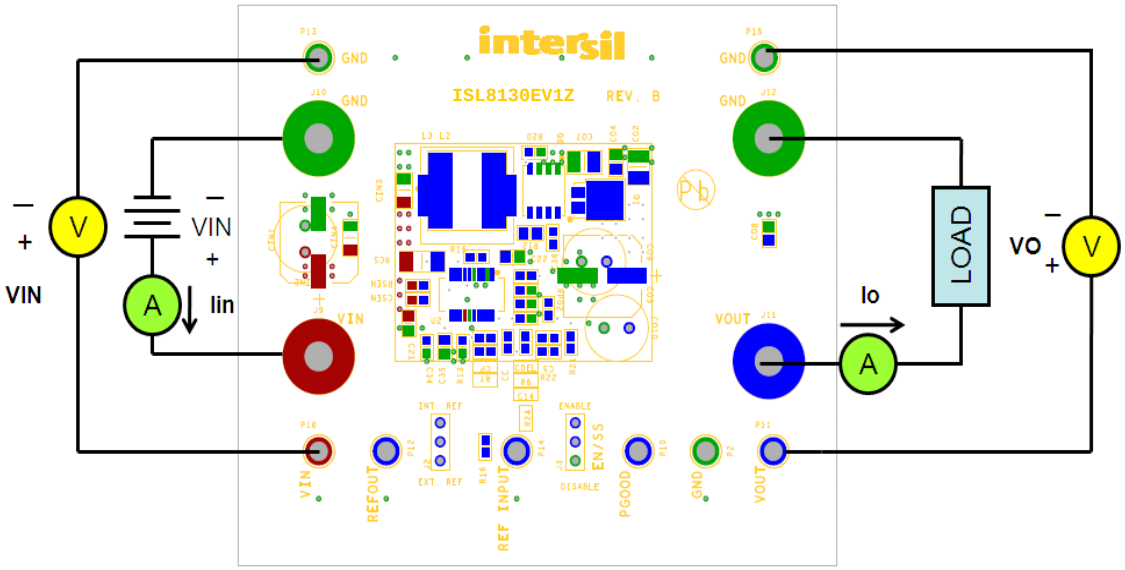


FIGURE 2. ISL8130EV1Z TEST SET-UP

Recommended Equipment

The following equipment is recommended for evaluation:

- 0V to 20V power supply with 15A source current capability
- Electronic load capable of sinking 2A @ 40V
- Digital Multi meters (DMMs)
- 100MHz Quad-Trace Oscilloscope

Quick Test Setup

1. Ensure that the Evaluation board is correctly connected to the power supply and the electronic load prior to applying any power. Please refer to Figure 2 for proper set-up.
2. Leave JP3 in the open position
3. Turn on the power supply; V_{IN}< 16V
4. Adjust input voltage V_{IN} within the specified range and observe output voltage. The output voltage variation should be within 5%.
5. Adjust load current within 1.25A. The output voltage variation should be within 5%.
6. Use oscilloscope to observe output ripple voltage and phase node ringing. For accurate measurement, please refer to Figure 3 for proper probe set-up.
7. Optimization. Please refer to Table 2 on page 1 for optimization recommendation.
8. For 5V input applications, please tie the VCC5V to VIN and do not allow V_{IN} to go above 5.5V.

NOTE: Test points: VIN+, VIN-, VO+ and VO- are for voltage measurement only. Do not allow high current through these test points.

Probe Set-up

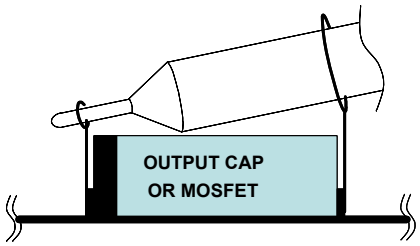


FIGURE 3. OSCILLOSCOPE PROBE SET-UP

VOUT Setting

The output voltage is set by the resistor divider, R_{13} and R_{22}.

$$V_{OUT} = \frac{R_{13} + R_{22}}{R_{13}} \times 0.6V \quad \text{(EQ. 1)}$$

Resistor R_{21} is a resistor jumper for loop gain measurement. It is recommended to set R_{21} = 50Ω for loop gain measurement.

