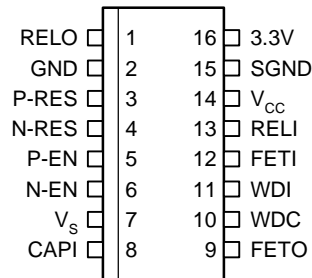




## Pin Configuration

Figure 2. Pinning SO16



## Pin Description

Pin	Symbol	Description	Function	Type
1	RELO	Open-collector output driver	Fail-safe relay driver	Driver on: L
2	GND	Supply	General ground	
3	P-RES	Digital output	Positive reset signal	Reset: H
4	N-RES	Digital output	Negative reset signal	Reset: L
5	P-EN	Digital output	Positive enable signal	Enable: H
6	N-EN	Digital output	Negative enable signal	Enable: L
7	V <sub>S</sub>	Battery supply	Voltage for charge pump	
8	CAPI	Analog input	Input bootstrap capacitor	
9	FETO	Power FET output	High voltage for N-channel FET	
10	WDC	Analog input	External RC for watchdog timer	
11	WDI	Digital input	Watchdog trigger signal	Pulse sequence
12	FETI	Digital input	Activation of power FET	FET on: H
13	RELI	Digital input	Activation of relay driver	Driver on: H
14	V <sub>CC</sub>	Supply	5-V supply	
15	SGND	Supply	Sense ground, reference for V <sub>CC</sub> and 3.3 V	
16	3.3V	Analog input	3.3-V supply	

## Fail-safe Functions

A fail-safe IC has to maintain its monitoring function even if there is a fault condition at one of the pins (e.g., short circuit), ensuring that a microcontroller system does not reach a “critical status”. A critical status means, for example, if the system is not able to switch off the relay or disable the power MOSFET, or if the system is not able to provide a signal to the microcontroller via ENABLE- and RESET-outputs in the case of a fault condition. The U6813B is designed to handle those fault conditions according to Table 1 for a maximum of system safety.

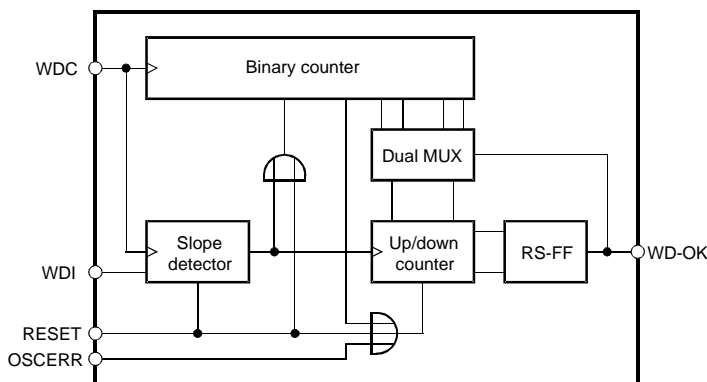
Table 1. Truth Table

VCC	3.3V	WDI	RELI	FETI	RELO	FETO	N-RES	P-RES	P-EN <sup>(2)</sup>	N-EN <sup>(3)</sup>
ok	ok	ok	H	x	on	x	H	L	H	L
ok	ok	ok	L <sup>(1)</sup>	x	off	x	H	L	H	L
ok	ok	ok	x	H	x	on	H	L	H	L
ok	ok	ok	x	L <sup>(1)</sup>	x	off	H	L	H	L
ok	ok	wrong	x	x	off	off	H	L	L	H
x	wrong	x	x	x	off	off	L	H	L	H
wrong	x	x	x	x	off	off	L	H	L	H

Notes: 1. default state at open input  
 2. P-EN disable: low  
 3. N-EN disable: high

## Watchdog Description

Figure 3. Watchdog Block Diagram



The microcontroller is monitored by a digital window watchdog which accepts an incoming trigger signal of a constant frequency for correct operation. The frequency of the trigger signal can be varied in a broad range as the watchdog's time window is determined by external R/C components. The following description refers to the watchdog timing diagram with tolerances (see Figure 4).

### WDI Input (Pin 11)

The microcontroller has to provide a trigger signal with the frequency  $f_{WDI}$  which is fed to the WDI input. A positive edge of  $f_{WDI}$  detected by a slope detector resets the binary counter and clocks the up/down counter. The latter one counts only from 0 to 3 or reverse. Each correct trigger increments the up/down counter by 1, each wrong trigger decrements it by 1. As soon as the counter reaches status 3, the RS flip-flop is set; see Figure 5 (Watchdog state diagram). A missing incoming trigger signal is detected after 250 clocks of the internal watchdog frequency  $f_{RC}$  (see WD\_OK output) and resets the up/down counter directly.

### WDC Input (Pin 10)

It is to be equipped by external R/C components. By means of an external R/C circuitry, the IC generates a time base (frequency  $f_{WDC}$ ) independent from the microcontroller. The watchdog's time window refers to a frequency of  $f_{WDC} = 100 \times f_{WDI}$ .

