WIRELESS USER IDENTIFIER

AND AZIMUTHAL LOCATION INDICATOR

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Submitted to Department of Electrical Engineering, Military College of Signals National University of Sciences and Technology, Rawalpindi in partial fulfillment for the requirements of a B.E Degree in Telecom Engineering
June 2013

ABSTRACT

WIRELESS USER IDENTIFIER

AND AZIMUTHAL LOCATION INDICATOR

Location estimating technologies have been gaining importance with the advancement of communication and computing. People are interested in finding out locations of users. Location indicator technologies have traditionally been of interest to the military and intelligence communities. It would be helpful in caring out survey for deploying wireless networks. Moreover this project will help wireless service providers in providing intelligent services to users.

This project can identify the wireless standard of the transmitter (e.g. Wi-Fi) along with its location from some reference point. The azimuthal location will be displayed graphically on visual monitor.

CERTIFICATE OF CORRECTNESS AND APPROVAL

It is certified that the work contained in this thesis titled "Wireless User Identifier And Azimuthal Location Indicator", carried out by Muhammad Ahsen, Faiz Khalid and Muhammad Omer Farooq under the supervision of Asst. Prof. Zeeshan Zahid in partial fulfillment of the Bachelors of Telecommunication Engineering, is correct and approved.

Approved By

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Asst. Prof. Zeeshan Zahid

Project Supervisor

Military College of Signals, NUST

DEDICATION

Almighty Allah,

Faculty for their help

And our parents for their support

ACKNOWLEDGEMENTS

Nothing happens without the will of Allah Almighty. Special thanks to Allah Almighty for giving us knowledge and strength to accomplish this task successfully.

The team likes to thank our project supervisor, Asst. Prof Zeeshan Zahid, without his support and encouragement; it would not have been possible to complete this project.

The group is indebted by the immense help given to us by fellow students especially Rano Mal, Hasan Masood, Talha Arhsed and Imtiaz.

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LIST OF ABBREVIATIONS

RSSI	Received Signal Strength Indicator
TOA	Time of Arrival
HFSS	High Frequency Simulation Software
PIC	Peripheral inline Controller
MHz	Megahertz
RF	Radio Frequency

CHAPTER 1

INTRODUCTION

Computer and exchange of information are pervading in every part of life because they of their empowerment and cheap availability. Products can be made more useful if they are equipped with the ability to measure and reply to the context or situation in which they are being used e.g. user's location.

1.1 Motivation

For deploying wireless communication services in any area, location of users must be known precisely. User requiring extra services and higher data rates, there location must be known.

GPS is a very useful service for identifying the location of wireless user with approximate longitude and latitude but rendered ineffective within building.

Buildings having fire detectors enabled should also have location estimation system. Location of fire sensor should be known which is activated, so that proper action should be taken at proper location with in time.

Location-based services have increased in popularity over recent years. As the availability of equipment at affordable prices increases, more and more consumer goods are being fitted with the means of locating the user. The leading location technology is the Global Positioning System (GPS) which is commonly used to provide real-time directions and traffic information. The mobile phone network is also becoming widely used to provide location information. Service providers have recognized a revenue stream in providing information tailored to the customer's location, such as providing a list of nearby hotels. While these technologies work well outdoors, being able to locate someone within a building is not as easy. GPS cannot be used reliably inside as it requires 'line of sight' to the satellites , and with an accuracy range of 10-100m location using the mobile phone network is not suitable for offices where desk areas can cover as little as 2m. This has led to a lot of research into location technologies which work accurately indoors, such as Microsoft's RADAR and Active Bat from AT&T .These systems, however, do not fit with our requirements for ease of use. For example, RADAR requires a comprehensive Signal Strength map of a building which is time-consuming to create, and

Active Bat needs many ceiling mounted ultrasonic detectors which are expensive to install.

1.2 Problem statement

- For deploying wireless networks and providing intelligent service to users, wireless service providers must know the number of wireless users along with their location.
- This project tackles this problem by utilizing wireless signal receivers along with digital signal processing network to indicate the location and number of wireless users.

1.3 Project Objectives

The main objective of this project is finding the location of Wi-Fi source. Also meeting the requirements of some of its applications such as Indoor GPS enabling, Intelligent Service to users and protection against fire.

1.3.1 Academic Objectives

Study of Location Estimation techniques, antenna theory, antenna simulation software, microwave engineering, integrated circuits and electronics and learning integration of PIC with computer.

1.3.2 Industrial Objectives

- To provide location estimation system within building because GPS rendered ineffective within building.
- To provide a system with directional antenna for provision of intelligent service to user.
- To provide a location estimating system for carrying out survey for service deployment.

1.4 Project Scope

- This project helps in identifying all wireless sources within its range and also helps in tracking a specific wireless source which may be roaming within its range.
- It can be used for surveillance by monitoring the locations of wireless sources. It can be used for localization of wireless sensor node.
- It can also be used for estimating the location of roaming sensor e.g. if fire sensors are installed in building and one of these

sensor is showing the indication of fire but for proper action location of that sensor should also be known.

- Although it is a server based project but it can be enhanced to client as well for enabling GPS within the buildings with the help of wireless routers which are already installed in the buildings.

1.5 Project Limitation

We have chosen trilateration to make our project cost effective but its accuracy is very sensitive to shadow fading. So shadow fading dependent on environment increases the error in our project.

CHAPTER 2

LITERATURE REVIEW

2.1 Basic Wi-Fi signal

Wi-Fi (wireless fidelity) enables an electronic device to communicate using wireless medium (using radio waves) over a network, and provide Internet service within its vicinity. Wi-Fi is a synonym for wireless local area network (WLAN). It can be defined as any "WLAN products that are based on the IEEE 802.11 standards".

Wi-Fi device provide connectivity to network resource which enables internet via wireless network access point. Its range depend on environment i.e. for indoor environment it has a range of 20 meters and for outdoor environment it has a greater range than indoor environment. Radio waves are block by walls and other objects so its range may be as small as single room or its range can be increased to many square miles by using more than one access points.

Wi-Fi has to use encryption algorithms because an intruder can intercept the signal without any physical connection. Different encryption algorithms were adopted and limitations of one algorithm lead to another. First encryption algorithm adopted was WEP but it broke easily which lead to adoption of WPA and WPA2. Test plan and certification program were updated by Wi-Fi Alliance to ensure all newly certified devices resist attacks

In ISM band i.e. 2.4 GHz band there are different channels available and five of them are occupied by a Wi-Fi signal. In these channels some are overlapping channels and some are not e.g. 2 and 7 do not overlap whereas 2 and 3 overlap.

Its output power is also control and limited by regulatory authority's i.e. EIRP in the EU is limited to 20 dB (100 mW).

There are different protocols used such as 802.11n, 802.11a or 802.11g. They have different characteristics 802.11n is the fastest but its bandwidth requirement is double (40 MHz) as compare to bandwidth requirement of 802.11a or 802.11g. 802.11n can be used to avoid interference as it is used in such a way that there is only one 802.11n at a specific location and its bandwidth is reduced to 20 MHz.

2.2 RSSI

RSSI is Received Signal Strength Indicator [5]. It has value ranging between 0-255. Defined by IEEE 802.11. It ensures that RF energy is measured. Every vendor does not ensure to measure 256 different values. Some vendor measure 100 different values and other measures different levels. Different vendors have different maximum RSSI i.e. RSSI_Max. So range of RSSI is from 0 to RSSI_Max. This is a numerical value and has no unit like dBm or mW. It is for an internal use. Transmission channel must detected before transmission that it is free or not. Certain value is associated for indication that channel is free and this is known as clear channel threshold and similarly certain value is used to indicate that channel is busy. When an 802.11 client is associated to an access point and is roaming, there comes a point when the signal level received from the access point drops to a somewhat low value (because the client is moving away from the access point). This level is called the "Roaming Threshold" and some intermediate (but low) RSSI value is associated with it. Different vendors use different signal levels for the Clear Channel Threshold and the Roaming Threshold and, moreover, the RSSI value that represents these thresholds differs from vendor-to-vendor because different vendors have different RSSI_Max values.2.3 Applications

2.3 Location Estimation Techniques

Location estimation technologies have traditionally been of interest to the military and intelligence communities. It would be helpful in caring out survey for deploying wireless networks. For estimating the direction of wireless user two techniques are used i.e. Triangulation and Trilateration.

RF localization is the location (position) calculation of a wireless user. It has numerous application like navigation and tracking, sensor monitoring and numerous other applications which promote research in this field. Global Positioning System uses Geo-stationary satellite for localization and is most useful applications.

Contents of electromagnetic signals which are the source of medium of exchange of information, are very helpful in position computation. There are different electromagnetic techniques based on properties of signals having electromagnetic behavior. Properties of electromagnetic signals that are helpful in localization are time of arrival (TOA), angle of arrival (AOA) and received signal strength indicator (RSSI). These techniques are used individually or in combination like time difference of arrival and angle of arrival are used simultaneously in some techniques.

Techniques of localization are differentiated on the basis of type of information and communication involved. On the basis of type of information used, techniques of localization are classified into range-based and range free techniques. In Range-based techniques information of range is the primary element in localization whereas proximity to known locations are used by range free techniques. TOA, AOA, RSSI, TDOA (Time Difference of Arrival) and also hybrid techniques which are the mixture of the above four employ range-based techniques. For wireless sensor networks range free techniques are used.

Localization techniques can be active or passive depending on the communication. Technique in which communication with neighbor or target is necessary for localization is known as active technique. RADAR is one of the example of active technique where an electromagnetic signal is transmitted and receive the echo signal reflected so that range can be determined. In passive techniques no communication is involved and localization can be done using RF signals of that target present in the air. MUSIC, Matrix Pencil and ESPRIT algorithms employ passive technique which determine the angle of arrival without any communication between receiver and transmitter.

2.4 Triangulation

Triangulation involves measuring angles from fixed point of unknown point to determine its location instead of measuring range to that point.

