TOSHIBA BiCD Integrated Circuit Silicon Monolithic

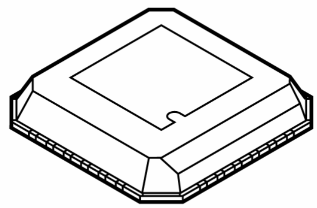
TB6558FLG

DC Motor Driver

The TB6558FLG is a dual bridge driver IC for DC motor control using LDMOS output transistors with low ON-resistance.

Four operation modes are selectable via IN1 and IN2: forward, reverse, short brake and stop.

The TB6558FLG uses constant-current PWM chopper drive.



QON24-P-0505-0.50

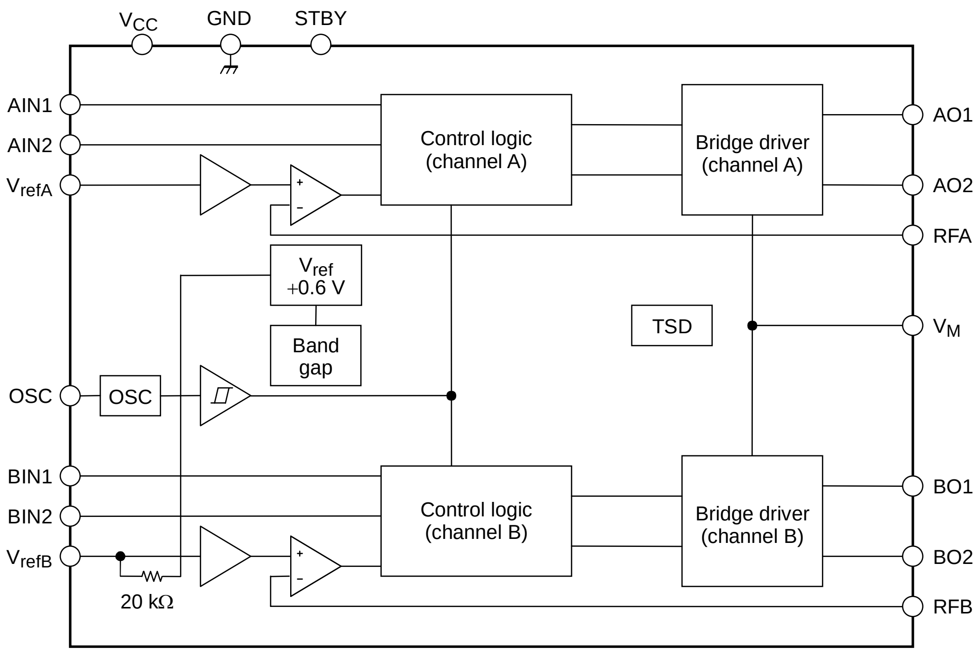
Weight: 0.05 g (typ.)

Features

- Motor power supply voltage: $V_M \leq 15$ V (max)
- Control power supply voltage: $V_{CC} = 2.7$ V to 6 V
- Output current: $I_{OUT} \leq 0.8$ A (max)
- Low ON-resistance: 1.5 Ω (upper and lower sum @ $V_M = 5$ V (typ.))
- Constant-current PWM chopper drive
- Separate VrefA and VrefB pins allow the constant-current values to be individually programmed for each channel.
- Forward, reverse, short brake and stop
- Thermal shutdown (TSD)
- Small QON-24 package
- Lead(Pb)-Free solderable

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

Block Diagram



Pin Functions

Pin No.	Symbol	Functional Description	Remarks
14	GND	Small signal ground	Ground for small-signal components powered by V_{CC}
5	OSC	Internal oscillation frequency setting pin	Connection pin for an external capacitor used for reference oscillation
15	V_{refA}	Channel-A coil current setting pin	This pin is externally controlled by using an external circuit.
11	AIN1	Control input 1 (channel A)	Internal pull-down resistor of 200 kΩ
9	AIN2	Control input 2 (channel A)	Internal pull-down resistor of 200 kΩ
19	RFA	Coil current sense pin (channel A)	
18	AO1	Output 1 (channel A)	Connection pin for the channel-A motor coil
21	AO2	Output 2 (channel A)	Connection pin for the channel-A motor coil
1	BO2	Output 2 (channel B)	Connection pin for the channel-B motor coil
22	BO1	Output 1 (channel B)	Connection pin for the channel-B motor coil
24	RFB	Coil current sense pin (channel B)	
3	VM	Motor power supply pin	V_M (ope) = 2.5 V to 13.5 V
6	BIN2	Control input 2 (channel B)	Internal pull-down resistor of 200 kΩ
8	BIN1	Control input 1 (channel B)	Internal pull-down resistor of 200 kΩ
12	V_{refB}	Channel-B coil current setting pin	An internal reference voltage generator (0.6 V typ.) is connected to this pin. (The voltage divider ratio can be determined by an external resistor.)
13	V_{CC}	Small-signal power supply pin	V_{CC} (ope) = 2.7 V to 5.5 V
4	STBY	Standby (power save) pin	H: Active (internal pull-down resistor of 300 kΩ)

