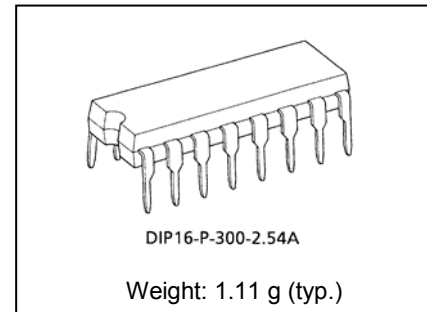TOSHIBA BiCD Process Integrated Circuit Silicon Monolithic

# TB67S112PG

## Parallel controlled solenoid driver

The TB67S112PG is a solenoid driver for parallel input.

Using the BiCD process, the output voltage of 50 V, and the output current of
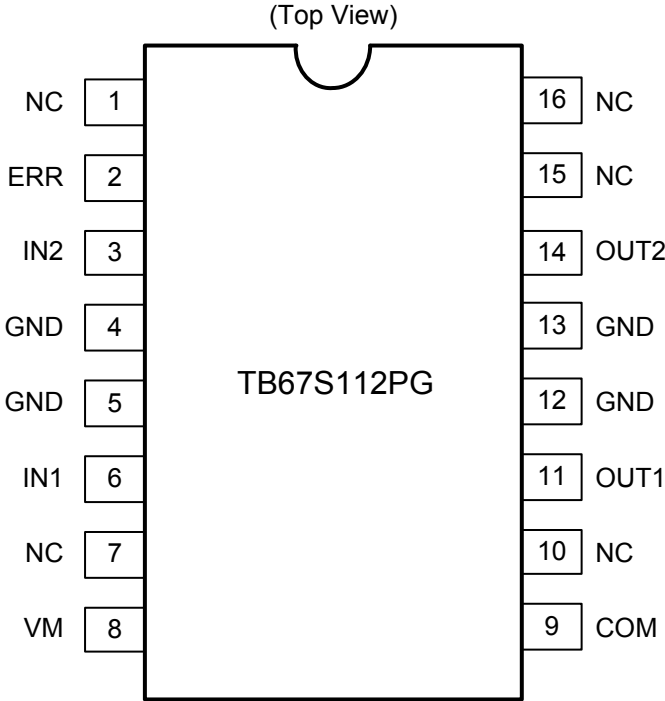
1.5 A/ch (absolute maximum rating) are realized.

DIP16-P-300-2.54A

Weight: 1.11 g (typ.)

## Features

· BiCD integrated circuit silicon monolithic.

· Capable of driving up to two solenoids simultaneously. (2-ch sink driver)

· Capable of driving a unipolar stepping motor with two chips.

· Built-in over current detection (automatic return / time control) at each output.

· Built-in thermal shutdown detection (automatic return / time control), which detects errors of the whole device.

· Built-in output MOSFET for low ON resistance (0.3 Ω (typ.)).

· High voltage and large current (Refer to "Absolute maximum ratings" and "Operating range".).

