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Description

The AM9789 is a low noise fan driver for driving a single-coil brushless direct current (BLDC) fans and motors. The integrated output staged uses BTL technology to minimize the audible noise and EMI generated by the motor commutation. The AM9789 is highly integrated and includes PWM speed control, standby mode, internally generated Hall bias and a Hall signal amplifier allowing it to be used with either a Hall element or a Hall Switch.

To help protect the motor coil the AM9789 includes rotor lock, over current and over temperature protection which shuts down the output drive. The device automatically re-starts when the rotor lock is removed or the operating conditions return to normal. A Tachometer output is provided by open-drain Frequency Generator (FG) Pin which allows external interface to monitor motor rotation or speed. The FG output is the magnetic change frequency.

The AM9789 is available in the MSOP-8, MSOP-10, U-DFN3030-8 and U-DFN3030-10 packages.

Features

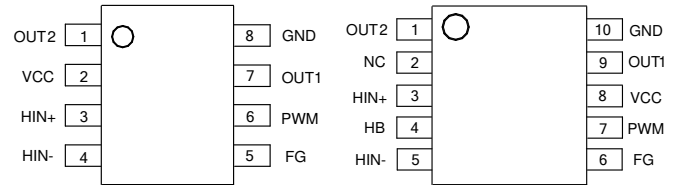
- BTL Output Single-phase Full-wave Linear Driver
- Silent Driver
- Low Supply Current (Normal Operation, Less than 4mA)
- Low Standby Current (PWM=0 Duty) @ Supply Current Less than 200µA
- Speed Controllable by PWM Input Signal
- Built-in Quick Start Function
- Built-in Lock Protection and Auto Restart Function
- Built-in Hall Bias Circuit
- Built-in FG Output
- Built-in Thermal Shutdown Circuit
- Built-in Over Current Protection Circuit
- **Totally Lead-free & Fully RoHS Compliant (Note 1 & 2)**
- **Halogen and Antimony Free. "Green" Device (Note 3)**

Notes:

1. No purposely added lead. Fully EU Directive 2002/95/EC (RoHS) & 2011/65/EU (RoHS 2) compliant.
2. See http://www.diodes.com/quality/lead_free.html for more information about Diodes Incorporated's definitions of Halogen- and Antimony-free, "Green" and Lead-free.
3. Halogen- and Antimony-free "Green" products are defined as those which contain <900ppm bromine, <900ppm chlorine (<1500ppm total Br + Cl) and <1000ppm antimony compounds.

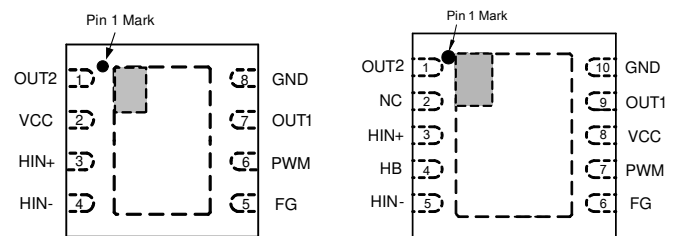
Pin Assignments

(Top View)



MSOP-8 (M8 Package)

MSOP-10 (MM Package)



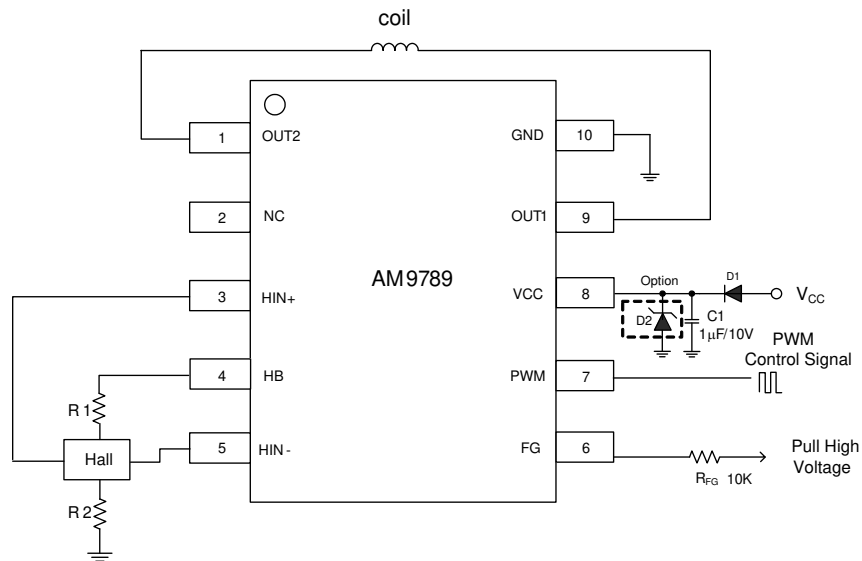
U-DFN3030-8 (DN8 Package)

U-DFN3030-10 (DN Package)

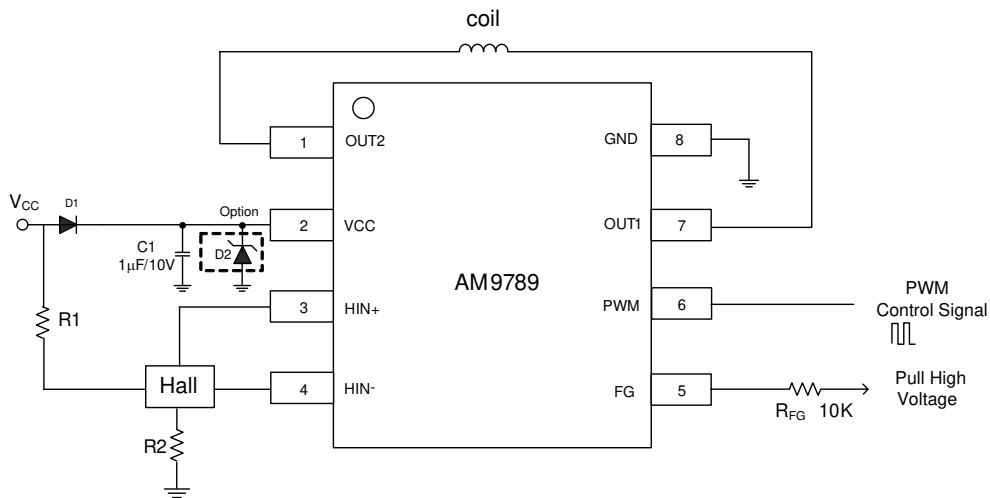
Applications

- Silent Fan Motors

Typical Applications Circuit (Note 4)



