6A, 40V, 2.1MHz Non-synchronous Step-Down Converter

General Description

The EML3420 is a frequency adjustable, 6A, current-mode step-down converter with an integrated high-side switch. The EML3420 operates with the wide input voltage from 4.5V to 40V and provides an adjustable output voltage from 0.8V to 30V. The EML3420 features a PWM mode operation with up to 2.1MHz adjustable switching frequency. The EML3420 also provides a highly efficient solution with current mode control for fast loop response and easy compensation. The EML3420 automatically enters PSM mode at light load.

Cycle-by-cycle current limiting and thermal shutdown are provided for fault condition protections. An internal 2ms soft-start design reduces input start-up current and prevents the output voltage and inductor current from overshooting during power-up.

The EML3420 is available in E-SOP-8L with thermally enhanced package.

Features

- 4.5V to 40V Input Voltage Range
- 6A Continuous Output Current
- 70mΩ Internal Power MOSFET Switch
- Output Adjustable from 0.8V
- Output Over-Voltage Protection
- Up to 2.1MHz Adjustable Switching Frequency
- Cycle-by-Cycle Current Limit, Frequency Fold Back and thermal shutdown
- Stable with Low ESR Output Ceramic Capacitors
- 2ms Internal Soft-Start
- Conditional 100% duty cycle
- Thermally Enhanced E-SOP-8L Package

Applications

- 12V and 24V Distributed Power Systems
- Battery Powered Systems
- Industrial Power Systems
- LCD and Plasma TVs
- Automotive Systems

Typical Application

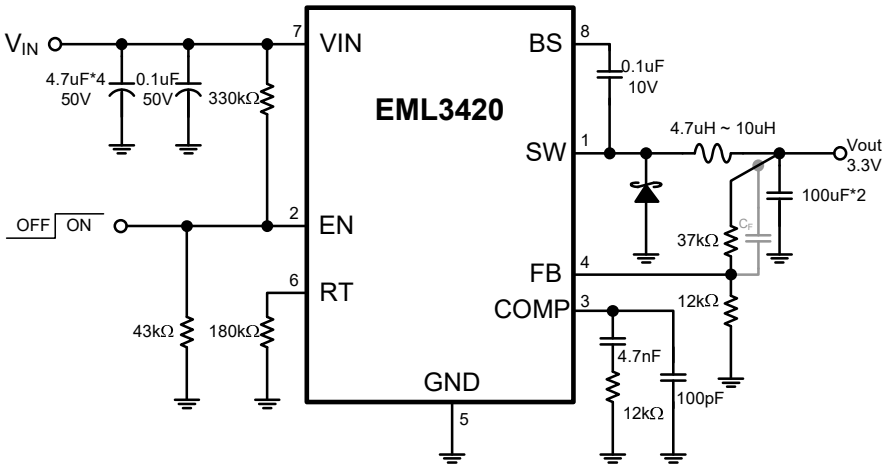
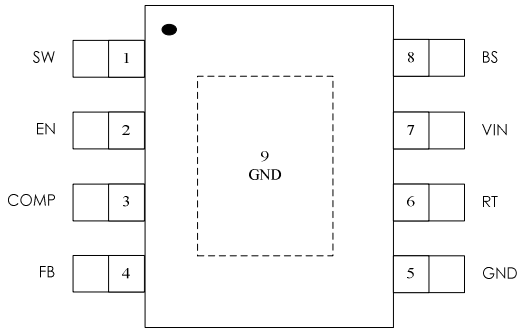


Fig.1

Package Configuration

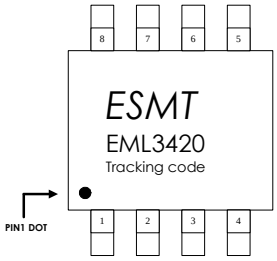


E-SOP-8L

EML3420-00SG08NRR

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	EML3420-00SG08NRR		Tape & Reel 3K units

Functional Block Diagram

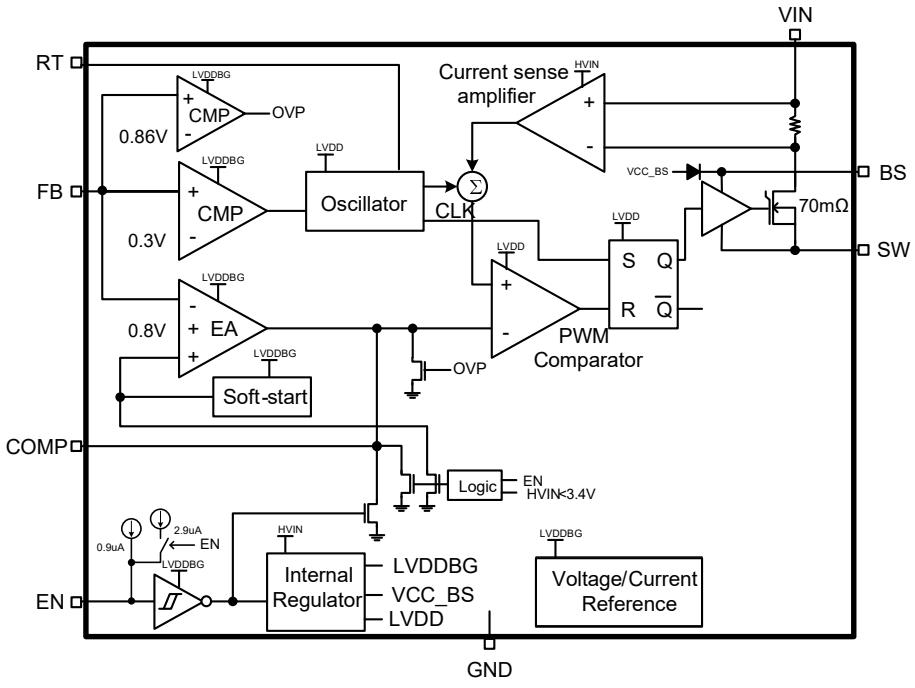


Fig.2

Pin Functions

Pin Name	E-SOP-8L	Function
SW	1	**Switch Out.** This is the output from the high-side switch.
EN	2	**Enable Pin.** On/Off control Input.
COMP	3	**Compensation.** This node is the output of Error Amplifier. Control loop frequency compensation is applied to this pin.
FB	4	**Feedback Pin.** This pin can be connected a resistor divider to set the output voltage range.
GND	5	**Ground Pin.** Connect exposed pad to GND plane for optimal thermal performance.
RT	6	**Frequency setting pin.** This pin can be connected to a resistor to GND to set the oscillator frequency (200kHz~2.1MHz adjustable switching frequency).
VIN	7	**Supply Voltage.** The EML3420 operates from a 4.5V to 40V.
BS	8	**Bootstrap.** This is the positive power supply for the internal floating high-side MOSFET driver. Connect a bypass capacitor (0.1uF) between BS and SW.
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 +44V
Switch Voltage (SW) ---------- – 0.3V to Vin+0.3V
Switch Voltage (SW, 10ns transient) –1.4V to Vin+0.3V
Bootstrap Voltage (BS)---------- V_{SW}-0.3V to V_{SW}+6V
Enable Voltage (EN) ---------- – 0.3V to Vin
All Other Pins (RT, FB, COMP) ---------- – 0.3V to +6V

