

### POWER MANAGEMENT

#### Description

The SC4508 is a low voltage current mode switching regulator controller that drives a P-channel power MOSFET with programmable switching frequency. It can be configured in either buck or buck boost (inverting) converters. The converters can be operated from 2.7V to 15V input voltage range. The typical operating supply current is 3mA and a shutdown pin allows the user to turn the controller off reducing it to less than 200 $\mu$ A. The output voltage can be adjusted by external resistor divider. The switching frequency is programmable up to 1.5MHz, allowing small inductor and capacitor values to minimize PCB space. The operating current level is programmable via an external sense resistor. Accessible reference voltage allows users to make output voltage as low as they want.

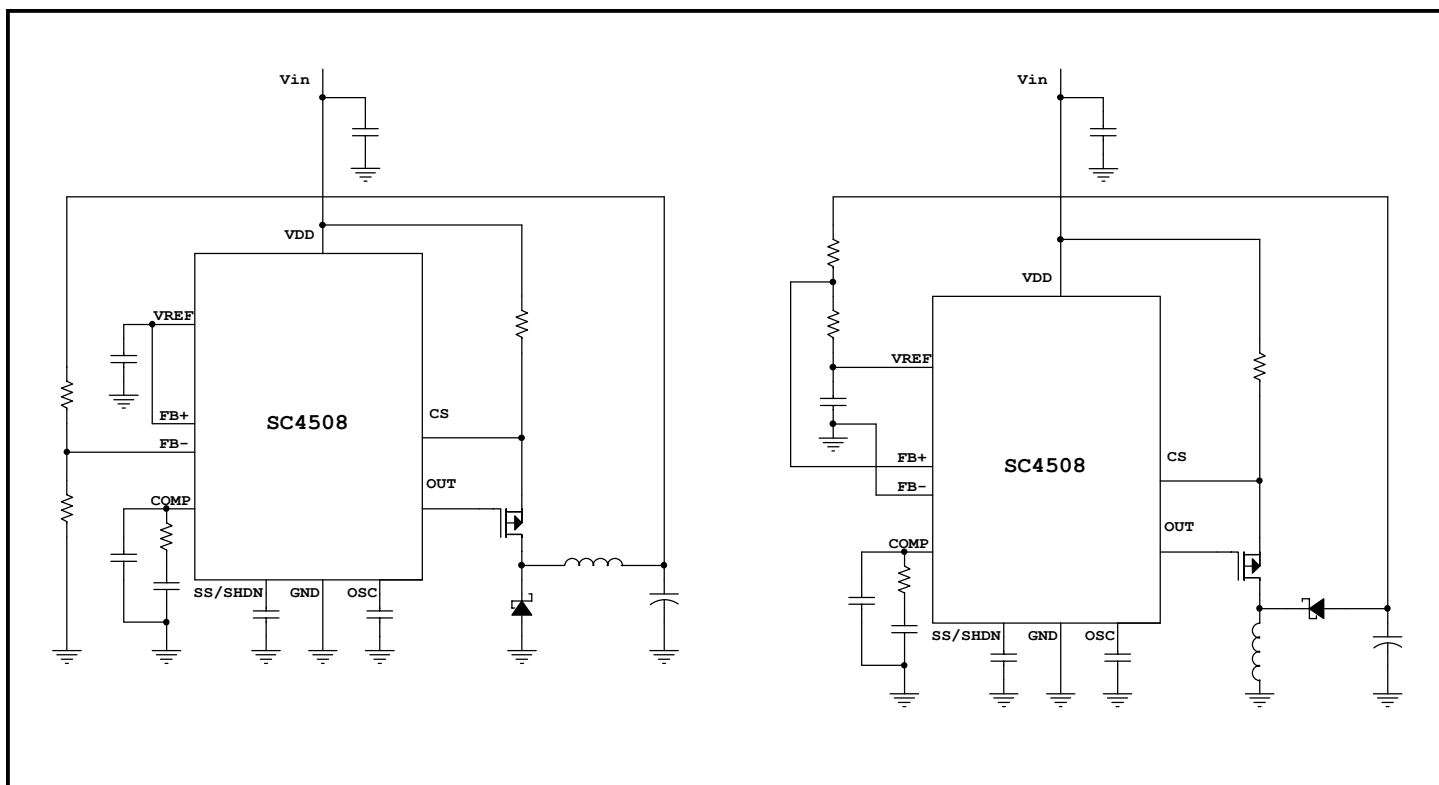
#### Features

- ◆ Wide input voltage range 2.7V to 15V
- ◆ Programmable output voltage
- ◆ Programmable switching frequency up to 1.5MHz
- ◆ Buck or buck boost(inverting) configuration
- ◆ Current mode control with slope compensation
- ◆ Very low quiescent current in shutdown mode
- ◆ Accessible reference voltage

#### Applications

- ◆ Low power point of use converters
- ◆ Single or multiple output low power converters
- ◆ Positive and/or negative output voltage
- ◆ DSL cards
- ◆ Graphic cards
- ◆ I/O cards
- ◆ Negative bias supplies

