INPUT MILLIMETER-WAVE MODULE WITH PARAMETRIC AMPLIFICATION

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Abstract

The paper presents the experimental results of an investigation into a low-noise non-cooled amplification module consisting of the parametric amplifier and the quasi-optical pumping oscillator, intended for implementation as an input circuit of the 60 GHz wave band receivers. The coaxial waveguide resonator was used as an idler frequency loop of the parametric amplifier, while the quasi-optical sphere-corner-echelette open resonator was used as the same for the oscillatory circuit of the pumping oscillator. The experimental results for the model of amplification module, which is executed using the unpacked Schottky-barrier diode and IMPATT diode, are provided. The gain is no less than 16 dB within the 1 GHz bandwidth and the noise temperature is no more than 550 K.

Key words: mm-wave band, parametric amplifier, coaxial waveguide resonator, quasi-optical pumping oscillator, sphere-corner-echelette open resonator.

1. Introduction

Parametric amplifiers (PA) based on the semiconductor diodes with non-linear capacity are widely applied in high-sensitivity receivers as the least noisy non-cooled input stages. Quite a number of papers [1-3] are devoted to design and calculation of this device. As can be seen from [2] HEMT-amplifier has the noise temperature in \( N \) times greater as compared with PA: \( N = \frac{m K_{HEMT}}{2} \frac{\tau_{\text{in}}}{\tau_{\text{rs}}} \), where \( m \) is a depth of modulation...
of varactor capacity, $K_{\text{HEMT}}$ is experimental factor ($K_{\text{HEMT}} = 1.5...2.5$)

$$\tau_{eq} = \sqrt{\frac{\tau_1 \tau_2}{\tau_1 + \tau_2}}, \quad \tau_1 = \frac{C_{sg}}{g_m}$$

is the carrier transit time through the HEMT gate, $C_{sg}$ is source-gain capacity, $g_m$ is internal $\tau_2 - C_{sg} \left( R_s + R_g \right)$, $R_s$ and $R_g$ are source and gate resistances correspondently. Hence it follows that the PA application has a much potential for the noise temperature decrease in 1.6...9 times approximately [2] in relation to HEMT-transistor amplifier. Nevertheless, at creation of low-noise mm-wave PA there occurs a number of difficulties related to insufficiently high critical frequencies of the semiconductor diodes and the complexity of realization of the oscillation systems, filters, pumping oscillators (PO) and other components of the amplifier.

Single-loop PA is applied in the noise receiver systems, in particular, as the radiometric detectors. In order to apply the PA in the high-speed data processing communication systems it is necessary to use the two-loop PA, in which the spectrum of the amplified signal should be in line with the input spectrum. Such PAs are more complicated compared to the single-loop ones and require an alternate approach at their development because the creation of an additional heterodyne frequency loop becomes a necessity.

The present paper provides for the results of the experimental research of the 60 GHz band non-cooled low-noise amplification module consisting of the PA and the quasi-optical pump oscillator. The heterodyne frequency loop of the PA is based upon the coaxial waveguide resonator and the oscillation circuit of the PO is based on the sphere-corner-echelette open resonator.

2. Design of the amplification module

The input low-noise amplification module consists of the circulator, PA based on the crosswise signal and pump waveguides and the quasi-optical PO. The cross-shaped intersection of signal (1) and pumping (3) waveguides makes possible the plunger matching independently for signal and pumping circuits [1]. The PA is designed as a single port one with the circulator at its input. Fig. 1 shows the design of the two-loop PA, in which the coaxial waveguide resonator 6 is applied as the heterodyne frequency loop. The unpacked Schottky-barrier (SB) diode 2 with the contact needle 5 is positioned in the point of the signal and pump waveguides crossing. Unpacked SB diode has a minimal parasitic capacity and inductance.