

## 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. 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  $\mu$ P's output lines for activity. If no output transition occurs during the watchdog timeout period, reset is activated.

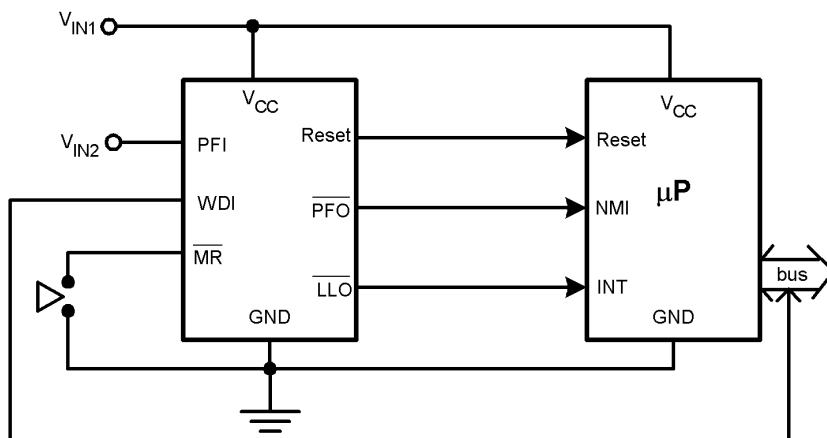
### Features

- 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  $\mu$ A  $V_{CC}$  supply current

### Applications

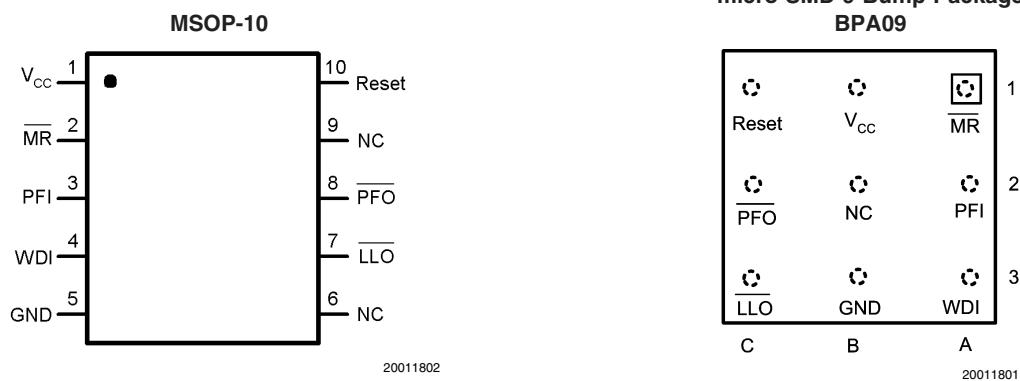
- Embedded Controllers and Processors
- Intelligent Instruments
- Automotive Systems
- Critical  $\mu$ P Power Monitoring

### Typical Application



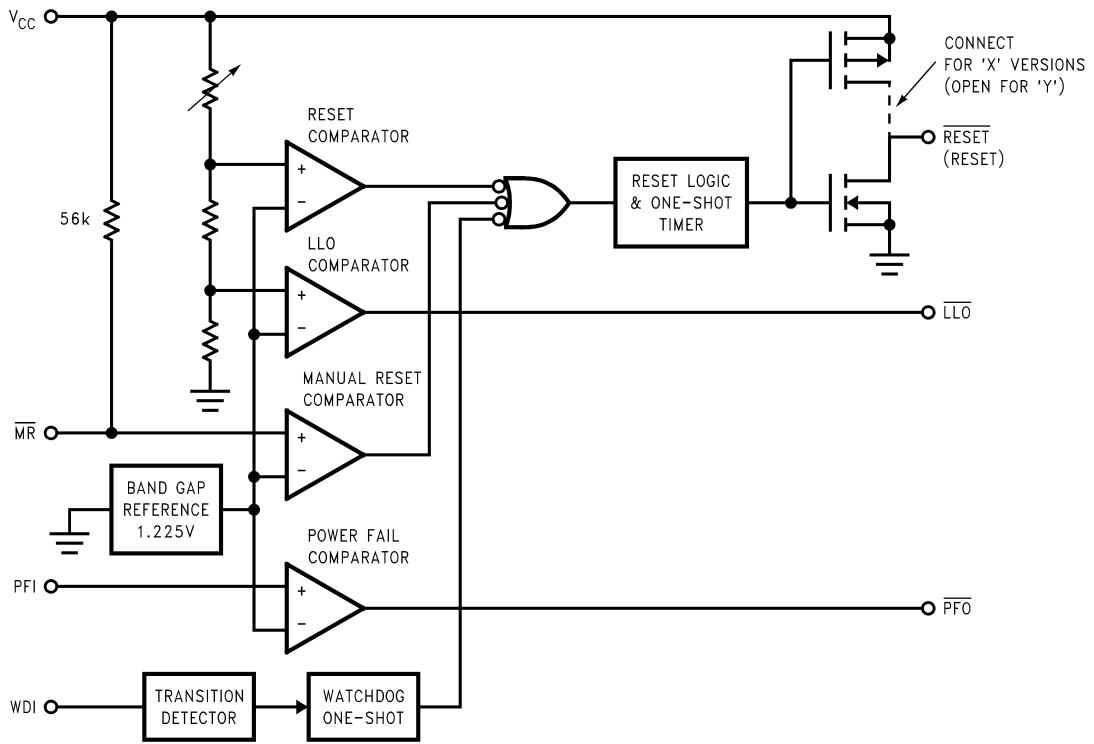
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## Connection Diagram