· Built-in various error detection functions (Thermal shutdown (TSD), over current detection (ISD), and Under voltage lockout(UVLO))
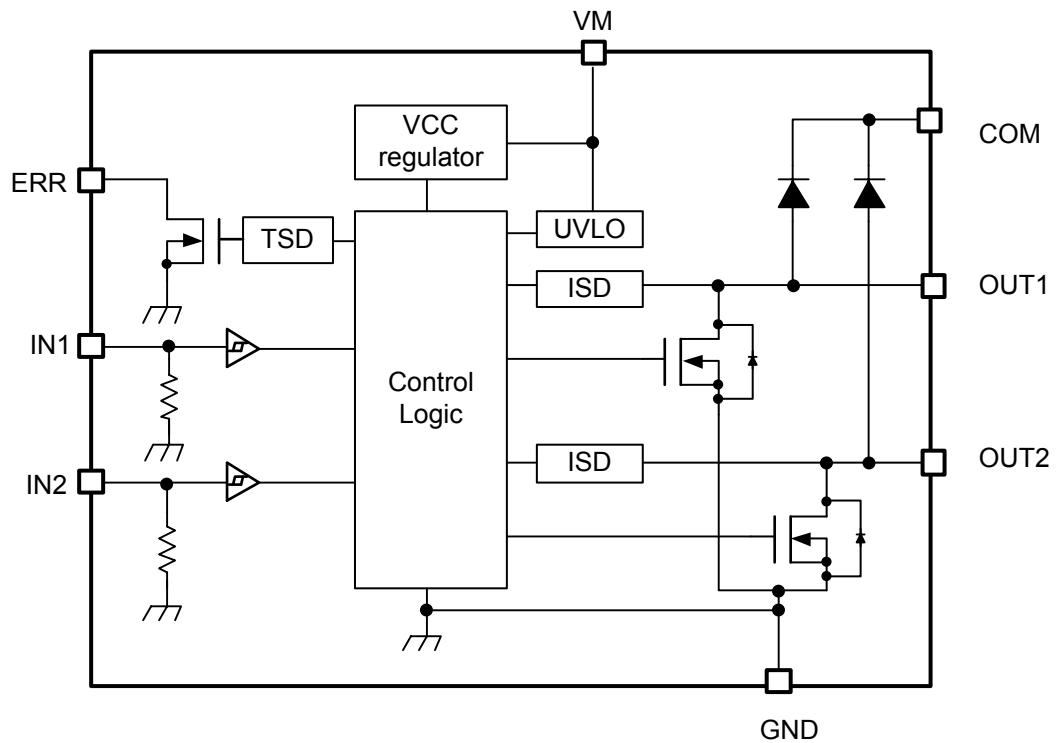
Note: Please be careful about the thermal conditions during use.

Start of commercial production
2019-09

**Pin Assignment**

(Top View)

| | | | | |
|---|---|---|---|---|
| NC | 1 | | 16 | NC |
| ERR | 2 | | 15 | NC |
| IN2 | 3 | | 14 | OUT2 |
| GND | 4 | TB67S112PG | 13 | GND |
| GND | 5 | | 12 | GND |
| IN1 | 6 | | 11 | OUT1 |
| NC | 7 | | 10 | NC |
| VM | 8 | | 9 | COM |

## Block Diagram



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

## IC considerations

When using TB67S112PG, the GND pattern of PCB should be a solid pattern and be externally terminated at only one point. Also, a grounding method should be considered for efficient heat dissipation.

Careful attention should be paid to the layout of the output, VM, COM, and GND traces, to avoid short circuits across output pins or to the power supply or ground. If such a short circuit occurs, the device may be permanently damaged.
Also, the utmost care should be taken for pattern designing and implementation of the device since it has power supply pins (VM, COM, OUT1, OUT2, and GND) through which a particularly large current may run. If these pins are wired incorrectly, an operation error may occur or the device may be destroyed.

The logic input pins must also be wired correctly. Otherwise, the device may be damaged owing to a current running through the IC that is larger than the specified current. Careful attention should be paid to design patterns and mountings.

## Pin Description

Pin description of pin No. 1 to 16.

| Pin No. | Pin name | Description |
|---|---|---|
| 1 | NC | Non-connection pin |
| 2 | ERR | Output pin for thermal shutdown signal |
| 3 | IN2 | OUT2 output control pin |
| 4 | GND | Ground pin |
| 5 | GND | Ground pin |
| 6 | IN1 | OUT1 output control pin |
| 7 | NC | Non-connection pin |
| 8 | VM | Connection pin for power supply |
| 9 | COM | COM pin |
| 10 | NC | Non-connection pin |
| 11 | OUT1 | Output pin 1 |
| 12 | GND | Ground pin |
| 13 | GND | Ground pin |
| 14 | OUT2 | Output pin 2 |
| 15 | NC | Non-connection pin |
| 16 | NC | Non-connection pin |

Please do not connect anything to the NC pins.

