TOSHIBA BiCMOS Integrated Circuit Silicon Monolithic

TB9005FNG

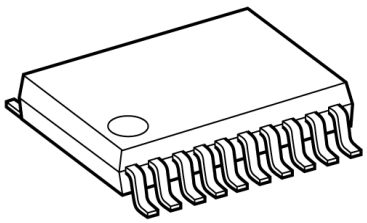
5 V Voltage Regulator with Watchdog Timer

1. Description

The TB9005FNG 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 TB9005FNG 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.



SSOP20-P-225-0.65A

Weight: 0.1 g (typ.)

2. Features

- Accurate output: 5.0 V ± 0.1 V (−40 to 125 °C)
- Low current consumption: 90 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
- Built-in VCC-open detector
- Small SMD package: SSOP-20-pin(0.65mm pitch)
- The product(s) is/are compatible with RoHS regulations (EU directive 2011 / 65 / EU) 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").

3. Block Diagram & Pin Layout

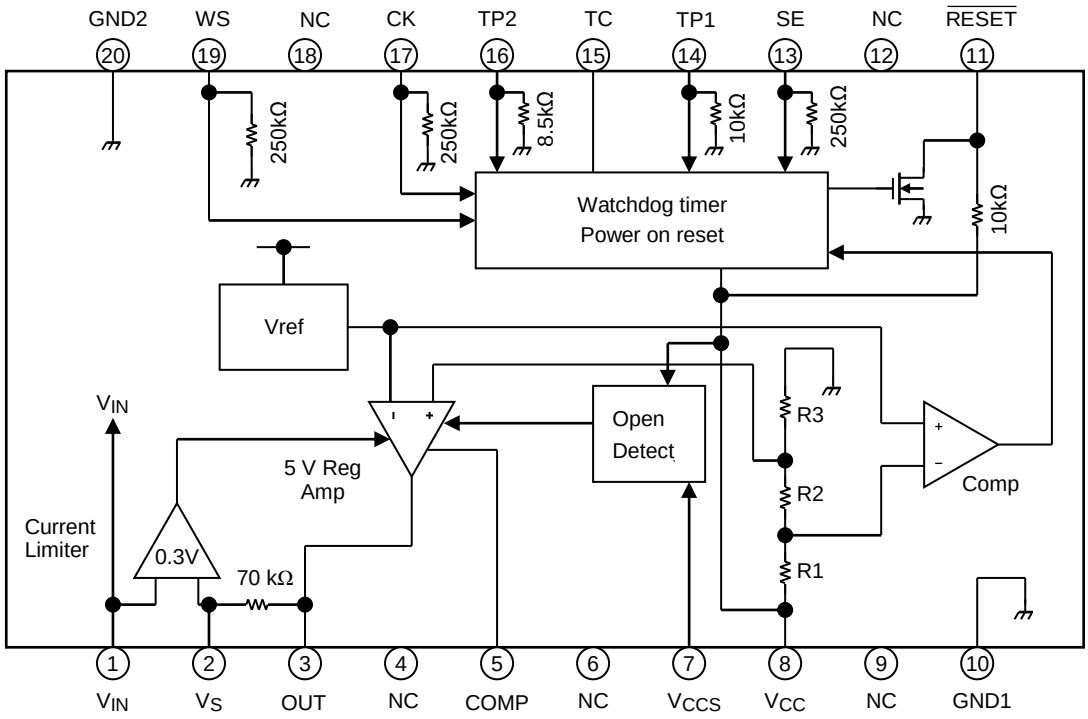


Fig. 3.1 Block Diagram & Pin Layout

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

4. Pin Description

Pin No.	Symbol	Description
1	V_{IN}	Power supply input pin. It contains a current limiter and startup circuit.
2	V_S	Detection pin for the V_{CC} current limiter. Any voltage drop occurring in the external resistor RS between pin1 and pin2 is monitored. The current limiter is actuated when the voltage drop exceeds 0.3 V (typ.). Ex.) When the current limiter need to be actuated at a load current of 300 mA: RS = 0.3 V/300 mA = 1.0 Ω.
3	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 (typ.). Since the recommended IOUT current is 6 mA, an output current of 480 mA can be run if HFE of the external transistor is 80 or more.
5	COMP	Phase-compensating pin for V_{CC}. Connect a phase-compensating capacitor between pin8 and this pin.
7	V_{CCS}	V_{CC} open detection pin.Connect to the collector of an external PNP transistor. If V_{CC} pin is open,V_{CCS} output voltage is limmited to less than 3.5 V.
8	V_{CC}	Voltage detection pin for the 5 V constant-voltage power supply, V_{CC}. Connect to the collector of an external PNP transistor. If V_{CCS} pin is open,V_{CC} output voltage is limmited to less than 3.5 V.
10	GND1	Grounded
11	$\overline{RESET}$	Reset output pin for power-on reset and watchdog timer. ・Generates a reset signal when a low voltage is detected for V_{CC}. ・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 10 kΩ pull-up resistor to V_{CC}.
13	SE	The selector of RESET Detection Voltage1 nad RESET Detection Voltage2. SE=H : RESET Detection Voltage1 : 4.75 V (typ.) SE=L : RESET Detection Voltage2 : 4.25 V (typ.) Build-In Pull Down resistance 250 kΩ.
14	TP1	TEST PIN. Connect to GND.
15	TC	Time setup pin for the reset and watchdog timers. Connect capacitor CT to GND. The time is set up by capacitor CT and internal constant current. Refer Electrical Specification, for the detail of Timer signal width.
16	TP2	TEST PIN. Connect to GND.
17	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. Build-In Pull Down resistance 250 kΩ.
19	WS	Watchdog timer function ON/OFF control pin. Set to LOW for active mode and HIGH for inactive mode. Build-In Pull Down resistance 250 kΩ.
20	GND2	Grounded
4, 6, 9,12,18	NC	Not connected. (Electrically, this pin is completely open.)

5. Functional Description

The TB9005FNG 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 Vref 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 (typ.) output. A current detecting resistor is inserted between the VIN and the VS 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 (typ.). In this way, a current limiter function is actuated to prevent any more current from flowing.

