REVIEWED INTERNATIONAL JOURNAL

Electronic International Interdisciplinary Research Journal (EIIRJ)

ISSN : 2277-8721)

Impact factor:0.987

Bi-Monthly

VOL - III | ISSUES - I | JAN -FEB | [2014]

Chief-Editor:

Ubale Amol Baban

[Editorial/Head Office: 108, Gokuldham Society, Dr.Ambedkar chowk, Near TV Towar,Badlapur, MS

NON-CONTACT TEMPERATURE MEASUREMENT SYSTEM BASED ON EMBEDDED

Ms. Deepika A. Pawar[1],
Prof. Dr. A. A. Bhargave[2]
[12]K. K. Wagh Institute of Engineering Education & Research, Nashik, India
Department of Electronics and Telecommunications.

Abstract

Surface-contact temperature measurement technology is very successful, but the survey on the non-contact temperature measurement technology is also relatively less. Based on MLX90614, this system surveyed and analyzed a non-contact temperature measurement system, which uses embedded hardware platform Atmega328 and the system applies embedded IIC (Inter-Integrated Circuit) bus module's communication procedure and control methods. Experimental analysis of survey show that the system is of high stability, speed, and precision. The system may be widely used in many applications such as fault diagnosis, performance testing, etc.

1. Introduction

1.1 Overview

The temperature measurement system is involved in many applications, with the successful temperature measurement technology. But the wire temperature measurement occupies the market mainly, or in some cases even if the actual temperature is wireless but it is the wireless transceiver with wired temperature measurement system, so it is not really a wireless non-contact temperature measurement. At present, there are many infrared temperature measurement applied for measuring body temperature. It can measure the temperature directly without contacting the surface, so it can be called non-contact temperature measurement. But such equipment is often very expensive and designed for special purposes, which makes the user cannot do further development according to their own requirements.

The seminar, based on MLX90614 infrared temperature measurement module, applying a method with ATmega328 IIC interface connection and communication control, developed and designed a non-contact temperature measurement system. Users can design and develop their needed non-contact temperature measurement system by themselves according to their own requirements.

1.2 Discovery Of An Infrared Radiation

Searching for new optical material William Herschel by chance found the infrared radiation in 1800. He blackened the peak of a sensitive mercury thermometer. This thermometer, a glass prism that led sun rays onto a table made his measuring arrangement. With this, he tested the heating of different colors of the spectrum. Slowly moving the peak of the blackened thermometer through the colors of the spectrum, he noticed the increasing temperature from violet to red. The temperature rose even more in the area behind the red end of the spectrum. Finally he found the maximum temperature far behind the red area. Nowadays this area is called "infrared wavelength area".

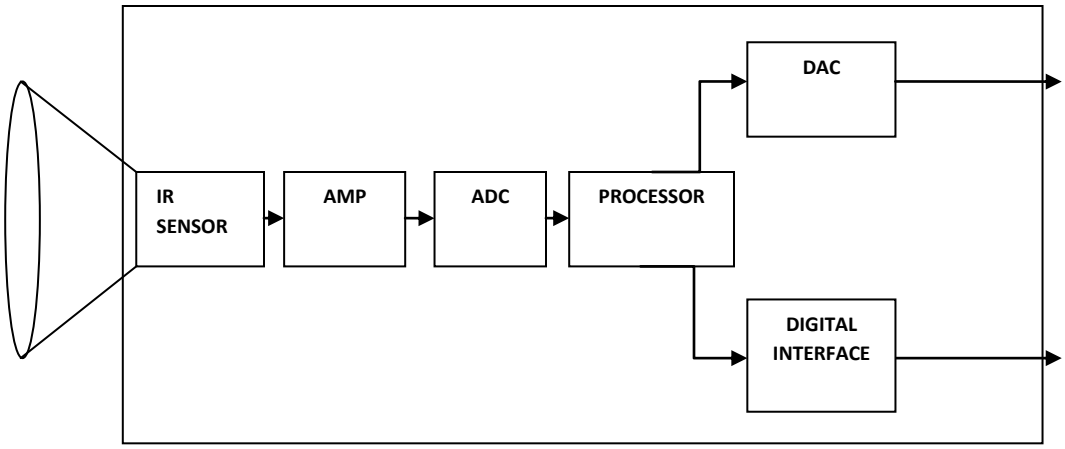


Fig 1: Block Diagram of IR system Block diagram of an infrared thermometer

The illustration shows the general construction of an infrared thermometer. With the help of input optics the emitted object radiation is focused onto an infrared detector. The detector generates a corresponding electrical signal which then is amplified and may be used for further processing. Digital signal processing transforms the signal into an output value proportional to the object temperature. The temperature result is either shown on a display or may be used as analog signal for further processing. In order to compensate influences from the surroundings a

second detector catches the temperature of the measuring device and of his optical channel, respectively. Consequently, the temperature of the measuring object is mainly generated in three steps:

1. Transformation of the received infrared radiation into an electrical signal
2. Compensation of background radiation from thermometer and object
3. Linearization and output of temperature information.

2. THE ADVANTAGES OF NON CONTACT MEASUREMENT

It supports:

- Temperature measurements of moving or overheated objects and of objects in hazardous surroundings
- Very fast response and exposure times
- Measurement without interaction, no influence on the measuring objects
- Non-destructive measurement
- Long lasting measurement, no mechanical wear

3 DESIGN OF EMBEDDED IIC SYSTEM

3.1 Design of Embedded IIC Hardware System

The processor of the whole temperature measurement system is Atmega328, and the temperature sampling device of that is sensor MLX90614. Temperature measurement system can also pass the temperature of the samples collected information to the host system through the serial port by using the serial communication function of ATmega328 so that it is convenient for users to make observation and statistics. The temperature measurement system hardware architecture is shown in Figure3.

