

30V 3A Synchronous Step-Down DC/DC Converter with Adjustable Soft-start Time

Features

- High Efficiency: Up to 95% @ 12V to 5V
- Wide input voltage: 4.5V ~ 30V
- Up to 3A Output Current
- Low Typical 3 μ A Shutdown Current
- Adjustable Soft-Start Time
- Fixed 340kHz Switching Frequency
- Stable with Low ESR Ceramic Output
- Peak Current Mode with External Compensation
- PFM in Light Load Condition
- 0.8V Voltage Reference with $\pm 2\%$ Accuracy
- Thermal Shutdown
- Cycle-by-cycle Current Limit Protection
- Over Current Protection with Hiccup Mode
- ESOP8 Package

Description

TMI3343 is a wide input voltage of 4.5V to 30V, high efficiency current mode, synchronous step-down DC/DC converter capable of delivering 3A current with adjustable soft-start time. TMI3343 integrates main switch and synchronous switch with low $R_{DS(on)}$ to minimize the conduction loss. The device integrates 120m Ω High-Side and 80m Ω Low-side Power MOS, and has advanced features include UVLO, Thermal Shutdown, Soft Start, input OVP.

Applications

- Smart Home Applications
- Vacuum Robot
- Printer
- Consumer Applications: TV and Set Top Box
- General 5V, 12V, 24V DC/DC Power Bus Supply

Typical Application

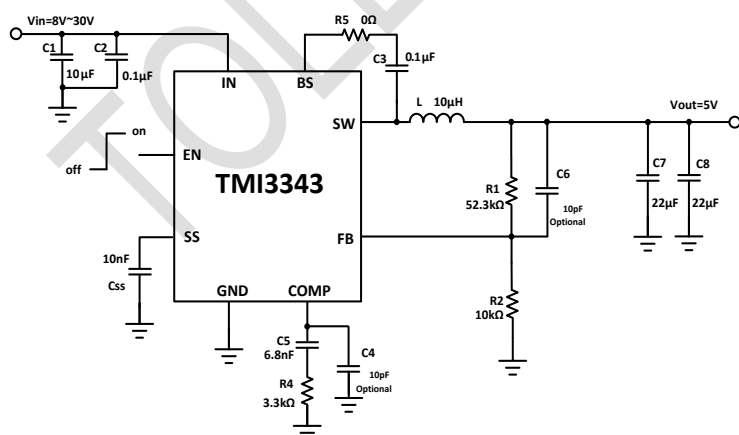
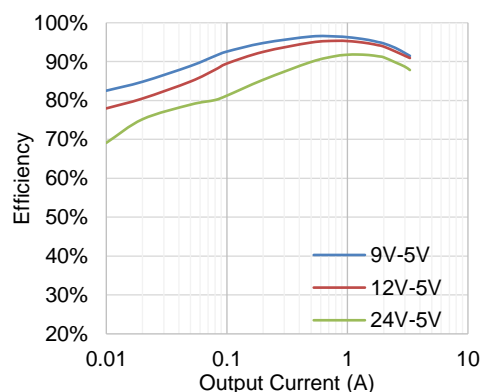


Figure 1. Basic Application Circuit

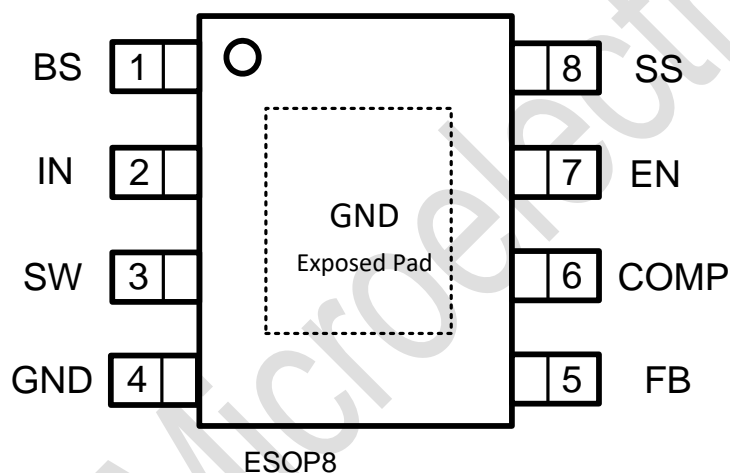
Efficiency

$V_{OUT}=5V$, $I_{OUT}=0.01A$ to 3.3A, $T_A=25^{\circ}C$



Absolute Maximum Ratings (Note 1)

Parameter	Min	Max	Unit
Input Supply Voltage, SW	-0.3	33	V
LX to GND (20ns transient)	-5.0	35	V
BS to SW Voltage	-0.3	6.0	V
All Other Pins (FB, EN, SS, COMP) Voltage	-0.3	6.0	V
PG to GND	-0.3	14	V
Junction Temperature (Note 2)	-40	150	°C
Storage Temperature Range	-50	150	°C
Lead Temperature (Soldering, 10s)		260	°C

Package/Order Information

Top Mark: T3343/YYXXX (T3343: Device Code, YYXXX: Inside Code)

Part Number	Package	Top mark	Quantity/ Reel
TMI3343	ESOP8	T3343 YYXXX	3000

TMI3343 devices are Pb-free and RoHS compliant.

