

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

Features

- **Single Phase Full Wave Fan Driver**
- **Silent Driver**
- **Three Speed Control Methods**
- **Low Supply Current**
- **Built-In Lock Protection and Auto Restart Function**
- **Low Standby Current (PWM=0%), Supply Current Less than 200mA (Type C/D Only)**
- **Adjustable Fan Speed Slope (Type B Only)**
- **Enhance Low Duty Start UP Power (Type D Only)**
- **FG Output**
- **Include Hall Bias Circuit**
- **Built-In Thermal Protection Circuit**
- **Lead Free and Green Devices Available (RoHS Compliant)**

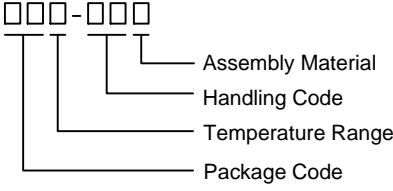
General Description

The APX9258 is a single phase full wave motor driver for DC fan motors, and can apply to three type speed control methods. 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 the 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 less than 5mA. The APX9258 is available in MSOP-10 and VTDFN3x3-10 packages.

Applications

- **Motor Drivers For Silent Fan Motors**

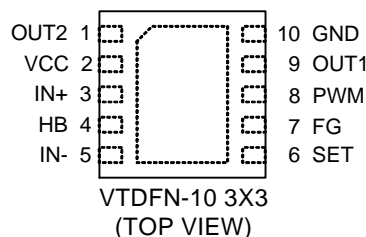
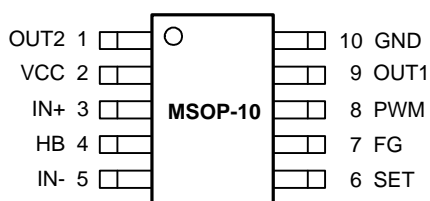
Ordering and Marking Information


<p>APX9258 □□□-□□□</p>  <p style="margin-left: 150px;"> □□□ — Assembly Material □□□ — Handling Code □□□ — Temperature Range □□□ — Package Code </p>	<p>Package Code X : MSOP - 10 QF : VTDFN3x3-10</p> <p>Temperature Range I : -40 to 105 °C</p> <p>Handling Code TR : Tape & Reel</p> <p>Assembly Material G : Halogen and Lead Free Device</p>
<p>APX9258 X : X9258 XXX XX</p>	<p>XXXXX - Date Code</p>
<p>APX9258 QF : APX 9258 XXXXX</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).

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.

Pin Configuration



 = Thermal Pad (connected to the GND plane for better heat dissipation)

Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Rating	Unit
V_{CC}	VCC Pin Supply Voltage (VCC to GND)	-0.3 to 10	V
I_{OUT}	Output Pin Maximum Output Current	1	A
V_{OUT}	Output Pin Output Voltage	-0.3 to 10	V
I_{HB}	HB Pin Maximum Output Current	10	mA
	FG Pin Output Voltage	-0.3 to 10	V
I_{FG}	FG Pin Maximum Output Sink Current	10	mA
V_{SET}	VH/VL Pin Supply Voltage	-0.3 to 10	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

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.

Thermal Characteristics

Symbol	Parameter	Typical Value	Unit
θ_{JA}	Thermal Resistance-Junction to Ambient ^(Note 2)	MSOP-10	208
		VTDFN3x3-10	119
P_D	Power Dissipation, $T_A=25^\circ\text{C}$	MSOP-10	0.6
		VTDFN3x3-10	1.05

Note 2: θ_{JA} is measured with the component mounted on a 55mm x 40mm x 1.6mm glass epoxy board (two-layer) in free air.

Recommended Operating Conditions (Note 3)

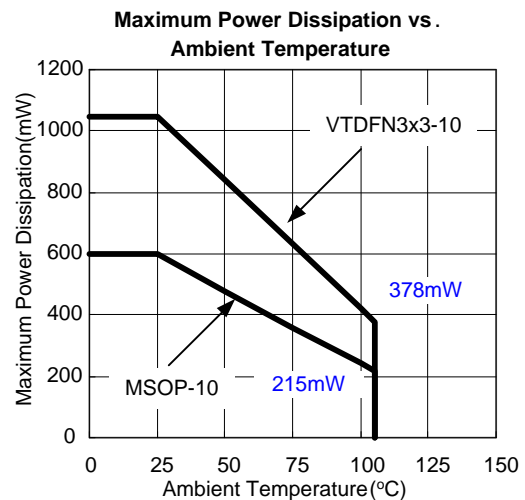
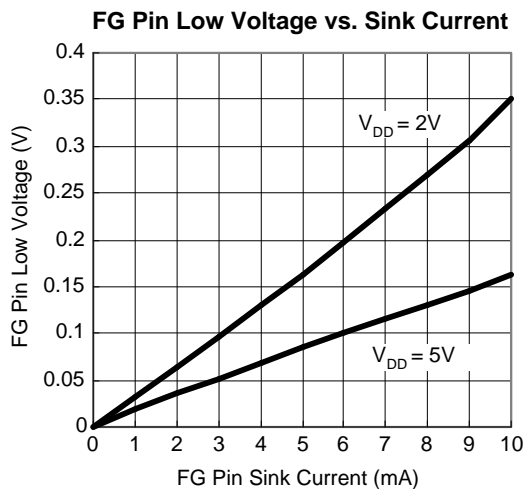
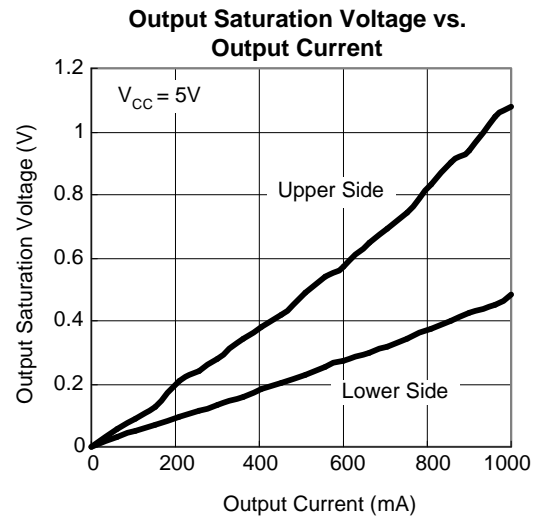
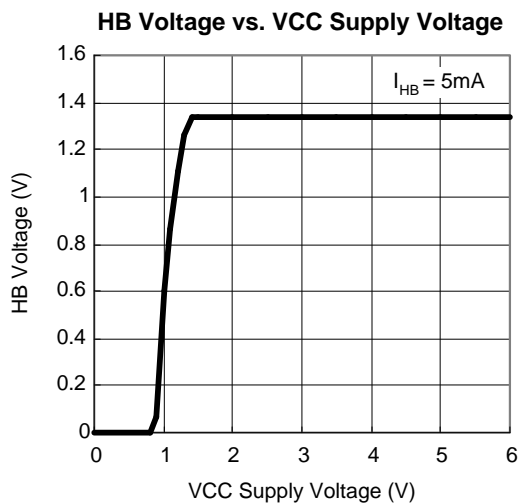
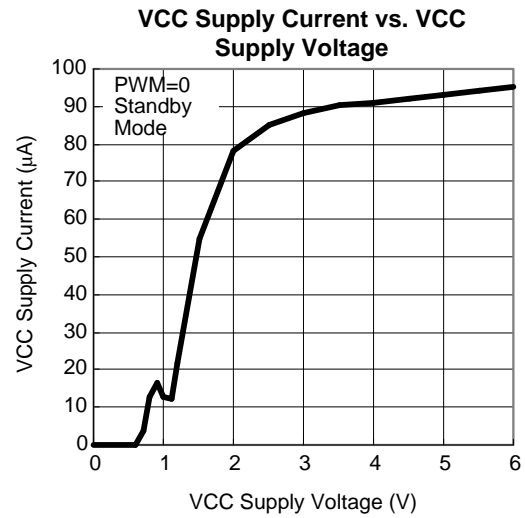
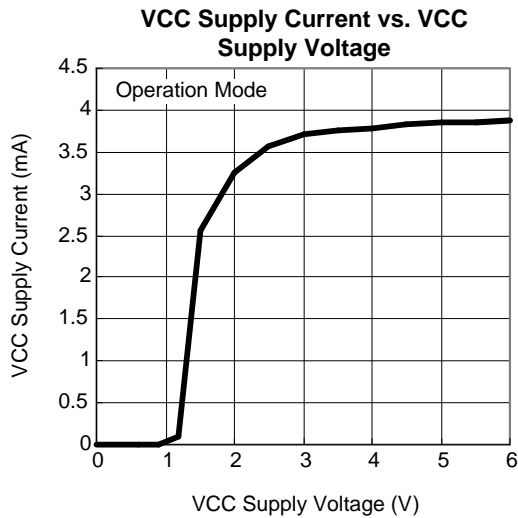
Symbol	Parameter	Range	Unit
V_{CC}	VCC Pin Supply Voltage Range	2 to 6	V
V_{HALL}	Hall Input Voltage Range	0.4 to $V_{CC}-1.1$	V
V_{SET}	SET Pin Input Voltage Range	GND or 0.25 to V_{HB}	V
T_A	Ambient Temperature	-40 to 105	°C
T_J	Junction Temperature	-40 to 125	°C

