

## DESCRIPTION

The MPQ6411 is a windowed watchdog timer. It is used to reset and monitor the microcontroller. In normal operation, the MCU sends a trigger signal to the MPQ6411 in a defined time window cyclically. A missing or fault trigger signal causes the watchdog to reset the MCU.

The MPQ6411 provides a reset signal (low-level voltage) to the MCU during power-up or under voltage. Its power supply (VCC) has 5V and 3.3V options.

By setting MODE to high or low, the watchdog operates in long window mode or short window mode; the window is programmable.

The MPQ6411 is available in SOIC8 package.

## FEATURES

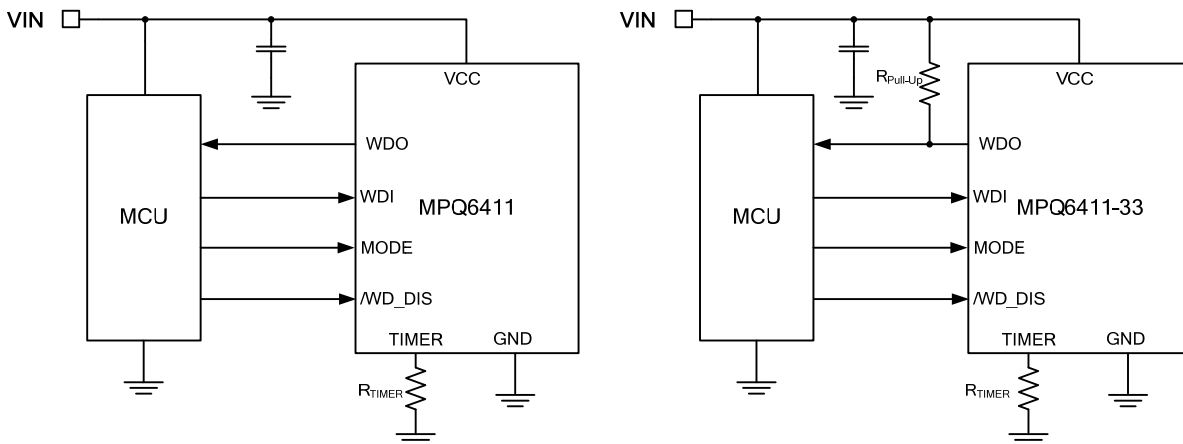
- Windowed Watchdog
- Power-On Reset during Power-Up and Under Voltage
- Programmable Short Window Mode or Long Window Mode
- Watchdog Disable Function
- Low Shutdown Mode Current
- SOIC8 Package
- Available in AEC-Q100 Grade 1

## APPLICATIONS

- Automotive Systems
- Industrial Systems

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## TYPICAL APPLICATION



### ORDERING INFORMATION

Part Number*	Package	Top Marking
MPQ6411GS	SOIC-8	<i>See Below</i>
MPQ6411GS-AEC1	SOIC-8	
MPQ6411GS-33**	SOIC-8	
MPQ6411GS-33-AEC1**	SOIC-8	

\* For Tape & Reel, add suffix -Z (e.g. MPQ6411GS-Z);

\*\* Pre-release

### TOP MARKING

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**MP6411**  
**LLLLLLLLL**  
**MPSYWW**

MP6411: Product code of MPQ6411GS and MPQ6411GS-AEC1  
 LLLLLLLL: Lot number  
 MPS: MPS prefix  
 Y: Year code  
 WW: Week code

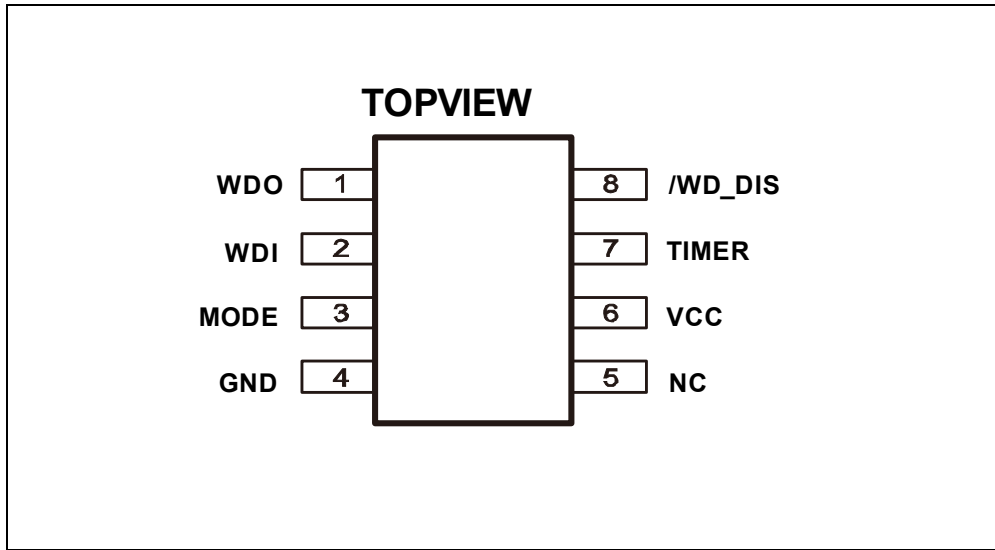
### TOP MARKING

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**M6411-33**  
**LLLLLLLLL**  
**MPSYWW**

