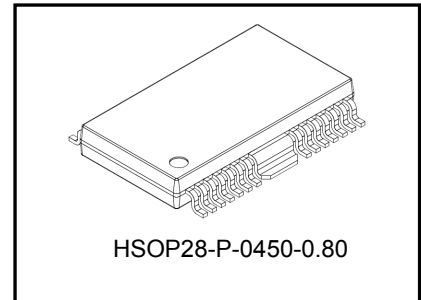


# TB62213AFG

## PHASE-in controlled Bipolar Stepping Motor Driver IC

The TB62213AFG is a two-phase bipolar stepping motor driver using a PWM chopper. Fabricated with the BiCD process, the TB62213AFG is rated at 40 V/3.0 A . The on-chip voltage regulator allows control of a stepping motor with a single VM power supply.



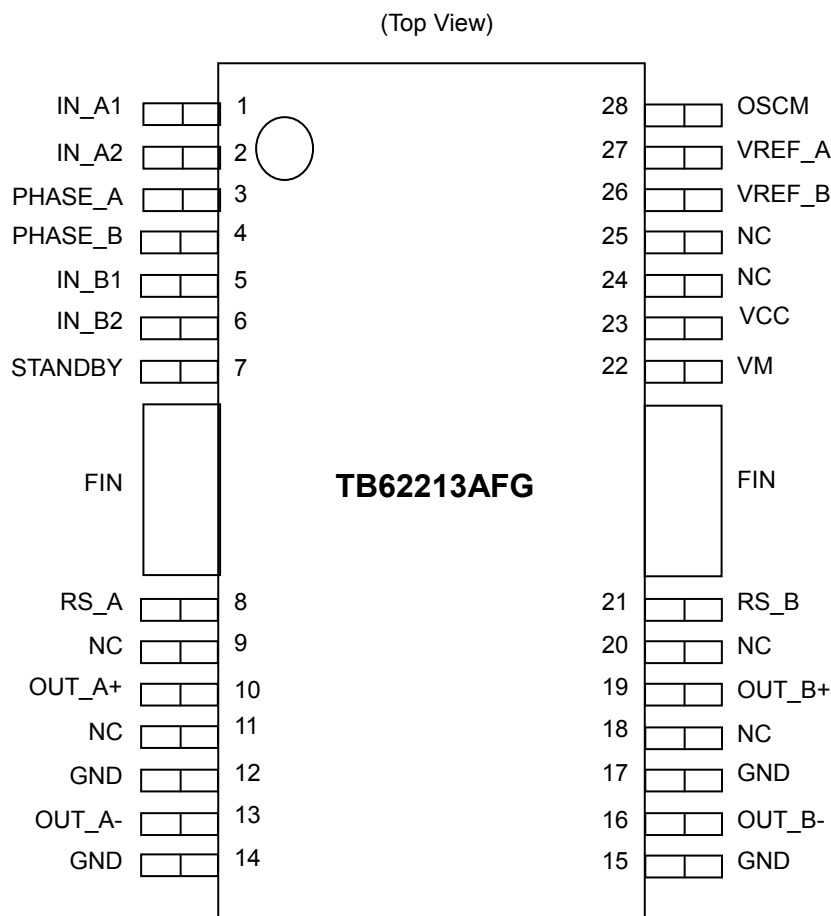
Weight: 0.79g(Typ.)

### Features

- Capable of controlling 1 bipolar stepping motor.
- BiCD process integrated monolithic IC.
- PWM controlled constant-current drive.
- Allows Full Step, Half Step and 1/4 Step excitations.
- Output stage low on resistance by a BiCD process
- High voltage and current (For specification, please refer to absolute maximum ratings and operation ranges)
- Built-in error detection circuits  
(Thermal shutdown (TSD), over-current shutdown (ISD), and power-on reset (POR))
- Built-in VCC regulator for internal circuit use. Therefore it's possible to operate only by a VM power supply.
- Chopping frequency of a motor can be customized by external resistance and condenser.  
High-speed Chopping by more than 100 kHz is possible.
- Packages: HSOP28-P-0450-0.80

Note) Please be careful about thermal conditions during use.

Pin Assignment



The diagram illustrates the internal architecture of the 6402 stepper motor driver. Key components and their interconnections include:

- Inputs:** IN\_A1, IN\_A2, PHASE\_A, IN\_B1, IN\_B2, PHASE\_B, and STANDBY are connected to the StepDecoder (Input Logic).
- Power and Reference:** VCC is connected to the VCC Voltage Regulator and the OSCM pin. VREF is connected to the Torque Control block. VM is connected to the RS (sense resistor) and the current feedback circuit.
- Control Logic:** The StepDecoder (Input Logic) provides signals to the Torque Control and 2bit D/A (Angle Control) blocks. The Torque Control block outputs to the 2bit D/A block.
- Current Feedback:** The 2bit D/A block outputs to the Rs COMP1 and Rs COMP2 blocks. The Rs COMP1 and Rs COMP2 blocks output to the Output Control (Mixed Decay Control) block.
- Output Stage:** The Output Control (Mixed Decay Control) block outputs to the Output (H-Bridge × 2) block, which drives the Stepping Motor.
- Protection and Timing:** The VCC Voltage Regulator provides VMR Detect feedback. The Chopper OSC block (containing OSC and CR-CLK Converter) provides a clock signal to the Output Control block. The Detection Circuit (containing ISD and TSD blocks) provides feedback to the Output Control block.

### Note

Careful attention should be paid to the layout of the output, VM and GND traces, to avoid short circuits across output pins or to the power supply or ground. If such a short circuit occurs, the IC may be permanently damaged. Also, the utmost care should be taken for pattern designing and implementation of the IC since it has power supply pins (VM, RS, OUT, GND) through which a particularly large current may run. If these pins are wired incorrectly, an operation error may occur or this IC may be destroyed.

2015-03-09

**Pin Function**

| Pin No. | Pin name | Function                                                 |
|---------|----------|----------------------------------------------------------|
| 1       | IN_A1    | Motor Ach excitation control input                       |
| 2       | IN_A2    | Motor Ach excitation control input                       |
| 3       | PHASE_A  | Current direction signal input for motor Ach             |
| 4       | PHASE_B  | Current direction signal input for motor Bch             |
| 5       | IN_B1    | Motor Bch excitation control input                       |
| 6       | IN_B2    | Motor Bch excitation control input                       |
| 7       | STANDBY  | All-function-initializing and Low power dissipation mode |
| 8       | RS_A     | Motor Ach current sense pin                              |
| 9       | NC       | Non-connection pin                                       |
| 10      | OUT_A+   | Motor Ach (+) output pin                                 |
| 11      | NC       | Non-connection pin                                       |
| 12      | GND      | Ground pin                                               |
| 13      | OUT_A-   | Motor Ach (-) output pin                                 |
| 14      | GND      | Ground pin                                               |
| 15      | GND      | Ground pin                                               |
| 16      | OUT_B-   | Motor Bch (-) output pin                                 |
| 17      | GND      | Ground pin                                               |
| 18      | NC       | Non-connection pin                                       |
| 19      | OUT_B+   | Motor Bch (+) output pin                                 |
| 20      | NC       | Non-connection pin                                       |
| 21      | RS_B     | Motor Bch current sense pin                              |
| 22      | VM       | Motor power supply pin                                   |
| 23      | VCC      | Internal VCC regulator monitor pin                       |
| 24      | NC       | Non-connection pin                                       |
| 25      | NC       | Non-connection pin                                       |
| 26      | VREF_B   | Motor Bch output set pin                                 |
| 27      | VREF_A   | Motor Ach output set pin                                 |
| 28      | OSCM     | Oscillating circuit frequency for chopping set pin       |

Please use the pin of NC with Open.

