Analysis of Gunn diode Loaded Circular Microstrip Antenna

Isha Singh, Ajay Kumar Yadav, Alka Verma

***Abstract*— In our project work the first step is designing of Circular microstrip Antenna in X and. In designing of CMSA the first step is the selection of substrate, which in our project is chosen as RT Duroid 5870 with a height of 1.59 cm and dielectric constant of 2.2 . The designed frequency is selected as 9.8 GHz. The design procedure is presented which includes calculation of parameters of Circular microstrip antenna (CMSA) such as radius, effective radius, effective dielectric constant, and input impedance. After calculating the various parameters the input impedance of patch antenna is matched with the coaxial feed.**

The second part of the project is concerned with loading Gunn diode on the Circular microstrip antenna and thus observing how the antenna performance is improved in comparison to CMSA.

The thesis is concluded with the results obtained through MAT LAB programming. The Circular patch antenna has also been simulated with the help of Computer Simulation Technology software (CST) and the theoretical result has been matched with the simulated result. It is observed that the analysis conducted on Gunn diode integrated Circular microstrip antenna and evaluation of various parameters such as input impedance, voltage standing-wave radio (VSWR), return loss, bandwidth, radiation pattern etc., as a function of bias voltage and threshold voltage reveals that the Gunn diode loaded patch offers wider tunability, better matching, enhanced radiated power as compared to the patch alone. Bandwidth of the Gunn loaded patch improves to 10.43%over the 2.9% bandwidth of the patch.

The radiated power of Gunn diode loaded patch antenna is enhanced by 0.13 db as compared to the patch alone. It is also observed that the Gunn diode loaded patch antenna exhibits frequency tunability with the bias voltage.

***Index Terms*— Microstrip Antenna, DST.**

I. INTRODUCTION

Microstrip antenna received considerable attention starting in the 1970s,although the idea of a microstrip antenna can be traced to 1953[1] and a patent in 1955.[2].Microstrip antennas have been used extensively in applications where the antenna must have a very low profile .[3]

Wireless communication has been made possible by the use of antennas. Some of them are Parabolic Reflectors, Patch Antennas, Slot Antennas, Folded Dipole Antennas, Microstrip Antenna etc. Each type of antenna has its own properties and usage. Microstrip antennas have been used extensively' in applications where the antenna must have, a very low profile.[4]

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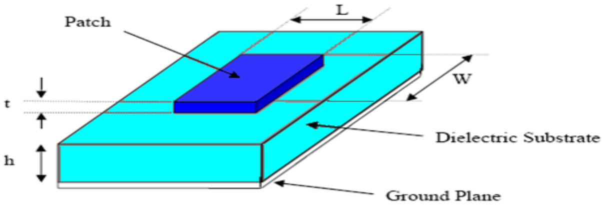

Figure 1.: Structure of a Microstrip Patch Antenna substrate.

II. ANTENNA DESIGN

The three essential parameters for the design of a circular Microstrip Patch Antenna are:

- Frequency of operation (f_o): The resonant frequency of the antenna must be selected appropriately. The antenna designed must be able to operate in this frequency range. The resonant frequency selected for my design is 9.8 GHz.
- Dielectric constant of the substrate (ε_r): The dielectric material selected for my design is 2.2 A substrate with a high dielectric constant has been selected since it reduces the dimensions of the antenna.
- Height of dielectric substrate (h): For the microstrip patch antenna to be used in, the height of the dielectric substrate is selected as 0.159 cm.

