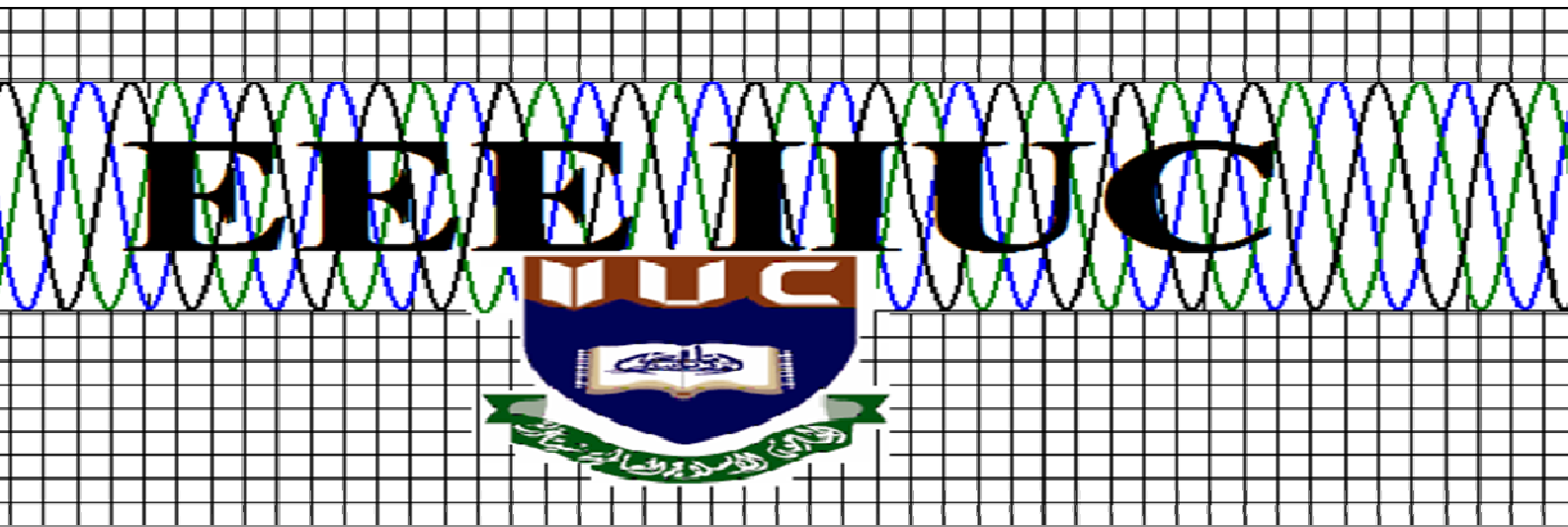




Project on Design and Implementation of a Wireless Multi-meter

This project submitted in partial fulfillment of the
requirements for the award of the degree of
Bachelor of Engineering (Electrical and Electronics Engineering)

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Report No. 2012.24

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Design and Implementation of a Wireless Multi-meter

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Cover Page: Design and Implementation of a Wireless Multi-meter

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Chittagong, Bangladesh 2012

The Project “**Design and Implementation of a Wireless Multi-meter**” Submitted by Md. Shahed Hossain (ET 071016), Md. Jashim Uddin (ET 071043) and Md. Shoyaibur Rahman Chowdhury (ET 071064), Session: Spring 2007, to the department of Electrical & Electronic Engineering, International Islamic University Chittagong, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of Bachelor of Science in Electrical & Electronic Engineering and approved as to its style and contents for the examination held on November, 2012.

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Declaration

It is hereby declared that the work presented in this project report is done by us under the supervision of Prof. Anil Kanti Dhar, Professor, Department of Electrical and Electronic Engineering, Chittagong University of Engineering and Technology. This report or any part of this project has not been submitted elsewhere for the award of any degree or diploma, does not contain any unlawful statements.

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ABSTRACT

A wireless multi meter is an instrument used to measure the current, voltage, frequency and power at a load from a distance. In this project a wireless multi meter was designed which consisted of two major parts: 1) Measuring Section Module and 2) Remote Display Module. Measuring Section Module consisted of three major section which are i) signal input, ii) Micro controller, iii) RF transmitter whereas the remote display module also consisted of three parts i) RF Receiver, ii) Microcontroller and iii) LCD Display Module. At first the signal under measurement, was converted to a 6 volt signal through a transformer and was fed to the microcontroller (ATmega8A) input. After all relevant calculations the dc voltage produced by the micro controller was sent through an RF Frequency transmitter module (BX-R433A) having an omnidirectional antenna. The RF receiver module (KST-RX806E), situated at a maximum distance of 150 meters from the transmitter, received the transmitted data and the microcontroller next to it was used to decode the signal intercepted by the receiving antenna. The result of the calculations is then displayed through a 16-bit LCD display module (TM162A). This multi meter was found to measure the values of the voltage, current, power and frequency ranging from (0-250) V, (0-20) A, (0-5000) VA and (0-125) KHz respectively. The main attraction of our designed circuit was the simplicity of the circuit, easiness of implementation and the availability of components required in our country.

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ACRONYM

AC	–	Alternating Current
V	–	Volt
LCD	–	Liquid Crystal Display
RF	–	Radio Frequency
CMOS	–	Complementary Metal Oxide Semiconductor
Ω	–	ohm (Unit of Resistance)
AVO	–	Ampere, Volt, Ohm
IC	–	Integrated Circuit
SRAM	–	Static Random Access Memory
DAC	–	Digital to Analog Converter
ADC	–	Analog to Digital Converter
mA	–	mili ampere

CHAPTER 1

INTRODUCTION

The **Multi-meter** is one of the most essential Instruments for power system to measure the current, voltage, frequency and power of a load. Here we design and implement a **wireless Multi-meter** to monitor the voltage, current, frequency and power from vast distance. We made it by using micro controller and LCD for display the values of the parameters. In Industries or others fields where heavy industrial machineries are used, it is difficult to physically monitor the different parameters of each machine every time because of the distance between one machine to another, location, heat, dust etc. whenever we can do this from a suitable place and monitor a number machines at a glance. So, it can be use widely for monitoring to take control action from the distance of the load, like control room. Wireless multi meter design by us is capable to work for input signal voltage range 0–220v AC. In this wireless multi meter nothing but a multi meter but its specialty is that, it can measure voltage, current, frequency and apparent power and display away from the measuring point without any cable connection. We can describe its working principle in four steps-

- 1) At first it will receive data from 220v ac power line through a step down transformer. Transformer will reduce input voltage into 6v. Then this signal voltage will enter in the Micro controllers input through the voltage limiter circuit.
- 2) In second step Micro controller will process and calculate the signal frequency from incoming signal and calculated value will be convert as digital data to transfer through RF transmitter module (Transmitter & Receiver) for desired destination.
- 3) In step three the RF module (Transmitter) will transfer data that has been send from Micro controller section. Another RF module (Receiver) will receive data and send it for displaying to the display circuit.
- 4) In step four Microcontrollers will demodulate the incoming signal and will display it through the LCD. We use a LCD for displaying information. This LCD also controlled by another Micro controller.

CHAPTER 2

DESCRIPTION OF THE WORK

2.1 OBJECTIVES:

The main objective of our project is to develop a technique of voltage, current, frequency and power measurement, operation and data processing technique of microcontroller, digital data transmission and receiving technique, analyzing the overall operation of a wireless multi meter.

2.2 BACKGROUND

At any power generation system or at any industry it is necessary to continuous monitoring of line voltage, line current, line frequency and also power. In conventional system a multi meter is attached with input/output power line. As a routine work when we need to observe power line parameters then we must go to near about it. But at any power generation system used heavy machineries to produce power which make a big amount of mechanical sound which is intolerable. Beside cause of distance/location of machine, noise, heat, dust etc. it is difficult to monitor each machine physically every time. Then we think to make a solution for this. Firstly we think to place multi meter at control room by wired connection, but it is not suitable. Then we imagine a system which will reduce cable connection & released us from suffering. So, we decide to construct a wireless multi meter. Finally we become successful to make a RF based & effective **wireless multi meter** which we represented here.

2.3 PROJECT VISION

The main aims of the project are -

Save time:

In any power system measurement of the different parameters is a regular work which will become faster by using this wireless measurement system.

Increase Reliability:

The system will be reliable to the user for monitoring the voltage, current frequency and apparent power and control. Because it will be integrated, user friendly, wireless and micro controller will be implemented for signal processing etc.

Reduce Operating Cost:

For manual system the user has to spend a big amount of money for operating (such as like manpower, Equipment cost etc.). Installation cost also reduced after using the wireless multi meter because it is cheaper than conventional multi meter and it should be used one device to measure different point's frequency. It will reduce manpower cost also.

