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E931.98A
PIR Controller
Integrated Circuit

General Description_____

The M931.98 integrated circuit combines all required functions for a single chip Passive Infra-Red (PIR) motion sensor.

Motion detection is signaled through the push-pull REL output. A digital input OEN enables REL output.

The load is switched during mains voltage zero crossing. The algorithm adapts to the relay type and mains frequency.

A LED output indicates whenever the PIR Signal is above the selected threshold.

The M931.98 interfaces directly with up to two conventional PIR sensors via a high impedance differential input. The PIR signal is converted to a 15 bit digital value on chip.

The parameters for sensitivity and timing are set by connecting the corresponding inputs to DC voltages. The voltage levels on the inputs are converted to digital values with 7 bit resolution. All signal processing is performed digitally.

The M931.98 is available in TSSOP-14 and SOIC14 packages.

Applications_____

- ♦ Mains powered motion sensor lights that require relay switching on zero crossing, common requirement for low cost relays and capacitive loads.
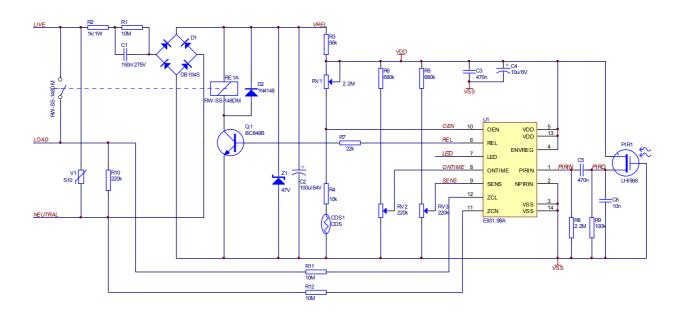
Features_____

- ♦ Digital signal processing
- ♦ On chip supply shunt regulator
- ♦ Low power consumption
- ♦ Differential PIR sensor input
- ♦ Excellent power supply rejection
- ♦ Insensitive to RF interference
- ♦ Inputs for sensitivity, on time and daylight sensor
- ♦ Outputs for relay and LED
- ♦ Instantaneous settling after power up
- ♦ Adaptive Zero Crossing Switching

Mains Powered Motion Sensor Light Application Circuit_____

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Designator	Typ. Value	Description	Note
U1	M931.98	PIR Controller IC	TSSOP-14 or SOIC14
U2	LHI968	Dual Element PIR Sensor	TO-5
R1	1M	Discharge resistor	
R2	100R	Transient protection resistor	Wire wound
R3	56k	Current limiting resistor	$R3 < (V_{Rel}-V_{VDD})/(I_{IDD} + I_{REL}/\beta_{Q1} + I_{R4} +I_{R5} +I_{R6})$
R7	22k	REL drive current setting resistor	$R7 = I_{REL}/\beta_{Q1}$
R4	10k	Current limiting resistor	In case $V_{CDS}=0$ and RV1 is also turned to 0
R5	680k	Voltage divider	$V_{VDD}/4 = (RV3) / (RV3+R5)$
R6	680k	Voltage divider	$V_{VDD}/4 = (RV2) / (RV2+R6)$
R8	2.2M	Pull down resistor	
R9	100k	Pull down resistor	
R10	220k	Pull down resistor	Load voltage clamp resistor,R10 must be able to drop full load when REL is active
R11	10M	Load voltage sensing resistor	
R12	10M	Neutral voltage sensing resistor	
D1	1N4148	Fly back protection diode	
D2	DB104S	Diode bridge	
Z1	ZD47	47V Zener Diode	Choose according to RE1 voltage
CdS1		Light dependent resistor	
RV1	2.2M	OEN Voltage Adjust (Dark level)	
RV2	220k	Sensitivity adjustment	Select in conjunction with R6
RV3	220k	On Time adjustment	Select in conjunction with R5
V1	S10275VAC	Transorb, for high voltage spike protection	
C1	150n/230VAC	Voltage dropper capacitor	
C2	10µF/64V	Supply voltage storage	Voltage rating dependant on RE1 voltage
C3	1µF/6V	Decoupling capacitor	Ceramic, close to supply pins of device
C4	10µF/6V	Sensor supply storage	Regulator compensation capacitor
C5	470nF	PIR signal bypass capacitor	
RE1	47V	N.O. REL	High coil voltage, less drive current
S1		3 position Mains switch	

