

Single-Phase Full-Wave Motor Driver with Built-in Hall Sensor

Features

- On-chip Hall Sensor
- PWM Soft Switch
- High Sensitivity Hall Effect Sensor IC: $\pm 10\text{G}(\text{typ.})$
- Built-in Lock Protection and Auto Restart Function
- Built-In Quick Start Function
- Speed Controllable by PWM Input Signal
- FG (Rotation Speed Detection) Output
- Built-in Thermal Protection Circuit
- 6 Pin TSOT23-6F Package
- Lead Free and Green Devices Available (RoHS Compliant)

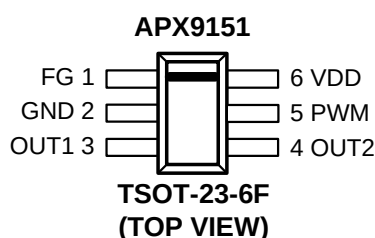
General Description

The APX9151 is an integrated Hall Effect Sensor IC designed for electric commutation of single-phase DC brushless motor applications. The device is built-in lock protection. When fan is locked, the device will enter the lock protection mode. It is also with thermal shutdown function. The APX9151 is available in a low cost TSOT23-6F packages.

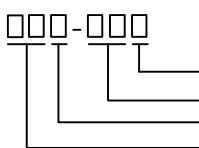
Pin Configuration

Applications

- Brushless DC Fans
- Brushless DC Motors



Ordering and Marking Information

APX9151  Assembly Material Handling Code Temperature Range Package Code	Package Code CE : TSOT-23-6F Operating Ambient Temperature Range I : -40 to 105 °C Handling Code TR : Tape & Reel Assembly Material G : Halogen and Lead Free Device
APX9151 CE : 	The last X is referred as Date Code

Note: ANPEC lead-free products contain molding compounds/die attach materials and 100% matte tin plate termination finish; which are fully compliant with RoHS. ANPEC lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J-STD-020D for MSL classification at lead-free peak reflow temperature. ANPEC defines "Green" to mean lead-free (RoHS compliant) and halogen free (Br or Cl does not exceed 900ppm by weight in homogeneous material and total of Br and Cl does not exceed 1500ppm by weight).

ANPEC reserves the right to make changes to improve reliability or manufacturability without notice, and advise customers to obtain the latest version of relevant information to verify before placing orders.

Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Rating	Unit
V _{DD}	VDD Pin Supply Voltage (VDD to GND)	-0.3 to 7	V
V _{OUT}	Output Pin (OUT1, OUT2) Output Voltage	-0.3 to 7	V
I _{OUT}	Output Pin (OUT1, OUT2) Maximum Output Current – Continuous Hold	500 1000	mA
V _{PWM}	PWM Pin Input Voltage	-0.3 to 7	V
I _{FG}	FG Pin Output Sink Current	20	mA
	FG Pin Output Voltage	-0.3 to 7	V
T _J	Maximum Junction Temperature	150	°C
T _{STG}	Storage Temperature	-65 to 150	°C
T _{SOR}	Maximum Lead Soldering Temperature, 10 Seconds	260	°C

Note1: Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Thermal Characteristics

Symbol	Parameter	Typical Value	Unit
θ _{JA}	Thermal Resistance-Junction to Ambient ^(Note 2)		°C/W
	TSOT-23-6F	240	
P _D	Power Dissipation, T _A = 25°C		mW
	TSOT-23-6F	520	

Note 2 : The maximum allowable power dissipation at any T_A (ambient temperature) is calculated using: $P_D = (T_J - T_A) / \theta_{JA}$; T_J = 150°C. Exceeding the maximum allowable power dissipation will result in excessive die temperature.

Recommended Operation Conditions

Symbol	Parameter	Range	Unit
V _{DD}	VDD Supply Voltage	1.8 to 6	V
T _A	Operating Ambient Temperature	-40 to 105	°C
T _J	Junction Temperature	-40 to 125	°C

Electrical Characteristics ($T_A=25^{\circ}\text{C}$, $V_{DD}=5\text{V}$, unless otherwise noted)

