High Efficency Two Slope Fan Voltage Convertor

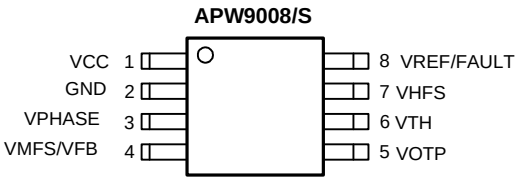
Features

- **Switching Topology to Save The Power Loss**
- **Programmable Two Level Slope Fan Curve**
- **Sleep Mode to Turn Off FAN and Reduce Power Loss**
- **APW9008S : Sleep Mode**
- **APW9008 : No Sleep Mode**
- **Programmable Minimum Fan Speed**
- **Programmable OTP Point**
- **NTC Open Protection**
- **Full Fan Control at Initial Power On**
- **OTP Easy to Shutdown Power**
- **SOP-8 Package**
- **Lead Free and Green Devices Available (RoHS Compliant)**

Applications

- **PC power supply**
- **Fan control**

Pin Configuration



SOP-8 (Top View)

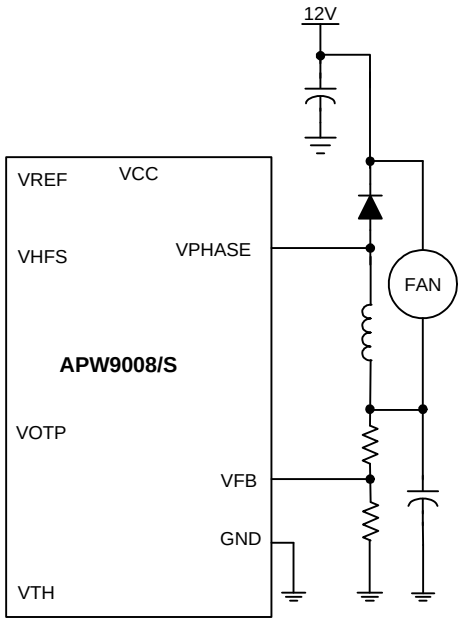
General Description

The APW9008/S is designed for programming the curve of DC fan speed versus temperature via a NTC thermistor. The APW9008/S integrates many functions.

A Power-On-Reset circuit monitors VCC pin to prevent erroneous operations. The sleep mode can turn off fan to reduce power loss, and it can be released. The function of current limit and NTC open protection protect the device against current over load and NTC open. The speed curve in APW9008/S can be programmed to accelerate when temperature over the setting point.

The APW9008/S is available in a SOP-8 package.

Simplified Application Circuit

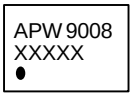


Ordering and Marking Information

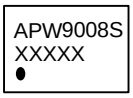
APW9008 □□-□□□
APW9008S

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

Package Code
K : SOP-8
Operating Ambient Temperature Range
I : -40 to 85 °C
Handling Code
TR : Tape & Reel
Assembly Material
G : Halogen and Lead Free Device

APW9008 K: 

X- Date Code

APW9008S K: 

X- 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 (Note 1)

Symbol	Parameter	Rating	Unit
V_{CC}	V_{CC} to GND Voltage	-0.3 ~ 16	V
V_{REF}/V_{FAULT}	V_{REF}/V_{FAULT} to GND Voltage	-0.3 ~ 7	V
V_{TH}	V_{TH} to GND Voltage	-0.3 ~ 7	V
V_{HFS}	V_{HFS} to GND Voltage	-0.3 ~ 7	V
V_{OTP}	V_{OTP} to GND Voltage	-0.3 ~ 7	V
V_{PHASE}	V_{PHASE} to GND Voltage	-0.3 ~ 16	V
V_{MFS}/V_{FB}	V_{FB} to GND Voltage	-0.3 ~ 16	V
T_J	Maximum Junction Temperature	-40 ~ 150	°C
T_{STG}	Storage Temperature	-65 ~ 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}	Junction-to-Ambient Resistance in Free Air (Note 2) SOP-8	130	°C/W

Note 2: θ_{JA} is measured with the component mounted on a high effective thermal conductivity test board in free air.

