APX9280

Single-Phase Full-Wave Motor Pre-Driver For Fan Motor

Features

- **Single Phase Fan Pre-Driver**
- **Low Supply Current**
- **Built in Variable Speed Control Function**
- **Hall Bias Circuit included**
- **Minimum Speed Setting**
- **Built-in Current-Limit**
- **Built-in Lock Protection and Auto Restart Function**
- **FG (Rotation Speed Detection) and RD (Lock Detection) Output**
- **Built-in Reactive Current Cut Circuit**
- **Built-in Thermal Protection Circuit**
- **Lead Free and Green Devices Available (RoHS Compliant)**

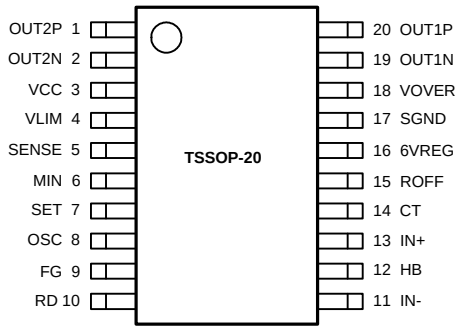
Applications

- **Mainframe and Personal Computer Fans and Blowers**
- **Instrumentation Fans**
- **Variable Speed Control Fans**

General Description

The APX9280 is a single phase, DC brushless motor pre-driver with features of PWM variable speed control and current-limit, which is suitable for fans, blowers, and pump motors. The right ROFF resistor value could tune the adequate soft switch time to cut reactive current before phase changes. PWM control system works depending on the comparison between the voltage of SET, MIN, and OSC. The device is equipped with built-in lock protection; when fan is locked, the device will enter the lockup protection mode. It is also with rotation detection output and thermal shutdown functions. In normal operation, the supply current is less than 10mA. The APX9280 is available in TSSOP-20 package (See Pin Configuration).

Pin Configuration



Ordering and Marking Information

APX9280 □□-□□□

- Assembly Material
- Handling Code
- Temp. Range
- Package Code

Package Code
O : TSSOP-20
Operating Ambient Temp. Range
I : -40 to 95 °C
Handling Code
TR : Tape & Reel
Assembly Material
L : Lead Free Device
G : Halogen and Lead Free Device

APX9280 O :

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-020C 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.

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Absolute Maximum Ratings

Symbol	Parameter	Ratings	Unit
V_{CC}	VCC Pin Supply Voltage	-0.3 to 18	V
I_{OUTP}	Output Pin Sink Current	50	mA
I_{OUTN}	Output Pin Sink and Source Current	50	mA
$V_{OUTP,OUTN}$	Output Pin Output Voltage	-0.3 to 18	V
I_{HB}	HB Pin Source Current	10	mA
V_{SET}	SET Pin Input Voltage	-0.3 to 8	V
V_{MIN}	MIN Pin Input Voltage	-0.3 to 8	V
$V_{RD/FG}$	RD/FG Pin Output Voltage	-0.3 to 18	V
$I_{RD/FG}$	RD/FG Pin Output Sink Current	10	mA
$R_{TH,JA}$	Thermal Resistance-Junction to Ambient TSSOP-20	 100	°C/W
P_D	Power Dissipation	1	W
T_J	Junction Temperature	-40 to 150	°C
T_{STG}	Storage Temperature	-65 to 150	°C
T_{SDR}	Lead Soldering Temperature	260, 10 seconds	°C

Note 1: Stresses above those listed in "Absolute Ratings" may cause permanent damage to the device.
Note 2: Mounted on a board (80x80x1.6 mm, Glass epoxy).

Recommended Operating Conditions

Symbol	Parameter	Rating	Unit
V_{CC}	VCC Pin Supply Voltage Range	6 to 16	V
V_{SET}	SET Pin Input Voltage Range	0 to 7	V
V_{MIN}	MIN Pin Input Voltage Range	0 to 7	V
V_{ICM}	Hall Input Common Phase Input Voltage Range	0.2 to 3	V
T_A	Operating Ambient Temperature	-40 to 95	°C
T_J	Junction Temperature	-40 to 125	°C

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

Symbol	Parameter	Test Conditions	APX9280			Unit
			Min.	Typ.	Max.	
SUPPLY CURRENT						
V_{6VREG}	6VREG Pin Output Voltage	I_{6VREG} = 5mA	5.8	6	6.15	V
V_{HB}	HB Pin Output Voltage	I_{HB} = 5mA	1.25	1.3	1.35	V
V_{OVER}	VOVER Pin Voltage	Connect 0.47kΩ to 15V	11.5	12.8	14	V
I_{CC1}	Operating Current Drain	Rotation Mode	6	8	10	mA
I_{CC2}		Lock Protection Mode	6	8	10	mA
OSCILLATOR						
V_{OSCH}	OSC High Level Voltage	C_{OSC} = 100pF	4.35	4.55	4.75	V
V_{OSCL}	OSC Low Level Voltage	C_{OSC} = 100pF	1.45	1.65	1.85	V
I_{OSC1}	OSC Charge Current		15	18	22	µA
I_{OSC2}	OSC Discharge Current		15	18	22	µA
F_{OSC}	OSC Oscillation Frequency	C_{OSC} = 100pF	18	25	32	kHz

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

Symbol	Parameter	Test Conditions	APX9280			Unit
			Min.	Typ.	Max.	
LOCK PROTECTION						
V_{CTH}	CT Pin High Level Voltage	C_{CT} = 1µF	3.4	3.6	3.8	V
V_{CTL}	CT Pin Low Level Voltage	C_{CT} = 1µF	1.4	1.6	1.8	V
I_{CT1}	CT Charge Current	V_{CT} = 0V	1.6	2	2.5	µA
I_{CT2}	CT Discharge Current	V_{CT} = 3.6V	0.16	0.2	0.28	µA
R_{CT}	CT Charge/Discharge Current Ratio	$R_{CT} = I_{CT1} / I_{CT2}$	8	10	12	-
OUTPUT DRIVERS						
V_{OUTPL}	OUT_P Output Low Voltage	I_{OUTP} = 20mA	-	0.5	1	V
I_{OUTPH}	OUT_P Output High Leakage	V_{OUTP} = 12V	-	35	100	µA
V_{OUTNH}	OUT_N Output High Voltage	I_{OUTN} = -20mA	V_{CC}-2	V_{CC}-1	-	V
V_{OUTNL}	OUT_N Output Low Voltage	I_{OUTN} = 20mA	-	0.5	1	V
V_{RD}/V_{FG}	RD/FG Pin Low Voltage	I_{FG} = 5mA	-	0.1	0.3	V
I_{RDL}/I_{FGL}	RD/FG Pin Leak Current	V_{FG} = 12V	-	0.1	1	µA
HALL SENSITIVITY						
V_{HN}	Hall Input Sensitivity	Zero to peak including offset and hysteresis	-	10	20	mV
THERMAL SHUTDOWN						
OTS	Over Temperature Shutdown		-	160	-	°C
	Over Temperature Shutdown Hysteresis		-	20	-	