Fasten Response:

When need to know the value of voltage, current, frequency and apparent power for any point which situated far from control room then wireless multi meter will give data more quickly than the manual data collecting system by operator witness.

Increase Accuracy:

As the whole system is manual there is a greater possibility of error in eye vision and taking control action. Wireless multi meter will give accurate data for the system in digital form which will help to make decision for necessary control action.

Skill development:

By completing this project successfully it will develop our skill to make electronics project and acquire adequate knowledge about RF base communication system. We will be successful to apply micro controller, RF module, LCD practically and we will be more confident to complete further big project in future.

CHAPTER 3

THEORY OF THE WORK

3.1 REQUIRED COMPONENTS

- ATmega8A (CMOS-8-bit micro controller) - 02 nos.
- BX-R433A (433.92 MHz RF transmitter module)-01 nos.
- KST-RX806E (433.92 MHz RF receiver module)-01 nos..
- L7805 (Voltage regulator)-02 nos.
- Capacitor ($100\mu f$, 35 volt) - 02 nos.
- Rectifier diode (1N4001)
- Resistors (10k Ω -01 no, 1k Ω -01 no, 330 Ω - 03 nos.)
- 16 bit LCD (TM162A) -01 no.
- Iron core transformer (220v~6v, 300mA)-01 nos.
- Antenna (Short Dipole).
- Breadboards, dc power supply, connecting wire, etc.
- AVO meter, Soldering iron, solders.
- IC base, copper wire for antenna etc.

3.2 DESCRIPTION OF THE COMPONENTS

3.2.1 ATmega8A (CMOS-8-bit micro controller)

Internal block diagram of ATmega8A:

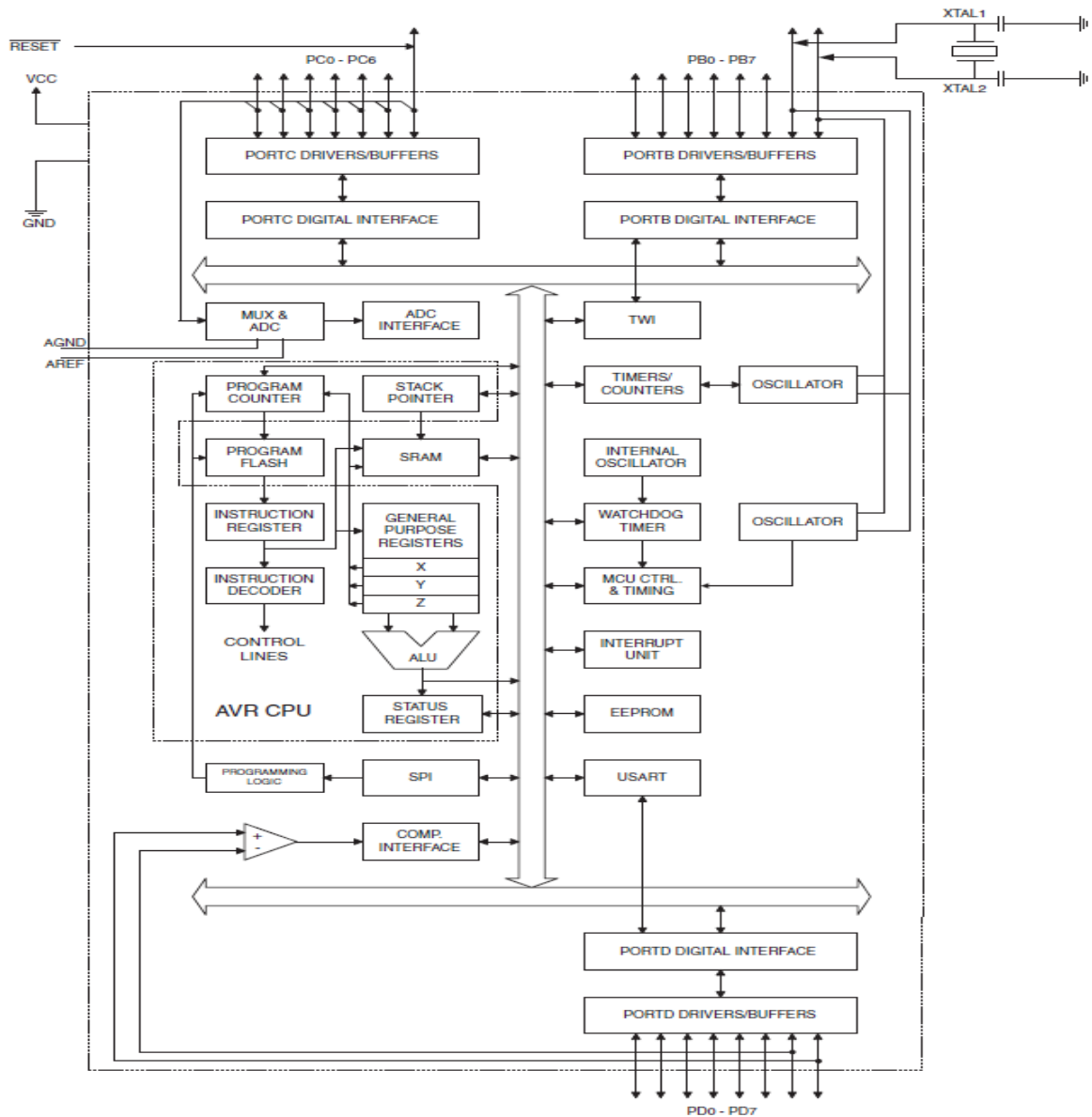


Fig 3.1 - Internal Block diagram of ATmega8A.

Features of ATmega8A

- 1 - High-performance, Low-power AVR® 8-bit Micro controller
- 2 - Advanced RISC Architecture
- 3 - 130 Powerful Instructions – Most Single-clock Cycle Execution
- 4 - 32 x 8 General Purpose Working Registers
- 5 - Fully Static Operation
- 6 - Up to 16 MIPS Throughput at 16 MHz
- 7 - On-chip 2-cycle Multiplier
- 8 - High Endurance Non-volatile Memory segments
- 9 - 8K Bytes of In-System Self-programmable Flash program memory
- 10 - 512 Bytes EEPROM
- 11 - 1K Byte Internal SRAM
- 12 - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
- 13 - Data retention: 20 years at 85°C/100 years at 25°C
- 14 - Optional Boot Code Section with Independent Lock Bits
- 15 - In-System Programming by On-chip Boot Program
- 16 - True Read-While-Write Operation
- 17 - Programming Lock for Software Security
- 18 - Peripheral Features
- 19 - Two 8-bit Timer/Counters with Separate Prescale, one Compare Mode
- 20 - One 16-bit Timer/Counter with Separate Prescale, Compare Mode, and Capture Mode
- 21 - Real Time Counter with Separate Oscillator
- 22 - Three PWM Channels
- 23 - 8-channel ADC in TQFP and QFN/MLF package
- 24 - Eight Channels 10-bit Accuracy
- 25 - 6-channel ADC in PDIP package

- 26 - Six Channels 10-bit Accuracy
- 27 - Byte-oriented Two-wire Serial Interface
- 28 - Programmable Serial USART
- 29 - Master/Slave SPI Serial Interface
- 30 - Programmable Watchdog Timer with Separate On-chip Oscillator
- 31 - On-chip Analog Comparator
- 32 - Special Micro controller Features
- 33 - Power-on Reset and Programmable Brown-out Detection
- 34 - Internal Calibrated RC Oscillator
- 35 - External and Internal Interrupt Sources
- 36 - Five Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, and Standby
- 37 - I/O and Packages
- 38 - 23 Programmable I/O Lines
- 39 - 28-lead PDIP, 32-lead TQFP, and 32-pad QFN/MLF
- 40 - Operating Voltages
- 41 - 2.7 - 5.5V for ATmega8A
- 42 - Speed Grades
- 43 - 0 - 16 MHz for ATmega8A
- 44 - Power Consumption at 4 KHz, 3V, 25°C
- 45 - Active: 3.6 mA
- 46 - Idle Mode: 1.0 mA
- 47 - Power-down Mode: 0.5 μ A

Pinout ATmega8A

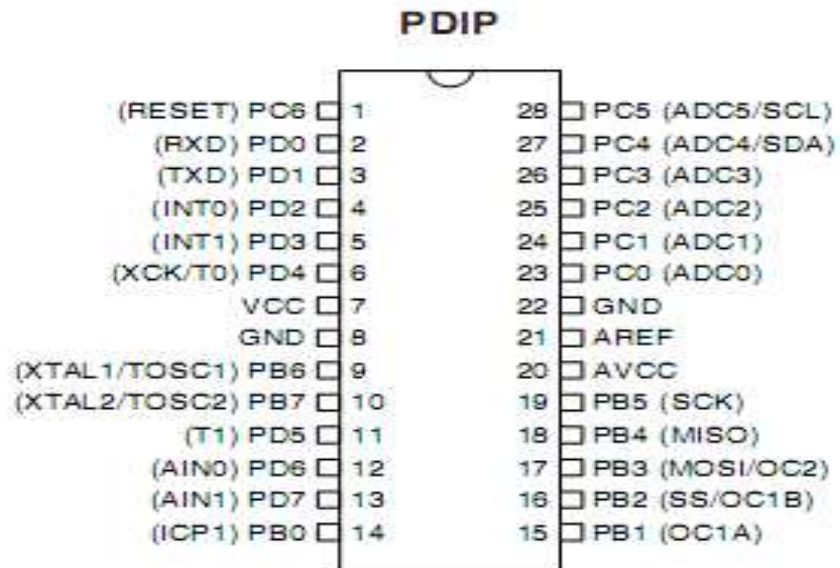


Fig 3.2 - Pin connection details of an ATmega8A chip.

