18V 3A, COT, Synchronous Step-Down DC/DC Converter

General Description

EML3470 is a high efficiency step down DC/DC converter. It features very fast transient response, and excellent line and load regulation via constant on time (COT) control architecture. The device can accept input voltage from 4.5V to 18V and deliver up to 3A output current. Furthermore, the built-in synchronous switch improves efficiency and eliminates external schottky diode. The EML3470 uses pulse skip modulation (PSM) for improving light load efficiency, the adjustable version of this device is available in TSOT-23-6 package.

Features

- Achieve 92% efficiency
- Input voltage : 4.5V to 18V
- Output current up to 3A
- Constant On Time (COT) operation
- Cycle by cycle over current protection
- Adjust output voltage
- No schottky diode needed
- Shutdown current <4uA
- Excellent line and load transient response
- Over-temperature protection
- Short circuit protection
- Available in TSOT-23-6 package
- ROHS compliant

Applications

- Set Top Box
- AP Router
- LCD TV
- Wireless Networking

Typical Application

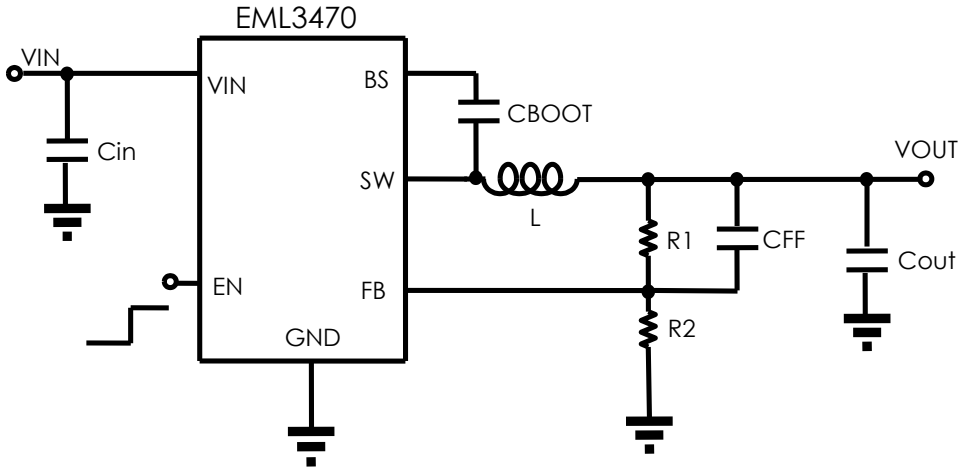
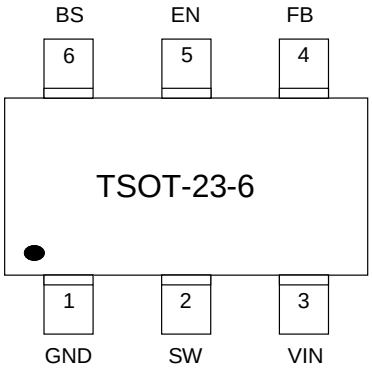


Fig. 1

Package Configuration

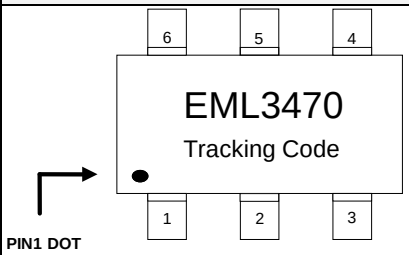


TSOT-23-6

EML3470-00VU06NRR

00	Adjustable
VU06	TSOT-23-6 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
TSOT-23-6	adjustable	EML3470-00VU06NRR		Tape & Reel 3K units

Pin Functions

Pin Name	TSOT-23-6	Function
GND	**1**	Ground Pin.
SW	**2**	Switch Pin. Must be connected to Inductor. This pin connects to the drains of the internal main and synchronous power MOSFET switches.
VIN	**3**	Power Input Pin. Must be closely decoupled to GND pin with a 4.7μF or greater ceramic capacitor.
FB	**4**	Feedback Pin. Receives the feedback voltage from an external resistive divider across the output.
EN	**5**	Enable Pin. Minimum 1.6V to enable the device. Maximum 0.6V to shut down the device. Don't allow it floating.
BS	**6**	Boot-strap Pin. This is the positive power supply for the internal floating high-side MOSFET driver. Connect a bypass capacitor (0.1uF) between BS and SW pin.

