

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

Features

- On-chip Hall Sensor
- High Sensitivity Hall Effect Sensor IC: $\pm 15\text{G}$ (Typ.)
- Built-in Lock Protection and Auto Restart Function
- Speed Controllable by PWM Input Signal
- FG Output (for APX9172)
- 1/2FG Output (for APX9172A)
- RD Output (for APX9172B)
- Built-in Thermal Protection Circuit
- 6 Pin TSOT23-6F, TSOT23-6 and SOP-8F Packages
- Lead Free and Green Devices Available (RoHS Compliant)

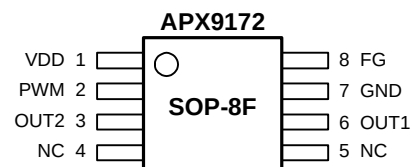
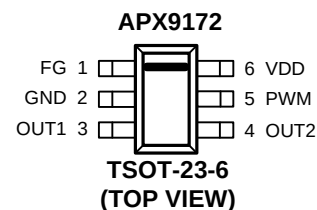
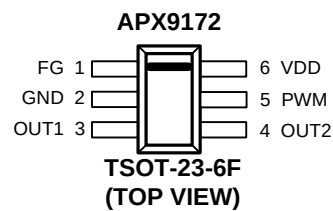
General Description

The APX9172 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 APX9172 is available in a low cost TSOT23-6F, TSOT23-6 and SOP-8F packages.

Pin Configuration

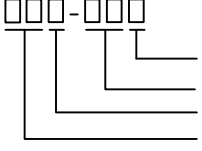
Applications

- Brushless DC Fans
- Brushless DC Motors



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.

Ordering and Marking Information

APX9172 □□□ - □□□  Assembly Material Handling Code Temperature Range Package Code	Package Code CE : TSOT-23-6F CT : TSOT-23-6 KE : SOP-8F Operating Ambient Temperature Range I : -40 to 105 °C Handling Code TR : Tape & Reel Assembly Material G : Halogen and Lead Free Device
APX9172 CE/CT : X72X	The last X is referred as Date Code
APX9172A CE/CT : A72X	The last X is referred as Date Code
APX9172B CE/CT : B72X	The last X is referred as Date Code
APX9172 KE : APX9172 XXXXX	XXXXXX - Date Code
APX9172A KE : APX9172A XXXXX	XXXXXX - Date Code
APX9172B KE : APX9172B XXXXX	XXXXXX - 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).

Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Rating	Unit
V _{DD}	VDD Pin Supply Voltage (VDD to GND)	-0.3 to 20	V
V _{OUT}	Output Pin (OUT1, OUT2) Output Voltage	-0.3 to 20	V
I _{OUT}	Output Pin (OUT1, OUT2) Maximum Output Current – Continuous Hold	300 600	mA
V _{PWM}	PWM Pin Input Voltage	-0.3 to 20	V
I _{FG}	FG Pin Output Sink Current	20	mA
	FG Pin Output Voltage	-0.3 to 20	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) TSOT-23-6F TSOT-23-6 SOP-8F	240 240 156.25	°C/W
P _D	Power Dissipation, T _A = 25°C TSOT-23-6F TSOT-23-6 SOP-8F	520 520 800	mW

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	3 to 17	V
V _{PWM}	PWM Pin Input Voltage	0 to V _{CC}	V
T _A	Operating Ambient Temperature	-40 to 105	°C
T _J	Junction Temperature	-40 to 125	°C

Electrical Characteristics ($T_A=25^{\circ}\text{C}$, $V_{DD}=12\text{V}$, unless otherwise noted)

Symbol	Parameter	Test Conditions	APX9172/72A/72B			Unit
			Min.	Typ.	Max.	
I_{DD1}	Operating Current	Rotation Mode	-	5	7	mA
I_{DD2}	Standby Supply Current	PWM = 0	-	4	6	mA
V_O	Output Driver Saturation Voltage	$I_{OUT}=300\text{mA}$, Upper and Lower total	-	0.6	0.9	V
V_{FGRD}	FG/RD Pin Low Voltage	$I_{FG}=5\text{mA}$	-	0.1	0.3	V
I_{FGLRDL}	FG/RD Pin Off Leakage Current	$V_{FG}=12\text{V}$	-	<0.1	1	μA
V_{PWMH}	Pulse Mode PWM Input High Level Voltage		2.5	-	$V_{DD}+0.5$	V
V_{PWML}	Pulse Mode PWM Input Low Level Voltage		0	-	0.8	V
I_{PWML}	PWM Pin Internal pull-up current	PWM=0V	5	10	20	μA
T_{ON}	Lock Detection On Time		0.28	0.4	0.52	sec
T_{OFF}	Lock Detection Off Time		2.8	4	5.2	sec
T_{QS}	Quick Start Enable Time		-	66.5	90	ms
F_{PWM}	PWM Input Frequency		20	-	50	kHz
OTS	Over Temperature Shutdown Threshold		-	165	-	$^{\circ}\text{C}$
	Over Temperature Shutdown Hysteresis		-	30	-	$^{\circ}\text{C}$