3.2.2 BX-R433A (433.92 MHz RF transmitter module)

As a RF transmitter module we use here KST-TX01 (BX R433A) module. It is special types of module which can transmit digital data. It is used 433.92 MHz frequency range for transmit data.



Figure 3.3 - Practical view of module KST-TX01 (BX R433A) RF transmitter.

Specifications:

- Frequency Range: 433.92 MHz
- Module Mode: ASK
- Circuit Shape: SAW
- Data Rate: 8kbps
- Supply Voltage: 3~12V
- Power Supply and All Input/Output Pins: -0.3 to +12.0V
- Non-Operating Case Temperature: -20 to +85 C
- Soldering Temperature (10 Seconds) : 230 C (10 Seconds)

Electrical Characteristics, T=25 C, Vcc=3.6v, Freq = 433.92MHz

Characteristic	Sym	Min.	Typ.	Max.	Unit
Operating Frequency (200KHz)	Vcc		433.92		MHz
Data Rate	ASK			8K	Kbps
Transmitter Performance (OOK@2.4kbps)					
Peak Input Current, 12 Vdc Supply	ITP			45	mA
Peak Output Power	PO		10		mW
Tum on/ Tum Off Time	T ON/T OFF			1	US
Power Supply Voltage Range	Vcc			12	VDC
Operating Ambient Temperature	TA	3		+85	°C
Tx Antenna Out (3V) +2.4dB	Vcc	-20			Ma

Table: 3.1 Electrical characteristics of KST-TX01 (BX433A)

3.2.3 KST-RX806E (433.92 MHz RF receiver module)

As a RF receiver module we use here KST-RX806E (BXR423) module. it is a special types of module which can receive specific frequency range signal. We use it because it will receive only 433.92 MHz frequency signal. So, it will not receive noise signal and its output will be noiseless operation. Detailed circuitry RF receiver section & Practical RF receiver module KST-RX806E (BXR 423) are given below:-



Pin 1: GND
Pin 2: Digital Output
Pin 3: Linear Out
Pin 4: VCC
Pin 5: VCC
Pin 6: GND
Pin 7: GND
Pin 8: ANT (About 30~35cm)

Modulation: AM
Supply Voltage: 5V DC

Figure 3.4: - Practical RF receiver module KST-RX806E (BXR 423).

Specifications:

- * Frequency Range: 433.92MHz
- * Modulate Mode: ASK
- * Circuit Shape: LC
- * Data Rate: 4800bps
- * Selectivity: -106dBm
- * Channel Spacing: ± 500 KHz
- * Supply Voltage: 5V
- * High Sensitivity Passive Design.
- * Simple to Apply with Low External Count.

Electrical Characteristics:

Characteristic	Sym.	Min.	Typ.	Max.	Unit
Operating Radio Frequency	FC	433.42	433.92	434.42	MHz
Sensitivity	Pref.	-106	-106	-108	dBm
Channel Width		-500		+500	KHz
Noise Equivalent BW	NEB		5	4	
Baseband Data Rate				3	KB/S
Receiver Turn On Time				3	Ms

Table 3.2: Electrical characteristics of KST-RX806E (BXR423)

3.2.4 L7805 (Voltage regulator IC)

We use L7805 voltage regulator IC for both module. L7805 is a voltage regulator IC which will regulate the input supply voltage at 5V. It has three pins, pin-1 is input pin, pin-2 is control (Ground) pin and the pin-3 is output pin. By using this regulator IC we are able to supply a constant supply voltage to the Micro controller. Benefit of using L7805 Voltage regulator IC that now we can use a wide voltage range (6V-15V) for input operating voltage.

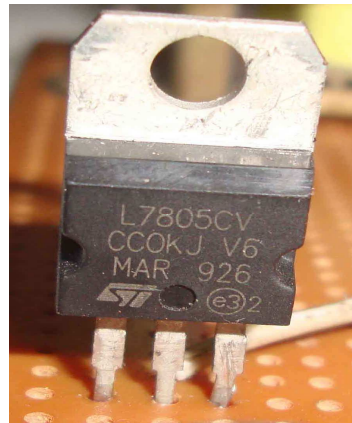


Figure 3.5: - Practical view of L7805 Voltage regulator IC.

3.2.5 Capacitor (100 μ f, 35 volt)

We use Capacitor (100 μ f, 35 volt) for both modules. The function of capacitor is filtering the input supply voltage. Here we use capacitor to ensure the supply voltage is pure dc.

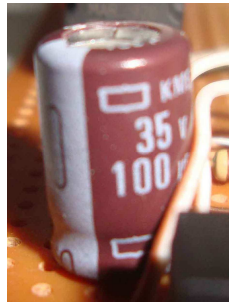


Figure 3.6: - Practical view of Capacitor (100 μ f, 35 volt).

3.2.6 Rectifier Diode (1N4001)

The 1N4001 series (or 1N4000 series) is a family of popular 1.0 amp general purpose silicon rectifier diodes commonly used in AC adapters for common household appliances. Blocking voltage varies from 50 to 1000 volts. This diode is made in an axial-lead DO-41 plastic package. The 1N5400 series is a similarly popular series for higher current applications, up to 3 A. These diodes come in the larger DO-201 axial package. These are fairly low-speed rectifier diodes, being inefficient for square waves of more than 15 kHz. The series was second sourced by many manufacturers. The 1N4000 series were in the Motorola Silicon Rectifier Handbook in 1966, as replacements for 1N2609 through 1N2617. The 1N5400 series were announced in Electrical Design News in 1968, along with the now lesser known 1.5-ampere 1N5391 series.

3.2.7 Resistors (10k Ω , 1k Ω , 330 Ω)

We use Resistors (10k Ω , 1k Ω , 330 Ω) for different biasing action and to giving input pulse. We need those resistors for both modules. Since internal resistances of LCD are very low, if moderate amount of current flows through them, they may damage. To prevent this external resistors are used in series with LCD. The higher will be the value of the resistors, the more will be the decrease of the intensity of display. About 1K Ω resistor is suitable for this purpose.

3.2.8 16 bit LCD Module (TM162A) :

We use here 16 bit LCD (TM162A) for display. LCD module is the output displaying device. We used for this project TM162A-3 LCD module. It has 5 $\times$ 8 dot matrix 16 character displays with cursor. It can display two lines at a time and each line contains sixteen characters. When power will be on then initially it will show its name and maximum frequency range what it can be measure. After that LCD will display University & Department name, then student name & ID no. who made this project for 0-5 second each. Then it will display “Frequency Counter” in the first line and in second line it will display “Freq... Hz” depending on input power line frequency. When power line frequency will fail it will display freq: 00000Hz. Here LCD Block diagram, circuit diagram and actual view of module are given below:-

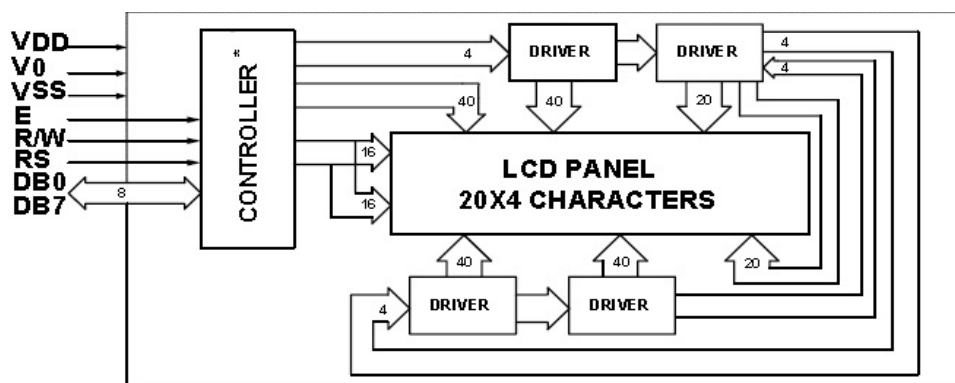


Figure 3.7: - Block diagram of LCD module section.

