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Original Article

Slot Loading Effects on 5G mm-wave Rectangular Patch Antenna

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Abstract: *In the proposed article the slot loading effects has been analysed by loading the slot on the different position of rectangular patch and the performance parameter has been shown for the proposed structure. Loading the slots on the rectangular patch improving the Antenna Gain, RL and the Bandwidth parameters. The antenna has been designed on the HFSS software.*

Keywords: *mm-wave, 5G, Slot, Dual-Band, Defected Ground Structure (DGS), Array.*

I. INTRODUCTION

Performance parameter enhancement for an antenna is a necessity to contribute a good structure in modern technology. Enhancement in the antenna output characterstics can be attained by various methods Slot loading is one of them .5G antennas can be used for various applications. Also antenna design at mm-wave is a good area of interest as 5G covers this frequency band and provides high speed but because of some disadvantageous features the enhanced antenna characterstics should be achieved. In this article the slot loading method has been used to improve the antenna performance parameter as it is easy to implement and provides various beneficial output parameters.

II. LITERATURE REVIEW

Slot loading is to patch out slot from the patch. Various kind of slots can be eathed out in [1] U-shaped slot has been design on the patch and antenna is useful for S, C and X band applications. In [2] L slots has been used and the multiband characterstics has been achieved. In [3] a circular slot microstrip patch antenna has been proposed with the CP ploarisation characterstics. In [4] Patch antenna for 5G applications has been proposed with the slot loaded method and the triple band has been achieved. In [5] star shape slot along with six circular slots are eatched and the wideband characterstics has been attained. In[6] H shape slot has been loaded and the triple resonating bands has been achieved. In [7] the MPA with H shape slot is designed to enhance the antenna characterstics for 5G WLAN applications. In [8] the H shape slot has been design for mm-wave frequency range and the dual band frequencies has been achieved. A cslot of diamond shape has been implemented on circular patch of the antenna in [9] and the broadband characterstics has been achieved. In [10] L, T, U and F shape slots are used on patch antenna and also the performance paramters are compared by choosing different substrate material. The parameters of the designed antenna are stated in Table 1.

III. ANTENNA DESIGN

The rectangular patch antenna has been designed on the $5.764 \times 6.635 mm^2$ ground plane. The substrate is choosen as Rogers RT-duroide 5880 of relative permittivity 2.2 and realative permeability1. A slot has been loaded on the different position of the rectangular patch and the performance characterstics has been analysed.Also the parameters are given in the Table 1.

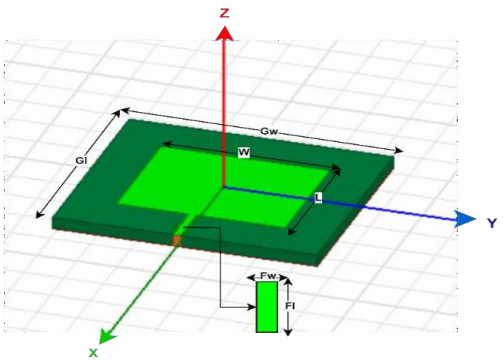

Figure 1: Designed Rectangle Patch Antenna Isometric View

Table 1: Designed Antenna Parameters

Parameter	Size(mm)	Parameter	Size(mm)
W	4.235	LS3	2.7
L	3.364	WS3	0.2
Gw	6.635	LS4	0.25
Gl	5.764	WS4	2.12
LS1	2.12	Fw	0.2
WS1	0.8	Fl	1.202
LS2	1	WS2	1

IV. RESULTS

A. Slots

Slot cutting on the patch of the antenna is the technique to improve antenna performance characteristics various literatures [1-10] have been done on it. Slots on the patch can improve the antenna gain,bandwidth and return loss parameter. In Figure the slots have been represented for different performance enhancement .Slots on the patch improve the Antenna performance characteristics by changing the current distribution plot. Slots can be any shape or size. In the Figure 2 (a),(b),(c),(d) .The Four slots have been etched out at the different position of the patch and the antenna performance parameter has been represented. In the Figure 4 due to slot SL1 the antenna is resonating on two resonating frequencies with the slight shifting in the fundamental frequency the two frequencies are 27.3103GHz (26.916-27.832) GHz and 52.6897 GHz (52.235-53.109) GHz. and the RL values are - 24.896GHz and -10.479GHz and in the gain plot for SL1 the maximum gain attained is 7.931dB at 28.2759 GHz. In Figure 5 SL2 due to slot 2 also the two resonating bands are achieved at the two bands 27.3103GHz (26.864-27.803GHz) and 52.275GHz (51.708-53.0101) GHz with the good RL value -33.7446dB and -12.5343dB respectively with the maximum gain of 7.969dBi at 28.275GHz. In the SL3 also two resonating frequencies 28.137GHz(27.6126- 28.548)GHz,51.724GHz(50.4-62-53.130)GHz and the RL value -18.964GHz,-14.727GHz respectively and the maximum gain is 7.994dBi at the 28.827GHz is shown in Figure 6 .While the slot SL4 open ended slot providing the single band 55.586(51.986-57.397)GHz with the RL value - 19.6267dB and maximum gain 7.4415dBi.wide band frequency range is given in Figure 7 So, the different positing of the slot on the patch of the antenna is improving the antenna characteristic