Recommended Operating Conditions (Note 3)

Symbol	Parameter	Range	Unit
V_{CC}	V_{CC} to GND Voltage	10.8~13.2	V
V_{TH}	V_{TH} to GND Voltage	0~6.5	V
V_{HFS}	V_{HFS} to GND Voltage	0~6.5	V
V_{OTP}	V_{OTP} to GND Voltage	0~6.5	V
T_A	Ambient Temperature	-40~85	°C
T_J	Junction Temperature	-40~125	°C

Note 3 : Refer to the typical application circuit.

Electrical Characteristics

Unless otherwise specified, these specifications apply over V_{cc}=12V and T_A=25°C.

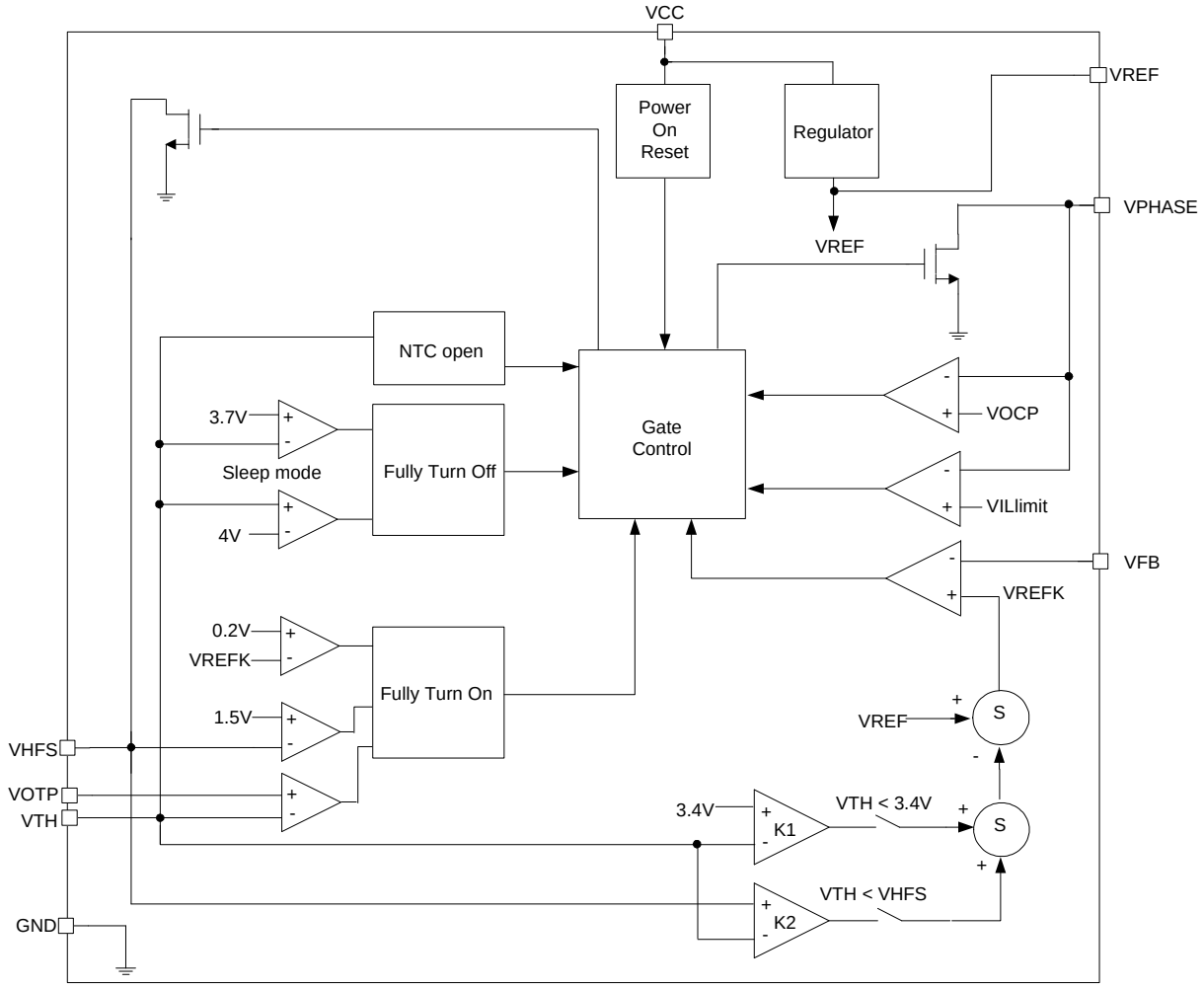
01Symbol	Parameter	Test Conditions	APW9008			Unit
			Min.	Typ.	Max.	
SUPPLY CURRENT AND POWER ON RESET						
I_{VCC}	V_{CC} Operation Current	No Switching(VREF floating)	0.95	-	1.3	mA
	Rising V_{CC} Threshold		9.3	9.8	10.3	V
	Falling V_{CC} Threshold		8	8.4	8.8	V
POWER MOSFET and PWM CONTROL						
R_{DS}	Internal MOSFET On Resistance		-	400	-	mΩ
	Maximum On Time		10.5	12.5	14.5	μs
	Minimum Off Time		-	140	-	ns
	Current Limit Level		-	0.8	-	A
	Over Current Protection		-	2	-	A
REGULATOR						
V_{REF}	Regulator V_{REF} Output Voltage	I(VREF)=2mA	6.3	6.45	6.6	V
FAN CONTROL						
	Factor K1 Of V_{REF}		1.45	1.6	1.75	
	Factor K2 Of V_{REF}		12.5	15.5	18.5	
	V_{TH} Enter Sleep Mode Voltage	APW9008S only	3.85	4	4.1	V
	V_{TH} Release Sleep Mode Voltage	APW9008S only	3.55	3.7	3.85	V
	Max Fan Speed Threshold Voltage	V_{HFS} Voltage	1.4	1.5	1.7	V
		V_{TH} Voltage(NTC Open)	97.3	98.2	99.1	%V_{REF}
	NTC Open Function Disable(Note4)		-	-5	-	°C

