Three-Phase Sine-Wave Brushless DC Motor Controller

Features

- **Three-Phase Brushless Motor Controller**
- **Sine-Wave PWM Control**
- **Support hall element & hall IC**
- **Built-in Triangular-Wave Generator**
- **Built-in Lead Angle Control Function(0° to 58°)**
- **Built-in Dead Time Function**
- **Built-In Regulator**
- **Built-in Variable Speed Function**
- **Built-in Current Limit Circuit**
- **Built-in Lock Protection and Auto Restart Function**
- **Built-in FG & 3FG output signal selection**
- **Lead Free and Green Devices Available (RoHS Compliant)**

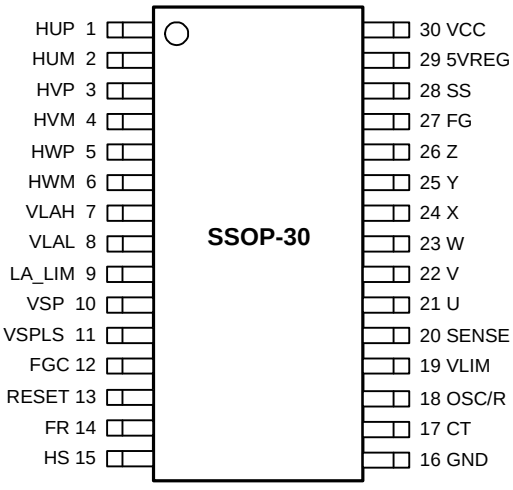
General Description

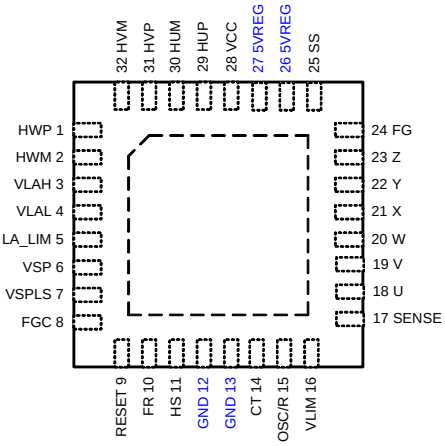
The APX7311 is a three-phase sine-wave DC brushless motor driver with PWM variable speed control, current limit protection and lead angle control features suitable for the motor of air conditioners, household energy saving fans and pumps. This sine-wave motor drive product uses the hall sensor signals, and the control system is able to execute the PWM commutation by switching the three-phase inverter. This function can improve efficiency and reduce noises in fan motors. It also has rotation speed detection output. The APX7311 is available in SSOP-30 and TQFN4X4-32B packages (see Pin Configuration).

Applications

- **Three Phase Brushless DC Motor Control**
- **Low Vibration Motor Applications**
- **Energy Saving Fan**

Pin Configuration





TQFN4X4-32B
(Top View)

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

Pin12 and Pin13 must be short for GND.
Pin26 and Pin27 must be short for 5VREG.

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.

Ordering and Marking Information

APX7311 □□□-□□□ Assembly Material Handling Code Temperature Range Package Code	Package Code NL : SSOP-30 QB : TQFN4X4-32B Operating Ambient Temperature Range I : -40 to 110 °C Handling Code TR : Tape & Reel Assembly Material G : Halogen and Lead Free Device
APX7311 NL : 	XXXXX - Date Code
APX7311 QB : 	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).

Absolute Maximum Ratings (Note1)

Symbol	Parameter	Ratings	Unit
V_{CC}	VCC Pin Supply Voltage (VCC to GND)	-0.3 to 18	V
$I_{U,V,W}$	$OUT_{U,V,W}$ Pin Maximum Output Current	20	mA
$V_{X,Y,Z,U,V,W}$	$OUT_{X,Y,Z,U,V,W}$ Pin Output Voltage	-0.3 to 5VREG	V
V_{VSP}	VSP Pin Input Voltage (VSP to GND)	-0.3 to 18	V
$V_{VLAH,VLAL,LA\_LIM}$	VLAH,VLAL,LA_LIM Pin Input Voltage	-0.3 to 7	V
V_{RESET}	RESET Pin Input Voltage (RESET to GND)	-0.3 to 7	V
V_{FGC}	FGC Pin Input Voltage (FGC to GND)	-0.3 to 7	V
$V_{FR,HS}$	FR,HS Pin Input Voltage (FR,HS to GND)	-0.3 to 7	V
$V_{SENSE,VLIM}$	SENSE,VLIM Pin Input Voltage (SENSE,VLIM to GND)	-0.3 to 7	V
$V_{HUP,HUM}$	HUP,HUM Pin Input Voltage	-0.3 to 7	V
$V_{HVP,HVM}$	HVP,HVM Pin Input Voltage	-0.3 to 7	V
$V_{HWP,HWM}$	HWP,HWM Pin Input Voltage	-0.3 to 7	V
V_{FG}	FG Pin Output Voltage	-0.3 to 5VREG	V
I_{FG}	FG Pin Maximum Output Sink Current	10	mA
I_{5VREG}	5VREG Pin Output Source Current	20	mA
T_J	Maximum Junction Temperature	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
$R_{TH,JA}$	Thermal Resistance-Junction to Ambient (Note 2) SSOP-30	119	°C/W
P_D	Power Dissipation, T_A=25°C	1.05	W

Note2: Mounted on a board (60x38x1.6t mm, Glass epoxy).

Recommended Operation Conditions (Note3)

Symbol	Parameter	Range	Unit
V_{CC}	VCC Pin Supply Voltage Range	6 to 15	V
V_{VSP}	VSP Pin Supply Voltage Range	-0.3 to 10	V
T_A	Ambient Temperature	-40 to 110	°C
T_J	Junction Temperature	-40 to 125	°C

Note3: Refer to the typical application circuit.

Electrical Characteristics (V_{CC} = 12V, T_A = 25°C, unless otherwise specified)

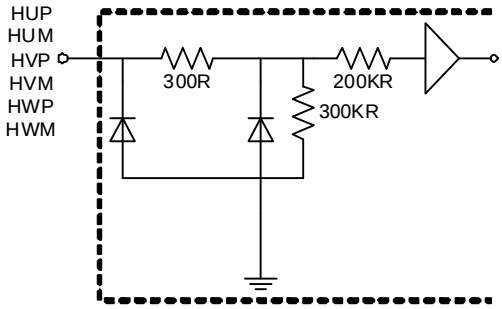
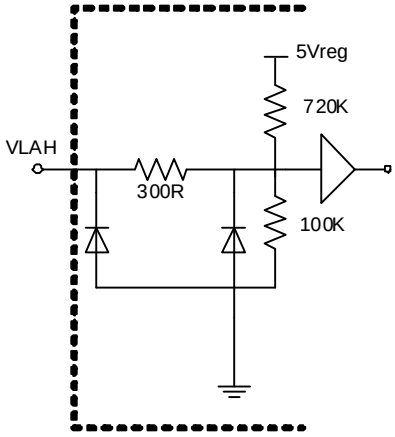
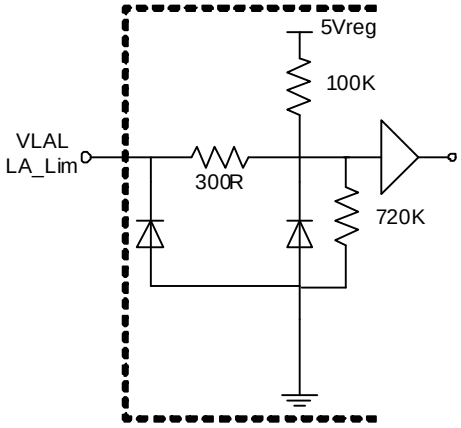
Symbol	Parameter	Test Conditions	APX7311			Unit
			Min	Typ	Max	
SUPPLY CURRENT						
V_{5VREG}	5VREG Pin Output Voltage	I_{5VREG} = 5mA	4.75	5	5.25	V
I_{CC}	Operating Current	Rotation Mode	-	5	8	mA
V_{CCH}	Output Start Operation Point		3.2	3.5	3.8	V
V_{CCL}	No Output Operation Point		2.7	3	3.3	
INPUT						
I_{VSP}	VSP Pin Input Current	VSP=5V	-	40	80	μA
V_{VSP}	Standby mode -> Motor Start up	VSPLS = High	0.7	1	1.3	V
	Standby mode -> Motor Start up	VSPLS = Low	0.4	0.6	0.8	
	Drive mode PWM Duty 92%		4.5	4.8	5.1	
	Drive mode ->Test mode		7.2	8	8.8	
I_{in1}	HS、FR、FGC、VSPLS Pin Input Current	V_{in} = 0 V HS、FR、FGC、VSPLS	-120	-60	-	μA
V_{in}	Input Voltage – High (Digital voltage)	HS、FR、FGC、VSPLS	V_{5VREG} -1	-	V_{5VREG}	V
	Input Voltage – Low (Digital voltage)	HS、FR、FGC、VSPLS	-	-	0.8	
I_{RESET}	Charge Current	V_{RESET} = 0 V	-2	-1	-	μA
V_{RESETH}	RESET Pin High Level Voltage		1.6	1.8	2	V