2019-07-08

## Input and Output Equivalent Circuit

| Pin name | Input / Output signal | Equivalent circuit |
|---|---|---|
| IN1<br>IN2 | Digital input (VIN(H)/VIN(L)) |  |
| ERR | Digital output VOD(L)<br>(Pull-up resistance: 10 kΩ to 100 kΩ) |  |
| OUT1<br>OUT2<br>GND<br>COM | VM power supply voltage(VM)<br>Output voltage(VOUT) |  |

The equivalent circuit may omitted or simplified for explanatory purposes.

2019-07-08

## Functional Description

### Relation between logic inputs and output MOSFETs

| Logic input | | Output MOSFET | |
|---|---|---|---|
| IN1 | IN2 | OUT1 | OUT2 |
| L | L | Off | Off |
| H | L | On | Off |
| L | H | Off | On |
| H | H | On | On |

### Output pin for thermal shutdown signal (ERR output function)

| ERR | Function |
|---|---|
| H | Normal operation |
| L | Thermal shutdown (TSD): active |

Note: ERR pin is the Nch MOS output pin of open drain type. When using this function, please pull up the ERR pin to VIN(H) level. It is in the Hi-Z state (internal MOS = OFF) in the normal operation. It outputs low (internal MOS = ON) when the thermal shutdown (TSD) is active.

When the thermal shutdown detection is cleared, the ERR pin outputs high level again (internal MOS = OFF).

Moreover, when the ERR pin is not used, please leave this pin open.
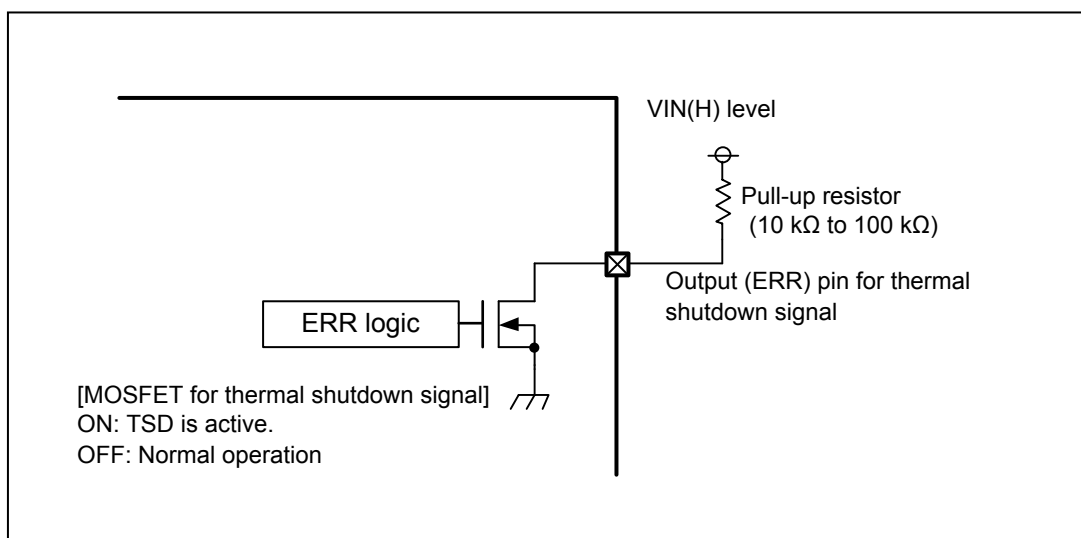
## Absolute Maximum Ratings (Ta = 25°C)

