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Design and Implementation of a Corporate Fed Two Element Antennae Array using Miters

G. V. P. Pranathi, N. Deepika Rani, Leela Kumari .B

Abstract: In wireless communication systems, designing of antennae with required parameters is an challenging issue. So, The approach in this paper is to design a corporate fed 2 element antenna array is designed to operate at 2.4 GHz using an FR-4 substrate of height h=1.6mm. For wireless application all the antenna parameters are analysed for two element array antenna with element spacing λ, λ/2 and with miters. It is observed that bandwidth decreases by decreasing the element spacing. But by using miters for antenna with element spacing $\lambda/2$ bandwidth and reflection coefficient are improved. All the antennae are fabricated and tested using VNA E5071C.

Keywords **: Corporate fed , Element spacing and Miters**

I. INTRODUCTION

In long distance communications, antennas with high directivity are often required. A single element antenna is unable to meet high gain or high directivity. High gain can be achieved by an assemblage of antennas, called an array. For constructing an array, feed network design is essential. [1]

A parallel or corporate feed offers a practical solution to the array feed problem by allowing one coaxial line to feed a network composed of microstrip transmission lines.

II. ANTENNA DESIGN

A 2-element array antenna feed design using parallel feed network along with quarter wave transformer. [2]

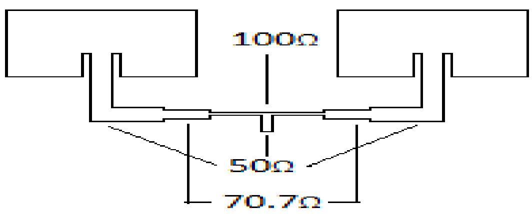

Figure 1.1. An 2-element corporate-fed microstrip array.

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Figure 1.1 is a 2-element corporate-fed microstrip uniform array. The tree-like structure of the feed appropriately combines/distributes the signals from/to the elements.

A quarter-wave transformer appears at the splits in order to match the lines of different impedances. The 50 Ω input line splits into two 100 Ω lines. If the microstrip line continues to split like this, then the lines feeding the elements would be 200 Ω, 400 Ω and so on. Then the microstrip line will be very thin, and also the element impedance should be very high for matching. But the element is fed with inset feed hence the transmission line will have an impedance of 50 Ω. Thus, the 100Ω line is converted back to 50 Ω. using a quarter-wave transformer of 70.7 Ω.

A. 2 ELEMENT ARRAY

A 2 element antenna array with a parallel feed network [4] is shown in Figure 1.2. The dimensions of a 2 element array are given in Table I.