Pin Functions

Pin	Name	Function
1	BS	High-side Gate Driver Bootstrap pin, Provide supply to high-side LDMOS Gate Driver. Connect a 100nF capacitor between BS and SW
2	IN	Power Input pin
3	SW	Switch Pin, Connect to external Inductor
4	GND	Ground Pin
5	FB	Feedback Pin
6	COMP	External Compensation Pin
7	EN	Drive this pin to a logic-high to enable the IC. Drive to a logic-low to disable the IC and enter micro-power shutdown mode. Do not leave EN pin floating.
8	SS	The SS pin is the soft-start and tracking pin. An external capacitor connected to this pin sets the internal voltage-reference rise time. The voltage on this pin overrides the internal reference.
9	GND	Ground (Exposed pad)

ESD Rating

Items	Description	Value	Unit
V_{ESD}	Human Body Model for all pins	± 2000	V

JEDEC specification JS-001

Recommended Operating Conditions

Items	Description	Min	Max	Unit
Voltage Range	V_{IN}	4.5	30	V

Thermal Resistance (Note 3)

Items	Description	Value	Unit
θ_{JA}	Junction-to-ambient thermal resistance	60	$^{\circ}\text{C/W}$

Electrical Characteristics (Note 3)(V_{IN}=12V, V_{OUT}=5V, T_A = 25°C, unless otherwise noted.)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Input Voltage Range	V _{IN}		4.5		30	V
Under Voltage Lockout	V _{UVLO}	V _{IN} rising		4.3		V
UVLO Hysteresis	V _{UVLO_HY}			0.35		V
Input OVP Voltage	V _{INOVP}			32		V
Input Quiescent Current	I _Q	V _{FB} =1V		0.38	0.48	mA
Input Supply Current	I _{IN}	No load		0.45		mA
Shutdown Current	I _{SD}	EN = 0V		3	10	μA
Feedback Threshold Voltage	V _{FBTH}	PWM operation	784	800	816	mV
FB Pin input current	I _{FB}		-50		50	nA
EN Rising Threshold			1.00	1.15	1.30	V
EN Hysteresis				100		mV
EN sink current (Note 3)	I _{EN_Sink}				1	mA
Soft start Time	T _{SS}	C _{SS} =NC		1.2		ms
		C _{SS} =10nF		3.5		ms
Current limit cycle-by-cycle	I _{LIM_MAX}			4.2		A
SW leakage	I _{SW_LEAK}				10	μA
Switch On-Resistance (high side)	R _{DSONH}			120		mΩ
Switch On-Resistance (low side)	R _{DSONL}			80		mΩ
Switching Frequency	F _{SW}			340		kHz
Minimum Turn-on Time (Note 4)	T _{ON_MIN}			200		ns
Hiccup on Time (Note 4)				2		ms
Hiccup Time Before Restart				64		ms
Maximum Duty-cycle	D _{MAX}			91		%
Thermal Shutdown Threshold (Note 4)	T _{SDN}			160		°C
Thermal Shutdown Hysteresis (Note 4)	T _{SDN_HY}			10		°C

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired.

Note 2: T_J is calculated from the ambient temperature T_A and power dissipation P_D according to the following formula: T_J = T_A + (P_D) × θ_{JA}.

Note 3: EN external resistor divide requirement is described in below Enable and Disable section.

Note 4: Guaranteed by design.

