APX9370

Three-Phase Sensor-Less Fan Motor Driver

Features

- **Three-Phase Full-Wave Sensor-Less Drive**
- **Low Quiescent Current (6mA Typical)**
- **Built-In External PWM Speed Function**
- **Minimum Speed Setting**
- **Direct PWM Input Speed Control (Circuit 2)**
- **Built-in Current Limit Circuit (2A Typical)**
- **Built-in Lock Protection and Auto Restart Function**
- **Soft Start Function**
- **FG (Rotation Speed Detection) Output**
- **Built-in Thermal Protection Circuit**
- **Lead Free and Green Device Available (RoHS Compliant)**

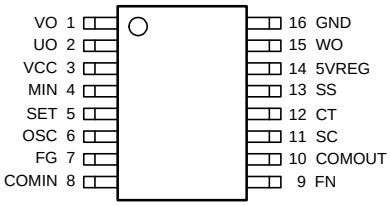
Applications

- **CPU Cooler Fans**
- **Instrumentation Fans**
- **Variable Speed Control Fans**

General Description

The APX9370 is a three phase full wave DC brushless motor driver with PWM variable speed control, current limit and soft start features suitable for the fan of personal computer¡¦s power supply, CPU cooler and server. Adequate SS pin capacitor could reduce the peak current at power on and lock-restart mode. The PWM control system works depending on the comparison among the voltage of SET, MIN, and OSC. The device is equipped with a built-in lock protection, which protects the fan when it is locked. It also has rotation speed detection output and thermal protection function. The APX9370 is available in SSOP-16 package (see Pin Configuration).

Pin Configuration



SSOP-16
(Top View)

Ordering and Marking Information

APX9370 □□□-□□□

- Assembly Material
- Handling Code
- Temperature Range
- Package Code

Package Code
N : SSOP-16
Operating Ambient Temperature Range
I : -40 to 90 °C
Handling Code
TR : Tape & Reel
Assembly Material
G : Halogen and Lead Free Device

APX9370 N : 

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.

Rev. A.1 - Sep., 2013

Absolute Maximum Ratings (Note 1)

Symbol	Parameter	Rating	Unit
V_{CC}	VCC Pin Supply Voltage (VCC to GND)	-0.3 to 18	V
I_{OUT}	OUT1, OUT2 Pin Maximum Output Current	2	A
$V_{UO, VO, WO}$	UO, VO and WO Pin Output Voltage	V_{GND}-0.3 to V_{CC}	V
V_{COMIN}	COMIN Pin Input Voltage	-0.3 to V_{CC}	V
V_{SET}	SET Pin Input Voltage (SET to SGND)	-0.3 to 7	V
V_{MIN}	MINT Pin Input Voltage (MINT to SGND)	-0.3 to 7	V
V_{S-S}	S-S Pin Withstand Voltage (S-S to SGND)	-0.3 to 7	V
V_{FG}	FG Pin Output Voltage	-0.3 to 18	V
I_{FG}	FG Pin Maximum Output Sink Current	10	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
θ_{JA}	Thermal Resistance-Junction to Ambient (Note2) SSOP-16	125	°C/W
P_D	Power Dissipation, T_A=25°C	1	W

Note 2: Mounted on a board (60x38x1.6t mm, Glass epoxy).

Recommended Operating Conditions

Symbol	Parameter	Range	Unit
V_{CC}	VCC Pin Supply Voltage Range	4.5 to 15	V
V_{SET}	SET Pin Input Voltage Range	0 to V_{5VREG}	V
V_{MIN}	MIN Pin Input Voltage Range	0 to V_{5VREG}	V
T_A	Ambient Temperature	-40 to 90	°C
T_J	Junction Temperature	-40 to 125	°C

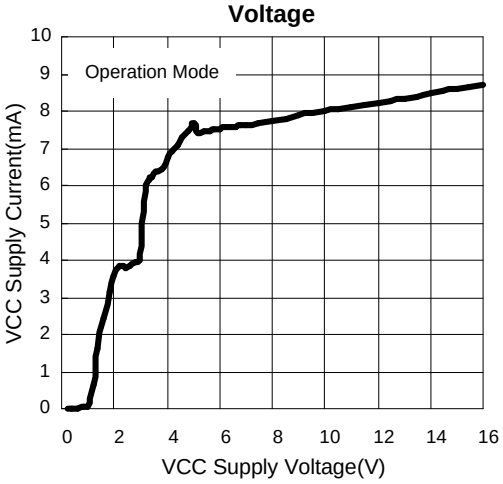
Note 2: Refer to the typical application circuit