Note 3: Refer to the typical application circuit.

Electrical Characteristics ($V_{CC} = 5V, T_A = 25^\circ C$, unless otherwise specified)

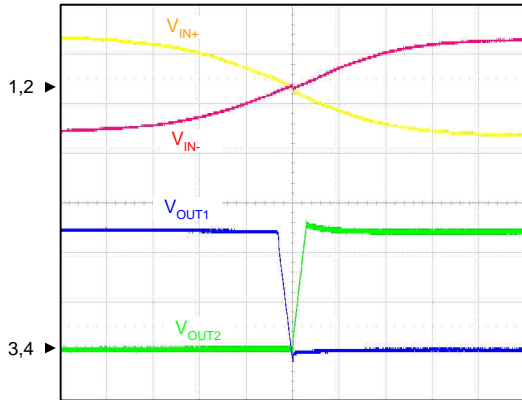
Symbol	Parameter	Test Conditions	APX9258			Unit
			Min.	Typ.	Max.	
SUPPLY CURRENT						
V_{HB}	HB Pin Output Voltage	$I_{HB} = 5mA$	1.1	1.3	1.5	V
I_{CC1}	Operating Current	Rotation Mode	-	4	5	mA
I_{CC2}		Lock Protection Mode	-	4	5	
I_{CC3}		Standby Mode (PWM=0)	-	0.1	0.2	
LOCK PROTECTION						
T_{ON}	Lock Detection On Time		0.35	0.5	0.65	s
T_{OFF}	Lock Detection Off Time		3.5	5	6.5	s
OUTPUT DRIVERS						
V_O	Output Driver Saturation Voltage	$I_{OUT} = 250mA$, Upper and Lower total	-	0.3	0.44	V
V_{FG}	FG Pin Low Voltage	$I_{FG} = 5mA$	-	0.1	0.2	V
I_{FGL}	FG Pin Leakage Current	$V_{FG} = 5V$	-	<0.1	1	μA
G_{IO}	Input - Output Gain	$V_{OUT}/V_{IN+}-V_{IN-}$	44	45	46	dB
VOLTAGE TO DUTY CONTROL (TYPE B ONLY)						
I_{SETH}	SET Pin High Level Input Leakage	$V_{SET} = V_{CC}$	-	-	0.1	μA
I_{SETL}	SET Pin Low Level Output Current	$V_{SET} = 0V$	-	1	-	μA
PWM CONTROL (TYPE C ONLY)						
V_{PWMH}	PWM Input High Level Voltage		$0.5xV_{CC}$	-	$V_{CC}+0.5$	V
V_{PWML}	PWM Input Low Level Voltage		0	-	$0.2xV_{CC}$	V
I_{PWMH}	PWM High Input Current	PWM=VCC	-	0	5	μA
I_{PWML}	PWM Low Input Current	PWM=GND	-5	-10	-15	μA
F_{PWM}	PWM Input Frequency		0.02	-	50	kHz
T_{QS}	Quick Start Enable Time		-	66.5	90	ms
HALL SENSITIVITY						
V_{HOFS}	Hall Input Offset Voltage		-	-	± 6	mV
V_{HYS}	Input Hysteresis Voltage		± 5	± 10	± 15	mV
THERMAL SHUTDOWN						
OTS	Over Temperature Shutdown Threshold		-	165	-	$^\circ C$
	Over Temperature Shutdown Hysteresis		-	30	-	$^\circ C$

Typical Operating Characteristics



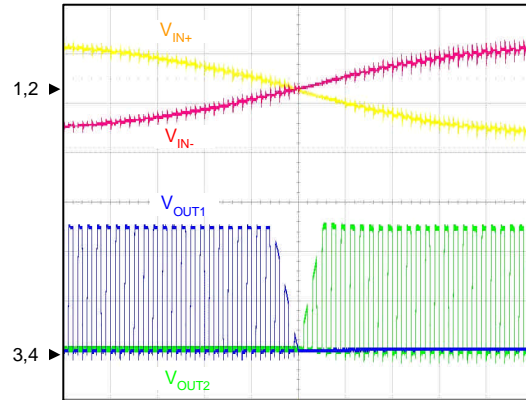
Operating Waveforms

Rotation Mode Waveform1 (NORMAL)



