Smart Sensors Interpreter and Acquisition Device with Notification System using GSM Technology

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Abstract— **This paper describes the modeling of a system to interpret and log data from temperature and light sensor. Using LM35 as the sensor to sense heat or ambient temperature, the data gain by LM35 will be sent to Arduino Microcontroller thus translating it into a number which are easier to comprehend. Electrical signal data received from sensor will be transformed to a value of numbers in degree Celsius correspond to the surrounding ambient temperature in real time. The intensity of light is measured by light dependent resistor, also known as LDR. Different intensity of light shine on LDR, will manipulate the resistivity of LDR thus providing different electrical signal fed to the microcontroller. Data will be processed and displayed in percentage of light (%) that will vary from 0 to 100 according to the intensity. Red and green LED will be used to symbolize state of temperature for the device. Built in buzzer is used to notify the user that the device had reach a temperature that might damages it. The device will call and send a short message to the specific user using built in GSM technology, when it is experiencing temperature above 36 Celsius.**

I. INTRODUCTION

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Temperature or heat sensors are devices that measure degree of temperature of a specific medium. They are applied in almost every device. Mostly are found in houses, universities and even in our public transportation. They are even in planes, trains and boats. It is also applied in our everyday electronic appliances such as fridge, oven, and computers [3]. Temperature sensor consists of two main type, contact temperature sensor and noncontact temperature sensor.

Contact sensors work by measuring temperature of the medium in contact with the sensors. The sensors assume that both medium had an equal thermal level. Example of contact sensors are Thermocouples, Resistance Temperature Detectors (RTDs), Full System Thermometers and Bimetallic Thermometers.

Noncontact Sensors is the most wide usage sensor in the industry to date. The sensor detects and measure heat by using radiant power or optical method. To obtain perfect temperature measuring, volume and area are also considered. An example of noncontact temperature sensors is a pyrometer.

Light sensor is a mechanism use to measure light intensity. There are many different types of light sensors, each of which works in a slightly different way. A photoresistor work by changing its resistance according to the intensity of light shine on it, the higher intensity of light the smaller resistivity of photoresistor will become [6]. It can be found in many type of consumer electronic since it is easy to design and cost efficient. Devices that include these sensors have many uses in scientific applications, but are also found in items that people encounter each day. A simple light sensor may be part of a security or safety device.

Both sensors has play a huge role in evolving human technology, Industry such as photovoltaic uses both sensors to operate. Since photovoltaic system needs maximum light to produce maximum power, light sensors and temperature sensor are used to find or detect the highest intensity of light in every direction [11]. Once the sensor detected the highest intensity of light, microprocessor will move the motor thus changing the angle of solar panel to the specific angle with maximum intensity[10]. Temperature and light sensor also use to record annual temperature and light intensity of a specific place by local weather station. They use the data gathered to produce a specific pattern which represent the greenhouse effect of the earth. Since data gathered from these sensors are accurate, precise and work with minimum supervision, it is widely used all around the world [2].

The main objective of this project is to interpret data from sensors and display it in an understandable figure for consumer daily usage. Secondly is to log all the data from the sensors into a personal domain or digital storage system for further analysis. Since finding a device to measure temperature and light at the same time is difficult and sometimes expensive to buy for an individual entity, this project is developed to overcome such obstacle and provide consumer with a smart solution to record and measure both temperature and light. Futher detail on the device construction and component will be explain in methodology and all the result gathered will be compiled and explained in results and discussion section.

II. METHODOLOGY

The sensor used to detect temperature is LM35, it is a contact sensor which has an ability to measure ambient temperature of a specific medium. Mechanism used to measure light is LDR, since LDR is very sensitive to light intensity; it is a perfect match for this project. Main brain of this project are Arduino microcontrollers, they processes all the data from sensors and execute them according to the source code embedded into the microprocessor of the Arduino. Source code is written in C programming coding and uploaded it into Arduino using a compiler known as Arduino IDE. Arduino IDE converts C programming language into machine language before sending it to the microcontroller.

To display the readings, Liquid Crystal Display (LCD) with dimension of 16 x 2 lines is used. Data is displayed and refreshed every 1 second. For data acquisition, Secure Digital (SD) card shield is used, where all the data processed by Arduino microcontroller is saved in SD card.

