TOSHIBA BiCMOS Integrated Circuit Silicon Monolithic

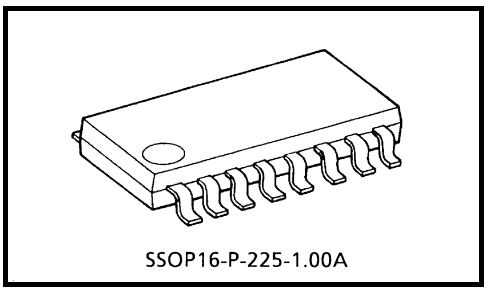
TB9000FG

5 V Voltage Regulator with Watchdog Timer

The TB9000FG 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 TB9000FG 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.



Weight: 0.14 g (typ.)

Features

- Accurate output: 5.0 V ± 0.15 V
- Low current consumption: 120 μA (V_{IN} = 12 V,Ta = 25°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-16pin
- The product(s) is/are compatible with RoHS regulations (EU directive 2002 / 95 / EC) as indicated, if any, on the packaging label ("[[G]]/RoHS COMPATIBLE", "[[G]]/RoHS [[Chemical symbol(s) of controlled substance(s)]]", "RoHS COMPATIBLE" or "RoHS COMPATIBLE, [[Chemical symbol(s) of controlled substance(s)]]>MCV").

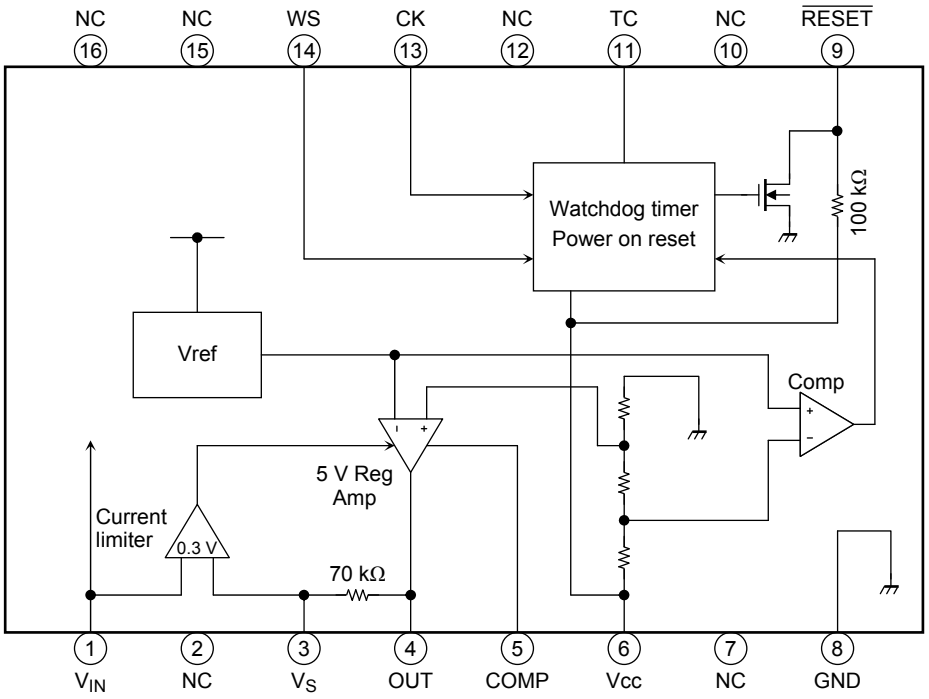
About solderability, the following conditions were confirmed.

Solderability

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

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 V/600 mA = 0.5 Ω.
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	$\overline{\text{RESET}}$	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 kΩ 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 TB9000FG 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 5 V 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 VTH. When powered off, this voltage monitoring function outputs a reset signal immediately when V_{CC} drops below VTH. 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 VTH, the power-on reset timer starts counting.

The reset signal is output from the $\overline{\text{RESET}}$ 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 VTH. 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**

