

# TB6562ANG/AFG

## Dual Full-Bridge Driver IC for Stepping Motors

The TB6562ANG/AFG is a 2-phase bipolar stepping motor driver that contains DMOS transistors in the output stage. The driver achieves high efficiency through the use of low ON-resistance DMOS transistors and PWM current control circuitry.

### Features

2-phase / 1–2-phase / W 1–2-phase excitation

PWM current control

Power supply voltage: 40 V (max)

Output current: 1.5 A (max)

Low ON-resistance: 1.5  $\Omega$  (upper and lower transistors/typ.)

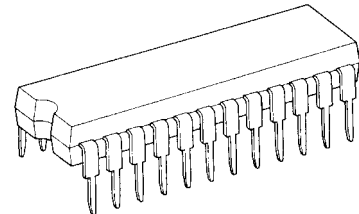
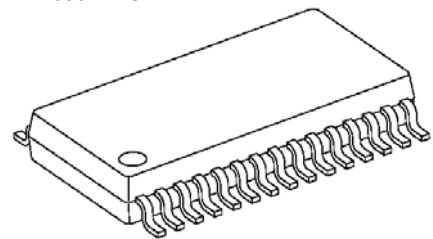
Power-saving function

Overcurrent protection:  $I_{lim} = 2.5$  A (typ.)

Thermal shutdown

Package: TB6562ANG; SDIP24-P-300-1.78

TB6562ANG; SSOP30-P-375-1.00

**TB6562ANG****SDIP24-P-300-1.78****TB6562AFG****SSOP30-P-375-1.00**

TB6562ANG/AFG is lead-free (Pb-free) product.

The following conditions apply to solderability:

**\*Solderability**

1. Use of Sn-37Pb solder bath
  - \*solder bath temperature = 230°C
  - \*dipping time = 5 seconds
  - \*number of times = once
  - \*use of R-type flux
2. Use of Sn-3.0Ag-0.5Cu solder bath
  - \*solder bath temperature = 245°C
  - \*dipping time = 5 seconds
  - \*number of times = once
  - \*use of R-type flux

**Weight:**

SDIP24-P-300-1.78: 1.62 g (typ.)

SSOP30-P-375-1.00: 0.63 g (typ.)

This product has a MOS structure and is sensitive to electrostatic discharge. When handling the product, ensure that the environment is protected against electrostatic discharge by using an earth strap, a conductive mat and an ionizer. Ensure also that the ambient temperature and relative humidity are maintained at reasonable levels.

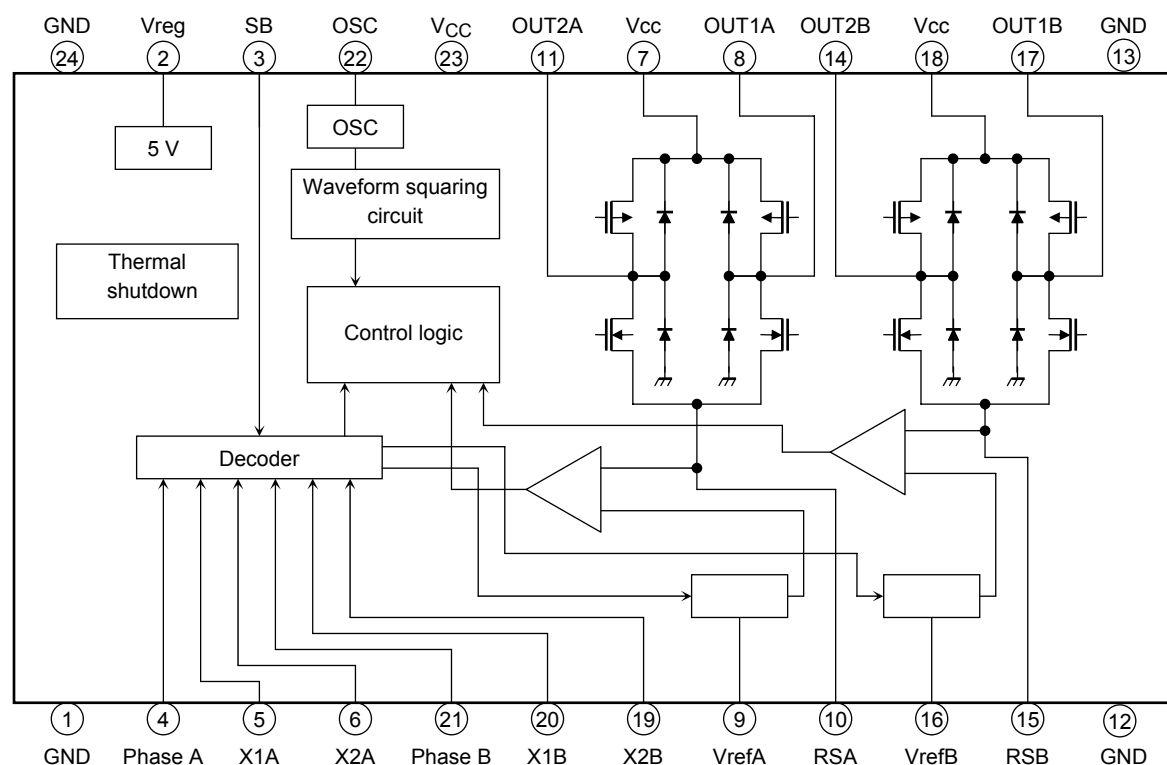
Special care should be taken with the following pins, which are vulnerable to surge current.

Pins with low surge withstand capability:

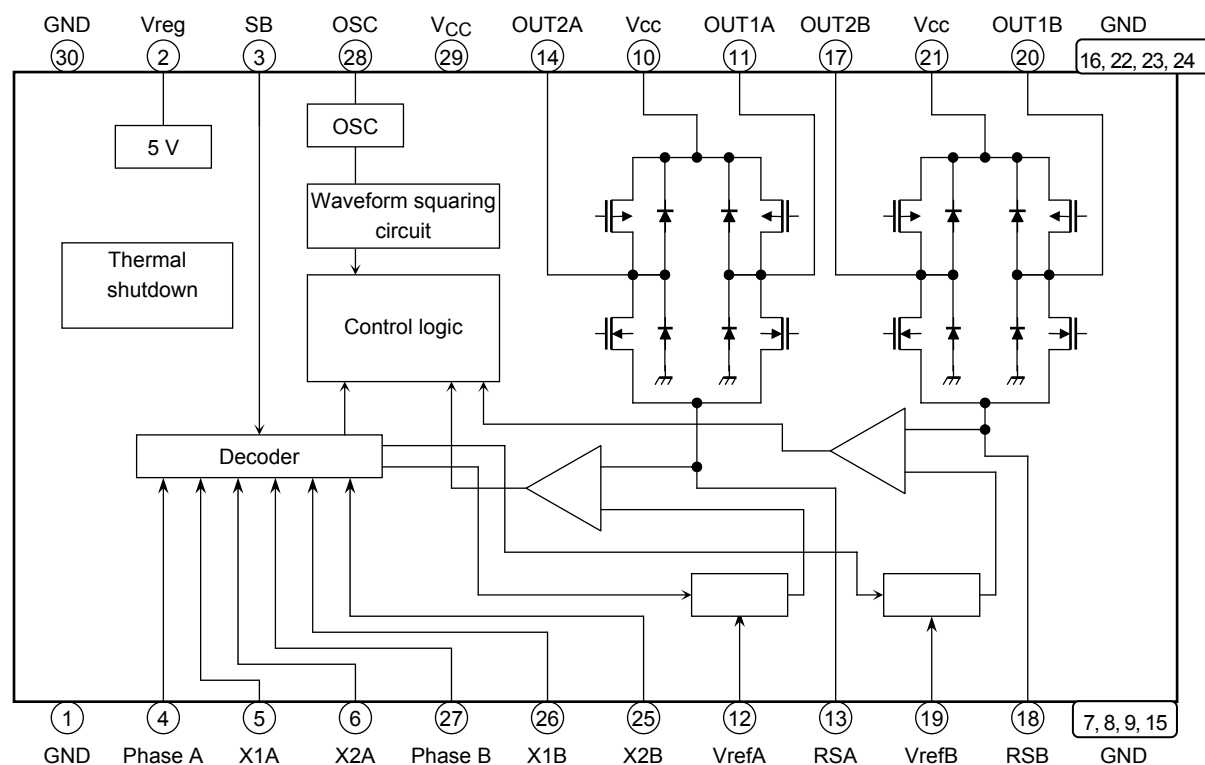
TB6562ANG: pins 10, 15      TB6562AFG: pins 13, 18