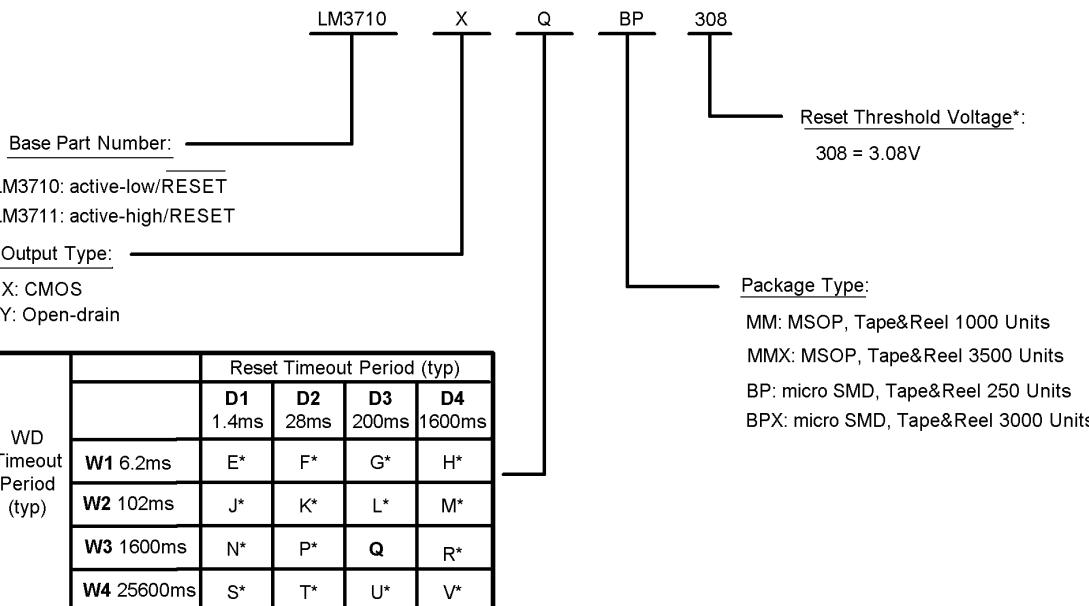
## Pin Descriptions

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) $\overline{RESET}/RESET$ 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