Absolute Maximum Ratings

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

Input Voltage ---------- – 0.3V to 20V
VFB Voltages ---------- – 0.3V to 6
SW Voltage ---------- – 0.3V to (V_{IN} + 0.3V)
Switch Voltage (SW, 10ns transient) –3.5V to Vin+0.3V
Boost Voltage (BS) ---------- VSW-0.3V to SW+6V
Enable Voltage (EN) ---------- – 0.3V to Vin
Lead Temperature (Soldering, 10 sec) ---------- 260°C

Ambient Operating Temperature Range –40°C to 85°C
Junction Temperature (Notes 1, 3) ---------- 150°C
Storage Temperature Range -------- – 65°C to 150°C
ESD Susceptibility HBM ---------- 2KV
CDM ---------- 750V

Recommend Operation Condition

Input Supply Voltage VIN..... 4.5~18V

Output Voltage VOUT..... <6.5V

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

Thermal data

Package	Thermal resistance	Parameter	Value
TSOT-23-6	θ_{JA} (Note 4)	Junction-ambient	92.6°C/W
	θ_{JC} (Note 5)	Junction-case	48.5°C/W

Note 1: T_J is a function of the ambient temperature T_A and power dissipation P_D ($T_J = T_A + (P_D) * (92.6°C/W)$).

Note 2: Dynamic quiescent current is higher due to the gate charge being delivered at the switching frequency.

Note 3: This IC has a built-in over-temperature protection to avoid damage from overloaded conditions.

Note 4: θ_{JA} is measured in the natural convection at T_A=25℃ on a highly effective thermal conductivity test board according to the JEDEC 51-7 thermal measurement standard.

Note 5: θ_{JC} represents the heat resistance between the chip and the package top case.

Electrical Characteristics

V_{IN} = 12V, T_A = 25°C, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
V_{IN}	Input Voltage Range		4.5		18	V
I_{VFB}	Feedback Current				±100	nA
V_{FB}	Regulated Feedback Voltage		755	770	785	mV
I_Q	No switching Quiescent Current	V_{FB}=0.85V		370	580	uA
I_{SD}	Shutdown Current	V_{EN}=0V		1	4	uA
RON	$R_{DS(ON)}$ of Highside	VBST-SW=5V		100		mΩ
RON	$R_{DS(ON)}$ of Lowside			55		mΩ
V_{UVLO}	VIN UVLO Threshold	VIN Raise		3.8		V
$V_{UVLO(Hys)}$	UVLO Hysteresis	Hysteresis VIN		320		mV
IOCL	Inductor Current (Note 6)	V_{FB}=0.5V	3.1	4.3		A
Fsw	Switching Frequency	VIN=12V, VOUT=5V		600		KHz
V_{EN}	Enable Threshold	V_{EN}	1.6			V
	Shutdown Threshold	V_{EN}			0.6	V
I_{EN}	EN Input Current	V_{EN} =2V		2	10	uA
T_{SD}	Thermal Shutdown			155		℃
	Thermal Shutdown Hysteresis			35		℃
VOV	OVP detect (Note 6)	VFB		125%		V
VUV	UVP detect (Note 6)	VFB		55%		V
DMAX	Max duty cyle			70		%
Ton	Min on time (Note 6)			135		nS
Toff	Minimum off Time			280		nS
TSS	Soft-Start Time			1		mS

Note 6: Design guaranteed.

