

## Digital Window Watchdog Timer

### Description

The digital window watchdog timer, U5020M, is a CMOS integrated circuit. In application where safety is critical, it is especially important to monitor the microcontroller. Normal microcontroller operation is indicated by a cyclically transmitted trigger signal, which is received by a window watchdog timer within a defined time window. A missing or a wrong trigger signal makes the watchdog

timer reset the microcontroller. The IC is tailored for microcontrollers which can work in both full-power and sleep mode. With an additional voltage monitoring (power-on reset and supply voltage drop reset) U5020M offers a complete monitoring solution for microsystems in automotive and industrial applications.

### Features

- Low current consumption:  $I_{DD} < 100 \mu A$
- RC-oscillator
- Internal reset during power-up and supply voltage drops (POR)
- “Short” trigger window for active mode  
“long” trigger window for sleep mode
- Cyclical wake-up of microcontroller in sleep mode
- Trigger input
- Six wake-up inputs
- Reset output
- Enable output

### Ordering Information

Extended Type Number	Package	Remarks
U5020M-FP	SO16	

### Block Diagram

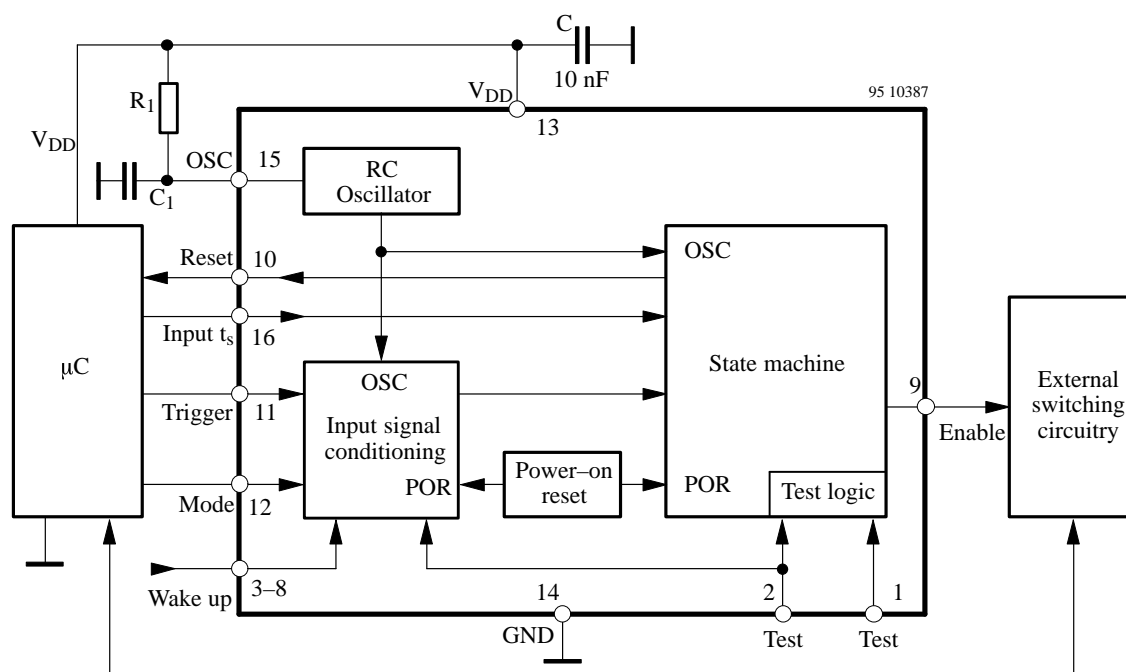


Figure 1. Block diagram with external circuit

## Pin Description

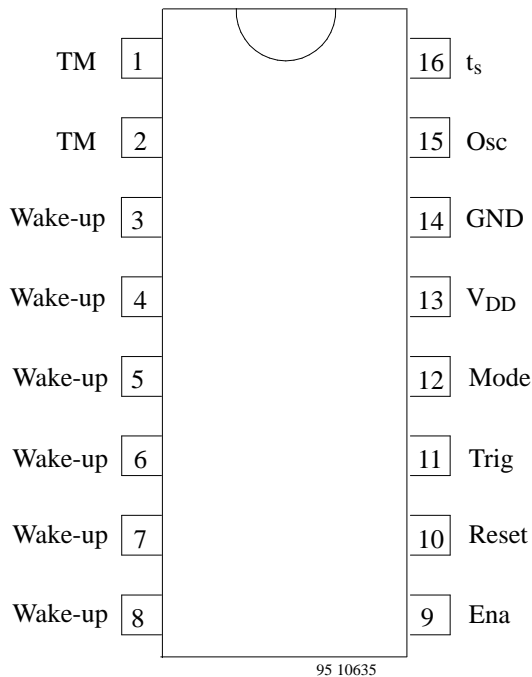


Figure 2. Pin connections

Pin	Symbol	Function
1	TM	Test must not be connected
2	TM	Test must be connected to GND
3 to 8	Wake-up	Wake-up inputs (pull-down resistor) There are six digitally debounced wake-up inputs. During the long trigger mode each signal slope at the inputs initiates a reset pulse at Pin 10.
