National Semiconductor

July 2002

# LM3712/LM3713
# Microprocessor Supervisory Circuits with Separate Watchdog Timer Output, Power Fail Input and Manual Reset

## General Description

The LM3712/LM3713 series of microprocessor supervisory circuits provide the maximum flexibility for monitoring power supplies and battery controlled functions in systems without backup batteries. The LM3712/LM3713 series are available in a 9-bump micro SMD package.

Built-in features include the following:

Reset: Reset is asserted during power-up, power-down, and brownout conditions. $\overline{\text{RESET}}$ is guaranteed down to $V_{CC}$ of 1.0V.

Manual Reset Input: An input that asserts reset when pulled low.

Power-Fail Input: A 1.225V threshold detector for power fail warning, or to monitor a power supply other than $V_{CC}$.

Watchdog Timer: The WDI (Watchdog Input) monitors one of the µP's output lines for activity. If no output transition occurs during the watchdog timeout period, the watchdog output ($\overline{\text{WDO}}$) pulls low.

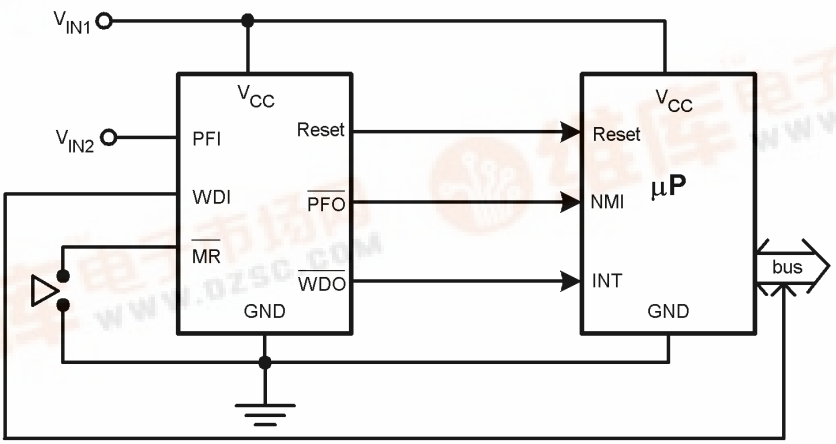
## Features

- Standard Reset Threshold voltage: 3.08V
- Custom Reset Threshold voltages: For other voltages between 2.2V and 5.0V in 10mV increments, contact National Semiconductor Corp.
- No external components required
- Manual-Reset input
- $\overline{\text{RESET}}$ (LM3712) or RESET (LM3713) outputs
- Precision supply voltage monitor
- Factory programmable Reset and Watchdog Timeout Delays
- Separate Watchdog output
- Separate Power Fail comparator
- Available in micro SMD package for minimum footprint
- ±0.5% Reset threshold accuracy at room temperature
- ±2% Reset threshold accuracy over temperature extremes
- Reset assertion down to 1V $V_{CC}$ ($\overline{\text{RESET}}$ option only)
- 28 µA $V_{CC}$ supply current

## Applications

- Embedded Controllers and Processors
- Intelligent Instruments
- Automotive Systems
- Critical µP Power Monitoring

## Typical Application

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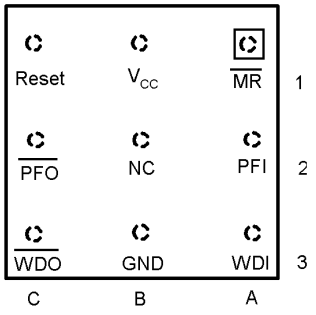
## Connection Diagram