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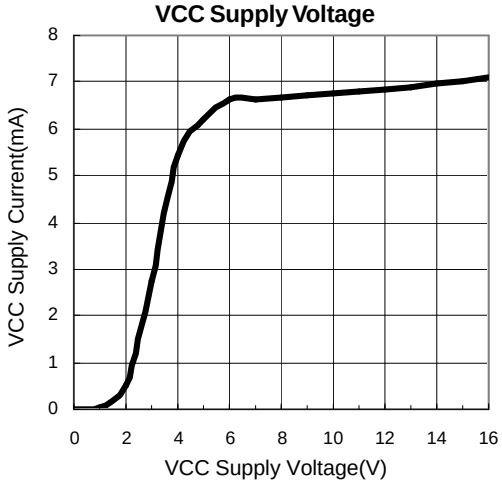
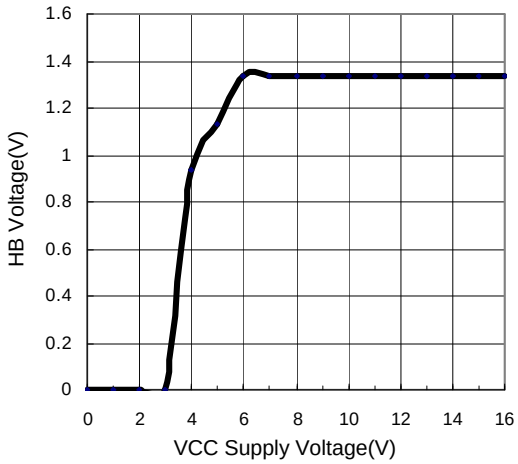
Typical Operating Characteristics

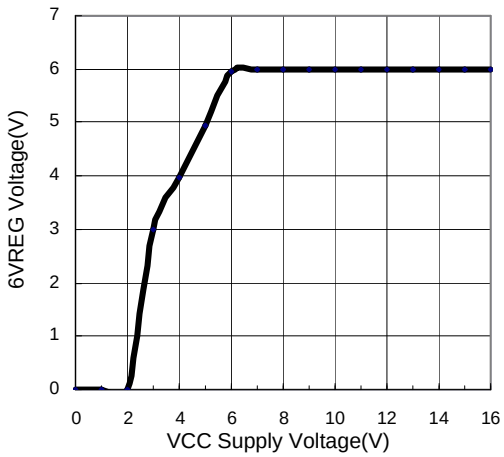
VCC Supply Current vs. VCC Supply Voltage



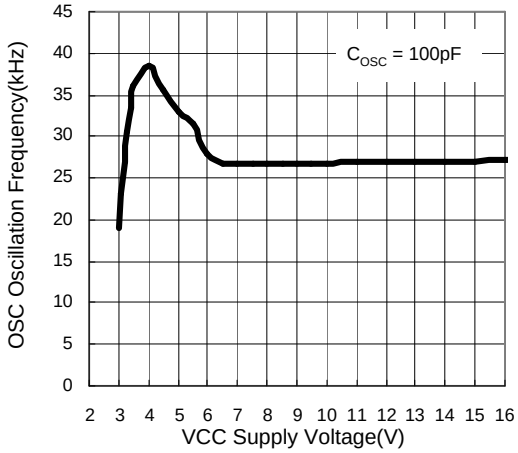
HB Voltage vs. VCC Supply Voltage



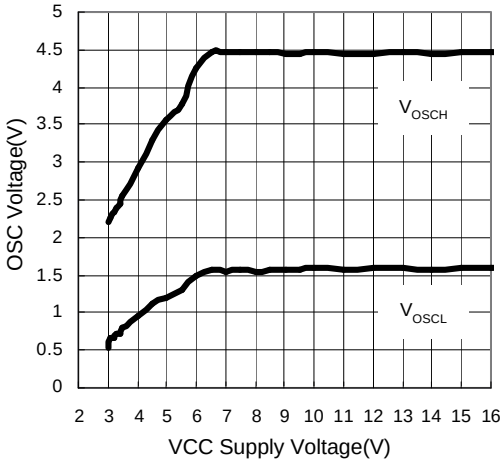
6VREG Voltage vs. VCC Supply Voltage



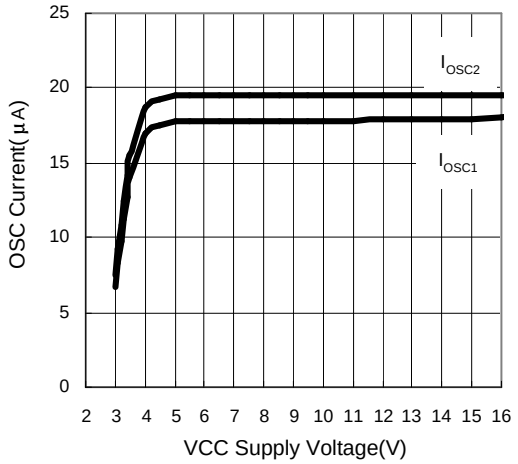
OSC Frequency vs. VCC Supply Voltage



OSC Voltage vs. VCC Supply Voltage

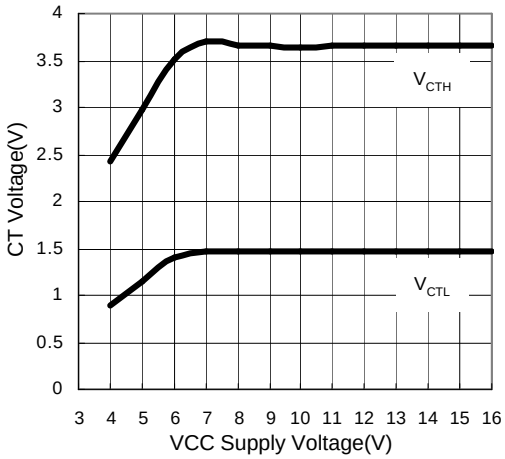


OSC Current vs. VCC Supply Voltage

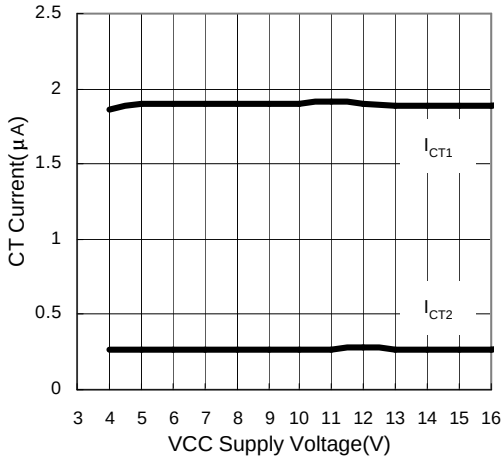


Typical Operating Characteristics (Cont.)

