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

Features

- **Single Phase Full Wave Fan Driver**
- **Silent Driver (45dB Gain for Low Noise)**
- **Low Supply Current**
- **Low Standby Current (PWM=0 Duty), Supply Current Less than 250㎃A**
- **Speed Controllable by PWM Input Signal**
- **Enhance Low Duty Start UP Power (Type B Only)**
- **Built-In Quick Start Function**
- **Lock Protection and Auto Restart Function**
- **Include Hall Bias Circuit**
- **Built-In FG Output**
- **Built-In Thermal Protection Circuit**
- **Lead Free and Green Devices Available (RoHS Compliant)**

General Description

The APX6980 is a single phase full wave motor driver for DC fan motor, and speed 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 is built-in lock protection. When the fan is locked, the device will enter the lockup protection mode. It is also with thermal shut-down function. In normal operation, supply current is less than 6mA, but in PWM=0 standby mode, it is just around 125μA. Moreover, this feature will shutdown Amplifier and FG. The APX6980 is available in MSOP-10 and VTDFN3x3-10 packages.

Applications

- **Motor Drivers For Silent Fan Motors**

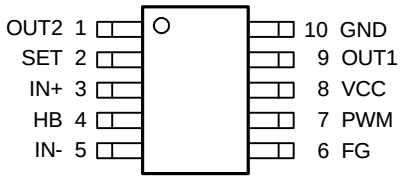
Ordering and Marking Information

APX6980 □□-□□□ Assembly Material Handling Code Temperature Range Package Code		Package Code X: MSOP - 10 QF : VTDFN3x3-10 Operating Ambient Temperature Range I : -40 to 105 °C Handling Code TR : Tape & Reel Assembly Material G: Halogen and Lead Free Device
APX6980 X :	X6980 XXX ● XX	XXXXX - Date Code
APX6980 QF :	X6980 XXX ● XX	XXXXX - Date Code

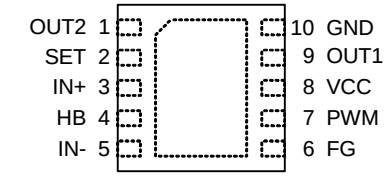
Note: ANPEC lead-free products contain molding compounds/die attach materials and 100% matte tin plate termination finish;which are fully compliant with RoHS. ANPEC lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J-STD-020D for MSL classification at lead-free peak reflow temperature.ANPEC 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



MSOP-10
(TOP VIEW)



VTDFN-10 3X3
(TOP VIEW)

= 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 8	V
I_{OUT}	Output Pin Maximum Output Current	1	A
V_{OUT}	Output Pin Output Voltage	-0.3 to 8	V
I_{HB}	HB Pin Maximum Output Current	10	mA
	FG Pin Output Voltage	-0.3 to 8	V
I_{FG}	FG Pin Maximum Output Sink Current	10	mA
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
θ_{JA}	Thermal Resistance-Junction to Ambient (Note 2) MSOP-10 VTDFN3x3-10	 208 119	°C/W
P_D	Power Dissipation, T_A=25 °C MSOP-10 VTDFN3x3-10	 0.6 1.05	W

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

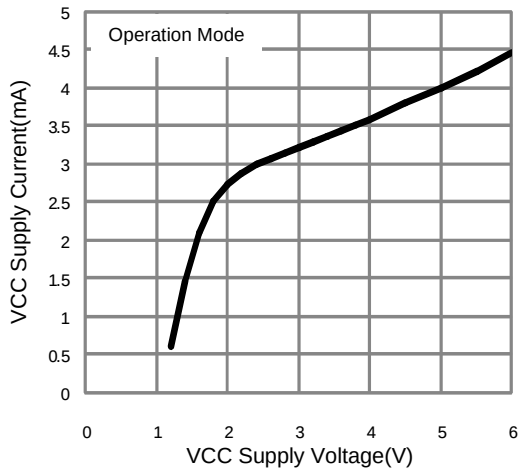
Symbol	Parameter	Range	Unit
V_{CC}	VCC Pin Supply Voltage	1.8 to 6	V
V_{Hall}	Hall Input Voltage Range	0.4 to Vcc-1.1	V
T_A	Ambient Temperature	-40 to 105	°C
T_J	Junction Temperature	-40 to 125	°C