#### Typical Application Circuits



## POWER MANAGEMENT

### Absolute Maximum Rating

Exceeding the specifications below may result in permanent damage to the device, or device malfunction. Operation outside of the parameters specified in the Electrical Characteristics section is not implied.

Parameter	Symbol	Maximum	Units
VDD to GND		-0.3 to 16	V
SS/SHDN to GND		3.2	V
FB+, FB-, COMP, OSC to GND		5	V
VREF Current		1	mA
OUT Source or Sink		250	mA
Storage Temperature Range	$T_{STG}$	-60 to +150	°C
Junction Temperature Range	$T_J$	-40 to +150	°C
Lead Temperature (Soldering) 10 Sec.	$T_{LEAD}$	260	°C

### Electrical Characteristics

Unless specified:  $V_{DD} = 2.7V$  to  $15V$ ,  $T_A = T_J = -40^{\circ}C$  to  $105^{\circ}C$

Parameter	Test Conditions	Min	Typ	Max	Unit
<b>Power Supply</b>					
Input Voltage Range		2.7		15	V
Quiescent Current	SHDN = low		200	500	$\mu A$
Operating Current	SHDN = high, No load		3		mA
<b>Undervoltage Lockout</b>					
Start Threshold			2.5		V
UVLO Hysteresis			100		mV
<b>Oscillator</b>					
Frequency Range		100		1500	KHz
Frequency	$C_T = 300pF$	450	500	550	KHz
Charge Current			100		$\mu A$
<b>Error Amplifier</b>					
Feedback Input Voltage		0.75			V
Input Bias Current				200	nA
Transconductance			5		mS
Output Source or Sink Current			100		$\mu A$

**POWER MANAGEMENT**
**Electrical Characteristics**

Unless specified:  $V_{DD} = 2.7V$  to  $15V$ ,  $T_A = T_J = -40^{\circ}C$  to  $105^{\circ}C$

