

Voltage Detectors

# Voltage Detector ICs with Watchdog Timer

**BD37Axx Series    BD87Axx Series    BD99A41F**

● **General Description**

The BD37A19FVM, BD37A41FVM, BD87A28FVM, BD87A29FVM, BD87A34FVM, BD87A41FVM and BD99A41F are watchdog timer reset ICs. It delivers a high precision detection voltage of  $\pm 1.5\%$  and a super-low current consumption of 5  $\mu\text{A}$  (Typ.). It can be used in a wide range of electronic devices to monitor power supply voltages and in system operation to prevent runaway operation.

● **Features**

- Built-in watchdog timer
- Reset delay time can be set with the CT pin's external capacitance
- Watchdog timer monitor time and reset time can be set with the CTW pin's external capacitance.
- Output circuit type: N-channel open drain

● **Applications**

All devices using microcontrollers or DSP, including vehicle equipment, displays, servers, DVD players, and telephone systems

● **Key Specifications**

- RESET power supply voltage range: 1.0V to 10V
- WDT power supply voltage range: 2.5V to 10V
- High precision detection voltage:
  - (Ta = 25°C)  $\pm 1.5\%$
  - (Ta = -40°C to 105°C)  $\pm 2.5\%$
- Super-low current consumption: 5 $\mu\text{A}$ (Typ.)
- Operating temperature range: -40°C to +105°C

● **Packages**

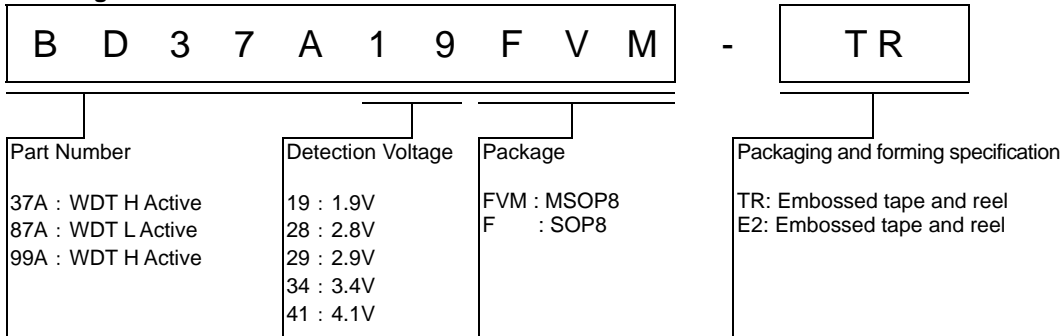
- MSOP8                      W (Typ.) x D (Typ.) x H (Max.)  
2.90mm x 4.00mm x 0.90mm



- SOP8                        5.00mm x 6.20mm x 1.71mm



● **Ordering Information**



● **Lineup**

Detection voltage (Typ.)	INH logic	Package		Orderable Part Number
1.9V	H: Active	MSOP8	Reel of 3000	BD37A19FVM-TR
4.1V	H: Active	MSOP8	Reel of 3000	BD37A41FVM-TR
2.8V	L: Active	MSOP8	Reel of 3000	BD87A28FVM-TR
2.9V	L: Active	MSOP8	Reel of 3000	BD87A29FVM-TR
3.4V	L: Active	MSOP8	Reel of 3000	BD87A34FVM-TR
4.1V	L: Active	MSOP8	Reel of 3000	BD87A41FVM-TR
4.1V	H: Active	SOP8	Reel of 2500	BD99A41F-E2

● Pin Configurations

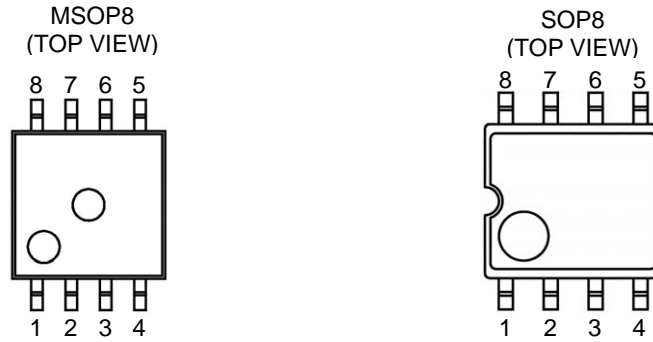
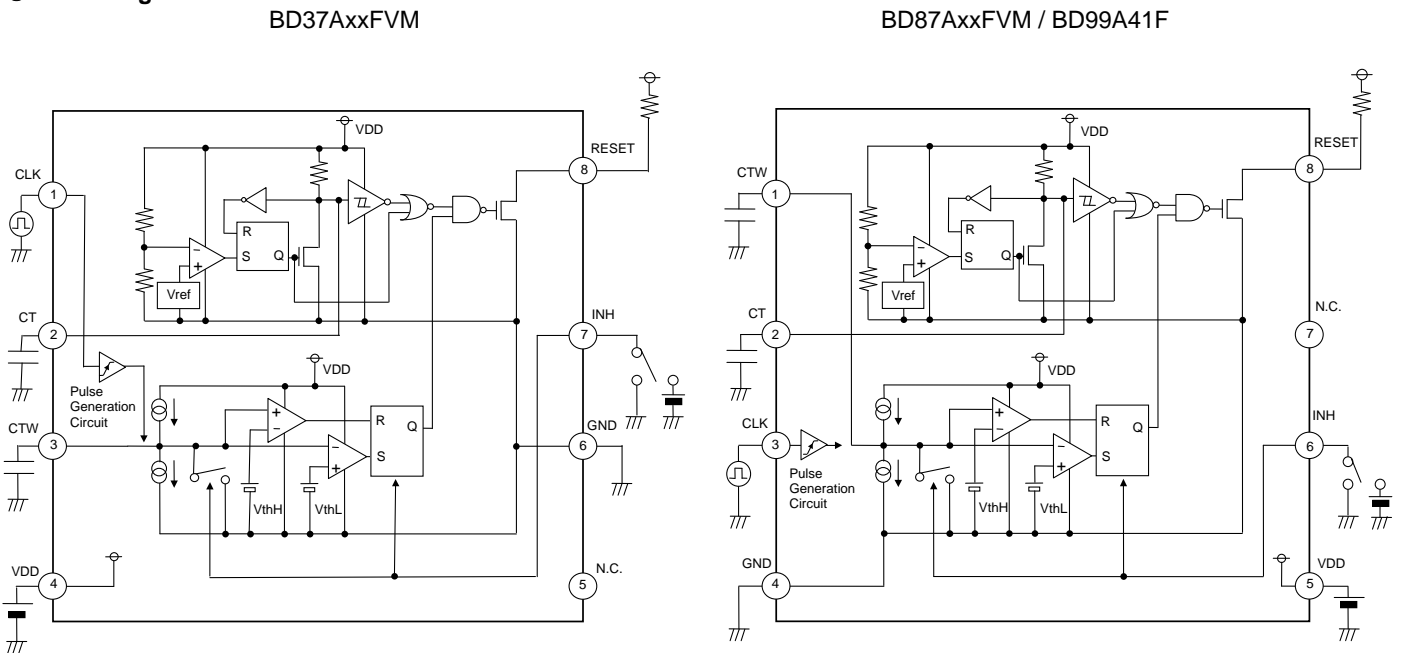


Figure 1. Pin Configurations

● Pin Descriptions

BD37AxxFVM			BD87AxxFVM / BD99A41F		
No.	Pin name	Function	No.	Pin name	Function
1	CLK	Clock input from microcontroller	1	CTW	WDT time setting capacitor connection pin
2	CT	Reset delay time setting capacitor connection pin	2	CT	Reset delay time setting capacitor connection pin
3	CTW	WDT time setting capacitor connection pin	3	CLK	Clock input from microcontroller
4	VDD	Power supply pin	4	GND	GND pin
5	N.C.	NC pin	5	VDD	Power supply pin
6	GND	GND pin	6	INH	WDT ON/OFF setting pin INH=H/L:WDT=OFF/ON(BD87AxxFVM) INH=H/L:WDT=ON/OFF(BD99A41F)
7	INH	WDT ON/OFF setting pin INH=H/L:WDT=ON/OFF	7	N.C.	NC pin
8	RESET	Reset output pin	8	RESET	Reset output pin

● Block Diagrams



CT pin capacitor: 470pF to 3.3μF  
CTW pin capacitor: 0.001μF to 10μF

Figure 2. Block Diagrams

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

Parameter	Symbol	Ratings	Unit
Power supply voltage <sup>*1</sup>	VDD	-0.3 to 10	V
CT pin voltage	VCT	-0.3 to VDD + 0.3	V
CTW pin voltage	VCTW	-0.3 to VDD + 0.3	V
RESET pin voltage	VRESET	-0.3 to VDD + 0.3	V
INH pin voltage	VINH	-0.3 to VDD + 0.3	V
CLK pin voltage	VCLK	-0.3 to VDD + 0.3	V
Power dissipation	Pd	470 <sup>*2</sup>	mW
		550 <sup>*3</sup>	
Operating ambient temperature	Topr	-40 to + 105	°C
Storage temperature	Tstg	-55 to + 125	°C
Maximum junction temperature	Tjmax	125	°C

\*1 Do not exceed Pd.

