30V, 3A Wide-Input Range Step-Down Synchronous DC/DC Converter

FEATURES

- 36V Input Voltage Surge
- Wide input voltage Range: 8V~30V
- Up to 3A Output Current
- 130kHz~500kHz Adjustable Frequency
- Internal Compensation
- 32V Input OVP Protection
- Output OVP Protection
- Efficiency up to 93%
- Force PWM Operation: TMI3331
- PFM Operation in Light Load: TMI3331A
- ±2% Feedback Voltage Accuracy
- Integrated Soft Start
- Thermal Shutdown
- Constant Current Limit
- Short Circuit Hiccup Mode
- Cycle-by-Cycle Current Limit
- ESOP8 Package

GENERAL DESCRIPTION

TMI3331 and TMI3331A are wide input voltage, high efficiency step-down DC/DC converter. TMI3331 operates in force PWM mode with adjustable switching frequency, and TMI3331A operates in PFM mode at light load condition. TMI3331 and TMI3331A provide up to 3A output current. Switching frequency can be set by external resistor. TMI3331 and TMI3331A internal Integrate 80mΩ high side and 60mΩ low side power MOSFET, which allows a high efficiency over the wider range of the load. Advanced production features include input UVLO, thermal shutdown, soft start and input and output OVP.

The TMI3331 and TMI3331A require a minimum number of readily available standard external components and is available in an 8-pin ESOP ROHS compliant package.

APPLICATIONS

- Auto Electronic Equipment
- TV/Monitor
- Distributed Power Systems
- Networking Systems

TYPICAL APPILCATION

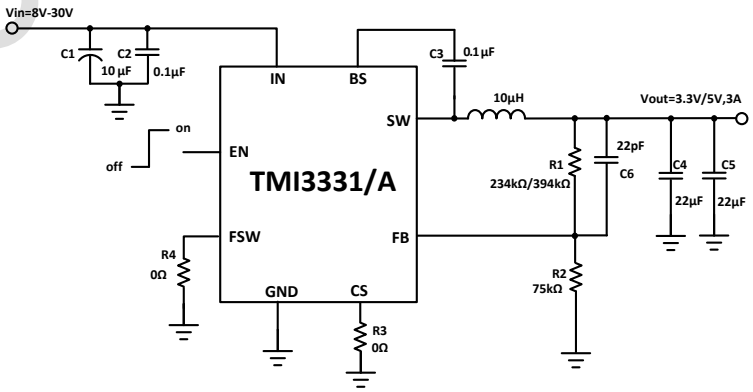

Figure 1. Basic Application Circuit as DC/DC Converter

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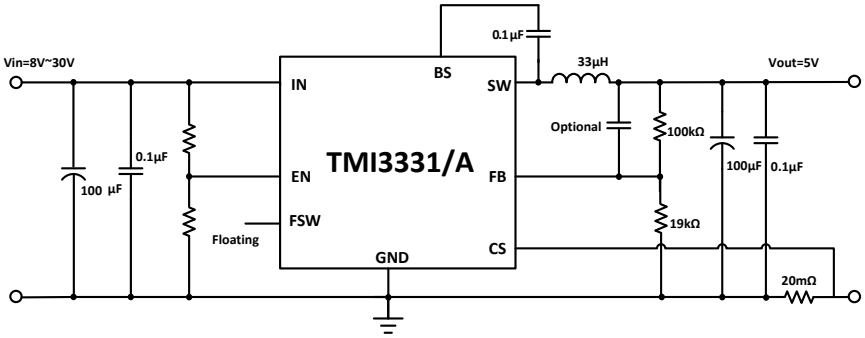