## Operation explanation

IOUT: The current that flows OUT\_A+(OUT\_B+) to OUT\_A-(OUT\_B-) is defined plus current. The current that flows OUT\_A-(OUT\_B-) to OUT\_A+(OUT\_B+) is defined minus current.

<Full Step>

| PHASE A |       |       |         | PHASE B |       |       |         |
|---------|-------|-------|---------|---------|-------|-------|---------|
| Input   |       |       | Output  | Input   |       |       | Output  |
| PHASE_A | IN_A1 | IN_A2 | IOUT(A) | PHASE_B | IN_B1 | IN_B2 | IOUT(B) |
| H       | H     | H     | 100%    | H       | H     | H     | 100%    |
| L       | H     | H     | -100%   | H       | H     | H     | 100%    |
| L       | H     | H     | -100%   | L       | H     | H     | -100%   |
| H       | H     | H     | 100%    | L       | H     | H     | -100%   |

Please make IN\_A1, IN\_A2, IN\_B1, and IN\_B2 Low when you turn on the power supply.

<Half Step>

| PHASE A |       |       |         | PHASE B |       |       |         |
|---------|-------|-------|---------|---------|-------|-------|---------|
| Input   |       |       | Output  | Input   |       |       | Output  |
| PHASE_A | IN_A1 | IN_A2 | IOUT(A) | PHASE_B | IN_B1 | IN_B2 | IOUT(B) |
| H       | H     | H     | 100%    | H       | H     | H     | 100%    |
| X       | L     | L     | 0%      | H       | H     | H     | 100%    |
| L       | H     | H     | -100%   | H       | H     | H     | 100%    |
| L       | H     | H     | -100%   | X       | L     | L     | 0%      |
| L       | H     | H     | -100%   | L       | H     | H     | -100%   |
| X       | L     | L     | 0%      | L       | H     | H     | -100%   |
| H       | H     | H     | 100%    | L       | H     | H     | -100%   |
| H       | H     | H     | 100%    | X       | L     | L     | 0%      |

X: Don't care

&lt;1/4 Step&gt;

| PHASE A |       |       |        | PHASE B |       |       |        |
|---------|-------|-------|--------|---------|-------|-------|--------|
| Input   |       |       | Output | Input   |       |       | Output |
| PHASE_A | IN_A1 | IN_A2 | IOU(A) | PHASE_B | IN_B1 | IN_B2 | IOU(B) |
| H       | H     | L     | 71%    | H       | H     | L     | 71%    |
| H       | L     | H     | 38%    | H       | H     | H     | 100%   |
| X       | L     | L     | 0%     | H       | H     | H     | 100%   |
| L       | L     | H     | -38%   | H       | H     | H     | 100%   |
| L       | H     | L     | -71%   | H       | H     | L     | 71%    |
| L       | H     | H     | -100%  | H       | L     | H     | 38%    |
| L       | H     | H     | -100%  | X       | L     | L     | 0%     |
| L       | H     | H     | -100%  | L       | L     | H     | -38%   |
| L       | H     | L     | -71%   | L       | H     | L     | -71%   |
| L       | L     | H     | -38%   | L       | H     | H     | -100%  |
| X       | L     | L     | 0%     | L       | H     | H     | -100%  |
| H       | L     | H     | 38%    | L       | H     | H     | -100%  |
| H       | H     | L     | 71%    | L       | H     | L     | -71%   |
| H       | H     | H     | 100%   | L       | L     | H     | -38%   |
| H       | H     | H     | 100%   | X       | L     | L     | 0%     |
| H       | H     | H     | 100%   | H       | L     | H     | 38%    |

X: Don't care

## Other Functions

| Pin Name                         | H                     | L                 | Notes                                                                                                                                   |
|----------------------------------|-----------------------|-------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| IN_A1<br>IN_A2<br>IN_B1<br>IN_B2 | Outputs enabled       | Outputs disabled  | When IN_A1(IN_B1), IN_A2(IN_B2) are deasserted Low, its outputs assume the high-impedance state, regardless of the state of that phase. |
| PHASE_A<br>PHASE_B               | OUT_A+(OUT_B+): H     | OUT_A-(OUT_B-): H | When PHASE_X is High, a current normally flows from OUT_A+(OUT_B+) to OUT_A-(OUT_B-).                                                   |
| STANDBY                          | Normal operation mode | Standby mode      | When STANDBY is Low, both the oscillator and output drivers are disabled. Cannot drive a motor.                                         |

**Protection Features****(1) Thermal shutdown (TSD)**

The thermal shutdown circuit turns off all the outputs when the junction temperature ( $T_j$ ) exceeds 150°C (typ.). The outputs retain the current states.

The TB62213AFG exits TSD mode and resumes normal operation when the TB62213AFG is rebooted or both the STANDBY pin are switched to 'H' → 'L' → 'H'.

**(2) POR for VMR and VCCR (Power-ON-resets: VM and VCC voltage monitor)**

The outputs are forced off until VM and VCC reach the rated voltages.

**(3) Overcurrent shutdown (ISD)**

Each phase has an overcurrent shutdown circuit, which turns off the corresponding outputs when the output current exceeds the shutdown trip threshold (above the maximum current rating: 3.0 A minimum).

The TB62213AFG exits ISD mode and resumes normal operation when the TB62213AFG is rebooted or both the STANDBY pin are switched to Low.

This circuit provides protection against a short circuit by temporarily disabling the device. Important notes on this feature will be provided later.

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

| Characteristics             | Symbol           | Rating     | Unit |
|-----------------------------|------------------|------------|------|
| Motor power supply          | V <sub>M</sub>   | 40         | V    |
| Motor output voltage        | V <sub>OUT</sub> | 40         | V    |
| Motor output current(Note1) | I <sub>OUT</sub> | 3.0        | A    |
| Logic input voltage         | V <sub>IN</sub>  | 6.0        | V    |
| VREF reference voltage      | V <sub>REF</sub> | 5.0        | V    |
| Power dissipation (Note 2)  | P <sub>D</sub>   | 1.15       | 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>j</sub>   | 150        | °C   |

Note 1: The absolute maximum rating is 3.0A.

Note 2: Stand-alone (Ta = 25°C)

When Ta exceeds 25°C, it is necessary to do the derating with 9.2 mW/°C.

Ta: Ambient temperature

T<sub>opr</sub>: Ambient temperature while the IC is active

T<sub>j</sub>: Junction temperature while the IC is active. The maximum junction temperature is limited by the thermal shutdown (TSD) circuitry.

**About Absolute Maximum Ratings**

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 device breakdown, damage or deterioration, and may result in injury by explosion or combustion.

The value of even one parameter of the absolute maximum ratings should not be exceeded under any circumstances. The TB62213AFG does not have overvoltage protection. Therefore, the device is damaged if a voltage exceeding its rated maximum is applied.

All voltage ratings, including supply voltages, must always be followed. The other notes and considerations described later should also be referred to.



