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WIRELESS REAL TIME PROPORTIONAL CONTROL SYSTEM

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Abstract— This system provides low power consuming and low cost wireless sensor network. This system provides a real time temperature and humidity. It also gives proportional control action. This system consists of TI's MSP430 microcontroller which consumes ultra low power and improves the overall system performance. The Sensorion's SHT 11 sensor is used to measure temperature and humidity. Sensor SHT 11 consumes low power and gives the fully calibrated digital output. Zigbee technology is used for wireless communication. Zigbee is low power consuming transceiver module. It operates within the ISM 2.4 GHz frequency band. AT and API command modes configure module parameters. RF data rate is 250 kbps. To achieve the proportional control triac and MOC 3022 are used. The star network topology is implemented. The temperature of earth goes on increasing due to global warming, deforestation, pollution, etc. Due to this the temperature of atmosphere also increases which is harmful and dangerous for many systems. This system provides precise control of temperature and humidity in Green House, Art Galleries and Industries.

Keywords— Mixed Signal Processor 430; SHT11; Zigbee; Triac; MOC3022.

I. INTRODUCTION

Wireless sensor networks consist of sensor nodes and each sensor node consists of sensing, data processing and communicating components. These low power consuming sensor nodes are randomly dispersed over the interest area. Wireless sensor networks support different kinds of applications in distinct areas such as military, healthcare, agriculture, home, industry, automation [1,3]. The traditional cable data transmission is high cost and big interference, instead, the wireless data transmission has advantages like: low cost, better applicability and lower interference. The technological development in wireless sensor networks made it possible to use in monitoring and control of greenhouse parameters in precision agriculture [2]. Due to global warming, uneven natural distribution of rain water, erosion, soil degradation many farmers move towards the green house technology.

Crop production in greenhouses is an increasing industry in the fields of agriculture. Greenhouse with all measures of environmental controlling and monitoring is important component for crop production and protection. Climate control and monitoring of greenhouses is an important application which has some peculiar features.

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From a practical point of view, in order to achieve effective cultivation plans, the best environmental conditions inside a greenhouse have to be ensured. This requires that some specific variables, such as temperature and humidity are controlled in order to follow desired profiles [6].

In museums, it is critical to properly conserve the existing artwork. For this purpose, it is fundamental to continuously monitor its environment, either in storage or exhibition rooms [4]. Artworks in museums and art galleries are significantly affected by temperature and relative humidity variations. Significant variations in temperature can double the deterioration rate of paper and other canvases. Fluctuating levels of relative humidity cause materials to corrode, shrink, swell, or warp. Monitoring and control of indoor climate conditions is thus crucial in ensuring the preservation of art collections.

II. THE SYSTEM DESIGN

The system architecture is as shown in figure1. System consists of sensor nodes, transceiver and base station as control unit. Sensor SHT11 senses the temperature and humidity data and sends it to the base station with the help of Zigbee module.

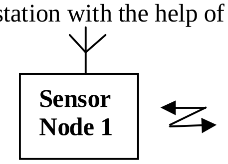


Figure1. System Architecture

At the base station transceiver zigbee module receives the signal and display it on computer. The set points for temperature and humidity are entered at base station and are sent to each sensor node.

Each sensor node consists of SHT 11 temperature and humidity sensor, MSP430 microcontroller, Zigbee transceiver, MOC3022, Triac driving circuit. Set points are compared with the actual temperature and humidity. This difference is used to generate control trigger pulse for triac. Trigger pulse is generated in such a way that the firing angle is proportional to the difference between the set point and measured value of parameter. Control trigger pulse triggers the triac for each half cycle of AC power supply. Figure2 shows the Node-1 architecture.

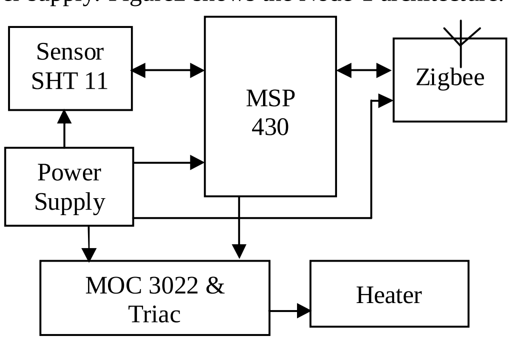


Figure2. Node-1 Architecture

Microcontroller sends the trigger pulse to triac. Power supplied to the heater and humidifier is thus controlled through the triac. When the difference between the set point and measured value of parameter is less then very less power is given to the heater and humidifier and vice versa. Thus, the heater and humidifier output is controlled proportional to the difference between set point and measured parameter through triac triggering. Figure3 shows the Node-2 architecture.

