Design and Analysis of Microstrip Array Antenna for 20.2GHz Applications

Bondili.Kohitha Bai, Govardhani. Immadi

Abstract: ***Microstrip antenna technology is widely used for many applications, one of which is used for Ka-band BECON frequency communications. In this paper single element, 2-element (1×2), 4-element (1×4) and 8-element (2×4) array antenna is designed at 20.2GHz BECON frequency. The substrate used here is Rogers duroid with a thickness of 3mm and di-electric permittivity of 2.2. The microstrip antenna is rectangular patch shape with corporate feeding network. The antenna proposed is designed and analyzed, which results to achieve high gain and effective return loss.***

Keywords: ***Microstrip array antenna, BECON frequency, two-element array, Four-element array, Eight-element array, Ka-band.***

I. INTRODUCTION

To enable millimeter-wave(mm-wave) communications high gain is required. To achieve high gain, antenna arrays are preferred [1][2]. The main concerns of antenna arrays are low profile, conformal installation, weight, size and cost effective. Especially, at mm-wave frequency or in Ka-band gain and impedance band width will have more adverse effects than at the lower frequencies [3].

In this proposed work, a microstrip patch antenna is designed which is generally rectangular, circular, triangular and square and other shapes [4]. The rectangular shape is most widely used. The performance of antenna is determined by the shape, substrate, material, dimensions and feed type of the antenna [5][6].

They are two types of feeding methods, contact method and non-contact method [7]. The microstrip line feed and co-axial probe feed are contact methods and aperture coupling and proximity coupling are non-contact method.

The remaining of this paper is organized as follows-- firstly, the designs of single, 2-element (1×2), 4-element (1×4) and eight (2×4) element with an inset feed technique is presented in section 2. In section 3, the simulation results are displayed, in section 4, the four antenna elements are compared and in section 5, the conclusion is drawn.

II. CONSTRUTION AND DESIGN

I. **Construction of single patch:** The microstrip patch antenna is designed and simulated. The software tool used Ansoft HFSS software. The designed microstrip antenna is rectangular shaped patch antenna as in fig-1 which operates at BECON frequency 20.2GHz.

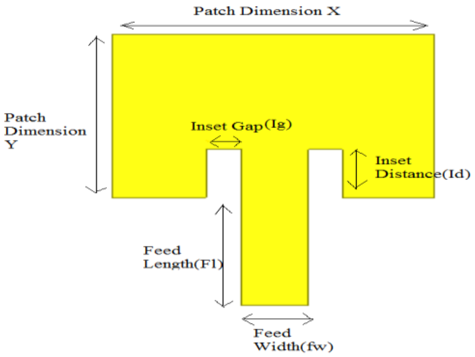

Figure 1: Single element rectangular microstrip patch antenna.

The substrate material used for the proposed four antenna design is Rogers Duroid 5880 with a thickness of 3mm, Dielectric constant ε_r=2.2 and loss tangent is 0.0009. The calculations of the antenna parameters are done using standard equations from the above substrate material specifications.

The calculated antenna design parameters are in table-1

Table I. Single Element Antenna Parameters

Parameter	Value	parameter	value
patch Dimension X	6.6mm	Inset Distance (Id)	0.8mm
patch Dimension y	4.6mm	Feed Length(Fl)	4.5mm
Inset Gap(Ig)	1.5mm	Feed Width(Fw)	3.0mm

The standard equations for patch antenna design are

$w = \frac{c}{2f_0\sqrt{\frac{\varepsilon_r+1}{2}}}$ (1) where $c = 3 \times 10^8 m/s$ is for width of the patch

Length $L = l_{eff} - 2\Delta l$ (2) where

$$l_{eff} = \frac{c}{2f_0\sqrt{\varepsilon_{reff}}} \quad \Delta l = 0.412hr\frac{(\varepsilon_{reff}+0.3)\left(\frac{w}{h}+0.264\right)}{(\varepsilon_{reff}-0.258)\left(\frac{w}{h}+0.8\right)}$$

I. **Construction of two (1×2), four (1×4) and eight (2×4) rectangular microstrip array antenna:** Fig 2, Fig 3 and Fig-4 shows the proposed simulated 2-element (1×2),4-element (1×4) and 8-element (2×4) rectangular microstrip array antenna. These three antenna elements are having the same substrate material specifications and antenna parameters as single element antenna. The uniform spacing

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is maintained between the array element.