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.

(2) System Reset Function

When powered on V_{CC} drops and MCU is at hang-up, TB9005FNG outputs a reset signal for external system including MCU from $\overline{\text{RESET}}$ pin. ("L") The duration of this time can be set as desired by choosing appropriate values for the external capacitor connected to the TC pin.
Low voltage detection value of V_{CC} is selectable with pin setting, VTH-1=4.75 V (typ.) and VTH-2 = 4.25 V (typ.). Following description is representative example of VTH-1, but VTH-1 and VTH-2 are same operation except detection value.

- **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-1. When this charge voltage exceeds 4 V (typ.), the capacitor is discharged by the IC's internal transistor. When the capacitor is discharged down to 2 V (typ.), the reset signal is inverted to deactivate the reset. (Therefore, the width of this signal is determined by the value of external capacitor.)

Voltage to start Power-on reset timer function is can be selected with SE pin as described below.

SE pin="H" : 4.75 V (typ.)
="L" : 4.25 V (typ.) (Refer Electrical Specification, for the detail.)

Signal width ("L") output from $\overline{\text{RESET}}$ pin at power-on reset is following.

TPOR(ms) = 400 x CT(μF) (typ.) (Refer Electrical Specification, for the detail.)

- **Voltage monitoring function**

When powered off, or V_{CC} drops for some reason during normal operation, this voltage monitoring function outputs "L" from $\overline{\text{RESET}}$ pin immediately when V_{CC} drops below VTH-1. Then, when V_{CC} is restored to the normal voltage and exceeds VTH-1+Vhys-1, the power-on reset timer starts counting and "L" is output from $\overline{\text{RESET}}$ pin for above-mentioned TPOR determined by external capacitor.

- **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 (typ.) and 4 V (typ.). However, when a clock is input, it switches over and starts discharging in the middle of charging and then starts charging from 2 V (typ.) 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 (typ.). However, if no clock is input while being charged from 2 V (typ.) to 4 V (typ.), the clock is assumed to have stopped, i.e., the CPU system has gone wild, so that "L" from $\overline{\text{RESET}}$ pin is output to reset the CPU system. This output, "L" is continued until the voltage of TC pin is discharged from 4 V (typ.) to 2 V (typ.), and it is released at 2 V (typ.) and TC pin is charged again. Therefore, it is possible to use this function as external watchdog timer by using this signal from this pin. (See Timing Chart 1.)

TWD, the required time charged from 2 V (typ.) to 4 V (typ.), (the time to determine runaway of MCU) and TRST, signal width for watchdog timer can be determined by the value of external capacitor connected to the TC pin.

TWD (ms) = 200 x CT (μF) (typ.)
TRST(ms) = 8.0 x CT (μF) (typ.) (Refer Electrical Specification, for the detail.)

- **Watchdog timer ON/OFF function**

The watchdog timer can be switched ON or OFF by use of the WS pin.

WS pin = "L" : watchdog timer on
= "H" : watchdog timer off

Such as using the watchdog function of MCU built-in or another circuit, in case this watchdog timer is not used, fix WS pin to "H". In this case, only power-on reset and voltage monitoring are operated.
In this case, Fix CK pin at "L". (See Timing Chart 2,3.)