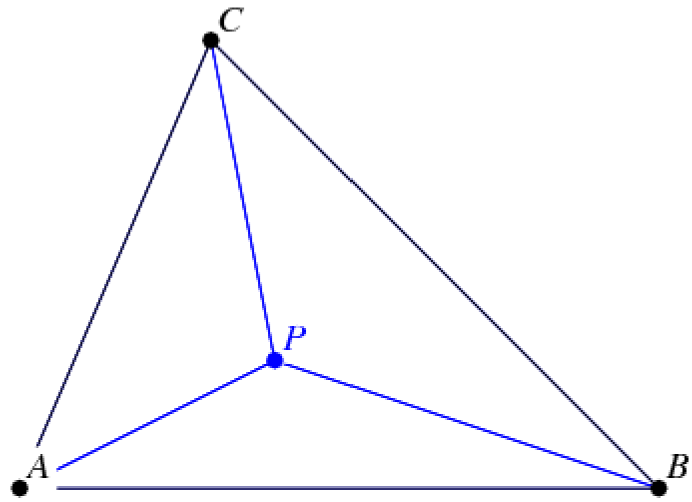

Figure 2. 1 : Triangulation

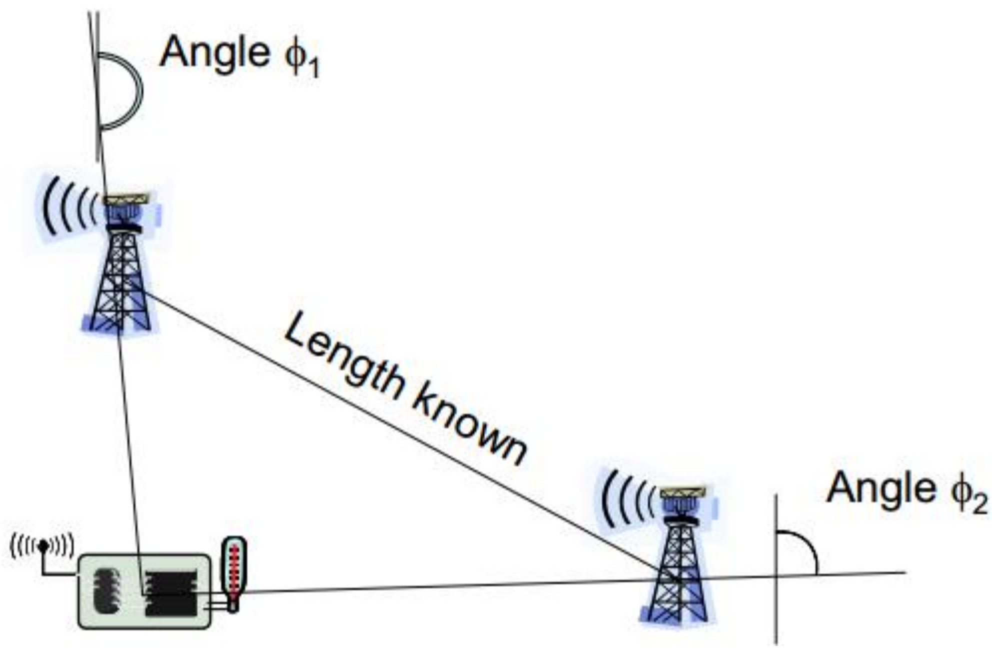

Figure 2. 2: Finding source through triangulation

If location of Point P is to be found out then angle of point P is measured with respect to point A, point B and point C. Their point of intersection is the estimated location of point P. For finding angles of point P with respect to point A, point B and point c different techniques of angle of arrival or direction of arrival are used. Several method are used for DOA[1] estimation.

2.4.1 Correlation

The model is of signals incident on the array, corrupted by noise, i.e.

$$x = \sum_{m=1}^{M} \alpha_m s(\varphi_m) + n$$

The goal therefore is to estimateφ_m, m = 1 . . . M. The easiest way to estimate the angles is through correlation. We know that by the Cauchy-Schwarz inequality, as a function ofφ_m, $s^H(\varphi)s(\varphi_m)$ has a maximum at φ=φm. Therefore, the correlation method plots $P_{corr}(\varphi)$ versus φ where

$$P_{corr}(\varphi) = s^H(\varphi)x$$

$P_{corr}(\varphi)$ is anon-adaptiveestimate of the spectrum of the incoming data. The M largest peaks of this plot $s(\varphi)$ are the estimated directions of arrival.

In the case of linear, equispaced array, the steering vector is equivalent to Fourier coefficients, i.e., the correlation is equivalent to a DFT of the data vector$x$. This technique is optimal (in the maximum likelihood sense) in the single user situation.

2.4.2 Maximum Likelihood

One way of estimating the DOA of an incoming signal is to maximize the likelihood that the signal came from that particular angle. The data model is same as in correlation, focusing on estimating the DOA of single user.

2.4.3 MUSIC (MULtiple Signal Classification)

Estimate the correlation matrix using Eqn. $R = \frac{1}{K}\sum_{k=1}^{K} x_k x_k^H$. Find its Eigen decomposition $R = Q\Lambda Q^H$.

Partition to obtain, corresponding to the (N−M) smallest eigenvalues of Q, which spans the noise subspace.

Plot, as a function of Φ, the MUSIC [1] function $P_{MUSIC}(\Phi) = \frac{1}{s^H(\Phi)Q_nQ_n^H s(\Phi)}$

The M signal directions are the M largest peaks of $P_{MUSIC}(\Phi)$.

2.4.4 ESPRIT

ESPRIT [2] is another parameter estimation technique, based on the fact that in the steering vector, the signal at one element is a constant phase shift from the earlier element.

The steps of ESPRIT are:

Estimate the correlation matrix $R = \frac{1}{K}\sum_{k=1}^{K} x_k x_k^H$. Find its Eigen decomposition$R = Q\Lambda Q^H$.

Partition Q to obtain Qs corresponds to the M largest eigenvalues of Q, which spans the signal subspace.

Using least squares solve Eqn. (71) to obtain an estimate of the M×M matrix Ψ.

Find the eigenvalues of Ψ. Its diagonal elements are the estimates of z_m that we are looking for.

Obtain the DOA using Eqn. $\Phi_m = \cos^{-1}\left[\frac{img \ln(z_m)}{kd}\right]$, m=1 ...M

ESPRIT represents a significantly greater computation load than MUSIC. This is because we need two Eigen decompositions, of the correlation matrix R and the estimated Ψ.

2.4.5 Matrix Pencil

The steps of Matrix Pencil [3] are therefore

Given N and M, choose L to satisfy Eqn. $M \leq L \leq N - L$

Form matrices X0 and X1

Find z_m as the generalized eigenvalues of the matrix pair [X0, X1].

Find the DOA using Eqn. $\Phi_m = \cos^{-1}\left[\frac{img \ln(z_m)}{kd}\right]$, m=1….M

The similarities of Matrix Pencil and ESPRIT are clear. Both algorithms estimate a diagonal matrix whose entries are the poles of the system (z_m). The major difference is that ESPRIT works with the signal subspace as defined by the correlation matrix, while Matrix Pencil works with the data directly. This represents a significant savings in terms of computation load.

2.5 Trilateration

In geometry, trilateration[6] is the process of determining absolute or relative locations of points by measurement of distances, using the geometry of circles, spheres or triangles. In addition to its interest as a geometric problem, trilateration does have practical applications in surveying and navigation, including global positioning systems (GPS). In contrast to triangulation it does not involve the measurement of angles.

In two-dimensional geometry, it is known that if a point lies on two curves such as the boundaries of two circles then the circle centers and the two radii provide sufficient information to narrow the possible locations down to two. Additional information may narrow the possibilities down to one unique location.

In three-dimensional geometry, when it is known that a point lies on three surfaces such as the surfaces of three spheres then the centers of the three spheres along with their radii provide sufficient information to narrow the possible locations down to no more than two. If it is known that the point lies on the surface of a fourth sphere then knowledge of this sphere's center along with its radius is sufficient to determine the one unique location.

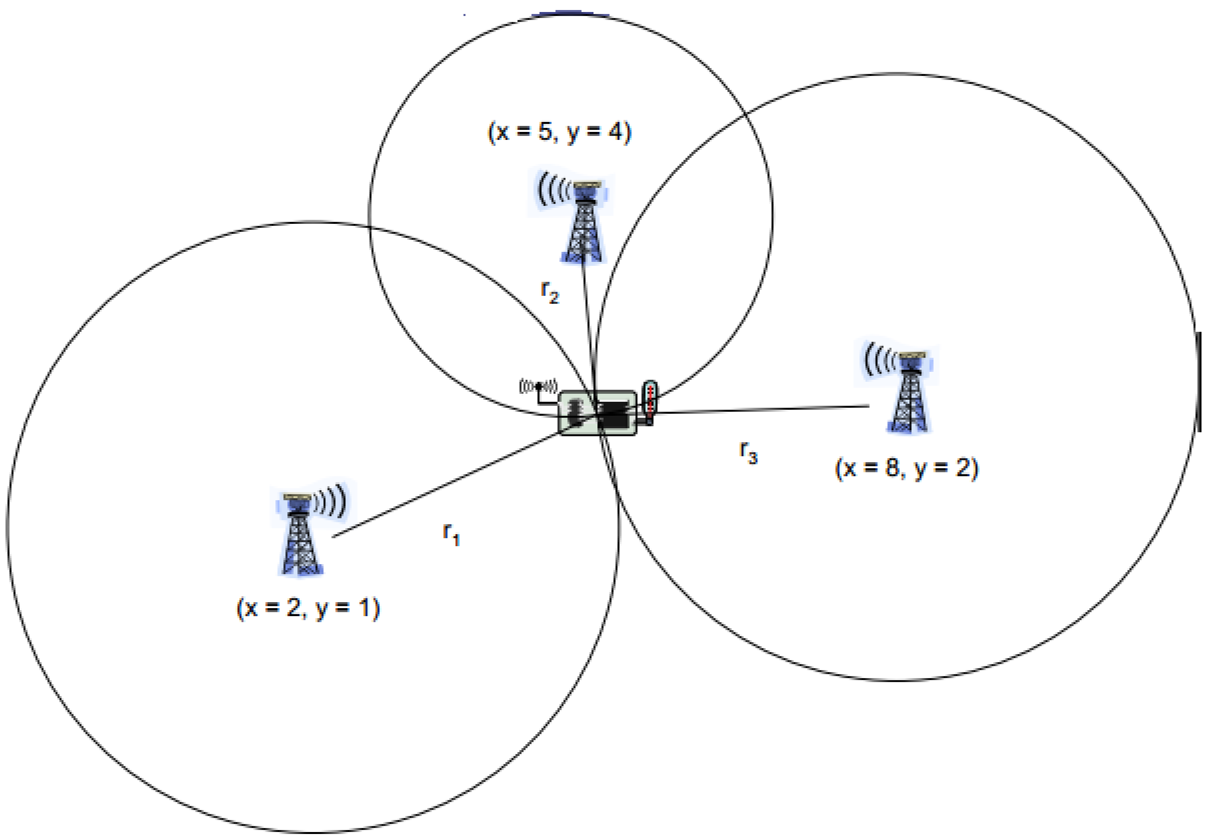

Figure 2. 3: Trilateration

Distance can be estimated using

- **RSSI**

Use received signal strength and path loss coefficient to estimate distance

- **Time of Arrival**

  Use time of transmission, propagation speed, time of arrival to compute distance

  Problem: Exact time synchronization

- **Time Difference of Arriva**

  Use two different signals with different propagation speeds

  Example: ultrasound and radio signal

  Propagation time of radio negligible compared to ultrasound. Compute difference between arrival times to compute distance

  Problem: Calibration, expensive/energy-intensive hardware.