9	Ena	Enable output (push-pull) It is used for the control of peripheral components. It is activated after the processor triggers three times correctly.
10	Reset	Reset output (open drain) Resets the processor in the case of a trigger error or if a wake-up pulse occurs during the long watchdog period.
11	Trig	Trigger input (pull-up resistor) It is connected to the microprocessor's trigger signal.
12	Mode	Mode input (pull-up resistor) The processor's mode signal initiates the switchover between the long and the short watchdog time.
13	V <sub>DD</sub>	Supply voltage
14	GND	Ground, reference voltage
15	Osc	RC oscillator
16	t <sub>s</sub>	Time switch input Programming pin to select different time durations for the long watchdog time.

## Functional Description

### Supply, Pin 13

The U5020M requires a stabilized supply voltage  $V_{DD} = 5\text{ V} \pm 5\%$  to comply with its electrical characteristic.

An external buffer capacitor of  $C = 10\text{ nF}$  may be connected between Pin 13 and GND.

### RC-Oscillator, Pin 15

The clock frequency,  $f$ , can be adjusted with the components  $R_1$  and  $C_1$  according to the formula:

$$f = \frac{1}{t}$$

where  $t = 1.35 + 1.57 R_1 (C_1 + 0.01)$

$R_1$  in  $k\Omega$ ,  $C_1$  in  $nF$  and  $t$  in  $\mu s$

The clock frequency determines all time periods of the logic part as shown in the last section of the data sheet (timing). With an appropriate selection of components, the clock frequency,  $f$ , is nearly independent of the supply voltage as shown in figure 3. Frequency tolerance  $\Delta f_{\max} = 10\%$  with  $R_1 \pm 1\%$ ,  $C_1 \pm 5\%$ .

