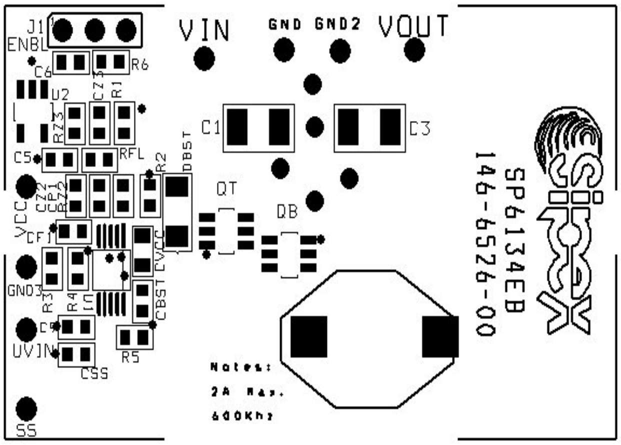
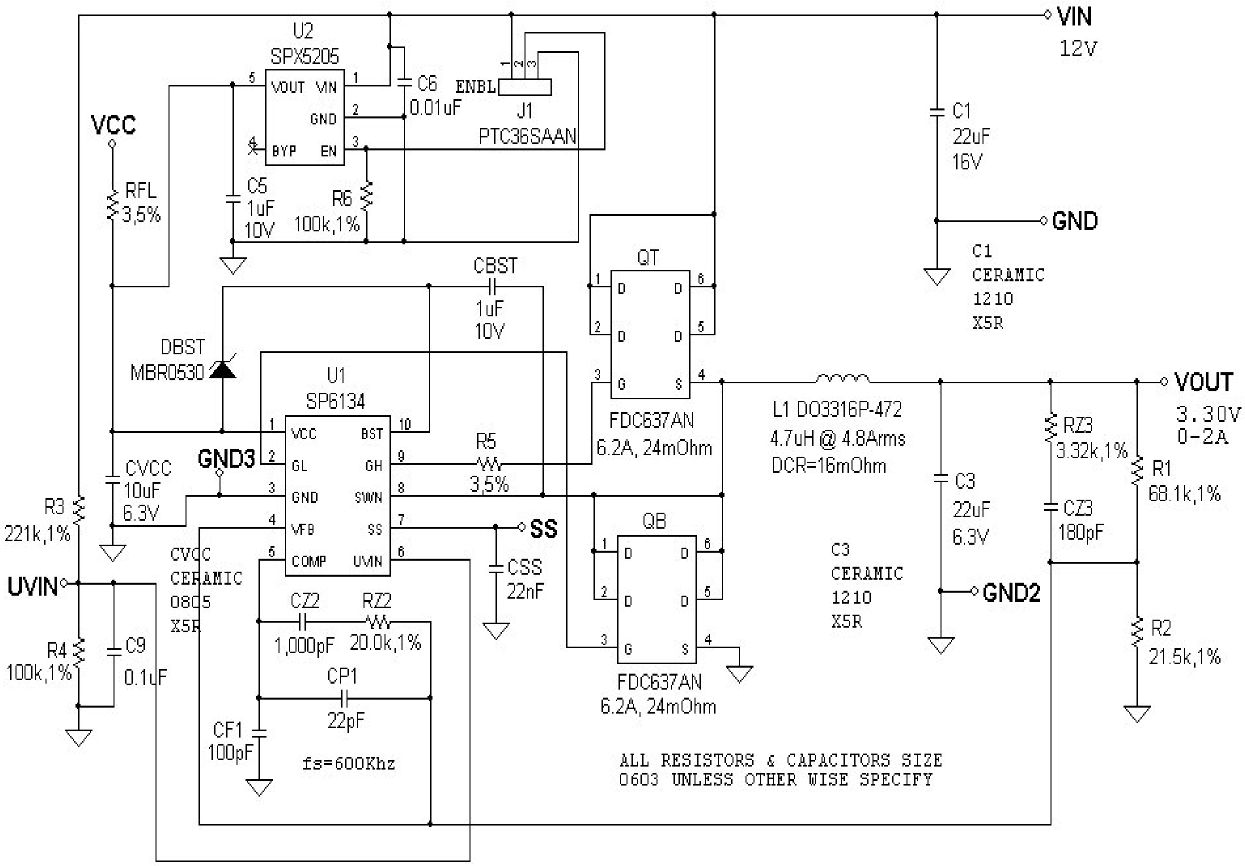
SP6134 (2A MAX.) Evaluation Board Manual



- Easy Evaluation for the SP6134CU 12V Input, 0 to 2A Output Synchronous Buck Converter
- Precision 0.80V with ±1% High Accuracy Reference.
- UVIN and Output Dead Short Circuit Shutdown Protection Features.
- High Efficiency: 92%
- Feature Rich: UVIN, Programmable Softstart, External VCC Supply and Output Dead Short Circuit Shutdown Protection.

SP6134EB SCHEMATIC



USING THE EVALUATION BOARD

1) Powering Up the SP6134EB Circuit

Connect the SP6134 Evaluation Board with an external +12V power supply. Connect with short leads and large diameter wire directly to the "VIN" and "GND" posts. Connect a Load between the VOUT and GND2 posts, again using short leads with large diameter wire to minimize inductance and voltage drops.

2) Measuring Output Load Characteristics

It's best to GND reference scope and digital meters using the Star GND post in the center of the board. VOUT ripple can best be seen touching probe tip to the pad for COUT and scope GND collar touching Star GND post – avoid a GND lead on the scope which will increase noise pickup.

3) Using the Evaluation Board with Different Output Voltages

While the SP6134 Evaluation Board has been tested and delivered with the output set to 3.30V, by simply changing one resistor, R2, the SP6134 can be set to other output voltages. The relationship in the following formula is based on a voltage divider from the output to the feedback pin VFB, which is set to an internal reference voltage of 0.80V. Standard 1% metal film resistors of surface mount size 0603 are recommended.

$$V_{out} = 0.80V (R1 / R2 + 1) \Rightarrow R2 = R1 / [(V_{out} / 0.80V) - 1]$$

Where $R1 = 68.1K\Omega$ and for Vout = 0.80V setting, simply remove R2 from the board. Furthermore, one could select the value of R1 and R2 combination to meet the exact output voltage setting by restricting R1 resistance range such that $50K\Omega \leq R1 \leq 100K\Omega$ for overall system loop stability.

Note that since the SP6134 Evaluation Board design was optimized for 12V down conversion to 3.30V, changes of output voltage and/or input voltage will alter performance from the data given in the Power Supply Data section.

POWER SUPPLY DATA

The SP6134EB is designed with a very accurate 1.0% reference over line, load and temperature. Figure 1 data shows a typical SP6134CU Evaluation Board efficiency plot, with efficiencies to 91% and output currents to 2A. SP6134CU Load Regulation shown in Figure 2 shows only 0.02% change in output voltage from no load to 2A load. Figures 3 and 4 illustrate a 1A to 2A and 0A to 2A Load Steps. Start-up Response in Figures 5, 6 and 7 show a controlled start-up with different output load behavior when power is applied where the input current rises smoothly as the Softstart ramp increases. In Figure 8 the SP6134CU is configured for hiccup mode in response to an output dead short circuit condition and will Softstart until the over-load is removed. Figure 9 and 10 show output voltage ripple less than 22mV at no load to 2A load.