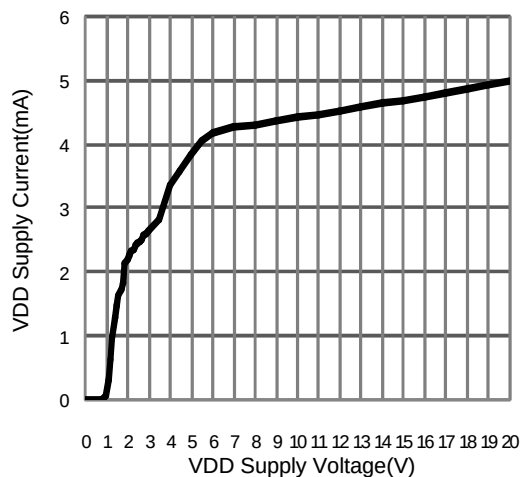
Magnetic Characteristics ($T_A=25^{\circ}\text{C}$, $V_{DD}=12\text{V}$, unless otherwise noted)

Symbol	Parameter	Test Condition	APX9172/72A/72B			Unit
			Min.	Typ.	Max.	
Bop	Magnetic Operation Point		5	15	30	Gauss
Brp	Magnetic Release Point		-30	-15	-5	Gauss
Bhys	Magnetic Hysteresis			30		Gauss

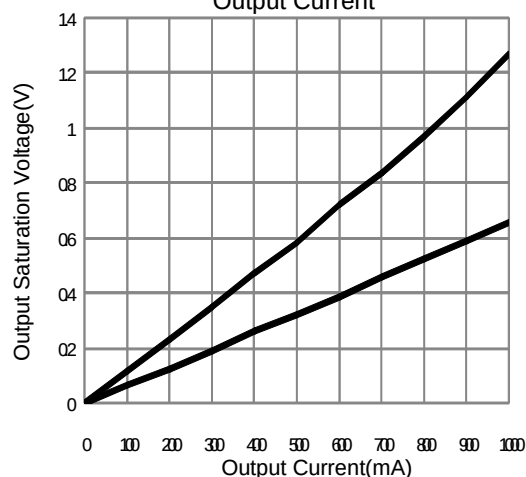
Note : The Magnetic of fan recommend more than 60 gauss for normal operation.

Typical Operating Characteristics

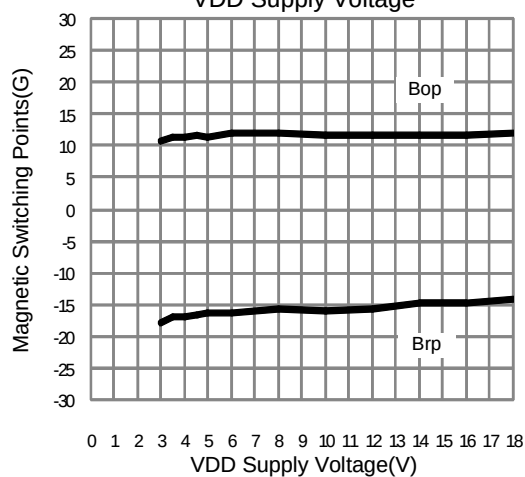
VDD Supply Current vs. VDD Supply Voltage



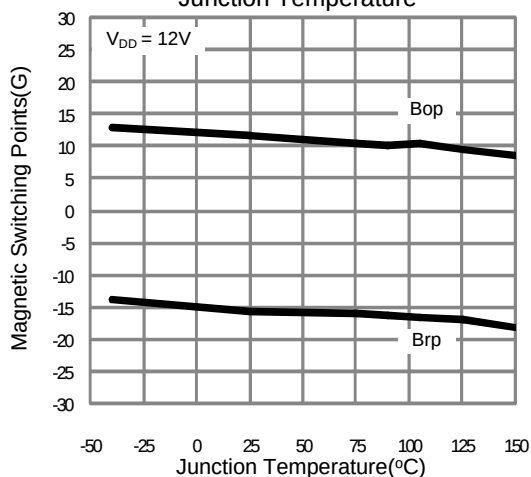
Output Saturation Voltage vs. Output Current