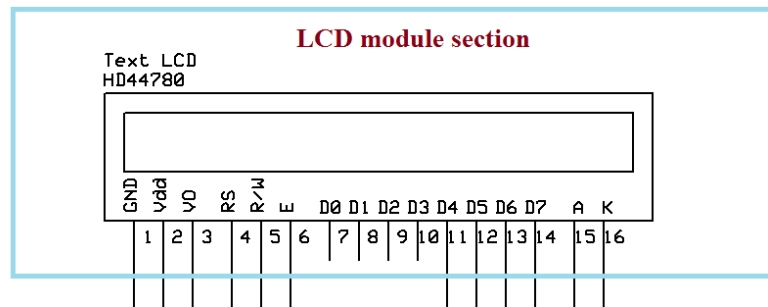


Figure 3.8: - Circuit diagram of LCD module section.

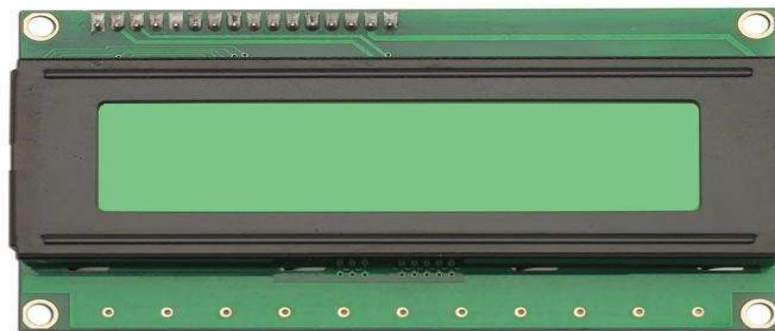


Figure 3.9: - Practical view of LCD module.

Feature:

1. 5X8 dots with Cursor
2. Built-in controller (KS0066U or Equivalent)
3. +5V power supply (Also available for +3.0V)
4. 1/16 duty cycle
5. BKL to be driven by pin1, pin2 or pin15, pin16 or A,K
6. N.V. Optional

Interface pin Connections

Pin No	Symbol	Function
1.	VSS	GND
2.	VDD	+5V
3.	V0	Contrast adjustment
4.	RS	H/L Register Select Signal
5.	R/W	H/L read/Write Signal
6.	E	H/L Enable Signal
7.	DB0	H/L Data bus line
8.	DB1	H/L Data bus line
9.	DB2	H/L Data bus line
10.	DB3	H/L Data bus line
11.	DB4	H/L Data bus line
12.	DB5	H/L Data bus line
13.	DB6	H/L Data bus line
14.	DB7	H/L Data bus line
15.	A	+4.2V for BKL
16.	K	Power supply for BKL (0V)

Table 3.3: - Interface pin connection table of LCD module.

3.2.9 Iron core transformer (220v~6v, 300mA)

We use for this project an ordinary Iron core transformer (220v~6v, 300mA). The input 220v AC signal which frequency will be measured by this meter will give the input of this transformer. By transformer action the transformer will convert the input 220v ac into 6v ac which will be suitable for measuring. Although transformer will reduce the input voltage but frequency will remain unchanged.

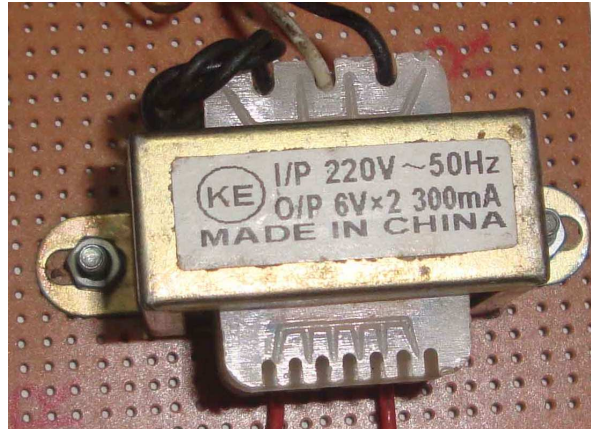


Figure 3.10: - Practical view of transformer.

3.2.10 Antenna

The short dipole antenna is the simplest of all antennas. It is simply an open-circuited wire, fed at its center as shown in Figure 1.

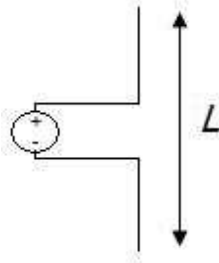


Figure 3.11 Short dipole antenna of length L .

The words "short" or "small" in antenna engineering always imply "relative to a wavelength". So the absolute size of the above dipole antenna does not matter, only the size of the wire relative to the wavelength of the frequency of operation. Typically, a dipole is short if its length is less than a tenth of a wavelength:

$$L < \frac{\lambda}{10}$$

If the short dipole antenna is oriented along the z-axis with the center of the dipole at $z=0$, then the current distribution on a thin, short dipole is given by:

$$I(z) = I_0 \left(1 - \frac{2|z|}{L}\right)$$

The current distribution is plotted in Figure 2. Note that this is the amplitude of the current distribution; it is oscillating in time sinusoidally at frequency f .

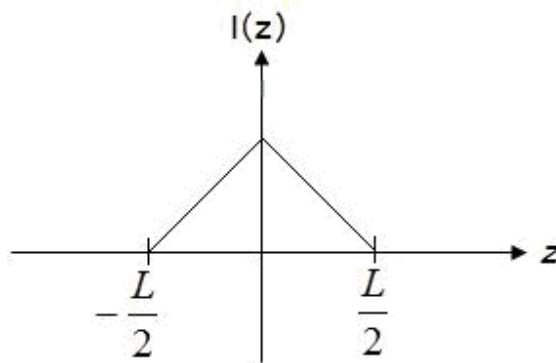


Figure 3.12 Current distributions along a short dipole antenna.

3.2.11 Breadboards, dc power supply, connecting wire, etc

To connect all the components and completing the whole circuit bread-board, wire etc. are required. To energize all the chips and related components 5- volt dc power supply is essential. Our circuit can work in variable supply voltage (05v-12v dc). We will need also AVO meter, Soldering iron and 30cm long copper wire for transmitting & receiving antenna.

CHAPTER 4

PROPOSED SYSTEM

4.1 INTRODUCTION

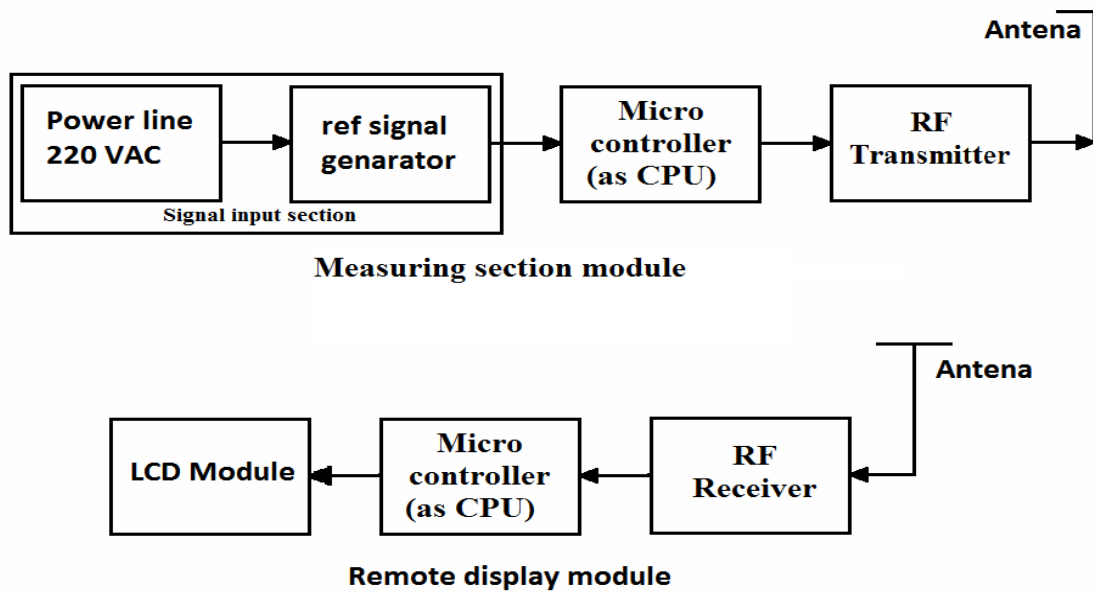


Figure 4.1: - The complete block diagram of the **WIRELESS MULTI METER**.