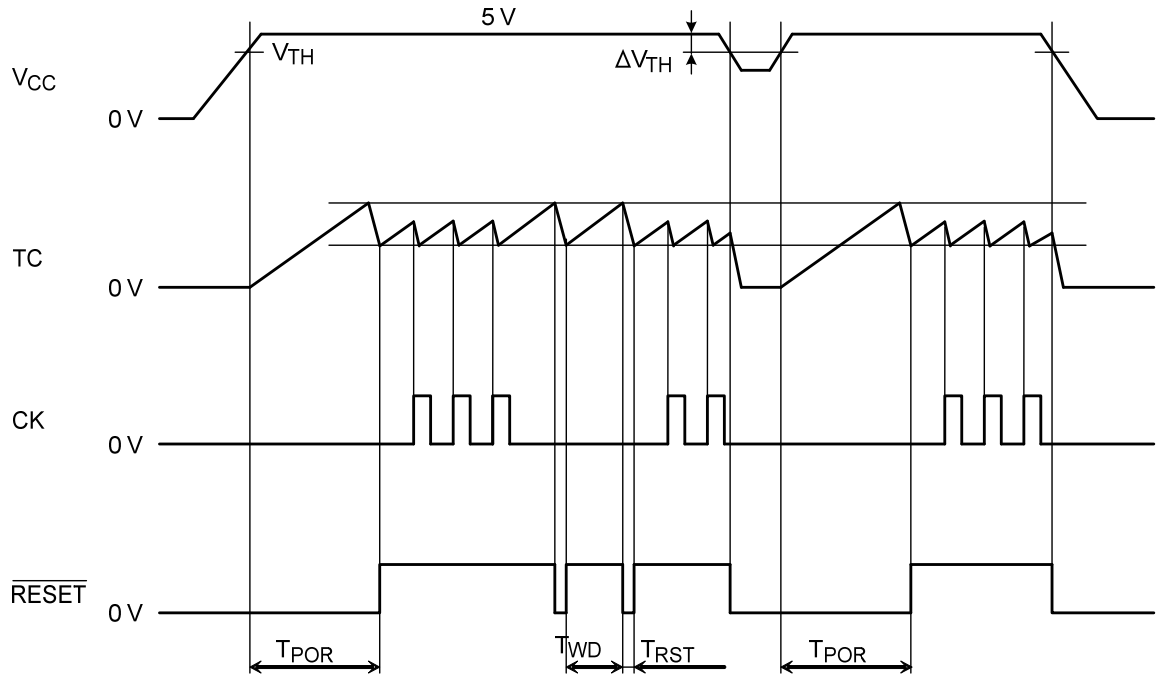
Program your system to output a clock each time one program routine is finished in the CPU system software, and input this clock to the CK pin of the IC. The IC's TC pin is repeatedly charged and discharged between 2 V and 4 V. However, when a clock is input, it switches over and starts discharging in 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**

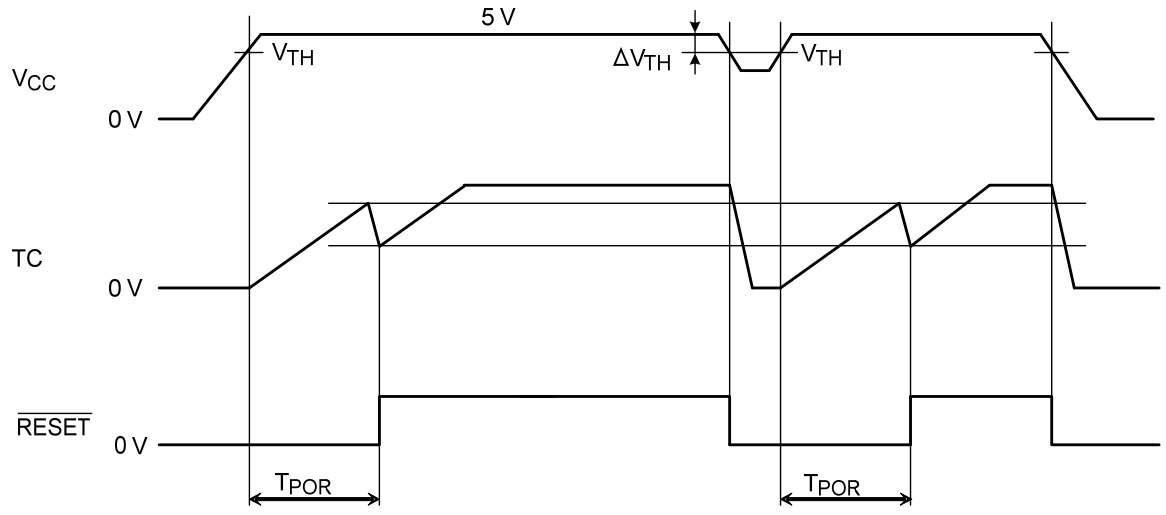
The watchdog timer can be switched ON or OFF by use of the WS pin. If the WS pin is fixed to LOW, the watchdog timer will be active. (See Timing Chart 1.) If the WS pin is fixed to HIGH, the watchdog timer will be inactive. (See Timing Chart 2.) When the WS pin is fixed to HIGH, no reset signal is output, 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 1: Definitions of symbols used in this timing chart are provided in the Electrical Characteristics table.