Note 4: Guaratee by design, not product test.

Pin Description

PIN		FUNCTION
NO.	NAME	
1	VCC	Power Supply Input
2	GND	GND
3	VPHASE	Switching Node
4	VMFS/VFB	Minimum Fan Speed Setting and Feedback Input Pin
5	VOTP	Over Temperature Trip Point
6	VTH	Temperature Sensor (NTC Thermistor) Input
7	HFS	High Fan Speed Setting Pin
8	VREF/FAULT	Regulator Output Pin and FAULT indicator.

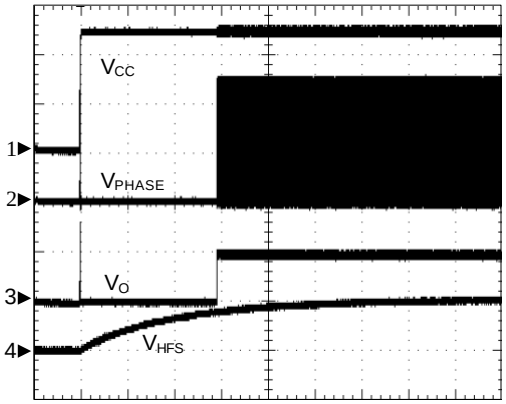
Block Diagram



Operating Waveforms

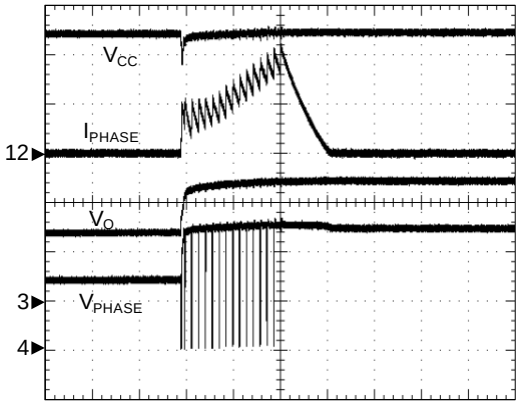
Refer to the typical application circuit. The test condition is V_{CC}=12V, T_A= 25°C unless otherwise specified.

