

## DESCRIPTION

The MP6411 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 MP6411 in a defined time window cyclically. A missing or fault trigger signal causes the watchdog to reset the MCU.

The MP6411 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 MP6411 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

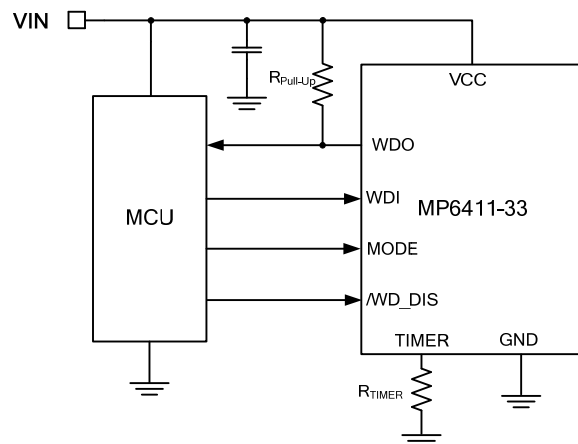
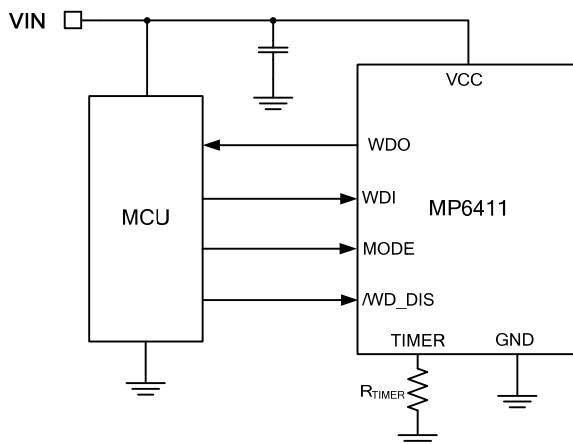
## APPLICATIONS

- Automotive Systems
- Industrial Systems

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## TYPICAL APPLICATION



## ORDERING INFORMATION

| Part Number* | Package | Top Marking |
|--------------|---------|-------------|
| MP6411GS     | SOIC-8  | See Below   |
| MP6411GS-33  | SOIC-8  |             |

\* For Tape & Reel, add suffix -Z (e.g. MP6411GS-Z);

### TOP MARKING (MP6411GS)

**MP6411**  
**LLLLLLLL**  
**MPSYWW**

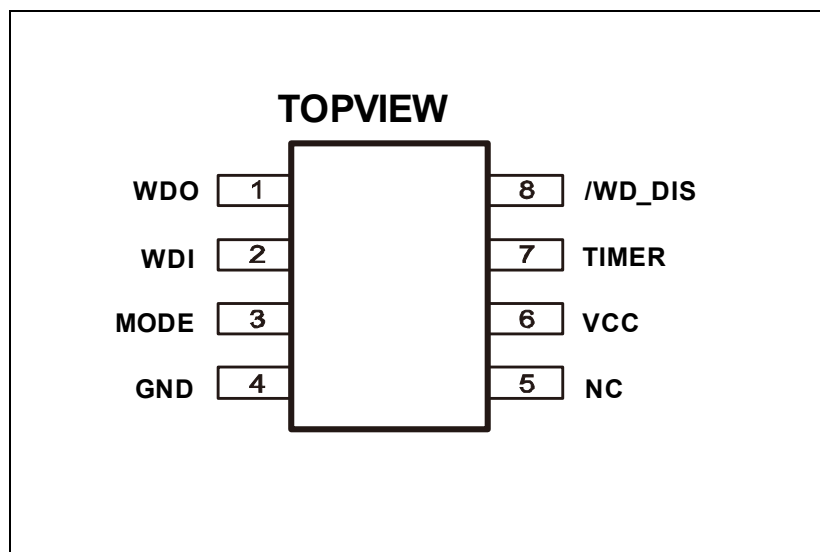
MP6411: Product code of MP6411GS  
LLLLLLLL: Lot number  
MPS: MPS prefix  
Y: Year code  
WW: Week code

