# PIR CONTROLLER INTEGRATED CIRCUIT E931.97

**PRELIMINARY INFORMATION - JUL 28, 2011**

RoHS compliant

## Features

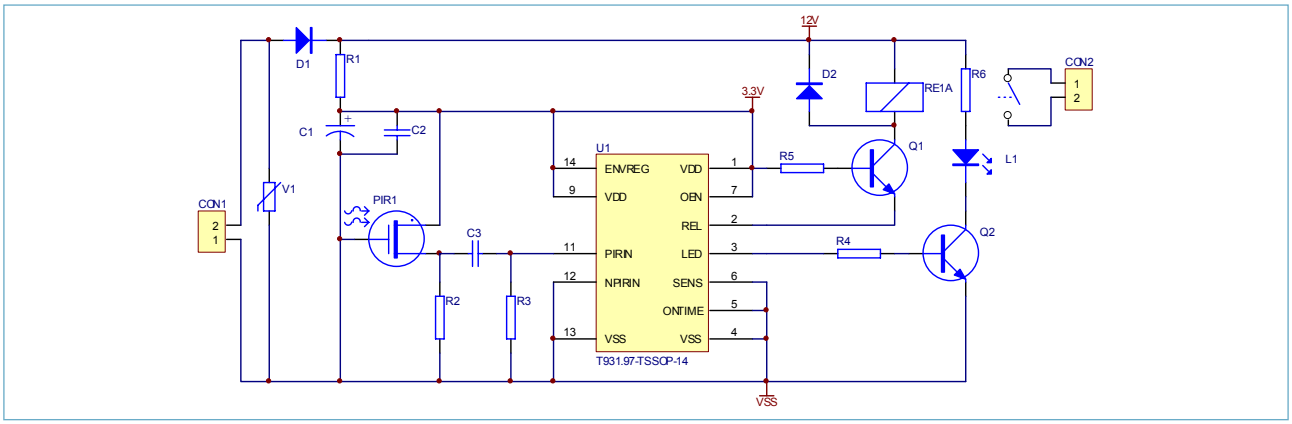
- Digital signal processing
- On chip supply shunt regulator
- Low power consumption
- Differential PIR sensor input
- Excellent power supply rejection
- Insensitive to RF interference
- Inputs for sensitivity, on time and daylight sensor
- Outputs for relay and LED
- Instantaneous settling after power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

## Applications

- PIR motion detection
- Intruder detection
- Occupancy detection
- Motion sensor lights

## General Description

The E931.97 integrated circuit combines all required functions for a single chip Passive Infra Red (PIR) motion detector. Motion detection is signaled through the push-pull REL output. A digital input OEN enables REL output. A LED output indicates whenever the PIR Signal is above the selected threshold. The E931.97 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 E931.97 is available in TSSOP-14 and SOIC14 packages.