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

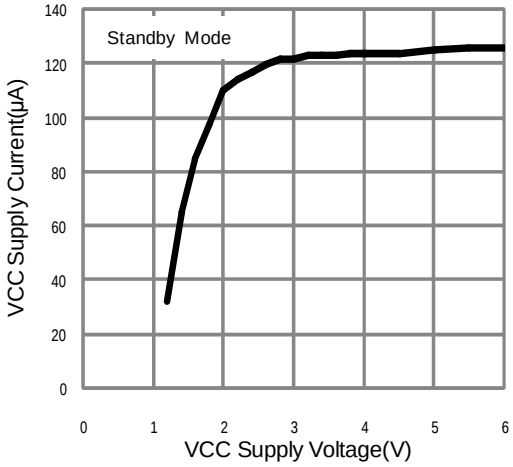
Symbol	Parameter	Test Conditions	APX6980			Unit
			Min.	Typ.	Max.	
SUPPLY CURRENT						
V_{HB}	HB Pin Output Voltage	I_{HB} = 5mA	1.15	1.25	1.35	V
I_{CC1}	Operating Current	Rotation Mode	-	4	6	mA
I_{CC2}	Standby Supply Current	PWM=0	-	125	250	µA
LOCK PROTECTION						
T_{ON}	Lock Detection On Time		0.35	0.5	0.65	sec
T_{OFF}	Lock Detection Off Time		3.5	5	6.5	sec
T_{QS}	Quick Start Enable Time		0.5	1	2	msec
OUTPUT DRIVERS						
V_O	Output Driver Saturation Voltage	I_{OUT} = 250mA, Upper and Lower total	-	0.2	0.3	V
V_{FG}	FG Pin Low Voltage	I_{FG} = 5mA	-	0.1	0.3	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
PWM CONTROL						
V_{PWMH}	PWM Input High Level Voltage		2.5	-	V_{CC}+0.3	V
V_{PWML}	PWM Input Low Level Voltage		-0.3	-	0.8	V
I_{PWMH}	PWM High Input Current	PWM=V_{CC}	-	0	-	µA
I_{PWML}	PWM Low Input Current	PWM=GND	-20	-30	-40	µA
F_{PWM}	PWM Input Frequency		3	-	50	kHz
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		-	170	-	°C
	Over Temperature Shutdown Hysteresis		-	30	-	°C

Typical Operating Characteristics

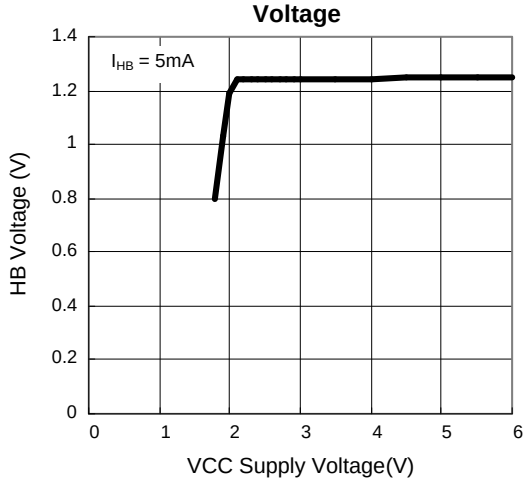
VCC Supply Current vs. VCC Supply Voltage



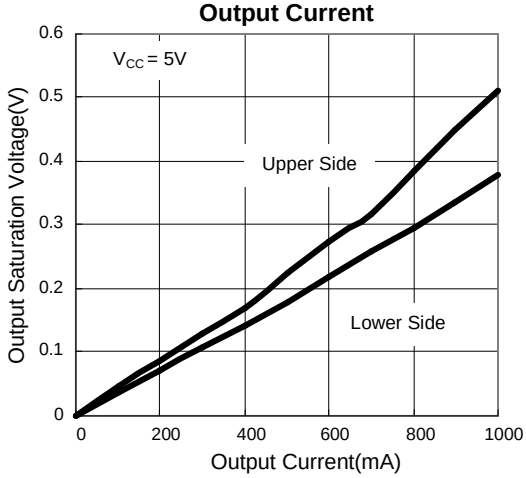
VCC Supply Current vs. VCC Supply Voltage



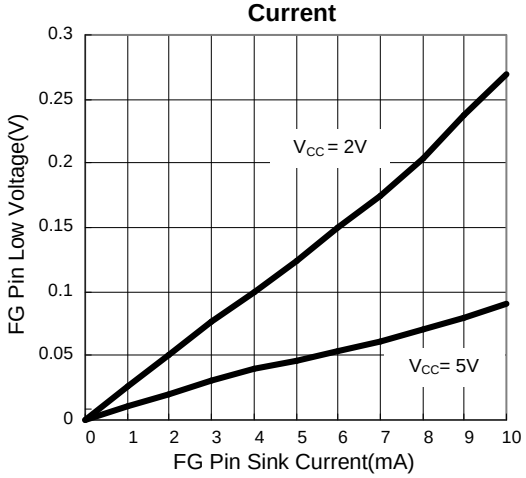
HB Voltage vs. VCC Supply Voltage



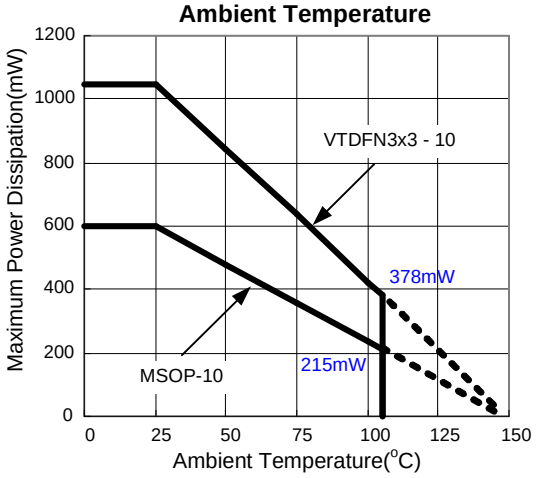
Output Saturation Voltage vs. Output Current