## OSCERR Input

A smart watchdog has to ensure that internal problems with its own time base are detected and do not lead to an undesired status of the complete system. If the RC oscillator stops oscillating, a signal is fed to the OSCERR input after a timeout delay. It resets the up/down counter and disables the WD-OK output. Without this reset function, the watchdog would freeze its current status when  $f_{RC}$  stops.

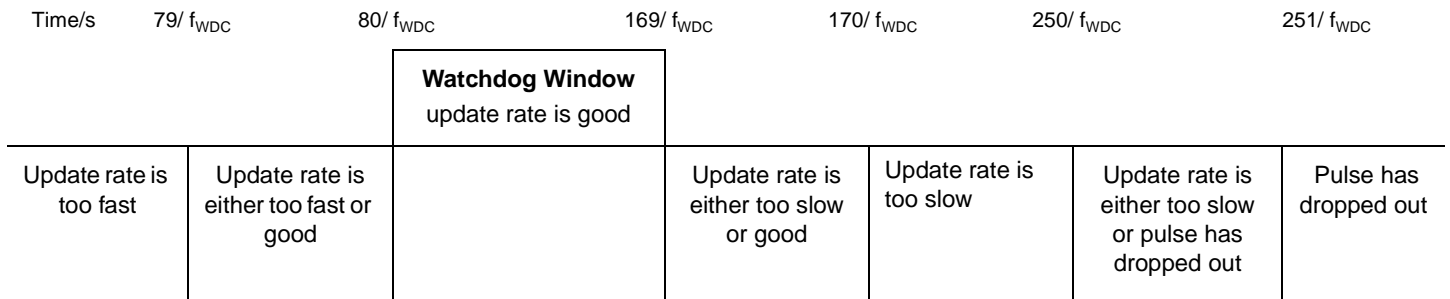
## RESET Input

During power-on and under/overvoltage detection, a reset signal is fed to this pin. It resets the watchdog timer and sets the initial state.

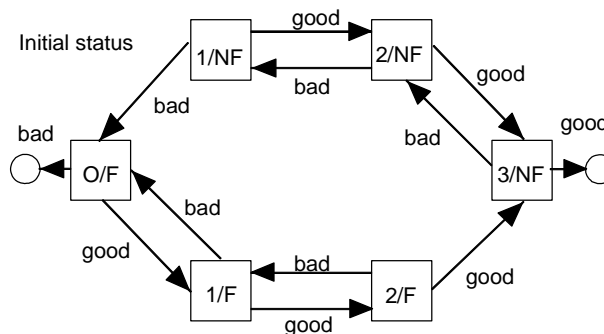
## WD-OK Output

After the up/down counter has reached to status 3 (see Figure 5, Watchdog State Diagram), the RS flip-flop is set and the WD-OK output becomes logic "1". As WD-OK is directly connected to the enable pins, the open-collector output P-EN provides also logic "1" while a logic "0" is available at N-EN output. If on the other hand the up/down counter is decremented to "0", the RS flip-flop is reset, the WD-OK output and the P-EN output are logic "0" and N-EN output is logic "1". The WD-OK output also controls a dual MUX stage which shifts the time window by one clock after a successful trigger, thus forming a hysteresis to provide stable conditions for the evaluation of the trigger signal "good or false". The WD-OK signal is also reset in case the watchdog counter is not reset after 250 clocks (missing trigger signal).

**Figure 4.** Watchdog Timing Diagram with Tolerances



**Figure 5.** Watchdog State Diagram



## Explanation

In each block, the first character represents the state of the counter. The second notation indicates the fault status of the counter. A fault status is indicated by an "F" and a no-fault status is indicated by an "NF". When the watchdog is powered up initially, the counter starts at the 0/F block (initial state). "Good" indicates that a pulse has been received whose width resides within the timing window. "Bad" indicates that a pulse has been received whose width is either too short or too long.

## Watchdog Window Calculation

### Example with recommended values

$C_{osc} = 6.8 \text{ nF}$  (should be preferably 10%, NPO)

$R_{osc} = 36 \text{ k}\Omega$  (can be 5%,  $R_{osc} < 200 \text{ k}\Omega$  due to leakage current and humidity)

### RC oscillator

$$t_{WDC} \text{ (s)} = 10^{-3} [C_{osc} \text{ (nF)} [(0.00078 R_{osc} \text{ (k}\Omega) + 0.0005)]]$$

$$f_{WDC} \text{ (Hz)} = 1 / (t_{WDC})$$

### Watchdog WDI

$$f_{WDI} \text{ (Hz)} = 0.01 f_{WDC}$$

$$t_{WDC} = 200 \text{ }\mu\text{s} \rightarrow f_{WDC} = 5 \text{ kHz}$$

$$f_{WDI} = 50 \text{ Hz} \rightarrow t_{WDI} = 20 \text{ ms}$$

### WDI pulse width for fault detection after 3 pulses:

#### Upper watchdog window

$$\text{Minimum: } 169 / f_{WDC} = 33.8 \text{ ms} \rightarrow f_{WDC} / 169 = 29.55 \text{ Hz}$$

$$\text{Maximum: } 170 / f_{WDC} = 34 \text{ ms} \rightarrow f_{WDC} / 170 = 29.4 \text{ Hz}$$

