Direct PWM Variable Speed Fan Motor Driver

Features

- **Single Phase Full Wave Fan Driver**
- **Low Supply Current**
- **Built-in Variable Speed Function**
- **Include Hall Bias Circuit**
- **Minimum Speed Settable**
- **Built-in Lock Protection and Auto Restart Function**
- **FG Output and RD Output Signal available**
- **Built-in Current Limit Circuit**
- **Built-in Thermal Protection Circuit**
- **SSOP-16 Package**
- **Lead Free and Green Devices Available (RoHS Compliant)**

General Description

The APX9262/3 is a high efficient direct PWM drive IC with single phase and CMOS drive. Such IC design is suitable for variable speed control FAN of personal computer's power supply radiation and CPU cooler. PWM control system works by comparing the voltage of SET, MIN and OSC. 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 6mA. The APX9262/3 is available in SSOP-16 package (See Pin Configurations).

Applications

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

Ordering and Marking Information

APX9262 □□-□□□

APX9263

- Assembly Material
- Handling Code
- Temperature Range
- Package Code

Package Code
N : SSOP-16
Operating Ambient Temperature Range
I : -40 to 90°C
Handling Code
TR : Tape & Reel
Assembly Material
L : Lead Free Device G : Halogen and Lead Free Device

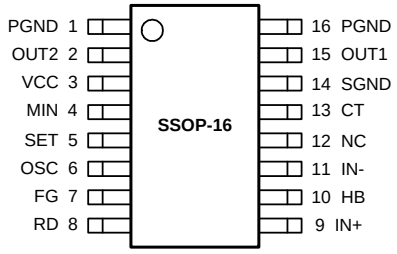
APX9262 N : APX9262 XXXXX

APX9263 N : APX9263 XXXXX

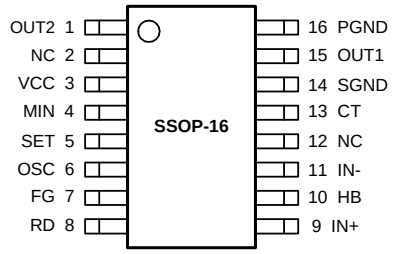
XXXXX - Date Code

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-020C 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).

Pin Configurations



APX9262



APX9263

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

Symbol	Parameter	Ratings	Unit
V_{CC}	VCC Pin Supply Voltage	-3 to 18	V
I_{OUT}	OUT1/OUT2 Pin Output Current	0 to 1	A
V_{OUT1}/V_{OUT2}	OUT1/OUT2 Pin Output Voltage	-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 6	V
V_{RD} / V_{FG}	RD/FG Output Voltage	-0.3 to18	V
I_{RD} / I_{FG}	RD/FG Sink Current	0 to 10	mA
$R_{TH,JA}$	Thermal Resistance-Junction to Ambient SSOP-16	156	℃/W
P_D	Power Dissipation (Note2)	0.8	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

Note 1: Stresses above those listed in “Absolute Maximum Ratings” may cause permanent damage to the device.
Note 2: Mounted on a board (60x38x1.6t mm, Glass epoxy).

Recommended Operating Conditions

Symbol	Parameter	Rating	Unit
V_{CC}	VCC Pin Supply Voltage	4.5 to 15	V
V_{SET}	SET Pin Input Voltage Range	0 to 6	V
V_{MIN}	MIN Pin Input Voltage Range	0 to 6	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)

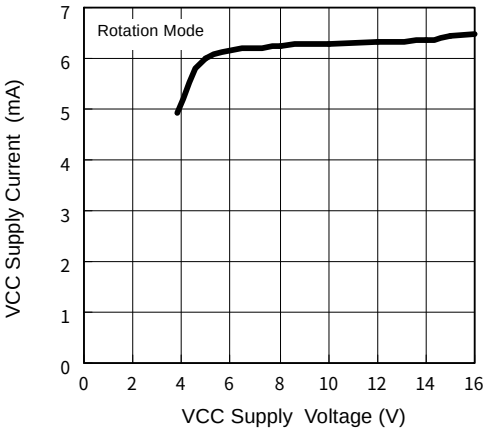
Symbol	Parameter	Test Conditions	APX9262/3			Unit
			Min.	Typ.	Max.	
Supply Current						
V_{HB}	HB Pin Output Voltage	I_{HB} = 5mA	1.15	1.3	1.45	V
I_{CC1}	Operating Current	Rotation Mode	-	6	10	mA
I_{CC2}		Lock Protection Mode	-	6	10	mA
Oscillator						
V_{OSCH}	OSC High Level Voltage	C_{OSC} = 100pF	3.45	3.6	3.75	V
V_{OSCL}	OSC Low Level Voltage	C_{OSC} = 100pF	1.95	2.05	2.15	V
F_{OSC}	OSC Oscillation Frequency	C_{OSC} = 100pF	18	25	32	KHz