M6411-33: Product code of MPQ6411GS-33 and MPQ6411GS-33-AEC1  
 LLLLLLLL: Lot number  
 MPS: MPS prefix  
 Y: Year code  
 WW: Week code

**PACKAGE REFERENCE**



**ABSOLUTE MAXIMUM RATINGS <sup>(1)</sup>**

All pins .....	-0.3V to +6V
Continuous power dissipation (T <sub>A</sub> = +25°C) <sup>(2)</sup>	
SOIC8.....	1.3W
Junction temperature.....	150°C
Lead temperature .....	260°C
Storage temperature.....	-65°C to +150°C

**Recommended Operating Conditions**

Supply voltage (VCC)	
MPQ6411.....	5V
MPQ6411-33.....	3.3V
Operating junction temp. (T <sub>J</sub> ).....	-40°C to 125°C

<b>Thermal Resistance <sup>(3)</sup></b>	<b>θ<sub>JA</sub></b>	<b>θ<sub>JC</sub></b>
SOIC-8.....	96.....	45...°C/W

**Notes:**

- 1) Exceeding these ratings may damage the device.
- 2) The maximum allowable power dissipation is a function of the maximum junction temperature T<sub>J</sub> (MAX), the junction-to-ambient thermal resistance θ<sub>JA</sub>, and the ambient temperature T<sub>A</sub>. The maximum allowable continuous power dissipation at any ambient temperature is calculated by P<sub>D</sub> (MAX) = (T<sub>J</sub> (MAX)-T<sub>A</sub>)/θ<sub>JA</sub>. Exceeding the maximum allowable power dissipation will cause an excessive die temperature, causing the regulator to go into thermal shutdown. Internal thermal shutdown circuitry protects the device from permanent damage.
- 3) Measured on JESD51-7, 4-layer PCB.

**ELECTRICAL CHARACTERISTICS**

VCC = 5V for MPQ6411, VCC = 3.3V for MPQ6411-33, T<sub>J</sub> = - 40°C to +125°C, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
<b>Power Supply</b>						
Timer voltage		R <sub>TIMER</sub> = 51k		0.3		V
Quiescent current	I <sub>Q</sub>	MPQ6411, R <sub>TIMER</sub> = 100k		16	19	μA
		MPQ6411-33, R <sub>TIMER</sub> = 100k		10	14	
		MPQ6411, R <sub>TIMER</sub> = 51k		25	32	μA
		MPQ6411-33, R <sub>TIMER</sub> = 51k		14	18	
Power on reset threshold	V <sub>POR-HIGH</sub>	MPQ6411, WDO goes high with rising VCC	4.4	4.6	4.8	V
		MPQ6411-33, WDO goes high with rising VCC	2.9	3	3.1	
	V <sub>POR-LOW</sub>	MPQ6411, WDO goes low with falling VCC	4.3	4.5	4.7	V
		MPQ6411-33, WDO goes low with falling VCC	2.8	2.9	3	
<b>Timing</b>						
Single period	T	R <sub>TIMER</sub> = 51k	-10%	880	+10%	μs
Power on delay <sup>(4)</sup>	t <sub>0</sub>	R <sub>TIMER</sub> = 51k		10		cycle
Sync signal monitoring time <sup>(4)</sup>	t <sub>1</sub>	R <sub>TIMER</sub> = 51k		450		cycle
Watchdog window close time (short mode) <sup>(4)</sup>	t <sub>2</sub>	R <sub>TIMER</sub> = 51k, MODE = low		15		cycle
Watchdog window open time (short mode) <sup>(4)</sup>	t <sub>3</sub>	R <sub>TIMER</sub> = 51k, MODE = low		10		cycle
Watchdog window close time (long mode) <sup>(4)</sup>	t <sub>4</sub>	R <sub>TIMER</sub> = 51k, MODE = high		1500		cycle
Watchdog window open time (long mode) <sup>(4)</sup>	t <sub>5</sub>	R <sub>TIMER</sub> = 51k, MODE = high		1000		cycle
WDO reset pulse width <sup>(4)</sup>	t <sub>6</sub>	R <sub>TIMER</sub> = 51k		4		cycle
WDI_OK pulse width			10		5000	μs
<b>Input and Output</b>						
WDI logic high		MPQ6411	3.2			V
		MPQ6411-33	2.1			
WDI logic low		MPQ6411			0.8	V
		MPQ6411-33			0.6	
MODE logic high		MPQ6411	3.2			V
		MPQ6411-33	2.1			
MODE logic low		MPQ6411			0.8	V
		MPQ6411-33			0.6	

**ELECTRICAL CHARACTERISTICS (continued)**

VCC = 5V for MPQ6411, VCC = 3.3V for MPQ6411-33, T<sub>J</sub> = - 40°C to +125°C, unless otherwise noted.