Symbol	Parameter	Test Conditions	APX9151			Unit
			Min.	Typ.	Max.	
I_{DD1}	Operating Current	Rotation Mode	-	5	8	mA
I_{DD2}	Standby Supply Current	PWM = 0	-	75	100	μA
V_O	Output Driver Saturation Voltage	$I_{OUT}=250\text{mA}$, Upper and Lower total	-	0.18	0.36	V
V_{FG}	FG Pin Low Voltage	$I_{FG}=5\text{mA}$	-	0.2	0.4	V
I_{FGL}	FG Pin Off Leakage Current	$V_{FG}=7\text{V}$	-	<0.1	1	μA
V_{PWMH}	Pulse Mode PWM Input High Level Voltage		$0.5 \times V_{DD}$	-	$V_{DD}+0.5$	V
V_{PWML}	Pulse Mode PWM Input Low Level Voltage		0	-	$0.2 \times V_{DD}$	V
I_{PWML}	PWM Pin Low Input Current	$V_{PWM}=0$	-	-10	-20	μA
T_{ON}	Lock Detection On Time		0.35	0.5	0.65	sec
T_{OFF}	Lock Detection Off Time		3.5	5	6.5	sec
T_{QS}	Quick Start Enable Time		-	66.5	90	ms
F_{PWM}	PWM Input Frequency		0.2	-	50	kHz
D_{ST}	Start Up PWM input Duty		6	-	9	%
OTS	Over Temperature Shutdown Threshold		-	165	-	$^{\circ}\text{C}$
	Over Temperature Shutdown Hysteresis		-	30	-	$^{\circ}\text{C}$

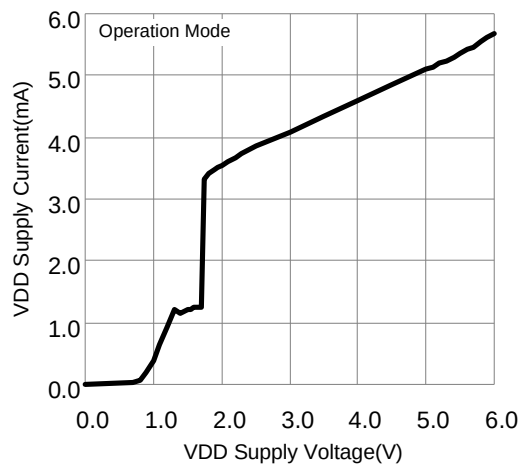
Magnetic Characteristics ($T_A=25^{\circ}\text{C}$, $V_{DD}=5\text{V}$, unless otherwise noted)^(Note 3)

Symbol	Parameter	Test Conditions	APX9151			Unit
			Min.	Typ.	Max.	
Bop	Magnetic Operation Point		0	10	20	Gauss
Brp	Magnetic Release Point		-20	-10	-0	Gauss
Bhys	Magnetic Hysteresis		-	20	-	Gauss

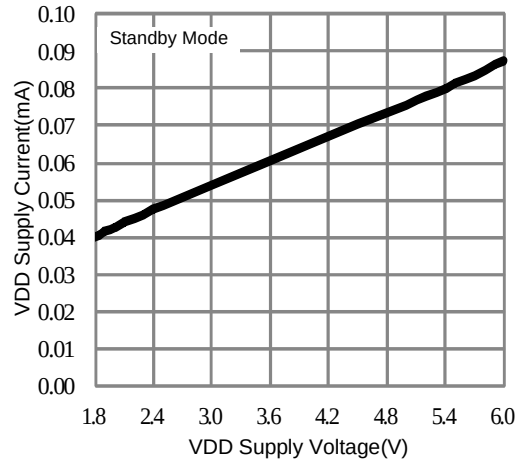
Note3 : For start up only.

Typical Operating Characteristics

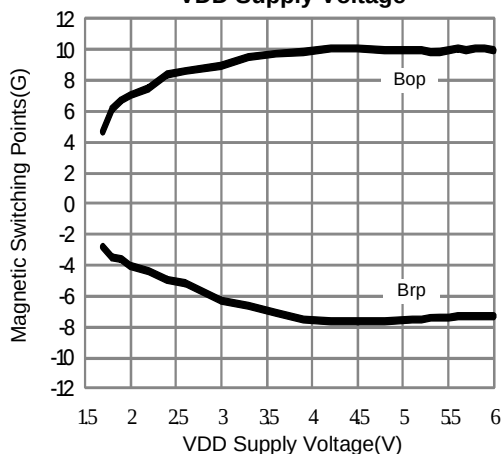
VDD Supply Current vs. VDD Supply Voltage



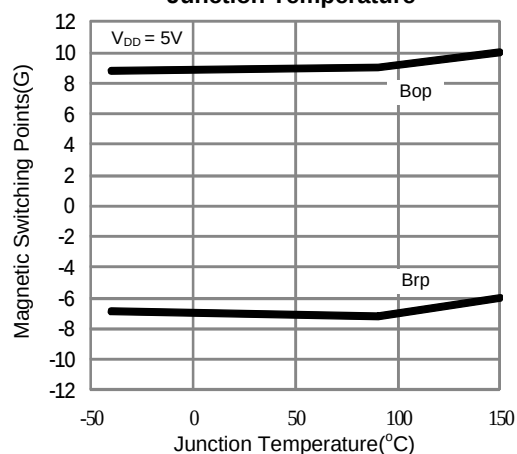
VDD Supply Current vs. VDD Supply Voltage



