DESIGN OF RECTENNA FOR WIRELESS POWER TRANSMMISON

SUBMITTED BY

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181-31-249

This Report Presented in Partial Fulfillment of the Requirements for the Degree of Master of Science in Electronics and Telecommunication Engineering

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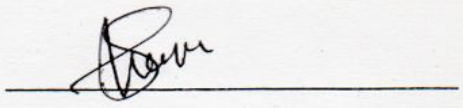
Approval

For these Project “Design For rectenna wps”, submitted by Ismail Bile Nour for Department of Electronic and Telecommunication Engineering, Daffodil International University, which accepted as satisfactory for the partial fulfillment of the requirements for the degree of MSc. in Electronics and Telecommunication Engineering and approved as to its style and contents

DECLARATION

I declare that this thesis entitled "Design of Rectenna for Wireless power transmission is my own original work and that it has not been presented to any other University for a similar or any other degree award. This research has reference where I got the software and the information.

Supervised by:



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First Al hamdullilah

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Next I would like to say thanks all my family who give me their support, also my class mated that we take together three semester and

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Abstract

The rectennas, that was combinations for rectifiers or/and antennas, was devices at “WPS” by air. By these thesis concentrate in the study, designed or measurements at compacts rectenna with WiFi “WPS” application. An objective for thesis into design a 2.44GHz rectennas at converts micro-wave signals onto Direct Current powers. rectennas presents general for rectifier antennas (rectennass) circuit-topology of WPS. Especially, rectennas constructed by the micro-strip patch antennas design software known as CST-suit-micro-wave-studio ADS, will described or fabricate by FR4 boards. Measurements experiments are taken for transmitted dissimilar I/P to used actuality restrained by dissimilar loads (650-10000Ω). Grounded of investigational results, AN thorough going Output voltages measured for loads are 194Mv at 21cm or 171MV at 30.0cm above 10000Ω resistors or 10.0dBm transmitted I/p or (-14.04Dbm) received I/P. for micro-wave into Direct Current conversions productivity for rectenna was measured as 95% for 20cm and 170mV for 30 cm respectively over1000 Ω resistor with 10 dBm transmit I/P OR -20.1dBM received I/P. this thesis effectively showed energy could be harvested consuming rectennass technologies.

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LIST OF ABBREVIATIONS

AC	Alternating Current
DC	Direct Current
FR4	Flame Retardant 4
RF	Radio Frequency
RECTENNA	Rectifying Antenna
WPT	Microwave Wireless Power Transmission
Z_{in}	Input Impedance
Z_O	Output Impedance
RFID	Radio Frequency Identification
CST	Computer Software Technology
ADS	Advance Design System
BW	Bandwidth
SMA	Sub Miniature A
R_L	Return Loss
PCB	Advanced Printed Circuit

CHAPTER ONE

Introduction

Remote Powers Transmissions be able to be portrayed in place of methodology that's contract spot now some capacity where by electrically power acquired from vitality sources or radiation towards electrically burden aside from communicating wire. two Wirless influence transmissions is used circumstances someplace quickly and relentless quality switch are required, anyway interconnection wire to be a difficult to reach, perilous, expensive, or impractical [1].In any case, the material science of WPT and wi-fi media transmission are unsettling however WPT is unique from remote transmission for transport records, (for example, radio and cell phones), where the offer of the power that is picked up is exclusively fundamental on the off chance that it shows excessively low to unequivocally improve the flag. two With wi-fi quality transmission, the effectiveness is an increasingly far reaching parameter and this creates fundamental forms in these connected sciences [2]. Close by more electronics gadgets or sensor that's work now states the spot its expensive, ungainly and unrealistic reestablish batteries or else salvage wire powers. Thus, close by expanded interest wi-fi vitality provider for these gadgets. Give us a chance to utilize the low power sensor or framework for instance; its typically work a short responsibility cycles or surroundings within low dimensions mature and wavering. In this way RF wi-fi control providers give a conceivable decision to continuing free tasks [3]One of the beneficiant imperative and central components of wireless power transmissioms contraption exists energetic switch for electrically powers.important factor for machine comprises ana receiving wire couple at an amending units. The total a reception apparatus or rectifiers normally alluded to as rectennas plus its can be trade electro-magnetic capacity at coordinate present day dc vitality [4].

1.2 problem statements

Remote purposes incorporate a first class arrangement of overabundance electromagnetic (EM) power into nature power which can be reused if adequately figured it out. A correcting radio wire and rectennas it's stimulating and testing such as it's intended at lessen the consonant flag avoids to the rectennas voltages misfortune via method for adjusting radio frequence flag to the dc voltages. So as demonstrate capacities as a design, a novels rectennas used to be advanced a low controls work to industrial scientific medical ISM recurrence of 2.5GHZ. Query round rectennas has prepared previous, anyway there are obstacles articulated approximately rectennas graph or generally execution are short vitality recipient radio wire that desires to fix it. In this undertaking, we will draw 2 by 2 exhibit microstrip fix stage to make greater a recipient quality reception apparatus in a verbal trade framework. Then, rectennasneeded by clear situated in the middle of the receiving wires or the diodes pleasantly to outfit greater yield control, by most extreme transformation productivity at burden resistor. Furthermore, the pushed configuration should be utilized for Wi-Fi application.

1.3 research objectives

To develop , analysis Micro strip patch antenna To

incorporate an rectifier

To learn and understand how to work rectenn

1.4scope for project

Plan , pretend a micro strip antennas that’s operate 2.5GHZworking software cst suite

Develop only one diode working advanced design(ads)software

Make an rectenna fr4 materials

Match simulators results and measurements results

1.5 project outline

This document comprises of (5) sections which are will clarify component about the test two The format of rectenna for wi-fi quality transmission.

The primary section in this report is a presentation. This section will give a synopsis of the errand as task foundation, adventure objective, mission scope, This part will give a clarification for rapidly about the typical task advance from opening until the task is finished.The 2d part is a writing audit. This part will discuss the truth and measurements from various supply sooner than continuing within venture. segment moreover examine about the present or earlies find out about for rectennas finding.party three are hypothetical foundation. that section was assessment substances or gear's this utilized herein venture. agreeable methodologies or material could picked at actualize in this undertaking.Party four section spirit portray the systems or strategies there has been utilized for this paper. An expected results or assessment could bee ensured for section four That subject had been unpredictable for accept final product of the absolute activities such as appropriately looking at estimated or reenacted results

CHAPTER 2

LITERATURE REVIEWS

2.0 INTRODUCTION

A remote power transmissions framework is appeared in Figure. 2.0 comprise for 3 primary useful squares. The primary squares to change the electrical to smaller scale waves DC-AC. Next emanates over spreading reception apparatuses, the radio forces is involved inside a consumed small scale wave beam investigations through allowed spaces toward recipient. It os accepting squares can be changes above radio frequency vitalities' from at power DC [1].

Proficiency of the frameworks is fundamental equals to it is exchanged works. An all-purpose sense at one efficiency η utilize hence forth is proportions for income controls done information's controlled . at common ability of remote power transmissions frameworks is the proportional for dc produce controls for that receiver or finale above at dc and ac ip controls for transmitters finale

2.1 rectenna of transmission power wireless

Proportions for produce controlling Power out above informational controlling Power in, Thus general efficiency ηall for a remote power transmissions frameworks are proportions at produce dc controls to recipient conversion of dc to the ac i/p controller for the transmit final. Which obtained ηall equal η-t.η-c*η-r (2.2)

It is starts and finished efficiency incorporates at every the substitute efficiencies start for DC supplier sustain radio frequency sources to transmitted at DC controller interfaces for receiver. Someplace (nt) is electrical conversion t0 micro-wave changes proficiency or transmitters productivity; ηc it is accumulation effectiveness; or ηr is the micro-wave conversion fir electrical transformations productivity DC TO RF change effectiveness of rectenna.

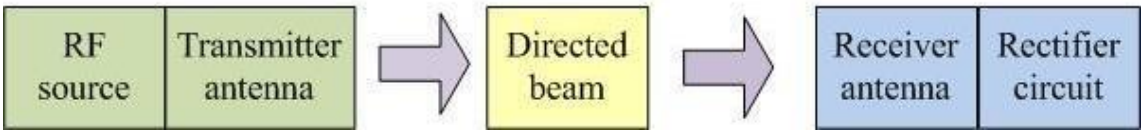


Figure 2.0

The principal term (ηt) equivalents for the results of magnetrons productivity "ηmag" and the transmitters receiving wire proficiency "ηa". thus magnetrons effectiveness it is utilize at prompt do product]e the radio frequency source function. The receptions apparatus effectiveness of the transmitters portrayed there is radio wires absolutely productivity which considers the recieving wire crisscrossing factor.

It's accept for in cooperation magnetrons proficiency or transmitters productivity are 99.9%. which suggests the generators of a perfect gadget which can give needed transmission power.

Gathering productivity "η-c" for proportion to gotten control above for pass on power. the greatest gathering proficiency,An ideal powers thickness circulation necessity chosen for the transmission radio wire gap. For gathering proficiency should be great while the impedances investigation collectors are coordination which has open planetary impedances. For gathering productivity are corresponding for the structure parameters τ, that is communicated by way of Goubau's connection [1, 1]

$$T = \sqrt{(A\text{-}r\ A\text{-}t\ )}/\lambda * D \quad (2.1)$$

Whereas , “Ar or At” are accepting or transmission compelling opening zones separately. λ are equal the wavel-ength of the radiations; the separation between the transmitting and getting gaps are D . for the capacity at collectors are gather to the approach radio frequecy powers to converts it’s to back to DC power. for right selection of gadget for achieves this assignments ares diode type rectennas.

customar rectennas frameworks is performed in Figure. 2.1. wireless power transmissions is to make out of receiving wire connected for a redressing circuits transmitting channel or] coordination circuits. for redressing circuits change terminated the get remoted power transmissions to the “DC” through low_pass channels and “DC” passes channels while circuits. The low_pass channels be able to recognized at response apparatus within circuits or squared for high_requested musics produced in amending diodes so as for improves great radio frequency to the DC changes productive. for correcting diodes fo embodiment component for rectifiers circuits. A heap resistors are agreed of produce terminals at gauge of “DC” produce voltage [2].

Figure 2.1 rectennas blocks diagrams

2.1 rectennas translating affiance

For radio frequency to Direct current change proficiency at rectennas is basically acknowledged such as rate of the yield control Po over the info control pin. That subsidizing for transformation productivity for totally framework are “DC” control to collector finale overs of “AC” I/P control caught through rectennass.

“ηt” = p-out/p-in = ((V_Dc^2)/R-load)1/(p-d A-eff) (2.2)

This change effectiveness emphatically relies upon the power thickness (〖 P〗 _d) conveyance over the collector opening. The compelling zone of the getting recieving wire (〖 A〗 _eff) obtained utilized the additional G-rrand wave-length.

{A}-eff = ((〖λ 〗 _0^2)/4π)G-r (2.3)

The most extreme occurrence control thickness can be inferred as pursues. Expecting a recieving wire which has an increase of G,t for transmitters. Directivity at

D-0 = (4πA-t)/(λ)-0^2)*(2.4)

The greatest happening power thickness can be determined as pursues. influencing a recieving wire which has an addition of Gt for transmitters. directivity eff gaine [3], that implies at intensity for primary shaft raise for d=0 a guaranteed way. Of the compelling regions of transmission receiving wires. Likewise, of dispersed that for separations between at transmission radio wire to the getting recieving wire would been relatively extensive of rectennas at works by farfield. Along these lines, for greatest extremely powers thicknesses of central points at gap are guarantee

〖 P〗 _ d = (Pt*Gt)/(λ-0^2) (2.5)

After this condition, a high PD look at the biggest Gt Working recurrence likewise an astounding parameters of looks time of design rectennas. this frequently directed in pined for applications. the least frequency (beneath 1.0GHz) hight increase reception apparatus faced actuality very. Expanding at recurrence in this manner approve the utilization of progressively implicit radio wires. something else, the measure of attackable power at a guaranteed separation from a producer are determined at "Friis" condition::

Pt = P-t *G-t*Gr (λ/4πR)^2 (2.6)

Where Pout are intensity at the producer, Gt and Gr are the producer or beneficiary recieving wire gains, separately λ are wave-length utilize for R are space disengage at producer or at recipient. It is implies reachable powers of guaranteed from space the producer diminishes such as recurrence increments. Frequency at 2.4 GHz up to 3GHZ array are hoped at source a decent change the point of freespace constriction at recieving wire measurements. They selected at format thier circuits are a focal recurrence of 2.5GHz

2.2 primary step rectenna

For beginning time, by request of finish up, the remote powers transmissions framework rectennass where improved towards or change over an electromagnetics waves to "DC" control. for primary rectennass has nonexistent of Raytheon's Enterprise by1963th as appeared at Figure 2.2; that has constructed or/and tried (R.H. George at Purdue University). They made out a proximally 27-29 half wave dipole, individually completed at extension rectifiers produced using by (1N82G points approaches, semiconductors diode above a reflect interceptors). Also powers yield at seven Watt by

made of foreordained 39% effectiveness. build powers yield fitting at helicopters explore, at coordinating system by supplementary in this structure or deliberate yield control has expanded at 265 Watt [4].