2.5.1 2D Trilateration

In 2D trilateration unknown location of wireless user is found out by the intersection of three circles drawn from known point with radius equal to distance between unknown wireless user and known point.

2.5.2 3D Trilateration

In 3D trilateration unknown location of wireless user is found out by the intersection of three spheres drawn from known point with radius equal to distance between unknown wireless user and known point. It is the same technique used in GPS (Global positioning system).

Since wireless channels suffer from fading so accuracy of range-based techniques is sensitive to variations. Fading affects different properties of received signal differently. Different parameters of signals are affected by shadow fading. Range based techniques e.g. RSSI based are most sensitive variations in shadow fading whereas direction of arrival techniques like TOA and AOA based are sensitive to variation in multipath fading. Therefore, one has to maintain caution while choosing the wireless channel models, for obtaining better range estimates.

Range based techniques require signal strength of received signal which is then converted to approximate range based on path loss and propagation constant of environment. Range free techniques also require signal strength to be measured but its main requirement direction of arrival or time difference of arrival. Range based technique also require receiver and transmitter to be synchronized for calculation of time of flight (TOF) or propagation time. Beam-forming is used to steer the antenna beam which can be mechanical or electrical and is used to determine direction of arrival by measuring signal strength from all directions and then indicate the direction with highest signal strength. It can be deduced that in range based techniques RSSI has minimum requirements and is passive technique whereas time difference of arrival require synchronization of receiver and transmitter for TOF calculation. AOA based techniques is also a passive technique but it require complex circuitry at increased cost which can extract baseband signal for computation of direction of arrival. Apart from the above mentioned reasons, RSSI information is readily available from off-the-shelf receivers (e.g. Wi-Fi receivers), making it feasible to apply this technique. This motivates us to adopt localization based on RSSI. RSSI based techniques of localization uses signal strength indicator received for two reasons (a) to approximate the distance so that Trilateration can be applied and (b) to generate signatures/fingerprints. In the first case, RSSI is used to calculate range based on path loss model. Then trilateration is applied for estimating the location. This technique is sensitive to shadow fading and multipath and but its accuracy largely depend on this factor. Eco location in , makes use of distance constraints based on RSSI and develop sequences to determine the relative position of transmitter with respect to known reference stations but it require heavy computations on large sum of data. Trilateration is preferred over the signature based technique as it does not require creation of database

For providing intelligent service we need direction antenna with mechanical beam forming. So that service could only be provided to desired wireless user and nobody else knows about it.

2.6 Antenna Theory

For the indication of intelligent service to users a directional antenna is designed.

2.6.1 Directional Antenna

A directional antenna or beam antenna is an antenna which radiates greater power in one or more directions allowing for increased performance on transmit and receive and reduced interference from unwanted sources.

Some important directional antennas are:

- Yagi-Uda antenna
- Dipole antenna
- Horn antenna
- Microstrip Patch antenna

The most useful is patch antenna.

2.6.1.1 Rectangular Patch Antenna

Recently, there has been a growing demand of microwave, and wireless communication systems in various applications resulting in an interest to improve antenna performances. Modern communication systems and instruments such as Wireless local area networks (WLAN), mobile handsets require lightweight, small size and low cost. The selection of microstrip antenna technology can fulfill these requirements. WLAN in the 2.4 GHz band 2.4-2.483 GHz) has made rapid progress and several IEEE standards are available namely 802.11a, b, g and j.

A microstrip patch antenna is very simple in construction using a conventional microstrip fabrication technique. Microstrip antennas consist of a patch of metallization on a grounded dielectric substrate. They are low profile, lightweight antennas, most suitable for aerospace and mobile applications.

2.6.1.2 Rectangular Patch Array

In certain applications, desired antenna characteristics may be achieved with a single microstrip element. However, as in the case of conventional microwave antenna, characteristics such as high gain, beam scanning, or steering capability are possible only when discrete radiators are combined to form arrays. The elements of an array may be spatially distributed to form a linear, planar, or volume array. A linear array consists of elements located finite distances apart along a straight line. In practice, the array type is usually chosen depending on the intended application.

2.6.1.3 Power Divider

Power divider is passive device used in the field of radio technology. It couples a defined amount of the electromagnetic power in a transmission line to a port enabling the signal to be used in another circuit. An essential feature of directional couplers is that they only couple power flowing in one direction. Power entering the output port is coupled to the isolated port but not to the coupled port.

Wilkinson Power Divider is a specific class of power divider circuit that can achieve isolation between the output ports while maintaining a matched condition on all ports. The Wilkinson design can also be used as a power combiner because it is made up of passive components and hence reciprocal.

2.6.2 Mechanical Beam Forming

Beam forming is used to steer the beam of antenna. It could be used to avoid interference or to provide special coverage to specific user or to track some user. It can done mechanically or electronically. In mechanical beam forming some kind of motor assembly is used to rotate antenna. In electronic beam forming main lobe of antenna is moved without moving antenna. Using electronic beam forming the maximum shift of main lobe from center of antenna is 45° on either and on the other hand main lobe can be shifted to any angle within the 360° using mechanical beam forming. So mechanical beam forming is used.

2.6.2.1 Stepper Motor

For mechanical beam forming motor is required. Stepper motor is a motor which rotates through certain angle step. So stepper motor cannot move to every angle within the 360° unless step angle is 1°. Rotation of stepper motor would be discrete.

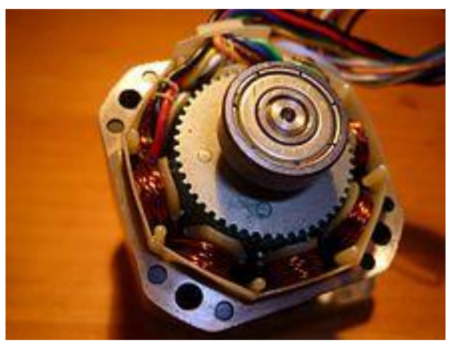

Figure 2. 4: Stepper Motor

2.6.2.2 PIC 18F452

Microcontroller has a processor, memory and programmable input/output peripherals and it can be programmed according to specific requirements. It has four ports for input and output and each port has seven pins. A crystal oscillator is attached for clock. Its code can be compiled in c language and a hex file is created which is burned on this microcontroller. It is a type of computer on small integrated chip. Its pin are shown in diagrams. It has numerous general purpose input/output pins.

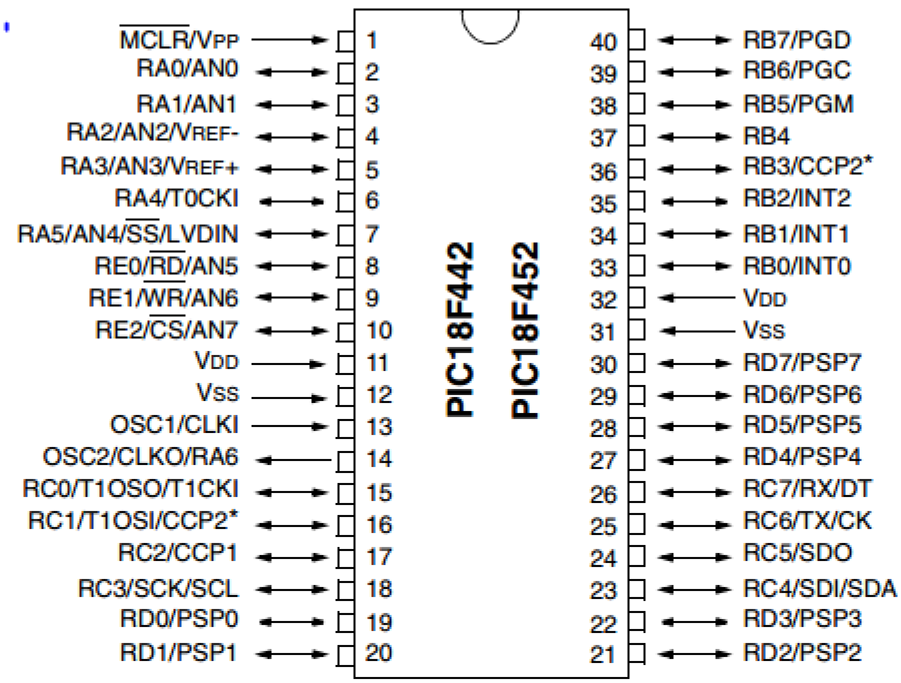

Figure 2. 5: PIC 18F452 pin diagram

2.6.2.3 L293D

L293d is motor driver used to provide the required current for proper working of motor. Stepper motor required digital sequence for its rotation and this sequence is provided by microcontroller but it does not fulfill the requirement of current needed by motor for rotation. So step sequence from microcontroller is fed into L293D and it output the same sequence but with increased current.

