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Microstrip Line Fed Leaky Wave Antenna with Shorting Vias for Wideband Systems

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ABSTRACT

In this work a complex structured shorted vias microstrip leaky wave antenna is designed and analysed. A Leaky wave antenna is a travelling wave structure with complex propagation constant. When shorting vias are loaded in a periodic structure the fundamental resonant mode shows some stop band characteristics and some of the modes will strongly attenuated. Three different types of iterations are examined in this work with and without defected ground structures. The defected ground structure based leaky wave antennas are showing better performance characteristics with respect to efficiency and phase. A micro strip line feeding with impedance of 50 ohms at both ports are providing excellent impedance matching to the conducting path on the microstrip surface. The shorting vias are suppressing certain higher order frequency bands and providing excellent wide band characteristics with low loss.

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1. INTRODUCTION

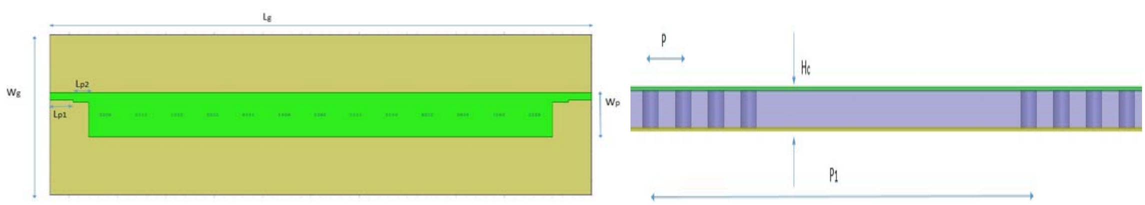
The transverse slotted rectangular waveguide is a simple structure that works as a leaky-wave antenna having frequency beam-scanning capability, with an orthogonal polarization from the conventional travelling-wave slotted antenna. Because of the polarization, the transverse slotted rectangular waveguide can scan from near broadside to end fire if the waveguide is filled with a dielectric material .Microstrip antennas underwent a broad range of development since it was proposed first by Menzel. This microstrip antenna has typical properties like wide bandwidth. These antennas mostly operate in the first higher mode. The microstrip leaky-wave antenna has received intensive Investigation since Menzel first made a microstrip leaky-wave antenna in 1979 .The microstrip leaky-wave antenna Usually operates in the first higher order mode of the microstrip line [1],[2]. The microstrip leaky-wave antenna has the merits of being low profile and having structural simplicity, a Wide bandwidth, a narrow beam width, and a frequency scanning Ability. Recently, the half-width microstrip leaky-wave antenna was also proposed and its characteristics are very similar to the full-width microstrip line operating in the mode [3],[4]. The Half-width microstrip leaky-wave antenna has the advantages of reduced size and a simpler feeding structure compared to the Full-width microstrip leaky-wave antenna [5],[6].

In earlier stage the antenna was fed using an asymmetrical feeding structure. This feeding gave the result and also produced some unwanted results like basic fundamental mode which does not contribute to useful radiation. Then a technique was proposed to suppress the fundamental mode. This procedure involves inserting of conducting vias in the microstrip antennas [7],[8]. As the technique was not elaborated clearly, it was not taken into account. To overcome this drawback in these antennas are different feeding techniques were proposed. These include, Microstrip to slot line, coplanar wave guide. But these structures also gave rise to unwanted radiation which leads to their rejection. Balun proposed the inclusion of phase out network to the feeding which successfully suppressed the fundamental mode [9],[10]. The Idea of including phase out network lead to complexity in design and analysis of the antenna. Further it disturbs the basic advantage of microstrip antenna it increases the antenna size.

This method of inserting vias involves placing conducting vias inside the microstrip antenna which suppresses the unwanted fundamental mode. This technique gives rise to stop band for fundamental mode. In this stop band the fundamental mode is highly attenuated. There is also disadvantage that antenna has to suffer a little bit in terms of bandwidth [11],[12]. In this paper we study the design of such antenna and improve its performance by making the ground defective. The inserted vias give rise to a stop band for the fundamental mode. In this stop band the fundamental mode is highly attenuated which suppresses the fundamental mode. We try to improve the performance of antenna by improving its gain and bandwidth of such structure [13],[14].

