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ARM Based Green House Monitoring And Control Using Zigbee.

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Abstract: *Increased demands for grains and agriculturalproducts have expedited the commercialization of agriculture in India. To support commercialization it is necessary to develop supporting advance technology for agricultural. More than 50 countries in the World are fully using green house technology for cultivation of crops on commercial scale. Monitor and control the green house different controller based system have been developed, to handle the system complexity, interfacing of number of sensors and networking with low power consumption it is necessary to develop advance processor based green house controller system.*

In this paper ARM based embedded system with ZIGBEE to monitor and control the microclimate parameter of green house on regular basis, is presented. System also employs keyboard and LCD for display of data and ZIGBEE for wireless transmission of data to remote computer monitoring

Key Words: *ARM Controller, ZIGBEE Protocol, Isolationfor relay driver, Signal Conditioning*

I. Introduction

A recent survey of green house has reviewed that there are more than 50 countries in the world, where cultivation of crops is undertaken on a commercial scale under cover. India is on the verge of commercialization of agricultural. To expedite the commercialization of agricultural in India it is necessary to develop cost effective sophisticated green house controller with latest technology.

Digitally greenhouse monitoring and controlling of a system based on ATMEL89S51 is proposed in [1]. This system comprises of external peripheral such as Analog to digital converter, external interface of actuator and other devices. 89c51 based system also has less internal memory hence limits software overhead required for making system generic. For wireless monitoring of green house controller RF communication is proposed in [2]. RF wireless transmission has less data rate and implementation needs more power consumption. There are many wireless systems, developed with Bluetooth technology but ZIGBEE protocol provides low cost and low power connectivity for equipment and consumes less power than other protocol.

Many of the embedded system developed for green house controller employs standard signal conditioning circuits which limits the range and sensitivity of sensor. Special circuits are used for signal conditioning of following sensors; temperature: 0-100˚C (RTD-PT100) temperature sensor is used. Humidity sensor SY-HS-230 is used of improved sensitivity. Simple LDR is used for sunlight monitoring the NPN transistor BC547 is used in novel way for soil moisture measurement.Gas sensor (MQ7) is used for concentration of gas measurement.

II. System Hardware:

A. System model:

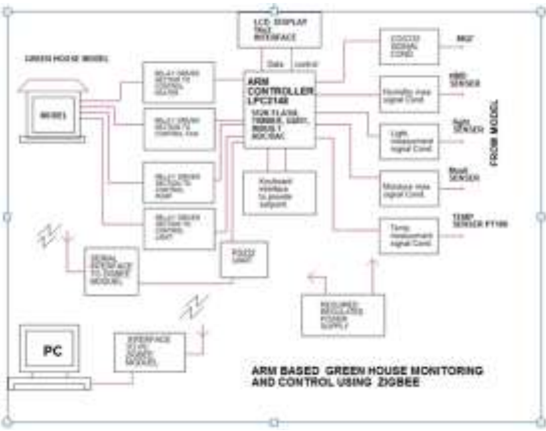

Fig.1 Block Diagram

i. Sensors and Actuators:

Parts/ components of the system: • sensors (for data acquisition system): • temperature sensor (PT100) • humidity sensor (SY-HS-230) • light sensor (LDR) • BC547 as a moisture sensor • liquid crystal display (hitachi's hd44780) Gas sensor (MQ7) • actuator relays for controlling devices like water pump, cooler, heater, artificial lights.

ii.ARM7:

LPC2148 is ARM7TDMI-S Core Board Microcontroller that uses 16/32-Bit 64 Pin (LQFP) Microcontroller No.LPC2148 from Philips (NXP).It is having inbuilt ADC & two UARTs.

iii. ZIGBEE:

ZIGBEE is a low data rate, low power consumption, low cost, wireless networking IEEE 802.15.4 protocol targeted towards automation and remote control. ZIGBEE compliant wireless devices are expected to transmit 10-75 meters, depending on the RF environment and the power output consumption required. It operates in the unlicensed RF worldwide (2.4GHz global, 915MHz Americas or 868 MHz Europe). The data rate is 250kbps at 2.4GHz, 40kbps at 915MHz and 20kbps at 868MHz.XB24-Z7WTI ZIGBEE model is connected to UART of ARM controller which will transmit data to receiver connected to PC which is located away from Greenhouse and Greenhouse parameters can be observed in GUI developed in Visual Basic on PC.

