

TOSHIBA BiCMOS Integrated Circuit Silicon Monolithic

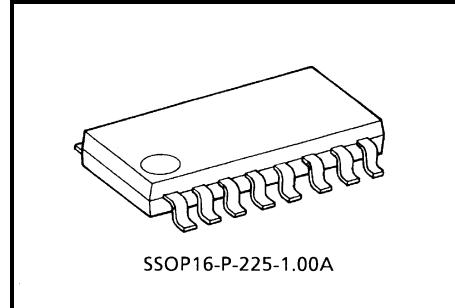
TB9000F

5V Voltage Regulator with Watchdog Timer

The TB9000F is an IC specially designed for microcomputer systems in automobiles. It features low standby current and various system reset functions.

With an external pass Tr., the TB9000F can supply a high output current. A current limiter function is incorporated as a protective function.

System reset includes low-voltage reset, power-on reset, and watchdog timer functionality.



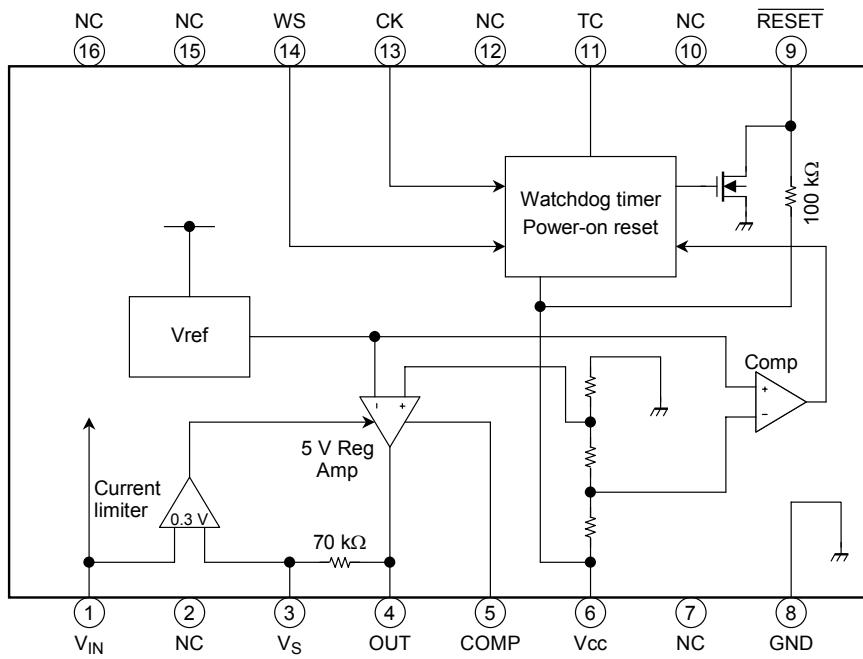
SSOP16-P-225-1.00A

Weight: 0.14 g (typ.)

Features

- Accurate output: $5.0 \text{ V} \pm 0.15 \text{ V}$
- Low current consumption: $120 \mu\text{A}$ ($\text{VIN} = 12 \text{ V}$, $\text{Ta} = 25^\circ\text{C}$) at 5 V output + reset timer
- Reset functions: Low-voltage reset/power-on reset/watchdog timer
- Current limiter: Adjustable with external resistor
- Operating temperature: -40 to 125°C
- Small SMD package: SSOP- 16-pin

Block Diagram & Pin Layout



Note: Some functional blocks, circuits, or constants are omitted or simplified in the block diagram to clarify the descriptions of the relevant features.

