

LM3710/LM3711

Microprocessor Supervisory Circuits with Power Fail Input, Low Line Output, Manual Reset and Watchdog Timer

General Description

The LM3710/LM3711 series of microprocessor supervisory circuits provide the maximum flexibility for monitoring power supplies and battery controlled functions in systems without backup batteries. The LM3710/LM3711 series are available in MSOP-10 and 9-bump micro SMD packages.

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} .

Low Line Output: This early power failure warning indicator goes low when the supply voltage drops to a value which is 2% higher than the reset threshold voltage.

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, reset is activated.

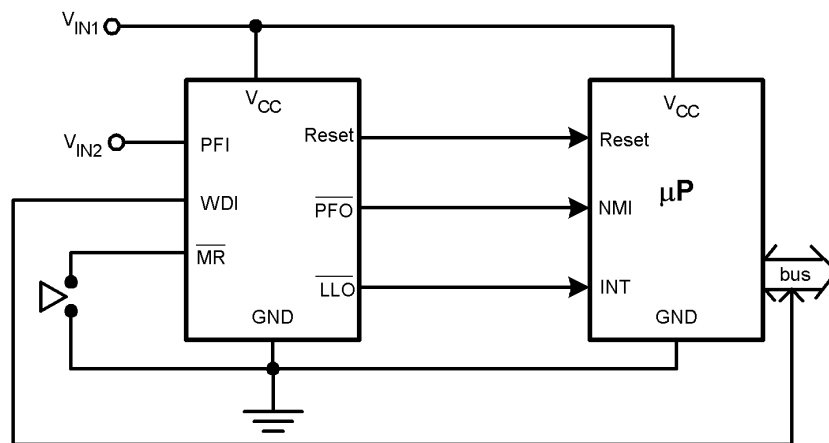
Features

- 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
- $\overline{\text{RESET}}$ (LM3710) or RESET (LM3711) outputs
- Precision supply voltage monitor
- Factory programmable Reset and Watchdog Timeout Delays
- Separate Power Fail comparator
- Available in micro SMD package for minimum footprint
- $\pm 0.5\%$ Reset threshold accuracy at room temperature
- $\pm 2\%$ 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

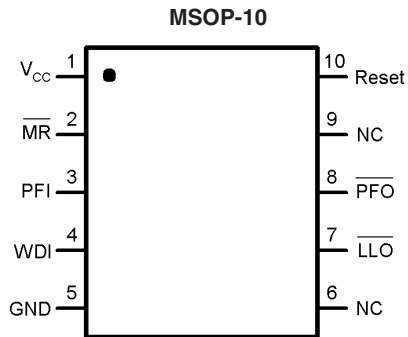
- Embedded Controllers and Processors
- Intelligent Instruments
- Automotive Systems
- Critical μP Power Monitoring

Typical Application



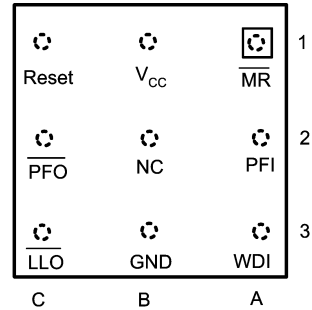
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Connection Diagram