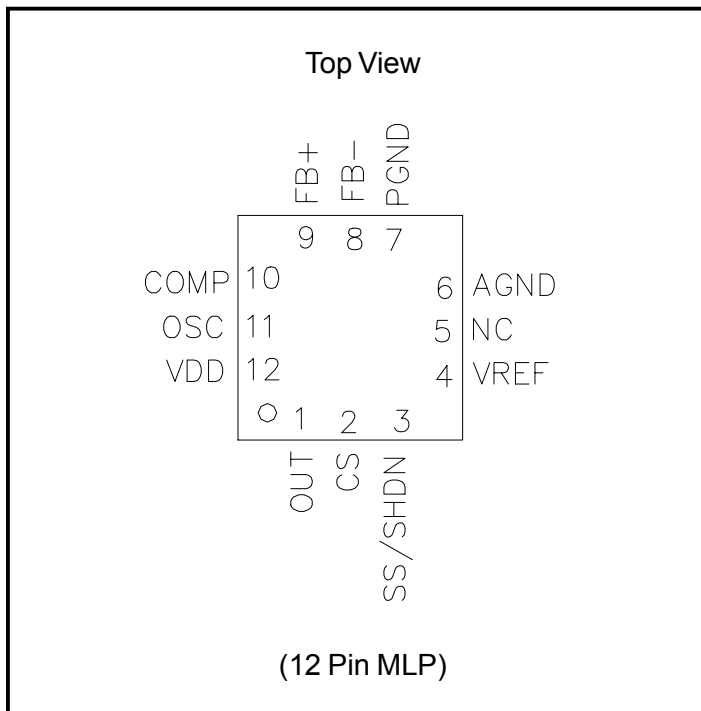
Parameter	Test Conditions	Min	Typ	Max	Unit
<b>PWM Comparator</b>					
Delay to Output			50		ns
<b>VREF Reference</b>					
Output Voltage		1.231	1.25	1.269	V
Output Current			1		mA
Line Regulation	$V_{DD} = 2.7$ to $15V$ , $I_{VREF} = 1mA$		4		mV
Load Regulation	$V_{DD} = 5V$ , $I_{VREF} = 0$ to $1mA$		4		mV
<b>Soft Start/Shutdown</b>					
Charge Current			10		$\mu A$
Discharge Current			12		mA
SHDN Logic Hight Voltage		2			V
SHDN Logic Low Voltage				0.25	V
<b>Current Limit</b>					
Cycle by Cycle Threshold			0.12		V
Shutdown Threshold			0.16		V
Delay to Output			50		nS
<b>Output</b>					
Gate Drive On-Resistance(H)	$V_{DD} = 5V$ , $I_{SOURCING} = 250mA$		20		Ohm
Gate Drive On-Resistance(L)	$V_{DD} = 5V$ , $I_{SINK} = 250mA$		20		Ohm
Rise Time	$C_{OUT} = 200pF$		20		nS
Fall Time	$C_{OUT} = 200pF$		20		nS

Note:

(1) This device is ESD sensitive. Use of standard ESD handling precautions is required.

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### Pin Configuration



### Ordering Information

DEVICE <sup>(1)</sup>	PACKAGE	Temp. Range (T <sub>j</sub> )
SC4508IMLTR	MLP-12	-40°C to 150°C

Note:

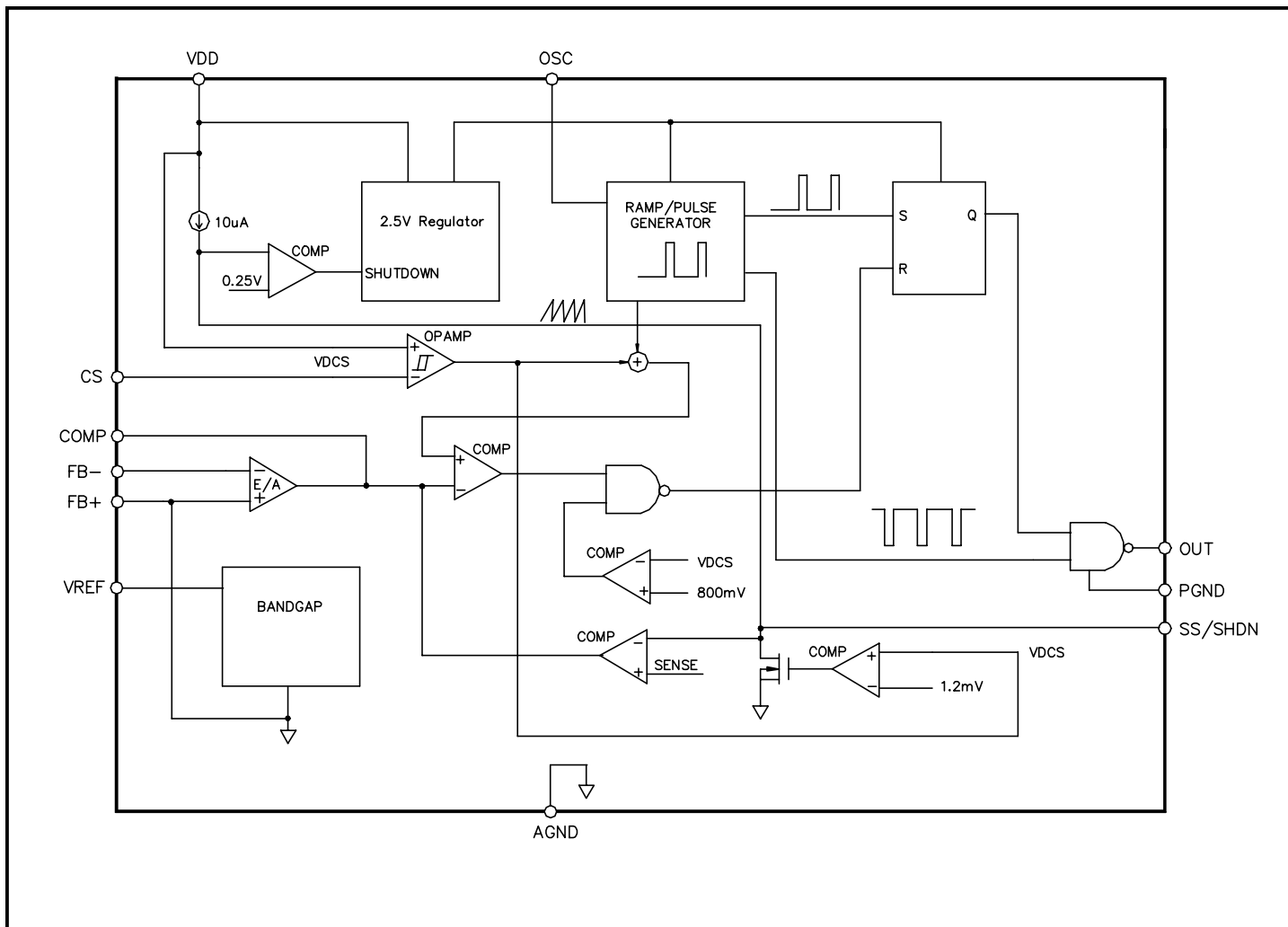
(1) Only available in tape and reel packaging. A reel contains 3000 devices.

### Pin Descriptions

Pin #	Pin Name	Pin Function
1	OUT	Gate drive output.
2	CS	Current limit sense.
3	SS/SHDN	Soft start pin. Hold low to shutdown the device.
4	VREF	1.25V reference voltage output.
5	NC	No connection.
6	AGND	Analog ground.
7	PGND	Power ground.
8	FB-	Error amplifier inverting input.
9	FB+	Error amplifier non-inverting input.
10	COMP	Error amplifier output for compensation.
11	OSC	Connect a capacitor to GND to program oscillator frequency.
12	VDD	Supply voltage.

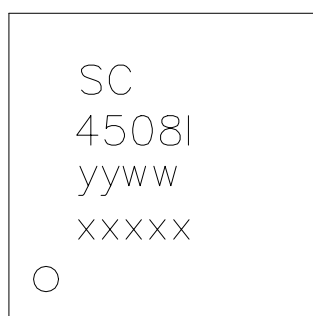
## POWER MANAGEMENT

### Block Diagram



### Marking Information

#### Top View



yyww = Date Code (Example: 0012)

## POWER MANAGEMENT

### Application Information

The SC4508 is designed to control buck (step down) or buck-boost (inverting) converter with P-channel MOSFET as a switch using current mode, programmable switching frequency architecture. During steady state operation, the switch is turned on each cycle and turned off when the voltage across current sense resistor exceeds the voltage level at COMP pin set by voltage loop error amplifier. A fixed 0.5V artificial ramp is added internally to the sensed current signal for operations when duty-cycle is larger than 50%. In over load or output shortage condition, if the sensed current signal reaching typical 120mV, the switch is turned off immediately in the same cycle. If the sensed current signal further increases to typical 160mV, not only the switch is turned off but also the soft start capacitor is discharged by a internal MOSFET to ground then charging back to threshold 250mV during which the switch is held off. With the “hiccup” mode over current protection, the thermal stress is reduced in the faulty conditions.

