2A, 23V, 340KHz Synchronous Step-Down Converter

General Description

The EML3220 is a synchronous step-down DC/DC converter that provides wide 4.5V to 23V input voltage range and 2A continuous load current capability.

Fault protection includes cycle-by-cycle current limit, input UVLO, output over voltage protection and thermal shutdown. Besides, adjustable soft-start function prevents inrush current at turn-on. This device uses current mode control scheme that provides fast transient response. In shutdown mode, the supply current is about 10uA.

The EML3220 is available in an 8-pin SOP package, provides a very compact system solution and good thermal conductance.

Features

- Wide Input Voltage from 4.5V to 23V
- 2A Output Current
- Adjustable Output Voltage from 0.925V to 20V
- 130mΩ integrated Power MOSFET
- High Efficiency Up to 93%
- Fixed 340KHz Switching Frequency
- Current Mode Operation
- Adjustable Soft-Start
- Cycle-by-Cycle current limit
- Input Under Voltage Lockout
- Over-Temperature Protection
- Thermal Enhanced SOP-8 Package
- RoHS Compliant

Applications

- Set-Top-Box
- DVD, LCD Displays
- OLPC, Netbook
- Distributed Power System
- Datacom, XDSL

Typical Application

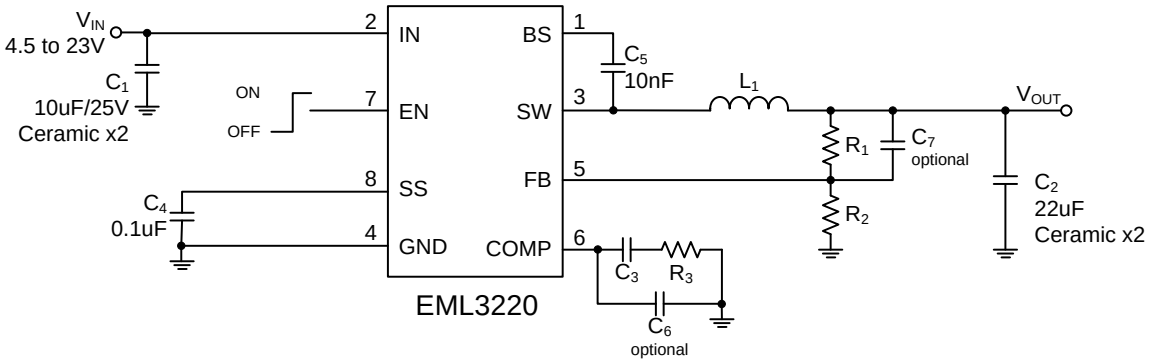
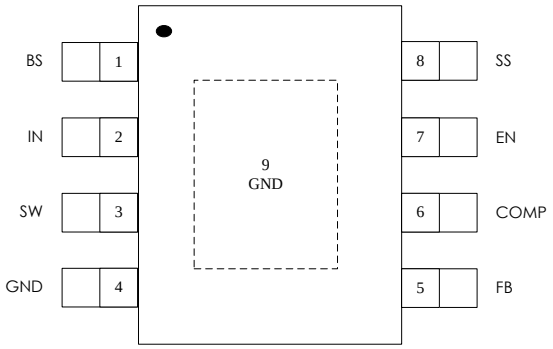


Fig. 1

Package Configuration

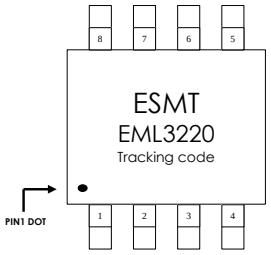


E-SOP-8L

EML3220-00SG08NRR

00	Adjustable
SG08	E-SOP-8L Package
NRR	RoHS & Halogen free package
	Commercial Grade Temperature
	Rating: -40 to 85°C
	Package in Tape & Reel

Order, Mark & Packing information

Package	Vout(V)	Product ID	Marking	Packing
E-SOP-8L	adjustable	EML3220-00SG08NRR		Tape & Reel 3K units