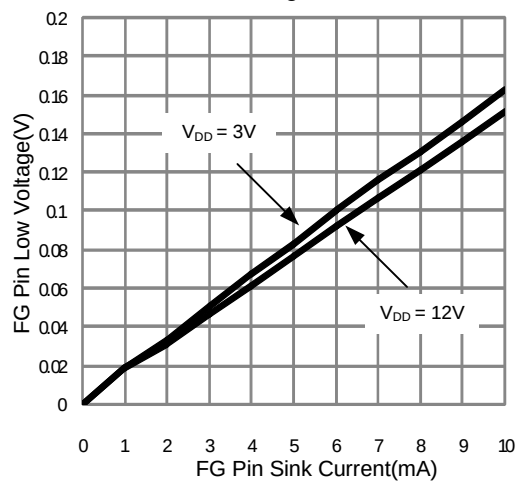
Magnetic Switching Points vs. VDD Supply Voltage



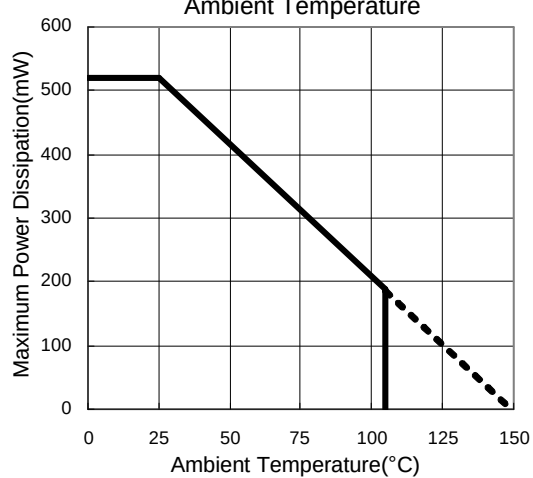
Magnetic Switching Points vs. Junction Temperature



FG Pin Low Voltage vs. Sink Current



Maximum Power Dissipation vs. Ambient Temperature



Pin Description

TSOT-23-6F / TSOT-23-6

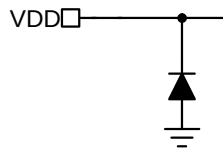
PIN		Function
NO.	NAME	
1	FG (APX9172)	Rotation Speed or Detection Output. This is an open-drain output.
	1/2FG (APX9172A)	
	RD (APX9172B)	
2	GND	Ground of the IC.
3	OUT1	H-bridge output connection.
4	OUT2	H-bridge output connection.
5	PWM	PWM Signal Input Terminal.
6	VDD	Supply Voltage Input.

SOP-8F

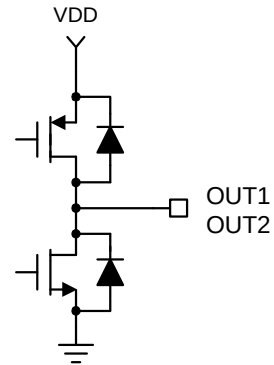
PIN		Function
NO.	NAME	
1	VDD	Supply Voltage Input.
2	PWM	PWM Signal Input Terminal.
3	OUT2	H-bridge output connection.
4	NC	No connection.
5	NC	No connection.
6	OUT1	H-bridge output connection.
7	GND	Ground of the IC.
8	FG (APX9172)	Rotation Speed or Detection Output. This is an open-drain output.
	1/2FG (APX9172A)	
	RD (APX9172B)	

I / O Equivalent Circuit

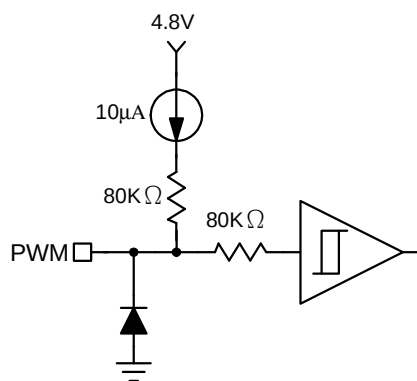
(1) Power supply input pin (VDD)



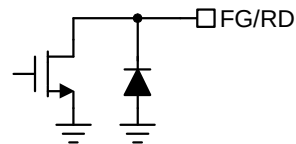
(2) Driver output pin (OUT1, OUT2)



(3) PWM speed control input pin (PWM)



(4) Rotation speed output pin (FG/RD)

