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Improving UWB Array Antenna Performance in Biomedical Applications Using the Cuckoo Search Algorithm

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Abstract

This study presents an innovative design for a four-port square sector power splitter, showcasing its practical applications. To enable precise signal manipulation of phase and amplitude across power divider branches, insertion and insertion fitting techniques are employed. Impedances are tailored to achieve the required power ratio through pairing techniques. The design process leverages electromagnetic solvers based on the Method of Moments (MOM). Key parameters for the power divider include a dielectric constant (Er) of 4.3, a loss tangent of 0.02, and a height of 1.6 mm. In addition to the antenna array, an ultra-wideband antenna is also designed. To further enhance its performance, optimization techniques such as the fly flight algorithm, cuckoo search algorithm, and spring cuckoo algorithm are applied. These strategies focus on minimizing mutual coupling and refining key antenna parameters, including return loss, gain pattern, directivity, and radiation.

Antenna design

Substrate material selection

2.1 Substrate Materials Selection

Table 1: Substrate materials used for proposed designs

Materials used	Dielectric constant	Thickness (mm)	Loss tangent
FR-4	4.3	1.6	0.025

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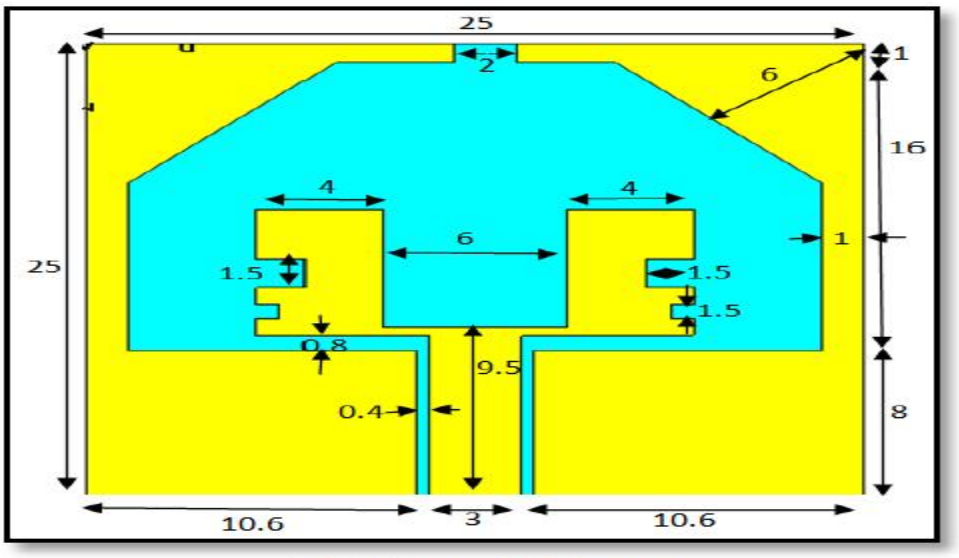

Fig.1: Proposed U-slot antenna

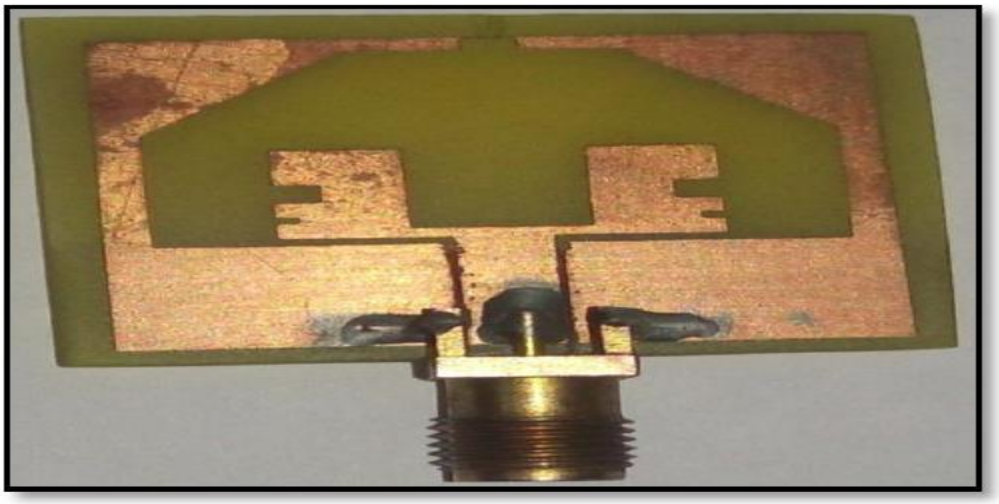

Fig. 2: Prototype of Proposed U-Slot antenna

Fig .3: Testing Arrangement of Proposed U-Slot

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Table 2: Dimensions of the U slot antenna

Dimension	Value (mm)
L	25
W	25
W_1	10.6
L_1	1
L_2	16
L_3	8
W_2	1
W_{p1}	4
g_1	0.4
g_2	0.8
L_d	6
L_p	7
L_f	9.5
W_f	3
H	1.6

1X2 Array Antenna Implementation

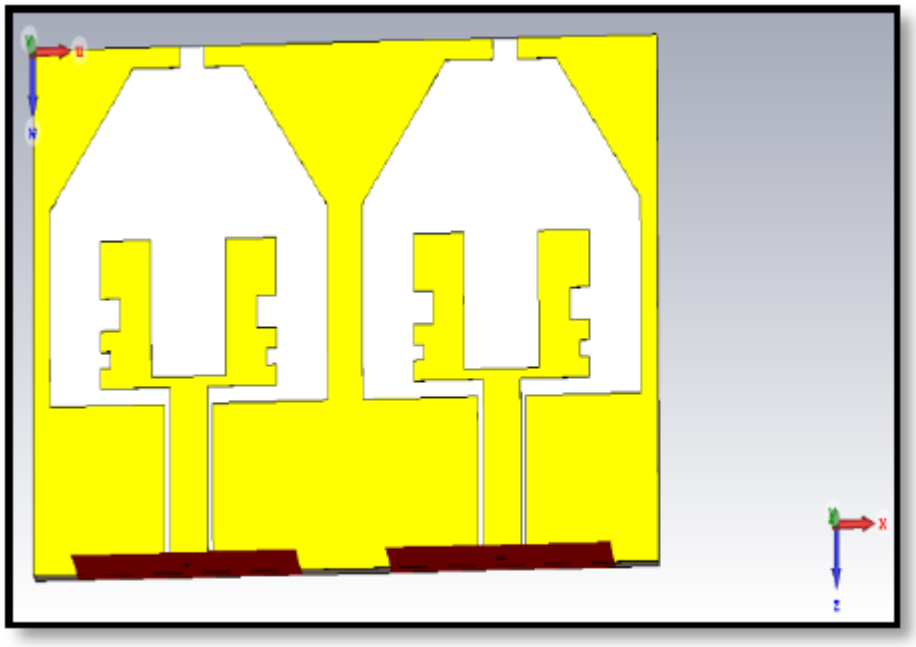

Fig 4: 1X2 proposed array antenna

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1X4 Array Antenna Implementation

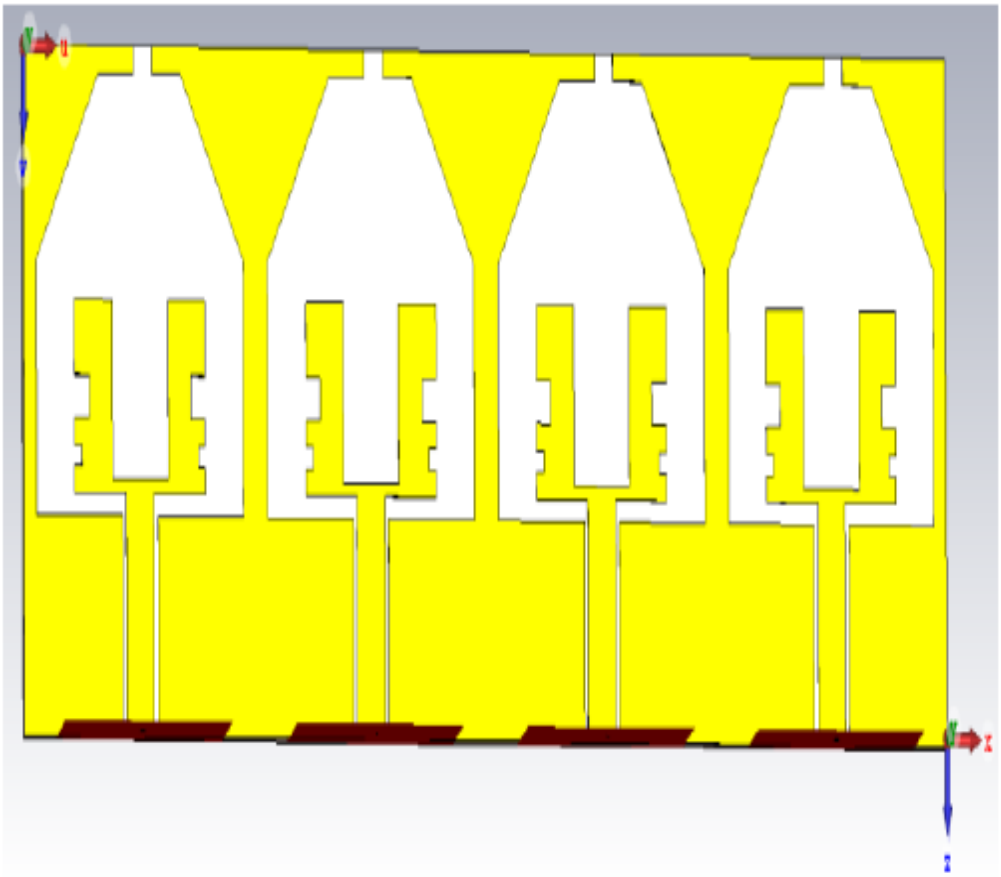

Fig.5: 1X4 proposed antenna Array

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Design Procedure for Proposed for Proposed Power Divider

