

LMP8646EB

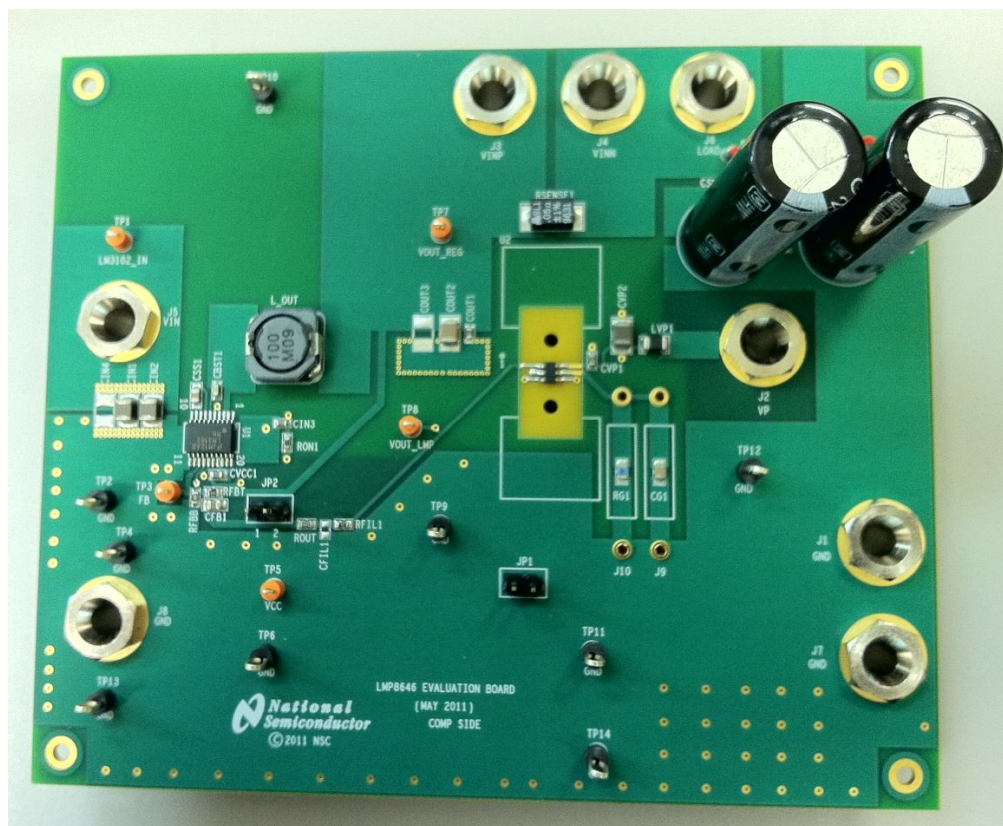


Figure 1 – LMP8646EB

The LMP8646 Evaluation Board (LMP8646EB) is designed to ease evaluation and design-in of Texas Instruments' LMP8646, a Precision Current Limiter. The LMP8646 is used to detect small differential voltages across a sense resistor in the presence of high input common mode voltages. On board with the current limiter is the LM3102, a Step Down Switching Regulator that is capable of supplying 2.5A to loads. This document describes super cap and resistive load applications utilizing the LM3102 voltage regulator and the LMP8646 precision current limiter. The document also provides the schematic, layout, and BOM for the LMP8646 evaluation board.

Table of Contents

1. EVM OVERVIEW	3
1.1. LIST OF FEATURES	3
1.2. EQUIPMENT.....	3
1.3. ADDITIONAL RESOURCES.....	3
2. QUICK START: SUPERCAP APPLICATION.....	4
3. QUICK START: RESISTIVE LOM AD APPLICATION.....	8
4. POWERING THE LMP8646EB.....	11
5. SCHEMATIC	12
6. LAYOUT	13
7. BOM.....	18

List of Figures

FIGURE 1 – LMP8646EB.....	1
FIGURE 2 – SCHEMATIC FOR THE SUPERCAP APPLICATION	4
FIGURE 3 – PLOT FOR THE SUPERCAP APPLICATION	7
FIGURE 4 – SCHEMATIC FOR THE RESISTIVE LOAD APPLICATION	8
FIGURE 5 – RECOMMENDED COMPONENTS FOR THE LM3102	9
FIGURE 6 – PLOTS FOR THE RESISTIVE LOAD APPLICATION	10
FIGURE 7 – SCHEMATIC.....	12
FIGURE 8 - LAYOUT TOP LAYER	13
FIGURE 9 - LAYOUT TOP LAYER	14
FIGURE 10 - LAYOUT LAYER #2: POWER	15
FIGURE 11 - LAYOUT LAYER #3: GROUND	16
FIGURE 12 - LAYOUT BOTTOM LAYER.....	17

1. EVM Overview

1.1. List of Features

The LMP8646 evaluation board consists of:

1. The LMP8646 precision current limiter and its supporting circuitries
2. Two super capacitors for the load
3. LM3102 voltage regulator and its circuitries
4. Sense resistor of 50 mOhm.

1.2. Equipment

1. LMP8646 evaluation board (NSID: LMP8646EB)
2. 2 Power supplies to source LM3102's VIN and LMP8646's V+
3. Multimeter
4. Oscilloscope
5. Current probe

1.3. Additional Resources

1. LM3102 Datasheet located at <http://www.ti.com/product/lm3102>
2. LM3102 Evaluation Board App Note located at <http://www.ti.com/lit/snva248>

2. Quick Start: Supercap Application

A supercap application requires a very high capacitive load to be charged. This example assumes the output capacitor is 3.3F with a limited load current at 1.5A. The LM3102 will provide the current to charge the supercap, and the LMP8646 will monitor this current to make sure it does not exceed the desired 1.5A value.

This is done by connecting the LMP8646 output to the feedback pin of the LM3102, as shown in **Figure 1**. This feedback voltage at the FB pin is compared to a 0.8V internal reference. Any voltage above this 0.8V means the output current is above the desired value of 1.5A, and the LM3102 will reduce its output current to maintain the desired 0.8V at the FB pin.

The following steps show the design procedures for this supercap application. The first step is to select the discrete components for the LM3102 by following the design steps described in its application note. Next, integrate the LMP8646 into the system and select the proper values for its gain, bandwidth, and output resistor. Lastly, capture the results and adjust the components to yield the desired performance.

