



# AP1025BEN

## 45V Single Stepper Motor Driver IC

### 1. Description

The AP1025BEN provides a complete stepper motor driver solution with built-in LDMOS FET and its internal capacitors type charge pump circuit for the 45V & 1.6A constant current operation. Clock-in input mode and Parallel input mode is selectable by the setting of an external terminal. 2 phase, 1-2 phase(1/2step), W1-2 phase(1/4step) can be selected during parallel input mode, and 2 phase, 1-2 phase(1/2step), W1-2 phase(1/4step), 4W1-2 phase(1/16step) can be selected during clock-in input mode to realize calm motor operation. The IC is housed in a small 32-pin QFN package and excellent in heat dissipation. It also includes under voltage detection and thermal shut down circuits. It is suitable for various types of stepper motors.

### 2. Features

- Selectable input logic (Clock in input, Parallel input)
- Excitation mode is configurable
  - Parallel input mode 2 phase, 1-2 phase(1/2step), W1-2 phase(1/4step)
  - Clock-in input mode 2 phase, 1-2 phase(1/2step), W1-2 phase(1/4step), 4W1-2 phase(1/16step)
- Operating Temperature Range -30°C to +85°C
- Operating Voltage Range
  - Control Power Supply Voltage (VC) 3.0V to 5.5V
  - Motor Power Supply Voltage (VM) 9.0V to 45V
- Low H-Bridge On Resistance 0.85Ω@25°C
- Built-in UVLO (under voltage lockout circuit)
- Built-in TSD (thermal shut down circuit)
- Built-in charge pump circuit
- Built-in Sub-harmonic noise reduction function
- Built-in Phase Synchronous function
- Package 32-pin QFN (5.0mm□)

**3. Table of Contents**

|   |    |
|---|----|
| 1. Description .....                      | 1  |
| 2. Features .....                         | 1  |
| 3. Table of Contents .....                | 2  |
| 4. Block Diagram .....                    | 3  |
| 5. Ordering Guide .....                   | 3  |
| 6. Pin Configuration and Functions .....  | 4  |
| ■ Pin Configuration .....                 | 4  |
| ■ Functions .....                         | 4  |
| 7. Absolute Maximum Ratings .....         | 5  |
| 8. Recommended Operation Conditions ..... | 6  |
| 9. Electric Characteristics .....         | 6  |
| 10. Functional Description .....          | 8  |
| 11. Recommended External Circuit .....    | 17 |
| ■ External circuit .....                  | 17 |
| ■ Recommended Layout Example .....        | 18 |
| 12. Package .....                         | 19 |
| ■ Outline Dimensions .....                | 19 |
| ■ Marking .....                           | 19 |
| 13. Revise History .....                  | 20 |
| IMPORTANT NOTICE .....                    | 21 |

## 4. Block Diagram

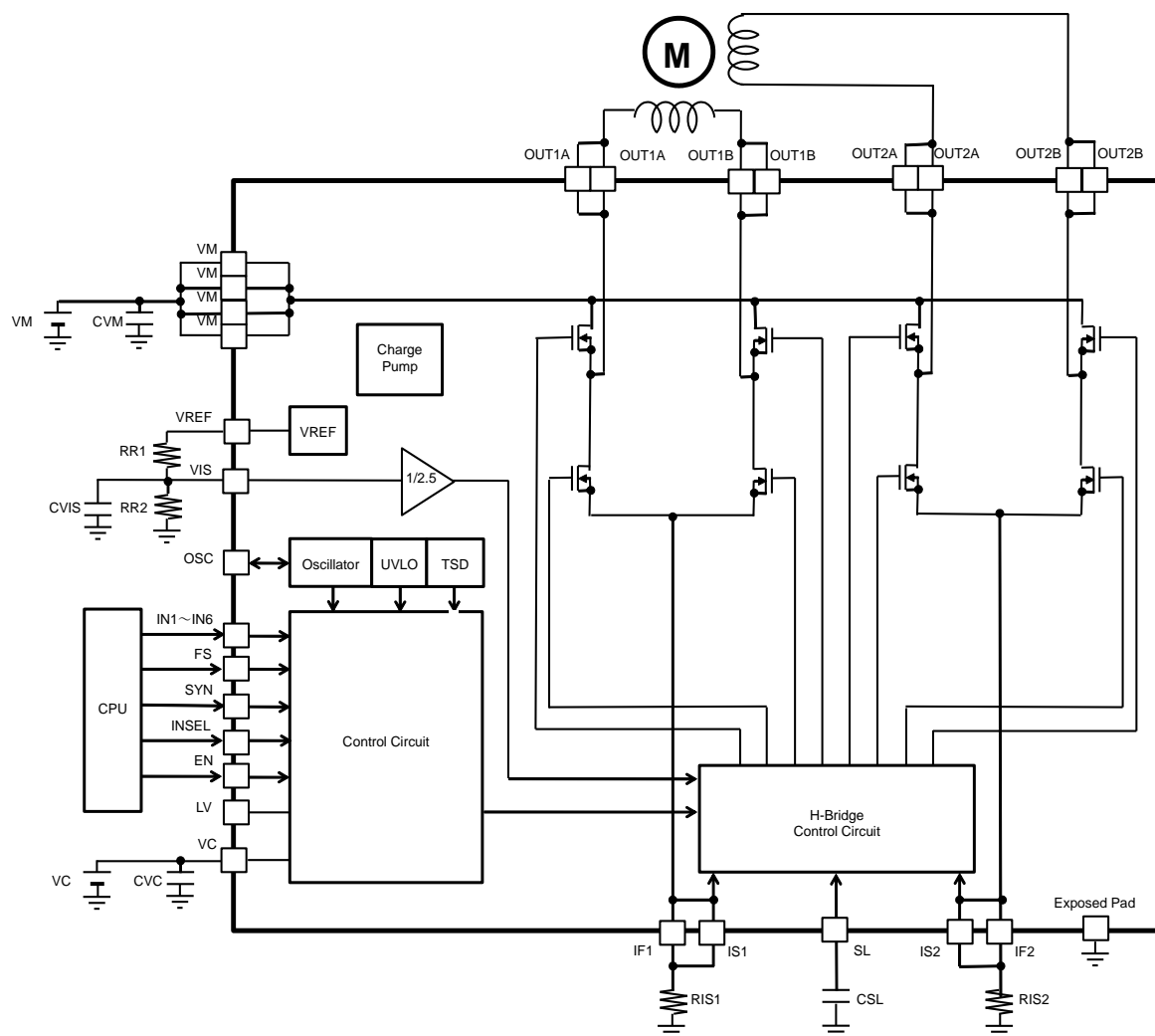


Figure 1. Block Diagram

## 5. Ordering Guide

AP1025BEN      -30°C ~+85°C      32-pin QFN

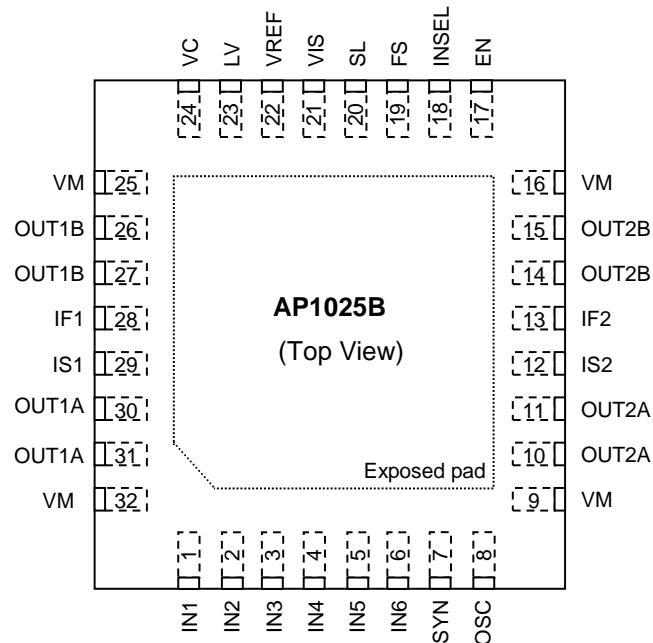
When AP1025AEN is replaced with AP1025BEN, note that the excitation mode(H,H) is changed as follows.

