

TOSHIBA Bi-CD Integrated Circuit Silicon Monolithic

# TB67B008FTG, TB67B008FNG TB67B008AFTG, TB67B008AFNG TB67B008BFTG, TB67B008BFNG TB67B008CFTG, TB67B008CFNG

## 3-Phase PWM Driver for Sensorless Brushless Motors

The TB67B008 is a three-phase PWM chopper driver for sensorless brushless motors. It controls motor rotation speed by changing the PWM duty cycle, based on the speed control input.

TB67B008FTG/TB67B008FNG: Rotation speed detecting signal (FG\_OUT) corresponds to 8pin and 23pin. 1ppr (1 pulse/1 electrical angle).

TB67B008AFTG/TB67B008AFNG: Lock detecting signal (LD\_OUT) corresponds to 8pin and 23pin. Normal state: High, Abnormal state: Low.

TB67B008BFTG/TB67B008BFNG: Rotation speed detecting signal (FG\_OUT) corresponds to 8pin and 23pin. 3ppr (3 pulses/1 electrical angle).

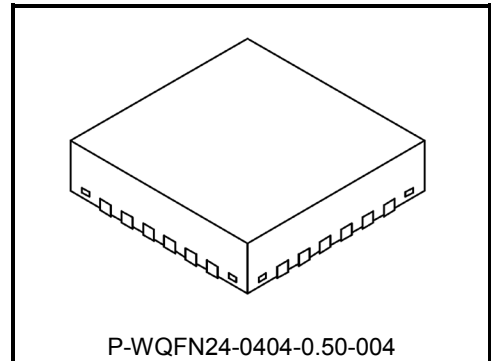
TB67B008CFTG/TB67B008CFNG: Lock detecting signal (LD\_OUT) corresponds to 8pin and 23pin. Normal state: Low, Abnormal state: High.

Packages of TB67B008FTG, TB67B008AFTG, TB67B008BFTG, and TB67B008CFTG: WQFN24

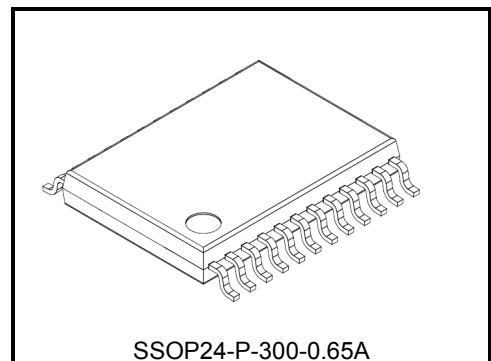
Packages of TB67B008FNG, TB67B008AFNG, TB67B008BFNG, and TB67B008CFNG: SSOP24 Products can be selected as usage.

### Features

- Sensorless drive in three-phase full-wave mode
- PWM chopper control
- Control based on the pulse duty input
- Output current: Absolute maximum rating: 3 A
- Power supply: Absolute maximum rating: 25 V
- Adjustable output PMW duty
- Lead angle control
- Overlapping commutation (150°) and Soft switching
- Rotation speed detecting signal (FG\_OUT): 1ppr: TB67B008FTG(8pin)/TB67B008FNG(23pin)
- Lock detecting signal (LD\_OUT):  
Normality is High: Abnormality is Low: TB67B008AFTG(8pin)/TB67B008AFNG(23pin)
- Rotation speed detecting signal (FG\_OUT): 3ppr: TB67B008BFTG(8pin)/TB67B008BFNG(23pin)
- Lock detecting signal (LD\_OUT):  
Normality is Low: Abnormality is High: TB67B008CFTG(8pin)/TB67B008CFNG(23pin)
- Adjustable startup settings
- Forced commutation frequency control
- Selectable PWM frequency
- Restart
- Overcurrent protection (ISD), thermal shutdown (TSD), and under voltage lockout (UVLO)
- Current limiter



