20V Low Saturation Voltage Stepper Motor Driver with Built-in Micro-step Control Algorithm

FEATURES

- Drive One Stepper Motor
- Built-in Micro-Step Algorithm to Decrease the Noise and Jittering of Stepper Motor
- Three Adjustable Preset Speed Levels
- Wide 4V to 20V Operating Voltage of VCC
- LDMOS $R_{DS(ON)}$ (HS+LS): 0.83Ω (typical)
- 1.0-A Peak Current Drive
- No PWM Control Signal Needed
- Low-Power Sleep Mode
- VCC Undervoltage Lockout (UVLO)
- Thermal Shutdown Protection (TSD)
- ESOP8 Package and Footprint
- RoHS Compliant and 100% Lead (Pb)-Free and Halogen-Free

APPLICATIONS

- TV Camera
- IP Camera
- Industrial Equipment
- Other Low Noise Stepper Motor

GENERAL DESCRIPTION

The TMI88221/B devices are the stepper motor drivers for TV camera, IPC, industrial equipment, and other low noise stepper motor application. With wide 4V to 20V input voltage range, TMI88221/B can be powered by DC power supply and single or multi-cell lithium battery.

Different from traditional chips, there is no pulse width modulated (PWM) signals needed to drive stepper motors, which means only two logic signals are able to switch all the modes, and the built-in micro step algorithm in TMI88221/B can help to decrease the common noise and jittering of motor. Moreover, the TMI88221/B preset 3-level speed mode and can be adjusted easily.

The TMI88221/B preset the low-power sleep mode, and the power consumption is narrowly closed to zero at this mode.

The TMI88221/B can drive motors with up to 1A current. ESOP8 package is adopted.

TYPICAL APPILCATION

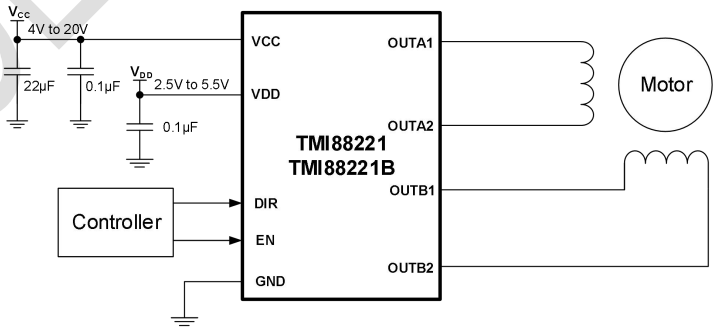
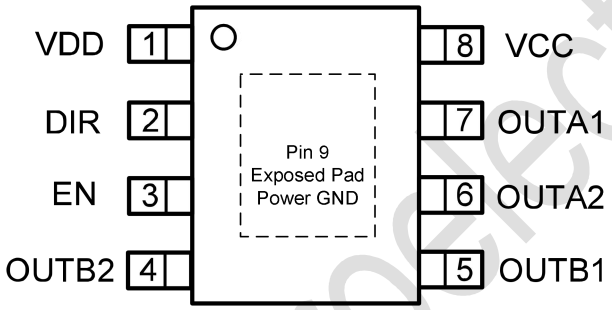


Figure 1. Typical Application of TMI88221/B

ABSOLUTE MAXIMUM RATINGS (Note1)

Items	Symbol	Value	Max	Unit
VCC power supply voltage	V_{CC}	-0.3	24	V
VDD Logic power supply voltage	V_{DD}	-0.3	6	V
Output impression voltage	V_{OUTA1}, V_{OUTA2}, V_{OUTB1}, V_{OUTB2}	-0.3	V_{CC}+0.3	V
Control input impression voltage	V_{EN}, V_{DIR}	-0.3	V_{DD}+0.3	V
GND pin flow current per channel	I_{GND}	-	1.0	A
Allowable Power dissipation	P_D max	-	1.0	W
Junction Temperature (Note2)	T_J	-40	150	°C
Storage temperature	T_{stg}	-40	165	°C

PACKAGE/ORDER INFORMATION



ESOP8

Top Mark: TMI88221/XXXXX (TMI88221: Device Code, XXXXX: Inside Code)

Part Number	Package	Top mark	Quantity/ Reel
TMI88221 TMI88221B	ESOP8	TMI88221 XXXXX	3000

TMI88221/B devices are Pb-free and RoHS compliant.