Therefore our WIRELESS MULTI METER consists of two major section, they are: -

1. MEASURING (voltage, current, frequency and power) SECTION MODULE and
2. REMOTE DISPLAY MODULE

4.2 MEASURING (voltage, current, frequency and power) SECTION MODULE

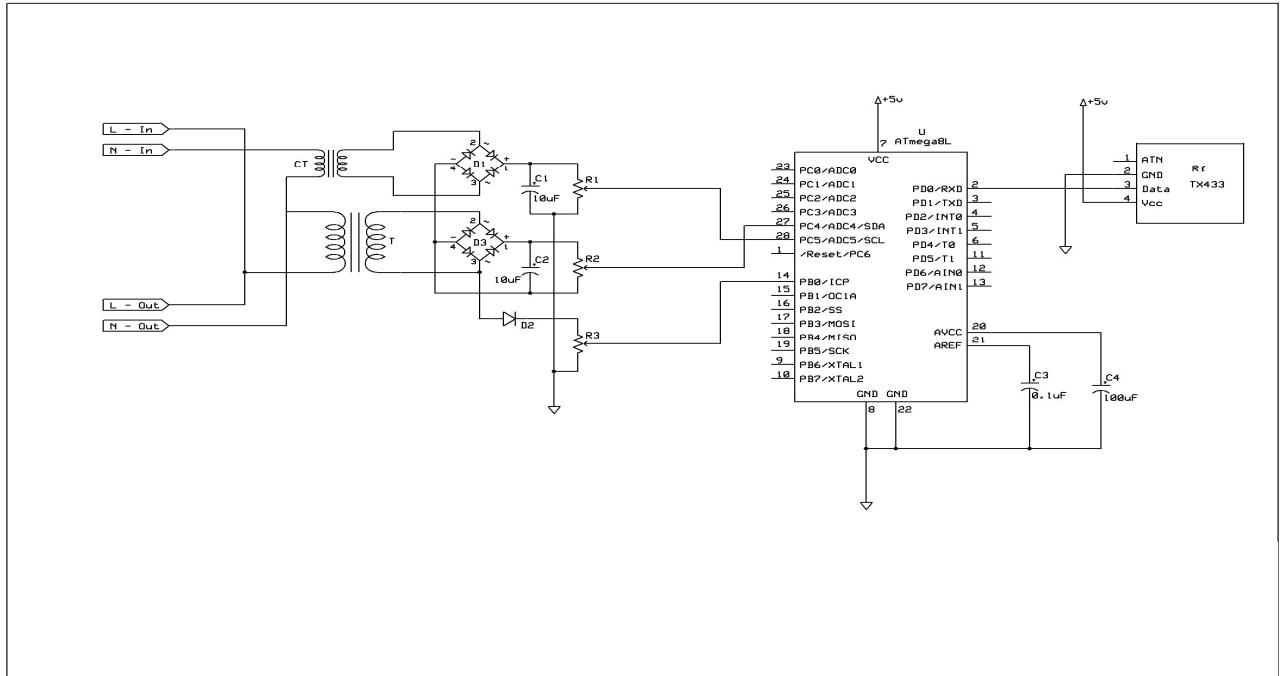


Figure 4.2: - The complete circuit diagram of the measuring section.

This MEASURING section are constructed with sub section, they are-

1. Signal input section
2. Voltage measurement section
3. Current measurement section
4. Power factor measurement section
5. Micro controller section
6. RF Transmitter section

4.2.1 SIGNALS INPUT SECTION: -

In this experiment we are going to measure the AC voltage, current, frequency and power by using Micro controller. The mains AC voltage is 220V, so we should not directly feed it into PIC port of the Micro controller. We need to first step down the 220V AC first to appropriate level. We have used here a 6V transformer for this purpose. For measuring the frequency the

6V AC sine wave output from the transformer will be further converted to 6V dc using a rectifier diode. Here we use simple 1N 4007 rectifier diode. we used an additional voltage regulator as over voltage protection or get a stable signal voltage for input signal using 6v zener diode. This additional circuit will protect Micro controller from input over voltage signal. The 6V sine waves will be fed to ICP1 port of ATmega8A Micro controller. The number of pulses arrived at port ICP1 within 1 second will be the frequency of the input signal.

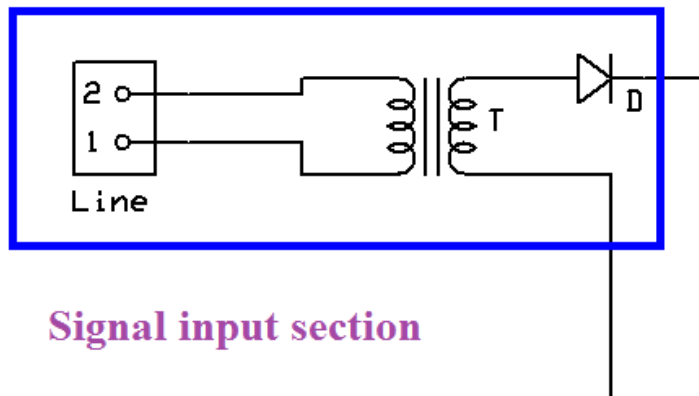


Fig 4.3: - 220v AC frequency signal input section.

4.2.2 VOLTAGE MEASUREMENT: -

For measuring the voltage we used a bridge rectifier with the secondary of 6v transformer. The 6v dc output voltage further fed into the port PC4 of microcontroller, which is the value of the line voltage.

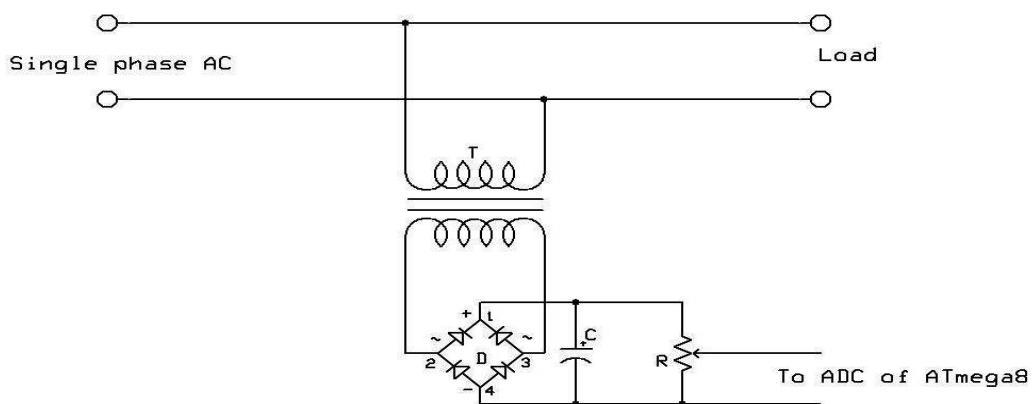


Fig: 4.4 Voltage measurements

4.2.3 CURRENT MEASUREMENT: -

For measuring the current of the load we used a CT (Current Transformer). Another bridge rectifier used with the output of the CT. This rectifier converts the value of AC current into the DC. The output of the rectifier connects to the port PC5 of the microcontroller.

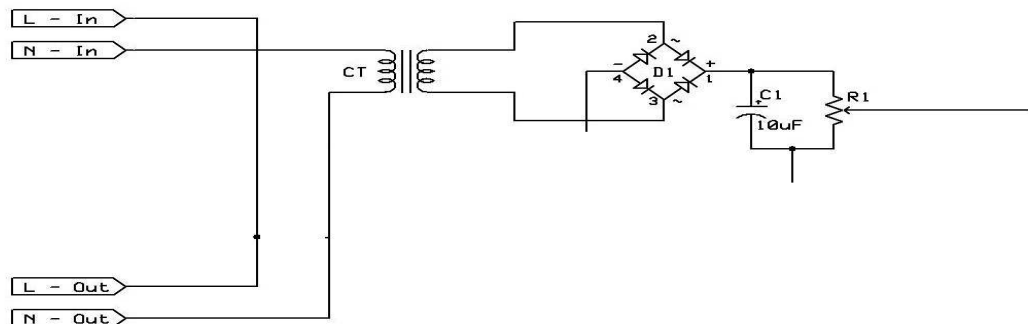


Fig: 4.5 Current Measurements

4.2.4 POWER FACTOR MEASUREMENT:

For measure the power factor we take the angle between voltage and current of the line. At first we pass the voltage to the microcontroller then pass the current and take the angle between voltage and current and calculate the power factor $\cos\phi$.