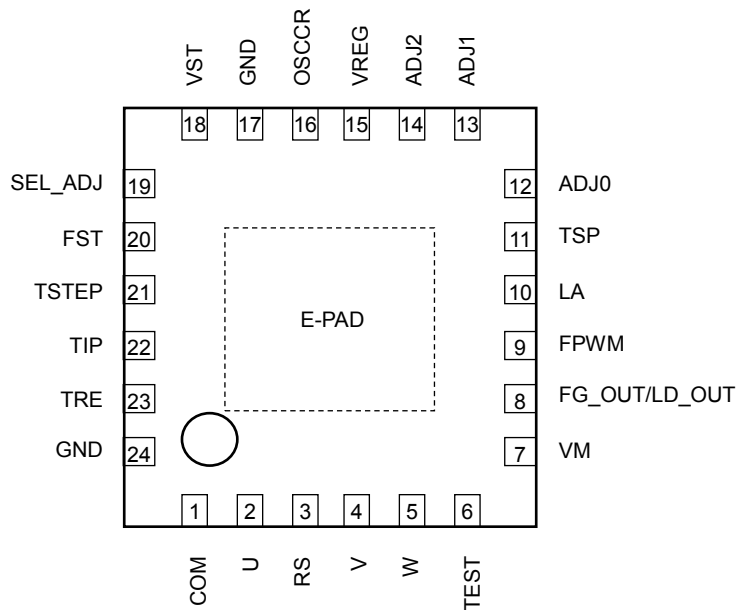
Weight: 0.04 g (typ.)



Weight: 0.13g (typ.)

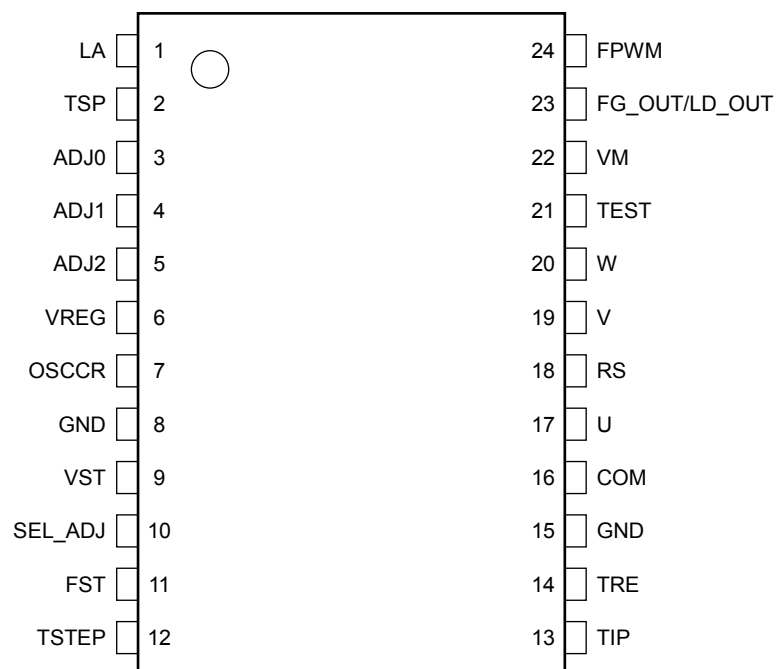
## Pin Assignment (Top view)

· TB67B008FTG/TB67B008AFTG/TB67B008BFTG/TB67B008CFTG



Note 1: Design the pattern in consideration of the heat design because the back side (E-PAD (2.6 mm×2.6 mm)) have the role of heat radiation. (The back side (E-PAD) should be connected to GND because they are connected to the back of the chip electrically.)

· TB67B008FNG/TB67B008AFNG/TB67B008BFNG/TB67B008CFNG



## Pin Description

· TB67B008FTG/TB67B008AFTG/TB67B008BFTG/TB67B008CFTG (WQFN24)

| Pin No. | Symbol  | I/O | Description  |
|---------|---------|-----|--|
| 1       | COM     | I   | Connection pin for the center tap of the motor                             |
| 2       | U       | O   | U-phase output   |
| 3       | RS      | —   | Connection pin for output current detecting resistance                     |
| 4       | V       | O   | V-phase output   |
| 5       | W       | O   | W-phase output   |
| 6       | TEST    | —   | Test pin (Connect to GND pin)  |
| 7       | VM      | —   | Motor power supply pin   |
| 8       | FG_OUT  | O   | TB67B008FTG/TB67B008BFTG<br>Rotation speed output pin (open-drain)         |
|         | LD_OUT  | O   | TB67B008AFTG/TB67B008CFTG<br>Lock detecting signal output pin (open-drain) |
| 9       | FPWM    | I   | PWM frequency select input   |
| 10      | LA      | I   | Lead angle setting input   |
| 11      | TSP     | I   | Rotation speed command input (Pulse duty control)                          |
| 12      | ADJ0    | I   | Characteristics adjustment of input duty                                   |
| 13      | ADJ1    | I   | Characteristics adjustment input of PWM output duty 1                      |
| 14      | ADJ2    | I   | Characteristics adjustment input of PWM output duty 2                      |
| 15      | VREG    | —   | Reference voltage output   |
| 16      | OSCCR   | —   | Internal OSC setting pin   |
| 17      | GND     | —   | Ground connection pin  |
| 18      | VST     | I   | Duty cycle setting pin for DC excitation and forced commutation modes      |
| 19      | SEL_ADJ | I   | PWM duty function setting input  |
| 20      | FST     | I   | Forced commutation frequency select input                                  |
| 21      | TSTEP   | —   | PWM duty increasing time setting pin                                       |
| 22      | TIP     | —   | Connection pin for a capacitor to set the DC excitation time               |
| 23      | TRE     | —   | Connection pin for a capacitor to set the restart time                     |
| 24      | GND     | —   | Ground connection pin  |