Parameter	Symbol	Condition	Min	Typ	Max	Units
MODE input Current		MPQ6411, MODE = 5V		0.1	1	μA
		MPQ6411-33, MODE = 3.3V				
		MPQ6411, MODE = 0V		5	8	μA
		MPQ6411-33, MODE = 0V				
/WD_DIS logic high		MPQ6411	3.2			V
		MPQ6411-33	2.1			
/WD_DIS logic low		MPQ6411			0.8	V
		MPQ6411-33			0.6	
/WD_DIS input Current		MPQ6411, WD_DIS = 5V		0.1	1	μA
		MPQ6411-33, WD_DIS = 3.3V				
		MPQ6411, WD_DIS = 0V		5	8	μA
		MPQ6411-33, WD_DIS = 0V				
WDO high		MPQ6411, VCC = 5V, I <sub>WDO</sub> = 1mA	V <sub>CC</sub> -0.2			V
		MPQ6411-33, VCC=3.3V, R <sub>Pull-Up</sub> =100KΩ	3.29			
WDO low		MPQ6411, VCC = 5V, I <sub>WDO</sub> = 1mA			0.2	V
		MPQ6411, VCC = 1V, I <sub>WDO</sub> = 300μA			0.1	
		MPQ6411-33, Sink 1mA Current			0.1	

**Notes:**

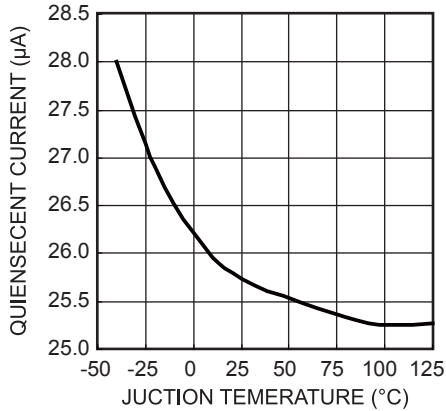
4) Derived from bench characterization. Not tested in production.

### TYPICAL CHARACTERISTICS

VCC=5V for MPQ6411, VCC=3.3V for MPQ6411-33, unless otherwise noted.

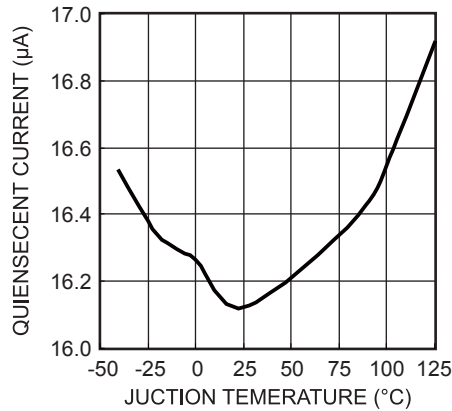
**Quiescent Current vs. Junction Temperature**

MPQ6411, R<sub>TIMER</sub>=51k



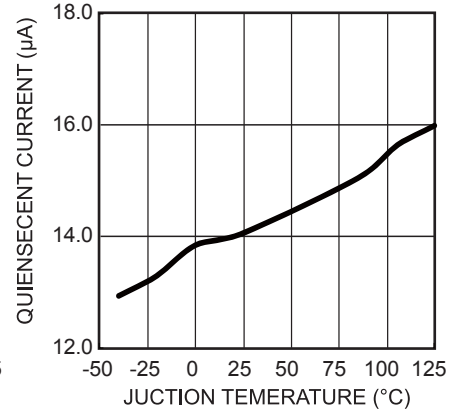
**Quiescent Current vs. Junction Temperature**

MPQ6411, R<sub>TIMER</sub>=100k



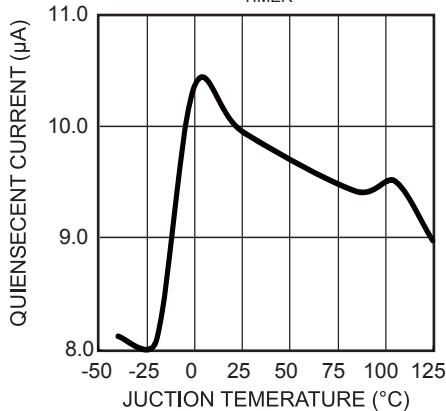
**Quiescent Current vs. Junction Temperature**