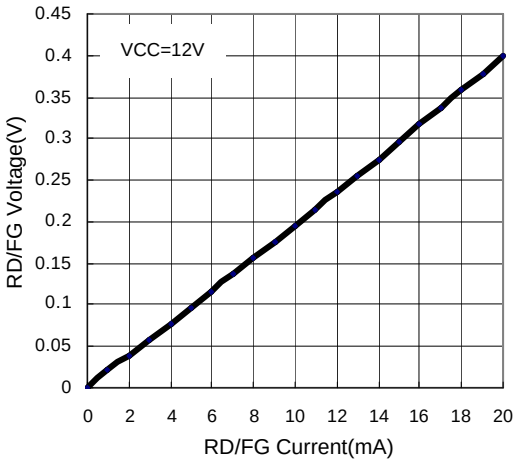
CT Voltage vs. VCC Supply Voltage



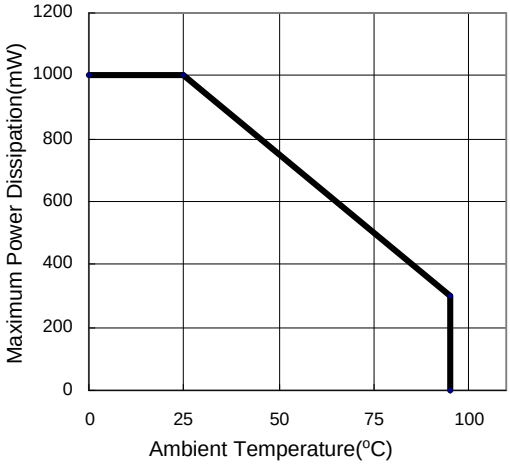
CT Current vs. VCC Supply Voltage



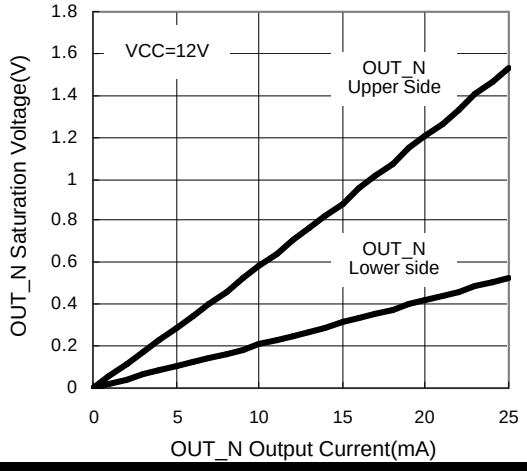
RD/FG Voltage vs. RD/FG Current



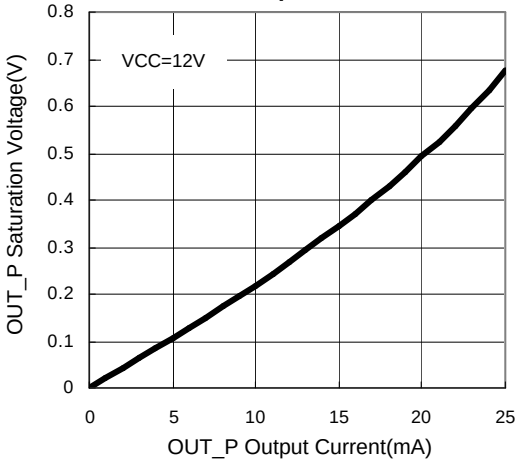
Maximum Power Dissipation vs. Ambient Temperature



OUT_N Saturation Voltage vs. OUT_N Output Current

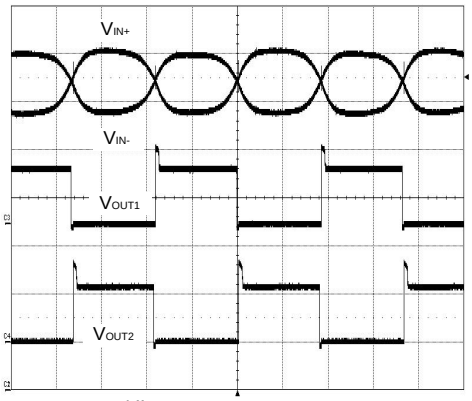


OUT_P Saturation Voltage vs. OUT_P Output Current



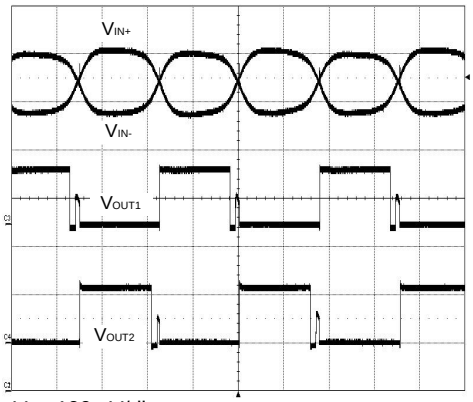
Operating Waveforms

Rotation Mode Waveform1 without R_{OFF}



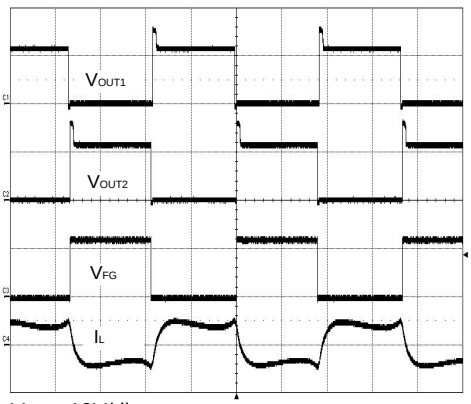
V_{IN+}:100mV/div
V_{IN-}:100mV/div
V_{OUT1}:10V/div
V_{OUT2}:10V/div
Time:2ms/div

Rotation Mode Waveform1 with R_{OFF}



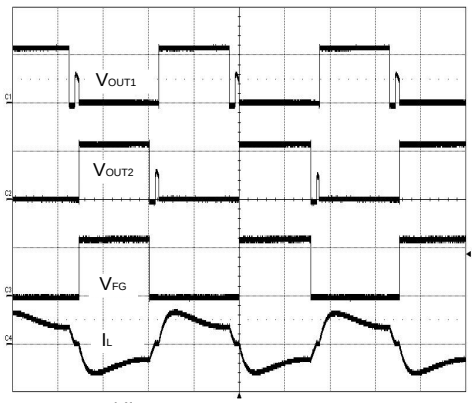
V_{IN+}:100mV/div
V_{IN-}:100mV/div
V_{OUT1}:10V/div
V_{OUT2}:10V/div
Time:2ms/div

Rotation Mode Waveform2 without R_{OFF}



V_{OUT1}:10V/div
V_{OUT2}:10V/div
V_{FG}:10V/div
I_L:2A/div
Time:2ms/div

Rotation Mode Waveform2 with R_{OFF}



V_{OUT1}:10V/div
V_{OUT2}:10V/div
V_{FG}:10V/div
I_L:2A/div
Time:2ms/div

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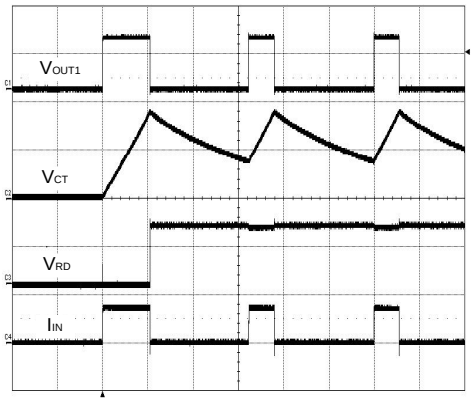
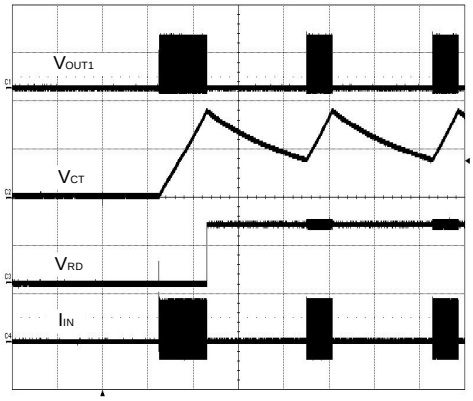
Operating Waveforms (Cont.)