Lead Temperature (Soldering, 10 sec) ---------- 260°C
Junction Temperature (Note 1) ---------- –40°C to 150°C
Storage Temperature Range ---------- – 65°C to 150°C
ESD Susceptibility HBM ---------- 2KV
MM ---------- 200V

Recommended Operating Conditions

Input Voltage(VIN) ---------- +4.5V to +40V

Junction Operating Temperature Range –40°C to 125°C

Thermal data

Package	Thermal resistance	Parameter	Value
E-SOP-8L	θ_{JA} (Note 2)	Junction-to-ambient	50°C/W
	$\theta_{JC(top)}$ (Note 3)	Junction-case (top)	39°C/W
	$\theta_{JC(bottom)}$ (Note 4)	Junction-case (bottom)	10°C/W

Electrical Characteristics

VIN=12V, T_A=+25°C, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{FB}	Feedback Voltage	4.5V≦V_{IN}≦40V	0.784	0.8	0.816	V
$R_{DS(ON)}$	Switch on Resistance			70	105	mΩ
I_{SW}	High-side Switch Leakage	V_{EN}=0V, V_{SW}=0V			10	μA
I_{LIM}	Current Limit	F_{OSC}=500KHz		10.8		A
G_{CS}	COMP to Current Sensing Transconductance (note5)			16		A/V
A_{EA}	Error Amplifier Voltage Gain (note5)			2000		V/V
G_{EA}	Error Amplifier Transconductance (note5)	I_{COMP}=±3uA		500		μA/V
	Error Amplifier Min Source Current	FB=0.7V		30		μA
	Error Amplifier Min Sink Current	FB=0.9V		-30		μA
V_{UVLO}	VIN UVLO Threshold		3.9	4.2	4.5	V
	VIN UVLO Hysteresis			800		mV
F_{OSC}	Oscillation Frequency	V_{FB}=0.6V; RT=180kΩ	440	540	640	kHz
	Fold-Back Frequency	V_{FB}=0V; RT=180kΩ	40	62.5	100	kHz
I_{SD}	Shutdown Supply Current	V_{EN}=0		7	12	μA
I_Q	Quiescent Supply Current	V_{EN}=2V, No load, switching supply current (Fig.1 condition)		330	420	μA
		V_{EN}=2V, V_{FB}=1V, non-switching supply current		180	240	μA
T_{SD}	Thermal Shutdown			170		℃

Symbol	Parameter	Conditions	Min	Typ	Max	Units
	Thermal Shutdown Hysteresis			20		℃
T_{OFF}	Minimum Off Time (note5)			150		ns
T_{ON}	Minimum On Time (note5)			120		ns
	EN Input Low Voltage				0.4	V
	EN Input High Voltage		1.2			V

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 simulated in the natural convection at T_A=25℃ on a highly effective thermal conductivity (thermal land area completed with >3x3cm^2 area) board (2 layers , 2S0P) according to the JEDEC 51-7 thermal measurement standard.

Note 3: $\theta_{JC(top)}$ represents the heat resistance between the chip junction and the top surface of package.

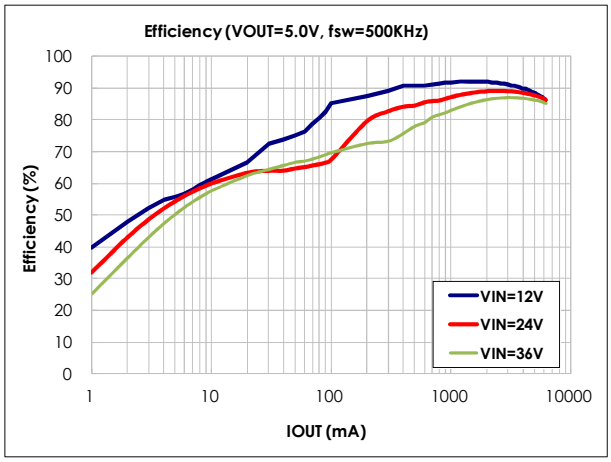
Note 4: $\theta_{JC(bottom)}$ represents the heat resistance between the chip junction and the center of the exposed pad on the underside of the package.

Note 5: Guaranteed by design.

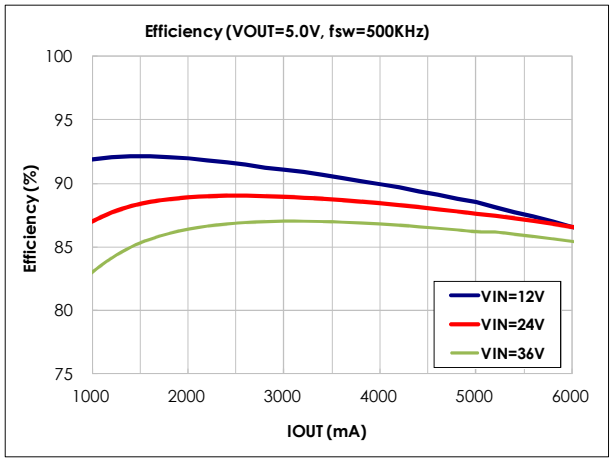
Typical Performance Characteristics

V_{IN}=12V, V_{OUT}=5.0V, T_A=25℃, unless otherwise specified.

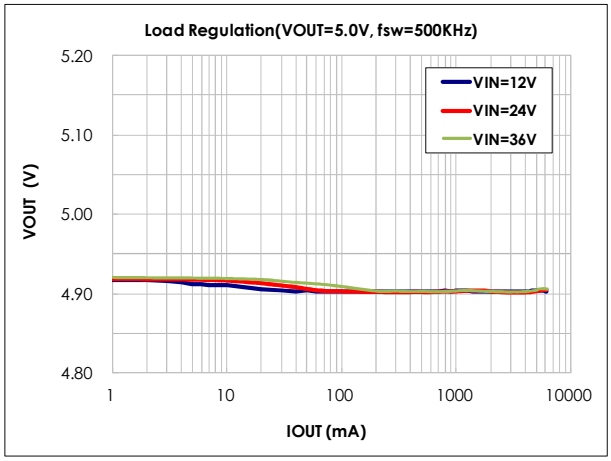
Efficiency vs. Output Current (Fig.3)



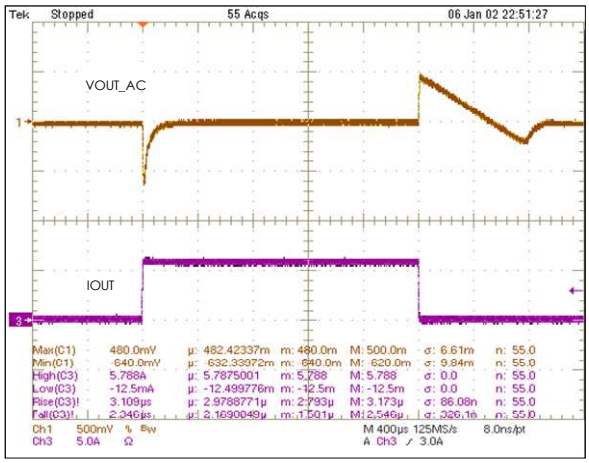
Efficiency vs. Output Current (Fig.4)



