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Thesis Paper

On

Towards an IEEE 802.22 (WRAN) based Wireless Broadband for Rural Bangladesh-

Point-to-Point Link, Coverage, and CPE Antenna Design

Towards an IEEE 802.22 (WRAN) based Wireless Broadband for Rural Bangladesh-

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A Thesis

Submitted to the Department of Electrical & Electronic Engineering,

BRAC University, Bangladesh.

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DECLARATION

We, hereby declare that this thesis is based on the results found by ourselves. Materials of work found by other researcher are mentioned by reference. This Thesis, neither in whole nor in part, has been previously submitted for any degree, nor published elsewhere. .

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ABSTRACT

In accordance with the global awareness and national agenda of providing digital services to the rural population of Bangladesh to improve their quality of lives, broadband internet connectivity to the remote corners of the country has been a major infrastructural concern. The purpose of this paper is to evaluate the potential of IEEE802.22 Wireless Regional Area Network (WRAN) to serve this purpose. The initial hypothesis was that due to the flat nature of terrain in most areas of the country, it would be economic to deploy WRAN infrastructure in the unused TV white spaces covering large flat areas. However, establishing Point-to-point links might be challenging due to the same reason. To come to a concrete conclusion about the technical feasibility of this technology and an infrastructural estimate, we started this project from scratch, i.e. designing necessary antennas, up to evaluating their coverage and P2P performance in a computer simulation tool. The contribution of this thesis is to theoretically design the necessary antennas and Customer Premises Equipment (CPE) needed for such a deployment.

ACKNOWLEDGEMENT

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We also want to acknowledge our fellow thesis group who were in charge of the computer simulation counterpart of this WRAN project: Rafi Rahman and Farhat Nizam Ayon. They have been very supportive in complementing our work, and we really enjoyed working in this collaboration.

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CHAPTER-01

INTRODUCTION

Background:

In the recent emerging market, vast population of the rural area is derived from broadband connectivity. Internet will enhance the education system of Bangladesh and our project is based on the intention of connecting the maximum of Bangladesh. In this paper it is theoretically proven that IEEE 802.22 deployment is possible in Bangladesh and this will also ensure maximum coverage. This is already done in some rural parts of the world and this also proved to be very much effective. Unfortunately, no such work has been done before or none of such initiative was taken. However, this new concept will be very much helpful to Bangladesh. Bangladesh is a poor country and thus setting up a whole new infrastructure for broadband connectivity will not be much efficient as the rural people will not be willing to and cannot pay a lot for the internet. Moreover, connecting a lot of user will be difficult. Thus, this initiative will ensure that the user can avail this service accordance to their payment preference. This will also connect a lot of user and this will also not hamper the spectrum.

Motivation:

In the recent emerging market, vast population of the rural area of our country is deprived of broadband connectivity, whereas now it is considered as a necessity. The region of our country is reasonably flat and small but yet due to the lacking of a perfectly planned infrastructure is holding us behind. However, the use of the TV white space can bridge this difference. HD channels are not much used in Bangladesh and thus the empty spectrum can be utilized to provide with broadband connectivity using the IEEE 802.22 standard. This will ensure connecting many users and a low data rate. However, the existing telecom companies are much more oriented to achieve their profit from the business and thus they are most unlikely to set up new coverage antenna in a less populated area. The revenue earned will be quite less than setting up the same coverage antenna in a more populated and demanding region. Although, the demand also exists within the people of the rural area but they are currently helpless. In this project, we will be introducing cognitive radio by which we can provide connectivity in the maximum rural area of Bangladesh. This will also be very much economically feasible and also cost effective in the perspective of Bangladesh. This project is an initiative to improve the educational quality of Bangladesh as internet connectivity will help people explore the world and also learn a lot from it. Thus, this will be very much effective for the people of Bangladesh. Although this idea is completely new in the perspective of Bangladesh but this is already done and in some regions of the world. Thus, this increases the liability of the project [1].

Major definitions:

End-fire array:

It is organized in a linear or cylindrical antenna array that directs most of the radiation in the direction of the axis. In this project we used half-wave horizontal dipole of end-fire. In end-fire array many identical antenna used with equidistance manner. It can be unidirectional or bidirectional radiation pattern.

Broadside array:

It is a typical collinear antenna that consist half-wave (1/2 wavelength) dipoles. It directs maximum radiation which is perpendicular on the plane of its array. Basically, Broadside array is bidirectional with narrow beam width and it has high gain.

CPE:

Customer Premises Equipment (CPE) is none other than our telecommunication service provider equipment that placed in customer's devices rather that the provider's physical location. The devices are the equipment we use for communication like: telephone, mobile, set up box for cable TV, router, modem, VOIP base stations are basically the examples of CPE. However, Most of the CPE owned by the service provider except modem, router that bought by the customers. In our project we used end-fire array to design Customer Premises Equipment (CPE).

Array Factor:

N number of identical Omni-directional (faced in same direction) Antenna usually defined as the array factor that follow similar pattern. Because of array factor we can combine multiple antennas that help in transmitting and receiving of signal.

Shield Attenuation:

Shielding is necessary for antenna and electronic devices in case of controlling electromagnetic interference. Shielding is located in equipment's circuit board. Basically, shield work by reflecting, absorbing, redirecting the magnetic and electronic fields. Here, we used shield attenuation for P2P (point to point) antenna to reduce the interference of antenna and control the attenuation.

Cognitive radio technology:

Cognitive radio is a technology that can detect free wireless spectrum automatically. Cognitive radio improve the performance like: increasing the transmission rate. Cognitive radio is an innovative technology for wireless communication.

TV White Space:

TV white space is usually the unlicensed broadcasting frequencies that remain unused (not used for television broadcasting). There is a space that placed between TV channels for buffering its like guard band. That free wireless spectrum is defined as white space. Similar type of spectrum is used 4G network that is why we can use TV white space for broadband internet. This spectrum is placed in VHF (very high frequency) and UHF (ultra-high frequency) range is 470MHz to 790MHz.

Radio mobile: Radio Mobile is a Free Radio Propagation simulation program which works over the frequency range of 20MHz to 20GHz. It totally depends on the ITS (Institute for Telecommunication Sciences, Longley-Rice) engendering model. The program enables the elevation maps to be drawn of specific areas using downloaded SRTM data from the Space Shuttle Radar Terrain Mapping Mission, elevation curve and road maps to be added and Radio Units (base stations) specified for performance and placed where they are required. Individual Radio Unit performance is specified as a Radio Operating 'System' for transmission power, sensitivity, antenna parameters etc. and all 'Radio Links' between Units can be examined for path profile and signal parameters.

IEEE 802.22

We mainly followed IEEE 802.22 standard in this work. IEEE 802.22 is a standard for wireless regional area network also known as WRAN, using white spaces in the television frequency spectrum. A standard is method developed by international standards organizations like as IEEE and use world widely. In telecommunications, those frequencies allocated to a broadcasting service but not used locally is called white spaces. [Wiki] So basically it involves frequency sharing among different operators to operate in vacant channels in TV broadcast bands using cognitive radio technology. Cognitive radio technology is a promising technology for efficient utilization of the available spectrum. IEEE 802.22 has some characteristic as like as it operates in lower population density areas like rural area or in a village and its coverage range is considerably larger than other IEEE standards like WiMAX or Wi-Fi. It provides broadband using vacant TV channels in the VHF and UHF bands and also operates in the range of frequencies between 54 MHz and 862 MHz It avoids interference on these bands and operate in a point to multipoint basis. This system is formed by base stations and customer-premises equipment (CPE).

Previous work:

The deployment of IEEE 802.22 is already done in few regions of the world. This is getting quite popular for the rural region [2]. However, no such initiative is still taken in Bangladesh. There are a lot of demand for internet in the rural region of Bangladesh but setting up the infrastructure in the rural area is very difficult. The transportation of Bangladesh will cause a threat and also the implementation cost will be very much high. Thus utilizing the standard and also setting the infrastructure will be cost effective and also will be economically feasible [3]. Moreover, Bangladesh has much available white space and thus utilization of this will be very much effective in the perspective of Bangladesh.

White space broadband might conceivably change the manner we get of the web, especially for the individuals for common zones; the place there may be abundant free, unlicensed White space spectrum to utilize. There may be small White space spectrum open over thickly populated urban areas, the place where more individuals would use more television channels and there need aid All the more TV stations. The improvement will be reasonably new Also questionable, thereabouts practically plans are still in trial phases. Regarding ten (10) trials would happening viewing providing for association of the libraries, the open spots and schools.

