PWM Power Control with Low Duty Cycle Switch Off

Description

U6081B is a PWM IC in bipolar technology for the control of an N-channel power MOSFET used as a high side switch. The IC is ideal for the use in the brightness control (dimming) of lamps e.g., in dashboard applications.

Features

- Pulse width modulation up to 2 kHz clock frequency
- Protection against short circuit, load dump overvoltage and reverse V_S
- Duty cycle 0 to 100%
- Output stage for power MOSFET
- Interference and damage protection according to VDE 0839 and ISO/TR 7637/1.
- Ground wire breakage protection
- Charge pump noise suppressed

Package: DIP 8

Block Diagram

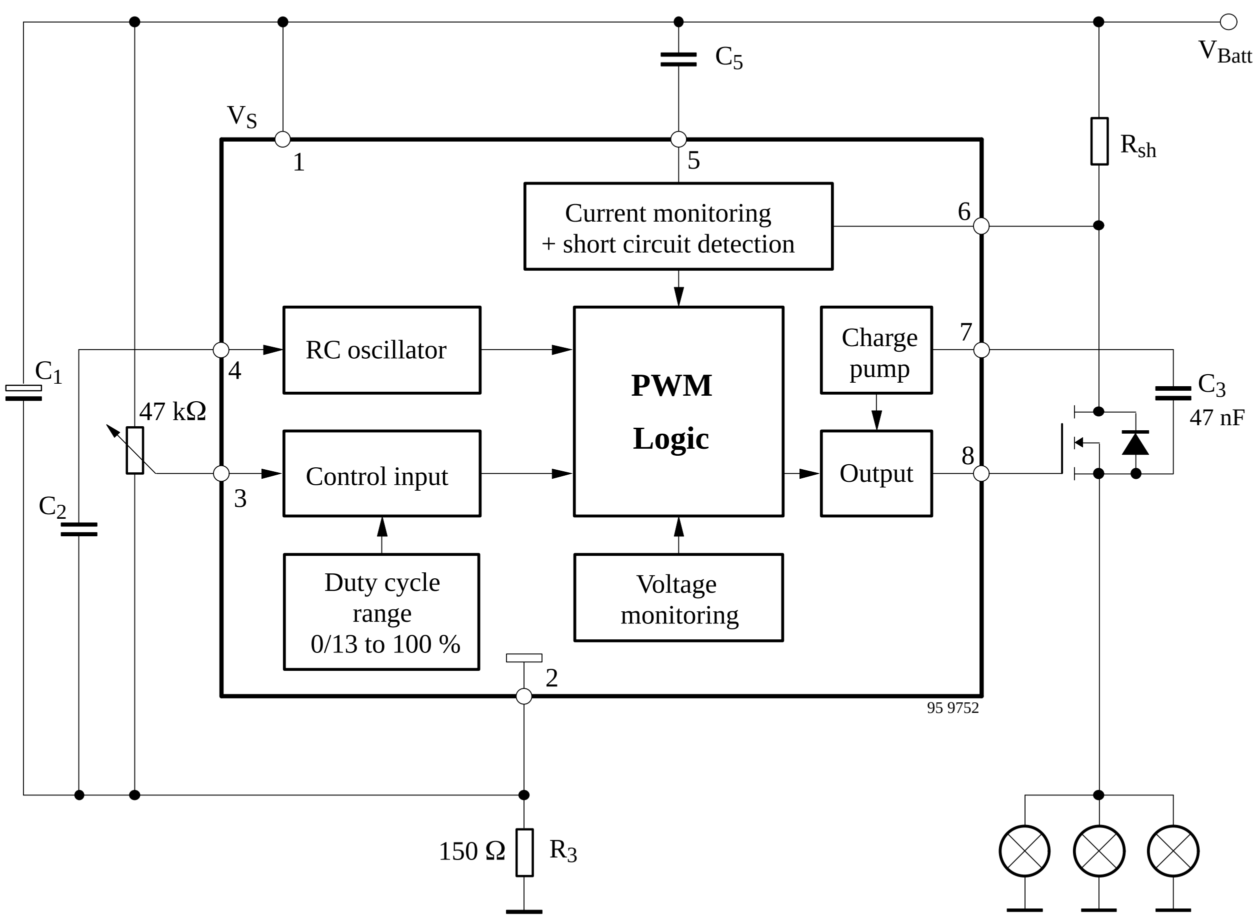
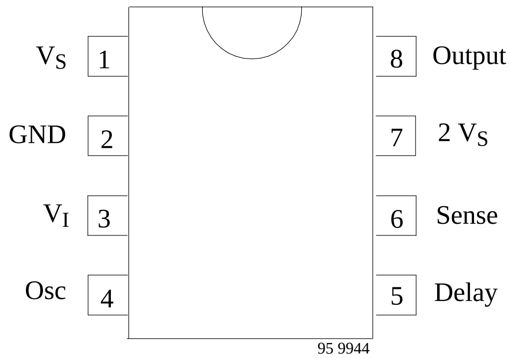


