E910.84

PIR Light Controller For 2 and 3 Wire Applications

General Description

The E910.84 integrated circuit combines all required functions for a single chip Passive Infra Red (PIR) light controller.

It is designed for load switching with a TRIAC in 2 wire and 3 wire systems.

A conventional PIR sensor connects directly to the PIRIN input. The pull-down resistors and DC decoupling circuitry are integrated on chip. The PIR signal is converted to a 15 bit digital value.

External potentiometers or resistors are used to set the operating parameters for sensitivity, on-time, brightness, fade, daylight sensor and environment temperature correction. The corresponding voltage levels are converted to digital values with a 4 bit resolution

All signal processing is performed digitally.

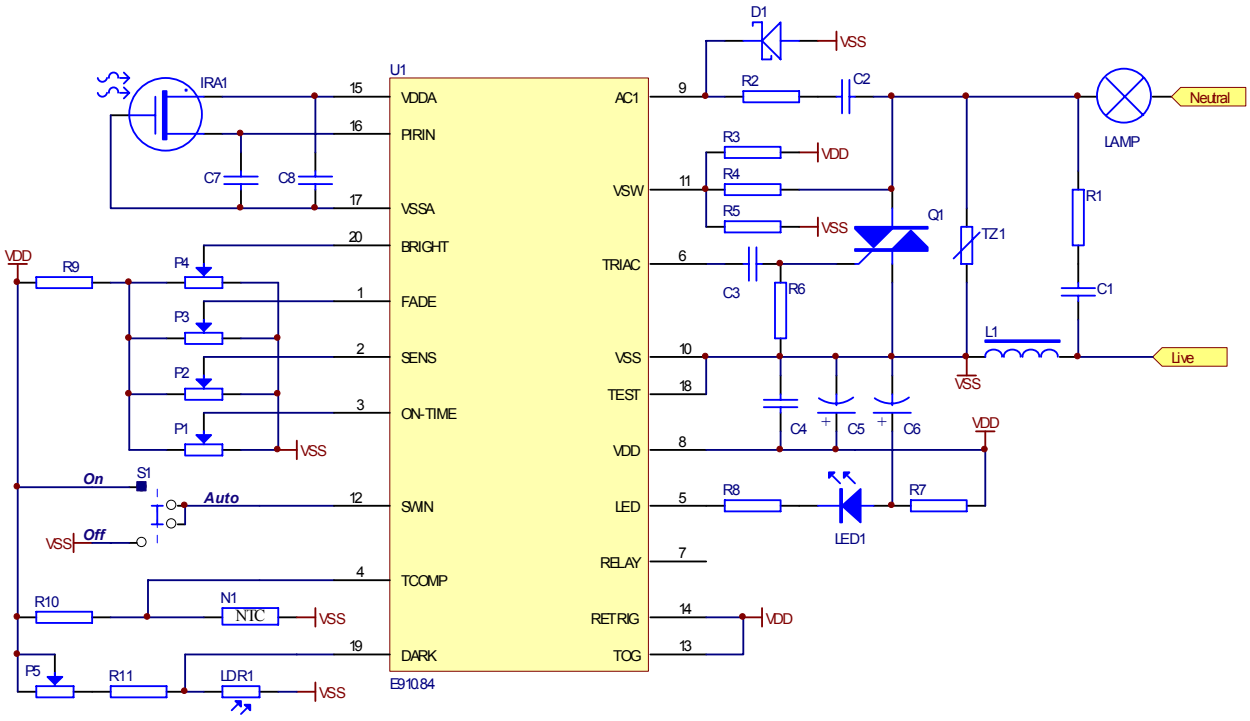
Applications

- Outdoor and indoor motion sensor lights
- High end lighting switches
- Automatic bedroom night lights
- Energy saving

