Dual-Frequency Rectangular Patch Antenna with Monolithic Reactive Loading

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ABSTRUCT

In this paper the characteristics of a single-layer, dual-frequency antenna, which uses a stub-strip loaded rectangular microstrip patch, are studied. This antenna is easy to achieve good impedance matching at both resonance frequencies by setting the feed position or using other design parameters (tapered transmission lines). A detailed parameter study is performed and the theoretical analysis is based on the general transmission line theory. The effects of the various antenna parameters on two resonant frequencies, frequency ratio, bandwidth, and input impedance characteristics of the antenna are analyzed and discussed. It is shown that various frequency ratios (1.5–2.04) can be obtained by varying the length and width of the stub-strip loaded. A comparison between this work and other single layer dual-band techniques is made.

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1. Introduction

Due to their inherent advantages of low profile, light weight, low cost, conformability, ease of fabrication and integration with RF devices, microstrip patch antennas have been widely employed in many practical applications for several decodes. Single-layer dual-frequency microstrip antenna with a single feed is urgently required in various radar and communications systems, such as synthetic aperture radar system, dual band GSM/DCS 1800 mobile communications systems, global positioning systems and satellite communications [1].

Generally, the dual-frequency microstrip antennas are divided into two categories, namely multi-resonator antennas and reactive loading. In the first kind of structures, the dual-frequency operations is achieved by means of multiple radiating elements, this category includes the multi-layer stacked patch antennas using circular, annular, rectangular and triangular patches [2-5] . These antenna structures usually involved multiple substrate layers are of high cost and has very cross polarization level [6]. The reactive-loading microstrip patch antenna consists of a single radiating element in which the double resonant behavior is obtained by a microstrip stub at the edges of a rectangular patch.

2. Antenna Configuration and Analysis Method

The transmission line model will be discussed for a rectangular patch antenna loaded with a stub-strip line. The antenna consists of a rectangular conducting patch characterized by the resonant length L and the width W, loaded by a stub-strip line has a length of S and a width of t (see figure (1)), placed on a substrate material has a thickness of h and relative permittivity ϵ_r grounded by a conductive plate. The antenna feed by a strip line has length of L_m and width of W_m.

The main step in the modeling of the antenna by a transmission-line equivalent is the representation of the open-ended terminations by parallel admittances Y_1, Y_2 and Y_3 as shown in figure (1). But, its an open-ended microstrip line does not perform as a perfect open circuited that, the field lines do not stop abruptly at the end of the strip conductor, there is a stray field extending beyond the end of the strip, which implies an amount of stored energy, on the other hand, the stray field is also source of power radiated in the space above the antenna and launched as a surface waves along the substrate [6].

At the cross-section $A\bar{A}$ in figure (1), the microstrip line with aspect ratio W/h has an open-ended termination and loaded at section $B\bar{B}$ by a stub-strip line (reactive load). At the cross section $C\bar{C}$ the microstrip line with aspect ratio t/h (stub-strip) represent an open-ended (not perfect) which can be represented by a parallel admittance Y_3.

The total admittance at the cross section $A\bar{A}$ (input admittance of the antenna) is obtained by transferring the admittance of the cross sections $B\bar{B}$ and $C\bar{C}$ from the output terminal to the input terminal using the impedance transformation equation of transmission line.

At section $B\bar{B}$ the total admittance is the summation of the slot admittance Y_2 with the transformation slot admittance Y_3 along the transmission line characterized by aspect ratio of (t/h) at section $B\bar{B}$ hence:

$$\bar{Y}_{in} = Y_2 + \bar{Y}_3 \qquad \text{...(1)}$$

Where:

$\bar{Y}_{in}$ is the total admittance looking from $B\bar{B}$ section.

Y_2 is the slot admittance of section $B\bar{B}$.

$\bar{Y}_3$ is the slot admittance refers to $B\bar{B}$ section given by [7]:

$$\bar{Y}_3 = \frac{1}{\bar{Z}_3} \qquad \text{...(2)}$$

$$\bar{Z}_3 = Z_{CS}\left(\frac{Z_3 + jZ_{CS}\tan\beta S}{Z_{CS} + j\tan\beta S}\right) \qquad \text{...(3)}$$

Where:

Z_{CS} is the characteristic impedance of the stub-strip line.

$$\beta = k_o\sqrt{\varepsilon_r}\,. \qquad \text{...(4)}$$

$$k_o = \frac{2\pi}{\lambda} \qquad \text{...(5)}$$

is obtained by the $A\bar{A}$ The input admittance at the cross section with the $A\bar{A}$ summation of the slot admittance of section along the transmission line $\bar{Y}_{in}$ transformed admittance characterized by W/h aspect ratio.

$$Y_{in} = Y_1 + \bar{Y}_{in} \qquad \text{...(6)}$$

Where:

$$\bar{Z}_{in} = Z_C\left(\frac{\bar{Z}_{in} + jZ_C \tan\beta L}{Z_C + j\,\bar{Z}_{in} \tan\beta L}\right) \qquad \text{...(7)}$$

Z_C **is the characteristic impedance of a microstrip line which has aspect ratio of W/h.**

By loading a microstrip antenna with a reactive load, the impedance frequency response of the load will be added to self antenna impedance. A very important change in the total impedance frequency response will be occurred. The total impedance frequency response will be separated and by governs the frequency response of the load the dual operation can be achieved.

