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A Slot Antenna Array Based on Substrate Integrated Waveguide

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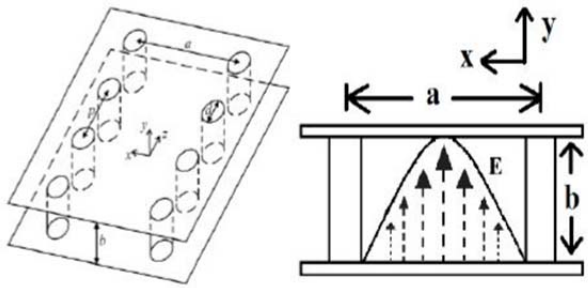
Abstract—*In this research work , Substrate integrated waveguide based array of antenna are presented, a new idea of feeding technique is taken for implementation of a slot antenna array .We have used four slots on patch.These four slots are used for radiating slots, cut on patch to provide best results for radiating an antenna array.In this four slots are cut symmetrically. A H slot cut on centre of patch for coupling energy from micro-strip line to patch. By new feeding technique, we couples energy to H slot by which four slots are excited. Adopting this concept we improve bandwidth starts from 8.02 Ghz to 9.14 Ghz (13.05%) and maximum gain is better than 8.97 dB. For improvement of gain and bandwidth we proposes asymmetric type antenna array.*

Keywords*: Substrate integrated waveguide, slot antenna, antenna array, micro-strip feeding network.*

1. INTRODUCTION

In communication system, both transmission lines and conventional waveguides creates the same fabrication problem. To minimize the system fabrication losses, a systematic Fig. called SIW has been put ahead , as represent in Fig. 1 (a). However, the structure created by the SIW have excellent physical advantages of planar printed transmission lines, and gives the favorable performance of solid waveguide. The major benefits of SIW concept is the chances to fabricate a complete circuit in planar form (including plane circuit, transitions from other, waveguides, antennas , active components), using a specific printing circuit board or some other plane processing concept. However, the possibility to kept one or more than one sets of chip on substrate. Here is no requirement of transitions in between fabricated element with the different concept.



(a) **(b)**

Fig.1(a)Schematic diagram of Substrate Integrated Waveguide(SIW), 1(b) Distribution of Electric Field component.

Due to various benefits of Substrate integrated waveguide ,various antennas are presented in [1]-[7].

Slot Antenna array are used to enhance the 3 dB gain and impedance bandwidth of an antenna. The technique of power distributor & combiner for proper distribution of energy is used for micro-strip feeding network.

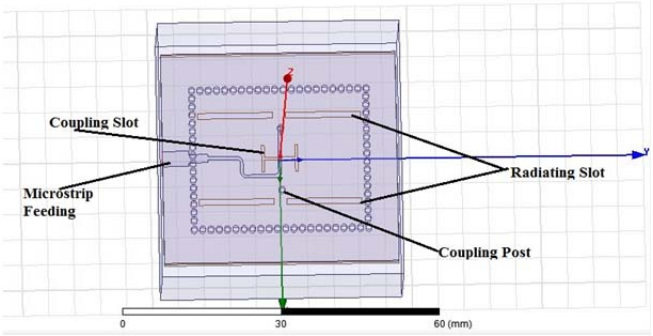


Fig. 2: Diagram of proposed antenna array

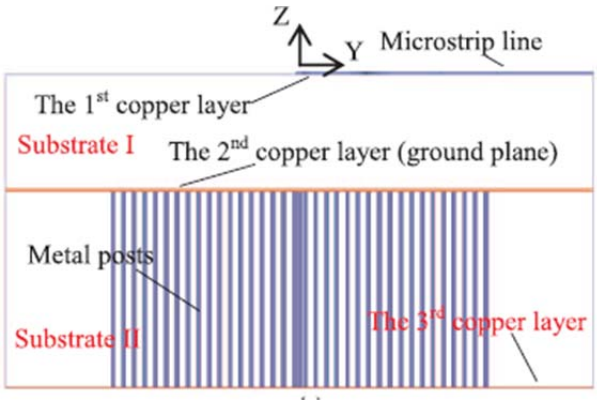


Fig. 3: Side view of proposed Slot antenna array

In this research work, Substrate integrated waveguide based slot antenna array are executed on HFSS 14.0. A micro-strip line feeding technique is used to gives the energy to the coupling slot i.e. H slot to which all four slots which are symmetrically energies, metallic posts used in between antenna which divides energy into two equal parts and antenna starts radiating .