In 2012, very nearly three years following the FCC (Federal correspondences Commission) recommended those essential White space business framework to Wilmington, north Carolina, the city finally actualized this one task. The dare may be gone through range Bridge, a standout amongst those principle FCC-affirmed White space databases, and Wilmington might have been picked on the fact a result it might have been the essential city of the progress from simple to advanced TV, which sanctioned those remote range to White space. Since the one task started, those administration is using the framework will interface two nearby parks What's more a couple state funded gardens, regulate water levels, water quality, What's more state funded lighting. The city might have been similarly a pilot territory to trying White space gadgets with be asserted Toward the FCC for business utilize. [4]

The Pascagoula school District, Mississippi, after the Hurricane Katrina, required will have White space innovation organization open concerning disaster recovery asset. The venture might have been planned to extend web get to the impostor individuals i.e. for those community. That Group based a versatile unit including of a tower as well as telescope. It can be a chance to be moved for Group occasions, if that is a province reasonable or a show, or about crises, turns under a transportable Wi-Fi hotspot. Pascagoula also arrangements should use those engineering on supplant An DSL connection done in an adult learning Centre, which will triple those data transfer capacity limit and reduce the month with month bill. [4]

Of the delta province libraries system, five libraries serve 30,000 people. That standard White space gadget might have been set up on a library in Paonia, Colorado, a town from claiming around 1,500 people. The Gigabit Libraries system pilot off Previously, October 2013, then again amidst the trial, the country done the reduction in financial plan. The individuals thought they might require returning the gadgets to stop the White space pilot. The hotspots On Paonia, downtown Also in the park, used advanced radio gear starting with Carlson wireless and Wi-Fi access points are starting with Cisco Meraki. However, with wrap dependent upon those project, the town sorted program out a kick starter campaign, endeavouring with raise $4,000. With 63 benefactors starting with the community and someplace else around the country, it might have been financed for 30 days. [4]

The pilot tests done philippines for White space broadband are those practically unreasonable in Asia. Means, the country may be a immaculate region should test White space broadband, with its thick foliage, remote areas, Furthermore far reaching areas. The pilot tests started following those Bohol earthquake and hurricane Haiyan (Yolanda) over 2013, Also provided for essential calamity assuagement What's more permitted data will make sent all through the impacted zones about Bohol as well as leyte territories in the Visayas. [4]

After pilot ventures through the Microsoft 4Afrika project over Tanzania Also Kenya, the association completed An White space wander in the Limpopo region in South Africa. It interfaces schools on rusticate regions and uses sun oriented powered base stations to control those framework. The guideline base station is on the University of Limpopo campus. Google might have been the essential critical player in the nation, sending a similar project for 10 neighbourhood schools clinched alongside Cape Town over 2013. The town is encompassed by hills and mountains, thus there would three transmitting antennas should transmit the wireless broadband Internet. The primary base station uses An 10 Gbps connection. [4]

In April 2013, White space touched the ground of "Gold Country" el Dorado County, California, At Carlson wireless joined strengths for Cal. Net, A northern California Internet administration provider, to convey Internet should segments of the domain. Carlson's Rural Connect, which is passed on previously, a couple domains around those US, conveys broadband connection toward transmitting in television White space frequencies ranges starting with 470 to 698 MHz [4].

The Singapore White Spaces Pilot Group, which incorporates organizations, to example, Microsoft, Adaptrum, Spectrum Bridge and Grid Communications, need passed on three ventures that show the administrations White space could offer. Those three ventures are: (1) national University of Singapore (2) Singapore island country club (3) Changi region abutting the airport. At this time the Internet is expensive, thus this experiment task is to choose how we can reduce those expanses. [4]

Strathclyde University's focus to White space communications in Scotland may be a pioneer din investigation once White space broadband. The isle for Bute encouraged an 18-month wander starting over 2012 that might have been the 1st of its kind in the UK. The trial offered Wi-Fi access using White space spectrum on eight homes on the south part of the isle from claiming Bute, which officially had restricted the Internet. [4]

Libraries to Kansas City are trying White space to An four month pilot, passing on Wi-Fi openly libraries for remote territories of the city. The Kansas City K-20 Libraries movement will be participation between academic, school, and government funded libraries that is endeavoring with spread Internet access over the society. [4]

Faculties and students of West Virginia University's (WVU) campus in Morgantown, West Virginia have Wi-Fi accessibility on particular fast travel stage through An White space broadband task. More than 15,000 riders come to the campus every day using electric-controlled vehicles. This might have been the first venture propelled through air. U, whose target is to convey White space in University territories. At WVU, 12 Mbps broadband could go more than two miles through one TV channel. [4]

Problem area:

The geographical map of Bangladesh presented with some problem. The terrain of Bangladesh is quite flat and reasonably small. Thus the P2P antenna needs to be placed close to each other to achieve perfect LOS. Although the antennae can be set of top of high rise buildings but the rural area does not have much high rise buildings. However, the number of antennae required will be quite less as the region is quite small. Additionally, Bangladesh beds to a lot of small rivers and thus this had also to be considered. Thus implementing P2P for coverage purpose will be very much costly. Although this paper does represent the solutions and the alternatives that can be implemented for the mentioned problem areas. [5]

Research gap & contribution:

There has been no commercially available antenna that would fit in the particular applications we are talking about. That is, working with the TV spectrum, and being a part of a high performance point to point broadband link. Antenna array was a logical option. Designing the antenna arrays has been a key concern for the project, there is no commercially available CPE array antenna as well working in this application. [6] So, we came up with the idea if it is possible to introduce Cognitive Radio technology in the context of Bangladesh. Besides, the cost for setting up this technology in our country will be very less comparing with the GSM technology setting up cost. In our project we design the CPE using planer end-fire array and used dipole antenna for coverage.

Research question:

The main question of our research is how to design antenna arrays theoretically for point to point links, coverage and CPE to evaluate the feasibility and for a WRAN based wireless broadband network in a given territory within the VHF-UHF spectrum, with the use of radio-planning software.

Outcome of the thesis:

After completing our thesis work we come to a decision that on the context of Bangladesh introducing Cognitive radio technology using WRAN with TV white space spectrum is a beneficial project which will give a very fast broadband internet connection to the remote part of Bangladesh i.e. in the rural areas. We have designed the necessary antenna arrays required for the project.

Summary of chapters:

In our thesis we have highlighted the working principle of the new technology named Cognitive radio witch the help of IEE 802.22 WRAN using TV white space spectrum of Bangladesh. We have designed CPE, point to point Antenna, Arrayfactor(for antenna radiation pattern) and also through our calculation found out minimum number of antenna for maximum number of coverage.

CHAPTER-02

METHODOLOGY

METHODOLOGY

The antennae are designed in a sequential manner. The P2P antenna link will have to have accurate line of sight (LOS). Thus the P2P antenna links has to be designed so to such a manner that it will cover the maximum of the terrain of Bangladesh. Each house of the rural area will be equipped with an individual CPE. The CPE will be able to sense its surrounding spectrum and will connect to the available white space. One cell will contain an individual Base Station and that will connect to several CPE at a time. Thus in this way many users can be linked and also the transfer rate will be very effective. Each Base Station will be implemented with WRAN coverage. In the rural areas the white space will be much available and thus the connectivity will be efficient and also effective. [6]

The data collection is done of certain assumptions. That is the reason that the data is quite limited. However, we tried several times with placing the base antenna at several destinations and the best suitable places are then chosen. Base stations are placed on the areas and separated in such manner that there is least overlapping. This is to ensure that maximum coverage can be done using the minimum number if antennae to make it economically feasible concerning the economic condition of Bangladesh. [7]

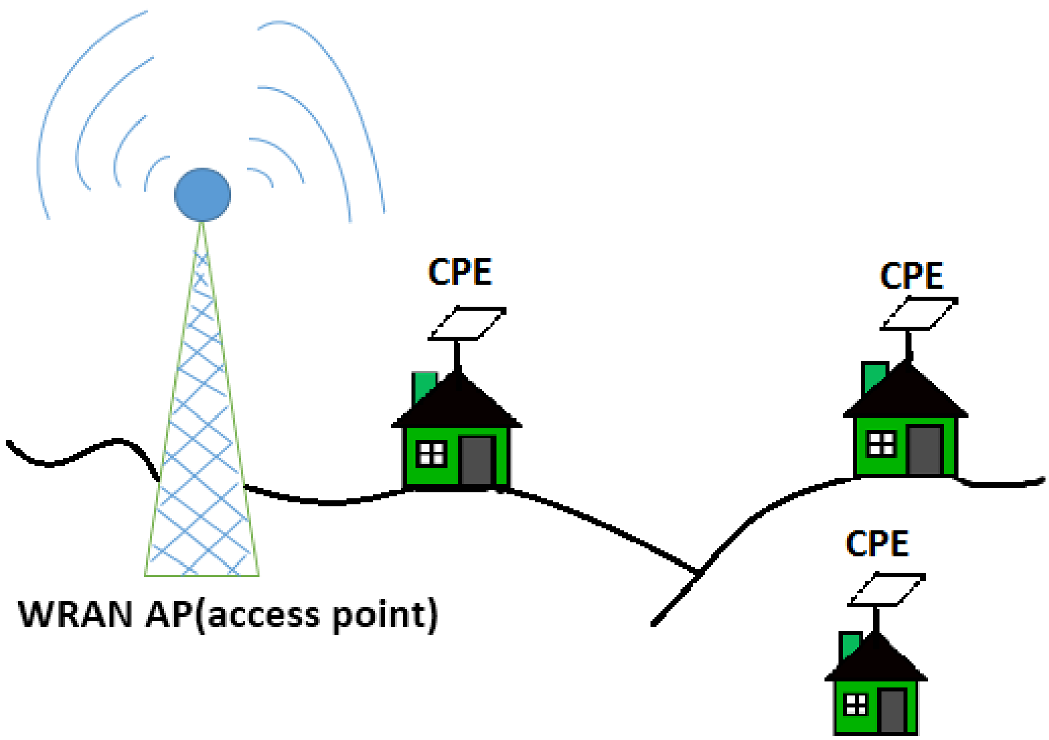


Fig 1: topology of CPE.

Fig (1) shows the topology of the planned process. Each individual will have a CPE for its own and there will be one WRAN AP to connect to several CPE at a time so less WRAN AP will be required. Thus this will make the process cost effective and efficient.

CHAPTER-03

ANALYSIS

ANALYSIS

Assumptions

1. The antennas need to work in the VHF-UHF TV white space.
2. Antenna array parameters need to be derived.
3. CPE should work in the same frequency.

Customer-premises equipment(CPE)

In general CPE is referred to the equipment that will be located on the physical location of the customer's premises. We are planning each customer to have an individual CPE. The antenna that we are using for this purpose is λ/2 vertically polarized antennas. The planar end fire array can be described by:

$N_{H,}$ N_V = No. of Horizontal and Vertical elements

d_H, d_v = Horizontal/Vertical distance between elements

d_H/λ = Horizontal distance-wavelength ratio

d_V/λ = Vertical distance-wavelength ratio

For endfiire,

$\theta_{max\text{-}Horizontal} = 0^o$

For broadside,

$\theta_{max\text{-}vertical} = 90^o$

Central frequency, f= 768.78 MHz

so, λ =c/f = 0.39m

Avoiding the grating lobes, the following equation holds,

$$\frac{d_H}{\lambda} \leq \frac{(1-1/N_H)}{1+\cos\theta_{max}} \quad (1)$$

We also know, for horizontal alignment,

$\theta_{max} = 0^o$

$d_H \leq 1.3/(N_H - 1)$

Hence, for maximum condition,

$$d_H/\lambda = 0.474$$

$N_H = 8$

So Horizontal Size = $d_H \times (N-1)$ = 1.12m

For vertical alignment, $\frac{d_V}{\lambda} = \frac{1}{2}$

d_V= 0.195

N_v= 2

Vertical size,

$$\text{dV} + \frac{\lambda}{2} = 0.39m$$

And, not to exceed the limit of 0.5m, the number of vertical elements with $\lambda/2$ size should be 2.

