

# Single Phase Full-Wave Motor Driver for Fan Motor AM7302

High efficiency, Rotation speed adjustable application for AM7302 optimum for driving 12V fan for general consumer equipment. This IC employs soft switching drive, turbo start, Bi-CMOS process and realizes silent drive, low ON resistor, and low power consumption. This also incorporate lock protection and auto restart circuit

## ● Applications

12V Fan optimum solution for variable rotation speed setting by external resistor. Such as LED, general consumer equipment...etc.

## ● Features

- |                                                                     |                                                                |
|---------------------------------------------------------------------|----------------------------------------------------------------|
| 1) High efficiency, Rotation speed adjustable by external resistor. | 5) Rotating speed pulse signal (FG) output                     |
| 2) Power Tr incorporated.                                           | 6) Incorporating lock protection and automatic restart circuit |
| 3) Soft switched drive.                                             | 7) Hall Bias built                                             |
| 4) Lock detection signal (RD) output.                               |                                                                |

## ● Absolute Maximum Ratings (Ta = 25°C)

| Parameter                      | Symbol                | Limits   | Unit |
|--------------------------------|-----------------------|----------|------|
| Supply voltage                 | V <sub>CC</sub>       | 18       | V    |
| Output current                 | I <sub>omax</sub>     | 400**    | mA   |
| FG single output current       | I <sub>FG(SINK)</sub> | 10       | mA   |
| FG single output voltage       | V <sub>FG</sub>       | 18       | V    |
| HB output current              | I <sub>HB(SINK)</sub> | 10       | mA   |
| Power dissipation (1Layer PCB) | P <sub>d</sub>        | *1.31    | W    |
| Power dissipation (2Layer PCB) | P <sub>d</sub>        | *3.42    | W    |
| Operate temperature range      | T <sub>opr</sub>      | -25~+105 | °C   |
| Storage temperature range      | T <sub>stg</sub>      | -55~+150 | °C   |
| Junction temperature           | T <sub>j</sub>        | 170      | °C   |

\*When mounted on a 114.3mm×76.1mm×1.6mm JEDEC standard test board.

\*\*Should not exceed Pd or ASO and T<sub>j</sub> values

## ● Recommended operating conditions

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

| Parameter                      | Symbol          | Min | Typ     | Max | Unit |
|--------------------------------|-----------------|-----|---------|-----|------|
| Operating supply voltage range | V <sub>CC</sub> |     | 3.0~15  |     | V    |
| Hall input voltage range       | V <sub>H</sub>  |     | 0.2~2.1 |     | V    |

### ● Electrical Characteristics

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

| Parameter                | Symbol            | Limit |      |      | Unit | Conditions                            |
|--------------------------|-------------------|-------|------|------|------|---------------------------------------|
|                          |                   | Min   | Typ  | Max  |      |                                       |
| Supply current 1         | I <sub>CC1</sub>  | 3     | 5    | 7    | mA   | PWM=GND                               |
| Supply current 2         | I <sub>CC2</sub>  | 3     | 6    | 9    | mA   | PWM=OPEN                              |
| <b>Hall input</b>        |                   |       |      |      |      |                                       |
| Input offset voltage     | V <sub>HOFs</sub> | —     | —    | ±6   | mV   |                                       |
| <b>CPWM input</b>        |                   |       |      |      |      |                                       |
| CPWM PIN H level         | V <sub>CPH</sub>  | 1.45  | 1.65 | 1.85 | V    |                                       |
| CPWM PIN L level         | V <sub>CPL</sub>  | 0.15  | 0.3  | 0.45 | V    |                                       |
| CPWM PIN frequency       | F <sub>PWM</sub>  | 18    | 22.5 | 27   | kHz  | C=100p                                |
| <b>Output</b>            |                   |       |      |      |      |                                       |
| Output voltage           | V <sub>O</sub>    | —     | 0.4  | 0.6  | V    | I <sub>O</sub> =200mA (Upper + Lower) |
| Input-output Gain        | G <sub>IO</sub>   | 45    | 48   | 51   | dB   |                                       |
| FG low voltage           | V <sub>FGL</sub>  | —     | 0.2  | 0.4  | V    | I <sub>FG</sub> = 3mA                 |
| FG leakage current       | I <sub>FGL</sub>  | —     | —    | 20.0 | μA   | V <sub>FG</sub> = 15V                 |
| RD low voltage           | V <sub>RDL</sub>  | —     | —    | 0.4  | V    | I <sub>RD</sub> = 3mA                 |
| RD leakage current       | I <sub>RDL</sub>  | —     | —    | 20.0 | μA   | V <sub>RD</sub> = 15V                 |
| Input hysteresis voltage | V <sub>HYS</sub>  | ±10   | ±17  | ±25  | mV   |                                       |
| Hall bias voltage        | V <sub>HB</sub>   | 1.5   | 1.8  | 2.1  | V    | I <sub>HB</sub> =-5mA                 |
| <b>Lock protection</b>   |                   |       |      |      |      |                                       |
| Lock detection ON time   | T <sub>ON</sub>   | 0.35  | 0.50 | 0.65 | Sec  |                                       |
| Lock detection OFF time  | T <sub>OFF</sub>  | 3.5   | 5.0  | 6.5  | Sec  |                                       |