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

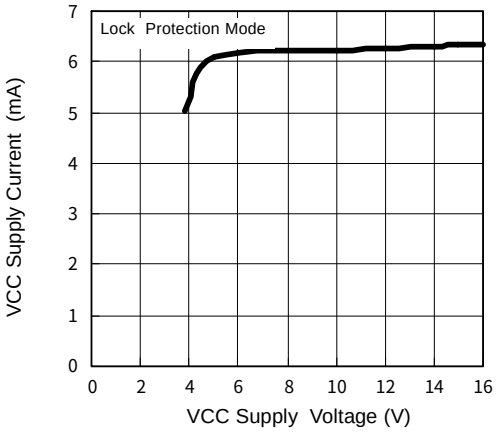
Symbol	Parameter	Test Conditions	APX9262/3			Unit
			Min.	Typ.	Max.	
Lock Protection						
V_{CTH}	CT Pin High Level Voltage	C_{CT} = 1µF	3.24	3.6	3.96	V
V_{CTL}	CT Pin Low Level Voltage	C_{CT} = 1µF	1.2	1.4	1.6	V
I_{CT1}	CT Charge Current	V_{CT} = 0V	1.5	2	2.5	µA
I_{CT2}	CT Discharge Current	V_{CT} = 3.6V	0.15	0.2	0.25	µA
R_{CT}	CT Charge/Discharge Current Ratio	$R_{CT} = I_{CT1}/I_{CT2}$	8.5	10	11.5	-
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_{RD}/V_{FG}	RD/FG Pin Low Voltage	I_{FG} = 5mA	-	0.2	0.3	V
I_{RDL}/I_{FGL}	RD/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		-	160	-	°C
	Over Temperature Shutdown Hysteresis		-	20	-	
Current Limit						
I_{LIM}	Current Limit Value		0.85	1	1.15	A

Typical Operating Characteristics

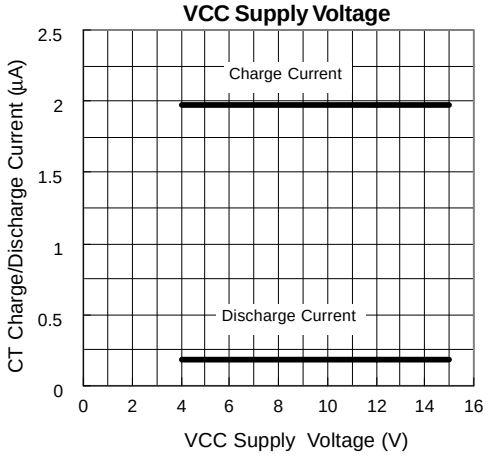
VCC Supply Current vs. VCC Supply Voltage



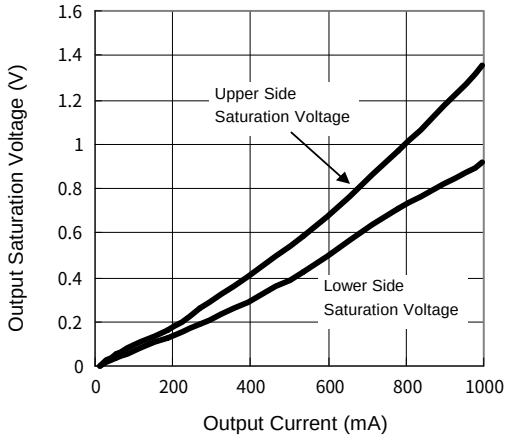
VCC Supply Current vs. VCC Supply Voltage



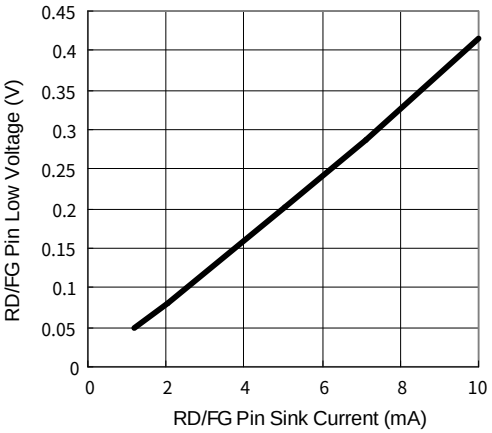
CT Charge/Discharge Current vs. VCC Supply Voltage