Note 2: Timing charts may be simplified to clarify the descriptions of features and operations.

Absolute Maximum Rating (Ta = 25°C)

Characteristics	Symbol	Pin	Rating	Unit
Input voltage	$V_{IN}1$	V_{IN}, V_S	45 (1 s)	V
	$V_{IN}2$	V_{CC}	6.0	
	$V_{IN}3$	CK, WS, TC	V_{CC}	
Output current	$I_{OUT}1$	OUT	10	mA
	$I_{OUT}2$	$\overline{RESET}$	5	
Output voltage	$V_{OUT}1$	OUT	45 (1 s)	V
	$V_{OUT}2$	$\overline{RESET}$	V_{CC}	
Operating temperature	T_{opr}	−	−40 to 125	°C
Storage temperature	T_{stg}	−	−55 to 150	°C

SSOP16-P-225-1.00A Thermal Resistance Data (Ta = 25°C)

Characteristics	Rating	Unit	Test Condition
Rθj-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 absolute 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

(Unless otherwise specified, 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	VOL	$\overline{RESET}$	−	IOL = 2 mA	−	−	0.3	V
Output leakage current	ILEAK	$\overline{RESET}$	−	$V_{IN}(\overline{RESET})$ = V_{CC}	−	−	5	μA
Input current	IIN	TC	−	V_{IN}(TC) = GND	−	−10	−	μA
Input current	IIN	CK	−	V_{IN}(CK) = 0 to V_{CC}	-5	−	5	μA
Input current	IIN	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_{IN}, V_S	−		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	VTH	V_{CC}	−		4.5	4.7	4.9	V
	ΔVTH			V_{CC} − VTH	0.25	0.30	0.35	
Power-on reset	TPOR	$\overline{RESET}$	−		280 × CT	400 × CT	520 × CT	ms
Watchdog timer	TWD	$\overline{RESET}$	−		140 × CT	200 × CT	260 × CT	ms
Reset timer	TRST	$\overline{RESET}$	−		4.0 × CT	8.0 × CT	12.0 × CT	ms
Clock pulse width	Tw	CK	−		3	−	−	μs

Note1: CT is measured in units of μF.

Note2: 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.

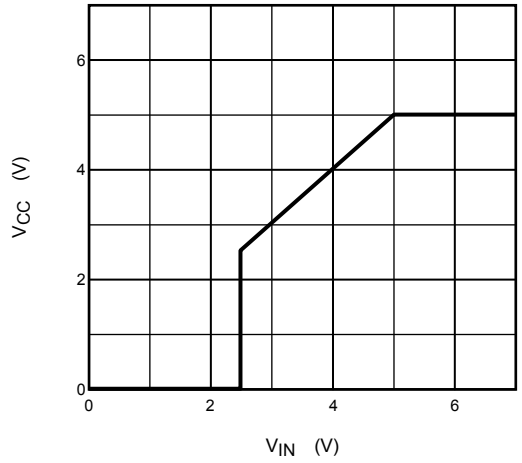
Note3: For the above current consumption Icc, it is specified that ILOAD = 0 mA.

Operating Conditions

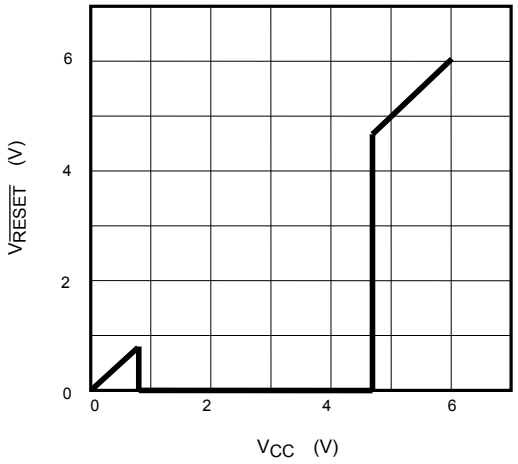
Part Name	Min	Typ.	Max	Unit
CT	0.01	0.25	10	μF