Functional Block Diagram

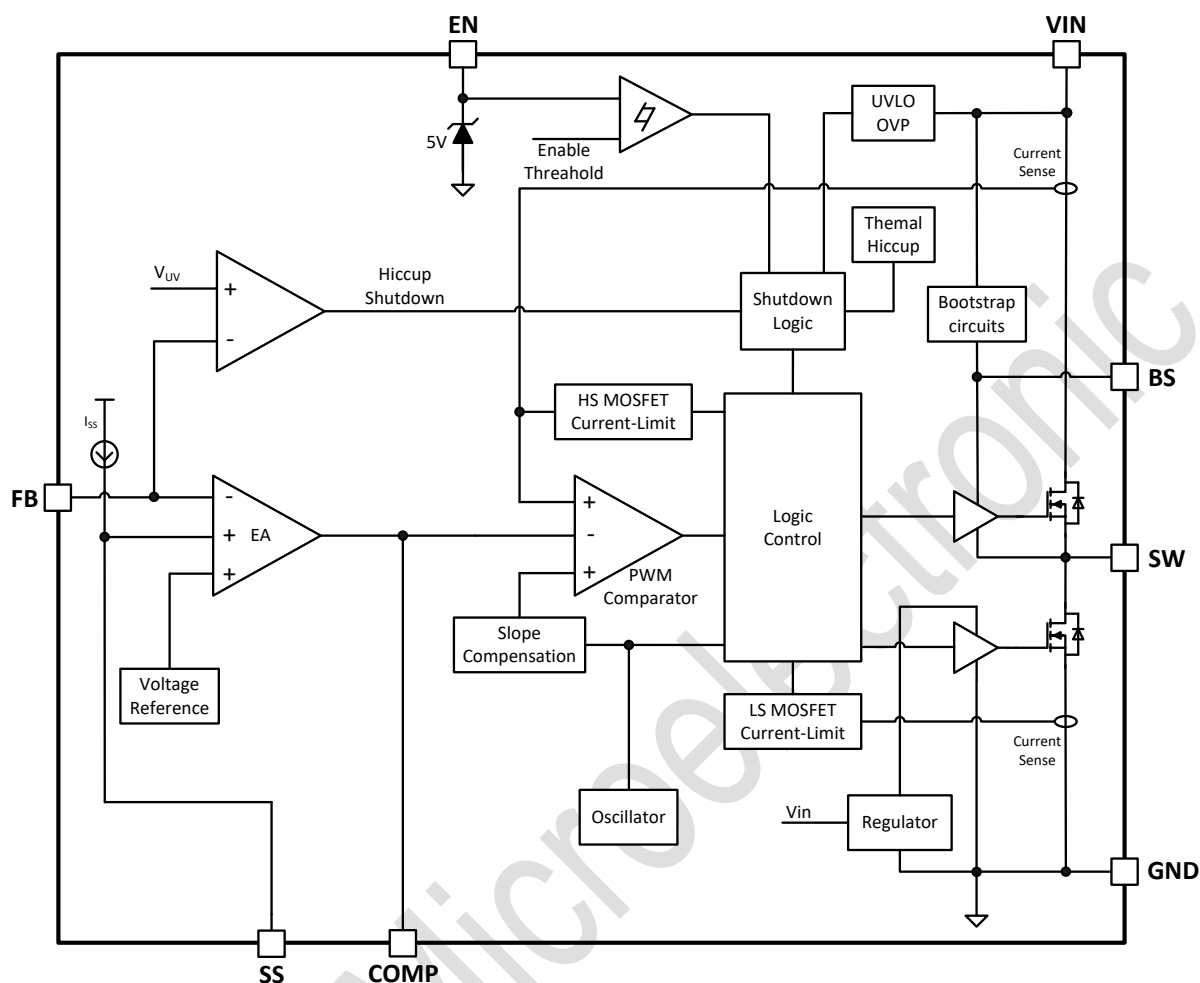


Figure 2. TMI3343 Block Diagram

Operation Description

Overview

As seen in Functional Block Diagram, the TMI3343 is a peak current mode pulse width modulation (PWM) converter with fixed 340kHz switching frequency. The converter operates as follows:

A switching cycle starts when the rising edge of the oscillator clock output causes the High-Side Power Switch to turn on and the Low-Side Power Switch to turn off. With the SW side of the inductor now connected to IN, the inductor current ramps up to store energy in the magnetic field. The inductor current level is measured by the Current Sense Amplifier and added to the Oscillator ramp signal. If the resulting summation is higher than the COMP voltage, the output of the PWM Comparator goes high. When this happens or when Oscillator clock output goes low, the High-Side Power Switch turns off.

At this point, the SW side of the inductor swings to a diode voltage below ground, causing the inductor current to decrease and magnetic energy to be transferred to output. This state continues until the cycle starts again. The High-Side Power Switch is driven by logic using BS as the positive rail. This pin is charged to $V_{SW} + 5V$ when the Low-Side Power Switch turns on. The COMP voltage is the integration of the error between FB input and the internal 0.8V reference. If V_{FB} is lower than the reference voltage, COMP tends to go higher to increase inductor current to the output side and try to increase output voltage. In light or no load condition, TMI3343 is operating in PFM mode for power saving. In PFM mode, the device ramps up its output voltage with one or several SW switching pulse, while the error amplifier output voltage V_{COMP} drops. The device stops switching when V_{COMP} voltage drops down the inner threshold, then the output voltage falls down and V_{COMP} voltage rises until V_{COMP} voltage is high enough to generate SW switching pulse.

Input Over Voltage Protection

The thresholds of input OVP circuit include are typical 32V. Once the input voltage is higher than the threshold, the high-side MOSFET is turned off. When the input voltage drops lower than the threshold with hysteresis, the high-side MOSFET will be enabled again. This function protects device from switching in abnormal high input voltage and input surge condition.

Over-Current-Protection and Short Circuits Protection

The TMI3343 has cycle-by-cycle peak current limit function. The periodic current limit of the high side MOSFET can protect this device in case of overload, and prevent the current from losing control through valley current limit. Low side charge current limiting can shut down low side MOSFET to prevent excessive reverse current.

If the output is short to GND and the output voltage drop until feedback voltage V_{FB} is below the output under-voltage V_{UV} threshold which is typically 35% of V_{REF} , TMI3343 enters into hiccup mode to periodically disable and restart switching operation. The hiccup mode helps to reduce power dissipation and thermal rise during output short condition. The period of TMI3343 hiccup mode is typically 66ms.

Input Under Voltage Lockout

TMI3343 implements input under voltage lockout function to avoid mis-operation at low input voltages. When the input voltage is lower than input UVLO threshold with UVLO hysteresis, the device is shut down. The typical 350mV input UVLO hysteresis value of TMI3343 is useful to prevent device from abnormal switching caused by input voltage oscillation around UVLO threshold during input voltage power-up and power-down with high load condition.

Enable and Disable

TMI3343 EN pin has a 5V Zener diode to clamp EN pin voltage. Drive EN to logic high level to turn on the device. Drive EN to logic low level to turn it off. If there is no EN logic control signal implemented on EN pin, EN could be pulled up to input voltage by a resistor. Please note the pull-up resistance value and make sure EN sink current is smaller than 1mA. EN pin cannot be floating.

For example, in below Figure 3, EN pin has pull-up resistor R_{up} to VIN and pull-down resistor R_{down} to GND. We can get:

$$V_{EN} = 5V + I_z \times 1k\Omega ,$$

$$\frac{V_{IN} - (5V + I_z \times 1k\Omega)}{R_{up}} = I_z + \frac{5V + I_z \times 1k\Omega}{R_{down}}$$

Since I_z should be smaller than 1mA:

$$V_{EN} \leq 6V, \text{ and}$$

$$I_z = \frac{V_{IN} \cdot R_{down} - 5V \cdot (R_{up} + R_{down})}{(R_{up} + R_{down}) \cdot 1k\Omega + R_{up} \cdot R_{down}} \leq 1mA$$

If no R_{down} attached and $V_{IN_max} = 24V$, $R_{up} \geq 18k\Omega$.

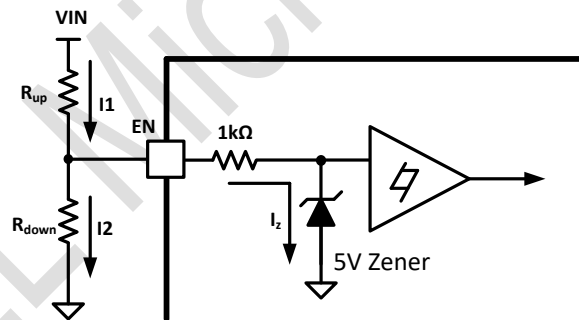


Figure 3. EN pin external connection

Thermal Shutdown

The TMI3343 disables switching when its junction temperature exceeds 160°C typically. Once the device junction temperature falls below the threshold with hysteresis, TMI3343 returns to normal operation automatically.