For MSOP-10 Package



For MSOP-8 Package

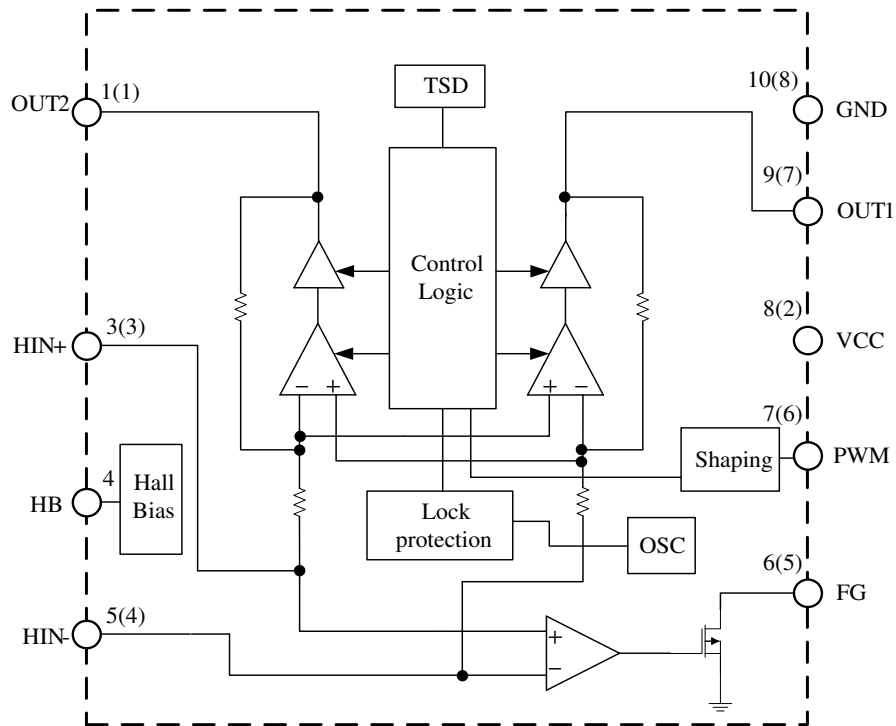
Note 4:

D1 is an ordinary diode used to filter the noise from VCC and protect IC if VCC and GND are plugged reversed.
 C1=1µF/10V typical.
 R1 and R2 should be fine tuned based on system design. They can be removed according to the system requirements.
 Zener diode (D2) is an optional choice.
 R_{FG}=10kΩ typical.

Pin Descriptions

Pin Number		Pin Name	Function
MSOP-10/ U-DFN3030-10	MSOP-8/ U-DFN3030-8		
1	1	OUT2	Output Connection 2
2	–	NC	No connected
3	3	HIN+	Hall input(+). Connect to Hall element positive output
4	–	HB	Hall bias
5	4	HIN-	Hall input(-). Connect to Hall element negative output
6	5	FG	Rotation speed output
7	6	PWM	PWM signal input terminal
8	2	VCC	Power supply
9	7	OUT1	Output Connection 1
10	8	GND	Ground

Functional Block Diagram



A(B)
A: MSOP-10/U-DFN3030-10
B: MSOP-8/U-DFN3030-8

Absolute Maximum Ratings ($T_A=+25^{\circ}\text{C}$, Note 5)

Symbol	Parameter	Value		Unit
V_{CC}	Supply Voltage	10		V
I_{OUT}	Output Current	1		A
V_{OUT}	Output Voltage	10		V
I_{HB}	HB Output Current	10		mA
V_{FG}	FG Output Voltage	10		V
I_{FG}	FG Output Sink Current	10		mA
T_{OP}	Operation Temperature	-40 to +125		$^{\circ}\text{C}$
T_{STG}	Storage Temperature Range	-55 to +150		$^{\circ}\text{C}$
T_{LEAD}	Lead Temperature (Soldering 10s)	+260		$^{\circ}\text{C}$
θ_{JA}	Thermal Resistance (Junction to Ambient)	MSOP-8	205	$^{\circ}\text{C}/\text{W}$
		MSOP-10	195	
		U-DFN3030-8	71	
		U-DFN3030-10	71	
θ_{JC}	Thermal Resistance (Junction to Case)	MSOP-8	48	$^{\circ}\text{C}/\text{W}$
		MSOP-10	46	
		U-DFN3030-8	48	
		U-DFN3030-10	48	
P_D	Power Dissipation	MSOP-8	585	mW
		MSOP-10	585	
		U-DFN3030-8	1760	
		U-DFN3030-10	1760	
–	ESD (Human Body Model)	4000		V
–	ESD (Machine Model)	400		V