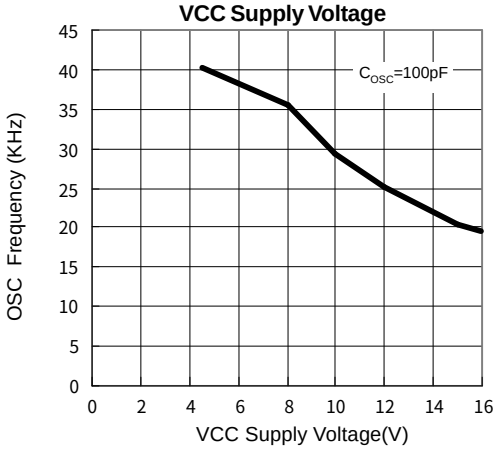
Output Saturation Voltage vs. Output Current



RD/FG Pin Low Voltage vs. Sink Current

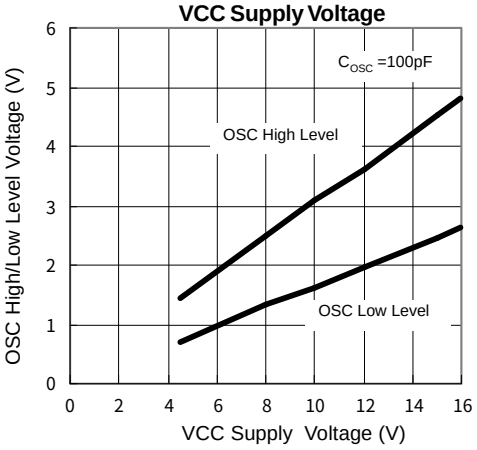


OSC Frequency vs. VCC Supply Voltage

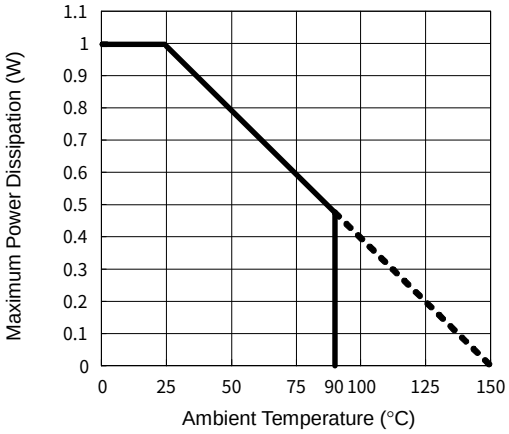


Typical Operating Characteristics (Cont.)

