Single-Phase Full-Wave Motor Driver for Silent Fan Motor

Features

- **Single Phase Full Wave Fan Driver**
- **Silent Driver**
- **Low Supply Current**
- **Low Standby Current (PWM=0), Supply current less than 200㎃A**
- **Speed controllable by PWM input signal**
- **Built-in Quick Start Function**
- **Lock Protection and Auto Restart Function**
- **Built-in FG Output**
- **Built-in Hall Bias Circuit**
- **Built-in Thermal Protection Circuit**
- **Lead Free and Green Devices Available (RoHS Compliant)**

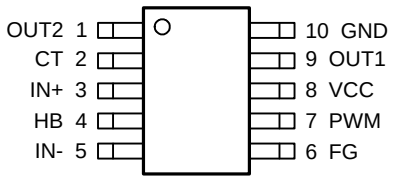
Applications

- **Motor Drivers For Silent Fan Motors**

General Description

The APX9266 is a single-phase full-wave motor driver for DC fan motor, and its speed can be controlled by PWM input signal. The output signal of this IC is the amplified hall input signal. It is suitable for both game machine and CPU cooler that need silent drivers. The device has lock protection function and the lock-restart timing can be tunable by CT capacitor. The device is also with thermal shutdown function. In normal operation, the supply current is less than 3mA, but in PWM=0 standby mode, it is just around 130μA. Moreover, this feature will shutdown HB, Amplifier, and FG. The APX9266 is available in MSOP-10 package.

Pin Configuration



MSOP-10

Ordering and Marking Information

APX9266 □□-□□□ Assembly Material Handling Code Temperature Range Package Code	Package Code X : MSOP-10 Operating Ambient Temperature Range I : -40 to 105°C Handling Code TR : Tape & Reel Assembly Material L : Lead Free Device G : Halogen and Lead Free Device
APX9266 X : A9266 XXX XX	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).

Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Rating	Unit
V_{CC}	VCC Pin Supply Voltage	7	V
I_{OUT}	Output Pin Output Current	1	A
V_{OUT}	Output Pin Output Voltage	7	V
I_{HB}	HB Pin Output Current	25	mA

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 (Cont.)

Symbol	Parameter	Rating	Unit
V_{FG}	FG Pin Output Voltage	7	V
I_{FG}	FG Pin Sink Current	10	mA
$R_{TH, JA}$	Thermal Resistance-Junction to Ambient MSOP-10	192	°C/W
P_D	Power Dissipation (Note2)	0.8	W
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

Note 1: Absolute Maximum Ratings are those values beyond which the life of a device may be impaired. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Note 2: Mounted on a board (48x38x1.6t mm, Glass epoxy).

Recommended Operating Conditions

Symbol	Parameter	Ratings	Unit
V_{CC}	VCC Pin Supply Voltage	2 to 5.5	V
V_{Hall}	Hall Input Voltage Range	0.2 to Vcc-1.1	V
T_A	Ambient Temperature	-40 to 105	°C

Electrical Characteristics (V_{CC} = 5V, T_A=-25°C, unless otherwise specified)

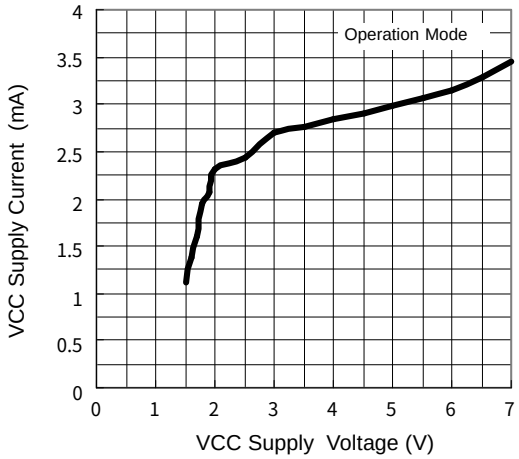
Symbol	Parameter	Test Conditions	APX9266			Unit
			Min.	Typ.	Max.	
SUPPLY CURRENT						
V_{HB}	Hall Bias Voltage	I_{HB}=5mA	1.2	1.3	1.4	V
		Lock Protect T_{OFF} or PWM=0	-	0	-	V
I_{HB}	HB Supply Current		-	15	20	mA
T_{HBR}	HB Recovery Time	None Capacitor	-	5	10	µSec
I_{CC1}	Operating Current	Rotation Mode	-	3	5	mA
I_{CC2}	Standby Supply Current	PWM=0	-	130	200	µA
CT						
V_{CTH}	CT Pin High Level Voltage	C_{CT}=0.47µF	1.4	1.3	1.5	V
V_{CTL}	CT Pin Low Level Voltage	C_{CT}=0.47µF	0.25	0.325	0.4	V
I_{CT1}	CT Charge Current	V_{CT}=0V	0.75	0.95	1.15	µA
I_{CT2}	CT Discharge Current	V_{CT}=2V	0.13	0.16	0.19	µA
R_{CT}	CT Charge/Discharge Current Ratio	$R_{CT}=I_{CT1}/I_{CT2}$	5	6	7	
PWM						
V_{PWMH}	PWM Input High Level Voltage		2.5	-	V_{CC}+0.5	V
V_{PWML}	PWM Input Low Level Voltage		0	-	1	V
F_{PWM}	PWM Input Frequency		0.02	-	50	kHz

