

## 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

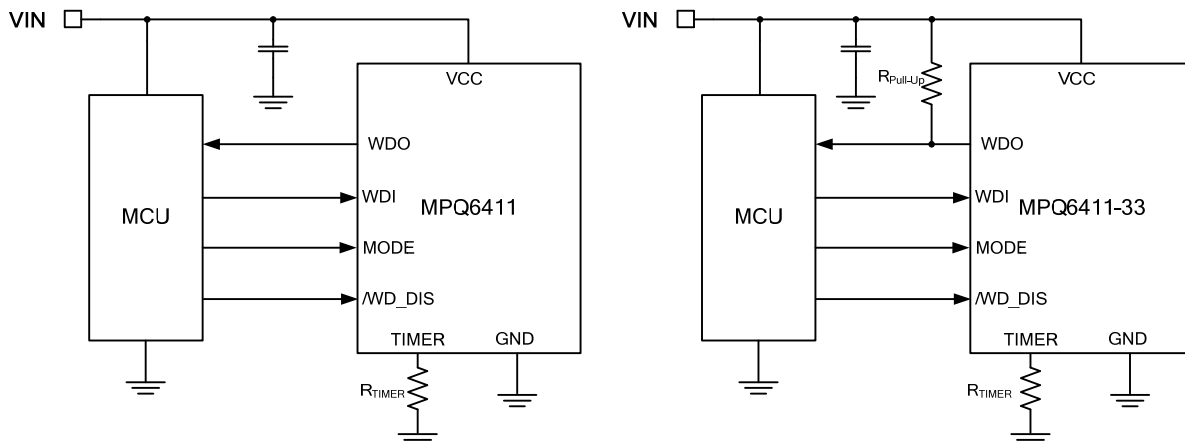
- Windowed Watchdog
- Power-On Reset during Power-Up and Under Voltage
- Programmable Short Window Mode or Long Window Mode
- Watchdog Disable Function
- Low Shutdown Mode Current
- SOIC8 Package
- Available in AEC-Q100 Grade 1