Power On



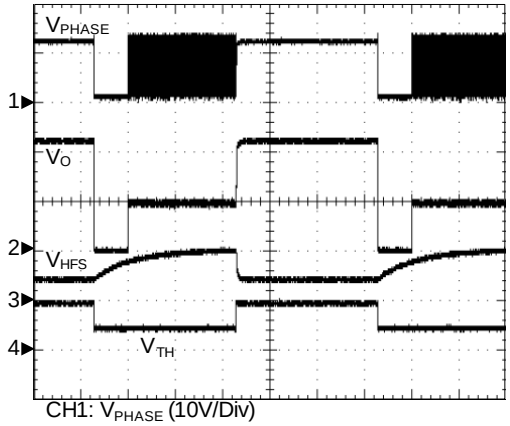
CH1: V_{CC} (5V/Div)
CH2: V_{PHASE} (5V/Div)
CH3: V_O (5V/Div)
CH4: V_{HFS} (2V/Div)
Time: 400ms/Div

OCP



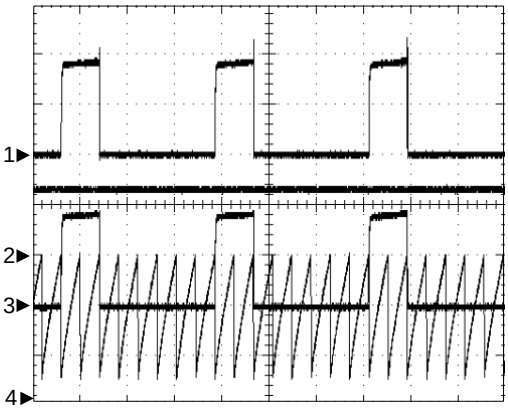
CH1: V_{CC} (5V/Div)
CH2: I_{PHASE} (1A/Div)
CH3: V_O (5V/Div)
CH4: V_{PHASE} (5V/Div)
Time: 20us/Div

Sleep Mode



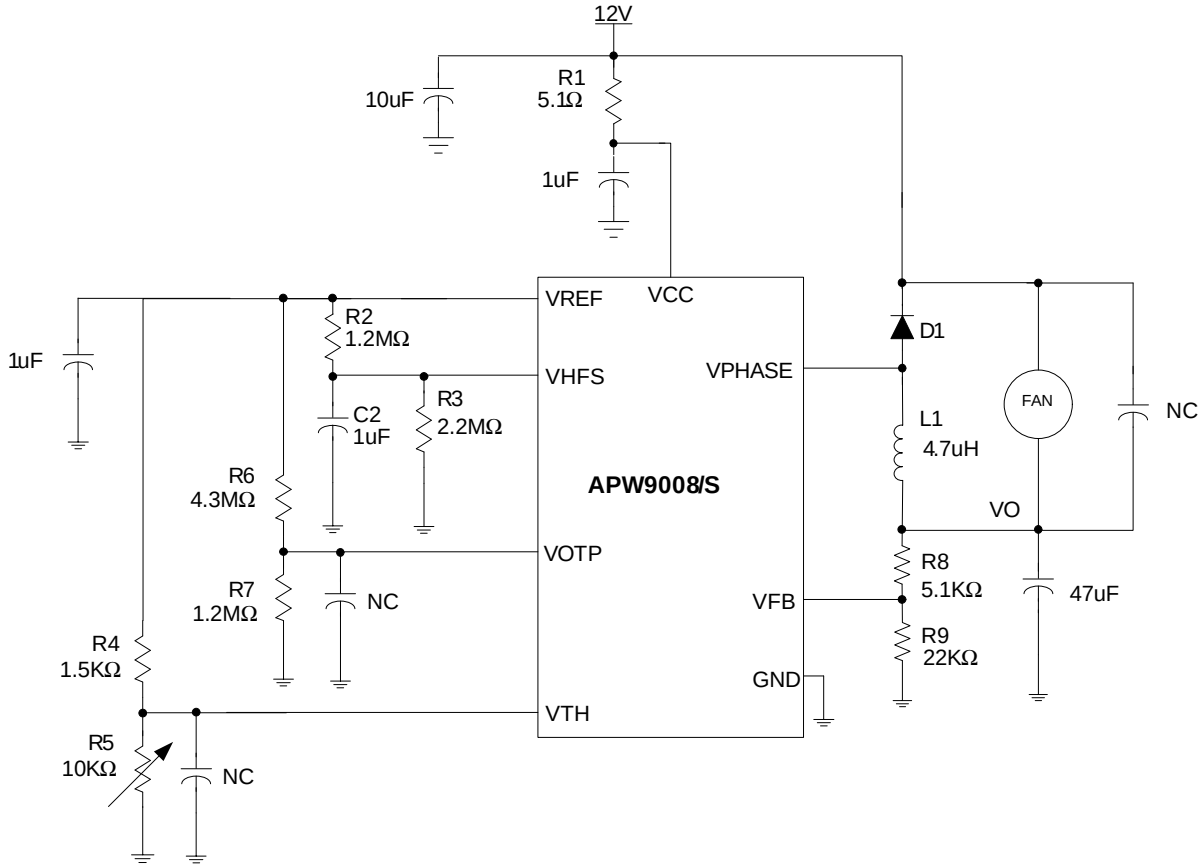
CH1: V_{PHASE} (10V/Div)
CH2: V_O (5V/Div)
CH3: V_{HFS} (2V/Div)
CH4: V_{TH} (5V/Div)
Time: 1s/Div

