

### Features

- Low power consumption
- Low temperature coefficient
- Built-in high-stability reference source
- Built-in hysteresis characteristic
- TO-92 & SOT-89 package

### Applications

- Battery checkers
- Level selectors
- Power failure detectors
- Microcomputer reset
- Battery memory backup
- Non-volatile RAM signal storage protectors

### General Description

The HT70XX series is a set of three-terminal low power voltage detectors implemented in CMOS technology. Each voltage detector in the series detects a particular fixed voltage ranging from 2.2V to 7V. The voltage detectors consist of a high-precision and low power consumption standard voltage source, a comparator, hysteresis circuit, and an output driver. CMOS technology ensures low power consumption.

Although designed primarily as fixed voltage detectors, these devices can be used with external components to detect user specified threshold voltages (NMOS open drain type only).

### Selection Table

| Part No. | Detectable Voltage | Hysteresis Width | Tolerance |
|----------|--------------------|------------------|-----------|
| HT7022A  | 2.2V               | 0.11V            | ±5%       |
| HT7024A  | 2.4V               | 0.12V            | ±5%       |
| HT7027A  | 2.7V               | 0.135V           | ±5%       |
| HT7033A  | 3.3V               | 0.165V           | ±5%       |
| HT7039A  | 3.9V               | 0.195V           | ±5%       |
| HT7044A  | 4.4V               | 0.22V            | ±5%       |
| HT7050A  | 5.0V               | 0.25V            | ±5%       |
| HT7070A  | 7.0V               | 0.35V            | ±5%       |

Note: The output type selection codes are:

NMOS open drain normal open, active low

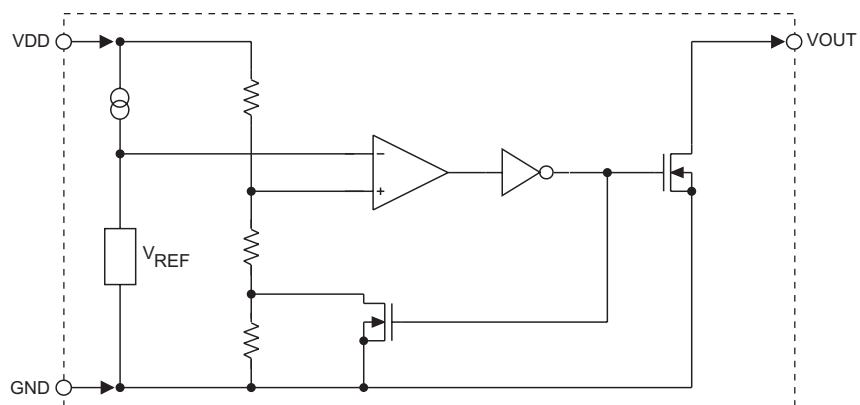
For example: The HT7070A is a 7.0V, NMOS open drain active low output

### Output type selection table

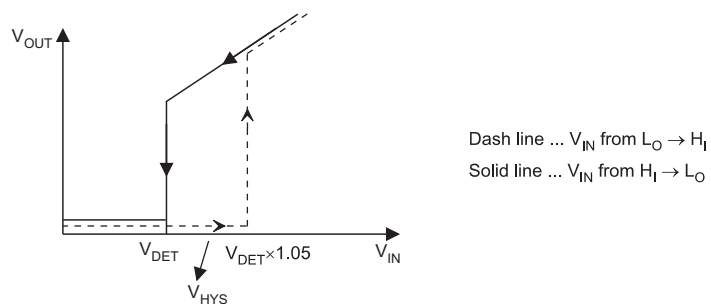
| Type | $V_{DD}$  |                                 |
|------|-----------|---------------------------------|
|      | $V_{OUT}$ |                                 |
| A    |           | $V_{DD} > V_{DET}(+)$<br>Hi-Z   |
|      |           | $V_{DD} \leq V_{DET}(-)$<br>VSS |

## Block Diagram

N channel open drain output (normal open; active low)