While data on individual power supply boards may vary, the capability of the SP6134CU of achieving high accuracy over a range of load conditions shown here is quite impressive and desirable for accurate power supply design.

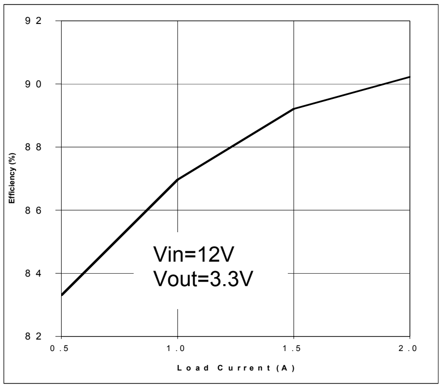


Figure 1. Efficiency vs Load

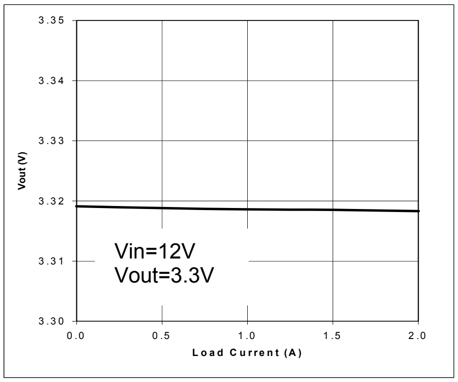


Figure 2. Load Regulation

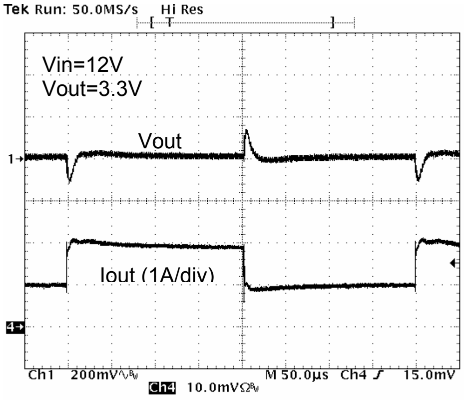


Figure 3. Load Step Response: 1->2A

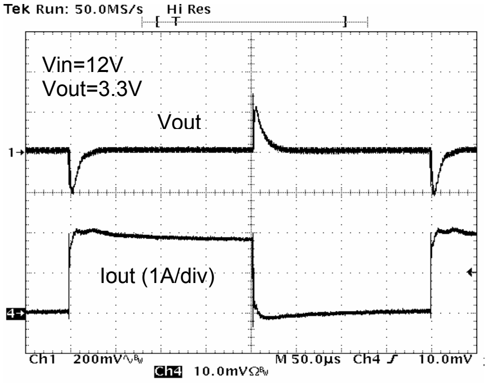


Figure 4. Load Step Response: 0->2A

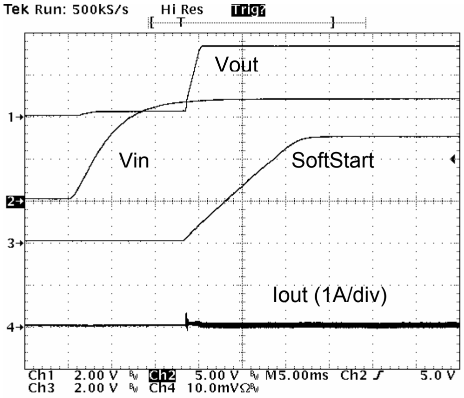


Figure 5. Start-Up Response: No Load

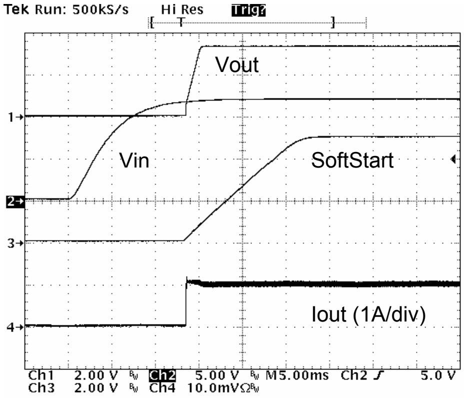


Figure 6. Start-Up Response: 1A Load

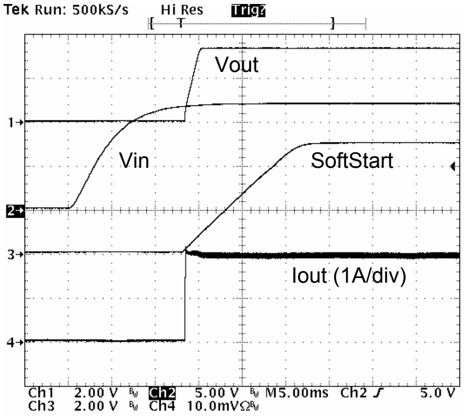


Figure 7. Start-Up Response: 2A Load

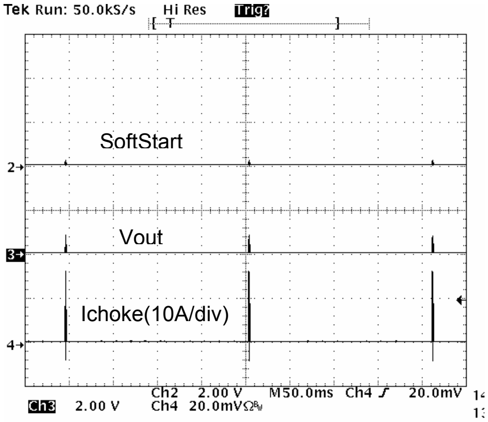
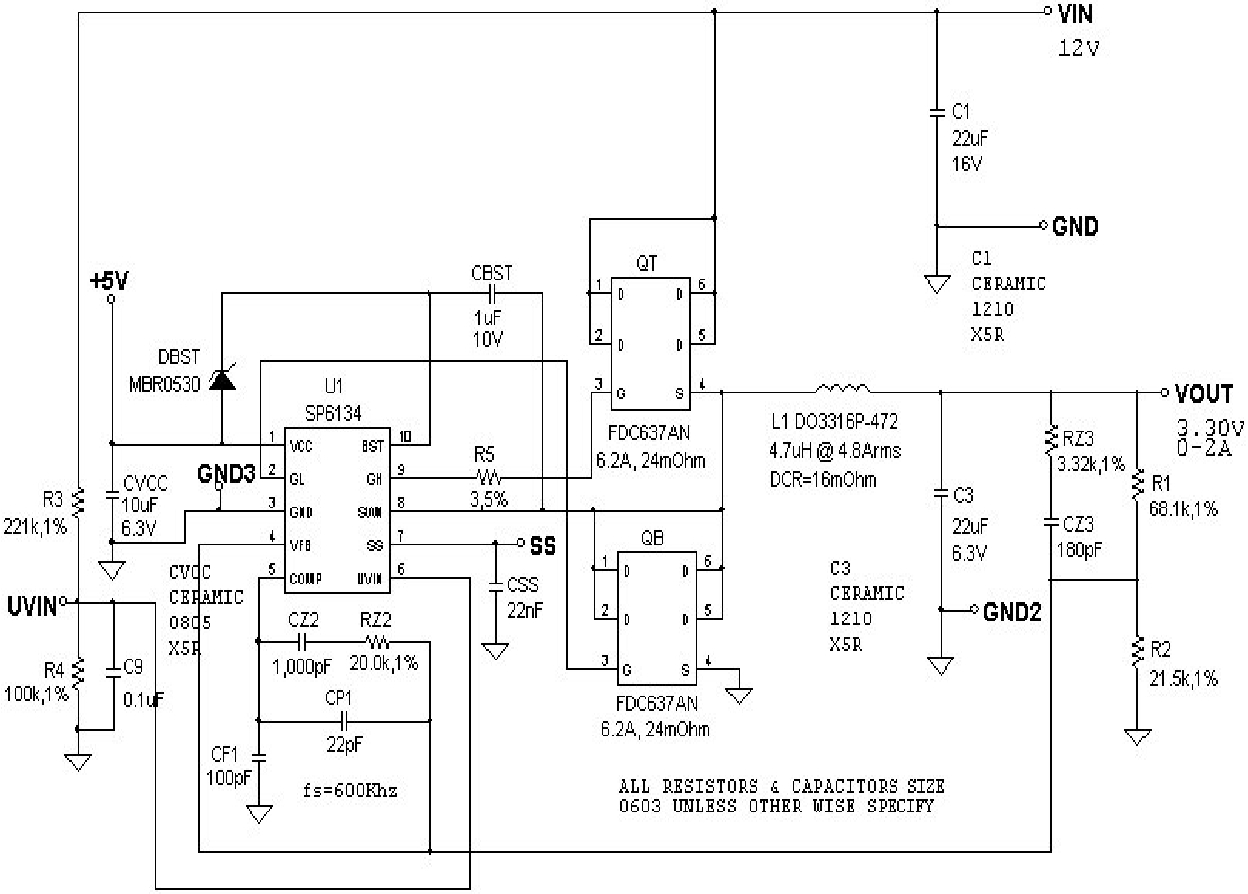