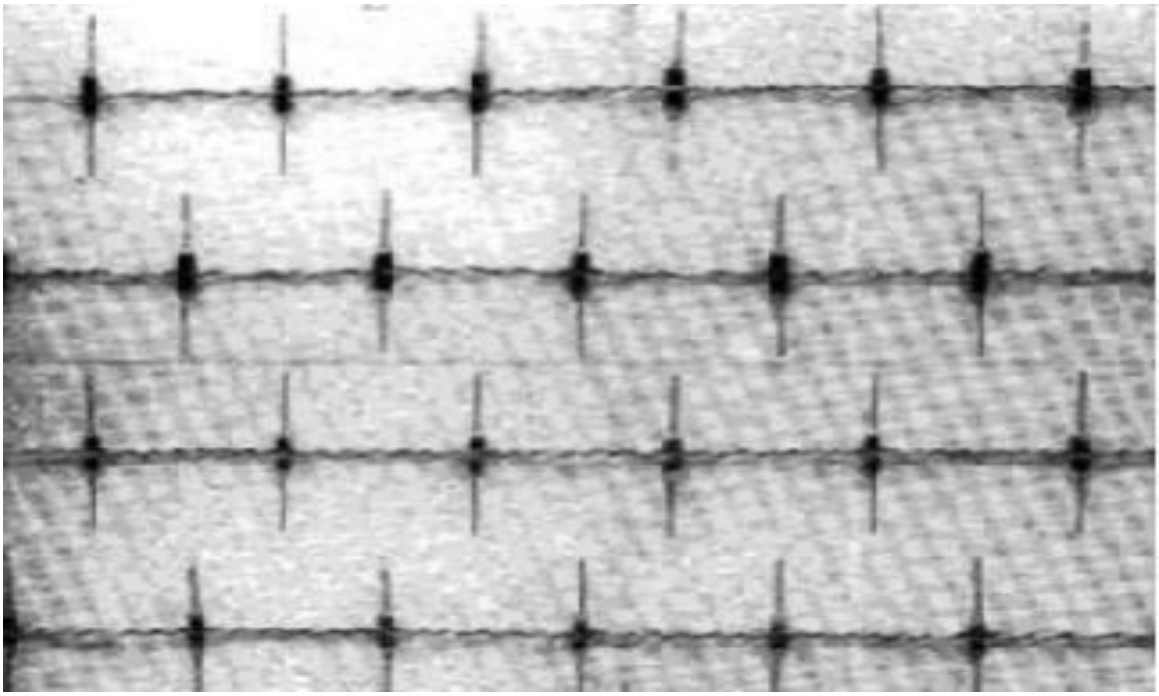
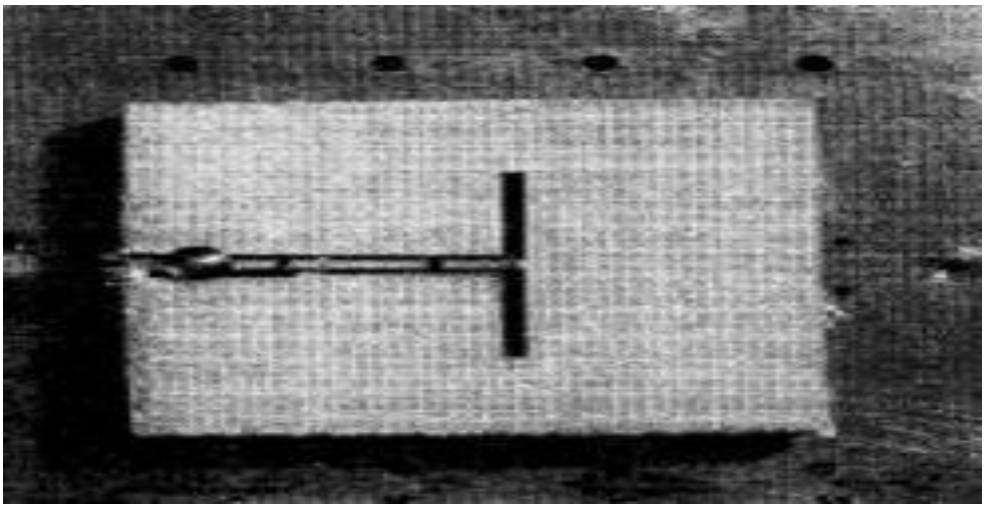
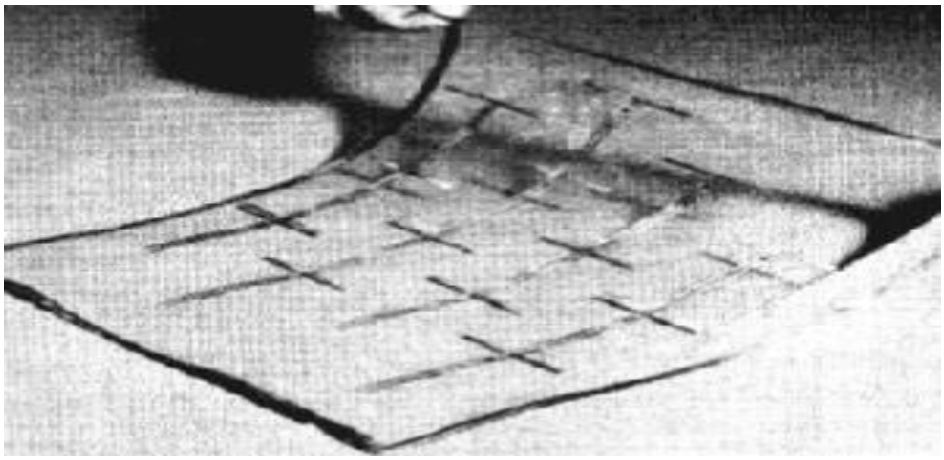


Figure 2.3

Afterwards by others dipoles types rectennas, appeare in Figure.2.4, attempt to recurrences at 2.43GHZ has displayed too. for more elevated change effectiveness's record for 90.8% had make by WC-Dark colore in 1978 utilized a "GaASPt Schottky's" obstruction diodes by data micro-wave controls dimensions at 8 W [6-9] for start periods, By requested close, of remote powers transmissions framework rectenna where improve change and to get above of electromagnetics waves onto Direct Current control. first rectennas has farfetched to Raytheon'z organization by 1962-3 such appeared for Figure2.3: that has constructed or tried of "R"H". George's University of Purdues. they made out by 27-28 half waves dipole, for each complete at scaffold's rectifiers yield used for 1N82G points_approachs, semiconductors diode above reflect interceptors. Besides powers yield at seven Watts has made to foreordained 39% effectiveness. for expand the powers yield suitable to helicopters try, coordinating system that add by structure of deliberate yield control has expanded at 270% Watts [4].



1) Rectennas elements beyond reflect planes



2) A rectenna of aircraft make to original slight films scratched circuits position 1982th

Figure:2.3: About primary rectennas

2.4GHZ normally utilized such as the transmission recurrence because of it is progressed or effective innovation, of an area for focal point of a modern-logical- medicinals (I-S-M) bands, it is little constriction from side to side of air level at substantial rainstorm.

Segments the micro-wave controlled transmissions where generally engaged to 2.5GHZ. for lessen the transmission or rectennas gap region, increment for transmitted run, A.P.C.P Powers Technology design at the 75% effective rectennas component at 36GHz by 1990-1.

By remote power transmissions, reception apparatuses by rectennas framework which has every about characterize polarizations, higher amendment productivity empower at single recurrences or higher power width occurrence by range the rectenna. Application with kind of this strength exchanges

was planned with micro-wave controller helicopters. Sun-based controlled satellite to ground transmission, among satellites transmitted to distance shor_tscope of remote power exchanges. [4, 11-12].

By 1992th Brown studied a 2.44HZ rectennas was assimilate tiny calculations ”MW” for micro-wave controller to episodes thicknesses level. for these new innovations that will modification above wireless power to lowest dimension onto Direct Current controller to help full voltages points, for orther’s applications with rectennas has true off the wink reference, that is Radio Frequency wireless powers collected. An potentials applications area for places of devices are hard at reached for displace battery or were Sun-oriented and others lighted is not accessed to photovoltaics power benefactors [5].
for rectennas can receive or changes terminate border remoted capability at Direct Current controls such as power providers. by Radio Frequency energy saving, rectenna should be manageable at gain surrounding Radio Frequency regulator. Beside this line. of rectennas wanted discretionary polarity, relatives highs improvement ability to Wide information transferring ability or countless executions to lower occurrences controller width.

An serving with investigation to the wireless powers collecting was complete by year of 1999-2000. An Planars rectennass display to the improvement at the broadband electro-magnetic flood for flexible polarizations has structure and/or described by2000-2001 [13]. Moreover, another rectennas reliant on open

couple smaller scaled striped dipoles or wide-band band-passes channels implanted coversion for range wire and the redress diodes has developed by 2002-3[14]. Remain these it's be, the 2 impartial givens of Direct Currents produce voltages or didn't have of after effected of transformations effective was is a key exhibition pointer

These days, the vast majority of the rectenna scientists were still unite on the remote power transmission. Because of the huge test of format wideband rectennas, just a couple of rectennas were a design for the RF control transmission [17].

2.4

2.4.1

An 2.43GHZ Dual Diode Radio Frequence to direct current Rectifiers for Rectennas Application

By these paper. Repugnance double diodes micro-wave rectifiers was offer, respectfully utilized worldwide analyzation instrument. Such that appeared 2.4 presentation of yield DC voltages or proficiency, for rectennas circuits, beside information control start 0.0 to the 16MW.to 10.0MW information control, of distinction among recreated or estimated efficacies at lower than 4% (60% to 56.1%). A symphonious equalization strategy predicts where AT direct current yield. they estimate a yield direct current voltages over 2.5V an ideal heap at 1050.1 Ω to 17 MW Radio Frequency controller levels

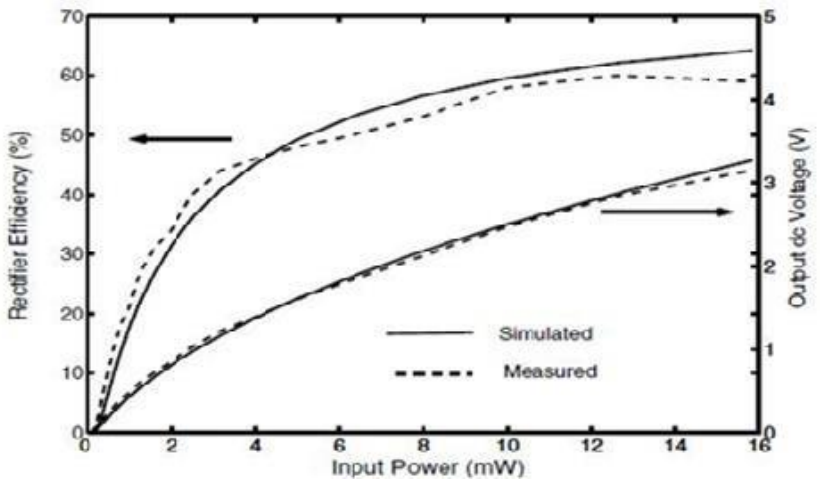
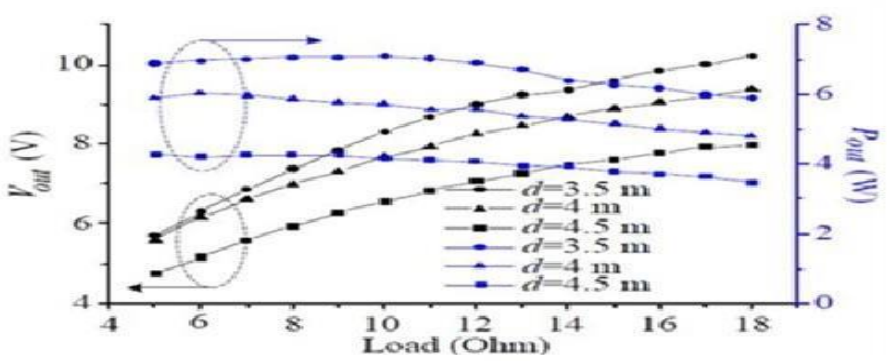


Figure:-2.4: - Description an rectennas circuits contrast concerning simulations and experimental

2.5,2 Learning S-Band Rectennas of Wireless Transmission Power Microwave

The deliberate transformation proficiency for rectifiers is above 59% for -10 dB dynamic scope of info control or most elevated productivity achieves 83.1%. The most extreme DC yield control and most noteworthy change effectiveness of rectennas exhibit are 7.2W or 68.7%, separately



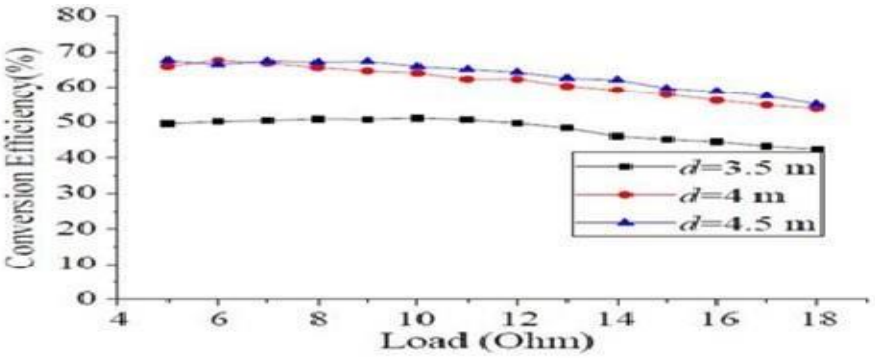


Figure .2.6 measure of DC voltage and and translation

2.5.3 Rectennas, Developments and Applications

This paper depicts the dynamic advancement of rectenna regarding its applications in different fields. The most extreme productivity as microwave control transmission was found to 91 % with 1.2 W of information control while if there should be an occurrence of symphonious dismissal, rectenna planned with round division recieving wire furnishes transformation effectiveness of 77.8 % with 150 Ω load and exceptionally exceptional yield misfortune at second and third harmonics.The RF to dc change proficiency for circularily enraptured is 78% at 16.5 mW/cm2 episode influence thickness while in the event of double recurrence the RF to dc transformation productivity of 65% and 46% are accomplished at 2.45 GHz and 5.8 GHz separately when influence thickness is 10mW/cm2.

2.5.4 2.5.5 Broadband Modeling of a Great Efficacy Rectennas of Battery less radio frequency ID System

These papers propose identical circuits models for dipoles reception apparatus which recognized utilizing experimental estimation results as appeared in figure 2.14, that an extremely decent minimized among of efficacies anticipate in my models to the deliberate one's to bee procured. Dependence offn rectennas productivity within of powers made out for dipoles recieving wire great

predicted onto test system. These clarifies at capacity of their comparable circuits demonstrate way for deal with accurately portray the conduct of the rectifier. In any case, it's necessity reference wich modification for diodes breaks down voltages factor By at value leaving since at segment datasheets must be performed which achieve this understanding.