Calculating the array factor before applying shield:

We know,

$$\theta = \left| \sum_{n=0}^{N-1} (e^{j\psi})^n \right| \quad (2)$$

$$\psi = 2\pi d\cos\theta/\lambda + \phi \quad (3)$$

θ= the angle with the direction of alignment

N= No. of elements in each alignment

Also, for endfire array,

$\theta_{max}= 0$

For Broadside array,

$\theta_{min}= \pi/2$

As $\psi=0$ in case of θ_{max}

$\phi= -2\pi d\cos\theta_{max}/\lambda$

So, as a result, we get for ψ,

$$\psi= 2\pi d\cos\theta/\lambda - 2\pi d\cos\theta_{max}/\lambda \quad (3)$$

Hence, in case of endfire horizontal array,

$$\psi_H = 2\pi d_V(\cos\theta_h - 1)/\lambda \quad (4)$$

where, $\theta_h \epsilon [0, \pi]$

which gives us the visibility range ψ_H ranging in [-1.64π, 0]

similarly, for the vertical array,

$$\psi v = 2\pi d_V cos\theta_V / \lambda \quad (5)$$

Where θ_v range from 0 to π, which gives us the visibility range ψ_H in the interval [-π,π]

Configuring the shield for CPE:

For an Endfire configuration,

$\theta_{max} = 0$

N= 2

ϕ= -π

Hence,

$$\psi_s = 2\pi d_V cos\theta_s / \lambda - \pi \quad (6)$$

Where, θ_s€ [0,π]

Visibility ψ_s€ [-2π,0]

$d_s/\lambda = ½$ □ ►$d_s = \lambda/2 = 0.195$m

so, the placement of the shield should be 0.195m array.

The array factors obtained will now be chronologically applied to the radiation pattern of the dipole antenna in order to get the final radiation pattern. The Horizontal Array Factor is applied to the Horizontal Radiation pattern of the dipole and the vertical Radiation pattern, we use the following formula:

$$G(\theta) = Gd(\theta)dB + 20\log_{10}(AF_{hor}(\theta)) + 20\log_{10}(AF_{vert}(\theta)) + 20\log_{10}(AF_{sh}(\theta)) \qquad (7)$$

The symbols stand for:

$G(\theta)$ = Gain of planar shielded array

$Gd(\theta)$ =Gain of dipole

$AF_{hor}(\theta)$ =Horizontal Array Factor

$AF_{vert}(\theta)$ =Vertical Array Factor

$AF_{sh}(\theta)$ =Array Factor due to shield

Calculating the Dimension and CPE field Attenuation:

Let, a and b be the dimensions of the CPE shield slots and D be the thickness of the shield. Based on the assumption that we are operating it in TE_{10} mode, we can find out the thickness in the following steps of calculations.

Cut-off frequency,

$$f_{c} = \frac{c}{2a}$$

$$\gg a = \frac{c}{2f_c} = \frac{3\times 10^8}{2\times 800\times 10^6} = 0.1875m$$

For the shield thickness, we use the following formula:

$$\coth(\alpha D)^2 = \frac{\left(\frac{\left(\frac{f_c}{f}\right)^4}{\gamma^2} - (1-x)\frac{\left(\frac{f_c}{f}\right)^2 - 2}{\gamma^2}\right)^2}{4(1-x)} \; ; \; f = 768.75Mhz\ const.frequency \qquad (8)$$

Meanings of the symbols,

$$\gamma = \sqrt{\left(\frac{f_c}{f}\right)^2 - 1}$$

$x = Attenuation$

$$\alpha = k \times \gamma$$

$$k = 2\pi f\sqrt{\mu \in}\; ; \; \begin{matrix} \mu\ and\ \epsilon\ vary\ upon\ materials, \\ for\ Aluminium, \mu = 1.256 \times 10^{-6} Hm^{-1} \\ \epsilon = 1.6 \times 10^{-11}\ F/m \end{matrix}$$

Rearranging the equation in terms of an unknown D,

$$D = \frac{1}{\alpha}\coth^{-1}\sqrt{\frac{\left(\frac{\left(\frac{f_c}{f}\right)^4}{\gamma^2} - (1-x)\frac{\left(\frac{f_c}{f}\right)^2 - 2}{\gamma^2}\right)^2}{4(1-x)}} \qquad (9)$$

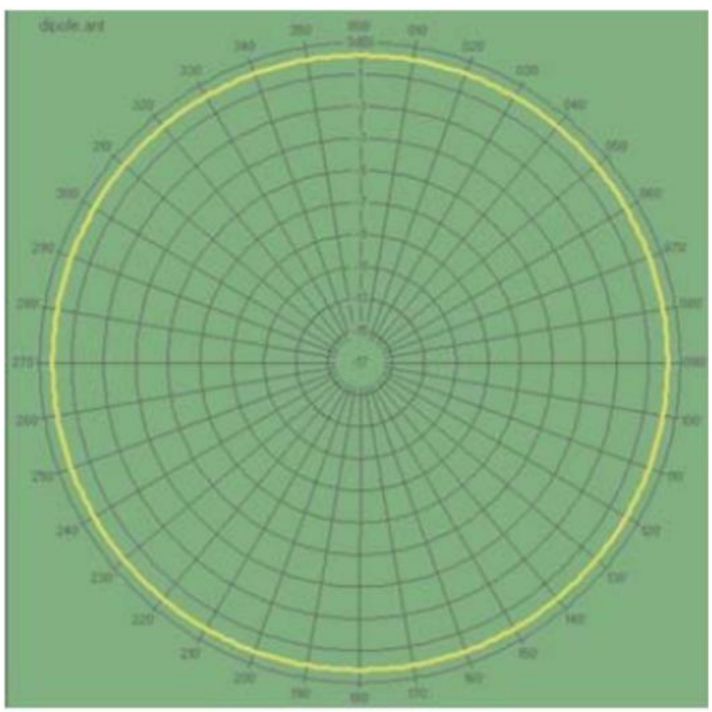
Now, if we plug-in different values of attenuation (-20DB/-30DB/-60DB)

We get our corresponding D value

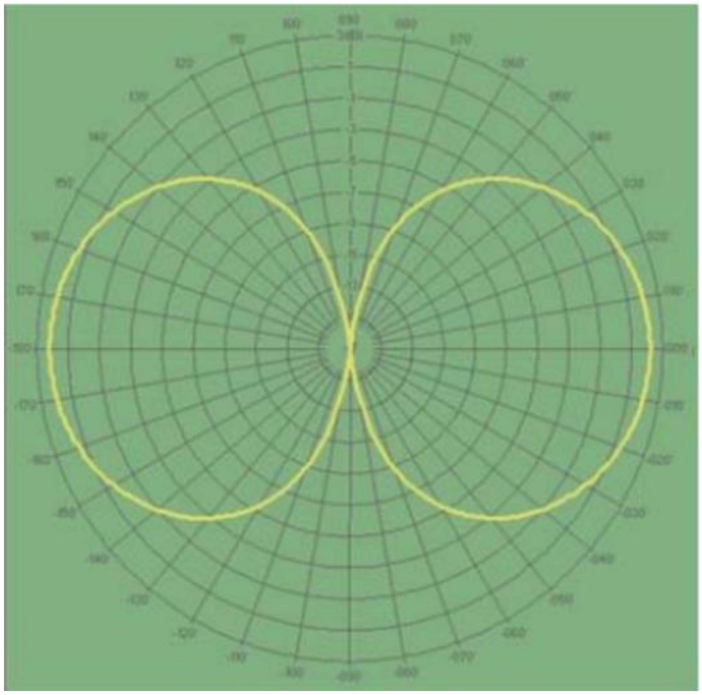
Corresponding to -60DB attenuation, we get a D value of 0.5007cm.

Dipole Antenna:

A Dipole antenna is that the simplest, typically the smallest amount costly and most popular kind of omnidirectional antenna utilized in radio communications. A dipole antenna uses 2 conductors of a similar length to find radio waves and transmit the corresponding variable electrical current to a receiver. It is designed in such a manner that is to operate at end to end. Every conductor represents one-quarter of a wavelength, and once combined, the dipole will find a half-wavelength signal. The length of the 2 conductors determines the operational frequency. Dipole antenna are used for uniform coverage within an area which is reasonably flat in nature and free of obstacles. [6] They have a horizontal radiation pattern uniform in all directions, like a circle with the antenna in the center. Its gain is 2.16dBi and its radiation pattern is given below:



Horizontal



Vertical

Fig: Dipole antenna radiation patterns

P2P Antenna:

The P2P antenna is designed as an end fire array of λ/2 horizontally polarized dipoles with maximum dimensions of 3m*0.50m. A planar shield array is also designed for Base Stations using λ/2 horizontally polarized dipole antennas which is endfire in vertical and broadside in horizontal [3]. Thus, the relating relevant calculations are shown:

N_{H}, N_V = No. of Horizontal and Vertical elements

d_H, d_v = Horizontal/Vertical distance between elements

d_H/λ = Horizontal distance-wavelength ratio

d_V/λ = Vertical distance-wavelength ratio

We know,

For broadside, $\theta_{max\text{-}horaizooontal} = 90^o$

For endfire, $\theta_{max\text{-}vertical} = 0^o$

Frequency, f = 5.4 GHz

So, λ= c/f

= $3*10^8/5.4*10^9$ = 0.055m

For the vertical alignment,

$d_v \leq \lambda/2(1-1/N_v)$ and $d_v \leq 0.5/(N_v-1)$

Solving, we get (for max)

d_v=0.026m

N_v=20

d_v/λ = 0.47

and vertical size= 0.5m

similarly, for horizontal(max),

$d_h \leq \lambda(1-1/N_H)$

and$(N_H-1)d_h+\lambda/2 \leq 3$m

so, $d_h \leq 3/(N_H-1)$ (appx)

these lead to the solution,

d_h = 0.055m,

N_h= 55

d_h/λ = 0.99

so, we can select

d_h/λ = 0.7

=>d_h=0.039

AndN_H = 30d

hence, the horizontal size will become = d_h*(N-1)+ $\lambda/2$ = 1.15m

so finally, we will be having (30*20) planer array

<u>Computing the array Factor:</u>

From vertical alignment we can get,

$$\theta \ = |\sum_{n=0}^{N-1} (e^{j\psi})^n |$$

$$\psi = 2\pi d cos\theta/\lambda + \phi$$

ϕ_{vent}= $-2\pi d_v/\lambda$

ψ_{vent}= $2\pi d_v(\cos\theta-1)$

when $\theta_{max-vent}$= 0^o, ψ= 0

Limit of $\phi_{vert}[0,\pi]$ &$\psi_{vert}[-1.9\pi,0]$

The horizontal Array factor can be calculated similarly

For broadside, $\theta_{max\text{-}hor} = 90^o$

& $\phi_h = 0^o$

S0, $\psi H = 2\pi \frac{d_h}{\lambda} cos\theta_{hor}$

When θ_{hor}€$[0,\pi]$

& ψ_{hor} $[-1.4\pi, 1.4\pi]$

Designing the shield for P2P Antenna:

$\theta_{max} = 0°$,

$N_{shield} = 2$,

$\emptyset = -\pi$,

$\varphi_{shield} = 2\pi \ d_s \ \lambda \ \cos\theta_s - \pi$ (10)

$d_s \ \lambda$=1/2 $\gg d_s = \lambda \ 2 = 0.028m$

So,θ_{shield} =in the interval $0, \pi$

φ_{shield} =in the interval $-2\pi, 0$

<u>Calculation of P2P shield Attenuation</u>:

Let a and b be the dimension and D the thickness of the shield as we operate in TE_{10} mode, we can find out the thickness with the following calculation:

Cut-off frequency,

$f_{c=}c/2a$

$\gg a = c \ \ 2f_c$

$\gg a =$2.73cm; (5.5GH_z)

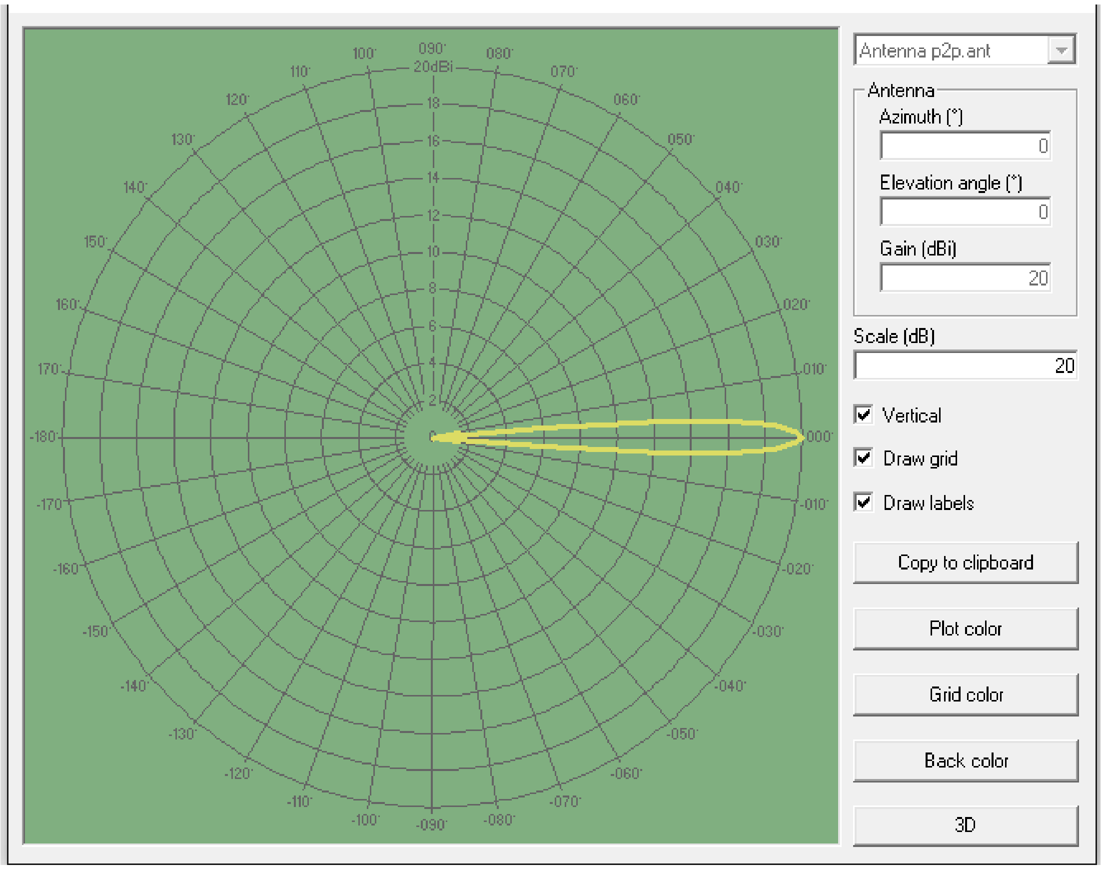
For shield thickness we use following equation

$$\coth \ \alpha D \ ^2 = \ \ f_c \ \ f \ ^4 \ \gamma^2 - \ 1 - x \ \ \ f_c \ \ f \ ^2 - 2 \ \ \gamma^{2\ 2} \ \ 4 \ 1 - x$$

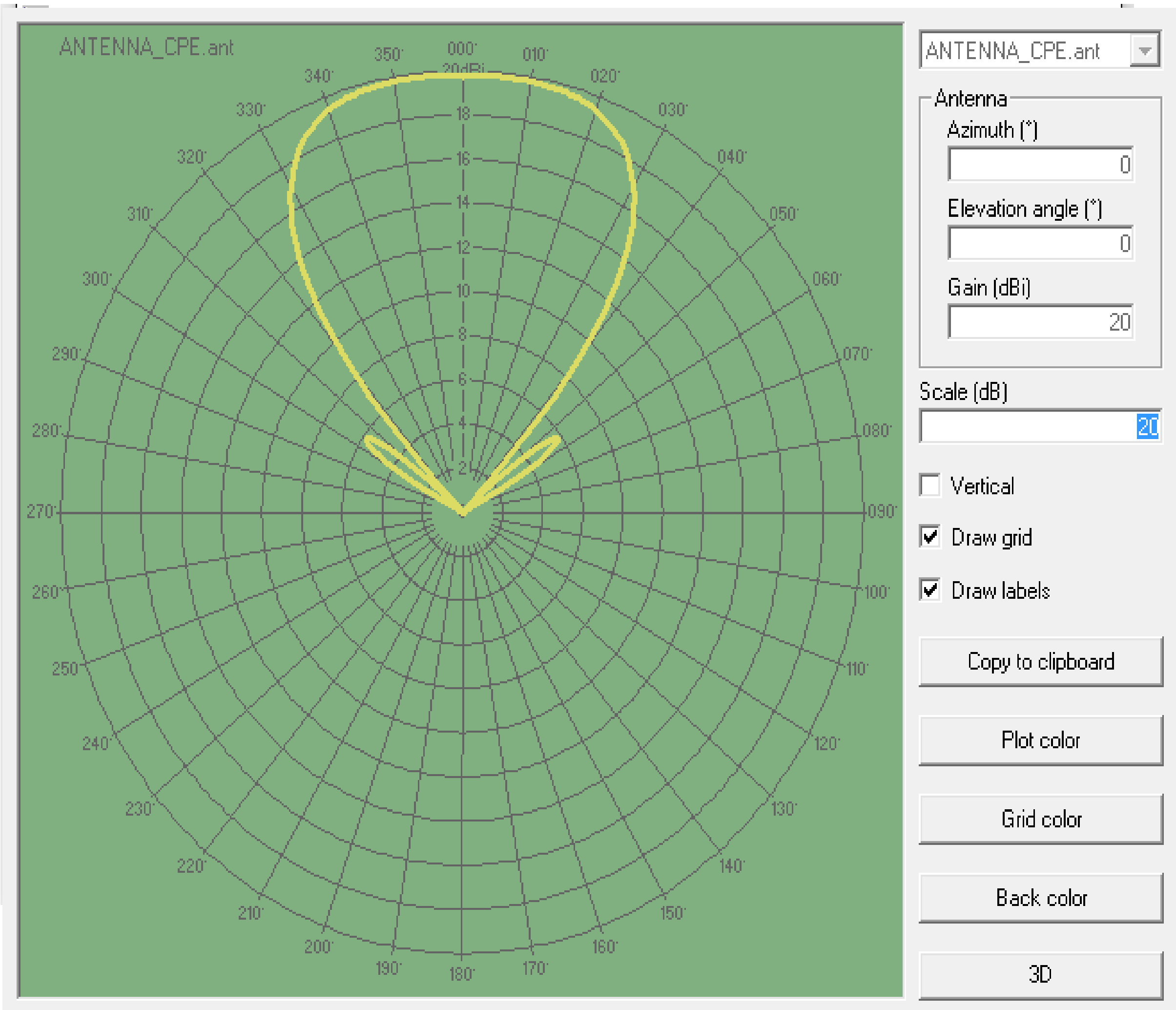
Where, $D = 1 \ \ \alpha \coth^{-1} \ \ f_c \ \ f \ ^4 \ \gamma^2 - \ 1 - x \ \ \ f_c \ \ f \ ^2 - 2 \ \ \gamma^{2\ 2} \ \ 4 \ 1 - x \ \ ^{\frac{1}{2}}$

Now, if we plug-in different values of attenuation (-20DB,-30DB,-55DB,-65DB) we can choose the thickness corresponding to -65DB, which calculates as 0.27cm.

