

## Digital Window Watchdog Timer

### Description

The digital window watchdog timer, U5021M, is a CMOS integrated circuit. In applications 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 additional voltage monitoring (power-on reset and supply voltage drop reset), The U5021M 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
- Single wake-up input
- Reset output
- Enable output

### Ordering Information

Extended Type Number	Package	Remarks
U5021B-FP	SO8	

### Block Diagram

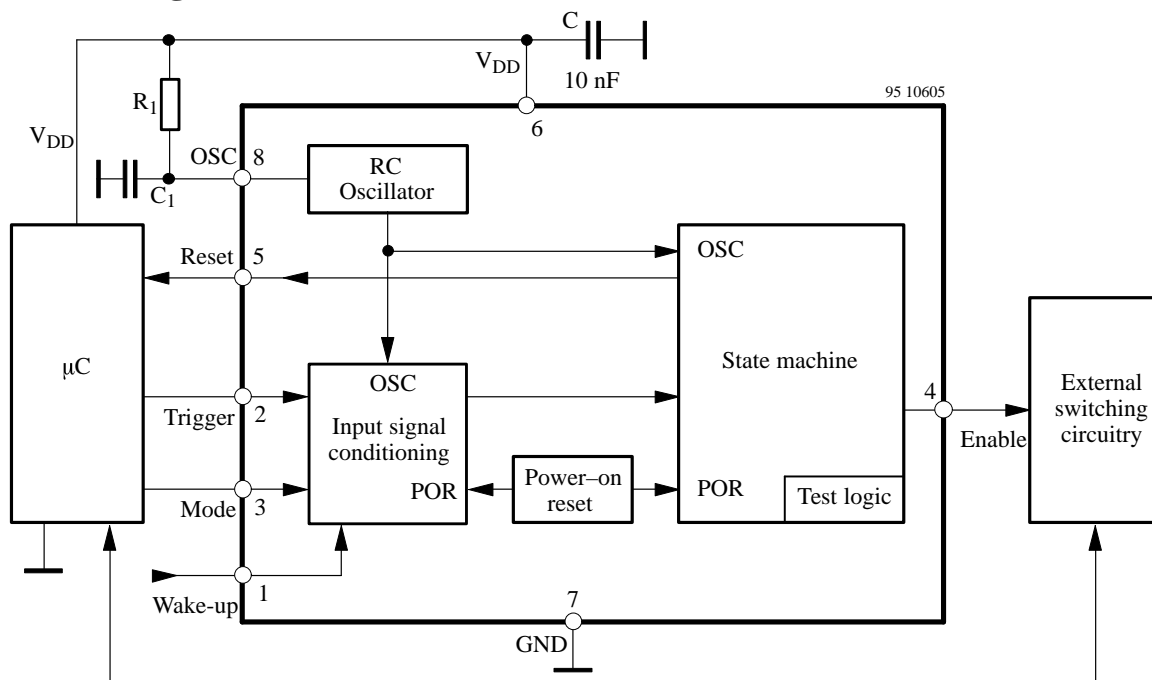


Figure 1. Block diagram with external circuit

## Pin Description

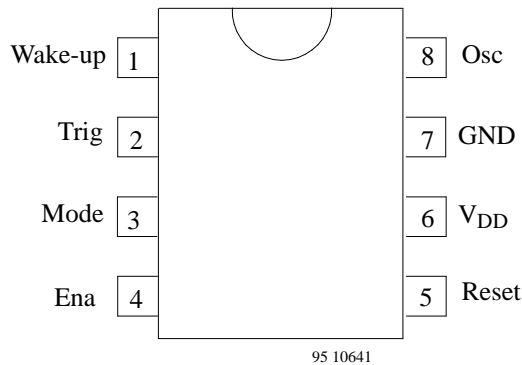


Figure 2. Pinning

Pin	Symbol	Function
1	Wake-up	Wake-up input (pull-down resistor) There is one digitally debounced wake-up input. During the long trigger mode each signal slope at the input initiates a reset pulse at Pin 5.
2	Trig	Trigger input (pull-up resistor) It is connected to the microprocessor's trigger signal.
3	Mode	Mode input (pull-up resistor) The processor's mode signal initiates the switchover between the long and the short watchdog time.
4	Ena	Enable output (push-pull) It is used for the control of peripheral components. It is activated after the processor triggers three times correctly.
5	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.
6	V <sub>DD</sub>	Supply voltage
7	GND	Ground, reference voltage
8	Osc	RC oscillator

## Functional Description

### Supply Voltage, Pin 6

The U5021M 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 6 and GND.

### RC-Oscillator, Pin 8

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

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

$$\text{where } t = 1.35 + 1.57 R_1 (C_1 + 0.01)$$

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

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  $R_1 \pm 1\%$ ,  $C_1 = \pm 5\%$ .

