Single Phase Full-Wave Motor Pre-Driver for Fan Motor AM5138

This is the summary of application for AM5138 optimum for driving 12V fan for general consumer equipment. The most attractive function of AM5138 is slope adjust by external resistor, that can meet most of fan request. This IC employs soft switching drive, Bi-CMOS process, and realizes silent drive, low ON resistor, and low power consumption. This also incorporate lock protection and auto restart circuit which does not require external capacitor.

● Applications

Optimum for driving 12V fan for general consumer equipment

● Features

1) Slope adjust mode for VH and VL pin control.
2) Soft switched drive.
3) PWM speed control.
4) Rotating speed pulse signal (FG) output.
5) Incorporating lock protection and automatic restart circuit.
6) Power Tr incorporated.
7) Hall Bias voltage built-in.
8) Soft start function built-in for reducing power up acoustic noise.

● Absolute Maximum Ratings (Ta = 25℃)

Parameter	Symbol	Limits	Unit
Supply voltage	V_{CC}	18	V
FG single output current	I_{FG}	10	mA
FG single output voltage	V_{FG}	18	V
Vref output current	Iref	10	mA
HB output current	I_{HB}	10	mA
High duty slope setting voltage	VH	6	V
Low duty slope setting voltage	VL	6	V
Minimum Speed setting voltage	VRMI	6	V
Operate temperature range	T_{opr}	-40～+105	℃
Storage temperature range	T_{stg}	-55～+150	℃
Junction temperature	Tjmax	150	℃

Those are stress rating only and functional operating at those conditions for extended periods may damage to the device.

● Recommended operating conditions

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

Parameter	Symbol	Min	Typ	Max	Unit
Operating supply voltage range	Vcc		3.5～16		V
Hall input voltage range	V_{HB}		0.2～2.1		V
High duty slope setting voltage range	VH		0~Vref		V
Low duty slope setting voltage range	VL		0~Vref		V
Minimum Speed setting voltage range	VRMI		0~Vref		V

● Electrical Characteristics

(Unless otherwise specified, Ta = 25℃, VCC = 12V)

Parameter	Symbol	Limit			Unit	Conditions
		Min	Typ	Max		
Supply current 1	$I_{CC}1$	1	3	6	mA	PWM=GND
Supply current 2	$I_{CC}2$	2	5	8	mA	PWM=OPEN
Reference Voltage	VREF	4.5	5	5.5	V	Ivref=5mA
Hall input						
Input offset voltage	V_{HOFS}	—	—	±6	mV	
PWM input						
Input H level	V_{PWMH}	2.5	—	Vref	V	
Input L level	V_{PWML}	-0.3	—	0.8	V	
Input frequency	F_{PWM}	5	—	100	kHz	
Output						
FG low voltage	V_{FGL}	—	0.3	0.4	V	I_{FG} = 5mA
FG leakage current	I_{FGL}	—	—	20.0	μA	V_{FG} = 15V
Input hysteresis voltage	V_{HYS}	±10	±17	±25	mV	
Hall bias voltage	V_{HB}	1.0	1.15	1.3	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

