A NOVEL VARACTOR TUNABLE COPLANAR WAVEGUIDE-SLOTLINE GUNN VCO*

Julio A. Navarro, Yong-Hui Shu† and Kai Chang

Department of Electrical Engineering
Texas A&M University
College Station, Texas 77843-3128

ABSTRACT

A novel varactor tunable CPW-slotline Gunn VCO has been developed. The oscillator provides 16.3 ±0.45 dBm throughout a 300 MHz tuning range centered at 10.40 GHz. The signal quality and stability are very good throughout the tuning range. The circuit is small and lightweight and offers low cost, good reproducibility and excellent performance.

I. INTRODUCTION

Considerable effort has been directed toward the development of microwave and millimeter-wave hybrid and monolithic integrated circuits. These circuits include mixers, receivers and transmitters. A common component in these applications is the local oscillator. Several good oscillator designs have been proposed [1]-[3]. Each of these designs offers some electronic tuning, fairly good signal quality and reasonable stability. This paper presents an alternative hybrid circuit design which integrates a Gunn and varactor diode with a CPW and slotline to create a planar VCO.

The VCO incorporates a CPW-slotline resonator, slotline-to-microstrip transition and a slotline low-pass filter. The planar design can be easily scaled to millimeter-wave bands and is suitable for monolithic circuit implementation. The VCO exhibits an electronic tuning bandwidth from 10.25 to 10.55 GHz with an output power of 16.3 ±0.45 dBm. The spectral purity and stability are comparable to waveguide and dielectric resonator stabilized microstrip oscillators.

The circuit offers many advantages which include low cost, simplicity, small size, moderate electronic tuning range, good stability and excellent performance. Although Gunn and varactor diodes were used here, other active devices can also be used. Due to their planar nature, these circuits are amenable to monolithic implementation and offer many applications in radar, communications and electronic warfare systems.

II. CIRCUIT DESIGN AND MODELING

The configuration of the varactor-tunable CPW-Slotline Gunn VCO is shown in Figure 1. The circuit integrates a Gunn and a varactor diode with a CPW-slotline resonator, slotline-to-microstrip transition and a slotline low-pass filter. The CPW-slotline resonator provides several DC-blocked areas for biasing the Gunn and varactor diodes. The resonator also acts as a stabilized circuit to the oscillator. The varactor is coupled to the resonator and efficiently tunes the circuit. Slotline is used to couple energy from the resonator into a slotline-to-microstrip transition. Due to device biasing, the slotline could not be terminated in a short circuit. Since a slotline open circuit tends to radiate, a slotline low-pass filter was used as an RF choke. The output power is extracted from the microstrip line via an SMA connector.

The equivalent circuit model is shown in Figure 2. A computer program based on the equivalent circuit was developed and used to optimize the performance of the components of the oscillator. The characteristic impedances of the CPW, slotline and microstrip lines are Z_{co}, Z_{so} and Z_{mo}, respectively. Z_{co} and Z_{mo} are 50 Ω while Z_{so} is 75 Ω. The low impedance (Z_L) and the high impedance (Z_H) values used in the slotline low-pass filter design are 75 and 300 Ω, respectively. The optimized lengths of the transmission lines are listed in Table I.

III. EXPERIMENTAL RESULTS

Packaged Gunn (MA49106) and varactor (MA46602F) diodes from M/A COM were used for the circuit integration. The Gunn diode was rated at 80 mW in an optimized waveguide cavity while the varactor was rated at 1.6 pF at 0 Volts. The circuit was fabricated on a 25 mil (0.635 mm) thick RT-Duroid 6010.5 substrate. A photo of the circuit and housing is shown in Figure 3 (Note that this circuit does not require feed-through capacitors).

Figure 4 shows the varactor tuning voltage vs. frequency and power output of the novel VCO for a constant Gunn diode bias voltage of 13.5 Volts. Varactor voltages ranging from 0 to 30 Volts introduce a continuous and nearly linear tuning range from 10.25 to 10.55 GHz. There are no mode jumps in the electronic tuning range, the signal spectrum remains clean and very stable as shown in Figure 5 with a nearly constant power output of 16.3 ±0.45 dBm.

