Research on passive millimeter wave multi beam antenna scanning imaging

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Abstract

The millimeter wave is between the centimeter wave and the optical band, has the optical detection accuracy and the microwave all-weather work characteristic. The development trend of millimeter wave instead of the guide head. MMW imaging guidance technology is the development trend of millimeter wave guidance technology, at present by the non coherent development to the one-dimensional high resolution imaging, toward broadband 2D and 3D imaging direction. It has higher target acquisition resolution and signal to noise ratio, and lower false alarm rate and weight volume, and the disadvantage is that the detector response is not uniform. The linear scan imaging has the advantages of low cost, small difficulty.

Keywords

Millimeter wave, focal plane, millimeter wave radiometer, millimeter wave imaging.

1. Introduction

In recent years, with the development of computer technology, millimeter wave solid state technology, signal treatment technology, photo electron technology and materials, parts, structure, process and development, solid conformal control the successful application of array antennas and millimeter wave integrated circuit technology and other related technology for millimeter wave seeker of up good foundation.The millimeter wave detection technology has become one of the main direction of the development of space exploration technology, and has become an emerging technology, which is widely used in many high and new technologies.[1] On the basis of the famous black body radiation theory, Planck proved that all the objects in the absolute zero degree would radiate electromagnetic waves, and the millimeter wave detection is to identify the target by the millimeter wave radiometer. Finally, the millimeter wave imaging technology is developed. Now the millimeter wave imaging technology has been developed through the first generation of imaging to second generation imaging and third generation imaging .

In this thesis, the basic theory of millimeter wave detection is studied, and the working principle of millimeter wave radiometer is analyzed. The focusing characteristics of millimeter wave antenna are analyzed by using the geometrical optics method. The mathematical model of the output signal of millimeter wave radiometer is simplified, and the simulation and verification are carried out. The temperature of the antenna is studied, and the influence of the parameters of the radiometer is discussed.[2]

2. Theoretical basis

According to Planck's law, when an object is in the electronic energy level transition, the object will absorb or radiate a certain wavelength of energy.All natural objects that are in absolute zero will radiate electromagnetic waves. The electromagnetic wave absorbing and reflecting the radiation of the object at the same time as the electromagnetic wave is absorbed and reflected by the object.With the rapid development of MMIC, high speed VLSI device and signal processing technology, a wide range of applications of the millimeter wave "staring" imaging technology to the core of the focal plane array receiver is widely used.[3]

The millimeter wave focal plane imaging can obtain high resolution images, which can improve the spatial resolution by using large aperture antennas. The single focal plane array technology can

greatly reduce the cost and realize real-time imaging.The basic principle of focal plane array imaging is that the space target can be regarded as a set of targets, and the spatial position of each point is different, the image points on the focal plane are different.

The millimeter wave passive detection technology is the use of the difference between the object to transmit rate, obtain different radiation brightness to distinguish different objects.Because of the extremely low millimeter wave emission rate, the temperature of the metal is mainly from the sky temperature and the ambient temperature.Therefore, millimeter wave detection of metal target occupies an important position.The essence of passive millimeter wave imaging theory is to establish the mathematical model of the imaging system, and the performance index of the system is based on the mathematical model of the system. Assuming that the system has the function of the null point spread function, the system can be obtained by a single pass.

3. Millimeter wave multi beam antenna

Antenna technology is the key technology of millimeter wave imaging.Antenna feed General requirements as large as possible within the field of view to keep the antenna gain, beam width and minimum beam quality changes, as far as possible is realized by resampling the feed interval was required. The feed is widely used in millimeter wave antenna array in the horn, tapered slot antenna and taper dielectric rod.

At present, in the millimeter wave passive detection, the main use of the lens or reflector antenna to focus on the characteristics of the beam array to achieve the scene of the gaze. Uniform feed array due to offset feed, the beam will appear non uniformity.Therefore, the study of non uniform feed array generated uniform beam to cover the field, is very important to realize the image of high resolution.[4]Regarding the type of lens, the lens can be divided into a medium lens and a metal lens according to the different media. According to the number of the electromagnetic wave in the lens, it can be divided into single and double refraction lens.According to the different application of the dielectric lens, there are a variety of special lenses, hemisphere, hemisphere, ellipsoid lens, etc.The design of the millimeter wave quasi optical system mainly follows two principles:(1) the principle of optical wavefront.(2) the Snell refraction theorem.