Note: Pins 2, 7, 10, 16, 17, 20 and 23: No connect (NC)

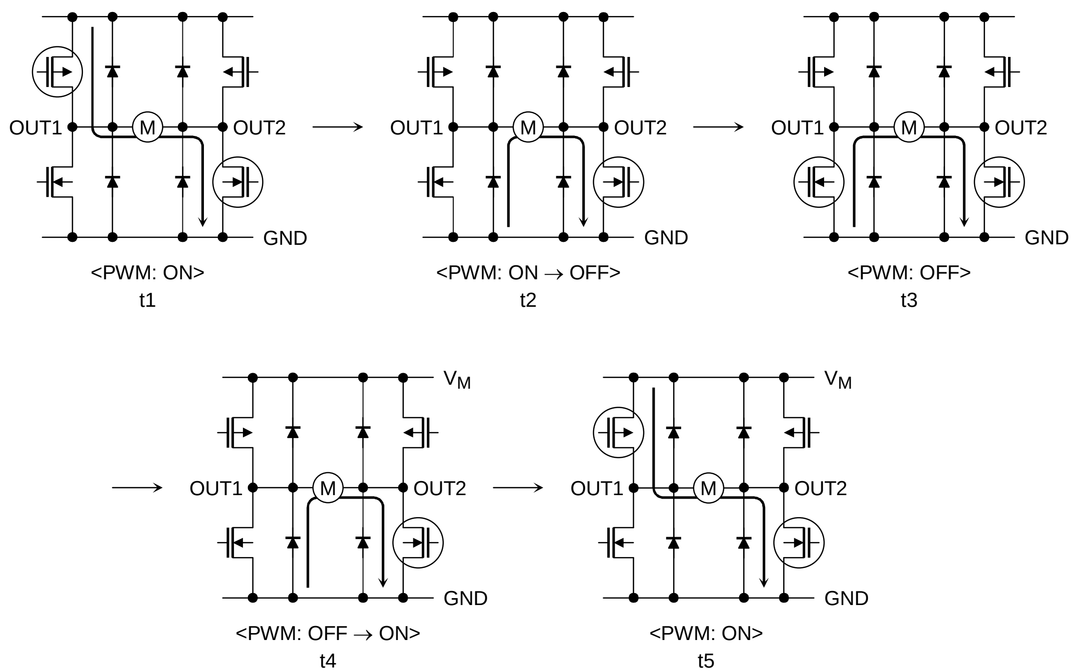
Function Table

Input			Output		
IN1	IN2	STBY	OUT1	OUT2	Drive Mode
H	H	H	L	L	Short brake
L	H	H	L	H	Reverse/forward
H	L	H	H	L	Forward/reverse
L	L	H	OFF (high impedance)		Stop
H/L	H/L	L	OFF (high impedance)		Standby (power save)

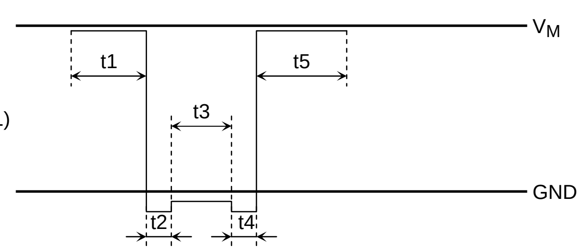
Functional Description

PWM Control

In PWM mode, the PWM chopper circuit alternates between on (t1, t5) and short brake (t3).
(To eliminate shoot-through current, a dead time (t2, t4) is inserted when the PWM is turned on and off.)

