Gap- Coupled Microstrip Antennas For Dual Frequency Operations

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Abstract:
Low cost, ease of fabrication and planar structure of microstrip antenna makes it very popular today. It is basically a metal patch over a dielectric substrate. Rectangular Microstrip antennas when separated by a suitable gap, dual frequency operation is obtained. A study on dual frequency operation of antenna for variable length and different array configurations are presented in this paper. Parametric studies for the effect of the gap and feed point location, along with radiation characteristics have been investigated.

Keywords: Microstrip antenna, Dual frequency antenna, effect of gap coupling, bandwidth improvement technique.

1. Introduction:

The most commonly used microstrip antenna is the patch antenna. When conformal and low profile antennas are required, the patch antenna is the best choice. This type of antenna also has the advantage of low cost and weight, design flexibility and ease of installation [Garg, et. al 2001; Wong 2002; Girish kumar et. al 2003]. The radiating elements together with feed lines are metals, easily photo etched on a thin dielectric sheet whose other side is a metal ground plane. The rectangular patch size with single feed point is considered in this study. The main disadvantage of this kind of structure is its bandwidth. Here a new technique of using array of parasitic element along the length of driven element is used to improve bandwidth.

Numerous techniques have been devised to develop dual frequency microstrip antenna [Ray et. al 2007; Garg, et. al 2001; Girish kumar et. al 2003; Rajesh kumar et. al 1999]. One of these techniques uses additional parasitic resonators which have nearly the same dimensions, and are gap coupled to fed patch. If two rectangular patches of equal dimensions are placed side by side along the length, the dual frequency operation is obtained by proper gap coupling. In this paper the effect of gap on the dual frequency operation is studied. Addition of one more patch as parasitic element along the length will increase the bandwidth approximately one and half times.

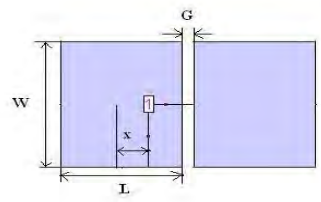
2. Antenna configuration:

The geometry of proposed antennas are shown in fig 1(a) & 1(b). In the first structure two patches of equal dimensions are placed side by side and are electromagnetically fed by a single coaxial line at the optimized feed position of the driven element. In the second structure three patches of equal dimensions are placed along the length of the driven element. Here we choose the left most patch as driven element and the substrate material used here is the glass epoxy for both the structures. The length and width of every antenna patch is calculated as 19mm and 25mm using the design equation (1) and (2) respectively. The dielectric constant of the material is 4.4 and its thickness is 1.59mm. The gap between the two patch elements is chosen 2 mm for both the antenna configurations.

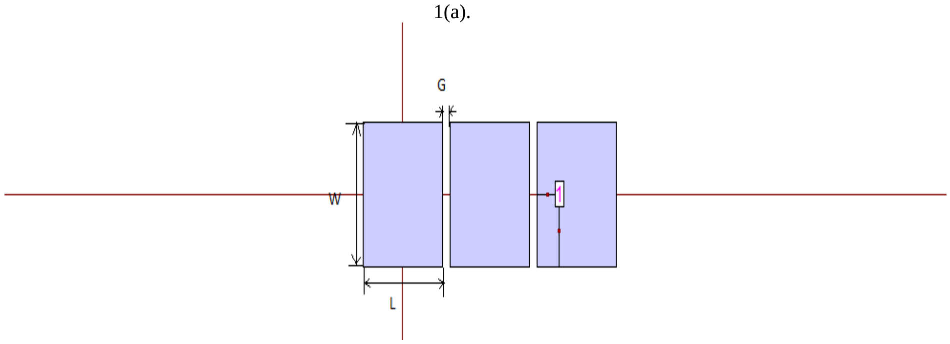
$$L_e = L + 2\Delta L = \frac{\lambda_0}{2\sqrt{\epsilon_e}} = \frac{c}{2f_0\sqrt{\epsilon_e}} \quad (1)$$

$$W = \frac{c}{2f_0\sqrt{\frac{(\epsilon_r + 1)}{2}}} \quad (2)$$

Where λ is the wavelength in the dielectric medium. Here, λ is equal to $\lambda_0/\sqrt{\epsilon_e}$, where λ_0 is the free space wavelength and ϵ_e is the effective dielectric constant of the patch. C is the velocity of light in free space and f0 is the resonating frequency. ϵ_r is the dielectric constant of the substrate.



1(a).