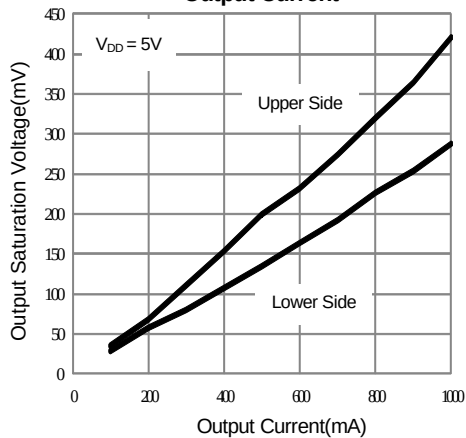
Magnetic Switching Points vs. VDD Supply Voltage



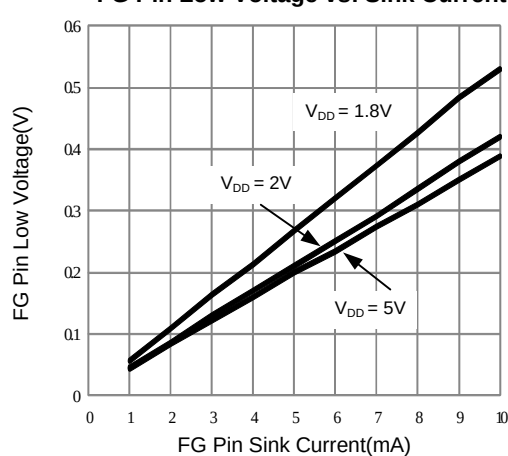
Magnetic Switching Points vs. Junction Temperature



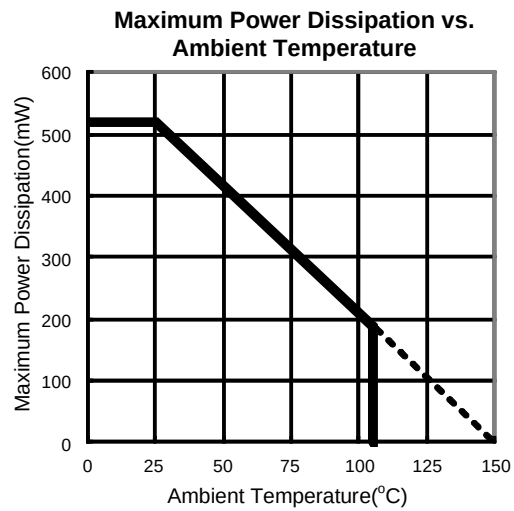
Output Saturation Voltage vs. Output Current



FG Pin Low Voltage vs. Sink Current



Typical Operating Characteristics



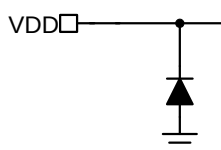
Pin Description

TSOT-23-6F

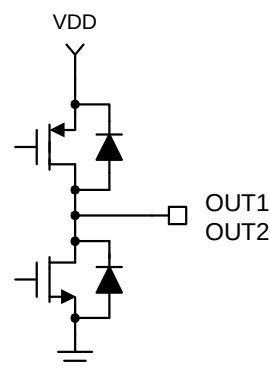
PIN		FUNCTION
NO.	NAME	
1	FG	Rotation Speed Output. This is an open-drain output.
2	GND	Ground of the IC.
3	OUT1	H-bridge output connection. The output stage is a H-bridge formed by four transistors and four-protection diode for switching applications.
4	OUT2	H-bridge output connection. The output stage is a H-bridge formed by four transistors and four-protection diode for switching applications.
5	PWM	PWM Signal Input Terminal.
6	VDD	Supply Voltage Input.