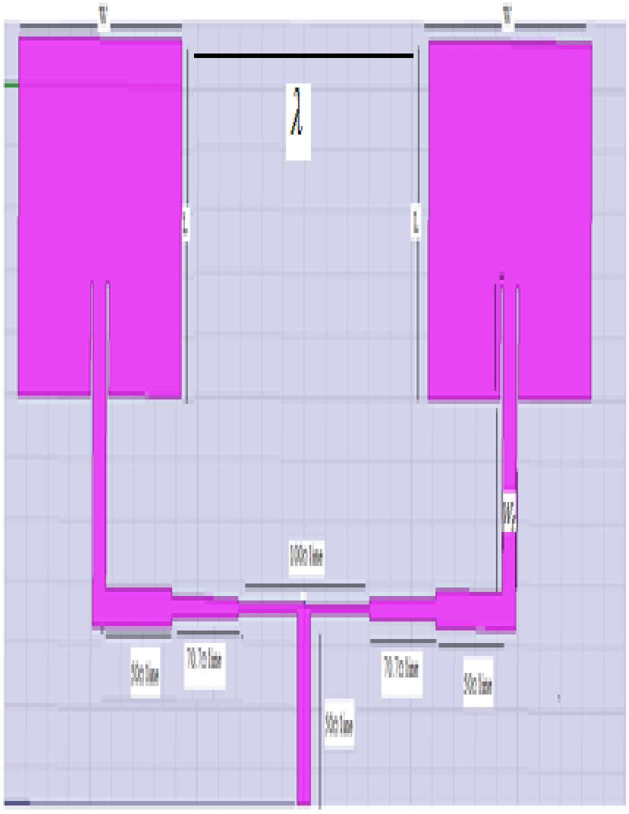


Figure 1.2. Top view 2 element antenna array with element spacing λ

Table –I: Dimensions of 2 element antenna array with element spacing λ

Description	Value (mm)
Width of the Patch(W)	38.036
Length of Patch(L)	29.1
Height (or thickness) of FR4 Substrate(h)	1.6
Width of Microstrip feed(W_f)	3.059
Notch gap (g)	0.6
Distance of inset fed(d)	9.044
Width of substrate(W_s)	129.6
Length of substrate(L_s)	73.6
Length of 50Ω line	15.46
Width of 50Ω line	3.059
Length of 100Ω line	30.92
Width of 100Ω line	0.709
Length of 70.7Ω line	15.46
Width of 70.7Ω line	1.654

III. RESULTS AND DISCUSSION

Reflection coefficient and VSWR curves for a 2 element array with element spacing λ are shown in Figure 1.3 and Figure1.4.

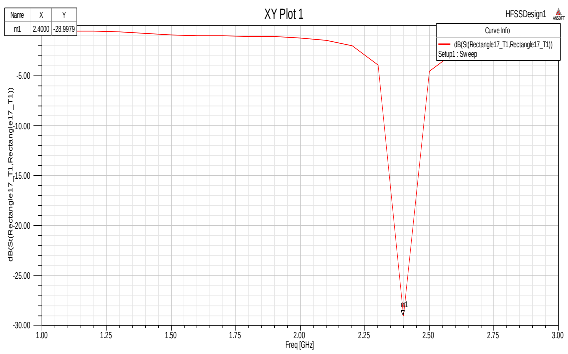


Figure 1.3. Reflection coefficient curve of the 2 element antenna array with element spacing λ

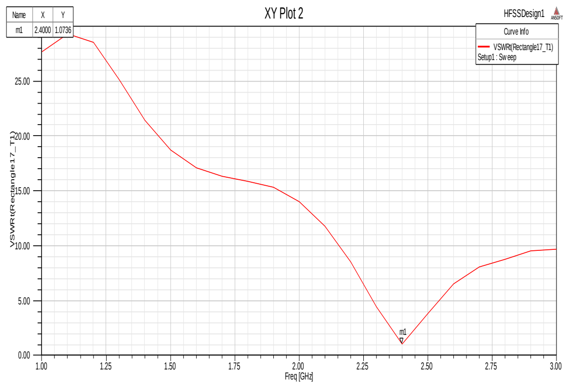


Figure 1.4. VSWR curve of the 2 element antenna array with element spacing λ

From Figure 1.3 and 1.4, it is observed that the reflection coefficient (S_{11}) is -28.9979dB and VSWR is 1.0736at 2.4GHz.

Gain and directivity plots for a 2 element array with element spacing λ are also shown in Figure 1.5 and 1.6 respectively

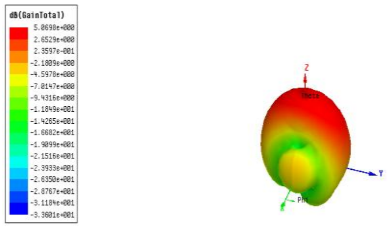


Figure 1.5. Gain plot of the 2 element antenna array with element spacing λ

Figure 1.6. Directivity plot of the 2 element antenna array with element spacing λ

The gain observed from Figure 1.5 is 5.0698dB and from Figure 1.6 directivity is observed as 8.5707 dB at 2.4GHz.

