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WEARABLE MICROSTRIP ANTENNA WITH DEFECTED GROUND STRUCTURE FOR BREAST CANCER DETECTION

Putri Angelia[1], Levy Olivia Nur[1], Bambang Setia Nugroho[1]

[1] School of Electrical Engineering, Telkom University, Bandung – INDONESIA

Corresponding author: levyolivia@telkomuniversity.ac.id,
bambangsetianugroho@telkomuniversity.ac.id

Abstract

A wearable antenna application has been spread in many fields including a solution in the medical application. One of their application in the medical field is the detection of breast cancer in the human body. This paper reports the microstrip antenna for breast cancer detection at a frequency of 2.46 GHz made from wearables material. The proximity coupled and the addition of a defected ground structure to the ground plane is used to get the wider bandwidth. Detection of breast cancer is performed by using breast modeling or breast phantom.

The dimensions of the designed antenna are 39 mm x 46.5 mm and realized using Rogers RT6006 material. Based on the results of simulations that have been done, the antenna has a return loss value ≤ -40.28 dB and a VSWR value ≤ 1.01. The antenna can detect cancer based on the different properties of materials in the breast phantom which affects changes in the value of S_{11} parameters.

Based on the simulation, if the size of the cancer is getting bigger, then the value of return loss obtained increases or headed to 0 dB. The value of return loss caused by the differences in electromagnetic absorption of different cancer material.

Keywords: microstrip antenna, wearable antenna, breast cancer, cancer detection, breast phantom.

1. Introduction

Cancer is a disease that is caused by cells in the body's tissues that change to become malignant and divide faster than normal cells in general until out of control. Cancer cells will grow continuously, and it will not die when they are old enough. As a result, it will urge or make normal cells die in the body [1]. Several cancers have big numbers that cause die including lung cancer, liver cancer, blood cancer (leukemia), cervical cancer, tongue cancer, and breast cancer. According to the World Health Organization (WHO), breast cancer is the most common cancer among women and causes large numbers of deaths. Female deaths due to the breast cancer in 2018 is about 15% [2].

In general, cancer can be caused by genetic or genetic hereditary and unhealthy lifestyles. However, even knowledge about breast cancer is still inadequate. Therefore, self-vigilance and care are needed to detect breast cancer early to prevent or take appropriate treatment before it is too late so that it has a chance to be cured. Although early detection can be done every day by Breast Self-Examination (BSE) which is to feel the presence or absence of a lump in the breast, but this method is certainly not accurate in detecting breast cancer. To be more accurate, several methods can be performed, such as ultrasound, magnetic resonance imaging (MRI), and mammography. However, these methods are generally only available in large hospitals and require quite expensive costs. The simple and cheap method to detect early breast cancer in the human body is urgently required so that the doctor can take appropriate treatment to the patients.

Previous research has been carried out in the design and fabrication of breast cancer detection devices in the form of rectangular microstrip antennas at a working frequency of 2.4 GHz with FR4 as an antenna substrate material [3]. Other studies have made microstrip antennas with rectangular patches made by Rogers Duroid RT5880 [4] and Rogers 3003 [5]. This research will continue and develop on breast cancer detection instrument using a microstrip antenna made from Rogers Duroid 6006 which has a thickness of 1.27 mm with a working frequency of 2.46 GHz. Rogers Duroid 6006 material is used because it has a fairly high permittivity. In this study observing changes in return loss has been performed to improve the sensitivity of the sensors.

2. Basic concepts

2.1 Microstrip Antenna

Microstrip antenna is a special type of printed antenna that consists of two parts. The upper part is commonly called the 'patch', and the lower part which is usually called the 'ground' [6]. The top or patch is made by a metal material that is printed on a dielectric medium or called a substrate that serves as a source of the transmitter. Moreover, the bottom or ground has a function as a reflection of electromagnetic energy into free air. Microstrip antenna is an antenna that is simple in shape and small in size or compact [7].