## Block Diagram

Some functional blocks, circuits, or constants may be omitted or simplified in the block diagram for explanatory purposes.  
< TB6562ANG >



< TB6562AFG >

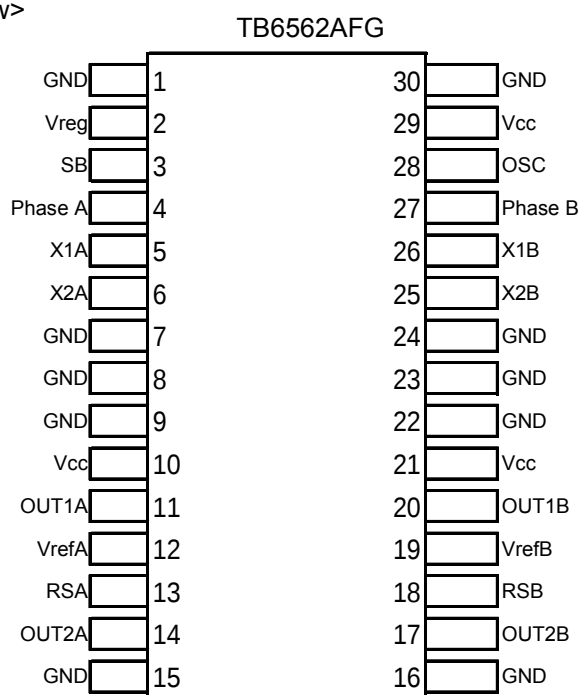
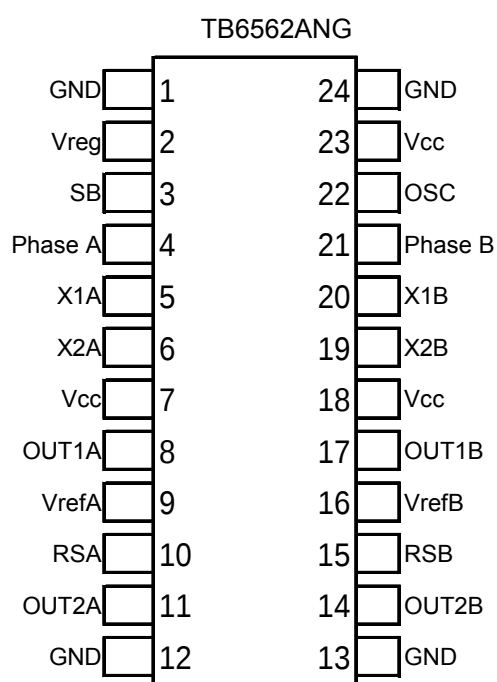


## Pin Description

< TB6562ANG >

| Pin No. | Symbol  | Function Description                                      | Remarks                                                                         |
|---------|---------|-----------------------------------------------------------|---------------------------------------------------------------------------------|
| 1       | GND     | Ground pin                                                |                                                                                 |
| 2       | Vreg    | 5 V output pin                                            | Connect a capacitor between this pin and the GND pin.                           |
| 3       | SB      | Standby pin                                               | H: start, L: Standby, Built-in pull down resistance of 100k $\Omega$ (typ.)     |
| 4       | Phase A | Rotation direction control pin (Ch. A)                    | Apply a 0 V / 5 V signal, Built-in pull down resistance of 100k $\Omega$ (typ.) |
| 5       | X1A     | Input pin used to set output current level (Ch. A)        | Apply a 0 V / 5 V signal, Built-in pull down resistance of 100k $\Omega$ (typ.) |
| 6       | X2A     | Input pin used to set output current level (Ch. A)        | Apply a 0 V / 5 V signal, Built-in pull down resistance of 100k $\Omega$ (typ.) |
| 7       | Vcc     | Power supply voltage input pin                            | Vcc (opr) = 10 V to 34 V                                                        |
| 8       | OUT1A   | Output pin 1 (Ch. A)                                      | Connect to a motor coil pin.                                                    |
| 9       | VrefA   | Input pin for external reference voltage (Ch. A)          |                                                                                 |
| 10      | RSA     | Output current detection resistor connection pin (Ch. A). |                                                                                 |
| 11      | OUT2A   | Output pin 2 (Ch. A)                                      | Connect to a motor coil pin.                                                    |
| 12      | GND     | Ground pin                                                |                                                                                 |
| 13      | GND     | Ground pin                                                |                                                                                 |
| 14      | OUT2B   | Output pin 2 (Ch. B)                                      | Connect to a motor coil pin.                                                    |
| 15      | RSB     | Output current detection resistor connection pin (Ch. B)  |                                                                                 |
| 16      | VrefB   | Input pin for external reference voltage (Ch. B)          |                                                                                 |
| 17      | OUT1B   | Output pin 1 (Ch. B)                                      | Connect to a motor coil pin.                                                    |
| 18      | Vcc     | Power supply voltage input pin                            | Vcc (opr) = 10 V to 34 V                                                        |
| 19      | X2B     | Input pin used to set output current level (Ch. B)        | Apply a 0 V / 5 V signal, Built-in pull down resistance of 100k $\Omega$ (typ.) |
| 20      | X1B     | Input pin used to set output current level (Ch. B)        | Apply a 0 V / 5 V signal, Built-in pull down resistance of 100k $\Omega$ (typ.) |
| 21      | Phase B | Rotation direction control pin (Ch. B)                    | Apply a 0 V / 5 V signal, Built-in pull down resistance of 100k $\Omega$ (typ.) |
| 22      | OSC     | External capacitor pin for triangular-wave oscillation    |                                                                                 |
| 23      | VCC     | Power supply voltage input pin                            | VCC (opr) = 10 V to 34 V                                                        |
| 24      | GND     | Ground pin                                                |                                                                                 |

<Top View>



< TB6562AFG >

| Pin No. | Symbol  | Function Description                                        | Remarks                                                                         |
|---------|---------|-------------------------------------------------------------|---------------------------------------------------------------------------------|
| 1       | GND     | Ground pin                                                  |                                                                                 |
| 2       | Vreg    | 5 V output pin                                              | Connect a capacitor between this pin and the GND pin.                           |
| 3       | SB      | Standby pin                                                 | H: start, L: Standby, Built-in pull down resistance of 100k $\Omega$ (typ.)     |
| 4       | Phase A | Rotation direction control pin (Ch. A)                      | Apply a 0 V / 5 V signal, Built-in pull down resistance of 100k $\Omega$ (typ.) |
| 5       | X1A     | Input pin used to set output current level (Ch. A)          | Apply a 0 V / 5 V signal, Built-in pull down resistance of 100k $\Omega$ (typ.) |
| 6       | X2A     | Input pin used to set output current level (Ch. A)          | Apply a 0 V / 5 V signal, Built-in pull down resistance of 100k $\Omega$ (typ.) |
| 7       | GND     | Ground pin                                                  |                                                                                 |
| 8       | GND     | Ground pin                                                  |                                                                                 |
| 9       | GND     | Ground pin                                                  |                                                                                 |
| 10      | Vcc     | Power supply voltage input pin                              | Vcc (opr) = 10 V to 34 V                                                        |
| 11      | OUT1A   | Output pin 1 (Ch. A)                                        | Connect to a motor coil pin.                                                    |
| 12      | VrefA   | Reference voltage external set pin (Ch. A)                  |                                                                                 |
| 13      | RSA     | Resistance connect pin for detecting output current (Ch. A) |                                                                                 |
| 14      | OUT2A   | Output pin 2 (Ch. A)                                        | Connect to a motor coil pin.                                                    |
| 15      | GND     | Ground pin                                                  |                                                                                 |
| 16      | GND     | Ground pin                                                  |                                                                                 |
| 17      | OUT2B   | Output pin 2 (Ch. B)                                        | Connect to a motor coil pin.                                                    |
| 18      | RSB     | Output current detection resistor connection pin (Ch. B)    |                                                                                 |
| 19      | VrefB   | Input pin for external reference voltage (Ch. B)            |                                                                                 |
| 20      | OUT1B   | Output pin 1 (Ch. B)                                        | Connect to a motor coil pin.                                                    |
| 21      | Vcc     | Power supply voltage input pin                              | Vcc (opr) = 10 V to 34 V                                                        |
| 22      | GND     | Ground pin                                                  |                                                                                 |
| 23      | GND     | Ground pin                                                  |                                                                                 |
| 24      | GND     | Ground pin                                                  |                                                                                 |
| 25      | X2B     | Input pin used to set output current level (Ch. B)          | Apply a 0 V / 5 V signal, Built-in pull down resistance of 100k $\Omega$ (typ.) |
| 26      | X1B     | Input pin used to set output current level (Ch. B)          | Apply a 0 V / 5 V signal, Built-in pull down resistance of 100k $\Omega$ (typ.) |
| 27      | Phase B | Rotation direction control pin (Ch. B)                      | Apply a 0 V / 5 V signal, Built-in pull down resistance of 100k $\Omega$ (typ.) |
| 28      | OSC     | External capacitor pin for triangular-wave oscillation      |                                                                                 |
| 29      | VCC     | Power supply voltage input pin                              | VCC (opr) = 10 V to 34 V                                                        |
| 30      | GND     | Ground pin                                                  |                                                                                 |