B. Design of Signal Conditioning Blocks:

Different parameters to be monitored, their range and type of sensor:

1) Temperature: 0-100˚C
2) Humidity: 0%-100 %
3) Light concentration: 0%-100%
4) Moisture measurement: 0%-100%
5) Gas conc.measurement:20 to 2000ppm

i. Temperature Measurement and signal Conditioning:

For temperature measurement Resistance Temperature Detector (RTD) sensor, PT-100 having linear response and sensitivity of 0.39Ω/˚C is used.PT 100 is connected in one arm of the bridge and resistors of rest of the arms are selected such that at 0˚C the bridge is balanced and 0V appear at the output of the bridge circuit .The resistance of the sensor changes with respect to temperature, widely specifying RTD is having positive temperature coefficient.

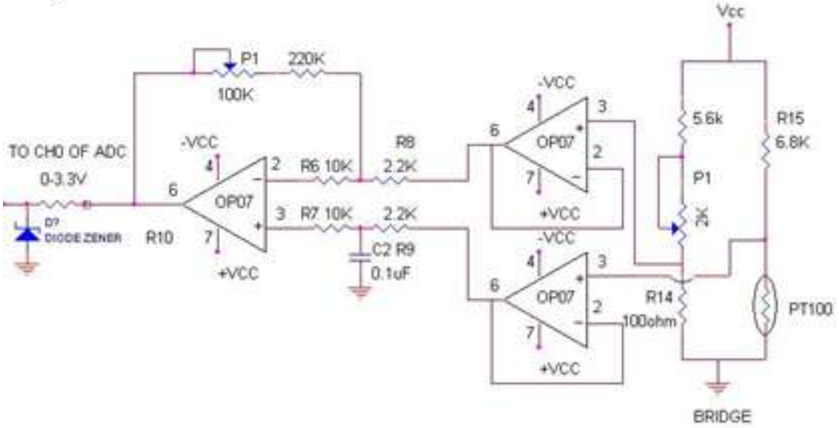

Fig.2.Temperature signal conditioning block

ii. **Humidity Measurement and signal Conditioning**:The relative humidity of the atmosphere can be measured with the help of humidity sensor SY-HS-230.This is resistance type humidity sensor. Its resistance varies exponentially with variation of relative humidity. It is having sensitivity 0.025V/% relative humidity. SY-HS-230model consists of SYH-2 sensor and integrated circuit to provide linear dc output. It has wide temperature compensation range and long term stability. By providing the external biasing and faithful amplification of the DC mV, relative humidity from 0% to 100% can be calibrated. The amplification is done with the help of differential Amplifier having gain from 1.5 to 2.5 and is adjusted to 0-5V for a span of relative humidity.

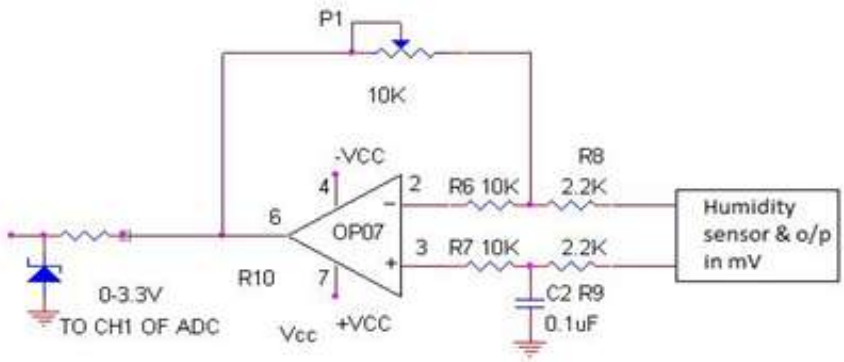

Fig.3.Humidity Signal conditioning block

iii. Sun light Measurement and signal Conditioning: To measure and calibrate this parameter a nonlinear sensor i.e. light dependent resistor (LDR) having maximum resistance of 20K to 100K and Sensitivity of 60Ω to 100Ω/Lux.LDR is connected in parallel a trim pot to have a maximum resistance of combination in full dark. This parallel combination is connected in series with potential divider arrangement of high value resistor. To avoid the loading effect the output from LDR is buffered with the help of OP-amp.