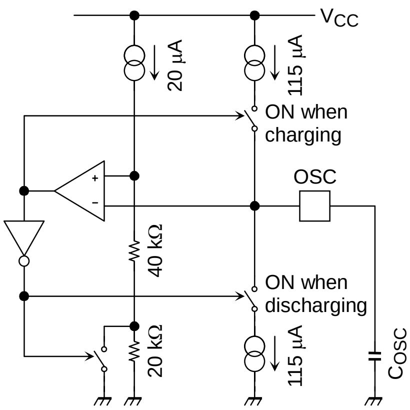


Example:
Output voltage waveform (OUT1)

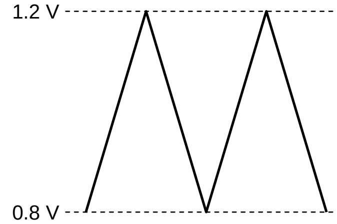


Oscillator Circuit Operational Description

The on-chip oscillation is controlled by the charging and discharging of an external capacitor C_{OSC}.



Oscillator



V_{OSC} Waveform

In the above circuit, the charging and discharging rate (V_{OSC}) of the external capacitor (C_{OSC}) is calculated as follows:

$$V_{OSC} = \frac{1}{C_{OSC}} \int i \, dt$$

Let the time at V_{OSC} = 0.8 V be t1 and the time at V_{OSC} = 1.2 V be t2, then the V_{OSC} slope (ΔV_{OSC}) is calculated as:

$$\Delta V_{OSC} = I \times \frac{t_1 - t_2}{C_{OSC}}$$

which can be rewritten as:

$$\frac{1}{t1 - t2} = \frac{I}{\Delta V_{OSC} \cdot C_{OSC}}$$

The cycle period of the triangular wave oscillation is equal to the period of rise and fall times of V_{OSC} slope, which is, twice the time from t1 to t2.

Hence, f_{OSC} can be expressed as a function of C_{OSC} as follows:

$$f_{OSC} = \frac{1}{2(t1 - t2) + \Delta t} = \frac{I}{2 \cdot \Delta V_{OSC} \cdot C_{OSC} + \Delta t}$$

In the above diagram, ΔV_{OSC} = | 1.2 V − 0.8 V | = 0.4 V. Thus, f_{OSC} can be calculated as:

$$f_{OSC} = \frac{1}{2 \times 0.4/115\ \mu A \times C_{OSC} + \Delta t} = \frac{1}{6.957 \times 10^3 \times C_{OSC} + \Delta t}$$

(Δt = 350 ns (typ.): Turn-on time of a switching transistor)

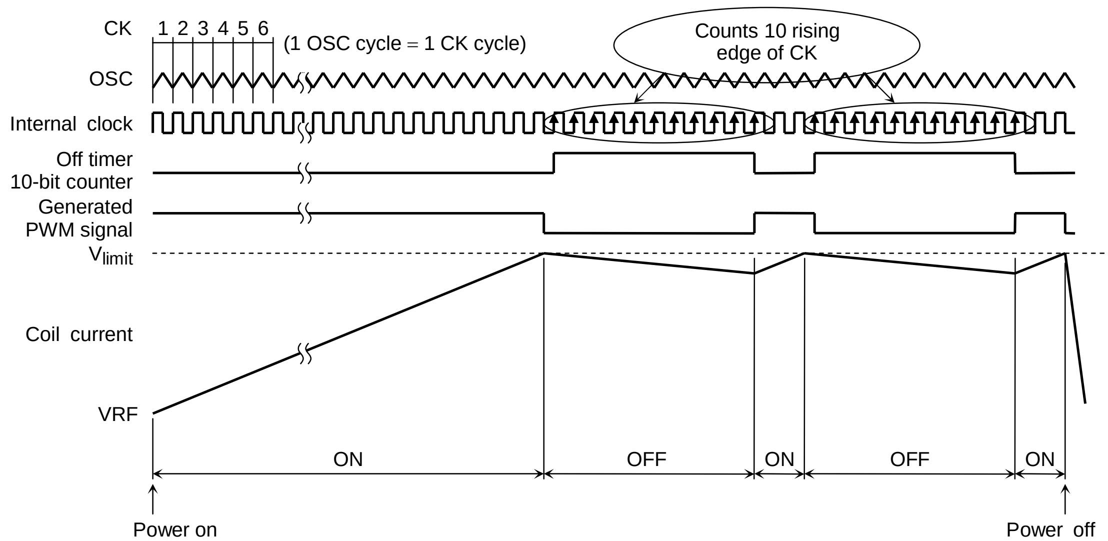
PWM Chopper Control

Turning on the power supply causes a current to flow into the motor coils. The peak current through the winding is sensed via an external current-sense resistor. As the current increases, a voltage (VRF) develops across the resistor, which is fed back to the comparator. At the predetermined reference voltage (V_{limit}), the comparator turns off (chops) the power supply.