Component Selection

Component Voltage Stress

The controller, ISL8130 and input capacitors are connected from the VIN rail to GND. MOSFET, diode and the output capacitors are connected from the VOUT rail to GND. Please select component with sufficient voltage rating.

Inductor Selection

It is recommended to select inductor so that the ripple current ratio is between 30% to 50%. For low-core-loss magnetic material, higher ripple ratio would ease the compensation design

and help to reduce the size of the inductor. Please refer to Equation 2 for recommended indcutor value:

$$L_{BST} = \frac{V_{OUT}}{\Delta i_R \times I_{Omax} \times F_{SW}} \times D \times (1-D)^2 \quad \text{(EQ. 2)}$$

Where D is the duty cycle, Δi_R is the inductor ripple ratio.

It is recommended to select an inductor with a saturation current higher than the maximum overcurrent threshold.

Current Sensing:

For accurate overcurrent detection, it is recommended to set the voltage across the current sensing resistor, RCS, higher than 50mV. Taking variation into consideration, when precision current sensing resistor is used, RSEN = 665Ω. .

The OC threshold should be higher than the peak inductor current at maximum load current. The maximum peak inductor usually occurs at VINmin and can be calculated using Equation 3.

$$I_{LPK} = \frac{I_{Omax} \times V_{OUT}}{V_{INmin}} + \frac{1}{2} \times \frac{V_{INmin}}{L_{BST} \times F_{SW}} \times \left(1 - \frac{V_{INmin}}{V_{OUT}}\right) \quad \text{(EQ. 3)}$$

Refer to Equation 4 for R_{CS} calculation.

$$R_{CS} < \frac{R_{SEN} \times I_{OCSET(min)}}{I_{LPK}} \quad \text{(EQ. 4)}$$

Where: I_{OCSET} is the OCSET pin sinking current for overcurrent detection. The $I_{OCSET(min)}$ = 80µA.

In “Inductor Selection” on page 2, it is recommended that the inductor saturation current be higher than the maximum overcurrent threshold. The maximum overcurrent threshold can be calculated by Equation 5.

$$I_{OCmax} = \frac{R_{SEN} \times I_{OCSET(max)}}{R_{CS}} \quad \text{(EQ. 5)}$$

Where $I_{OCSET(max)}$ = 120µA.

Input Capacitors

The input RMS current of a boost is much smaller than the output RMS in general. Please refer to Equation 6 for input RMS current calculation:

$$I_{INRMS} = \frac{V_{IN}}{L_{BST} \times F_{SW}} \times \left(1 - \frac{V_{IN}}{V_{OUT}}\right) \div (\sqrt{12}) \quad \text{(EQ. 6)}$$

The bulk capacitor used is used to stabilize system stability and can be considered as the output capacitor of the input power supply.

Output Capacitors

It is recommended to use a combination of aluminum capacitors with high capacitance and low ESR ceramic capacitors at the output for optimum ripple and load transient performance.

The low ESL and ESR ceramic capacitors should be placed close to the MOSFET and diode.

When selecting the output capacitors, there are two important requirements: the ripple current and the stability.

The output RMS current worst case occurs at VIN_min and maximum load. See Equation 7 for output ripple current calculation:

$$I_{ORMS} = I_{OUT} \times \sqrt{\frac{D_{max}}{1 - D_{max}}} \quad \text{(EQ. 7)}$$

For example:

V_{OUT} = 32V, I_{OUT} = 1.25A, VINmin = 6V

D_{max} = 81.25%

I_{ORMS} = 2.6A

For applications with F_{SW} < 1MHz, it is still rule of thumb that the aluminum electrolytic capacitors take the ripple current. Please select electrolytic capacitors with ripple current greater than the maximum I_{ORMS}, as calculated by Equation 7.

The other important factor is stability. The right-half-plane zero, f_{RHP} of a boost converter imposes a big challenge for stability. It is recommended to set cross over frequency below the f_{RHP} and above the boost converter natural resonant frequency, f_N. It is recommended to use sufficient output capacitors so that the f_N is much lower than f_{RHP}. Equation 8 is provided for total output capacitance estimation.

$$C_{out} > \left(\frac{I_{Omax}}{V_{INmin}}\right)^2 \times L_{BST} \times 400 \quad \text{(EQ. 8)}$$

where L_{BST} is the boost inductor.