20011802

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

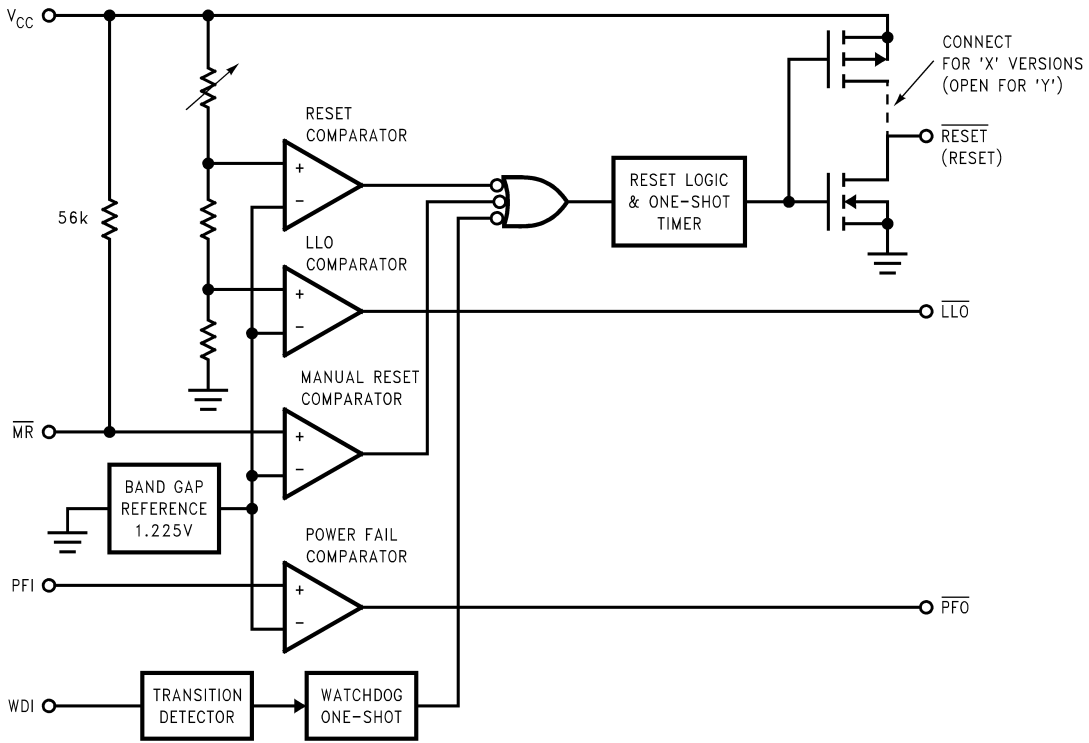


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Pin Descriptions

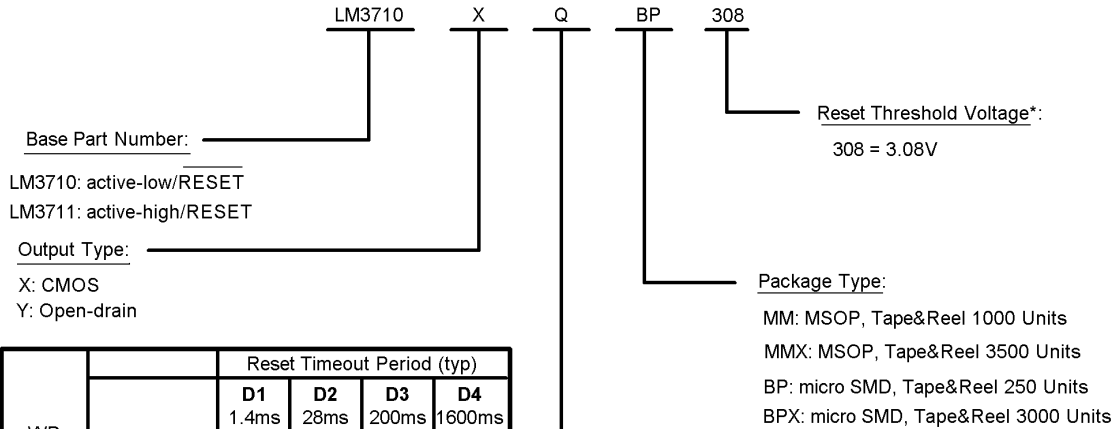
| Pin No. | | Name | Function |
|-----------|------|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| micro SMD | MSOP | | |
| A1 | 2 | \overline{MR} | Manual-Reset input. When \overline{MR} is less than V_{MRT} (Manual Reset Threshold) RESET/RESET is engaged. |
| B1 | 1 | V_{CC} | Power Supply input. |
| C1 | 10 | \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} (LM3710 only). |
| | | RESET | Reset Logic Output. RESET is the inverse of \overline{RESET} (LM3711 only). |
| C2 | 8 | \overline{PFO} | Power-Fail Logic Output. When PFI is below V_{PFT} , \overline{PFO} goes low; otherwise, \overline{PFO} remains high. |
| C3 | 7 | \overline{LLO} | Low-Line Logic Output. Early Power-Fail warning output. Low when V_{CC} falls below V_{LLOT} (Low-Line Output Threshold). This output can be used to generate an NMI (Non-Maskable Interrupt) to provide an early warning of imminent power-failure. |
| B3 | 5 | GND | Ground reference for all signals. |
| A3 | 4 | WDI | Watchdog Input Transition Monitor: If no transition activity occurs for a period exceeding t_{WD} (Watchdog Timeout Period), reset is engaged. |
| A2 | 3 | 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 | 6, 9 | NC | No Connect. Test input used at factory only. Leave floating. |

Block Diagram



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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

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

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LM3710/LM3711

| Part Number | Output | Reset Timeout Period | Watchdog Timeout Period | Package | | Package Marking |
|-----------------|------------|----------------------|-------------------------|---------|-----------|-----------------|
| | | | | MSOP | micro SMD | |
| LM3710XQBP-308 | totem-pole | 200ms | 1600ms | | x | %%IA |
| LM3710XQBPX-308 | totem-pole | 200ms | 1600ms | | x | %%IA |
| LM3710XQMM-308 | totem-pole | 200ms | 1600ms | x | | R37B |
| LM3710XQMMX-308 | totem-pole | 200ms | 1600ms | x | | R37B |
| LM3711XQBP-308 | totem-pole | 200ms | 1600ms | | x | %%IB |
| LM3711XQBPX-308 | totem-pole | 200ms | 1600ms | | x | %%IB |
| LM3711XQMM-308 | totem-pole | 200ms | 1600ms | x | | R38B |
| LM3711XQMMX-308 | totem-pole | 200ms | 1600ms | x | | R38B |