2.6.2.4 Serial Communication

Microcontroller also supports serial communication through serial port of computer. It has two specific pins for serial input and serial output. This allows us to control the rotation of motor automatically after localization

CHAPTER 3

PROJECT DESIGN

3.1 Block Diagram

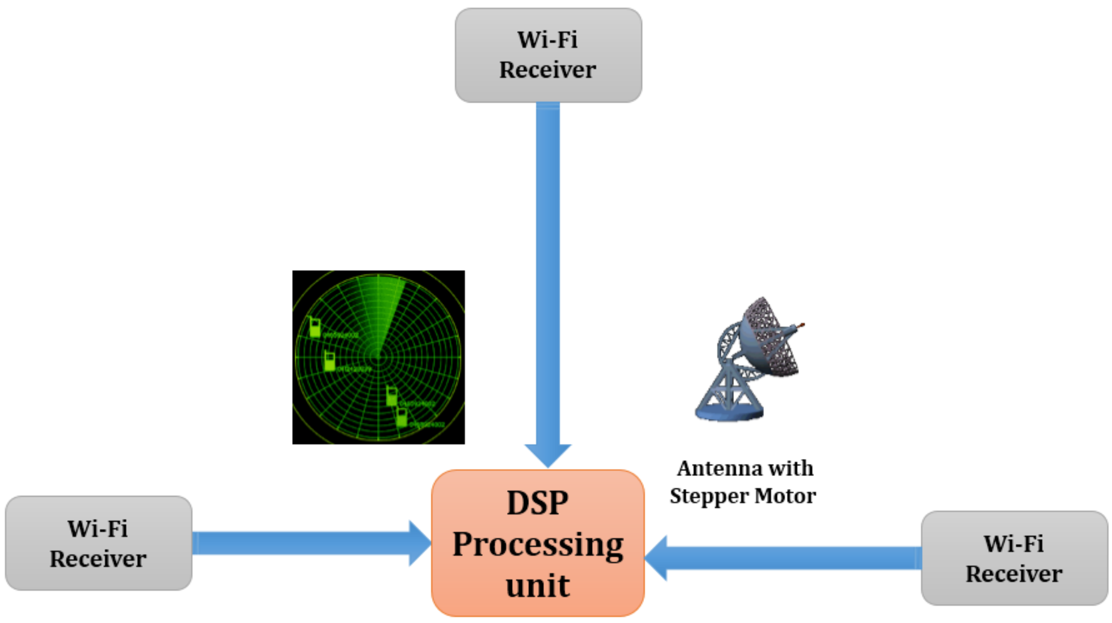

Figure 3. 1 : Block Diagram Of the Proposed Design

3.1.1 Wi-Fi Receivers

Wi-Fi receivers are used to receive the signals and decode them according to the source i.e. separate the signals of different Wi-Fi source which is used to identify the wireless user and it measures the RSSI of each signal. Then RSSI of desired source is collected from Wi-Fi receivers by DSP processing unit.

3.1.2 DSP Processing Unit

In DSP processing unit range based location estimating techniques are applied on RSSI of desired source to estimate the location of source. RSSI is converted to approximate distance after applying path loss model and then trilateration is applied to estimate the unknown location of Wi-Fi source using these distances.

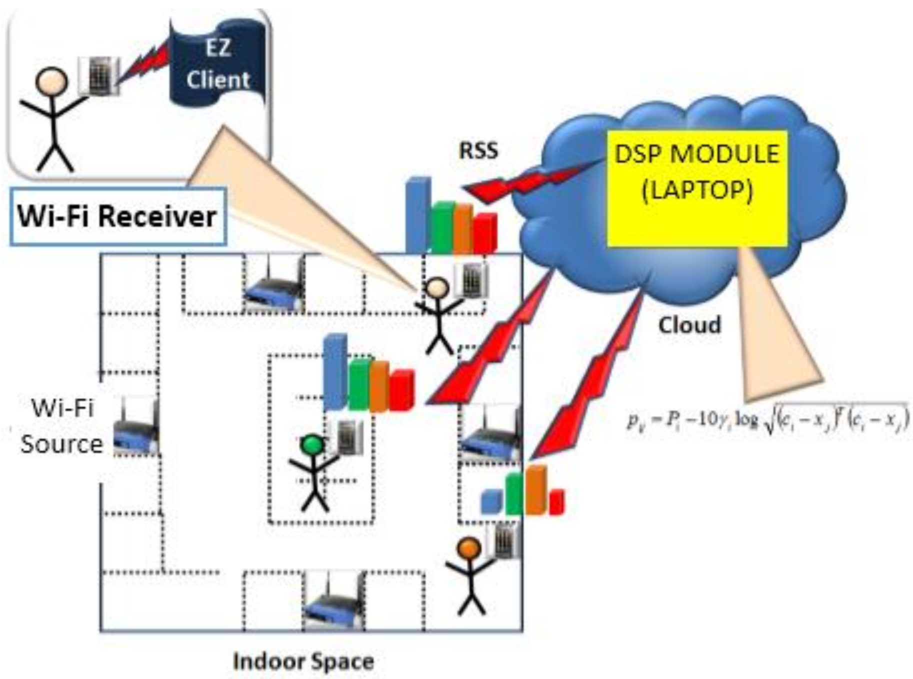

Figure 3. 2: Indoor based localization

3.1.3 Visual Monitor

After applying passive localization technique, estimated direction is displayed on visual monitor from some reference point. Both abscissa and ordinate are shown with respect to some reference point.

3.1.4 Directional Antenna With Mechanical Beam Forming

The angle, which is calculated by DSP Module, is fed to microcontroller via serial port. Microcontroller rotate stepper motor to that angle, as antenna is mounted on the motor so by rotating the motor mechanical beam forming is achieved.

3.2 Design Approach

We started with Wi-Fi receivers and to access these Wi-Fi receivers was a great task to accomplish. Then after accessing RSSI from Wi-Fi receivers we started working on trilateration technique. For directional antenna we choose rectangular patch antenna with power divider network to supply power from one source. Then to rotate this directional antenna we choose stepper motor.

CHAPTER 4

Wi-Fi Receivers

Wi-Fi receiver is the device which is used to receive ISM band signals and provide connectivity to access point for internet service or network connectivity. Wi-Fi receivers are used to receive the signals and decode them according to the source i.e. separate the signals of different Wi-Fi source which is used to identify the wireless user and it measures the RSSI of each signal. It is also used to exchange information after connection between transmitter and receiver is ensured. But to implement RSSI based technique connectivity between receiver and transmitter is not required. Then RSSI of desired source is collected from Wi-Fi receivers by DSP processing unit. Three Wi-Fi USB adaptors are used as receivers placed at known points. These are equipped with omnidirectional antenna which can receive the signal from all direction. These adaptors can calculate the RSSI. To access the RSSI of SSID (Wi-Fi source) in numerical format we use visual studio.

TL-WN722N are used as Wi-Fi receivers. These are equipped with detachable antenna. It is connected to laptop through USB port. Mostly software's show RSSI of each SSID (Service Set Identification) but to access this in numerical format is quite challenging and it cannot be done using simple wireless utility software. To solve this problem we have used visual studio to access these wifi receivers and capture SSID (Service Set Identification) along with RSSI of each receiving signal.

4.1 Visual Studio

Visual Studio can access almost all the devices of the computer. It is a very versatile software. It support different libraries. It is a very useful tool for accessing computer's devices and computer device's data. It support C language, C# language. We used C# as a mode of language. Using this software we have access wireless adaptor connected through USB port of computer to measure RSSI along with SSID. We do not have to run this software again and again because an exe file is created once code is debug. To access wireless receivers exe file is to run and not the whole software which reduces computation for laptop. Normally one wireless adaptor is connected to laptop and it can be accessed using above technique but what happens when multiple USB adaptors are connected to single computer and how to differentiate between them. This problem is solved by using the number assigned to each Wi-Fi receiver. Wi-Fi receiver attached first is assigned ‘0’ number, next Wi-Fi receiver is assigned ‘1’ number and so on. So to access first USB adaptor ‘0’ argument is used and ‘1’ for next USB adaptor. Visual Studio code is in appendix A

4.2 Integration of Visual Studio With MATLAB

Main processing of signal is done in MATLAB and RSSI information along with SSID should be accessed in MATLAB. Since using visual studio an exe file is created which can be run independently and this exe file can be accessed from MATLAM to access RSSI information along with SSID. This allows us to integrate two software’s data. RSSI is accessed through visual studio and then this information is passed to MATLAB for further processing. Command which is used to access exe file is as follows

System (‘wifi 0’)

Wifi: name of exe file

0: argument for accessing first wireless receiver.

Its output contain SSID (Service Set Identification) along with RSSI which can be converted to numerical format for further manipulation.

CHAPTER 5

DSP PROCESSING UNIT

After receiving the desire's signal RSSI range based estimation technique i.e. Trilateration has to be applied to determine the location of target. And this algorithm is applied in digital signal processing unit. Digital Signal processing unit is the heart of this project. Its function are as follows

- Convert RSSI to approximate distance using path loss model and propagation constant. These are the input to trilateration.
- Three distances calculated from known location are used as a main part of location estimating technique.

5.1 RSSI To Distance Model

Suppose in a region there are 3 nodes (nodes of known location). Coordinates are (x_1, y_1), (x_2, y_2) and (x_3, y_3). These nodes receive signal of desired user with different intensity depending on the distance between the user and the node. Based on these signal strength distance between each node and user is approximated after applying path loss model. As the distance between user and node increases signal strength decreases. It means RSSI and distance are directly proportional but RSSI also depends on propagation environment (whether indoor or outdoor). Indoor and outdoor environment have different propagation constant. Signal strength is also dependent shadow fading. User is located at the circumference of circle formed by an approximate distance calculated using respective RSSI from each node. To find the exact location of target point of intersection of these circles is to be found out.

The commonly accepted transmission model expresses the received power pi [4] (in dBm) as

$p_i = p_o + n10\log(r_i/r_o)$

p_i is received power in dBm from distance r_i

p_o is received power in dBm at a reference distance r_o

n is the path loss exponent which is a constant depending on the transmission medium (indoors, outdoors) and ranges typically from 2 to 4.

5.2 2D Trilateration

Basic function of DSP module is to estimate the distance of Wi-Fi source and then estimate the location in terms of coordinates from reference point. , Using the geometry of circles, spheres or triangles location of target point is determined by measuring distances. This process is known as trilateration.

In 2D trilateration[7] unknown location of wireless user is found out by the intersection of three circles drawn from known point with radius equal to distance between unknown wireless user and known point.

- Three Wi-Fi receivers are placed at three known points and used to calculate the RSSI of Wi-Fi source placed at unknown location.
- Distances (d_1,d_2,d_3) are measured by an RSSI signal (r_1, r_2, r_3).
- Distances (d_1,d_2,d_3) are the radius of three circles that could be drawn on three known points of Wi-Fi receivers respectively.
- These circles intersect at one point which is probable location of Wi-Fi source.