Figure 1. Block diagram with external circuit

Pin Description



Pin	Symbol	Function
1	V_S	Supply voltage V_S
2	GND	IC ground
3	V_I	Control input (duty cycle)
4	Osc	Oscillator
5	Delay	Short circuit protection delay
6	Sense	Current sensing
7	2 V_S	Voltage doubler
8	Output	Output

Functional Description

Supply Voltage, V_s or V_{Batt}, Pin 1

GND Pin 2

Control Input, Pin 3

The pulse width is controlled by means of an external potentiometer (47 kΩ). The characteristic (angle of rotation/duty cycle) is linear. The duty cycle can be varied from 0 to 100%. To avoid inadmissibly high filament cold currents, the dimmer is switched off at duty cycles of approximately < 10% or is switched on only at duty cycles of approximately > 13% (hysteresis). It is possible to further restrict the duty cycle with the resistors R_1 and R_2. Pin 3 is protected against short-circuit to V_{Batt} and ground GND ($V_{Batt} \leqq 16.5$ V).

Output Slope Control

The rise and fall time (t_r, t_f) of the lamp voltage can be limited to reduce radio interference. This is done with an integrator which controls a power MOSFET as source follower. The slope time is controlled by an external capacitor and the oscillator current.

Calculation:

$$t_f = t_r = V_{Batt} \cdot \frac{C_4}{I_{osc}}$$

With V_{Batt} = 12 V, C_4 = 470 pF and I_{osc} = 40 µ A,we thus obtain a controlled slope of

$$t_f = t_r = 12\ V \cdot \frac{470\ pF}{40\ \mu A} = 141\ \mu s$$

Oscillator, Pin 4

The oscillator determines the frequency of the output voltage. This is defined by an external capacitor, C_2. It is charged with a constant current, I, until the upper switching threshold is reached. A second current source is then activated which taps a double current, 2 I, from the charging current. The capacitor, C_2, is thus discharged by the current, I, until the lower switching threshold is reached. The second source is then switched off again and the procedure starts again.

Example for oscillator frequency calculation:

$$V_{T100} = V_S \cdot \alpha_1 = (V_{Batt} - I_S \cdot R_3) \cdot \alpha_1$$

$$V_{T<100} = V_S \cdot \alpha_2 = (V_{Batt} - I_S \cdot R_3) \cdot \alpha_2$$

$$V_{TL} = V_S \cdot \alpha_3 = (V_{Batt} - I_S \cdot R_3) \cdot \alpha_3$$

where

V_{T100} = High switching threshold (100% duty cycle)

$V_{T<100}$ = High switching threshold (< 100% duty cycle)

V_{TL} = Low switching threshold

α_1, α_2 and α_3 are fixed constant.

The above mentioned threshold voltages are calculated for the following values given in the data sheet.

