Single-Phase Full-Wave Motor Driver for Fan Motor

Features

- **Single Phase Full Wave Fan Driver**
- **Low Supply Current**
- **Built-In Variable Speed Function**
- **Include Hall Bias Circuit**
- **Built-In Lock Protection and Auto Restart Function**
- **FG Output**
- **Built-In Current Limit Circuit**
- **Built-In Thermal Protection Circuit**
- **SSOP-16 and TSSOP-16 Packages**
- **Lead Free and Green Devices Available (RoHS Compliant)**

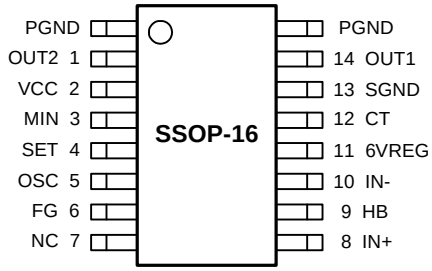
General Description

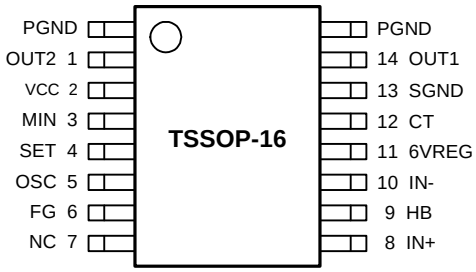
The APX9292 is a single phase full wave DC brushless motor driver with PWM variable speed control and current limit features suitable for the fan of personal computer's power supply and CPU cooler. The device is built-in lock protection. When fan is locked, the device will enter the lockup protection mode. It is also with rotation detection output and thermal shutdown function. In normal operation, supply current is 4mA. The APX9292 is available in SSOP-16 and TSSOP-16 packages.

Applications

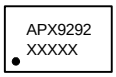
- **CPU Cooler**
- **Variable Speed Control Fan**

Pin Configuration





Ordering and Marking Information

APX9292 □□□-□□□ Assembly Material Handling Code Temperature Range Package Code	Package Code N: SSOP - 16 O: TSSOP-16 Operating Ambient Temperature Range I : -40 to 90 °C Handling Code TR : Tape & Reel Assembly Material G: Halogen and Lead Free Device
APX9292 N : 	XXXXX - Date Code
APX9292 O : 	XXXXX - 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	Ratings	Unit
V_{CC}	VCC Pin Supply Voltage	-0.3 to 18	V
$I_{OUT(PEAK)}$	OUT1/OUT2 Pin Output Peak Current (pulse width < 45µs, 20KHz)	1.5	A
I_{OUT}	OUT1/OUT2 Pin Output Current	0 to 1	A
V_{OUT1}/V_{OUT2}	OUT1/OUT2 Pin Output Voltage	-0.3 to 18	V
I_{HB}	HB Pin Output Current	0 to 10	mA
V_{SET} / V_{MIN}	SET/MIN Pin Input Voltage	-0.3 to 18	V
V_{FG}	FG Output Voltage	-0.3 to18	V
I_{FG}	FG Sink Current	0 to 10	mA
$R_{TH,JA}$	Thermal Resistance-Junction to Ambient SSOP-16 TSSOP-16	 125 147	°C/W
P_D	Power Dissipation (Note2) SSOP-16 TSSOP-16	 1 0.85	W
T_J	Junction Temperature	-40 to 150	°C
T_{STG}	Storage Temperature	-55 to 150	°C
T_{SDR}	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.
Note2: Mounted on a board (60x38x1.6tmm, Glass epoxy).

Recommended Operating Conditions

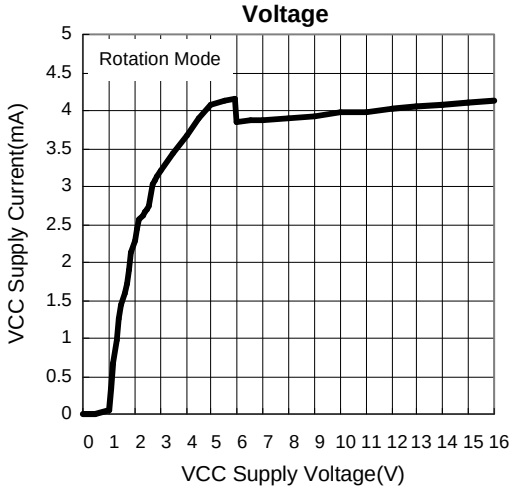
Symbol	Parameter	Rating	Unit
V_{CC}	VCC Pin Supply Voltage	3.5 to 15	V
V_{SET}	SET Pin Input Voltage Range	0 to V_{6VREG}	V
V_{MIN}	MIN Pin Input Voltage Range	0 to V_{6VREG}	V
V_{ICM}	Common-Mode Hall Input Voltage Range	0.2 to 3	V
T_A	Ambient Temperature	-40 to 90	°C

Electrical Characteristics (V_{CC} = 12V, T_A = 25°C, unless otherwise specified)