2. ANTENNA STUCTURE

Symmetric type Antenna array

The presented slot antenna array represented in Fig. 2.The slot antenna array is simulated for operating at frequency of 8.7Ghz.By presented slot antenna array figure, it can be observe that the antenna array is equally symmetric in plane about XZ . It consists of four slot which is radiated after coupling energy from H slot, a micro-strip feeding network, a coupled energy H slot & metal vias. The paper [8] which is based on substrate waveguide design formed by doing metal vias, by doing this it creates a resonant cavity.

In this design we use two substrate which is presented in fig. 3, having height of 1.5mm and 0.76 mm and used teflon of dielectric constant of 2.1. The micro-strip feeding line placed on upper layer which is formed by copper and main part of antenna drawn on 2nd copper layer. Initially H slot gives the energies from micro-strip feeding network to four slots which starts radiating.

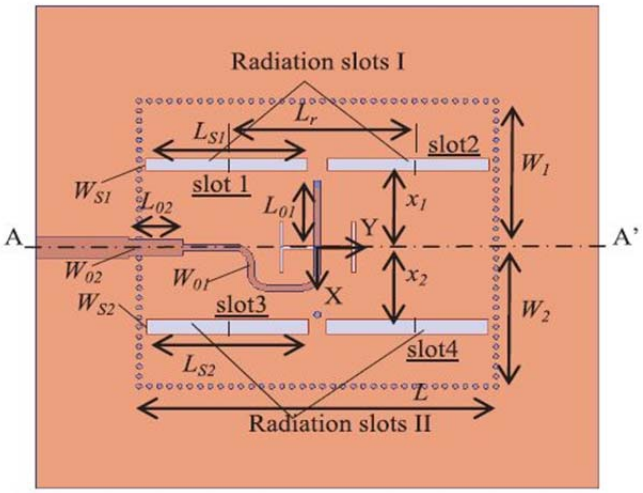


Fig 4 Top view of Antenna Array of 2×2

The measurements of presented antenna array listed below-

S.N.	Parameter	Dimension(mm)
1	L	31.4
2	W_1, W_2	13.7
3	Ls_1, Ls_2	14.5
4	Ws_1, Ws_2	1.13
5	x_1, x_2	7.93
6	L_{01}	6.08
7	W_{01}	0.6
8	L_{02}	4.89
9	W_{02}	1.49

The metal posts used for Substrate integrated waveguide taken 0.6 mm as radius and 1.6 mm as spacing or pitch which is calculated with the help of following equation -

Radius(r)< $\lambda g/2$

Pitch(p) < 4r

Where,
λ_g is known as guided wavelength

$$\lambda_g = \frac{2\pi}{\sqrt{\frac{\varepsilon_R(2\pi f)^2}{c^2} - (\frac{\pi}{a})^2}}$$

3. ASYMMETRIC TYPE ANTENNA ARRAY

In asymmetric type antenna array we varying three parameter i.e. length of slot , width of slot and distance between the slots. By varying all three parameter we get improvement in bandwidth and gain too. Besides these three parameter, all other parameter are unchanged.

The comparison table for all three cases listed below-

Table 1: Comparison of width of slots

Width(Ws_1) of slot(mm)	Gain(dB)	Bandwidth(%)	VSWR
0.93	8.7381	12.96	1.5610
1.13	8.9748	13.05	1.5449
1.33	9.1794	13.16	1.4807
1.53	9.154	12.93	1.5176

Table 2: Comparison of length of slots

Length(Ls_1) of slot(mm)	Gain(dB)	Bandwidth(%)	VSWR
13.5	9.0433	13.05	1.4874
14	8.999	13.05	1.4763
14.5	8.9748	13.05	1.5449
15	8.7553	13.05	1.6318

Table 3: Comparison of length between slots

Length (x_1) between slot(mm)	Gain(dB)	Bandwidth(%)	VSWR
7.53	8.4834	13.3	1.6037
7.73	8.7943	13.18	1.5191
7.93	8.9748	13.05	1.5449
8.13	9.1881	12.82	1.4534

4. EXPERIMENTAL RESULTS

This type of slot antenna array is analyze on HFSS 14.0.The dimension of length and width of proposed antenna array is approx. one and one fourth of wavelength.