\*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°C ≤  $T_J$  ≤ 85°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:  $V_{CC} = +2.2\text{V}$  to 5.5V.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>POWER SUPPLY</b>						
$V_{CC}$	Operating Voltage Range: $V_{CC}$	LM3710	<b>1.0</b>		<b>5.5</b>	V
		LM3711	<b>1.2</b>		<b>5.5</b>	
$I_{CC}$	$V_{CC}$ Supply Current	All inputs = $V_{CC}$ ; all outputs floating		28	<b>50</b>	μA
<b>RESET THRESHOLD</b>						
$V_{RST}$	Reset Threshold	$V_{CC}$ falling	-0.5	$V_{RST}$	+0.5	%
		$V_{CC}$ falling: $T_A = 0^\circ\text{C}$ to $70^\circ\text{C}$	<b>-2</b>		<b>+2</b>	
$V_{RSTH}$	Reset Threshold Hysteresis		-1.5		<b>+1.5</b>	
$t_{RP}$	Reset Timeout Period	Reset Timeout Period = E, J, N, S Reset Timeout Period = F, K, P, T Reset Timeout Period = G, L, Q, U Reset Timeout Period = H, M, R, V	1 <b>20</b> 140 1120	1.4 28 200 1600	<b>2</b> <b>40</b> <b>280</b> <b>2240</b>	ms
$t_{RD}$	$V_{CC}$ to Reset Delay	$V_{CC}$ falling at 1mV/μs		20		
<b>RESET (LM3711)</b>						
$V_{OL}$	RESET	$V_{CC} > 2.25\text{V}$ , $I_{SINK} = 900\mu\text{A}$			<b>0.3</b>	V
		$V_{CC} > 2.7\text{V}$ , $I_{SINK} = 1.2\text{mA}$			<b>0.3</b>	
		$V_{CC} > 4.5\text{V}$ , $I_{SINK} = 3.2\text{mA}$			<b>0.4</b>	
$V_{OH}$	RESET	$V_{CC} > 1.2\text{V}$ , $I_{SOURCE} = 50\mu\text{A}$	<b>0.8 <math>V_{CC}</math></b>			V
		$V_{CC} > 1.8\text{V}$ , $I_{SOURCE} = 150\mu\text{A}$	<b>0.8 <math>V_{CC}</math></b>			
		$V_{CC} > 2.25\text{V}$ , $I_{SOURCE} = 300\mu\text{A}$	<b>0.8 <math>V_{CC}</math></b>			
		$V_{CC} > 2.7\text{V}$ , $I_{SOURCE} = 500\mu\text{A}$	<b>0.8 <math>V_{CC}</math></b>			
		$V_{CC} > 4.5\text{V}$ , $I_{SOURCE} = 800\mu\text{A}$	<b><math>V_{CC} - 1.5\text{V}</math></b>			
$I_{LKG}$	Output Leakage Current	$V_{RESET} = 5.5\text{V}$			<b>1.0</b>	μA
<b>RESET (LM3710)</b>						
$V_{OL}$	RESET	$V_{CC} > 1.0\text{V}$ , $I_{SINK} = 50\mu\text{A}$			<b>0.3</b>	V
		$V_{CC} > 1.2\text{V}$ , $I_{SINK} = 100\mu\text{A}$			<b>0.3</b>	
		$V_{CC} > 2.25\text{V}$ , $I_{SINK} = 900\mu\text{A}$			<b>0.3</b>	
		$V_{CC} > 2.7\text{V}$ , $I_{SINK} = 1.2\text{mA}$			<b>0.3</b>	
		$V_{CC} > 4.5\text{V}$ , $I_{SINK} = 3.2\text{mA}$			<b>0.4</b>	
$V_{OH}$	RESET	$V_{CC} > 2.25\text{V}$ , $I_{SOURCE} = 300\mu\text{A}$	<b>0.8 <math>V_{CC}</math></b>			V
		$V_{CC} > 2.7\text{V}$ , $I_{SOURCE} = 500\mu\text{A}$	<b>0.8 <math>V_{CC}</math></b>			
		$V_{CC} > 4.5\text{V}$ , $I_{SOURCE} = 800\mu\text{A}$	<b><math>V_{CC} - 1.5\text{V}</math></b>			

## 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  $5.5\text{V}$ .

Symbol	Parameter	Conditions	Min	Typ	Max	Units
<b>WDI</b>						
WDI	Watchdog Input Current		-1		+1	$\mu\text{A}$
WDI <sub>T</sub>	Watchdog Input Threshold		<b>0.2•V<sub>CC</sub></b>	1.225	<b>0.8•V<sub>CC</sub></b>	V
t <sub>WD</sub>	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	<b>4.3</b> <b>71</b> <b>1120</b> <b>17900</b>	6.2 102 1600 25600	<b>9.3</b> <b>153</b> <b>2400</b> <b>38400</b>	ms
<b>PFI/MR</b>						
V <sub>PFT</sub>	PFI Input Threshold		<b>1.200</b>	1.225	<b>1.250</b>	V
V <sub>MRT</sub>	MR Input Threshold	MR, Low MR, High			<b>0.8</b>	V
V <sub>PFTH</sub> / V <sub>MRTH</sub>	PFI/MR Threshold Hysteresis	PFI/MR falling: $V_{CC} = V_{RST\ MAX}$ to $5.5\text{V}$		0.0032•V <sub>RST</sub>		mV
I <sub>PFI</sub>	Input Current (PFI only)		-75		<b>75</b>	nA
R <sub>MR</sub>	MR Pull-up Resistance		<b>35</b>	56	<b>75</b>	k $\Omega$
t <sub>MD</sub>	MR to Reset Delay			12		$\mu\text{s}$
t <sub>MR</sub>	MR Pulse Width		<b>25</b>			$\mu\text{s}$
<b>PFO, LLO</b>						
V <sub>OL</sub>	PFO, LLO Output Voltage	$V_{CC} > 2.25\text{V}$ , $I_{SINK} = 900\mu\text{A}$			<b>0.3</b>	V
		$V_{CC} > 2.7\text{V}$ , $I_{SINK} = 1.2\text{mA}$			<b>0.3</b>	
		$V_{CC} > 4.5\text{V}$ , $I_{SINK} = 3.2\text{mA}$			<b>0.4</b>	
V <sub>OH</sub>		$V_{CC} > 2.25\text{V}$ , $I_{SOURCE} = 300\mu\text{A}$	<b>0.8 V<sub>CC</sub></b>			V
		$V_{CC} > 2.7\text{V}$ , $I_{SOURCE} = 500\mu\text{A}$	<b>0.8 V<sub>CC</sub></b>			
		$V_{CC} > 4.5\text{V}$ , $I_{SOURCE} = 800\mu\text{A}$	<b>V<sub>CC</sub> - 1.5V</b>			
<b>LLO OUTPUT</b>						
V <sub>LLOT</sub>	LLO Output Threshold ( $V_{LLO} - V_{RST}$ , $V_{CC}$ falling)		<b>1.01•V<sub>RST</sub></b>	1.02•V <sub>RST</sub>	<b>1.03•V<sub>RST</sub></b>	V
V <sub>LLOTH</sub>	Low-Line Comparator Hysteresis			0.0032•V <sub>RST</sub>		mV
t <sub>CD</sub>	Low-Line Comparator Delay	$V_{CC}$ falling at $1\text{mV}/\mu\text{s}$		20		$\mu\text{s}$

