

## General Description

The EMT3571 is a high efficiency, 3A current mode synchronous step-down DC/DC converter with a wide input voltage range from 4.7V to 18V. The device integrates high side and low side MOSFETs to achieve high efficiency conversion. The current mode architecture supports fast transient response and internal compensation. The EMT3571 provides complete fault protection including input under voltage lockout, output short circuit protection, over current protection, and thermal shutdown. The switching frequency is internally set at 500kHz. EMT3571N and EMT3571A have different operation modes:

- EMT3571N is automatic PSM/PWM mode
- EMT3571A is Forced PWM mode

To improve the light load efficiency, EMT3571N has proprietary light load power saving mode (PSM) to minimize the switching loss by reducing the switching frequency. The EMT3571 is available in the SOT23\_6L.

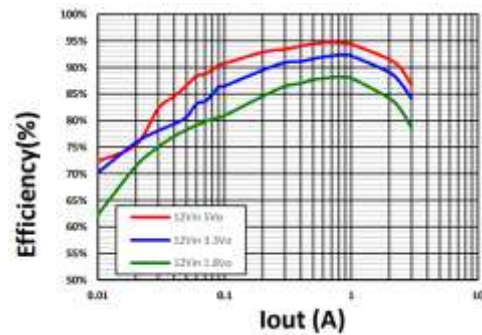
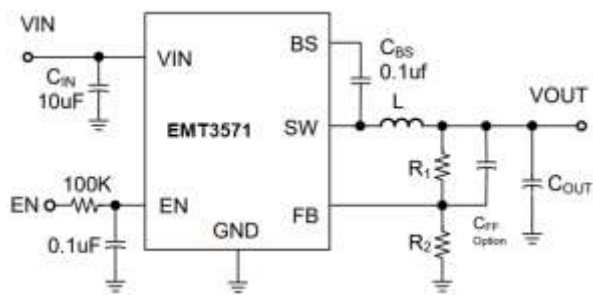
## Features

- Input Voltage Range from 4.7V to 18V
- Adjustable Output Voltage from 0.8V to 12V
- Support 100% Duty Cycle Operation
- 500kHz Switching Frequency
- Built-in 110mΩ/60mΩ Power Switch
- 3A Continuous Output Current
- High Efficiency up to 95%
- Internal 1msec Soft-Start
- Peak Current Mode Operation
- Over-temperature Protection
- Input Under Voltage Lockout (UVLO)
- Cycle-by-Cycle Current Limit Protection
- Over-Load and Short Circuit Protection
- Thermal Shutdown Protection
- Available in a Small SOT23\_6L Package
- Pb-Free RoHS Compliant

## Applications

- Wireless and DSL Card
- Portable/Handheld Device
- STB, TV, Sound Bar, MP3 Player
- Microprocessor and DSP Core Supply

## Typical Application Circuit



## Ordering Information

**EMT3571 □ □ GR**

R = Tape & Rail

G = Green

B1 = SOT23-6L

N = automatic PSM/PWM mode

A = Forced PWM mode

| Part No.     | Marking        | Temp. Range  | Remark       | Package   | MOQ              |
|--------------|----------------|--------------|--------------|-----------|------------------|
| EMT3571NB1GR | 3571<br>YWWxx  | -40°C ~+85°C | PFM/PWM mode | SOT23_6L  | 3000/Tape & Reel |
| EMT3571AB1GR | 3571A<br>YWWxx | -40°C ~+85°C | FPWM mode    | TSOT23_6L | 3000/Tape & Reel |

### Note:

Y= Year, WW = Week, xx = Manufacture Control Code

## Pin Configuration



TOP VIEW

## Pin Description

| Pin No.<br>SOT23_6L | Pin No.<br>CPC8_6L | Symbol | Description   |
|---------------------|--------------------|--------|---|
| 1                   | 5                  | GND    | Ground<br>This is the reference of the ground connection for all components in the power supply.  |
| 2                   | 3                  | SW     | Power Switches Node   |
| 3                   | 6                  | VIN    | Main Input Supply Voltage   |
| 4                   | 1                  | FB     | Voltage Feedback  |
| 5                   | 2                  | EN     | Regulator Enable Control Input. There is an internal 1000kΩ from EN to GND.<br>• Drive EN High Level to turn on the converter<br>• Drive EN Low Level to turn off the converter |
| 6                   | 4                  | BS     | Supply input for the high-side FET gate drive circuit.<br>Connect a 0.1uF ceramic capacitor between BS and SW pins.   |

## Absolute Maximum Rating (Reference to GND) (Note1)

|  |       |                 |
|--|-------|-----------------|
| VIN, SW Voltage                          | ----- | +20V            |
| Dynamic V <sub>SW</sub> in 10ns Duration | ----- | -3V to VIN+3V   |
| BS-SW Voltage                            | ----- | +6V             |
| FB, EN Voltage                           | ----- | +6V             |
| Junction Temperature Range               | ----- | -40°C to +150°C |
| Storage Temperature Range                | ----- | -65°C to +150°C |
| Lead Temperature (Soldering 10s)         | ----- | +260°C          |
| ESD Classification                       | ----- | Class           |

## Recommend Operating Conditions (Note2)

|                             |       |                  |
|-----------------------------|-------|------------------|
| Input Voltage (VIN)         | ----- | + 4.7V V to +18V |
| Operating Temperature Range | ----- | -40°C to +85°C   |

## Thermal information (Note3)

|  |                             |
|--|-----------------------------|
| Maximum Power Dissipation( $T_A=+25^{\circ}\text{C}$ ) |                             |
| SOT23_6L   | .1.25W                      |
| Thermal Resistance ( $\theta_{JA}$ )                   | 136.68 $^{\circ}\text{C/W}$ |
| Thermal Resistance ( $\theta_{JC}$ )                   | 81.68 $^{\circ}\text{C/W}$  |
| Thermal Resistance ( $\theta_{JA}$ )                   | 94.4 $^{\circ}\text{C/W}$   |
| Thermal Resistance ( $\theta_{JC}$ )                   | 47.6 $^{\circ}\text{C/W}$   |