\*2 MSOP8 : Reduced by 4.70 mW/°C over 25°C, when mounted on a glass epoxy board (70 mm × 70 mm × 1.6 mm).

\*3 SOP8 : Reduced by 5.50 mW/°C over 25°C, when mounted on a glass epoxy board (70 mm × 70 mm × 1.6 mm).

### ● Recommended Operating Ratings (Ta = -40°C to 105°C)

Parameter	Symbol	Min.	Max.	Unit
RESET power supply voltage	VDD RESET	1.0	10	V
WDT power supply voltage	VDD WDT	2.5	10	V

### ● Electrical Characteristics

(Unless otherwise specified, Ta = -40°C to 105°C, VDD = 5V)

Parameter	Symbol	Limits			Unit	Conditions	
		Min.	Typ.	Max.			
[Overall]							
Total supply current 1 (during WDT operation)	IDD1	—	5	14	μA	INH : WDT ON Logic Input CTW = 0.1μF	
Total supply current 2 (when WDT stopped)	IDD2	—	5	14	μA	INH : WDT OFF Logic Input	
Output leak current	Ileak	—	—	1	μA	VDD = VDS = 10V	
Output current capacity	IOL	0.7	—	—	mA	VDD = 1.2V, VDS = 0.5V	
[RESET]							
Detection voltage 1	1.9V Detect	VDET1	1.871	1.900	1.929	V	Ta = 25°C
	2.8V Detect	VDET1	2.758	2.800	2.842	V	Ta = 25°C
	2.9V Detect	VDET1	2.886	2.930	2.974	V	Ta = 25°C
	3.4V Detect	VDET1	3.349	3.400	3.451	V	Ta = 25°C
	4.1V Detect	VDET1	4.039	4.100	4.162	V	Ta = 25°C
Detection voltage 2	1.9V Detect	VDET2	1.852	1.900	1.948	V	Ta = -40°C to 105°C
	2.8V Detect	VDET2	2.730	2.800	2.870	V	Ta = -40°C to 105°C
	2.9V Detect	VDET2	2.857	2.930	3.003	V	Ta = -40°C to 105°C
	3.4V Detect	VDET2	3.315	3.400	3.485	V	Ta = -40°C to 105°C
	4.1V Detect	VDET2	4.007	4.100	4.202	V	Ta = -40°C to 105°C
Hysteresis width	1.9V Detect	Vrhys	VDET×0.03	VDET×0.13	VDET×0.19	V	Ta=-40°C~105°C
	2.8V Detect	Vrhys	VDET×0.018	VDET×0.045	VDET×0.060	V	Ta=-40°C~105°C
	2.9V Detect	Vrhys	VDET×0.02	VDET×0.05	VDET×0.06	V	Ta=-40°C~105°C
	3.4V Detect	Vrhys	VDET×0.02	VDET×0.05	VDET×0.07	V	Ta=-40°C~105°C
	4.1V Detect	Vrhys	VDET×0.018	VDET×0.035	VDET×0.050	V	Ta=-40°C~105°C

## ●Electrical Characteristics - Continued

(Unless otherwise specified, Ta = -40°C to 105°C, VDD = 5V)

Parameter	Symbol	Limits			Unit	Conditions
		Min.	Typ.	Max.		
RESET transmission delay time: low → high	TPLH	3.9	6.9	10.1	ms	CT = 0.001μF *1 When VDD = VDET ±0.5V
Delay circuit resistance	Rrst	5.8	10.0	14.5	MΩ	VCT = GND
Delay pin threshold voltage	VCTH	VDD×0.3	VDD×0.45	VDD×0.6	V	RL = 470KΩ
Delay pin output current	ICT	150	—	—	μA	VDD = 1.50V, VCT = 0.5V
Min. operating voltage	VOPL	1.0	—	—	V	VOL ≤ 0.4V, RL = 470KΩ
[WDT]						
WDT monitor time	TwH	7.0	10.0	20.0	ms	CTW = 0.01μF *2
WDT reset time	TwL	2.4	3.3	7.0	ms	CTW = 0.01μF *3
Clock input pulse width	TWCLK	500	—	—	ns	
CLK high threshold voltage	VCLKH	VDD × 0.8	—	VDD	V	
CLK low threshold voltage	VCLKL	0	—	VDD × 0.3	V	
INH high threshold voltage	VINHH	VDD × 0.8	—	VDD	V	
INH low threshold voltage	VINHHL	0	—	VDD × 0.3	V	
CTW charge current	ICTWC	0.25	0.50	0.75	μA	VCTW = 0.2V
CTW discharge current	ICTWO	0.75	1.50	2.00	μA	VCTW = 0.8V

\*1 TPLH can be varied by changing the CT capacitance value.  
 $TPLH (s) \approx 0.69 \times Rrst (M\Omega) \times CT (\mu F)$  Rrst = 10 MΩ (Typ.)

\*2 TwH can be varied by changing the CTW capacitance value.  
 $TwH (s) \approx (0.5 \times CTW (\mu F)) / ICTWC (\mu A)$  ICTWC = 0.5 μA (Typ.)

\*3 TwL can be varied by changing the CTW capacitance value.  
 $TwL (s) \approx (0.5 \times CTW (\mu F)) / ICTWO (\mu A)$  ICTWO = 1.5 μA (Typ.)

