# DATA SHEET

| Part No. | AN44066A |
|---|---|
| Package Code No. | SSOP032-P-0300B |

# Contents

# AN44066A

## Driver IC for Stepping Motor

### ■ Overview

AN44066A is a two channels H-bridge driver IC. Bipolar stepping motor can be controlled by this single driver IC.
2-phase, half-step, 1-2 phase, W1-2 phase can be selected.

### ■ Features

- 2-phase input control by rationalization of interface (2-phase excitation, half-step, and 1-2 phase excitation enabled)
- 4-phase input control (W1-2 phase excitation enabled)
- Built-in CR chopping (with frequency selected)
- Built-in standby function
- Built-in thermal protection and low voltage detection circuit
- Built-in 5 V power supply

### ■ Applications

- IC for stepping motor drives

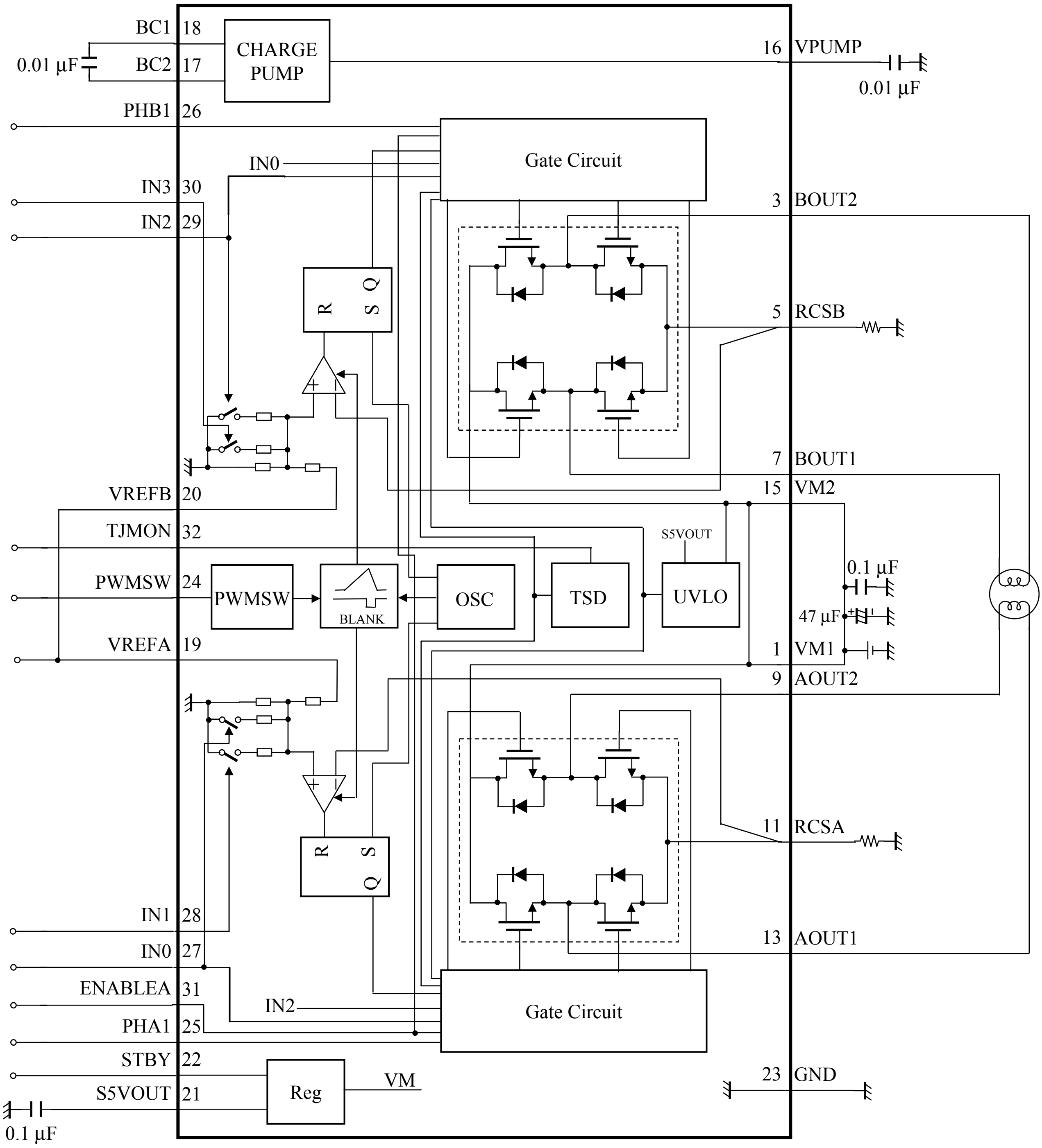
### ■ Package

- 32 pin Plastic Shrink Small Outline Package (SSOP Type)

### ■ Type

- Bi-CDMOS IC

■ Application Circuit Example




Note) • This application circuit is shown as an example but does not guarantee the design for mass production set.

■ Pin Descriptions

| Pin No. | Pin name | Type | Description |
|---|---|---|---|
| 1 | VM1 | Power supply | Motor power supply 1 |
| 2 | N.C. | — | N.C. |
| 3 | BOUT2 | Output | Phase B motor drive output 2 |
| 4 | N.C. | — | N.C. |
| 5 | RCSB | Input / Output | Phase B current detection |
| 6 | N.C. | — | N.C. |
| 7 | BOUT1 | Output | Phase B motor drive output 1 |
| 8 | N.C. | — | N.C. |
| 9 | AOUT2 | Output | Phase A motor drive output 2 |
| 10 | N.C. | — | N.C. |
| 11 | RCSA | Input / Output | Phase A current detection |
| 12 | N.C. | — | N.C. |
| 13 | AOUT1 | Output | Phase A motor drive output 1 |
| 14 | N.C. | — | N.C. |
| 15 | VM2 | Power supply | Motor power supply 2 |
| 16 | VPUMP | Output | Charge Pump circuit output |
| 17 | BC2 | Output | Charge Pump capacitor connection 2 |
| 18 | BC1 | Output | Charge Pump capacitor connection 1 |
| 19 | VREFA | Input | Phase A torque reference voltage input |
| 20 | VREFB | Input | Phase B torque reference voltage input |
| 21 | S5VOUT | Output | Internal reference voltage (5 V output) |
| 22 | STBY | Input | Standby setting |
| 23 | GND | Ground | Signal ground |
| 24 | PWMSW | Input | PWM frequency selection input |
| 25 | PHA1 | Input | Phase A phase selection input |
| 26 | PHB1 | Input | Phase B phase selection input |
| 27 | IN0 | Input | Phase A output torque control 1 |
| 28 | IN1 | Input | Phase A output torque control 2 |
| 29 | IN2 | Input | Phase B output torque control 1 |
| 30 | IN3 | Input | Phase B output torque control 2 |
| 31 | ENABLEA | Input | Phase A/B start/stop signal input |
| 32 | TJMON | Output | VBE monitor |

## ■ Absolute Maximum Ratings

Note) Absolute maximum ratings are limit values which are not destructed, and are not the values to which operation is guaranteed.

| A No. | Parameter | Symbol | Rating | Unit | Note |
|---|---|---|---|---|---|
| 1 | Supply voltage (Pin 1, 15) | $V_M$ | 37 | V | *1 |
| 2 | Power dissipation | $P_D$ | 0.427 | W | *2 |
| 3 | Operating ambient temperature | $T_{opr}$ | –20 to +70 | °C | *3 |
| 4 | Storage temperature | $T_{stg}$ | –55 to +150 | °C | *3 |
| 5 | Output pin voltage (Pin 3, 7, 9, 13) | $V_{OUT}$ | 37 | V | *4 |
| 6 | Motor drive current (Pin 3, 7, 9, 13) | $I_{OUT}$ | ±0.8 | A | *4 |
| 7 | Flywheel diode current (Pin 3, 7, 9, 13) | $I_f$ | 0.8 | A | *4 |

Notes) *1 : The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.

*2 : The power dissipation shown is the value at $T_a$ = 70°C for the independent (unmounted) IC package without a heat sink. When using this IC, refer to the $P_D$-$T_a$ diagram of the package standard and design the heat radiation with sufficient margin so that the allowable value might not be exceeded based on the conditions of power supply voltage, load, and ambient temperature.

*3 : Except for the power dissipation, operating ambient temperature, and storage temperature, all ratings are for $T_a$ = 25°C.

*4 : Do not apply external currents or voltages to any pin not specifically mentioned. For the circuit currents, "+" denotes current flowing into the IC, and "−" denotes current flowing out of the IC.