Electrical Characteristics (Cont.) (V_{CC} = 5V, T_A=-25°C, unless otherwise specified)

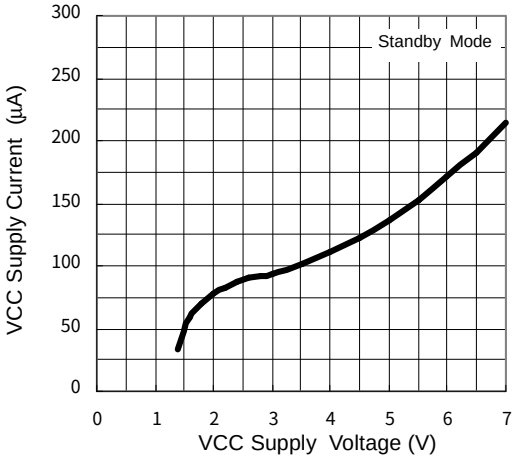
Symbol	Parameter	Test Conditions	APX9266			Unit
			Min.	Typ.	Max.	
OUTPUT						
V_{OL}	Output Lower Side Saturation	I_O=250mA	-	0.15	0.22	V
V_{OH}	Output Upper Side Saturation	I_O=250mA	-	0.15	0.22	V
V_{FG}	FG Pin Low Voltage	I_{FG}=3mA	-	0.2	0.3	V
I_{FG}	FG Pin Leak Current	V_{FG}=5V	-	-	1	μA
GAIN						
V_{HOFS}	Input Offset Voltage		-	±1	±6	mV
Gio	Input – Output Gain	V_O/(IN+ - IN-) (ratio)	45	48	51	dB
THERMAL SHUTDOWN						
OTS	Over Temperature Shutdown		-	170	-	°C
	Over Temperature Shutdown Hysteresis		-	35	-	
QUICK START						
T_{QS}	Quick Start Enable Time		-	66.5	90	mSec

Typical Operating Characteristics

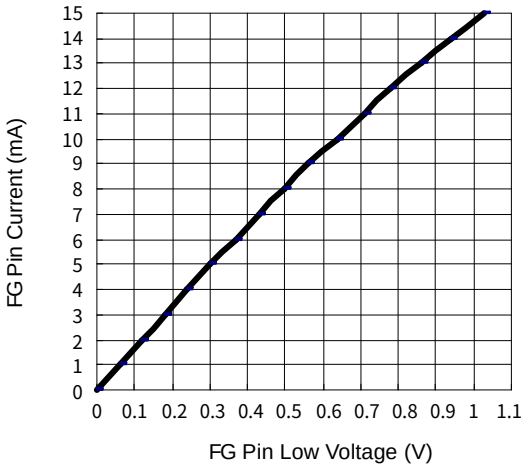
VCC Supply Current vs. VCC Supply Voltage



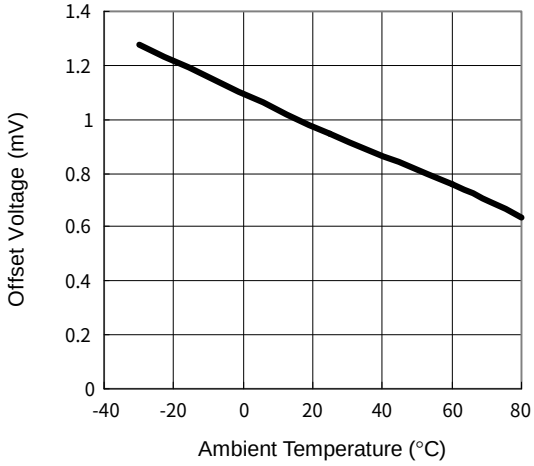
VCC Supply Current vs. VCC Supply Voltage



