Single Phase Full-Wave Motor Driver for Fan Motor AM3933

The AM3933 is a single phase DC fan motor Combo driver IC. Rotation speed can be controlled by PWM input signal and voltage. The drivers include Lock Detection, Thermal Shutdown, and Over-current Protection. Maximum output current is 1A. Package is PB-free and Halogen-Free.

● **Applications**

Single Phase DC Fan Motor.

● **Features**

1) Operation voltage 1.8 to 8.0V.
2) Lock detection/Automatic restart circuit.
3) Control output terminal. (FG)
4) Thermal shutdown circuit.
5) Over current protection.
6) Combo PWM and Voltage controllable.
7) Low cross-over noise.
8) Noise Free.

● **Absolute Maximum Ratings (Ta = 25℃)**

Parameter	Symbol	Limits	Unit
Supply voltage	V_{CC}	8	V
Output current	Iomax	1000**	mA
FG single output current	$I_{FG(SINK)}$	10	mA
FG single output voltage	V_{FG}	8	V
HB output current	I_{HB}	10	mA
Power dissipation	Pd	1097*	mW
Operate temperature range	T_{opr}	-40～+125	℃
Storage temperature range	T_{stg}	-40～+150	℃
Junction temperature	Tjmax	150	℃

＊ Reducing by 8.77mW/℃ over 25℃ (On 114.3mm X 76.1mm X 1.6mm single layer board)

** This value is not to exceed Pd.

● **Recommended operating conditions**

(Set the power supply voltage taking allowable dissipation into considering)

Parameter	Symbol	Min	Typ	Max	Unit
Operating supply voltage range	Vcc		1.8～8.0		V
Hall input voltage range	V_H		0.4～Vcc-1.1		V

● **Electrical Characteristics**

(Unless otherwise specified, Ta = 25℃, VCC = 5V)

Parameter	Symbol	Limit			Unit	Conditions
		Min	Typ	Max		
Supply current	I_{CC}	—	3	6	mA	
Hall input						
Input offset voltage	V_{HOFS}	—	—	±6	mV	
PWM input						
Input H level	V_{PWMH}	2.5	—	V_{CC}	V	
Input L level	V_{PWML}	0	—	0.7	V	
Input frequency	F_{PWM}	0.02	—	50	kHz	
Output						
Output voltage	V_0	—	0.3	0.5	V	I_0=250mA (Upper + Lower)
Input-output Gain	G_{IO}	45	48	51	dB	
FG low voltage	V_{FGL}	—	0.2	0.3	V	$I_{FG(sink)}$ = 5mA
FG leakage current	I_{FGL}	—	—	10.0	μA	V_{FG} = 5V
Input hysteresis voltage	V_{HYS}	±7	±12	±17	mV	
Hall bias voltage	V_{HB}	0.8	1.0	1.2	V	I_{HB}=-5mA
Lock protection						
Lock detection ON time	T_{ON}	0.35	0.50	0.65	sec	
Lock detection OFF time	T_{OFF}	3.5	5.0	6.5	sec	