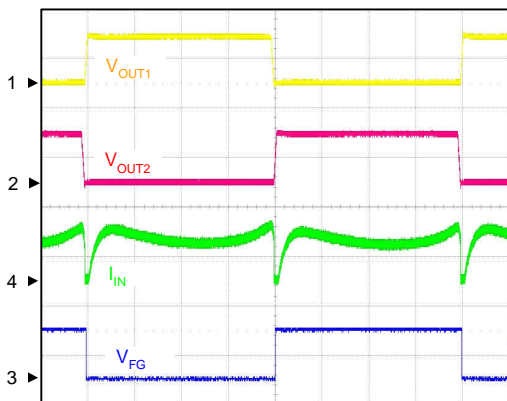
CH1: V_{IN+} , 100mV/div, AC
 CH2: V_{IN-} , 100mV/div, AC
 CH3: V_{OUT1} , 2V/div, DC
 CH4: V_{OUT2} , 2V/div, DC
 Time: 200 μ s/div

Rotation Mode Waveform1 (PWM)



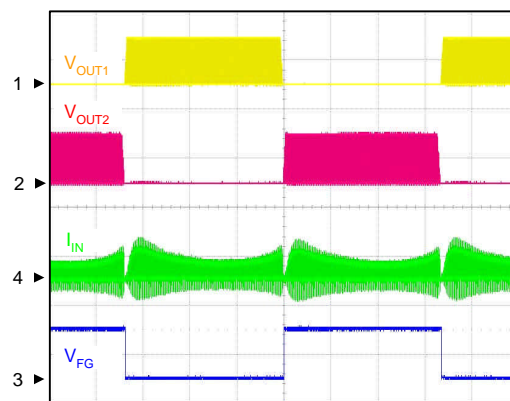
CH1: V_{IN+} , 100mV/div, AC
 CH2: V_{IN-} , 100mV/div, AC
 CH3: V_{OUT1} , 2V/div, DC
 CH4: V_{OUT2} , 2V/div, DC
 Time: 200 μ s/div

Rotation Mode Waveform2 (NORMAL)



CH1: V_{OUT1} , 5V/div, DC
 CH2: V_{OUT2} , 5V/div, DC
 CH3: V_{FG} , 5V/div, DC
 CH4: I_{IN} , 200mA/div, DC
 Time: 1ms/div

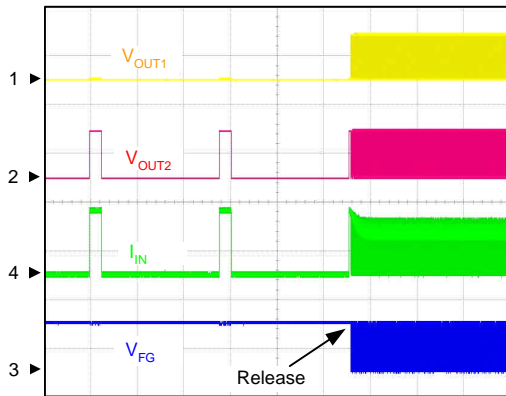
Rotation Mode Waveform2 (PWM)



CH1: V_{OUT1} , 5V/div, DC
 CH2: V_{OUT2} , 5V/div, DC
 CH3: V_{FG} , 5V/div, DC
 CH4: I_{IN} , 200mA/div, DC
 Time: 2ms/div

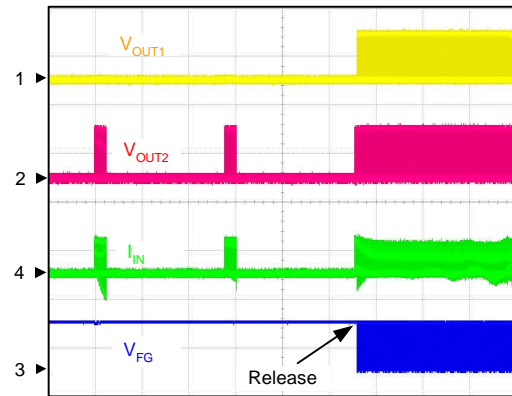
Operating Waveforms (Cont.)

Lock Protection Waveform (NORMAL)



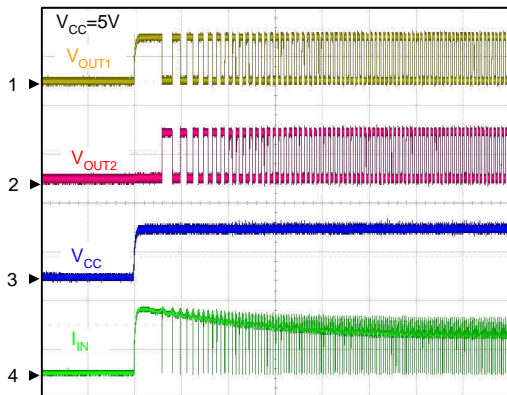
CH1: V_{OUT1} , 5V/div, DC
 CH2: V_{OUT2} , 5V/div, DC
 CH3: V_{FG} , 5V/div, DC
 CH4: I_{IN} , 200mA/div, DC
 Time: 2s/div

Lock Protection Waveform (PWM)



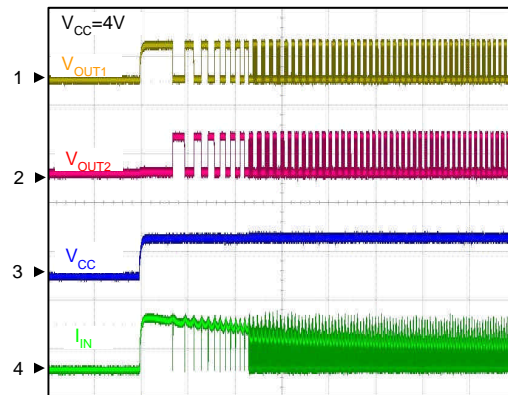
CH1: V_{OUT1} , 5V/div, DC
 CH2: V_{OUT2} , 5V/div, DC
 CH3: V_{FG} , 5V/div, DC
 CH4: I_{IN} , 200mA/div, DC
 Time: 2s/div

Power On Waveform (Type A)



CH1: V_{OUT1} , 5V/div, DC
 CH2: V_{OUT2} , 5V/div, DC
 CH3: V_{CC} , 5V/div, DC
 CH4: I_{IN} , 200mA/div, DC
 Time: 100ms/div

Power On Waveform (Type B)