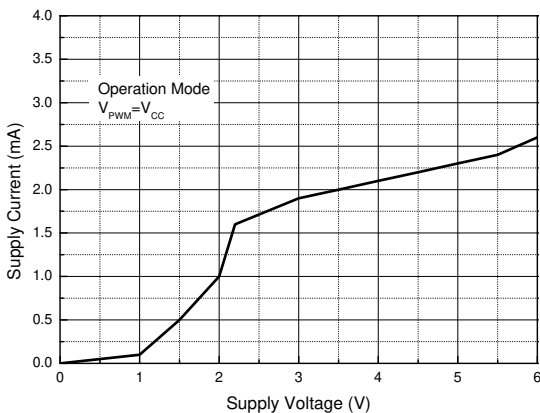
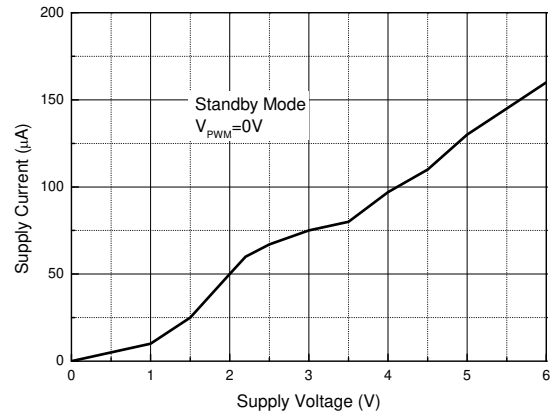
Note 5: Stresses greater than those listed under “Absolute Maximum Ratings” may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under “Recommended Operating Conditions” is not implied. Exposure to “Absolute Maximum Ratings” for extended periods may affect device reliability.

Recommended Operating Conditions ($T_A=+25^{\circ}\text{C}$)

Symbol	Parameter	Min	Max	Unit
V_{CC}	Supply Voltage	2	6	V
V_{HB}	Hall Input Voltage Range	0.4	$V_{CC} - 1.1$	V
T_A	Operating Ambient Temperature	-40	+105	$^{\circ}\text{C}$

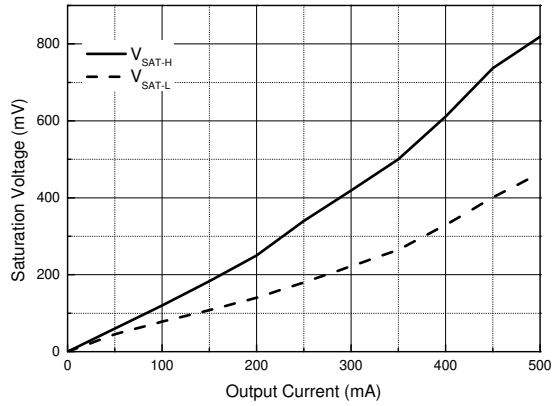
Electrical Characteristics ($V_{CC}=5V$, $T_A=+25^{\circ}C$, unless otherwise specified.)

Symbol	Parameter	Conditions	Min	Typ	Max	Unit
I_{CC1}	Operation Current	Rotation Mode	–	2	4	mA
I_{CC2}	Standby Current	$V_{PWM}=0$	–	130	200	μA
V_{HB}	HB Pin Output Voltage	$I_{HB}=5mA$	1.1	1.3	1.5	V
t_{ON}	Lock Detection ON Time	–	0.3	0.4	0.5	s
t_{OFF}	Lock Detection OFF Time	–	3	4	5	s
t_{OS}	Quick Start Enable Time	–	–	55	75	ms
$V_{SAT(H+L)}$	Output Drivers Saturation Voltage	$I_{OUT}=250mA$, upper and lower total	–	0.5	0.7	V
G_{IO}	Input-Output Gain	$V_{OUT}/(V_{HIN+}-V_{HIN-})$	44	47	50	dB
V_{FG}	FG Pin Low Voltage	$I_{FG}=5mA$	–	0.2	0.3	V
I_{FGL}	FG Pin Leakage Current	$V_{FG}=5V$	–	0.1	1	μA
V_{PWMH}	PWM Input High Level Voltage	–	$0.5 \times V_{CC}$	–	V_{CC}	V
V_{PWML}	PWM Input Low Level Voltage	–	0	–	$0.2 \times V_{CC}$	V
f_{PWM}	PWM Input Frequency	–	0.02	–	50	kHz
V_{HOFS}	Hall Input Offset Voltage	–	–	–	± 10	mV
V_{HYS}	Hall Input Hysteresis Voltage	–	± 5	± 10	± 15	mV
T_{SD}	Thermal Protection Temperature	–	–	+165	–	$^{\circ}C$
ΔT_{SD}	Thermal Hysteresis Width	–	–	+30	–	$^{\circ}C$

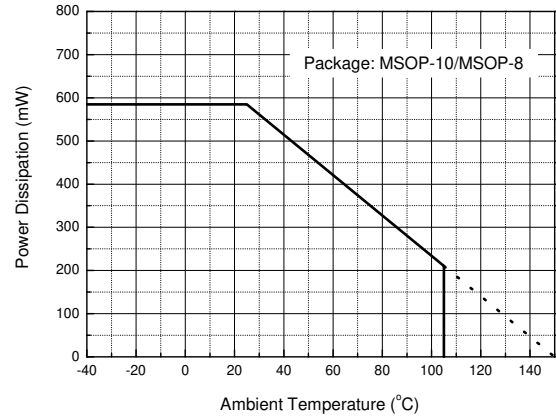
Performance Characteristics
Supply Current vs. Supply Voltage ($V_{PWM}=V_{CC}$)

Supply Current vs. Supply Voltage ($V_{PWM}=0V$)


Performance Characteristics (Cont.)

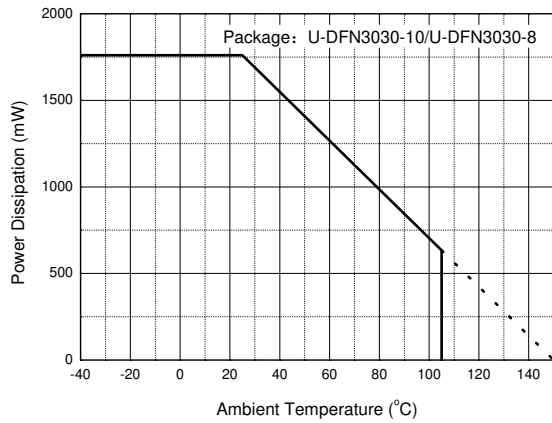
Saturation Voltage vs. Output Current



Power Dissipation vs. Temperature (MSOP)



Power Dissipation vs. Temperature (DFN)



Truth Table

INPUT			OUTPUT			Mode
HIN-	HIN+	PWM	OUT1	OUT2	FG	
L	H	H	H	L	L	Operation Mode
H	L		L	H	OFF	
H	L	L	L	L	OFF	
L	H		L	L	L	
L	H	-	L	L	OFF	Lock Mode
H	L		L	L	OFF	
-	-	L	OFF	OFF	OFF	Standby Mode

Application Information

1. Reverse Connection of Power Supply Connector

Reverse connection of power supply connector may break IC. Some methods such as inserting a diode between power supply and VCC terminal can be taken to avoid the reverse connection destruction.

