ZIGBEE and GSM based Smart Agriculture System

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Abstract— In the Indian context, awareness has increased about implementing technology in the agriculture industry. Manual collection of desired farm environment data required for analysis can be sporadic leading to incorrect measurements and findings. This can cause difficulty in controlling various important factors. Wireless distinct sensor nodes can reduce time and effort required for monitoring an environment. The graphical representation of PC data allows simplified diagnosis and analysis. Monitoring systems can ensure quicker response times to adverse factors and conditions, better quality control of the produce and low labour cost. Generally, farming lands, greenhouse/polyhouse are at remote locations from the farmer's residence and requires 24*7 monitoring. The utilization of technology would allow for remote measurement of factors such as temperature, humidity, soil moisture, water level and light detection leading to increase in productivity. Crops are prone to various diseases due to various factors. One such factor is dew condensation in greenhouses which can be overcome by humidity monitoring. The proposed system includes all the above features. In addition to this, there are provisions of security like password lock and human/animal intrusion detection mechanism and according notification SMS is sent to farmer. The farmer is also notified on his mobile phone of the soil moisture level, water level, temperature, humidity, power status of motor, etc. using a GSM module. The overall proposal is optimized taking into consideration the intellectual and understanding level of farmers.

Key words: CMOS logic, GSM module, Agricultural Factors Taken into Consideration

I. INTRODUCTION

Within an agricultural environment, awareness has increased about implementing technology into the industry. Manual collection of data for desired factors can be sporadic, not-continuous and produce variations from incorrect measurement taking. This can cause difficulty in controlling these important factors. Wireless distinct sensor nodes can reduce time and effort required for monitoring an environment. The logging of data allows for reduction of data being lost or misplaced. Also it would allow placement in critical locations without the need to put personnel in hazardous situations. Monitoring systems can ensures quicker response times to adverse factors and conditions, better quality control of the produce and a lower labor cost. The utilization of technology would allow for remote measurement of factors such as temperature, humidity, atmospheric pressure, soil moisture; water level and light detection. There appears to be increased development aimed towards wireless solutions compared to wired-based systems. One particular reason is that the sensor location can often require being repositioned and a traditional wire layout could cost a substantial deal of time and energy in order to address such wiring problems.

Environmentally-friendly high-quality agriculture has been investigated in order to improve the farming practices in greenhouses. Recent developments in the field of wireless sensor networks as well as miniaturization of the sensor nodes has allowed precision agriculture to emerge. Precision agriculture concentrates on providing the means for harvest information, work management and growth information. Greenhouse environment monitoring and control is essential to improve productivity through prevention of diseases in the crops. The dew condensation phenomenon occurs in the greenhouse when the dew point temperature is higher than the temperature of crops, and it is deeply related to relative humidity. Especially, too close to sunrise with the high humidity at daybreak or when humidity inside a greenhouse is too high, the temperature inside a greenhouse gets to rise rapidly but the temperatures of crops rise slowly. Thus the huge difference between the environmental temperature and the crop temperature causes the dew condensation phenomenon to occur. Forecasting dewdrop generation and removing the dewdrops are important for growing crops in the greenhouse.