Table 3: Dimensions of the Proposed 1X2 Power Divider

S.No	Dimension	Calculated Value (Millimetres)
1	L_1	4.3
2	L_2	6
3	L_3	4.5
4	L_4	1.7
5	L_5	11.42
6	L_6	10.3
7	W	1
8	g_1	1
9	g_2	0.7
10	g_3	0.2

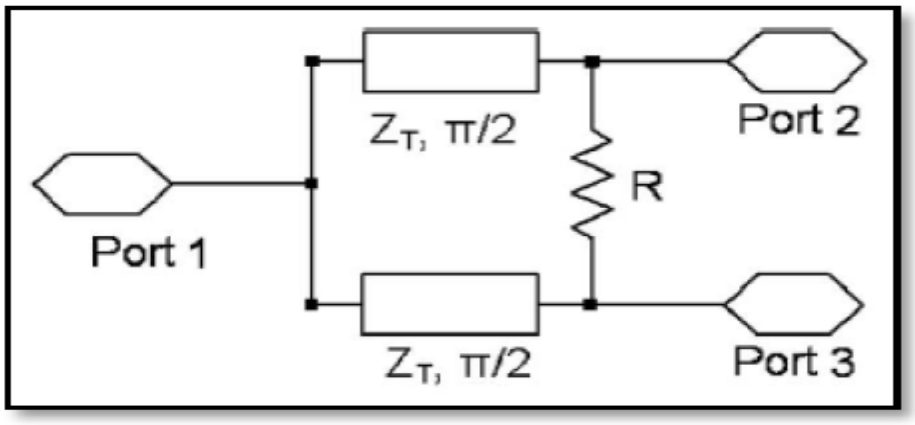

Fig. 6: Schematic diagram of 1X2 Wilkinson power divider

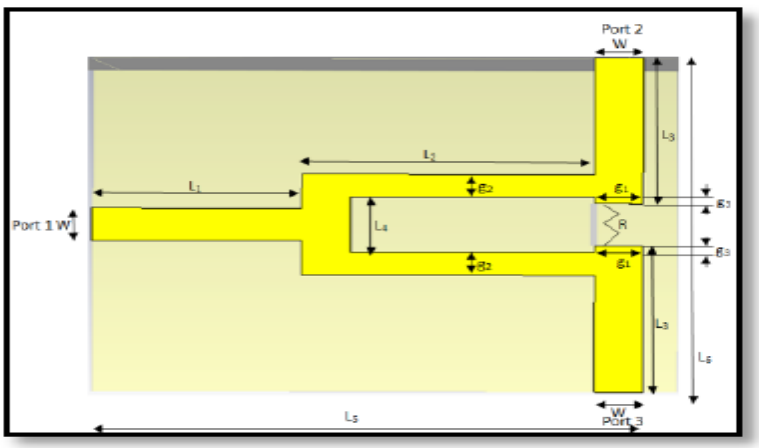

Fig.7: Layout of Proposed 1X2 WB Power Divider (Dimension is 11.42 mm×10.3 mm)

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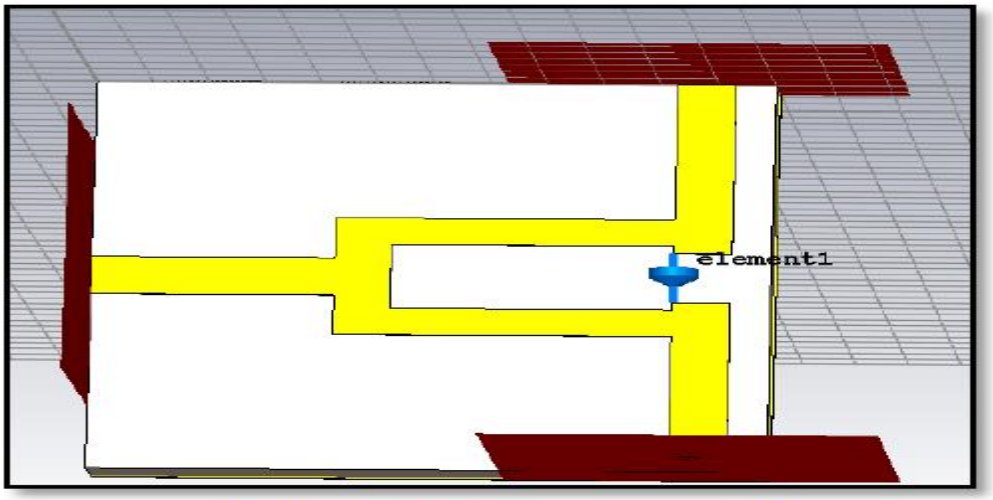

Fig 8: Basic 1X2 Wilkinson power divider

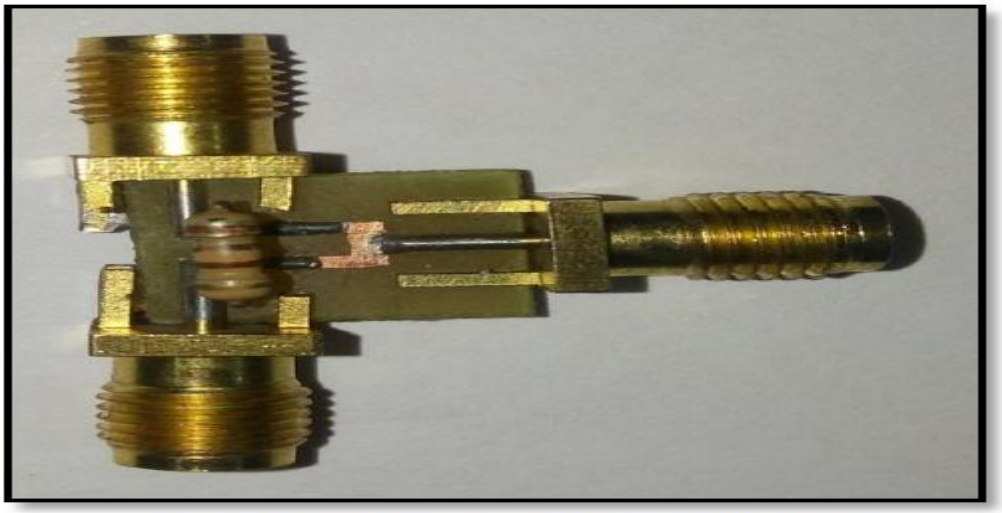

Fig 9: Fabricated Structure of Proposed WB Power

Fig 10: Testing arrangement of proposed1X2 power Divider on FR4 material

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Structure of Proposed Four-Way Wilkinson Power Divider

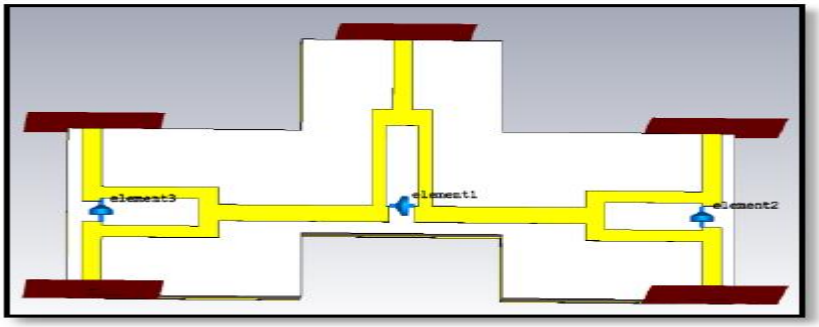

Fig. 11: Basic 1X4 Wilkinson power divider

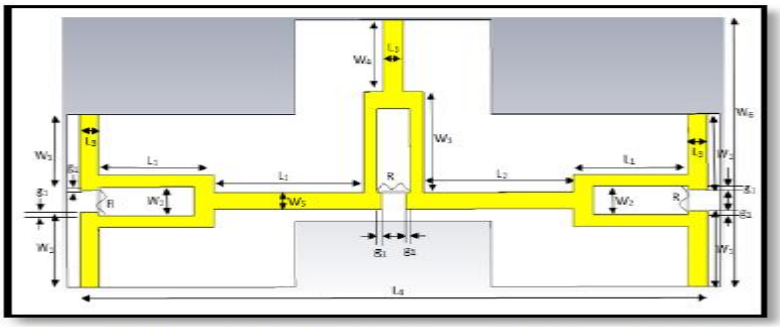

Fig. 12: Layout of Proposed 1X4 WB Power Divider (Dimension 32.9mm × 22.55mm)