● Typical Performance Curves

(Unless otherwise specified, Ta = 25°C) : 4.1V Detection

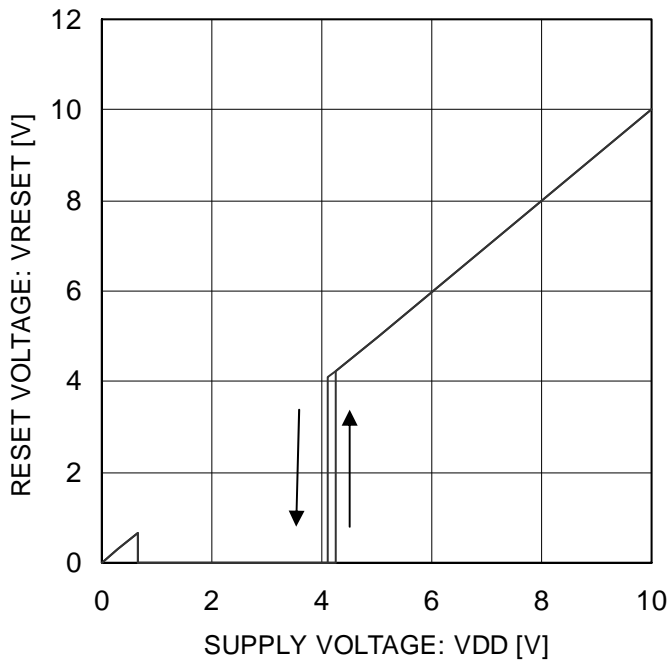


Figure 3. Detection Voltage

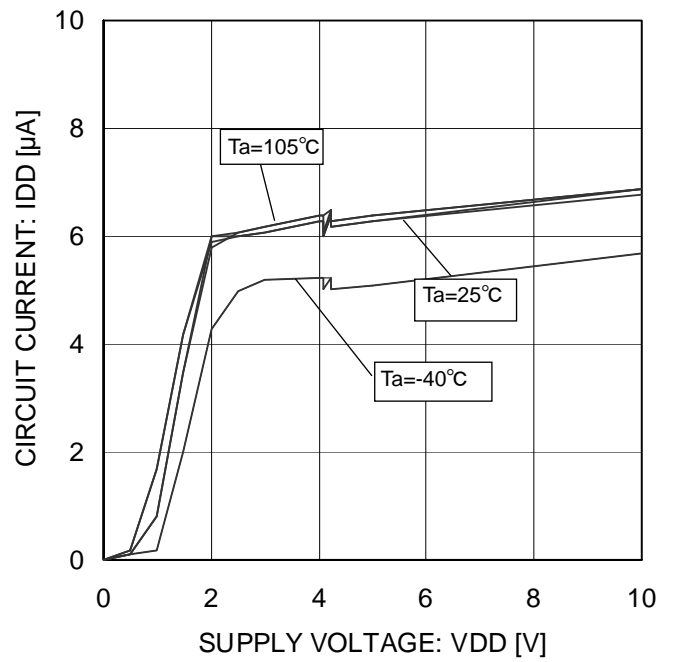


Figure 4. Total Supply Current

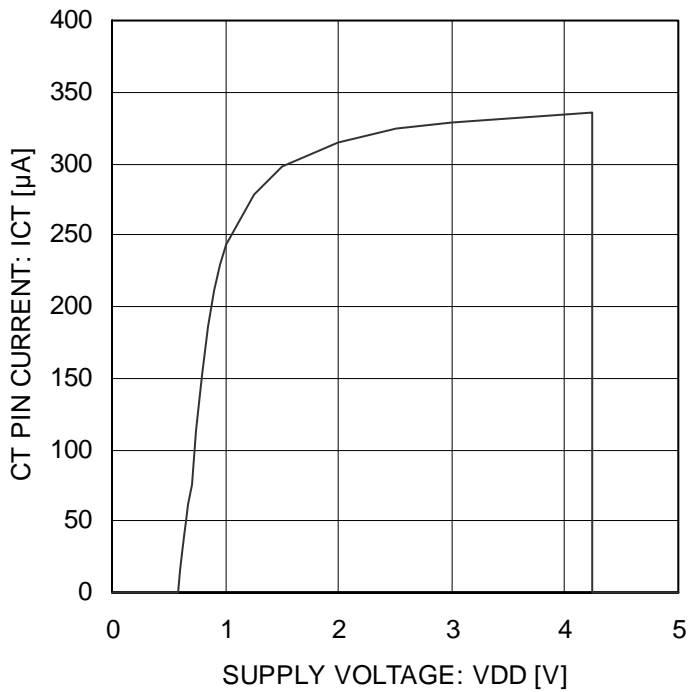


Figure 5. Delay Pin Current vs Power Supply Voltage

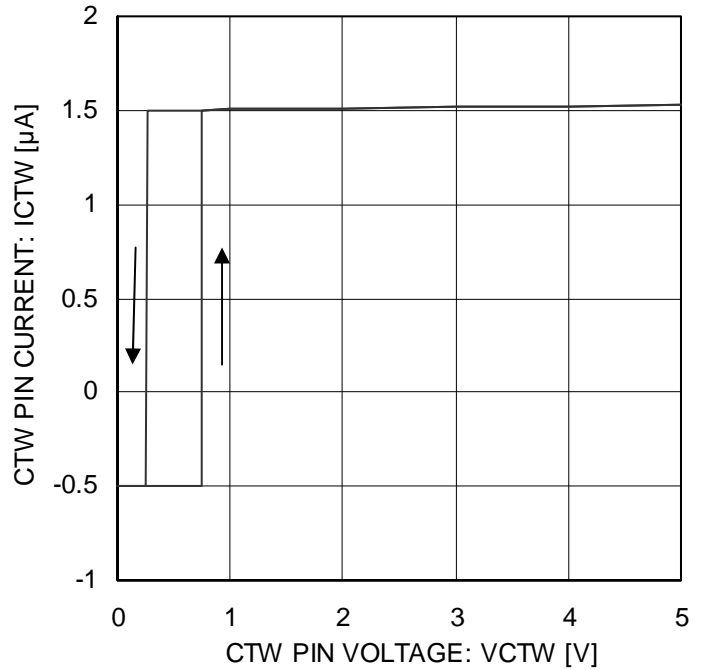


Figure 6. CTW Charge Discharge Current

● Typical Performance Curves – continued  
 (Unless otherwise specified, Ta = 25°C) : 4.1V Detection