Electrical Characteristics (V_{CC} = 12V, T_A = 25°C, unless otherwise specified)

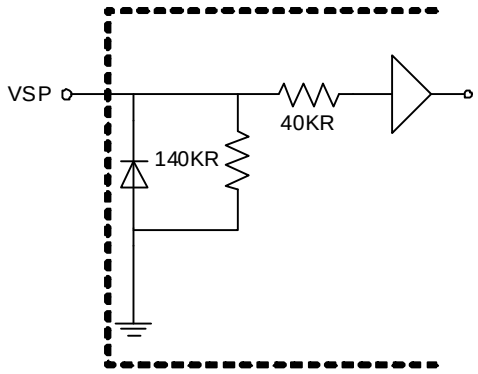
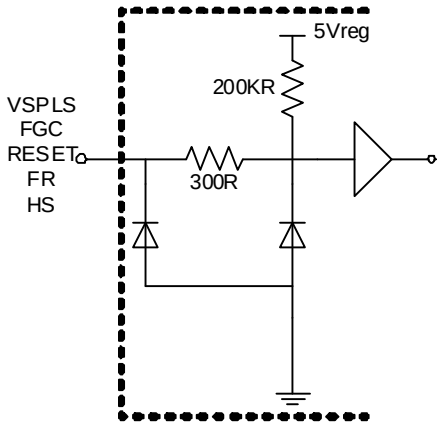
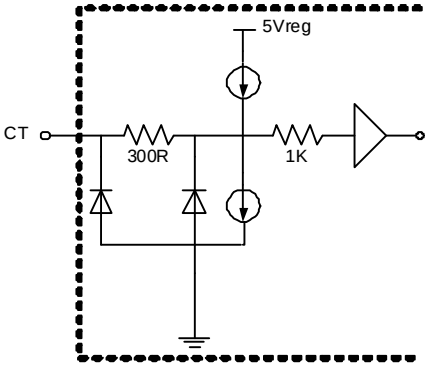
Symbol	Parameter	Test Conditions	APX7311			Unit
			Min	Typ	Max	
Output DRIVERS						
V_{OUT}	Output Voltage - High	I_{OUT} = -2 mA U、V、W、X、Y、Z	V_{5VREG} - 0.78	V_{5VREG} - 0.4	-	V
	Output Voltage - Low	I_{OUT} = 2 mA U、V、W、X、Y、Z	-	0.4	0.78	
V_{FG}	FG Voltage - High	I_{OUT} = -1 mA	V_{5VREG} - 1	V_{5VREG} - 0.5	-	
	FG Voltage - Low	I_{OUT} = 1 mA	-	0.5	1	
I_{OL}	Output Pin Leakage Current - High	V_{OUT} = 0 V	-	0	10	µA
	Output Pin Leakage Current - Low	V_{OUT} = 3.5 V	-	0	10	
T_{OFF}	Output Off Time	TD input level and dead time	1.6	2	2.4	µs
CORRECTION						
T_{LA1}	Lead Angle Correction (VSP=4.8V)	VLA_LIM = 0 V,VLAH=5V,VLAL=0	-	0	-	°
T_{LA2}		VLA_LIM = 2.5 V, VLAH=5V,VLAL=0	26	30	32.5	
T_{LA3}		VLA_LIM = 5 V, VLAH=5V,VLAL=0	56	58	61.5	
PROTECTION						
V_{SENSE}	Internal Current Limit	VLIM=0.5V	0.46	0.5	0.54	V
HALL SENSITIVITY						
V_{HN}	Input hysteresis	Zero to peak including offset and hysteresis	-	10	-	mV
V_S	Input sensitivity	Differential inputs	100		-	mV_{PP}
V_W	Commom-mode input volage		1.5		3.5	V
OSC/R OSCILLATOR						
F_{PWM}	PWM Frequency	OSC/R=120KΩ	16.2	18	19.8	kHz
$T_{ON(MAX)}$	Maximum conduction duty	OSC/R=120KΩ,V_{SP}=4.8V	89	92	95	%
LOCK PROTECTION						
V_{CTH}	CT Pin High Level Voltage		2.75	3	3.3	V
V_{CTL}	CT Pin Low Level Voltage		0.9	1	1.1	V
I_{CT1}	CT Charge Current	V_{CT}=0.5V	2.3	2.9	3.5	µA
I_{CT2}	CT Discharge Current	V_{CT}=3.5V	0.3	0.4	0.5	µA
R_{CT}	CT Charge/Discharge Current Ratio	$R_{CT}=I_{CT1}/I_{CT2}$	-	7	-	-
SOFT-START						
V_{SSH}	SS Pin High Level Voltage		1.08	1.2	1.32	V
V_{SSL}	SS Pin Low Level Voltage		0.54	0.6	0.66	V
I_{SS1}	SS Charge Current	V_{SS}=0V	10	12.5	15	µA
I_{SS2}	SS Discharge Current	V_{SS}=1.5V	10	12.5	15	µA

Pin Description

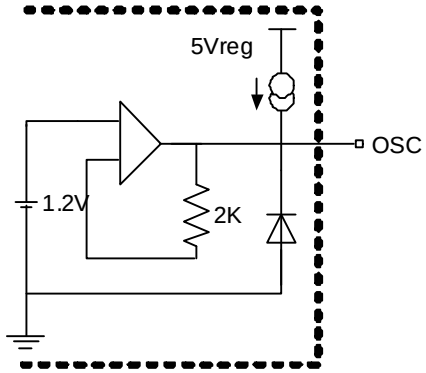
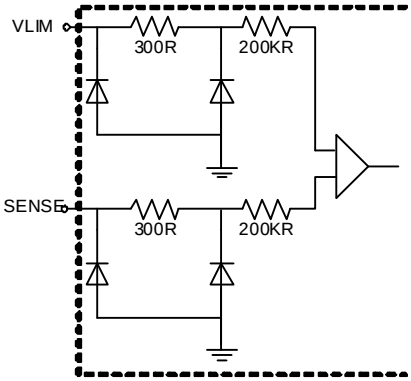
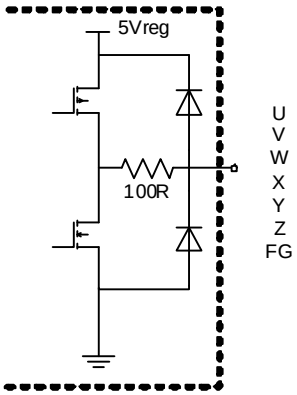
SSOP-30

Pin ON.	Pin Name	Pin function	Equivalent Circuit
1 2 3 4 5 6	HUP HUM HVP HWP HWM	This is the Hall signal input pin. H*P : Hall+ Input H*M :Hall- Input When H*P is greater than H*M is a high state, and the low state is the reverse.	
8	VLAL	VLAL: Setting LA Lower Limit	
7 9	VLAH LA_LIM	Setting LA Upper Limit LA_LIM: Setting LA Constant	

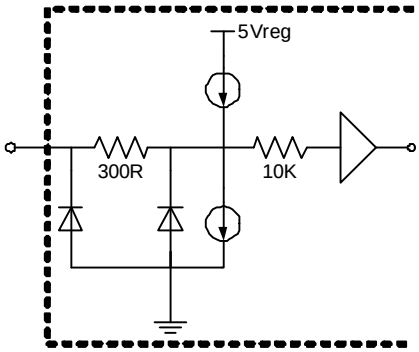
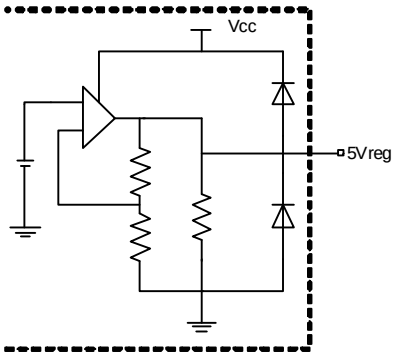
Pin Description

Pin ON.	Pin Name	Pin function	Equivalent Circuit
10	VSP	Motor PWM Duty Control Pin by Voltage. Drive mode: 0.6V~4.8V (VSPLS=Low) or 1V~4.8V (VSPLS=High or open), Output duty MAX 92%	
11 12 13 14 15	VSPLS FGC RESET FR HS	VSPLS: VSP Low voltage select 0.6V (VSPLS=Low) or 1V (VSPLS=High or Open) FGC: Select FG & 3FG RESET: Stop the motor FR:Forward / Reverse Rotation Setting. HS: Select one hall or three hall Input	
16	GND	Control stage GND.	
17	CT	Lock Protection ON/OFF Setting	

