

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 : $\pm 10\text{G}$
- Built-in Lock Protection and Auto Restart Function
- Force Start Drive by Full Duty
- 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)

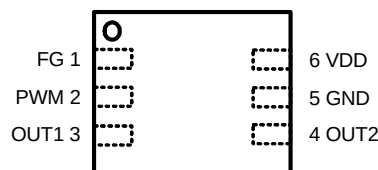
Applications

- Brushless DC Fans
- Brushless DC Motors

General Description

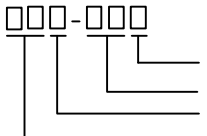
The APX9154C is an integrated Hall Effect Sensor IC designed for electric commutation of single-phase DC brushless motor applications. The device is built-in lock protection. When fan is locked, the device will enter the lock protection mode. It is also with thermal shutdown function. The APX9154C is available in a low cost XTDFN 2x1.5-6 package.

Pin Configuration



XTDFN 2x1.5-6
(Top View)

Ordering and Marking Information

APX9154C 	Package Code QH : XTDFN 2x1.5-6 Operating Ambient Temperature Range I : -40 to 105 °C Handling Code TR : Tape & Reel Assembly Material G : Halogen and Lead Free Device
APX9154C QH : 	The last X is referred as 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.

Absolute Maximum Ratings

Symbol	Parameter	Rating	Unit
V _{DD}	VDD Pin Supply Voltage (VDD to GND)	-0.3 to 7	V
V _{OUT}	Output Pin (OUT1, OUT2) Output Voltage	-0.3 to 7	V
I _{OUT}	Output Pin (OUT1, OUT2) Maximum Output Current – Continuous Hold	500 1000	mA
I _{FG}	FG Pin Output Sink Current	20	mA
	FG Pin Output Voltage	-0.3 to 7	V
T _J	Maximum Junction Temperature	150	°C
T _{STG}	Storage Temperature	-65 to 150	°C
T _{SOR}	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 _{TH,JA}	Thermal Resistance-Junction to Ambient XTDFN 2x1.5-6	138.8	°C/W
P _D	Power Dissipation, T _A = 25°C XTDFN 2x1.5-6	900	mW

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

Recommended Operating Conditions

Symbol	Parameter	Range	Unit
V _{DD}	VDD Supply Voltage	1.7 to 6	V
T _A	Operating Ambient Temperature	-40 to 105	°C
T _J	Junction Temperature	-40 to 125	°C