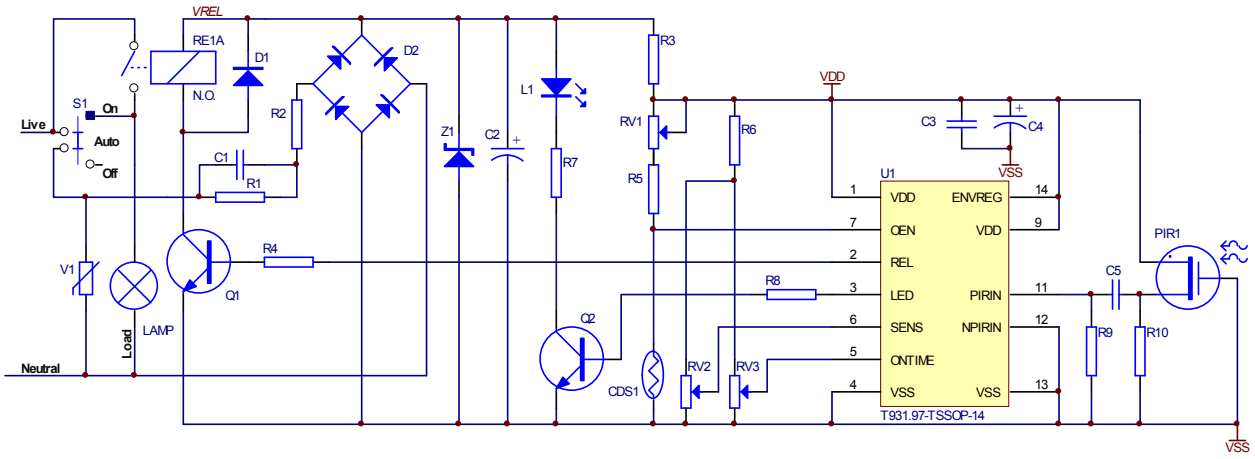

*Typical application circuit for Wired Alarm Systems*

| Comp | Typ. Value | Function | Note |
|---|---|---|---|
| U1 | E931.97 | PIR Controller IC | TSSOP-14 or SOIC-14 |
| PIR1 | LHI878 | Dual Element PIR Sensor | TO-5 |
| R1 | 10k | Series voltage drop resistor | $R1 < (V_{Supply}-0.6-V_{Reg})/(I_{IDD}+I_{LED}/\beta_{Q2}+I_{REL}/\beta_{Q1})$ |
| R2 | 100k | Pull down resistor | |
| R3 | 2.2M | Pull down resistor | |
| R4 | 22k | Base current setting resistor | $R4 = (V_{Supply}-0.6-V_{LED})/(I_{LED}/\beta_{Q2})$ |
| R5 | 22k | Base current setting resistor | $R5 = (V_{Reg}-V_{Q1BE})/(I_{REL}/\beta_{Q1})$ |
| R6 | 1.2k | LED drive current limiting resistor | $R6 = (V_{Supply}-0.6-V_{LED})/(I_{LED})$ |
| C1 | 10uF/6V | Power supply storage capacitor | |
| C2 | 100nF | Vdd-Vss Supply bypass capacitor | |
| C3 | 470nF | PIR signal bypass capacitor | |
| RE1 | TAA1A12F00 | N.O. REL | Active if no movement is detected |
| V1 | SMBJ-12 | Transorb, voltage spike protection | |
| Q1,Q2 | BC849B | NPN transistors for LED & REL drive | |
| D1 | 1N4007 | Supply Reverse connection protector diode | |
| D2 | 1N4148 | Fly back protection diode | |
| L1 | | LED | |

*Table 1: Component Values for simple intruder detector ($V_{Supply}$ = 12V)*

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## *Mains Powered Motion Sensor Light Application Circuit*




| Designator | Typ. Value | Description | Note |
|---|---|---|---|
| U1 | E931.97 | PIR Controller IC | TSSOP-14 or SOIC14 |
| U2 | LHI878 | Dual Element PIR Sensor | TO-5 |
| R1 | 1M | Discharge resistor | |
| R2 | 100R | Transient protection resistor | Wire wound |
| R3 | 10k | Current limiting resistor | R3 < $(V_{Rel}-V_{VDD})/(I_{IDD} + I_{REL}/\beta_{Q1} + I_{R7}/\beta_{Q2} + I_{R5} + I_{R6})$ |
| R4 | 22k | REL drive current setting resistor | R4 = $I_{REL}/\beta_{Q1}$ |
| R5 | 47k | Current limiting resistor | In case $V_{CDS}$=0 and RV1 is also turned to 0 |
| R6 | 270k | Voltage divider | $V_{VDD}/4$ = (RV2+RV3) / (RV2+RV3+R6) |
| R7 | 10k | LED drive current limiting resistor | R7 = $(V_{REL} -0.6- V_{LED})/( I_{LED})$ |
| R8 | 100k | Base current setting resistor | R8 = $(V_{REL}-0.6- V_{LED})/( I_{LED}/\beta_{Q2})$ |
| R9 | 2.2M | Pull down resistor | |
| R10 | 100k | Pull down resistor | |
| L1 | | LED | LED of own choice |
| 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 and RV3 |
| RV3 | 220k | On Time adjustment | Select in conjunction with R6 and RV2 |
| V1 | S10275VAC | Transorb, for high voltage spike protection | |
| C1 | 330n/230VAC | Voltage dropper capacitor | |
| C2 | 10µF/50V | 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 2: 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 | $I_{DD}$ | | 25 | 30 | µA | VDD < Regulator voltage, Outputs unloaded |
| Supply current, ENREG=VSS | $I_{DD}$ | | 12 | 15 | 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 | |
| **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