The device is equipped with notification system. They are consists of Red LED, Green LED, Buzzer and GSM Technology. GSM Technology used for this device came from GSM Shield with the main chip of SIM 900. This technology is capable of sending and receiving messages and calls. With specific coding in the source code, the device will send messages and called the user at specific occurrences.

The construction and all the connection of the device are illustrated in Fig. 1.

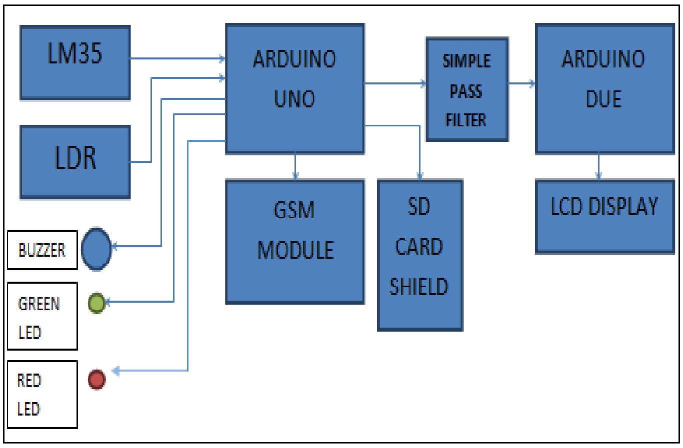

Figure 1: Block diagram of Smart Sensors Interpreter and Acquisition Device with Notification System using GSM Technology

The main character of this device are Arduino Uno and Due microcontroller, both of it is powered by ATMEL ATMega328 and ARM microprocessor. Two sensors are pinned to the microcontroller, LM35 are pinned at analog input 1 and LDR are pinned at analog input 5. LM35 is supplied with 5V of input voltage while LDR is supplied with 3.3V of input voltage. LM35 will provide specific output correspond to the surrounding ambient temperature. As the temperature increases, the output voltage to the microcontroller will also increase.

LDR is a sensor that is very sensitive to light, a slight change in light intensity could utter the resistivity of the sensor. 3.3V is fed to LDR because the output of LDR is connected to both Arduino Uno and Arduino Due. Since the maximum operating voltage for Arduino Due is 3.3V, it is wise to set the input voltage to 3.3V. As the light intensity increases, the output voltage from LDR will also increase.

Voltage fed into Arduino controller will be converted into a series of numbers which represent the number of ADC resolution of the microcontroller. Since Arduino Uno have a resolution of 10 bit, the numbers will vary from 0 to 1023. Arduino Due in another hand have a resolution of 12 bit and a much faster microprocessor, the numbers will vary from 0 – 4095. By understanding the maximum and minimum value of the resolution, the data fed from sensor to the microcontroller can be understood and changed into a value that are much easier to comprehend.

Data from temperature sensor will be converted from voltage to degree Celsius, to do that, a specific formula need to be applied using C programming coding and embed it into microprocessor using Arduino Integrated Development Environment (IDE). Same processes are used for LDR sensor, data produced from light sensor will be converted from voltage to percentage of light using a specific formula and embed into the microcontroller.

Data from light sensor are fed straight into both microcontroller, but data from temperature sensor are only fed into Arduino Uno. Arduino Due could not read low voltage signal, the only solution to send temperature data to Arduino Due is via Arduino Uno. Temperature data are processed and the value is increased before sending it to Arduino Due. Since data send from Arduino Uno is in Pulse Width Modulator (PWM) signal, a simple low pass filter shown in Fig. 2 is needed to convert PWM signal into true voltage signal. Arduino Due will gather the data from low pass filter, shrink the value and send it to the LCD display connected to it at pin 8,9,10,11,12 and 13. lcd.print coding are used to display any numbers or words onto the LCD. LCD display will be used in this project to display both temperature and light reading in real time. The reading will change or refresh every 1 second, this can be changed or controlled by manipulating the value of delay in the source code.

