Design and Enhancement of A Embedded Surveillance System with Ultra Low Alert Standby Power

[1]Suryasree J [2]Arokia Magdaline. S
[1]PG Student [2]Assistant Professor, Department Of ECE
Parisutham Institute Of Technology And Science
Thanjavur,India

***Abstract*— Security and safety is one of the most talked of topics in almost every facet like surveillance, industrial applications, offices, and in general, in smart environments. Traditional surveillance systems suffer from an unnecessary waste of power and the shortcomings of memory conditions in the absence of invasion. In this paper we design a home embedded surveillance system which evaluates the development of a Low-cost security system using small PIR (Pyroelectric Infrared) sensor built around a microcontroller with ultra-low alert power. The system senses the signal generated by PIR sensor detecting the presence of individuals not at thermal equilibrium with the surrounding environment. Detecting the presence of any unauthorized person in any specific time interval, it triggers an alarm & sets up a call to a predefined number through a GSM modem. After the MCU sends the sensor signals to the embedded system, the program starts the Web camera. Our sensing experiment will show that we reduce not only memory consumption but also the system's power consumption [1-3], [21-23].**

***Index Terms* — Embedded Surveillance System, PIR Sensor, Ultrasonic Sensor, Low-Power State, PIC, GSM**

I. Introduction

The major issues as Security and safety is one of the most talked of topics in almost every facet like surveillance, industrial applications, offices, and in general, in smart environments. The traditional surveillance systems take a long time to detect whether there is any intruder. If there is no intruder, the sensing device which continuous to work and consumes much power [1-5]. To meet the increased requirements of the IEA we have to reduce the standby power of each electrical apparatus to less than 1 Watt [6-8]. A recently published survey shows that various attempts have been made to reduce such power loss by to making the adapters more efficient [9-12]. Another way to improve power efficiency is accurate control of the apparatus by both software and microcontroller [13-15].

In this paper the alerting sensors with low-power consumption are placed near those home windows and doors where an intruder must pass through. Also paper proposes a PIR sensor based low cost security system for home applications in which Passive Infrared (PIR) sensor has been implemented to sense the motion of human through the detection of infrared radiated from that human body. PIR device does not emit an infrared beam but passively accepts incoming infrared radiation. Fig. 1 shows the block diagram whole system. PIR sensor detects the presence of human in the home and generates pulse which is read by the microcontroller. According to the pulse received by microcontroller, a call is established to mobile station through a GSM modem and thus warns the presence of human in the home to owner-occupier.

When an intruder enters the sensing area, the sensors wake up the sleeping MCU (Micro Controller Unit) which starts the power supply for the indoor sensors and for the sensor signal transmission to the embedded system. The embedded surveillance system determines the sensor results and then decides whether to start the Web camera to capture images [18-20]. We use the MCU's sleep mode to reduce the alert power consumption for our home embedded surveillance system when there is no intruder so as to improve the traditional surveillance system without wasting the power. To secure embedded surveillance system against theft, crime, fire, etc. a powerful security system is required not only to detect but also pre-empt hazards. Conventional security systems use cameras and process large amounts of data to extract features with high cost and hence require significant infrastructures.

II. System Architecture

Fig. 1 shows the home embedded surveillance system which has two groups of sensors, indoor and outdoor. The outdoor sensor group contains a number of PIR and pressure sensors placed near windows and doors of a home. When the outdoor sensors sense an intruder, the MCU is woken up and turns on the power for the indoor PIR and ultrasonic sensors for the Majority Voting Mechanism. When this is completed, the decision signal passes to the embedded board GPIO (General purpose input and output). The software module of the power embedded board turns on the Web camera to capture images and user can view the images captured by the home surveillance system.