Now by considering element spacing as $\lambda/2$ (removing 50Ω transformer) and with the dimensions in Table-II a 2 element antenna array with element spacing $\lambda/2$ is drawn as shown in Figure 6.19.

Table –II : Dimensions of 2 element antenna array with element spacing λ/2

Description	Value (mm)
Width of the Patch(W)	38.036
Length of Patch(L)	29.1
Height (or thickness) of FR4 Substrate(h)	1.6
Width of Microstrip feed(W_f)	3.059
Notch gap (g)	0.6
Distance of inset fed(d)	9.044
Width of substrate(W_s)	129.6
Length of substrate(L_s)	73.6
Length of 50Ω line	15.46
Width of 50Ω line	3.059
Length of 100Ω line	30.92
Width of 100Ω line	0.709

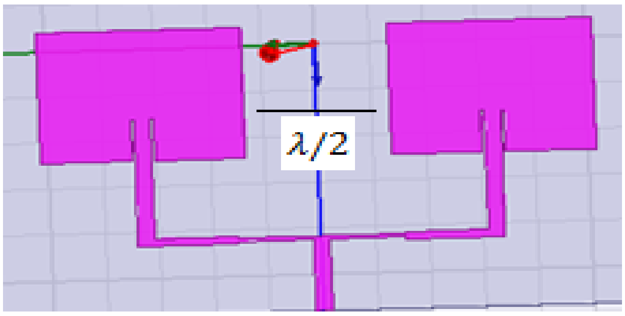


Figure 1.7. Geometry of 2 element antenna array with element spacing $\lambda/2$.

The parameters such as reflection coefficient, VSWR, gain and directivity of a 2 element antenna array with element spacing $\lambda/2$ are observed in Figure 1.8 to Figure 1.11.

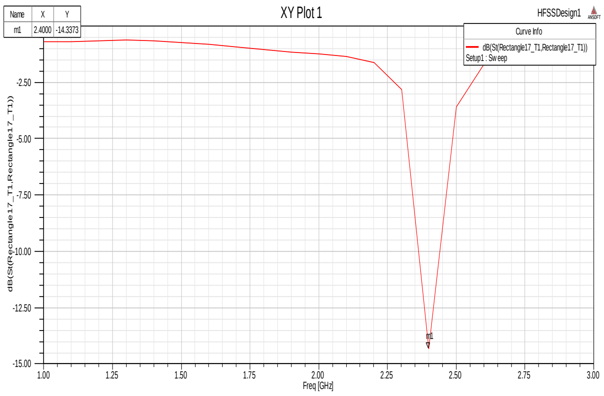


Figure 1.8. Reflection coefficient curve of 2 element antenna array with element spacing $\lambda/2$

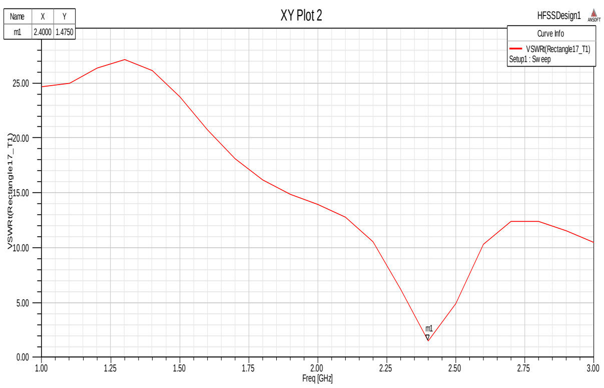


Figure 1.9. VSWR curve of 2 element antenna array with element spacing $\lambda/2$

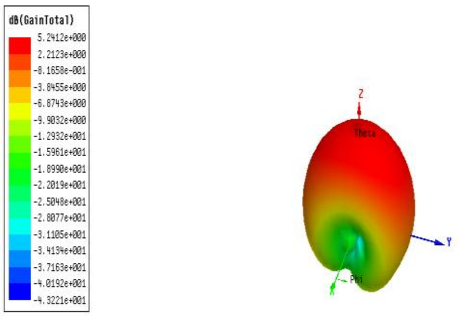


Figure 1.10. Gain plot of the 2 element antenna array with element spacing $\lambda/2$