### TOP MARKING (MP6411GS-33)

**M6411-33**  
**LLLLLLLL**  
**MPSYWW**

M6411-33: Product code of MP6411GS-33  
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 ( $T_A = +25^\circ\text{C}$ ) <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)  
 MP6411 .....5V  
 MP6411-33 .....3.3V  
 Operating junction temp. ( $T_J$ )..... -40°C to 125°C

**Thermal Resistance** <sup>(3)</sup>       $\theta_{JA}$        $\theta_{JC}$   
 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  $T_J$  (MAX), the junction-to-ambient thermal resistance  $\theta_{JA}$ , and the ambient temperature  $T_A$ . The maximum allowable continuous power dissipation at any ambient temperature is calculated by  $P_D$  (MAX) =  $(T_J$  (MAX)- $T_A$ )/ $\theta_{JA}$ . 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 MP6411, VCC = 3.3V for MP6411-33, T<sub>J</sub> = +25°C, unless otherwise noted.

| Parameter                                              | Symbol                | Condition                                | Min  | Typ  | Max  | Units |
|--------------------------------------------------------|-----------------------|------------------------------------------|------|------|------|-------|
| Power Supply                                           |                       |                                          |      |      |      |       |
| Timer voltage                                          |                       | R <sub>TIMER</sub> = 51k                 |      | 0.3  |      | V     |
| Quiescent current                                      | I <sub>Q</sub>        | MP6411, R <sub>TIMER</sub> = 100k        |      | 16   | 19   | μA    |
|                                                        |                       | MP6411-33, R <sub>TIMER</sub> = 100k     |      | 10   | 14   |       |
|                                                        |                       | MP6411, R <sub>TIMER</sub> = 51k         |      | 25   | 32   |       |
|                                                        |                       | MP6411-33, R <sub>TIMER</sub> = 51k      |      | 14   | 18   |       |
| Power on reset threshold                               | V <sub>POR-HIGH</sub> | MP6411, WDO goes high with rising VCC    | 4.4  | 4.6  | 4.8  | V     |
|                                                        |                       | MP6411-33, WDO goes high with rising VCC | 2.9  | 3    | 3.1  |       |
|                                                        | V <sub>POR-LOW</sub>  | MP6411, WDO goes low with falling VCC    | 4.3  | 4.5  | 4.7  |       |
|                                                        |                       | MP6411-33, WDO goes low with falling VCC | 2.8  | 2.9  | 3    |       |
| Timing                                                 |                       |                                          |      |      |      |       |
| 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>(5)</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    |
| Input and Output                                       |                       |                                          |      |      |      |       |
| WDI logic high                                         |                       | MP6411                                   | 3.2  |      |      | V     |
|                                                        |                       | MP6411-33                                | 2.1  |      |      |       |
| WDI logic low                                          |                       | MP6411                                   |      |      | 0.8  | V     |
|                                                        |                       | MP6411-33                                |      |      | 0.6  |       |
| MODE logic high                                        |                       | MP6411                                   | 3.2  |      |      | V     |
|                                                        |                       | MP6411-33                                | 2.1  |      |      |       |
| MODE logic low                                         |                       | MP6411                                   |      |      | 0.8  | V     |
|                                                        |                       | MP6411-33                                |      |      | 0.6  |       |

# ELECTRICAL CHARACTERISTICS (continued)

VCC = 5V for MP6411, VCC = 3.3V for MP6411-33, T<sub>J</sub> = +25°C, unless otherwise noted.