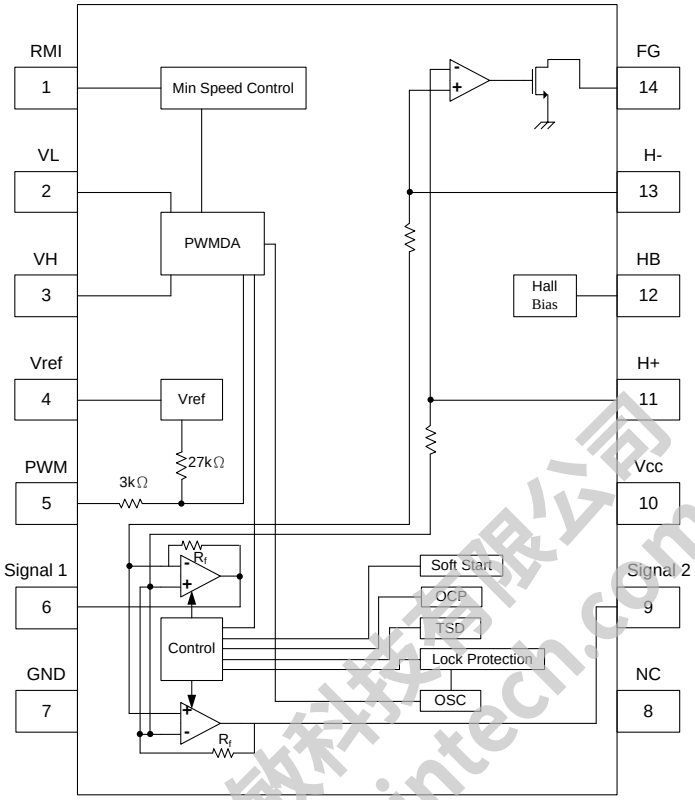


Fig.1 Block diagram

Pin Description

PIN No	Pin Name	Function	PIN No	Pin Name	Function
1	RMI	Minimum Speed setting terminal	8	NC	No Connection
2	VL	Hi duty slope setting terminal	9	Signal 2	Signal output terminal
3	VH	Low duty slope setting terminal	10	VCC	Power supply terminal
4	VREF	Reference voltage output terminal	11	H+	Hall input terminal
5	PWM	PWM signal input terminal	12	HB	Hall Bias terminal
6	Signal 1	Signal output terminal	13	H-	Hall input terminal
7	GND	Ground terminal	14	FG	FG signal output terminal

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

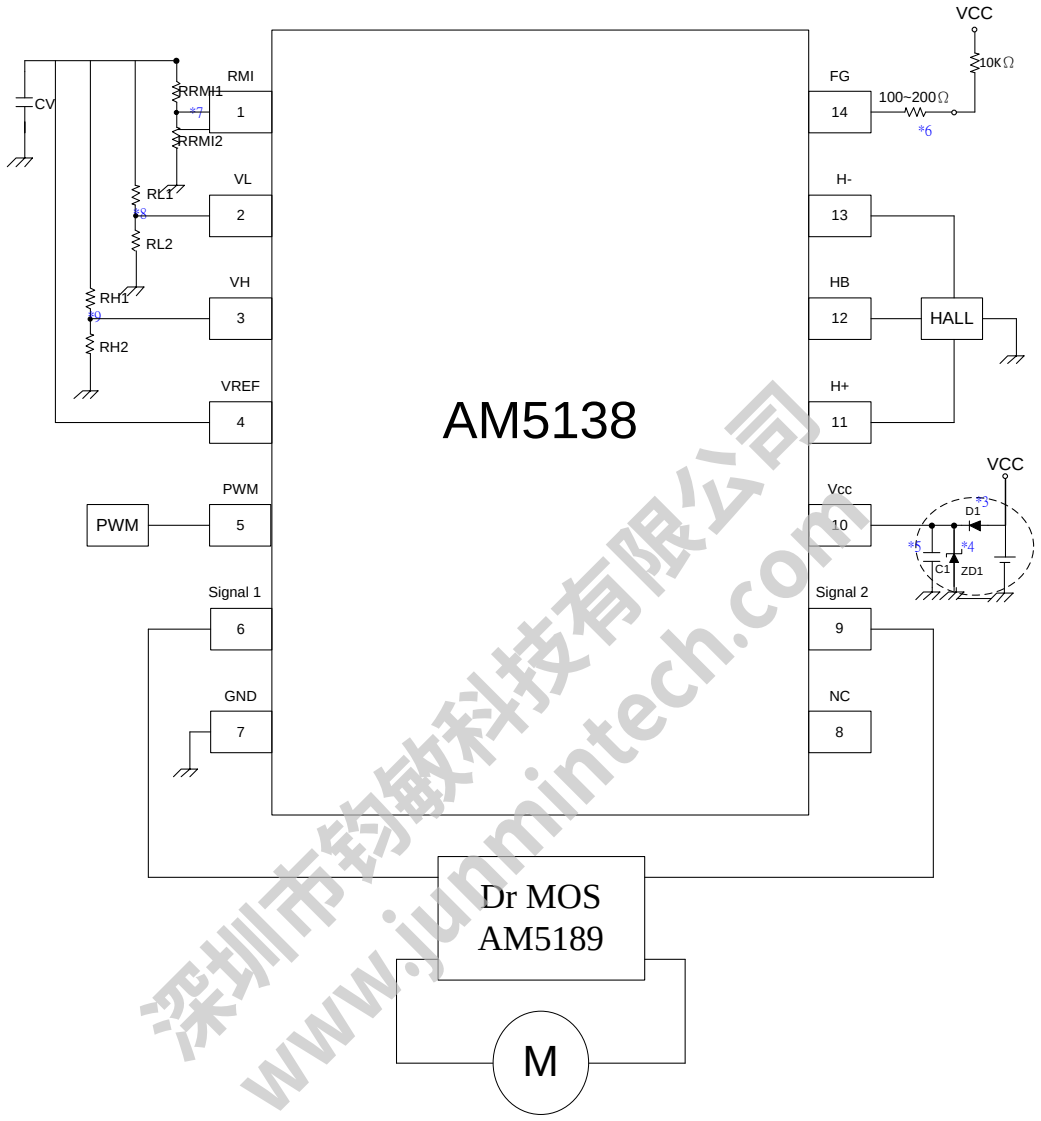


Fig.2 Application circuit

Notes:

1. AM5138 with AM5189 is the optimum solution.
   A. AM5138: Pre-Driver IC which could easily adjust RPM curve slope through only 6 resistors.
   B. AM5189: Highly integrated Dr MOS which could be controlled by two signals. The continue working current is up to 2.0A. Have OCP, TSD protection.
2. Hall element location degree is one of the key for the fan working efficiency. Set the hall element in the proper location degree and balance the working current could got a better working efficiency.