The general transmission line model can be applied in the both cases for feeding of microstrip antenna, microstrip line and coaxial feed. In the case of microstrip line (figure (1)), the antenna is connected with a microstrip line has a characteristic impedance Z_m equal to the input impedance of the antenna at the two resonances. While, in the case of coaxial feed, the feed point is moved across the length by L_m to match this antenna to 50Ω typical impedance using [8,9] .

$$Z_{in} = Z_C\left(\frac{Z_{in}(at\ L_m = 0) + jZ_C \tan(\beta L_m)}{Z_C + jZ_{in}(at\ L_m = 0)\tan(\beta L_m)}\right) \qquad \text{....(8)}$$

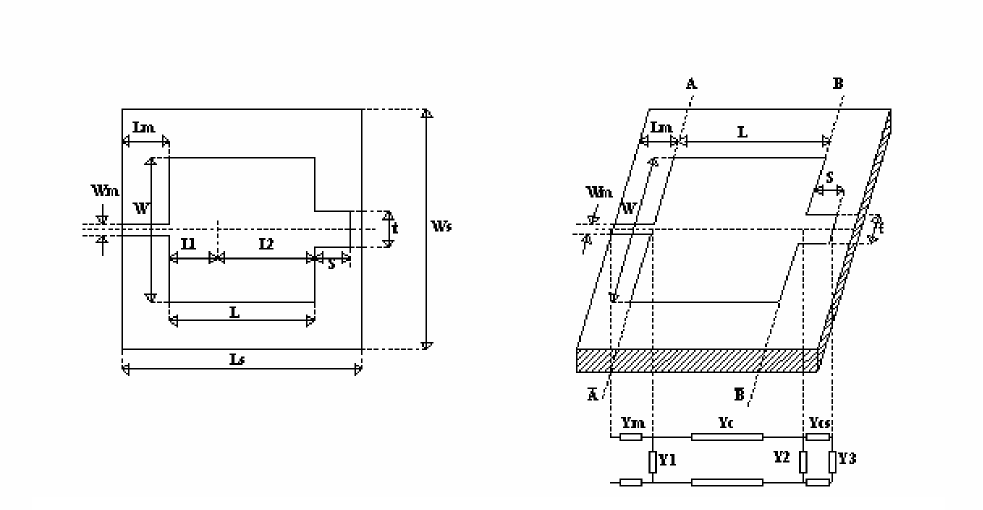


Figure (1) Rectangular Patch Antenna with Monolithic Reactive Loading

3. Slot Admittances Calculation

As shown in the previous section that, the field lines do not stop abruptly at the end of the strip conductor, there is a stray field extending beyond the end of the strip. The stray field from the strip line can be divided into two parts. The first part represents the power radiated in the space above the antenna and lunched as a surface waves along the substrate. This field can be represented by the conductance G$_S$ as shown in figure (3) [9].

$$G_S = G + G_{12} \qquad \text{...(9)}$$

Where:

G is the self conductance which can be computed as [10]:

$$G = \frac{2p_{rad}}{|V_o|^2} \qquad \text{...(10)}$$

Where V_o is the peak feed voltage.

$$P_{rad} = \frac{|V_o|^2}{2\pi\eta_o} \int_0^{\pi} \left[\frac{\sin\left(\frac{K_o W \cos\theta}{2}\right)}{\cos\theta} \right]^2 \sin\theta^2 d\theta \qquad \text{...(11)}$$

G_{12} is the mutual conductance given by:

$$G_{12} = \frac{1}{120\pi} \int_0^{\pi} \left[\frac{\sin\left(\frac{K_o W \cos\theta}{2}\right)}{\cos\theta} \right]^2 J_o(K_o L \sin\theta) \sin^3\theta \, d\theta \qquad \text{...(12)}$$

J_o is the Bessel function of first kind and zero order.

The second part represents the stored energy between the patch and the ground plan represented by B_s given by [9]:

$$B_S = \frac{K_o \Delta L \sqrt{\varepsilon_e}}{Z_o} \qquad \text{...(13)}$$

Where:

ΔL is the length extension given by [9]:

$$\Delta L = 0.412h \frac{(\varepsilon_e + 0.3)\left(\frac{W}{h} + 0.264\right)}{(\varepsilon_e - 0.258)\left(\frac{W}{h} + 0.8\right)} \qquad \text{...(14)}$$

Z_0 is the characteristic impedance of the transmission line and ε_e is the effective dielectric constant which is given later then:

$$Y_S = G_S + jB_S \qquad \text{...(15)}$$

And hence, this can be applied to the slot admittances of cross sections $A\bar{A}$ (Y_1), $B\bar{B}$ (Y_2) and $C\bar{C}$ (Y_3).

4. Expressions of the Microstrip Line Parameters

A microstrip line with aspect ratio (W/h) and with a dielectric substrate of relative permittivity ε_r has an characteristic impedance of Z_C is given by [10]:

$$Z_C = \frac{\eta_o}{\sqrt{\varepsilon_e}}\frac{h}{W_e} \qquad \text{...(16)}$$

Where:

W_e is the effective width due to the stray field and given by:

$$W_e = \frac{2\pi h}{\ln\left\{\frac{hF}{T}\right\} + \sqrt{1 + \left(\frac{2h}{T}\right)^2}} \qquad \text{...(17)}$$

Where

$$F = 6 + (2\pi - 6)\exp\left\{-\frac{4\pi^2}{3}\left(\frac{h}{T}\right)^{\frac{3}{4}}\right\} \qquad \text{...(18)}$$

$$T = W + \frac{\bar{t}}{\pi}\left\{1 + \ln\left(\frac{4}{\sqrt{\left(\bar{t}/h\right)^2 + \frac{(1/\pi)^2}{\left(W/\bar{t}\right) + 1.1^2}}}\right)\right\} \qquad \text{(19)}$$

$\bar{t}$ **is the conductor thickness.**

$$\varepsilon_e = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2}\left[1 + 12\frac{h}{W}\right]^{-\frac{1}{2}} \qquad \text{...(20)}$$

5. Results and Discussion

In this section the computations based upon the results of the previous sections will be presented and compared with other single layer dual-frequency techniques. For a given patch dimensions, the antenna performance is governed by varying of the stub dimensions (S,t). The patch is chosen such that:

The center frequency is 10GHz, ε_r=2.2, h=1.59mm.

