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## Features

- Integrated Reverse Phase Control
- Mode Selection:
  - Zero-voltage Switch with Static Output
  - Two-stage Reverse Phase Control with Switch-off
  - Two-stage Reverse Phase Control with Dimming Function
- Current Monitoring:
  - High-speed Short-circuit Monitoring with Output
  - High-current Monitoring with Integrating Buffer
- Integrated Chip Temperature Monitoring
- Adjustable and Retriggerable Tracking Time
- External Window Adjustment for Sensor Input
- Enable Input for Triggering



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## Multifunction Timer IC

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**U2102B**

## Applications

- Two- or Three-wire Applications
- Motion Detectors
- Time-delay Relays
- Dimmers
- Reverse Phase Controls
- Timers

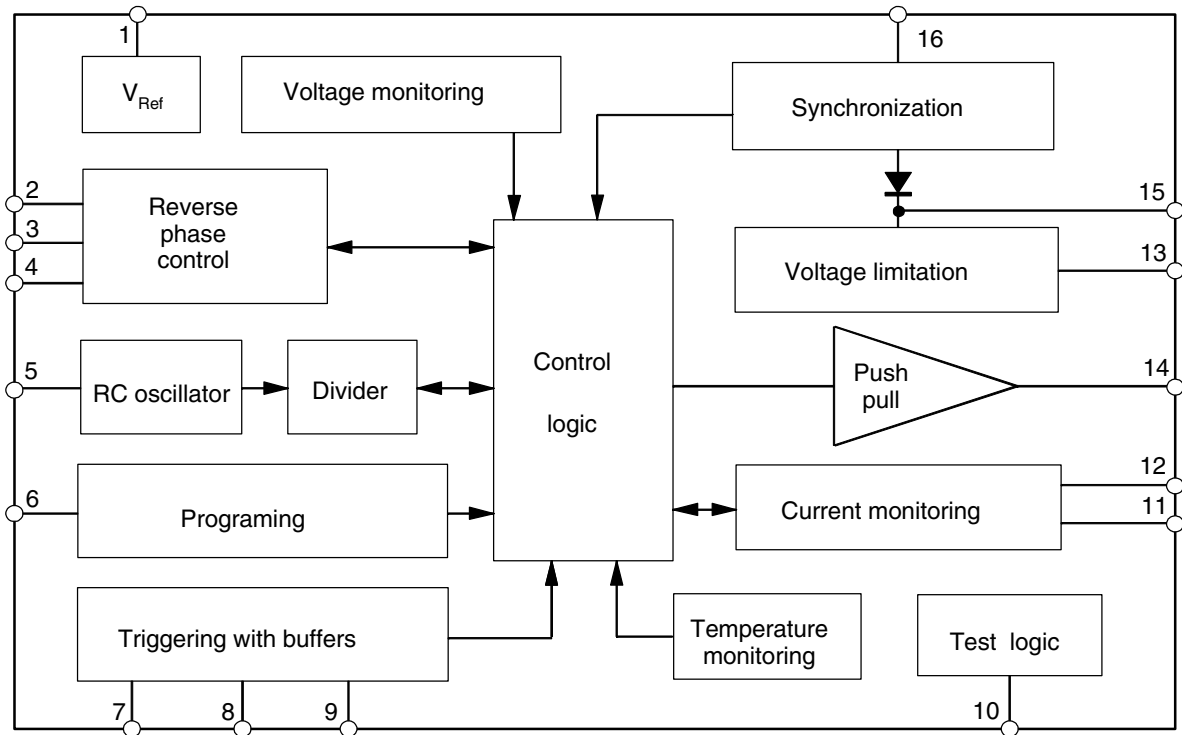
## 1. Description

The timer control circuit U2102B is based on bipolar technology. The output stage can switch either a MOSFET or an IGBT. Two sensor inputs and the retriggerable and adjustable tracking time useful for a wide range of applications. By using the reverse phase-control technique, the resistive load can be dimmed without the need of a compensation inductance. The integrated current monitoring function provides a very fast switch-off in case of a short-circuit condition. No additional fuse is needed.