For right-half-plane zero calculation, f_{RHP}:

$$f_{RHP} = \frac{V_{in}}{2\pi \times I_L \times L_{BST}} \quad \text{(EQ. 9)}$$

For boost converter natural resonant frequency, f_N:

$$f_N = \frac{1-D}{2\pi \times \sqrt{C_{OUT} \times L_{BST}}} \quad \text{(EQ. 10)}$$

Output Disconnect

The boost converter cannot protect from an output short circuit event. It relies on the input power supply overcurrent protection or output disconnect circuit for output short circuit events. Figure 4 is a simple output disconnect circuit, which can be used as a reference. The circuit is inserted between the cathode of the diode and the boost output.

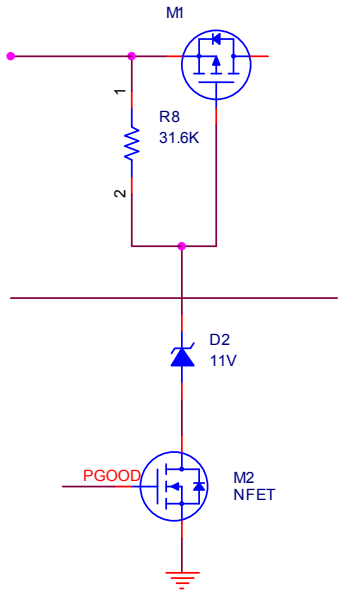


FIGURE 4. OUTPUT DISCONNECT CIRCUIT

Typical Performance Curves

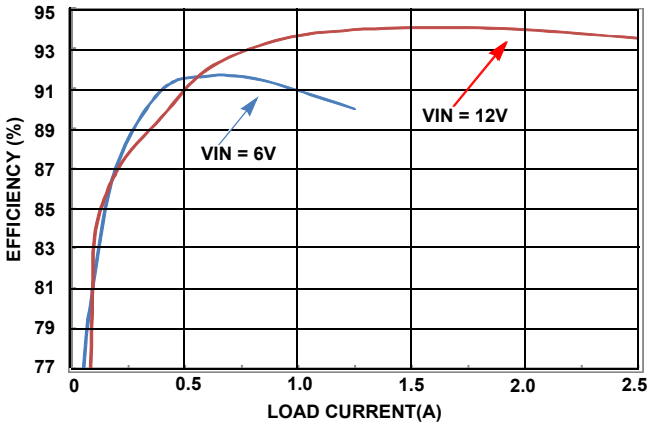


FIGURE 5. EFFICIENCY vs LOAD CURRENT

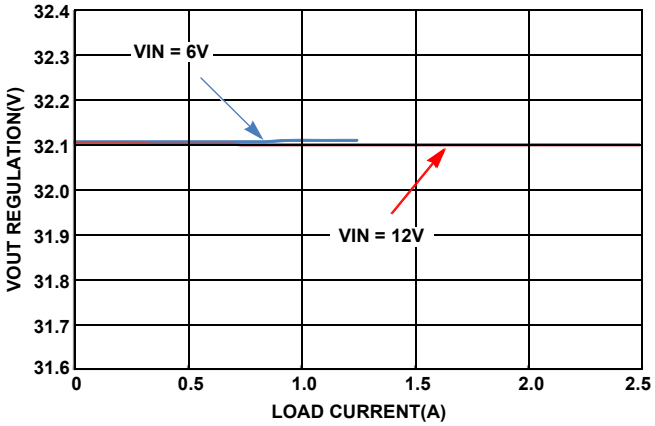


FIGURE 6. VOUT LOAD REGULATION

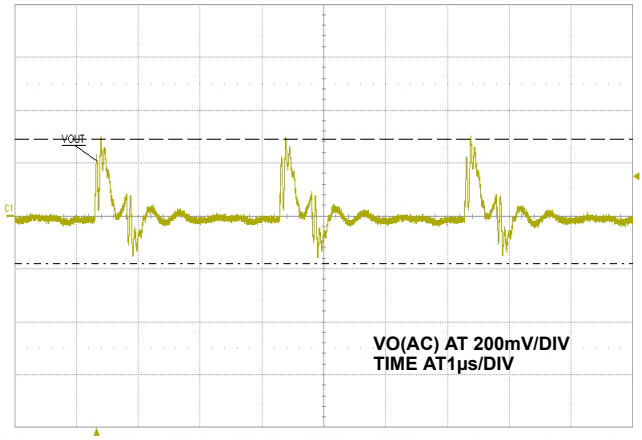


FIGURE 7. OUTPUT RIPPLE (V_{IN} = 6V, LOAD = 1.25A, 20MHz BW)