V_{Batt} = 12 V, I_S = 4 mA, R_3 = 150 Ω ,
α_1 = 0.7, α_2 = 0.67 and α_3 = 0.28.

$$V_{T100} = (12\ V - 4mA \cdot 150\Omega) \cdot 0.7 \approx 8\ V$$

$$V_{T<100} = 11.4\ V \cdot 0.67 = 7.6\ V$$

$$V_{TL} = 11.4\ V \cdot 0.28 = 3.2\ V$$

For a duty cycle of 100%, an oscillator frequency, f, is as follows:

$$f = \frac{I_{osc}}{2 \cdot (V_{T100} - V_{TL}) \cdot C_2} \text{ , whereas } C_2 = 22 \text{ nF and } I_{osc} = 40 \text{ µA}$$

Therefore:

$$f = \frac{40 \text{ µA}}{2 \cdot (8 \text{ V} - 3.2 \text{ V}) \cdot 22 \text{ nF}} = 189 \text{ Hz}$$

For a duty cycle of less than 100%, the oscillator frequency, f, is as follows:

$$f = \frac{I_{osc}}{2 \cdot (V_{T<100} - V_{TL}) \cdot C_2 + 2 \cdot V_{Batt} \cdot C_4}$$

whereas C_4 = 470 pF

$$= \frac{I_{osc}}{2 \cdot (7.6 \text{ V} - 3.2 \text{ V}) \cdot 22 \text{ nF} + 2 \cdot 12 \text{ V} \cdot 470 \text{ pF}}$$

$$= 195 \text{ Hz}$$

A selection of different values of C_2 and C_4, provides a range of oscillator frequency, f, from 10 to 2000 Hz.

Short-Circuit Protection and Current Sensing, Pins 5 and 6

1. Short-Circuit Detection and Time Delay, t_d

The lamp current is monitored by means of an external shunt resistor. If the lamp current exceeds the threshold for the short-circuit detection circuit ($V_{T2} \approx$ 90 mV), the duty cycle is switched over to 100% and the capacitor C_5 is charged by a current source of 20 µ A ($I_{dis} - I_{ch}$). The external FET is switched off after the cut-off threshold (V_{TL}) is reached. Renewed switching on the FET is possible only after a power-on reset. The current source, I_{ch}, ensures that the capacitor C_5 is not charged by parasitic currents. The capacitor C_5 is discharged by I_{ch} to typ. 0.7 V.

Time delay, t_d, is as follows:

$$t_d = C_5 \cdot (V_{TL} - 0.7 \text{ V})/(I_{dis} - I_{ch})$$

With C_5 = 330 nF and V_{TL} = 9.8 V, ($I_{dis} - I_{ch}$) = 20 µA, we have

$$t_d = 330 \text{ nF} \cdot (9.8 \text{ V} - 0.7 \text{ V})/20 \text{ µA}$$
$$= 150 \text{ ms.}$$

Charge Pump and Output, Pins 7 and 8

Output, Pin 8, is suitable for controlling a power MOSFET. During the active integration phase, the supply current of the operational amplifier is mainly supplied by the capacitor C_3 (bootstrapping). Additionally, a trickle charge is generated by an integrated oscillator ($f_7 \approx$ 400 kHz) and a voltage doubler circuit. This permits a gate voltage supply at a duty cycle of 100%.

Undervoltage Detection

In the event of voltages of approximately V_{Batt} < 5.0 V, the external FET is switched off and the latch for short-circuit detection is reset.

A hysteresis ensures that the FET is switched on again at approximately $V_{Batt} \geq$ 5.4 V.

Ground-Wire Breakage

To protect the FET in the case of ground-wire breakage, a 820 kΩ resistor between gate and source it is recommended to provide proper switch-off conditions.

Absolute Maximum Ratings

Parameters	Symbol	Value	Unit
Supply voltage	V_S	25	V
Junction temperature	T_j	150	°C
Ambient temperature range	T_{amb}	–40 to +110	°C
Storage temperature range	T_{stg}	–55 to +125	°C

Thermal Resistance

Parameters	Symbol	Maximum	Unit
Junction ambient	R_{thJA}	120	K/W

Electrical Characteristics

T_{amb} = –40 to +110°C, V_{Batt} = 9 to 16.5 V, (Basic function is guaranteed between 6.0 V to 9.0 V) reference point GND, unless otherwise specified (see figure 1).