## 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

LLLLLLLLL: 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

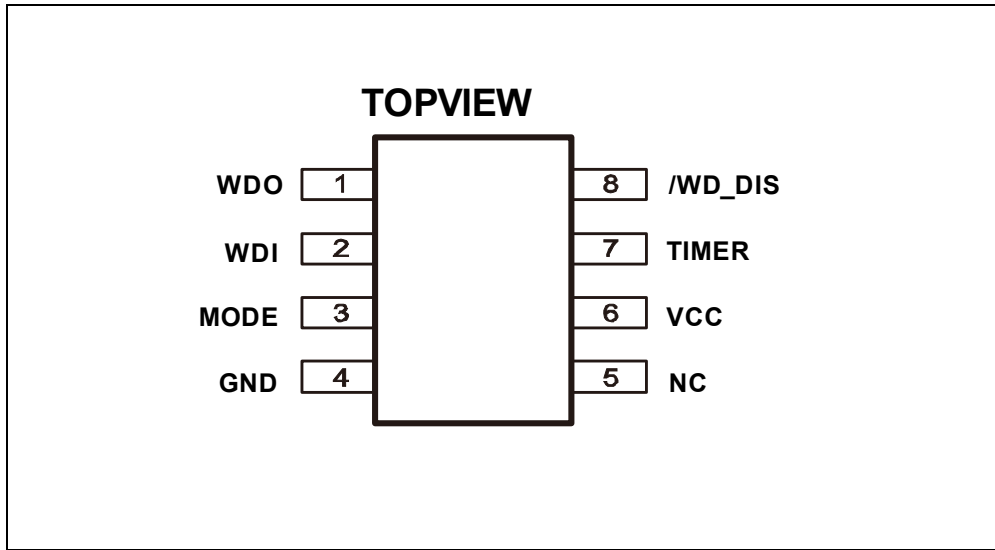
LLLLLLLLL: Lot number

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,<br>WDO goes high with rising VCC    | 4.4  | 4.6  | 4.8  | V     |
|  |                       | MPQ6411-33,<br>WDO goes high with rising VCC | 2.9  | 3    | 3.1  |       |
|  | V <sub>POR-LOW</sub>  | MPQ6411,<br>WDO goes low with falling VCC    | 4.3  | 4.5  | 4.7  | V     |
|  |                       | MPQ6411-33,<br>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,<br>VCC = 5V, I <sub>WDO</sub> = 1mA         | V <sub>CC</sub> -0.2 |     |     | V     |
|                       |        | MPQ6411-33,<br>VCC=3.3V, R <sub>Pull-Up</sub> =100KΩ | 3.29                 |     |     |       |
| WDO low               |        | MPQ6411,<br>VCC = 5V, I <sub>WDO</sub> = 1mA         |                      |     | 0.2 | V     |
|                       |        | MPQ6411,<br>VCC = 1V, I <sub>WDO</sub> = 300μA       |                      |     | 0.1 |       |
|                       |        | MPQ6411-33,<br>Sink 1mA Current                      |                      |     | 0.1 |       |

**Notes:**

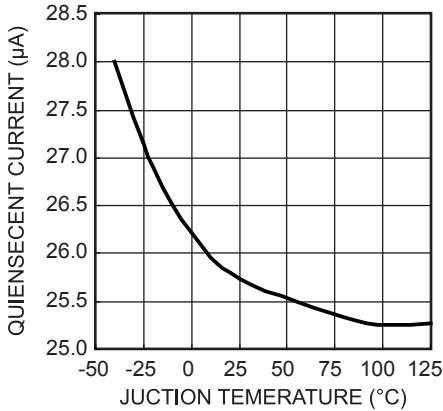
4) Derived from bench characterization. Not tested in production.

### TYPICAL CHARACTERISTICS

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

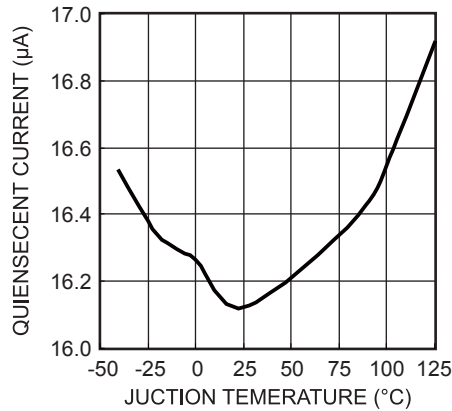
**Quiescent Current vs. Junction Temperature**

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



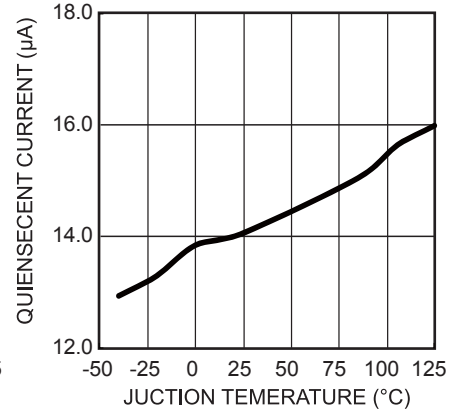
**Quiescent Current vs. Junction Temperature**

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



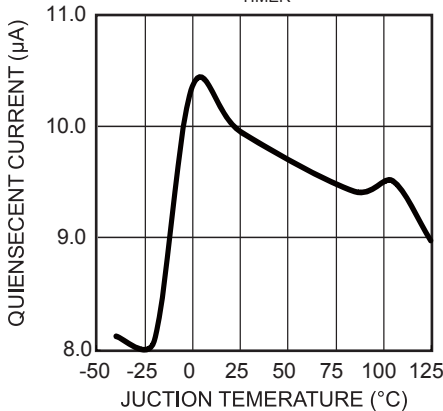
**Quiescent Current vs. Junction Temperature**

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



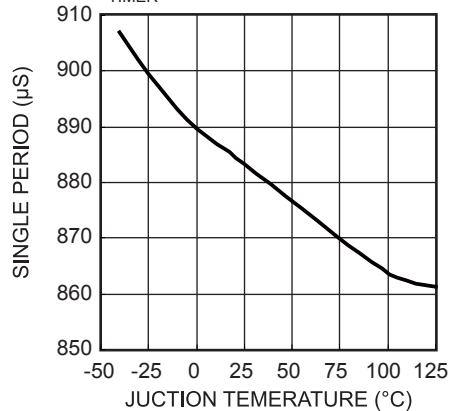
**Quiescent Current vs. Junction Temperature**