(3) V_{CC}-open detector

When V_{CC} pin is open, V_{CCS} is reduced to less than 3.5 V. In addition, when V_{CCS} pin is open, V_{CC} is reduced to less than 3.5 V. (See Timing Chart 4.)

6. Timing Chart

Timing Chart 1: WS = LOW

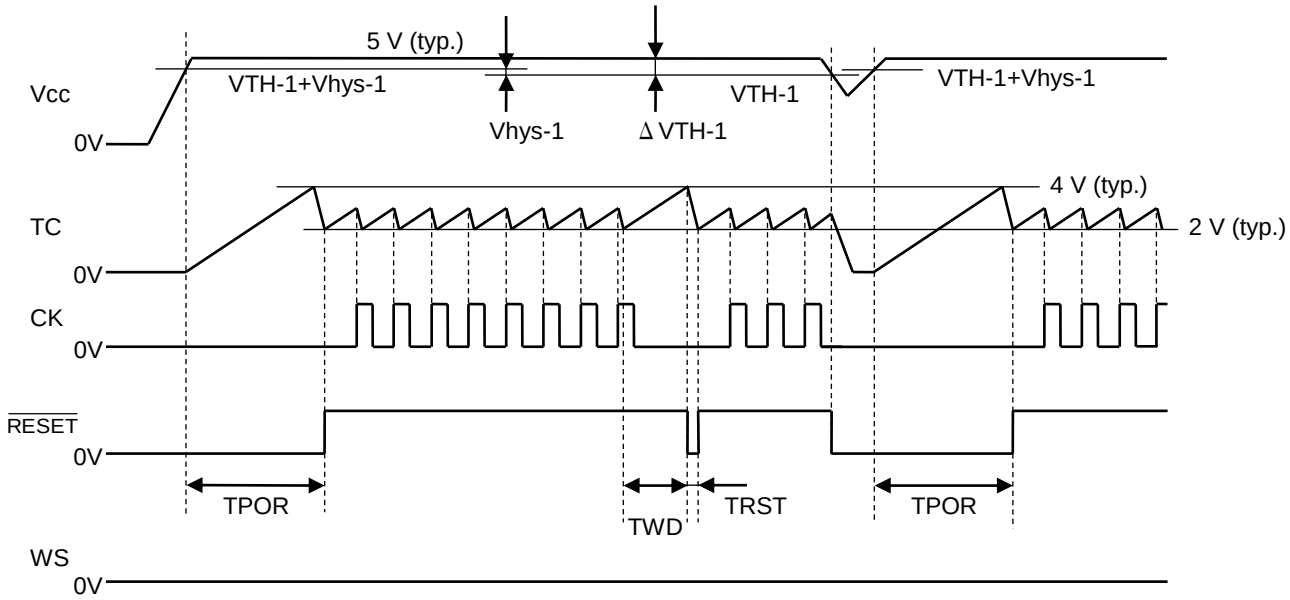


Fig. 6.1 Timing Chart (WS = LOW)

