CHAPTER 3

METHODOLOGY

3.1 Introduction

Proper design is indispensable in the goal to achieve appropriate results. Therefore, correct step is designed to obtain corresponding results. This chapter will describe the methods used in this project, including equipment, flowcharts, and equipment associated therewith.

3.2 Project Assessment

In this project rectagular microstrip patch antenna will be integrated with EBG structure to obtain the desired results. The desired result is to widen the bandwidth or the working frequency of the antenna mcrostrip. As is known microstrip antenna is the antenna that has a narrow operating frequency. Microstrip antenna on this project built on FR-4 substrate which was originally designed for the 2.4GHz frequency.

3.3 Project Design

In the process of project design, there are several steps that must be applied to the antenna and the EBG on purpose of obtaining the propher results. The process is shown in Figure 3.1. EBG and antenna will be integrated so that the desired results are achieved. In this study the main design consists of:

1) Rectangular Microstrip Antenna patch
2) The structure of Electromagnetic Band Gap (EBG)
3) Antenna rectangular microstrip patch antenna coupled electromagnetic band gap (EBG) structure.

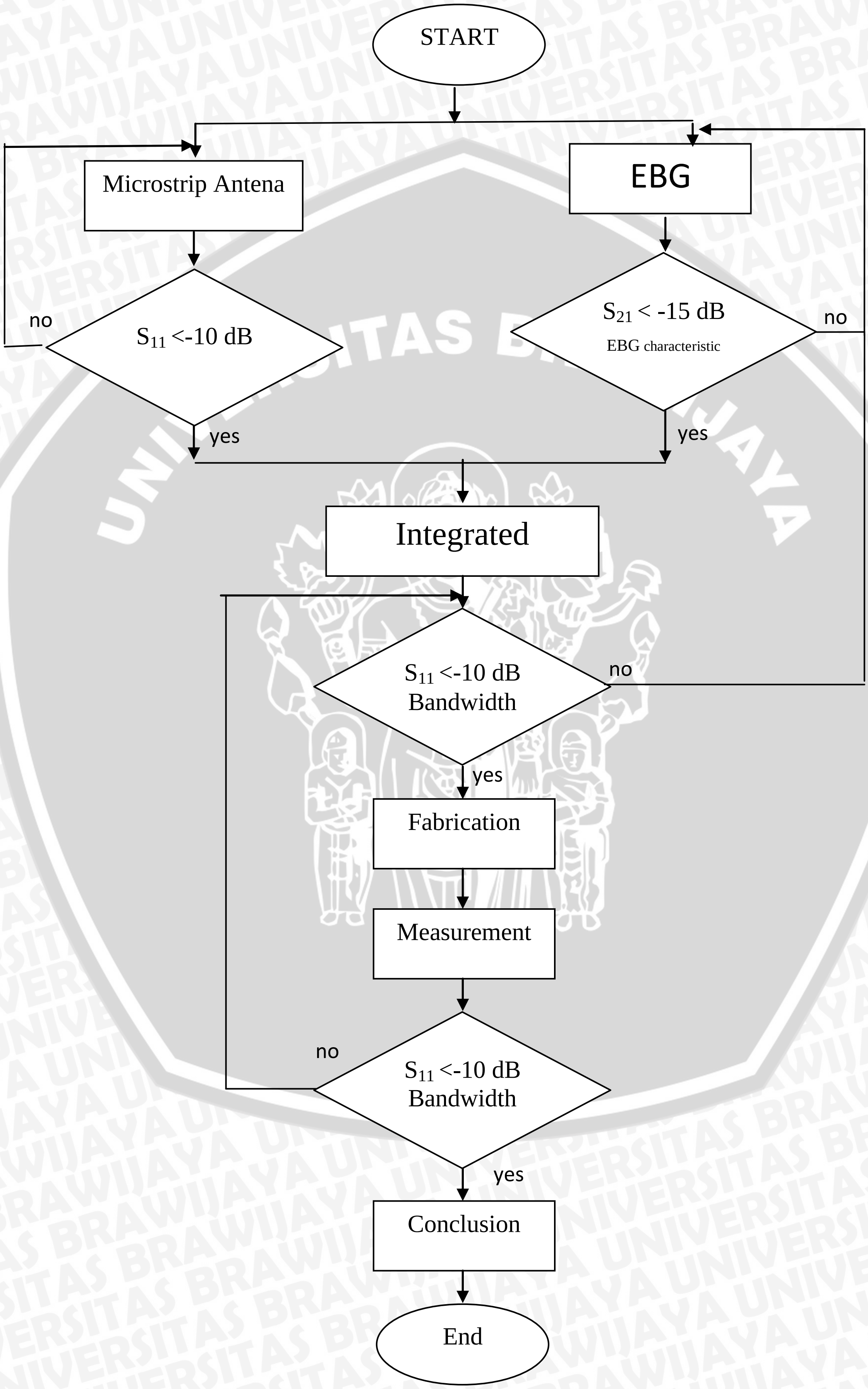

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Figure 3.1 Project's flow chart

3.3.1 Microstrip Antenna

The proposed microstrip antenna was design on FR-4 substrate with dielectric permitivty is 4.3 and 1.6 thickness. FR-4 is a low cost material, has good strength,and well known as material with high flexibility . FR-4 can operate in 10 MHz until 10 GHz frequency.

the design strategy is try to keep the return loss as minimum as possible. Design procedure is conventional based on existing literature. Here two important parameters in microstrip inset feed line is Inset gap width (notch width) and the Inset fed (notch length). Figure 3.2 shows the geometry of microstrip rectangular patch antenna.