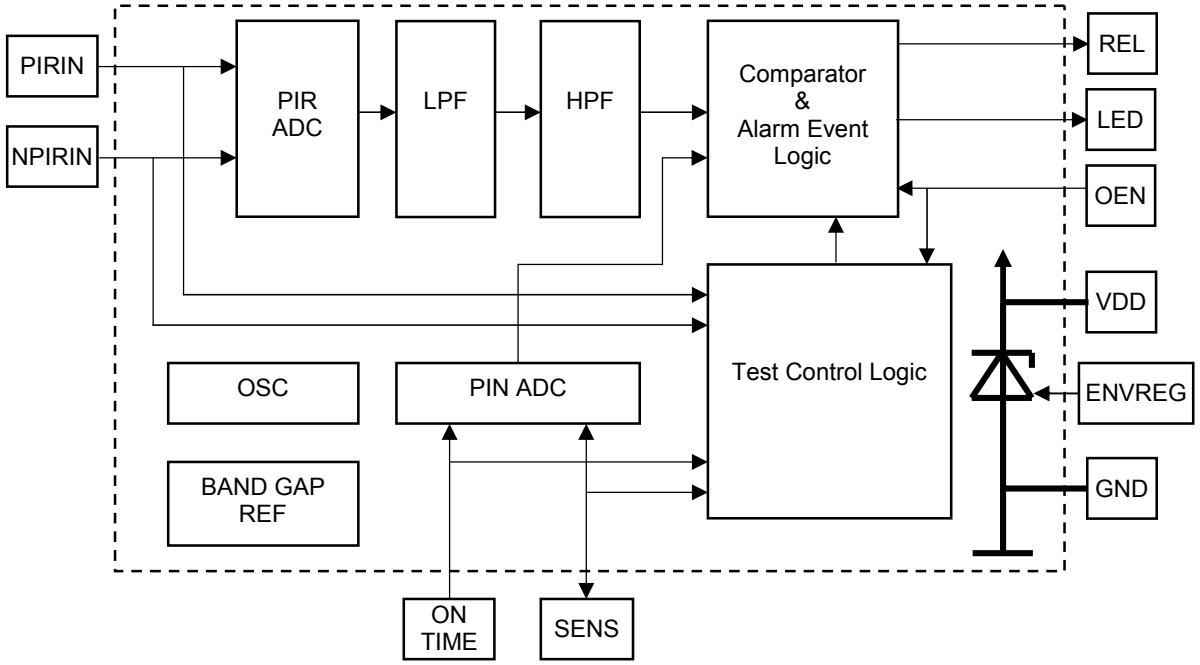



*Fig 1: Block diagram of E931.97*

## 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 E931.97 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 E931.97 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 2$^{nd}$ 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 set sensitivity threshold, an internal pulse is generated. A second pulse is counted, when the signals changes sign and exceeds the threshold again.
Whenever 2 pulses appear within 4s, the REL output is activated. The LED output is activated, whenever the signal level is above the sensitivity threshold.
Large signals in excess of 5 x the selected threshold result in immediate activation of the relay output.

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.