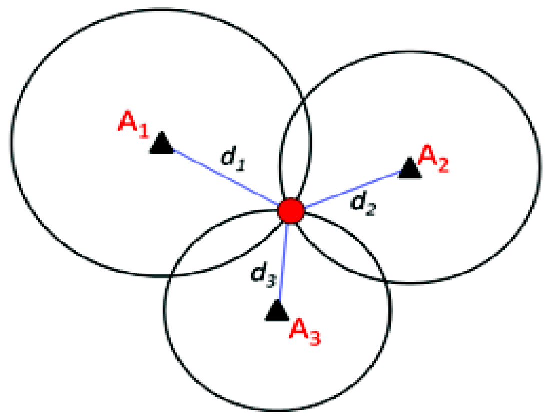

Figure 5. 1: 2D trilateration

5.2.1 Algorithm

- Suppose location of three known Wi-Fi receivers is (x_1, y_1), (x_2, y_2), (x_3, y_3).
- d_1, d_2, d_3 are the distances calculated using RSSI from Wi-Fi source respectively.
- d_1 is the radius of circle centered at (x_1, y_1).
- d_2 is the radius of circle centered at (x_2, y_2).
- d_3 is the radius of circle centered at (x_3, y_3).
- These circles intersect at one point which is the location of user having unknown location.

- The location for the unknown tag can be found by solving the following system of quadratic equations:
- $(x - x_1)^2 + (y - y_1)^2 = d_1^2$
- $(x - x_2)^2 + (y - y_2)^2 = d_2^2$
- $(x - x_3)^2 + (y - y_3)^2 = d_3^2$
- Solving these equations we find the x and y which are the coordinate of estimated Wi-Fi source.
- $X = \frac{\begin{vmatrix} (d_1^2 - d_2^2) - (x_1^2 - x_2^2) - (y_1^2 - y_2^2) & 2(y_2 - y_1) \\ (d_1^2 - d_3^2) - (x_1^2 - x_3^2) - (y_1^2 - y_3^2) & 2(y_3 - y_1) \end{vmatrix}}{\begin{vmatrix} 2(x_2 - x_1) & 2(y_2 - y_1) \\ 2(x_3 - x_1) & 2(y_3 - y_1) \end{vmatrix}}$
- $Y = \frac{\begin{vmatrix} 2(x_2 - x_1) & (d_1^2 - d_2^2) - (x_1^2 - x_2^2) - (y_1^2 - y_2^2) \\ 2(x_3 - x_1) & (d_1^2 - d_3^2) - (x_1^2 - x_3^2) - (y_1^2 - y_3^2) \end{vmatrix}}{\begin{vmatrix} 2(x_2 - x_1) & 2(y_2 - y_1) \\ 2(x_3 - x_1) & 2(y_3 - y_1) \end{vmatrix}}$

Trilateration code is in appendix B

CHAPTER 6

DIRECTIONAL ANTENNA

A directional antenna or beam antenna is an antenna which radiates greater power in one or more directions allowing for increased performance on transmit and receive and reduced interference from unwanted sources.

The purpose of direction antenna is the indication of providing intelligent services to users.

6.1 Single Rectangular Patch

Microstrip or patch antennas are becoming increasingly useful because they can be printed directly onto a circuit board. Microstrip antennas are becoming very widespread within the mobile phone market. Patch antennas are low cost, have a low profile and are easily fabricated.

Consider the microstrip antenna shown in Figure 1, fed by a microstrip transmission line. The patch antenna, microstrip transmission line and ground plane are made of high conductivity metal (typically copper). The patch is of length L, width W, and sitting on top of a substrate of thickness h with permittivity ϵ_{γ}

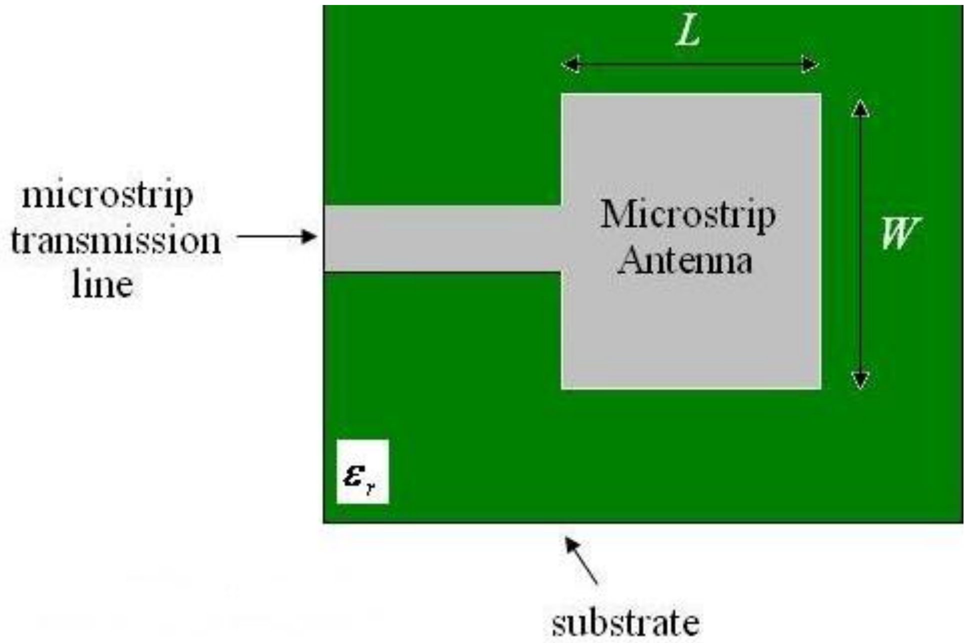

Figure 6. 1: patch antenna

- Length and width depends upon the ϵ_γ (substrate).our designed values are:
- FR4 substrate
    - $\epsilon_\gamma = 4.4$
    - h= 1.6 mm
- f_r=2.4 GHz
- Patch Dimensions
    - Width= 38.036 mm
    - Length= 29.44 mm

➢ Feed line Dimensions

- Width= 3.059 mm
- Length = 17.124 mm

6.2 Rectangular Patch Array

We choose linear array for our design because of its less complexity and ease in fabrication.

For linear array we placed 4 radiators at a distance of $\frac{\lambda}{2} = 62.5$ mm

We designed this antenna by using software tool HSFF.

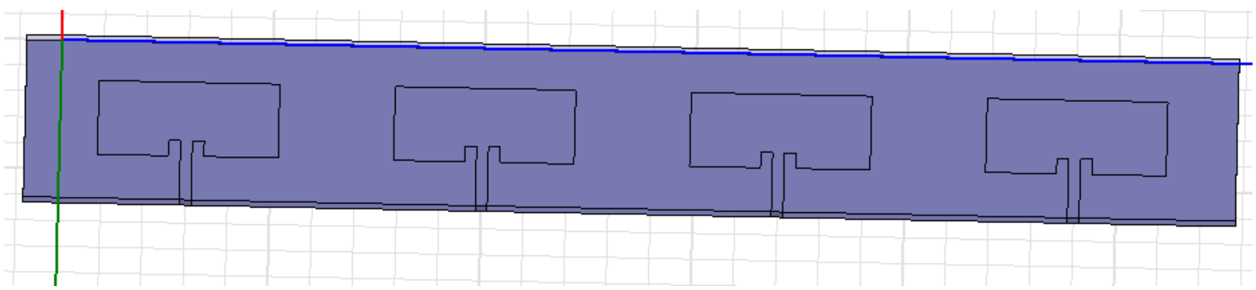

Figure 6. 2: HFSS layout of patch array

Gain and reflection coefficients results of array on HFSS

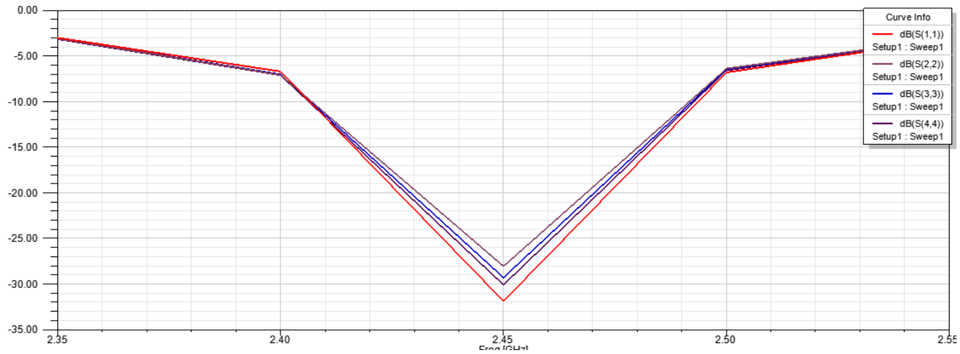

Figure 6. 3: Refelection coeeficients of antenna array

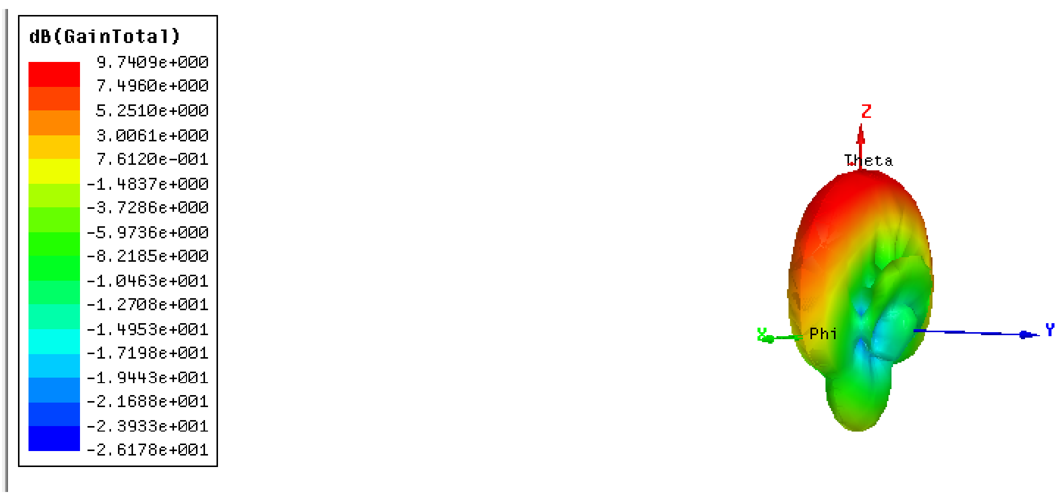

Figure 6. 4: HFSS 3D gain plot of array

6.3 Power Divider

We found Wilkinson power divider is suitable for our design. HFSS diagram of power deign is

