Dual-band C-band and X-band Array Antenna Microstrip for SAR on UAV

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***Abstract*—Imaging RADAR has become important nowadays, collecting more data in anytime and any whether condition has to be challenged. One of RADAR is SAR (Synthetic Aperture Radar) which process echo from reflection wave that has been transmitted. Unmanned Aerial Vehicle (UAV) is the one of airborne which can support SAR to transmit electromagnetic waves from the sky. In this research, microstrip antenna array for dual-band on C-band (5,8 GHz) and X-band (9,65 GHz) has designed. Using both of frequency at the same time, SAR will be obtained more data and more specific. The result of simulation has given the best result from the antenna microstrip array 1x8 that achieved the highest gain in both of frequency which is 9,11 dBi on 5,8 GHz and 5,37 dBi on 9,65 GHz.**

Index Terms—*Array Antenna, Dual-band Antenna, Microstrip Antenna, SAR.*

I. INTRODUCTION

SAR (Synthetic Aperture Radar) make use of range and position of target to imaging process. The operation of SAR is supported by flying vehicle, one of them is UAV (Unmanned Aerial Vehicle). UAV has become the first choice because the operation is cheap, low risk, and dynamic operation time[1].

System SAR is divided by 3 subsystem, there are transmitter, receiver, and antenna[2]. In this research, antenna in transmitter side has designed. To maximizing the operation of antenna in UAV fuselage, antenna microstrip is the best choice to be applied. The polarization of antenna is linier vertical, because it is more sensitive with the canopy structure of vegetation and able to classified type of harvest also the growth level [3].

In this research, SAR will be operated in 5,8 GHz (C-band) and 9,65 GHz (X-band). The use of high frequency as both, can obtain the high-resolution imaging. SAR which operate in dual frequency at the same time will increase amount of data and information about target [4]. For support the directivity and increase the gain, microstrip antenna array has designed in this research.

II. ANTENNA DESIGN

A. Antenna Material

Antenna microstrip is designed by FR-4 Epoxy as dielectric substrate with the thickness 1,6 mm and the permittivity 4,6. While the ground plane and patch as conductor element are used cooper with the thickness 0,035 mm.

B. Design Antenna Microstrip Single Element

The design of dual-band antenna is begin from design single element antenna which use the smaller frequency as in [4]. The single element antenna is designed with rectangular patch formulas based on [5].

The minimum of size of antenna microstrip is dependent on the ground plane. As in [5] finite ground plane can be calculated. Furthermore, the dimension of microstrip line feed can be calculated based on [6].

$$W_f = \frac{8h\, e^A}{e^{2A} - 2} \tag{1}$$

with

$$A = \frac{Z_0}{60}\left\{\frac{\varepsilon_r + 1}{2}\right\}^{\frac{1}{2}} + \frac{\varepsilon_r - 1}{\varepsilon_r + 1}\left\{0{,}23 + \frac{0.11}{\varepsilon_r}\right\} \tag{2}$$

where W_f is width of feed in mm and Length of feed assumed a half of length of ground plane. The value of impedance (Z_0) is 50 ohm.

III. DESIGN METHOD

A. Dual-band Antenna

To provide dual-band resonant frequency, there is some methods that can be used. In this research, microstrip antenna has designed with slotted on its patch as the method to obtain dual-frequency. The shape of the patch has made as E-shaped, shown in Figure 1. As in [7] E-shaped patch can made resonant frequency in C-band and X-band. The dimension and position of slot can affect the resonant frequency. The value of parameter a, b, and c can made by the experiment as in [7].

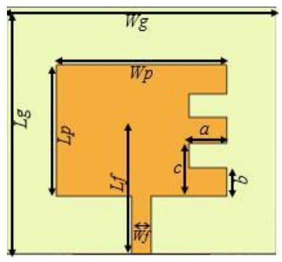


Fig. 1. Design Microstrip Antenna Single Element Dual-Band E-Shaped Antenna Microstrip.

B. Microstrip Array Antenna

The main problem that occurs in single element antenna is provide low gain and wide radiation pattern. One of the solution is to design microstrip array antenna. Design microstrip array antenna has done gradually, from 1x2, 1x4, and 1x8.