Rev. 4767B-INDCO-10/05

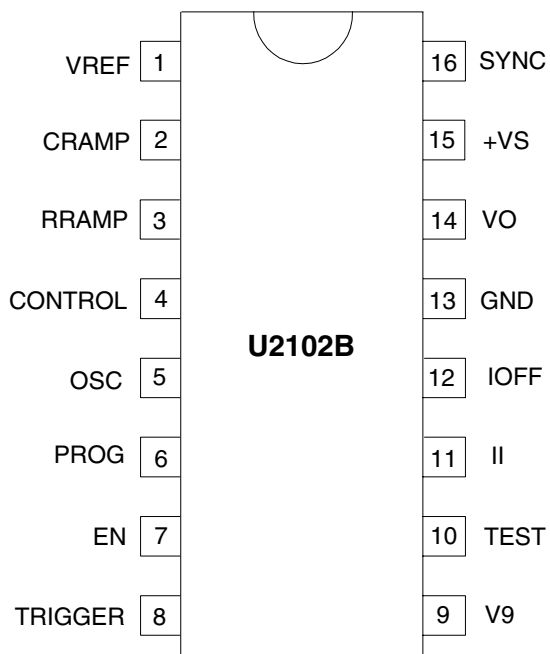


Figure 1-1. Block Diagram



## 2. Pin Configuration

**Figure 2-1.** Pinning DIP16/SO16



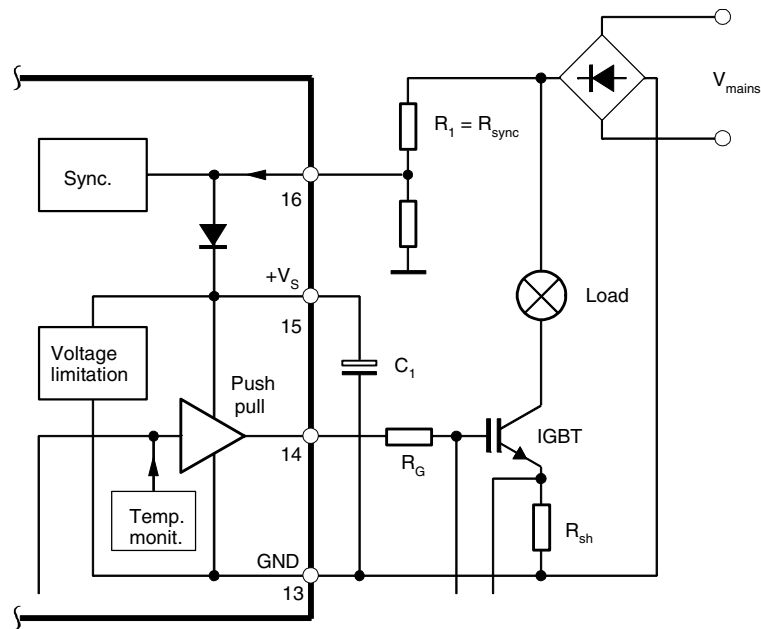
Pin	Symbol	Function
1	VREF	Reference voltage 5 V
2	CRAMP	Ramp capacitance
3	RRAMP	Current setting for ramp
4	CONTROL	Control voltage
5	OSC	RC oscillator
6	PROG	Tri-state programming
7	EN	Enable input
8	TRIGGER	Trigger input (window)
9	V9	Window adjustment
10	TEST	Test output
11	II	Input current monitoring
12	IOFF	Fast output current monitoring
13	GND	Ground
14	VO	Output voltage
15	+VS	Supply voltage
16	SYNC	Synchronization input



### 3. Power Supply, Synchronization Pins 15 and 16

The U2102B's voltage limitation circuit enables the power supply via the dropping resistor  $R_1$ . In the case of DC loads, the entire supply current flows into pin 16 and is supplied via an internal diode to pin 15, where the resultant supply voltage is limited and smoothed by  $C_1$ . The pull-down resistor at pin 16 is necessary in order to guarantee reliable synchronization. As a result, the rectified and divided line voltage appears at pin 16, where the amplitude is limited. The power supply for the circuit can be realized in all modes for DC loads as shown in [Figure 2-2 on page 4](#). The voltage at pin 16 is used to synchronize the circuit with the mains and generate the system clock required for the buffers. The circuit detects a "zero crossing" when the voltage at pin 16 falls below an internal threshold of approximately 8 V.

**Figure 3-1.** Power Supply for DC Loads ( $R_1$  is identical with  $R_{sync}$ )



$R_1$  is calculated as follows:

$$R_{1max} = 0.85 \times \frac{V_{Nmin} - V_S}{I_{tot}}$$

where:

$$V_{Nmin} = V_{mains} - 15\%$$

$$V_S = \text{Supply voltage}$$

$$I_{tot} = I_{Smax} + I_x$$

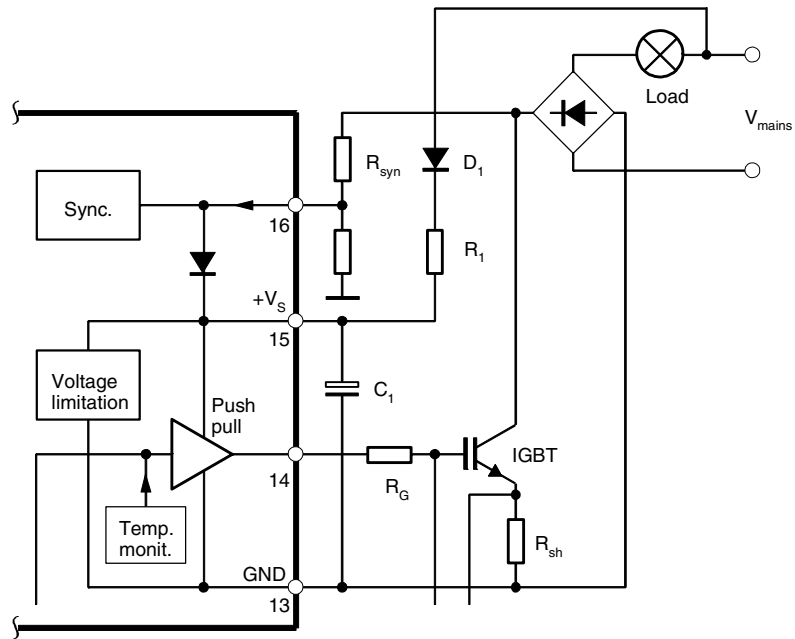
$$I_{Smax} = \text{Maximum current consumption of the IC}$$

$$I_x = \text{Current consumption of the external components}$$

In the case of AC loads, it is necessary to distinguish the power supply purposes of the individual operating modes. In reverse phase control mode (see [Figure 3-1 on page 5](#)), pin 15 must be additionally supplied with power via a dropping resistor, since no current flows in pin 16 when the power switch is switched on. Here, the dropping resistor,  $R_1$ , is connected to the AC line and has therefore only one mains half-wave.  $R_1$  is then calculated as follows:

$$R_{1\max} = 0.85 \times \frac{V_{N\min} - V_S}{2 \times I_{\text{tot}}}$$

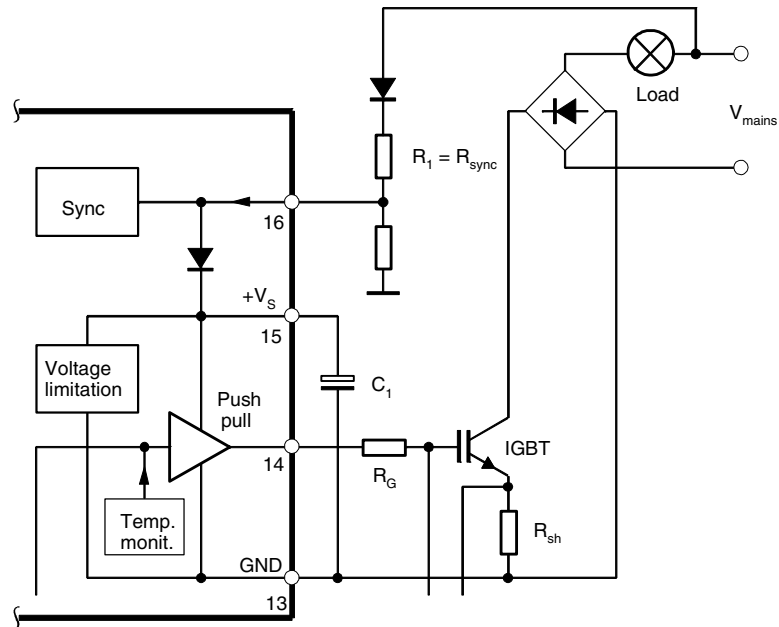
**Figure 3-2.** Power Supply in Reverse Phase Control Mode for AC Loads



In two-wire systems, the additional power supply at pin 15 is not possible (see [Figure 3-1 on page 5](#), by omitting  $R_1$  and diode  $D_1$ ). In this case, the resistor  $R_{\text{sync}}$  is identical with  $R_1$  and should be as low as the power dissipation allows it. A sufficiently large residual phase angle must remain in this case to guarantee the device's supply.

The power supply is simplified if the device is operated as a static zero-voltage switch for AC loads (see [Figure 3-2](#)). All delay times are then twice as long, since the synchronization of the module is connected directly to the AC line.

Figure 3-3. Power Supply as Static Zero-voltage Switch for AC Loads



## 4. Voltage Monitoring

The internal voltage monitoring circuit suppresses uncontrolled conditions or output pulses of insufficient amplitude which may occur while the operating voltage is being built up or reduced. All latches in the circuit, the divider and the control logic are reset. When the supply voltage is applied, the enable threshold (clamp voltage) of approximately 16 V must be reached so that the circuit is enabled. The circuit is reset at approximately 11 V if the supply voltage breaks down. A further threshold is activated in reverse phase control mode. If the supply voltage breaks down in this mode, after the circuit has been enabled, the output stage is switched off at approximately 12.5 V, while the other parts of the circuit are not affected. The output stage can then be switched on again in the following half-wave. As a result, the residual phase angle remains just large enough, (e.g., in two-wire systems), so that the circuit can still be properly supplied with power. In all operating modes, a single operating cycle is started after the supply voltage is applied, independently of the trigger inputs, in order to immediately demonstrate the overall function.

## 5. Chip Temperature Monitoring

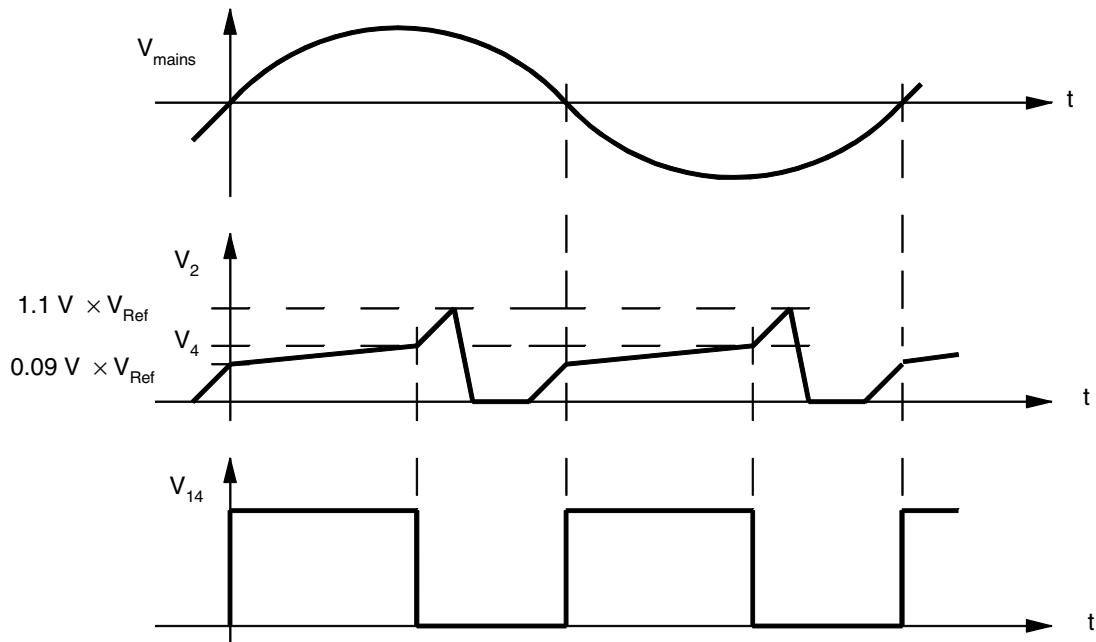
The U2102B includes a chip temperature monitoring circuit which disables the output stage when a temperature of approximately 140°C is reached. The circuit will only be enabled again after cooling down and when the operating voltage has been additionally switched off and on.

## 6. Reverse Phase Control

In the case of normal phase controls, e.g., with a triac, the load current will only be switched on at a certain phase angle after the zero crossing of the mains voltage. In the following zero crossing of the current, the triac gets extinguished (switched-off) automatically. Reverse phase control differs from this in that the load current is always switched on by a semiconductor switch (for example, IGBT) at the zero crossing of the mains voltage and then switched back off again after a certain phase angle  $\alpha$ . This has the advantage that the load current always rises with the mains voltage in a defined manner and thus keeps the required interference suppression to a minimum.