OSC High/Low Level Voltage vs. VCC Supply Voltage

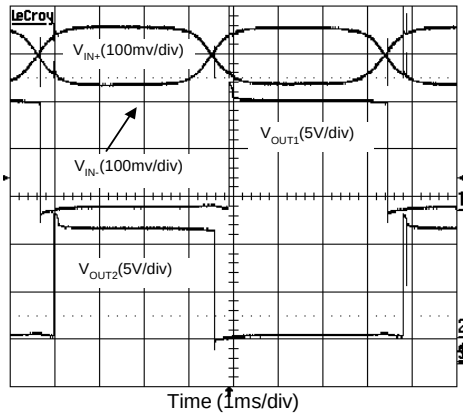


Maximum Power Dissipation vs. Ambient Temperature

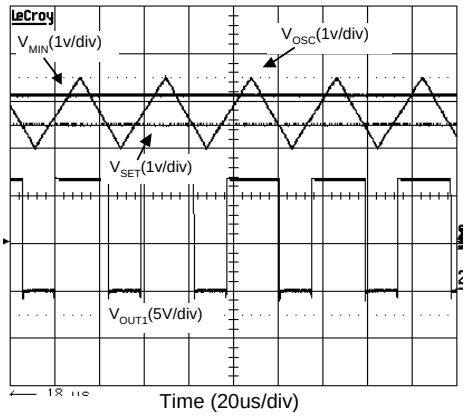


Operating Waveforms

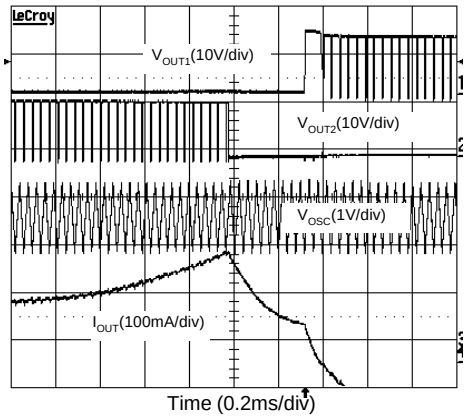
Rotation Waveform 1



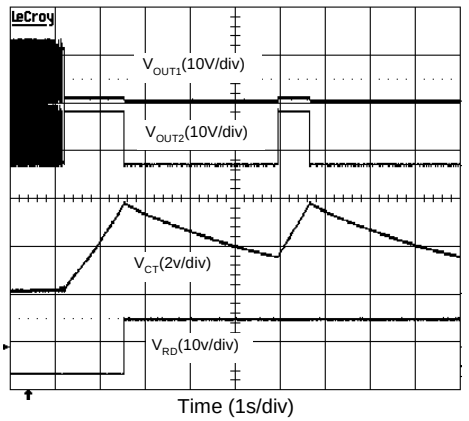
Rotation Waveform 2



Rotation Waveform 3

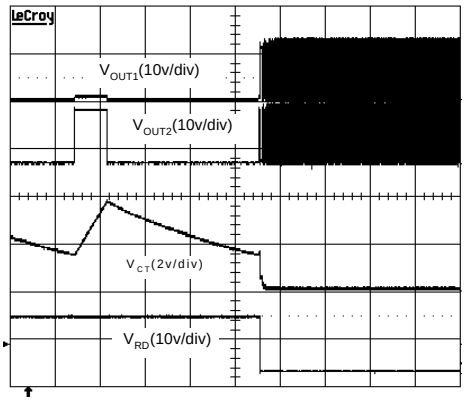


Lock Protection Waveform 1



Operating Waveforms (Cont.)

Lock Protection Waveform 2

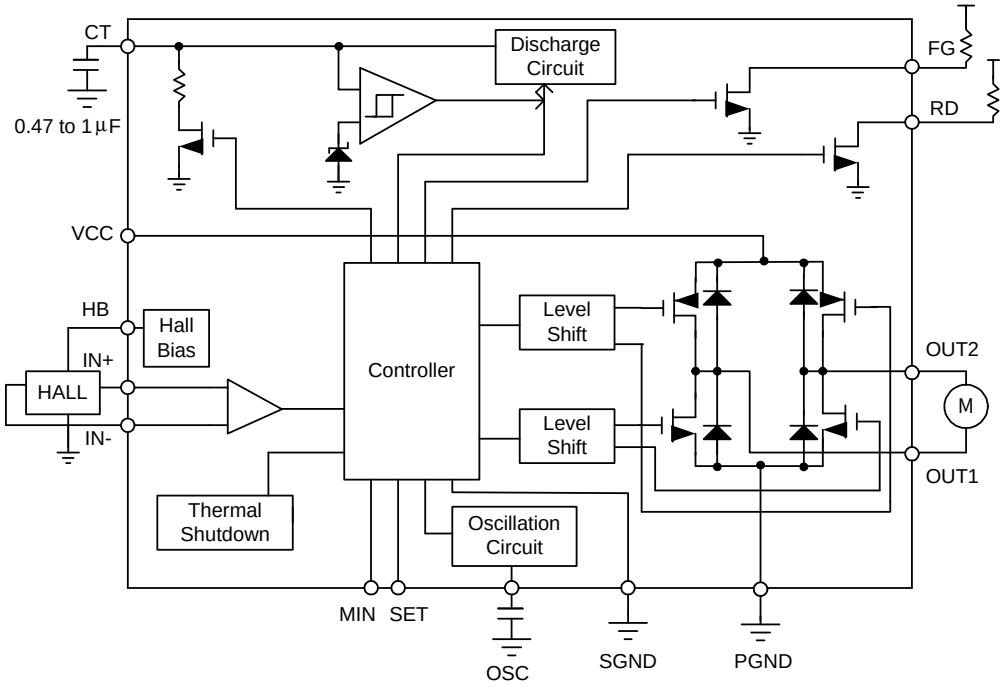


Time (1s/div)

