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ARDUINO BASED WIRELESS SYSTEM FOR TEMPERATURE AND HUMIDITY MONITORING

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ABSTRACT

ATmega328 microcontroller based onthe Arduino Uno platform is the core of the wireless system. DHT11 temperature&humidity sensor is used to collect the data of ambient temperature and humidity. The processed data is transmitted through nRF24L01 wireless transceiver module. Finally, the results of communication are displayed on dot-matrix LCD12864. Additionally, we have set low and high limits of temperature and humidity through potentiometer, which if reached will be known through buzzer. It is a kind of environmental conditions monitoring project which consumes low power, has low cost, works in real time and at remote places.

Keywords:- Arduino Uno,DHT11 sensor, Humidity Sensing, LCD12864, nRF24L01, Temperature Sensing.

I. INTRODUCTION

Due to the development of microelectronics technology and high-speed digital signal processing technologies, wireless communication is undoubtedly a convenient, fast and effective method. It has been used widely in industrial production and people's life, especially it has enabled new advanced methods of data acquisition and transmission for complicated terrain conditions, hostile environmental conditions and other places that are inconvenient to reach for humans.

Here, we design a scheme of wireless communication system that has small size, low cost and can collect environmental factors such as temperature and humidity data remotely and in real time. The core of the system control module ATMEGA328 microcontroller is a high-performance single chip microcomputer with a wide voltage, low power consumption, high integration, strong anti-interference and strong portability characteristics. Sensor DHT11 is a digital-signal-acquisition temperature&humidity sensor. The sensor has anti-interference ability, high integration, high precision, low power consumption, small size and low price. Software is based on the Arduino exploitation environment. Arduino has its own exploitation environment which is based on Eclipse IDE development environment, similar to the JAVA and C/C ++, the UI is user friendly and program compilation & flashing of software with Arduino IDE is simple.

II. OVERALL DESIGN OF THE SYSTEM

System overall block diagram is shown in figure 1. To achieve the function of the design and convenient man-machine interaction, system is divided into two main parts: data acquisition and system control. The data acquisition system consists of ATMEGA328 MCU based on Arduino platform, DHT11 temperature & humidity sensor and wireless transceiver module nRF24L01. Control system is through single-chip microcomputer ATMEGA328 which controls the wireless transceiver module nRF24L01 and then displays the received information on LCD12864 in real-time. The control part also provides the flexibility of setting the upper and lower limits of temperature and humidity data at any time. The received data is checked for the upper and lower limits, if the received values are not within the original data range, the buzzer will sounded for alarming the people's attention, to make a timely dispose. A COTS 230V AC to 5V DC charger can be used for powering Arduino boards and LCD. nRF24L01 requires a +3.3V for power requirement.

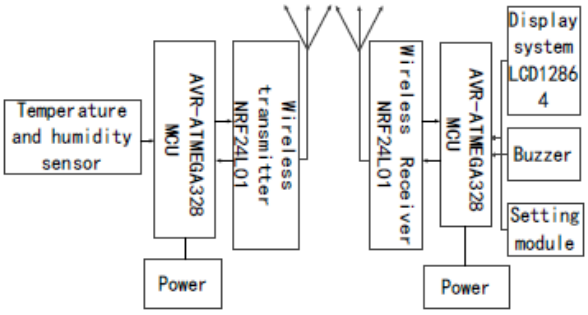

Fig .1 Block diagram of system

III. HARDWARE DESIGN OF SYSTEM

3.1 Main Control Module

This control module uses the Arduino platform. Arduino isan open source software and hardware platform that is based on the Atmel AVR and ARM micro controllers. Due to its low cost, convenience and flexibility, it is developing rapidly and used widely in recent years, especially in various system prototypes based on sensor design. Its hardware design uses the CC - BY - SA - 3.0 protocol, software design uses a high-level language like C/C++.

The core of Arduino UNO processor is ATmega328. It has 14 pins for digital input/output (six pins can be used as a PWM output), 6 analog input pins, 32 KB Flash Memory and 1 KB EEPROM [1]. The ATmega328 of Arduino UNO presets the bootloader and program can be downloaded in UNO directly by the Arduino software IDE.