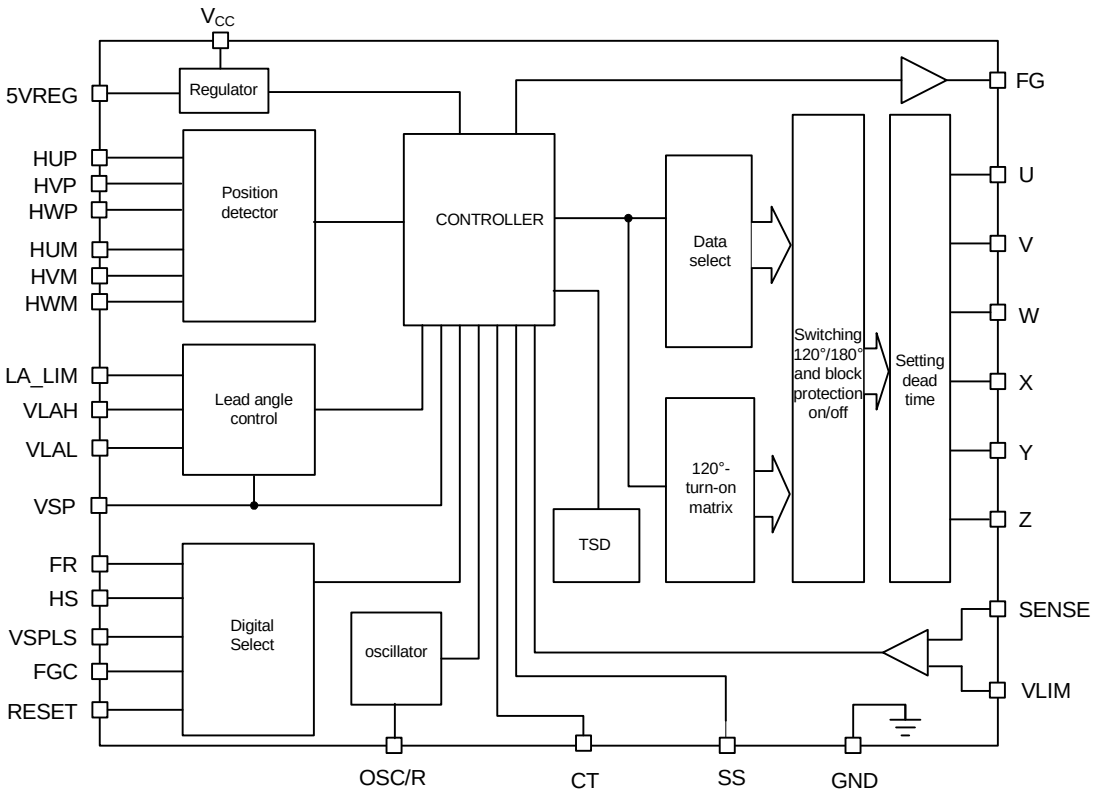
Pin Description

Pin ON.	Pin Name	Pin function	Equivalent Circuit
18	OCS/R	Built-in Clock Oscillator Frequency Setting, 4.6MHz	
19 20	VLIM SENSE	VLIM:Current-Limit Setting. Use a voltage divider from 5VREG to set VLIM pin voltage to set current limit value. SENSE: Current-Limit Input. Connect to external N-MOSFET source pins and connect a resistor RCL to GND to sense coil current.	
21 22 23 24 25 26 27	U V W X Y Z FG	U,V,W,: Phase High Side Pre-Driver X,Y,Z,: Phase Low Side Pre-Driver FG: Rotation Speed Output.	

Pin Description

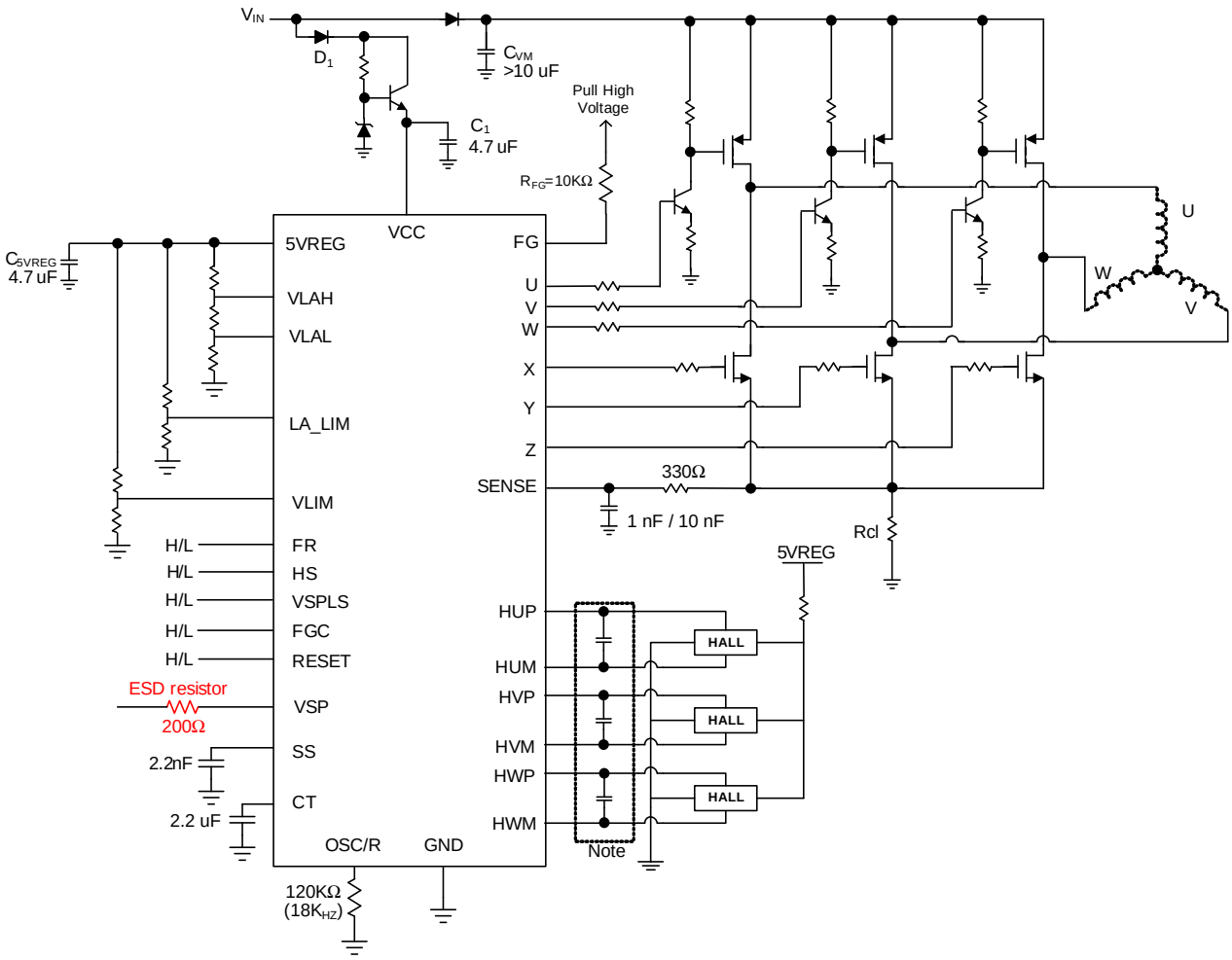
Pin ON.	Pin Name	Pin function	Equivalent Circuit
28	SS	Soft-Start Time Setting. Connect a capacitor to GND to set soft-start time to reduce the large current at power on and lock mode.	
29	5VREG	5V Regulator Output. This is a 5V constant-voltage output for application circuit biases.	
30	VCC	Supply Voltage Input.	