## 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.

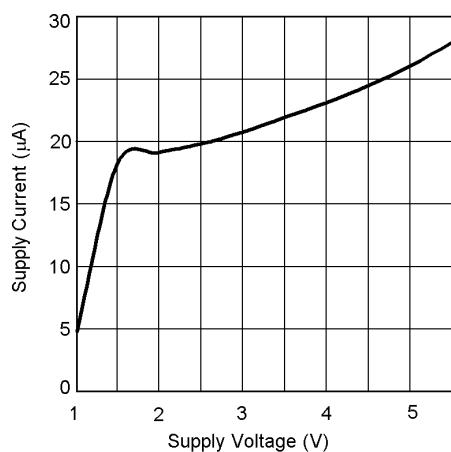
**Note 3:** The maximum allowable power dissipation is a function of the maximum junction temperature,  $T_J(\text{MAX})$ , the junction-to-ambient thermal resistance,  $\theta_{J-A}$ , and the ambient temperature,  $T_A$ . The maximum allowable power dissipation at any ambient temperature is calculated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

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

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

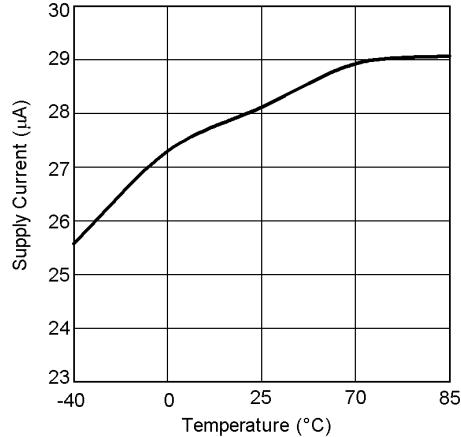
## Typical Performance Characteristics

Supply Current vs Supply Voltage



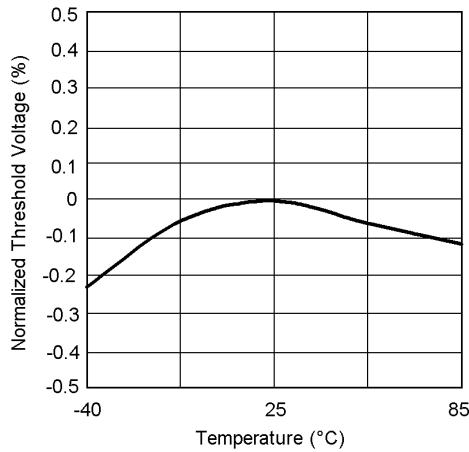
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3.3V Supply Current vs Temperature



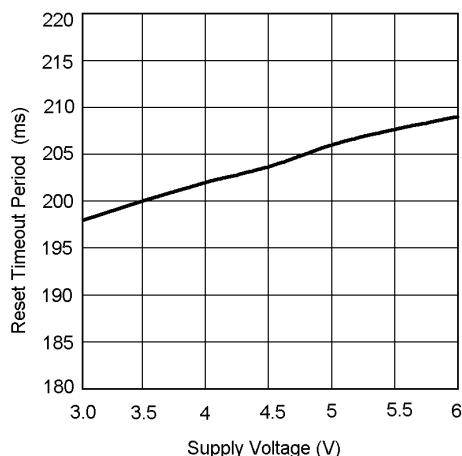
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Normalized Reset Threshold Voltage vs Temperature



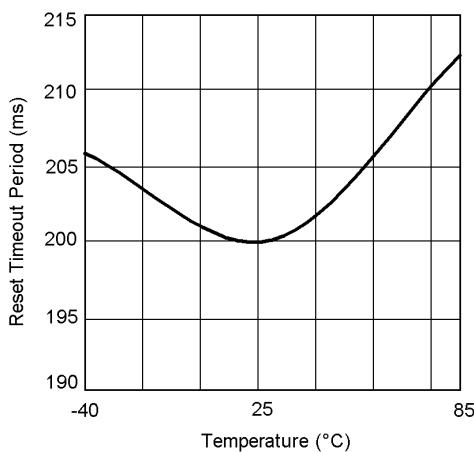
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Reset Timeout Period vs  $V_{CC}$