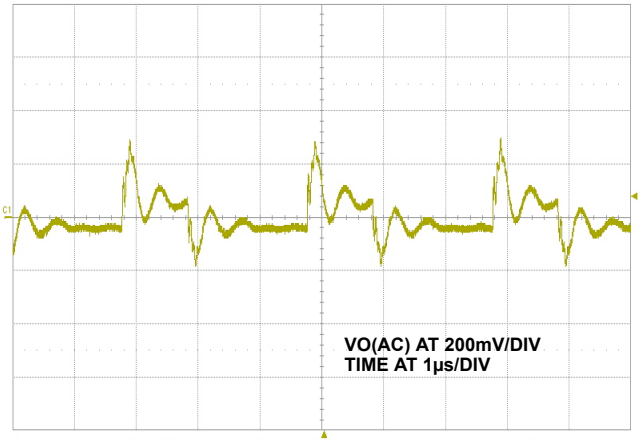


FIGURE 8. OUTPUT RIPPLE (V_{IN} = 12V, LOAD = 2.5A, 20MHz BW)

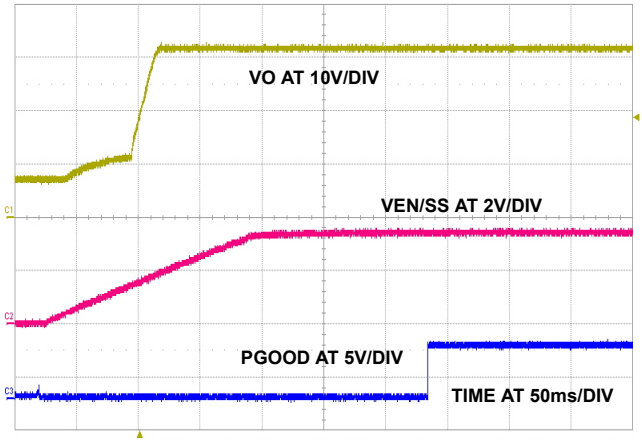


FIGURE 9. SOFT-START (C_{SS} - 0.47µF, C_{DEL} = 0.1µF)

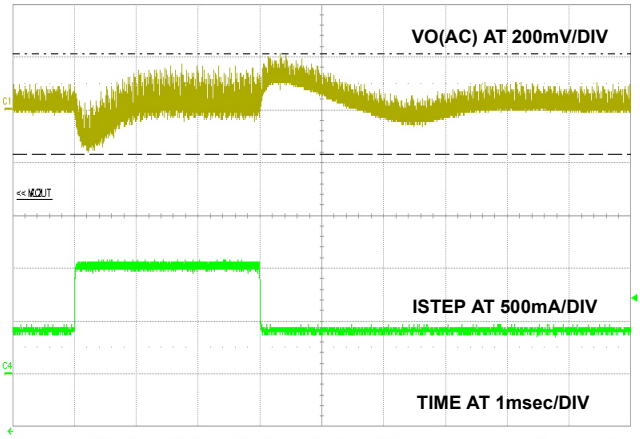


FIGURE 10. LOAD TRANSIENT (V_{IN} = 12V, LOADSTEP FROM 0.375A TO 1.0A)

Typical Performance Curves (Continued)