NTC Open



CH1: V_{PHASE} (5V/Div)
CH2: V_{TH} (5V/Div)
CH3: V_O (5V/Div)
CH4: V_{HFS} (0.5V/Div)
Time: 1s/Div

Typical Application Circuit



Function Description

VCC Power-On-Reset (POR)

The APW9008/S keeps monitoring the voltage on VCC pin to prevent wrong logic operations which may occur when VCC voltage is not high enough for internal control circuit to operate. The VCC POR rising threshold is 9.8V. During startup, the VCC voltage must exceed the POR threshold.

Over Current Protection (OCP)

The APW9008/S provides over current protection function (OCP). This event will shutdown the IC when current > 2A and need POR to restart. It prevents the IC from damaging when overload.

The Sleep Mode

The APW9008/S provides sleep mode to reduce power loss at light load. Before entering the sleep mode, fan is at minimum speed when V_{TH} reaches 3.4V. The sleep mode turns off fan during V_{TH}>4V. and wakes up until V_{TH} <3.7V again.

The NTC Mode

The APW9008S provides NTC mode to check if the NTC resistor connect correctly or not. If NTC resistor open, V_{TH} is close to V_{REF}. When $|V_{TH}-V_{REF}|$ <1.8% V_{REF}, VHFS pin discharge by internal MOSFET to 0.2V, and charge to 1.5V during the NTC mode. After several times, VPHASE pin discharge by internal MOSFET to 0, the fan is at max fan speed, and VHFS pin keep on charging and discharging. After next several times, MOSFET in VPHASE close, the fan is close. VHFS pin and VPHASE pin repeat this action until the APW9008S is not in the NTC mode. The fan operate different speed in the NTC mode, and according to the fan speed, it can be seen that APW9008S is in the NTC mode or not.

The Max Fan Speed

The APW9008/S has two way to let fan operate in maximum fan speed. One is at the OTP mode, during V_{TH} <V_{OTP}, the fan is at maximum speed and the IC need POR to restart. The other one is at V_{HFS} < 1.5V, the fan speed is recovery until V_{HFS}>1.5V.

Application Information

Knee Point

The fan speed has two slopes at a specific temperature named knee point. The knee point can be changed by the resistors in series with the pin VREF. The knee point voltage(V_{HFS}) is decided by a voltage divider.

$$V_{HFS} = V_{REF} \times \frac{R3}{R1+R3}$$

The Slope Of (V_{CC}-V_O) VS. V_{TH}

By adjusting V_{TH} and V_{HFS}, the IC can provide different V_O (See Figure 1.). The V_O is calculated as follows:

$$V_O = V_{FB} \times \frac{R8+R9}{R9}$$

The V_{FB} is calculated as follows:

$$V_{FB} = V_{REF} - K1 \times V1 - K2 \times V2$$

Where V1= 3.4-V_{TH}, V2=V_{HFS}-V_{TH}, and V1 and V2 must equal or larger than 0V

The V_{OTP} is calculated as follows:

$$V_{OTP} = V_{REF} \times \frac{R7}{R6+R7}$$

The V_{TH} is calculated as follows:

$$V_{TH} = V_{REF} \times \frac{R5}{R4+R5}$$

Input Capacitor Selection

The input capacitor is chosen based on the voltage rating and the RMS current rating. For reliable operation, select the capacitor voltage rating to be at least 1.3 times higher than the maximum input voltage. A 1µF ceramic bypass capacitor from V_{CC} to GND, located near the APW9008/S, is strongly recommended to suppress the ringing. Without the bypass capacitor, the output short may cause suffucuent ringing on the input (from supply lead inductance) to damage internal control circuitry.

