Single-Phase Full-Wave Motor Driver for Fan Motor

Features

- **Single Phase Full Wave Fan Driver**
- **Silent Driver**
- **Low Supply Current**
- **Speed Controllable by DC Voltage or PWM Input Signal**
- **Built-in Quick Start Function**
- **Built-in Lock Protection and Auto-restart Function**
- **Enhance Low Duty Start UP Power**
- **FG/RD Output**
- **Include Hall Bias Circuit**
- **Built-in Current Limit Circuit**
- **Built-in Thermal Protection Circuit**
- **SSOP16 Package**
- **Lead Free and Green Device Available (RoHS Compliant)**

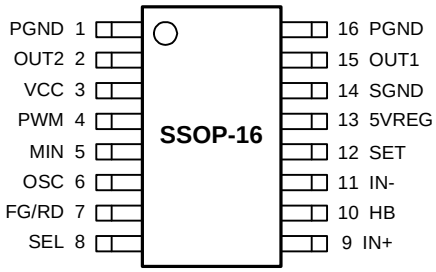
Applications

- **CPU Cooler Fans**
- **Variable Speed Control Fans**
- **Motor Drivers for Silent Fans**

General Description

The APX9208A is a single phase full wave motor driver for DC fan motors. The output signals of this IC are the amplifications of hall input signals. It is suitable for both game machine and CPU cooler that need silent fans. The device is built-in lock protection, when fan is locked, the device will enter the lockup protection mode. It is also with thermal shutdown function. In normal operation, the supply current is 5mA. The APX9208A is available in SSOP-16 packages.

Pin Configuration



Ordering and Marking Information

APX9208A □□-□□□ Assembly Material Handling Code Temperature Range Package Code	Package Code N: SSOP - 16 Operating Ambient Temperature Range I : -40 to 105 °C Handling Code TR : Tape & Reel Assembly Material G: Halogen and Lead Free Device
APX9208A N : 	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 (VCC to GND)	-0.3 to 20	V
I_{OUT}	Output Pin Maximum Output Current	1	A
V_{OUT}	Output Pin Output Voltage	V_{PGND}-0.3 to V_{CC}	V
I_{HB}	HB Pin Maximum Output Current	10	mA
V_{FG}	FG Pin Output Voltage	-0.3 to 20	V
I_{FG}	FG Pin Maximum Output Sink Current	10	mA
V_{PWM}	PWM Pin Supply Voltage	-0.3 to 20	V
T_J	Junction Temperature	-40 TO 150	°C
T_{STG}	Storage Temperature	-65 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.

Thermal Characteristics

Symbol	Parameter	Typical Value	Unit
$R_{TH,JA}$	Thermal Resistance-Junction to Ambient (Note 2) SSOP-16	125	°C/W
P_D	Power Dissipation, T_A=25°C SSOP-16	1	W

Note 2: $R_{TH,JA}$ is measured with the component mounted on a high effective thermal conductivity test board in free air.

Recommended Operating Conditions (Note3)

Symbol	Parameter	Rating	Unit
V_{CC}	VCC Pin Supply Voltage Range	3.5 to 16	V
V_{HALL}	Hall Input Voltage Range	0 to 5	V
T_A	Ambient Temperature	-40 to 105	°C

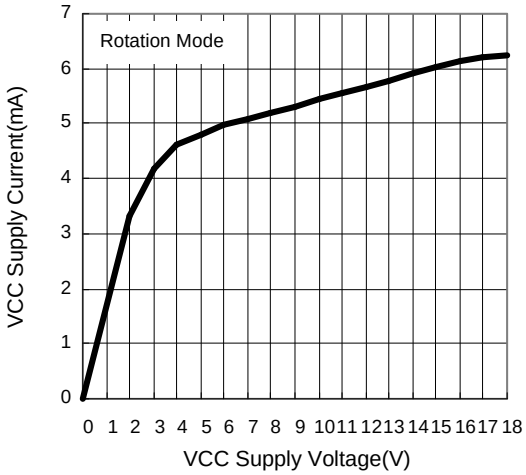
Note 3: Refer to the typical application circuit.