From these data the length (L) and width (W) are computed as: L=0.906 cm, W= 1.186 cm.

5.1 The Effect of the Stub Dimensions

Table (1) shows the effect of the stub dimensions (S,t) on all antenna performance. From this table, the 1st resonance frequency f_1 is increased by increased the stub length S, while it is decreased when the stub width t is decreasing.

Table (1) Variation of Antenna parameters w.r.t stub dimensions

(a) $t = 0.02\lambda$.

S/λ	f_1	f_2	BW_1	BW_2	Z_1	Z_2	F.R
0.3	**8.1**	**10.9**	**zero**	**1.83%**	**440**	**234**	**1.345**
0.26	**8.3**	**11.5**	**0.84%**	**1.04%**	**499**	**212**	**1.385**
0.24	**8.6**	**11.9**	**1.4%**	**1%**	**445**	**200**	**1.383**
0.22	**8.9**	**12.6**	**2%**	**0.714%**	**414.25**	**195.3**	**1.415**
0.2	**9.1**	**13.4**	**2.19%**	**0.522%**	**382**	**200**	**1.4725**
0.18	**9.3**	**14.5**	**2.6%**	**0.413%**	**357.4**	**213.8**	**1.559**
0.16	**9.4**	**15.8**	**2.66%**	**0.3723%**	**343.32**	**226.5**	**1.68**
0.14	**9.5**	**17.3**	**3.15%**	**0.924%**	**329.91**	**174.7**	**1.8210**
0.12	**9.6**	**18.5**	**3.125%**	**0.756%**	**321.46**	**115**	**1.927**
0.11	**9.7**	**19**	**2.5%**	**Zero**	**312.3**	**100**	**1.958**
0.1	**9.7**	**19.2**	**3.09%**	**Zero**	**314**	**91.23**	**1.979**
0.09	**9.7**	**19.4**	**3.09%**	**Zero**	**309**	**85.8**	**2**
0.07	**9.8**	**19.7**	**3.06%**	**Zero**	**305**	**80**	**2.01**
0.05	**9.9**	**19.8**	**3.03%**	**zero**	**294.63**	**76.43**	**2**

(b) t =0.04λ .

S/λ	f_1	f_2	BW_1	BW_2	Z_1	Z_2	F.R
0.3	7.4	11.2	zero	zero	748.5	222.46	1.5135
0.26	8	11.9	0.625%	zero	598	204	1.4875
0.24	8.3	12.4	1.2%	0.645%	527.7	193.4	1.493
0.22	8.5	13	1.6%	0.769%	445	194.2	1.529
0.2	8.8	13.8	2.27%	0.724%	427	195.5	1.568
0.18	9	14.7	2.22%	0.68%	396.5	220	1.633
0.16	9.1	15.9	2.19%	0.88%	368	218.12	1.747
0.14	9.3	17.1	3.22%	1%	358	183.4	1.838
0.12	9.4	18.2	2.65%	1%	342.2	130	1.936
0.11	9.5	18.6	3.15%	0.2%	334.6	113.2	1.957
0.1	9.5	18.9	3.15%	zero	327.8	101.9	1.989
0.09	9.6	19.1	3.125%	zero	324.3	94	1.989
0.07	9.7	19.5	3.1%	zero	314.3	85	2.01
0.05	9.8	19.7	3.06%	zero	304.9	80	2.01

(c) $t = 0.06\lambda$.

S/λ	f_1	f_2	BW_1	BW_2	Z_1	Z_2	F.R
0.3	**zero**	**zero**	**zero**	**Zero**	**801**	**215**	**1.53**
0.26	**7.9**	**12.1**	**0.6%**	**Zero**	**600**	**200**	**1.5316**
0.24	**8.1**	**12.5**	**1.23%**	**0.56%**	**512.8**	**200**	**1.543**
0.22	**8.4**	**13.1**	**1.4%**	**0.53%**	**508**	**195**	**1.559**
0.2	**8.6**	**13.9**	**2.09%**	**0.575%**	**453**	**207.5**	**1.616**
0.18	**8.8**	**14.8**	**2.27%**	**0.675%**	**416**	**220**	**1.681**
0.16	**9**	**15.9**	**2.77%**	**0.75%**	**395**	**225**	**1.766**
0.14	**9.2**	**17**	**2.717%**	**1.05%**	**370**	**183.6**	**1.847**
0.12	**9.3**	**18.1**	**2.688%**	**1.1%**	**353.5**	**136**	**1.946**
0.11	**9.4**	**18.4**	**3.19%**	**0.5%**	**346.15**	**118.8**	**1.957**
0.1	**9.5**	**18.8**	**2.6%**	**Zero**	**332**	**107**	**1.978**
0.09	**9.5**	**19**	**2.63%**	**Zero**	**333**	**99**	**2**
0.07	**9.6**	**19.4**	**3.125%**	**Zero**	**320**	**88**	**2.02**
0.05	**9.7**	**19.6**	**3.09%**	**Zero**	**308.3**	**81.2**	**2.026**

(d) $t=0.08\lambda$.

