

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

Features

- **On-chip Hall Sensor**
- **High Sensitivity Hall Effect Sensor IC: $\pm 15G$ (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)**

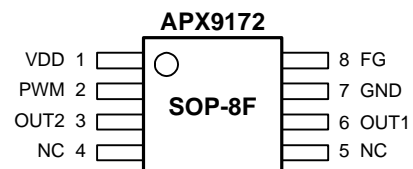
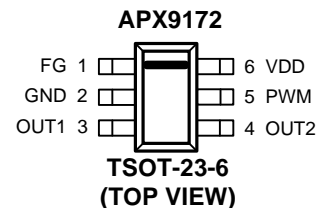
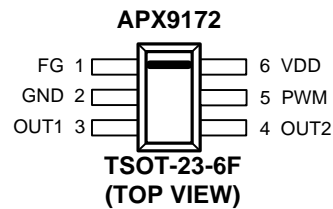
General Description

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.

Applications

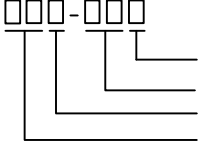



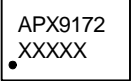
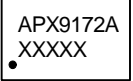
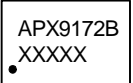
- **Brushless DC Fans**
- **Brushless DC Motors**

Pin Configuration



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

| | |
|---|---|
| <p>APX9172 </p> | <p>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</p> |
| <p>APX9172 CE/CT : </p> | <p>The last X is referred as Date Code</p> |
| <p>APX9172A CE/CT : </p> | <p>The last X is referred as Date Code</p> |
| <p>APX9172B CE/CT : </p> | <p>The last X is referred as Date Code</p> |
| <p>APX9172 KE : </p> | <p>XXXXX - Date Code</p> |
| <p>APX9172A KE : </p> | <p>XXXXX - Date Code</p> |
| <p>APX9172B KE : </p> | <p>XXXXX - Date Code</p> |

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 | 240 |
| | | TSOT-23-6 | 240 |
| | | SOP-8F | 156.25 |
| P _D | Power Dissipation, T _A = 25°C | TSOT-23-6F | 520 |
| | | TSOT-23-6 | 520 |
| | | SOP-8F | 800 |

Note 2 : The maximum allowable power dissipation at any T_A (ambient temperature) is calculated using: P_D = (T_J – T_A) / θ_{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)

