

## Single-Phase Full-Wave Motor Driver with Built-in Hall Sensor

### Features

- **On-chip Hall Sensor**
- **PWM Soft Switch**
- **Built-in Reverse Voltage Protection Circuit**
- **High Sensitivity Hall Effect Sensor IC :  $\pm 10G$**
- **Built-in Lock Protection and Auto Restart Function**
- **Soft Start Function**
- **Built-In Quick Start Function**
- **Speed Controllable by PWM Input Signal**
- **FG (Rotation Speed Detection) Output**
- **Built-in Thermal Protection Circuit**
- **6 Pin XTDFN 2x1.5-6 Package**
- **Lead Free and Green Devices Available (RoHS Compliant)**

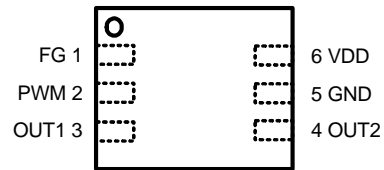
### Applications

- **Brushless DC Fans**
- **Brushless DC Motors**

### General Description

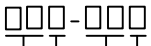
The APX9154 is an integrated Hall Effect Sensor IC designed for electric commutation of single-phase DC brushless motor applications. The device is built-in lock protection. When fan is locked, the device will enter the lock protection mode. It is also with thermal shutdown function. The APX9154 is available in a low cost XTDFN 2x1.5-6 package.

### Pin Configuration



XTDFN 2x1.5-6  
(Top View)

### Ordering and Marking Information

<p>APX9154 </p> <p style="margin-left: 100px;">             Assembly Material              Handling Code              Temperature Range              Package Code         </p>	<p>Package Code              QH : XTDFN 2x1.5-6              Operating Ambient Temperature Range              I : -40 to 105 °C              Handling Code              TR : Tape &amp; Reel              Assembly Material              G : Halogen and Lead Free Device</p>
<p>APX9154 QH : <span style="border: 1px solid black; padding: 2px;">X54X</span></p>	<p style="text-align: center;">The last X is referred as 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.

## Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
V <sub>DD</sub>	VDD Pin Supply Voltage (VDD to GND)	-0.3 to 7	V
V <sub>OUT</sub>	Output Pin (OUT1, OUT2) Output Voltage	-0.3 to 7	V
I <sub>OUT</sub>	Output Pin (OUT1, OUT2) Maximum Output Current – Continuous	300	mA
	Hold	500	
I <sub>FG</sub>	FG Pin Output Sink Current	20	mA
	FG Pin Output Voltage	-0.3 to 7	V
T <sub>J</sub>	Maximum Junction Temperature	150	°C
T <sub>STG</sub>	Storage Temperature	-65 to 150	°C
T <sub>SOR</sub>	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.

## Thermal Characteristics

Symbol	Parameter	Typical Value	Unit
R <sub>TH,JA</sub>	Thermal Resistance-Junction to Ambient XTDFN 2x1.5-6	138.8	°C/W
P <sub>D</sub>	Power Dissipation, T <sub>A</sub> = 25°C XTDFN 2x1.5-6	900	mW

Note 2: The maximum allowable power dissipation at any T<sub>A</sub> (ambient temperature) is calculated using:  $P_D = (T_J - T_A) / R_{TH,JA}$ ; T<sub>J</sub> = 150°C. Exceeding the maximum allowable power dissipation will result in excessive die temperature.

## Recommended Operating Conditions

Symbol	Parameter	Range	Unit
V <sub>DD</sub>	VDD Supply Voltage	1.8 to 6.2	V
T <sub>A</sub>	Operating Ambient Temperature	-40 to 105	°C
T <sub>J</sub>	Junction Temperature	-40 to 125	°C

