1.6X Linear Regulator for DC Fan Driver Control

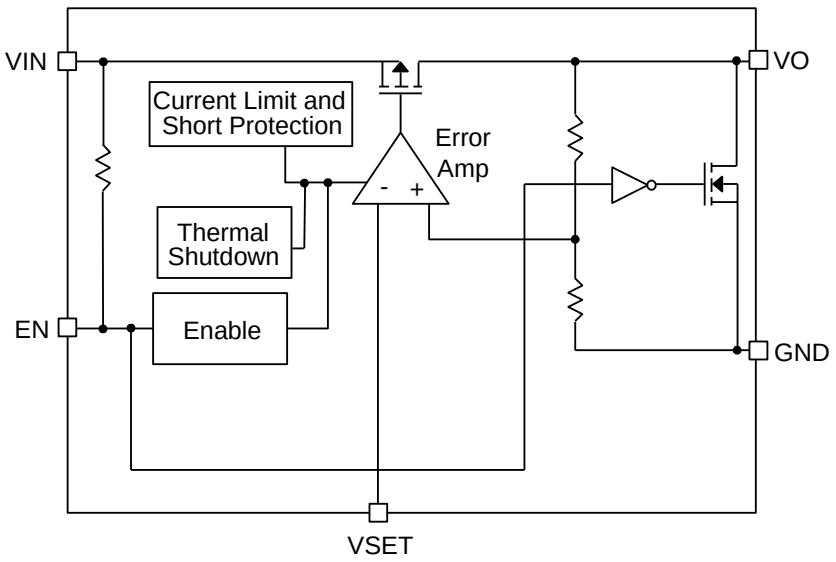
❖ GENERAL DESCRIPTION

The AX993B is a low dropout linear regulator which is designed to power a DC fan and delivers up to 600mA output current. The output voltage follows the 1.6 times of VSET voltage and typical dropout voltage is only 200mV (typical) at 600mA output current. The VSET voltage can form 0.1V to 3.3V to guarantee V_O 1.6 times of VSET. An enable pin further reduces power dissipation while shut-down. The features of current limit (with fold back current) and over temperature protection protect the device against current over-loads and over temperature. The AX993B is available in a TSOT23-6L package.

❖ FEATURES

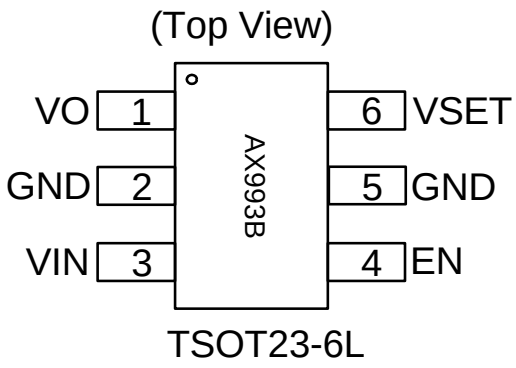
- Low Dropout Voltage: 200mV@0.6A
- V_O Follows 1.6 times of VSET
- Enable/Shutdown function
- Stable with Low ESR Ceramic Capacitors
- Current-Limit and Thermal Shutdown Protection
- TSOT23-6L Pb-Free Package
- RoHS and Halogen free compliance

❖ BLOCK DIAGRAM



❖ PIN ASSIGNMENT

The package of AX993B is TSOT23-6L; the pin assignment is given by:



Name	Description
VO	Output Pin. Its voltage is 1.6 times of VSET
GND	GND pin
VIN	IC power supply pin
EN	This pin is pulling High inside. If EN input < 0.8V, the IC is into shutdown mode.
VSET	This pin sets the output voltage. Its voltage can form 0.1V to 3.3V to guarantee VO 1.6 times of VSET

❖ ORDER/MARKING INFORMATION

Order Information	Top Marking
AX993B XX X Package Type CT: TSOT23-6L Packing Blank: Bag A : Taping	HCY WX → ID code:internal WW:01~26 (A~Z) 27~52 (a~z) Year: 8=2018 9=2019 B=2020 C=2021 D=2022 : Z=2044 AX993B

❖ ABSOLUTE MAXIMUM RATINGS (at T_A=25°C)