Table 1. Selection of the excitation mode

| IN5 | IN6 | AP1025AEN            | AP1025BEN              |
|-----|-----|----------------------|------------------------|
| H   | H   | W1-2 phase (1/4step) | 4W1-2 phase (1/16step) |

## 6. Pin Configuration and Functions

### ■ Pin Configuration



### ■ Functions

| No.        | Pin Name    | I/O | Function   | Condition       |
|------------|-------------|-----|--|-----------------|
| 1~6        | IN1~IN6     | I   | Control signal input terminal                      |                 |
| 7          | SYN         | I   | Synchronic mode select input terminal              |                 |
| 8          | OSC         | I/O | Chopper frequency I/O terminal                     |                 |
| 9,16,25,32 | VM          | P   | Motor power supply terminal                        |                 |
| 10,11      | OUT2A       | O   | Motor driver output terminal                       |                 |
| 12         | IS2         | I   | Current sense terminal                             |                 |
| 13         | IF2         | O   | Current force terminal                             |                 |
| 14,15      | OUT2B       | O   | Motor driver output terminal                       |                 |
| 17         | EN          | I   | Enable signal input terminal                       | 200kΩ pull-down |
| 18         | INSEL       | I   | Control logic select input terminal                |                 |
| 19         | FS          | I   | Chopper frequency select terminal                  |                 |
| 20         | SL          | I   | Slope setting terminal                             |                 |
| 21         | VIS         | I   | Motor current setting terminal                     |                 |
| 22         | VREF        | O   | Reference voltage output terminal                  |                 |
| 23         | LV          | O   | Logic voltage output capacitor connection terminal |                 |
| 24         | VC          | P   | Control power supply terminal                      |                 |
| 26,27      | OUT1B       | O   | Motor driver output terminal                       |                 |
| 28         | IF1         | O   | Current force terminal                             |                 |
| 29         | IS1         | I   | Current sense terminal                             |                 |
| 30,31      | OUT1A       | O   | Motor driver output terminal                       |                 |
| -          | Exposed Pad | P   | Ground   |                 |

Note 1. I(Input terminal), O(Output terminal), P(Power terminal)

Note 2. Exposed Pad must be connected to GND.

## 7. Absolute Maximum Ratings

| Parameter   | Symbol | min  | max | Unit | Condition        |
|---|--------|------|-----|------|------------------|
| Control power supply voltage                            | VC     | -0.5 | 5.5 | V    |                  |
| Motor power supply voltage                              | VM     | -0.5 | 45  | V    |                  |
| VC level terminal<br>(SL, EN, SYN, OSC, FS, INSEL, INn) | Vterm1 | -0.5 | VC  | V    |                  |
| VM level terminal<br>(OUTnA, OUTnB)                     | Vterm2 | -0.5 | VM  | V    |                  |
| 1.8V level terminal<br>(LV, VREF, VIS)                  | Vterm3 | -0.5 | 1.9 | V    |                  |
| 1.2V level terminal<br>(ISn, IFn)                       | Vterm4 | -0.5 | 1.3 | V    |                  |
| Maximum DC output current                               | Iload  | -    | 1.6 | A    | Ta=25°C (Note 6) |
|   |        | -    | 1.2 | A    | Ta=85°C (Note 6) |
| Power dissipation                                       | PD     | -    | 3.9 | W    | Ta=25°C (Note 6) |
|   |        | -    | 2.0 | W    | Ta=85°C (Note 6) |
| Junction temperature                                    | Tj     | -    | 150 | °C   |                  |
| Storage temperature                                     | Tstg   | -40  | 150 | °C   |                  |
| ESD rating  | HBM    | -    | -   | ±2   | kV               |

Note 3. All above voltages are with respect to GND(Exposed Pad).

Note 4. Exposed Pad must be connected to GND.

Note 5. The each power supply of VC and VM is sequence-free.

Note 6.  $\theta_{JA}=32^{\circ}\text{C/W}$  with 4 layer board (JEDEC51).

**WARNING:** Operation at or beyond these limits may result in permanent damage to the device. Normal operation is not guaranteed at these extremes.

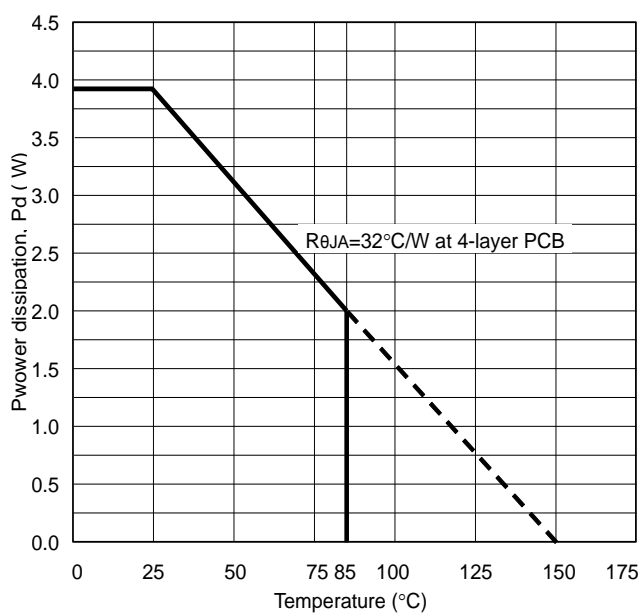


Figure 2. Maximum power dissipation

## 8. Recommended Operation Conditions

| Parameter                    | Symbol | min | typ  | max              | Unit | Condition                                  |
|------------------------------|--------|-----|------|------------------|------|--|
| Motor power supply voltage   | VM     | 9.0 | 24.0 | 45.0             | V    |  |
| Control power supply voltage | VC     | 3.0 | 5.0  | 5.5              | V    |  |
| VIS input voltage range      | VIS    | 0.2 | -    | V <sub>REF</sub> | V    | I <sub>load</sub> (100%)[A]=(VIS/2.5)/RISn |
| Clock in input frequency     | FCL    | -   | -    | 20               | kHz  |  |
| Operating Temperature range  | Ta     | -30 | -    | 85               | °C   |  |

Note 7. All above voltages are with respect to GND(Exposed Pad).