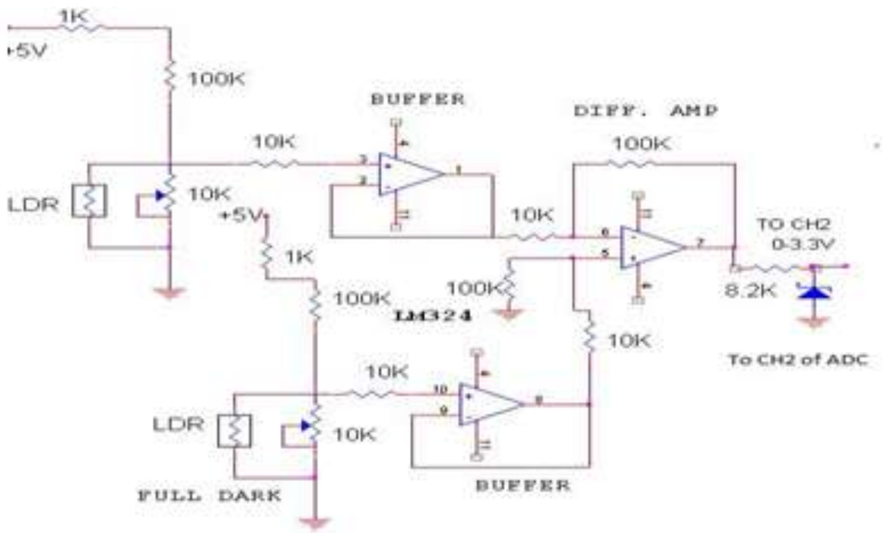

Fig.4. Sun light Signal Conditioning block

iv. Moisture measurement and signal conditioning:

For measuring the soil moisture content, VH400 & SM150 sensors are available but the response of these sensors are linear upto 70% of relative humidity and after that it is nonlinear and its accuracy is also less, so Water content of soil is measured using NPN Transistor BC547 having Vce(max) 100V,Ic(max) 100-150mA,hfe: current gain 100(typ) in[9].The base bias to transistor is provided.

V.Gas measurement

The Carbon Monoxide (CO) gas sensor detects the concentrations of CO in the air, and outputs its reading as an analog voltage. The sensor can measure concentrations of 10 to 10,000 ppm. The MQ-7 sensor has 6 pins, 4 of them are used to fetch signals, and other 2 are used for providing heating current.

from +5V and one trim pot. Base and collector terminals are inserted in soil using suitable probe to detect the variation in soil resistance with respective the water content in soil. Transistor works in active region and will change its collector current which is proportional to the moisture content in soil.

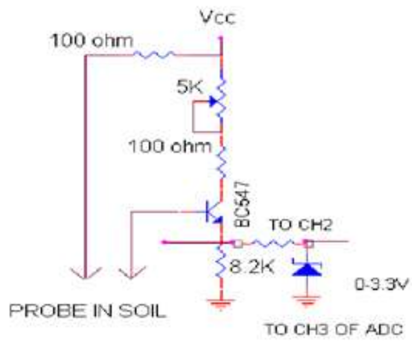

Fig.5. Soil moisture signal conditioning

Soil resistance when soil is wet (100% moisture) is approximate, 250K Ωand as soil becomes dry itsresistance becomes in MΩ.
As soil is wet, transistor will be in saturation and voltage across 8.2K is 3.3V. By applying KVL,

$$I_B = \frac{Vcc - V_{BE} - V(8.2k)}{(100\Omega + Rsoil)} \quad ..(i)\ ,Rsoil = 250K$$

$$= \frac{5 - 0.7 - 3.3}{(0.1 + 250)k} = 4\ uA$$

$$Ic = hfe * I_B = 100 * 4uA = 400uA\ Vout$$

$$= Vcc - (R + 0.1k)\, IC - VCE$$

$$R(variable\ 5k) = \frac{5 - 3.3 - 0.6}{400uA} - 0.1k$$

$$R(variable) = 2.65k$$

C.Keypad Design:

Hexadecimal keyboard is used to provide the set point for various parameters to the system. Keypad is designed using priority encoder IC 74148 which will give direct binary number of key, which is pressed. The circuit diagram is as shown in fig.

