A 115 GHz MONOLITHIC GaAs FET OSCILLATOR

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ABSTRACT

A monolithic GaAs FET oscillator with an operating frequency as high as 115 GHz has been demonstrated. A 75 μm x 0.2 μm GaAs FET with monolithic feedback and matching elements was used for the oscillator design. The chip size is 28 mils x 35 mils x 4 mils.

INTRODUCTION

Advantages of millimeter-wave systems, such as broad bandwidth, high spatial resolution, low probability of intercept, and ability to penetrate smoke and dust, have stimulated the research and development of solid-state sources for system applications. Until recently, these sources have been dominated by two-terminal devices, such as IMPATTs and Gunn diodes. This is especially true for operating frequencies higher than 60 GHz. While these devices can generate considerably more power than the GaAs FETs can, it is difficult to monolithically integrate these two-terminal devices with other components such as mixers, switches, and IF amplifiers in a subsystem. For millimeter-wave systems operating in the 70 to 110 GHz frequency range, there is a need for a planar source for local oscillator applications. The intensive development of millimeter-wave GaAs FETs not only extended the amplifier performance to 60 GHz [1] but also resulted in oscillators operating as high as 110 GHz.[2,3] Continued progress in the development of millimeter-wave FETs will certainly make the FET devices attractive in local oscillator applications through W-band. Since it is also compatible with monolithic integration of other FET based receiver components such as mixer, low-noise preamplifier, and IF amplifier, the use of the FET as the oscillating element will eventually lead to a "receiver-on-a-chip" for emerging millimeter-wave systems. In this paper, the design and performance of the first monolithic GaAs FET oscillator operating beyond 110 GHz are reported.

OSCILLATOR DESIGN

The W-band GaAs FET oscillator described in this paper is a monolithic version of the hybrid oscillator reported in Reference 2. A 75 μm x 0.2 μm GaAs FET was used for the monolithic oscillator design. Details of the device design were reported previously.[1,2] It was a single gate stripe FET with an electron-beam defined gate using MBE grown material. Figure 1 shows the circuit topology of the monolithic oscillator. A common-gate configuration with a high-impedance gate feedback transmission line was used. Two sections of transmission lines were symmetrically connected from each end of the FET sources to a MIM rf by-pass capacitor. The drain output was designed for a 50-ohm load. The gate bias was introduced through the low-impedance point of the gate circuit (by-pass MIM capacitor). For the drain bias choke, a combination of MIM capacitor and quarter-wave high-impedance line was used. An appropriate device model derived from S-parameter measurements of a similar device was used for the oscillator design using CAD techniques. The computed negative conductance at the drain is shown in Figure 2. It is shown that a peak in the negative conductance exists. Figure 3 shows a photograph of the oscillator chip. Key features of the oscillator are indicated. Figure 4 shows the SEM photograph of the gate region. The chip size is 28 mils x 35 mils x 4 mils. Conventional MMIC fabrication techniques with silicon nitride as the capacitor dielectric were used.

OSCILLATOR PERFORMANCE

An antipodal microstrip-to-waveguide transition was used for testing the oscillator in a W-band waveguide circuit. Oscillation frequencies in the 90 to 115 GHz frequency range has been observed. With a drain bias of 3 to 4 volts, the output power was about 0.1 mW. Further device structure and circuit optimization should result in a much higher output power. Bias tuning capability of the oscillator was also measured. Figures 5 and 6 show the tuning range versus the gate and drain bias. A tuning range of ~ 250 MHz was achieved with the gate bias tuning. It should be noted that over part of the tuning curve, extremely linear tuning can be obtained. The highest oscillating frequency observed was 115 GHz. Figure 7 shows the spectrum analyzer display. This is the first time a monolithic GaAs FET oscillator with an operating frequency as high as 115 GHz has been reported. The highest frequency previously reported for a monolithic GaAs FET oscillator was 69 GHz.[3]

CONCLUSIONS

A monolithic GaAs FET oscillator with operating frequency as high as 115 GHz has been demonstrated. With further device and circuit optimizations, output power can be improved to a level suitable for local oscillator application. This monolithic GaAs FET oscillator can eventually be integrated with other FET

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based receiver components on the same chip for EW and communication applications at around 100 GHz.

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2. H. Q. Tserng and B. Kim, "110 GHz GaAs FET oscillator," Electronic Letters, vol. 21, No.5, 28th Feb., 1985, pp. 178-179.