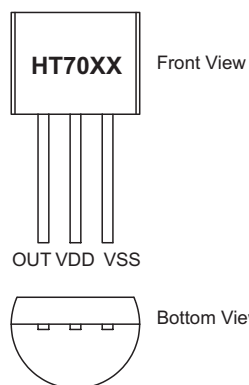


## A type

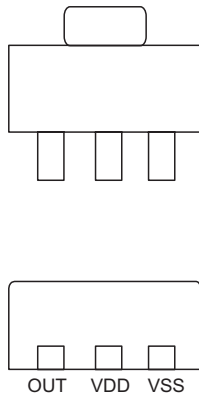


## Pin Assignment

### TO-92

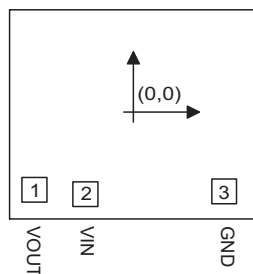


### SOT-89



## Pad Assignment

HT70XX (except HT7022A)



Chip size:  $1317 \times 1158 (\mu\text{m})^2$

\* The IC substrate should be connected to VDD in the PCB layout artwork.

## Pad Coordinates

HT70XX (except HT7022A)

Unit:  $\mu\text{m}$

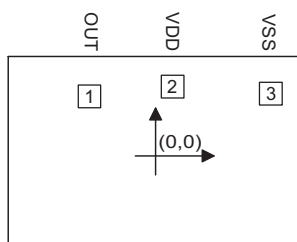
| Pad No. | X       | Y       |
|---------|---------|---------|
| 1       | -483.30 | -379.50 |
| 2       | -234.60 | -399.50 |
| 3       | 443.90  | -386.00 |

HT7022A only

Unit:  $\mu\text{m}$

| Pad No. | X       | Y      |
|---------|---------|--------|
| 1       | -434.34 | 394.97 |
| 2       | 120.65  | 461.01 |
| 3       | 774.70  | 412.75 |

HT7022A only



Chip size:  $2032 \times 1321 (\mu\text{m})^2$

\* The IC substrate should be connected to VDD in the PCB layout artwork.

## Absolute Maximum Ratings

|                                     |                                              |
|-------------------------------------|----------------------------------------------|
| Supply Voltage, except HT7022A..... | -0.3V to 26V                                 |
| Supply Voltage, HT7022A only.....   | -0.3V to 13V                                 |
| Output Voltage.....                 | $V_{SS}-0.3\text{V}$ to $V_{DD}+0.3\text{V}$ |
| Output Current.....                 | 50mA                                         |
| Storage Temperature.....            | -50°C to 125°C                               |
| Power Consumption.....              | 200mW                                        |
| Operating Temperature.....          | 0°C to 70°C                                  |

Note: These are stress ratings only. Stresses exceeding the range specified under "Absolute Maximum Ratings" may cause substantial damage to the device. Functional operation of this device at other conditions beyond those listed in the specification is not implied and prolonged exposure to extreme conditions may affect device reliability.

**Electrical Characteristics**
**HT7022A**

Ta=25°C

| Symbol                              | Parameter                | Test Conditions |                        | Min.                     | Typ.                     | Max.                    | Unit  |
|-------------------------------------|--------------------------|-----------------|------------------------|--------------------------|--------------------------|-------------------------|-------|
|                                     |                          | V <sub>DD</sub> | Conditions             |                          |                          |                         |       |
| V <sub>DET</sub>                    | Hi→Lo Detectable Voltage | —               | —                      | 2.09                     | 2.2                      | 2.31                    | V     |
|                                     | Lo→Hi Detectable Voltage | —               | —                      | 2.132                    | 2.31                     | 2.541                   | V     |
| V <sub>HYS</sub>                    | Hysteresis Width         | —               | —                      | 0.02<br>V <sub>DET</sub> | 0.05<br>V <sub>DET</sub> | 0.1<br>V <sub>DET</sub> | V     |
| I <sub>DD</sub>                     | Operating Current        | 3.2V            | No load                | —                        | 1.8                      | 4                       | μA    |
| V <sub>DD</sub>                     | Operating Voltage        | —               | —                      | 1.6                      | —                        | 12                      | V     |
| I <sub>OL</sub>                     | Output Sink Current      | 2V              | V <sub>OUT</sub> =0.2V | 0.5                      | 1                        | —                       | mA    |
| $\frac{\Delta V_{DET}}{\Delta T_A}$ | Temperature Coefficient  | —               | 0°C<Ta<70°C            | —                        | ±0.9                     | —                       | mV/°C |