When high-side output transistors are turned off, the TB6558FLG, by default, counts 10 rising edges of the internal CK signal as turn-off period. (The counter resets at the 11^{th} rising edge of CK.)

Based on this turn-off period, the TB6558FLG generates a PWM signal that turns on and off the output transistors.

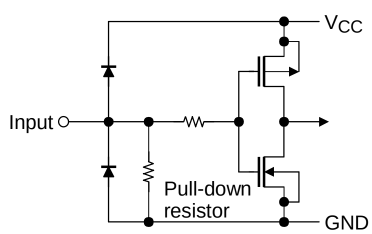
Timing Diagram of the PWM Chopper Circuit



(The upper limit of the coil current (I_O peak) can be calculated as: $I_O = V_{limit}/RNF$.)

Other

The IN1 and IN2 input pins have a pull-down resistor of about 200 kΩ.
The STBY pin has a pull-down resistor of about 300 kΩ.



Absolute Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Rating	Unit	Remarks
Supply voltage	V_M	15	V	
	V_{CC}	6	V	
Input voltage	V_{IN}	−0.2 to 6	V	AIN1, AIN2, BIN1, BIN2, STBY, V_{refA} and V_{refB} pins
Output voltage	I_{OUT}	0.8	A	
Power dissipation	P_D	0.78 (Note)	W	
Operating temperature	T_{opr}	−20 to 85	°C	
Storage temperature	T_{stg}	−55 to 150	°C	

Note: When mounted on a single-sided glass epoxy PCB (size: 50 mm × 30 mm × 1.6 mm) with a 40% dissipating copper surface.

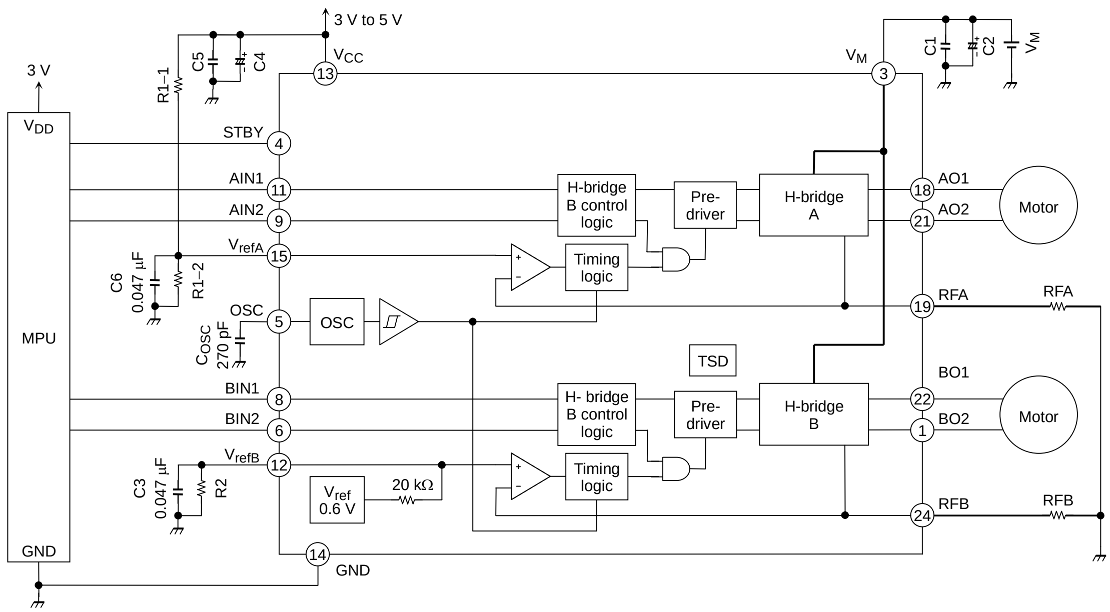
Operating Ranges (Ta = −20 to 85°C)

Characteristics	Symbol	Min	Typ.	Max	Unit
Supply voltage (V_{CC})	V_{CC}	2.7	3	5.5	V
Supply voltage (V_M)	V_M	2.5	5	13.5	V
Output current	I_{OUT}	—	—	0.6	A
OSC fequency	f_{OSC}	—	—	1	MHz
Chopping frequency	f_{chop}	20	—	250	kHz

Electrical Characteristics (unless otherwise specified, Ta = 25°C, V_{CC} = 3 V, V_M = 5 V)