3. 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.

4. Connect a Zener diode (ZD1) between V_{CC} and GND terminal not to exceed the absolute maximum rating voltage.
5. Connect a capacitor (C1) between VCC and GND terminal to make a path of return current to power supply.
6. Open drain output. Suggest add a 100~200Ω resistor before a pull-up 10kΩ resistances.
7. Minimum Speed Control:
   When the IC using as minimum speed control. The minimum speed is setting by RMI pin, and minimum speed can be adjusted by RM1 and RM2 ratio. The relation is shown as the Fig. 3 below. When not need this feature, set the RMI pin connected to Vref, avoid noise interference..

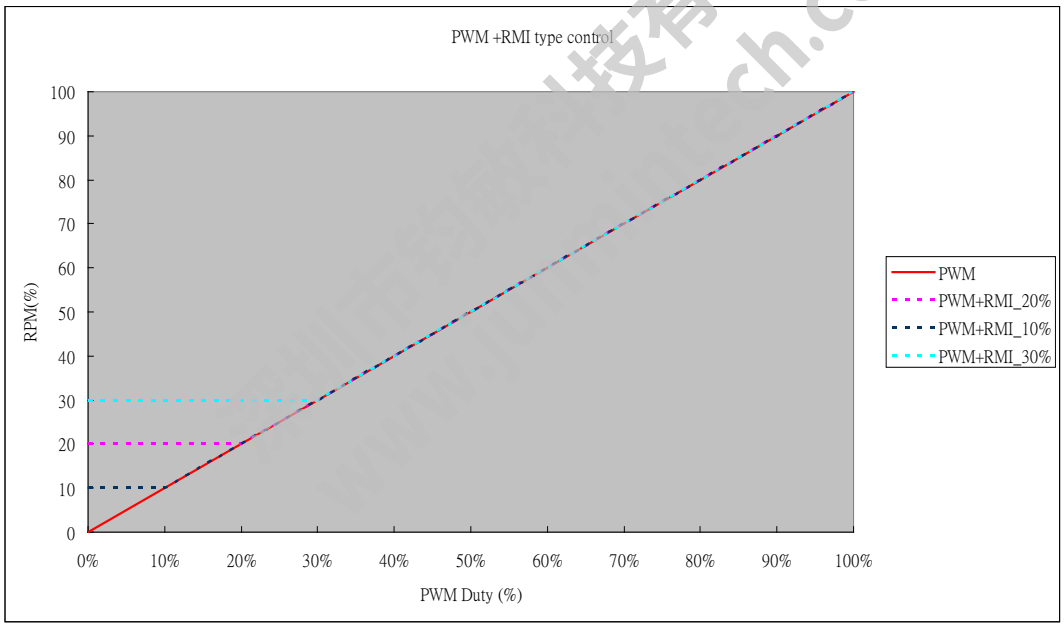


Fig.3

8. Slope Low duty control:
   When the IC using as Slope low duty control. The low duty control is setting by VH pin, and low duty control can be adjusted by RH1 and RH2 ratio. Typical setting is 0.75VREF, The relation is shown as the Fig. 4 below.