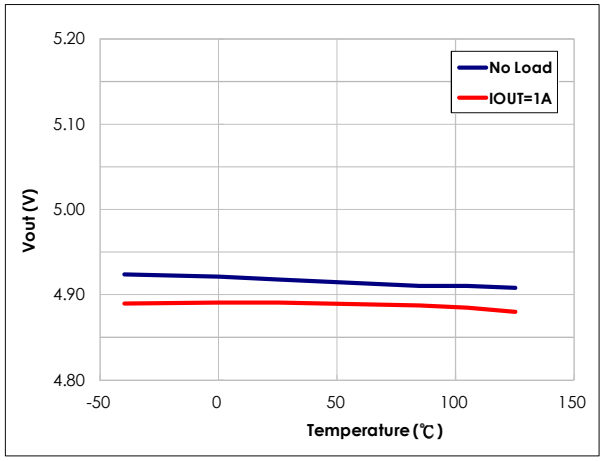
Load Regulation (Fig.5)



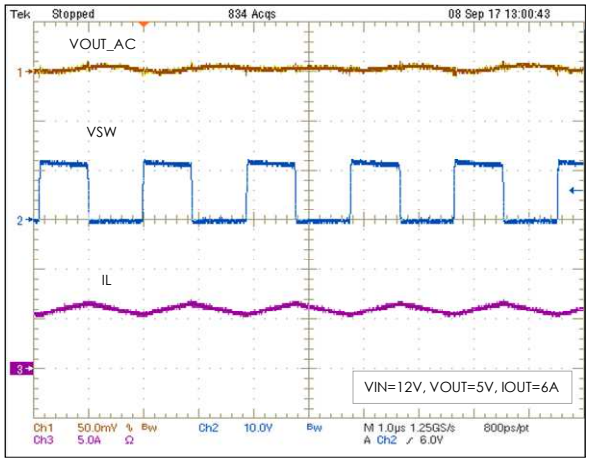
Load Transient (10mA→6A→10mA) (Fig.6)



Output Voltage vs. Temperature (Fig.7)



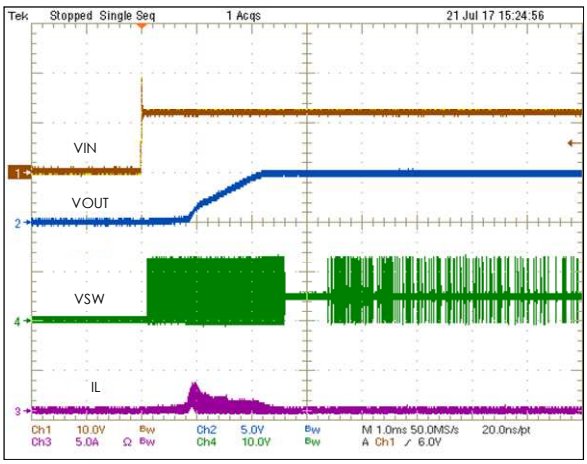
Output Ripple Voltage (Fig.8)



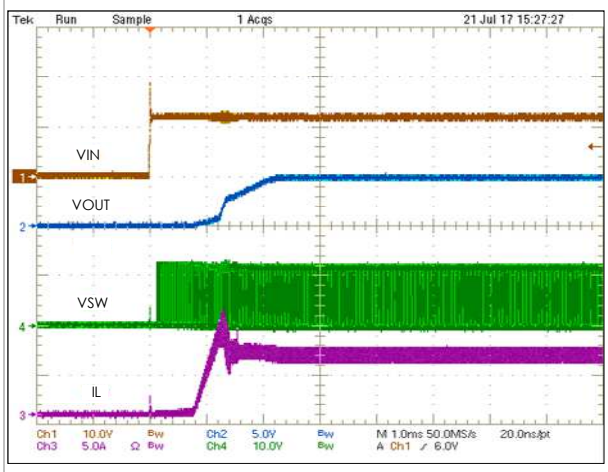
Typical Performance Characteristics

V_{IN}=12V, V_{OUT}=5.0V, T_A=25℃, unless otherwise specified.

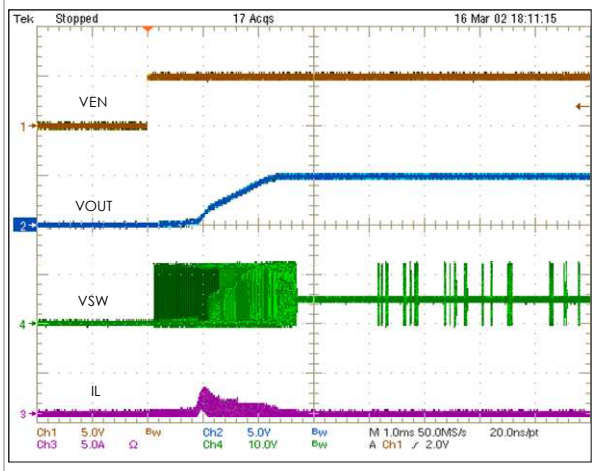
Power Up Without Load (Fig.9)



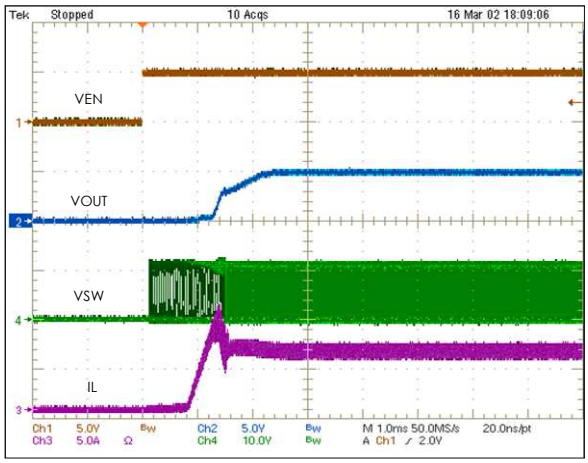
Power Up With Full Load (Fig.10)



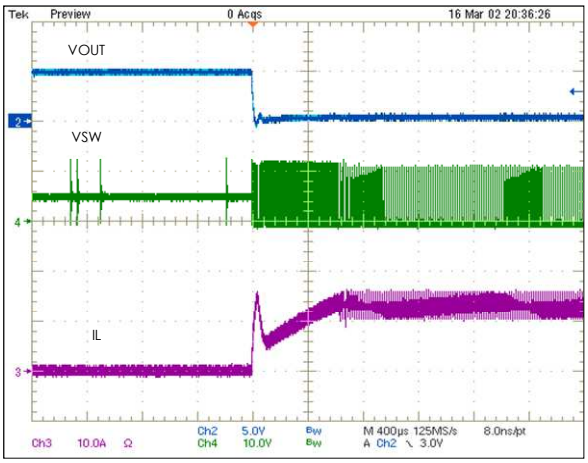
Enable Startup at No Load (Fig.11)