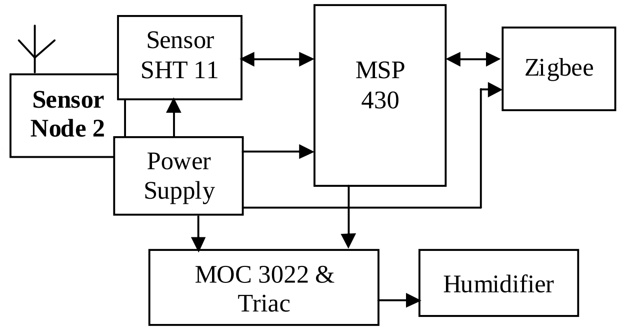


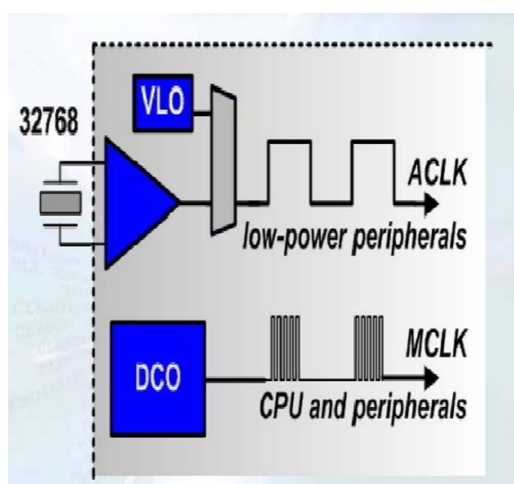
Figure3. Node-2 Architecture

III. THE HARDWARE DESIGN

A. MSP430 Microcontroller:

MSP430 is a 16 bits mixed signal ultra-low power processor. It has one active mode and five software selectable low power modes of operation. The basic clock module provides the following three clock signals as auxiliary clock main clock and sub main clock. It has strong processing ability, high performance simulation technology and rich chip peripheral modules. It adapts to wide range of temperature, 62.5ns instruction cycle time, serial onboard programming, on-chip emulation logic. It contains ADC, simulation comparator, digital module such as UART, SPI, I2C, IrDA encoder and decoder and the watchdog timer. So can reduce the complexity of the peripheral control circuit, also reduce design costs, improve the reliability of system. In order to adapt to the industrial operation environment working temperature is -40° C to + 85°C.

Clock system has the ability to enable and disable various clocks and oscillators which allow the device to enter various low-power modes (LPMs). The flexible clocking system optimizes overall current consumption by only enabling the required clocks when appropriate. Figure4 shows the multiple oscillator clock system.



Low Power Modes	LPM0,LPM1	LPM2, LPM3	LPM4
MCLK	OFF	OFF	OFF
SMCLK	ON	OFF	OFF
ACLK	ON	ON	OFF

Figure4. Multiple Oscillator Clock System

a] Main Clock (MCLK) – CPU source that may be driven by
the internal Digitally Controlled Oscillator (DCO) up to 16
MHz or with external crystal.

b] Auxiliary Clock (ACLK) – Source for individual peripheral
modules driven by the internal low-power oscillator or
external crystal.

c] Sub-Main Clock (SMCLK) – Source for faster individual
peripheral modules that may be driven by the internal DCO
up to 16 MHz or with external crystal.

MSP430 controller supports several power management features. Table1 shows the statuses of main clock, sub-main clock and auxiliary clock at different low power modes of operation. The MSP430 MCU can wake-up instantly from LPMs. This ultra-fast wake-up is enabled by the MSP430 MCU's internal digitally controlled oscillator (DCO), which can source up to 16MHz and be active and stable in 1µs.

Table1. Statuses of Clocks at different low power modes

B. *Temperature Humidity sensor SHT 11:*

SHT11 is fully calibrated, digital output, small-sized, low power consumption, muti-function, intelligent sensor from the sensirion. It can measure temperature and humidity. A unique capacitive sensor element is used for measuring relative humidity while temperature is measured by a band-gap sensor. Both sensors are seamlessly coupled to a 14bit analog to digital converter and a serial interface circuit. This results in superior signal quality, a fast response time and insensitivity to external disturbances. Temperature measuring range is -40ºC to 123.8ºC and humidity measuring range is 0 to 100%. Resolution is 0.1ºC, response time is less than 3s. SHT11 is intelligent new sensor with free of calibration, free of debugging and almost no outer circuit.