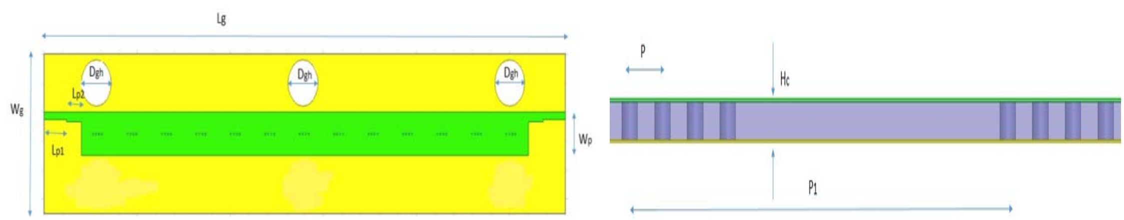
2. MATERIALS AND METHOD

The leaky-wave antennas are essential to provide the benefit of high directivity without complex feeding network. The same thing can be achieved with arrays also but for compact structure, leaky-wave antennas are more preferable compared with array models. However, they suffer of major limitations in their scanning capabilities, which have limited their applications to date. The geometry of the microstrip line feed antenna with shorting vias along the centre line is shown in Figure 1. The arrangement of shorting vias to suppress surface waves can be observed from the structure. Figure 2 shows the modified structure of the leaky-wave antenna with defected ground structure on another side of the substrate.



(a) (b)

Figure 1. Microstrip Line Fed Leaky Wave Antenna, (a) Antenna Structure, (b) Side View



(a) (b)

Figure 2. Modified Microstrip Line Fed Leaky Wave Antenna with DGS, (a) Antenna Structure, (b) Side View

Figure 3 shows proposed leaky-wave antenna with modification of 6 slots as defected ground structure. The dimensional characteristics of the designed 3 models are shown in Table1.

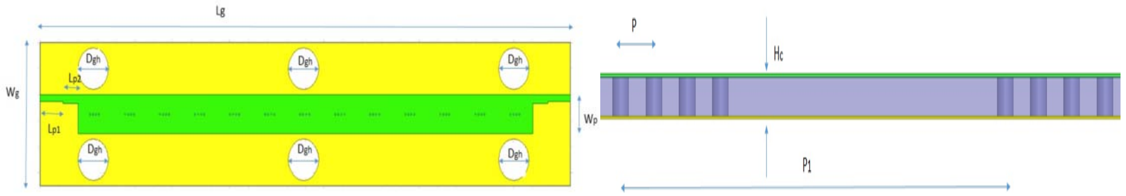


Figure 3. Modified Proposed Microstrip Line Fed Leaky Wave Antenna with DGS,
(a) Antenna Structure, (b) Side View

In order to enhance the stop band of the fundamental mode, more shorting vias can be employed for each period. The reason behind this is when we place more shorting vias then we will get stronger perturbation to the fundamental mode. To achieve this, we loaded a microstrip line with 50-ohm impedance.

Table 1. Antenna dimensions in mm

Lg	Wg	Wp	Lp1	Lp1	Dc	P	Hc	P1	Dgh
280	55	15	12	8	0.8	1.6	0.8	18.5	16

L_g=length of ground, length of substrate, length of total patch
W_g=Width of ground, width of substrate
W_p=Width of patch, Lp1, Lp2=length of patch united structures
D_c=diameter of the via cylinder
P=Distance between two cylinder centres in same period
P_1=Distance between two cylinder centres in consecutive periods
H_c=height of the cylinder
D_{gh}=diameter of the hole made in ground

3. RESULTS AND DISCUSSION

The antenna models are designed and simulated using HFSS tool and results related to antenna output parameters are presented in this section. Figure 4 shows the reflection coefficient characteristics of the designed antenna models. The fundamental resonant mode is blocked with the proposed structure and the antenna models are resonating between 6.2GHz to 8.5 GHz. An impedance bandwidth of 35% is achieved from the proposed antenna model 3 with defected ground structure.

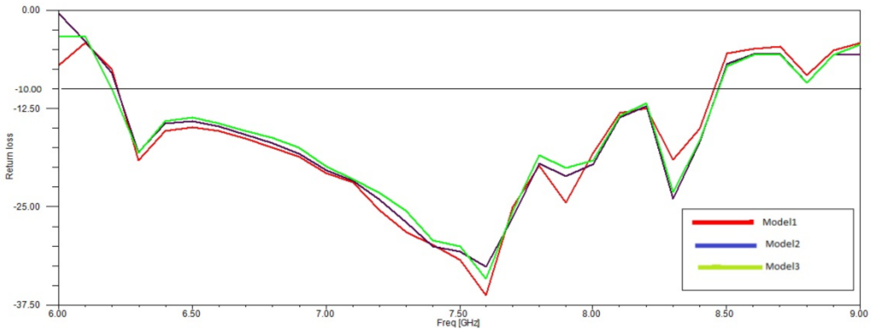


Figure 4. Reflection Coefficient of the antenna models

Figure 5 shows VSWR characteristics of 2:1 ratio in the desired operating band. Figure 6 shows the impedance characteristics of antenna models with respect to change in frequency. A stop band at fundamental resonant mode is attained because of more number of shorting vias in the periodic structure. When the number of shorting vias is increased the phase constant of fundamental mode will decrease.