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

| Characteristic        | Symbol                | Rating          | Unit |
|-----------------------|-----------------------|-----------------|------|
| Power supply voltage  | V <sub>CC</sub>       | 40              | V    |
| Output voltage        | V <sub>o</sub>        | 40              | V    |
| Output current        | I <sub>O</sub> (Peak) | 1.5<br>(Note 1) | A    |
| Input voltage         | V <sub>in</sub>       | −0.2 to 5.5     | V    |
| Power dissipation     | P <sub>D</sub>        | 2.5<br>(Note 2) | W    |
| Operating temperature | T <sub>opr</sub>      | −20 to 85       | °C   |
| Storage temperature   | T <sub>stg</sub>      | −55 to 150      | °C   |
| Junction temperature  | T <sub>jmax</sub>     | 150             | °C   |

Note 1: Output current may be controlled by excitation mode, ambient temperature, or heatsink.

When designing a circuit, ensure that the maximum junction temperature, T<sub>jMAX</sub> = 150°C, is not exceeded when the IC is used.

Avoid using the IC in abnormal conditions that would cause the T<sub>j</sub> to exceed 150°C, even though the heat protection circuit of the IC will continue to operate in such conditions.

Note 2: When mounted on a board (50 mm × 50 mm × 1.6 mm, Cu area: 50%)

The absolute maximum ratings of a semiconductor device are a set of specified parameter values that must not be exceeded during operation, even for an instant.

If any of these ratings are exceeded during operation, the electrical characteristics of the device may be irreparably altered, in which case the reliability and lifetime of the device can no longer be guaranteed.

Moreover, any exceeding of the ratings during operation may cause breakdown, damage and/or degradation in other equipment. Applications using the device should be designed so that no maximum rating will ever be exceeded under any operating condition.

Before using, creating and/or producing designs, refer to and comply with the precautions and conditions set forth in this document.

## Operating Range (Ta = −20 to 85°C)

| Characteristic                        | Symbol           | Rating     | Unit |
|---------------------------------------|------------------|------------|------|
| Power supply voltage                  | V <sub>CC</sub>  | 10 to 34   | V    |
| Input voltage                         | V <sub>in</sub>  | 0 to 5     | V    |
| V <sub>ref</sub> voltage              | V <sub>ref</sub> | 0.5 to 7.0 | V    |
| PWM frequency                         | f <sub>pwm</sub> | 15 to 80   | kHz  |
| Triangular-wave oscillation frequency | f <sub>osc</sub> | 45 to 400  | kHz  |

Electrical Characteristics ( $V_{CC} = 24\text{ V}$ ,  $T_a = 25^\circ\text{C}$ )

| Characteristic                                 |                          | Symbol                  | Test Circuit | Test Condition                                    | Min  | Typ. | Max  | Unit |
|------------------------------------------------|--------------------------|-------------------------|--------------|---------------------------------------------------|------|------|------|------|
| Supply current                                 |                          | I <sub>CC1</sub>        | —            | XT1A = XT2A = H, XT1B = XT2B = H<br>Output = Open | —    | 6.5  | 10   | mA   |
|                                                |                          | I <sub>CC2</sub>        |              | XT1A = XT2A = L, XT1B = XT2B = L<br>Output = Open | —    | 7.0  | 12   |      |
|                                                |                          | I <sub>CC3</sub>        |              | Standby mode                                      | —    | 2.0  | 4.0  |      |
| Control circuit<br>(Note 1)                    | Input voltage            | V <sub>INH</sub>        | —            | —                                                 | 2    | —    | 5.5  | V    |
|                                                |                          | V <sub>INL</sub>        |              | —                                                 | -0.2 | —    | 0.8  |      |
|                                                | Input hysteresis voltage | V <sub>IN</sub> (HYS)   | —            | (Target spec.)                                    | —    | 0.4  | —    |      |
|                                                | Input current            | I <sub>INH</sub>        | —            | V <sub>IN</sub> = 5 V                             | 30   | 50   | 75   | μA   |
|                                                |                          | I <sub>INL</sub>        |              | V <sub>IN</sub> = 0 V                             | —    | —    | 5    |      |
| Standby circuit                                | Input voltage            | V <sub>INSH</sub>       | —            | —                                                 | 2.3  | —    | 5.5  | V    |
|                                                |                          | V <sub>INSL</sub>       |              | —                                                 | -0.2 | —    | 0.8  |      |
|                                                | Input hysteresis voltage | V <sub>IN</sub> (HYS)   | —            | (Target spec.)                                    | —    | 0.4  | —    |      |
|                                                | Input current            | I <sub>INSH</sub>       | —            | V <sub>IN</sub> = 5 V                             | 30   | 50   | 75   | μA   |
|                                                |                          | I <sub>INSL</sub>       |              | V <sub>IN</sub> = 0 V                             | —    | —    | 5    |      |
| Output ON-resistance                           |                          | R <sub>on</sub> (U + L) | —            | I <sub>O</sub> = 0.2 A                            | —    | 1.5  | 2.0  | Ω    |
|                                                |                          |                         |              | I <sub>O</sub> = 1.5 A                            | —    | 1.5  | 2.0  |      |
| Output leakage current                         |                          | I <sub>L</sub> (U)      | —            | V <sub>CC</sub> = 40 V                            | —    | —    | 10   | μA   |
|                                                |                          | I <sub>L</sub> (L)      |              | V <sub>CC</sub> = 40 V                            | —    | —    | 10   |      |
| Diode forward voltage                          |                          | V <sub>F</sub> (U)      | —            | I <sub>O</sub> = 1.5 A                            | —    | 1.3  | 2.0  | V    |
|                                                |                          | V <sub>F</sub> (L)      |              | I <sub>O</sub> = 1.5 A                            | —    | 1.3  | 2.0  |      |
| Internal reference voltage                     |                          | V <sub>reg</sub>        | —            | 1 mA                                              | 4.75 | 5    | 5.25 | V    |
| V <sub>ref</sub> circuit                       | Input current            | I <sub>ref</sub>        | —            | V <sub>ref</sub> = 0.5 V                          | —    | 5    | 10   | μA   |
|                                                | Current limit voltage    | V <sub>ref</sub> (1/10) | —            | X1 = X2 = L<br>V <sub>ref</sub> = 5 V             | 0.45 | 0.5  | 0.55 | V    |
|                                                |                          | V <sub>ref</sub> (1/15) | —            | X1 = L, X2 = H<br>V <sub>ref</sub> = 5 V          | 0.28 | 0.33 | 0.38 |      |
|                                                |                          | V <sub>ref</sub> (1/30) | —            | X1 = H, X2 = L<br>V <sub>ref</sub> = 5 V          | 0.12 | 0.17 | 0.22 |      |
| Triangular-wave oscillation frequency          |                          | f <sub>osc</sub>        | —            | C = 4700 pF                                       | 88   | 110  | 132  | kHz  |
| Thermal shutdown circuit operating temperature |                          | T <sub>SD</sub>         | —            | (Target spec.)                                    | —    | 160  | —    | °C   |