**HT7024A**

Ta=25°C

| Symbol                              | Parameter                | Test Conditions |                        | Min.                     | Typ.                     | Max.                    | Unit  |
|-------------------------------------|--------------------------|-----------------|------------------------|--------------------------|--------------------------|-------------------------|-------|
|                                     |                          | V <sub>DD</sub> | Conditions             |                          |                          |                         |       |
| V <sub>DET</sub>                    | Hi→Lo Detectable Voltage | —               | —                      | 2.28                     | 2.4                      | 2.52                    | V     |
|                                     | Lo→Hi Detectable Voltage | —               | —                      | 2.325                    | 2.52                     | 2.772                   | V     |
| V <sub>HYS</sub>                    | Hysteresis Width         | —               | —                      | 0.02<br>V <sub>DET</sub> | 0.05<br>V <sub>DET</sub> | 0.1<br>V <sub>DET</sub> | V     |
| I <sub>DD</sub>                     | Operating Current        | 8V              | No load                | —                        | 4                        | 7                       | μA    |
| V <sub>DD</sub>                     | Operating Voltage        | —               | —                      | 1.5                      | —                        | 24                      | V     |
| I <sub>OL</sub>                     | Output Sink Current      | 2V              | V <sub>OUT</sub> =0.2V | 0.5                      | 1                        | —                       | mA    |
| $\frac{\Delta V_{DET}}{\Delta T_A}$ | Temperature Coefficient  | —               | 0°C<Ta<70°C            | —                        | ±0.9                     | —                       | mV/°C |

**HT7027A**

Ta=25°C

| Symbol                              | Parameter                | Test Conditions |                        | Min.                     | Typ.                     | Max.                    | Unit  |
|-------------------------------------|--------------------------|-----------------|------------------------|--------------------------|--------------------------|-------------------------|-------|
|                                     |                          | V <sub>DD</sub> | Conditions             |                          |                          |                         |       |
| V <sub>DET</sub>                    | Hi→Lo Detectable Voltage | —               | —                      | 2.565                    | 2.7                      | 2.835                   | V     |
|                                     | Lo→Hi Detectable Voltage | —               | —                      | 2.616                    | 2.835                    | 3.118                   | V     |
| V <sub>HYS</sub>                    | Hysteresis Width         | —               | —                      | 0.02<br>V <sub>DET</sub> | 0.05<br>V <sub>DET</sub> | 0.1<br>V <sub>DET</sub> | V     |
| I <sub>DD</sub>                     | Operating Current        | 8V              | No load                | —                        | 4                        | 7                       | μA    |
| V <sub>DD</sub>                     | Operating Voltage        | —               | —                      | 1.5                      | —                        | 24                      | V     |
| I <sub>OL</sub>                     | Output Sink Current      | 2V              | V <sub>OUT</sub> =0.2V | 0.5                      | 1                        | —                       | mA    |
| $\frac{\Delta V_{DET}}{\Delta T_A}$ | Temperature Coefficient  | —               | 0°C<Ta<70°C            | —                        | ±0.9                     | —                       | mV/°C |

**HT7033A**

Ta=25°C

| Symbol                              | Parameter                | Test Conditions |                         | Min.                     | Typ.                     | Max.                    | Unit  |
|-------------------------------------|--------------------------|-----------------|-------------------------|--------------------------|--------------------------|-------------------------|-------|
|                                     |                          | V <sub>DD</sub> | Conditions              |                          |                          |                         |       |
| V <sub>DET</sub>                    | Hi→Lo Detectable Voltage | —               | —                       | 3.135                    | 3.3                      | 3.465                   | V     |
|                                     | Lo→Hi Detectable Voltage | —               | —                       | 3.197                    | 3.465                    | 3.811                   | V     |
| V <sub>HYS</sub>                    | Hysteresis Width         | —               | —                       | 0.02<br>V <sub>DET</sub> | 0.05<br>V <sub>DET</sub> | 0.1<br>V <sub>DET</sub> | V     |
| I <sub>DD</sub>                     | Operating Current        | 8V              | No load                 | —                        | 4                        | 7                       | μA    |
| V <sub>DD</sub>                     | Operating Voltage        | —               | —                       | 1.5                      | —                        | 24                      | V     |
| I <sub>OL</sub>                     | Output Sink Current      | 2.5V            | V <sub>OUT</sub> =0.25V | 1.2                      | 2.5                      | —                       | mA    |
| $\frac{\Delta V_{DET}}{\Delta T_A}$ | Temperature Coefficient  | —               | 0°C<Ta<70°C             | —                        | ±0.9                     | —                       | mV/°C |

