

TOSHIBA BiCMOS Integrated Circuit Silicon Monolithic

# TB9004FNG

## 5 V and 3.3/2.5/1.5 V Dual-Voltage Regulator with Watchdog Timer

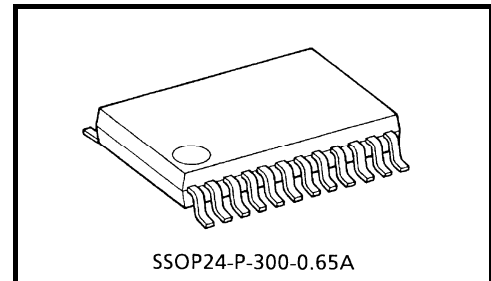
The TB9004FNG is a system regulator IC for automotive applications, specially designed for 3.3/2.5/1.5V microcomputer systems. It incorporates two constant-voltage power outputs and various system reset functions.

One of the power outputs, VCC1, supplies 3.4, 2.5, or 1.5 V, as selected according to the application. This output uses an external output transistor. Any desired current limiter value can be set using an external adjusting resistor.

The other power output, VCC2, supplies 5.0 V and also uses an external output transistor. Any desired current limiter value can be set using an external adjusting resistor.

For a system reset, both power outputs have a low-voltage monitor, power-on reset, and watchdog timer.

With the both power outputs turned off, the TB9004FNG consumes 0  $\mu$ A.



SSOP24-P-300-0.65A  
Weight: 0.14 g (typ.)

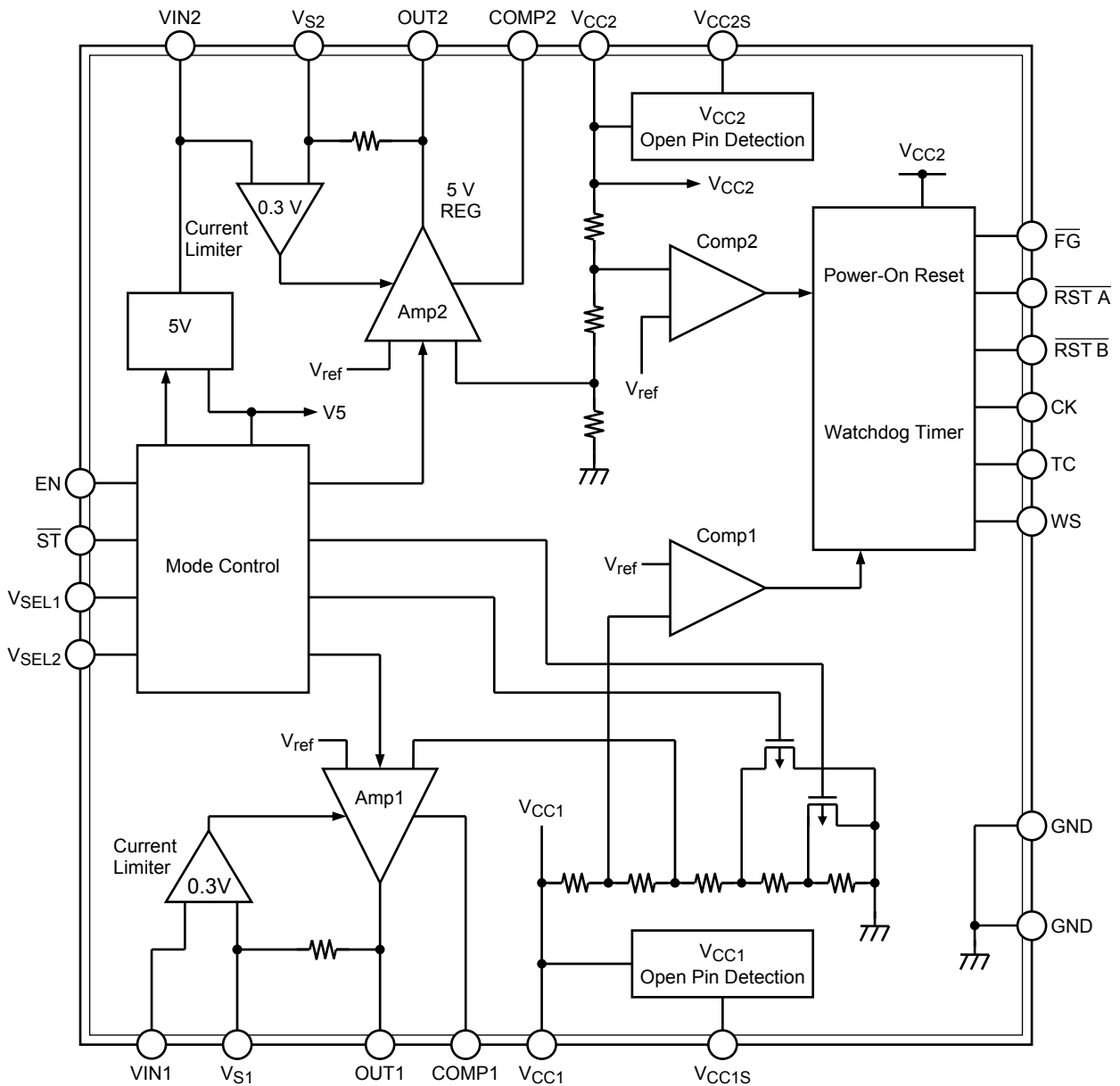
### Features

- Power output VCC1
  - Output voltage: 3.4 V  $\pm$  0.10 V/2.55 V  $\pm$  0.10 V/1.55 V  $\pm$  0.07 V (selectable)
  - Output current: 600 mA (with external transistor)
  - Current limiter: Variable using external adjusting resistor
- Power output VCC2
  - Output voltage: 5.0 V  $\pm$  0.12 V
  - Output current: 600 mA (with external transistor)
  - Current limiter: Variable using external adjusting resistor
- Reset functions: Low-voltage monitor, power-on reset, and watchdog timer
- Low current consumption: Active (VCC1/VCC2 = ON): 300  $\mu$ A (typ.)  
Standby (VCC1 = ON, VCC2 = OFF): 150  $\mu$ A (typ.)  
Stop (VCC1/VCC2 = OFF): 0  $\mu$ A (typ.)
- W/D stop control: Control start/stop of watchdog timer
- Operating temperature range: -40 to 125°C
- Small flat package: 24-pin SSOP (0.65-mm pitch)
- 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, following conditions were confirmed