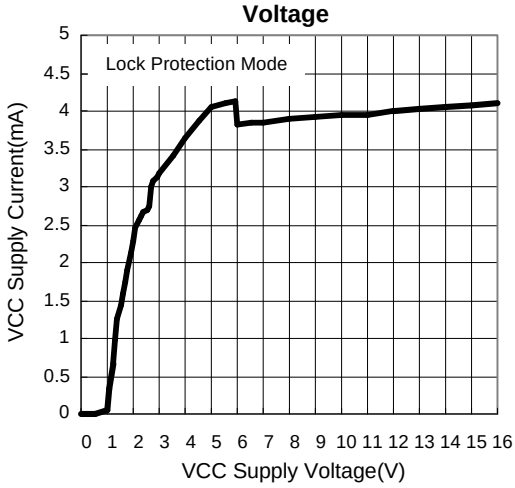
Symbol	Parameter	Test Conditions	APX9292			Unit
			Min.	Typ.	Max.	
SUPPLY CURRENT						
V_{HB}	HB Pin Output Voltage	I_{HB} = 5mA	1.15	1.3	1.45	V
V_{6VREG}	6VREG Pin Output Voltage	I_{6VRGE}=5mA	5.85	6	6.15	V
I_{CC1}	Operating Current	Rotation Mode	-	4	6	mA
I_{CC2}		Lock Protection Mode	-	4	6	mA
OSCILLATOR						
V_{OSCH}	OSC High Level Voltage		3.85	4	4.15	V
V_{OSCL}	OSC Low Level Voltage		0.9	1	1.1	V
F_{OSC}	OSC Oscillation Frequency	C_{OSC} = 100pF	20	30	40	kHz
LOCK PROTECTION						
V_{CTH}	CT Pin High Level Voltage	C_{CT} = 1µF	3.24	3.6	3.96	V
V_{CTL}	CT Pin Low Level Voltage	C_{CT} = 1µF	1.2	1.4	1.6	V
I_{CT1}	CT Charge Current	V_{CT} = 0V	1.5	2	2.5	µA
I_{CT2}	CT Discharge Current	V_{CT} = 3.6V	0.15	0.2	0.25	µA
R_{CT}	CT Charge/Discharge Current Ratio	$R_{CT} = I_{CT1}/I_{CT2}$	9.5	11	12.5	-
OUTPUT DRIVERS						
V_{OL}	Output Lower Side Saturation	I_{OUT} = 200mA	-	0.1	0.2	V
V_{OH}	Output Upper Side Saturation	I_{OUT} = 200mA	-	0.25	0.5	V
V_{FG}	FG Pin Low Voltage	I_{FG} = 5mA	-	0.2	0.3	V
I_{FGL}	FG Pin Leak Current	V_{FG} = 7V	-	-	0.1	µA
HALL SENSITIVITY						
V_{HN}	Hall Input Sensitivity	Zero to peak including offset and hysteresis	-	10	25	mV
THERMAL SHUTDOWN						
	Over-Temperature Shutdown Threshold		-	175	-	°C
	Over-Temperature Shutdown Hysteresis		-	30	-	
CURRENT LIMIT						
I_{LIM}	Current Limit Value		0.85	1	1.15	A

Typical Operating Characteristics

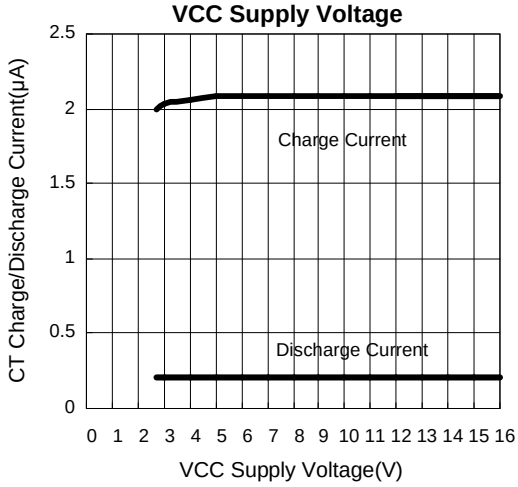
VCC Supply Current vs. VCC Supply Voltage



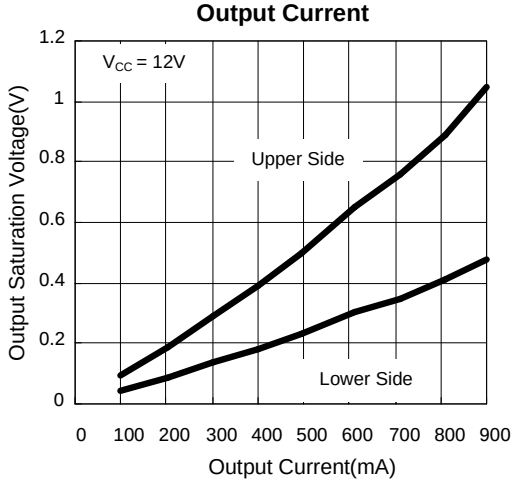
VCC Supply Current vs. VCC Supply Voltage



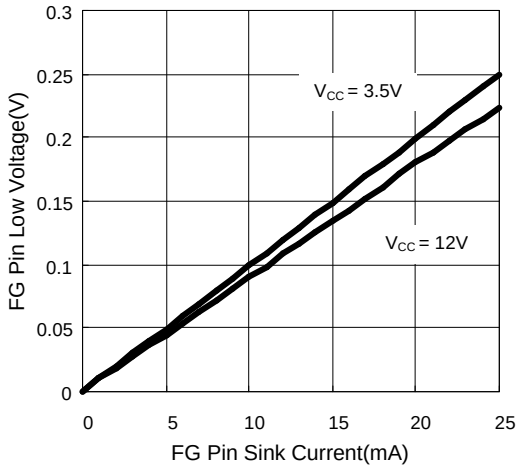
CT Charge/Discharge Current vs. VCC Supply Voltage