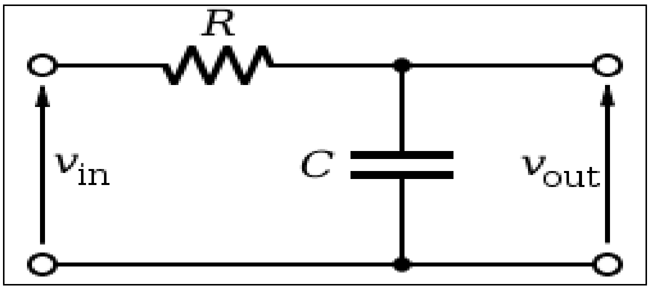

Figure 2: Simple low pass filter circuit, consists of resistor and capacitor. The ability of capacitor to charge and discharge make it useful to convert PWM signal to true voltage.

LED and buzzer are used for notification and monitoring mechanism. If the temperature detected is below 36 °C, microprocessor will send a signal to green LED, thus the LED will blink every half a second symbolizing the system is in a safe mode. If the temperatures detected are more than 36 °C, microprocessor will send a signal to red LED and buzzer, causing the red LED to turn ON and the buzzer to produce a loud noise, this state is known as danger state, where system will damage if expose for a long period of time.

GSM module is installed into the device to improve the notification mechanism. By using this technology, the user can be notified directly no matter where he or she is. GSM will only be used once the device experiencing temperature more than 36 °C. Once the sensors detected the temperature, microprocessor will send a signal to the GSM module, hence it will call the user for 5 second and hang up. GSM module will then send a SMS stating that the device had experience high level of temperature.

To record all the data sent from the sensors, SD card shield are used to log all the data sent to it in real time. Data is recorded in the SD card every 1 second and saved in excel format for easier views and recording. Since data is saved in excel format, graph and table can be generated for further analysis and review. SD shield are connected to microcontroller via Serial Peripheral Interface (SPI) connection, these connection are consists of MISO, MOSI, SLK and SS. These connections are used to send data from the microprocessor to the SD card through serial connection. MOSI port is connected to digital pin 12, MISO at digital pin 11, SLK at digital pin 13 and SS at digital pin 10. 5 V of input voltage is used to power up SD shield, supplying voltage lower than 5V will result in inaccurate value of data save to the SD card.

Fig. 3 shows the flowchart of the device system. It will start by recording or measuring light and temperature using LM35 and LDR. Next, Arduino microcontroller will read the analog input and execute. If the temperature did not reach 36 degree celsius, microcontroller will send signal to green LED, but if the microcontroller detect the temperature is more than 36 degree celsius, it will send signal to red LED, buzzer and GSM. At the same time, data will be sent directly to SD module and LCD display for data logging and display.