PIN FUNCTION

Pin	Name	Function
1	VDD	Logic control power supply voltage pin.
2	DIR	Motor drive direction control pin. Internal pull-down.
3	EN	Motor drive enable control pin. When EN input is “H” level, the device is in stand-by mode. When EN input is pulled “L” level from “H” level, the device shifts from the stand-by state to a prescribed output operation mode. Internal pull-up. EN signal could set motor speed, please see function description.
4	OUTB2	OUTB2 Driving output pin. The motor coil is connected between this pin and pin5.
5	OUTB1	OUTB1 Driving output pin. The motor coil is connected between this pin and pin4.
6	OUTA2	OUTA2 Driving output pin. The motor coil is connected between this pin and pin7.
7	OUTA1	OUTA1 Driving output pin. The motor coil is connected between this pin and pin6.
8	VCC	Power-supply voltage pin for inner MOSFETs. The capacitors to GND pin are connected for stabilization of input supply voltage.
9	GND	Exposed pad. It is ground pin.

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
V_{CC}	Power supply voltage of VCC	4	20	V
V_{DD}	Logic power supply voltage	2.5	5.5	V
T_J	Operating junction temperature range	-40	125	°C

ELECTRICAL CHARACTERISTICS

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

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
VCC Voltage Range	V_{CC}		4		20	V
VCC Supply Current	I_{CC0}	Standby mode, EN=H			1	μA
	I_{CC1}	EN=L		2.5	3	mA
VCC UVLO Rising Threshold	V_{th_VCC}			3.8	3.9	V
VCC UVLO Hysteresis	V_{sys_VCC}			0.25		V
VDD Voltage Range	V_{DD}		2.5		5.5	V
VDD Supply Current	I_{DD}	V_{DD}=5V		2.7		mA
		V_{DD}=3.3V		1.8		mA
Output ON Resistance (HS+LS)	$R_{DS(ON)}$	I_{OUT}=1.0A		0.83		Ω
Output Leak Current	I_{O_leak}	V_{OUTx}=16V	0		10	μA
Diode Forward Voltage	V_D	I_D=1.0A			1.2	V
EN and DIR Logic High Level Voltage Threshold	V_{IN_H}			0.58 x V_{DD}	0.75 x V_{DD}	V
EN and DIR Logic Low Level Voltage Threshold	V_{IN_L}		0.2 x V_{DD}	0.35 x V_{DD}		V
The Reserved Time of Speed Level Setting	T_{EN}			420		μs
The Duration of EN High Level	T_H		55	70	80	μs
The Duration of EN Low Level	T_L		55	70	80	μs
Thermal Shutdown Threshold	T_{SD}	Guaranteed by Design		160		°C
Thermal Shutdown Hysteresis	T_{SD_H}	Guaranteed by Design		40		°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 $P_{D\,(MAX)} = (T_{J(MAX)}-T_A)/\theta_{JA}$.