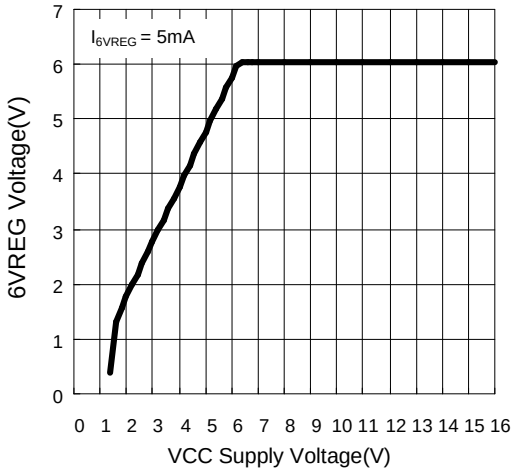
Output Saturation Voltage vs. Output Current



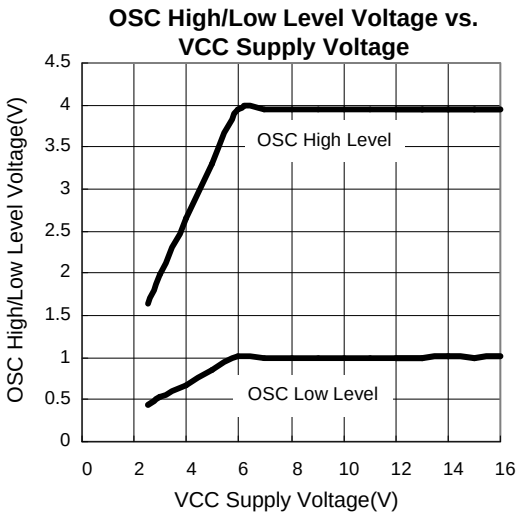
FG Pin Low Voltage vs. Sink Current

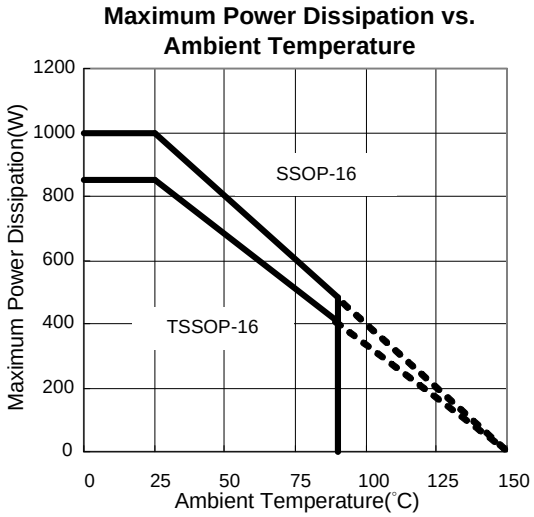


6VREG Voltage vs. VCC Supply Voltage



Typical Operating Characteristics



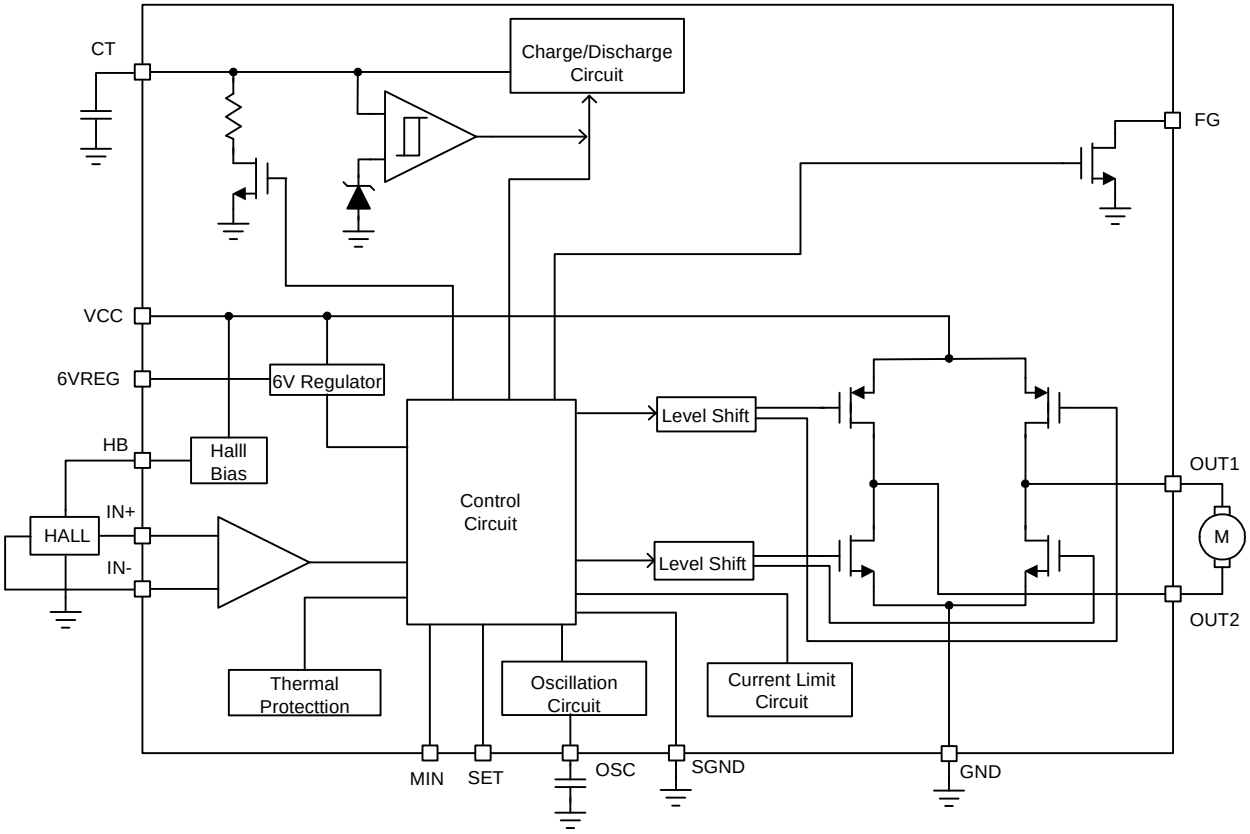


Pin Descriptions

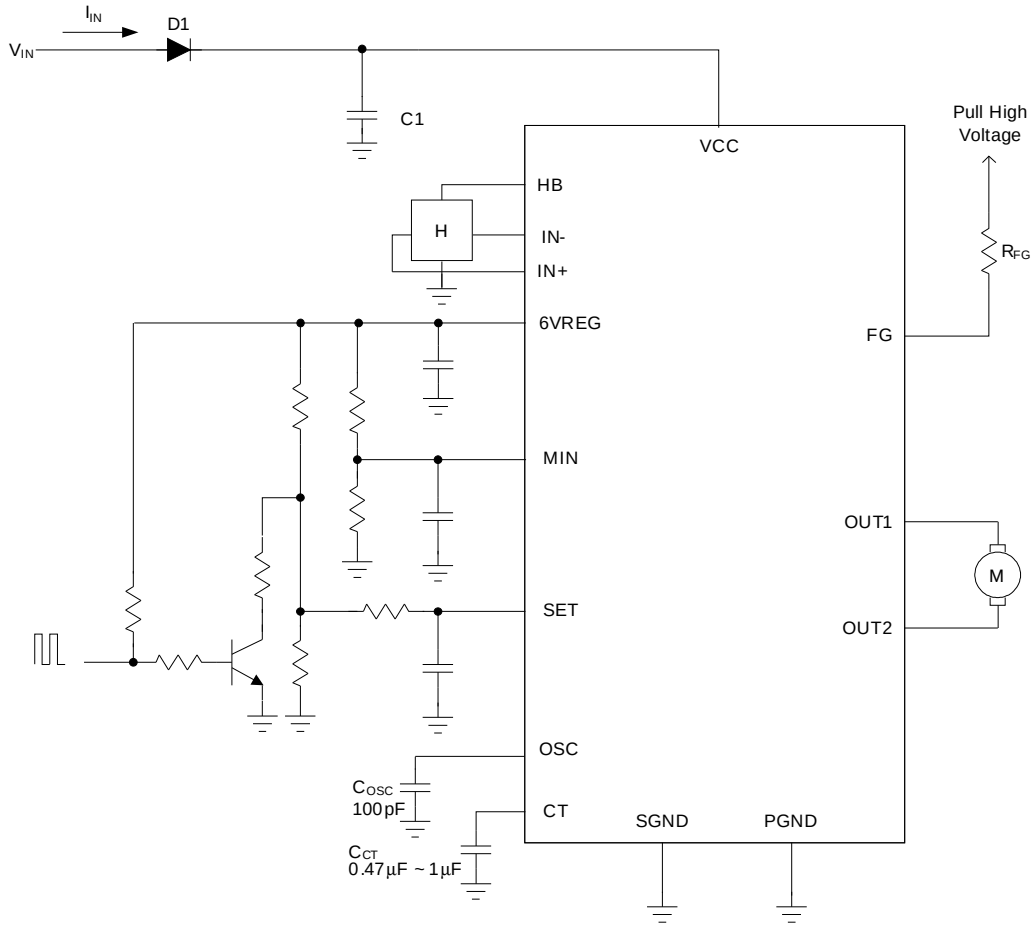
PIN		FUNCTION
NO.	NAME	
1	OUT2	H-bridge Output Connection.
2	VCC	Supply Voltage Input Pin.
3	MIN	Minimum Speed Setting. An external voltage into MIN pin to set fan speed.
4	SET	Speed Setting. An external voltage into SET pin to set fan speed.
5	OSC	Oscillation Frequency Setting. Connect a capacitor to GND to set oscillation frequency.
6	FG	Rotation Speed Output. This is an open–drain output.
7	NC	No Connection.
8	IN+	Hall Input +. Connect to hall element positive output.
9	HB	Hall Bias. This is a 1.3V constant–voltage output for hall element bias.
10	IN-	Hall Input -. Connect to hall element negative output.
11	6VREG	6V Regulator Output. This is a 6V constant-voltage output for application circuit biases.
12	CT	Shutdown Time and Restart Time Setting. Connect a capacitor to GND to set shutdown time and restart time in lock mode.
13	SGND	Control Stage GND.
14	OUT1	H-bridge Output Connection.

Note : PGND pads are power ground of driver circuit. Please connect to input power.

Block Diagram



Typical Application Circuit



Functional Descriptions

Variable speed control

The APX9292 has a variable speed controller, which is operated by comparing the voltage of OSC, MIN and SET. Fan's minimum speed is set by comparing the OSC oscillating voltage and MIN pin voltage. PWM control system works by comparing the voltage of SET and OSC. When SET voltage is lower than OSC voltage, one OUT pulled high and another OUT pulled low. On the contrary, when SET voltage is higher than OSC voltage, upper side transistors are OFF, meanwhile, the coil current re-circulates lower side transistor. Therefore, with decreasing SET voltage, the output ON-Duty will be increasing, which results in the increasing of the coil current and motor rotation speed. Rotation speed is able to feedback by FG output. PWM basic frequency becomes 30 KHz, when putting on C_{OSC}=100pF. (See Figure 1: Rotation Waveform).