IV. CONCLUSIONS

A novel varactor tunable Gunn VCO has been developed with a 300 MHz electronic tuning bandwidth centered at 10.40 GHz and a nearly constant power output of

*Patent Pending
†Y. Shu is now with Epsilon Lambda Electronics Corp., Geneva, IL 60134

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16.3 ±0.45 dBm. The spectral purity and signal stability are very good throughout the tuning range. This circuit offers a small, simple, lightweight, low-cost, reproducible and truly planar tunable source for many microwave applications. The varactor tuning range should prove useful for frequency modulated communication links, frequency-agile transmitters or local oscillators and electronic warfare applications. The circuits are amenable to monolithic circuit integration for mass production and scaling up to millimeter-wave bands.

V. ACKNOWLEDGEMENTS

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$Z_{co} = 50\ \Omega$, $Z_{so} = 75\ \Omega$, $Z_{mo} = 50\ \Omega$, $Z_L = 75\ \Omega$, $Z_H = 300\ \Omega$

Variable	L_0	L_1	L_2	L_3	L_4	L_5	L_c	L_m
mm	5.98	2.00	1.55	3.70	5.16	3.70	6.00	3.71

Table I. Optimized Lengths of the CPW-Slotline Gunn VCO

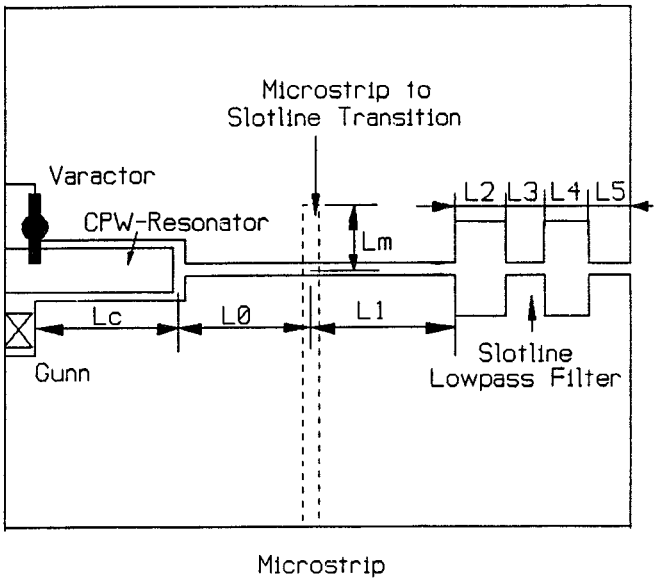

Fig. 1. The Varactor-tuned CPW-Slotline Gunn VCO Configuration

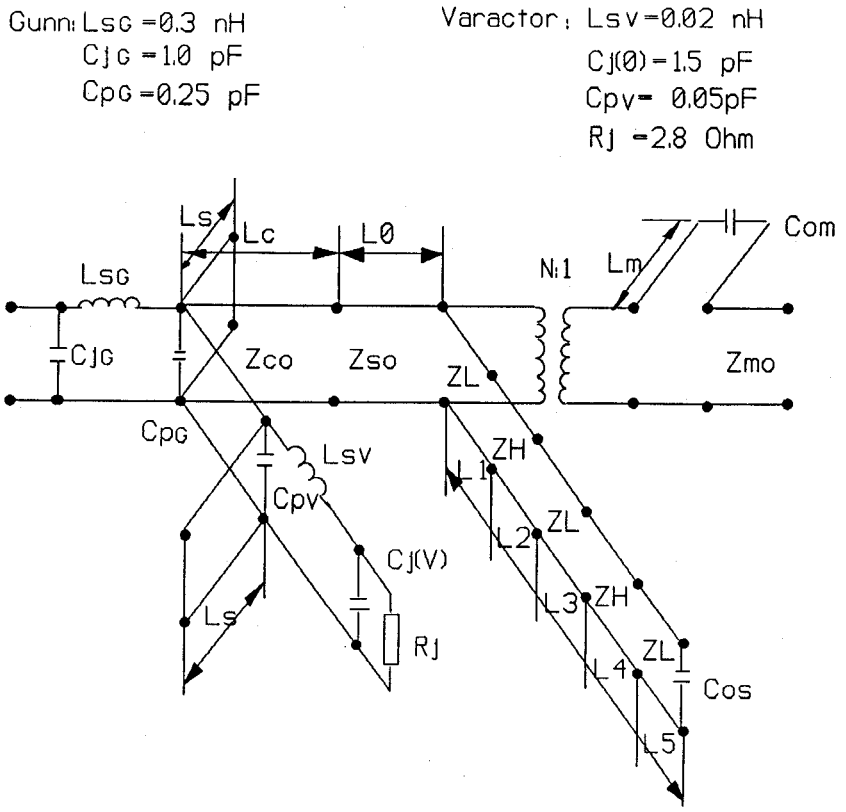

Figure 2. The Varactor-tuned CPW-Slotline Gunn VCO Circuit Model

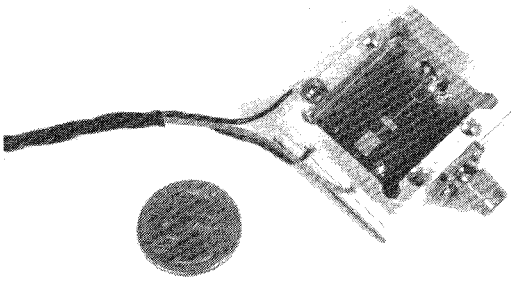

Figure 3. A Photograph of the Varactor-tuned CPW-Slotline Gunn VCO

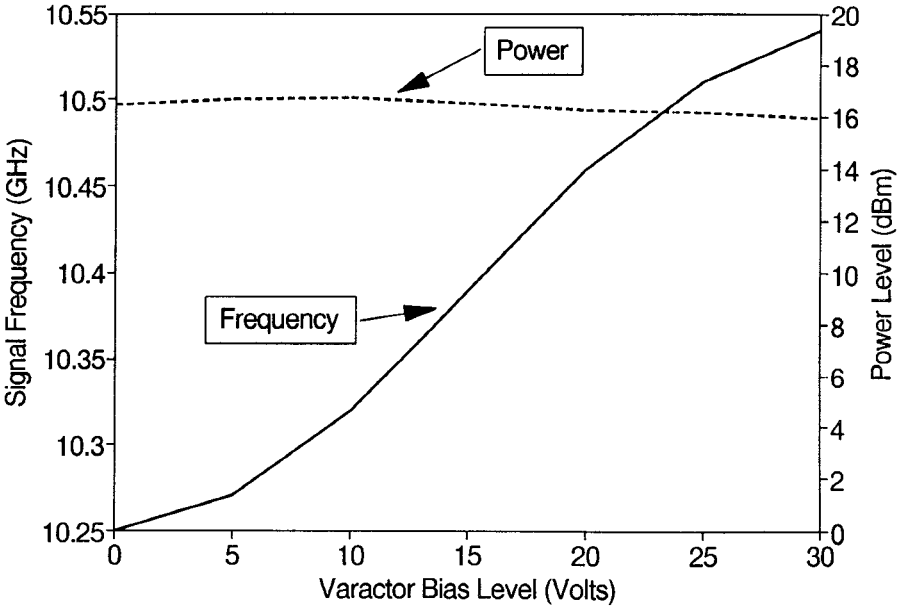

Figure 4. Varactor Bias Voltage vs. Frequency and Power Output

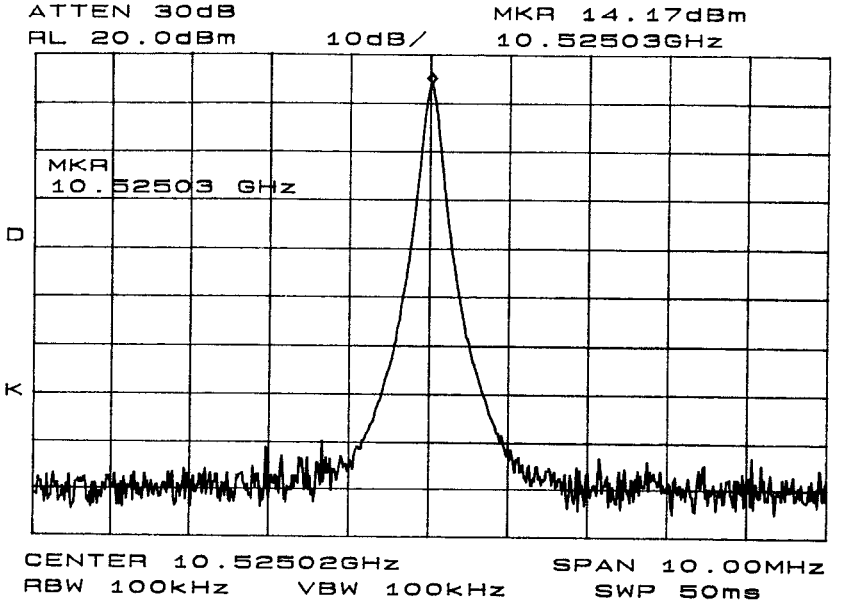

Figure 5. The Varactor-tuned CPW-Slotline Gunn VCO Spectrum