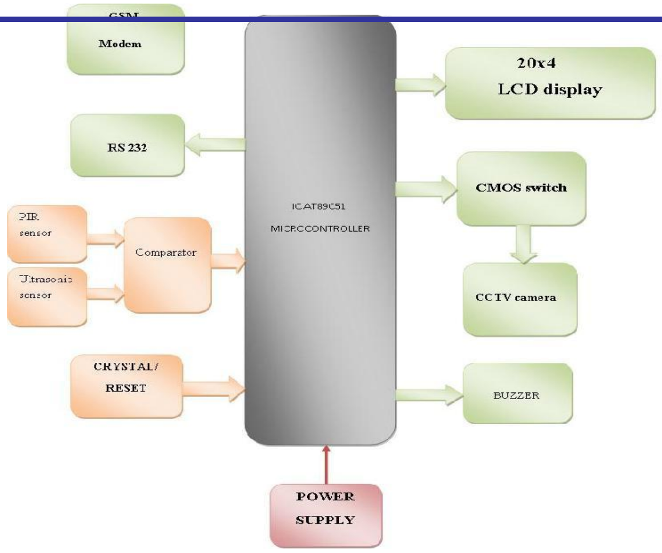

Fig.1.The home embedded surveillance system with ultra-low alert & GSM modem

A. PIR Sensor

PIR is basically made of Pyroelectric sensors to develop an electric signal in response to a change in the incident thermal radiation. Every living body emits some low level radiations and the hotter the body, the more is emitted radiation. Commercial PIR sensors typically include two IR-sensitive elements with opposite polarization housed in a hermetically sealed metal with a window made of IR-transmissive material (typically coated silicon to protect the sensing element). When the sensor is idle, both slots detect the same amount of IR, the ambient amount radiated from the room or walls or outdoors. When a warm body like a human or an animal passes by, it first intercepts one half of the PIR sensor which causes a positive differential change between the two halves. When the warm body leaves the sensing area, the reverse happens, whereby the sensor generates a negative differential change. These change pulses are what is detected. In order to shape the FOV, i.e. Field Of View of the sensor, the detector is equipped with lenses in front of it. The lens used here is inexpensive and lightweight plastic materials with transmission characteristics suited for the desired wavelength range. To cover much larger area, detection lens is split up into multiple sections, each section of which is a Fresnel lens. Fresnel lens condenses light. Providing a larger range of IR to the sensor it can span over several tens of degree width. Thus total configuration improves immunity to changes in background temperature, noise or humidity and causes A

shorter settling time of the output after a body moved in or out the FOV. Along with Pyroelectric sensor, a chip named Micro Power PIR Motion Detector IC has been used. This chip takes the output of the sensor and does some minor processing on it to emit a digital output pulse from the analog sensor. Schematic of PIR sensor output waveform is shown in Fig. 2.

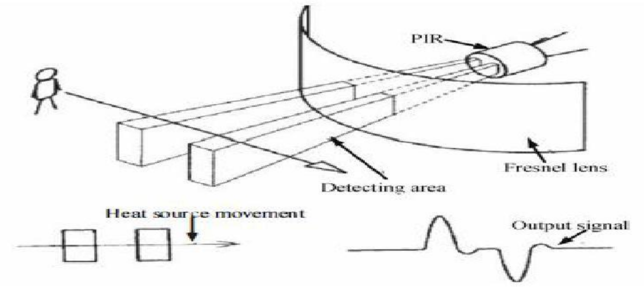

Fig.2.PIR sensor output waveform

B. Ultrasonic Sensor

Ultrasonic sensor is non-contact distance measurement module, which is also compatible with electronic brick. It's designed for easy modular project usage with industrial performance. A short ultrasonic pulse is transmitted at the time 0, reflected by an object. The senor receives this signal and converts it to an electric signal. The next pulse can be transmitted when the echo is faded away. This time period is called cycle period. The recommend cycle period should be no less than 50ms. If a 10μs width trigger pulse is sent to the signal pin, the Ultrasonic module will output eight 40 kHz ultrasonic signal and detect the echo back. The measured distance is proportional to the echo pulse width and can be calculated by the formula above. If no obstacle is detected, the output pin will give a 38ms high level signal.

C. GSM Modem

Global System for Mobile communications (GSM: originally from Group Special Mobile) is the most popular standard for mobile phone in the world. GSM/GPRS Smart Modem is a multi-functional, ready to use, rugged and versatile modem that can be embedded or plugged into any application. The Smart Modem can be customized to various applications by using the standard AT commands. The modem is fully type-approved and can directly be integrated into your projects with any or all the features of Voice, Data, Fax, SMS, and Internet etc.

III. WORKING CIRCUIT

The total system can be divided into three segments

A. Sensor and signal processing segment:

This segment consists of five parts:

- PIR sensor module: The PIR sensor module is fed from the output of fixed output voltage regulator IC LM7805. PIR positive input terminal is fed with a +5V supply and negative terminal is grounded. PIR sensor module output pin is connected to MCU pin. For re-triggering purpose, a jumper (JP) is attached on the COMMON (C) pin and HIGH (H) pin.
- LM7805: LM7805 is a fixed output voltage regulator IC. 7805 takes + 12V input and gives a fixed regulated output voltage of +5V.
- LM35: This is temperature sensor IC rated for full -55° to + 150°C temperature range. This is a transducer IC that takes voltage input and gives a voltage output proportional to the ambient temperature. +VS pin is connected to the output pin of LM7805 and the VOUT pin is connected to one of the analog input channels available on MCU.