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

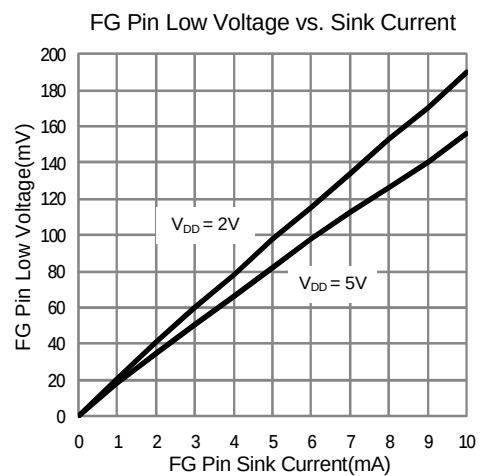
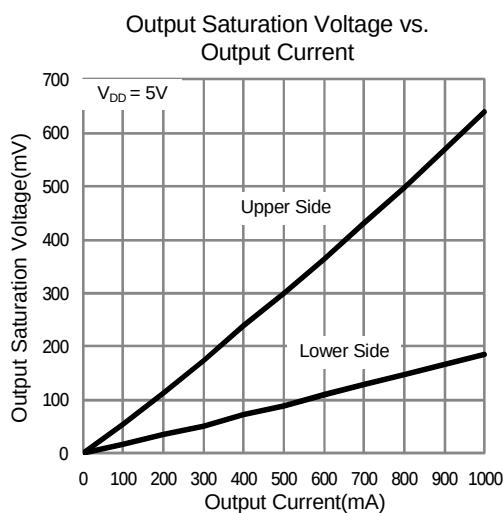
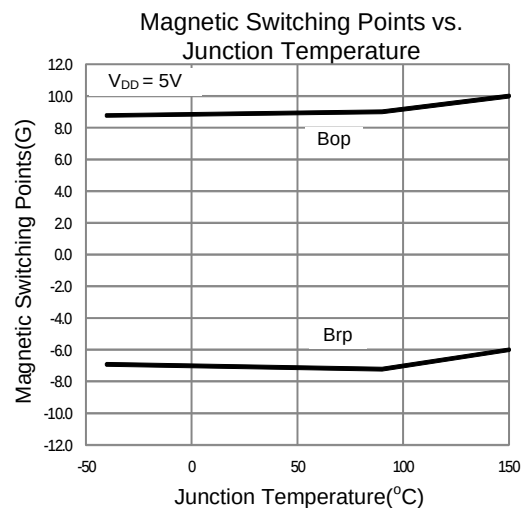
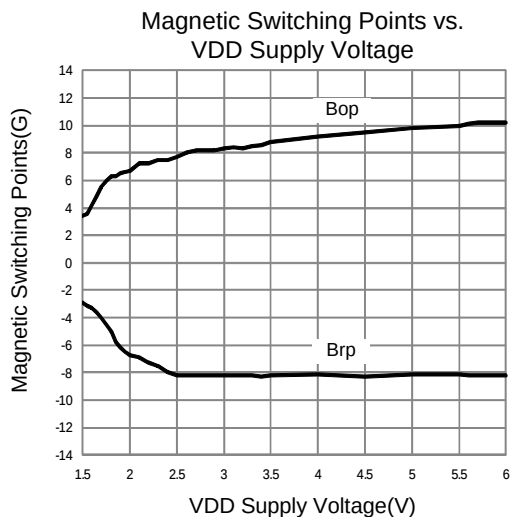
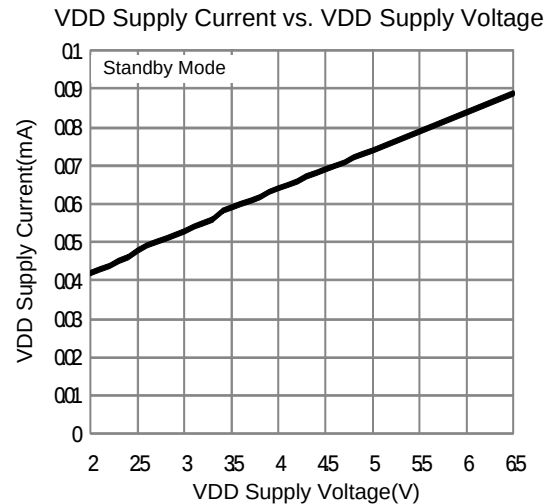
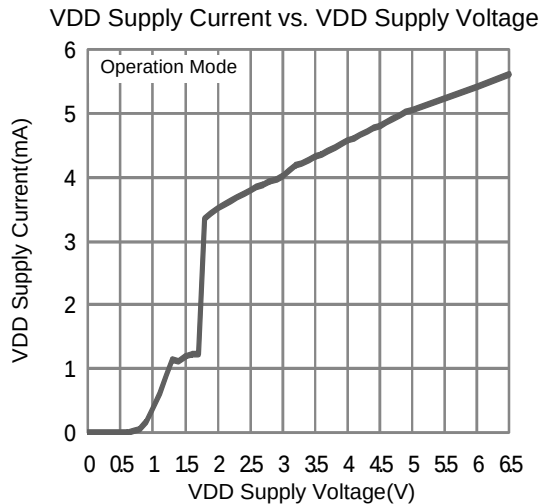
Symbol	Parameter	Test Condition	APX9154			Unit
			Min.	Typ.	Max.	
I _{DD}	VDD Supply Current	V _{DD} =5V	-	5	7	mA
I _{DD1}	Standby Supply Current	PWM=0	-	75	100	μA
V _O	Output Driver Saturation Voltage	I _{OUT} =250mA, Upper and Lower total	-	0.25	0.4	V
V _{FG}	FG Pin Low Voltage	I _{FG} =5mA	-	0.2	0.4	V
I _{FGL}	FG Pin Off Leakage Current	V _{FG} =5V	-	<0.1	1	μA
V _{PWMH}	Pulse Mode PWM Input High Level Voltage		0.5*V _{DD}	-	V _{DD} +0.5	V
V _{PWML}	Pulse Mode PWM Input Low Level Voltage		0	-	0.2*V _{DD}	V
I _{PWML}	PWM Pin Low Level Input Current	V _{PWM} = 0V	-	-10	-20	μA
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	ms
F _{PWM}	PWM Input Frequency		0.2	-	50	kHz
F _{OUT}	Output Switch Frequency		20	30	40	kHz
D _{ST}	Start Up PWM input Duty		6	-	9	%
OTS	Over Temperature Shutdown Threshold		-	165	-	°C
	Over Temperature Shutdown Hysteresis		-	30	-	°C