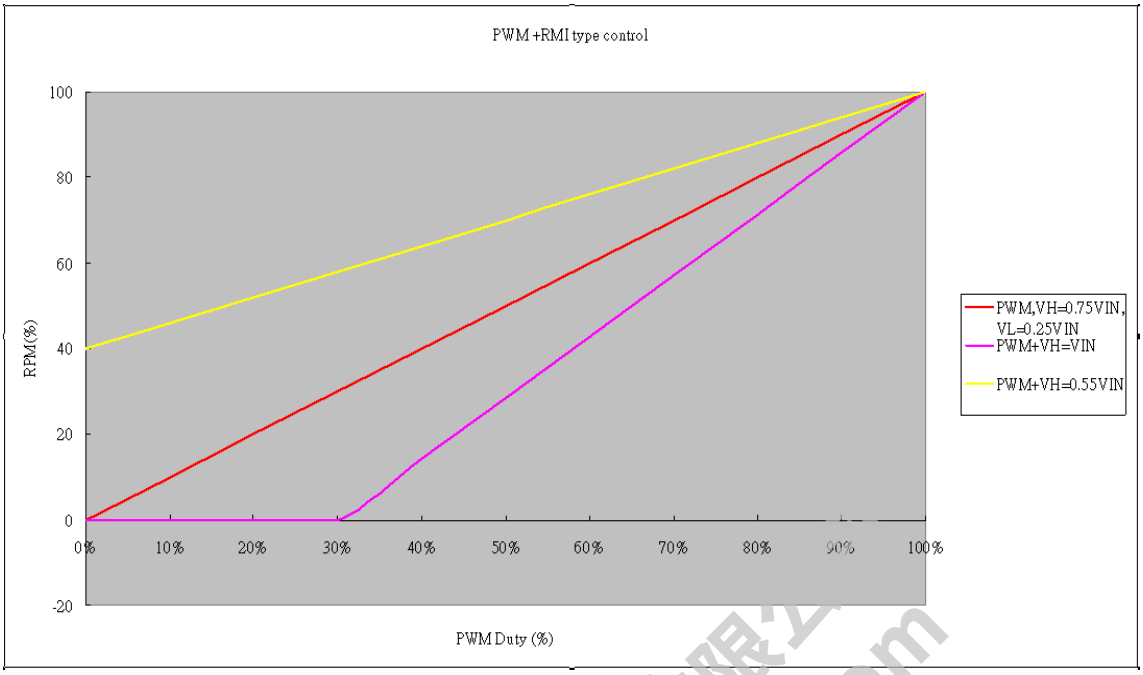


Fig.4

9. Slope Hi duty control:
When the IC using as Slope Hi duty control. The Hi duty control is setting by VL pin, and Hi duty control can be adjusted by RL1 and RL2 ratio. Typical setting is 0.25VREF. The relation is shown as the Fig. 5 below.

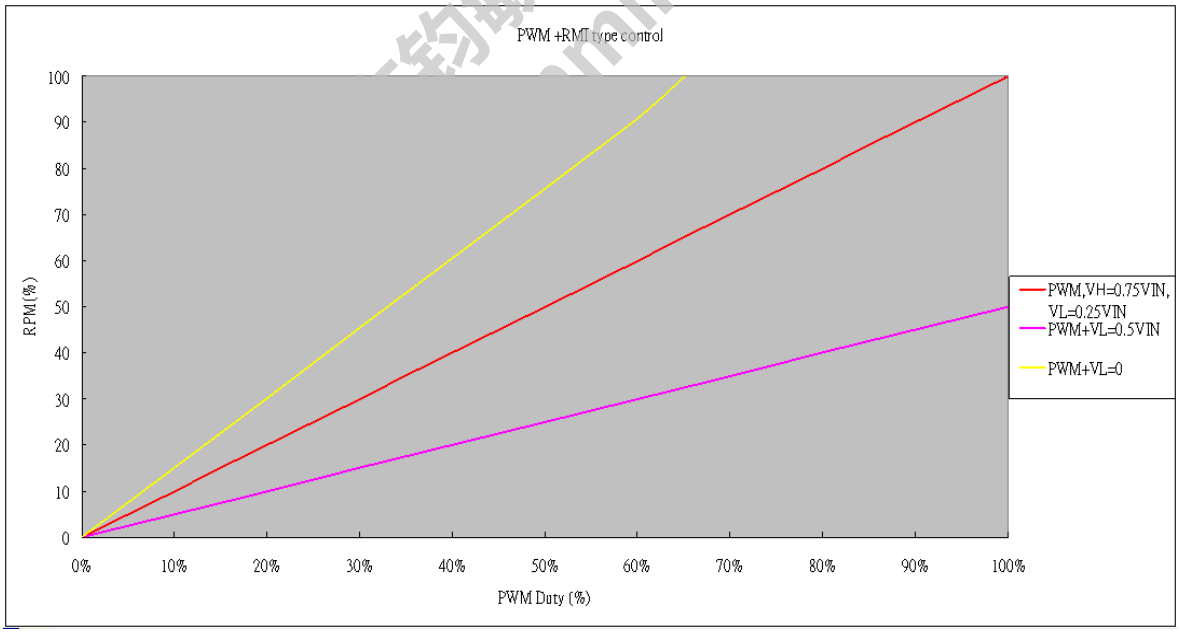


Fig.5

● 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.