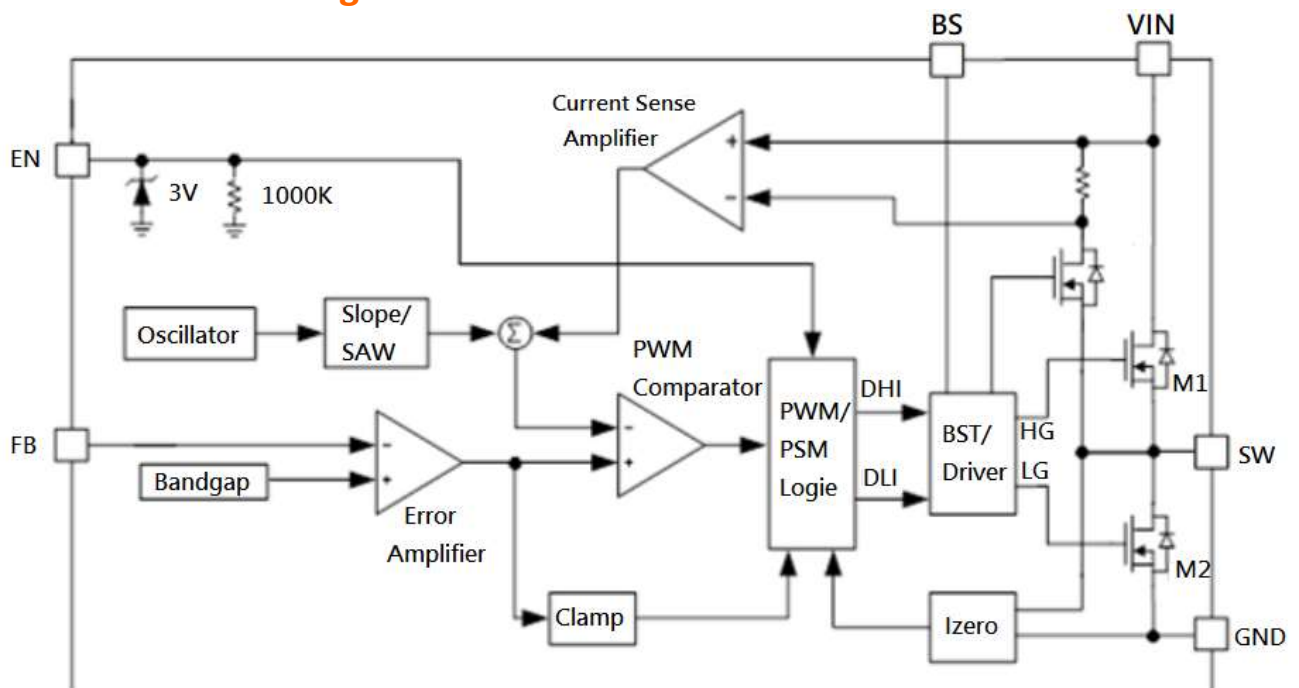
Note (1): Stress exceeding those listed “Absolute Maximum Ratings” may damage the device.

Note (2): The device is not guaranteed to function outside of the recommended operating conditions.

Note (3): Measured on JESD51-7, 4-Layer PCB.

Note (4): The maximum allowable power dissipation is a function of the maximum junction temperature  $T_{J\_MAX}$ , the junction to ambient thermal resistance  $\theta_{JA}$ , and the ambient temperature  $T_A$ . The maximum allowable continuous power dissipation at any ambient temperature is calculated by  $P_{D\_MAX} = (T_{J\_MAX} - T_A) / \theta_{JA}$ . Exceeding the maximum allowable power dissipation will cause excessive die temperature, and the regulator will go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.