### Current Sense and Current Limit

The typical cycle-by-cycle current limit threshold in the current sense pin of the SC4508 is 120mV. The over current limit is assumed typical 120% of full load current. Then the current sense resistor can be calculated by the following equation:

$$R_s = \frac{120\text{mV}}{120\% \cdot I_L(\text{pk})}$$

$$I_L(\text{pk}) = I_o + \frac{1}{2} \frac{V_{IN} - V_o}{f_s \cdot L} \left( \frac{V_o + V_D}{V_{IN} + V_D} \right) \text{ for Buck}$$

$$I_L(\text{pk}) = I_o \frac{V_{IN} + |V_o| + V_D}{V_{IN}} + \frac{1}{2} \frac{V_{IN}}{f_s \cdot L} \left( \frac{|V_o| + V_D}{V_{IN} + |V_o| + V_D} \right)$$

for Buck – Boost

$I_o$  - full load current

$V_o$  - output voltage

$V_{IN}$  - input voltage

$V_D$  - diode forward voltage drop

$f_s$  - switching frequency

$L$  - inductor

### Inductor Selection

A inductor is chosen based on the required output ripple current which is usually 20-30% of load current. The ripple current  $\Delta I$  decreases with higher inductance and increases with higher input voltage  $V_{IN}$  or output voltage  $V_o$ .

$$L = \frac{V_{IN} - V_o}{f_s \cdot \Delta I_L} \left( \frac{V_o + V_D}{V_{IN} + V_D} \right) \text{ for Buck}$$

$$L = \frac{V_{IN}}{f_s \cdot \Delta I_L} \left( \frac{|V_o| + V_D}{V_{IN} + |V_o| + V_D} \right) \text{ for Buck-Boost}$$

Specify the maximum inductor current larger than  $I_L(\text{pk})$  set by the current sense resistor  $R_s$  to avoid the inductor core saturation.

### Input Capacitor $C_{IN}$ and Output Capacitor $C_{OUT}$ Selection

Both input and output capacitors need to be sized to handle the ripple current safely. Buck converters have high ripple current in the input side while buck-boost converters have high ripple current in the both input and output capacitors. Therefore, the RMS value of the current must be less than the high frequency ripple rating of the capacitors. In continuous mode operation,

$$I_{\text{RMS\_INPUT\_CAP}} \approx I_o \frac{\sqrt{V_o(V_{IN} - V_o)}}{V_{IN}} \text{ for Buck}$$

$$I_{\text{RMS\_CAP}} \approx I_o \sqrt{\frac{V_o + V_D}{V_{IN}}} \text{ for Buck-Boost input and output capacitors.}$$

The  $C_{OUT}$  is selected for Buck converter is by required output ripple voltage and converter loop stability. The output ripple is determined by:

$$\Delta V_o \approx \Delta I_L \left( \text{ESR} + \frac{1}{8f_s C_{OUT}} \right)$$

where  $f$  is converted switching frequency,  $C_{OUT}$  is output capacitance and  $\Delta I_L$  is inductor ripple current.

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### Application Information (Cont.)

In Buck converter, the worst case input RMS ripple current occurs at 50% duty cycle, or at  $V_{IN} = 2V_{OUT}$ . Under this condition, the input capacitors RMS ripple current is about half of the load current.

#### MOSFET Selection

The selection criteria for the power MOSFET is its operating junction temperature not exceeding the maximum junction temperature. Therefore, from a specified ambient temperature, the maximum junction to ambient temperature rise has to be determined, which is related to the MOSFET power dissipation or power loss. The power loss includes conduction loss and switching loss. The conduction loss is given by:

$$P_{ON} = \left( \frac{V_O + V_D}{V_{IN} + V_D} \right) I_O^2 R_{DS(ON)} \text{ for Buck}$$

$$P_{ON} = \left( \frac{V_{IN} + |V_O| + V_D}{V_{IN}} \right) (|V_O| + V_D) I_O^2 R_{DS(ON)} \text{ for Buck-Boost}$$