Function Block Diagram

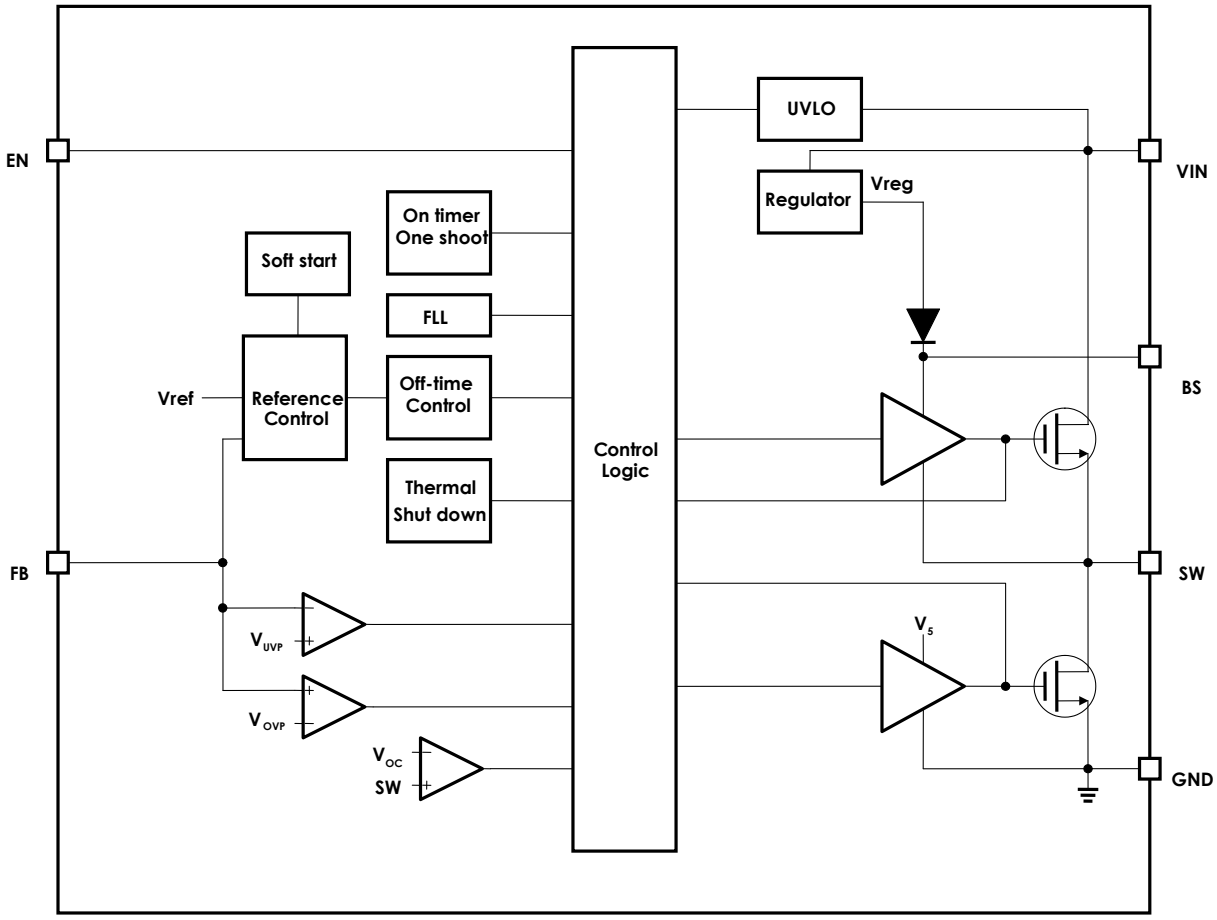
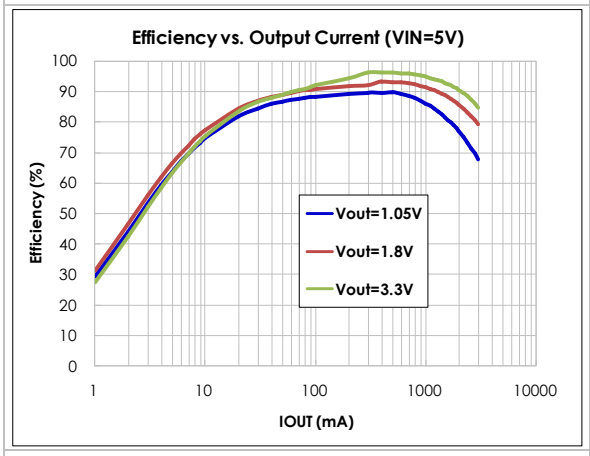


Fig.2 Function Block Diagram of EML3470

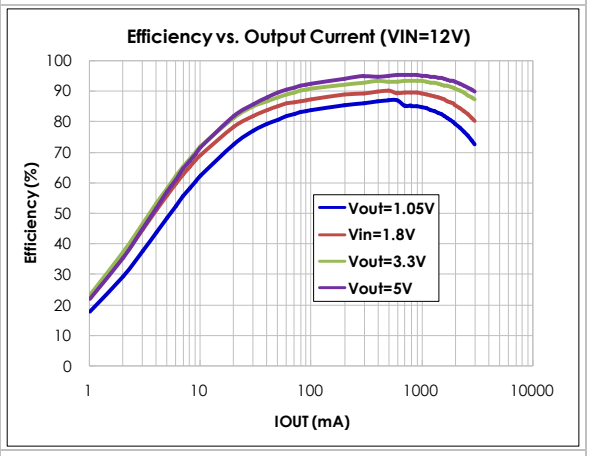
Typical Performance Characteristics

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

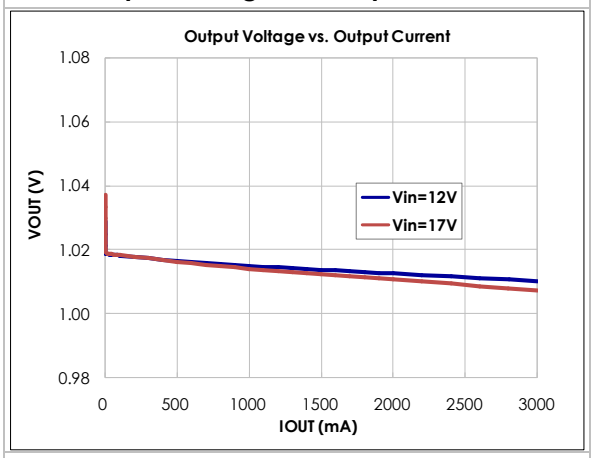
Efficiency vs. Output Current (VIN=5V)