2.2 Proximity Coupled

This study uses antenna rationing with the proximity coupled method. This method was chosen because it requires a wide bandwidth and a greater gain value. Proximity coupled uses two layers of substrate where the feed is located between substrate 1 and substrate 2 as shown in Figure 2.1 [8].

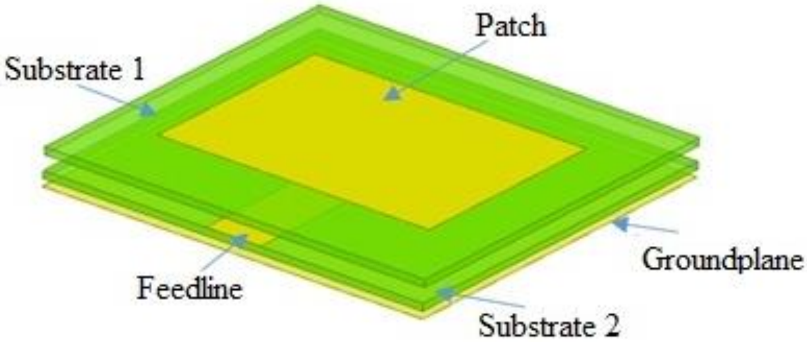

Fig. 2.1: Feedline scheme using proximity coupled.

2.3 Breast cancer

Breasts are organs that have tissue extending from the collarbone to the lower ribs, sternum, and armpits. Each woman's breasts have 15 to 20 glands called lobes, where milk is produced in women who are breastfeeding [9]. Breast cancer is the growth of abnormal tissue cells and become malignant in the breast. Breast cancer has many types but the most common ones are invading ductal carcinoma and invasive lobular carcinoma. In this study, the breast tissue has been modeled using the geometry size that can be seen in Table 2.1 [10].

Table 1 Geometry and Permittivity of Breast Phantom.

Item	ε_r	Geometry (mm^3)
Breast Skin	36	96 × 2 × 96
Normal Breast Tissue	9	96 × 96 × 96
Cancerous Breast Tissue	50	

3. System design

3.1 Determination of Specifications

Microstrip antenna made from Duroid 6006 as substrate and copper as patch and ground plane is designed with the following specifications.

- Frequency: 2.46 GHz
- Bandwidth: ≥ 80 MHz
- Radiation Pattern: Unidirectional
- Return Loss: ≤ -10 dB

3.2 Calculation of Antenna Dimensions

The following results of the calculation of the dimensions of the microstrip antenna can be seen in the Table 3.1 and the results of the microstrip antenna design can be seen in Figure 3.1 below.

Table 2 The dimensions of microstrip antennas.

Dimensions	Value (mm)	Dimensions	Value (mm)
Width patch (W_p)	29,5	Length DGS Above	11
Length patch (L_p)	28,8	Width DGS Above	46,5
Width ground plane (W_g)	46,5	Length DGS Below	9
Length ground plane (L_g)	39	Width DGS Below	2
Width feed (W_f)	1	Slotted Patch	1,5
Length Feed (L_f)	9,5		

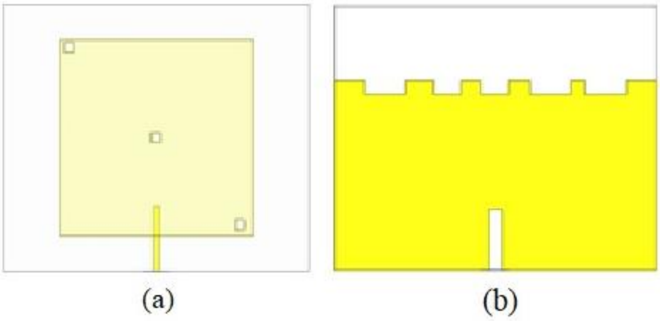

Fig. 3.1: Antenna design, (a) front view (b) rear view.