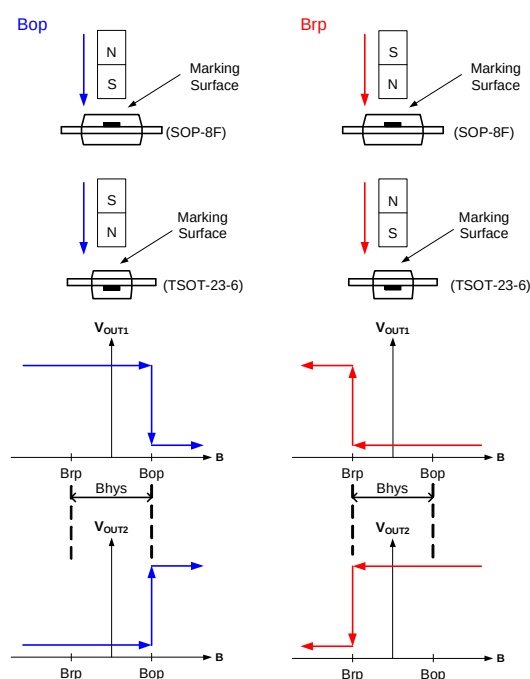


The figure contains two circuit diagrams for the APX9172. The left diagram, labeled 'Normal Mode', shows the APX9172 with pins 1 (FG) connected to a pull-up resistor $R_{PG}:10K\Omega$ and a resistor $R_{FGS}:50-100\Omega$ to the FG output. The right diagram, labeled 'Fault Mode', shows the APX9172 with pins 1 (FG) connected to a pull-up resistor $R_{PG}:10K\Omega$ and a resistor $R_{FGS}:50-100\Omega$ to the FG output, and pins 2 (PWM) connected to a pull-up resistor $R_{PG}:10K\Omega$ and a resistor $R_{FGS}:50-100\Omega$ to the FG output.

Function Description

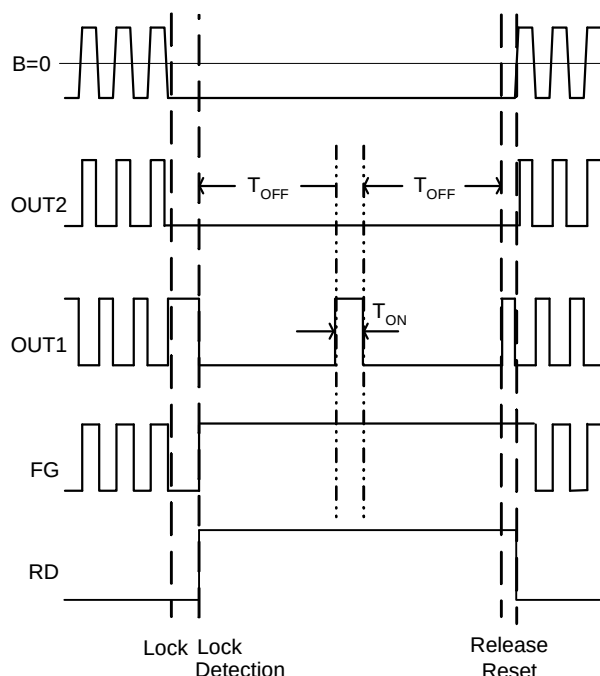
Output Switch Principle

The APX9172/72A/72B built in a Hall-effect sensor plane to sense the vertical magnetic flux density (B). There are two output drivers in APX9172/72A/72B to drive single-phase DC brushless motor. For example of TSOT/23-6 package, 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.



Lockup Protection and Automatic Restart

The APX9172/72A/72B 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.

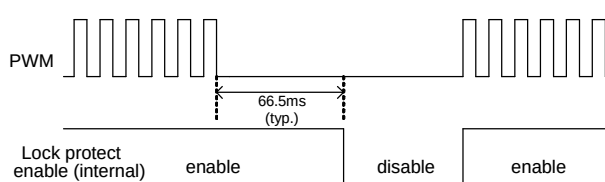


Speed Control by Direct PWM Input Signal

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 2.5V and the low level should be lower than 0.8V. When the PWM pin is floating, the output driver of APX9172/72A/72B will be full duty to drive the motor.

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.