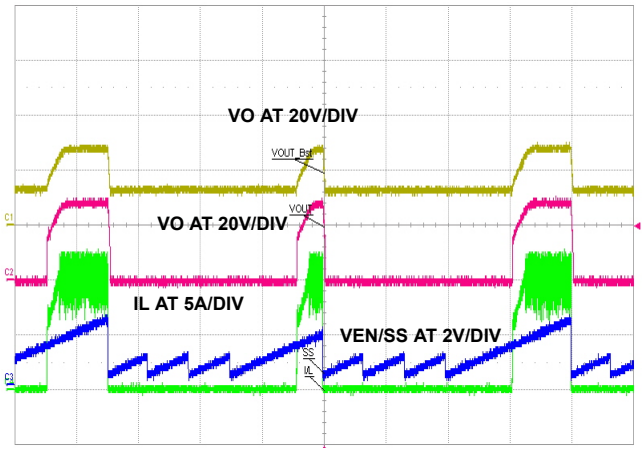
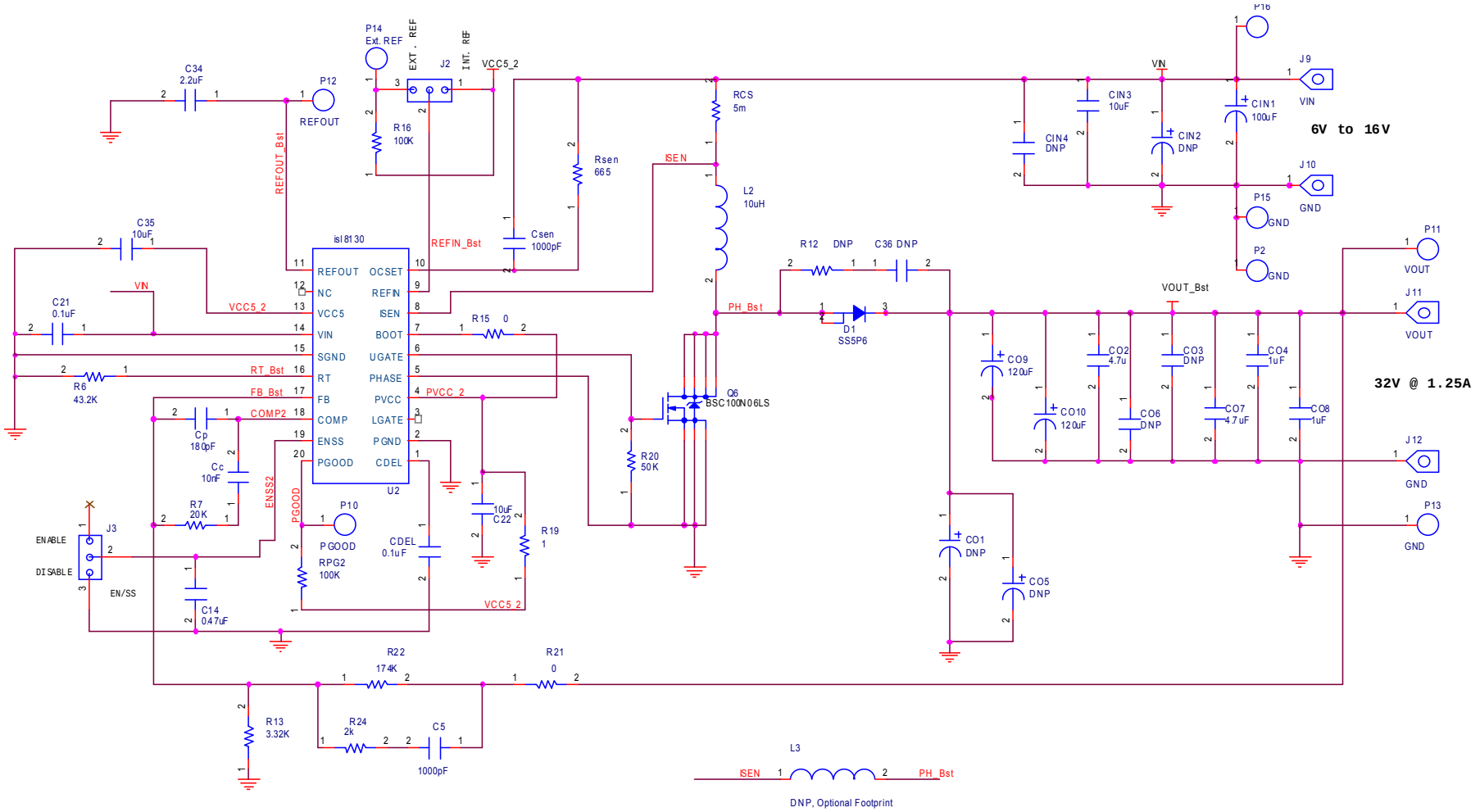


FIGURE 11. OVERCURRENT PROTECTION AT OVERLOAD WITH OUTPUT DISCONNECT (VBST IS THE OUTPUT BEFORE THE OUTPUT DISCONNECT FET. VO IS THE OUTPUT AFTER THE DISCONNECT FET)