| Characteristics | Symbol | Rating | Unit |
|---|---|---|---|
| VM power supply | VM (max) | 50 | V |
| Output voltage (Note 3) | VOUT (max) | 50 | V |
| Output current (per one channel) | IOUT (max) | 1.5 | A |
| Logic input voltage | VIN(H) (max) | 6.0 | V |
| | VIN(L) (max) | -0.4 | V |
| ERR output pin voltage range | VOD (max) | 6.0 | V |
| ERR output pin inflow current range | IOD (max) | 20 | mA |
| Power dissipation | PD | 1.47 (Note 1)<br>2.7 (Note 2) | W |
| Operating temperature | Topr | -40 to 85 | °C |
| Storage temperature | Tstg | -55 to 150 | °C |
| Junction temperature | Tj (max) | 150 | °C |

Note 1: Standalone. When Ta exceeds 25°C, derating with 11.8 mW/°C is necessary.

Note 2: On PCB (size: 50 mm × 50 mm × 1.6 mm, Cu area: 50 %, single-side glass epoxy). When Ta exceeds 25°C, derating with 21.6 mW/°C is necessary.

Note 3: OUT1 pin, OUT2 pin, and COM pin

## Caution) 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 device does not have overvoltage detection circuit. 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 Range (Ta=-40 to 85°C)

| Characteristics | Symbol | Test condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| VM power supply voltage | VM | — | 4.5 | — | 47 | V |
| Output voltage (Note 1) | VOUT | — | 0 | — | 50 | V |
| Output current | IOUT | Ta=25°C, per one channel | — | 0.75 | 1.5 | A |

Note: Please use the device with extra margin regarding the absolute maximum ratings. Moreover, please pay attention to the thermal conditions enough during use.

Note 1: OUT1 pin, OUT2 pin, and COM pin

## Electrical Characteristics 1 (Ta=25°C, VM=24 V unless otherwise specified)

| Characteristics | | Symbol | Test conditions | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|---|
| Logic input voltage | | VIN(H) | Logic input voltage High level | 2.0 | — | 5.5 | V |
| | | VIN(L) | Logic input voltage Low level | GND | — | 0.8 | V |
| Input hysteresis voltage | | VIN(HYS) | Logic input pin (Note 1) | 100 | — | 300 | mV |
| Logic input current | High | IIN(H) | Logic input voltage High level (VIN=3.3 V) | — | 33 | 55 | μA |
| | Low | IIN(L) | Logic input voltage Low level (VIN=0 V) | — | — | 1 | μA |
| Consumption current | | IM | Output pins: open, in normal operation, output-stage operation | — | 1.6 | 3.2 | mA |
| Remaining voltage of ERR output | | VOD(L) | IOD=10 mA | 0 | — | 0.5 | V |
| Regenerative diode forward voltage | | VFN | IOUT=1.5 A | 0.5 | 1.1 | 1.5 | V |
| Output MOSFET OFF leakage current | | Ileak | VOUT=50 V, Output MOSFET: OFF | — | — | 1 | μA |
| Output MOSFET On-resistance between drain and source | | RON(D-S) | IOUT=1.5 A | — | 0.3 | 0.4 | Ω |

Note 1:  VIN (HYS) is defined as the difference between VIN (H) and VIN (L). VIN (H) is the voltage when the voltage (VIN) to the input pins (IN1 and IN2) is raised and the output pins (OUT1 and OUT2) change from H to L. VIN (L) is the voltage when the VIN (H) is lowered and the output pins (OUT1 and OUT2) change from L to H.
VIN (HYS) = VIN (H) – VIN (L)

Note:  The internal circuits are designed to avoid EMF or leakage current; when the logic signal is applied while the VM is not supplied. Please consider the control signal timing before supplying the VM.