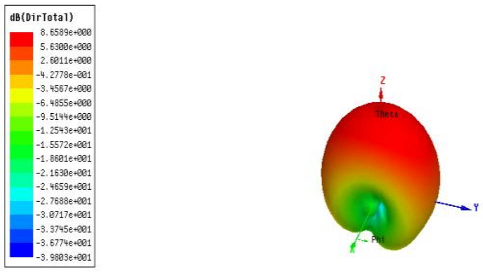


Figure 1.11. Directivity plot of 2 element antenna array with element spacing $\lambda/2$

From Figure 1.8 reflection coefficient is observed as -14.3373dB at 2.4 GHz and the VSWR of 1.4750 at 2.4GHz is shown in Figure 1.9.Gain is noticed as 5.2412 dB and directivity as 8.6589 dB at 2.4GHz as shown in Figure 1.10 and 1.11 respectively.

By considering miter bends for the dimensions given in Table -II a 2 element antenna array with element spacing $\lambda/2$with miter bends is drawn and simulated using HFSS 13.0 and shown in Figure 1.12.

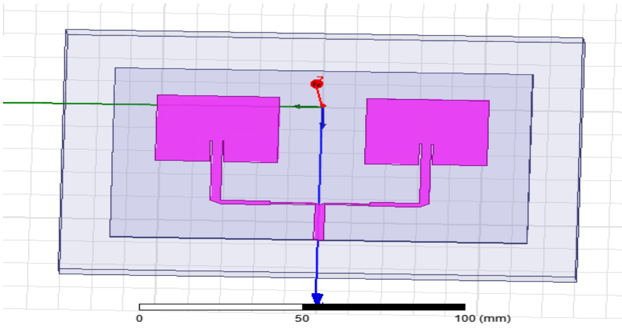


Figure 1.12. Geometry of 2 element antenna array array with element spacing $\lambda/2$ with miter bends

For the dimensions in Table 6.7 and table 6.8 a 2 element antenna array with spacing λ, with element spacing $\lambda/2$ along with and without miter are fabricated and tested using VNA E5017C. Figure 1.13 shows the fabricated 2 element array antenna with spacing λ. Figure 1.15 and 1.17 shows without and with miters of 2 element antenna array with element spacing $\lambda/2$.

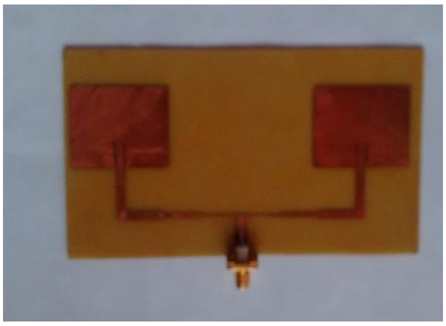


Figure 1.13. Fabricated patch of 2 element array antenna with element spacing λ

The reflection coefficient curves of the fabricated antennas are shown in Figure 1.14, Figure 1.16 and in Figure 1.18.

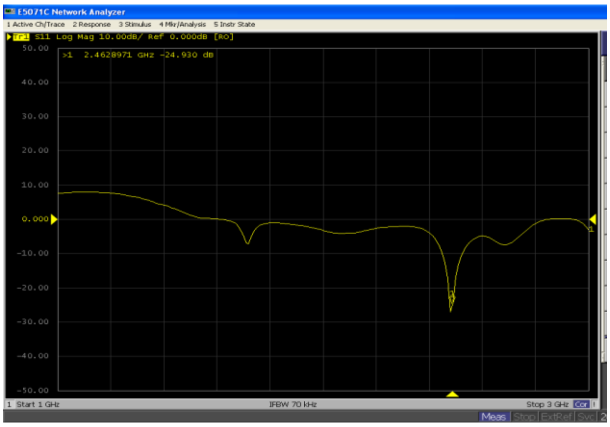


Figure 1.14. Reflection coefficient curve of the fabricated 2 element antenna array with element spacing λ