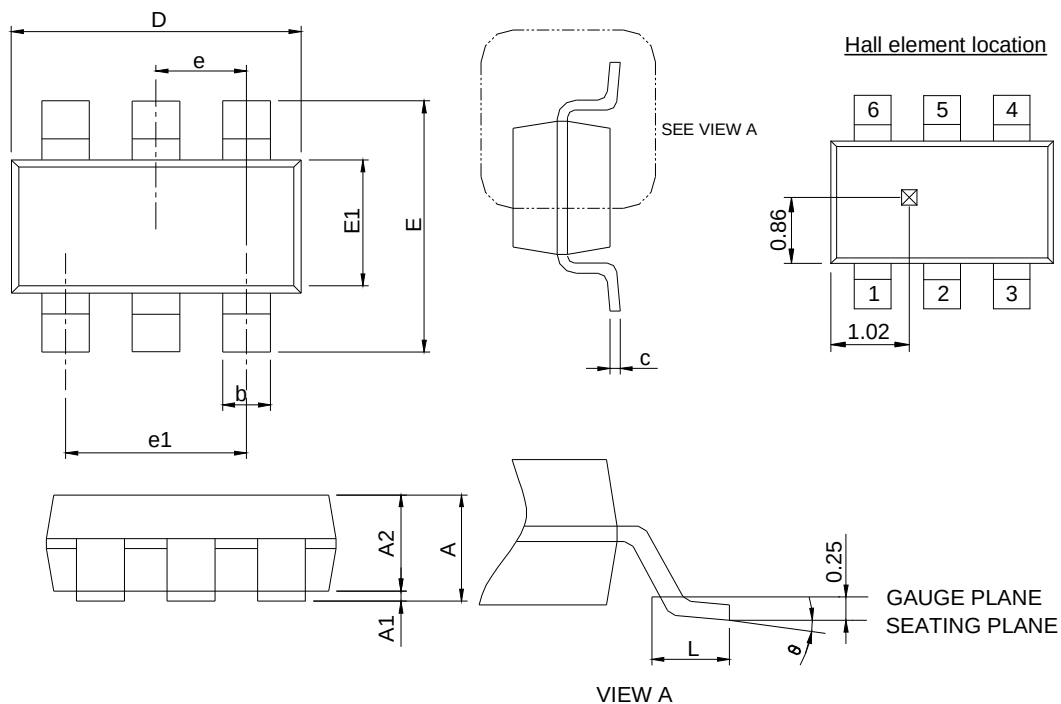


Truth Table

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

Package Information

TSOT-23-6



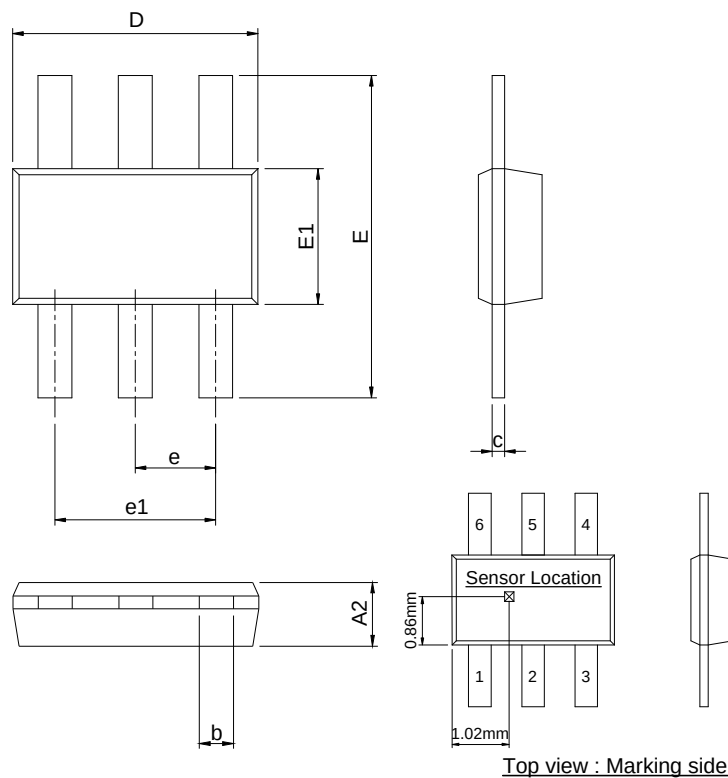
SYMBOL	TSOT-23-6			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	1.00	0.028	0.039
A1	0.01	0.10	0.000	0.004
A2	0.70	0.90	0.028	0.035
b	0.30	0.50	0.012	0.020
c	0.08	0.20	0.003	0.008
D	2.70	3.10	0.106	0.122
E	2.60	3.00	0.102	0.118
E1	1.40	1.80	0.055	0.071
e	0.95 BSC		0.037 BSC	
e1	1.90 BSC		0.075 BSC	
L	0.30	0.60	0.012	0.024
θ	0°	8°	0°	8°

Note : 1. Followed from JEDEC TO-178 AB.

2. 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.