#### Freewheeling Diode Selection

The Schottky diode is recommended as freewheeling diode in the both Buck and Buck-Boost applications. The diode conducts during the off-time. The diode voltage and current ratings are selected based upon the peak reverse voltage, the peak current and average power dissipation.

$$V_{D(REV)} = V_{IN}, I_{D(PEAK)} = I_O + \frac{\Delta I_L}{2}, I_{D(AVG)} = I_O \frac{V_{IN} - V_O}{V_{IN} + V_D} \text{ for Buck}$$

$$V_{D(REV)} = V_{IN} + |V_O|, I_{D(PEAK)} = I_O \left( \frac{V_{IN} + |V_O| + V_D}{V_{IN}} \right) + \frac{\Delta I_L}{2}, I_{D(AVG)} = I_O$$

for Buck – Boost

The most stressful condition for the diode occurs when the output is shorted. Under this condition, due to the  $V_{OUT} = 0$ , the diode conducts at close to 100% duty cycle. Therefore, attention should be paid to the thermal condition when laying out a board.

### LAYOUT GUIDELINES

Careful attention to layout requirements are necessary for successful implementation of the SC4508 PWM controller. High switching currents are present in the application and their effect on ground plane voltage differentials must be understood and minimized.

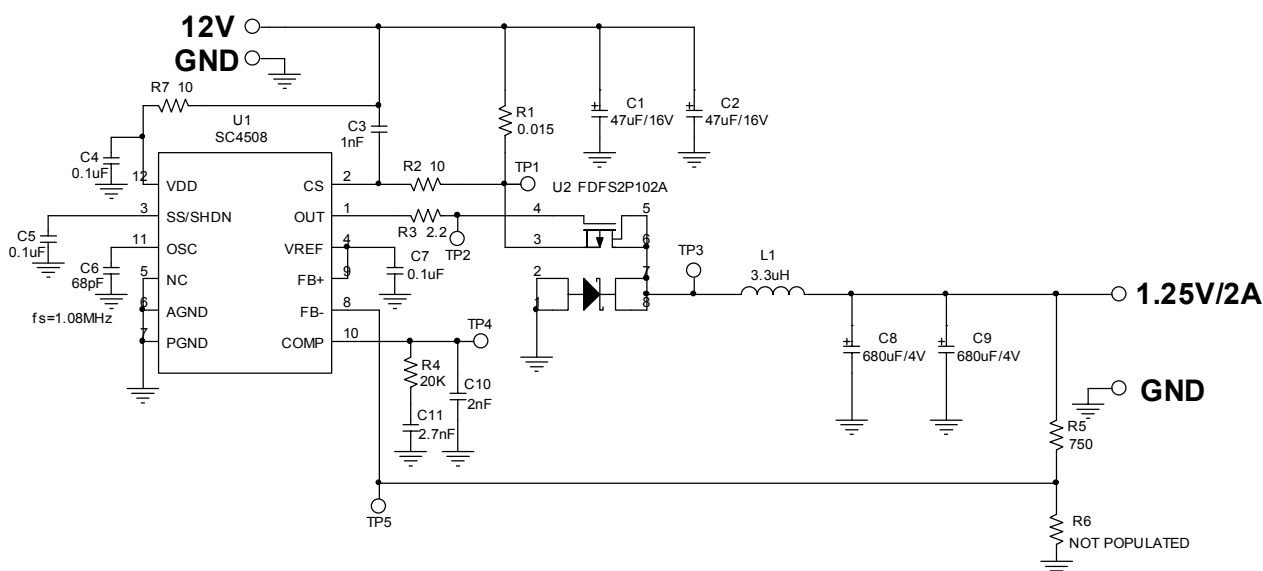
1). The high power parts of the circuit should be laid out first. A ground plane should be used, the number and position of ground plane interruptions should be such as to not unnecessarily compromise ground plane integrity. Isolated or semi-isolated areas of the ground plane may be deliberately introduced to constrain ground currents to particular areas, for example, the input capacitor and output capacitor ground.