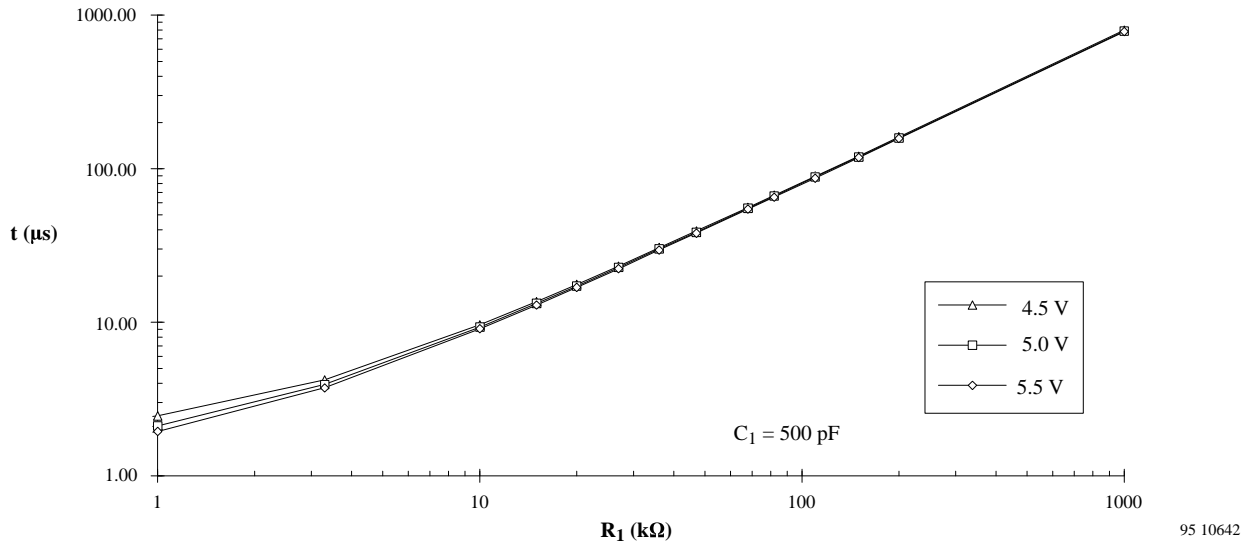


Figure 3. Period  $t$  vs.  $R_1$ , @  $C_1 = 500$  pF

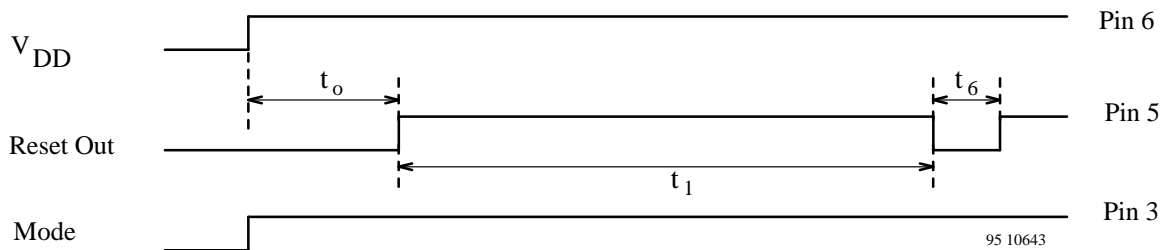


Figure 4. Power-on reset and mode switch-over

### Supply Voltage Monitoring, Pin 5

During ramp-up of the supply voltage and in the case of supply-voltage drops 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 5. 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,  $t_o$ , in order to bring the microcontroller into its defined reset status (see figure 4). Pin 5 has an open-drain output.

### Switch-over Mode Time, Pin 3

The switch-over mode time enables the synchronous operation of microcontroller and watchdog. After the power-on reset time, the watchdog has to be switched to its monitoring mode by the microcontroller with a “low” signal transmitted to the mode pin (Pin 3) 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. Microcontroller and watchdog are synchronized with the switch-over 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

