E931.96B
Ultra-Low Power PIR Controller Integrated Circuit

General Description

The E931.96B is an ultra-low power motion detector controller integrated circuit. The device is ideally suited for battery operated wireless motion sensors that make use of an MCU for handling communication.
The MCU does not need to be active while the E931.96B does continuous motion sensing. It only activates the external controller, when motion is detected. Motion is signaled through the push-pull output (INT). The criteria for motion detection are programmable and can be changed by the external controller.
The E931.96B interfaces directly with up to two conventional PIR sensors via a high impedance differential input. The PIR signal is converted to a 14 bit digital value on chip.
All signal processing is performed digitally.

The E931.96B is available in a SOIC-8 package.

Applications

- Wireless intruder detectors
- Battery powered door chimes
- Emergency lighting
- Motion and presence detection

Features

- Programmable detection criteria and operating modes
- Digital signal processing
- On chip supply regulator for conventional PIR detectors
- Ultra Low power consumption
- Differential PIR sensor input
- Supply voltage measurement
- Temperature measurement
- Instantaneous settling after power up

Application Circuits

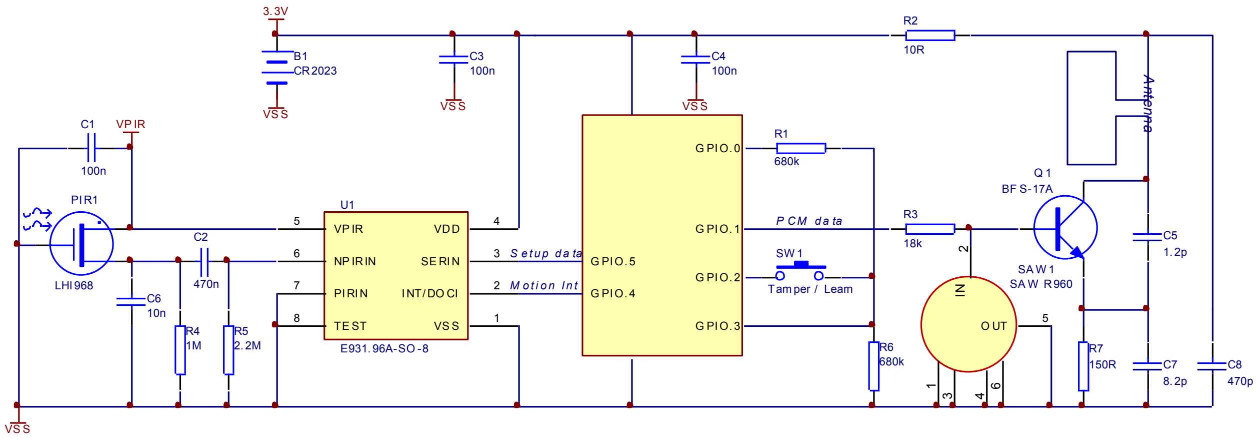


Fig 1: Wireless Intruder Detector

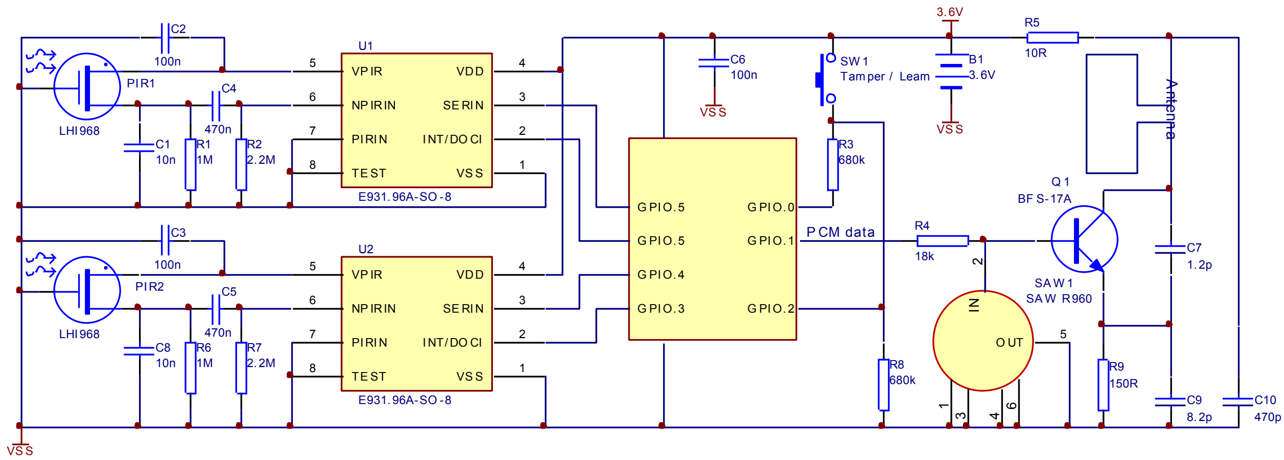


Fig 2: Wireless Intruder Detector with Two Controllers

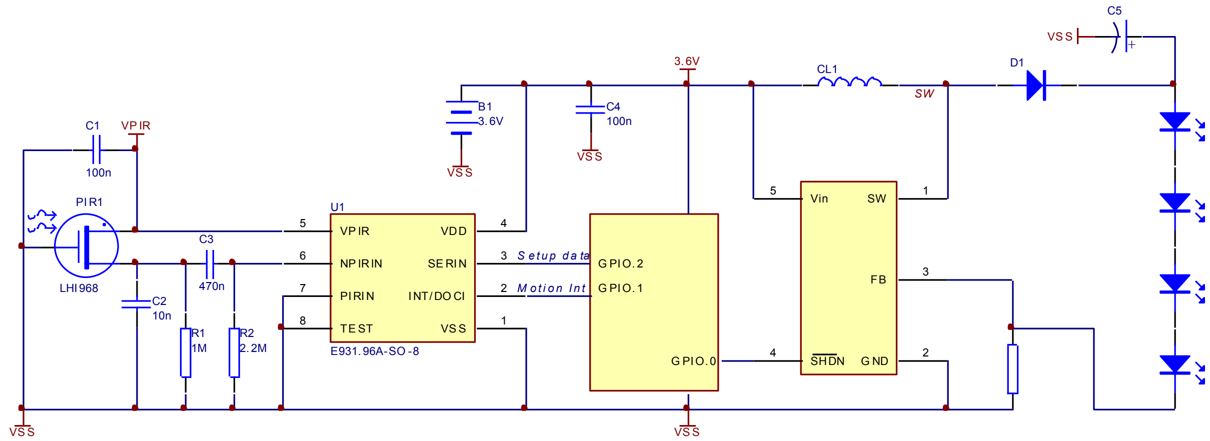


Fig 3: Emergency Lighting

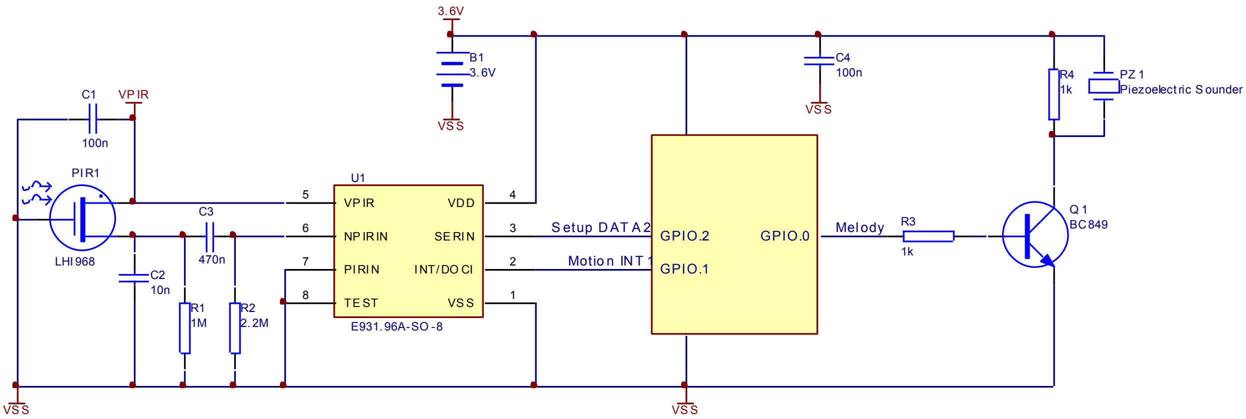


Fig 4: Door Chime

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 1: 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=25ºC, unless stated otherwise)