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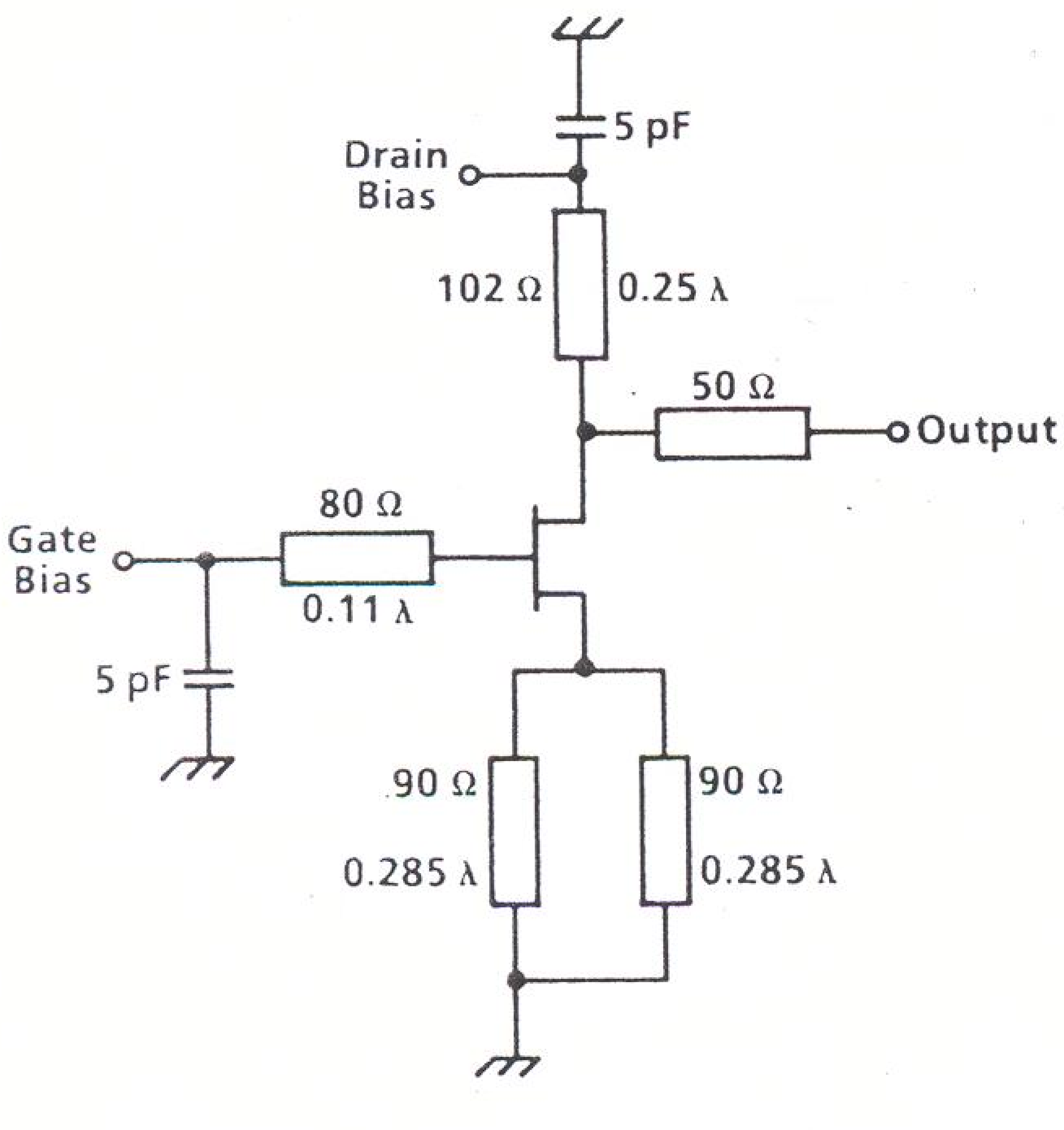