● **Block Diagram**
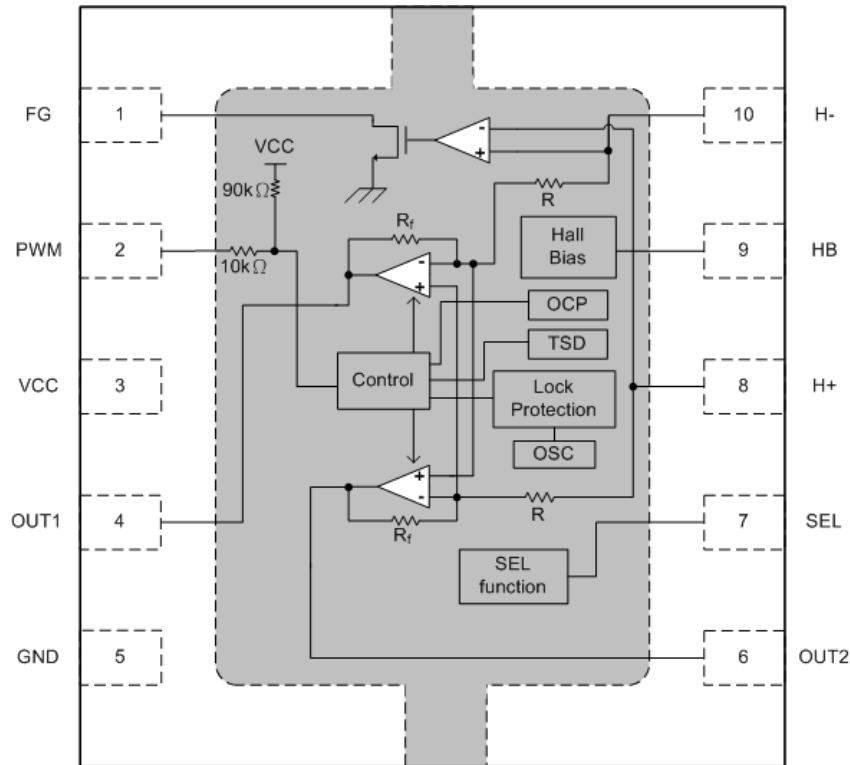
Fig.1 Block diagram

● **Pin Description**

PIN No	Pin Name	Function
1	FG	FG signal output terminal
2	PWM	PWM signal input terminal
3	VCC	Power supply terminal
4	OUT1	Motor output terminal
5	GND	Ground terminal
6	OUT2	Motor output terminal
7	SEL	Noise Free
8	H+	Hall input terminal
9	HB	Hall Bias
10	H-	Hall input terminal
Thermal pad	Thermal pad	Connect to Ground for maximum thermal efficiency.

● **Truth Table**

H+	H-	PWM	OUT1	OUT2	FG	Mode
H	L	H	H	L	L (Output Tr : ON)	Operation mode
L	H		L	H	Z (Output Tr : OFF)	
H	L	L	L	L	L (Output Tr : ON)	
L	H		L	L	Z (Output Tr : OFF)	
H	L	-	L	L	L (Output Tr : ON)	Lock mode
L	H		L	L	Z (Output Tr : OFF)	