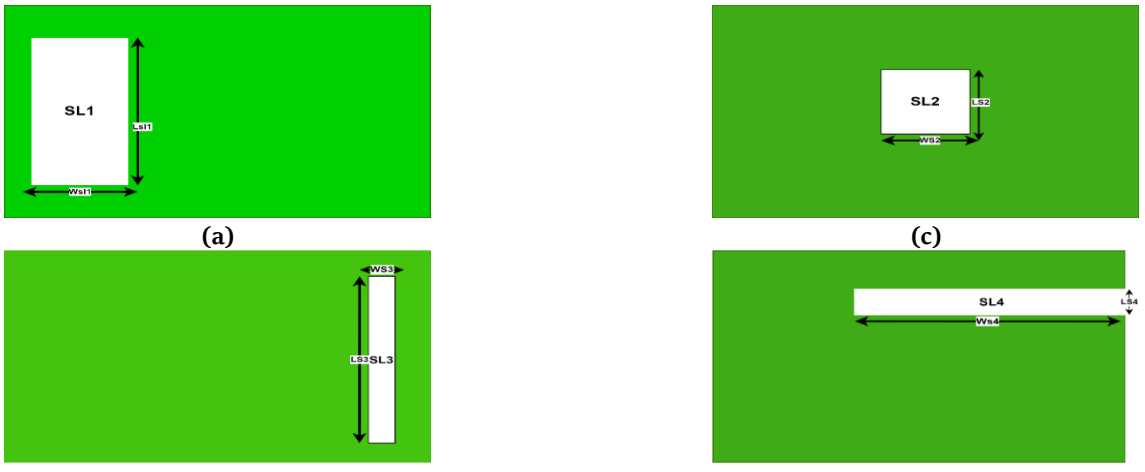

Figure 2: Rectangle Patch (a) with slot SL1 (b) with slot Sl2 (c) with slot SL3 (d) with slot SL4

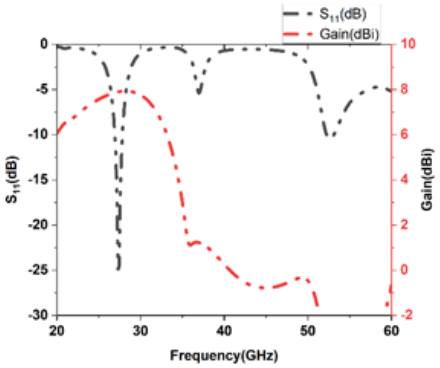

Figure 3: Return Loss and Gain V/s Frequency plot of Rectangular Patch antenna

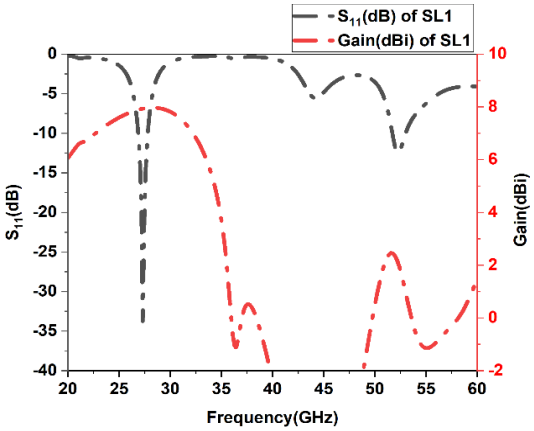

Figure 4: Return Loss and Gain V/s Frequency plot of Rectangular Patch with slot SL1

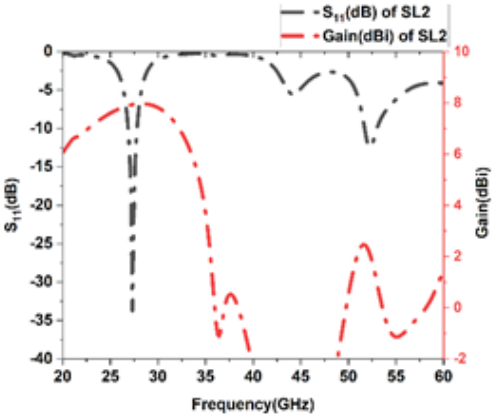

Figure 5: Return Loss and Gain V/s Frequency plot of Rectangular Patch with with slot SL2