## ■ Operating Supply Voltage Range

| Parameter | Symbol | Range | Unit | Note |
|---|---|---|---|---|
| Operating supply voltage range | $V_M$ | 10.0 to 34.0 | V | * |

Note) *: The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.

## ■ Allowed Voltage and Current Ranges

Notes)
- Rating Voltage is voltage of pin on GND
- Do not apply current or voltage from outside to any pin not listed above.
- For the circuit currents, "+" denotes current flowing into the IC, and "−" denotes current flowing out of the IC.

| Pin No. | Pin name | Rating | Unit | Note |
|---|---|---|---|---|
| 5 | RCSB | 2.5 | V | — |
| 11 | RCSA | 2.5 | V | — |
| 16 | VPUMP | $(V_M - 1)$ to 43 | V | *1 |
| 17 | BC2 | $(V_M - 1)$ to 43 | V | *1 |
| 18 | BC1 | $V_M + 0.3$ | V | *1 |
| 19 | VREFA | –0.3 to 6 | V | — |
| 20 | VREFB | –0.3 to 6 | V | — |
| 22 | STBY | –0.3 to 6 | V | — |
| 24 | PWMSW | –0.3 to 6 | V | — |
| 25 | PHA1 | –0.3 to 6 | V | — |
| 26 | PHB1 | –0.3 to 6 | V | — |
| 27 | IN0 | –0.3 to 6 | V | — |
| 28 | IN1 | –0.3 to 6 | V | — |
| 29 | IN2 | –0.3 to 6 | V | — |
| 30 | IN3 | –0.3 to 6 | V | — |
| 31 | ENABLEA | –0.3 to 6 | V | — |

| Pin No. | Pin name | Rating | Unit | Note |
|---|---|---|---|---|
| 21 | S5VOUT | –5 to 0 | mA | *1<br>*2 |

Notes) *1 : Do not apply external voltages to this pin. Set not to exceed allowable range at any time.

*2 : This is the rating under the condition that $V_M$ is used in the range between 16 V and 34 V. When $V_M$ is used in the range between 10 V and 16 V, the rating is –1.4 mA to 0.

## ■ Electrical Characteristics at $V_M$ = 24 V

Note) $T_a$ = 25°C±2°C unless otherwise specified.

| B No. | Parameter | Symbol | Conditions | Limits Min | Typ | Max | Unit | Note |
|---|---|---|---|---|---|---|---|---|
| Power Block | | | | | | | | |
| 1 | High-level output saturation voltage | $V_{OH}$ | $I_{IN}$ = –0.5 A | $V_M$ – 0.47 | $V_M$ – 0.31 | — | V | — |
| 2 | Low-level output saturation voltage | $V_{OL}$ | $I_{IN}$ = 0.5 A | — | 0.47 | 0.71 | V | — |
| 3 | Flywheel diode forward voltage | $V_{DI}$ | $I_{IN}$ = ±0.5 A | 0.5 | 1.0 | 1.5 | V | — |
| 4 | Output leakage current | $I_{LEAK}$ | $V_M$ = 37 V, $V_{RCS}$ = 0 V | — | 10 | 20 | μA | — |
| 5 | Supply current (at when only control system and charge Pump circuit are ON) | $I_M$ | ENABLEA = 3.3 V<br>STBY = 0 V | — | 5.4 | 8.2 | mA | — |
| 6 | Supply current (at standby mode) | $I_{STBY}$ | STBY = 2.1 V | — | 120 | 190 | μA | — |
| I/O Block | | | | | | | | |
| 7 | High-level IN input voltage | $V_{INH}$ | | 2.2 | — | 5.5 | V | — |
| 8 | Low-level IN input voltage | $V_{INL}$ | | 0 | — | 0.6 | V | — |
| 9 | High-level IN input current | $I_{INH}$ | IN0 = IN1 = IN2 = IN3 = 5 V | –10 | — | 10 | μA | — |
| 10 | Low-level IN input current | $I_{INL}$ | IN0 = IN1 = IN2 = IN3 = 0 V | –15 | — | 15 | μA | — |
| 11 | High-level PHA1/PHB1 input voltage | $V_{PHAH}$<br>$V_{PHBH}$ | | 2.2 | — | 5.5 | V | — |
| 12 | Low-level PHA1/PHB1 input voltage | $V_{PHAL}$<br>$V_{PHBL}$ | | 0 | — | 0.6 | V | — |
| 13 | High-level PHA1/PHB1 input current | $I_{PHAH}$<br>$I_{PHBH}$ | PHA1 = PHB1 = 3.3 V | 16.5 | 33 | 66 | μA | — |
| 14 | Low-level PHA1/PHB1 input current | $I_{PHAL}$<br>$I_{PHBL}$ | PHA1 = PHB1 = 0 V | –15 | — | 15 | μA | — |
| 15 | High-level ENABLEA input voltage | $V_{ENABLEAH}$ | | 2.2 | — | 5.5 | V | — |
| 16 | Low-level ENABLEA input voltage | $V_{ENABLEAL}$ | | 0 | — | 0.6 | V | — |
| 17 | High-level ENABLEA input current | $I_{ENABLEAH}$ | ENABLEA = 5 V | –10 | — | 10 | μA | — |
| 18 | Low-level ENABLEA input current | $I_{ENABLEAL}$ | ENABLEA = 0 V | –15 | — | 15 | μA | — |
| 19 | High-level PWMSW input voltage | $V_{PWMSWH}$ | | 2.2 | — | 5.5 | V | — |
| 20 | Low-level PWMSW input voltage | $V_{PWMSWL}$ | | 0 | — | 0.6 | V | — |
| 21 | High-level PWMSW input current | $I_{PWMSWH}$ | PWMSW = 3.3 V | 8 | 16.5 | 33 | μA | — |
| 22 | Low-level PWMSW input current | $I_{PWMSWL}$ | PWMSW = 0 V | –15 | — | 15 | μA | — |
| 23 | High-level STBY input voltage | $V_{STBYH}$ | | 2.1 | — | 5.5 | V | — |
| 24 | Low-level STBY input voltage | $V_{STBYL}$ | | 0 | — | 0.6 | V | — |
| 25 | High-level STBY input current | $I_{STBYH}$ | STBY = 5 V | — | 30 | 45 | μA | — |
| 26 | Low-level STBY input current | $I_{STBYL}$ | STBY = 0 V | –2 | — | 2 | μA | — |

■ Electrical Characteristics (continued) at $V_M$ = 24 V

Note) $T_a$ = 25°C±2°C unless otherwise specified.

| B No. | Parameter | Symbol | Conditions | Limits | | | Unit | Note |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | | |
| Torque Control Block | | | | | | | | |
| 27 | Input bias current | $I_{REFA}$<br>$I_{REFB}$ | $V_{REFA}$ = 5 V<br>$V_{REFB}$ = 5 V | 83.3 | 100 | 125 | µA | — |
| 28 | PWM frequency1 | $f_{PWM1}$ | PWMSW = 0.6 V | 34 | 52 | 70 | kHz | — |
| 29 | PWM frequency2 | $f_{PWM2}$ | PWMSW = 2.2 V | 17 | 26 | 35 | kHz | — |
| 30 | Pulse blanking time | $T_B$ | $V_{REFA}$ = $V_{REFB}$ = 0 V | 0.38 | 0.75 | 1.12 | µs | — |
| 31 | Comp threshold H (100%) | $VT_H$ | $V_{REFA}$ = $V_{REFB}$ = 3.3 V<br>IN0 = IN1 = 0.6 V<br>IN2 = IN3 = 0.6 V | 627 | 660 | 693 | mV | — |
| 32 | Comp threshold C (67%) | $VT_C$ | $V_{REFA}$ = $V_{REFB}$ = 3.3 V<br>IN0 = 2.2 V, IN1 = 0.6 V<br>IN2 = 2.2 V, IN3 = 0.6 V | 410 | 440 | 470 | mV | — |
| 33 | Comp threshold L (33%) | $VT_L$ | $V_{REFA}$ = $V_{REFB}$ = 3.3 V<br>IN0 = 0.6 V, IN1 = 2.2 V<br>IN2 = 0.6 V, IN3 = 2.2 V | 200 | 220 | 240 | mV | — |
| Reference Voltage Block | | | | | | | | |
| 34 | Reference voltage | $V_{S5VOUT}$ | $I_{S5VOUT}$ = 0 mA | 4.5 | 5.0 | 5.5 | V | — |
| 35 | Output impedance | $Z_{S5VOUT}$ | $I_{S5VOUT}$ = –1.5 mA, –3.5 mA | — | 18 | 27 | Ω | — |

## ■ Electrical Characteristics (Reference values for design) at $V_M$ = 24 V

Notes) $T_a$ = 25°C±2°C unless otherwise specified.
The characteristics listed below are reference values derived from the design of the IC and are not guaranteed by inspection.
If a problem does occur related to these characteristics, we will respond in good faith to user concerns.