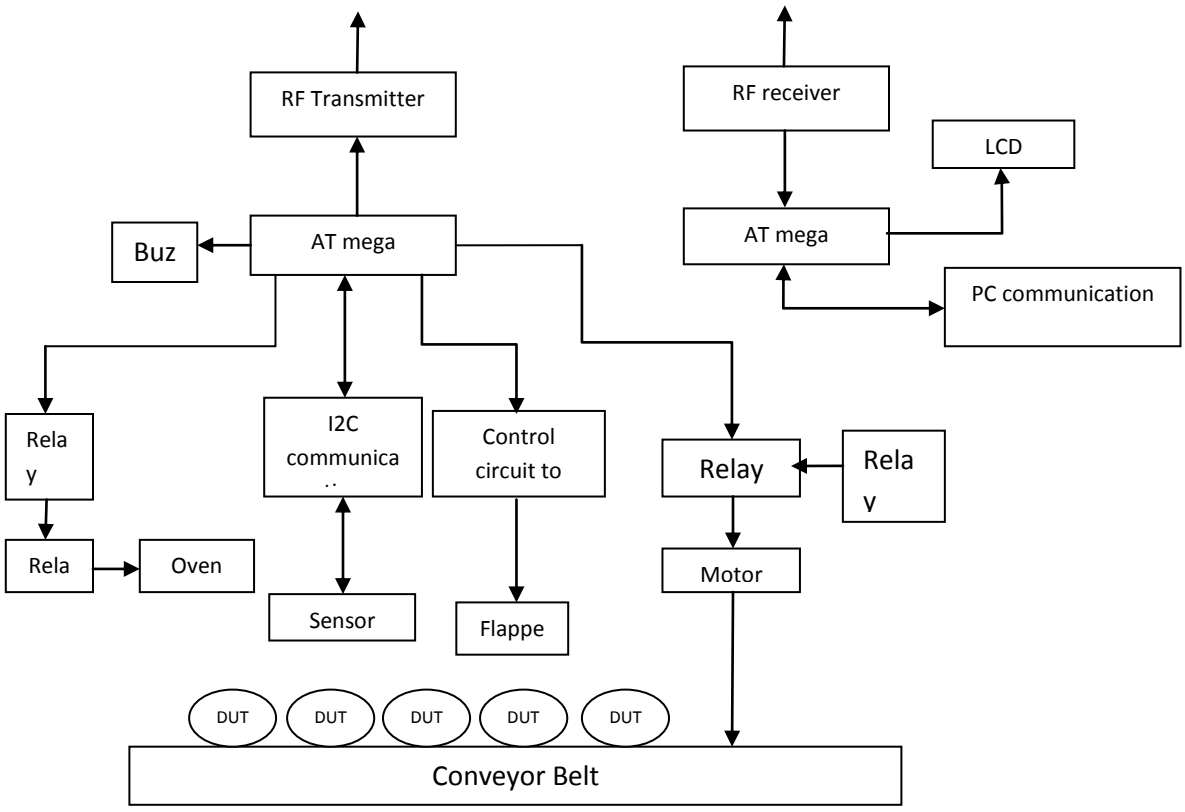


Fig3. Non-contact temperature measurement system based on embedded IIC

In order to meet the needs of running embedded operating system, a lot of memory space of storing the module is composed of the RAM chips of 2K Bytes, 8Bit and the FLASH of 32K bytes, 1K Bytes EEPROM. Debug interface is the debug interface of a RS232 serial port. Motherboard chip is designed directly with the built-in SRAM controller and a series of interface controller such as IIC controller, etc. The Idle mode stops the CPU while allowing the RAM, Timer/Counters, USART, 2-wire Serial Interface, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or hardware reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low power consumption. The device is

manufactured using Atmel's high density non-volatile memory technology. The On-chip ISP Flash allows the program memory to be reprogrammed In-System through an SPI serial interface, by a conventional non-volatile memory programmer, or by an On-chip Boot program running on the AVR core. The Boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega328 is a powerful microcontroller that provides a highly flexible and cost effective solution to many embedded control. The maximum operating frequency of the master chip ATmega328 is up to 20MHz. Sensor MLX90614 features are Small size TO-39 can, easy to integrate, Low cost, competitive prices, Standard calibration in wide temperature range, -40 to 125°C for ambient temperature, -70 to 380°C for object temperature, Better than 0.5°C accuracy in the range 0-50°C, 0.01°C readout resolution possible, High refresh rate, Easy emissivity correction, Continuous temperature readout through PWM (Pulse Width Modulated) output, 2-wire SMBus compatible interface for reading, temperatures and sensor reconfiguration, Building block for sensor network with up to 100 thermometers, High reliability and long-term stability, Excellent ESD/EMC characteristics, Available for 3 and 5V applications, Easy to adapt for voltage sources in range 6-24V, Power saving mode for battery operation, Traceability through unique ID number in memory, Single or Dual zone thermometer version. The basic working principle is detection of infrared radiation with a thermopile sensor, which turns incoming radiation to an analogue voltage; Determination of sensor temperature using a thermistor; Further analogue signal processing and conditioning; Calculation of ambient and object temperature using a processing unit; providing the ambient and objects temperature at digital output bus (I2C). The MLX90614 is suitable for a wide range of application where non-contact temperature measurement and high accuracy are required. This module is always operating in pure slave mode of a two wire interface similar to 12C. The typical baud rate of this device is 20kBytes. The supported address length is seven bits. The 12C slave address is 5Ah. The command for reading object temperature is OxB6, and object temperature is in hundredth of degree. The non-ideal filter characteristics have to been considered for the correct measurement distance with respect to the measurement object surface size. To achieve most accurate measurement results, measurement object should at least cover 99% of the sensors field of view.