FG Pin Low Voltage vs. Sink Current

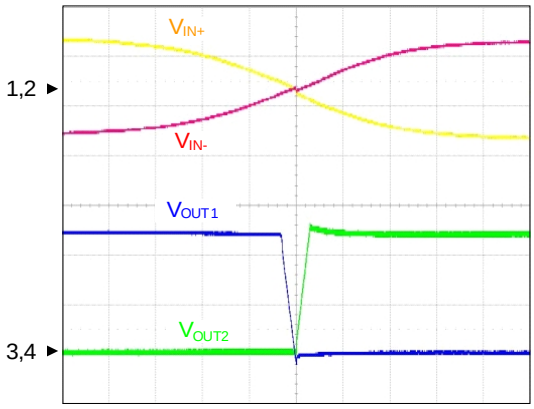


Maximum Power Dissipation vs. Ambient Temperature



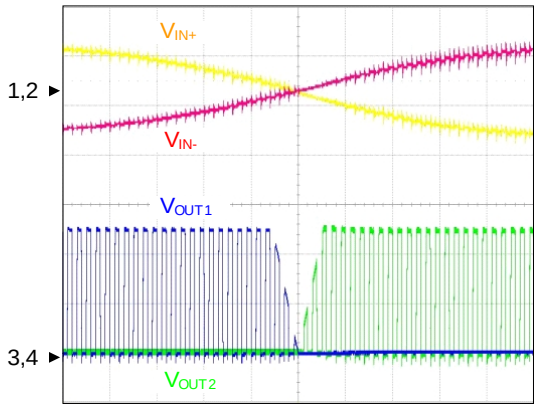
Operating Waveforms

Rotation Mode Waveform1 (NORMAL)



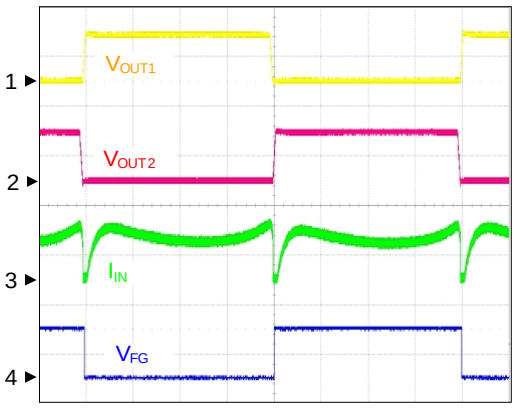
CH1:V_{IN}+,100mV/div,AC
CH2:V_{IN}-,100mV/div,AC
CH3:V_{OUT1},2V/div,DC
CH4:V_{OUT2},2V/div,DC
Time:200µs/div

Rotation Mode Waveform1 (PWM)



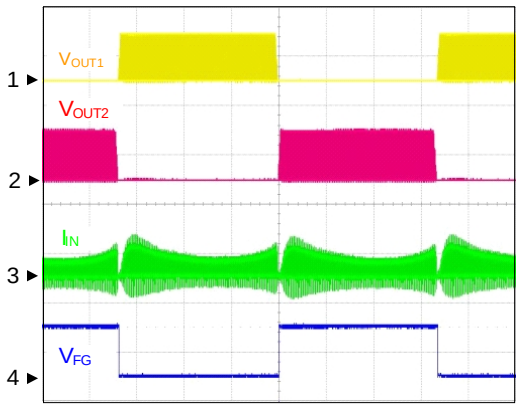
CH1:V_{IN}+,100mV/div,AC
CH2:V_{IN}-,100mV/div,AC
CH3:V_{OUT1},2V/div,DC
CH4:V_{OUT2},2V/div,DC
Time:200µs/div

Rotation Mode Waveform2 (NORMAL)



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

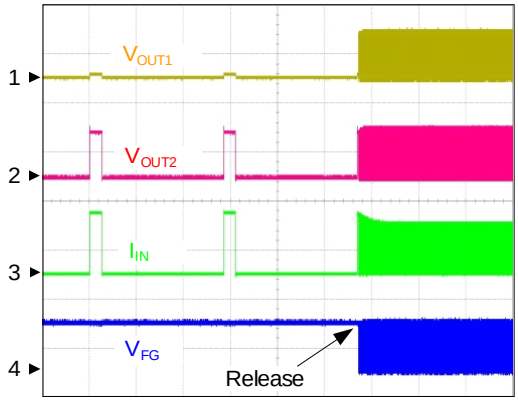
Rotation Mode Waveform2 (PWM)



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

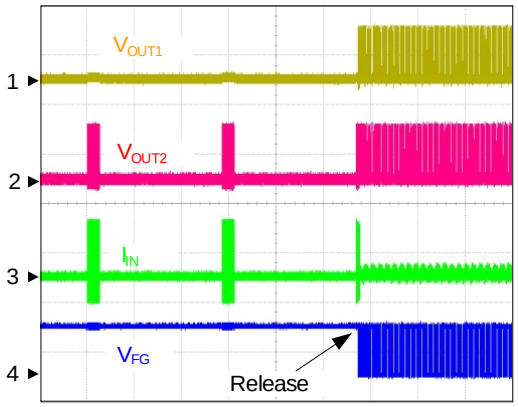
Operating Waveforms

Lock Protection Waveform (NORMAL)



CH1:V_{OUT1},5V/div,DC
CH2:V_{OUT2},5V/div,DC
CH3:I_{IN},500mA/div,DC
CH4:V_{FG},5V/div,DC
Time:2s/div

Lock Protection Waveform (Type B PWM15%)