Table 1: Component Values for Motion Sensor Light

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Electrical Characteristics

Absolute Maximum Ratings

Parameter	Symbol	Min	Max	Unit	Remarks
Supply Voltage	V_{DD}	-0.3	3.6	V	
Current into any pin		-100	100	mA	One pin at a time
Storage Temperature	T_{st}	-45	125	°C	

Table 3: 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, unless stated otherwise)

Parameter	Symbol	Min	Typ	Max	Unit	Remarks
Temperature						
Operating temperature range		-25		85	°C	
Regulator						
Shunt regulator current	I_R			5	mA	
Supply current, ENREG=VDD	I_{DD}			70	µA	VDD < Regulator voltage, Outputs unloaded
Supply current, ENREG=VSS	I_{DD}			50	µA	Regulator not active, VDD=3.3V
Regulator voltage	V_{DD}	2.7	3	3.3	V	I_R = 0.5mA
Input OEN						
Input low voltage	V_{IL}			0.8	V	
Input high voltage	V_{IH}	0.9			V	
Input Current	I_I	-1		1	µA	$V_{SS}<V_{IN}<V_{DD}$
Input ENVREG						
Input low voltage	V_{IL}			0.2	V_{DD}	
Input high voltage	V_{IH}	0.8			V_{DD}	
Input Current	I_I	-1		1	µA	$V_{SS}<V_{IN}<V_{DD}$
Outputs REL, LED						
Output current high	I_{OH}			-10	mA	$V_{OL}>(V_{DD}-1V)$
Output current low	I_{OL}	10			mA	$V_{OL}<1V$
Inputs SENS, ONTIME						
Input voltage range		0		V_{DD}		Adjustment between 0V and ¼ VDD
Input leakage current		-1		1	µA	
ZCH / ZCN Inputs						
Input low current	I_{IL}	3	30	100	µA	
Input high current	I_{IH}	3	30	100	µA	
Input Voltage	I_I	0.3	0.5	0.7	V_{DD}	Input current +/-30uA
PIRIN / NPIRIN Inputs						
PIRIN /NPIRIN input resistance to V_{SS}		20			GΩ	-60mV < VIN < 60mV
PIRIN /NPIRIN input resistance differential		40			GΩ	-60mV < VIN < 60mV
PIRIN input voltage range		-60		60	mV	
Oscillator and Filter						
LPF cutoff frequency			7		Hz	
HPF cutoff frequency			0.44		Hz	
On chip oscillator frequency	F_{CLK}		64		kHz	
System Clock	C_G		$F_{CLK}/2$			

Table 4: Operating Conditions

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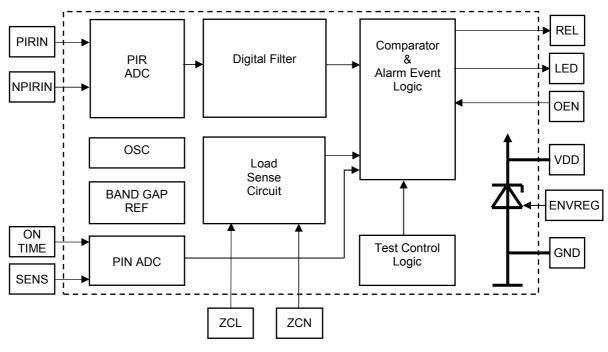
Detailed Description

Fig 1: Block diagram of M931.98

PIR Sensor Input

A differential input stage provides for the connection of up to two PIR sensors. The analog to digital converter generates a digital signal from the voltage level measured between the PIRIN and NPIRIN pins.

A band gap reference ensures a temperature and supply voltage independent gain.

Voltage Regulator

The integrated shunt voltage regulator can be activated by the user through the ENVREG input. The M931.98 can be operated directly from batteries or regulated supply voltages ranging from 2.7V to 3.6V. In this case, the voltage regulator needs to be switched off and the user can benefit from the very low current consumption.

In applications with higher voltages, the user would activate the on chip shunt regulator, which generates a stable supply voltage of 3V for the M931.98 and the PIR detector. The V_{DD} pin requires a bypass capacitor to V_{SS}. The reference for the shunt regulator is taken from the integrated band gap reference.

Oscillator

The IC contains an on chip low power oscillator. The frequency is set to 64kHz. The timing signals and cutoff frequencies of the digital filters are derived from this frequency.

Band-Pass Filter

A 2nd order low-pass filter with a cut-off frequency of 7Hz eliminates unwanted higher frequency components. This signal is then passed to a 2nd order high pass filter with a 0.4Hz cut-off frequency.