Characteristics	Symbol	Rating	Unit
VIN Supply Voltage	V_{IN}	-0.3 to 6.5	V
EN Voltage	V_{EN}	-0.3 to VIN	V
VSET Voltage	V_{SET}	-0.3 to VIN	V
Power Dissipation	PD	Internally limited	W
Storage Temperature Range	T_{ST}	-65 to +150	°C
Junction Temperature Range	T_J	-40 to 125	°C
Operating Temperature Range	T_{OP}	-40 to +85	°C
Thermal Resistance from Junction to case	θ_{JC}	50	°C/W
Thermal Resistance from Junction to ambient	θ_{JA}	100	°C/W

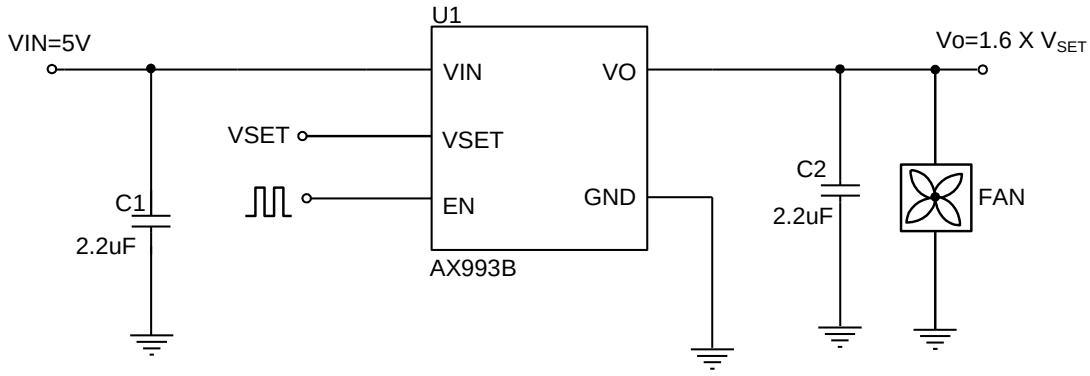
Note: θ_{JA} is measured with the PCB copper area approximately 1.5 in^2 (Multi-layer) that connect to GND Pins.

❖ ELECTRICAL CHARACTERISTICS

(V_{SET} = 2V, V_{IN} = 5V, I_{OUT} = 0.5A, C_{IN}=C_{OUT}=2.2uF, T_A=25°C unless otherwise specified)

Characteristics	Symbol	Conditions	Min	Typ	Max	Units
VIN Supply Voltage Range	V_{IN}		4.5	-	6	V
Quiescent Current	I_{CCQ}	No Load	-	50	80	uA
Standby Current	I_{STB}	V_{EN}=0V	-	1	10	uA
Output Voltage/V_{SET} Voltage	V_O/V_{SET}	V_{IN}=5.5V, V_{SET}=1V~3.3V	1.552	1.6	1.648	V/V
Line Regulation		V_{IN}=4.5V to 5.5V	-	0.2	0.5	%
Load Regulation		I_{OUT}=10mA ~ 0.6A	-	30	60	mV
Dropout Voltage	V_{Drop}	I_{OUT}=0.6A, V_{SET}=3.3V	-	200	320	mV
Current Limit	I_{Limt}		700	-	-	mA
Short Circuit Current	I_{Short}	Vo<0.6V	-	250	-	mA
V_{SET} Voltage Range	V_{SET}		0.1	-	3.3	V
V_{SET} Pin Current	I_{SET}	V_{SET}=5V	-	80	200	nA
EN Pin Logic Threshold Voltage	V_{EN-H}	Operating mode	2.0	-	-	V
	V_{EN-L}	Shutdown mode	-	-	0.8	
Enable Pin Current	I_{ENH}	V_{EN}=V_{IN}	-	0.003	0.1	μA
	I_{ENL}	V_{IN}=5V, V_{EN}=0V	-	1	5	μA
VO pull Low Resistance	R_O	V_{EN}=0V	-	60	-	Ω
Thermal shutdown Temp	T_{SD}		-	150	-	°C
Thermal Shutdown Hysteresis			-	30	-	°C

❖ APPLICATION CIRCUIT



❖ FUNCTION DESCRIPTIONS

Output Voltage Regulation

The Output Voltage is set by VSET voltage. VO output voltage follows the 1.6 times of VSET voltage until it reaches VIN voltage.