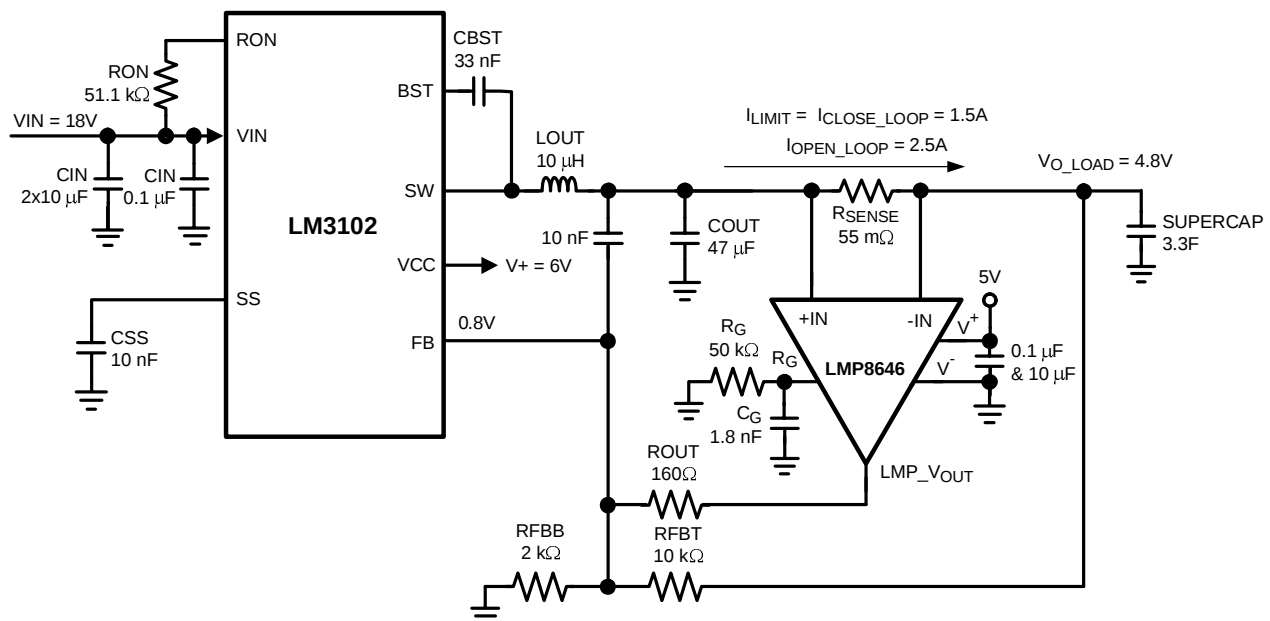


Figure 2 – Schematic for the SuperCap Application

1. Step 1: Choose Components for the LM3102

Refer to the LM3102 evaluation board app note (AN-1646) located at <http://www.ti.com/lit/snva248> to choose the appropriate components for the LM3102.

2. Step 2: Choose the gain resistor, R_g , for LMP8646

If $R_{sense} = 55 \text{ m}\Omega$, then use the equation below to calculate the appropriate gain resistor, R_G , for an output current of 1.5A.

$$V_{OUT} = (R_{SENSE} I_{LIMIT}) (Gain)$$

$$\text{where Gain} = \frac{R_G}{1 / \text{transconductance}} = \frac{R_G}{1 / 200 \mu A / V} = \frac{R_G}{5k\Omega}$$

$$R_G = \frac{V_{OUT} 5k\Omega}{R_{SENSE} I_{LIMIT}}$$

$$R_G = \frac{(0.8V)(5k\Omega)}{(55m\Omega)(1.5A)}$$

$$R_G \approx 50k\Omega$$

Note: Refer to the "Selection of the Sense Resistor, R_{SENSE} " section of the LMP8646 datasheet to select your own R_{SENSE} if 55 m Ω is not desired.

3. Step 3: Choose the Bandwidth Capacitance, C_G .

The product of C_G and R_G determines the bandwidth for the LMP8646. Refer to the Typical Performance Characteristics plots of the LMP8646 datasheet to see the range for the LMP8646 bandwidth and gain. Since each application is very unique, the LMP8646 bandwidth capacitance, C_G , needs to be adjusted to fit the appropriate application.

Bench data has been collected for the supercap application with the LM3102 regulator. We found that this application works best for a bandwidth of 500 Hz to 3 kHz. Operating outside of this recommended bandwidth range might create an undesirable load current ringing. We recommend choosing a bandwidth that is in the middle of this range and using the following equation to find C_G :

$$C_G = \frac{1}{2\pi(R_G)(\text{Bandwidth})}$$

$$C_G = \frac{1}{2\pi(50k\Omega)(1.75kHz)}$$

$$C_G = 1.8nF$$

Once C_G is chosen, capture the output regulator current plot and adjust C_G to get the desired value. If adjusting C_G isn't enough, we also recommend adjusting the regulator's C_{OUT} to reduce the current ringing. We found that this application works best for a C_{OUT} value of 47 μF .

4. Step 4: Calculate the Output Accuracy and Choose a Tolerable System Error

Since the LMP8646 is a precision current limiter, the output current accuracy is extremely important. This accuracy is affected by the system error contributed by the LMP8646 device error and other errors contributed by the regulator and external resistances, such as R_{SENSE} and R_G . However, we cannot control for external errors, but we can predict the LMP8646 device error using the following equations:

$$\text{Output Accuracy} = \left| \frac{V_{\text{OUT_THEO}} - V_{\text{OUT_CAL}}}{V_{\text{OUT_THEO}}} \right| \times 100(\%)$$

$$\text{where } V_{\text{OUT_THEO}} = (V_{\text{SENSE}}) \times \frac{R_G}{1/G_m}$$

$$\text{and } V_{\text{OUT_CALC}} = \frac{(V_{\text{SENSE}} + V_{\text{OFFSET}}) \times R_G}{1/[G_m (1 + G_m_Accuracy)]}$$

- a) Using the formula above, calculate for the LMP8646 output accuracy knowing that $V_{\text{SENSE}} = (1.5A)(55 \text{ m}\Omega)$, $R_G = 50 \text{ k}\Omega$, $V_{\text{OFFSET}} = 1 \text{ mV}$, and $G_m_Accuracy = 2\%$ (LMP8646 datasheet, electrical characteristics table).

$$V_{\text{OUT_THEO}} = (1.5A)(55 \text{ m}\Omega) \frac{50 \text{ k}\Omega}{1/200 \mu V} = 0.825V$$

$$V_{\text{OUT_CALC}} = \frac{[(1.5A)(55 \text{ m}\Omega) + 100 \text{ mV}](50 \text{ k}\Omega)}{1/[200 \mu V(1 + 2/100)]} = 0.852V$$

$$\text{Output Accuracy} = \left| \frac{0.825 - 0.852}{0.825} \right| \times 100 = 3.27\%$$

- b) After figuring out the LMP8646 output accuracy, choose a tolerable system error or the output current accuracy that is bigger than the LMP8646 output accuracy. This tolerable system error will be labeled as I_{ERROR} , which has the equation $I_{\text{ERROR}} = (I_{\text{MAX}} - I_{\text{LIMIT}})/I_{\text{MAX}} (\%)$. In this example, we can choose $I_{\text{ERROR}} = 5\%$. This value will be used to calculate for R_{OUT} in the next step.