I / O Equivalent Circuits

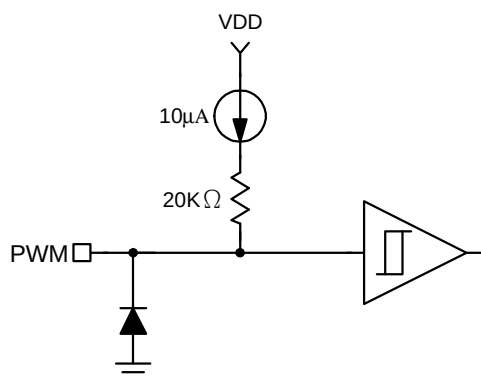
(1) Power supply input pin (VDD)



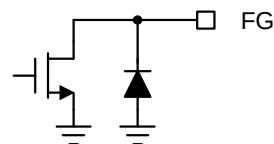
(2) Driver output pin (OUT1, OUT2)



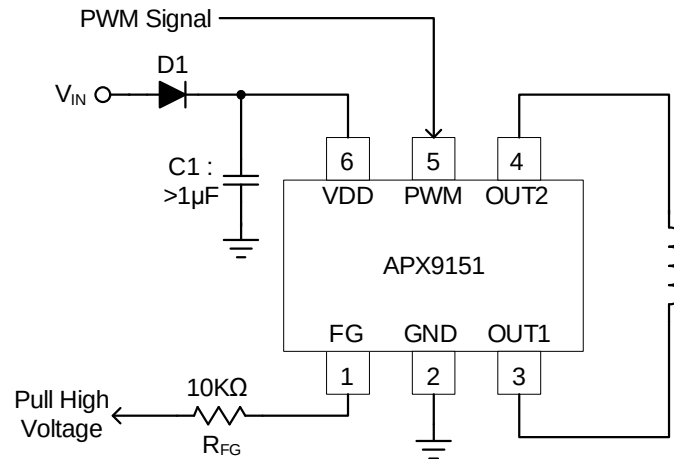
(3) PWM speed control input pin (PWM)



(4) Rotation speed output pin (FG)

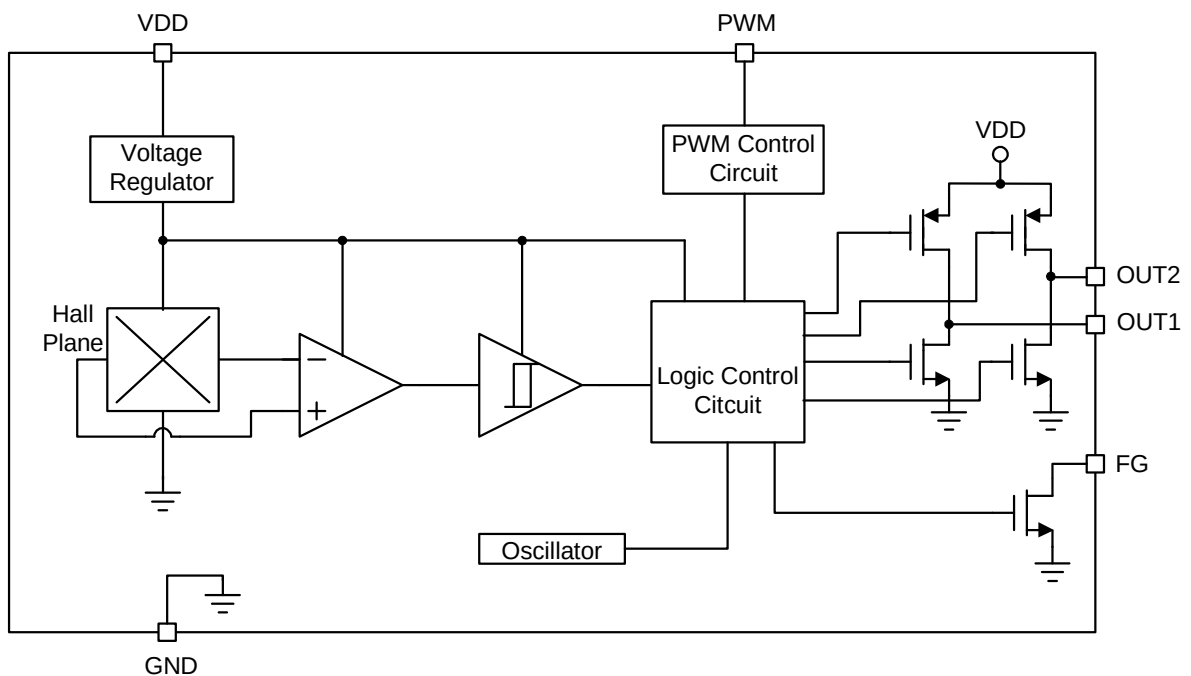


Typical Application Circuit



Note: D1 is protect IC when reverse power input, and recommend to use schottky diode with lower V_{th} for low-voltage operation.
 Note: The C1 value is adjusted by motor characteristic.