## 9. Electric Characteristics

(Ta = 25°C, VM=24V, VC = 5.0V, unless otherwise specified.)

| Parameter                                      | Symbol             | Condition  | min    | typ  | max    | Unit |
|--|--------------------|--|--------|------|--------|------|
| Quiescent current                              |                    |  |        |      |        |      |
| VC Quiescent current at OFF                    | I <sub>VCOFF</sub> | EN="L"   | -      | -    | 10     | μA   |
| VM Quiescent current at OFF                    | I <sub>VMOFF</sub> | EN="L"   | -      | -    | 20     | μA   |
| VC Quiescent current at operate                | I <sub>VC</sub>    | EN="H", INSEL="H",<br>SYN="L", FS="L", IN1=1kHz                              | -      | 1.7  | 2.8    | mA   |
| H-bridge circuit                               |                    |  |        |      |        |      |
| Driver on resistance<br>(High side + Low side) | R <sub>ON1</sub>   | I <sub>load</sub> 1ch/2ch=0.1A/0.1A<br>Ta = 25°C                             | -      | 0.85 | 1.0    | Ω    |
|  |                    | I <sub>load</sub> 1ch/2ch=0.1A/0.1A<br>Ta = 25°C、VC=3.0V                     | -      | 1.0  | 1.5    | Ω    |
|  | R <sub>ON2</sub>   | I <sub>load</sub> 1ch/2ch=<br>1.1A / 0A or 0.8A / 0.8A<br>Ta = 85°C (Note 9) | -      | 1.0  | 1.5    | Ω    |
|  |                    | I <sub>load</sub> 1ch/2ch=<br>1.1A / 0A or 0.8A / 0.8A<br>Ta = 85°C (Note 9) | -      | 1.5  | 2.0    | Ω    |
| Body diode forward voltage                     | V <sub>F</sub>     | I <sub>F</sub> = 100mA   | -      | 0.8  | 1.2    | V    |
| Control logic                                  |                    |  |        |      |        |      |
| High level input voltage                       | V <sub>IH</sub>    | VC = 3.0V-5.5V   | 0.7xVC | -    | -      | V    |
| Low level input voltage                        | V <sub>IL</sub>    |  | -      | -    | 0.3xVC | V    |
| Input pulse rise time                          | t <sub>R</sub>     |  | -      | -    | 1.0    | μs   |
| Input pulse fall time                          | t <sub>F</sub>     |  | -      | -    | 1.0    | μs   |
| High level input current                       | I <sub>IH</sub>    | without EN terminal  | -1.0   | -    | 1.0    | μA   |

| Parameter                              | Symbol       | Condition                        | min    | typ  | max    | Unit        |
|--|--------------|----------------------------------|--------|------|--------|-------------|
| High level input current               | $I_{IHEN}$   | EN terminal                      | 15     | 25   | 40     | $\mu A$     |
| Low level input current                | $I_{IL}$     |                                  | -1.0   | -    | 1.0    | $\mu A$     |
| Reference voltage                      |              |                                  |        |      |        |             |
| VREF terminal voltage                  | $V_{REF}$    | $R1+R2=12k+47k \Omega$           | 1.22   | 1.25 | 1.28   | V           |
| VREF terminal current                  | $I_{VREF}$   |                                  | -      | -    | 100    | $\mu A$     |
| Current operation                      |              |                                  |        |      |        |             |
| Blanking time                          | $t_B$        |                                  | 2.0    | 2.23 | 2.6    | $\mu s$     |
| VIS offset voltage                     | $V_{OSIS}$   |                                  | -50    | 0    | 50     | mV          |
| SL terminal output current             | $I_{SL}$     |                                  | -      | 50   | -      | $\mu A$     |
| OSC terminal frequency 1               | $f_{CPL}$    | FS="L", SYN="L"                  | 20     | 25   | 30     | kHz         |
| OSC terminal frequency 2               | $f_{CPH}$    | FS="H", SYN="L"                  | 40     | 50   | 60     | kHz         |
| OSC terminal High level output voltage | $V_{CPOH}$   | SYN="L", Iload=100 $\mu A$       | VC-0.1 | -    | -      | V           |
| OSC terminal Low level output voltage  | $V_{CPOL}$   | SYN="L", Iload=-100 $\mu A$      | -      | -    | 0.1    | V           |
| OSC terminal frequency input range     | $f_{CPIN}$   | SYN="H"                          | 20     | -    | 60     | kHz         |
| OSC terminal input voltage range       | $V_{CPIN}$   | SYN="H"                          | 0      | -    | VC     | V           |
| OSC terminal High level input voltage  | $V_{CPIH}$   | SYN="H"                          | 0.7xVC | -    | -      | V           |
| OSC terminal Low level input voltage   | $V_{CPIL}$   | SYN="H"                          | -      | -    | 0.3xVC | V           |
| Protection circuit                     |              |                                  |        |      |        |             |
| VC under voltage detect voltage        | $V_{VCUV}$   |                                  | 1.9    | 2.2  | 2.5    | V           |
| Thermal shut down temperature          | $T_{TSD}$    | Guaranteed by Design<br>(Note 9) | 150    | 175  | 200    | $^{\circ}C$ |
| Temperature hysteresis                 | $T_{TSDHYS}$ | Guaranteed by Design<br>(Note 9) | -      | 30   | -      | $^{\circ}C$ |

Note 8. All above voltages are with respect to GND.

Note 9. Not tested in production.

## 10. Functional Description

### 10.1 Input terminal and protection circuit

#### ■ Common description (Parallel input mode and Clock-in input mode)

Table 2. Internal circuit operation by the ENABLE(EN) signal

| EN pin | UVLO | TSD | Reference Voltage Circuit | H-Bridge |
|--------|------|-----|---------------------------|----------|
| H      | L    | L   | ON                        | Output   |
|        |      | H   | ON                        | Hi-Z     |
|        | H    | -   | OFF                       | Hi-Z     |
| L      | -    | -   | OFF                       | Hi-Z     |

Note 10. UVLO, TSD and Reference Voltage Circuit show internal status. “-” is Don’t Care.

Table 3. Selection of the chopper frequency by the SYN signal

| SYN pin | FS pin | OSC pin | PWM chopper frequency |
|---------|--------|---------|-----------------------|
| L       | L      | Output  | 25kHz(typ)            |
|         | H      |         | 50kHz(typ)            |
| H       | -      | Input   | External frequency    |

Note 11. Do not change input level of the SYN and FS pin during operation. “-” is Don’t Care.

Table 4. Selection of the chopper frequency by the INSEL signal

| INSEL | Input Mode  |
|-------|---|
| L     | Parallel input mode.<br>H-Bridge is controlled by input logic.<br>Excitation mode : 2phase, 1-2phase(1/2step), W1-2phase(1/4step)   |
| H     | Clock-in input mode.<br>H-Bridge is controlled by the count number of the clock.<br>Excitation mode : 2phase, 1-2phase(1/2step), W1-2phase(1/4step), 4W1-2phase(1/16step) |

Note 12. Do not change input level of the INSEL terminal during operation.