Block Diagram



Typical Application Circuit

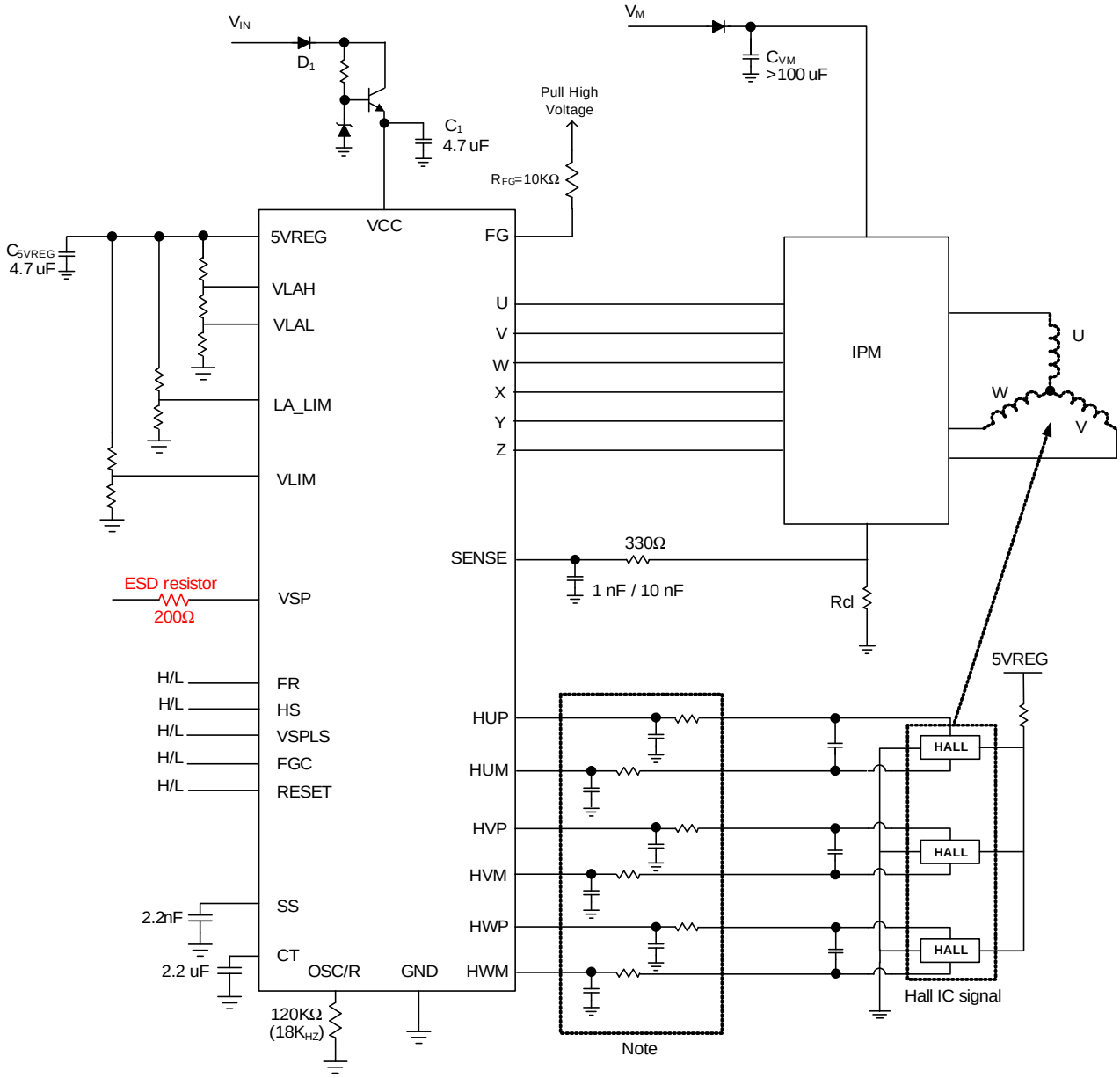
Circuit 1: Voltage Input Speed Control (Vin=12V~24V)



Note: Insert the capacitor CHN to avoid noise coupling at power switch.

Typical Application Circuit

Circuit 2: Voltage Input Speed Control (Vin=12V~24V,VM>100V)



Note: The low-pass filter to prevent excessive noise from the drive circuit. The recommended value is 10nF and 10KΩ.

Function Description

VSP PIN Voltage Command With 3 Mode Control

(a) Standby mode, VSP ≤ VIL (0.9V : VSPLS=High OR OPEN) OR (0.5V : VSPLS=Low) standby mode is set.

The low side transistors are turned on at a regular frequency. (PWM carrier, duty 8%)

(b) Drive mode, VIL (1V : VSPLS=High OR OPEN) OR (0.6V : VSPLS=Low) ≤ VSP< 7V.

When VSP pin voltage is VIL ≤ VSP < VIH (4.8V TYP.), drive mode is set & the motor runs at PWM duty in accordance with VSP.

When PWM duty reaches to the point of VIH, the duty is maximized (92%: TYP).

(c) Test mode, 8V < VSP < 10V(Max.)

When VSP pin voltage is 8V or higher, test mode is set. The motor runs at 120° energization with maximum duty.

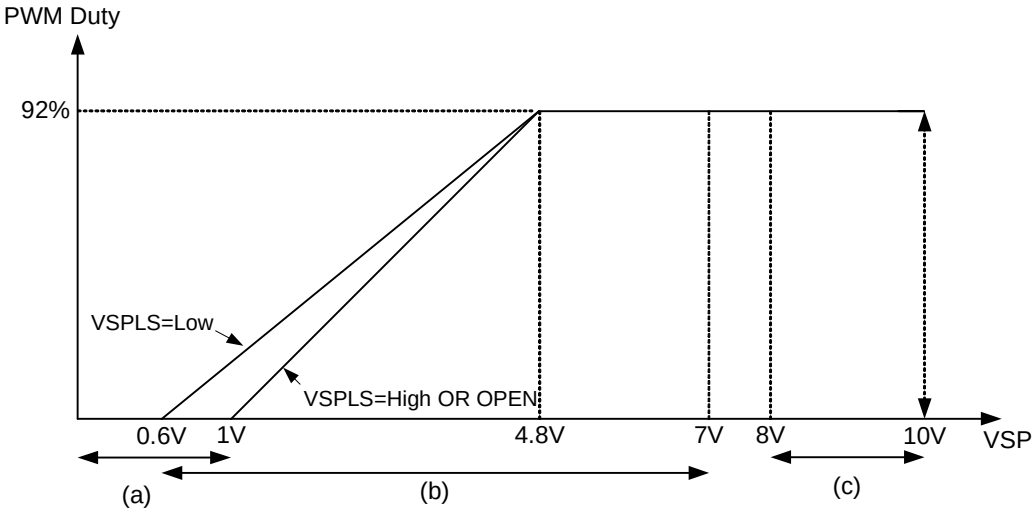


Figure 1. VSP PIN Voltage Command With 3 Mode Control

Lead Angle Control

The lead angle can be adjusted between 0° and 58° in 32 separate steps according to the induced voltage level on the LA input, which works with 0 to 5 V.

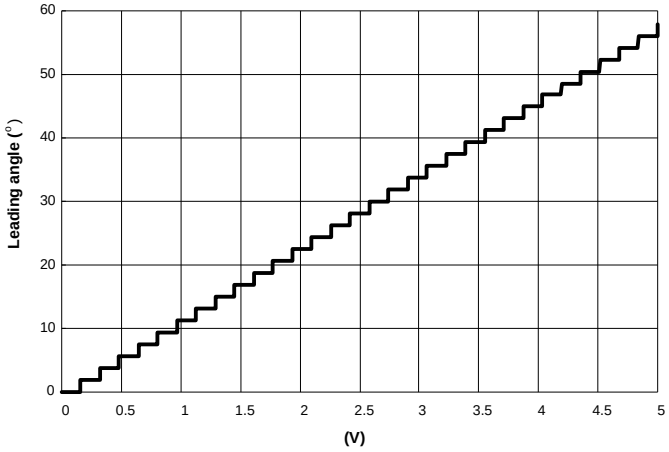


Figure 2. VLAH,VLAL,VLA_LIM(V) and Lead angle (°)

Function Description

0 V = 0°

5 V = 58° (A lead angle of 58° is assumed when the LA voltage exceeds 5 V.)

VLAH --- Setting LA MAX

VLAL --- Setting LA MIN

LA_LIM --- Setting LA LIMIT

VSP Control Function

The APX7311 with VSP Pin can control Output PWM 0 ~ 92% DUTY, and lead angle from 0 to 58 degrees.

The lead angle can be made VLAH, VLAL, VLA_LIM setting range. VSPLS : VSP Low voltage select 0.6V (VSPLS=Low) or 1V (VSPLS=High or Open)

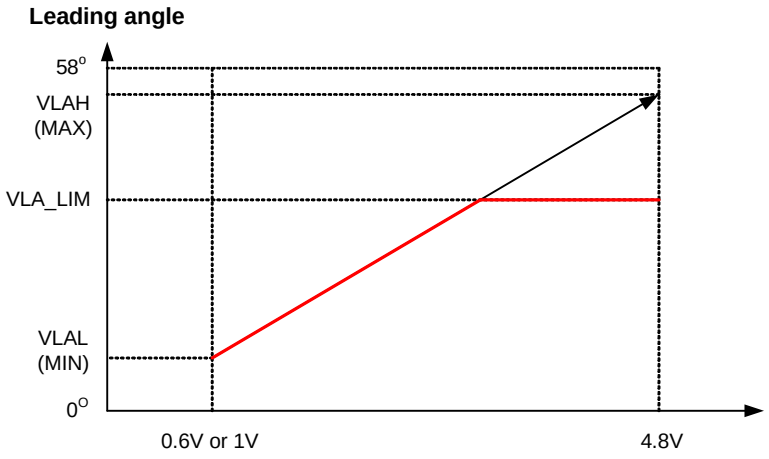


Figure 3. VSP PIN Voltage and Leading angle

Hall Element & Hall IC

This HUP HUM HVP HVM HWP HWM offers two types of Hall Element and Hall IC, the design will be more flexible.