MPQ6411-33, R<sub>TIMER</sub>=51k



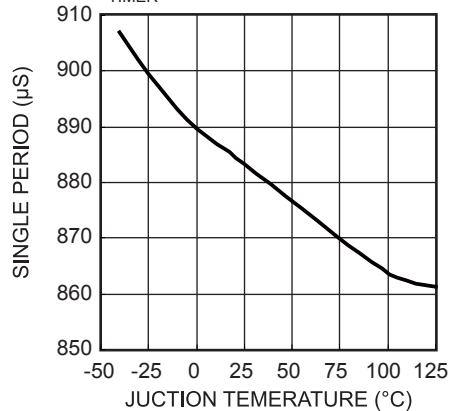
**Quiescent Current vs. Junction Temperature**

MPQ6411-33, R<sub>TIMER</sub>=100k



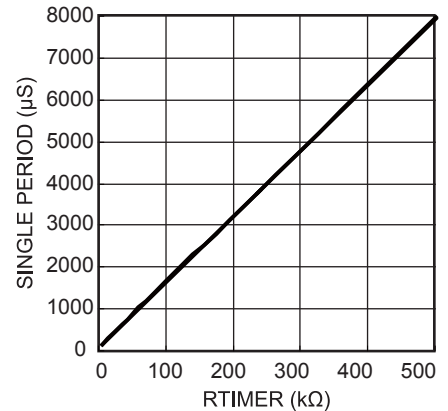
**Single Period vs. Junction Temperature**

R<sub>TIMER</sub>=51k



**Single Period vs. R<sub>TIMER</sub>**

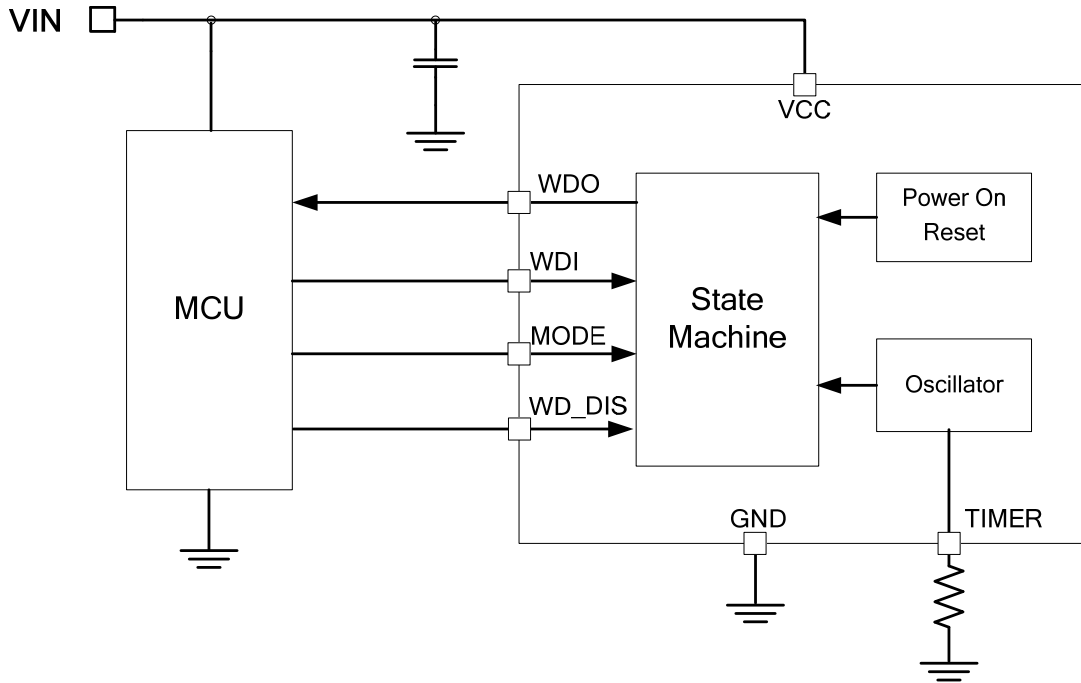
T<sub>A</sub>=25°C



**PIN FUNCTION**

Pin #	Name	Description
1	WDO	Watchdog output. WDO outputs a reset signal to the MCU. MPQ6411 WDO is the output of a inverter, it is not must to connect WDO to VCC or another voltage source through a resistor. MPQ6411-33 WDO is the open drain of a MOSFET and should be connected to VCC or another voltage source through a resistor (e.g.100kΩ).
2	WDI	Watchdog input. WDI receives the trigger signal from the MCU.
3	MODE	Mode switching pin. Pull MODE high to make the watchdog operate in long window mode; pull MODE low to make it work in short window mode. MODE has a weak internal pull-up.
4	GND	Ground.
5	NC	Not connected.
6	VCC	Power input.
7	TIMER	Watchdog timer pin. TIMER sets the time-out with an external resistor
8	/WD_DIS	Watchdog disable pin. Pull /WD_DIS low to disable the watchdog; pull /WD_DIS high to enable the watchdog. It has a weak internal pull-up.