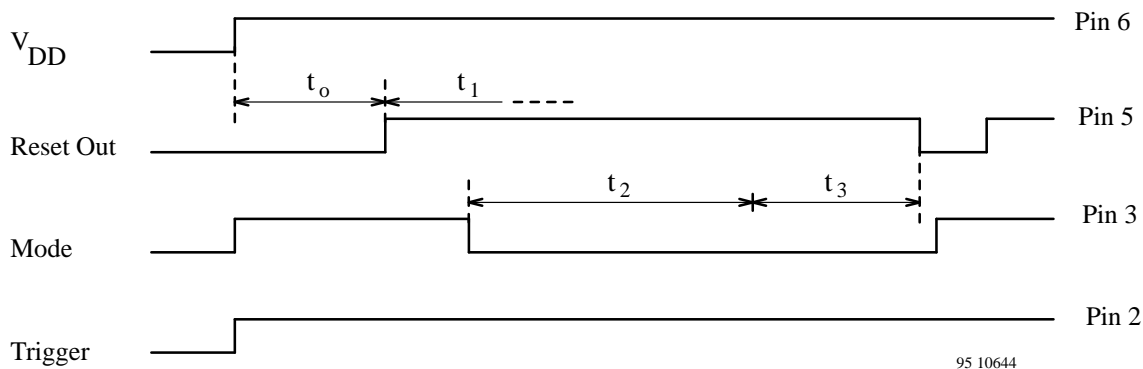


Figure 5. Pulse diagram with no trigger pulse during the short watchdog time

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

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 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 a three correct trigger sequence again before enable is reset

## Microcontroller in Sleep Mode

### Monitoring with the “Long” Trigger Window

The long watchdog mode allows cyclical wake up of the microcontroller during the sleep mode. As 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 3). In contrast to the short watchdog mode, the time periods are now much longer and the enable output remains inactive so that other components can be switched off to effect a further decrease in current consumption. As soon as a wake-up signal at the wake-up input (Pins 1) 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.

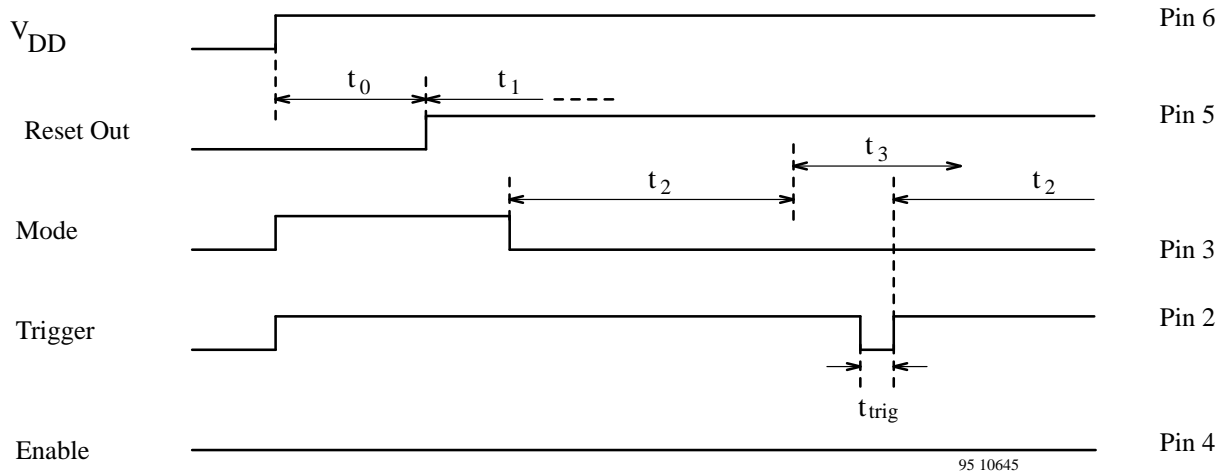


Figure 6. Pulse diagram of a correct trigger sequence during the short watchdog time

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 3).