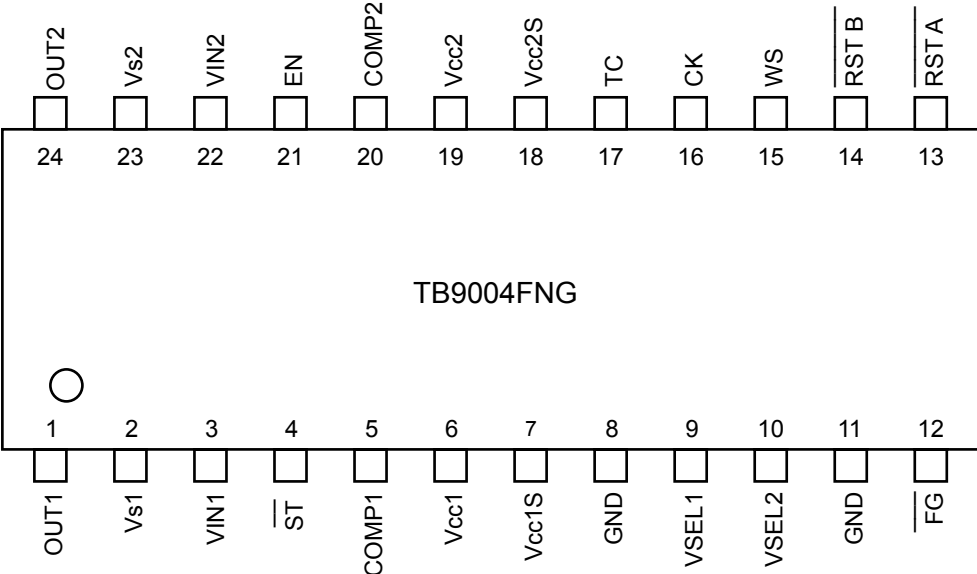
- Solderability
  - (1) Use of Sn-37Pb solder Bath
    - solder bath temperature = 230°C
    - dipping time = 5 seconds
    - the number of times = once
    - use of R-type flux
  - (2) Use of Sn-3.0Ag-0.5Cu solder Bath
    - solder bath temperature = 245°C
    - dipping time = 5 seconds
    - the number of times = once
    - use of R-type flux

**Block Diagram**



Note: The block diagram may show some of the functional blocks, circuits, or constants in abbreviated or simplified format for clarity in describing the relevant features.