Lock Protection Waveform1 without Current Limit



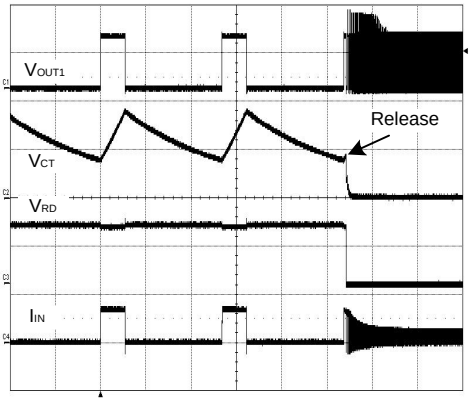
V_{OUT1}: 10V/div
V_{CT}: 2V/div
V_{RD}: 10V/div
I_{IN}: 5A/div
Time: 1s/div

Lock Protection Waveform1 with Current Limit



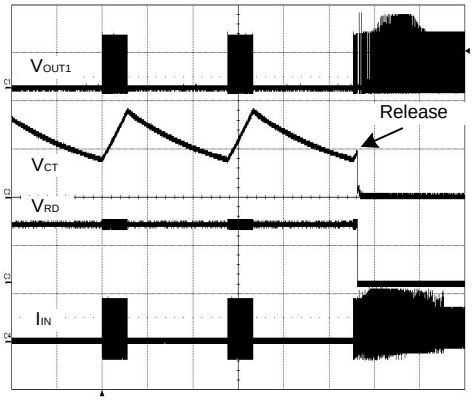
V_{OUT1}: 10V/div
V_{CT}: 2V/div
V_{RD}: 10V/div
I_{IN}: 2A/div
Time: 1s/div

Lock Protection Waveform2 without Current Limit



V_{OUT1}: 10V/div
V_{CT}: 2V/div
V_{RD}: 10V/div
I_{IN}: 5A/div
Time: 1s/div

Lock Protection Waveform2 with Current Limit



V_{OUT1}: 10V/div
V_{CT}: 2V/div
V_{RD}: 10V/div
I_{IN}: 2A/div
Time: 1s/div

Pin Description

PIN		Description
No.	Name	
1	OUT2P	High side external H-bridge Driver. Connect this pin to the upper P-MOSFET gate of OUT2.
2	OUT2N	Low side external H-bridge Driver. Connect this pin to the lower N-MOSFET gate of OUT2.
3	VCC	Supply Voltage.
4	VLIM	Current-Limit Setting. Use a voltage divider from 6VREG to set VLIM pin voltage to set current limit value.
5	SENSE	Current-Limit Input. Connect to external N-MOSFET source pins and connect a resistor R_F to GND to sense coil current.
6	MIN	Minimum Speed Setting. Use a voltage divider from 6VREG to set MIN pin voltage to set minimum speed of fan.
7	SET	Speed Setting. Input an external voltage to SET pin to set fan speed.
8	OSC	Oscillation Frequency Setting. Connect a capacitor to GND to set oscillation frequency.
9	FG	Rotation Speed Output. This is an open-collector output.
10	RD	Rotation Detection Output. This is an open-collector output.
11	IN-	Hall Input -. Connect to hall element negative output.
12	HB	Hall Bias. This is a 1.3V constant-voltage output for hall element bias.
13	IN+	Hall Input +. Connect to hall element positive output.
14	CT	Shutdown Time and Restart Time Setting. Connect a capacitor to GND to set shutdown time and restart time in lock mode.
15	ROFF	Soft Switch Time Setting. Connect a resistor to 6VREG to set soft-switch time to avoid high voltage peaking at output phase changes.
16	6VREG	6V Regulator Output. This is a 6V constant-voltage output for application circuit biases.
17	SGND	Control stage GND.
18	VOVER	This pin is for voltage reference bias (24,48V) to clamp V_{CC} to 12V.
19	OUT1N	Low side external H-bridge Driver. Connect this pin to the lower N-MOSFET gate of OUT1.
20	OUT1P	High side external H-bridge Driver. Connect this pin to the upper P-MOSFET gate of OUT1.