BLOCK DIAGRAM

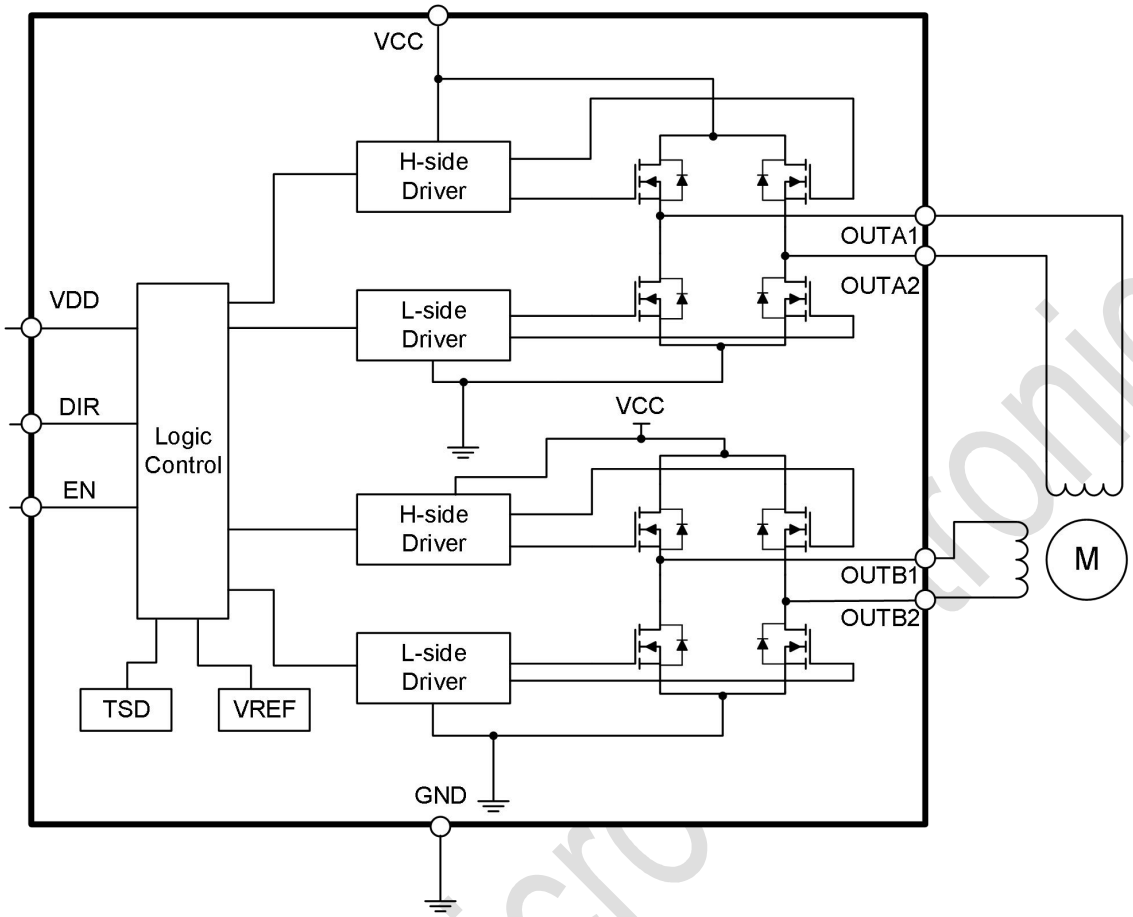


Figure 2. TMI88221/B Block Diagram

FUNCTION DESCRIPTION

1. General description

The TMI88221/B are capable of driving stepper motors and needs no PWM signals. Two logic control pins EN and DIR are designed to realize all the functions of motor control. With the built-in micro-step algorithm, TMI88221 drives stepper motors extremely quiet and the common noise problem is not existed. The TMI88221 can drive motors with up to 1A current. The TMI88221/B integrate 3 speed levels controlled by EN signal to fix all the conditions.

2. Output Current Control

The TMI88221/B integrate micro-step current control function, which means the output currents can be regulated as a sine curve and a cosine curve. The TMI88221/B will deliver a full square wave into a sine or cosine wave, and this can significantly reduce the working noise and current spike. The micro-step control current curve is shown as follows, and in order to easy read, the curve is simplified to 64 steps for example.

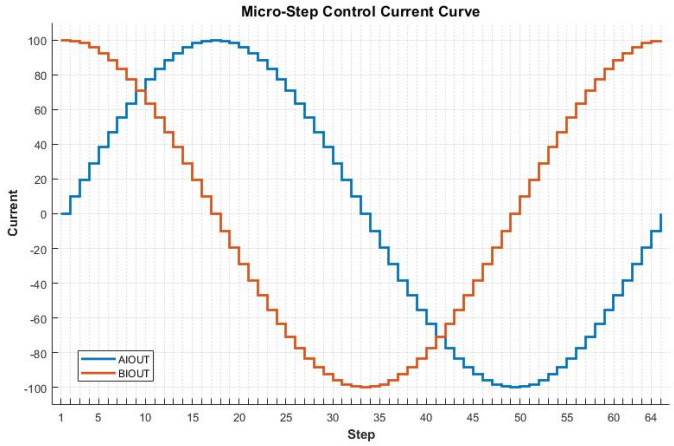


Figure 3. Output Current Waveforms of 64 Micro-step

3. The logic control operation state

When EN pin is "H", this IC is going to a standby mode. After about 7μs of an internal setting, it shifts to a prescribed output status corresponding to the state of the input when the logic low signal enters the EN pin, then the motor current will run follow the state until the EN pin turns up.