%% 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 | Low Line Output |
|-------------|------------------|-------------------|------------------------------------------|----------------------|-------------------------|--------------|-----------------------|-----------------|
| LM3710 | x | | X, Y* | Customized | Customized | x | x | x |
| LM3711 | | x | X | Customized | Customized | x | 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

 $-40^{\circ}\text{C} \leq T_J \leq 85^{\circ}\text{C}$ **LM3710/LM3711 Series Electrical Characteristics**

Limits in the standard typeface are for $T_J = 25^{\circ}\text{C}$ 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} | LM3710 | 1.0 | | 5.5 | V |
| | | LM3711 | 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 -2 | V_{RST} | +0.5 +2 | % |
| | | V_{CC} falling: $T_A = 0^{\circ}\text{C}$ to 70°C | -1.5 | | +1.5 | |
| V_{RSTH} | Reset Threshold Hysteresis | | | $0.0032 \cdot V_{RST}$ | | 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 $1\text{mV}/\mu\text{s}$ | | 20 | | μs |
| RESET (LM3711) | | | | | | |
| V_{OL} | RESET | $V_{CC} > 2.25V$, $I_{SINK} = 900\mu\text{A}$ | | | 0.3 | V |
| | | $V_{CC} > 2.7V$, $I_{SINK} = 1.2\text{mA}$ | | | 0.3 | |
| | | $V_{CC} > 4.5V$, $I_{SINK} = 3.2\text{mA}$ | | | 0.4 | |
| V_{OH} | RESET | $V_{CC} > 1.2V$, $I_{SOURCE} = 50\mu\text{A}$ | 0.8 V_{CC} | | | V |
| | | $V_{CC} > 1.8V$, $I_{SOURCE} = 150\mu\text{A}$ | 0.8 V_{CC} | | | |
| | | $V_{CC} > 2.25V$, $I_{SOURCE} = 300\mu\text{A}$ | 0.8 V_{CC} | | | |
| | | $V_{CC} > 2.7V$, $I_{SOURCE} = 500\mu\text{A}$ | 0.8 V_{CC} | | | |
| | | $V_{CC} > 4.5V$, $I_{SOURCE} = 800\mu\text{A}$ | $V_{CC} - 1.5V$ | | | |
| I_{LKG} | Output Leakage Current | $V_{RESET} = 5.5V$ | | | 1.0 | μA |
| RESET (LM3710) | | | | | | |
| V_{OL} | RESET | $V_{CC} > 1.0V$, $I_{SINK} = 50\mu\text{A}$ | | | 0.3 | V |
| | | $V_{CC} > 1.2V$, $I_{SINK} = 100\mu\text{A}$ | | | 0.3 | |
| | | $V_{CC} > 2.25V$, $I_{SINK} = 900\mu\text{A}$ | | | 0.3 | |
| | | $V_{CC} > 2.7V$, $I_{SINK} = 1.2\text{mA}$ | | | 0.3 | |
| | | $V_{CC} > 4.5V$, $I_{SINK} = 3.2\text{mA}$ | | | 0.4 | |
| V_{OH} | RESET | $V_{CC} > 2.25V$, $I_{SOURCE} = 300\mu\text{A}$ | 0.8 V_{CC} | | | V |
| | | $V_{CC} > 2.7V$, $I_{SOURCE} = 500\mu\text{A}$ | 0.8 V_{CC} | | | |
| | | $V_{CC} > 4.5V$, $I_{SOURCE} = 800\mu\text{A}$ | $V_{CC} - 1.5V$ | | | |

LM3710/LM3711 Series Electrical Characteristics (Continued)

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

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

LM3710/LM3711 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.

