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Surface Wave Minimizing in 2x2 Microstrip Antenna Array

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Abstract
Key research area is improving band width and gain in design of microstrip patch antennas. reducing surface waves, which can be excitation in patch antennas, by using Electromagnetic Band Gap (EBG) structures ,which increasing the band width and gain . The surface of EBG are selective in supporting surface waves. The paper analyses the performance of 2x2 microstrip antenna array with and without EBG cells . It is observed the performance of the 2x2 antenna array with EBG is found to be better as compared to microstrip antenna array without EBG . Simulation results show improvements in the band width and gain, redusing surface wave means reduction in mutual coupling between elements in antenna array. in this work using HFSS software to simulated the antennas array .
Keywords: (EBG), Microstrip antenna array ,Mutual coupling , Surface waves, HFSS .

1. Introduction:-

The simplicity of Microstrip antennas and compatibility with printed circuit technology led to great interest in them Recently and its use on a widely in the microwave frequency spectrum . It is consists of a conducting patch printed on a dielectric substrate in one side and in the other side printed a conducting ground plane **[1].**

The antenna enters into many important applications in the medical field , the satellites application and in the system of military, aircrafts missiles. Antenna applications are widespread in all areas and regions, and currently thriving in commercial aspects because its low cost and easy manufacturing, this makes them overcome the use of traditional antennas for many applications [2].

Microstrip antenna arrays are well known for being low cost, low profile, easy to design and fabricate. Their easy integration with RF circuit has made them as a good candidate for wireless communication. Thus, in the recent years a lot of research have been done to reach a compact and miniaturized microstrip antenna .The microstrip patch antenna just can provide a medium range for the radiation gain, so they are used in antenna array to achieve a high gain antenna [3].

the Surface waves can be lead to mutual coupling between antennas in array . the mutual coupling is strong in situations where the antennas are placed on dielectric substrates with low permittivity [4]. Mutual coupling caused degradation to the antenna's radiation characteristics .The surface waves are weakly excited in very thin grounded dielectric substrates, space waves dominate as well as produces strong coupling when antennas are close to each other's [5]. By reducing the mutual coupling in antenna array, the parameters of antenna radiation is improving [6].

To reduction of mutual coupling some of methods were used, one of these methode using some structures like Electromagnetic Band Gap (EBG) structure, which can be used to bloke the surface wave [7].

In this work, rectangular microstrip patch antenna, have been design, with 2- shaped slot [8], planar array of four antennas have been used and Electromagnetic Band Gap (EBG) are placed between four elements of array to reducing the mutual coupling.

2. Design of 2x2 microstrip antenna array

The antenna array of (2x2) is simulated by arranging these four microstrip patch antennas in planar configuration . Each patch element is excited individually using separate port and the responses integrated. The dimension of 2x2 array shown as figure (1) .The length of substrate is 120 mm , the width of substrate is 128.7 mm. Here four elements are used. The separation between elements (edge to edge) is d .

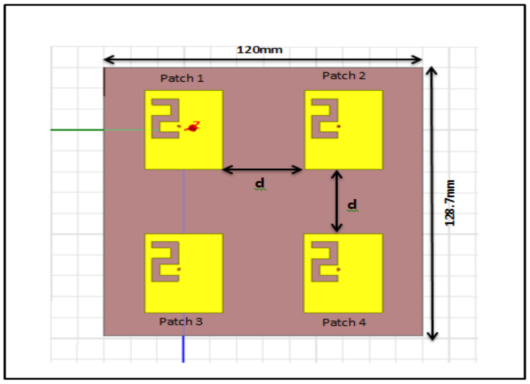


Figure (1): 2x2 Array dimensions of proposed antenna .

3. Design of EBG STRUCTURE

The simplest form of EBG patterns represented generically by the schematic shown in figure (2). These structures are characterized by periodic metallic patches connected to a common ground (or reference) plane by via. In this work we consider rectangular EBG patches with parameters as shown in previous figure, where the length and the width is L_E , W_E respectively. T- and L with opposite L – shaped slots was make on the EBG cells , the optimum dimension of T and L slots shown in figures (2) and (3).