· TB67B008FNG/TB67B008AFNG/TB67B008BFNG/TB67B008CFNG (SSOP24)

| Pin No. | Symbol  | I/O | Description  |
|---------|---------|-----|--|
| 1       | LA      | I   | Lead angle setting input   |
| 2       | TSP     | I   | Rotation speed command input (Pulse duty control)                          |
| 3       | ADJ0    | I   | Characteristics adjustment of input duty                                   |
| 4       | ADJ1    | I   | Characteristics adjustment input of PWM output duty 1                      |
| 5       | ADJ2    | I   | Characteristics adjustment input of PWM output duty 2                      |
| 6       | VREG    | —   | Reference voltage output   |
| 7       | OSCCR   | —   | Internal OSC setting pin   |
| 8       | GND     | —   | Ground connection pin  |
| 9       | VST     | I   | Duty cycle setting pin for DC excitation and forced commutation modes      |
| 10      | SEL_ADJ | I   | PWM duty function setting input  |
| 11      | FST     | I   | Forced commutation frequency select input                                  |
| 12      | TSTEP   | —   | PWM duty increasing time setting pin                                       |
| 13      | TIP     | —   | Connection pin for a capacitor to set the DC excitation time               |
| 14      | TRE     | —   | Connection pin for a capacitor to set the restart time                     |
| 15      | GND     | —   | Ground connection pin  |
| 16      | COM     | I   | Connection pin for the center tap of the motor                             |
| 17      | U       | O   | U-phase output   |
| 18      | RS      | —   | Connection pin for output current detecting resistance                     |
| 19      | V       | O   | V-phase output   |
| 20      | W       | O   | W-phase output   |
| 21      | TEST    | —   | Test pin (Connect to GND pin)  |
| 22      | VM      | —   | Motor power supply pin   |
| 23      | FG_OUT  | O   | TB67B008FNG/TB67B008BFNG<br>Rotation speed output pin (open-drain)         |
|         | LD_OUT  | O   | TB67B008AFNG/TB67B008CFNG<br>Lock detecting signal output pin (open-drain) |
| 24      | FPWM    | I   | PWM frequency select input   |

## Functional Description

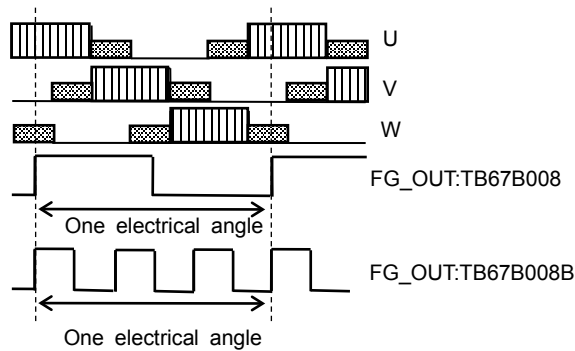
The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.

Timing charts may be simplified for explanatory purposes.

### 1. Sensorless Drive Mode

Based on the TSP input for a startup operation, the rotor is aligned to a known position in DC excitation mode. Then, the forced commutation signal is generated to start the motor rotation. As the motor rotates, the back-EMF occurs in each phase of the coil. When an input signal indicating the polarity of three phase voltage of the motor, including the back-EMF, is detected as a position signal, the motor driving signal is automatically switched from forced commutation signal to the normal commutation PWM signal that is based on the position signal input (back-EMF). Then, a BLDC motor starts running in sensorless commutation mode.

1) Forward rotation direction switching



2) Output of rotation speed signal: FG\_OUT pin

TB67B008

Signal of 1 ppr (one pulse/one electrical angle) is outputted according to the motor induced voltage.