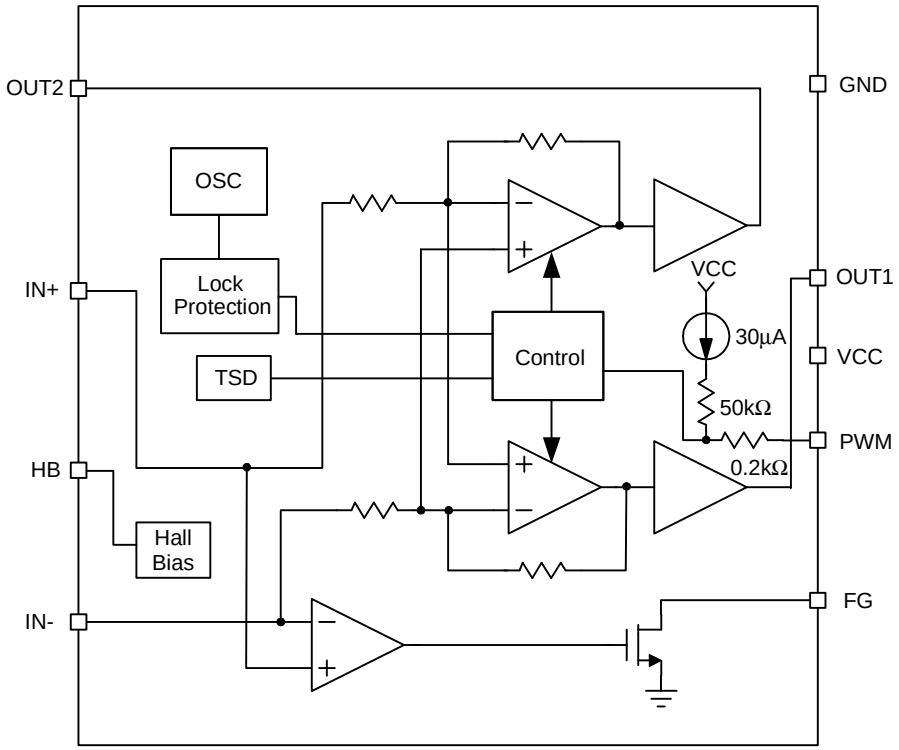


CH1:V_{OUT1},5V/div,DC
CH2:V_{OUT2},5V/div,DC
CH3:I_{IN},500mA/div,DC
CH4:V_{FG},5V/div,DC
Time:2s/div

Pin Description

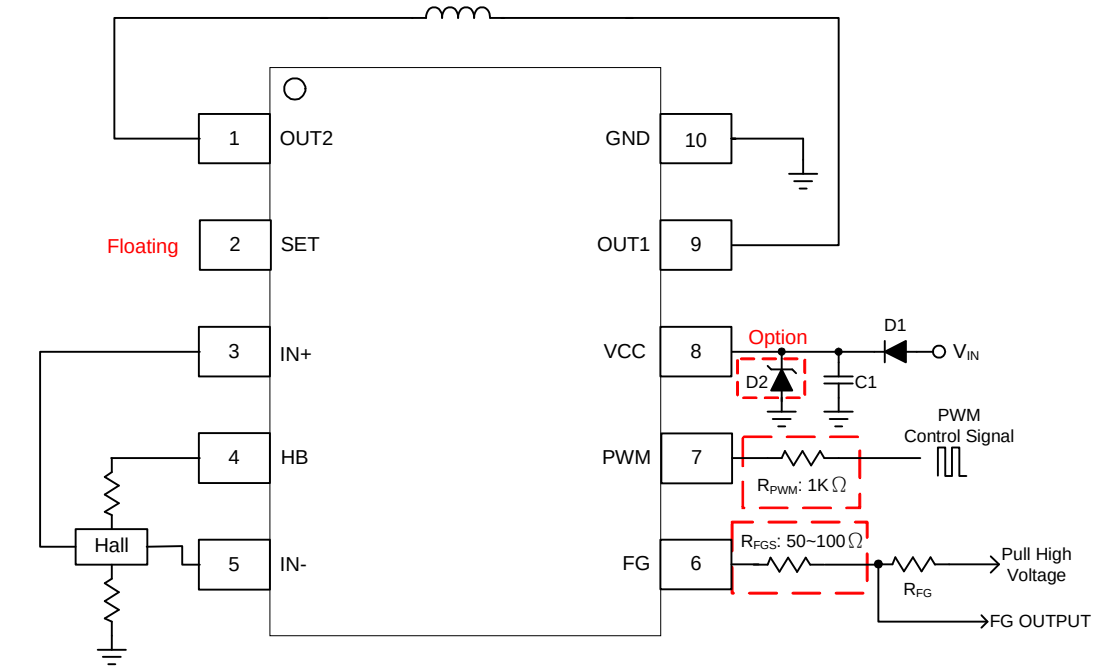
PIN		FUNCTION
NO.	NAME	
1	OUT2	H-bridge Output Connection.
2	SET	SET PIN GND enable 50% (Typ.) DUTY start up. Start up duty follow the PWM input duty when SET pin floating.
3	IN+	Hall Input +. Connect to hall element positive output.
4	HB	Hall Bias. This is a 1.3V constant-voltage output for hall element bias.
5	IN-	Hall Input -. Connect to hall element negative output.
6	FG	Rotation Speed Output.
7	PWM	PWM Signal Input Terminal. The output will be full duty when PWM pin floating.
8	VCC	Supply Voltage Input Pin.
9	OUT1	H-bridge Output Connection.
10	GND	Ground.