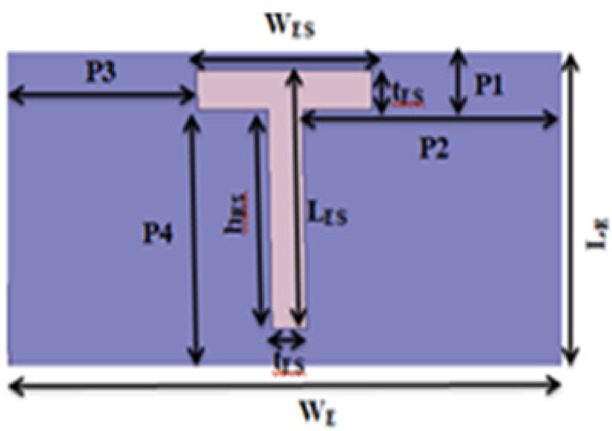


Figure (2): Dimension of EBG with T-slot.

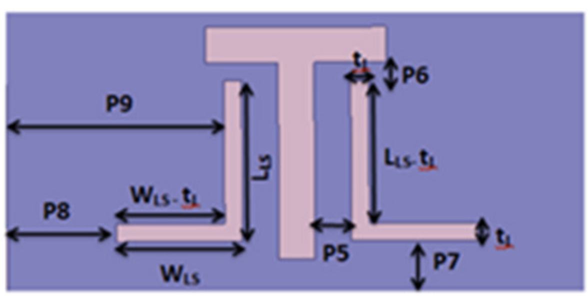


Figure (3): Dimension of EBG with T and L slots

The EBG cells are placed within the distance between adjacent elements of the 2x2 antenna array, as shown in the figure (4) , the optimum dimension for EBG in 2x2 antenna array are listed in table (1) .

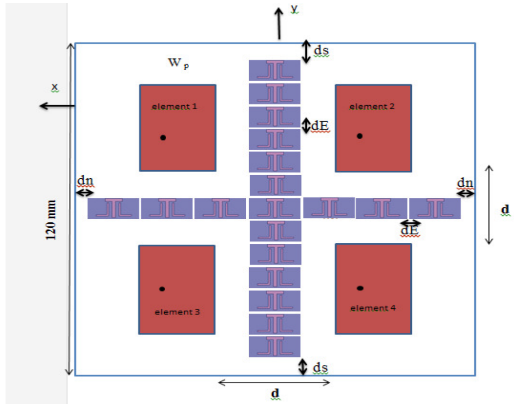


Figure (4): 2x2 antenna array with proposed EBG

Table (1): Optimum dimension for EBG in 2x2 antenna array

Parameter	Value (mm)
L_E	8.0
W_E	16.0
d	31.7
L_{ES}	6.5
W_{ES}	5.0
t_{ES}	1.0
h_{ES}	5.5
d_E	1.0
ds	6.0
dn	1.5
t_L	0.5
L_{LS}	4.5
W_{LS}	3.0
P1	1.5
P2	7.5
P3	5.5
P4	6.5
P5	1.0
P6	0.5
P7	1.5
P8	3.0
P9	6.0

4. Simulation of 2x2 antenna array with and without EBG

When we used the EBG cells with opposite L-shaped slot loading T- shaped slot in the distance between adjacent elements in the 2×2 antenna array, as in figure (5) the dimension of EBG and slots in table (3.27) with ds = 6mm and dn=1.5mm .

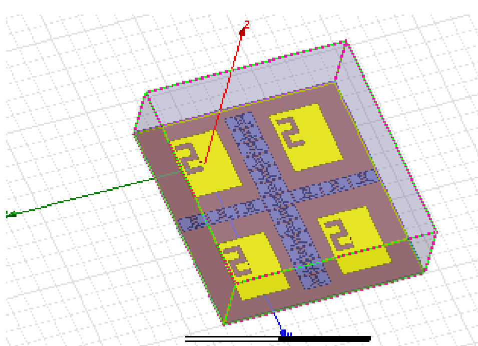


Figure (5) : 2x2 antenna array with EBG cells

The parameters of 2×2 microstrip antenna array such as the return loss, mutual coupling, VSWR, radiation pattern and gain, with EBG and compared with results of 2×2 antenna array without EBG ,were shown in figures (6) to (8) .

