Tunnel Diode Loaded Rectangular Microstrip Antenna with Passive Components for Millimeter Range

Priti Sharma, Tazeem Ahmad Khan, B. R. Vishwakarma

Abstract:- ***The present work describes the circuit model based analysis of tunnel diode(Active Device) loaded microstrip antenna with parasitic elements using equivalent circuit concept. To optimize the antenna characteristics a study has been carried out as a function of tunnel diode space with microstrip patch. It is observed that the antenna can be operated over a range of frequency form 39.163GHz to 57.688GHz for Germenium tunnel diode loaded patch just by varying the value of passive elements. The return loss improves to -43.3dB.***

Keywords: Microstrip Antenna; Active tunnel diode loaded patch and passive elements patch,

I. INTRODUCTION

In high-performance aircraft, spacecraft, satellite, and missile applications, where size, weight, cost, performance, ease of installation, and aerodynamic profile are constraints, low-profile antennas may be required. Microstrip antenna have attracted widespread interest due to their small size, light weight, low cost, low profile Presently there are many other government and commercial applications, conformable to planar and nonplanar surfaces, inexpensive to manufacture using modern printed-circuit technology but their low gain and narrow bandwidth and low power capacity make limited use of these antenna. In this paper here proposed a tunnel diode-loaded rectangular patch for achieving the frequency tenability in the millimeter range. The equivalent circuit of a tunnel diode consists of a junction capacitance Cd, which varies with the bias voltage which in turn changes the operating frequency. The major advantage of using a tunnel diode is its low voltage and power requirements, vary wide temperature range of operation and extremely high speed of operation. Various antenna parameters such as input impedance, VSWR, Return loss, frequency range ets are obtained by selecting passive element value.

II. ANTENNA DESIGN

Tunnel diode loaded microstrip antenna is shown in figure1. A mictostrip device in its simplest form consists of sandwich of two parallel conducting layers separated by a single thin substrate [4]. The lower conductor function as a ground plane and the upper conductor may be a simple resonant rectangular or circular patch, a resonant dipole, or a monolithically printed array of patches or dipoles and the associated feed network.

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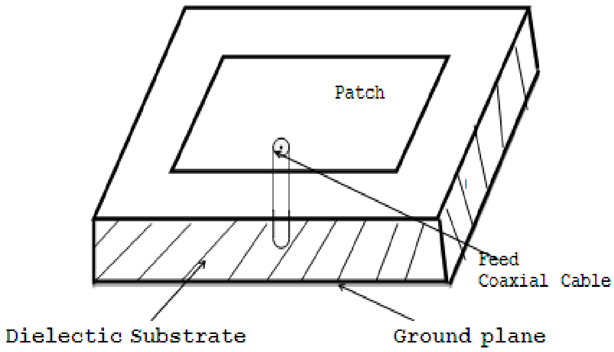

Figure 1 Tunnel Diode Loaded Rectangular Microstrip Antenna

The equivalent circuit of a rectangular patch microstrip antenna is a parallel combination of resistance R, inductance L, and capacitance C as shown in fig2.

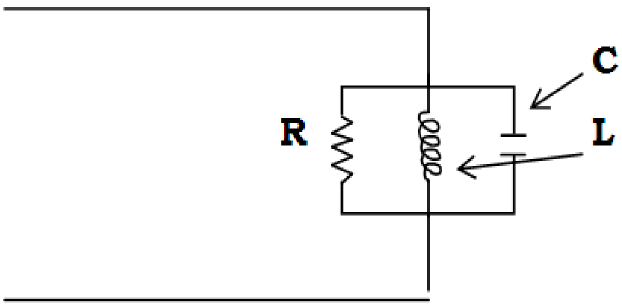

Figure 2 Equivalent Circuit of Rectangular Micro Strip Patch

The equivalent circuit [1], [2] for a tunnel diode has a resistance Rs and inductance Ls in series and the negative resistance and junction capacitance Cd in parallel as shown in fig. 3.

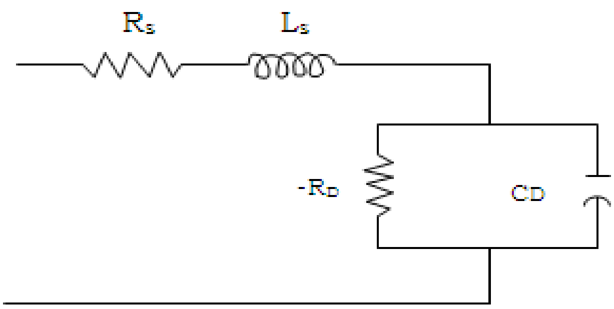

Figure 3 Equivalent Circuit of Tunnel Diode

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Inductor Ls and resistor Rs represent parasitic element Capacitor Cd capacitance caused mainly by the internal depletion region. Resistor Rd represents the ac negative resistance of the device. The tunnel diode equivalent circuit acts like a series resonant circuit where its input terminals are ac short circuited. The value of resistance R, inductance L, and capacitance C are giving as

