

Reconfigurable frequency using Electromagnetic Band Gap Structures for Single Band and Wideband

#Osman Ayop , Mohamad Kamal A. Rahim , Noor Asniza Murad

Department of Radio Communication Engineering
Faculty of Electrical Engineering,
Universiti Teknologi Malaysia
Johor Malaysia

osman@fke.utm.my mkamal@fke.utm.my asniza@fke.utm.my

1. Introduction

Electromagnetic bandgap (EBG) structures have become a favorable field of research within the microwaves, photonics, and antenna design. The unusual properties of this structure such as frequency bandgap [1], in phase reflector arrays [2] and high impedances surface [3] made this structure unique. Several reports have been published to show the ability of EBG structures to improve the performance of the conventional devices when they are integrated together [4]. Some of them are improving radiation pattern of antenna [5], suppressing surface waves for planar antenna design [6], reducing mutual coupling [7] and steering the beam of antenna's radiation pattern for array design [8]. The resonance frequency of EBG structures depend on the equivalent LC network of the structure. To obtain the specific resonance frequency, many researchers proposed different kind of structures which is normally obtained by modifying the shape of EBG patches itself [9]. The operating frequency is tuned by varying the value of total capacitance, C . Several researchers work on tuning the operating frequency of the EBG structures by introducing tuning element, which mean to vary the inductance value. But, that kind of design do not provide much degree of freedom on selecting which frequency band to operate and which types of bandwidth it prefer to be whether single narrowband frequency, multiband frequency or wideband frequency.

2. Proposed Design of Tunable EBG Structure

The tunable EBG structure based on inductive tuning is designed on 1.6 mm FR4 substrate which has relative permittivity of 4.6 and tangent loss of 0.019. The constructed structure which is shown in Figure 1 is simulated using CST Microwave Studio.

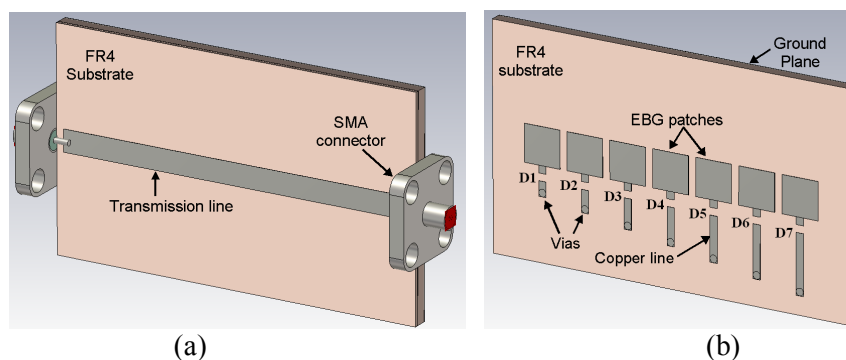


Figure 1: Tunable EBG Structure (a) Top Layer (b) Bottom Layer

From Figure 1 (a), the top layer of tunable EBG consists of 50 Ohm transmission line on 0.5 mm thick FR4 substrate connected to two 50 Ohm SMA connectors. At the bottom layer, seven square patches EBG which are connected to different length of copper lines each are etched on 1.6 mm FR4 board. All the copper lines are grounded using vias at the end of each line. Figure 1 (b) shows a small gap of 1mm by 1mm for switching purpose using PIN diodes. All the switches are labeled as D1-D7. Figure 2 shows the label of dimension for the proposed design. The dimension of the EBG structure are $W=50\text{mm}$, $L=30\text{mm}$, $a=b=5\text{mm}$, $s=1\text{mm}$, $g=1\text{mm}$, $l_1=4\text{mm}$, $l_2=5\text{mm}$, $l_3=6\text{mm}$, $l_4=7\text{mm}$, $l_5=8\text{mm}$, $l_6=9\text{mm}$, $l_7=10\text{mm}$