Parameter	Symbol	Min	Typ	Max	Unit	Remarks
Operating Temperature						
Operating temperature range		-40		85	°C	
Operating Voltage						
Supply Voltage	V_{DD}	2.5		3.6	V	
Supply Current						
Supply current, V_{PIR} Regulator On	I_{DD1}		6	8	µA	VDD=3V, no load
Supply current, V_{PIR} Regulator Off	I_{DD}		3	5	µA	VDD=3V, no load
Voltage Regulator VPIR						
Regulator voltage	V_{DP}		2.2		V	I_R = 5uA
Regulator Output Current	I_R	10			µA	
Input SERIN						
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	$V_{SS}<V_{IN}<V_{DD}$
Data clock low time	t_L	200			ns	
Data clock high time	t_H	200			ns	
Data bit write time	t_{BW}	$2/F_{CLK}$			µs	
Write timeout	t_{WL}	$16/F_{CLK}$			µs	
Input / Output INT/DOCI						
Input low voltage	V_{IL}			0.2	V_{DD}	
Input high voltage	V_{IH}	0.8			V_{DD}	
Output current high	I_{OH}	-125	-95	-70	µA	$V_{OUT} = V_{SS}$
Output current low	I_{OL}	120	155	200	µA	$V_{OUT} = V_{DD}$
Input Capacitance			5		pF	
Force read setup time	t_{FR}	$2/F_{CLK}$				
Time to clear interrupt	t_{CL}	$2/F_{CLK}$				
Data clock low time	t_L	200		t_{RA}	ns	
Data clock high time	t_H	200			ns	
Data bit settling time, DOCI out	t_{bit}			1	µs	CLOAD = 10pF
Read timeout	t_{RA}	$4/F_{CLK}$			µs	

PIRIN / NPIRIN Inputs						
PIRIN /NPIRIN input resistance to V_{SS}		30		60	GΩ	-60mV < VIN < 60mV
PIRIN /NPIRIN input resistance differential		60		120	GΩ	-60mV < VIN < 60mV
PIRIN input voltage range		-53		53	mV	
Resolution		5.9	6.5	7.2	µV/count	
ADC output range		511		2^14-511	Counts	
ADC Offset		7000	8000	9000	Counts	
ADC Noise referred to Input					√Hz	F = 0.1Hz .. 10Hz
Supply Voltage Measurement						
Resolution		590	650	720	µV/count	
ADC output range		2^13		2^14-511	counts	
Temperature Measurement						
Resolution			80		Counts/K	
ADC output range		511		2^14-511	Counts	
Value at 300K		6700	8200	9900	Counts	
Oscillator and Filter						
LPF cutoff frequency		F_{CLK} * 1.41 / 2048 / PI			Hz	
HPF cutoff frequency		F_{CLK}/16 * 1.41 / 2048 / PI			Hz	
On chip oscillator frequency	F_{OSC}	56	64	74	kHz	
System Clock	F_{CLK}		F_{OSC}/2			