Application Information

Output Voltage Setting

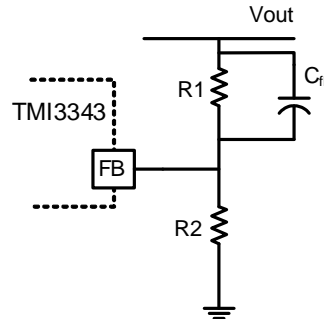


Figure 4. Output Voltage Setting

Figure 3 shows the connections for setting the output voltage. Select the proper ratio of the two feedback resistors R1 and R2 based on the output voltage. Adding a capacitor in parallel with R1 helps the system stability. Typically, use $R2 \approx 10k\Omega$ and determine R1 from the following equation:

$$R1 = R2 \cdot \left(\frac{V_{OUT}}{V_{REF}} - 1 \right)$$

Soft-Start Time Setting

The TMI3343 device use the SS pin voltage as the reference voltage and regulates the output accordingly. A capacitor on the SS pin to ground implements a soft-start time. The device has an internal pullup current source of $2.6\mu A$ that charges the external soft-start capacitor. Use following equation to calculate the soft time (t_{SS} , 10% to 90%) and soft capacitor (C_{SS}).

$$t_{SS}(ms) = \frac{C_{SS}(nF) \times V_{REF}(V)}{I_{SS}}$$

where

V_{REF} is the voltage reference (0.8 V)

I_{SS} is the soft-start charge current ($2.6\mu A$)

Inductor Selection

Inductance value is related to inductor ripple current value, input voltage, output voltage setting and switching frequency. The inductor value can be derived from the following equation:

$$L = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{V_{IN} \times \Delta I_L \times f_{SW}}$$

Where ΔI_L is inductor ripple current. Large value inductors result in lower ripple current and small value inductors result in high ripple current, so inductor value has effect on output voltage ripple value, however large value inductor have large size and is more expensive. DC resistance of inductor which has impact on efficiency of DC/DC converter should be taken into account when selecting the inductor.

The saturation current rating of the inductor should be considered. The saturation current must be larger than peak inductor current with maximum load conditions in all operation conditions, for example, maximum load transient condition. The peak inductor current value can be calculated according to the

following equation. Meanwhile, if the system has output short condition, the saturation current of inductor should cover peak current limit value of the device.

$$I_{L_peak} = I_{OUT_MAX} + \frac{1}{2} \times \Delta I_L = I_{OUT_MAX} + \frac{V_{OUT} \times (V_{IN_MAX} - V_{OUT})}{2 \times V_{IN_MAX} \times L \times f_{SW}}$$

Input Capacitor Selection

Since the input current of the Buck converter is discontinuous, the input capacitor is needed to supply the AC current while maintaining the DC input voltage. The input capacitor impedance at the switching frequency should be less than input source impedance to prevent high frequency switching current passing to the input. A low ESR input capacitor sized for maximum RMS current must be used. Ceramic capacitors with X5R or X7R dielectrics are highly recommended because of their low ESR and small temperature coefficients. The voltage rating should be greater than the maximum input voltage plus input voltage ripple. A 10μF effective capacitance value ceramic capacitor for most applications is sufficient. A large value may be used for improved input voltage filtering. Additionally, a small 0.1μF ceramic capacitor located close on input pin and GND pad is help for high frequency filter.

Output Capacitor Selection

The output capacitor is required to keep the output voltage ripple small in steady status and load transient condition, and to ensure regulation loop stability. The output ripple ΔV_{OUT} is determined by:

$$\Delta V_{OUT} \approx \Delta I_L \times \left(ESR + \frac{1}{8 \times f_{SW} \times C_{OUT}} \right) = \frac{V_{OUT} \times (V_{IN} - V_{OUT})}{2 \times V_{IN} \times L \times f_{SW}} \times \left(R_{ESR} + \frac{1}{8 \times f_{SW} \times C_{OUT}} \right)$$

Where R_{ESR} is the equivalent series resistance value of output capacitor. As shown in above equation, the smaller ESR value and larger capacitance value of output capacitors, the smaller output voltage ripple. If ceramic capacitors are used as output capacitors, the output ripple is mainly depended on output capacitance value since the ceramic capacitors have low ESR value. If tantalum or electrolytic capacitors are used as output capacitors, R_{ESR} dominates the output ripple value since the electrolytic capacitors have significantly higher ESR value. The TMI3343 can be optimized for a wide range of output capacitance and ESR values.

PC Board Layout Guidance

When laying out the printed circuit board, the following checklist should be used to ensure proper operation of the IC.