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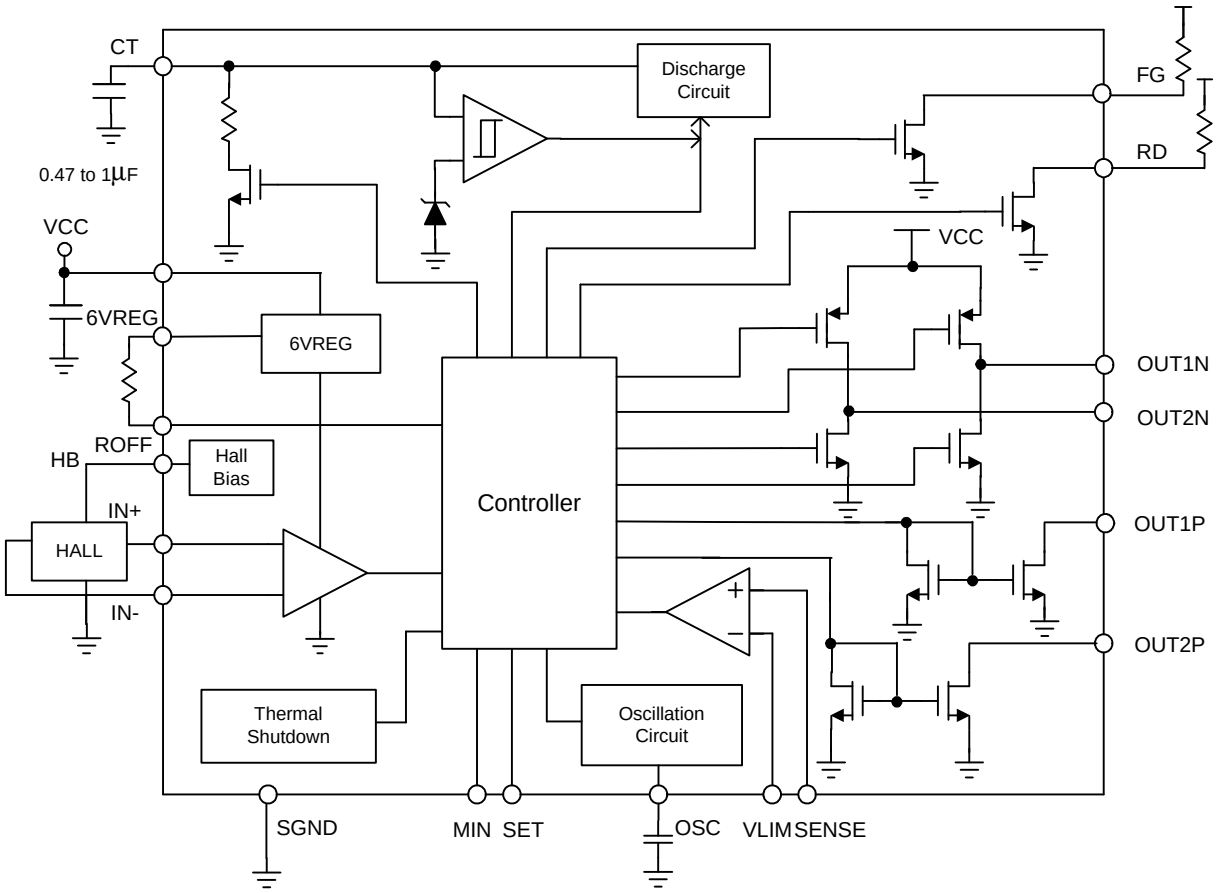
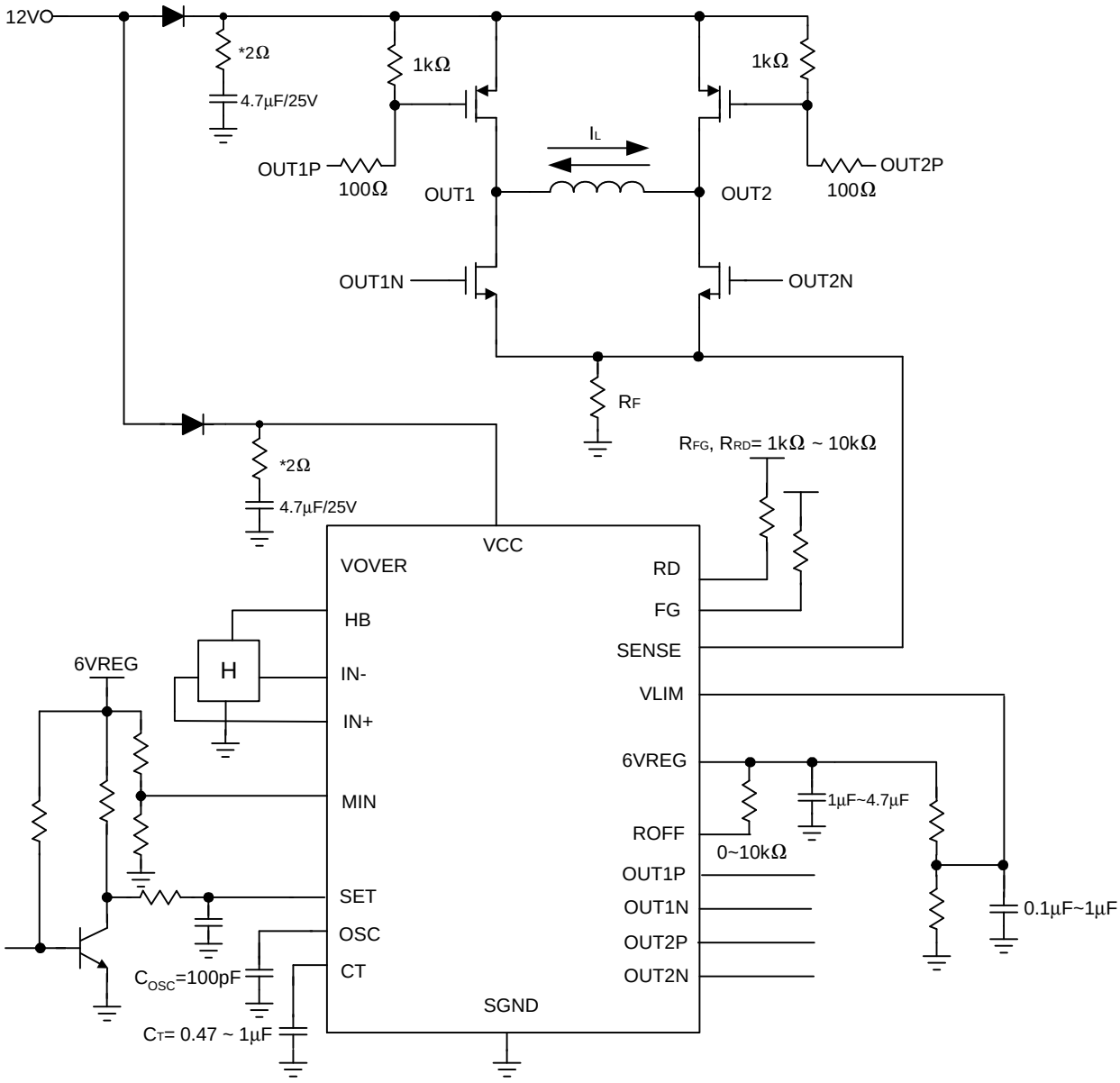
Block Diagram