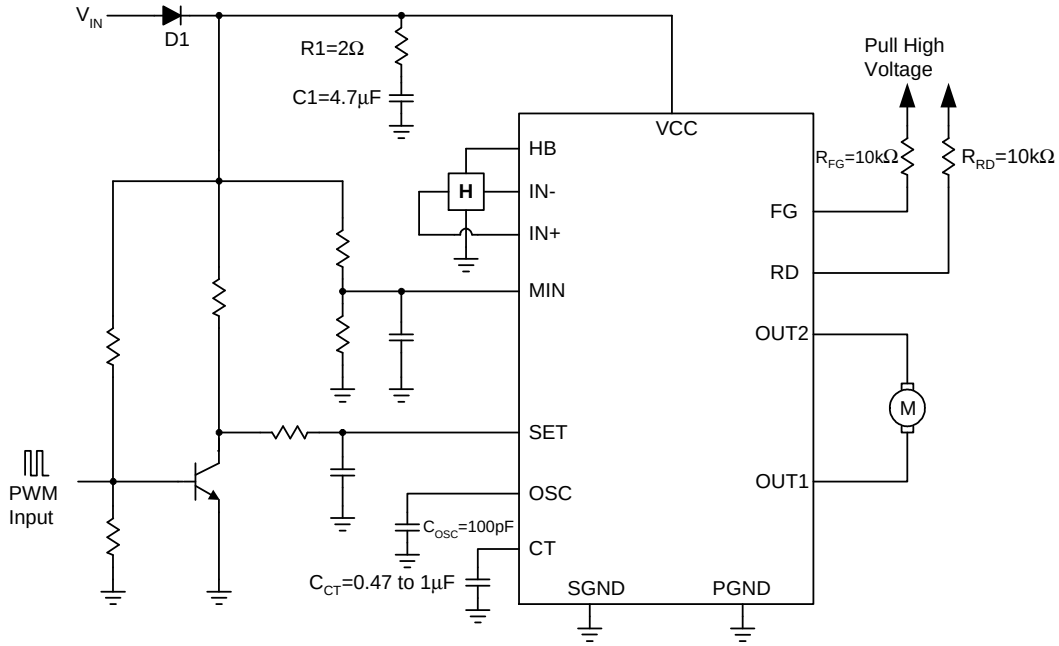
Pin Descriptions

PIN		Description
No.	Name	
1	PGND (APX9262)	Power Stage GND.
	OUT2 (APX9263)	H-bridge Output Connection. The output stage is a H-bridge formed by four transistors and four-protection diode for switching applications.
2	OUT2 (APX9262)	H-bridge Output Connection. The output stage is a H-bridge formed by four transistors and four-protection diode for switching applications.
	NC (APX9263)	No Connection.
3	VCC	Supply Voltage Input Pin.
4	MIN	Minimum Speed Setting. Use a voltage divider from VCC to set MIN pin voltage to set minimum speed of fan.
5	SET	Speed Setting. An external voltage into SET pin to set fan speed.
6	OSC	Oscillation Frequency Setting. Connect a capacitor to GND to set oscillation frequency.
7	FG	Rotation Speed Output. This is an open–collector output.
8	RD	Rotation Detection Output. This is an open–collector output.
9	IN+	Hall Input +. Connect to hall element positive output.
10	HB	Hall Bias. This is a 1.3V constant–voltage output for hall element bias.
11	IN-	Hall Input -. Connect to hall element negative output.
12	NC	No Connection.
13	CT	Shutdown Time and Restart Time Setting. Connect a capacitor to GND to set shutdown time and restart time in lock mode.
14	SGND	Control Stage GND.
15	OUT1	H-bridge Output Connection. The output stage is a H-bridge formed by four transistors and four-protection diode for switching applications.
16	PGND	Power Stage GND.

Block Diagram



Typical Application Circuit



Note 3: In hot plug application, it's necessary to protect against a hot plug input voltage overshoot. Placing a 2Ω resistor (R1) in series with a 4.7µF capacitor (C1) dampens the overshoot.

Functional Descriptions

Variable speed control

The APX9262/3 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 25 KHz, when putting on C_{OSC}=100pF. (See Figure 1: Rotation Waveform).

Lockup Protection and Automatic Restart

The APX9262/3 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).