Enable/Shutdown

Driving the EN high turns on the regulator, driving the EN low puts the regulator into shutdown mode. A logic low also causes the output voltage to discharge to the GND. The EN is pulled Hight by an internal resistor.

Current-Limit

The AX993B monitors the current via the output PMOS and limits the maximum current to prevent load and AX993B from damages during overload or short circuit conditions.

Short Current Protection

When the output voltage drops below 0.6V (typical), which is caused by over load or short circuit, the fold back current limit circuitry limits the output current to 250mA. The fold back current limit is used to reduce the power dissipation during short circuit condition.

Thermal Shutdown

A thermal shutdown circuit limits the junction temperature of AX993B. When the junction temperature exceeds +150°C, a thermal sensor turns off the output PMOS, allowing the device to cool down. The regulator regulates the output again through initiation of a new soft-start cycle after the junction temperature cools by 30°C, resulting in a pulsed output during continuous thermal overload conditions.

❖ APPLICATION INFORMATION

Capacitor Selection

Normally, use a 2.2μF capacitor on the input and a 2.2μF capacitor on the output of the AX993B. In order to insure the circuit stability, the proper output capacitor value should be larger than 1uF. With X5R and X7R dielectrics, 2.2uF is sufficient at all operating temperatures.

Thermal Considerations

The AX993B series can deliver a current of up to 600mA over the full operating junction temperature range. However, the maximum output current must be dated at higher ambient temperature to ensure the junction temperature does not exceed 125°C. With all possible conditions, the junction temperature must be within the range specified under operating conditions. Power dissipation can be calculated based on the output current and the voltage drop across regulator.

$$PD = (V_{IN} - V_O)\, I_O$$

The final operating junction temperature for any set of conditions can be estimated by the following thermal equation:

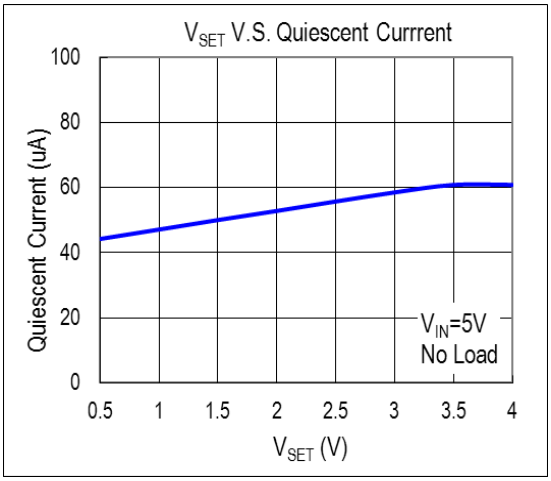
$$PD\ (MAX) = (T_{J\,(MAX)} - T_A) / \theta_{JA}$$

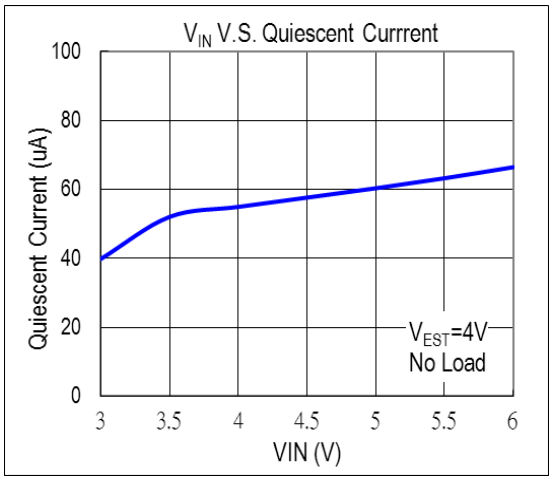
Where $T_{J\,(MAX)}$ is the maximum junction temperature of the die (125°C) and T_A is the maximum ambient temperature. The junction to ambient thermal resistance (θ_{JA}) for TSOT23-6L package at recommended minimum footprint is 100°C/W.