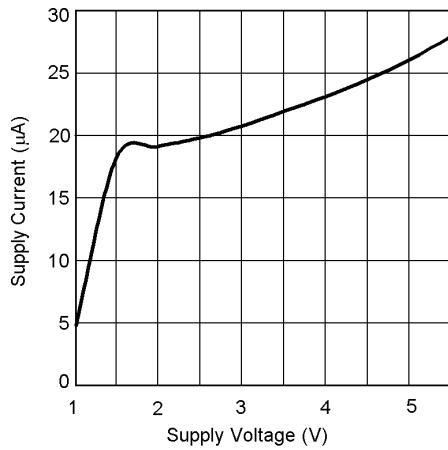
Note 3: The maximum allowable power dissipation is a function of the maximum junction temperature, $T_J(\text{MAX})$, the junction-to-ambient thermal resistance, θ_{J-A} , and the ambient temperature, T_A . The maximum allowable power dissipation at any ambient temperature is calculated using:

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

Where the value of θ_{J-A} for the MSOP-10 package is 195°C/W in a typical PC board mounting and the micro SMD package is 220°C/W.

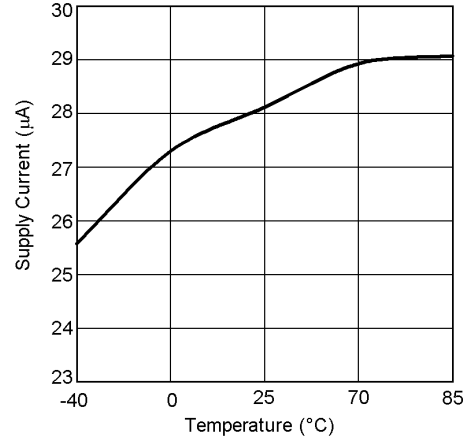
Typical Performance Characteristics

Supply Current vs Supply Voltage



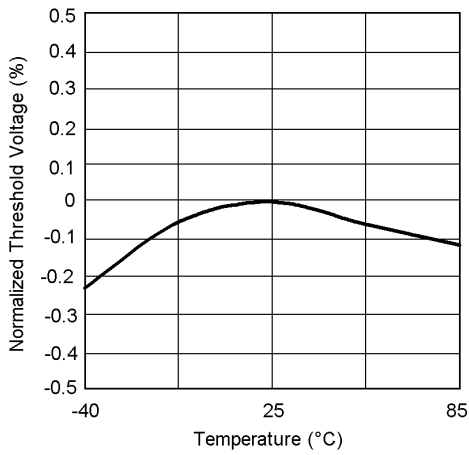
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3.3V Supply Current vs Temperature



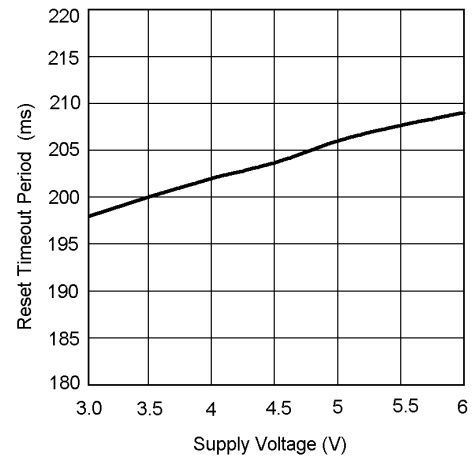
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Normalized Reset Threshold Voltage vs Temperature



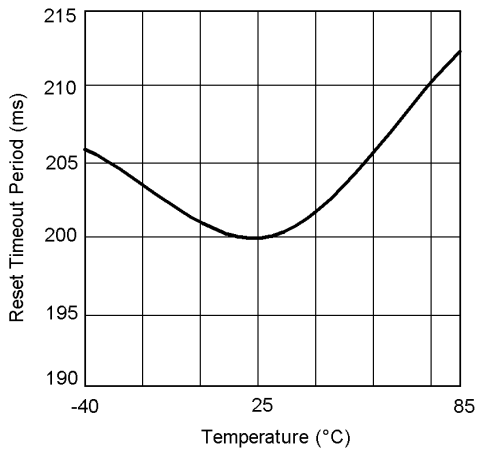
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Reset Timeout Period vs V_{CC}



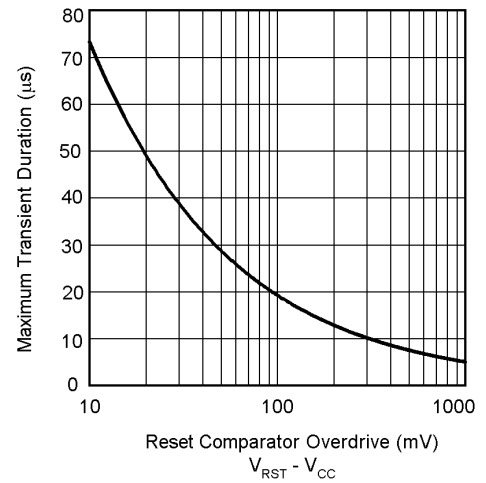
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Reset Timeout Period vs Temperature