**10.2 Parallel input mode (INSEL="L")**

Table 5. Parallel input mode truth table

| IN1 | IN2 | IN3 | IN4 | OUT1A | OUT1B | IS1  | OUT2A | OUT2B | IS2  |
|-----|-----|-----|-----|-------|-------|------|-------|-------|------|
| L   | L   | L   | L   | H     | L     | 100% | Hi-Z  | Hi-Z  | 0%   |
| L   | L   | L   | H   |       |       | 93%  |       |       | 38%  |
| L   | L   | H   | H   |       |       | 71%  |       |       | 71%  |
| L   | L   | H   | L   |       |       | 38%  |       |       | 93%  |
| L   | H   | L   | L   | Hi-Z  | Hi-Z  | 0%   | H     | L     | 100% |
| L   | H   | L   | H   | L     | H     | 38%  |       |       | 93%  |
| L   | H   | H   | H   |       |       | 71%  |       |       | 71%  |
| L   | H   | H   | L   |       |       | 93%  |       |       | 38%  |
| H   | H   | L   | L   | L     | H     | 100% | Hi-Z  | Hi-Z  | 0%   |
| H   | H   | L   | H   |       |       | 93%  | L     | H     | 38%  |
| H   | H   | H   | H   |       |       | 71%  |       |       | 71%  |
| H   | H   | H   | L   |       |       | 38%  |       |       | 93%  |
| H   | L   | L   | L   | Hi-Z  | Hi-Z  | 0%   | L     | H     | 100% |
| H   | L   | L   | H   | H     | L     | 38%  |       |       | 93%  |
| H   | L   | H   | H   |       |       | 71%  |       |       | 71%  |
| H   | L   | H   | L   |       |       | 93%  |       |       | 38%  |

Note 13. The IN5 and IN6 pins are not used in Parallel input mode. They must be connected to ground.

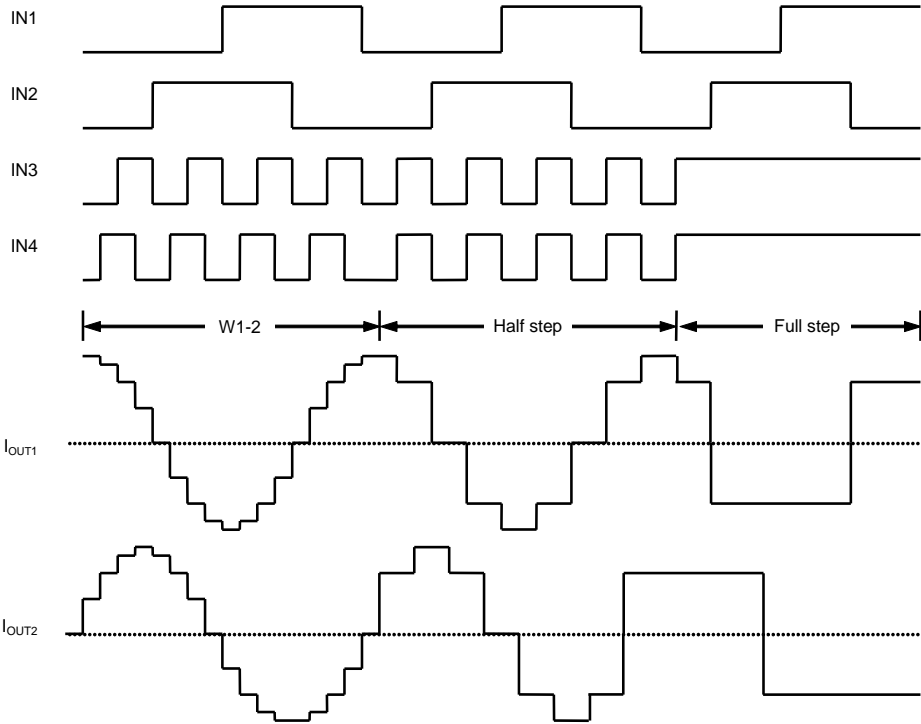


Figure 3. Input signal (Parallel input mode)

### 10.3 Clock-in input mode (INSEL="H")

Table 6. Clock-in input mode truth table

| IN1 | IN2 | IN3 | IN4 | Condition    |
|-----|-----|-----|-----|--------------|
| ↑   | L   | L   | -   | Step +1(CW)  |
| ↑   | H   | L   | -   | Step -1(CCW) |
| ↑   | -   | H   | -   | Reset        |
| -   | -   | -   | H   | Output       |
| -   | -   | -   | L   | Hi-Z         |

Note 14. “-” is Don’t Care. “↑” shows the rising edge.

Table 7. Selection of the excitation mode

| IN5 | IN6 | Step                   |
|-----|-----|------------------------|
| L   | L   | W1-2 phase (1/4step)   |
| L   | H   | 1-2 phase (1/2step)    |
| H   | L   | Full step              |
| H   | H   | 4W1-2 phase (1/16step) |

Note 15. Do not change input level of the IN5 and IN6 terminals during operation.

#### ■ ISn terminal current revel

Table 8. Set current ratio at each excitation mode

| 2 phase | 1-2 phase (1/2step) | W1-2 phase (1/4step) | 4W1-2 phase (1/16step) | Phase1 Current [%] | Phase2 Current [%] | Step Angle [°] |
|---------|---------------------|----------------------|------------------------|--------------------|--------------------|----------------|
|         | 0                   | 0                    | 0                      | 100                | 0.00               | 0.0            |
|         |                     |                      | 1                      | 99.61              | 9.80               | 5.6            |
|         |                     |                      | 2                      | 98.04              | 19.61              | 11.3           |
|         |                     |                      | 3                      | 96.69              | 29.02              | 16.9           |
|         |                     | 1                    | 4                      | 92.55              | 38.43              | 22.6           |
|         |                     |                      | 5                      | 88.24              | 47.06              | 28.1           |
|         |                     |                      | 6                      | 83.14              | 55.69              | 33.8           |
|         |                     |                      | 7                      | 77.25              | 63.53              | 39.4           |
| 0       | 1                   | 2                    | 8                      | 70.59              | 70.59              | 45.0           |
|         |                     |                      | 9                      | 63.53              | 77.25              | 50.6           |
|         |                     |                      | 10                     | 55.69              | 83.14              | 56.2           |
|         |                     |                      | 11                     | 47.06              | 88.24              | 61.9           |
|         |                     | 3                    | 12                     | 38.43              | 92.55              | 67.4           |
|         |                     |                      | 13                     | 29.02              | 95.69              | 73.1           |
|         |                     |                      | 14                     | 19.61              | 98.04              | 78.7           |
|         |                     |                      | 15                     | 9.80               | 99.61              | 84.4           |
|         | 2                   | 4                    | 16                     | 0.00               | 100                | 90.0           |
|         |                     |                      | 17                     | -9.80              | -99.61             | 95.6           |
|         |                     |                      | 18                     | -19.61             | -98.04             | 101.3          |
|         |                     |                      | 19                     | -29.02             | -95.69             | 106.9          |
|         |                     | 5                    | 20                     | -38.43             | -92.55             | 112.6          |
|         |                     |                      | 21                     | -47.06             | -88.24             | 118.1          |
|         |                     |                      | 22                     | -55.69             | -83.14             | 123.8          |
|         |                     |                      | 23                     | -63.53             | -77.25             | 129.4          |
| 1       | 3                   | 6                    | 24                     | -70.59             | -70.59             | 135.0          |
|         |                     |                      | 25                     | -77.25             | -63.53             | 140.6          |
|         |                     |                      | 26                     | -83.14             | -55.69             | 146.2          |