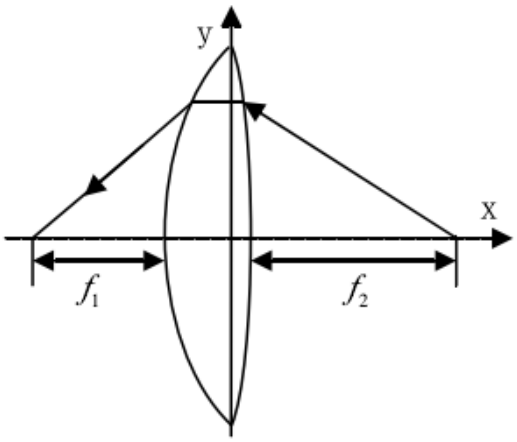

Figure 3.1,The geometrical shape of a double refraction lens is shown here.

According to the principle of antenna design by ray tracing method, design a simple point focusing lens shape, and the imaging light path diagram of simulation calculation, and discuss lens multi-point focus performance.Because the lens is symmetrical, the optical lens can be obtained by optical path profile.Lens face feed side we call the lighting surface facing the target side, we call the dark side.

4. Study of millimeter wave radiometer

The millimeter wave radiometer is a kind of high sensitivity microwave receiver.With the development of millimeter wave integrated circuit technology, it is usually to make the oscillation,

amplification, mixing and other components of the system become a subsystem, which can greatly reduce the size and quality, but also reduce the cost. At present, the frequency of 94GHz integrated

oscillator, amplifier, mixer, attenuator and phase shifter has mass production.Millimeter wave radiometer working principle: when the beam between the different target scan, due to objects in millimeter wave band emissivity e differences, input radiometer power difference between the larger, power of the input signal through the detector detector, after filter to filter out unwanted signal components, the voltage signal to change were quantized output, and system calibration were comparison can be objects of millimeter wave image.[5]

The millimeter wave radiometer can be classified into types, which can be divided into two categories: total power and comparison. The Dick type radiometer in the comparison type radiometer is a widely used radiometer at present.[6]

In the millimeter wave frequency band, most of the domestic use of the super heterodyne receiver system, so the antenna noise signal will be directly into the mixer for lower frequency. The main technical indicators of the radiometer are the equivalent noise temperature, temperature sensitivity, angular resolution, range and data rate of the machine.

5. Simulation and analysis of millimeter wave scanning imaging

There are three main ways of radiation meter scanning: rotating scanning, pendulum scanning and scanning. Array scan mode is between single channel scanning and focal plane array full gaze.

It is the result of the spatial resolution, imaging time and the cost of the system. In this chapter, the output signal of the millimeter wave passive detection system is simulated. [7]The output signals of the rotary scanning and the pendulum are simulated respectively.

According to the characteristics of the output signals, the target recognition and positioning are discussed.

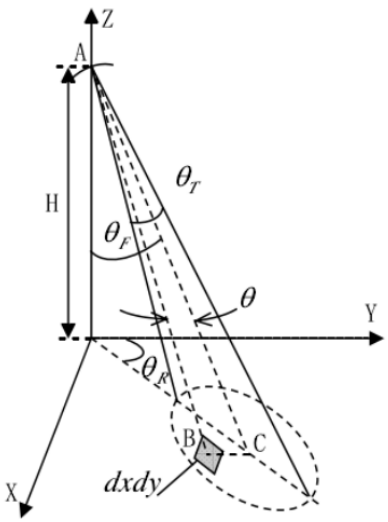

Figure 5.1,The single beam scanning space model of the millimeter wave radiometer is shown .

In this chapter, the simulation calculation of the millimeter wave temperature signal of the target output is carried out in the simplified millimeter wave output antenna.It gets the target wave profile.In the case of single beam and multi beam, the wave characteristics of the radiometer received by different scanning conditions are studied respectively.[8]

The image of one dimensional wave data obtained from single beam scanning is studied. The effect of antenna sampling rate and spatial resolution is discussed.The waveform data of millimeter wave frequency detection circuit can be used to guide the design, to target recognition and imaging.

6. Conclusion

Millimeter wave imaging technology, as an advanced precision guidance technology, is becoming more and more used by many precision guided weapons.

The high frequency characteristic of millimeter wave, which has the advantages of both optical and microwave.Millimeter wave can penetrate clouds, fog, etc., with a full day and quasi all-weather work ability; imaging results and optical imaging is similar to the visual identification of the target, the metal target is sensitive, has the ability to counter stealth.

In this paper, we mainly study the basic theory and method of millimeter wave imaging, the millimeter wave antenna multi-poly stool characteristics, analyses the working principle of the radiometer, on the simulation platform of radiation meter RF front-end are simulated and analyzed, in the simplified radiation output meter antenna temperature model, the antenna temperature were simulation analysis.

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