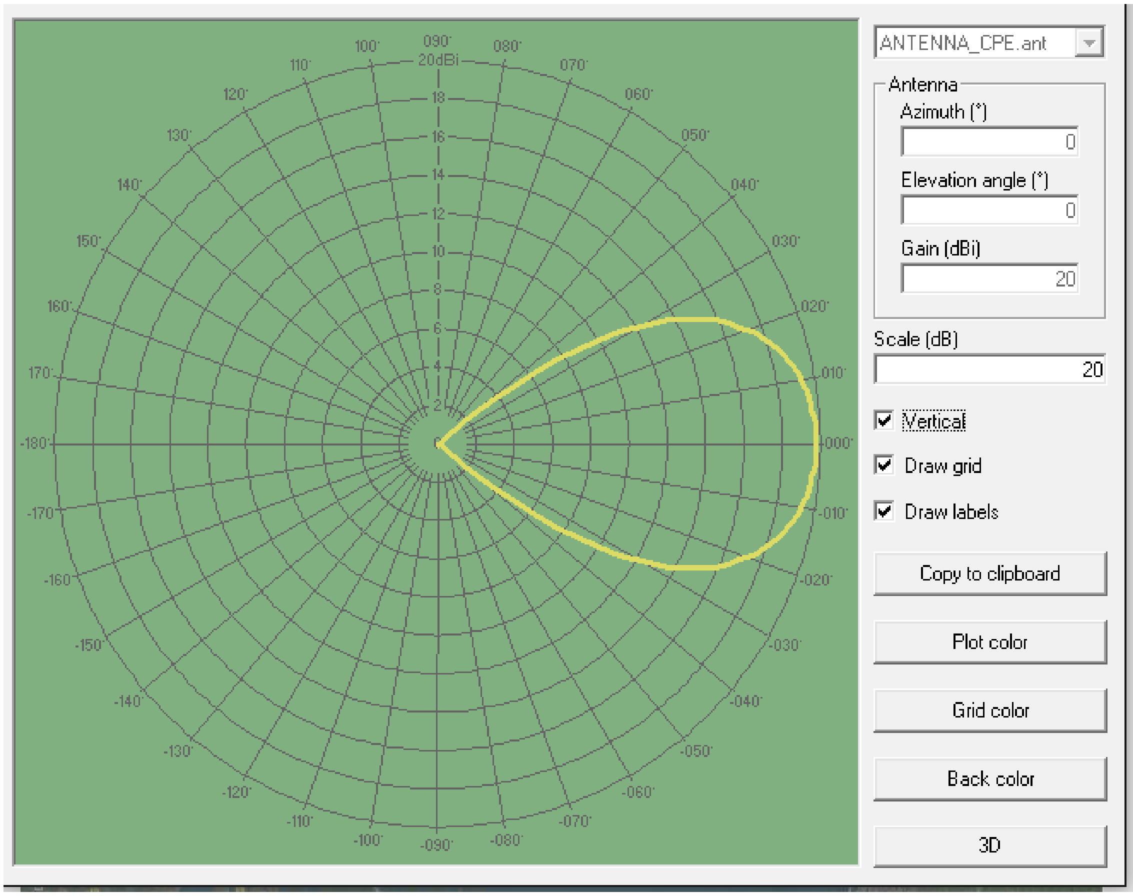
Radiation Pattern of various antenna:



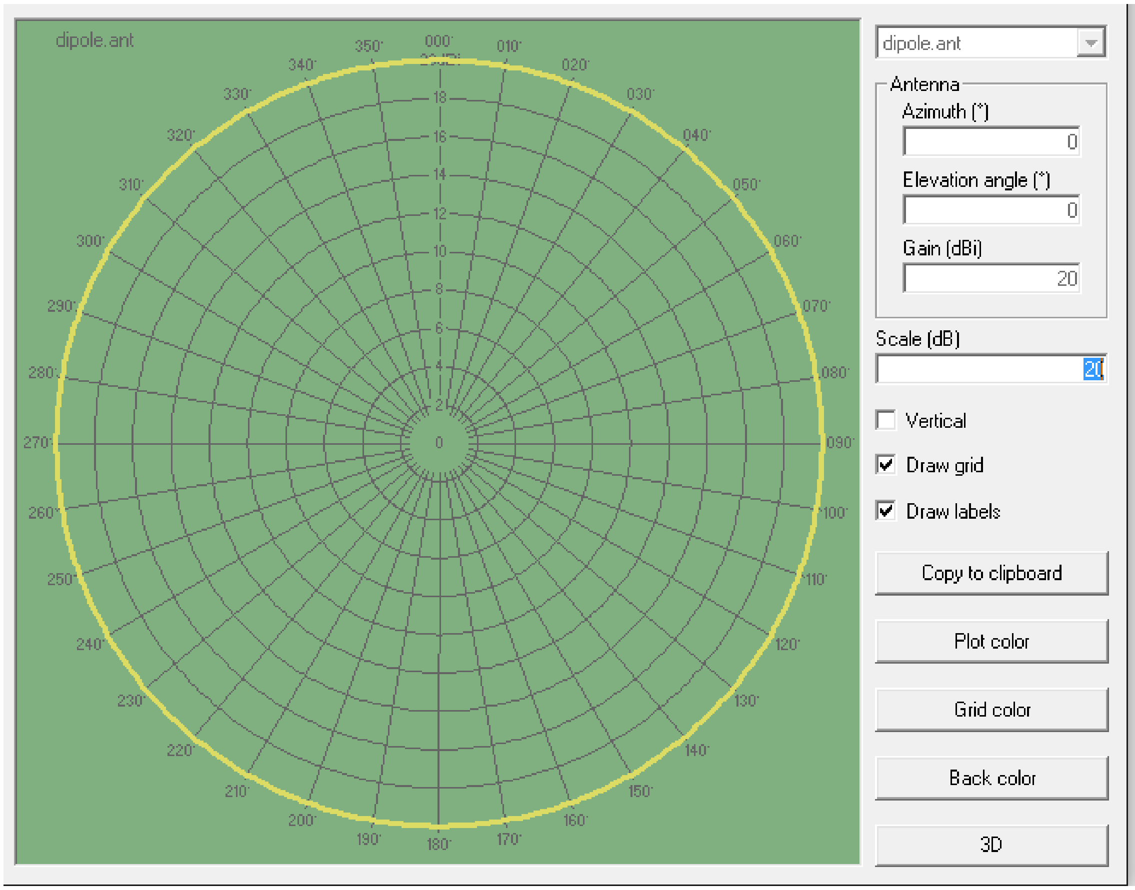
P2P antenna Radiation Pattern Vertical (only antenna/not array)



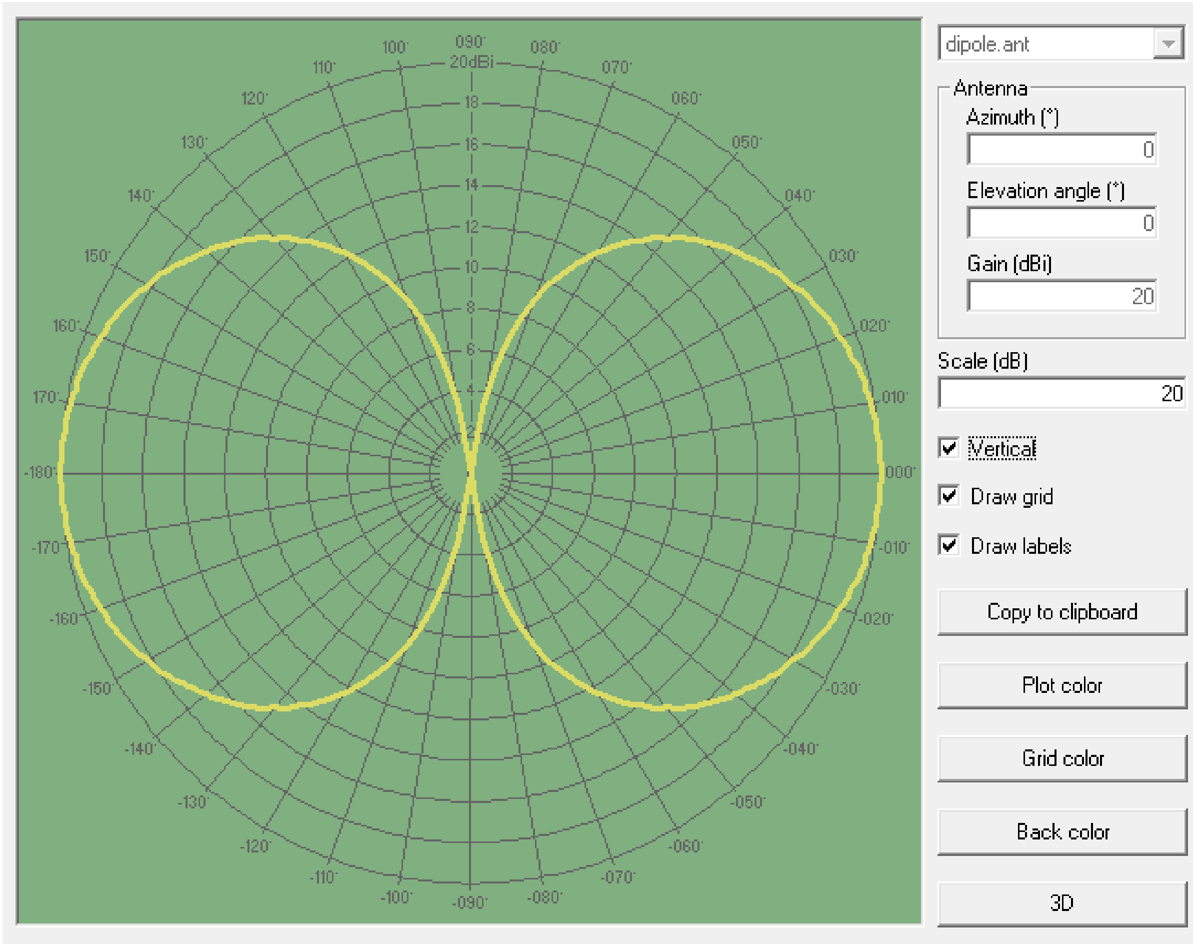
CPE radiation pattern (horizontal)