(See Figure 4. Hall Element and Hall IC control)

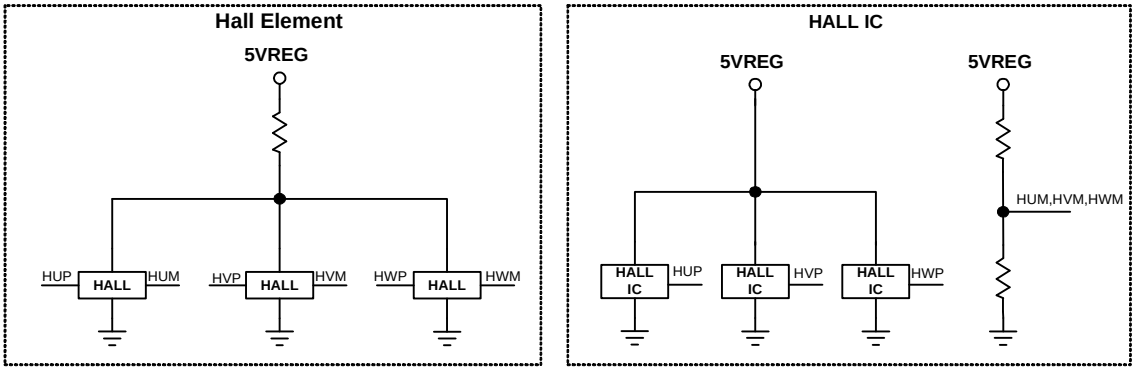


Figure 4. Hall Element and Hall IC control

Function Description

FGC control pin

FG output. If the FGC pin is connected to 5VREG or Open, the output has a period equal to 3FG. If the FGC pin is connected to GND, the output has a period equal to FG. (See figure 5. FG / 3FG control) Please note that the "HS = Low" case there will be no 3FG function

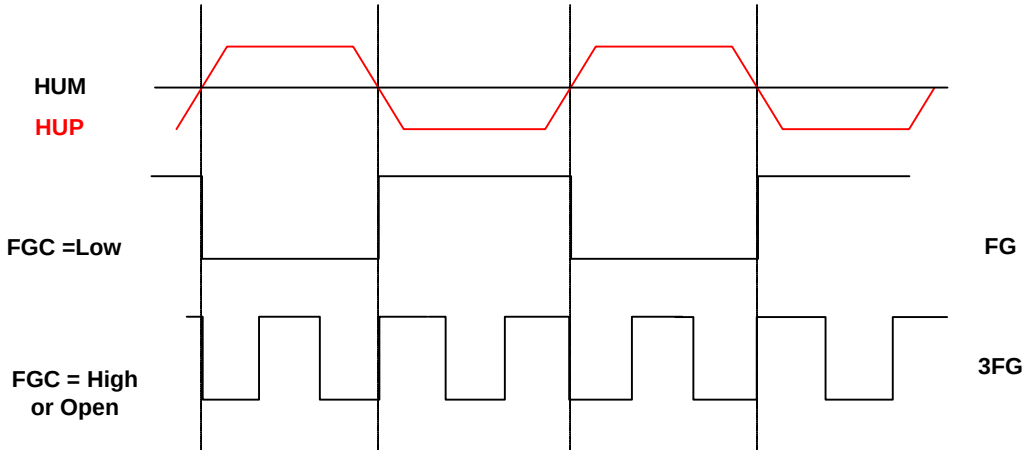


Figure 5. FG / 3FG control

Soft Switch (sine-wave output)

The is a soft switch function to make phase current become more gentle, which can reduce the noise of motor in switching interval. Using PWM duty cycle control to create the sinusoidal current waveform. close to the ideal sine wave output.(See Figure 6. Sinusoidal PWM)

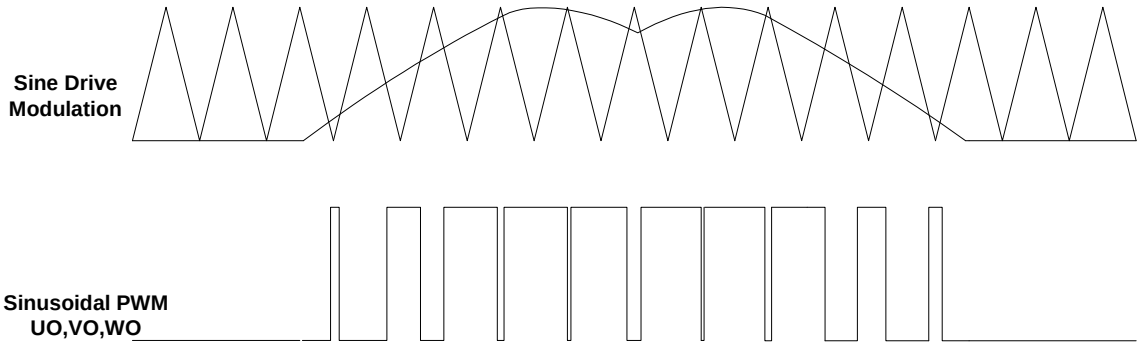
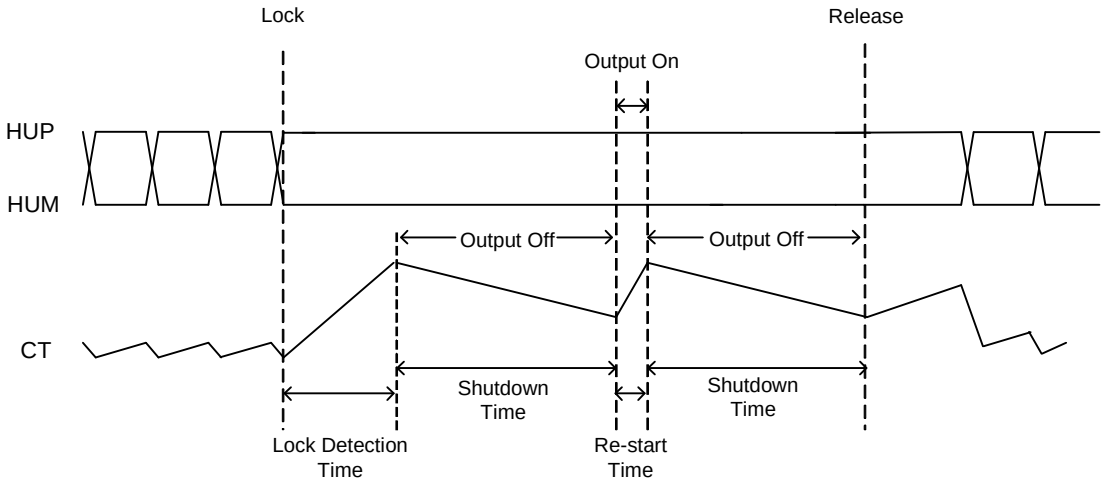


Figure 6. Sinusoidal PWM

Function Description

Lockup Protection and Automatic Restart

The APX7311 provides the lockup protection and automatic restart functions for preventing the coil burnout while the fan is locked. Connecting the capacitor from CT pin to GND can determine the shutdown time and restart time.