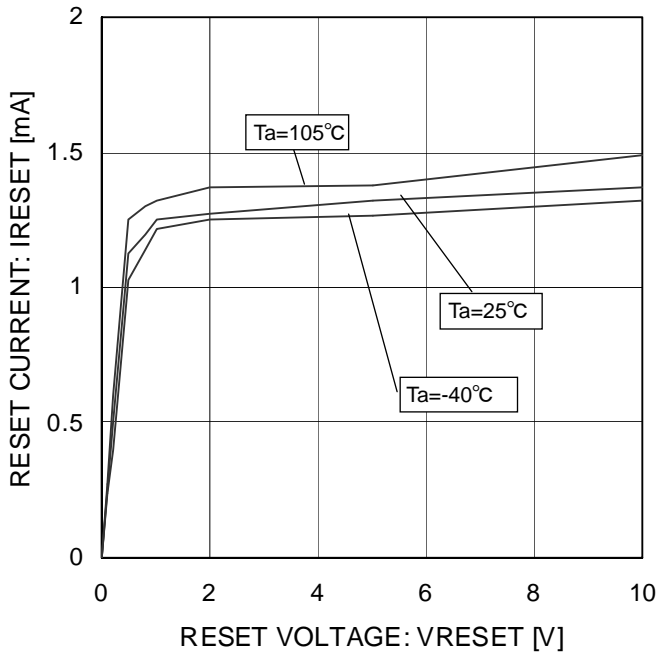


Figure 7. Output Current

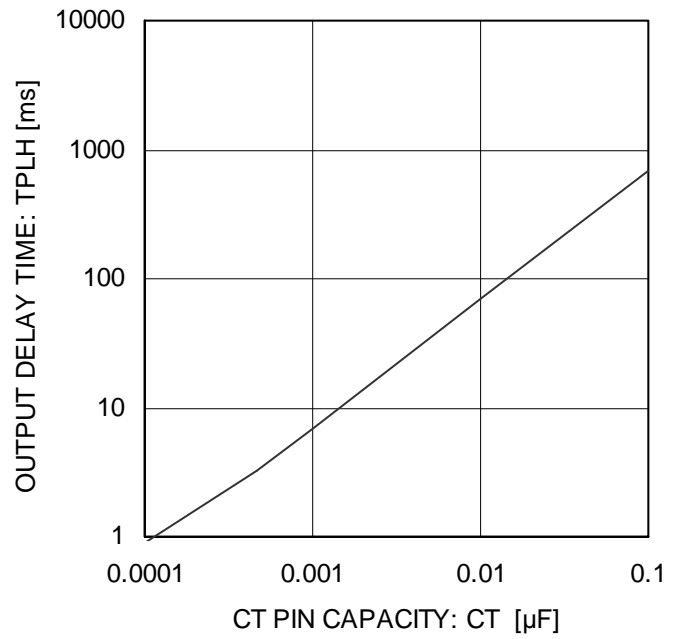


Figure 8. T RESET Transmission Delay Time vs Capacitance

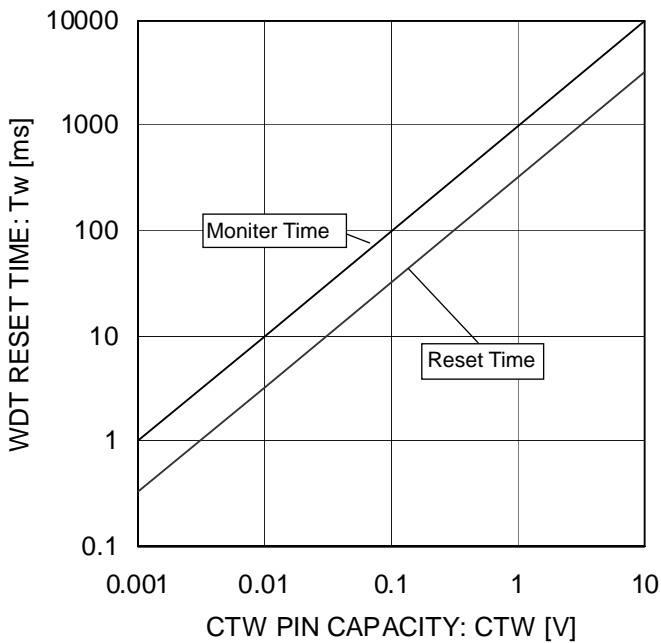


Figure 9. WDT Time vs Capacitance

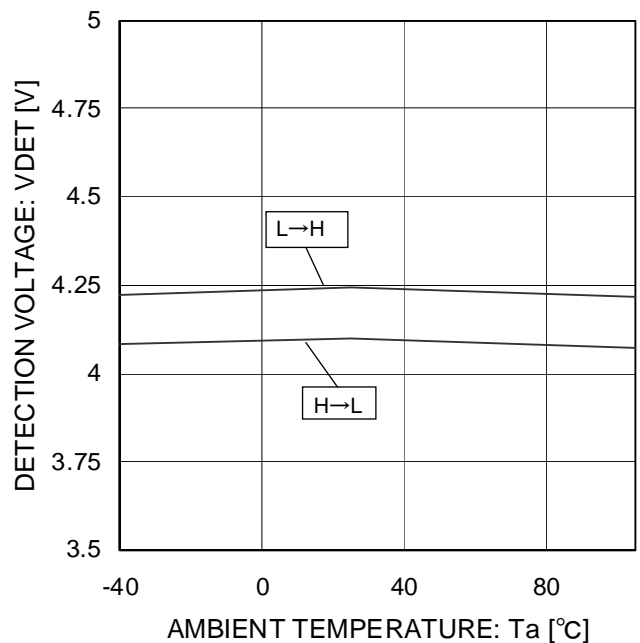


Figure 10. Detection Voltage vs Temperature

● **Typical Performance Curves – continued**  
 (Unless otherwise specified,  $T_a = 25^\circ\text{C}$ ) : 4.1V Detection