Characteristics		Symbol	Test Condition	Min	Typ.	Max	Unit
Supply current		$I_{CC\ (STP)}$	Stop mode	—	1.4	3	mA
		$I_{CC\ (W)}$	Forward/reverse mode	—	1.4	3	
		$I_{CC\ (SB)}$	Short brake mode	—	1.4	3	
		$I_{CC\ (STB)}$	Standby mode STBY = L	—	—	15	μA
		$I_{M\ (STB)}$		—	—	1	
Control circuit	Input voltage	V_{INH}		2	—	V_{CC} + 0.2	V
		V_{INL}		−0.2	—	0.8	
	Hysteresis voltage	$V_{IN\ (HIS)}$	(design target only)	—	0.2	—	
	Input current	I_{INH}		10	15	20	μA
		I_{INL}		—	—	1	
Standby circuit	Input voltage	V_{INSH}		2	—	V_{CC} + 0.2	V
		V_{INSL}		−0.2	—	0.8	
	Input current	I_{INSH}		5	10	15	μA
		I_{INSL}		—	—	1	
Output saturation voltage		$V_{sat\ (U + L)}$	I_O = 0.2 A	—	0.3	0.4	V
			I_O = 0.6 A	—	0.8	1.2	
Comparator reference voltage		VRF	V_{limt} = 0.6 V, RF = 1 Ω	0.575	0.6	0.635	V
Internal reference voltage		V_{ref}	When V_{refB} = open	0.57	0.6	0.63	V
Output leakage current		$I_{L\ (U)}$	V_M = 15 V	—	—	1	μA
		$I_{L\ (L)}$		—	—	1	
Diode forward voltage		$V_{F\ (U)}$	I_O = 0.6 A (design target only)	—	1	—	V
		$V_{F\ (L)}$		—	1	—	
Oscillation frequency		f_{OSC}	C_{OSC} = 220 pF	400	530	660	kHz
Thermal shutdown threshold		TSD	(design target only)	—	170	—	°C
Thermal shutdown hysteresis		ΔTSD		—	20	—	°C

Application Circuit Example



- Setting output current: I_{OUT} (A) = V_{ref} (V) ÷ RF (Ω), Channel A: I_O − A = V_{refA} ÷ RFA, Channel B: I_O − B = V_{refB} ÷ RFB
- Setting V_{refA} and V_{refB} V_{refA} = V_{CC} × R1 − 2/(R − 1 + R1 − 2), V_{refB} = V_{ref} (0.6 V) × R2/(20 k + R2)

(The application circuits shown in this document are provided for reference purposes only. Thorough evaluation is required, especially at the mass production design stage. Toshiba does not grant any license to any industrial property rights by providing these examples of application circuits.)

Note 1: Bypass capacitors and a capacitor that is connected to the OSC pin should be places as close to the IC as possible.

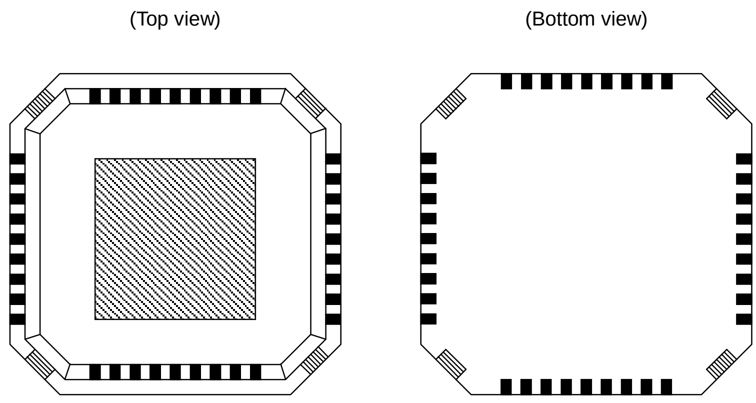
Note 2: The TB6558FLG must be powered on either when the STBY pin is set Low (standby mode), or when the IN1 and IN2 pins are set Low (stop mode).

Note 3: Care should be taken in the design of the output, V_{CC}, V_M and ground lines. The IC might be permanently damaged in case of a short-circuit across its outputs, a short-circuit to power supply, a short-circuit to ground or a short-circuit to adjacent pins. Any of these events might cause a current larger than the rated maximum to flow through the IC. To ensure the safety of the system, overcurrent protection should be provided by using fuses or other protection devices.

Note 4: The IC should be installed correctly. Otherwise, the IC or peripheral parts and devices may be degraded or permanently damaged.