**HT7039A**

Ta=25°C

| Symbol                              | Parameter                | Test Conditions |                         | Min.                     | Typ.                     | Max.                    | Unit  |
|-------------------------------------|--------------------------|-----------------|-------------------------|--------------------------|--------------------------|-------------------------|-------|
|                                     |                          | V <sub>DD</sub> | Conditions              |                          |                          |                         |       |
| V <sub>DET</sub>                    | Hi→Lo Detectable Voltage | —               | —                       | 3.705                    | 3.9                      | 4.095                   | V     |
|                                     | Lo→Hi Detectable Voltage | —               | —                       | 3.779                    | 4.095                    | 4.504                   | V     |
| V <sub>HYS</sub>                    | Hysteresis Width         | —               | —                       | 0.02<br>V <sub>DET</sub> | 0.05<br>V <sub>DET</sub> | 0.1<br>V <sub>DET</sub> | V     |
| I <sub>DD</sub>                     | Operating Current        | 8V              | No load                 | —                        | 4                        | 7                       | μA    |
| V <sub>DD</sub>                     | Operating Voltage        | —               | —                       | 1.5                      | —                        | 24                      | V     |
| I <sub>OL</sub>                     | Output Sink Current      | 2.5V            | V <sub>OUT</sub> =0.25V | 1.2                      | 2.5                      | —                       | mA    |
| $\frac{\Delta V_{DET}}{\Delta T_A}$ | Temperature Coefficient  | —               | 0°C<Ta<70°C             | —                        | ±0.9                     | —                       | mV/°C |

**HT7044A**

Ta=25°C

| Symbol                              | Parameter                | Test Conditions |                         | Min.                     | Typ.                     | Max.                    | Unit  |
|-------------------------------------|--------------------------|-----------------|-------------------------|--------------------------|--------------------------|-------------------------|-------|
|                                     |                          | V <sub>DD</sub> | Conditions              |                          |                          |                         |       |
| V <sub>DET</sub>                    | Hi→Lo Detectable Voltage | —               | —                       | 4.18                     | 4.4                      | 4.62                    | V     |
|                                     | Lo→Hi Detectable Voltage | —               | —                       | 4.263                    | 4.62                     | 5.082                   | V     |
| V <sub>HYS</sub>                    | Hysteresis Width         | —               | —                       | 0.02<br>V <sub>DET</sub> | 0.05<br>V <sub>DET</sub> | 0.1<br>V <sub>DET</sub> | V     |
| I <sub>DD</sub>                     | Operating Current        | 8V              | No load                 | —                        | 4                        | 7                       | μA    |
| V <sub>DD</sub>                     | Operating Voltage        | —               | —                       | 1.5                      | —                        | 24                      | V     |
| I <sub>OL</sub>                     | Output Sink Current      | 3.6V            | V <sub>OUT</sub> =0.36V | 3                        | 6                        | —                       | mA    |
| $\frac{\Delta V_{DET}}{\Delta T_A}$ | Temperature Coefficient  | —               | 0°C<Ta<70°C             | —                        | ±0.9                     | —                       | mV/°C |

**HT7050A**

Ta=25°C

| Symbol                              | Parameter                | Test Conditions |                         | Min.                     | Typ.                     | Max.                    | Unit  |
|-------------------------------------|--------------------------|-----------------|-------------------------|--------------------------|--------------------------|-------------------------|-------|
|                                     |                          | V <sub>DD</sub> | Conditions              |                          |                          |                         |       |
| V <sub>DET</sub>                    | Hi→Lo Detectable Voltage | —               | —                       | 4.75                     | 5                        | 5.25                    | V     |
|                                     | Lo→Hi Detectable Voltage | —               | —                       | 4.845                    | 5.25                     | 5.775                   | V     |
| V <sub>HYS</sub>                    | Hysteresis Width         | —               | —                       | 0.02<br>V <sub>DET</sub> | 0.05<br>V <sub>DET</sub> | 0.1<br>V <sub>DET</sub> | V     |
| I <sub>DD</sub>                     | Operating Current        | 8V              | No load                 | —                        | 4                        | 7                       | μA    |
| V <sub>DD</sub>                     | Operating Voltage        | —               | —                       | 2.1                      | —                        | 24                      | V     |
| I <sub>OL</sub>                     | Output Sink Current      | 3.6V            | V <sub>OUT</sub> =0.36V | 3                        | 6                        | —                       | mA    |
| $\frac{\Delta V_{DET}}{\Delta T_A}$ | Temperature Coefficient  | —               | 0°C<Ta<70°C             | —                        | ±0.9                     | —                       | mV/°C |

