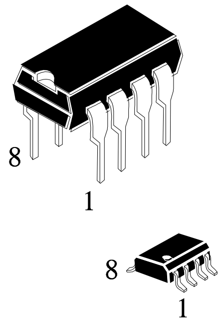
IL9961

HIGH STABILITY LED - DRIVER

Microcircuit IL9961 – average current control mode LED driver

FEATURES:

- Input voltage range V_{IN} from 8 to plus 450 V
- Control by average current;
- Programmed fixed duration of the current off state in the induction coil;
- Linear light Trimming;
- Option of LED brightness Dimming by low frequency PWM signal
- Output short circuit protection;
- IL9910 IC pin-to-pin compatibility;
- Operating temperatures range - 40 ~ + 125 °C.



N SUFFIX
PLASTIC

D SUFFIX
SOIC

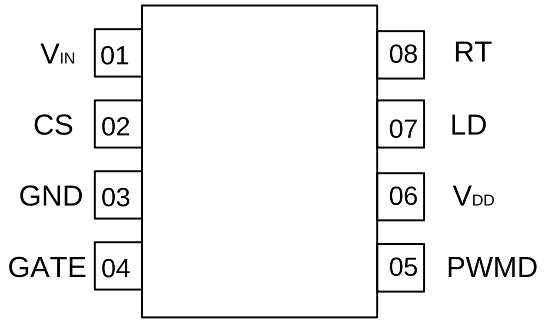
APPLICATION:

- DC/DC or AC/DC LED drivers;
- LED backlight for LCDs;
- Universal DC source;
- LED panels and screens;
- Architecture and decorative LED lighting.

ORDERING INFORMATION

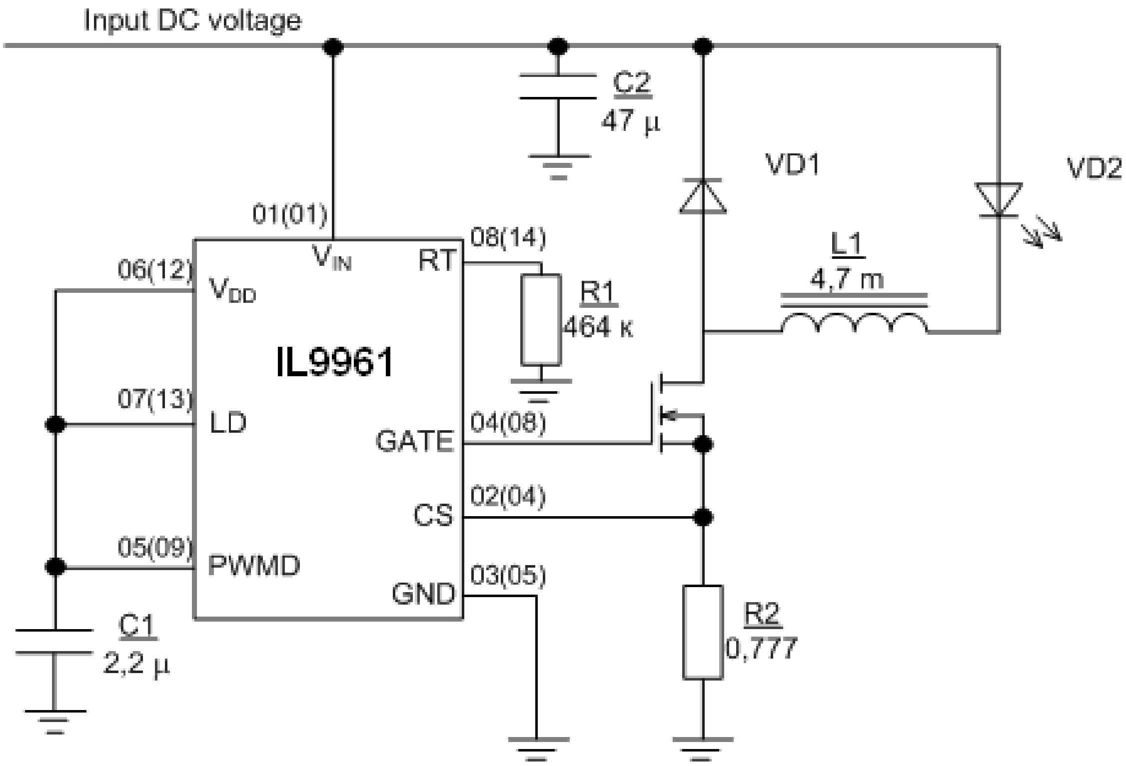
Device	Package	Packing
IL9961N	DIP-8	Tube
IL9961DT	SOP-8	Tape & Reel