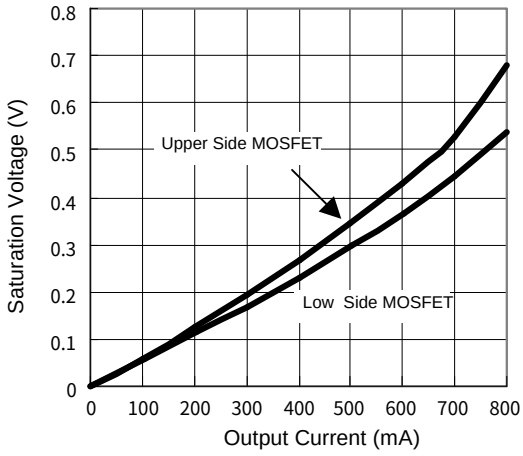
FG Pin Current vs. FG Pin Low Voltage



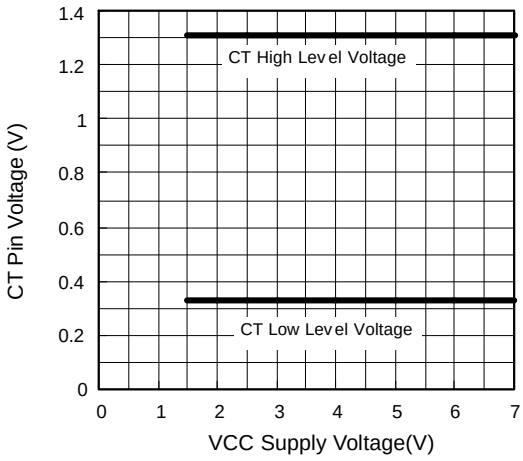
Offset Voltage vs. Ambient Temperature



Saturation Voltage vs. Output Current

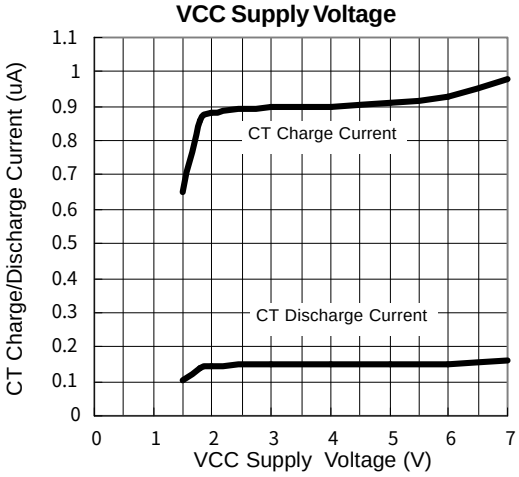


CT Pin Voltage vs. VCC Supply Voltage

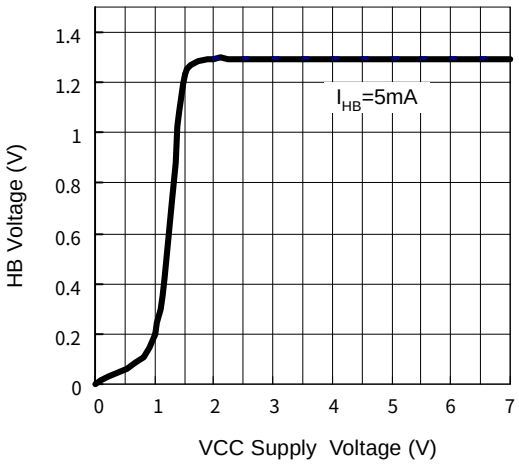


Typical Operating Characteristics (Cont.)

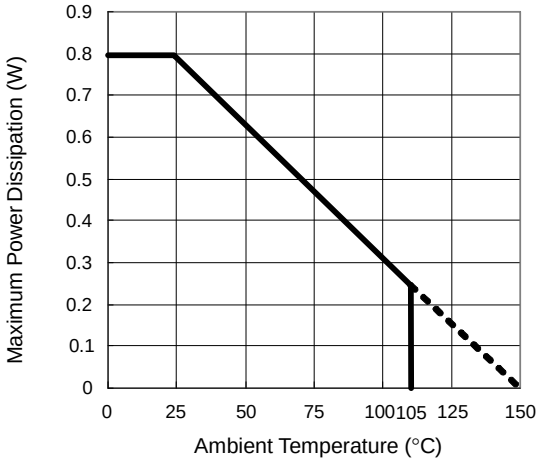
CT Charge/Discharge Current vs. VCC Supply Voltage