Z：Open drain output (High impedance)
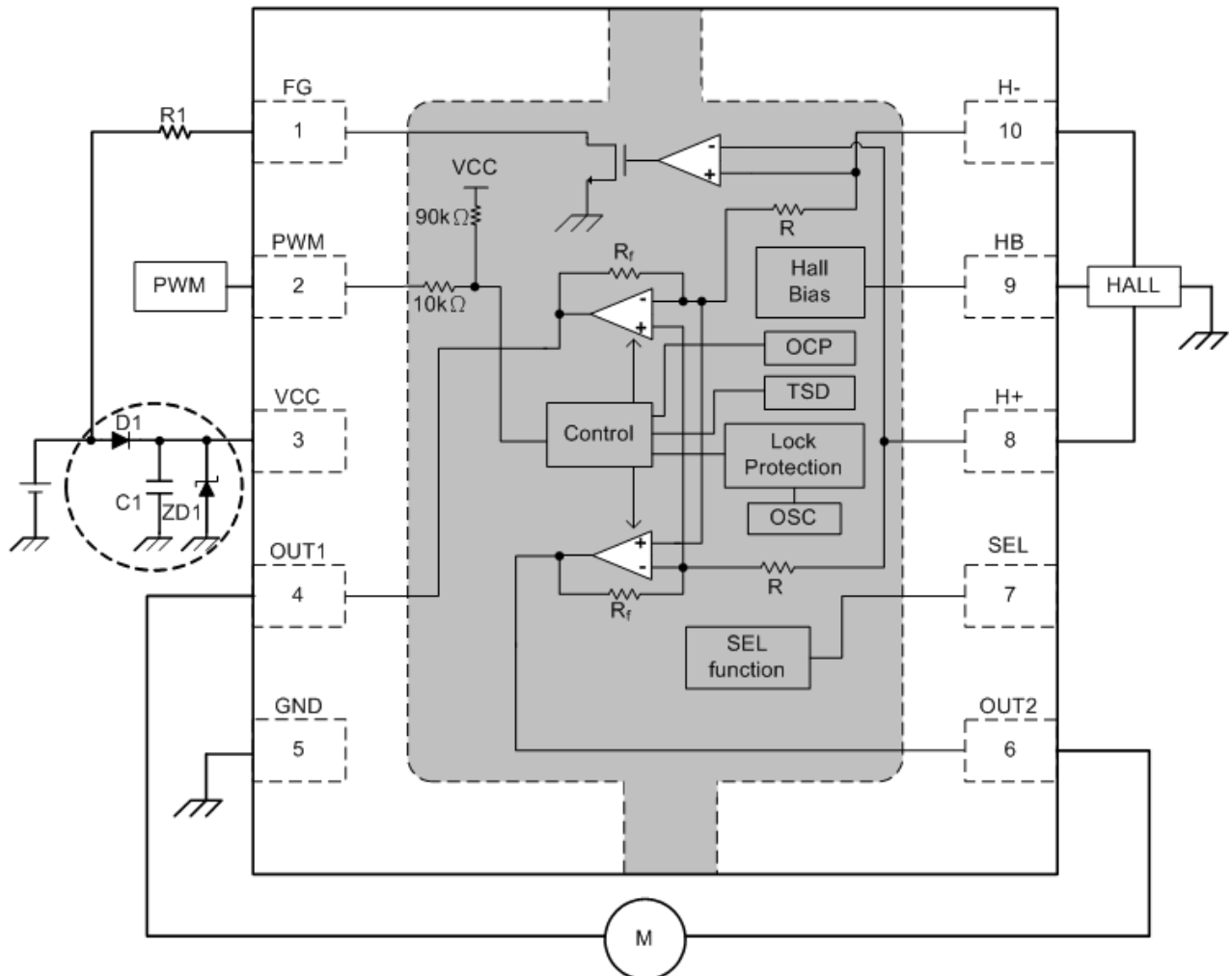
● **Application circuit**

Fig.2 Application circuit

Reverse connection of power supply may break the device. A countermeasure is needed such as using reverse current protection diode (D1) between power supply and V_{CC} terminal.

The BEMF causes re-circulate current to power supply, when power-on or output changes. It may cause V_{CC} terminal to raise voltage, especially using reverse current protection diode (D1) because there is no way to return current back to power supply. In such case, please take necessary measures like below.

Connect a Zener diode (ZD1) between V_{CC} and GND terminal not to exceed the absolute maximum rating voltage.

Connect a capacitor (C1) between V_{CC} and GND terminal to make a path of return current to power supply.