Magnetic Characteristics (T_A = 25°C, V_{DD} = 5V, unless otherwise noted) ^{Note3}

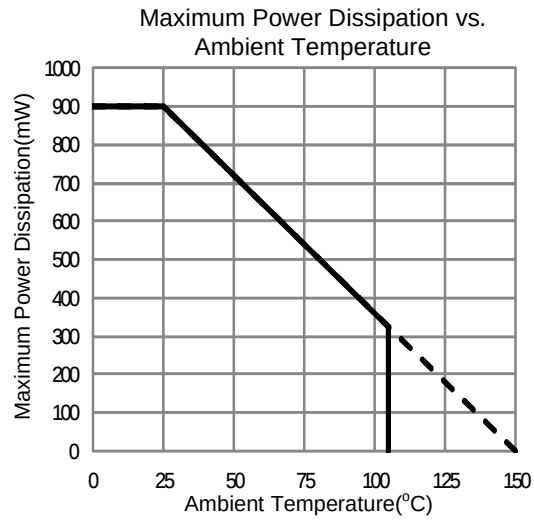
Symbol	Parameter	Test Condition	APX9154C			Unit
			Min.	Typ.	Max.	
B _{op}	Magnetic Operation Point		0	10	20	Gauss
B _{rp}	Magnetic Release Point		-20	-10	0	Gauss
B _{hys}	Magnetic Hysteresis		-	20	-	Gauss

Note 3 : For start up only.

Typical Operating Characteristics



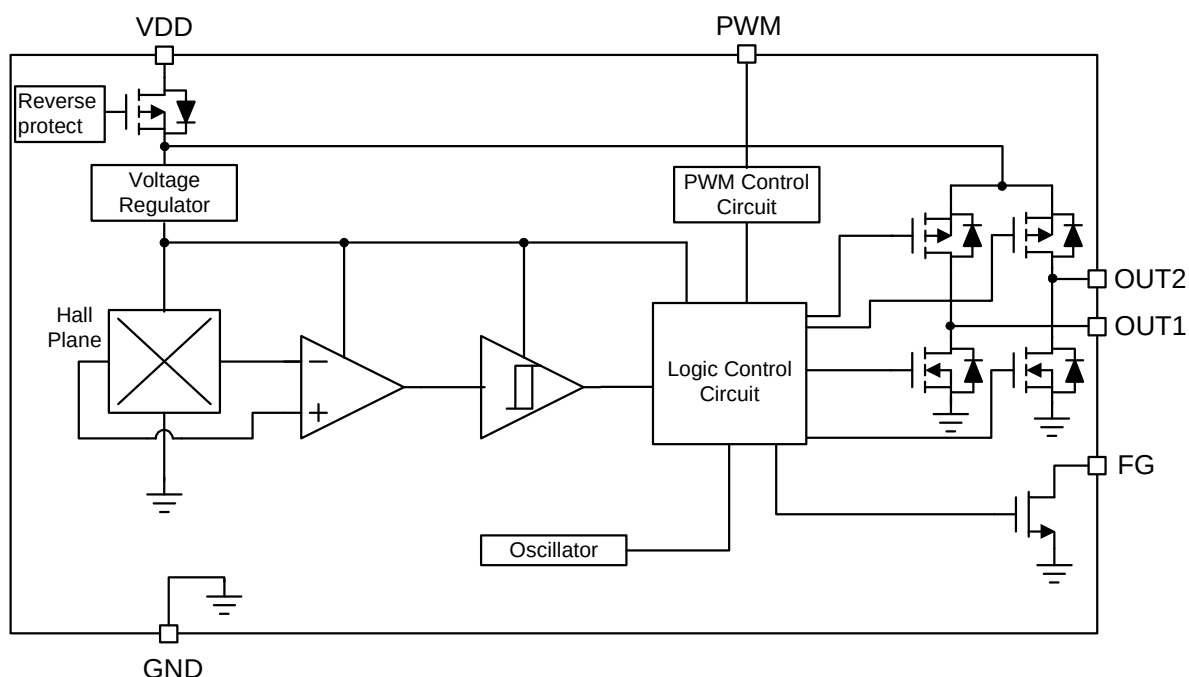
Typical Operating Characteristics (Cont.)