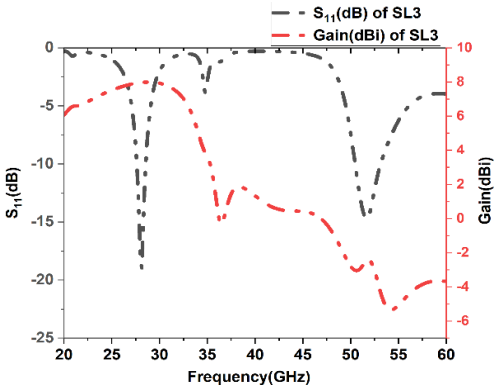

Figure 6: Return Loss and Gain V/s Frequency plot of Rectangular Patch with with slot SL3

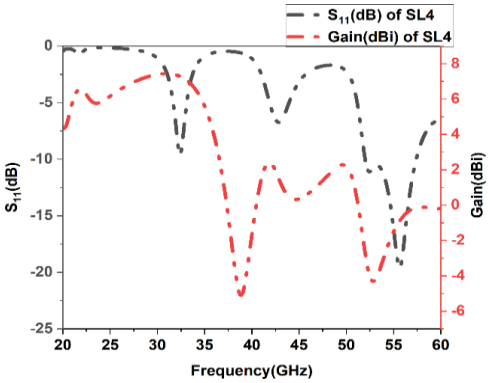

Figure 7: The Different Positing of the Slot on the Patch of the Antenna

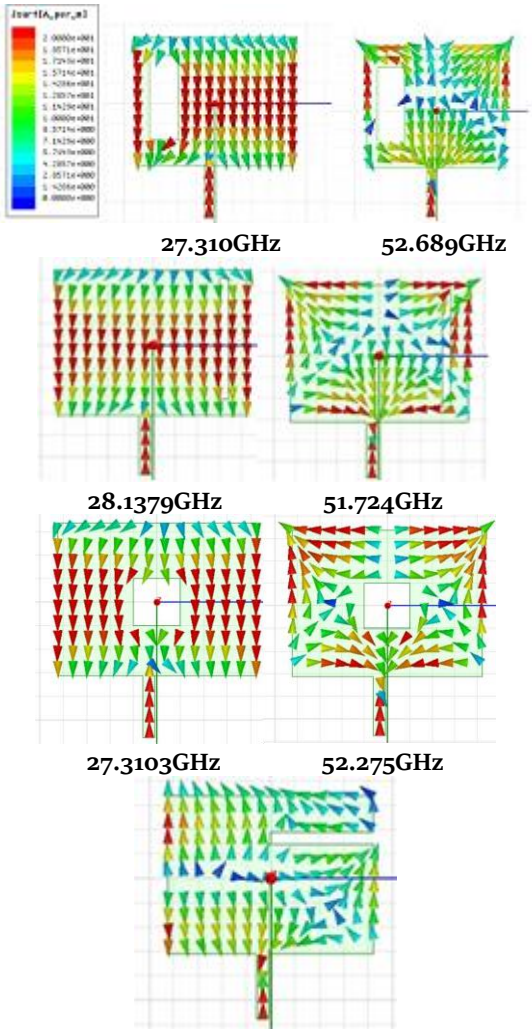

Figure 8: Current Distribution plot at (a) 27.310GHz (b) 52.689GHz (c) 28.137GHz (d) 51.724GHz (e) 27.310GHz (f) 52.275GHz (g) 55.586 GHz

The Current distribution plot at resonating frequencies for different slots are given in Figure 8 and the RL, Bandwidth, Gain characterstics of the proposed antenna with slot structures is given in Table II.

Table 2: Characterstics of the Proposed Antenna with Slot Structures

Slots	RL	Gain	Bandwidth
SL1	-24.896 GHz and -10.479 GHz	7.931d B	27.3103GHz(26.916 - 27.832)GHz and 52.6897 GHz(52.235 - 53.109)GHz
SL2	-33.7446 dB and -12.5343 dB	7.969 d Bi	27.3103GHz(26.864 - 27.803GHz) and 52.275GHz(51.708-53.0101)GHz
SL3	- 18.964 GHz,- 14.727 GHz	7.994d Bi	28.137GHz(27.6126 - 28.548)GHz,51.724G Hz(50.462- 53.130)GH
SL4	- 19.6267 dB	7.4415 dBi	55.586(51.986 - 57.397)GHz

V. CONCLUSION

In the designed structure a rectangular patch slot antenna has been designed for 5G applications the slot loading effects on the different position of rectangular patch has been analysed .the four slots S1, S2, S3, S4 are loaded on the rectangular patch and the effects on the different characterstics like gain, Bandwidth and Return loss has been analysed. The proposed antenna structure is a good design and resonating on the 5G mm-wave bands.

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