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

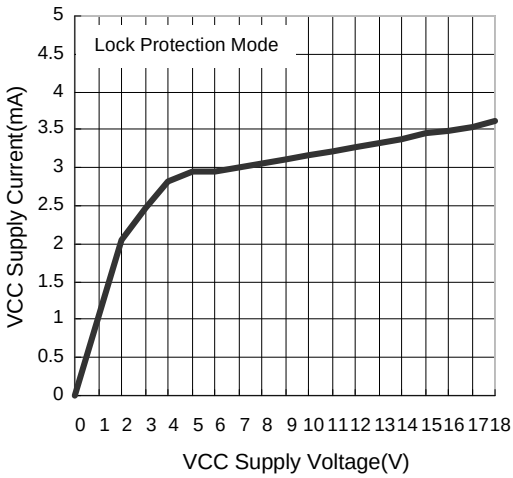
Symbol	Parameter	Test Conditions	APX9208A			Unit
			Min	Typ	Max	
SUPPLY CURRENT						
VHB	HB Pin Output Voltage	IHB = 5mA	1.2	1.3	1.4	V
V_{5VREG}	5VREG Pin Output Voltage	I_{5VREG} = 5mA	4.85	5	5.15	V
I_{CC1}	Operating Current	Rotation Mode	-	5	8	mA
I_{CC2}		Lock Protection Mode	-	3	5	
OSCILLATOR						
V_{OSCH}	OSC Pin High Level Voltage		3.35	3.5	3.65	V
V_{OSCL}	OSC Pin Low Level Voltage		0.95	1	1.05	V
I_{OSC1}	OSC Charge Current	V_{OSC}=1V	-	15	-	µA
I_{OSC2}	OSC Discharge Current	V_{OSC}=3.5V	-	15	-	µA
F_{OSC}	OSC Oscillation Frequency	C_{OSC}=100pF	-	25	50	kHz
LOCK PROTECTION						
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		-	2	3	msec
OUTPUT DRIVERS						
V_O	Output Driver Saturation Voltage	IOUT = 400mA, Upper and Lower total	-	0.5	0.7	V
V_{FG}	FG Pin Low Voltage	I_{FG} = 5mA	-	0.1	0.2	V
V_{TH}	Gain Switch Threshold Voltage	VCC Falling	6	6.5	7	V
V_{THYS}			-	-	1.5	V
I_{FGL}	FG Pin Leakage Current	V_{FG} = 12V	-	-	0.1	µA
GIO1	High Voltage Input-Output Gain	VOUT/VIN+-VIN-, VCC=12V	51	52	53	dB
GIO2	Low Voltage Input-Output Gain	VOUT/VIN+-VIN-, VCC=6V	44	45	46	dB
PWM CONTROL						
V_{PWMH}	PWM Input High Level Voltage		2.5		VCC+0.3	V
V_{PWML}	PWM Input Low Level Voltage		-0.3		0.7	V
F_{PWM}	PWM Input Frequency		20		50	kHz
DTS	Start Up PWM Duty	FPWM=20KHz~50KHz	6	8	10	%
HALL SENSITIVITY						
V_{HOFS}	Hall Input Offset Voltage		-	-	±6	mV
V_{HYS}	Input Hysteresis Voltage		-	±10	±15	mV
PROTECTION						
I_{LIM}	Internal Current Limit			1000		mA
THERMAL PROTECTION						
	Over-Temperature Shutdown Threshold		-	170	-	°C
	Over-Temperature Shutdown Hysteresis		-	25	-	

Typical Operating Characteristics

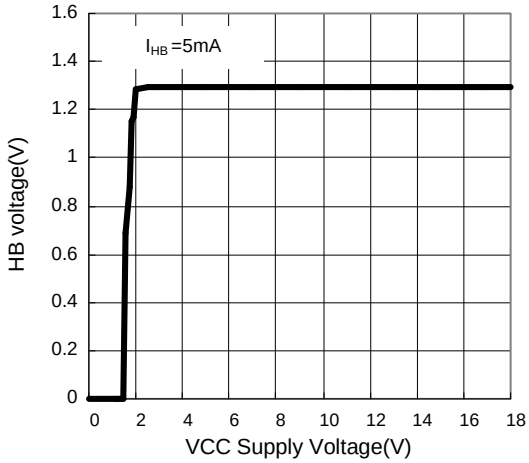
VCC Supply Current vs. VCC Supply Voltage



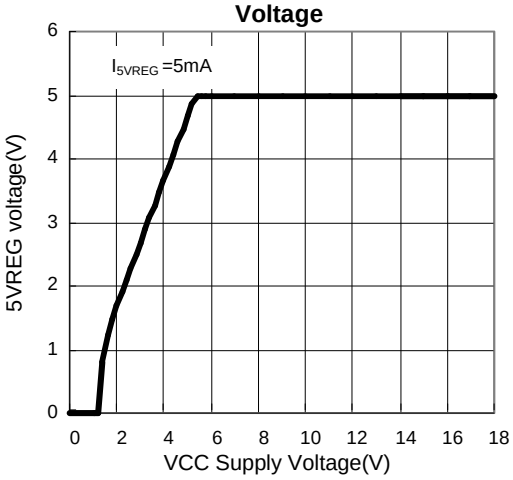
VCC Supply Current vs. VCC Supply Voltage