## Operating Ranges (Note1)

| Characteristics                     | Symbol      | Test Condition       | Min  | Typ. | Max  | Unit |
|-------------------------------------|-------------|----------------------|------|------|------|------|
| Motor power supply                  | $V_M$       | -                    | 10.0 | 24.0 | 38.0 | V    |
| Motor output voltage                | $I_{OUT}$   | Ta = 25°C, Per phase | -    | 1.8  | 2.4  | A    |
| Logic input voltage                 | $V_{IN(H)}$ | Logic high level     | 2.0  | 3.3  | 5.5  | V    |
|                                     | $V_{IN(L)}$ | Logic low level      | GND  | -    | 0.8  | V    |
| PHASE signal input frequency(Note2) | $f_{PHASE}$ | -                    | 1.0  | -    | 400  | kHz  |
| Chopper frequency                   | $f_{chop}$  | -                    | 40   | 100  | 150  | kHz  |
| VREFreference voltage               | $V_{REF}$   | -                    | GND  | -    | 3.6  | V    |

Note 1: Please have and use the margin for the absolute maximum rating.

Note 2: There is no problem in the condition of 500ns or less at the risetime of the CLK signal even if a frequency less than it is input though the lower bound of the frequency of the input of the signal of the CLK input is assumed to be 1kHz.

Please note that repeated input of the signal by chattering can be generated when standing up of the signal becomes duller.

Electrical Characteristics 1 (Ta = 25°C, V<sub>M</sub> = 24 V, unless otherwise specified)

| Characteristics                                                            |           | Symbol                | Test Condition                                                                                               | Min | Typ. | Max | Unit |
|----------------------------------------------------------------------------|-----------|-----------------------|--------------------------------------------------------------------------------------------------------------|-----|------|-----|------|
| Logic input voltage                                                        |           | V <sub>IH</sub>       | Logic input pins                                                                                             | 2.0 | 3.3  | 5.5 | V    |
|                                                                            |           | V <sub>IL</sub>       |                                                                                                              | GND | -    | 0.8 |      |
| Input hysteresis voltage                                                   |           | V <sub>IN(HIS)</sub>  | Logic input pins (Note1)                                                                                     | 100 | 200  | 300 | mV   |
| Logic input current                                                        | High      | I <sub>IN(H)</sub>    | Logic input pins, V <sub>IN</sub> = 5 V                                                                      | 35  | 50   | 75  | μA   |
|                                                                            | Low       | I <sub>IN(L)</sub>    | Logic input pins, V <sub>IN</sub> = 0 V                                                                      | -   | -    | 1   |      |
| Power consumption                                                          |           | I <sub>M1</sub>       | Outputs: open, non-operation<br>STANDBY = Low                                                                | -   | 2.0  | 3.0 | mA   |
|                                                                            |           | I <sub>M2</sub>       | Outputs: open, non-operation<br>STANDBY = High<br>f <sub>PHASE</sub> =1kHz                                   | -   | 3.5  | 5.0 |      |
|                                                                            |           | I <sub>M3</sub>       | Outputs: open, two-phase excitation<br>STANDBY = High<br>f <sub>PHASE</sub> =4kHz, f <sub>chop</sub> =100kHz | -   | 5.0  | 7.0 |      |
| Output leakage current                                                     | High-side | I <sub>OH</sub>       | V <sub>RS</sub> = V <sub>M</sub> = 40V, V <sub>OUT</sub> = 0V<br>IN_A1=IN_A2=IN_B1=IN_B2=Low                 | -   | -    | 1   | μA   |
|                                                                            | Low-side  | I <sub>OL</sub>       | V <sub>RS</sub> = V <sub>M</sub> = V <sub>OUT</sub> = 40V<br>IN_A1=IN_A2=IN_B1=IN_B2=Low                     | 1   | -    | -   |      |
| Chanel-to-channel current differential                                     |           | ΔI <sub>OUT1</sub>    | I <sub>OUT</sub> = 2.0A                                                                                      | -5  | 0    | +5  | %    |
| Output current error relative to the predetermined value                   |           | ΔI <sub>OUT2</sub>    | I <sub>OUT</sub> = 2.0A                                                                                      | -5  | 0    | +5  | %    |
| R <sub>S</sub> pin current                                                 |           | I <sub>RS</sub>       | V <sub>RS</sub> = V <sub>M</sub> = 24V<br>STANDBY = Low<br>IN_A1=IN_A2=IN_B1=IN_B2=Low                       | 0   | -    | 10  | μA   |
| Drain-source ON-resistance of the output transistors (upper and lower sum) |           | R <sub>ON (D-S)</sub> | I <sub>OUT</sub> = 2.0 A, T <sub>J</sub> = 25°C                                                              | -   | 0.6  | 0.8 | Ω    |
| Chopping current                                                           |           | Phase                 | Step0                                                                                                        | -   | 0    | -   | %    |
|                                                                            |           |                       | Step1                                                                                                        | 33  | 38   | 43  | %    |
|                                                                            |           |                       | Step2                                                                                                        | 66  | 71   | 76  | %    |
|                                                                            |           |                       | Step3                                                                                                        | -   | 100  | -   | %    |

Note: V<sub>IN (L → H)</sub> is defined as the V<sub>IN</sub> voltage that causes the outputs to change when a pin under test is gradually raised from 0 V. V<sub>IN (H → L)</sub> is defined as the V<sub>IN</sub> voltage that causes the outputs to change when the pin is then gradually lowered.

The difference between V<sub>IN (L → H)</sub> and V<sub>IN (H → L)</sub> is defined as the input hysteresis.

**Electrical Characteristics 2 (Ta = 25°C, V<sub>M</sub> = 24 V, unless otherwise specified)**

| Characteristics                       | Symbol                 | Test Condition                                    | Min   | Typ.  | Max   | Unit |
|---------------------------------------|------------------------|---------------------------------------------------|-------|-------|-------|------|
| Supply voltage for internal circuitry | V <sub>CC</sub>        | I <sub>CC</sub> = 5.0 mA                          | 4.75  | 5.00  | 5.25  | V    |
| Supply current for internal circuitry | I <sub>CC</sub>        | -                                                 | -     | 2.5   | 5.0   | mA   |
| VREF input voltage range              | V <sub>REF</sub>       | STANDBY = H,<br>f <sub>PHASE</sub> = 1 kHz        | GND   | -     | 3.6   | V    |
| VREF input current                    | I <sub>REF</sub>       | Output: non-operation<br>V <sub>ref</sub> = 3.0 V | -     | 0     | 1.0   | μA   |
| VREF decay rate                       | V <sub>REF(GAIN)</sub> | V <sub>ref</sub> = 2.0 V                          | 1/4.8 | 1/5.0 | 1/5.2 | -    |
| TSD threshold (Note 1)                | T <sub>JTSD</sub>      | -                                                 | 140   | 150   | 170   | °C   |
| VM recovery voltage                   | V <sub>MR</sub>        | STANDBY = H                                       | 7.0   | 8.0   | 9.0   | V    |
| Overcurrent trip threshold (Note 2)   | I <sub>SD</sub>        | -                                                 | 3.0   | 4.0   | 5.0   | A    |

**Note 1: Thermal shutdown (TSD) circuitry**

When the junction temperature of the device reaches the threshold, the TSD circuitry is tripped, causing the internal reset circuitry to turn off the output transistors.

