The 2018 International Conference on Radar, Antenna, Microwave, Electronics and Telecommunications (ICRAMET)
"Embracing Future Trends in Electronics & Telecommunications"
Serpong-Indonesia, November 1-2, 2018

Conference Tracks:
- Remote Sensing and Radar System
- Antenna Devices and Techniques
- RF and Microwave Theory and Devices
- Electronics Materials, Devices, Components, and Circuits
- Wireless and Wired Communications
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  UTM, Malaysia
- Dr. Purwoko Adhi Dipl.Ing., DEA
  Indonesian Institute of Sciences

Important dates:
- Call for paper: February 6, 2018
- Extended Final submission: August 31, 2018
- 1st Notification of accepted paper: September 3, 2018
- 2nd Notification of accepted paper: September 14, 2018
- Final registration: October 1, 2018
- Camera ready: October 5, 2018
- Conference event: November 1-2, 2018

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### Tentative Schedule of ICRAMET 2018
Meeting room GARUDA 15, ICE-BSD

**Thursday - November 1, 2018**

- 07.30 - 08.30  Registration
- 08.30 - 09.00  **Opening ceremony**
- 09.00 - 09.15  Photo session
- 09.15 - 10.00  **Leading talk 1**
- 10.00 - 10.15  Coffee break
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- 11.00 - 11.45  **Leading talk 2**
- 12.00 - 13.00  Lunch break
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- 07.30 - 08.30  Registration
- 08.30 - 09.15  **Leading talk 3**
- 09.15 - 10.00  **Leading talk 4**
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- 10.15 - 12.00  **Oral session III**
- 12.00 - 13.30  Lunch break
- 13.30 - 15.00  **Oral session IV**
- 15.00 - 15.15  Coffee break
- 15.15 - 17.15  **Oral session V**
- 17.15 - 17.30  **Closing ceremony**
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A Novel Structure of Electromagnetic MEMS Speaker for Hearing Aid Application
Design of Electromagnetic Band Gap to Improved Sidelobe Level for S-Band Antenna

Efri Sandi, Raka Kurnia and Wisnu Djamniko

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Jalan Rawamangun Muka Jakarta Timur, Indonesia 13220
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Abstract—The design of electromagnetic band gap (MEBG) to reduce the mutual coupling effect on array antenna is proposed in this paper. The proposed design model of EBG structure is mushroom like EBG (MEBG). The MEBG design is used for microstrip array antenna at frequency S-band radar antenna. Reducing the mutual coupling effect is expected to increase the sidelobe level (SLL) performance. The proposed MEBG structure is placed between the patch elements to reduce mutual coupling effect of each element at a distance of 0.13λ. The simulation results for the proposed design show slightly reduce the mutual coupling and an increase SLL performance compared to array antenna without MEBG.

Keywords—Mushroom Electromagnetic band gap (MEBG); Radar antenna; S-Band Radar; Mutual Coupling; Sidelobe Level (SLL).

I. INTRODUCTION

Electromagnetic band-gap (EBG) structure with various configurations has been widely applied for antenna development, especially in the array antenna to obtain smaller size and radiation efficiency [1]. In the array antenna to get high performance, a large number of elements are needed and will affect the size of the antenna to be large. Placing the antenna array elements close to each other is one way to reduce the size of the antenna, but this will have an impact on increasing mutual coupling which is highly correlated with the distance between the elements and the relative orientation of each element's radiation. Mutual coupling generated between array antenna elements will affect the characteristics and decrease in array antenna performance [2].

One solution to reduce the effect of mutual coupling is applying the EBG structure to the array antenna configuration [3]. Design techniques for using EBG structures to reduce mutual coupling effects and improve array antenna performance have been proposed in a number of literature [2]-[4]. The configuration of uniplanar compact electromagnetic band-gap (UC-EBG) provides characteristic to reduce in mutual coupling of 10dB and antenna size reduction 0.13λ compared to conventional array antenna structures [2]. Another solution is apply the combination method by using one-dimensional electromagnetic band-gap (1-D EBG) with the split ring resonator (SRR) structure placed between antenna monopole elements. The Combination of 1-D EBG and SRR were experimentally shown to very effective in suppressing mutual coupling in a wideband. The roles of the 1-D EBG and SRR structures design are identified to be a reflector and wave trap [3]. It is significantly can reduce the back lobes and be able to increase radiation efficiency [3]. Besides that the use of EBG structures is also applied to waveguide-slot antenna arrays. Using a Mushroom-like design EBG structure placed over the radiating face of a 2x4 waveguide-slot-array antenna can reduce significantly external mutual coupling compared without using EBG structures [4]. This method highly simplifies waveguide-slot-array antenna design and shown that EBG structure are a powerful tool in mutual coupling reduction [4].

The EBG structures are basically able to increase isolation between array antenna elements [5]. This structure is designed to produce high impedance from electromagnetic wave propagation along the surface of the microstrip antenna structure [6]. With high impedance generating capabilities, EBG structures are also applied in MIMO antenna applications [7]. Wearable wireless body area network [8] and antenna for wireless body sensor network in medical application [9].

In the MIMO for antenna application for handsets was designed using a 1-D EBG ground structure to achieved superior isolation and low correlation. The 1-D EBG structures and monopole antenna elements could be placed very close each other due to reflection characteristics [7]. It is occurs because 1-D EBG structure produces greater isolation and smaller correlation coefficients. The 1-D EBG structure reduced surface current on the common ground plane suppresses the coupling between antenna elements and improves isolation each other [7].