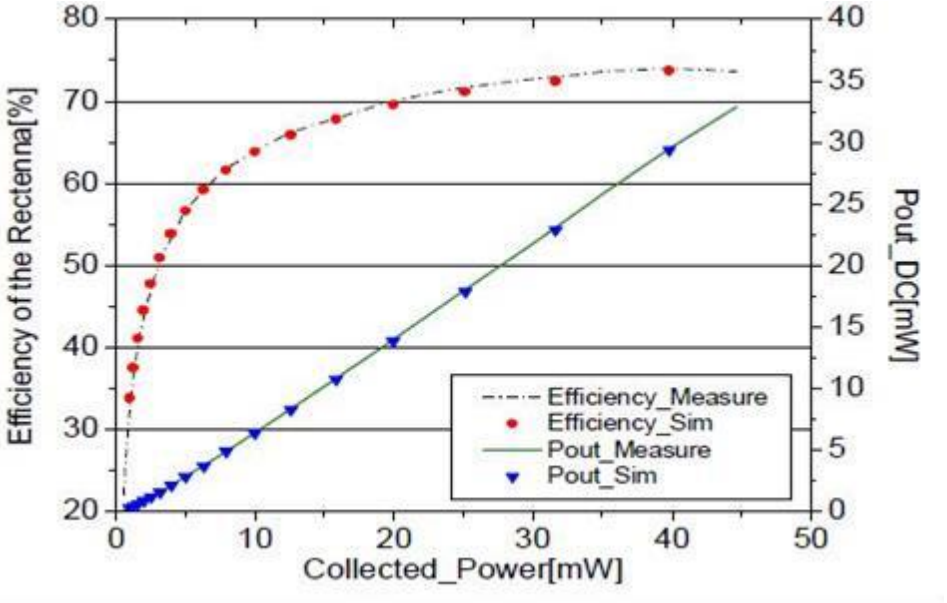


Figure: 2.9: -Efficacy an rectennas and POWER OUTPIT _Dc MW

2.55 Radio Energy Harvest Systems and Rectenna

this paper, an investigation of different techniques utilized for RF-vitality reaping takes existed make. To discovered which they do gather vitality on miniaturized scale Watts(w) extend after encompassing Radio Ffrequence source. Now for reaped powers very relies upon by separation concerning transmission for Radio frequency collecting framework. in utilizing a variety at reaping recieving wires they be able to collect extensive measure at intensity.

Such that appeared for Figure:2.12 demonstrates for recurrence reaction at a 898 MHz rectennas. At this point pinnacle to the 893MHZ for this recurrence they got a yield direct voltages of 2.9V. When all is said in done it is hard to anticipate how the rectenna framework is improved for the greatest transformation effectiveness. Be that as it may, there are a few hypothetical techniques to defeat this issue

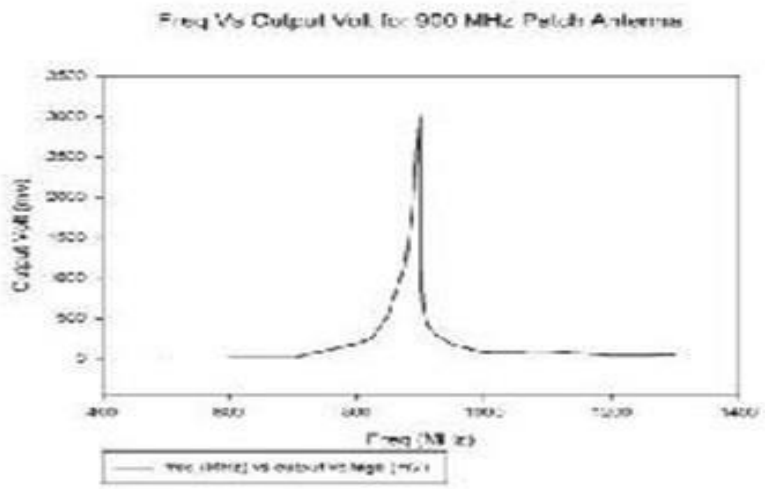


Figure:2:.10 Frequency Responses for 898 MHZ Rectennas

2.5.6 **Development of a 2.44 GHZ Circularly Polarization Rectenass an Electro magnetic Energy Harvest**

GHz circular spellbound rectennas was taken mannered utilizing Agilent's "ADS". to provide volt yield Direct Current voltages of 1.6db got I./ Radio Frequency control. Music level to that yield be situated securely diminished.Works for the continued for all intents and purposes bolster in designs. Of Direct Current voltage are procured on estimating foe voltages contrast somewhere in the range at voltage one and voltage two toward at 159.10Ω resistors.Deprived for references for Radio Frequency groundplanes

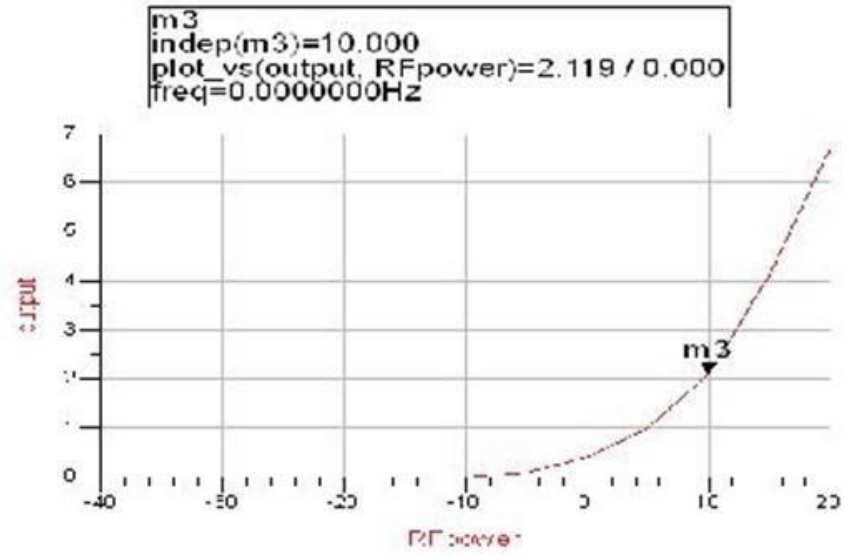


Figure:2.11 OP Direct Current voltages against receiver Radio frequency power

2.5 APPLICATION

The main mechanical improvement that has enabled these slicing gadgets to create enough power is through the advancement of collectors which can detect wide scopes of recurrence, not simply restricted to TV signals, while holding most noteworthy convergence of produced waves. Be that as it may, control vitality from various sources, for example, mobiles base stations, Wi-Fi, Radio waves and so on. A radio wires is utilized to hold signals, it might be a broadband reception apparatus or separate recevie wires for various frequencies. At high frequencies we can utilize little reception apparatuses like fix cluster get wire, however at low frequencies we need a vast radio wire, for example, an adjustable receiving wire in FM radios [20]

CHAPTER THREE

METHODOLOGY

3.1 Introduction

The task is begun by choosing the kind of reception apparatus use for rectenna structure and the working recurrence of a radio wire. At that point, the coordinating system is intended to ensure the radio wire is coordinate with the circuit and reject the high request consonant flag. Ultimately, the correcting circuit is configuration to change over the microwave flag to DC control.

For the reception apparatus part, the 2.45 GHz microstrip cluster recieving wire is chosen for this undertaking. Microstrip exhibit radio wire is chosen since it is

reasonable and little size. In this undertaking the fundamental exhibit fix embed feed is picked for rectenna arrangement. A reception apparatus is configuration by utilizing CST-microwave programming.

By to redressing circuits, here was 2 kind for diodes setup, the first is single diode design that determined by halfwaves rectifying, for next is double diodes arrangement that give full_wave rectifying . by these task, utilize GaAs's Schottkyies "HSMS 2862" sort chose. This diodes are put the center of the reception apparatus to walked circuits.

At first, these investigation had begun for broad hunt on data,informations accumulation, sorting to helpful data or breaking down data for serves at task. for procedures to planning for rectanna has been disentangled on utilizing stream diagram. for stream outline clarifies to undertaking procedures or It iss subtask for satisfy transient objectives. Figure 3.1 outlines the stream graph delineates the stream diagram. For the most part, this section centers around three noteworthy procedures, which are: Designing procedure, reenactment process

3.1 flows charts

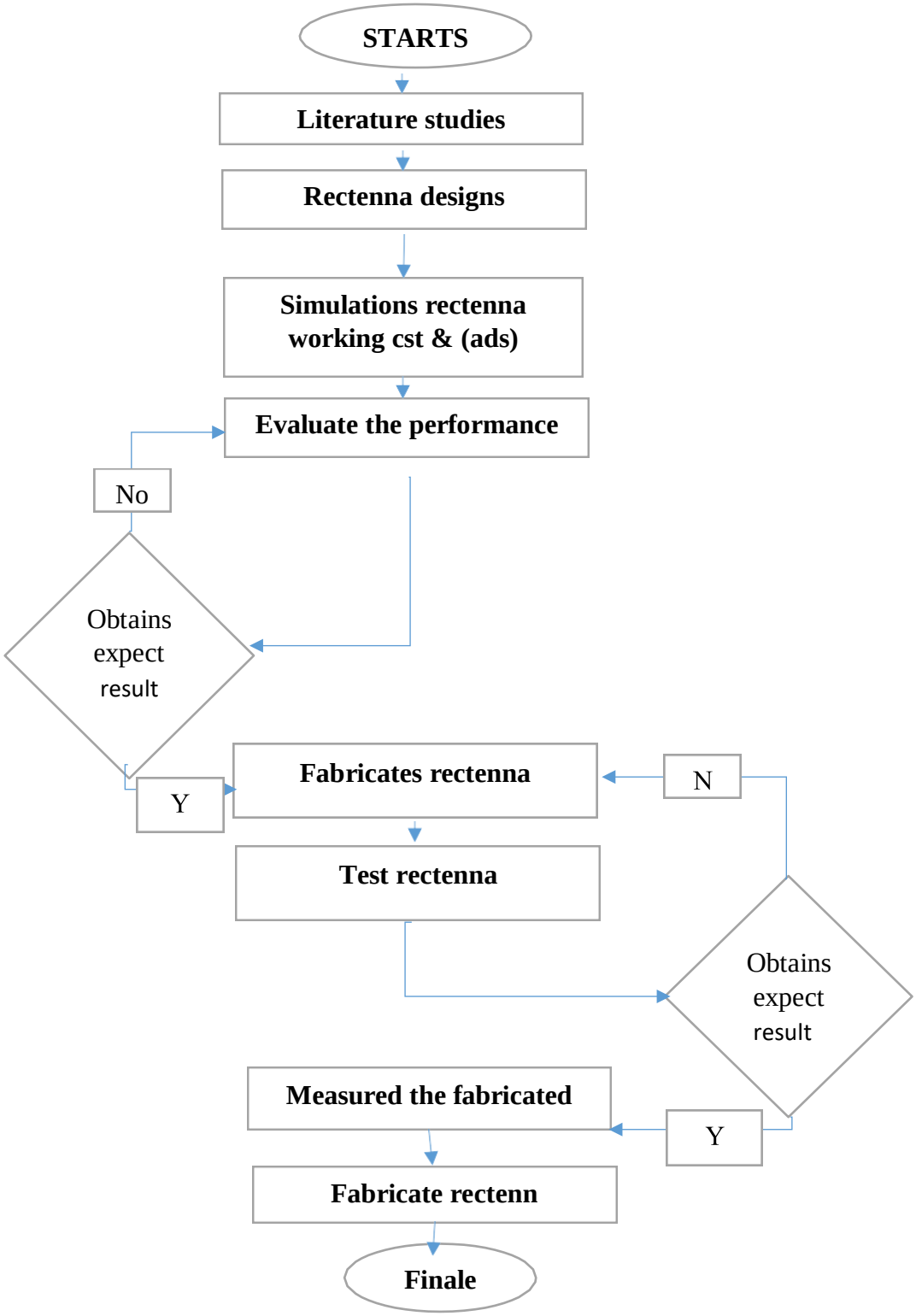


Figure:3,1 flows charts

3.3 Designs procedure

This part clarifies about the structuring and determinations of the rectennas receive wire. By and large, the structure procedure of this receiving wire is three sections traditional square micro strip fix radio wire, low-channel and rectifier circuit

3.3 designs squares patch antennas

There 3 important parameter of designs for square micro-strip antennas

Table 3,1 parameter that are essentials are

freq	2.44ghz
Ɛr	4.2
h	0.9mm

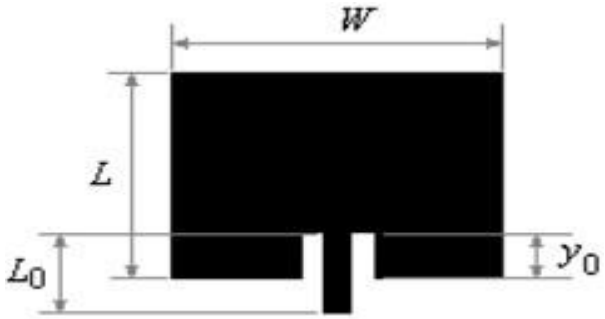


Figure:3.1:- design a one by one e patch antennas for insert feeds

for engendering te electro magnetic fields are normally considere for the space of free, someplace to goes for speeds to the light c equal 3x10⟧^8m/s.

λ lamda was wave-length, communicated by meter

Wave-length for GSM-band

By GSM-band, for accompanying articulations are utilized

λ=C/(FR[GHz]) (3.2)

Subsequently, for wave-length for at reception apparatus while working for 2.44GHz equal .1223mm

The width and the length of substrate is λ/2.