|   |   |    |    |        |        |       |
|---|---|----|----|--------|--------|-------|
|   |   |    | 27 | -88.24 | -47.06 | 151.9 |
|   |   | 7  | 28 | -92.55 | -38.43 | 157.4 |
|   |   |    | 29 | -95.69 | -29.02 | 163.1 |
|   |   |    | 30 | -98.04 | -19.61 | 168.7 |
|   |   |    | 31 | -99.61 | -9.80  | 174.4 |
|   | 4 | 8  | 32 | -100   | 0.00   | 180.0 |
|   |   |    | 33 | -99.61 | -9.80  | 185.6 |
|   |   |    | 34 | -98.04 | -19.61 | 191.3 |
|   |   |    | 35 | -96.69 | -29.02 | 196.9 |
|   |   | 9  | 36 | -92.55 | -38.43 | 202.6 |
|   |   |    | 37 | -88.24 | -47.06 | 208.1 |
|   |   |    | 38 | -83.14 | -55.69 | 213.8 |
|   |   |    | 39 | -77.25 | -63.53 | 219.4 |
| 2 | 5 | 10 | 40 | -70.59 | -70.59 | 225.0 |
|   |   |    | 41 | -63.53 | -77.25 | 230.6 |
|   |   |    | 42 | -55.69 | -83.14 | 236.2 |
|   |   |    | 43 | -47.06 | -88.24 | 241.9 |
|   |   | 11 | 44 | -38.43 | -92.55 | 247.4 |
|   |   |    | 45 | -29.02 | -95.69 | 253.1 |
|   |   |    | 46 | -19.61 | -98.04 | 258.7 |
|   |   |    | 47 | -9.80  | -99.61 | 264.4 |
|   | 6 | 12 | 48 | 0.00   | 100    | 270.0 |
|   |   |    | 49 | 9.80   | -99.61 | 275.6 |
|   |   |    | 50 | 19.61  | -98.04 | 281.3 |
|   |   |    | 51 | 29.02  | -95.69 | 286.9 |
|   |   | 13 | 52 | 38.43  | -92.55 | 292.6 |
|   |   |    | 53 | 47.06  | -88.24 | 298.1 |
|   |   |    | 54 | 55.69  | -83.14 | 303.8 |
|   |   |    | 55 | 63.53  | -77.25 | 309.4 |
| 3 | 7 | 14 | 56 | 70.59  | -70.59 | 315.0 |
|   |   |    | 57 | 77.25  | -63.53 | 320.6 |
|   |   |    | 58 | 83.14  | -55.69 | 326.2 |
|   |   |    | 59 | 88.24  | -47.06 | 331.9 |
|   |   | 15 | 60 | 92.55  | -38.43 | 337.4 |
|   |   |    | 61 | 95.69  | -29.02 | 343.1 |
|   |   |    | 62 | 98.04  | -19.61 | 348.7 |
|   |   |    | 63 | 99.61  | -9.80  | 354.4 |
|   |   |    | 64 | 100    | 0.00   | 360.0 |

: Home microstep position at Step Angle 45°

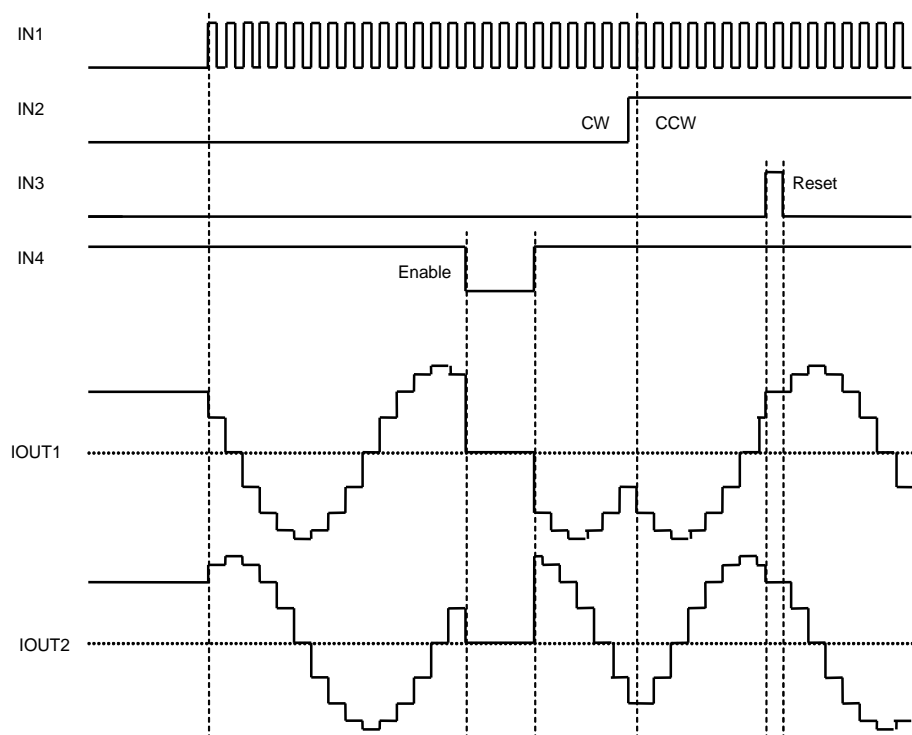


Figure 4. Input signal (Parallel input mode, IN5="L", IN6="L")

#### 10.4 PWM Current Control

The current value of 100% PWM constant current setting ratio at each excitation mode of AP1025 (Iload (100%) [A]) is determined by H-Bridge sense resistor(RIS) and PWM constant current setting voltage(VIS) as follows.

$$I_{load}(100\%)[A] = (VIS / 2.5) / RIS \quad \text{--- (1)}$$

|                                      |       |
|--------------------------------------|-------|
| PWM constant current setting voltage | VIS   |
| VIS damping ratio                    | 1/2.5 |
| H-Bridge sense resistor              | RIS   |

Calculation example1 : VIS=1V, RIS=0.5ohm

$$I_{load}(100\%)[A] = (1 / 2.5) / 0.5ohm = 0.8A \quad \text{--- (2)}$$

The minimum value of the control current in the PWM constant current control in each excitation mode (Iload (min) [A]) is determined by the following equation.

$$I_{load}(min)[A] = VM / (R_m + R_{ON} + RIS) \times t_B \times f_{CP} \quad \text{--- (3)}$$

|                            |                              |
|----------------------------|------------------------------|
| Motor power supply voltage | VM                           |
| OSC frequency              | $f_{CP} (f_{CPL} / f_{CPH})$ |
| Blanking time              | $t_B$                        |
| Motor on resistance        | $R_m$                        |
| H-Bridge on resistance     | $R_{ON}$                     |
| H-Bridge sense resistor    | RIS                          |

Calculation example2 : VM=24V,  $f_{CP}$ =25kHz,  $t_B$ =2.23us,  $R_m$ =9.4ohm,  $R_{ON}$ =1ohm, RIS=1ohm

$$I_{load}(min)[A] = 24V / (9.4ohm + 1ohm + 1ohm) \times 2.23us \times 25kHz = 0.117A \quad \text{--- (4)}$$

The current value of 100% PWM constant current setting ratio should be set so that the minimum control current (Iload (min) [A]) becomes larger than the minimum value of the PWM constant current setting ratio in 4W1-2 phase excitation. In case of calculation example 2, the current value of the 100% PWM constant current setting ratio (Iload (100%) [A]) is as follows.

$$I_{load}(100\%)[A] = 0.117 / 9.8\% = 1.19A \quad \text{---(5)}$$

If the current value of 100% PWM constant current setting value ratio (Iload (100%) [A]) is smaller than equation (5), minimum control current value (Iload (min) [A]) may be larger than 9.8%.