2). The loop formed by the Input Capacitor(s) ( $C_{in}$ ), the MOSFET and the Schottky diode or inductor must be kept as small as possible. This loop contains all the high current, fast transition switching. Connections should be as wide and as short as possible to minimize loop inductance

3). The connection between the junction of MOSFET, Schottky diode and the output inductor should be a wide trace or copper region. It should be as short as practical. Since this connection has fast voltage transitions, keeping this connection short will minimize EMI.

4) The Output Capacitor(s) ( $C_{out}$ ) should be located as close to the load as possible, fast transient load currents are supplied by  $C_{out}$  only, and connections between  $C_{out}$  and the load must be short, wide copper areas to minimize inductance and resistance.

5) A separate analog ground plane connects to the SC4508 AGND pin. All analog grounding path including decoupling capacitors, feedback resistors, compensation components, and current-limit setting resistors should be connected to this plane.

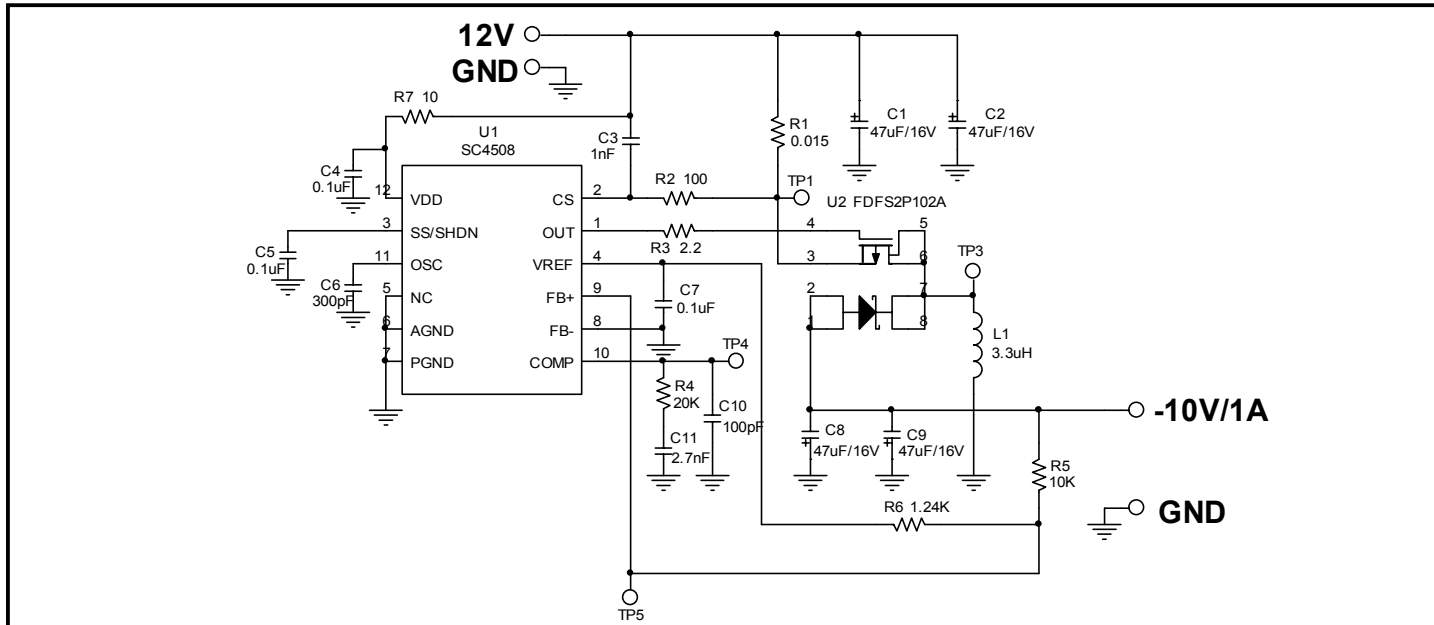
**POWER MANAGEMENT**
**Evaluation Board Schematic, Buck**