- **Block Diagram**

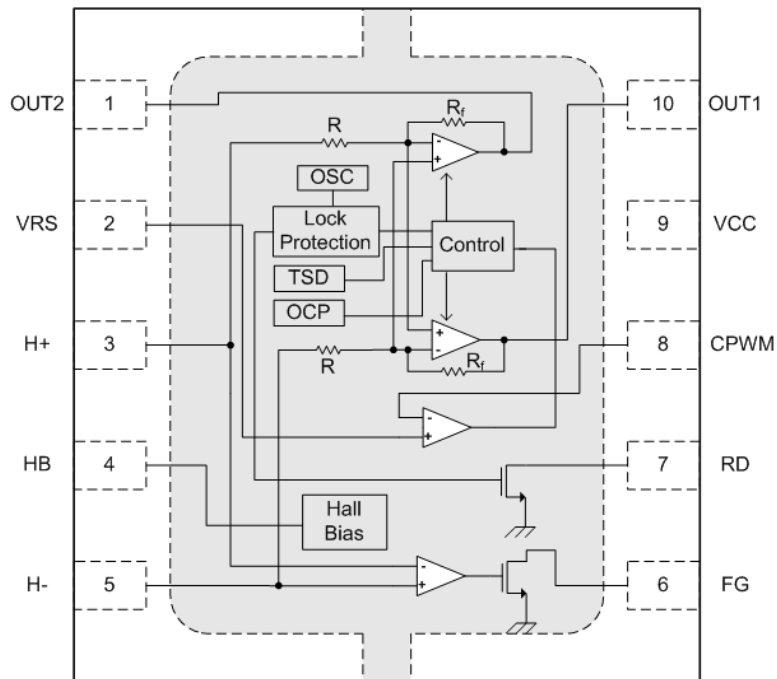


Fig.1 block diagram

## ● Pin Description

| PIN No | Pin Name | Function                                |
|--------|----------|-----------------------------------------|
| 1      | OUT2     | Motor output terminal                   |
| 2      | VRS      | Rotation Speed Setting terminal.        |
| 3      | H+       | Hall input terminal                     |
| 4      | HB       | Hall Bias                               |
| 5      | H-       | Hall input terminal                     |
| 6      | FG       | FG signal output terminal               |
| 7      | RD       | RD signal output terminal               |
| 8      | CPWM     | Oscillation pin with external capacitor |
| 9      | VCC      | Power supply terminal                   |
| 10     | OUT1     | Motor output terminal                   |
| E-pad  | GND      | Ground terminal                         |

- **Truth Table**

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

Z : Open drain output (High impedance)