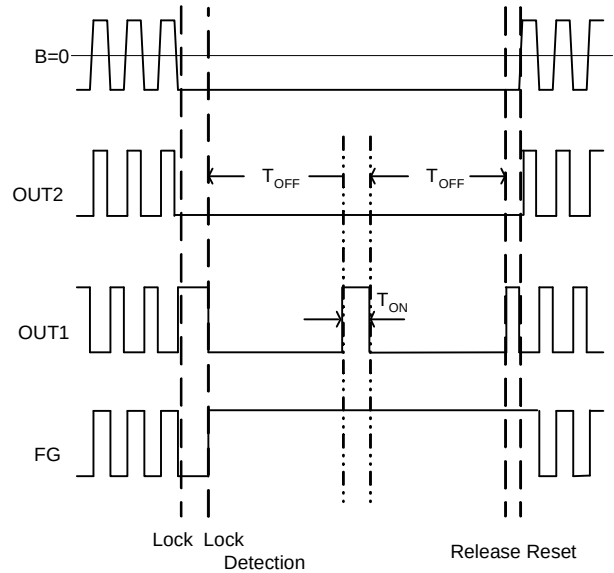
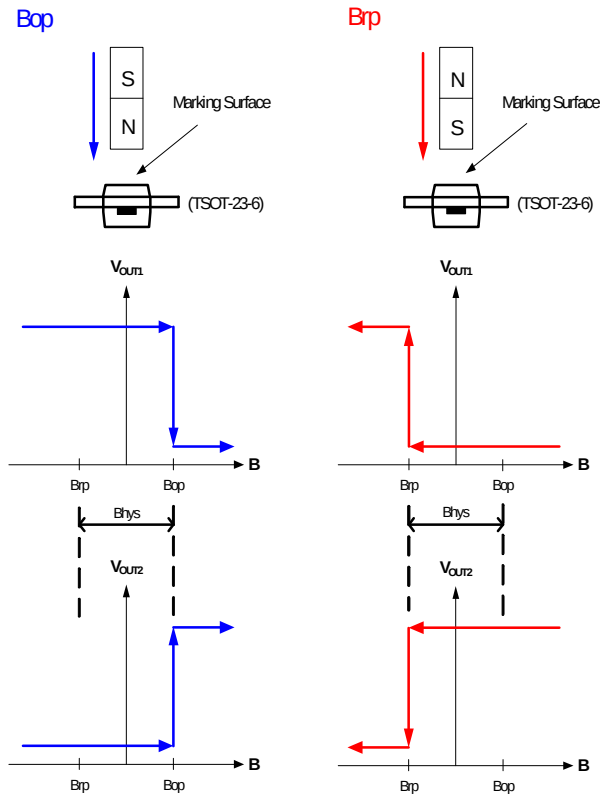
Block Diagram



Function Description

Output Switch Principle

The APX9151 built in a Hall-effect sensor plane to sense the vertical magnetic flux density (B). There are two output drivers in APX9151 to drive single-phase DC brushless motor. When the N pole magnetic field close to the IC marking surface and the magnetic flux density higher than operate point (Bop), the OUT1 pin output will turn to LOW and the OUT2 pin output will turn to HIGH. When the N pole magnetic field far away the IC marking surface and S pole magnetic field close to the IC marking surface until the magnetic flux density higher than release point (Brp), the OUT1 pin output will turn HIGH and the OUT2 pin output will turn LOW.



Speed Control by Direct PWM Input Signal

Applying PWM pulses to the PWM pin directly, the duty cycle of PWM pulses will control the output driver ON duty directly. In PWM control, the high level of pulse signal should be higher than $0.5 \times V_{DD}$ and the low level should be lower than $0.2 \times V_{DD}$. When the PWM pin is floating, the output driver of APX9151 will be full duty to drive the motor.

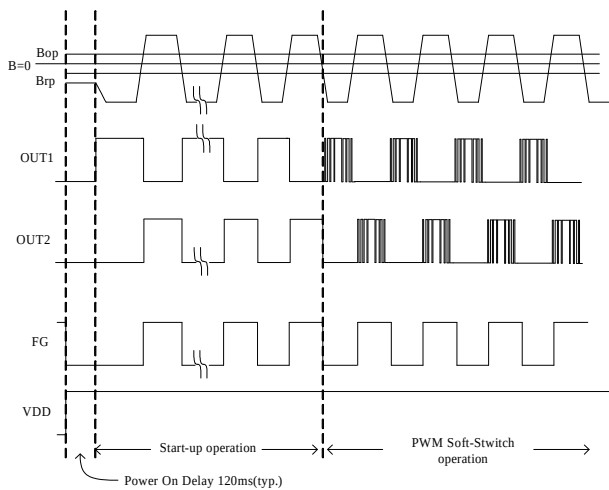
Lockup Protection and Automatic Restart

The APX9151 detects the rotation of the motor by internal hall sensor signal, and adjusts lock detection ON time (T_{ON}) and lock detection OFF time (T_{OFF}) by internal counter.

