Design And Development of 5.5 Ghz Dual Polarized Dish Antenna For ISM Applications

Pundaraja[1], Chandrakala V[2], Sandeep Vedagarbham[3]
[1]Dept of Telecommunication Engineering
[2]Assistant Professor, Dept of Telecommunication Engineering
[3]Chief Technical Officer (RF division)
[1, 2] Dr. Ambedkar Institute of Technology, Bengaluru
[3]Lambdoid Wireless Communications, Bengaluru

Abstract- *The 5.5GHz frequency band is quickly emerging ISM technology that is getting to be famous over the long existing 2.4 GHz technology that we are altogether acclimated as well. Unlike the 5.5GHz band, the 2.4GHz band is so vigorously used to the point of being packed, Signal Quality debasement caused by such clashes can cause as often as possible dropped associations and unreliability of service. The more noteworthy measure of channels that are non-overlapping in 5.5 GHz band gives more degree to the aggregate number of remote gadgets. The 5.5 GHz band has higher output power control on hardware and better NLOS. The Scatter abilities expands the penetrative impact through structures with respect to 2.4 GHz. The high levels of gain and high directivity properties of the reflector antenna can be combined with 5.5 GHz antenna, to design a reflector antenna with better gain in 5.5GHz band. As the 5GHz band has various advantages with regard to 2.4GHz band.*

Hence in this project a dual polarized reflector antenna with rectangular horn feed is intended for 5.5 GHz band for ISM applications. The Reflector antenna is designed using CST software which is a commercially available electromagnetic simulator. The proposed antenna is expected to be cost effective with high gain and high directivity covering a wide range of frequencies from 4.9GHz to 5.9GHz.

Keywords- Rectangular Horn Antenna, Parabolic Antenna, Vector Network Analyzer, CST Tool, Waveguide

I. INTRODUCTION

Wireless communication is among technology's biggest contributions to mankind. Remote correspondence includes the transmission of data over a distance without help of wires, links or some other type111s of electrical conveyors. The transmitted distance between 10-15 meters, for Ex: TV's remote control and for hundreds of kilometers, Ex: Radio correspondence. Antenna is defined as a metallic device for radiating or receiving radio waves.

A means for radiating or receiving radio waves. In other words, Antenna is a transducer which is used to transmit and receive electromagnetic waves. a conductor by which electromagnetic waves are sent out or received, consisting commonly of a wire or set of wires. In the field of wireless networking, a receiving wire or elevated, is an electronic gadget which changes over electric output power into radio signals. It is normally utilized with a transmitter or radio beneficiary. While transmitting electric power to the reception equipment's end and the receiving wire receives the signal from the present as EM waves. the end destiny is to deliver an electric current at its terminals, which is joined to a beneficiary to be opened up.

An explanatory reception apparatus is a receiving wire that uses an illustrative reflector, a bended surface with the cross-sectional state of a parabola, to coordinate the EM waves. The most widely recognized frame is formed like a parabola and is famously called a reflector reception apparatus or illustrative dish. The primary favorable position of an illustrative reception apparatus is that it has high directivity. It works likewise to a searchlight or electric lamp reflector to coordinate the radio waves in a restricted bar, or get radio waves from one specific bearing as it were. Allegorical reception apparatuses have a portion of the worthy additions, implying that they can create the tightest pillar width of any receiving wire compose. the end destiny is to finish limit pillar width, the illustrative reflector must be significantly bigger than the bandwidth of the radio waves utilized, so explanatory receivers are utilized as high recurrence of the EM wave range, at UHF and microwave (SHF) frequencies, at which the wavelengths are sufficiently little that helpfully estimated reflectors can be utilized.

II. METHODOLOGY AND TOOLS USED

The main aim of this work is to design and build high gain, low cost, low profile 5.5 GHz reflector antenna. Investigate the ITU standards to determine the operation frequency of proposed antenna and determine the antenna configuration which will meet the gain, low cost, and low profile standards of the project. Once an antenna design is chosen, the design parameters must be formulated, shape and feeder of the antenna has to be designed. Simulation tool is used to analyze the design parameters. To build the design and test the antenna to compare simulated results with experimental results to evaluate whether or not the designs goals were achieved.