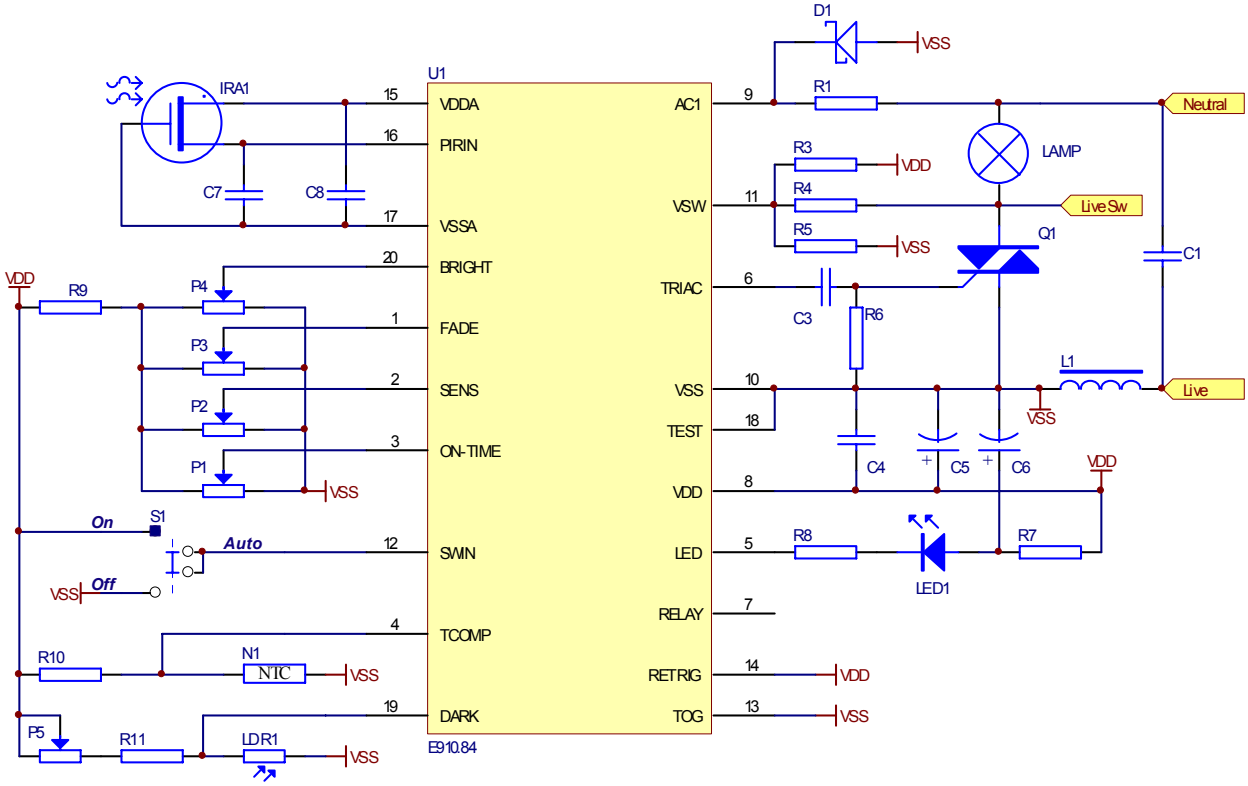
Features

- Digital signal processing
- On chip rectifier and supply regulator
- Low power consumption
- Temperature compensation input
- Adjustable soft on/off switching (fading)
- Light mode: Increase lamp brightness from set brightness to full brightness on movement.
- Light mode: Increase lamp brightness from off to set brightness on movement.
- Dimmer function
- Inductive load switching
- Capacitive load on/off switching
- Four quadrant TRIAC driver
- Suitable for 115V/60Hz and 230V/50Hz applications
- Low TRIAC switching noise

2 Wire Application Circuit



3 Wire Application Circuit



Component values for both applications

Designator	Description 2 Wire Application	Description 3 Wire Application
R1	1kΩ 2W	2x 47kΩ
R2	1kΩ 2W	Not Used
R3	470kΩ	
R4	2MΩ	
R5	470kΩ	
R6	10kΩ	
R7	47kΩ	
R8	470Ω	
R9	33kΩ	
R10	100kΩ	
P1, P2, P3, P4	47kΩ Trim pot	
P5	2.2MΩ Trim pot	
C2	220nF / 250V AC	Not Used
C3	100nF	
C4, C8	470nF	
C5, C6	470µF, 16V	
C7	1nF	
D1	10MQ100N Schottky	
IRA1	LHI 878, Perkin Elmer	
C1*	100..220nF, class X (dependent on local EMC regulations)	
Q1	BT136 TRIAC 600V, 4A	
L1	Inductor 100..1500µH	
N1	100kΩ NTC Resistor β = 4500	
LDR1*	Light Dependant Resistor	