Timing Chart 2: WS = HIGH

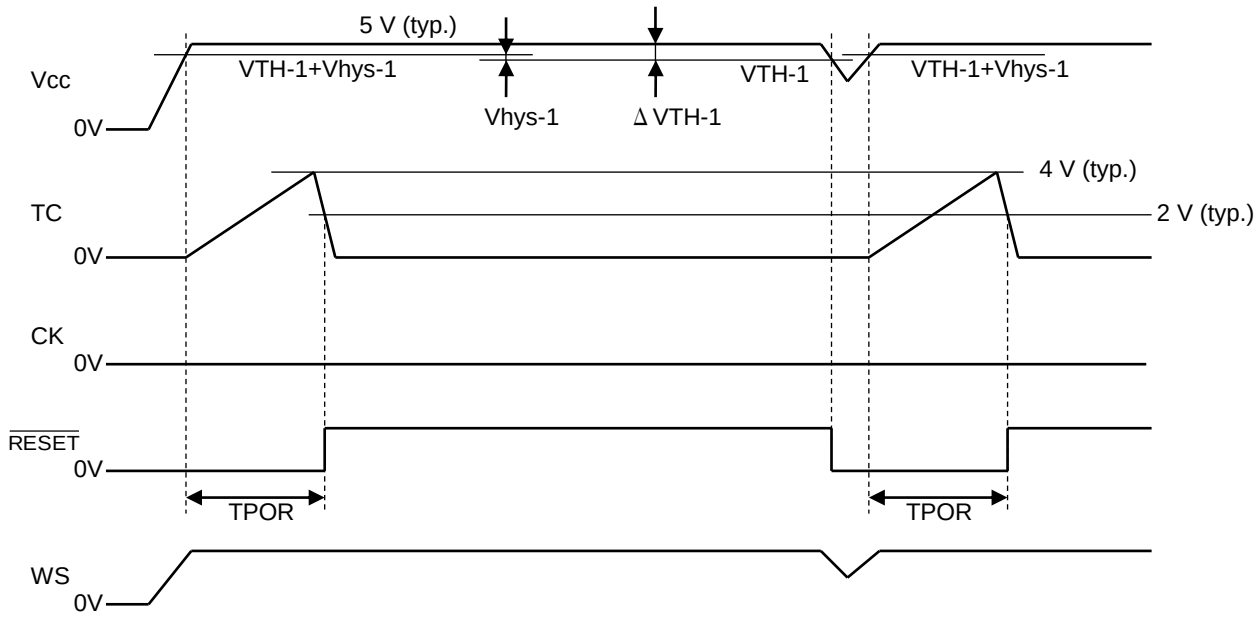


Fig. 6.2 Timing Chart (WS = HIGH)

Note : Definitions of symbols used in this timing chart are provided in the Electrical Characteristics table.
Note : Timing charts may be simplified to clarify the descriptions of features and operations.
Note : VTH-1 is represented as a representative example of notations of reset detection voltage of V_{CC}.

Timing Chart 3: Switching WS in the middle

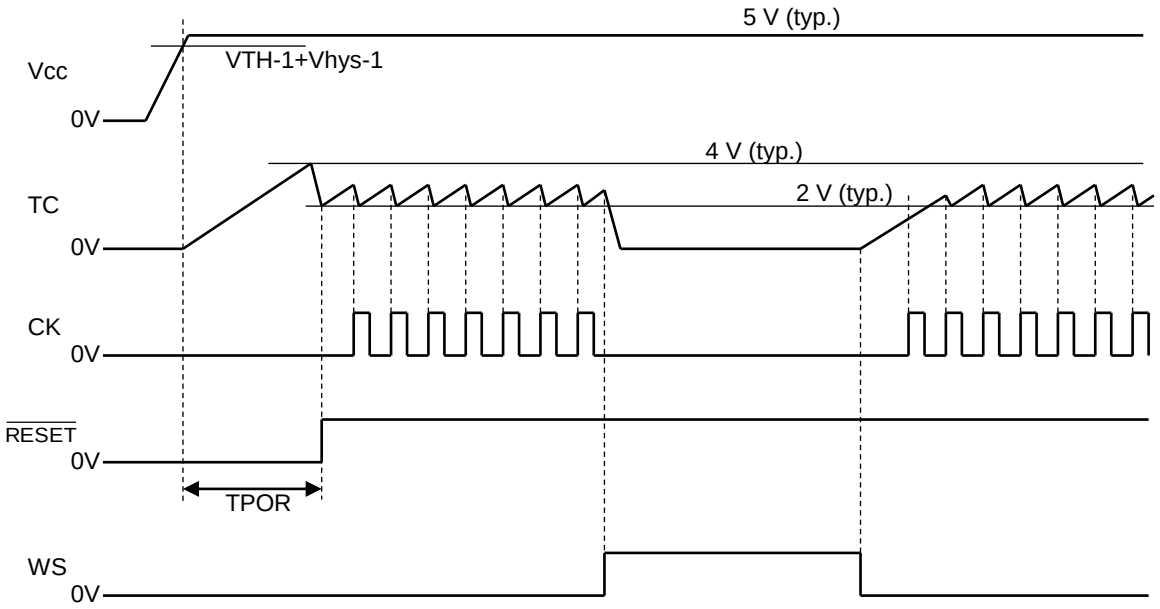


Fig. 6.3 Timing Chart (Switching WS in the middle)