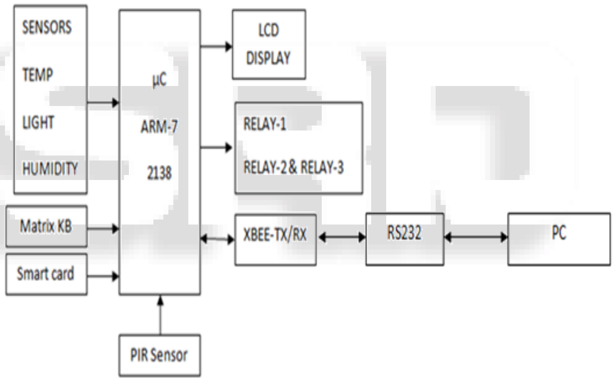

Fig. 1: Block Diagram 1 of System being developed

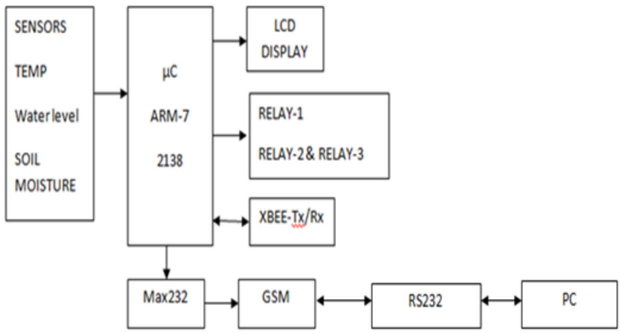

Fig. 2: Block Diagram 2 of System being developed

II. DESCRIPTION OF SYSTEM BEING DEVELOPED

The system being developed is based on the ARM 7 LPC2138 module The ARM 7 module is connected to the various sensors like temperature, light, float, etc. A GSM900 module is being used to control and get alerts of the system wirelessly on user's mobile providing more dynamism. A Max 232 is being used to convert TTL to

CMOS logic and vice versa for efficient communication between the GSM module and ARM 7. The module can be connected to the network either Wireless itself or through a wired Ethernet connection. . A Zigbee 2.4 GHZ IEEE 802.15.4 is being used in order to communicate data wirelessly to a selected Server/PC (Figure 1). The server stores the received data and draws graphs for the performance of the system, which can be straightforwardly imported into a database, other software in order to perform analysis and displaying of data. A PIR sensor is used for security to detect intrusion and alert the user of it.

III. AGRICULTURAL FACTORS TAKEN INTO CONSIDERATION

A. *Temperature:*

One vital measurement essential for monitoring in many agricultural environments is temperature. Dependent on the agricultural product being grown temperature can affect growth such as germination, sprouting, flowering and fruit development [1]. Particular agricultural products have suitable temperature ranges; accordingly the system investigates using the LM35 temperature sensor (Figure 3).

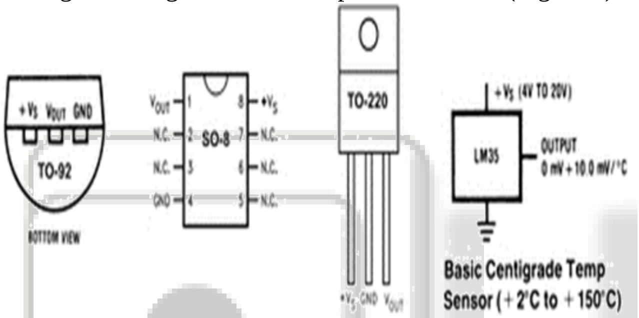

Fig. 3: LM35 pin configuration

The LM35 provides an analogue output that varies depending on the temperature being measured. The voltage output is then connected to ARM7 module allowing for measurement and transmission. The output of the LM35 is linear with regards to temperature and is proportional to degrees centigrade. The formula used for calculation is

$$T=5*ADC*100/255 \qquad (1.1)$$

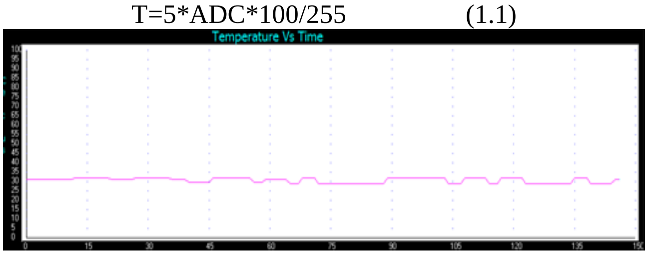

Fig. 4: Graph of actual temperature output of Slave 1

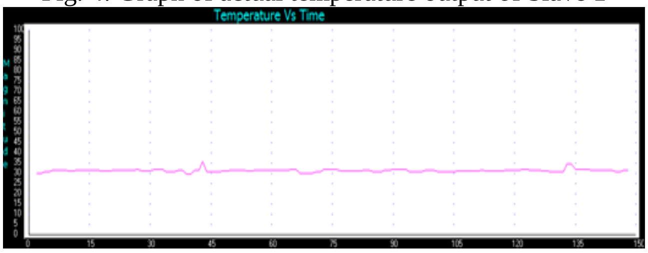

Fig. 5: Graph of actual temperature output of Slave 2

B. *Humidity:*

Humidity is of importance as when levels are too low or high agricultural products can suffer. If humidity is held below 50 percent for extended periods of time, growth can suffer as loss of water from leaves might be faster than replacement. Similarly if Humidity is above 80 percent for extended periods risk of disease can increase [3]. The system uses the HIH-4010 Humidity sensor produced by Honeywell. The HIH-4010 provides an analogue output [8] that is connected to a voltage buffer followed by a voltage divider configuration. This is in order for the voltage value to be within the ARM7's ADC's voltage range. Various calculations are needed in order to get the humidity value from the analogue output [10]. There is a need to calculate the Sensor's Relative Humidity (RH) value dependent upon Voltage Supply (VSUPPLY). For a system that would run of battery power it is important to know Voltage Supply over different periods, as both the Humidity sensor and ARM7 module are running on the same power supply the regular voltage readings by the ARM7 can be used for calculation. There also requires some compensation for temperature (T) which will be acquired from the LM35 temperature sensor. The voltage divider configuration implemented also needs to be considered when performing the calculation of the result.