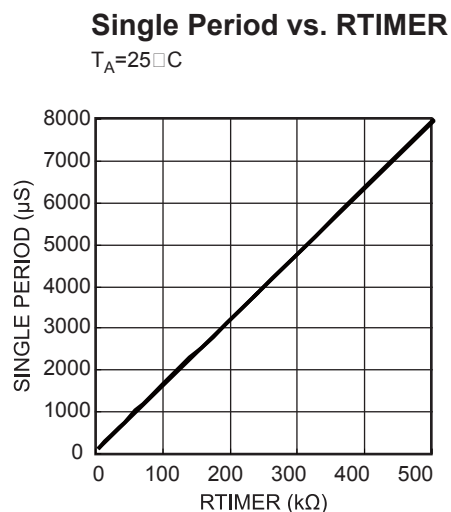
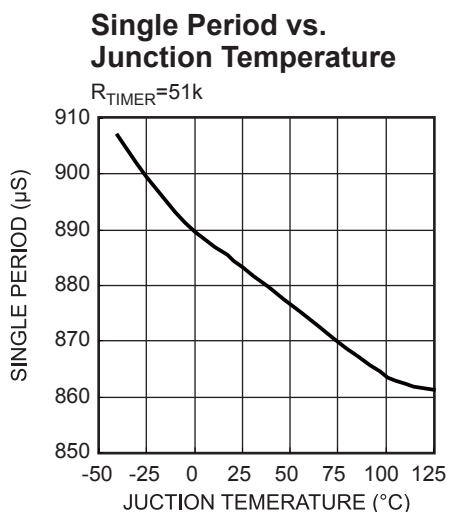
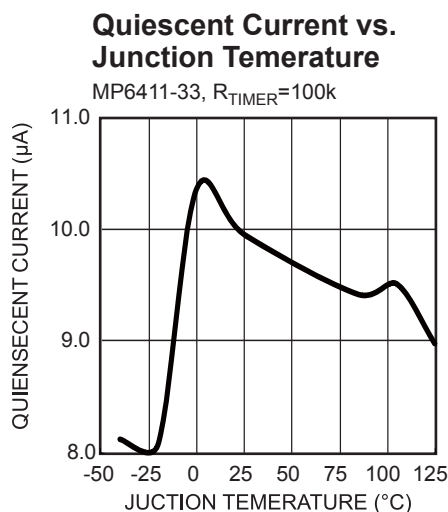
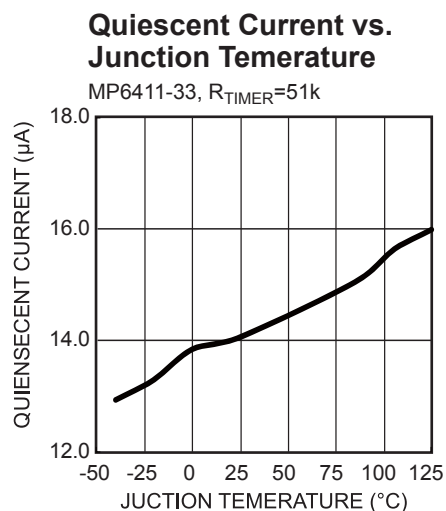
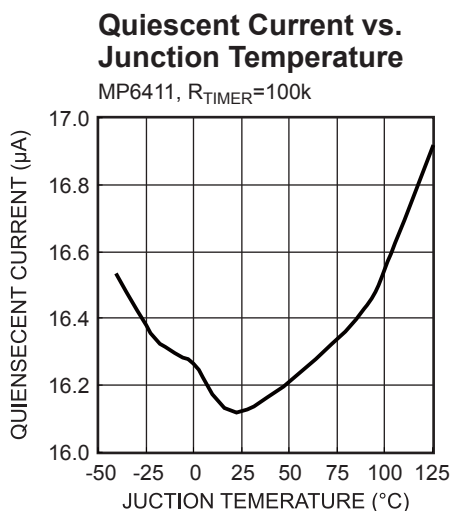
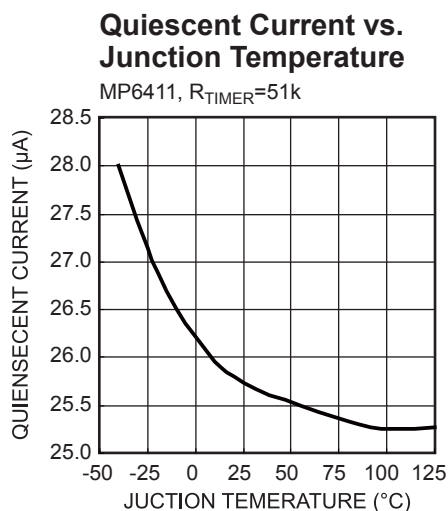
| Parameter             | Symbol | Condition                                           | Min     | Typ | Max | Units |
|-----------------------|--------|-----------------------------------------------------|---------|-----|-----|-------|
| MODE input Current    |        | MP6411, MODE = 5V                                   |         | 0.1 | 1   | μA    |
|                       |        | MP6411-33, MODE = 3.3V                              |         |     |     |       |
|                       |        | MP6411, MODE = 0V                                   |         | 5   | 8   |       |
|                       |        | MP6411-33, MODE = 0V                                |         | 3.3 | 6   |       |
| /WD_DIS logic high    |        | MP6411                                              | 3.2     |     |     | V     |
|                       |        | MP6411-33                                           | 2.1     |     |     |       |
| /WD_DIS logic low     |        | MP6411                                              |         |     | 0.8 | V     |
|                       |        | MP6411-33                                           |         |     | 0.6 |       |
| /WD_DIS input Current |        | MP6411, WD_DIS = 5V                                 |         | 0.1 | 1   | μA    |
|                       |        | MP6411-33, WD_DIS = 3.3V                            |         |     |     |       |
|                       |        | MP6411, WD_DIS = 0V                                 |         | 5   | 8   | μA    |
|                       |        | MP6411-33, WD_DIS = 0V                              |         | 3.3 | 6   |       |
| WDO high              |        | MP6411,<br>VCC = 5V, I <sub>WDO</sub> = 1mA         | VCC-0.2 |     |     | V     |
|                       |        | MP6411-33,<br>VCC=3.3V, R <sub>Pull-Up</sub> =100KΩ | 3.29    |     |     |       |
| WDO low               |        | MP6411,<br>VCC = 5V, I <sub>WDO</sub> = 1mA         |         |     | 0.2 | V     |
|                       |        | MP6411,<br>VCC = 1V, I <sub>WDO</sub> = 300μA       |         |     | 0.1 |       |
|                       |        | MP6411-33,<br>Sink 1mA Current                      |         |     | 0.1 |       |