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

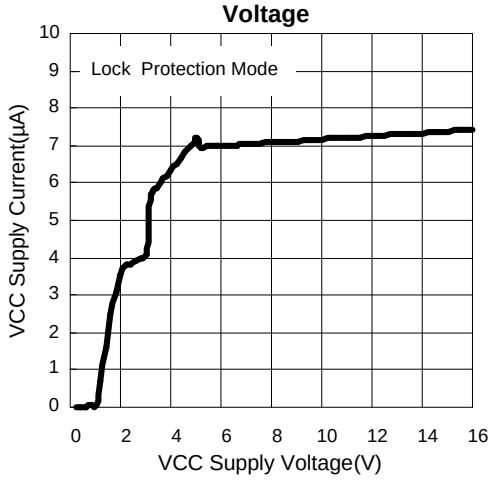
Symbol	Parameter	Test Conditions	APX9370			Unit
			Min.	Typ.	Max.	
SUPPLY CURRENT						
V5VREG	5VREG Pin Output Voltage	I5VREG=5mA	4.75	5	5.25	V
I_{CC1}	Operating Current	Rotation Mode	-	6	10	mA
I_{CC2}		Lock Protection Mode	-	6	10	
OSCILLATOR						
V_{OSCH}	OSC High Level Voltage		3.75	4	4.25	V
V_{OSCL}	OSC Low Level Voltage		0.85	1	1.15	V
I_{OSC1}	OSC Charge Current	V_{OSC} = 0.5V	16	20	24	µA
I_{OSC2}	OSC Discharge Current	V_{OSC} = 4.5V	16	20	24	µA
F_{OSC}	OSC Oscillation Frequency	C_{OSC}=100pF	25	30	35	KHz
LOCK PROTECTION						
V_{CTH}	CT Pin High Level Voltage		2.75	3	3.25	V
V_{CTL}	CT Pin Low Level Voltage		0.85	1	1.15	V
I_{CT1}	CT Charge Current	V_{CT} = 0.5V	1.6	2	2.5	µA
I_{CT2}	CT Discharge Current	V_{CT} = 3.5V	0.16	0.2	0.25	µA
R_{CT}	CT Charge/Discharge Current Ratio	$R_{CT} = I_{CT1}/I_{CT2}$	8	10	12	-
OUTPUT DRIVERS						
V_O	Output Driver Saturation Voltage	I_{OUT} = 800mA, Upper and Lower total	-	0.4	0.5	V
V_{FG}	FG Pin Low Voltage	I_{FG} = 3mA	-	0.2	0.4	V
I_{FGL}	FG Pin Leakage Current	V_{FG} = 12V	-	<0.1	1	µA
CURRENT-LIMIT AND SOFT-START						
I_{LIM}	Output Current Limit		-	2000	-	mA
I_{S-S}	S-S Pin Charge Current	V_{S-S} = 3V	-	0.5	-	µA
THERMAL PROTECTION						
	Thermal Protection Temperature		-	165	-	°C
	Thermal Protection Hysteresis		-	25	-	

Typical Operating Characteristics

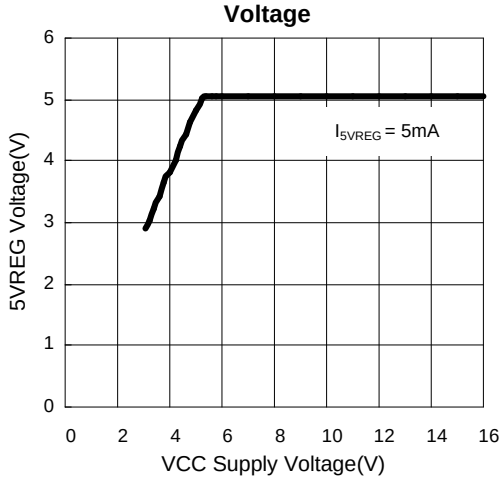
VCC Supply Current vs. VCC Supply Voltage



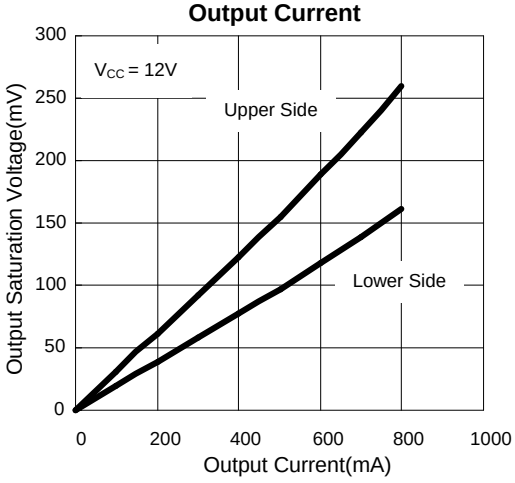
VCC Supply Current vs. VCC Supply Voltage



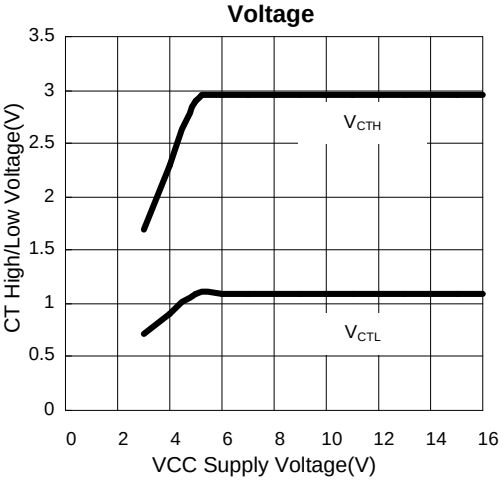
5VREG Voltage vs. VCC Supply Voltage



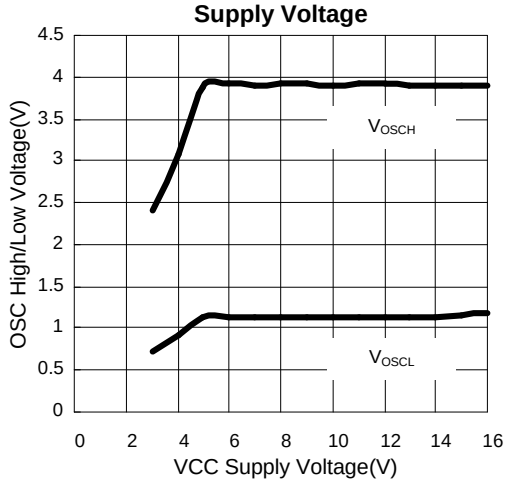
Output Saturation Voltage vs. Output Current