Function Description (Cont.)

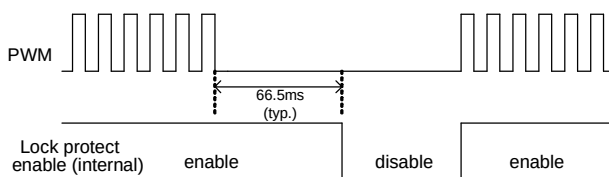
PWM Soft-Switch Function

The APX9151 built in PWM soft-switch output control circuit to improve the vibration and noise of fan motor operation. At start-up operation, the APX9151 drive the output driver by square wave to force the fan motor start to rotate. After several square wave outputs, the internal PWM soft-switch control circuit will be enable to drive fan motor to improve vibration and noise.



Quick Start and Standby Mode

This IC would enter standby mode when the PWM input keeps low level for then 66.5m(typ.). In standby mode, it will shutdown amplifier and FG. In standby mode, the lock protection function doesn't work, therefore, starting fan is unobstructed when releasing standby mode.

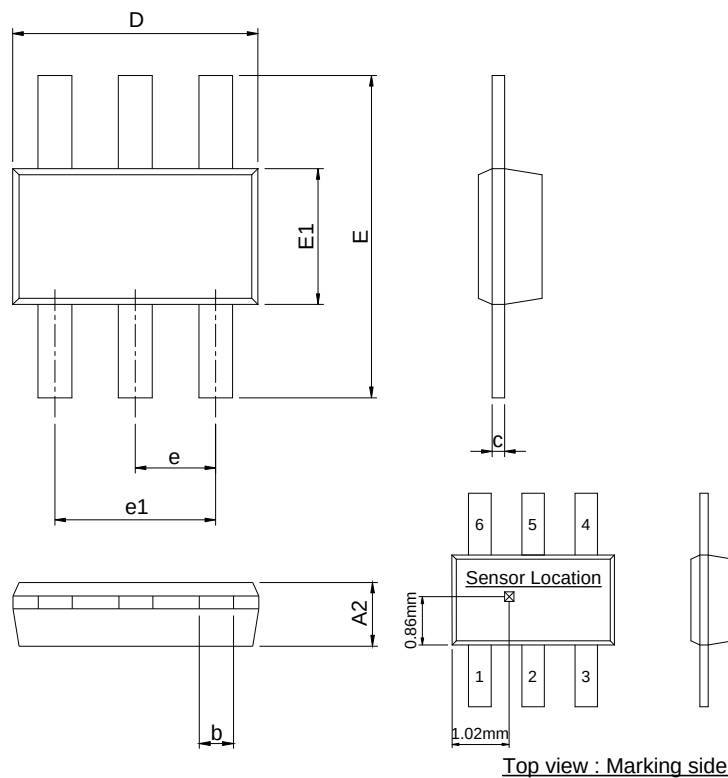


Truth Table

Input		Output			Mode
B	PWM	OUT1	OUT2	FG	
Bop	H	L	H	OFF	Operation Mode
Brp		H	L	L	
Bop	L	L	L	OFF	
Brp		L	L	L	
Bop	-	L	L	OFF	Lock Mode
Brp		L	L	OFF	
-	L	OFF	OFF	OFF	Standby Mode