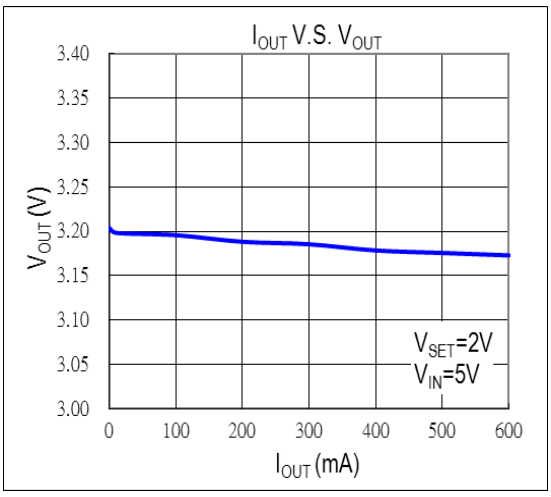
PCB Layout

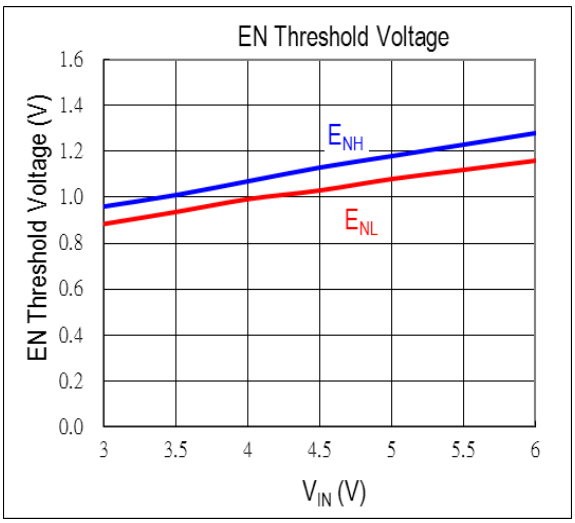
1. Please place the input capacitors close to the VIN
2. Ceramic capacitors for load must be placed near the load as close as possible
3. To place AX993B and output capacitors near the load is good for performance.
4. Large current paths that VIN and Output lines must have wide tracks.
5. GND connect large copper area can reduced IC temperature.

