Automotive Lamp Outage Monitor

Description

The U2481B and the U2482B multicomparator circuits are designed to monitor automotive illumination by sensing the voltage drop across shunt resistors. Provided with extremely low comparator thresholds, these ICs can be used together as a chip set to build an entire lamp monitor system. Single operation of both circuits is also possible.

As a special feature for brake lamp monitoring, the U2481B contains a latch stage connected to one of its triple comparators.

With

– 4 single comparators

– 1 double comparator and

– 2 triple comparators

each of the integrated circuits monitors up to 12 lamps and up to 6 fuses.

All comparator stages are combined together to control the common output stage.

Features

- Extremely low comparator thresholds of typically 3.5 mV
- Internal compensation for copper shunts
- Internal compensation for voltage-dependent bulb characteristic
- Comparator input voltage may exceed supply voltage
- Internal protection measures for pulses according to ISO TR 7637/1
- ESD according to MIL-SID-883 C test method 3015.7
  – Human body model: 4 kV
  – Machine model: 200 V
  EMI protection (TEM cell up to 100 V/m)

Benefits

- Extremely low threshold voltage gives low voltage drop via shunt resistor. Power dissipation of the lamp monitor module is minimized
- Perfect EMC in conjunction with an appropriate pc board layout

Applications

Both ICs can be used in any kind of vehicle with a 12 V supply. It is sufficient to insert small resistors into the lamp wiring and to provide the dashboard instrument cluster with a pilot lamp. These ICs increase the safety and add comfort features.