Figure 1. Circuit Topology of W-Band Monolithic GaAs FET Oscillator

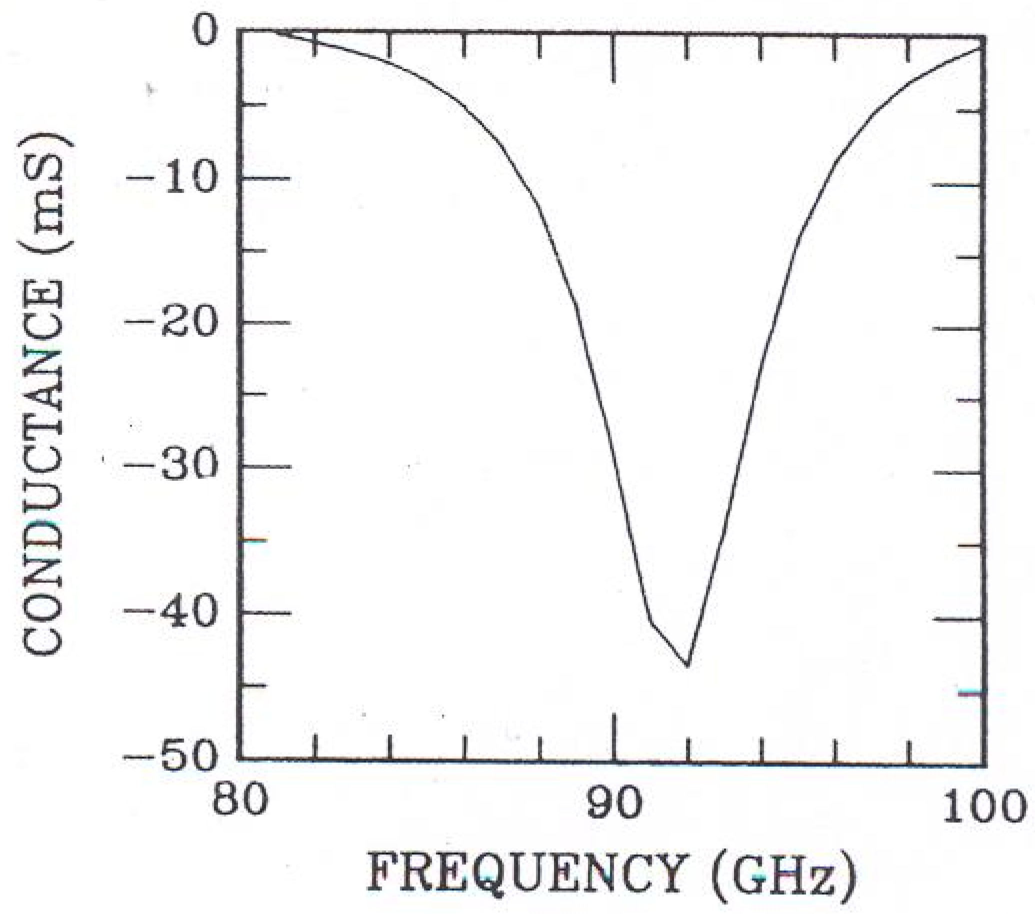

Figure 2. Computed Negative Conductance of a Monolithic Oscillator