- Switch: This is a mechanical switch which is of NO (Normally Open) type. One end of the switch is connected to the +5V supply and the other end is connected to one of the MCU input pins. For practical use, electronic remote controlled switch is a better option to secure the system operation.
- MCU: For this system, PIC 16f876A is used as the MCU, i.e. Microcontroller unit. It has built-in USART module which is necessary for passing AT commands to the GSM modem. The PIR sensor module output is tied to the pin RB I. The output of temperature sensor IC and one end of the mechanical switch is connected to pins RA3 and RBO respectively. A LED is connected to the pin RC3. The MCLRI VPP is connected to +5 V supply. A 4 MHz crystal is connected between OSCI an OSC2 pins. This crystal determines the clock speed of the MCU operation.

B. Alarm segment:

This segment consists of three parts:
- 74LS75: This is a D-Latch IC. The input voltage level on D 1 is kept unchanged on Ql and inverted on Q2. Inverted output images the voltage level set by MCU keeping the alarm on even when MCU is at SLEEP mode.
- Alarm: The alarm has two pins- VCC and GNO. The power pin is connected to Ql output pin of the D-Latch IC. The alarm can be set to ring by MCU.
- MCU: Pin RC4 of PIC 16f876A is connected to the 0 1 input of 74LS75.

C. GSM Modem interfacing segment:

As GSM modem uses serial communication to interface with other peripherals, an interface is needed between MCU and GSM modem. This segment consists of four parts:
-DB9 male connector: The serial port used here is a 9 pin DB9 male connector as the GSM modem side uses a female connector. Pin 14 and 13 of MAX232 are connected to pin 2 and 3 ofOB9 respectively. Pin 5 ofOB9 is grounded.
- MAX232: This particular IC is necessary for increasing the voltage swing at the outputs. It takes OV and +5V inputs and makes it a + 12V and - 12V output voltages. This increased voltage swing is a requirement for serial communications. Two 1 µF capacitors are connected between pins 4, 5 and 1, 3 of MAX232. V+ and V- pins are fed from VCC and GNO, i.e. G round through two 1 µIF capacitors. Between VCC and GNO pins, one 10 µF capacitor is placed.
- GSM modem: GSM modem is connected through a DB9 female connector to the interfacing circuit.
- MCU: The VCC, i.e. power pin, TTL input and TTL output pins of MAX232 are connected to the pins RCO, RCI and RC2 of MCU respectively.

IV. Circuit Operation

A. Sensor and signal processing segment:

As the jumper of PIR sensor module is placed between C and H, the output will stay on the entire time something is moving. The regulator IC serves regulated +5V to the LM35 and PIR sensor module. Prior to any operation, external interrupt is disabled in software of MCU. When the mechanical switch is closed, pin RBO gets an input voltage. This sets the system to run. The analog voltage output from LM35 is taken and converted to an equivalent binary value which represents the ambient temperature. As PIR sensor module does not perform satisfactorily below 15°C temperature, MCU monitors the temperature and light LED on pin RC3 when the temperature is equal to or greater than the critical temperature [5]. After the LED is on, the MCU waits a pre-defined time for the place to be fully evacuated. After that time is over, the system is online. After activation of the system, if there is any movement on that place within the coverage region of the PIR sensor module, it outputs a pulse which is taken as input by MCU. MCU then waits a pre defined time and checks for that signal again. This is done for avoiding false triggering.

B. Alarm segment:

RC4 remains HIGH right from the beginning. Thus, the output pin IQ of 74LS75 stays LOW and the alarm does not ring. If the signal is still present during the second check, MCU makes pin RC4 LOW. This makes a HIGH on IQ of 74LS75 and the alarm rings.

C. GSM Modem interfacing segment:

MCU makes HIG H on RCO which in turn, activates MAX232 IC. Then MCU starts sending AT commands to the GSM modem through the pins RCI and RC2. The commands are sent through the interface to the modem. The modem receives the commands and sets up a call to a pre-defined number. The call is not disconnected until the call time - up or the recipient disconnects the call. After the call is disconnected, MCU goes to SLEEP, i.e. low power consuming mode. Before going into SLEEP, MCU enables the external interrupt in software. When the mechanical switch is open, an interrupt occurs and MCU is brought out of SLEEP mode.