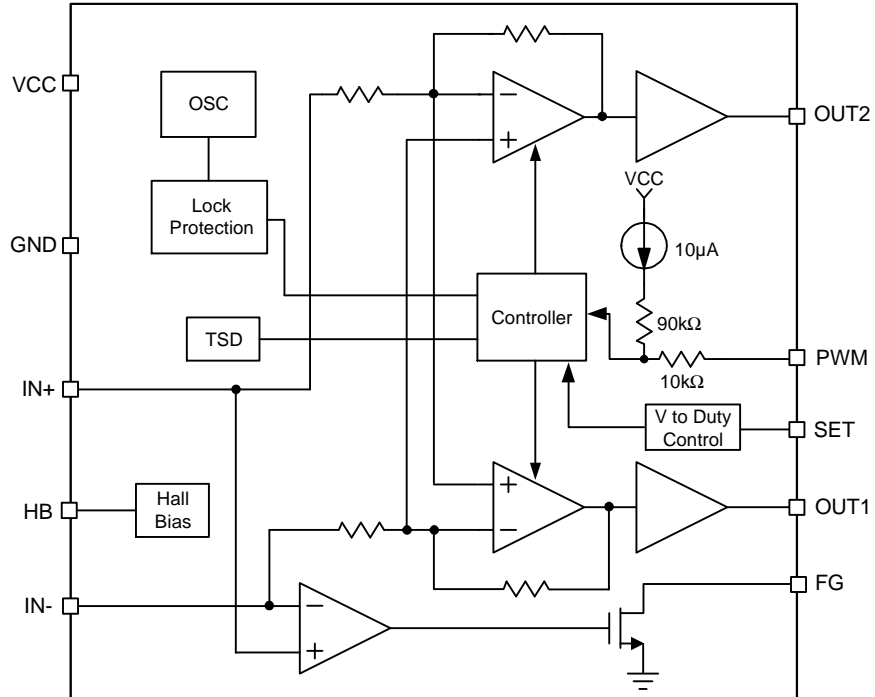


CH1: V_{OUT1} , 5V/div, DC
 CH2: V_{OUT2} , 5V/div, DC
 CH3: V_{CC} , 5V/div, DC
 CH4: I_{IN} , 200mA/div, DC
 Time: 100ms/div

Pin Description

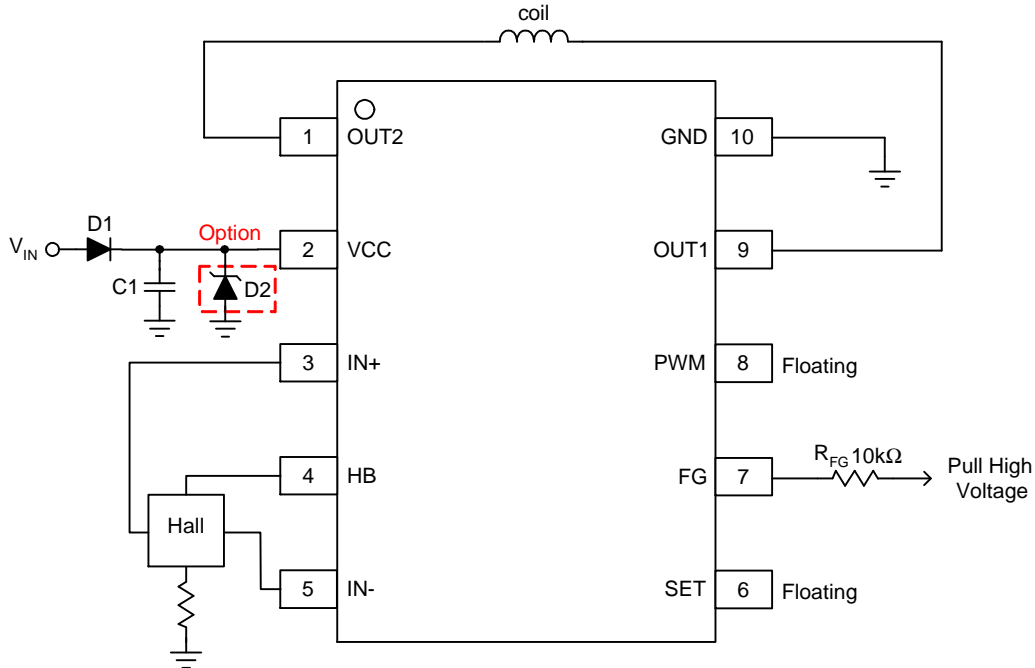
PIN		FUNCTION
NO.	NAME	
1	OUT2	H-bridge output connection.
2	VCC	Supply Voltage.
3	IN+	Hall Input +. Connect to hall element positive output.
4	HB	Hall Bias. This is a 1.3V constant-voltage output for hall element bias.
5	IN-	Hall Input -. Connect to hall element negative output.
6	SET	Speed slope setting pin. Use a voltage divider from HB to set the input voltage to adjust the fan speed slope of supply voltage region. Please let it be floating when use type A or type C to control speed.
7	FG	Rotation Speed Output. This is an open-drain output.
8	PWM	PWM Signal Input Terminal. Please let it be floating when use type A or type B to control speed.
9	OUT1	H-bridge output connection.
10	GND	Power GND.