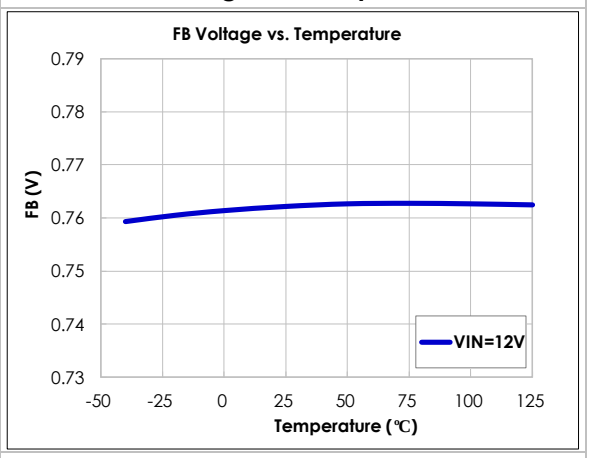
Efficiency vs. Output Current (VIN=12V)



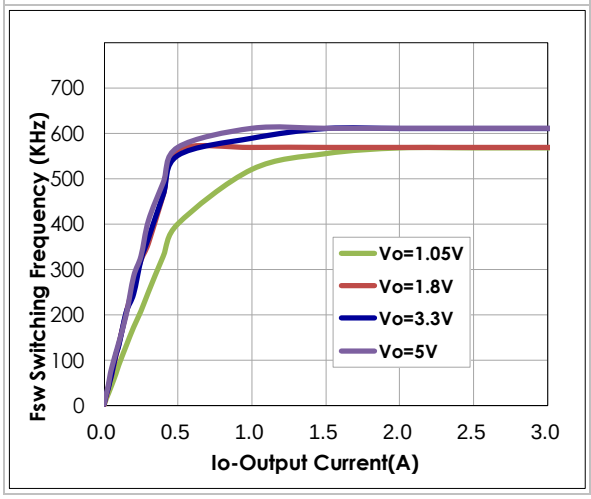
Output Voltage vs. Output Current



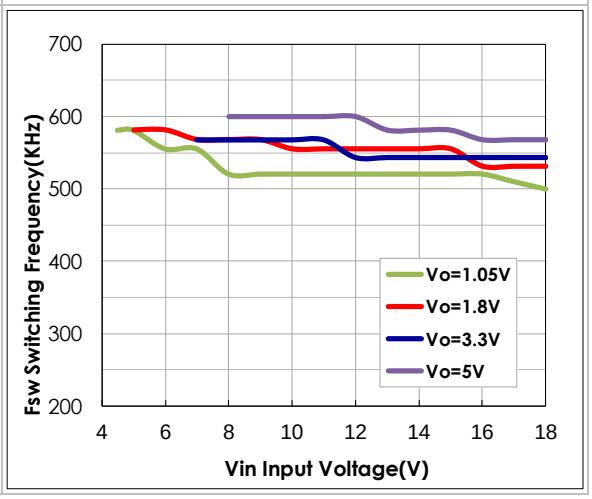
FB Voltage vs. Temperature



Fsw vs. Output Current



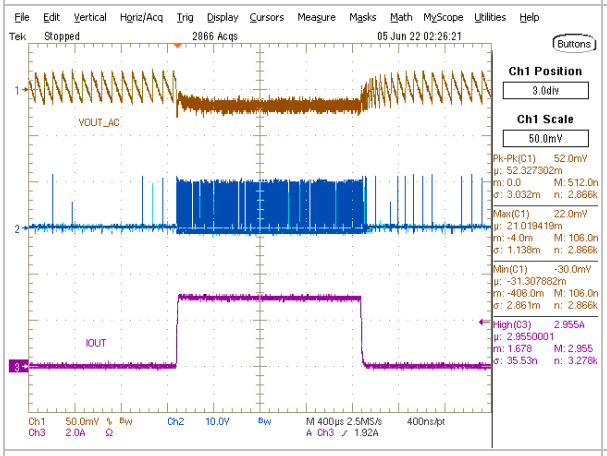
Fsw vs. Input Voltage



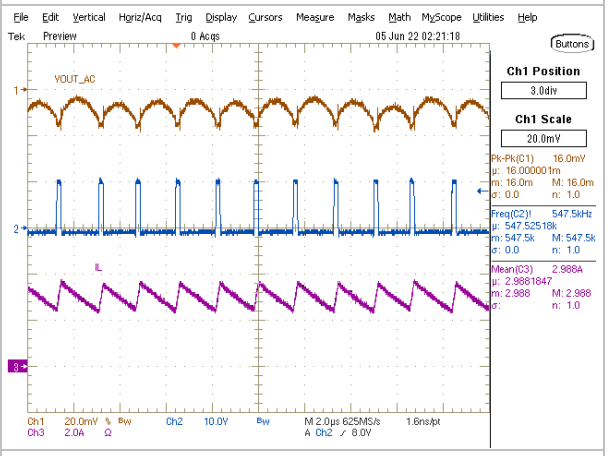
Typical Performance Characteristics (cont.)