The charging current for the capacitor  $C_3$  at pin 2 is set with the resistor  $R_3$  at pin 3. When the synchronization circuit recognizes a zero crossing, an increased charging current of  $I_2 \approx 4 \times I_3$  is enabled which then charges  $C_3$  up to  $\approx 0.45$  V. The output stage is switched on at this value and the charging current for  $C_3$  is reduced to  $I_2 = I_3$ . Since the actual zero crossing of the supply voltage occurs later than recognized by the circuit, the load current starts to flow quite close to the exact zero crossing of the supply voltage. While the output stage is switched on,  $C_3$  is charged until the control voltage, set externally at pin 4, is reached. When this condition is reached, the output stage is switched off and  $C_3$  is charged again with the increased current ( $I_2 \approx 4 \times I_3$ ) to  $V_2 \approx 5.5$  V. The charging current is switched off at this point and  $C_3$  is discharged internally. The whole process then starts again when the circuit recognizes another zero crossing (Figure 3-3 on page 7).

**Figure 6-1.** Signal Characteristics of Reverse Phase Control





## 7. Programming

Three operating modes can be programmed with the tri-state input pin 6:

- Zero-voltage switch (ZVS) with static output ( $V_6 = V_1 = V_{Ref}$ ):  
The reverse phase control is inactive here. The output stage is statically switched on after triggering by the timer and switched off again after the running down of the time (at the zero crossing of the supply voltage in each case). This operating mode is not possible in two-wire systems.
- Reverse phase control with two-stage switch-off ( $V_6 = V_{15} = V_S$ ):  
The maximum current flow angle,  $\alpha_{max}$ , is set when the timer has enabled the output stage. Switchover to the phase angle  $\alpha$ , which can be set arbitrarily at pin 4, takes place after expiry of 3/4 of the tracking time set at pin 5. The output stage switches off after expiry of the whole tracking time.
- Two-stage reverse phase control with dimming function ( $V_6 = V_{13} = GND$ ):  
The output stage switches to the maximum current flow angle,  $\alpha_{max}$ , (adjustable) if the trigger condition for both inputs (pins 7, 8) is satisfied. Switchover to the current flow angle,  $\alpha$ , set at pin 4 takes place after expiry of 3/4 of the tracking time set at pin 5. The whole process is repeated from the beginning if renewed triggering takes place at pin 8. The lamp is switched-off in the following half-wave of the mains voltage if the trigger condition at pin 7 disappears. In this mode, the output stage is switched-on even if only pin 7 is in the ON state. The current flow angle is then determined by  $V_4$  (e.g., house number illumination, twilight switch).

## 8. Trigger Inputs

The trigger condition of the timer is determined by the two inputs at pins 7 and 8. A Light Dependent Resistor (LDR) can be connected to pin 7, for example, and an IR sensor to pin 8. Since both inputs are equal and AND-gated they must both be in the ON state to initiate triggering. In the operating mode “2-stage reverse phase control”, the output stage can additionally be switched on and switched off by pin 7 alone and independently of the timer.

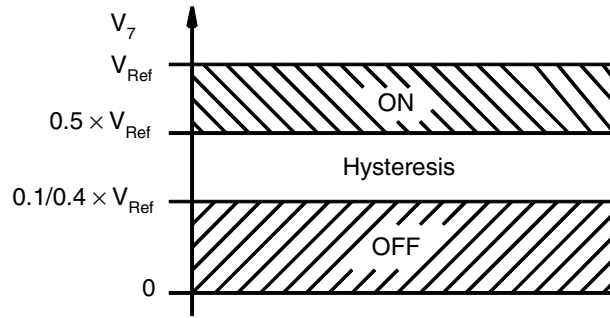
The enable input pin 7 is implemented as a comparator with hysteresis. The enable threshold is approximately 2.5 V. The blocking threshold is switched by the control logic in order to avoid faults as a result of load switching. This threshold is approximately 2 V in switched off condition and also during the second current flow angle,  $\alpha$ , in two-stage reverse phase control mode. Otherwise, the blocking or switch-off threshold is 0.5 V.

The input pin 8 is designed as a window discriminator, its window is set at pin 9. The minimum window of approximately 250 mV is set with  $V_9 = V_{13}$ , and the maximum window of approximately 1.25 V with  $V_9 = V_1$ . The window discriminator is in the OFF state when the voltage at pin 8 lies within the window set at pin 9.

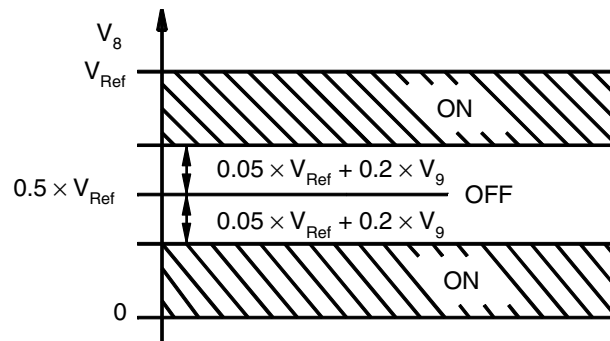
If a resistor divider with an NTC resistor is connected to pin 9, for example, it is possible to compensate the temperature dependence of the IR sensor, i.e., the range is made independent of temperature.

Noise suppression for  $t_{ON} = 40$  ms guarantees that there are no peak noise signals at the inputs which could trigger the circuit. Equally, renewed triggering is prevented for  $t_{OFF} = 640$  ms after load switch-off to avoid any self interference.

**Figure 8-1.** Trigger Condition Pin 7



**Figure 8-2.** Trigger Condition Pin 8



## 9. RC Oscillator

An internal RC oscillator with following divider stage 1:2<sup>11</sup> permits a very long and reproducible tracking time.

The RC values for a certain tracking time,  $t_t$ , are calculated as follows:

$$R_2(\text{k}\Omega) = \frac{t_t(\text{s})10^3}{1.4 \times 2048 C_2(\mu\text{F})}$$

$$C_2(\mu\text{F}) = \frac{t_t(\text{s})10^3}{1.4 \times 2048 R_2(\text{k}\Omega)}$$

In reverse phase control mode, switchover from maximum current flow angle to the value set at pin 4 takes place after expiry of 3/4 of the total tracking time  $t_t$ .