V. Software

The whole system is built around a MCU. MCU requires to be burned with software written for specific applications. The code is written using ASSEMBLY language and compiled using MPLAB. MPLAB generated a hex file which is burned using a burner into the IC. This section demonstrates the flowchart of the software which helps to visualize the coding steps as shown in fig.3. At the beginning of the program, external interrupt of MCU is disabled in software. Therefore, any signal input on the pin RBO cannot generate interrupt. Then, MCU looks for the switch whether it is closed or open. When the switch is open the signal is LOW and when the switch is closed, the signal is HIGH on pin RBO. If the signal is LOW, MCU repeatedly checks for the switch status.

When the signal gets HIGH, MCU converts the analog signal from the temperature sensor to the binary equivalent and checks repeatedly if the temperature of the surrounding is greater or equal to 15° Celsius. When the temperature rises to 15° Celsius or more, MCU waits for a pre-defined time before executing any instruction. This wait state is introduced to ensure proper evacuation of the place where the system is to run. After the wait state is over, MCU starts checking for any signal from the PIR sensor module. When there is no signal from the sensor, MCU checks the status of the switch. If the switch is still closed, it continues to check for sensor signal.

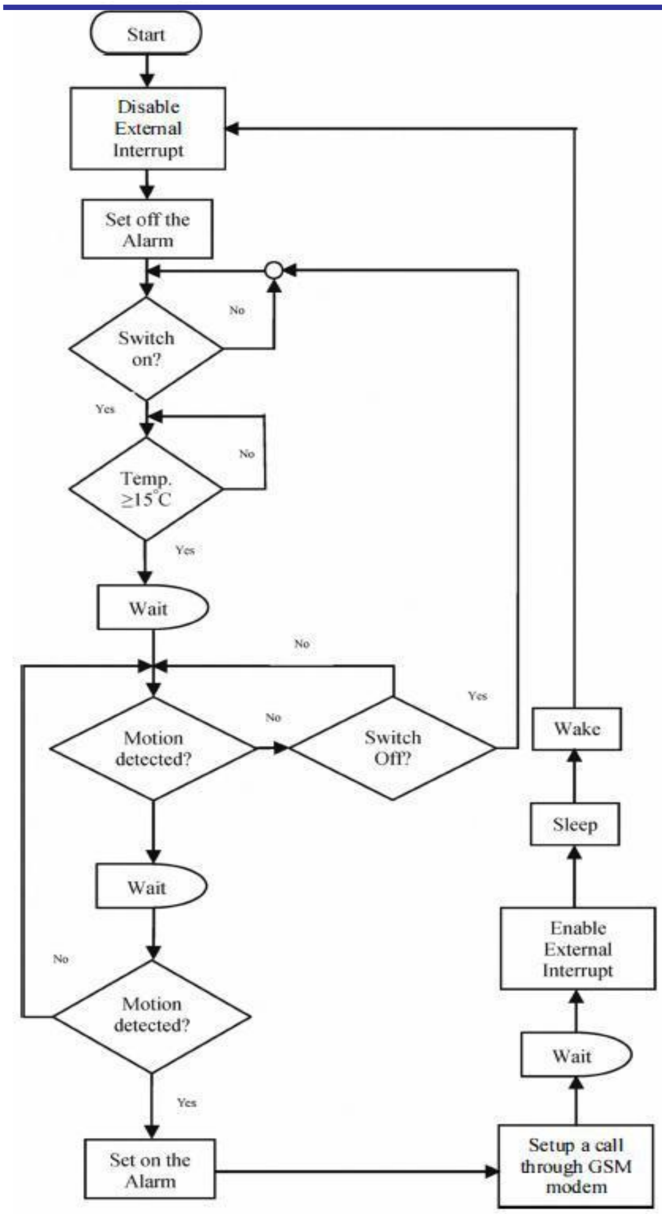

Fig.3.Software flowchart

wait state allows the call to be completed successfully. After that, MCU enables the external interrupt and goes to SLEEP mode. Enabling the external interrupt prior to SLEEP mode ensures that MCU will wake from the SLEEP mode whenever there is a HIGH to LOW transition on RBO, i.e. when the switch gets opened. When an external interruption occurs, MCU wakes up from sleep mood and disable the external interrupt and the program goes to the beginning of the algorithm.