3.2 Design of Embedded IIC Software System

Software system design, primarily for the IIC interface communication, the system is divided into two phases: the master transmitter mode phase and the master receiver mode phase; the lie communication process is complete by four steps: detecting whether the slave device of IIC is online, transmitting temperature measurement commands, returning the measurement data, finishing the IIC communication. The flow chart of the IIC communication is shown in Figure4.

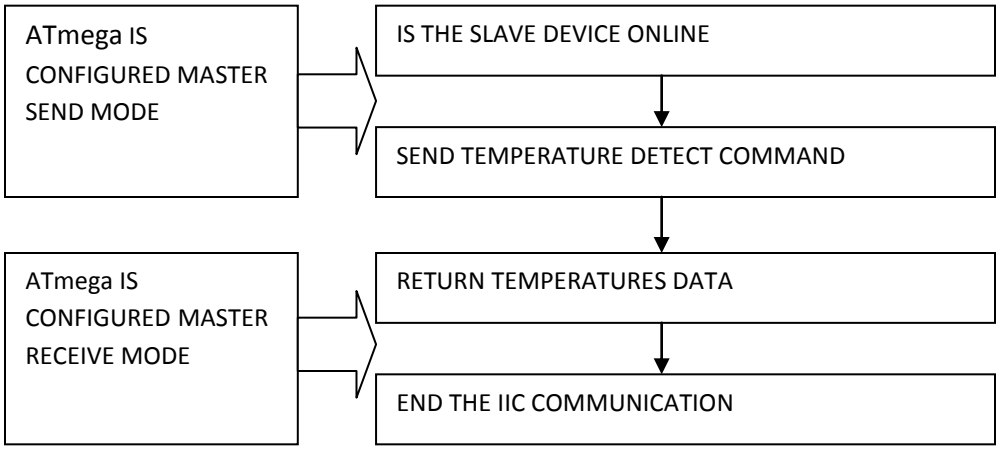


Fig3: Flow chart of the lIC communication

The communication control of IIC is partially completed by internal IIC Bus control section of ATmega 0, involving IIC bus controller IICDS transmit / receive data shift register, IICCON control register, IICSTAT status register. The following introduction based on the method of each phase's operation. Before starting communication of ATmega IIC module, the starting mode is set to the master receiver firstly, and then the slave device's address is written to the IICDS register, and we write OxFO to the IICSTAT register to start an IIC communication. At this time the data from the IICDS register is sent one by one, and wait the response from the slave device. After receiving a response, the master device ATmega I 0 continues the next communication or finishes this communication. The software operation process is shown in Fig5.