2. Power Supply Line

Back electromotive force (EMF) causes regenerated current to the power supply line, so insert a capacitor (recommended value: 1μF or larger) as close as possible to the space between the power supply pin (VCC pin) and ground pin (GND pin) for routing regenerated current.

3. GND Potential and External Components

Ensure that the potential of GND terminal is the minimum potential in any operating condition. External components connected to the ground must be connected with lines that are as short as possible and external components connected between IC pins must be placed as close to the pins as possible.

4. Mounting Failures

In the process of attaching IC to the printed board, more attention must be paid to the direction and location of the IC, since mounting failures may also break IC. In addition, destruction is also possible when the circuit is shorted by foreign substance between outputs or between output and power supply or between output and GND.

5. Thermal Consideration

Refer to "Power Dissipation vs. Ambient Temperature (MSOP-10/MSOP-8)" in page 6, the IC is safe to operate below the curve and the thermal protection will be caused if the operating area is above the line. For example, when $T_A=+75^{\circ}\text{C}$, the maximum power dissipation is about 0.35W.

The power dissipation can be calculated by the following equation:

$$P_D = V_{\text{SAT(H+L)}} \times I_{\text{OUT}} + V_{\text{CC}} \times I_{\text{CC}}$$

For example, $V_{\text{CC}}=5\text{V}$, $I_{\text{CC}}=2\text{mA}$, $I_{\text{OUT}}=250\text{mA}$, $V_{\text{SAT(H+L)}}=0.5\text{V}$, then $P_D=0.135\text{W}$.

The GND pin provides an electrical connection to the ground and channeling heat away. The printed circuit board (PCB) forms a heat sink and dissipates most of the heat to the ambient air.

6. Thermal Shutdown Circuit

Considering the power dissipation under actual operating condition, the thermal design must be applied with sufficient margin.

AM9789 features thermal shutdown (TSD) circuit (operation temperature is $+165^{\circ}\text{C}$ typical and hysteresis width is $+30^{\circ}\text{C}$ typical). When the chip temperature reaches the TSD circuit temperature, the output terminal becomes an open state. TSD circuit is designed simply for the purpose of intercepting IC from overheating. Make sure that the IC should not be used again after this circuit operating. Figure 1 shows a fan rotates normally first and then enters into OTP mode since the chip temperature reaches $+165^{\circ}\text{C}$. Finally the chip temperature decreases below $+135^{\circ}\text{C}$, then OTP mode is canceled and the fan rotates normally again.

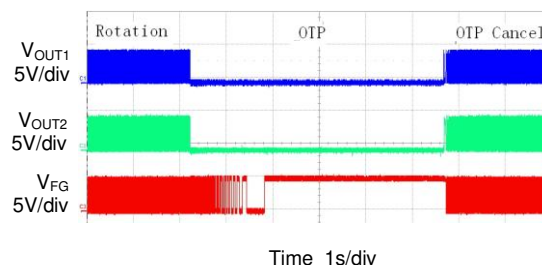


Figure 1. OTP Function

7. Over Current Protection

The driver current is detected by AM9789 internal circuit. When the output current is over 1A or larger, AM9789 will close the output driver. After that if the output current decreases, AM9789 will enable the fan to rotate again. Figure 2 shows the detailed process.

Application Information (Cont.)

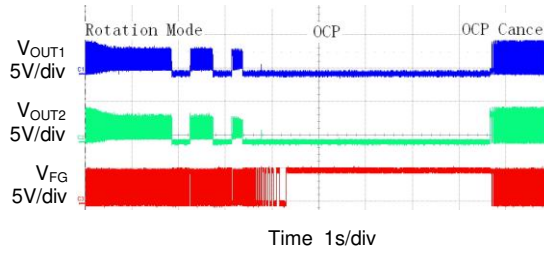


Figure 2. OCP Function

8. PWM Mode

The output transistor is on when a high-level voltage is input to the PWM pin, and is off when a low-level voltage is input. PWM controls the speed of the motor by inputting the pulse in accordance with the duty cycle to the PWM pin. When the motor is operated with the PWM pin open, the built-in resistor enables the PWM pin to change to high-level voltage and the motor speed rises to full speed. When the PWM pin is fixed at low-level voltage, the motor decelerates, and after the motor stops, it enters “Power Saving Mode”. Figure 3 shows a rotating fan’s waveform at PWM Mode. Figure 4 shows Lock Mode Waveform at PWM input condition in the same fan.

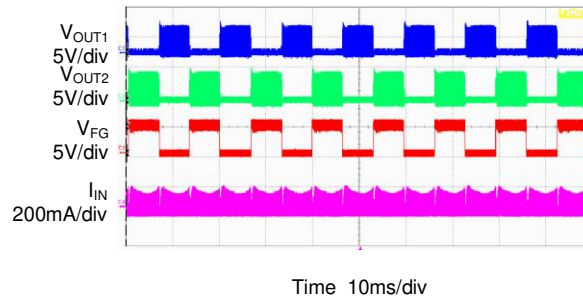


Figure 3. PWM Mode Waveform (PWM: 50% duty cycle, $V_H=5V$, $V_L=0V$)

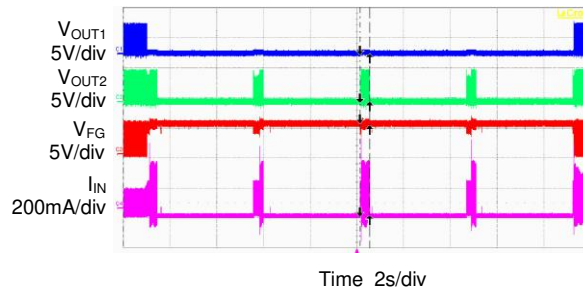


Figure 4. Lock Mode at PWM Input Condition (PWM: 50% duty cycle, $V_H=5V$, $V_L=0V$)

9. Frequency Generator Function

The FG pin is an open collector output, connecting a pull-up resistor to a high level voltage for the frequency generator function. During the lock mode, FG pin output will be always high. Open the terminal when not in use. Figure 5 shows how this function works.