Pin Description

| Pin No. | Symbol | Description |
|-------------------------|----------|---|
| 1 | V_{IN} | Power supply input pin. It contains a current limiter and startup circuit. |
| 3 | V_S | Detection pin for the V_{CC} current limiter. Any voltage drop occurring in the external resistor R_S between pins V_{IN} and V_S is monitored. The current limiter is actuated when the voltage drop exceeds 0.3 V. Ex.) When the current limiter need to be actuated at a load current of 600 mA: $R_S = 0.3 \text{ V} / 600 \text{ mA} = 0.5 \Omega$. |
| 4 | OUT | This pin is used to connect the base of an external PNP transistor. The output voltage is controlled by an internal op-amp to maintain it stably at 5 V. Since the recommended I_{OUT} current is 8 mA, an output current of 600 mA can be run if H_{FE} of the external transistor is 80 or more. |
| 5 | COMP | Phase-compensating pin for V_{CC} . Connect a phase-compensating capacitor between pin V_{CC} and this pin. |
| 6 | V_{CC} | Voltage detection pin for the 5 V constant-voltage power supply, V_{CC} . It also supplies power to the reset timer circuit. |
| 8 | GND | Grounded |
| 9 | RESET | Reset output pin for power-on reset and watchdog timer. • Generates a reset signal that is determined by CT at the TC pin. • If no clock is fed to the CK input, this pin generates a reset pulse intermittently. This is an N-MOS drain output with a 100 k Ω pull-up resistor to V_{CC} . |
| 11 | TC | Time setup pin for the reset and watchdog timers. Connect capacitor CT to GND. The time is set up by internal constant current. |
| 13 | CK | Clock input pin for the watchdog timer. This pin detects the rising edge of the input signal and does not require external coupling capacitor. |
| 14 | WS | Watchdog timer function ON/OFF control pin. Set to LOW for active mode and HIGH for inactive mode. |
| 2, 7, 10, 12, 15, 16 | NC | Not connected. (Electrically, this pin is completely open.) |

Functional Description

The TB9000F incorporates a constant-voltage 5 V power supply function to feed stable power to the CPU, while the system reset and CPU monitor functions ensure stable operation of the CPU, etc. These functions are explained below.

(1) Constant-voltage 5V power supply function

This constant-voltage function has a reference voltage V_{ref} in the IC that is insusceptible to temperature changes and input voltage fluctuations. The power supply circuit is designed in such a way that this voltage is stepped up to 5 V by using an OP amp and a voltage-dividing resistor. The OP amp, dividing resistor and an output transistor connected to the OP amp output together configure a closed loop.

An overcurrent protection function is incorporated as a protective measure in case a fault such as shorting to GND occurs in the 5 V output. A current detecting resistor is inserted between the V_{IN} and the V_S pins, and a voltage drop across this resistor is detected by a comparator, thereby suppressing the operation of the OP amp to ensure that the voltage drop will not exceed 0.3 V. In this way, a current limiter function is actuated to prevent any more current from flowing.

(2) System reset function (see Timing Charts)

- **Voltage monitoring function**

When powered on, the power-on reset timer starts counting the moment the voltage V_{CC} applied to the CPU exceeds V_{TH} . When powered off, this voltage monitoring function outputs a reset signal immediately when V_{CC} drops below V_{TH} . A reset signal is also output immediately when V_{CC} drops for some reason during normal operation. Then, when V_{CC} is restored to the normal voltage and exceeds V_{TH} , the power-on reset timer starts counting.

The reset signal is output from the $RESET$ pin.

- **Power-on reset timer function**

To allow the 5 V constant voltage to stabilize at power-on, as well as provide sufficient time for the clock oscillation in the CPU to stabilize, the device remains reset for a predetermined time before being released from the reset state. The duration of this time can be set as desired by choosing appropriate values for the external capacitor connected to the TC pin.

The system starts charging the capacitor when the V_{CC} voltage exceeds V_{TH} . When this charge voltage exceeds 4 V, the capacitor is discharged by the IC's internal transistor. When the capacitor is discharged down to 2 V, the reset signal is inverted to deactivate the reset.