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



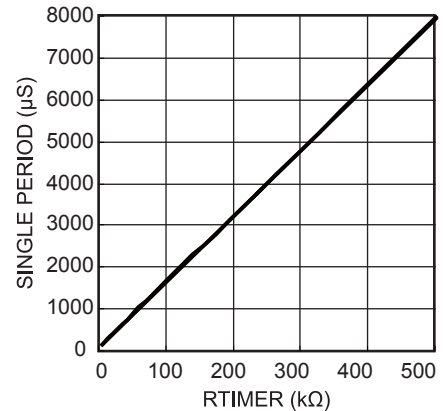
**Single Period vs. Junction Temperature**

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.<br>MPQ6411 WDO is the output of a inverter, it is not must to connect WDO to VCC or another voltage source through a resistor.<br>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

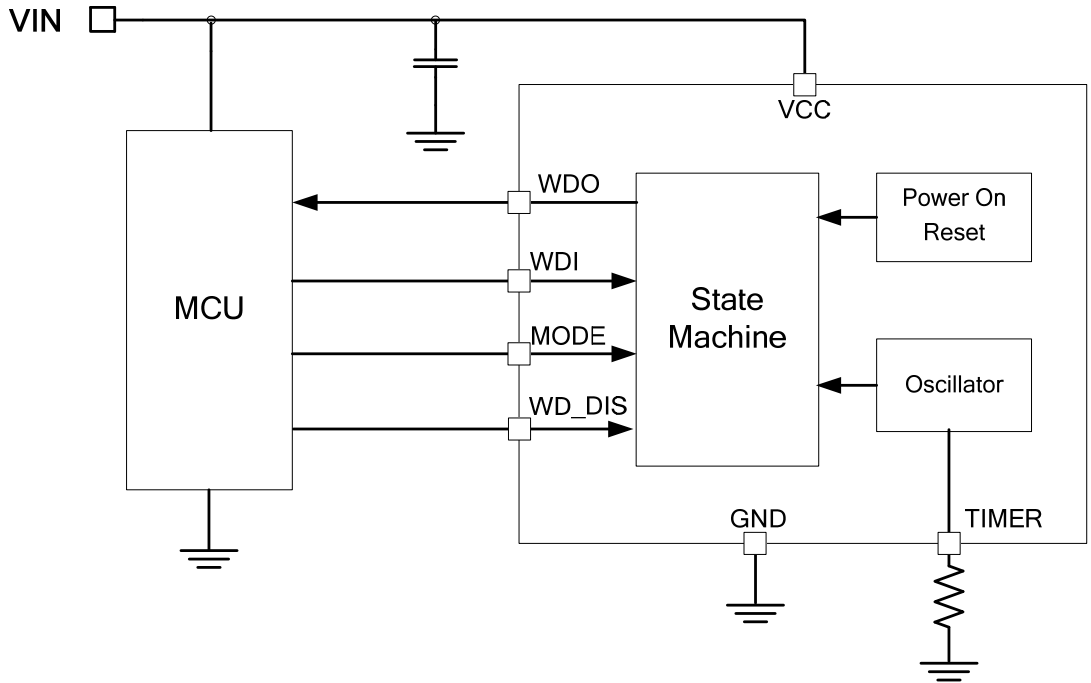
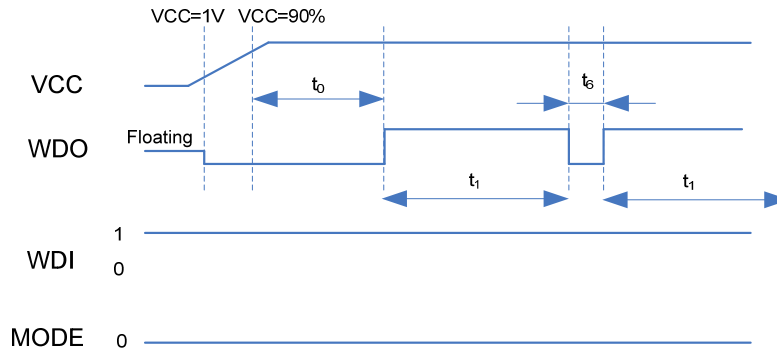