## Functional Block Diagram



## Electrical Characteristics

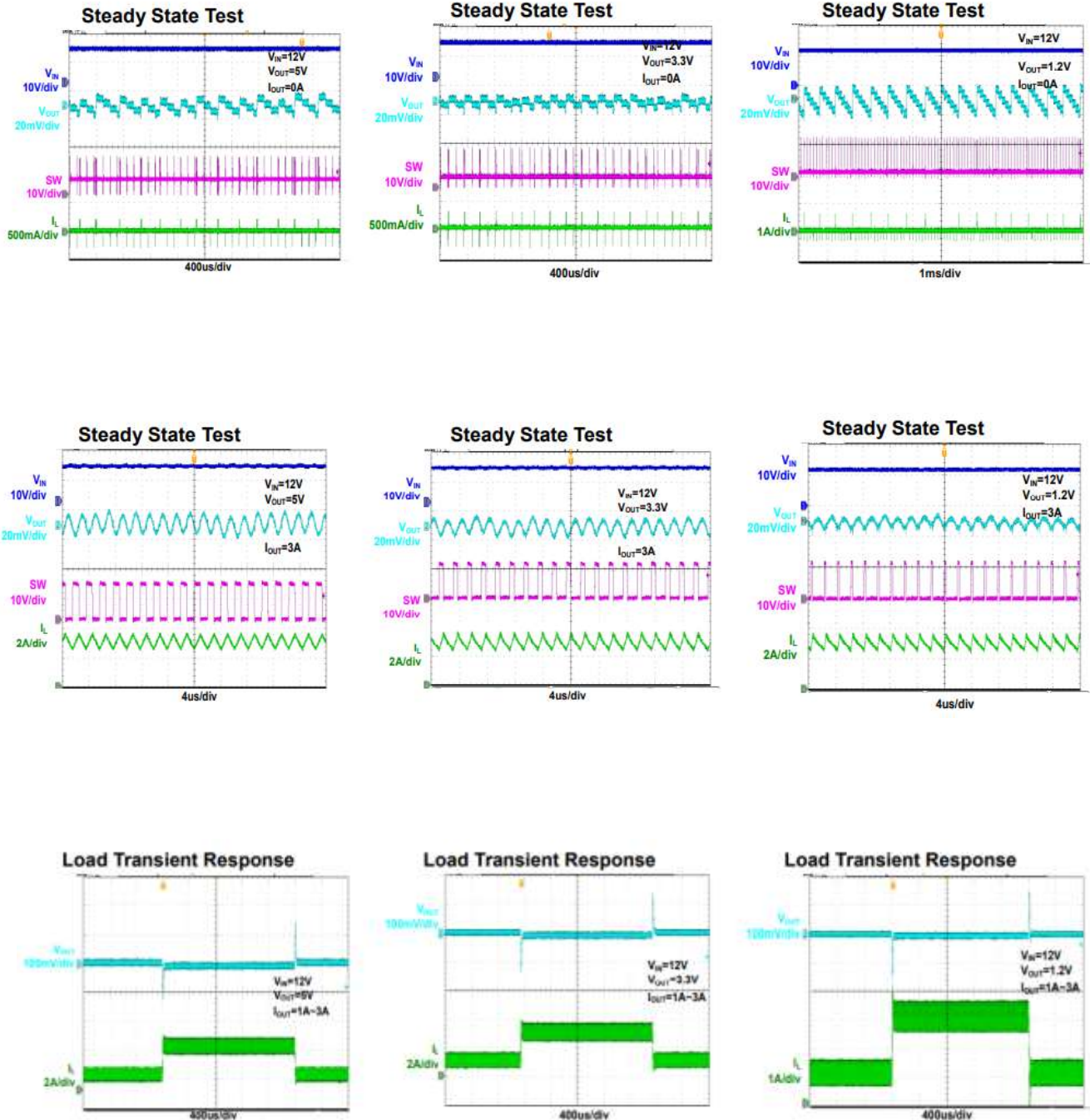
Recommended Operating Conditions,  $T_A = +25^{\circ}\text{C}$ ,  $V_{IN}=12\text{V}$ , unless otherwise noted.

| PARAMETER                              | TEST CONDITIONS                           | MIN  | TYP  | MAX  | UNIT               |
|--|---|------|------|------|--------------------|
| Input Supply Voltage                   |   | 4.7  |      | 18   | V                  |
| Shutdown Current                       | $V_{EN} = 0\text{V}$                      |      | 0.1  | 5    | $\mu\text{A}$      |
| Regulated Feedback Voltage $V_{REF}$   | $4.7\text{V} \leq V_{IN} \leq 18\text{V}$ | 0.78 | 0.80 | 0.82 | V                  |
| VIN Under Voltage Lockout Threshold    | Rising Threshold                          |      | 4.4  |      | V                  |
| Input Under Voltage Lockout Hysteresis |   |      | 310  |      | mV                 |
| High Side MOSFET On Resistance         | $I_{SW}=0.2\text{A}$                      |      | 110  |      | m $\Omega$         |
| Low Side MOSFET On Resistance          | $I_{SW}=0.2\text{A}$                      |      | 60   |      | m $\Omega$         |
| Switch Current Limit                   |   |      | 5.1  |      | A                  |
| SW Leakage Current                     | $V_{EN}=0\text{V}$ , $V_{SW}=0\text{V}$   |      | 1    | 10   | $\mu\text{A}$      |
| Oscillator Frequency                   |   | 400  | 500  | 600  | kHz                |
| Short Circuit Oscillator Frequency     | $V_{FB}=0\text{V}$                        |      | 160  |      | kHz                |
| Min. On-Time for HS Switch             |   |      | 120  |      | ns                 |
| Maximum Duty                           | $V_{FB}=0.7\text{V}$                      |      | 100  |      | %                  |
| EN On Threshold                        |   | 1.2  |      |      | V                  |
| EN Off Threshold                       |   |      |      | 0.5  | V                  |
| EN Pull Down Resister                  |   | 400  | 1000 |      | k $\Omega$         |
| EN Internal Voltage Clamp              |   |      | 3    |      | V                  |
| Soft Start Time                        |   |      | 1    |      | msec               |
| Thermal Shutdown Threshold             |   |      | 160  |      | $^{\circ}\text{C}$ |