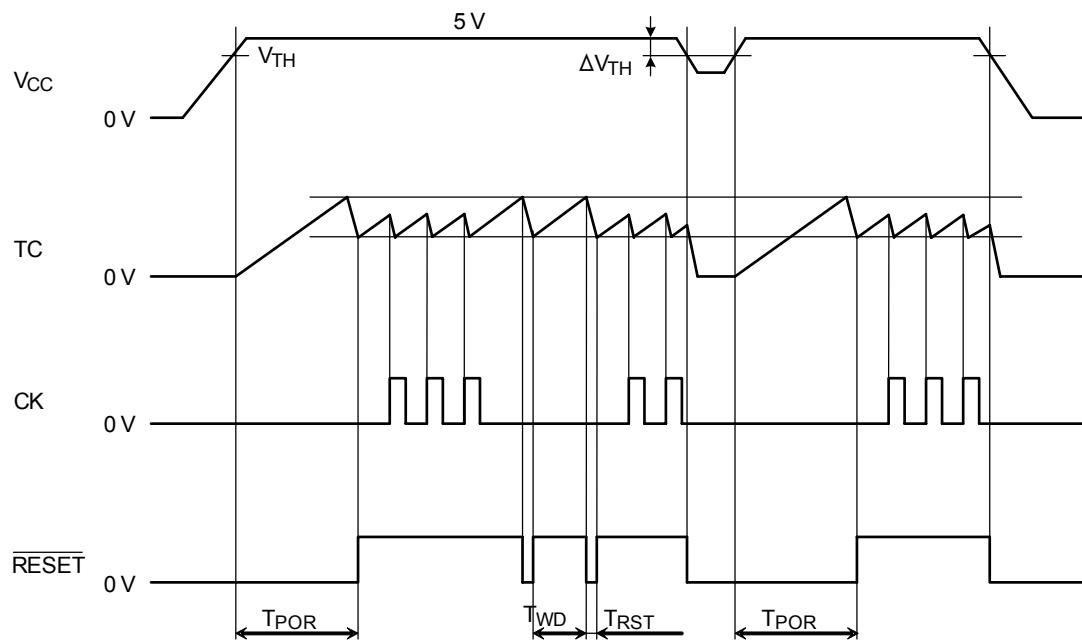
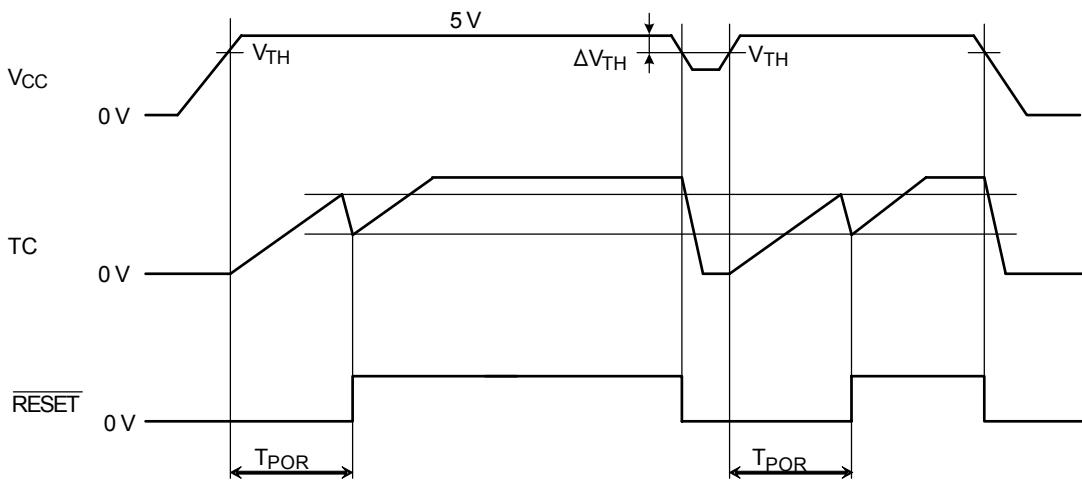
- **Watchdog timer function**