**HT7070A**

Ta=25°C

| Symbol                              | Parameter                | Test Conditions |                        | Min.                     | Typ.                     | Max.                    | Unit  |
|-------------------------------------|--------------------------|-----------------|------------------------|--------------------------|--------------------------|-------------------------|-------|
|                                     |                          | V <sub>DD</sub> | Conditions             |                          |                          |                         |       |
| V <sub>DET</sub>                    | Hi→Lo Detectable Voltage | —               | —                      | 6.65                     | 7                        | 7.35                    | V     |
|                                     | Lo→Hi Detectable Voltage | —               | —                      | 6.783                    | 7.35                     | 8.085                   | V     |
| V <sub>HYS</sub>                    | Hysteresis Width         | —               | —                      | 0.02<br>V <sub>DET</sub> | 0.05<br>V <sub>DET</sub> | 0.1<br>V <sub>DET</sub> | V     |
| I <sub>DD</sub>                     | Operating Current        | 8V              | No load                | —                        | 4                        | 7                       | μA    |
| V <sub>DD</sub>                     | Operating Voltage        | —               | —                      | 2.1                      | —                        | 24                      | V     |
| I <sub>OL</sub>                     | Output Sink Current      | 5V              | V <sub>OUT</sub> =0.5V | 5                        | 10                       | —                       | mA    |
| $\frac{\Delta V_{DET}}{\Delta T_A}$ | Temperature Coefficient  | —               | 0°C<Ta<70°C            | —                        | ±0.9                     | —                       | mV/°C |

**Functional Description**

The HT70XX series is a set of voltage detectors equipped with a high stability voltage reference which is connected to the negative input of a comparator—denoted as V<sub>REF</sub> in the following figure for NMOS output voltage detector.

When the voltage drop to the positive input of the comparator (i.e, V<sub>B</sub>) is higher than V<sub>REF</sub>, V<sub>OUT</sub> goes high, M1 turns off, and V<sub>B</sub> is expressed as V<sub>BH</sub>=V<sub>DD</sub>×(RB+RC)/(RA+RB+RC). If V<sub>DD</sub> is decreased so that V<sub>B</sub> falls to a value less than V<sub>REF</sub>, the comparator output inverts from high to low, V<sub>OUT</sub> goes low, V<sub>C</sub> is high, M1 turns on, RC is bypassed, and V<sub>B</sub> becomes: V<sub>BL</sub>=V<sub>DD</sub>×RB/(RA+RB), which is less than V<sub>BH</sub>. By so doing, the comparator output will stay low to prevent the circuit from oscillating when V<sub>B</sub> ≈ V<sub>REF</sub>.

If V<sub>DD</sub> falls below the minimum operating voltage, the output becomes undefined. When V<sub>DD</sub> goes from low to V<sub>DD</sub>×RB/(RA+RB) > V<sub>REF</sub>, the comparator output and V<sub>OUT</sub> goes high.

The detectable voltage is defined as:

$$V_{DET}(-) = \frac{RA + RB + RC}{RB + RC} \times V_{REF}$$

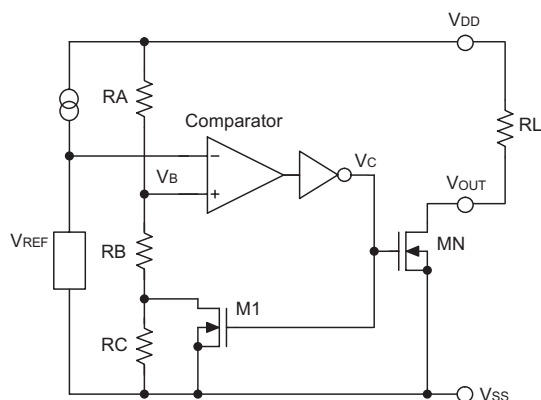
The release voltage is defined as:

$$V_{DET}(+) = \frac{RA + RB}{RB} \times V_{REF}$$

The hysteresis width is:

$$V_{HYS} = V_{DET}(+) - V_{DET}(-)$$

The figure demonstrates the NMOS output type with positive output polarity (V<sub>OUT</sub> is normally open, active low). The HT70XX series also supplies options for other output types with active high outputs. Application circuits shown are examples of positive output polarity (normally open, active low) unless otherwise specified.