❖ TYPICAL CHARACTERISTICS

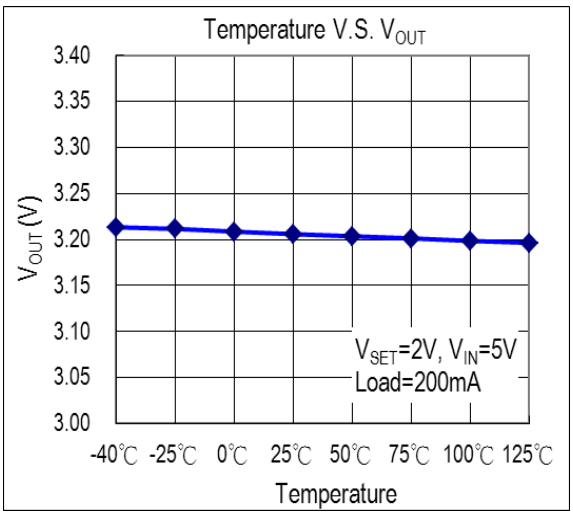


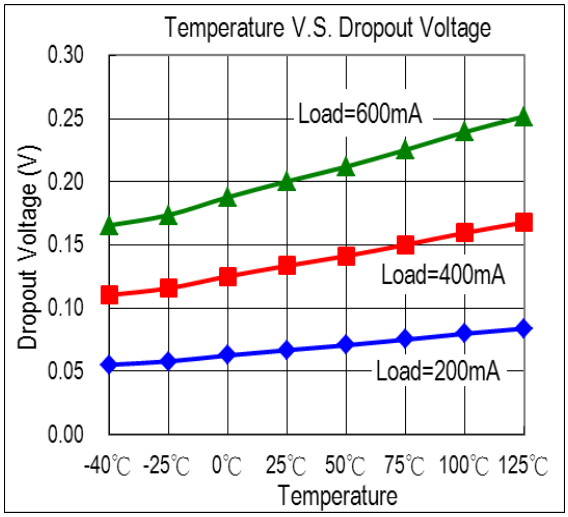


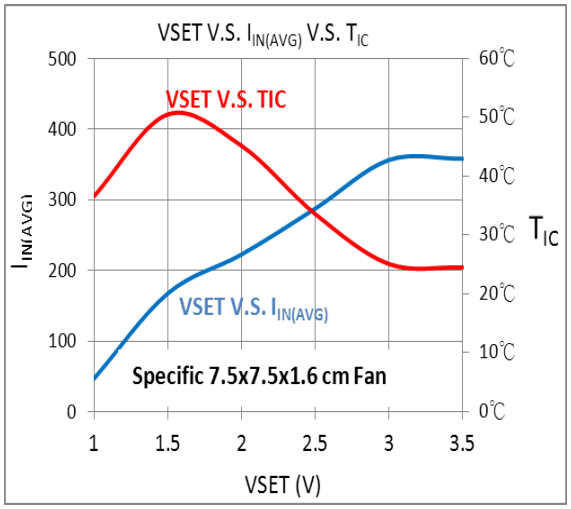


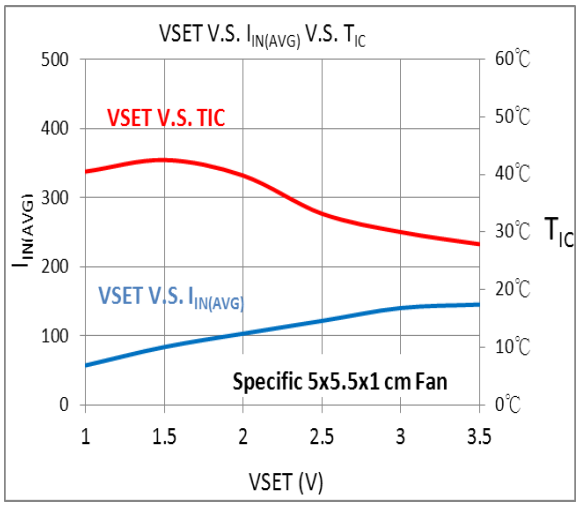


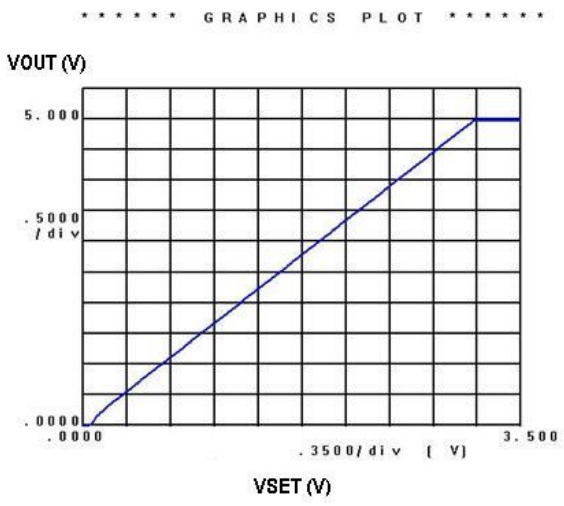
❖ TYPICAL CHARACTERISTICS (CONTINUES)