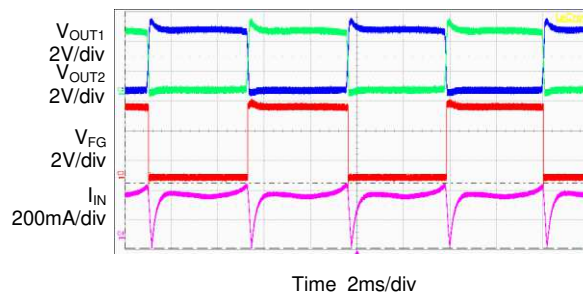


Figure 5. Rotation Mode Waveform

Application Information (Cont.)

10. Lock Protection and Auto-restart

The IC detects the rotation of the motor by Hall signal and the lock detection ON time (t_{ON}) and OFF time (t_{OFF}) are adjusted by the internal counter. As showed below.

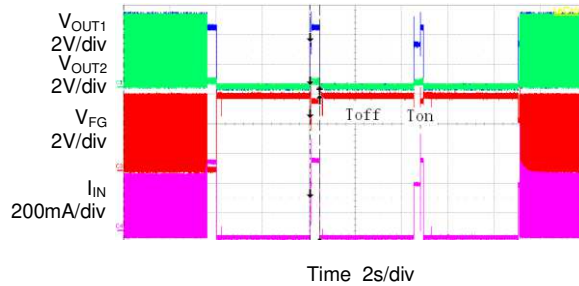


Figure 6. Lock Mode Waveform

11. Quick Start and Standby Mode

The IC will enter standby mode when PWM input keeps low level for more than 55ms (typ.). In standby mode, shutdown amplifier and FG will be shut down, and the supply current is around 130 μ A. In standby mode, the lock protection function doesn't work; the fan will restart when released from standby mode. Figure 7 describes this function.

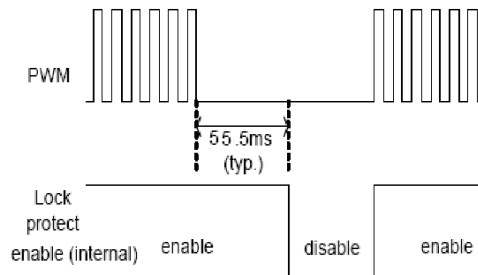
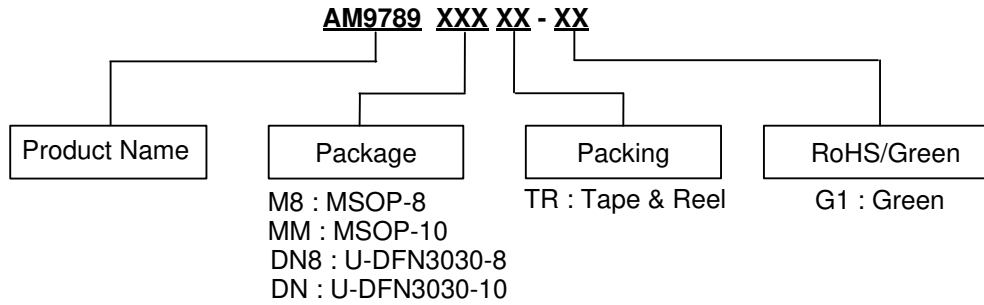


Figure 7. Quick Start and Standby Mode

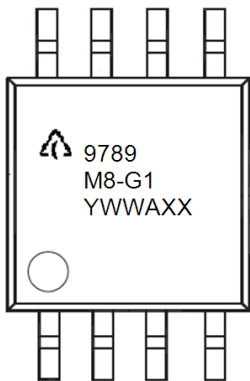
Ordering Information



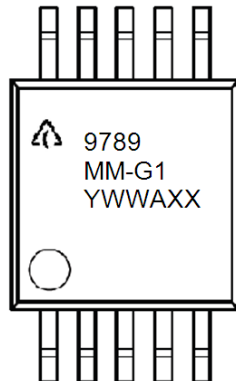
Package	Temperature Range	Part Number	Marking ID	Packing
MSOP-10	-40 to +105°C	AM9789MMTR-G1	9789MM-G1	3000/Tape & Reel
MSOP-8		AM9789M8TR-G1	9789M8-G1	3000/Tape & Reel
U-DFN3030-8		AM9789DN8TR-G1	B6E	5000/Tape & Reel
U-DFN3030-10		AM9789DNTR-G1	BFD	5000/Tape & Reel

Marking Information

MSOP-8 (Top View)

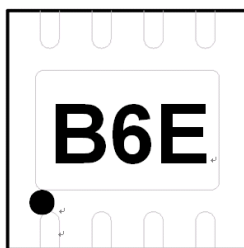


MSOP-10 (Top View)

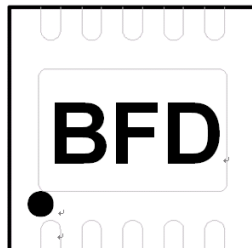


First and Second Lines: Logo and Marking ID
 Third Line: Date Code
 Y: Year
 WW: Work Week of Molding
 A: Assembly House Code
 XX: 7th and 8th Digits of Batch No.