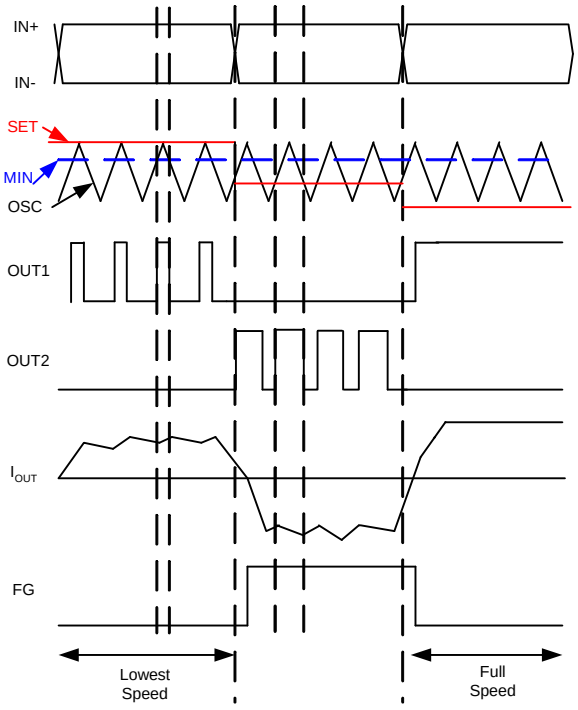


Figure 1: Rotation Waveform

Lockup Protection and Automatic Restart

The APX9292 provides the lockup protection and automatic restart functions for preventing the coil burnout while the fan is locked. Connecting the capacitor from CT pin to GND determines the shutdown time and restart time. As the fan is locked, the charge/discharge circuit will charge the CT capacitor to 3.6V by a 2μA source current for a locked detection time, and then the circuit will switch the capacitor to discharge. During the discharging interval, the output drivers are switched off until the CT voltage is discharged to 1.4V by a 0.2μA sink current, and the circuit will switch the capacitor to charge. In the charging interval, the IC enters the restart time; one output is high and another is low, which makes a torque for fan rotation until the CT voltage is charged to 3.6V by a 2μA source current. If the locked condition still remains, the charge/discharge process will be recurred until the locked condition is released (See Figure 2: Lock/Auto Restart Waveform).

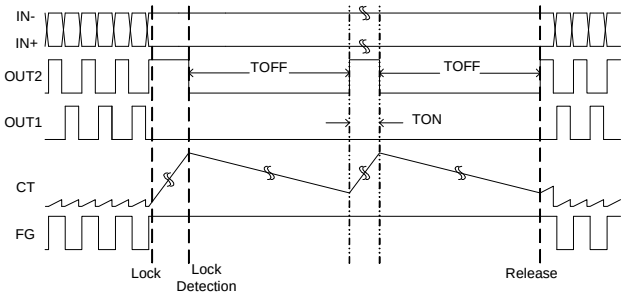


Figure 2: Lock/Auto Restart Waveform

Functional Descriptions (Cont.)

Output Drivers

All four drivers in the bridge output are designed for single coil fans. An internally generated dead time prevents cross-over currents that can occur when switching the output devices. Built-in re-circulation diodes make the output current flows through the internal re-circulation diodes between the output devices are switched off in dead time.

Frequency Generator Function

The FG pin is an open collector output, connecting a pull up resistor to a high level voltage for the frequency generator function. When IN- is larger than IN+, the FG is low (switch on); when IN- is smaller than IN+, the FG is high (switch off). RD pin is also open corrector output. Low level is at rotation mode and high level is at stop mode (See Truth Table). Open the terminal when not in using.

Thermal Protection

The APX9292 has thermal protection. When internal junction temperature reaches 175°C, the output devices will be switched off. When the IC's junction temperature cools by 30°C, the thermal sensor will turn the output devices on again, resulting in a pulsed output during continuous thermal protection.

Truth Table

Input				Output			
IN-	IN+	OSC	CT	OUT1	OUT2	FG	Mode
H	L	H	L	H	L	L	Rotation (Drive)
L	H			L	H	OFF	PWM ON
H	L	L		OFF	L	L	Rotation (Re-Circulation)
L	H			L	OFF	OFF	PWM OFF
H	L	-	H	L	L	OFF	Lock Mode
L	H			L	L	OFF	

Note 4: OSC-H corresponds to OSC>SET and OSC-L corresponds to OSC<SET.

Application Information

Input Protection Diode & Capacitor

The IC should be added a protection diode (D1) to prevent the damage from the power reverse connection. However, the protection diode will cause a voltage drop on the supply voltage. The current rating of the diode must be greater than the maximum output current. For the noise reduction purpose, a capacitor (C1) must connect between VCC and GND. It is the suggestion that C1 should be placed as close as possible to the device VCC pin

HB Pin & Hall Input

1.3V voltage reference is for hall element bias. Wiring needs to be shortened to prevent carrying of the noise. Hall input amplifier has 25mV hysteresis. Then, we recommend the hall input level to be 60mV or over.

CT Capacitor

The capacitor that is connected from CT pin to GND determines the shutdown time and restart time.

$$\text{Locked Detection Time} = \frac{C_{CT} \times (V_{CTH} - 0.2V)}{I_{CT1}}$$

$$\text{Restart Time} = \frac{C_{CT} \times (V_{CTH} - V_{CTL})}{I_{CT1}}$$

$$\text{Shutdown Time} = \frac{C_{CT} \times (V_{CTH} - V_{CTL})}{I_{CT2}}$$

where:

C_{CT} = CT pin capacitor

For example:

V_{CC}= 12V, C_{CT}= 1μF
Locked Detection Time = 1.7s
Restart Time = 1.1s
Shutdown Time = 11s

The value of charge capacitor is recommended from 0.47μF to 1μF.