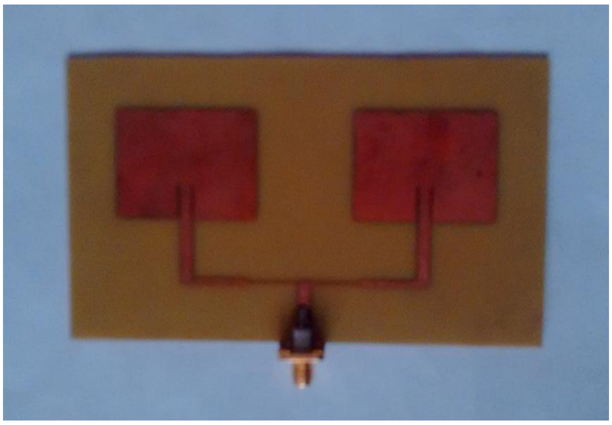


Figure 1.15. Fabricated patch of 2 element antenna array with element spacing $\lambda/2$

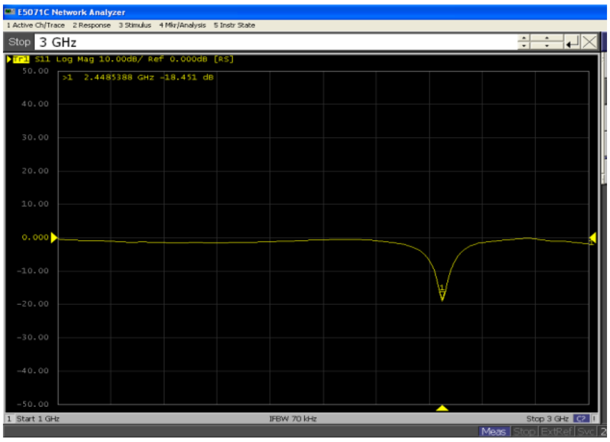


Figure 1.16. Reflection coefficient curve of the fabricated 2 element antenna array with element spacing $\lambda/2$

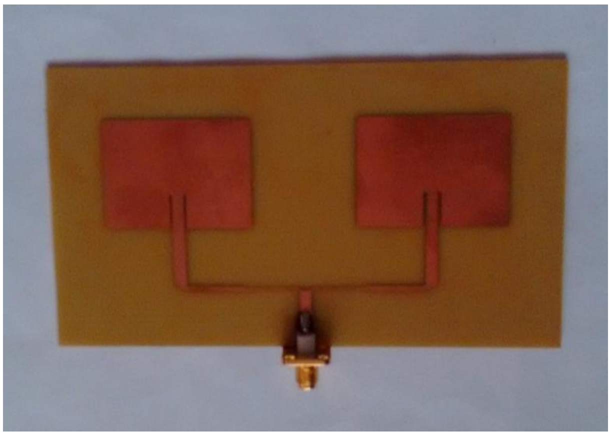


Figure 1.17. Fabricated patch of 2 element antenna array with element spacing $\lambda/2$ along with miter bends

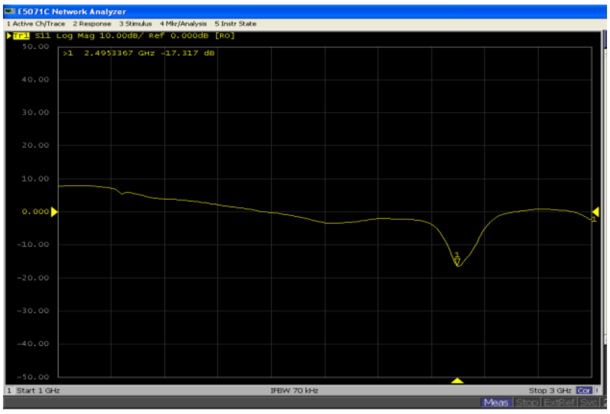


Figure 1.18. Reflection coefficient curve of the fabricated 2 element antenna array with element spacing $\lambda/2$ along with miter bends