● **Lock detection, automatic restart circuit**

This IC detect the rotation of the motor by hall signal, and adjust lock detection ON time (Ton) and lock detection OFF time (Toff) by the internal counter. These time (Ton, Toff) are showed below.
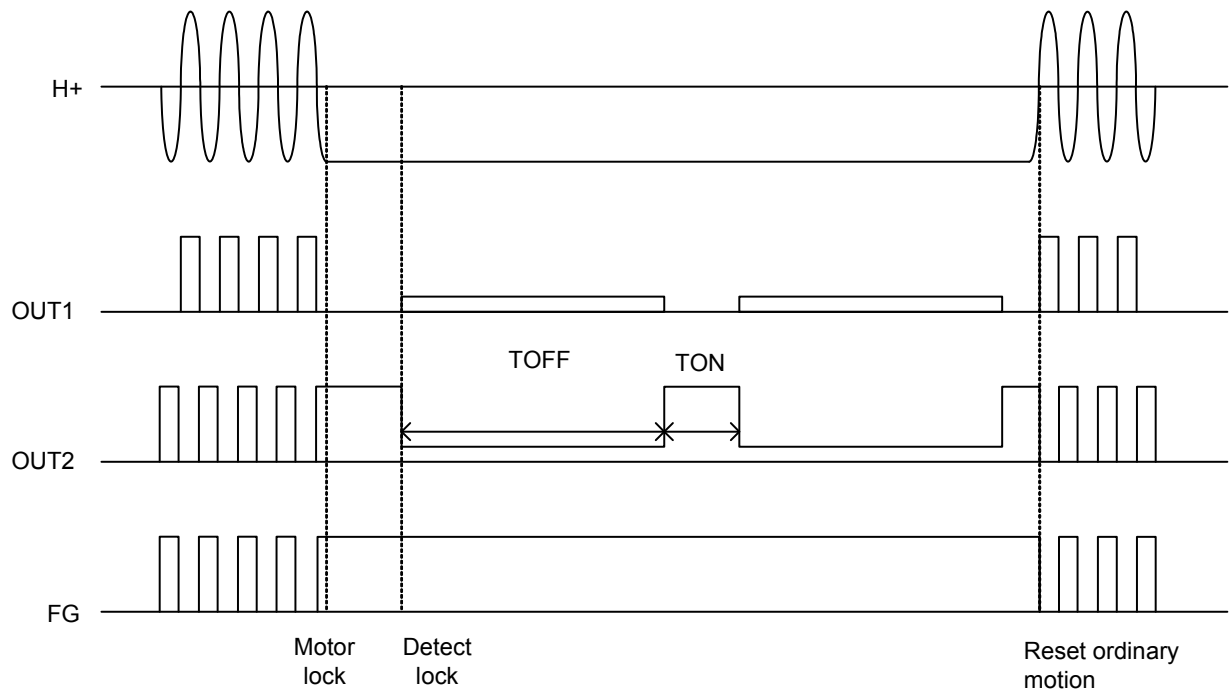

Fig.3 Lock detect and auto restart motion

Only in Lock detection ON Time (Ton), motor will be rest ordinary motion by switching over of hall signal.

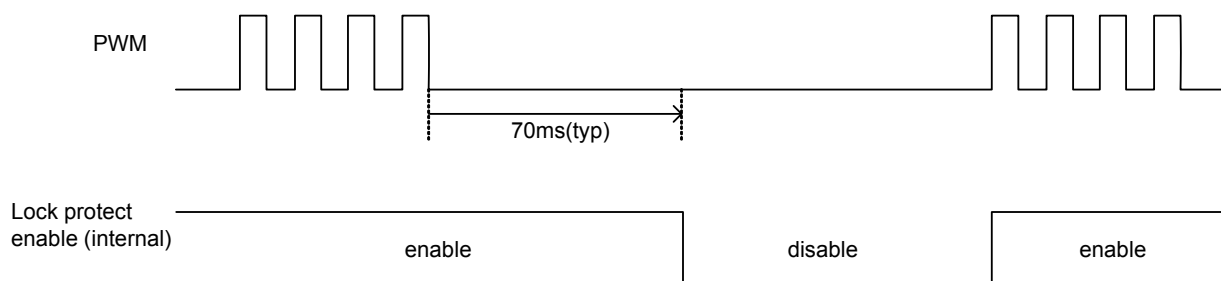This IC make the lock protection function off, when the PWM input keeps low level for more than 70ms (typ.)

Fig.4 PWM input signal and lock protect function

Lock protect function does not work if PWM input frequency is slower than 15Hz (typ.)