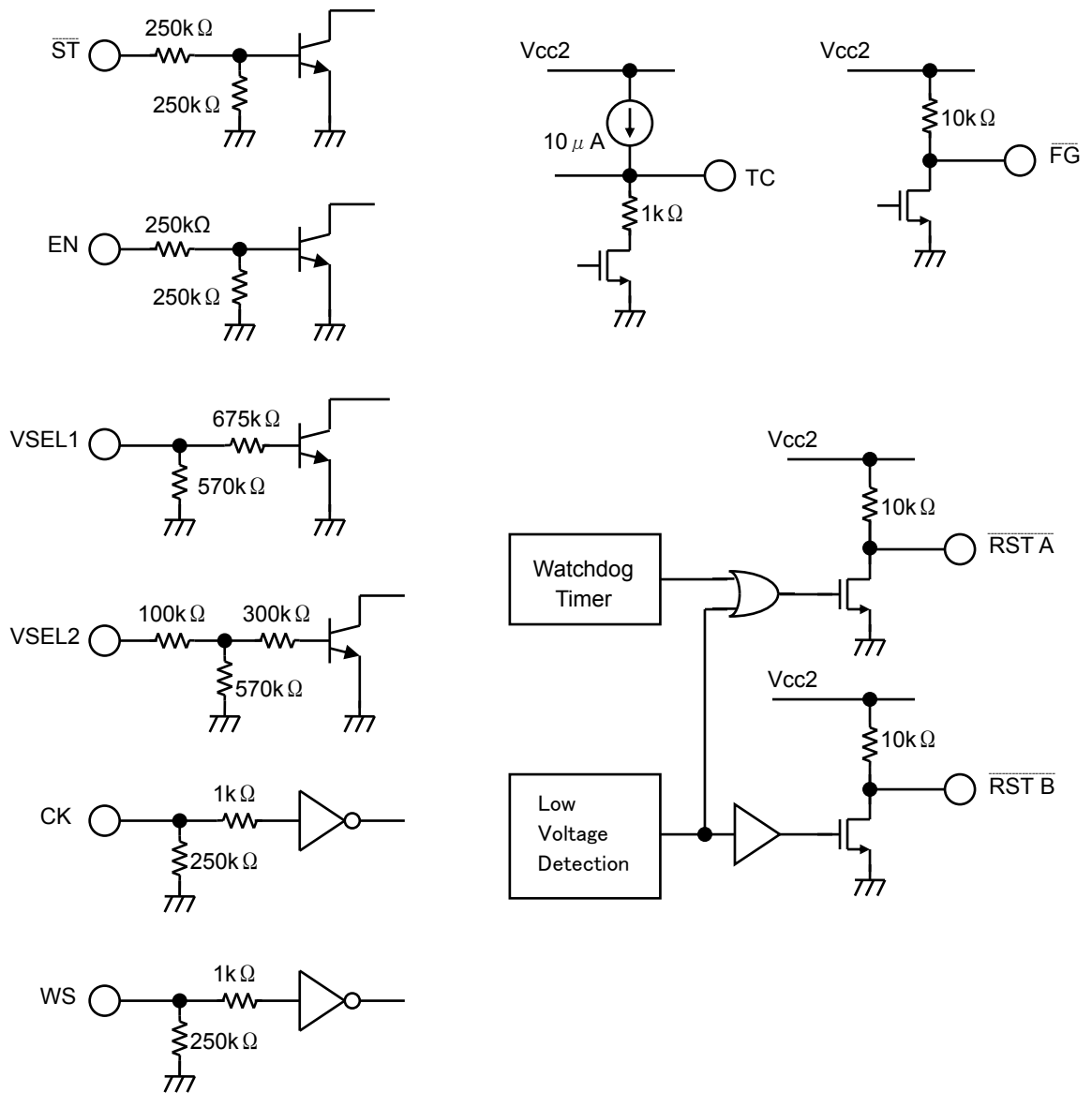
Pin Layout



## Pin Description

Pin No.	Symbol	Description
1	OUT1	External transistor control pin. Connect the base of the external PNP transistor to this pin.
2	V <sub>S1</sub>	Detection pin for the V <sub>CC1</sub> current limiter. A voltage drop occurring in the external resistor R <sub>S1</sub> between V <sub>IN1</sub> and V <sub>S1</sub> is monitored. The current limiter is actuated when the voltage drop exceeds 0.3 V.
3	V <sub>IN1</sub>	Power supply input pin for V <sub>CC1</sub> .
4	$\overline{ST}$	Enable pin for ON/OFF control of the V <sub>CC1</sub> /V <sub>CC2</sub> constant-voltage power outputs. Driving ST high turns the outputs on while driving it low turns them off. When both outputs are turned off, the TB9004FNG consumes a current of 0 $\mu$ A (typ.). It contains a 250 k $\Omega$ pull-down resistor.
5	COMP1	Phase compensating pin for V <sub>CC1</sub> . Connect a phase compensating capacitor between V <sub>CC1</sub> and this pin.
6	V <sub>CC1</sub>	Voltage detection output pin for V <sub>CC1</sub> . Connect the collector of the external PNP transistor to this pin. This pin provides a 3.3, 2.5, or 1.5 V constant-voltage feedback.
7	V <sub>CC1S</sub>	Pin for detecting whether the V <sub>CC1</sub> pin is open. If there is a voltage difference between V <sub>CC1</sub> and V <sub>CC1S</sub> , the TB9004FNG lowers the V <sub>CC1</sub> output voltage.
8	GND	Ground pin
9	V <sub>SEL1</sub>	Pin for selecting the V <sub>CC1</sub> output voltage from among 3.3, 2.5, and 1.5 V. The voltage is selected using a combination of V <sub>SEL1</sub> and V <sub>SEL2</sub> . This pin incorporates a pull-down resistor.
10	V <sub>SEL2</sub>	
11	GND	Ground pin
12	$\overline{FG}$	Flag output when V <sub>CC1</sub> or V <sub>CC2</sub> is detected to be open. The pin is usually high but driven low when either pin is detected to be open. N-ch MOS drain output with a 10 k $\Omega$ pull-up resistor connected to V <sub>CC2</sub> .
13	$\overline{RST A}$	V <sub>CC1</sub> /V <sub>CC2</sub> low-voltage monitor output and power-on reset/watchdog timer reset output pin <ul style="list-style-type: none"> <li>· Generates a reset signal when a low voltage is detected for V<sub>CC1</sub> or V<sub>CC2</sub>.</li> <li>· Generates a reset signal which is determined by the capacitor C<sub>T</sub> connected to the TC pin.</li> <li>· Intermittently generates reset pulses if no clock is supplied to the CK pin.</li> </ul> N-ch MOS drain output with a 10 k $\Omega$ pull-up resistor connected to V <sub>CC2</sub> .
14	$\overline{RST B}$	Low-voltage monitor output pin for V <sub>CC1</sub> and V <sub>CC2</sub> . Generates a reset signal when a low voltage is detected for V <sub>CC1</sub> or V <sub>CC2</sub> . Linked with a power-on reset but not linked with the watchdog timer.
15	WS	Enable pin for ON/OFF control of the watchdog timer. Driving WS low turns the timer on while driving it high turns the timer off. Use this pin when the watchdog timer is not necessary or to stop it temporarily. It contains a 250 k $\Omega$ pull-down resistor to GND.
16	CK	Clock input pin for the watchdog timer. It contains a 250 k $\Omega$ pull-down resistor connected to GND.
17	TC	Pin for setting a time for the power-on reset timer and watchdog timer when V <sub>CC1</sub> and V <sub>CC2</sub> rise. It connects to a capacitor C <sub>T</sub> which is grounded. It contains a 10 $\mu$ A pull-up constant current.
18	V <sub>CC2S</sub>	Pin for detecting whether the V <sub>CC2</sub> pin is open. If there is a voltage difference between V <sub>CC2</sub> and V <sub>CC2S</sub> , the TB9004FNG lowers the V <sub>CC2</sub> output voltage.
19	V <sub>CC2</sub>	Voltage detection pin for the 5 V constant-voltage power supply, V <sub>CC2</sub> . It also supplies power to the reset timer block.
20	COMP2	Phase compensating pin for V <sub>CC2</sub> . Connect a phase compensating capacitor between V <sub>CC2</sub> and this pin.
21	EN	Enable pin for ON/OFF control of the V <sub>CC2</sub> constant-voltage power output. Driving EN high turns the 5 V output on while driving it low turns the output off. It contains a 250 k $\Omega$ pull-down resistor.
22	V <sub>IN2</sub>	Power supply input pin.
23	V <sub>S2</sub>	Detection pin for the V <sub>CC2</sub> current limiter. A voltage drop occurring in the external resistor R <sub>S2</sub> between V <sub>IN2</sub> and V <sub>S2</sub> is monitored. The current limiter is actuated when the voltage drop exceeds 0.3 V.
24	OUT2	External transistor control pin. Connect the base of the external PNP transistor to this pin.

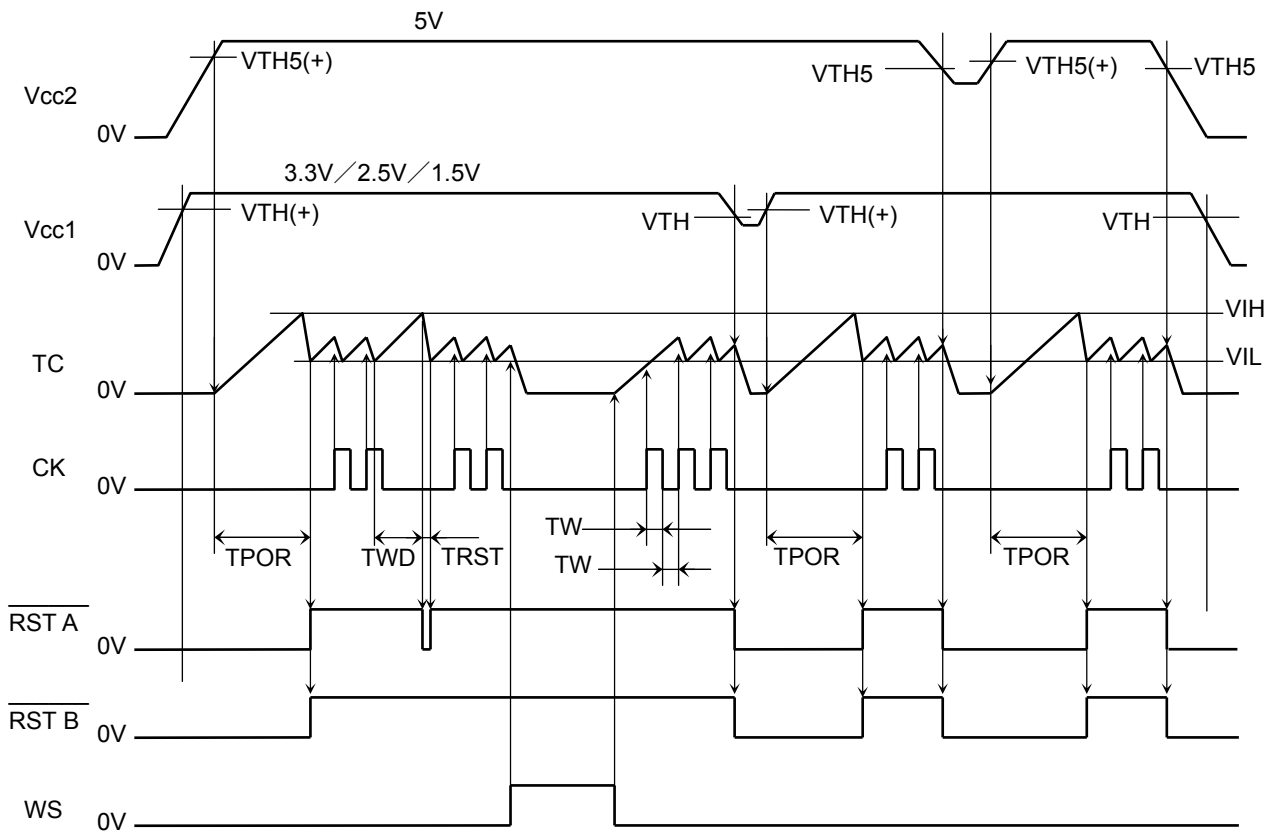
**Internal Circuits of Input/Output Pins**