S/λ	f_1	f_2	BW_1	BW_2	Z_1	Z_2	F.R
0.3	7.2	11.5	Zero	Zero	742.7	214.2	1.59
0.26	7.8	12.2	0.1%	0.009%	587.5	201.7	1.564
0.24	8	12.7	1%	0.07%	582	198	1.5875
0.22	8.3	13.3	1.4%	0.45%	513	200	1.6
0.2	8.5	14	1.88%	0.57%	486	208.8	1.647
0.18	8.7	14.9	2.29%	0.671%	444.53	223.7	1.712
0.16	8.9	15.9	2.247%	0.943%	413.3	224.15	1.786
0.14	9.1	17	2.74%	1.17%	383.3	189.4	1.868
0.12	9.2	17.9	2.7%	1.11%	362	141.5	1.945
0.11	9.3	18.3	2.68%	0.655%	356.8	124.5	1.967
0.1	9.4	18.6	2.65%	Zero	345.5	111.5	1.978
0.09	9.5	18.9	3.15%	Zero	335	102.5	1.989
0.07	9.6	19.3	3.125%	Zero	323.7	90.37	2.01
0.05	9.7	19.8	3.1%	Zero	314.17	82.8	2.04

(e) t=0.1λ .

S/λ	f_1	f_2	BW_1	BW_2	Z_1	Z_2	F.R
0.3	7.1	11.6	Zero	Zero	649.8	210	1.6
0.26	7.7	12.4	Zero	Zero	579	195	1.61
0.24	7.9	12.8	Zero	1.56%	361.75	195.8	1.62
0.22	8.1	13.4	1.7%	0.597%	515.8	200	1.65
0.2	8.4	14.1	1.9%	0.7%	500.7	207	1.678
0.18	8.6	15	2.09%	0.8%	466.5	222.5	1.799
0.16	8.8	15.9	2.27%	1.13%	430.5	220	1.8
0.14	9	16.9	2.7%	1.18%	396.5	190.18	1.877
0.12	9.1	17.8	2.77%	1.4%	371	147	1.956
0.11	9.2	18.2	3.3%	0.879%	366.4	130	1.978
0.1	9.3	18.5	3.2%	Zero	357.8	116.6	1.989
0.09	9.4	18.8	3.19%	Zero	345	106.5	2
0.07	9.5	19.2	3.15%	Zero	332.34	93.175	2.02
0.05	9.7	19.5	3.09%	Zero	312	84.75	2.02

(f) t=0.12λ .

S/λ	f_1	f_2	BW_1	BW_2	Z_1	Z_2	F.R
0.3	7.1	11.7	0.16%	Zero	885.4	208.38	1.647
0.26	7.6	12.5	0.16%	Zero	595.65	195.5	1.647
0.24	7.8	12.9	0.897%	Zero	634.25	195	1.653
0.22	8.1	13.5	1.481%	0.37%	542.2	201.6	1.666
0.2	8.3	14.4	1.68%	0.55%	528.66	211.79	1.734
0.18	8.5	15	2.35%	0.8%	484.75	220.8	1.764
0.16	8.7	16	2.29%	1%	445.96	216.85	1.833
0.14	8.9	16.9	2.8%	1.1%	414.119	193.7	1.898
0.12	9.1	17.8	2.8%	1.68%	382.8	150	1.956
0.11	9.2	18.1	2.7%	0.828%	365.8	133.7	1.967
0.1	9.2	18.4	3.2%	Zero	359.6	120	2
0.09	9.3	18.7	3.2%	Zero	354.4	109	2.01
0.07	9.5	19.1	3.15%	Zero	334.12	95.25	2.01
0.05	9.6	19.4	3.125%	Zero	320.7	85.8	2.02

(g) t =0.14λ .

S/λ	f_1	f_2	BW_1	BW_2	Z_1	Z_2	F.R
0.3	7	11.8	Zero	Zero	843.34	206.5	1.685
0.26	7.5	12.6	Zero	Zero	764.6	196.8	1.68
0.24	7.7	13.1	0.66%	Zero	618.5	193.6	1.7
0.22	8	13.6	0.65%	0.02%	588	202.4	1.7
0.2	8.2	14.3	1.25%	0.4%	553.25	214.3	1.74
0.18	8.4	15.1	1.8%	0.66%	501.25	225.6	1.79
0.16	8.6	16	2.3%	0.93%	458.5	220.7	1.86
0.14	8.8	16.9	2.9%	1.1%	426.25	193.3	1.92
0.12	9	17.7	2.9%	1.12%	398.4	154.6	1.96
0.11	9.1	18	2.9%	0.85%	384.4	137.3	1.97
0.1	9.2	18.3	3.2%	Zero	369.8	123.5	1.989
0.09	9.3	18.6	3.2%	Zero	354.5	113	2
0.07	9.4	19	3.2%	Zero	341	97.5	2.02
0.05	9.5	19.2	3.2%	Zero	340	93	2.03

(h) t =0.16λ .

S/λ	f_1	f_2	BW_1	BW_2	Z_1	Z_2	F.R
0.3	7	11.9	Zero	Zero	816.5	205	1.7
0.26	7.4	12.7	0.2%	Zero	722.35	196.6	1.716
0.24	7.7	13.4	0.2%	Zero	625.5	194.3	1.74
0.22	7.9	13.7	1.139%	Zero	631.1	204.4	1.74
0.2	8.1	14.4	1.7%	0.34%	570.4	214.1	1.77
0.18	8.3	15.1	1.8%	0.92%	507.3	220.3	1.819
0.16	8.5	16	2.3%	1.125%	460.8	222.7	1.93
0.14	8.7	16.8	2.3%	1.2%	428.6	195	1.93
0.12	8.9	17.6	2.8%	1.11%	403.6	158	1.97
0.11	9	18	3.3%	0.88%	392.45	140.5	2
0.1	9.1	18.3	3.2%	Zero	381.3	196.9	2.01
0.09	9.2	18.5	2.71%	Zero	369.9	116	2.01
0.07	9.3	18.8	2.2%	Zero	355.9	95	2.02
0.05	9.4	19	1.5%	Zero	345.5	82.2	2.02

(i) t =0.2λ.