HB Voltage vs. VCC Supply Voltage

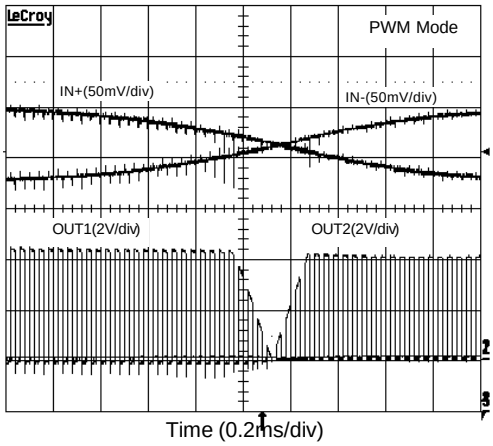


Maximum Power Dissipation vs. Ambient Temperature

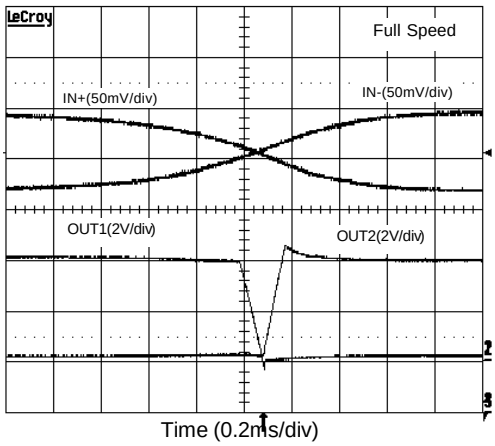


Operating Waveforms

Rotation Waveform 1

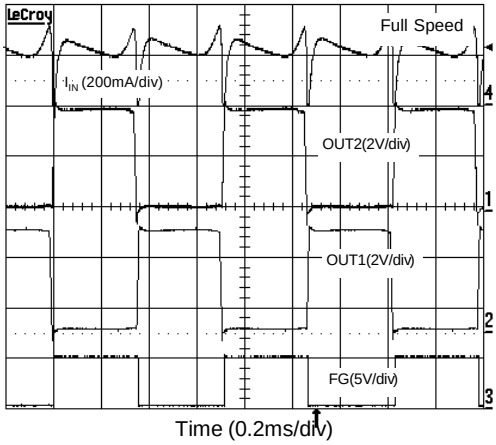


Rotation Waveform 2

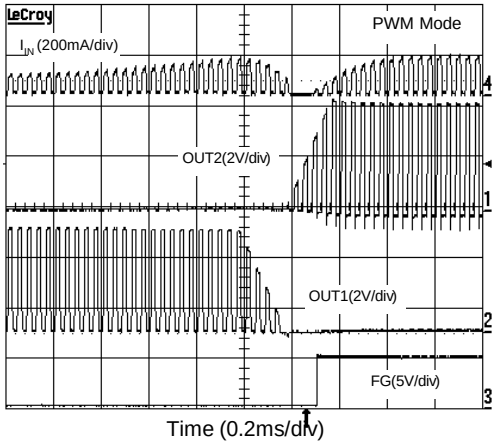


Operating Waveforms (Cont.)