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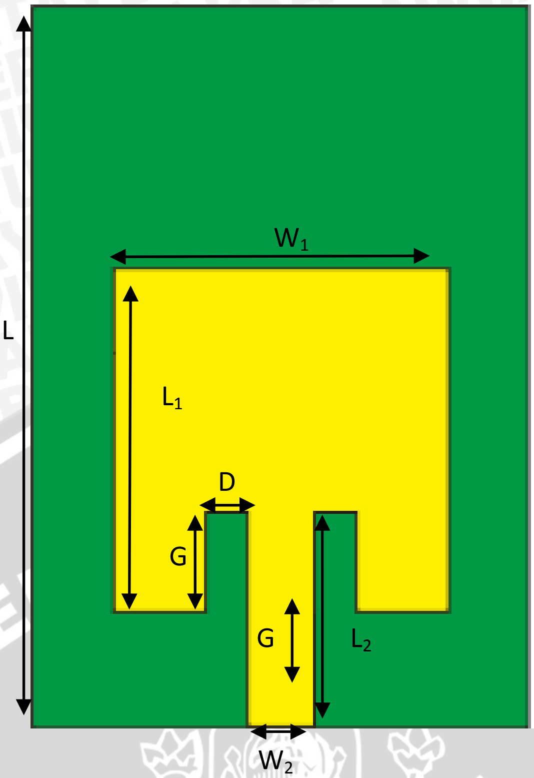

Figure 3.2 Geometry of microstrip antenna

Table 3.1 Microstrip antenna specification

Label	**Size (mm)**
L	60
L_1	31.1
L_2	14.4
W	40
W_1	28
W_2	3.1
G	9.5
D	5.5

Table 3.1 presents the size of antenna. As can be seen in Table 3.1 size of the antenna's substrate is 60x40 mm. This size is chosen with consideration to antenna compatibility. Equations (3.1) - (3.4) are the formulas that been used in order to design a rectangular microstrip patch with inset microstrip feed line:

i. Calculate width

(3.1)

$$w = \frac{c}{2f\sqrt{\frac{\varepsilon r + 1}{2}}}$$

ii. Calculate ε_{reff} based on equation 2.11

iii. Calculate ΔL i.e. normalized length based on equation 2.9

iv. Calculate L_P

$$Lp = \frac{c}{2fr\sqrt{\varepsilon reff}} \quad (3.2)$$

v. For calculating notch width we use equation [10]

$$fr = \frac{c}{\sqrt{2\ \varepsilon reff}} \frac{4.6\ x\ 10^{-14}}{g} + \frac{f}{1.01} \quad (3.3)$$

vi. Rearrange for value g

$$g = \frac{c}{\sqrt{2\ \varepsilon reff}} \frac{4.65\ x\ 10^{-12}}{f} \quad (3.4)$$

where ε_{reff} = Effective dielectric constant

εr = Dielectric constant of substrate

h = Height of dielectric substrate

W = Width of the patch

3.3.1 EBG (Electromagnetic Band Gap)

Surface wave are produced in many antenna design. Directing electromagnetic wave propagation along the ground plane instead of radiation into free space, the surface wave reduce antenna performance including bandwidth. Microstrip antena have a narrow bandwidth. EBG structures are very promising candidates to solve the

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problems created by surface waves while at the same time improving the performance.