PIN ASSIGNMENT



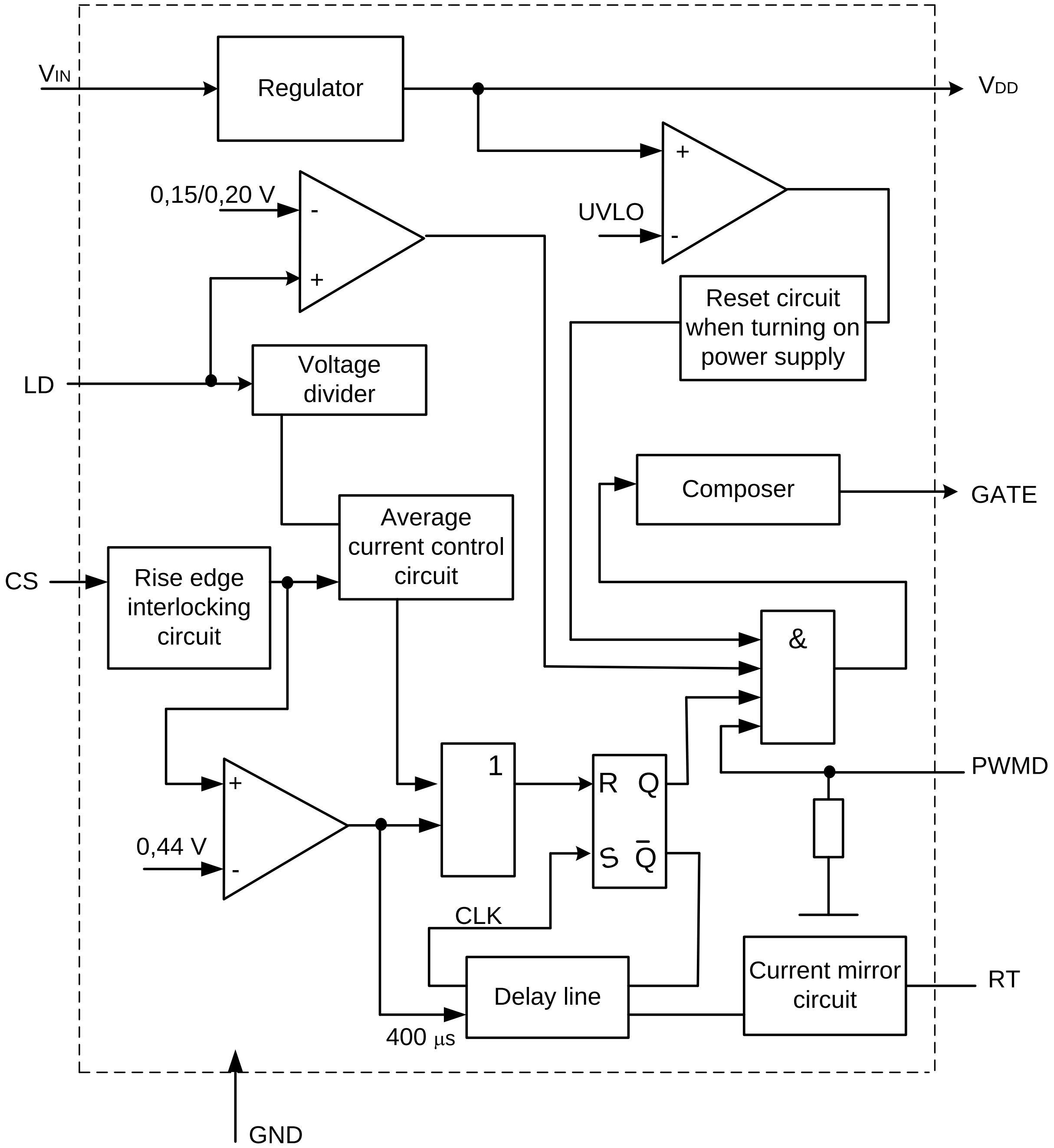
Pin Number IL9961N/D	Symbol	Description
01	V_{IN}	Input voltage input
02	CS	Current control input of LEDs
03	GND	Common pin
03	GND	Common pin
04	GATE	Output for control external MOSFET-transistor control
06	V_{DD}	Pin of internally controlled supply voltage
05	PWMD	Pin of attenuation low frequency PWM
06	V_{DD}	Internally controlled supply voltage
07	LD	Linear attenuation input
08	RT	RC-generator resistor connection pin

