Perspectives in Planar Antenna Engineering Research in Indonesia

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Abstract **–** In wireless communication, antenna plays an important role since it is impossible to have a communication link without the employment of antenna. With the shrinking of many devices therefore it is required to have antennas that fit in the devices. Planar antenna is one candidate that best suited for such devices. In this paper, the development of planar antennas and it recent applications of the antennas are described. The researches of planar antennas in Indonesia have also been described in this paper.

Key words: *Planar antenna, microstrip antenna, antenna engineering*

Introduction

In the wireless communication era, antenna plays an important role since it is impossible to have a communication link without the employment of antenna. Various applications become shrinking in their dimensions, therefore, a compact, small and light-weight antenna is required to be ported to the terminal despite its well performance. A candidate that best suites for this requirement is planar antenna. Various planar antennas have been developed and been studied, e.g. Microstrip antennas, Coplanar waveguide antennas, and Stripline antennas. Various derivatives of those antennas have also been developed.

Microstrip antenna is one type of planar antenna that is introduced in early 1950's when Deschamp published his paper in [1]. However research activities on microstrip antennas did not published until early 1970's since the first publication. Since the decade 70's until recently, a tremendous proliferation research on microstrip antenna has been generated as shown in many journal, transaction and conference proceedings. Another type of planar antenna is based on coplanar waveguide (CPW) technology that has been introduced by C. P. Wen in 1978 [2].

However, the research on planar antenna in Indonesia has just begun in the last decade. Recently, the active institution carrying out the antenna research is, to say the least, at the Indonesia Institute of Science (LIPI), Bandung Institute of Technology (ITB), Hassanudin University, Sepuluh November Institute of Technology and University of Indonesia (UI).

In this paper, perspectives of planar antenna research activities in Indonesia are described as well as research cooperation established.

Basic Planar Antenna

A simple configuration of planar antenna is a microstrip antenna as shown in Fig. 1. The antenna system is built on a double sided conductor layers pasted on a dielectric substrate. The radiating element is fabricated at the one sided conductor and the ground plane is on the other side. The dielectric substrate usually has permittivity of less than $\varepsilon_r = 10$. The geometry of the radiating element can be a rectangular, a circular, a triangle, a ring or other shapes. Generally the geometry to be chosen is the simplest one to be built and be analyzed. In order to connect to the rest of the circuit, various feeding systems have also been studied. In principle there are three types feeding system. They are direct coupling, proximity or electromagnetic coupling and aperture coupling.

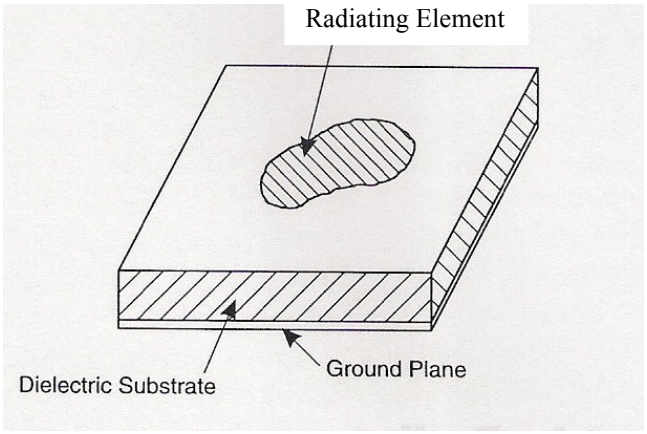


Fig. 1. Planar antenna configuration [3]

Radiation mechanism for microstrip antenna can be determined from the field distribution between the radiating element and ground plane. Alternatively radiation can be described in term of surface current distribution on the radiating element. To simplify the analysis, a model of planar antenna is used a cavity model with electric walls at the top and bottom of the substrate, and magnetic walls along the edge of the radiating element as shown in Fig. 2 [4]. Using Huygens field equivalence principle and then using image theory, the radiation from the radiating element can be ascribed to four ribbons of magnetic current along the magnetic wall radiating into free space.

