Chapter 9
Microstrip Patch Antenna

Kim Huat Yeap
Westlake International School, Malaysia

ABSTRACT

This chapter elaborates in detail on the microstrip patch antenna, which is widely utilized in the receivers of radio telescopes, as well as in the wireless communication industry today. Several models have been developed to analyze and design the patch antennas. The three most common ones are the transmission line model, the cavity model, and the Method of Moments model. Apart from this, the important parameters used in characterizing the patch antenna are also covered, which are its gain, efficiency, directivity, radiation pattern, return loss, bandwidth, and polarization. This is followed by the introduction of the radiation regions, which are basically classified as the Fresnel region and the Fraunhofer region. Finally, the dual-frequency microstrip patch antenna is introduced. Three popular approaches adopted for the design are orthogonal-mode polarization, multi-layer patching, and reactive loading.

INTRODUCTION

Be it leading corporate or mere civilian, the fact that many could hardly keep track with the concatenated release of wireless gadgets is a sheer witness of how rampancy technological advancement is altering in the telecommunication industry today. Indeed, such occurrence is attributed to the rapid evolution of the microstrip patch antenna (or simply, patch antenna).

Though its debut could be traced back as early as the 1950s (Deschamps, 1953; Gutton, 1955), the patch antenna only received considerable attention by the 1970s (Howell, 1975; Derneryd, 1976, 1978, 1979a, 1979b; Shen *et al.*, 1977; Agrawal & Bailey, 1977; Long & Walton, 1979; Uzunoglu *et al.*, 1979; Bailey, 1979), as transition to wireless mediums commenced. It became the prime subject of study since then. Extensive development has been conducted and designs of various geometries have been produced (Wong, 2002; Lee & Chen, 1997).

Among the shapes most popularly adopted for the patch antenna design is the rectangular patch, as shown in Figure 1. This is due to its ease of analysis and fabrication. It is a narrowband, wide-beam antenna fabricated by photo-etching a thin conductive patch onto the top layer of an insulating dielectric substrate (Richards, 1988). Meanwhile, the bottom side is continuously electroplated with a conductive

DOI: 10.4018/978-1-7998-2381-0.ch009

platform to act as its ground plane. Consequently, the substrate is embraced in a sandwich-like structure. A feed, usually in the form of a microstrip or a coaxial probe, is also connected to the patch as a transmission channel to the external circuitries. The conductive layers are usually made of copper or gold material while the substrates are commonly made of the Flame-Retardant level 4 (FR4), Duroid, or polytetrafluoral ethylene (PTFE) material.

A rectangular patch antenna could be viewed as an open-ended transmission line which is significantly widened at its end, such that when electromagnetic (EM) wave propagates along it, the energy is primarily radiated into the surrounding at the non-homogeneities of the line. Deliberately sized and shaped, such antenna is geometrically corresponsive to the maximum radiation of the desired wavelength. Its radiation is an effect of a strong horizontal component of electric field intensity vector at its edges due to the current distribution source. With the ground plane acting as a reflector with null potential, the rearward radiation is limited and the gain is increased in the forward direction. Thereon, the maximum radiation pattern is normal to the patch and a broadside radiator is designed.

Advantages

The overwhelming popularity the patch antenna received is absolutely non-coincidental. It is in fact, the many advantages incorporated in its appearance which have placed it under the core of research. Namely, the patch antenna is small sized and light weight (Yang *et al.*, 2008), offering a low profile well-suited for high-performance airframes. Its versatility and flexibility enable it to produce a wide variety of patterns and polarizations, depending on the mode of excitation and the shape of the patch (Boualleg & Merabtine, 2005). It is also conformable to non-planar surfaces where its curved implementations can be made to conform to aircraft hulls (Wong, 1999). Mechanically robust but inexpensive, the patch antenna is well producible (Stutzman & Thiele, 1998), since it is manufactured the same way as a printed circuit board (PCB).

Further still, by adding appropriately-loaded elements, such as pin/varactor diodes between the patch and its ground plane (Richards & Long, 1986a), as well as by changing the bias voltage on the diodes (Richards & Long, 1986b), the patch antenna can easily vary its resonant frequency, polarization, impedance, and other parameters accordingly (Richards & Lo, 1983; Richards *et al.*, 1981; Bhartia & Bahl, 1982; Purchine *et al.*, 1994). This subsequently, offers an ease of installation and integration into microwave circuitries, avoiding the additional need of transmission lines, connectors, and symmetrization circuits. Such planar technology is well-compatible with Monolithic Microwave Intergrated Circuit (MMIC) and

Figure 1. Rectangular microstrip patch antenna