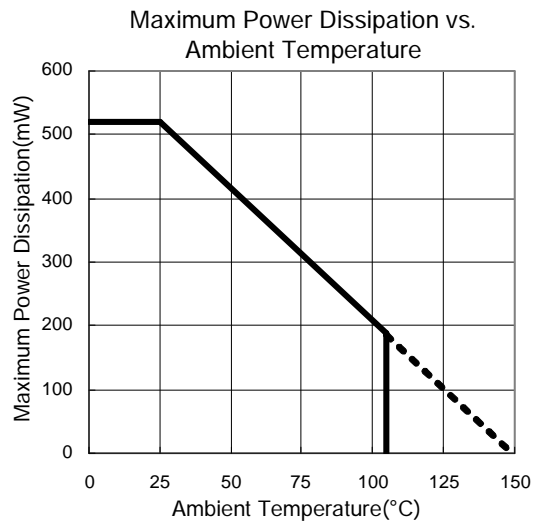
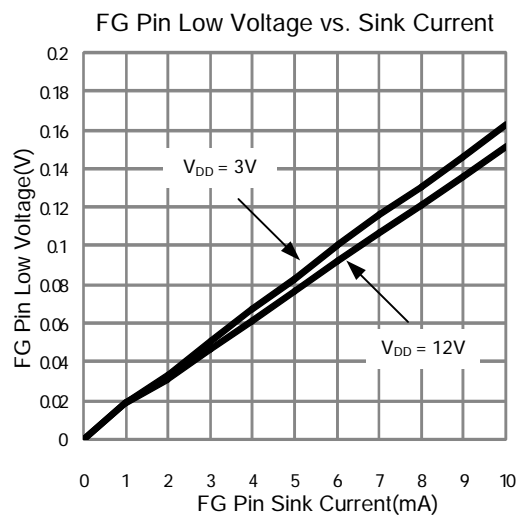
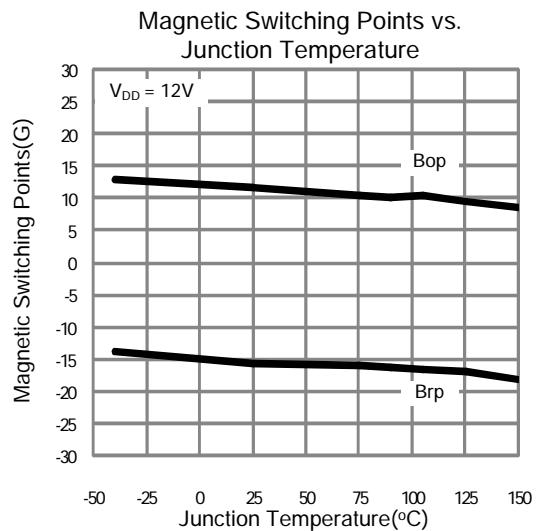
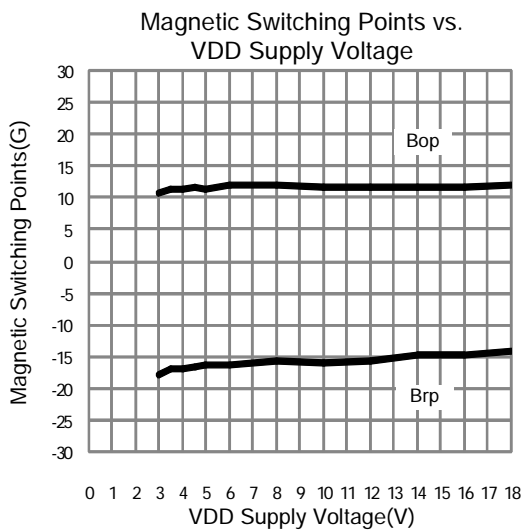
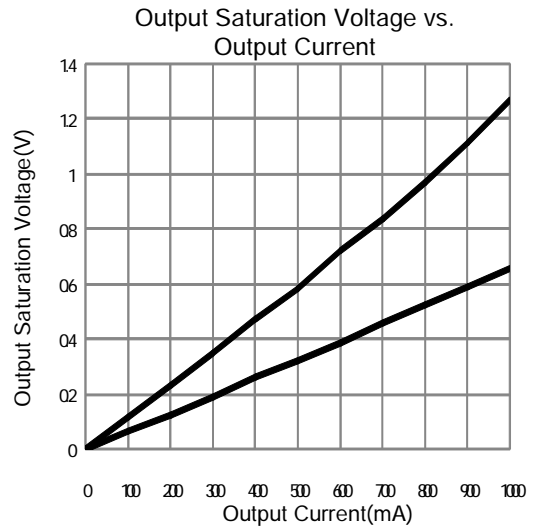
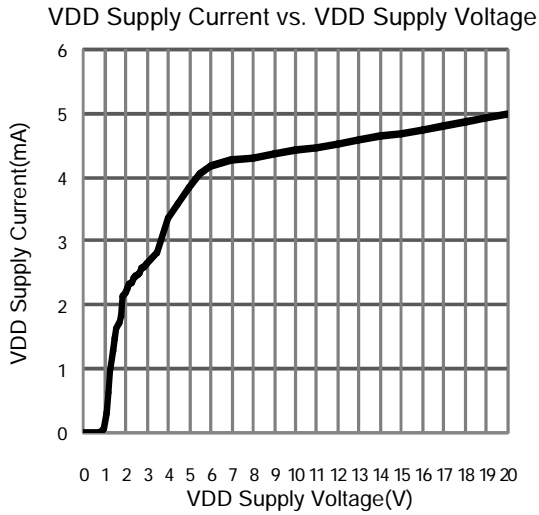
| Symbol | Parameter | Test Conditions | APX9172/72A/72B | | | Unit |
|--------------|---|---|-----------------|------|--------------|--------------------|
| | | | Min. | Typ. | Max. | |
| I_{DD1} | Operating Current | Rotation Mode | - | 5 | 7 | mA |
| I_{DD2} | Standby Supply Current | PWM = 0 | - | 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