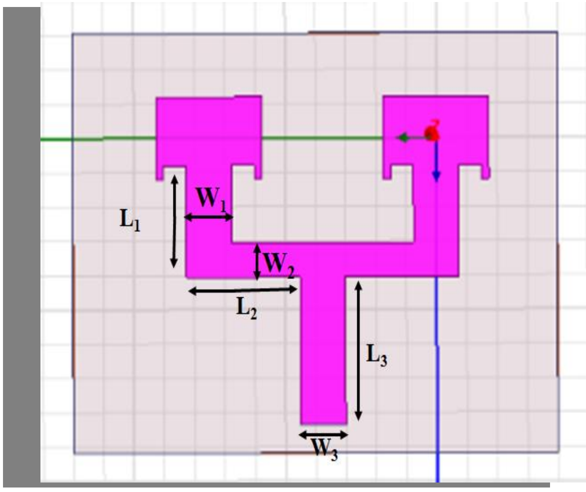

Figure 2: Two (1×2) element patch antenna.

TABLE II. Array element patch parameters.

Parameter(P)	Value (V in mm)	P	V(mm)	P	V(mm)
Patch Dimension (X)	6.6	W 1	3.0	L1	6.3
Patch Dimension (Y)	4.6	W 2	3.0	L2	8.0
Inset Gap (Ig)	0.8	W 3	3.0	L3	10.0
Inset Distance(Id)	1.5	W 4	3.0	L4	10.0
Feed Lemgth(Fl)	4.5	W 5	11.0	L5	12.0
Feed Width(Fw)	3.0	W 6	13.0	L6	18.0

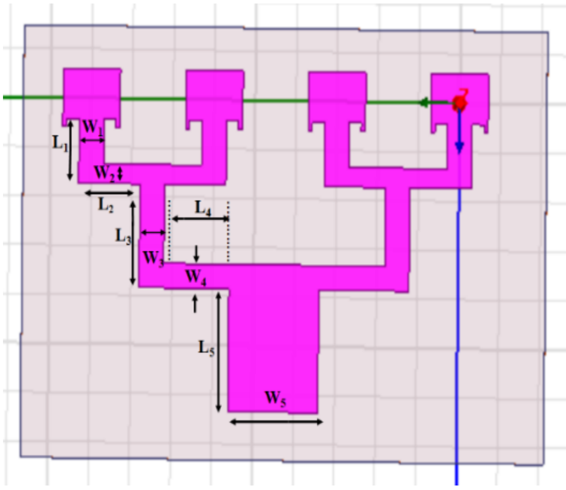
Figure 3: Four (1×4) element patch antenna.

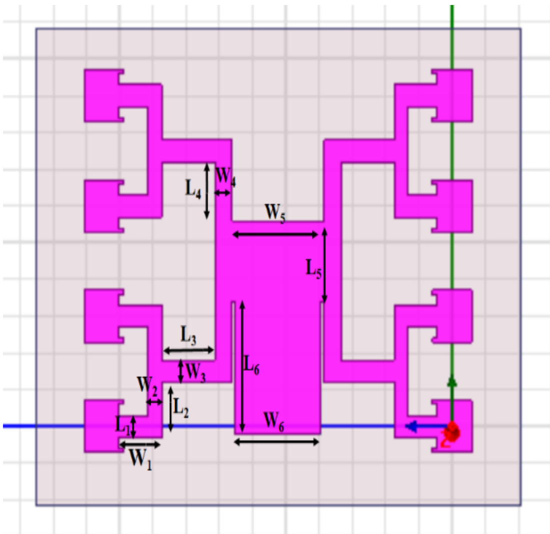
Figure 4: Eight (2×4) element patch antenna

The contact method feeding technique is used i.e. parallel/corporate feeding network is used for the design of proposed rectangular microstrip array antenna element to feed from single source.

The feed widths of different impedance are calculated using below equation

$$\frac{w_f}{h} = \begin{cases} \frac{8e^A}{e^{2A}-2} & , \frac{w_0}{h} \le 2 \\ \frac{2}{\mu}\left\{B - 1 - \ln(2B-1) + \frac{\epsilon_r - 1}{2\epsilon_r}\left[\ln(B-1) + 0.39 - \frac{0.61}{\epsilon_r}\right]\right\} & , \frac{w_0}{h} \ge 2 \end{cases} \quad (3)$$

Where

$$A = \frac{Z_0}{60}\sqrt{\frac{\epsilon_r + 1}{2}} + \frac{\epsilon_r + 1}{\epsilon_r - 1}\left(0.23 + \frac{0.11}{\epsilon_r}\right)$$

$$B = \frac{377\pi}{2z_0\sqrt{\epsilon_r}}$$

Wilkinson power divider is used for dividing the power into equal amounts. This RF power divider uses Quarter wave transformer lines on the printed circuit boards.