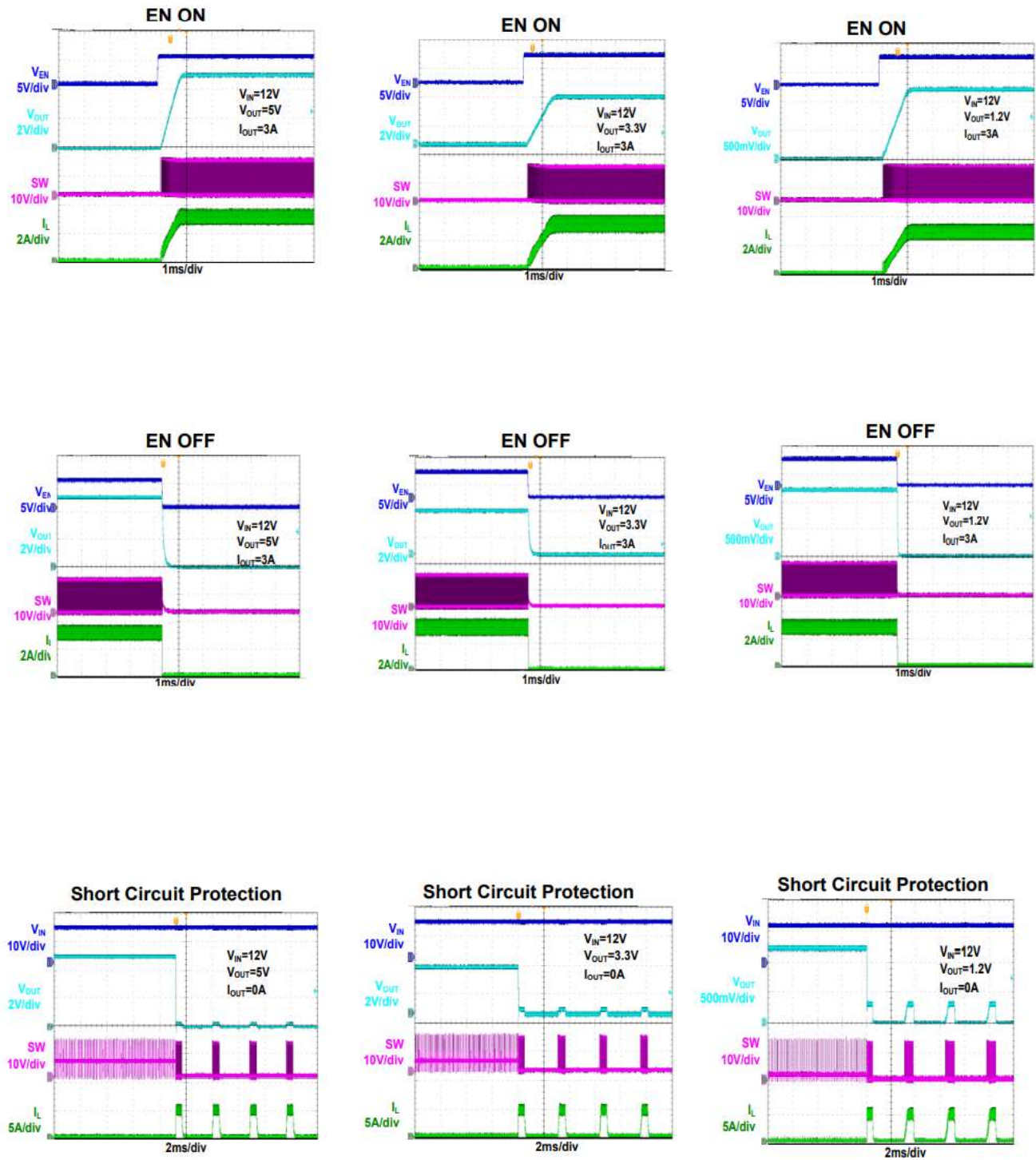


## TYPICAL PERFORMANCE CHARACTERISTICS

$C_{IN}=10\mu F$ ,  $C_{OUT}=44\mu F$ ,  $L=6.8\mu H$  for  $V_{OUT}=5V$ ;  $L=4.7\mu H$  for  $V_{OUT}=3.3V$ ;  $L=2.2\mu H$  for  $V_{OUT}=1.2V$ ,  $T_A=+25^\circ C$



## TYPICAL PERFORMANCE CHARACTERISTICS



## Theory of Operation

The EMT3571 is a constant frequency current mode PWM step-down converter with integrated main switch and synchronous rectifier, which provides high efficiency operation and eliminates external Schottky diode.

## Current Mode PWM Control

Current mode PWM control provides stable switching and cycle-by-cycle current limit for superior load and line response and protection of the internal main switch and synchronous rectifier. The EMT3571 switches at a constant frequency and regulates the output voltage. During steady state operation, the high side switch is turned on at the beginning of a clock cycle driving the inductor current to ramp up. When the inductor current reaches the level defined by internal control voltage from the error amplifier, the high side switch is turned off and the low side switch is turned on to sustain the inductor current until the next clock cycle comes, when the high side switch is turned on again.

## Power Saving Mode

EMT3571 automatically reduces switching frequency to enter power saving mode (PSM) at light load. Its proprietary control provides seamless transition between PSM mode and PWM mode which gives minimal output voltage ripple over the full load current range.

## Enable

The EN pin provides ON/OFF control of the regulator. Once the voltage of the EN pin exceeds the ON threshold voltage, the regulator starts operation and the internal soft-start begins to ramp. If the voltage of the EN pin is pulled below the OFF threshold, the regulator will stop switching and reset the internal soft-start.

## Boost Capacitor

The BS pin and SW pin can be connected by a 100nF low ESR ceramic capacitor, providing the gate drive voltage for the high side MOSFET.

## Input Under Voltage Lockout

The EMT3571 features an Input Under-Voltage Lockout circuit, which shuts down the part when the input voltage drops below failing threshold to prevent unstable operation.

## Internal Soft-start

The EMT3571 comes with internal soft-start function, which reduces inrush current and overshoot of the output voltage. Soft-start is achieved by ramping up the reference voltage ( $V_{ref}$ ) applied to the input of the error amplifier. The typical soft-start time is 1ms.



## Short Circuit Protection

The EMT3571 has short circuit protection. When the output is shorted, the oscillator's frequency is reduced to prevent the inductor's current from running away beyond the high side MOSFET current limit. The frequency will return to the normal level once the short circuit condition is removed and the feedback voltage  $> 0.25V$ .

## Maximum Load Current

The EMT3571 can operate down to 4.7V input voltage; however the maximum load current decreases at lower input due to large IR drop on the main switch and synchronous rectifier. The slope compensation signal also reduces the inductor's peak current as a function of the duty cycle. For current mode control, slope compensation is needed to prevent sub-harmonic oscillations at duty cycles greater than 50%.