So, please input faster frequency more than 20Hz

● **SEL – Noise Free Function**

Pin2 (SEL) is for noise-free function which need to be pulled low to enable this function. When this function enable, start-up output will work at PWM Duty 50% in the first 2.5~3 FG cycle. The function characteristic is showed as blow:
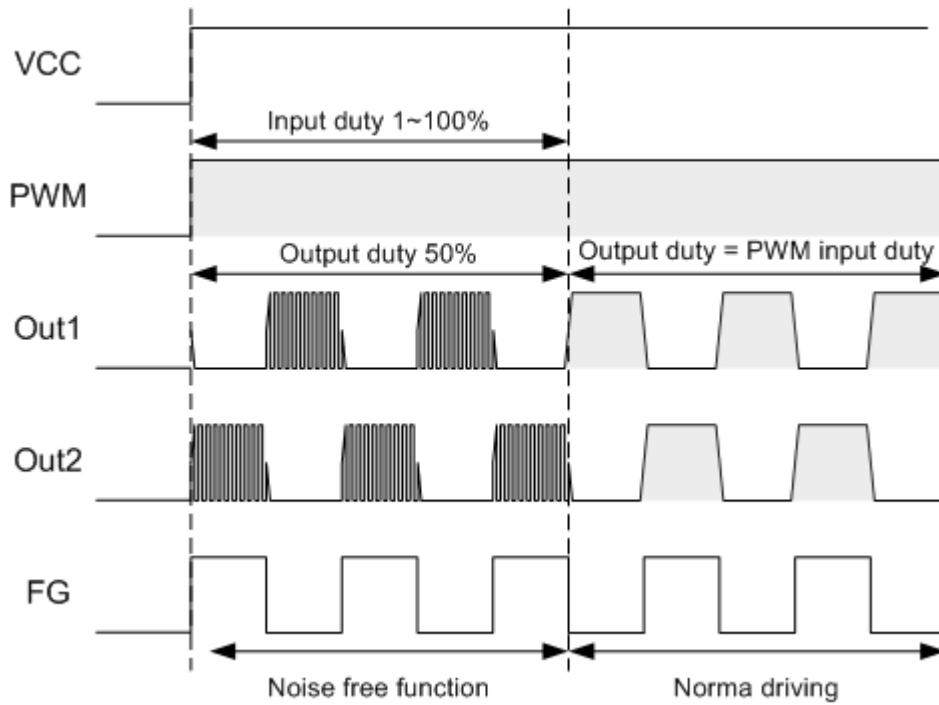

Fig.5 Noise free function

● **Application Note**

1) Absolute maximum ratings

This product is produced with strict quality control, but destroyed in using beyond absolute maximum ratings. Once IC destroyed, a failure mode cannot be defined (like short-mode or open-mode).Therefore, physical security counter measure, like fuse, is to be given when a specific mode to be beyond absolute maximum rating is considered.

2) Reverse connection of power supply

Reverse connection of the power supply may break the device. A countermeasure is needed such as using reverse current protection diodes between the power supply and the V_{CC} terminal.

3) Power supply line

The BEMF causes re-circulate current to power supply, Please connect a capacitor between power supply and GND as a route of re-circulate current. And please determine the capacitance after confirmation that the capacitance does not causes any problems.

4) GND potential

The GND terminal should be the location of the lowest voltage on the chip.

5) Thermal design

The thermal design should allow enough margin for actual power dissipation.

6) Mounting failures

Mounting failures, such as misdirection or miss-mounts, may destroy the device.

The electrical short caused by falling particle, between outputs; power supply and output; or output and ground, may damage the device.

7) Layout guide

<a> There are 2 Bars on AM3799N thermal pad, the advantage of these 2 bars is to detect if thermal pad is well mounted on PCB ground.

<b> The PCB ground layout should be larger enough to cover thermal pad bar in order to detect thermal pad is well mounted on PCB.