1) Power Divider

The power divider that usually used is Wilkinson power divider [8]. The value of impedance on transformator λ/4 T-junction (Z_T) can be calculated from [8].

$$Z_T = \sqrt{N} Z_0 \tag{3}$$

Where N is the number of branch, Z_0 is source impedance 50 ohm.

2) Matching Impedance

Transmission feed on microstrip array antenna should be matched at the T-junction. Power supply from connector port divided in two line feed to each element in same value. Matching impedance that can be used is transformator λ/4. The value of width and length of transformator λ/4 can be calculated from

$$l_{f2} = \frac{\lambda_g}{4} \quad (4)$$

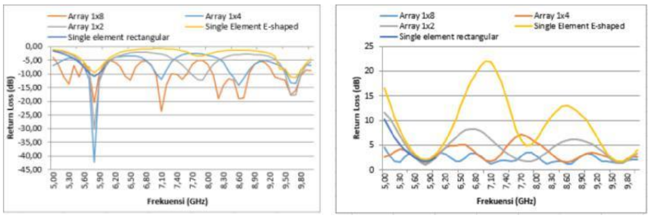
with

$$\lambda_g = \frac{\lambda_0}{\varepsilon_{eff}} \quad (5)$$

Where λ_0 is 0,051 meter and l_{f2} is the length transformator λ/4 feed in mm and f_r is resonant frequency which is 5,8 GHz. While the width of transformator λ/4 feed (W_{f2}) can be calculated from formula (1) and (2) and use the impedance value from formula (3).

IV. Simulation Result

After designed antenna microstrip single element, single element E-shaped, array 1x2, array 1x4, and array 1x8, this section will discuss about the result of the simulation. The result of return loss and VSWR result is shown in Figure 2.



(a) (b) Fig. 2. The Result Simulation of (A) Return Loss (b) VSWR.

Based on the result of simulation, microstrip single element provide lowest return loss and VSWR. While, the optimum result of return loss and VSWR result is provided by antenna microstrip array 1x4. Furthermore, the result of gain and bandwidth are shown in Table 1.

TABLE I. SIMULATION RESULT OF GAIN AND BANDWIDTH

Design of Antenna		Gain (dBi)	Bandwidth (MHz)
Single element		2,5	171,7
Single element e-shaped	5,8 GHz	0,613	33,7
	9,65 GHz	1,04	227,5
Array 1x2	5,8 GHz	6,5	286,4
	9,65 GHz	2,76	297,1
Array 1x4	5,8 GHz	8,68	263,1
	9,65 GHz	1,62	221
Array 1x8	5,8 GHz	9,11	192,8
	9,65 GHz	5,37	555,7

The result of gain is gradually increase and achieve the highest result in array 1x8. Also, the bandwidth is reach the good result. With this result, antenna microstrip array 1x8 can be support the SAR system on the UAV. Antenna microstrip array 1x8 is shown in Figure 3 with the radiation pattern in Figure 4.

V. Conclusion

SAR system in the UAV require the high gain and bandwidth as in [1][3]. Antenna microstrip array 1x4 is provide the highest return loss and VSWR, but the result of gain is not enough to support the system in both of frequency. Therefore, antenna microstrip array 1x8 is the best design for SAR on UAV, because the result of return loss, VSWR, gain, and bandwidth is shown the best result from the other design.

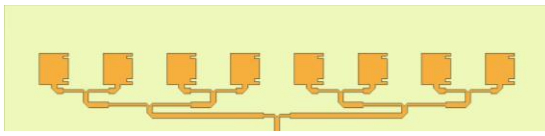


Fig. 3. Design of Antenna Microstrip Array 1x8.

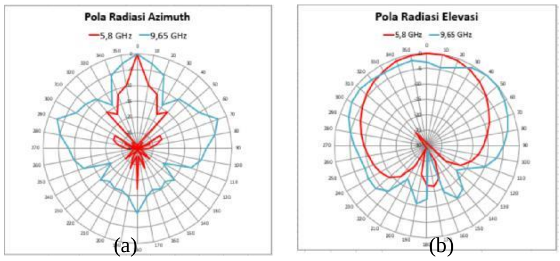


Fig. 4. Radiation Pattern of Antenna Microstrip Array 1x8 (a) Azimuth and (b) Elevation.

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