## Electrical Characteristics ( $T_A = 25^\circ\text{C}$ , $V_{DD} = 5\text{V}$ , unless otherwise noted)

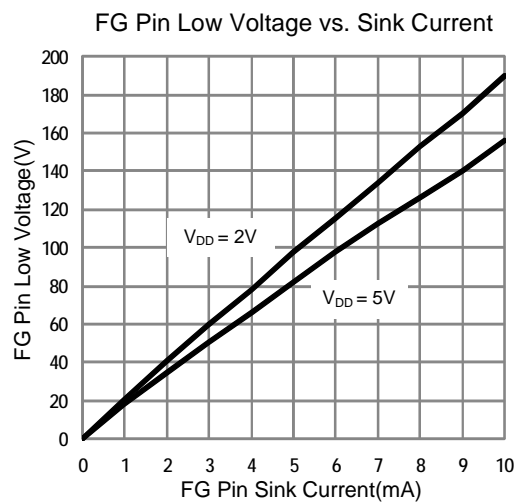
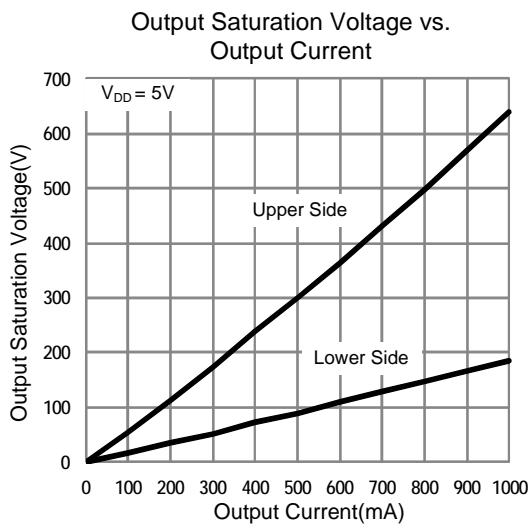
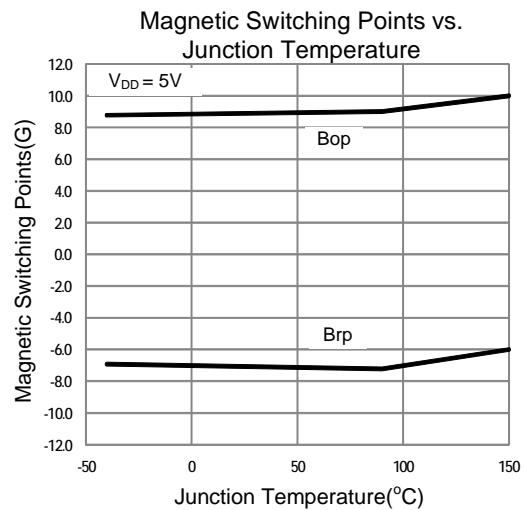
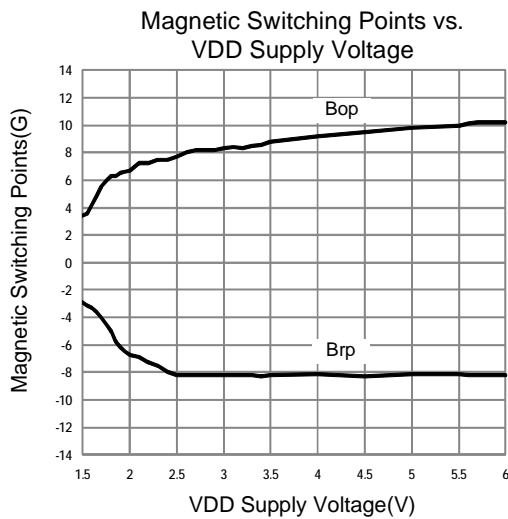
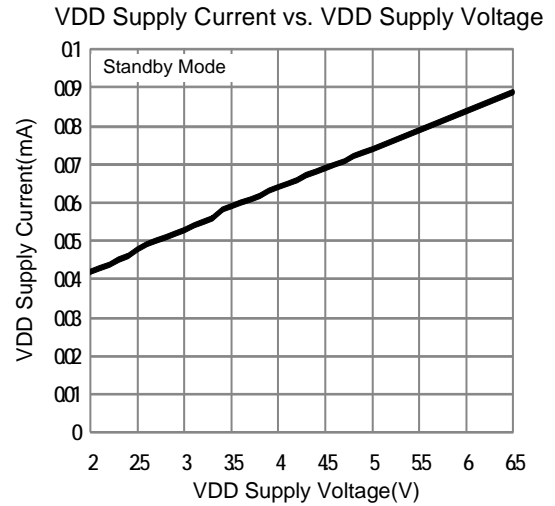
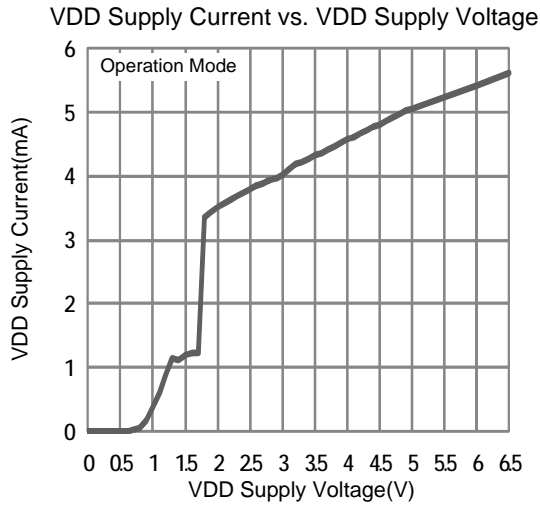
Symbol	Parameter	Test Condition	APX9154			Unit
			Min.	Typ.	Max.	
$I_{DD}$	VDD Supply Current	$V_{DD}=5\text{V}$	-	5	7	mA
$I_{DD1}$	Standby Supply Current	PWM=0	-	75	100	$\mu\text{A}$
$V_O$	Output Driver Saturation Voltage	$I_{OUT}=250\text{mA}$ , Upper and Lower total	-	0.25	0.4	V
$V_{FG}$	FG Pin Low Voltage	$I_{FG} = 5\text{mA}$	-	0.2	0.4	V
$I_{FGL}$	FG Pin Off Leakage Current	$V_{FG} = 5\text{V}$	-	<0.1	1	$\mu\text{A}$
$V_{PWMH}$	Pulse Mode PWM Input High Level Voltage		$0.5 \cdot V_{DD}$	-	$V_{DD} + 0.5$	V
$V_{PWML}$	Pulse Mode PWM Input Low Level Voltage		0	-	$0.2 \cdot V_{DD}$	V
$I_{PWML}$	PWM Pin Low Level Input Current	$V_{PWM} = 0\text{V}$	-	-10	-20	$\mu\text{A}$
$T_{ON}$	Lock Detection On Time		0.35	0.5	0.65	sec
$T_{OFF}$	Lock Detection Off Time		1.75	2.5	3.25	sec
$T_{QS}$	Quick Start Enable Time		-	66.5	90	mA
$F_{PWM}$	PWM Input Frequency		0.2	-	50	kHz
$D_{ST}$	Start Up PWM input Duty		6	-	9	%
OTS	Over Temperature Shutdown Threshold		-	165	-	$^\circ\text{C}$
	Over Temperature Shutdown Hysteresis		-	30	-	$^\circ\text{C}$