III. SIMULATED RESULTS

After designing and simulation of the proposed antenna design with Ansoft designer HFSS, the single element,2-element (1×2),4-element (1×4) and 8-element (2×4) rectangular microstrip patch array antenna with corporate feeding networks are analyzed. The simulation results Gain, return loss, Radiation pattern, and VSWR of proposed antenna designs are compared.

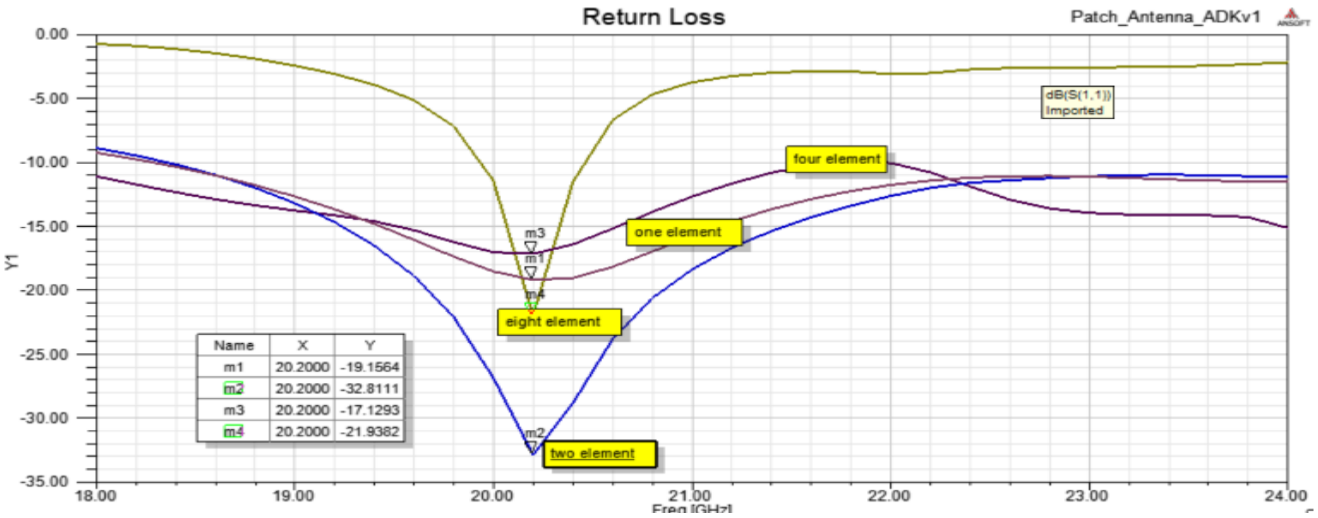

Figure 5: Return Loss of Single, Two (1×2), Four (1×4) and Eight (2×4) element patch antenna.