CT High/Low Voltage vs. VCC Supply Voltage

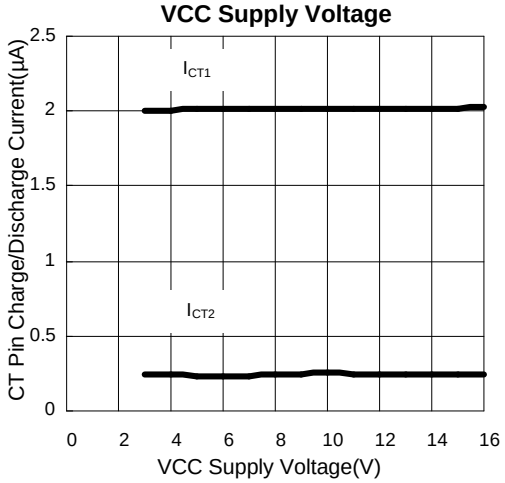


OSC High/Low Voltage vs. VCC Supply Voltage

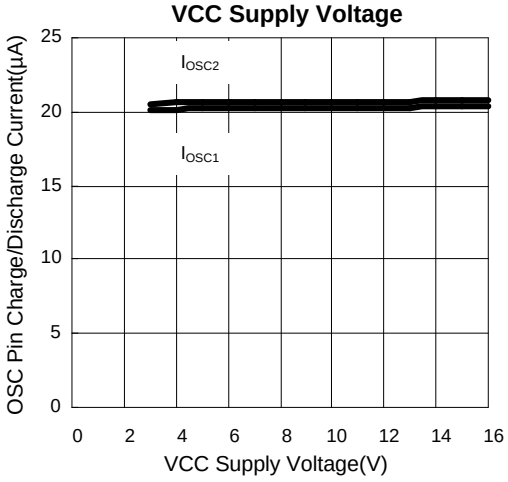


Typical Operating Characteristics

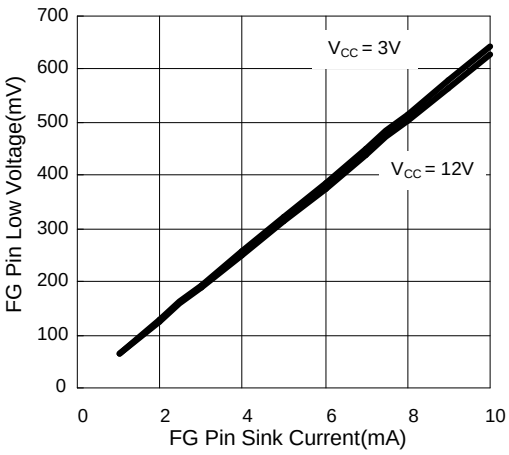
CT Pin Charge/Discharge Current vs. VCC Supply Voltage



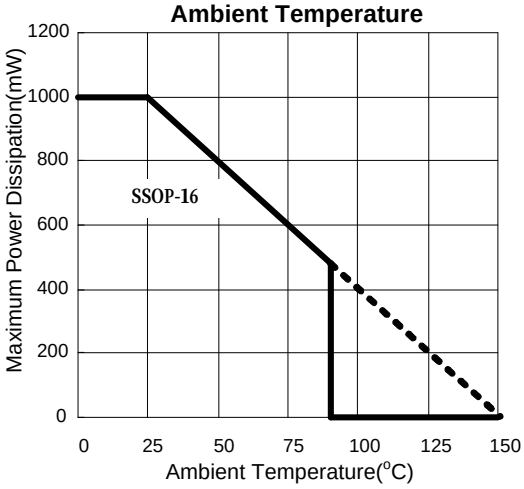
OSC Pin Charge/Discharge Current vs. VCC Supply Voltage