Figure 8. Output Load Short Circuit

+5V BIAS SUPPLY APPLICATION SCHEMATIC

In this application example, the SP6134CU is power by an external +5V bias supply which current consumption of 16mA Maximum. If this supply is not available than it is recommend Sipex SPX5205 Low-Noise LDO Voltage Regulator which is included on the SP6134CU Evaluation Board.



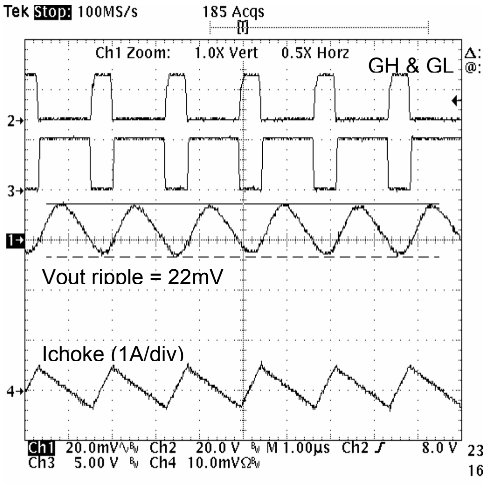


Figure 9. Output Ripple: No Load

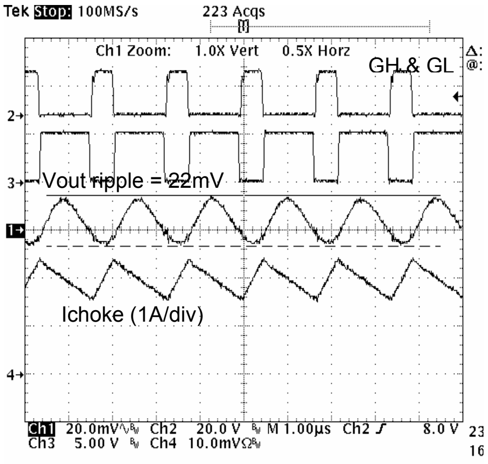


Figure 10. Output Ripple: 2A Load

DIFFERENT +5V BIAS SUPPLY SCHEMES APPLICATION SCHEMATIC

The SP6134CU VCC Bias Supply can be derived from Vin or external bias with several biasing options depending on the output power, load current, and additional biasing for the protection feature circuitry under many different application considerations. For example the transistor plus zener diode +5V bias supply could be used as shown in Figure 11. The reason is that if there is significant SP6134CU output stage current is needed to drive both the external MOSFET gate charges especially when application that require a few external parallel MOSFETs to achieve high output current. However, Figure 12 shows a very simple zener diode +5V VCC bias supply when very low external gate charge is used. In any case the SP6134CU is consuming no more than 16mA since both of the external MOSFETs gate charge is small base on its smaller footprint selections. Figure 13 shows an application circuit with SP6134CU using Sipex SPX5205 Low Drop Out (LDO) Voltage Regulator for +5V VCC Bias Supply. Note that there is an advantage of using the LDO for the +5V VCC bias since the LDO output voltage is very stable and precise allowing other to derived the voltage from it as example when additional over current clamp limit is added.