### 10.5 Decay Mode

The AP1025 selects decay mode automatically for better current following property. Basically, it operates in slow decay mode, but it operates in fast decay mode when the current setting value is lowered, till it reaches to the setting value.

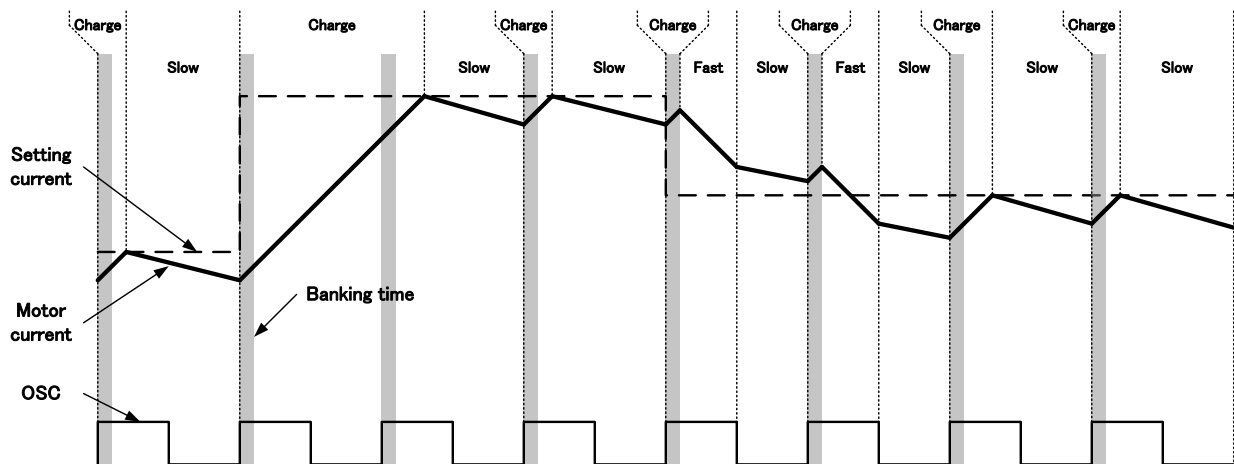
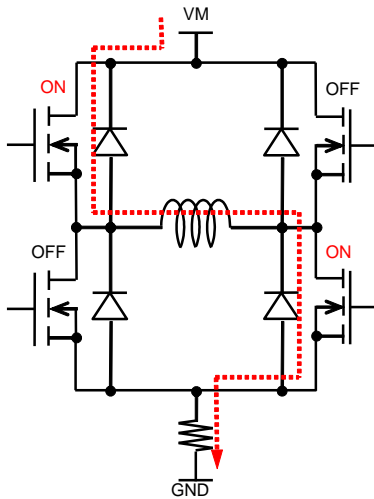
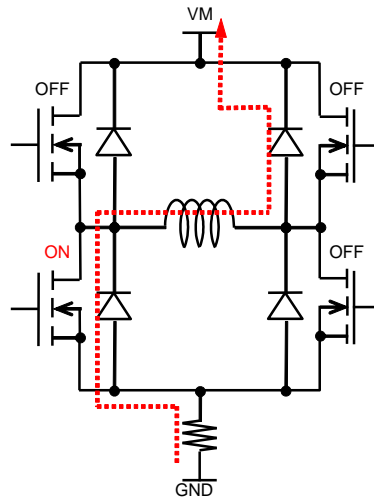


Figure 5. Current waveform image during decay mode

#### ■ Charge Mode



#### ■ Fast Decay Mode



#### ■ Slow Decay Mode

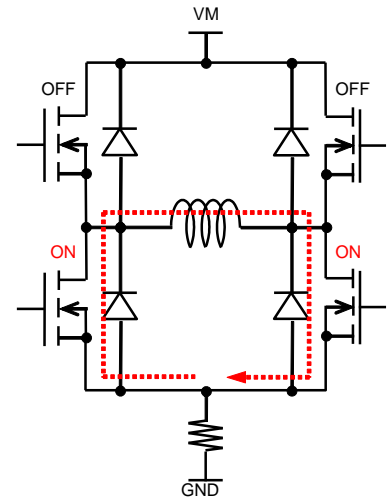


Figure 6. Decay Mode Image

## 10.6 Protection Circuits

- Under Voltage Lockout Circuit (UVLO)

UVLO monitors Control power supply voltage (VC) and changes H-bridge driver output to Hi-Z if VC is lower than the specified value ( $V_{VCUV}=2.2V$ ) when starting the VC source.

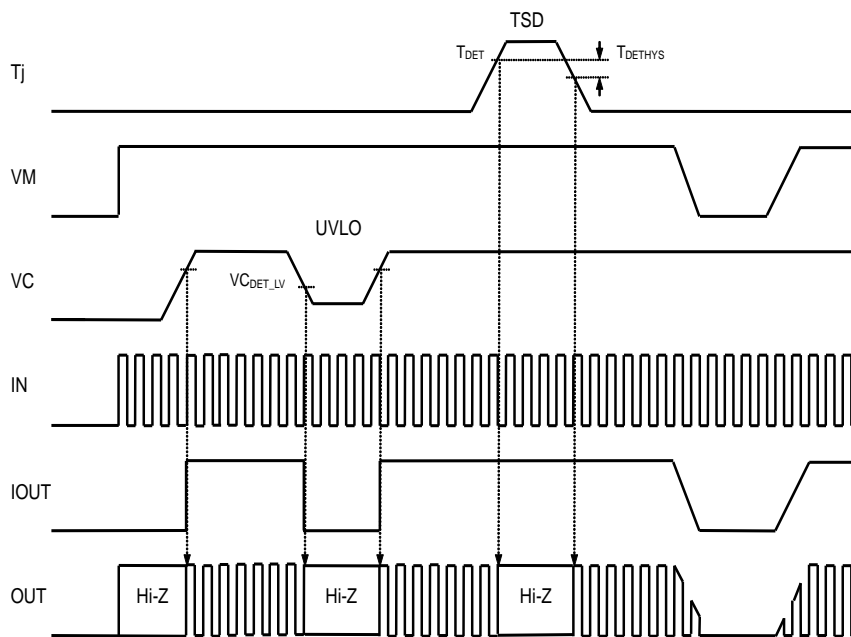
- Thermal Shut Down Circuit(TSD)

As soon as abnormal high temperature ( $T_{TSD}=150^{\circ}C$ ) is detected, H-Bridge driver output becomes Hi-Z.