#### Lower watchdog window

$$\text{Minimum: } 79 / f_{WDC} = 15.8 \text{ ms} \rightarrow f_{WDC} / 79 = 63.3 \text{ Hz}$$

$$\text{Maximum: } 80 / f_{WDC} = 16 \text{ ms} \rightarrow f_{WDC} / 80 = 62.5 \text{ Hz}$$

### WDI dropouts for immediate fault detection:

$$\text{Minimum: } 250 / f_{WDC} = 50.0 \text{ ms}$$

$$\text{Maximum: } 251 / f_{WDC} = 50.2 \text{ ms}$$

### Remarks to reset relay

The duration of the over- or undervoltage pulses determines the enable- and reset outputs. A pulse duration shorter than the debounce time has no effect on the outputs. A pulse longer than the debounce time results in the first reset delay. If a pulse appears during this delay, a second delay time is triggered. Therefore, the total reset delay time can be longer than specified in the data sheet.

## Absolute Maximum Ratings

Parameters	Symbol	Value	Unit
Supply voltage range	$V_S$	- 0.2 to +26	V
Power dissipation	$P_{tot}$	$V_S = 5\text{ V}; T_{amb} = -40^\circ\text{C}$	250
		$V_S = 5\text{ V}; T_{amb} = 125^\circ\text{C}$	150
Junction temperature	$T_j$	150	$^\circ\text{C}$
Ambient temperature range	$T_{amb}$	-40 to +125	$^\circ\text{C}$
Storage temperature range	$T_{stg}$	-55 to +155	$^\circ\text{C}$

## Thermal Resistance

Parameters	Symbol	Value	Unit
Junction ambient	$R_{thJA}$	110	K/W

## Electrical Characteristics

$V_{CC} = 5\text{ V}$ ,  $T_{amb} = -40\text{ to }+125^\circ\text{C}$ ; reference pin is GND or SGND (over- and under-voltage detection);  
 $f_{intern} = 200\text{ kHz } +50\%/-45\%$ ,  $f_{WDC} = 5\text{ kHz } \pm 10\%$ ;  $f_{WDI} = 50\text{ Hz}$ , bootstrap capacitor  $C_{Boot} = 47\text{ nF}$  at Pin CAPI

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
<b>1</b>	<b>Supply</b>								
1.1	Operation-voltage range		14	$V_{CC}$	4.5		5.5	V	D
1.2	Operation-voltage range of RESET outputs		14	$V_{CC}$	1.1		18.0	V	A
1.3	Current consumption	$V = 5.25\text{ V}$ , Relay on $T_{amb} = -40^\circ\text{C}$ $T_{amb} = +125^\circ\text{C}$	14	$I_{CC}$ $I_{CC}$			15 10	mA mA	A
<b>2</b>	<b>Digital Input WDI</b>								
2.1	Detection low		11	$V_{WDI}$	-0.2		$0.3 \times V_{CC}$	V	D
2.2	Detection high		11	$V_{WDI}$	$0.7 \times V_{CC}$		$V_{CC} + 0.2\text{ V}$	V	D
2.3	Internal pull-down resistor		11	$R_{INT11}$	10		40	$k\Omega$	A
2.4	Input current low	Input voltage = 0 V	11	$I_{WDI}$	-5		5	$\mu\text{A}$	A
2.5	Input current high	Input voltage = 5 V	11	$I_{WDI}$	100		550	$\mu\text{A}$	A
<b>3</b>	<b>Digital Input RELI</b>								
3.1	Detection low		13	$V_{RELI}$	-0.2		$0.3 \times V_{CC}$	V	D
3.2	Detection high		13	$V_{RELI}$	$0.7 \times V_{CC}$		$V_{CC} + 0.2\text{ V}$	V	D
3.3	Internal pull-down resistor		13	$R_{INT13}$	10		40	$k\Omega$	A
3.4	Input current low	Input voltage = 0 V	13	$I_{RELI}$	-5		5	$\mu\text{A}$	A

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

Note: 1. If  $V_S > 26\text{ V}$  the current has to be limited at 5 mA by an external resistor.