From the above the essential parameters are

- f_o = 9.8 GHz
- ε_r = 2.2
- h = 31 mils

III. EQUIVALENT CIRCUIT OF CIRCULAR MICROSTRIP ANTENNA (CMSA)

The Equivalent circuit for Circular microstrip Antenna (CMSA) can be expressed as parallel combination on an inductance L, a capacitance C and a resistance R

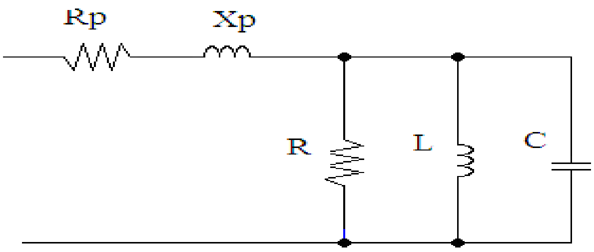

Figure 2 Equivalent circuit of resonant cavity (CMSA)

Here R_p and X_p are added in the model due to the effects of coaxial probe feed. According to modal expansion cavity the values of L, C, R are calculated

$$C = \frac{Q_T}{2\Pi R_1 f_r}$$

$$L = \frac{R_1}{2\Pi Q_1 f_r}$$

$$R = \frac{h^2 E_o^2 J_n^2 (kx_o)}{2P_T}$$ in which

$J^2_n(kx_o)$ = Bessel functions of order 'n' x_o= feed location from the center of the disk patch h = thickness between ground plane and fed patch

Q_T = total quality factor of the resonator

T p = total power loss in the cavity

$$f_r = \frac{k_{nm} c}{2\Pi R_e \sqrt{\varepsilon_r}}$$

IV. IMPEDANCE OF THE CIRCULAR MICROSTRIP ANTENNA (CMSA)

There are three different kinds of impedance relevant to antennas. One is the terminal impedance of the antenna, another is the characteristic impedance of a transmission line, and the third is wave impedance. Terminal impedance is defined as the ratio of voltage to current at the connections of the antenna (the point where the transmission line is connected). The complex form of Ohm's law defines impedance as the ratio of voltage across a device to the current flowing through it. The most efficient coupling of energy between an antenna and its transmission line occurs when the characteristic impedance of the transmission line and the terminal impedance of the antenna are the same and have no reactive component

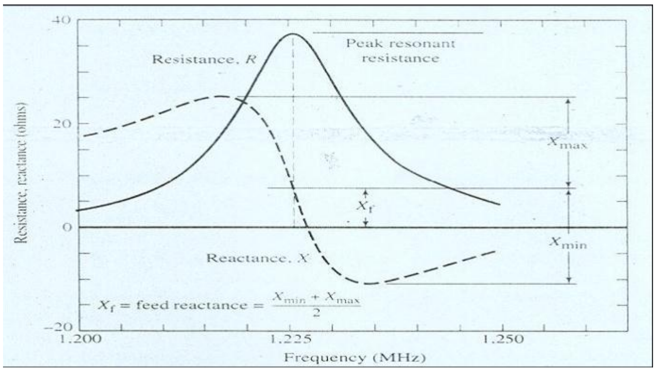

Figure3. Typical variation of resistance and reactance of circular Microstrip antenna versus frequency

V. DESIGNING OF CMSA

The theoretical results were obtained by considering an equivalent circuit of CMSA and using MATLAB for calculating various parameters. The design was then simulated on CST software