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

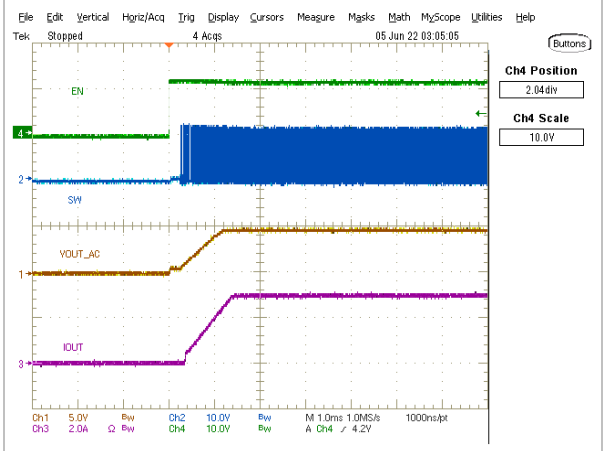
Load Transient (10mA to 3A)



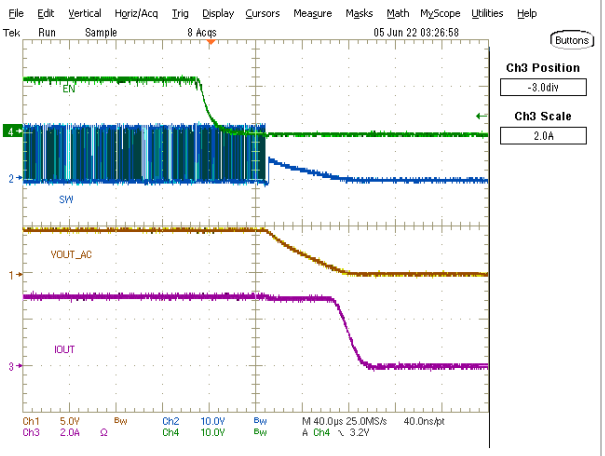
Output Ripple Voltage (Vo=1.05V, Io=3A)



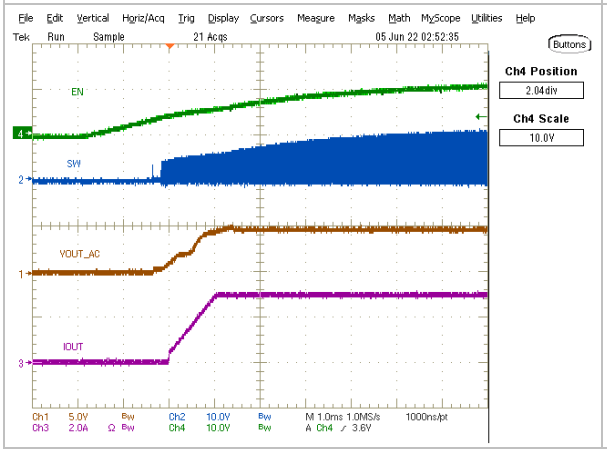
Power On from EN



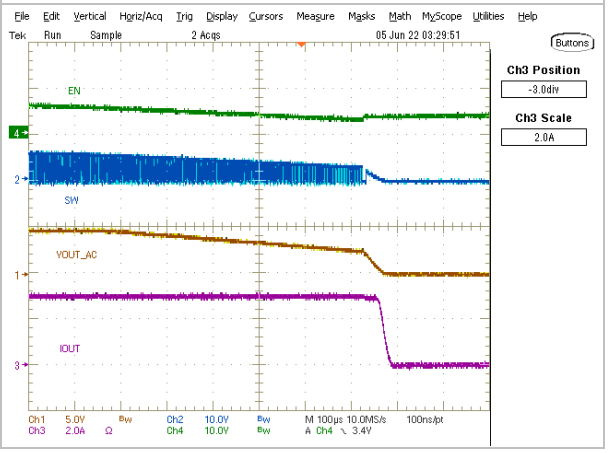
Power Off from EN



Power On from VIN



Power Off from VIN



Functional Description

Detailed Descriptions

The EML3470 is a Constant On Time (COT) operation buck converter with an integrated high and low side switch. The device operates with input voltages from 4.5V to 18V. The constant on time control with an internal compensation circuit for pseudo-fixed frequency, it supports with low-ESR output ceramic capacitors.

At the beginning of each cycle, the high-side MOSFET is turned on. This MOSFET is turned off after internal oneshot timer expires. This one shot duration is set proportional to the converter input voltage, VIN, and inverselyproportional to the output voltage, VO, to maintain a pseudo-fixed frequency over the input voltage range, hence it is called adaptive on-time control. The one-shot timer is reset and the high-side MOSFET is turned onagain when the feedback voltage falls below the reference voltage.