Package Information

TSOT-23-6F

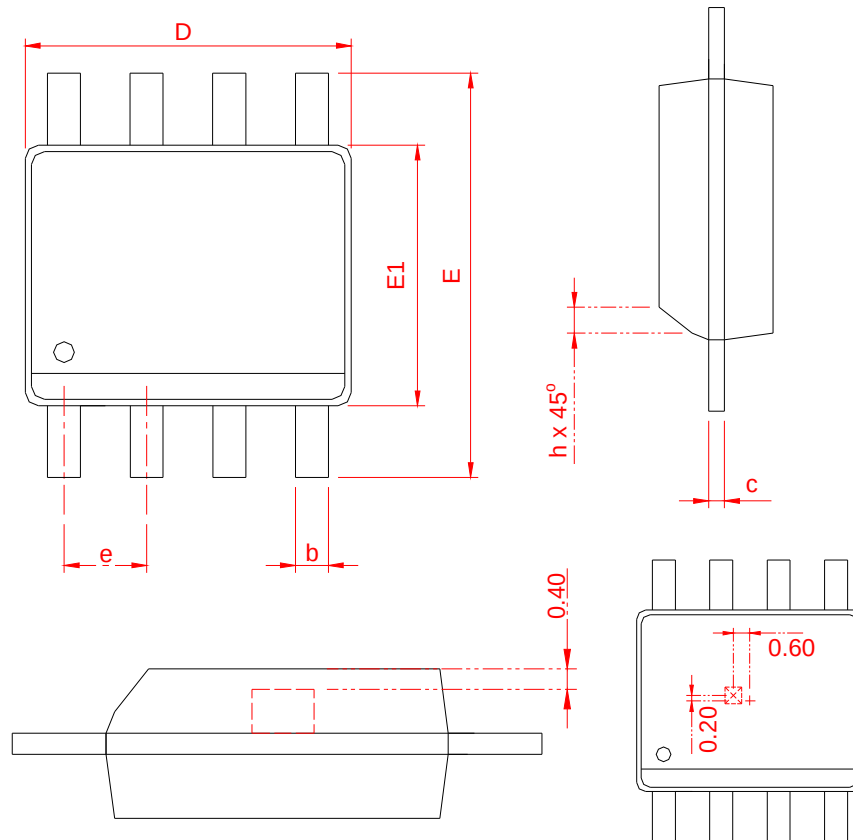


SYMBOL	TSOT-23-6F			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A2	0.70	0.775	0.028	0.031
b	0.30	0.50	0.012	0.020
c	0.08	0.22	0.003	0.009
D	2.80	3.00	0.110	0.118
E	3.70	3.90	0.146	0.154
E1	1.50	1.70	0.059	0.067
e	0.95 BSC		0.037 BSC	
e1	1.90 BSC		0.075 BSC	

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.