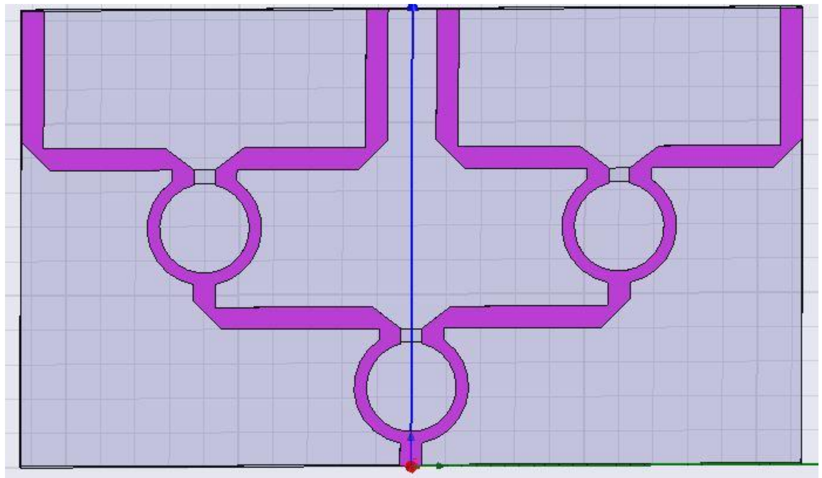

Figure 6. 5: Wilkison power divider design

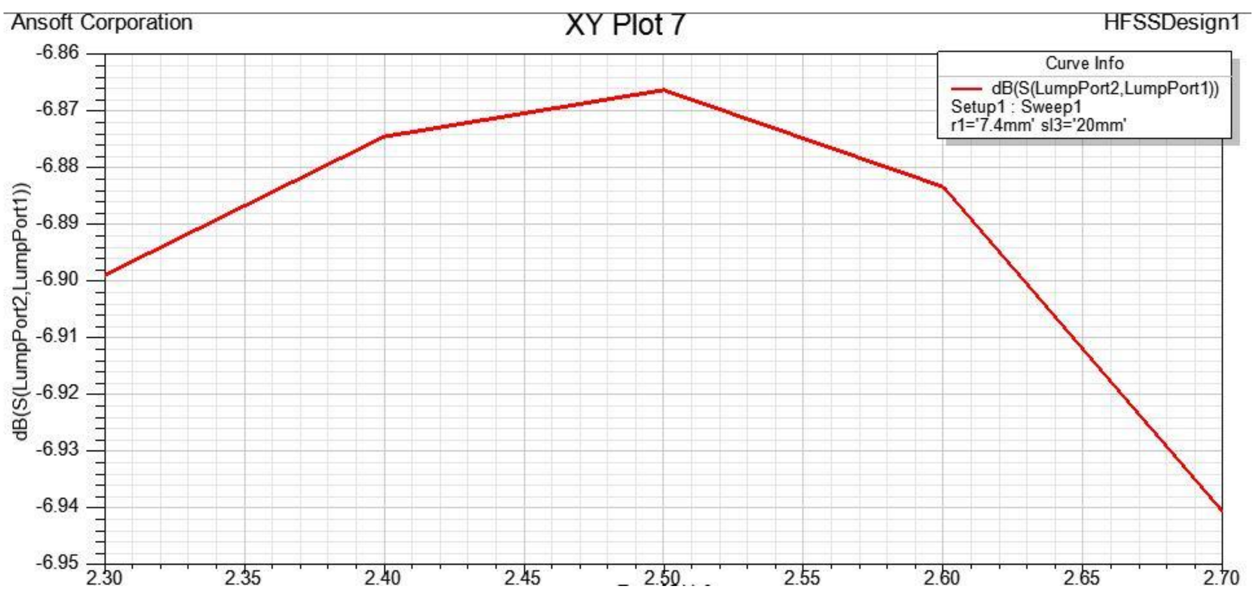

Figure 6. 6: Wilkinson scattering parameter

6.4 Stepper Motor Controller

It is an assembly used to rotate the patch antenna with the help of stepper motor. Stepper motor is controlled through microcontroller which provide the required sequence used to rotate the motor.

6.4.1 Bipolar Stepper Motor

Stepper motor converts electric pulses into Mechanical rotation. Minimum angle at which motor will rotate with application of single electric pulse is called step angle.

The Bipolar Stepper motor has 2 coils. The coils are identical and are not electrically connected. And a magnet is placed between these coils.

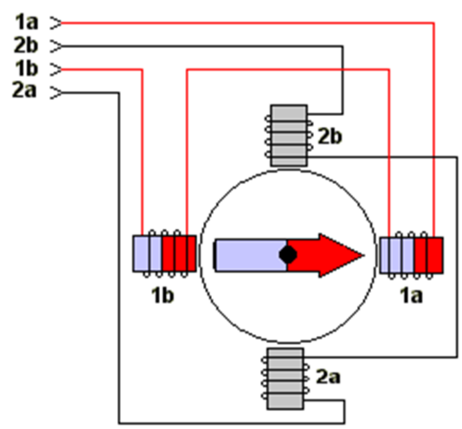

Figure 6. 7: bipolar stepper motor

To rotate motor:

Wire 1 is activated in rightward direction.

Wire 2 is activated in downward Direction.

Wire 1 is activated in leftward direction.

Wire 2 is activated in upward direction.

If both coils are on motor will not move

From we conclude following step sequence:

Step	1a	1b	2a	2b
0	1	0	0	0
1	0	0	1	0
2	0	1	0	0
3	0	0	0	1

So at the four input terminals of bipolar stepper motor we need to provide above step. Step sequence logic will be provided by Microcontroller.

Since beamwidth of antenna is 22.5° so we rotate antenna in 16 steps to cover 360°. In each step angle of arrival is calculated from range [-90,0]u[0,90]. To move antenna to one of the 16 steps irrespective of its previous position, 4 bit unique pattern is fed to the microcontroller and microcontroller provide proper step sequence.

6.4.2 L293D

Microcontroller can provide the logic but microcontroller does not provide enough current to drive motor. L293D provide amplified current to motor. It outputs the same input as it is provided but voltage and current are amplified to the required level.

6.4.3 Microcontroller PIC 18F452

Microcontroller is used to output Step Sequence. This Step Sequence is first delivered to L293D. L293D then gives the amplified Step Sequence to Bipolar Stepper Motor.

- Port D is used to output step sequence i.e. input to L293D
- Port C is used to control the angle i.e. manual switching.
- Port B controls LCD output which displays angle of rotation.

It is also controlled through serial port for automatic control. The step sequence is given to microcontroller by computer via serial port. This sequence is generated as a result in calculation of angle of Wi-Fi user, then motor is rotated to that angle. PIC code is given in Appendix C.

6.4.4 Simulation Results

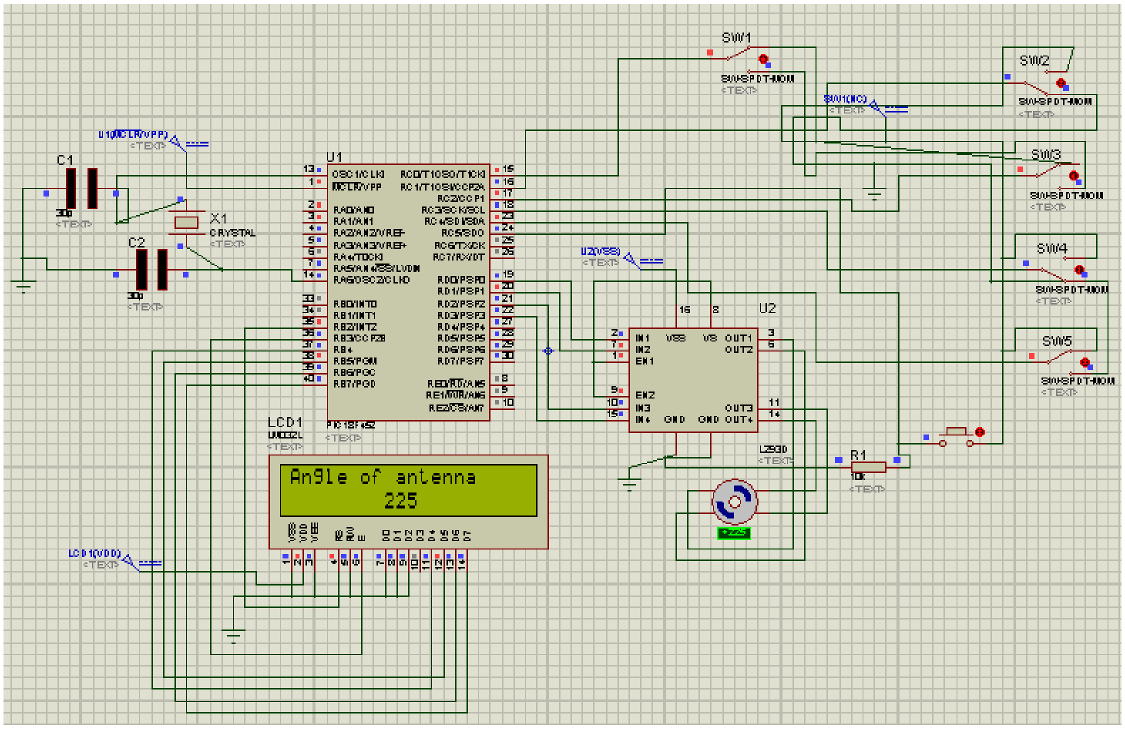

Figure 6. 8: proteus simulation result

CHAPTER 7

HARDWARE IMPLEMENTATION AND RESULTS

Three Wi-Fi receiver TL-WN722N placed at (0, 0), (10, 10) and (20, 0) attached with DSP processing Unit (Laptop). In DSP VS is used to access and measure RSSI of required Wi-Fi source from each receiver and then signal processing technique is applied to estimate the location with reference. This calculated angle is then communicated to stepper motor controller through serial communication and then directional antenna is rotated in the desired direction with the help of stepper motor.