**Top View**
**(looking from the coating side)**
**micro SMD 9 Bump Package**
**BPA09**

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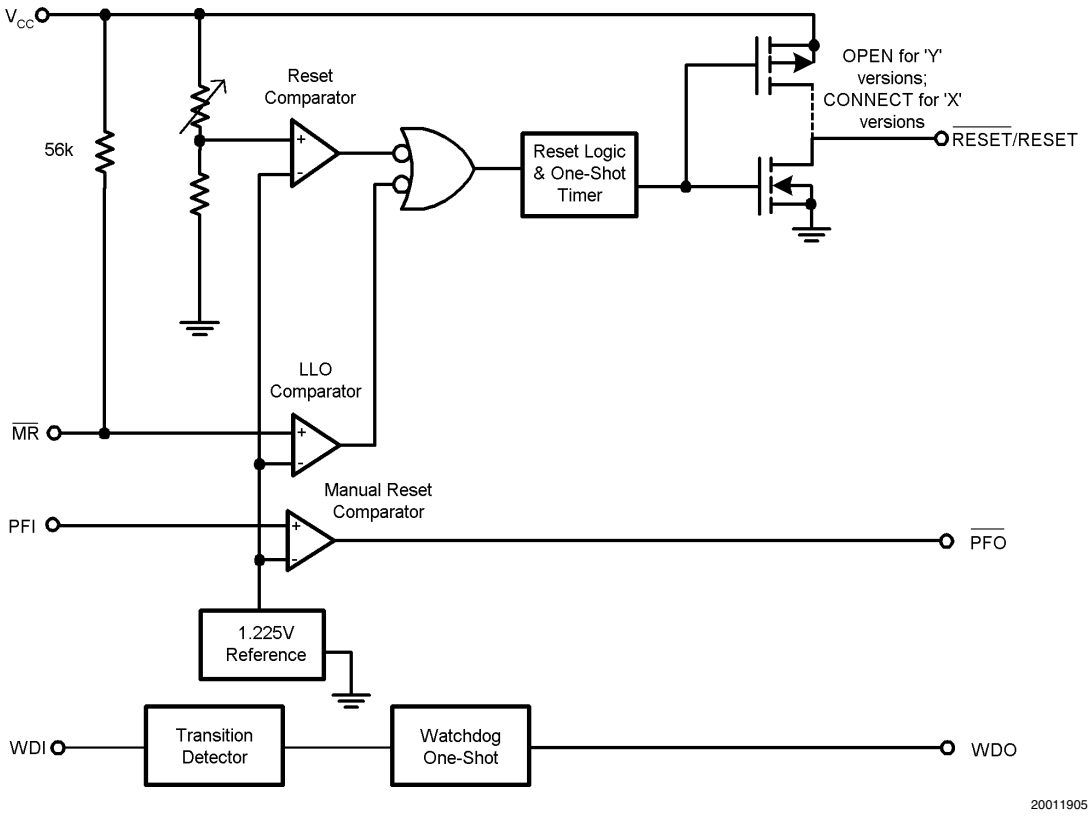
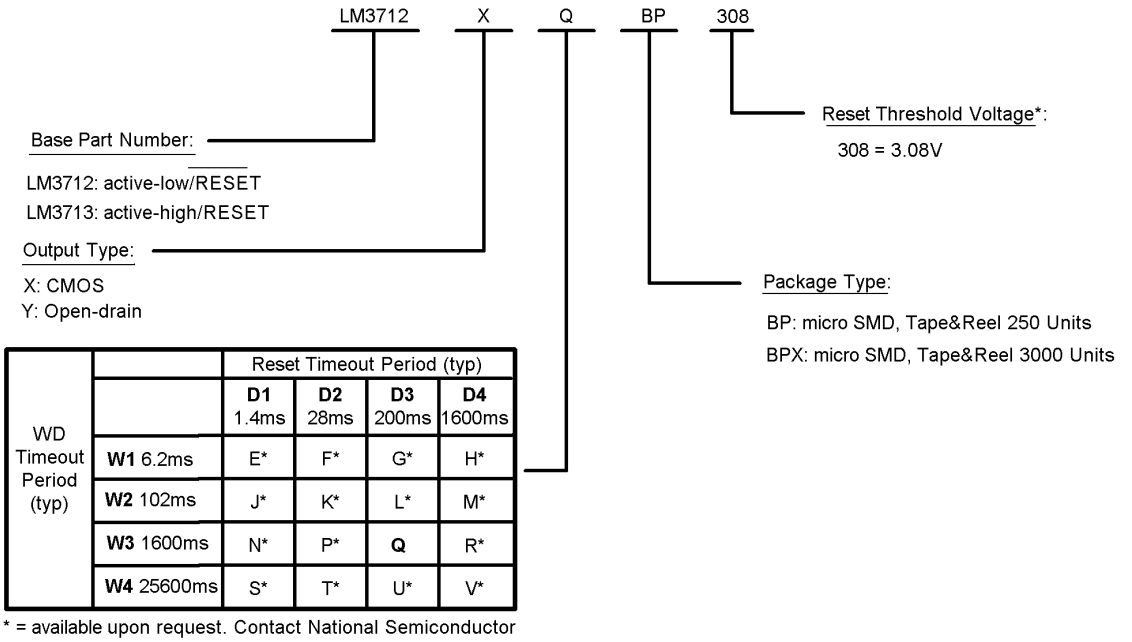
## Pin Description

| Bump No. | Name | Function |
|---|---|---|
| A1 | $\overline{MR}$ | Manual-Reset input. When $\overline{MR}$ is less than $V_{MRT}$ (Manual Reset Threshold) $\overline{RESET}$/RESET is engaged. |
| B1 | $V_{CC}$ | Power Supply input. |
| C1 | $\overline{RESET}$ | Reset Logic Output. Pulses low for $t_{RP}$ (Reset Timeout Period) when triggered, and stays low whenever $V_{CC}$ is below the reset threshold or when $\overline{MR}$ is below $V_{MRT}$. It remains low for $t_{RP}$ after either $V_{CC}$ rises above the reset threshold, or after $\overline{MR}$ input rises above $V_{MRT}$ (LM3712 only). |
| | RESET | Reset Logic Output. RESET is the inverse of $\overline{RESET}$ (LM3713 only). |
| C2 | $\overline{PFO}$ | Power-Fail Logic Output. When PFI is below $V_{PFT}$ $\overline{PFO}$ goes low; otherwise, $\overline{PFO}$ remains high. |
| C3 | $\overline{WDO}$ | Watchdog Output. If no digital activity is detected on WDI (Watchdog Input) for a period exceeding $t_{WD}$, this output pulls low. |
| B3 | GND | Ground reference for all signals. |
| A3 | WDI | Watchdog Input Transition Monitor: If no transition activity occurs for a period exceeding $t_{WD}$ (Watchdog Timeout Period), reset is engaged. |
| A2 | PFI | Power-Fail Comparator Input. When PFI is less than $V_{PFT}$ (Power-Fail Reset Threshold), the $\overline{PFO}$ goes low; otherwise, $\overline{PFO}$ remains high. |
| B2 | NC | No Connect. Test input used at factory only. Leave floating. |