QON Package Considerations

Package Appearances



Please follow the following guidelines for the QON package.

Guidelines:

(1) The solder plated pads at the four corners of the package (shaded areas in the bottom view) should not be soldered for the purpose of improving the mechanical strength of solder joints.

(2) When using the TB6558FLG, it should be ensured that the thermal pad and solder plated pads (shaded areas in the top and bottom views) are electrically insulated (Note).

Note: Care should be taken in the board design to prevent solder for through-hole joints from flowing to the solder plated pads on the bottom of the package (shaded areas in the bottom view).

- When mounting or soldering this package, care must be taken to avoid electrostatic discharge or electrical overstress to the IC. (This is to avoid electrical leakage and a buildup of electrostatic charge in the end product.)
- It should be ensured that no voltage is directly applied to the solder plated pads when designing the PC board.

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.

Points to Remember on Handling of ICs

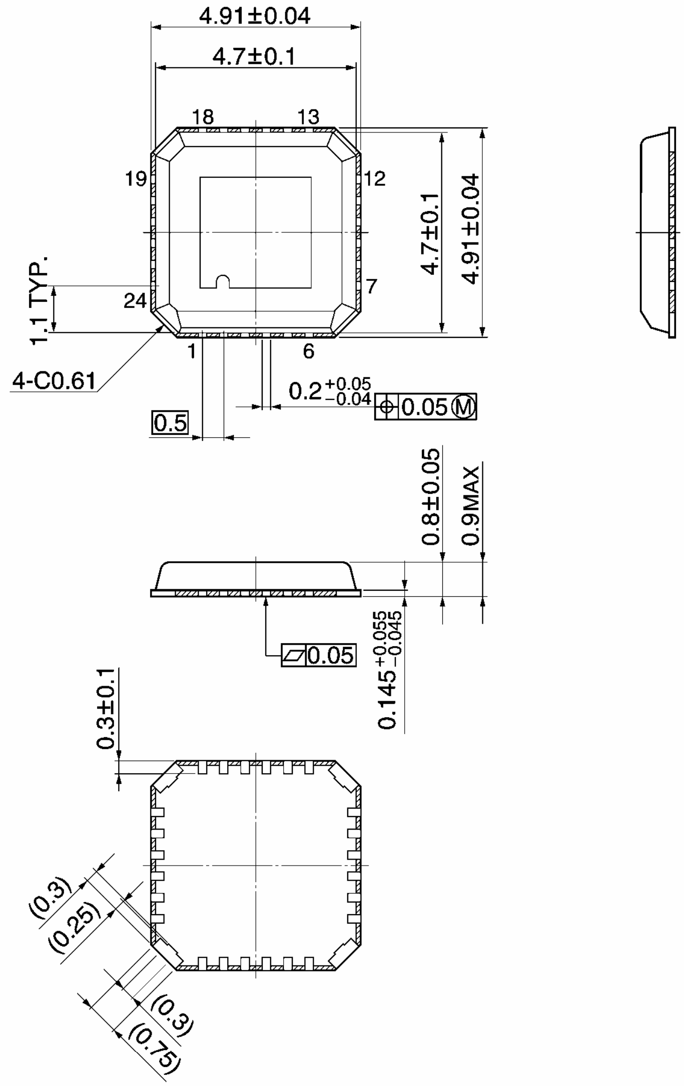
(1) Thermal shutdown circuit
Thermal shutdown circuits do not necessarily protect ICs under all circumstances. If the thermal shutdown circuits operate against the over temperature, clear the heat generation status immediately. Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the thermal shutdown circuit to not operate properly or IC breakdown before operation.

(2) 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 (TJ) 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 considerate the effect of IC heat radiation with peripheral components.

(3) 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.

Package Dimensions

QON24-P-0505-0.50 Unit: mm



Note 1) The solder plating portion in four corners of tne package shall not be treated as an external terminal.

Note 2) Don`t carry out soldering to four corners of the package.

Note 3) [hatched] area : Resin surface

Weight: 0.05 g (typ.)

About solderability, following conditions were confirmed

- Solderability

  (1) Use of Sn-37Pb solder Bath
  - solder bath temperature = 230°C
  - dipping time = 5 seconds
  - the number of times = once
  - use of R-type flux

  (2) Use of Sn-3.0Ag-0.5Cu solder Bath
  - solder bath temperature = 245°C
  - dipping time = 5 seconds
  - the number of times = once
  - use of R-type flux