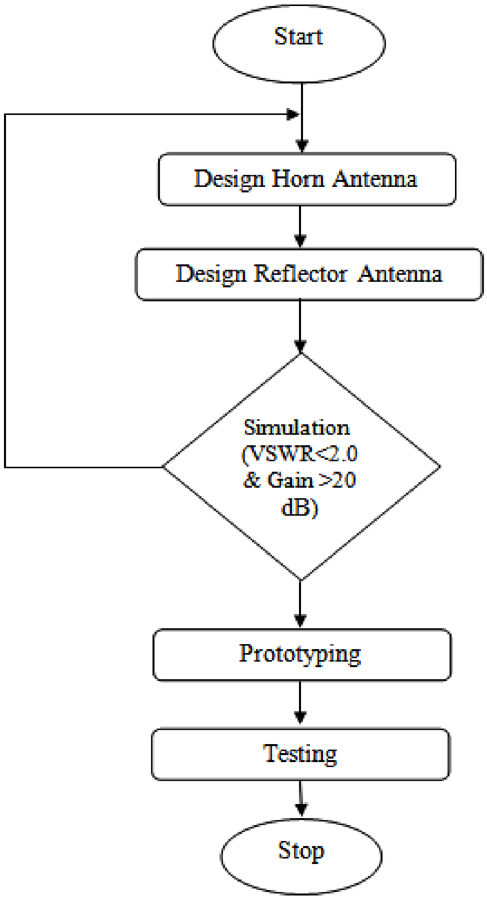

Figure 1: Design Flow Chart

CST offers correct, economical process solutions for magnetic force style and analysis. Standard time 3D EM simulation computer code is easy and permits to decide on the foremost acceptable technique for look and optimization of devices for operation in a very wide selection of frequencies.

Microwave studio part of the CST studio is one of the important application of CST STUDIO SUITE.RF design engineers make use of the CST MWS STUDIO for designing of antennas, filters and couplers due its promising performance in the field of microwaves.

CST MWS STUDIO has a lot to offer in convergent thinker technologies, it is operative in both the time and frequency domain. It is also capable in mistreatment surface meshes and tetrahedral volume meshes. To enhance the basic solving techniques known as solvers, local time Microwave wave Studio conjointly inherits associate integral equation convergent thinker, associate straight line convergent thinker, associate Eigen mode {solver problem convergent thinker convergent thinker} and TLM solver, and every application is well-suited to different situations. “Complete Technology” approach of the CST to simulation, it is the best 3D EM solver With CST’s “Complete Technology” approach to simulation, the best 3D EM solver for any given problem in Electromagnetic design.

The network parameters play an important role deciding the quality of a network and hence measuring of the same becomes very important and the instrument that can be used to measure rather analyze such type of parameters are known as network analyzers. Network measurement devices usually measure S parameters since return loss and VSWR parameters are bound by S parameters and also other parameters are y-parameters, z-parameters, and h-parameters that can be measured. The Network measurement can also be done at higher frequencies; operating frequencies can range from five cycles to one to 1.05 THz. Some types of analyzers can also cover lower frequency ranges down to 1 Hz.

The two basic types of network analyzers are

- SNA—only amplitude characteristics can be measured.
- VNA—both amplitude and phase characteristics can be measured.

III. DESIGN OF FEED HORN

A horn antenna or microwave horn is an antenna that consists of a flaring metal waveguide shaped like a horn to direct radio waves in a beam. Horns are widely used as antennas at UHF and microwave frequencies, above 300 MHz. They are used as feed antennas or feed horns for larger antenna structures such as parabolic antennas, as standard calibration antennas to measure the gain of other antennas, and as directive antennas for such devices as radar guns, automatic door openers, and microwave radiometers. Their advantages are moderate directivity, low standing wave ratio (SWR), broad bandwidth, and simple construction and adjustment.

The rectangular horn feed is design for a desired forward to backward ratio F/D by selecting the perfect dimensions. Selecting of waveguide diameter is done by some calculations.