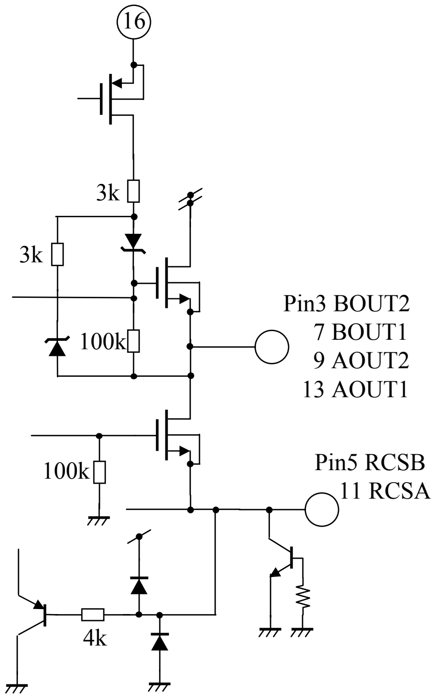
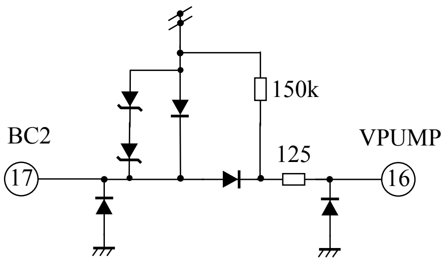
| B No. | Parameter | Symbol | Conditions | Reference values | | | Unit | Note |
|---|---|---|---|---|---|---|---|---|
| | | | | Min | Typ | Max | | |
| Output Drivers | | | | | | | | |
| 36 | Output slew rate 1 | $VT_r$ | Output voltage rising edge | — | 270 | — | V/µs | — |
| 37 | Output slew rate 2 | $VT_f$ | Output voltage falling edge | — | 330 | — | V/µs | — |
| 38 | Dead time | $T_D$ | | — | 2.8 | — | µs | — |
| Thermal Protection | | | | | | | | |
| 39 | Thermal protection operating temperature | $TSD_{on}$ | | — | 150 | — | ºC | — |
| 40 | Thermal protection hysteresis width | ΔTSD | | — | 40 | — | ºC | — |
| VREF Block | | | | | | | | |
| 41 | Input impedance | $Z_{VREFA}$<br>$Z_{VREFB}$ | $V_{REFA}$ = 5 V<br>$V_{REFB}$ = 5 V | 40 | 50 | 60 | kΩ | — |
| 42 | Input impedance precision | — | | –20 | — | 20 | % | — |
| I/O Block | | | | | | | | |
| 43 | High-level PHA1/PHB1 input current 2 | $I_{PHAH2}$<br>$I_{PHBH2}$ | PHA1 = PHB1 = 5 V | — | 68 | — | µA | *1 |
| 44 | High-level PWMSW input current 2 | $I_{PWMSWH2}$ | PWMSW = 5 V | — | 42 | — | µA | *1 |

Note) *1 : Refer to the "Usage Notes" (P.35) for the input current characteristics about PHA1, PHB1, PWMSW.

■ Technical Data

- Circuit diagrams of the input/output part and pin function descriptions

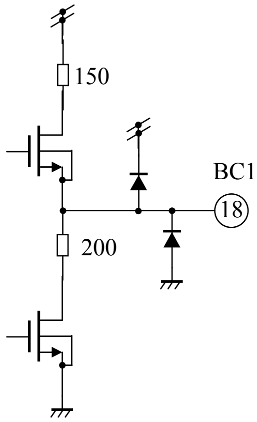
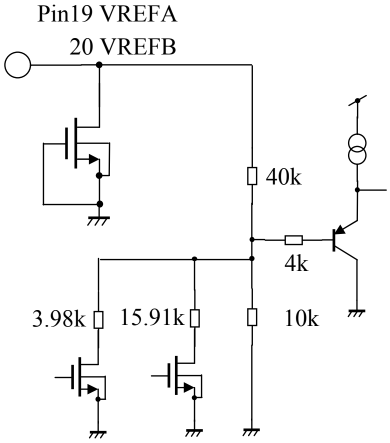
Note) The characteristics listed below are reference values based on the IC design and are not guaranteed.

| Pin No. | Waveform and voltage | Internal circuit | Impedance | Description |
|---|---|---|---|---|
| 3<br>5<br>7<br>9<br>11<br>13 | — |  | — | Pin3 : Phase B motor drive output 2<br>5 : Phase B current detection<br>7 : Phase B motor drive output 1<br>9 : Phase A motor drive output 2<br>11 : Phase A current detection<br>13 : Phase A motor drive output 1 |
| 16<br>17 | — |  | — | Pin16 : Charge Pump circuit output<br>17 : Charge Pump capacitor connection 2 |

## ■ Technical Data (continued)

- Circuit diagrams of the input/output part and pin function descriptions (continued)

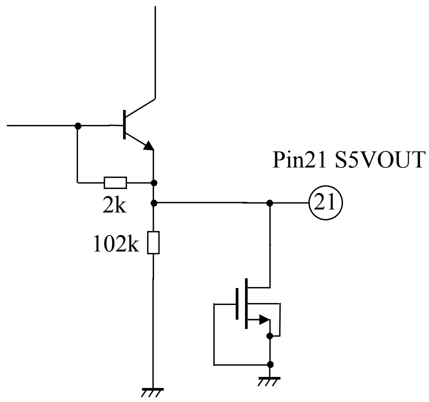
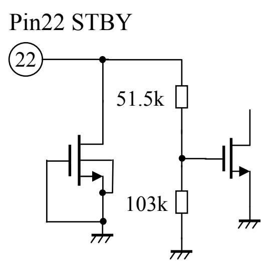
Note) The characteristics listed below are reference values based on the IC design and are not guaranteed.

| Pin No. | Waveform and voltage | Internal circuit | Impedance | Description |
|---|---|---|---|---|
| 18 | — |  | — | Pin18 : Charge Pump capacitor connection 1 |
| 19<br>20 | — |  | 50 kΩ | Pin19 : Phase A torque reference voltage input<br>20 : Phase B torque reference voltage input |

■ Technical Data (continued)

• Circuit diagrams of the input/output part and pin function descriptions (continued)

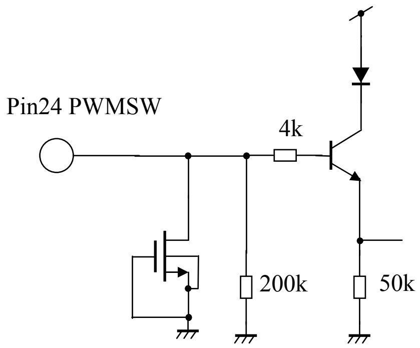
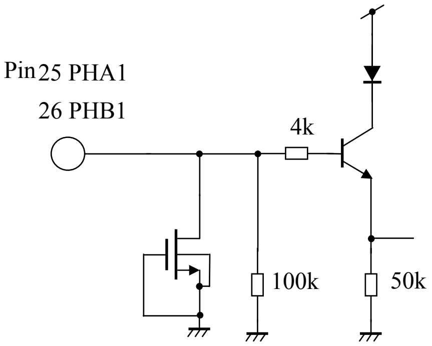
Note) The characteristics listed below are reference values based on the IC design and are not guaranteed.

| Pin No. | Waveform and voltage | Internal circuit | Impedance | Description |
|---|---|---|---|---|
| 21 | — |   | — | Pin21 : Internal reference voltage (5 V output) |
| 22 | — |   | 154.5 kΩ | Pin22 : Standby setting |

■ Technical Data (continued)

• Circuit diagrams of the input/output part and pin function descriptions (continued)

