HIGH-PERFORMANCE PASSIVE MICROWAVE SURVEY ON JOSEPHSON JUNCTIONS

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The quasi-optical generations of image of objects with their internal structure in millimeter (MM) and submillimeter (SMM) bands is one of prime problems of modern radioelectronics. The main advantage of passive MM imaging systems in comparision with visible and infrared (IR) systems is small attenuation of signals in fog, cloud, smoke, dust and other obscurants. However at a panoramic scanning of space the observation time lengthens and thereby the information processing rate become restricted. So that single-channel system cannot image in real time. Therefore we must use many radiometers in parallel to reduce the observation time. Such system must contain receiving sensors as pixels in multibeam antenna. The use of Josephson Junctions (JJ) for this purpose together with the cryoelectronic devices like GaAs FET or SQUIDS for signal amplifications after JJ is of particular interest in this case.

1. INTRODUCTION

The conception of the optic imaging systems at present is more widely employed in millimeter wave range [1-3]. Fig.1 displays attenuations of radiations in MM and SMM bands in various environments such as fog, rain, drizzle, etc, where we see relatively small attenuation of radiation in MM-wave range compared to the radiations in the infrared and visible range [4].

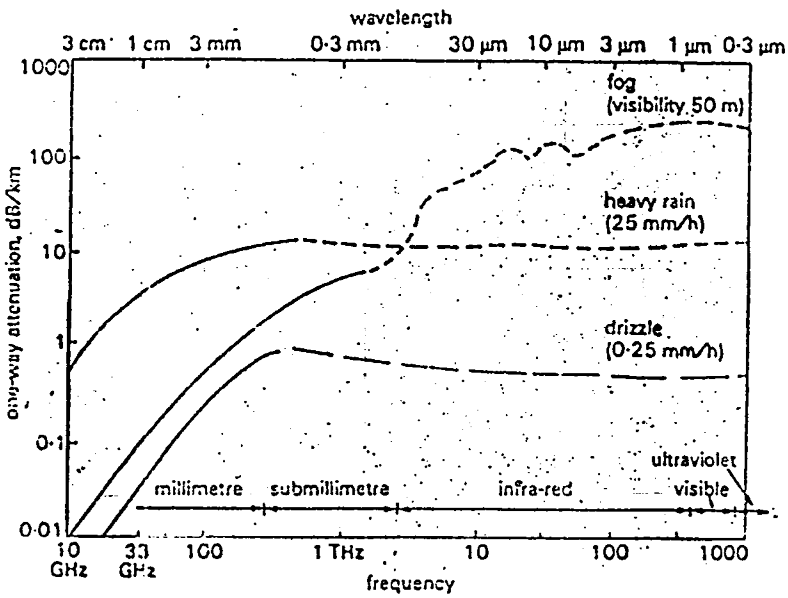

Fig. 1. Attenuations of the radiations in various wavebands for different environments

The problem of development of devices for obtaining images of objects in the optical and IR bands has practically been solved both physically and technologically. A number of physical and technical difficulties, howerer, arise in MM and SMM bands, first of all because at the corresponding radiation frequencies the quantum energy is low and becomes lower than the photoeffect threshold. Due to this, bringing these bands to a practical use calls for developing basically new techniques and sensors for reception and detection of the radiation.

At the same time the developing of new future microwave systems must be more at the base of idea of ecologically pure devices without any artificial radiations or with small radiated power. In some cases the passive many elements and multifrequency systems of the artificial vision (including stereo) are principal or competive for employing [5].

There have been substantial progresses in MM technics, including radiometric systems, due to the availability of high-quality, small-sized elements of the conventional types such as Shottky diodes, FET's, Gunn oscillators, etc, with the fluctuational sensitivity of the uncooled radiometer being better than 0.04 K at signal averaging time of 1 s. The sizes of radiometric modules produced by "Iceberg" in the "tranparent windows" at 8 mm and 3 mm wave bands are about 70x40x20 mm^3 or in a tube with the diameter about 20 mm. In principal there may be future decision concerning the diminishing of radiometer but as for the matrix must be another principal idea for doing manyelement systems. It is desirable that this system must be analyzed in terms of the sensitivity, dynamic range, simplicity, frequency bands, size and mass as well as of the electromagnetic compatibility and of feasibility of the use of the integral technology for their fabrication.

The development of a radiometer as an elementary sensor (cell) of a multielement matrix is practically feasible with the using of three types of receiving devices: amplifiers, frequency converters and microwave detectors.

According to experimental and theoretical analysis performed in "Iceberg" the use of JJ in the self-pumping mode [6], which is one of the varieties of the heterodyne detection, is particular interest in this case.

2. ARRAY OF SENSORS.

The array of the receiving sensors is the main functional block of the multichannel passive imager. The number of the sensors and its sensitivity determines the efficiency of systems in the whole. Matrix of JJ with down convertion to the intermediate frequency Ga FET amplifier or SQUID [7,2] at the detector output yields a level of sensitivity not worse than 0.01 K.