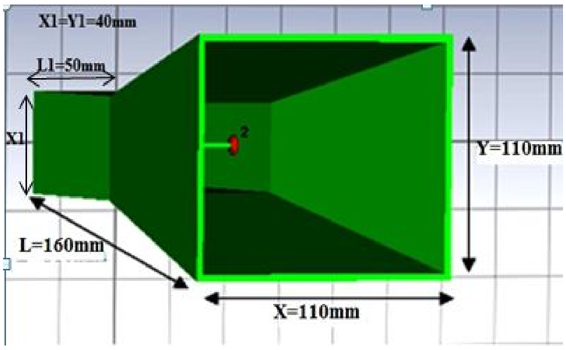

Figure 2: Horn Antenna Design

The horn feed is consisting of two parts one is waveguide part and another one is horn part which are having the following dimensions, flange X=110mm, flange Y=110mm and total length of horn is L=160mm and waveguide is having X1=40mm, Y1=40mm with length of waveguide is L1=50mm.The length of dual pole antenna is exactly λ/4=13.62, where λ=54.5 for 5.5 GHz frequency.

Following dimensions are the standard horn antenna dimensions which are used to calculate the Vertical and Horizontal Beam Width:

X=110, Y=110, L=160

Where, X is Width of horn antenna
Y is Height of horn antenna
L is Length of horn antenna

$\text{Gain}=10*A/\lambda^2$
$=10*12100/(54.5)^2$
=40.73
=10log(40.73)
Gain =16 dB

$\Phi_v=51*\lambda/Y$
Where, Φ_v- Vertical beam width
Φ_h- Horizontal beam width
=51*54.5/110
$\Phi_v =25.26°$

$\Phi_h=70*\lambda/X$
=70*54.5/110
$\Phi_h=34.68°$
λ/4 =13.62 ------>Length of dual pole antenna

IV. DESIGN CALCULATIONS OF PARABOLIC REFLECTOR ANTENNA

The parabolic antenna is completely described by two parameters, the diameter D and focal length F. The following parameters are used for designing the parabolic reflector antenna.

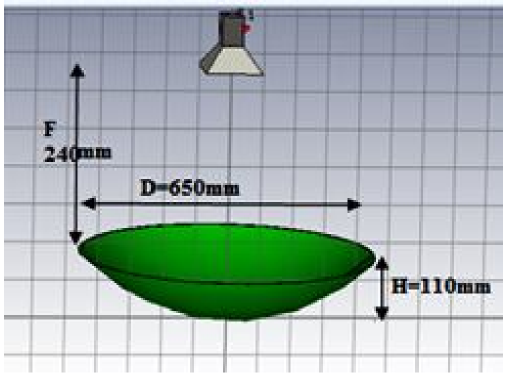

Figure 3: Parabolic Reflector Antenna Design

In software implementation, we have designed a reflector in CAD software and then designed reflector is imported to CST with horn antenna with this scenario we adjusted some axes for proper positioning, after this simulation is done. The main advantage of a parabolic antenna is that it has high directivity. It functions similarly to a searchlight or flashlight reflector to direct the radio waves in a narrow beam, or receive radio waves from one particular direction only.

λ=c/f
$=3*10^{-11}/5.5*10^9$
λ= 54.5

$\text{Gain} =6(D/\lambda)^2$
$=6(0.45*10^3/54.5)^2$
Gain =409.05
=10 log (409.05)
Gain =26.11dB

Focal Length Calculation:

$F=D^2/16*H$
$=620^2 /16*100$
F =240 mm

For simulation of dish antenna will take more time because it will check all the electromagnetic properties with far field, VSWR, E-plane and H-plane.

V. RESULTS AND DISCUSSION

The Signal Hound USB-SA124B may be a package outlined Radio (SDR) optimized as a twelve.4 Giga cycle spectrum analyzer. it's compact, straightforward to use, and an efficient troubleshooting tool for general research lab use. The signal hound is constructed around a narrow-band IF-to-bits receiver with a most information measure of 250 kHz. It receives up to 2MB of I/Q information every second, that it processes into trace. I/Q area unit the important and unreal parts of the complex-valued transmitted baseband signal. In communication systems "I/Q data" typically refers to the important (I) and unreal (Q) samples of the constellation for the modulation kind used. There area unit typically lots of I/Q "samples" (rather than "data") that happen throughout interim process.

Figure 4: Experimental setup for return loss measurement of prototype

The I/Q information comes in over USB associated is processed victimization an FFT with a Flat high Window. The package controls the bit rates and therefore the size of the supported elect RBW(Resolution Bandwidth). The offered RBWs area unit a operate of the span, since terribly giant RBWs with a tiny low span would lead to a trace with solely some information points and a blockish look, and extremely tiny RBWs with an outsized span would lead to an outsized information set that may be troublesome to manage and method.