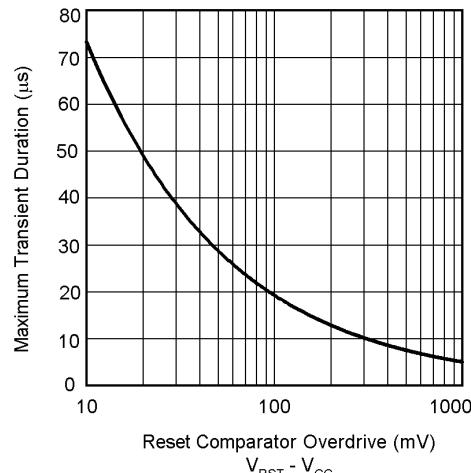
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Reset Timeout Period vs Temperature



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

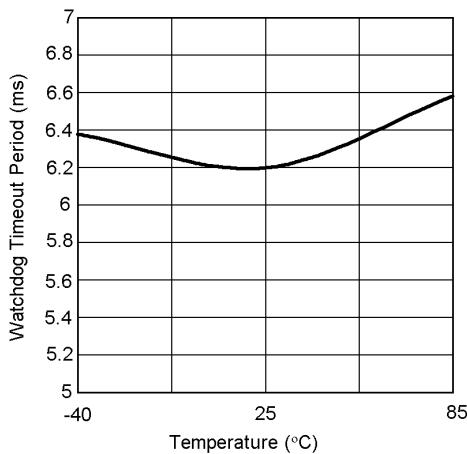


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## Typical Performance Characteristics

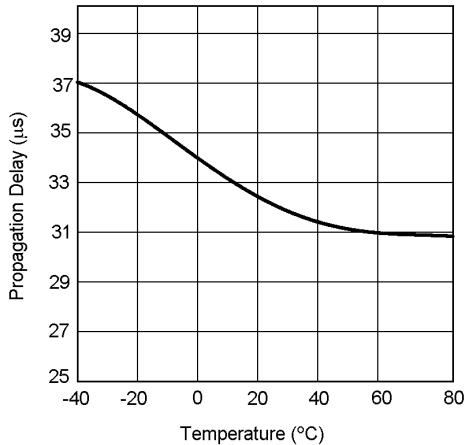
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Watchdog Timeout Period vs Temperature  
( $t_{WD}$  programmed as 6.2ms)



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Low-Line Comparator Propagation Delay vs Temperature



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## Circuit Information

### Reset Output

The Reset input of a  $\mu$ P 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.

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 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 (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 (MR)

Many  $\mu$ P-based products require a manual reset capability, allowing the operator to initiate a reset. The MR input is fully debounced and provides an internal 56 k $\Omega$  pull-up. When the MR input is pulled below  $V_{MRT}$  (1.225V) for more than 25  $\mu$ s, reset is asserted after a typical delay of 12  $\mu$ s. Reset remains active as long as MR is held low, and releases after the reset timeout period expires after MR rises above  $V_{MRT}$ . Use 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/PFO)

The PFI is compared to a 1.225V internal reference,  $V_{PFT}$ . If PFI is less than  $V_{PFT}$ , the Power Fail Output 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 (LLO)

The low-line output comparator is typically used to provide a non-maskable interrupt to a  $\mu$ P when  $V_{CC}$  begins falling. 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