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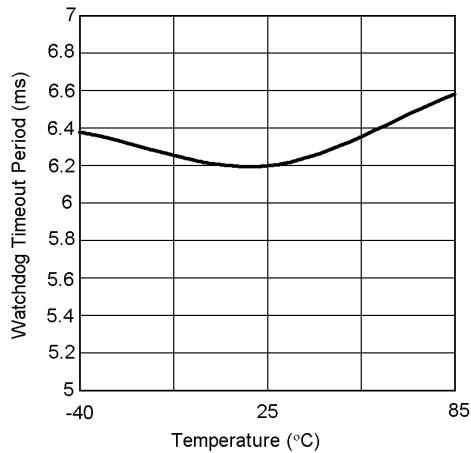
Max. Transient Duration vs Reset Comparator Overdrive (V_{CC} = 3.3V)



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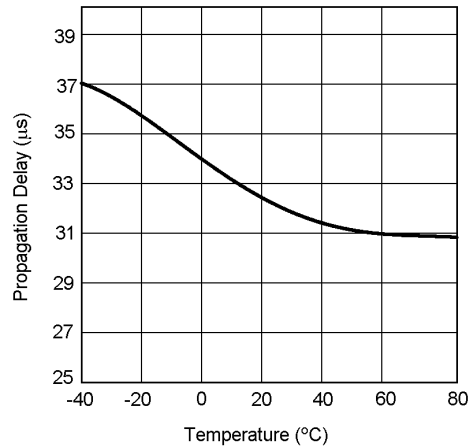
Typical Performance Characteristics (Continued)

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



20011813

Low-Line Comparator Propagation Delay vs Temperature



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Circuit Information

Reset Output

The Reset input of a μP initializes the device into a known state. The LM3710/LM3711 microprocessor supervisory circuits assert a forced reset output to prevent code execution errors during power-up, power-down, and brownout conditions.

\overline{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 LM3710 offers an active-low \overline{RESET} ; The LM3711 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{MR}) will initiate a forced reset also. See the *Manual Reset Input* section.

Reset Threshold

The LM3710/LM3711 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{MR})

Many μP -based products require a manual reset capability, allowing the operator to initiate a reset. The \overline{MR} input is fully debounced and provides an internal 56 k Ω pull-up. When the \overline{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{MR} is held low, and releases after the reset timeout period expires after \overline{MR} rises above V_{MRT} . Use \overline{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{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{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:

$$V_{PFT} = \left(\frac{R_1 + R_2}{R_2} \right) \times 1.225V$$

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

Low-Line Output (\overline{LLO})

The low-line output comparator is typically used to provide a non-maskable interrupt to a μP when V_{CC} begins falling. \overline{LLO} monitors V_{CC} and goes low when V_{CC} falls below V_{LLOT} (typically $1.02 \cdot V_{RST}$) with hysteresis of $0.0032 \cdot V_{RST}$.

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 LM3710/LM3711 assumes that the microprocessor has locked up and the reset output is activated.

WDI is a high impedance input.

Special Precautions for the micro SMD Package

As with most integrated circuits, the LM3710 and LM3711 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

Circuit Information (Continued)