Package Information

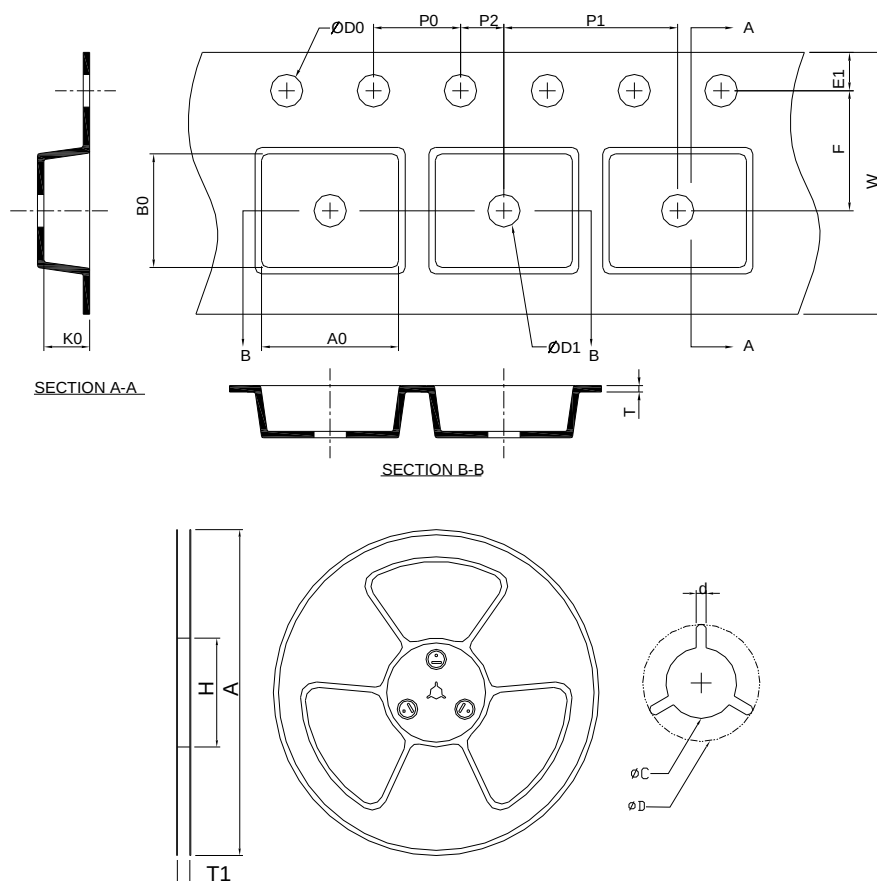
TSOT-23-6F



SYMBOL	TSOT-23-6F			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A2	0.70	0.775	0.028	0.031
b	0.30	0.50	0.012	0.020
c	0.08	0.22	0.003	0.009
D	2.80	3.00	0.110	0.118
E	3.70	3.90	0.146	0.154
E1	1.50	1.70	0.059	0.067
e	0.95 BSC		0.037 BSC	
e1	1.90 BSC		0.075 BSC	

Note : 1. Dimension D and E1 do not include mold flash, protrusions or gate burrs.
Mold flash, protrusion or gate burrs shall not exceed 10 mil per side.

Carrier Tape & Reel Dimensions



Application	A	H	T1	C	d	D	W	E1	F
TSOT-23-6F	178.0±2.00	50 MIN.	16.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	12.0±0.30	1.75±0.10	5.5±0.10
	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	3.10±0.20	4.00±0.20	1.15±0.20

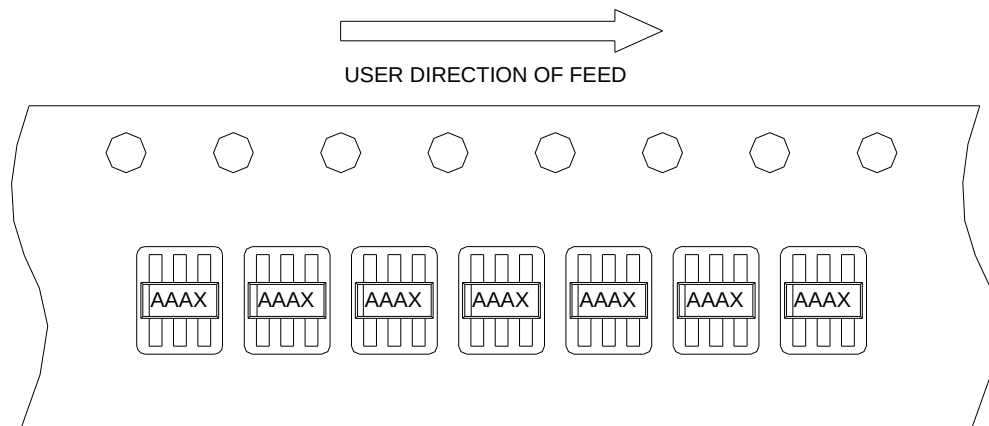
(mm)