EML3470 with adaptive on-time control, which can reduce the output capacitance and provide ultrafast transient responses, and allow minimal component sizes without any additional external compensation network.

Enable Control

Enable input control to turn on/off device, don't allow it floating. When EN pin voltage was exceeded threshold voltage to enable the device. If EN pin voltage is lower than the shutdown threshold voltage, the device will be disable.

Over-Temperature Protection (OTP)

OTP limits the total power dissipation in the device. When the junction temperature exceeds 155˚C, the internal thermal sensor will shuts down the whole chip directly. Once the junction temperature drops below 120°C, OTP is deactivated and EML3470 turns to normal operation.

Output Over-Voltage Protection (OVP)

Once the FB pin voltage of EML3470 is over (~1.25 times of VFB), the high-side switch would be turned off and the low-side switch would be turned on immediately. When inductor current is down to around zero current, the low-side switch would be turned off.

Input Under Voltage Lock-out (UVLO)

UVLO is implemented to protect the chip from operating at insufficient supply voltage. When VIN exceed the input threshold voltage, the internal circuit and driver are active. When Vin below the input UVLO threshold voltage, the driver will be disable. The UVLO falling threshold is about 3.5V, and rising threshold is about 3.8V.

Boost Capacitor

Connect a 0.1uF capacitor between the BS and SW. This capacitor provides the gate driver voltage for thehigh-side MOSFET. In addition, 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 2.3V while its hysteresis is about 0.15V.

Over-Current protection (OCP)

Over-current limitation is implemented by sensing the current across the low-side MOSFET. If the monitored current is above the OCL level, the converter maintains low-side FET on and delays the creation of a new set pulse, even the voltage feedback loop requires one, until the current level becomes OCL level or lower the new switching cycle will be start.

Output Under-Voltage Protection and Short circuit protection (Hiccup mode)

The EML3470 includes output under-voltage protection (UVP) against over-load or short-circuited condition by constantly monitoring the feedback voltage VFB. If VFB drops below the under-voltage protection trip threshold (typically 55% of the internal feedback reference voltage), the UV comparator will go high to turn off both the internal high-side and low-side MOSFET switches. If the output under-voltage condition continues for a period of time, the EML3470 will enter short circuit protection with hiccup mode. During hiccup mode, the drive will shut down for HICCUP_OFF (8ms), and then attempt to recover automatically for driver on (2.7ms).

Applications

Inductor Selection

Inductor ripple current and core saturation current are the two main factors that decide the Inductor value. A low DCR inductor is preferred.

C_{IN} and C_{OUT} Selection

A low ESR input capacitor can prevent large voltage transients at V_{IN}. The RMS current of input capacitor is required larger than I_{RMS} calculated by:

$$I_{RMS} \cong I_{OMAX} \frac{\sqrt{V_{OUT}(V_{IN} - V_{OUT})}}{V_{IN}} \quad \text{Eq. 1}$$

ESR is an important parameter to select C_{OUT}, which can be seen in the following output ripple V_{OUT} equation:

$$\Delta V_{OUT} \cong \Delta I_L \left(ESR + \frac{1}{8 \cdot f \cdot C_{OUT}} \right) \quad \text{Eq. 2}$$

Cheaper and smaller ceramic capacitors with higher capacitance values are now commercially available. These ceramic capacitors have low ripple currents, high voltage ratings and low ESR which make them suitable for switching regulator applications. It is feasible to optimize very low output ripples by Cout since Cout does not affect the internal control loop stability. X5R or X7R types are recommended since they have the best temperature and voltage characteristics of all ceramics capacitors.

Output Voltage

In the adjustable version, the output voltage can be determined by:

$$V_{OUT} = 0.77\,V \left(1 + \frac{R_1}{R_2} \right) \quad \text{Eq. 3}$$

Thermal Considerations

Although the thermal shutdown circuit is designed in EML3470 to protect the device from thermal damage, the total power dissipation that EML3470 can sustain depends on the thermal capability of the package. The formula to ensure the safe operation is shown in note 1 on page 3.

To avoid the EML3470 from exceeding the maximum junction temperature, the user should perform some thermal analysis during PCB design.

Guidelines for PCB Layout

To ensure proper operation of the EML3470, please note the following PCB layout guidelines:

1. The GND, SW and the VIN trace should be kept short, direct and wide.
2. VFB pin must be connected directly to the feedback resistors. Resistive divider R1/R1 must be connected parallel to the output capacitor C_{OUT}.
3. The Input capacitor C_{IN} must be connected to the pin VIN as close as possible.
4. Keep SW node away from the sensitive VFB node since this node has high frequency and voltage swing.
5. Keep the (–) plates of C_{IN} and C_{OUT} as close as possible.