Schematic



Bill of Materials

ITEM	QTY	REFERENCE	VALUE	DESCRIPTION	PART #	VENDOR
ESSENTIAL COMPONENTS						
1	1	CIN1	100µF	Alum. CAP, 35V	AVE107M35F24T-F	CDE
2	1	CIN3	10µF	Ceramic CAP, X5R, 25V, sm1206	Generic	Generic
3	1	C14	0.47µF	Ceramic CAP, X5R, 16V, sm0603	Generic	Generic
4	2	C21, CDEL	0.1µF	Ceramic CAP, X5R, 50V, sm0603	Generic	Generic
5	2	C22, C35	10µF	Ceramic CAP, X5R, 10V, sm0805	Generic	Generic
6	1	C34	2.2µF	Ceramic CAP, X5R, 16V, sm0805	Generic	Generic
7	2	CO4, CO8	1µF	Ceramic CAP, X5R, 50V, sm0805	Generic	Generic
8	2	CO7, CO2	4.7µF	Ceramic CAP, X5R, 50V, sm1206	Generic	Generic
9	1	Cc	10nF	Ceramic CAP, NP0 or C0G, sm0603	Generic	Generic
10	2	C5, Csen	1000pF	Ceramic CAP, NP0 or C0G, sm0603	Generic	Generic
11	1	Cp	180pF	Ceramic CAP, NP0 or C0G, sm0603	Generic	Generic
12	2	CO9, CO10	120µF	Alum. Cap, 50V, Radial 8 X 8 X 15	EEU-FR1H121L	Panasonic ECG
13	1	D1		Schottky Diode, 60V	SS5P6	Vishay
14	1	L2	10µH	Inductor	DR127-100-R	Cooper
15	1	Q6		Single Channel NFET, 60V	BSC100N06LS	Infineon
16	1	RCS	5m	Precision RES, sm2010, 1W	PMR50HZPJU5L0	ROHM
17	2	RPG2, R16	100k	Resistor, sm0603, 10%	Generic	Generic
18	1	Rsen	665	Resistor, sm0603, 1%	Generic	Generic
19	1	R6	43.2k	Resistor, sm0603, 1%	Generic	Generic
20	1	R7	20k	Resistor, sm0603, 1%	Generic	Generic
21	1	R13	3.32k	Resistor, sm0603, 1%	Generic	Generic
22	2	R15, R21	0	Resistor, sm0603, 10%	Generic	Generic
23	1	R19	1	Resistor, sm0603, 10%	Generic	Generic
24	1	R20	51k	Resistor, sm0603, 10%	Generic	Generic
25	1	R22	174k	Resistor, sm0603, 1%	Generic	Generic
26	1	R24	2k	Resistor, sm0603, 10%	Generic	Generic
27	1	U2		PWM Controller, 20L QSOP	ISL8130IAZ	Intersil
EVALUATION BOARD HARDWARE						
27	2	J10, 12		Banana Jack (Black)	111-0703-001	Emerson
28	2	J9, J11,		Banana Jack (Red)	111-0703-002	Emerson
29	2	J2, J3		1x3 Header	Generic	Generic
30	2	J2, J3		Connector Jumper	SPC02SYAN	Sullins
31	8	P2, P10, P11, P12, P13, P14, P15, P16,			1514-2	Keystone
OPTIONAL COMPONENTs						
32		CIN2, CIN4, CO3, CO6, CO1, CO5, C36, L3, R12	DO NOT POPULATE	N/A	N/A	N/A