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

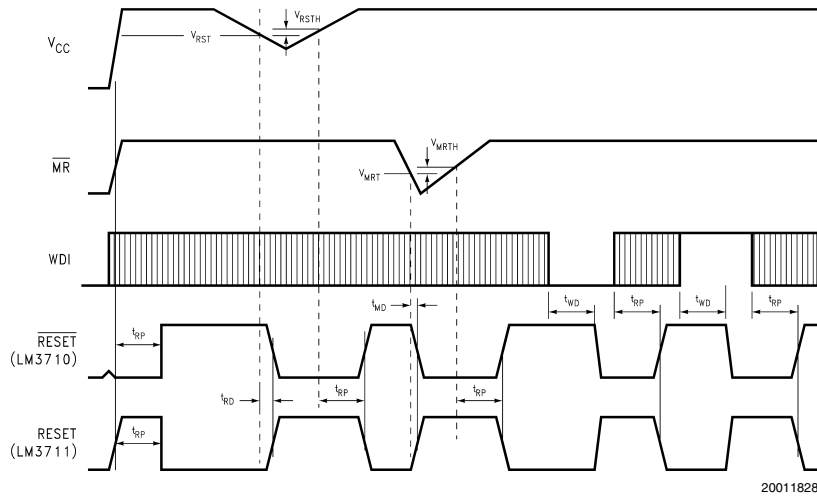


FIGURE 1. LM3710/LM3711 Reset Time with \overline{MR} and WDI

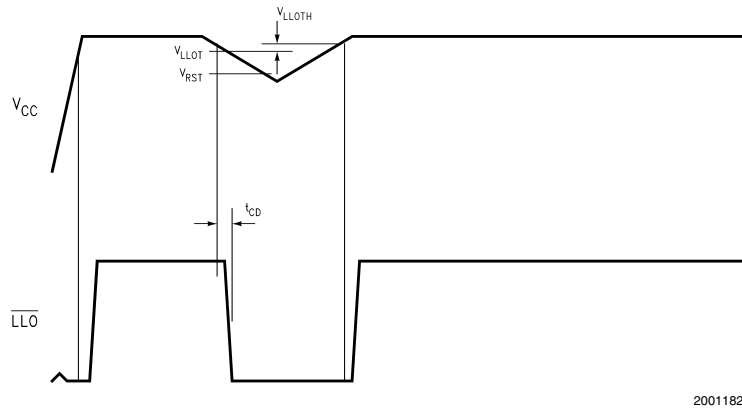


FIGURE 2. \overline{LLO} Output

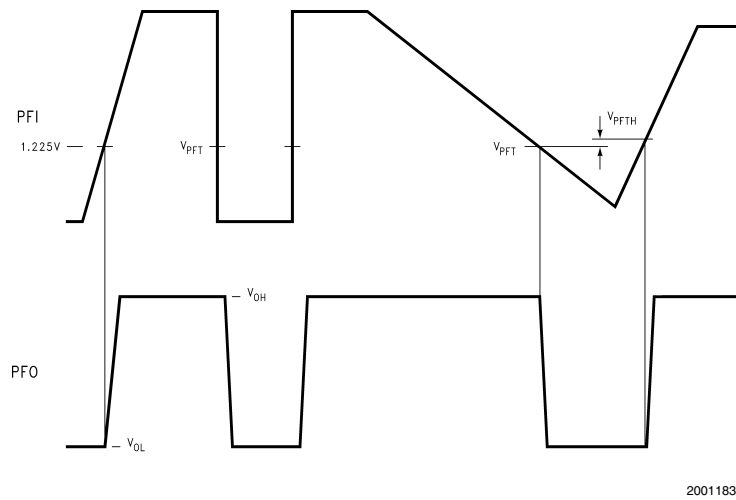
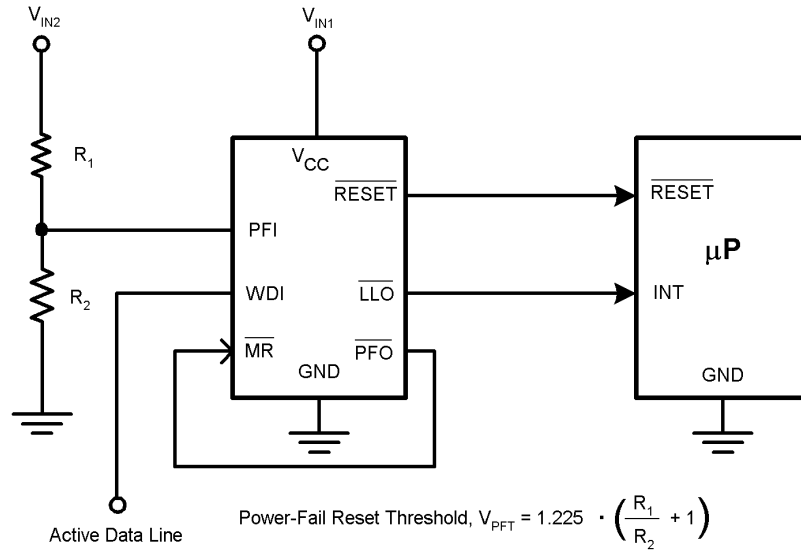