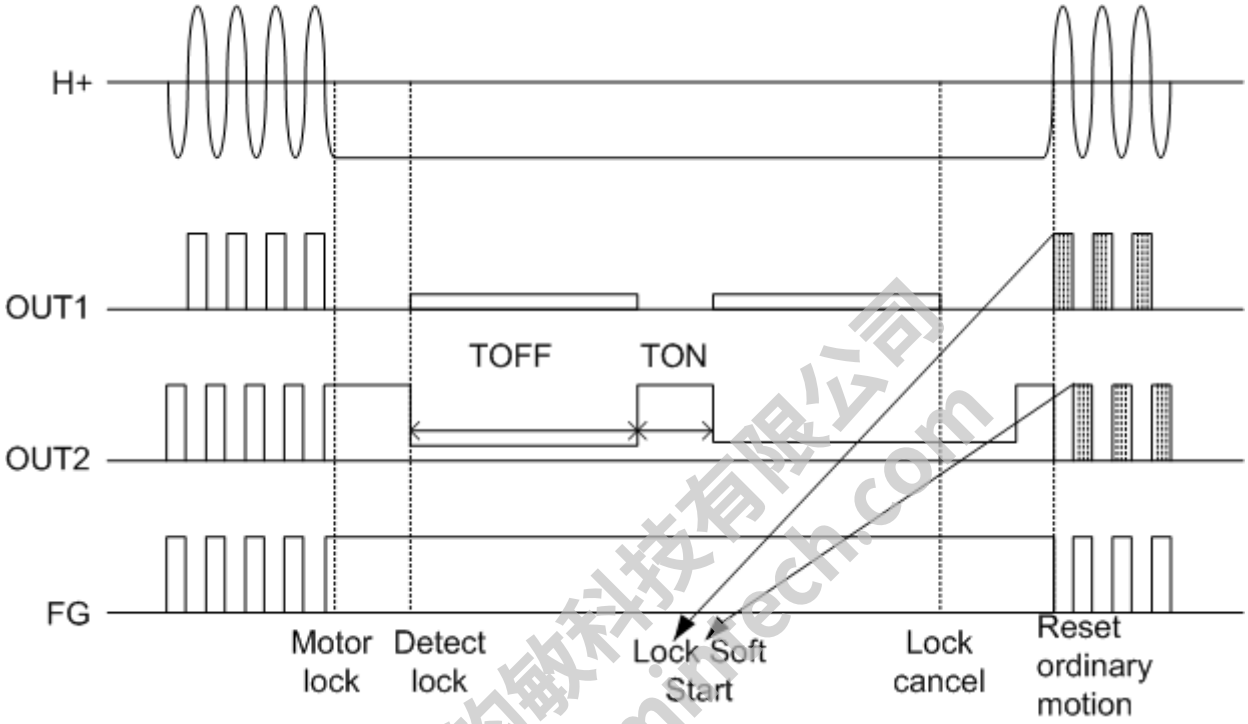


Fig.6 Lock detect and auto restart motion

Only in Lock detection ON Time (Ton), motor will be rest ordinary motion by switching over of hall signal. There is lock soft start function, When IC in reset ordinary motion, Output will shaping by 50% duty to start-up the motor, that will reduce lock start current and acoustic noise.

When RMI connect to Vref, this IC make the lock protection function off, when the PWM input keeps low level for more than 70ms (typ.)

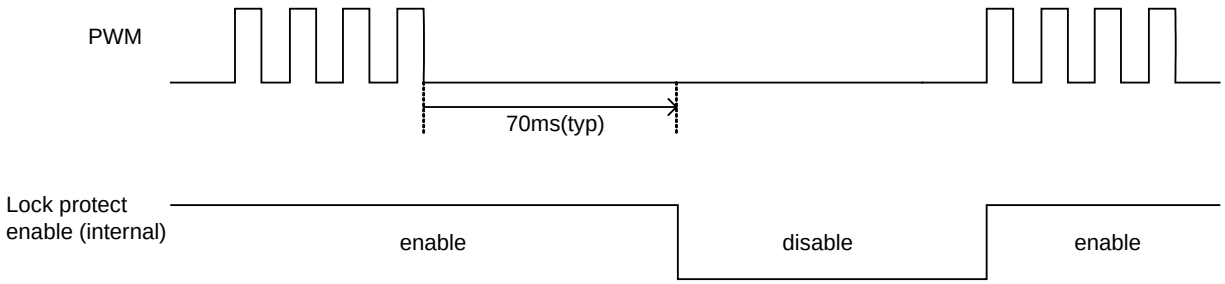


Fig.7 PWM input signal and lock protect function

Lock protect function does not work if PWM input frequency is slower than 15Hz (typ.)
So, please input faster frequency more than 20Hz

Soft switching function (silent drive setting)

Input signal to hall amplifier is amplified to produce an output signal.
When the hall element output signal is small, the gradient of switching of output waveform is gentle; When it is large on the contrary, the gradient of switching of output waveform is steep. Gain of 500 times (Typ.) is provided between input and output, therefore enter an appropriate hall element output to IC where output waveform swings sufficiently.