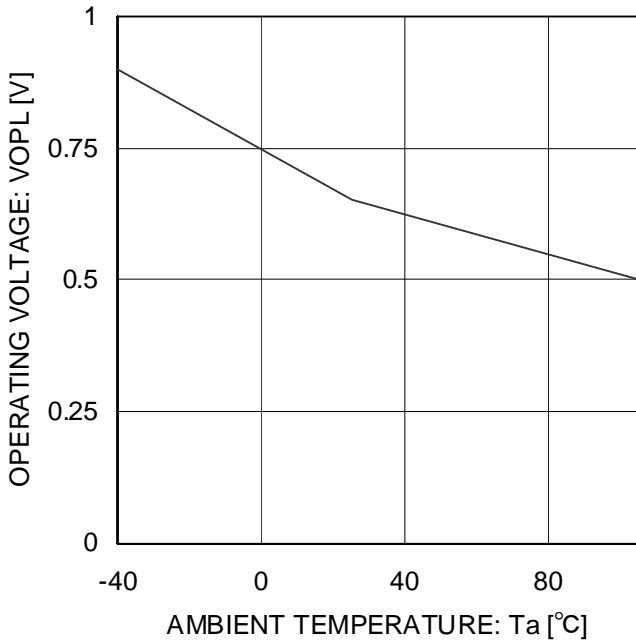


Figure 11. Operating Marginal Voltage vs Temperature

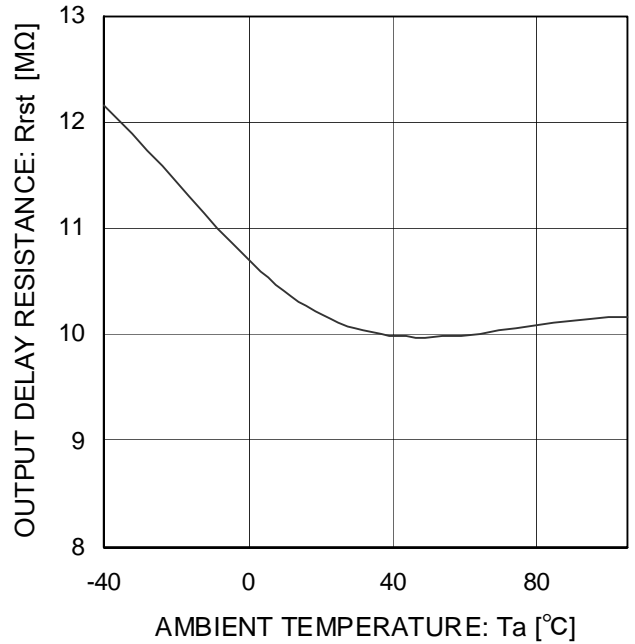


Figure 12. CT Pin Circuit Resistance vs Temperature

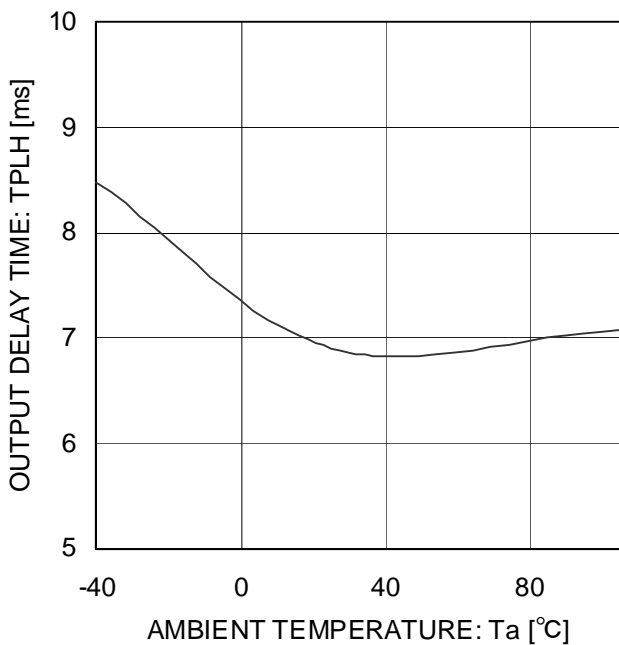


Figure 13. RESET Transmission Delay Time vs Temperature

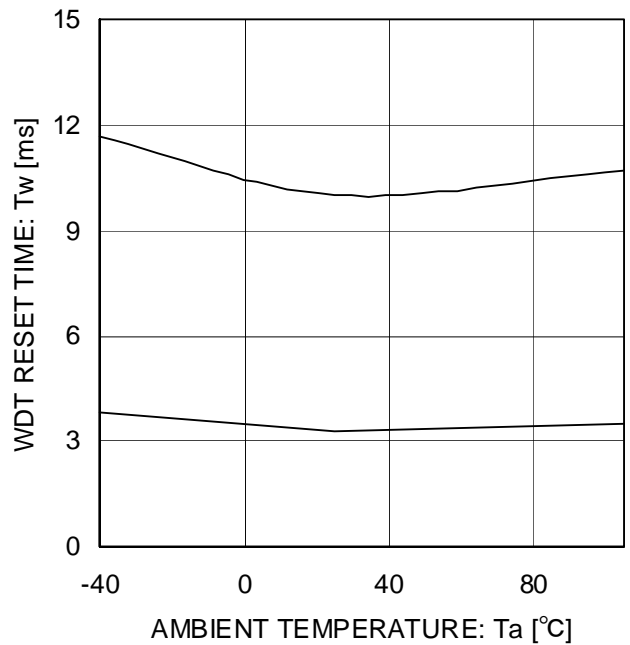


Figure 14. WDT Time vs Temperature

●Timing chart

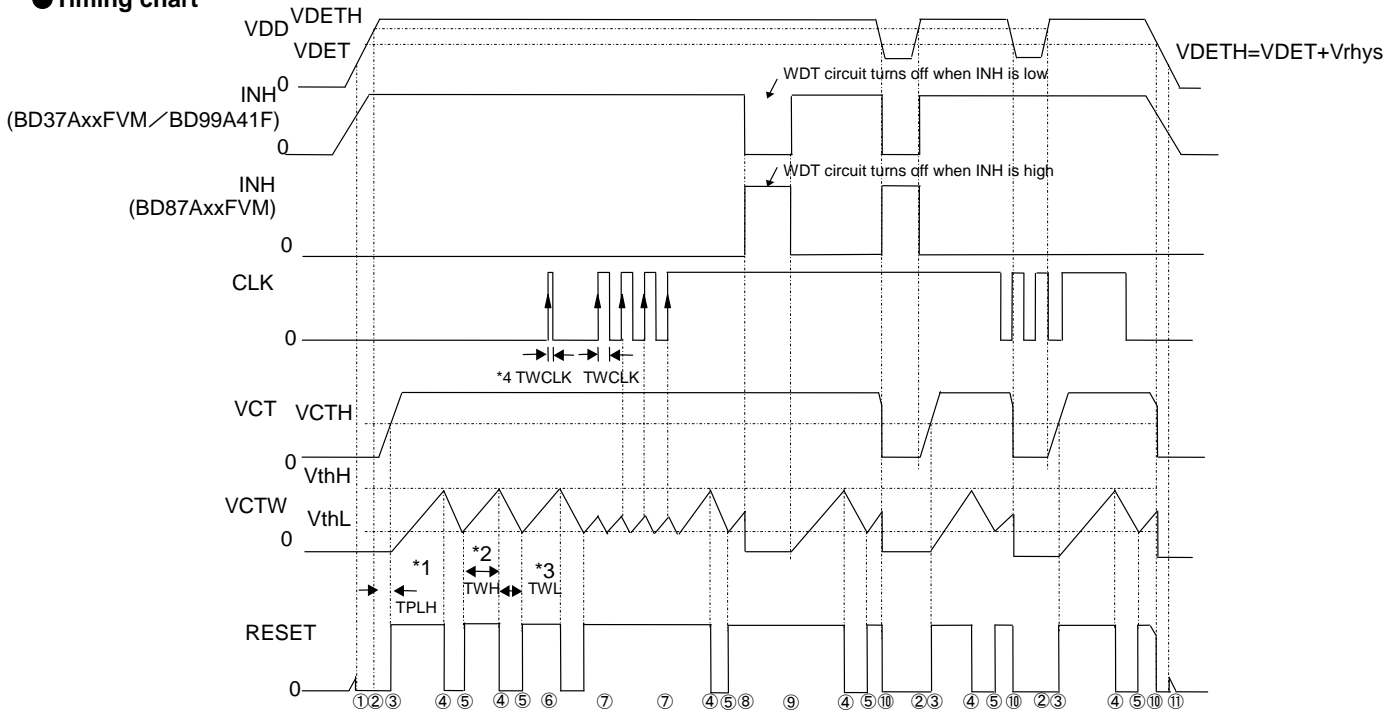


Figure 15. Timing Chart

●Explanation

- ① The RESET pin voltage (RESET) switches to low when the power supply voltage (VDD) falls to 0.8 V.
- ② The external capacitor connected to the CT pin begins to charge when VDD rises above the reset detection voltage (VDETH). The RESET signal stays low until VDD reaches the VDETH voltage and switches to high when VDD reaches or exceeds the VDETH voltage. The RESET transmission delay time TPLH allowed to elapse before RESET switches from low to high is given by the following equation:  

$$T_{PLH} (s) \approx 0.69 \times R_{rst} \times C_T (\mu F) \cdot \cdot [1]$$
 Rrst denotes the IC's built-in resistance and is designed to be 10 MΩ (Typ.). CT denotes the external capacitor connected to the CT pin.
- ③ The external capacitor connected to the CTW pin begins to charge when RESET rises, triggering the watchdog timer.
- ④ The CTW pin state switches from charge to discharge when the CTW pin voltage (VCTW) reaches VthH, and RESET switches from high to low. The watchdog timer monitor time TWH is given by the following equation:  

$$T_{WH} (s) \approx (0.5 \times C_{TW} (\mu F)) / (I_{CTWC}) \cdot \cdot [2]$$
 ICTWC denotes the CTW charge current and is designed to be 0.50 μA (Typ.). CTW denotes the external capacitor connected to the CTW pin.
- ⑤ The CTW pin state switches from charge to discharge when VCTW reaches VthL, and RESET switches from low to high. The watchdog timer reset time TWL is given by the following equation:  

$$T_{WL} (s) \approx (0.5 \times C_{TW} (\mu F)) / (I_{CTWO}) \cdot \cdot [3]$$
 ICTWO denotes the CTW discharge current and is designed to be 1.50 μA (Typ.).
- ⑥ The CTW pin state may not switch from charge to discharge when the CLK input pulse width TWCLK is short. Use a TWCLK input pulse width of at least 500 ns.  

$$TWCLK \geq 500 \text{ ns (Min.)}$$
- ⑦ When a pulse (positive edge trigger) of at least 500 ns is input to the CLK pin while the CTW pin is charging, the CTW state switches from charge to discharge. Once it discharges to VthL, it will charge again.
- ⑧ Watchdog timer operation is forced off when the INH pin switches to low (L: BD37Axx Series, BD99A41F, H: BD87AxxSeries). At that time, only the watchdog timer is turned off. Reset detection is performed normally.
- ⑨ The watchdog timer function turns on when the INH pin switches to high(H: BD37Axx Series, BD99A41F, L: BD87AxxSeries). The external capacitor connected to the CTW pin begins to charge at that time.
- ⑩ RESET switches from high to low when VDD falls to the RESET detection voltage (VDET) or lower.
- ⑪ When VDD falls to 0 V, the RESET signal stays low until VDD reaches 0.8 V.