## 10. Current Monitoring

The U2102B's current monitoring circuit represents a double electronic fuse. The circuit measures the current flowing through the power switch by means of the voltage drop across the shunt resistor  $R_{sh}$ . This voltage is supplied to pin 11. If this voltage exceeds a value of 500 mV due to a high load current (e.g., short circuit), the switch-off latch is set and the switching output pin 11 closes immediately. Pin 11 can be connected to the gate via a resistor or network, depending on load conditions, thus allowing the switch-off behavior to be adapted to the respective requirements. The short-circuit current is reduced to a problem-free value by this procedure.

There is a second threshold at 100 mV. Without exceeding the switch-off threshold of 500 mV, the output stage is also disabled in the voltage at pin 11 exceeds the value of 100 mV for  $\geq 120$  ms at one half-wave. To prevent the occurrence of high-voltage peaks in the over current condition due to the line and leakage inductances, the output stage is not switched off immediately. It is disabled during the next half-wave.

## 11. Absolute Maximum Ratings

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

Reference point pin 13, unless otherwise specified.

Parameters	Pin	Symbol	Value	Unit
Power supply Current $t < 10 \mu s$	15	$I_S$	20	mA
		$i_s$	60	mA
Synchronization Input current $t \leq 10 \mu s$	16	$I_I$	20	mA
		$i_i$	60	mA
Reference voltage source Output current	1	$-I_{Ref}$	10	mA
Push-pull output stage Output current $t \leq 2 ms$	14	$\pm I_O$	10	mA
	14	$\pm i_o$	60	mA
Input currents	2	$-I_I$	1	mA
	2	$I_I$	8	mA
	3	$-I_I$	0.2	mA
	10	$\pm I_I$	1	mA
	12	$I_I$	20	mA
Input voltage	4, 5, 7, 8, 9, 11	$V_I$	0 to $V_1$	V
	6 and 12	$V_I$	0 to $V_{15}$	V
Storage temperature range		$T_{stg}$	-40 to +125	°C
Junction temperature		$T_j$	+125	°C
Ambient temperature		$T_{amb}$	-10 to +100	°C

## 12. Thermal Resistance

Parameters		Symbol	Value	Unit
Junction ambient	DIP16	$R_{thJA}$	120	K/W
	SO16 on PC board	$R_{thJA}$	180	K/W
	SO16 on ceramic	$R_{thJA}$	100	K/W

## 13. Electrical Characteristics

$V_S = 15.0\text{ V}$ ,  $f_{mains} = 50\text{ Hz}$ ,  $T_{amb} = 25^\circ\text{C}$ , reference point pin 13, unless otherwise specified.

Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit
Supply Voltage Limitation	$I_S = 2\text{ mA}$	15	$V_S$	15		17	V
	$I_S = 5\text{ mA}$		$V_S$	15.2		17.2	V
Current Consumption	$V_S = 15\text{ V}$	15	$I_S$			2	mA
<b>Voltage Monitoring</b>		15					
Switch-on threshold			$V_{SON}$	14.8		16.5	V
Switch-off threshold			$V_{SOFF}$	10.4	11	11.6	V
Undervoltage threshold			$V_{15}$	11.7	12.5	13.3	V
Reference Voltage	$-I_1 = 0\text{ to }5\text{ mA}$	1	$V_{Ref}$	4.75	5	5.25	V
<b>Synchronization</b>		15, 16					
Voltage limitation	$I_{16} = 2\text{ mA}$	15, 16	$V_{limit}$		0.8		V
Input current	$V_{16} = 0\text{ V}$	16	$-I_1$		100		$\mu\text{A}$
Zero crossing switch-on threshold		16	$V_{TON}$	7.3	7.7	8.1	V
Zero crossing switch-off threshold		16	$V_{TOFF}$	7.9	8.3	8.7	V
<b>Reverse Phase Control</b>		3					
Ramp current setting							
Input current			$-I_1$			50	$\mu\text{A}$
Input voltage	$I_3 = -10\text{ }\mu\text{A}$		$V_3$	4.7	5	5.3	V
Ramp	$I_3 = -10\text{ }\mu\text{A}$	2					
Charging current 1			$-I_{ch1}$	9	10	11	$\mu\text{A}$
Charging current 2			$-I_{ch2}$	37	40	43	$\mu\text{A}$
Discharge impedance			$R_{dis}$		1		$\text{k}\Omega$
Switch-on threshold, output stage			$V_{TON}$	410	450	490	mV
Discharge threshold voltage		1, 2	$V_{dis}$		600		mV
<b>Control Voltage</b>		4					
Input voltage			$V_1$			$V_{Ref}$	V
Input current	$V_{13} \leq V_4 \leq V_1$		$\pm I_1$	0		500	nA
<b>Programming, Tri-state Input</b>		6					
Input current	$V_{13} \leq V_6 \leq V_{15}$		$\pm I_1$			1	$\mu\text{A}$
Operating mode: Static zero-voltage switch				1		$V_{Ref} + 0.3$	
2-stage reverse phase control with switch-off			$V_1$	$V_{Ref} + 1$		$V_S$	V
2-stage reverse phase control			$V_1$	0		0.3	V
<b>RC Oscillator</b>		5					
Input current	$V_{13} \leq V_5 < 3.6\text{ V}$		$\pm I_1$			500	nA
Upper threshold			$V_{TU}$	3.6	4	4.4	V
Lower threshold			$V_{TL}$	0.9	1	1.1	V
Discharge impedance			$R_{dis}$		1		$\text{k}\Omega$

### 13. Electrical Characteristics (Continued)

$V_S = 15.0\text{ V}$ ,  $f_{\text{mains}} = 50\text{ Hz}$ ,  $T_{\text{amb}} = 25^\circ\text{C}$ , reference point pin 13, unless otherwise specified.