Pin Description

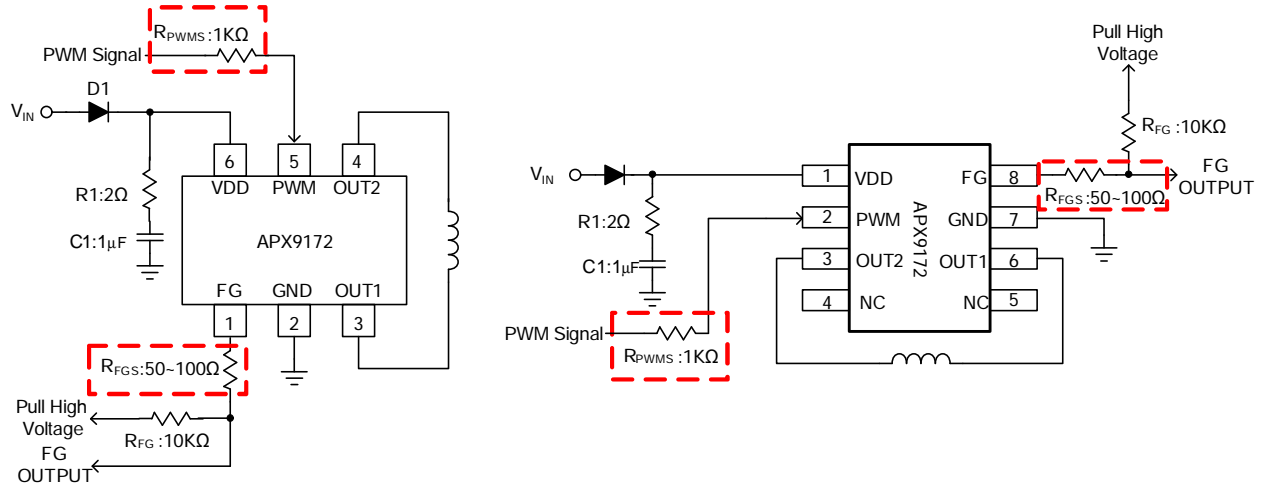
TSOT-23-6F / TSOT-23-6

| 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

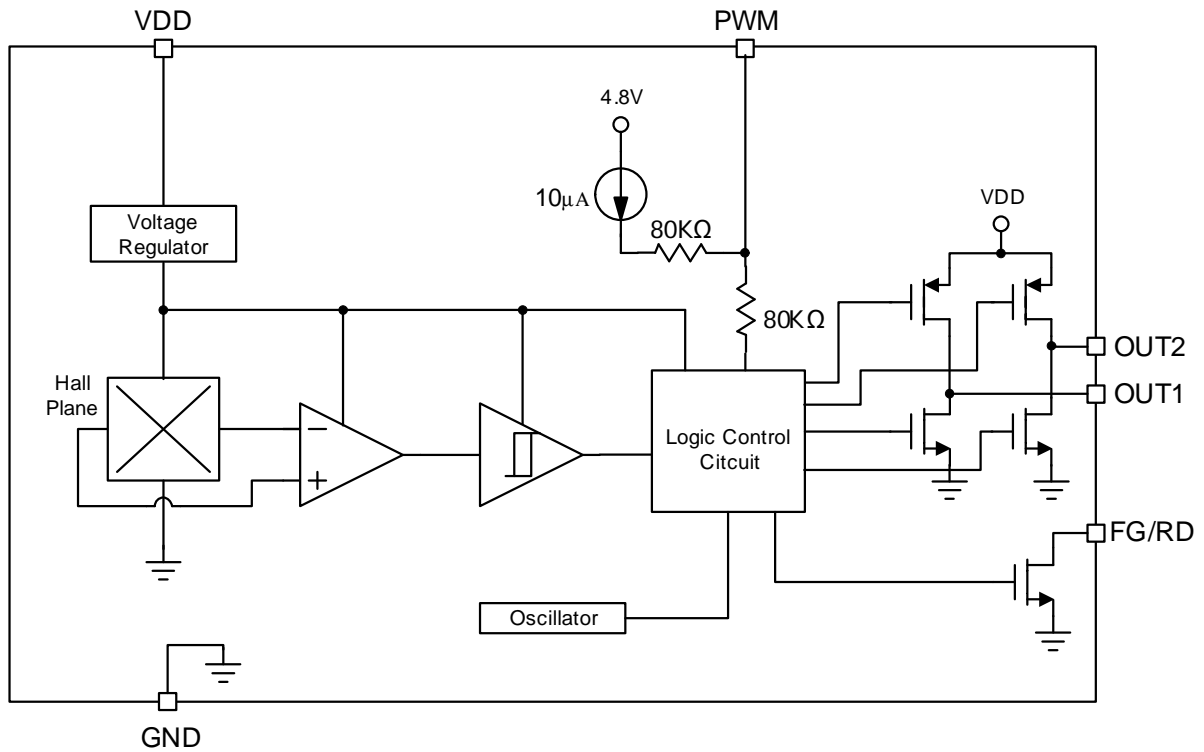
| PIN | | Function |
|-----|---------------------|---|
| NO. | NAME | |
| 1 | VDD | Supply Voltage Input. |
| 2 | PWM | PWM Signal Input Terminal. |
| 3 | OUT2 | H-bridge output connection. |
| 4 | NC | No connection. |
| 5 | NC | No connection. |
| 6 | OUT1 | H-bridge output connection. |
| 7 | GND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