Timing Chart 4: V_{CC} or V_{CCS} is disconnected (open) and connected

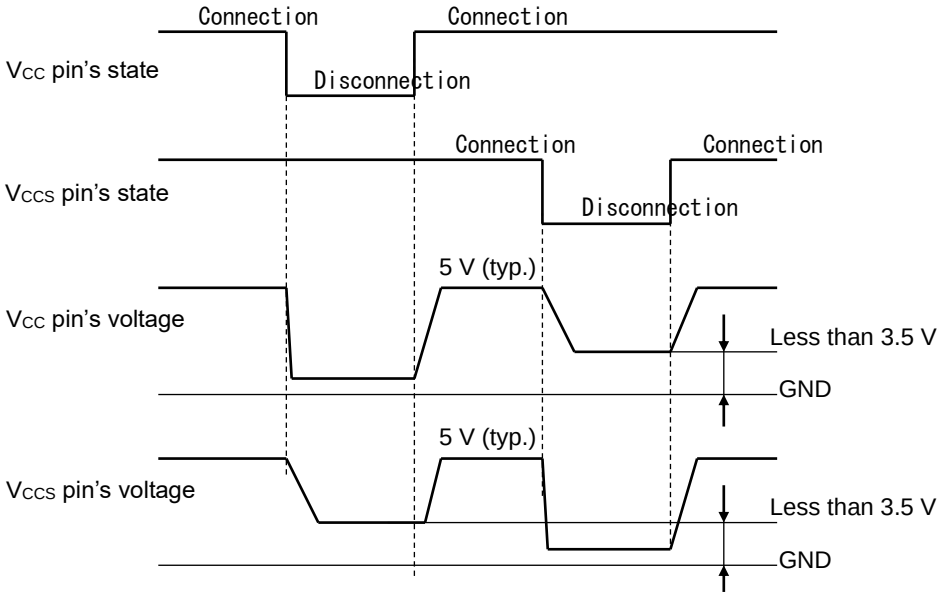


Fig. 6.4 Timing Chart (VCC or VCCS is disconnected (open) and connected)

Note : Definitions of symbols used in this timing chart are provided in the Electrical Characteristics table.
Note : Timing charts may be simplified to clarify the descriptions of features and operations.
Note : VTH-1 is represented as a representative example of notations of reset detection voltage of V_{CC}.

7. Absolute Maximum Rating (Ta = 25 °C)

Characteristics	Symbol	Pin	Rating	Unit
Input voltage	$V_{IN}1$	V_{IN}, V_S	45 (60 s) (Note 1)	V
	$V_{IN}2$	V_{IN}, V_S	18	
	$V_{IN}3$	V_{CC}, V_{CCS}	6.0	
	$V_{IN}4$	CK, WS, TC, SE, COMP, TP1, TP2	V_{CC}	
Output current	$I_{OUT}1$	OUT	8	mA
	$I_{OUT}2$	$\overline{\text{RESET}}$	5	
Output voltage	$V_{OUT}1$	OUT	45 (60 s) (Note 1)	V
	$V_{OUT}2$	$\overline{\text{RESET}}$	V_{CC}	
Operating temperature	T_{opr}	—	−40 to 125	°C
Storage temperature	T_{stg}	—	−55 to 150	°C

8. SSOP20-P-225-0.65A Thermal Resistance Data (Ta = 25°C)

Characteristics	Rating	Unit	Condition
Rθj-a	200	°C/W	Only IC
PD1	0.6	W	Only IC
PD2	1.0	W	75x114x1.6 mm 20% Cu PCB

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.

Note 1: V_{IN} = 45 V assumes load dump surge and jump start, so please note that it must not be applied as DC.

9. Electrical Characteristics

(Unless otherwise specified, V_{IN} = 6 to 18 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 125°C	4.9	5.0	5.1	V
Line regulation	VLINE1	V_{CC}	—	V_{IN} = 6 to 18 V	—	0.1	0.5	%
	VLINE2	V_{CC}	—	V_{IN} = 6 to 40 V (60s) (Note 1)	—	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	$\overline{\text{RESET}}$	—	IOL = 2 mA	—	—	0.3	V
Output leakage current	ILEAK	$\overline{\text{RESET}}$	—	$V_{IN}(\overline{\text{RESET}})$ = V_{CC}	—	—	5	μA
Input current	IIN	TC	—	V_{IN}(TC) = GND	—	−10	—	μA
Input current	IIH	CK	—	V_{IN}(CK) = V_{CC}	5	—	45	μA
	IIL		—	V_{IN}(CK) = 0 V	−5	—	5	μA
Input current	IIH	WS	—	V_{IN}(WS) = Vcc	5	—	45	μA
	IIL		—	V_{IN}(WS) = 0 V	−5	—	5	μA
Input current	IIH	SE	—	V_{IN}(SE) = Vcc	5	—	45	μA
	IIL		—	V_{IN}(SE) = 0 V	−5	—	5	
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}	
Input voltage	VIH	SE	—	—	0.8 V_{CC}	—	—	V
	VIL		—	—	—	—	0.2 V_{CC}	
Current limiter detection	VLIMIT	V_{IN},Vs	—	—	0.225	0.3	0.375	V
Current consumption (Note 2)	I_{CC}	—	1	Ta = 25°C, V_{IN} = 12 V	—	90	140	μA
			1	Ta = −40 to 125°C, V_{IN} = 12 V	—	90	160	
Reset detection voltage-1	VTH-1	V_{CC}	—	SE = H	4.6	4.75	4.9	V
	ΔVTH-1		—	SE = H、VREG − VTH-1	0.2	0.25	0.3	
	Vhys-1		—	—	—	0.10	—	
Reset detection voltage-2	VTH-2	Vcc	—	SE = L or OPEN	4.1	4.25	4.4	V
	ΔVTH-2		—	SE = L or OPEN, VREG − VTH-2	0.7	0.75	0.8	
	Vhys-2		—	—	—	0.10	—	
Power-on reset (Note 3)	TPOR	$\overline{\text{RESET}}$	—	—	280 × CT	400 × CT	520 × CT	ms
Watchdog timer (Note 3)	TWD	$\overline{\text{RESET}}$	—	—	140 × CT	200 × CT	260 × CT	
Reset timer (Note 3)	TRST	$\overline{\text{RESET}}$	—	—	4.0 × CT	8.0 × CT	12.0 × CT	
Clock pulse width	Tw	CK	—	—	3	—	—	μs