Parameters	Test Conditions	Pin	Symbol	Min.	Typ.	Max.	Unit
<b>Window Discriminator</b>							
Input current	$0\text{ V} \leq V_8 \leq V_1$	8	$\pm I_i$			500	nA
Upper threshold		8, 9	$V_{TU}$	$0.55 \times V_{\text{Ref}} + (0.2 \times V_9)$			V
Lower threshold			$V_{TL}$	$0.45 \times V_{\text{Ref}} - (0.2 \times V_9)$			V
Input current window adjustment	$0\text{ V} \leq V_9 \leq V_1$	9	$\pm I_i$			500	nA
Minimum window:		8					
Lower threshold	$V_9 = V_{13}$		$V_{TL1}$	2.05	2.75	2.45	V
Upper threshold		$V_{TU1}$	2.55	3.75	2.95	V	
Maximum window:		8					
Lower threshold	$V_9 = V_1$		$V_{TL2}$	1.1	1.25	1.4	V
Upper threshold		$V_{TU2}$	3.4	3.75	4.1	V	
<b>Enable Schmitt Trigger</b>							
7							
Input current	$0\text{ V} \leq V_7 \leq V_1$		$\pm I_i$			500	nA
Enable threshold			$V_T$	2.3	2.5	2.7	V
Blocking threshold:							
Output stage OFF			$V_T$	1.8	2	2.2	V
Output stage ON, except in the case of two-stage reverse phase control in second stage ( $\alpha$ )			$V_T$	0.45	0.5	0.55	V
Threshold for test mode			$V_T$	85	100	115	mV
<b>Current Monitoring</b>							
11							
Input current	$0\text{ V} \leq V_{11} \leq V_1$		$\pm I_i$			500	nA
Switch-off threshold 1			$V_{T1}$	80	100	120	mV
Switch-off threshold 2			$V_{T2}$	450	500	550	mV
<b>Switching Output</b>							
12							
Leakage current	$V_{11} < 450\text{ mV}$ , $V_{12} \leq V_{15}$		$I_{\text{lk}}$			1	$\mu\text{A}$
Saturation voltage	$V_{11} > 550\text{ mV}$ $I_{12} = 0.5\text{ mA}$ $I_{12} = 10\text{ mA}$		$V_{\text{Sat}}$			1.0	V
			$V_{\text{Sat}}$			1.2	V
<b>Push-pull Output Stage</b>							
Upper saturation voltage, ON state	$I_{14} = -10\text{ mA}$	14, 15	$-V_{\text{Sat}}$			2.4	V
Lower saturation voltage, OFF state	$I_{14} = 10\text{ mA}$	14	$V_{\text{SatL}}$			1.2	V
Output current	ON state	14	$-I_O$	50			mA
	OFF state		$I_O$	50			mA

**Figure 13-1.** House Number or Staircase Illumination for AC Loads  
 House Number Illumination:  $V_6 = V_{13}$   
 Staircase Illumination:  $V_6 = V_{15}$