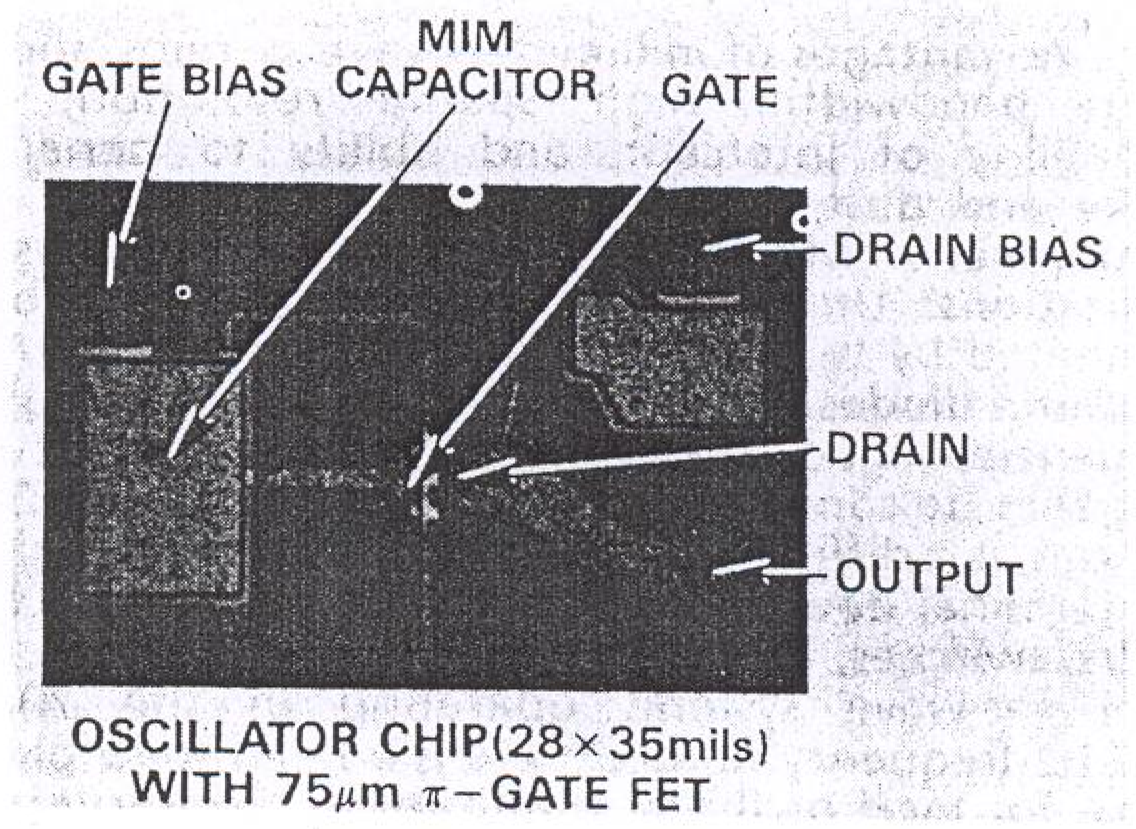

Figure 3. Photograph of a W-Band Monolithic Oscillator Chip

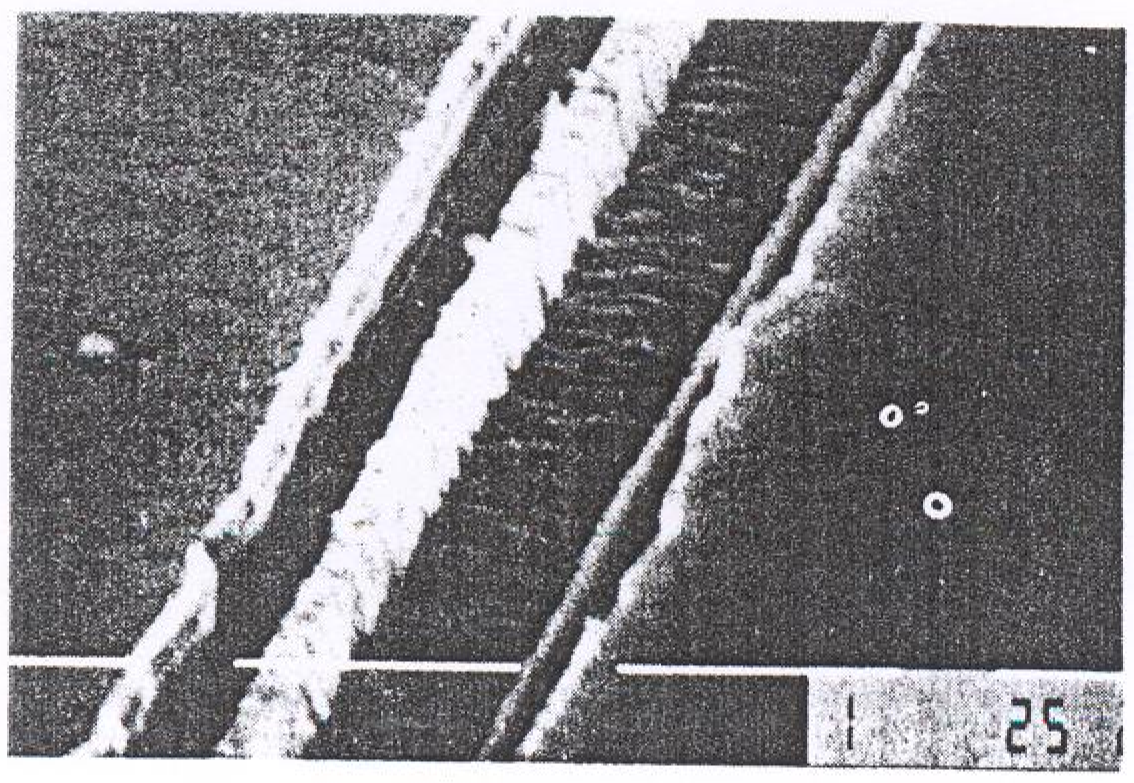