3.2 Wireless Transceiver Module

The nRF24L01 is a new single chip of transceivercomponents used in the 2.4 ~ 2.5 GHz ISM frequency band with data transmission speeds upto 2 Mbps. nRF24L01 has various kinds of low power operation mode, such as, power down mode and standby modes. It has 130us of quick switch and wake time. In addition, nRF24L01 is combined with enhanced ShockBurst technology which features automatic packet assembly and timing,

automatic acknowledgement and re-transmissions of packets and can be configured by software program. [2] In conclusion, nRF24L01 wireless module can provide with the higher data transmission speed under the premise of small power consumption.

nRF24L0l through configuration registers, define all the configuration characteristics. The configuration register can be set-upthrough SPI. SPI (Serial Peripheral interface) is a synchronous serial communication interface. It has10 Mbps maximum transmission rate and Twelve instructions are associated with SPI [3]. The control commands are issued using MOSI pin, status and data information are outputted from MISO pin to the microprocessor. There are 25 configuration registers, it can configure nRF241L01 wireless transmission module in four modes of operation. Its typical peripheral circuit and the interface circuit with Atmega328 are shown in Figure 2.

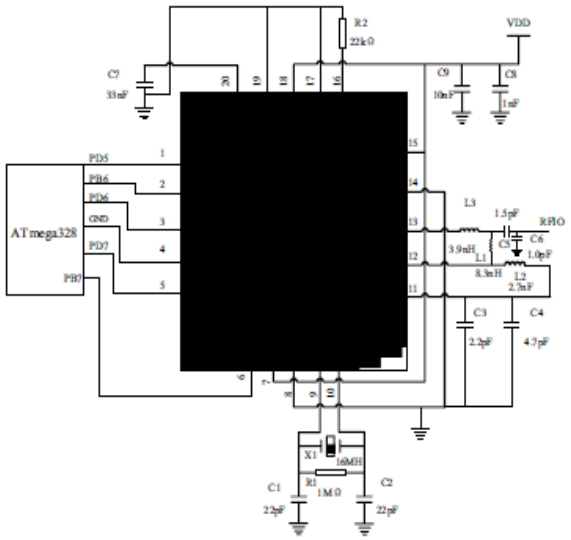

Fig 2. Peripheral circuit of Nrf 24L01 and interface circuit with Atmega 328

The power supply voltage for microcontroller is 5V, but nRF24L01 requires 3.3V power supply. Consequently, it is connected to 3.3V low voltage chip to ensure that it works normally.

3.3 Temperature & Humidity Sensor DHT11

DHT11 is a composite humidity and temperature sensor which shows a calibrated digital signal output for the humidity and temperature. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component. Each DHT11 element is calibrated that is extremely accurate on humidity calibration. The calibration coefficients are stored as programs in the OTP memory, which are used by the sensor's internal signal detecting process. The component is 4-pin single row pin package [4]. Single wire and serial interface makes the system integration simple and easy.

The connection of DHT11 and MCU are shown in figure 3.When the connecting cable between MCU and DHT11 is within 20m, a 5k pull-up resistor is recommended. Temperature&humidity sensor DHT11 has a 3-5.5V power supply voltage. One capacitor valued 100nF can be added between VDD and GND for power

filtering. When DHT11 is powered on, we can rule out the factors of instability by 1s waiting time. During this 1s waiting time, no instructions should be sent to the sensor. Single-bus data format is used for communication and synchronization between MCU and DHT11 sensor. One communication process is about 4ms.

When MCU sends a start signal, DHT11 changes from the low-power-consumption mode to the running-mode, waiting for MCU completing the start signal. Once it is completed, DHT11 sends a response signal of 40-bit data that includes the relative humidity, temperature information and data checksum to MCU. Without the start signal from MCU, DHT11 will not give the response signal to MCU. Once data is collected, DHT11 will change to the lowpower-consumption mode until it receives a start signal from MCU again.[5]. DHT11 has fast response, strong anti-interference, low cost and long term tability.

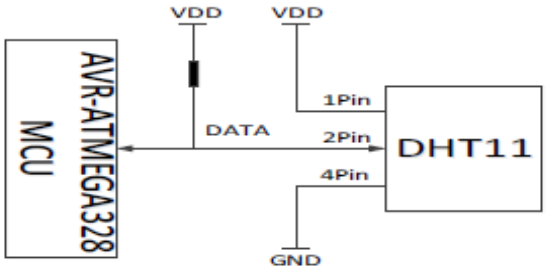

Fig 3. Connection diagram of DHT11and MCU

3.4 liquid crystal display module LCD12864

128x64 LCD is a Graphics LCD with 128 bit columns and 64 bit rows. 128x64 LED is divided into two halves with each half being controlled by a separate controller. Such LCD's involve paging scheme i.e. whole LCD is divided equally into pages. Each page consists of 8 rows and 64 columns so two horizontal pages make 128(64x2) columns and 8 vertical pages make 64 rows(8x8) using flexible interface method of LCD module, simple and convenient operating instruction.

Another significant feature of LCD12864 is ultra-low voltage and ultra-low power consumption. As Compared with the same type of display module, design of this LCD module, both in the aspect of hardware circuit structure and software program are easier. Also the price of LCD12864 is relatively lower.