$$C = \frac{1}{2} C_{dc} \cos^{-2}(\pi y0/l)$$

With Cdc being the dc patch capacitance[6]

$$C_{dc} = \frac{\varepsilon l W}{h}$$

so

$$C = \frac{1}{2}\frac{\varepsilon W l}{h} \cos^{-2}(\pi y_0/l)$$

$$\varepsilon_e = \frac{\varepsilon_r+1}{2} + \frac{\varepsilon_{r-1}}{2}\left(1+\frac{10h}{W}\right)^{-1/2}$$

Where er is the relative permittivity of the substrate material.

WhereYo = Y-coordinate of feed point

h = Thickness of the substrate

ε0 = Permittivity of free space

εe= Effective dielectric constant

l= Length of the patch.

W=Width of the patch.

c=Velocity of light

In the millimeter wave range, the calculations for length and width, are done according to the moment method solution of a printed rectangular radiating element on a grounded dielectric slab[3]. Width (W) is 0.3 λ0, where λ0 is the free space wavelength. The patch (εr) stops resonating at h>0.11 λ0. Hence, we have taken h=O.1 λ0 and correspondingly l = 0.25/ λ0.

$$L = \frac{1}{\omega^2 C}$$

$$R = \frac{Q_r}{\omega C}$$

The combined equivalent circuit of the tunnel diode and the microstrip patch is shown in fig.4. When a bias voltage V is applied to the terminals, it is transferred to the external circuit because of the negative resistance of the tunnel diode

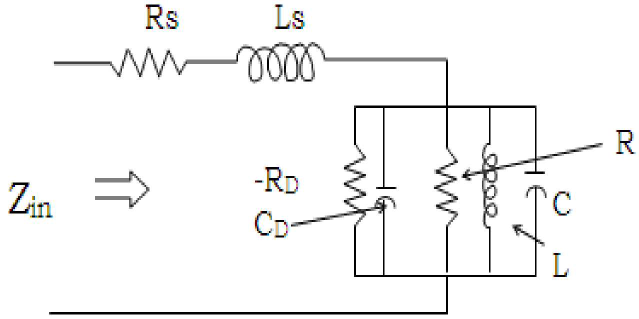

Figure 4 Combined Equivalent Circuit of Rectangular Patch Antenna with Tunnel Diode

2.1.Impedance : The input impedance is calculated as

$$Zin = (Rs + j\omega L_s) + \frac{j\omega LRR_D}{j\omega L(R_D - R) - \omega^2 LRR_D(C + C_D) + RR_D}$$

2.2. Operating frequency : The operating frequency of a tunnel diode oscillator circuit is givenby [4]

$$f_0 = \frac{1[(C + C_D)(2RR_sL^2 + 2R^2LL_s + R^2L^2) + L^2L_s \pm \{[(C + C_D)(2R^2LL_s + 2R_sRL^2 + R^2L^2) + L^2L_t]}{2\pi 2R^2L^2L_t(C + C_D)^2}$$

2.3 Design specifications for microstrip patch antenna

The detail designed frequency of the rectangular patch antenna is given in Table1.[7]

Components	Values
Series resistance (Rs)	4.5 Ω
Series inductance (Ls)	0.169 nH
Negative resistance (R'd)	-106 Ω
Junction capacitance(CD)	0.03550pF
Charge concentration(np/(n + p)	2.295*1017 cm-3
Junction area(A)	4.906 * 10-10 cm2
Diffusion potential(Vd)	1.1 V
Design frequency	(f)50 GHz
Element width(W)	1.8 mm
Element length(l)	1.60 mm
Resistance(R)	130 Ω
Inductance(L)	0.12843 nH
Capacitance (C)	0.0800 pF

III. RESULT AND DISCUSSION

The range of frequency obtainable for operation is'18525MHz'.And the antenna could be operated in the millimeter wave range(39.163GHz -57.688GHz). Variation of the magnitude of input impedance (Zin)withfrequency is shown in figure (5). Maximum value of Zin is 62.86Ω. Variation of the VSWR with frequency is shown in figure (6). The VSWR should be less than 2. VSWR is 1.259. The figure (7), shows the variation of return loss with frequency. The return loss should be less than -10dB. It is -43.3dB.