Typical Application Circuits

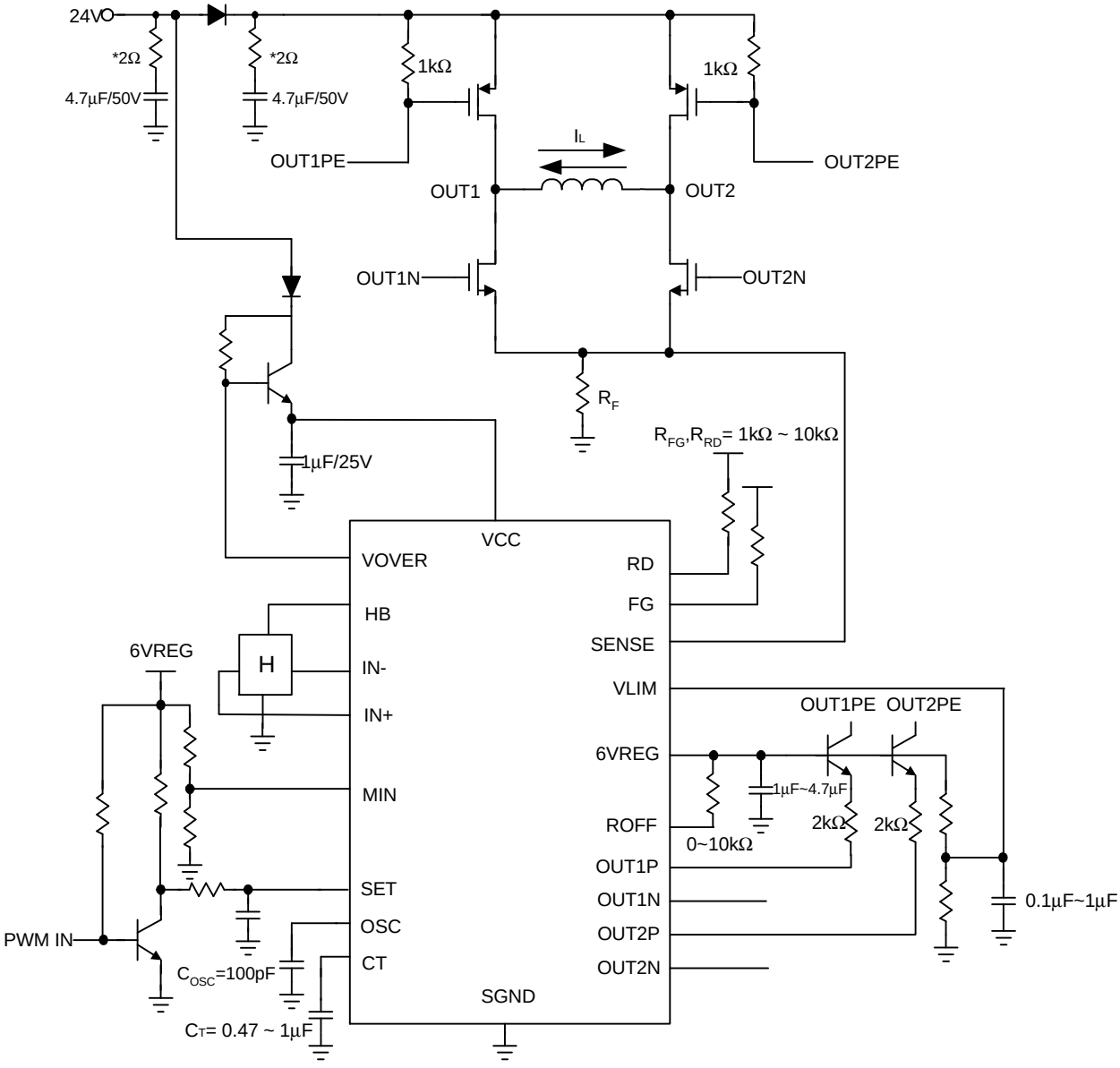
1. For 12V Application



*2Ω resistor and 4.7µF capacitor circuits are to decline peaking voltage in hot plug condition.

Typical Application Circuits (Cont.)

2. For 24V Application



*2Ω resistor and 4.7µF capacitor circuits are to decline peaking voltage in hot plug condition.

Founction Description

Variable speed control

The APX9280 has a variable speed controller. The speed is controlled by comparing the voltage of OSC, MIN, and SET. The lowest speed drive duty is set by comparing the OSC oscillating voltage and MIN pin voltage when MIN pin voltage is lower than SET. When SET pin voltage is lower than MIN, PWM control system works by comparing the voltage of SET and OSC. When SET pin voltage is lower than OSC, upper and lower side's transistors are ON. When SET pin voltage is higher than OSC, upper side transistors are OFF and coil current re-circulates lower side transistor. The lower the SET pin voltage is, the more output ON duty will be. Hence, the coil current will be enlarged and motor speed will be faster. Rotation speed is able to feedback by FG output. PWM basic frequency becomes 25 kHz, when putting on C_P=100pF. (See Figure1 Rotation Waveform)

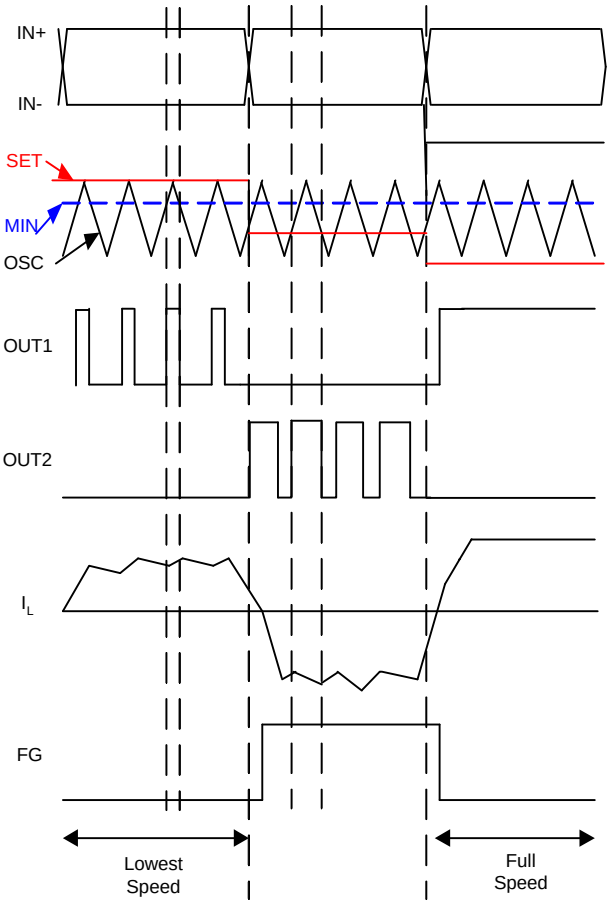


Figure1 Rotation Waveform

Lockup Protection and Automatic Restart

The APX9280 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. As the fan is locked, the charge/discharge circuit will charge the CT capacitor to 3.6V by a 2μA source current for a locked detection time, and then the circuit will switch the capacitor to discharge. During the discharging interval, the output drivers are switched off until the CT voltage is discharged to 1.6V by a 0.2μA sink current, and the circuit will switch the capacitor to charge. During this charging interval, the IC enters the restart time; one output is high and another is low, which makes a torque for fan rotation until the CT voltage is charged to 3.6V by a 2μA source current. If the locked condition still remains, the charge/discharge process will be recurred until the locked condition is released. (See Figure2 Lock/Auto Restart Waveform)

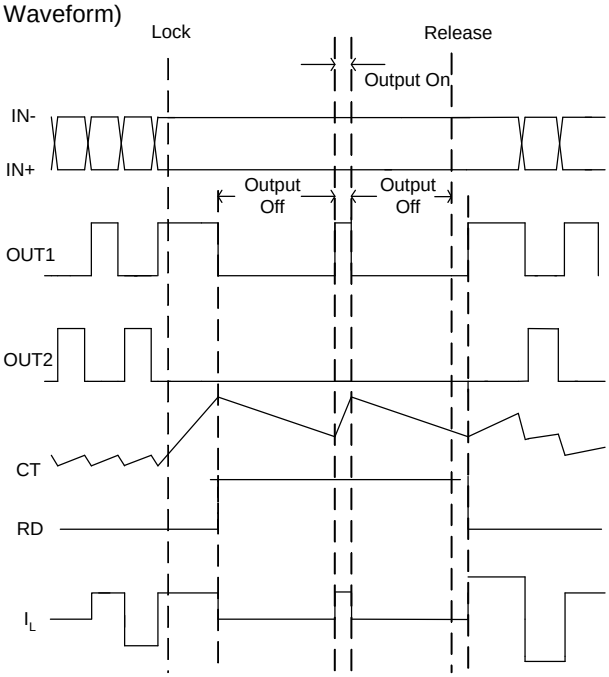


Figure2 Lock/Auto Restart Waveform

Founction Description (Cont.)