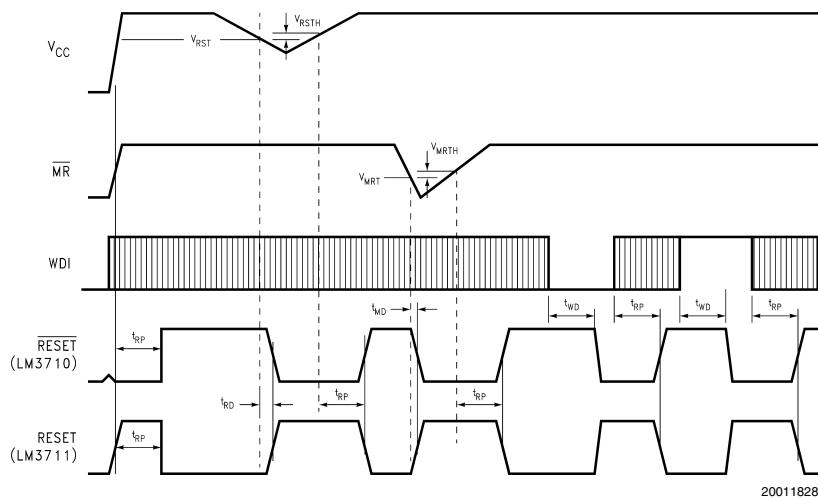


FIGURE 1. LM3710/LM3711 Reset Time with  $\overline{MR}$  and  $WDI$

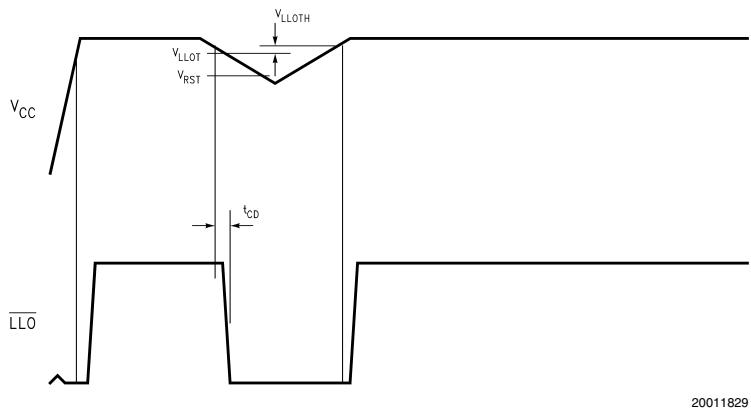


FIGURE 2.  $\overline{LLO}$  Output

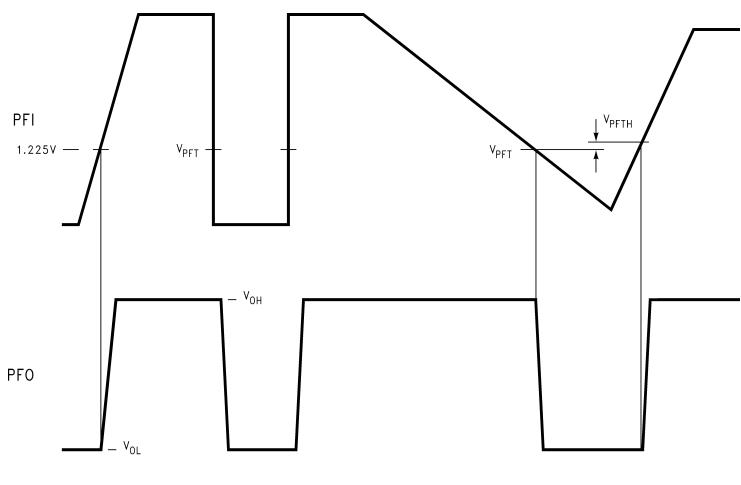
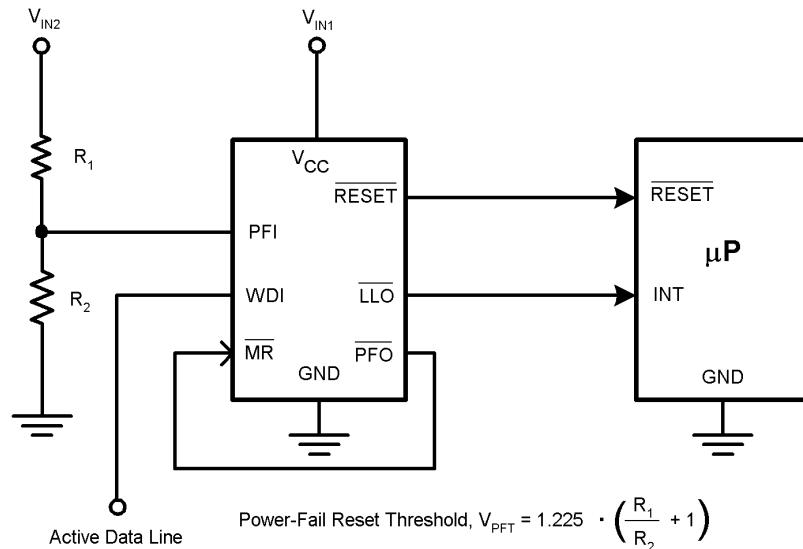