S/λ	f_1	f_2	BW_1	BW_2	Z_1	Z_2	F.R
0.3	6.9	12.1	Zero	Zero	870.5	201.7	1.753
0.26	7.3	12.9	0.54%	Zero	840	193.9	1.767
0.24	7.5	13.3	0.8%	Zero	723.14	198.5	1.77
0.22	7.7	13.9	1%	0.09%	608.5	207.3	1.8
0.2	8	14.5	1.875%	0.4%	572.8	216.5	1.8125
0.18	8.2	15.2	1.83%	0.98%	547.27	223.7	1.853
0.16	8.4	16	2.1%	1%	507.2	223.6	1.9
0.14	8.6	16.8	2.3%	1.2%	466.5	198.35	1.95
0.12	8.8	17.5	2.27%	1.15%	430.16	164.08	1.988
0.11	8.9	17.8	2.8%	0.786%	413.8	147.7	2
0.1	9	18.1	2.81%	0.11%	398.5	133.85	2.01
0.09	9.1	18.4	3.2%	Zero	384.2	122	2.02
0.07	9.3	18.8	2.1%	Zero	358	104.3	2.02
0.05	9.5	19	1.1%	Zero	340	100	2.02

(j) $t=0.25\lambda$.

S/λ	f_1	f_2	BW_1	BW_2	Z_1	Z_2	F.R
0.3	6.8	12.3	Zero	Zero	877.85	197	1.8
0.26	7.2	13.1	Zero	Zero	746.4	194.3	1.82
0.24	7.4	13.5	0.54%	Zero	768.2	201.5	1.824
0.22	7.6	14.1	1%	0.09%	723.5	707.5	1.855
0.2		14.7	1.28%	0.4%	663	217.5	1.884
0.18	8	15.3	1.5%	0.52%	596.8	225.7	1.9125
0.16	8.2	16	2.2%	1%	534.4	221.9	1.915
0.14	8.4	16.7	2.2%	1.4%	480	200.6	1.988
0.12	8.7	17.4	2.3%	1.15%	433	169.7	2
0.11	8.8	18	2.3%	0.76%	421.9	154.6	2.04
0.1	8.9	18	3.3%	0.66%	409.5	140.5	2.04
0.09	9.1	18.2	2.7%	Zero	396.7	128.8	2.04
0.07	9.2	18.8	1%	Zero	385	113	2.04
0.05	9.3	19	0.55%	Zero	374	100	2.04

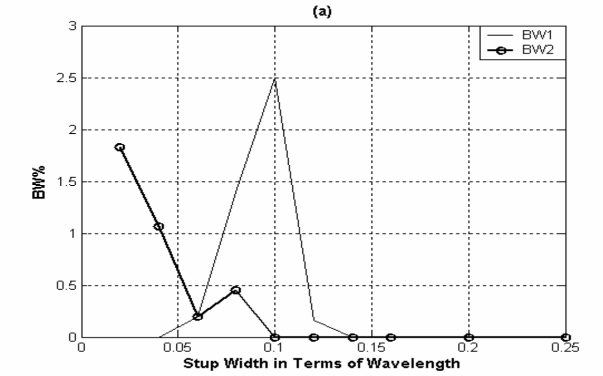
Table (1) Variation of Antenna parameters w.r.t stub dimensions

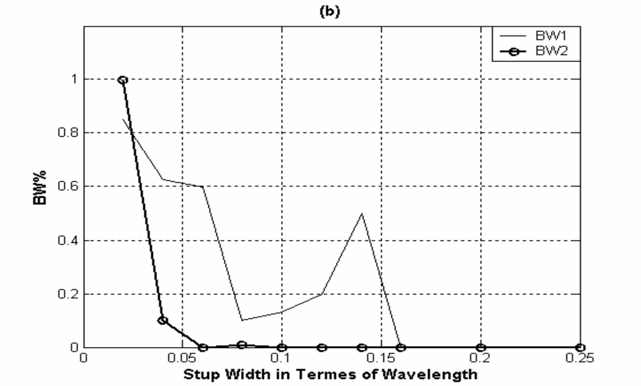
5.2 Bandwidth Variation w.r.t Stub Dimensions

Figure (2) shows the variation of the antenna bandwidth with respect to the stub width for several values of stub length. The bandwidth is calculated for conditionVSWR≤2

From this figure it can be shown that, the performance of the antenna is not the same in both resonances. Five cases of the stub dimension are chosen which gives approximate behavior which are:

a- S=0.14λ b- S=0.16λ c- S=0.12λ
t=0.25λ t=0.16λ t=0.14λ
d- S=0.26λ e- S=0.14λ
t=0.02λ t=0.02λ