The TSD circuitry is tripped at a temperature between 140°C (min) and 170°C (max). Once tripped, the TSD circuitry keeps the output transistors off until both the STANDBY pin are switched to Low or the TB62213AFG is rebooted. The TSD circuit is a backup function to detect a thermal error, therefore is not recommended to be used aggressively.

**Note 2: Overcurrent shutdown (ISD) circuitry**

When the output current reaches the threshold, the ISD circuitry is tripped, causing the internal reset circuitry to turn off the output transistors (OSCM is stopped.).

To prevent the ISD circuitry from being tripped owing to switching noise, it has a masking time of four OSCM cycles. Once tripped, it takes a maximum of four OSCM cycles to exit ISD mode and resume normal operation.

The ISD circuitry remains active until both the STANDBY pin are switched to Low or the TB62213AFG is rebooted.

The TB62213AFG remains in Standby mode while in ISD mode.

**Back-EMF**

While a motor is rotating, there is a timing at which power is fed back to the power supply. At that timing, the motor current recirculates back to the power supply owing to the effect of the motor back-EMF.

If the power supply does not have enough sink capability, the power supply and output pins of the device might rise above the rated voltages. The magnitude of the motor back-EMF varies with usage conditions and motor characteristics. It must be fully verified that there is no risk that the TB62213AFG or other components will be damaged or fail owing to the motor back-EMF.

**Cautions on Overcurrent Shutdown (ISD) and Thermal Shutdown (TSD)**

- The ISD and TSD circuits are only intended to provide temporary protection against irregular conditions such as an output short circuit; they do not necessarily guarantee complete IC safety.
- If the device is used beyond the specified operating ranges, these circuits may not operate properly: then the device may be damaged owing to an output short circuit.
- The ISD circuit is only intended to provide temporary protection against an output short circuit. If such a condition persists for a long time, the device may be damaged owing to overstress. Overcurrent conditions must be removed immediately by external hardware.

**IC Mounting**

Do not insert devices in the wrong orientation or incorrectly. Otherwise, it may cause device breakdown, damage and/or deterioration.

**AC Electrical Characteristics ( $T_a = 25^\circ\text{C}$ ,  $V_M = 24\text{ V}$ ,  $6.8\text{ mH}/5.7\ \Omega$ )**

| Characteristics                             | Symbol                                | Test Condition                                                                                   | Min  | Typ. | Max  | Unit |
|---------------------------------------------|---------------------------------------|--------------------------------------------------------------------------------------------------|------|------|------|------|
| Phase frequency                             | $f_{\text{PHASE}}$                    | $f_{\text{OSCM}} = 1600\text{ kHz}$                                                              | 1.0  | -    | 400  | kHz  |
| Minimum phase pulse width                   | $t_{\text{PHASE}}$                    | $f_{\text{OSCM}} = 1600\text{ kHz}$                                                              | 100  | -    | -    | ns   |
|                                             | $t_{\text{wp}}$                       |                                                                                                  | 50   | -    | -    |      |
|                                             | $t_{\text{wn}}$                       |                                                                                                  | 50   | -    | -    |      |
| Output transistor switching characteristics | $t_r$                                 | -<br><br>PHASE to OUT                                                                            | 150  | 200  | 250  | ns   |
|                                             | $t_f$                                 |                                                                                                  | 100  | 150  | 200  |      |
|                                             | $t_{\text{pLH}}(\text{P})\text{ MAX}$ |                                                                                                  | 500  | 850  | 1200 |      |
|                                             | $t_{\text{pHL}}(\text{P})\text{ MAX}$ |                                                                                                  | 500  | 850  | 1200 |      |
|                                             | $t_{\text{pLH}}(\text{P})\text{ MIN}$ |                                                                                                  | 250  | 600  | 950  |      |
|                                             | $t_{\text{pHL}}(\text{P})\text{ MIN}$ |                                                                                                  | 250  | 600  | 950  |      |
| Blanking time for current spike prevention  | $t_{\text{BLANK}}$                    | $I_{\text{OUT}} = 1.0\text{ A}$                                                                  | 300  | 400  | 500  | ns   |
| OSC oscillation reference frequency         | $f_{\text{OSCM}}$                     | $C = 270\text{ pF}$ , $R_1 = 3.6\text{ k}\Omega$                                                 | 1200 | 1600 | 2000 | kHz  |
| Chopper frequency range                     | $f_{\text{chop}}(\text{RANGE})$       | Outputs enabled active<br>$I_{\text{OUT}} = 1.0\text{ A}$                                        | 40   | 100  | 150  | kHz  |
| Predefined chopper frequency                | $f_{\text{chop}}$                     | Outputs enabled active<br>$I_{\text{OUT}} = 1.0\text{ A}$<br>$f_{\text{OSCM}} = 1600\text{ kHz}$ | -    | 100  | -    | kHz  |
| ISD masking time                            | $t_{\text{ISD}}(\text{Mask})$         | This time will be the number of CLK OSCM.                                                        | -    | 4    | -    | -    |
| ISD on-time                                 | $t_{\text{ISD}}$                      | After ISD threshold is exceeded owing to an output short circuit to power or ground              | -    | -    | 8    | -    |

Note: There is no problem in the condition of 500ns or less at the risetime of the CLK signal even if a frequency less than it is input though the lower bound of the frequency of the input of the signal of the CLK input is assumed to be 1kHz. Please note that repeated input of the signal by chattering can be generated when standing up of the signal becomes duller.