PLS refer to following drawing

PCB ground layout should be larger to cover thermal pad bar
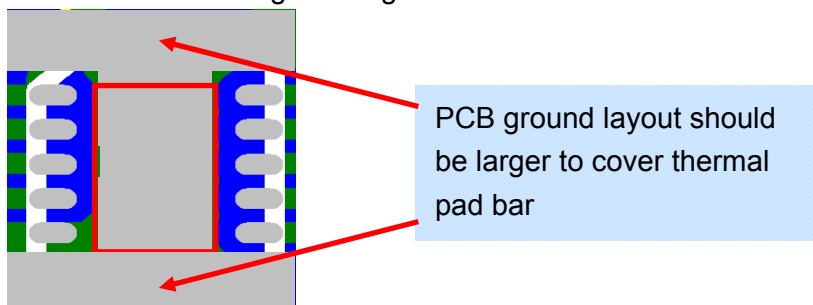
● **Power dissipation curve:**
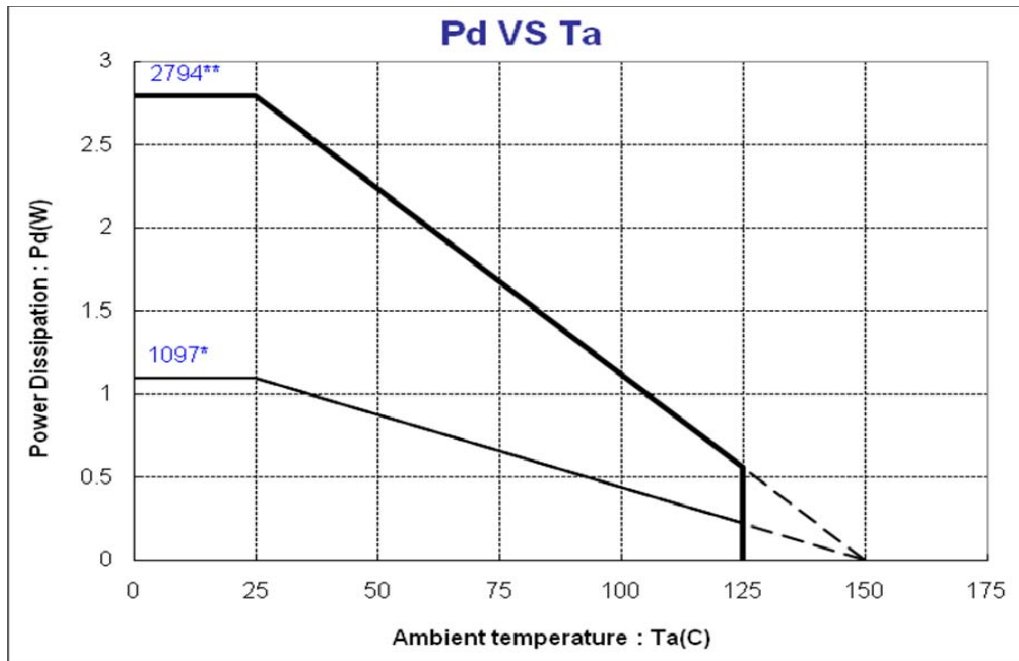
Power dissipation by ambient temperature de-rating curve

Notes:

*114.3mm X 76.1mm X 1.6mm single layer board(JEDEC 51-3).

De-rating is done at 8.77mW/℃ for operating above Ta=25℃

ΘJa=113.87 ℃/W, ΘJc= 43 ℃/W, Tj = 150℃, Pd max 1097mW

**114.3mm X 76.1mm X 1.6mm dual layer board(JEDEC 51-7).

De-rating is done at 22.35mW/℃ for operating above Ta=25℃

ΘJa=44.73 ℃/W, ΘJc=16.74 ℃/W, Tj = 150℃, Pd max 2794mW

Calculated formulation Pd = (Tj-Ta) /θJa

Symbol θJa is called thermal resistance

Thermal resistance:

θJa depends on the power consumption, package ambient temperature, packaging condition, wind velocity, chip size etc.
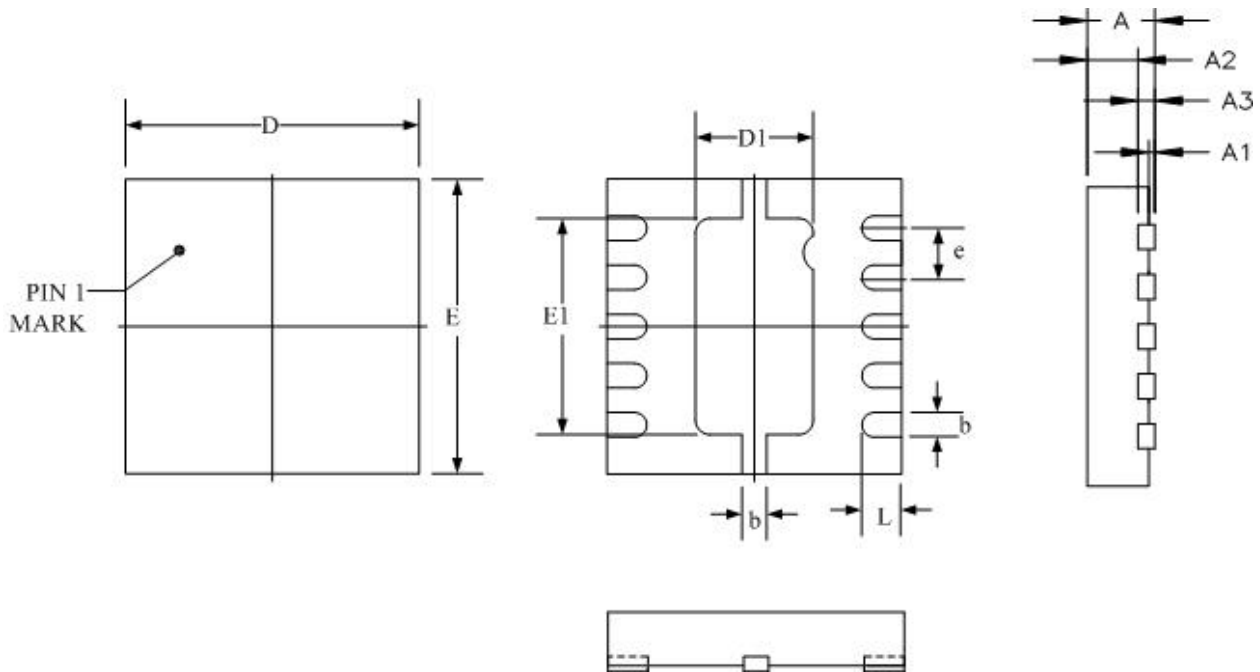
The curve of thermal de-rating can determine the reference value at the ambient temperature base on the specified condition.

Condition:

Mounted on FR4 glass epoxy board, dimension is 114.3mm x 76.1 mm x 1.6 mm, copper foil area : < 3%, the core thickness: 1.0 mm, trace thickness: 0.07 mm (2 oz),plane thickness: 0.035 mm (1 oz)

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● **Packaging outline --- DFN 3X3L**   **Unit : mm**

SYMBOL	MILLIMETERS		INCHES	
	Min.	Max.	Min.	Max.
A	-	0.50	-	0.020
A1	-	0.05	-	0.002
A2	-	0.43	-	0.017
A3	0.15 REF		0.006 REF	
b	0.18	0.30	0.007	0.012
D/E	3.00 BSC		0.118 BSC	
D1	1.10	1.30	0.043	0.051
E1	2.10	2.30	0.083	0.091
L	0.30	0.50	0.012	0.020
e	0.5 BSC		0.020 BSC	

● **Condition of Soldering**

1).Manual Soldering

Time / Temperature $\leq$ 3 sec / 400 $\pm$ 10 ^{o}C （2 Times）

Test Results：0 fail/ 22 tested

Manual Soldering count：2 Times
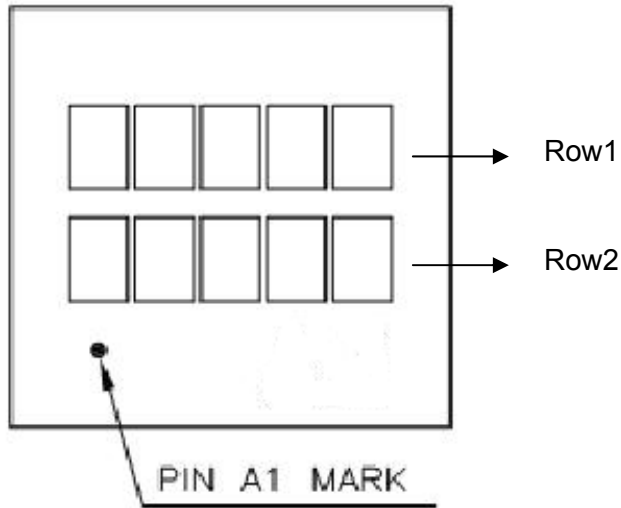
2).Re-flow Soldering (follow IPC/JEDEC J-STD-020D)