**Bill of Materials**

Item	Quantity	Reference	Part	Manufacturer
1	2	C1,C2	47uF/16V	Sanyo P/N: 16TPB47M
2	1	C3	1nF	
3	3	C4,C5,C7	0.1uF	
4	1	C6	68pF	
5	2	C8,C9	680uF/4V	
6	1	C10	2nF	
8	1	JO1	1.25V/2A	
9	1	JO3	12V	
10	2	JO1GND1,JO1GND3	GND	
11	1	L1	3.3uH	
12	1	R1	0.015	
13	2	R2,R7	10	
14	1	R3	2.2	
15	1	R4	20K	
16	1	R5	750	
17	1	R6	not populated	
18	8	TP1 - TP8	T POINT R	
19	1	U1	SC4508	Semtech Corp.
20	1	U2	FDFS2P102A	Fairchild P/N: FDFS2P102A



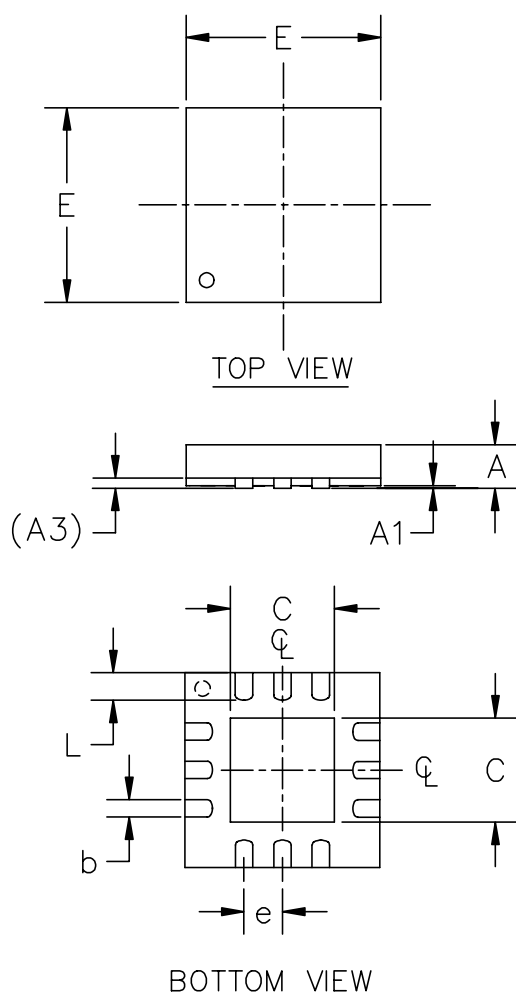
## POWER MANAGEMENT

## Evaluation Board Schematic, Buck-Boost



## Bill of Materials

Item	Quantity	Reference	Part	Manufacturer
1	4	C1,C2,C8,C9	47uF/16V	Sanyo P/N: 16TPB47M
2	1	C3	1nF	
3	3	C4,C5,C7	0.1uF	
4	1	C6	300pF	
5	1	C10	100pF	
6	1	C11	2.7nF	
7	1	JO1	-10V/1A	
8	1	JO3	12V	
9	2	JO1GND1,JO1GND3	GND	
10	1	L1	3.3uH	
11	1	R1	0.015	
12	1	R2	100	
13	1	R3	2.2	
14	1	R4	20K	
15	1	R5	10K	
16	1	R6	1.24K	
17		R7	10	
18	8	TP1 - TP8	T POINT R	
19	1	U1	SC4508	Semtech Corp.
20	1	U2	FDFS2P102A	Fairchild P/N: FDFS2P102A

**POWER MANAGEMENT**
**Outline Drawing - MLP-12**


DIMENSIONS					
DIM <sup>N</sup>	INCHES		MM		NOTE
	MIN	MAX	MIN	MAX	
A	.032	.039	0.80	1.00	—
A1	0	.002	0	0.05	—
A3	—	.008	—	0.20	REF
b	.011	.016	0.28	0.40	—
C	.079	.088	2.00	2.25	—
E	.157		4.00		NOM
e	.031	BSC	0.80	BSC	—
l	.018	.025	0.45	0.65	—

① CONTROLLING DIMENSIONS: MILLIMETERS.

**Contact Information**

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