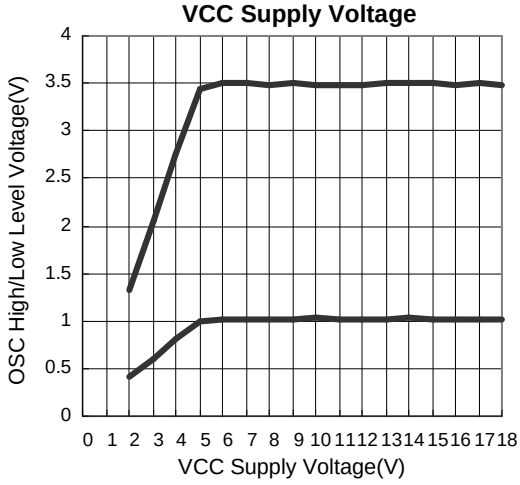
HB Voltage vs. VCC Supply Voltage



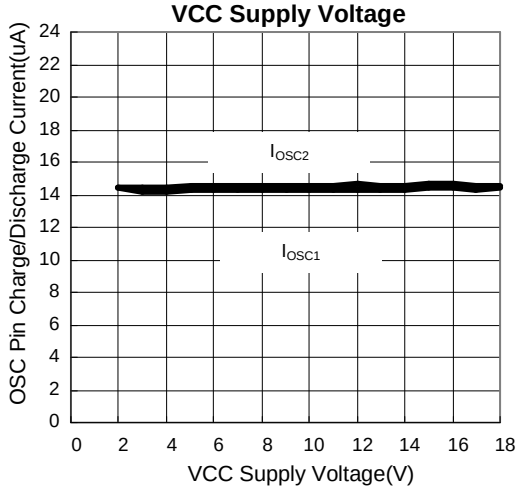
5VREG Voltage vs. VCC Supply Voltage



OSC High/Low Level Voltage vs. VCC Supply Voltage

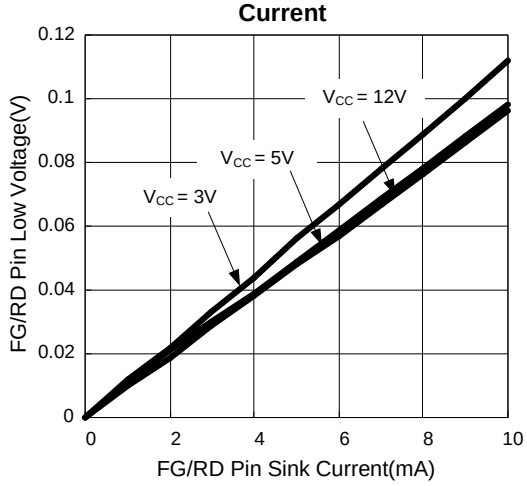


OSC Pin Charge/Discharge Current vs. VCC Supply Voltage

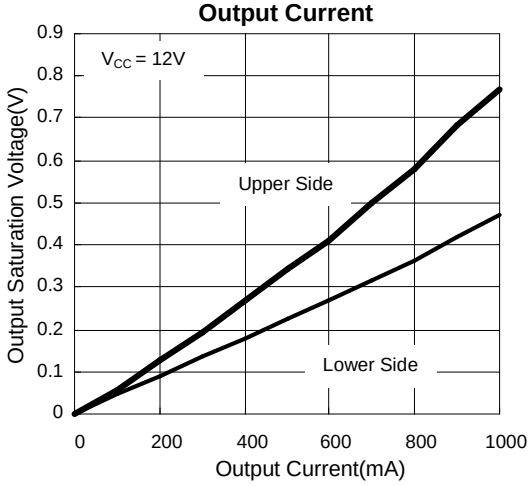


Typical Operating Characteristics

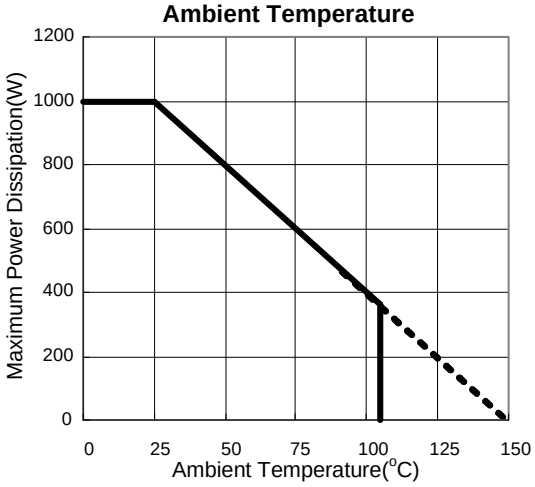
FG/RD Pin Low Voltage vs. Sink Current



Output Saturation Voltage vs. Output Current



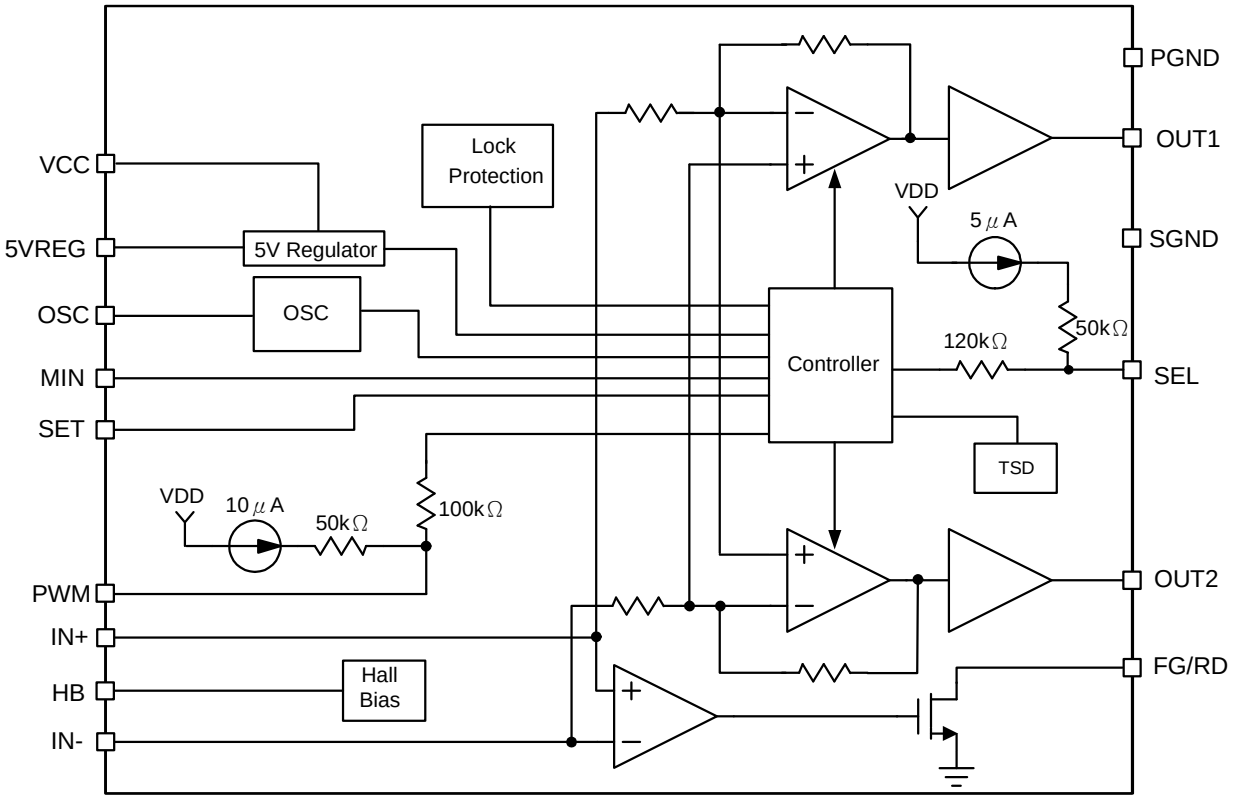
Maximum Power Dissipation vs. Ambient Temperature