Block Diagram

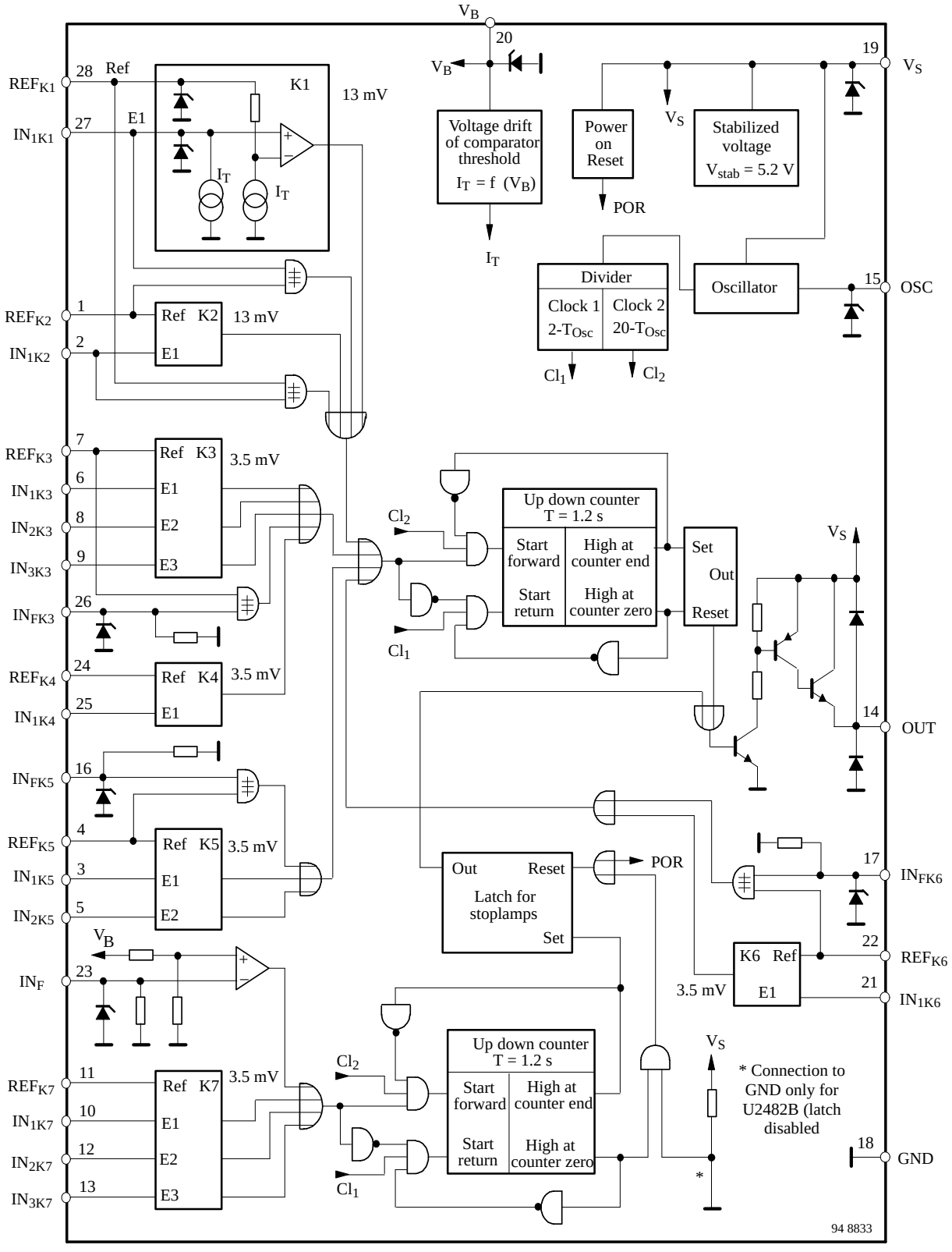


Figure 1.