## Magnetic Characteristics ( $T_A = 25^\circ\text{C}$ , $V_{DD} = 5\text{V}$ , unless otherwise noted) <sup>Note3</sup>

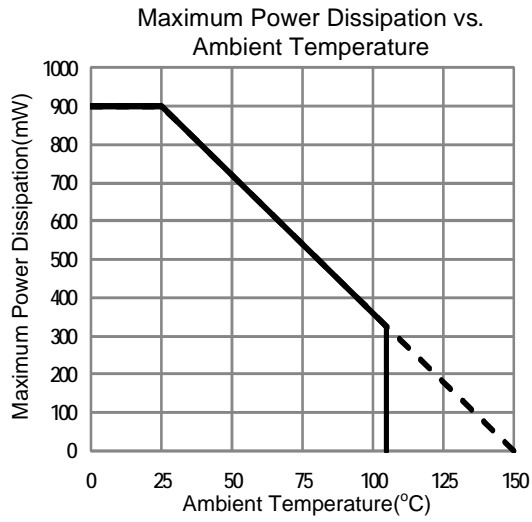
Symbol	Parameter	Test Condition	APX9154			Unit
			Min.	Typ.	Max.	
Bop	Magnetic Operation Point		0	10	20	Gauss
Brp	Magnetic Release Point		-20	-10	0	Gauss
Bhys	Magnetic Hysteresis		-	20	-	Gauss

Note 3 : For start up only.