Figure 2. Basic Application Circuit as Car Charger Converter with CC function

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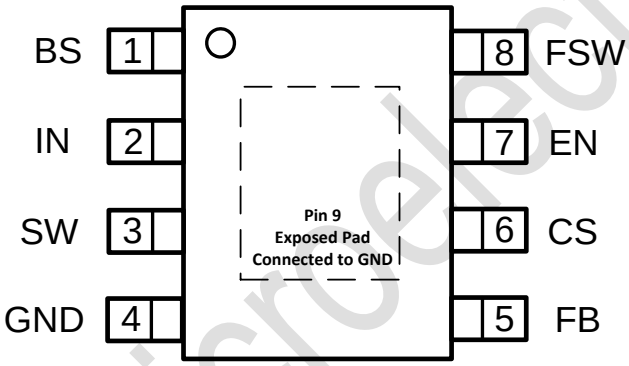
ABSOLUTE MAXIMUM RATINGS (Note 1)

Parameter	Value	Unit
IN, SW and EN Voltages	-0.3~36	V
BS to SW Voltages	-0.3~6	V
All other pins Voltage	-0.3~6	V
Junction Temperature (Note 2)	-40~150	°C
Storage Temperature	-65~150	°C
Junction-to-ambient Thermal Resistance	60	°C/W
Junction-to-case Thermal Resistance	46	°C/W
Package Dissipation	2	W

Over operating free-air temperature range (unless otherwise noted)

PIN CONFIGURATION



ESOP8

Top Mark: T3331/YYXXX (T3331: Device Code, YYXXX: Inside Code)
T3331A/YYXXX (T3331A: Device Code, YYXXX: Inside Code)

Part Number	Package	Top Mark	Quantity/ Reel
TMI3331	ESOP8	T3331/YYXXX	3000
TMI3331A	ESOP8	T3331A/YYXXX	3000

TMI3331 and TMI3331A devices are Pb-free and RoHS compliant.

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PIN FUNCTIONS

Pin	Name	Function
1	BS	High side Gate Driver bias 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	Power Ground
5	FB	Output Voltage Feedback Pin
6	CS	Output Current Sense Pin for Constant Current Limit
7	EN	Enable Pin
8	FSW	Switching Frequency set pin. Short to GND: F_S=500kHz
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	IN	8	30	V
T_J	Operating Junction Temperature Range	-40	125	°C

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ELECTRICAL CHARACTERISTICS

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

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Input Voltage Range	V_{IN}		8		30	V
Under Voltage Lockout	V_{UVLO}	V_{IN} rising		7.2		V
UVLO Hysteresis	V_{UVLO_HY}			0.6		V
Quiescent Supply Current	I_{CCQ}	no load, V_{FB} > 0.83V		1		mA
Shut-down Current	I_{SD}	EN=0V		6	10	μA
Standby Supply Current of TMI3331	I_{STBY}	V_{OUT}=5V, No Load		10	15	mA
Standby Supply Current of TMI3331A	I_{STBY}	V_{OUT}=5V, No Load		1.5	3	mA
Feedback Threshold Voltage	V_{FBTH}		784	800	816	mV
FB Pin Input Current	I_{FB}		-50		50	nA
Input OVP Voltage	V_{INOVP}		31.5			V
Output OVP Voltage	V_{OUTOVP}			10	20	%
Soft start Time	T_{SST}			4		ms
CS Current Limit Voltage	V_{LIM_CS}			61.7		mV
SW leakage	I_{SW_LEAK}				10	μA
Maximum Duty Cycle	D_{DUTY}	F_S=300kHz			90	%
Switching Frequency	F_S	R_{FSW}=300kΩ		310		kHz
		FSW pin floating		130		kHz
		FSW short to GND		500		kHz
Switch On-Resistance (H side)	R_{ON_HS}	By design		80		mΩ
Switch On-Resistance (L side)	R_{ON_LS}	By design		60		mΩ
Short circuit Frequency	F_{SC}	V_{FB}=0V		35		kHz
Minimum Turn-on Time	T_{ON_MIN}			200		ns
EN High Level Input Voltage	V_{EN_H}		1.5			V
EN Low Level Input Voltage	V_{EN_L}				0.3	V
Thermal Shutdown Threshold (Note 3)	T_{SDN}			155		°C
Thermal Shutdown Hysteresis (Note 3)	T_{SDN_HY}			20		°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: $T_J = T_A + P_D \times \theta_{JA}$. The maximum allowable continuous power dissipation at any ambient temperature is calculated by $P_{D\,(MAX)} = (T_{J(MAX)}-T_A)/\theta_{JA}$.