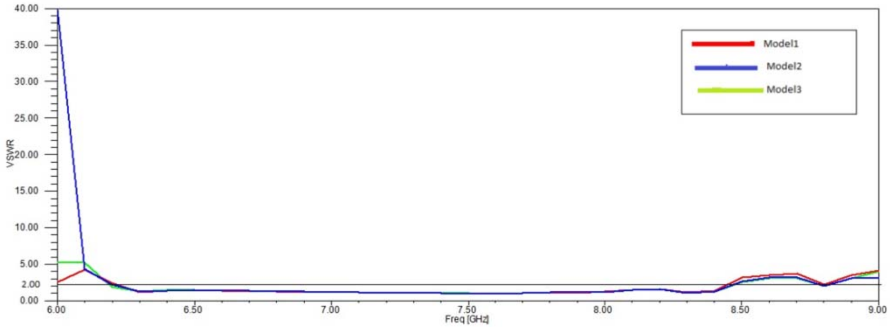


Figure 5. VSWR Vs Frequency

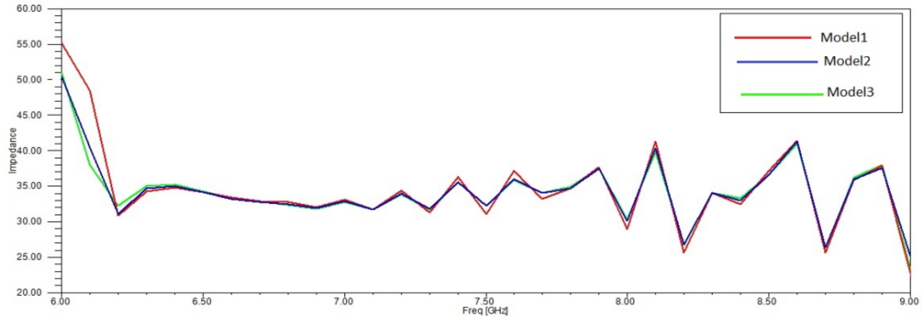


Figure 6. Impedance Vs Frequency

Figure 7, 8, 9 shows the radiation pattern of the designed antenna models at centre resonant frequency. A pencil beam like radiation pattern is obtained from these leaky-wave antennas which are more suitable for applications such as local multipoint distribution service (LMDS), WI-MAX and satellite communications. Such a beam cannot be produced efficiently with dynamic scanning capability in the 2D structure of the conventional antennas.

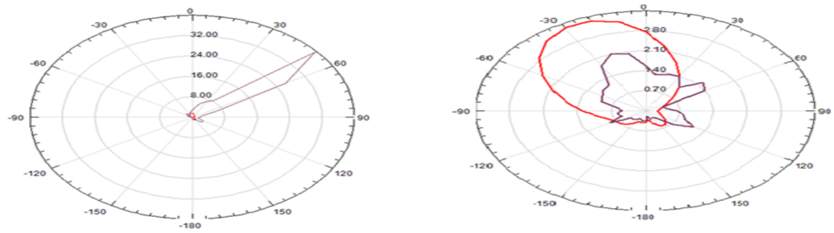


Figure 7. Radiation Pattern of Antenna Model 1

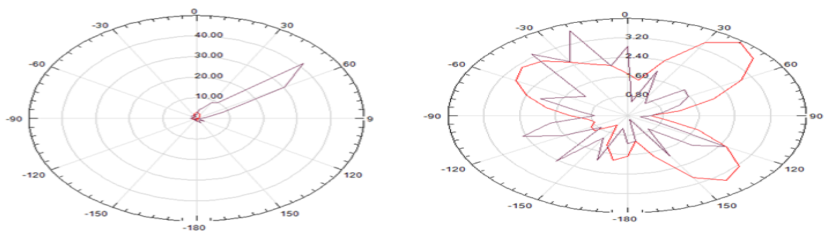


Figure 8. Radiation Pattern of Antenna Model 2

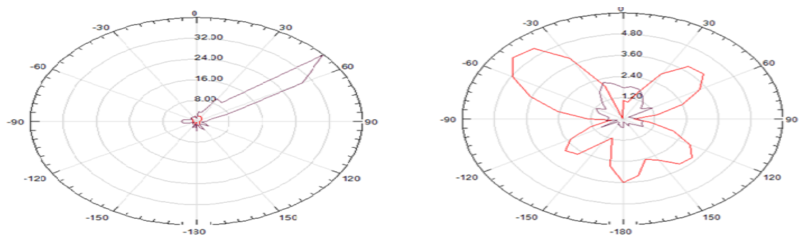


Figure 9. Radiation Pattern of Antenna Model 3

Figure 10 shows the 3 dimensional radiation pattern of the designed antenna models at centre resonant frequency. The proposed antenna model 3 is showing a maximum directivity of 4.14 in the desired direction.