Note 1: V_{IN} = 40 V assumes load dump surge and jump start, so please note that it must not be applied as DC.
Note 2: For the above current consumption ICC, it is specified that ILOAD = 0 mA and it don't include the input current of WS and CK pin.
Note 3: CT is measured in units of μF. 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.

10. Operating Conditions

Part Name	Min	Max	Unit
CT	0.01	10	μF

11. Test Circuit

Test Circuit 1: Current Consumption Icc

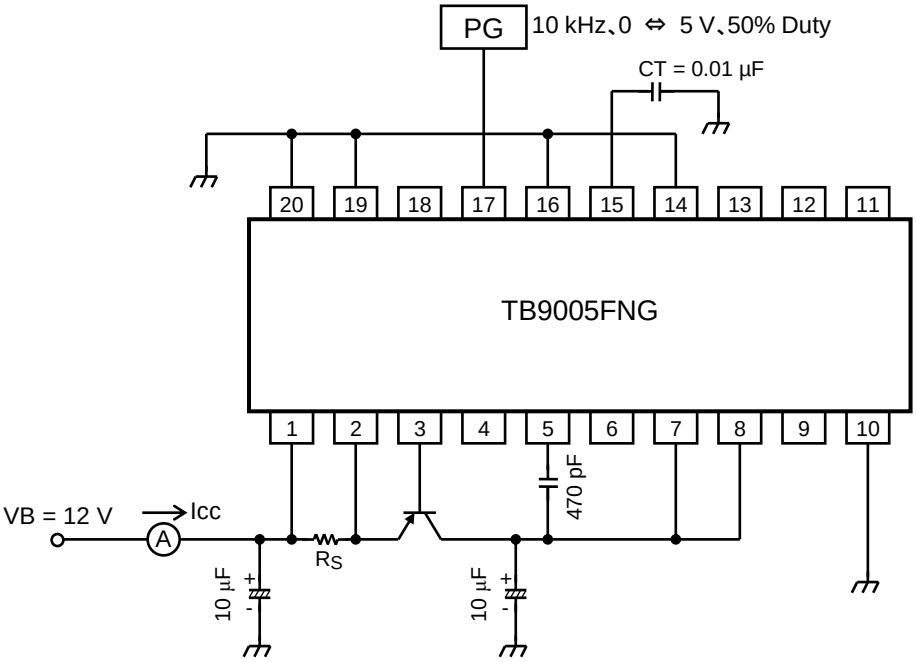


Fig. 11.1 Test Circuit 1 (Current Consumption Icc)