Note 3: Thermal shutdown threshold and hysteresis are guaranteed by design.

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FUNCTIONAL DESCRIPTION

TMI3331 and TMI3331A are peak current mode pulse width modulation (PWM) converter with CC and CV control. 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 VSW + 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 FB is lower than the reference voltage, COMP tends to go higher to increase current to the output. Output current will increase, and the output voltage be regulated.

FUNCTIONAL BLOCK DIAGRAM

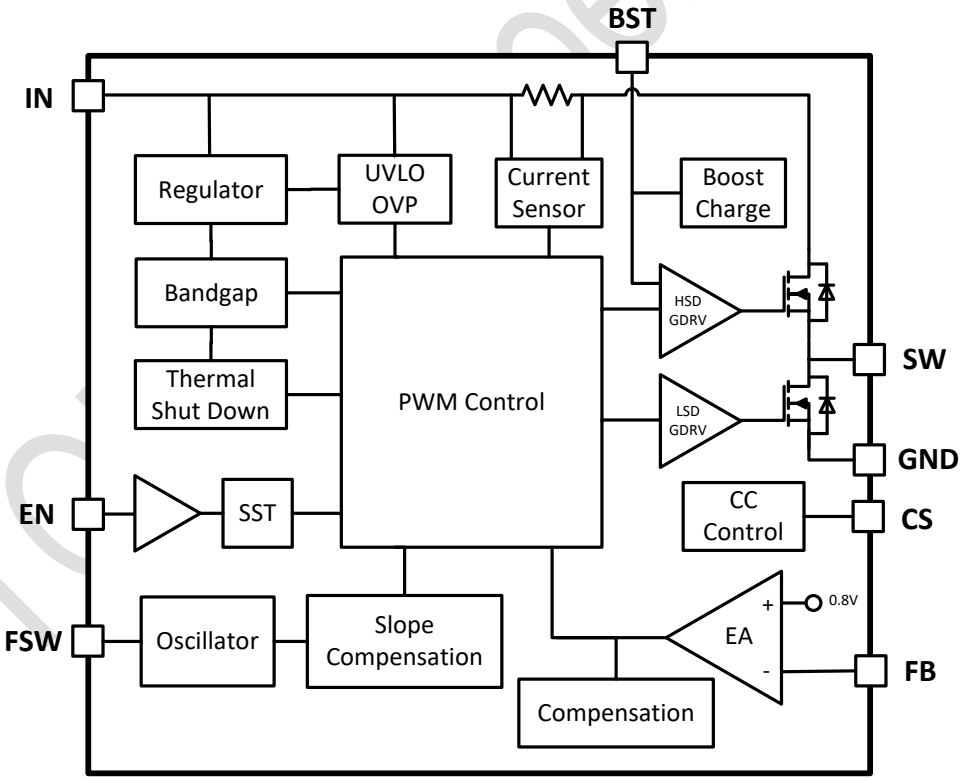

Figure 3. TMI3331 and TMI3331A Block Diagram

APPLICATION INFORMATION

Output Voltage Setting

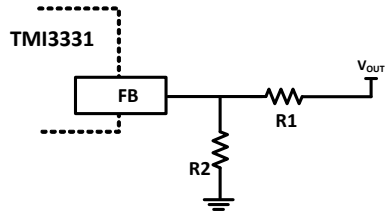

Figure 4: Output Voltage Setting

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 ≈75kΩ and determine R1 from the following equation:

$$R1=R2\cdot\left(\frac{V_{OUT}}{0.8V}-1\right)$$

For DC/DC application with only ceramic output capacitors (two paralleling 22µF capacitors or one 47µF capacitor are recommended), a 22pF feedforward capacitor paralleling with R1 (R1 is recommended larger than 200kΩ resistance) is recommended for stability and better load transient performance.