$$V_{SensorOut} = V_{Supply}[0.0062(SensorRH) + 0.16],$$

$$RH_{TempCom} = \frac{SensorRH}{1.0546 - 0.00216T},$$

$$V_{OutDiv} = \frac{HR2}{HR1 + HR2} V_{SENSOROUT},$$

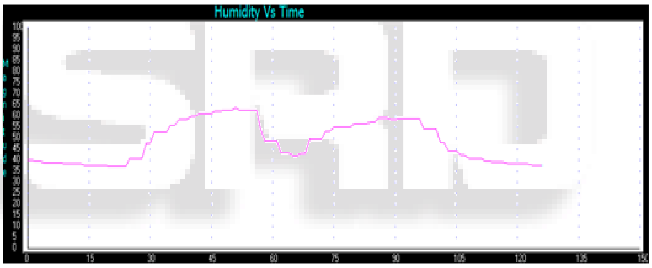

Fig. 6: Graph of actual humidity output

C. *Light:*

The measurement of light intensity and duration can be of significance as in certain cases it has an effect on growth processes of farm and plants in an agricultural environment. Monitoring light for control and management of light sources can play a role with flowering, blooming and ripening of produce [3]. It could be of use in a system that utilizes or implements supplemental lighting options. The system investigates the use of an APDS-9002 ambient LDR sensor[3]. There after it's then connected to one of the ARM7 ADC channels.

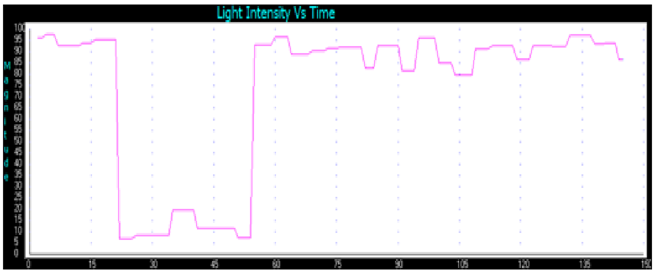

Fig. 7: Graph of actual Light Intensity output of Slave 1

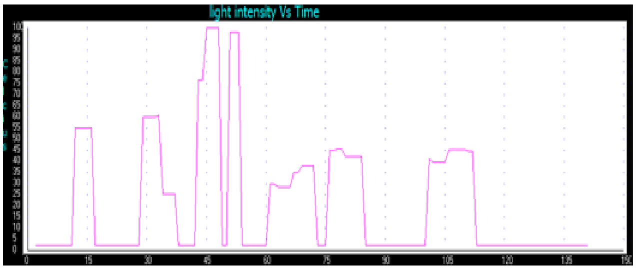

Fig. 8: Graph of actual Light Intensity output of Slave 2

D. *Water Level and Soil Moisture:*

The measurement of water level or soil moisture can be of significance with regards to agricultural products for their survival and growth. Low level of soil moisture can lead to withering away of the crop[2]. The utilization of the float sensor (figure 4) is used for the measurement of water level. They are insensitive to water salinity and are designed to have low power consumption. As the level of water decreases the float sensor falls and a circuit is connected at the level and arm joint in the float sensor which according to the level of the float lever decides whether the whether the water level is low or high.

Fig. 9: Float Sensor

Instead of the soil moisture sensor, we are connecting a moisture based electrode sensor and signal conditioning circuit (figure 5). As soon as the water dries up then the electrode voltage rises to 5V which is applied to the non inverting terminal and the output of the amplifier is 0V. When the water level is up then the electrode voltage drops to 0V which is applied to the non inverting terminal and the output of the amplifier is 5V.