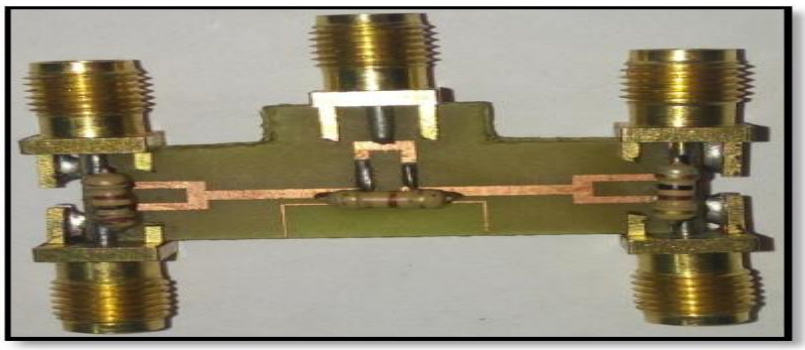

Fig.13: Fabricated Structure of Proposed 1X4 WBPowerDivider (Dimension is 32.9 mm×22.55 mm

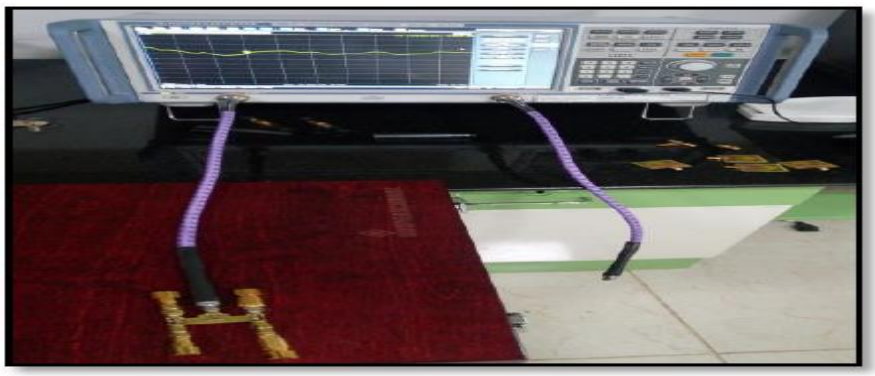

Fig 14: Testing arrangement of proposed 1X4 powerDivider on FR4 Material

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Table 4: Dimensions of the Proposed 1X4 Power Divider

S.No	Dimension	Calculated Value (Millimetres)
1	W_1	4.5
2	W_2	1.7
3	W_3	6
4	W_4	4.3
5	W_5	1
6	W_6	22.55
7	L_1	6
8	L_2	7.9
9	L_3	1
10	L_4	32.9
11	g_1	0.2
12	R	100Ω

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Array Implementation Using 1X2 Power Divider

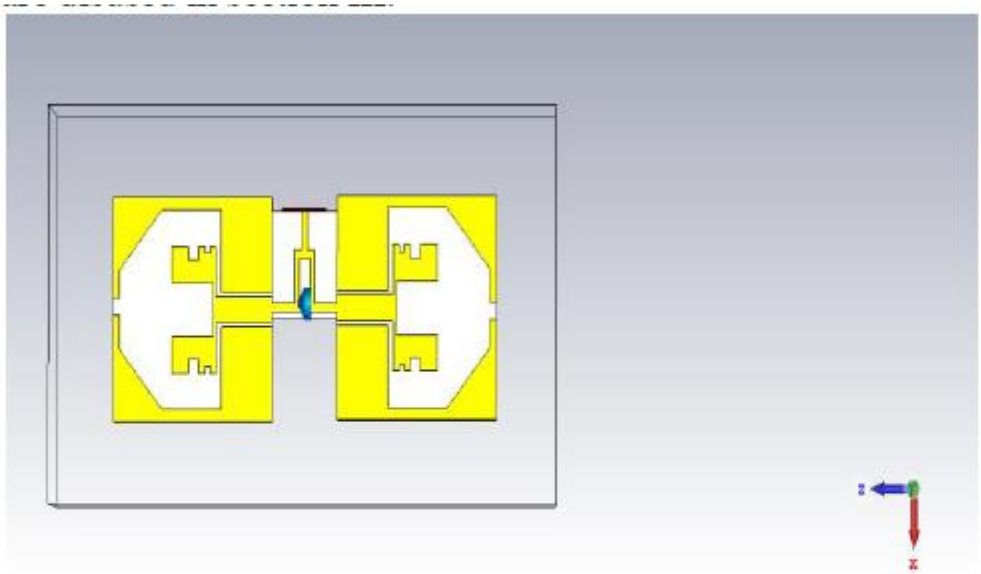

Fig. 15: 1X2 Antenna Array using power divider

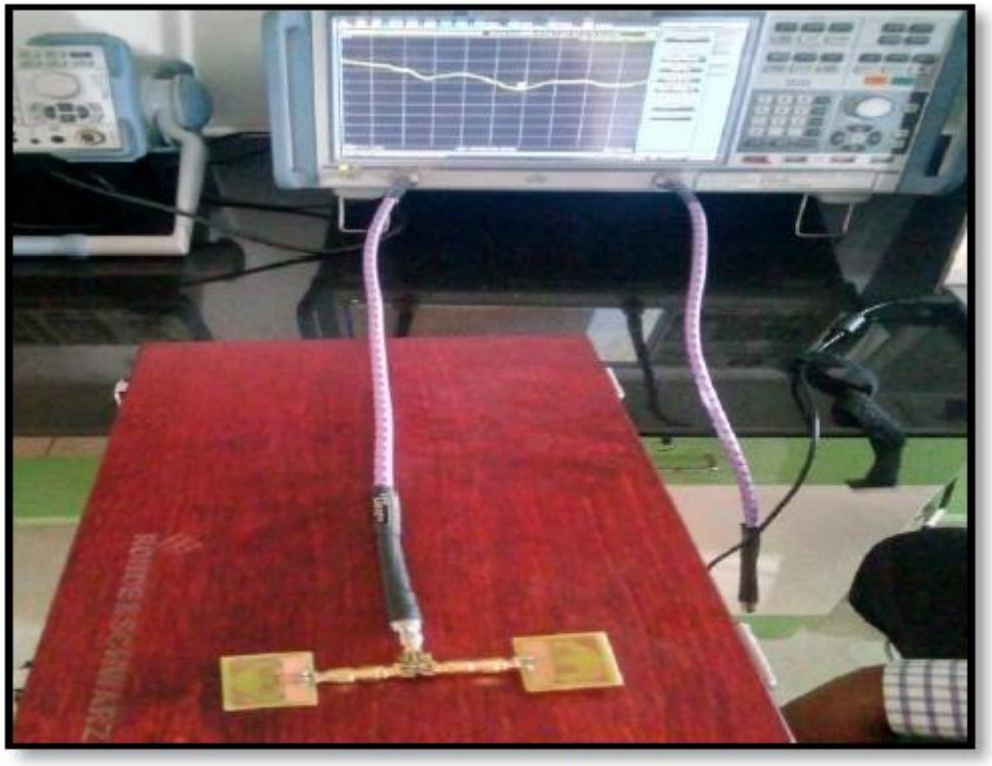

Fig. 16: Testing arrangement of proposed1X2 Antenna Array using power divider

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Array Implementation Using 1X4 Power Divider