λ/2 = 61.22 mm

From the abovementioned, the basic parameters for the structure we can compute that

Computation of the width

W=c/(〖2f〗_r √((〖(ε〗_r+1))/2)). (3.2)

Substitution C = 3x〖10〗^8m/s, ε_r =4.3, fr = 2.45GHz

37.34mm

Computation of compelling dielectric steady

ε_reff=(εr+1)/2+(εr-1)/2〔1/(√(1+12〔h/w)〕)〕 (3.3)

Substitution ε_r =4.3, W =36.266mm, h =1.6mm

= 4.3459

Computation of length augmentation

ΔL=0.412h (ε_reff+0.3)(W⁄h+0.264)/(ε_reff-0.258)(W⁄h+0.8) (3.4)

Substitution W =16.75mm, h =1.6mm, = 4.3459

=0.732069 mm

Computation of the genuine length of the fix L=

c/(2f_r √(ε_reff))- 2ΔL (3.5)

Substitution C = 3x〖10〗^8m/s, =3.78, fr = 5.5GHz

L = 29.09mm

Computation of a microstrip feed line width

W1/h=(8e^A)/(e^(2A)- 2) W_1/h<2 (3.6)

Where, An is Z_o/60 √((εr+1)/2)+(εr-1)/(εr+1)(0.23+0.11/εr)

Substitution ε_r =4.3, h =1.6mm, Z0 =50

A= 1.516, Substitution back in to condition 3.6 W1

= 2.87mm

Line length

Lo= λ/4 (3.7)

= 14.52mm

Figuring of supplement

$$y_o = [10]^{(-4)} \{0.001699\varepsilon_r^7 + 0.1376\varepsilon_r^6 - 6.1783\varepsilon_r^5 + 93.187\varepsilon_r^4 - 682.69\varepsilon_r^3 + 2561.6\varepsilon_r^2 - 4043\varepsilon_r^1 + 6697\} \times L/2 \quad 2 \leq \varepsilon_r \leq 10 \quad (3.8)$$

Patch	
W	37.25mm
Length, L	30mm
Feedline 50Ω	
W1	2.9mm
LO	15mm
YO	6.2
Inserts gap	1.1mm

the current investigation we planned a cluster with two components. Figure. 3.3 outline the geometry of the exhibit with all measurements utilized and the discontinuities in feed arrange. The feed system of the exhibit was intended for the flag can achieve the radio wires in an equivalent manner. For the dissemination of the evened out flag to the two components of the exhibit, a few discontinuities have been consolidated in feed lines that make up the system.

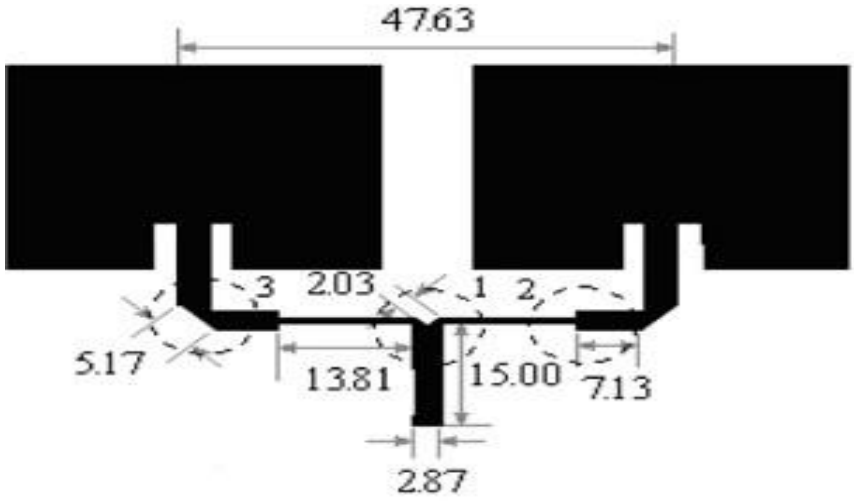


Figure 3.3: Design an single square patch antenna with insert feed

Rectifiers & match circuits

The Rectennas named as amending reception apparatus which is the mix of the receiving wire and a non-straight redressing component. The two components are coordinated into a solitary circuit, such a framework is able to get RF control and to changes over the RF control into dc control. Schottky diode is utilized for amendment. The three primary segments of rectenna are reception apparatus, coordinating circuit and rectifier. Figure 3.44 demonstrates the square outline of rectennas.

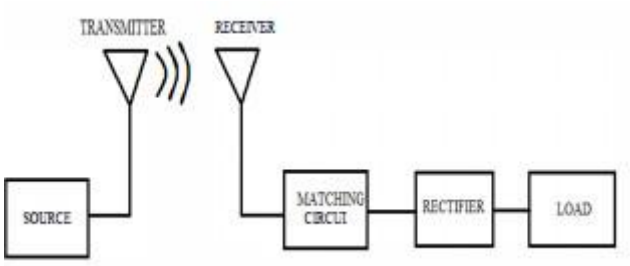


Figure:- 3.4 Figure 3.4: rectennass Blocks diagram

The reception apparatus is utilized to gather RF power and exchange the vitality to the Matching Circuit. The rectifier is maybe the most vital part inside the rectenna, changing over approaching RF control into DC control. It as a rule comprises of a diode with a high exchanging velocity. Coordinating circuit is utilized to coordinate the impedance of the recieving wire and the rectifier.
Picking a legitimate diode is one of the imperative factor since the diode is the fundamental wellspring of misfortune and its execution decides the general execution of the circuit

3.4 two by one Arrays CST.suite Models

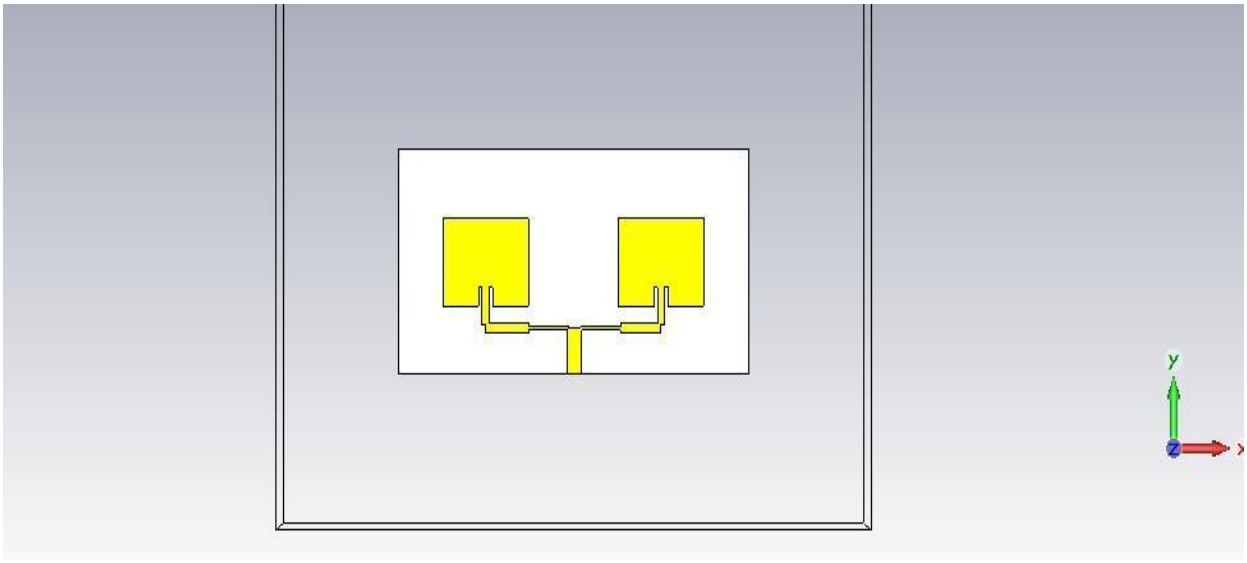
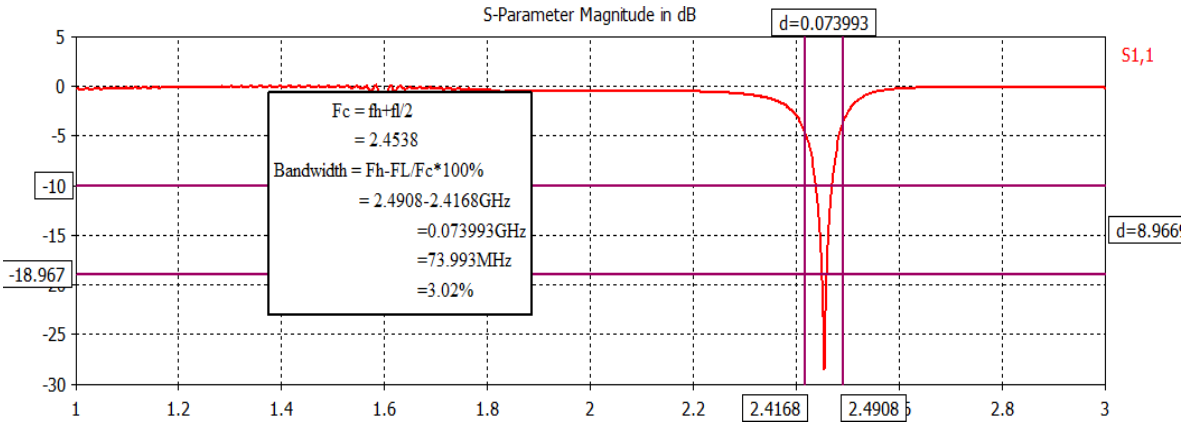


Figure 3.5 2 by 1 antenna

Figure:-3.6 come to results displayed, antennas that operate the rate 2..45GHZ and return losses of -24.444074dB This is correctly WFi frequencies operations.



Figue. 3.6 return losses 2 by 2 array antenna

3.4,2 Rectifiers Investigation

The schematic chart of the proposed amending circuit is appeared in Figure 3.7. The rectifier comprises of two decreased microstrip lines, a Schottky diode, a λ/4 microstrip line, a coordinating microstrip line, and a yield low pass channel. The circuit is carved on the substrate of FR4 (Dielectric steady = 4.3, Height = 1.6 mm, Thickness = 0.035 mm). The circuit was planned and streamlined utilizing Advance Design System (ADS), at that point created utilizing small scale strip lines with a FR4 substrate.

C channels the throbbing sign by the diode and to smoothen the DC yield. The heap obstruction RL (600-1000) Ω is changed in accordance with produce the most noteworthy DC voltage. A flag wellspring of 2.45 GHz with two a λ/4 decreased microstrip lines is associated with the rectifier circuit as the proposed radio wire is intended to coordinate at this estimation of impedance.

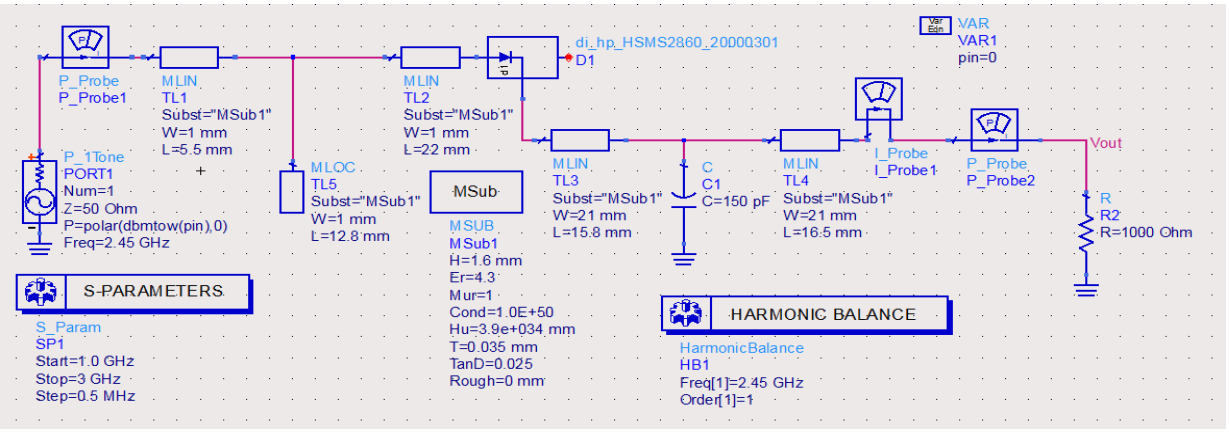


Figure:3.7 Schematics single rectifier diode circuits

Figure:3.8:- Displayed return misfortune plot, it very well may be seen that the ideal receiving wire has - 10dB transmission capacity which is in S-band district. It very well may be seen from return misfortune that this reception apparatus is reasonable for being utilized in wire-less correspondence. It is reverberates at 2.45GHZ.

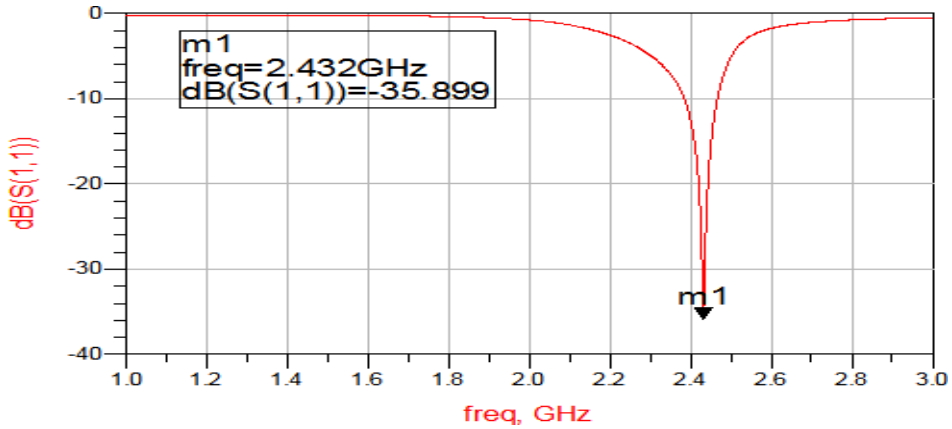


Figure:3.8:- simulation return losses

Rectifiers is a non-linear circuits, which changes over RF control into DC control. The primary normal for the working viability of rectennas is its proficiency, dictated by misfortunes, which emerge amid its transformation into DC influence. The numerical connection that depicts the RF-DC change effectiveness is given underneath condition.