12. Reference Characteristics

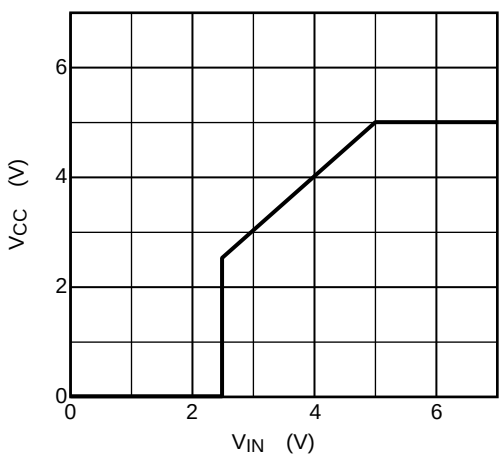


Fig. 12.1 Input - Output Characteristics

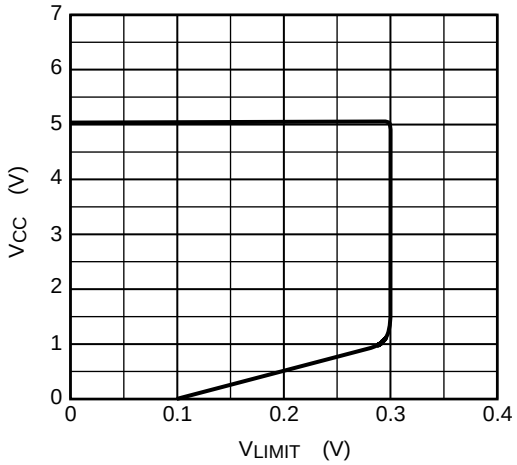


Fig. 12.2 Current Limiter Characteristics

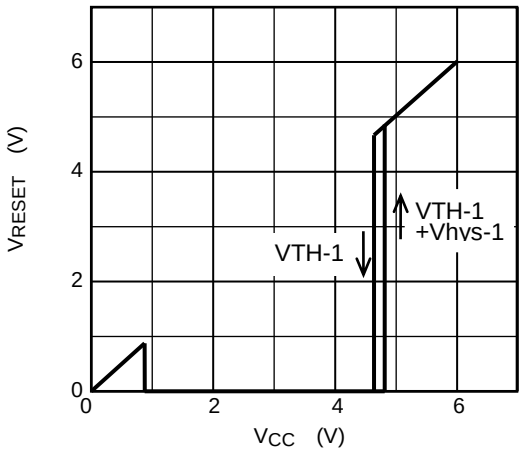


Fig. 12.3 Output Characteristics ($\overline{\text{RESET}}$)

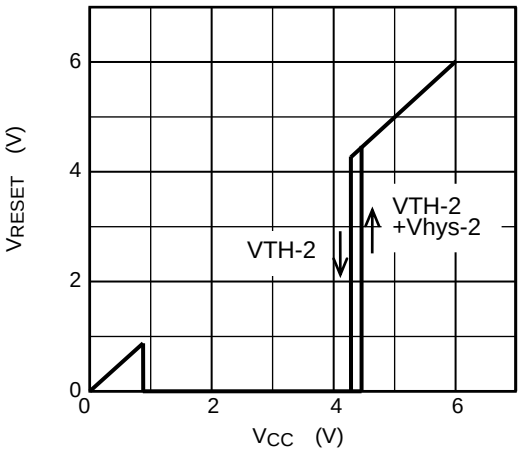


Fig. 12.4 Output Characteristics ($\overline{\text{RESET}}$)