## Electrical Characteristics (Continued)

$V_{CC} = 5\text{ V}$ ,  $T_{amb} = -40\text{ to }+125^{\circ}\text{C}$ ; reference pin is GND or SGND (over- and under-voltage detection);  
 $f_{intern} = 200\text{ kHz }+50\%/-45\%$ ,  $f_{WDC} = 5\text{ kHz } \pm 10\%$ ;  $f_{WDI} = 50\text{ Hz}$ , bootstrap capacitor  $C_{Boot} = 47\text{ nF}$  at Pin CAPI

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
3.5	Input current high	Input voltage = 5 V	13	$I_{RELI}$	100		550	$\mu\text{A}$	A
<b>4</b>	<b>Digital Input FETI</b>								
4.1	Detection low		12	$V_{FETI}$	-0.2		$0.3 \times V_{CC}$	V	A
4.2	Detection high		12	$V_{FETI}$	$0.7 \times V_{CC}$		$V_{CC} + 0.2\text{ V}$	V	A
4.3	Internal pull-down resistor		12	$R_{INT12}$	10		40	$\text{k}\Omega$	A
4.4	Input current low	Input voltage = 0 V	12	$I_{FETI}$	-5		5	$\mu\text{A}$	A
4.5	Input current high	Input voltage = 5 V	12	$I_{FETI}$	100		550	$\mu\text{A}$	A
<b>5</b>	<b>Digital Output N-RES (Open Collector)</b>								
5.1	Saturation voltage low	$I_{reset} \leq 2.5\text{ mA}$	4	$V_{SAT4}$			0.5	V	A
5.2	Leakage current	at 5 V, high state	4	$I_{LEAK4}$			0.5	$\mu\text{A}$	A
5.3	Reset debounce time (switch to low)	Over- or undervoltage	4	$t_{DEB4}$	120	320	500	$\mu\text{s}$	A
5.4	Reset delay (switch back to high)	Over- or undervoltage	4	$t_{DEL4}$		50		ms	A
<b>6</b>	<b>Digital Output P-RES (Internal Pull-down Resistor)</b>								
6.1	Saturation voltage high	$I_{reset} \leq 0.3\text{ mA}$	3	$V_{SAT3}$	$V_{CC} - 0.5\text{ V}$		$V_{CC}$	V	A
6.2	Leakage current	at 0 V, low state	3	$I_{LEAK3}$			0.5	$\mu\text{A}$	A
6.3	Internal pull-down resistor	at 5 V	3	$R_{INT3}$	25		100	$\text{k}\Omega$	A
6.4	Reset debounce time (switch to low)	Over- or undervoltage	3	$t_{DEB3}$	120	320	500	$\mu\text{s}$	A
6.5	Reset delay (switch back to high)	Over- or undervoltage	3	$t_{DEL3}$		50		ms	A
<b>7</b>	<b>Digital Output N-EN (with Open Collector and Internal Pull-down Resistor)</b>								
7.1	Saturation voltage high	$I \leq 1\text{ mA}$	6	$V_{SAT6}$	$V_{CC} - 0.5\text{ V}$		$V_{CC}$	V	A
7.2	Leakage current	at 0 V, low state	6	$I_{LEAK6}$			0.5	$\mu\text{A}$	A
7.3	Internal pull-down resistor	at 5 V	6	$R_{INT6}$	25		100	$\text{k}\Omega$	A
7.4	Enable debounce time (switch to low)	Over- or undervoltage	6	$t_{DEB6}$	120	320	500	$\mu\text{s}$	A
7.5	Enable delay (switch back to high)	Over- or undervoltage	6	$t_{DEL6}$		85		ms	A

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

Note: 1. If  $V_S > 26\text{ V}$  the current has to be limited at 5 mA by an external resistor.

## Electrical Characteristics (Continued)

$V_{CC} = 5\text{ V}$ ,  $T_{amb} = -40\text{ to }+125^{\circ}\text{C}$ ; reference pin is GND or SGND (over- and under-voltage detection);  
 $f_{intern} = 200\text{ kHz } +50\%/ -45\%$ ,  $f_{WDC} = 5\text{ kHz } \pm 10\%$ ;  $f_{WDI} = 50\text{ Hz}$ , bootstrap capacitor  $C_{Boot} = 47\text{ nF}$  at Pin CAPI