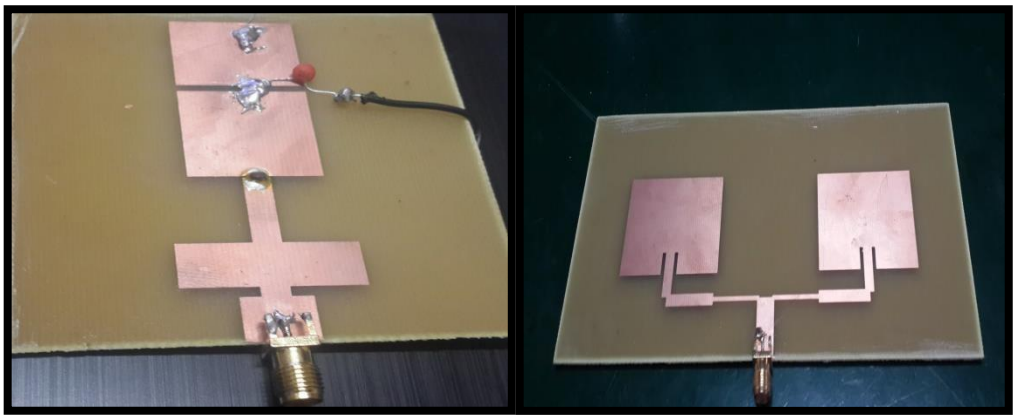
% η=(P-(DC))/p_r = 〖Vr〗^2/(R/Pr) ×100 (3.9)

Where Vr (V) is the yield voltage drop over the heap, R (Ω) the heap esteem, Pr (W) the RF input control at the getting reception apparatus' yield port, and PDC the DC control entering at the heap R. The change proficiency of the rectifier depends for the most part on a power transformation gadget. Appropriately, the diode must have low invert recuperation time and the change proficiency should likewise be high.

The manufactures procedure was done at UTHM Advanced Printed Circuit Board (PCB) Design Laboratory. The reenacted radio wires by CST Microwave is sent out to AutoCAD programming. From AutoCAD programming the illustration of the reception apparatuses is imprinted on straightforward film.

Figure 3.9 demonstrated the means includes manufacture process. The

manufactured fix clusters recieving wire and rectifier circuit are appeared in Figure 3.10.



Figue:3.10:- : (a) Fabrication of two by one patch array antenna (b) Fabrication of circuit rectifiers

3.4: Rectennas measurements

The experiment process is done to measure the achievement of the rectenna circuit. Frist it is very important to setup before the measurement. This is to avoid errors and to achieve reliable result. Measurements were performed by placing the proposed rectenna at a distance of 20 cm and 30 cm away from the horn antenna as shown in Figure 3.12. For both cases, the far field conditions should be met for both antennas. The output voltage is measured from the load resistant connected to the rectenna by a voltage meter.

Chapter four

Result and analyses

4.0 introduction

This section introduces every one of the outcomes acquired by utilizing CST Microwave Studio test system programming, propelled plan framework ADS and estimation results utilizing Network Analyzer to assess estimated S11 while control get and transmit is done utilizing signal generator and yield voltage we recode from the multimeter.

.

The correlation of the arrival misfortune (dB) and the information impedance for estimation and recreation results will likewise be clarified and talked about through this part. Generally speaking, the investigation of the outcomes and talks will give the correlation between the estimation and reproduction consequences of the rectenna that demonstrates a decent understanding between them.

4.1 Simulation Result of Design two by one Array Patch Antennas

Later manuals calculation, the antenna design & simulation two by one patch array antennas by sing csc-suit-microwave Studio simulation . this unit, the simulations results of the return losses RL, impedances input, band-width & gains are discusse.

4.2.2 Return losses

The execution of the proposed reception apparatus has been investigated and streamlined by utilizing economically accessible programming CST Microwave Studio test system. The recreated return loss of the proposed recieving wire is appeared in figure 4.1. From the arrival misfortune plot, it very well may be seen that the ideal recieving wire has -10dB data transmission 3.02% (from 1-3GHz) which is in S-band locale. It very well may be seen from return misfortune that this reception apparatus is appropriate for being utilized in warless correspondence (W-Fi). It is reverberates at 2.45GHz

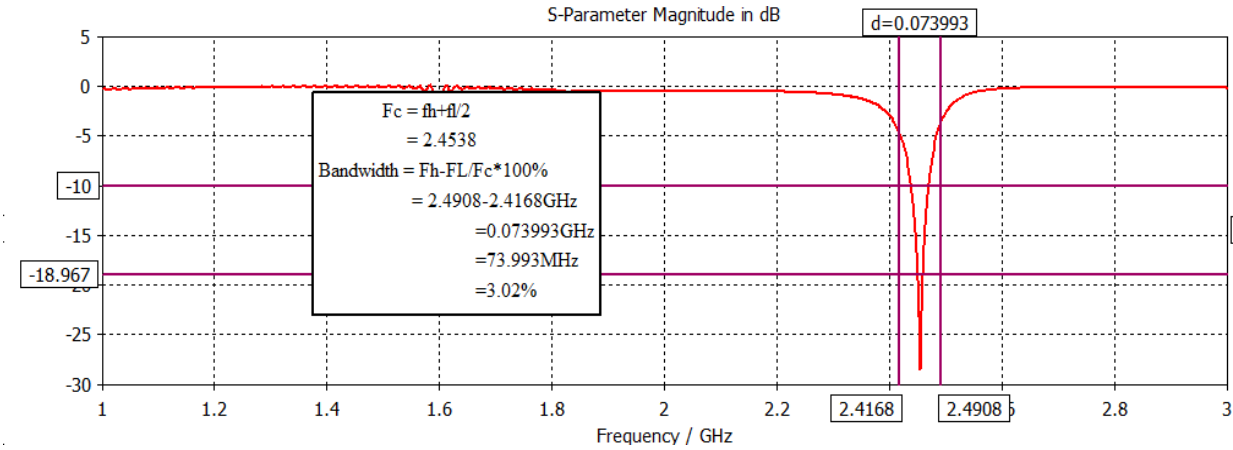


Figure:4.1- simulation return loses

4.1.2 simulation input impedances

As appeared in Figure 4.3, the information impedance for reenacted result was coordinated at impedance of 50 Ω. The recreated outcome is equivalent to the coordinating impedance. As indicated by the hypothesis, the impedance confuse between the reception apparatus and transmission line is influenced by the feed-point.

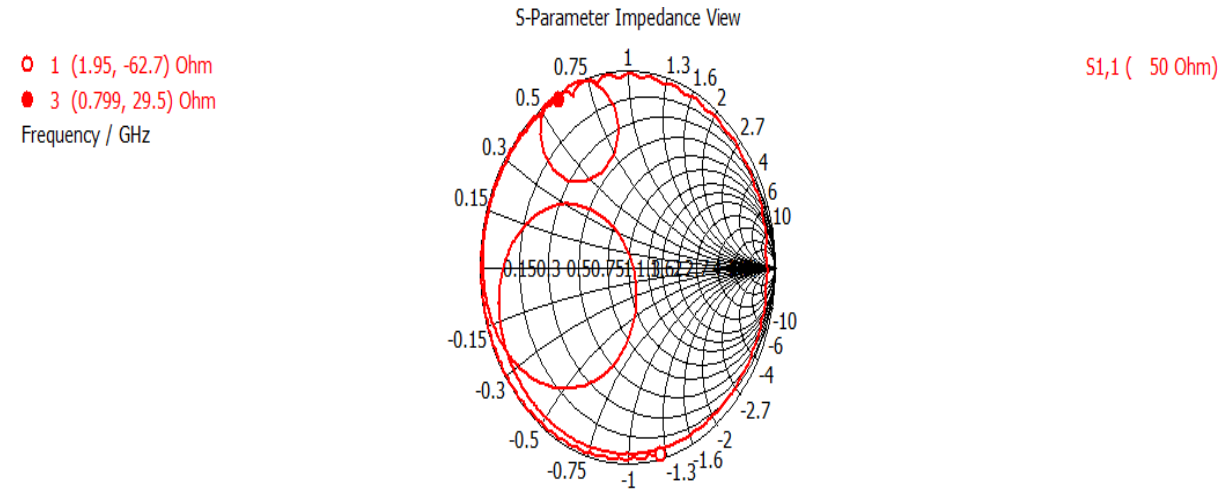
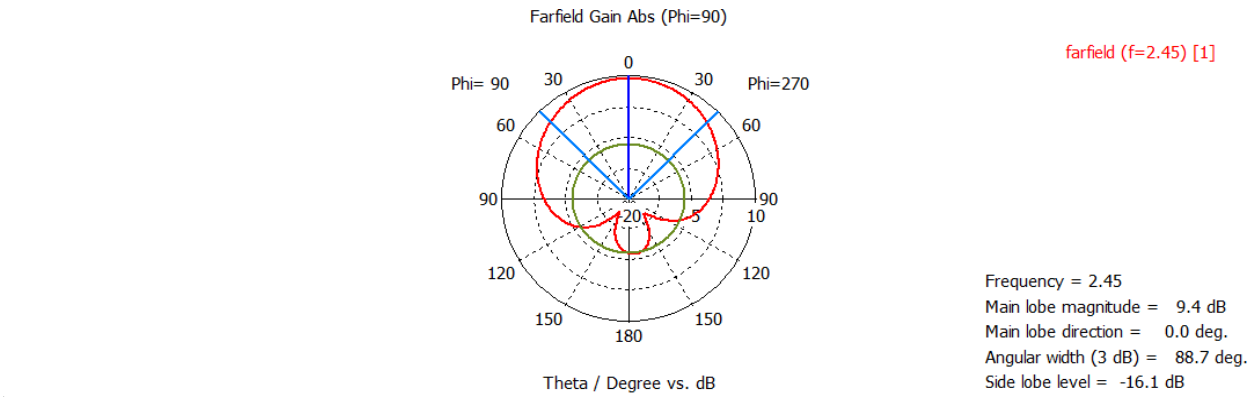


Figure 4.2: Simulation input impedances patch antennas

4.2.1 Simulate radiations pattern two by one Array patch antenna

Radio wire Gain depicts how much power is transmitted toward pinnacle radiation to that of an isotropic source the increase of the microstrip fix exhibit reception apparatus is 9.44dB is appeared in Figure:4.4



4.2.3 Measure Radiations patterns and antennas gains

A similar method of radiation design estimation of the proposed recieving wire is connected to coordinate rectenna in which the rectenna goes about as getting radio wire. Figure 4.4 demonstrates the deliberate radiation examples of radio wire .The co-polarization designs are displayed in standardized qualities. It very well may be seen that the E-plane c-polarization design demonstrated a noteworthy flap however it is tilted at ~210˚. This radiation is ordinary to the reception apparatus plane. The tilting might be because of the misalignment of the transmitting and accepting recieving wires amid the estimations. The unpleasant diagram of the example might be brought about by poor binding of the SMA connector ar rectenna input.

Furthermore this is additionally influenced by inside condition factors such us impedance from cell phones, reflection from human bodies and articles in the estimation room. There are no accessible safeguards that can lessen these variables. The co and cross polar separation of E-plane is roughly 9.4dBi while for H plane; the segregation is around 4.18dBi. The issue of errors between the two ports can be improved via completing the estimation procedure in anechoic chamber.

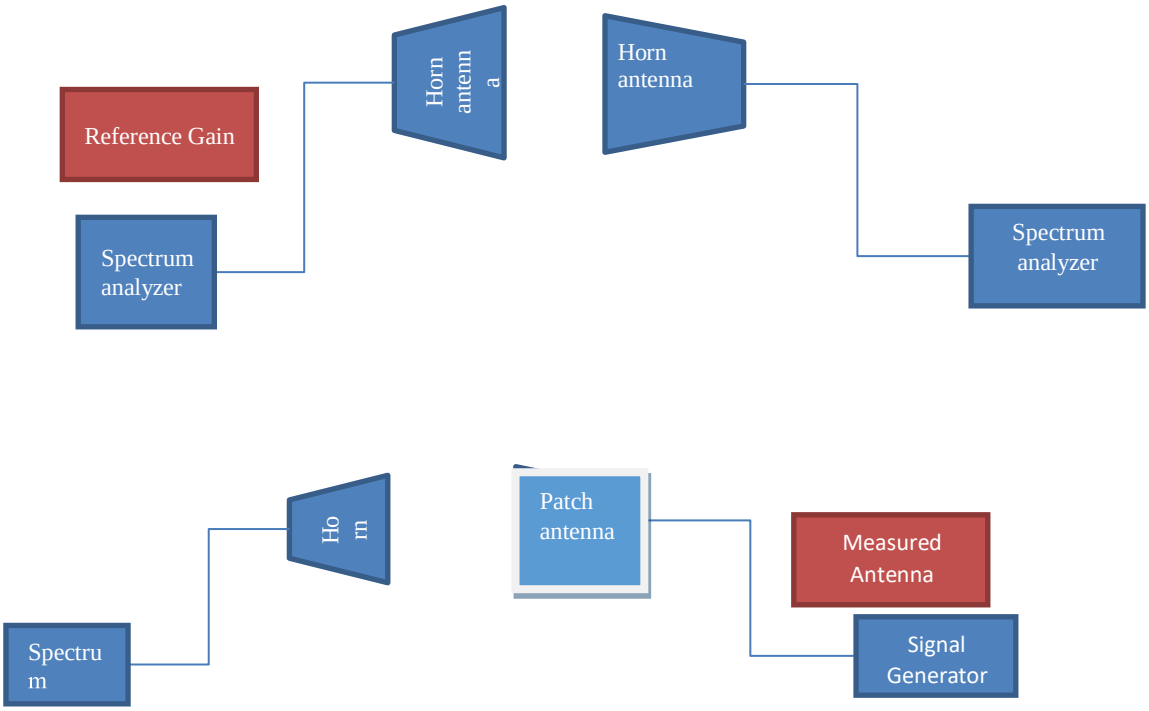


Figure 4.4: (b) Second step

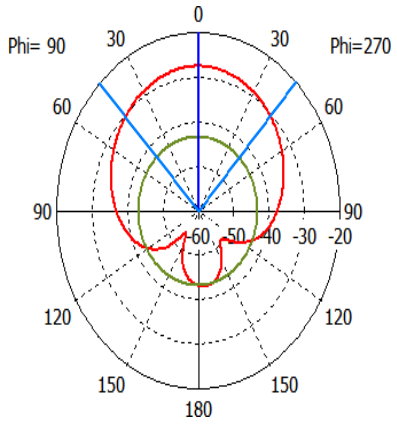
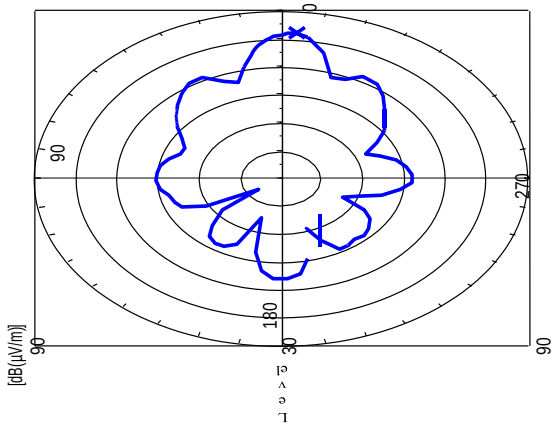
	Simulated	measured
E-plane		