Typical Application Circuit



L1 - induction coil 4.7mH
VD1 – diode
VD2 – LED

Block Diagram



Absolute Maximum Ratings

Symbol	Description	Limit		Unit
		Min	Max	
V_{IN}	Input voltage	-0.5	470	V
V_{DD}	Voltage, applied to the pin V_{DD}	-0.3	12.3	V
-	Voltage at pin PWMD, CS, LD, GATE, RT	-0.3	V_{DD} + 0.3	V
Ta	Limit ambient temperature	-60	150	°C

* Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied.
Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

Recommended Operating Ratings

Symbol	Description	Limit		Unit
		Min	Max	
V_{IN}	Input voltage[1)]	8	450	V
V_{DDMAX}	Maximum voltage, applied to the pin V_{DD}	–	12	V
Tj	Maximum chip temperature	–	150	°C
P_{DIS}	Dissipated power, in package SO-8	–	650[2)]	mW
	In package SO-16		1000[2)]	

[1)] It is limited by dissipated power in the package
[2)] Value P_{DIS} is indicated at the ambient temperature of Ta ≤ 25 °C

Electrical Parameters

Symbol	Description	Test Conditions		Limit		Ambient Temperature, °C	Unit
				Min	Max		
V_{DDR}	Internally controlled supply voltage	V_{IN} = 8 V, $I_{DD(ext)}$ =0mA	25	7.05	7.75	25 ± 10	V
			-40 ~ 125	7.00	8.00	–40 ~125	
		V_{IN} = 450 V, $I_{DD(ext)}$ = 0 mA		7.05 7.00	8.75 9.00		
$\Delta V_{DD(load)}$	Non-stability of the internally controlled voltage by load	V_{IN} = 12.0 V, $I_{DD(ext)}$ = 1.0 mA, $I_{DD(ext)}$ = 0 mA		-	0.1 0.2		V
$UVLO_{RISE}$	Threshold value of the internal supply voltage at supply voltage rise	V_{DD} rises		6.06 6.00	6.88 6.95		V
$UVLO_{FAL}$	Threshold value of the internal supply voltage at supply voltage fall	V_{DD} falls		5.0 4.8	-		V
$V_{EN(hi)}$	PWMD pin high level input voltage	V_{DD} = $V_{DDR,}$ V_{IN} = 450 V		1.95 2.00	-		V
$V_{EN(lo)}$	PWMD pin low level input voltage	V_{DD} = $V_{DDR,}$ V_{IN} = 8 V		-	0.82 0.80		V
R_{EN}	Attenuating resistance at PWMD pin	V_{PMW_D} = 5 V		50 45	150 160		kOhm
$V_{CS(AVG)}$	Threshold voltage of the average current control block in load	V_{IN} = 12.0 V, V_{LD} = 3 V, V_{DD} = V_{DDR}		264.0 259.0	280.0 285.0		mV
$V_{CS(LD)}$		V_{IN} = 12.0 V, V_{LD} = 1 V, V_{DD} = V_{DDR}		171.0 170.0	189.2 190.0		
$V_{LD(OFF)}$	Driver switch-off voltage by LD input	V_{IN} = 12.0 V, V_{DD} = $V_{DDR,}$ V_{LD} falls		100 80	-		mV
$V_{LD(ON)}$	Driver switch-on voltage by LD input	V_{IN} = 12.0 V, V_{DD} = $V_{DDR,}$ V_{LD} rises		-	300 330		mV