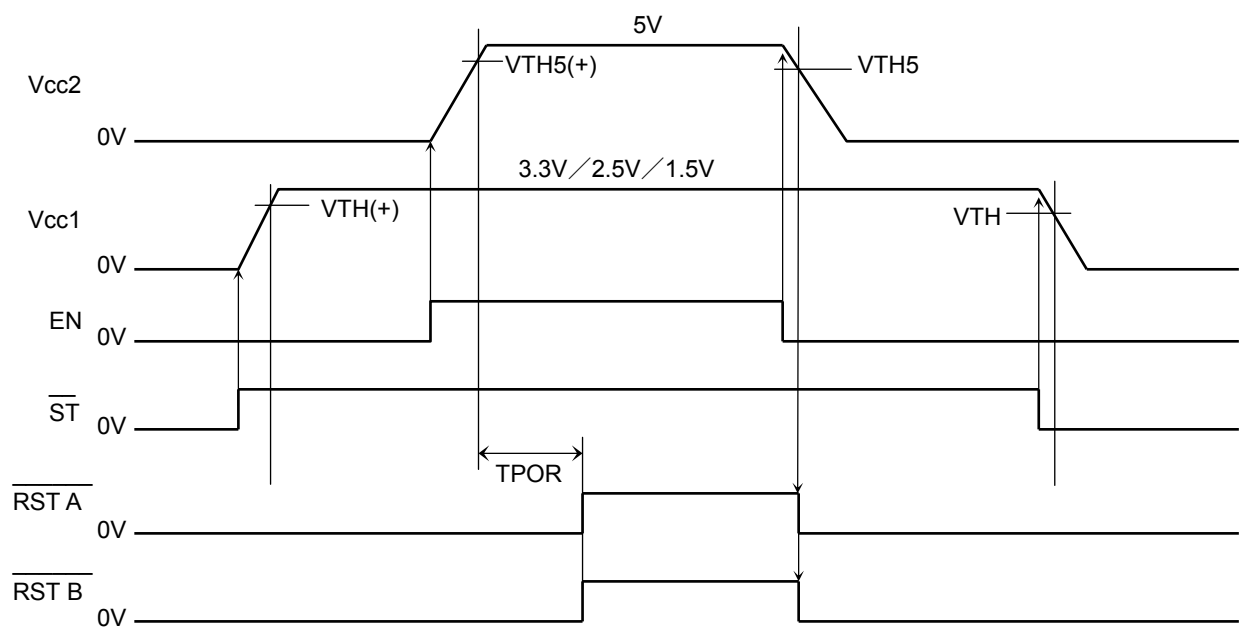
Note: The internal circuit diagrams are intended as an aid for describing circuits; they may be shown in abbreviated or simplified format.

**Timing Charts**

**Timing (1)**



**Timing (2)**



Note1: See Electrical Characteristics about symbols in timing charts.

Note2: Timing charts may be simplified to clarify the descriptions of features and operations.

## Absolute Maximum Ratings (Ta = 25°C)

Characteristics	Symbol	Pins	Rating	Unit
Input voltage	VIN-1	VIN1, VIN2	45 (1 s)	V
	VIN-2	EN, ST, VSEL1, VSEL2	VIN2	
	VIN-3	CK, TC, WS	Vcc2	
	VIN-4	VIN1, VIN2	40	
Output current	IOUT1	RST A , RST B	10	mA
	IOUT2	FG	10	
Operating temperature	T <sub>opr</sub>	–	–40 to 125	°C
Storage temperature	T <sub>stg</sub>	–	–55 to 150	°C

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 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, VIN = 6 to 16 V, I<sub>LOAD-1</sub> = 10 mA, I<sub>LOAD-2</sub> = 10 mA, Ta = -40 to 125°C)