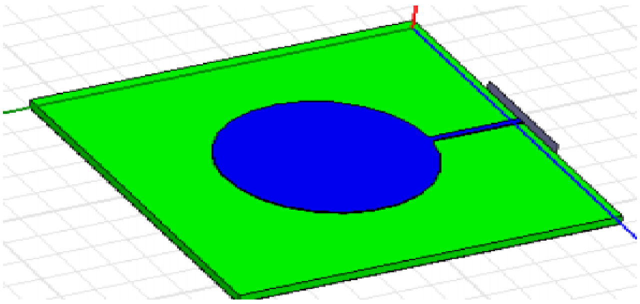

Figure 4 CMSA model designed using CST

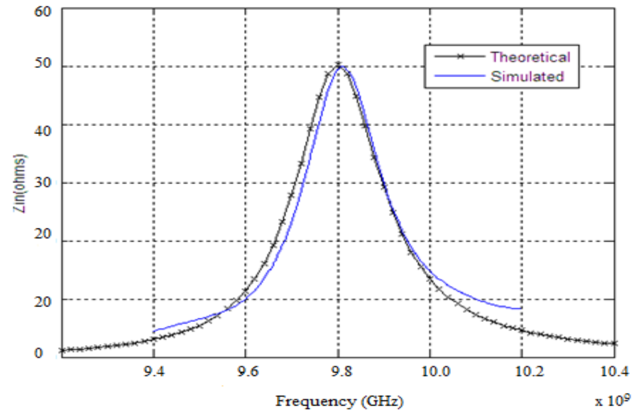

Figure 5: Variation of Real [Z_{in}] with frequency

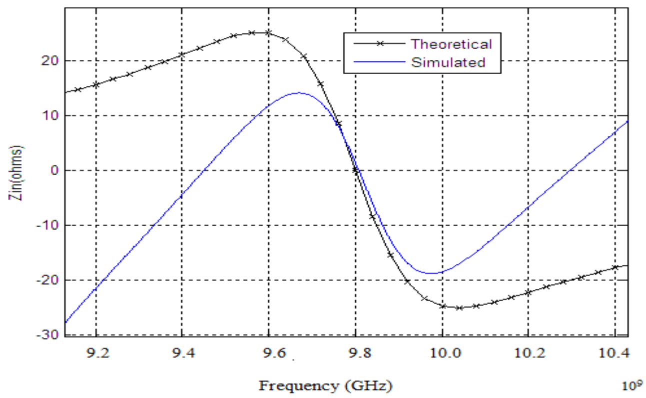

Figure 6: Variation of Imaginary [Z_{in}] with frequency

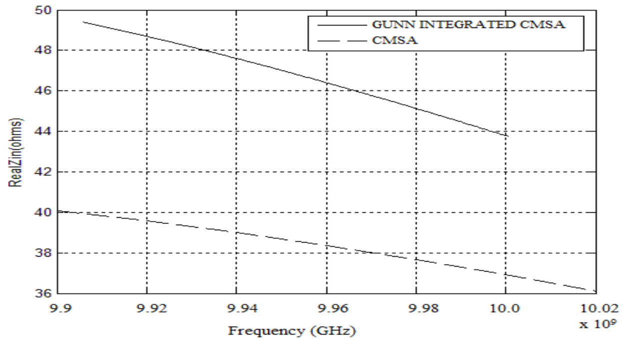

Figure 7: Variation of Real [Z_{in}] versus frequency

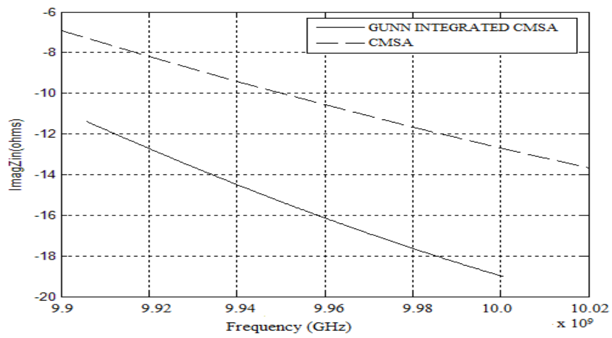

Figure 8: Variation of Image Z_{in} versus frequency10^9

VI. CONCLUSION

The work in this thesis presented the designing of Circular Microstrip Antenna and improving its performance by loading Gunn diode on it and analyzing their effect on various aspect of the antenna such as VSWR, Return Loss, and Radiation Pattern etc.

The Circular microstrip Antenna is designed for a frequency of 9.8 GHz using RT Duroid 5870 as a substrate. The parameters is calculated which is discussed in chapter 3.It is then loaded first with a single Gunn diode and it is observed that it offers better matching ,wider tunability and enhanced bandwidth and enhanced radiated power in comparison to CMSA. It is hence concluded that on loading Gunn diode on CMSA the Bandwidth is enhanced and thus overcomes the limitation of limited Bandwidth of patch. The radiation pattern is also enhanced as compared to CMSA alone. It is also seen that the frequency agility is achieved by symmetrical loading of two identical Gunn diodes in which the operating frequency of the circular microstrip antenna is electronically controlled by the of Gunn diode.

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