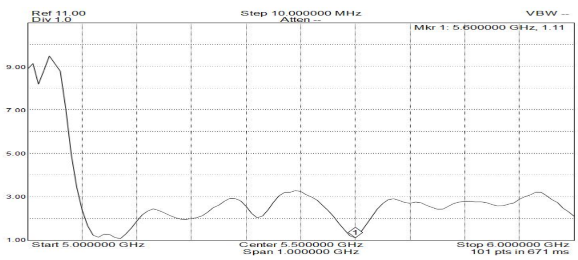

Figure 5: VSWR of reflector antenna(prototype) for port 1

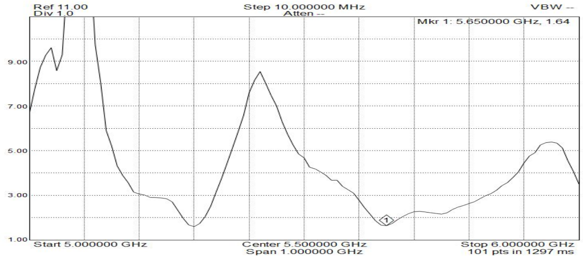

Figure 6: VSWR of reflector antenna(prototype) for port 2

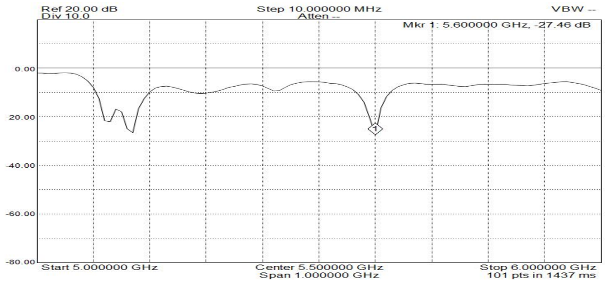

Figure 7: Return loss of dish antenna for port 1

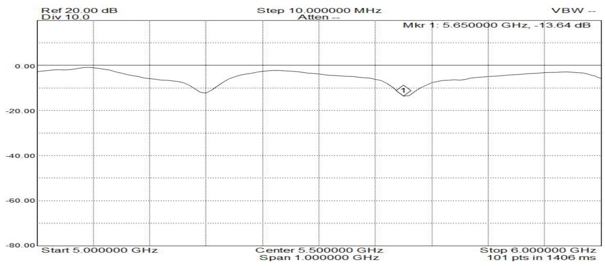

Figure 8:Return loss of dish antenna for port 2

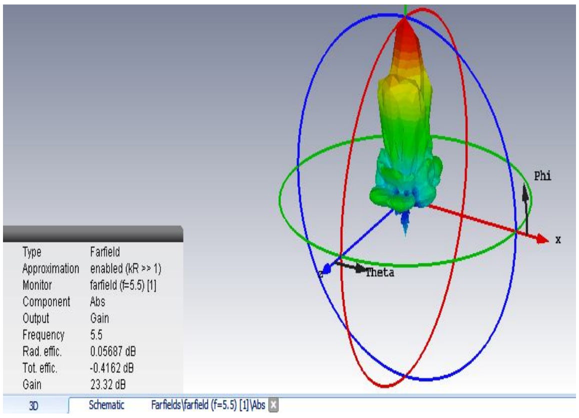

Figure 9:3D representation of far field pattern of reflector antenna at 5.5GHz for Port 1

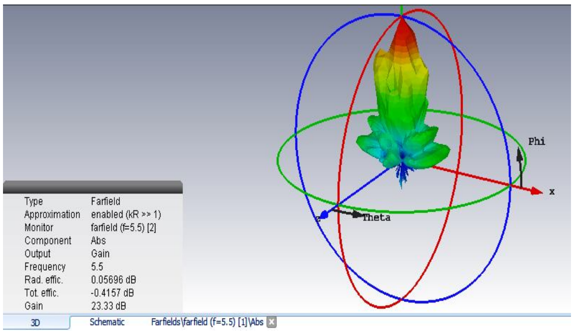

Figure 10: 3D representation of far field pattern of reflector antenna at 5.5GHz for Port 2