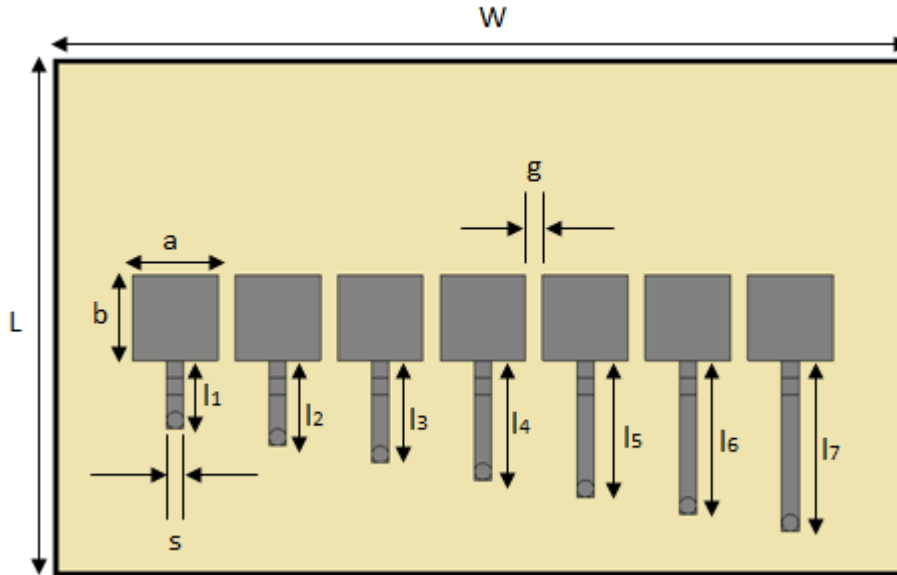


Figure 2: Dimension of the proposed design

3. Results and Discussion

The design of tunable EBG as shown in Figure 1 is simulated using CST software. The structure is simulated by using only one switch is “ON” state while others are “OFF” state. Seven different state can be obtained for this designed. The simulated S_{21} is shown in Figure 3 and the detail result is presented in Table 1.

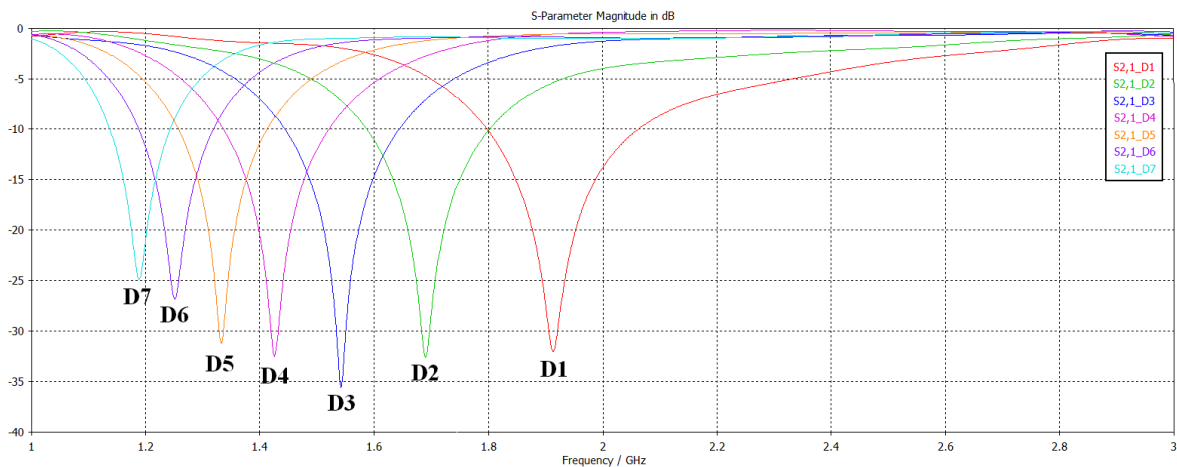


Figure 3: Simulated Transmission Coefficient for only one Diode Switch “ON”

From the result, it is clearly shown that when the switch is ON state, each EBG patch provides single narrowband stop band frequency. Since the size of the EBG patches is same, the different resonant frequencies are based on copper lines that are attached on each patch. The longer the copper line attached to the EBG patches, the lower the operating frequency. This is due to the increment of the inductance from the line.

Table 1: Operating Frequency for one Diode is ON state

Diode	Resonance Frequency (GHz)	Operating Frequency (GHz)	Bandwidth (%)
D1	1.91	1.8-2.06	13.5
D2	1.69	1.59-1.8	12.41
D3	1.54	1.44-1.65	13.62
D4	1.43	1.34-1.52	12.61
D5	1.33	1.26-1.41	11.25
D6	1.25	1.19-1.32	10.37
D7	1.19	1.14-1.24	8.41

The simulation is then conducted for a combination of three switches are ON state which are D1, D4 and D7. These combination are selected because the position of the structure are located at the first, middle and last part of the array configuration. From Figure 4, the stop band frequency becomes wideband with three depth at the frequencies as same as the three connected EBG patches. The -10 dB bandwidth for this states is fall between 1.15 GHz and 2.03 GHz (57.6 %).