● Power Dissipation

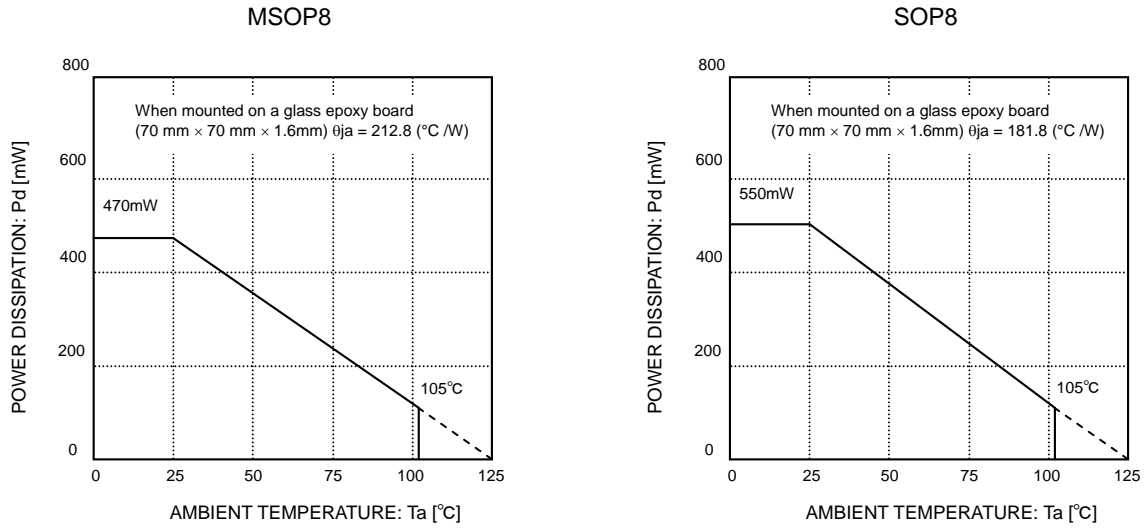


Figure 16. Power Dissipation

● I/O equivalence circuit

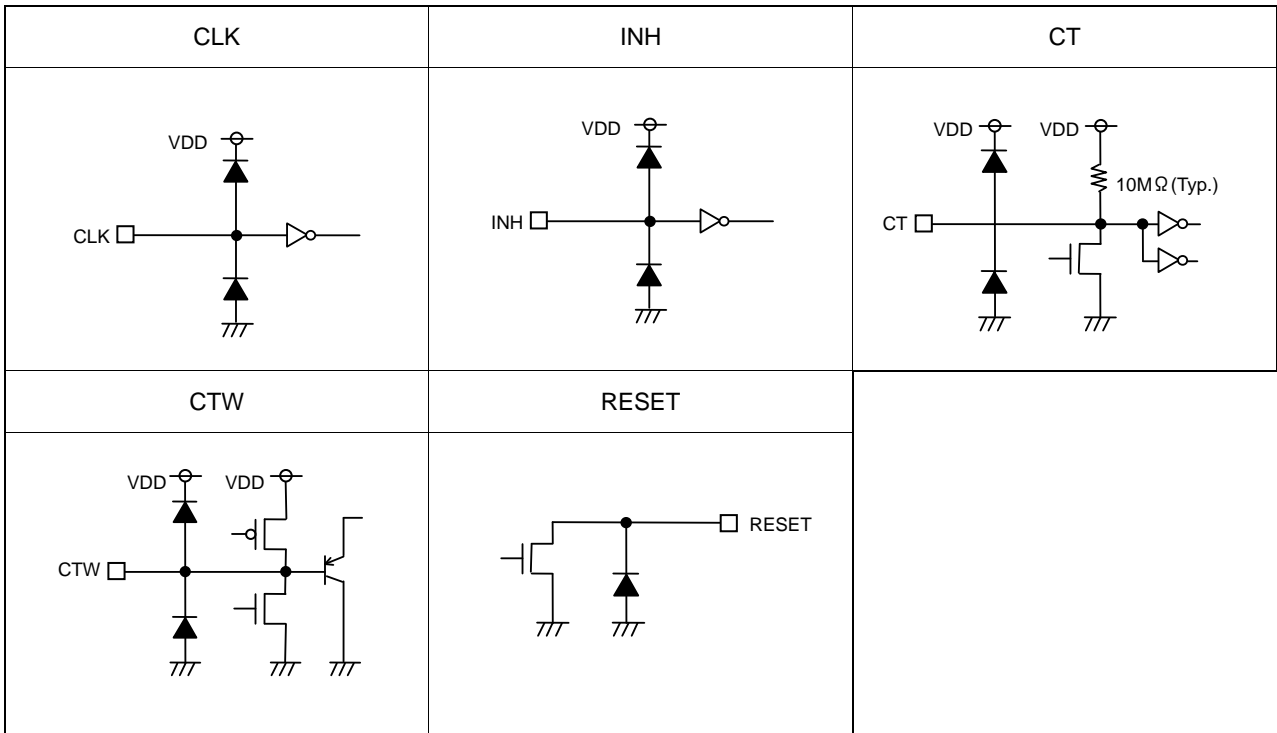


Figure 17. I/O equivalence circuit

●External settings for pins and precautions

- 1) Connect a capacitor (0.001  $\mu\text{F}$  to 1,000  $\mu\text{F}$ ) between the VDD and GND pins when the power line impedance is high. Use of the IC when the power line impedance is high may result in oscillation.
- 2) External capacitance  
A capacitor must be connected to the CTW pin. When using a large capacitor such as 1  $\mu\text{F}$ , the INH pin must allow a CTW discharge time of at least 2 ms. The power-on reset time is given by equation [1] on page 8. The WDT time is given by equations [2] and [3] on page 8. The setting times are proportional to the capacitance value from the equations, so the maximum and minimum setting times can be calculated from the electrical characteristics according to the capacitance. Note however that the electrical characteristics do not include the external capacitor's temperature characteristics.

●Operational Notes

- 1) Absolute maximum ratings  
An excess in the absolute maximum ratings, such as supply voltage, temperature range of operating conditions, etc., can break down the devices, thus making impossible to identify breaking mode, such as a short circuit or an open circuit. If any over rated values will expect to exceed the absolute maximum ratings, consider adding circuit protection devices, such as fuses.
- 2) GND voltage  
The potential of GND pin must be minimum potential in all operating conditions.
- 3) Thermal design  
Use a thermal design that allows for a sufficient margin in light of the power dissipation ( $P_d$ ) in actual operating conditions.
- 4) Inter-pin shorts and mounting errors  
Use caution when positioning the IC for mounting on printed circuit boards. The IC may be damaged if there is any connection error or if pins are shorted together.
- 5) Actions in strong electromagnetic field  
Use caution when using the IC in the presence of a strong electromagnetic field as doing so may cause the IC to malfunction.
- 6) Testing on application boards  
When testing the IC on an application board, connecting a capacitor to a pin with low impedance subjects the IC to stress. Always discharge capacitors after each process or step. Always turn the IC's power supply off before connecting it to or removing it from a jig or fixture during the inspection process. Ground the IC during assembly steps as an antistatic measure. Use similar precaution when transporting or storing the IC.
- 7) Regarding input pin of the IC  
This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of these P layers with the N layers of other elements, creating a parasitic diode or transistor. For example, the relation between each potential is as follows:  
  - When  $\text{GND} > \text{Pin A}$  and  $\text{GND} > \text{Pin B}$ , the P-N junction operates as a parasitic diode.
  - When  $\text{GND} > \text{Pin B}$ , the P-N junction operates as a parasitic transistor.
Parasitic diodes can occur inevitable in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Accordingly, methods by which parasitic diodes operate, such as applying a voltage that is lower than the GND (P substrate) voltage to an input pin, should not be used.

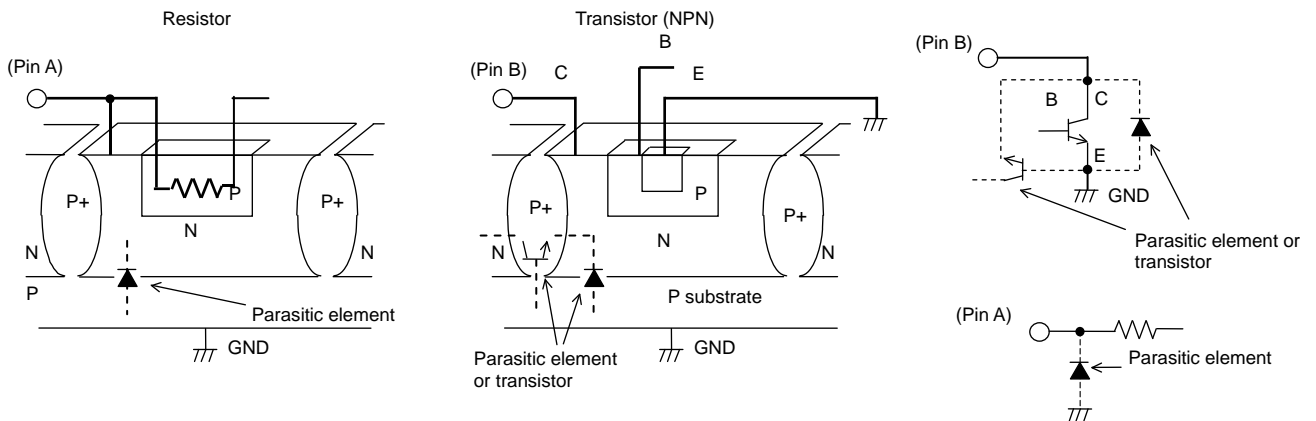


Figure 18. Example of IC structure

## 8) Ground Wiring Pattern

When using both small signal and large current GND patterns, it is recommended to isolate the two ground patterns, placing a single ground point at the ground potential of application so that the pattern wiring resistance and voltage variations caused by large currents do not cause variations in the small signal ground voltage. Be careful not to change the GND wiring pattern of any external components, either.

- 9) Applications or inspection processes with modes where the potentials of the VDD pin and other pins may be reversed from their normal states may cause damage to the IC's internal circuitry or elements. Use an output pin capacitance of 1000  $\mu\text{F}$  or lower in case VDD is shorted with the GND pin while the external capacitor is charged. It is recommended to insert a diode for preventing back current flow in series with VDD or bypass diodes between Vcc and each pin.