## Block Diagram



## Ordering Information




| WD Timeout Period (typ) | | Reset Timeout Period (typ) | | | |
|---|---|---|---|---|---|
| | | **D1** 1.4ms | **D2** 28ms | **D3** 200ms | **D4** 1600ms |
| | **W1** 6.2ms | E* | F* | G* | H* |
| | **W2** 102ms | J* | K* | L* | M* |
| | **W3** 1600ms | N* | P* | **Q** | R* |
| | **W4** 25600ms | S* | T* | U* | V* |

* = available upon request. Contact National Semiconductor

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*For other voltages between 2.2V and 5.0V, please contact National Semiconductor sales office.

**LM3712/LM3713**

| Part Number | Output | Reset Timeout Period | Watchdog Timeout Period | Package Marking |
|---|---|---|---|---|
| LM3712XQBP-308 | totem-pole | 200ms | 1600ms | %%IC |
| LM3712XQBPX-308 | totem-pole | 200ms | 1600ms | %%IC |
| LM3713XQBP-308 | totem-pole | 200ms | 1600ms | %%ID |
| LM3713XQBPX-308 | totem-pole | 200ms | 1600ms | %%ID |

%% is the datecode and will vary with time.

## Table Of Functions

| Part Number | Active Low Reset | Active High Reset | Output (X = totem-pole) (Y = open-drain) | Reset Timeout Period | Watchdog Timeout Period | Manual Reset | Power Fail Comparator |
|---|---|---|---|---|---|---|---|
| LM3712 | x | | X, Y* | Customized | Customized | x | x |
| LM3713 | | x | X | Customized | Customized | x | x |

* = available upon request. Contact National

## Absolute Maximum Ratings (Note 1)

**If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/ Distributors for availability and specifications.**

| | |
|---|---|
| Supply Voltage ($V_{CC}$) | −0.3V to 6.0V |
| All Other Inputs | −0.3V to $V_{CC}$ + 0.3V |
| ESD Ratings (Note 2) | |
| Human Body Model | 1.5kV |
| Machine Model | 150V |
| Power Dissipation | (Note 3) |

## Operating Ratings (Note 1)

| | |
|---|---|
| Temperature Range | −40˚C ≤ $T_J$ ≤ 85˚C |

## LM3712/LM3713 Series Electrical Characteristics

Limits in the standard typeface are for $T_J$ = 25˚C and limits in **boldface type** apply over full operating range. Unless otherwise specified: $V_{CC}$ = +2.2V to 5.5V.

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **POWER SUPPLY** | | | | | | |
| $V_{CC}$ | Operating Voltage Range: $V_{CC}$ | LM3712 | **1.0** | | **5.5** | V |
| | | LM3713 | **1.2** | | **5.5** | |
| $I_{CC}$ | $V_{CC}$ Supply Current | All inputs = $V_{CC}$; all outputs floating | | 28 | **50** | µA |
| **RESET THRESHOLD** | | | | | | |
| $V_{RST}$ | Reset Threshold | $V_{CC}$ falling | −0.5<br>**−2** | $V_{RST}$ | +0.5<br>**+2** | % |
| | | $V_{CC}$ falling: $T_A$ = 0˚C to 70˚C | **−1.5** | | **+1.5** | |
| $V_{RSTH}$ | Reset Threshold Hysteresis | | | 0.0032•$V_{RST}$ | | mV |
| $t_{RP}$ | Reset Timeout Period | Reset Timeout Period = E, J, N, S | **1** | 1.4 | **2** | ms |
| | | Reset Timeout Period = F, K, P, T | **20** | 28 | **40** | |
| | | Reset Timeout Period = G, L, Q, U | **140** | 200 | **280** | |
| | | Reset Timeout Period = H, M, R, V | **1120** | 1600 | **2240** | |
| $t_{RD}$ | $V_{CC}$ to Reset Delay | $V_{CC}$ falling at 1mV/µs | | 20 | | µs |
| **RESET (LM3713)** | | | | | | |
| $V_{OL}$ | RESET | $V_{CC}$ > 2.25V, $I_{SINK}$ = 900µA | | | **0.3** | V |
| | | $V_{CC}$ > 2.7V, $I_{SINK}$ = 1.2mA | | | **0.3** | |
| | | $V_{CC}$ > 4.5V, $I_{SINK}$ = 3.2mA | | | **0.4** | |
| $V_{OH}$ | RESET | $V_{CC}$ > 1.2V, $I_{SOURCE}$ = 50µA | **0.8 $V_{CC}$** | | | V |
| | | $V_{CC}$ > 1.8V, $I_{SOURCE}$ = 150µA | **0.8 $V_{CC}$** | | | |
| | | $V_{CC}$ > 2.25V, $I_{SOURCE}$ = 300µA | **0.8 $V_{CC}$** | | | |
| | | $V_{CC}$ > 2.7V, $I_{SOURCE}$ = 500µA | **0.8 $V_{CC}$** | | | |
| | | $V_{CC}$ > 4.5V, $I_{SOURCE}$ = 800µA | **$V_{CC}$ − 1.5V** | | | |
| $I_{LKG}$ | Output Leakage Current | $V_{RESET}$ = 5.5V | | | **1.0** | µA |
| **$\overline{\text{RESET}}$ (LM3712)** | | | | | | |
| $V_{OL}$ | $\overline{\text{RESET}}$ | $V_{CC}$ > 1.0V, $I_{SINK}$ = 50µA | | | **0.3** | V |
| | | $V_{CC}$ > 1.2V, $I_{SINK}$ = 100µA | | | **0.3** | |
| | | $V_{CC}$ > 2.25V, $I_{SINK}$ = 900µA | | | **0.3** | |
| | | $V_{CC}$ > 2.7V, $I_{SINK}$ = 1.2mA | | | **0.3** | |
| | | $V_{CC}$ > 4.5V, $I_{SINK}$ = 3.2mA | | | **0.4** | |
| $V_{OH}$ | $\overline{\text{RESET}}$ | $V_{CC}$ > 2.25V, $I_{SOURCE}$ = 300µA | **0.8 $V_{CC}$** | | | |
| | | $V_{CC}$ > 2.7V, $I_{SOURCE}$ = 500µA | **0.8 $V_{CC}$** | | | |
| | | $V_{CC}$ > 4.5V, $I_{SOURCE}$ = 800µA | **$V_{CC}$ − 1.5V** | | | |