### Typical Operating Characteristics



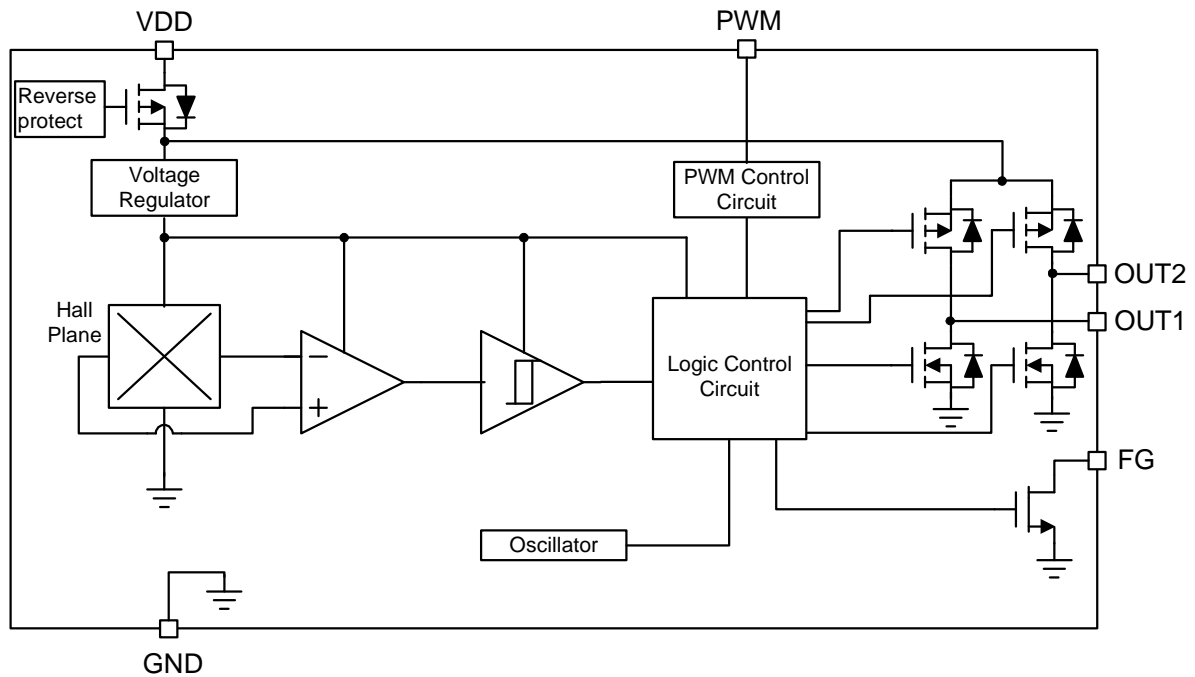
## Typical Operating Characteristics (Cont.)



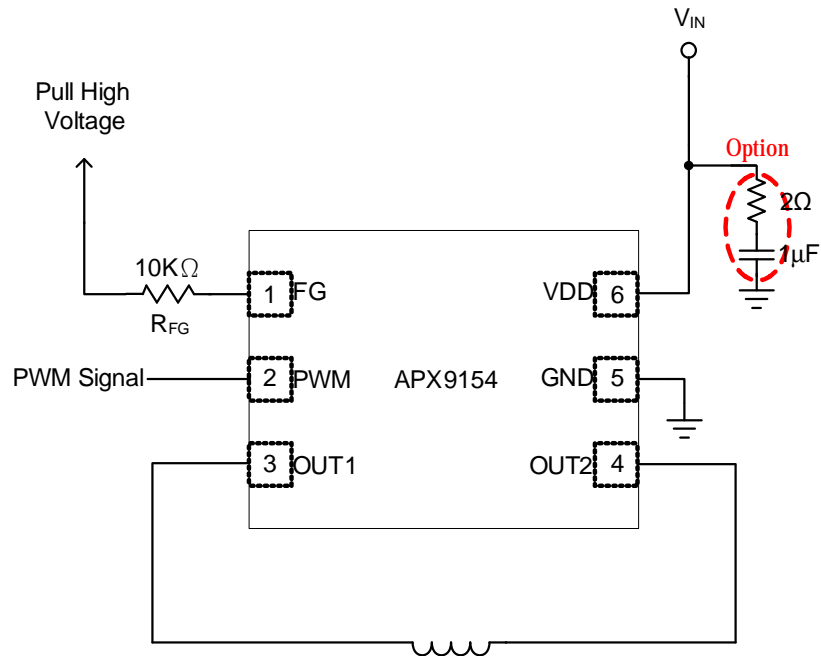
## Pin Descriptions

PIN		Function
NO.	NAME	
1	FG	Rotation Speed Output. This is an open-drain output.
2	PWM	PWM Signal Input Terminal.
3	OUT1	H-bridge output connection. The output stage is a H-bridge formed by four transistors and four-protection diode for switching applications.
4	OUT2	H-bridge output connection. The output stage is a H-bridge formed by four transistors and four-protection diode for switching applications.
5	GND	Ground of the IC.
6	VDD	Supply Voltage Input.

## Block Diagram



## Typical Application Circuit



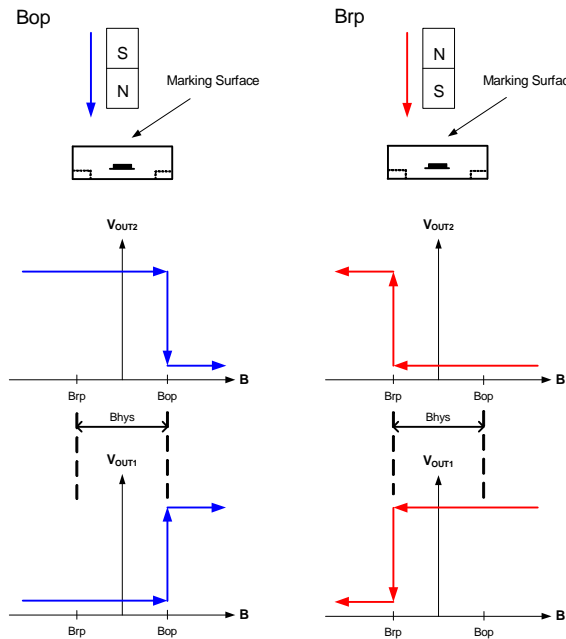
Note : The  $1\mu F$  is option to avoid power noise.