7.1 Practical Result

- Wi-Fi receivers placed at (0,0),(10,10),(20,0)
- Source placed at (12,2.5)
- Calculated coordinates are (12.1,4.9)

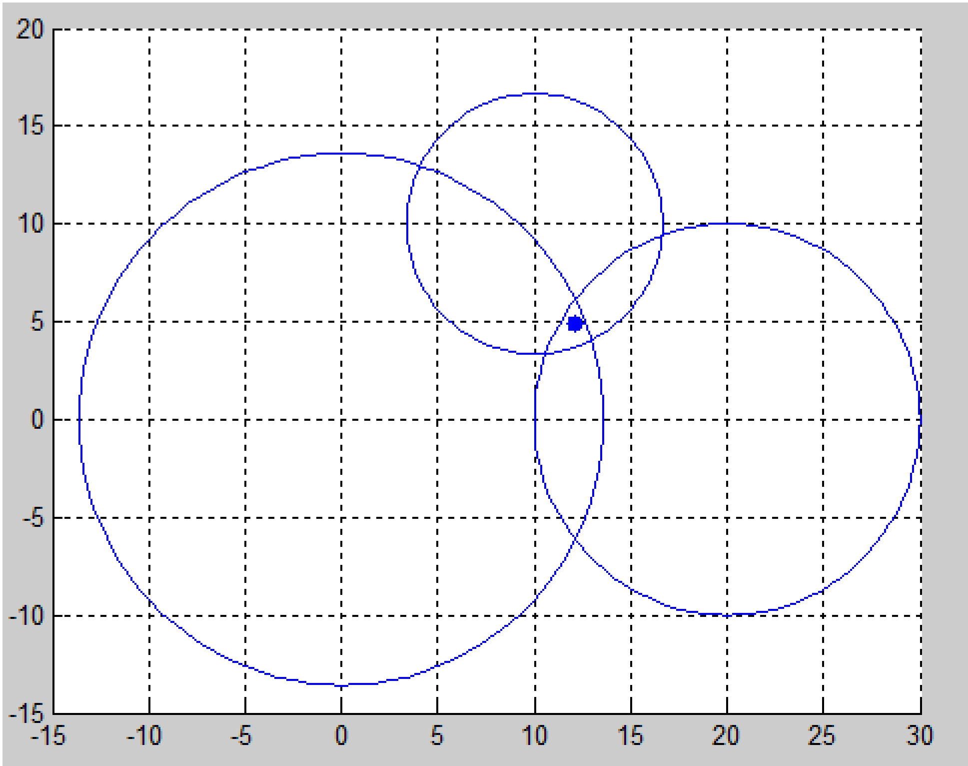

Figure 7. 1: wi-fi source location practical result

When source is within the range of 20 meters, a number tests have been performed and its result is shown in following table along with the actual location and estimated location.

WITHIN 20M RANGE		
WIRELESS SOURCE ACTUAL LOCATION (M)	ESTIMATED LOCATION (M)	ERROR (M)
(12,5)	(13,4)	(1,-1)
(3,4)	(4,5.5)	(1,1.5)
(9,8)	(10,10)	(1,2)
(13,0)	(13,-1)	(0,-1)

Table 7. 1: Estimated Results within 20m Range

Same test have been performed but location of source is changed and is placed whitin 30 meters range.

WITHIN 30 M RANGE		
WIRELESS SOURCE ACTUAL LOCATION (M)	ESTIMATED RESULTS (M)	ERROR (M)
(24,10)	(27,8)	(3,-2)
(3,24)	(5,20)	(2,-4)
(10,28)	(9,31)	(-1,3)
(25,0)	(28,-2)	(3,-2)

Table 7. 2: Estimated Results within 30m Range

Error in the estimated result can be reduced by taking multiple samples and averaging them.

WIRELESS SOURCE ACTUAL LOCATION	ESTIMATED LOCATION WITH 1 SAMPLE	NO. OF SAMPLE 'N'	ESTIMATED LOCATION WITH N SAMPLES	ERROR AFTER MULTIPLE SAMPLES
(12,5)	(13,4)	10	(12.8,4.1)	(0.8,0.9)
(3,4)	(4,5.5)	12	(4.1,5)	(1.1,1)
(9,8)	(10,10)	15	(8.5,9)	(.5,1)
(13,0)	(13,-1)	18	(12.5,-0.5)	(0.5,-0.5)

Table 7. 3: Estimated Results With Multiple Samples

Code of visual studio for Accessing USB Wireless Adaptor

```
using NativeWifi;
using System;
using System.Text;
using System.Collections.Generic;
namespace WifiExample
{
    class Program
    {
        /// <summary>
        /// Converts a 802.11 SSID to a string.
        /// </summary>
        public Dictionary<string, int> Dict;
        Program()
        {
            Dict = new Dictionary<string, int>();
        }
        static string GetStringForSSID(Wlan.Dot11Ssid ssid)
        {
```

```
            return Encoding.ASCII.GetString(ssid.SSID, 0,
(int)ssid.SSIDLength);
        }
        static void Main(string[] args)              // main program
        {
            Program p = new Program();
            int arg1 = Int32.Parse(args[0]);
            p.GetWIFI_Dict(arg1);                // dictionary is accessed
            p.Test();
        }
        void Test()
        {
            foreach (var P in Dict)
            {
                Console.WriteLine(P.Key + " " + P.Value+",");
            }
        }
        /*Returns SSIDs of with an Interface Parameter*/
        void GetWIFI_Dict(int Interface)
        {
            WlanClient client = new WlanClient();
```

```
            WlanClient.WlanInterface wlanIface =
client.Interfaces[Interface];
            Wlan.WlanAvailableNetwork[] networks =
wlanIface.GetAvailableNetworkList(0);
            int i = 0;
            foreach (Wlan.WlanAvailableNetwork network in networks)
            {
              if (!Dict.ContainsKey(GetStringForSSID(network.dot11Ssid))
Dict.Add(GetStringForSSID(network.dot11Ssid),(int)network.wlanSign
alQuality);             // storing SSID along with RSSI

                i++;

                }



        }



    }
```

Appendix B

Code of MATLAB for Trilateration

Main function for identifying and locating wireless user

```
function final()

[aaa,inpt]=system('Wifi 0')

var=find(inpt==',');

noofssids=length(var);

j=1;

f=noofssids;

ssid1=0;

ssid2=0;

ssid3=0;

ssid4=0;

ssid5=0;

if(inpt(var(1)-3)==1)

    ssid1=inpt(j:var(1)-4)

    rssi1=inpt(var(1)-3:var(1)-1);

else

    ssid1=inpt(j:var(1)-3);

   rssi1=inpt(var(1)-2:var(1)-1);

end
```

```
f=f-1;
j=var(1)+2;
if(f>0)
if(inpt(var(2)-3)==1)
    ssid2=inpt(j:var(2)-4)
    rssi2=inpt(var(2)-3:var(2)-1);
else
    ssid2=inpt(j:var(2)-3)
   rssi2=inpt(var(2)-2:var(2)-1);
end
j=var(2)+2;
f=f-1;
if(f>0)
if(inpt(var(3)-3)==1)
    ssid3=inpt(j:var(3)-4);
    rssi3=inpt(var(3)-3:var(3)-1);
else
    ssid3=inpt(j:var(3)-3)
   rssi3=inpt(var(3)-2:var(3)-1);
end
j=var(3)+1;
f=f-1;
```

```
if(f>0)
if(inpt(var(4)-3)==1)
    ssid4=inpt(j:var(4)-4);
    rssi4=inpt(var(4)-3:var(4)-1);
else
    ssid4=inpt(j:var(4)-3)
   rssi4=inpt(var(4)-2:var(4)-1)
end
j=var(4)+2;
f=f-1;
if(f>0)
if(inpt(var(5)-3)==1)
    ssid5=inpt(j:var(5)-4);
    rssi5=inpt(var(5)-3:var(5)-1);
else
    ssid5=inpt(j:var(5)-3);
   rssi5=inpt(var(5)-2:var(5)-1);
end
j=var(5)+1;
end
end
end
```

```
end
fprintf('1. %s\n2. %s \n3. %s \n4. %s \n5.
%s',ssid1,ssid2,ssid3,ssid4,ssid5)
key=input('enter no.')
switch key
  case 1
    ss=ssid1;
  case 2
    ss=ssid2;
  case 3
    ss=ssid3;
  case 4
    ss=ssid4;
  case 5
    ss=ssid5;
end
rr1=samplerssi(ss);
rr2=samplerssi2(ss);
rr3=samplerssi3(ss);
lx=10; ly=0;     // location of Laptop
r1=-50-(100-rr1)/2;
r2=-50-(100-rr2)/2;
```

```
r3=-50-(100-rr3)/2;
p=-58;    % 10
p2=-66 ;       % 13
n=4.5;
%n=(p2-p1)/(10*log10(13/10))
d1=10*10^((p-r1)/(10*n))
x1=0;y1=0;
circle(x1,y1,d1);
hold on
d2=10*10^((p-r2)/(10*n))
x2=10;y2=10;
circle(x2,y2,d2);
hold on
d3=10*10^((p-r3)/(10*n))
x3=20;y3=0;
circle(20,0,d3);
A=2*[x3-x1 y3-y1;x3-x2 y3-y2];
B=[(d1^2-d3^2)-(x1^2-x3^2)-(y1^2-y3^2);(d2^2-d3^2)-(x2^2-
x3^2)-(y2^2-y3^2)];
X=A\B
xu=X(1); yu=X(2);
    x=xu-lx;    y=yu-ly;
```

```
theta=atand(y/x);
if (theta<0)
   thata=180-theta;
end
angle_of_source=theta
distance=sqrt(x^2+y^2)
grid on
end
```

Function for accessing RSSI of desired user

```
function [r]=samplerssi(ss)
r=0; C=0;
[aaa,inpt]=system('Wifi 1');
var=find(inpt==',');
noofssids=length(var);
j=1;
for i=1:noofssids;
if(inpt(var(i)-3)==1)
    ssid=inpt(j:var(i)-4)
    rssi=inpt(var(i)-3:var(i)-1);
else
    ssid=inpt(j:var(i)-3);
```

```
   rssi=inpt(var(i)-2:var(i)-1);
end
j=var(i)+1;
C=strcmp(ss,ssid);
if(C==1);
    break;
end
end
x=str2num(rssi);
r=x;
end
```

Function of circle

```
function h = circle(x,y,r)
hold on
th = 0:pi/50:2*pi;
xunit = r * cos(th) + x;
yunit = r * sin(th) + y;
h = subplot(1,2,2)
plot(xunit, yunit);
hold off
end
```