Input		Output Current		State
EN	DIR	IOUTA	IOUTB	
H	-	OFF	OFF	Standby
L	L	SIN	COS	Step 1
	H	-SIN	COS	Step 2

The DIR pin is used to control the motor direction and the state is shown in DCM table. The direction can be switched anytime, and if the DIR is changed when the motor is running, the IC will be shut down for about 60μs, then the motor goes around in the opposite direction.

The EN and DIR control function is shown as the following table and figures:

DIR=L

IOUTA = SIN, IOUTB = COS

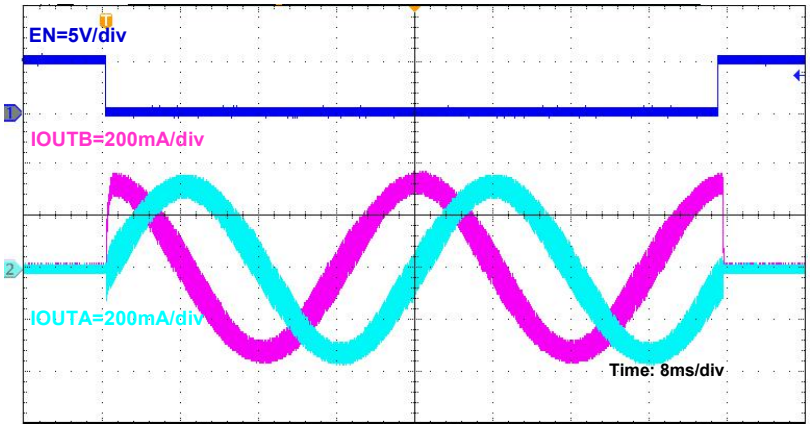


Figure 4. Output Current and EN signal Waveforms with DIR=L

DIR=H

IOUTA = SIN, IOUTB = COS

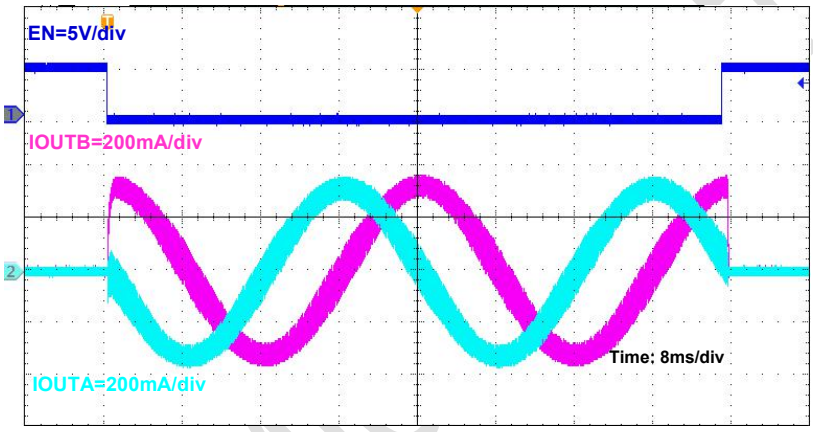


Figure 5. Output Current and EN signal Waveforms with DIR=H

When the VDD is turned low, the inner logic control will reset.

4. Motor speed control

The TMI88221/B integrate 3 preset speed levels and can be adjusted by pulse counts of EN control signal. The control details are shown as follows.

T_{EN}: The reserved time to set motor speed level after every EN pull low event from standby mode. During the T_{EN} time, the dual H-bridge is still in standby mode and four output port is in Hi-Z status. The EN sign could be pulled low and pulled high to indictor speed level needed. When the T_{EN} time is over, the micro-step control output starts to action according to the EN pulse counts within T_{EN} time. Then, the EN signal is used as the shutdown control. The output is disable and the device in standby mode after a complete IOUTA current sine wave period once EN signal is pulled up to high level.

The EN pulse counts signal to reset motor speed level must be performed after every EN pull low event from standby mode.

T_H: During the T_{EN} time, the duration time of the EN pulse high level is required;

T_L: During the T_{EN} time, the duration time of the EN pulse low level is required.

Noticing the time requirements of T_H and T_L should be set to the same value.