Over Voltage Protection

The thresholds of input OVP circuit include are minimum 31.5V. 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, the high-side MOSFET will be enabled again.

Thermal Shutdown

The TMI3331 and TMI3331A disables switching when its junction temperature exceeds 155°C and resumes when the temperature has dropped by 20°C.

Setting the Switching Frequency

The Oscillator normally switches at 130kHz~500kHz, which is set by FSW resistance as Table 1

R_{FSW}	Floating	R_{FSW}=300kΩ	R_{FSW}=250kΩ	R_{FSW}=200kΩ	Short to GND
Frequency (typ.)	130kHz	310kHz	350kHz	410kHz	500kHz

Table 1. Switching frequency vs. R_{FSW}

Constant Current Limit Setting

TMI3331 and TMI3331A have output constant current limit function. The constant current value is set by a resistor Rcs connected between the CS pin and GND. The CC output current is calculated by $I_{LIM}= V_{LIM\_CS}$ /Rcs. If there is no constant current limit requirement, CS could be connected to GND directly and internal cycle-by-cycle peak current limit function is active with over current condition.

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Setting the Cable Compensation

TMI3331 and TMI3331A provide programmable cable voltage drop compensation using the impedance at the FB pin to compensate voltage drop across the charger's output cable if Rcs resistor is used between CS pin and GND. The cable compensation voltage can be expressed as: $V_{comp}=I_{load} \times 10^{-6} \times R_{FB1}$. By adjusting the value of R_{FB1}, the cable compensation voltage can be programmed.

EMI Consideration

Since parasitic inductance and capacitance effects in PCB circuitry would cause a spike voltage on SW node when high-side MOSFET is turned on/off, this spike voltage on SW may impact on EMI performance in the system. In order to enhance EMI performance, there are two methods to suppress the spike voltage. One is to place an RC snubber between SW and GND and make them as close as possible to the high-side MOSFET's source and low-side MOSFET's drain. Another method is to add a resistor in series with the bootstrap capacitor C3. But this method will decrease the driving capability to the high-side MOSFET. It is strongly recommended to reserve the RC snubber during PCB layout for EMI improvement. Moreover, reducing the PHASE trace area and keeping the main power in a small loop will be helpful on EMI performance.

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 CIN, IN pin, SW pin.
2) Place input decoupling ceramic capacitor C_{IN} as close to IN pin as possible. C_{IN} is connected power GND short and wide path or with vias.
3) Return FB 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

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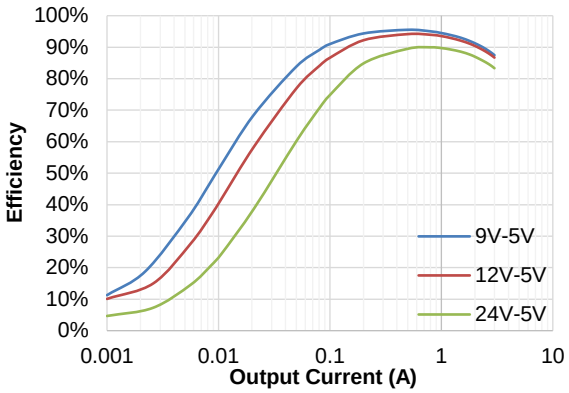
Typical Performance Characteristics