Pin Description

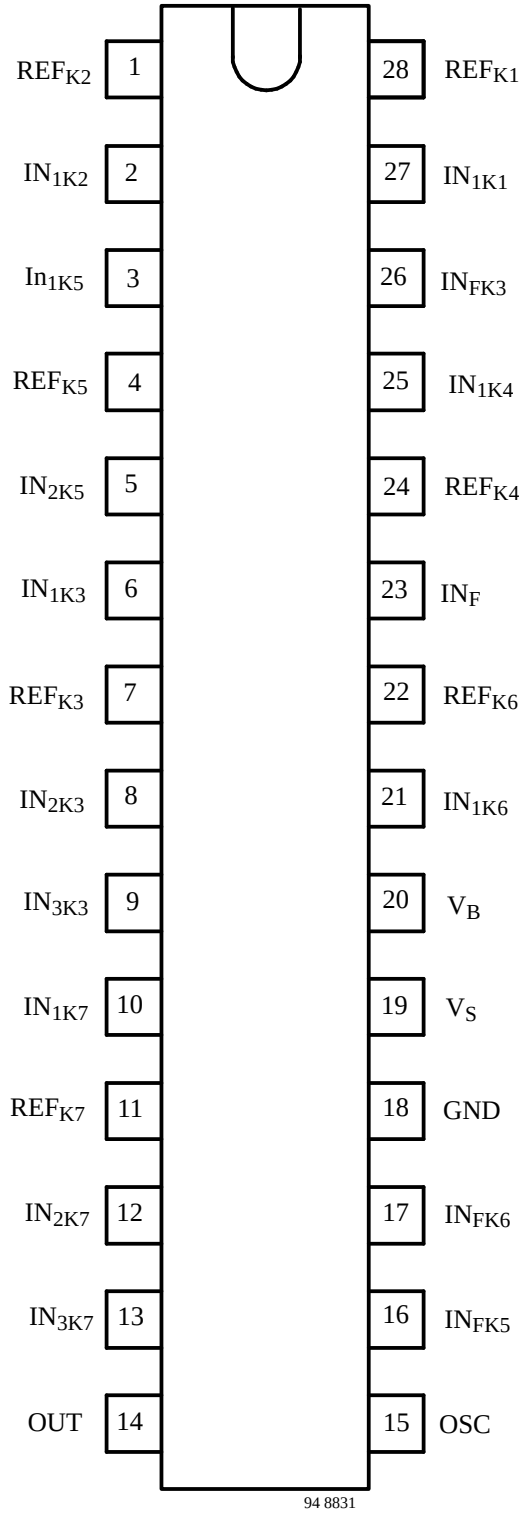
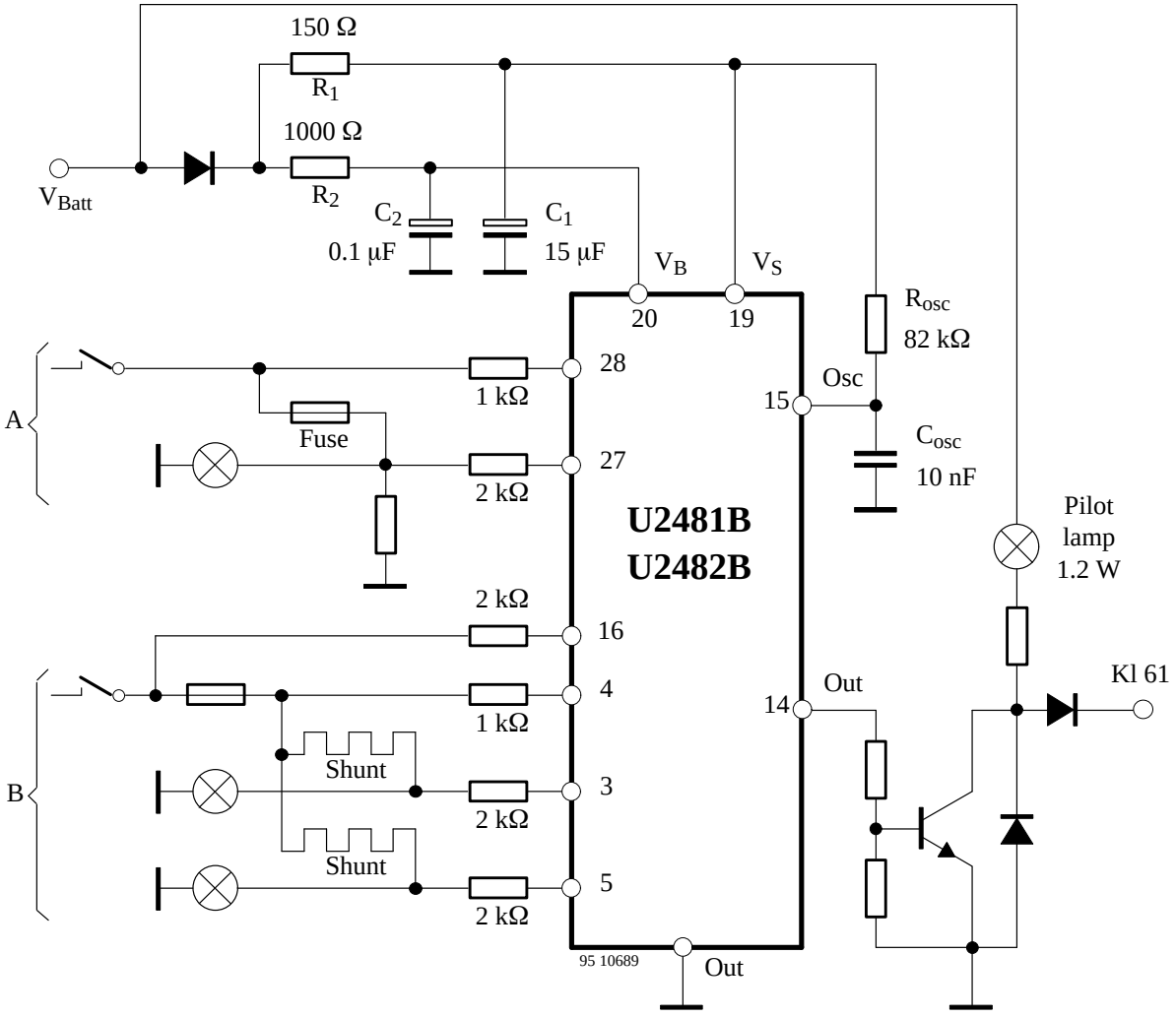