Typical Application Circuit



Note: R_{PWMS} and R_{FGS} are optional to protect internal circuit for abnormal voltage stress.

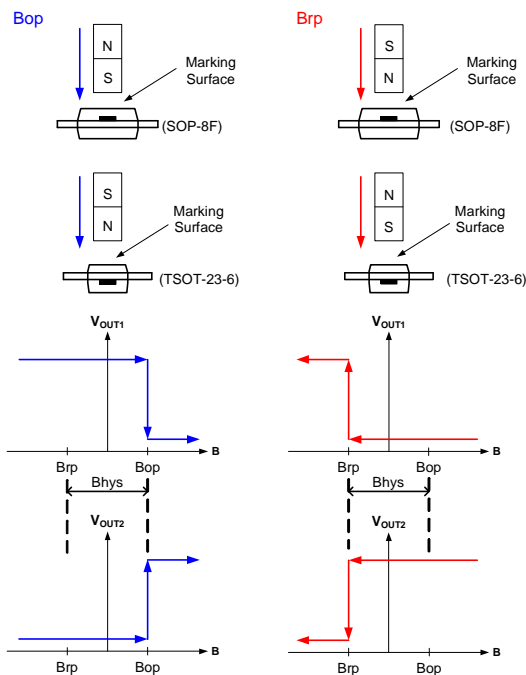
Block Diagram



Function Description

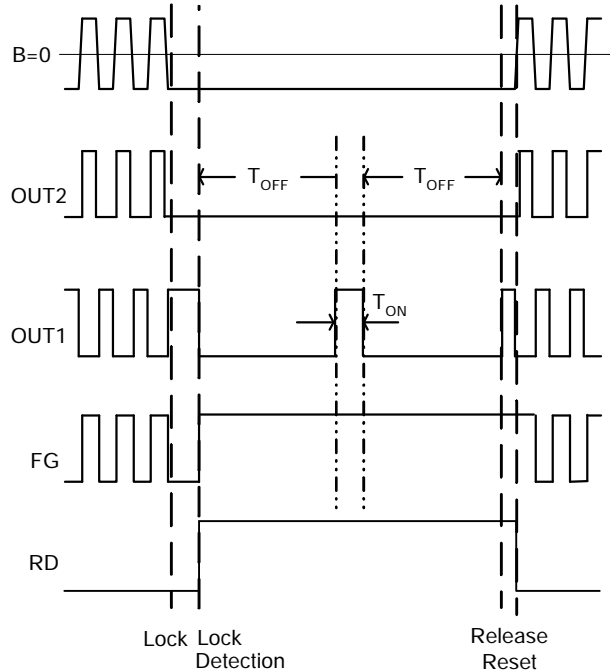
Output Switch Principle

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.

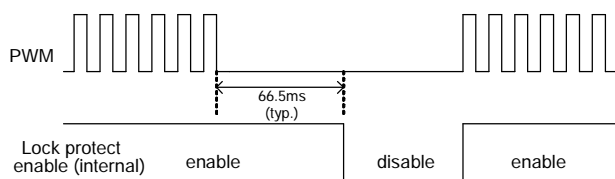


Speed Control by Direct PWM Input Signal

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.