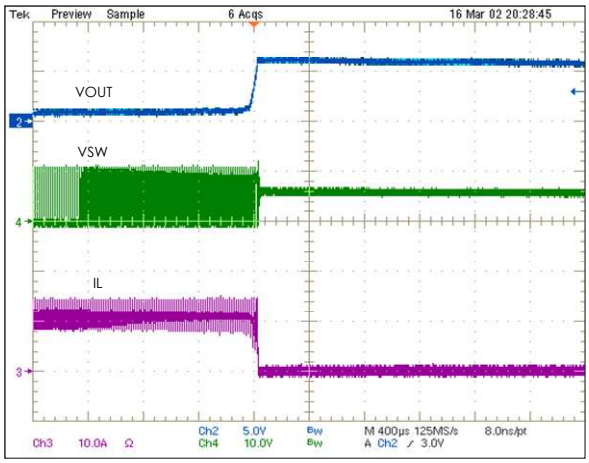
Enable Startup at Full Load (Fig.12)



Vout Short waveform (Fig.13)



Short release waveform (Fig.14)



Detailed Description

The EML3420 is a variable frequency, current mode, automotive buck converter with an integrated high-side switch. The device operates with input voltages from 4.5V to 40V and tolerates input transients up to 42V. During light-load conditions, the device enters Pulse Skip Mode, automatically.

Wide Input Voltage Range (4.5V to 40V)

The EML3420 includes two separate supply inputs, VIN and BS, specified for a wide 4.5V to 40V input voltage range. VIN provides power to the device and BS provides power to the internal high-side switch driver. With respect to PWM minimum duty limit in EML3420, the safe operating voltage area shall be considering in here. The Safe Operating Voltage Area (SOVA) is showed in the Fig.15.

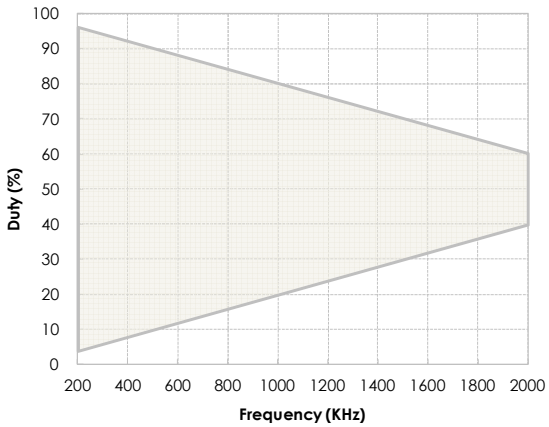


Fig.15 EML3420 Safe Operating Voltage Area

Error Amplifier

The error amplifier compares t he FB pin voltage with the internal 0.8V reference and outputs a current proportional to the difference between the two. This output current is then used to charge or discharge the external compensation network on COMP pin to form the COMP voltage, which is used to control the power MOSFET current. During operation, the COMP voltage is range from 0.2V to 2.8V. COMP is internally pulled down to GND in shutdown mode. The voltage over 3.4V on COMP pin is not allowed due to 3.4V internal power.

Minimum On-Time

The device features a 120ns minimum on-time that ensures proper operation at high switching frequency and high differential voltage between the input and the output.

Enable Control

The EML3420 has a dedicated enable control pin, EN. By pulling it high or low, that can be enabled and disabled. Tie EN to VIN through a 100kΩ resistor for automatic start up. To disable the part, EN must be pulled low. EN should be pulled up to VIN through a resistor if the output current is more than 4A application.

Over-Temperature protection

Thermal overload protection limits the total power dissipation in the device. When the junction temperature exceeds 150℃, an internal thermal sensor shuts down the whole chip. The thermal sensor turns on the IC again after the junction temperature is cooled by 20℃.

Under Voltage Lock-out (UVLO)

UVLO is implemented to protect the chip from operating at insufficient supply voltage. The UVLO rising threshold is about 4.2V while its falling threshold is about 3.4V. If a higher UVLO is required for a specified application, as the EN pin had shown in Fig.16 below to adjust input voltage UVLO via two external resistors.

The EN enable threshold is around 1.0V (EN_{ON}), and with 100mV hysteresis window (EN_{OFF}) for shutdown. An internal pull-up current source I_E (1uA) is in default operating when EN pin floats. Once the EN pin voltage exceed the EN_{ON}, an additional 3 μA of hysteresis, I_H, is added. This additional current facilitates adjustable input voltage UVLO hysteresis. Use Equation (a) to set the external UVLO hysteresis voltage. Use Equation (b) to set the external UVLO start voltage. For example, choosing R_3=330kΩ and R_4=43kΩ, the external UVLO V_{UVLO_start} and V_{UVLO_stop} would be around 9V and 7V.

$$R_3 = \frac{V_{UVLO\_start} - k \cdot V_{UVLO\_stiop}}{k \cdot 4u - 1u} \quad \text{.....}(a)$$

$$R_4 = \frac{EN_{on}}{\frac{V_{UVLO\_start} - EN_{on}}{R_3} + 1u} \quad \text{.....}(b)$$

$$k = \frac{EN_{on}}{EN_{off}} = 1.1$$

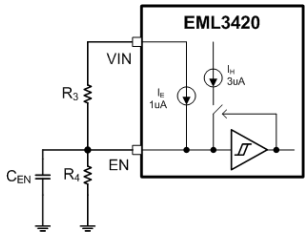


Fig.16 External UVLO Lock-out

Bootstrap Capacitor

Connect a 0.1uF capacitor between the BS pin and SW pin. This capacitor provides the gate driver voltage for the high-side MOSFET. Also, an UVLO in the floating supply is implemented to protect the high-side MOSFET and its driver from operating at insufficient supply

voltage. The UVLO rising threshold is about 2.2V while its hysteresis is about 0.16V.

Over-Current protection

Over-current limiting is implemented by sensing the drain-to-source voltage across the high-side MOSFET. The drain to source voltage is then compared to a voltage level representing the over-current threshold limit. If the drain-to-source voltage exceeds the over-current threshold limit, the over-current indicator is set true. Once over-current indicator is set true, over-current limiting is triggered. The high-side MOSFET is turned off for the rest of the cycle. The output voltage will start to drop if the output is dead-short to ground, suddenly. Once the FB is lower than 0.3V, the switching frequency of EML3420 is down to around quarter of setting frequency till the dead-short event is removed.

Over-Voltage protection

The EML3420 is with an output voltage protection circuit to minimize output voltage overshoot when fast unload transients or fast supply transients or recovering from overloaded conditions, especially in application design with high inductance and low output capacitance. If the FB pin voltage is rising over 108% of reference voltage (V_{ref}=0.8V), the high side MOS is turned-off immediately. When the FB pin voltage drops below 104% of reference voltage, the high side MOS goes to normal operation.