Classification Reflow Profile

Profile Feature	Pb-Free Assembly
Average ramp-up rate (T_L to T_P)	3°C/second max.
Preheat - Temperature Min (Ts min) - Temperature Max (Ts max) - Time (ts) from (Tsmin to Tsmax)	150°C 200°C 60-120 seconds
Ts max to T_L - Temperature Min (Ts min)	3°C/second max.
Time maintained above: - Liquid us temperature (T_L) - Time (t_L) maintained above TL	217°C 60-150 seconds
Peak package body temperature (Tp)	260 +0/-5°C
Time with 5°C of actual Peak - Temperature (tp)	30 seconds
Ramp-down Rate	6°C/second max.
Time 25°C to Peak Temperature	8 minutes max.
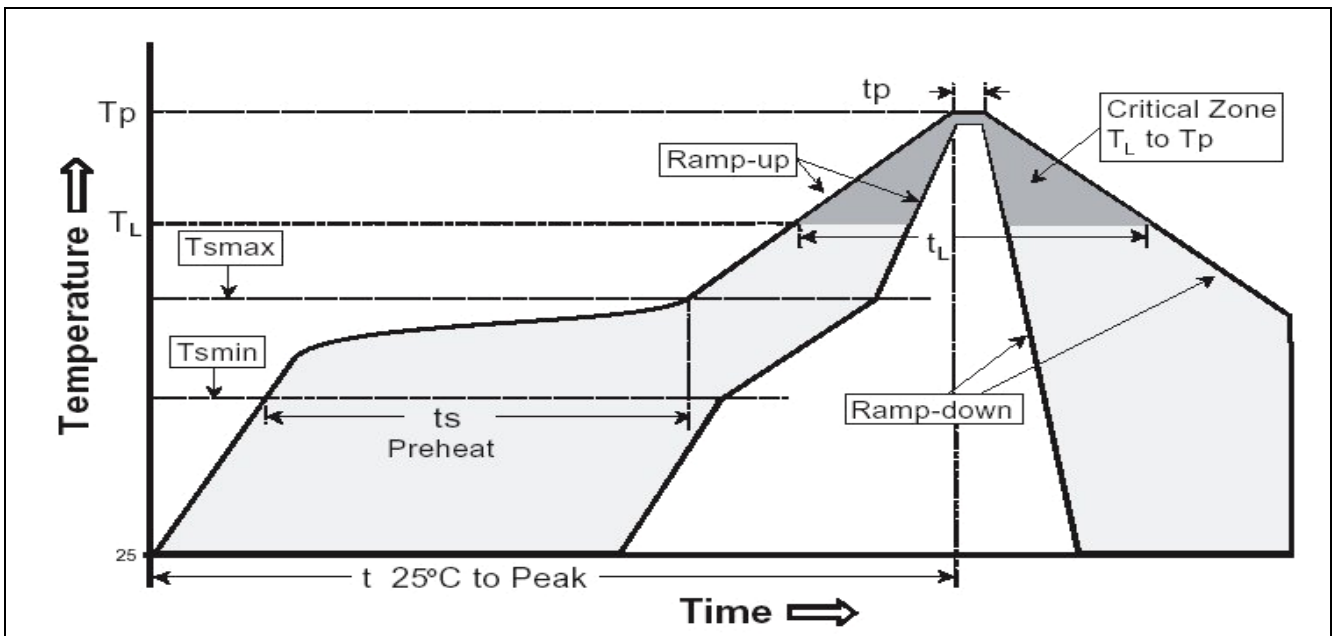
Test Results：0 fail/ 32 tested　Reflow count：3 cycles

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● **Marking Identification**

Row 1
A3933

Row 2
Date & Lot number

Week

Year - A:0, B:1 ... J:9
e.g. 2007:H, 2010:A, 2011:B

Lot No