Table 9. Recovery type of abnormal heat generation detect circuit

| Interface Mode | Recovery type |
|----------------|---------------|
| Parallel input | Automatic     |
| Clock-in input | Latch         |

### ■ Parallel Input Mode



Operation flow when detecting abnormal heat generation

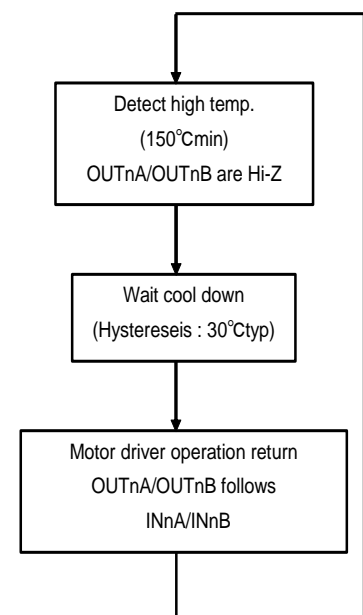


Figure 7. Timing Chart of the protection circuits (parallel input mode)

### ■ Clock-in input mode

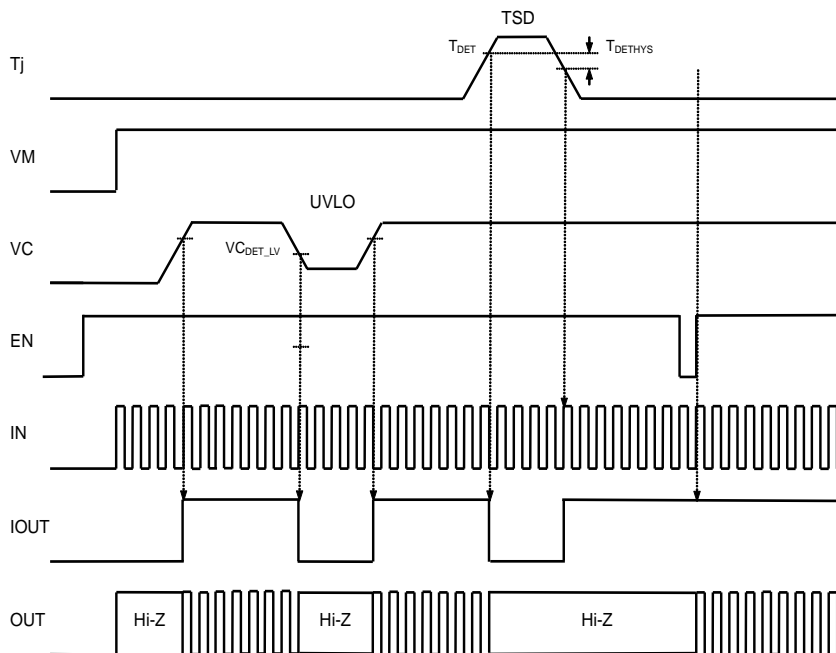
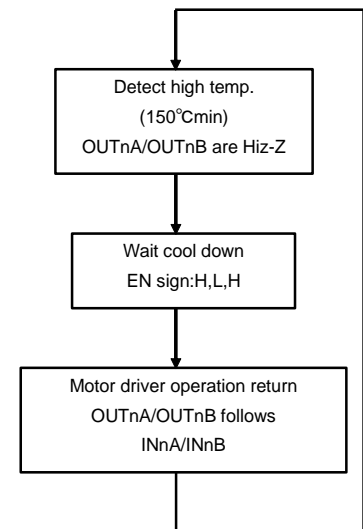


Figure 8. Timing chart of the Protection circuit (parallel input mode)

### Operation flow when detecting abnormal heat generation



### • Shorted-Load, Shorted-to-Ground and Shorted-to-Power Protection

If the motor leads are shorted together, or if one of the leads is shorted to ground or shorted to power, when current flowing is 3.3A or less, the motor driver IC will protect itself by hiccup behavior of thermal shutdown circuit (TSD). When there is a power supply capacity of 3.3A or more, the appropriate protection fuse is implemented between the motor power supply line (VM) and the power supply on the PCB.



## 11. Recommended External Circuit

### ■ External circuit

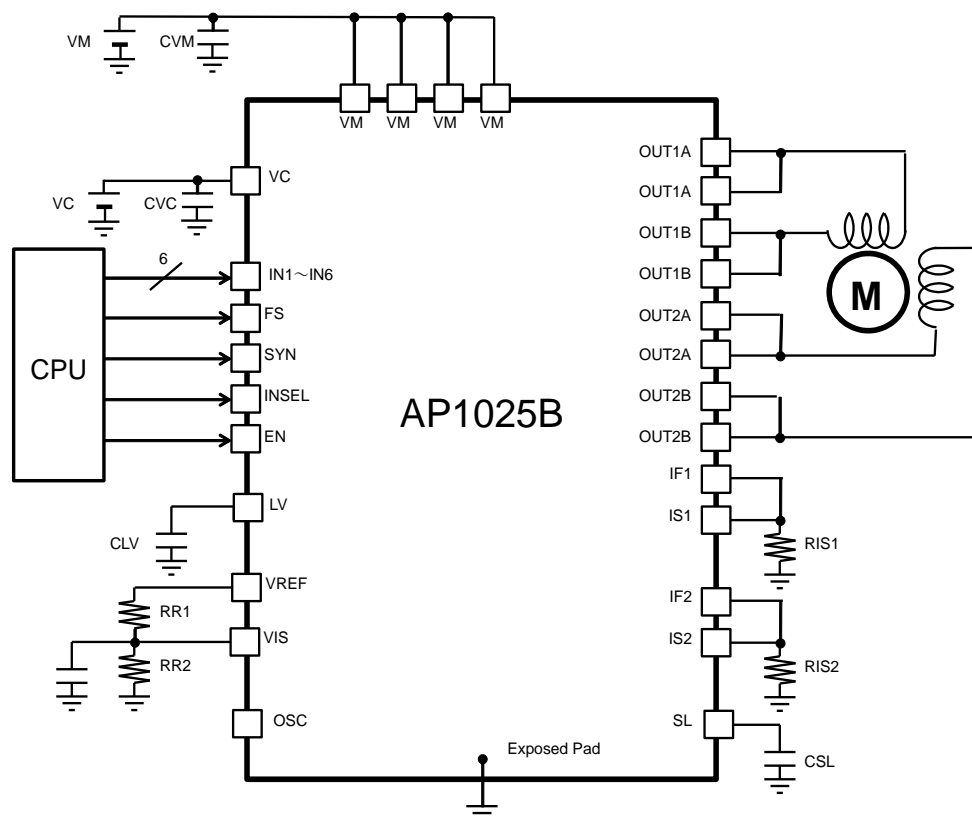


Figure 9. External Circuit Example

Table 10. Recommended external components

| Items | min   | typ | max  | Unit             | Remark                               |
|-------|-------|-----|------|------------------|--------------------------------------|
| CVM   | -     | 47  | -    | $\mu\text{F}$    | Electrolytic Capacitor               |
|       | -     | 1   | -    | $\mu\text{F}$    | Ceramic Capacitor                    |
| CVC   | -     | 1.0 | -    | $\mu\text{F}$    |                                      |
| CLV   | 0.68  | 1.0 | 1.5  | $\mu\text{F}$    |                                      |
| CSL   | 0.001 | -   | 0.01 | $\mu\text{F}$    |                                      |
| CVIS  | -     | 1.0 | -    | $\mu\text{F}$    |                                      |
| RISn  | -     | 500 | -    | $\text{m}\Omega$ | $I_{\text{load}}(100\%)=0.8\text{A}$ |
| R1    | -     | 12  | -    | $\text{k}\Omega$ |                                      |
| R2    | -     | 47  | -    | $\text{k}\Omega$ |                                      |

Note 16. Above capacitances are examples. Please choose the best external capacitors for CVM, CVC and CVIS for your system board.