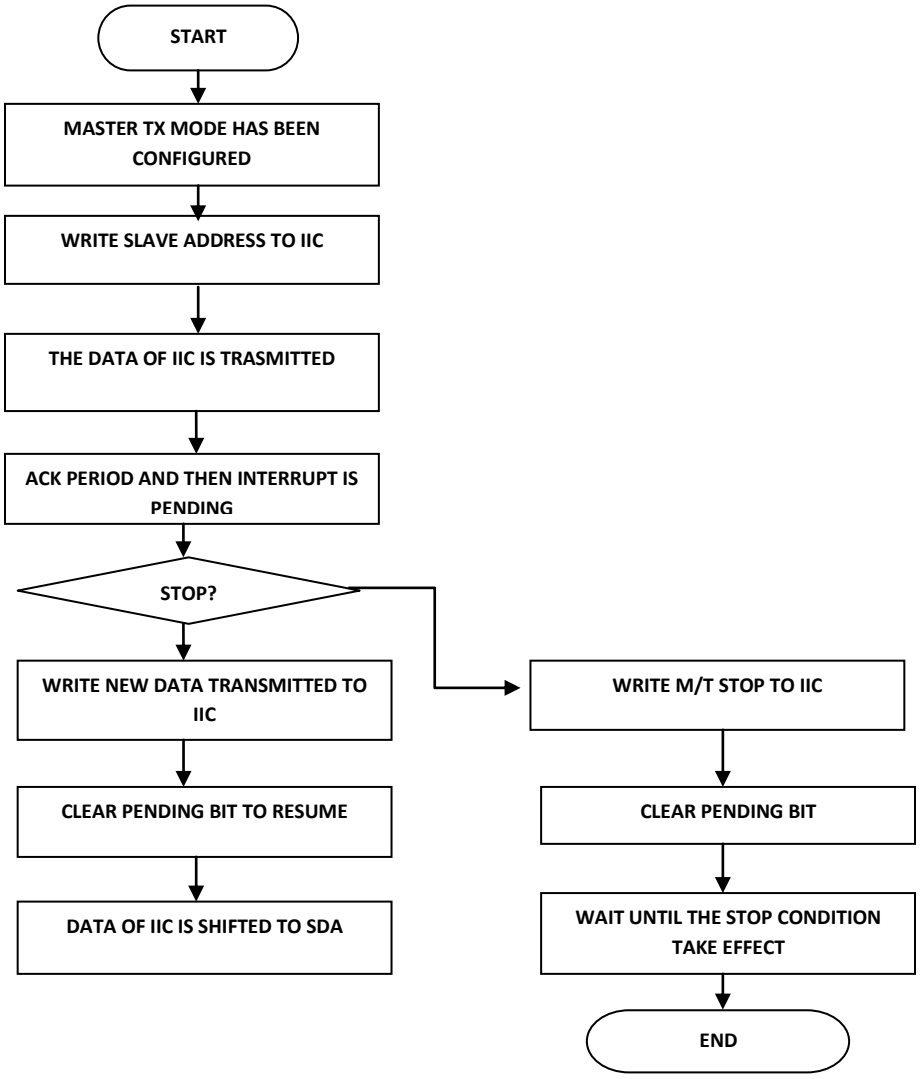


Fig5: Master transmitter mode phase

The second phase is the master receiver phase: Similarly, before starting communication of ATmega 0' s IIC module, the starting mode is set to the master receiver firstly, and then the slave device's address is wrote to the IIC register, and we write OxBO to the IIC register to start an IIC communication. At this time the data from the IICDS register is sent one by one, and wait the response from the slave device. After receiving a response, the master device ATmega continues the next communication or finishes this communication. The software operation process is shown in Fig6.

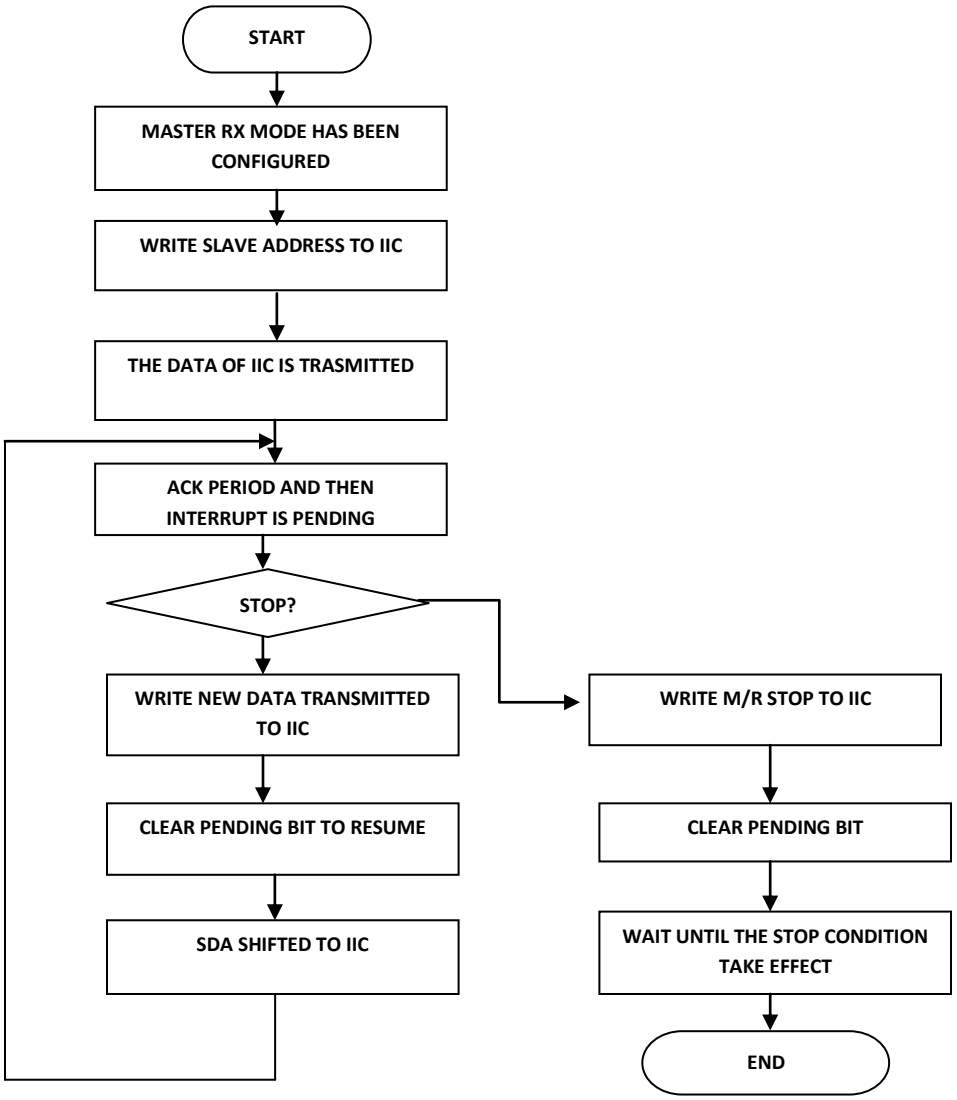
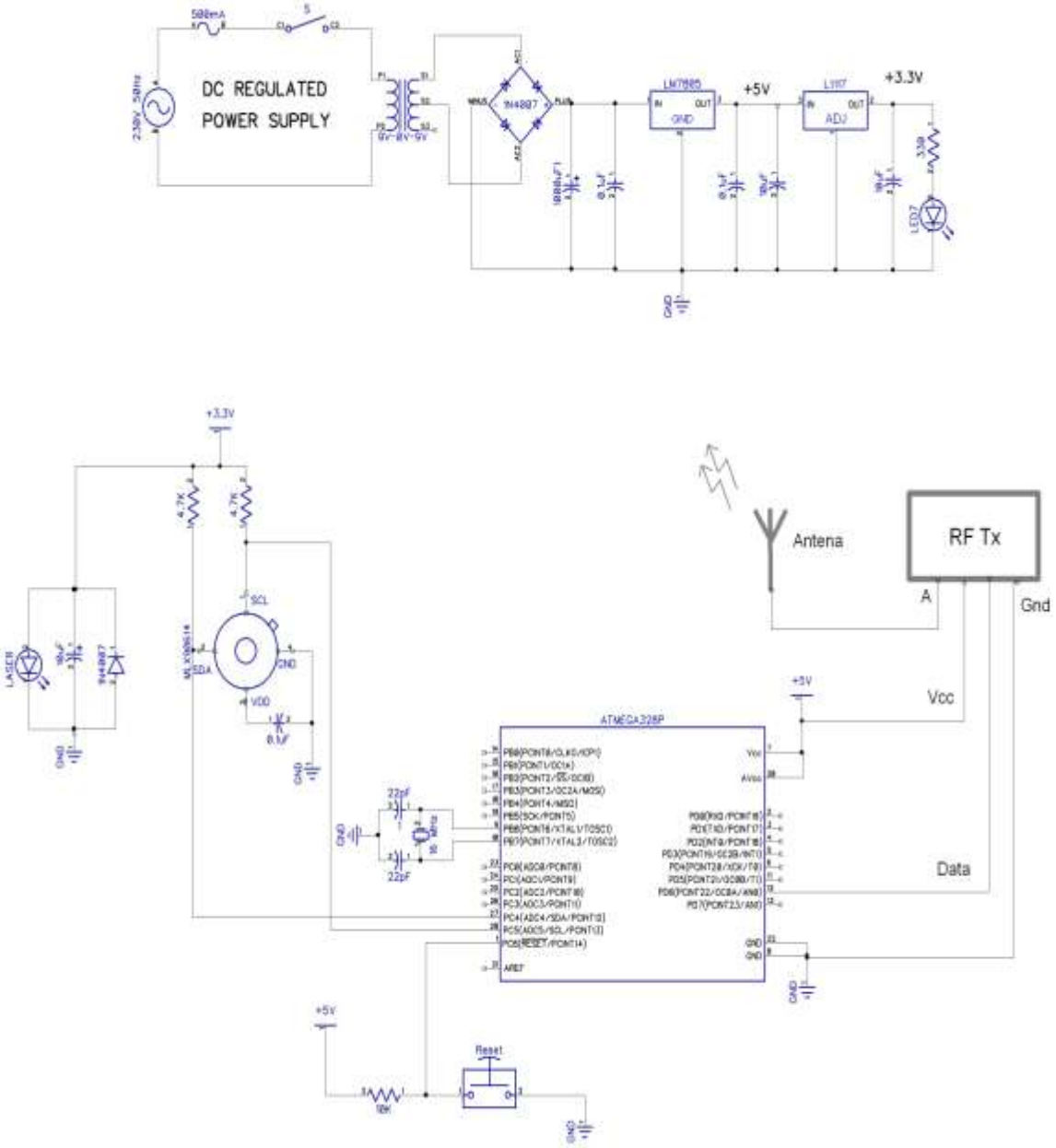