## Application Information

### Input Capacitor Selection

The input capacitor must sustain the ripple current produced during the period of "ON" state of the high side MOSFET, so a low ESR ceramic capacitor is required to minimize the loss. The input ripple current RMS value can be calculated by the following equation:

$$I_{INRMS} = I_{OUT} \sqrt{D \times (1-D)}$$

$$P_{CIN} = ESR_{CIN} \times I_{INRMS}^2$$

Where  $P_{CIN}$  is the power loss of the input capacitor and  $ESR_{CIN}$  is the effective series resistance of the input capacitance. Due to large di/dt through the input capacitor, electrolytic or ceramics should be used.

### Inductor Selection

The inductor selection is to meet the requirements of the output voltage ripple and affects the load transient response. The higher inductance can reduce the inductor's ripple current and induce the lower output ripple voltage. The ripple voltage and current are approximated by the following equations:

$$\Delta I = \frac{V_{IN} - V_{OUT}}{F_S \times L} \cdot \frac{V_{OUT}}{V_{IN}}$$

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

Although the increase of the inductance reduces the ripple current and voltage, it contributes to the decrease of the response time for the regulator to load transient. The way to set a proper inductor value is to have the ripple current ( $\Delta I$ ) be approximately **20%~50%** of the maximum output current. Once the value has been determined, select an inductor capable of carrying the required peak current without going into saturation. It is also important to have the inductance tolerance specified to keep the accuracy of the system. 20% tolerance (at room temperature) is reasonable for the most inductor manufacturers. For some types of inductors, especially those with ferrite core, the ripple current will increase abruptly when it saturates, which will result in larger output ripple voltage.

### Output Capacitor Selection

An output capacitor is required to filter the output and supply the load transient current. The high capacitor value and low ESR will reduce the output ripple and the load transient drop. In typical switching regulator design, the ESR of the output capacitor bank dominates the transient response. The number of output capacitors can be determined by the following equations:

$$ESR_{MAX} = \frac{\Delta V_{ESR}}{\Delta I_{OUT}}$$

$$\text{Number of capacitors} = \frac{ESR_{CAP}}{ESR_{MAX}}$$

$ESR_{CAP}$  = maximum ESR per capacitor (specified in manufacturer's data sheet)

$ESR_{MAX}$  = maximum allowable ESR

$\Delta V_{ESR}$  = change in output voltage due to ESR

$\Delta I_{OUT}$  = load transient

High frequency decoupling capacitors should be placed as closely to the power pins of the load as physically possible. For the decoupling requirements, please consult the capacitor manufacturers for confirmation.

### Output Voltage

The output voltage is set using the FB pin and a resistor divider connected to the output as shown in AP circuit below. The output voltage ( $V_{OUT}$ ) can be calculated according to the voltage of the FB pin ( $V_{FB}$ ) and ratio of the feedback resistors by the following equation, where ( $V_{FB}$ ) is 0.8V:

$$V_{FB} = V_{OUT} \times \frac{R_2}{(R_1 + R_2)}$$

Thus the output voltage is:

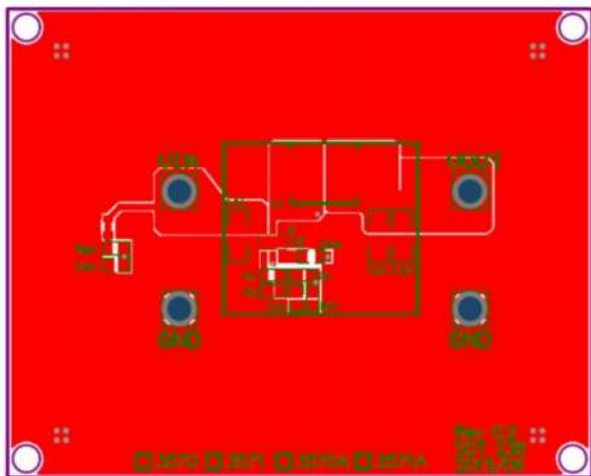
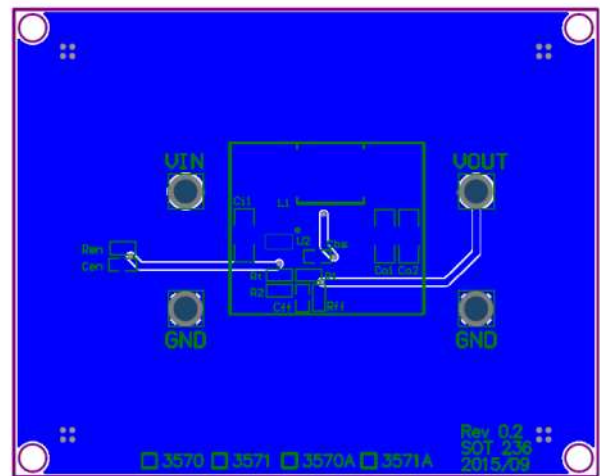
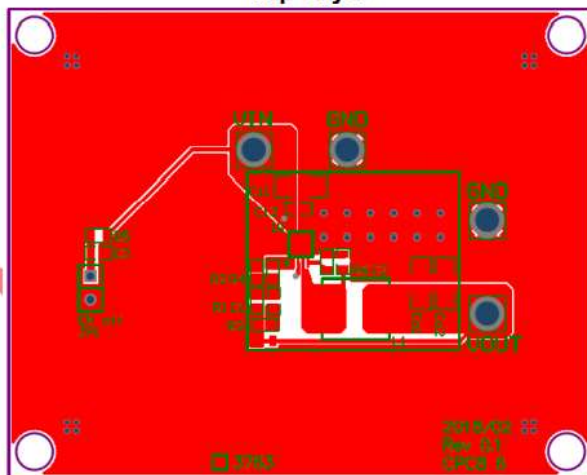
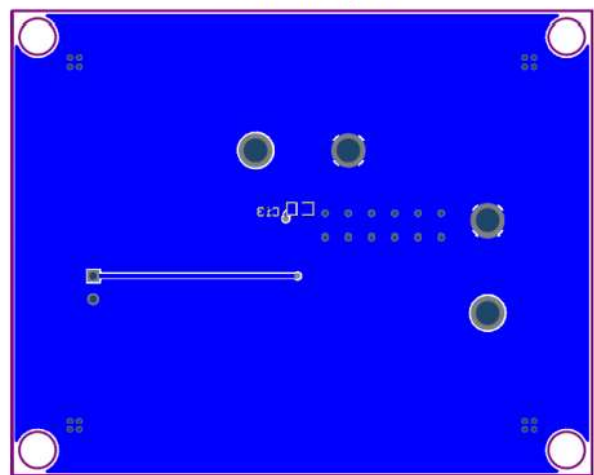
$$V_{OUT} = V_{FB} \times \left( \frac{R_1}{R_2} + 1 \right)$$