Note 1: Phase, X1 and X2 pins

## Truth Tables

< 2-phase excitation > (\*) I<sub>O</sub>: OUT1 → OUT2; + current OUT2 → OUT1; - current

| Phase A |     |     |                    | Phase B |     |     |                    |
|---------|-----|-----|--------------------|---------|-----|-----|--------------------|
| Input   |     |     | Output             | Input   |     |     | Output             |
| Phase A | X1A | X2A | I <sub>O</sub> (A) | Phase B | X1B | X2B | I <sub>O</sub> (B) |
| H       | L   | L   | 100%               | H       | L   | L   | 100%               |
| L       | L   | L   | -100%              | H       | L   | L   | 100%               |
| L       | L   | L   | -100%              | L       | L   | L   | -100%              |
| H       | L   | L   | 100%               | L       | L   | L   | -100%              |

< 1-2-phase excitation >

| Phase A |     |     |                    | Phase B |     |     |                    |
|---------|-----|-----|--------------------|---------|-----|-----|--------------------|
| Input   |     |     | Output             | Input   |     |     | Output             |
| Phase A | X1A | X2A | I <sub>O</sub> (A) | Phase B | X1B | X2B | I <sub>O</sub> (B) |
| H       | L   | L   | 100%               | H       | L   | L   | 100%               |
| X       | H   | H   | 0%                 | H       | L   | L   | 100%               |
| L       | L   | L   | -100%              | H       | L   | L   | 100%               |
| L       | L   | L   | -100%              | X       | H   | H   | 0%                 |
| L       | L   | L   | -100%              | L       | L   | L   | -100%              |
| X       | H   | H   | 0%                 | L       | L   | L   | -100%              |
| H       | L   | L   | 100%               | L       | L   | L   | -100%              |
| H       | L   | L   | 100%               | X       | H   | H   | 0%                 |

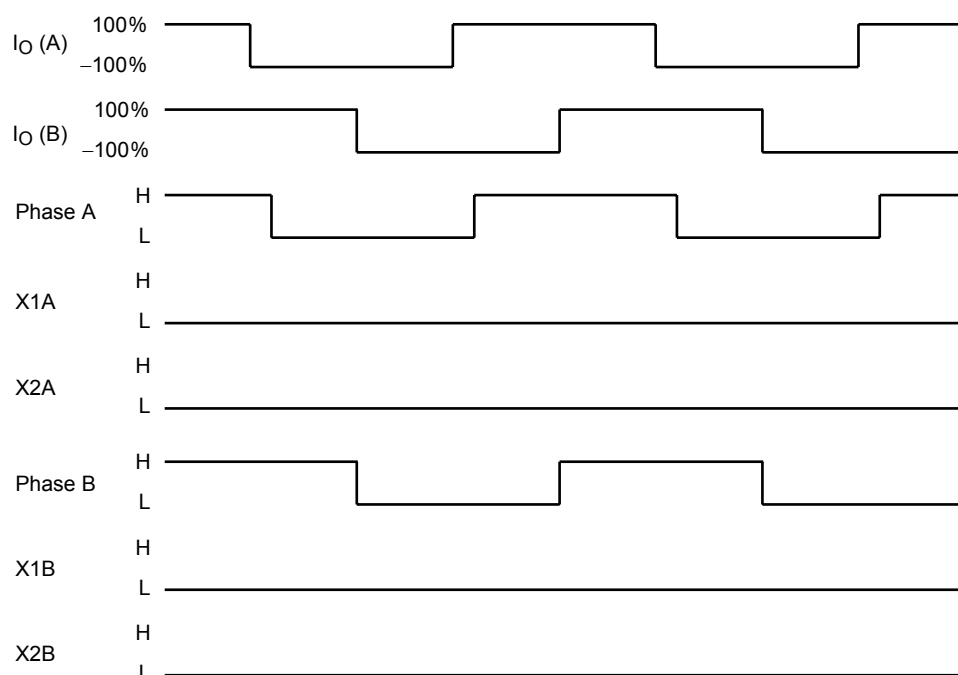
< W 1-2-phase excitation >

| Phase A |     |     |                    | Phase B |     |     |                    |
|---------|-----|-----|--------------------|---------|-----|-----|--------------------|
| Input   |     |     | Output             | Input   |     |     | Output             |
| Phase A | X1A | X2A | I <sub>O</sub> (A) | Phase B | X1B | X2B | I <sub>O</sub> (B) |
| X       | H   | H   | 0%                 | L       | L   | L   | -100%              |
| H       | H   | L   | 33.3%              | L       | L   | L   | -100%              |
| H       | L   | H   | 66.7%              | L       | L   | H   | -66.7%             |
| H       | L   | L   | 100%               | L       | H   | L   | -33.3%             |
| H       | L   | L   | 100%               | X       | H   | H   | 0%                 |
| H       | L   | L   | 100%               | H       | H   | L   | 33.3%              |
| H       | H   | L   | 33.3%              | H       | L   | H   | 66.7%              |
| H       | L   | H   | 66.7%              | H       | L   | L   | 100%               |
| X       | H   | H   | 0%                 | H       | L   | L   | 100%               |
| L       | H   | L   | -33.3%             | H       | L   | L   | 100%               |
| L       | L   | H   | -66.7%             | H       | L   | H   | 66.7%              |
| L       | L   | L   | -100%              | H       | H   | L   | 33.3%              |
| L       | L   | L   | -100%              | X       | H   | H   | 0%                 |
| L       | L   | L   | -100%              | L       | H   | L   | -33.3%             |
| L       | L   | H   | -66.7%             | L       | L   | H   | -66.7%             |
| L       | H   | L   | -33.3%             | L       | L   | L   | -100%              |

## Timing Charts

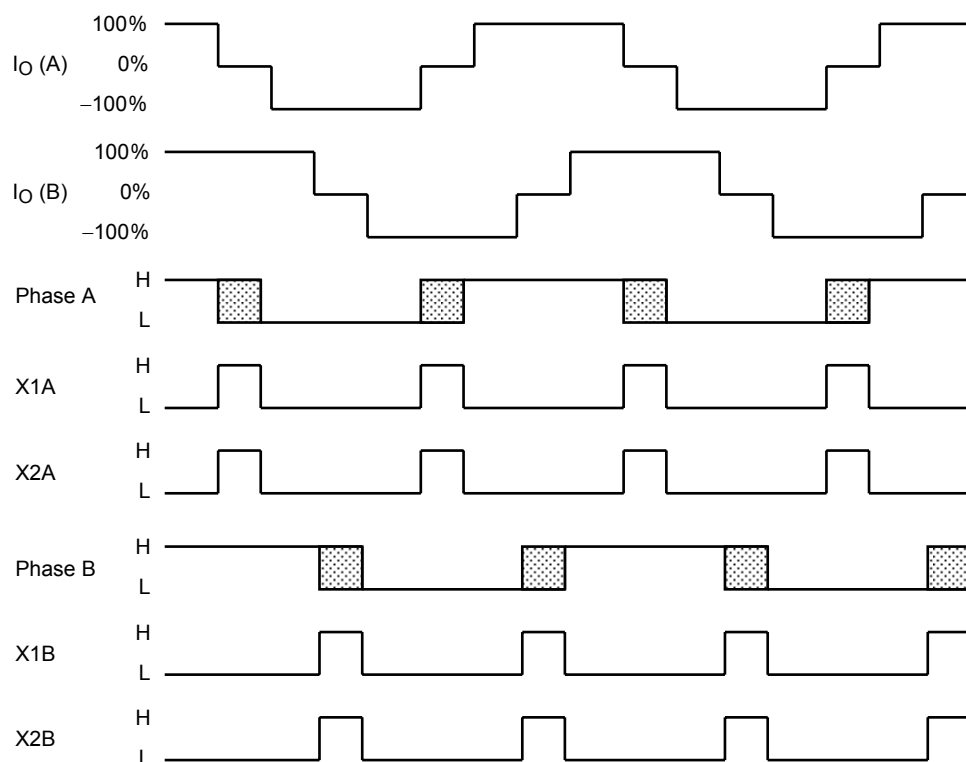
Timing charts may be simplified for explanatory purposes.