## Electrical Characteristics 2 (Ta =25°C, VM = 24 V, unless otherwise specified)

| Characteristics | Symbol | Test conditions | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| Thermal shutdown (TSD) circuit operating temperature (Note 1) | TjTSD | — | 150 | 160 | 175 | °C |
| Thermal shutdown (TSD) hysteresis | TjTSDhys | — | — | 30 | — | °C |
| UVLO voltage (Note 2) | VUVLO | At rising VM | 3.8 | 4.0 | 4.2 | V |
| UVLO hysteresis voltage | Vhys_uvlo | — | — | 200 | — | mV |
| Over current detection (ISD) circuit operating current (Note 3) | ISD | (Design value) | 2.1 | 3.0 | 5.0 | A |

Note 1: Thermal shutdown (TSD)
When the junction temperature of the IC reaches the TSD threshold, the TSD circuit is triggered; the internal reset circuit then turns off the output transistors. In order to avoid malfunction by switching etc., detection mask time is prepared inside IC. Since the operating temperature of TSD circuit has a hysteresis width, the IC returns automatically when the junction temperature is lowered to the temperature to return.
The TSD circuit is a backup function to detect a thermal error, therefore is not recommended to be used aggressively.

Note 2: Under voltage lockout (UVLO)
When the supply voltage to VM pin is 3.8V or less (typ.), the internal circuit is triggered; the internal reset circuit then turns off the output transistors. Once the UVLO is triggered, it can be cleared by reasserting the VM supply voltage to 4.0V or more (typ.)

Note 3: Over current detection (ISD)
When the output current reaches the threshold, the ISD circuit operates and turns off the output transistors. Noise rejection blanking time is provided to avoid misdetection by switching. The IC operation recovers automatically after specified recovery time passes.

## Cautions on Over current detection (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 the 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 due to an output short-circuit.
The ISD circuit is only intended to provide a temporary protection against an output short-circuit. If such a condition persists for a long time, the device may be damaged due to overstress. Overcurrent conditions must be removed immediately by external hardware.

## 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 due 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 device or other components will be damaged or fail due to the motor back-EMF.

## IC Mounting

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

### AC Electrical Characteristics (Ta = 25°C, VM = 24 V, unless otherwise specified)

| Characteristics | Symbol | Test condition | Min | Typ. | Max | Unit |
|---|---|---|---|---|---|---|
| Minimum pulse width of logic input | tIN(twp) | (Design value) | 500 | — | — | ns |
| | tIN(twn) | (Design value) | 500 | — | — | ns |
| Output MOSFET switching characteristics | tr | L=350mH,R=84Ω | 50 | 100 | 200 | ns |
| | tf | L=350mH,R=84Ω | 40 | 80 | 160 | ns |
| Output MOSFET response characteristics | tpLH(IN) | Between IN and OUT , OUT: pull-up(2kΩ/VM) | — | 500 | — | ns |
| | tpHL(IN) | Between IN and OUT, OUT: pull-up(2kΩ/VM) | — | 500 | — | ns |
| Over current detection (ISD) masking time | tISD(mask) | — | — | 1.25 | — | µs |
| Off time after over current detection (ISD) | — | — | — | 3 | — | ms |
| Thermal shutdown (TSD) masking time | tTSD(mask) | — | 2.0 | 5.0 | 8.0 | µs |