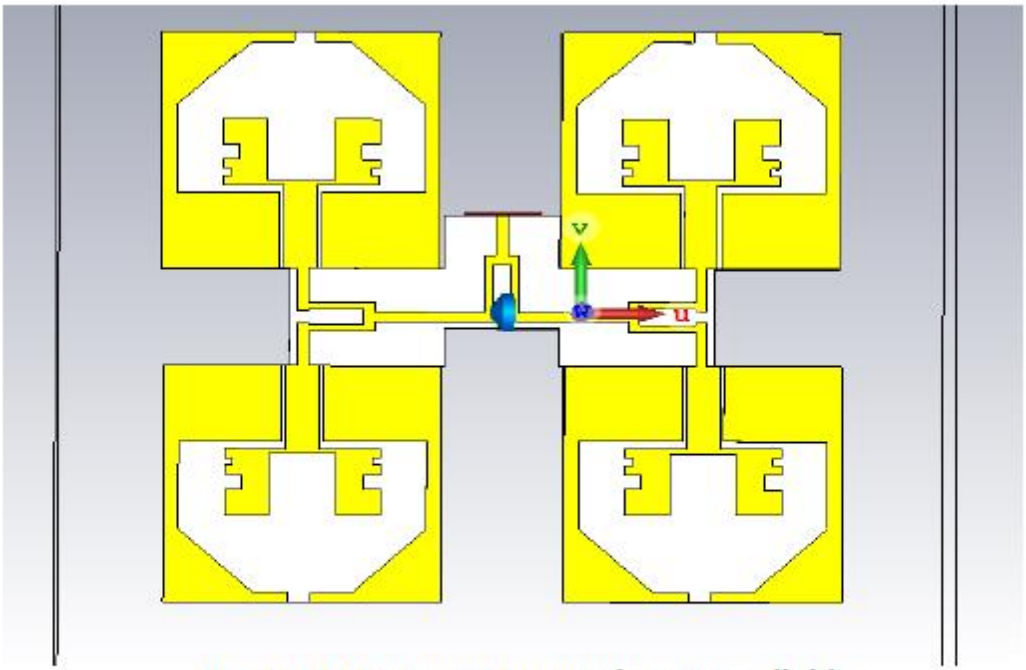

Fig. 17:1X4 antenna Array using power divider

Fig. 18: Testing arrangement of proposed1X4 Antenna Array using power divider

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Results

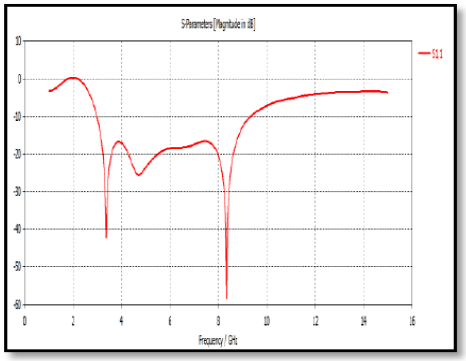

Fig.11 (a): Return loss parameter of U-Slot antenna

3.2 VSWR

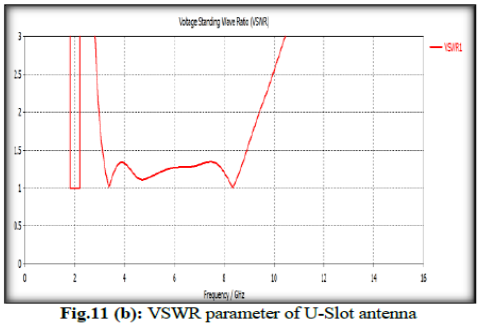

Fig.11 (b): VSWR parameter of U-Slot antenna

3.3 Directivity

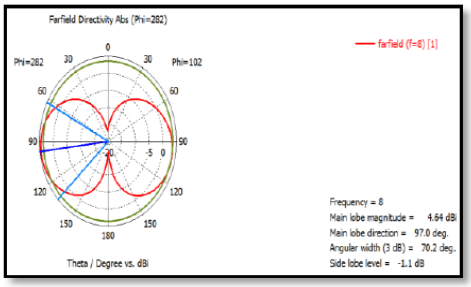

Fig.11(c): Directivity parameter of U-Slot antenna

3.4 Gain

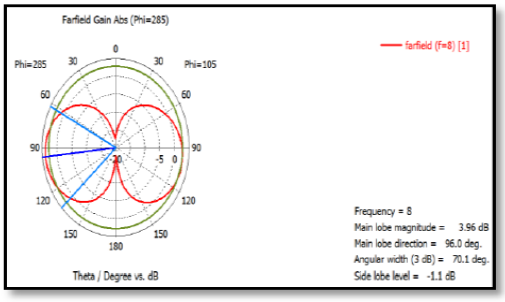

Fig.11 (d): Gain parameter of U-Slot antenna

3.5 Radiation pattern

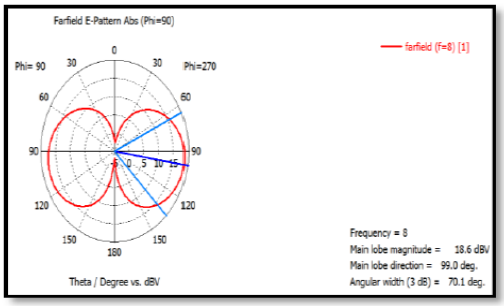

Fig.11 (e): Radiation parameter of U-Slot antenna

3. b. Validation Results of U-Slot antenna

3.6 Return loss

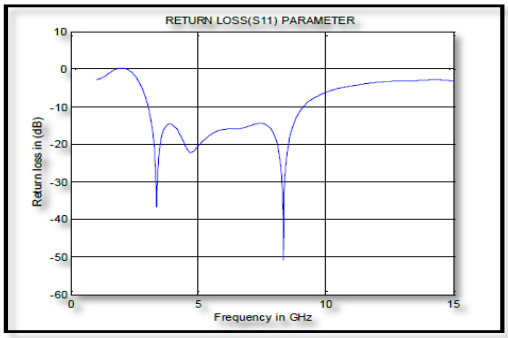

Fig.11 (f): Validation of Return loss parameter of proposed antenna

3.7 VSWR

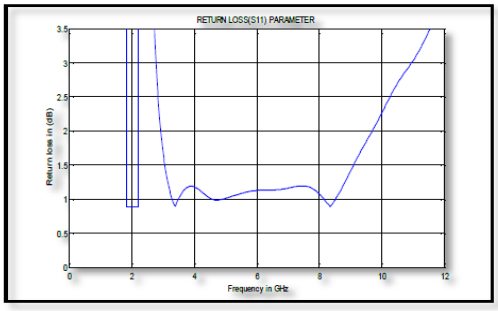

Fig.11 (g): Validation of VSWR parameter of proposed antenna

3. c. 1X2 Array antenna Results

3.8 Return loss

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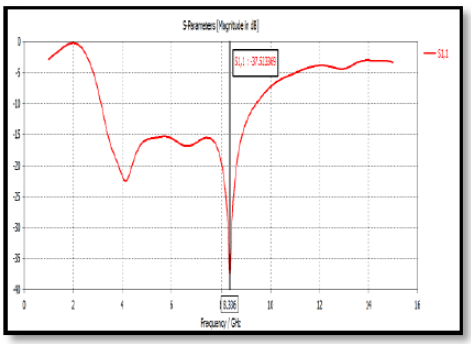

Fig.12 (a):.Return loss parameter of 1X2 proposed antenna

3.9 VSWR

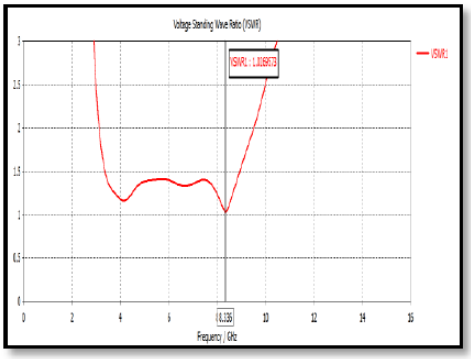

Fig.12 (b): VSWR parameter of 1X2 Proposed antenna

3.10 Directivity

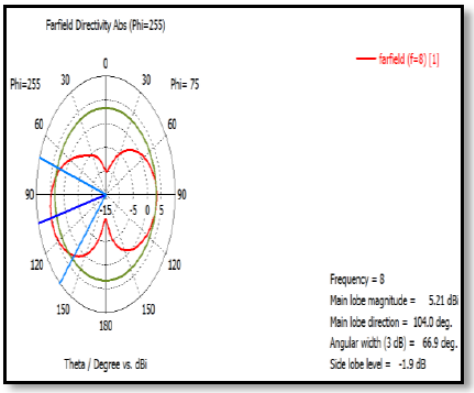

Fig.12(c): Directivity parameter of 1X2proposed antenna

3.11 Gain

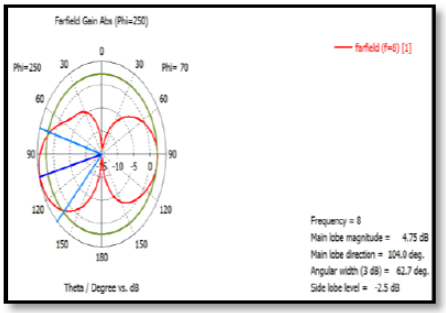

Fig.12 (d): Gain Parameter of 1X2 proposed antenna

3.12 Radiation Pattern

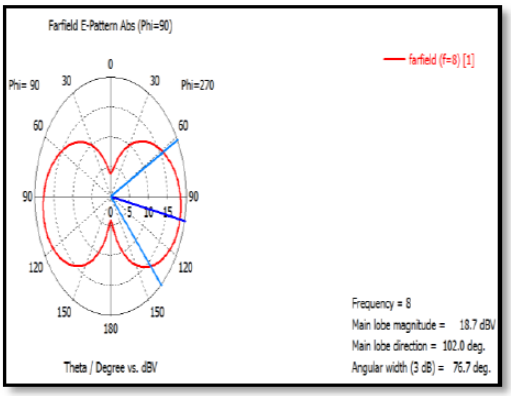

Fig.12 (e): Radiation Parameter of 1X2 proposed antenna

3. d. 1X4 Array antenna Results

3.13 Return loss

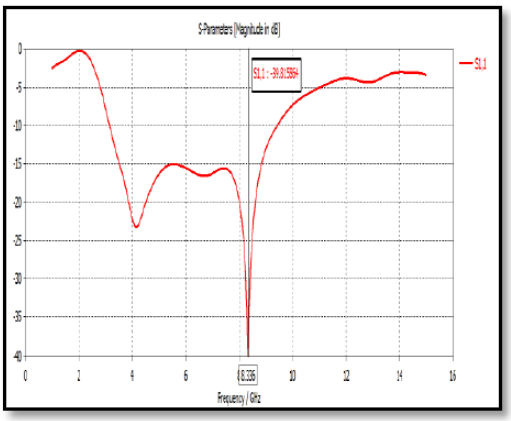

Fig.13 (a) Return loss parameter of 1X4 proposed antenna

3.14 VSWR

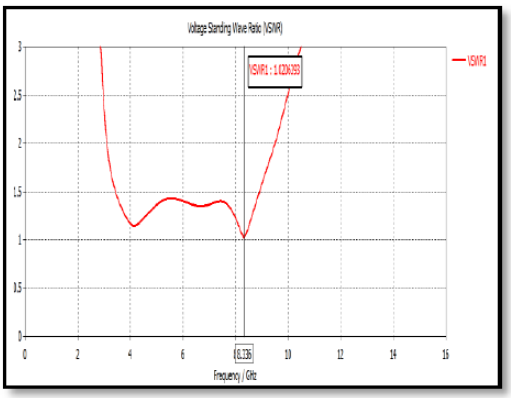

Fig.13 (b): VSWR parameter of 1X4 proposed antenna

3.15 Directivity

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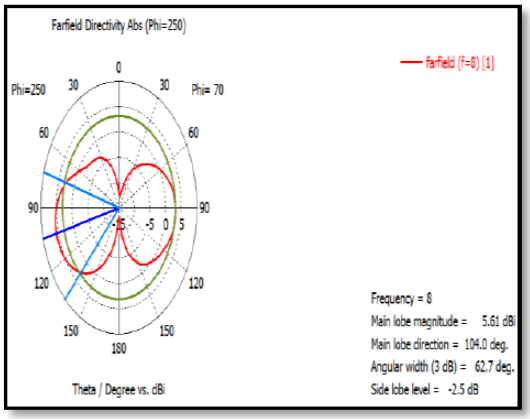