Fig6: Master receiver mode phase

In the four-step operation, testing whether the slave device of the IIC is online and transmitting the temperature command, the two phases are completed in the master transmitting phase. Temperature data returns back from the master receiver phase. End of the IIC communication is effective to achieve at any phase or mode, directly by setting the STOP bit in the IlC register.

5. Hardware implementation

5.1 Transmitter circuit Diagram



1 Atmega328P -:

The ATmega328P is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega328P achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed.

2 MLX90614 -:

The MLX90614 is an Infra Red thermometer for non contact temperature measurements. Both the IR sensitive thermopile detector chip and the signal conditioning ASSP are integrated in the same TO-39 can. Thanks to its low noise amplifier, 17-bit ADC and powerful DSP unit, a high accuracy and resolution of the thermometer is achieved. The thermometer comes factory calibrated with a digital PWM and IIC output. As a standard, the 10-bit PWM is configured to continuously transmit the measured temperature in range of -20…120°C, with an output resolution of 0.14°C.

3 RF Transmitters -:

RF 1 315/433 Mhz Ask Module. This is Crystal tuned PLL based ASK Module. This module uses the technique of On-off keyed (OOK) Modulation. Local oscillator is based on PLL. The module is high performance. Simple to use and miniaturized. Applications like remote control, wireless security, etc… operating at 315/434 MHz can easily be implemented using this module.