Parameters	Test Conditions / Pins	Symbol	Min	Typ	Max	Unit
Current consumption	Pin 1	I_S			6.8	mA
Supply voltage	Overvoltage detection, stage 1	V_{Batt}			25	V
Stabilized voltage	I_S = 10 mA Pin 1	V_Z	24.5		27.0	V
Battery undervoltage detection	ON OFF	V_{Batt}	4.4 4.8	5.0 5.4	5.6 6.0	V
Oscillator f = 10 to 2000 Hz Pin 4						
Threshold cycle Upper	V_8 = High, $\alpha_1 = \frac{V_{T100}}{V_S}$	α_1	0.68	0.7	0.72	
	V_8 = Low, $\alpha_2 = \frac{V_{T<100}}{V_S}$	α_2	0.65	0.67	0.69	
Lower	$\alpha_3 = \frac{V_{TL}}{V_S}$	α_3	0.26	0.28	0.3	
Constant oscillator current	V_{Batt} = 12 V	$\pm I_{osc}$	26	40	54	µA
Frequency tolerance	C_4 open, C_2 = 470 nF, duty cycle = 50%	Δf	6.0	9.9	13.5	Hz
Stabilized voltage	I_S = 30 mA Pin 1	V_Z	18.5	20.0	21.5	V
Gate output Pin 8						
Voltage	Low level	V_8	0.35	0.70	0.95	V
	V_{Batt} = 16.5 V, T_{amb} = 110°C, R_3 = 150 Ω				1.5	
	High level, duty cycle 100%	V_8		V_7		
Current	V_8 = Low level	I_8	1.0			mA
	V_8 = High level, $I_7 > \| I_8 \|$		–1.0			
Short-circuit protection Pin 6						
Short-circuit current regulation	$V_{T1} = V_S - V_6$	V_{T1}	85	100	120	mV
Short-circuit detection	$V_{T2} = V_S - V_6$	V_{T2}	75	90	105	mV
		$V_{T1} - V_{T2}$	3	10	30	mV
Short circuit recognition, V_{Batt} = 12 V Pin 5						
Switched off threshold	$V_{TL} = V_S - V_5$	V_{TL}	9.5	9.8	10.1	V
Charge current		I_{ch}		23		µA
Dicharge current		I_{dis}		3		µA
Capacitance current	$I_5 = I_{ch} - I_{dis}$	I_5	13	20	27	mA
Voltage doubler Pin 7						
Voltage	Duty cycle 100%	V_7	2 V_S			
Oscillator frequency		f_7	280	400	520	kHz
Internal voltage limitation	I_7 = 5 mA	V_7	26	27.5	30.0	V
	or whichever is lower	V_7	V_{S+14}	V_{S+15}	V_{S+16}	
Switch-off at small duty cycles V_{Batt} = 12 V Pin 3						
Output disabled		V_3/V_S	0.3	0.32	0.34	
Output active		V_3/V_S	0.32	0.34	0.36	
Hysteresis switch-on		$\Delta V_3/V_S$	0.004		0.032	