Electrical Parameters continued

Symbol	Description	Test Conditions	Limit		Ambient Temperature, °C	Unit
			Min	Max		
$V_{CS(LIM)}$	Threshold voltage of the absolute maximum current control block in load	$V_{DD} = V_{DDR},$ V_{IN} = 12.0 V	410 390	470 490	25 ± 10 –40~125	mV
I_{SOURCE}	GATE pin high level output current	V_{DD} = 7.5 V, V_{GATE} = 0 V	|-165| |-100|	-		mA
I_{SINK}	GATE pin low level output current	V_{DD} = 7.5 V, $V_{GATE} = V_{DD}$	165 100	-		mA
I_{INsd}	Consumption current in off-mode	V_{IN} = 12.0 V, $V_{LD} = V_{DD},$ V_{PWMD} = 0 V	-	0.9 1.0		mA
t_{BLANK}	Front edge blanking time of the current control	V_{IN} = 12.0 V, $V_{DD} = V_{DDR}$	155 150	310 320		ns
$t_{ON(MIN)}$	Driver enable minimum time	V_{IN} = 12.0 V, $V_{DD} = V_{DDR},$ V_{CS} = 520 mV	-	1000 1500		ns
t_{DELAY}	Switch-over delay time of the output GATE during the sinal alteration at the input CS	V_{IN} = 12.0 V, $V_{DD} = V_{DDR},$ V_{CS} = 520 mV	-	150 200		ns
t_{HICCUP}	Driver disable time in the limit current mode	V_{IN} = 12.0 V, $V_{DD} = V_{DDR},$ $V_{CS} = V_{DD}$	330 250	550 650		us
$t_{ON(LIM)}$	Driver enable minimum time in absolute maximum current mode	V_{IN} = 12.0 V, $V_{DD} = V_{DDR},$ $V_{CS} = V_{DD}$	-	430 515		us
t_{OFF}	Driver disable time duration	V_{IN} = 12.0 V, $V_{DD} = V_{DDR},$ R_{OSC} = 1 mOhm	32 25	48 55		us
		V_{IN} = 12.0 V, $V_{DD} = V_{DDR},$ R_{OSC} = 226 kOhm	8 6	12 14		

Brief Description of Microcircuit

IL9961 is essentially a LED driver microcircuit, ensuring trimming by average current and functioning in the mode with the fixed duration of the off-state.

Opposite to the microcircuits with the peak current control the given microcircuit does not have errors, caused by the difference «peak current – average current». This substantially enhances accuracy and efficiency of trimming the LED current during alteration of the supply voltage or load without necessity to apply the compensation circuits.

Supply of driver IL9961 may be provided from the DC voltage mains of 8 ~ 450 V or the AC mains rectifier of 85 ~ 265 V.

Average value of output current may be programmed by selecting the various value of the current metering resistor by the internal (stabilized with the accuracy of ±3 %) reference voltage, equal to (272 ± 8) mV. It is possible to adjust the mean value of output current, presetting at the light power linear trimming input the voltage within the range of 0 ~ 1.5 V. The LED dimming adjustment is ensured by alteration of the off-duty signal at the input of the PWM-regulator.