Figure 2. Pin configuration

Pin	Symbol	Function
1	REF_{K2}	Reference for threshold voltage single comparator K2
2	IN_{1K2}	Input 1; single comparator K2
3	IN_{1K5}	Input 1; double comparator K5
4	REF_{K5}	Reference for threshold voltage; double comparator K5
5	IN_{2K5}	Input 2; double comparator K5
6	IN_{1K3}	Input 1; triple comparator K3
7	REF_{K3}	Reference for threshold voltage; triple comparator K3
8	IN_{2K3}	Input 2; triple comparator K3
9	IN_{3K3}	Input 3; triple comparator K3
10	IN_{1K7}	Input 1; triple comparator K7 (U2481B with latch)
11	REF_{K7}	Reference for threshold voltage; triple comparator K7 (U2481B with latch)
12	IN_{2K7}	Input 2; triple comparator K7 (U2481B with latch)
13	IN_{3K7}	Input 3; triple comparator K7 (U2481B with latch)
14	OUT	Output for pilot lamp
15	OSC	R/C combination for oscillator
16	IN_{FK5}	Fuse monitor input ; double comparator K5
17	IN_{FK6}	Fuse monitor input; single comparator K6
18	GND	Ground
19	V_S	Supply voltage
20	V_B	Reference voltage of compara-tors
21	IN_{1K6}	Input1; single comparator K6
22	REF_{K6}	Reference for threshold voltage; single comparator K6
23	IN_F	Input; brake fuse comparator
24	REF_{K4}	Reference for threshold voltage; single comparator K4
25	IN_{1K4}	Input 1; single comparator K4
26	IN_{FK3}	Fuse monitor input; triple comparator K3
27	IN_{1K1}	Input 1; single comparator K1
28	REF_{K1}	Reference for threshold voltage; single comparator K1



A: Example of a “single comparator” using the fuse as a shunt resistor
B: Example of a “double comparator” using copper shunts and additional fuse monitoring

Figure 3. Basic application diagram

Functional Description

Power Supply, Pins 19 and 20

The Ics have two supply pins. The IC itself is supplied via Pin 19 (stabilized voltage, POR-circuitry). Pin 20 supplies only the current sources of the comparators. Both pins have an an internal 21 V Zener Diode for protection. For reasons of interference protection and surge immunity the supply voltage pins have to be provided with RC-circuitries as shown in figure... The resistors limit the current in the case of overvoltage, whereas the capacitors smooth the supply voltage.

Recommended values:

Pin 19: R = 150 Ω; K = 0.1 µF

Pin 20: R = 1000 Ω; K = 0.1 µF

An external diode protects the IC against battery reversal.

Power-On-Reset

When the supply voltage is switched on, a power-on-reset pulse is generated internally which resets the brake lamp monitor latch and the counter stages.

Oscillator, Pin 15

The RC-oscillator is the time base for clock 1 and clock 2 (see block diagram) which are desired from a divider stage and fed to the two upward and downward counters.

The oscillator frequency f_{osc} is mainly determined by the external R/C components and an integrated resistor. The capacitor K is charged by the external resistor and discharged by the integrated one. Because of the temperature characteristic and the tolerances of the integrated 2 kΩ-resistor, the external one has to have considerable higher value in order to achieve a stable frequency.

Calculation of the frequency:

$$f_{osc} = \frac{1}{f_{osc}} = \frac{1}{c_{osc}} \times (0.74\ R_{osc} + 2260\ \Omega)$$

With the recommended values

R_{osc} = 82 kΩ and C_{osc} = 10 nF

$f_{osc} \approx 1.58$ kHz

Comparators

Comparators K1 and K2: threshold voltage of typically V_{th} = 13 mV; designed to monitor high- and low-beam bulbs, where the fuses can be used as shunt resistors.

Comparators K3 to K7: threshold voltage of typically V_{th} = 3.5 mV; designed for all other monitor purposes. Due to the integrated compensation circuitry, these comparators are suitable for pc layer copper shunts.

A bulb is detected as “good” as long as the voltage drop via the shunt resistor exceeds the threshold voltage. The pilot lamp is off. A failed bulb is detected if the voltage drop via the shunt resistor is smaller than the threshold voltage. The pilot lamp is on. An external transistor is necessary to drive the pilot lamp.

In order to disable monitoring when the lamps are switched off, therefore the comparator outputs are disabled if the reference voltage $V_{ref} < V_{Min}$ with $V_{Min} = 0.33 \times V_B$.

As protection against transients on the supply, all comparator inputs require external resistors. Their tolerances directly influence the comparator threshold accuracy. Resistors with a ± 1% tolerance are recommended.

Single comparators: The inputs (K1, K2, K4, K6) sink currents of typically 10 µA each. During switch-over, the currents of reference and input pins are identical. Therefore identical external protection resistors (R = 1 kΩ) are required.

Double comparator: The reference input (K5) sinks a current of typically 20 µA; its inputs sink currents of typically 10 µA each during switch-over. Therefore the external protection resistors must provide R = 1 kΩ for REF_{K5} and R = 2 kΩ each for IN_{1K5} and IN_{2K5}.