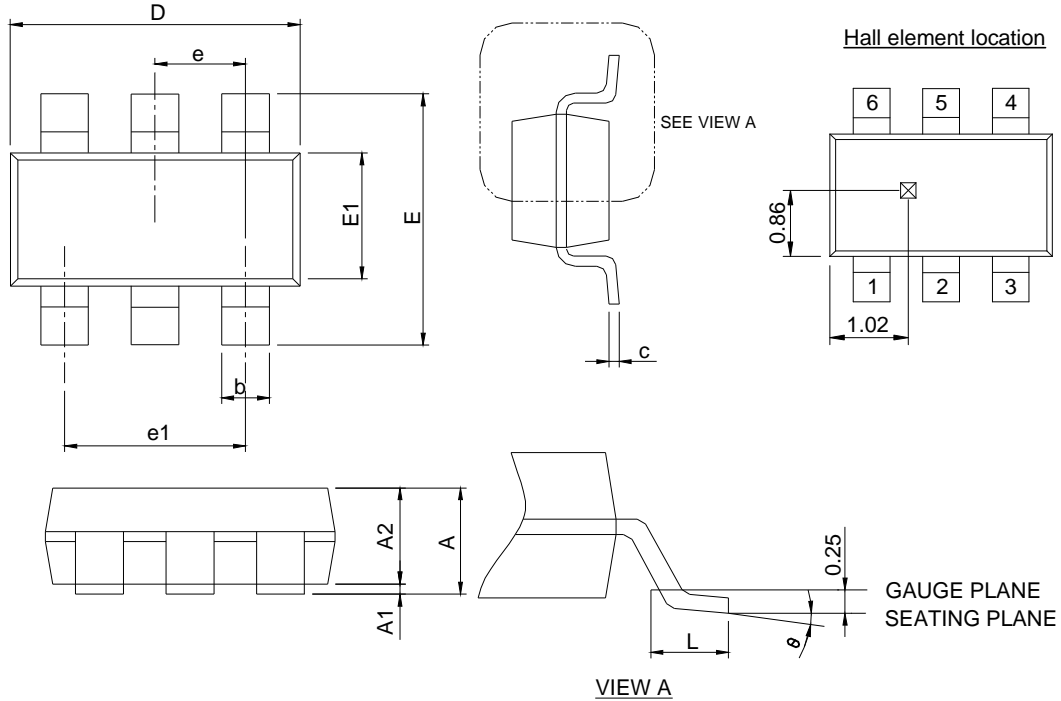


Truth Table

| 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

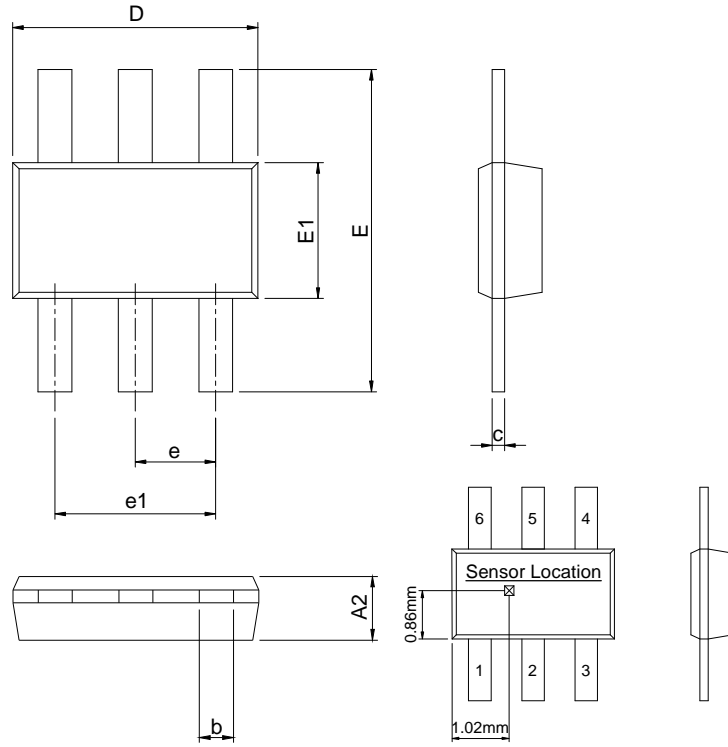


| SYMBOL | TSOT-23-6 | | | |
|--------|-------------|------|-----------|-------|
| | MILLIMETERS | | INCHES | |
| | MIN. | MAX. | MIN. | MAX. |
| A | 0.70 | 1.00 | 0.028 | 0.039 |
| A1 | 0.01 | 0.10 | 0.000 | 0.004 |
| A2 | 0.70 | 0.90 | 0.028 | 0.035 |
| b | 0.30 | 0.50 | 0.012 | 0.020 |
| c | 0.08 | 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