**FUNCTIONAL BLOCK DIAGRAM**

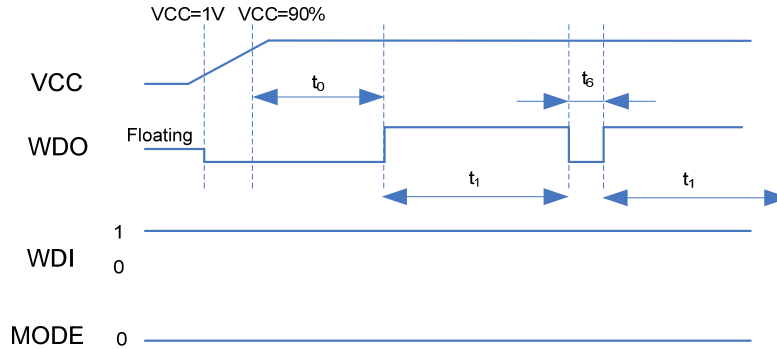


**Figure 1: Functional Block Diagram**

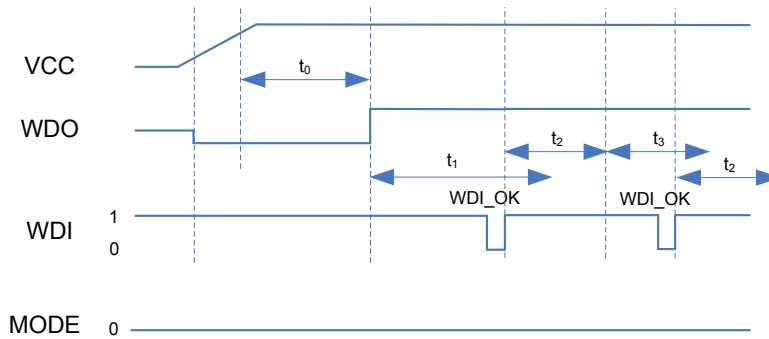


## TIMING DIAGRAM

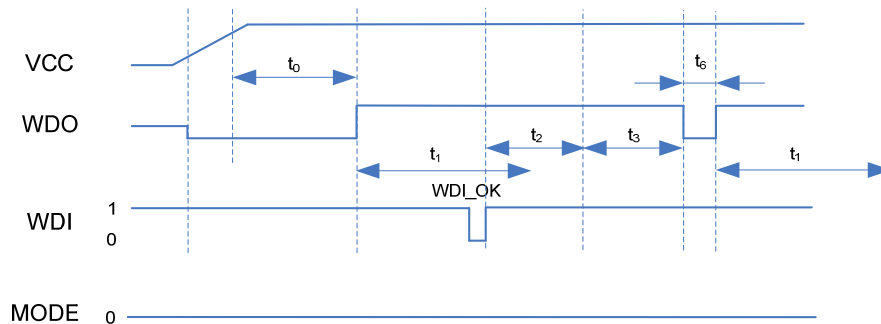
### Power-on reset and no sync signal



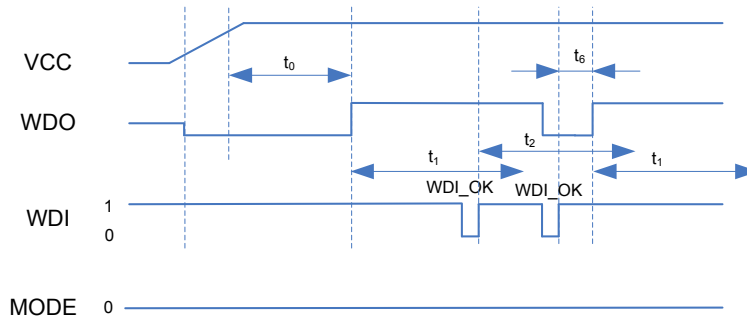
### Synchronized by WDI and triggered in open window (MODE=0, short window mode)