Functional Block Diagram

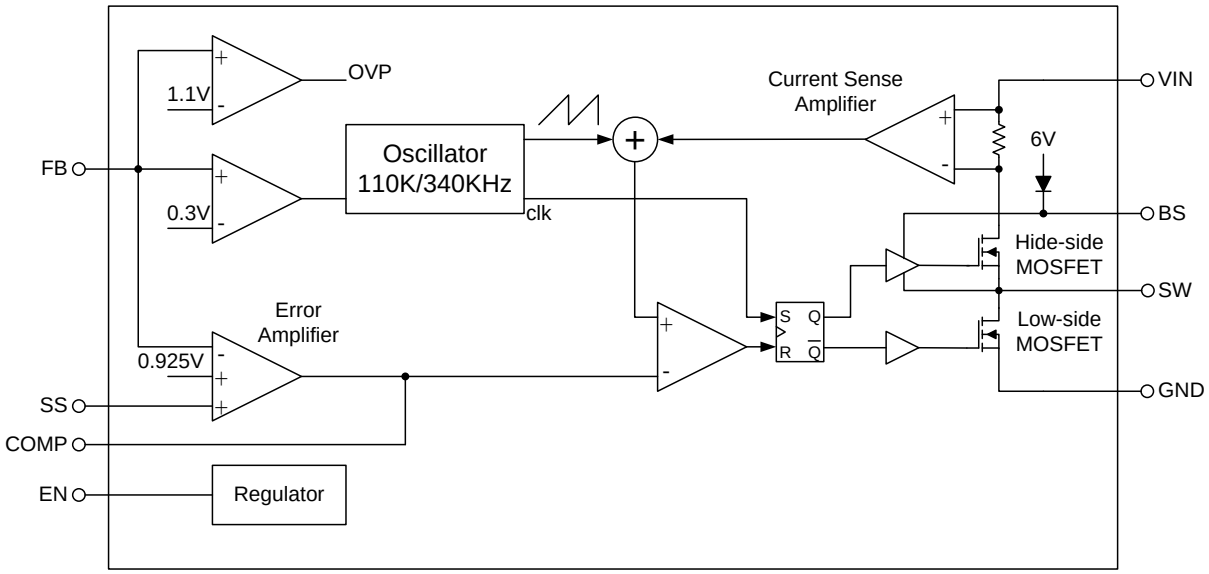


Fig. 2

Pin Functions

Pin Name	E-SOP-8L	Function
BS	1	**Bootstrap.** A 10nF or greater capacitor must be connected from this pin to SW. It can boost the gate drive to fully turn on the internal high side NMOS.
IN	2	**Power Input Pin.** Drive 4.5V to 23V voltage to this pin to power on this chip. Connecting a 10uF ceramic bypass capacitor between V_{IN} and GND to eliminate noise.
SW	3	**Switch Pin.** Must be connected to Inductor. This pin connects to the drains of the internal main and synchronous power MOSFET switches.
GND	4	**Ground Pin.**
FB	5	**Feedback Pin.** Receives the feedback voltage from an external resistive divider across the output, it regulates at 0.925V.
COMP	6	**Compensation.** This pin is used to compensate the regulation control loop. Connect a series RD network from COMP pin to GND.
EN	7	**Enable Pin.** This pin provides a digital control to turn the converter on or off. Connect to V_{IN} with a 100KΩ resistor for self-startup.
SS	8	**Soft-start.** This pin controls the soft-start period. Connect a capacitor from SS to GND to set the soft start period. To disable the soft-start feature, leave SS unconnected.
GND	9	**Ground Pin/Thermal Pad** This Pin must be connected to ground. The thermal pad with large thermal land area on the PCB will helpful chip power dissipation.

Absolute Maximum Ratings

Devices are subjected to fail if they stay above absolute maximum ratings.

Input Voltage (VIN) ---------- – 0.3V to 26V
EN Voltages ---------- – 0.3V to V_{IN}
SW Voltage ---------- – 1V to (V_{IN} + 0.3V)
BS Voltage ---------- (V_{SW} – 0.3V) to (V_{SW} + 6V)
Others pin ---------- – 0.3V to 6V
Lead Temperature (Soldering, 10 sec)---------- 260°C

Operating Temperature Range ---------- –40°C to 85°C
Junction Temperature (Note 1) ---------- 150°C
Storage Temperature Range ---------- – 65°C to 150°C
ESD Susceptibility HBM ---------- 2KV
MM ---------- 200V

Thermal data

Package	Thermal resistance	Parameter	Value
E-SOP-8L	θ JA (Note 2)	Junction-ambient	75°C/W
	θ JC (Note 3)	Junction-case	15°C/W

Electrical Characteristics

V_{IN}=12V, V_{OUT}=3.3V, V_{FB}=0.925V, L=10uH, C_{IN}=10uFx2, C_{OUT}=22uFx2. The ● denotes specifications which apply over the full operating temperature range, otherwise specifications are T_A = 25°C.