< 2-phase excitation >



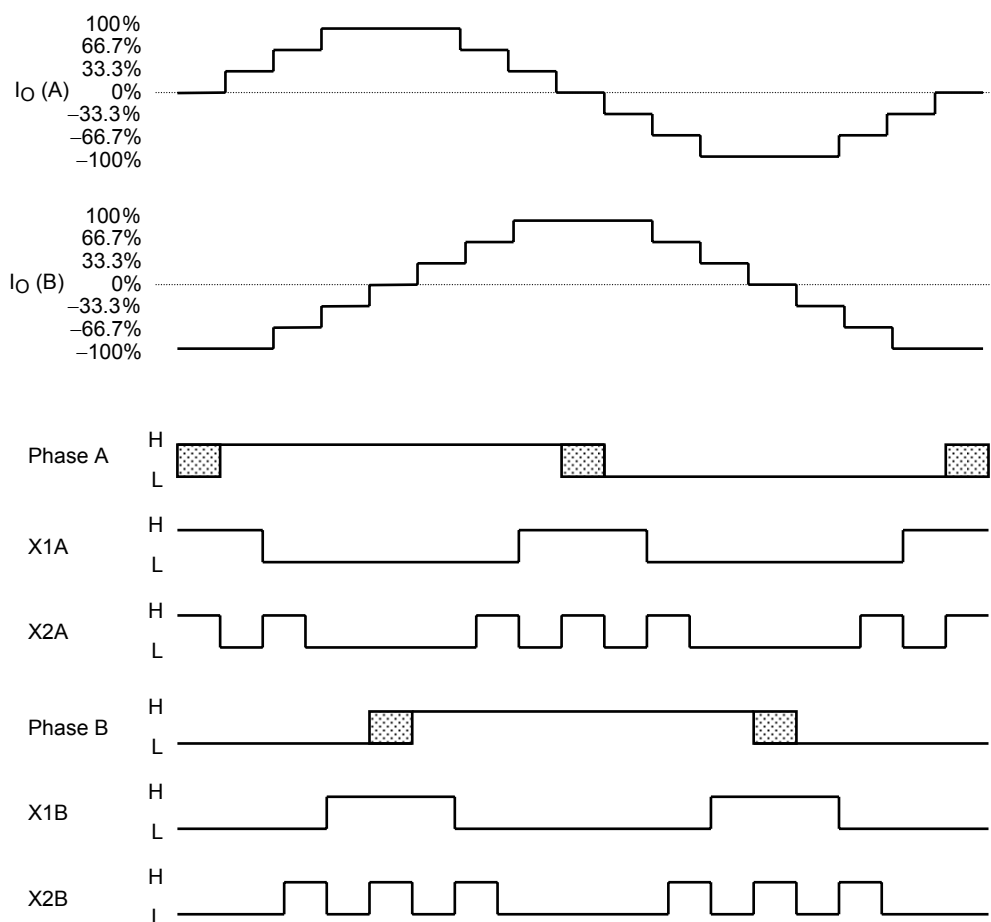
(\*)  $I_O$ : OUT1  $\rightarrow$  OUT2; + current    OUT2  $\rightarrow$  OUT1; - current

< 1-2-phase excitation >



(\*)  $I_O$ : OUT1  $\rightarrow$  OUT2; + current    OUT2  $\rightarrow$  OUT1; - current

< W 1-2-phase excitation >



(\*)  $I_O$ : OUT1 → OUT2; + current      OUT2 → OUT1; - current

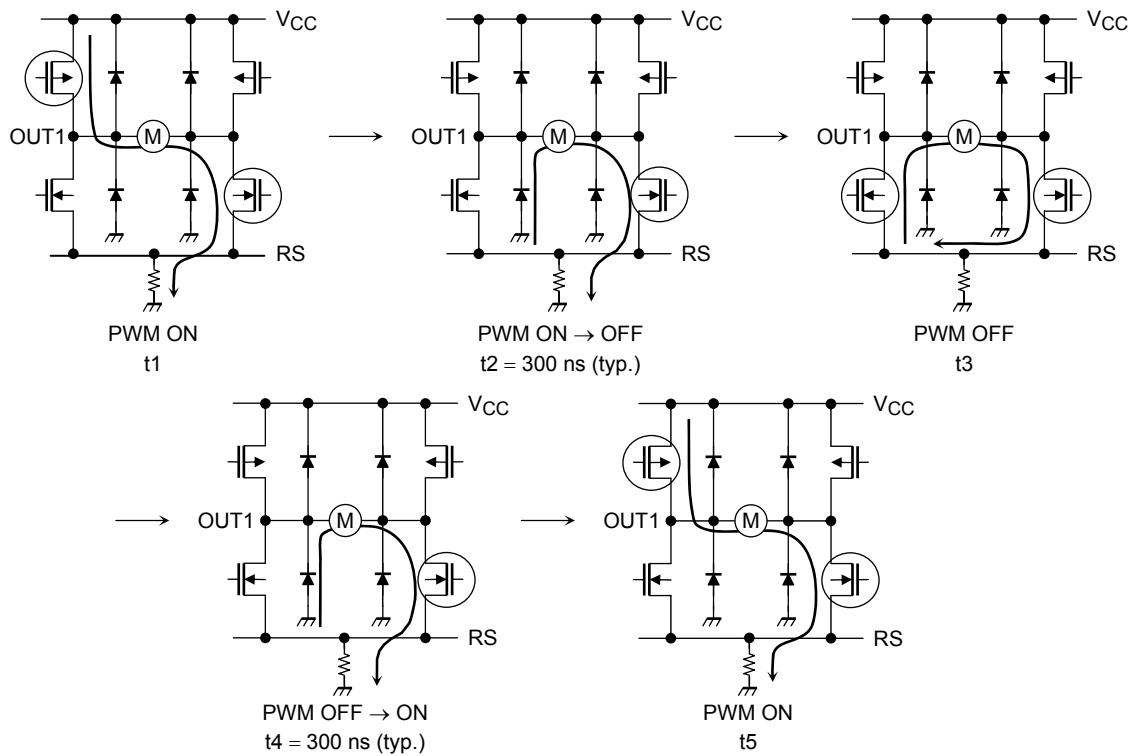
## PWM Current Control

The IC enters CW (CCW) mode and short brake mode alternately during PWM current control.

To prevent shoot-through current caused by simultaneous conduction of upper and lower transistors in the output stage, a dead time is internally generated for 300 ns (target spec) when the upper and lower transistors are being switched.