Rotation Detection Function

The FG pin is an open collector output, connecting a pull up resistor to a high level voltage for the rotation detection function. When IN- is larger than IN+, the FG is low (switch on); when IN- is smaller than IN+, the FG is high (switch off),and RD pin is also open corrector output. Low level is at rotation mode and High Level is at stop mode. (See Truth Table). Open the terminal when not in using.

Current Limit Function

The APX9280 includes external current-limit circuit which works when SENSE pin voltage is higher than VLIM pin voltage.

$$\text{Limit Current} = \frac{V_{VLIM}}{R_F}$$

where:

V_{VLIM} = VLIM pin voltage

R_F = SENSE pin resistor

For example:

V_{VLIM} = 0.2V, R_F = 0.1Ω

Limit Current = 2A

PCB layout wiring of RF between SENSE pin and external N-MOSFET source pin must to be short to set an accurate limit current value.

Thermal Protection

The APX9280 has thermal protection. When internal junction temperature reaches 160°C, the output devices will be switched off. When the IC's junction temperature cools by 20°C, the thermal sensor will turn the output devices on again, resulting in a pulsed output during continuous thermal protection.

Truth Table

Input				Output						
IN-	IN+	OSC	CT	OUT1P	OUT1N	OUT2P	OUT2N	FG	RD	Mode
H	L	H	L	L	-	-	H	L	L	Rotation (Drive)
L	H			-	H	L	-	OFF	L	
H	L	L		OFF	-	-	H	L	L	Rotation (Re-Circulation)
L	H			-	H	OFF	-	OFF	L	
H	L	-	H	OFF	-	-	H	L	OFF	Lock Mode
L	H			-	H	OFF	-	OFF		

OSC-H corresponds to $V_{OSC}>V_{SET}$ and OSC-L corresponds to $V_{OSC}<V_{SET}$

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Application Information

HB pin & Hall input

1.3V voltage reference is for hall element bias. Being short lines is for noise immunity. Hall input amplifier has 20mV hysteresis. Therefore, we recommend the hall input revel to be 60mV or above.

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}=1μF
Locked Detection Time = 1.7s
Restart Time = 1s
Shutdown Time= 10s
The value of charge capacitor is recommended 0.47μF to 1μF.

FG /RD Resistor

The value of the FG/RD resistor could be calculated by the following equation:

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

For example:
V_{CC}=12V, I_{FG}=5mA, V_{FG}=0.1V, R_{FG}=2.38KΩ
The value of resistor in the range of 1kΩ to 10kΩ is recommended.

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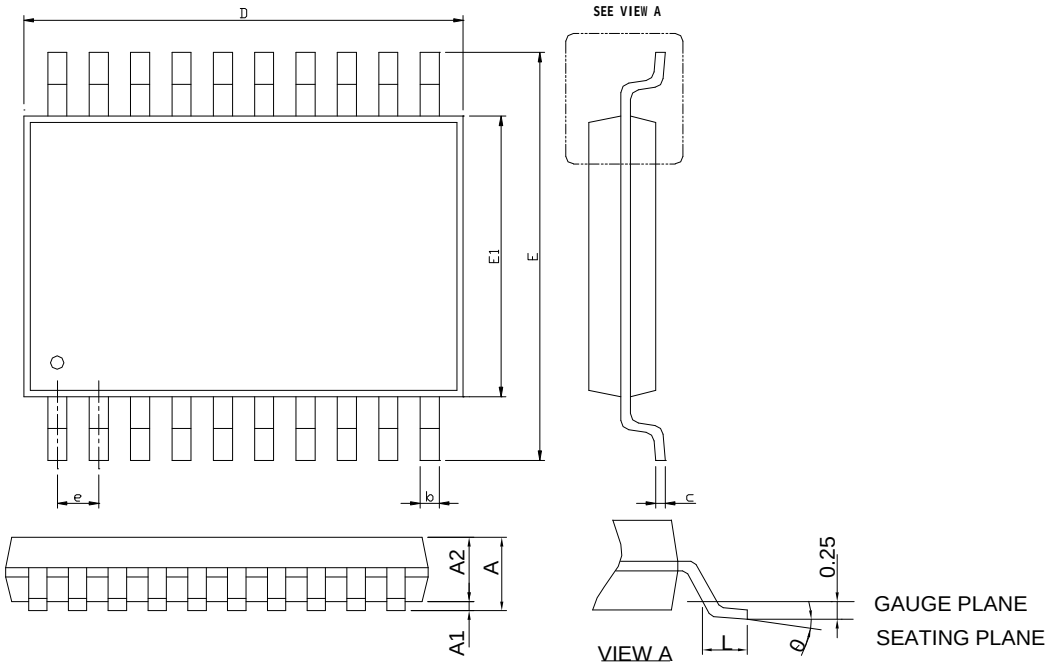
Package Information

TSSOP-20



SYMBOL	TSSOP-20			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.20		0.047
A1	0.05	0.15	0.002	0.006
A2	0.80	1.05	0.031	0.041
b	0.19	0.30	0.007	0.012
c	0.09	0.20	0.004	0.008
D	6.40	6.60	0.252	0.260
E	6.20	6.60	0.244	0.260
E1	4.30	4.50	0.169	0.177
e	0.65 BSC		0.026 BSC	
L	0.45	0.75	0.018	0.030
θ	0°	8°	0°	8°

Note : 1. Follow JEDEC MO-153 AC.

2. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 6 mil per side .

3. Dimension "E1" does not include inter-lead flash or protrusions. Inter-lead flash and protrusions shall not exceed 10 mil per side.