### Timing chart of AC characteristics
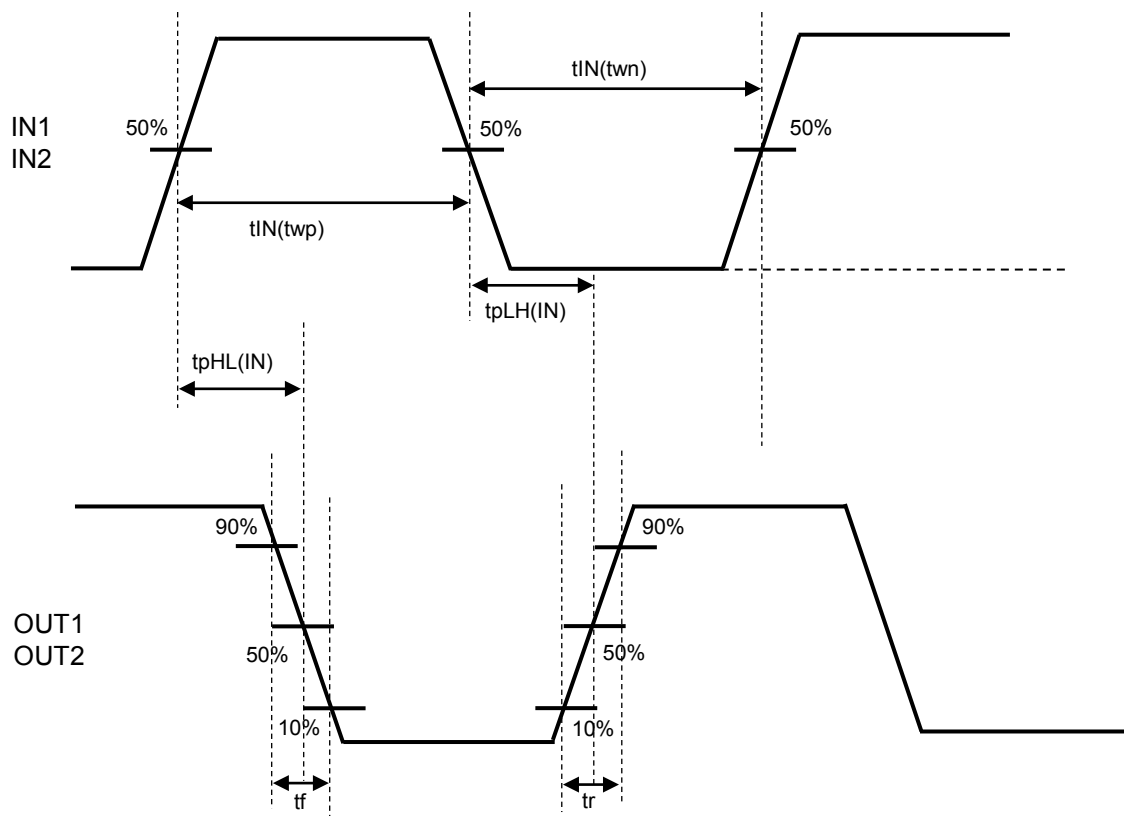


Timing charts may be simplified for explanatory purposes.