Triple comparators: The reference inputs (K3 and K7) sink currents of typically 30 µA. All inputs (IN_{1K3}, IN_{2K3} $IN_{3K3,}$ and IN_{1K7}, IN_{2K7}, IN_{3K7}) sink the identical typical current of 10 µA during switch-over. Therefore the external protection resistor must provide R = 1 kΩ for REF_{K3} and REF_{K7} and R = 3 kΩ at each input.

Fuse Monitoring

The internal EXOR conjunction of comparators K1 and K2 allows fuse monitoring for both lamps. Even a simultaneous blowout of both fuses is detected.

The pins IN_{FK3}, IN_{FK5} and IN_{FK6} with their EXOR gates can be used for additional fuse monitoring.

Detection threshold for a blown fuse is $V_{ref} < V_{Min}$ with $V_{Min} = 0.33\ \ V_B$ (V_B = reference voltage of comparators).

Pin IN_F is used for brake fuse monitoring. With a voltage drop $V_F > 4.8$ V across the fuse, the comparator detects a blown fuse. A voltage drop $V_F < 2.8$ V represents a “good” fuse. U2481B’s comparator K7 is connected to a latch, thus a brake lamp outage is memorized.

Integrated Delay, Debouncing, Failure Display

As soon as a comparator detects a failure a slow upward counter is started in order to generate the delay time, t_{del} = 1.2 s. With a consistent failure the output stage is enabled after t_{del}. If the failure disappears during t_{del} a fast downward counter is started in order to generate the reset time $t_{reset} \geqq$ 135 ms. The upward counter is reset, the output stage stays disabled.

Benefits: Intermittent contacts in the wire harness do not activate the pilot lamp! Even cyclical intermittent contacts are screened out as long as the pulse/pause ratio is smaller than 10:1. In the case of higher duty cycles the upward counter may reach its trigger threshold for the output activation after $t > t_{del}$.

Individual delay- and reset times can be adjusted with external R/C components according to (see “oscillator”)

– $t_{del} = 1930 \times t_{osc}$
– $t_{reset} = 198 \times t_{osc}$

Latch for Brake Lamp Monitor

A failure of a brake lamp detected by comparator K7 or a blown fuse in the brake circuitry is memorized after the delay time has expired.

A reset of the latch can only be performed with a “power-on-reset”.

Output Stage

The output is a Darlington stage stage with protection diodes to V_S and IC ground. The output is designed to drive an external pilot lamp with an external PNP transistor.

At the end of the delay time the output stage is switched on and can source a current of $I_{out} = -10$ mA with a typical saturation voltage of V_{sat} = 1 V.

Test Mode

With V_{TEST} = 23 V (20 mA) applied to Pin osc, via a 200 Ω resistor the delay time stage can be bypassed for test purposes. A failure detection will be displayed immediately to save time during threshold testing.

Application Hints

Layout Recommendations for Copper Layer Shunts

Lamp outage monitor systems can be produced most cost-efficiently if stamped shunt resistors are replaced by copper layer shunts which are generated with the pc board layout.

The U2481B and the U2482B are suitable for this application because of their comparator thresholds, which are compensated in reference to the temperature characteristic of copper.

A constant lamp current, $I_{LAMP} = V_{Th}/R_{sh}$ with threshold voltage V_{Th} = f(T) and shunt resistor R_{sh} = f(T), is achieved if the comparator threshold and the shunt resistor have identical temperature characteristics. With the temperature coefficient of copper $a_{cu} = 3.9 * 10^{-3}$ 1/K, a copper shunt changes its nominal value by 52% if the automotive ambient temperature range of t_{amb} = –40 to +95°C is taken into consideration.

Examples for sheet resistances of copper shunts (T_{amb} = 25°C):
R_A = 0.5 mΩ/square (35.1 µm layer thickness)
R_A = 0.25 mΩ/square (70 µm layer thickness)

How to Lay Out Copper Shunts (figure 3)

The width of the copper trace has to be selected in reference to a low current-effected temperature increase.

The copper trace must be capable of peak currents which do not blow the fuse. The peak currents are specified by the car manufacturers.

Example:
A 7.5 A fuse allows a peak current of 26 A (1 s), 15 A (10 s) or 10 A (60 s).