Devices Per Unit

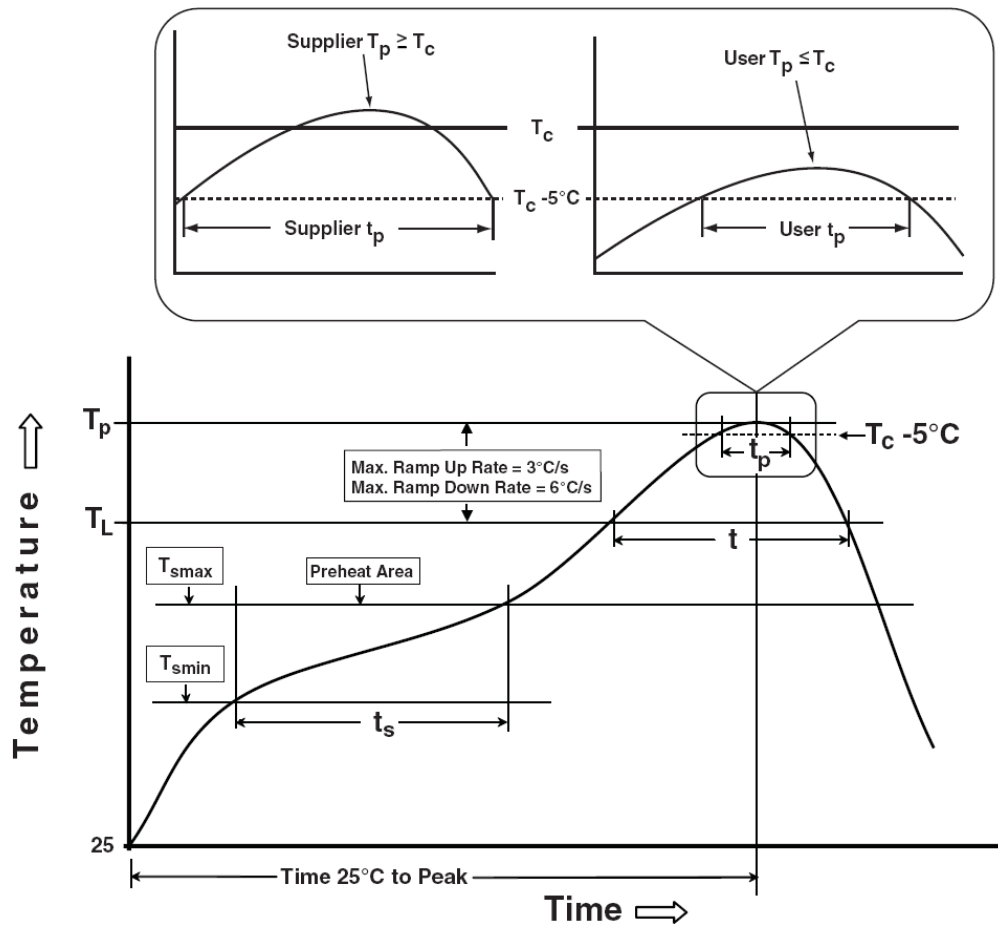
Package Type	Unit	Quantity
TSOT-23-6F	Tape & Reel	3000

Taping Direction Information

TSOT-23-6F



Classification Profile



Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Preheat & Soak Temperature min (T_{smin}) Temperature max (T_{smax}) Time (T_{smin} to T_{smax}) (t_s)	100 °C 150 °C 60-120 seconds	150 °C 200 °C 60-120 seconds
Average ramp-up rate (T_{smax} to T_p)	3 °C/second max.	3 °C/second max.
Liquidous temperature (T_L) Time at liquidous (t_L)	183 °C 60-150 seconds	217 °C 60-150 seconds
Peak package body Temperature (T_p)*	See Classification Temp in table 1	See Classification Temp in table 2
Time (t_p)** within 5°C of the specified classification temperature (T_c)	20** seconds	30** seconds
Average ramp-down rate (T_p to T_{smax})	6 °C/second max.	6 °C/second max.
Time 25°C to peak temperature	6 minutes max.	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. SnPb Eutectic Process – Classification Temperatures (T_c)

Package Thickness	Volume mm ³ <350	Volume mm ³ ≥ 350
<2.5 mm	235 °C	220 °C
≥2.5 mm	220 °C	220 °C

Table 2. Pb-free Process – Classification Temperatures (T_c)

Package Thickness	Volume mm ³ <350	Volume mm ³ 350-2000	Volume mm ³ >2000
<1.6 mm	260 °C	260 °C	260 °C
1.6 mm – 2.5 mm	260 °C	250 °C	245 °C
≥2.5 mm	250 °C	245 °C	245 °C

Reliability Test Program

Test item	Method	Description
SOLDERABILITY	JESD-22, B102	5 Sec, 245°C
HOLT	JESD-22, A108	1000 Hrs, Bias @ $T_j=125^{\circ}\text{C}$
PCT	JESD-22, A102	168 Hrs, 100%RH, 2atm, 121°C
TCT	JESD-22, A104	500 Cycles, -65°C~150°C
HBM	MIL-STD-883-3015.7	VHBM ≥ 2KV
MM	JESD-22, A115	VMM ≥ 200V
Latch-Up	JESD 78	10ms, $1_{tr} \geq 100\text{mA}$

Customer Service

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