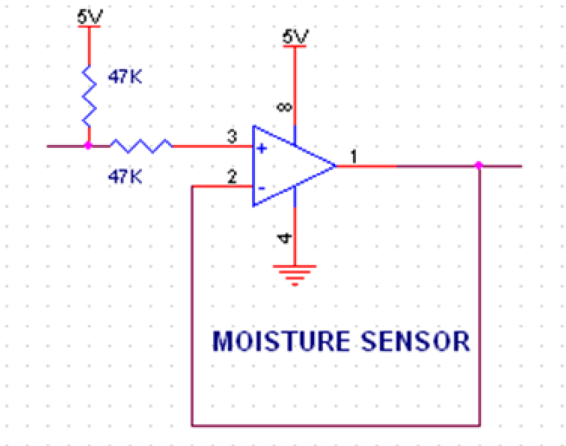

Fig. 10: Moisture sensor

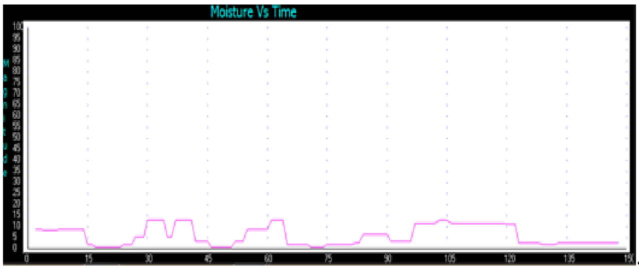

Fig. 11: Graph of actual Water Level output

IV. SECURITY AND INTRUSION DETECTION COMPONENTS

A. *Passive Infrared Sensor:*

This energy saving control system includes hardware and software. Software that be used is Visual Basic and programming in Microcontroller. The sensor is most the important element in this project. The PIR sensor will be used to detect the human/animal presence in the surroundings. A Passive Infrared sensor (PIR sensor)(Figure 6) is an electronic device which measures infrared light radiating from objects in its field of view. Apparent motion is detected when an infrared source with one temperature, such as a human, passes in front of an infrared source with another temperature, such as a walls of a greenhouse or air. All objects emit what is known as black body radiation. This energy is invisible to the human eye but can be detected by electronic devices designed for such a purpose. The term ‘passive’ in this instance means the PIR does not emit energy of any type but merely accepts incoming infrared radiation. A PIR sensor with a wide angle of 160degress and 30ft range is being used (Figure 7).

Fig. 12: Passive Infrared Sensor

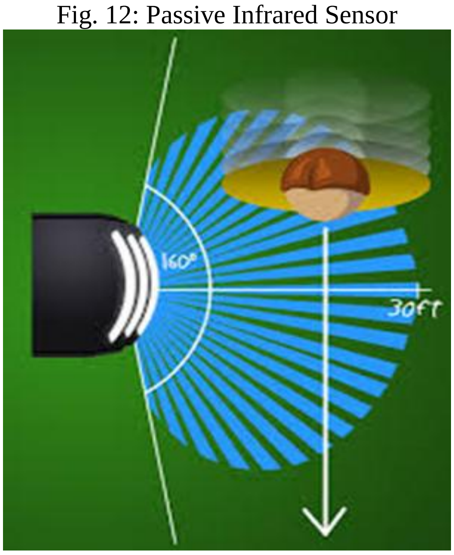

Fig. 13: Angle and range

B. Matrix Keypad:

A matrix keypad lock (Figure 8) is used to provide security to greenhouse, if the wrong code is entered a specific number of times the user is alerted on his mobile using wireless GSM module. A mobile keypad (4*3) is being used. The keypad is directly connected to the ARM7 module.