Reference Characteristics

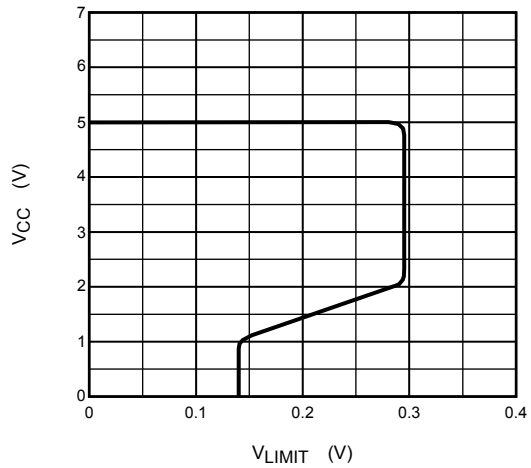
Input – Output Characteristics



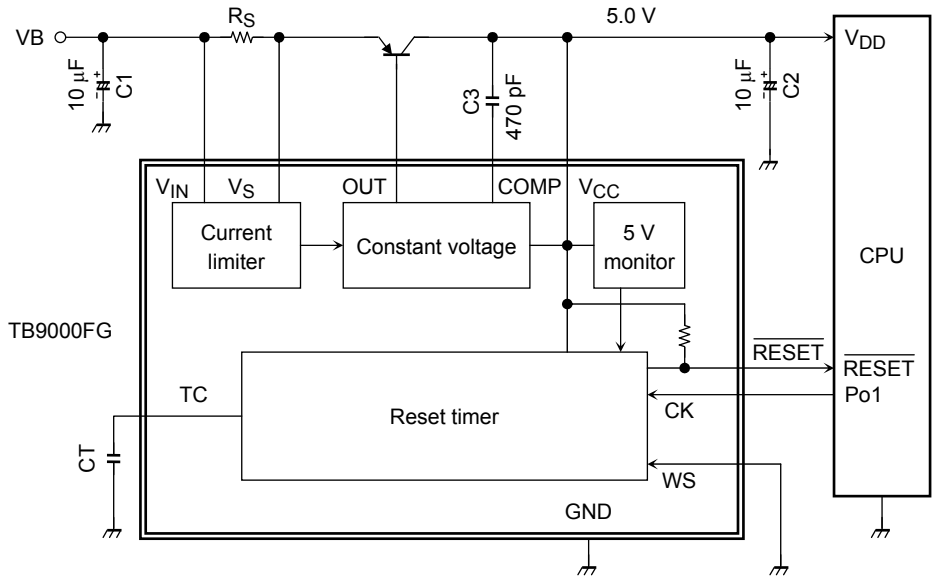
$\overline{\text{RESET}}$ Output Characteristics



Current Limiter Characteristics



Example of Application Circuit



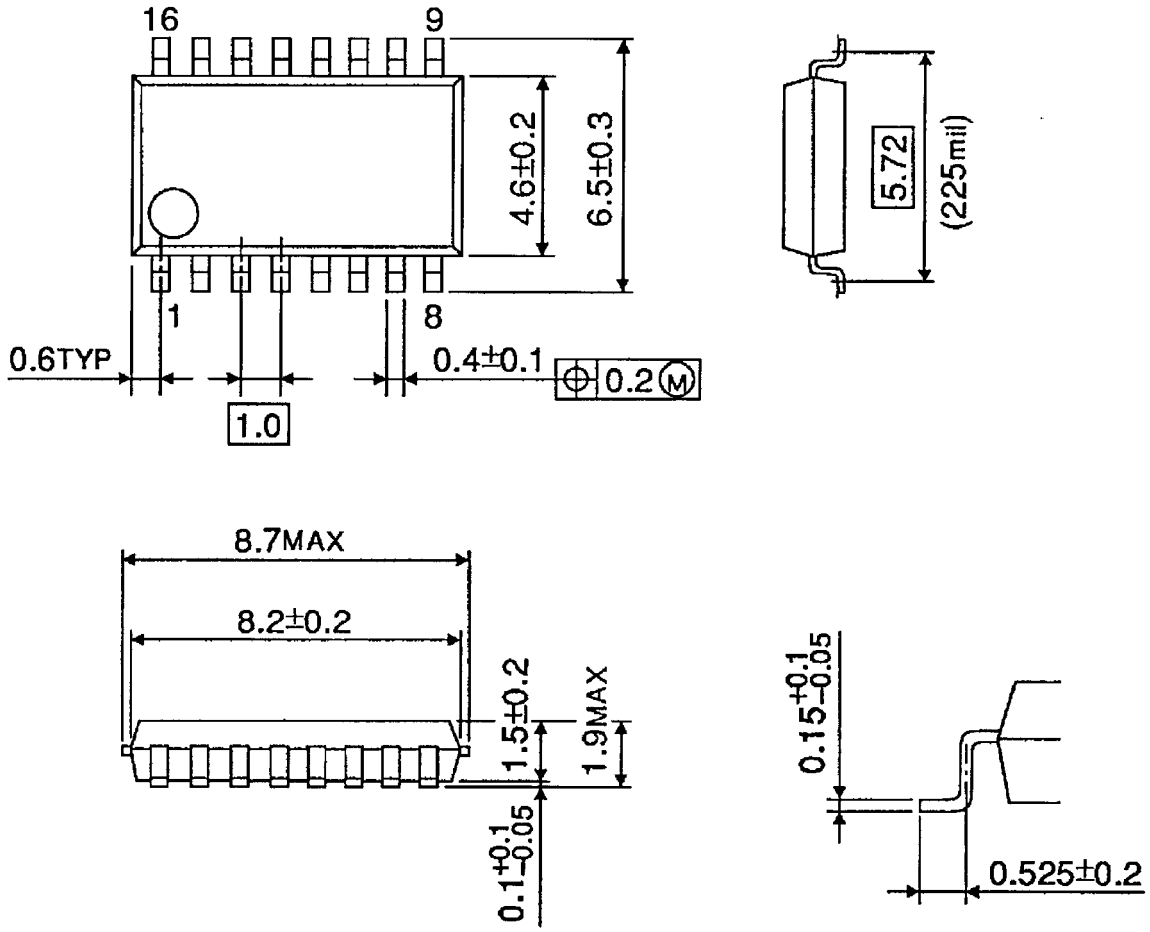
Note 1: Caution for Wiring
C1 and C2 are for absorbing disturbances, noise, etc. C3 is for phase compensation.
Connect each capacitor as close to the IC as possible.