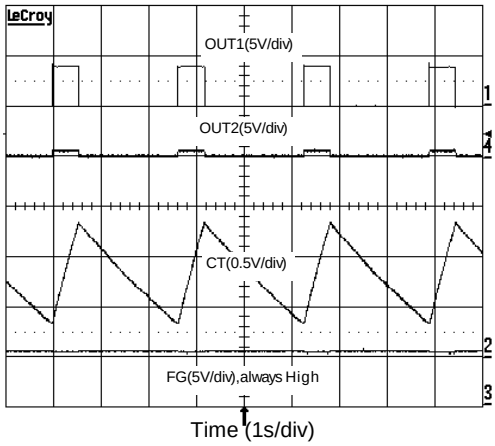
Rotation Waveform 3



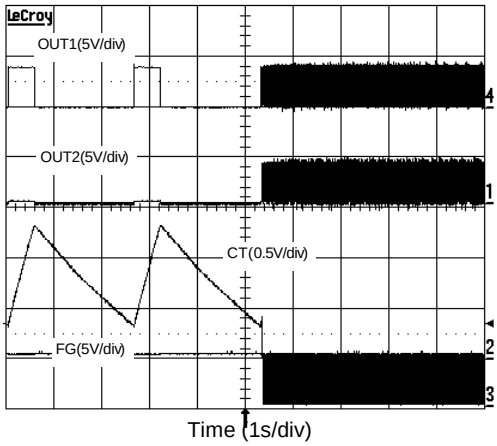
Rotation Waveform 4



Lock Protection Waveform 1



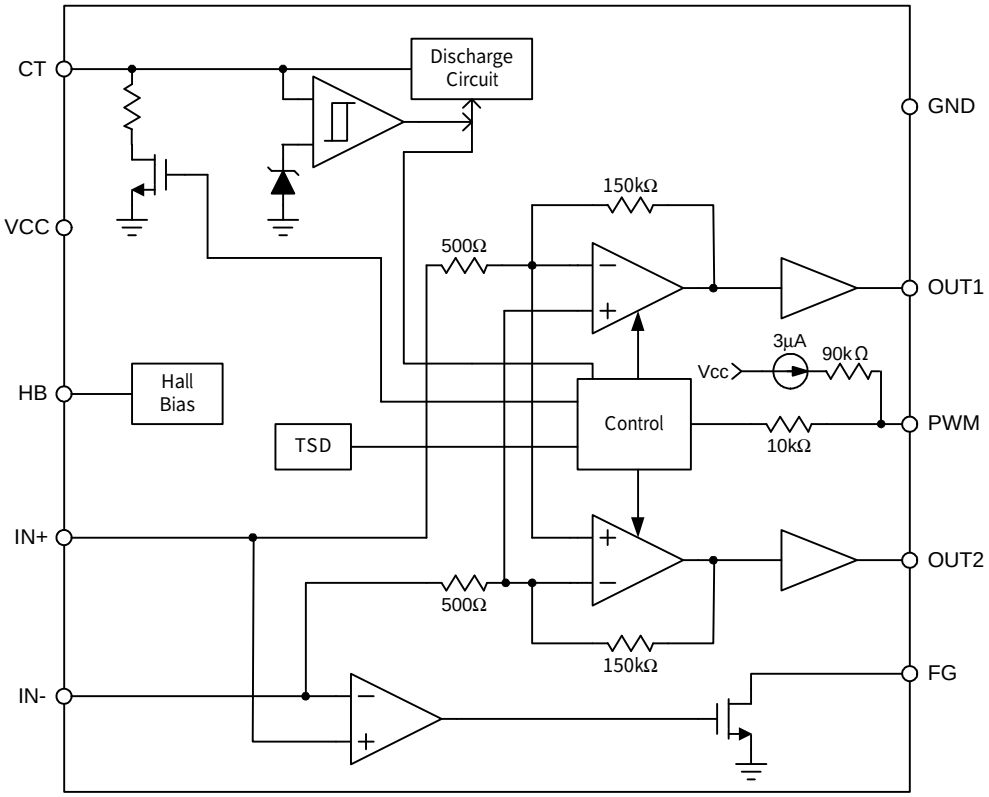
Lock Protection Waveform 2



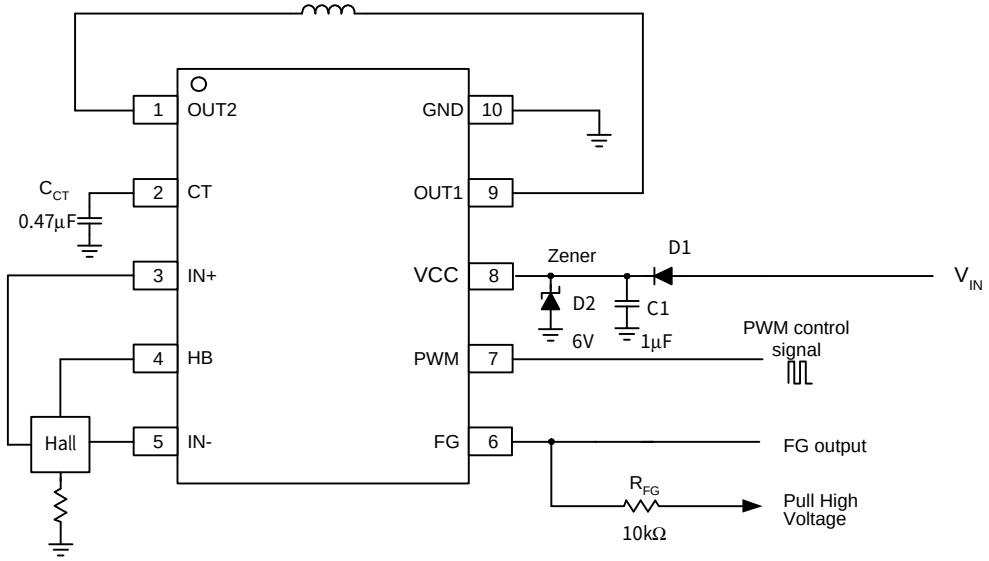
Pin Description

PIN		Description
No.	Name	
1	OUT2	H-bridge Output Connection. The output stage is a H-bridge formed by four transistors and four-protection diode for switching applications.
2	CT	Shutdown Time and Restart Time Setting.
3	IN+	Hall Input +.
4	HB	Hall Bias.
5	IN-	Hall Input -.
6	FG	Rotation Speed Output.
7	PWM	PWM Signal Input Terminal.
8	VCC	Supply Voltage Input Pin.
9	OUT1	H-bridge Output Connection. The output stage is a H-bridge formed by four transistors and four-protection diode for switching applications.
10	GND	Power Ground.

Block Diagram



Typical Application Circuit



Note 3: In hot plug application, it's necessary to protect against a hot plug input voltage overshoot. Add an input zener diode, between the VCC and GND, to clamp the overshoot. In normal operation, the zener diode isn't stressed because output current doesn't reverse to VCC.

Function Description

Lockup Protection and Automatic Restart

The APX9266 provides the lockup protection and automatic restart functions for preventing the coil burnout in the locked fan. Connecting the capacitor from CT pin to GND determines the shutdown time and restart time. As the fan is locked the charge/discharge circuit, charging the CT capacitor to 1.3V by a 0.95μA source current for a locked detection time and then switches the capacitor to discharge. During this discharge interval, the output drivers are switched off until the CT voltage is discharged to 0.325V by a 0.16μA sink current and switches the capacitor to charge. During this 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 1.3V by a 0.95μA source current. If the locked condition is not removed, the charge/discharge process will be recurred until the locked condition is released (See Figure 1. Lockup Protection and Automatic Restart Waveform).

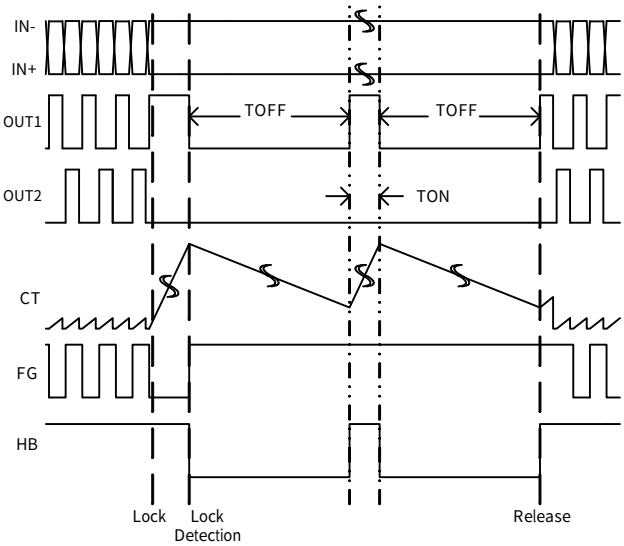


Figure 1. Lockup Protection and Automatic Restart Waveform

Quick Start

This IC disables the lock protection function when the PWM input keeps low level for more than 66.5ms (typ.) (see Figure 2. Quick Start Waveform).

Lock protect function does not work if PWM input frequency is slower than 15Hz (typ.). Therefore, the PWM input frequency must be more than 20Hz.