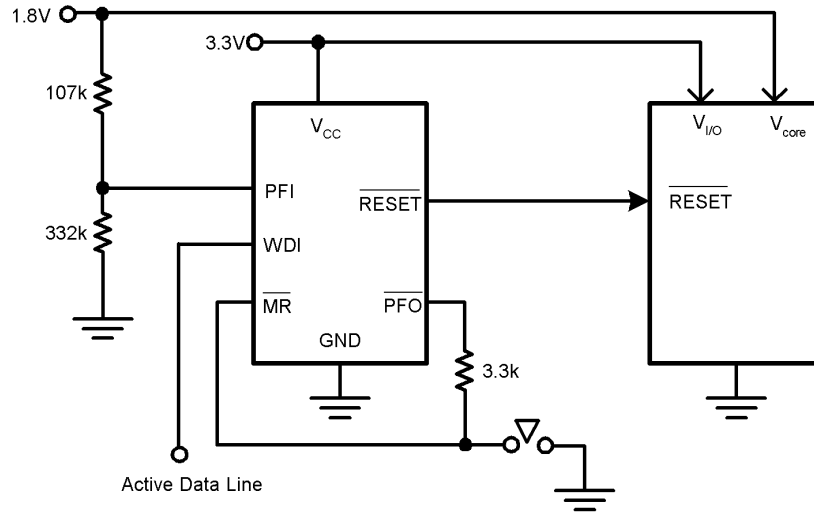
FIGURE 3. PFI Comparator Timing Diagram

Typical Application Circuits



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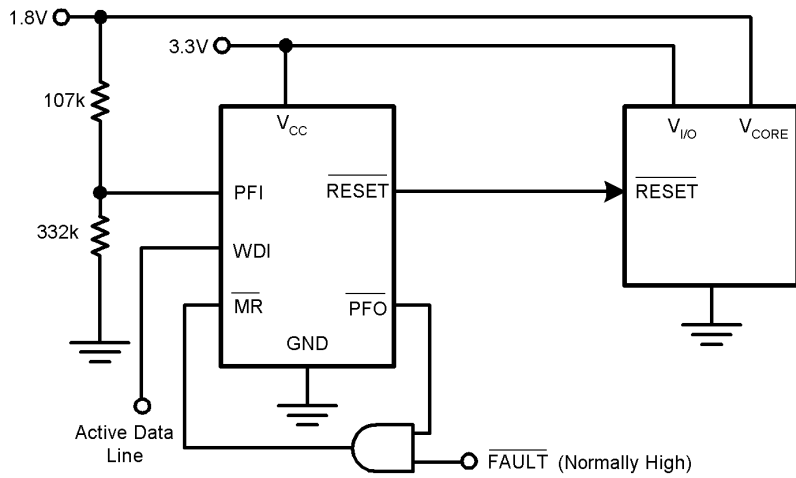
FIGURE 4. Monitoring Two Critical Supplies And Dataline



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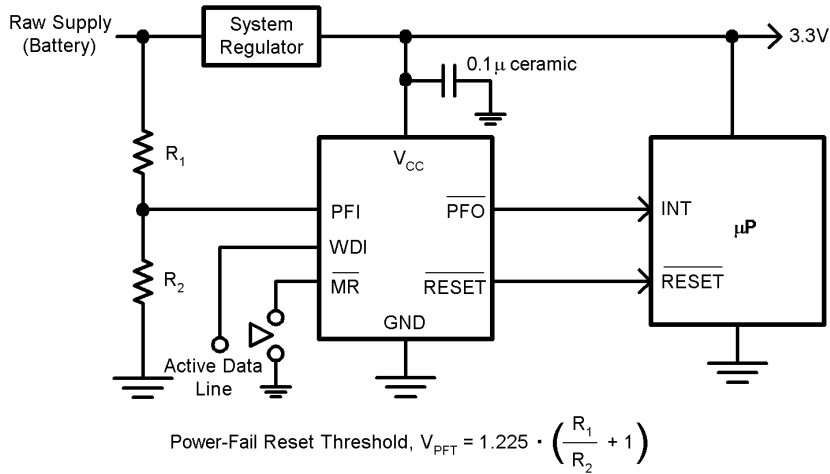
FIGURE 5. Monitoring Two Supplies plus Manual Reset And Dataline

Typical Application Circuits (Continued)



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FIGURE 6. Monitoring Dual Supplies plus External Fault Input And Dataline



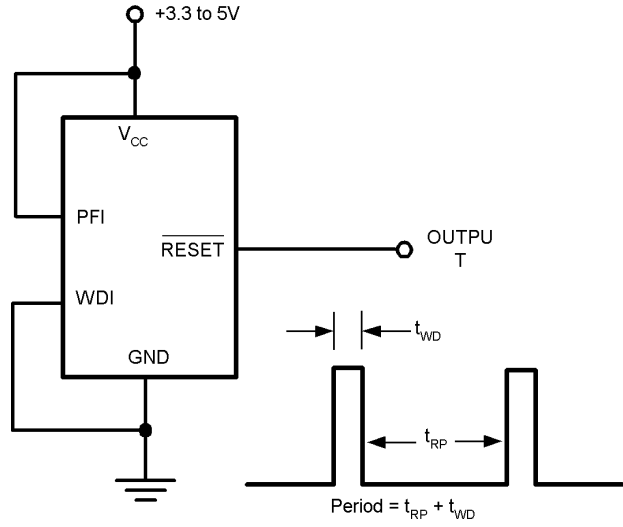
$$\text{Power-Fail Reset Threshold, } V_{PFT} = 1.225 \cdot \left(\frac{R_1}{R_2} + 1 \right)$$

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Note: \overline{MR} input with its 1.225V nominal threshold, may monitor an additional supply voltage. An internal 56 kΩ pull-up resistor is included on this input.