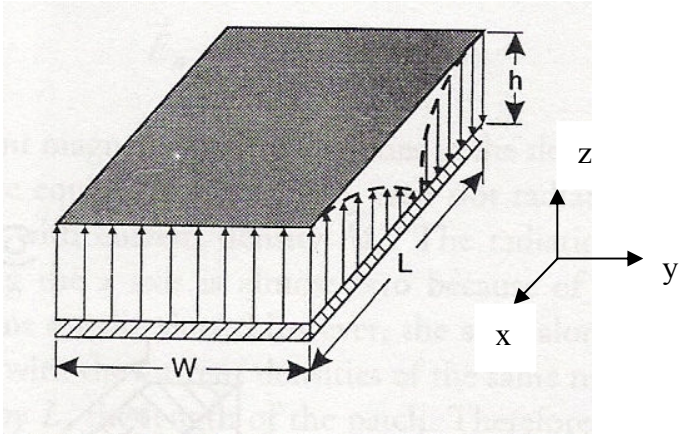


Fig 2. Electric field distribution in microstrip cavity [4]

Using the equivalence principle it is known that the radiation produced by the slots along the *x*-axis is almost zero. However, the slots along the *y*-axis form two-element array. Since it is difficult to analyze vertical slots (*z*-axis) in inhomogeneous dielectric substrate then the vertical slots are replaced by the planar slots as in Fig. 3. The radiating E and H field then can be calculated using array theory.

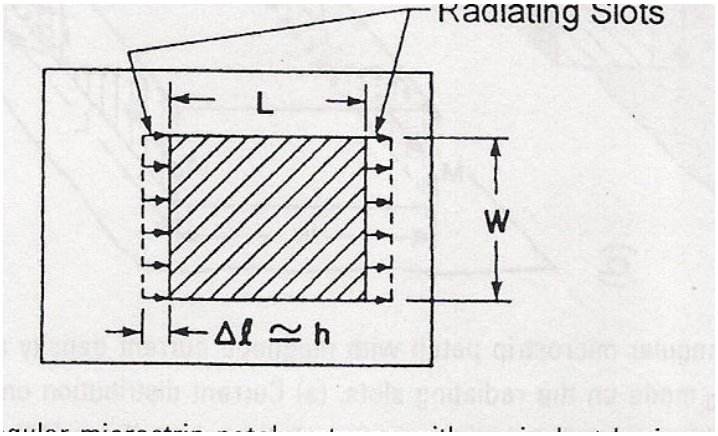


Fig. 3. Rectangular radiating element of microstrip antenna with its array of radiating slot [3]

Research on Planar Antenna

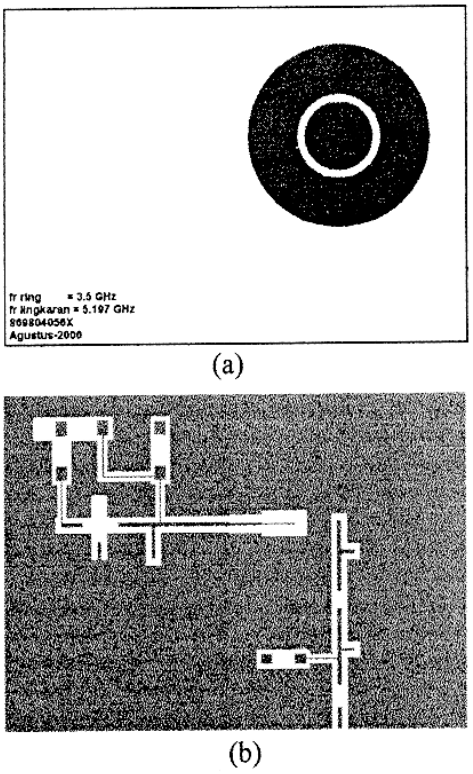
In this section some perspectives of planar antenna research are described mainly based on the activities that carried out at the Universitas Indonesia.

The research on antenna in the Universitas Indonesia is started in 1997. At that time we established Antenna propagation and Microwave Research Group (AMRG) to accommodate our research activities. The AMRG is attached in the Center for Information and Communication Research (CICER) under the Department of Electrical Engineering Universitas Indonesia. We started with research grant from the Ministry of Education and Culture through University Research for Graduate Education (URGE) project and from the Ministry of Research and Technology through Integrated Competitive Research grant (RUT) under research partnership with ITB. The themes of the research were microstrip active antenna and microstrip array antenna, respectively. In the following years we also obtained the research grant such as Hibah Pascasarjana, the Ministry of Information and Communication, Chiba University Japan and research cooperation with BPPT and International Research Center on Telecommunication and Radar (IRCTR) – Delft University of Technology, the Netherlands.