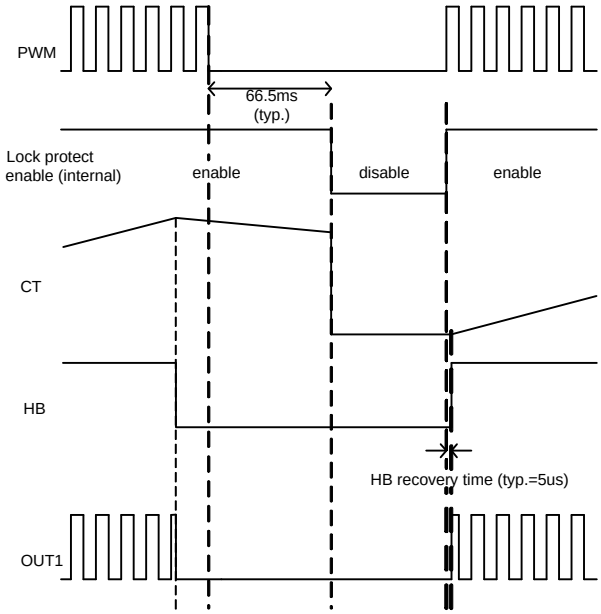


Figure 2. Quick Start Waveform

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.

During the Lock Mode, the FG will be always high (switch off). (See Truth Table) Open the terminal is at no use.

Thermal Protection

The APX9266 has thermal protection. When internal junction temperature reaches 170°C, the output devices will be switched off. When the IC's junction temperature cools by 35°C, the thermal sensor will turn the output devices on again, resulting in a pulsed output during continuous thermal protection.

Truth Table

Input				Output			Mode
IN-	IN+	PWM	CT	OUT1	OUT2	FG	
L	H	H	L	H	L	L	Operation Mode
H	L			L	H	OFF	
H	L	L		L	L	OFF	
L	H			L	L	L	
L	H	-	H	L	L	OFF	Lock Mode
H	L			L	L	OFF	
-	-	L	-	OFF	OFF	OFF	Standby Mode

Application Information

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. Connecting a capacitor (C1) between VCC and GND is used for a noise reduction purpose (See the Application Circuit).

HB pin & Hall input

1.3V reference is for hall element bias. In case VCC influences the hall signal by board wiring pattern, please connect 0.1μF capacitor between HB and GND. The supply current is just around 130μA at PWM=0 standby mode. This feature will shutdown HB, Amplifier and FG. The output signal of this IC is the amplified hall input signal, therefore, the output signal depends on hall input. When the hall input is small, the output signal becomes gentle. Oppositely, the input signal is large, the output becomes steep (See Figure 3. Different of output signal depending on the shape of Hall input signal).The input/ output gain is 48dB (typ.). Therefore, please adjust the amplitude of hall input to meet the adequate output voltage. In the case of long board wiring pattern from hall element to hall signal input terminal, please connect a capacitor between IN+ and IN-.

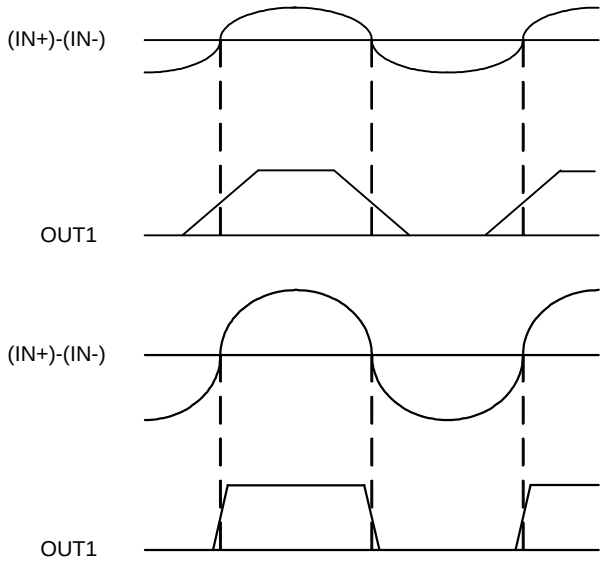


Figure 3. Different of output signal depending on the shape of Hall input signal

PWM input

It is possible to change rotation speed of the motor by switching high side output transistor. The on-duty of switching depends on the input signal to PWM terminal. (See Figure 4. PWM Input Waveform)

Application Information (Cont.)

PWM input (Cont.)

The input level of PWM terminal is

H : High side output transistor is ON
L : High side output transistor is OFF
(see Truth Table).

When PWM terminal is open, it is equal to high

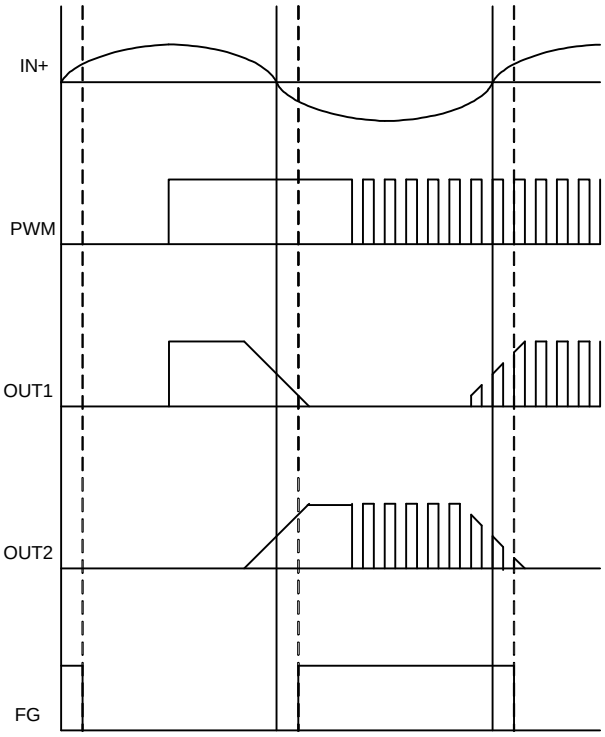


Figure 4.PWM Input Waveform

CT Capacitor

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

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

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

Where:

C_{CT} = CT pin capacitor

For example:

C_{CT}= 0.47µF

Restart Time=0.52s, Shutdown Time=3.13s

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

FG Resistor

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

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

For example:

V_{CC}= 5V, I=3mA, V_{FG}= 0.2V, R_{FG}= 1.6kΩ

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 eable the thermal protection if the operating area is above the line. For example, T_A= 75°C, the maximum power dissipation is about 0.48w.