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## On Time

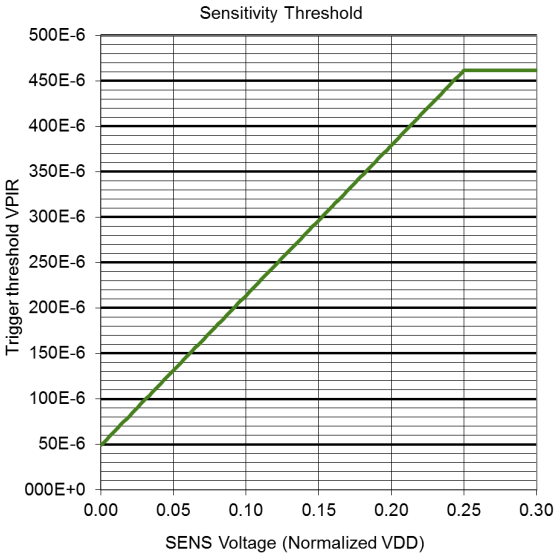
A voltage applied to the ONTIME input set the time the REL output is active with a single trigger event. Any voltage above VDD/4 will select the maximum on time.

| Pin voltage | PIN ADC count | ON Time in seconds | ON Time |
|---|---|---|---|
| $V_{DD}$*1/128 or less | 0 | 2 | 2 sec |
| $V_{DD}$*3/128 | 1 | 4 | 4 sec |
| $V_{DD}$*5/128 | 2 | 6 | 6 sec |
| $V_{DD}$*7/128 | 3 | 8 | 8 sec |
| $V_{DD}$*9/128 | 4 | 16 | 16 sec |
| $V_{DD}$*11/128 | 5 | 33 | 32 sec |
| $V_{DD}$*13/128 | 6 | 49 | 49 sec |
| $V_{DD}$*15/128 | 7 | 66 | 1 min 5 sec |
| $V_{DD}$*17/128 | 8 | 131 | 2 min 11 sec |
| $V_{DD}$*19/128 | 9 | 262 | 4 min 22 sec |
| $V_{DD}$*21/128 | 10 | 393 | 6 min 33 sec |
| $V_{DD}$*23/128 | 11 | 524 | 8 min 44 sec |
| $V_{DD}$*25/128 | 12 | 1049 | 17 min 28 sec |
| $V_{DD}$*27/128 | 13 | 2097 | 34 min 57 sec |
| $V_{DD}$*29/128 | 14 | 3146 | 52 min 25 sec |
| $V_{DD}$*31/128 or above | 15 | 4194 | 1 hour 10 min |

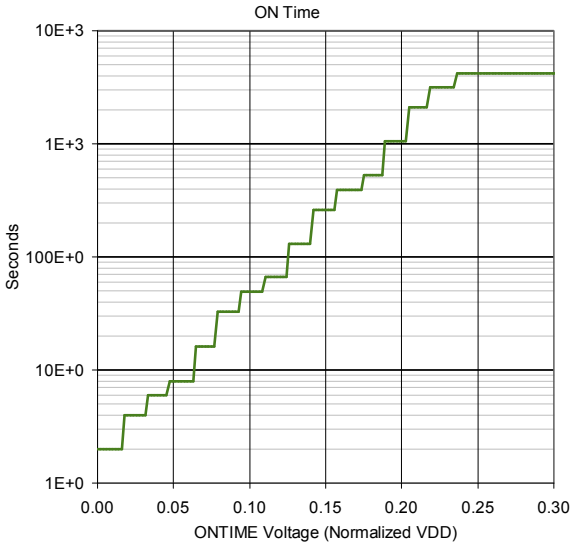
*Table 5: DC input voltages and parameter values*

## *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 Name | Pin Number | Description |
|---|---|---|
| $V_{DD}$ | 1, 9 | Supply voltage, shunt regulator |
| REL | 2 | REL Output (push-pull) |
| LED | 3 | LED Output (push-pull) |
| $V_{SS}$ | 4 | Negative supply voltage |
| ONTIME | 5 | On time selection input |
| SENS | 6 | Sensitivity selection input |
| OEN | 7 | (> $V_{THRH}$ <= $V_{DD}$) : REL output is enabled<br>(>= $V_{SS}$ < $V_{THRL}$) : REL output is disabled |
| N.C. | 8, 10 | Not connected |
| PIRIN | 11 | PIR sensor input |
| NPIRIN | 12 | Negative PIR sensor input |
| $V_{SS}$ | 13 | Negative supply voltage |
| ENVREG | 14 | 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 3.3V. |

*Table 6: Pin Out*

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