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
<b>8</b>	<b>Digital Output P-EN (Internal Pull-up Resistor)</b>								
8.1	Saturation voltage high	$I \leq 3\text{ mA}$	5	$V_{SAT5}$			0.5	V	A
8.2	Leakage current	at 5 V, high state	5	$I_{LEAK5}$			0.5	$\mu\text{A}$	A
8.3	Internal pull-up resistor	at 0 V	5	$R_{INT5}$	12.5		50	$\text{k}\Omega$	A
8.4	Enable debounce time (switch to high)	Over- or undervoltage	5	$t_{DEB5}$	120	320	500	$\mu\text{s}$	A
8.5	Enable delay (switch back to low)	Over- or undervoltage	5	$t_{DEL5}$		85		ms	A
<b>9</b>	<b>Relay Driver (RELO)</b>								
9.1	Saturation voltage	$I \leq 150\text{ mA}$	1	$V_{SAT1}$	0.1		0.5	V	A
9.2	Current limitation		1	$I_{LIM}$	150		300	mA	A
9.3	Internal clamping voltage		1	$V_{CL}$	26		30	V	A
9.4	Turn-off energy		1		30			mJ	C
9.5	Leakage current	$V_{Batt} = 16\text{ V}$ $V_{Batt} = 26\text{ V at } 25^{\circ}\text{C}$	1	$I_{LEAK1}$ $I_{LEAK1}$			20 200	$\mu\text{A}$ $\mu\text{A}$	A
<b>10</b>	<b>Power-FET Output FETO (Maximum Load Capacitor at FET Gate 470 pF, Charge-pump Frequency 110 to 300 kHz)</b>								
10.1	Output voltage	$V_S = 9\text{ V to } 15\text{ V}$	9	$V_{OUT9}$	$V_S + 10\text{ V}$		$V_S + 15\text{ V}$	V	A
10.2	Operation range		7	$V_S$	9		20	V	A
10.3	Overvoltage shut-down		7	$V_S$	20		24	V	A
10.4	Internal clamping voltage		9	$V_{CL}$	26		30	V	A
10.5	On/off frequency		9	f			200	Hz	A
10.6	Maximum current	FETO	9	$I_{FETO}$	10			$\mu\text{A}$	A
<b>11</b>	<b>Battery Supply</b>								
11.1	Internal clamping voltage		7	$V_{CL}$	26		30	V	A
11.2	Clamping current capability <sup>(1)</sup>		7	$I_{VS}$	5			mA	A
11.3	Leakage current	at FETI = low	7	$I_{LEAVS}$			100	$\mu\text{A}$	A
<b>12</b>	<b>Reset and <math>V_{CC}</math> Control</b>								
12.1	Lower reset level	Reference SGND	14	$V_{CC}$	4.5		4.75	V	A
12.2	Upper reset level	Reference SGND	14	$V_{CC}$	5.25		5.5	V	A
12.3	Hysteresis		14	$V_{HYST14}$	25		100	mV	A
12.4	Reset debounce time		14	$t_{DEB}$	120	320	500	$\mu\text{s}$	A
12.5	Reset delay		14	$t_{DEL}$	20	50	80	ms	A

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

Note: 1. If  $V_S > 26\text{ V}$  the current has to be limited at 5 mA by an external resistor.



## Electrical Characteristics (Continued)

$V_{CC} = 5\text{ V}$ ,  $T_{amb} = -40\text{ to }+125^{\circ}\text{C}$ ; reference pin is GND or SGND (over- and under-voltage detection);  
 $f_{intern} = 200\text{ kHz } +50\%/-45\%$ ,  $f_{WDC} = 5\text{ kHz } \pm 10\%$ ;  $f_{WDI} = 50\text{ Hz}$ , bootstrap capacitor  $C_{Boot} = 47\text{ nF}$  at Pin CAPI

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
<b>13</b>	<b>Reset and 3.3 V Control</b>								
13.1	Lower reset level	Reference SGND	16	$V_{3.3V}$	2.97		3.13	V	A
13.2	Upper reset level	Reference SGND	16	$V_{3.3V}$	3.47		3.63	V	A
13.3	Hysteresis		16	$V_{HYST16}$	15		70	mV	A
13.4	Reset debounce time		16	$t_{DEB16}$	120	320	500	$\mu\text{s}$	A
13.5	Reset delay		16	$t_{DEL16}$	20	50	80	ms	A
13.6	Current		16	$I_{3.3V}$			0.5	mA	C
<b>14</b>	<b>RC Oscillator WDC</b>								
14.1	Oscillator frequency	$R_{OSC} = 36\text{ k}\Omega$ $C_{OSC} = 6.8\text{ nF}$	10	$f_{WDC}$	4.5	5	5.5	kHz	A
<b>15</b>	<b>Watchdog Timing</b>								
15.1	Power-on-reset prolongation time			$t_{POR}$	34.3		103.1	ms	A
15.2	Detection time for RC-oscillator fault	$V_{CR} = \text{constant}$		$t_{RCerror}$	81.9		246	ms	A
15.3	Time interval for over/under-voltage detection			$t_{D,OUV}$	0.16		0.64	ms	A
15.4	Reaction time of reset output at over/under voltage			$t_{R,OUV}$	0.187		0.72	ms	A
15.5	Nominal frequency for WDI	$f_{RC} = 100 f_{WDI}$		$f_{WDI}$	10		65	Hz	D
15.6	Nominal frequency for WDC	$f_{WDI} = 1/100 f_{WDC}$		$f_{WDC}$	1		6.5	kHz	D
15.7	Minimum pulse duration for a guaranteed WDI input-pulse detection	$f_{WDC} = 5\text{ kHz}$		$t_{P,WDI}$	364			$\mu\text{s}$	A
15.8	Frequency range for a correct WDI signal	$f_{WDC} = 5\text{ kHz}$		$f_{WDI}$	32.35		56.25	Hz	D
15.9	Number of incorrect WDI trigger counts for locking the outputs			$n_{lock}$		3			A
15.10	Number of correct WDI trigger counts for releasing the outputs			$n_{release}$		3			A
15.11	Detection time for a stucked WDI signal	$V_{WDI} = \text{constant}$ $f_{WDC} = 5\text{ kHz}$		$t_{WDIerror}$	49		51	ms	A

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

Note: 1. If  $V_S > 26\text{ V}$  the current has to be limited at 5 mA by an external resistor.