5. Step 5: Choose the output resistor, R_{OUT} , for LMP8646

At startup, the capacitor is not charged yet and thus the output voltage of the LM3102 is very small ($V_{\text{O}_3102_MIN}$, see Figure 3). Therefore, at this point, the output current is at its maximum (I_{MAX}). When the output voltage is at its nominal, then the output current will settle to the desired target value. Because a large current error is not desired, R_{OUT} needs to be chosen to stabilize the loop with minimal initial startup current error. Follow the equations and example below to choose the appropriate value for R_{OUT} to minimize this initial error.

- a) Target current $I_{\text{LIMIT}} = 1.5A$
In the previous example, we chose the maximum tolerable system error I_{ERROR} as 5%. Now, let's calculate the maximum tolerable current, I_{MAX} :

$$I_{\text{MAX}} = I_{\text{LIMIT}} (1 + I_{\text{ERROR}})$$

$$I_{\text{MAX}} = (1.5A) \left(1 + \frac{5}{100} \right) = 1.575A$$

- b) Calculate for R_{OUT} , assuming that the minimum output voltage for the LM3102 is 0.6V (see figure 3).

$$\begin{aligned}
 I_{RFB3} &= I_{RFBT} + I_{ROUT} \\
 \frac{V_{FB}}{R_{FBB}} &= \frac{(V_{O_3102_min} - V_{FB})}{R_{FBT}} + \frac{(V_{O_8646} - V_{FB})}{R_{OUT}} \\
 \frac{V_{FB}}{R_{FBB}} &= \frac{(V_{O_3102_min} - V_{FB})}{R_{FBT}} + \frac{(I_{max} R_{SENSE} G_{ain} - V_{FB})}{R_{OUT}} \\
 \frac{(I_{max} R_{SENSE} G_{ain} - V_{FB})}{R_{OUT}} &= \frac{V_{FB}}{R_{FBB}} - \frac{(V_{O_3102_min} - V_{FB})}{R_{FBT}} \\
 R_{OUT} &= \frac{(I_{max} R_{SENSE} G_{ain} - V_{FB})}{\frac{V_{FB}}{R_{FBB}} - \frac{(V_{O_3102_min} - V_{FB})}{R_{FBT}}} \\
 R_{OUT} &= \frac{[(1.575)(55mOhm)(10) - 0.8]}{\frac{0.8}{2k} - \frac{(0.6 - 0.8)}{10k}} \\
 R_{FBB} &= 157.74 \approx 160 \text{ ohm}
 \end{aligned}$$

This equation provides an initial value for ROUT. To get the desired results, ROUT should be adjusted. We recommend having an ROUT value of at least 50 ohm.

- 6. Step 6: Adjusting Components** – capture the output current and output voltage plots and adjust the components as necessary. The most common components to adjust are Cg to minimize the current ripple and ROUT to decrease the current error.

A plot for the load current (black), output voltage of the LM3102 (blue), voltage the feedback pin of the LM3102 (red), and switch frequency of the LM3102 (green), can be seen in figure 3.

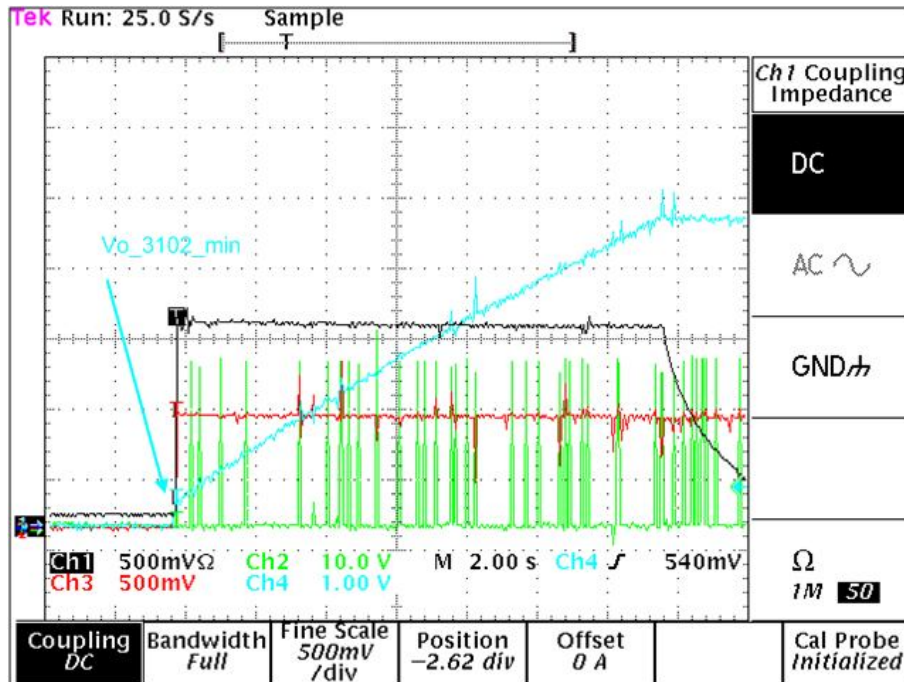


Figure 3 – Plot for the SuperCap Application

3. Quick Start: Resistive Load Application

Now, let's look at the design process for a resistive load application as seen in Figure 4. To see the current limiting capability of the LMP8646, the open-loop current must be greater than the close-loop current. An open-loop occurs when the LMP8646 output is not connected the LM3102's feedback pin. For this example, we will let the open-loop current to be 1.5A and the close-loop current, I_{LIMIT} , to be 1A.

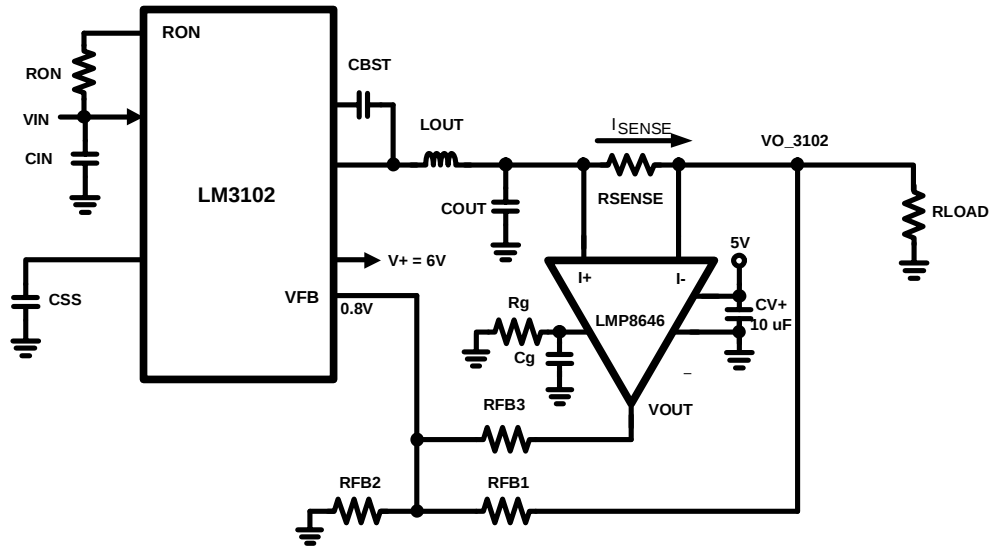


Figure 4 – Schematic for the Resistive Load Application

1. Design Parameters:

- $V_{IN_3102} = 8V$ to $42V$, typical $18V$
- $V_{out_3102} = 3V$
- $R_{sense} = 55\text{ m}\Omega$
- Load resistance = $2\text{ }\Omega$