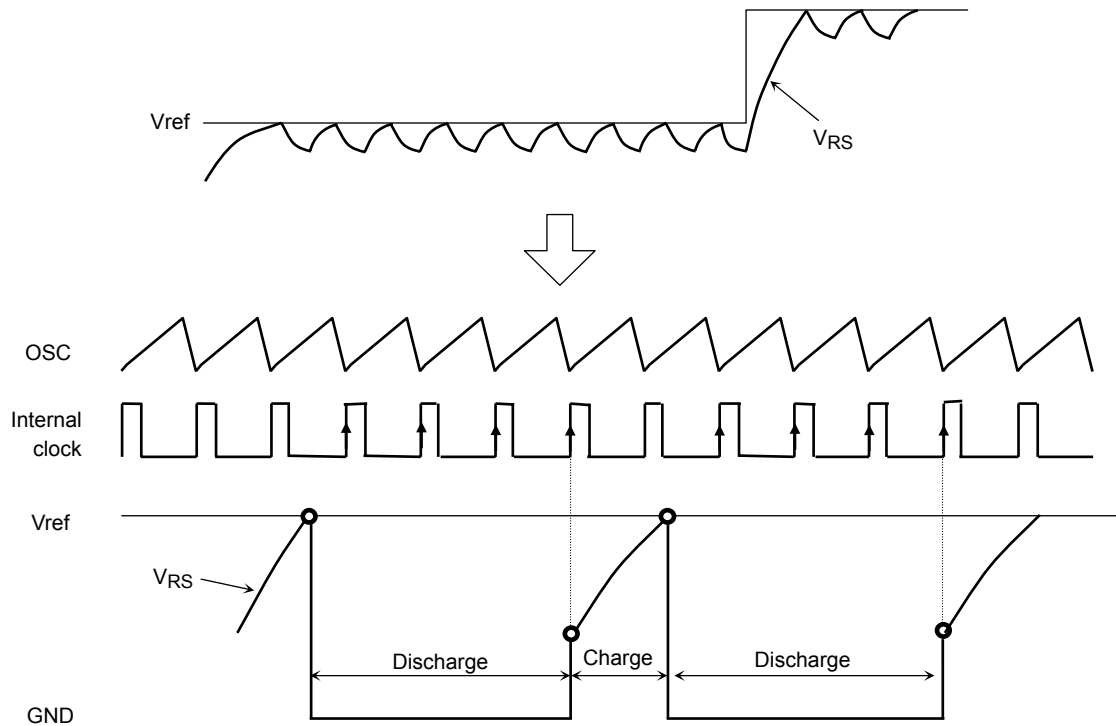
Therefore synchronous rectification for high efficiency in PWM current control can be achieved without an off-time generated via an external input.

Even for toggling between CW and CCW modes, and CW (CCW) and short brake modes, no off-time is required due to the internally generated dead time.



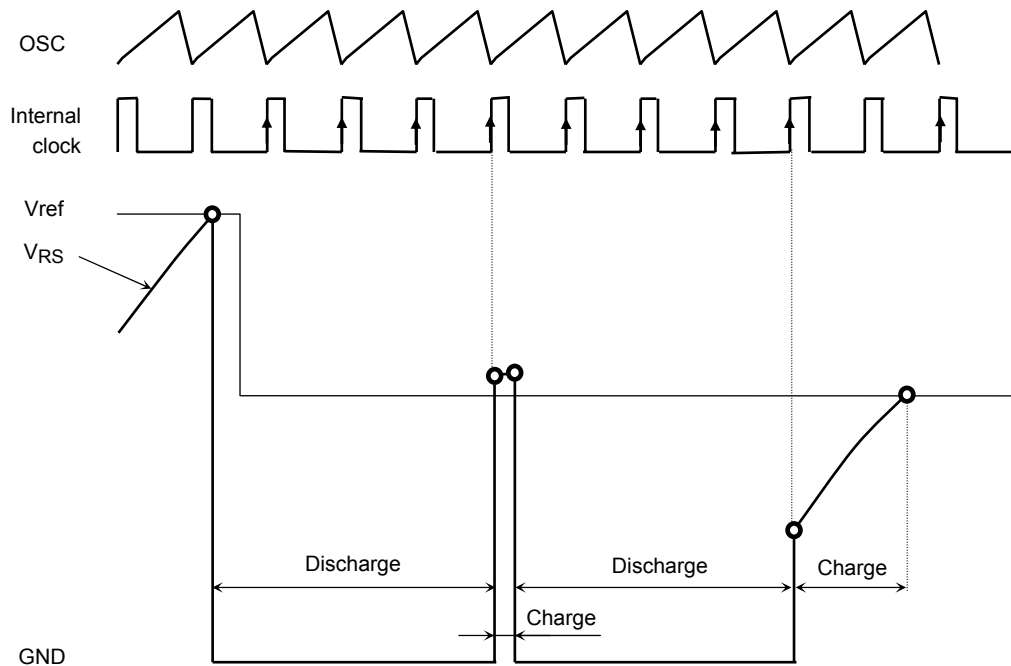
## Constant current regulation

When  $V_{RS}$  reaches the reference voltage ( $V_{ref}$ ), the IC enters discharge mode. After four clock signals are generated from the oscillator, the IC moves from discharge mode to charge mode.



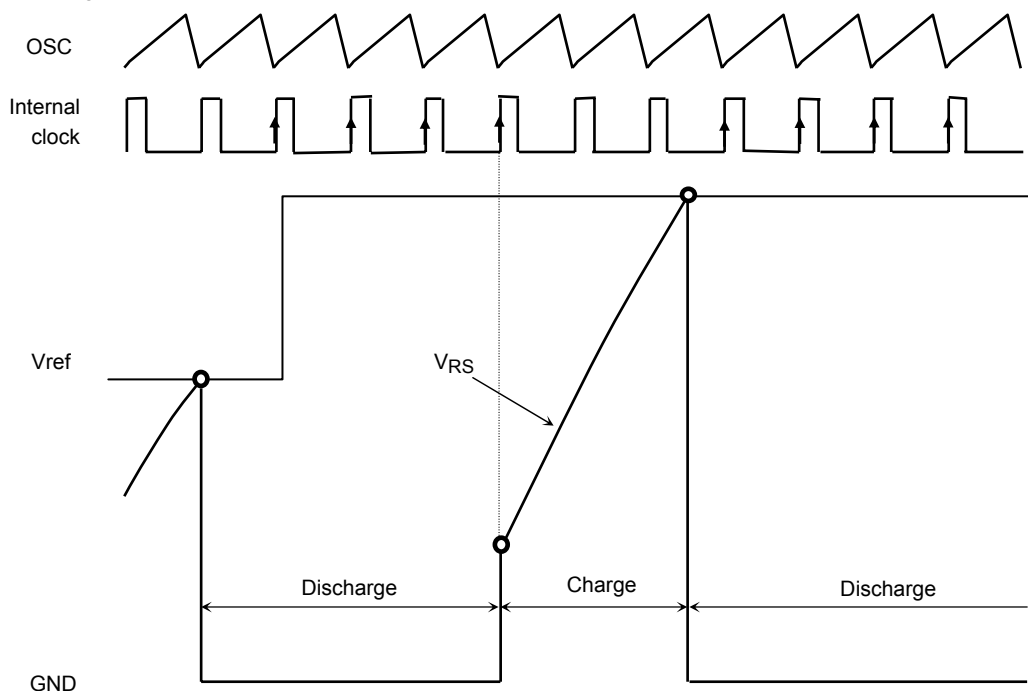
## Transition from charge mode to discharge mode

If  $V_{RS} > V_{ref}$  after four clock signals in charge mode, the IC again enters discharge mode. After a further four clock signals in discharge mode,  $V_{RS}$  is compared with  $V_{ref}$ . If  $V_{RS} < V_{ref}$ , the IC operates in charge mode until  $V_{RS}$  reaches  $V_{ref}$ .



## Transition from discharge mode to charge mode

Even when the reference voltage has risen, discharge mode lasts for four clock signals and is then toggled to charge mode.



Timing charts may be simplified for explanatory purposes.