Note1: The  $1\mu F$  and  $2\Omega$  are to avoid IC damage at hot plug ON/OFF moments.

## Function Description

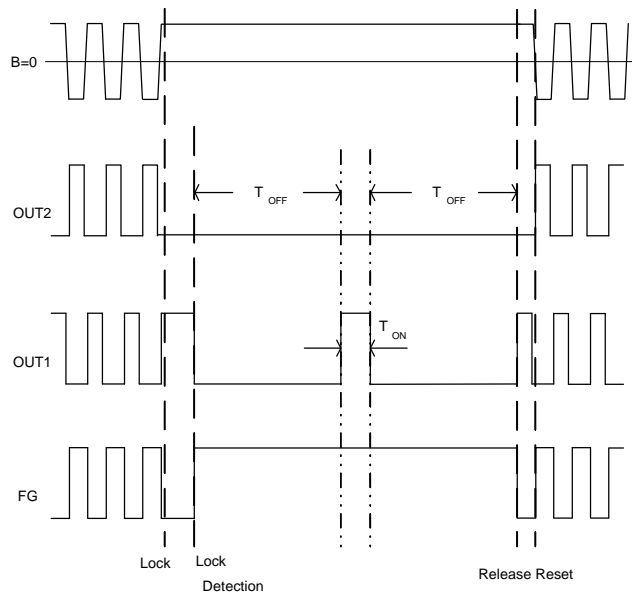
### Output Switch Principle

The APX9154 built in a Hall-effect sensor plane to sense the vertical magnetic flux density (B). There are two output drivers in APX9154 to drive single-phase DC brushless motor. When the N pole magnetic field close to the IC marking surface and the magnetic flux density higher than operate point (Bop), the OUT1 pin output will turn to HIGH and the OUT2 pin output will turn to LOW. When the N pole magnetic field far away the IC marking surface and S pole magnetic field close to the IC marking surface until the magnetic flux density higher than release point (Brp), the OUT1 pin output will turn LOW and the OUT2 pin output will turn HIGH.



### Lockup Protection and Automatic Restart

The APX9154 detects the rotation of the motor by internal hall sensor signal, and adjusts lock detection ON time ( $T_{ON}$ ) and lock detection OFF time ( $T_{OFF}$ ) by internal counter.



### Speed Control by Direct PWM Input Signal

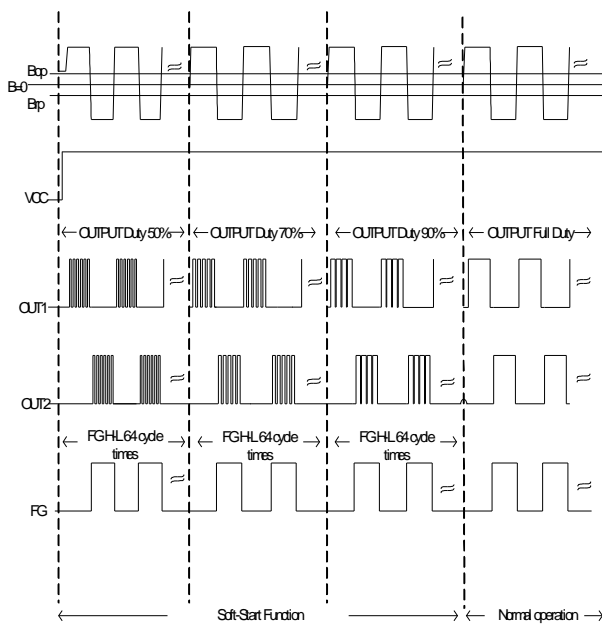
Applying PWM pulses to the PWM pin directly, the duty cycle of PWM pulses will control the output driver ON duty directly. In PWM control, the high level of pulse signal should be higher than  $0.5 \cdot V_{DD}$  and the low level should be lower than  $0.2 \cdot V_{DD}$ . When the PWM pin is floating, the output driver of APX9154 will be full duty to drive the motor.