### ● Application circuit

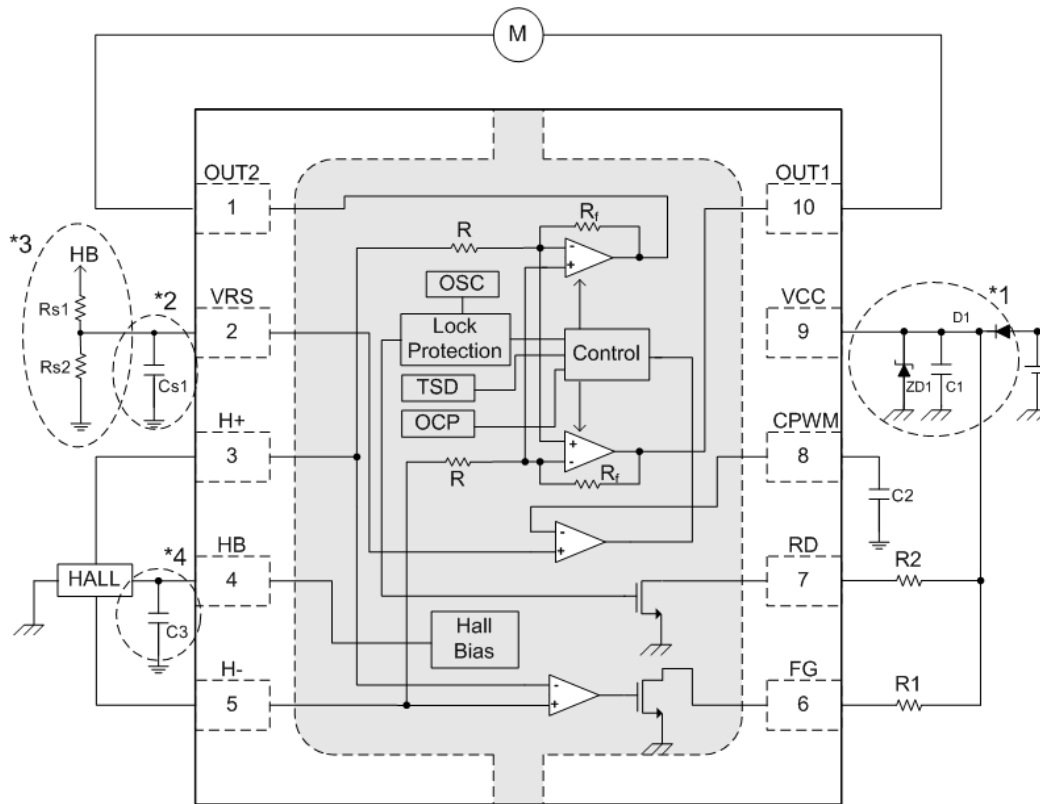


Fig.2 Application circuit

- \*1. 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.

- \*2. Cs1 is for turbo-start function. When power on, the VRS voltage will be arise from 0V, and will be charged by HB, Rs1 and Rs2 resistor. The time constant is defined by Rs1, Rs2 and Cs1.

- \*3. Both of Rs1 and Rs2 are for Rotation Speed setting. Floating of VRS pin is unacceptable.

When adds Rs1 connect to HB pin, that will reduce turn-on duty on output transistor; reducing rotation speed.

When adds Rs2 connect to GND, that will increase turn-on duty on output transistor; increasing rotation speed.

- \*4. Hall element may be affected by Vcc noise or depending on the wiring pattern of PCB board. In this case, adds C3 can be reducing the noise of hall signal.