U-DFN3030-8 (Top View)



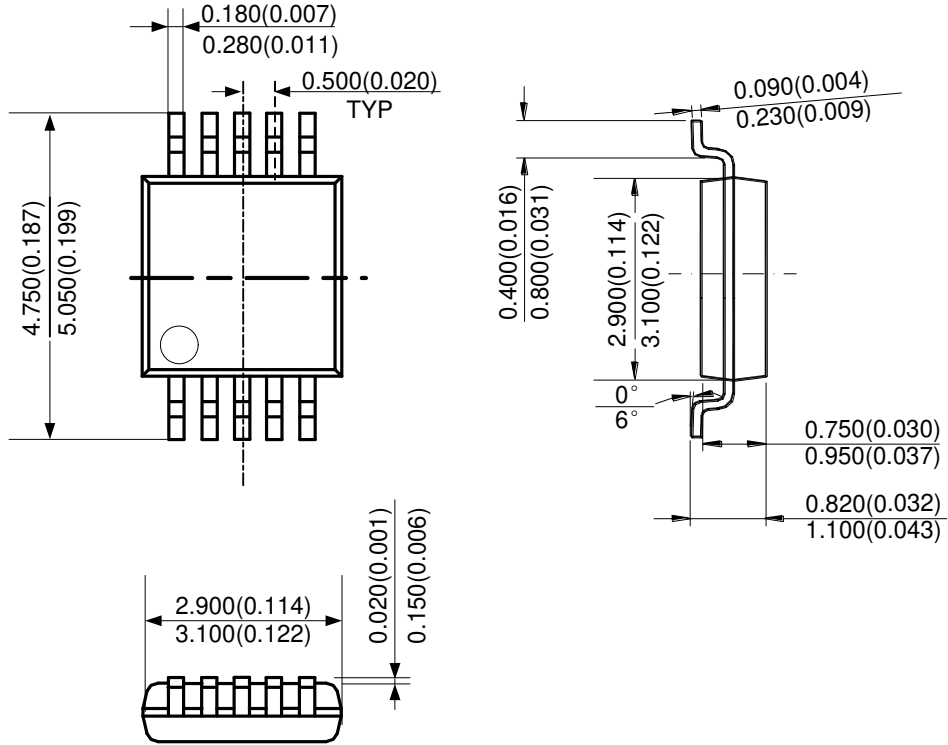
U-DFN3030-10 (Top View)



First Line: Marking ID
 ●: Pin 1 Mark

Package Outline Dimensions (All dimensions in mm(inch).)

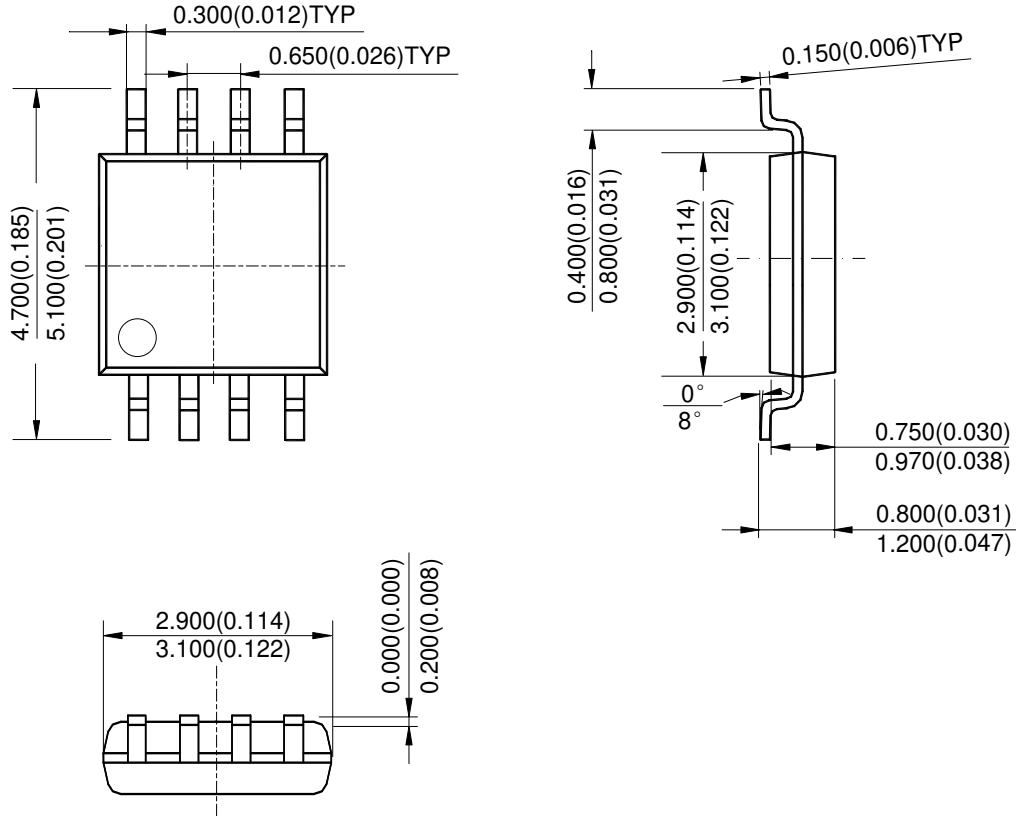
(1) Package Type: MSOP-10



Note: Eject hole, oriented hole and mold mark is optional.

Package Outline Dimensions (All dimensions in mm (inch). Cont.)