## LM3712/LM3713 Series Electrical Characteristics (Continued)

Limits in the standard typeface are for $T_J$ = 25˚C and limits in **boldface type** apply over full operating range. Unless otherwise specified: $V_{CC}$ = +2.2V to 5.5V.

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---|---|---|---|---|---|---|
| **WDI** | | | | | | |
| WDI | Watchdog Input Current | | **–1** | | **+1** | µA |
| $WDI_T$ | Watchdog Input Threshold | | **0.2•$V_{CC}$** | 1.225 | **0.8•$V_{CC}$** | V |
| $t_{WD}$ | Watchdog Timeout Period | Watchdog Timeout Period = E, F, G, H | **4.3** | 6.2 | **9.3** | ms |
| | | Watchdog Timeout Period = J, K, L, M | **71** | 102 | **153** | |
| | | Watchdog Timeout Period = N, P, Q, R | **1120** | 1600 | **2400** | |
| | | Watchdog Timeout Period = S, T, U, V | **17900** | 25600 | **38400** | |
| **PFI/$\overline{MR}$** | | | | | | |
| $V_{PFT}$ | PFI Input Threshold | | **1.200** | 1.225 | **1.250** | V |
| $V_{MRT}$ | $\overline{MR}$ Input Threshold | $\overline{MR}$, Low | | | **0.8** | V |
| | | $\overline{MR}$, High | **2.0** | | | |
| $V_{PFTH}$/ $V_{MRTH}$ | PFI/$\overline{MR}$ Threshold Hysteresis | PFI/$\overline{MR}$ falling: $V_{CC}$ = $V_{RST\ MAX}$ to 5.5V | | 0.0032•$V_{RST}$ | | mV |
| $I_{PFI}$ | Input Current (PFI only) | | **–75** | | **75** | nA |
| $R_{MR}$ | $\overline{MR}$ Pull-up Resistance | | **35** | 56 | **75** | kΩ |
| $t_{MD}$ | $\overline{MR}$ to Reset Delay | | | 12 | | µS |
| $t_{MR}$ | $\overline{MR}$ Pulse Width | | **25** | | | µS |
| **$\overline{PFO}$, $\overline{WDO}$** | | | | | | |
| $V_{OL}$ | $\overline{PFO}$, $\overline{WDO}$ Output Voltage | $V_{CC}$ > 2.25V, $I_{SINK}$ = 900µA | | | **0.3** | V |
| | | $V_{CC}$ > 2.7V, $I_{SINK}$ = 1.2mA | | | **0.3** | |
| | | $V_{CC}$ > 4.5V, $I_{SINK}$ = 3.2mA | | | **0.4** | |
| $V_{OH}$ | | $V_{CC}$ > 2.25V, $I_{SOURCE}$ = 300µA | **0.8 $V_{CC}$** | | | |
| | | $V_{CC}$ > 2.7V, $I_{SOURCE}$ = 500µA | **0.8 $V_{CC}$** | | | |
| | | $V_{CC}$ > 4.5V, $I_{SOURCE}$ = 800µA | **$V_{CC}$ – 1.5V** | | | |
| **$\overline{LLO}$ OUTPUT** | | | | | | |
| $V_{LLOT}$ | $\overline{LLO}$ Output Threshold ($V_{\overline{LLO}}$ – $V_{RST}$, $V_{CC}$ falling) | | **1.01•$V_{RST}$** | 1.02•$V_{RST}$ | **1.03•$V_{RST}$** | V |
| $V_{LLOTH}$ | Low-Line Comparator Hysteresis | | | 0.0032•$V_{RST}$ | | mV |
| $t_{CD}$ | Low-Line Comparator Delay | $V_{CC}$ falling at 1mV/µs | | 20 | | µs |

## LM3712/LM3713 Series Electrical Characteristics (Continued)

**Note 1: Absolute Maximum Ratings** indicate limits beyond which damage to the device may occur. **Operating Ratings** indicate conditions for which the device is intended to be functional, but do not guarantee specific performance limits. For guaranteed specifications and test conditions, see the Electrical Characteristics. The guaranteed specifications apply only for the test conditions listed. Some performance characteristics may degrade when the device is not operated under the listed conditions.