Table 2: Operating Conditions

Detailed Description

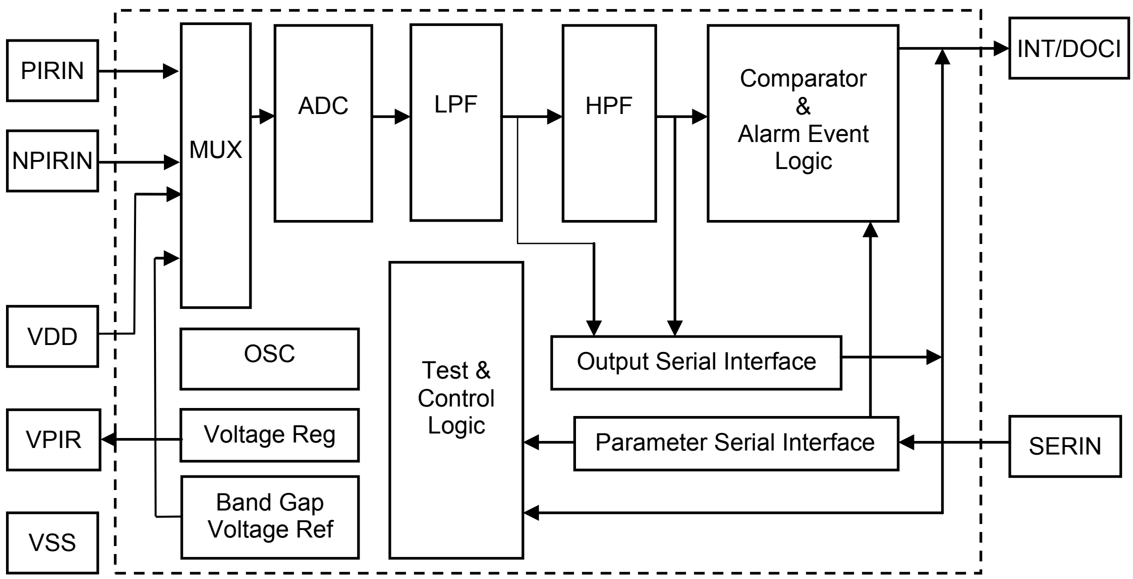


Fig 5: Block diagram of E931.96B

MUX

The multiplexer selects the source signal for the ADC. It can select between the differential PIR inputs, differential temperature sensor output and asymmetrical supply voltage divider.

Voltage Regulator
The integrated voltage regulator provides a regulated 2.2V supply for an externally connected conventional PIR detector. The regulator can be activated through the control register.

Bandgap Voltage Reference
The bandgap voltage reference provides constant reference currents and voltages to the analog circuitry on chip across the specified operating temperature range of the device.
In addition, it contains a temperature voltage generator (temperature sensor).

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. Both filter output are accessible through the serial interface.

Alarm Event Logic
The signal from the band pass filter is rectified. When the signal level exceeds the sensitivity threshold, an internal pulse is generated. Subsequent pulses are counted, whenever the signals changes sign and exceeds the threshold again. The conditions for an alarm event such as the amount of pulses as well as the time window in which the pulses occur are programmable.

If an alarm event is cleared by resetting the interrupt, any motion detection is stopped during the programmable blind time. This feature is important to prevent self-triggering in applications, where high detection sensitivity is required.

The interrupt will be cleared by driving a "0" (<0.8V) for at least 100ns (t_{CL}). Thereafter, the processor can switch the port back to high impedance.

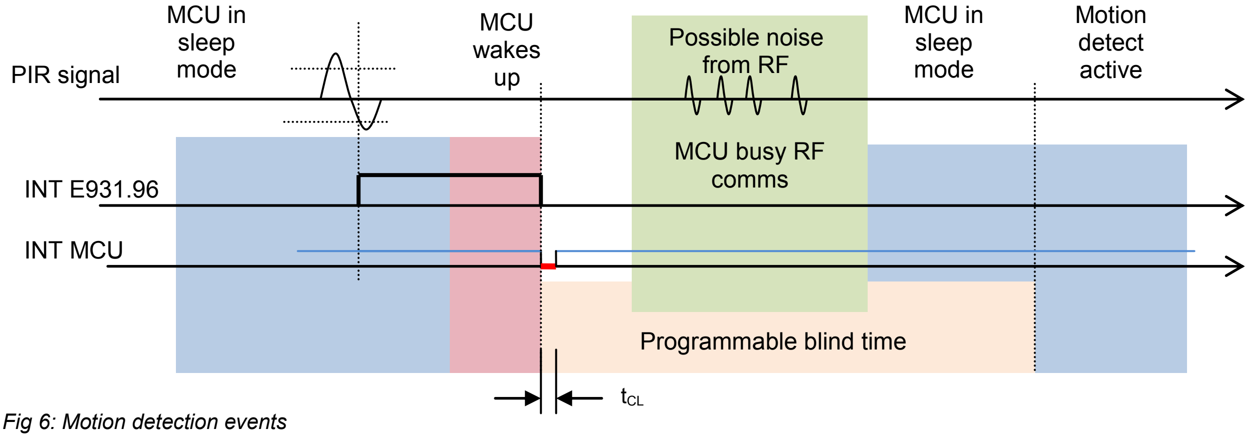


Fig 6: Motion detection events

Serial Interface
The device setup is done by programming setup registers via the SERIN pin. A simple clocked data-in protocol is used. Information from the device is read out with the INT/DOCI pin. A similar clocked data-out protocol is used.
The E931.96B accepts new data, whenever the SERIN has been at low level for at least 16 system clocks and the supply voltage is above 2V.