To initiate a transmission, a Transmission Start sequence has to be issued. Different commands are sent to the sensor for proper measurement. After issuing a measurement command ('00000101' for relative humidity, '00000011' for temperature) the controller has to wait for the measurement to complete. This takes a maximum of 20/80/320 ms for 8/12/14bit measurement respectively.

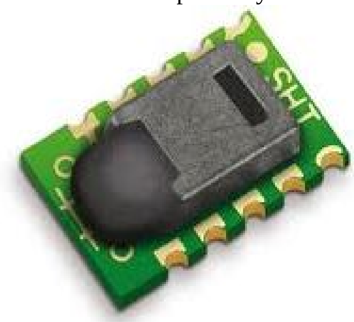


Figure5. Sensor SHT11.

C. *Zigbee wireless transceiver module:*

Zigbee is IEEE 802.15.4 compatible wireless communications standard. It is very low cost, low power consumption transceiver module. It operate within the ISM 2.4 GHz frequency band. AT and API Command Modes configure module parameters. RF data rate is 250 kbps and operating temperature is 40º C to 85° C. Indoor Communication range is 100 ft (30 m) and outdoor RF line-of-sight range is 300 ft (90 m). MSP430 sends the measured temperature and humidity to the base station via zigbee transceiver.

Figure6. Zigbee module

At base station the measured temperature is received through zigbee module. The XBee RF modules interface to a host device through a logic level asynchronous serial port. Devices that have a UART interface can connect directly to the pins of the RF module as shown in the figure7 below.

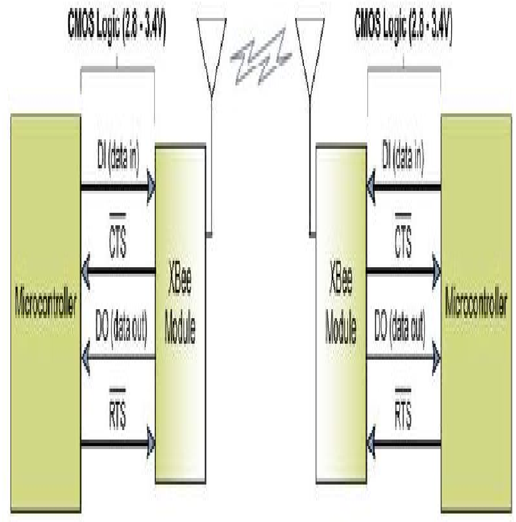


Figure7. System Data Flow Diagram in a UART-interfaced environment

Data enters the module UART through the DI pin as an asynchronous serial signal. The signal should idle high when no data is being transmitted. Each data byte consists of a low start bit, 8 data bits (least significant bit first) and a high stop bit. The following Figure8 illustrates the serial bit pattern of data passing through the module.

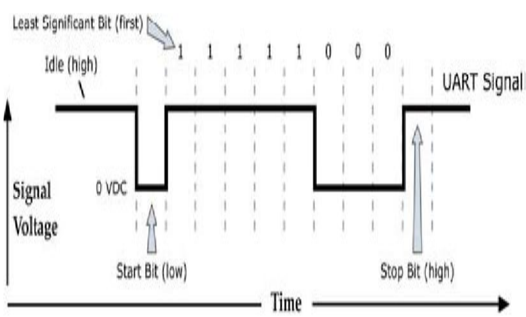


Figure8.UART data packet 0x1F transmitted through the RF module

The module UART performs tasks, such as timing and parity checking, that are needed for data communications. Serial communications depend on the two UARTs to be configured with compatible settings such as baud rate, parity, start bits, stop bits, data bits.

When serial data enters the RF module through the DI (Data In) pin , the data is stored in the DI Buffer until it can be processed. Hardware Flow Control (CTS). When the DI buffer is 17 bytes away from being full; by default, the module de-asserts CTS (high) to signal to the host device to stop sending data. CTS is re-asserted after the DI Buffer has 34 bytes of memory available.