1(b)

figure1: (a) two element patch antenna, (b) three element patch antenna. (top view)

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3. Table:

RMSA TYPE	L (mm)	S (mm)	X (mm)	fr (GHz)	BW (MHz)	Directivity (dBi)	RL_1 (dB)
Single RMSA	19	_	4.2	3.579	95.4	4.34	-24
Two Separated RMSA(equal patch dimensions)	19	0.5	4.4	3.682	61	4.32	-12
	19	1	4.4	3.640	56	5.02	-12
	19	1.5	4.3	3.617	116	5.25	-41
	19	2	4.2	3.602	98	5.25	-16
	19	4	3.9	3.552	71	4.84	-13
Three Separated RMSA(equal patch dimension and separation)	19	2	37	3.615	143	5.01	-16

Table1: Effect of coupling gap on performance of two separated configurations.
(w=25mm, h=1.59mm, dielectric const.=4.4)

L_1 (mm)	L_2 (mm)	S (mm)	X (mm)	fr_1 (GHz)	RL_1 dB	BW_1 (MHz)	fr_2 (GHz)	RL_2 dB	BW_2# (MHz)	BW_2/# BW_1	fr_2/ fr_1
19	17.5	2	4.2	3.556	-16	112	5.656	-14	114	1.018	1.59
17.5	19	2	4.2	3.64	-12	70	5.656	-14	119	1.7	1.55
19	18	2	4.2	3.556	-16	110	5.628	-14	121	1.1	1.58
18	19	2	4.2	3.752	-16	102	5.67	-12	98	0.96	1.51
19	19	2	4.2	3.59	-24	95	5.60	-20	117	1.23	1.56
20	19	2	4.2	3.402	-14	98	5.614	-20	124	1.265	1.65
19	20	2	4.2	3.598	-15	84	5.628	-15	112	1.33	1.56
20.5	19	2	4.2	3.346	-13	84	5.614	-20	130	1.56	1.68
19	20.5	2	4.2	3.598	-14	98	5.628	-15	112	1.14	1.56

Table2: Dual frequency response of separated RMSA with variable length configurations.
(w=25mm, h=1.59mm, dielectric const.=4.4)

4. Results & discussions:

Dual frequency operation of a microstrip antenna can be obtained by using a single parasitic element and its band width has been improved by inserting another patch element along its length. It has also been observed that insertion of more than two parasitic elements does not improved the BW further.

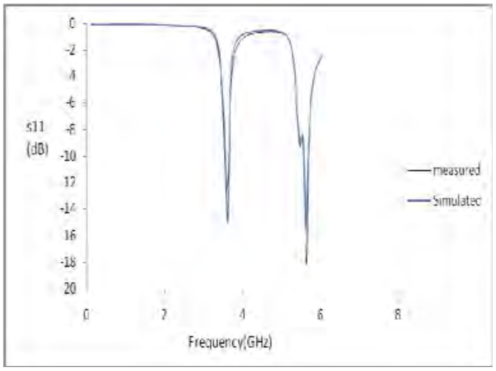
For the first structure we found that the first resonant frequency is obtained at 3.602 GHz with -10 dB impedance BW of 98 MHz and the second resonant frequency is obtained at 5.6 GHz with -10 dB impedance BW of 117 MHz. In the second structure the two resonant frequencies are obtained at almost same frequencies but the BW at first resonant frequency is 143 MHz which is almost 50 percent more than the previous case. It is clear from the result that instead of using one if we use two parasitic patch then bandwidth can increase further.

From table 2 results we see that if the parasitic element length is slightly more than the driven element length then the second resonant frequency to first resonant frequency ratio decreases.

Frequency ratio can be varied by changing the length of the patches. If the length of the parasitic element is slightly longer than the driven element patch length then the frequency ratio is smaller.

For three element array configuration if the left element is considered as driven element then first resonant frequency is properly matched. When we consider the right element as driven element, in this case second resonant frequency is properly matched.

Choice of proper gap between two elements is important for BW enhancement and impedance matching point of view. The result for different gap coupled antenna is illustrated in table1.



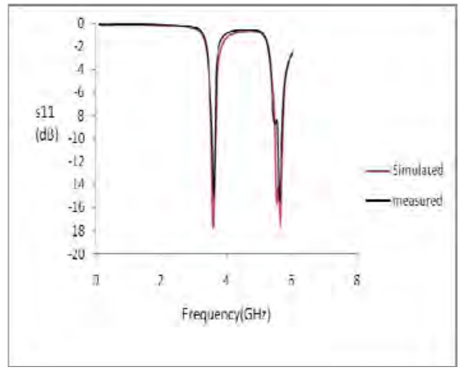


figure2(a): s11 plot of two element patch antenna. Figure 2(b). s11 plot of three element patch antenna.

Conclusion:

The objective of the paper was to develop a compact dual frequency patch antenna for the use of WLAN. Also the objective was to improve the BW of the antenna by using more parasitic elements along the length of the driven element. Here, the design of the antenna is made successfully and the desired result is obtained by using the fabricated antenna.

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