Pin Descriptions

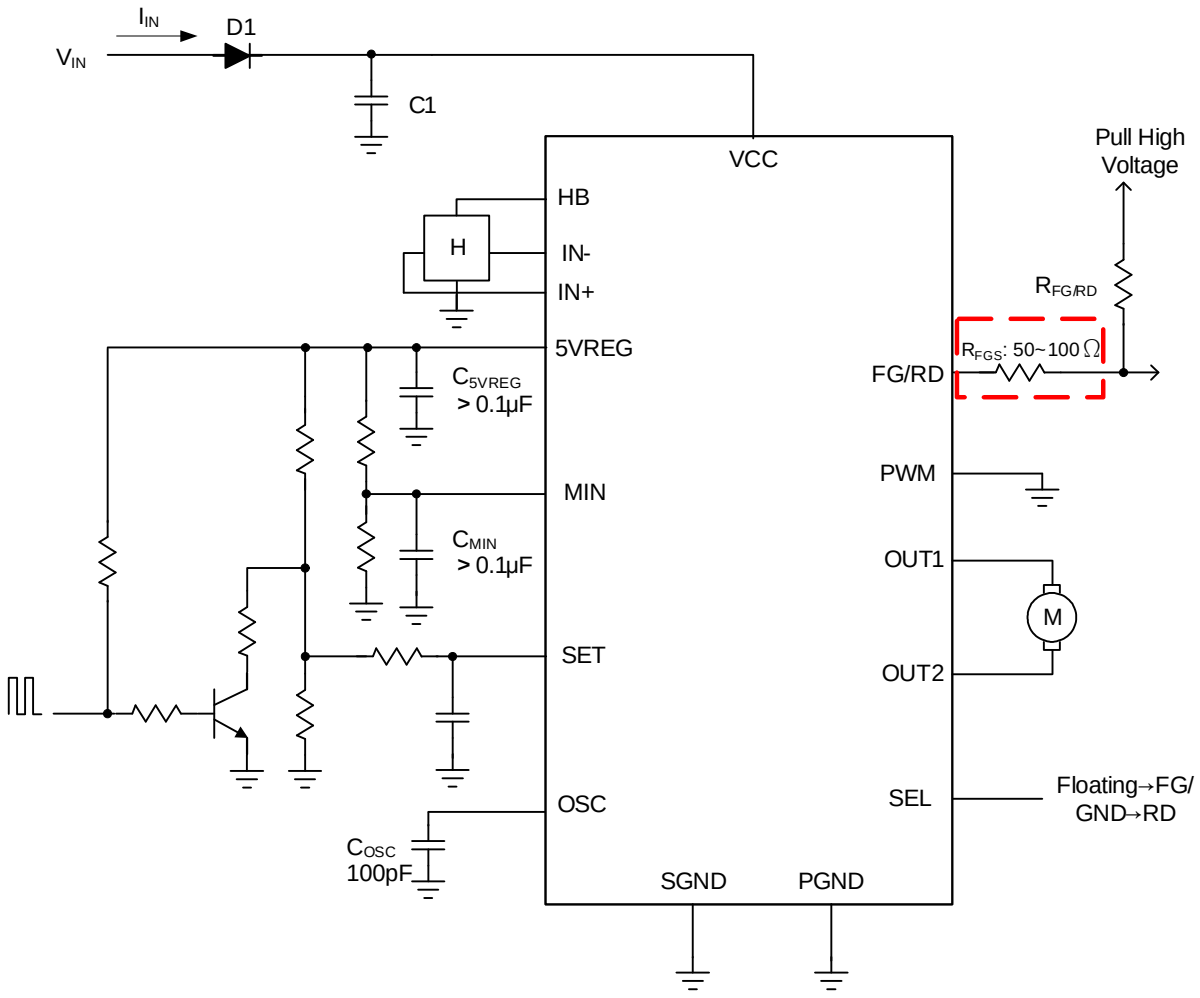
PIN		FUNCTION
NO.	NAME	
1	PGND	Power Stage GND.
2	OUT2	H-bridge Output Connection.
3	VCC	Supply Voltage Input Pin.
4	PWM	PWM Signal Input Terminal.
5	MIN	Minimum Speed Setting. An external voltage into MIN pin to set fan speed.
6	OSC	Oscillation Frequency Setting. Connect a capacitor to GND to set oscillation frequency.
7	FG/RD	Rotation Speed Output/Rotation Detection Output.
8	SEL	FG/RD output select pin.
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	SET	Speed Setting. An external voltage into SET pin to set fan speed.
13	5VREG	5V Regulator Output. This is a 5V constant-voltage output for application circuit biases.
14	SGND	Control Stage GND.
15	OUT1	H-bridge Output Connection.
16	PGND	Power Stage GND.