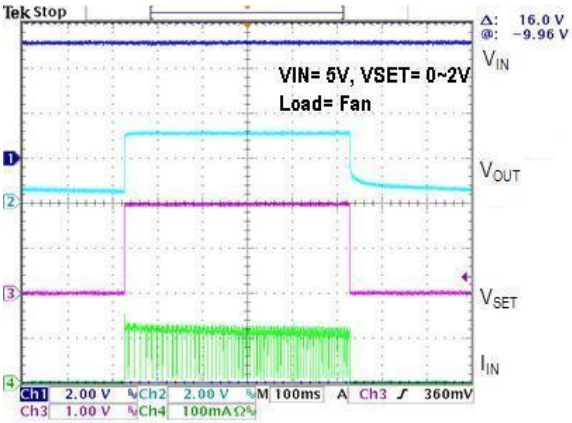




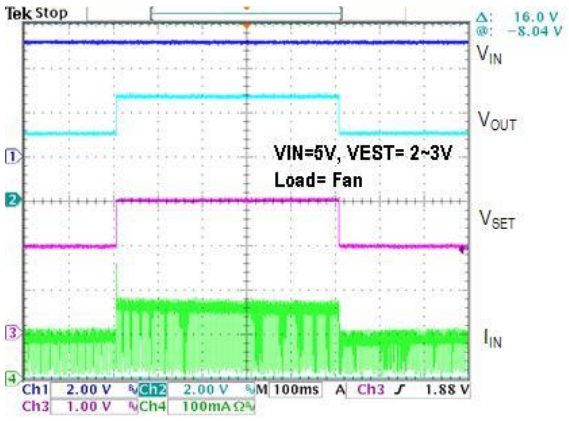


❖ TYPICAL CHARACTERISTICS (CONTINUES)