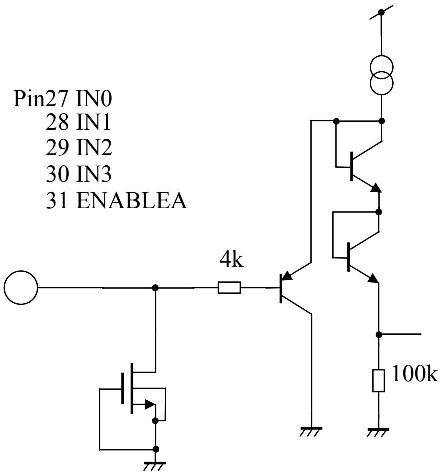
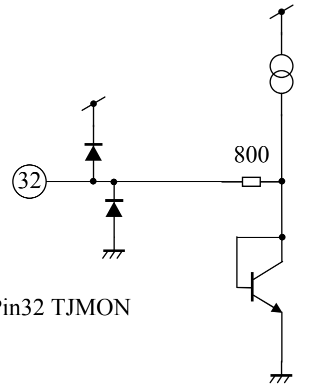
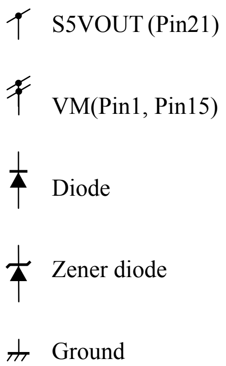
Note) The characteristics listed below are reference values based on the IC design and are not guaranteed.

| Pin No. | Waveform and voltage | Internal circuit | Impedance | Description |
|---|---|---|---|---|
| 24 | — |  | 200 kΩ | Pin24 : PWM frequency selection input |
| 25<br>26 | — |  | 100 kΩ | Pin25 : Phase A phase selection input<br>26 : Phase B phase selection input |

## ■ Technical Data (continued)

• Circuit diagrams of the input/output part and pin function descriptions (continued)

Note) The characteristics listed below are reference values based on the IC design and are not guaranteed.

| Pin No. | Waveform and voltage | Internal circuit | Impedance | Description |
|---|---|---|---|---|
| 27<br>28<br>29<br>30<br>31 | — |  | — | Pin27 : Phase A output torque control 1<br>28 : Phase A output torque control 2<br>29 : Phase B output torque control 1<br>30 : Phase B output torque control 2<br>31 : Phase A/B start/stop signal input |
| 32 | — |  | — | Pin32 : VBE monitor |
| Sym bols | — |  | — | — |

## ■ Technical Data

• Control mode

1. Truth table

1) Control/Charge pump circuit

| STBY | ENABLE | Control/Charge pump circuit | Output transistor |
|---|---|---|---|
| High | — | OFF | OFF |
| Low | High | ON | OFF |
| Low | Low | ON | ON |

2) Output polarity

| ENABLEA | PHA1/PHB1 | AOUT1/BOUT1 | AOUT2/BOUT2 |
|---|---|---|---|
| Low | High | High | Low |
| Low | Low | Low | High |
| High | — | OFF | OFF |

3) Output current of 2-phase excitation / half step / 1-2 phase excitation

| IN0 | IN2 | A-ch. Output Current | B-ch. Output Current |
|---|---|---|---|
| Low | Low | (VREF / 5) × (1 / Rs) | (VREF / 5) × (1 / Rs) |
| High | Low | 0 | (VREF / 5) × (1 / Rs) |
| Low | High | (VREF / 5) × (1 / Rs) | 0 |
| High | High | (VREF / 5) × (1 / Rs) × (2 / 3) | (VREF / 5) × (1 / Rs) × (2 / 3) |

Notes) Rs : current detection region
IN1 = IN3 = Low level

4) Output current of W1-2 phase excitation

A-ch. output

| IN0 | IN2 | IN1 | A-ch. Output Current |
|---|---|---|---|
| Low | Low | Low | (VREF / 5) × (1 / Rs) |
| Low | Low | High | (VREF / 5) × (1 / Rs) × (1 / 3) |
| High | Low | Don't care | 0 |
| Low | High | Low | (VREF / 5) × (1 / Rs) |
| High | High | Low | (VREF / 5) × (1 / Rs) × (2 / 3) |

Note) Rs : current detection region

B-ch. output

| IN0 | IN2 | IN3 | B-ch. Output Current |
|---|---|---|---|
| Low | Low | Low | (VREF / 5) × (1 / Rs) |
| Low | Low | High | (VREF / 5) × (1 / Rs) × (1 / 3) |
| High | Low | Low | (VREF / 5) × (1 / Rs) |
| Low | High | Don't care | 0 |
| High | High | Low | (VREF / 5) × (1 / Rs) × (2 / 3) |

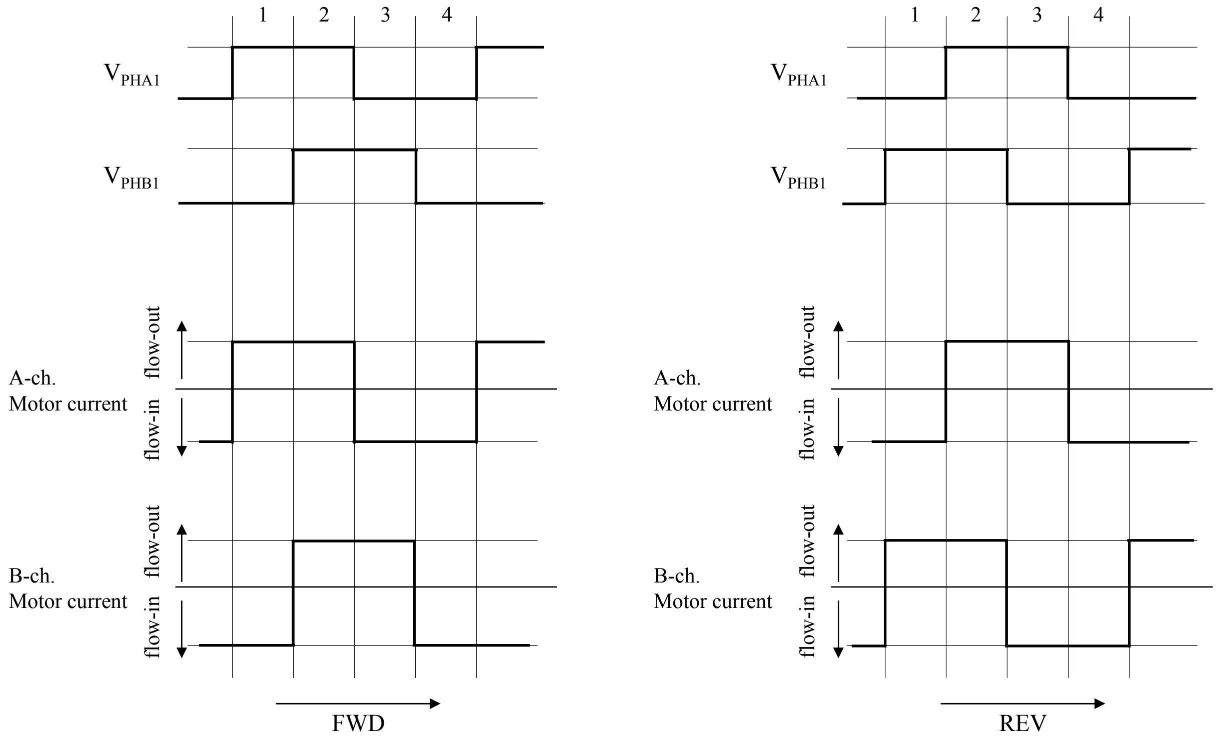
Note) Rs : current detection region

■ Technical Data (continued)

• Control mode (continued)

2. Output wave

1) Drive of 2-phase excitation (4steps sequence)
(IN0 to IN3 = Low)