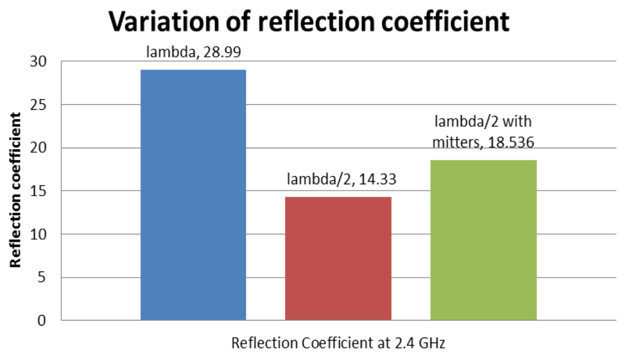
It observed from the figure 1.14 that fabricated 2 element array antenna with element spacing λ's reflection coefficient of -24.930 dB at 2.4628971GHz and fabricated 2 element antenna array with element spacing $\lambda/2$ observes reflection coefficient as -18.451 dB at 2.4485388GHz in Figure 1.16.And Reflection coefficient of the fabricated 2 element antenna array with element spacing $\lambda/2$ along with miter bends is observed to be -17.317 dB at 2.4953367GHz in Figure 1.18.

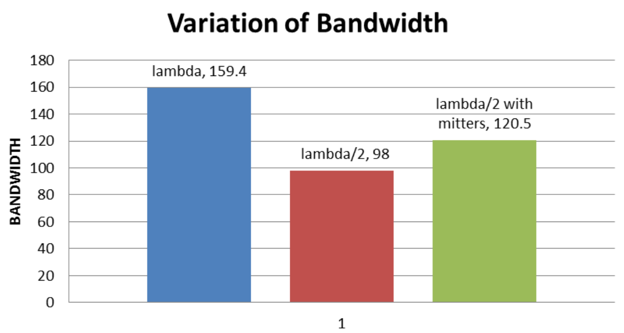
All the parameters that are observed by simulation and fabrication of antennas are compared in Table-III.

Table –III : Comparsion of parameters in 2 element antenna array with different elementspacing and with miters

Element spacing	Resonant Frequency in GHz		Reflection coefficient (S11) in dB		VSWR	Gain in dB	Directivity in dB	Band width in MHz	Efficiency (%)
	Simulated	Measured	Simulated	Measured	Simulated	Simulated	Simulated	Simulated	Simulated
λ	2.4	2.462	-28.999	-24.930	1.0736	5.0698	8.5707	159.4	59.15
$\lambda/2$	2.4	2.448	-14.333	-18.451	1.4750	5.2412	8.6589	98	60.52
$\lambda/2$ with miters	2.4	2.495	-18.536	-17.317	1.268	5.0208	8.5827	120.5	58.499

From Table-III there in an improvement in the reflection coefficient if an antenna is designed using miter bends. From Table 6.9 Reflection coefficient is varying from -14.3373 dB to -18.536 dB for a 2 element patch array antenna with element spacing $\lambda/2$.





IV. CONCLUSION

From Table-III and charts it is clearly observed that by decreasing the element spacing the bandwidth decreases. It is also analyzed that reflection coefficient decreases by decreasing the element spacing. But by using miters for antenna with element spacing $\lambda/2$ bandwidth and reflection coefficient are improved. As there is an improvement in reflection coefficient, it indicates that impedance matching is properly done.

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