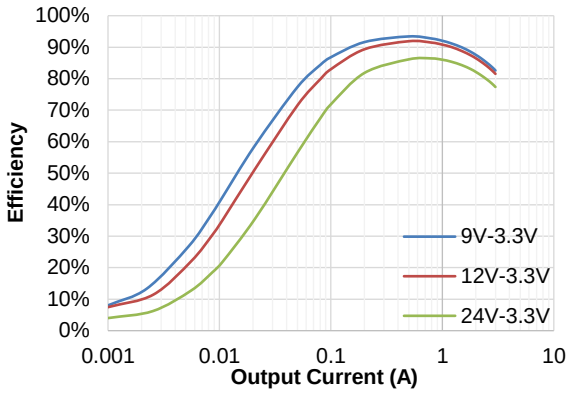
Efficiency

V_{OUT} =5V, L=10μH



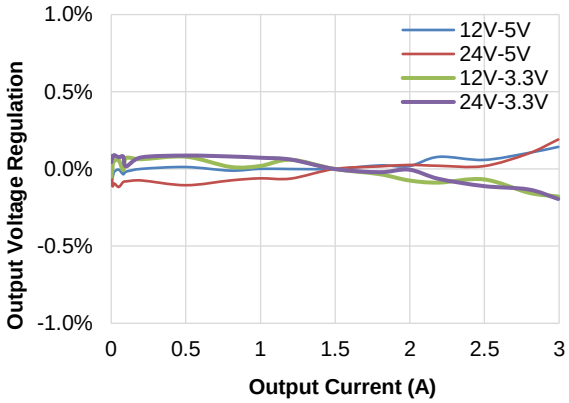
Efficiency

V_{OUT} =3.3V, L=10μH



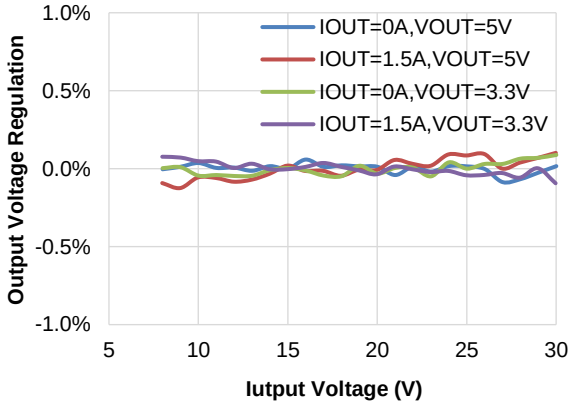
Load Regulation

T_A=25°C



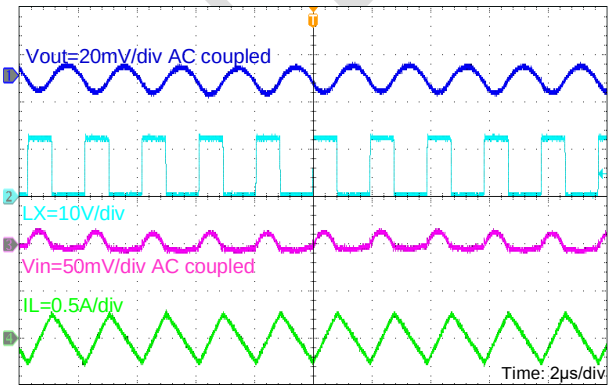
Line Regulation

T_A=25°C



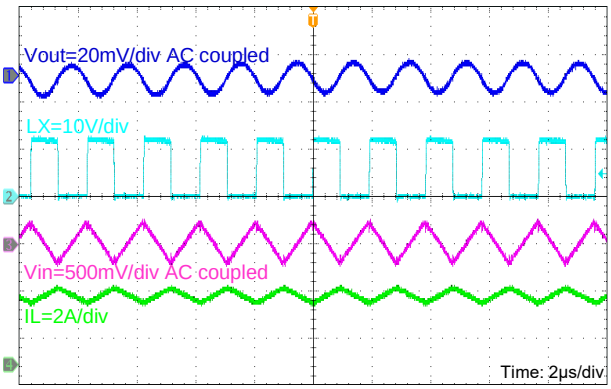
Steady State Operation

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



Steady State Operation

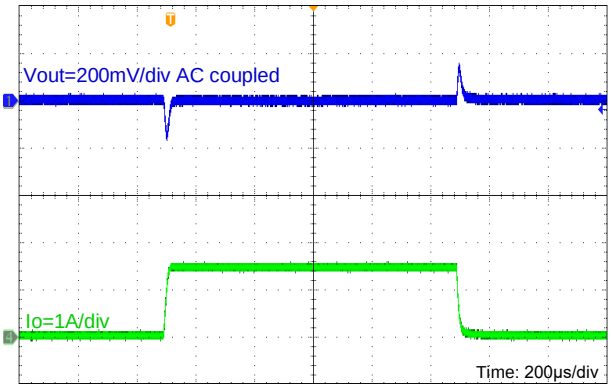
V_{IN} =12V, V_{OUT} =5V, I_o= 3A



Typical Performance Characteristics(continued)