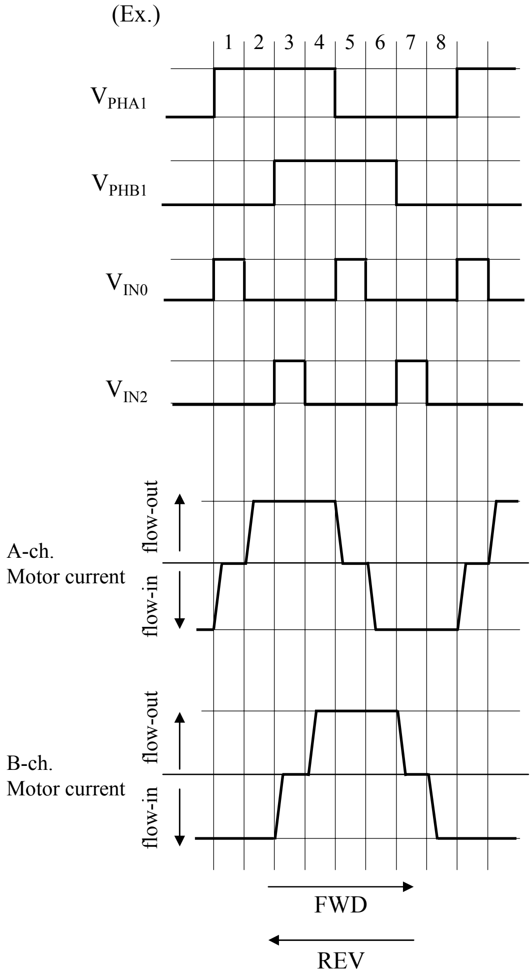


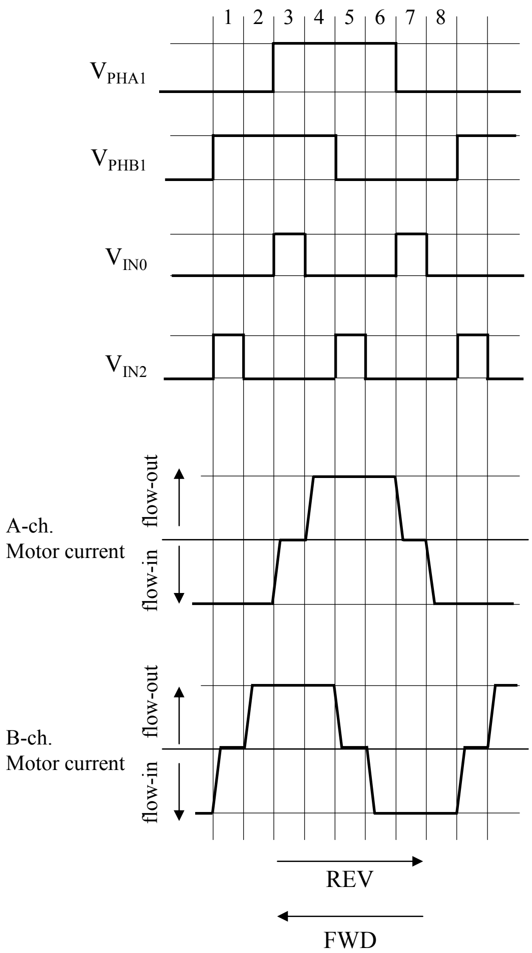
## ■ Technical Data (continued)

• Control mode (continued)

2. Output wave (continued)

2) Drive of half step (8-steps sequence)
(IN1 = IN3 = Low)



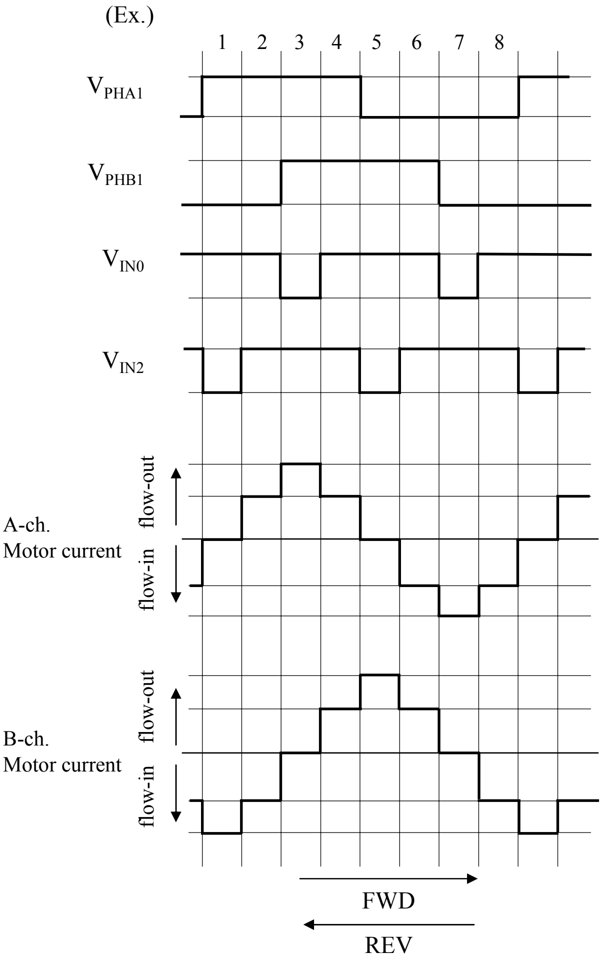



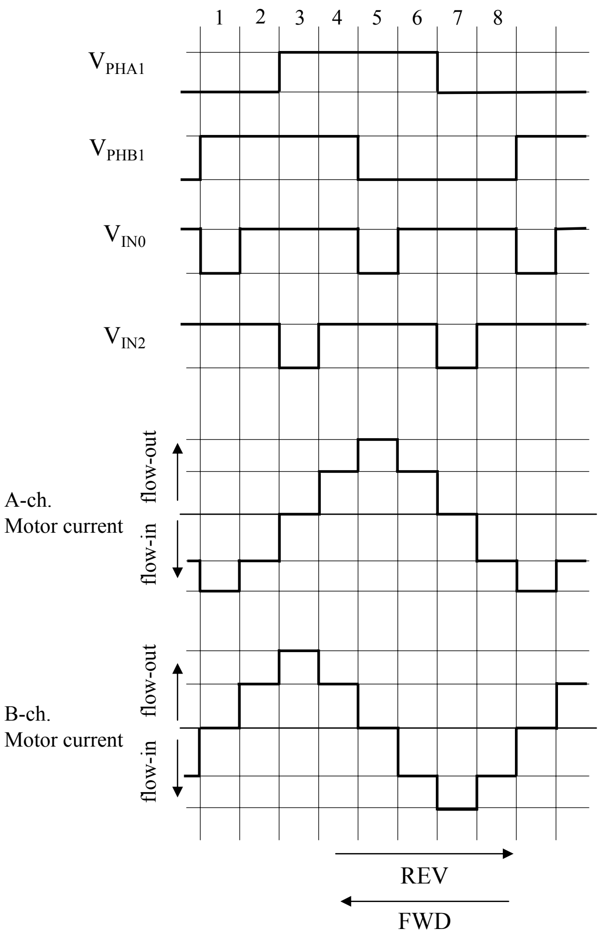
■ Technical Data (continued)

- Control mode (continued)

2. Output wave (continued)

3) Drive of 1-2 phase excitation (8-steps sequence)
(IN1 = IN3 = Low)