Table 1: Component Values for Application Circuits
*Values must be determined by the manufacturer

Electrical Characteristics

Absolute Maximum Ratings

Parameter	Symbol	Min	Max	Unit	Remarks
Supply voltage	V_{DD}	-0.3	7	V	
Current into any pin		-100	100	mA	One pin at a time
Storage temperature	T_{st}	-45	125	°C	

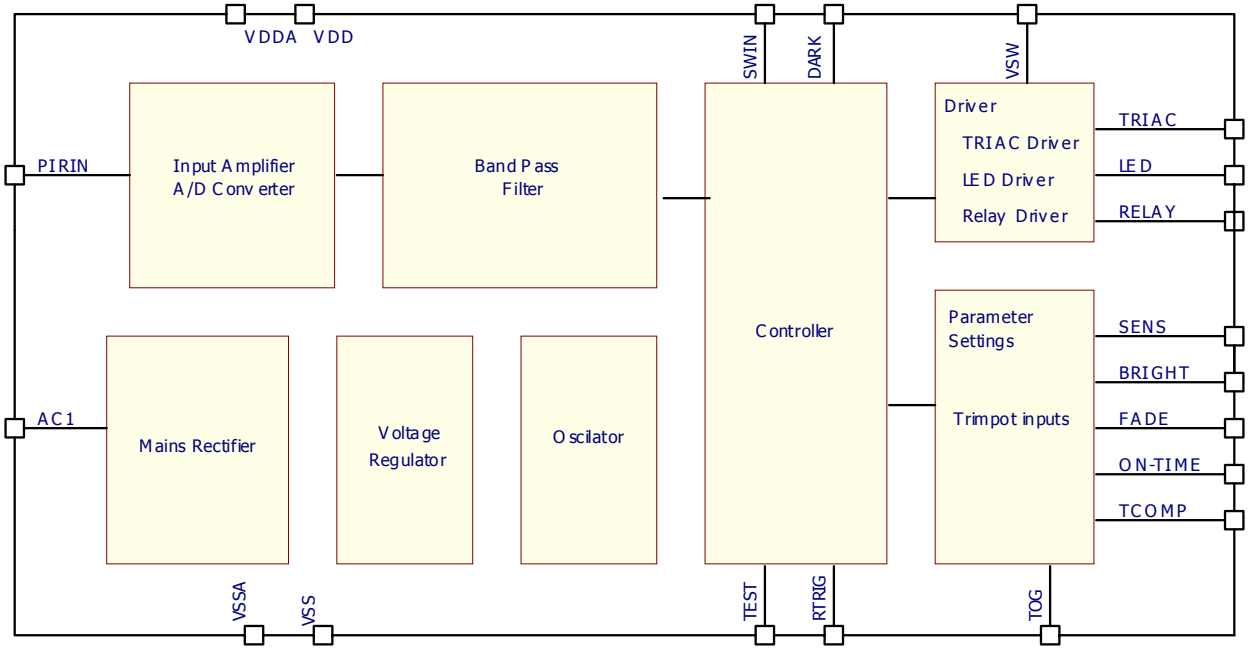
Table 2: Electrical Characteristics (Stresses beyond those listed above may cause permanent damage to the device. Exposure to absolute maximum ratings may affect the device reliability. ESD protection: all pins will be able to withstand a discharge of a 100pF capacitor charged to 1.6kV through a 1500Ω series resistor. Test method: MIL-STD-883D method 3015).