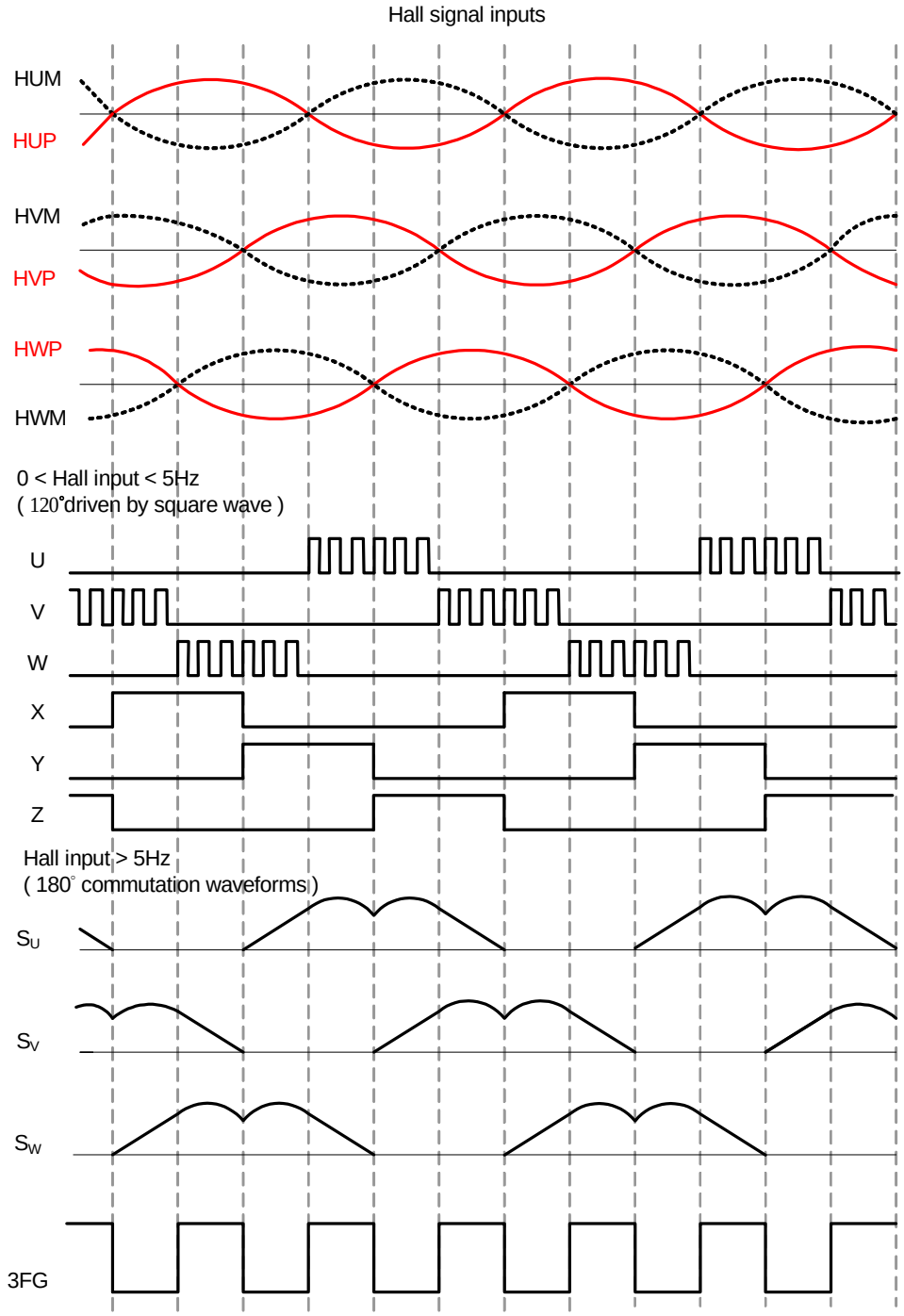


Function Description(Cont.)

Forward Rotation Timing Chart (HS = High, VLA_LIM = GND, FGC=High , FR = High)

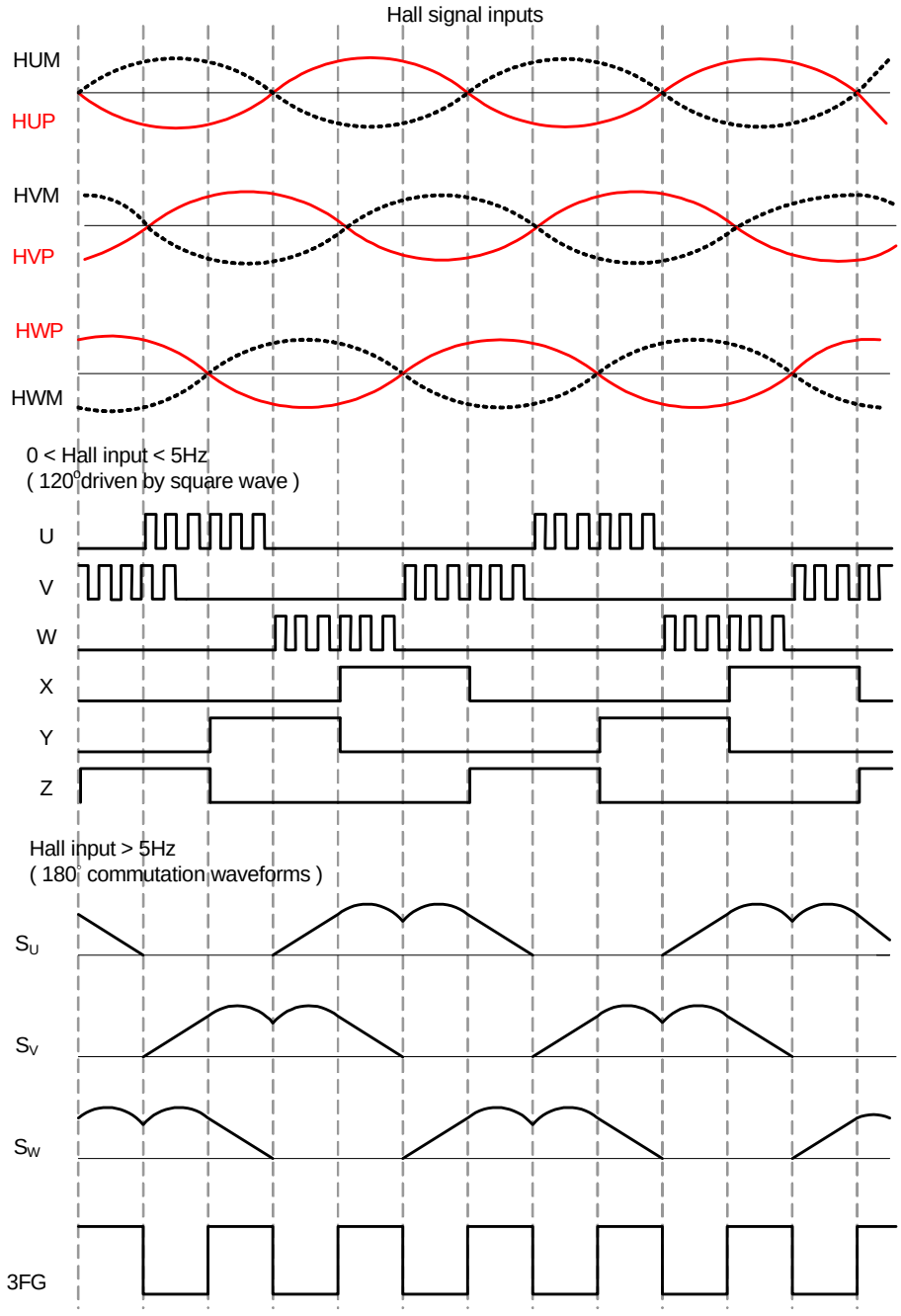
From start to 5 Hz : When driven by square wave.

5 Hz or higher : When driven by sine-wave PWM.



Function Description(Cont.)

Reverse Rotation Timing Chart (HS = High, VLA_LIM = GND, FGC=High , FR = Low)



Thermal Protection

The APX7311 is designed with a thermal protection to protect the IC from the damage of over temperature. When internal junction temperature reaches 175°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 Protection Diode & Capacitor

The IC should be added a protection diode (D1) to prevent 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. For the noise reduction purpose, a capacitor (C1) must connect between VCC and GND. It is the suggestion that C1 should be placed as close as possible to the device VCC pin.

CT Capacitor

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

$$\text{Locked Detection Time} = \frac{C_{CT} \times (V_{CTH} - 0.2V)}{I_{CT1}}$$

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

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

where:

C_{CT} = CT pin capacitor

For example:

V_{CC}=12V, C_{CT}= 2.2µF

Locked Detection Time = 2.27s

Restart Time = 1.52s

Shutdown Time = 11s

The value of charge capacitor is recommended from 1µF to 4.7µF.

RESET Capacitor

The capacitor that is connected from RESET pin to GND determines the electric motor braking time of power on and quick start.

$$\text{Start-up delay Time} = \frac{C_{RESET} \times (V_{RESET} - 0.2V)}{I_{RESET}}$$

For example:

V_{RESETH}=1.8V ; I_{RESET}= 1µA

V_{CC}=12V, C_{RESET} = 0.1µF

Start-up delay Time = 0.16s

The RESET pin must normally be pulled up to 5V regulator for unused.

Application Information

OSC/R Resistance

The resistance connected from OSC/R pin to GND can be determined the frequency of force commutation. The optimal design of the frequency could make sure the motor succeed in start-up. The resistance from 120KΩ to 106KΩ is recommended.