Block Diagram



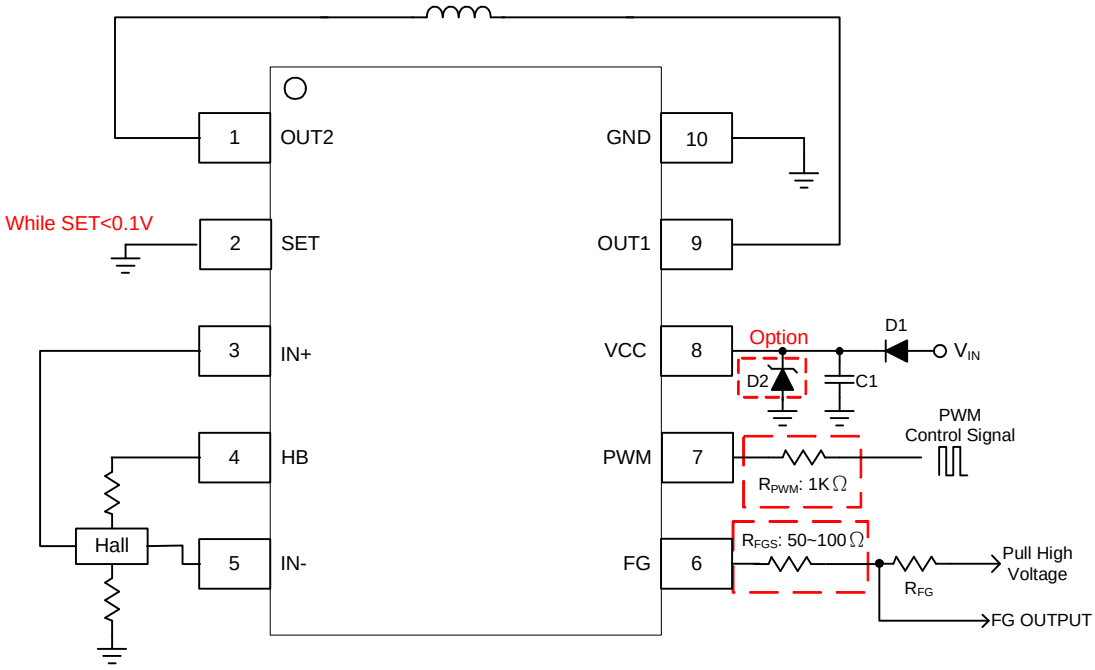
Typical Application Circuit

Type A : Direct PWM Input Speed Control



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

Type B : enable LOW DUTY start up



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

Function Description

Lockup Protection and Automatic Restart

This IC detects the rotation of the motor by hall signal, and adjusts lock detection ON time (T_{ON}) and lock detection OFF time (T_{OFF}) by internal counter. These times (T_{ON}, T_{OFF}) are shown as below.

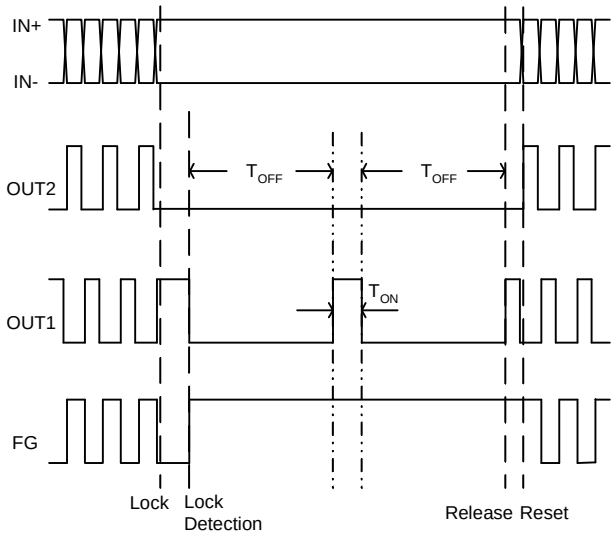


Figure 1. Lock Protection and Automatic Protection Waveform.

Quick Start and Standby Mode

This IC would enter standby mode when the PWM input keeps low level for more than 1ms (typ.). In standby mode, it will shutdown amplifier and FG. Thus, the supply current is around 125μA. In standby mode, the lock protection function doesn't work, therefore, starting fan is unobstructed when releasing standby mode.

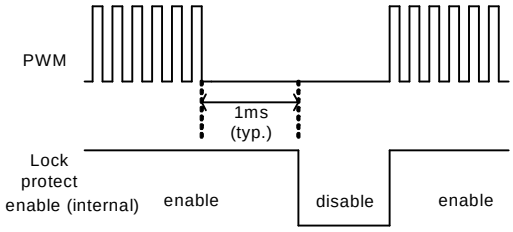


Figure 2. Quick Start Waveform

Frequency Generator Function

The FG pin is an open drain output, connecting a pull up resistor to a high level voltage for the frequency generator function. During the Lock Mode, the FG will always high (switch off) (See Truth Table). Open the terminal when not in use.

Thermal Protection

The APX6980 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 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	Operation Mode
H	L		L	H	OFF	
H	L	L	L	L	OFF	
L	H		L	L	L	
L	H	-	L	L	OFF	Lock Mode
H	L		L	L	OFF	
-	-	L	OFF	OFF	OFF	Standby Mode

Application Information

Input Protection Diode & Zener Diode & Capacitor

The APX6980 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 greater 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 transients. For the noise reduction purpose, a capacitor (C1) 1μF is connected between VCC and GND (See Typical Application Circuit).

Hall Input

Please adjust hall input voltage by value of resistance so that hall signal contains amplitude input within range 0.4V to V_{cc}-1.1V.