## Notes:

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

# TYPICAL CHARACTERISTICS

VCC=5V for MP6411, VCC=3.3V for MP6411-33, unless otherwise noted.



## PIN FUNCTION

| Pin # | Name    | Description                                                                                                                                                                                                                                                                                                                   |
|-------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1     | WDO     | Watchdog output. WDO outputs a reset signal to the MCU.<br>MP6411 WDO is the output of a inverter, it is not must to connect WDO to VCC or another voltage source through a resistor.<br>MP6411-33 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

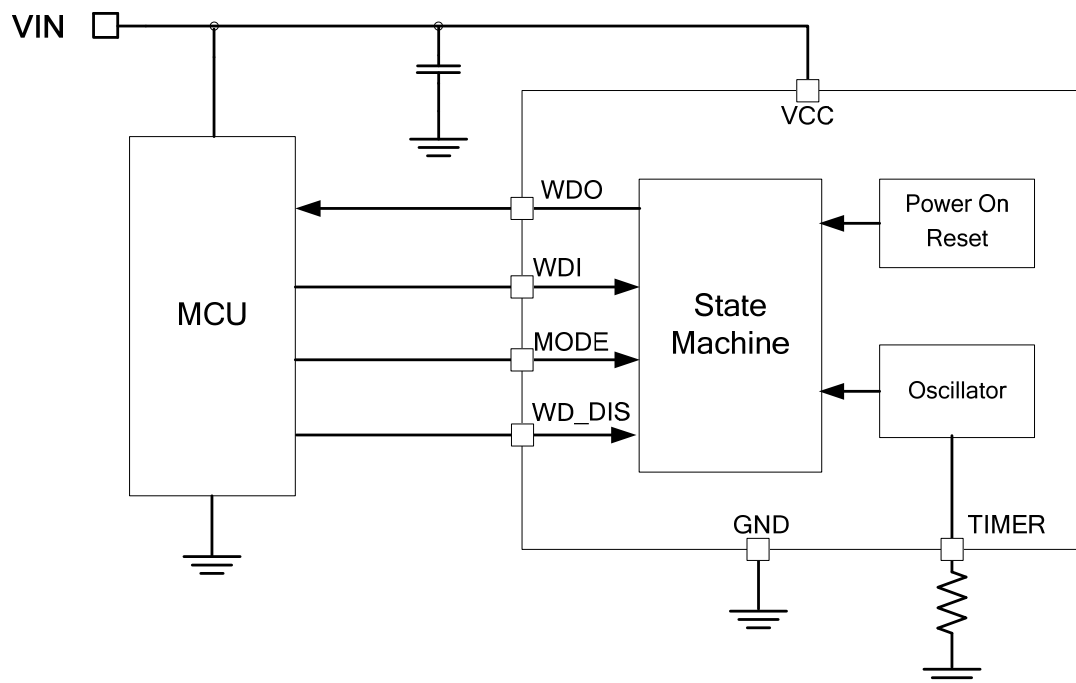
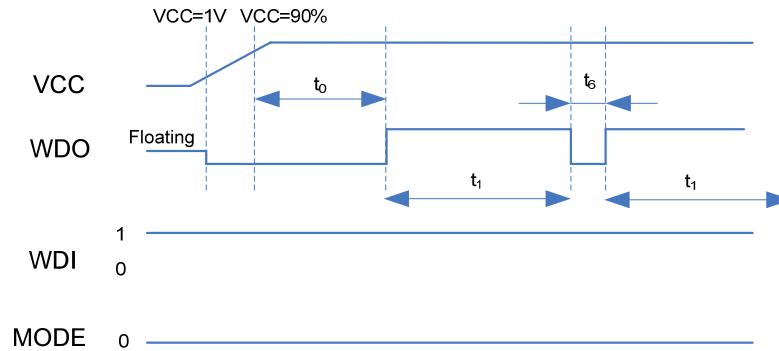