Figure 4. SEM Photograph of the Gate Region of the FET

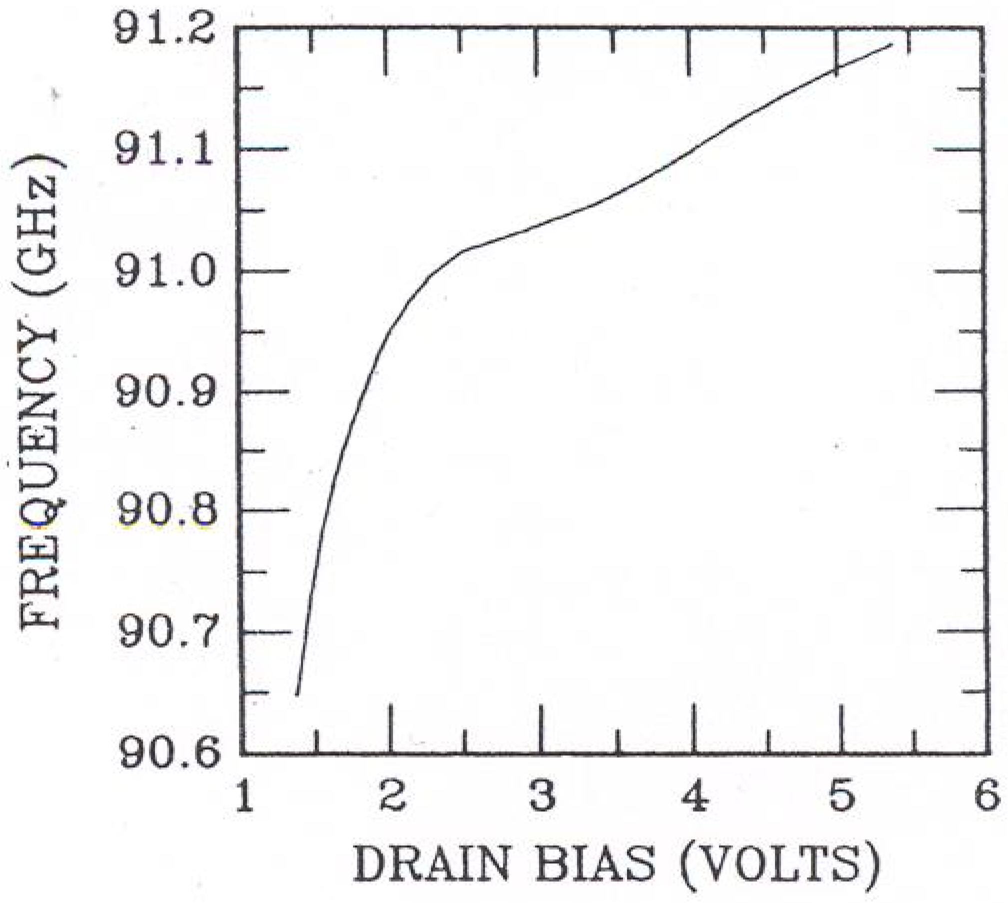

Figure 6. Oscillation Frequency versus Drain Bias

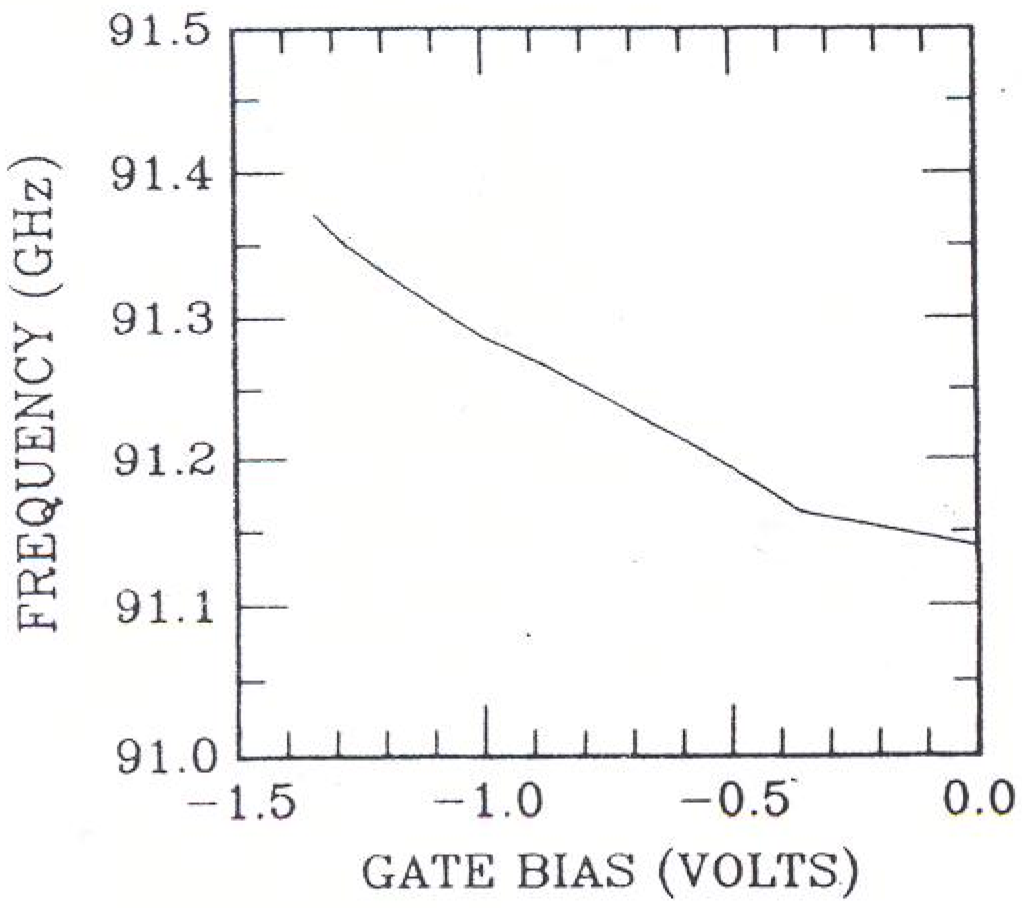