Symbol	Parameter	Conditions		Min	Typ	Max	Units
V_{IN}	Input Voltage Range			4.5		23	V
I_{SB}	Standby Current	V_{EN}≧1.8V			1.1		mA
I_{ST}	Shutdown Supply Current	V_{EN}=0V				15	μ A
V_{FB}	Regulated Feedback Voltage			0.900	0.925	0.95	V
	Feedback Over Voltage Threshold				1.1		V
A_{EA}	Error Amplifier Voltage Gain				400		V/V
G_{EA}	Error Amplifier Transconductance	△IC=±10uA			800		μ A/V
F_{OSC}	Oscillator Frequency			280	340	400	KHz
F_{SC}	Short Circuit Oscillation Frequency	V_{FB}=0V			110		KHz
$R_{ON(HS)}$	R DS(ON) of High Side	V_{FB}=0.7V, I_{OUT}=500mA			130		mΩ
$R_{ON(LS)}$	R DS(ON) of Low Side	V_{FB}=0.9V, I_{OUT}=500mA			130		mΩ
I_{IL}	High Side Switch Leakage Current	V_{EN}=0V, V_{SW}=0V				10	μ A
I_{HCL}	High Side Current Limit			3.0	3.5		A
I_{LCL}	Low Side Current Limit				2		A
G_{CS}	COMP to Current Sense Transconductance				4.8		A/V
D_{MAX}	Maximum Duty Cycle	V_{FB}=0.8V			90		%
T_{ON}	Minimum On Time				220		ns
V_{UVLO}	Input Under Voltage Lockout Threshold	V_{IN} Rising			4.4		V
	Input Under Voltage Lockout Threshold Hysteresis				400		mV
V_{EN}	EN Threshold Voltage				1.5		V
	EN Threshold Voltage Hysteresis				100		mV
I_{SS}	Soft-start Period	V_{SS}=0V			6		μ A
T_{SS}	Soft-start Time	C_{SS}=0.1uF			15		mS

Symbol	Parameter	Conditions		Min	Typ	Max	Units
T_{TS}	Thermal Shutdown				160		℃

Note 1: T_J is a function of the ambient temperature T_A and power dissipation P_D ($T_J = T_A + (P_D) * \theta_{JA}$)).

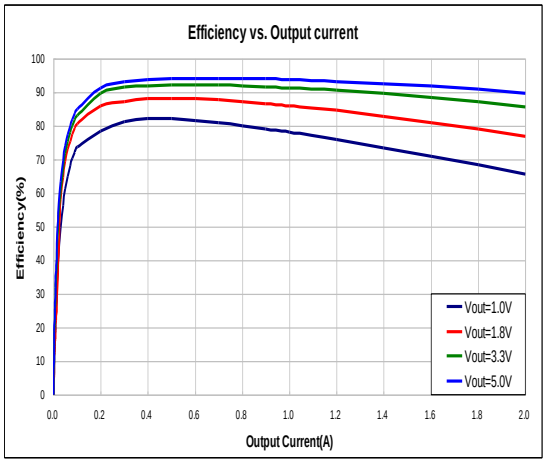
Note 2: θ_{JA} is measured in the natural convection at T_A=25℃ on a highly effective thermal conductivity test board (2 layers , 2S0P) according to the JEDEC 51-7 thermal measurement standard.

Note 3: θ_{JC} represents the heat resistance between the chip and the package top case.