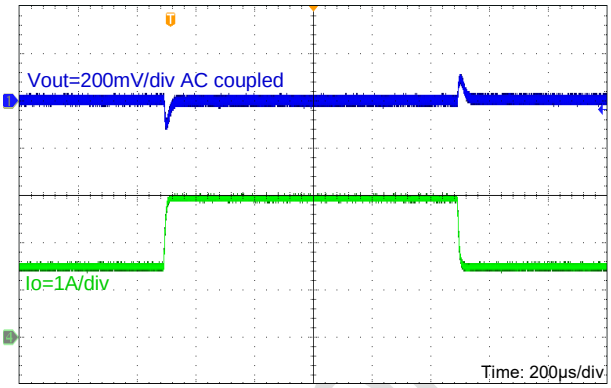
Load Transient

V_{IN} =12V, V_{OUT} =5V, I_o =0A to 1.5A



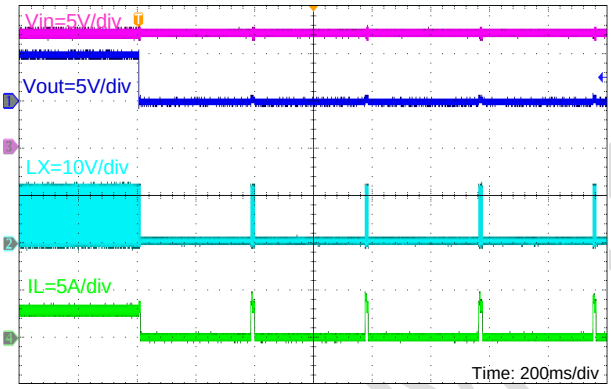
Load Transient

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



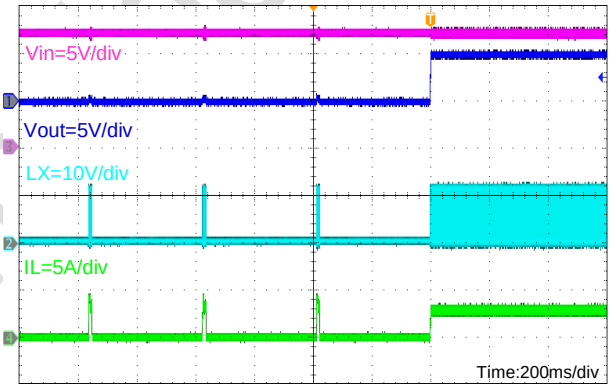
Output Short Entry

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