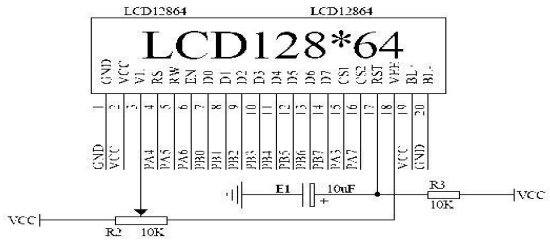

Fig. 4. Circuit diagram of LCD12864

IV. SOFTWARE DESIGN OF SYSTEM

The software design is based on the Arduino development environment. Arduino has open source code. The software programming uses modular programming ideas. All main functional modules in the system, such as,

wireless data transceiver module, temperature and humidity data acquisition module, etc., are divided into independent functions and then called by the main program.

4.1 Software design of acquisition node

The connection of wireless transceiver module and MCU communication I/O port pin are shown in figure 5.

Wireless Module	Pin	Describe		Pin	Describe
NRF24L01	#1	CE	→	#11	PD5
	#2	CSN	→	#9	PB6
	#3	SCK	→	#12	PD6
	#4	MOSI	→	#8	GND
	#5	MISO	→	#13	PD7
	#6	IRQ	→	#10	PB7

Fig. 5. Pin connection diagram

Temperature&humidity acquisition device DHT11 sensor is connected to MCU through single bus, when the microcontroller sends a start signal, then DHT11 send its response signal and 40 bits of data to the data buffer of single-chip microcomputer. MCU and wireless data module nRF24L01 communicate through simulation SPI bus, the clock frequency is about 1MHz which is set-up by software. When wireless module nRF24L01 receipt of data by the single-chip microcomputer, it will remove the preamble and CRC check code automatically.

The main program of system transmitting terminal is settings initialization of the pin mode first, then the initialization of wireless mode nRF24L01 and setting it to Transmit mode. Next, collecting temperature and humidity data, processing temperature and humidity data, packaging the

collected data and sending it at the same time. The main program of system transmitting terminal is as follows:

```
void setup()
    {
  pinMode(CE, OUTPUT); pinMode(SCK, OUTPUT); pinMode(CSN, OUTPUT);
  pinMode(MOSI, OUTPUT); pinMode(MISO, INPUT); pinMode(IRQ, INPUT);
  Serial.begin(9600); init_io();
  unsigned char status=SPI_Read(STATUS); Serial.print("status = "); Serial.println(status,HEX);
  Serial.println("*********************TX_Mode Start*****************************");
  TX_Mode();
                    }
```

4.2 Software design of control node

The flow diagram of software design of control node is shown in figure 6.