Fig.13(c): Directivity parameter of 1X4 proposed antenna

3.16 Gain

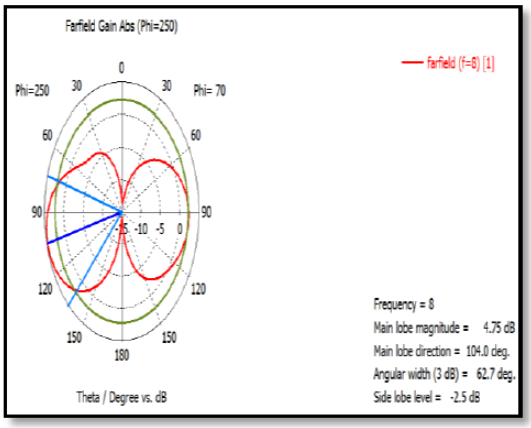

Fig.13 (d): Gain parameter of 1X4 proposed antenna

3.17 Radiation Pattern

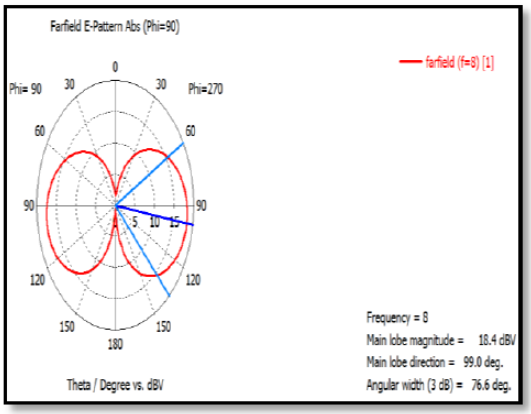

Fig.13 (e): Return loss parameter of 1X4 proposed antenna

3. E. Basic 1X2 Wilkinson Power Divider Results

3.18 Return Loss of Proposed 1X2 Power Divider

S_{11}

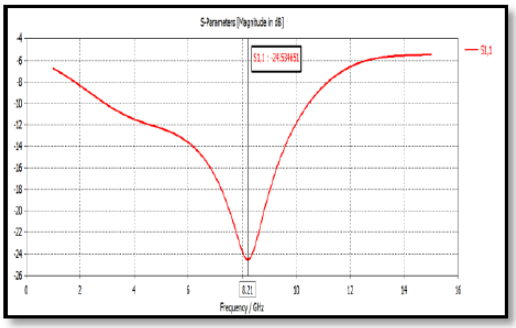

Fig. 14(a): Return loss (S_{11}) parameter Performance of proposed 1X2 power divider

S_{22}

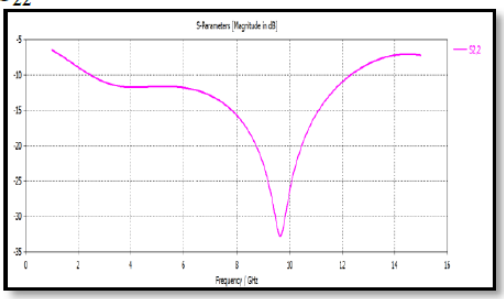

Fig. 14(b): Return loss (S_{22}) parameter performance of proposed 1X2 power divider

S_{33}

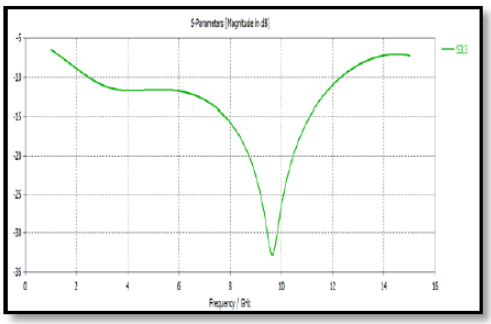

Fig. 14(c): Return loss (S_{33}) parameter performance of proposed 1X2 power divider

3.19 Insertion Loss or Transmission Parameter Of proposed 1X2 power divider

S_{21}

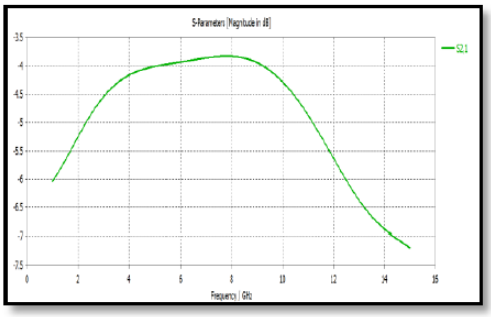

Fig 15(a): Insertion loss (S_{21}) parameter Performance of proposed 1X2 power divider

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S_{31}

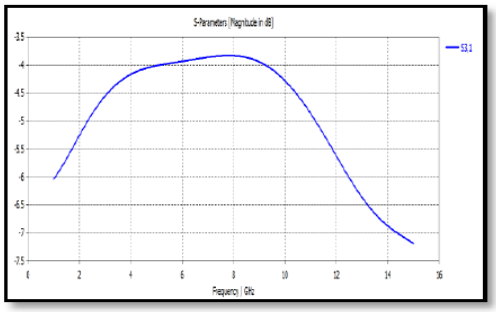

Fig 15(b): Insertion loss (S_{31}) parameter Performance of proposed 1X2 power divider

3.20 Isolation Loss of Proposed 1X2 Power Divider

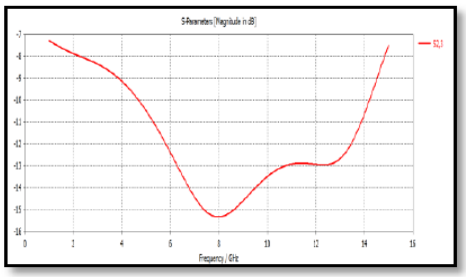

Fig. 16: Isolation loss (S23) performance of proposed 1X2 power divider

3.21 VSWR of Proposed 1X2 Power Divider

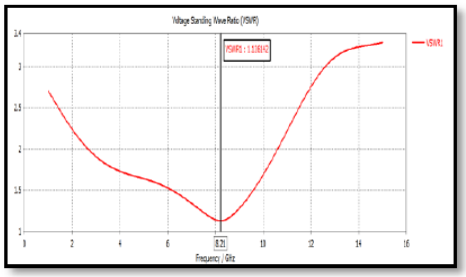

Fig. 17: VSWR performance of proposed 1X2 Power divider

3. F. Basic 1X4 Wilkinson Power Divider Results

3.22 Return Loss of 1X4 Power Divider

S_{11}

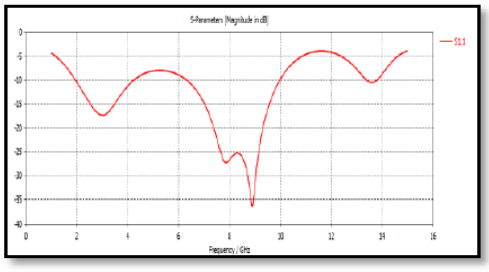

Fig. 18(a): Return loss (S_{11}) parameter performance of proposed 1X4 power divide

S_{22}

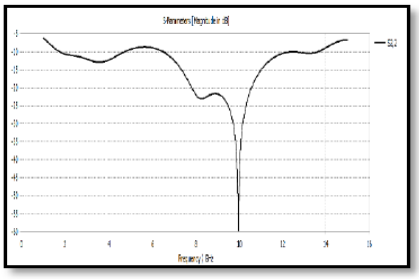

Fig. 18(b): Return loss (S_{22}) parameter Performance of proposed 1X4 power divider

S_{33}

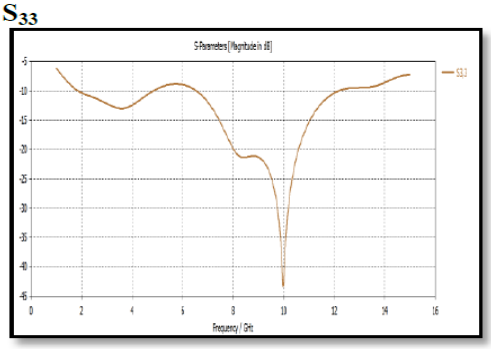

Fig. 18(c): Return loss (S_{33}) parameter performance of proposed 1X4 power divider