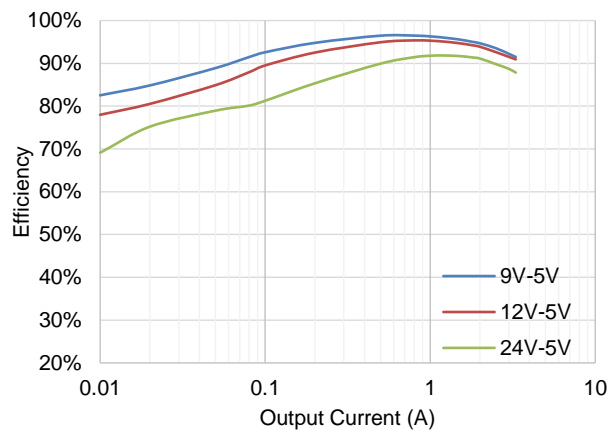
- 1) Arrange the power components to reduce the AC loop size consisting of C_{IN} , IN pin and SW pin.
- 2) Place input decoupling ceramic capacitor C_{IN} as close to IN pin as possible. C_{IN} is connected power GND with vias or short and wide path.
- 3) Return FB, COMP and SS/RT to signal GND pin, and connect the signal GND to power GND at a single point for best noise immunity. Connect exposed pad to power ground copper area with copper and vias.
- 4) Use copper plane for power GND for best heat dissipation and noise immunity.
- 5) Place feedback resistor close to FB pin.
- 6) Use short trace connecting BS- C_{BS} -SW loop

Typical Performance Characteristics

($V_{IN}=12V$, $V_{OUT}=5V$, $C_{IN}=22\mu F$, $C_{OUT}=22\mu F \times 4$, $L1=12\mu H$, $T_A=25^\circ C$, unless otherwise noted.)