### ● CPWM Control

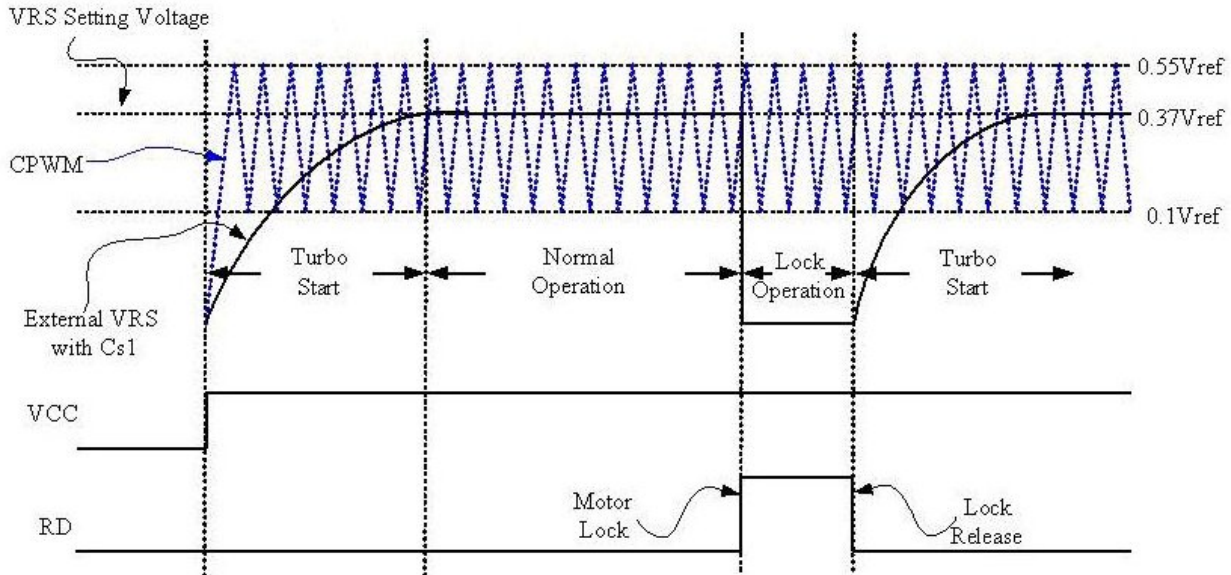


Fig.3 CPWM control principle

Assume  $R_{s1}$  and  $R_{s2}$  ratio equal to  $0.37V_{ref}$ .

#### 1. Turbo start mode:

Turbo start function can be apply, when adds  $C_{s1}$  capacitor on VRS PIN. The time constant is defined by  $C_{s1}$ ,  $R_{s1}$  and  $R_{s2}$ . When power on, The VRS voltage will be rising from 0V to setting voltage by dividing  $R_{s1}$  and  $R_{s2}$  ratio.

In Turbo start area, the motor will full speed rotation at the beginning. After VRS voltage arising to  $0.1V_{ref}$ , the motor will reduce the rotation speed. That is due to chopping CPWM by VRS voltage. Finally the motor will into normal operation area.

#### 2. Normal operation mode:

The VRS voltage will be setting by  $R_{s1}$  and  $R_{s2}$ . Adjust the  $R_{s1}$  and  $R_{s2}$  ratio that can control the rotation speed of Fan module by chopping the CPWM signal. When VRS voltage rising to  $0.37V_{ref}$  (our assumption). The Motor will be fixed rotation speed in normal operation mode.

#### 3. LOCK operation mode:

When motor into lock mode operation, the VRS voltage will be reset to 0V by internal circuit. And the VRS voltage will be recharged by  $R_{s1}$ ,  $R_{s2}$  and  $C_{s1}$ , when lock function is released.