Block Diagram



Typical Application Circuit

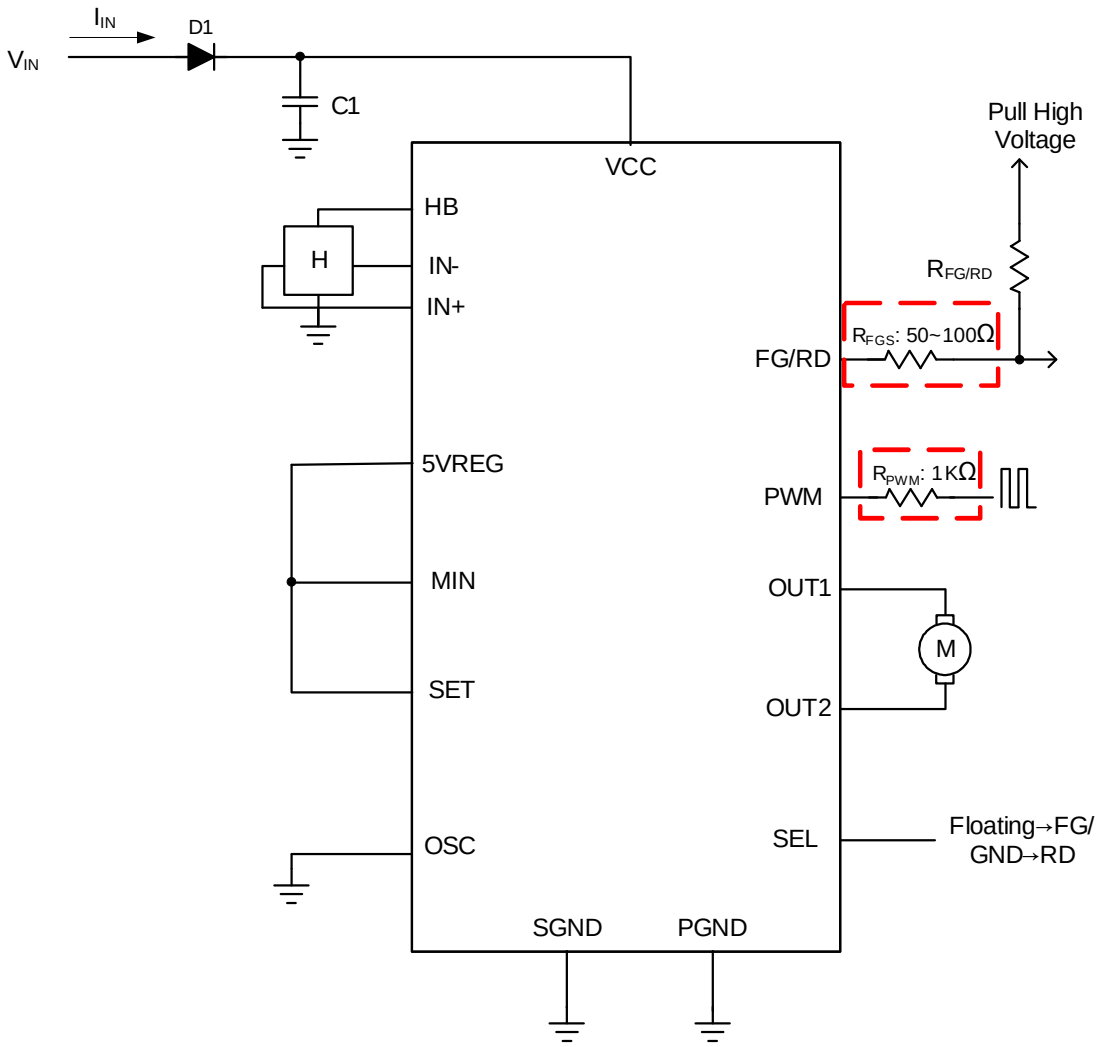
1. SET Voltage Input Speed Control



Note: R_{FGS} is optional to protect internal circuit for abnormal voltage stress

Typical Application Circuit

2. Direct PWM Input Speed Control.



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

Function Descriptions

Lockup Protection and Automatic Restart

The APX9208A provides the lockup protection and automatic restart functions for preventing the coil burn-out when the fan is locked. This IC has an internal counter to determine the shutdown time (T_{OFF}) and restart time (T_{ON}). During shutdown time, the output drivers keep turn off for 5 seconds and then enter the restart time. During the restart time, one output is high and the other is low, which makes a torque for fan rotation. The restart time has 0.5 second. If the locked condition is not removed, the shutdown/restart process will be recurred until the locked condition is released (see Fig1. Lockup/Auto Restart Waveform).