Characteristics	Symbol	Applicable Pins	Test Conditions	Min	Typ.	Max	Unit
<b>DC characteristics</b>							
Supply current	I <sub>CC</sub>	VIN1 + VIN2	$\overline{ST} = EN = H$	-	300	500	μA
Standby current	I <sub>CC-stb</sub>		$\overline{ST} = H, EN = L$	-	150	250	
Stop current	I <sub>CC-off</sub>		$\overline{ST} = L$	-	0	10	
<b>Regulator</b>							
Output voltage	V <sub>REG3.3</sub>	V <sub>CC1</sub>	V <sub>SEL1</sub> = H, V <sub>SEL2</sub> = H	3.3	3.4	3.5	V
	V <sub>REG2.5</sub>	V <sub>CC1</sub>	V <sub>SEL1</sub> = H, V <sub>SEL2</sub> = L	2.45	2.55	2.65	
	V <sub>REG1.5</sub>	V <sub>CC1</sub>	V <sub>SEL1</sub> = L, V <sub>SEL2</sub> = L	1.48	1.55	1.62	
	V <sub>REG5.0</sub>	V <sub>CC2</sub>	-	4.88	5.0	5.12	
Output current	I <sub>OUT</sub>	OUT1, OUT2	-	10	-	-	mA
Line regulation	V <sub>LINE1</sub> (1)	V <sub>CC1</sub>	VIN1 = 6 to 40 V	-	0.1	0.5	%
	V <sub>LINE2</sub> (1)	V <sub>CC2</sub>	VIN2 = 6 to 40 V	-	0.1	0.5	
	V <sub>LINE1</sub> (2)	V <sub>CC1</sub>	VIN1 = 4 to 5.15 V	-	0.02	0.1	
Load regulation	V <sub>LOAD1</sub>	V <sub>CC1</sub>	I <sub>LOAD</sub> = 1 to 200 mA	-	0.2	1.0	%
	V <sub>LOAD2</sub>	V <sub>CC2</sub>	I <sub>LOAD</sub> = 1 to 300 mA	-	0.2	1.0	
Temperature coefficient	-	V <sub>CC1</sub> , V <sub>CC2</sub>	-	-	0.01	-	%/°C
Current limiter detection	V <sub>LIMIT</sub>	V <sub>CC1</sub> -V <sub>S1</sub> , V <sub>CC2</sub> -V <sub>S2</sub>	-	0.225	0.300	0.375	V
<b>Mode Select</b>							
Input current	I <sub>IN</sub>	$\overline{ST}$	VIN (ST) = 14 V	25	50	100	μA
Input voltage	V <sub>IH</sub>		-	2	-	-	V
	V <sub>IL</sub>	-	-	-	0.5		
Input current	I <sub>IN</sub>	EN	VIN (EN) = 14 V	25	50	100	μA
Input voltage	V <sub>IH</sub>		-	2	-	-	V
	V <sub>IL</sub>	-	-	-	0.5		
Input current	I <sub>IN</sub>	V <sub>SEL1</sub> V <sub>SEL2</sub>	VIN (V <sub>SEL</sub> ) = 3.4 V	5	10	20	μA
Input voltage	V <sub>IH</sub>		-	1.0	-	-	V
	V <sub>IL</sub>	-	-	-	0.3		
Input voltage difference	ΔV <sub>TH-SEL</sub>	V <sub>SEL1</sub> V <sub>SEL2</sub>	V <sub>TH</sub> (V <sub>SEL2</sub> ) - V <sub>TH</sub> (V <sub>SEL1</sub> )	0.05	0.1	0.15	V

Note: The specification value for supply current is the value measured when I<sub>LOAD</sub> = 0 mA.



## Electrical Characteristics (unless otherwise specified, $V_{IN} = 6$ to $18$ V, $I_{LOAD-1} = 10$ mA, $I_{LOAD-2} = 10$ mA, $T_a = 40$ to $125^\circ\text{C}$ )

Characteristics	Symbol	Applicable Pins	Test Conditions	Min	Typ.	Max	Unit
<b>Reset timer DC characteristics</b>							
Output voltage	VOL	$\overline{\text{RST A}}, \overline{\text{RST B}}$	$I_{OL} = 2$ mA	–	–	0.3	V
Output leakage current	ILEAK		$V_{IN}(\text{RST}) = V_{CC2}$	–	–	5	$\mu\text{A}$
Output voltage	VOL	$\overline{\text{FG}}$	$I_{OL} = 2$ mA	–	–	0.3	V
Output leakage current	ILEAK		$V_{IN}(\text{FG}) = V_{CC2}$	–	–	5	$\mu\text{A}$
Input current	IIN	TC	–	-13	-10	-7	$\mu\text{A}$
Threshold voltage	VIH	TC	–	3.75	4	4.25	V
	VIL		–	1.8	2	2.2	
Input current	IIH	CK	$V_{IN}(\text{CK}) = 5$ V	10	20	40	$\mu\text{A}$
	IIL		$V_{IN}(\text{CK}) = 0$ V	–	–	10	
Input voltage	VIH	CK	–	$0.8 \times V_{CC2}$	–	–	V
	VIL		–	–	–	$0.2 \times V_{CC2}$	
Input current	IIH	WS	$V_{IN}(\text{WS}) = 5$ V	10	20	40	$\mu\text{A}$
	IIL		$V_{IN}(\text{WS}) = 0$ V	–	–	10	
Input voltage	VIH	WS	–	$0.8 \times V_{CC2}$	–	–	V
	VIL		–	–	–	$0.2 \times V_{CC2}$	
Reset threshold voltage	VTH3.3	$V_{CC1}$	VREG3.3	3.0	3.15	3.3	V
	$\Delta V_{TH3.3}$		$V_{REG3.3} - V_{TH3.3}$	0.20	0.25	0.30	
	Vhys3.3		$V_{TH3.3(+)} - V_{TH3.3}$	–	0.05	–	
	VTH2.5	$V_{CC1}$	VREG2.5	2.3	2.4	2.5	V
	$\Delta V_{TH2.5}$		$V_{REG2.5} - V_{TH2.5}$	0.10	0.15	0.20	
	Vhys2.5		$V_{TH2.5(+)} - V_{TH2.5}$	–	0.04	–	
	VTH1.5	$V_{CC1}$	VREG1.5	1.35	1.41	1.47	V
	$\Delta V_{TH1.5}$		$V_{REG1.5} - V_{TH1.5}$	0.10	0.14	0.18	
	Vhys1.5		$V_{TH1.5(+)} - V_{TH1.5}$	–	0.03	–	
	VTH5	$V_{CC2}$	–	4.5	4.7	4.9	V
	$\Delta V_{TH5}$		$V_{REG5.0} - V_{TH5}$	0.25	0.30	0.35	
	Vhys5		$V_{TH5(+)} - V_{TH5}$	–	0.10	–	
"L" Hold voltage of reset output	VRLo	$V_{CC2}$	*see note3	–	–	1.5	V
<b>Reset timer AC characteristics</b>							
Power-on reset	TPOR	$\overline{\text{RST A}}, \overline{\text{RST B}}$	–	$280 \times \text{CT}$	$400 \times \text{CT}$	$520 \times \text{CT}$	ms
Watchdog timer	TWD	$\overline{\text{RST A}}$	–	$140 \times \text{CT}$	$200 \times \text{CT}$	$260 \times \text{CT}$	ms
Reset timer	TRST		–	$0.3 \times \text{CT}$	$0.7 \times \text{CT}$	$1.5 \times \text{CT}$	
Clock pulse width	TW	CK	–	3	–	–	$\mu\text{s}$