Note 17. Capacitance of CVM and CVC should be adjusted considering the load current profile, the load capacitance, the line resistance and etc. of the actual system board.

Note 18. Please choose the best external capacitor for CSL as sub harmonic noise measures. If not using the CSL capacitor, please connect the SL terminal to ground.

## ■ Recommended Layout Example

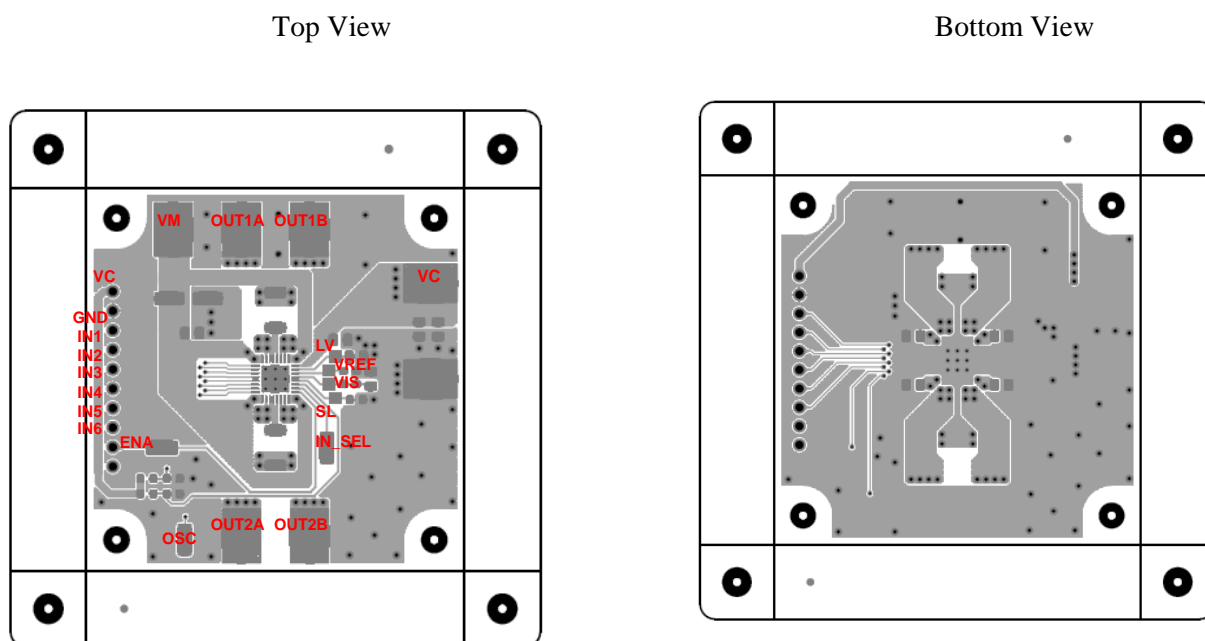


Figure 10. Layout pattern example

Note 19. Please design the ground plane of the PCB as large as possible.

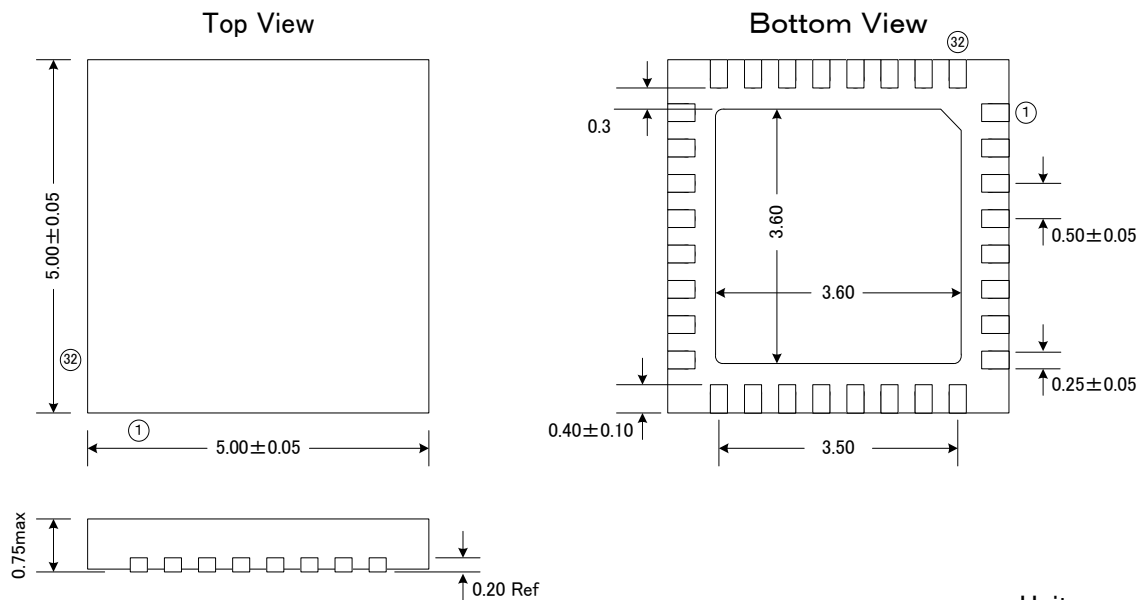
Note 20. Exposed Pad (exposed backside pad) must be connected to the ground of the PCB, because the ground of IC and Exposed pad is in common.

Note 21. The ground via on the IC mounted area is effective for heat radiation to each layer of the PCB.

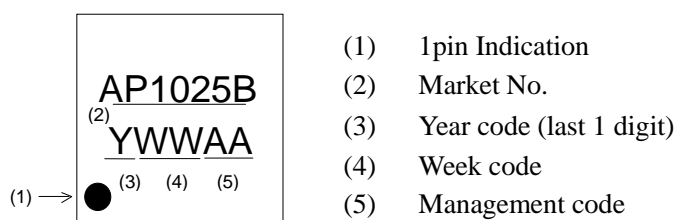
## 12. Package

### ■ Outline Dimensions

- 32-pin QFN package



### ■ Marking



**13. Revise History**

| Date<br>(YY/MM/DD) | Revision | Page | Contents      |
|--------------------|----------|------|---------------|
| 15/01/09           | 00       | -    | First Edition |

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