Although there is an output overvoltage protection, the overshooting voltage would still be seen in designs with improper inductance (L) and output capacitance (C_{out}) due to the energy stored in inductor transfer to output capacitor. For example with V_O=5V, the output protection voltage $V_{O,OVP}$=5V*1.08=5.4V, the output overshoot voltage $V_{overshoot}$ would be around 7.35V during a fast load transient current (i) from 5A to 1mA with L=22uH and C_{out}=22uF. But with the same fast load transient, the output overshoot voltage would be down to around 5.62V with L=10uH and C_{out}=100uF. The value of output overshoot voltage $V_{overshoot}$ can be calculated from:

$$V_{overshoot} = \sqrt{\frac{L}{C_{out}} i^2 + V_{O,OVP}^2}$$

Programmable Oscillator

The EML3420 oscillating frequency (200kHz~2.1MHz adjustable switching frequency) is set by an external resistor, R_T from the RT pin to GND. The value of RT can be calculated from:

$$Frequency(kHz) = \frac{7.35 \times 10^4}{R_T^{0.947}(k\Omega)}$$

Low dropout operation

The EML3420 can operate with a low voltage difference from supply to output. And, the high-side MOSFET of EML3420 would be turned-on with 100% duty cycle till the voltage difference between BS and SW is smaller than 2.1V. Once the difference between BS and SW is smaller than 2.1V during normal operating, the small low-side MOSFET would be turned on to recharge the bootstrap capacitor.

Although the current of gate driver is small, the high-side MOSFET could not be turned-on with 100% duty cycle due to limited bootstrap capacitor. So, it calls 'conditional 100% duty cycle.'

The dropout voltage of the conditional 100% duty cycle almost depends with the Ron of high-side MOSFET, DCR of inductor and the inductor current. Follow figures show the trend of dropout voltage and its corresponding output ripple for trade-off during system design.

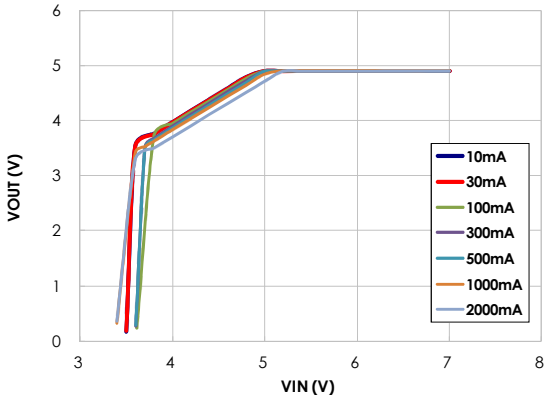


Fig.17 EML3420 Drop-out voltage with low VIN

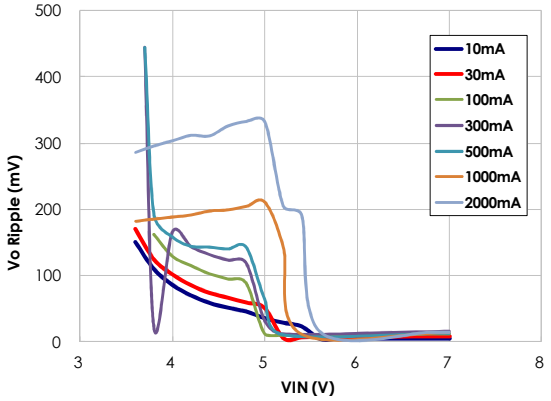


Fig.18 EML3420 Output ripple voltage in low VIN

Application Information

The schematic on the front page shows a typical application circuit. The IC can provide up to 6A output current at a 3.3V output voltage. For proper thermal performances, the exposed pad of the device must be soldered down to the PCB.

Setting the Output Voltage

The output voltage is set by the resistive voltage divider from the output voltage to FB pin. The voltage divider divides the output voltage down to the feedback voltage by the ratio

$$V_{FB} = Vout \times \frac{R2}{R1+R2} \Rightarrow Vout = V_{FB} \times \frac{R1+R2}{R2}$$

Table1-Resistor Selection for Common Output Voltages

Vout	R1 (kΩ)	R2 (kΩ)
1.8V	14.8 (1%)	11.8 (1%)
2.5V	25 (1%)	11.8 (1%)
3.3V	37 (1%)	11.8 (1%)
5.0V	62 (1%)	11.8 (1%)
12V	166 (1%)	11.8 (1%)

Selecting the Inductor

The common rule for determining the inductance to use is to allow the peak-to-peak ripple current in the inductor to be between 20% and 40% of the DC maximum load current, typical 30%. And also have sufficiently high saturation current rating and a DCR as low as possible. Generally, it is desirable to have lower inductance in switching power supplies, because it usually corresponding to faster transient response, smaller DCR and reduced size for more compact designs. But too low of an inductance results in higher ripple current such that over-current protection at full load could be falsely triggered. Also, the output ripple voltage and efficiency become worse with lower inductance. Under light load condition, like below 100mA, larger inductance is recommended for improved efficiency. The inductance and its peak current could be calculated by:

$$L = \frac{V_{OUT}}{f_S \times \Delta I_L} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

$$I_{LP} = I_{LOAD} + \frac{\Delta I_L}{2} = I_{LOAD} + \frac{V_{OUT}}{2 \times f_S \times L} \cdot \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Which f_S is the switching frequency; I_{LOAD} is the load current.

Table2-Inductor Selection Guide

Model	ISAT (A)	DCR (mΩ)	Manufacture
PCM104T-100MS	8.5	27 (typ.)	CYNTEC

Selecting the Diode

The diode connected between SW and GND is the path for the inductor current during the high-side MOSFET turns off. Choose the diode with minimum forward voltage drop and recovery time, like Schottky. And, the reverse voltage rating is greater than maximum input voltage and whose current rating is greater than the maximum load current.

Table3-Diode Selection Guide

Diode	Voltage/Current Rating	Manufacture
SVM1045VB	45V, 10A	PANJIT

Selecting the Input capacitor

The input current to the step-down converter is discontinuous, therefore a capacitor is required to supply the AC current for step-down converter to maintain the DC input voltage. Use low ESR capacitor for the best performance. The high frequency impedance of the capacitor should be lower than the input source impedance for bypassing the high frequency switching current locally. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. To prevent excessive voltage ripple at input, the relationship between the input ripple and the capacitance could be estimated by:

$$\Delta V_{IN} = \frac{I_{LOAD}}{f_S \times C_{IN}} \times \frac{V_{OUT}}{V_{IN}} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

For 6A output applications, four 4.7uF ceramic capacitors are sufficient. For VIN<6V application, the recommended C_{IN} would be 22uF*4.

Selecting the Output capacitor

The output capacitor (C_O) is required to maintain the DC output voltage, keeps the output ripple small, and ensures regulation loop stability. The lower ESR capacitors are preferred to keep lower output ripple. The output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times \left(R_{ESR} + \frac{1}{8 \times f_S \times C_O}\right)$$

Which L is the inductance and R_{ESR} is the equivalent series resistance (ESR) of the output capacitor.