2. Step 1: Choose Components for the LM3102

Refer to the LM3102 evaluation board app note (AN-1646) located at <http://www.ti.com/lit/snva248> to choose the appropriate components for the LM3102. For this application, we recommend increasing the input capacitance to $67\text{ }\mu F$.

For this example, the following LM3102 components are recommended:

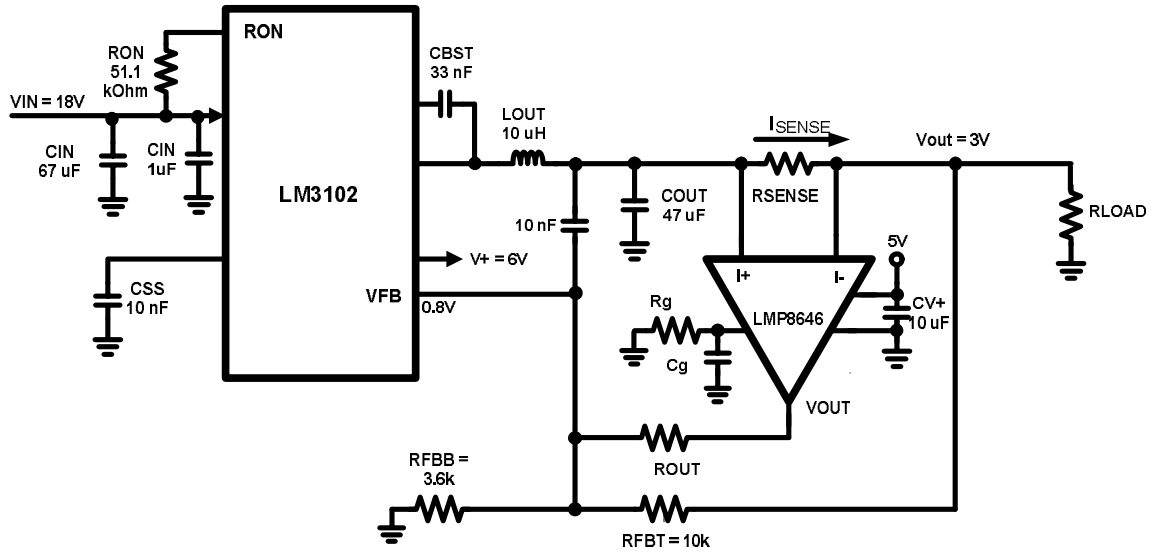


Figure 5 – Recommended Components for the LM3102

3. Step 2: Choose the gain resistor, R_g , for LMP8646

If $R_{sense} = 55 \text{ mOhm}$, then use the equation below to calculate for the appropriate gain resistor, R_g , for a close-loop output current of 1A.

$$VFB = (I_{LIMIT})(R_{SENSE})(Gain_{LMP8646})$$

$$\text{where } Gain = \frac{R_g}{1 / \text{transconductance}} = \frac{R_g}{1 / 200 \mu A / V} = \frac{R_g}{5kOhm}$$

$$VFB = (I_{LIMIT})(R_{SENSE}) \left(\frac{R_g}{5kOhm} \right)$$

$$R_g = \frac{(VFB)(5k)}{(I_{LIMIT})(R_{SENSE})}$$

$$R_g = \frac{(0.8V)(5k)}{(1A)(55mOhm)}$$

$$R_g = 73k \text{ Ohm}$$

4. Step 3: Choose the Bandwidth Capacitance, C_g .

The product of C_g and R_g determines the bandwidth for the LMP8646. Because each application is very unique, the LMP8646 gain capacitance, C_g , needs to be adjusted to fit the appropriate application.

Bench data has been collected for the resistive load application. We found that this application works best for a bandwidth between 2 kHz to 30 kHz. If the bandwidth is not large enough, the LMP8646 will take a longer time to limit the output current.

For example, if $R_g = 73 \text{ k}\Omega$ and the chosen bandwidth is 2 kHz, then the initial C_g value can be calculated as:

$$C_g = \frac{1}{2\pi(R_g)(\text{Bandwidth})}$$

$$C_g = \frac{1}{2\pi(73 \text{ k}\Omega)(2 \text{ k Hz})}$$

$$C_g = 0.109 \text{ nF}$$

Once C_g is chosen, capture the output regulator current plot and adjust C_g to get the desired value.

5. Step 4: Choose the output resistor, R_{OUT} , for LMP8646

For the resistive load application, we found that R_{OUT} plays a very small role in the performance. R_{OUT} was important in the supercap application because it affects the initial current error. Because current is directly proportional to voltage for a resistive load, the output current is not large at startup. In fact, the larger the R_{OUT} , the longer it takes for the output voltage to reach its final value. In our example, we chose a value of 2 k Ω for R_{OUT} .

6. Step 5: Adjusting Components – capture the output current and output voltage plots and adjust the components as necessary. The most common component to adjust is C_g for the bandwidth.

A plot for the load current (yellow), output voltage of the LM3102 (pink) can be seen in Figure 6.