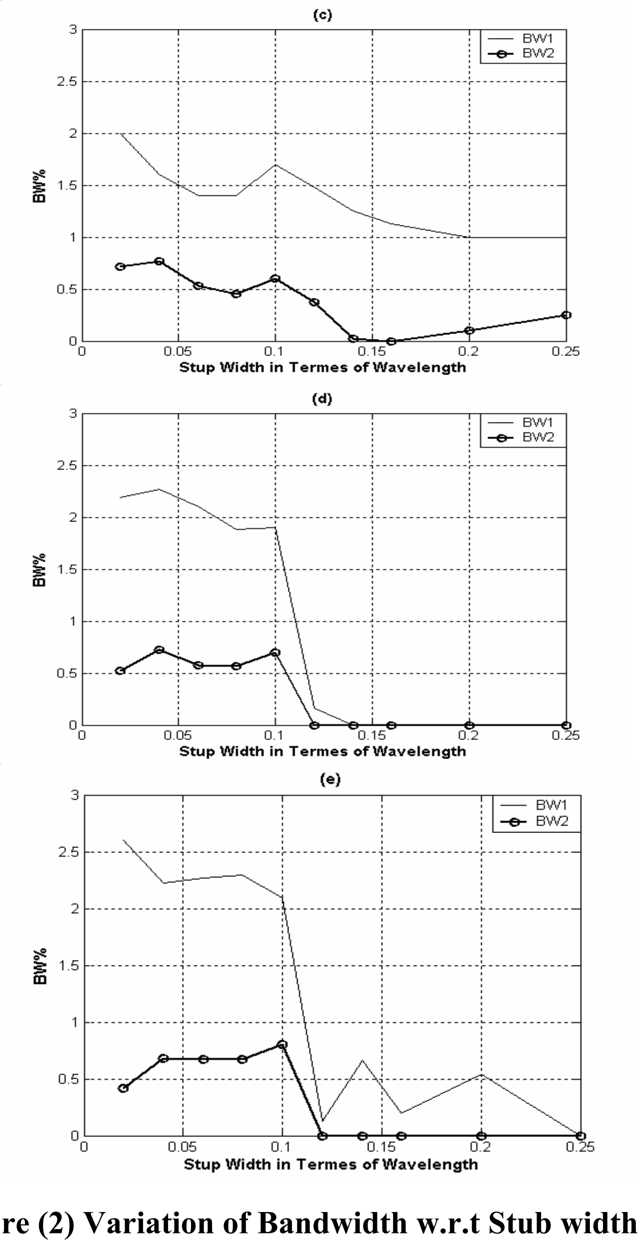


Figure (2) Variation of Bandwidth w.r.t Stub width t/λ

5.3 Input Impedance and VSWR Frequency Response

Figures (3,4 and 5) show the variation of the over all antenna input impedance with respect to frequency for five cases of the stub dimensions. As shown in the figures the input impedance response is separated into two bands due to the addition of the stub impedance response. Figure (6) shows the variation of the VSWR w.r.t frequency and the two bands can be seen clearly.