FG Resistor

The value of the FG resistor could be decided by the following equation:

$$R_{FG} = \frac{V_{DC} - V_{FG}}{I_{FG}}$$

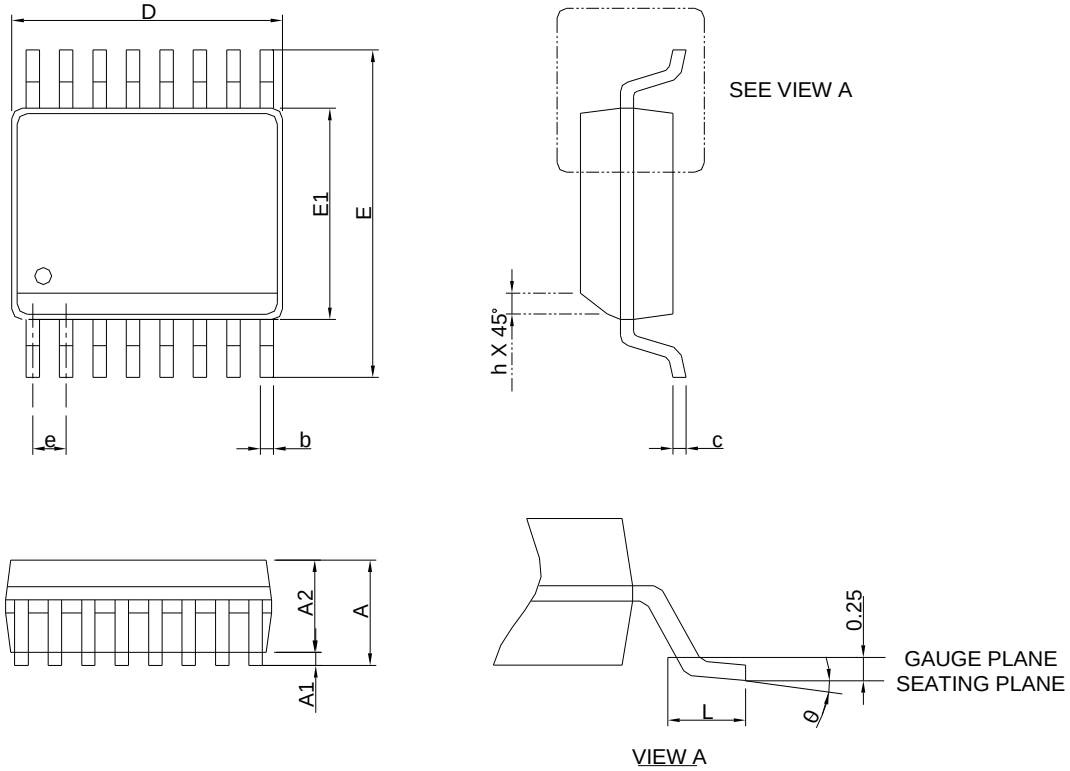
For example:

V_{DC}= 6V, I_{FG} = 5mA, V_{FG}= 0.2V, R_{FG} = 1.16kΩ

The value of resistor in the range of 1kΩ to 10kΩ is recommended.