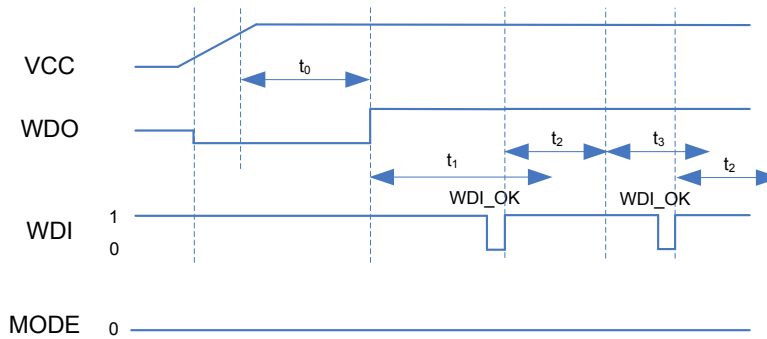
Figure 1: Functional Block Diagram

# TIMING DIAGRAM

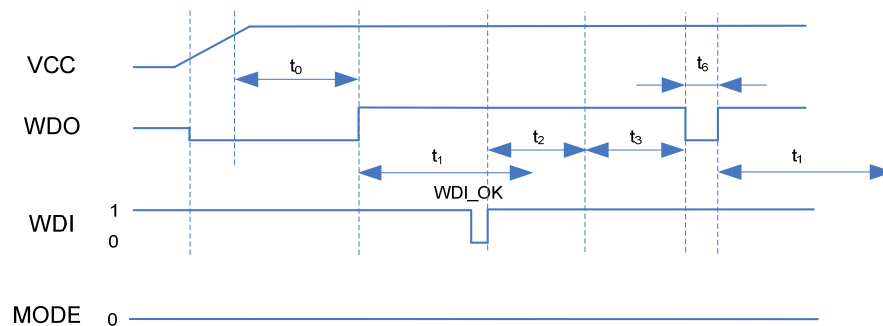
## Power-on reset and no sync signal



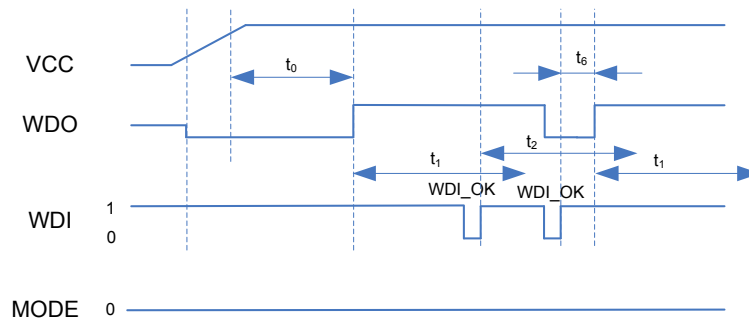
## Synchronized by WDI and triggered in open window (MODE=0, short window mode)



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

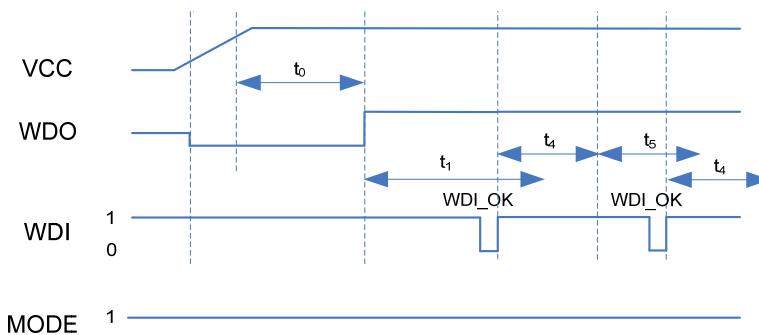


**Synchronized by WDI and triggered in closed window (MODE=0, short window mode)**

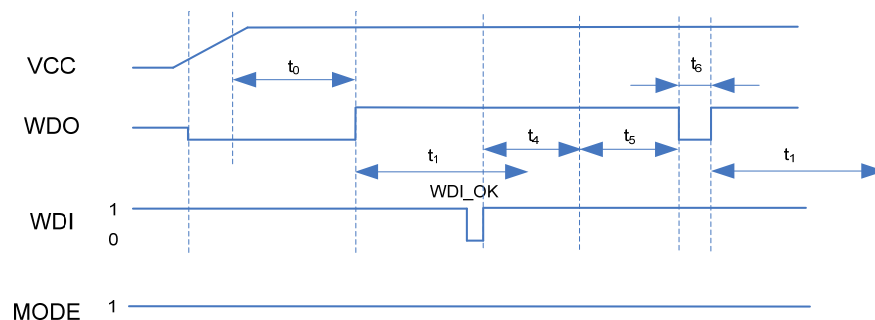


Note: When the WDI\_OK rising edge that comes at WDO is low, the  $t_6$  timer will be reset. Therefore, in the situation above, the WDO reset signal maintains a  $t_6 + \text{WDI\_OK}$  time.

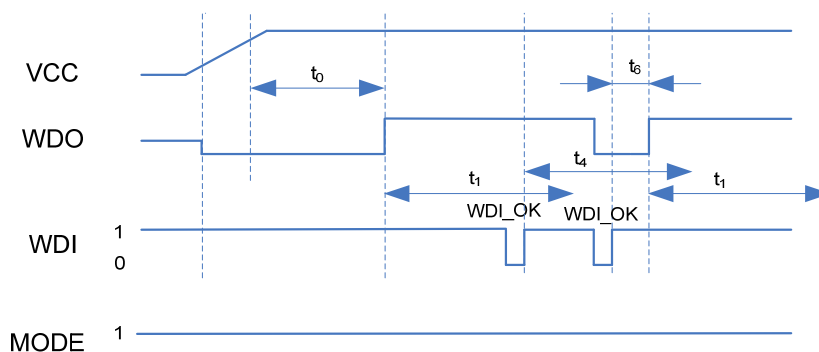
**Synchronized by WDI and triggered in open window (MODE=1, long window mode)**