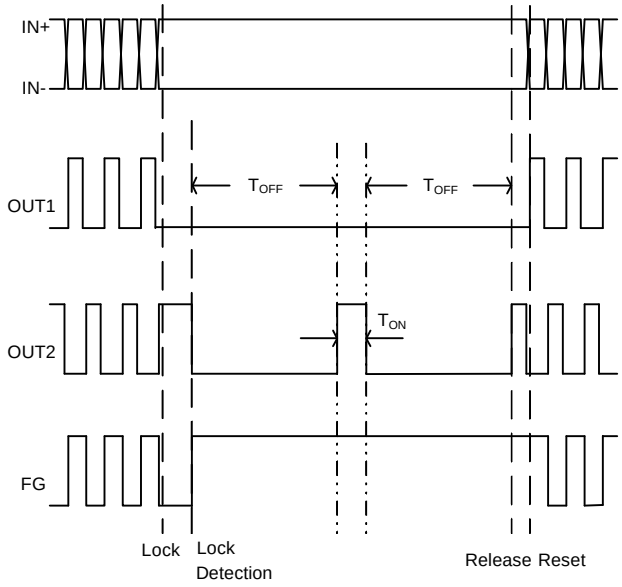


Figure 1. Lockup /Auto Restart Waveform

Quick Start and Standby mode

This IC would enter standby mode when the PWM input keeps low level for more than 2 ms (typ.). In standby mode, it will shut down amplifier and FG. Thus, the supply current is around 3mA. In standby mode, the lock protection function doesn't work, therefore, starting fan is unobstructed when releasing standby mode.

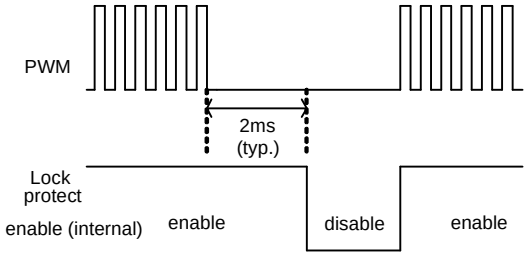


Figure 2. Quick Start Waveform

Output Drivers

All four drivers in the bridge output are designed for single phase full wave motor driver for fan motor. The linear output architecture is used as output driver.

Rotation Detection Function

The FG pin is an open drain output, connecting a pull up resistor to a high level voltage for the frequency generator function. When IN+ is larger than IN- then FG is high (switch off) and IN+ is smaller than IN- then FG is low (switch on). Open the terminal when not in using. RD pin is also open drain output. Low level is at rotation mode and High Level is at stop mode. Open the terminal when not in using. RD pin is also open corrector output. Low level is at rotation mode and High Level is at stop mode. Open the terminal when not in using. FG and RD are using the same pin, both selected by SEL decision. SEL floating FG / RD pin output FG. SEL is connected to ground FG / RD pin output RD.

Thermal Protection

The APX9208A has thermal protection function, when internal junction temperature reaches 170°C, the output devices will be switched off. When the IC's junction temperature cools by 25°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	PWM	OUT1	OUT2	FG	RD	Mode
H	L	H	H	H	L	L	L	Normal Operation Mode
L	H			L	H	OFF	L	
L	H	L	L	L	L	OFF	L	
H	L			L	L	L	L	
H	L	-	-	L	L	OFF	OFF	Lock Protection Mode
L	H			L	L	OFF		
-	-	-	L	OFF	OFF	OFF	OFF	Standby Mode

Note 4: OSC-H corresponds to $V_{OSC}>V_{SET}$ and OSC-L corresponds to $V_{OSC}<V_{SET}$

Function Descriptions

Input Protection Diode & Capacitor

It should be added a protection diode (D1) to protect 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 larger than the maximum output current. For the noise reduction purpose, there is a least 1mF capacitor (C1) recommended connecting between VCC and GND (see Typical Application Circuit).

Hall Input & Output

The output signals of this IC are the amplification of hall input signals, therefore, the output signals depend on hall input. When the hall input signals are small, the output signals become gentle. Oppositely, the input signals are large, the output signals become steep (see Fig3. Different of output signal depending on the shape of hall input signal). The input/output gain is 52dB (typ.). Thus, please adjust the amplitude of hall input to meet the adequate output voltage.

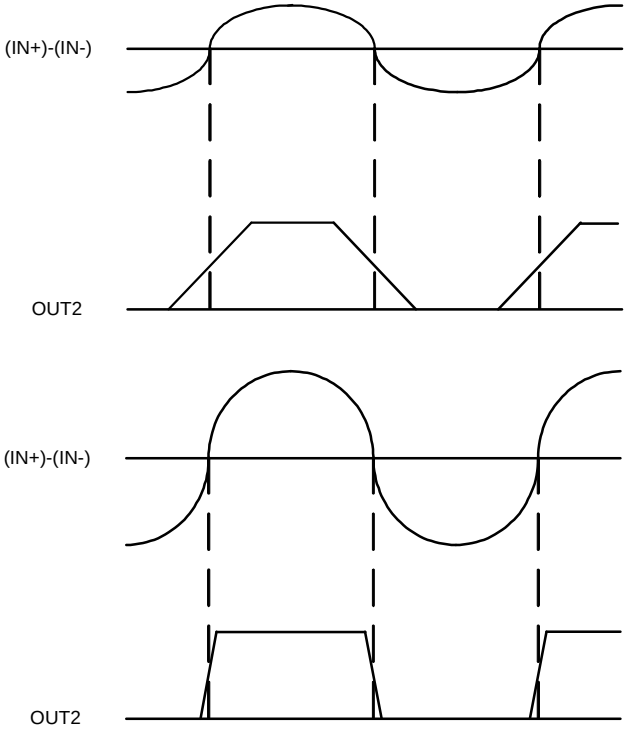


Figure 3. Different of output original depending on the shape of hall input signal