Package Information

SSOP-16

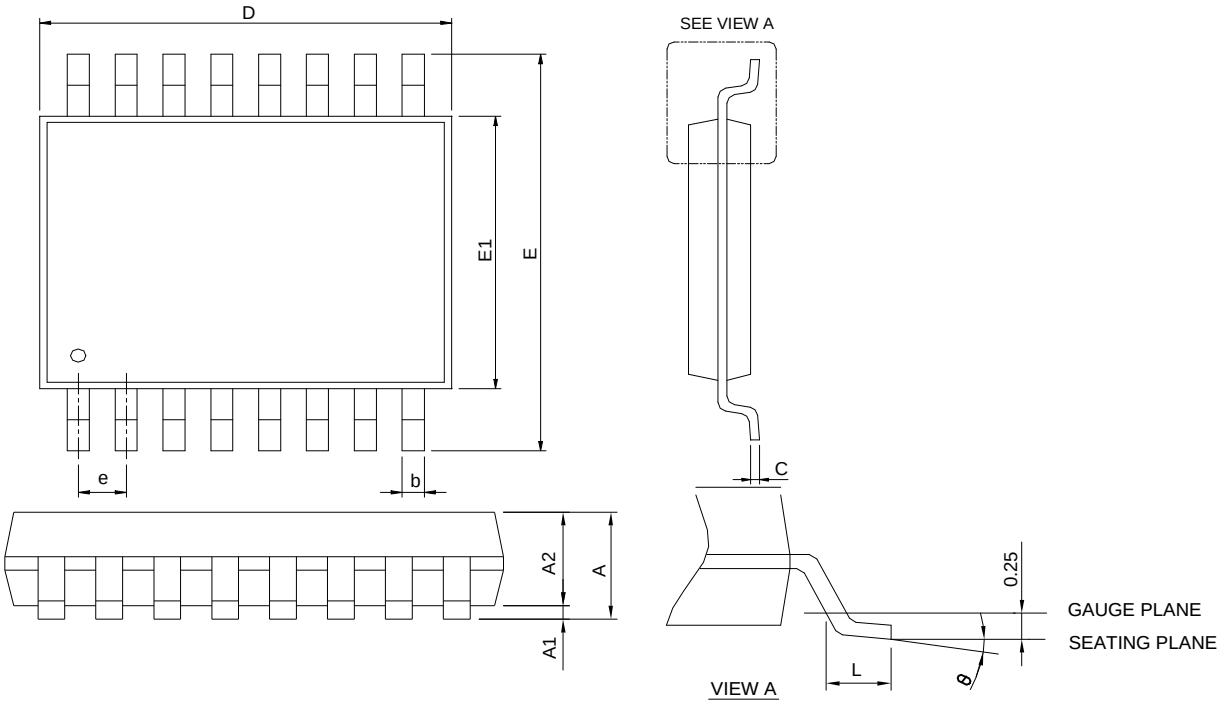


SYMBOL	SSOP-16			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.75		0.069
A1	0.10	0.25	0.004	0.010
A2	1.24		0.049	
b	0.20	0.30	0.008	0.012
c	0.15	0.25	0.006	0.010
D	4.80	5.00	0.189	0.197
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	0.635 BSC		0.025 BSC	
L	0.40	1.27	0.016	0.050
h	0.25	0.50	0.010	0.020
θ	0°	8°	0°	8°

Note : 1. Follow JEDEC MO-137 AB.
2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 6 mil per side.
3. Dimension "E" does not include inter-lead flash or protrusions. Inter-lead flash and protrusions shall not exceed 10 mil per side.

Package Information

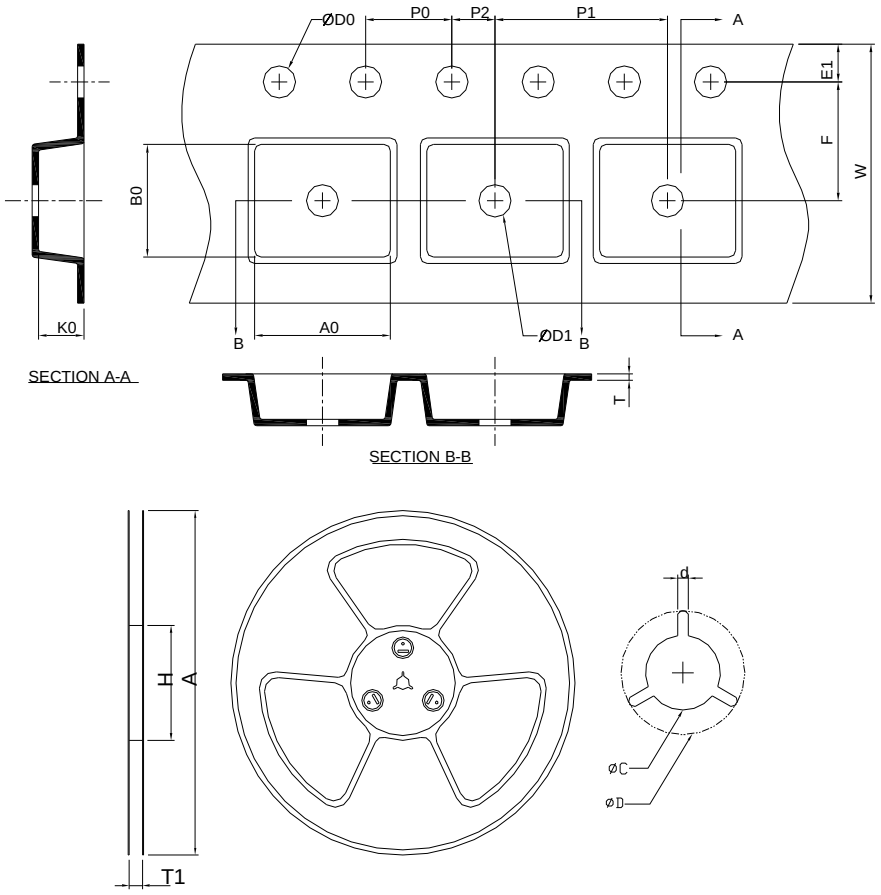
TSSOP-16



SYMBOL	TSSOP-16			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.20		0.047
A1	0.05	0.15	0.002	0.006
A2	0.80	1.05	0.031	0.041
b	0.19	0.30	0.007	0.012
c	0.09	0.20	0.004	0.008
D	4.90	5.10	0.193	0.201
E	6.20	6.60	0.244	0.260
E1	4.30	4.50	0.169	0.177
e	0.65 BSC		0.026 BSC	
L	0.45	0.75	0.018	0.030
θ	0°	8°	0°	8°

Note : 1. Follow from JEDEC MO-153 AB.
2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 6 mil per side.
3. Dimension "E1" does not include inter-lead flash or protrusions. Inter-lead flash and protrusions shall not exceed 10 mil per side.

Carrier Tape & Reel Dimensions



Application	A	H	T1	C	d	D	W	E1	F
SSOP-16	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	5.50±0.10
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.00±0.10	8.00±0.10	2.00±0.05	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	6.40±0.20	5.20±0.20	2.10±0.20
Application	**A**	**H**	**T1**	**C**	**d**	**D**	**W**	**E1**	**F**
TSSOP-16	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	5.50±0.05
	4.00±0.10	8.00±0.10	2.00±0.05	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	6.80±0.20	5.40±0.20	1.60±0.20