(\*4-polar motor: 2 pulses are outputted per 1 motor rotation.)

TB67B008B

Signal of 3 ppr (one pulse/one electrical angle) is outputted according to the motor induced voltage.

(\*4-polar motor: 6 pulses are outputted per 1 motor rotation.)

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

| Characteristics       | Symbol        | Rating           | Unit |
|-----------------------|---------------|------------------|------|
| Power supply voltage  | VM            | 25               | V    |
| Input voltage         | VIN1 (Note1)  | -0.3 to 6.0      | V    |
|                       | VIN2 (Note2)  | -0.3 to 25       | V    |
|                       | VIN3 (Note3)  | -0.3 to VREG+0.3 | V    |
| Output voltage        | VOUT1 (Note4) | 25               | V    |
|                       | VOUT2 (Note5) | 25               | V    |
| Output current        | IOUT1 (Note6) | 3 (Note9)        | A    |
|                       | IOUT2 (Note7) | 10               | mA   |
|                       | IOUT3 (Note8) | 5                | mA   |
| Power dissipation     | PD1           | 3.37 (Note10)    | W    |
|                       | PD2           | 2.2 (Note11)     | W    |
| Operating temperature | Topr          | -40 to 105       | °C   |
| Storage temperature   | Tstg          | -55 to 150       | °C   |

Note: 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.

Please use the TB67B008 within the specified operating ranges.

Note1: VIN1 is applicable to the voltage at the following pins: TSP

Note2: VIN2 is applicable to the voltage at the COM pin.

Note3: VIN3 is applicable to the voltage at the following pins:

ADJ0, ADJ1, ADJ2, OSCCR, VST, FPWM, LA, SEL\_ADJ, FST, TSTEP, TIP, and TRE

Note4: VOUT1 is applicable to the voltage at the following pins: U, V and W

Note5: VOUT2 is applicable to the voltage at the following pins: FG\_OUT and LD\_OUT

Note6: IOUT1 is applicable to the voltage at the following pins: U, V and W

Note7: IOUT2 is applicable to the voltage at the following pins: FG\_OUT and LD\_OUT

Note8: IOUT3 is applicable to the voltage at the VREG pin.

Note9: Output current may be limited by the ambient temperature or the device implementation.

The maximum junction temperature should not exceed  $T_{jmax} = 150^{\circ}\text{C}$

Note10: WQFN24: When mounted on the board (4 layers: FR4: 74 mm x 74 mm x 1.6 mm)

Note11: SSOP24: When mounted on the board (JEDEC-compatible 4 layers: FR4: 76.2 mm x 114.3 mm x 1.6 mm)

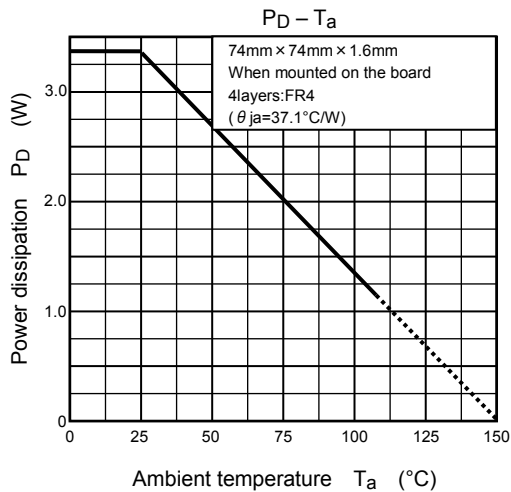
## Operating Ranges

| Characteristics                 | Symbol  | Min | Typ. | Max | Unit |
|---------------------------------|---------|-----|------|-----|------|
| Power supply voltage 1          | VMopr1  | 5.5 | 12   | 22  | V    |
| Power supply voltage 2 (Note12) | VMopr2  | 4   | 5    | 5.5 | V    |
| Input frequency of TSP pin      | foprTSP | 0.4 | 25   | 100 | kHz  |

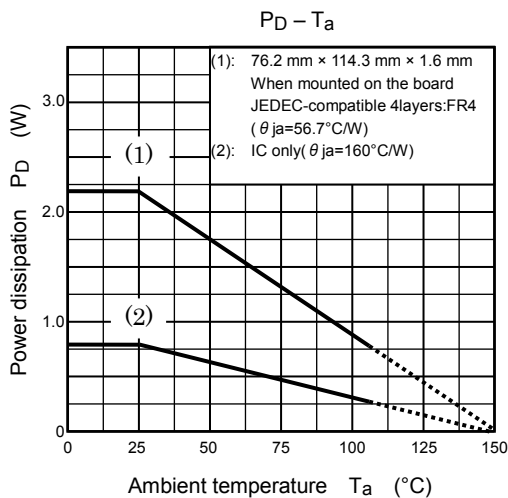
Note12: When voltage of VM is 5.5 V or less, pay attention to use the IC because the characteristics of the output ON resistance and VREG output voltage change.