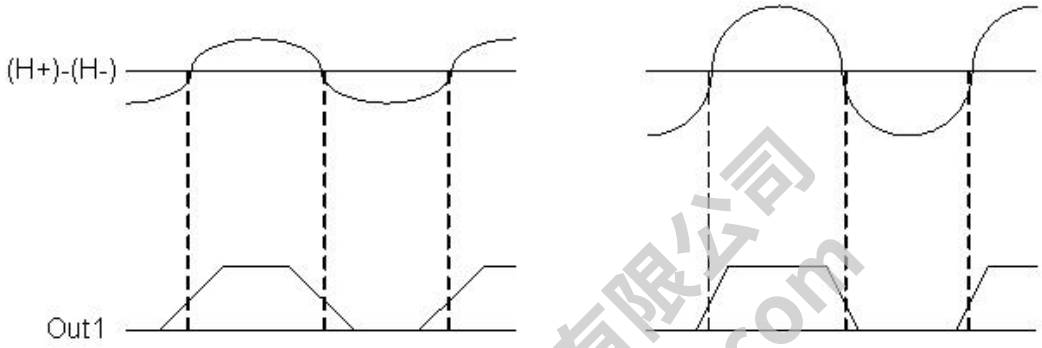


Fig.8 Relation between hall element output amplitude and output waveform

Hall input setting

Hall input voltage range is shown in operating conditions.

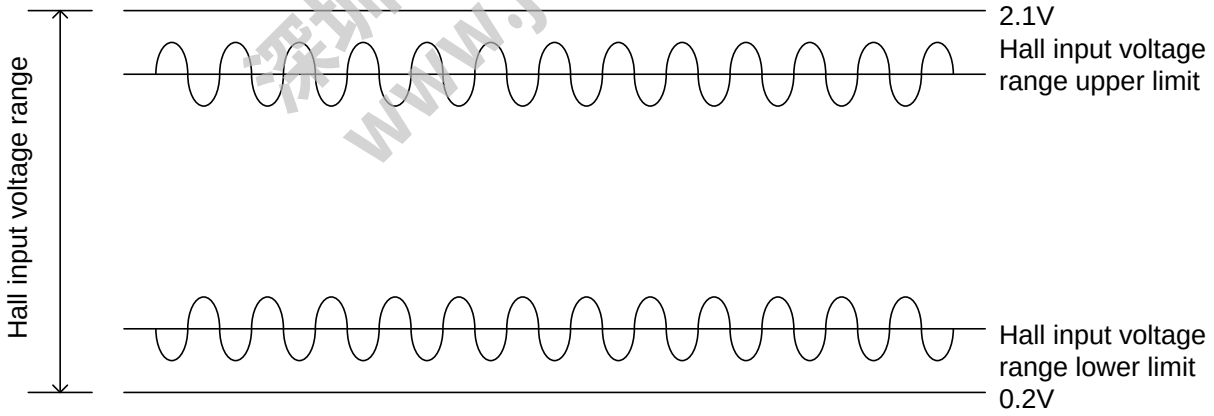


Fig.9 Hall input voltage range

Adjust the value of hall element bias resistor R1 in Fig.10 so that the input voltage of a hall amplifier is input in "hall input voltage range" including signal amplitude. Input out of the hall input voltage range may cause unexpected operation of output.

Reducing the noise of hall signal

Hall element may be affected by the depending on the wiring pattern of board. In this case, place a capacitor like C1 in Fig.10. In addition, when wiring from the hall element output to IC hall input is long, noise may be loaded on wiring. In this case, place a capacitor like C2 in Fig.10.

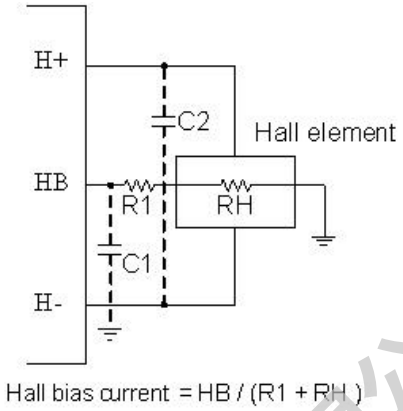


Fig.10 Application in the vicinity of hall signal

- **PWM input**

Rotation speed of motor can be changed by controlling ON/OFF of the upper output depending on duty of the signal input to PWM terminal.