Information on Application

Trimming by the peak current of the step-up converter (as in IL9910B) is the most economic and simple means of adjusting the output current. However, during such adjustment the problems emerge with the accuracy and stabilization of current due to occurrence of the errors, generated by the difference «peak current – mean current», which shows up as a result of the current pulsation in the output inductor and the signal propagation delay in the current reading comparator.

It is also impossible to measure up the continuous signal of the inductor current relative to the ground in the volt-boosting converter as the power transistor is open only during the small time periods.

Although it is sufficient to simply detect the peak current at the circuit transistor, trimming by means of the inductor mean current is usually tied to the current signals relative to voltage V_{IN}.

In IL9961 the appropriate control circuit is used, ensuring the rapid and a very fine trimming by the average current in the inductor by means of reading the transistor current only. No compensation current trimming circuit is required. Current pulsations in the inductor circuit do not have any significant influence on this control circuit, and therefore the LED current does not depend on variation of the inductance values, switch-over frequency and output voltage.

Functioning in the mode of the fixed duration of the current off-state in the inductance coil is used for stabilization and efficiency enhancement of the of LED current trimming in the wide range of input voltages (opposite of IL9910, the microcircuits IL9961 does not support the operational mode at the constant frequency).

The type output parameters of the LED driver IL9961 are indicated in Figure 5. For comparison reasons the corresponding parameters of IL9910 are also indicated.