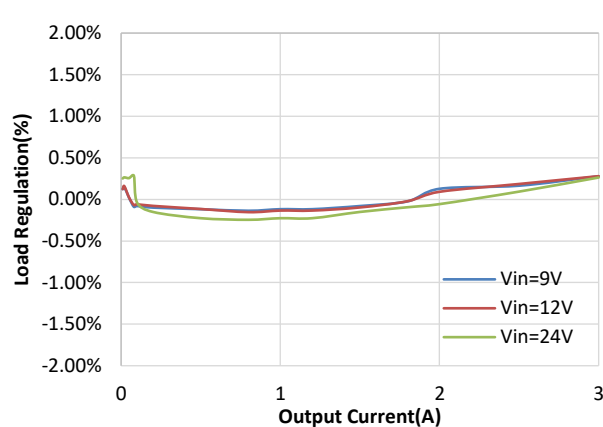
Efficiency

$V_{OUT}=5V$, $T_A=25^\circ C$



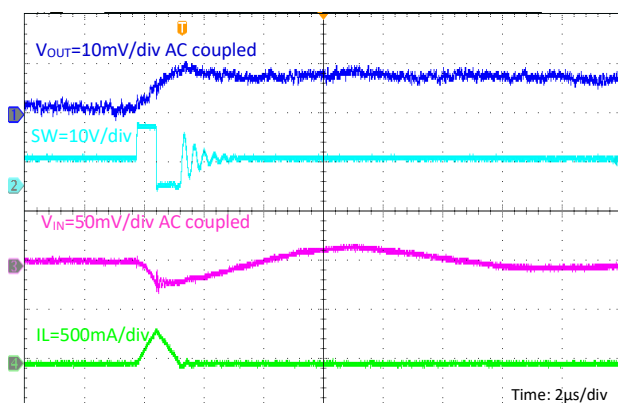
Load Regulation

$V_{OUT}=5V$, $T_A=25^\circ C$



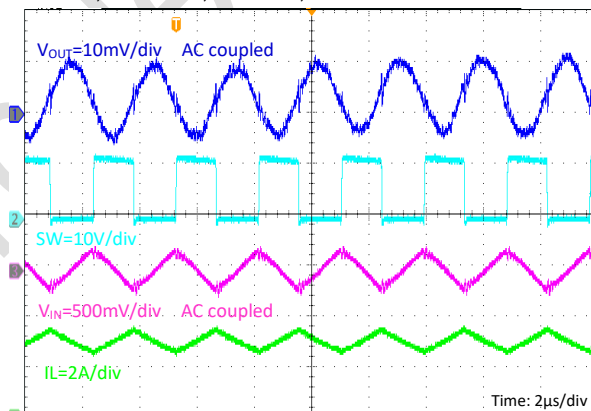
Steady State

$V_{in}=12V$, $V_{OUT}=5V$, $I_{OUT}=0A$, $T_A=25^\circ C$



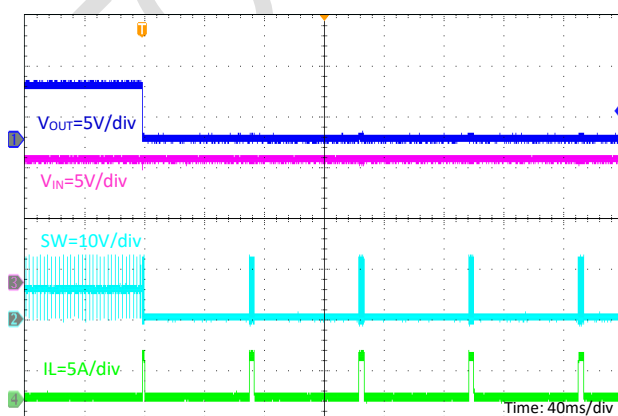
Steady State

$V_{in}=12V$, $V_{OUT}=5V$, $I_{OUT}=3A$, $T_A=25^\circ C$



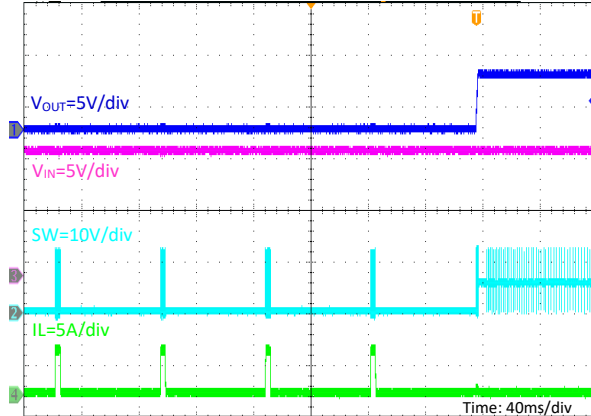
Output Short Entry

$V_{IN}=12V$, $V_{OUT}=5V$, No load



Output Short Recovery

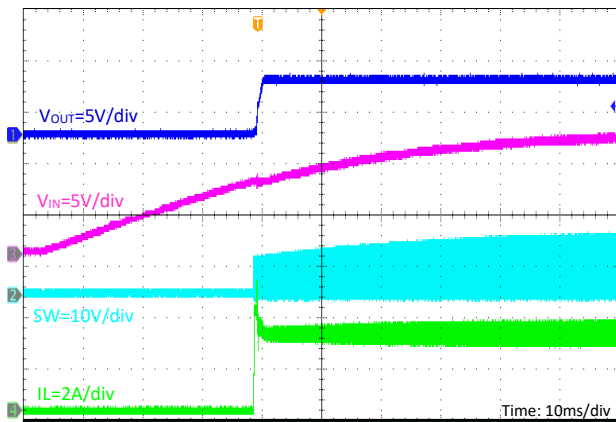
$V_{IN}=12V$, $V_{OUT}=5V$, No Load



Typical Performance Characteristics (Continued)