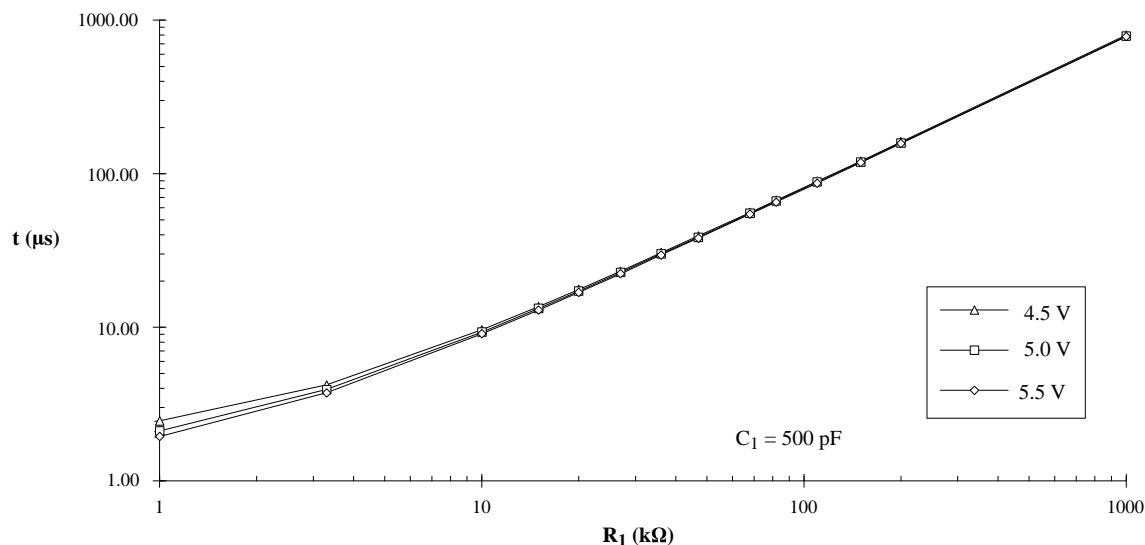


Figure 3. Period  $t$  vs.  $R_1$ , @  $C_1 = 500$  pF

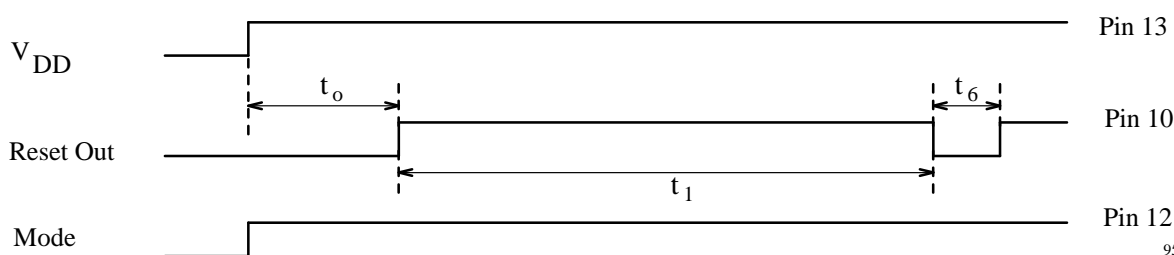


Figure 4. Power-up reset and mode switchover

### Supply Voltage Monitoring, Pin 10

The integrated power-on reset (POR) circuitry sets the internal logic to a defined basic status and generates a reset pulse at the reset output, Pin 10, during ramp-up of the supply voltage and in the case of voltage drops of the supply. A hysteresis in the POR threshold prevents the circuit from oscillating. During ramp-up of the supply voltage the reset output stays active for time,  $t_0$ , in order to bring the microcontroller in its defined reset status (see figure 4). Pin 10 has an open-drain output.

### Switch-over Mode Time, Pin 12

The switch-over mode time enables the synchronous operation of micro and watchdog. After the power-up reset time the watchdog has to be switched to its monitoring mode by the micro with a “low” signal transmitted to the mode pin (Pin 12) within the time out period,  $t_1$ . If the low signal does not occur within time,  $t_1$ , (see figure 4) the watchdog generates a reset pulse,  $t_6$ ,

and the time,  $t_1$ , starts again. Micro and watchdog are synchronized with the switchover mode time,  $t_1$ , each time a reset pulse is generated.

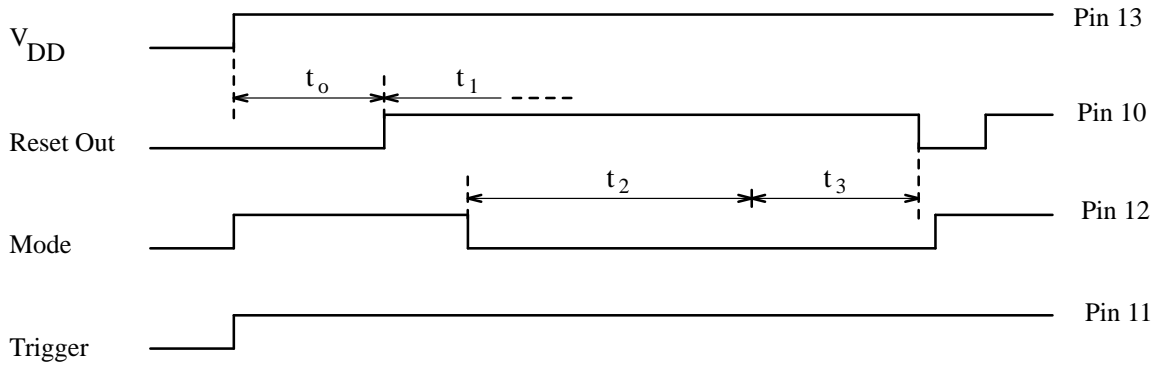
### Microcontroller in Active Mode

#### Monitoring with the “Short” Trigger Window

After the switch-over mode the watchdog works in the short watchdog mode and expects a trigger pulse from the microcontroller within the defined time window,  $t_3$ , (enable time). The watchdog generates a reset pulse which resets the microcontroller if