S_{44}

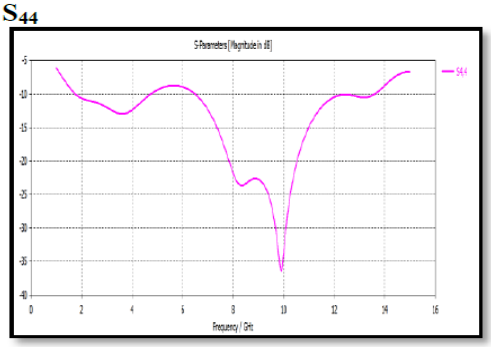

Fig. 18(d): Return loss (S_{44}) parameter Performance of proposed 1X4 power divider

S_{55}

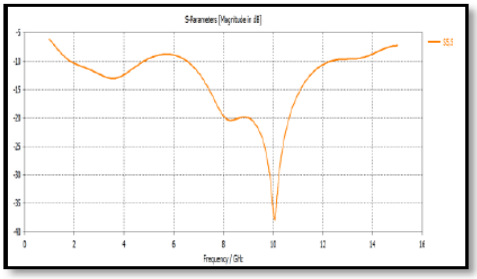

Fig. 18(e): Return loss (S_{55}) parameter performance of Proposed 1X4 power divider

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3.23 Insertion loss of proposed 1X4 power divider

S_{21}

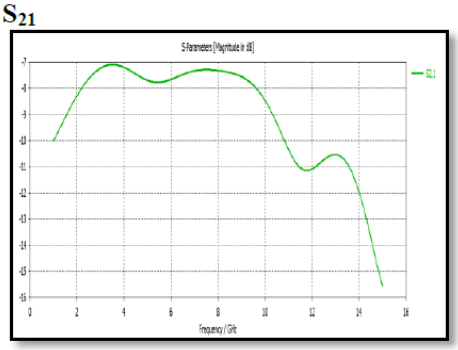

Fig. 19(a): Insertion loss (S21) parameter Performance of proposed 1X4 power divider

S_{31}

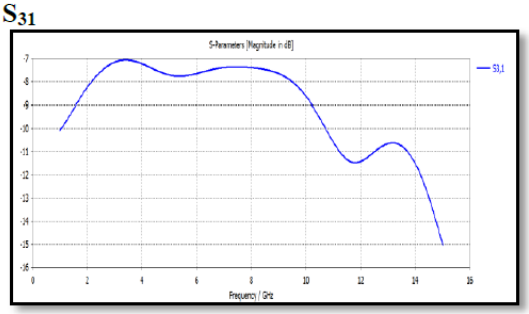

Fig. 19(b): Insertion loss (S31) parameterperformance of proposed 1X4 power divider

S_{41}

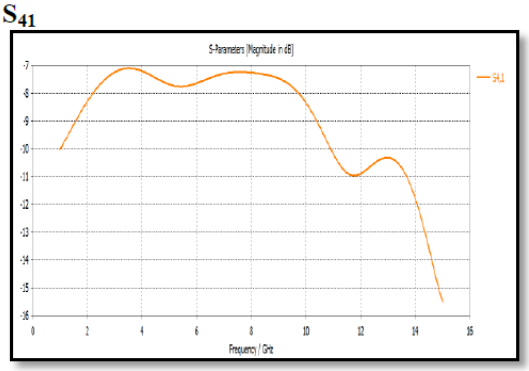

Fig. 19(c): Insertion loss (S41) parameterPerformance of Proposed 1X4 power divider

S_{51}

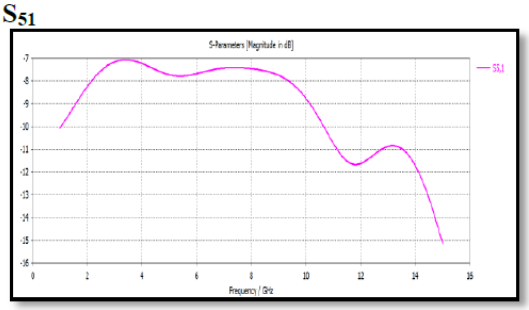

Fig. 19(d): Insertion loss (S51) parameter performance of proposed 1X4 power divider

3.24 Isolation Loss of Proposed 1X4 Power Divider

S_{23}

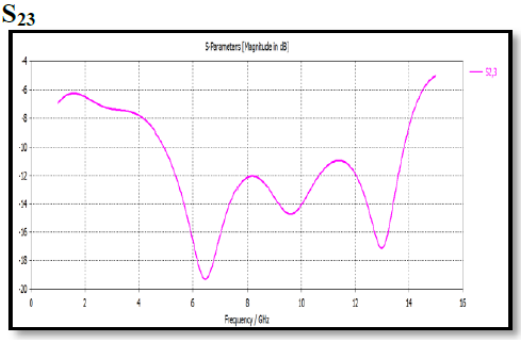

Fig. 20(a): Isolation loss (S23) parameter Performance of proposed 1X4 power divider

S_{24}

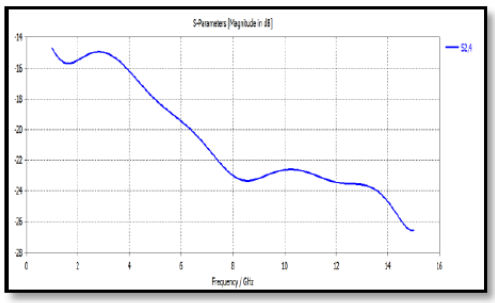

Fig. 20(b): Isolation loss (S24) parameter performance of proposed 1X4 power divider

S_{25}

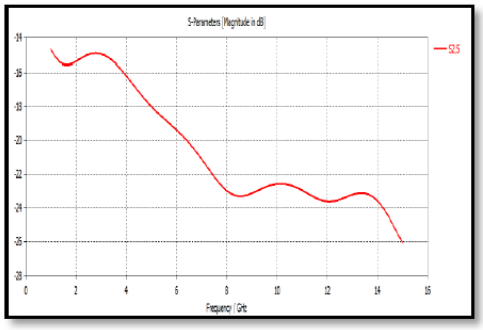

Fig 20(c): Isolation loss (S25) parameterPerformance of proposed 1X4 power divider

S_{34}

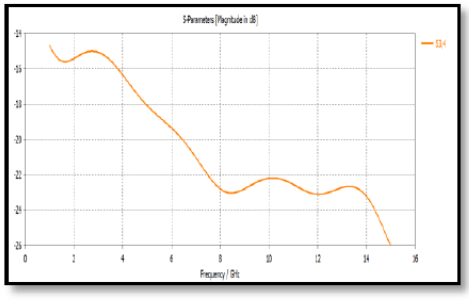

Fig. 20(d): Isolation loss (S34) parameter performance of proposed 1X4 power divider

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S_{35}

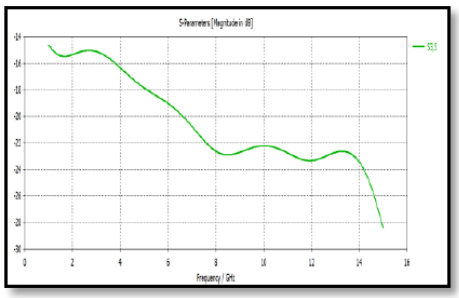

Fig. 20(e): Isolation loss (S35) parameter Performance of proposed 1X4 power divider

S_{45}

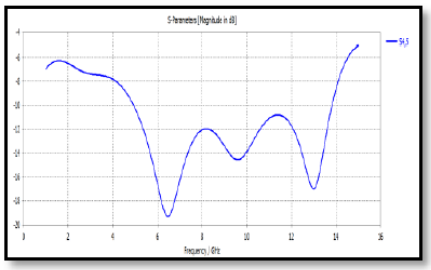

Fig. 20(f): Isolation loss (S45) parameterperformance of proposed 1X4 power divider

3. G. Validation of Proposed 1X2 Power Divider Parameters

3.25 Return Loss Parameter

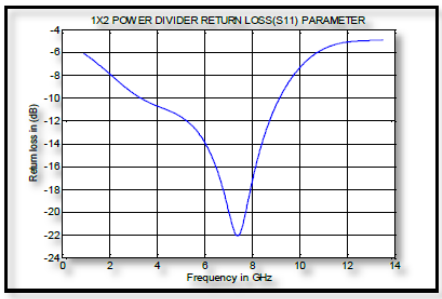

Fig. 21: Validation of Return loss parameter of proposed 1X2 power Divider of FR4 material

3.26 Insertion Loss Parameter

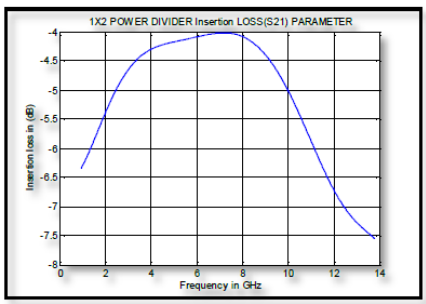

Fig. 22: Validation of Insertion loss parameter of proposed 1X2 power Divider of FR4 material