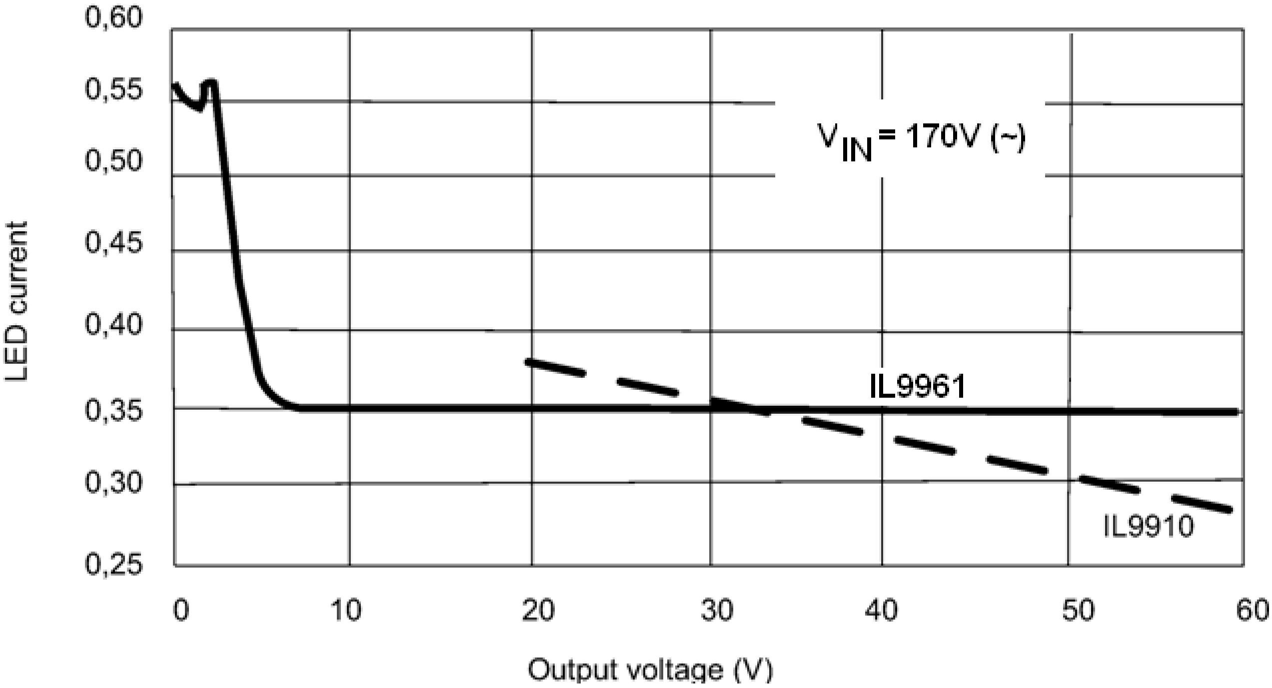


Figure 6 – LED Driver IL9961 typical output parameters

Driver's Operation Description

ICs IL9961 make it possible to control all main types of the key volt-boosting converters, both with the insulated output and the non-insulated one. When the permitting signal arrives at the gate of the external MOSFET-transistor, the LED-driver starts to build up the internal energy on the inductance coil or the transformer's primary winding, then the given energy, by various ways, depending on the type of the volt-boosting converter, arrives directly to LEDs. The energy, accumulated in the magnetic element, arrives in the output circuit within the time period of switching off the power MOSFET-transistor, presetting the current in the circuit of LEDs.

With the input supply voltage applied, when the voltage at the pin V_{DD} reaches the threshold value of the internal supply voltage of the low voltage part of the circuit UVLO, the voltage at the pin GATE rises, and the external MOSFET-transistor switches over to the open state. The value of output current is controlled by means of limiting by the external MOSFET-transistor the mean current of the inductance coil. The voltage, falling at the reading resistor, in a serial connection with the source of the external MOSFET-transistor, arrives at the input CS IC IL9961. When the given voltage reaches the threshold value of the comparator actuation, the voltage at the pin GATE remains unchanged during the time, equal to the enable time of GATE prior to actuation of the comparator. Thus the trimming is ensured by the current mean value. Then the external MOSFET-transistor switches over to the closed state. The threshold value of the comparator actuation is preset inside the circuit and constitutes 272 mV or can alter outside by means of applying voltage at the input LD.

Input voltage control

Supply for driver IL9961 may be realized directly from mains of voltage of direct current 8.0~450 V through pin V_{IN}. When this voltage supplied on pin V_{IN} integrated circuit forms direct voltage 7.5 V on pin V_{DD}. To pin V_{DD} there should be connected capacitor with small equivalent series resistance (ESR), in order to provide low resistance of bus for pulses of large current through GATE pin during integrated circuit operation. IC IL9961 also can be supplied directly through V_{DD} pin with voltage larger than internally-regulated 7.5 V, but less than 12 V.

Direct voltage supplied on V_{IN} pin, is limited by dissipated power in the package. For example, in eight pin SO package at consumption in operating mode of current I_{IN} = 2.5 mA through V_{IN} pin, maximum direct voltage on V_{IN} pin is calculated by formula (1)

$$U_{IN} = \frac{(T_j - T_a)}{R_{\theta.ja} \cdot I_{IN}} = 347\ V, \qquad (1)$$

where T_j = 150 – maximum operating temperature of chip, ^{O}C;
T_a = 25 - ambient temperature, ^{0}C;
$R_{\theta,\,ja}$ = 148 - thermal resistance of chip - ambient, ^{O}C / Watt.

In cases when integrated circuit should operate at higher voltage, sequentially to V_{IN} pin can be connect resistor or Zener diode for removal of dissipated power from IC. In mentioned example, use of 100 V Zener diode allows the scheme to operate up to 447 V. Input current, consumed by integrated circuit through V_{IN} pin is calculated by formula (2)