- the trigger pulse duration is too long,
- the trigger pulse is within the disable time,  $t_2$
- there is no trigger pulse

Figure 5 shows the pulse diagram with a missing trigger pulse.



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Figure 5. Pulse diagram with no trigger pulse during the short watchdog time

Figure 6 shows a correct trigger sequence. The positive edge of the trigger signal starts a new monitoring cycle with the disable time,  $t_2$ . To ensure a correct operation of the microcontroller the watchdog needs to be triggered three times correctly before it sets its enable output. This feature is used to activate or deactivate safety critical components, which have to be switched to a certain condition (emergency status) in the case of a microcontroller malfunction. As soon as there is an incorrect trigger sequence the enable signal is reset and it takes again a three correct trigger sequence before enable is reset.

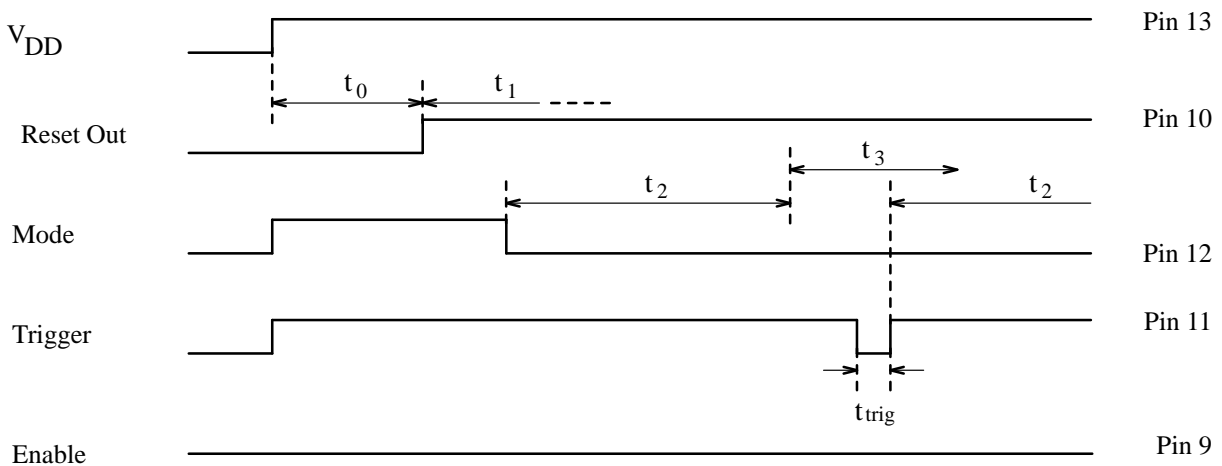
### Microcontroller in Sleep Mode

### Monitoring with the “Long” Trigger Window

The long watchdog mode allows cyclical wake up of the

micro during the sleep mode. Like in the short watchdog mode there is a disable time,  $t_4$ , and an enable time,  $t_5$ , in which a trigger signal is accepted. The watchdog can be switched from the short trigger window to the long trigger window with a “high” potential at the mode pin (Pin 12). In contrast to the short watchdog mode the time periods are now much longer and the enable output remains inactive that other components can be switched off to effect a further decrease in current consumption. As soon as a wake-up signal at one of the 6 wake up inputs (Pins 3 to 8) is detected, the long watchdog mode ends, a reset pulse wakes-up the sleeping microcontroller and the normal monitoring cycle starts with the mode switch-over time.

With the help of a low or high potential at Pin 16 (time switch) the long watchdog time can be selected in two values.



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Figure 6. Pulse diagram of a correct trigger sequence during the short watchdog time

Figure 7 shows the switch-over from the short to the long watchdog mode. The wake up signal during the enable time,  $t_5$ , activates a reset pulse,  $t_6$ .