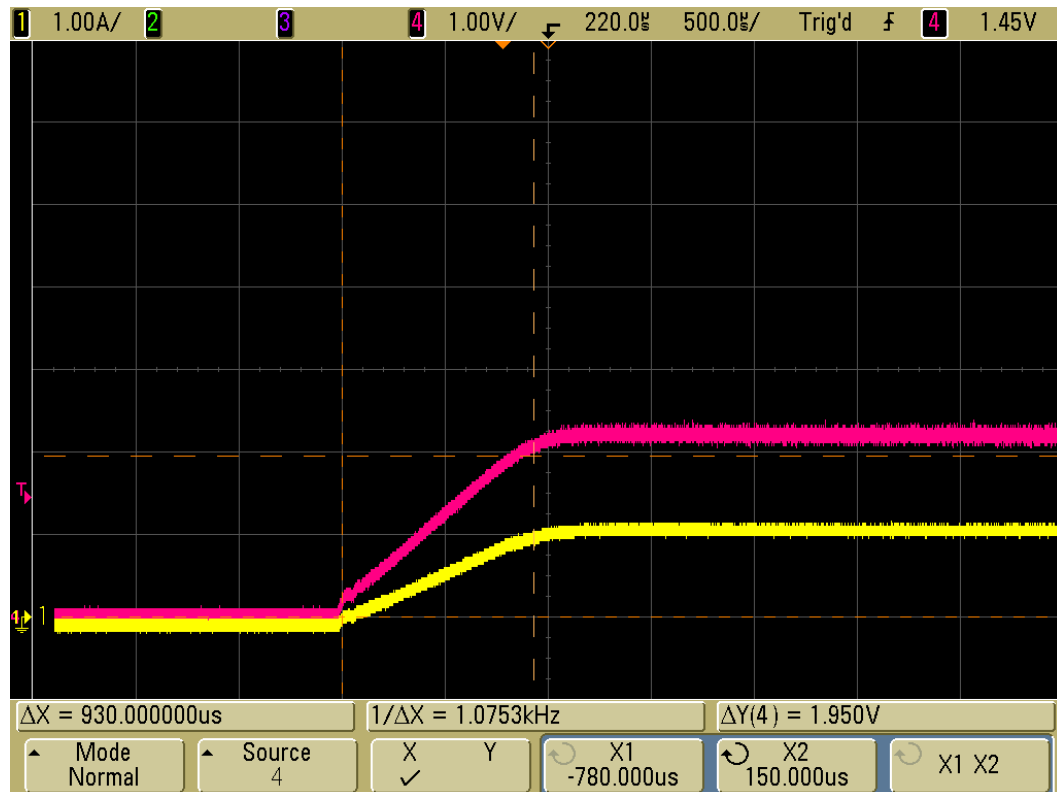


Figure 6 – Plots for the Resistive Load Application

4. Powering the LMP8646EB

Source V+ with an external voltage between 3.3V and 12V. Do this by connecting the external source to banana connector J2, VP, and J1, GND.

To activate the LM3102, source its VIN with external voltage of 4.5V to 42V. This can be done by connecting the external source to J5, VIN, and J8, GND.