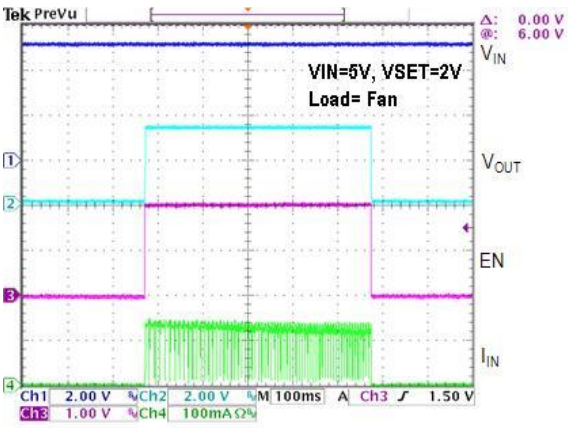
Line Transient



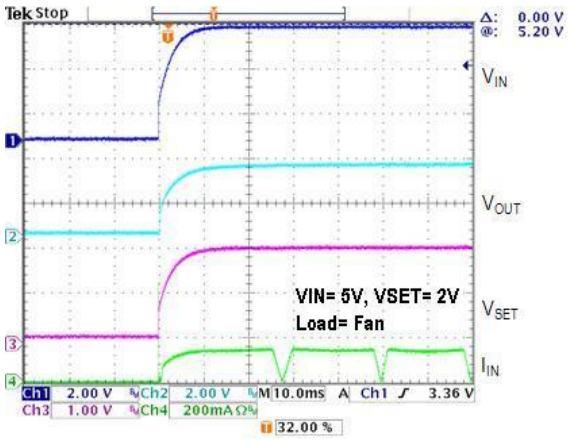
Line Transient



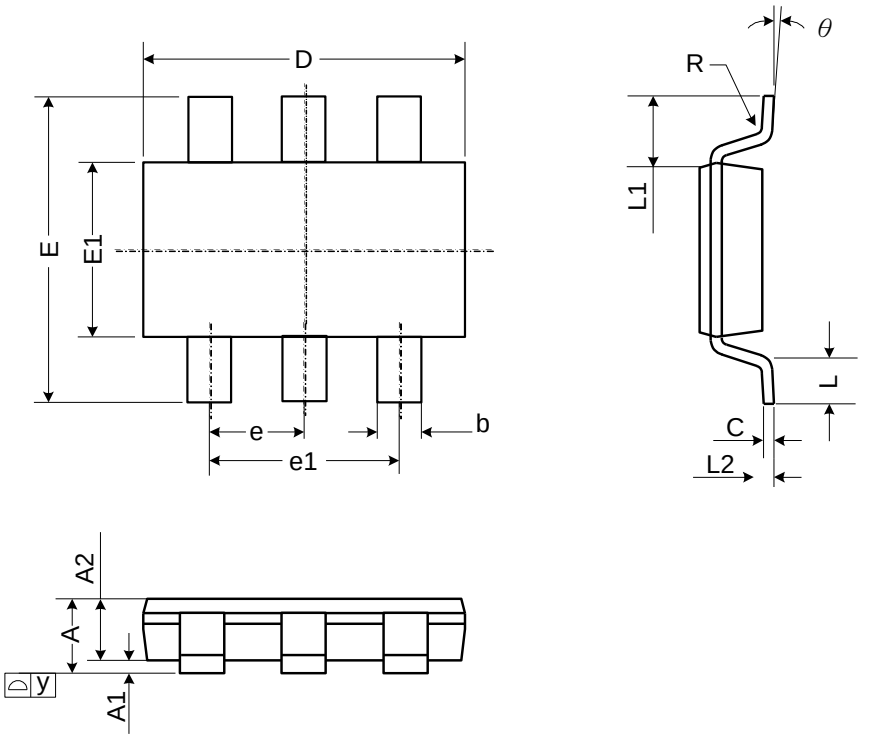
EN ON/OFF



Power ON



❖ PACKAGE OUTLINES

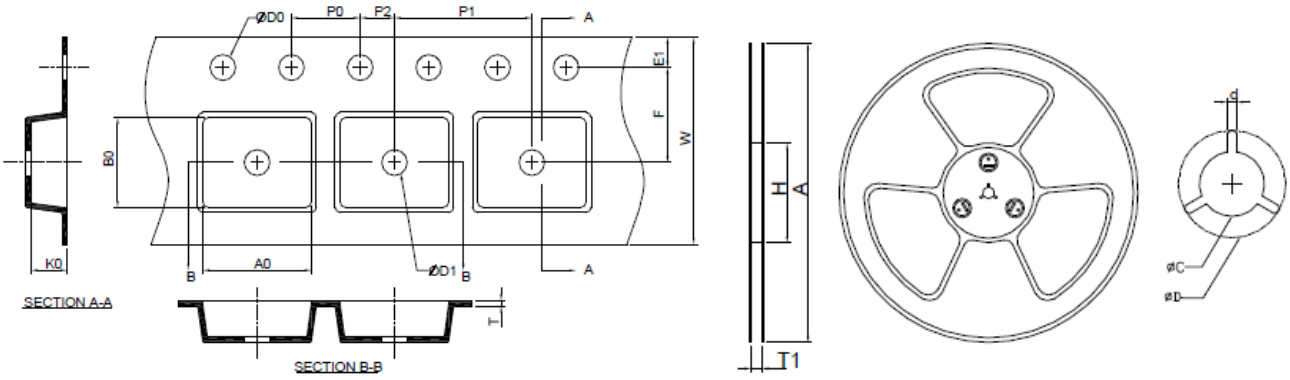


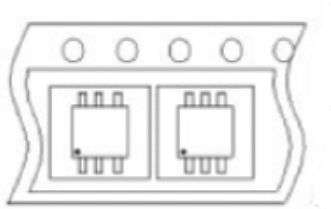
Symbol	Dimensions in Millimeters			Dimensions in Inches		
	Min.	Nom.	Max.	Min.	Nom.	Max.
A	-	-	1.10	-	-	0.043
A1	0.00	-	0.10	0	-	0.004
A2	0.70	0.90	1.00	0.028	0.035	0.039
b	0.30	0.40	0.50	0.012	0.016	0.020
C	0.08	0.14	0.20	0.003	0.006	0.008
D	2.80	2.90	3.00	0.110	0.114	0.118
E	2.60	2.80	3.00	0.102	0.110	0.118
E1	1.50	1.60	1.70	0.059	0.063	0.067
e	0.95 BSC.			0.037 BSC.		
e1	1.90 BSC.			0.075 BSC.		
L	0.30	0.45	0.60	0.012	0.018	0.024
L1	0.60 REF.			0.024 REF.		
L2	0.25 BSC.			0.010 BSC.		
y	-	-	0.10	-	-	0.004
R	0.10	-	-	0.004	-	-
θ	0°	-	8°	0°	-	8°

JEDEC outline: MO-193 AA

❖ Carrier tape dimension

TSOT-23-6L





A	H	T1	C	d	D	W	E1	F
178.0±2.00	50 MIN.	8.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	8.0±0.30	1.75±0.10	3.5±0.05
P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
4.0±0.10	4.0±0.10	2.0±0.05	1.5+0.10 -0.00	1.0 MIN.	0.6+0.00 -0.40	3.20±0.20	3.10±0.20	1.50±0.20

(mm)