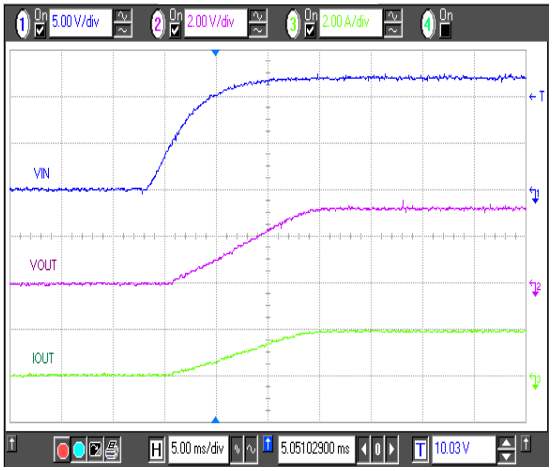
Typical Performance Characteristics

V_{IN}=12V, TA=25℃, unless otherwise specified

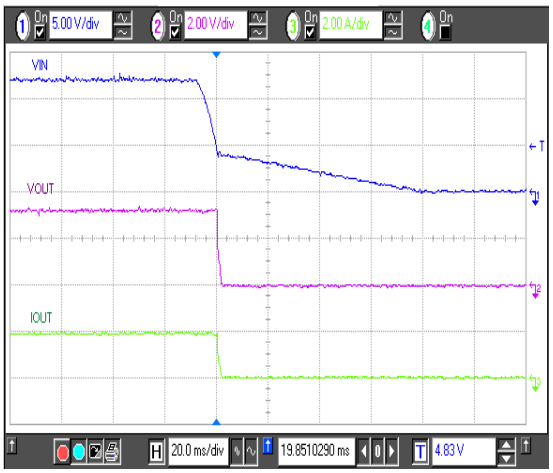
Efficiency vs Output Current



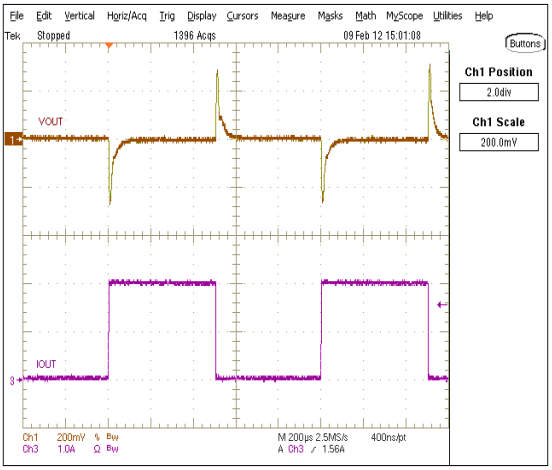
Power on (Vout=3.3V)



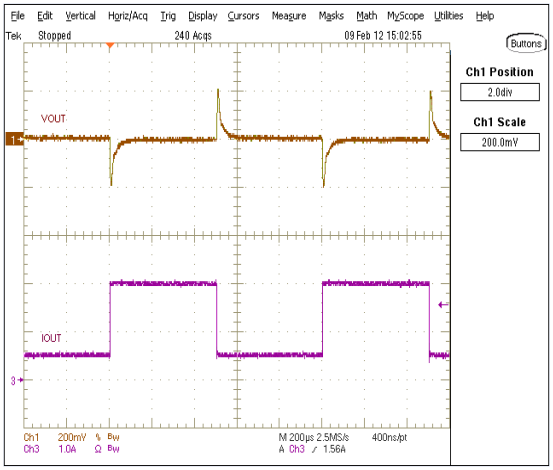
Power Off (Vout=3.3v)



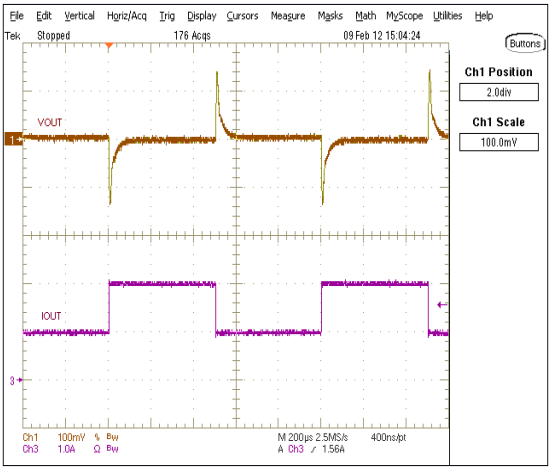
Load Transient Response (Vout=3.3V, Iout=0A to 2A)



Load Transient Response (Vout=3.3V, Iout=0.5A to 2A)



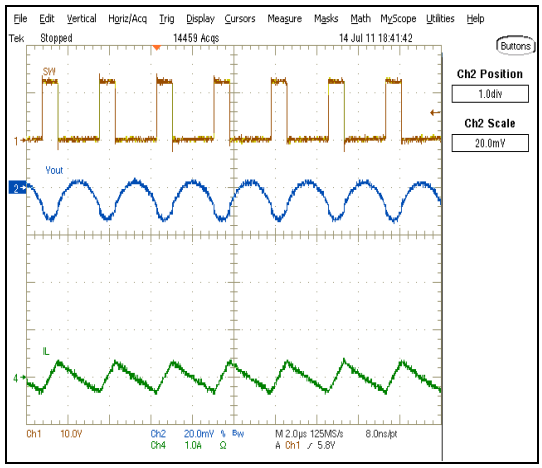
Load Transient Response (Vout=3.3V, Iout=1A to 2A)