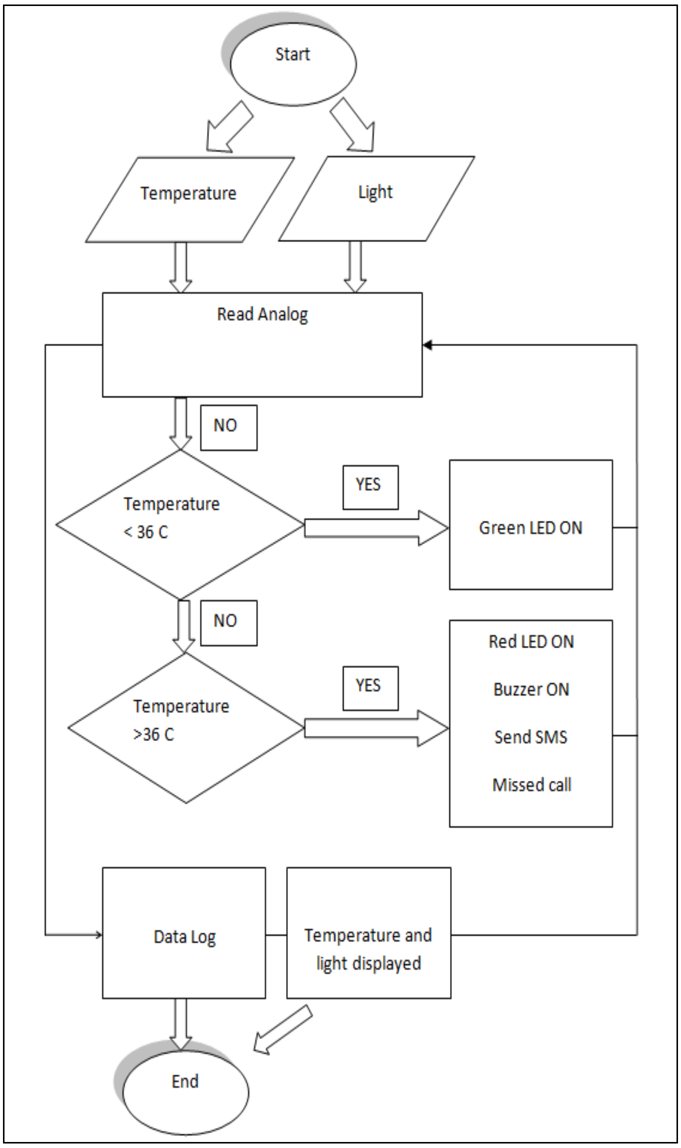

Figure 3: Flowchart of Smart Sensors Interpreter and Acquisition Device with Notification System using GSM Technology

III. RESULTS AND DISCUSSION

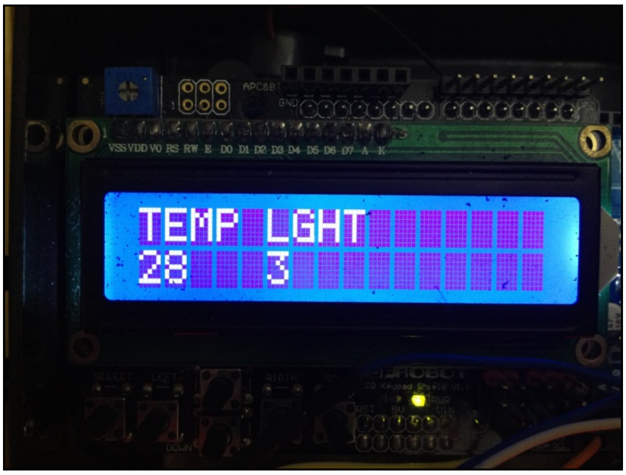

Figure 4 : LCD displaying temperature and percentage of light. Temperature is measured in degree Celsius (°C) and light is measure in percentage (%). LCD display used is pin directly to Arduino Due sitting below it.

Fig. 4 shows LCD displaying value of temperature in degree Celsius and light intensity in percentage of light. Data is refresh every 1 second and displayed in real time. Referring to Fig. 4, data is collected in a room in at 11.34 p.m. The temperature measured is 28°C and only 3% of light are measured because the LDR sensor is shaded with human hand to check its responsiveness.

Fig. 5 and 6 shows the final product of this device. The system is fitted into a compact and solid black box, where specific areas are drilled to make way for power jack, USB connector, antenna and SD card. On the top of the box, a few opening are drilled to make an opening for LCD display and sensors. Referring to Fig. 6, the construction of this device is all connected using male to male connector and female to male connectors. All the modules, circuits and microcontrollers are drilled, organized and attached to glass perspex. The glass perspex is attached to the black box main body firmly and neat. The design is compact and steady to avoid damages to occur in the box if any accidents happen. The black box is made with thick plastic body, the middle part of the body can be detached making it easy to place the project inside it. The main issue regarding this package is, its body is very thick, making it hard to drill a hole on top of the box. To overcome the problem, a hot solder iron is used to pierce through the body of the box, and a small saw is used to cut the body for an opening on top of the box.

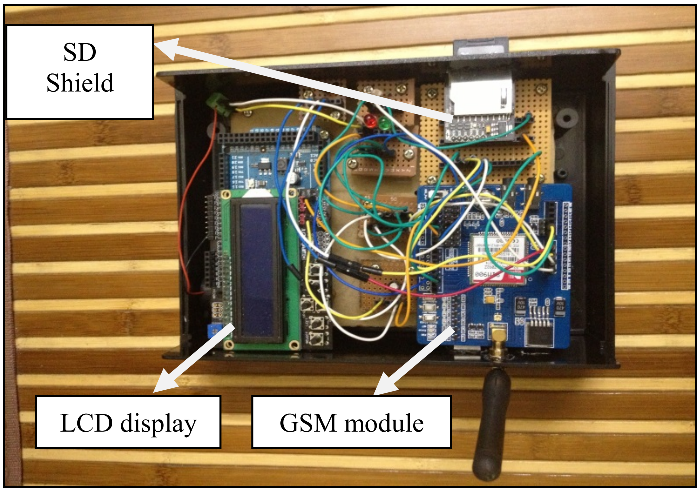

Figure 5: Complete packaging of device without cover. From top view, the location of all components can be seen clearly. Jumpers are the main method use to connect all the component. By observing the picture, LCD display, GSM module and SD card shield can be seen on the top, below and at the right side of the image.