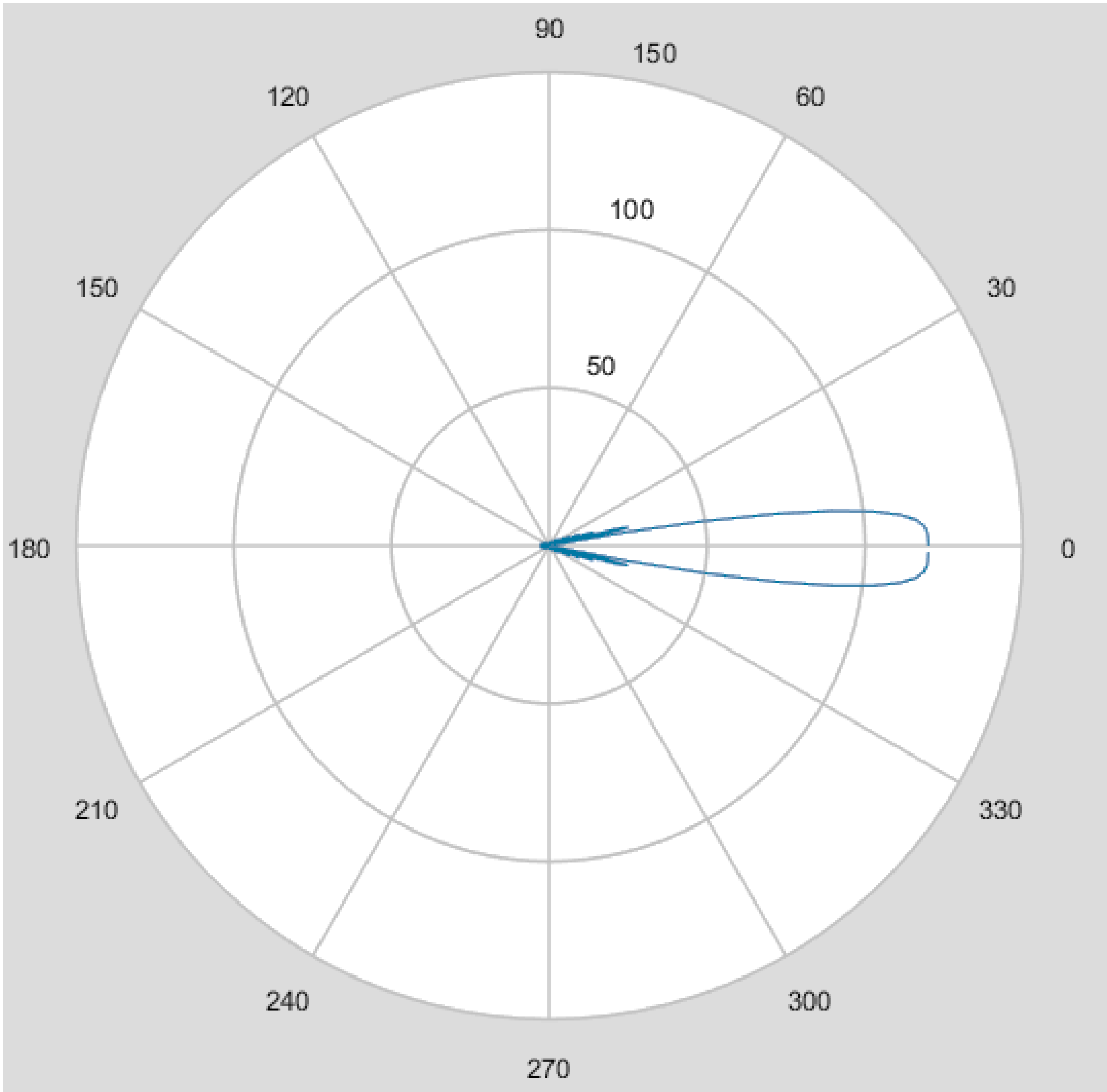
CPE radiation pattern (vertical)



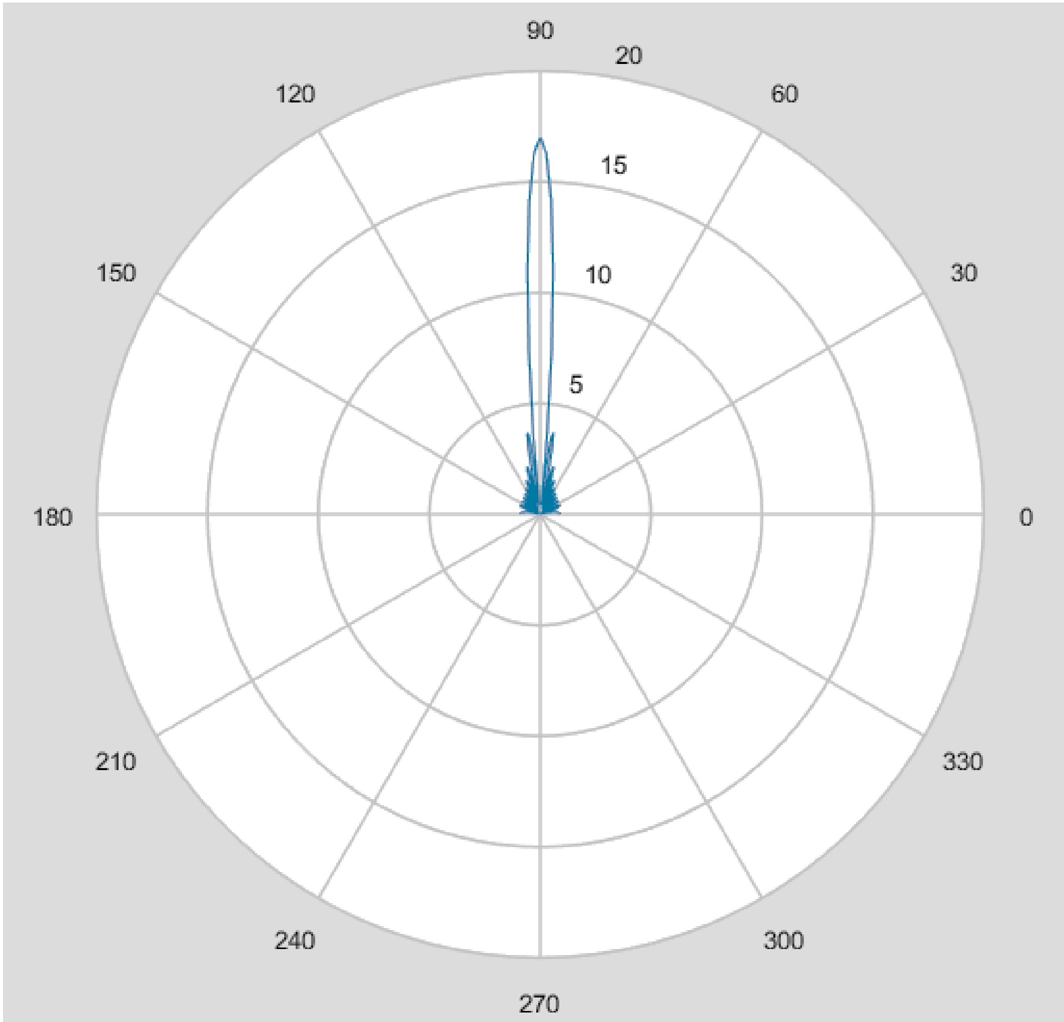
Dipole Antenna (used for coverage) radiation pattern (horizontal)