Output Capacitor Selection

The higher capacitor value provides the lowest output voltage ripple. Ceramic capacitors with low ESR values are recommended, and the voltage rating of the output capacitors also must be considered.

Inductor Selection

The inductor value determines the V_O ripple and the switching frequency. A smaller inductor will give the smaller VO ripple, but increase switching frequency, so it will increase the switching loss of the MOSFET and the power dissipation of the APW9008/S, a tradeoff will exist between VO ripple and switching loss depending on applications.

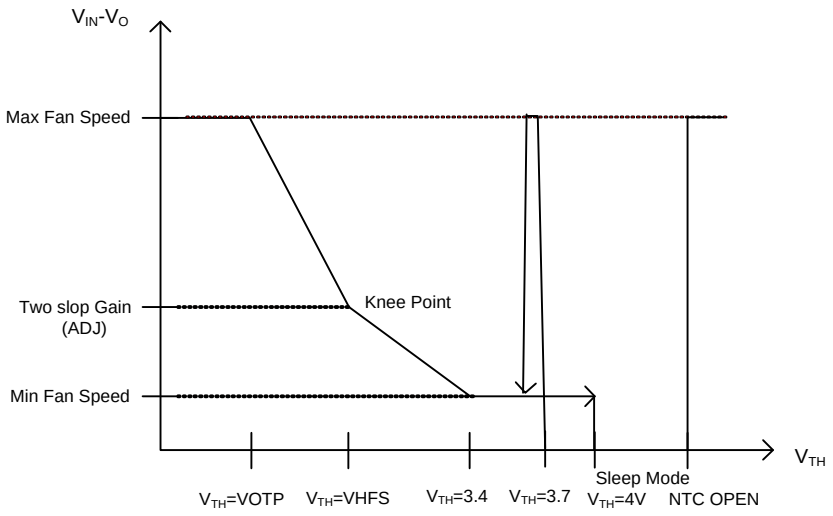
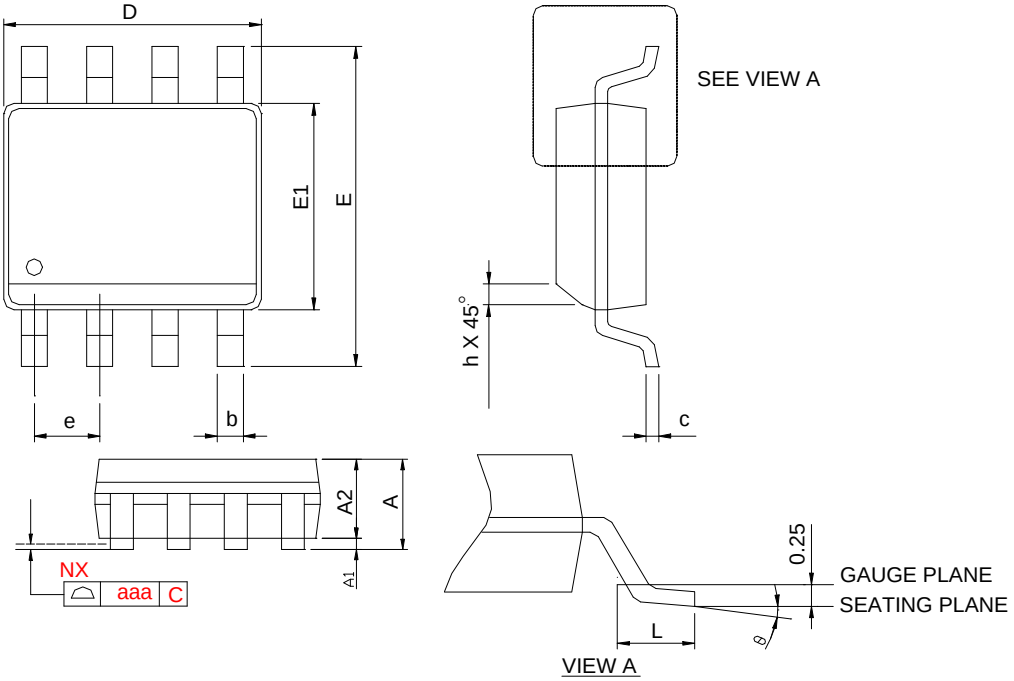