Block Diagram

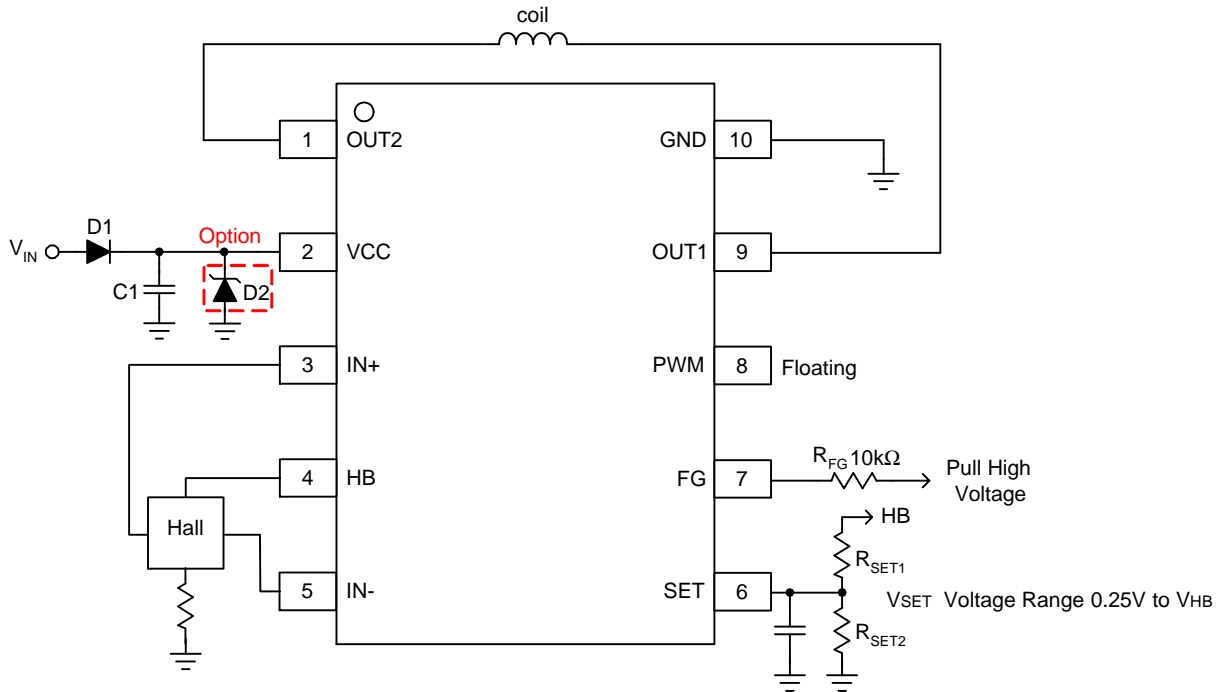


Typical Application Circuit

Type A: VCC speed control

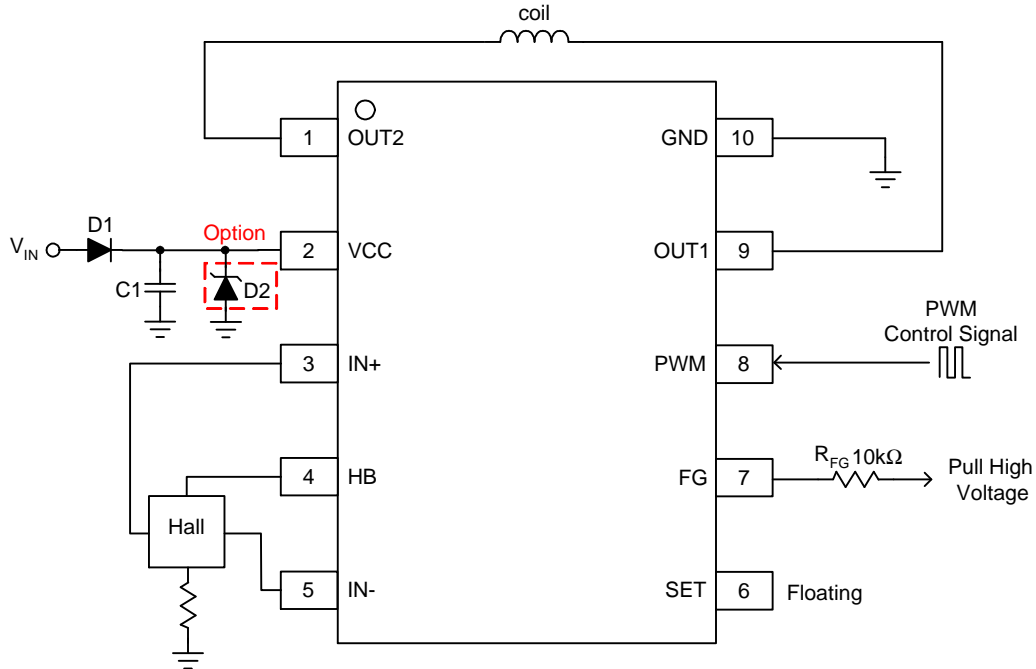


Type B: VCC speed control with slope setting

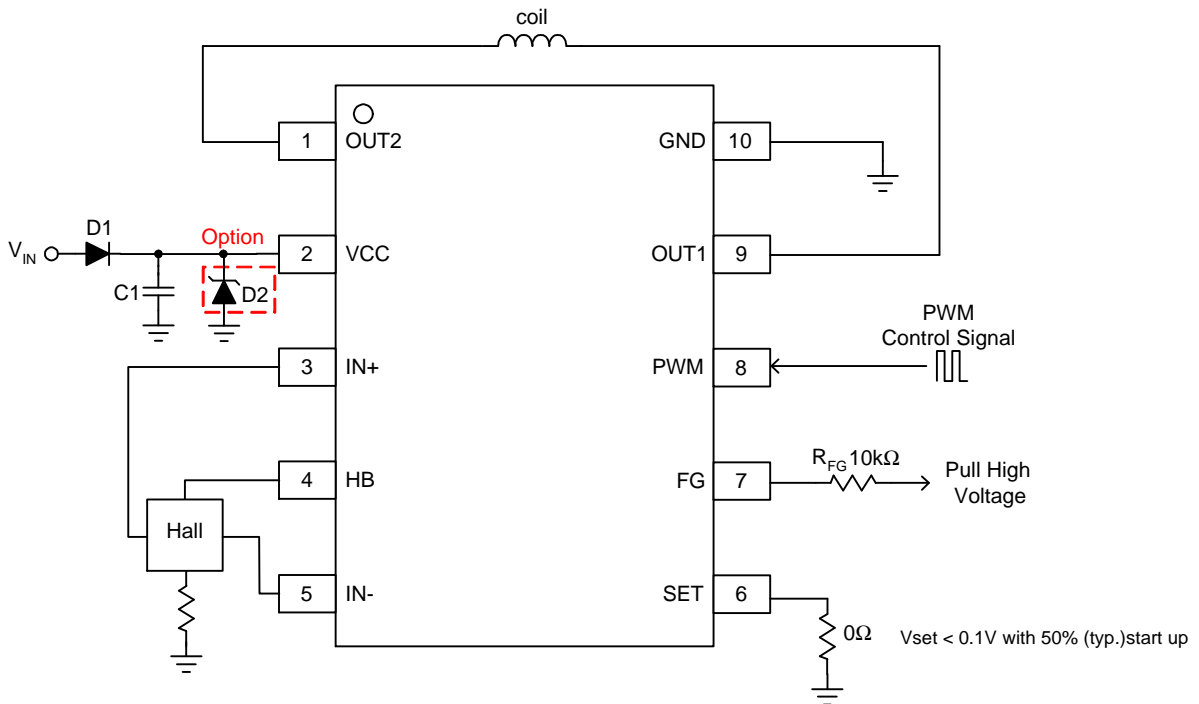


Typical Application Circuit (Cont.)

Type C: Direct PWM input speed control



Type D: Direct PWM input speed control with 50% (typ.) start up



Note : For zener diode (D2) is optional choice.

Function Description

Lockup Protection and Automatic Restart

The APX9258 provides the lockup protection and automatic restart functions for preventing the coil burn-out in 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 turning 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 Figure 1 Lockup/Auto Restart Waveform).