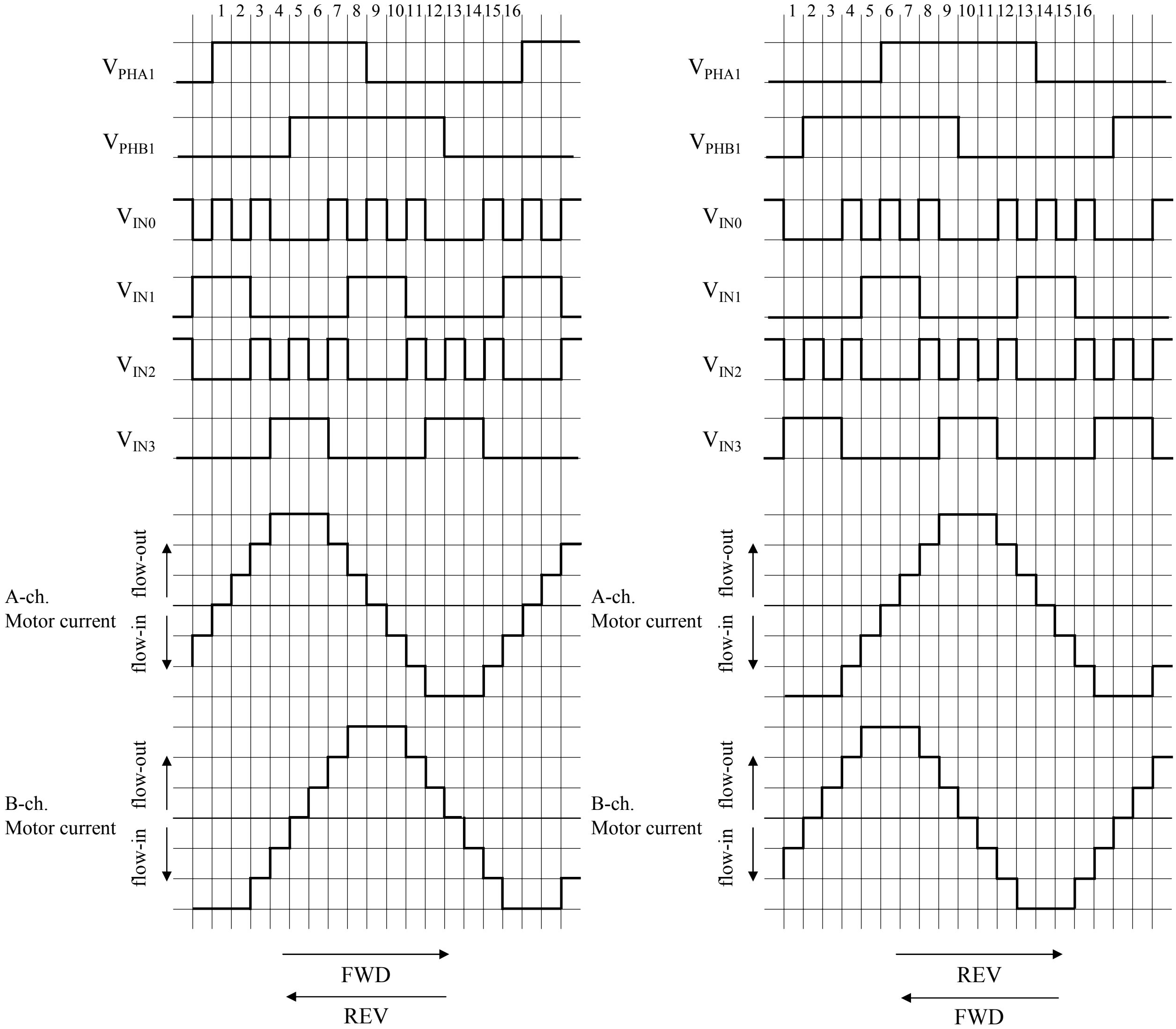



## ■ Technical Data (continued)

- Control mode (continued)

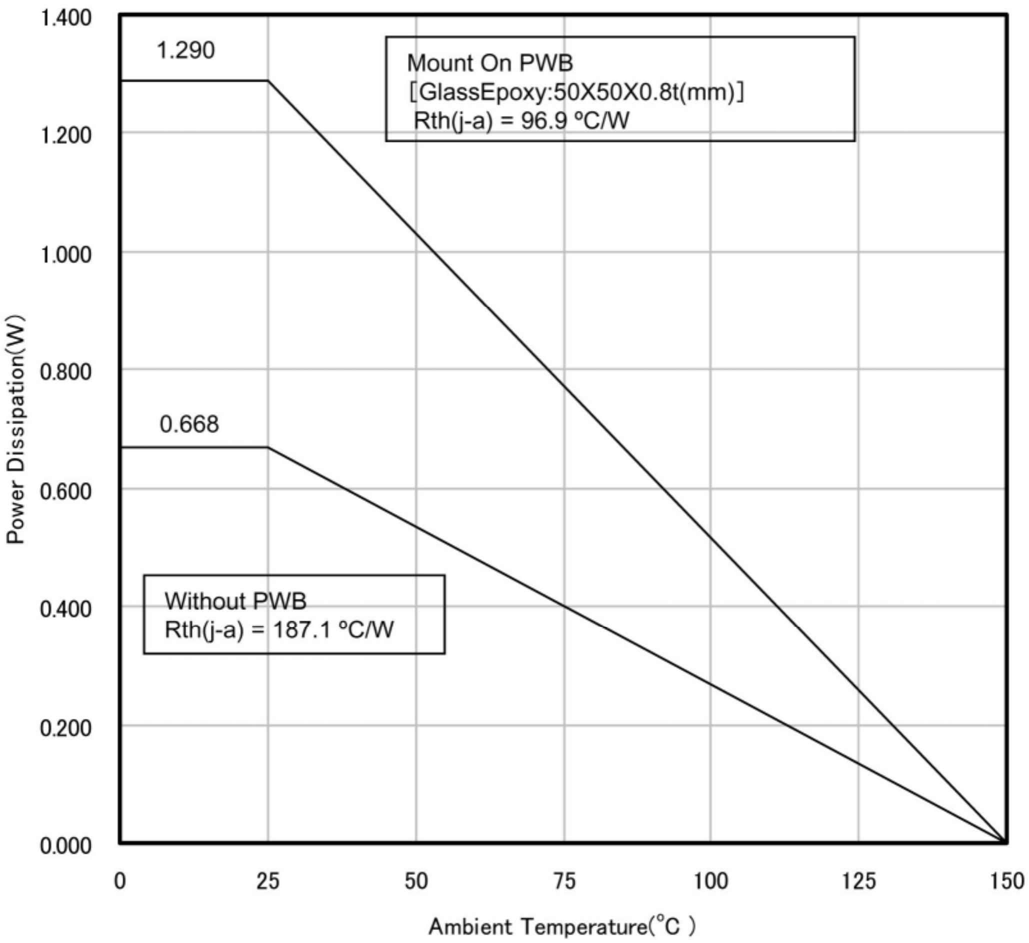
2. Output wave (continued)

   4) Drive of W1-2 phase excitation (16-steps sequence)



■ Technical Data (continued)

- $P_D$ — $T_a$ diagram



## ■ Usage Notes

• Special attention and precaution in using

1. This IC is intended to be used for general electronic equipment and driving stepping motor.
   Consult our sales staff in advance for information on the following applications:
   - Special applications in which exceptional quality and reliability are required, or if the failure or malfunction of this IC may directly jeopardize life or harm the human body.
   - Any applications other than the standard applications intended.
     (1) Space appliance (such as artificial satellite, and rocket)
     (2) Traffic control equipment (such as for automobile, airplane, train, and ship)
     (3) Medical equipment for life support
     (4) Submarine transponder
     (5) Control equipment for power plant
     (6) Disaster prevention and security device
     (7) Weapon
     (8) Others : Applications of which reliability equivalent to (1) to (7) is required
2. Pay attention to the direction of LSI. When mounting it in the wrong direction onto the PCB (printed-circuit-board), it might smoke or ignite.
3. Pay attention in the PCB (printed-circuit-board) pattern layout in order to prevent damage due to short circuit between pins. In addition, refer to the Pin Description for the pin configuration.
4. Perform a visual inspection on the PCB before applying power, otherwise damage might happen due to problems such as a solder-bridge between the pins of the semiconductor device. Also, perform a full technical verification on the assembly quality, because the same damage possibly can happen due to conductive substances, such as solder ball, that adhere to the LSI during transportation.
5. Take notice in the use of this product that it might break or occasionally smoke when an abnormal state occurs such as output pin-$V_M$ short (Power supply fault), output pin-GND short (Ground fault), or output-to-output-pin short (load short) .
   And, safety measures such as an installation of fuses are recommended because the extent of the above-mentioned damage and smoke emission will depend on the current capability of the power supply.
   Pay special attention to the following pins so that they are not short-circuited with the VM pin, ground pin, other output pin, or current detection pin.
     (1) AOUT1 (Pin 13), AOUT2 (Pin 9), BOUT1 (Pin 7), BOUT2 (Pin 3)
     (2) BC2 (Pin 17), VPUMP (Pin 16)
     (3) VM1 (Pin 1), VM2 (Pin 15), S5VOUT(Pin 21)
     (4) RCSA (Pin 11), RCSB (Pin 5)
   The higher the current capacity of power supply is, the higher the possibility of the above destruction or smoke generation. Therefore, it is recommended to take safety countermeasures, such as the use of a fuse.
6. When using the LSI for new models, verify the safety including the long-term reliability for each product.
7. When the application system is designed by using this LSI, be sure to confirm notes in this book.
   Be sure to read the notes to descriptions and the usage notes in the book.

## ■ Usage Notes (continued)

• Notes of Power LSI

1. Perform thermal design work with consideration of a sufficient margin to keep the power dissipation based on supply voltage, load, and ambient temperature conditions.
   (The IC is recommended that junctions are designed below 70% to 80% of Absolute Maximum Rating.)
2. The protection circuit is incorporated for the purpose of securing safety if the IC malfunctions.
   Therefore, design the protection circuit so that the protection circuit will not operate under normal operating conditions. The temperature protection circuit, in particular, may be destructed before the temperature protection circuit operates if the area of safety operation of the device or the maximum rating is exceeded instantaneously due to the short-circuiting between the output pin and VM pin or a ground fault caused by the output pin and ground pin.
3. Unless specified in the product specifications, make sure that negative voltage or excessive voltage are not applied to the pins because the device might be damaged, which could happen due to negative voltage or excessive voltage generated during the ON and OFF timing when the inductive load of a motor coil or actuator coils of optical pick-up is being driven.
4. The product which has specified ASO (Area of Safe Operation) should be operated in ASO.
5. Verify the risks which might be caused by the malfunctions of external components.
6. Set the value of the capacitor between the VPUMP and GND pins so that the voltage on the VPUMP (Pin 16) will not exceed 43 V in any case regardless of whether it is a transient phenomenon or not while the motor standing by is started.
7. This IC employs a PWM drive method that switches the high-current output of the output transistor. Therefore, the IC is apt to generate noise that may cause the IC to malfunction or have fatal damage. To prevent these problems, the power supply must be stable enough. Therefore, the capacitance between the S5VOUT and GND pins must be 0.1 µF and the one for power supply stabilization between the VM and GND pins must be a minimum of 47 µF (recommendation) and as close as possible to the IC so that PWM noise will not cause the IC to malfunction or have fatal damage.