Applications

Typical schematic for PCB layout

PCB Layout hints:
The R1, R2 and C5 should as close to FB pin as possible to avoid noise coupling.

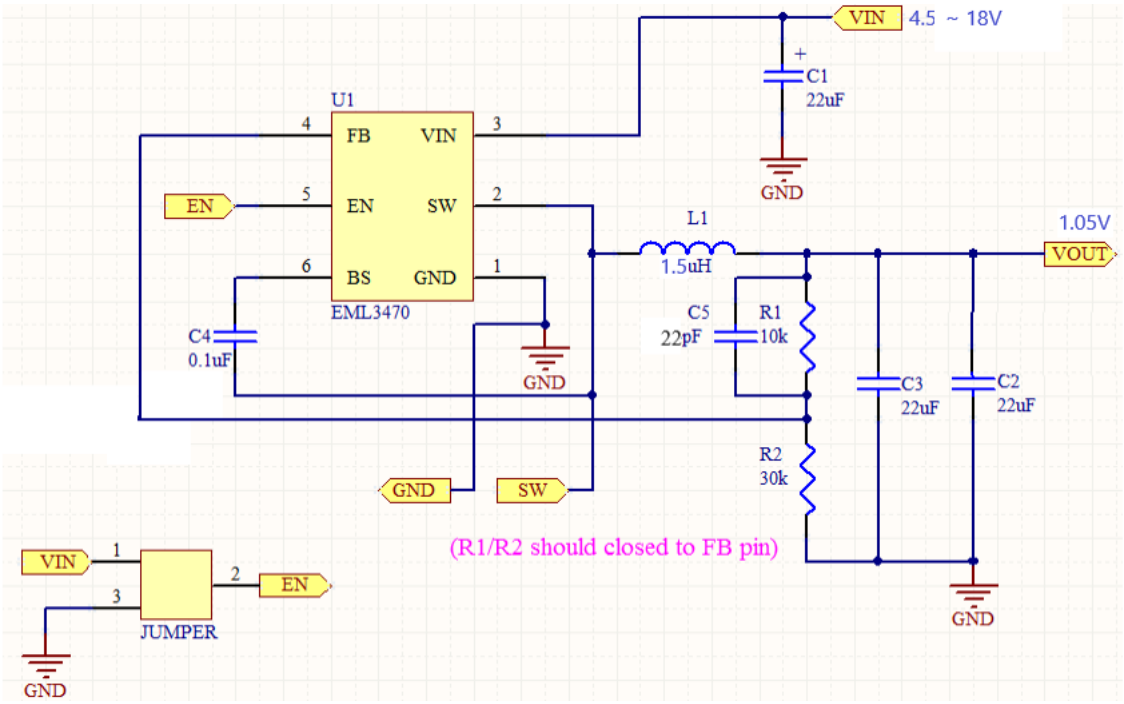
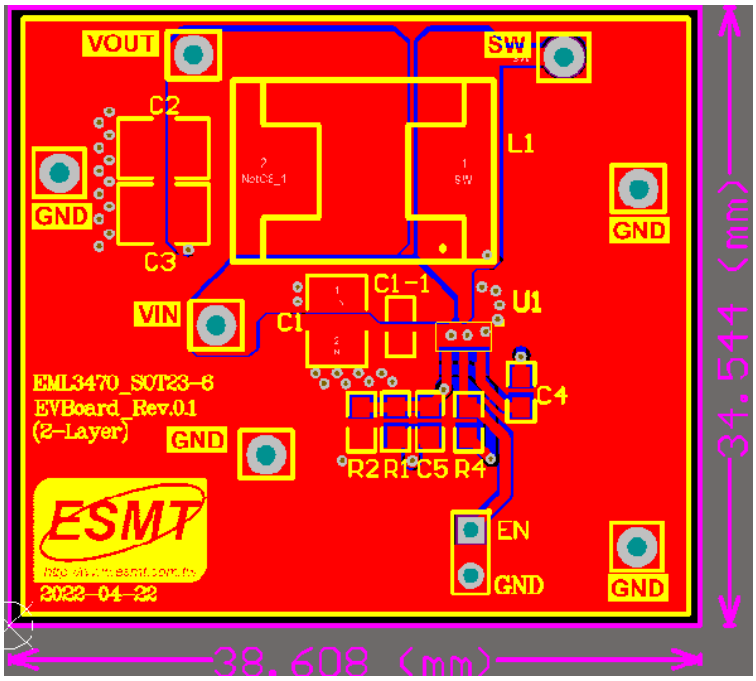