Configuration Register

The device contains a configuration register. Write access is through the serial input. Read access is performed through the interrupt output.
The following parameters can be adjusted through the control / configuration registers:

1. **Sensitivity**
   The sensitivity / detection threshold is defined with the register value. The resolution of the register is 6.5µV.
   The threshold is [Register Value] * 6.5µV

2. **Blind Time**
   Ignores motion after the interrupt output is switched back to 0
   Range: 0.5s... 8s.
   The blind time is [Register Value] *0.5s

3. **Programmable pulse counter**
   1... 4 pulses with sign change in between
   Amount of pulses = [Register Value] + 1

4. **Window time**
   For noisy environments
   2s... 8s window
   Window time = [Register Value] * 2s + 2s

5. **Motion Detect Enable**
   0 = disable, 1 = enabled

6. **Interrupt Source**
   The interrupt source can be selected between Motion (default) or ADC Decimation Filter. If the decimation filter is selected, interrupts are generated every 14ms.
   0 = Motion, 1 = Filter
   The Interrupt can be switched off by setting the mask bit to Motion and switching off the motion detector function.

7. **Voltage Source**
   There is only one ADC integrated on chip. The following source voltages are selectable for the ADC:
   PIR Signal, BFP Output = 0
   PIR Signal, LPF Output = 1
   Chip Supply Voltage = 2
   On Chip Temperature Sensor = 3
   For Motion Detector Mode, ‘0’ or ‘1’ has to be selected.

8. **Supply Regulator Enable for conventional PIR Detector (2.2V)**
   Supply a regulated 2.2V on the V_{REG} output.
   1 = disabled, 0 = enabled

9. **Start Self-Test**
   Initiates PIR self-test procedure that takes 2seconds to complete.
   0 to 1 change = start

10. **Sample Capacitor Value**
    For different size pyro ceramics, different sample capacitors can be selected for the pyro ceramic test

11. **Input Clamp**
    1 = PIR inputs are grounded for fast settling during offset measurement

12. **User test-mode**
    Reserved, program with 0

Serial Data Input

The configuration data is transferred into the device via the serial input. The external microcontroller has to generate a zero to one transition on the SERIN input and subsequently apply the data bit value (0/1).
The 'zero' and 'one' time for the transition can be very short (1 instruction cycle of the microcontroller). The data bit value must be applied for at least 2 system clocks (t_{bit}) of the E931.96B.

Whenever the transfer of data bits is interrupted for a period greater than 16 system clocks (t_R), the last data received is latched into the configuration register. The transmission of a 25 bit data should not be interrupted for more than 15 system clocks, as the device may latch the data already at this stage.

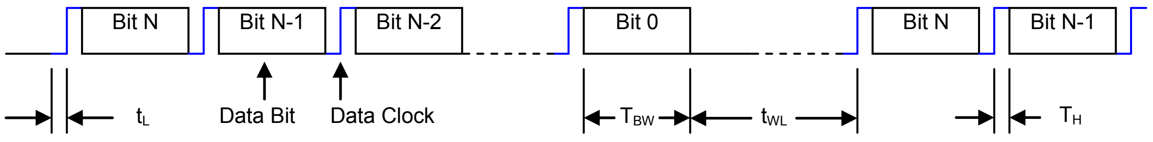


Fig 7: Serial Data clocked into device by MCU

Serial Data Output / Interrupt

The serial output serves as an Interrupt output, indicating motion and as a serial output for reading status and configuration data from the circuit.

Read Procedure

The E931.96B accepts readout with MCU defined timing. The MCU has to force DOCI to a high level for the duration of more than 2 device clock cycles (t_{FR}) and subsequently read out the data bits as described in the timing diagram below. Reading can be terminated at any time by forcing the DOCI line to "0" for at least 4 system clock cycles.