## Internal oscillation frequency ( $f_{osc}$ )

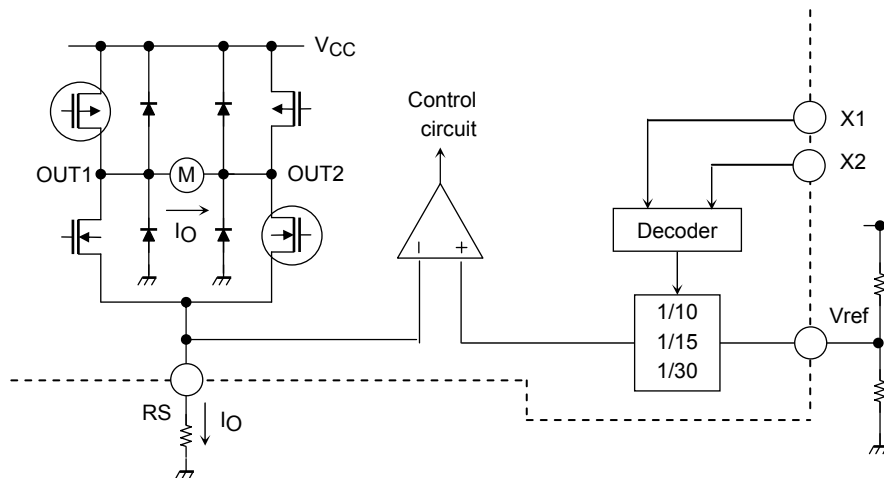
The internal oscillation frequency is approximated by the formula below:

$$f_{osc} = 1 / (0.523 \times (C_{osc} \times 3700 + C_{osc} \times 600)).$$

## Reference Voltage Generator

The current value at 100% is determined by applying voltage at the Vref pin.

The value can be calculated as follows:  $I_O (100\%) = V_{ref} \times 1/10 \times 1/RS[A]$  ( $X1 = X2 = L$ )



## Thermal Shutdown Circuit (TSD)

The IC incorporates a thermal shutdown circuit. When the junction temperature ( $T_j$ ) reaches 160°C (typ.), the output transistors are turned off.

After 50  $\mu$ s (typ.), the output transistors are turned on automatically.

The IC has 40°C temperature hysteresis.

TSD = 160°C (target spec)

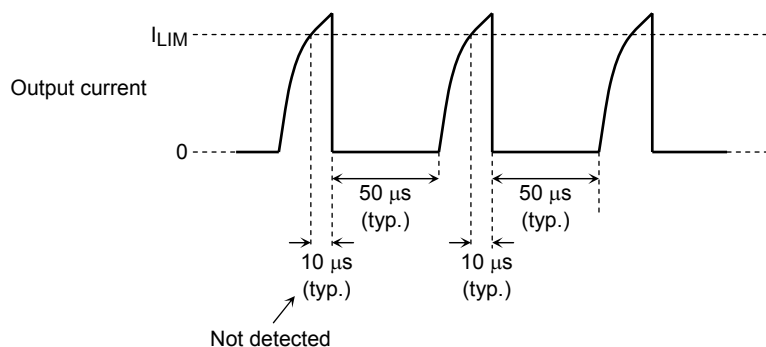
$\Delta$ TSD = 40°C (target spec)

## Overcurrent Protection Circuit (ISD)

The IC incorporates an overcurrent protection circuit to detect voltage flowing through the output transistors. The overcurrent threshold is 2.5 A (typ.).

Currents flowing through the eight output transistors are monitored individually. If overcurrent is detected in at least one of the transistors, all transistors are turned off.

The IC incorporates a timer to count the 50  $\mu$ s (typ.) for which the transistors are off. After the 50  $\mu$ s, the transistors are turned on automatically. If an overcurrent occurs again, the same operation is repeated. To prevent false detection due to glitches, the circuit turns off the transistors only when current exceeding the overcurrent threshold flows for 10  $\mu$ s or longer.



The target specification for the overcurrent limiter value (overcurrent threshold) is 2.5 A (typ.), and varies in a range from approximately 1.5 A to 3.5 A.

These protection functions are intended only as a temporary means of preventing output short circuits or other abnormal conditions and are not guaranteed to prevent damage to the IC.

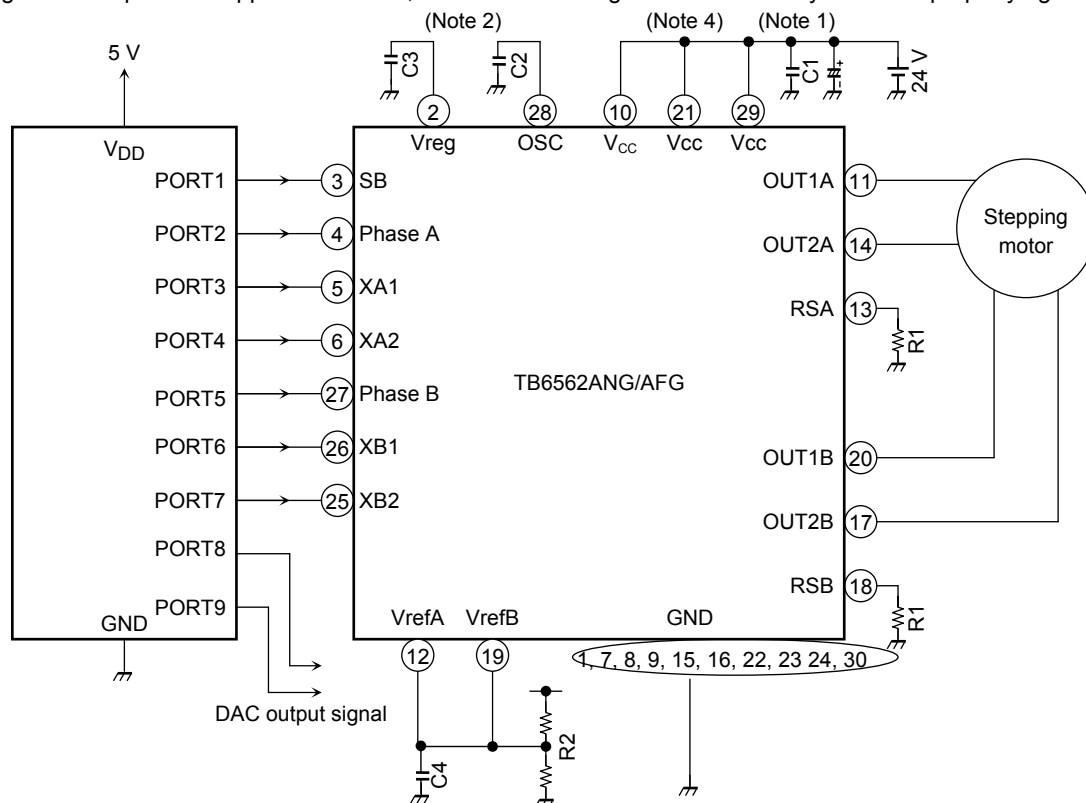
If the guaranteed operating ranges of this product are exceeded, these protection features may not operate and some output short circuits may result in the IC being damaged.

The overcurrent protection feature is intended to protect the IC from temporary short circuits only.

Short circuits persisting over long periods may cause excessive stress and damage the IC. Systems should be configured so that any overcurrent condition will be eliminated as soon as possible.

## Application Circuit

The application circuit below is for reference only and requires thorough evaluation at the mass production design stage. In furnishing this example of an application circuit, Toshiba does not grant the use of any industrial property rights.



Note 1: A power supply capacitor should be connected between  $V_{CC}$  and RSA (RSB), and as close as possible to the IC.

Note 2: C2 and C3 should be connected as close as possible to S-GND.

Note 3: In powering on, set the IC as follows:  
 SB = Low (standby mode)  
 or  
 XA1 = XA2 = XB1 = XB2 = High (current value = 0%)

Note 4: When the Vref is being changed, a DAC output can be connected directly to the Vref pin.