Fig. 3 Input Reactance Variation w.r.t Frequency

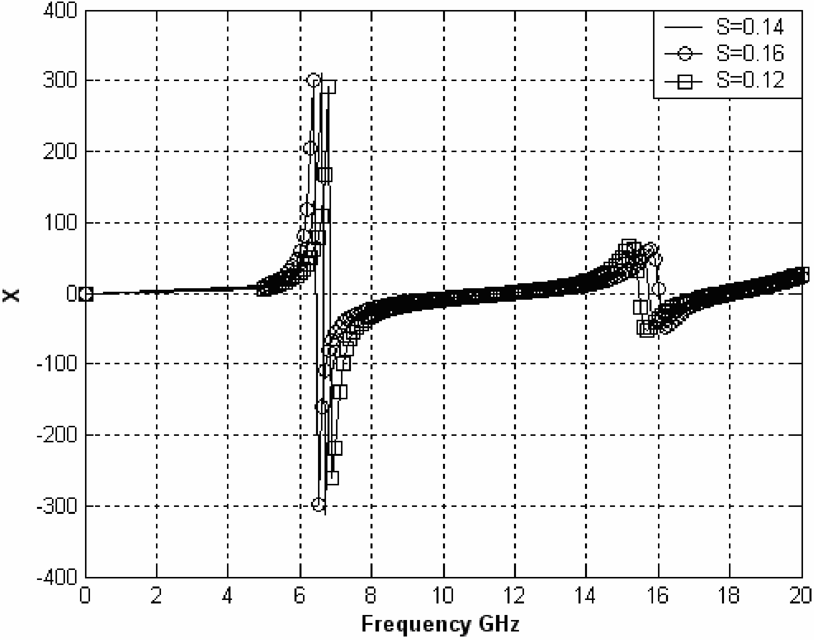


Fig.4 Imput Impedance Variation w.r.t Frequency

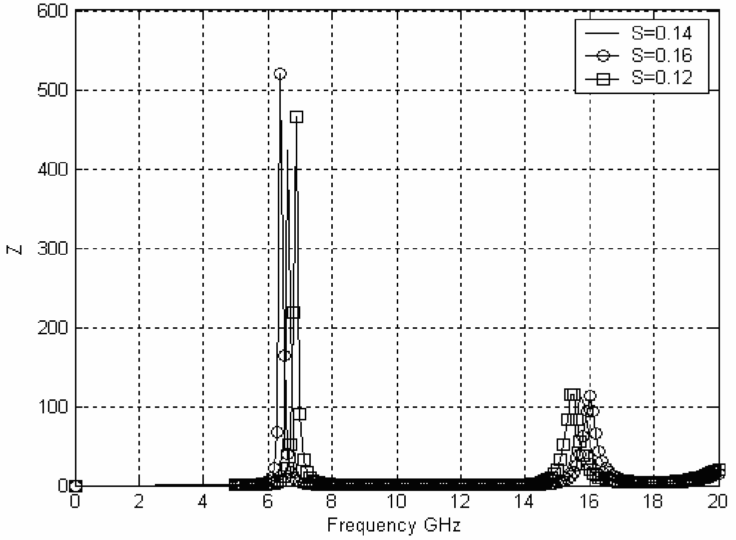


Fig. 5 Input Resistance Variation w.r.t Frequency

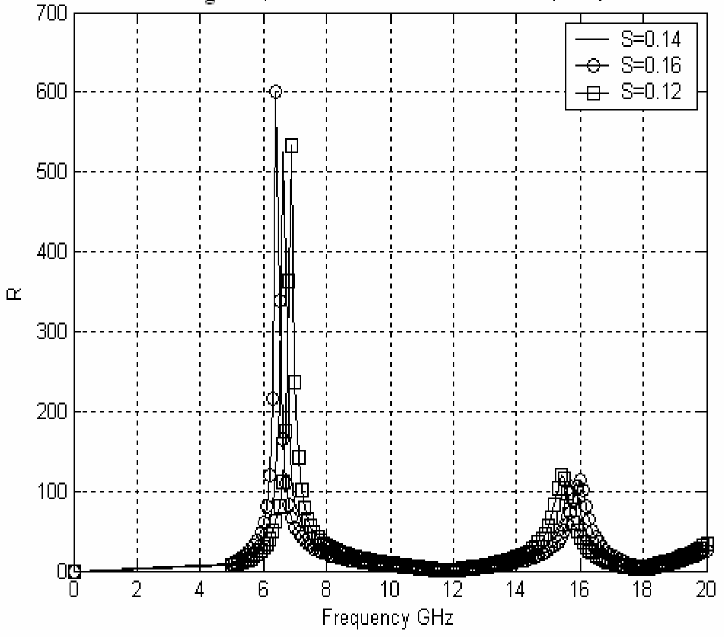
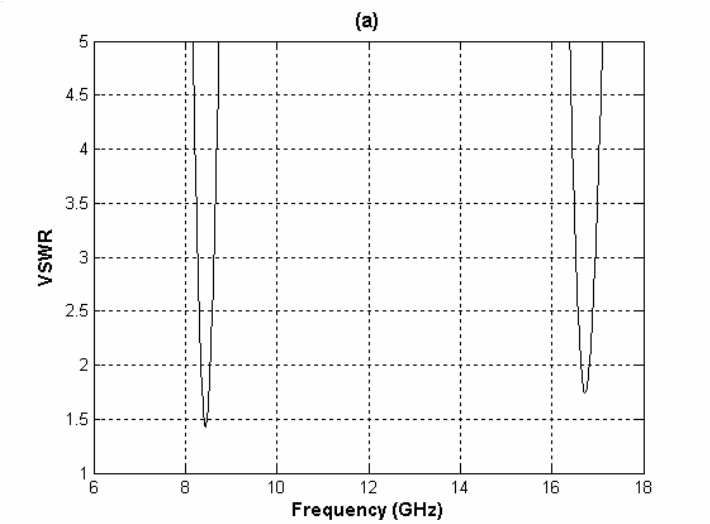
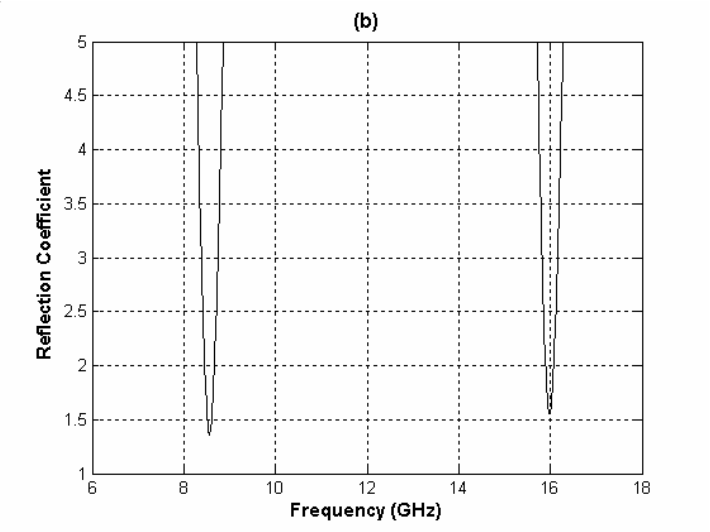


Figure (6) VSWR Frequency Response for:

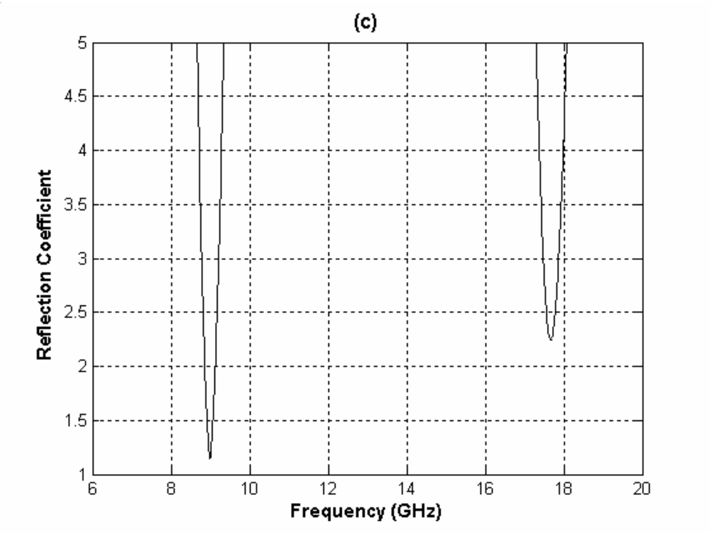
a-S=0.14λ
t=0.25λ
b- S=0.16λ
t=0.16λ
c- S=0.12λ
t=0.14λ
d- S=0.26λ
t=0.02λ
e- S=0.14λ
t=0.02λ