The analyzed results of symmetric type slot antenna array are shown in fig 5,6 and 8.By analysis of Fig. as shown , S_{11} parameter at 8.7 Ghz is 13.39 dB , but max. return loss with in -10 dB is 30 dB, impedance bandwidth of presented antenna array is from 8.02 Ghz to 9.14 Ghz which is approx 13.05% , but there is improvement from previous slot antenna array discuss in [9]. The VSWR of proposed symmetric antenna array is approx 1.5449.Fig. 7 shows the distribution of electric field , by fig. we analyze that antenna is radiating.

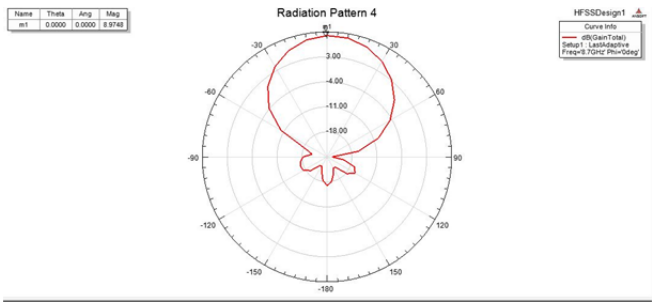


Fig. 5 Simulated result of Radiation pattern of proposed Slot antenna array

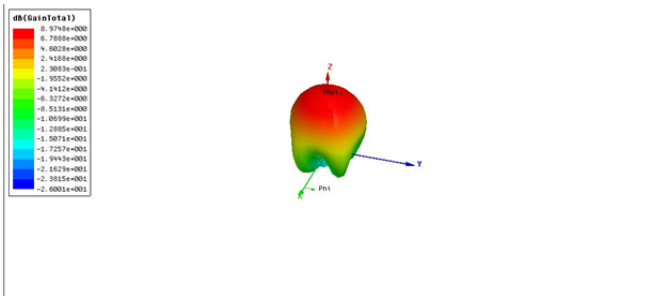


Fig.6 Simulated results of 3D Gain of Slot antenna array.