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, when the input signal is large, the output becomes steep (See Figure 3 Differences 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.

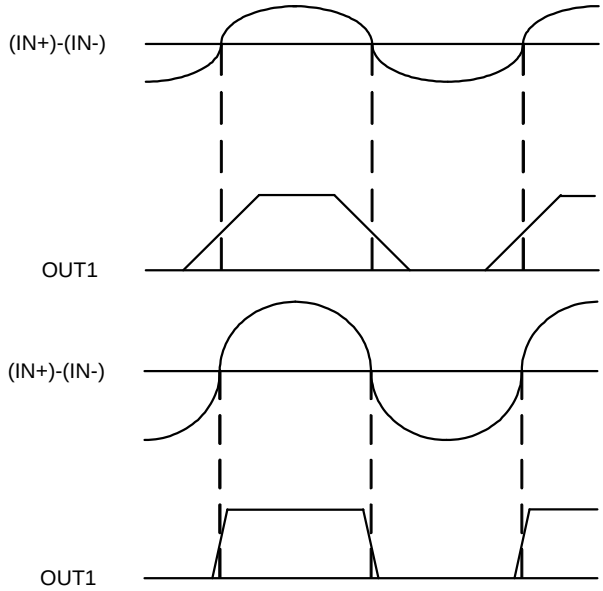


Figure 3. Differences of Output Signal Depending on the Shape of Hall Input Signal

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)

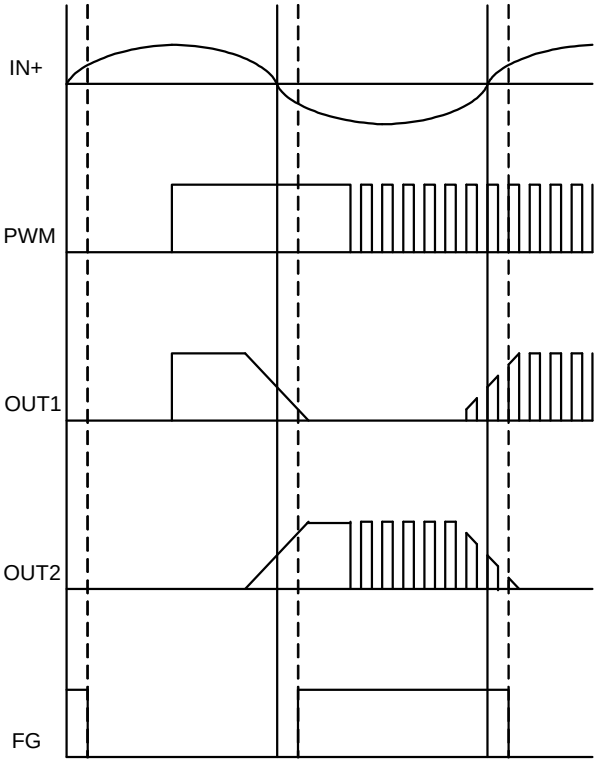


Figure 4. PWM Input Waveform

The input level of PWM terminal is
H : High side output transistor is ON
L : High side output transistor is OFF
When PWM terminal is open, it is equal to H.

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}=0.96kΩ

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

Application Information (Cont.)

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= 75°C, the maximum power dissipation is about 0.35W.

The power dissipation can be calculated by the following equation:

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

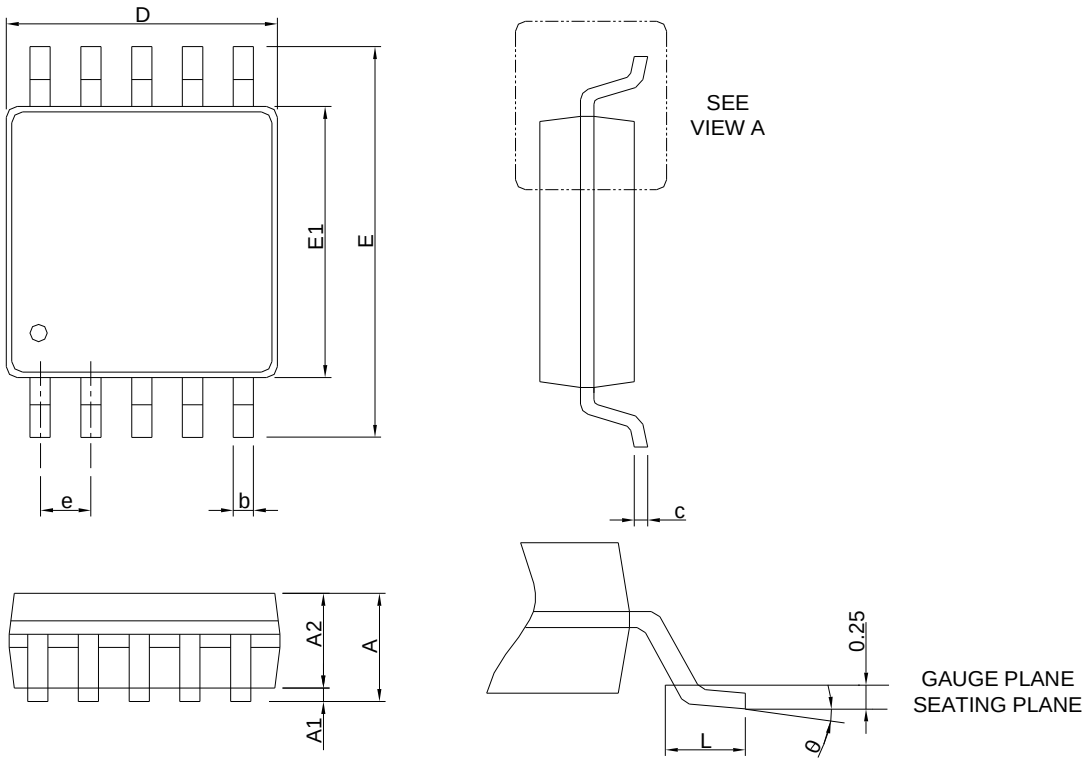
For example:

V_{CC} = 5V, I_{CC} = 4mA, I_{OUT} = 250mA, V_{OUT1} = 4.76V, V_{OUT2} = 0.11V, then P_D = 0.108W

The GND pin provides an electrical connection to the 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

MSOP-10



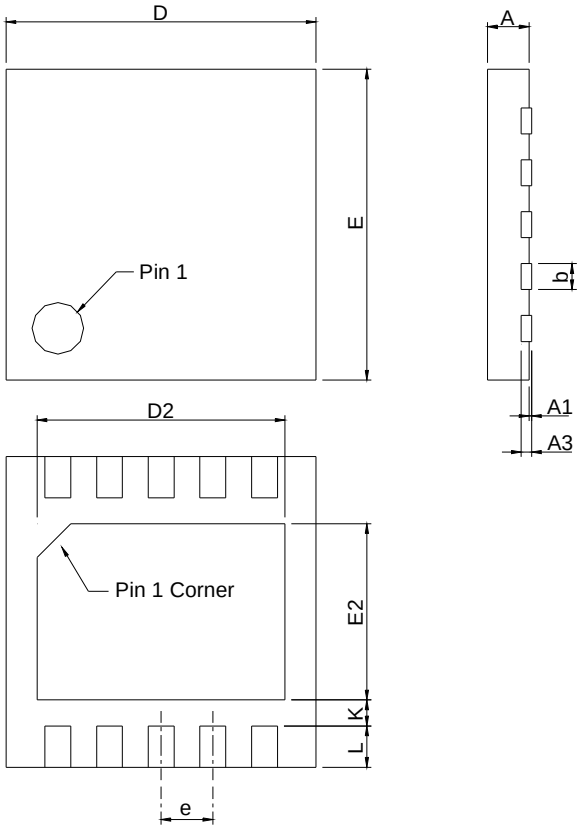
VIEW A

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.

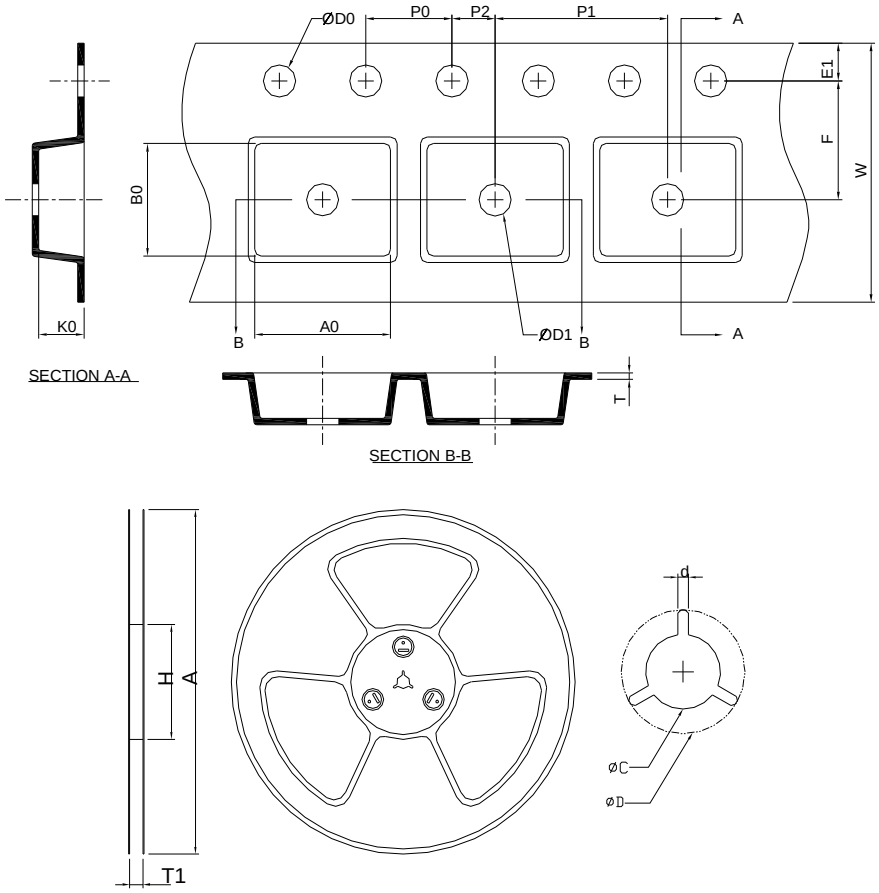
Package Information

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±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±0.05
	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±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±0.05
	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