Operating Conditions (T=25°C, VDD=5V, unless stated otherwise)

Parameter	Symbol	Min	Typ	Max	Unit	Remarks
Temperature						
Operating temperature range		-25		70	°C	
Rectifier / Regulator						
AC1, input current, t<200us			500		mA	Repetitive @ 60Hz
Regulated supply voltage	V_{DD}			4.5	V	
Supply current	I_{DD}			0.3	mA	V_{DD}=4.5V Outputs unloaded
Digital Inputs, Schmitt Triggers (TEST, RETRIG, DARK, SWIN)						
Input low voltage	V_{IL}	80			%V_{DD}	
Input high voltage	V_{IH}			20	%V_{DD}	
Pull down current on TEST			140		µA	input to V_{DD}
Pull up current on RETRIG			140		µA	input to V_{SS}
Leakage current on DARK				±1	µA	input to V_{SS} or V_{DD}
Pull up/ pull down scanning current on SWIN				6	mA	input to V_{SS} or V_{DD}
VSW Digital Inputs						
Input low voltage	V_{SWL}			1	V	
Input high voltage	V_{SWH}	V_{DD}-1			V	
Digital Outputs (LED, TRIAC, RELAY)						
Output low voltage	V_{OL}			10	%V_{DD}	I_{SOURCE}=5mA
Output high voltage	V_{OH}	90			%V_{DD}	I_{SINK}=2mA
Analog Inputs						
Input leakage current (ON-TIME, SENS, FADE, BRIGHT, TCOMP, TOG)		-1		1	µA	
PIRIN resistance to V_{SS}			60		kΩ	
PIRIN input AC voltage				5	mV	Peak-to-Peak
PIRIN input DC voltage		0		V_{DD}	V	
PIR resolution			7		µV	Per threshold count
Oscillator and Filter						
LPF cutoff frequency			7		Hz	
HPF cutoff frequency			0.5		Hz	
Internal clock frequency	F_{CLK}		28.5		kHz	

Table 3: Operating Conditions

Detailed Description



Mains Rectifier

The E910.84 contains an on chip one way rectifier. The negative half wave is shorted to VSS. The rectifier operates with capacitive and resistive voltage dropper circuits. The maximum peak current must be limited to 300mA. The average current must be less than 20mA.

Voltage Regulator

The voltage regulator acts as a Zener diode between V_{DD} and VSS. An external smoothing capacitor is required between the V_{DD} and V_{SS} pins. The device can tolerate 50Hz ripple on its supply, because the PIR signal is filtered with a second order digital low pass having a low cutoff frequency. The voltage regulator can shunt currents up to 20mA continuously.

Oscillator

The IC contains an on chip oscillator with frequency set to 57 kHz. All timing signals and cutoff frequencies of the digital filters are derived from this frequency.

Input amplifier and A/D Converter

The PIRIN input has an internal pull-down resistor and DC decoupling circuitry. The signal voltage on the PIR input is converted to a 15 bit digital value.

Band-Pass Filter

A 2nd order digital Butterworth band-pass filter eliminates unwanted frequency components above and below the band of interest (0.4Hz ... 7Hz).

Threshold Comparator

The output signal from the band pass filter is digitally rectified and its peak value compared against a threshold value calculated from the voltages on the SENS and TCOMP inputs. Whenever the PIR signal exceeds the threshold, the load is switched on.
The threshold comparator is disabled for 1.5s after the load has been switched off. In case, that the fade time has been set to a value bigger than zero, the threshold comparator ignores the signal from the PIR input during the fade time and for an additional 1.5s after the light has been completely switched off.

Parameter Settings

The E910.84 provides for six inputs, which are used to define the operational parameters. The voltages applied on these inputs are converted to 4 bit digital values.

SENS: Set the sensitivity threshold required to generate a trigger condition. Sixteen different threshold values are possible. The threshold value internally recalculated with the temperature compensation factor. Refer to table 4.

BRIGHT: Sets the maximum brightness of the light. The brightness levels are divided into 15 equal steps. One step corresponds to 90*(1- 1/16) degrees phase angle.

FADE: Sets the time it takes to fade the light from off to full brightness. On and off fading takes equally long. Refer to table 4.

ON-TIME: Sets the time the light remains on. Refer to table 4.

TCOMP: A temperature dependent resistor network can be connected to this pin. The temperature voltage, in the range from VSS to VDD/4 is converted to a set of threshold multiplication factors. The voltage on this pin must decrease as the temperature increases, so a NTC resistor (β=4500) is used. At 37°C, the TCOMP voltage should be between VDD*7/128 and VDD*9/128 for

maximum detection sensitivity. Temperature compensation may be disabled by connecting TCOMP to VSS. The temperature compensated threshold voltage is the comparator threshold multiplied with the Tcomp factor in table 4.