Figure 4.5: (a) Radiation Pattern with 2x1 patch array antenna

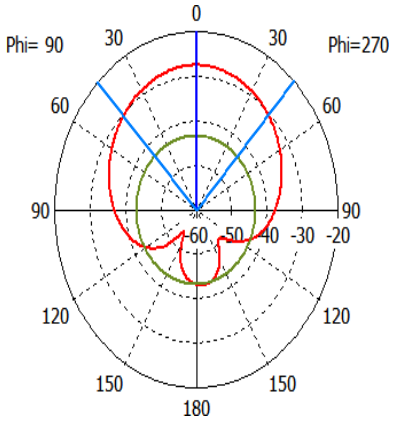
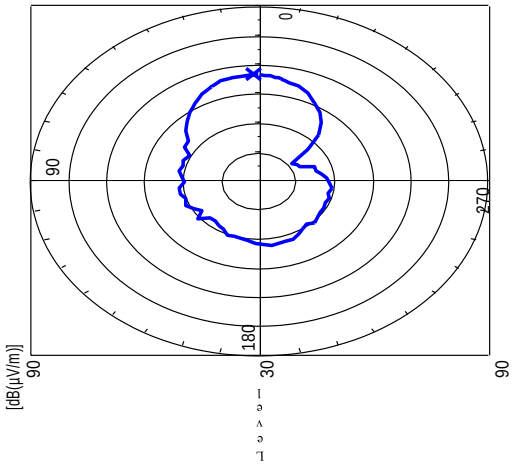
	Simulated	measured
E-plane		

Figure 4.5: (b) Radiation Pattern with single patch microstrip antenna.

In this Table4.1: shown the measured radiation pattern and gain process measurements was carried out at UTHM ECM lab using signal generator with horn antenna.

Reference frequency =2.45GHz	Gain [dBi]	dBi Reference Gain
Single patch	2.29	9.39
2x1 patch array antenna	2.49	9.39

The reception apparatus estimation is finished by utilizing the horn radio wire, for the initial step both, the recieving wire at the beneficiary to get the reference gain esteem. When reference gain is acquired the recieving wire at the recipients side will be changed to microstrip fix reception apparatus to get the estimation gain. The addition equation are as per the following:

G = Reference Gain + Measured receiving wire – reference level

4.3 Simulated Results of the Designed Rectifier

The single wave rectifier consists of two tapered microstrip lines, a Schottky diode, a λ/4. Microstrip line, a matching microstrip line, and an output low pass filter. The circuit is etched on the substrate of FR4 (Dielectric constant = 4.3, Height = 1.6 mm, Thickness = 0.035 mm). The circuit was designed and optimized using Advance Design System (ADS), then fabricated using micro-strip lines with a FR4 substrate.

4.3.1 S Parameter

The performance of the proposed antenna has been analysed and optimized by using commercially available software Advance Design System (ADS). The simulated return loss of the proposed antenna is shown in figure 4.4. From the return loss plot, it can be observed that the optimum antenna has -10dB bandwidth which is in S-band region. It can be observed from return loss that this antenna is suitable for being used in warless communication (W-Fi). It is resonates at 2.45GHz.

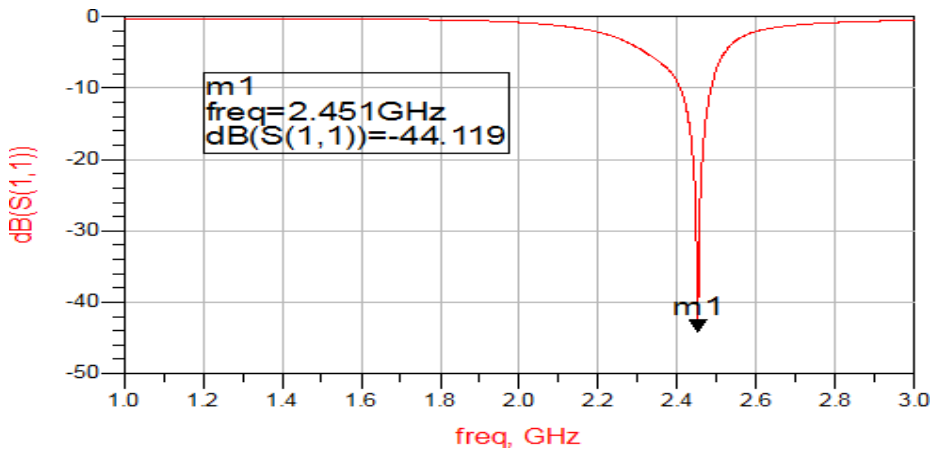


Figure 4.6: The simulated return loss

4.3.2 Simulated Input Impedance

As shown in Figure 4.5, the input impedance for simulated rectifier circuit result was matched at impedance of 50 Ω. The simulated result is the same as the matching
Impedance.

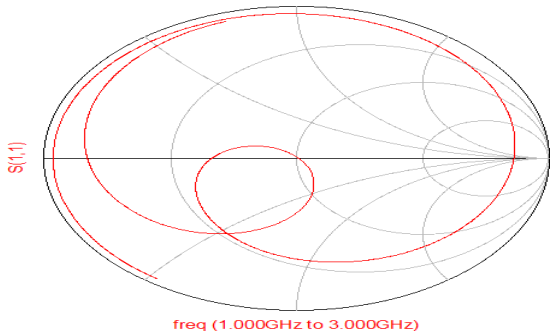


Figure 4.7: Simulated input impedance rectifier circuit.

4.3.3 Simulated DC Voltage

Figure 4.6 shows the simulation results of DC voltage as a function of input power. It is observed that the DC voltage increases dramatically when the input power is increases. The optimum output DC voltage for the load residence at 500Ω and at *Pin* = 20 dBm is achieved 2.690V. It can be inferred that the rectifier operates at higher input power due to the voltage threshold of Schottky diode.