The power dissipation can be calculated by the following equation:

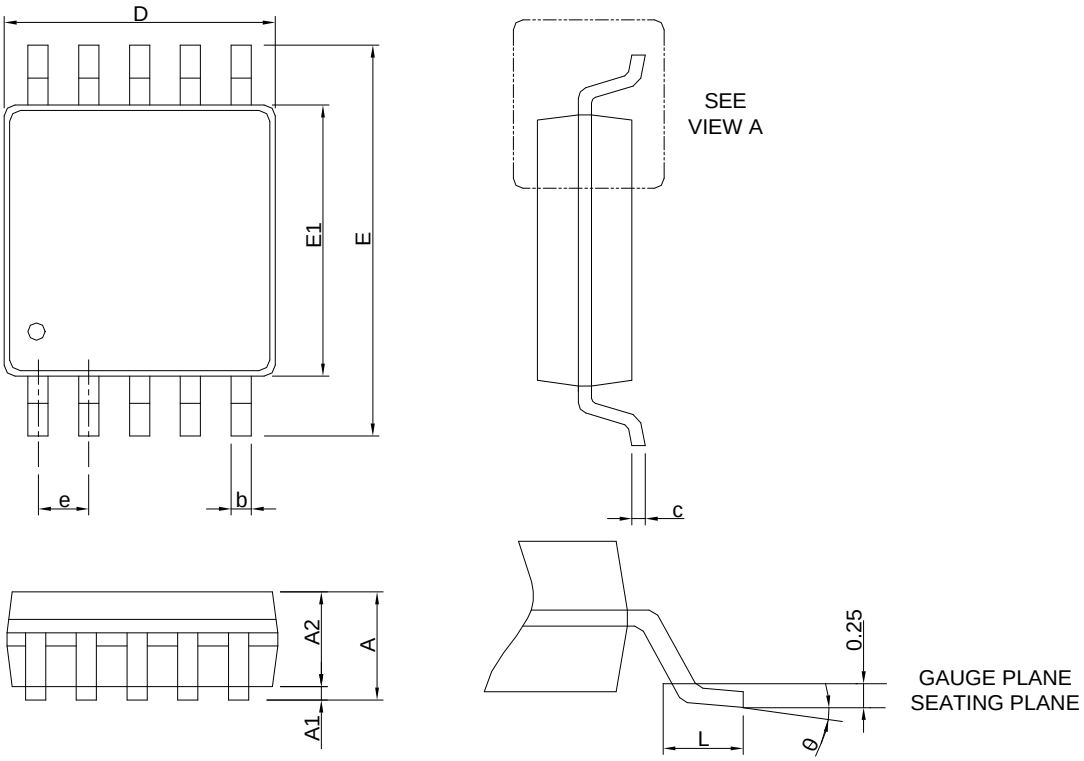
$$P_D = (V_{CC} - |V_{OUT1} - V_{OUT2}|) \times I_{OUT} + V_{CC} \times I_{CC}$$

For example:
if V_{CC}=5V, I_{CC}=4mA, I_{OUT}=300mA, V_{OUT1}=4.81V,
V_{OUT2}=0.17V, then P_D=0.128W

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.