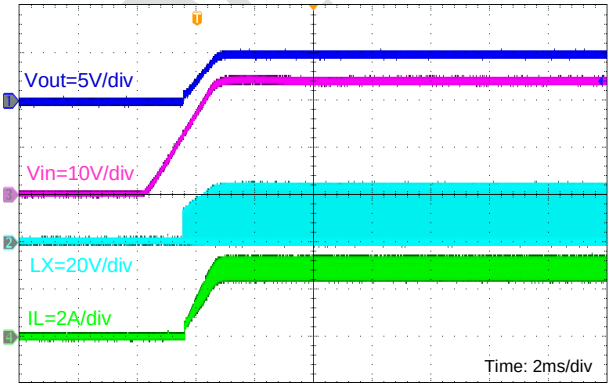
Output Short Recovery

V_{IN}=12V, V_{OUT} =5V, I_o = 1.2A



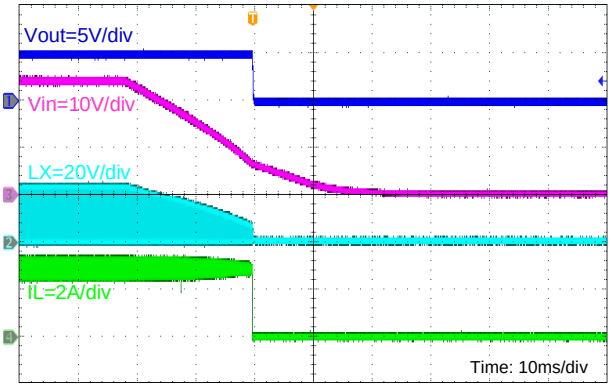
Input Power On

V_{IN} =24V, V_{OUT} =5V, I_o = 3A



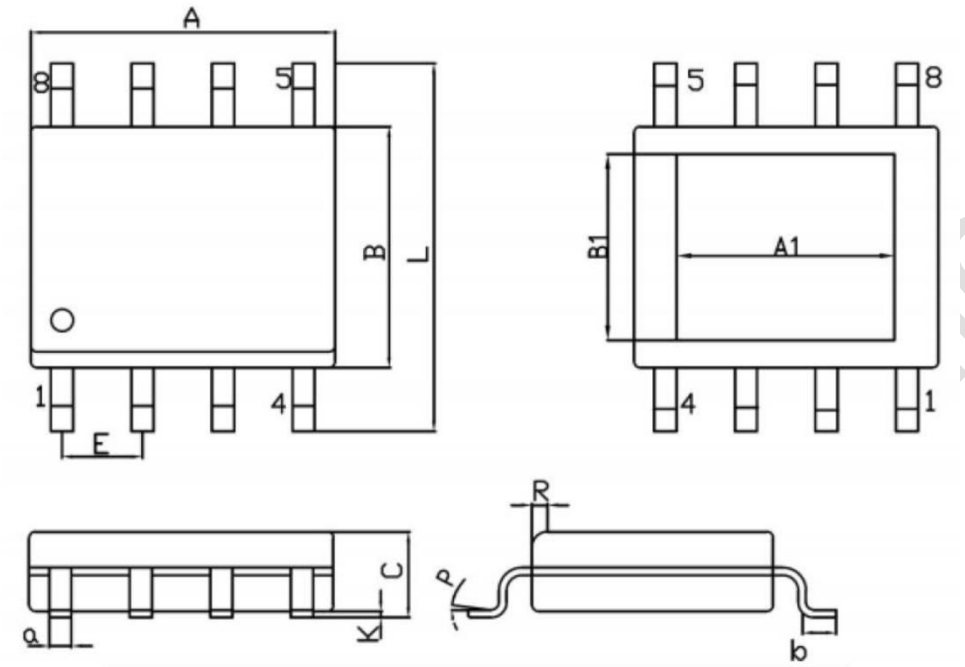
Input Power Down

V_{IN} =24V, V_{OUT} =5V, I_o = 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.