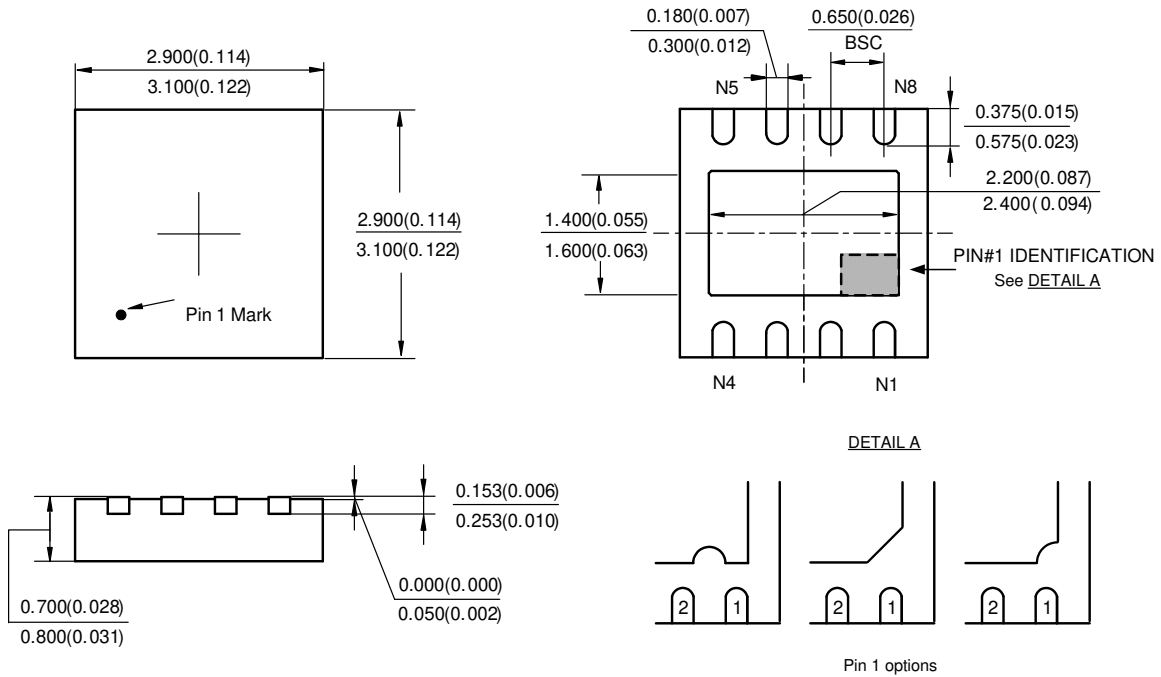
(2) Package Type: MSOP-8



Note: Eject hole, oriented hole and mold mark is optional.

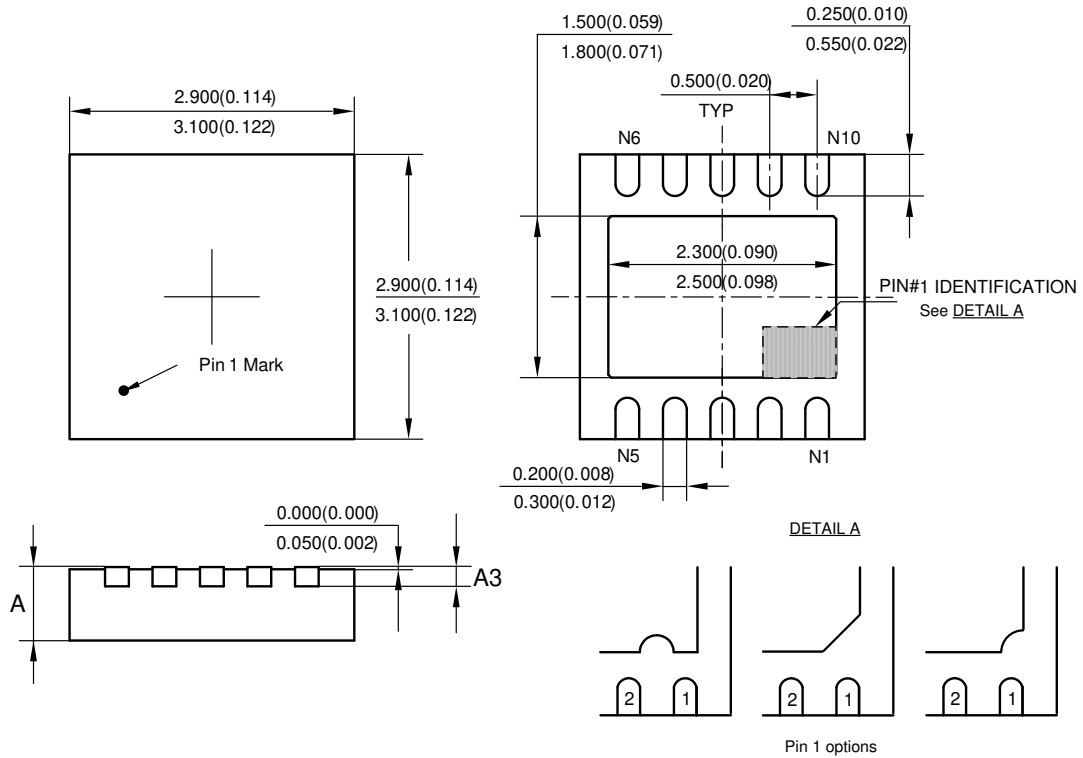
Package Outline Dimensions (All dimensions in mm(inch). Cont.)

(3) Package Type: U-DFN3030-8



Package Outline Dimensions (All dimensions in mm (inch). Cont.)

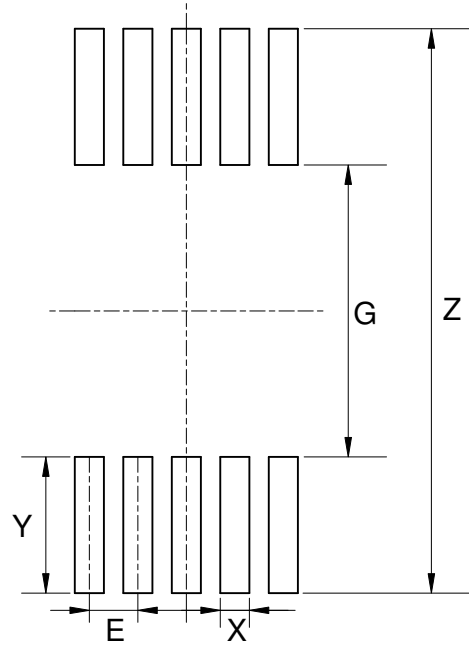
(4) Package Type: U-DFN3030-10



Symbol	A				A3			
	min(mm)	max(mm)	min(inch)	max(inch)	min(mm)	max(mm)	min(inch)	max(inch)
Option 1	0.700	0.800	0.028	0.031	0.153	0.253	0.006	0.010
Option 2	0.570	0.630	0.022	0.025	0.150 (Typ)		0.006 (Typ)	