## Package Power Dissipation (Reference data)

· WQFN24



· SSOP24



## Electrical Characteristics (Ta = 25°C, VM = 12 V, unless otherwise specified)

| Characteristics                                       | Symbol   | Test Conditions                   | Min          | Typ.  | Max          | Unit |
|---|----------|-----------------------------------|--------------|-------|--------------|------|
| Static power supply current at VM                     | IM       | TSP=GND                           | —            | 5.5   | 8            | mA   |
| Dynamic power supply current at VM                    | IM (opr) | TSP=VREG<br>RS = TIP = COM = GND, | —            | 6     | 8.5          | mA   |
| Input current   | IIN1 (H) | VIN = 5 V,<br>FST, SEL_ADJ        | —            | 100   | 150          | μA   |
|   | IIN1 (L) | VIN = 0 V,<br>FST, SEL_ADJ        | -150         | -100  | —            |      |
|   | IIN2D    | TSP=5 V                           | —            | 100   | 150          |      |
|   | IIN2D    | TSP=0 V                           | -1           | —     | 1            |      |
|   | IIN3     | ADJ0,ADJ1, ADJ2, VST,LA,FPWM      | -1           | —     | 1            |      |
| Input voltage   | VIN1 (H) | TSP                               | 2.0          | —     | —            | V    |
|   | VIN1 (L) |                                   | GND          | —     | 0.8          |      |
|   | VIN2 (H) | FST, SEL_ADJ                      | VREG×<br>0.8 | —     | VREG+<br>0.3 |      |
|   | VIN2 (M) |                                   | VREG×<br>0.4 | —     | VREG×<br>0.6 |      |
|   | VIN2 (L) |                                   | GND          | —     | VREG×<br>0.2 |      |
| Input voltage hysteresis                              | V1hys    | TSP (Reference data)              | —            | 0.12  | —            | V    |
| TSTEP pin setting time                                | Tsoft    | TSTEP = 0.01 μF (Reference data)  | —            | 0.099 | —            | s    |
| TIP pin setting time                                  | Tip      | TIP = 0.1 μF (Reference data)     | —            | 0.99  | —            | s    |
| TRE pin setting time                                  | Tre      | TRE = 1 μF (Reference data)       | —            | 9.9   | —            | s    |
| High-level TIP, TRE, and TSTEP voltage                | VH       |                                   | 2.25         | 2.5   | 2.75         | V    |
| Low-level TIP, TRE, and TSTEP voltage                 | VL       |                                   | 0.45         | 0.5   | 0.55         | V    |
| COM pin input current                                 | Icom     |                                   | -5           | -1.3  | 1            | μA   |
| Position detection comparator offset voltage          | Voffset  | (Reference data)                  | -10          | 0     | 10           | mV   |
| Low-level FG_OUT/LD_OUT output voltage                | VFG_OUT  | IOUT = 5 mA                       | GND          | —     | 0.5          | V    |
| FG_OUT/LD_OUT leakage current                         | IFG_OUT  | VOUT = 25 V                       | —            | 0     | 2            | μA   |
| Output ON-resistance at the U, V and W pins           | RON1 (H) | IOUT = -0.1 A                     | —            | 0.3   | 0.6          | Ω    |
|   | RON1(L)  | IOUT = 0.1 A                      | —            | 0.3   | 0.6          |      |
|   | RON2 (H) | IOUT = -0.1 A, VM = 4.0 V         | —            | 0.33  | 0.6          |      |
|   | RON2 (L) | IOUT = 0.1 A, VM = 4.0 V          | —            | 0.33  | 0.6          |      |
| Output leakage current at the U, V and W pins         | IL (H)   | VOUT = 0 V                        | -10          | 0     | —            | μA   |
|   | IL (L)   | VOUT = 25 V                       | —            | 0     | 10           |      |
| Output diodes' forward voltage at the U, V and W pins | VF (H)   | IOUT = 1.5 A (Reference data)     | —            | 1.0   | 1.4          | V    |
|   | VF (L)   | IOUT = - 1.5 A (Reference data)   | —            | 1.0   | 1.4          |      |
| VST ON resistance in power on                         | RVST     |                                   | —            | 600   | 1000         | Ω    |
| Masking time of current limit detection               | TRS      | (Reference data)                  | —            | 3     | —            | μs   |