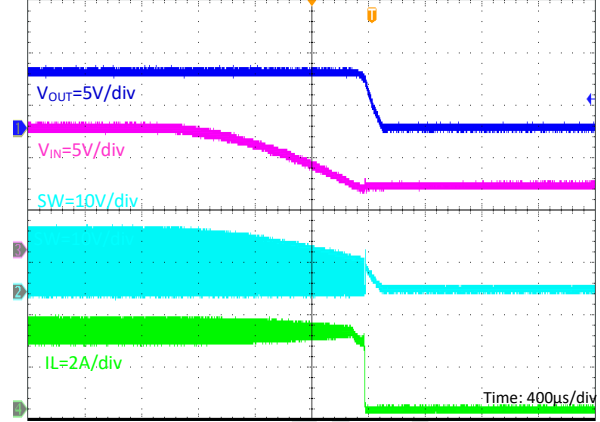
VIN Power On

$V_{IN}=12V$, $V_{OUT}=5V$, $I_O=3A$



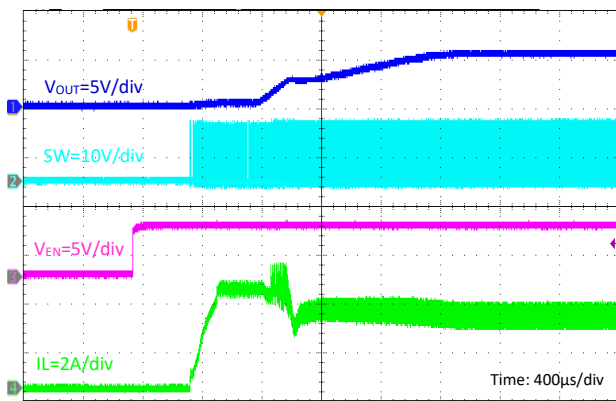
VIN Power Off

$V_{IN}=12V$, $V_{OUT}=5V$, $I_O=3A$



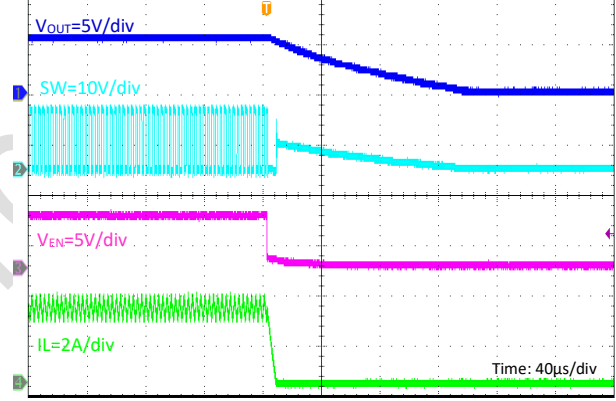
Power On through EN

$V_{IN}=12V$, $V_{OUT}=5V$, $R_O=1.6\Omega$



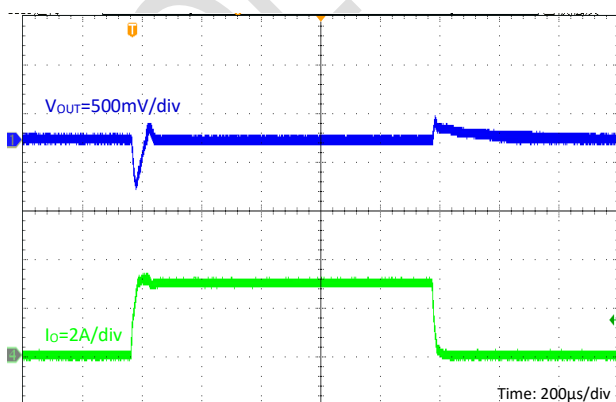
Power Off through EN

$V_{IN}=12V$, $V_{OUT}=5V$, $R_O=1.6\Omega$



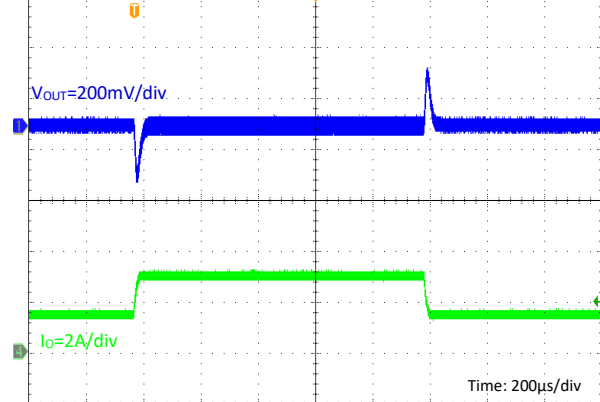
Load Transient

$V_{IN}=12V$, $V_{OUT}=5V$, $I_{OUT}=0A$ to $3A$



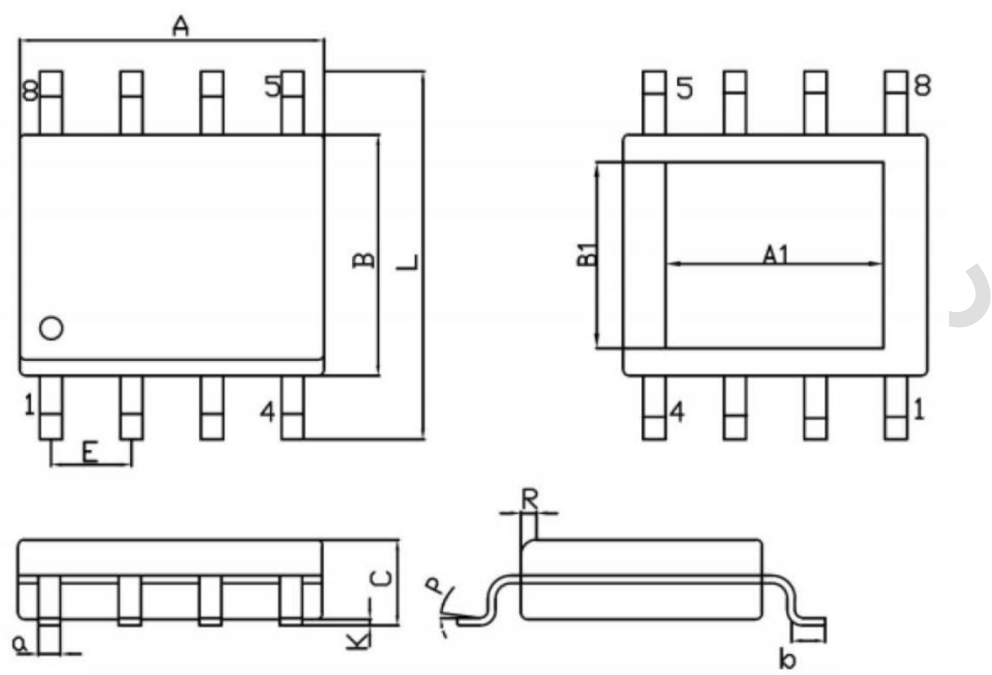
Load Transient

$V_{IN}=12V$, $V_{OUT}=5V$, $I_{OUT}=1.5A$ to $3A$



Package Information

ESOP8



Unit: mm

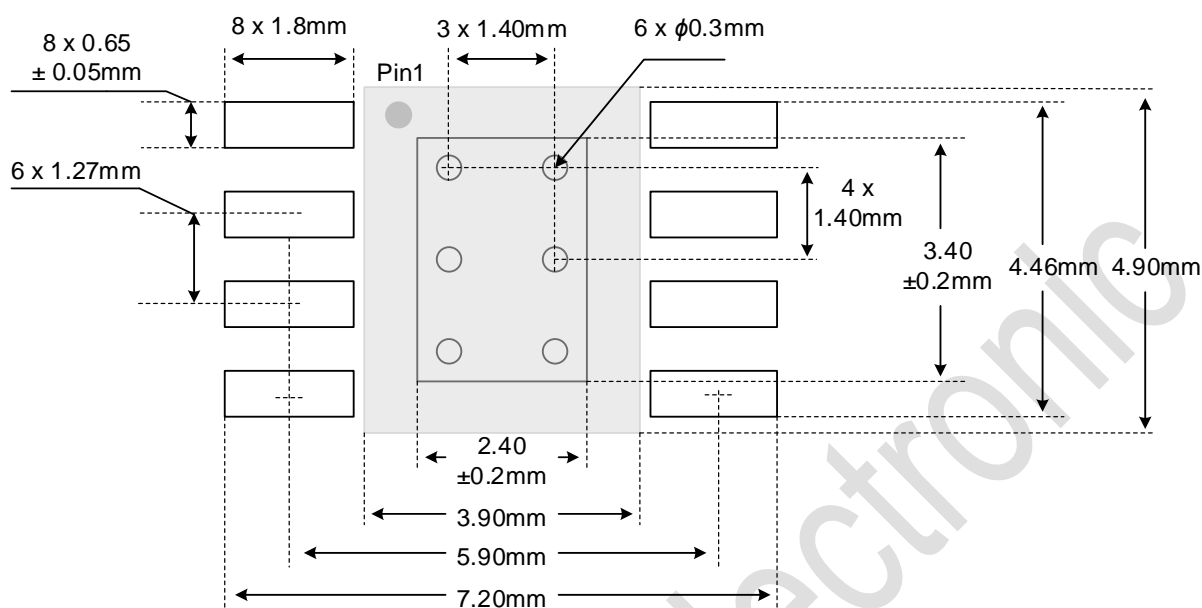
Symbol	Dimensions In Millimeters		Symbol	Dimensions In Millimeters	
	Min	Max		Min	Max
A	4.70	5.10	C	1.35	1.75
B	3.70	4.10	a	0.35	0.49
L	5.80	6.40	R	0.30	0.60
E	1.27 BSC		P	0°	7°
K	0.02	0.15	b	0.40	1.25
A1	3.1	3.5	B1	2.2	2.6

Note:

- 1) All dimensions are in millimeters;
- 2) Package length does not include mold flash, protrusion or gate burr;
- 3) Package width does not include inter lead flash or protrusion;
- 4) Lead popularity (bottom of leads after forming) shall be 0.10 millimeters max;
- 5) Pin 1 is lower left pin when reading top mark from left to right.