Alarm Event Processor

The signal from the band pass filter is rectified. When the signal level exceeds the selected sensitivity threshold, the REL output is activated. The LED output is active (high), whenever the signal level is above the sensitivity threshold.

The voltage applied to the ONTIME input determines how long the REL output stays active. The REL output remains active from the first alarm condition to the last alarm condition plus the time selected with the ONTIME input.

Relay Switching

The M931.98 ensures, that the load is only switched on during mains voltage zero crossing. This function prevents early relay failure due to excessive contact wear when switching capacitive loads such as compact fluorescent lights.

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Power Up

The on chip power on reset keeps the circuit in a reset condition until the supply voltage is high enough for a stable operation. The REL output is activated independently of the OEN input signal for the duration, which is selected with the voltage on the ONTIME input. Activation of the RELAY output takes place 500ms after it detects uninterrupted mains signal (zero crossings) on the ZCN input.

Mains Voltage Presence Detection

The integrated circuit monitors mains voltage/frequency presence through the ZCN input. Whenever the mains zero crossings disappear for duration of more than 0.5s, the circuit assumes, that the voltage has been disconnected. If the voltage is re-connected, the load is switched on in the same way like after a power up. This feature does not require the discharge of the power supply in order to force a power on reset.

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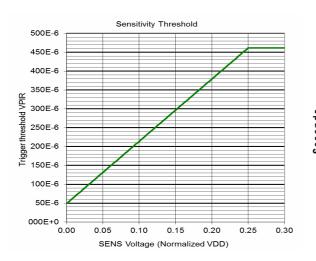**E931.98A
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On Time

A voltage applied to the ONTIME input set the time the REL output is active with a single trigger event. Any voltage above VDD/4 will select the maximum on time.

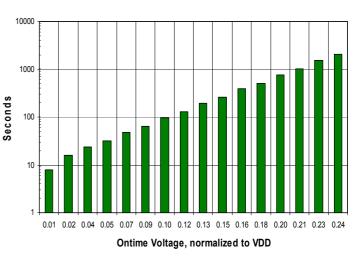| Pin voltage	PIN ADC count	ON Time in seconds	ON Time in minutes
$V_{DD}*1/128$ or less	0	8	0.1
$V_{DD}*3/128$	1	16	0.3
$V_{DD}*5/128$	2	24	0.4
$V_{DD}*7/128$	3	32	0.5
$V_{DD}*9/128$	4	48	0.8
$V_{DD}*11/128$	5	64	1.1
$V_{DD}*13/128$	6	96	1.6
$V_{DD}*15/128$	7	128	2.1
$V_{DD}*17/128$	8	192	3.2
$V_{DD}*19/128$	9	256	4.3
$V_{DD}*21/128$	10	384	6.4
$V_{DD}*23/128$	11	512	8.5
$V_{DD}*25/128$	12	768	12.8
$V_{DD}*27/128$	13	1024	17.1
$V_{DD}*29/128$	14	1536	25.6
$V_{DD}*31/128$ or above	15	2048	34.1

Table 5: DC input voltages and parameter values

Sensitivity

A voltage applied to the SENS input sets the threshold used to detect a PIR signal between the PIRIN and NPIRIN inputs. VSS selects the minimum threshold voltage. Any voltage above VDD/4 will select the maximum threshold, which is the least sensitive setting for PIR signal detection.

Graph 1: PIR voltage trigger threshold vs. SENS pin voltages normalized to VDD.

Graph 2: REL Output On Time in seconds vs. ONTIME pin voltages normalized to VDD.

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*Pin Out*_____

Pin Name	Pin Number	Description
PIRIN	1	PIR sensor input
NPIRIN	2	Negative PIR sensor input
V_{SS}	3, 14	Negative supply voltage
ENVREG	4	Regulator enable, connect to V_{DD} to enable regulator, connect to V_{SS} to disable regulator for low current battery based applications, where V_{DD} will be less than 3.6V.
V_{DD}	5, 13	Positive supply voltage, shunt regulator
REL	6	RELAY output (push-pull)
LED	7	LED output (push-pull)
ONTIME	8	On time selection input
SENS	9	Sensitivity selection input
OEN	10	> V_{IH} : REL output is enabled | This input is used for factory test and the < V_{IL} : REL output is disabled | voltage needs to remains between V_{DD} and V_{SS}
ZCN	11	Current sense input for Neutral
ZCL	12	Current sense input for Load

Table 6: Pin Out

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