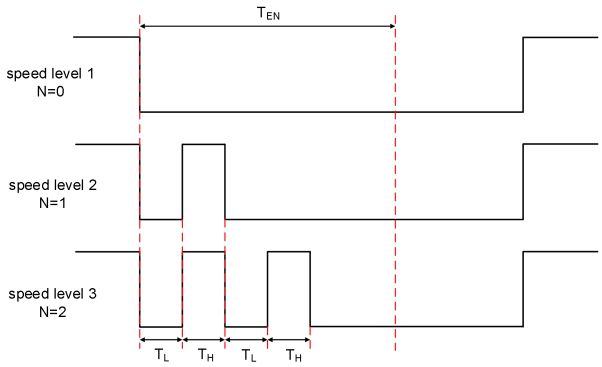


Figure 6. Three Speed Level EN Signals

Determine the speed levels according to the count number N of T_H and T_L within the T_{EN} time:

AS FOR TMI88221:

N=0. It is the speed level 1：the output control current cycle is 1.8ms with 32 micro-step control;

N=1. It is the speed level 2：the output control current cycle is 3.6ms with 64 micro-step control;

N=2. It is the speed level 3：the output control current cycle is 7.2ms with 128 micro-step control;

All speed control signals and the speed modes are shown as follows:

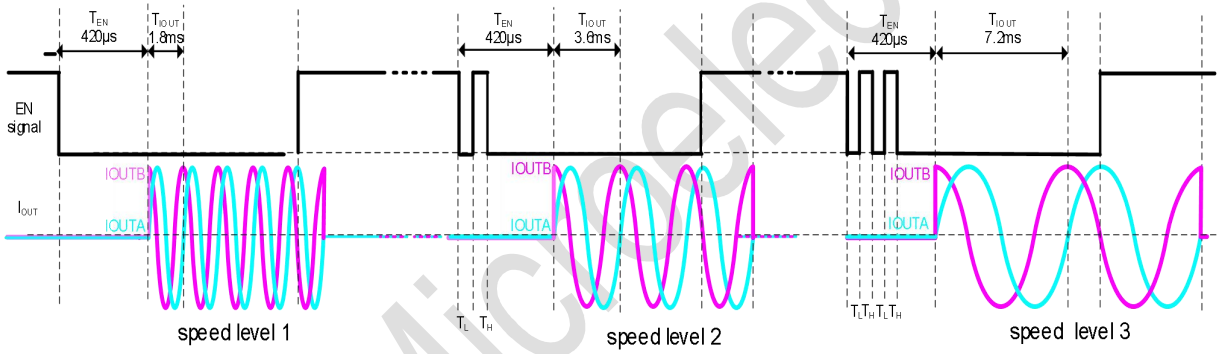


Figure 7. Three Speed Level EN Signals and Two Output Current Waveforms for TMI88221

AS FOR TMI88221B:

N=0. It is the speed level 1：the output control current cycle is 7.2ms with 128 micro-step control;

N=1. It is the speed level 2：the output control current cycle is 3.6ms with 64 micro-step control;

N=2. It is the speed level 3：the output control current cycle is 1.8ms with 32 micro-step control;

All speed control signals and the speed modes are shown as follows:

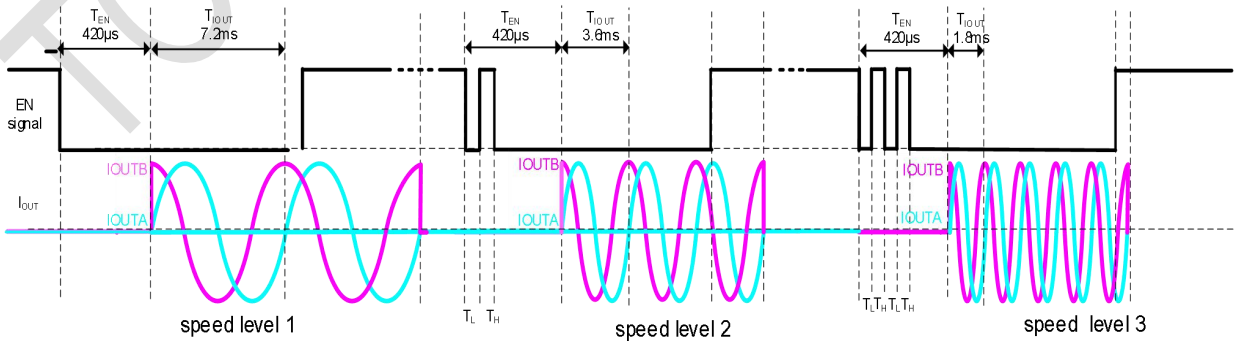


Figure 8. Three Speed Level EN Signals and Two Output Current Waveforms for TMI88221B