### Synchronized by WDI and no trigger signal (MODE=0, short window mode)

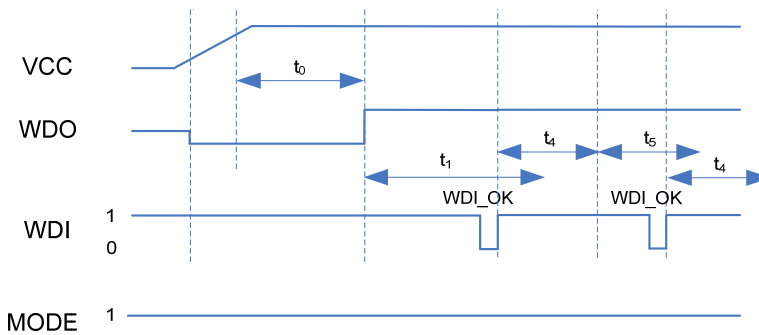


**Synchronized by WDI and triggered in closed window (MODE=0, short window mode)**

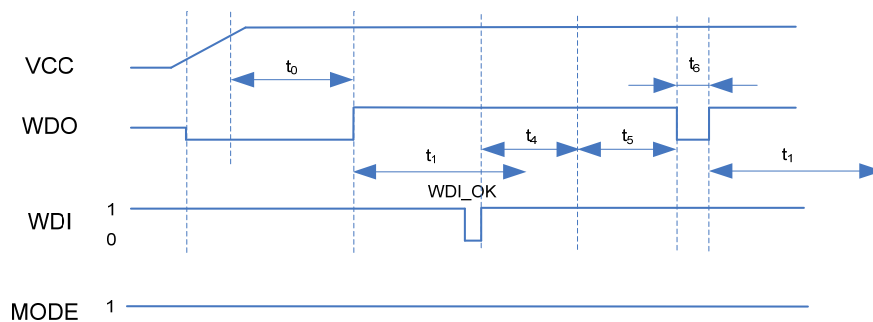


Note: When the WDI\_OK rising edge that comes at WDO is low, the  $t_6$  timer will be reset. Therefore, in the situation above, the WDO reset signal maintains a  $t_6 + \text{WDI\_OK}$  time.

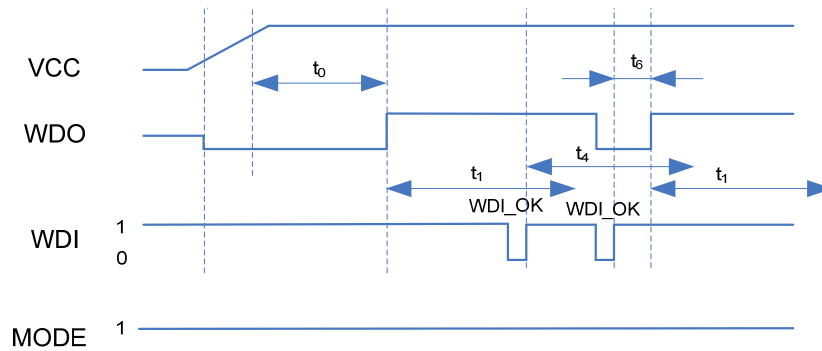
**Synchronized by WDI and triggered in open window (MODE=1, long window mode)**