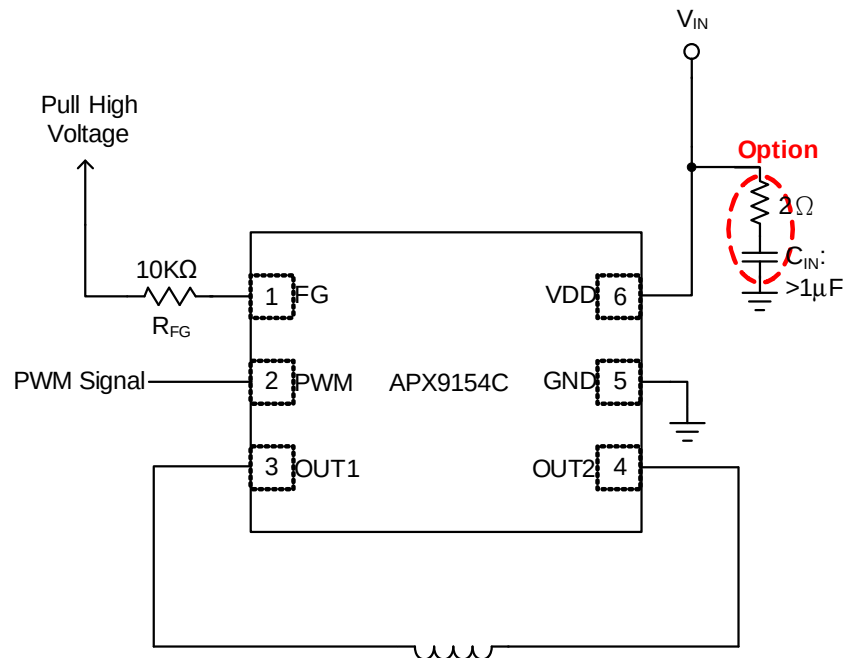
Pin Descriptions

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 C_{IN} is option to avoid power noise.

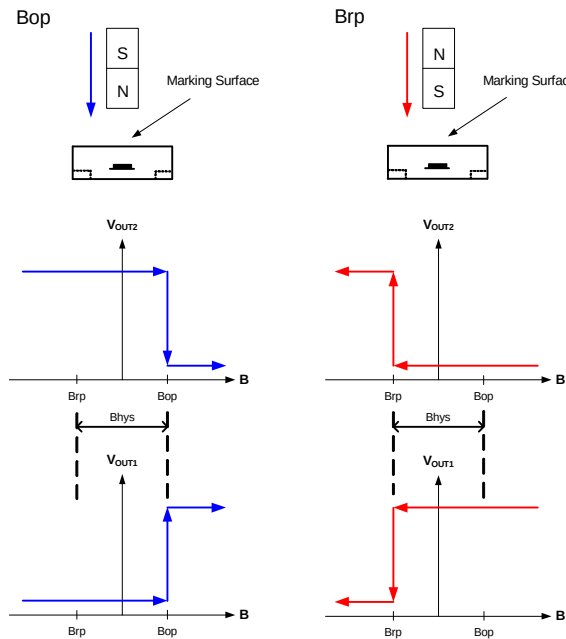
Note1:The 2Ω is option to avoid inrush current at power ON moments.

Note2:The R and C_{IN} are must consider IC recommended operating conditions.

Function Description

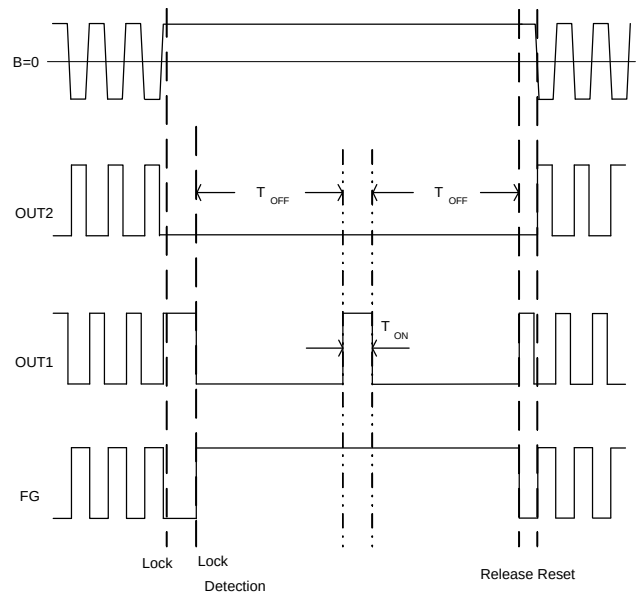
Output Switch Principle

The APX9154C built in a Hall-effect sensor plane to sense the vertical magnetic flux density (B). There are two output drivers in APX9154C 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 APX9154C 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.