13. Example Application Circuit

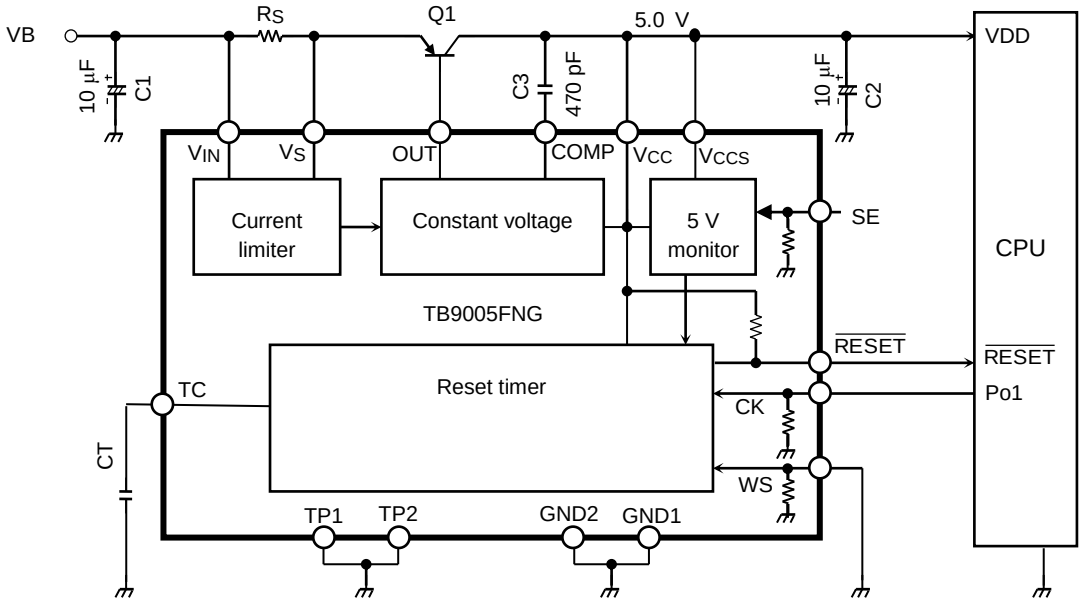


Fig. 13.1 Example Application Circuit

Note : Caution for Parts and Wiring

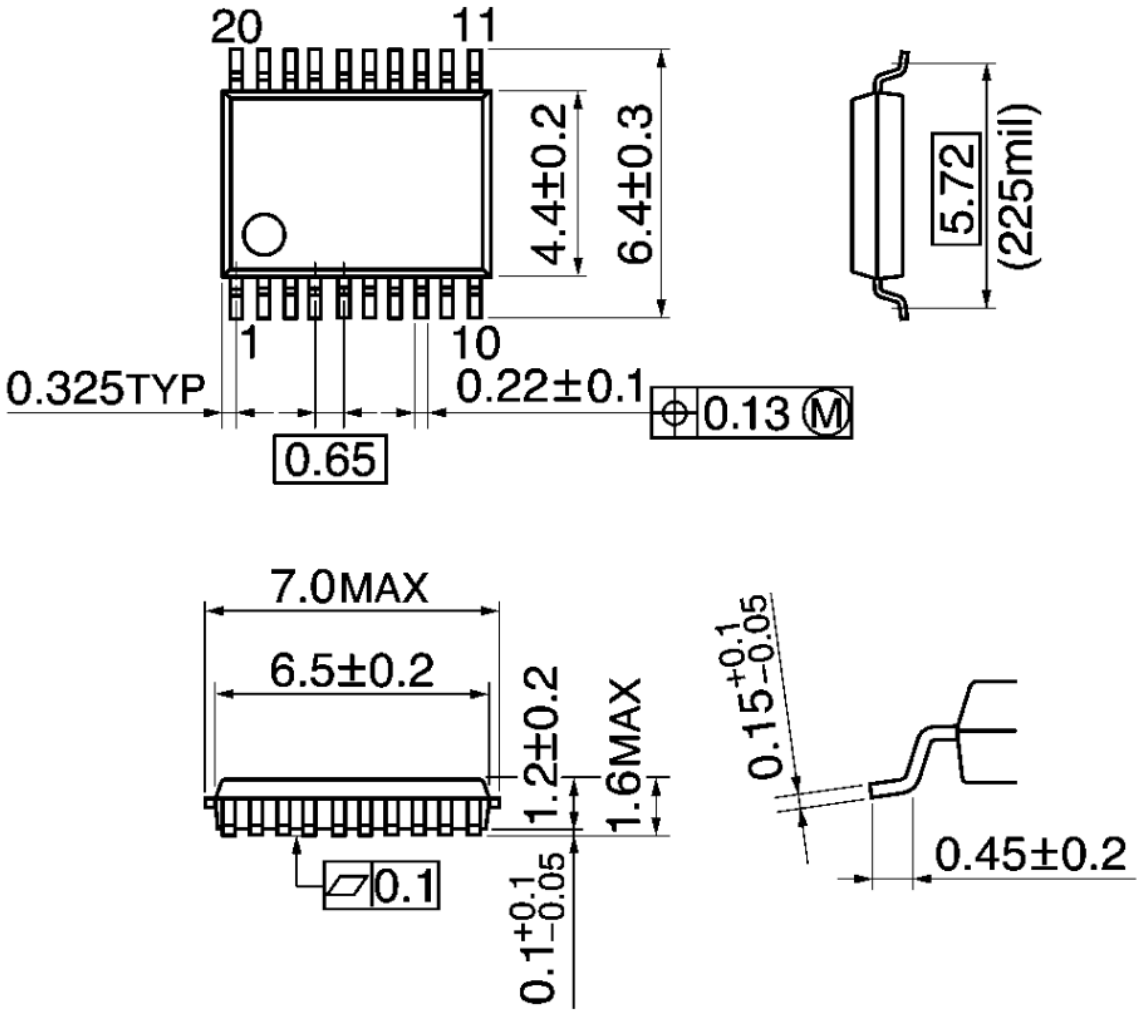
- Please use single type for Q1. Darlington type is not recommended. Also please design a sufficient heat dissipation because large heat generation occurs depending on the 5 V load current.
- C1 and C2 are for absorbing disturbances, noise, etc. Connect each capacitor as close to the IC as possible.
- C3 is for phase compensation. Connect 470 pF (typ.) capacitor as recommended value as close to the IC as possible.

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

Note : 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.

14. Package Dimensions

SSOP20-P-225-0.65A Unit: mm



Weight: 0.1 g (typ.)

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