Array of Triangular Microstrip Antenna and Combined Triple Rectangular Microstrip Antenna for Radio Altimeter and Ground Penetrating Radar

Merna Baharuddin[1], Elyas Palantei[1], Zulfajri B. Hasanuddin[1], Rusli[1], Andi Azizah[1], Josaphat T. Sri Sumantyo[2]

[1]*Dept. Of Electrical Engineering, Hasanuddin University, INDONESIA,*

[2]*Microwave Remote Sensing Laboratory, Chiba University, JAPAN,*

merna@unhas.ac.id

Abstract

This study presents microstrip antenna developments for GPR and radio altimeter applications. An array of triangular antenna is designed for radio altimeter in the frequency of 4,25 GHz. A shape of combined triple rectangular microstrip antenna is designed for GPR appilication in the frequency of 1 GHz. Design and simulation was conducted using the software Ansoft High Frequency Structural Simulator (HFSS) V.13. Then the design is created in the form of prototypes by using Printed Circuit Board (PCB) made of FR4-Epoxy which has a thickness of 1.6 mm and a dielectric constant of 4.4. The measurement was done using a Vector Network Analyzer E5071C ENA and ED 3200.

***Keywords* :** microstrip antenna, radio altimeter, ground penetrating radar

1. Introduction

A radio altimeter [1] is a device, which is used to measure a low altitude or distance from an aircraft or spacecraft to ground surface or to a sea level. This distance is calculated under the craft in vertical direction. Radio altimeter is a part of radar. The working principle of radar is, it transmits radio waves towards ground level or sea level and receives an echo signal after time duration. This value of time is depending on speed of the vehicle and height between craft (air or space) and ground. Radio altimeter is working in the band of 4.2GHz to 4.4GHz

Ground Penetrating Radar (GPR) systems [2] are used for the subsurface investigation of earth. They are used in the detection of objects buried beneath the earth surface such as pipes, cables, land mines, and hidden tunnels. A GPR system consists of a transmitting antenna and a receiving antenna. The transmitting antenna is connected to a source and the receiving antenna is connected to a suitable signal processing device. It is required to develop efficient GPR antennas to satisfy a number of demands. A GPR system should have low and short coupling between transmitting and receiving antennas to avoid false detection. Since it operates very close to ground, its characteristics should not be affected strongly with ground properties

This study presents microstrip antenna developments for GPR and radio altimeter applications. An array of triangular antenna is designed for radio altimeter in the frequency of 4,25 GHz. A shape of triangular of a microstrip antenna previously has been investigated for CP SAR [3]. A shape of combined triple rectangular microstrip antenna is designed for GPR appilication in the frequency of 1 GHz.

2. Methods

The microstrip antennas have the form of triangular array and a combined triple rectangulars.. Design and simulation is done using HFSS V.13 software. By this software, then obtained shape and size dimensions desired of the microstrip antennas. Antenna prototype is made based on the shape and size dimensions of microstrip antennas that have been obtained from the HFSS v13 software. The design was done by making the antenna design in three dimensions. The dimensions of the designed antenna design are made in accordance with the results of mathematical calculations. After three dimensional antenna design has been established, next step is material selection. The patch, feed and ground plane, the materials is perfect-E, for substrate the material is FR4-Epoxy (relative permitivity (ε_r) 4.4, Dielectric loss tangent (tan δ) 0.2, substrate thickness (h) 1.6 mm), while air is used for the boundary.

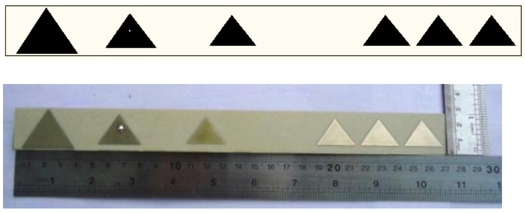

Fig. 1 Designed Array of triangular microstrip antenna and the fabricated prototype.

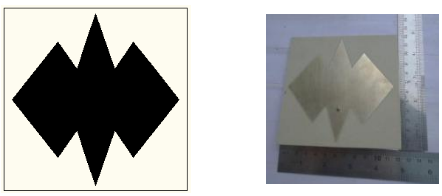

Fig. 2 Designed Combined triple rectangular microstrip antenna and the fabricated prototype.

Tabel 1 Microstrip Triangular Array Dimension

Triangular patch driven element	Triangular side length (a) = 26,14 mm, Height (t) = 18,01 mm
Reflector Size	Longer 0,3 cm than the driven element , Triangular Side Length (a) = 32,14 mm, Height (t) = 21,01 mm
Director Size	Shorter 0,1 cm from the driven element, Triangular side length (a) = 24,14 mm, Height (t) = 17,01 mm
Distance between reflector and driven element	D1 = 0,2λ = 14,117 mm
Distance between 1 and driven element	D2 = 0,4λ = 28,235 mm
Distance between director 2 and director 1	D3 = 0,8λ = 56,470 mm
Distance between director 3 and director 2	D4 = 0,05λ = 3,529 mm
Distance between director 4 and director 3	D1 = 0,05λ = 3,529 mm

Tabel 2.Microstrip Combined Triple Rectangular Dimension

Dimension Part	Size (mm)
Wtrc (wider side) patch	48,5
L_{MAX} patch	113
W_g (width) groundplane	120,71
L_g (length) groundplane	120,54
d (diameter) feed point hole	1.27
X_f *(coaxial Feed)*	16,61

The design of the antennas from the mathematic calculation of its dimension apparently not giving the desired results. Therefore, the optimization process is carried out by varying the dimensions of the components of Microstrip Antennas. Changes in patch dimensions, length and width of the feed, the dimensions of the ground plane and substrate dimensions provide significant changes to the antenna parameters.

Process optimization is done by numerical experimental to obtain the results as expected. From the optimization process final dimensions of designing an array antenna Microstrip Triangular and a combined triple rectangulars are obtained as shown in Table 1 and Table 2 . The final shape of the array triangular Microstrip Antenna and combined triple rectangular that are simulated in HFSS v13.0 are shown in Figure 1 and Figure 2.

3. Results and Discussion

Prototype microstrip antennas were measured using Antena Trainner System ED-3200 and Network Analyzer Agilent 5017C. This measurement is done in the Laboratorium of Telematika Electrical Engineering Department Hasanuddin University.

For the array of triangular microstrip antenna, the bandwidth obtained from the measurement is 270 MHz in the 4,25 GHz frequency. Further measurements are conducted to obtain the radiation pattern, and gain. Testing to measure height from certain position off the ground as this antenna will be applied for altimeter.

For the combined triple rectangular microstrip antennas, the bandwidth obtained from the measurement is 22 MHz in the 1 GHz frequency. Further measurements are conducted to obtain the radiation pattern, gain, and S21 parameters. As this antenna will be applied for GPR, the testing with certain soil depth using 2 antennas, one as transmitter and another as a receiver, will be conducted.

4. Summary

An array of triangular microstrip antennas (4,25 GHz) and a combined triple rectangular antenna (1 GHz) has been developed for radar altimeter and ground penetrating radar respectively. The simulation and measurement results have shown good results. Further measurement and testing will be conducted and more improvement on the antenna systems will be applied.

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