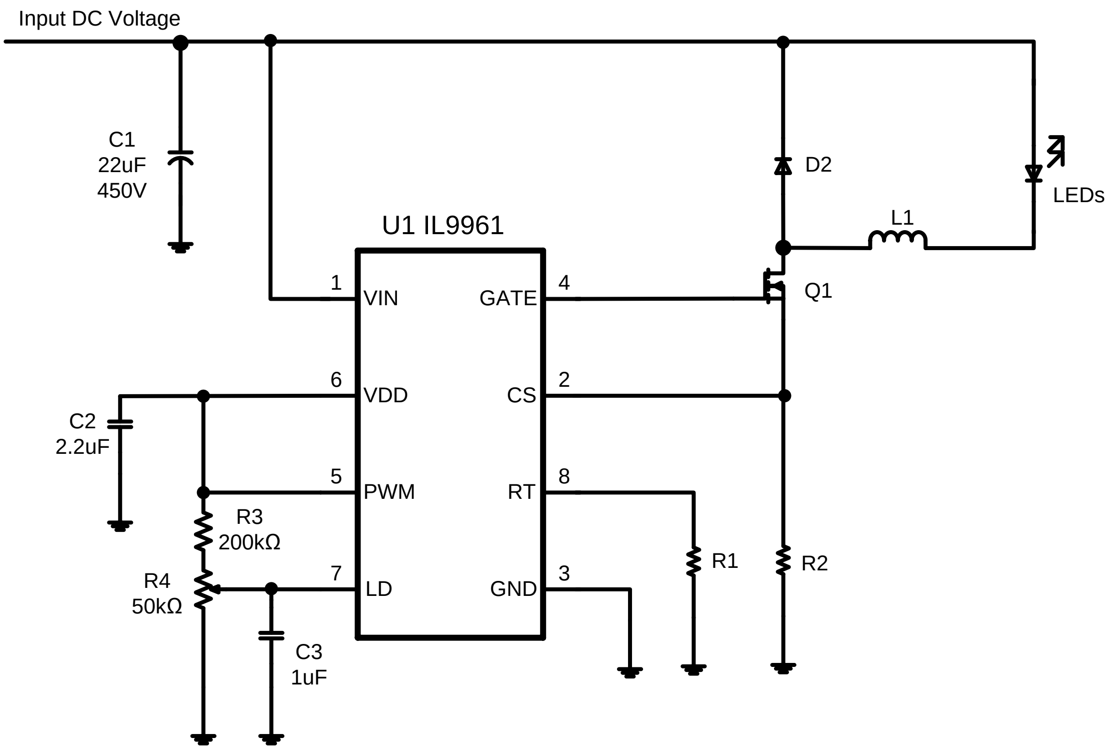
$$I_{IN} \approx 1{,}0mA + Q_G \cdot f_s, \qquad (2)$$

where Q_G - capacity of gate of exterior transistor (from producer specification), pF;
f_s - switching frequency, Hz.

LEDs Dimming Control

The LEDs dimming control may be performed by two means, separately or in combination, depending on the application circuit. The LEDs dimming may be controlled either by means of the linear alteration of the current value via LEDs, or by switching on / off this current at its constant value. The second adjustment method (the so called MWM-attenuation) is based on LEDs dimming by means of altering the fill-up ratio of the output current pulses.

The linear adjustment of LEDs dimming (linear attenuation) is performed by means of applying the voltage with the value from 0 to 1.5 V at the input LD. In this case the actuation threshold of the comparator, controlling the voltage at the pin CS, is preset equal to the value: V_{LD}·0.18. It is in this way, that adjustment of the output current value takes place. The value of the controlled voltage at the pin CS can be altered by means of the variable resistor, included into the lower shoulder of the resistive voltage divider of the low voltage part of the circuit V_{DD} and connected to the pin LD. Application of the voltage over 1.5 V at the input LD does not result in increase of the preset mean value of the output current. In order to obtain the current of the greater value it is necessary to select the reading resistor with the smaller nominal resistance.