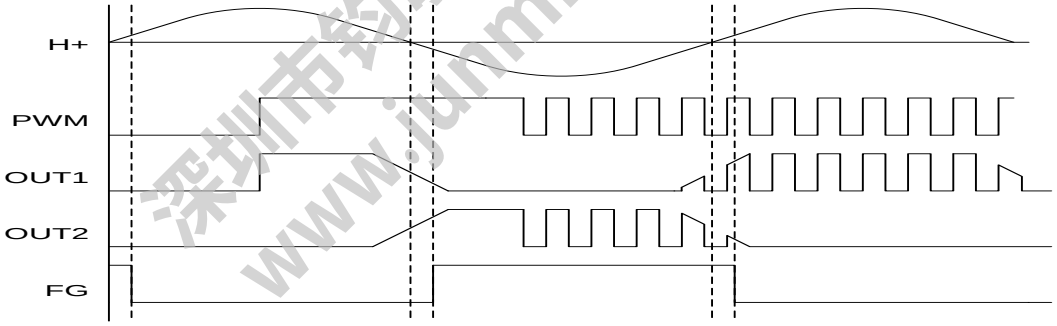


Fig.10 Timing chart in PWM control

When the voltage input to PWM terminal applies
H logic : normal operation
L logic : H side output is off

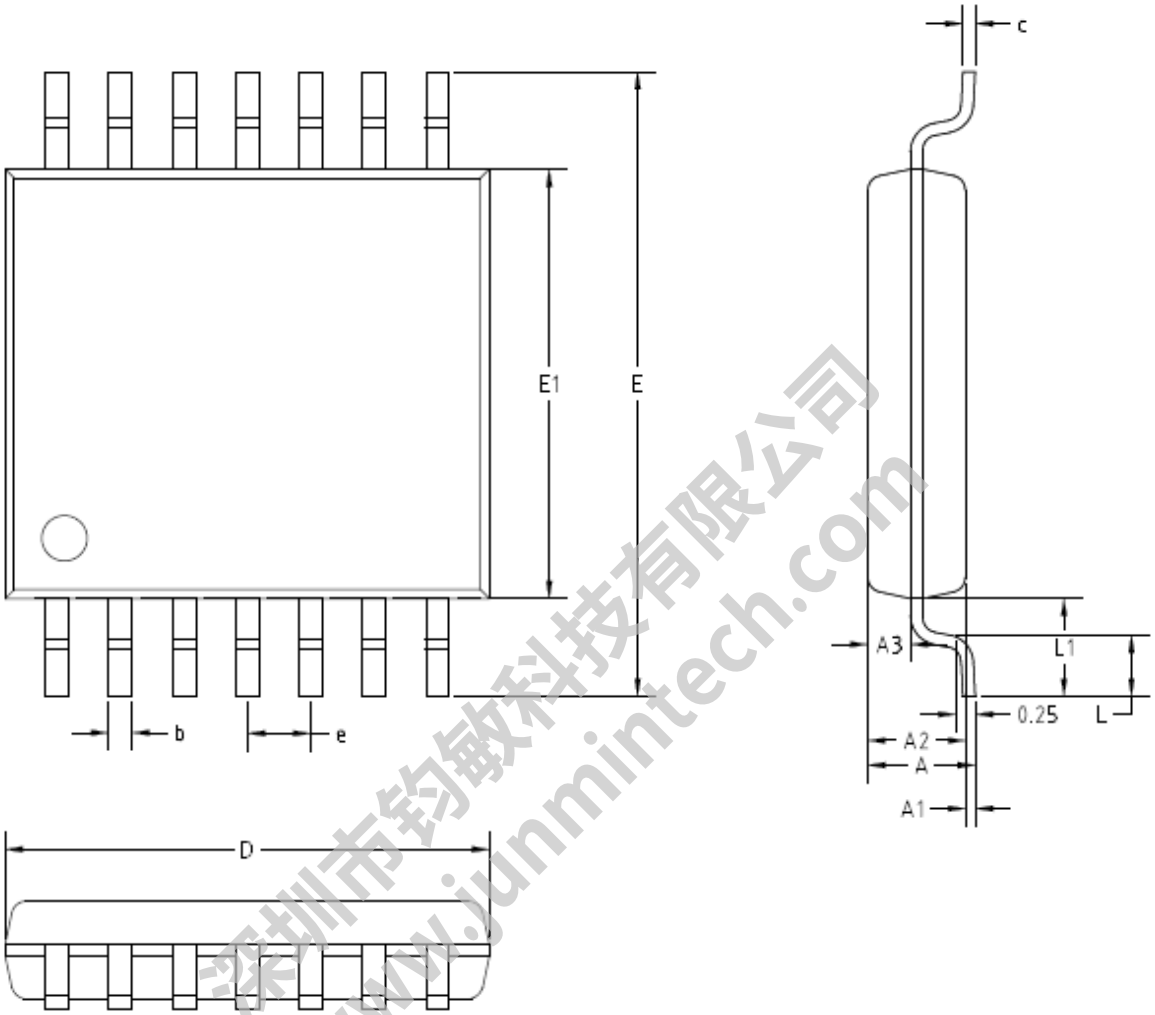
When PWM terminal is open, H logic is applied.
PWM terminal has hysteresis of 100mV (Typ.).