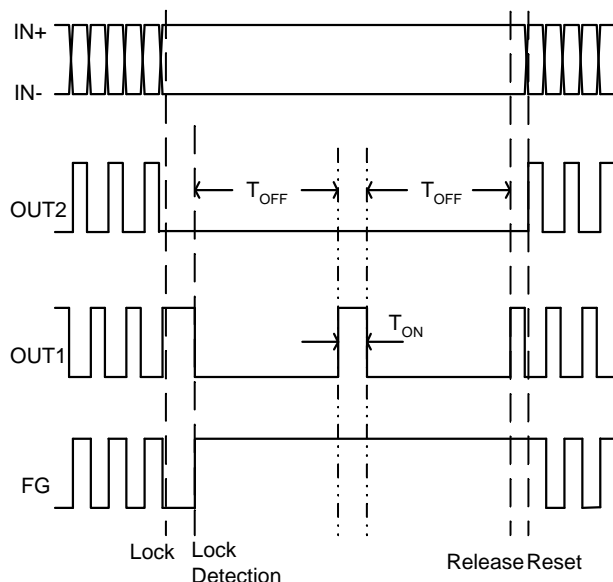


Figure 1. Lockup /Auto Restart Waveform

Speed Control Function

The APX9258 builds in three speed control types, which are VCC speed control (Type A), VCC speed control slope setting (Type B), and direct PWM input speed control (Type C/D). (See Figure 2-1 Fan speed controlled by VCC input and Figure 2-2 Fan speed controlled by direct PWM input signal).

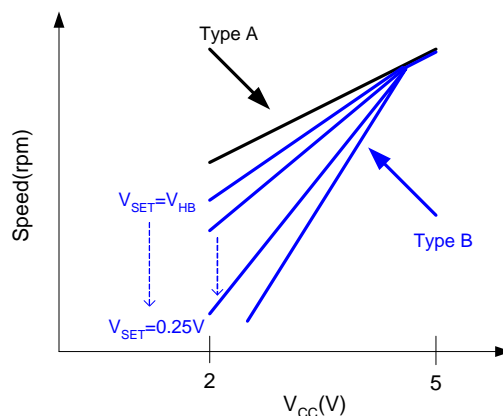


Figure 2-1. Fan speed controlled by VCC input

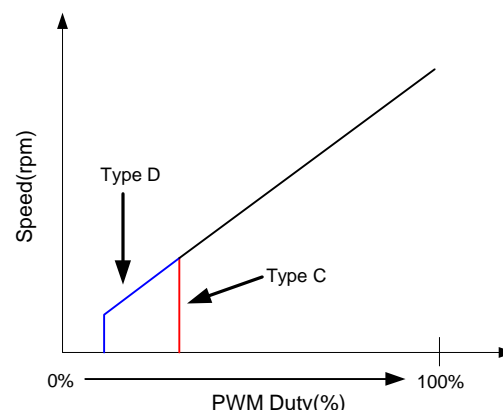


Figure 2-2. Fan speed controlled by direct PWM input signal

Quick Start and Standby Mode (Type C/D)

This IC would enter standby mode when the PWM input keeps low level for more than 66.5ms (typ.). In standby mode, it will shutdown amplifier and FG. Thus, the supply current is around 100 μ A. In standby mode, the lock protection function doesn't work, therefore, starting fan is unobstructed when releasing standby mode.

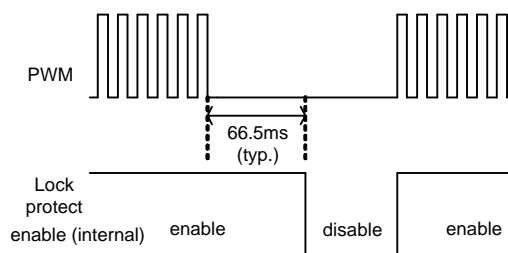


Figure 3. Quick Start Waveform

Function Description (Cont.)

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.

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 high (switch off); when IN- is smaller than IN+, the FG is low (switch on).

Open the terminal when not in use.

Thermal Protection

The APX9258 has thermal protection function. When internal junction temperature reaches 165°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			Mode
IN-	IN+	PWM	OUT1	OUT2	FG	
L	H	H	H	L	L	Normal Operation Mode
H	L		L	H	OFF	
H	L	L	L	L	OFF	
L	H		L	L	L	
L	H	-	L	L	OFF	Lock Protection Mode
H	L		L	L	OFF	
-	-	L	OFF	OFF	OFF	Standby Mode

Application Information

Input Protection Diode & Zener 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 VCC and GND with a Zener diode (D2) can avoid exceeding the absolute maximum rating voltage when power on or system power transient. For the noise reduction purpose, there is a 1μF capacitor (C1) recommended connecting between VCC and GND (see Typical Application Circuit).

Hall Input & Output

The output signal of this IC is 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 Figure 4 Different of output signal depending on the shape of hall input signal). The input/output gain is 45dB (typ.). Thus, please adjust the amplitude of hall input to meet the adequate output voltage.

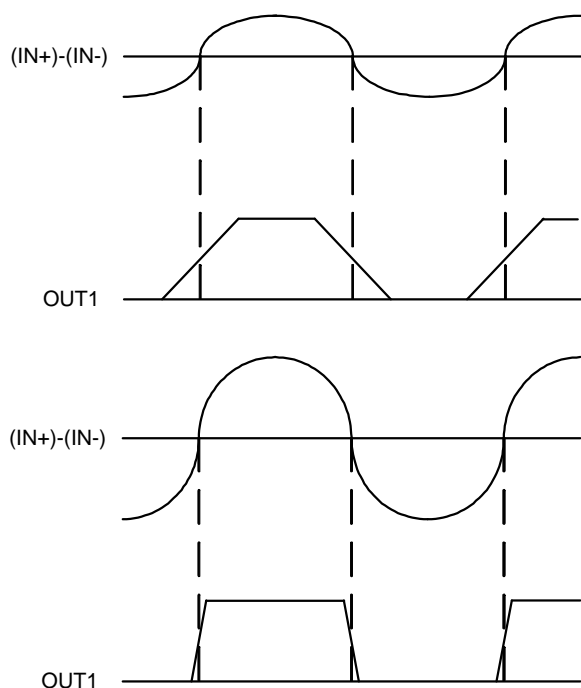


Figure 4. Different of output original depending on the shape of hall input signal