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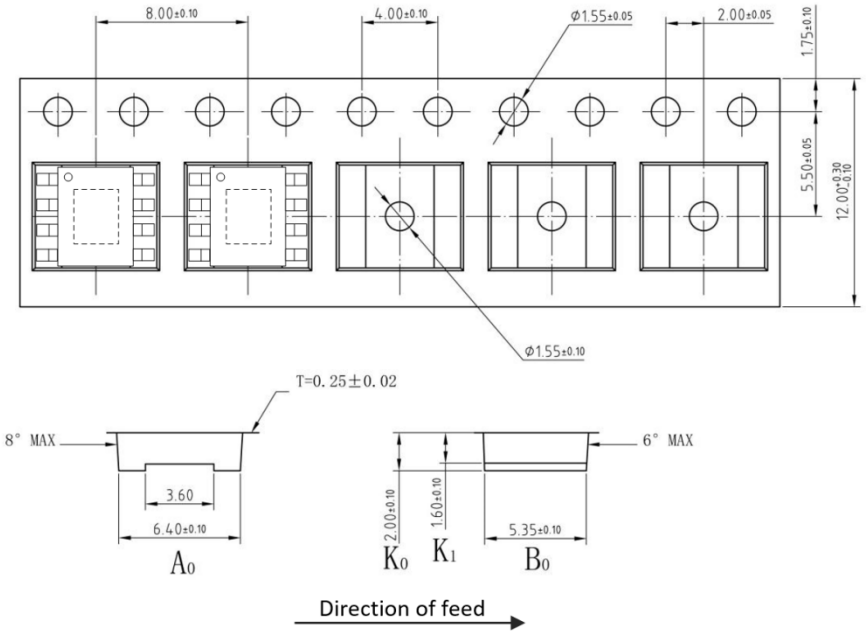
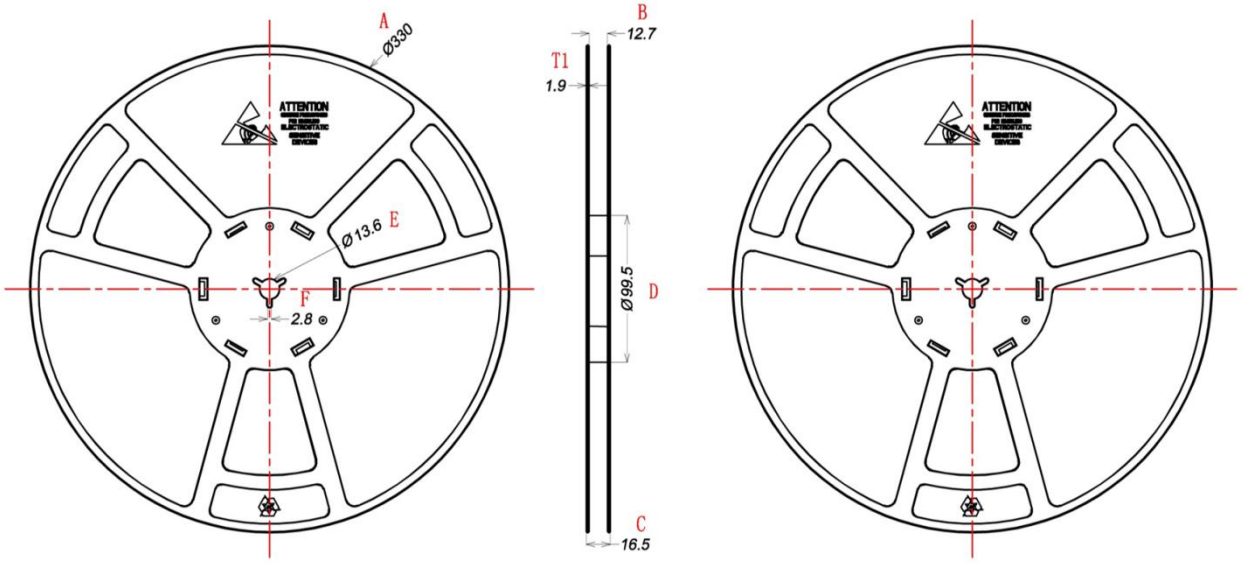
TAPE AND REEL INFORMATION

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.