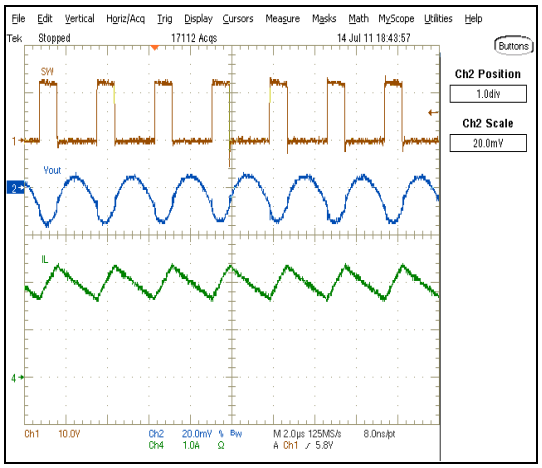
Typical Performance Characteristics (Cont.)

V_{IN}=12V, T_A=25℃, unless otherwise specified

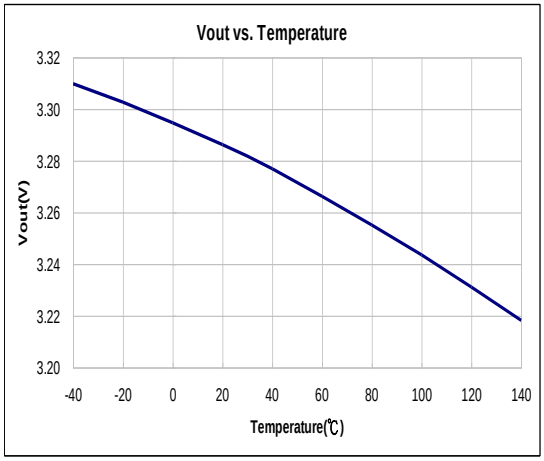
Steady State (Vout=3.3V, No load)



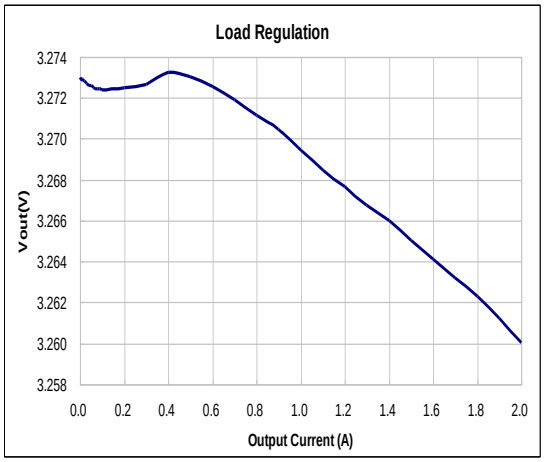
Steady State (Vout=3.3V, Iout=2A)



Vout vs. Temperature



Load Regulation



Function Description

The EML3220 is a constant frequency current mode step-down synchronous DC/DC converter. It regulates input voltage from 4.5V to 23V, down to an output voltage as low as 0.925V, and can provide 2A of continuous load current.

Control Loop

During normal operation, the output voltage is sensed at FB pin through a resistive voltage divider and amplified through the error amplifier. The voltage of error amplifier output pin – COMP is compared to the switch current to controls the RS latch. At each cycle, the high side NMOS would be turned on when the oscillator sets the RS latch and would be turned off when current comparator resets the RS latch. When the load current increases, the FB pin voltage drops below 0.925V, it causes the COMP voltage increase until average inductor current arrive at new load current.

Enable

The EML3220 EN pin provides digital control to turn on/turn off the regulator. When the voltage of EN exceeds the threshold voltage, the regulator starts the soft start function. If the EN pin voltage is below than the threshold voltage, only the bandgap voltage is alive. If the EN pin voltage is below than the shutdown threshold voltage, the regulator will be disable and into the shutdown mode.

Maximum Load Current

The maximum load current decreases at lower input voltage because of large IR drop on the high side switch and low side switch. The slope compensation signal reduces the peak inductor current as a function of the duty cycle to prevent sub-harmonic oscillations at duty cycles greater than 50%.

Output Over Voltage Protection

When the FB pin voltage exceeds 20% of the regulation voltage, the output over voltage protection function will discharge the COMP pin and the SS pin to GND, turning the high side MOSFET off.

Input Under Voltage Lockout

When the EML3220 power on, the internal circuits are held inactive until VIN exceeds the input UVLO threshold voltage. And the regulator will be disabled when VIN below the input UVLO threshold voltage. The hysteretic of the UVLO comparator is 400 mV.