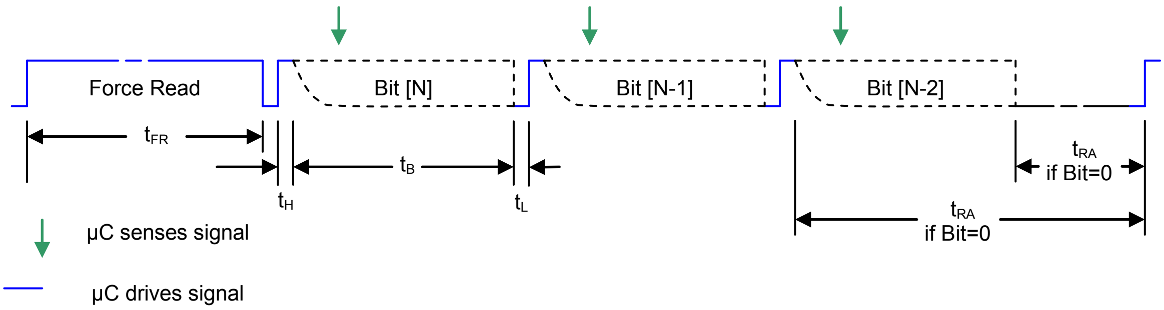


Fig 8: Timing diagram for the DOCI interface

The interrupt source for the DOCI/INT output can be selected between the ADC and the motion detect logic. If the ADC is selected, an interrupt is produced every 512 system clocks.

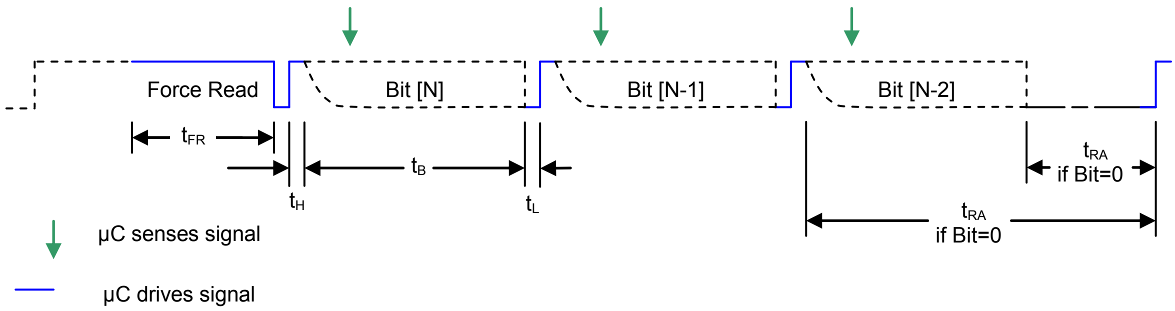


Fig 9: Timing diagram for the DOCI interface

If the "Interrupt Source" bit is 0 and "Motion Detect Enable" bit is 1 the interrupt will be set when motion is detected. No interrupt will be generated while the microcontroller accesses the interface.

Status and Configuration Data

The PIR voltage as well as all internal data can be read through the DOCI interface. The sequence of the data is fixed due to priority. The device outputs the PIR voltage value first, followed by status and configuration information. It is not required to read all data.

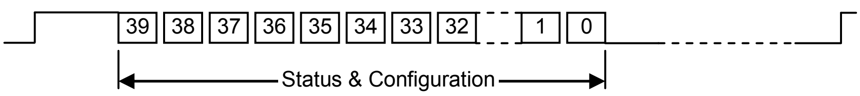


Fig 10: Data words available on DOCI interface

Bit-No	Register	Remarks
[39]	[0] PIR out of range	Indicates, that Sensor Ceramic was discharged
[38:25]	[13:0] PIR Voltage, 6.5µV/cnt	LPF or BPF output, depending on configuration
[24:17]	[7:0] Sensitivity	The values defines threshold for detection
[16:13]	[3:0] Blind Time	No motion detection for the time programmed, after the interrupt output changed from “H” to “L”
[12:11]	[1:0] Pulse Counter	Amount of pulses during the specified time window which triggers an alarm event (interrupt = “H”)
[10:9]	[1:0] Window Time	The specified time window in which the amount of pulses will trigger an alarm event (interrupt = “H”)
[8]	[0] Motion detector Enable	
[7]	[0] Interrupt Source	0 = Motion, 1 = Filter
[6:5]	[1:0] ADC / Filter Voltage source	0 = PIR (HPF), 1 = PIR, 2 = Supply Voltage, 3 = Temperature Sensor
[4]	[0] Supply Regulator Enable	0 = Switches on supply voltage regulator for conventional detector
[3]	[0] Start Self-Test	Initiates PIR self-test procedure
[2]	[0] Sample capacitor size	1 = 2 * default capacitance
[1]	[1] Clamp Input	1 = clamp PIR input for quick offset measurement
[0]	[0] User test-mode select	Test mode

Table 3: Register values and corresponding parameters

PIR Voltage Measurement

a) LPF Output
The ADC Source [6:5] has to be switched to the PIR inputs and the digital LPF output needs to be selected (=1).
V_{PIR} = (ADC_out – ADC_offset) * 6.5µV.

b) HPF Output
The ADC Source [6:5] has to be switched to PIR input and the digital HPF output needs to be selected (=0).
V_{PIR} = ADC_out * 6.5µV.