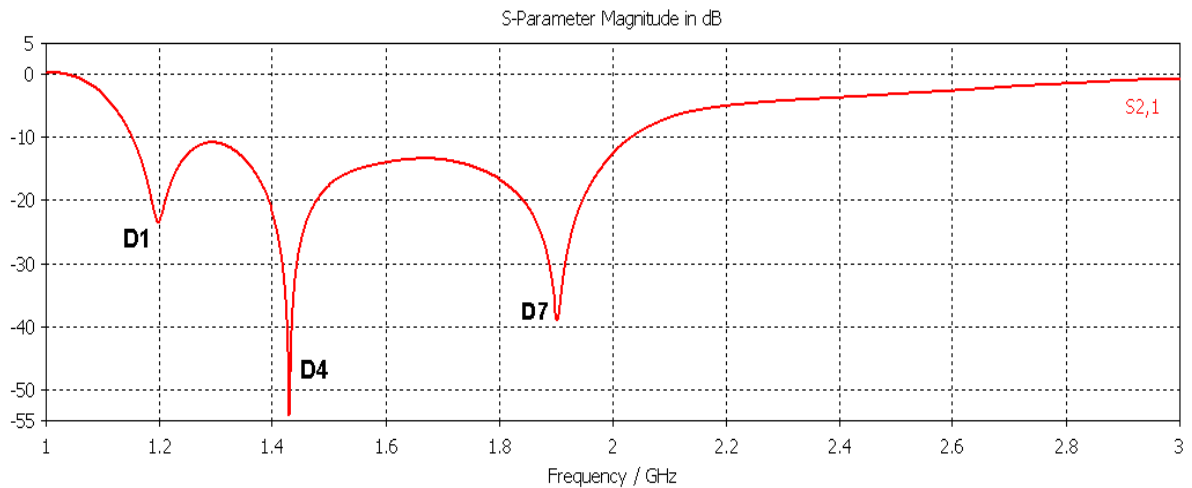


Figure 4: Transmission Coefficient when Diodes D1, D4 and D7 are ON state

The simulation is then conducted for the configuration where all the PIN diodes are switch ON. The result is shown in Figure 5. From Figure 5, the wideband stopband frequency is achieved with seven depths due to the seven different patches. The -10 dB bandwidth is noticed between 1.17 GHz and 2.33 GHz (70.26%). From this result, the wider stopband frequency is possible to be achieved if the number of EBG patches is increased.

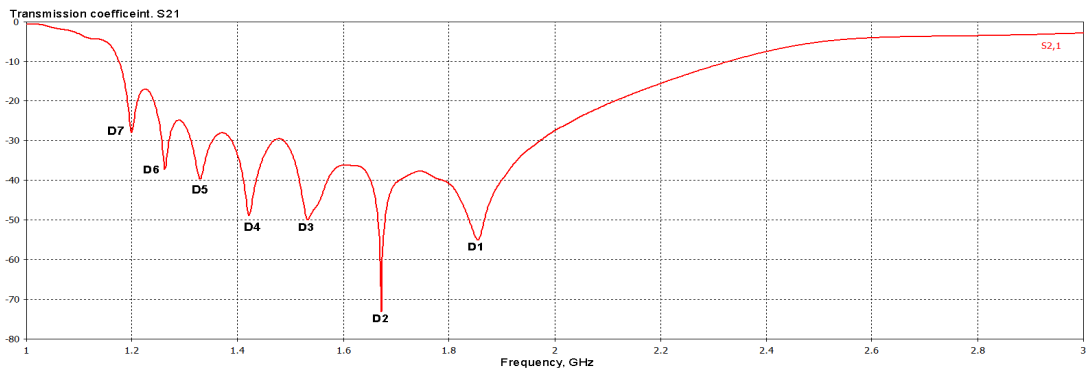


Figure 5: Transmission Coefficient for all Diodes “ON” State

4. Conclusion

The characteristic of transmission coefficient for Tunable Electromagnetic Bandgap Structure is presented in this paper. Using the inductive tuning, the size of the EBG patches can be maintained which means the capacitance value for all EBG patches are the same. This can provide more degree of freedom when designing EBG structures for operating at specific ranges of frequencies. This work shows some promising results to obtain single band, multiband or wideband operating frequency of EBG structure.

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