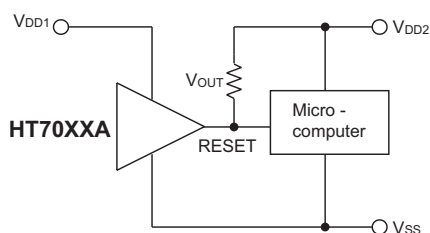
NMOS output voltage detector (HT70XXA)

## Application Circuits

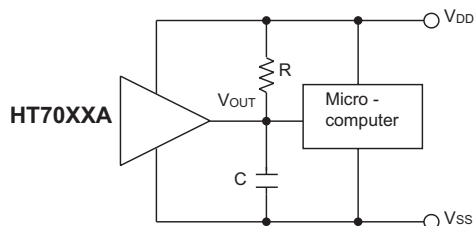
### Microcomputer reset circuit

Normally a reset circuit is required to protect the micro-computer system from malfunctions due to power line interruptions. The following examples show how different output configurations perform a reset function in various systems.

- NMOS open drain output application for separate power supply

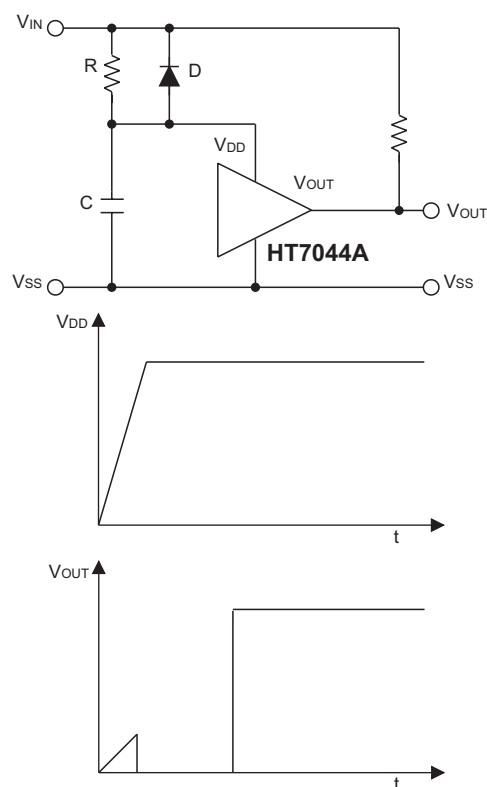


- NMOS open drain output application with R-C delay



### Power-on reset circuit

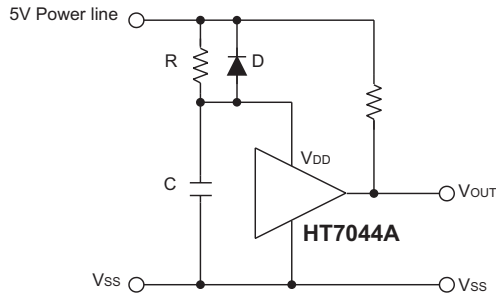
With several external components, the NMOS open drain type of the HT70XX series can be used to perform a power-on reset function as shown:



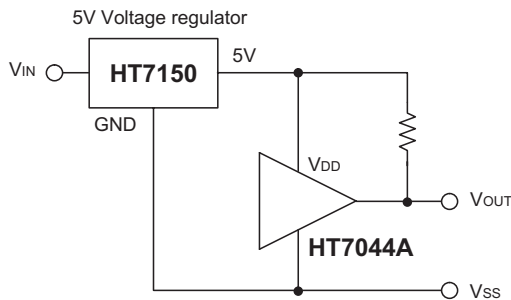
### 5V power line monitoring circuit

Generally, a minimum operating voltage of 4.5V is guaranteed in a 5V power line system. The HT7044A is recommended for use as 5V power line monitoring circuit.

- 5V power line monitor with power-on reset



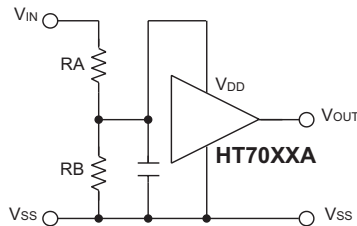
- with 5V voltage regulator



### Change of detectable voltage

If the required voltage is not found in the standard product selection table, it is possible to change it by using external resistance dividers or diodes.