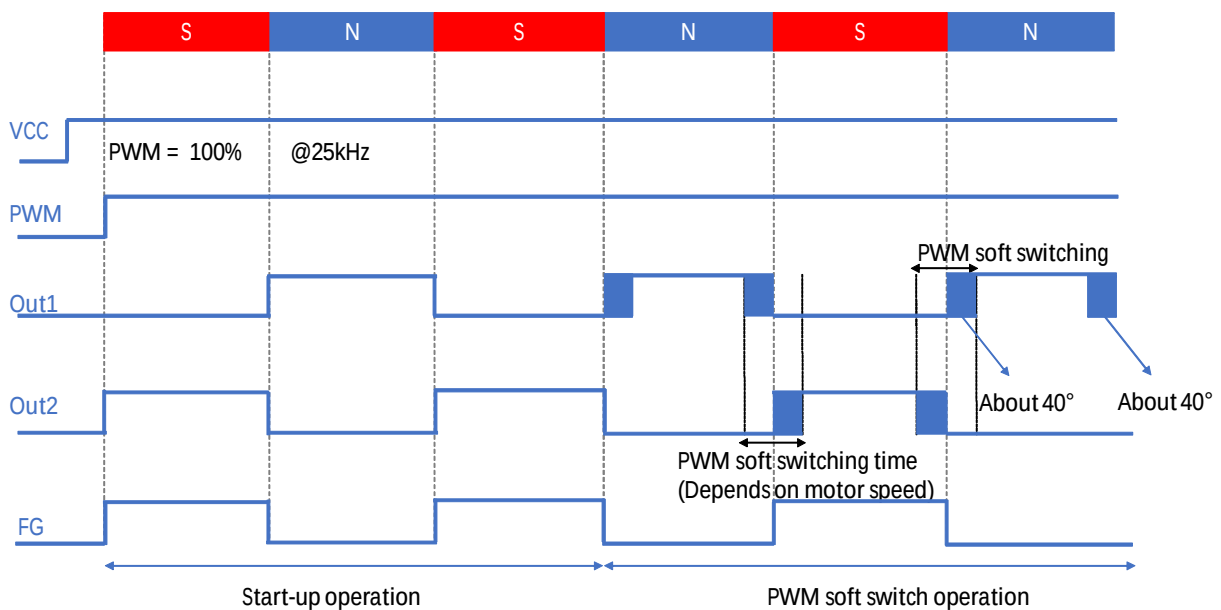
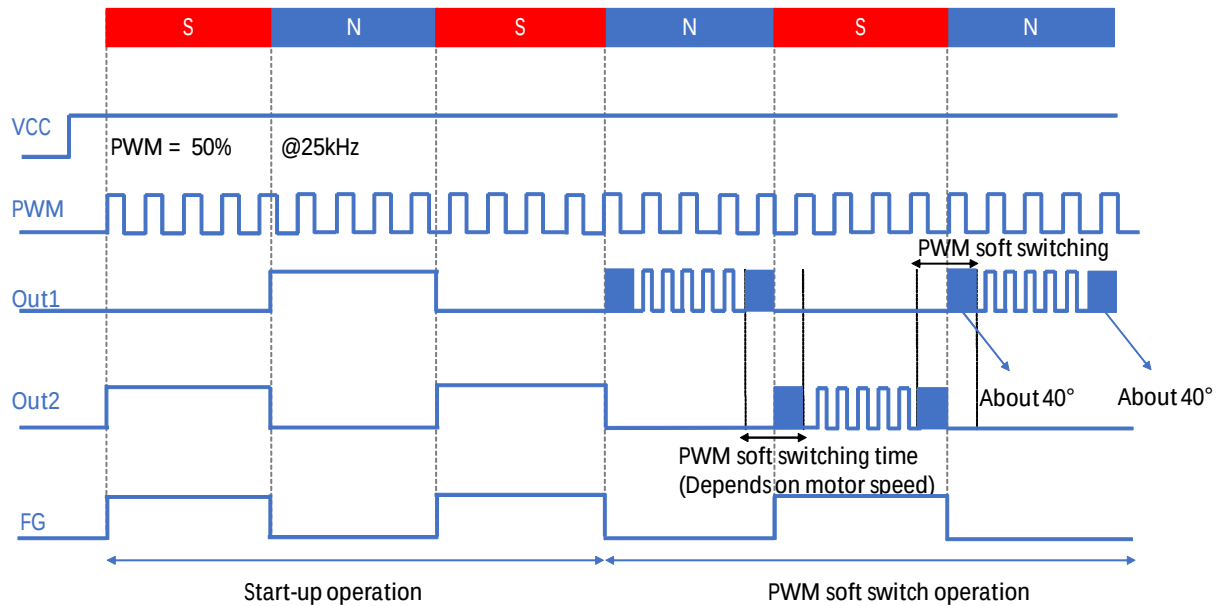
Speed Control by Direct PWM Input Signal