### ● 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.

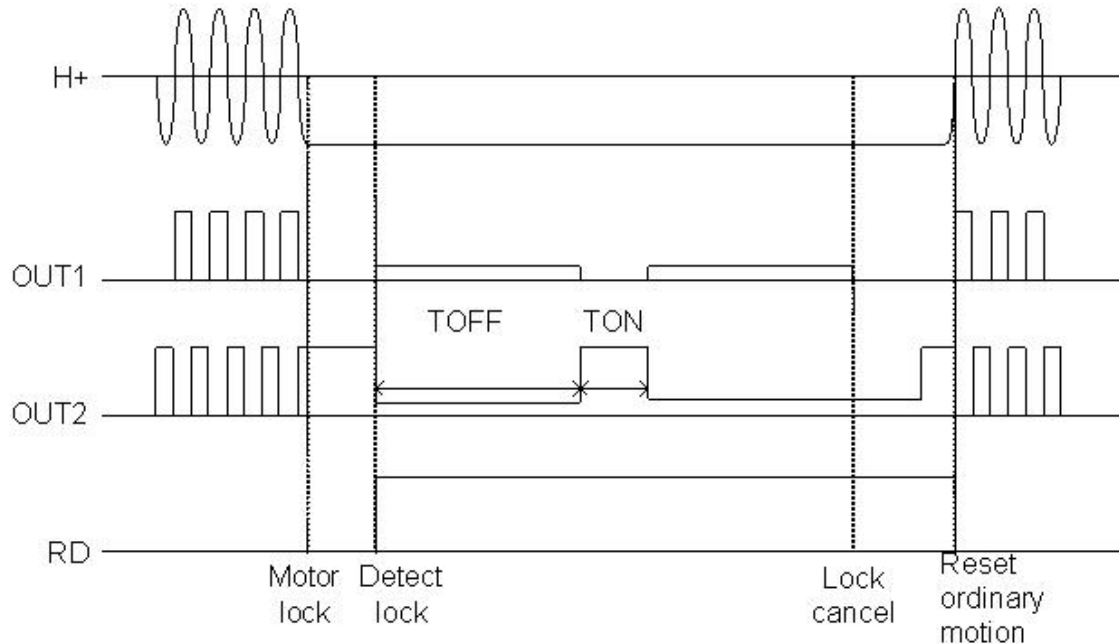


Fig.4 Lock detect and auto restart motion

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

### ● 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 300 times (Typ.) is provided between input and output, therefore enter an appropriate hall element output to IC where output waveform swings sufficiently.

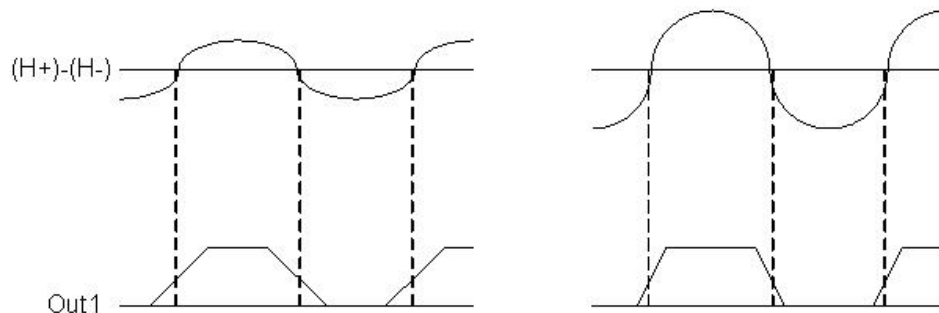


Fig.5 Relation between hall element output amplitude and output waveform

### ● Hall input setting

Hall input voltage range is shown in operating conditions.

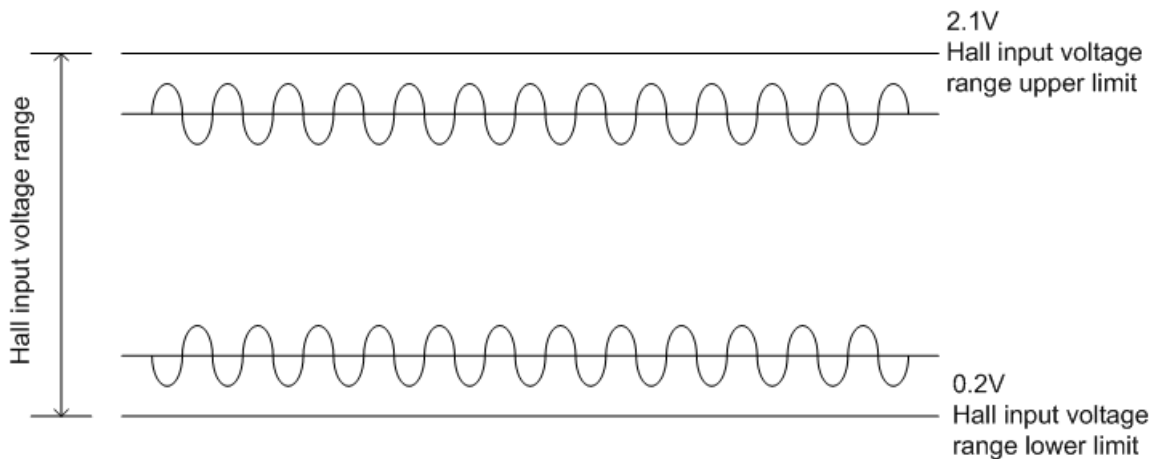


Fig.6 Hall input voltage range

Adjust the value of hall element bias resistor R1 in Fig.7 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.7. 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.7.