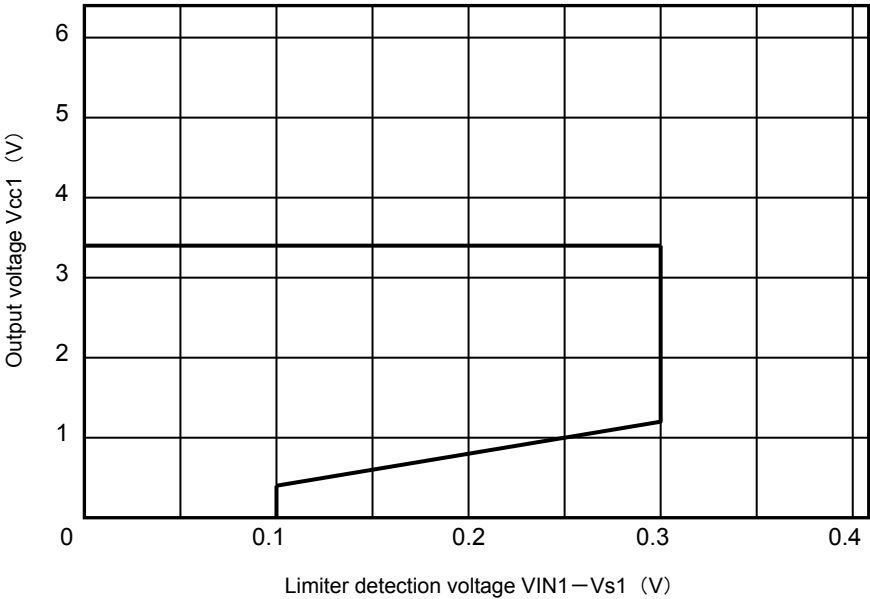
Note 1: The units for CT are  $\mu\text{F}$ .

Note 2: The specification values for power-on reset, watchdog timer and reset timer above are intended to guarantee only for this IC. Note that the fluctuations of the CT value should be taken into consideration for practical use of the IC.

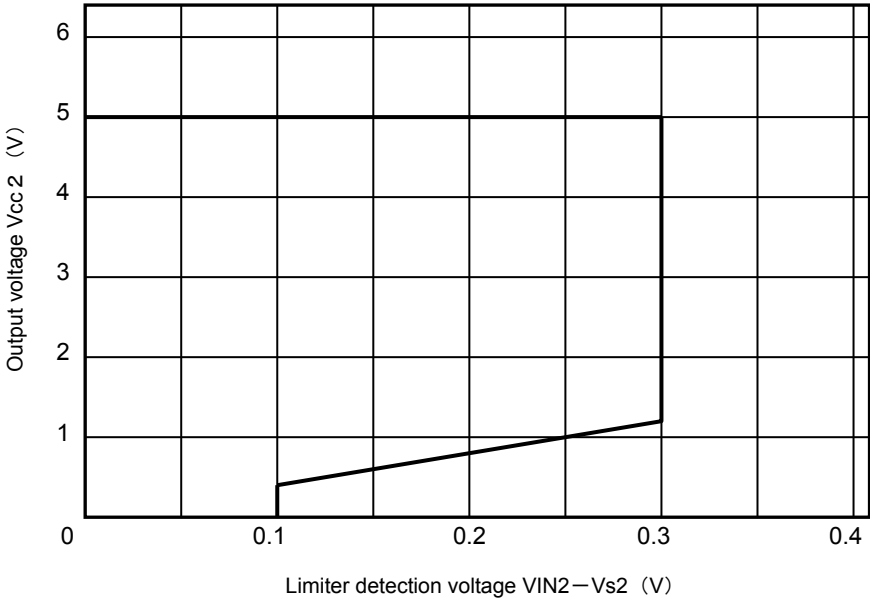
Note 3: VCC2 threshold voltage which  $\overline{\text{RST A}}$  or  $\overline{\text{RST B}}$  can output "L"-level when  $V_{\text{CC2}}$  level rises or falls.

Reference Characteristics

Current limiter detection voltage characteristics  
 $V_{CC1}$



Current limiter detection voltage characteristics  
 $V_{CC2}$



**Table of Truth Value(1)**

Input				Output		Mode
$\overline{ST}$	EN	VSEL1	VSEL2	V <sub>CC1</sub>	V <sub>CC2</sub>	
H	H	L	L	1.5 V	5 V	Active
H	H	H	L	2.5 V	5 V	
H	H	H	H	3.4 V	5 V	
H	L	L	L	1.5 V	0 V (OFF)	Standby
H	L	H	L	2.5 V	0 V (OFF)	
H	L	H	H	3.4 V	0 V (OFF)	
L	Don't Care	Don't Care	Don't Care	0 V (OFF)	0 V (OFF)	Stop

**Table of Truth Value(2) (V<sub>CC1</sub> states during normal operation and when V<sub>SEL1/2</sub> is open)**

Normal Operation			Pin is Open	
VSEL1	VSEL2	V <sub>CC1</sub>	Open Pin	V <sub>CC1</sub>
L	L	1.5 V	VSEL1	1.5 V
			VSEL2	1.5 V
H	L	2.5 V	VSEL1	1.5 V
			VSEL2	2.5 V
H	H	3.4 V	VSEL1	1.5 V
			VSEL2	2.5 V