Packaging Information

MSOP-10

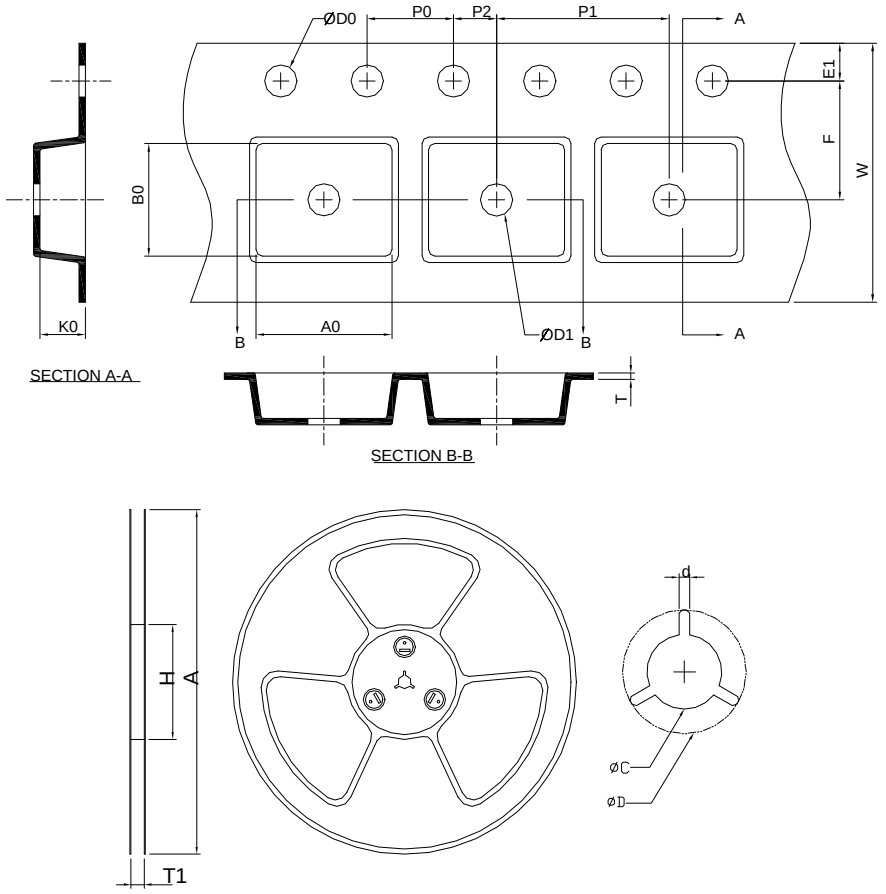


VIEW A

SYMBOL	MSOP-10			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.10		0.043
A1	0.00	0.15	0.000	0.006
A2	0.75	0.95	0.030	0.037
b	0.17	0.33	0.007	0.013
c	0.08	0.23	0.003	0.009
D	2.90	3.10	0.114	0.122
E	4.70	5.10	0.185	0.201
E1	2.90	3.10	0.114	0.122
e	0.50 BSC		0.020 BSC	
L	0.40	0.80	0.016	0.031
θ	0°	8°	0°	8°

Note: 1. Follow JEDEC MO-187 BA.
2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not flash or protrusions.
3. Dimension "E1" does not include inter-lead flash or protrusions. Inter-lead flash and protrusions shall not exceed 6 mil per side.

Carrier Tape & Reel Dimensions



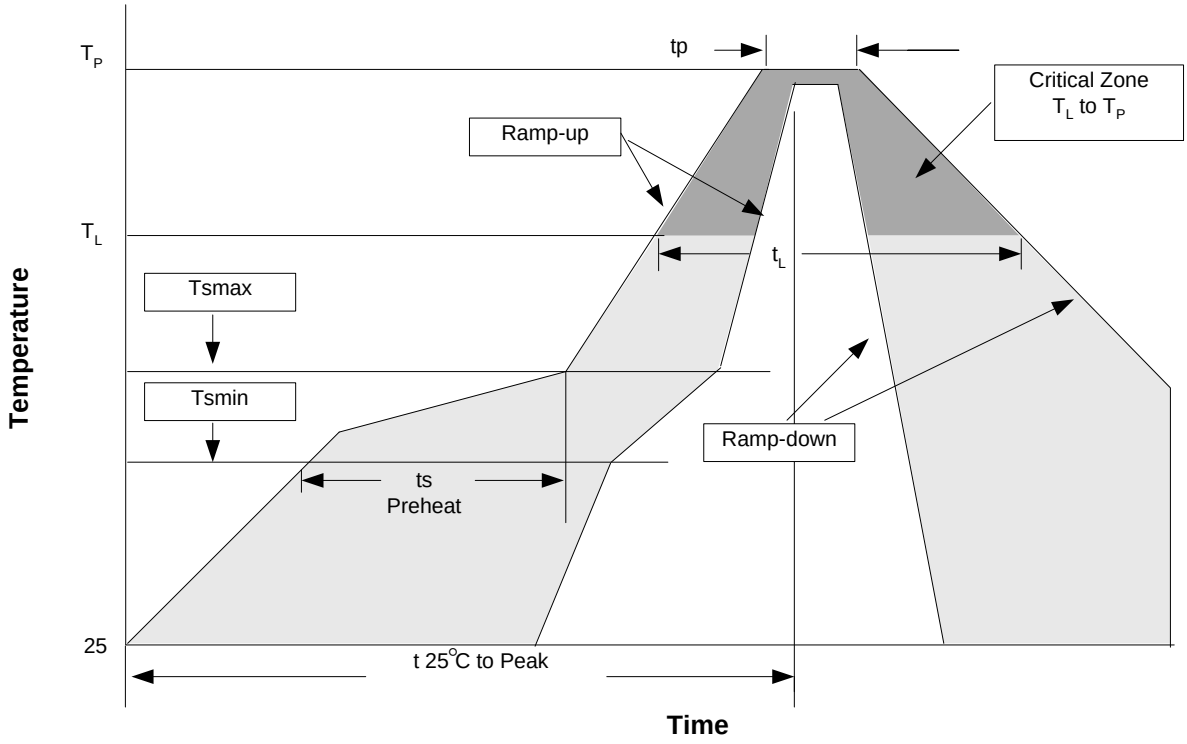
Application	A	H	T1	C	d	D	W	E1	F
MSOP-10	330.0±2.00	50 MIN.	12.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	12.0±0.30	1.75±0.10	5.5±0.10
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.00±0.10	8.00±0.10	2.00±0.10	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	6.70±0.20	3.30±0.20	1.40±0.20

(mm)

Devices Per Unit

Package Type	Unit	Quantity
MSOP- 10	Tape & Reel	3000

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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