Figure 1: Functional Block Diagram

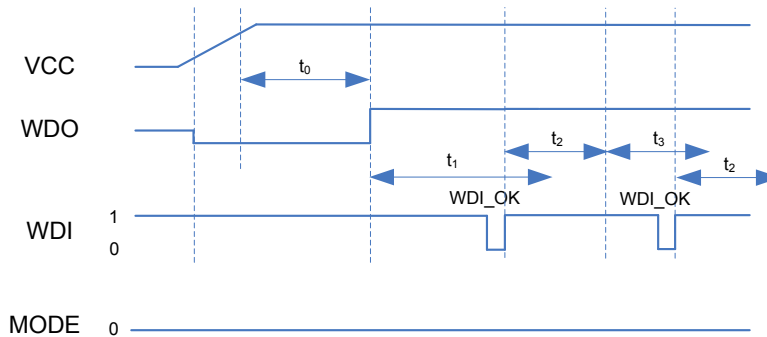


## TIMING DIAGRAM

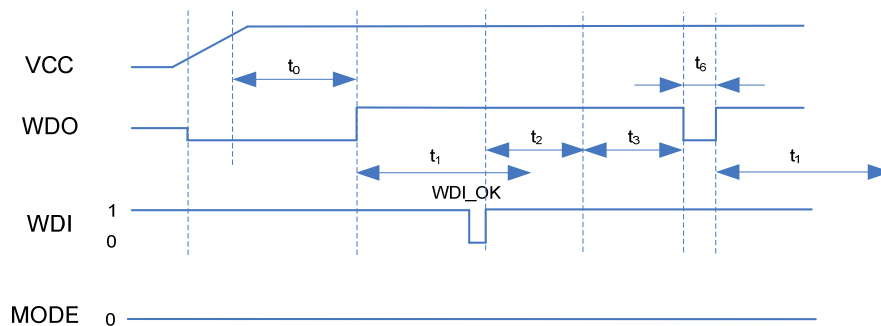
### Power-on reset and no sync signal



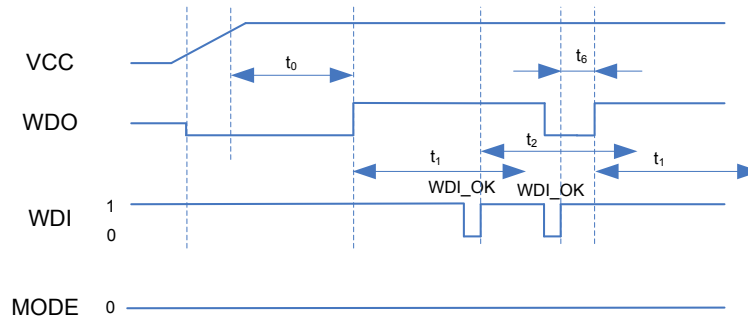
### Synchronized by WDI and triggered in open window (MODE=0, short window mode)



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

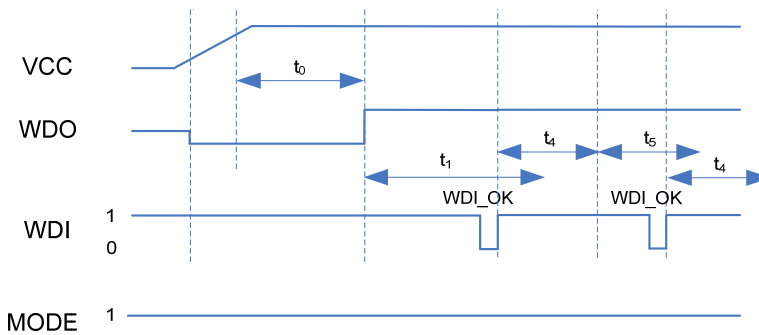


Synchronized by WDI and triggered in closed window (MODE=0, short window mode)

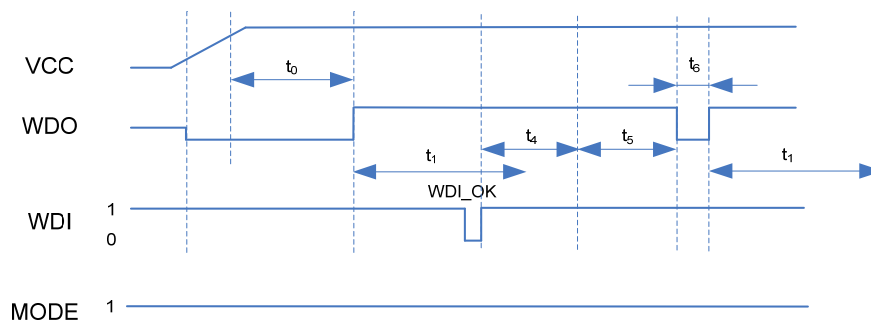


Note: When the WDI\_OK rising edge that comes at WDO is low, the  $t_6$  timer will be reset. Therefore, in the situation above, the WDO reset signal maintains a  $t_6 + \text{WDI\_OK}$  time.