## Application Circuit Example
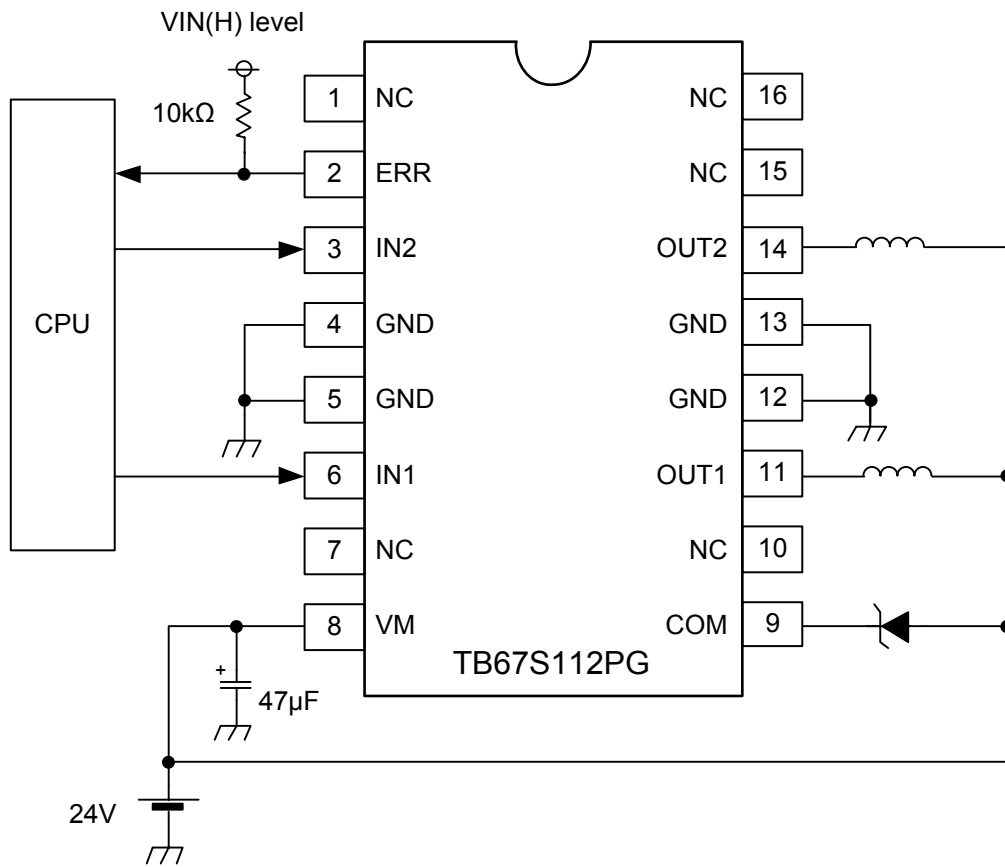


The application circuits shown in this document are provided for reference purposes only, and are not guaranteed for mass production.

Select the zener diode that meets the condition as follows; VM + VFN + VZ < output rating of 50V

When a zener diode is not used, the COM pin should be connected to VM.

## Package Dimensions

DIP16-P-300-2.54A

(Unit: mm)
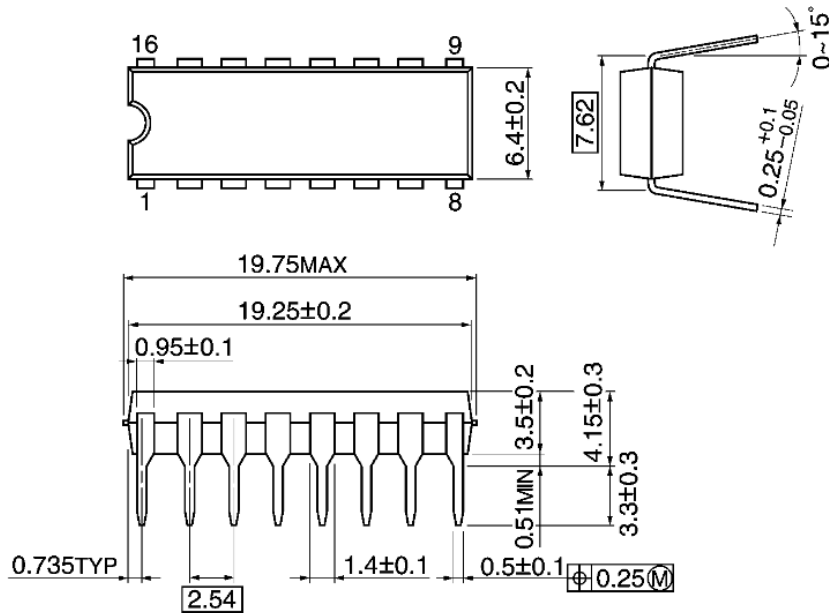


Weight 1.11g (typ.)

## Notes on Contents

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

(2) Equivalent Circuits
The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.

(3) Timing Charts
Timing charts may be simplified for explanatory purposes.

(4) Application Circuits
The application circuits shown in this document are provided for reference purposes only. Thorough evaluation is required, especially at the mass production design stage. Providing these application circuit examples does not grant a license for industrial property rights.

## 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 (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.

(4) Back-EMF

When a motor reverses the rotation 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.

# RESTRICTIONS ON PRODUCT USE

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https://toshiba.semicon-storage.com/