Recommended Pad Layout

ESOP8



Unit: mm

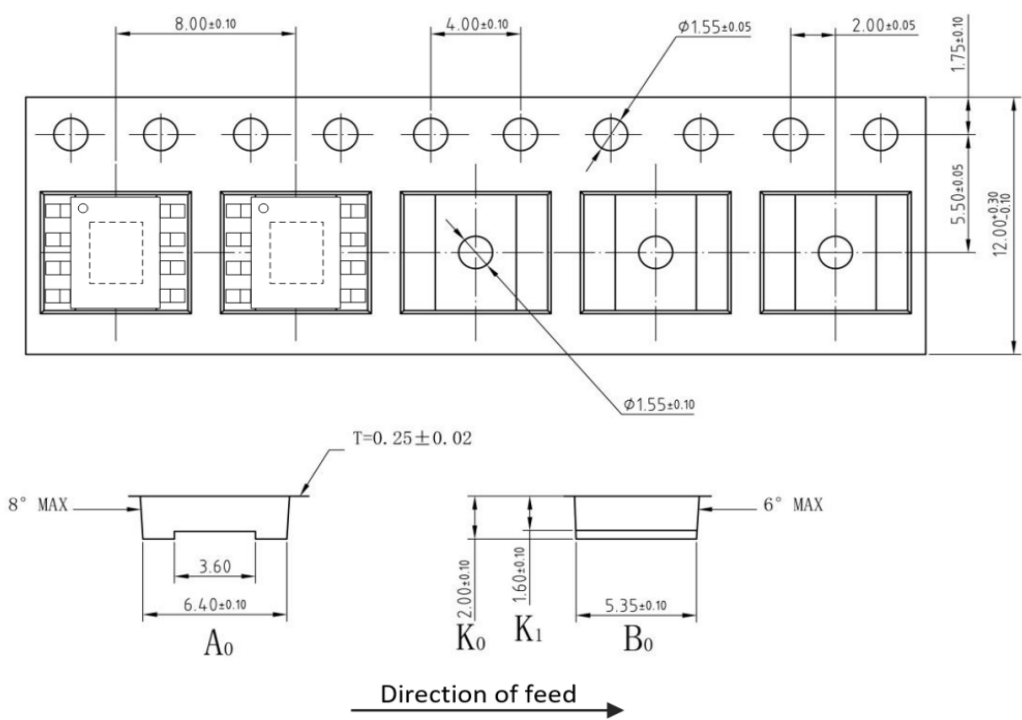
Central Exposed Power Pad Solder Stencil Opening		
Stencil Thickness	X	Y
0.1mm	2.6	3.6
0.127mm	2.4	3.4
0.152mm	2.2	3.2
0.178mm	2.1	3.0

Note:

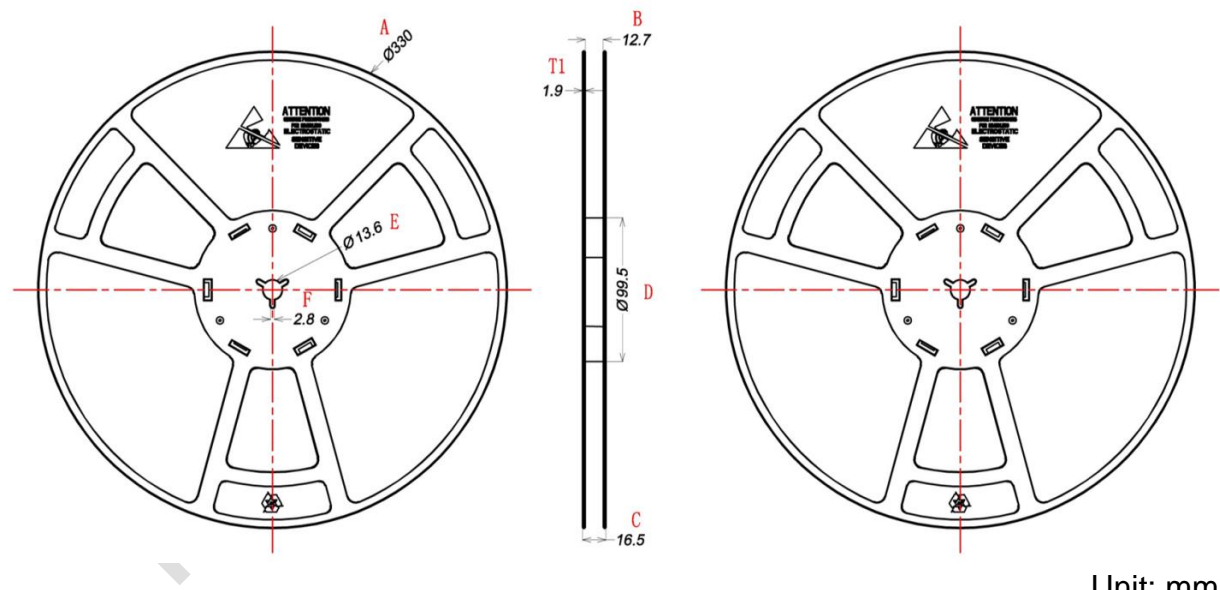
- 1) All Dimensions are in Millimeter;
- 2) Through via pattern and copper pad size can refer to the schematic diagram, if there are layout restrictions can be adjusted according to the actual situation;
- 3) The solder opening of the central exposed power pad can refer to the attached table;

Tape and Reel Information

Tape Dimensions: ESOP8



Reel Dimensions: ESOP8



Unit: mm

A	B	C	D	E	F	T1
Ø 330±1	12.7±0.5	16.5±0.3	Ø 99.5±0.5	Ø 13.6±0.2	2.8±0.2	1.9±0.2

Note:

- 1) All Dimensions are in Millimeter;
- 2) Quantity of Units per Reel is 3000;
- 3) MSL level is level 3.

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