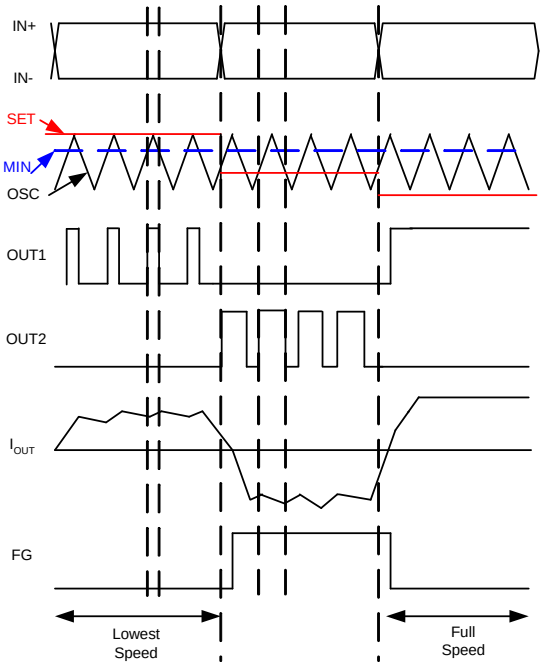


Figure 1: Rotation Waveform

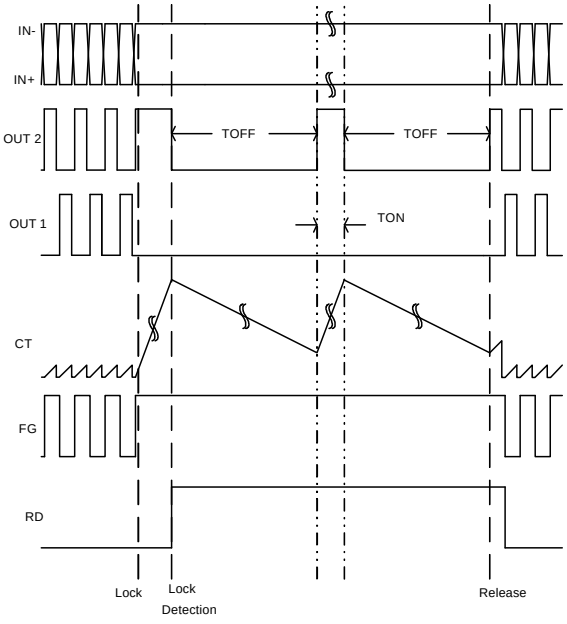


Figure 2: Lock/Auto Restart Waveform

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 and Rotation Detection 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 APX9262/3 has thermal protection. When internal junction temperature reaches 160°C, the output devices will be switched off. When the IC's junction temperature cools by 20°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	RD	Mode
H	L	H	L	H	L	L	L	Rotation (Drive)
L	H			L	H	OFF	L	PWM ON
H	L	L		OFF	L	L	L	Rotation (Re-Circulation)
L	H			L	OFF	OFF	L	PWM OFF
H	L	-	H	L	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 (see Figure 3: Recommended Layout Diagram).

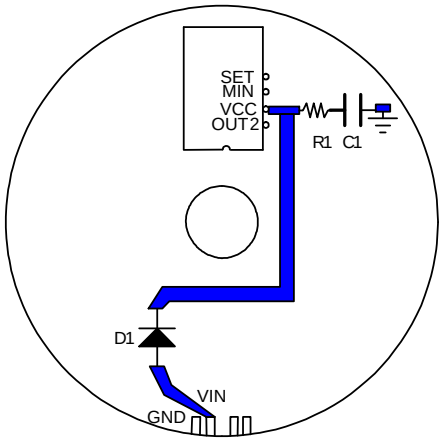


Figure 3: Recommended Layout Diagram

Application Information (Cont.)

HB pin & Hall input

1.3V voltage reference is for hall element bias. Wiring needs to be short to prevent carrying of the noise. Hall input amplifier has 20mV 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 /RD Resistor

The value of the FG/RD 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.

Thermal Consideration

Refer to "Maximum Power Dissipation vs. Ambient Temperature", the IC is safe to operate below the curve, and it will cause the thermal protection if the operating area is above the line. For example, T_A= 50°C, the SSOP-16 package maximum power dissipation is about 0.8W.
Power dissipation can be calculated by the following equation:

$$P_D = (V_{CC} - |V_{OUT1} + V_{OUT2}|) \times I_{OUT} + V_{CC} \times I_{CC}$$

For example:

When

V_{CC} = 12V, I_{CC} = 4mA, I_{OUT} = 300mA, V_{oUT1} = 11.7V, V_{OOUT2} = 0.22V,

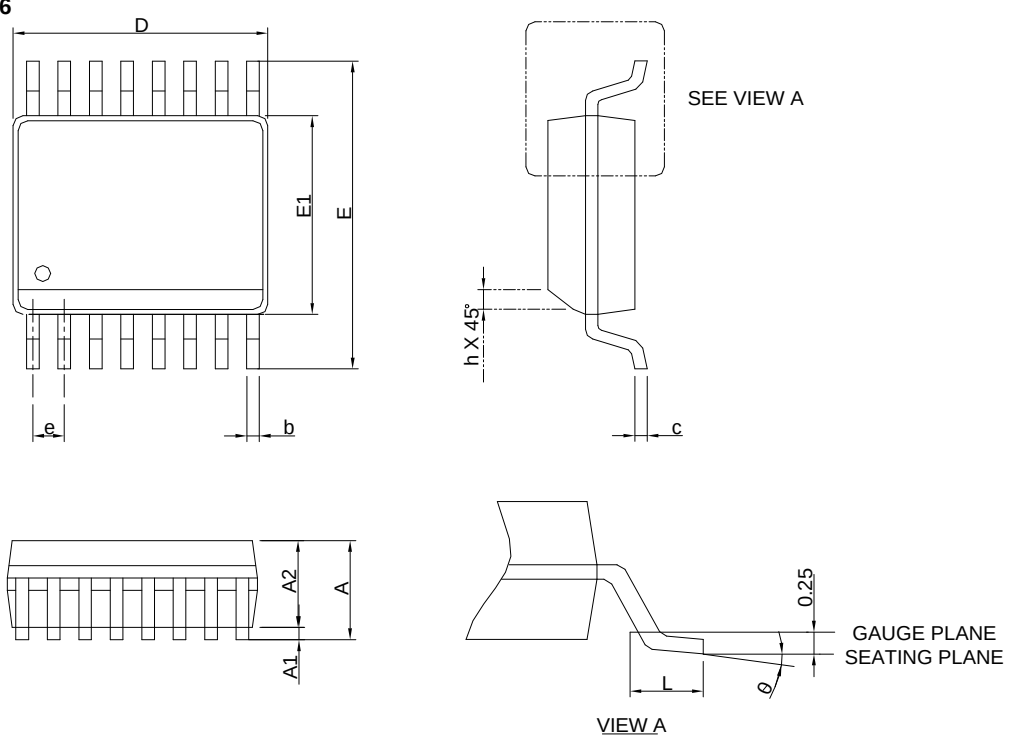
the P_D = 0.204W

According to the power dissipation issue, we could adapt this SSOP-16 package.

The GND pin provides an electrical connection to ground and channeling heat away. The printed circuit board (PCB) forms a heat sink and dissipates most of the heat into ambient air.

Package Information

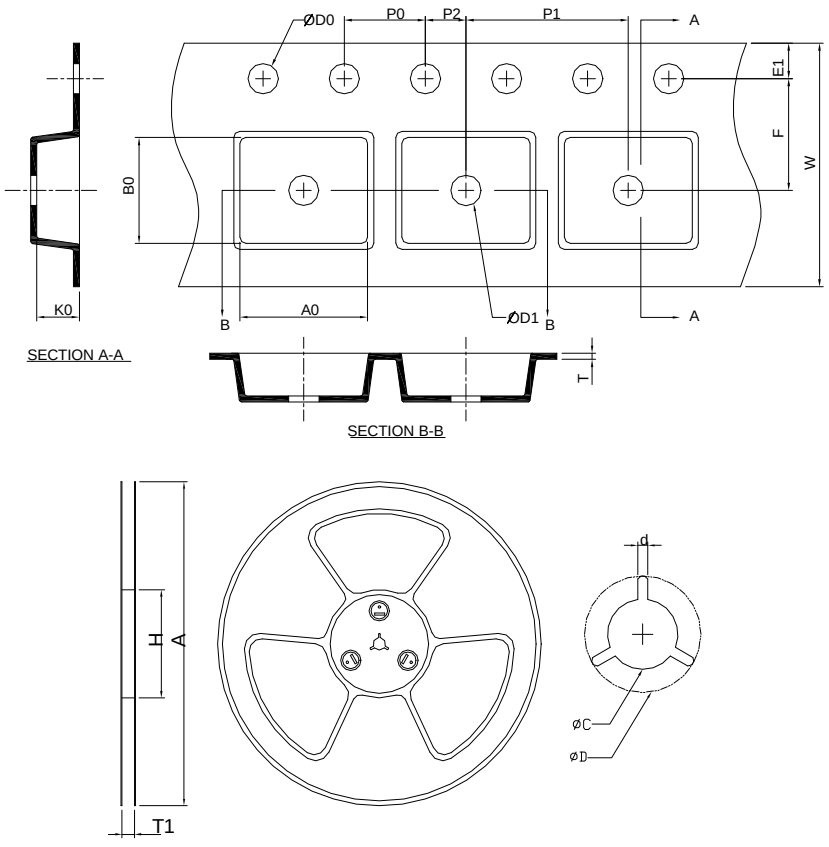
SSOP-16



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.