In case of lower ESR capacitor adopted, the output ripple is mainly caused by the capacitance and the output voltage ripple can be estimated by:

$$\Delta V_{OUT} = \frac{V_{OUT}}{8 \times f_S^{\,2} \times L \times C_O} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right)$$

Or, the ESR dominates the impedance at switching frequency. After simplification, the output voltage ripple can approximated to

$$\Delta V_{OUT} = \frac{V_{OUT}}{f_S \times L} \times \left(1 - \frac{V_{OUT}}{V_{IN}}\right) \times R_{ESR}$$

The characteristics of the output capacitor also affect the loop stability of regulation system. Low ESR ceramic capacitors with X5R or X7R dielectrics are recommended.

Compensation Components

The EML3420 employs current mode control for easy compensation and fast transient response. The system stability and transient response are controlled through the COMP pin. COMP pin is the output of the internal error amplifier. A series capacitor-resistor combination sets a pole-zero combination to control the characteristics of the control system. The DC gain of the voltage feedback loop is given by:

$$A_{VDC} = R_L \cdot G_{CS} \cdot A_{EA} \cdot \frac{V_{FB}}{V_O}$$

Where R_L is the load resistor value, G_{CS} is the current sensing transconductance and A_{EA} is the error amplifier gain. The system has two important poles. One is due to the compensation capacitor (C_{CMP}) and the output resistor (r_O) of error amplifier, and the other is due to the output capacitor (C_O) and the load resistor (R_L). These poles are located at:

$$f_{p1} = \frac{1}{2\pi \cdot C_{CMP} \cdot r_O} = \frac{G_{EA}}{2\pi \cdot C_{CMP} \cdot A_{VEA}}$$

$$f_{p2} = \frac{1}{2\pi \cdot C_O \cdot R_L}$$

Where, G_{EA} is the error amplifier transconductance.

The system has one important zero, due to the compensation capacitor (C_{CMP}) and the compensation resistor (R_{CMP}). The zero is located at:

$$f_{Z1} = \frac{1}{2\pi \cdot C_{CMP} \cdot R_{CMP}}$$

The system may have another important zero, if the output capacitor has a large capacitance with a high ESR value. The zero, due to the ESR and a capacitance of the output capacitor, is located at:

$$f_{ESR} = \frac{1}{2\pi \cdot C_O \cdot R_{ESR}}$$

In this case, a third pole set by the compensation capacitor (C_C) which is directly connected to COMP Pin between GND and the compensation resistor (R_{CMP}) is used to compensate the effect of the ESR zero(f_{ESR}) on the loop gain. This pole is located at:

$$f_{p3} = \frac{1}{2\pi \cdot C_C \cdot R_{CMP}}$$

To shape the converter transfer function for getting an adequate loop gain is the purpose of compensation design. The system open loop unity gain crossover frequency is important.

Lower crossover frequencies result in slower line and load transient responses, while higher crossover frequencies could system unstable. A good compromise is to set the crossover frequency to below one-tenth of the switching frequency. To optimize the compensation components, the following procedure can be used:

1. Choose the compensation resistor (R_{CMP}) to set the desired crossover frequency. Determine the R_{CMP} value by the following equation:

   $$R_{CMP} = \frac{2\pi \cdot C_O \cdot f_C}{G_{EA} \cdot G_{CS}} \cdot \frac{V_O}{V_{FB}}$$

   Where, f_C is the desired crossover frequency.

2. Choose the compensation capacitor (C_{CMP}) to get the desired phase margin. For applications with typical inductor values, setting the compensation zero, f_{Z1}, to below one-forth of the crossover frequency provides sufficient phase margin. Determine the C_{CMP} value by the following equation:

   $$C_{CMP} > \frac{4}{2\pi \cdot R_{CMP} \cdot f_C}$$

   Where, R_{CMP} is the compensation resistor value.

   To avoid the output voltage unstable due to the parasitic capacitor between the COMP pin and GND, the C_{CMP}>100pF is strongly recommended.

3. Determine if the second compensation capacitor (C_C) is required. It is required if the ESR zero of the output capacitor is located at less than half of the switching frequency, the following relationship is valid:

$$\frac{1}{2\pi \cdot C_O \cdot R_{ESR}} < \frac{f_S}{2}$$

If this is the case, then add the second compensation capacitor C_C to set the pole f_{P3} at the location of the ESR zero. Determine the C_C value in the following equation:

$$C_C > \frac{C_O \cdot R_{ESR}}{R_{CMP}}$$

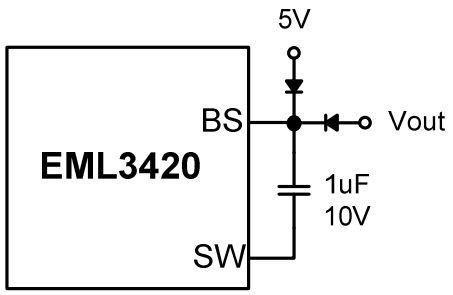
Table4-Components Selection Guide

Vout (V)	L (uH)	C_O (uF)	R_{CMP} (kΩ)	C_{CMP} (pF)	C_C (pF)
3.3	5~10	200	16.9	4700	100

4. The estimation is based on 15% of Iout current for this table. User can calculate it depend on peak-to-peak ripple current real requirement.

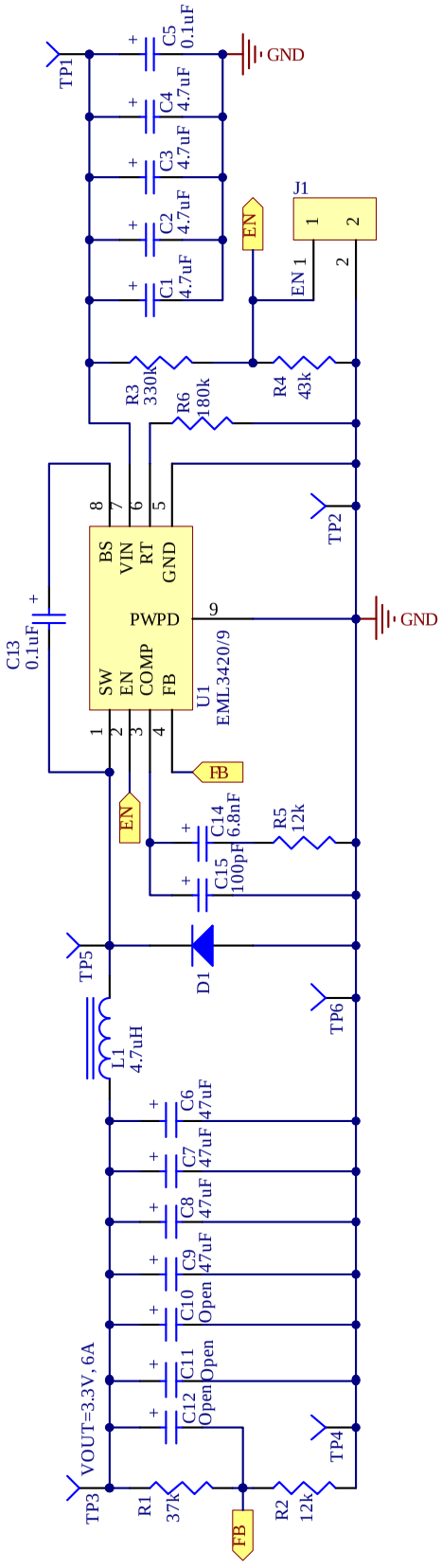
External Bootstrap Diode

An external bootstrap diode is recommended to add between external 5V and BS pin to enhance efficiency of the regulator. The external 5V can be a 5V fixed input from system or a 5V output of the EML3420. The low cost diode, like 1N4148, is sufficient. With such diode, 5V input voltage can output 3.3V and 2.5V with just 30mA load.