Note 2: Ensure that the IC is mounted correctly. Failure to do so may result in the IC or target equipment being damaged.

Note 3: 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

- Toshiba Corporation, and its subsidiaries and affiliates (collectively “TOSHIBA”), reserve the right to make changes to the information in this document, and related hardware, software and systems (collectively “Product”) without notice.
- This document and any information herein may not be reproduced without prior written permission from TOSHIBA. Even with TOSHIBA’s written permission, reproduction is permissible only if reproduction is without alteration/omission.
- Though TOSHIBA works continually to improve Product’s quality and reliability, Product can malfunction or fail. Customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Before customers use the Product, create designs including the Product, or incorporate the Product into their own applications, customers must also refer to and comply with (a) the latest versions of all relevant TOSHIBA information, including without limitation, this document, the specifications, the data sheets and application notes for Product and the precautions and conditions set forth in the “TOSHIBA Semiconductor Reliability Handbook” and (b) the instructions for the application with which the Product will be used with or for. Customers are solely responsible for all aspects of their own product design or applications, including but not limited to (a) determining the appropriateness of the use of this Product in such design or applications; (b) evaluating and determining the applicability of any information contained in this document, or in charts, diagrams, programs, algorithms, sample application circuits, or any other referenced documents; and (c) validating all operating parameters for such designs and applications. **TOSHIBA ASSUMES NO LIABILITY FOR CUSTOMERS’ PRODUCT DESIGN OR APPLICATIONS.**
- Product is intended for use in general electronics applications (e.g., computers, personal equipment, office equipment, measuring equipment, industrial robots and home electronics appliances) or for specific applications as expressly stated in this document. Product is neither intended nor warranted for use in equipment or systems that require extraordinarily high levels of quality and/or reliability and/or a malfunction or failure of which may cause loss of human life, bodily injury, serious property damage or serious public impact (“Unintended Use”). Unintended Use includes, without limitation, equipment used in nuclear facilities, equipment used in the aerospace industry, medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, devices related to electric power, and equipment used in finance-related fields. Do not use Product for Unintended Use unless specifically permitted in this document.
- Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy Product, whether in whole or in part.
- Product shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.
- The information contained herein is presented only as guidance for Product use. No responsibility is assumed by TOSHIBA for any infringement of patents or any other intellectual property rights of third parties that may result from the use of Product. No license to any intellectual property right is granted by this document, whether express or implied, by estoppel or otherwise.
- **ABSENT A WRITTEN SIGNED AGREEMENT, EXCEPT AS PROVIDED IN THE RELEVANT TERMS AND CONDITIONS OF SALE FOR PRODUCT, AND TO THE MAXIMUM EXTENT ALLOWABLE BY LAW, TOSHIBA (1) ASSUMES NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (2) DISCLAIMS ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO SALE, USE OF PRODUCT, OR INFORMATION, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.**
- Do not use or otherwise make available Product or related software or technology for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). Product and related software and technology may be controlled under the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of Product or related software or technology are strictly prohibited except in compliance with all applicable export laws and regulations.
- Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product. Please use Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. TOSHIBA assumes no liability for damages or losses occurring as a result of noncompliance with applicable laws and regulations.