The planar EBG is used in this research. Planar EBG is chosen due to easy to fabricate. Planar EBG when integrated with other microwave devices exhibits some interesting features such as distinctive passband and stopband, slow wave effects, low attenuation in the passband and suppression of surface waves.

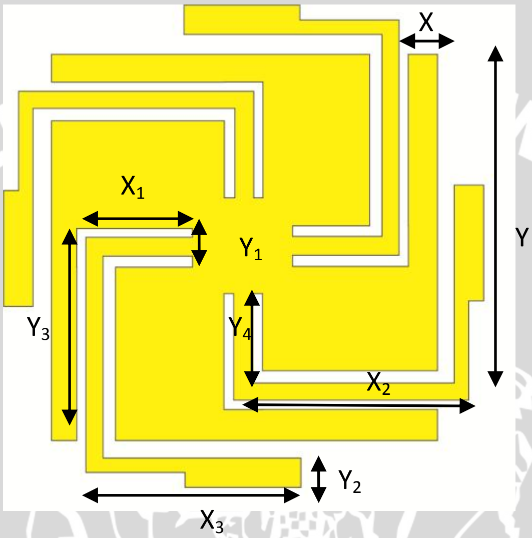

Figure 3.3 Geometry of Electromagnetic Band Gap (EBG) cell

Geometry of EBG is showed in Fig. 3.3. This figure shows the model of the unit cell of the EBG. The dimension of the EBG structure is given in Table 3.2.

Table 3.2 EBG specification

Label	Size (mm)
Y	11
Y_1	0.3
Y_2	0.4
Y_3	6.25
Y_4	2.5
X	0.75
X_1	2.5
X_2	6.3

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X_3	3.025

Equations (3.5) - (3.8) are formulas that used to determine size of EBG. Size of EBG obtains by define the value of resonant frequency. to obtain value of bandwidth, planar EBG can be calculated with LC element method.

$$fr = \frac{c}{\lambda 0\sqrt{\frac{\varepsilon r+1}{2}}} \quad (3.5)$$

$$\lambda ebg = \frac{\lambda_0}{2} \quad (3.6)$$

$$fr = \frac{c}{2\pi\sqrt{LC}} \quad (3.7)$$

$$Bandwidth = \frac{1}{\eta}\sqrt{\frac{L}{C}} \quad (3.8)$$

where :

C = Speed of light

εr = Dielectric permittivity

λebg = EBG wavelength

fr = Resonant frequency

L = Inductive value

C = Capacitance value

The periodic transmission line method is most popular technique to analyze EBG structure [18] . The advantages of microstrip have been well established, and it is a convenient form of transmission line structure for probe measurements of voltage, current and waves a microstrip transmission line is a "high grade" printed circuit construction, consisting of a track of copper or other conductor on an insulating substrate. There is a "backplane" on the other side of the insulating substrate, formed from a similar conductor. EBG is used as groundplane in this method. Tabel 3.3 presents suspended line specification.

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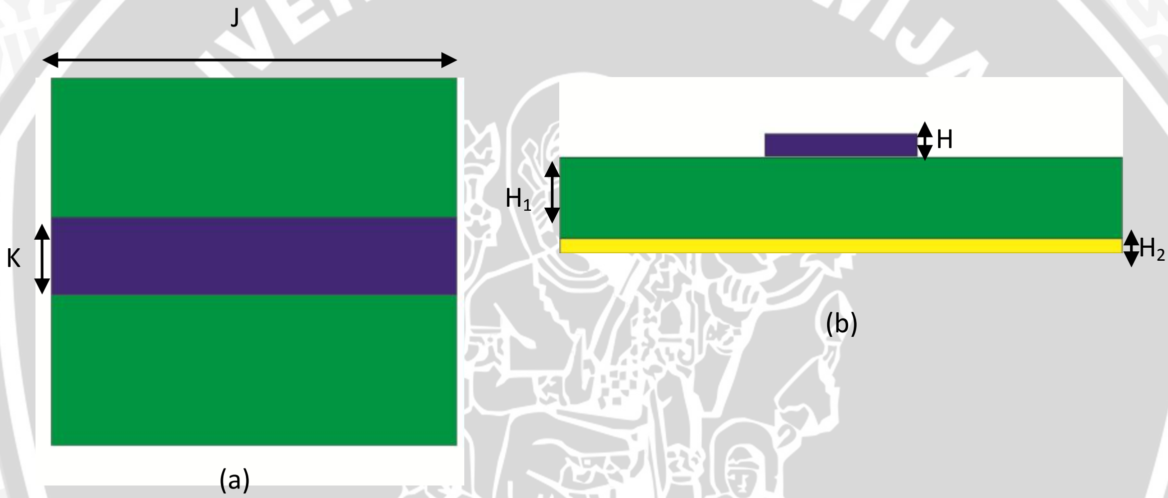
Table 3.3 Suspended microstrip line specification