The copper shunt length has to be calculated between the two sense connections to the comparator. The connection of the common reference input of double and triple comparators has to be considered carefully.

Calculation example for a copper shunt used with a 4 W bulb.

I_{LAMP} = 0.325 A
Failure criterion: $I = 1/2 * I_{LAMP}$
10 A fuse is capable of I = 13.5 A
Copper layer thickness: 70 µm
Comparator threshold voltage (U2481B, U2482B):
V_{Th} = 3.5 mV

Assumed copper width for temperature increase ΔT_{cu} < 50°C:
W_{cu} = 2.5 mm (13.5 A, 70 µm)

Two equations for calculation of the shunt resistance:

$R_{shunt} = R_A * L/W_{cn}$
(with R_A = Cu sheet resistance)
$R_{shunt} = V_{Th} / 1/2\ I_{LAMP}$

Thus the length of copper shunt is calculated as:

$L = 2 * V_{Th} * W_{cn} / R_A * I_{LAMP}$
L = 215 mm

For a reasonable pc-layout a meander-shaped shunt resistor is recommended. The high lamp currents may cause hot spots at sharp edges of the copper shunts. That may deteriorate accuracy of the measurement. Therefore it is recommended to layout the copper shunts with smoothed curves.

In accordance to figure...the meander may be formed by 4 straight tracks (length L_S each) and 3 connecting 180° ares (length L are each). If the mean are radius is selected to $r = W_{cn}$ the are lenght becomes $L_{are} = \pi \times W_{cn}$.

Thus the total lenght is

$L = 4 \times L_S + 3 \times L_{are}$

$= 4 \times L_S + 3 \times \pi \times W_{cn}$

With L = 215 mm the track length becomes

$$L_S = \frac{1}{4}(L - 3 \times \pi \times W_{cn})$$

L_S = 47.8 mm

Using Fuses as Shunt Resistors

This cost saving method can be used if the following assumptions are fulfilled:

– Each lamp needs a dedicated fuse
– The fuse socket is mounted within the monitor module to connect the sense linesare suitable for this monitor
– task because of their comparator thresholds are compensated for the fuse temperature coefficient of $a_F = 4.1 * 10^{-3}$ 1/K

Calculation Example for a 55 W Bulb and a 7.5 A fuse:

Measured voltage drop across the fuse: V_F = 52 mV
Measured current: I_{LAMP} = 4.2 A
Calculated resistance: R_F = 12.4 mΩ
Selected comparatore threshold:
$V_{Th} = 1/4\ V_F$ = 13 mV (typically);
With a lamp current $I_{LAMP} < V_{Th}/R_F$ =< 1.05 A
the comparator detects a blown fuse.