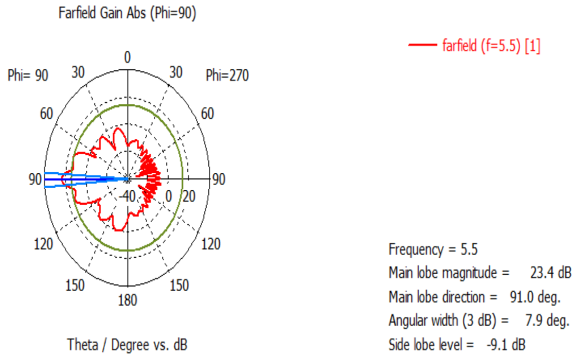

Figure 11:Polar representation of far field pattern of reflector antenna at 5.5GHz for Port 1

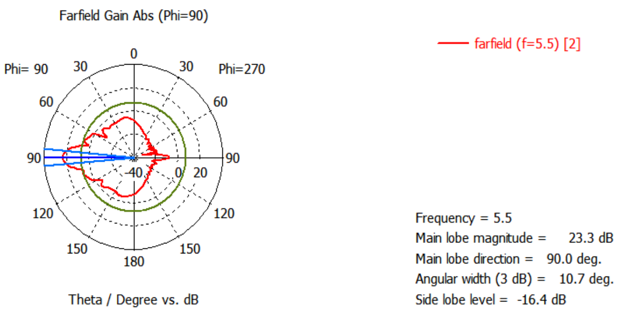

Figure 12:Polar representation of far field pattern of reflector antenna at 5.5GHz for Port 2

VI. CONCLUSION

The reflector antenna for 5.5 GHz band is designed, simulated and tested. The dual pole of the antenna is made up of copper, while the feed horn and reflector is made of aluminum in this project. The design is simulated using CST MWS software. The prototype is tested using Signal Hound tracking generator and Signal Hound scalar network analyzer. From both the simulation result and the experimental result the antenna is working over the complete band of 4.9 GHz to 5.9 GHz having a return loss less than -10dB over the complete frequency range.

REFERENCES

[1] MohmamadQudrat-E-Maula and LotfollahShafai, "Low-Cost Microstrip-Fed Printed Dipole for Prime Focus Reflector Feed", *IEEE Transaction*, Vol. 3, Issue 5, 2011

[2] Jagdish. M. Rathod and Y.P.Kosta, "Development of Feed for Parabolic Reflector Antenna", *International Journal of Engineering and Technology*, Vol. 1, No. 1,pp:1793-8236, , April 2009

[3] "Optimization of a Reflector Antenna System", Whitepaper CST AG.

[4] Chengda Yu, Shanhong He, Ping Li and Yongfeng Wang, "A Dual-band Low-Cost Printed Feed of Offset Parabolic Reflector Antennas for 2.4/5.5GHz WLAN systems", *IEEE Journals*, DOI:978-1-4244-8268-9/11/$26.00

[5] Rudan Jiang and Chen Wang, "Designing of Offset Gregorian Dual-Reflector Antennas with Non-circular Aperture using FEKO", *3rd Asia-Pacific Conference on Antennas and Propagation*, pp:54-59,2014

[6] Stutzman, Warren L, "Antenna Theory and Design", 3rd Ed. US: John Wiley & Sons, Gary A. Thiele, pp. 391–392. ISBN 0470576642, 2012

[7] Chatterjee, Rajeswari, "Antenna theory and practice", 2nd Ed. New Age International, p. 188. ISBN 81-224-0881-8, 2006

[8] Welch, W.J."Types of Astronomical Antennas", *Methods of experimental physics: Astrophysics. Radio telescopes*, Vol.12. US: Academic Press. pp. 13–14. ISBN 0-12-475952-1. Retrieved 2012

[9] Galindo, V. "Design of dual-reflector antennas with arbitrary phase and amplitude distributions". *Antennas and Propagation IEEETransactions*,pp:403–408. doi:10.1109/TAP.1964.1138236, 1964

[10] Willams, WF, "RF Design and Predicted Performance for a Future 34-Meter Shaped Dual-Reflector Antenna System Using the Common Aperture XS Feedhorn" , *Telecommunications and Data Acquisition Progress Report*, pp: 74–84, 1983

[11] Cheng, Jingquan, "The principles of astronomical telescope design", *New York: Springer*, pp. 359–360. ISBN 0-387-88790-3, 2009