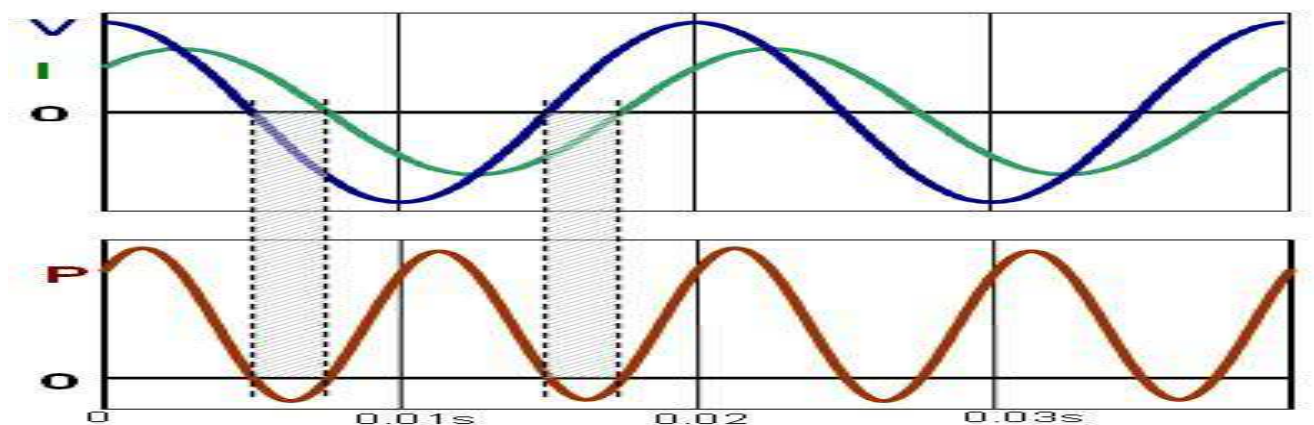


Fig: 4.6 Power factor measurements

For measure the power of the load we just multiply the value of voltage current and power factor.

4.2.5 MICRO CONTROLLER SECTION: -

As a Micro controller we used here ATmega8A chip. In this project it will work as signal processor and CPU of the line frequency counter section. Because the Micro controller core combines a rich instruction set with 32 general purposes working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC micro controllers. Figure given under the Micro controller sub-section of frequency counter section:-

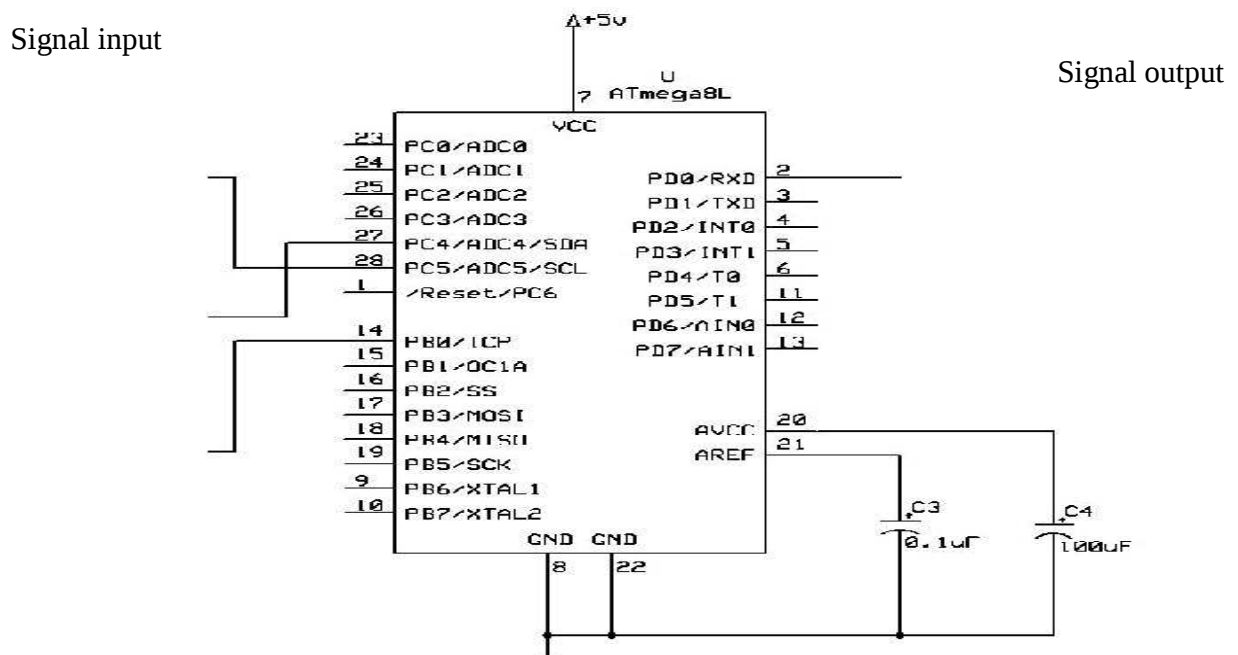


Fig: 4.7 Microcontroller section

The ATmega8A provides the following features: 8K bytes of In-System Programmable Flash with Read-While-Write capabilities, 512 bytes of EEPROM, 1K byte of SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte

oriented Two-wire Serial Interface, a 6-channel ADC (eight channels in TQFP and QFN/MLF packages) with 10-bit accuracy, a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and five software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM; Timer/Counters, 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 using high density non-volatile memory technology. The Flash Program memory can 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 ATmega8A is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications.

There are four calculation theories:-

1. VOLTAGE CALCULATION THEORY
2. CURRENT CALCULATION THEORY
3. FREQUENCY CALCULATION THEORY
4. POWER CALCULATION THERY

4.2.5.1 VOLTAGE CALCULATION THEOREM

The voltage between two ends of a path is the total energy required to move a small electric charge along that path, divided by the magnitude of the charge. Mathematically this is expressed as the line integral of the electric field and the time rate of change of magnetic field along that path. In the general case, both a static (unchanging) electric field and a dynamic (time-varying) electromagnetic field must be included in determining the voltage between two points.

Historically this quantity has also been called "tension" and "pressure". Pressure is now obsolete but tension is still used, for example within the phrase "high tension" (HT) which is commonly used in thermionic valve (vacuum tube) based electronics.

Voltage is defined so that negatively-charged objects are pulled towards higher voltages, while positively-charged objects are pulled towards lower voltages. Therefore, the conventional current in a wire or resistor always flows from higher voltage to lower voltage. Current can flow from lower voltage to higher voltage, but only when a source of energy is present to "push" it against the opposing electric field. For example, inside a battery, chemical reactions inside the battery provide the energy needed for current to flow from the negative terminal to the positive terminal.

4.2.5.2 CURRENT CALCULATION THEOREM

Electric current is a flow of electric charge through a medium. This charge is typically carried by moving electrons in a conductor such as wire. It can also be carried by ions in an electrolyte, or by both ions and electrons in a plasma. The SI unit for measuring the rate of flow of electric charge is the ampere, which is charge flowing through some surface at the rate of one coulomb per second. Electric current is measured using an ammeter.

4.2.5.3 FREQUENCY CALCULATION THEOREM

Frequency is the number of occurrences of a repeating event per unit time. It is also referred to as temporal frequency. The period is the duration of one cycle in a repeating event, so the period is the reciprocal of the frequency. For example, if a newborn baby's heart beats at a frequency of 120 times a minute, its period (the interval between beats) is half a second.

A traditional unit of measure used with rotating mechanical devices is revolutions per minute, abbreviated RPM. 60 RPM equals one hertz.^[1] The period, usually denoted by T , is the length of time taken by one cycle, and is the

$$T = \frac{1}{f}$$

Reciprocal of the frequency f :

The SI unit for period is the second

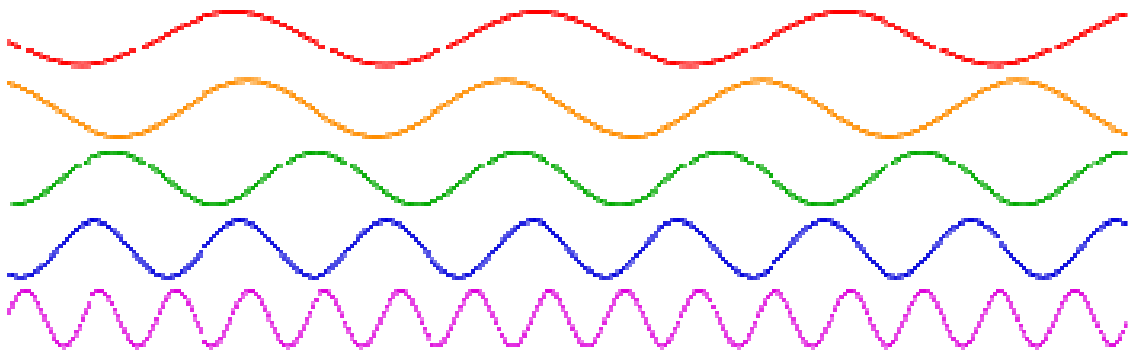


Fig 4.8:- wave form of different frequency AC wave.