The watchdog can be switched back from the long to the short watchdog mode with a low potential at the mode pin (Pin 12).

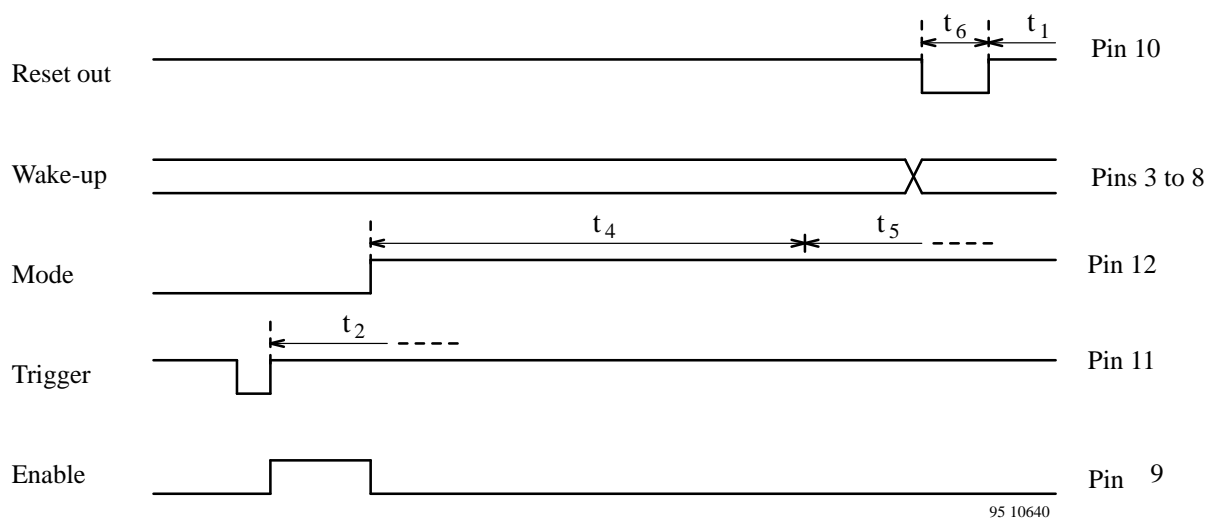


Figure 7. Pulse diagram of the long watchdog time

## Application Hint

In order to prevent the IC from an undesired reset output signal which may be caused by transients on the supply under certain conditions a pc board connection from Pin 2 to GND is strongly recommended.

## Absolute Maximum Ratings

Parameters	Symbol	Value	Unit
Supply voltage	$V_{DD}$	6.5	V
Output current	$I_{OUT}$	$\pm 2$	mA
Input voltage	$V_{IN}$	-0.5 V to $V_{DD} + 0.5$ V	V
Ambient temperature range	$T_{amb}$	-40 to +85	$^{\circ}C$
Storage temperature range	$T_{stg}$	-55 to +150	$^{\circ}C$

## Thermal Resistance

Parameters	Symbol	Value	Unit
Junction ambient SO16	$R_{thJA}$	160	K/W

## Electrical Characteristics

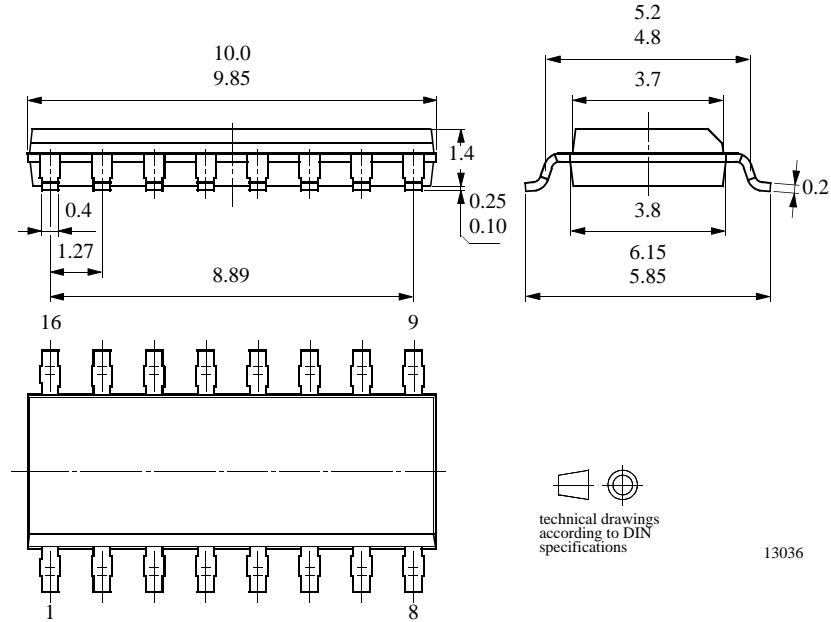
$V_{DD} = 5\text{ V}$ ;  $T_{amb} = 25\text{ °C}$ ; reference point is ground (Pin14); figure 4, unless otherwise specified