FG Pin Low Voltage vs. Sink Current



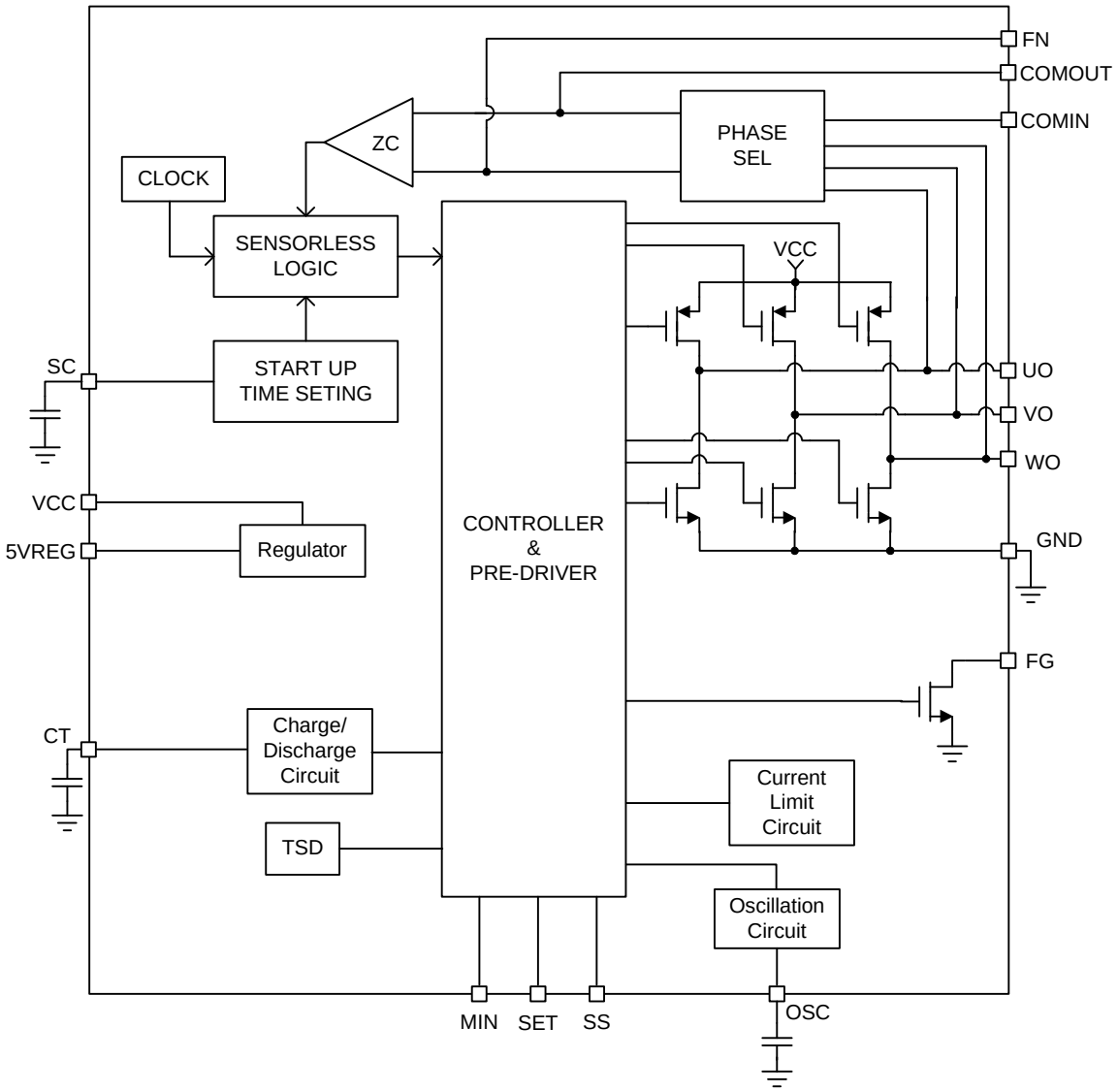
Maximum Power Dissipation vs. Ambient Temperature



Pin Description

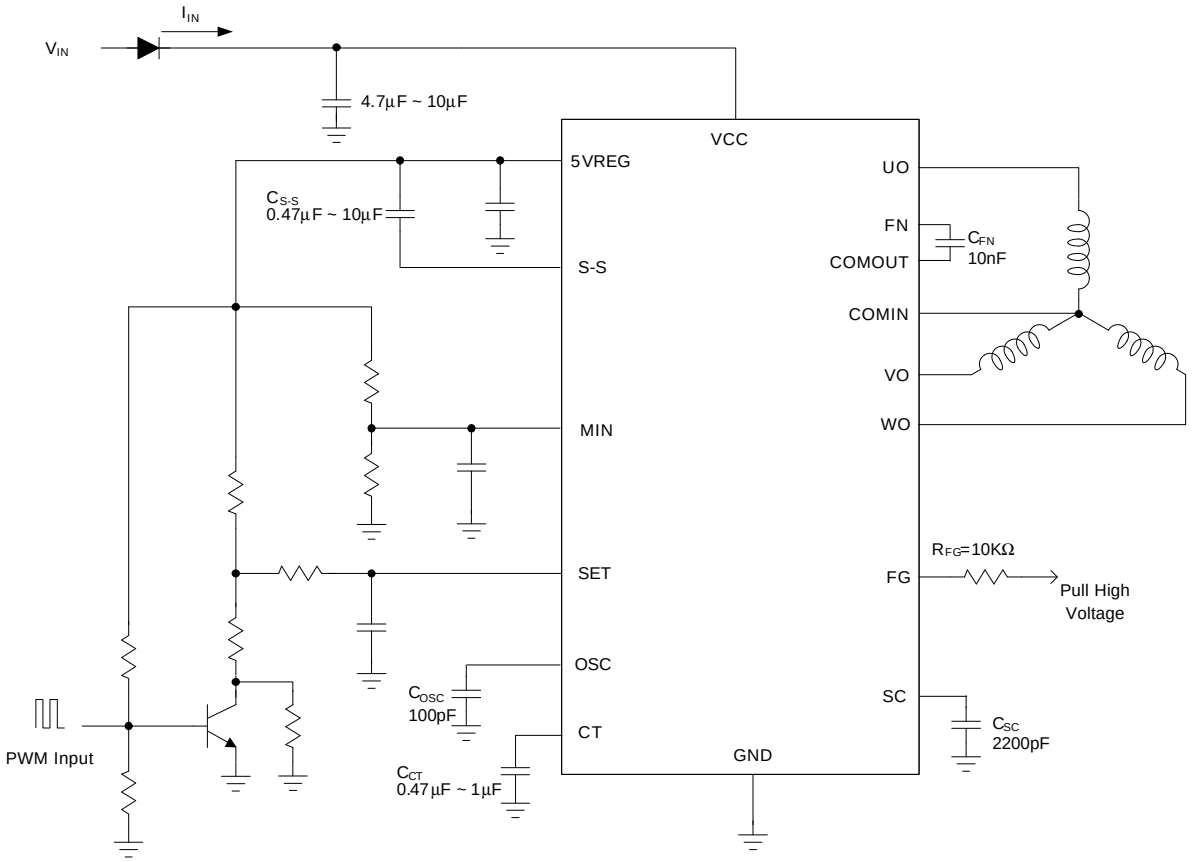
PIN		FUNCTION
NO.	NAME	
1	VO	Driver Output Pin. Output signal for driving motor phase V.
2	UO	Driver Output Pin. Output signal for driving motor phase U.
3	VCC	Supply Voltage Input Pin.
4	MIN	Minimum Speed Setting. Use a voltage divider from VCC to set MIN pin voltage for setting minimum speed of fan.
5	SET	Speed Setting. An external voltage into SET pin to set fan speed.
6	OSC	Oscillator Frequency Setting. Connect a capacitor to GND to set oscillation frequency.
7	FG	Rotation Speed Output. This is an open-drain output.
8	COMIN	MOTOR Neutral Point Input Pin.
9	FN	Motor Floating Terminal Voltage Output Pin.
10	COMOUT	MOTOR Neutral Point Signal Output Pin.
11	SC	Start-up Commutation Time Setting. Connect a capacitor to GND to set start-up commutation time.
12	CT	Shutdown Time and Restart Time Setting. Connect a capacitor to SGND to set shutdown time and restart time in lock mode.
13	S-S	Soft-Start Time Setting. Connect a capacitor to 5VREG to set soft-start time to reduce the large current at power on and lock mode.
14	5VREG	5V Regulator Output. This is a 5V constant-voltage output for application circuit biases.
15	WO	Driver Output Pin. Output signal for driving motor phase W.
16	GND	Power GND.