Suggested Pad Layout

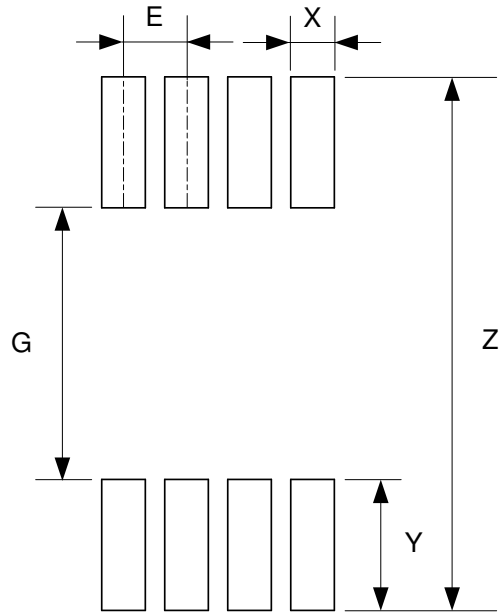
(1) Package Type: MSOP-10



Dimensions	Z (mm)/(inch)	G (mm)/(inch)	X (mm)/(inch)	Y (mm)/(inch)	E (mm)/(inch)
Value	5.800/0.228	3.000/0.118	0.300/0.012	1.400/0.055	0.500/0.020

Suggested Pad Layout (Cont.)

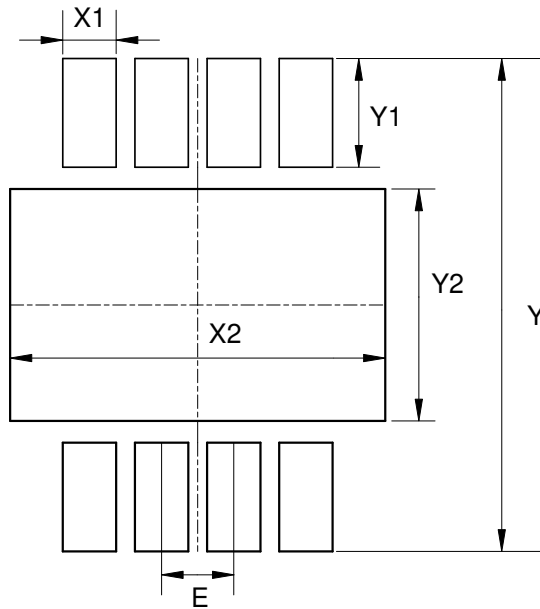
(2) Package Type: MSOP-8



Dimensions	Z (mm)/(inch)	G (mm)/(inch)	X (mm)/(inch)	Y (mm)/(inch)	E (mm)/(inch)
Value	5.500/0.217	2.800/0.110	0.450/0.018	1.350/0.053	0.650/0.026

Suggested Pad Layout (Cont.)

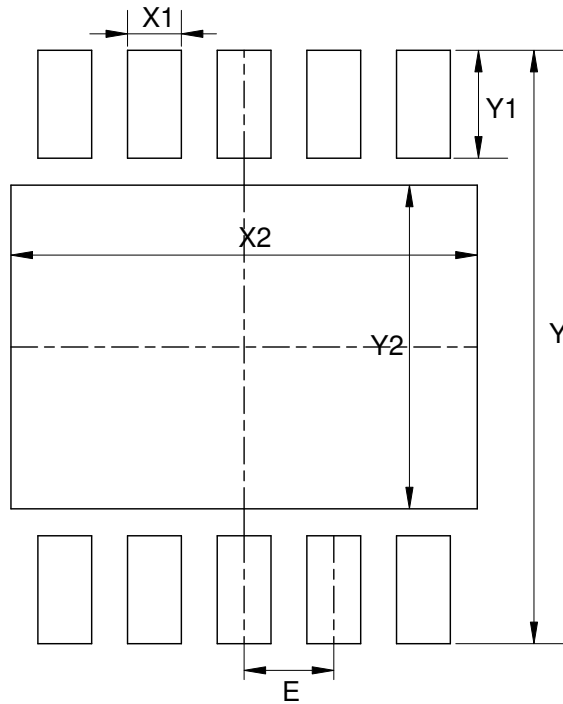
(3) Package Type: U-DFN3030-8



Dimensions	Y (mm)/(inch)	X1 (mm)/(inch)	Y1 (mm)/(inch)	X2 (mm)/(inch)	Y2 (mm)/(inch)	E (mm)/(inch)
Value	3.400/0.134	0.370/0.015	0.750/0.030	2.600/0.102	1.600/0.063	0.500/0.020

Suggested Pad Layout (Cont.)

(4) Package Type: U- DFN3030-10



Dimensions	Y (mm)/(inch)	X1 (mm)/(inch)	Y1 (mm)/(inch)	X2 (mm)/(inch)	Y2 (mm)/(inch)	E (mm)/(inch)
Value	3.300/0.130	0.300/0.012	0.600/0.024	2.600/0.102	1.800/0.071	0.500/0.020

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2. support or sustain life and whose failure to perform when properly used in accordance with instructions for use provided in the labeling can be reasonably expected to result in significant injury to the user.

B. A critical component is any component in a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or to affect its safety or effectiveness.

Customers represent that they have all necessary expertise in the safety and regulatory ramifications of their life support devices or systems, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of Diodes Incorporated products in such safety-critical, life support devices or systems, notwithstanding any devices- or systems-related information or support that may be provided by Diodes Incorporated. Further, Customers must fully indemnify Diodes Incorporated and its representatives against any damages arising out of the use of Diodes Incorporated products in such safety-critical, life support devices or systems.

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