Appendix C

CODE FOR PROGRAMMING PIC MICROCONTROLLER

```
void Lcd_Init();                                   // initializing LCD

sbit LCD_RS at RB2_bit;

sbit LCD_EN at RB3_bit;

sbit LCD_D4 at RB4_bit;

sbit LCD_D5 at RB5_bit;

sbit LCD_D6 at RB6_bit;

sbit LCD_D7 at RB7_bit;

sbit LCD_RS_Direction at TRISB2_bit;

sbit LCD_EN_Direction at TRISB3_bit;

sbit LCD_D4_Direction at TRISB4_bit;

sbit LCD_D5_Direction at TRISB5_bit;

sbit LCD_D6_Direction at TRISB6_bit;

sbit LCD_D7_Direction at TRISB7_bit;
```

```
  void angle(int v)          // function for displaying characters on LCD

{int z,u,y,e,o;char x;

e=0;y=0;

u=z=v;

while(z>0)

{z=z/10;

e=e+1; }

 o=12;

while(y<e)

{x=u%10;

u=u/10;y=y+1;

x=x+48;

 Lcd_Chr(2,o=o-1,x);}

delay_ms(500);

}

int step(int pp)                    // function for providing step sequence

{       int mm;
```

```
if (pp==1)

{mm=0x08;}

else if(pp==0x08)

{mm=0x02;}

else if(pp==0x02)

{mm=0x04;}

else if(pp==0x04)

{mm=0x01;}

else if(pp==0x01)

{mm=0x08;}

 return mm;

}

int steprev(int pp)

{	int mm;

if (pp==1)

{mm=0x01;}

else if(pp==0x08)
```

```
{mm=0x01;}

else if(pp==0x02)

{mm=0x08;}

else if(pp==0x04)

{mm=0x02;}

else if(pp==0x01)

{mm=0x04;}

 return mm;

}

void rotation(int ab)         // function output step sequence and delay

{

portd=ab;

delay_ms(100);                    // function providing a delay of 100ms

}

void main()                                    // main function

 {

    int p,m,s,q,a,num;
```

```
  int ang;

 char i;

int w,u,rot;

  p=1;  a=0;i=0;rot=0;num=0;

 trisA = 0x00;          // set direction to be output

 TRISD = 0x00;

 UART1_Init(2400);              // Initialize UART module at 9600 bps

Delay_ms(100);         // set direction to be output

 Lcd_Init();

 Lcd_Cmd(_LCD_CLEAR);

 Lcd_Cmd(_LCD_CURSOR_OFF);  // Cursor off

 Lcd_Out(1,1,"Direction Identifier");

  w=0;

  ang=0;

 while(1)

 {

   if (UART1_Data_Ready())
```

```
    {
    i = UART1_Read();                  // reading from serial port
    }
if (i==79)
{
s=0;              q=0;
if(a>1)
{
 q=16-a;
 q=q+1;
 }
 else if (a<1)
 {
 q=1;
 }
 rot=q*13;
 while(s<rot)
```

```
 {
 m=step(p);
p=m;          s=s+1;
 rotation(m);
 }
a=1;
UART1_Write(a);                               // writing on serial port
  Lcd_Cmd(_LCD_CLEAR);


  Lcd_Out(1,1,"Angle of antenna");
  angle(23);
}
else if (i==39)
{s=0;               q=0;
if(a>2)
{
 q=16-a;
```

```
 q=q+2;

 }

 else if (a<2)

 {

 q=2-a;

 }

 rot=q*13;

 while(s<rot)

 {

 m=step(p);

p=m;          s=s+1;

 rotation(m);

 }

a=2;

UART1_Write(a);

Lcd_Cmd(_LCD_CLEAR);

  Lcd_Out(1,1,"Angle of antenna");
```

```
  angle(45);
}
else if (i==78)
{s=0;               q=0;
if(a>3)
{
 q=16-a;
 q=q+3;
 }
 else if (a<3)
 {
 q=3-a;
 }
 rot=q*13;
 while(s<rot)
 {
 m=step(p);
```

```
p=m;          s=s+1;

 rotation(m);

 }

a=3;

UART1_Write(a);

Lcd_Cmd(_LCD_CLEAR);

  Lcd_Out(1,1,"Angle of antenna");

  angle(68);

}

else if (i==19)

{s=0;                    q=0;

if(a>4)

{

 q=16-a;

 q=q+4;

 }

 else if (a<4)
```

```
 {
 q=4-a;
 }
 rot=q*13;
 while(s<rot)
 {
 m=step(p);
p=m;                s=s+1;
 rotation(m);
 }
a=4;
UART1_Write(a);
Lcd_Cmd(_LCD_CLEAR);
  Lcd_Out(1,1,"Angle of antenna");
  angle(90);
}
else if (i==77)
```

```
{s=0;            q=0;
if(a>5)
{
 q=16-a;
 q=q+5;
 }
 else if (a<5)
 {
 q=5-a;
 }
 rot=q*13;
 while(s<rot)
 {
 m=step(p);
p=m;                  s=s+1;
 rotation(m);
 }
```

```
a=5;

UART1_Write(a);

Lcd_Cmd(_LCD_CLEAR);

  Lcd_Out(1,1,"Angle of antenna");

  angle(113);

}

else if (i==38)

{

s=0;            q=0;

if(a>6)

{

 q=16-a;

 q=q+6;

 }

 else if (a<6)

 {

 q=6-a;
```

```
 }
 rot=q*13;
 while(s<rot)
 {
 m=step(p);
p=m;           s=s+1;
 rotation(m);
 }
a=6;
UART1_Write(a);
Lcd_Cmd(_LCD_CLEAR);
  Lcd_Out(1,1,"Angle of antenna");
  angle(135);
}
else if (i==76)
{s=0;          q=0;
if(a>7)
```

```
{
 q=16-a;
 q=q+7;
 }
 else if (a<7)
 {
 q=7-a;
 }
 rot=q*13;
 while(s<rot)
 {
 m=step(p);
p=m;        s=s+1;
 rotation(m);
 }
a=7;
UART1_Write(a);
```

```
Lcd_Cmd(_LCD_CLEAR);
  Lcd_Out(1,1,"Angle of antenna");
  angle(158);
}
else if (i==9)
{s=0;                        q=0;
if(a>8)
{
 q=16-a;
 q=q+8;
 }
 else if (a<8)
 {
 q=8-a;
 }
 rot=q*13;
 while(s<rot)
```

```
 {
 m=step(p);
p=m;                    s=s+1;
 rotation(m);
 }
a=8;
UART1_Write(a);
Lcd_Cmd(_LCD_CLEAR);


  Lcd_Out(1,1,"Angle of antenna");
  angle(180);
}
else if (i==75)
{s=0;             q=0;
 if (a<8)
 {
 q=a;
```

```
 }
 rot=q*13;
 while(s<rot)
 {
 m=steprev(p);
p=m;          s=s+1;
 rotation(m);
 }
a=0;
UART1_Write(a);
Lcd_Cmd(_LCD_CLEAR);
  Lcd_Out(1,1,"Angle of antenna");
  angle(0);
}
else if (i==37)
{ s=0;                   q=0;
 if (a<10)
```

```
 {
 q=a-1;
 }
 rot=q*13;
 while(s<rot)
 {
 m=steprev(p);
p=m;              s=s+1;
 rotation(m);
 }
a=1;
UART1_Write(a);
Lcd_Cmd(_LCD_CLEAR);
  Lcd_Out(1,1,"Angle of antenna");
  angle(23);
}
else if (i==74)
```

```
{
s=0;          q=0;
 if (a<11)
 {
 q=a-2;
 }
 rot=q*13;
 while(s<rot)
 {
 m=steprev(p);p=m;
   s=s+1;
   rotation(m);
   }a=2;
   UART1_Write(a);
   Lcd_Cmd(_LCD_CLEAR);
   Lcd_Out(1,1,"Angle of antenna");
   angle(45);}
```

```
else if (i==18)
{s=0;                              q=0;
 if (a<12)
 {q=a-3;}rot=13*q;
 while(s<rot)
 {m=steprev(p);p=m;                          s=s+1;
 rotation(m);
 }a=3;
 UART1_Write(a);
 Lcd_Cmd(_LCD_CLEAR);
 Lcd_Out(1,1,"Angle of antenna");
 angle(68);}
else if (i==73)
{s=0;                      q=0;
if (a<13)
 {q=a-4;}rot=13*q;
 while(s<rot)
```

```
 { m=steprev(p);
p=m;               s=s+1;
 rotation(m);
 }a=4;
 UART1_Write(a);
 Lcd_Cmd(_LCD_CLEAR);
 Lcd_Out(1,1,"Angle of antenna");
 angle(90);}
else if (i==36)
{s=0;          q=0;
if (a<14)
 {q=a-5;}rot=13*q;
 while(s<rot)
 {m=steprev(p);p=m;
 s=s+1;rotation(m);
 }
 a=5;
```

```
 UART1_Write(a);

 Lcd_Cmd(_LCD_CLEAR);

 Lcd_Out(1,1,"Angle of antenna");

 angle(113);}

else if (i==72)

{s=0;    q=0;

 if (a<15)

 {q=a-6; }rot=13*q;

 while(s<rot)

 {m=steprev(p);

 p=m;

  s=s+1;

  rotation(m);

  }a=6;

  UART1_Write(a);

Lcd_Cmd(_LCD_CLEAR);

Lcd_Out(1,1,"Angle of antenna");
```

```
angle(138);}

else if (i==4)

{s=0; q=0;

if(a<9)

{q=a-8; }rot=13*q;

 while(s<rot)

 { m=steprev(p);

 p=m;

 rotation(m);

 s=s+1; }

a=8;

UART1_Write(a);

Lcd_Cmd(_LCD_CLEAR);

Lcd_Out(1,1,"Angle of antenna");

 angle(135);}

  else if(i==71)

  {w=0; num=0;
```

```
while(num<25)

{num=num+1;

Lcd_Out(1,1,"180 degree");

Lcd_Out(2,1,"Rotation");

w=w+1;

 PORTD=0X08;

 delay_ms(200);

 PORTD=0X02;

 delay_ms(200);

 PORTD=0X04;

 delay_ms(200);

  PORTD=0X01;

  delay_ms(200);

   } } }}
```

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