OSC/R=120 kΩ	Oscillation Frequency : 4.6 MHz	PWM Frequency: 18 kHz
OSC/R=106 kΩ	Oscillation Frequency : 5.1 MHz	PWM Frequency: 20 kHz

SS Capacitor

The capacitor that is connected from S-S pin to GND determines the soft start time.

$$\text{Start-up delay Time} = 86 \times \frac{2C_{S-S} \times (V_{SSH} - V_{SSL})}{(I_{SS1} + I_{SS2})/2} \times 255$$

where:

C_{SS} = SS pin capacitor

For example:

V_{CC}=12V, V_{SSH}=1.2V,V_{SSL}=0.6V,I_{SS1}=12.5μA,I_{SS2}=12.5μA , C_{SS}=2.2nF

Soft Start Time = 4.6s

HS Pin

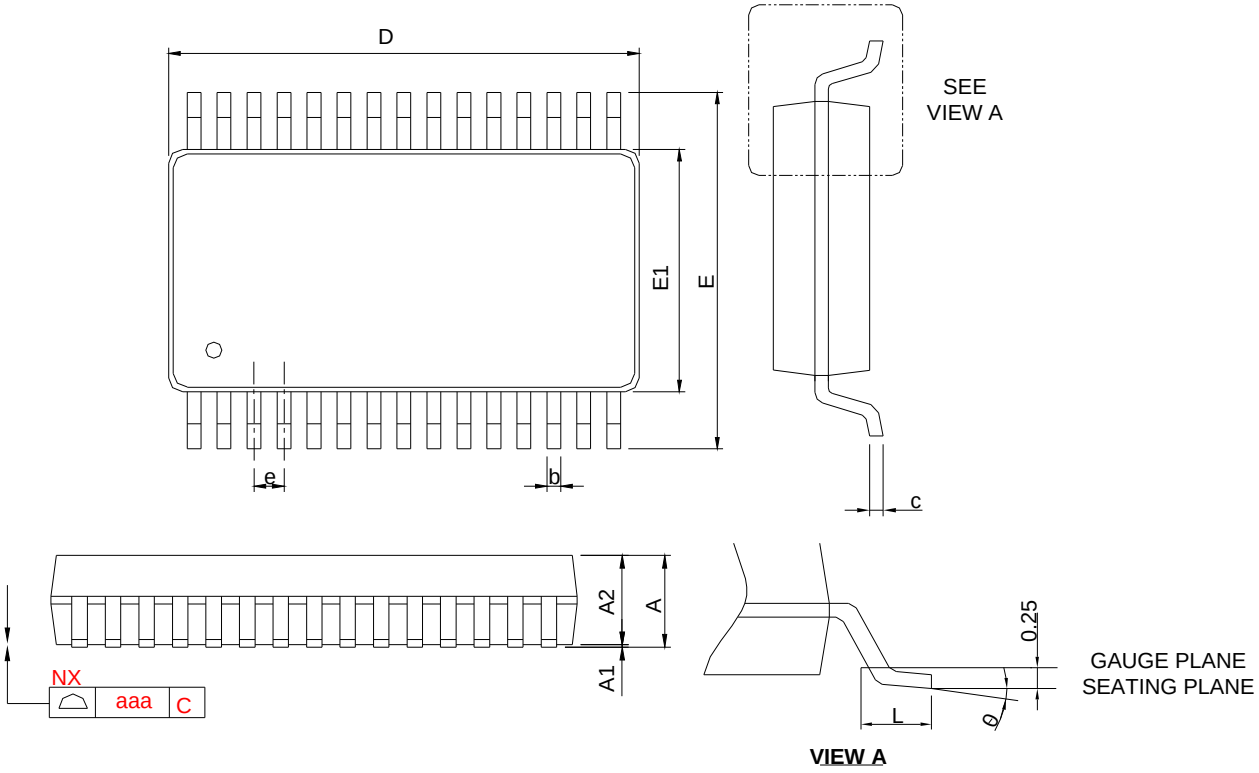
The HS PIN is a selection pin to define 1-Hall or 3-Hall input application. When the HS pin be pulled to GND to define 1-Hall application, the available Hall input signal will on HUP and HUM. However, the start up of fan motor may cause rotor swaing in 1-Hall application. Increasing soft start time can reduce the amplitude of swaying.

FIL Capacitor

The capacitor connects between HUP and HUM (HVP and HVM, HWP and HWM) pin to filter the noise when phase change to make sure phase change correctly. Its capacitance from 1nF to 10nF is recommended.

Package Information

SSOP-30

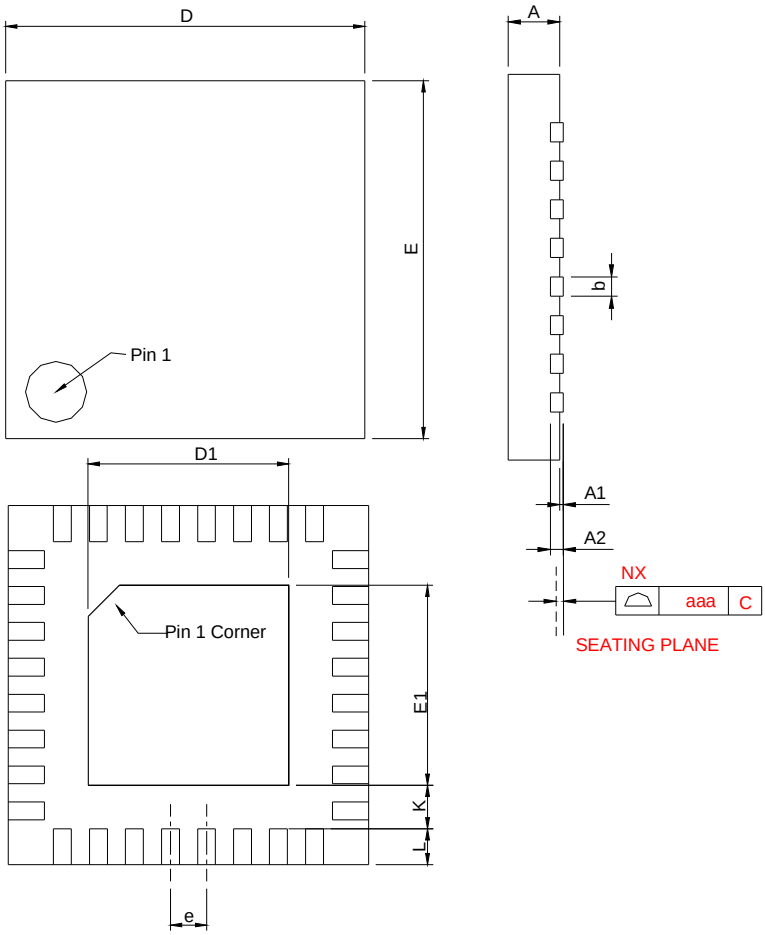


SYMBOL	SSOP-30			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		2.00		0.079
A1	0.05		0.002	
A2	1.65	1.85	0.065	0.073
b	0.22	0.38	0.009	0.015
c	0.09	0.21	0.004	0.008
D	9.90	10.50	0.390	0.413
E	7.40	8.20	0.291	0.323
E1	5.00	5.60	0.197	0.220
e	0.65 BSC		0.026 BSC	
L	0.55	0.95	0.022	0.037
θ	0°	8°	0°	8°
aaa	0.10		0.004	

Note : 1. Rerfence to JEDEC MO-150 AJ.
2. Dimension "D" & "E1" do not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 8 mil per side .