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 APX9154C will be full duty to drive the motor.

Function Description(Cont.)

PWM Soft-Switch Function

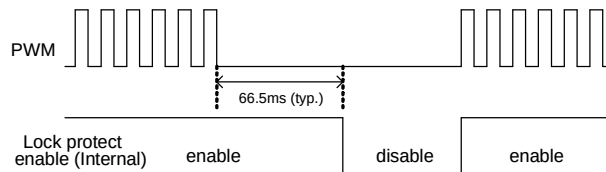
The APX9154C built in PWM soft-switch output control circuit to improve the vibration and noise of fan motor operation. At start-up operation, the APX9154C drive the output driver by full duty square wave to force the fan motor start to rotate. After several full duty square wave outputs, the internal PWM soft-switch control circuit will be enable and the output duty drive by target duty.



Function Description(Cont.)

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

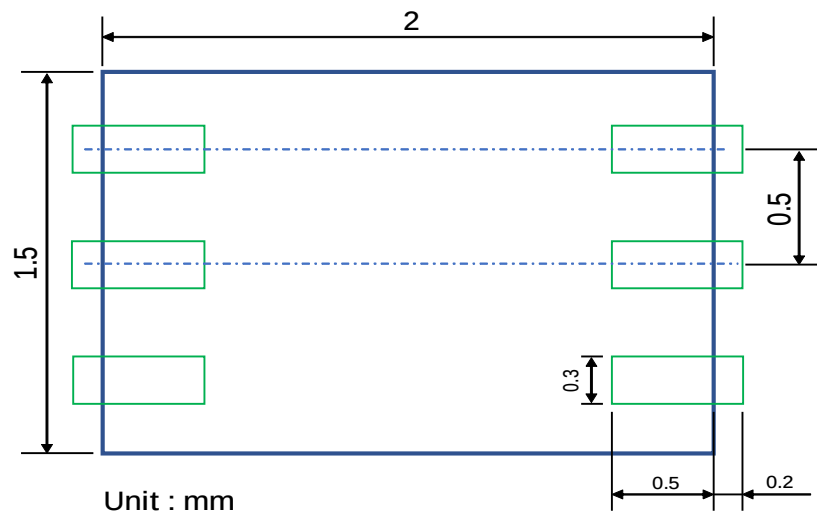
The APX9154C is designed with a thermal protection to protect the IC from the damage of over temperature. When internal junction temperature reaches 165°C, the output devices will be switched off. When the IC's junction temperature cools by 30°C, the thermal sensor will turn the output devices on again resulting in a pulsed Output during continuous thermal overload.

Truth Table

Input		Output			Mode
B	PWM	OUT1	OUT2	FG	
Bop	H	H	L	L	Operation Mode
Brp		L	H	OFF	
Bop	L	L	L	L	
Brp		L	L	OFF	
Bop	-	L	L	OFF	Lock Mode
Brp		L	L	OFF	
-	L	OFF	OFF	OFF	Standby Mode