## Test Mode

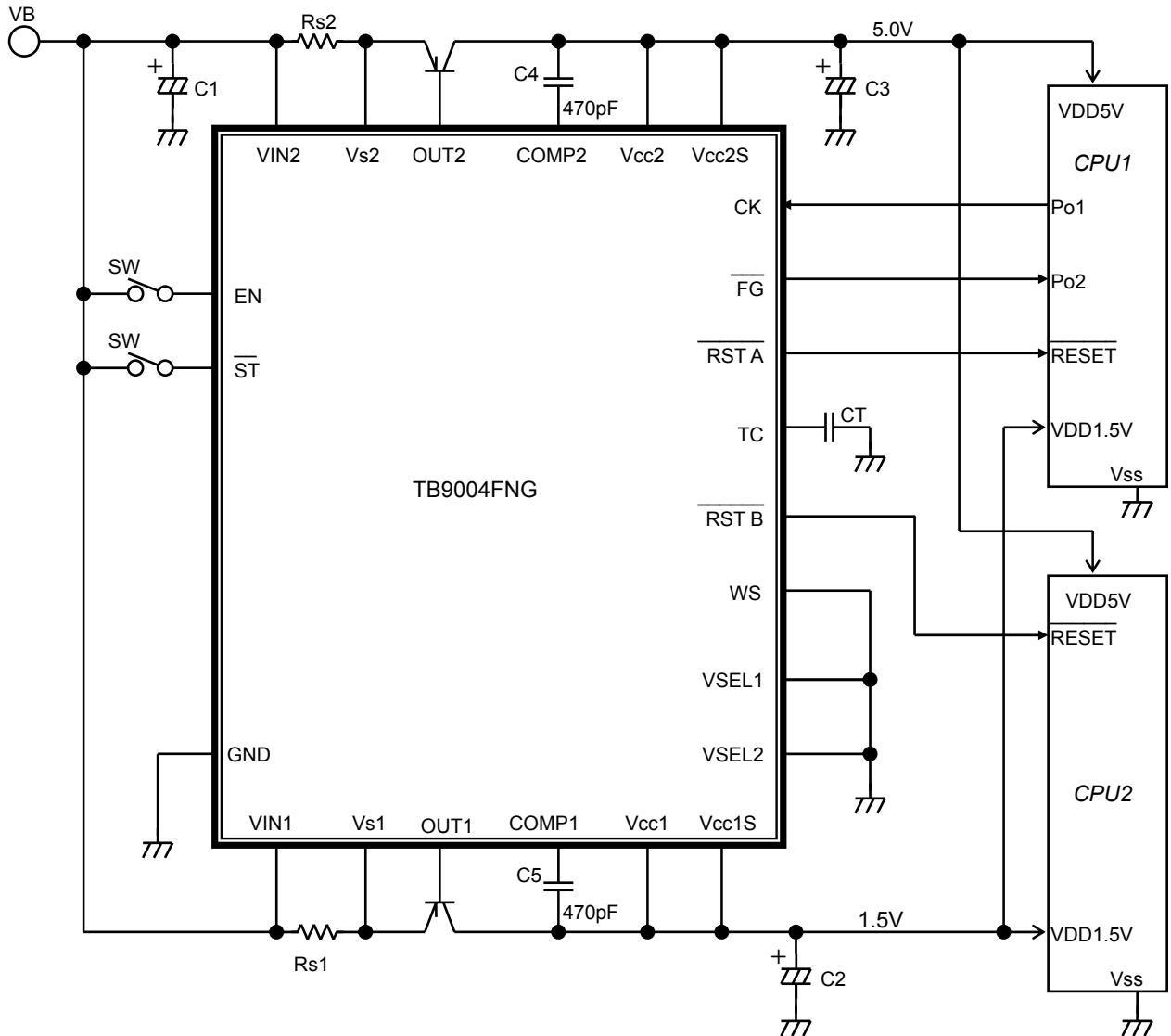
Driving VSEL1 low and VSEL2 high causes the TB9004FNG to enter test mode for evaluating and inspecting the IC.

This function must not be used in an actual application.

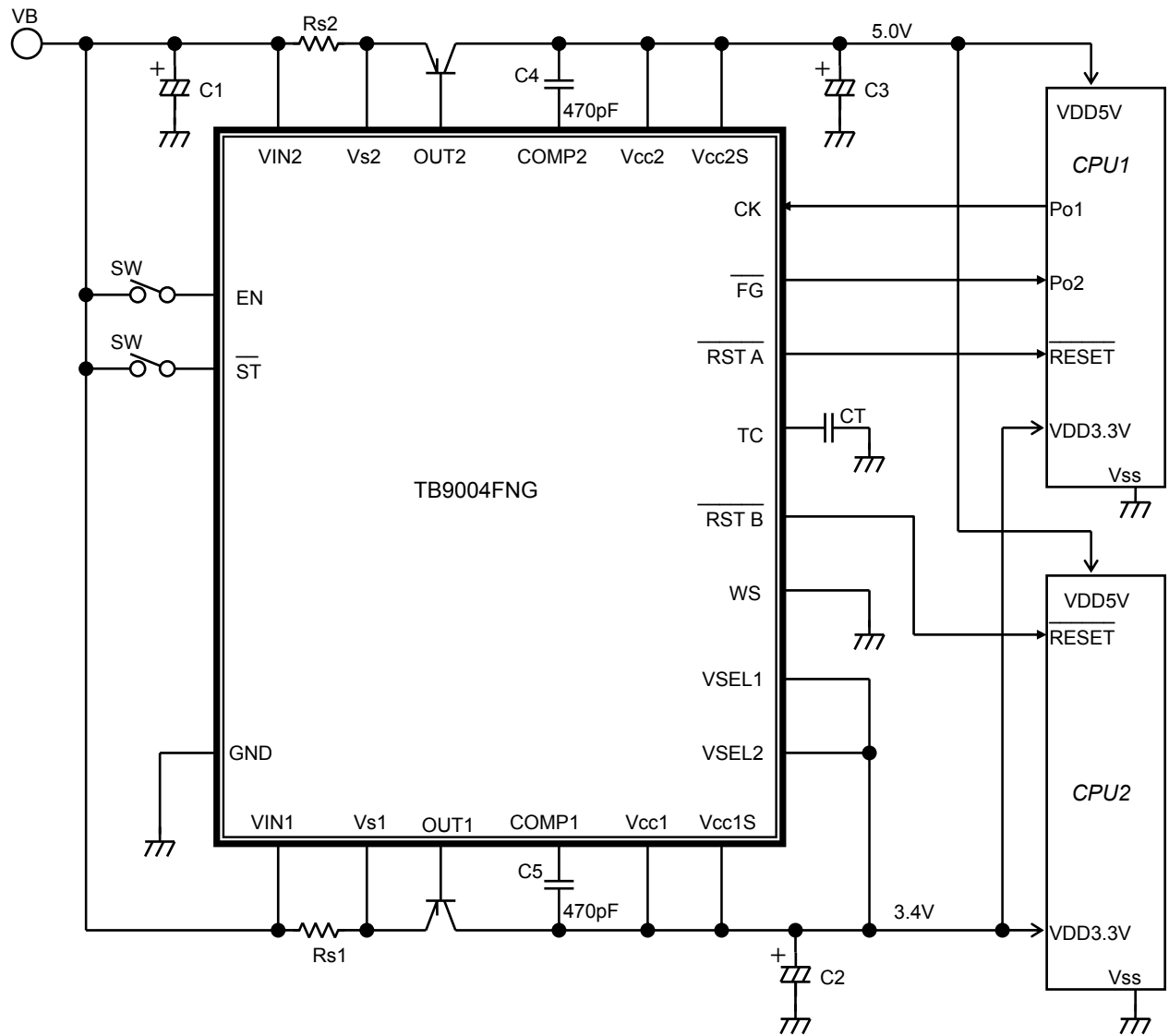
The input V<sub>TH</sub> for VSEL1 is 0.1 V (typ.) lower than that for VSEL2. The difference is specified as  $\Delta V_{TH-SEL}$  in the electrical characteristics. If voltage is applied with VSEL1 and VSEL2 short-circuited, the VSEL1/2 states can only become L/L, H/L or H/H, thus preventing the IC from entering test mode. When set VSEL1 or VSEL2 to L, please connect to GND.