## Electrical Characteristics (Continued)

$V_{CC} = 5\text{ V}$ ,  $T_{amb} = -40\text{ to }+125^{\circ}\text{C}$ ; reference pin is GND or SGND (over- and under-voltage detection);  
 $f_{intern} = 200\text{ kHz } +50\%/-45\%$ ,  $f_{WDC} = 5\text{ kHz } \pm 10\%$ ;  $f_{WDI} = 50\text{ Hz}$ , bootstrap capacitor  $C_{Boot} = 47\text{ nF}$  at Pin CAPI

No.	Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit	Type*
<b>16</b>	<b>Watchdog Timing Relative to <math>f_{WDC}</math></b>								
16.1	Minimum pulse duration for a guaranteed WDI input-pulse detection					2		cycles	A
16.2	Frequency range for a correct WDI signal				80		170	cycles	D
16.3	Hysteresis range at the WDI ok margins					1		cycle	A
16.4	Detection time for a stucked WDI signal (WDI dropout)	$V_{WDI} = \text{constant}$			250		251	cycles	A

\*) Type means: A = 100% tested, B = 100% correlation tested, C = Characterized on samples, D = Design parameter

Note: 1. If  $V_S > 26\text{ V}$  the current has to be limited at 5 mA by an external resistor.

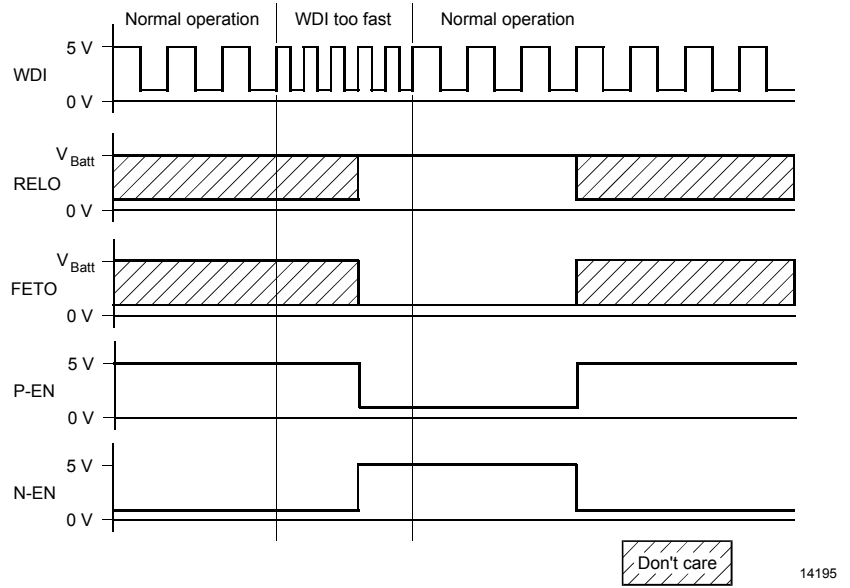
**Table 2.** Protection Versus Transient Voltages According to ISO TR 7637-1 Level 4 (Except Pulse 5)

Pulse	Voltage	Source Resistance <sup>(1)</sup>	Rise Time	Duration	Amount
1	- 110 V	10 $\Omega$	100 V/s	2 ms	15.000
2	+ 110 V	10 $\Omega$	100 V/s	0.05 ms	15.000
3a	- 160 V	50 $\Omega$	30 V/ns	0.1 $\mu\text{s}$	1 h
3b	+ 150 V	50 $\Omega$	20 V/ns	0.1 $\mu\text{s}$	1 h
5	55 V	2 $\Omega$	10 V/ms	250 ms	20

Note: 1. In the case of the relay driver, the coil resistance of  $R_{min} = 150\ \Omega$  has to be added to the source resistance.