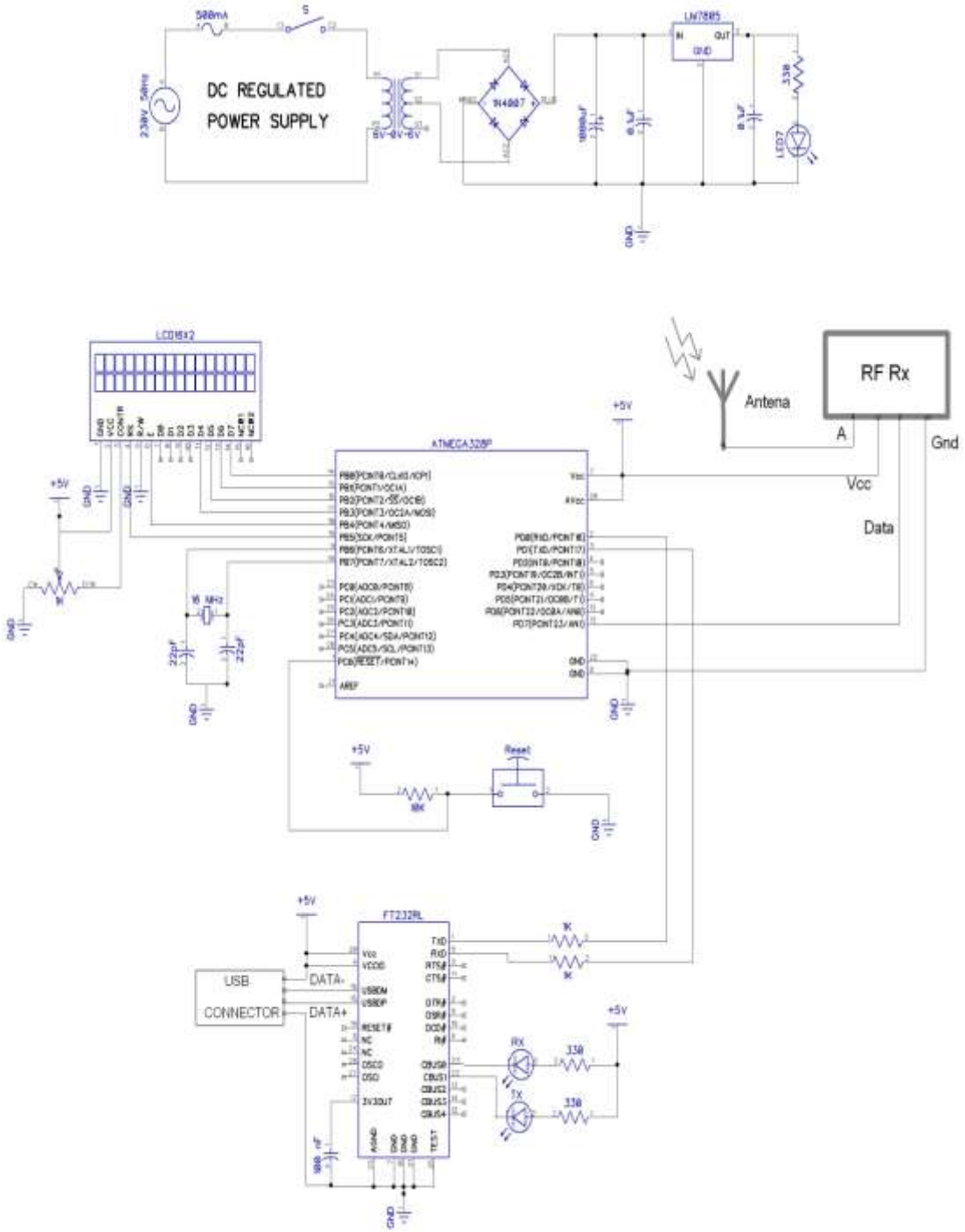
4 DC Regulated Power Supply -:

In this circuit 5V and 3.3V supply voltage is designed from power supply. LM 317 is used to design 3.3V regulated supply and LM705 is used to design 5V regulated supply.

5 Laser -:

A laser is a device that emits light through a process of optical amplification based on the stimulated emission of electromagnetic radiation. Lasers have many important applications. They are used in common consumer devices such as DVD players, laser printers, and barcode scanners. They are used in medicine for laser surgery and various skin treatments, and in industry for cutting and welding materials. They are used in military and law enforcement devices for marking targets and measuring range and speed. Here Laser is used for measuring spot temperature.

5.2 Receiver circuit Diagram



1 **RF Transmitters** -:

RF 1 315/433 Mhz Ask Module. This is Crystal tuned PLL based ASK Module. This module uses the technique of On-off keyed (OOK) Modulation. Local oscillator is based on PLL.

The module is high performance. Simple to use and miniaturized. Applications like remote control, wireless security, etc… operating at 315/434 MHz can easily be implemented using this module.

2 16X2 LCD -:

LCD (Liquid Crystal Display) screen is an electronic display module and find a wide range of applications. A 16x2 LCD display is very basic module and is very commonly used in various devices and circuits. These modules are preferred over seven segments and other multi segment LEDs. The reasons being: LCDs are economical; easily programmable; have no limitation of displaying special & even custom characters (unlike in seven segments), animations and so on A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data.

3. FT232RL -:

The FT232R is the latest device to be added to FTDI's range of USB UART interface Integrated Circuit Devices. The FT232R is a USB to serial UART interface with optional clock generator output, and the new FTDIChip-ID™ security dongle feature. In addition, asynchronous and synchronous bit bang interface modes are available. USB to serial designs using the FT232R have been further simplified by fully integrating the external EEPROM, clock circuit and USB resistors onto the device.