| Characteristics                             | Symbol    | Test Conditions                              | Min   | Typ.  | Max   | Unit         |
|---|-----------|--|-------|-------|-------|--------------|
| RS pin voltage for current detection        | VRS       |  | 0.225 | 0.25  | 0.275 | V            |
| PWM oscillation frequency                   | FPWM4     | (Reference data)                             | 171.5 | 190.6 | 209.7 | kHz          |
|   | FPWM3     | (Reference data)                             | 85.7  | 95.3  | 104.9 |              |
|   | FPWM2     | (Reference data)                             | 42.8  | 47.7  | 52.5  |              |
|   | FPWM1     | (Reference data)                             | 21.4  | 23.8  | 26.3  |              |
| OSC frequency                               | OSC       | OSCCR:20k $\Omega$ ,180pF(Reference data)    | 10.98 | 12.2  | 13.42 | MHz          |
| Masking time of over current detection      | TISD      | (Reference data)                             | —     | 3     | —     | $\mu$ s      |
| Current for over current detection          | IISD      | (Reference data)                             | —     | 4.5   | —     | A            |
| Thermal shutdown                            | TSD       | (Reference data)                             | —     | 165   | —     | $^{\circ}$ C |
|   | TSDhys    | Thermal shutdown hysteresis (Reference data) | —     | 15    | —     |              |
| UVLO trip threshold voltage at the VM pin   | VMUVLO    |  | 3.1   | 3.4   | 3.7   | V            |
| UVLO recovery voltage at the VM pin         | VMUVLOR   |  | 3.4   | 3.7   | 3.98  | V            |
| UVLO trip threshold voltage at the VREG pin | VREGUVLO  |  | 2.7   | 3.0   | 3.3   | V            |
| UVLO recovery voltage at the VREG pin       | VREGUVLOR |  | 2.9   | 3.2   | 3.45  | V            |
| VREG output voltage                         | VREG1     | IVREG = -5 mA                                | 4.5   | 5     | 5.5   | V            |
|   | VREG2     | IVREG = -5 mA, VM = 4.0 V                    | 3.6   | 3.9   | 4.0   | V            |

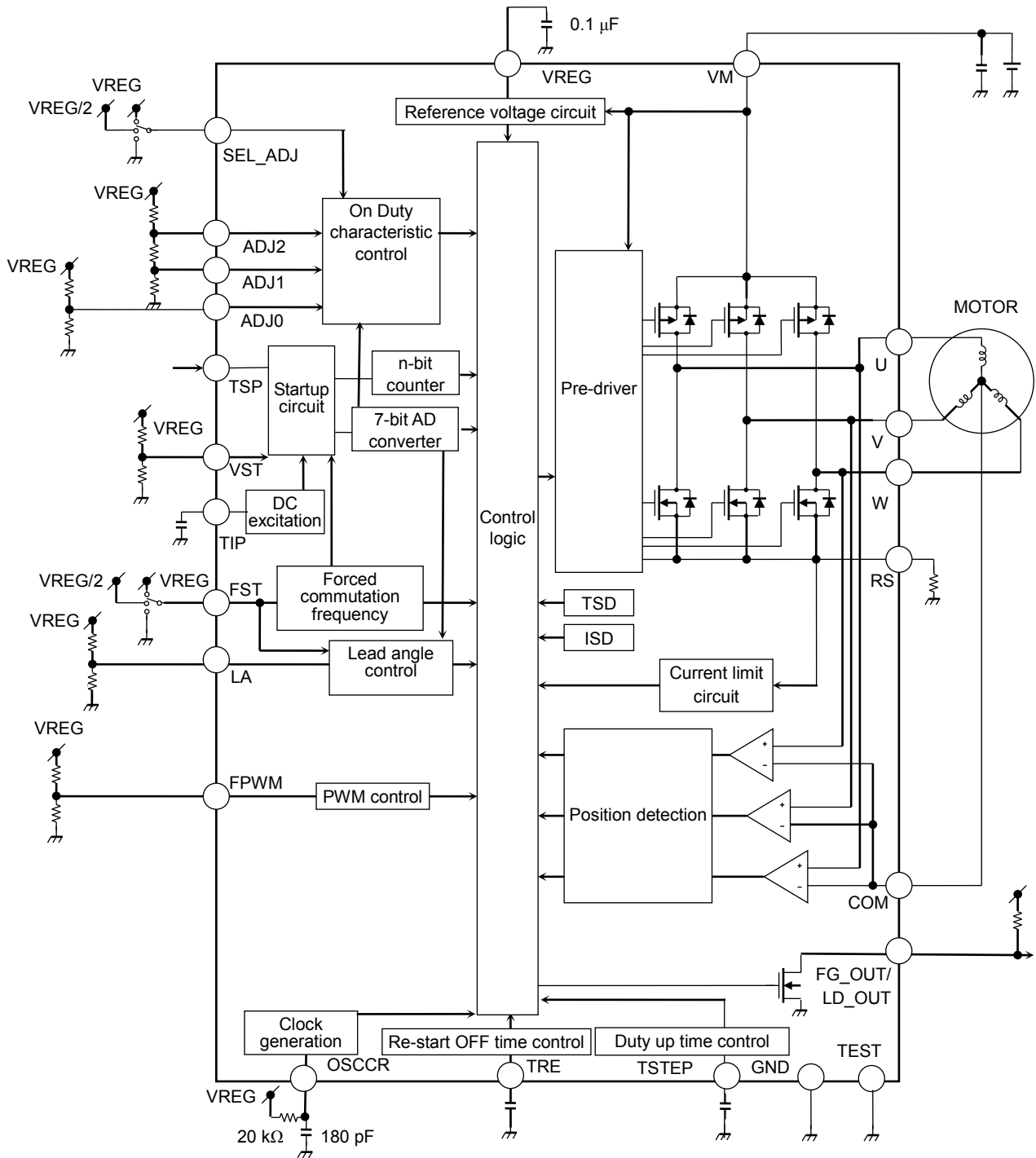
\*Reference data: Toshiba does not implement testing before shipping.