ISL8130EV1Z PCB Layout

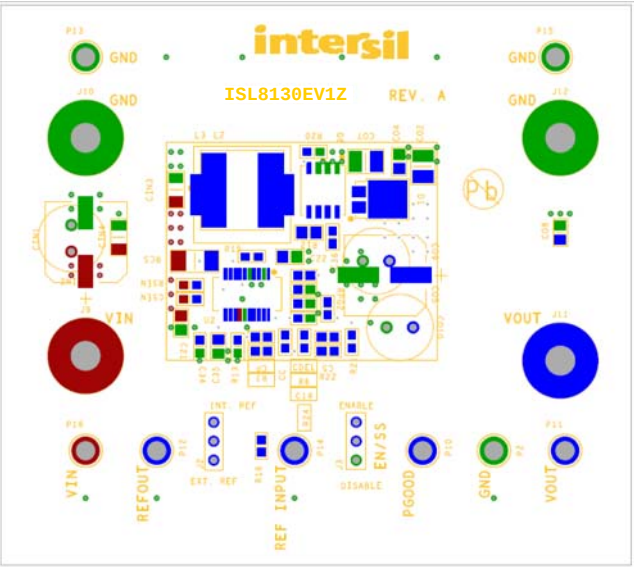


FIGURE 12. TOP SILKSCREEN

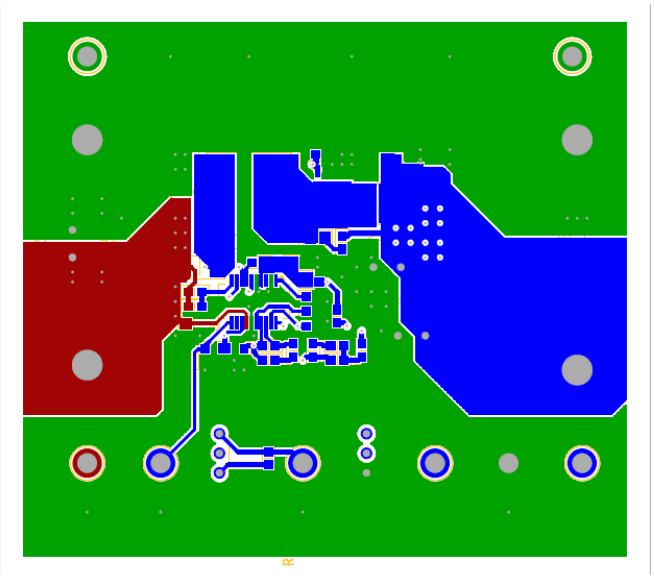


FIGURE 13. TOP LAYER

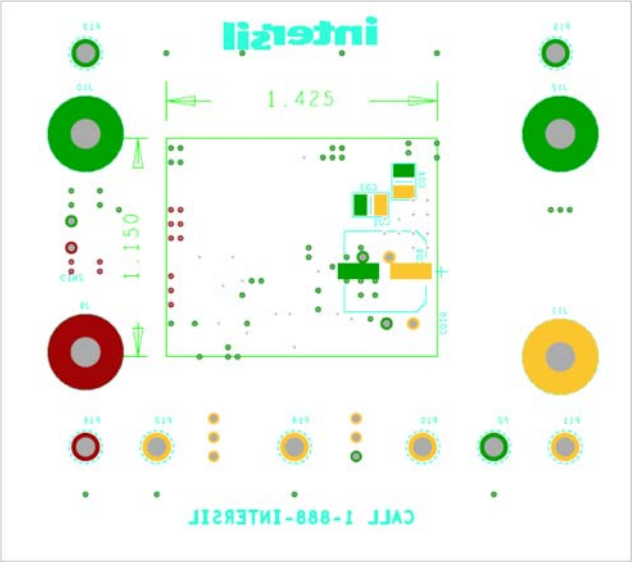


FIGURE 14. BOTTOM SILKSCREEN

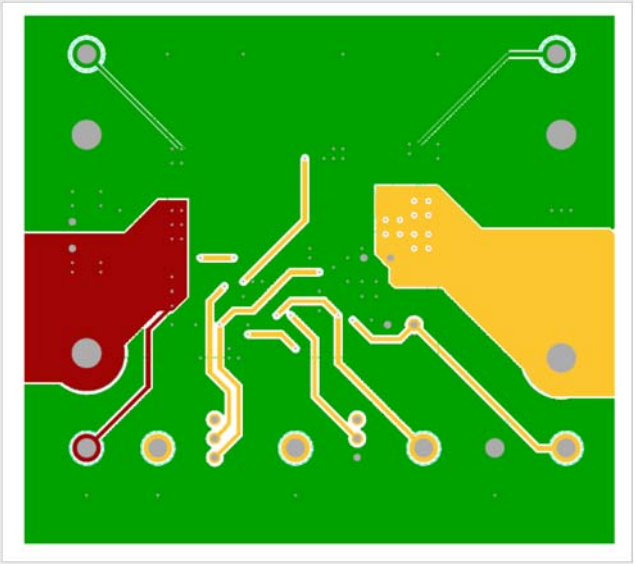


FIGURE 15. BOTTOM LAYER