Figure 1. V_{CC}-V_O VS. V_{TH}

Package Information

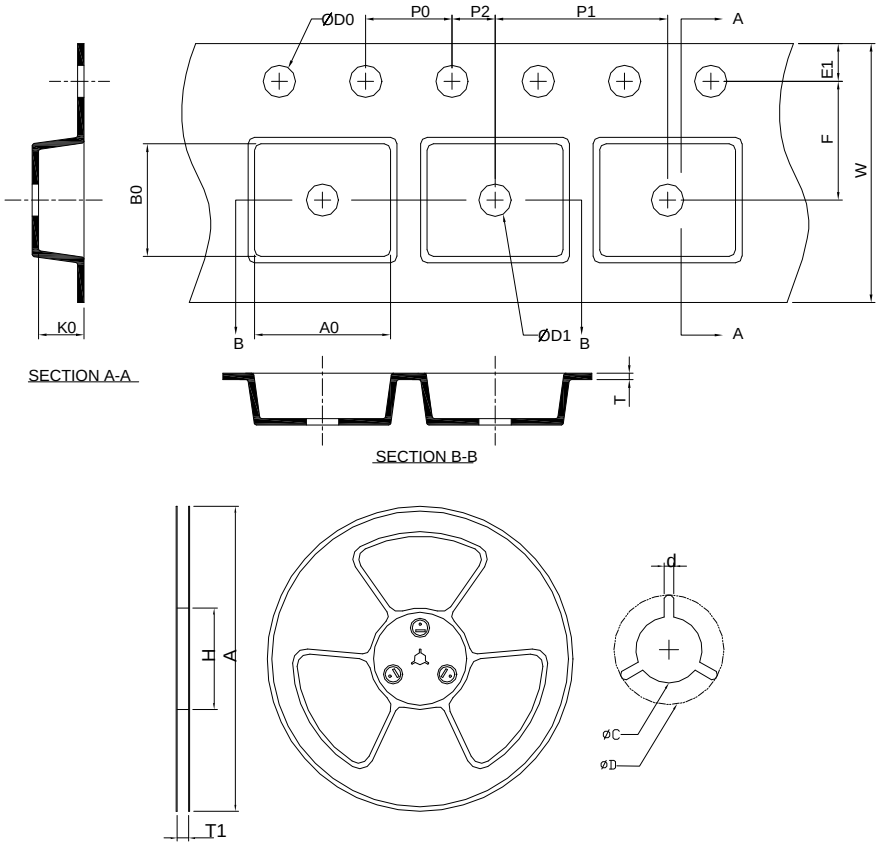
SOP-8



SYMBOL	SOP-8			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.75		0.069
A1	0.10	0.25	0.004	0.010
A2	1.25		0.049	
b	0.31	0.51	0.012	0.020
c	0.17	0.25	0.007	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	1.27 BSC		0.050 BSC	
h	0.25	0.50	0.010	0.020
L	0.40	1.27	0.016	0.050
θ	0°	8°	0°	8°
aaa	0.10		0.004	

Note: 1. Follow JEDEC MS-012 AA.
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
SOP-8	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	6.40±0.20	5.20±0.20	2.10±0.20

