Empirical Relation for Designing the Meander Line Antenna

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Abstract — **In meander line antenna the size of the dipole at given frequency is reduced by a factor that is proportional to the number of turns. The adjacent horizontal segments of the meander line antenna have opposite phase. The transmission line current neither contributes much to the radiated power nor produce losses. At the location where the current reaches maximum value at that point large amount of power is wasted which is close to the antenna centre. Hence the radiation resistance is affected by the vertical segments. The meander line structure is design on glass epoxy (FR4) substrate with thickness 3.2cm dielectric constant 4.4. The impedance matched between the feed and meander line antenna is being achieved by adjusting the width and length of the open end of the microstrip. The optimized parameters are obtaining by design equation d=0.16λg ,s=0.33λg ,w=0.06λg, L=0.7λg where λg is the guide wavelength in the glass epoxy substrate at the centre frequency of 1060MHZ. Similarly using design equation the dimension has also been obtained for 1025MHZ. An empirical relation between frequency and each dimension of the meander line and frequency relations giving the design of the meander line are validate for two different frequencies which are 1030MHZ and 1090MHZ. For validation dimensions of meander line antenna are calculated using above equations. Then separately the dimensions of the meander line are obtained using the standard formula. The value so obtained by two methods one by empirical relation and other by design equation are compared. It is found that the dimension obtained by both methods matched. Thus one can use these empirical relations for designing the meander line antenna.**

Index Terms – **Meander Line Antenna, Antenna, Microstrip Antenna.**

I. INTRODUCTION

This meander line antenna is a type of printed antenna that achieves miniaturization in size by embedding the wire structure on a dielectric substrate. In basic form meander line antenna is a combination of conventional wire and planer strip line. Benefits include configuration simplicity, easy integration to a wireless device, inexpensive and potential for low SAR features.

II. DESIGNING OF MEANDER LINE ANTENNA

The proposed new microstrip antenna element is a resonant meander line antenna (also called rampart line antenna). The meander line element consists of a meandering microstrip line formed by a series of sets of right angled bends. The fundamental element in this case is formed by four right angled bends and the radiation mainly occurs from the discontinuities (bend) of the structure. The right angle bends are chamfered to reduce the right angled discontinuity susceptance for impedance matching. The current directions are changing in every half wavelength and there are more than four half wavelength changes in this design. The radiations from the bend add up to produce the desired polarization depending on the dimensions of the meander line antenna. The spacing between two bends is very critical, where if the bends are too close to each other, then cross coupling will be more, which affects the polarization purity of the resultant radiation pattern. In other case the spacing is limited due to the available array grid space and also the polarization of the radiated field will vary with the spacing between the bends, and the spacing between the microstrip lines. The present meander line structure is designed with liner polarization with less cross coupling between the bends, to fit within the available array grid size.

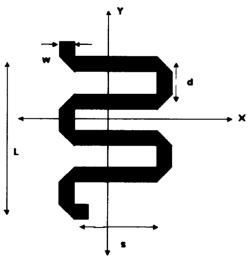

Fig.1 Figure showing various dimensions of Meander Line Antenna

III. MATHEMATICAL DESIGNING OF MEANDER LINE ANTENNA[1,2,3]

Referring to Fig.1 various dimensions of meander line antenna [1] – [3] are calculated from the following equations:

- Dimensions of Meander Line Antenna:

$$d = 0.16\lambda_g \tag{1}$$

$$s = 0.42\lambda_g \tag{2}$$

$$L = 0.70\lambda_g \tag{3}$$

$$w = 0.05\lambda_g \tag{4}$$

Where λ_g is the guided wavelength of the substrate which is given by:

$$\lambda_g = \frac{\lambda}{\sqrt{\epsilon_{reff}}} \tag{5}$$

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Where λ is free space wavelength and $\in_{reff}$ is the effective dielectric constant given by:

$$\in_{reff} = \frac{\in_r + 1}{2} + \frac{\in_r - 1}{2}\left[1 + 10\frac{h}{w}\right]^{\frac{-1}{2}} \qquad (6)$$

where:

h = height of substrate
$\in_r$ = dielectric constant of given material
w = width of meander line antenna
$\in_{reff}$ = effective dielectric constant

Calculated values of d, s, l and w needs to be corrected. The correct dimension can be calculated from the below equation

- Corrected dimension

$$S_P = S + \Delta L \qquad (7)$$

$$d_P = d + \Delta L \qquad (8)$$

$$L_P = L + \Delta L \qquad (9)$$

Where ΔL is equivalent length.