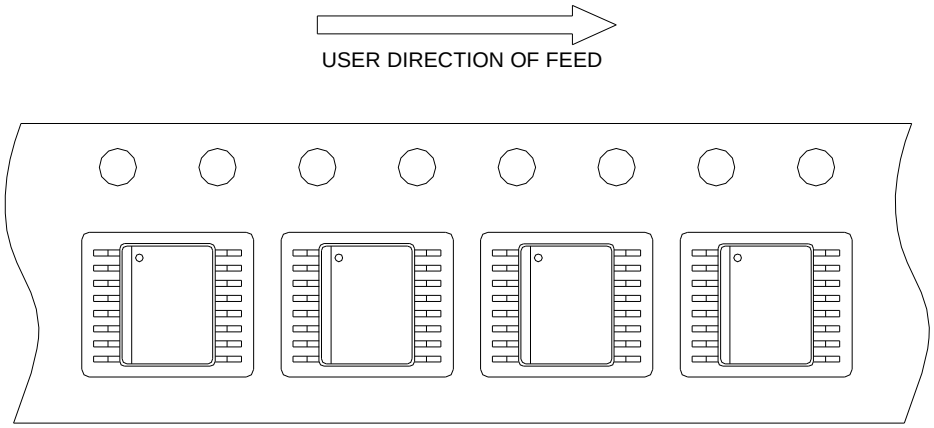
(mm)

Devices Per Unit

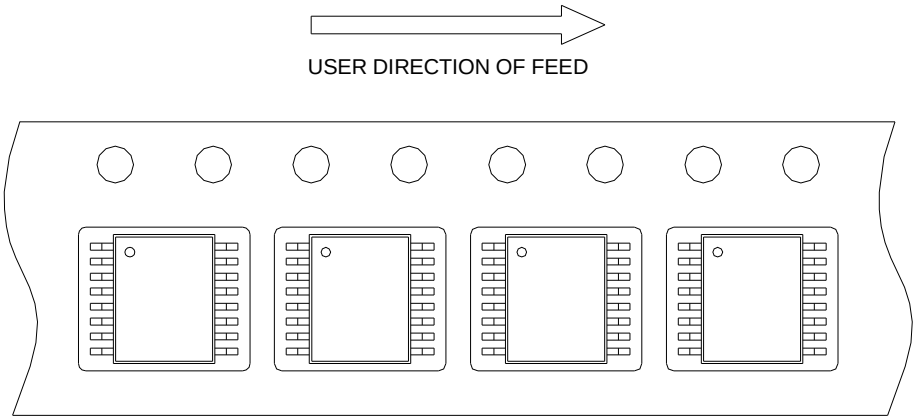
Package Type	Unit	Quantity
SSOP- 16	Tape & Reel	2500
TSSOP- 16	Tape & Reel	2500

Taping Direction Information

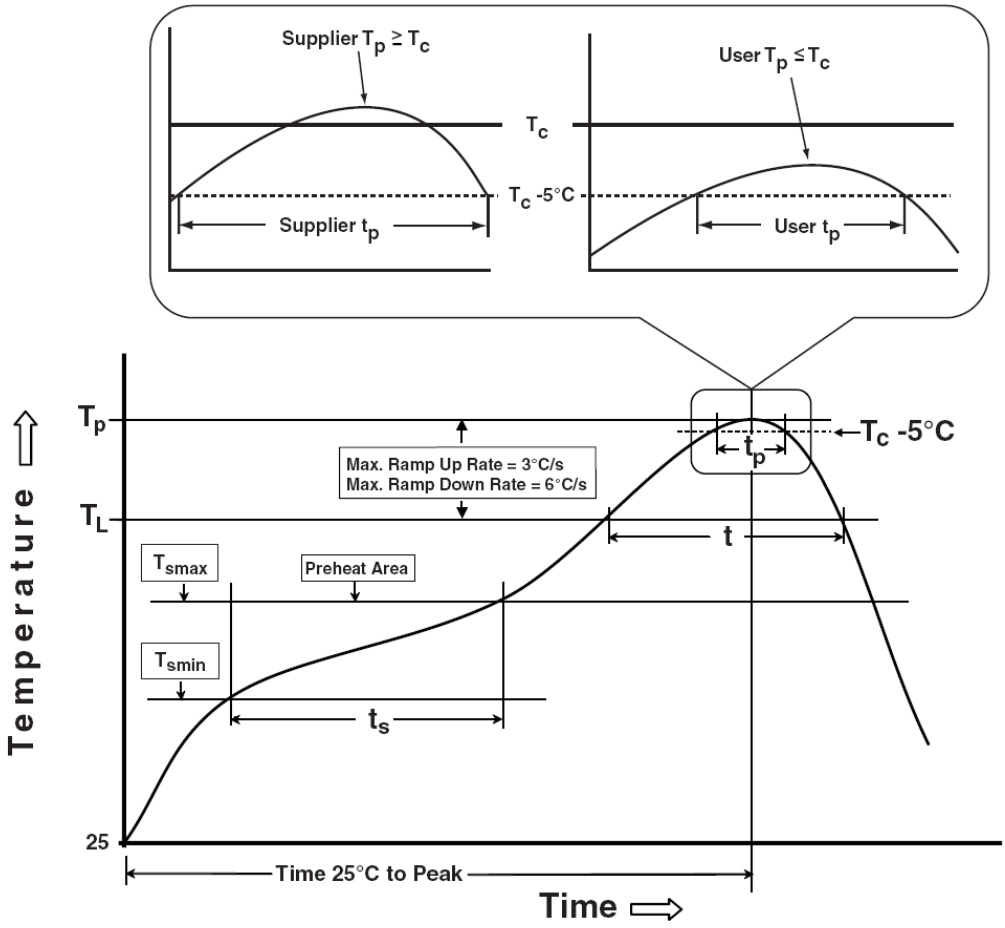
SSOP-16



TSSOP-16



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 (Tc)

Package Thickness	Volume mm^3 <350	Volume mm^3 ³350
<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 @ Tj=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, 1_{tr}≧100mA

Customer Service

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