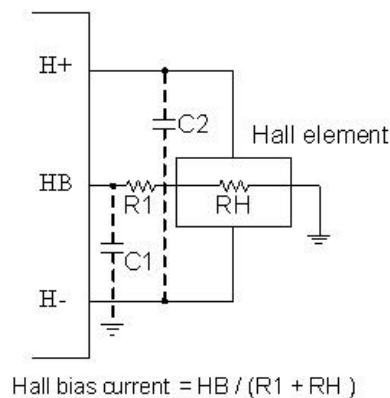
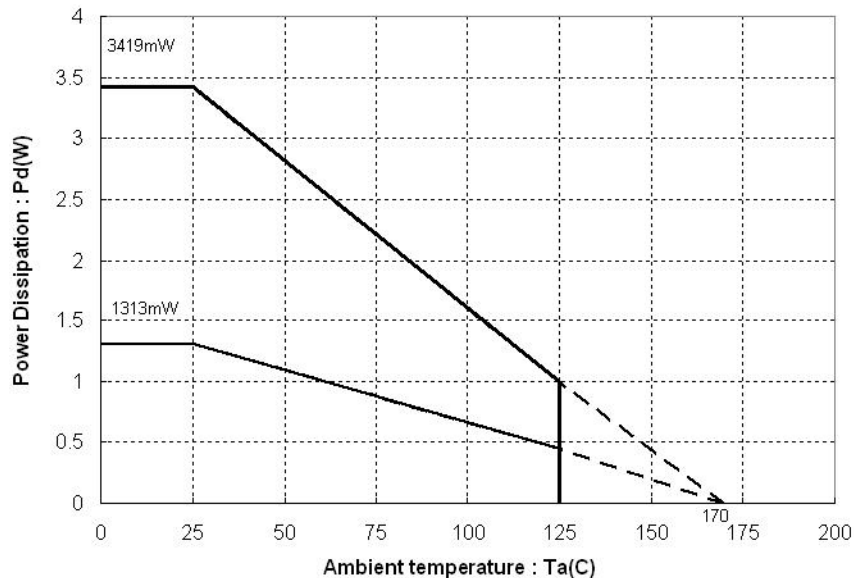


Fig.7 Application in the vicinity of hall signal

### ● 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 9.05mW/°C for operating above Ta=25°C

$\theta_{Ja}$ =110.4 °C/W,  $\theta_{Jc}$ = 34.8 °C/W,  $T_j$  = 170°C, Pd max 1313mW

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

De-rating is done at 23.58mW/°C for operating above Ta=25°C

$\theta_{Ja}$ =42.4 °C/W,  $\theta_{Jc}$ = 20.8 °C/W,  $T_j$  = 170°C, Pd max 3419mW

Calculated formulation  $P_d = (T_j - T_a) / \theta_{Ja}$

Symbol  $\theta_{Ja}$  is called thermal resistance

#### Thermal resistance:

$\theta_{Ja}$  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×76.1mm×1.6mm(JEDEC 51-3,7), copper foil area :< 3%, the core thickness: 1.0 mm, trace thickness: 0.07 mm (2 oz),plane thickness: 0.035 mm (1 oz)

### ● 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 margins for actual power dissipation.

#### 6) Mounting failures

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

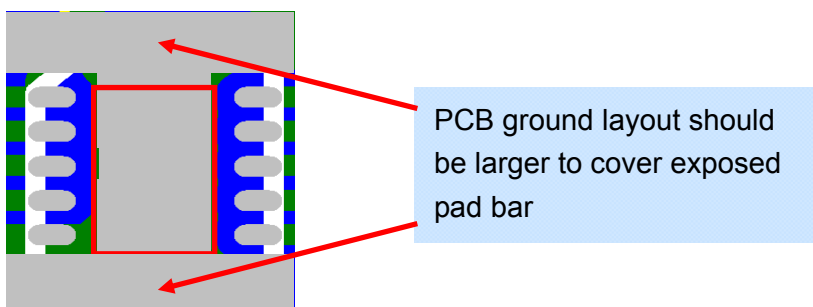
The electrical short caused by falling particle, between outputs; power supply and output; or output and ground, may damage the device.