Program your system to output a clock each time one program routine is finished in the CPU system software, and input this clock to the CK pin of the IC. The IC's TC pin is repeatedly charged and discharged between 2 V and 4 V. However, when a clock is input, it switches over and starts discharging in the middle of charging and then starts charging from 2 V again. Since the clock is generated at predetermined intervals when the CPU system is operating normally, the TC pin switches over and starts discharging before the charge voltage reaches 4 V. However, if no clock is input while being charged from 2 V to 4 V, the clock is assumed to have stopped, i.e., the CPU system has gone wild, so that a reset signal is output to reset the CPU system.

- **Watchdog timer stop function**

The watchdog timer can be switched ON or OFF by use of the WS pin. If the WS pin is fixed to LOW, the watchdog timer will be active. (See Timing Chart 1.) If the WS pin is fixed to HIGH, the watchdog timer will be inactive. (See Timing Chart 2.) When the WS pin is fixed to HIGH, no reset signal is output, in which case only the power-on reset timer is useful.

Note: The overcurrent protection feature is intended only to protect the IC from a temporary short circuit. A short circuit over an extended period of time may place excessive stress on the IC, possibly causing it to be damaged. The system must be configured so that any overcurrent condition will be eliminated as soon as possible.

Timing Chart 1**WS = LOW****Timing Chart 2****WS = HIGH**

Note: Timing charts may be simplified to clarify the descriptions of features and operations.

Maximum Rating (Ta = 25°C)

| Characteristics | Symbol | Rating | Unit |
|-----------------------|---|------------|------|
| Input voltage | V _{IN} | 45 (1 s) | V |
| | COMP, V _{cc} , RESET, CK, WS, TC | 6.0 | V |
| Output current | I _{OUT} | 10 | mA |
| Operating temperature | T _{opr} | –40 to 125 | °C |
| Storage temperature | T _{stg} | –55 to 150 | °C |
| Lead temperature-time | T _{sol} | 240 (10 s) | °C |

SSOP16-P-225 Thermal Resistance Data (Ta = 25°C)

| Characteristics | Rating | Unit | Test Condition |
|-------------------|--------|------|---------------------------------------|
| R _{θj-a} | 200 | °C/W | Without radiation board |
| PD1 | 0.6 | W | Without radiation board |
| PD2 | 0.78 | W | 50 × 50 × 1.6 mm 30% Cu board mounted |

Note: The absolute maximum ratings of a semiconductor device are a set of specified parameter values that must not be exceeded during operation, even for an instant.

If any of these levels is exceeded during operation, the device's electrical characteristics may be irreparably altered and the reliability and lifetime of the device can no longer be guaranteed, possibly causing damage to any other equipment with which it is used. Applications using the device should be designed so that the maximum ratings will never be exceeded in any operating conditions.

Ensuring that the parameter values remain within these specified ranges during device operation will help to ensure that the integrity of the device is not compromised.

Electrical Characteristics ($V_{IN} = 6$ to 16 V, $ILOAD = 10$ mA, $Ta = -40$ to 125 °C)