**Application Circuit Example**

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

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

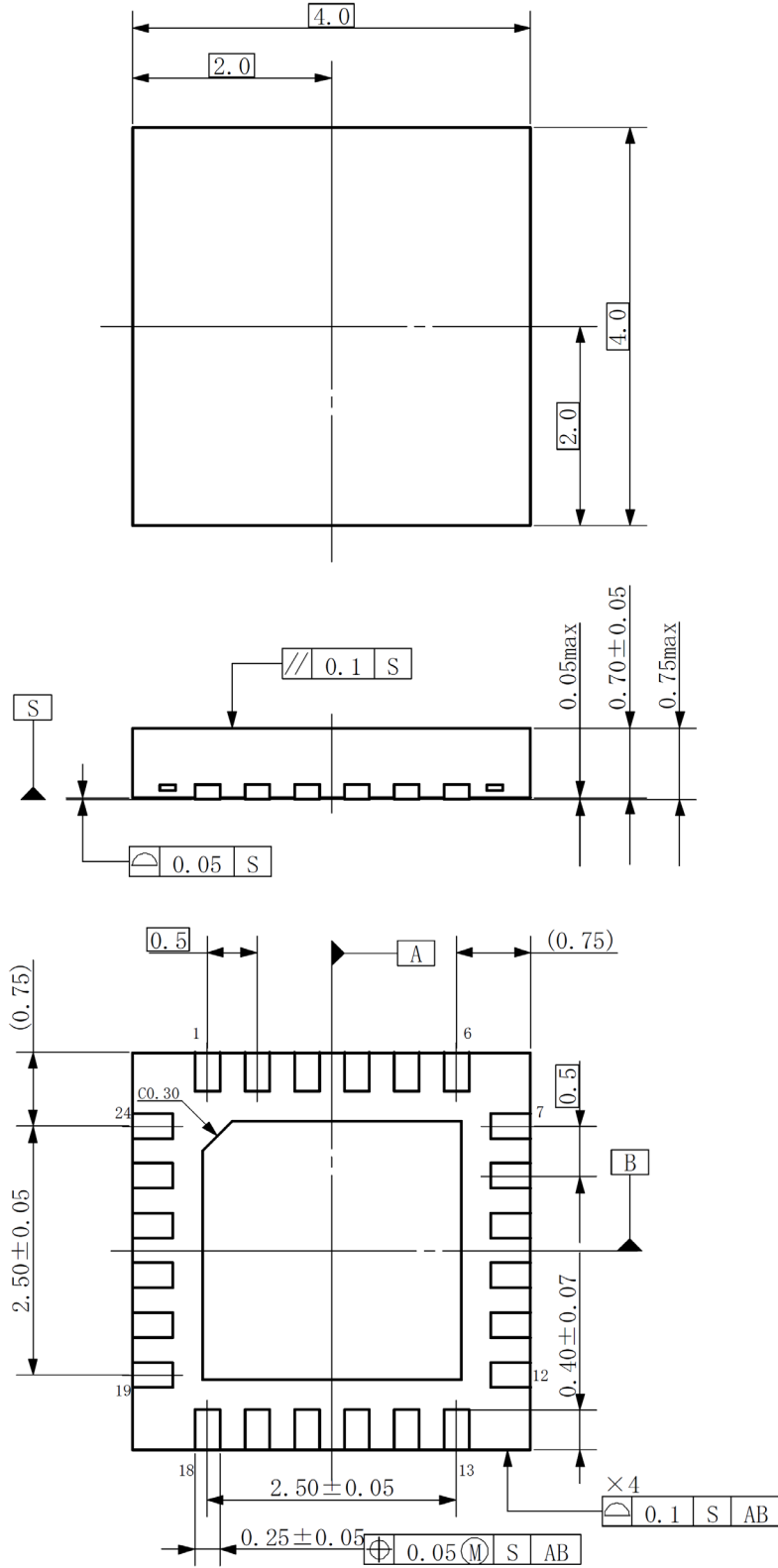
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**Package Dimensions**