In the certain application such as wearable applications, EBG cell sizes can be made miniature so that they can achieve of wearable devices requirement [8]. The EBG structure is used to eliminate the mismatch and frequency shifting caused of human body [9]. The EBG structure can minimize the effects caused by bending loss and reduce unwanted radiation toward the human body [9].

In radar antenna applications, improving performance by minimizing antenna size is a challenge. One approach to minimize antenna size is to make the distance between elements more close, but it will impact to the degradation of antenna performance due to the mutual coupling effect.

In this paper, the MEBG structure design to reduce the mutual coupling effect was observed. The MEBG design is used for microstrip array antenna at frequency S-band radar antenna.
II. DESIGN OF ANTENNA AND EBG

A. Antenna Design

The proposed microstrip antenna is designed numerically by using CST microwave studio software to operate at 3 GHz S-band radar frequency. Design of microstrip antennas using FR4-Epoxy substrate with a thickness of 1.6 mm. The Overall microstrip antenna dimensions resulting from design optimization are 76 mm x 76 mm for substrate material and 23 mm x 14.5 mm for patch antennas as shown in Fig. 1.

![Fig. 1, Single Element Design Microstrip Antenna](image)

In the study to observe the effect of MEBG structure, the sample array antenna was designed with 3 elements as shown in Fig. 2. Microstrip array antennas are designed using a single feeding system for each element.

![Fig. 2, Microstrip Array 3 Elements: (a) Top View; (b) Back View](image)

B. MEBG Design

MEBG structure design was developed based on four parts, ground plane, dielectric substrate, metallic patches and connecting vias [10]. Working principle of EBG structure based on LC filter on array antenna structure. This LC value will affect surface wave propagation on the microstrip antenna structure [10]. L and C values that can be expressed based on the formula [11]:

\[ L = \mu_0 h \]  \hspace{1cm} (1)

\[ C = \frac{W \varepsilon_0 (1 + \varepsilon_0) \cos h}{\pi} \frac{(2W + g)}{g} \]  \hspace{1cm} (2)

\( \mu_0 \) is the permeability of free space, \( h \) is substrate thickness, \( W \) is EBG structure patch width, \( g \) is gap between two EBG cell and \( \varepsilon_0 \) is permittivity of free space. By following L and C, the frequency of the band-gap structure can be predicted.

Follow above formula (1) and (2), the proposed MEBG design for the 3 GHz microstrip antenna as shown in Fig. 3. The proposed design consists of the construction of the MEBG cell and the gap between the cells. The proposed patch width is \( W = 4.254 \, mm \) and the gap between cell is \( g = 3.746 \, mm \).

![Fig. 3, Proposed MEBG Design: (a) Design of MEBG Cell; (b) Schematic of Array Antenna and MEBG Cell.](image)

III. RESULT AND DISCUSSION

The proposed MEBG structure is placed between the patch elements to reduce the coupling effect of each element. The MEBG Cell structure is placed in the middle of two patch element arrays with a distance of \( \lambda/8 \) from the edge of the patch as shown in Fig. 4.

The simulation result of microstrip antenna S-band using MEBG cell between patch as shown in Table 1. The MEBG effect is obtained by comparing the mutual coupling and SLL parameter using MEBG structure and without MEBG structure.
The radiation pattern performances comparison is showed in Fig. 5. This result shows that the use of MEBG can slightly improve SLL performance compared to without using MEBG. Although these results have not shown a significant improvement in SLL performance, these results conclude that the addition of the MEBG structure can improve the SLL performance of the microstrip array antenna. The simulation results show that the addition of three cell line from the MEBG structure can improve SLL performance by -1 dB. Thus, it can be predicted that the addition of more lines of MEBG structure will significantly improve SLL performance.

### TABLE I. PERFORMANCE COMPARISON

<table>
<thead>
<tr>
<th>No.</th>
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<th>Without MEBG</th>
<th>Using MEBG</th>
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<tr>
<td>1</td>
<td>Return Loss (dB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S11</td>
<td>-17.86</td>
<td>-26.74</td>
</tr>
<tr>
<td></td>
<td>S22</td>
<td>-17.48</td>
<td>-27.78</td>
</tr>
<tr>
<td></td>
<td>S33</td>
<td>-17.37</td>
<td>-27.42</td>
</tr>
<tr>
<td>2</td>
<td>Mutual Coupling (dB)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>S12</td>
<td>-24.64</td>
<td>-25.02</td>
</tr>
<tr>
<td></td>
<td>S21</td>
<td>-24.64</td>
<td>-25.02</td>
</tr>
<tr>
<td></td>
<td>S13</td>
<td>-32.15</td>
<td>-32.36</td>
</tr>
<tr>
<td></td>
<td>S31</td>
<td>-32.76</td>
<td>-33.02</td>
</tr>
<tr>
<td></td>
<td>S23</td>
<td>-24.29</td>
<td>-24.61</td>
</tr>
<tr>
<td></td>
<td>S32</td>
<td>-24.29</td>
<td>-24.61</td>
</tr>
</tbody>
</table>

In the future research will be developed with more MEBG structures around the patch elements. Thus there will be an effect on increasing performance to be significant.

### IV. CONCLUSION

A design of MEBG structure to reduce the mutual coupling and improve SLL performance has been described. The MEBG design was developed on the S-Band frequency for radar applications. The simulation result of proposed design was shown the SLL performances better than array antenna without additional MEBG cell structure. Therefore in the future research will be developed more MEBG structures around the patch elements to improved SLL performance significantly.

### ACKNOWLEDGEMENT

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### REFERENCES