FIGURE 7. Microprocessor Supervisor with Early Warning Detector

Typical Application Circuits (Continued)

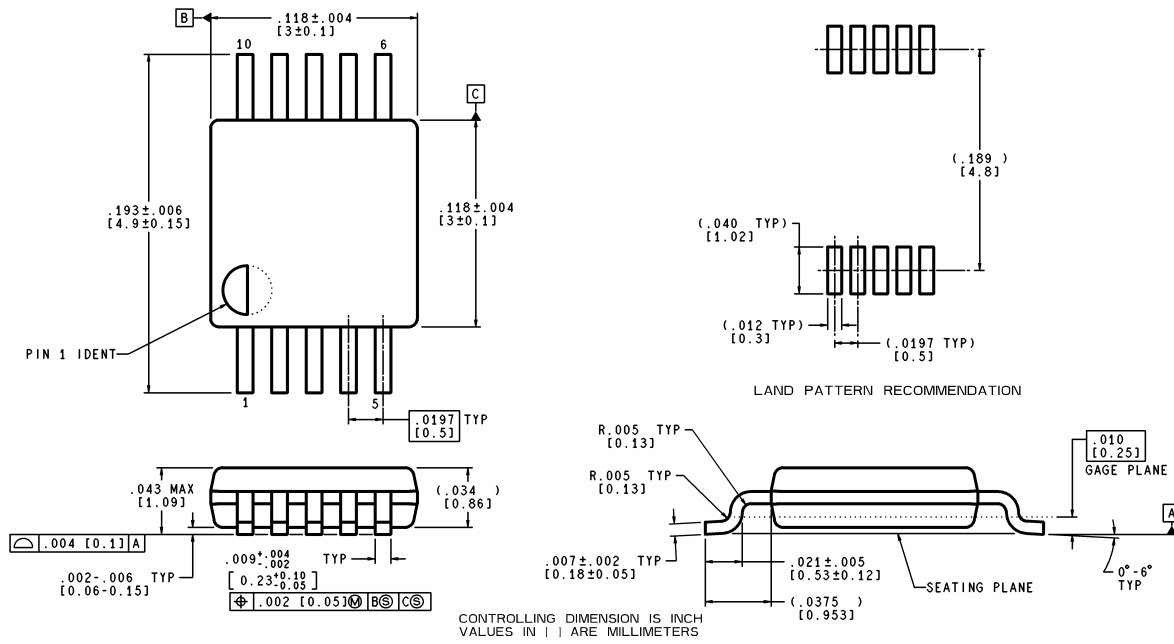


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FIGURE 8. LM3710 Long Period oscillator

Physical Dimensions inches (millimeters)

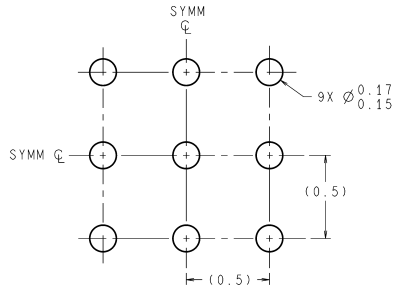
unless otherwise noted



**10 Lead MSOP Package
NS Package Number MUB10A**

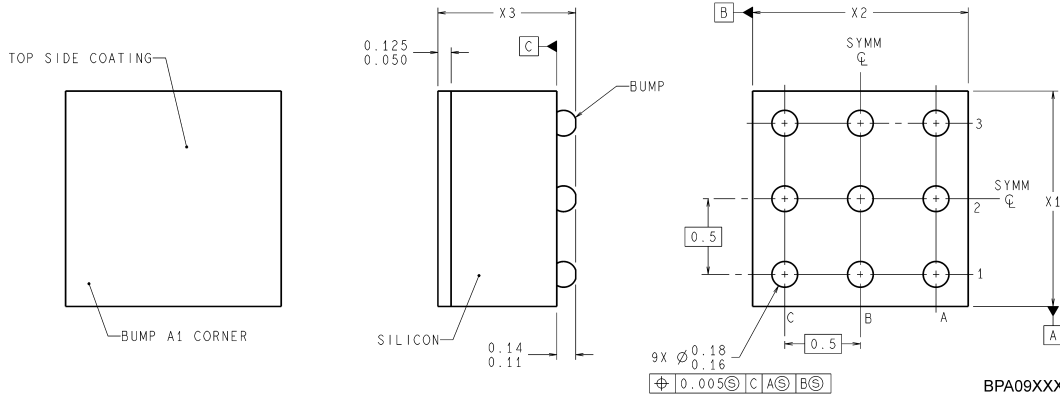
MUB10A (Rev A)

Physical Dimensions inches (millimeters) unless otherwise noted (Continued)



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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