Figure 5. Oscillation Frequency versus Gate Bias

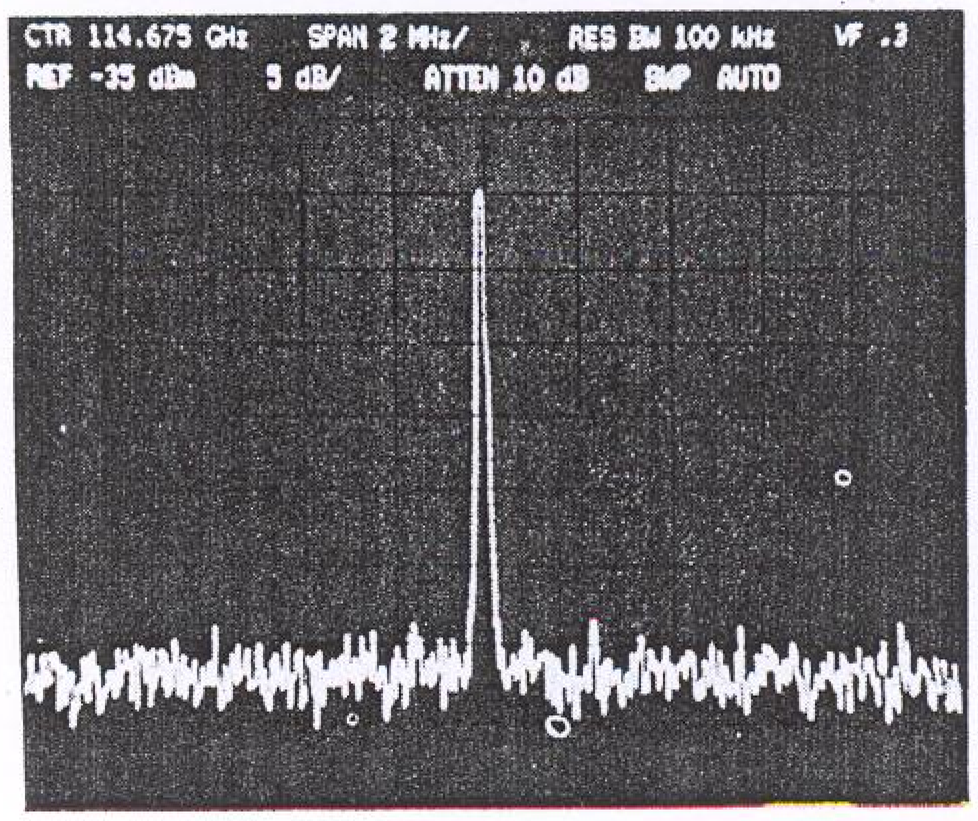

Figure 7. Spectrum Analyzer Display of a Monolithic GaAs FET Oscillator