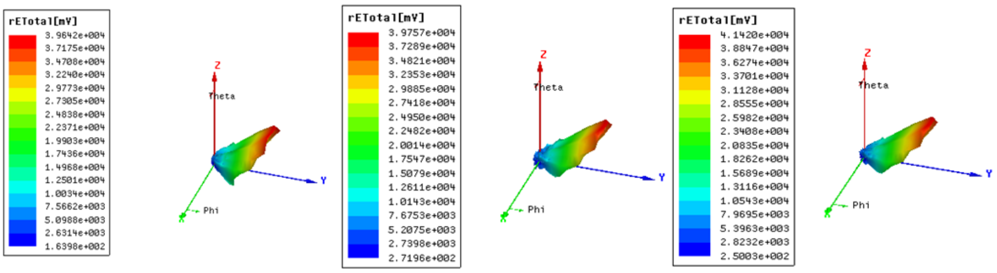


Figure 10. Radiation Pattern of Antenna Models in three dimensional view

The surface current distribution of antenna models at 7.5 GHz is presented in Figure 11, 12, 13. Model 1 is showing current distribution at the edges of feed line and more nearer to the port1 side conducting line. Model 2 is showing maximum intensity around the boundaries of the radiating structure. Model 3 is showing better current distribution characteristics over the surface in uni-direction towards the ports which contributes the additional resonant mode in the operating band.

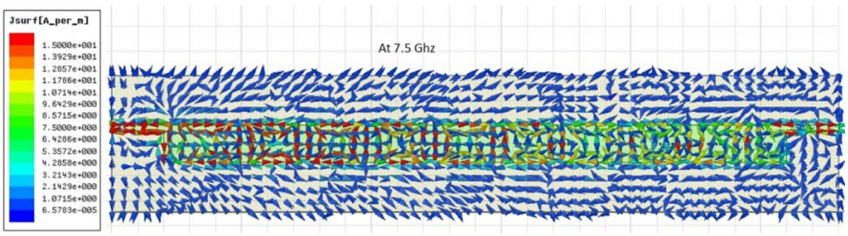


Figure 11. Current distribution of model 1 at 7.5 GHz

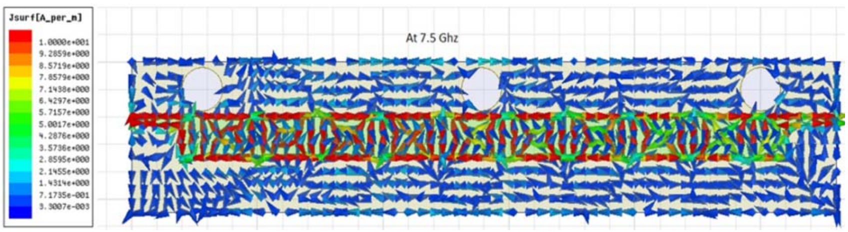


Figure 12. Current distribution of model 2 at 7.5 GHz

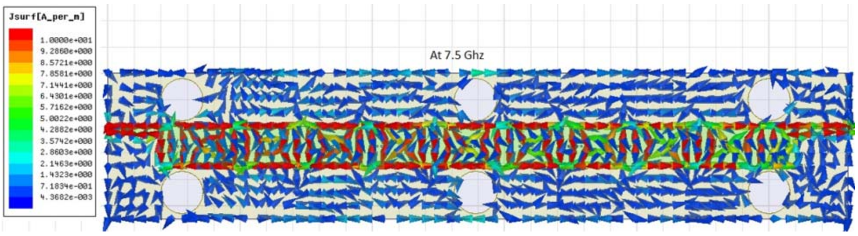


Figure 13. Current distribution of model 3 at 7.5 GHz

Figure 14 shows the gain characteristics of the designed antenna models with respect to operating band. A maximum peak realised gain of 15db is attained for the proposed DGS model where as 13db is attained for basic model.