5. Thermal shutdown function

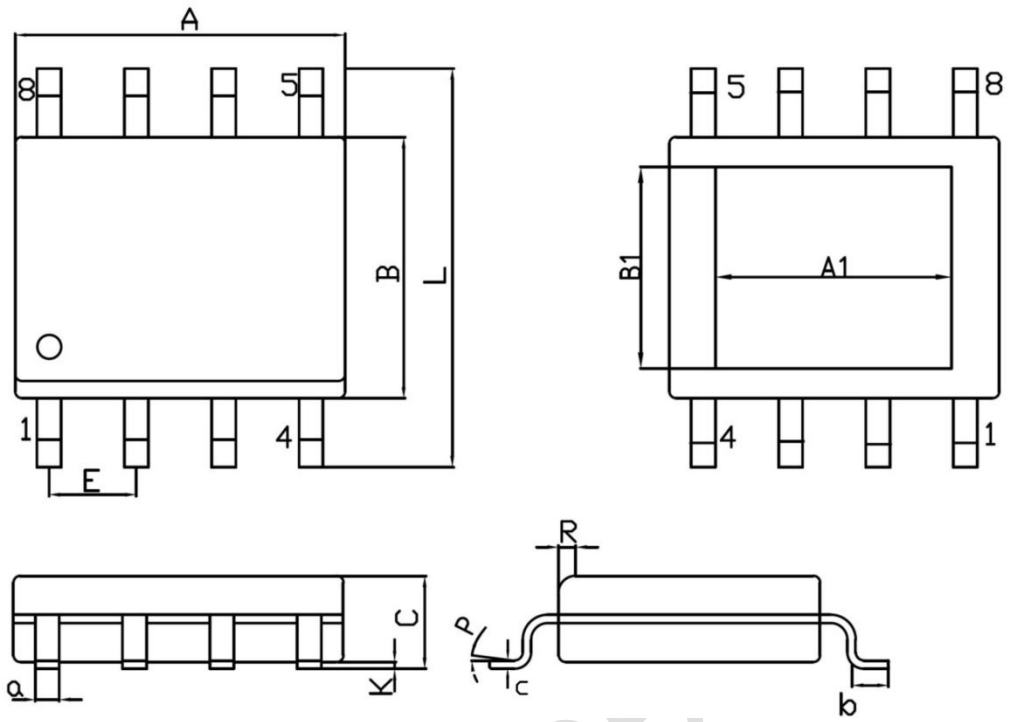
The thermal shutdown circuit is incorporated and the output of the device is turned off when junction temperature T_J exceeds 160°C. As the temperature falls by hysteresis, the output of the device is turned on again (automatic restoration). The thermal shutdown circuit does not guarantee the protection of the final product because it operates when the temperature exceeds the junction temperature of T_{J_max}=150°C.

T_{SD} = 160°C (typ)

ΔT_{SD} = 40°C (typ)