Carrier Tape & Reel Dimensions



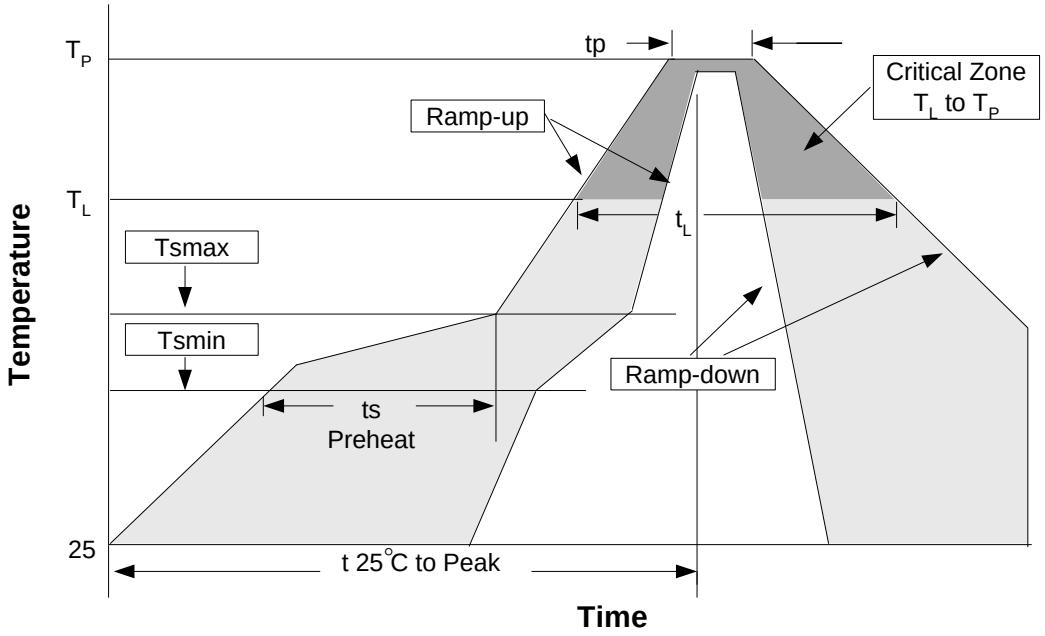
Application	A	H	T1	C	d	D	W	E1	F
SSOP-16	330.0±2.00	50 MIN.	16.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	12.0±0.30	1.75±0.10	7.5±0.10
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.00±0.10	8.00±0.10	2.00±0.10	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	6.4±0.20	5.20±0.20	2.1±0.20

(mm)

Devices Per Unit

Package Type	Unit	Quantity
SSOP- 16	Tape & Reel	2500

Reflow Condition (IR/Convection or VPR Reflow)



Reliability Test Program

Test item	Method	Description
SOLDERABILITY	MIL-STD-883D-2003	245°C, 5 sec
HOLT	MIL-STD-883D-1005.7	1000 Hrs Bias @125°C
PCT	JESD-22-B, A102	168 Hrs, 100%RH, 121°C
TST	MIL-STD-883D-1011.9	-65°C~150°C, 200 Cycles
ESD	MIL-STD-883D-3015.7	VHBM > 2KV, VMM > 200V
Latch-Up	JESD 78	10ms, 1_{tr} > 100mA

Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Average ramp-up rate (T_L to T_P)	3°C/second max.	3°C/second max.
Preheat - Temperature Min (Tsmin) - Temperature Max (Tsmax) - Time (min to max) (ts)	100°C 150°C 60-120 seconds	150°C 200°C 60-180 seconds
Time maintained above: - Temperature (T_L) - Time (t_L)	183°C 60-150 seconds	217°C 60-150 seconds
Peak/Classification Temperature (Tp)	See table 1	See table 2
Time within 5°C of actual Peak Temperature (tp)	10-30 seconds	20-40 seconds
Ramp-down Rate	6°C/second max.	6°C/second max.
Time 25°C to Peak Temperature	6 minutes max.	8 minutes max.

Notes: All temperatures refer to topside of the package. Measured on the body surface.

Classification Reflow Profiles (Cont.)

Table 1. SnPb Eutectic Process – Package Peak Reflow Temperatures

Package Thickness	Volume mm^3 <350	Volume mm^3 3350
<2.5 mm	240 +0/-5°C	225 +0/-5°C
≥2.5 mm	225 +0/-5°C	225 +0/-5°C

Table 2. Pb-free Process – Package Classification Reflow Temperatures

Package Thickness	Volume mm^3 <350	Volume mm^3 350-2000	Volume mm^3 >2000
<1.6 mm	260 +0°C*	260 +0°C*	260 +0°C*
1.6 mm – 2.5 mm	260 +0°C*	250 +0°C*	245 +0°C*
≥2.5 mm	250 +0°C*	245 +0°C*	245 +0°C*

*Tolerance: The device manufacturer/supplier **shall** assure process compatibility up to and including the stated classification temperature (this means Peak reflow temperature +0°C. For example 260°C+0°C) at the rated MSL level.

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