**Synchronized by WDI and no trigger signal (MODE=1, long window mode)**

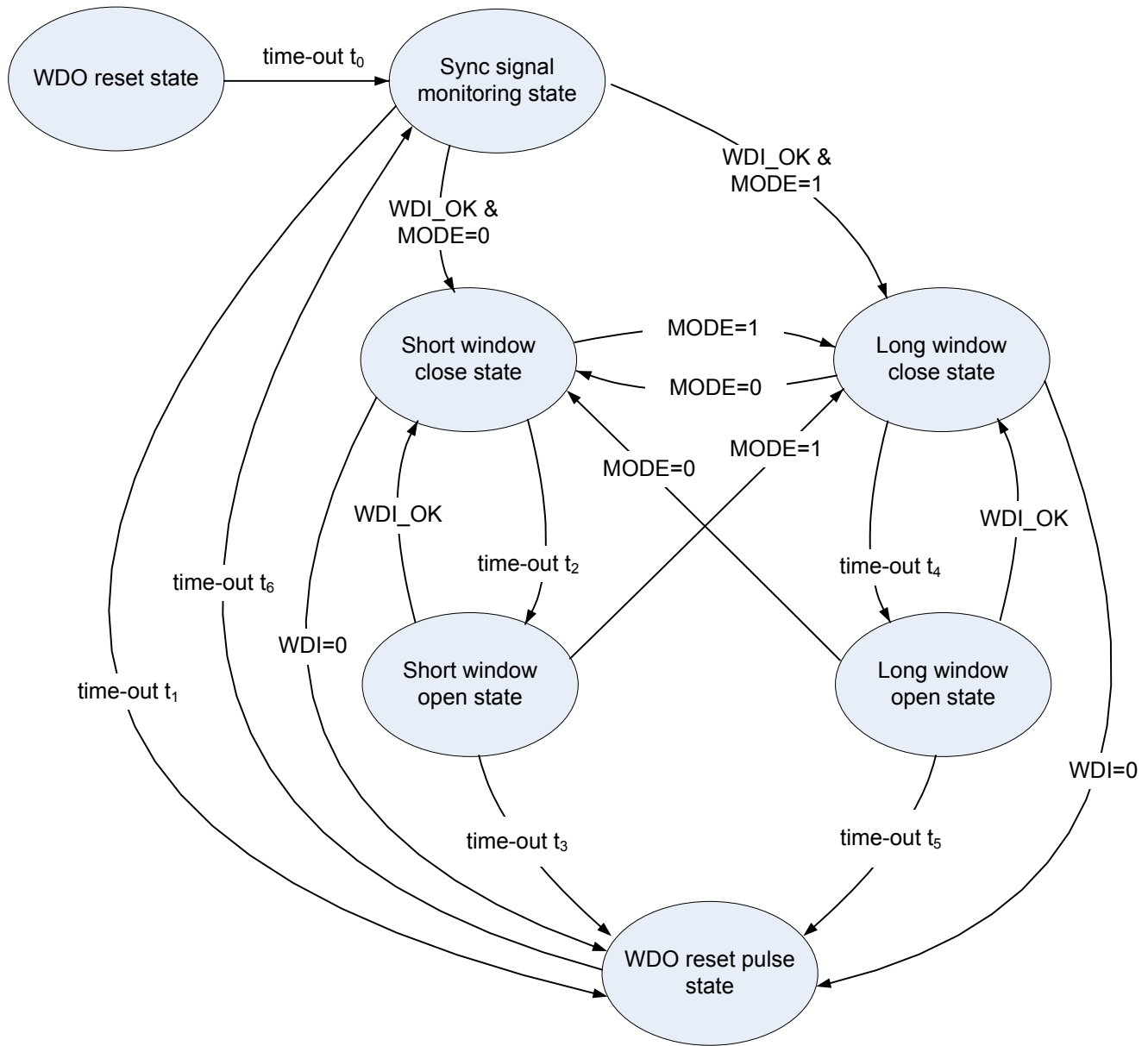


Synchronized by WDI and triggered in closed window (MODE=1, long window mode)



Note: When the WDI\_OK rising edge that comes at WDO is low, the  $t_6$  timer will be reset. Therefore, in the situation above, the WDO reset signal maintains a  $t_6 + \text{WDI\_OK}$  time.

STATE DIAGRAM



**Note:** The state diagram above does not include if a WDI error occurs.

## OPERATION

### Supply Voltage

VCC= 5V±10% is recommended for MPQ6411 /MPQ6411-AEC1 normal operation; while VCC= 3.3V±10% is recommended for MPQ6411-33/MPQ6411-33-AEC1 normal operation. WDO is pulled low when VCC rises to 1V or above. After VCC rises to 90% (typically), WDO will remain at a low level for  $t_0$  to reset the MCU.

### TIMER

Period T ( $\mu$ s):

$$T(\mu\text{s}) = 15.75 \times R_{\text{TIMER}}(\text{k}\Omega) + 73.5$$

$R_{\text{TIMER}}$  (k $\Omega$ ):

$$R_{\text{TIMER}}(\text{k}\Omega) = 0.063 \times T(\mu\text{s}) - 4.67$$

For example:  $R_{\text{TIMER}}=51\text{k}\Omega$ ,  $T \approx 0.88\text{ms}$

### Monitor MCU Synchronization Signal

When the watchdog is in a “sync signal monitoring state,” the following will occur:

- ◆ If the watchdog IC receives a WDI\_OK signal from the MCU within  $t_1$  (WDI remains low for 10 $\mu$ s to 5ms), the timer will be reset, and the watchdog works in normal operation.
- ◆ If the watchdog does not receive the WDI\_OK signal from the MCU during  $t_1$ , it will generate a reset signal and go into “sync signal monitor state” again.

### Short Window Mode

If the MCU and watchdog are synchronized correctly and MODE is low, the watchdog will work in short window mode:

- ◆ If WDI\_OK is received in a window close state ( $t_2$ ), the watchdog outputs a reset signal and goes into a sync signal monitoring state.
- ◆ If WDI\_OK is received in a window open state ( $t_3$ ), the watchdog goes into a window

close state. The MCU works in normal operation in this situation.

- ◆ If no WDI\_OK signal is received in  $t_2+t_3$ , the watchdog outputs a reset signal and goes into a sync signal monitoring state.
- ◆ If MODE is pulled high during short window mode, the watchdog will go into long window mode.