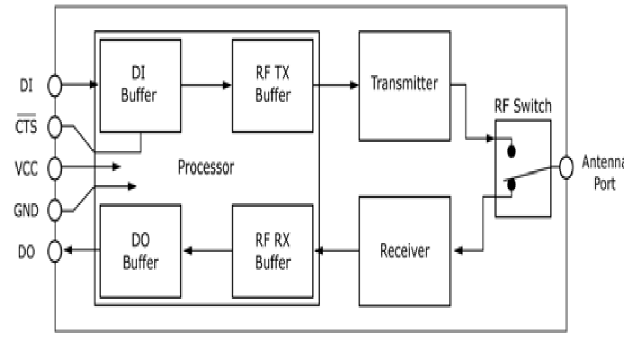


Figure9. Internal Data Flow Diagram

When RF data is received, the data enters the DO (Data Out)buffer and is sent out the serial port to a host device. Once the DO Buffer reaches capacity, any additional incoming RF data is lost. Hardware Flow Control (RTS). If RTS is enabled for flow control data will not be sent out the DO Buffer as long as RTS is de-asserted.

D. Triac triggering circuit:

Triac triggering circuit consists of MOC3022 triac triggering device, triac and zero crossing detector. Zero crossing detector detects the start of positive half cycle and negative half cycle. Then microcontroller sends the trigger pulse to triac for each half cycle.

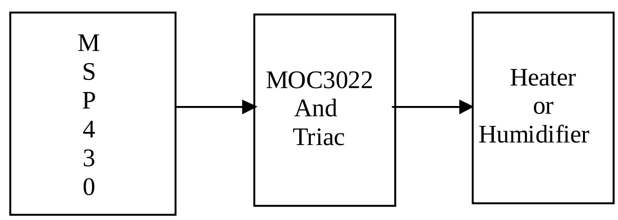


Figure10. Interfacing of Triac triggering circuit with MSP430

Trigger pulse is generated in such a way that the firing angle is proportional to the difference between the set point and measured value of parameter. Thus, the heater and humidifier output is controlled proportional to the difference between set point and measured parameter.

IV. SOFTWARE DESIGN

System flow chart is as shown in figure11. The digital output temperature and humidity sensor SHT11 gives the output to the microcontroller. This output is processed by the MSP430 and displayed it on computer using GUI. As per the system requirement the set point is entered through the computer. Set point is compared with the actual measured temperature and humidity.

