The Design of A Ku-K Band Single-Fed Wideband Circular-Polarized Patch Antenna

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Abstract. In this paper, a Ku-K band single-fed broadband circularly polarized microstrip antenna is designed. The antenna is composed of rectangular dielectric substrate and corner patch. The cut-angle patch makes the microstrip antenna work in circular polarization. The impedance bandwidth of 28.7% and the axial ratio bandwidth of 15.6% are obtained by using coaxial line feeding, tangential angle feeding and multi-patch resonance. The overall thickness of the antenna structure is 1.524mm, which meets the requirements of low profile.

Keywords: Single feed point, broadband, circular polarization.

1. Introduction
Microstrip antenna has the advantages of small size, light weight, simple and compact structure, easy integration, low profile, and easy to conformal with the carrier. It has been well applied in communication, remote sensing, electronic warfare and radar systems [1]. Linear polarization is a widely used polarization method in wireless communication. However, due to its polarization deflection, it is greatly limited in use. Circular polarization wave not only makes up for the deficiency of linear polarization wave, but also has better performance in anti-electromagnetic interference, anti-rain fog and anti-gain attenuation [2]. Another disadvantage of linear polarization wave is that when electromagnetic wave is emitted or received by linear polarization antenna, Faraday rotation effect will appear when electromagnetic wave passes through the ionosphere, resulting in polarization distortion. However, the polarization distortion can be effectively eliminated by receiving or transmitting circularly polarized antennas, so circularly polarized antennas are often used in aviation communication and remote sensing equipment [2]. At the same time, it is widely used in satellite communications, satellite navigation, military communications, radio and television and other fields, such as Russian satellite navigation system, the United States Global Positioning System (GPS) and China's Beidou satellite navigation system [2].

However, the traditional microstrip antenna is a resonant antenna with high Q value and narrow band, and its relative bandwidth is usually only 1%~6%. In order to broaden the working bandwidth of microstrip patch antenna, the coupling feed technology [3], multi-layer patch stack technology [4] and slot technology [5] are often used. Multi-layer microstrip patch antenna not only has the characteristics
of simple structure, but also can expand the bandwidth of traditional microstrip antenna to more than 30%, which is a feasible method to realize broadband demand. In this paper, the double-layer microstrip patch structure is adopted, and the low-level tangent angle is used to achieve circular polarization. The double-layer patch realizes multiple resonant points, and the coaxial probe is fed back to the microstrip patch. The microstrip antenna designed in this way has excellent characteristics such as wide bandwidth, wide beam and wide scanning angle.

The antenna designed in this paper has simple structure and can excite two resonant modes. The broadband coverage is 15.76~21.04GHz, the relative bandwidth is 28.7% (VSWR≤2), and the axial ratio bandwidth is 15.6% (AR≤4). In addition, the standard coaxial feeding size of SMA joint is adopted in the design, and the material and height of the dielectric layer are set in accordance with international standards, so the simulation test can be carried out as the array unit of the circularly polarized phased array.

2. Antenna analysis and structural design

In this paper, a broadband circularly polarized microstrip antenna with single feed point based on dual-layer structure is proposed. The dual-layer patch structure is used to increase the resonant point to achieve broadband. When the two resonant frequencies excited are close to each other, the dual-peak resonant circuit with bandwidth broadening can be realized. Therefore, coaxial line feed, corner feed, multi-patch resonance and other technologies can be integrated to make the antenna achieve more than 30% impedance bandwidth under low profile requirements. At the same time, the circular polarization can be realized by combining the coaxial feed and the rectangular patch tangent angle design, and the broadband can be realized by adjusting the patch size, the tangent angle size and the position of the coaxial feed.

The antenna structure is shown in Fig. 1. The broadband low-profile patch antenna is fabricated on the Rogers RT/duroid 5880 (tm) dielectric substrate with a thickness of 1.524mm, a dielectric constant of 2.2 and a loss tangent of 0.0009. The antenna structure is a double-layer patch structure, in which the lower patch is a feed patch and the upper patch is a coupling patch. The feed patch is fed by a coaxial probe with an impedance of 50Ω, and the feed patch is fed by a spatial electromagnetic coupling to achieve broadband performance.
3. Simulation results and analysis

In this paper, High frequency electromagnetic simulation software is used to simulate the antenna, including S11 parameters, VSWR, gain and axial ratio of circularly polarized antenna. Fig. 2 is the S11 parameter of the antenna. Fig. 3 is the voltage standing wave ratio of the antenna. It can be seen from Fig. 2 and 3 that when the VSWR of the antenna is less than 2, the impedance bandwidth is 15.76~21.04GHz, and the relative bandwidth is 28.7%. The antenna structure produces three resonant points, which are 16.43GHz, 19.15GHz and 20.75GHz, respectively. The broadband characteristics of the multi-layer microstrip antenna are realized. Fig. 4 is the antenna gain diagram, the gain at the center frequency of 17GHz is 6.47dB. Fig. 5 shows the axial ratio of the circularly polarized pattern. The axial ratio at 17GHz is 1.38dB and the axial ratio bandwidth is 15.6%. The above simulation results verify the feasibility of the antenna, indicating that the antenna structure can be used as a unit of circularly polarized phased array for array design.

![Figure 2. Simulation results of S11 antenna.](image1)

![Figure 3. Simulation VSWR of antenna.](image2)
4. Conclusions
A single-fed broadband circularly polarized microstrip patch antenna based on two-layer structure is presented. By comprehensively using coaxial line feeding, tangential angle feeding, multi-patch resonance and other technologies, the impedance bandwidth is 15.76–21.04GHz, the relative bandwidth is 28.7%, and the axial ratio bandwidth is 15.6 % when the VSWR of the antenna is less than 2. The gain at the center frequency of 17GHz is 6.47dB and the axial ratio is 1.38dB, which meets the requirements of broadband and low profile design.

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