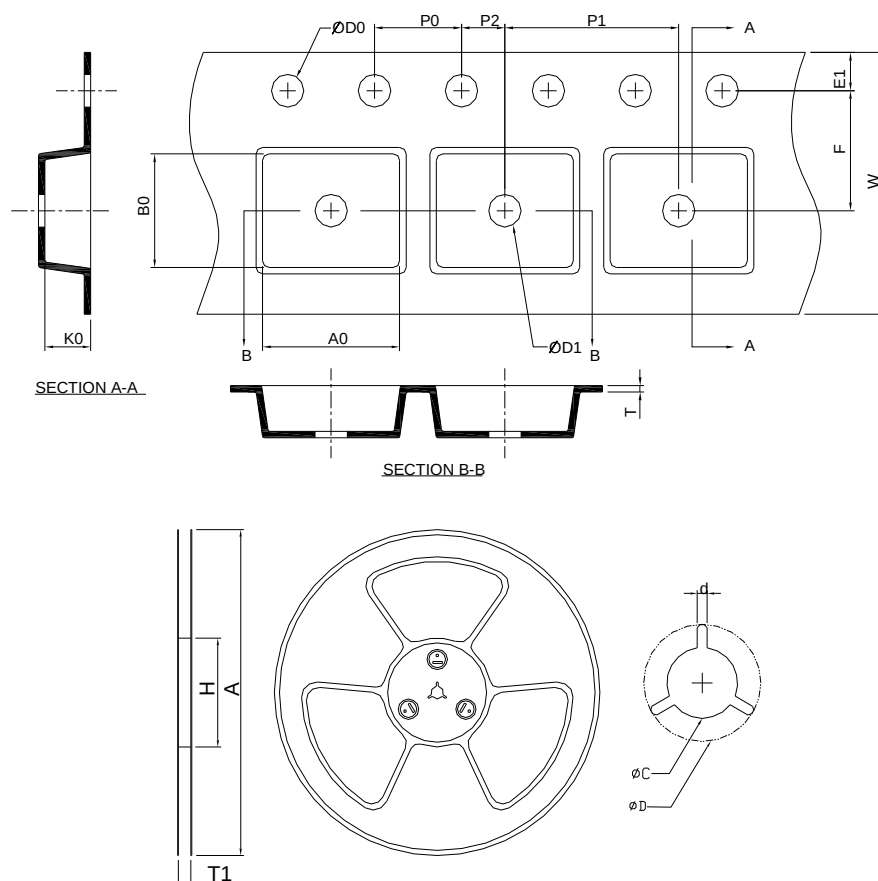
Package Information

SOP-8F



SYMBOL	SOP-8F			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.75		0.069
b	0.31	0.51	0.012	0.020
c	0.17	0.25	0.007	0.010
D	4.80	5.00	0.189	0.197
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	1.27 BSC		0.050 BSC	
h	0.25	0.50	0.010	0.020

Carrier Tape & Reel Dimensions



Application	A	H	T1	C	d	D	W	E1	F
TSOT-23-6	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	1.20±0.20
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
Application	A	H	T1	C	d	D	W	E1	F
SOP-8F	330.0±2.00	50 MIN.	12.4+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±0.05
	P0	P1	P2	D0	D1	T	A0	B0	K0
	4.0±0.10	8.0±0.10	2.0±0.05	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	6.90±0.10	5.30±0.10	2.00±0.10

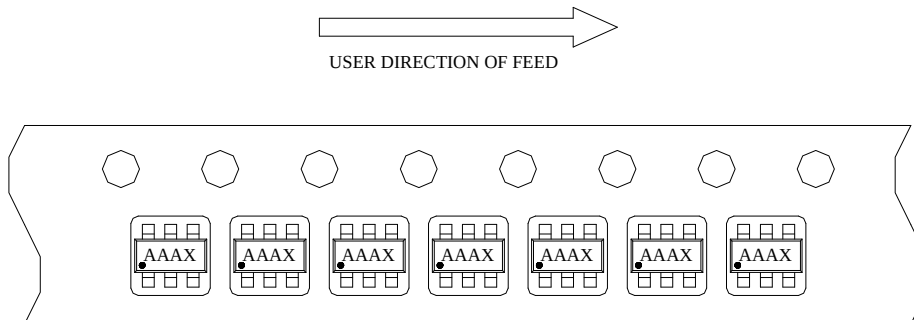
(mm)

Devices Per Unit

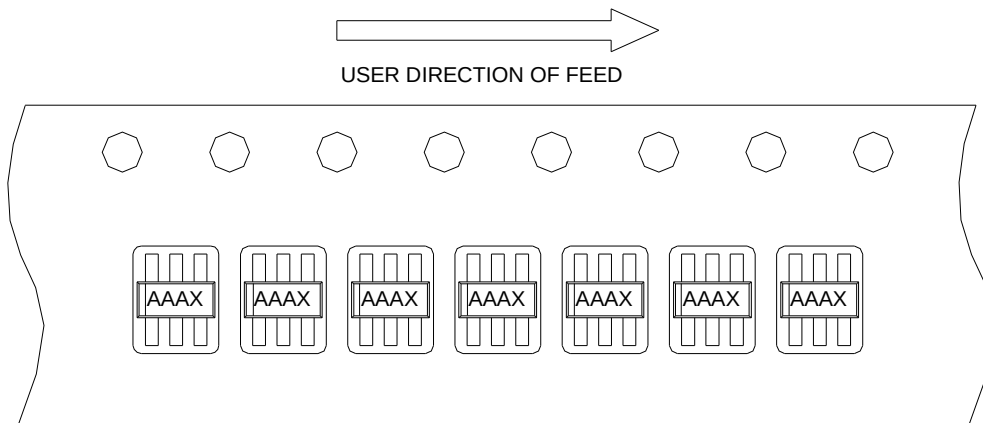
Package Type	Unit	Quantity
TSOT-23-6	Tape & Reel	3000
TSOT-23-6F	Tape & Reel	3000
SOP-8F	Tape & Reel	2500