**Note 2:** The Human Body model is a 100 pF capacitor discharged through a 1.5 kΩ resistor into each pin. The machine model is a 200pF capacitor discharged directly into each pin.

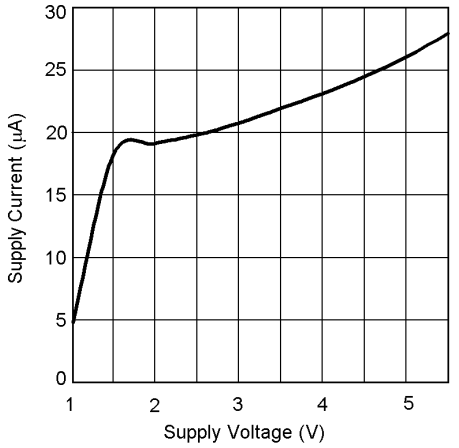
**Note 3:** The maximum allowable power dissipation is a function of the maximum junction temperature, $T_J$(MAX), the junction-to-ambient thermal resistance, $\theta_{J-A}$, and the ambient temperature, $T_A$. The maximum allowable power dissipation at any ambient temperture is calculated using:

$$P(MAX) = \frac{T_J(MAX) - T_A}{\theta_{J-A}}$$

Where the value of $\theta_{J-A}$ for the micro SMD package is 220˚C/W.

## Typical Performance Characteristics

**Supply Current vs Supply Voltage**

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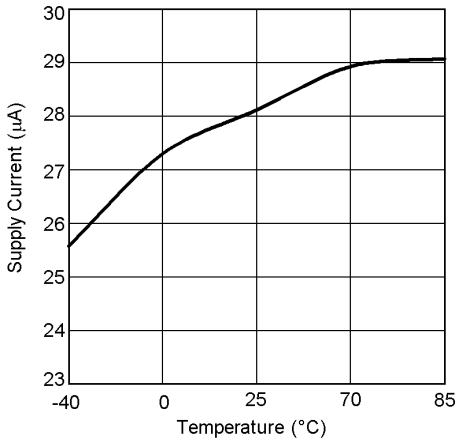
**3.3V Supply Current vs Temperature**

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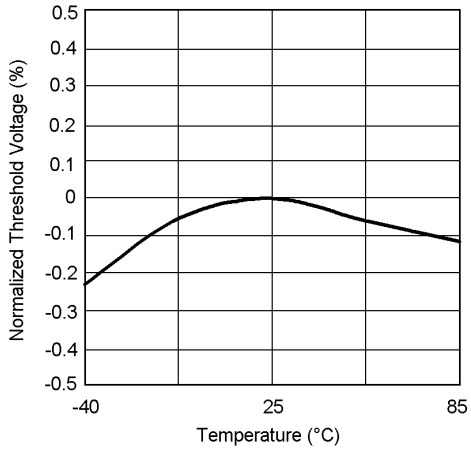
**Normalized Reset Threshold Voltage vs Temperature**

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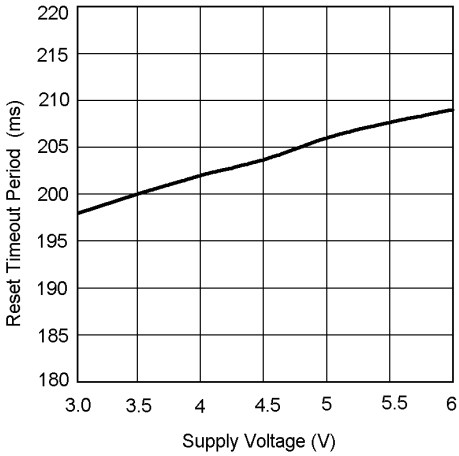
**Reset Timeout Period vs $V_{CC}$**

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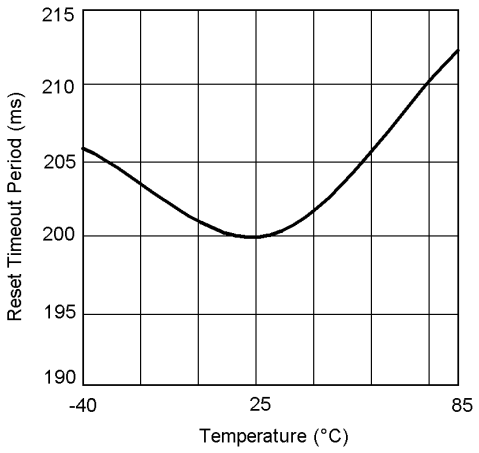
**Reset Timeout Period vs Temperature**