Choose  $R_1=40k\Omega\sim200k\Omega$  to ensure feedback loop noise immunity. It is optional to add a feed-forward capacitor  $C_{FF}=4.7\sim22pF$  in parallel with  $R_1$  to achieve better transient response performance.

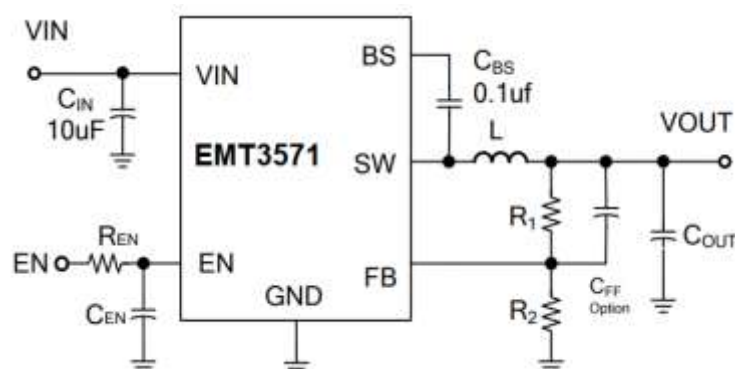
## Layout Consideration

The physical design of the PCB is the final stage in the design of power converter. The improperly designed PCB could radiate excessive EMI and contribute instability to the power converter. Follow the PCB layout guidelines below to ensure better performance of EMT3571.

- (1). The loop (Vin-SW-L-Cout-GND) indicates a high current path. The traces within the loop should be kept as wide and short as possible to reduce parasitic inductance and high-frequency loop area. It is also good for efficiency improvement.
- (2). Place Input capacitor as close as possible to the IC Pins (Vin and GND) and the input loop area should be as small as possible to reduce parasitic inductance, input voltage spike and noise emission.
- (3). Feedback components ( $R_1$ ,  $R_2$  and CFF) should be routed as far away from the inductor and the BS and SW pins to minimize noise and EMI issue.

**SOT23\_6L:**
**Top Layer**

**Bottom Layer**

**CPC8\_6L:**
**Top Layer**

**Bottom Layer**


## Application 1 (without Rt Schematic):

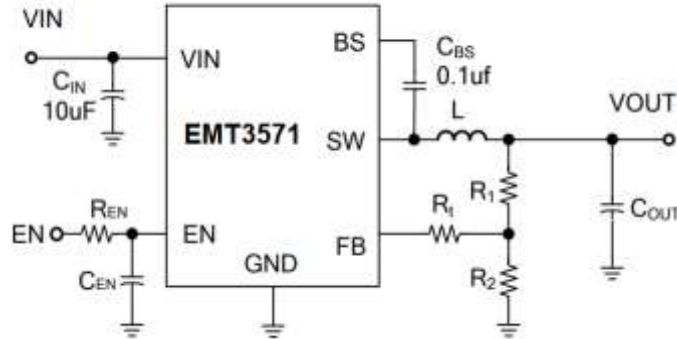


Application Circuit 1. and EVB BOM List

| Qty | Ref              | Value      |        | Description                    | Package             |
|-----|------------------|------------|--------|--------------------------------|---------------------|
| 1   | C <sub>IN</sub>  | 10μF       |        | Ceramic Capacitor, 25V, X5R    | 0805                |
| 2   | C <sub>OUT</sub> | 22μF       |        | Ceramic Capacitor, 25V, X5R    | 0805                |
| 1   | C <sub>EN</sub>  | 0.1μF      |        | Ceramic Capacitor, 16V, X5R    | 0603                |
| 1   | C <sub>BS</sub>  | 0.1μF      |        | Ceramic Capacitor, 25V, X5R    | 0603                |
| 1   | L                | Vout=5V    | 6.8μH  | Inductor, GSTM5030P 15mΩ, 6.5A | SMD                 |
|     |                  | Vout=3.3V  | 4.7μH  |                                |                     |
|     |                  | Vout=2.5V  | 3.3μH  |                                |                     |
|     |                  | Vout=1.8V  | 2.2μH  |                                |                     |
|     |                  | Vout=1.2V  | 2.2μH  |                                |                     |
|     |                  | Vout=1V    | 2.2μH  |                                |                     |
| 1   | R1               | Vout=5V    | 150KΩ  | Resistor, ±1%                  | 0603                |
|     |                  | Vout=3.3V  | 150KΩ  |                                |                     |
|     |                  | Vout=2.5V  | 150KΩ  |                                |                     |
|     |                  | Vout=1.8V  | 150KΩ  |                                |                     |
|     |                  | Vout=1.2V  | 150KΩ  |                                |                     |
|     |                  | Vout=1.05V | 150KΩ  |                                |                     |
| 1   | R2               | Vout=5V    | 28KΩ   | Resistor, ±1%                  | 0603                |
|     |                  | Vout=3.3V  | 47KΩ   |                                |                     |
|     |                  | Vout=2.5V  | 69.8KΩ |                                |                     |
|     |                  | Vout=1.8V  | 120KΩ  |                                |                     |
|     |                  | Vout=1.2V  | 300KΩ  |                                |                     |
|     |                  | Vout=1.05V | 470KΩ  |                                |                     |
| 1   | C <sub>FF</sub>  | Vout=5V    | 10pF   | Ceramic Capacitor, 50V, X5R    | 0603                |
|     |                  | Vout=3.3V  | 10pF   |                                |                     |
|     |                  | Vout=2.5V  | 10pF   |                                |                     |
|     |                  | Vout=1.8V  | 10pF   |                                |                     |
|     |                  | Vout=1.2V  | 10pF   |                                |                     |
|     |                  | Vout=1.05V | 10pF   |                                |                     |
| 1   | R <sub>EN</sub>  | 10K~100KΩ  |        | Resistor, ±1%                  | 0603                |
| 1   | Power IC         | MT3571     |        | Step-Down DC/DC Converter      | SOT23_6L<br>CPC8_6L |