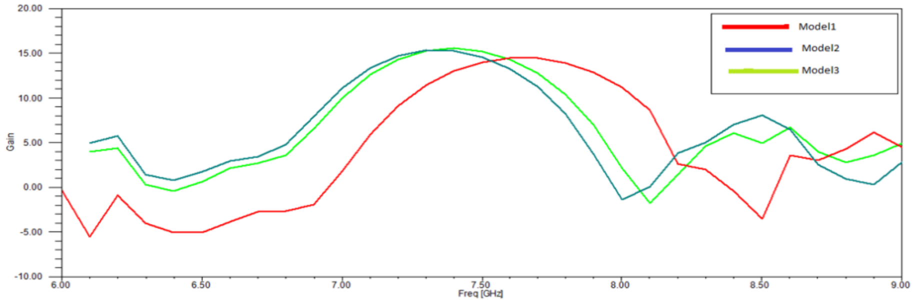


Figure 14. Gain Vs Frequency

4. CONCLUSION

Design and analysis of microstrip line fed, periodic shorting vias structure with DGS model is presented in this work. The fundamental resonant mode is suppressed in the proposed leaky-wave antenna with more number of shorting vias at the centre of the microstrip radiating element. Larger bandwidth with efficient reflection coefficient makes this antenna suitable for wide band applications. The additional advantages like high gain, low side and back lobes with low cross polarization will pull up this antenna model for desired satellite communication applications.

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REFERENCES

[1] B. T. P. Madhav, *et al.*, "Trident Shaped Ultra Wideband Antenna Analysis based on Substrate Permittivity," *International Journal of Applied Engineering Research*, ISSN 0973-4562, vol. 8, pp. 1355-1361, 2013.
[2] B. T. P. Madhav, *et al.*, "Tapered Step CPW-Fed Antenna for Wideband Applications," *ARPN Journal of Engineering and Applied Sciences*, vol. 9, pp. 1967-1973, 2014.
[3] B. T. P. Madhav, *et al.*, "Circularly Polarized Slotted Aperture Antenna with Coplanar Waveguide Fed for Broadband Applications," *Journal of Engineering Science and Technology*, vol. 11, pp. 267–277, 2016.
[4] B. T. P. Madhav, *et al.*, "Rectangular Microstrip Patch Antenna on Liquid Crystal Polymer Substrate," *Journal of Theoretical and Applied Information Technology*, vol. 18, pp. 62–66, 2010.
[5] M. V. Reddiah Babu, *et al.*, "Compact Serrated Notch Band MIMO Antenna for UWB Applications," *ARPN Journal of Engineering and Applied Sciences*, vol. 11, pp. 4358-4369, 2016.
[6] B. T. P. Madhav, *et al.*, "Tapered Step CPW-Fed Antenna for Wideband Applications," *ARPN Journal of Engineering and Applied Sciences*, vol. 9, pp. 1967-1973, 2014.
[7] P. Lotfi, *et al.*, "Rotatable dual band-notched UWB/triple-band WLAN reconfigurable antenna," *IEEE Antennas Wireless Propag. Lett*, vol. 12, pp. 104-107, 2003.

[8] B. T. P. Madhav, *et al.*, "Liquid crystal polymer substrate based wideband tapered step antenna," *Leonardo Electronic Journal of Practices and Technologies*, vol. 26, pp. 103-114, 2015.
[9] R. F. Hyneman, "Closely-spaced transverse slots in rectangular waveguide", *IRE Trans. Antennas Propag*., vol. AP-7, pp. 335–342, 1959.
[10] V. H. Rumsey, "Traveling wave slot antennas," *J. Appl. Phys*, vol. 24, pp. 1358–1365, 1953.
[11] J. Liu, *et al.*, "Modal analysis of dielectric-filled rectangular waveguide with transverse slots," *IEEE Trans. Antennas Propag*, vol. 59, pp. 3194–3203, 2011.
[12] B. T. P. Madhav, *et al.*, "CPW Fed Antenna for Wideband Applications based on Tapered Step Ground and EBG Structure," *Indian Journal of Science and Technology*, vol. 8, pp. 119-127, 2015.
[13] S. S. M. Reddy, *et al.*, "Asymmetric Defected Ground Structured Monopole Antenna for Wideband Communication Systems," *International Journal of Communications Antenna and Propagation*, vol. 5, pp. 256-262, 2015.
[14] T. V. Ramakrishna, *et al.*, "Triple Band linearly polarized Square Slotted Micro strip Antenna for X – Band Applications," *Far East Journal of Electronics and Communications*, vol. 15, pp. 99-110, 2015.