FG/RD Resistor

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

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

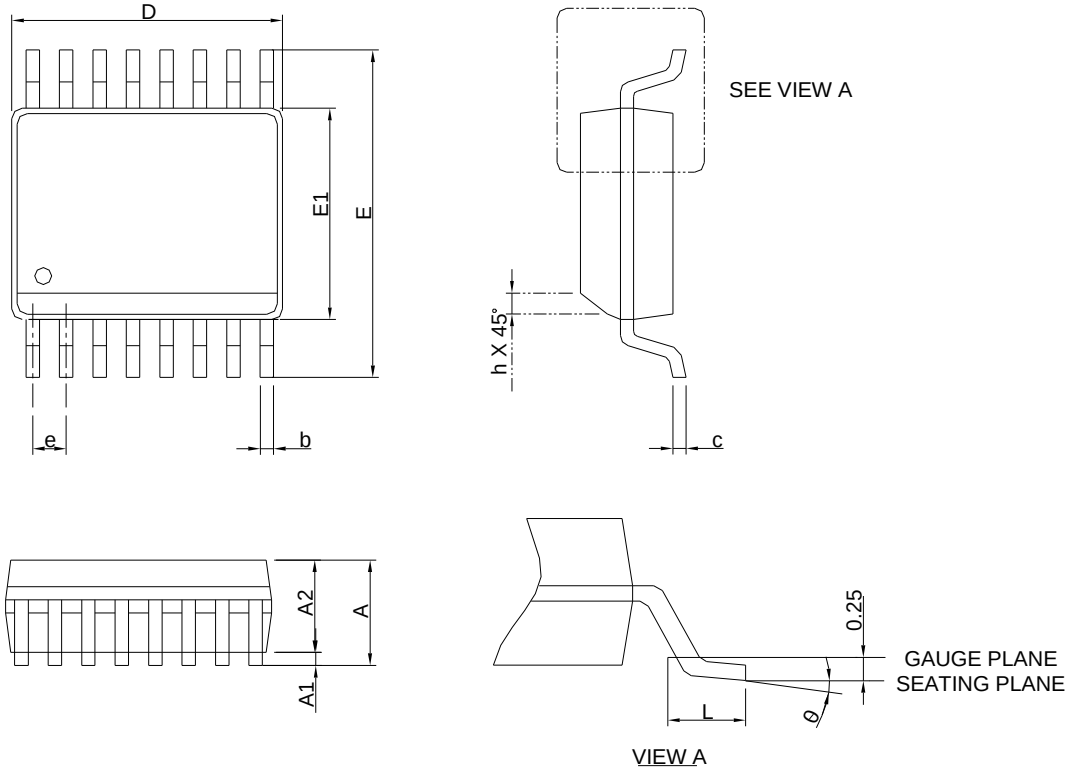
For example:

V_{CC}=12V, I_{FG} =5mA, V_{FG}=0.1V,R_{FG}=2.38kΩ

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

Package Information

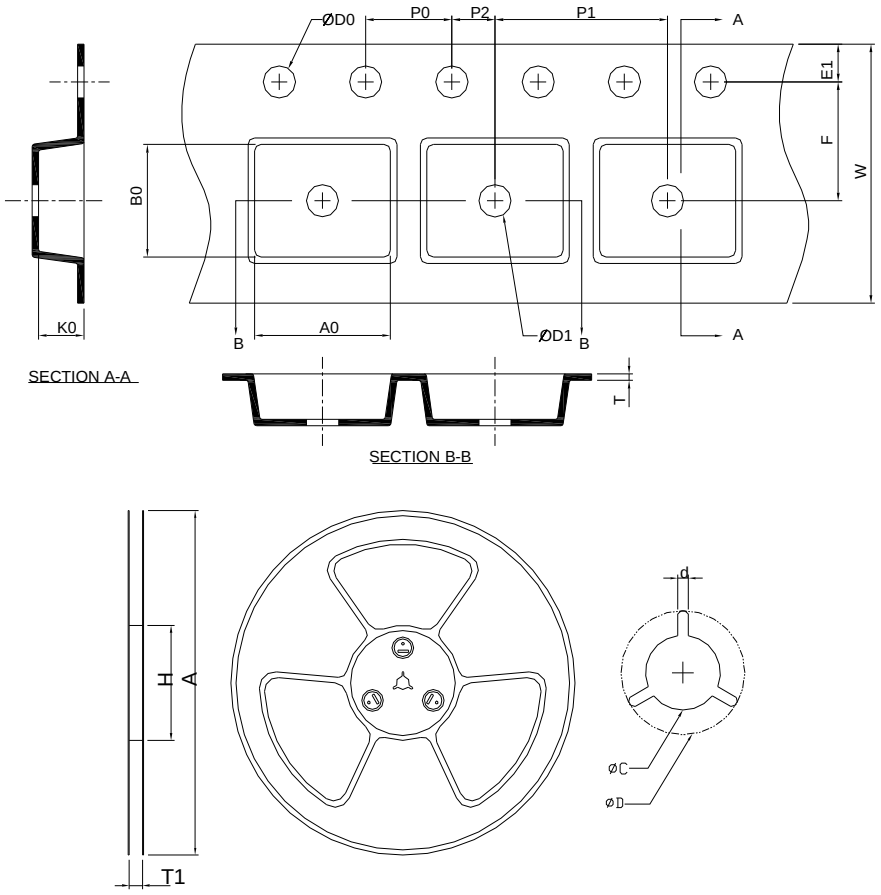
SSOP-16



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.