This Keypad design reduces I/O pin requirements of controller and also reduces programming complexity as there is no scanning for identification of pressed key.STB is output of AND gate having inputs as GS outputs of two ICS, which provides zero when any key is pressed, hence the status of STB pin should be checked first for identification of whether key is pressed or not. The output of keypad is as follows:

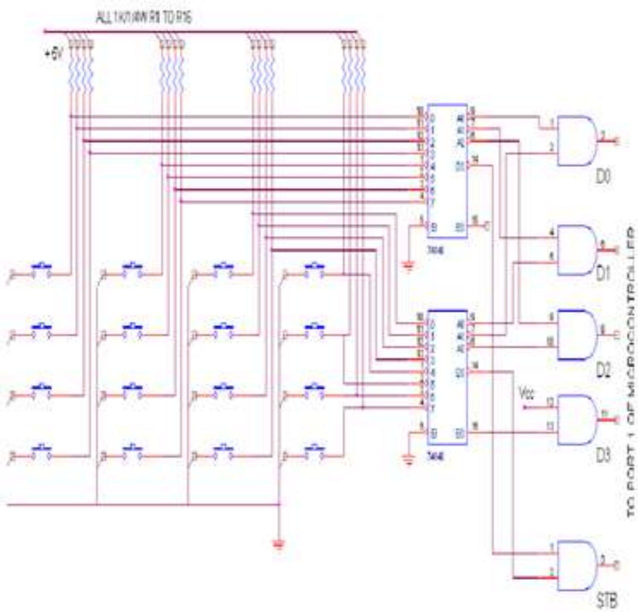

Fig.6. Keypad circuit

Pressed Key Number	STB	D3	D2	D1	D0
Initial	1	1	1	1	1
1	0	0	0	0	0
2	0	0	0	0	1
3	0	0	0	1	0
4	0	0	0	1	1
5	0	0	1	0	0
6	0	0	1	0	1
7	0	0	1	1	0
8	0	0	1	1	1
9	0	1	0	0	0
10	0	1	0	0	1
11	0	1	0	1	0
12	0	1	0	1	1
13	0	1	1	0	0
14	0	1	1	0	1
15	0	1	1	1	0
16	0	1	1	1	1

D. Relay driver Section:

To turn on light, pump, heater relay drive circuit is used. The Isolation is provided to four relay driver circuit.

The data line from port is used to drive the relay. To achieve isolation from noise pickup opto-coupler are inserted. The port data is applied to the photo LED of the opto-coupler through the 330 ohm current limiting resistor. As the logical input from the port is 1, Photo diode will goes into fully conduction and emits the light which is falling on the base of photo transistor of the opto-coupler. Hence photo transistor will goes into fully saturation. It will conduct from 12 V supply then collector to emitter and through 1 k resistor. 4.7k resistor is the base biasing for the transistor SL100. Regenerative feedback is applied to the op to-coupler through 470k resistor. When the Opto-coupler transistor is in fully saturation will drives the transistor SL100 into full saturation and hence relay will be in energized condition. Heater, pump are connected in NO and COMM terminal of the relay.

