4.4.3. UNCOOLED PLANAR RECEIVERS BASED ON SEMICONDUCTOR DEVICES FOR MILLIMETER-WAVE VISION SYSTEMS

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For real-time imaging in the millimeter-wavelength range, a radio vision system based on a focusing lens and a planar-receiver matrix located in the focal plane is used [1]. In this paper, we present the results of developing the simplest planar detector receivers for the three-millimeter wavelength range. Low-barrier Schottky diodes were used as the sensitive elements [2]. Planar antennas with a directive gain of up to 14.5 make the basis for the receiver design [3].

For validation of the concept of a tight-integrated planar matrix receiver, we developed and manufactured a detector line of eight elements arranged in a row with period $3\lambda / 2$, using a signal amplification and transformation circuit in each channel. A layout of the setup, which we used for the experiments on transmission of signals through objects is shown in fig. 1. A 94-GHz backwardwave oscillator (BWO) was used as the radiation source. A horn was employed for output of the radiation into space. The distance from the horn end to the detection plane amounted to about 1.5 m. For recording the field pattern, the line of detectors was mechanically moved in a 27 by 25 cm field along two orthogonal directions with a $3\lambda / 2$ or $3\lambda / 4$ step.

Transmitted-signal images of different home objects were obtained. Contours of the objects distorted by interference and diffraction phenomena are seen. The interference background is better detected as the scanning step decreases. On the whole, the intensity pattern of transmitted radiation is complex and depends on the distance between the object and the scanning plane. Images become more distinct as this distance decreases. This system of recording of electromagnetic-field intensity patterns permits one to control the quality and measure the characteristics of quasi-optical elements and record the diffraction and interference patterns.

To study the possibility of obtaining ref1ected-signal images, we manufactured an aspheric lens of 19 cm in diameter. The lens was designed in such a way that the point sources located at a distance of 18 cm from the principal plane of the lens formed an image on the opposite side of the lens at a distance of 29 cm from the principal plane, or vice versa. The sizes of a point source on the principal axis of the lens are $3\lambda / 2$ and 2.5λ for the far and near planes of the image, respectively, in agreement with the calculations.

For obtaining images of different objects in the ref1ected-signal experiments (fig. 2), the radiation source was placed in the lens focus and formed a “plane-parallel” beam of radiation. The objects were located in the near plane of the image. It turned out that there exists a more distinct resolution of plane objects than in the transmitted-signal experiment. The possibility of obtaining images of objects located behind the dielectric shield is also shown. In this case, the interference phenomena also manifest themselves, and they are also related to the reflection of a signal from the lens and aberration of the lens itself since this design is not ideal for the formation of a “plane-parallel” beam of radiation. The main result of the experiment is the possibility of using a lens to decrease scattering of the reflected signal and employ a detector receiver for the millimeter-wave imaging.

In this paper, we also present the results of studying a planar mixer with low-barrier diodes [4]. As the signal source a11d the heterodyne, we used two oscillators with frequencies near 94 GHz. The radiation was output into outer space via the horns and was directed to the planar antennas. The peak power received by the antenna from the heterodyne amounted to about 40μW. For the optimal output of an intermediate-frequency signal (700 MHz), we used inductance- and capacitance-based transformers closing the diode by direct current and matching it with the line having a wave resistance of 50 Ω. It is found that for a heterodyne power of 10– 40 μW for diodes with a differential resistance of 3 – 10 kΩ, the transformation coefficient corresponds to from –16 to –12.5 dB. The transformation coefficient decreases with decreasing effective Schottky-barrier height, which is due to the impairment of the diode perfectness coefficient. In comparison with the mixer that uses conventional Schottky diodes of this wavelength range, the transformation losses are greater by 9 to 6.5 dB, but for a significantly lower heterodyne power (1 mW instead of 10 – 40 mW). In a number of cases, a notable decrease in the required heterodyne power (by 14 – 20 dB) can make it possible to bring a tight-integrated matrix plane receiver with more than one hundred elements to the optimal mixing regime. This important result opens up the way to creating simple multielement matrix vision systems having a high sensitivity.

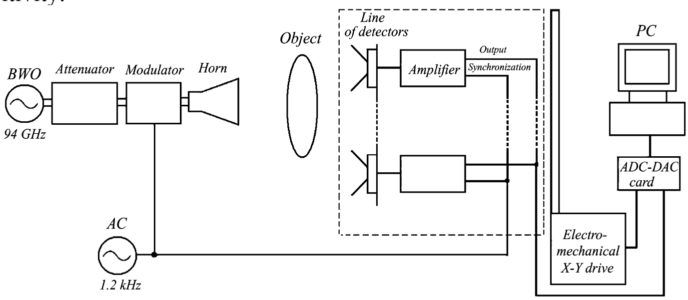

Fig. 1. Layout of the transmitted-signal experiment

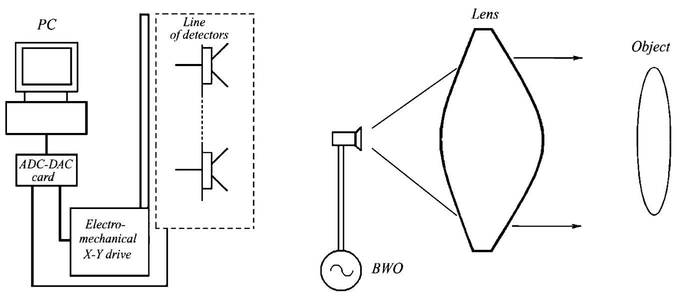

Fig. 2. Layout of the reflected-signal experiment

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