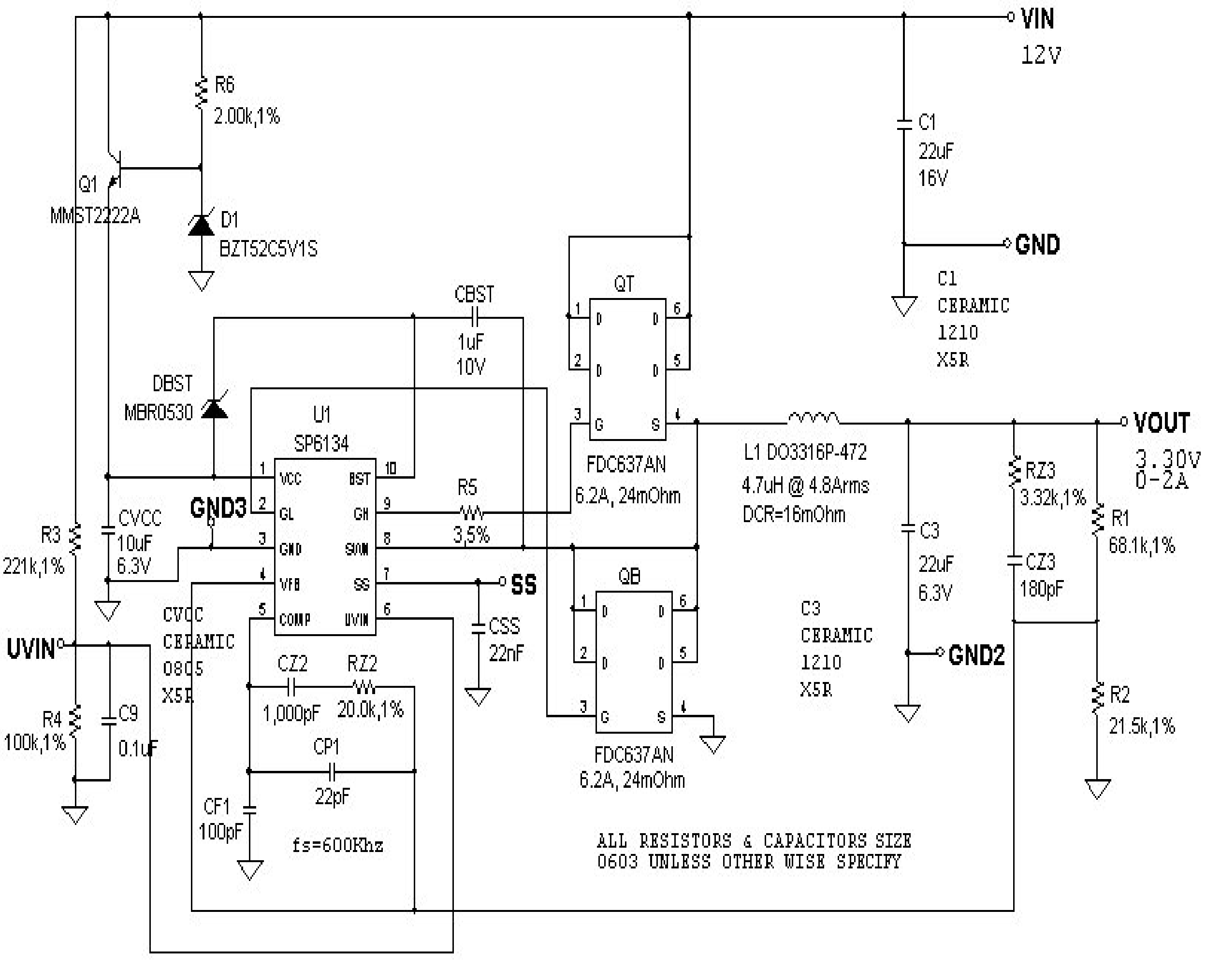


Figure 11. Transistor plus Zener Diode +5V Supply Application Schematic

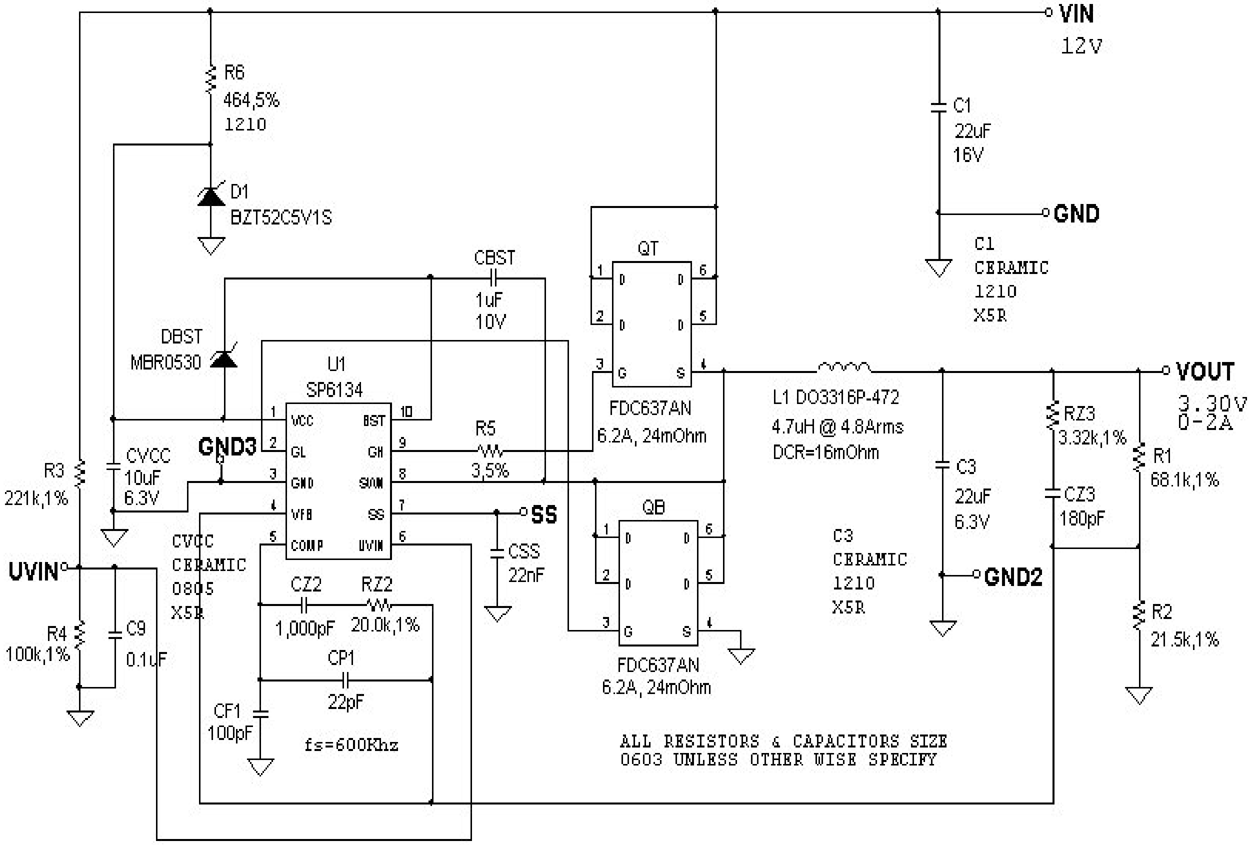


Figure 12. Very Simple Zener Diode +5V Bias Supply Application Schematic

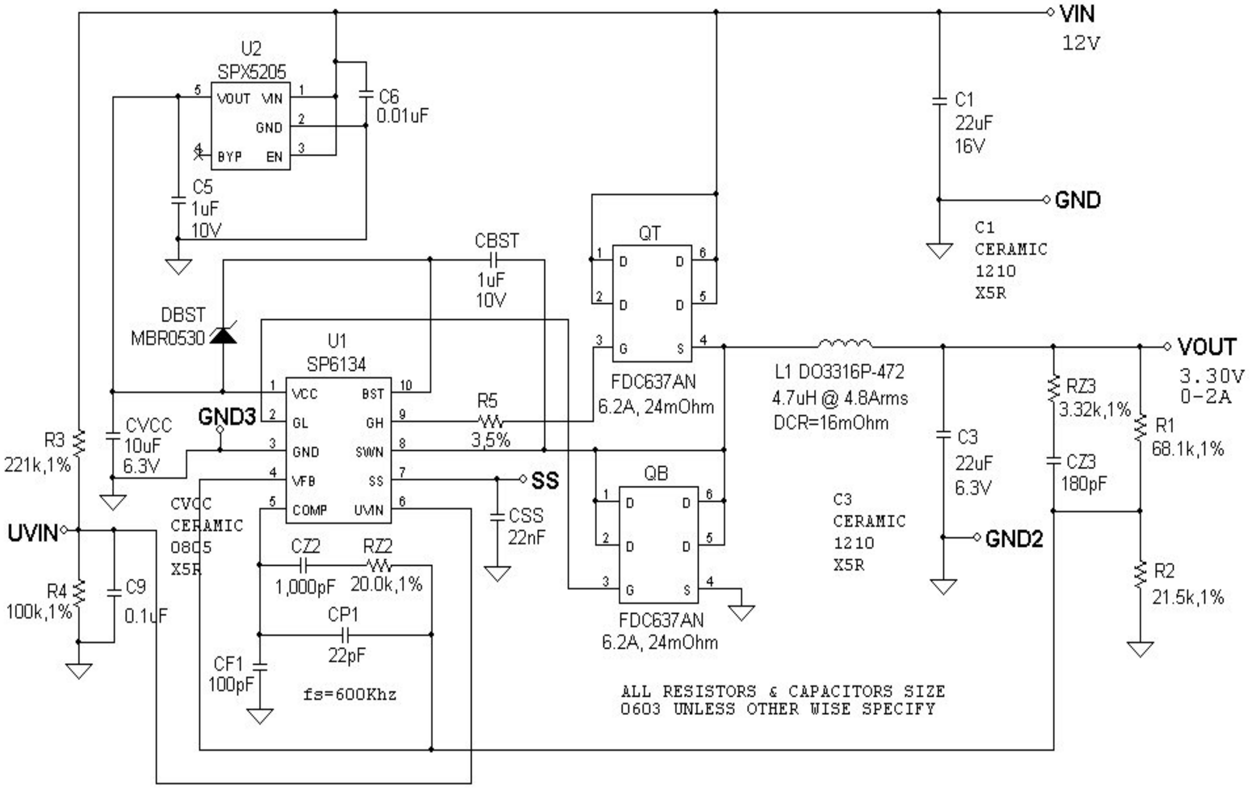


Figure 13. Simple SPX5205 +5V Low Drop Out (LDO) Bias Supply Application Schematic

SP6134CU OVER CURRENT LIMIT PROTECTION APPLICATION SCHEMATIC

The SP6134CU provides short circuit protection by sensing the output voltage at ground. However for a better and robust over current clamping protection, a comparator circuit could be used. A simplifies over current clamping circuit block diagram is shown on Figure 14. The output current clamping threshold and RC filter time constant resistors and capacitors component selections are approximately by the following equations (1) and (2).

$$I_{out\_limit} \cong (R/R')(VCC/R_{dc}) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

$$L/R_{dc} \cong 2RC \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

It is strongly recommend setting the over current limit threshold 130 to 150% of the maximum output load current for reliable operation under all operational condition. In Figure 15. application example, the over current limit is set at around 5A. Note that the comparator VCC is derived from the +5V Low Drop Out (LDO) Bias Supply output.

Figure 15 shows SP6134CU Evaluation Board integrates with external SPX5205 LDO for +5V VCC bias supply and output over current limit clamp comparator application circuitry. Note that the over current limit comparator referent voltage is derived from LDO output voltage. In addition, an external Power Schottky Diode DS (STPS2L25U) is added in parallel with Drain to Source of the Synchronous MOSFET in order to improve the efficiency of the converter at high output current application especially.