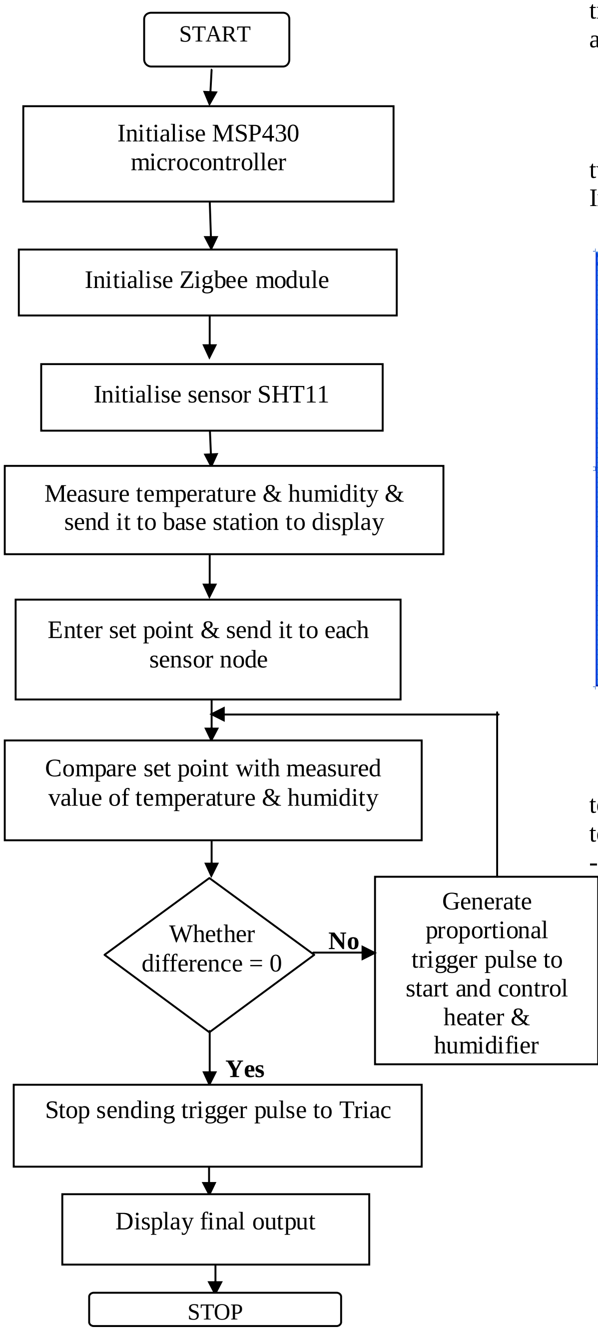


Figure11. System flow chart

The trigger pulse proportional to this difference is generated using the MOC3022 and zero crossing detector. This is given to the heater and humidifier. This trigger pulse controls the heater and humidifier action. These steps are repeated until the set points are not achieved. If the difference between the set point and actual measured value of parameter is less then the power supplied to the controlling devices is also less. If the difference between the set point and actual measured value of parameter is more then the power supplied to the controlling devices is also maximum. This is achieved through the triac triggering. Thus, precise proportional control is achieved.

V. RESULTS AND CONCLUSION

The real time temperature and humidity for two sensor nodes is displayed using Graphical User Interface. It is shown in figure12.

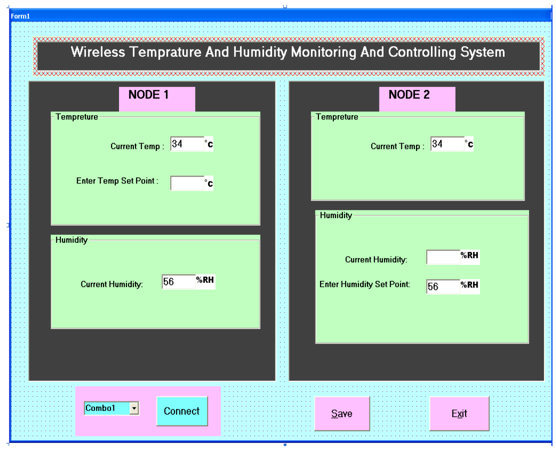


Figure12. Output using GUI

The node-1 is used to control the temperature. The set point 45˚C is entered for temperature for node-1. The controlled output of node -1 is shown in figure13.

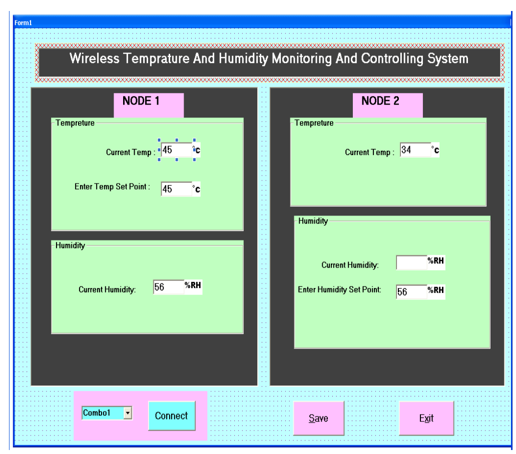


Figure13. Controlled output of node-1 showing temperature control

The node-2 is used to control the humidity. The set point 65%RH is entered for humidity for node-2. The controlled output of node -2 is shown in figure14.

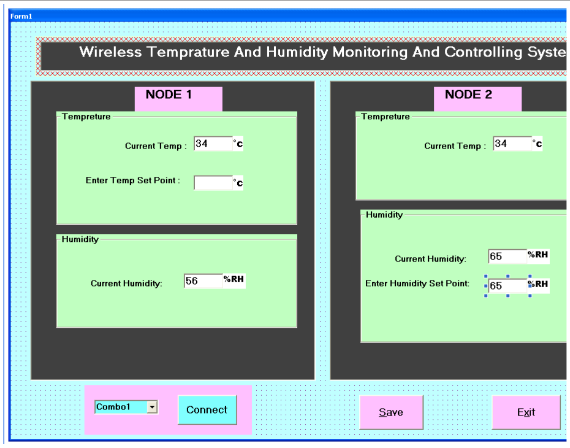


Figure14. Controlled output of node-2 showing humidity control

Figure 15 shows the hardware detail of system. It shows the interfacing of sensor SHT11, zigbee and control unit with MSP430.

Figure15. Interfacing of sensor SHT11, zigbee and control unit with MSP430

It can be widely used in various applications where the temperature and humidity control is needed.

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