5. Schematic

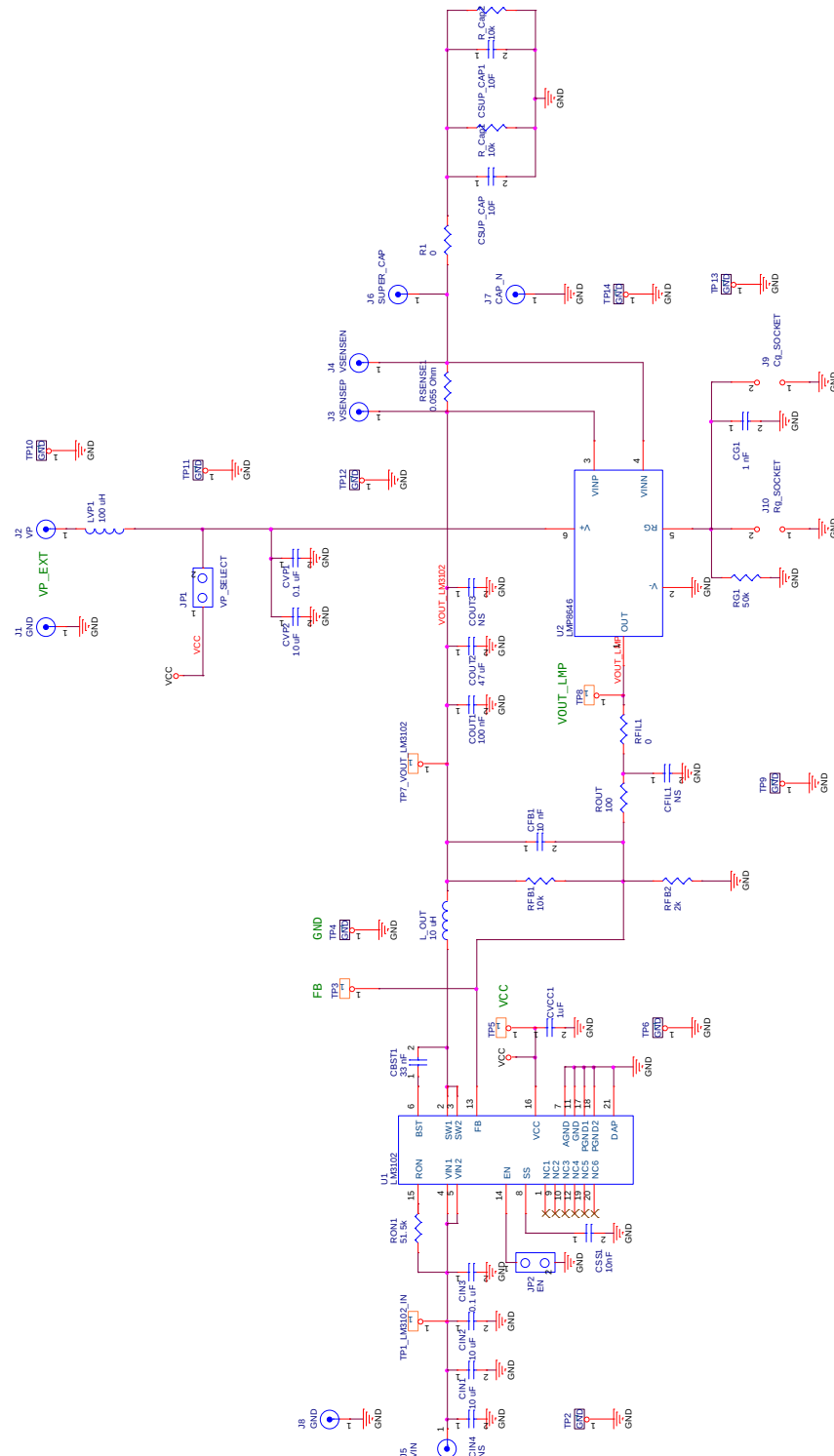


Figure 7 – Schematic

6. Layout

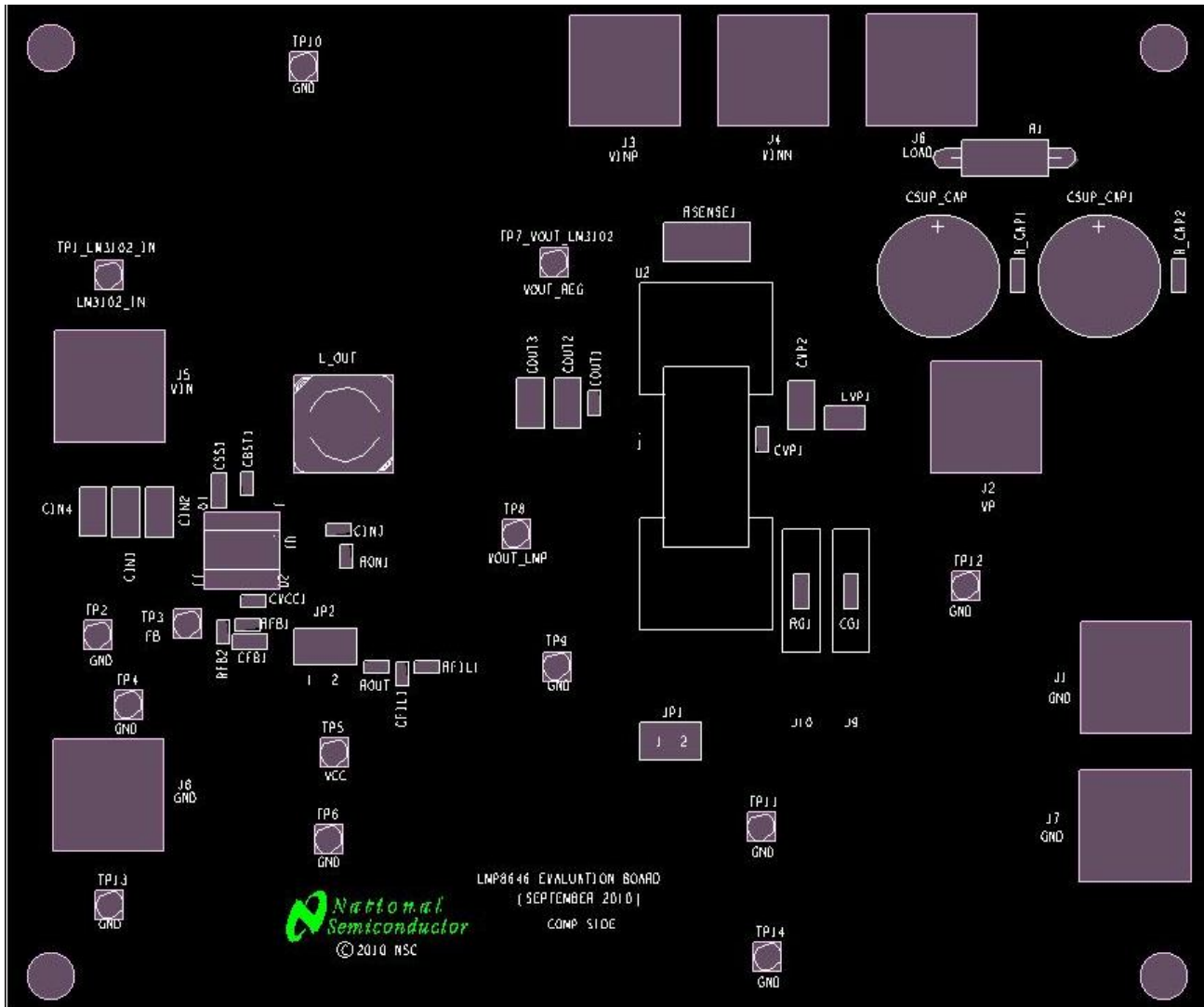


Figure 8 - Layout Top Layer

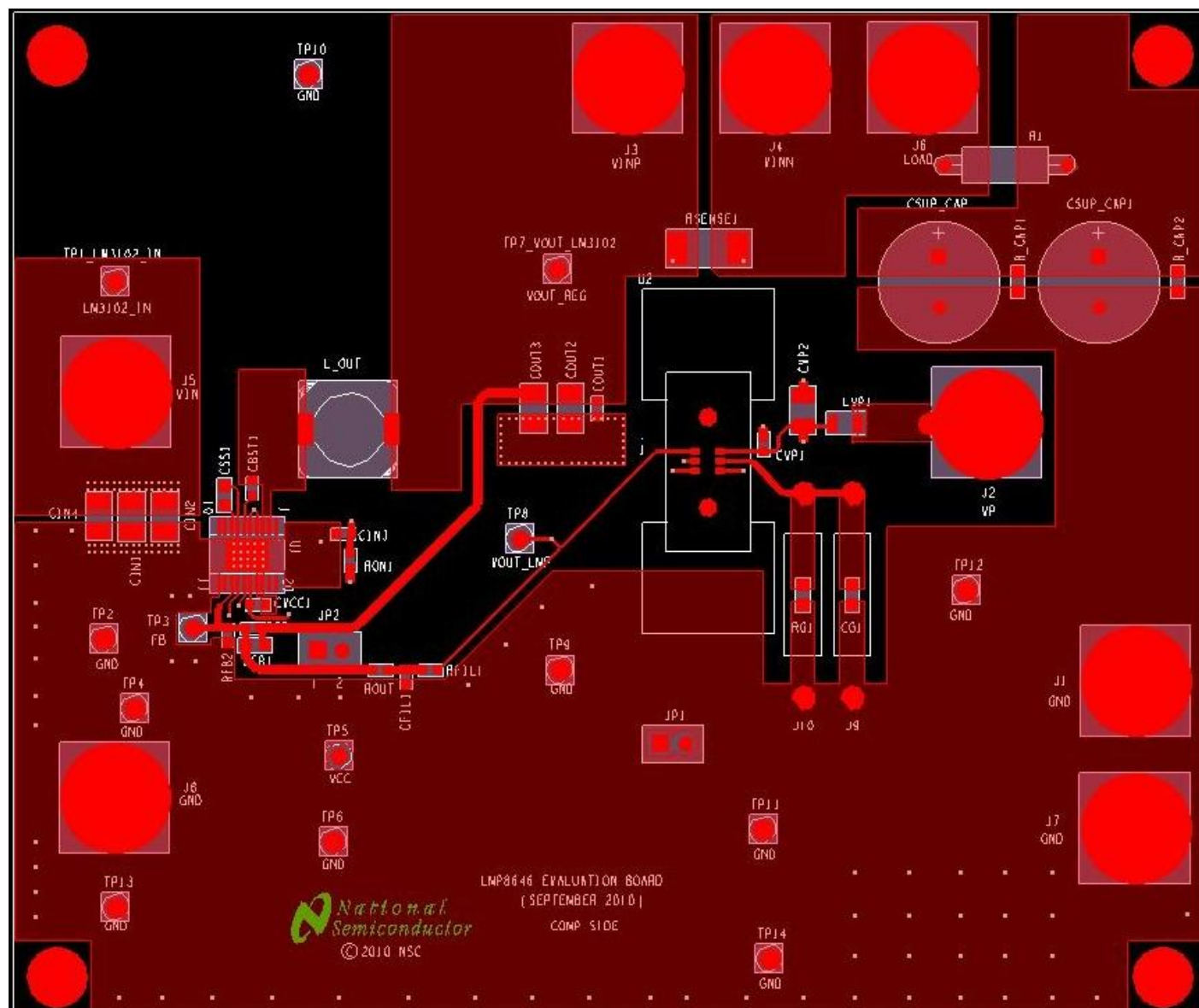


Figure 9 - Layout Top Layer

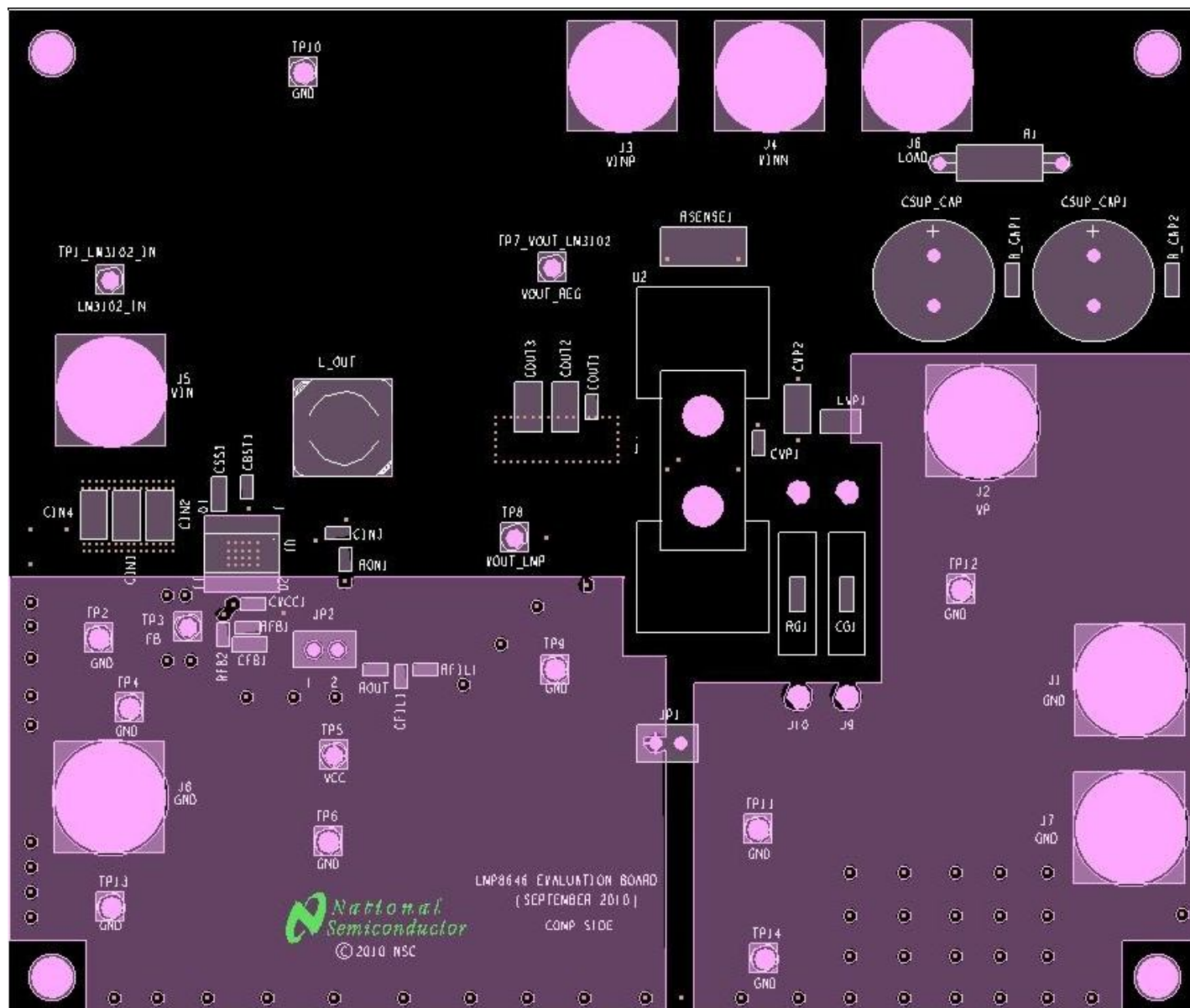


Figure 10 - Layout Layer #2: Power

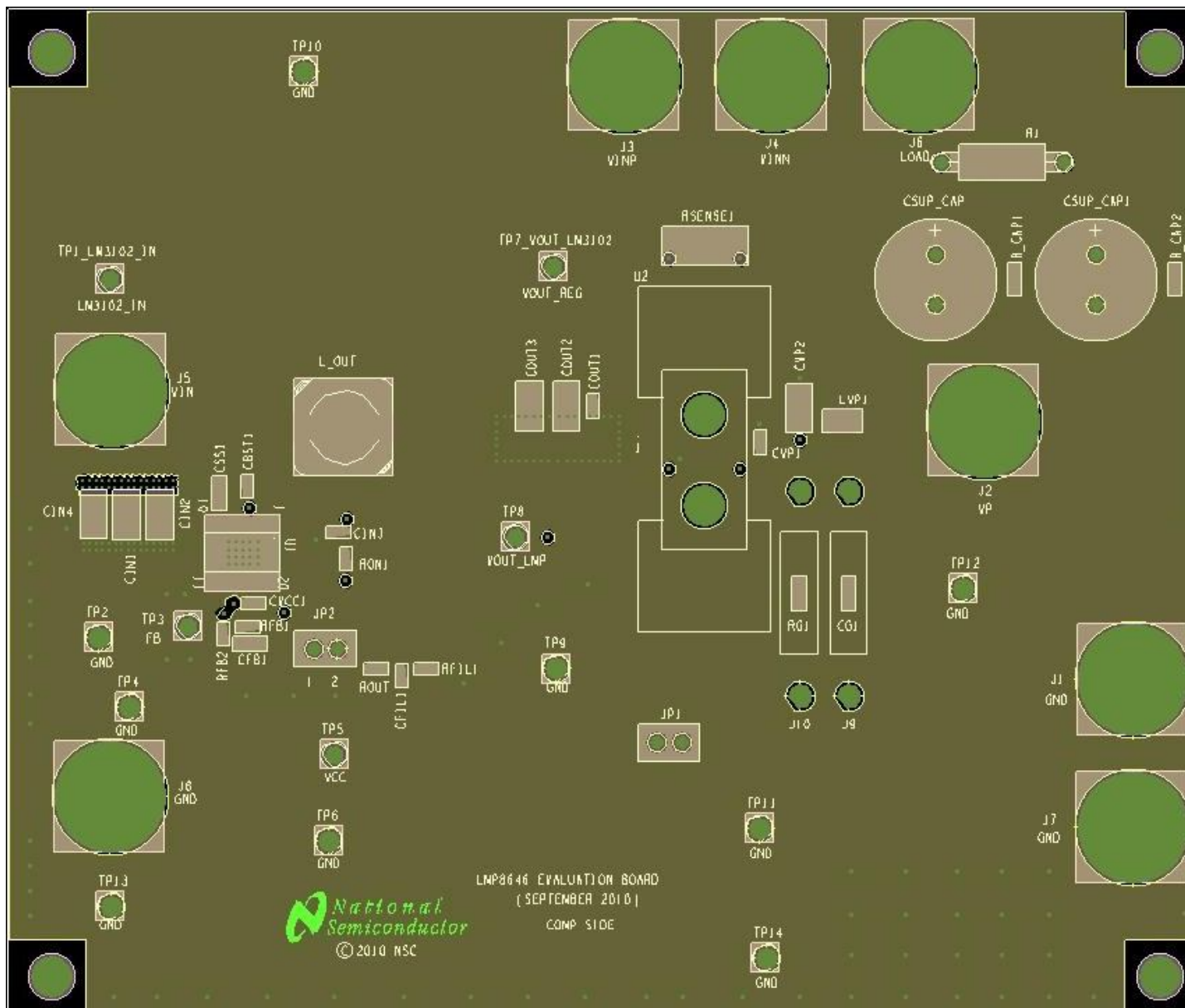


Figure 11 - Layout Layer #3: Ground

Figure 12 - Layout Bottom Layer

7. BOM

Item	Qnt	Reference	Value	Description	Package	Manufacturer	Manufacturer Part #
1	1	CBST1	33 nF	CAP CER 33000PF 25V 10% X7R 0603	603	Murata	GRM188R71E333KA01D
2	2	CSS1,CFB1	10nF	CAP CER 10000PF 50V 10% X7R 0805	805	Murata	GRM216R71H103KA01D
3	1	CFIL1	NS	CAP CER .1UF 25V 10% X7R 0603	603	Murata	GRM188R71E104KA01D
4	1	CG1	NS	CAP CER 100PF 50V C0G 5% 0805	805	TDK	C2012C0G1H101J
5	3	CIN1,VP2,CIN2	10 uF	CAP CER 10UF 50V Y5V 1210	1210	Murata	GRM32DF51H106ZA01L
6	2	VP1,CIN3	0.1 uF	CAP CERAMIC .1UF 50V X7R 0603	603	Panasonic	ECJ-1VB1H104K
7	1	COUT1	100 nF	CAP CER .1UF 25V 10% X7R 0603	603	Murata	GRM188R71E104KA01D
8	2	COUT2,COUT3	47 uF	CAP 47UF 6.3V CERAMIC X5R 1210	1210	Panasonic	ECJ-4YB0J476M
9	1	CSUP	SuperCap 10F	CAP 10F 2.3V GOLD HW RADIAL	Radial thru-hole	Panasonic	EEC-HW0D106
10	1	CVCC1	1uF	CAP CER 1.0UF 10V Y5V 0603	603	TDK	C1608Y5V1A105Z
11	1	JP1	VP_SELECT	CONN HEADER .100 SINGL STR 36POS	0.100"	Sullins Connector	PBC36SAAN
12	1	J1	GND	CONN JACK BANANA UNINS PANEL MOU	Bulk	Emerson Network	108-0740-001
13	1	J2	VP_EXT	CONN JACK BANANA UNINS PANEL MOU	Bulk	Emerson Network	108-0740-001
14	1	J3	VSENSEP	CONN JACK BANANA UNINS PANEL MOU	Bulk	Emerson Network	108-0740-001
15	1	J4	VSENSEN	CONN JACK BANANA UNINS PANEL MOU	Bulk	Emerson Network	108-0740-001
16	1	J5	VIN	CONN JACK BANANA UNINS PANEL MOU	Bulk	Emerson Network	108-0740-001
17	1	J6	CAP_P	CONN JACK BANANA UNINS PANEL MOU	Bulk	Emerson Network	108-0740-001