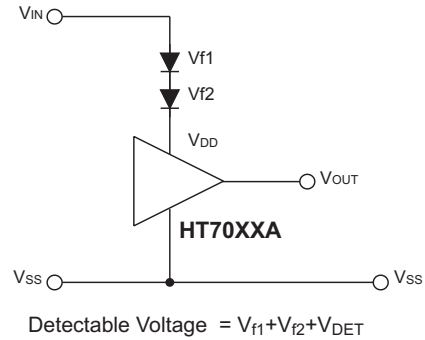
- Varying the detectable voltage with a resistance divider



$$\text{Detectable voltage} = \frac{RA + RB}{RB} \times V_{DET}$$

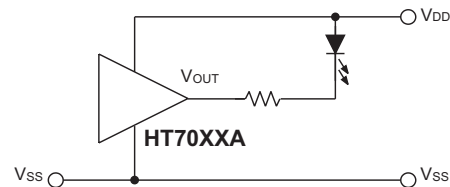
$$\text{Hysteresis width} = \frac{RA + RB}{RB} \times V_{HYS}$$

- Varying the detectable voltage with a diode



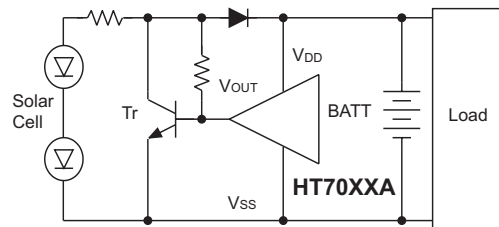
### Malfunction analysis

The following circuit demonstrates the way a circuit analyzes malfunctions by monitoring the variation or spike noise of power supply voltage.



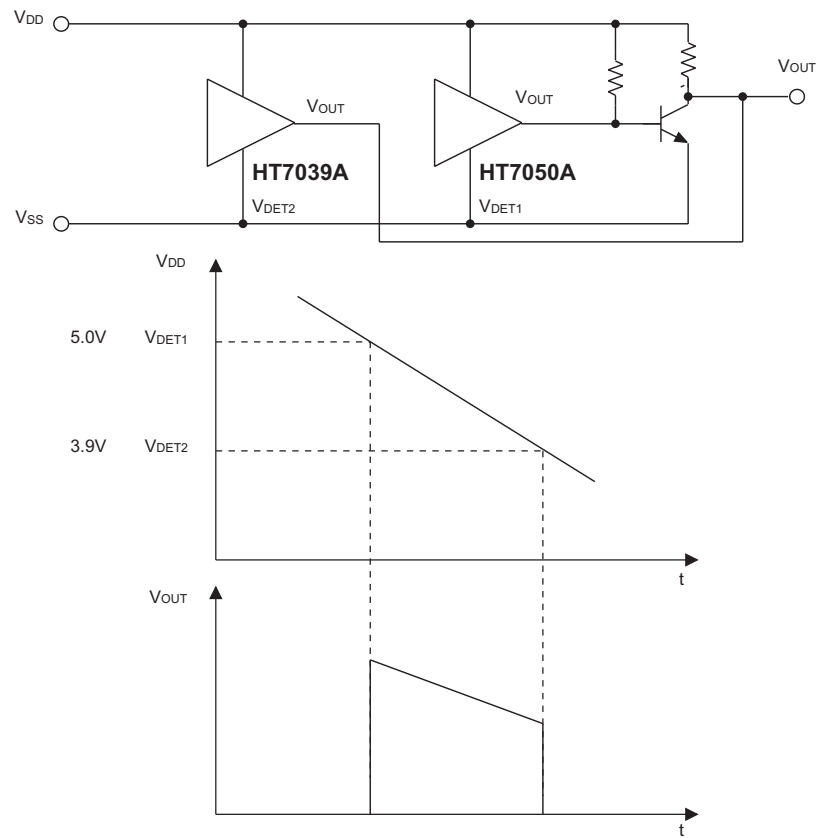
### Charge monitoring circuit

The following circuit shows a charged monitor for protection against battery deterioration by overcharging. When the voltage of the battery is higher than the set detectable voltage, the transistor turns on to bypass the charge current, protecting the battery from overcharging.



### Level selector

The following diagram illustrates a logic level selector.



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