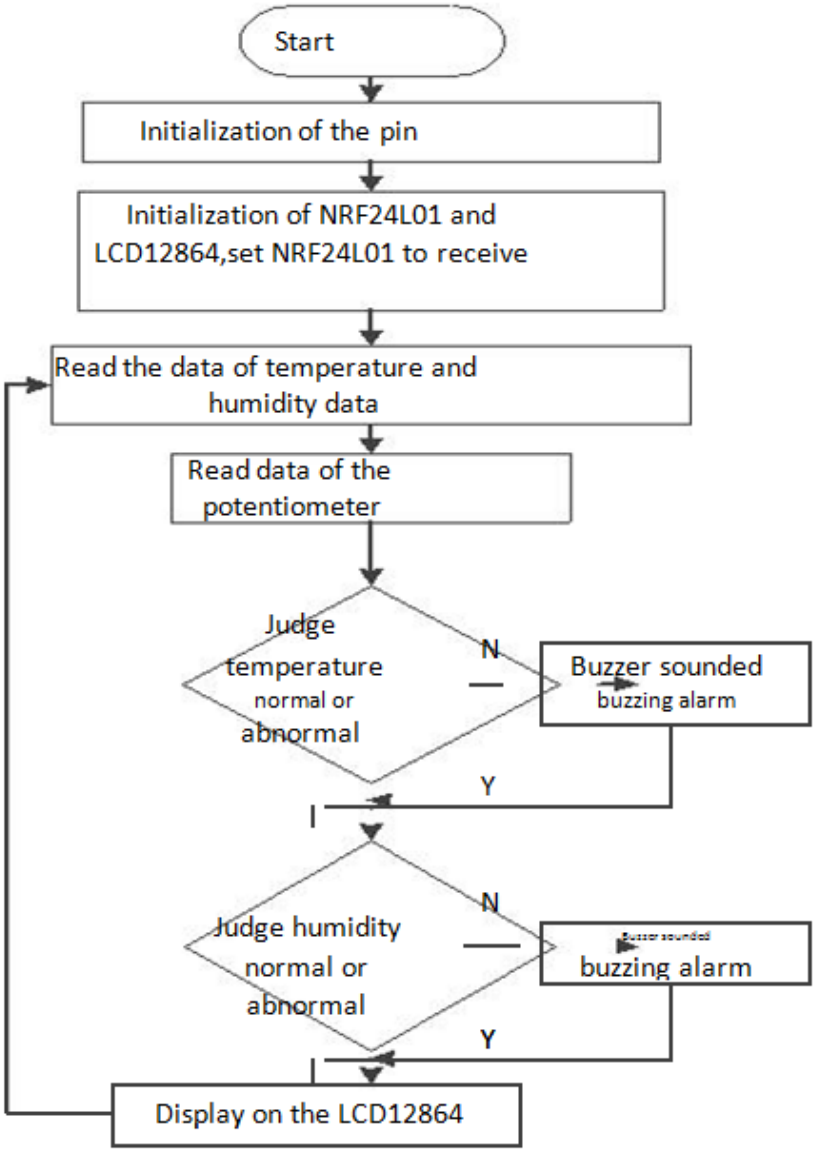

Fig. 6. Flow diagram of software design of control node

The program at the system control side first initializes the pins of Arduino board as I/O ports. Next is the initialization of the wireless transceiver and the LCD module.The nRF24L01 is then set to receive mode. When receiving terminal of nRF24L01 receives the data from transmitting terminal, it will send the data to data buffer of MCU by SPI bus.The MCU reads the temperature and humidity data and compares it with previously fed in range. If the received value of temperature or humidity is out of the stored range then a buzzer is sounded to alarm the personals for taking appropriate action. The information is also displayed. The information is also displayed on the LCD12864 at the same time. The information display on LCD and sounding of Buzzer happens at real-time.

The main program of control node is as follows:

```
void setup()
```

```
{
pinMode(CE, OUTPUT); pinMode(SCK, OUTPUT); pinMode(CSN, OUTPUT);
pinMode(MOSI, OUTPUT); pinMode(MISO, INPUT); pinMode(IRQ, INPUT);
pinMode(LCD_SCLK,OUTPUT); pinMode(LCD_SID,OUTPUT);
pinMode(LCD_CS,OUTPUT); pinMode(LCD_RST,OUTPUT); pinMode(BEEP,OUTPUT);
attachInterrupt(1, _ISR, LOW); Serial.begin(9600);
init_io();
unsigned char status=SPI_Read(STATUS); Serial.print("status = "); Serial.println(status,HEX);
Serial.println("*****************RX_Mode start*****************************R");
RX_Mode(); lcd_init(); digitalWrite(BEEP,LOW);
                                    }
```

4.3 System test and results

Wireless temperature and humidity data acquisition / transmission system and control system was designed and realized based on the hardware and software concept articulated above. The realization was done on a step by step basis wherein first the accurate working of DHT11 sensor and nRF24L01 transceiver was established. Then the LCD was interfaced for displaying information in real time. And finally potentiometer was interfaced for setting the safe-range of temperature and humidity. The test conditions were divided into outdoor environment and indoor environment. The ambient conditions of DHT11 sensor module was varied in order to test the working of buzzer for within range and out of range values. Test results are shown in figure 7

Distance	10m	20m	30m	40m	50m
Outdoor	Normal Communication	Normal Communication	Normal Communication	Normal Communication	Communication Outage
Indoor	Normal Communication	Normal Communication	Communication Outage	Communication Outage	Communication Outage

Under the testing condition of indoor environment, a drop in communication distance of wireless communication module was observed because of the obstacles. System test results show that the communication of wireless data transceiver module is good, LCD12864 can also reflect the sensor's acquisition of the temperature and humidity data accurately and it can generate corresponding changes with the change of the measured temperature and humidity value. Range of safe temperature and humidity values can also be set-u satisfactorily.

V. CONCLUSION

This work has successfully designed a low cost, reliable remote temperature and humidity monitoring system using low cost components such as Arduino UNO, DHT11 sensor and nRF24L01 transceiver module. The ambient conditions of sensor are successfully transmitted wirelessly to control & monitoring station and displayed on LCD12864 on a real-time basis. This design has lots of characteristics, such as, small size, low power consumption, low cost, high accuracy, superior anti-interference performance, real-time, easy

development andeasy Man Machine Interface. The system suitable for all kinds of short distance work conditions of wireless data acquisition and transmission.

The future scope of improvement in system is using keypad to enter the temperature and humidity range values. Also a secure password entry facility can be introduced to ensure that only authorized person can modify the settings. A flash LED/Bulb can also be interfaced along with the buzzer for initiating an alarm in case ambient conditions of sensor reach unsafe levels.

VI. ACKNOWLEDGEMENT

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