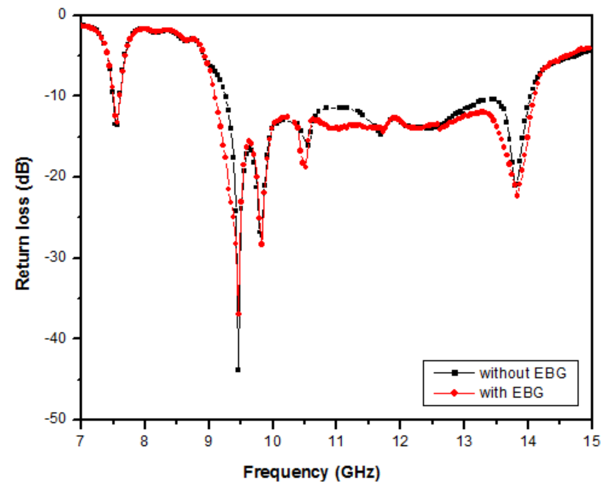
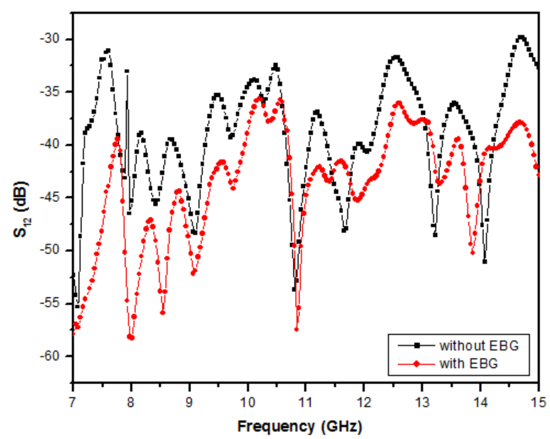
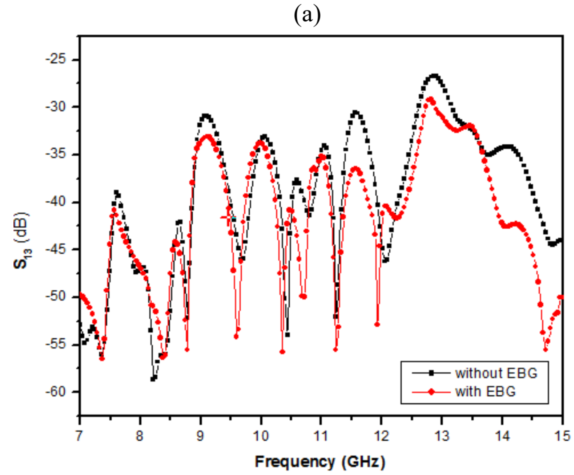


Figure (6): Return loss of 2x2 antenna array with and without EBG

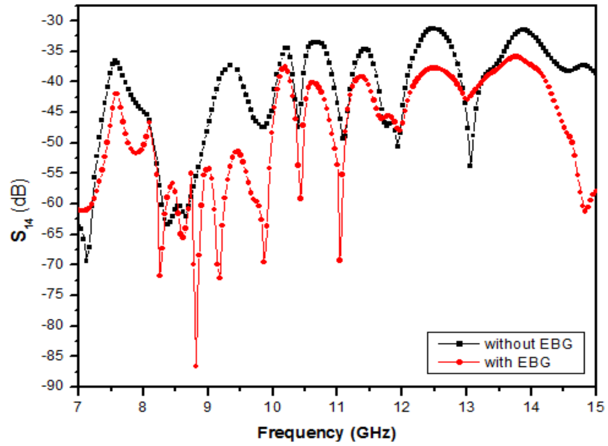
The simulation mutual coupling between four antenna in planar array with spacing d is shown in figure (7) . the figure show the isolation coefficients of scattering matrix related to mutual coupling for the 2×2 array antenna (S_{12} , S_{13} , S_{14} , S_{23} , S_{24} and S_{34}) respectively, the value of these coefficients at resonance frequency ,were listed in table (2).



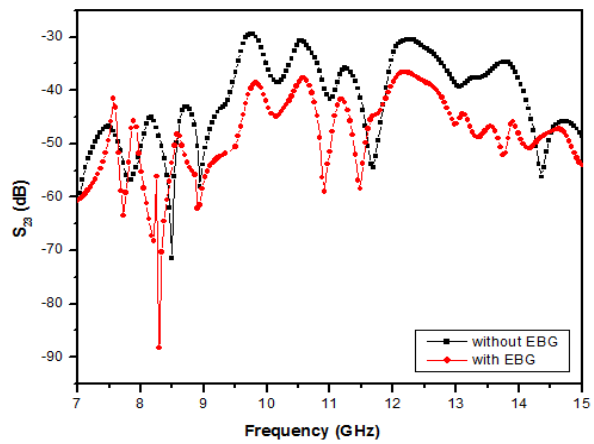
(a)