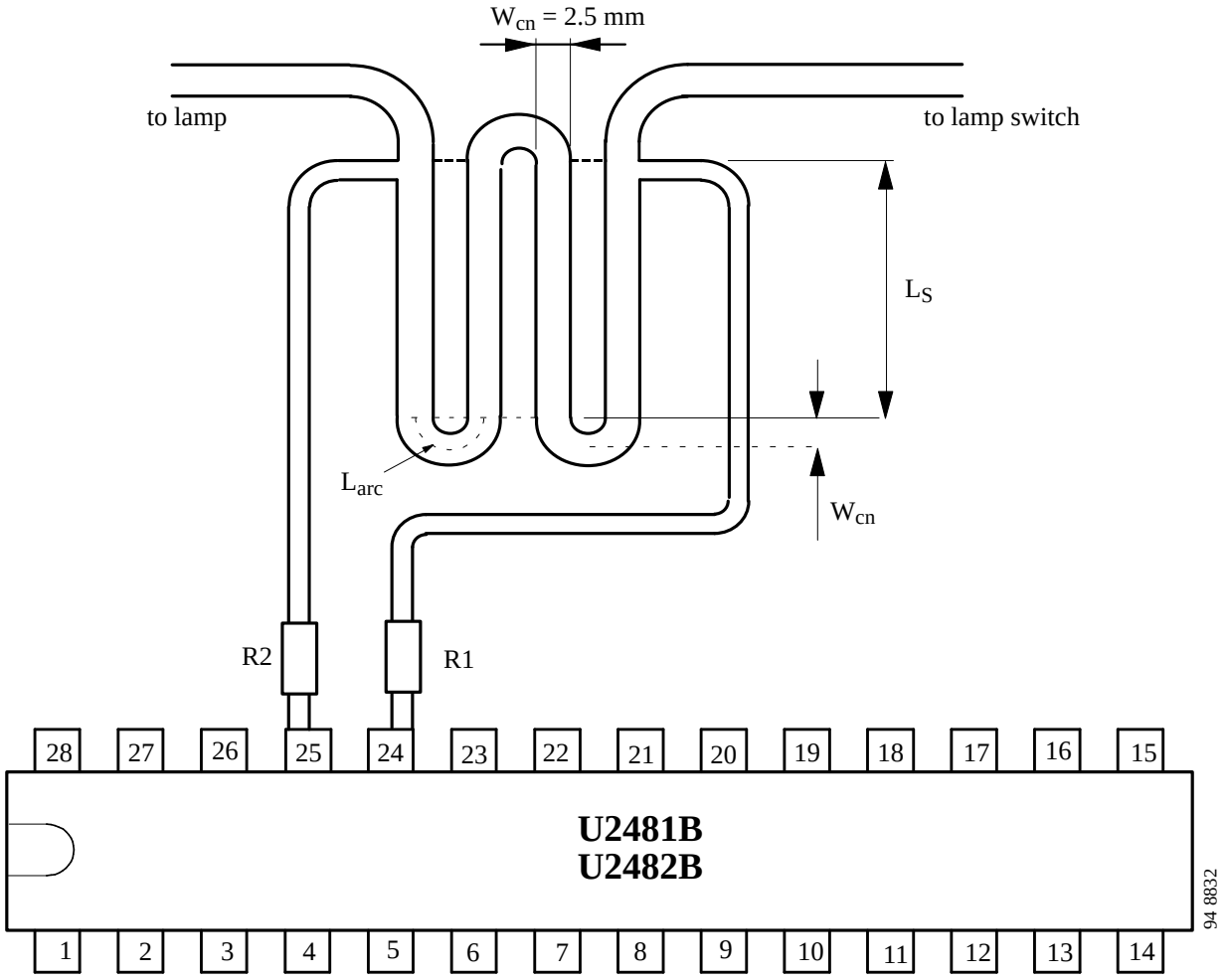


Figure 4. Design example for a copper shunt with meander shape

Absolute Maximum Ratings

Parameters	Symbol	Value	Unit
Supply voltage	V_S, V_{Batt}	16.5	V
Pulse current (2 ms)	I_S	1.1	A
Short circuit current (reversed battery)	I_{SC}	170	mA
Output current	I_{out}	–12	mA
Junction temperature	T_j	150	°C

Thermal Resistance

Parameters		Symbol	Value	Unit
Thermal resistance	SO 28	R_{thJA}	110	K/W
Ambient temperature range		T_{amb}	–40 to +100	°C
Storage temperature range		T_{stg}	–55 to +125	°C

Electrical Characteristics

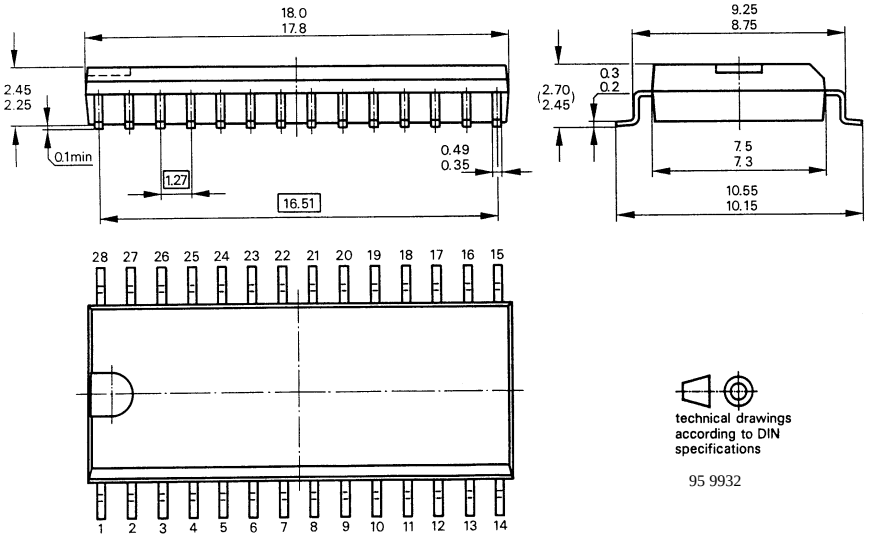
T_{amb} = –40 to +100°C, V_{Batt} (Kl. 15) = 10 to 15 V, supply series resistors and input protection rsistors connected (see figure 1 “block diagram” and figure 2 “basic application schematic”) unless otherwise specified.