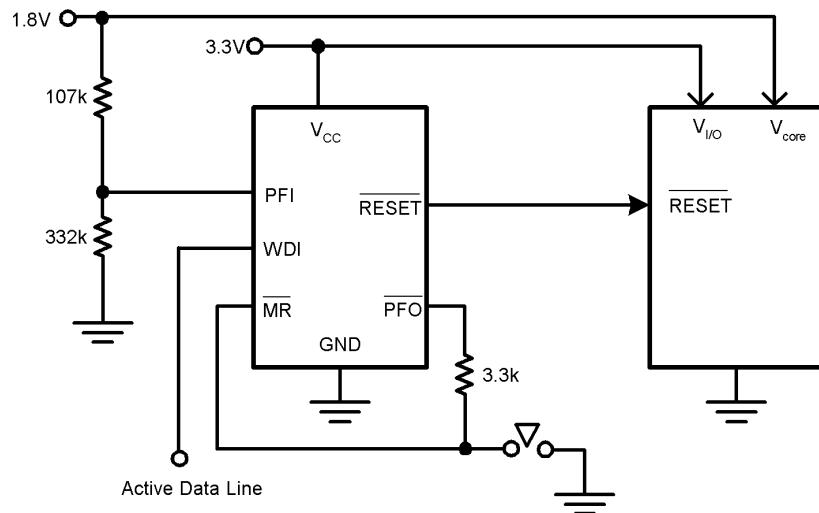
FIGURE 3. PFI Comparator Timing Diagram

## Typical Application Circuits



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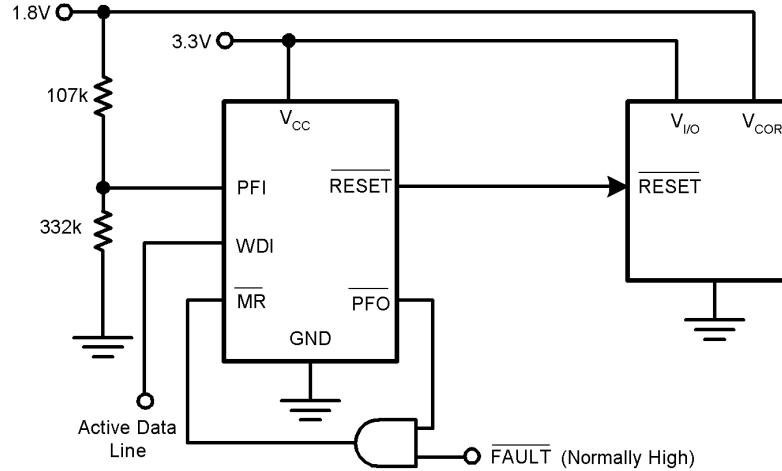
**FIGURE 4. Monitoring Two Critical Supplies And Dataline**



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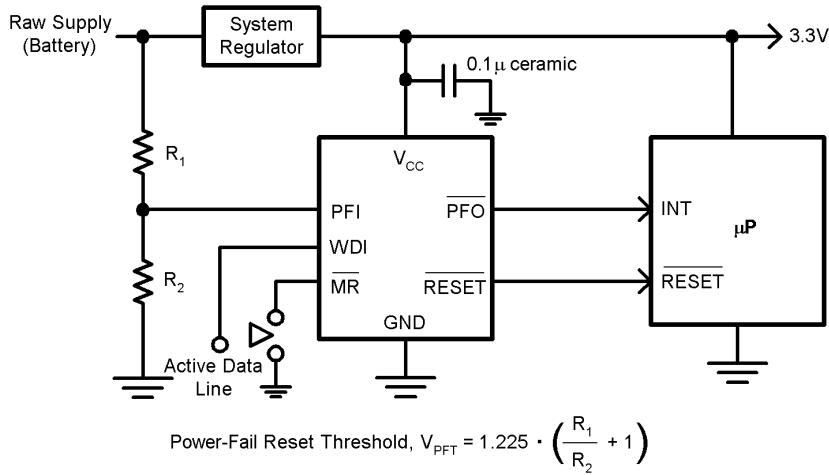
**FIGURE 5. Monitoring Two Supplies plus Manual Reset And Dataline**

## Typical Application Circuits (Continued)



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

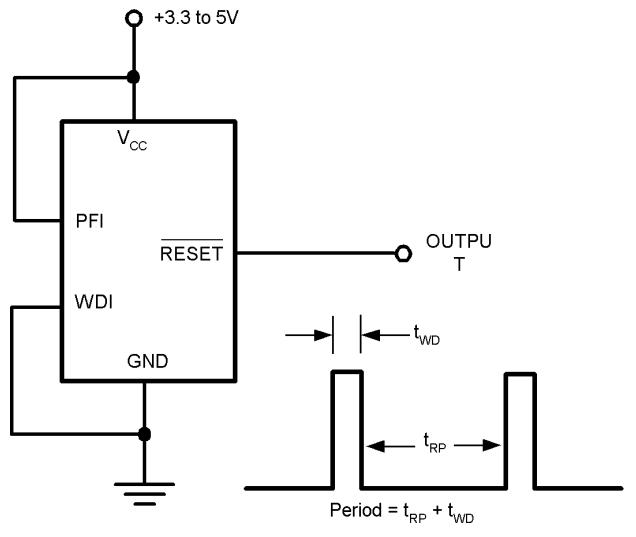


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Note: **MR** input with its 1.225V nominal threshold, may monitor an additional supply voltage. An internal 56 k $\Omega$  pull-up resistor is included on this input.