#### 7) Layout guide

<a> There are 2 Bars on AM7302 exposed pad, the advantage of these 2 bars is to detect if exposed pad is well mounted on PCB ground.

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

Please refer to following drawing



### ● Condition of Soldering

#### 1).Manual Soldering

Pb-free: Time / Temperature  $\leq 3 \text{ sec} / 400 \pm 10^\circ\text{C}$  (2 Times)

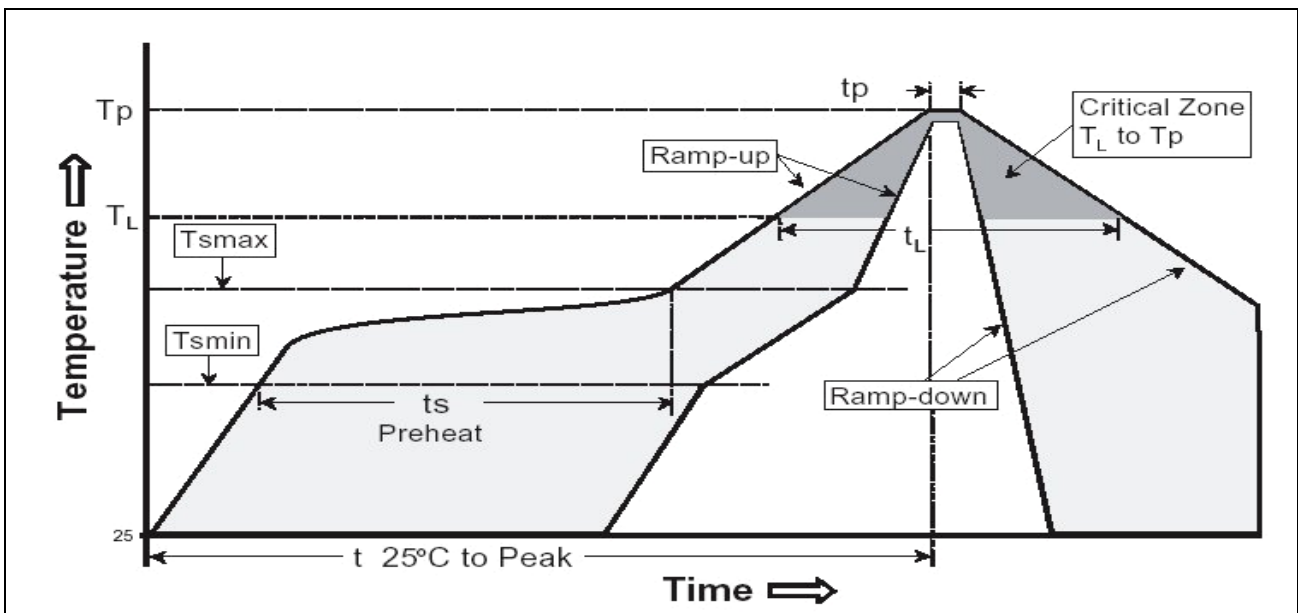
Test Results : 0 fail/ 22 tested

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 <ul style="list-style-type: none"> <li>- Temperature Min (<math>T_{s \text{ min}}</math>)</li> <li>- Temperature Max (<math>T_{s \text{ max}}</math>)</li> <li>- Time (<math>t_s</math>) from (<math>T_{s \text{ min}}</math> to <math>T_{s \text{ max}}</math>)</li> </ul> | 150°C<br>200°C<br>60-120 seconds |
| $T_{s \text{ max}}$ to $T_L$ <ul style="list-style-type: none"> <li>- Temperature Min (<math>T_{s \text{ min}}</math>)</li> </ul>                                                                                                                                                   | 3°C/second max.                  |
| Time maintained above: <ul style="list-style-type: none"> <li>- Liquid us temperature (<math>T_L</math>)</li> <li>- Time (<math>t_L</math>) maintained above <math>T_L</math></li> </ul>                                                                                            | 217°C<br>60-150 seconds          |
| Peak package body temperature ( $T_P$ )                                                                                                                                                                                                                                             | 260 +0/-5°C                      |
| Time with 5°C of actual Peak <ul style="list-style-type: none"> <li>- Temperature (<math>t_p</math>)</li> </ul>                                                                                                                                                                     | 30 seconds                       |
| Ramp-down Rate                                                                                                                                                                                                                                                                      | 6°C/second max.                  |
| Time 25°C to Peak Temperature                                                                                                                                                                                                                                                       | 8 minutes max.                   |