5.3 PCB Files

Diptrace is used to design circuit diagram and PCB layout. Schematic Capture is advanced circuit design tool with support of multi-sheet and multi-level hierarchical schematics. This module of DipTrace delivers number of features for visual and logical pin connections. Cross-modules management ensures that principal circuits can be easily converted to PCB, back annotated or imported/exported from/to other EDA, CAD and net-list formats. Verification and Spice export for simulation allow for full project analysis

6. RESULT

The IIC interface, power, ground, the IIC clock line SCL and IIC data line SDA are connected between ATmega and MLX60914 embedded infrared temperature measurement module. Through the communication test, the system becomes reliable, accurate and fast. Sample timing diagrams for reading and writing data for comparison are as follows:

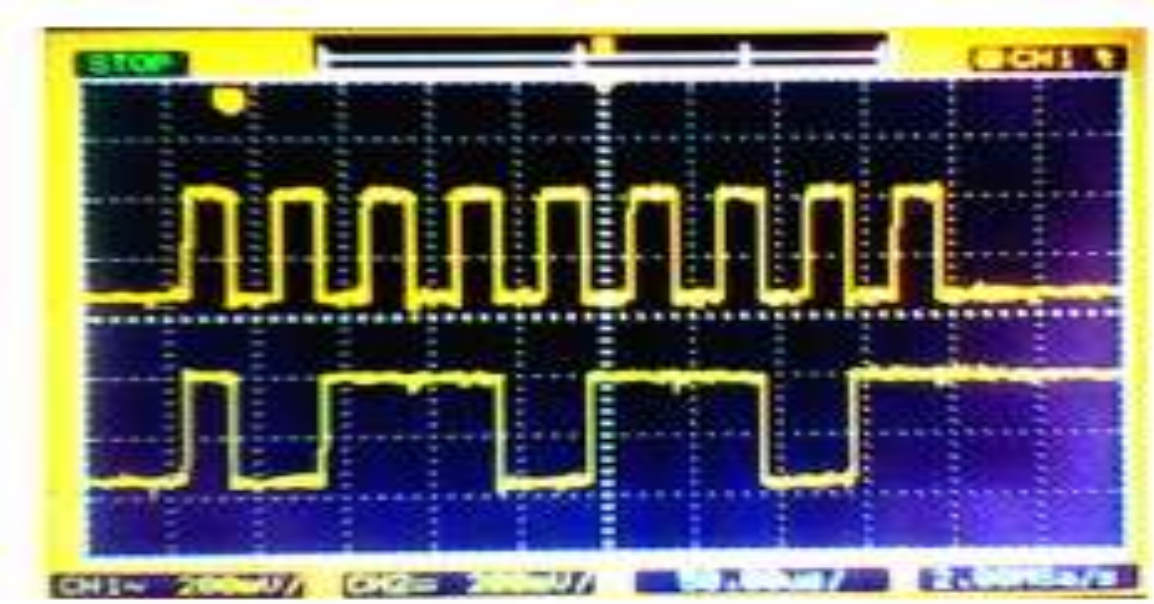


Fig7: Timing diagram for detecting whether the slave device is online

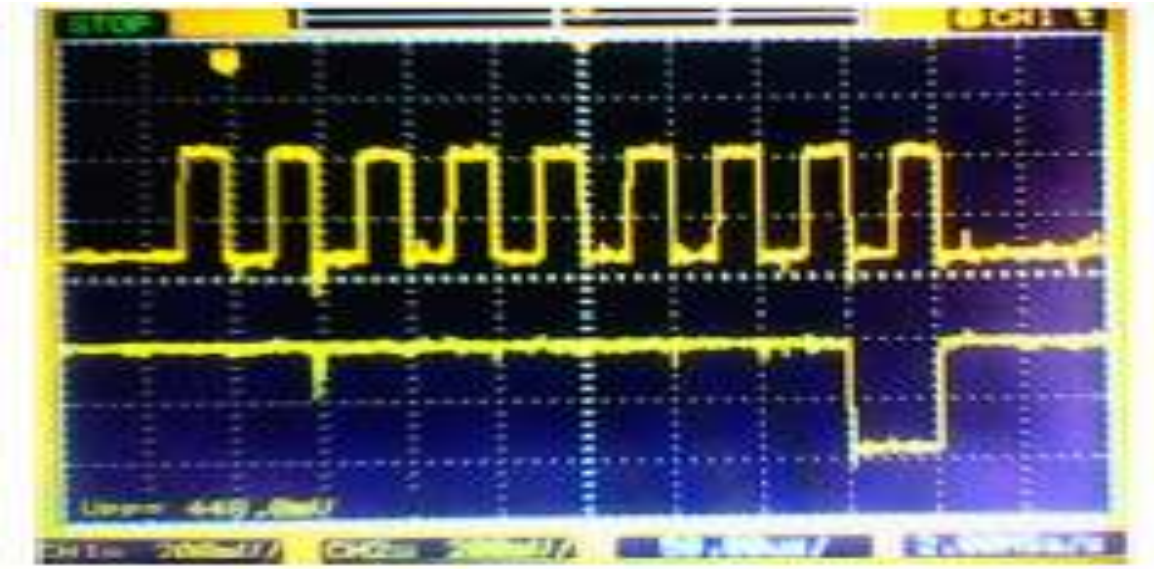


Fig8: Timing diagram for reading data

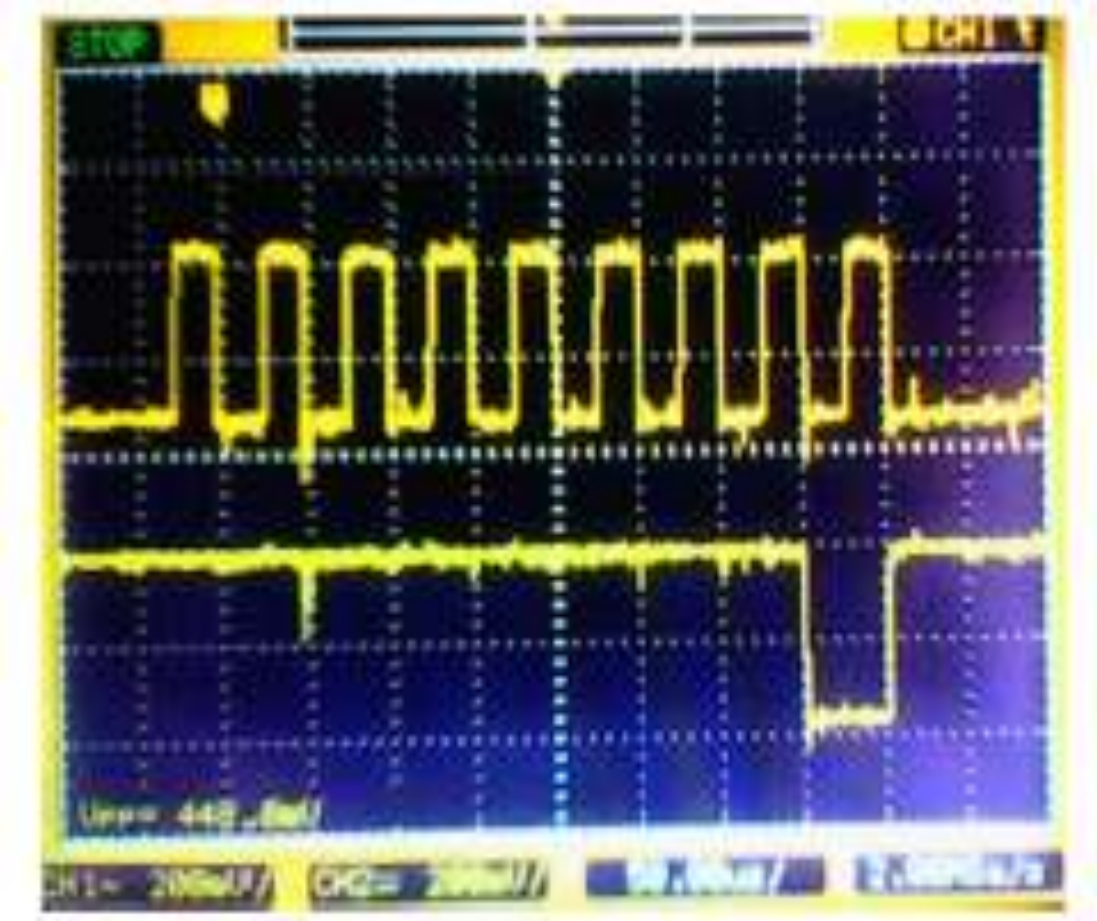


Fig9: Timing diagram of a signal to end the lIC communication transmitted by the master device

As is shown in Figure 7, Figure 8, Figure 9, when IICON is refreshed each time, an IIC communication is started. The master device transmits nine IICSCL clock signals, and the former eight IICSCL clock signals are used to transmit byte content from the IICDS, and the last one clock is used to receive a response from the slave device. When the mode is master receiver, the same former eight clocks are used to receive a byte of data online from the IICSDA by the slave device and storage them to the IICDS register, and the last one clock is used to transmit the master device's response. Using the system, we make five consecutive samples respectively about the human body surface temperature and the boiling water temperature. The IIC infrared temperature measurement module's standard working frequency is 20 KHz, and their error rates