**Examples of Application Circuit**

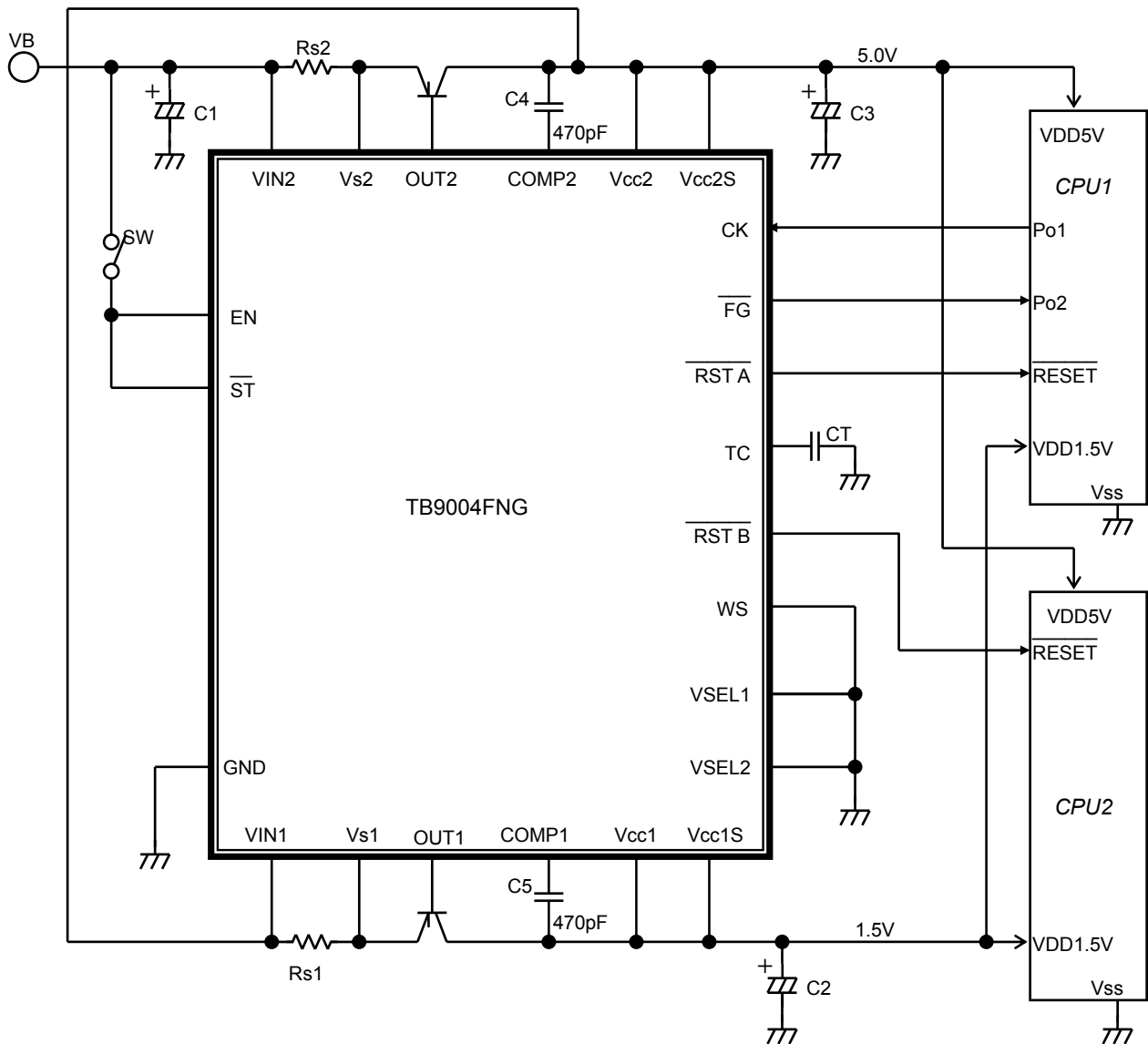
Example (1) 5V/1.5 V constant-voltage output power supply, 5V/1.5V parallel connection.



Example (2) 5V/3.4 V constant-voltage output power supply, 5V/3.4V parallel connection.



Example (3) 5V/1.5 V constant-voltage output power supply, 5V/1.5V series connection.



Note 1: Caution for wiring

C1, C2 and C3 are capacitors for absorbing disturbance noise, etc. Connect them as close to the IC as possible. C4 and C5 are capacitors for phase compensation. Connect them as close to the IC as possible.

Note 2: Ensure that the IC is mounted correctly as specified. Failing to observe the correct mounting procedure or requirements may result in the IC or target equipment being damaged.

Note 3: The example application circuit is not guaranteed for mass production. Additional thorough evaluation is required if the device is used in an application intended for mass production.

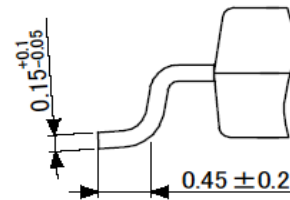
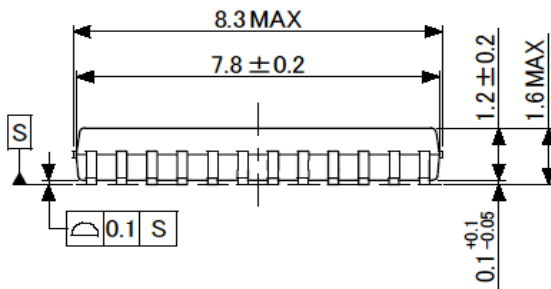
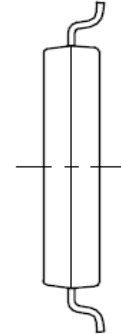
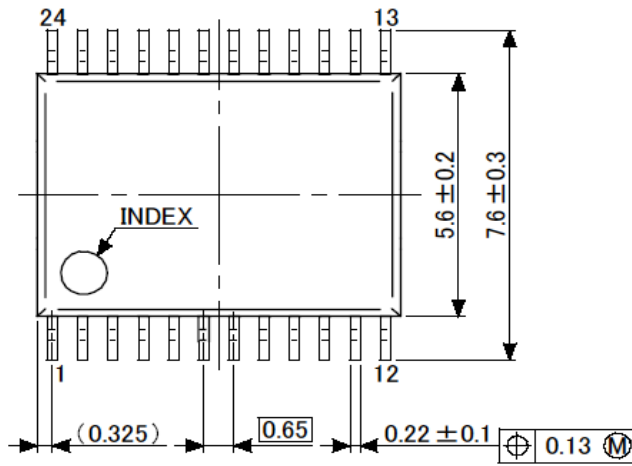
**Recommended Conditions**

Part Name	Min	Max	Unit
CT	0.01	10	μF

## Package Dimensions

Unit : mm

SSOP24-P-300-0.65A



Weight: 0.14 g (typ.)



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