In implementation the research we have done, we always involve our graduate students. It is important since the continuation and the development of this research depends upon the need of our society and industry. The involvement of the students who will become the human resources in the society in the future, therefore, is very important. During the last 10 years we have graduated more than 70 undergraduate students, approximately 40 Master degrees and 4 PhD degrees in antenna engineering specialty. Recently we have 4 undergraduate students, 4 master students and 3 doctor students who are working in antenna engineering. Therefore, in spite of the decline interest of many students to take in applied electromagnetic, we still maintain our student interest is increasing. This is not an easy task to attract the student to be interested in this field. Lots of promotion must be carried out. We offer laboratory facility, research and project activities, information about the job market and also the way we handle the student attract students to work in this area.

Various research themes have been done in our research group. We focus in the performance improvement of microstrip antenna, the feeding system and microwave circuit behind the antenna. It can be categorized as single element antenna, multiband antenna, array antenna, feeding system and beam-forming, electromagnetic band gap antenna and defected ground structure, ultra wideband antenna and antenna in system application. Several of research results will be briefly discussed.

- **Multiband antenna**
  Many applications require more than single frequency band to accommodate several applications using one antenna system. Dual band or multiband antenna, therefore, is also importance to study. Numerous studies multiband antennas have been done including active and fractal antenna. Some examples of multiband antennas are given here such as circular concentric microstrip antenna as shown in Fig. 4 and combination os S and U type microstrip antenna as shown in Fig. 5. The configuration of dual band antenna as in figure 4 uses amplifier type as an active antenna to enhance the antenna gain [5]. The antenna as in figure 5 was designed for both Wifi and WLAN applications with operating frequency of 2.4 GHz and 5 GHz [6].



(a)

(b)

Fig 4. An active dual band antenna using concentric antenna [5]

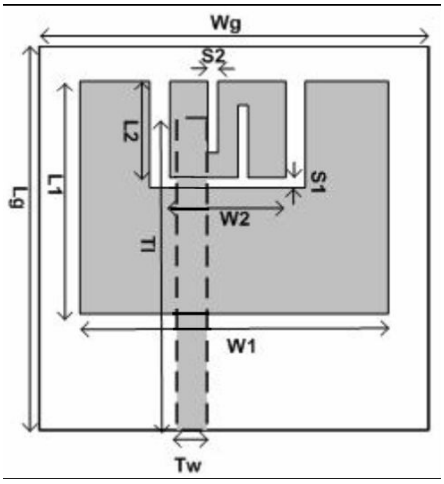


Fig. 5. Dual band antenna for wireless application [6]

- **Triangular radiating element**
  Microstrip antenna element has a variety of shape such as rectangular, circular, ring and triangular patch. The triangular geometry microstrip antenna has been chosen to be studied especially the equilateral shape.

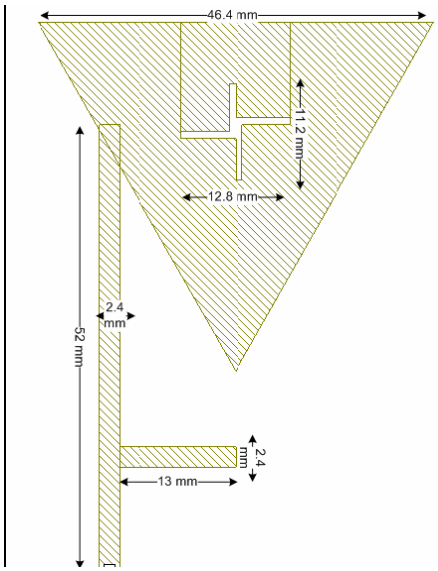


Fig. 6. A circularly polarized isosceles triangular microstrip antenna [7]

Previous studies showed that it is difficult to achieve good circular polarization for the equilateral triangular shape. An example of circularly polarized triangular microstrip antenna is displayed in Fig. 6. Using nearly cross slot then a good axial ratio can be obtained for a range of frequency. Furthermore, several studies on circular polarization generation of triangular radiating element have also been carried out and reported elsewhere [8] – [9]

- **Defected ground structure**
  Recently electromagnetic band gap becomes an increasing interest to many researchers of microstrip antenna. The excitation of surface waves in microstrip antenna will increase level of side lobe, reduce antenna gain, limit the bandwidth, reduce mutual coupling and increase cross polarization [3]. One solution to reduce surface waves is using electromagnetic band gap (EBG) or photonic band gap structure (PBG).

  Defected ground structure (DGS) is one of many techniques to implement the EBG. DGS has similar microwave circuit properties as of PBG and can also modify guided wave properties. In this case, the ground of microstrip antenna is defected by etching the ground plane. Several studies on DGS have been carried out in our research group. A number of DGS shapes are studied such as triangular, hexagonal and dumbell [10] – [12]. These DGS shapes can improve the antenna performance of the reference antenna.