FG Resistor

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

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

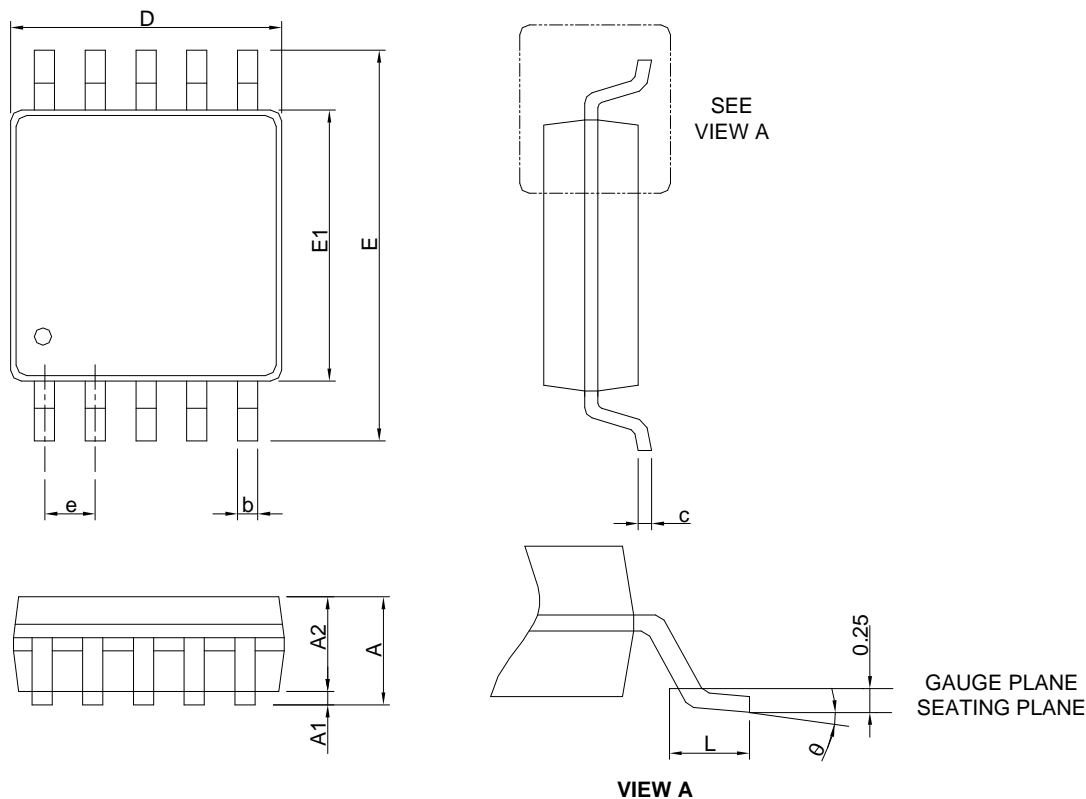
For example:

$$V_{CC} = 5V, I_{FG} = 5mA, V_{FG} = 0.2V, R_{FG} = 0.96k\Omega$$

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

Package Information

MSOP-10

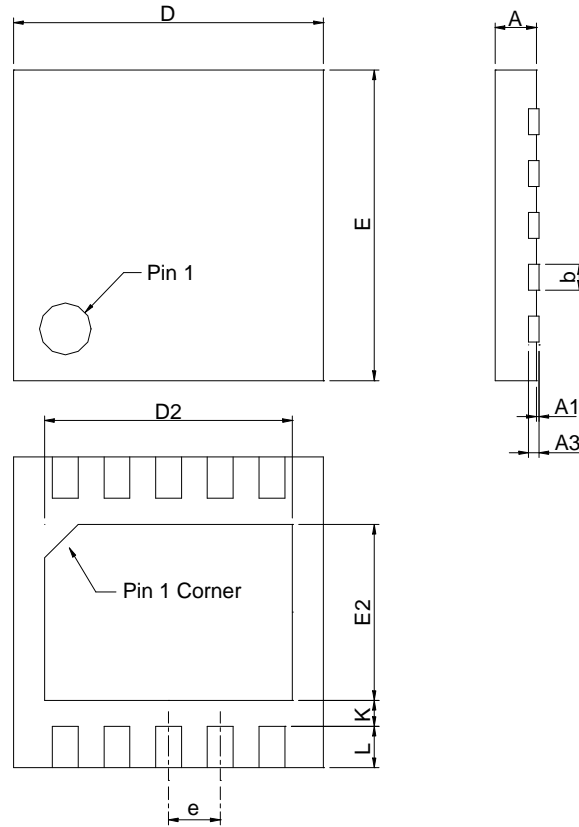


SYMBOL	MSOP-10			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.10		0.043
A1	0.00	0.15	0.000	0.006
A2	0.75	0.95	0.030	0.037
b	0.17	0.33	0.007	0.013
c	0.08	0.23	0.003	0.009
D	2.90	3.10	0.114	0.122
E	4.70	5.10	0.185	0.201
E1	2.90	3.10	0.114	0.122
e	0.50 BSC		0.020 BSC	
L	0.40	0.80	0.016	0.031
θ	0°	8°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

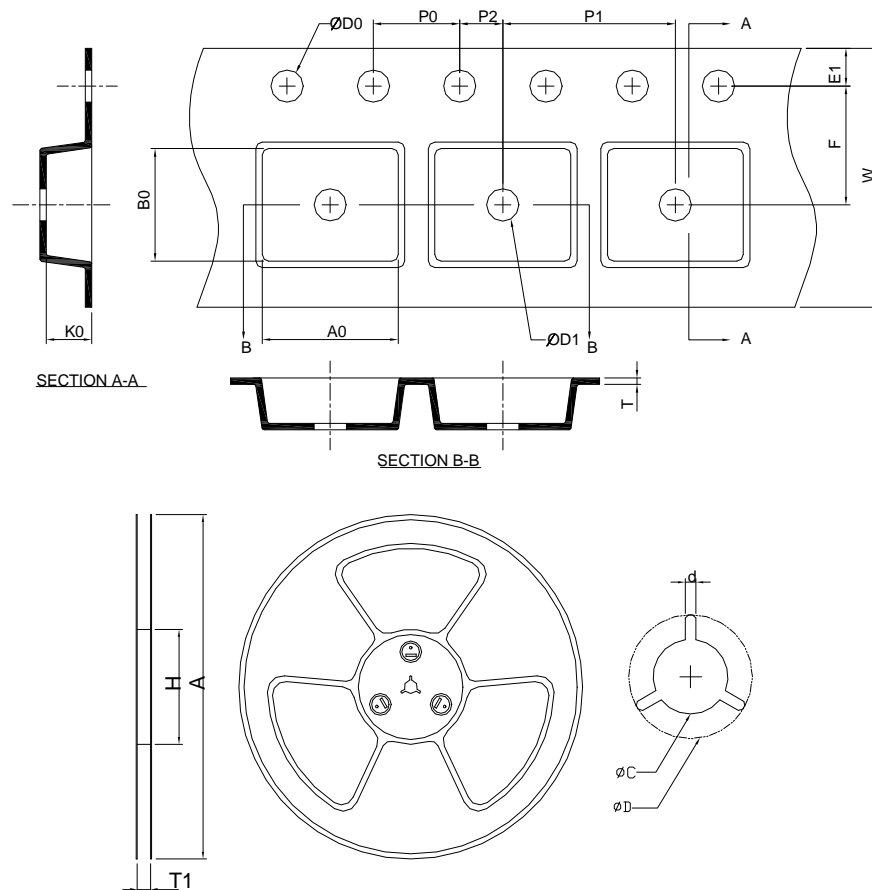
Package Information

VTDFN3x3-10



SYMBOL	VTDFN3x3-10			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.50	0.60	0.020	0.024
A1	0.00	0.05	0.000	0.002
A3	0.20 REF		0.008 REF	
b	0.18	0.30	0.007	0.012
D	2.90	3.10	0.114	0.122
D2	2.20	2.70	0.087	0.106
E	2.90	3.10	0.114	0.122
E2	1.40	1.75	0.055	0.069
e	0.50 BSC		0.016 BSC	
L	0.30	0.50	0.012	0.020
K	0.20		0.008	