Device Pin	ON-TIME	FADE	FADE	TCOMP	SENSE	TOG	
Voltage on pin relative to V_{DD}	On time	Fade time (50Hz)	Fade time (60Hz)	Tcomp factor	Comparator Threshold	Light Mode	Mains Toggle
V_{DD}*31/128 or above	78 min	4.5 s	3.7 s	2.67	672 µV	OTSB	Enable
V_{DD}*29/128	78 min	4.5 s	3.7 s	2.67	630 µV	OTSB	Enable
V_{DD}*27/128	39 min	3.8 s	3.2 s	2.50	588 µV	OTSB	Enable
V_{DD}*25/128	39 min	3.8 s	3.2 s	2.33	546 µV	OTSB	Enable
V_{DD}*23/128	20 min	3.2 s	2.7 s	2.17	504 µV	STFB	Enable
V_{DD}*21/128	20 min	3.2 s	2.7 s	2.00	462 µV	STFB	Enable
V_{DD}*19/128	10 min	2.6 s	2.1 s	1.83	420 µV	STFB	Enable
V_{DD}*17/128	10 min	2.6 s	2.1 s	1.67	378 µV	STFB	Enable
V_{DD}*15/128	5 min	1.9 s	1.6 s	1.5	336 µV	STFB	Disable
V_{DD}*13/128	5 min	1.9 s	1.6 s	1.33	294 µV	STFB	Disable
V_{DD}*11/128	2.5 min	1.3 s	1.1 s	1.17	252 µV	STFB	Disable
V_{DD}*9/128	2.5 min	1.3 s	1.1 s	1.00	210 µV	STFB	Disable
V_{DD}*7/128	37 s	0.6 s	0.5 s	1.00	168 µV	OTSB	Disable
V_{DD}*5/128	37 s	0.6 s	0.5 s	1.33	126 µV	OTSB	Disable
V_{DD}*3/128	9.2 s	0 s	0 s	2.00	84 µV	OTSB	Disable
V_{DD}*1/128 or less	9.2 s	0 s	0 s	2.67	42 µV	OTSB	Disable

Table 4: Parameter and operational settings related to pin voltage.

TRIAC Switching

The TRIAC output generates trigger pulses, synchronous with the mains voltage. Brightness control is achieved with firing the TRIAC at different phase angles of the mains voltage. The voltage sense input is monitored and load switching can only happen, if the voltage on this input is close or above VDD or close or below VSS. The maximum brightness = minimum phase angle for the load switching is set with an external voltage divider. This ensures that the electronics have enough power supply when switching the load to maximum brightness in 2 wire operation.

RELAY Output

The RELAY output is an active high output and changes state at the start of the fading cycle.

LED Output

The LED output is an open drain output that is active (16ms) when the PIR signal exceeds the set threshold. A capacitor charged with a limited current from the generated VDD supply is discharged through a LED connected to the LED output of the device.

Controller: Modes of Operation

Behavior of the light controller is separated in to two modes; switch from **O**ff **T**o **S**et **B**rightness (OTSB) or switch from **S**et brightness **T**o **F**ull **B**rightness (STFB). The two modes are selected by applying a specific voltage on the TOG input. All operating modes are determined by four inputs in table 5.

Pin Name	Description	
SWIN	Selects the ON-AUTO-OFF mode. V_{DD}: light permanently ON (to set brightness) V_{SS}: light permanently OFF Floating: PIR sensor mode (AUTO)	
TOGGLE [1]	Mains Toggle Mode If enabled a mains On – Off - On will switch the load permanently to set brightness if DARK.	
	V_{DD} *3/16 or greater	OTSB mode, mains toggling enabled.
	V_{DD} *5/32	STFB mode, mains toggling enabled.
	V_{DD} *3/32	STFB mode, mains toggling disabled
	V_{DD} *1/16 or less	OTSB mode, mains toggling enabled.
RETRIG	Re-trigger Mode V_{DD} or floating: The timer for the on-time is restarted whenever movement is detected. V_{SS}: The light will stay on for the on-time. Movement detection is ignored during this period.	
DARK [2]	Typically connected to a Light Dependant Resistor (LDR) or photo transistor, to prevent the light from switching on during daylight conditions. V_{DD}: Enable switching of the light V_{SS}: Disables switching of the light Do not leave this input floating.	