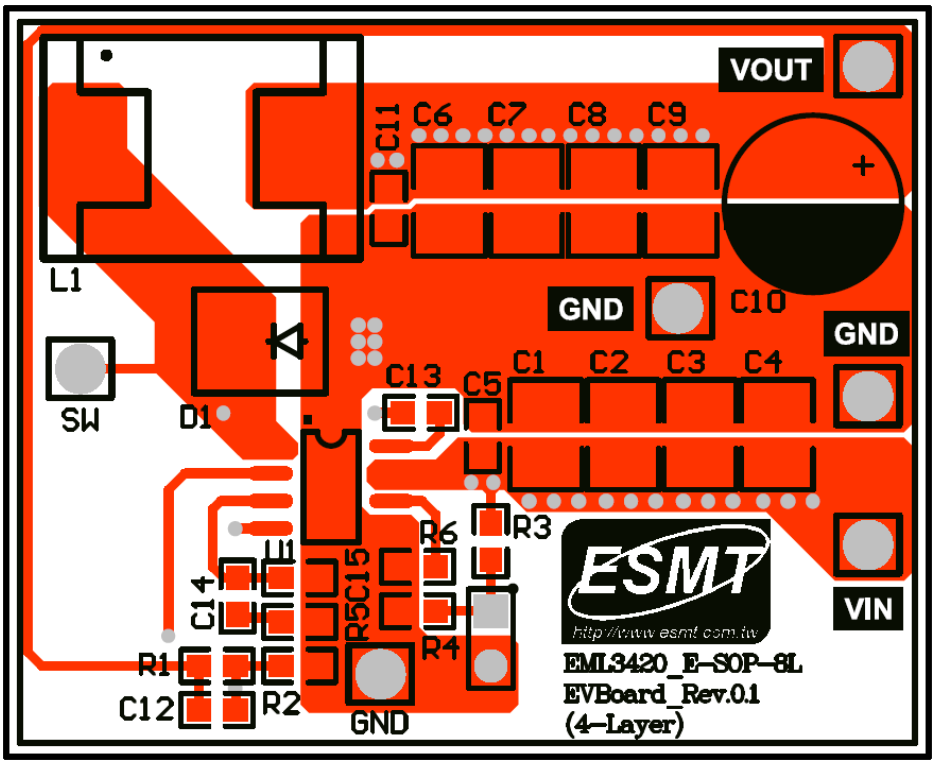


Applications

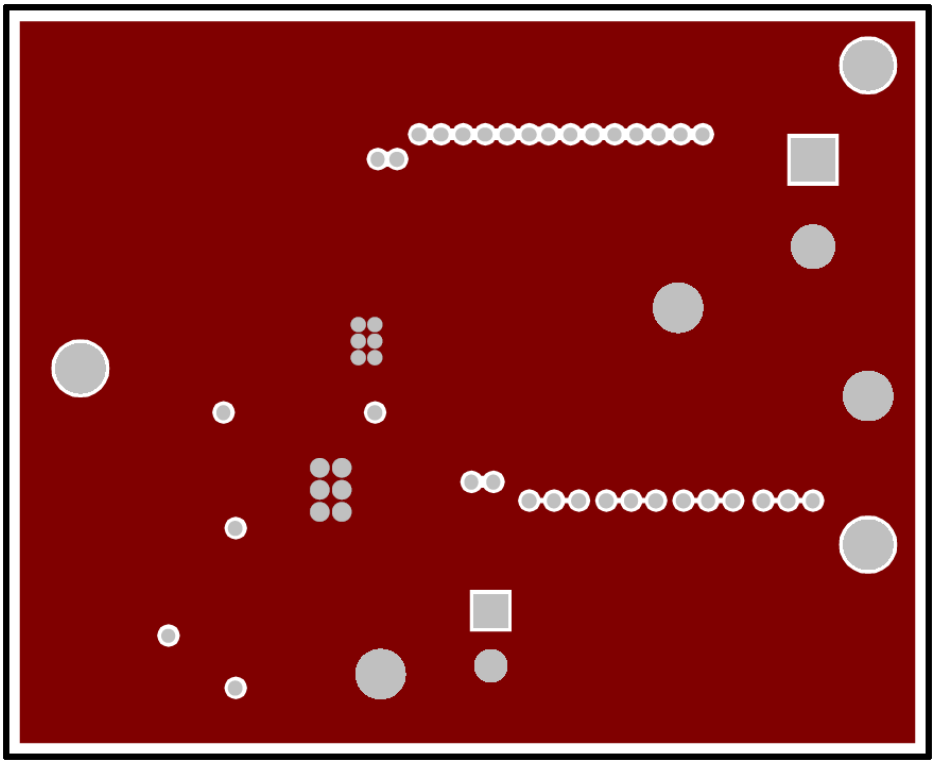
Typical schematic for PCB layout



Typical schematic for PCB layout (cont.)