P-WQFN24-0404-0.50-004

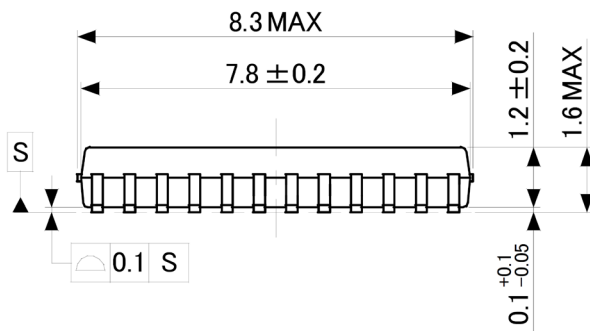
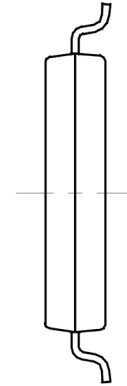
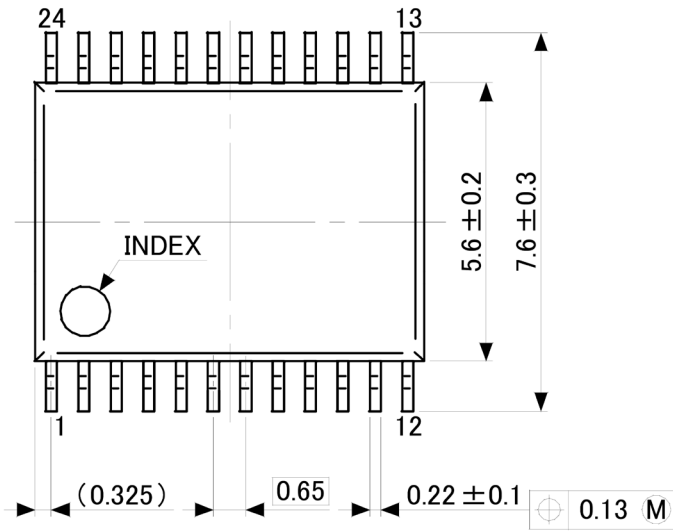
Unit: mm



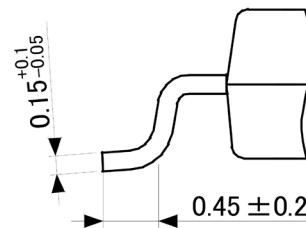
Weight: 0.04g (typ.)

SSOP24-P-300-0.65A

Unit: mm



Detailed diagram of tip of terminal



Weight: 0.13g (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

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### 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.

- (5) Carefully select external components (such as inputs and negative feedback capacitors) and load components (such as speakers), for example, power amp and regulator.  
If there is a large amount of leakage current such as input or negative feedback condenser, the IC output DC voltage will increase. If this output voltage is connected to a speaker with low input withstand voltage, overcurrent or IC failure can cause smoke or ignition. (The over current can 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

- (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 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 absolute maximum ratings. To avoid this problem, take the effect of back-EMF into consideration in system design.

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