If H logic is applied to PWM terminal before VCC voltage is applied to IC, current flows to VCC terminal through ESD protection diode inside PWM terminal, resulting in malfunction may possibly occur.
When VCC voltage is not apply to IC, do not apply voltage to PWM terminal.

Notes

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) 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.

- **Packaging outline --- TSSOP 14L** **Unit : mm**



SYMBOL	MILLIMETERS		INCHES	
	Min.	Max.	Min.	Max.
A	-	1.20	-	0.047
A1	0.05	0.15	0.002	0.006
A2	0.90	1.05	0.035	0.041
A3	0.39	0.49	0.015	0.019
b	0.20	0.28	0.008	0.011
c	0.13	0.17	0.005	0.007
D	4.90	5.10	0.193	0.201
E1	4.30	4.50	0.169	0.173
E	6.20	6.60	0.244	0.260
L	0.45	0.75	0.018	0.030
L1	1.00BSC		0.039 BSC	
e	0.65 BSC		0.026 BSC	

● Condition of Soldering

1).Manual Soldering

Time / Temperature ≤ 3 sec / 400 ± 10 °C （2 Times）

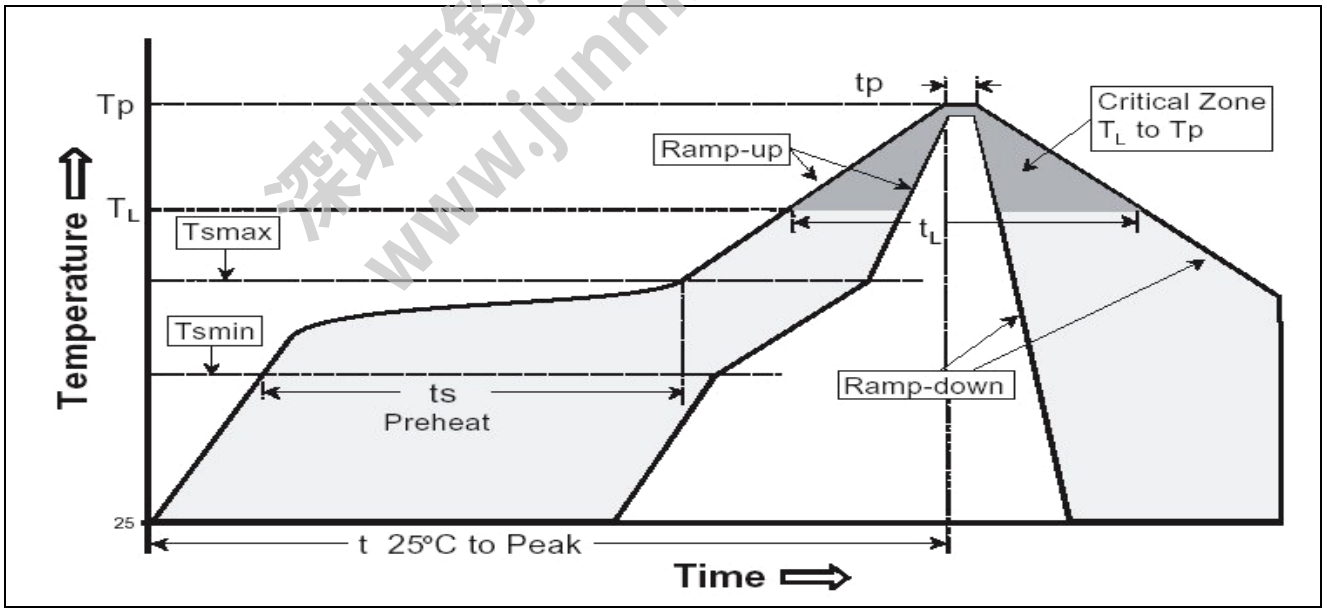
Test Results：0 fail/ 22 tested

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

- **Marking Identification**

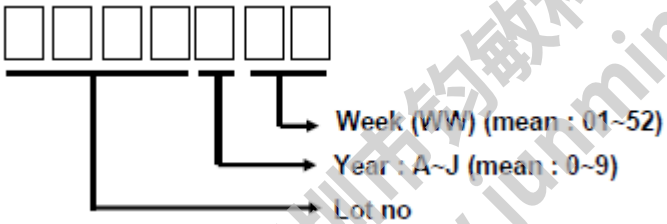
Row 1

AMtek

Row 2

Part number

Row 3



Week：Assembly Date Code

Year：Assembly Year

(Year_A=0,B=1,C=2,D=3,E=4,F=5,G=6,H=7,I=8,J=9, exp 2012=C)

Lot no：Wafer Lot No