Label	Size (mm)
J	37.2
K	3.1
H	0.1
H_1	1.6
H_2	0.1



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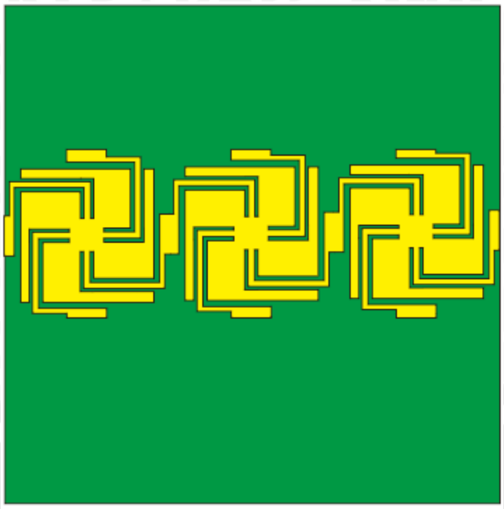

(c)

Figure 3.4 Geometry of suspended microstrip line (a) top view (b) side view (c) bottom view

Figure 3.4 shows geometry of suspended line method. In this method, EBG is applied as groundplane of 50 ohms transmission line with 2 ports.

3.3.3 Antenna with EBG Structures

To improve the performance of the antenna, arrangement 1 x 3 array of EBG strucures is employed with the antenna. EBG applies in same layer with antenna's patch. The optimum distance between the antenna's patch and the EBG is 1.5 mm (as shown as in Fig. 3.5). The EBG and antenna size are identical with that mentioned previously.

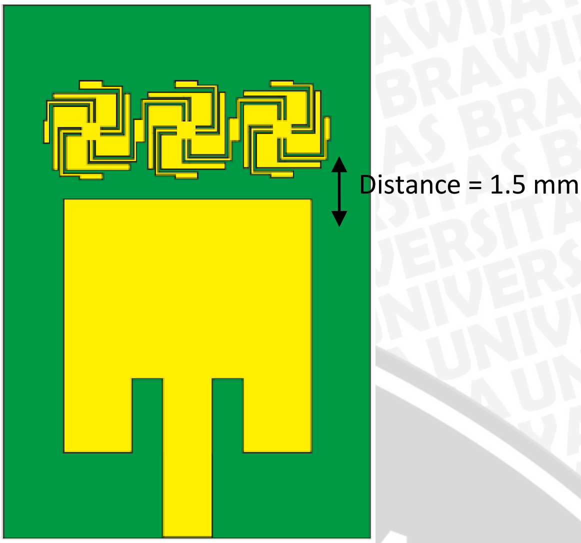

Figure 3.5 Geometry of antenna with EBG structure

3.4 Design Using CST Software

This software used to design and simulates antenna and EBG in computer device. CST can design in 3D model so model's approximation is displayed. After finished designing step then antenna is simulated. in CST there are many solver that can choose to simulate antenna. In simulation appeares antenna performance in 2 dimension graphic or in 3 dimension Graphic.

3.5 Antenna Fabrication

Fabrication process take place at communication project laboratory UTHM. Fabrication is done when appropriate result in simulation is reached. Fabricating process use milling machine tools that can fabricate antenna precisely.

3.6 Measurement

In order to get precise antenna measurement, use of correct tool is needed. Measurement result is important in order to know antenna performance when antenna connected or integrated with another microwave device. The measurement was carried out by using that Vector Network Analyzer (VNA) at RF and Microwave laboratory UTHM. Many antenna parameter can show in this tool like S-Parameter, VSWR.