This obviates the need for an external heterodyne, since the oscillation of the junction itself is employed and there exists the possibility of the JJ tuning to the frequency of the signal being received in accordance with the expression describing the nonstationary Josephson effect [8]:

$$2eV = \hbar \omega ,$$

where e and $\hbar$ are fundamental constants, V is the voltage across the JJ, and ω - the frequency of the oscillation generated by JJ.

As shown by the analisis [6], the equivalent temperature of the noise of such a receiver (T_s) is given by expression:

$$T_s = T_{in} + T_j + \frac{T_{ifa} \cdot L}{2\sqrt{\frac{\Delta\Gamma - f_{if}}{\Delta f_{if}}}}$$

where T_j - is the effective noise temperature of the Josephson generation, T_{in}- is the noise temperature due to background radiation; L - is the power loss at the frequency conversion in the JJ; f_{if}, Δf_{if} and T_{ifa} are respectively the central frequency, the amplification band, and the noise temperature of the intermediate frequency amplifier at the detector output, and $\Delta\Gamma$ - is the Josephson oscillation bandwidth.

The estimation of parameters being expected in accordance with [7] at a cooling temperature of about 20÷30 K and $T_{ifa} \leqslant 20$ K; $T_j \approx 60$ K, $\Delta\Gamma \approx 20$ GHz, $f_{if} \approx 4$ GHz, $\Delta f_{if} \geqslant 700$ MHz and $T_{in} \approx 20$ K (only the path loss) with the use of generally-accepted theories [8] and account of modern experiments [9] yields the fluctuational sensitivity value at a level not worse than 0.01 K (0.005 K). This value is quite adequate for solving of most problems.

In practice, the technical realization of such system may be performed at the base of the various types of the matching with antenna system depending on the real tasks and on the area coverage [10, 11, 12]. There are may by LTSA (Linearly Tapered Slot Antenna) [10] or an integrated-circuit antenna array [11] which was planned for analogy items in radar technics with multibeam antenna.

It should be noted that the problem of the microwave modulator (or beam chopper) which is principal but nonadvantagable device for the radiometer scheme and especially in case of matrix system may be decided by the another method in case of JJ sensors. Modulator can be removed from the entrance before the JJ according to the possibility of using the pilot-signal regime of radiometer scheme or the regime with the modulation of working point of JJ which was examined in [9]. In case of integrated-circuit antenna for the receiving sensor built on JJ there may be used the second

JJ as a generator for controlling signal. This JJ can be performed from the opposite side (to the entrance signal) of the substrate. At the fig.2

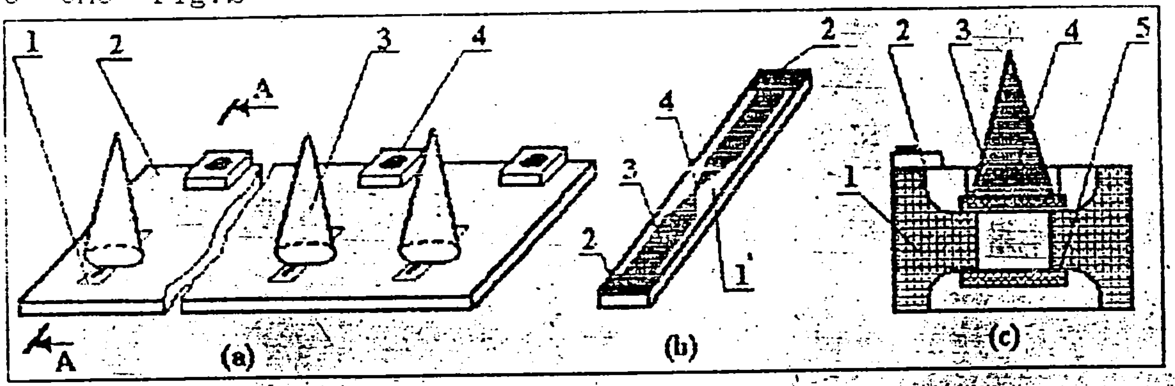

Fig. 2 The receiving module
a) 1 - the detector JJ; 2 - the copper plate; 3 - the matching cone; 4 - the SQUID sensor or a matching transformer
b) the Josephson element: 1 - the substrate (sapphire); 2 - the bonding pad-Cu; 3 - a HTSC film; 4 - weak coupling
c) 1 - the copper plate; 2 - the SQUID sensor or a matching transformer; 3 - the matching cone; 4 - the detector JJ; 5 - the generator JJ

are presented the possible decision of this construction which was designed in "ICEBERG".

CONCLUSION

So, the using of JJ for imaging systems can do the advantage of good sensitivity, exclusion of the special local oscillators and modulators. Besides this there exists the possibility of the electronic tuning to the frequency of the signal being received [13].

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