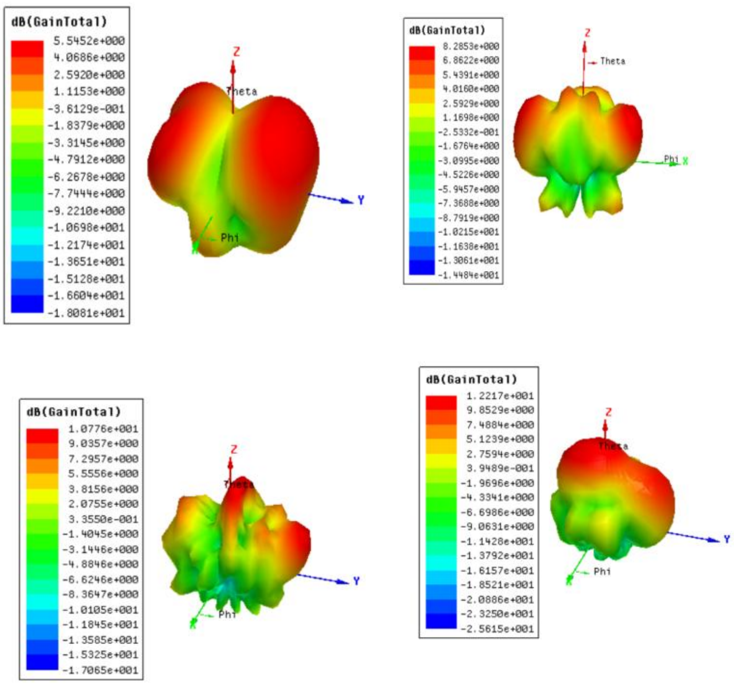

Figure 6: Gain of Single, Two (1×2), Four (1×4) and Eight (2×4) element antenna.

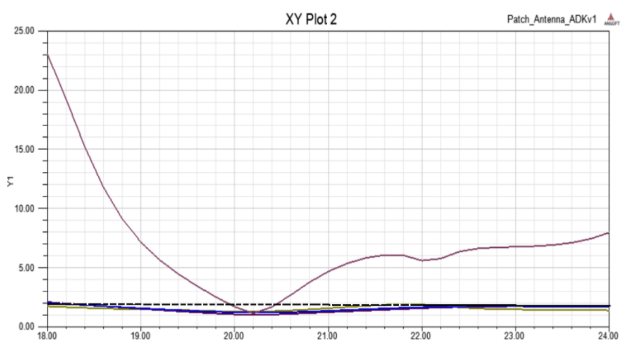

Figure 7: VSWR of proposed antennas.

As seen from the fig-5, the simulated return loss of single element patch antenna is -19.1dB, the two element (1×2) array is -32.8dB, the four element (1×4) array is -17.1dB and the eight (2×4) element array is -21.9dB.

The directivity and gain of antenna are related closely to each other, directivity measures the directional capabilities of radiation and gain represents the efficiency of antenna as in fig.6. The gain of the single, two (1×2), four (1×4) and eight (2×4) elements are 5.5dB,8.2dB,10.7dB and 12.2dB. The directivity obtained for the proposed antenna elements are 5.7dB, 9.2dB, 11.4dB and 14.5dB respectively. The value of VSWR (Voltage Standing Wave Ratio) is less than 2 at operating frequency 20.2GHz. fig 7 shows the minimum VSWR values of single element, 1×2 elements, 1×4 elements and 2×4 elements. as 1.02,1.0,1.4 and 1.3 respectively. .

IV. COMPARISON OF FOUR MODELS

Table 1. Comparison of single element, two (1×2), Four (1×4) and Eight (2×4) element Models.

Parameters	Single element	Two Element (1×2)	Four Element (1×4)	Eight Element (2×4)
Physical dimensions(mm)	10×14	25×28	60×40	60×75
Return loss(dB)	-19.1	-32.8	-17.1	-21.9
Gain (dB)	5.5	8.2	10.7	12.2
Directivity (dB)	5.7	9.2	11.4	14.5
VSWR	1.02	1.0	1.4	1.3
Efficiency (%)	99.2%	99.4%	99.3%	99.2%

V. CONCLUSION

Four model's single element, 2-element, 4-element and

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8-element array are designed and simulated. These designed models operate at BECON frequency 20.2GHz. The results from the above section concludes that with the increase of antenna elements the antenna efficiency is improved.

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REFERENCES

1. C.A. Balanis, "Antenna Theory, Analysis and Design," 2nd edition, John Wiley & Son New York, Chp.12,14, 1997.
2. C.A. Balanis, Antenna Theory, 3th ed., Canada, A John Wiley & Sons, Inc,2005.
3. David M. Pozar, "Microstrip Antennas", IEEE Proceedings, Vol. 80, No 1, January 1992.
4. Suryachand G.D, Ajay Kancharla, and Zaheer Shaik "An Antenna Array for Scanning Applications in ISM Band" 2016. IEEE.
5. N. Nahata and K. S. Bhagat, "A survey on microstrip patch antenna using shape of patch antenna" International Journal of Innovative Research and Development, vol.3, no.11, 2014.
6. Yiwei Wu, Qi Zhu Design of a Ka-Band Microstrip Antenna Array with Sharped-Beam Pattern and High Gain" 2013.IEEE.
7. HFSS v17, www.ansys.com.
8. Girish Kumar, K.P. Ray "Broadband Microstrip Antenna", Artech House, Boston, London.

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