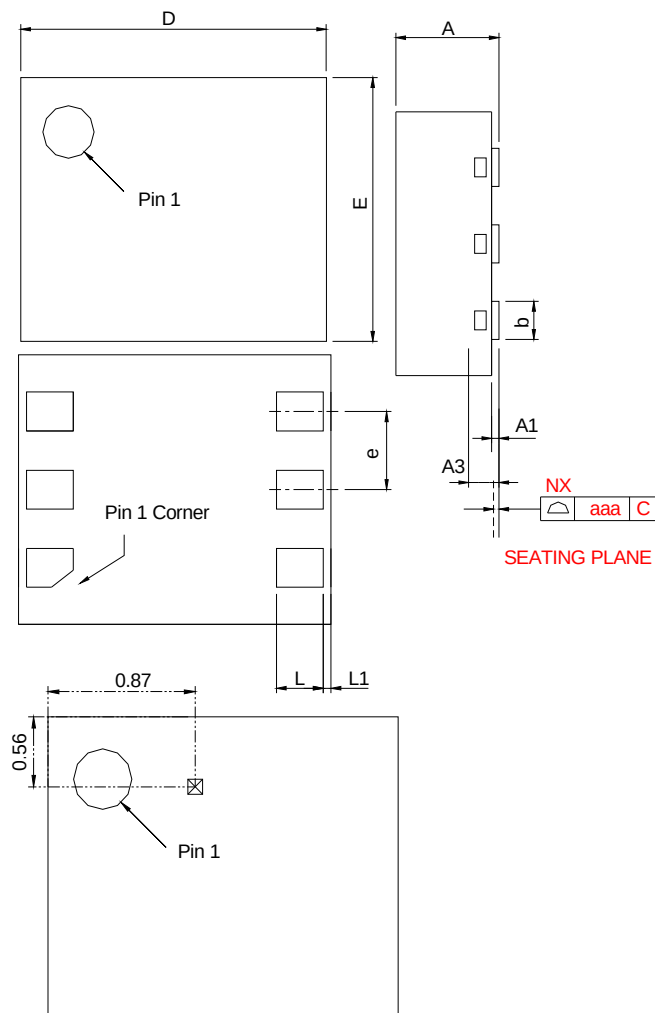
Recommended Minimum Footprint

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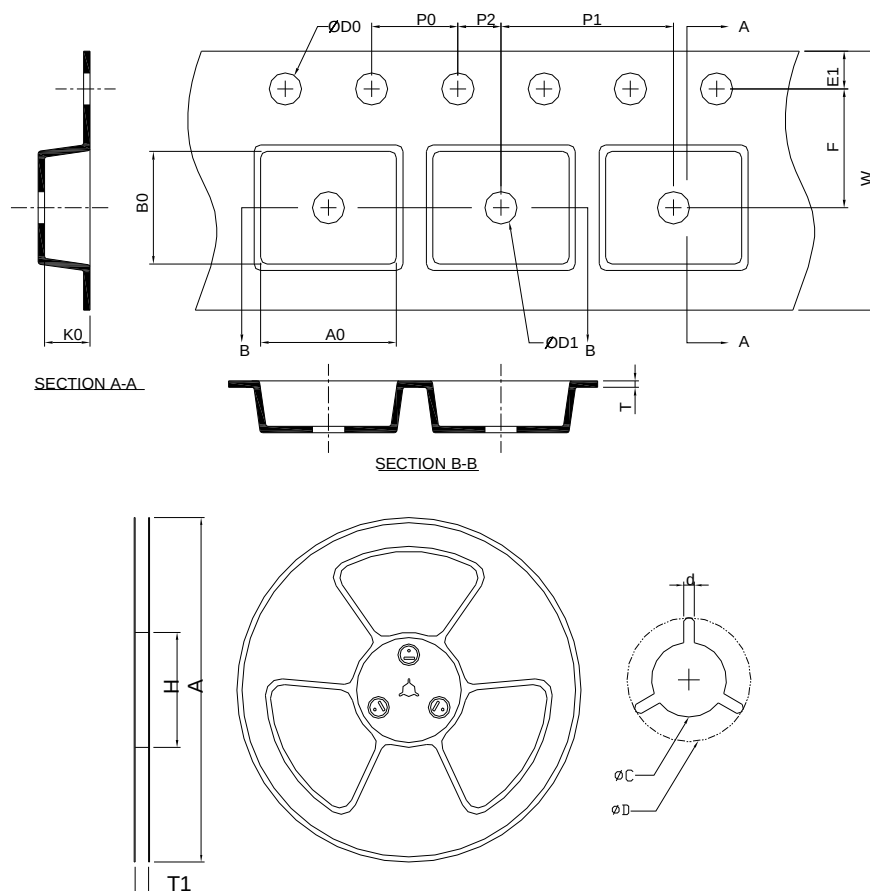
Package Information