$$\Delta L = 0.5 \text{ X } W. \qquad (10)$$

$$w = \frac{c}{2f_r}\sqrt{\frac{2}{\in_r + 1}} \qquad (11)$$

where:

f_r = center frequency
c = velocity of light

$$\theta_E = 2\sin^{-1}\sqrt{\frac{7.03}{(3L^2 + h^2)k_o^2}} \qquad (12)$$

$$\theta_H = 2\sin^{-1}\sqrt{\frac{1}{2 + k_o w}} \qquad (13)$$

where

$$k_o = \frac{\pi}{\sqrt{\in_{reff}}L} \qquad (14)$$

Finally directivity and gain can be calculated as given below

$$\text{Directivity } D = \frac{41253}{\theta_E \theta_H} \qquad (15)$$

$$\text{Gain } G = \frac{32400}{\theta_E \theta_H} \qquad (16)$$

IV EMPIRICAL RELATION FOR DESIGNING OF MEANDER LINE ANTENNA

An empirical relation between frequency and each dimension of the meander line and frequency relations giving the design of the meander line are validate for two different frequency .which are 1030 MHZ and 1090 MHZ. For validation using these equations the dimension of meander line antenna is calculated.

The empirical relationship for dimension **d** is shown in **Fig 2**, for dimension **s** is shown in **Fig 3**, for dimension **w** is shown in **Fig 4** and for dimension L it is shown in **Fig 5**. In **Fig 6** relationship of gain and frequency is plotted.

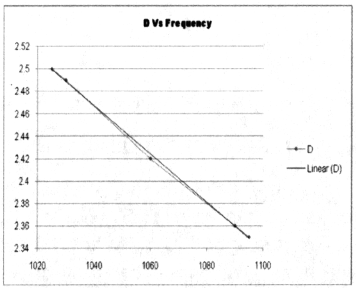

Fig 2 Figure showing variation of 'd' w.r.t. frequency

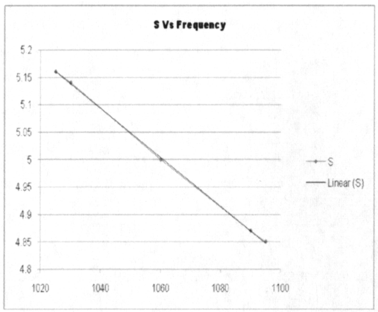

Fig 3 Figure showing variation of 's' w.r.t. frequency

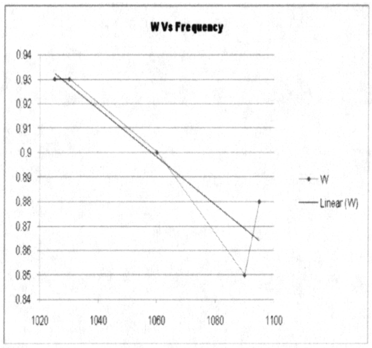

Fig 4 Figure showing variation of 'w' w.r.t. frequency

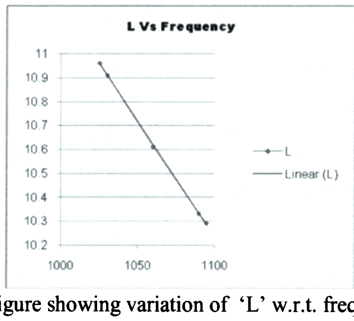

Fig 5 Figure showing variation of 'L' w.r.t. frequency

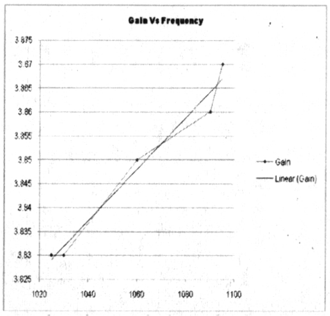

Fig 6 Figure showing variation of gain w.r.t. frequency

VI. Result and Discussion

The Meander Line Antenna was designed around the center frequency of 1060 MHz. It was then simulated at frequency 1030 MHz and 1090 MHz. From the above plots we can see that there is linear relationship between the dimensions of antenna at various frequencies. Hence with this empirical relationship we can design an antenna at required frequency.

V. Conclusion

It is seen that by theoretical calculation of meander line antenna parameter, the empirical relationship between dimension and various parameter of meander line antenna at desired frequency range can be calculated. The empirical relation obtained is useful for structuring the meander line antenna.

VI . References

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