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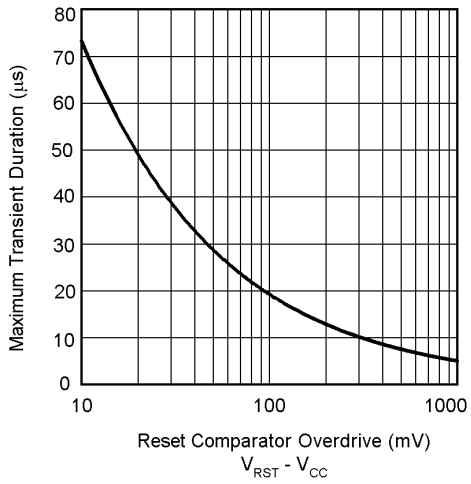
**Max. Transient Duration vs Reset Comparator Overdrive ($V_{CC}$ = 3.3V)**

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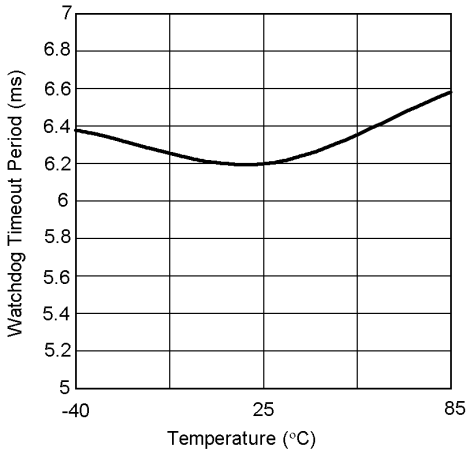
## Typical Performance Characteristics (Continued)

**Watchdog Timeout Period vs Temperature ($t_{WD}$ programmed as 6.2ms)**

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# Circuit Information

### Reset Output

The Reset input of a µP initializes the device into a known state. The LM3712/LM3713 microprocessor supervisory circuits assert a forced reset output to prevent code execution errors during power-up, power-down, and brownout conditions.

$\overline{\text{RESET}}$ is guaranteed valid for $V_{CC}$ > 1V. Once $V_{CC}$ exceeds the reset threshold, an internal timer maintains the output for the reset timeout period. After this interval, reset goes high. The LM3712 offers an active-low $\overline{\text{RESET}}$; The LM3713 offers an active-high RESET.

Any time $V_{CC}$ drops below the reset threshold (such as during a brownout), the reset activates. When $V_{CC}$ again rises above the reset threshold, the internal timer starts. Reset holds until $V_{CC}$ exceeds the reset threshold for longer than the reset timeout period. After this time, reset releases.

The Manual Reset input ($\overline{\text{MR}}$) will initiate a forced reset also. See the *Manual Reset Input* section.

### Reset Threshold

The LM3712/LM3713 family is available with a reset voltage of 3.08V. Other reset thresholds in the 2.20V to 5.0V range, in steps of 10 mV, are available; contact National Semiconductor for details.

### Manual Reset Input ($\overline{\text{MR}}$)

Many µP-based products require a manual reset capability, allowing the operator to initiate a reset. The $\overline{\text{MR}}$ input is fully debounced and provides an internal 56 kΩ pull-up. When the $\overline{\text{MR}}$ input is pulled below $V_{MRT}$ (1.225V) for more than 25 µs, reset is asserted after a typical delay of 12 µs. Reset remains active as long as $\overline{\text{MR}}$ is held low, and releases after the reset timeout period expires after $\overline{\text{MR}}$ rises above $V_{MRT}$. Use $\overline{\text{MR}}$ with digital logic to assert or to daisy chain supervisory circuits. It may be used as another low-line comparator by adding a buffer.

### Power-Fail Comparator (PFI/$\overline{\text{PFO}}$)

The PFI is compared to a 1.225V internal reference, $V_{PFT}$. If PFI is less than $V_{PFT}$, the Power Fail Output $\overline{\text{PFO}}$ drops low. The power-fail comparator signals a falling power supply, and is driven typically by an external voltage divider that senses either the unregulated supply or another system supply voltage. The voltage divider generally is chosen so the voltage at PFI drops below $V_{PFT}$ several milliseconds before the main supply voltage drops below the reset threshold, providing advanced warning of a brownout.

The voltage threshold is set by $R_1$ and $R_2$ and is calculated as follows:

$$V_{PFT} = \left(\frac{R1 + R2}{R2}\right) \times 1.225V$$

Note this comparator is completely separate from the rest of the circuitry, and may be employed for other functions as needed.

### Watchdog Timer Input (WDI)

The watchdog timer input monitors one of the microprocessor's output lines for activity. Each time a transition occurs on this monitored line, the watchdog counter is reset. However, if no transition occurs and the timeout period is reached, the LM3712/LM3713 assumes that the microprocessor has locked up and the watchdog output $\overline{\text{WDO}}$, is activated.

WDI is a high impedance input. $\overline{\text{WDO}}$ is an active-low totem pole output.