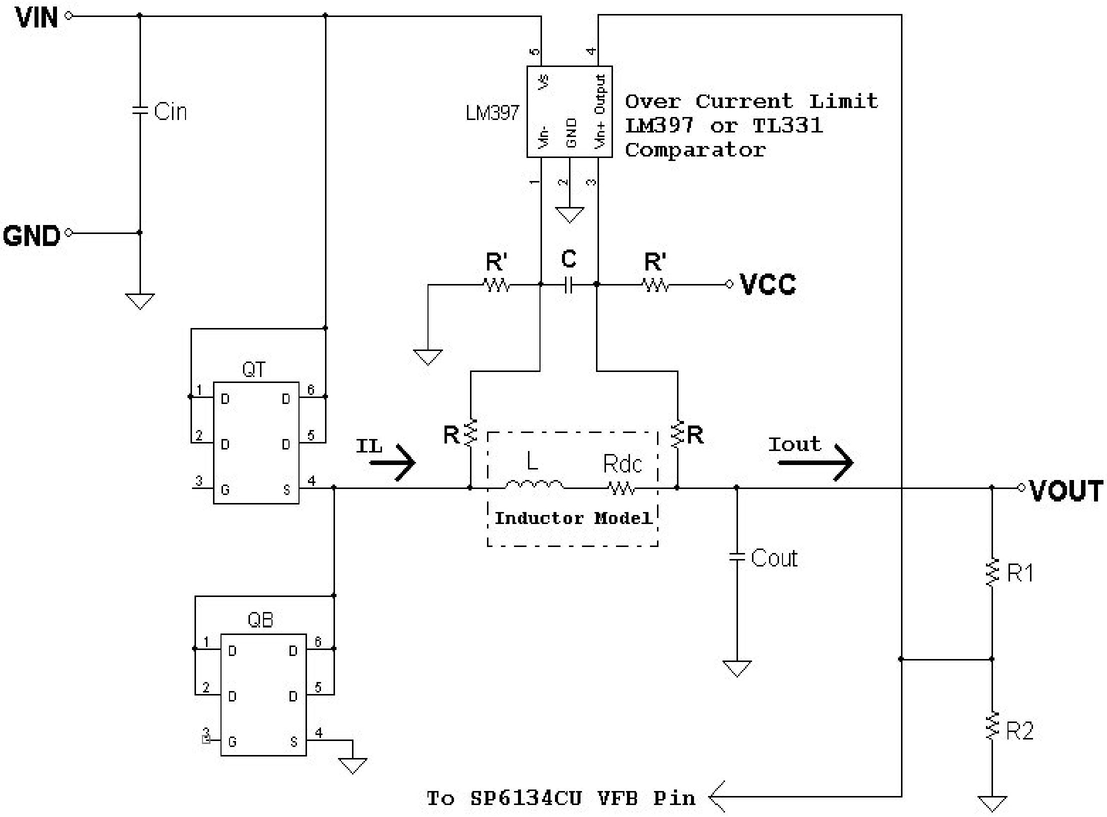


Figure 14. Simple Over Current Clamping Protection Circuit Block Diagram

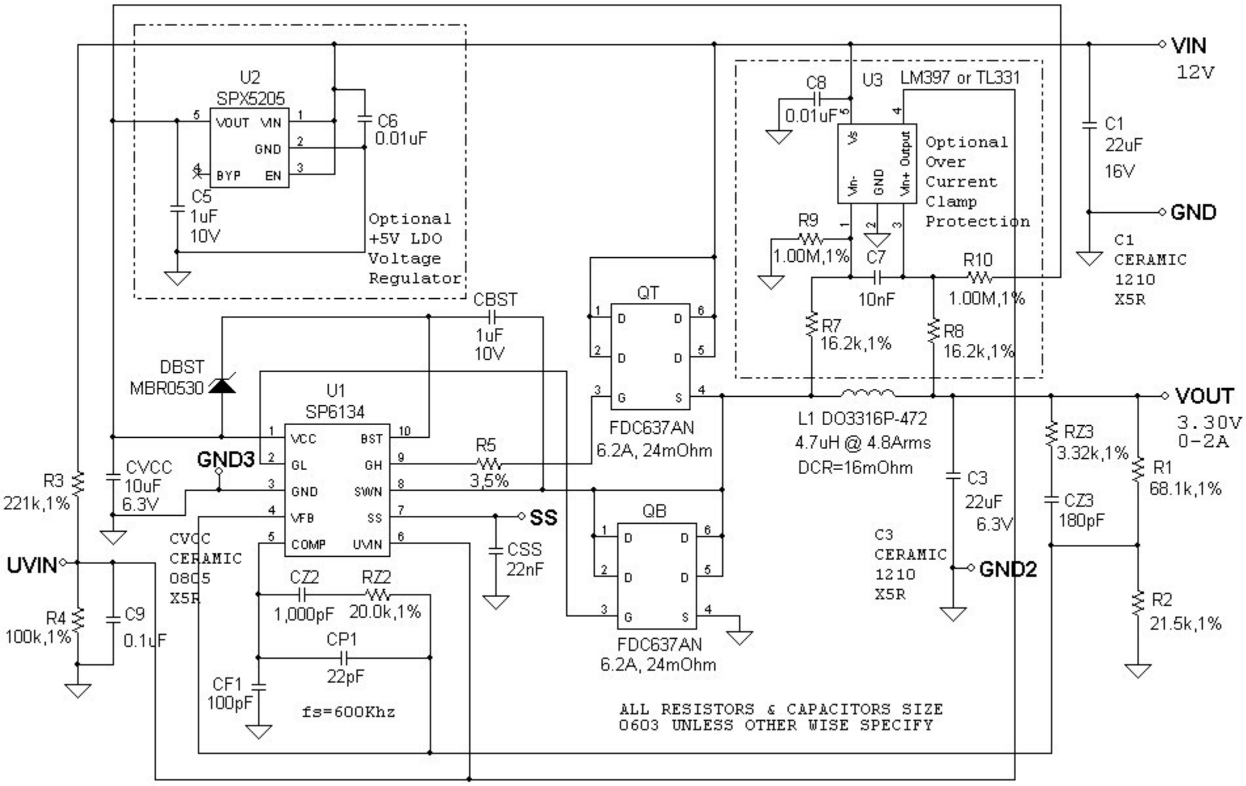


Figure 15. SP6134EB Over Current Clamping Protection Application Schematic

Table 1: SP6134EB Suggested Components and Vendor Lists

INDUCTORS - SURFACE MOUNT							
Inductance (uH)	Manufacturer/Part No.	Inductor Specification					Manufacturer Website
		Series R mOhms	Isat (A)	Size LxW(mm)	Ht.(mm)	Inductor Type	
4.7	**Coilcraft DO3316P-472**	**16.0**	**4.8**	**12.95x9.40**	**5.5**	**Unshielded Ferrite Core**	www.coilcraft.com
4.2	TDK SLF12565T-4R2N5R5	15.0	5.5	12.5x12.5	6.5	Shielded Ferrite Core	www.tdk.com
4.7	Inter-Technical SC5020-4R7M	6.7	12.0	12.6x13.6	5.1	Shielded Ferrite Core	www.inter-technical.com
5.6	TDK SLF12575T-5R6N6R3	11.6	6.3	12.5x12.5	7.5	Shielded Ferrite Core	www.tdk.com
6.8	Coilcraft DO3316P-682	19.0	4.4	12.95x9.40	5.5	Unshielded Ferrite Core	www.coilcraft.com

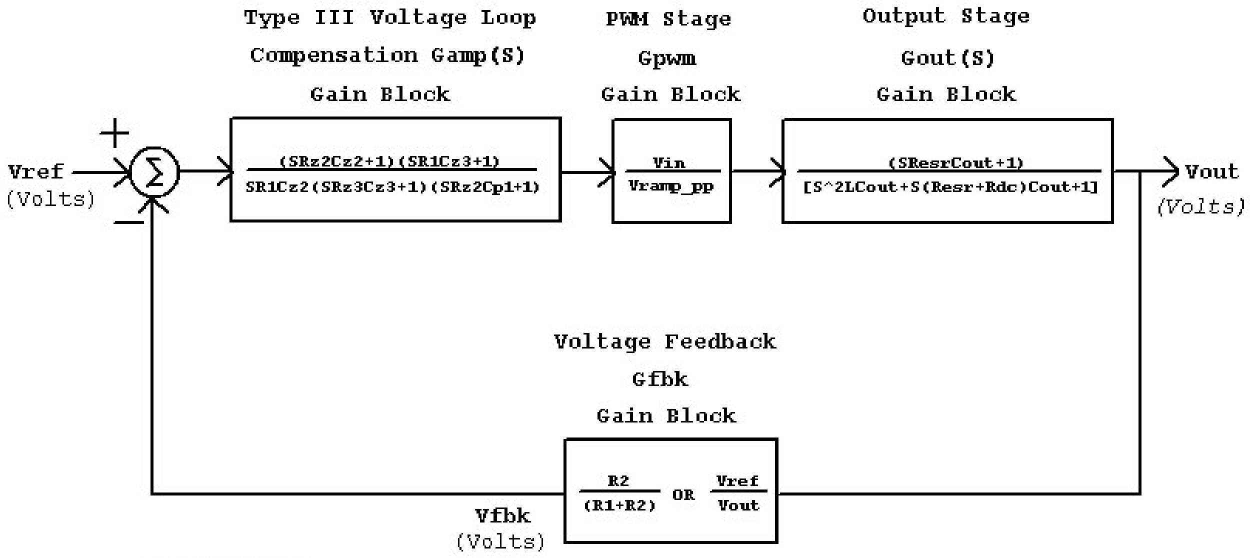
CAPACITORS - SURFACE MOUNT								
Capacitance(uF)	Manufacturer/Part No.	Capacitor Specification						Manufacturer Website
		ESR ohms (max)	Ripple Current (A) @45C	Size LxW(mm)	Ht.(mm)	Voltage (V)	Capacitor Type	
22	**TDK C3225X5R1C226M**	**0.002**	**4.00**	**3.2x2.5**	**2.0**	**16.0**	**X5R Ceramic**	www.tdk.com
22	**TDK C3225X5R0J226M**	**0.002**	**4.00**	**3.2x2.5**	**2.5**	**6.3**	**X5R Ceramic**	www.tdk.com

MOSFETS - SURFACE MOUNT								
MOSFET	Manufacturer/Part No.	MOSFET Specification						Manufacturer Website
		RDS(on) ohms (max)	ID Current (A)	Qg nC (Typ)	Qg nC (Max)	Voltage (V)	Foot Print	
N-Channel	**Fairchild Semi FDC637AN**	**0.024**	**6.2**	**10.5**	**16.0**	**20.0**	**SuperSOT-6**	www.fairchildsemi.com
N-Channel	Vishay Siliconix Si2316DS	0.085	2.6	4.3	7.0	30.0	SOT-23	www.vishay.com

Note: Components highlighted in **bold** are those used on the SP6134 (2A MAX.) Evaluation Board.

LOOP COMPENSATION DESIGN

The open loop gain of the SP6134EB can be divided into the gain of the error amplifier **Gamp(s)**, PWM modulator **Gpwm**, buck converter output stage **Gout(s)**, and feedback resistor divider **Gfbk**. In order to crossover at the selecting frequency **fco**, the gain of the error amplifier has to compensate for the attenuation caused by the rest of the loop at this frequency. The goal of loop compensation is to manipulate the open loop frequency response such that its gain crosses over 0dB at a slope of –20dB/dec.
The open loop crossover frequency should be higher than the ESR zero of the output capacitors but less than 1/5 of the switching frequency **fs** to insure proper operation. Since the SP6134EB is designed with a Ceramic Type output capacitors, a Type III compensation circuit is required to give a phase boost of 180° in order to counteract the effects of the output **LC** under damped resonance double pole frequency.