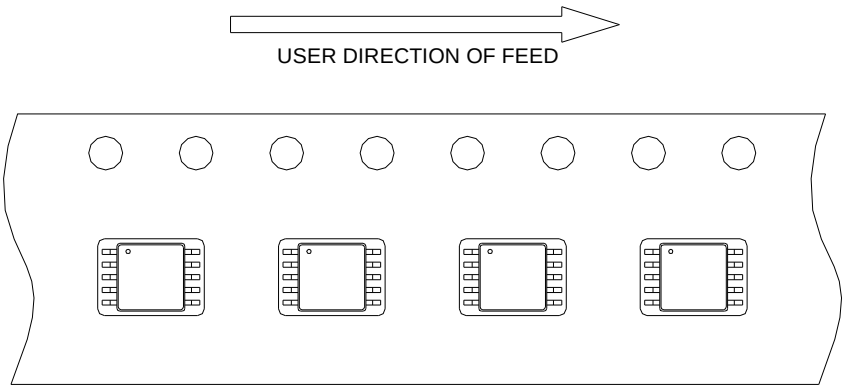
(mm)

Devices Per Unit

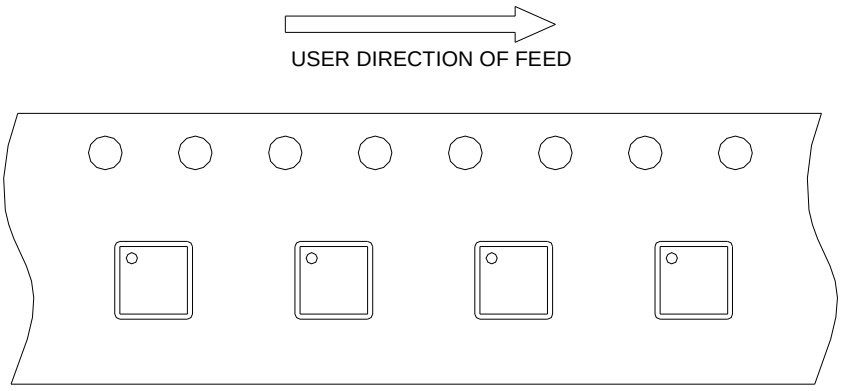
Package Type	Unit	Quantity
MSOP-10	Tape & Reel	3000
VTDFN3x3-10	Tape & Reel	3000

Taping Direction Information

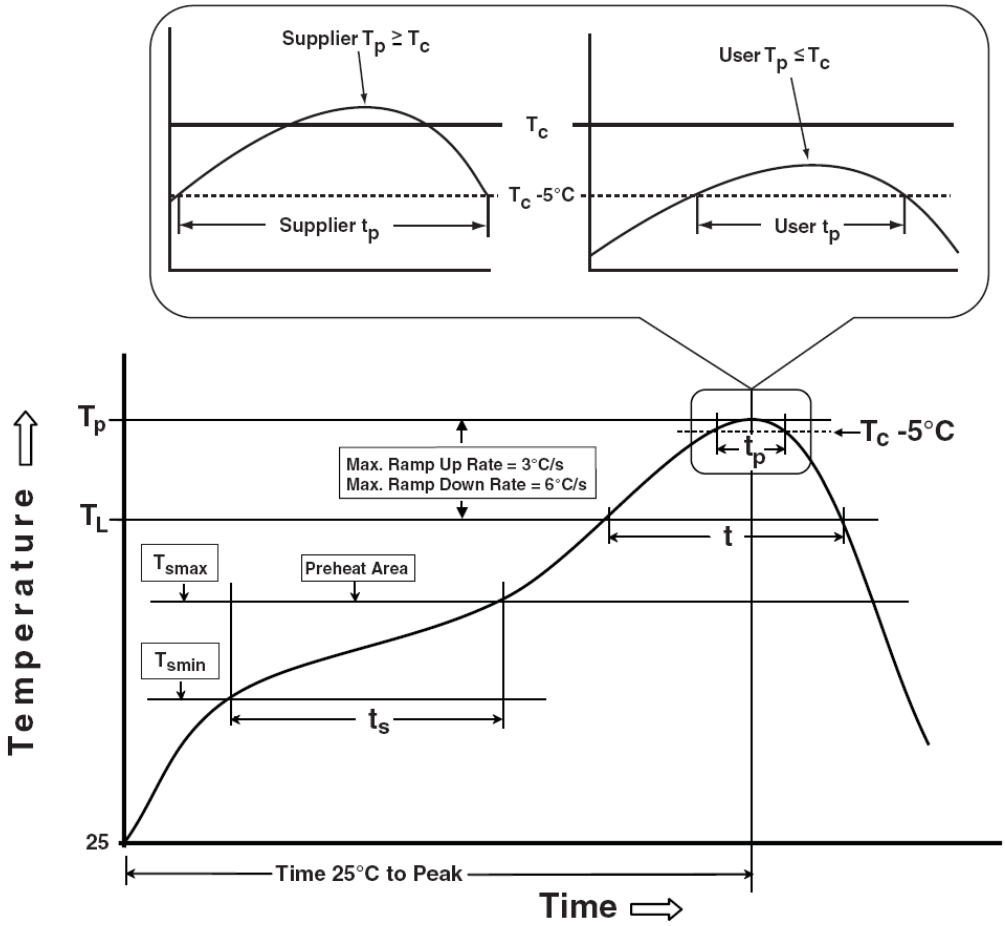
MSOP-10



VTDFN3x3-10



Classification Profile



Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Preheat & Soak Temperature min (T_{smin}) 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.		

Classification Reflow Profiles (Cont.)

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 @ 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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