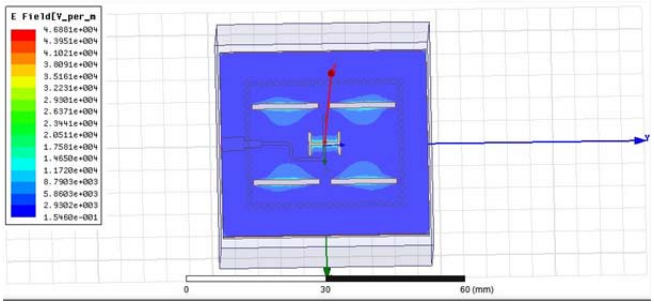


Fig.7 E- field of simulated slot antenna array

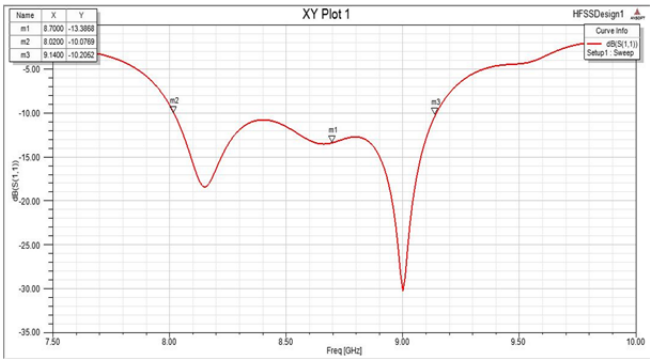


Fig.8(a) S_{11} of Simulated slot antenna array

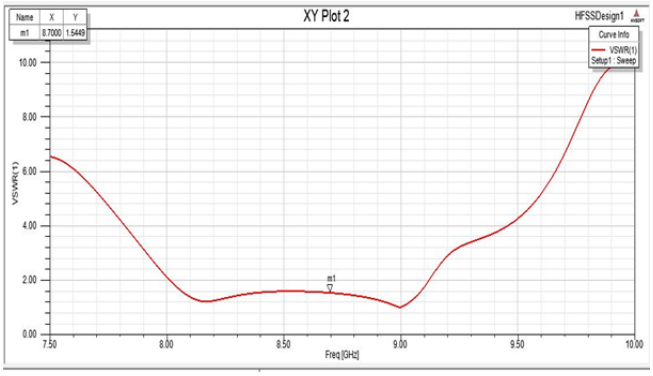


Fig. 8(b) VSWR of Simulated Slot antenna array

For improvement in gain, bandwidth we design asymmetric antenna array .The Simulation result of asymmetric array presented in fig. 9(a),9(b) and 9(c). By analysis of these graphs we concluded that the gain improved from 8.97 dB to 9.1881 dB and bandwidth improved from 13.05% to 13.3%.

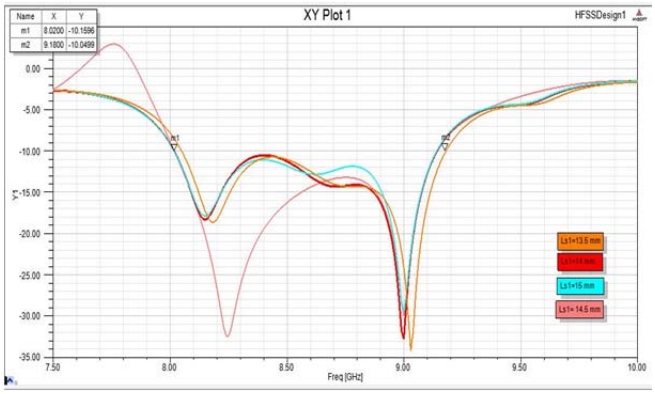


Fig 9(a) Plot of S_{11} for varying length of slots

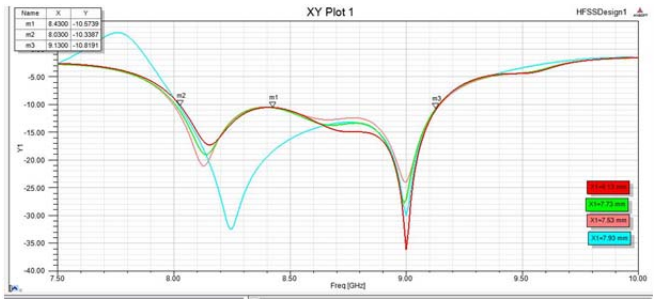


Fig 9(b) Plot of S_{11} for varying width of slots

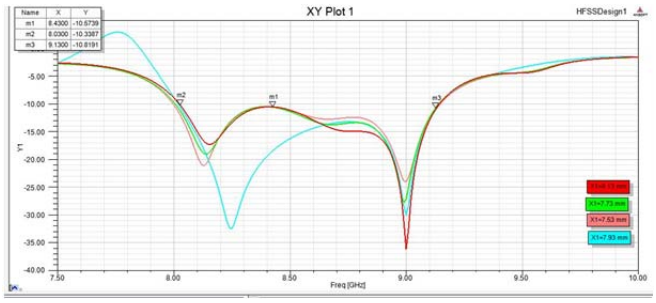


Fig 9(c) Plot of S_{11} for varying distance between slots

5. CONCLUSION

In research work, idea of new feeding concept is presented for the improvement of gain and bandwidth from previous presented slot antenna array. Here, we get bandwidth of 13.3% and gain of 9.19 dB.This type of slot antenna array can be used in the field of wireless communication system.We very Thankful to new concept micro-strip feeding, a coupling aperture slots technique and metal vias which are inserted in waveguide for the construction of substrate integrated waveguide. By doing this we can decreases metal vias by which cost of fabrication reduced.