Definitions:

Resr := Output Capacitor Equivalent Series Resitance
Rdc := Output Inductor DC Resistance
Vramp_pp := SP6134 Internal RAMP Amplitude Peak to Peak Voltage

Conditions:

Cz2 >> Cp1 and R1 >> Rz3
Output Load Resistance >> Resr and Rdc

Figure 16. SP6134EB Voltage Mode Control Loop with Loop Dynamic

The simple guidelines for positioning the poles and zeros and for calculating the component values for a type III compensation are as follows.

a. Choose **fco** = fs / 10

b. Calculate **fp_LC**
fp_LC = 1 / 2π [(L) (C)] ^ 1/2

c. Calculate **fz_ESR**
fz_ESR = 1 / 2π (Resr) (Cout)

d. Select **R1** component value such that $50k\Omega \leq R1 \leq 100k\Omega$

e. Calculate **R2** base on the desired Vout
$R2 = R1 / [(Vout / 0.80V) - 1]$

f. Select the ratio of **Rz2 / R1** gain for the desired gain bandwidth
$Rz2 = (R1) (Vramp\_pp / Vin\_max) (fco / fp\_LC)$

g. Calculate **Cz2** by placing the zero at ½ of the output filter pole frequency
$Cz2 = 1 / \pi (Rz2) (fp\_LC)$

h. Calculate **Cp1** by placing the first pole at ESR zero frequency
$Cp1 = 1 / 2\pi (Rz2) (fz\_ESR)$

i. Calculate **Rz3** by setting the second pole at ½ of the switching frequency and the second zero at the output filter double pole frequency
$Rz3 = 2 (R1) (fp\_LC) / fs$

j. Calculate **Cz3** from **Rz3** component value above
$Cz3 = 1 / \pi (Rz3) (fs)$

k. Choose $100pF \leq$ **Cf1** $\leq 220pF$ to stabilize the SP6134CU internal Error Amplify

As a particular example, consider for the following SP6134EB with a type **III** Voltage Loop Compensation component selections:

Vin_max = 15V
Vout = 3.30V @ 0 to 2A load
Select L = 4.7uH => yield ≈ 45% of maximum 2A output current ripple.
Select Cout = 22uF Ceramic capacitors (Resr ≈ 2mΩ)
fs = 600khz SP6134CU internal Oscillator Frequency
Vramp_pp = 1.0V SP6134CU internal Ramp Peak to Peak Amplitude

Step by step design procedures:

a. **fco** $= 600khz / 10 = 60khz$

b. **fp_LC** $= 1 / 2\pi [(4.7uH)(22uF)]^{1/2} \cong 16khz$

c. **fz_ESR** $= 1 / 2\pi (2m\Omega)(22uF) \approx 3.6Mhz$

d. **R1** = 68.1kΩ, 1%

e. **R2** $= 68.1k\Omega / [(3.30V / 0.80V) - 1] \cong 21.5k\Omega$, 1%

f. **Rz2** $= 68.1k\Omega (1.0V / 15V) (60khz / 16khz) \approx 20.0k\Omega$, 1%

g. **Cz2** $= 1 / \pi (20.0k\Omega) (16khz) \approx 1{,}000pF$, COG

h. **Cp1** $= 1 / 2\pi (20.0k\Omega) (3.6Mhz) \approx 2pF$ => **Cp1** = 22pF, COG for noise filtering