| Characteristics | Symbol | Pin | Test Circuit | Test Condition | Min | Typ. | Max | Unit |
|---------------------------|-------------------|-----------------|--------------|---|---------------------|-------------|---------------------|------|
| Output voltage | VREG | V _{CC} | — | Ta = -40 to 105°C | 4.85 | 5.0 | 5.15 | V |
| | | | | Ta = -40 to 125°C | 4.82 | 5.0 | 5.15 | |
| Line regulation | VLINE | V _{CC} | — | V _{IN} = 6 to 40 V | — | 0.1 | 0.5 | % |
| Load regulation | VLOAD | V _{CC} | — | ILOAD = 1 to 300 mA | — | 0.2 | 1.0 | % |
| Temperature coefficient | — | V _{CC} | — | | — | 0.01 | — | %/°C |
| Output voltage | V _O L | RESET | — | I _{OL} = 2 mA | — | — | 0.3 | V |
| Output leakage current | I _{LEAK} | RESET | — | V _{IN} (RESET) = V _{CC} | — | — | 5 | μA |
| Input current | I _{IN} | TC | — | V _{IN} (TC) = GND | — | -10 | — | μA |
| Input current | I _{IN} | CK | — | V _{IN} (CK) = 0 to V _{CC} | -5 | — | 5 | μA |
| Input current | I _{IN} | WS | — | V _{IN} (WS) = 0 to V _{CC} | -5 | — | 5 | μA |
| Input voltage | VIH | CK | — | | 0.8 V _{CC} | — | — | V |
| | VIL | | | | — | — | 0.2 V _{CC} | |
| Input voltage | VIH | WS | — | | 0.8 V _{CC} | — | — | V |
| | VIL | | | | — | — | 0.2 V _{CC} | |
| Current limiter detection | VLIMIT | V _{CC} | — | | 0.225 | 0.3 | 0.375 | V |
| Current consumption | I _{CC} | — | — | Ta = 25°C, V _{IN} = 12 V | — | 120 | 170 | μA |
| | | | | Ta = -40 to 125°C V _{IN} = 12 V | — | 120 | 190 | |
| Reset detection voltage | V _{TH} | V _{CC} | — | | 4.5 | 4.7 | 4.9 | V |
| | ΔV _{TH} | | | V _{CC} - V _{TH} | 0.25 | 0.30 | 0.35 | |
| Power-on reset | TPOR | RESET | — | | 280 × CT | 400 × CT | 520 × CT | ms |
| Watchdog timer | TWD | RESET | — | | 140 × CT | 200 × CT | 260 × CT | |
| Reset timer | TRST | RESET | — | | 4.0 × CT | 8.0 × CT | 12.0 × CT | |
| Clock pulse width | Tw | CK | — | | 3 | — | — | μs |

Note 1: CT is measured in units of μF.

Note 2: The specification values for power-on reset, watchdog timer and reset timer above are guaranteed only for the IC itself. Any practical application of the IC should take into account fluctuations in the CT value.

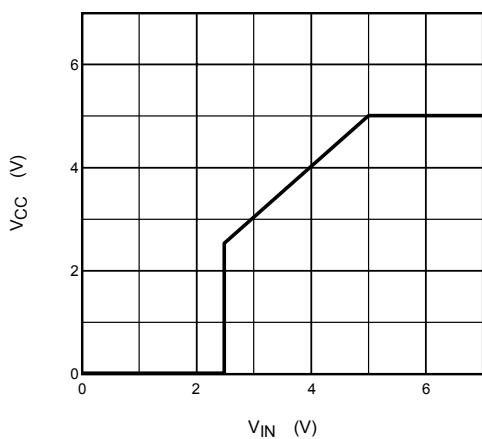
Note 3: For the above current consumption I_{CC}, it is specified that ILOAD = 0 mA.

Recommended Conditions

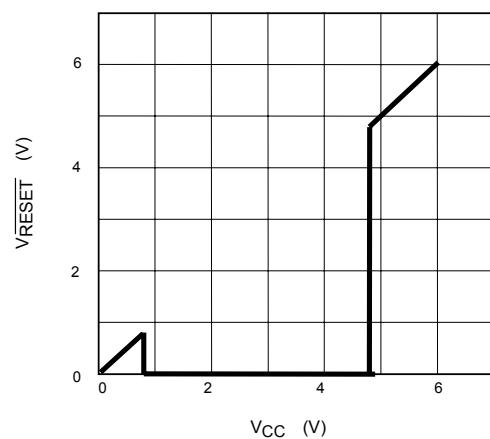
| Part Name | Min | Typ. | Max | Unit |
|-----------|------|------|-----|------|
| CT | 0.01 | 0.25 | 10 | μF |