Table 5: Operational settings

[1] The toggle mode is not cancelled by setting SWIN input to V_{SS}, although the light will be switched off
[2] DARK is ignored when the light is ON in PIR sensor mode (AUTO).

Operation

Power-up Mode

Whenever the circuit is powered up, the light is switched on for the selected on-time duration. The DARK input is ignored on power-up, to allow the user to verify the installation during daylight conditions.

Trigger condition

The threshold voltage (SENS) is multiplied with the TCOMP factor (refer to table 4), to obtain a temperature dependent threshold voltage. When the PIR signal exceeds this calculated threshold voltage, a trigger condition occurs.

Conditions for Switching the Light ON (AUTO mode, OTSB mode)

If a trigger condition occurs and the DARK input is high, the light will be switched on. The light's brightness will increase to the selected BRIGHTNESS within the selected FADE TIME.

The RELAY output is activated at the start of the fading-on cycle.

The relay will remain on and the light at the set BRIGHTNESS for the duration set by the ON-TIME input. The DARK input is ignored during this time.

If the TOGGLE MODE is enabled, the light can also be switched on by toggling the mains ON-OFF-ON within 3 seconds. In this mode, the PIR input is ignored; the DARK input will switch the light ON or OFF. This mode is disabled by disconnecting the mains for a few seconds.

Conditions for Switching the Light OFF (AUTO mode OTSB mode)

The light fades to zero after the selected ON-TIME has elapsed, within the selected FADE TIME.

The RELAY output is switched off at the start of the fading-off cycle.

Conditions for Switching the Light ON (AUTO mode, STFB mode)

If the DARK input is high, the light will be on at the set BRIGHTNESS. If a trigger condition occurs, the light will be switched to full brightness. The light's brightness will increase to maximum within the selected FADE TIME.

The RELAY output is activated at the start of the fading-on cycle.

The relay output will be active and the light remains at full brightness for the duration set by the ON-TIME input.

If the TOGGLE MODE is enabled, the light can also be switched on to the set brightness by toggling the mains ON-OFF-ON within 3 seconds. In this mode, the PIR input is ignored; the DARK input will switch the light ON or OFF. This mode is disabled by disconnecting the mains for a few seconds.

The RELAY output is switched off at the start of the fading-off cycle.

Condition for Switching the Light to set brightness (AUTO mode, STFB mode)

The light will fade within the selected FADE TIME to the set BRIGHTNESS after the selected ON-TIME has elapsed.

Device Pin Out

Pin No.	Name	Description
1	FADE	Fade time adjustment
2	SENS	Sensitivity threshold adjustment
3	ON-TIME	Light on-time adjustment
4	TCOMP	Temperature compensation input
5	LED	LED output pin, open drain
6	TRIAC	TRIAC gate signal, push-pull
8	VDD	Digital VDD
7	RELAY	RELAY output, push-pull
9	AC1	Mains power input
10	VSS	Digital ground
11	VSW	TRIAC voltage monitor input
12	SWIN	Operating mode input, Light On – Auto - Off
13	TOG	Toggle mode OTSB and STFB mode select
14	RETRIG	Retrigger mode select
15	VDDA	Analog VDD supply to PIR sensor
16	PIRIN	PIR sensor input
17	VSSA	Analog VSS supply to PIR sensor
18	TEST	Reserved, Test mode, connect to VSS
19	DARK	Dark mode input, connected to LDR/Photodiode
20	BRIGHT	Brightness adjustment

Table 7: Device Pin Out

Contact Information

Microsystems On Silicon (PTY) Ltd.
Pretoria, South Africa
Tel: +27 (12) 348 8367
Fax: +27 (12) 348 1790
Email: sales@mos.co.za

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Ordering Information

E910.84 SO20W (Surface mount, 300 mills)
E910.84 DIE (Unpackaged devices)