### Long Window Mode

If the MCU and watchdog are synchronized correctly and MODE is high, the watchdog will operate in long window mode, and the following will occur:

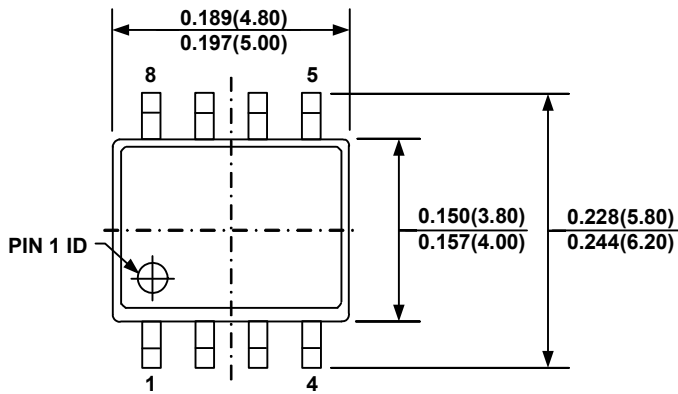
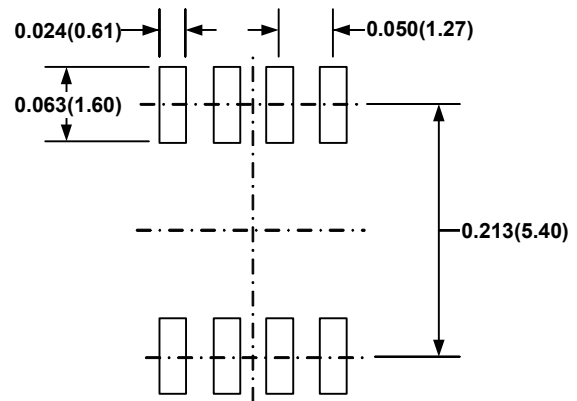
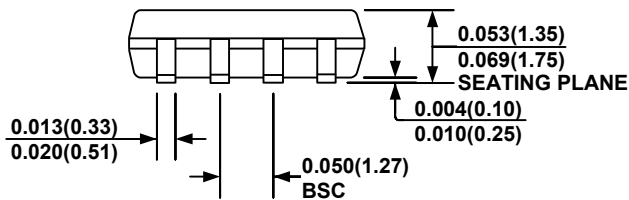
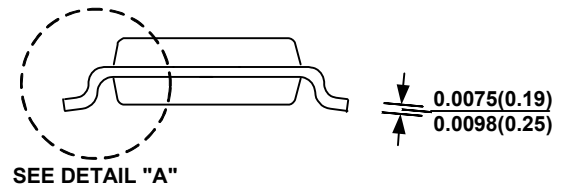
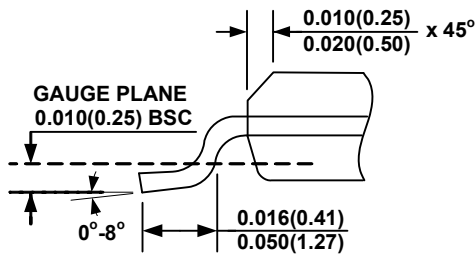
- ◆ If WDI\_OK is received in a window close state ( $t_4$ ), the watchdog outputs a reset signal and goes into a sync signal monitoring state.
- ◆ If WDI\_OK is received in a window open state ( $t_5$ ), the watchdog goes into a window close state. The MCU works in normal operation in this situation.
- ◆ If no WDI\_OK signal is received in  $t_4+t_5$ , the watchdog outputs a reset signal and goes into a sync signal monitoring state.
- ◆ If MODE is pulled low during a long window mode, the watchdog will go into a short window mode.

### Watchdog Disable

Pull /WD\_DIS low to disable the watchdog; pull it high to enable the watchdog. /WD\_DIS has a weak internal pull-up, so the watchdog is enabled if /WD\_DIS is left open.

### WDI Error

If a WDI signal remains at a low level for longer than the maximum WDI\_OK pulse width, it is regarded as an error. When this error occurs, WDO is pulled down until WDI returns to a high level.

**PACKAGE INFORMATION**
**SOIC-8**

**TOP VIEW**

**RECOMMENDED LAND PATTERN**

**FRONT VIEW**

**SIDE VIEW**

**DETAIL "A"**
**NOTE:**

- 1) CONTROL DIMENSION IS IN INCHES. DIMENSION IN BRACKET IS IN MILLIMETERS.
- 2) PACKAGE LENGTH DOES NOT INCLUDE MOLD FLASH, PROTRUSIONS OR GATE BURRS.
- 3) PACKAGE WIDTH DOES NOT INCLUDE INTERLEAD FLASH OR PROTRUSIONS.
- 4) LEAD COPLANARITY (BOTTOM OF LEADS AFTER FORMING) SHALL BE 0.004" INCHES MAX.
- 5) DRAWING CONFORMS TO JEDEC MS-012, VARIATION AA.
- 6) DRAWING IS NOT TO SCALE.

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