For periodic waves, frequency has an inverse relationship to the concept of wavelength; simply, frequency is inversely proportional to wavelength λ (lambda). The frequency f is equal to the phase velocity v of the wave divided by the wavelength λ of the wave:

$$f = \frac{v}{\lambda}.$$

In the special case of electromagnetic waves moving through a vacuum, then $v = c$, where c is the speed of light in a vacuum, and this expression becomes:

$$f = \frac{c}{\lambda}.$$

When waves from a monochrome source travel from one medium to another, their frequency remains exactly the same - only their wavelength and speed change.

Calculating the frequency of a repeating event is accomplished by counting the number of times that event occurs within a specific time period, then dividing the count by the length of the time period. For example, if 71 events occur within 15 seconds the frequency is:

$$f = \frac{71}{15 \text{ sec}} \approx 4.7 \text{ hertz}$$

If the number of counts is not very large, it is more accurate to measure the time interval for a predetermined number of occurrences, rather than the number of occurrences within a specified time. The latter method introduces a random error into the count of between zero and one count, so on average half a count. This is called *gating error* and causes an average error in the calculated frequency of $\Delta f = 1 / (2 T_m)$, or a fractional error of $\Delta f / f = 1 / (2 f T_m)$ where T_m is the timing interval and f is the measured frequency. This error decreases with frequency, so it is a problem at low frequencies where the number of counts N is small.

4.2.5.4 POWER CALCULATION THEOREM

Apparent power is a measure of alternating current (AC) power that is computed by multiplying the root-mean-square (rms) current by the root-mean-square voltage. In a direct current (DC) circuit, or in an AC circuit whose impedance is a pure resistance, the voltage and current are in phase, and the following formula holds:

4.2.6 Wireless communication:

The project required wireless transmitter and receiver, so that the users could have access to multiple power meters in one graphical interface. The Tx433 transmitter and Rx433 Receiver were used for this task. Other transceivers like Xbee, or Bluetooth were also reviewed. All three devices had low power consumption capability and had similar ranges. The transmitter and receiver used this project were the smallest, and familiarity with these lent itself to the choice as well. They also have the capability to communicate with other devices at the same time, as well as a new feature to Auto Acknowledge and Auto Re-Transmit if a package was not received.

4.3 REMOTE DISPLAY MODULE

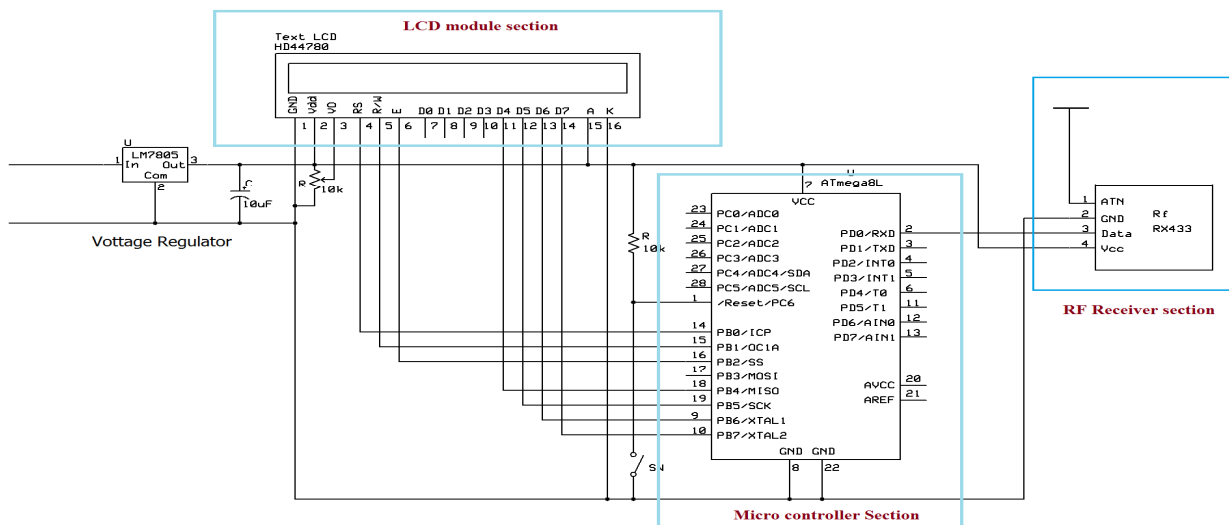


Figure 4.9: - Circuit diagram of remote display module.

This REMOTE DISPLAY MODULE section are also constructed with three sub section, they are -

1. RF RECEIVER SECTION
2. MICRO CONTROLLER SECTION
3. LCD MODULE SECTION

4.3.1 RF RECEIVER SECTION

As a RF receiver module we use here KST-RX806E (BXR423) module. It is special types of module which can receive specific frequency range signal. We use it because it will receive only 433.92 MHz frequency signal. So, it will not receive noise signal and its output will be noiseless operation. Detailed circuitry RF receiver section & Practical RF receiver module KST-RX806E (BXR 423) are given below:-

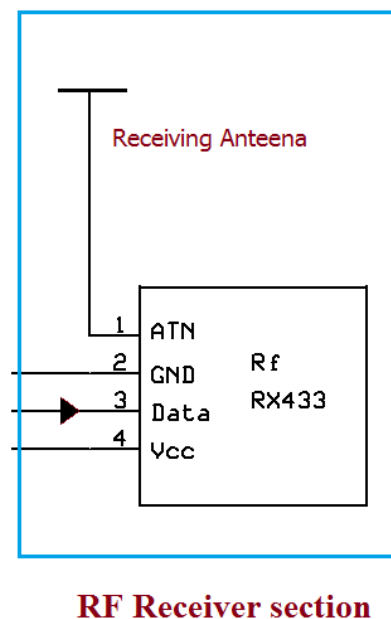


Figure 4.10: - Detailed circuitry of RF receiver section.

4.3.2 MICRO CONTROLLER SECTION

A **microcontroller** (also microcontroller unit, MCU or μC) is a small computer on a single integrated circuit consisting of a relatively simple CPU combined with support functions such as a crystal oscillator, timers, watchdog, serial and analog I/O etc. Neither program memory in the form of NOR flash or OTP ROM is also often included on chip, as well as a typically small amount of RAM. Microcontrollers are designed for small or dedicated applications. Thus, in contrast to the microprocessors used in personal computers and other high-performance or general purpose applications, simplicity is emphasized. Some microcontrollers may operate at clock frequencies as low as 32 kHz, as this is adequate for many typical applications, enabling low power consumption (milliwatts or microwatts). They will generally have the ability to retain functionality while waiting for an event such as a button press or other interrupt; power consumption while sleeping (CPU clock and most peripherals off) may be just nanowatts, making many of them well suited for long lasting battery applications. Other microcontrollers may serve performance-critical roles, where they may need to act more like a Digital signal processor (DSP), using higher clock speeds and not needing such very low powered operation.

Microcontrollers are used in automatically controlled products and devices, such as automobile engine control systems, remote controls, office machines, appliances, power tools, and toys. By reducing the size and cost compared to a design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control even more devices and processes.

4.3.3 LCD MODULE SECTION

A liquid crystal display (LCD) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals (LCs). LCs does not emit light directly.