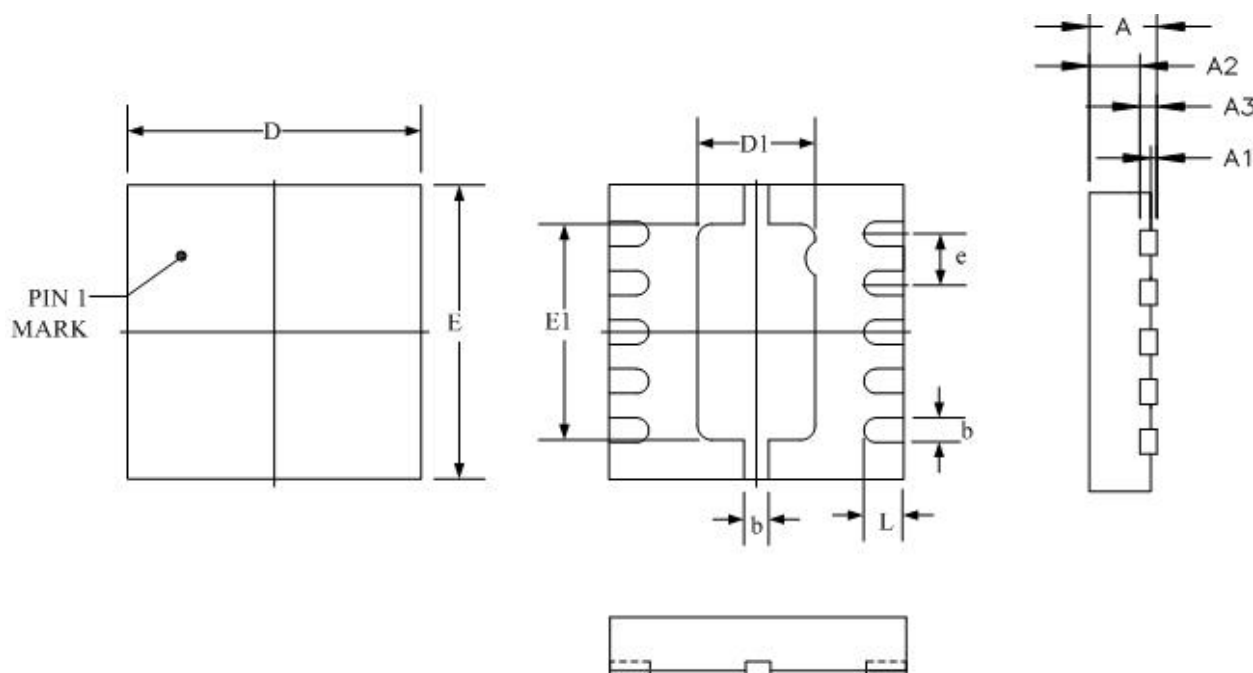


Test Results : 0 fail/ 32 tested

Reflow count : 3 cycles

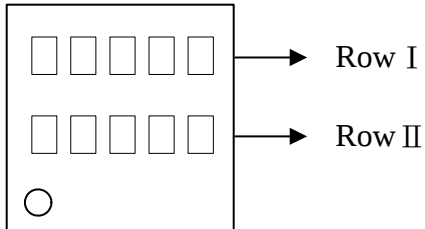
● Packaging outline --- DFN 3X3 10L

Unit : mm



| SYMBOL | MILLIMETERS |      | INCHES    |       |
|--------|-------------|------|-----------|-------|
|        | Min.        | Max. | Min.      | Max.  |
| A      | -           | 0.60 | -         | 0.023 |
| 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 |       |

### ● Marking Identification



Row I  
A7302

Row II  
Date & Lot number