are almost 0, and the average cost time is 7.2mS for a complete reading temperature data with high accuracy of 0.01 "C.

7. Conclusions

Temperature measurement system can be sampled on a sampling point; can also form into a target array of the measured multi-point sampling by reusing Temperature sensor module. It can pass the information of temperature condition of various collection points to the host system in real time. Detection of the temperature measurement system is with fast speed, high precision and good stability. In the host-side, through the software, we can also optimize the value of the temperature of each collection point, integrating with other parameters of engineering. It can be widely used in fault diagnosis, performance testing, Industrial use and other engineering fields.

8. References

[I] V. K. Bitukov and V. A. Petrov, "Noncontact Temperature Measurement on Dielectricsand Semiconductors",Rus-sian Microelectronics,

[2] Francisco Javier Meca Meca , Manuel Mazo Quintas, Francisco Javier Rodriguez Sanchez, Pablo Ramos Sainz,"Infrared temperature measurement system using photoconductive PbSe sensors without radiation chopping" ,Sensors and Actuators

[3] Slavko Pokorni," Error Analysis of Surface Temperature Measurement By Infraed Sensor" International Journal of Infrared and Millimeter Waves,

[4] ARMLtd. http//www.arm.com/products/DevTools.

[5] TSEVOIC-L5.5 Product Specification, http//www.HL-Planar.com

[6] Wan Han, Gao Xiaopeng, Deng Libo, Yu Ting,"Design and Implementation of a Simulation Framework for the ARM Embedded System", Tenth International Conference on Computer Modeling and Simulation.

[7] Wan Han, Gao Xiaopeng,"ArmSim: a Complete System Simulation Environment of the ARM Embedded System" Fifth International Conference on Information Technology: New Generations, pp.

[8] www.micro-epsilon.com