Block Diagram



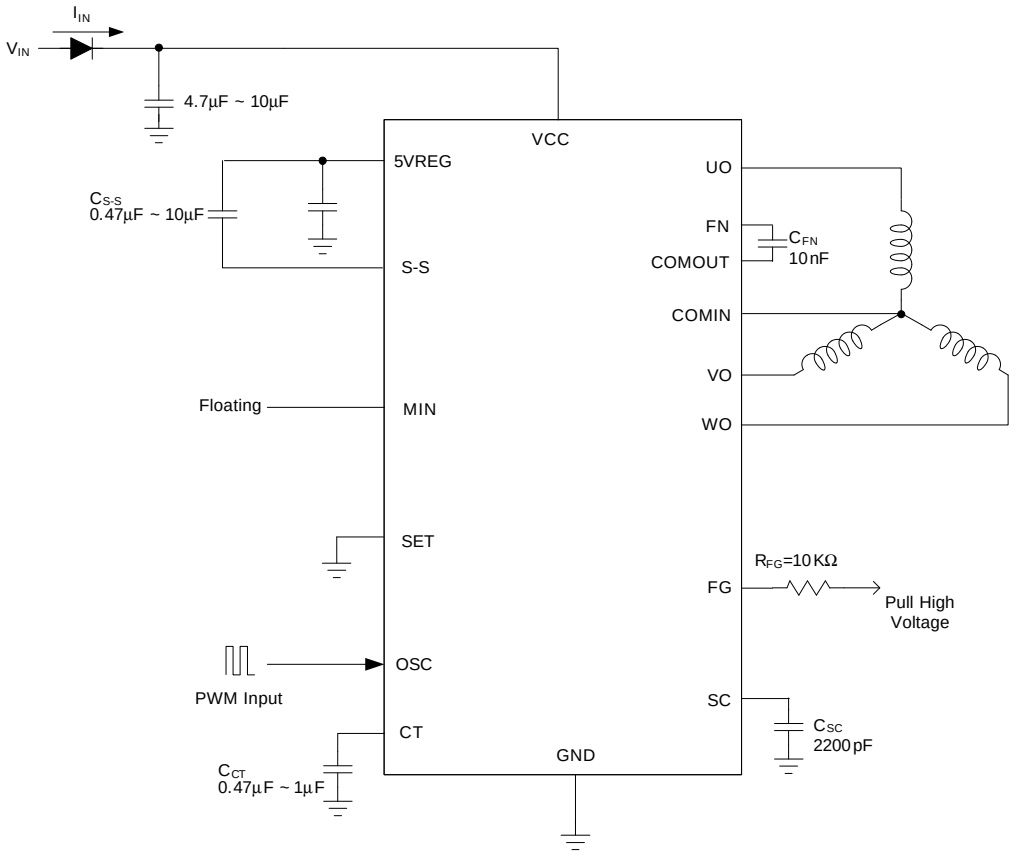
Typical Application Circuit

Circuit 1: Voltage Input PWM Speed Control



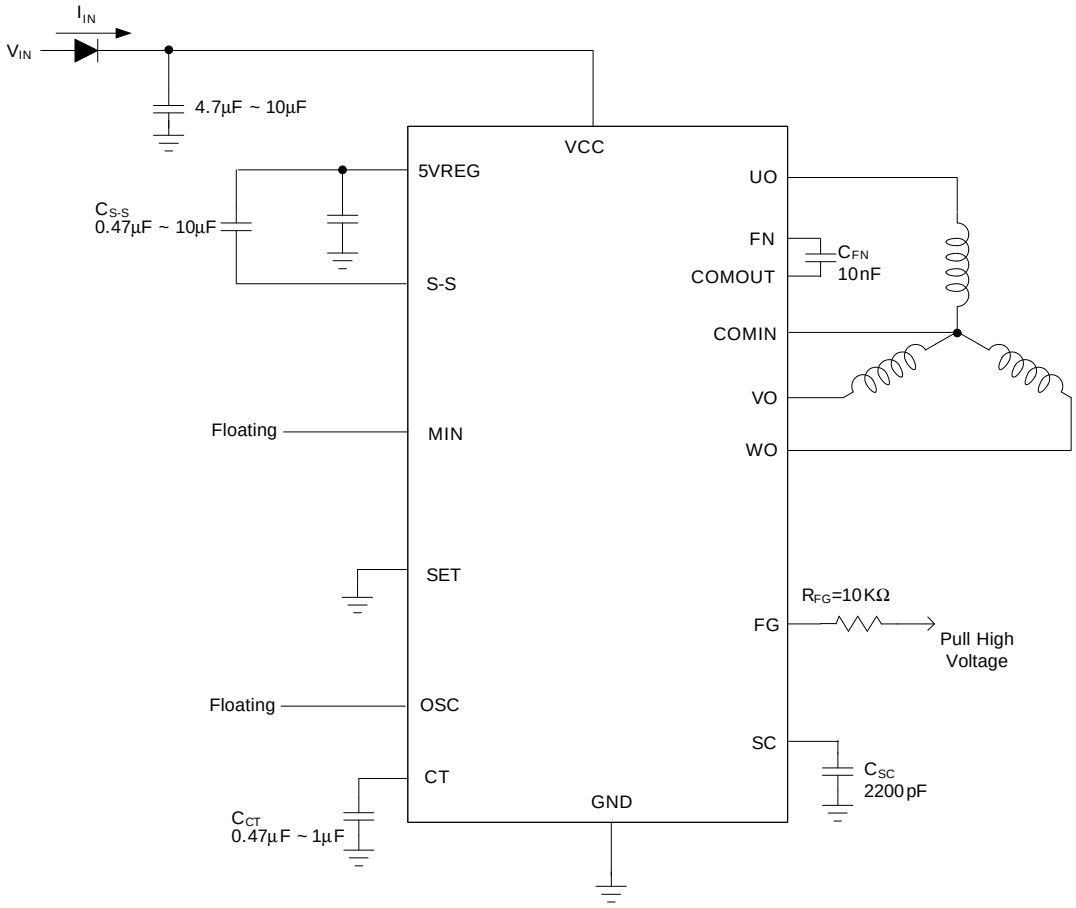
Typical Application Circuit (Cont.)

Circuit 2: Direct PWM Input Speed Control



Typical Application Circuit (Cont.)

Circuit 3: VCC speed control



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.

$$\text{Locked Detection Time} = \frac{C_{CT} \times (V_{CTH} - 0.2V)}{I_{CH1}}$$

$$\text{Restart Time} = \frac{C_{CT} \times (V_{CTH} - V_{CTL})}{I_{CH1}}$$

$$\text{Shutdown Time} = \frac{C_{CT} \times (V_{CTH} - V_{CTL})}{I_{CH2}}$$

Where:

C_{CT} = CT pin capacitor

For example:

$V_{CC} = 12V, C_{CT} = 1uF$
Locked Detection Time = 1.4s
Restart Time = 1s
Shutdown Time = 10s

The value of charge capacitor is recommended from 0.47µF to 1µF.

FG Resistor

The value of the FG resistor could be decided by the following equation:

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

For example:

V_{DC} = 5V, I_{FG} = 3mA, V_{FG} = 0.2V, R_{FG} = 1.6kΩ

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

COMOUT and FN pins

The APX9370 detects the BEMF generated when the motor is running to obtain the position information.
Inserting a capacitor (reference value 10nF) between pins COMOUT and FN is useful to reduce the noise which may result in the wrong position information. However, it should take care a extremely high capacitance will cause delays and decrease the efficiency, This condition is obvious when the motor is running at high speed.In addition, the path between the capacitor and those two pins should be as short as possible to avoid the noise from other sources.

S-S Capacitor

The capacitor that is connected from S-S pin to 5VREG determines the soft start time.

Case 1 : $V_{OSCL} < V_{SET} < V_{MIN}$

$$\text{Soft Start Time} = \frac{C_{S-S} \times (V_{OSCH} - V_{SET})}{I_{S-S}}$$

where:
C_{S-S} = S-S pin capacitor
For example:
V_{CC}=12V, V_{OSCH}=4V, V_{OSCL}=1V, V_{SET}=1.4V, I_{S-S}=0.5µA, C_{S-S}=1µF
Soft Start Time = 5.2s