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit
Supply voltage	Pin 13	$V_{DD}$	4.5		5.5	V
Current consumption	$R_1 = 66\text{ k}\Omega$ Pin 13	$I_{DD}$			100	$\mu\text{A}$
Power-on reset	Logic functions Pin 13	$V_{DD}$	1			V
Power-on reset	Threshold Pin 13	$V_{POR}$		3.8		V
Power-on reset	Hysteresis Pin 13	$V_{hys}$		100		mV
<b>Inputs</b> Pins 3 to 8, 11, 12 and 16						
Upper threshold ("1")		$V_{IH}$	4.0			V
Lower threshold ("0")		$V_{IL}$			1.0	V
Input voltage range		$V_{IN}$	-0.4		$V_{DD} + 0.2$	V
Input current	Depending on pin	$I_{IN}$	-20		20	$\mu\text{A}$
<b>Output Pin 9</b>						
Max. output current		$I_{OUT}$	2			mA
Upper output voltage ("1")	$I_{OUT} = 1\text{ mA}$	$V_{OH}$	4.5			V
Lower output voltage ("0")	$I_{OUT} = -1\text{ mA}$	$V_{OL}$			0.5	V
<b>Output Pin 10</b>						
Max. output current		$I_{OUT}$	2			mA
Lower output voltage ("0")	$I_{OUT} = -1\text{ mA}$	$V_{OL}$			0.5	V
<b>Timing</b>						
Debounce period	Trig, Mode, Pins 11 and 12		3		4	cyc
Debounce period	Wake-up 1-6, Pins 3 to 8		96		128	cyc
Max. trigger pulse period				45		cyc
Power-up reset time		$t_0$		201		cyc
Time out period		$t_1$		1112		cyc
Short disable time		$t_2$		130		cyc
Short enable time		$t_3$		124		cyc
Long disable time	Input switch = low (0) Pin 16	$t_4$		71970		cyc
Long enable time	Input switch = low (0) Pin 16	$t_5$		30002		cyc
Long disable time	Input switch = high (1) Pin 16	$t_4$		1200		cyc
Long enable time	Input switch = high (1) Pin 16	$t_5$		400		cyc
Reset out time		$t_6$		40		cyc

**Package Information**

Package SO16

Dimensions in mm



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2. Regularly and continuously improve the performance of our products, processes, distribution and operating systems with respect to their impact on the health and safety of our employees and the public, as well as their impact on the environment.

It is particular concern to control or eliminate releases of those substances into the atmosphere which are known as ozone depleting substances (ODSs).

The Montreal Protocol (1987) and its London Amendments (1990) intend to severely restrict the use of ODSs and forbid their use within the next ten years. Various national and international initiatives are pressing for an earlier ban on these substances.

**TEMIC TELEFUNKEN microelectronic GmbH** semiconductor division has been able to use its policy of continuous improvements to eliminate the use of ODSs listed in the following documents.

1. Annex A, B and list of transitional substances of the Montreal Protocol and the London Amendments respectively
2. Class I and II ozone depleting substances in the Clean Air Act Amendments of 1990 by the Environmental Protection Agency (EPA) in the USA
3. Council Decision 88/540/EEC and 91/690/EEC Annex A, B and C (transitional substances) respectively.

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