### Special Precautions for the micro SMD Package

As with most integrated circuits, the LM3712 and LM3713 are sensitive to exposure from visible and infrared (IR) light radiation. Unlike a plastic encapsulated IC, the micro SMD package has very limited shielding from light, and some sensitivity to light reflected from the surface of the PC board or long wavelength IR entering the die from the side may be experienced. This light could have an unpredictable affect on the electrical performance of the IC. Care should be taken to shield the device from direct exposure to bright visible or IR light during operation.

### Micro SMD Mounting

The micro SMD package requires specific mounting techniques which are detailed in National Semiconductor Application Note AN-1112. Referring to the section ***Surface Mount Technology (SMT) Assembly Considerations***, it should be noted that the pad style which must be used with the 9-pin package is the NSMD (non-solder mask defined) type.

For best results during assembly, alignment ordinals on the PC board may be used to facilitate placement of the micro SMD device.

## Timing Diagrams

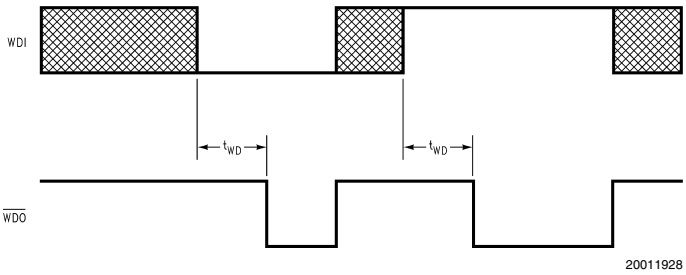



**FIGURE 1. LM3712 Reset Time with $\overline{MR}$**

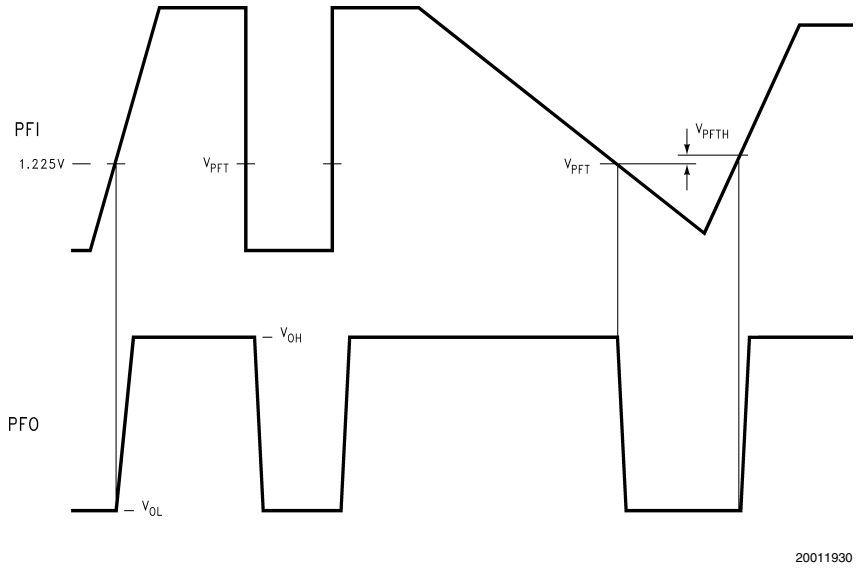



**FIGURE 2. PFI Comparator Timing Diagram**

## Typical Application Circuits

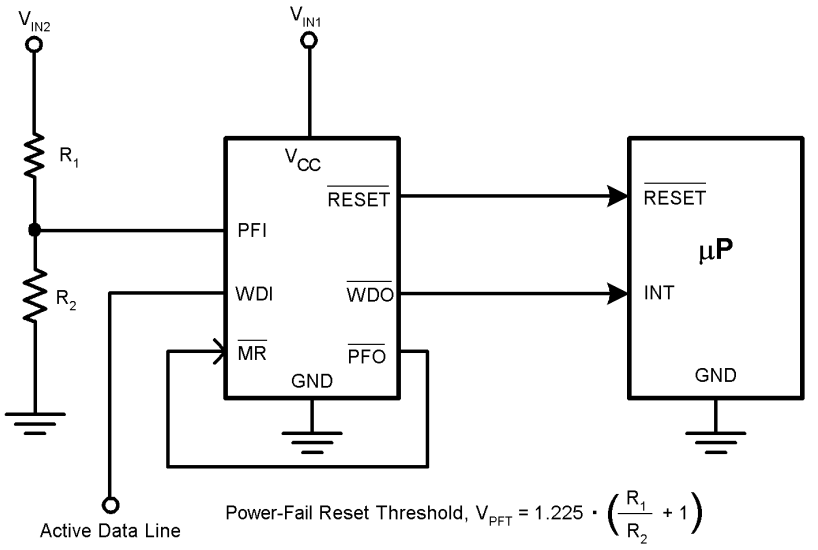



**FIGURE 3. Monitoring Two Critical Supplies Plus Dataline**

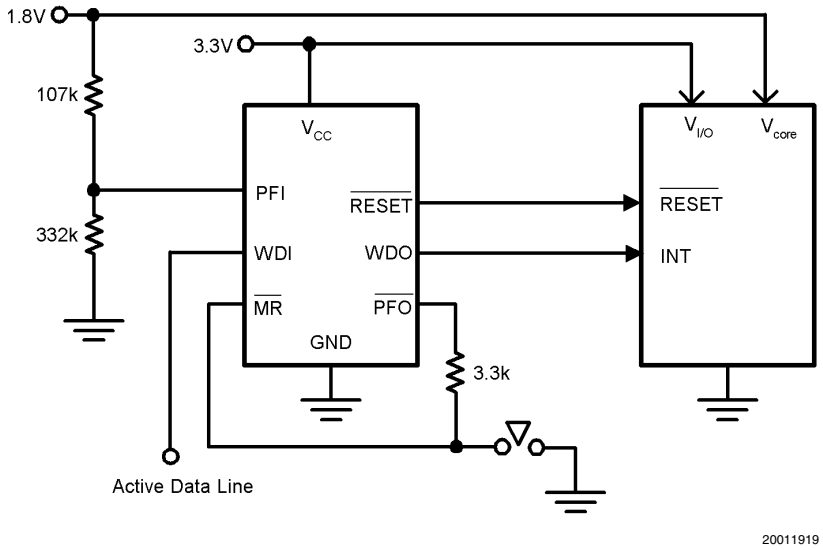
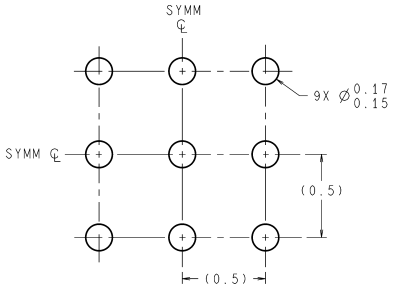