They are used in a wide range of applications, including computer monitors, television, instrument panels, aircraft cockpit displays, signage, etc. They are common in consumer

devices such as video players, gaming devices, clocks, watches, calculators, and telephones. LCDs have replaced cathode ray tube (CRT) displays in most applications. They are available in a wider range of screen sizes than CRT and plasma displays, and since they do not use phosphors, they cannot suffer image burn-in. LCDs are, however, susceptible to image persistence

4.3.3.1 2 rows x 16 columns text LCD

In this project we used a 2 rows x 16 columns text LCD consists of two lines by 16 characters and provides basic text wrapping so that your text looks right on the display. The LCD display is compatible with the C Stamp microcomputer's supplies and signal levels

Description of 2 rows x 16 columns text LCD

The CS410020 2 rows x 16 columns Intelligent Serial LCD display with backlight is a very functional and low-cost LCD that can be easily controlled by a C StampTM. The LCD display consists of two lines by 16 characters and provides basic text wrapping so that your text looks right on the display. The LCD display is compatible with the C Stamp microcomputer's supplies and signal levels. In addition, this Intelligent Serial LCD also provides you with full control over all of its advanced LCD features, allowing you to move the cursor anywhere on the display with a single instruction and turn the display on and off in any configuration. The CS410020 LCD display requires only a 5 V power supply and the connection related to transferring data to the LCD via the RS232 protocol. Many useful text formatting functions are built into the operation of the LCD, as described in the Programming Guide. With this display and the C Stamp, users can design a professional-looking text user interface on any microcontroller application, supply an easy-to-use debugging interface that does not require a PC, and provide real-time sensor data output on autonomous robotic applications.

Technical Specification

- Module size: 80.0mm(L) x 36.0mm(W) x 18.0mm(T)
- Display size: 56.2mm(L) x 11.5mm(W)
- Character size: 2.95 x 5.55mm
- Allows any device to display to the LCD with only 1 pin using the standard serial RS232 protocol
- User controllable backlight
- Consumes only 6mA of current while active without backlight
- <1mA during sleep mode
- User can extend display up to 20 feet
- Automatic character wrap at the end of each line
- Calendar and time tracking and automatic display on screen
- Correct handling of carriage return <CR> character
- Correct handling of backspace character
- Backlight control commands
- Hard reset function that powers down and brings up the LCD display
- Works with both RS232 or TTL voltage levels with any settings
- Commands to clear any display line without clearing the whole screen
- No contrast adjustment required
- Able to display byte value as decimal numbers on the screen
- Able to display byte value as numbers with zero in front if number is less than 10
- Able to display byte value as a Hexadecimal number on the screen

CHAPTER 5

RESULTS AND DISCUSSIONS

This **wireless multimeter** can measure the value of the voltage, current, power and frequency of a signal ranging from 0V to 250V, 0A to 20A, 0VA to 5000VA and 0Hz to 125 KHz respectively. The corresponding measured values of the parameters can be represented in the unit of mV or V, mA or A, VA or KVA and Hz or KHz. The transmitter and Receiver module can operate at a maximum distance of 150 meters. It is cheaper than the conventional multimeter used in different industries and laboratories. The total cost of our project is given below in a table:

Sl No.	Name of the using components	Total price (Tk)
1	ATmega8A (CMOS-8-bit micro controller)- 02 nos	400.00
2	BX-R433A(433.92 MHz RF transmitter module)-01 nos.	300.00
3	KST-RX806E (433.92 MHz RF receiver module)-01 nos.	700.00
4	L7805 (Voltage regulator)-02 nos.	25.00
5	16 bit LCD (TM162A) -01 nos.	300.00
6	Capacitor(100 μ f, 35 volt)- 02 nos.	05.00
7	Zener diode (5 volt)- 01 nos, PN diode(1N4007)-01 nos.	05.00
8	Resistors (10k Ω -01 nos, 1k Ω -01 nos, 330 Ω -03 nos.)	05.00
9	Iron core transformer (220v~6v, 300mA)-01 nos.	60.00
10	Breadboards, connecting wire, etc.	50.00
	Total in Tk.	1,850.00

Table: 5.1- Price list of the using components used in the project.

In the response of our country there is no more frequency but 50 Hz. So the device we design is only can measure 50 Hz.

CHAPTER 6

CONCLUSION

Electricity is the most important element of our modern civilization. Wireless Multi meter can play a vital role in power stations, power sub stations, industries and so on. But the main purpose of our designed wireless Multi meter is to understand the functions of every individual component of the circuit and joining of all the parts together. Every portion of the wireless Multi meter was examined individually before completing the joining and after joining the whole circuit, it was examined again. The main attraction of our designed circuit is the simplicity of the circuit, easiness of implementation and the availability of components required in our country.

APPLICATIONS

The Multi meter is one of the most essential Instruments for any power generation system to measure and keep a stable value of voltage, current power and frequency of output line. So, wireless Multi meter can be used widely in power plant and various industries to monitor voltage, current, power and frequency from a distant place. It can also be used at Power plants, sub-stations, Industries or others field where power line voltage, current, power and frequency plays an important role.

FUTURE SCOPE OF WORKS

Every invention has some limitations, so there are also some limitations of our wireless Multi meter. This wireless Multi meter can work in a limited area & limited range only. The Multi meter we designed can measure 250V, 20A and 0-125 KHz signal frequency and up to 150 meter of circulating area from the module. By using high power transmitter & receiver module coverage area can be increased. it cannot measure power factor etc. It has no battery

backup for display unit so it will not show data in case of power failure. We use RF module for data transmission which can receive noise from the surrounding area. In future work there will be some modification in the design to remove those described limitations. It is possible also to measure the power factor. By some modification in the module. Although the size of the designed circuit is not too big, it can be easily integrated into an IC in the near future for commercial purpose.

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4. Hand Book of Electronics, 17th revised edition by GUPTA & KUMAR.
5. Digital Electronics, 5th edition by D.C.GREEN.
6. Digital Circuits and Logic Design, 1st edition by SAMUAL.C.LEE.
7. Electrical power systems, 5th edition by ASFAQ HOSSAIN.
8. Signals and systems, second edition BY SIMON HAYKIN.

Program code for measuring and transmitting section

```
#include <avr/io.h>

#include <avr/pgmspace.h>

#include <util/delay.h>

#include <avr/interrupt.h>

#include "lcd_lib.h"

#include "lcd_lib.c"

#define Hz 1000000lu

#define ICP PINB0

//timer overflow counter

uint8_t ovs=0;

uint32_t T,S;

uint16_t PreviousTime, CurrentTime;

uint8_t buffer[16];

uint8_t calculate=0;

void send_pulse(void);

//timer1 input capture interrupt service routine

ISR(TIMER1_CAPT_vect)

{
```

```

if(calculate==0)

{

TCNT1=0;

calculate=1;

}

else if (calculate==1)

{

calculate=2;

CurrentTime=ICR1;

}

else if(calculate==2)

{

//CurrentTime=ICR1;

//CurrentTime = CurrentTime - (CurrentTime/2);

//T=(uint32_t)CurrentTime;

T=(((uint32_t)CurrentTime)*8); //

T = Hz/T;

//T = (T + (T/2));

//T = T - ((T*3)/100);

```

```

calculate=0;

}

}

int main(void)

{

LCDinit();           //init LCD 8 bit, dual line, cursor right

LCDclr();            //clears LCD

LCDhome();           //cursor home

_delay_ms(2000);

PORTB|=1<<ICP;       //pullup enable

DDRB=0XFF;

DDRC |= (1<<5);

DDRB&=~(1<<ICP);     //ICR1 as input

TCNT1=0;             // start counting from zero

TIMSK|=(1<<TICIE1);  //(1<<TOIE1);//enable input capture interrupts

TCCR1A=0;

TCCR1B|=(1<<CS11);   //start with prescaler 1024, rising edge ICP1

sei();

while(1)             //loop

```

```

{

sprintf(buffer,"V: %04dV,I:%0.2dA");

LCDGotoXY(0,0);

LCDstring(buffer, 16);

sprintf(buffer,"F: %04dHz,P:%0.4dVA");

LCDGotoXY(0,1);

LCDstring(buffer, 16);

_delay_ms(500);

else;

}

return 0;

}

```

Program code for remote display module

```

#include <avr/io.h>
#include <avr/pgmspace.h>
#include <avr/interrupt.h>
#include <util/delay.h>
#include "lcd_lib.c"
#include "UART_routines.c"
unsigned char Rx;
unsigned int intRx;
void sendLCD(unsigned char data);

```

```

ISR (USART_RXC_vect)
{
    sendLCD(receiveByte());
}

void sendLCD(unsigned char data)
{
    if (data==0X0C)                                //Form Feed clr + home
    {
        LCDclr();
        LCDhome();
    }
    else if (data==0X0D) LCDhome();                  //Carriage Return
    else if (data==0X80) LCDGotoXY(0,0);             //Line 1
    else if (data==0X90) LCDGotoXY(0,1);             //Line 2

    else
    {
        LCDsendChar(data);
    }
}

int main(void)
{
    LCDinit(); //init LCD bit, dual line, cursor right
    LCDclr();  //clears LCD
    uart_init(2400);
    sei();
    while(1)
    {
    }
    return 0;
}

```