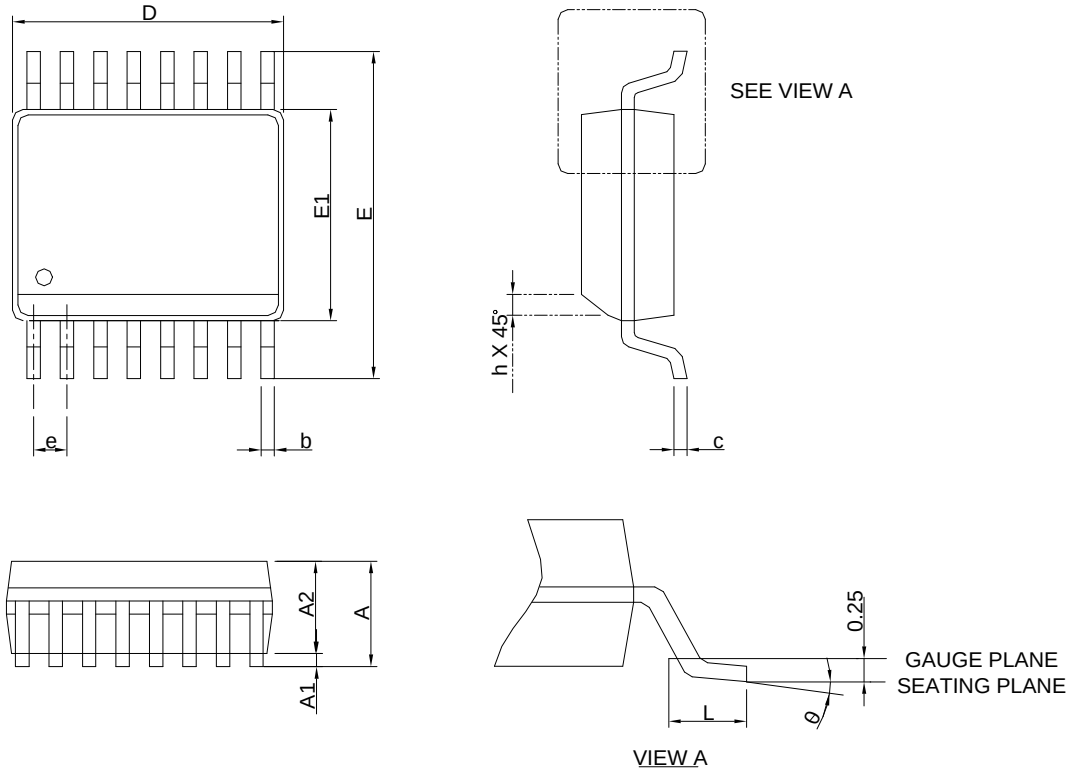
Case 2 : $V_{SCT} < V_{OSCL} < V_{MIN}$

$$\text{Soft Start Time} = \frac{C_{S-S} \times (V_{OSCH} - V_{OSCL})}{I_{S-S}}$$

For example:
V_{CC}=12V, V_{OSCH}=4V, V_{OSCL}=1V, V_{SET}=0.5V, I_{S-S}=0.5µA, C_{S-S}=1µF
Soft Start Time = 6s
The value of S-S pin capacitor is recommended 0.47µF to 10µF. The choices of CT pin and S-S pin capacitors should be considered that fan must start up during restart time at lock mode. When the C_{CT} is determined and the fan can?t start up at power-on or lock-restart mode, decrease the C_{S-S} capacitance can let the fan start up successfully but it will reduce the soft start time.

Package Information

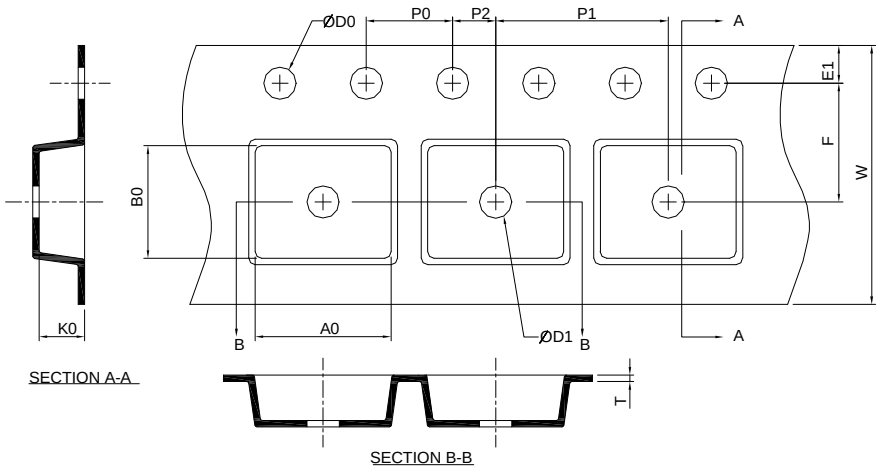
SSOP-16

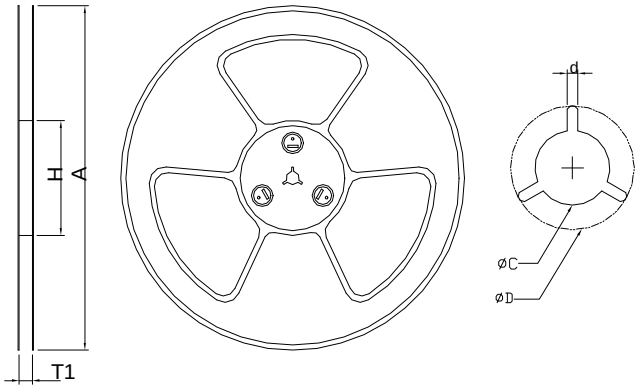


SYMBOL	SSOP-16			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.75		0.069
A1	0.10	0.25	0.004	0.010
A2	1.24		0.049	
b	0.20	0.30	0.008	0.012
c	0.15	0.25	0.006	0.010
D	4.80	5.00	0.189	0.197
E	5.80	6.20	0.228	0.244
E1	3.80	4.00	0.150	0.157
e	0.635 BSC		0.025 BSC	
L	0.40	1.27	0.016	0.050
h	0.25	0.50	0.010	0.020
θ	0°	8°	0°	8°

Note : 1. Follow JEDEC MO-137 AB.
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 "E" does not include inter-lead flash or protrusions. Inter-lead flash and protrusions shall not exceed 10 mil per side.