## Application 2 (with Rt Schematic):

The T-type network shown in below figure can also be used.



**Application Circuit 2. with T-type Feedback Network and EVB BOM List**

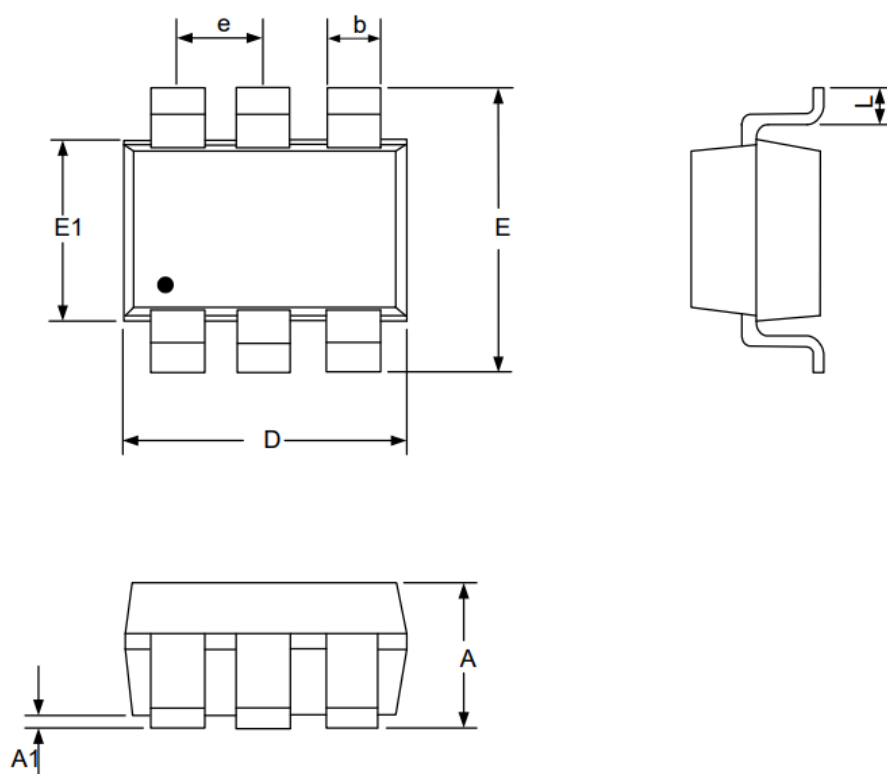
| Qty | Ref              | Value      |        | Description                    | Package             |
|-----|------------------|------------|--------|--------------------------------|---------------------|
| 1   | C <sub>IN</sub>  | 10μF       |        | Ceramic Capacitor, 25V, X5R    | 0805                |
| 2   | C <sub>OUT</sub> | 22μF       |        | Ceramic Capacitor, 25V, X5R    | 0805                |
| 1   | C <sub>EN</sub>  | 0.1μF      |        | Ceramic Capacitor, 16V, X5R    | 0603                |
| 1   | C <sub>BS</sub>  | 0.1μF      |        | Ceramic Capacitor, 25V, X5R    | 0603                |
| 1   | L                | Vout=5V    | 6.8μH  | Inductor, GSTM5030P 15mΩ, 6.5A | SMD                 |
|     |                  | Vout=3.3V  | 6.8μH  |                                |                     |
|     |                  | Vout=2.5V  | 4.7μH  |                                |                     |
|     |                  | Vout=1.8V  | 3.3μH  |                                |                     |
|     |                  | Vout=1.2V  | 2.2μH  |                                |                     |
|     |                  | Vout=1V    | 2.2μH  |                                |                     |
| 1   | R <sub>T</sub>   | Vout=5V    | 24.9KΩ | Resistor, ±1%                  | 0603                |
|     |                  | Vout=3.3V  | 40.2KΩ |                                |                     |
|     |                  | Vout=2.5V  | 59KΩ   |                                |                     |
|     |                  | Vout=1.8V  | 75 KΩ  |                                |                     |
|     |                  | Vout=1.2V  | 120KΩ  |                                |                     |
|     |                  | Vout=1V    | 150KΩ  |                                |                     |
| 1   | R <sub>1</sub>   | Vout=5V    | 40.2KΩ | Resistor, ±1%                  | 0603                |
|     |                  | Vout=3.3V  | 40.2KΩ |                                |                     |
|     |                  | Vout=2.5V  | 40.2KΩ |                                |                     |
|     |                  | Vout=1.8V  | 40.2KΩ |                                |                     |
|     |                  | Vout=1.2V  | 20.5KΩ |                                |                     |
|     |                  | Vout=1.05V | 10KΩ   |                                |                     |
| 1   | R <sub>2</sub>   | Vout=5V    | 7.68KΩ | Resistor, ±1%                  | 0603                |
|     |                  | Vout=3.3V  | 13KΩ   |                                |                     |
|     |                  | Vout=2.5V  | 19.1KΩ |                                |                     |
|     |                  | Vout=1.8V  | 32.4KΩ |                                |                     |
|     |                  | Vout=1.2V  | 41.2KΩ |                                |                     |
|     |                  | Vout=1.05V | 32.4KΩ |                                |                     |
| 1   | R <sub>EN</sub>  | 10K~100KΩ  |        | Resistor, ±1%                  | 0603                |
| 1   | Power IC         | MT3571     |        | Step-Down DC/DC Converter      | SOT23_6L<br>CPC8_6L |