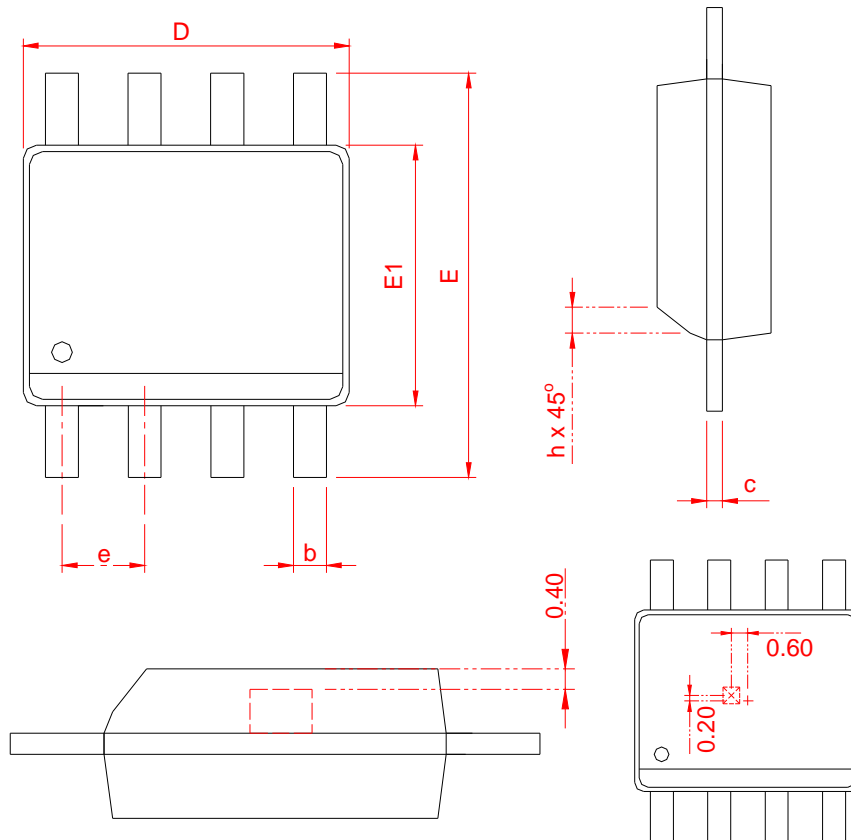
Top view : Marking side

| 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.