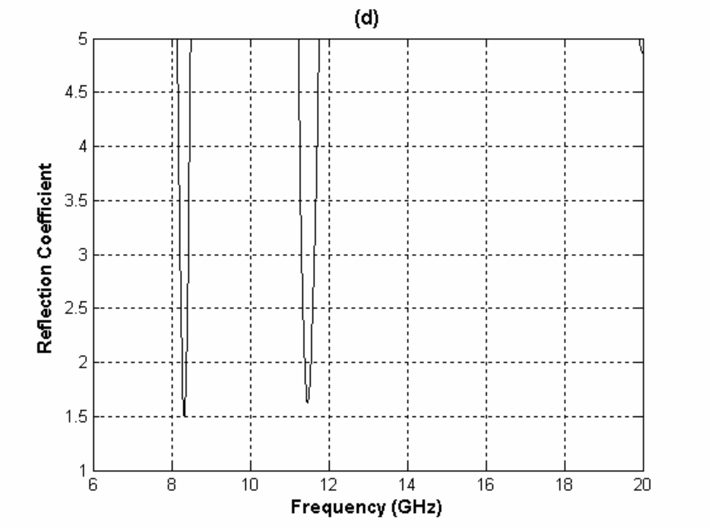
(b)

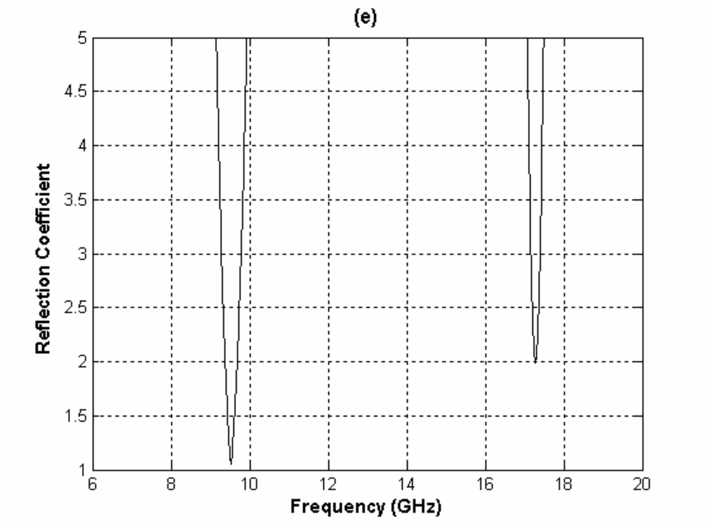
Reflection Coefficient
5
4.5
4
3.5
3
2.5
2
1.5
1
6
8
10
12
14
16
18
Frequency (GHz)



(c)

Reflection Coefficient
5
4.5
4
3.5
3
2.5
2
1.5
1
6
8
10
12
14
16
18
20
Frequency (GHz)


(d)
Reflection Coefficient
Frequency (GHz)
1
1.5
2
2.5
3
3.5
4
4.5
5
6
8
10
12
14
16
18
20


(e)
Reflection Coefficient
Frequency (GHz)
1
1.5
2
2.5
3
3.5
4
4.5
5
6
8
10
12
14
16
18
20

5.4 Compression between Rectangular Loaded Stub and Other Dual Bands Techniques

In this section a compression is made between the rectangular patch with reactive load and others single layer dual band techniques which are: Annular ring patch [11] , Circular patch with air gap in the substrate material [12].Table (2) shows the compression which based upon the bandwidth in each band and frequency ratio.

Type of Patch	f_1	f_2	$B.W_1$	$B.W_2$	F.R
Reactive Load Rectangular Patch	~8.3 GHz	~16.6 GHz	~3%	~1%	2.04
Annular Patch with Air Gap Substrate	626 MHz	778 MHz	0.6%	0.8%	1.24
Circular Patch with Air Gap Substrate	1.128 GHz	1.35 GHz	0.89%	2.07%	1.196

Table (2) Compression between reactive load dual band techniec and others techniecs

5.5 Conclusion

Based on the transmission-line model, characteristics of a single layer, dual-frequency microstrip antenna are studied in this paper. The variation of two resonance frequencies, frequency ratio and bandwidth with respect to several values of stub width and length are illustrated and discussed. It is shown that, this dual frequency antenna can obtain a frequency ratio in the rang of 1.6 to 2.04. Compared with other single layer dual band techniques, i.e, the reactive loaded rectangular patch antenna has advantages of easy of fabrication (no air gap needed), approximate suitable bandwidth and frequency ratio with approximate behavior in both frequencies.

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تصميم هوائي شريط دقيق مستطيل الشكل ثنائي الحزمة بواسطة حمل تفاعلي

م. م زيد أسعد عبد الحسين *

المستخلص

تم في هذا البحث دراسة مواصفات هوائي شريطي دقيق مستطيل الشكل ذو طبقة واحدة محمل بموائم يعمل بحزمتي تردد. و وجد في هذا البحث انه من السهولة موائمة هذا الهوائي في كلا الحزمتين و ذلك بضبط نقطة التغذية أو استخدام تقنيات أخرى (خطوط النقل المتدرجة). في هذا البحث تم اجراء تحليل مفصل لهذا الهوائي باستخدام النظرية العامة لخط النقل و تم دراسة تأثير مختلف مكونات الهوائي على ترددي الرنين و نسبة التردد و عرض كلا الحزمتين و الممانعة الداخلية. و قد تبين انه من الممكن الحصول على نسبة تردد تتراوح بين (1.5–2.04) ذللك بتغيير عرض و طول الموائم. وتم مقارنة نتائج هذا البحث مع نتائج هوائيات أخرى أحادية الطبقة تعمل بحزمتي تردد.

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