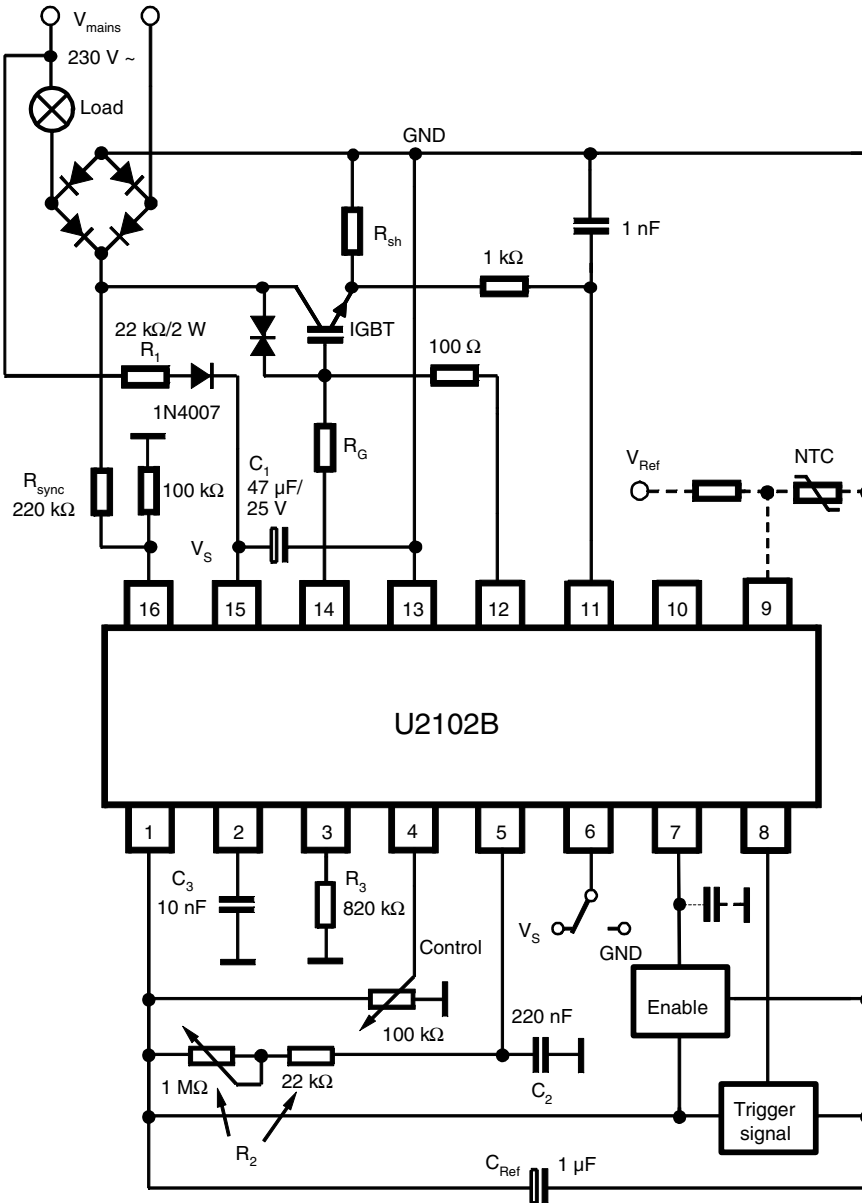
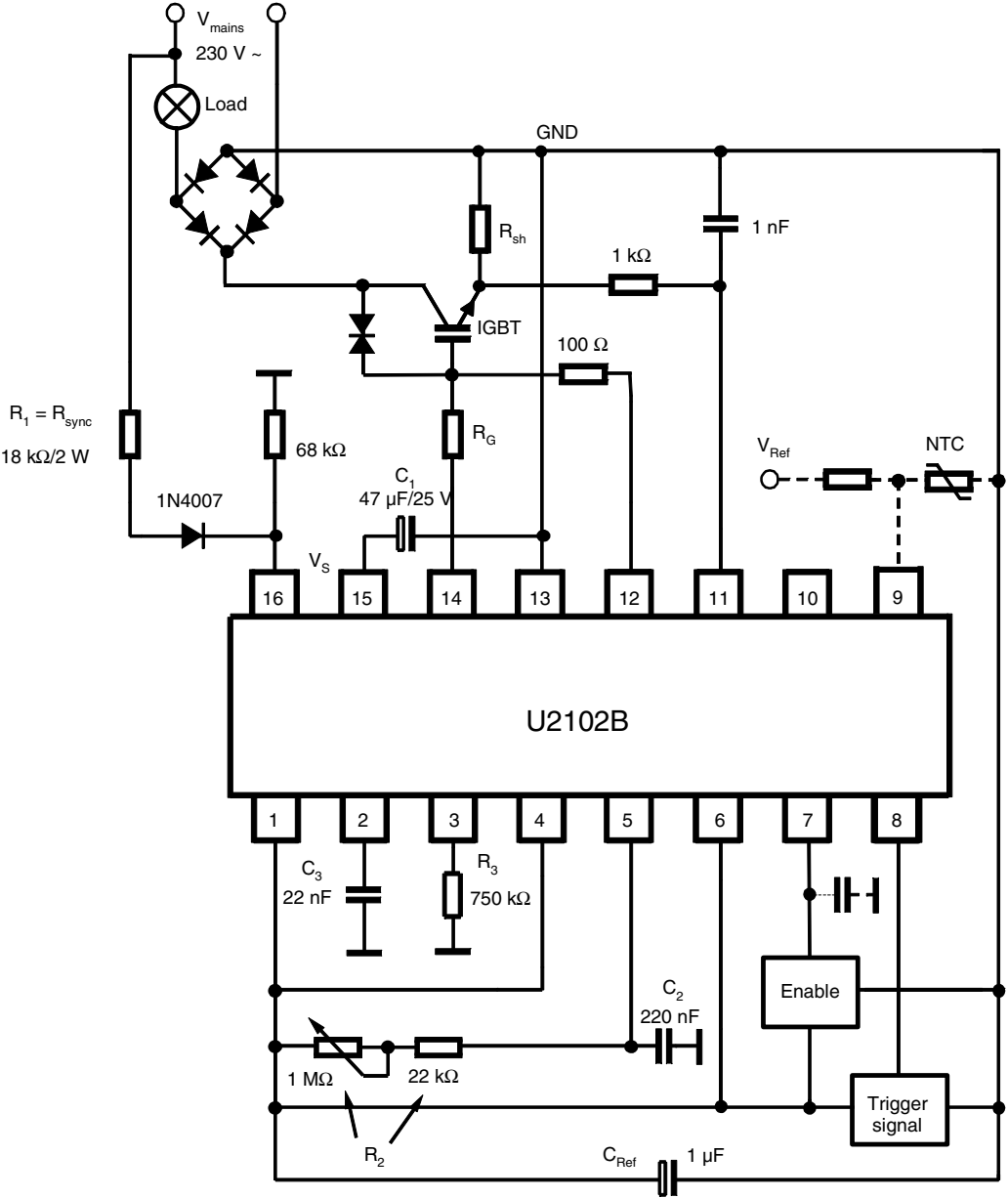
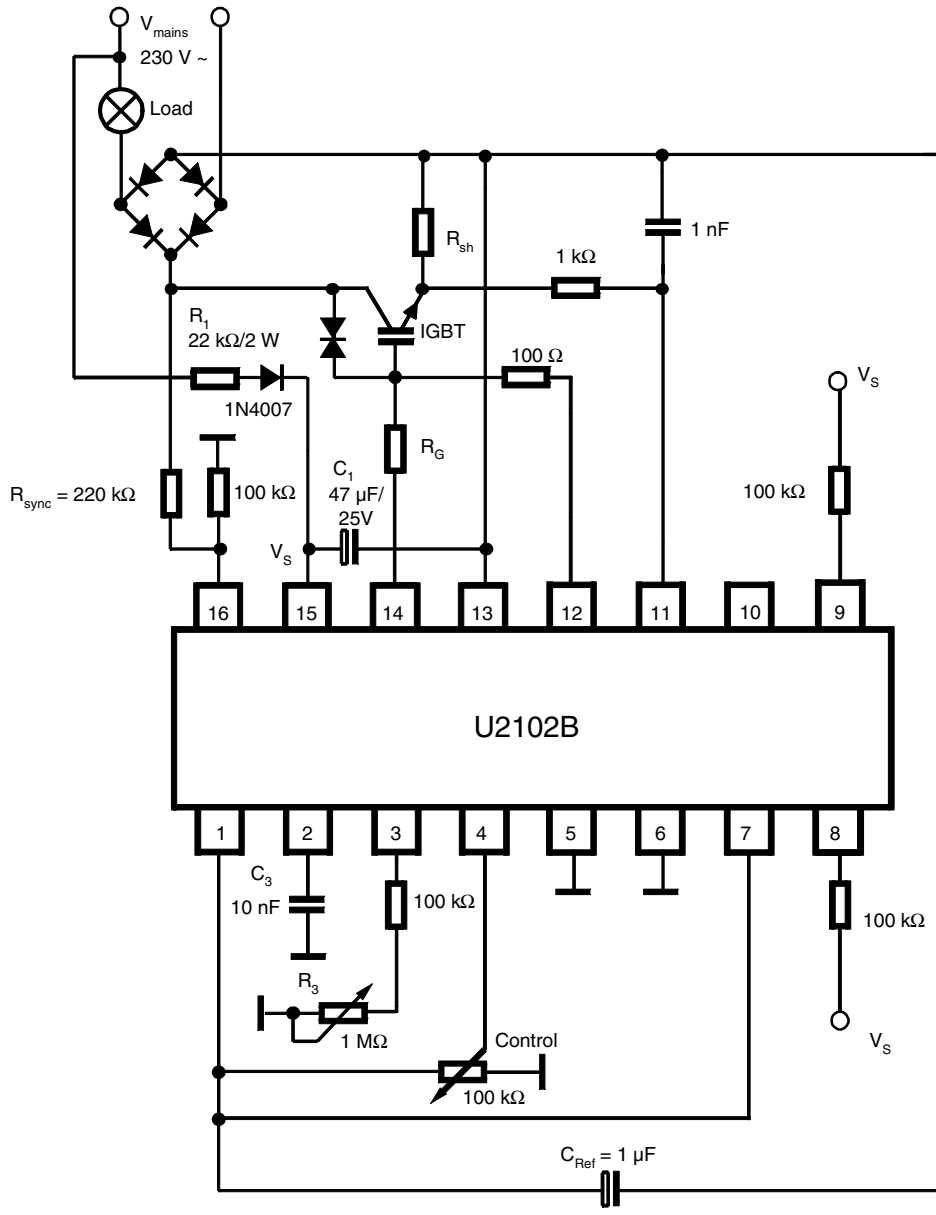