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

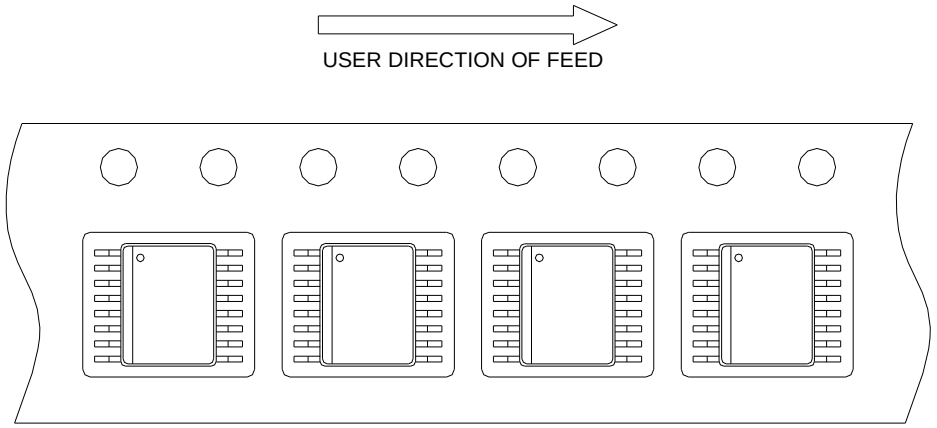
(mm)

Devices Per Unit

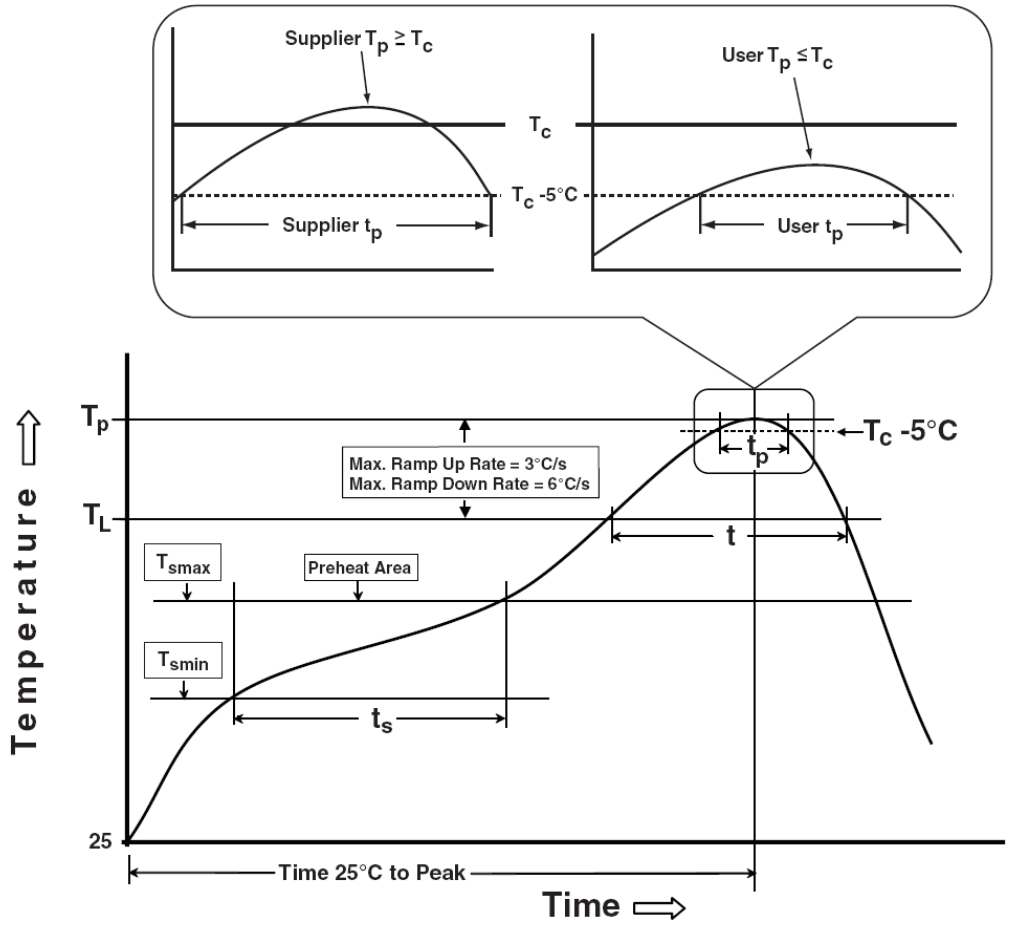
Package Type	Unit	Quantity
SSOP- 16	Tape & Reel	2500

Taping Direction Information

SSOP-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^3 350
<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 @ 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

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