PACKAGE INFORMATION

ESOP8



Unit: mm

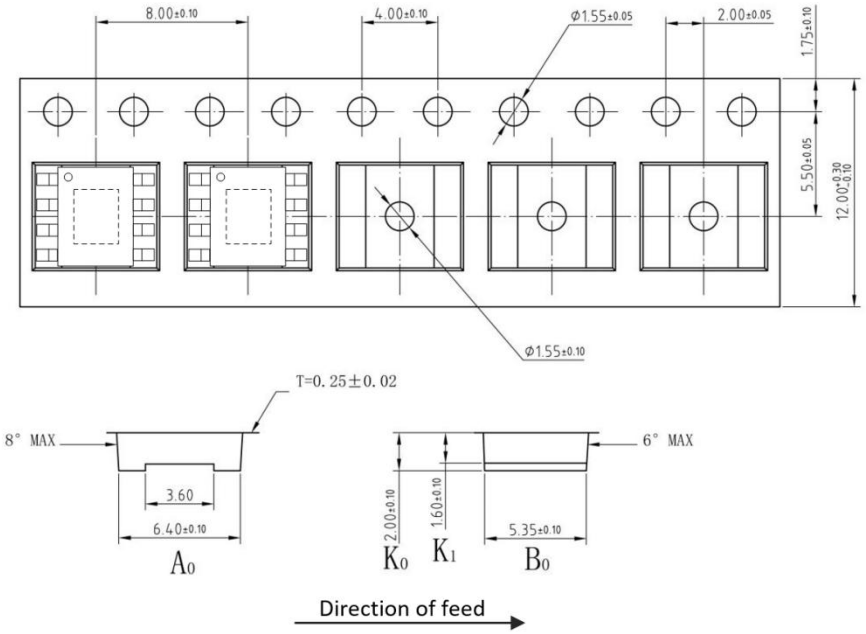
Symbol	Dimensions in Millimeters		Symbol	Dimensions in Millimeters	
	Min	Max		Min	Max
A	4.70	5.10	C	1.35	1.75
B	3.70	4.10	a	0.35	0.49
L	6.00	6.40	R	0.30	0.60
E	1.27 BSC		P	0°	7°
K	0.02	0.10	b	0.40	1.25
A1	3.1	3.5	B1	2.2	2.6
c	0.203	0.243			

Note:

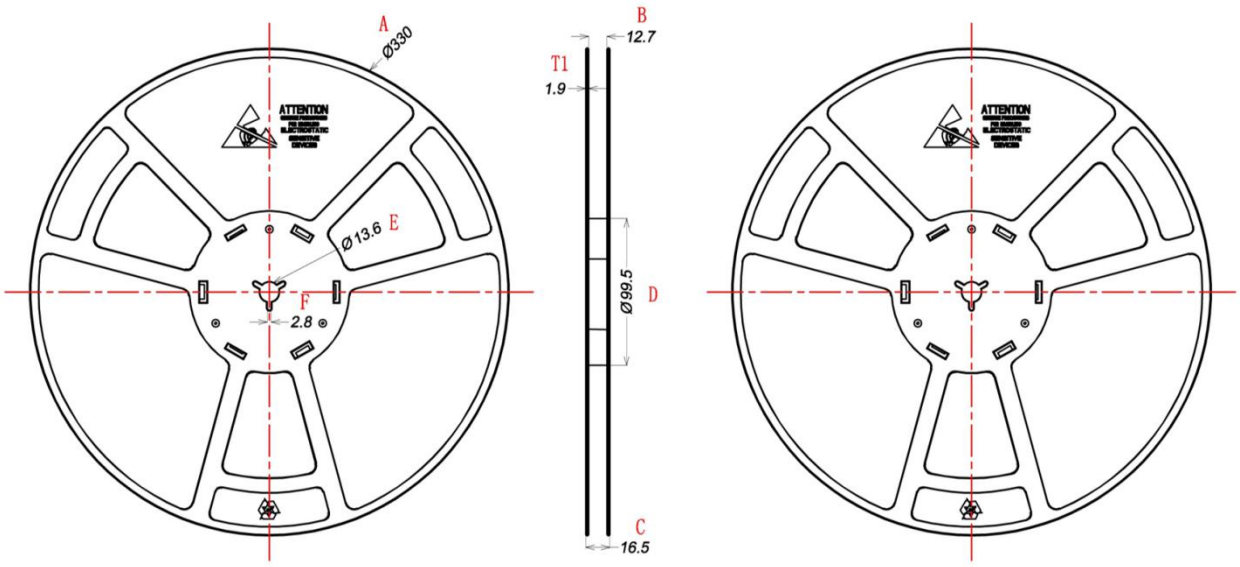
1) All dimensions are in millimeters.
2) Package length does not include mold flash, protrusion or gate burr.
3) Package width does not include inter lead flash or protrusion.
4) Lead popularity (bottom of leads after forming) shall be 0.10 millimeters max.
5) Pin 1 is lower left pin when reading top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

TAPE AND REEL INFORMATION

TAPE DIMENSIONS:



REEL DIMENSIONS:



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.