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

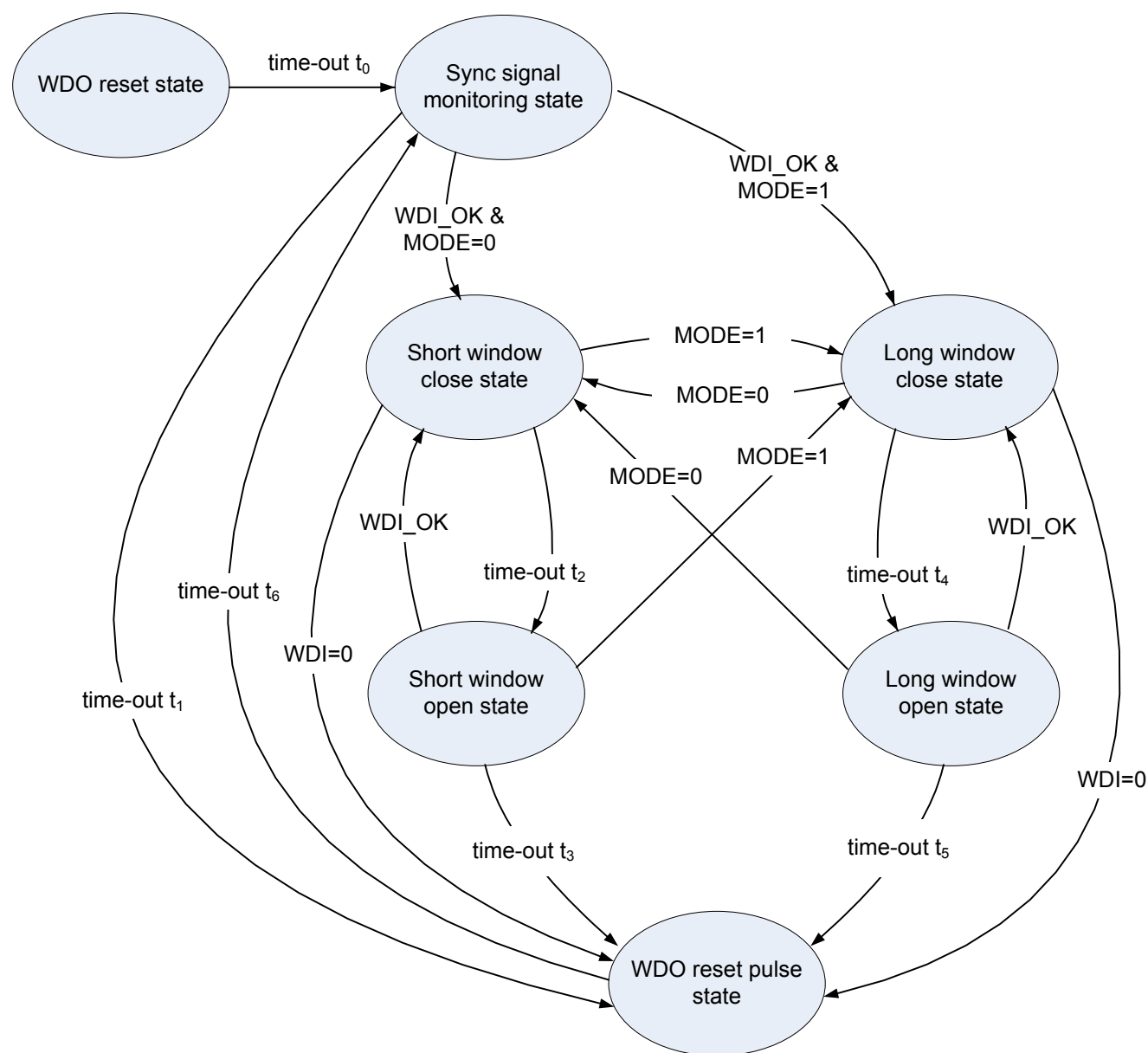


Synchronized by WDI and triggered in closed window (MODE=1, long window mode)