The proposed antenna design have benefits of simple design, high antenna array gain, and high impedance bandwidth.

REFERENCES

[1] K. S. Chin, W. Jiang, W. Q. Che, C. C. Chang, and H. Y. Jin, "Wideband LTCC 60 GHz antenna array with a dual-resonant slot and patch structure," *IEEE Trans. Antennas Propag.*, vol. 62, no. 1, pp. 174–182, Jan. 2014.

[2] M. H. Awida, S. H. Suleiman, and A. E. Fathy, "Substrate integrated cavity-backed patch arrays: A low-cost approach for bandwidth enhancement," *IEEE Trans. Antennas Propag.*, vol. 59, no. 4, pp. 1155–163, Apr. 2011.

[3] M.Mbaye, J. Hautcoeur, L. Talbi, and K. Hettak, "Bandwidth broadening of dual-Slot antenna using substrate integrated waveguide (SIW)," *IEEE Antennas Wireless Propag. Lett.*, vol. 12, pp. 1169–1171, Sep. 2013.

[4] J. F. Xu, Z. N. Chen, X.M. Qing, andW. Hong, "Bandwidth enhancement for a 60 GHz substrate integrated waveguide fed cavity array antenna on LTCC," *IEEE Trans. Antennas Propag.*, vol. 59, no. 3, pp. 826–832, Mar. 2011.

[5] J. F. Xu, Z. N. Chen, X. M. Qing, and W. Hong, "140-GHz TE20-mode dielectric-loaded SIW slot antenna array in LTCC," *IEEE Trans. Antennas Propag.*, vol. 61, no. 4, pp. 1784–1793, Apr. 2013.

[6] D. F. Guan, Z. P. Qian, Y. S. Zhang, and Y. Cai, "Novel SIW cavitybacked antenna array without using individual feeding network," *IEEE Antennas Wireless Propag. Lett.*, vol. 13, pp. 423–426, Mar. 2014.

[7]P. K. Park and I. P. Yu, "Characterization of dumbbell slots in rectangular waveguide by method of moments," in *Proc. Antennas Appl. Symp.*, Sep. 1984, pp. 1–6.

[8]D. Deslandes and K. Wu, "Accurate modeling, wave mechanisms, and design considerations of a substrate integrated waveguide," *IEEE Trans. Microw. Theory Techn.*, vol. 54, no. 6, pp. 2516–2526, Jun. 2006.

[9]P.Wu and Q. Xue, "A substrate integrated slot antenna array using higher order mode feeding network," in *Proc. Asia-Pac. Microw. Conf.*, 2014, pp. 348–350.

[10]D. F. Guan, Z. P. Qian, Y. S. Zhang, and J. Jin, "Hign-gain SIW cavitybacked array antenna with wideband and low sidelobe characteristics," *IEEE Antennas Wireless Propag. Lett.*, vol. 14, pp. 1774–1777, Sep. 2015.

[11]J. L. Volakis, *Antenna Engineering Handbook*, 4th ed., ch. 23. New York,NY, USA: McGraw-Hill, 2007.

[12] L. J. Hoon, N. Kidera, G. DeJean, S. Pinel, J. Laskar, and M. M. Tentzeris,"A V-band front-end with 3-D integrated cavityfilters/duplexers andantenna in LTCC technologies," *IEEE Trans. Microw. Theory Techn.*,vol. 54, no. 7, pp. 2925–2936, Jul. 2006.

[13] J. F. Xu, Z. N. Chen, X. M. Qing, and W. Hong, "A single layer SIW slotarray antenna with TE20 mode," in *Proc. Asia-Pac. Microw. Conf.*, 2011,pp. 1330–1333.

[14]W. L. Stutzman and G. A. Thiele, *Antenna Theory and Design*, 3nd ed.Hoboken, NJ, USA: Wiley, 2012.

[15] Y. Huang, *Handbook of Antenna Technologies*. New York, NY, USA:Springer, 2015.