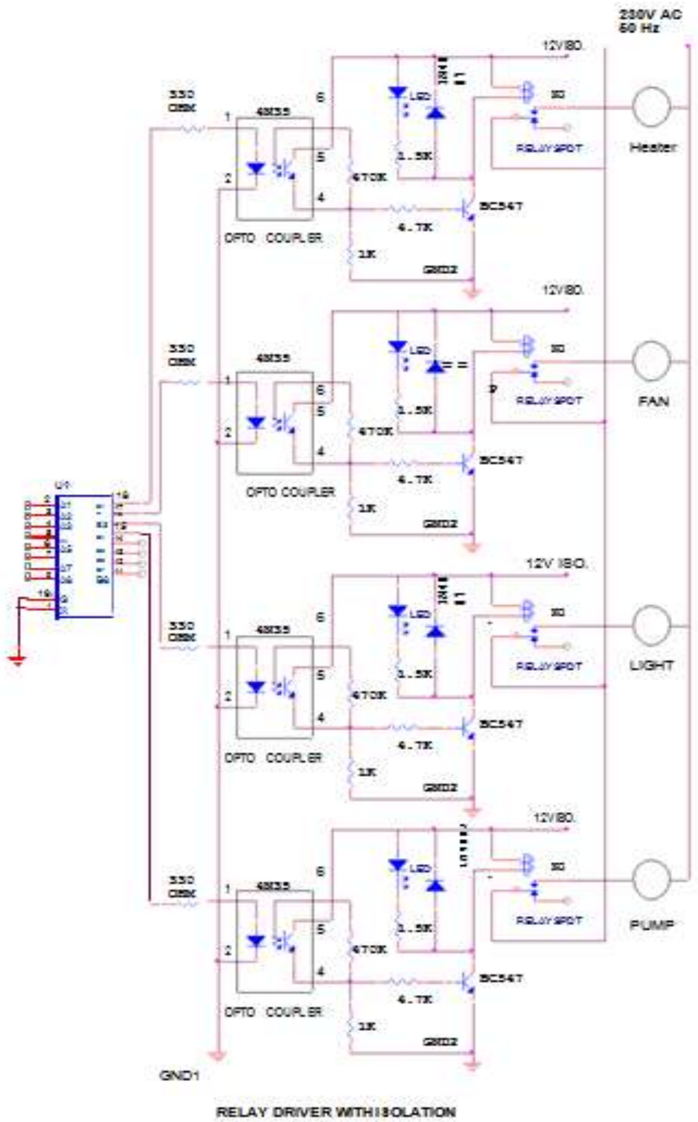

Fig.7.Relay driver section

III. Graphs

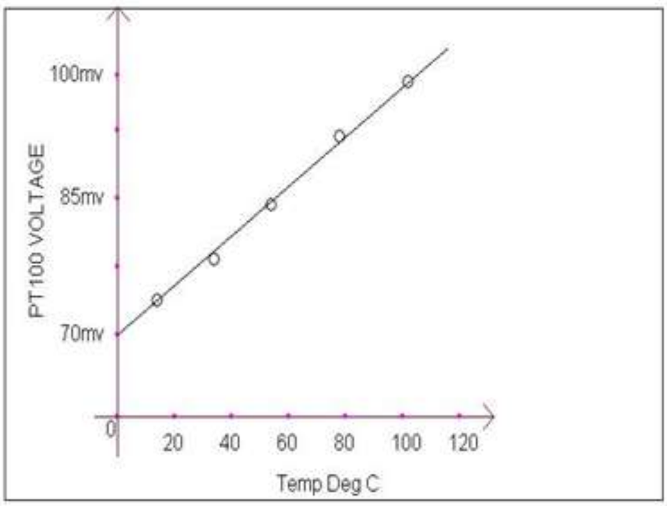

Fig.8. Graph of temperature Vs PT-100 output

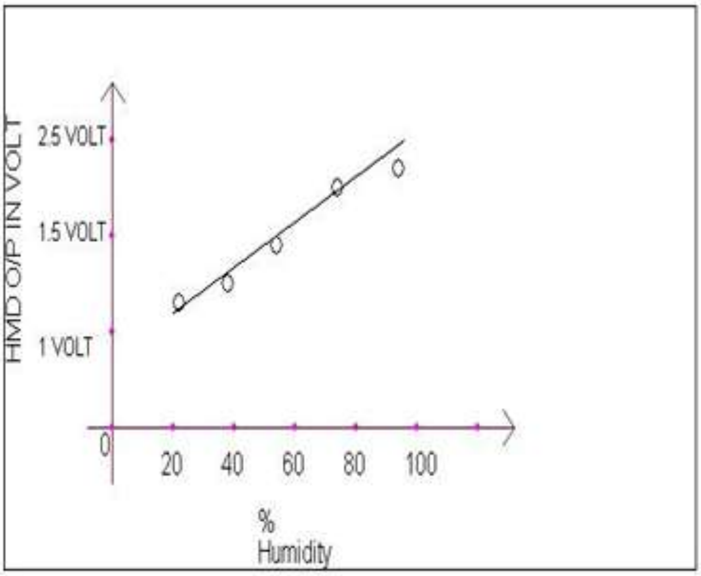

Fig.9. Humidity VS sensor oututput

IV. System Software:

System requires controlling for different physical parameters. For this controller should have in build ADC to reduce the hardware also for ZigBee interfacing we require inbuilt UART. These features are available in ARM7

PUMP LPC2148 Controller. The LPC2141/2/4/6/8 microcontrollers are based on a 32/16 bit ARM7TDMI-S CPU with real-time emulation and embedded trace support, that combines the microcontroller with embedded high speed flash memory ranging from 32kB to 512kB.128-bit wide memory interface and a unique accelerator architecture enable 32-bit code programming makes the program development cycle short, enables use of the modular programming approach. Readily available modules in C compilers for embedded system & library codes that can directly port into the system programmer codes.Keilµvision4 software is used for compiling program.

V. Conclusion

Designing the ARM based system for measurement and control of the four environmental parameters, essential for plant growth i.e. temperature, humidity, soil moisture and light intensity has been followed. The measurement results obtained from the circuit have shown that the system performance is quite accurate. This automation in greenhouse improves quality and quantity ofproduction in agricultural field. Keypad used in system is simple and reduces complexity by reducing IO requirement of the controller. Driver Circuit provides better isolation to avoid the noise pickups. Greenhouse status can be observed on PC, located away from the greenhouse due to use of ZIGBEE technology.

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