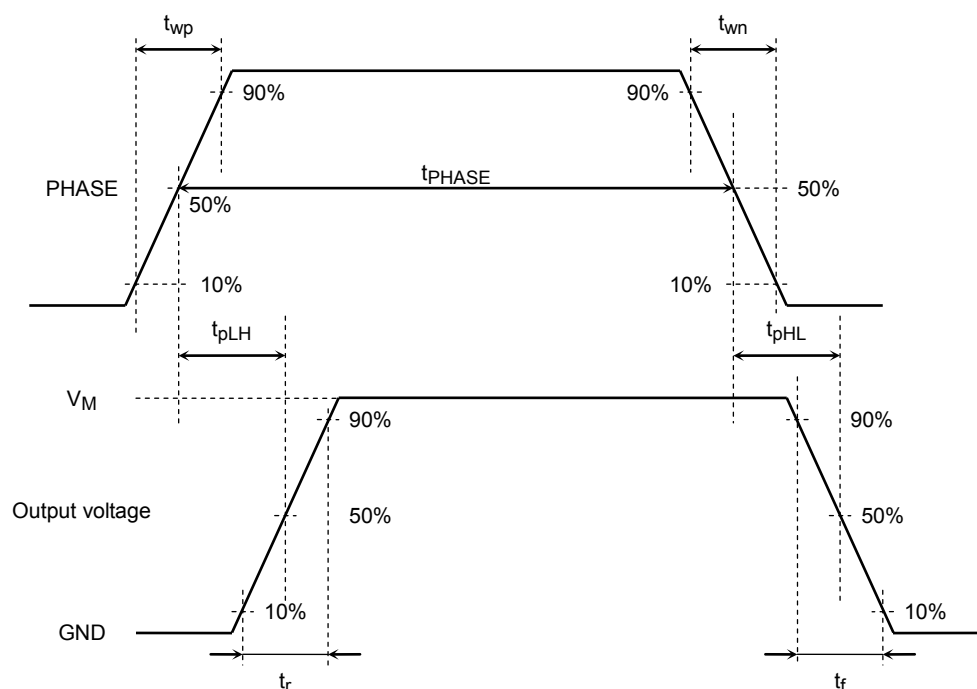
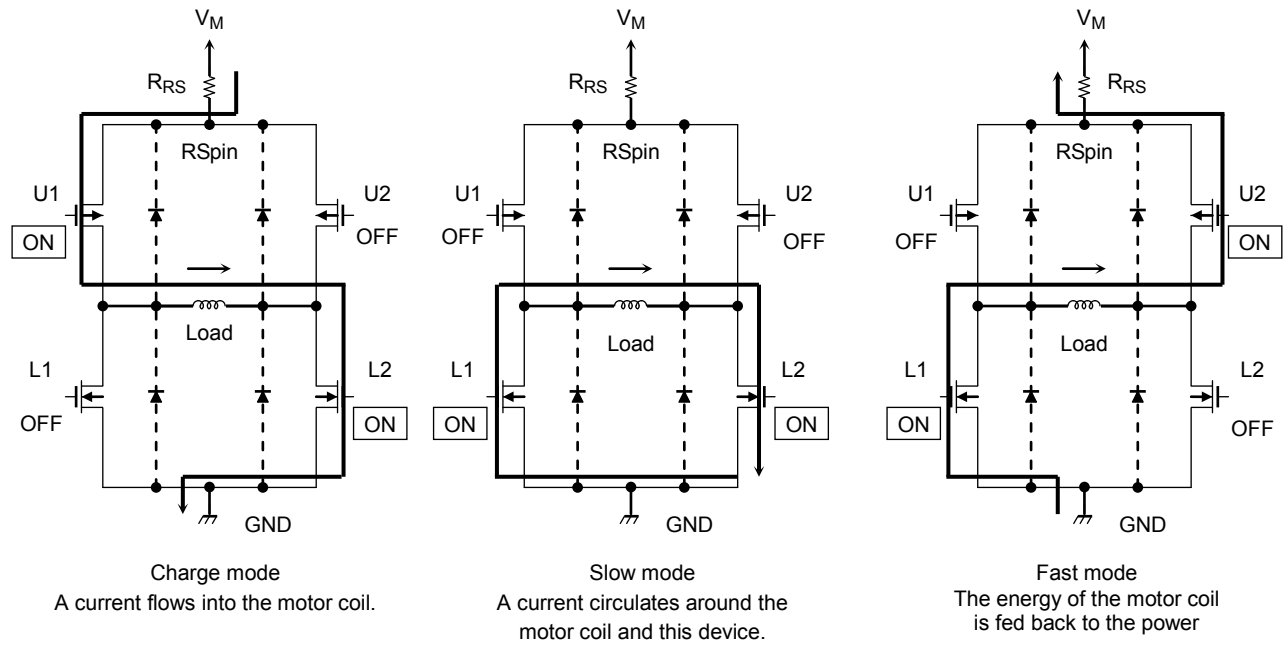


Figure 1: Timing Charts of Output Transistors Switching

Output transistor function mode



Output transistor function

| MODE   | U1  | U2  | L1  | L2  |
|--------|-----|-----|-----|-----|
| CHARGE | ON  | OFF | OFF | ON  |
| SLOW   | OFF | OFF | ON  | ON  |
| FAST   | OFF | ON  | ON  | OFF |

Note: This table shows an example of when the current flows as indicated by the arrows in the figures shown above. If the current flows in the opposite direction, refer to the following table.

| MODE   | U1  | U2  | L1  | L2  |
|--------|-----|-----|-----|-----|
| CHARGE | OFF | ON  | ON  | OFF |
| SLOW   | OFF | OFF | ON  | ON  |
| FAST   | ON  | OFF | OFF | ON  |

This IC controls the motor current to be constant by 3 modes listed above.

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

### Calculation of the Predefined Output Current

For PWM constant-current control, the TB62213AFG uses a clock generated by the OSCM oscillator circuit. The peak output current can be set via the current-sensing resistor ( $R_{RS}$ ) and the reference voltage ( $V_{REF}$ ), as follows:

$$I_{OUT} = V_{REF}/5/R_{RS}(\Omega)$$

where, 1/5 is the  $V_{REF}$  decay rate,  $V_{REF(GAIN)}$ . For the value of  $V_{REF(GAIN)}$ , see the Electrical Characteristics table.

For example, when  $V_{REF} = 3 \text{ V}$  and  $I_{OUT} = 1.8 \text{ A}$ . Necessary  $R_{RS}$  is  $0.33 \Omega (\geq 1.1 \text{ W})$ .