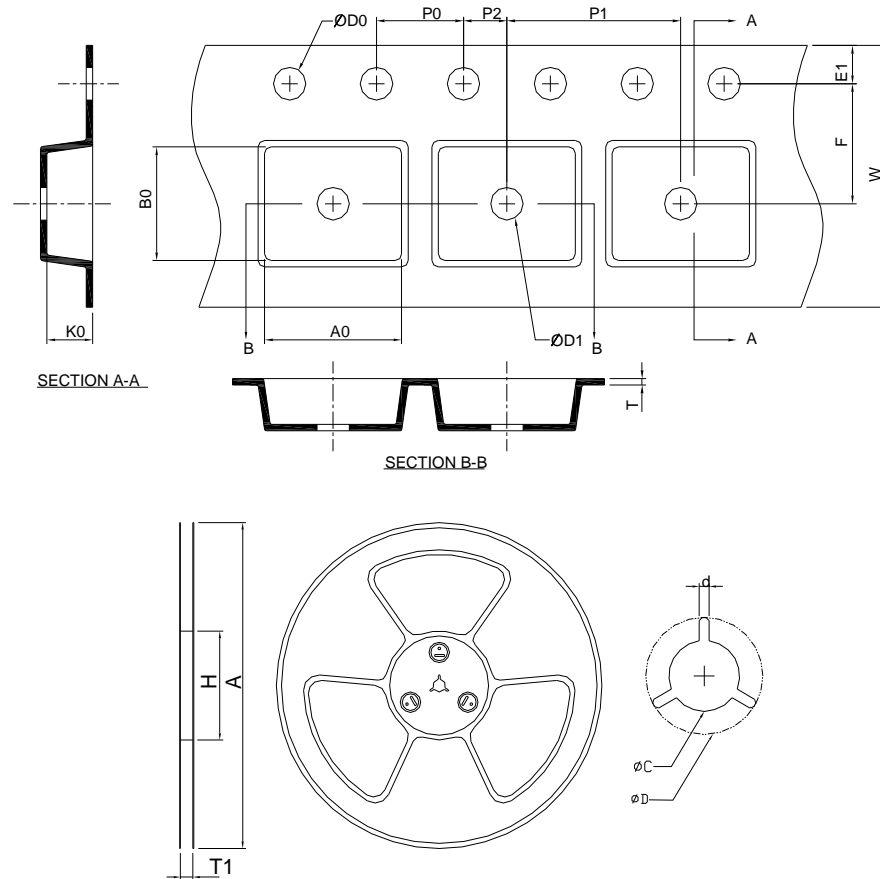
Package Information

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 |

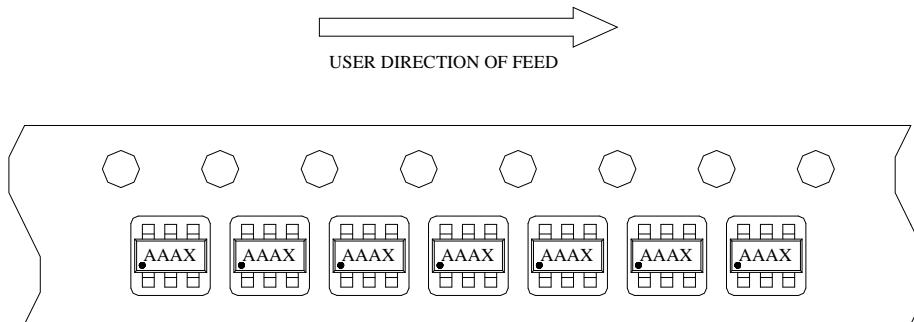
(mm)

Devices Per Unit

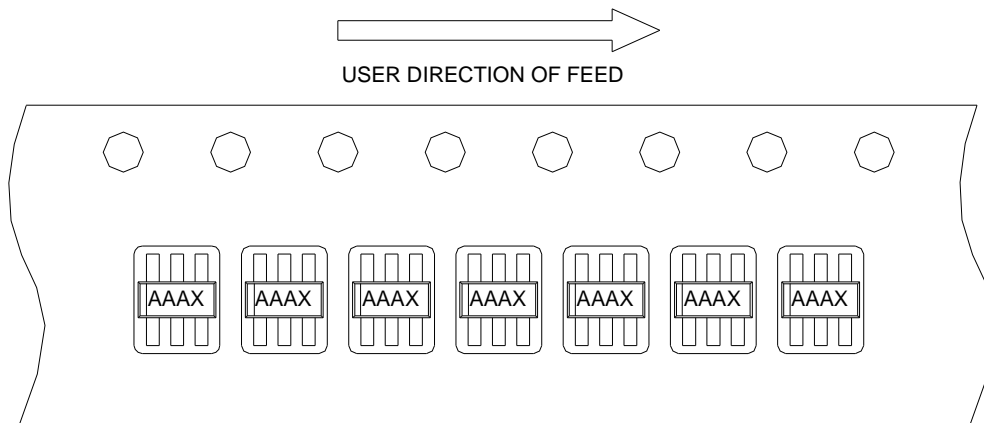
| Package Type | Unit | Quantity |
|--------------|-------------|----------|
| TSOT-23-6 | Tape & Reel | 3000 |
| TSOT-23-6F | Tape & Reel | 3000 |
| SOP-8F | Tape & Reel | 2500 |