Short Circuit Protection

The EML3220 provides short circuit protection function to prevent the device damage from short condition. When the output short to ground, the oscillator frequency is reduced to prevent the inductor current increasing beyond the current limit. In the meantime, the current limit is also reduced to lower the short current. Once the short condition is removed, the frequency and current limit will return to normal.

Over Temperature Protection

The EML3220 incorporates an over temperature protection circuit to protect itself from overheating. When the junction temperature exceeds the thermal shutdown threshold temperature, the regulator will be shutdown.

Compensation

The stability of the feedback circuit is controlled through COMP pin. The compensation value of the application circuit is optimized for particular requirements. If different conversions are requires, some of the components may need to be changes to ensure stability.

Application Information

Output Voltage Setting

The output voltage VOUT is set using a resistive divider from the output to FB. The FB pin regulated voltage is 0.925V. Thus the output voltage is:

$$VOUT = 0.925 \times \left(1 + \frac{R1}{R2}\right)$$

R2 recommended value is 10kΩ, so R1 is determined by:

R1 = 10.81 x (VOUT – 0.925) kΩ

Table 1 lists recommended values of R1 and R2 for most used output voltage.

Table 1. Recommended Resistance Values

VOUT	R1	R2
12V	121 kΩ	10kΩ
5V	66.0 kΩ	15kΩ
3.3V	25.9 kΩ	10kΩ
2.5V	17.0 kΩ	10kΩ
1.8V	9.40 kΩ	10kΩ

Note. Place resistors R1 and R2 close to FB pin to prevent stray pickup.

Input Capacitor Selection

The use of the input capacitor is controlling the input voltage ripple and the MOSFETS switching spike voltage. Because the input current to the step-down converter is discontinuous, the input capacitor is required to supply the current to the converter to keep the DC input voltage. The capacitor voltage rating should be 1.25 times to 1.5 times greater than the maximum input voltage. The input capacitor ripple current RMS value is calculated as:

$$Iin(RMS) = Iout \times \sqrt{D \times (1 - D)}$$

Where D is the duty cycle of the power MOSFET.

A low ESR capacitor is required to keep the noise minimum. Ceramic capacitors are better, but tantalum or low ESR electrolytic capacitors may also suffice. When using tantalum or electrolytic capacitors, a 0.1uF ceramic capacitor should be placed as close to the IC as possible.

Output Capacitor Selection

The output capacitor is used to keep the DC output voltage and supply the load transient current. Low ESR capacitors are preferred. Ceramic, tantalum or low ESR electrolytic capacitors can be used, depends on the output ripple requirement. Add a 100uF or 470uF Low ESR electrolytic capacitor when operated in high input voltage range (VIN > 20V). It can improve the device's stability. The output ripple voltage Δ VOUT is described as:

$$\Delta I = \frac{V_{OUT}}{F_{OSC} \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

$$\Delta V_{OUT} = \Delta I \times \left(R_{ESR} + \frac{1}{8 \times F_{OSC} \times C_{OUT}} \right)$$

Where Δ I is the peak-to-peak inductor ripple current, FOSC is the switching frequency, L is the inductance value, VIN is the input voltage, VOUT is the output voltage, RESR is the equivalent series resistance value of the output capacitor, and the COUT is the output capacitor. When using the ceramic capacitors, the RESR can be ignored and the output ripple voltage Δ VOUT is shown as:

$$\Delta V_{OUT} = \frac{\Delta I}{8 \times F_{OSC} \times C_{OUT}}$$

When using tantalum or electrolytic capacitors, typically 90% of the output voltage ripple is contributed by the ESR of output capacitors. The output ripple voltage Δ VOUT can be estimated as:

$$\Delta V_{OUT} = \Delta I \times R_{ESR}$$

Output Inductor Selection

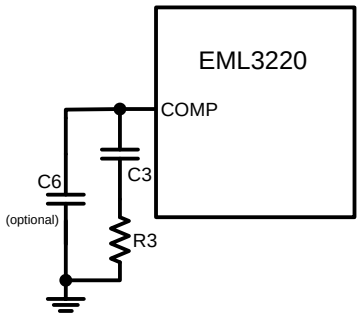
The output inductor is used for store energy and filter output ripple current. But the trade-off condition often happens between maximum energy storage and the physical size of the inductor. The first consideration for selecting the output inductor is to make sure that the inductance is large enough to keep the converter in the continuous current mode. That will lower ripple current and results in lower output ripple voltage. A good rule for determining the inductance is set the peak-to-peak inductor ripple current Δ I almost equal to 30% of the maximum load current. Then the minimum inductance can be calculated with the following equation:

$$\Delta I = 0.3 \times I_{OUT(MAX)}$$

$$L \geq (V_{IN} - V_{OUT}) \times \left(\frac{V_{OUT}}{F_{OSC} \times \Delta I \times V_{IN}} \right)$$

Where V_{IN} is the maximum input voltage.