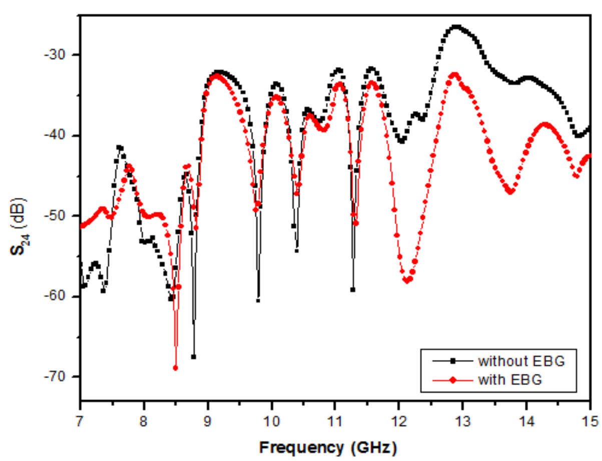
(b)


S14 (dB)
Frequency (GHz)
without EBG
with EBG

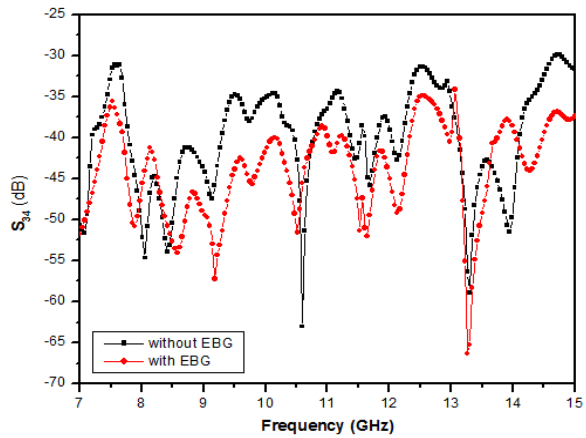
(c)


S23 (dB)
Frequency (GHz)
without EBG
with EBG

(d)


S24 (dB)
Frequency (GHz)
without EBG
with EBG

(e)



(f)

Figure (7): Isolation coefficient (a) S_{12} , (b) S_{13} , (c) S_{14} , (d) S_{23} , (e) S_{24} , (f) S_{34} of 2x2 array with and without EBG

The gain of 2×2 array of proposed antenna with and without EBG is shown in figure (8). The figure shows increasing in the gain when using EBG , it shows that the peak gain at 9.46 GHz is 13.55 dB. And the average gain is 11.76 dB, as shown in table (2).

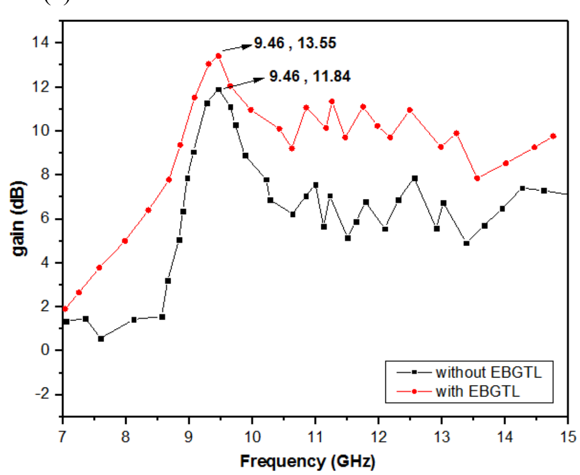


Figure (8): gain of 2×2 array with and without EBG

The performance of a 2×2 microstrip Antenna Array with and without EBG at dimension of table (1), are shown in table (2).

Table (2) parameters of 2x2 antenna array with and without EBG

parameters	Without EBG	With EBG
B.W	4.8 GHz	5.15 GHz
VSWR	1.0166	1.0289
Average gain	9.31 dB	11.76 dB
S11	-41.7 dB	-36.93 dB
S_{12}	-35.280 dB	-46.64 dB
S_{13}	-38.874 dB	-41.66 dB
S_{14}	-38.087 dB	-51.68 dB
S_{23}	-38.561 dB	-50.78 dB
S_{24}	-33.484 dB	-36.49 dB
S_{34}	-35.281 dB	-44.52 dB

5. Conclusion

A 2x2 microstrip patch antenna array was designed and try to reducing the mutual coupling between individual antenna elements . by using EBG structure, the mutual coupling between elements of array was reducing and the improvement in band width and gain was shown .

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