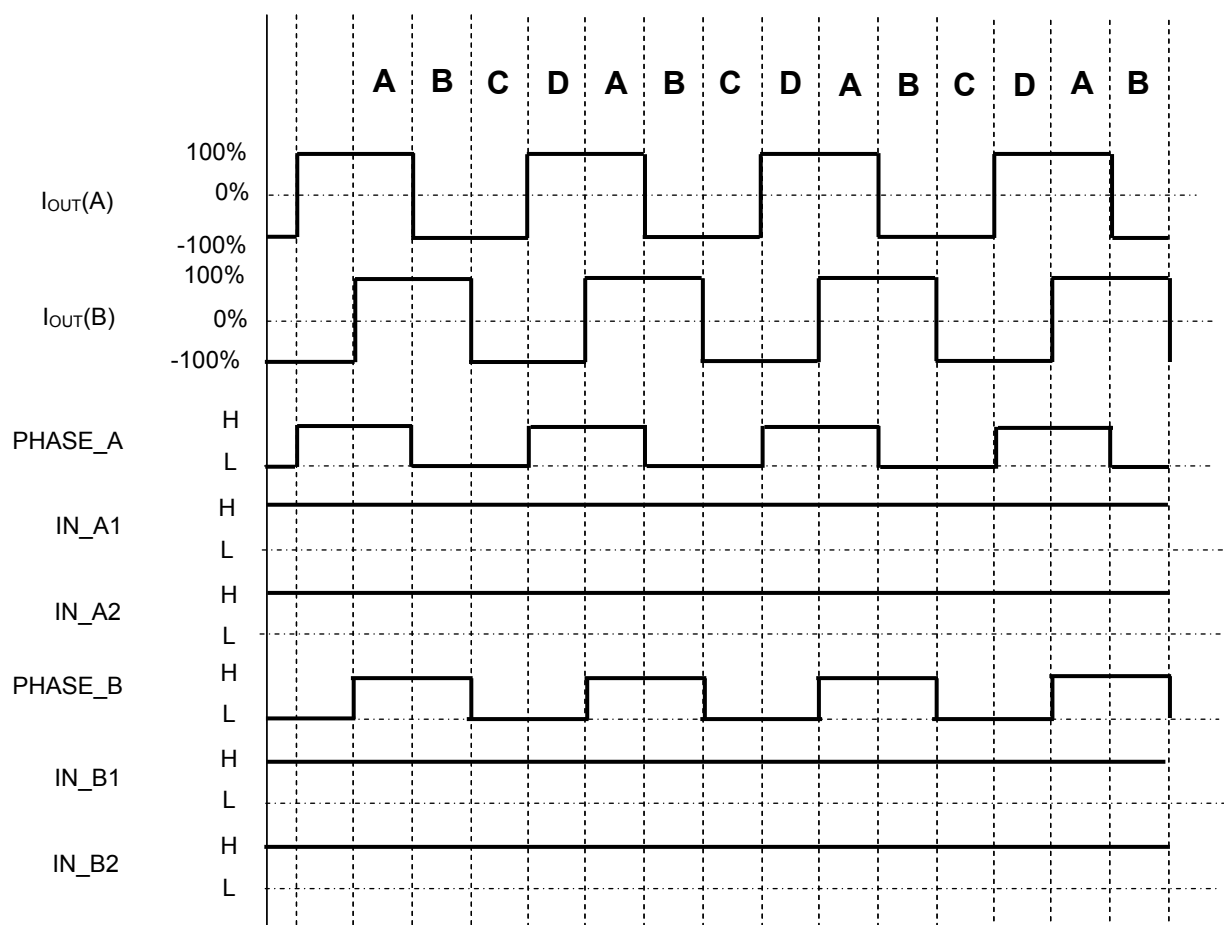
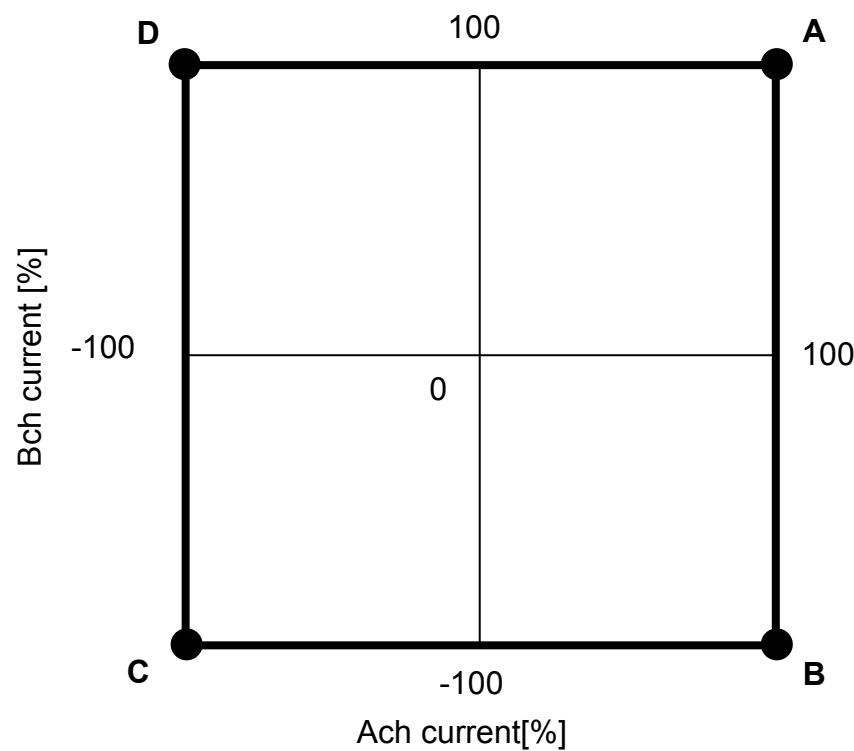
### Calculation of the OSCM oscillation frequency (chopper reference frequency)

OSCM oscillation frequency ( $f_{OSCM}$ ) and chopper frequency ( $f_{chop}$ ) are computable in the following expressions.

$$f_{OSCM} = 1/[0.56 \times \{C \times (R_1 + 500)\}] \quad \dots\dots\dots C, R_1: \text{External constant for OSCM (C=270pF, } R_1=3.6\text{k}\Omega)$$

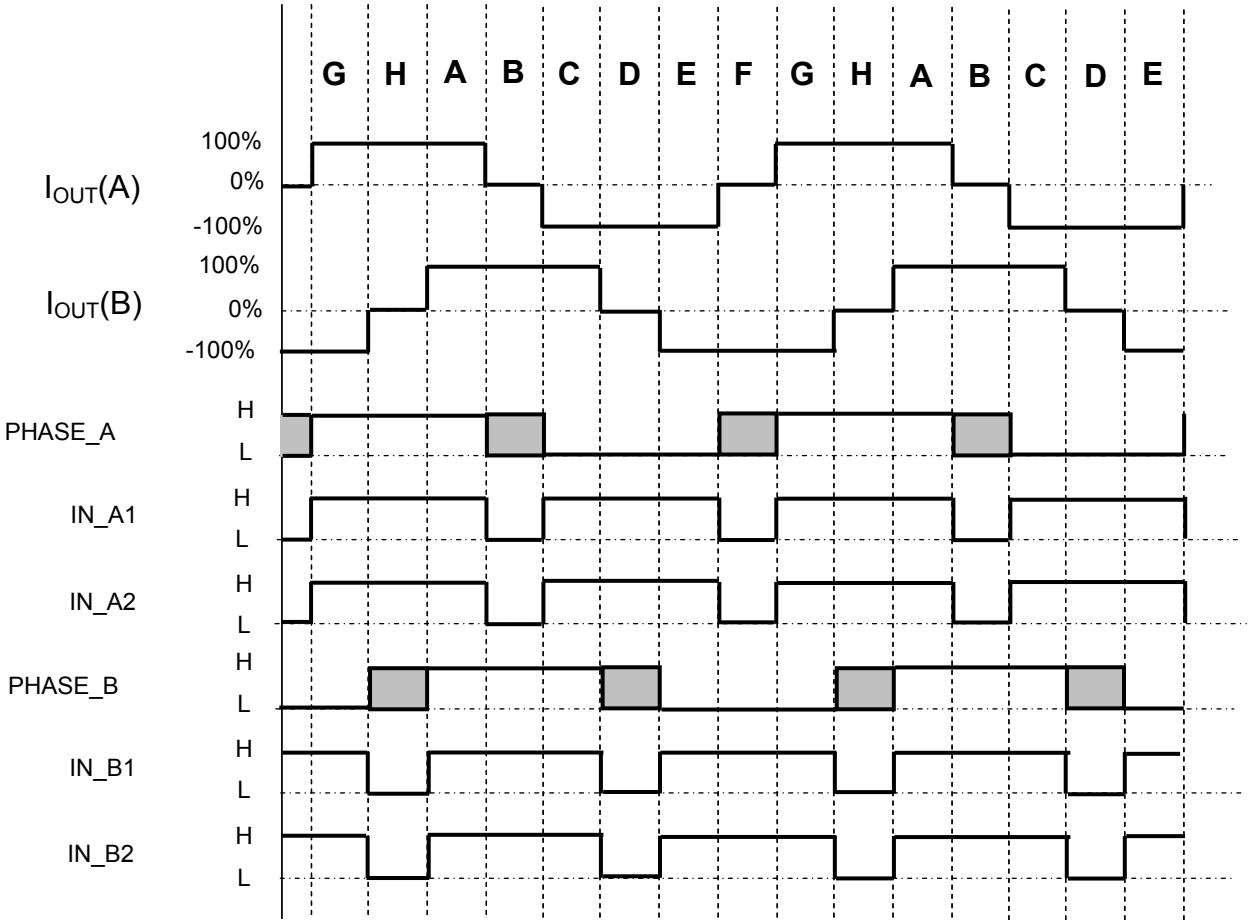
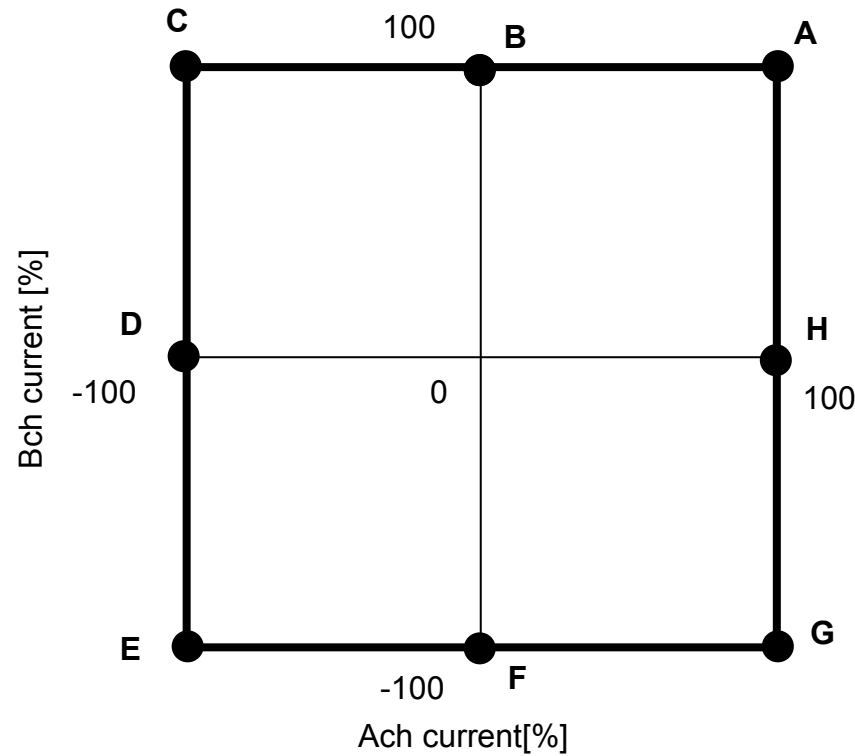
$$f_{chop} = f_{OSCM} / 16$$