Compensation Components Selection



Selecting the appropriate compensation value by following procedure:

1. Calculate the R3 value with the following equation:

$$R3 < \frac{2\pi \times C_{OUT} \times 0.1 \times F_{OSC} \times V_{OUT}}{G_{EA} \times G_{CS} \times V_{FB}}$$

where G_{EA} is the error amplifier voltage gain, and G_{CS} is the current sense gain.

2. Calculate the C3 value with the following equation:

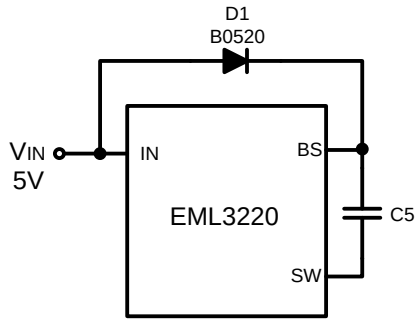
$$C3 > \frac{4}{2\pi \times R3 \times 0.1 \times F_{OSC}}$$

3. If the C_{OUT} ESR zero is less than half of the switching frequency, use C6 to cancel the ESR zero:

$$C6 = \frac{C_{OUT} \times R_{ESR}}{R3}$$

External Boost Diode Selection

For 5V input or 5V output applications, it is recommended that an external boost diode be added. This helps improve the efficiency. The boost diode can be a low cost one such as B0520.



Vout	R1	R2	R3	C3	L1	C2
5.0V	66K	15K	12K	3.3nF	10uH	22uF x 2
3.3V	25.9K	10K	7.5K	3.3nF	10uH	22uF x 2
2.5V	17K	10K	6.8K	3.3nF	6.8uH	22uF x 2
1.8V	9.4K	10K	5.6K	3.3nF	6.8uH	22uF x 2
1.2V	3.9K	10K	3.9K	3.3nF	4.7uH	22uF x 2
1.0V	1.3K	15K	3.3K	3.3nF	3.3uH	22uF x 2

Table 2. Recommended component selection

PCB Layout Recommendation

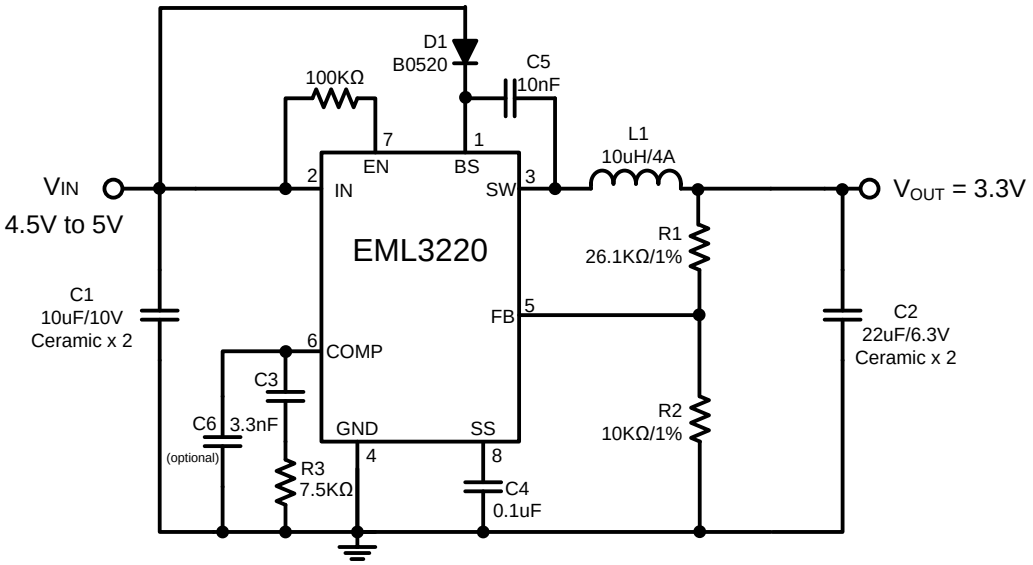
The device's performance and stability is dramatically affected by PCB layout. It is recommended to follow these general guidelines show bellow:

1. Place the input capacitors, output capacitors as close to the device as possible. Trace to these capacitors should be as short and wide as possible to minimize parasitic inductance and resistance.
2. Place VIN bypass capacitors close to the VIN pin.
3. Place feedback resistors close to the FB pin.
4. Place compensation components close to the COMP pin.
5. Keep the sensitive signal (FB, COMP) away from the switching signal (SW).
6. The exposed pad of the package should be soldered to an equivalent area of metal on the PCB. This area should connect to the GND plane and have multiple via connections to the back of the PCB as well as connections to intermediate PCB layers. The GND plane area connects to the exposed pad should be maximized to improve thermal performance.