18	1	J7	CAP_N	CONN JACK BANANA UNINS PANEL MOU	Bulk	Emerson Network	108-0740-001
19	1	J8	Rg_SOCKET	PIN RECPT .032/.046 DIA 0328 SER	N/A	Mill-Max	0328-0-15-15-34-27-10-0
20	1	J9	Cg_SOCKET	PIN RECPT .032/.046 DIA 0328 SER	N/A	Mill-Max	0328-0-15-15-34-27-10-0
21	1	L_OUT	22 uH	INDUCTOR POWER 22UH 3.6A SMD		JW Miller	PM5022-220M-RC

Evaluation Board/Kit Important Notice

Texas Instruments (TI) provides the enclosed product(s) under the following conditions:

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. Persons handling the product(s) must have electronics training and observe good engineering practice standards. As such, the goods being provided are not intended to be complete in terms of required design-, marketing-, and/or manufacturing-related protective considerations, including product safety and environmental measures typically found in end products that incorporate such semiconductor components or circuit boards. This evaluation board/kit does not fall within the scope of the European Union directives regarding electromagnetic compatibility, restricted substances (RoHS), recycling (WEEE), FCC, CE or UL, and therefore may not meet the technical requirements of these directives or other related directives.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. **THE FOREGOING WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE.**

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods. Due to the open construction of the product, it is the user's responsibility to take any and all appropriate precautions with regard to electrostatic discharge.

EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

TI currently deals with a variety of customers for products, and therefore our arrangement with the user **is not exclusive**.

TI assumes **no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.**

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please contact the TI application engineer or visit www.ti.com/esh.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used.

FCC Warning

This evaluation board/kit is intended for use for **ENGINEERING DEVELOPMENT, DEMONSTRATION, OR EVALUATION PURPOSES ONLY** and is not considered by TI to be a finished end-product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC rules, which are designed to provide reasonable protection against radio frequency interference. Operation of this equipment in other environments may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

EVM Warnings and Restrictions

It is important to operate this EVM within the input voltage range of 3.3V to 5V and the output voltage range of 0V to 5V.

Exceeding the specified input range may cause unexpected operation and/or irreversible damage to the EVM. If there are questions concerning the input range, please contact a TI field representative prior to connecting the input power.

Applying loads outside of the specified output range may result in unintended operation and/or possible permanent damage to the EVM. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative.

During normal operation, some circuit components may have case temperatures greater than +30°C. The EVM is designed to operate properly with certain components above +85°C as long as the input and output ranges are maintained. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors. These types of devices can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during operation, please be aware that these devices may be very warm to the touch.

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2011, Texas Instruments Incorporated

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Mobile Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community Home Page

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2012, Texas Instruments Incorporated