Taping Direction Information

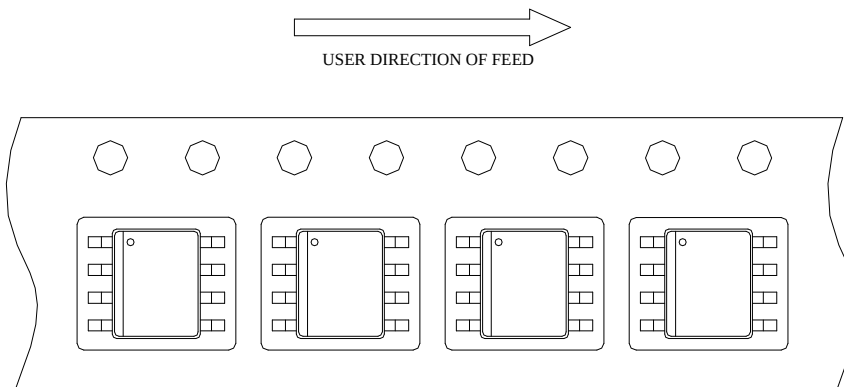
TSOT-23-6



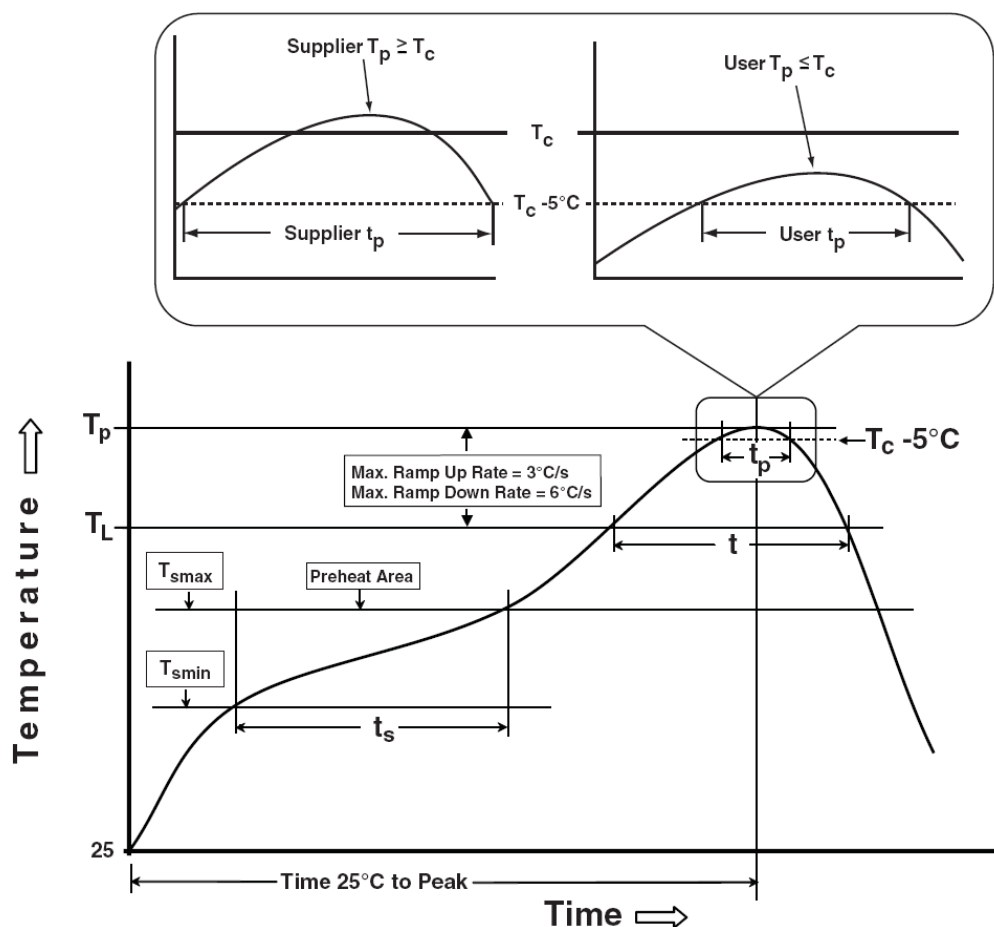
TSOT-23-6F



SOP-8F



Classification Profile



Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Preheat & Soak		
Temperature min (T_{smin})	100 °C	150 °C
Temperature max (T_{smax})	150 °C	200 °C
Time (T_{smin} to T_{smax}) (t_s)	60-120 seconds	60-120 seconds
Average ramp-up rate (T_{smax} to T_p)	3 °C/second max.	3 °C/second max.
Liquidous temperature (T_L)	183 °C	217 °C
Time at liquidous (t_L)	60-150 seconds	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.		

Classification Reflow Profiles (Cont.)

Table 1. SnPb Eutectic Process – Classification Temperatures (Tc)

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 (Tc)

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°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, I _{tr} ≥ 100mA

Customer Service

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