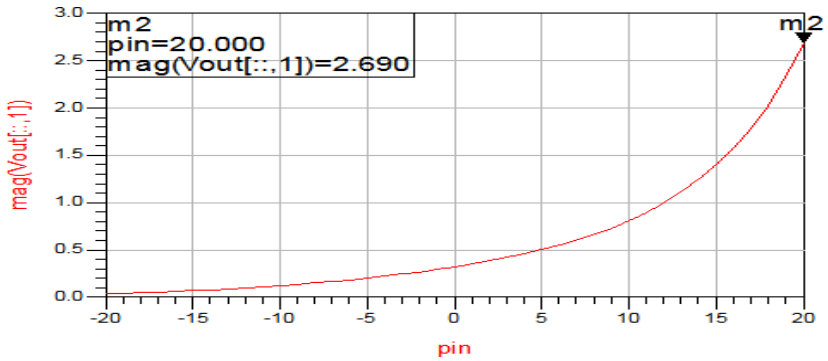


Figure 4.8: Simulated DC Voltage as a function of input power RL.500Ω

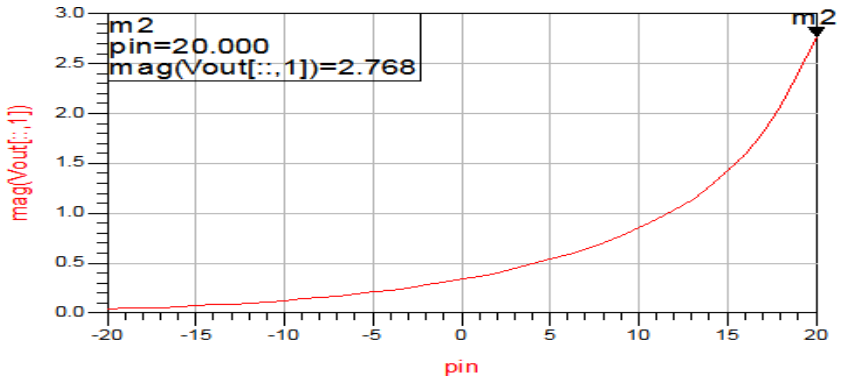


Figure 4.9: Simulated DC Voltage as a function of input power RL.600Ω

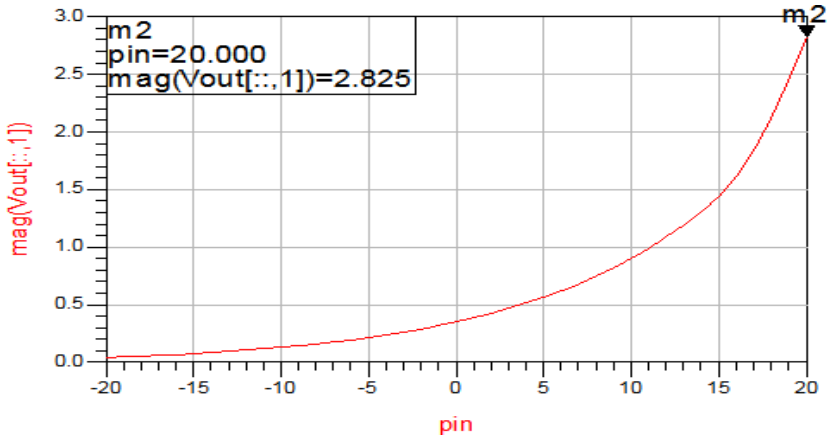


Figure 4.10: Simulated DC Voltage as a function of input power RL.700Ω

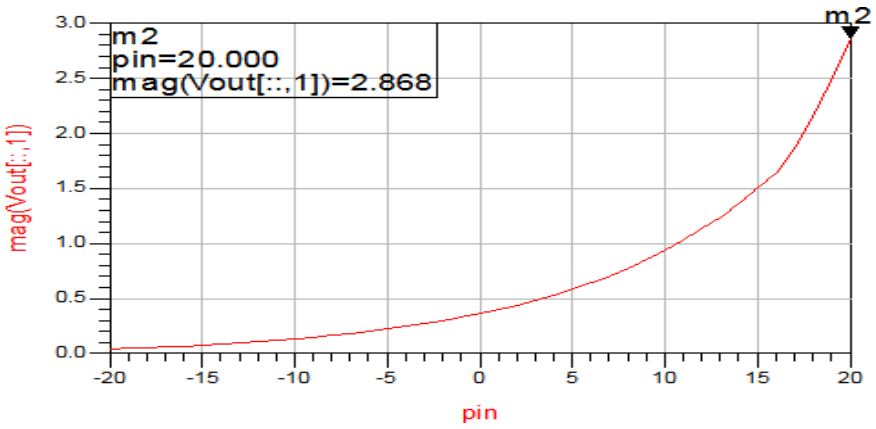


Figure 4.11: Simulated DC Voltage as a function of input power RL.800Ω

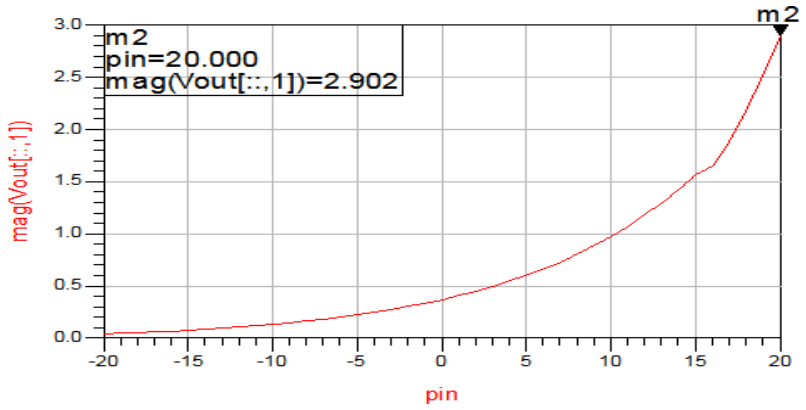


Figure 4.12: Simulated DC Voltage as a function of input power RL.900

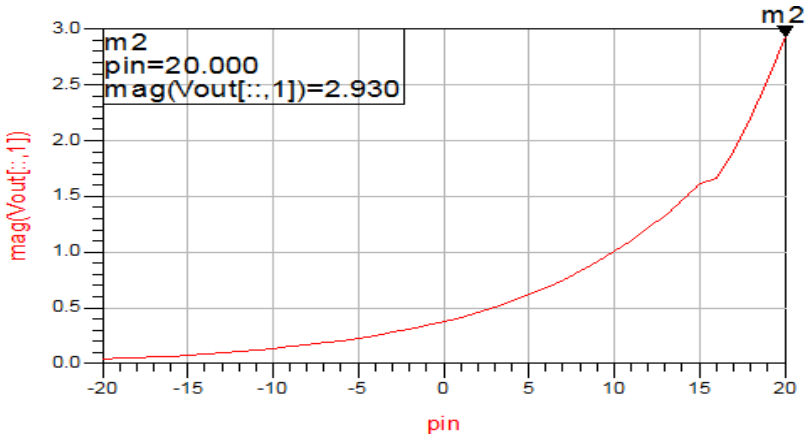
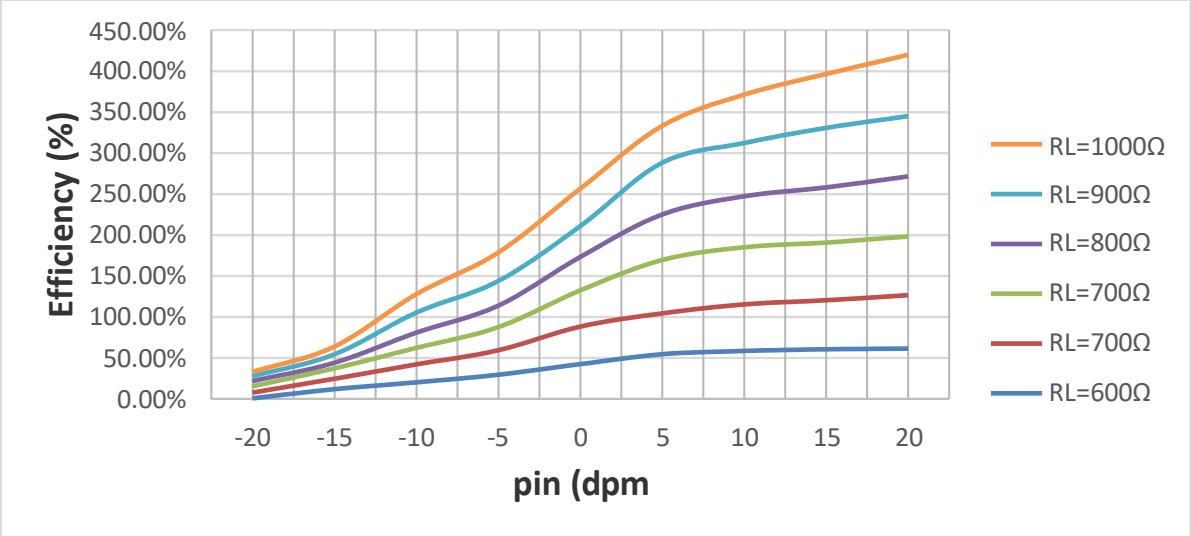


Figure 4.13: Simulated DC Voltage as a function of input power RL.1000

The execution of the proposed rectifier circuit has been investigated and improved by utilizing industrially accessible programming Advance Design System (ADS Studio test system. The reproduction consequences of DC voltage as a component of info intensity of the proposed rectifier circuit is appeared in figure 4.12. From the DC voltage plot, it very well may be seen that the DC voltage increments drastically when the info control is increments just as burden opposition



4.3.4 microstrip two by one patch array antennas Measure Return loses

A Vector Network Analyser is used to measure the return loss of microstrip patch 2x1 array antennas. Figure 4.15 shows the measured return loss of the antenna. This result also shows that the fabricated microstrip patch array antenna is approximately on frequency, which means it can operate at frequency of 2.45 GHz.

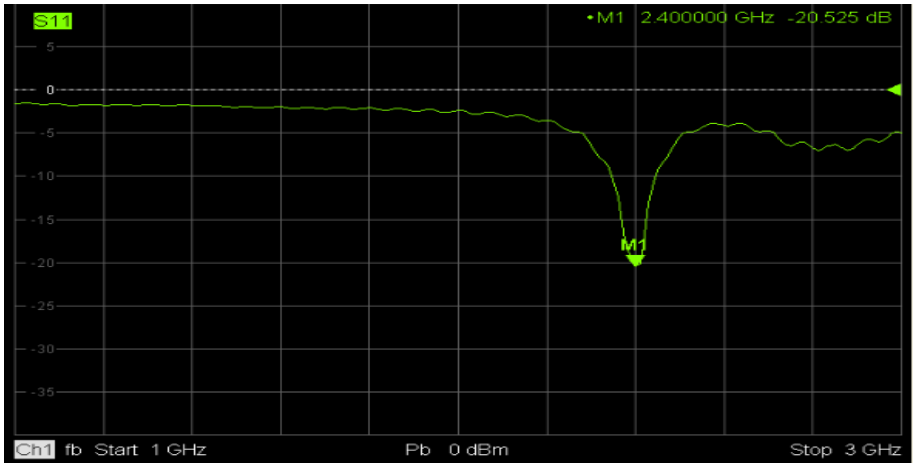


Figure 4.16: Measured Return loss of 2x1 patch antenna

4.3.6 Measured Input Impedance

The measured result is matching impedance. This gives a good result where the antenna is nearly matched to the matching impedance of 50 Ω. Figure 4.18. Shown the input impedance of the measured square-ring patch 2x1 array antennas.

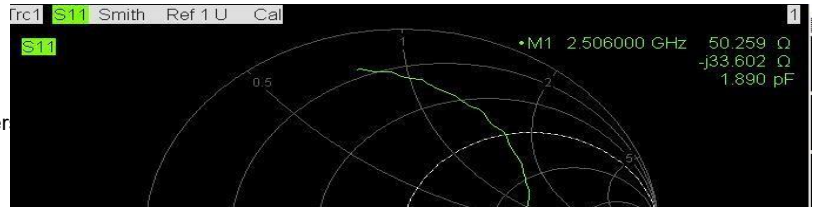


Figure 4.17: Measured input impedance of microstrip patch array antenna

4.3.7 Measured S11, Return loss for rectifier

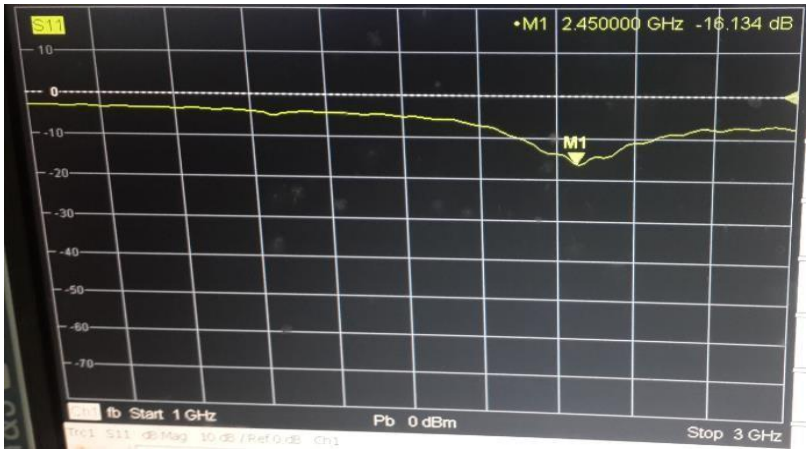


Figure 4.18: Measured Return loss for rectifier

4.3.8 Comparison between simulated and measured results

The simulated results are compared with measured results to observe that there is frequency difference between measurement and simulation results in arrays antennas. The discrepancy of the frequency in the results can be attributed due to fabrication tolerance.

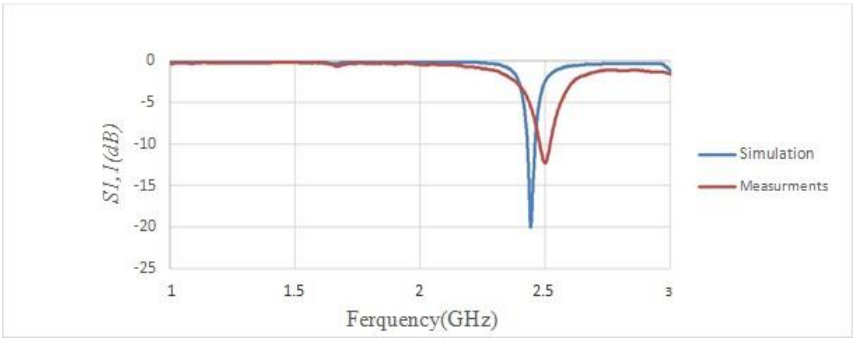


Figure.4.19 Simulation verses measurement

4.3.9 DC Output Voltage

To measure the ability of the single diode rectifier to convert the microwave AC signal into DC, a RF signal generator connected with horn antenna is used to generate a single frequency input signal at 2.45 GHz to the rectifier as a function of input power from 10 dBm to -15 dBm with steps of 5 dBm. Digital Multimeter is connected at the output in order to measure the DC output voltage across the load. Once the measurement setup is ready, the measurement data is recorded in the table 4.2 and 4.3.

Table 4.2: Recorded measured data for distance (d) =20 cm

Transmitted Power Pt (dBm)	Received Power Pr (dBm)	Output DC Voltage (mV)	Conversion Efficiency(%ή)
10	-14.02	197	95
5	-19.20	129	13.3
0	-24.36	109	60.5
-5	-29.42	84	31.7
-10	-33.9	84	1.87
-15	-38.75	19.5	2.9

The measured output DC voltages and overall efficiency are shown in Figure 4.19. In the receive power range (-14.02 to -38.75 dBm) the measured rectenna efficiency is above 95% and the corresponding output DC voltage is 197 mV over a 1000 Ω optimised load resistance. The measured results show that the output voltage and efficiency increase when the power receive increases.