## Package Information

### SOT23\_6L Outline Dimensions

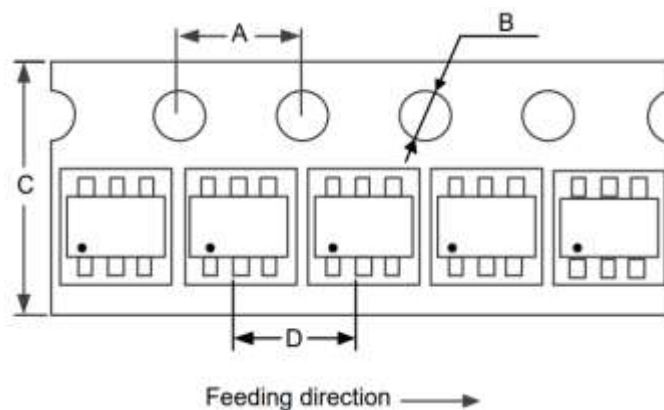
Unit: inches/mm



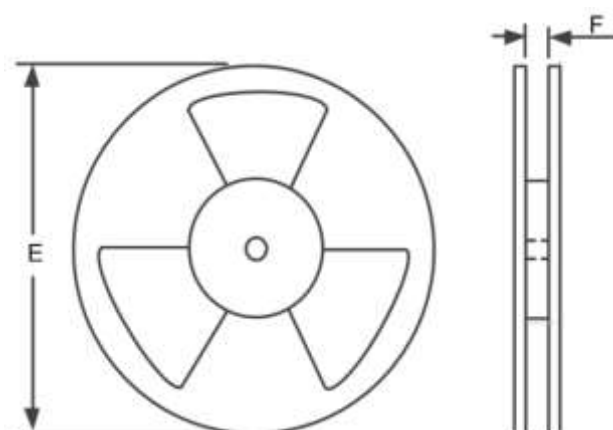
| SYMBOLS | MILLIMETERS |      | INCHES |       |
|---------|-------------|------|--------|-------|
|         | MIN.        | MAX. | MIN.   | MAX.  |
| A       | 0.89        | 1.45 | 0.035  | 0.057 |
| A1      | 0.00        | 0.15 | 0.000  | 0.006 |
| b       | 0.30        | 0.50 | 0.012  | 0.020 |
| D       | 2.70        | 3.10 | 0.106  | 0.122 |
| E1      | 1.40        | 1.80 | 0.055  | 0.071 |
| e       | 0.84        | 1.04 | 0.033  | 0.041 |
| E       | 2.60        | 3.00 | 0.102  | 0.118 |
| L       | 0.30        | 0.60 | 0.012  | 0.024 |

## Tape & Reel Carrier Dimensions

### 1. Orientation / Carrier Tape Information :



### 2. Rokreel Information :



### 3. Dimension Details :

| PKG Type | A      | B      | C      | D      | E        | F      | Q'ty/Reel |
|----------|--------|--------|--------|--------|----------|--------|-----------|
| SOT23_6L | 4.0 mm | 1.5 mm | 8.0 mm | 4.0 mm | 7 inches | 9.0 mm | 3,000     |

## Reflow Profile

### Classification Of IR Reflow Profile

| Reflow Profile                                      | Green Assembly                   |
|---|----------------------------------|
| Average Ramp-Up Rate ( $T_{s_{min}}$ to $T_p$ )     | 1~2°C/second, 3°C/second max.    |
| Preheat & Soak                                      |                                  |
| -Temperature Min( $T_{s_{min}}$ )                   | 150°C                            |
| -Temperature Max( $T_{s_{max}}$ )                   | 200°C                            |
| -Time( $t_{s_{min}}$ to $t_{s_{max}}$ )             | 60~120 seconds                   |
| Time maintained above:                              |                                  |
| -Temperature( $T_L$ )                               | 217°C                            |
| -Time( $t_L$ )                                      | 60~150 seconds                   |
| Peak Temperature( $T_p$ )                           | See Classification Temp intable1 |
| Time within 5°C of actual Peak Temperature( $t_p$ ) | 30 seconds max.                  |
| Ramp-Down Rate                                      | 6°C/second max.                  |
| Time 25°C to Peak Temperature                       | 8 minutes max.                   |

\* Tolerance for peak profile Temperature( $T_p$ ) is defined as a supplier minimum and a user maximum.

\*\* Tolerance for time at peak profile temperature ( $t_p$ ) is defined as a supplier minimum and a user maximum.

Table 1. Pb-free Process –Classification Temperatures ( $T_c$ )

| Package Thickness | Volume mm <sup>3</sup><br><350 | Volume mm <sup>3</sup><br>350-2000 | Volume mm <sup>3</sup><br>>2000 |
|-------------------|--------------------------------|------------------------------------|---------------------------------|
| <1.6mm            | 260°C                          | 260 °C                             | 260°C                           |
| 1.6mm~2.5mm       | 260°C                          | 250°C                              | 245°C                           |
| ≥2.5mm            | 250 °C                         | 245°C                              | 245°C                           |

**Note:** For all temperature information, please refer to topside of the package, measured on the package body surface.