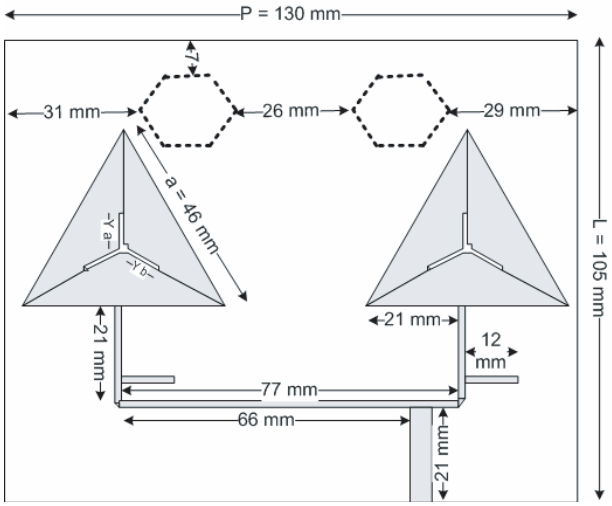


Fig. 7. Double hexagonal defected ground structure [10]

- **Ultra wideband antenna**
  Recently ultra wideband communication (UWB) is very attractive due to its advantages which include large channel capacity, low spectral density of transmitted power, and high immunity against electromagnetic interference (EMI). The 3.1 – 10.6 GHz frequency range allocated for UWB radio applications has stimulated research and development activities in UWB communication by the industry and academia. Several types of UWB antenna have been studied such as linear tapered microstrip slot antenna, log-periodic microstrip antenna and bow-tie antenna.

  An example of linearly tapered microstrip slot antenna is shown in Fig.8. This antenna is designed to operate between 3.1 – 6.0 GHz.

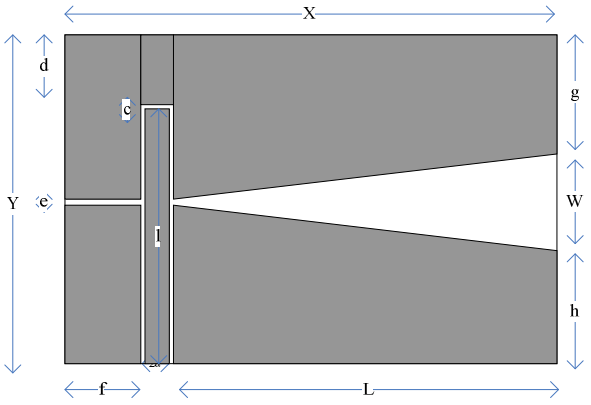


Fig. 8. A linearly tapered microstrip slot antenna fed by coplanar waveguide [13]

Antenna Research Cooperation

Many microstrip antennas have been developed in partnership with other institution. Several examples are mentioned as follow.

A small microstrip antenna array for satellite NOAA receiver was built up to acquire light weight, compact and low cost antenna system to be used by small fishery craft. The antenna was built using 4 x 4 array of rectangular shape antenna which has 14 dB gain. This type of antenna is elaborated with cooperation with BPPT.

Another antenna and balun circuit was also built up to be used for Ground Penetrating Radar (GPR). The antenna is a bow tie planar antenna which has ultra wide band characteristic from 3.1 – 10 GHz. In connecting with balance transmission line, a balun using microstrip was also developed. This antenna was built up under partnership with IRCTR – Delft University of Technology [14] – [15].

Several types of antenna are being developed in cooperation with industry and other institution for broadband wireless access (BWA) antenna. Thanks to the Directorate General Post and Telecommunication the Ministry of Information and Communication for their support in carrying out our research. A consortium of many universities and research institution, namely LIPI, Unhas, ITS, ITB and UI, is still actively engaging the antenna research for WiMAX.

In term of publication, our research results has been published and presented in both many national and international conferences as well as national and international journals. More than a hundred papers have been published. In addition we are also submitting applications for patent of our research.

Conclusion

In the last decade of planar antennas development in Indonesia it is found that planar antenna engineering as one of electromagnetic application is still very important subject and grows interest for both students and researchers. The development of planar antenna though has reached its maturity, there are still plenty room for further researches as well as find new applications. Cooperation with other institution in this area therefore should be more encouraged especially to industry to commercialize the research results.

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