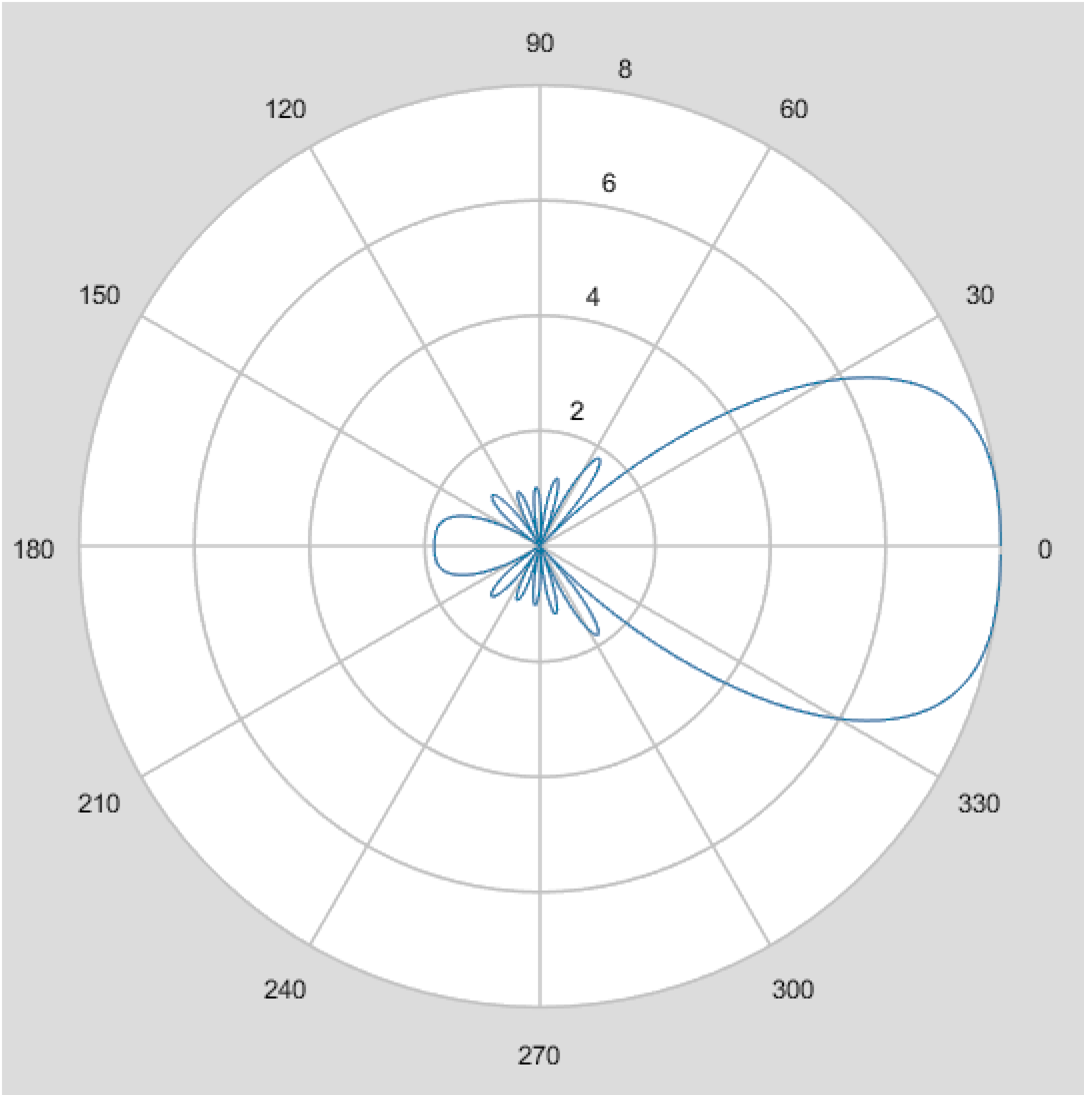
Dipole antenna radiation pattern (vertical)



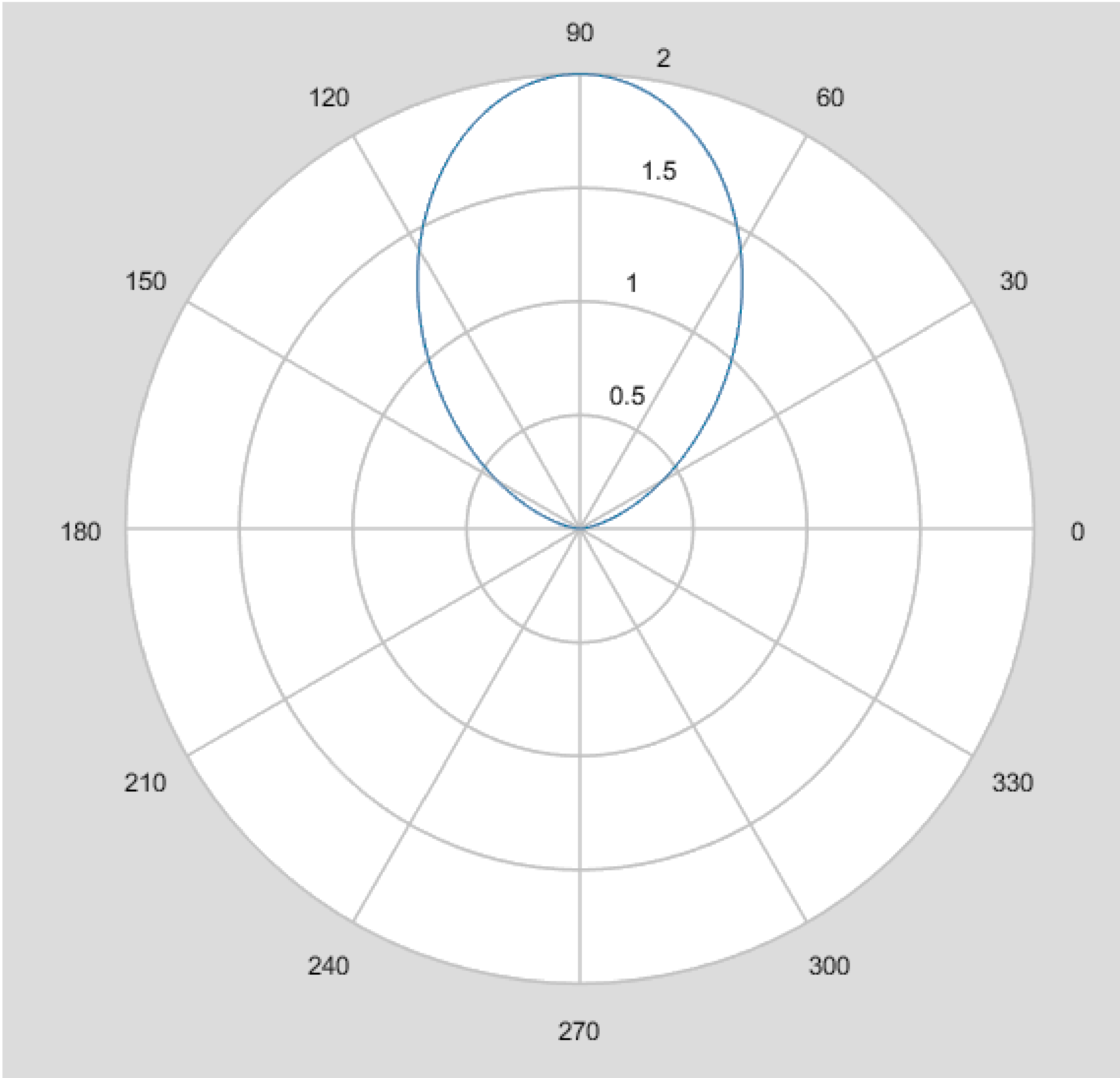
P2p Antenna Array factor (similar to radiation pattern just with the combined effect of the array) – horizontal.



P2p Antenna Array factor (similar to radiation pattern with the combined effect of the array) – vertical



Array factor for CPE Planar Endfire Array (horizontal)



Array factor for CPE Planar Endfire Array (vertical)

Evaluation in Radio mobile (simulation)

For Dipole Antenna:

i. The frequency range 740 MHz to 796 MHz

ii. Transmission power 19 dBm (943282 x e-02 watt)

iii. Receiver threshold -107 dBm (1 µV)