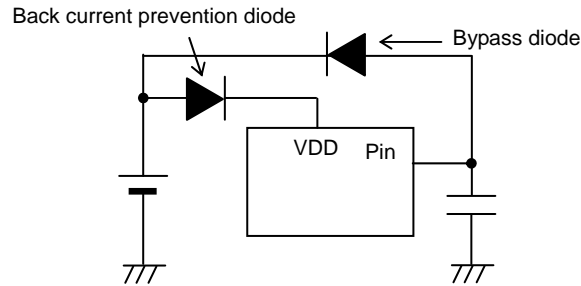
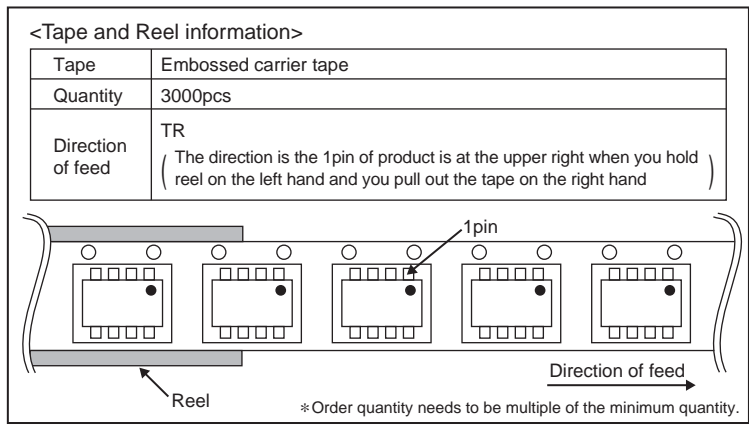
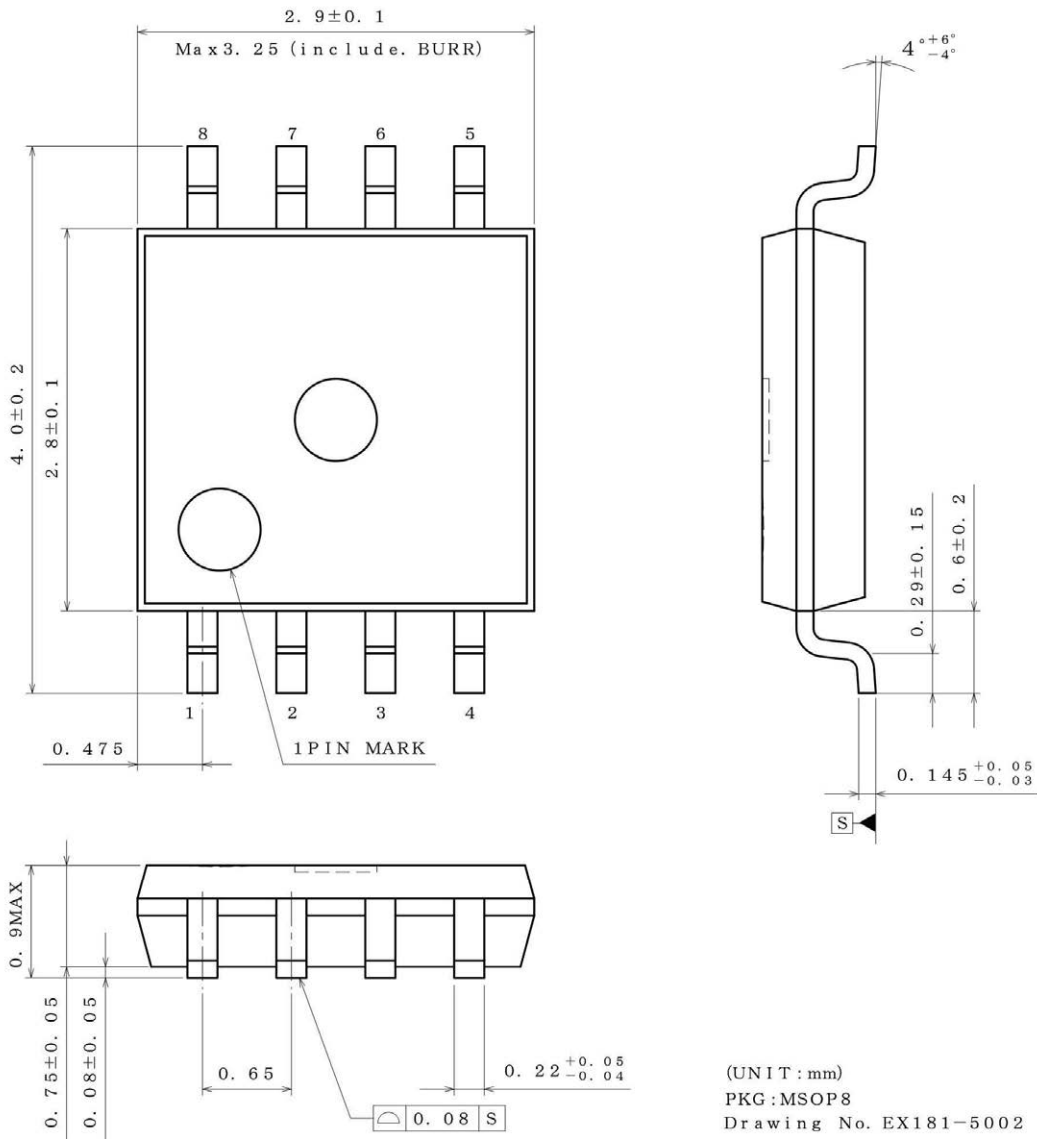


Figure 19.

- 10) When VDD falls below the operating marginal voltage, output will be open. When output is being pulled up to input, output will be equivalent to VDD.
- 11) Input pin  
The CLK and INH pins comprise inverter gates and should not be left open. (These pins should be either pulled up or down.) Input to the CLK pin is detected using a positive edge trigger and does not affect the CLK signal duty. Input the trigger to the CLK pin within the TWH time.

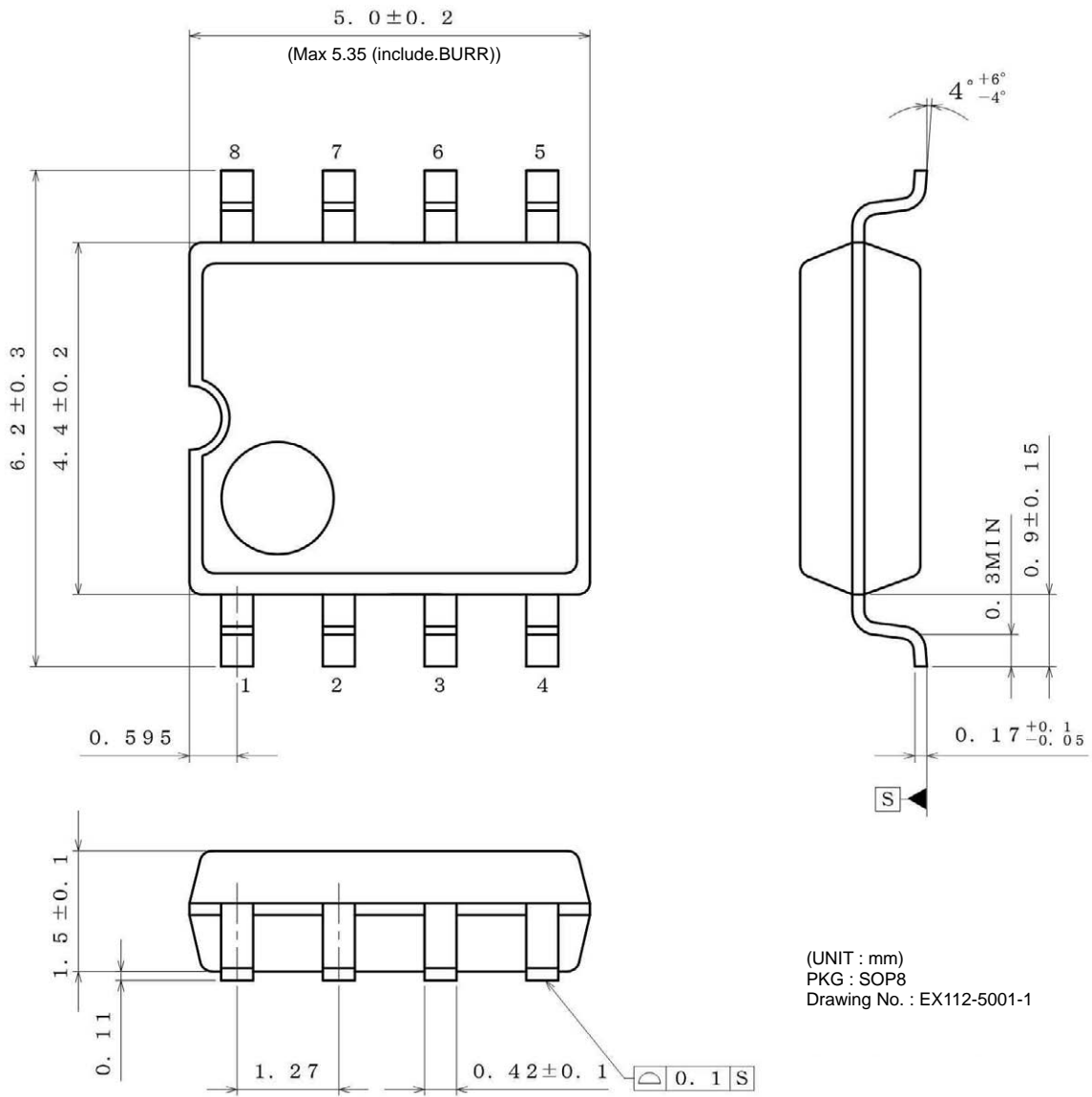
●Physical Dimension, Tape and Reel Information