VI. Result & Discussion

The proposed prototype system is implemented and tested for the desired functionalities. The green and red LEDs are employed to indicate the temperature above optimal level and the alarm respectively. The function of mechanical switch is done manually through a connecting wire. The system made 5 calls to a pre-specified cell phone number in 5 test runs which yields a hundred percent success rate. The whole test procedure is done in a laboratory having the mentioned criteria for optimal performance. Based on several expeSriments conducted under various conditions, it is verified that this system can resolve the presence of any warm body within the coverage area and execute subsequent actions. In order for a PIR sensor to work well most of the time, it is designed with certain limitations. A PIR sensor cannot detect a stationary or very slowly moving body. If the sensor was set to the required sensitivity, it would be activated by the cooling of a nearby wall in the evening, or by very small animals. Similarly, if someone walks straight towards a PIR sensor, it will not detect them until they are very close by. PIR sensors are temperature sensitive - they work optimally at ambient air temperatures of around 15-20 degree Celsius. If the temperature is over 30 degree Celsius, the field of view narrows and the sensor will be less sensitive. Alternatively, if the temperature is below 15 degree Celsius, the field of view widens and smaller or more distant objects will activate the sensor [5]. On cold nights, the difference in temperature between a person, e.g. normal body temperature is 37°C and the outside air temperature is relatively large, giving an apparent increase in performance of the sensor. On hot nights, this difference in temperature is relatively small and a decrease in performance of the sensor can be expected [7]. Moreover, the PIR sensors are sensitive to exposure to direct sunlight and direct wind from heaters and air conditioners. Precaution is required if there are pets in the house. PIR's are sensitive enough to detect dogs and cats. There are special lens available or a tape can be put on lower part of the existing lens, so as to avoid detection close to the ground. At the same time, it should be kept in mind that the intruder can also crawl

and avoid detection. So placement and subsequent testing of PIR sensor modules' is a must to avoid false alarms. These factors need to be kept in mind to ensure the proper operation of this system.

VII. Future Work & Conclusion

In this security system PIR sensor has been used which is low power, and low cost, pretty rugged, have a wide lens range, and are easy to interface with. This security system can be implemented in places like home, office, shop etc. The

sensitivity range for detecting motion of the system is about 3 to 4 feet. It can be raised up to 20 feet through careful use of concentrating optical lenses as future development. In addition to this, this system can be equipped with glass break detectors to enhance the level of protection. Use of multi-sensor data fusion and complex algorithm can be used to increase the effective FOV for larger spaces. In order to enhance the location accuracy and to enhance the method of processing the PIR sensor signal, use of more advanced techniques such as probabilistic theories and soft computing is left open for the future.

REFERENCES

[1] Cheng-Hung Tsai, Ying-Wen Bai, Wang Hao-Yuan and Ming-Bo Lin, "Design and Implementation of a Socket with Low Standby Power", *IEEE Transactions on Consumer Electronics*, Vol. 55, No. 3, pp. 1558- 1565, August 2009.

[2] A. Meier and W. Huber, "Results from the investigations on leaking electricity in the USA," Lawrence Berkeley National Laboratory, California, 1998.

[3] J. P. Ross and A. Meier, "Measurements of whole-house standby power consumption in California homes," Energy, vol. 27, pp. 861-868, Sep. 2000.

[4] A. Meier, "A worldwide review of standby power use in homes," Lawrence Berkeley National Laboratory, Dec. 2001.

[5] K. Clement, I. Pardon, and J. Driesen, "Standby Power Consumption in Belgium," *in Proc. EPQU*, pp. 1-4, Oct., 2007.

[6] International Energy Agency, Things That Go Blip in the Night: Standby Power and How to Limit It, Paris, France, International Energy Agency, 2001.

[7] International Energy Agency, Standby Power Use and the IEA "1-watt Plan", International Energy Agency, April 2007.

[8] L. McGarry, "The standby power challenge," *IEEE Transactions on Asian Green Electronics*, pp. 56-62, 2004.

[9] Bo-Teng Huang, Ko-Yen Lee and Yen-Shin Lai, "Design of a Two-Stage AC/DC Converter with Standby Power Losses Less than 1 W," *Proc. PCC*, pp. 1630-1635, Apr. 2007.