Carrier Tape & Reel Dimensions





Application	A	H	T1	C	d	D	W	E1	F
SSOP-16	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	5.50±0.10
	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	6.40±0.20	5.20±0.20	2.10±0.20

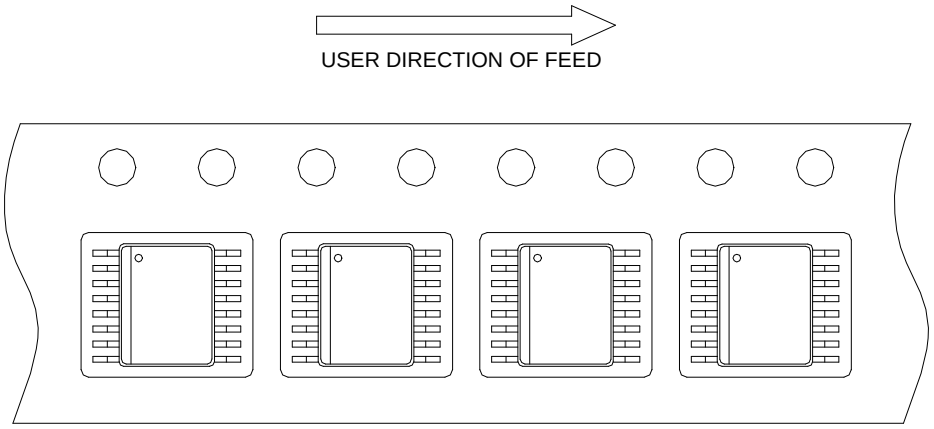
(mm)

Devices Per Unit

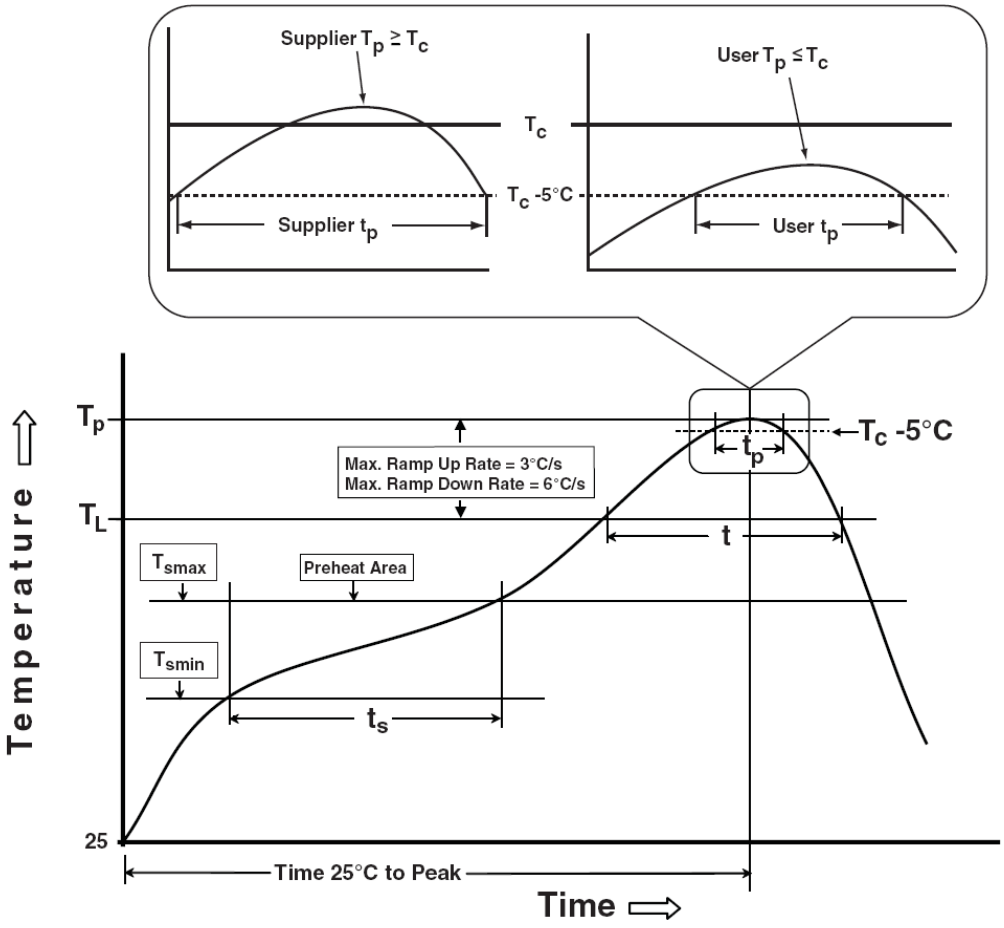
Package Type	Unit	Quantity
SSOP- 16	Tape & Reel	2500

Taping Direction Information

SSOP-16



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^3 350
<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