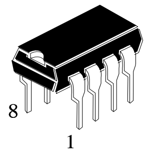


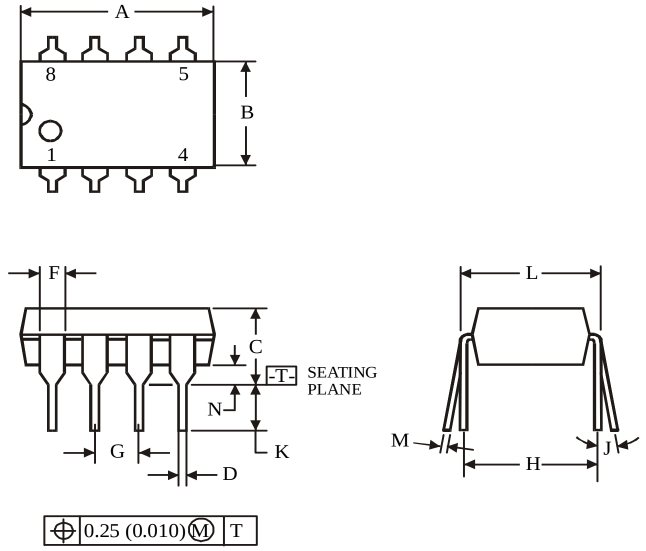
IL9961 Linear Dimming Control Schematic

PWM-attenuation is performed by means of application of the external PWM-signal at the pin PWMD. PWM-signal may be generated by the microcontroller or the pulse generator with the pulse fill-up ratio, proportionate to the LEDs dimming rate. This signal permits or denies the LEDs current modulation depending on the pulse shape. In this mode the current value through LEDs may be in one of two positions: zero or the current nominal value, preset by means of the reading resistor, connected to the source of the external MOSFET-transistor. Using the given method, it is impossible to attain the LEDs' brightness over the value, which is limited by the internally pre-set threshold of the comparator actuation. When using the PWM-attenuation in operation of IC IL9961, LEDs' brightness is adjusted from 0 to 100 %. Accuracy of the PWM-attenuation method is limited only by the minimum pulse duration, arriving at the gate of the external MOSFET-transistor, which constitutes fractions of percent from the fill-up ratio of the PWM-signal pulses.

Package Dimensions

N SUFFIX PLASTIC DIP
(MS – 001BA)



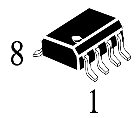


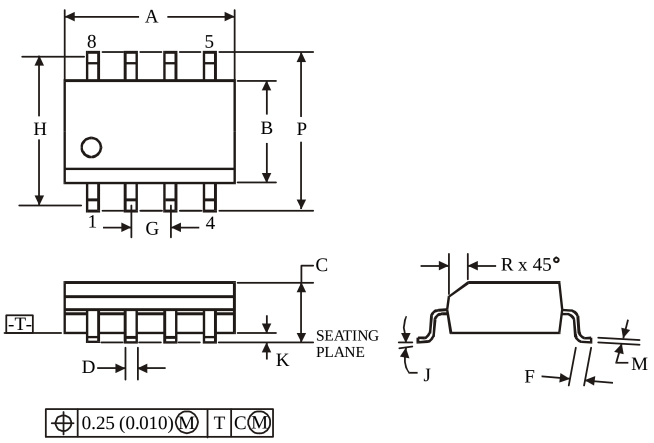
	Dimension, mm	
Symbol	**MIN**	**MAX**
A	8.51	10.16
B	6.1	7.11
C		5.33
D	0.36	0.56
F	1.14	1.78
G	2.54	
H	7.62	
J	0°	10°
K	2.92	3.81
L	7.62	8.26
M	0.2	0.36
N	0.38	

NOTES:

1. Dimensions "A", "B" do not include mold flash or protrusions.
   Maximum mold flash or protrusions 0.25 mm (0.010) per side.

D SUFFIX SOIC
(MS - 012AA)





	Dimension, mm	
Symbol	**MIN**	**MAX**
A	4.8	5
B	3.8	4
C	1.35	1.75
D	0.33	0.51
F	0.4	1.27
G	1.27	
H	5.72	
J	0°	8°
K	0.1	0.25
M	0.19	0.25
P	5.8	6.2
R	0.25	0.5

NOTES:

1. Dimensions A and B do not include mold flash or protrusion.
2. Maximum mold flash or protrusion 0.15 mm (0.006) per side
   for A; for B ‐ 0.25 mm (0.010) per side.