**FIGURE 4. Monitoring Two Supplies plus Manual Reset And Dataline**

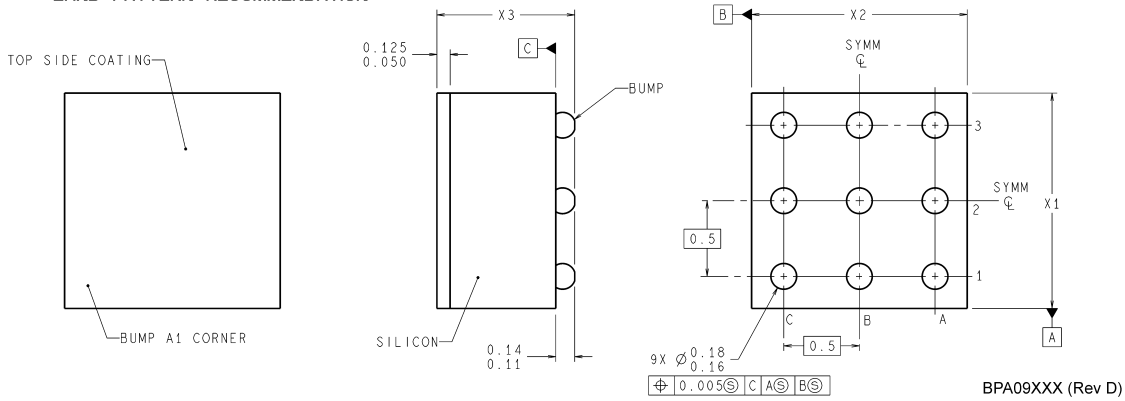
## Physical Dimensions inches (millimeters)

unless otherwise noted




DIMENSIONS ARE IN MILLIMETERS

LAND PATTERN RECOMMENDATION




BPA09XXX (Rev D)

NOTES: UNLESS OTHERWISE SPECIFIED

1. EPOXY COATING
2. 63Sn/37Pb EUTECTIC BUMP
3. RECOMMEND NON-SOLDER MASK DEFINED LANDING PAD.
4. PIN 1 IS ESTABLISHED BY LOWER LEFT CORNER WITH RESPECT TO TEXT ORIENTATION. REMAINING PINS ARE NUMBERED COUNTER CLOCKWISE.
5. XXX IN DRAWING NUMBER REPRESENTS PACKAGE SIZE VARIATION WHERE X1 IS PACKAGE WIDTH, X2 IS PACKAGE LENGTH AND X3 IS PACKAGE HEIGHT.
6. NO JEDEC REGISTRATION AS OF AUG.1999.

**9 bump micro SMD Package**
**NS Package Number BPA09FFB**
**The dimensions of X1, X2 and X3 are given below**
**X1 = 1.412mm**
**X2 = 1.412mm**
**X3 = 0.850mm**

### LIFE SUPPORT POLICY

NATIONAL'S PRODUCTS ARE NOT AUTHORIZED FOR USE AS CRITICAL COMPONENTS IN LIFE SUPPORT DEVICES OR SYSTEMS WITHOUT THE EXPRESS WRITTEN APPROVAL OF THE PRESIDENT AND GENERAL COUNSEL OF NATIONAL SEMICONDUCTOR CORPORATION. As used herein:

1. Life support devices or systems are devices or systems which, (a) are intended for surgical implant into the body, or (b) support or sustain life, and whose failure to perform when properly used in accordance with instructions for use provided in the labeling, can be reasonably expected to result in a significant injury to the user.
2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

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