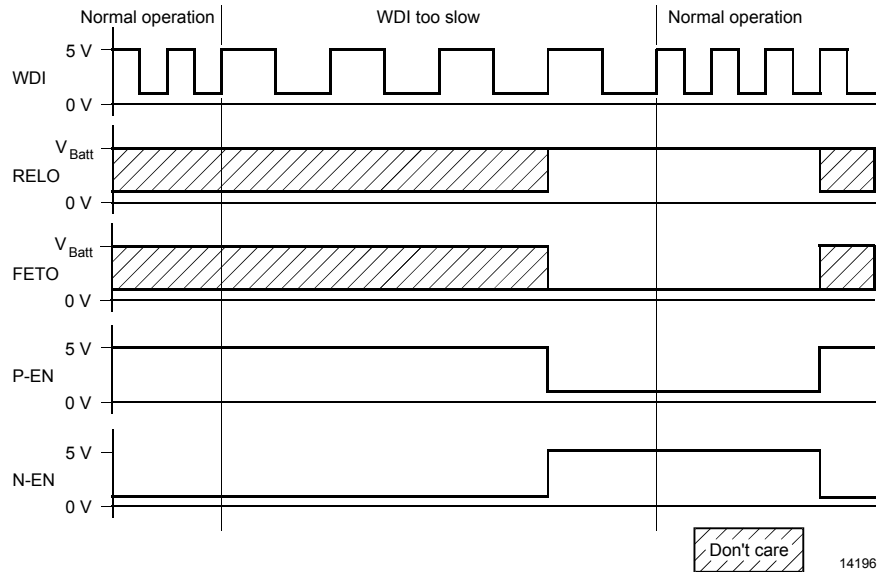
Timing Diagrams

Figure 6. Watchdog in Too-fast Condition



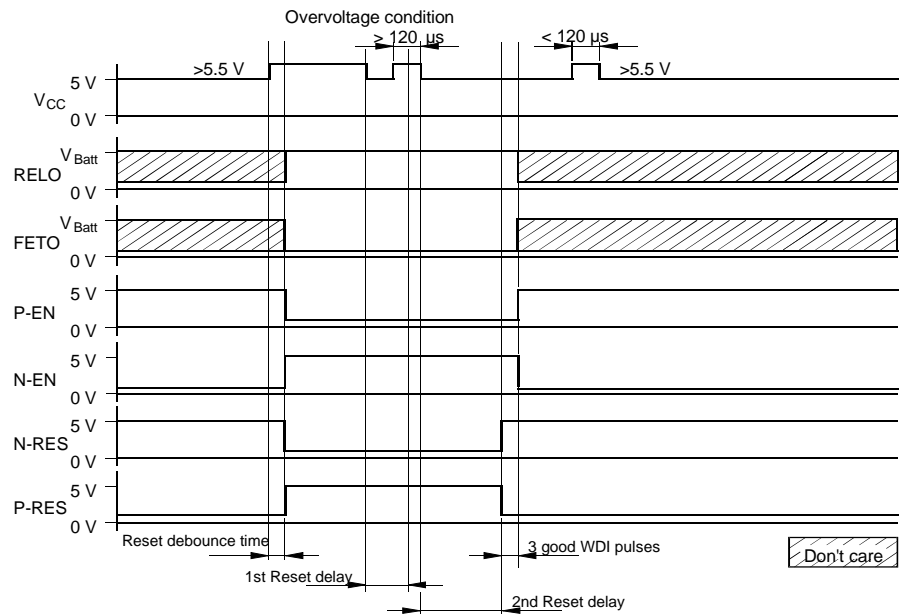
14195

Figure 7. Watchdog in Too-slow Condition



14196

**Figure 8. Overvoltage Condition**



**Figure 9. Undervoltage Condition**

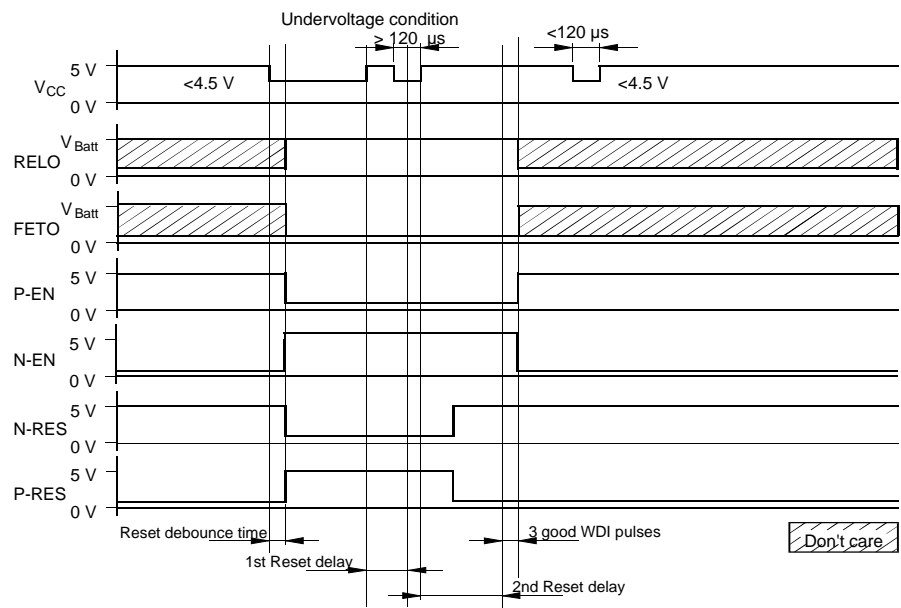