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit
Supply						
Operating voltage		V_{Batt}	9		16	V
Supply current	V_{Batt} = 13 V, V_{14} = low Pin 20 Pin 19		 0.3 3	 0.7 5	 1.1 7	 mA mA
Power on reset (POR)	T_{amb} = 25°C Pin 19 V_{Batt} (Kl. 15)		3.0 3.7		4.2 5.0	V V
Comparators						
Comparator input current during switch over	V_{Batt} = 13 V Pins 27, 28 Pins 1, 2 Pins 24, 25 Pins 21, 22 Pin 7 Pins 6, 8, 9 Pin 11 Pins 10–12 Pin 4 Pins 3,5	I_{27}, I_{28} I_1, I_2 I_{24}, I_{25} I_{21}, I_{22} I_7 I_6, I_8, I_9 I_{11} I_{10},I_{11},I_{12} I_4 I_3, I_5		10 10 10 10 30 10 30 10 20 10		µA
Comparator thresholds V_{T1} of comparators K1 and K2 ($V_{T1} = V_{Ref...} - V_{IN...}$)	V_S = 10 V Pins 1, 2, 27, 28 V_S = 13 V V_S = 15 V	V_{T1x} x = Pin No.	8.5 10.0 11.0	11.5 13.0 14.0	14.5 16.0 17.0	mV
Voltage characteristic		ΔV_{T1}		0.5		mV/V
Temperature characteristic		ΔT_{T1}		3900		ppm/°K
Comparator thresholds V_{T2} of comparators K3 to K7 ($V_{T2} = V_{Ref...} - V_{IN...}$)	Pins 6, 7, 8, 9 Pins 24, 25 Pins 3, 4, 5 Pins 21, 22 Pins 10, 11, 12 V_S = 10 V V_S = 13 V V_S = 15 V	V_{T1x} x = Pin No.	 1.5 2.0 2.3	 3.0 3.5 3.8	 4.5 5.0 5.3	 mV
Voltage characteristic		ΔV_{T2}		0.17		mV/V
Temperature characteristic		ΔT_{T2}		3900		ppm/°K
Min. comparator input voltage for detection	all Ref-pins	V_{Min}		0.33 × V_{Batt}		
Output						
Output current	V_{Batt} = 13 V Pin 14	I_{14}		–10.0		mA
Output saturation voltage	I_{out} = –10 mA Pin 19–Pin 14	V_{Sat}		1.0	1.5	V

Parameters	Test Conditions / Pins	Symbol	Min.	Typ.	Max.	Unit
Protection						
Voltage of Zener diodes	Pin 19 Pin 20 all Ref... and IN... pins	V_S V_B $V_{Ref...}$, $V_{IN...}$		21 19 19		V
Oscillator						
Oscillator frequency	R_{osc} = 82 kΩ, C_{osc} = 10 nF, Pin 15	f_{osc}		1.58		kHz
Delay time	R_{osc} = 82 kΩ, C_{osc} = 10 nF	t_d	1.1	1.2	1.3	s
Debounce time	R_{osc} = 82 kΩ, C_{osc} = 10 nF	t_{db}	115	125	135	ms
Break fuse						
Brake fuse detection threshold	V_{Batt} Pin 23	V_{TB}	2.8	3.8	4.8	V
Input current	V_{23} = 13 V Pin 23	I_{23}		100		µA
Trigger threshold (internal pull down resistor)	Pins 16, 17, 28	V_{TTx} x=16,17,18		0.33 × V_{Batt}		V
Input current	V_{Batt} = 13 V	I		100		µA
Test						
Test voltage for delay time override	I = 20 mA Pin 15	V_{15}		23		V

Dimensions in mm

Package: SO 28



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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.

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3. Council Decision 88/540/EEC and 91/690/EEC Annex A, B and C (transitional substances) respectively.

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