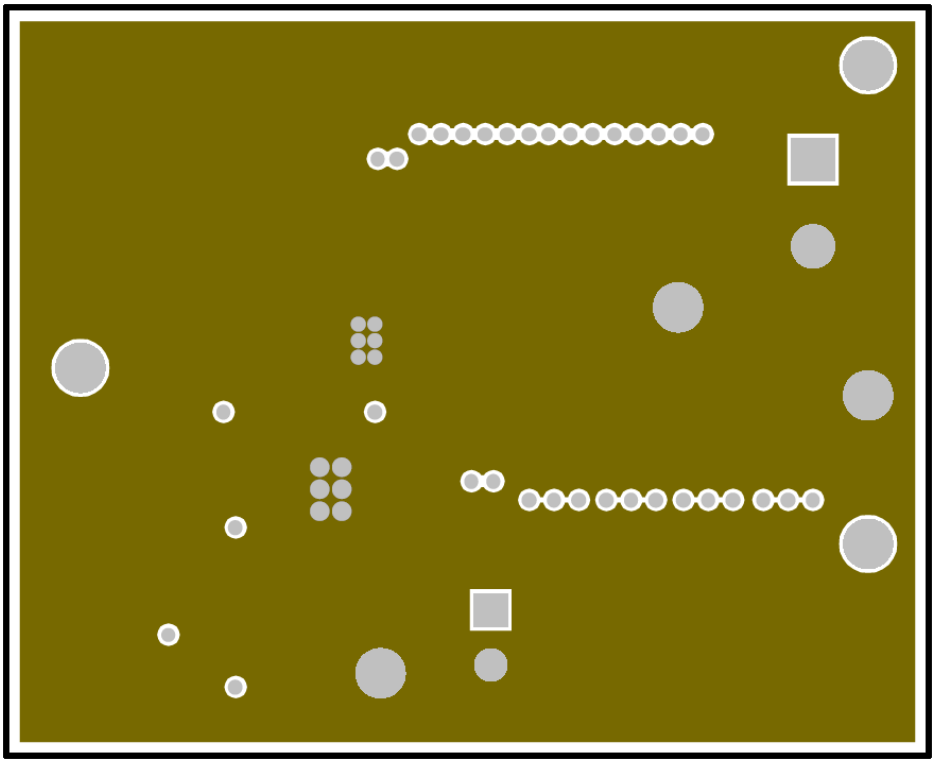


Top-Side Layout

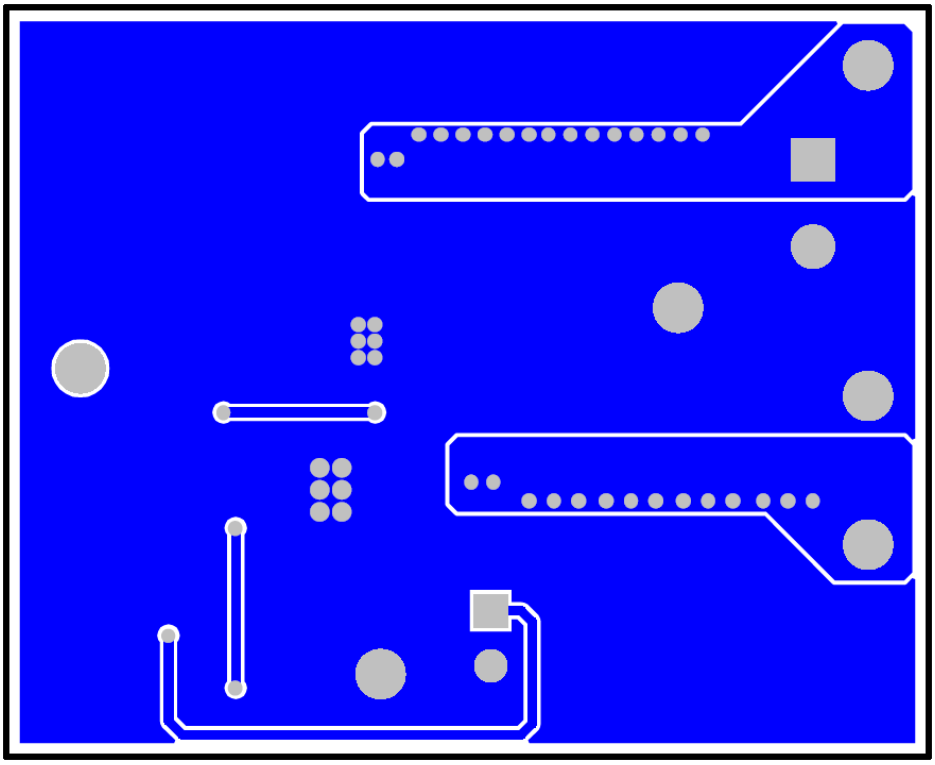


Layer 2 Layout

Typical schematic for PCB layout (cont.)

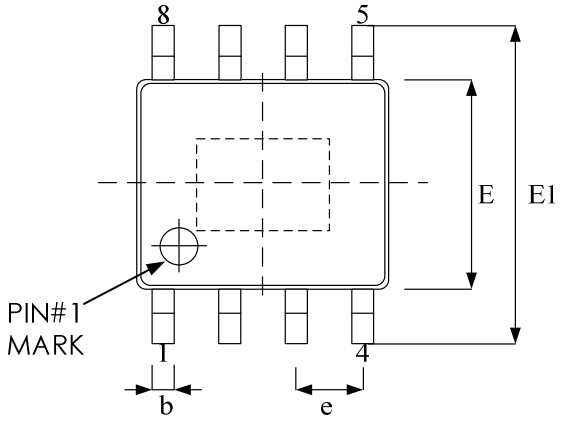


Layer 3 Layout

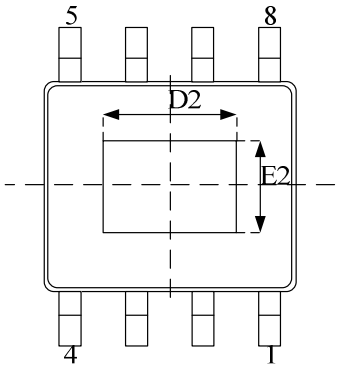


Bottom-Side Layout

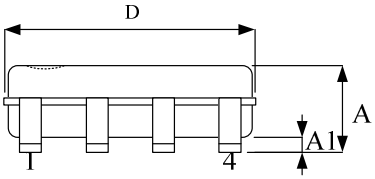
Package Outline Drawing
E-SOP-8L (150 mil)



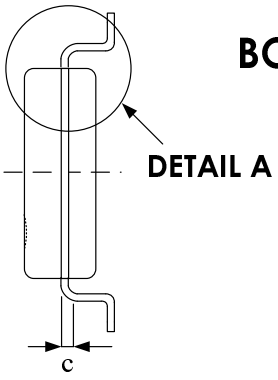
TOP VIEW

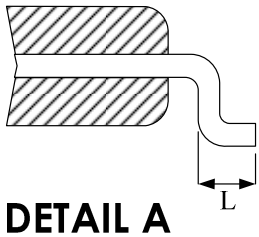


BOTTOM VIEW



SIDE VIEW





DETAIL A

Symbol	Dimension in mm	
	Min	Max
A	-	1.70
A1	0.00	0.15
b	0.31	0.51
c	0.10	0.25
D	4.80	5.00
E	3.81	4.00
E1	5.79	6.20
e	1.27 BSC	
L	0.40	1.27

Exposed pad

	Dimension in mm	
	Min	Max
D2	2.80	3.50
E2	2.00	2.60

Revision History

Revision	Date	Description
0.1	2017.10.12	Initial version.
1.0	2018.01.09	1. Add the description low dropout operation in the 'Detailed Description'. 2. Remove the word of preliminary.
1.1	2019.05.27	Modify functional block diagram.
1.2	2020.09.09	1.Delete I_{LIM} max value 2.Modify Oscillation Frequency specification
1.3	2021.07.13	Modify E-SOP-8 Dimension
1.4	2021.12.15	Modify frequency formula
1.5	2022.03.25	Modify bootstrap capacitor
1.6	2022.06.16	Add SW transient AMR spec

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