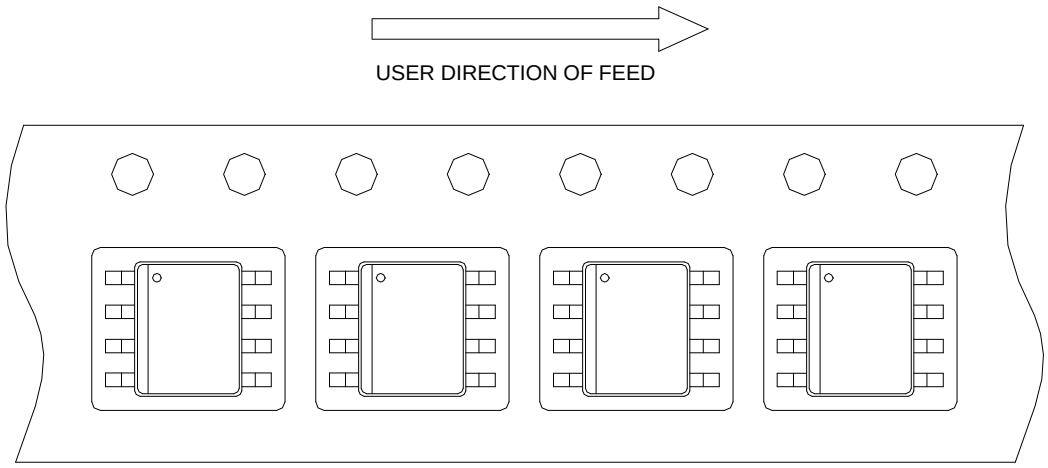
(mm)

Devices Per Unit

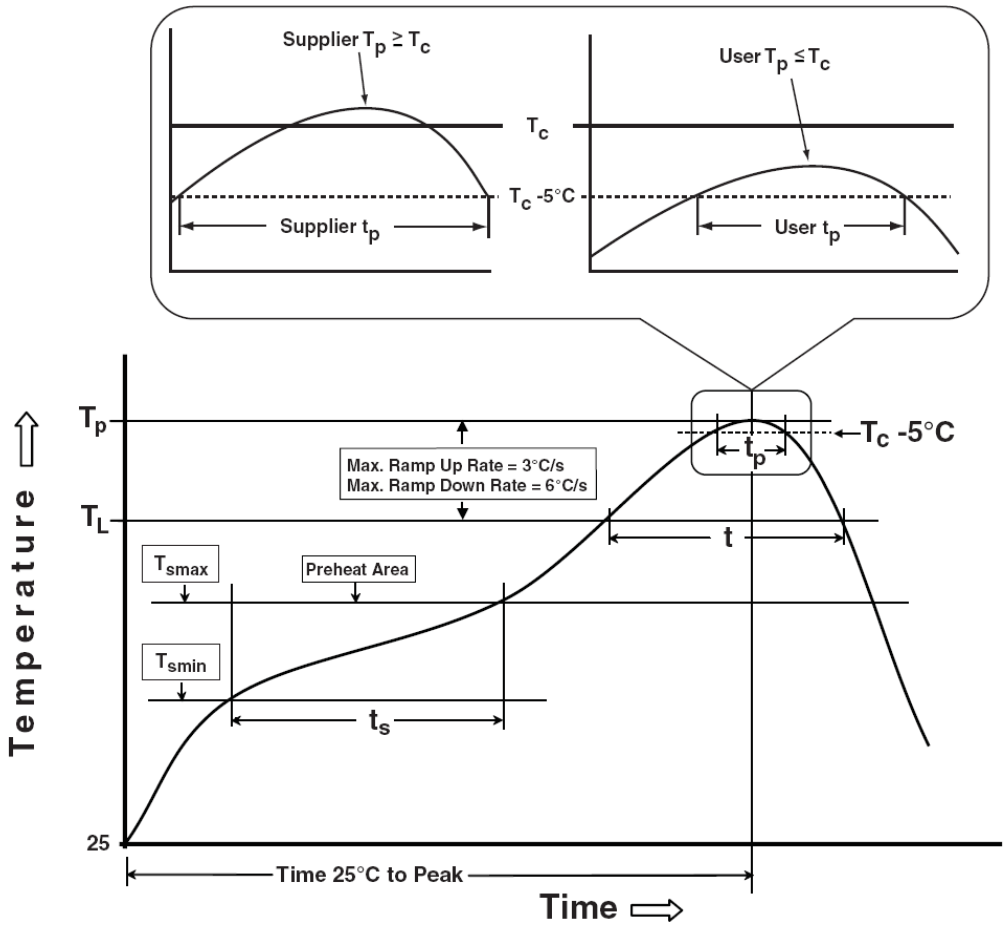
Package Type	Unit	Quantity
SOP-8	Tape & Reel	2500

Taping Direction Information

SOP-8



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
HBM	MIL-STD-883-3015.7	VHBM≥1KV
MM	JESD-22, A115	VMM≥100V
Latch-Up	JESD 78	10ms, 1_{tr}≧100mA

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