**Lab 7：Patch Antenna**

|  |  |
| --- | --- |
| **Author** | Name： 曹子惠 Student ID:12112441 |
| **Introduction**  **1 Basic Introduction**  In high-performance aircraft, spacecraft, satellites and missile applications, where size, weight, cost, performance, ease of installation and aerodynamic profile are all limiting factors, thin antennas are desperately needed. There are many other government and commercial applications such as mobile radio and wireless communications with similar specifications. To meet these requirements, a Microstrip antenna can be used. These antennas are compact, conform to both flat and non-flat surfaces, are simple and inexpensive to manufacture using modern printed circuit technology, are mechanically robust when mounted on rigid surfaces, are compatible with MMIC designs, and are extremely diverse in resonant frequency, polarization, orientation pattern, and impedance when selecting specific patch shapes and modes. In addition, impedance, polarization and pattern can be designed by adding load ground layers, such as pin and varactance diodes, adaptive elements with variable resonant frequencies between patches and patches.  The main operating disadvantages of microstrip antennas are low efficiency, low power, high Q (sometimes more than 100), poor polarization purity, poor scanning performance, and very narrow frequency bandwidth of stray feed radiation, usually only a few percent or at most a few percent. In some applications, such as in government security systems, narrow bandwidth is ideal. However, some methods can be used, such as increasing the substrate's height scaling efficiency (up to 90% if surface waves are not included) and bandwidth (up to about 35%). However, as height increases, surface waves are introduced, which are generally undesirable because they intercept energy from the direction of effective radiation. Surface waves propagate within the substrate and scatter discontinuities at bends and surfaces, such as dielectric and ground plane truncation, and reduce antenna pattern and polarization characteristics. By using cavities, surface waves can be eliminated while large bandwidths are obtained. Stacking of microstrip components and other methods can also be used to increase bandwidth. In addition, microstrip antennas also exhibit large electromagnetic signatures at certain frequencies outside of the operating band, are physically quite large at VHF and possibly UHF frequencies, and require tradeoffs between bandwidth and scan volume in large arrays.  Many commercial substrates are available for the design and manufacture of microstrip type antennas. Table 14.1 lists some common substrates and the most relevant parameters (company name, substrate name, thickness, frequency range, dielectric constant, loss Angle tangent).    FR4 is a very popular substrate.  **2 Basic Features**  Microstrip antennas have received considerable attention since the 1970s, although the idea of a microstrip antenna dates back to 1953 and was patented in 1955. a microstrip antenna, as shown in Figure 14.1(a), consists of a very thin (t ≪ λ0, where λ0 is a free-space wavelength) metallic strip (patch) placed above the ground plane for a small portion of the wavelength (h ≪ λ0, usually 0.003λ0 ≤ h ≤ 0.05λ0). The microstrip patch is designed so that its pattern maximum is perpendicular to the patch (side radiator). This is done by correctly selecting the mode (field configuration). End-shot radiation can also be achieved through wise mode selection. For rectangular surfaces, the length L of the element is usually λ 0/3 < L < λ 0/2. The line (patch) and ground layer are separated by dielectric sheets (called substrates), as shown in Figure 14.1(a).    There are many substrates that can be used for microstrip antenna design, and their performance varies. The dielectric constant is usually in the range 2.2 ≤ r ≤ 12. The most desired good antenna performance is in the thick substrate range with dielectric constant at the lower end, as they provide better efficiency, greater bandwidth, and loosely bound radiation fields into space, but at the cost of larger cell sizes. Thin substrates with higher dielectric constants are ideal for microwave circuits because they require tightly bound fields to minimize unwanted radiation and coupling and result in smaller component sizes; However, due to their greater loss, they are less efficient and have a relatively small bandwidth. Since microstrip antennas are usually integrated with other microwave circuits, a compromise must be considered between good antenna performance and circuit design.  Microstrip antennas are also commonly referred to as patch antennas. The radiating elements and feeders are usually photoengraved on a dielectric substrate. The radiant patch can be square, rectangular, thin strip (dipole), round, oval, triangle, or any other configuration. These are shown in Figure 14.2. Squares, rectangles, dipoles (bars), and circles are the most common, common due to their ease of analysis and fabrication and their attractive radiative properties, especially low cross-polarized radiation. Microstrip dipoles are attractive because they inherently have large bandwidth and take up less space, which makes them attractive to arrays. Linear and circular polarization can be achieved by a single element or array of microstrip antennas. Arrays of microstrip elements with single or multiple feeds can also be used to introduce scanning capabilities and achieve greater directivity.    There are many methods for analyzing microstrip antennas. The most popular methods are transmission line, cavity, and full wave (mainly consisting of integral equation/moment method). The transmission line model is the simplest, which provides good physical insight, but is less accurate and more difficult to model coupling. Compared with the transmission line model, the cavity model is more accurate, but at the same time more complex. However, it also provides good physical insight, and coupling modeling is quite difficult, although it has been used successfully. When applied correctly in general, full-wave models are very accurate and versatile, and can handle individual components, finite elements, as well as infinite arrays, stacked elements, arbitrarily shaped elements, and couplings. However, they are the most complex models and generally provide less physical insight. The single rectangular transmission line model method is introduced here.  Rectangular patches are by far the most widely used configuration.  **3 Size estimation of rectangular microstrip antenna**  The first step in designing a microstrip antenna is to select a suitable dielectric substrate. Assuming the dielectric constant of the medium is , for a rectangular microstrip antenna with operating frequency *f,* the width *w* of the high-efficiency radiation patch can be designed with the following formula:    The length of the radiation patch is generally /2; Here's Is the guided wave length in the medium,    Considering the edge shortening effect, the actual radiation unit length L should be:    **Lab results & Analysis**：  **HFSS simulation results**  **model diagram**    And the parameters I use are in below:    **S-parameter**    It’s clear that the result is not good as anticipate.  **optimization result**    First I set L0 from 26mm to 29mm, and I find 28.5mm is the best L0.  Then I set W0 from35mm to 55mm, the interval length is 0.5mm, and I get diagram below:    By comparing, I think W0=38.5mm is best.      **3D directional gain diagram** | |
| **Experience**  I learned a whole new image: the 3D directional gain graph. In HFSS simulation, the 3D gain pattern shows the radiation performance of the antenna, which is very useful for understanding the radiation power distribution and radiation characteristics of the antenna in different directions. It represents the radiation intensity (gain) and radiation pattern of the antenna in different directions in space.  I observed the direction of the radiation main lobe and the gain pattern of the microstrip patch antenna, and saw that the maximum radiation intensity was 1.3dB. In addition to the main lobe, I also observed the presence of a secondary lobe and its direction and intensity, which is the undesired radiation direction of the antenna and the possible interference or radiation loss in a particular direction. | |
| **Score** | 95 |