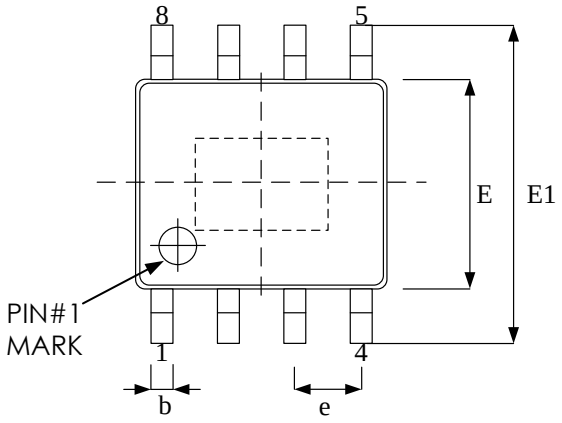
Multi-layer PCB design is recommended.

Application Circuit

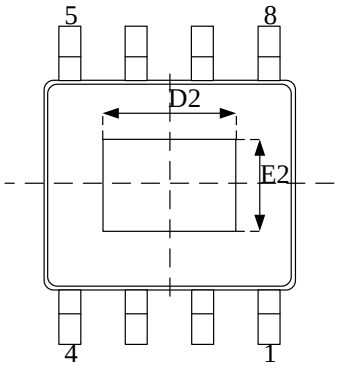
5V input application



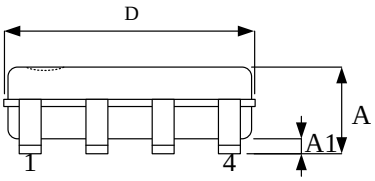
Package Outline Drawing
SOP-8 (E) (150 mil)



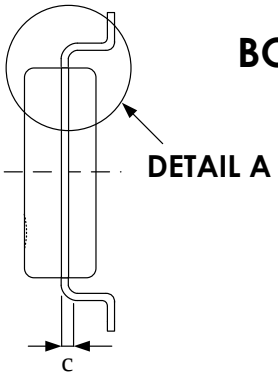
TOP VIEW

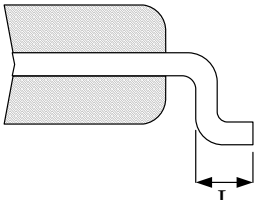


BOTTOM VIEW



SIDE VIEW





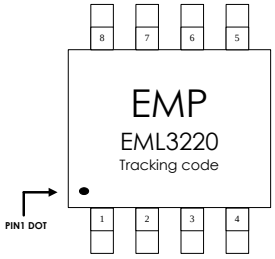
DETAIL A

Symbol	Dimension in mm	
	Min	Max
A	1.35	1.75
A1	0.00	0.25
b	0.33	0.51
c	0.17	0.25
D	4.80	5.00
E	3.81	4.00
E1	5.79	6.20
e	1.27 BSC	
L	0.41	1.27

Exposed pad

	Dimension in mm	
Option1		
D2	2.84	3.1
E2	2.06	2.31
Option2		
D2	3.00	3.20
E2	2.18	2.39
Option3		
D2	2.03	2.23
E2	2.03	2.23

Old order, Mark & Packing information

Package	Vout(V)	Product ID	Marking	Packing
E-SOP-8L	adjustable	EML3220-00SG08NRR		Tape & Reel 3K units

Revision History

Revision	Date	Description
0.1	2011.11.17	Original.
0.2	2011.11.17	1) Product ID corrected from EML3220-00SE08NRR to EML3220-00SG08NRR. 2) Corrected the electrical characteristics.
0.3	2012.03.29	Add typical performance characteristics into the datasheet.
0.4	2013.07.02	Explained the exposed pad pin function. “The exposed pad is connected to ground necessary.”
0.5	2013.11.20	1) ESMT logo instead. 2) Modified package outline drawing.

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