3.27 Isolation Loss Parameter

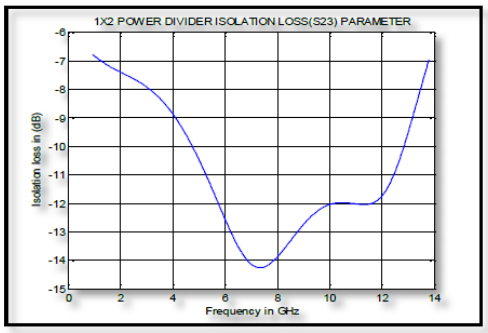

Fig. 23: Validation of Insertion loss parameter of proposed 1X2 power Divider of FR4 material

3. H. Validation of Proposed 1X4Power Divider Parameters

3.28 Return Loss Parameter

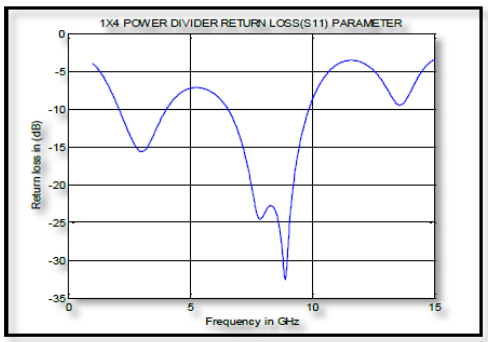

Fig 24: Validation of Return loss parameter of proposed 1X4 power Divider of FR4 material

3.29 Insertion Loss Parameter

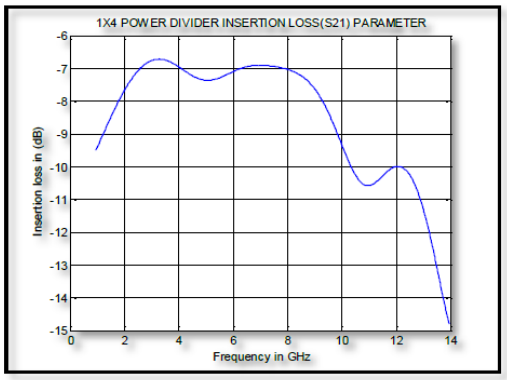

Fig. 25: Validation of Insertion loss parameter of proposed 1X4 Power Divider of FR4 material

3.30 Isolation Loss Parameter

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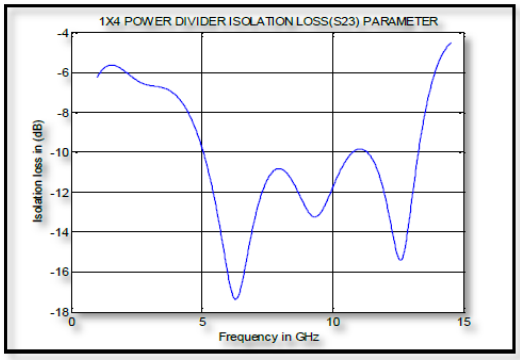

Fig.26: Validation of Insertion loss parameter of proposed 1X4 Power Divider of FR4 material

3. I Array Implementation Using 1X2 Power Divider Results

3.31 Return loss

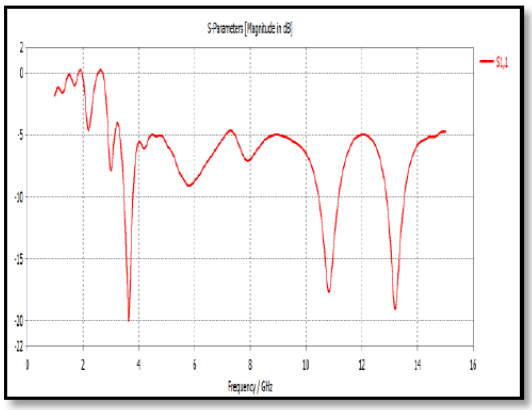

Fig.27 (a): Return loss parameter of 1X2 proposed antenna

3.32 VSWR

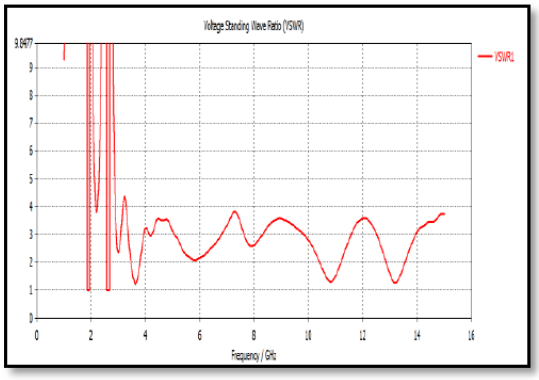

Fig. 27(b): VSWR parameter of 1X2 proposed antenna

3.33 Directivity

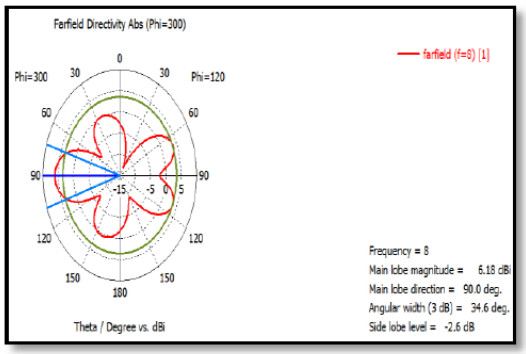

Fig. 27(c): Directivity parameter of 1X2 proposed antenna array

3.34 Gain

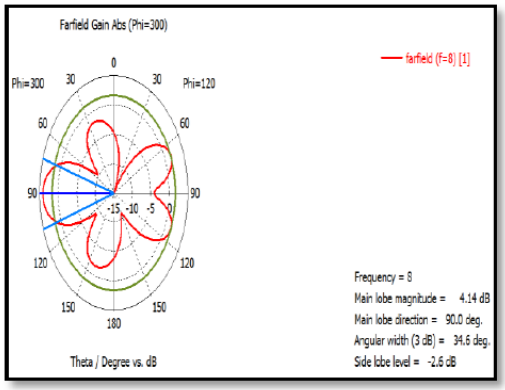

Fig. 27(d): Gain parameter of 1X2 proposed Antenna array

3.35 Radiation Pattern

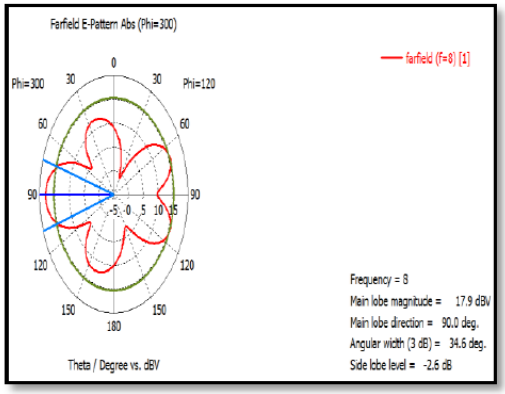

Fig.27 (e): Radiation parameter of 1X2 proposed Antenna array

3. j.Array Implementation Using 1X4 Power Divider Results

3.36 Return loss

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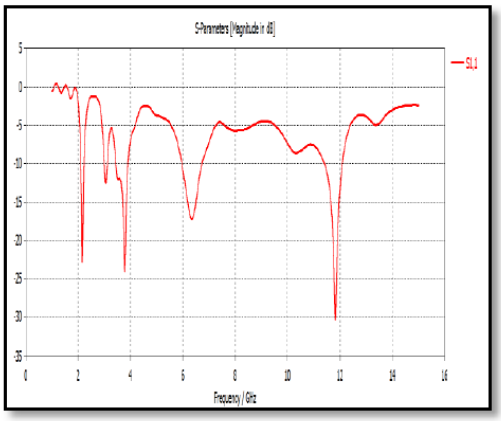