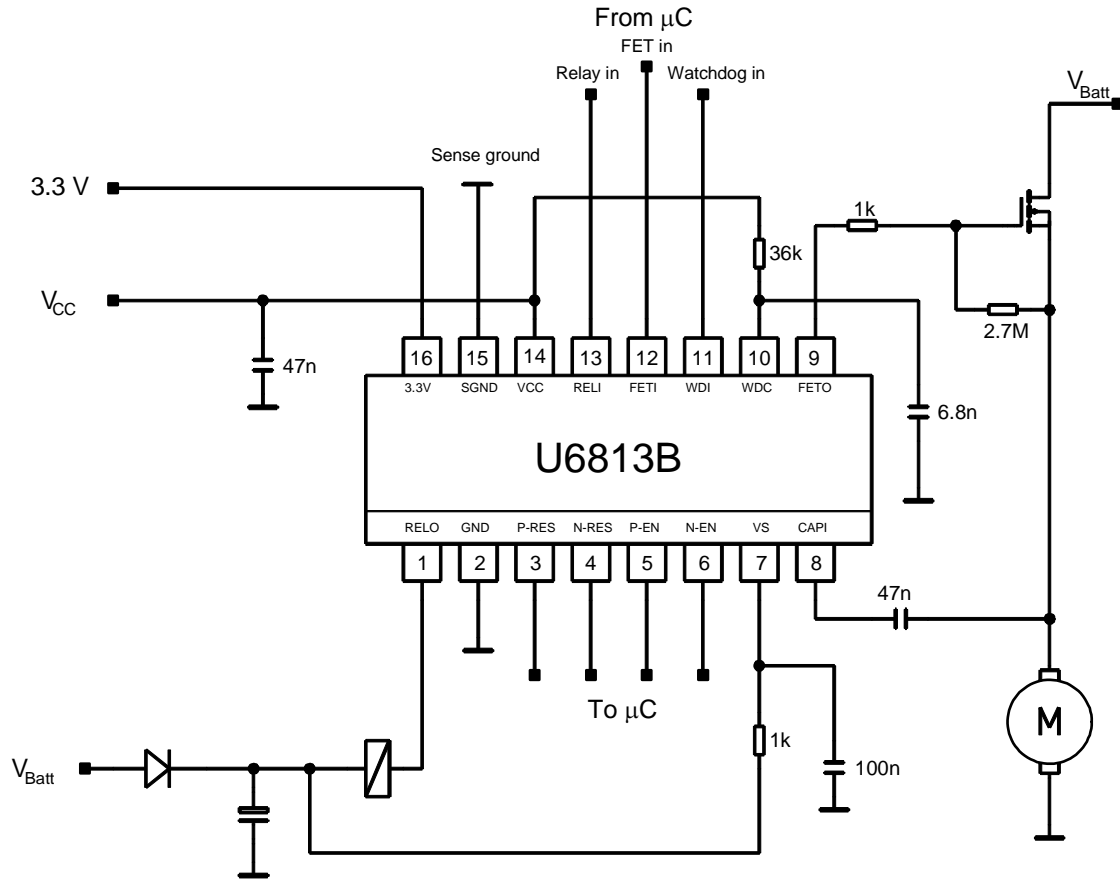


Figure 10. Application Circuit

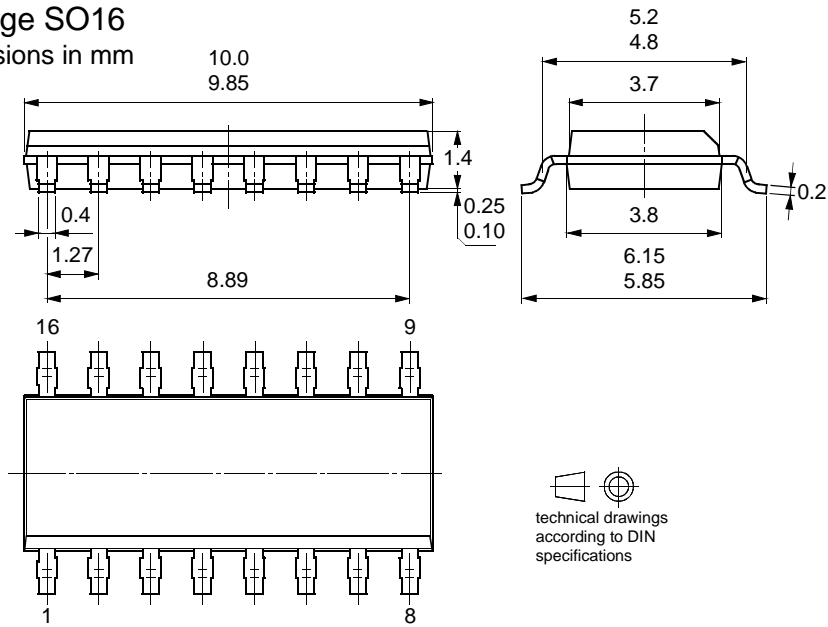


## Ordering Information

Extended Type Number	Package	Remarks
U6813B-MFPG3	SO16	Taped and reeled

## Package Information

Package SO16  
Dimensions in mm





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