## Function Description(Cont.)

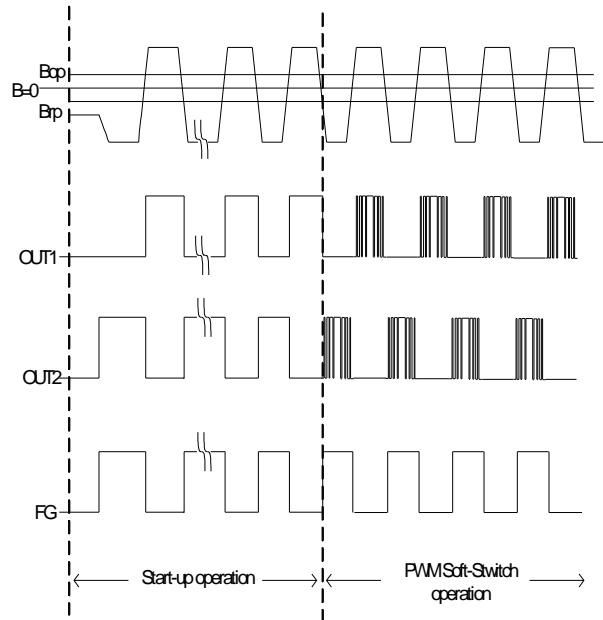
### Soft-Starf Function

The APX9154 provides the soft-start function to reduce vibration at power-on and lock-restart moments. The soft-start function has four stages 50% → 70% → 90% → 100%. At first the output duty is 50% after 64 FG H-L cycle times the output duty is change to next stage 70% until 192 FG H-L cycle times the soft-start function will end. If the voltage higher than 3.2V or Direct PWM Duty higher than 50% soft-start function is enable,else the soft-start function is disable.



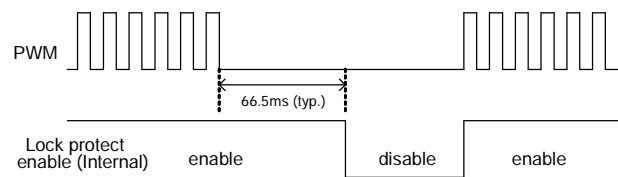
### PWM Soft-Switch Function

The APX9154 built in PWM soft-switch output control circuit to improve the vibration and noise of fan motor operation. At start-up operation, the APX9154 drive the output driver by square wave to force the fan motor start to rotate. After several square wave outputs , the internal PWM soft-switch control circuit will be enable to drive fan motor to improve vibration and noise.



### Quick Start and StandbyMode

This IC would enter standby mode when the PWM input keeps low level for then 66.5m(typ.). In standby mode, it will shutdown amplifier and FG. In standby mode, the lock protection function doesn't work, therefore, starting fan is unobstructed when releasing standby mode.



### Thermal Function

The APX9154 is designed with a thermal protection to protect the IC from the damage of over temperature. 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 overload.