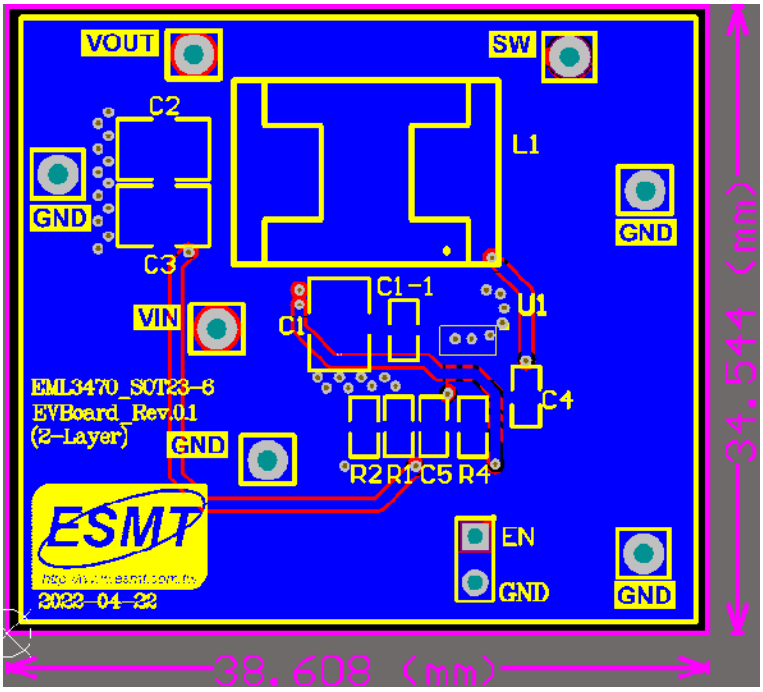
Table 1. Suggested Component Values (VIN= 12V)

VOUT (V)	R1 (kΩ)	R2 (kΩ)	L (uH)	COUT (uF)	CFF (pF)
1.05	10	30	1.5	22x2	22
1.2	15	30	2.2	22x2	22
1.8	39	30	3.3	22x2	22
2.5	68	30	3.3	22x2	22
3.3	20	6.2	3.3	22x2	22
5	30	5.6	4.7	22x2	22

Typical schematic for PCB layout (cont.)

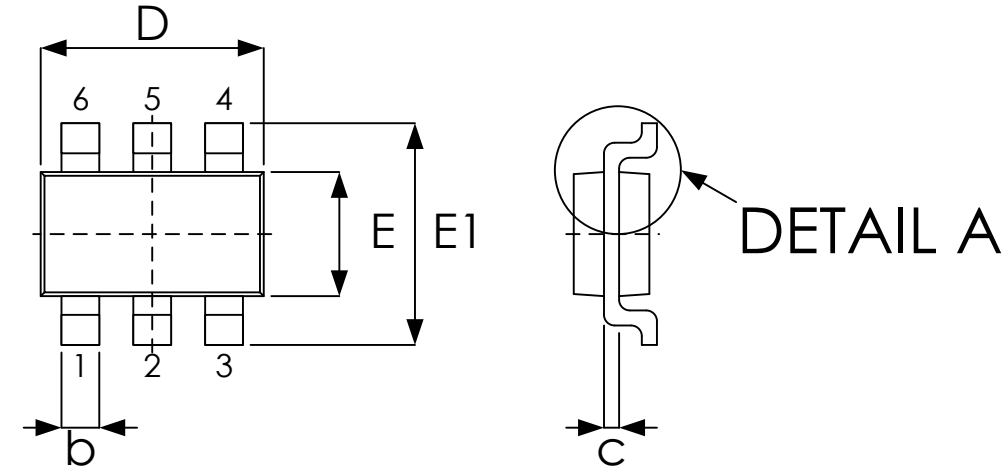


Top Layer

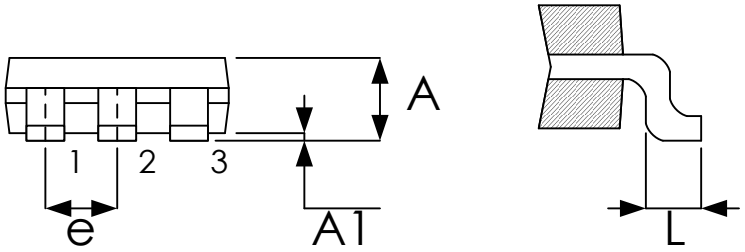


Bottom Layer

Package Outline Drawing
TSOT-23-6



TOP VIEW



SIDE VIEW **DETAIL A**

Symbol	Dimension in mm	
	Min.	Max.
A	0.70	1.10
A1	0.00	0.15
b	0.30	0.50
c	0.08	0.25
D	2.70	3.10
E	1.40	1.80
E1	2.60	3.00
e	0.95 BSC	
L	0.30	0.60

Revision History

Revision	Date	Description
0.1	2022.06.17	Initial version.
1.0	2022.12.23	Reomve “Preliminary”
1.1	2023.02.24	Updated operating voltage 4.5~17V to 4.5~18V. (Page1, 3, 4, 8)

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