Fig. 28(a): Return loss parameter of 1X4 proposedAntenna array

3.37 VSWR

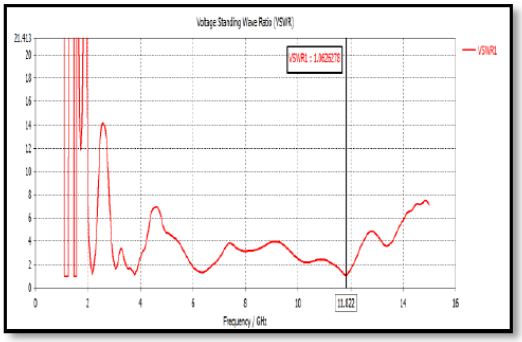

Fig. 28(b):VSWR parameter of 1X2proposedAntenna array

3.38 Directivity

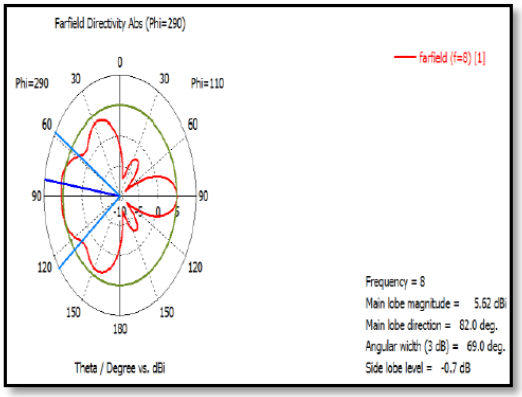

Fig. 28(c): Directivity parameter of 1X2 Proposed Antenna array

3.39 Gain

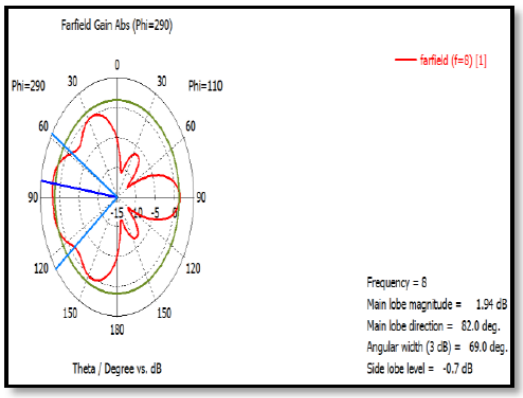

Fig. 28(d): Gain parameter of 1X2 proposed antenna array

3.40 Radiation Pattern

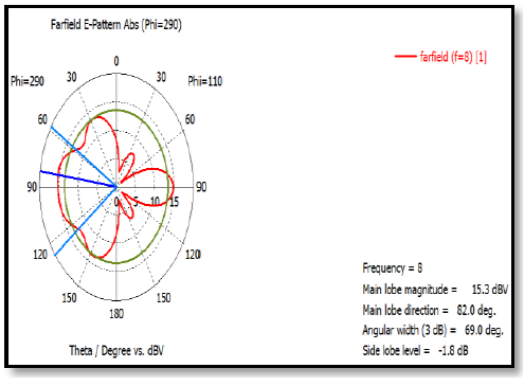

Fig. 28(e): Radiation parameter of 1X2 proposed Antenna array

3.k. Optimization Results 1X2 Array antenna with Power divider

3.41 Directivity

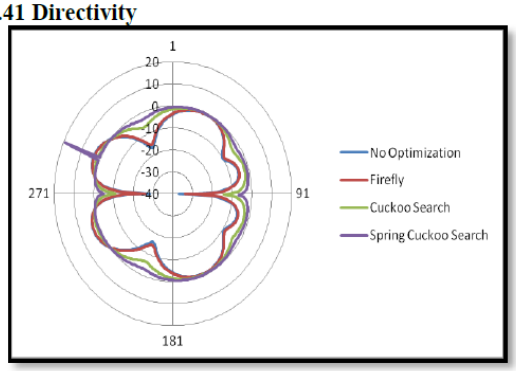

Fig.29 (a): Directivity of 1X2 Array antenna withPower divider

3.42 Gain

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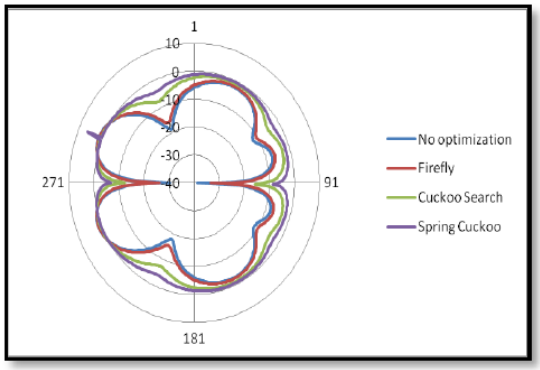

Fig.29 (b): Gain of 1X2 Array antenna with Power divider

3.43 Radiation Pattern

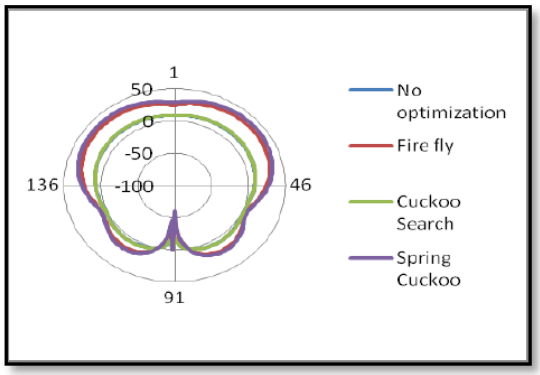

Fig.29(c): Radiation pattern of 1X2 Array antenna with Power divider

3.44 Return Loss

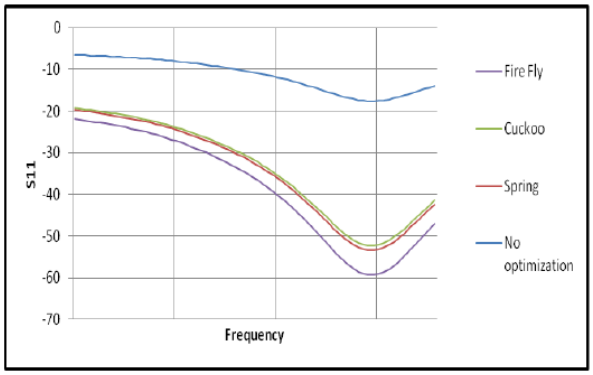

Fig.29 (d): Return loss of 1X2 Array antenna withPower divider

3. l. Optimization Results 1X4 Array Antenna with Power Divider

3.45 Directivity

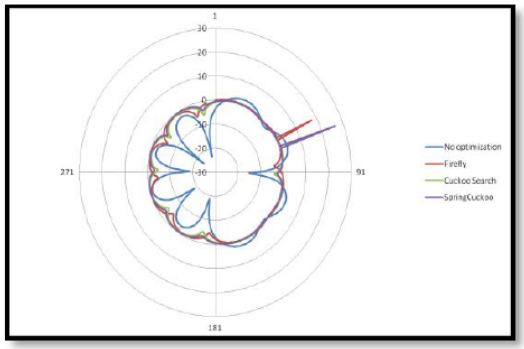

Fig.30 (a): Directivity of 1X4 Array antenna withPower divider

3.46 Gain

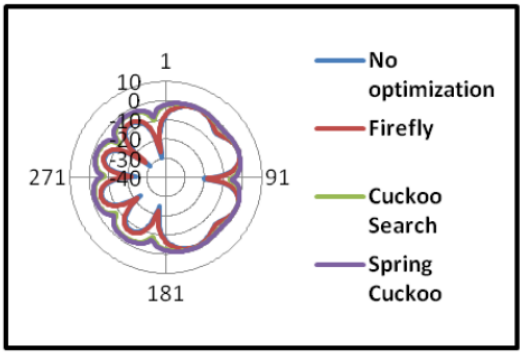

Fig.30 (b): Gain of 1X2 Array antenna withPower divider

3.47 Radiation Pattern

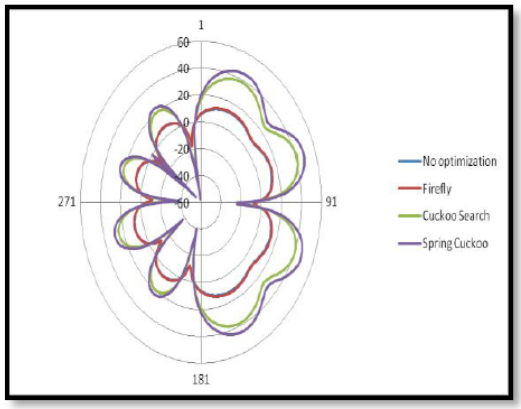

Fig.30(c): Radiation pattern of 1X2 Array antenna withPower divider

3.48 Return Loss

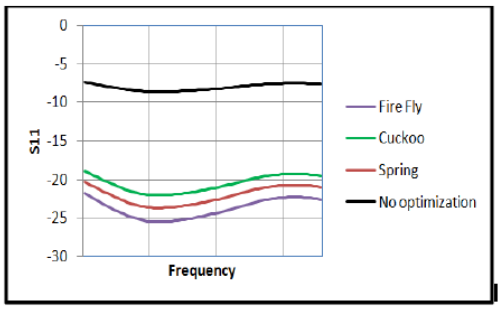

Fig.30 (d): Return loss of 1X4 Array antenna with Power divider

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conclusion

In this paper, we introduce a proposed CPW-fed co-planar Ultra-Wideband (UWB) antenna and its accompanying array system. The planned antenna array structure comprises two essential components: the antenna array itself and its feeding network. We present a novel design for the Wilkinson power divider, which serves as the feeding network, ensuring equal power division between output ports. The prototypes of both the power divider and the antenna array are fabricated using thin film technology and the photolithographic technique. We have designed 1X2 and 1X4 power dividers for the UWB frequency range, employing the Wilkinson topology.

References

[1] Chien-Hung Chen, Ching-Yun Wu, Chien-Ching Chiu, Shu-Han Liao "A multi-objective optimization for UWB antenna array in indoor environment " 978-1-4673-6361-7/13©2013 IEEE

[2] Xin-She Yang, Suash Deb, "Engineering Optimisation by Cuckoo Search" Int. J. Mathematical Modelling and Numerical Optimisation, Vol. 1, No. 4, pp.330–343 (2010).

[3] K. RajKamal, Govardhani Immadi "A Compact Uwb Micro Strip Patch Antenna Using Coplanar Wave Guide Feeding For Bio Medical Applications" ARPN Journal of Engineering and Applied Sciences, VOL. 13, NO. 3, FEBRUARY 2018

[4] K. Rajkamal, Dr. I.Govardhani "Miniaturized Ultra Wideband Planar Wilkinson Power Divider" International Journal of Pure and Applied Mathematics, Volume 117 No. 18 2017, pp.135-141

[5] Xing-Ping Ou, Qing-Xin Chu "A Modified Two-section UWB Wilkinson Power Divider" 978-1-4244-1880-0/08 ©2008 IEEE.sss