Carrier Tape & Reel Dimensions



Application	A	H	T1	C	d	D	W	E1	F
MSOP-10	330.0 ±0.00	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
	4.00 ±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	5.30 ±0.20	3.30 ±0.20	1.40 ±0.20
Application	A	H	T1	C	d	D	W	E1	F
VTDFN3x3-10	330.0 ±0.00	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	3.30 ±0.20	3.30 ±0.20	0.75 ±0.20

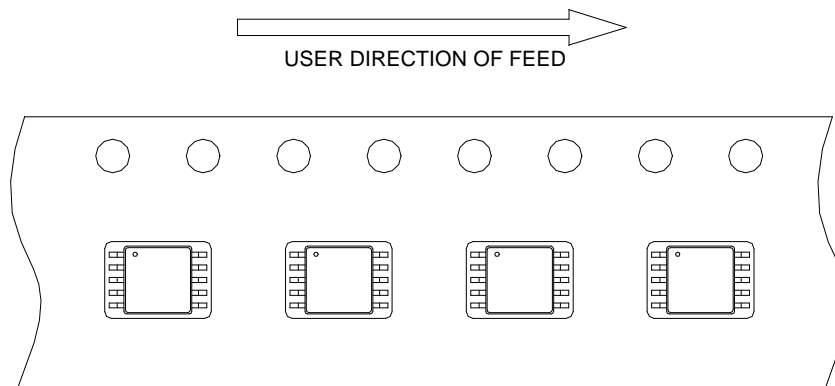
(mm)

Devices Per Unit

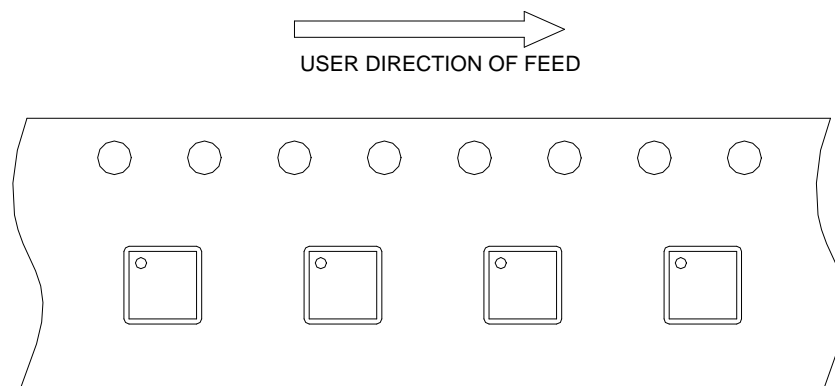
Package Type	Unit	Quantity
MSOP-10	Tape & Reel	3000
VTDFN3x3-10	Tape & Reel	3000

Taping Direction Information

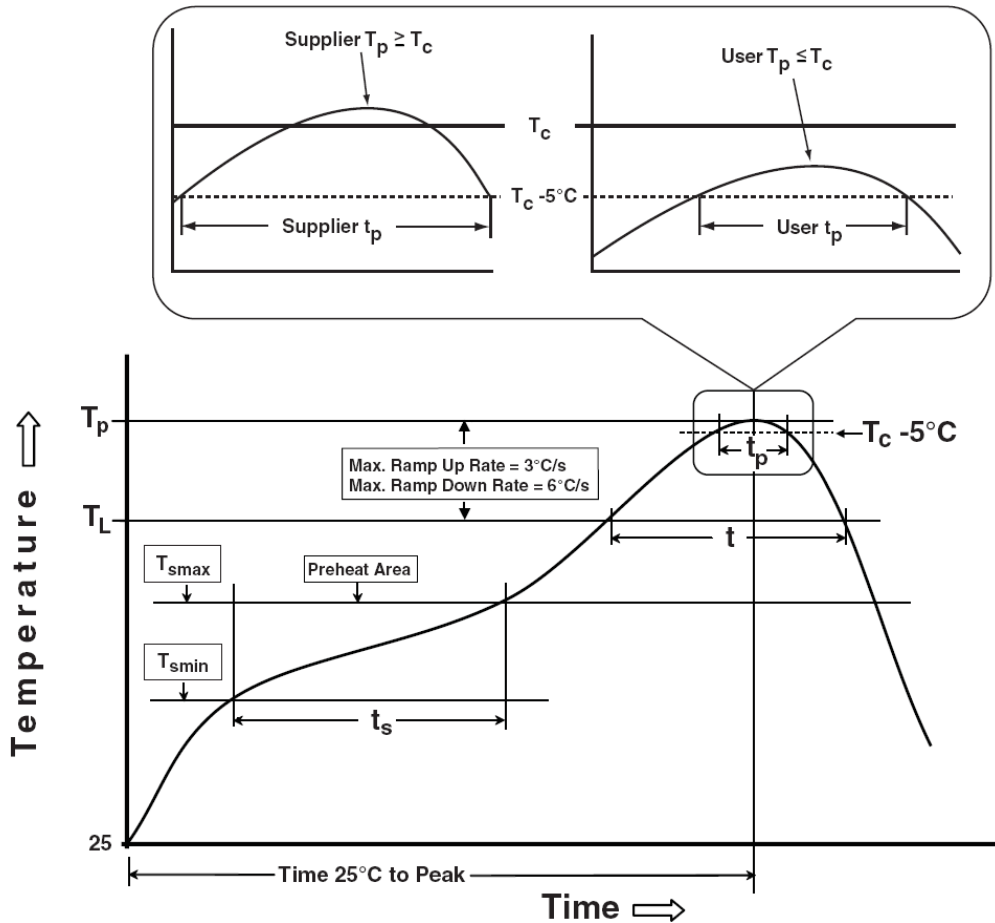
MSOP-10



VTDFN3x3-10



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, 1 _{tr} 100mA

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