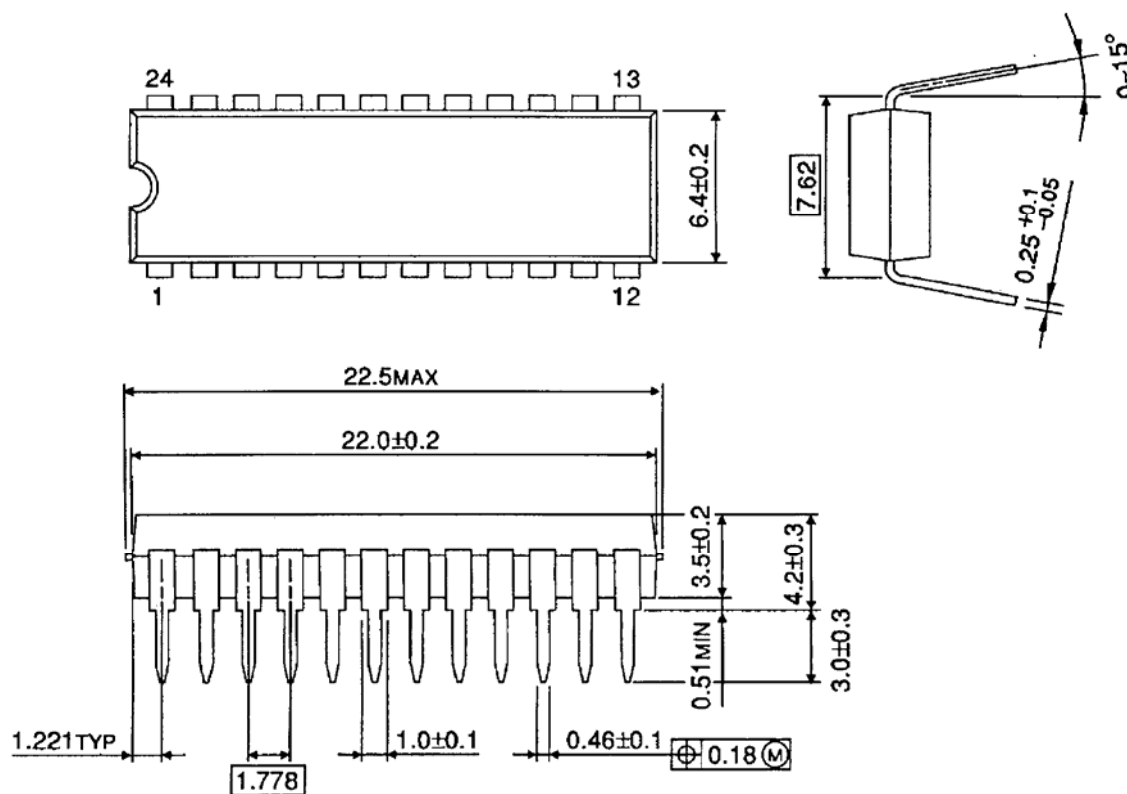
Note 5: The  $V_{CC}$  pins (pin 10, pin 21, pin 29) should be shorted externally.

Note 6: Connect the capacitor C4 to the Vref to reduce the switching noise.

## Package Dimensions

SDIP24-P-300-1.78

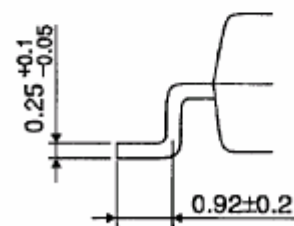
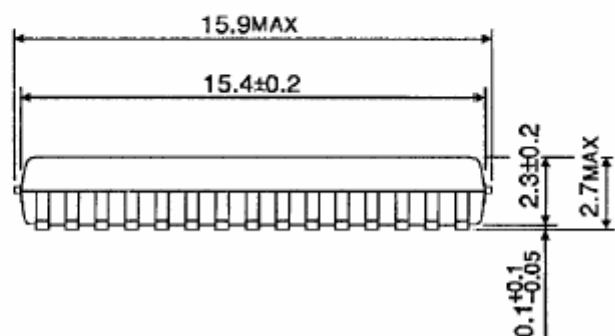
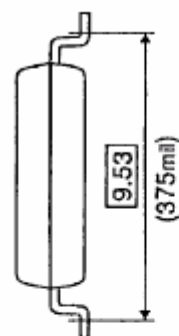
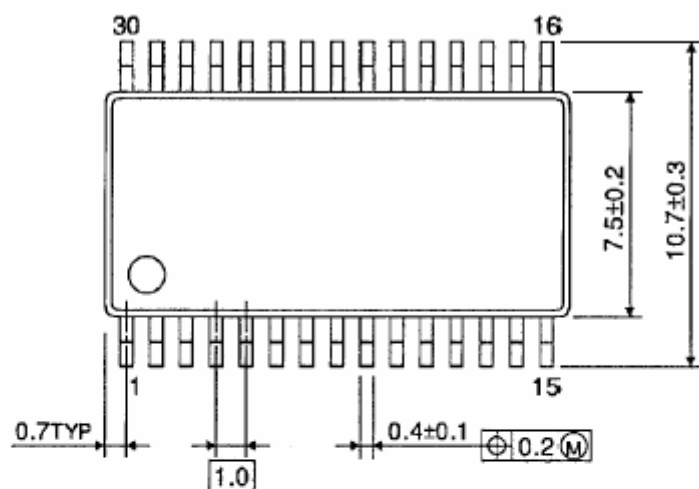
Unit : mm



Weight: 1.62 g (typ.)

SSOP30-P-375-1.00

Unit : mm



Weight: 0.63 g (typ.)

## **Notes on Contents**

### **1. Block Diagrams**

Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purposes.

### **2. Equivalent Circuits**

The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.

### **3. Timing Charts**

Timing charts may be simplified for explanatory purposes.

### **4. Application Circuits**

The application circuits shown in this document are provided for reference purposes only. Thorough evaluation is required, especially at the mass production design stage.

Toshiba does not grant any license to any industrial property rights by providing these examples of application circuits.

### **5. Test Circuits**

Components in the test circuits are used only to obtain and confirm the device characteristics. These components and circuits are not guaranteed to prevent malfunction or failure from occurring in the application equipment.

## **IC Usage Considerations**

### **Notes on handling of ICs**

- [1] The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. Do not exceed any of these ratings.  
Exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.
- [2] Use an appropriate power supply fuse to ensure that a large current does not continuously flow in case of over current and/or IC failure. The IC will fully break down when used under conditions that exceed its absolute maximum ratings, when the wiring is routed improperly or when an abnormal pulse noise occurs from the wiring or load, causing a large current to continuously flow and the breakdown can lead smoke or ignition. To minimize the effects of the flow of a large current in case of breakdown, appropriate settings, such as fuse capacity, fusing time and insertion circuit location, are required.
- [3] If your design includes an inductive load such as a motor coil, incorporate a protection circuit into the design to prevent device malfunction or breakdown caused by the current resulting from the inrush current at power ON or the negative current resulting from the back electromotive force at power OFF. IC breakdown may cause injury, smoke or ignition.  
Use a stable power supply with ICs with built-in protection functions. If the power supply is unstable, the protection function may not operate, causing IC breakdown. IC breakdown may cause injury, smoke or ignition.
- [4] Do not insert devices in the wrong orientation or incorrectly.  
Make sure that the positive and negative terminals of power supplies are connected properly.  
Otherwise, the current or power consumption may exceed the absolute maximum rating, and exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.  
In addition, do not use any device that is applied the current with inserting in the wrong orientation or incorrectly even just one time.

**Points to remember on handling of ICs****(1) Over current Protection Circuit**

Over current protection circuits (referred to as current limiter circuits) do not necessarily protect ICs under all circumstances. If the Over current protection circuits operate against the over current, clear the over current status immediately.

Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the over current protection circuit to not operate properly or IC breakdown before operation. In addition, depending on the method of use and usage conditions, if over current continues to flow for a long time after operation, the IC may generate heat resulting in breakdown.

**(2) Thermal Shutdown Circuit**

Thermal shutdown circuits do not necessarily protect ICs under all circumstances. If the thermal shutdown circuits operate against the over temperature, clear the heat generation status immediately.

Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the thermal shutdown circuit to not operate properly or IC breakdown before operation.

**(3) Heat Radiation Design**

In using an IC with large current flow such as power amp, regulator or driver, please design the device so that heat is appropriately radiated, not to exceed the specified junction temperature ( $T_J$ ) at any time and condition. These ICs generate heat even during normal use. An inadequate IC heat radiation design can lead to decrease in IC life, deterioration of IC characteristics or IC breakdown. In addition, please design the device taking into consideration the effect of IC heat radiation with peripheral components.

**(4) Back-EMF**

When a motor rotates in the reverse direction, stops or slows down abruptly, a current flows back to the motor's power supply due to the effect of back-EMF. If the current sink capability of the power supply is small, the device's motor power supply and output pins might be exposed to conditions beyond maximum ratings. To avoid this problem, take the effect of back-EMF into consideration in system design.

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