Reference Characteristics

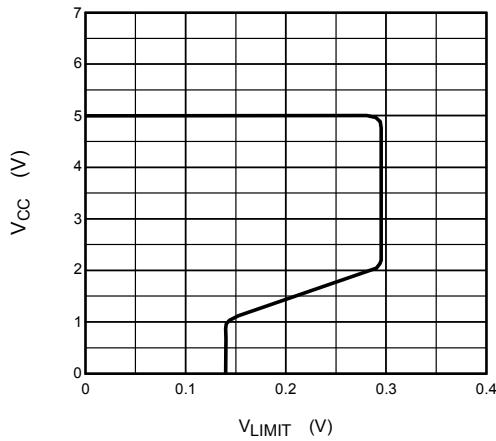
Input – Output Characteristics



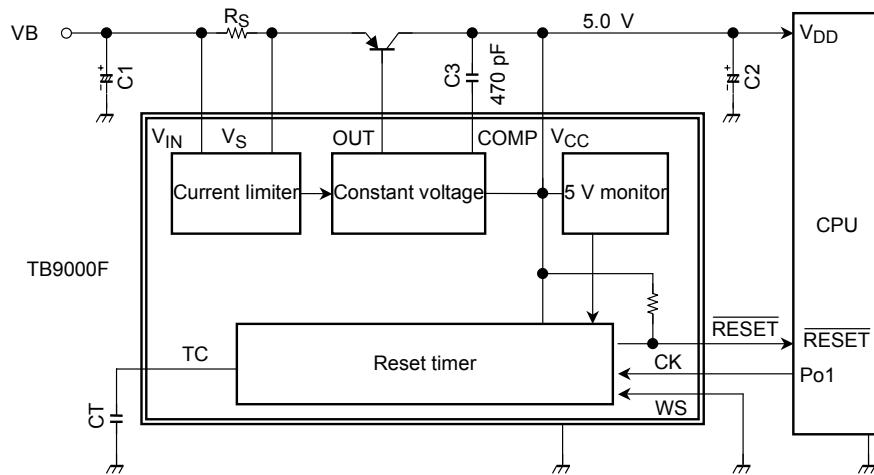
RESET Output Characteristics



Current Limiter Characteristics



Example of Application Circuit



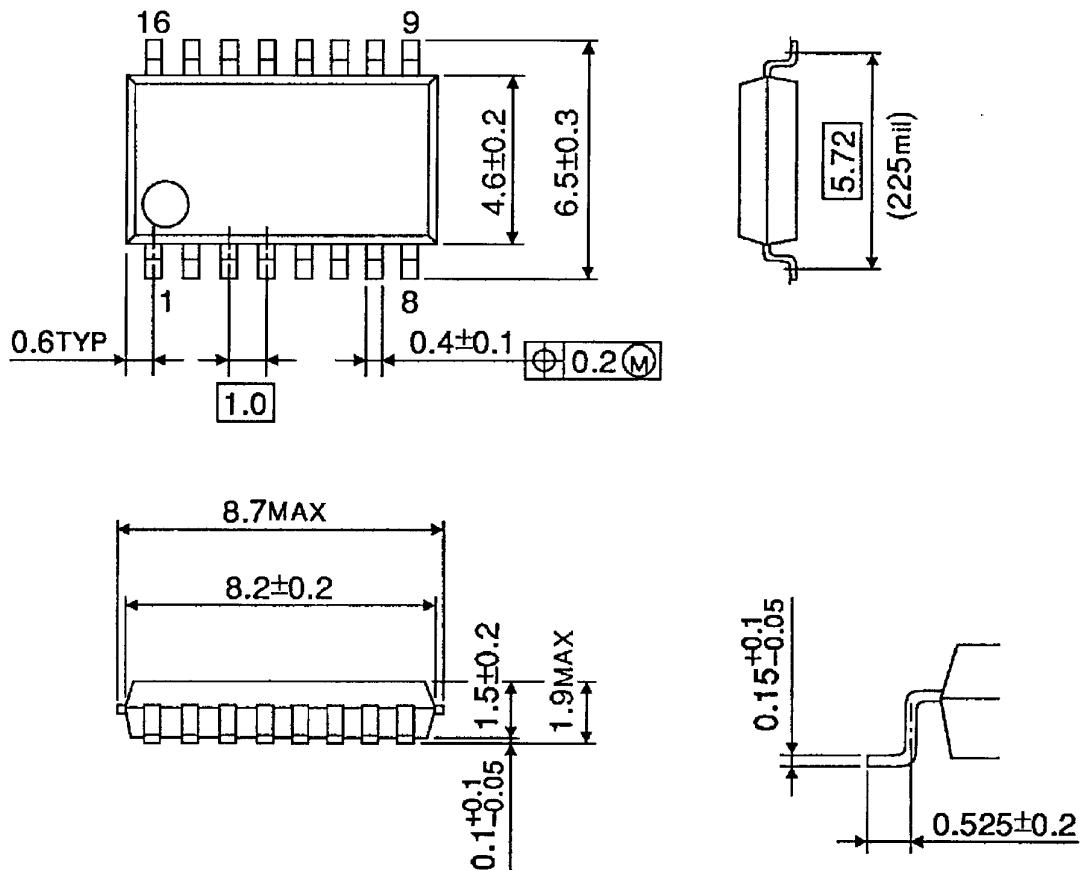
Caution for Wiring

- Note 1: C1 and C2 are for absorbing disturbances, noise, etc. C3 is for phase compensation.
- Note 2: Connect each capacitor as close to the IC as possible.
- Note 3: Ensure that the IC is mounted correctly. Failure to do so may result in the IC or target equipment being damaged.
- Note 4: The application circuit shown above is not intended to guarantee mass production. A thorough evaluation is required when designing an application circuit for mass production.

Package Dimensions

SSOP16-P-225-1.00A

Unit : mm



Weight: 0.14 g (typ.)

RESTRICTIONS ON PRODUCT USE

030619EBA

- The information contained herein is subject to change without notice.
- The information contained herein is presented only as a guide for the applications of our products. No responsibility is assumed by TOSHIBA for any infringements of patents or other rights of the third parties which may result from its use. No license is granted by implication or otherwise under any patent or patent rights of TOSHIBA or others.
- TOSHIBA is continually working to improve the quality and reliability of its products. Nevertheless, semiconductor devices in general can malfunction or fail due to their inherent electrical sensitivity and vulnerability to physical stress. It is the responsibility of the buyer, when utilizing TOSHIBA products, to comply with the standards of safety in making a safe design for the entire system, and to avoid situations in which a malfunction or failure of such TOSHIBA products could cause loss of human life, bodily injury or damage to property.
In developing your designs, please ensure that TOSHIBA products are used within specified operating ranges as set forth in the most recent TOSHIBA products specifications. Also, please keep in mind the precautions and conditions set forth in the "Handling Guide for Semiconductor Devices," or "TOSHIBA Semiconductor Reliability Handbook" etc..
- The TOSHIBA products listed in this document are intended for usage in general electronics applications (computer, personal equipment, office equipment, measuring equipment, industrial robotics, domestic appliances, etc.). These TOSHIBA products are neither intended nor warranted for usage in equipment that requires extraordinarily high quality and/or reliability or a malfunction or failure of which may cause loss of human life or bodily injury ("Unintended Usage"). Unintended Usage include atomic energy control instruments, airplane or spaceship instruments, transportation instruments, traffic signal instruments, combustion control instruments, medical instruments, all types of safety devices, etc.. Unintended Usage of TOSHIBA products listed in this document shall be made at the customer's own risk.
- The products described in this document are subject to the foreign exchange and foreign trade laws.
- TOSHIBA products should not be embedded to the downstream products which are prohibited to be produced and sold, under any law and regulations.