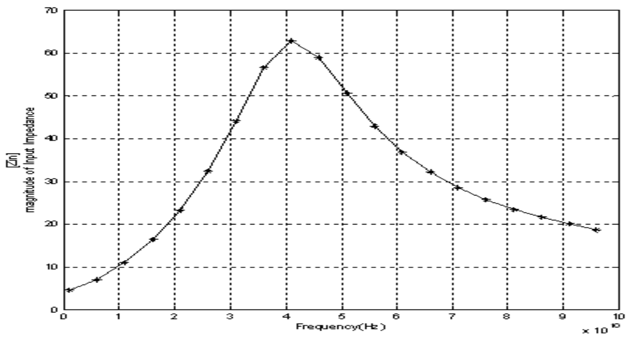

Figure5: Variation of Magnitude of Input Impedance with Frequency for Ge Tunnel Diode Loaded Patch

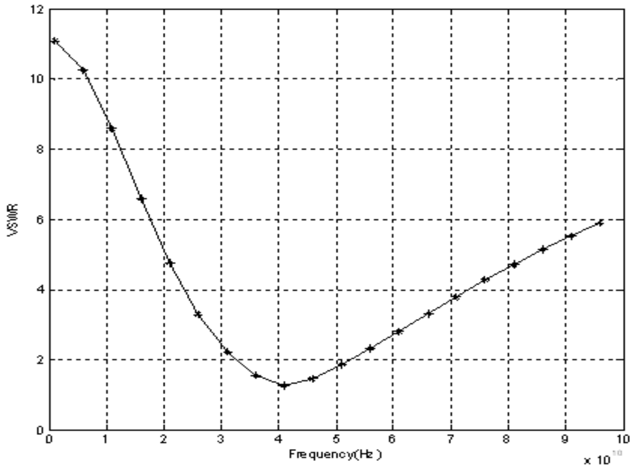

Figure 6 Variation of VSWR with Frequency for Ge Tunnel Diode Loaded Patch

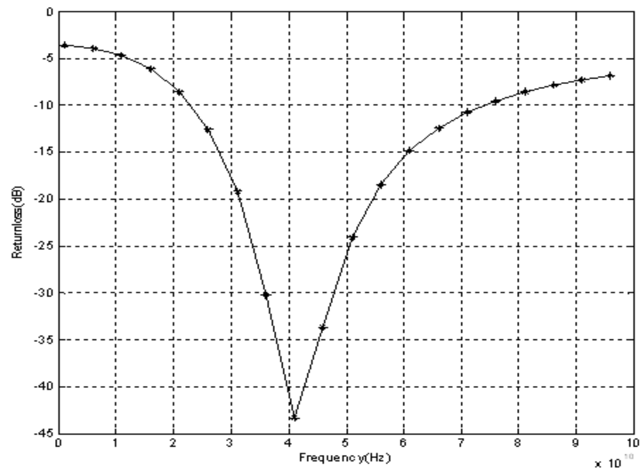

Figure 7 Variation of Return Loss with Frequency for Ge Tunnel Diode Loaded Patch

IV. CONCLUSION

In this paper investigate Performance of equivalent Circuit of Tunnel Diode Loaded Rectangular Microstrip Antenna at 41GHz Frequency Using Different value of Passive components. It concluded that the varying the value of passive element (R L & C) performance enhances the VSWR and Return loss of tunnel diode loaded Microstrip patch antenna. It is concluded from the above analysis that the bandwidth, return loss of the tunnel diode loaded Microstrip patch antenna is improved. In this way the performance of its can be improve by varying the value of passive elements. In future, we can performance enhancement using other material in place of Ge.

REFERENCES

1. S. PSylvesten P. Gentile, "Basic Theory and Application of Tunnel Diode", Princeton, NJ: Van Nostrand, 1962.
2. D. M. Pozar, "Input impedance and mutual coupling of rectangular microstrip antennas", IEEE Trans. On Antenna and propagation, Vol. AP-30, 1982, pp. 1190-1196.
3. M. V. Schneider, "Microstrip lines for microstrip integrated circuits," Bell Syst. Tech. J., vol. 48, 1969, pp. 1424-1444,.
4. Rakesh N. Tiwari[1], Prabhakar Singh[2],"Tunnel Diode Loaded Microstrip Antenna with Parasitic Elements"Journal of Electromagnetic Analysis and Applications, 2012, 4, 177-181
5. Yogesh Kumar Gupta[1], R. L. Yadava[2], R. K. Yadav[3], Performance Analysis of 2.3 GHz Microstrip Square Antenna Using ADS International Journal of Research in Management, Science & Technology (E-ISSN: 2321-3264) Vol. 1; No. 2, December 2013
6. shweta srivastava & Babau R. Vishwakarma, "Tunnel diode loaded integrated two layer microstrip patch antenna", Indian journal of Radio & space physics vol 29,December 2000.pp.349-356,
7. W. F. Woo, F. Chow, Principal of Tunnel Diode Circuits, Wile', 1964.