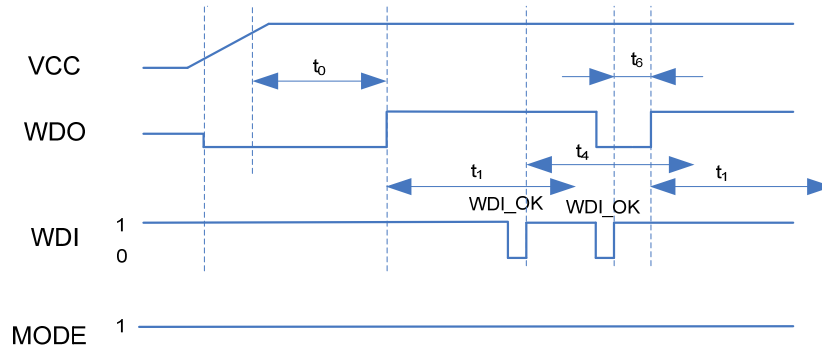
Synchronized by WDI and triggered in open window (MODE=1, long window mode)



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

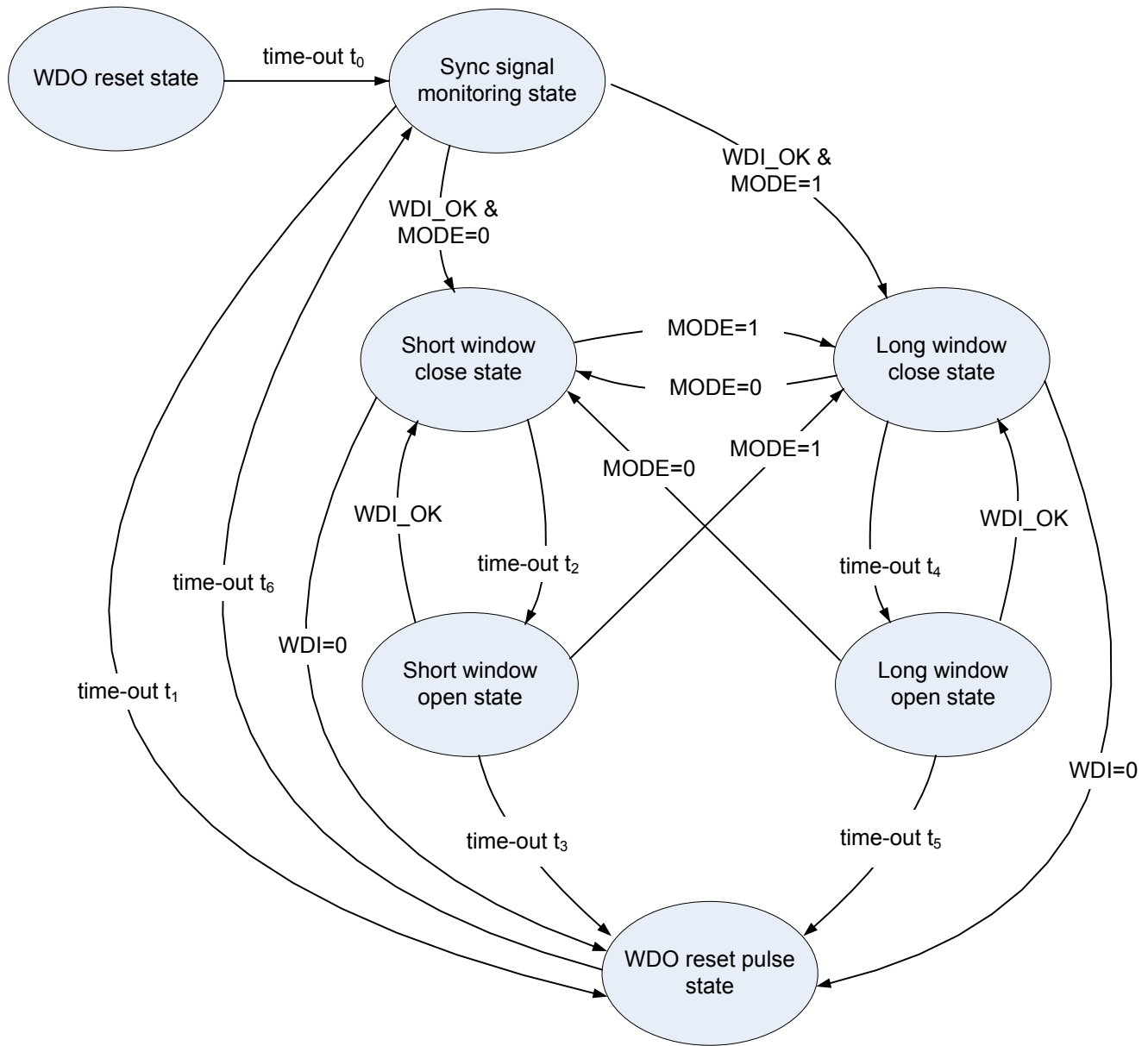


Synchronized by WDI and triggered in closed window (MODE=1, long window mode)



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:

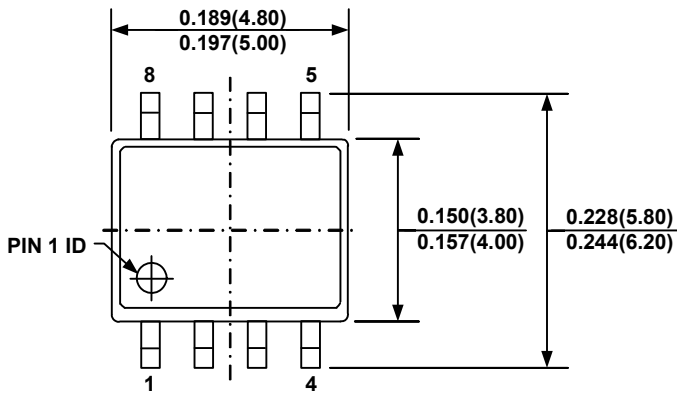
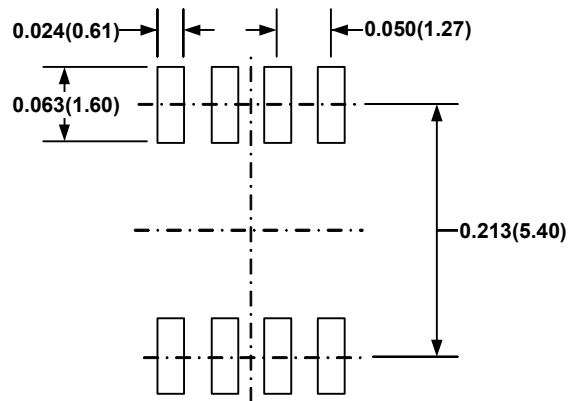
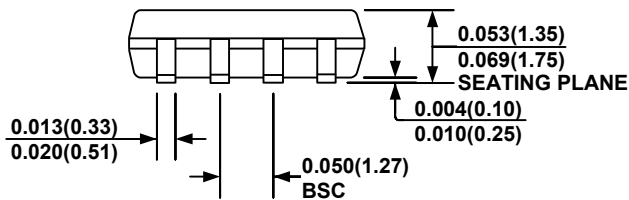
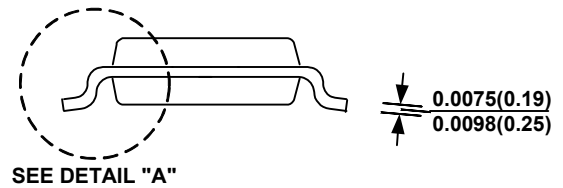
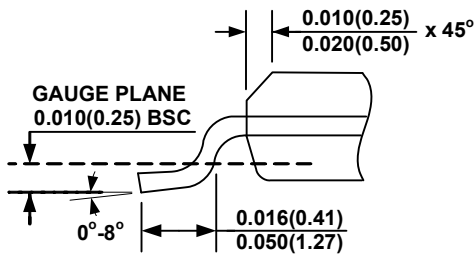
- ◆ If WDI\_OK is received in a window close state ( $t_4$ ), the watchdog outputs a reset signal and goes into a sync signal monitoring state.
- ◆ If WDI\_OK is received in a window open state ( $t_5$ ), the watchdog goes into a window close state. The MCU works in normal operation in this situation.
- ◆ 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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