**FIGURE 7. Microprocessor Supervisor with Early Warning Detector**

## Typical Application Circuits (Continued)

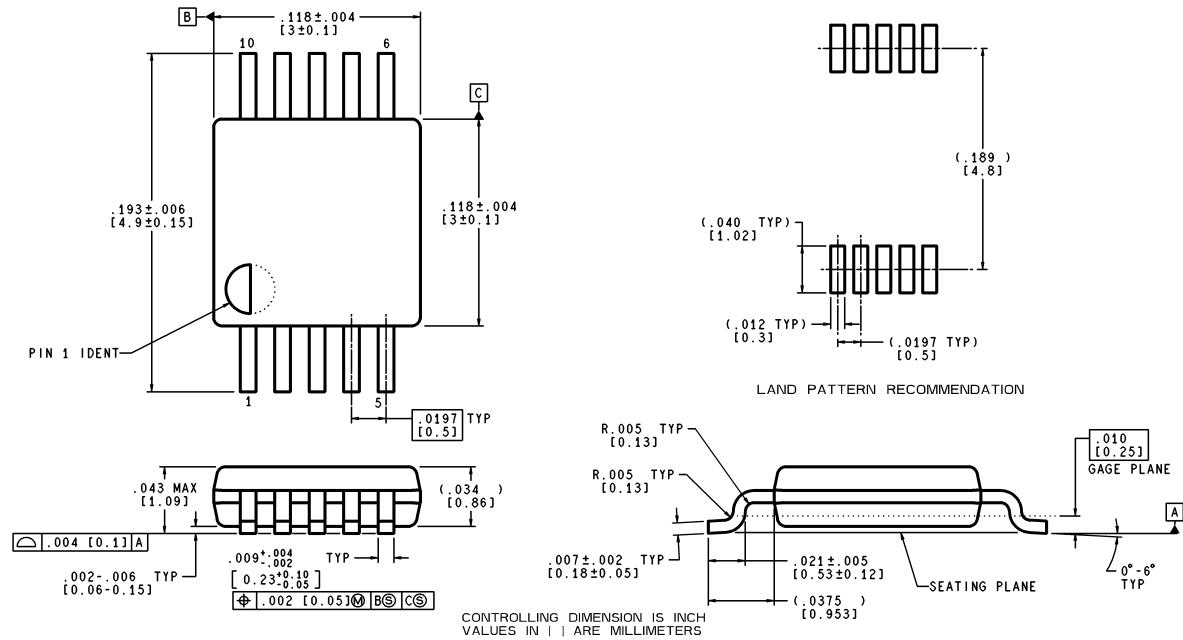


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FIGURE 8. LM3710 Long Period oscillator

## Physical Dimensions inches (millimeters)

unless otherwise noted

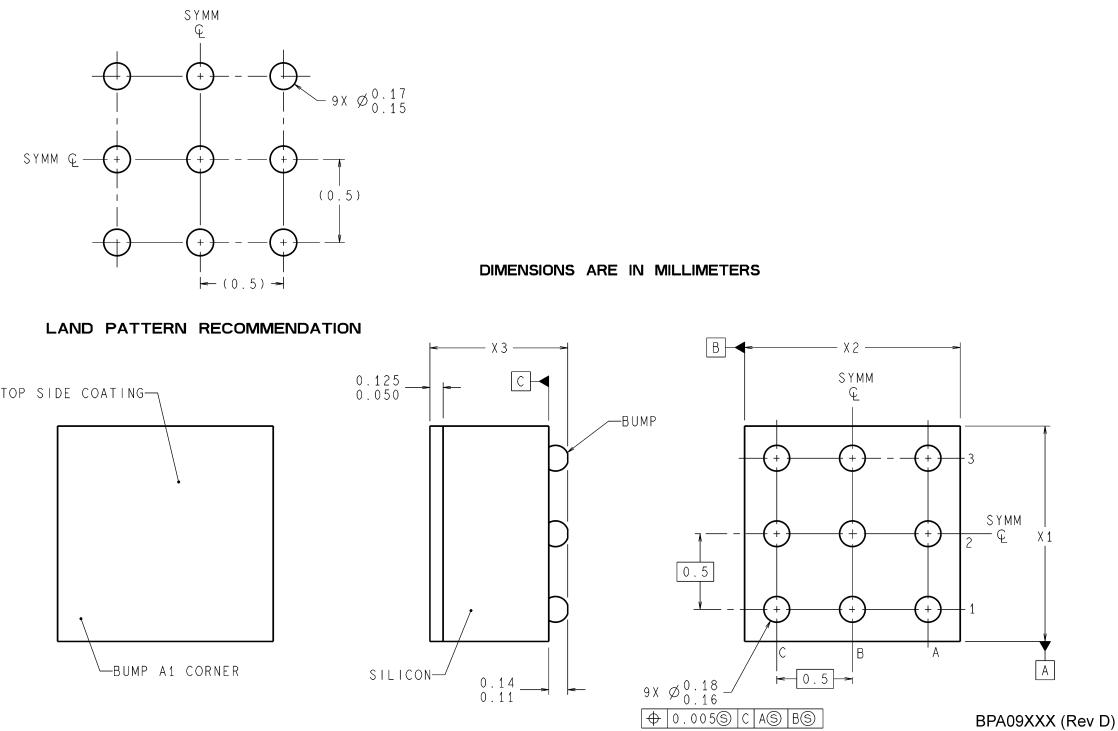


MUB10A (Rev A)

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

## Physical Dimensions

inches (millimeters) unless otherwise noted (Continued)



### 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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