The antenna specification results obtained based on the simulation are a return loss of -40.2 dB at a frequency of 2.46 GHz and a bandwidth of 100 MHz. The loss is calculated from the difference between the upper frequency of 2.5 GHz with a lower frequency of 2.4 GHz, and the antenna gain of 8 dB.

4. Simulation and Analysis Results

4.1 Simulation Using Breast Phantom

In the simulation, measurements are made with the antenna placed as far as 10 mm from the breast phantom which can be seen in the following Figure 4.1.

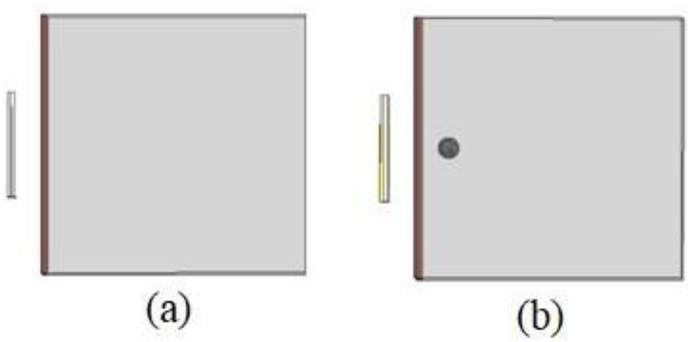

Fig. 4.1: Detection Antenna 10 mm away, (a) without cancer (b) with cancer.

The simulation is performed with the distance between the antenna and the breast phantom as far as 10 mm and measurements are made with different cancer sizes of 2 mm, 4 mm, 6 mm, and 8 mm. Simulation results with breast phantom can be seen in Figure 4.2 below. Based on the simulation, the result of return loss using breast phantom without cancer is -20.76 dB and measurment using breast phantom with different cancer sizes at 2 mm is -20.65 dB, at 4 mm is -20.22 dB, at 6 mm is -17.15 dB, and at 8 mm is -16.76 dB.

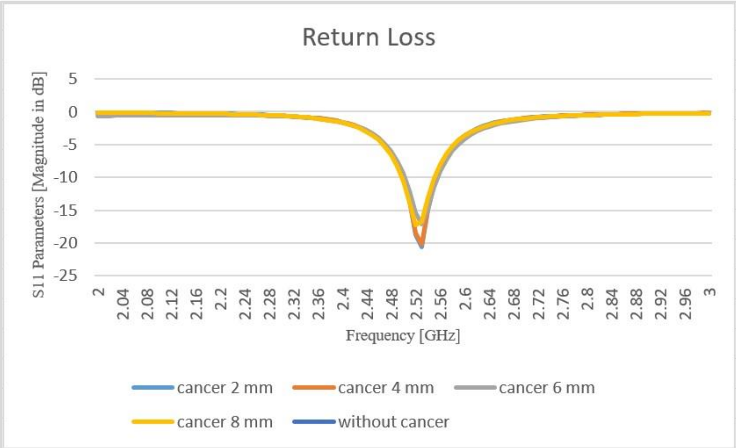

Fig. 4.2: The return loss simulation results in various size of breast cancer

4.2 Analysis of Simulation Results

Measurement using breast phantom without cancer obtained different return loss results, the greater the size of the cancer, the smaller the return loss produced. This change in return loss is due to additional material such as cancer that is detected, so that the value reflected back to the antenna is not the same due to partial absorption by the object.

5. **Conclusions**

Several conclusions can be drawn, viz.

- Antennas designed during simulation have met the specifications of having a return loss value of -40.28 dB and a VSWR value of 1.01.
- The use of the proximity coupled method and the addition of the antenna's defected ground structure can widen the bandwidth and increase the gain.
- Antenna can detect the presence of cancer based on changes in the value of return loss, return loss of breast phantom without cancer is used as a reference. The value of return loss without cancer is smaller than the value of return loss using cancer.
- The return loss value will increase if the size of the cancer is getting bigger

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