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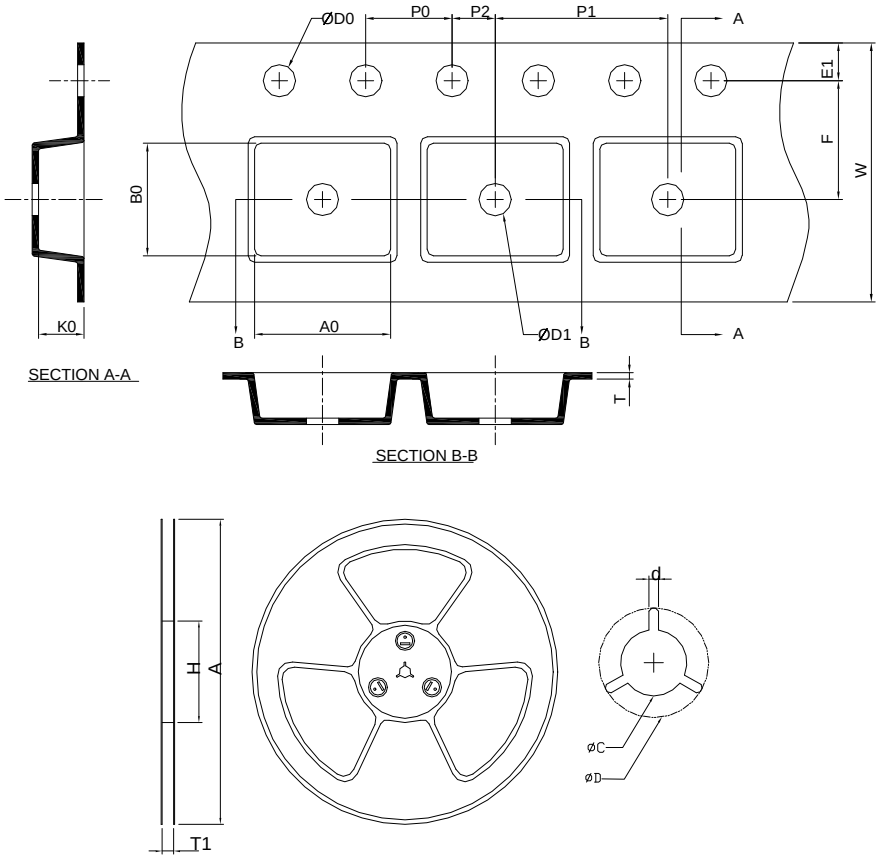
Carrier Tape & Reel Dimensions



Application	A	H	T1	C	d	D	W	E1	F
TSSOP- 20	330.0±2.00	50 MIN.	16.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	16.0±0.30	1.75±0.10	7.50±0.10
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.00±0.10	8.00±0.10	2.00±0.10	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	6.9±0.20	7.10±0.20	1.60±0.20

(mm)

Devices Per Unit

Package Type	Unit	Quantity
TSSOP- 20	Tape & Reel	2000

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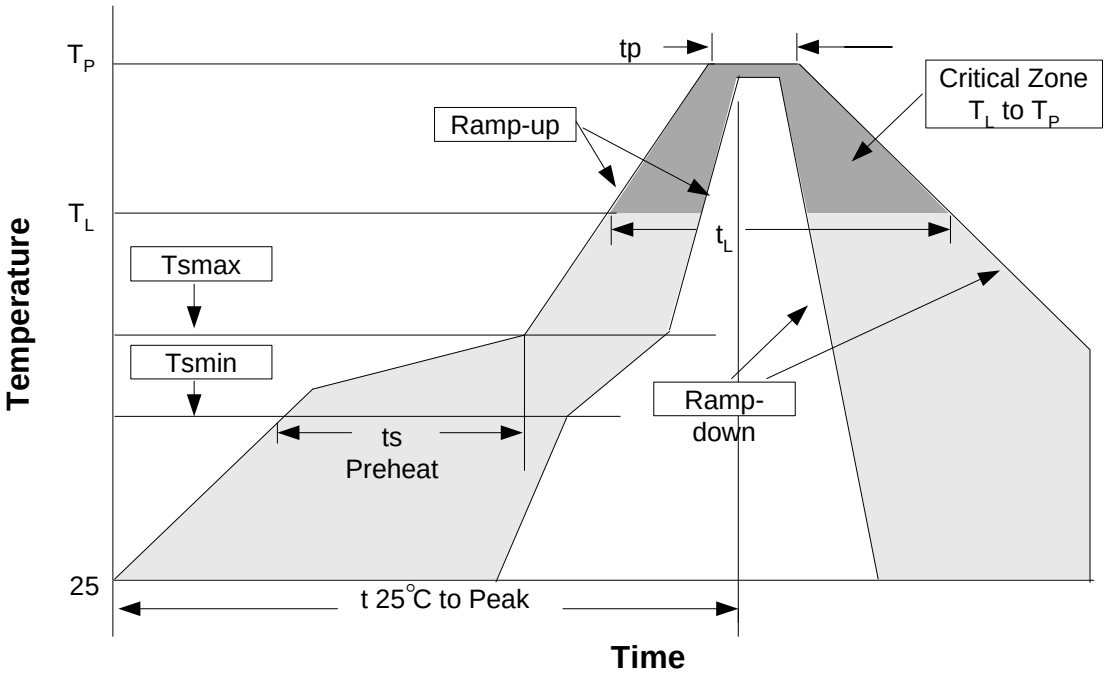
Reflow Condition (IR/Convection or VPR Reflow)



Reliability Test Program

Test item	Method	Description
SOLDERABILITY	MIL-STD-883D-2003	245°C, 5 sec
HOLT	MIL-STD-883D-1005.7	1000 Hrs Bias @125°C
PCT	JESD-22-B, A102	168 Hrs, 100%RH, 121°C
TST	MIL-STD-883D-1011.9	-65°C~150°C, 200 Cycles
ESD	MIL-STD-883D-3015.7	VHBM > 2KV, VMM > 200V
Latch-Up	JESD 78	10ms, 1_{tr} > 100mA

Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Average ramp-up rate (T_L to T_P)	3°C/second max.	3°C/second max.
Preheat - Temperature Min (Tsmin) - Temperature Max (Tsmax) - Time (min to max) (ts)	100°C 150°C 60-120 seconds	150°C 200°C 60-180 seconds
Time maintained above: - Temperature (T_L) - Time (t_L)	183°C 60-150 seconds	217°C 60-150 seconds
Peak/Classification Temperature (Tp)	See table 1	See table 2
Time within 5°C of actual Peak Temperature (tp)	10-30 seconds	20-40 seconds
Ramp-down Rate	6°C/second max.	6°C/second max.
Time 25°C to Peak Temperature	6 minutes max.	8 minutes max.

Notes: All temperatures refer to topside of the package. Measured on the body surface.

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Classification Reflow Profiles (Cont.)

Table 1. SnPb Eutectic Process – Package Peak Reflow Temperatures

Package Thickness	Volume mm^3 <350	Volume mm^3 ³350
<2.5 mm	240 +0/-5°C	225 +0/-5°C
≥2.5 mm	225 +0/-5°C	225 +0/-5°C

Table 2. Pb-free Process – Package Classification Reflow Temperatures

Package Thickness	Volume mm^3 <350	Volume mm^3 350-2000	Volume mm^3 >2000
<1.6 mm	260 +0°C*	260 +0°C*	260 +0°C*
1.6 mm – 2.5 mm	260 +0°C*	250 +0°C*	245 +0°C*
≥2.5 mm	250 +0°C*	245 +0°C*	245 +0°C*
*Tolerance: The device manufacturer/supplier **shall** assure process compatibility up to and including the stated classification temperature (this means Peak reflow temperature +0°C. For example 260°C+0°C) at the rated MSL level.			

Customer Service

Anpec Electronics Corp.
Head Office :
No.6, Dusing 1st Road, SBIP,
Hsin-Chu, Taiwan
Tel : 886-3-5642000
Fax : 886-3-5642050

Taipei Branch :
2F, No. 11, Lane 218, Sec 2 Jhongsing Rd.,
Sindian City, Taipei County 23146, Taiwan
Tel : 886-2-2910-3838
Fax : 886-2-2917-3838

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