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 MP6411 normal operation; while VCC= 3.3V±10% is recommended for MP6411-33 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 (μs):

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

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

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

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

### 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 10μs 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

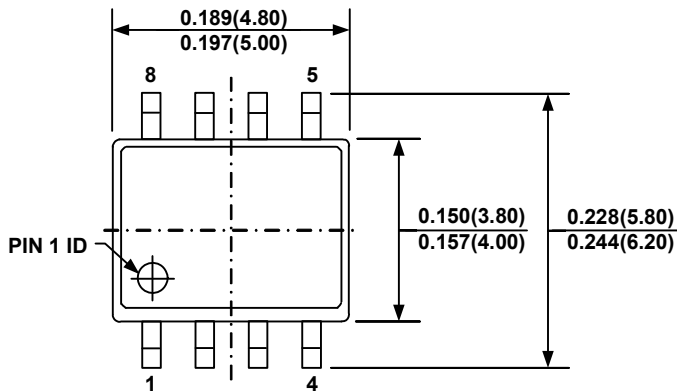
Pull /WD\_DIS low to disable the watchdog; pull it high to enable the watchdog. /WD\_DIS has a weak internal pull-up, so the watchdog is enabled if /WD\_DIS is left open.

### WDI Error

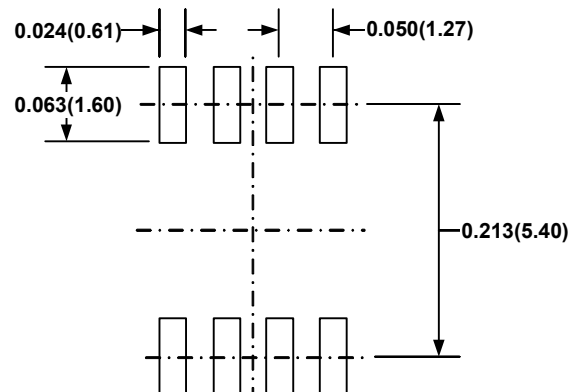
If a WDI signal remains at a low level for longer than the maximum WDI\_OK pulse width, it is regarded as an error. When this error occurs, WDO is pulled down until WDI returns to a high level.

# PACKAGE INFORMATION

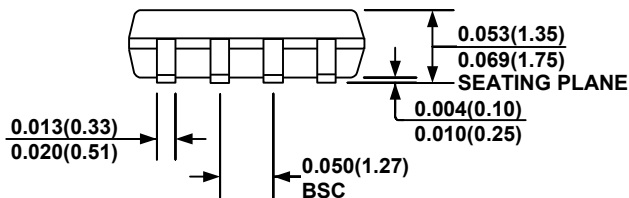
## SOIC-8



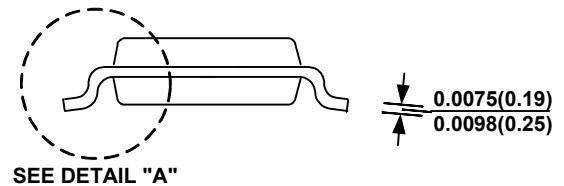
**TOP VIEW**



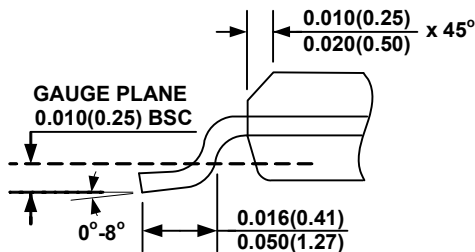
**RECOMMENDED LAND PATTERN**



**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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