Package Name	MSOP8
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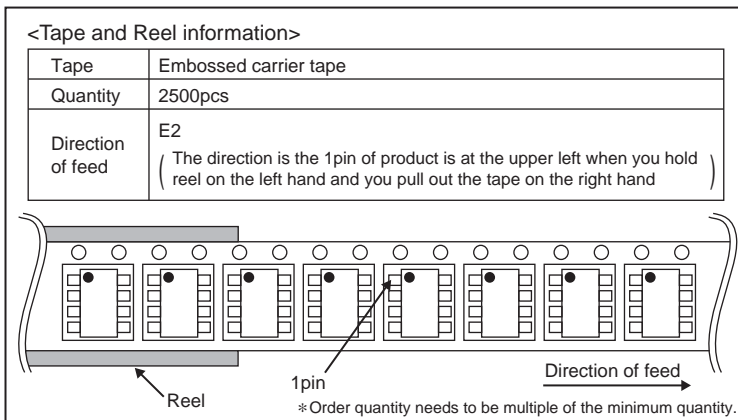


●Physical Dimension, Tape and Reel Information – continued

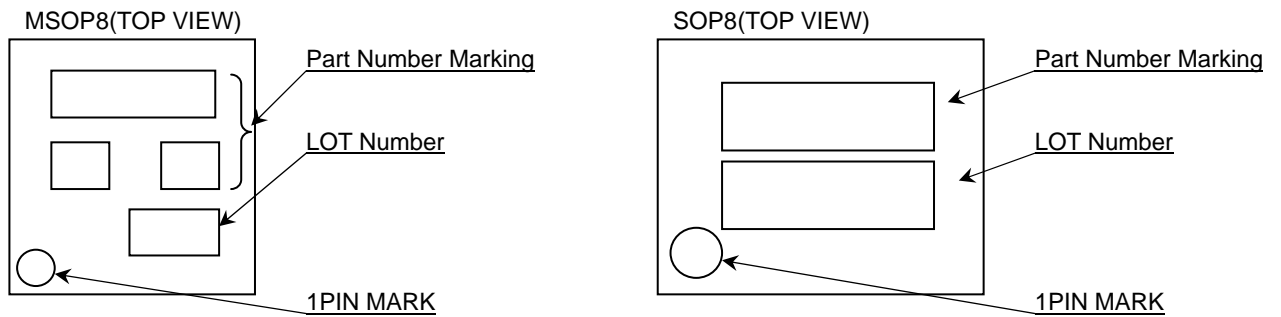
Package Name	SOP8
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(UNIT : mm)  
 PKG : SOP8  
 Drawing No. : EX112-5001-1



●Marking Diagrams



Part Number Marking	Package		Part Number
D3719	MSOP8	Reel of 3000	BD37A19FVM-TR
D3741	MSOP8	Reel of 3000	BD37A41FVM-TR
D8728	MSOP8	Reel of 3000	BD87A28FVM-TR
D8729	MSOP8	Reel of 3000	BD87A29FVM-TR
D8734	MSOP8	Reel of 3000	BD87A34FVM-TR
D8741	MSOP8	Reel of 3000	BD87A41FVM-TR
99A41	SOP8	Reel of 2500	BD99A41F-E2

●Revision History

Date	Revision	Changes
12.Apr.2013	001	New Release
25.Apr.2013	002	P.8 Explanation ⑨ modified. P.9 Figure 17. I/O equivalence circuit the error in writing of the part of CLK was corrected.

# Notice

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  - [a] Installation of protection circuits or other protective devices to improve system safety
  - [b] Installation of redundant circuits to reduce the impact of single or multiple circuit failure
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  - [a] Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
  - [b] Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
  - [c] Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - [d] Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
  - [e] Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
  - [f] Sealing or coating our Products with resin or other coating materials
  - [g] Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
  - [h] Use of the Products in places subject to dew condensation
- 4) The Products are not subject to radiation-proof design.
- 5) Please verify and confirm characteristics of the final or mounted products in using the Products.
- 6) In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse) is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.
- 7) De-rate Power Dissipation (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient temperature.
- 8) Confirm that operation temperature is within the specified range described in the product specification.
- 9) ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.



**●Precaution for Mounting / Circuit board design**

- 1) When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.
- 2) In principle, the reflow soldering method must be used; if flow soldering method is preferred, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

**●Precautions Regarding Application Examples and External Circuits**

- 1) If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.
- 2) You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

**●Precaution for Electrostatic**

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

**●Precaution for Storage / Transportation**

- 1) Product performance and soldered connections may deteriorate if the Products are stored in the places where:
  - [a] the Products are exposed to sea winds or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - [b] the temperature or humidity exceeds those recommended by ROHM
  - [c] the Products are exposed to direct sunshine or condensation
  - [d] the Products are exposed to high Electrostatic
- 2) Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.
- 3) Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.
- 4) Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

**●Precaution for Product Label**

QR code printed on ROHM Products label is for ROHM's internal use only.

**●Precaution for Disposition**

When disposing Products please dispose them properly using an authorized industry waste company.

**●Precaution for Foreign Exchange and Foreign Trade act**

Since our Products might fall under controlled goods prescribed by the applicable foreign exchange and foreign trade act, please consult with ROHM representative in case of export.

**●Precaution Regarding Intellectual Property Rights**

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● **Other Precaution**

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С конца 2013 года компания активно расширяет линейку поставок компонентов по направлению коаксиальный кабель, кварцевые генераторы и конденсаторы (керамические, пленочные, электролитические), за счёт заключения дистрибьюторских договоров

Мы предлагаем:

- Конкуренеспособные цены и скидки постоянным клиентам.
- Специальные условия для постоянных клиентов.
- Подбор аналогов.
- Поставку компонентов в любых объемах, удовлетворяющих вашим потребностям.
- Приемлемые сроки поставки, возможна ускоренная поставка.
- Доставку товара в любую точку России и стран СНГ.
- Комплексную поставку.
- Работу по проектам и поставку образцов.
- Формирование склада под заказчика.
- Сертификаты соответствия на поставляемую продукцию (по желанию клиента).
- Тестирование поставляемой продукции.
- Поставку компонентов, требующих военную и космическую приемку.
- Входной контроль качества.
- Наличие сертификата ISO.

В составе нашей компании организован Конструкторский отдел, призванный помогать разработчикам, и инженерам.

Конструкторский отдел помогает осуществить:

- Регистрацию проекта у производителя компонентов.
- Техническую поддержку проекта.
- Защиту от снятия компонента с производства.
- Оценку стоимости проекта по компонентам.
- Изготовление тестовой платы монтаж и пусконаладочные работы.



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