## ■ Usage Notes (continued)

8. Pulse blanking time
   In order to prevent mistakes in current detection resulting noise, this IC is provided with a pulse blanking time of 0.75 μs (typ.). The motor current will not be less than the current determined by the pulse blanking time. Pay utmost attention at the time of minute current control.
   Fig.1 shows the relationship between the pulse blanking time and minimum current value.
   The increase or decrease in the motor current is determined by a load and a resistance of a internal winding in the motor, induced voltage, and PWM on-duty.

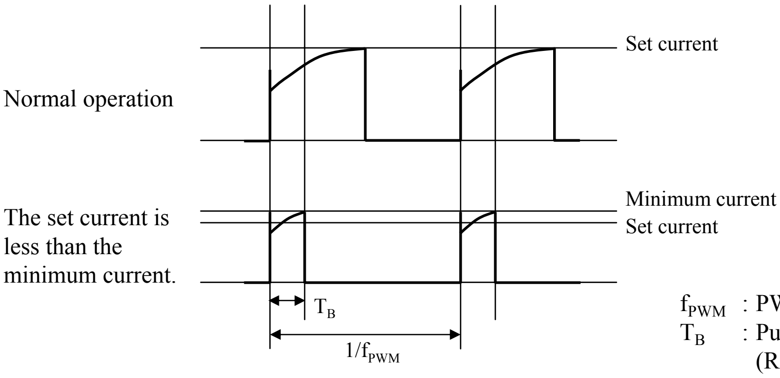



Fig. 1 RCS current waveform

$f_{PWM}$ : PWM frequency
$T_B$ : Pulse blanking time
(Refer to No. 28 to No. 30 of Electrical Characteristics)

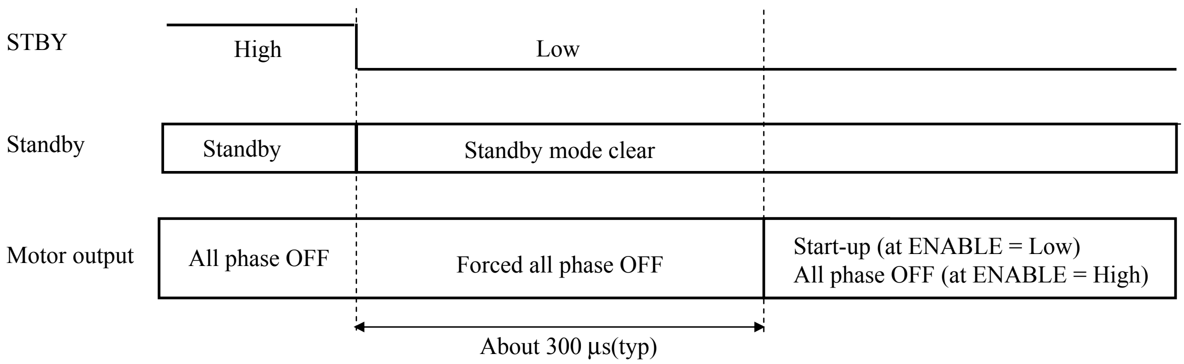
9. VREF voltage
   When VREF voltage is set to lower, an error detection of motor current might be caused by noise because Comp threshold voltage (No.31, 32, 33 in the "Electrical Characteristics" / P.10) becomes low. Use this IC after confirming there is no error detection when VREF voltage is less than the set value.

10. Notes on the interface
    Absolute maximum ratings of Pin 19, 20, 22 and Pin 24 to Pin31 are –0.3 V to 6 V. When the current setting for a motor is large and the lead line of GND is long, the potential of GND in this LSI will rise. Take notice that there is a possibility that potential of the interface pin is negative compared with that of GND in this LSI even if 0 V is applied to the interface pin. At that time, pay attention so that the input voltage of these pins might not exceed the values which are set in the allowable voltage range.

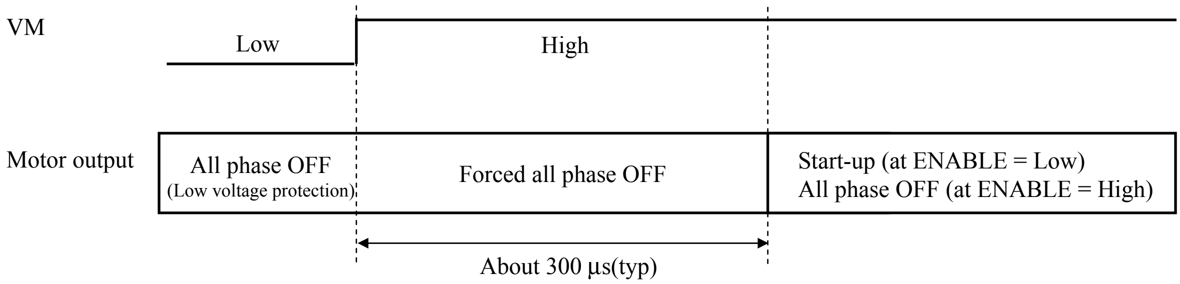
## ■ Usage Notes (continued)

11. Notes at the clear of standby mode / the rise of VM supply
    In this LSI, all phases are forced OFF for about 300 μs (typ.) after the clear of standby mode or the rise of VM supply. (See the following figure.) This is why the operation mode can be started after the charge pump circuit voltage boosts efficiently at shift to operation mode from standby mode / VM supply = OFF, when the charge pump operation stops. Therefore, the excitation patterns input after the forced all phase OFF period are effect.
    When the charge pump circuit rises slowly owing to that the capacitance value between VPUMP-GND is made large etc. and the booster voltage cannot rise efficiently for the forced all phase OFF, the IC might overheat. In this case, clear the standby mode at ENABLE = High or restart after VM supply is turned ON, the booster voltage rises efficiently, and ENABLE is shifted to Low.
    The thermal protection is same operation as that at VM supply OFF.

[In case that standby mode is cleared]




[In case that VM supply rises]
After VM supply exceeds threshold VM = 8.8 V(typ), all phases are forced OFF for about 300 μs(typ).



## ■ Usage Notes (continued)

12. PWMSW, PHA1, PHB1 pins
Under conditions where VM power supply is shutdown in standby mode (STBY pin = High level), when applying approx. 0.7 V (TYP) or more to PWMSW (Pin 24), PHA1 (Pin 25), PHB1 (Pin 26), the current flows into above-mentioned pins owing to parasitic elements in the LSI and the current flowing into the above-mentioned pins varies from the current determined by pull down resistance. In addition, the current flowing into PHA1/PHA2 is 341.4 μA (impedance = approx. 9.1 kΩ) at 3.3 V, while that into PWMSW is 323.2 μA (impedance = approx. 9.7 kΩ) at 3.3 V. There is no problem that the voltage up to rating is applied to the above-mentioned pins. However, it is recommended to set the voltage applied to the above-mentioned to 0.7 V or less at shutdown of VM power supply in standby mode.
Also, in case of the voltage of above-mentioned pins > S5VOUT(Pin 21) – 0.2 V at power on to VM power supply, the current flows owing to parasitic elements in the LSI, and the current flowing into the above-mentioned pins varies (refer to Fig. 2, 3).
As the same as at standby, there is no problem that the voltage up to rating is applied to the above-mentioned pins. However, it is recommended to set the voltage applied to the above-mentioned pins to 4.3 V or less.