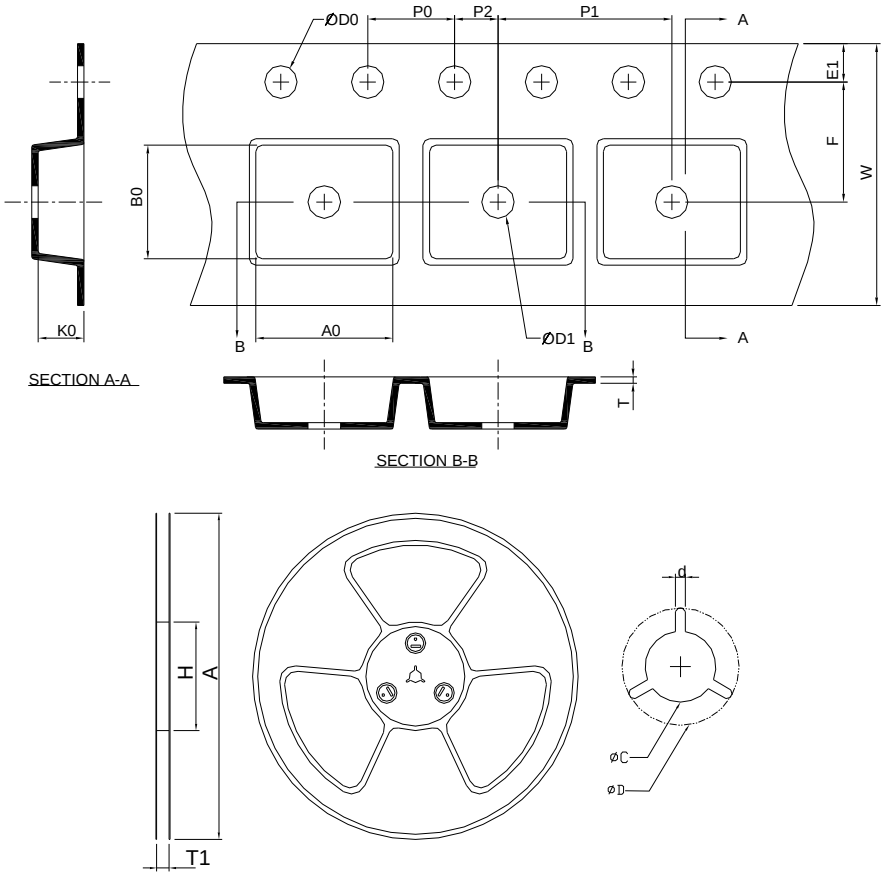
Package Information

TQFN4x4-32B



SYMBOL	TQFN4*4-32B			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A	0.70	0.80	0.028	0.031
A1	0.00	0.05	0.000	0.002
A3	0.20 REF		0.008 REF	
b	0.15	0.25	0.006	0.010
D	3.90	4.10	0.154	0.161
D1	2.50	2.80	0.098	0.110
E	3.90	4.10	0.154	0.161
E1	2.50	2.80	0.098	0.110
e	0.40 BSC		0.016 BSC	
L	0.30	0.50	0.012	0.020
K	0.20		0.008	
aaa	0.08		0.003	

Carrier Tape & Reel Dimensions



Application	A	H	T1	C	d	D	W	E1	F
SSOP-30	330.0±2.00	50 MIN.	24.40+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	24.0±0.30	1.75±0.10	11.5±0.10
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.0±0.10	12.0±0.10	2.0±0.10	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	8.40±0.20	10.90±0.20	2.20±0.40
Application	**A**	**H**	**T1**	**C**	**d**	**D**	**W**	**E1**	**F**
TQFN 4x4	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	4.30±0.20	4.30±0.20	1.00±0.20

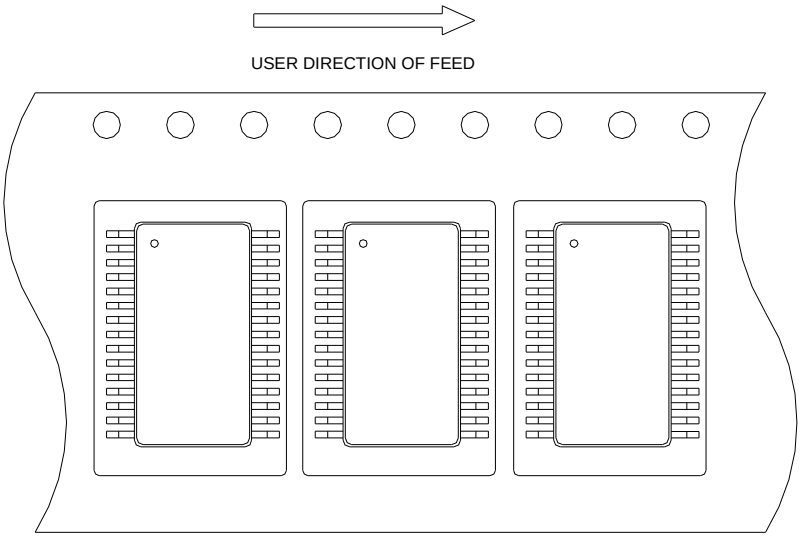
(mm)

Devices Per Unit

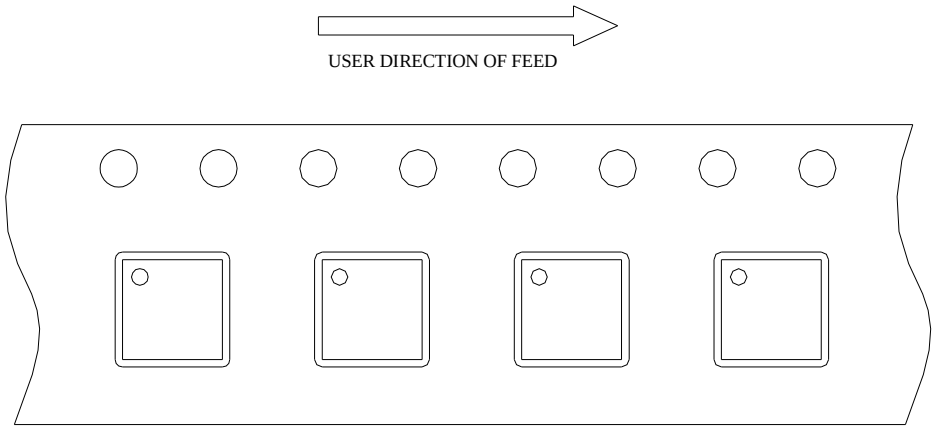
Package Type	Unit	Quantity
SSOP-30	Tape & Reel	2000
TQFN 4*4	Tape & Reel	3000

Taping Direction Information

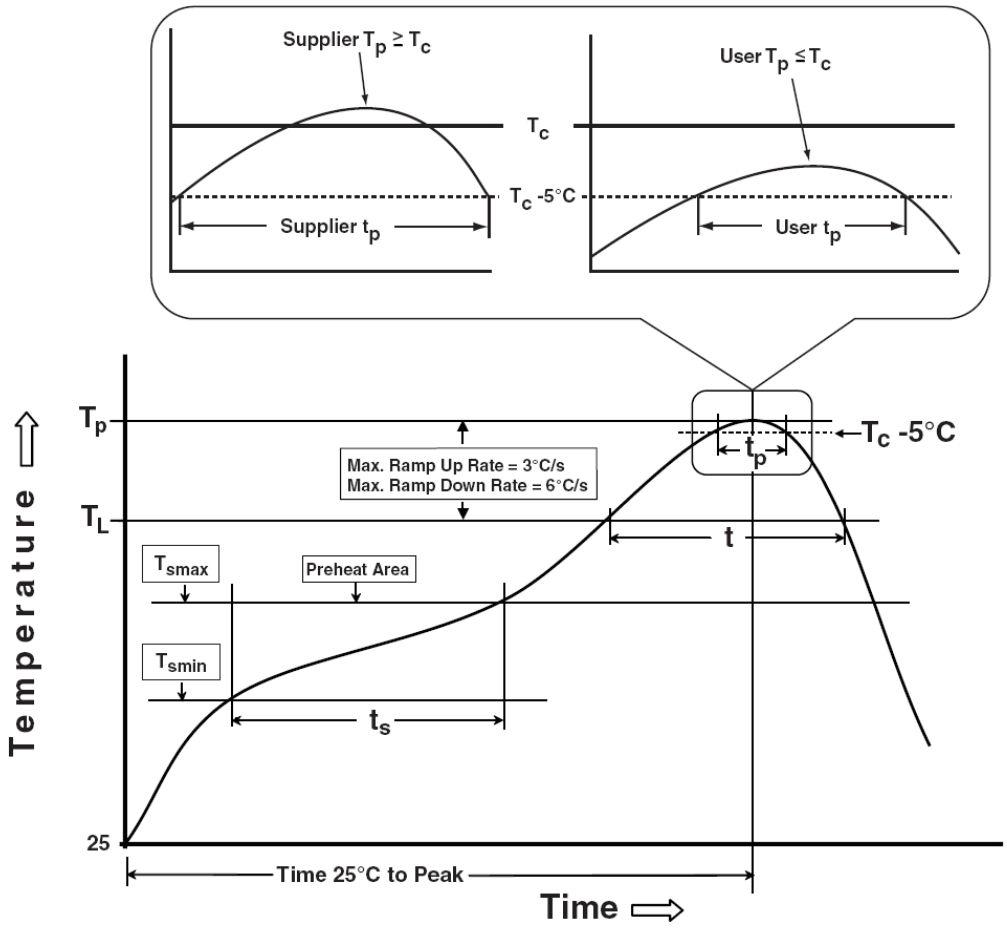
SSOP-30



TQFN4x4-32B



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.		

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 @ Tj=125°C
PCT	JESD-22, A102	168 Hrs, 100%RH, 2atm, 121°C
TCT	JESD-22, A104	500 Cycles, -65°C~150°C
ESD	MIL-STD-883-3015.7	VHBM≧2KV, VMM≧200V
Latch-Up	JESD 78	10ms, 1_{tr}≧100mA

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