[10] Jee-Hoon Jung, Jong-Moon Choi and Joong-Gi Kwon, "Novel techniques of the reduction of standby power consumption for multiple output converters," *Proc. APEC*, pp. 1575-1581, Feb. 2008.

[11] S. Y. R. Hui, H. S. H. Chung, and D. Y. Qiu, "Effective standby power reduction using non-dissipative single-sensor method," *Proc. PESC*, pp. 15-19, Jun. 2008.

[12] Yu-Kang Lo, Shang-Chin Yen, and Chung-Yi Lin, "A High-Efficiency AC-to-DC Adaptor with a Low Standby Power Consumption," *IEEE Transactions on Industrial Electronics*, pp. 963-965, Feb. 2008.

[13] Chia-Hung Lien, Chi-Hsiung Lin, Ying-Wen Bai, Ming-Fong Liu, and Ming-Bo Lin, "Remotely Controllable Outlet System for Home Power Management," *Proceedings of 2006 IEEE Tenth International Symposium on Consumer Electronics (ISCE 2006)*, St. Petersburg, Russia, pp. 7-12, June 28-July 1, 2006.

[14] Chia-Hung Lien, Ying-Wen Bai, and Ming-Bo Lin, "Remote-Controllable Power Outlet System for Home Power Management," *IEEE Transactions on Consumer Electronics*, pp. 1634-1641, Nov. 2007.

[15] Ying-Wen Bai, and Yi-Te Ku, "Automatic room light intensity detection and control using a microprocessor and light sensors," *IEEE Transactions on Consumer Electronics*, pp. 1173-1176, Aug. 2008.

[16] Ying-Wen Bai, Zong-Han Li and Zi-Li Xie, "Enhancement of the Complement of an Embedded Surveillance System with PIR Sensors and Ultrasonic Sensors", *The 14th IEEE International Symposium on Consumer Electronics*, Braunschweig, Germany, pp. 1-6, June 07-10, 2010.

[17] Ying-Wen Bai and Jung-Lu Chen, "The Enhancement of Speech Recognition Probability by Homogeneous Majority Voting Mechanism," *The International Association of Science and Technology for Development, Signals, and System*, pp.48-53, Nov. 2004.

[18] Jie Cao and Li Li, "Vehicle Objects Detection of Video Images Based on Gray-Scale Characteristics," *ETCS '09, First International Workshop on Education Technology and Computer Science*, 2009, pp.936-940, 7-8 Mar. 2009.

[19] Francesco Alonge, Marco Branciforte and Francesco Motta, "a novel method of distance measurement based on pulse position modulation and synchronization of chaotic signals using ultrasonic radar systems," *IEEE Transactions on Instrumentation and Measurement*, Feb. 2009, pp. 318- 329.

[20] SeungKeun Cho, TaeKyung Yang, MunGyu Choi and JangMyung Lee, "Localization of a high-speed mobile robot using global features," *4th International Conference Autonomous Robots and Agents, ICARA 2009*, pp.138-142, 10-12 Feb. 2009.

[21] Z. Zhi - hui, L. Hui, L. Yin, C. Jia - jia, "Design of the intelligent fire proof and theft - proof alann system for home", JOURNAL OF HENAN POLYTECHNIC UNIVERSITY, vol. 28,no. I, pp. 207-210, Feb. 2009.

[22] Q. Qu, Z. Guohao, W. Baohua, "Design of Home Safeguard System Based on GSM Technique", Electronic Engineer, vol. 32, no. I I, pp. 76- 78, Nov. 2006.

[23] M. Shankar, 1. Burchett, Q. Hao, B. Guenther, "Human-tracking systems using pyroelectric infrared detectors", Optical Engineering, vol. 10, no. 45, pp. 106401 (01-10), Oct. 2006.

[24] M. Moghavvemi and C.S. Lu, "Pyroelectric infrared sensor for intruder detection," in Proc. TENCON 2004 Conf., pp. 656-659.

[25] Renewable Energy UK. (2010, Aug.). Find out how to integrate PIR (passive infra red) sensors into renewable energy applications. [Online]. Available: http://www.reuk.co.uklPIR-Sensors.htm

[26] BISSOOOI Datasheet. [Online]. Available: http://cdn.shopity.com/s/files/ I 10038/9582/fi1es/BISSOOO I. pdf.

[27] Schneider Electric. PDL PIR Sensor Technical Guide. [Online]. Available:http://www.pdlglobal.comlbrochures/PIRSensorsTechnicalBooklet.pdf.