MONOLITHIC MICROWAVE INTEGRATED GaAs FET OSCILLATORS

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Abstract

The analysis by means of three-port S-parameters shows that larger output power can be obtained from GaAs MESFET oscillators at their source ports rather than at their drains. An output power of 40 mW was measured at 8.2 GHz on a finished monolithic oscillator with 15% efficiency and 300 μm gate-width.

Summary

The monolithic oscillators described in this paper are composed of GaAs MESFETs, which have 1 μm gate-length, 300 μm gate-width and 3 μm source-drain spacing. The doping concentration and thickness of the active layer are 1 x $10^{17}cm^{-3}$ and 0.28 μm, respectively.

Generally, a MESFET can be represented by a three-port network shown in Fig. 1 Based on the equivalent circuit of the device, the three-port S-parameters of the network can be derived in terms of the operating bias and frequency, as well as the geometrical and material parameters of the device.

When the gate port is terminated with a pure reactance Z_g, the three-port network becomes a two-port network, and the equation

$$|\Gamma_g| = \left| \frac{Z_g - Z_o}{Z_g + Z_o} \right| = 1$$

determines a circle on both the S_{22g} and S_{33g} planes, where S_{22g} and S_{33g} are the input reflection at the drain and the source ports, respectively. For the frequency of 10 GHz, these $|\Gamma_g| = 1$ circles are shown in Fig. 2. It can be seen that for Z_g values ranging from j50 to j100 ohms, both the values of $|S_{22g}|$ and $|S_{33g}|$ are greater than unity. That is, when the gate port is terminated with a certain inductive reactance, a negative resistance will appear at both drain and source terminals, and the oscillation will possibly take place. We have chosen Z_g=j62.3 ohms corresponding to an inductance L_g = 0.96 nH terminated at the gate port.

Under this condition, let's further consider the case that an impedance Z_s is connected to the source terminals and the drain taken as the output port. In this case, the circles for $|S'_{22g}|$ = constant on the plane of Γ_s [$=(Z_s-Z_o)/(Z_s+Z_o)$] are shown in Fig. 3, where S'_{22g} is the input reflection factor at the drain port. It is clear that most of the reactance Z_s that causes $|S'_{22g}|$ to be larger than unity (hence the oscillation) falls into the capacitive area, whereas the area in which the oscillation can be realized with an inductive reactance is much smaller. We hope that the source port is terminated with an inductance for the convenience of applying the DC bias voltage.

In a similar manner, consider the case that an impedance Z_d is connected to the drain terminals and the source taken as the output port. The circles for $|S'_{33g}|$ = constant on the plane of Γ_d[$=(Z_d-Z_o)/(Z_d+Z_o)$] are shown in Fig. 4, where S'_{33g} is the input reflection factor at the source port. It is evident that these circles are located in the desired inductive region of Z_d, and $|S'_{33g}|$ is much higher than that $|S'_{22g}|$ so that much higher output power can be obtained in the source output rather than in the drain output case.

Based on the above analysis, the monolithic oscillators were fabricated using the given MESFETs. The inductor values connected to the gate and drain terminals are 0.96 nH and 1.71 nH, respectively. The source acts as the output port. Lumped elements are employed in the circuits. The size of the chip is 1.06 x 1.0 x 0.02 mm^3 shown in Fig. 5. The measurements have shown that the monolithic oscillators mentioned here can give output powers on the order of mW in the frequency range of 8-11 GHz. The output power of 30 mW is obtained at 10.3 GHz with an efficiency of 11%, and 40 mW at 8.2 GHz with an efficiency of 15%.

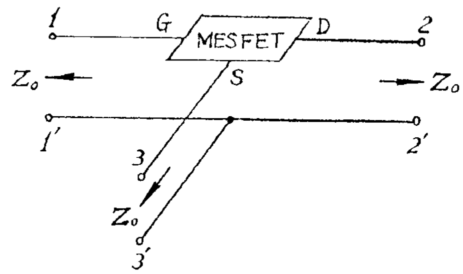

Fig. 1. MESFET 3-port network

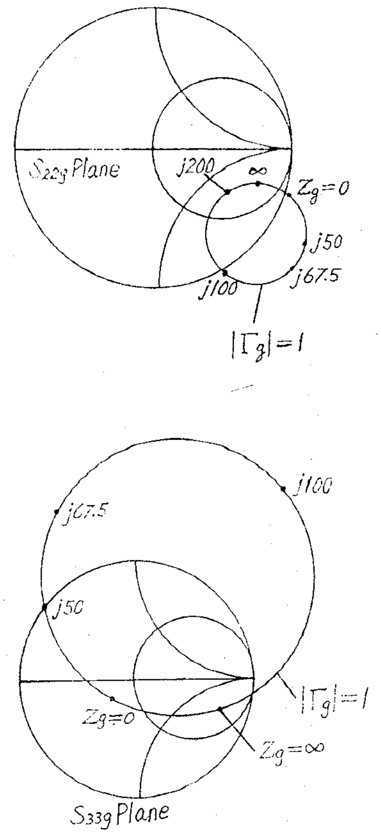

Fig. 2. $|\Gamma_g|$ = 1 circle on the plane of S_{22g} and S_{33g}

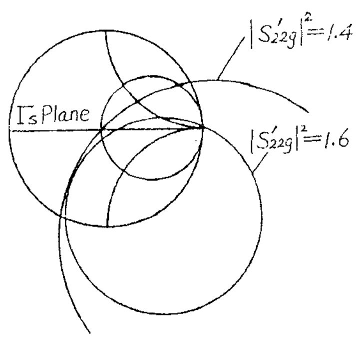

Fig. 3. $|S'_{22g}|$ = constant circles on the plane of Γ_s

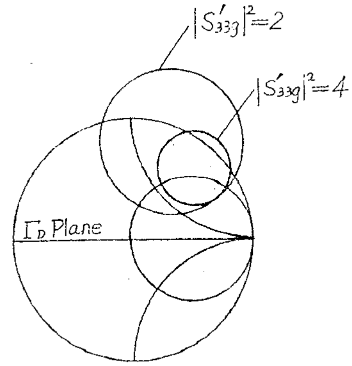

Fig. 4. $|S'_{33g}|$ = constant circles on the plane of Γ_d

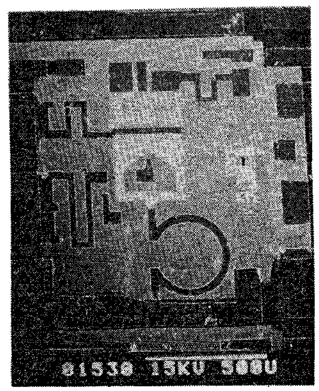

Fig. 5. The chip of the monolithic oscillator