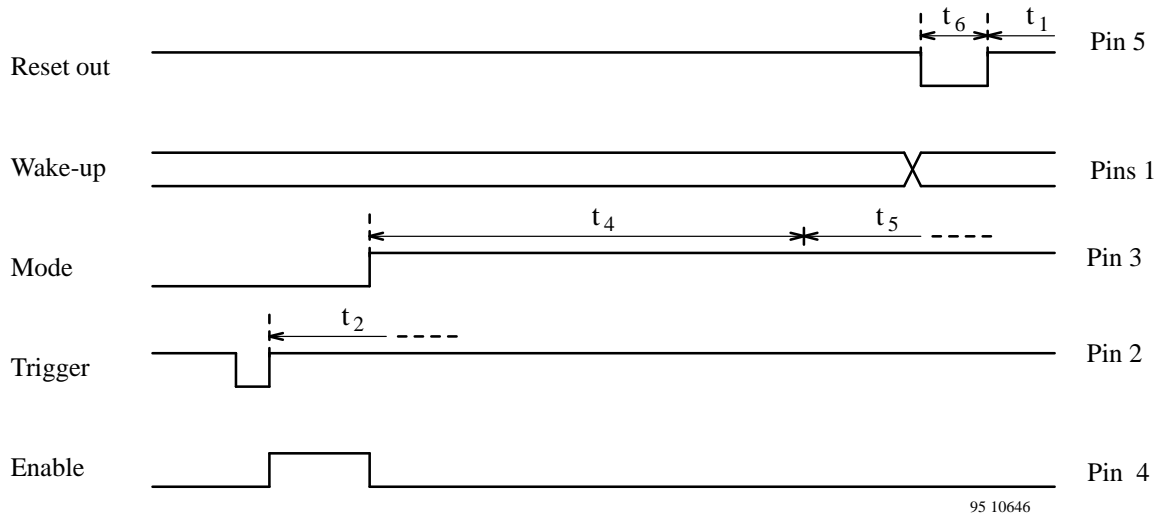


Figure 7. Pulse diagram of the long watchdog time

## 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 +125	°C
Storage temperature range	$T_{stg}$	-55 to +150	°C

## Thermal Resistance

Parameters	Symbol	Value	Unit
Junction ambient SO8	$R_{thJA}$	180	K/W

## Electrical Characteristics

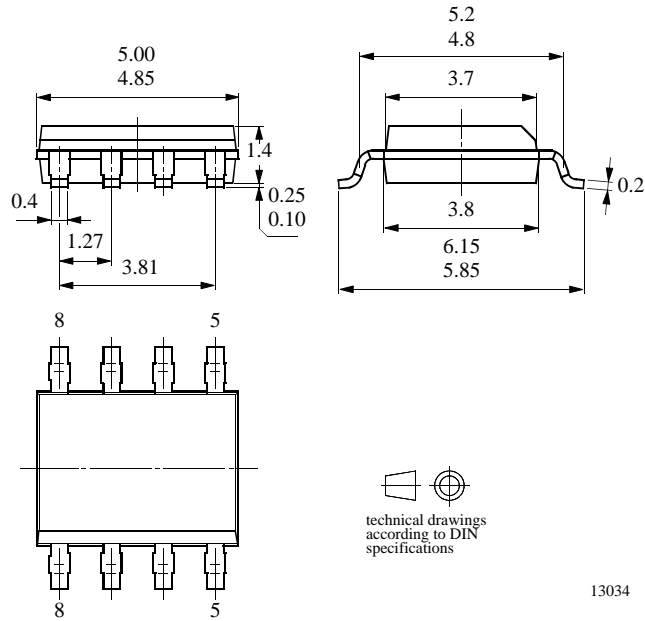
$V_{DD} = 5$  V;  $T_{amb} = 25$  °C; reference point is ground (Pin 7); figure 4, unless otherwise specified

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit
Supply voltage	Pin 6	$V_{DD}$	4.5		5.5	V
Current consumption	$R_1 = 66$ k $\Omega$ Pin 6	$I_{DD}$			100	$\mu$ A
Power-on reset	Logic functions Pin 6	$V_{DD}$	1			V
Power-on reset	Threshold Pin 6	$V_{POR}$		3.8		V
Power-on reset	Hysteresis Pin 6	$V_{hys}$		100		mV
<b>Inputs</b> Pins 1, 2, and 3						
Upper threshold ("1")		$V_{IH}$	4.0			V
Lower threshold ("0")		$V_{IL}$			1.0	V
Input voltage range		$V_{IN}$	-0.4		$V_{DD}$	V
Input current	Depending on pull-up/down	$I_{IN}$	-20		20	$\mu$ A
<b>Output Pin 4</b>						
Max. output current		$I_{OUT}$	2			mA
Upper output voltage ("1")	$I_{OUT} = 1$ mA	$V_{OH}$	4.5			V
Lower output voltage ("0")	$I_{OUT} = -1$ mA	$V_{OL}$			0.5	V
<b>Output Pin 5</b>						
Max. output current		$I_{OUT}$	2			mA
Lower output voltage ("0")	$I_{OUT} = -1$ mA	$V_{OL}$			0.5	V
<b>Timing</b>						
Debounce period	Trig, Mode, Pins 2 and 3		3		4	cyc
Debounce period	Wake-up, Pin 1		96		128	cyc
Max. trigger pulse period				45		cyc
Power-up reset time		$t_0$		201		cyc
Time out period		$t_1$		1112		cyc
Enable time	Short	$t_3$		124		cyc
	Long	$t_5$		30002		cyc
Disable time	Short	$t_2$		130		cyc
	Long	$t_4$		71970		cyc
Reset out time		$t_6$		40		cyc

**Package Information**

Package SO8

Dimensions in mm



## Ozone Depleting Substances Policy Statement

It is the policy of **TEMIC TELEFUNKEN microelectronic GmbH** to

1. Meet all present and future national and international statutory requirements.
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.

**TEMIC** can certify that our semiconductors are not manufactured with ozone depleting substances and do not contain such substances.

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