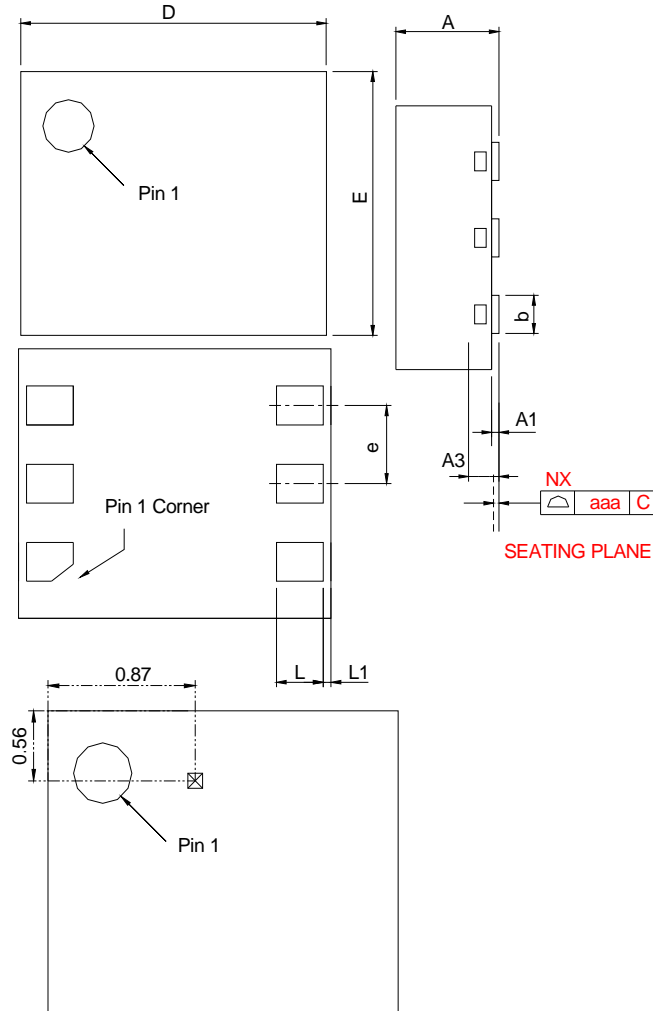
## Application Information

### Input Capacitor

The IC in order to noise reduction purpose, a capacitor (1 $\mu$ F) must connect between VDD and GND. It is the suggestion that 1 $\mu$ F should be placed as close as possible to the device VDD pin.

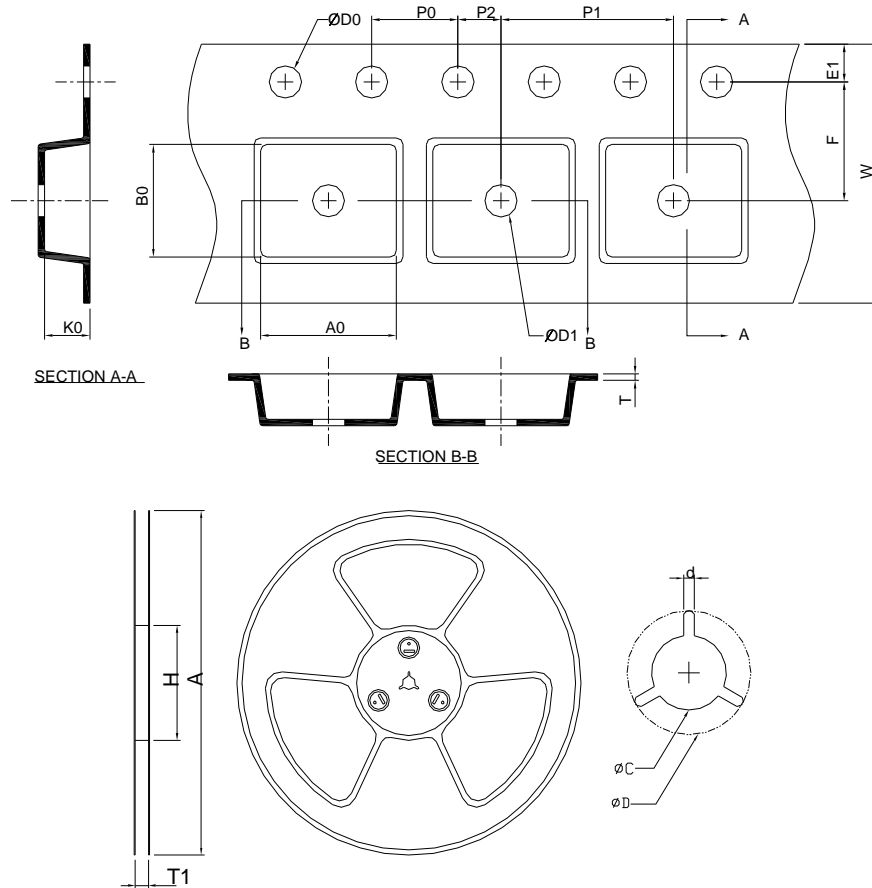
## Package Information

XTDFN 2x1.5-6



SYMBOL	XTDFN2*1.5-6			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.30	0.40	0.012	0.016
A1	0.00	0.05	0.000	0.002
A3	0.102 REF		0.004 REF	
b	0.20	0.30	0.008	0.012
D	1.90	2.10	0.075	0.083
E	1.40	1.60	0.055	0.063
e	0.50 BSC		0.020 BSC	
L	0.25	0.35	0.010	0.014
L1	0.075REF.		0.003REF.	
aaa	0.08		0.003	

Carrier Tape & Reel Dimensions



Application	A	H	T1	C	d	D	W	E1	F
XTDFN(2x1.5)	178.0±2.00	50 MIN.	8.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	8.0±0.20	1.75±0.10	3.5±0.05
	P0	P1	P2	D0	D1	T	A0	B0	K0
	4.0±0.10	4.0±0.10	2.0±0.05	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	1.70±0.10	2.20±0.10	0.56±0.05