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

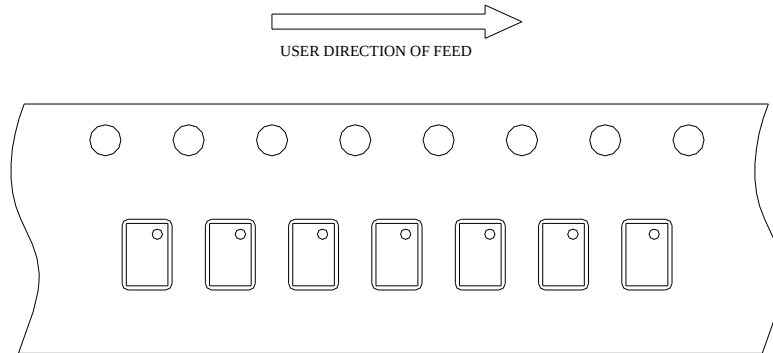
(mm)

Devices Per Unit

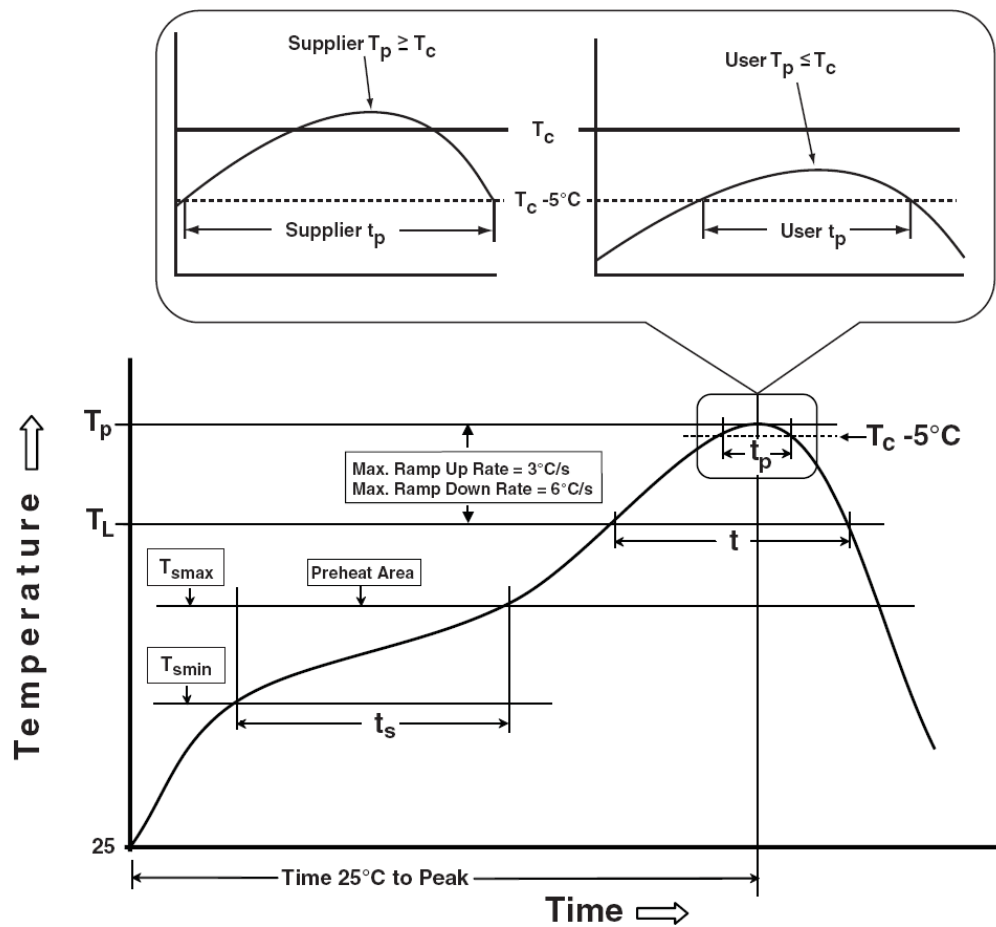
Package Type	Unit	Quantity
XTDFN(2x1.5)	Tape & Reel	3000

Taping Direction Information

XTDFN2x1.5



Classification Profile



Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
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.		

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

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 (T_c)

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 @ $T_j=125^{\circ}\text{C}$
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, $I_{tr} \geq 100\text{mA}$

Customer Service

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