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W-BAND MICROSTRIP OSCILLATOR USING InP GUNN DIODE

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ABSTRACT

A low cost, light weight, rugged microstrip oscillator with a very simple structure has been developed in W-Band (94 GHz). The active element is an InP Gunn device operating in its fundamental mode of oscillation. The oscillator provides 35 mW of CW output power and a bias tuning bandwidth of 400 MHz.

INTRODUCTION

In recent years, there has been considerable interest in the development of millimeter wave integrated circuit components and subsystems. The present trend is to concentrate on planar integrated circuits for low-cost system requirements. This planar technology is attractive due to its light weight and small size as well as its potential for high-volume, repeatable manufacturing.

One area, however, that needs increased attention is the development of W-Band integrated circuit oscillators. To date, most W-Band oscillators are fabricated in waveguide and use GaAs Gunn diodes. However, GaAs Gunn devices operating in W-Band suffer from low efficiency and low power output, due to their second harmonic mode(1), (2) of operation. InP Gunn devices show significant potential for such oscillator applications due to their superior performance, primarily higher efficiency(3) and fundamental mode of oscillation (4). This paper describes the design and performance of a simple, state-of-the-art microstrip oscillator built on a soft substrate using InP Gunn diodes.

CIRCUIT DESIGN

The microstrip circuit was fabricated on a 5 mil thick Cu-Flon ($\epsilon_r = 2.0$) substrate. This substrate material, rather than the traditional quartz, was selected for its low loss at millimeter frequencies, ease of handling, and low cost(5). Furthermore, the measured microstrip losses (approximately 1.0db/inch) are comparable to that achieved with a quartz substrate. The oscillator consists of a microstrip circuit pattern fabricated on the substrate and a packaged InP Gunn diode. The circuit is enclosed in a narrow rectangular channel and placed in a gold-plated brass housing. Dimensions of the channel are selected to be sufficiently small to prevent propagation of higher order modes(6), and the channel is shielded by a conducting cover to eliminate radiation losses. The overall circuit layout is shown in Figure 1.

A simple estimate of the device impedance was made by extrapolating lower-frequency models and by calculating the effects of the package. For the Gunn device used, this yielded an inductive impedance, the real part of which is about 5 ohms, at 94.0 GHz. This relatively high device impedance makes it easier to realize an efficient matching network to extract power from the device. The complex impedance is matched to a 50 ohm microstrip transmission line by a combination of shunt resonator, three section matching transformers, and a radial hat which is attached to the diode cap as indicated in Figure 1. The operating frequency of the oscillator is controlled by the length of the shunt resonator. DC connection is made to the device via a two section bias filter connected to one of the transformers. A coupled line section, which forms one of the transformers, acts as a DC block.

For testing purposes, waveguide to microstrip transitions were used. These can be eliminated if the oscillator is to be interfaced with other integrated circuit components. Broadband cosine tapered ridge-guide transitions were developed for this purpose(7). Measured loss of a typical transition is less than 1.0 dB one-way. The total circuit loss, including the transitions, was estimated to be 1.75 dB.

PERFORMANCE

Figure 2 shows the experimental W-Band oscillator. Figure 3 shows the measured output power and frequency, at the waveguide flange, of the microstrip oscillator as a function of bias voltage. The maximum output power measured was 35 mW at 92.0 GHz with a DC-RF efficiency of 1.2%. The bias tuning bandwidth was 400 MHz for a power variation of 2.0 dB. Calculation of the actual power generated by the diode indicated about 50 mW

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of power at a conversion efficiency of 1.7%. Since the InP diode was rated at 51 mW in a waveguide cavity, this shows that the microstrip circuit extracted almost 100% of the maximum available diode power. It was also found that the oscillator frequency can be readily changed by trimming the length of the shunt resonator, whereas the radial hat was used for maximizing the power output. A fairly linear bias tuning characteristic, useful for FMCW transceiver applications, is illustrated in Figure 3.

CONCLUSION

This paper has described a state-of-the-art microstrip integrated circuit oscillator using an InP Gunn diode operating in W-Band. The oscillator demonstrated a maximum power output of 35 mW at 92 GHz with a bias tuning bandwidth of 400 MHz. The oscillator performance is adequate for many systems applications and offers the advantages of light weight, compact structure, and ease of integration.

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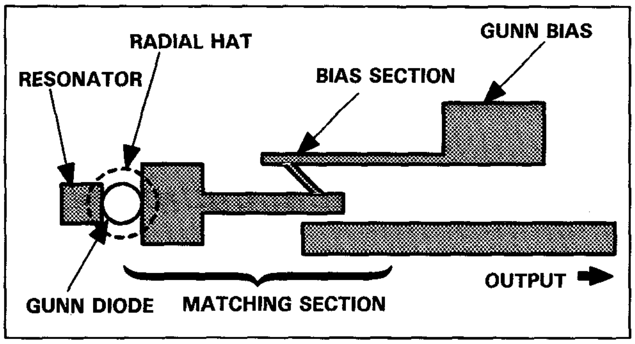

Figure 1. W-Band Microstrip Oscillator Circuit Layout

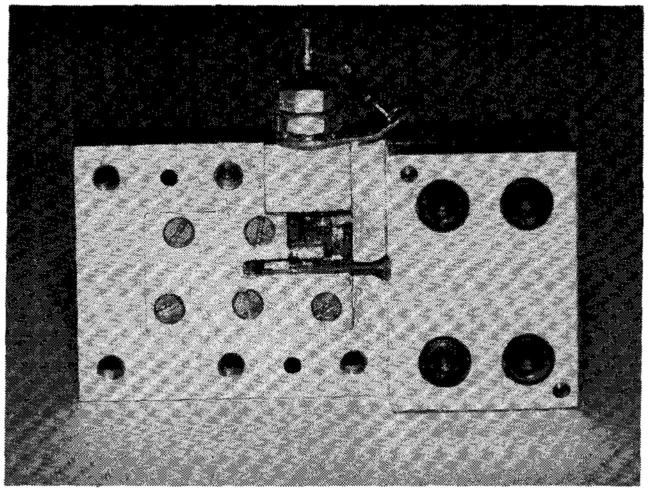

Figure 2. Complete W-Band Microstrip Oscillator In Test Housing

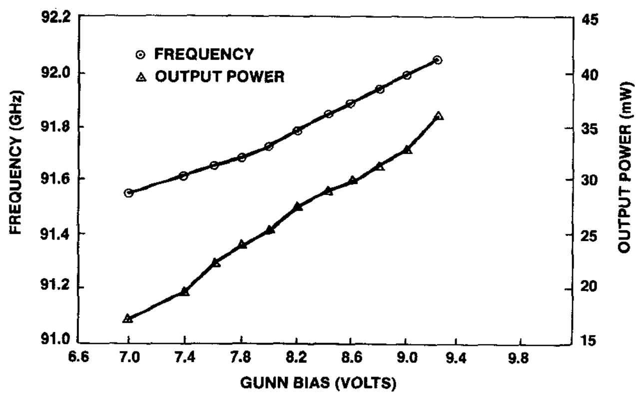

Figure 3. Output Power and Frequency vs Gunn Bias For W-Band Microstrip Oscillator