Phase Sequences  
Full step resolution



Timing charts may be simplified for explanatory purpose.  
Please set IN\_A1, IN\_A2, IN\_B1, and IN\_B2 to Low until VM power supply reaches the proper operating range.

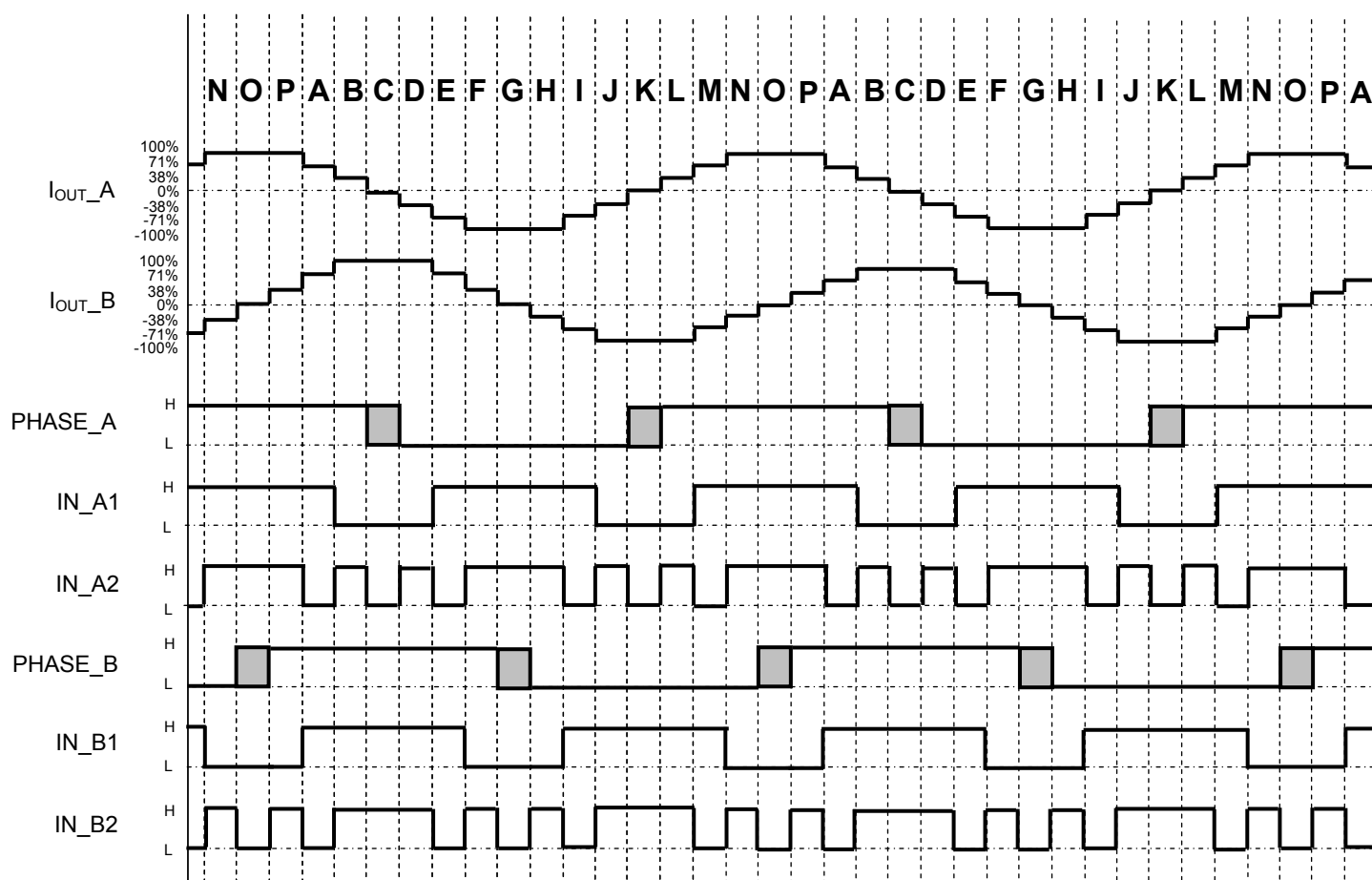
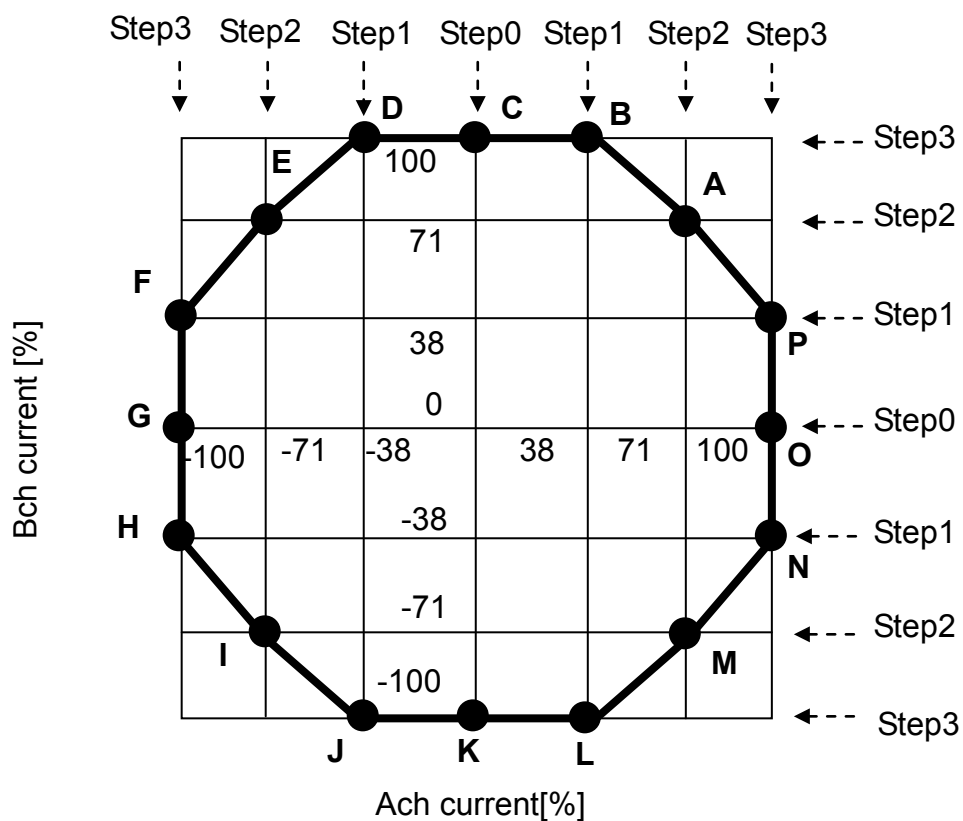
Half Step Excitation