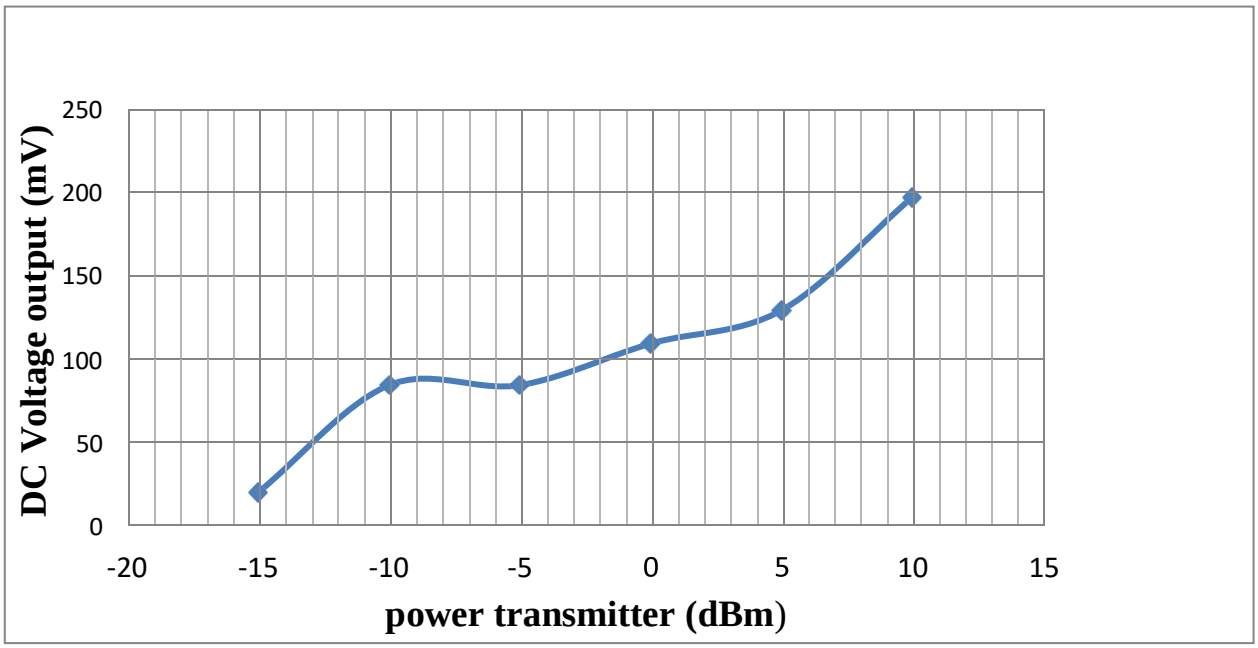


Figure 4.20: Measured output voltage verses transmitted power

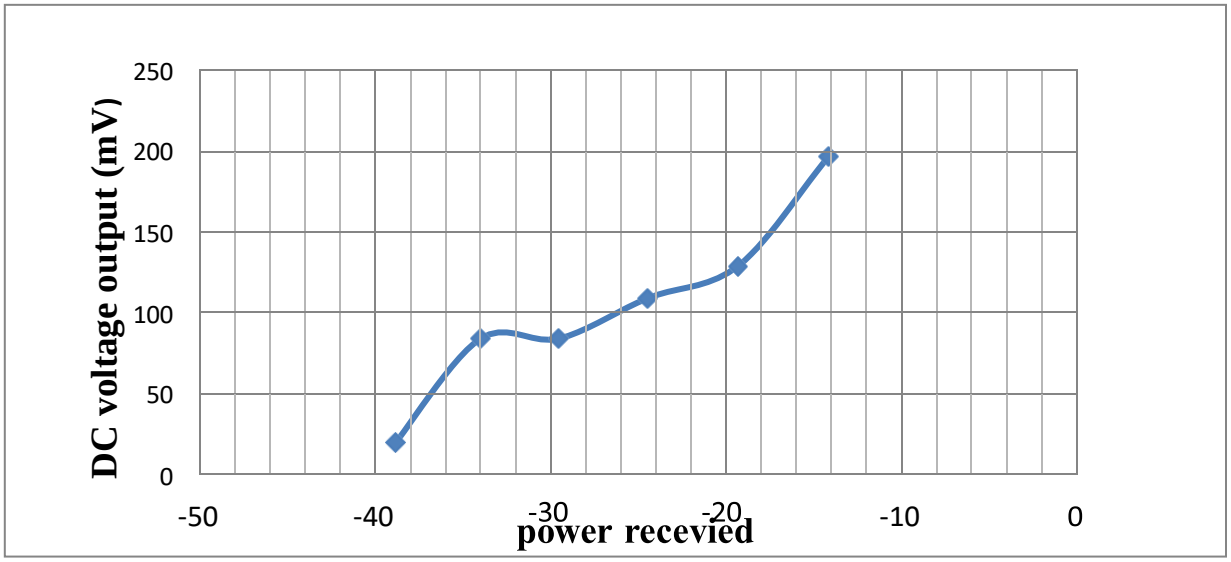


Figure 4.21: Measured output voltage verses received power

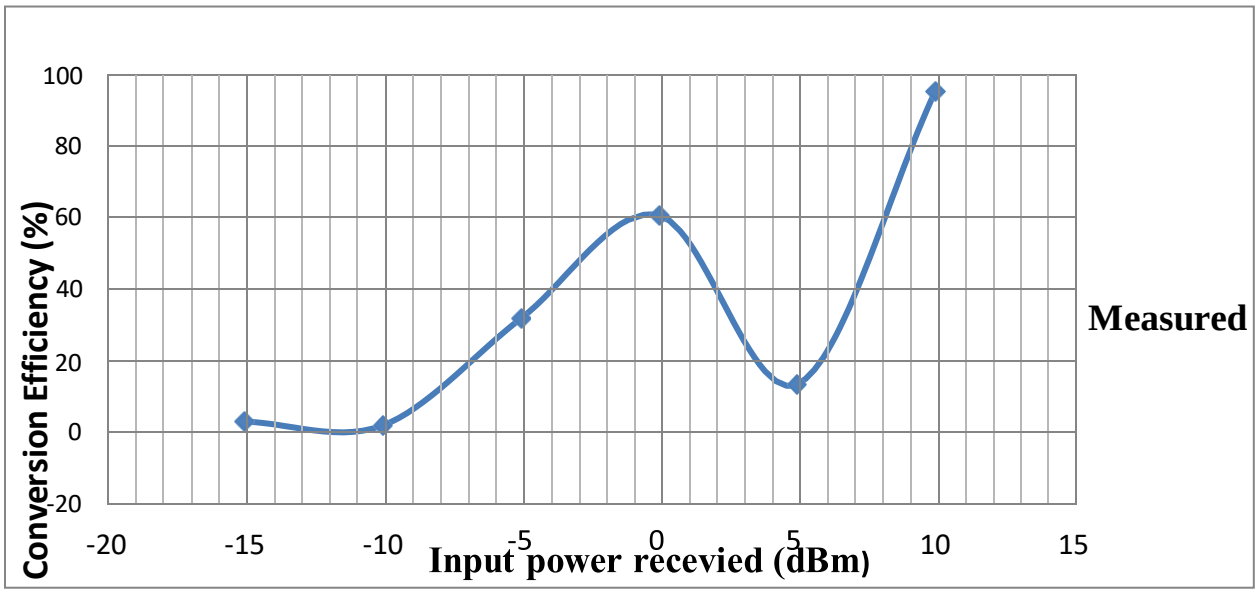


Figure 4.22: Measured conversion efficiency verses transmitted power

Table 4.3: Recorded measured data for distance (d) =30 cm

Transmitted Power Pt (dBm)	Received Power Pr (dBm)	Output DC Voltage (mV)	Conversion Efficiency(%ή)
10	-20	170	28
5	-25	145	18
0	-30.5	70	15
-5	-35.25	59	11
-10	-40.9	53.6	0.65
-15	-45.2	30.4	0.03

The measured output DC voltages and overall efficiency are shown in Figure 4.20. In the receive power range (-20 to -45.2 dbm) the measured rectenna efficiency is above 28% and the corresponding output DC voltage is 170 mV over a 1000 Ω optimised load resistance. The measured results show that

the output voltage and efficiency increase when the power receive increases.

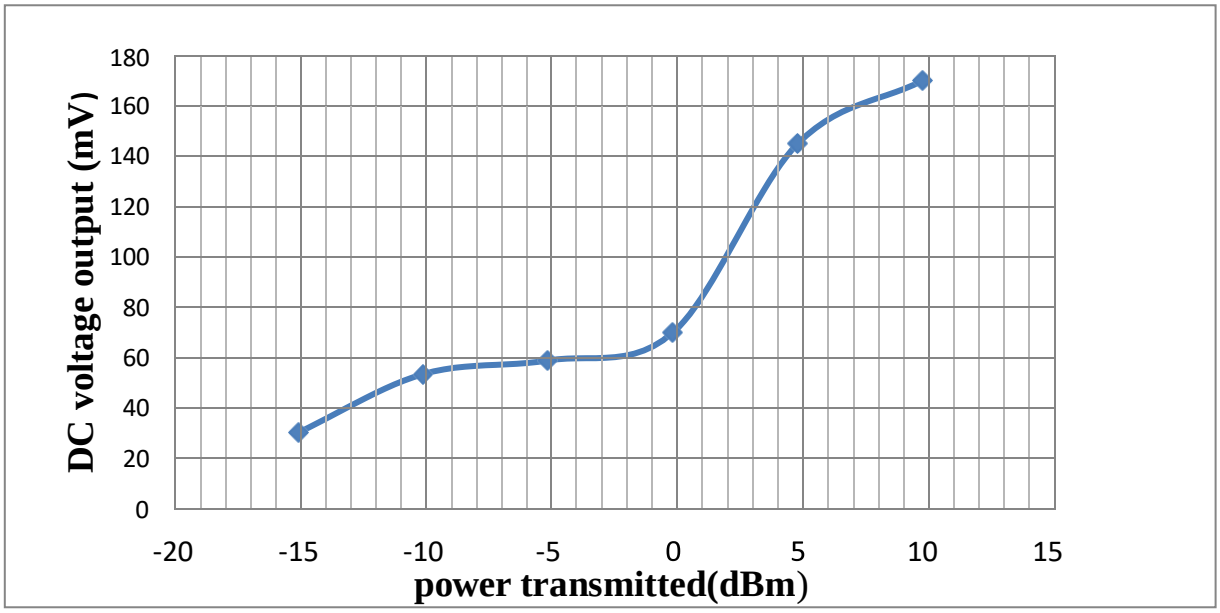


Figure 4.23: Measured output voltage verses transmitted power

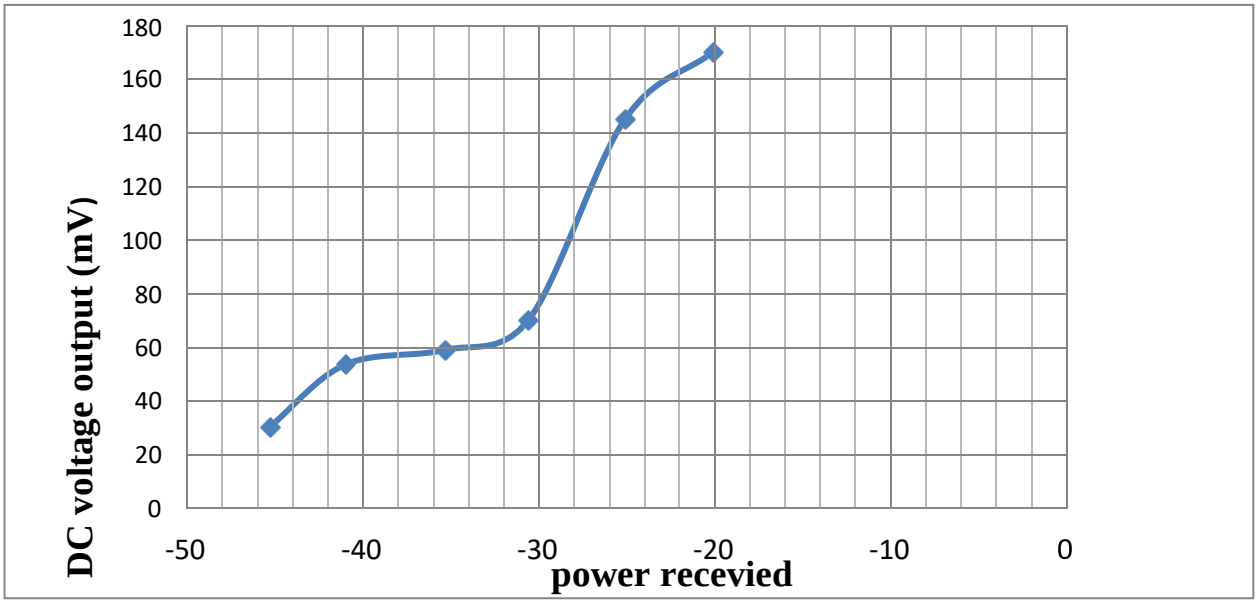


Figure 4.24: Measured output voltage verses received power

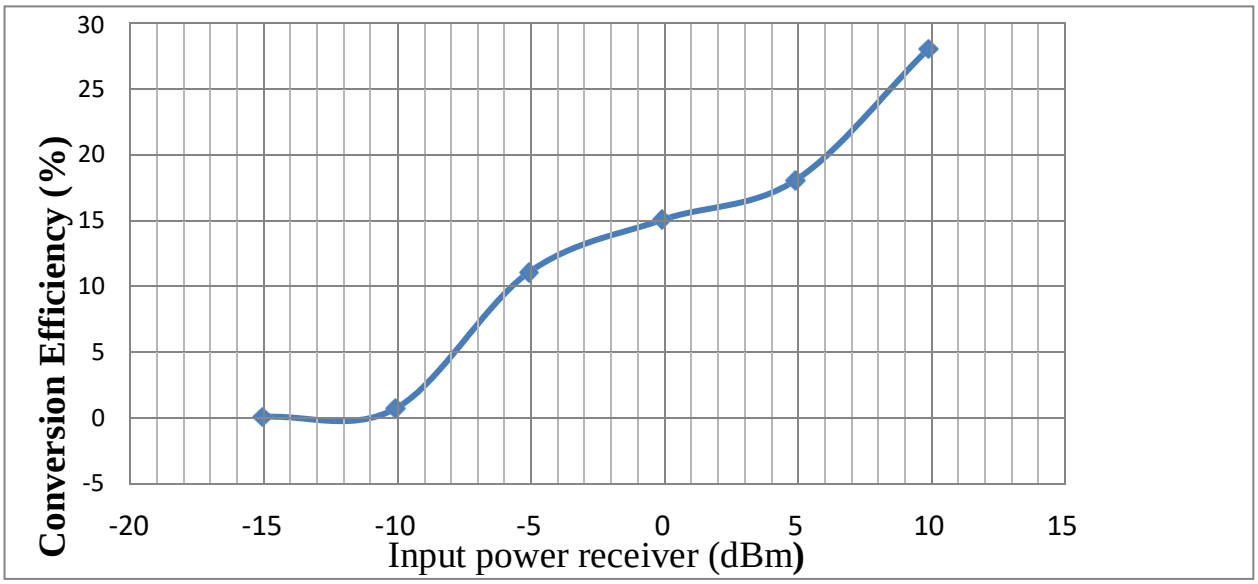


Figure 4.25: Measured conversion efficiency verses transmitted power

CHAPTER FIVE

Conclusion RECOMNDATIONS AND REFENCE

4.1 Conclusion

A rectennas is one of the key advancements for microwave remote power transmission. The rectennas circuit topology has been considered, planned and mimicked for remote power transmission. In our structure, the HSMS2860 Schottky diode was chosen to plan and reenactment the correcting circuits utilized for remote power transmission. Great exhibitions have been acquired as far as RF-DC transformation proficiency. This rectennas can be effectively manufactured on FR-4substrate material because of its little size and thickness. A trial model is created where the relative with recreations, results have been demonstrated great contract

5.2 recommendation

Recommendations for the future work are as follow:

1. Future work focuses on improving rectennas design. Furthermore, a closer look into power density is needed for further experimentation. With power density there will be a need for antenna and rectifier that can handle high power levels

2. Utilize new technique antenna array in the rectennas design for higher power receive and conversion efficiency.

3. Use RF signal generator that can transmit more than 20dBm to upgrade receive power.

4. DC bias Schottky diode needs to examine using similar methodology to improve voltage sensitivity of the rectifier circuits.

5.3 REFFERENCE

1. B. Strassner and Chang Kai, "5.8 GHz circular polarized rectenna for microwave power transmission," in Energy Conversion Engineering Conference and Exhibit, 2000. (IECEC) 35th Intersociety, 2000, pp. 1458-1468 vol.2.
2. Nicolas Tesla. "The transmission of electric energy without wires". The thirteenth Anniversary Number of the Electrical World and Engineer, 1904.
3. William C. Brown. "The history of power transmission by radio waves". IEEE Trans. MTT, 32(9):1230{1242, 1984.
4. Nicolas Tesla. "Experiments with Alternate Current of High Potential and High Frequency". McGraw, 1904.
5. J. O. McSpadden, T. Yoo, and Chang Kai, "Theoretical and experimental investigation of a rectenna element for microwave power transmission," *Microwave Theory and Techniques, IEEE Transactions on*, vol. 40, pp. 2359-2366, 1992.
6. William C. Brown, "The technology and application of free-space power transmission by microwave beam," *Proceedings of the IEEE*, vol. 62, pp. 11-25, 1974.
7. W.C.Brown, "The history of power transmission by radio waves," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-32, pp. 1230-1242, Sept. 1984.W.C.Brown, "The history of power transmission by radio waves," *IEEE Trans. Microwave Theory Tech.*, vol. MTT-32, pp. 1230-1242, Sept. 1984.
8. R. M. Dickinson, "Performance of a High-Power, 2.388-GHz Receiving Array in Wireless Power Transmission Over 1.54 km," in *Microwave Symposium, 1976 IEEE-MTT-S International*, 1976, pp. 139-141.
9. P.; Cha Koert, J.; Machina, M., "35 and 94 GHz rectifying antenna systems," presented at the SPS 91 - Power from space; Proceedings of the 2nd International Symposium, France, , 1991.