i. **Rz3** = 2 (68.1kΩ) (16khz) / 600khz ≈ 3.32kΩ, 1%

j. **Cz3** = 1 / π (3.32kΩ) (600khz) ≅ 180pF, COG

k. **Cf1** = 100pF to stabilize SP6134CU internal Error Amplify

PC LAYOUT DRAWINGS

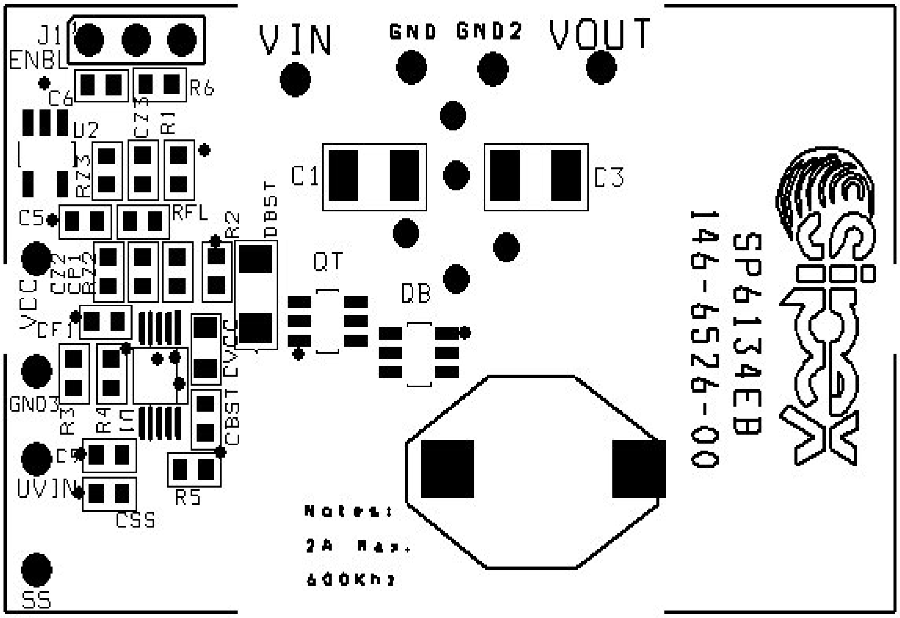


Figure 17. SP6134EB Component Placement

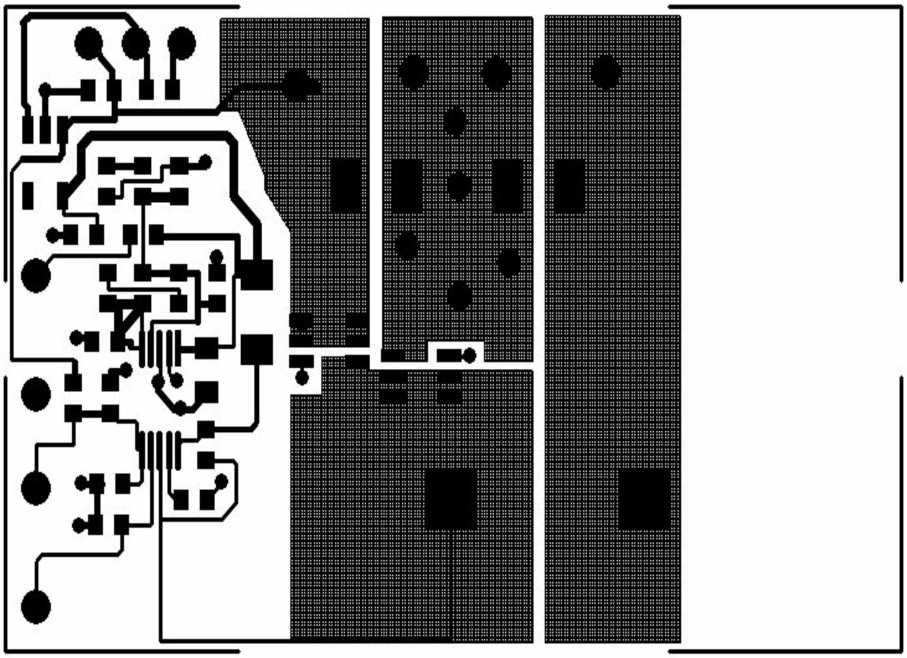


Figure 18. SP6134EB PC Layout Top Side

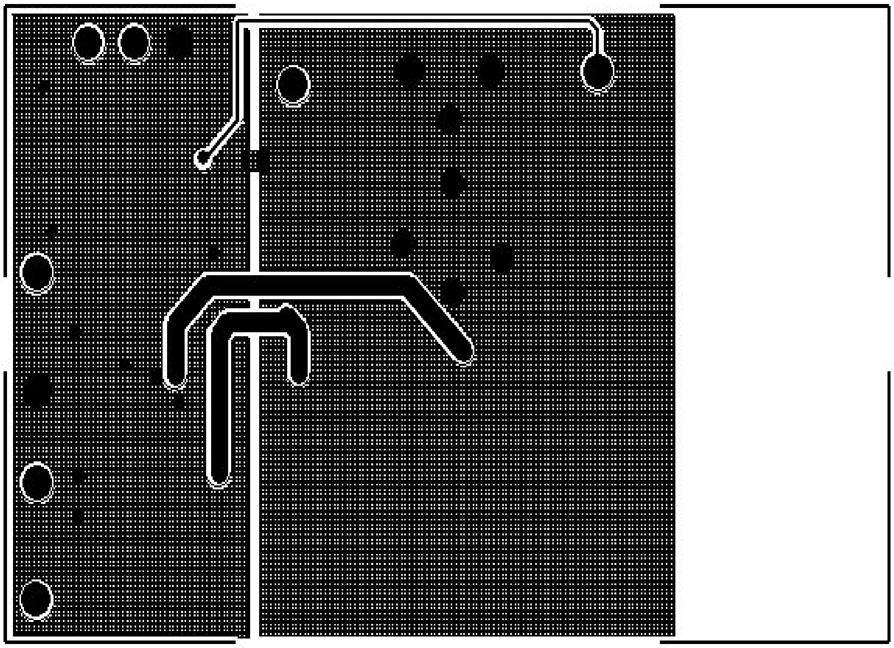


Figure 19. SP6134EB PC Layout Bottom Side

Table 3: SP6134EB List of Materials

SP6134 (2A MAX.) Evaluation Board List of Materials						
Line No.	Ref. Des.	Qty.	Manuf.	Manuf. Part Number	Layout Size	Component
1	PCB	1	Sipex	146-6526-02	1.75"X2.75"	SP6134EB
2	U1	1	Sipex	SP6134CU	MSOP-10	2-15A Any-FET Buck Ctrl
3	U2	1	Sipex	SPX5205M5-5.0	SOT-23-5	150mA LDO Voltage Reg
4	QT, QB	2	Fairchild Semi	FDC637AN	SOT-6	NFET
5	DBST	1	ON-Semi	MBR0530	SOD-123	0.5A Schottky
6	L1	1	Coilcraft	DO3316P-472	12.95X9.4mm	4.70uH Coil 4.8Arms 16mohm
7	C3	1	TDK	C3225X5R0J226M	1210	22uF Ceramic X5R 6.3V
8	C1	1	TDK	C3225X5R1C226M	1210	22uF Ceramic X5R 16V
9	CVCC	1	TDK	C2012X5R0J106M	0805	10uF Ceramic X5R 6.3V
10	C6	1	TDK	C1608X5R1C103K	0603	0.01uF Ceramic X5R 16V
11	C9	1	TDK	C1608X5R1C104K	0603	0.1uF Ceramic X5R 16V
12	C5, CBST	2	TDK	C1608X5R1A105K	0603	1.0uF Ceramic X5R 10V
13	CSS	1	TDK	C1608X7R1H223K	0603	22,000pF Ceramic X7R 50V
14	CZ2	1	TDK	C1608COG1H102J	0603	1,000pF Ceramic X7R 50V
15	CP1	1	TDK	C1608COG1H220J	0603	22pF Ceramic COG 50V
16	CF1	1	TDK	C1608COG1H101J	0603	100pF Ceramic COG 50V
17	CZ3	1	TDK	C1608COG1H181J	0603	180pF Ceramic COG 50V
18	RZ2	1	Panasonic	ERJ-3EKF2002V	0603	20.0K Ohm Thick Film Res 1%
19	R2	1	Panasonic	ERJ-3EKF2152V	0603	21.5K Ohm Thick Film Res 1%
20	RZ3	1	Panasonic	ERJ-3EKF3321V	0603	3.32K Ohm Thick Film Res 1%
21	R1	1	Panasonic	ERJ-3EKF6812V	0603	68.1K Ohm Thick Film Res 1%
22	R3	1	Panasonic	ERJ-3EKF2213V	0603	221K Ohm Thick Film Res 1%
23	R4, R6	2	Panasonic	ERJ-3EKF1003V	0603	100K Ohm Thick Film Res 1%
24	R5, RFL	1	Yageo America	9C06031A3R0JLHFT	0603	3.0 Ohm Thick Film Res 5%
25	J1	1	Sullins	PTC36SAAN	.32x.12	36-Pin (3x12) Header
26	(J1)	1	Sullins	STC02SYAN	.2x.1	Shunt
27	VIN, VOUT, VCC, GND, GND2, GND3	6	Vector Electronic	K24C/M	.042 Dia	Test Point Post
28	UVIN, SS	2	Mill-Max	3137-3002-10-0080	.042 Dia	Test Point Female Pin

ORDERING INFORMATION

Model	Temperature Range	Package Type
SP6134EB……….….................	0°C to +70°C..............…….	SP6134 Evaluation Board
SP6134CU...............................….	0°C to +70°C......................................…….	10-pin MSOP

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- Поставка сложных, дефицитных, либо снятых с производства позиций;
- Оперативные сроки поставки под заказ (от 5 рабочих дней);
- Экспресс доставка в любую точку России;
- Помощь Конструкторского Отдела и консультации квалифицированных инженеров;
- Техническая поддержка проекта, помощь в подборе аналогов, поставка прототипов;
- Поставка электронных компонентов под контролем ВП;
- Система менеджмента качества сертифицирована по Международному стандарту ISO 9001;
- При необходимости вся продукция военного и аэрокосмического назначения проходит испытания и сертификацию в лаборатории (по согласованию с заказчиком);
- Поставка специализированных компонентов военного и аэрокосмического уровня качества (Xilinx, Altera, Analog Devices, Intersil, Interpoint, Microsemi, Actel, Aeroflex, Peregrine, VPT, Syfer, Eurofarad, Texas Instruments, MS Kennedy, Miteq, Cobham, E2V, MA-COM, Hittite, Mini-Circuits, General Dynamics и др.);

Компания «Океан Электроники» является официальным дистрибьютором и эксклюзивным представителем в России одного из крупнейших производителей разъемов военного и аэрокосмического назначения **«JONHON»**, а так же официальным дистрибьютором и эксклюзивным представителем в России производителя высокотехнологичных и надежных решений для передачи СВЧ сигналов **«FORSTAR»**.

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