Timing charts may be simplified for explanatory purpose.



### 1/4 Step Excitation

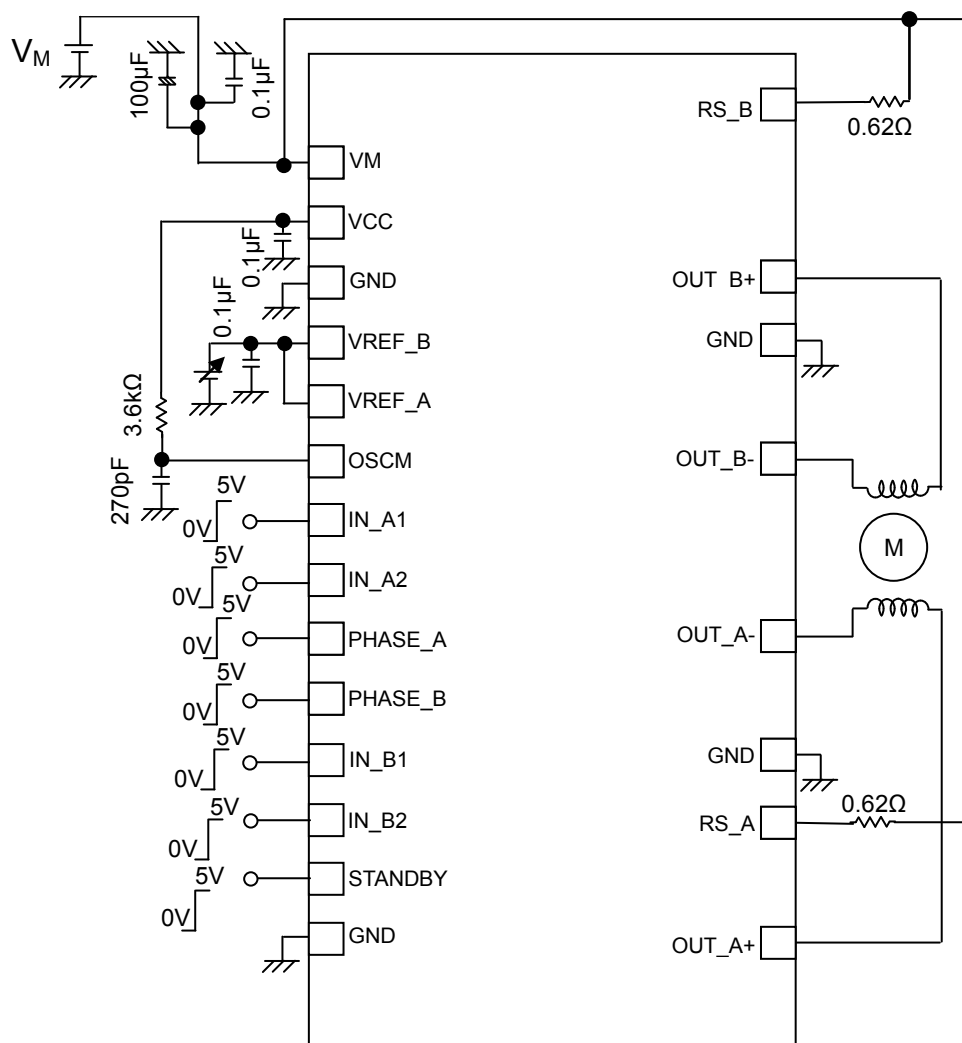


Timing charts may be simplified for explanatory purpose.

## Application Circuit Example

### TB62213AFG

The values shown in the following figure are typical values. For input conditions, see Operating Ranges.



**Note:** Bypass capacitors should be added as necessary.

It is recommended to use a single ground plane for the entire board whenever possible, and a grounding method should be considered for efficient heat dissipation.

In cases where mode setting pins are controlled via switches, either pull-down or pull-up resistors should be added to them to avoid floating states.

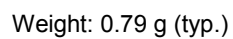
For a description of the input values, see the output function tables.

The above application circuit example is presented only as a guide and should be fully evaluated prior to production. Also, no intellectual property right is ceded in any way whatsoever in regard to its use.

The external components in the above diagram are used to test the electrical characteristics of the device: it is not guaranteed that no system malfunction or failure will occur.

Careful attention should be paid to the layout of the output,  $V_{DD}$  ( $V_M$ ) and GND traces to avoid short-circuits across output pins or to the power supply or ground. If such a short-circuit occurs, the TB62218AFG/AFTG may be permanently damaged. Also, if the device is installed in a wrong orientation, a high voltage might be applied to components with lower voltage ratings, causing them to be damaged. The TB62218AFG/AFTG does not have an overvoltage protection circuit. Thus, if a voltage exceeding the rated maximum voltage is applied, the TB62218AFG/AFTG will be damaged; it should be ensured that it is used within the specified operating conditions.

## Unit: mm



## 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 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

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 device breakdown, damage or deterioration, and may result in injury by explosion or combustion.

Use an appropriate power supply fuse to ensure that a large current does not continuously flow in the 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 to smoke or ignition. To minimize the effects of the flow of a large current in the case of breakdown, appropriate settings, such as fuse capacity, fusing time and insertion circuit location, are required.

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.

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 device breakdown, damage or deterioration, and may result in injury by explosion or combustion. In addition, do not use any device that has been inserted incorrectly.

Please take extra care when selecting external components (such as power amps and regulators) or external devices (for instance, speakers). When large amounts of leak current occurs from capacitors, the DC output level may increase. If the output is connected to devices such as speakers with low resist voltage, overcurrent or IC failure may cause smoke or ignition. (The over-current may cause smoke or ignition from the IC itself.) In particular, please pay attention when using a Bridge Tied Load (BTL) connection-type IC that inputs output DC voltage to a speaker directly.

## Points to remember on handling of ICs

### **Over current detection circuit**

Over current detection circuits (referred to as current limiter circuits) do not necessarily protect ICs under all circumstances. If the Over current detection 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.

### **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.

### **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.

### **Back-EMF**

When a motor rotates in the reverse direction, stops or slows down abruptly, a current flow 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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