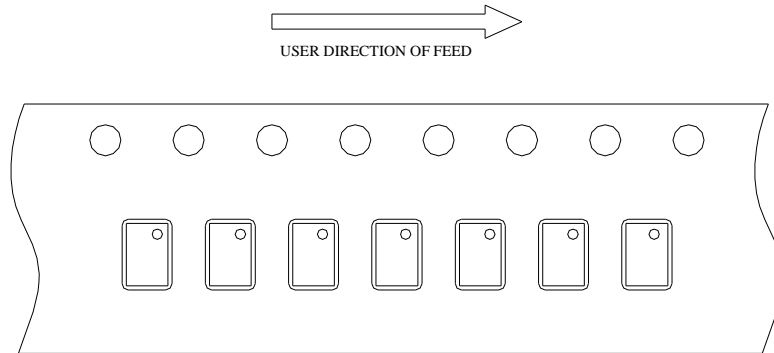
(mm)

Devices Per Unit

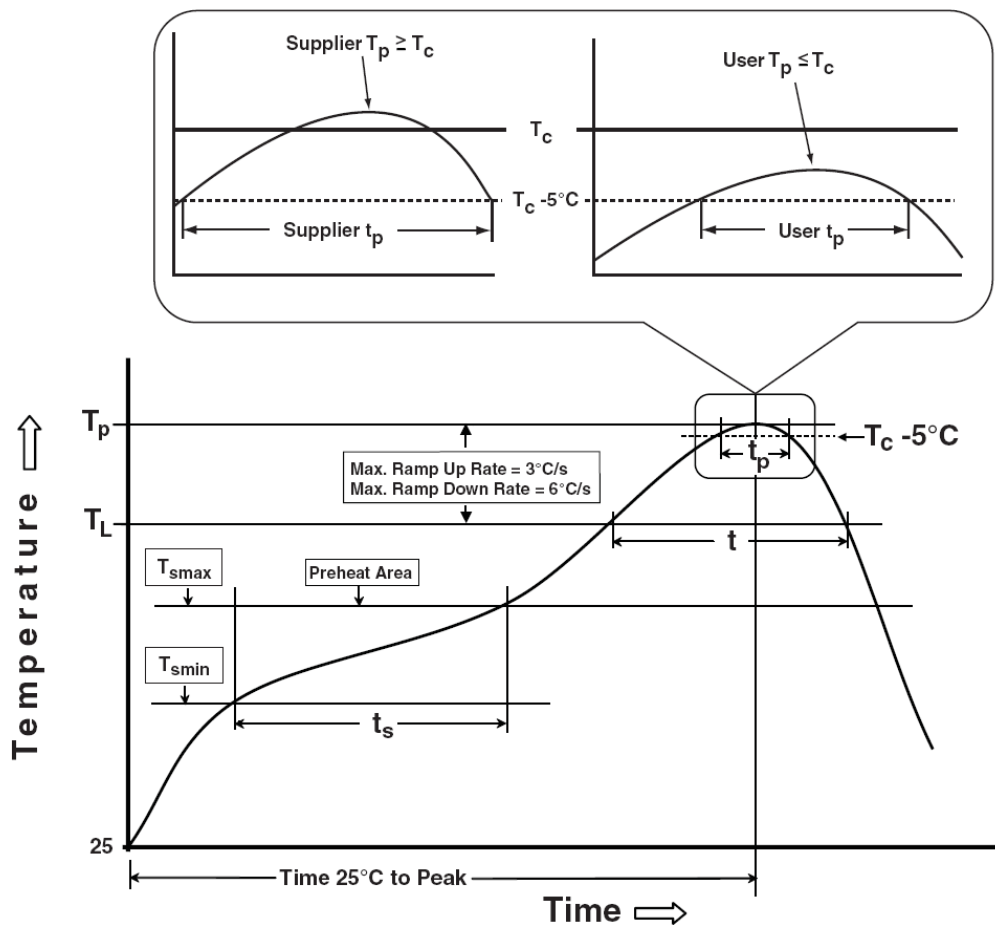
Package Type	Unit	Quantity
XTDFN(2x1.5)	Tape & Reel	3000

### Taping Direction Information

XTDFN2x1.5



### Classification Profile



### Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
<b>Preheat &amp; Soak</b>		
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.		

Table 1. SnPb Eutectic Process – Classification Temperatures ( $T_c$ )

Package Thickness	Volume mm <sup>3</sup> <350	Volume mm <sup>3</sup> ≥350
<2.5 mm	235 °C	220 °C
≥2.5 mm	220 °C	220 °C

Table 2. Pb-free Process – Classification Temperatures ( $T_c$ )

Package Thickness	Volume mm <sup>3</sup> <350	Volume mm <sup>3</sup> 350-2000	Volume mm <sup>3</sup> >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 @ $T_j=125^\circ\text{C}$
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, $1_{tr} \geq 100\text{mA}$

## Customer Service

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