Taping Direction Information

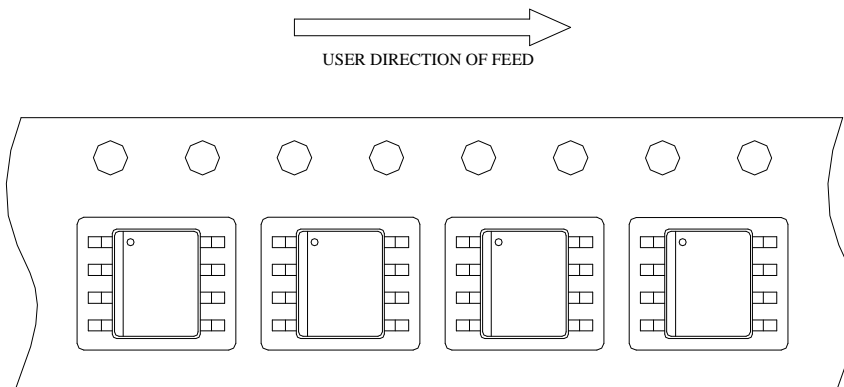
TSOT-23-6



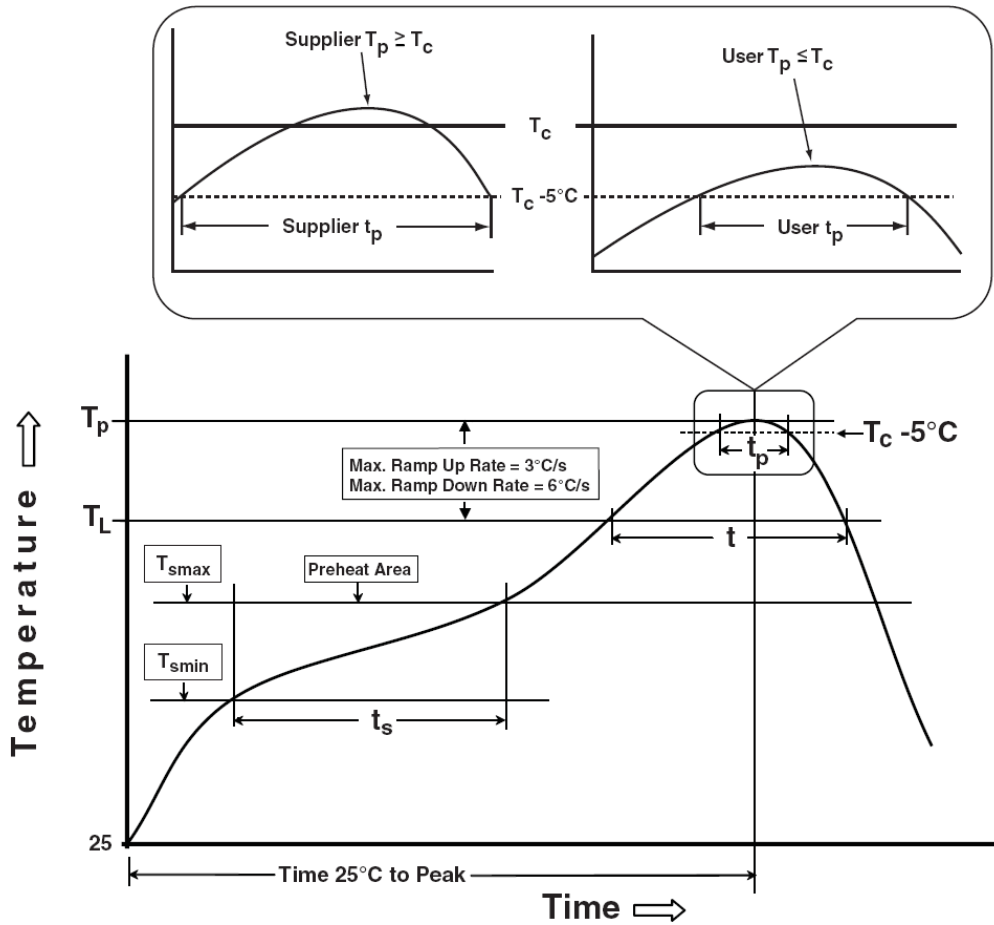
TSOT-23-6F



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

Anpec Electronics Corp.

Head Office :

No.6, Dusing 1st Road, SBIP,
Hsin-Chu, Taiwan
Tel : 886-3-5642000
Fax : 886-3-5642050

Taipei Branch :

2F, No. 11, Lane 218, Sec 2 Jhongsing Rd.,
Sindian City, Taipei County 23146, Taiwan
Tel : 886-2-2910-3838
Fax : 886-2-2917-3838