iv. Antenna gain 2.16 dBi

v. Antenna height 30 m

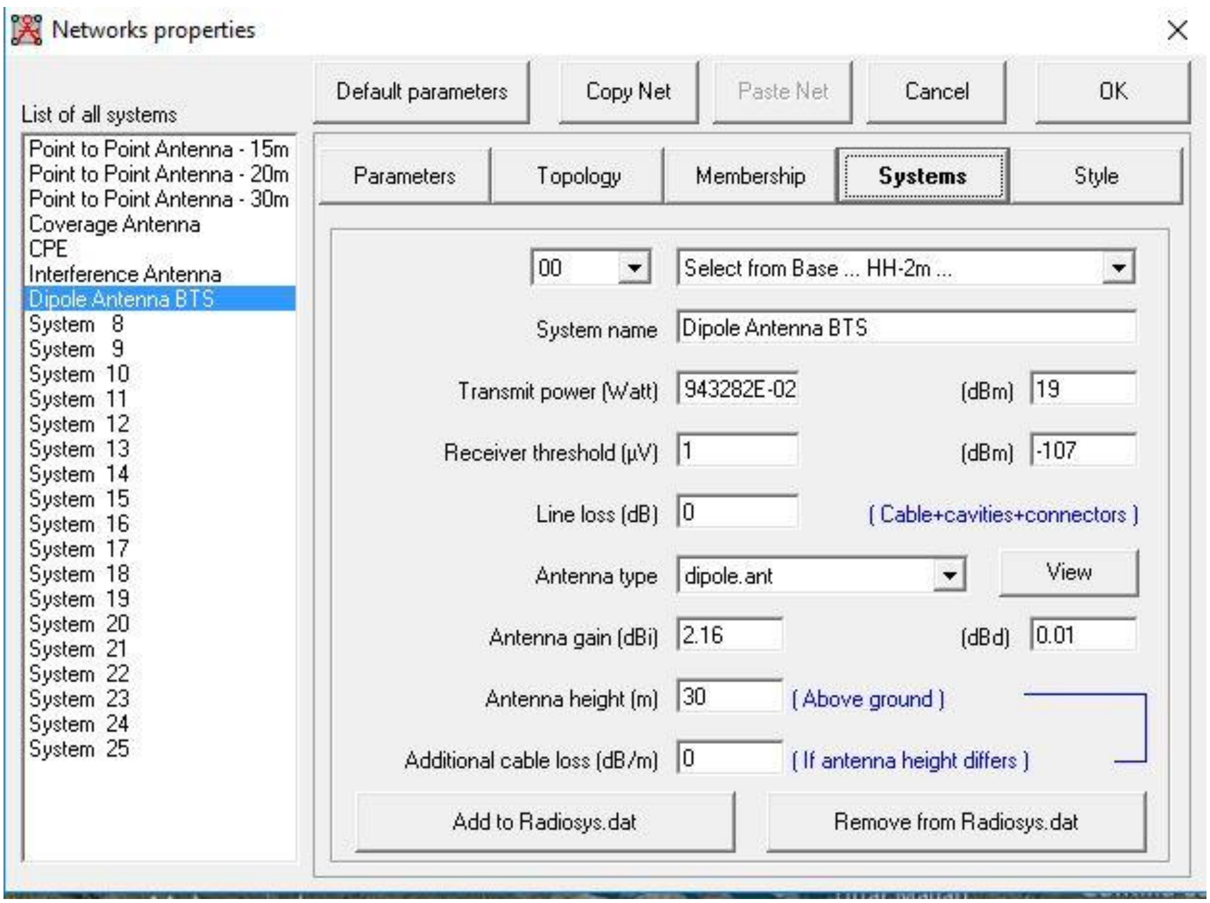


Fig: Antenna parameters in Radio-mobile

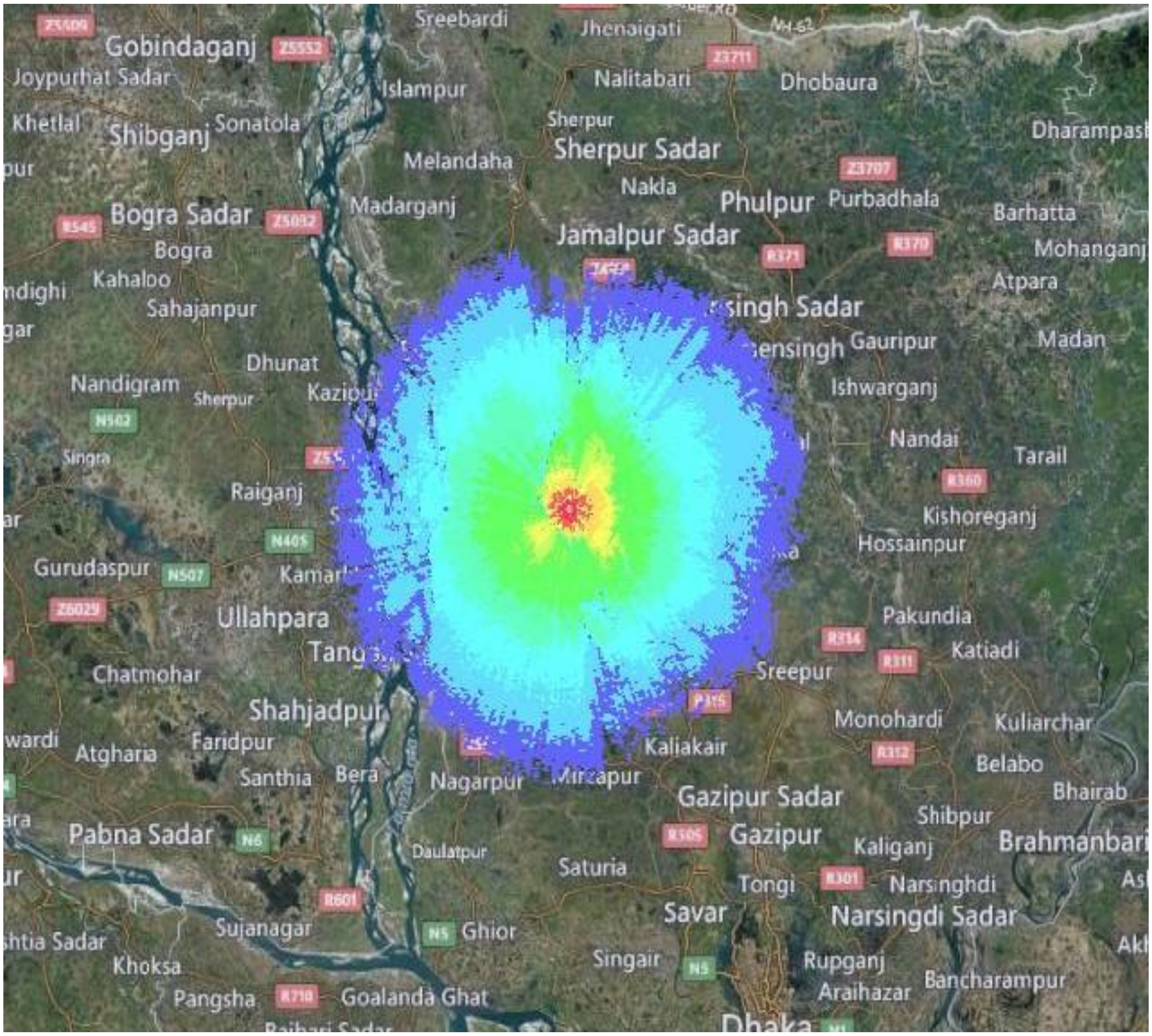


Fig: Antenna coverage in Radio-mobile

For P2P:

i. EIRP 2kW

ii. Transmission power 43 dBm

iii. Line loss 0 dB

iv. Antenna gain 20 dBi

v. Antenna height 30 m

vi. Receiver threshold -90 dBm (For 16 Mbps)

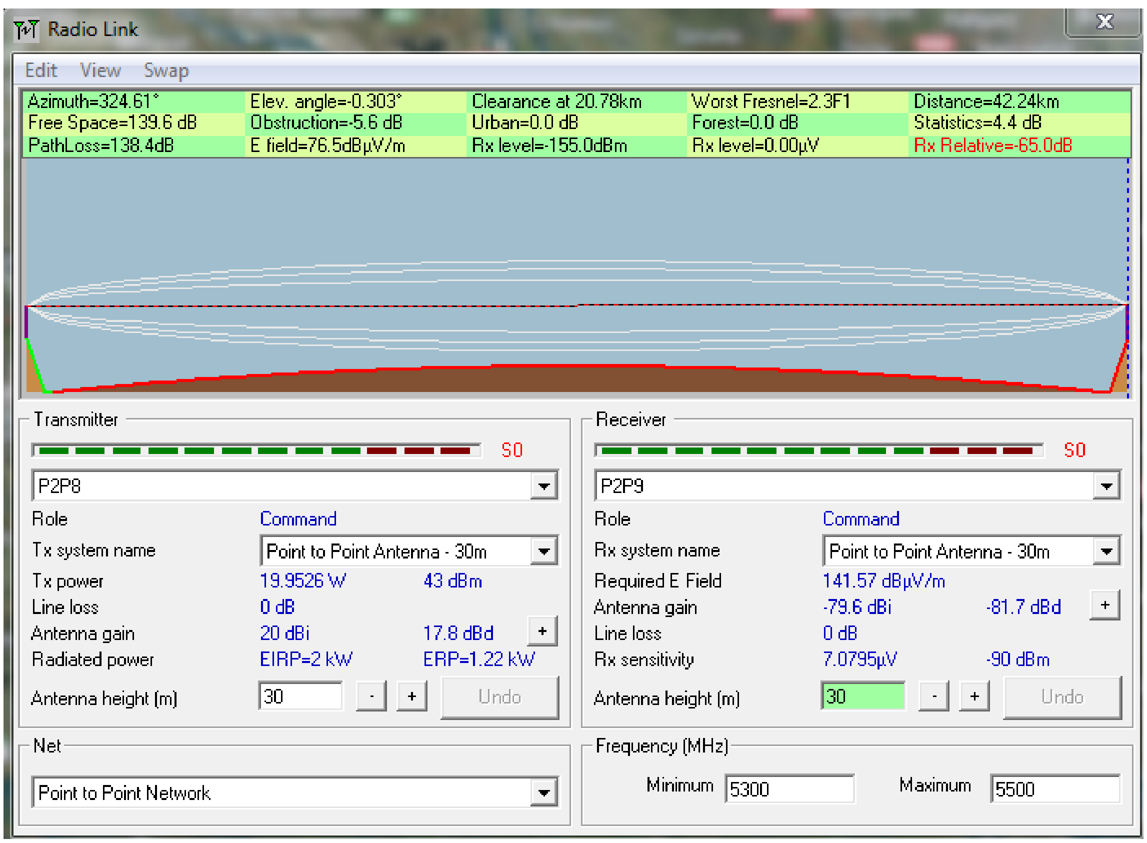


Fig: Antenna parameters in Radio-mobile

Fig: Antenna position in map through Radio-mobile

CHAPTER-05

CONCLUSION

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Summary of outcomes:

IEEE 802.22 is a widely discussed standard and this is also expertly implemented in many rural regions of the world. This is accepted and appreciated in many rural areas. Moreover, this is also proper utilization of the available white space. In many rural areas of the country, HD channels are not much used and the spectrum remains empty whereas, the spectrum for the broadband connectivity is already quite congested. Thus this new attempt and concept to provide broadband connectivity is very much efficient. According to the perspective of Bangladesh, this new technology will be very much cost effective and also economically feasible. However, this must be also concluded that P2P links will not be effective in the perspective of Bangladesh. Thus, implementation of broadcasting antennae will be much more effective as this will ensure uniform coverage on maximum area. This will also be cost effective as the number of antennae required will be much less required. Moreover, the CPE design is quite accurate to the point and can be implemented with the cognitive radio sensing as discussed in this paper. Even the antennae are chose in such a categorized manner so to serve the purpose of this project. Thus, this paper proves and enhances the potential of growth of WRAN in the rural areas of Bangladesh.

Future work:

The WRAN can be implemented in our country in many ways to accomplish better connectivity and also to provide educational facility. In this paper, it is proved that P2P can be provided but for coverage purpose this is not much feasible. Thus connecting the maximum of Bangladesh, broadcast antenna will be a better option. However, this is already known that the terrain of Bangladesh is reasonably flat but there are some hilly areas in Chittagong, Rangamati and Bandorban. In these areas broadcast antennae might not be as much effective as there will be a good amount of fading for the hills. Thus, for these certain areas P2P antenna needs to be used. In Bangladesh, these hilly areas are not much of primary focus and that is why they do not have any sort of broadband connectivity. So in these hilly areas P2P link can be implemented as they have natural elevation and so they will have constant Line of Sight. This will ensure a quite a significant coverage of the area. [10] Even in these areas the facility and quality of education is much backdated. Thus, if this technology can be successfully implemented there, then this will enhance the educational quality of these areas. Moreover, this will be very much cost effective to set up a P2P antenna links in these areas. Considering the hilly areas, not much antenna will be required. Additionally, the antenna and the whole of the infrastructure will not be much affected due to any sort of weather degrading. Thus, there are a lot of scope is presented by IEEE 802.22 and this can also be efficiently utilized in many rural regions of the world.

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