Figure 13-2. Zero-voltage Switch Mode for AC Loads



**Figure 13-3.** Reverse Phase Control for AC Loads



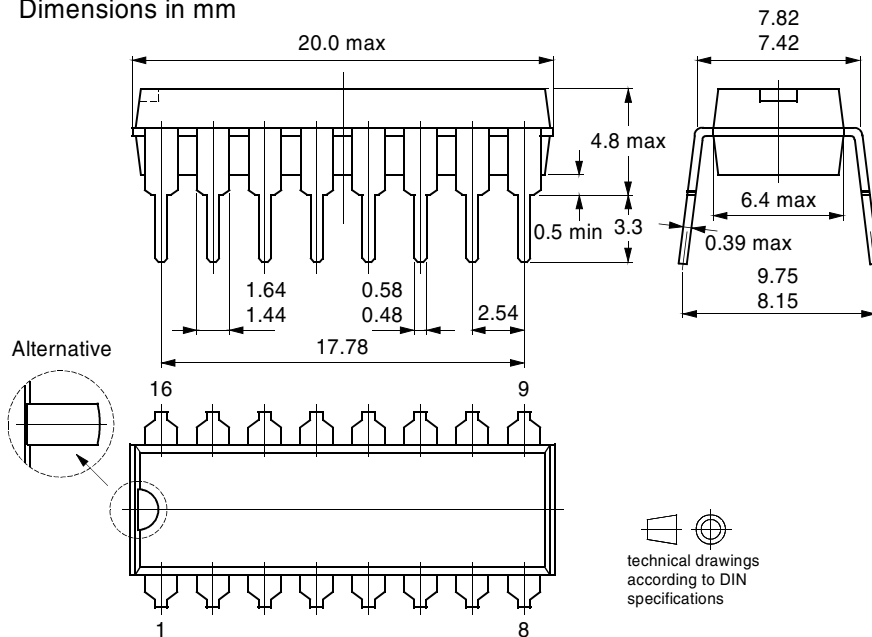


### 14. Ordering Information

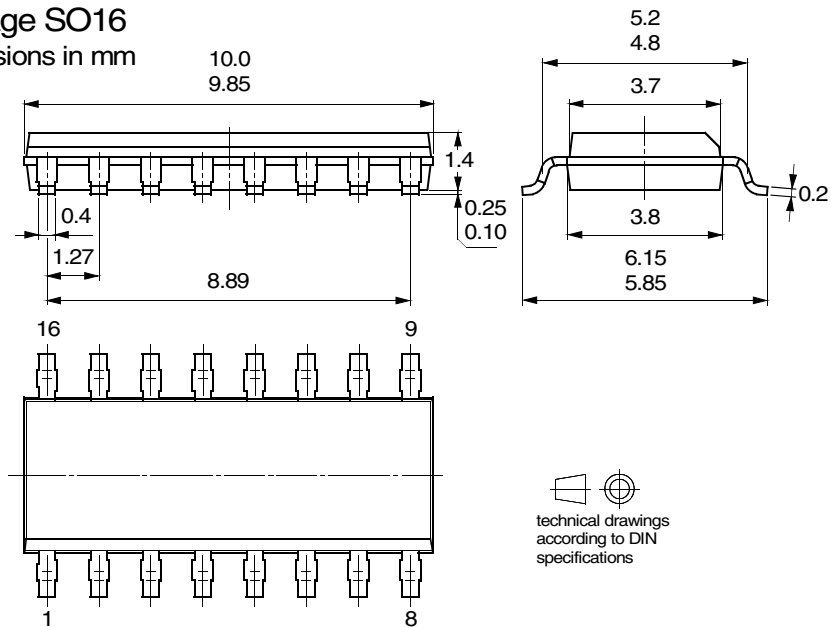
Extended Type Number	Package	Remarks
U2102B-xY	DIP16	Tube, Pb-free
U2102B-xFPY	SO16	Tube, Pb-free
U2102B-xFPG3Y	SO16	Taped and reeled, Pb-free

### 15. Package Information

Package DIP16  
Dimensions in mm



Package SO16  
Dimensions in mm



## 16. Revision History

Please note that the following page numbers referred to in this section refer to the specific revision mentioned, not to this document.

Revision No.	History
4767B-INDCO-08/05	<ul style="list-style-type: none"> <li>• Put datasheet in a new template</li> <li>• First page: Pb-free logo added</li> <li>• Page 17: Ordering Information changed</li> </ul>



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