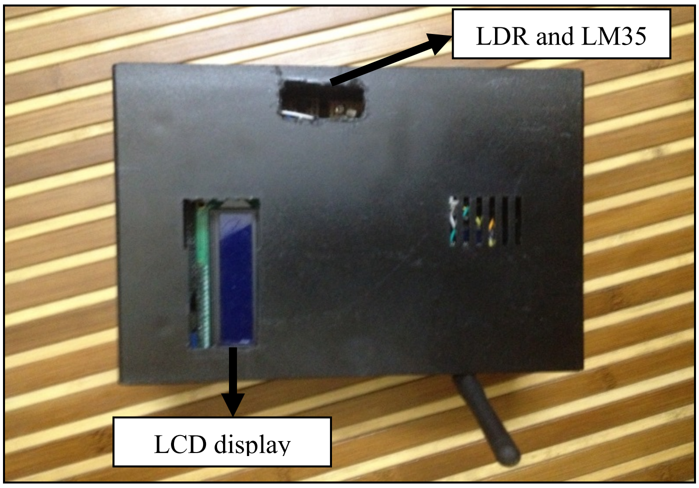

Figure 6: Complete packging of device with cover. From top view, two areas are opened for sensors and LCD display.

Fig. 7 shows the short message send by GSM module to the user hand phone. Short Messaging System or SMS are sent every time the system detected heat more than 36 °C. The message is embedded into the source code of this system, when it is time to send the message, microcontroller will send the signal and the message via tx digital pin to the GSM module, and it will send SMS to the specific user phone number.

Figure 7: Short message receive from GSM module by using personal mobile phone. SMS are sent once the device detects temperature more than 36°C.

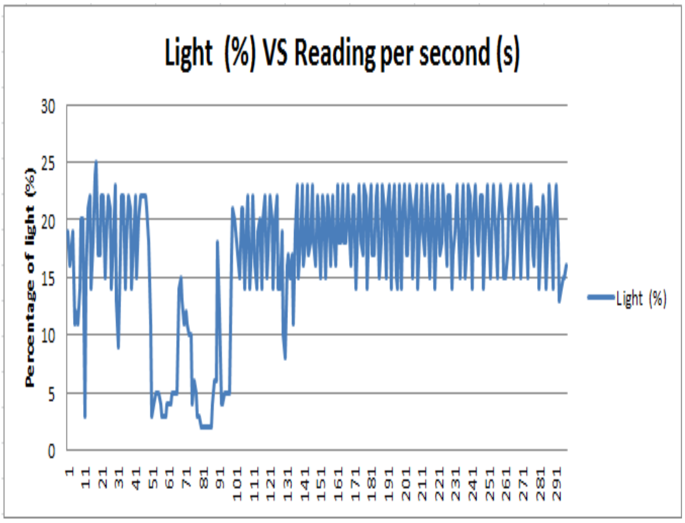

Figure 8: Graph of light versus reading per second. Light is measured in percent (%) and reading is measured every 1 second. The graph represents the percentage of light recorded for 5 minute in a room with constant light sources.

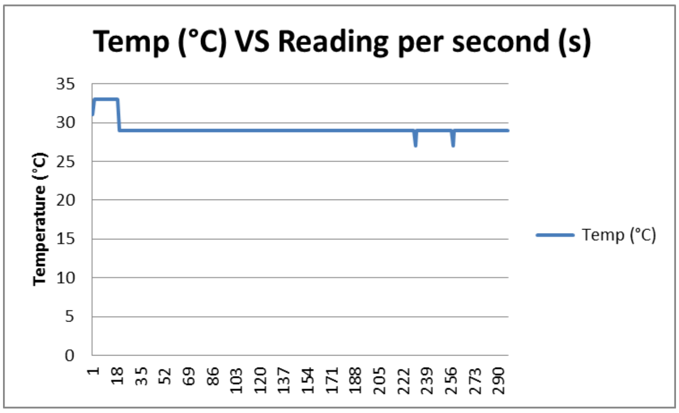

Figure 9: Graph of temperature versus reading per second. Temperatures are measured in degree Celsius (°C) for 5 mins duration.