Supply Voltage Measurement

The ADC Source [6:5] has to be switched to Chip Supply (=2).
V_{DD} = (ADC_out – ADC_offset) * 650µV.

Temperature Measurement

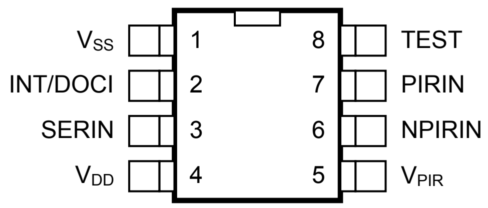
The ADC Source [6:5] has to be switched to the temperature sensor (=3).
Temperature = Tcal + (ADC_out – ADC_offset(Tcal)) / 80 * counts/K

ADC_offset = ADC value @ VIN = 0, typical value = 2^13
ADC_offset(Tcal) = ADC value at defined ambient temperature, typical value = 6400@300K

SOIC8 Pin Out

Pin Name	Pin Number	Description
V_{SS}	1	Negative supply voltage
INT/DOCI	2	Soft driver, MCU interface, Data Out Clock In, or Interrupt out
SERIN	3	Input, MCU interface
V_{DD}	4	Supply voltage
V_{PIR}	5	Regulated supply voltage for conventional PIR Detector
NPIRIN	6	Positive PIR sensor input
PIRIN	7	Negative PIR sensor input
TEST	8	Test input, connect to VSS

Table 4: Pin Out



Layout and Pads

Pad Name	X	Y
V_{SS}	0.812	0.786
INT/DOCI	0.692	0.786
SERIN	0.509	0.786
V_{DD}	0.396	0.786
V_{PIR}	0.073	0.304
NPIRIN	0.174	0.063
PIRIN	0.349	0.063
V_{SS}	0.657	0.063
TEST	0.807	0.063
Database	0.96	0.85

Table 5: Pad positions in mm

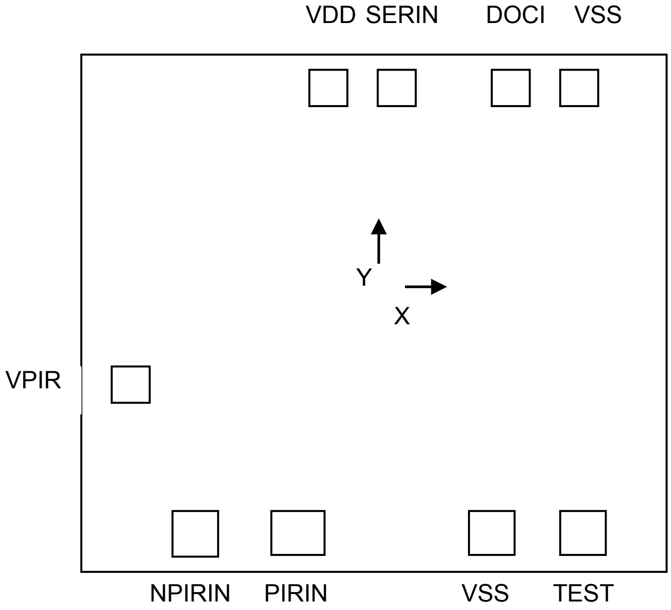


Fig 11: Die with pad names

Revision History

Rev.	Date	Remarks
1.0	November 12, 2014	
1.1	April 7, 2015	Window Time Calculation (4s ..16s to 2s .. 8s), Page 6
1.2	June 11, 2015	E931.96A to E931.96B Page 5 and Page 7
1.3	July 1, 2015	Page 3 – output current DOCI
1.4	July 28, 2015	Fig 1, 2, 3 and 4 NPIRIN and PIRIN swapped.

Contact Information

Microsystems On Silicon (PTY) Ltd.
Pretoria, South Africa
Tel: +27 (12) 998 4147
Fax: +27 (12) 998 4217
Email: sales@mos.co.za
Visit our website for the latest information