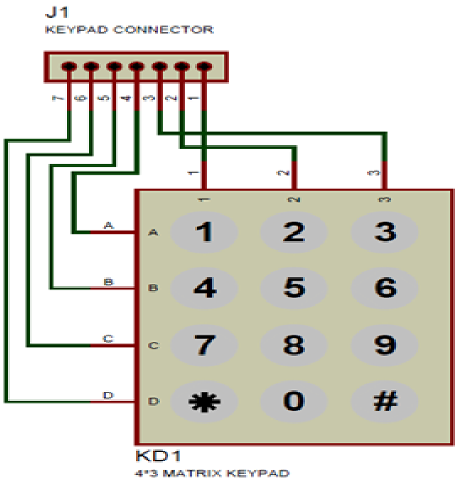

Fig. 14: 4*3 Matrix keypad

V. COMPONENTS FOR COMMUNICATION

A. Zigbee:

Zigbee is a specification for a suite of high level communication protocols using small, low-power digital radios based on an IEEE 802 standard for personal area networks. Zigbee devices are often used in mesh network form to transmit data over longer distances, passing data through intermediate devices to reach more distant ones. This allows zigbee networks to be formed ad-hoc, with no centralized control or high-power transmitter/receiver able to reach all of the devices. Any zigbee device can be tasked with running the network. Zigbee is targeted at applications that require a low data rate, long battery life, and secure networking. Zigbee has a defined rate of 250 kbit/s, best suited for periodic or intermittent data or a single signal transmission from a sensor or input device. A zigbee version 2 has been used which has range of 30meters indoors and 100meters outdoors in plain sight.

Fig. 15: Zigbee module

B. GSM Module:

The core of data communication about this system lay in wireless communication control terminals that uses GSM modules to transfer long-distance data extensively and reliably. It supports instructions of AT commands. SIM900 can be integrated with a wide range of applications. SIM900 is a quad-band GSM/GPRS engine that works on frequencies 850/ 900/ 1800/ 1900 MHz. Sim900 has a built in network status indicator LED plus a TCP/IP protocol stack for internet data transfer over GPRS. With a tiny configuration of 40mm x 33mm x 2.85 mm, SIM300 can fit almost all the space requirement in our application. Therefore, the MCU can connect with GSM modules very expediently through serial interfaces. GSM module operates on CMOS logic levels and ARM7 operates on TTL logic levels so an intermediate component MAX 232 IC is added which performs this function.

Fig. 16: Sim900

VI. ARM7 MODULE

A. ARM7 LPC2138 Specifications:

ARM7 has a 16/32 bit processor with 32 kb on-chip static RAM. It has In-System Programming/In-Application Programming (ISP/IAP) via on-chip bootloader software. Single flash sector or full chip erase in 400 ms and programming of 256 B in 1 ms. One (LPC2131/32) or two (LPC2134/36/38) 8-channel 10-bit ADCs provide a total of s per channel. up to 16 analog inputs, with conversion times as low as 2.44us. It has up to forty-seven 5 V tolerant general purpose I/O pins in tiny LQFP64 or HVQFN package. Two 32-bit timers/external event counters (with four capture and four compare channels each), PWM unit (six outputs) and watchdog.

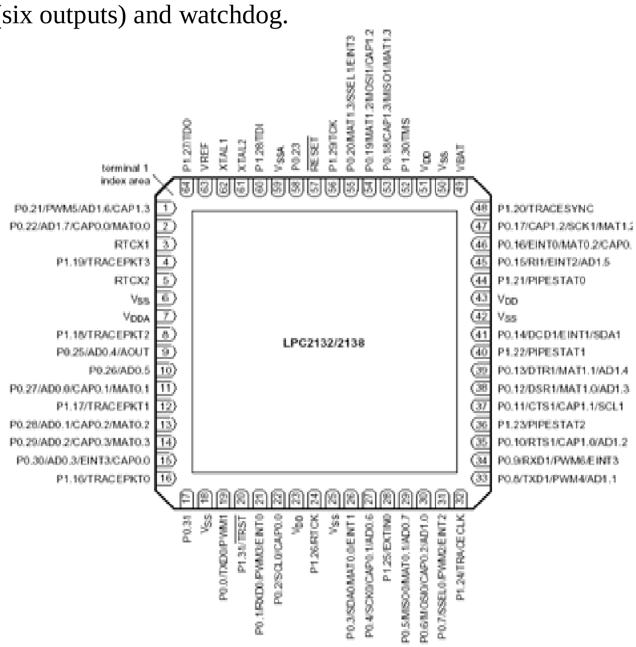

Fig. 17: ARM7 LPC2138 pin diagram

VII. CONCLUSION AND FURTHER INVESTIGATION

The current system still in the early stages of development performs well for transferring and logging of values from the various sensor nodes. It allows for relatively easy connection to nodes and communication. Further work is required with regards to battery and self-powering from solar panels or other renewable sources. The system will allow for additional or interchangeable sensors to be connected as the need occurs in the future. Further investigation is planned for integrating the measurement of nitrates in water sources near agricultural environments. Further an Android application can be created to make the interaction with the device for the farmer more user friendly. The system allows for relatively easy use and can be operated with standard commercial products that are widely in use allowing users to utilize equipment already in use.

VIII. ACKNOWLEDGMENT

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