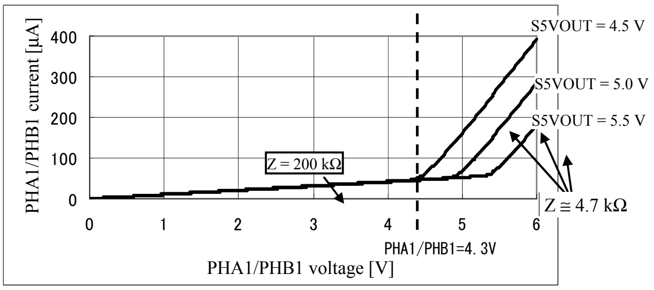



Fig. 2 Input impedance of PHA1/PHB1 at VM power supply power on

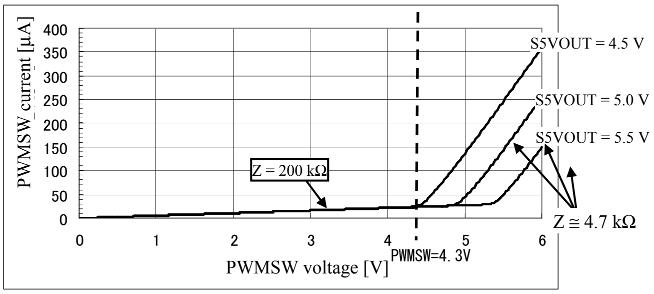
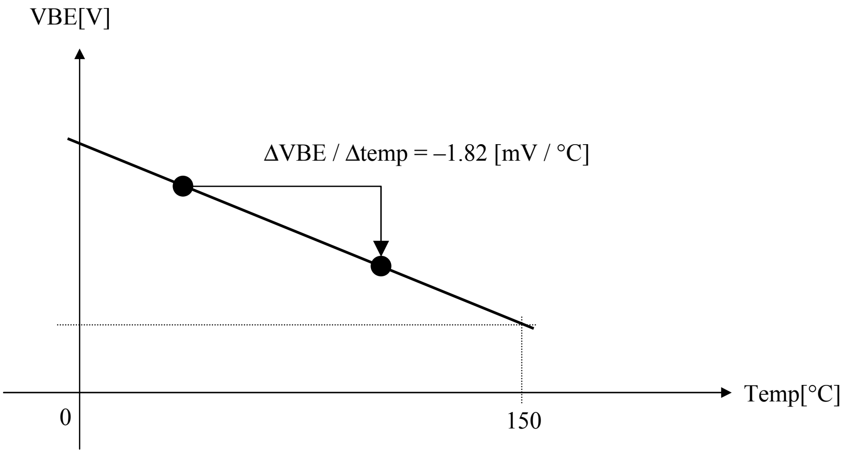



Fig. 3 Input impedance of PWMSW at VM power supply power on

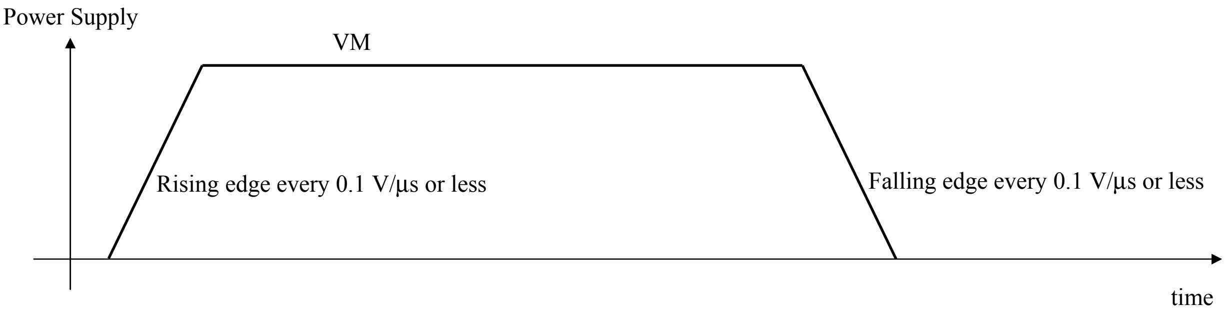
■ Usage Notes (continued)

13. In the case of measuring the chip temperature of the IC, measure the voltage of TJMON (Pin 32) and presume chip temperature from following data. Use the following data as reference data. Before applying the IC to a product, conduct a sufficient reliability test of the IC along with the evaluation of the product with the IC incorporated.

The temperature characteristic of TJMON

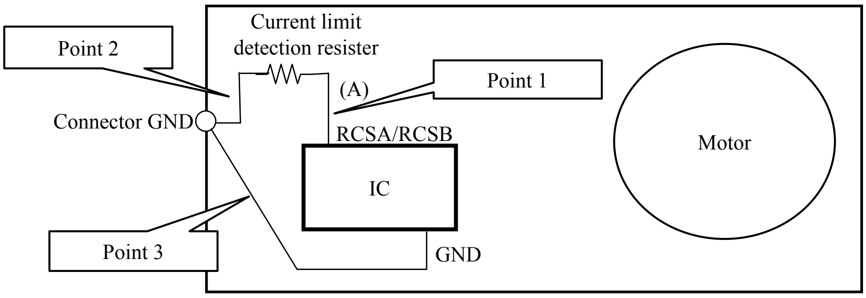



14. Power supply start up speed and shutdown speed
    Set the rising speed to 0.1 V/μs or less for VM voltage at power on to VM (Pin 1, 15).
    It is recommended that the falling speed of VM voltage is set to 0.1 V/μs or less on condition of STBY = High or ENABLE = High at shutdown. In case of shutdown at motor drive (STBY = Low and ENABLE = Low), the motor current might flow back to the power supply and supply voltage might not fall stably.
    If the rising or falling speed of power supply is too high, which might cause malfunctions or destruction on the IC. In this case, perform the long-term reliability test and confirm the sufficient evaluation for products.



## ■ Usage Notes (continued)

15. RCS line
 Take consideration in the following figure and the points and design PCB pattern.
 (1) Point 1
 Design so that the wiring to the current detection pins of this IC (RCSA, RCSB) should be thick and short in order to lower the impedance. This is why the current cannot be detected correctly owing to the wiring impedance, and the current might not be supplied to a motor sufficiently.
 (2) Point 2
 Design so that the wiring between the current detection resistor and the connector GND (Point 2 in the following figure) should be thick and short in order to lower the impedance. As the same as Point 1, a sufficient current might not be supplied due to the wiring impedance.
 In addition, if there is a common impedance between GND and RCSA or RCSB, a peak detection may be detected by mistake. Therefore, connect the wiring between GND and RCSA or RCSB independently.
 (3) Point 3
 Connect the GND of this IC to the connector on PCB independently. Separate the wiring which is a large current line (Point 2) from that of GND, and make these wirings with one-point shorted at the connector as the following figure. That can minimize the fluctuation of GND.




16. A high current flows into this IC. Therefore, the common impedance of the PCB pattern cannot be ignored. Take the following points into consideration and design the PCB pattern of the motor.

 A high current flows into the line between the VM1 (Pin 1) and VM2 (Pin 15) pins. Therefore, noise is generated with ease at the time of switching due to the inductance (L) of the line, which may result in the malfunctioning or destruction of the IC. (Fig. 4)
 As shown in the circuit diagram on the right-hand side, the escape way of the noise is secured by connecting a capacitor to the connector close to the VM pin of the IC. This makes it possible to suppress the direct VM pin voltage of the IC. Make the settings as shown in the circuit diagram on Fig. 5 as much as possible.

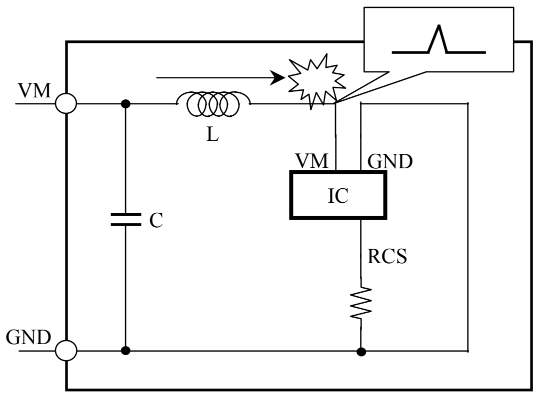



Fig. 4 Deprecated PCB

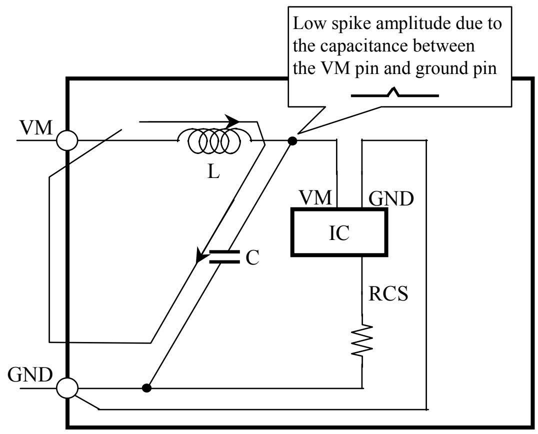



Fig. 5 Recommended PCB

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