	A	B
1		
2	Light (%)	Temp (°C)
3	19	31
4	16	33
5	17	33
6	19	33
7	11	33
8	12	33
9	11	33
10	14	33
11	20	33
12	20	33
13	3	33
14	15	33
15	21	33
16	22	33
17	14	33
18	18	33
19	24	33
20	25	33

Figure 10: Table of temperature and light reading using Microsoft Excel. 295 data are stored in 5 minutes of device operation. Data is recorded and sampled every 1 second.

Fig. 10 shows table of data recorded in the SD card for duration of 5 mins and opened in Microsoft Office Excel. Straight away data are compiled and sorted into a table that divided both temperature and light reading into two columns. For 5 mins, 295 data is recorded in a single table. Since the reading took place in a closed room, temperature varies from 33 to 28 °C. The constant temperature is 28 °C, the temperature increase once human hand is applied on top of the sensor. Light reading varies from 3% to 20% for every reading. This is because the light sensor is very sensitive to light and measured even a slight difference in light intensity. Plus there are other aspects that affect the readings, one of it is human presence in the rooms and ceiling fan that disrupt light from reaching the LDR.

Fig. 8 shows the graph of light versus reading. Light is measured in percentage and readings are measured every 1 second for 5 minute. Referring to the graph, percentage of light varies almost on every readings. This is because the LDR is very sensitive to light, a simple swipe on top of the sensor could change the reading dramatically. At reading 50 to 90, a human hand is used to block light from reaching the sensors by placing it on top of the sensors, the reading drop from 23% to only 3% and stay until reading 99. The scale should be from 0 to 100, for this graph it only display scale from 0 to 35, that is the reason why the graph for light looks fairly unstable

Fig. 9 shows a graph obtain from the table in Fig. 10. It can be generated using Microsoft Excel by using view mode and click on graph. The graph represents temperature measured in Celsius versus with reading for every second. Temperature constant on the first 30 readings at 33°C before decreases to 28°C and stay until the test is finished. At the first 30 readings, a human hand is applied at LM35 sensors causing the reading to stay at 33°C, when the human hand is remove from sensor, temperature drop from 33 to 28°C. There are two glitch occur in the graph at reading 232 and 260, the glitch occur from Arduino Uno microprocessor conflict. This problem could not be overcome by editing source code, the only solution is to replace the microcontroller with a much faster and stable replacement such as Raspberry Pi or PIC.

By using the data collected, the device can be used in a very wide range of working field. Using the data recorded, a researcher working in renewable energy field could analyze ambient temperature of a certain location and the intensity of light to determine the perfect solar panel to use or to determine the perfect tilt angle that absorb the highest intensity of light. Temperature can be monitored regularly to avoid any system damage causes by extreme high temperature. Plus temperature can change the output voltage produce by solar panel, and by measuring the ambient temperature, photovoltaic system designer can design the best photovoltaic system in the specific ambient temperature.

IV. CONCLUSION

This device is designed to interpret and log data from temperature sensor and light sensor. It is also installed with a smart notification system which consisted of GSM technology, LED and buzzer. Data from sensors are displayed using LCD display, the data displayed are easy to understand and straight forward. Temperatures are measured using degree Celsius and light are measured in percentage of light. All the data processed by microprocessor will be saved in the SD card in real time. Data saved in excel format for better analysis and review by the user. Since this device has a lot of function regarding temperature and light monitoring, it will be a valuable technology in the renewable energy and astronomy working field. Both objective of this project are met, according to the result shown in the Fig. 4 to Fig. 10, the device has successfully display an accurate reading of the temperature and light hence able to save all the data in the SD card. Plus the data is able to be analyzed using table and graph generated by Microsoft Excel. Although there are few problems occured such as microprocessor conflict and black box body is too thick, these problems do not give huge implication to the project. In a nut shell, the project is a success and further analysis and improvement will be added to the project so that it will be completely ready for consumer to use.

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