Application

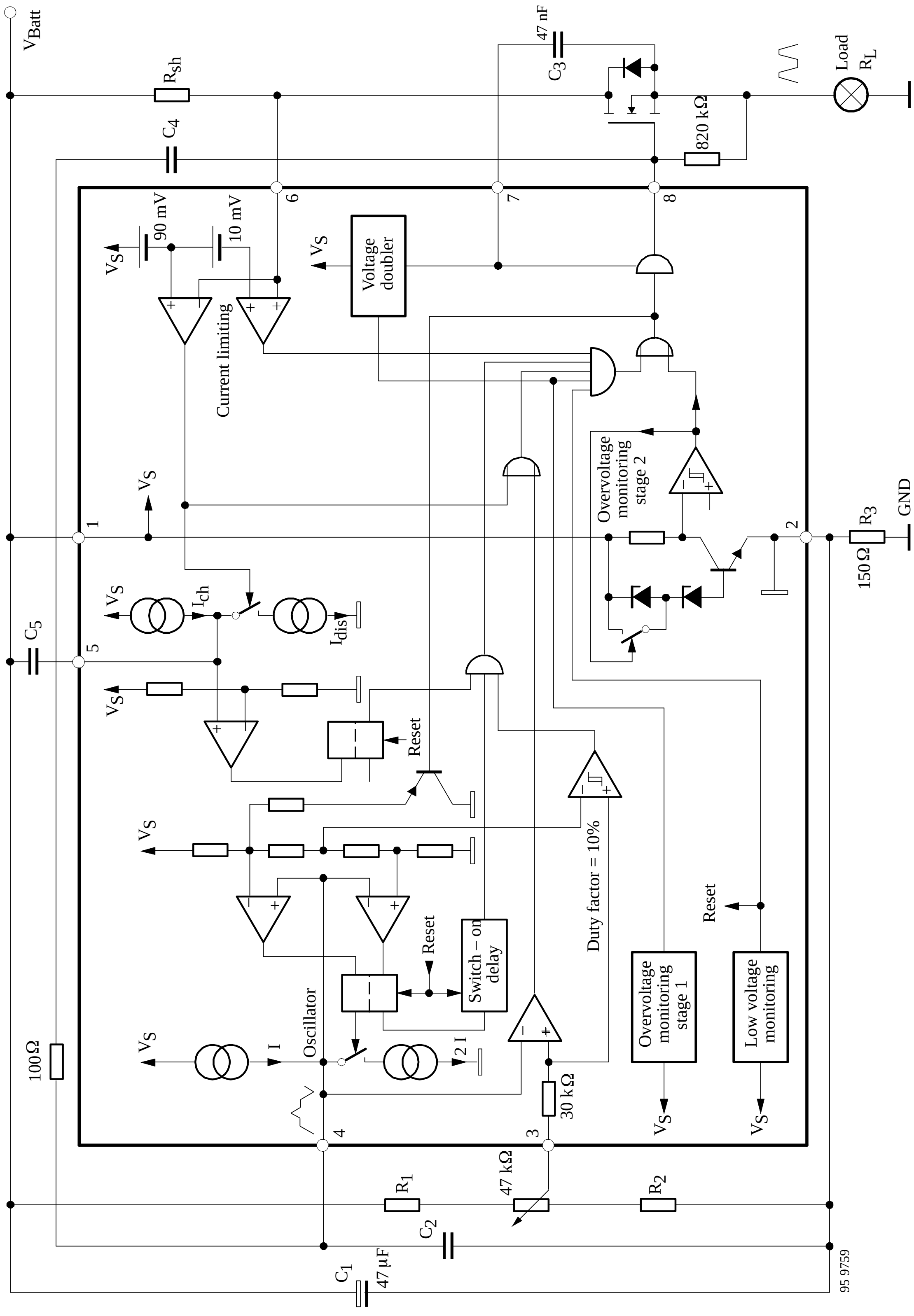
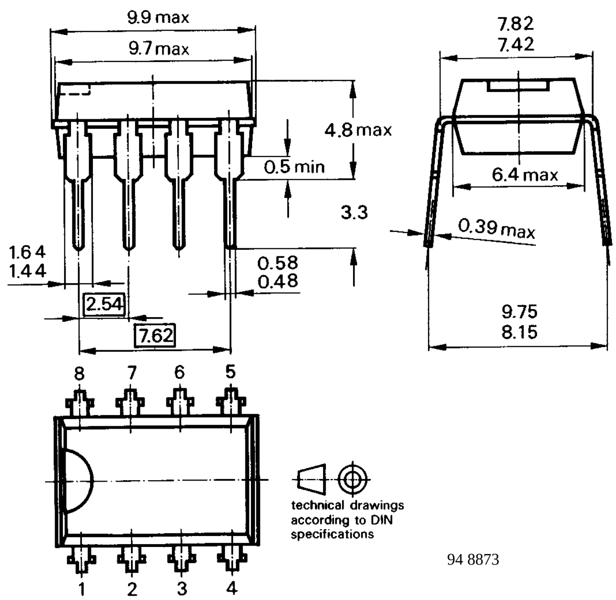


Figure 2.

Dimensions in mm

Package: DIP 8



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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