A Novel Microwave Oscillator using Double-Sided MIC

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Abstract **— A novel microwave feedback oscillator utilized advantages of "double-sided MIC" is proposed. The oscillator is formed incorporating microstrip lines on a dielectric substrate and CPW on a reverse side with no via holes. The fabricated and demonstrated oscillator exhibits the output power of 9.17dBm and the harmonic suppression is –45 dBc at X-band. The phase noise performance is –114.5 dBc/Hz at the offset frequency of 1 MHz. The voltage controlled oscillators and sub-harmonic injection locked oscillators can be easily realized up to millimeter wave band.**

I. INTRODUCTION

Recently, the communication networks are getting to be high-speed broadband; the demand of higher frequency band is increasing up to millimeter wave. The oscillator plays an important role and comparatively costly functional circuit. Various kinds of MIC and MMIC microwave oscillators have been developed so far, but a lot of problems on the cost and the characteristics are left.

By using the technical feature of double-sided MIC [1], this paper proposes a novel microwave oscillator, which has following technical points,

1)Employing coplanar waveguides in addition to microstrip lines to compose the oscillator.

2)Regulating the feedback characteristics due to the combination effects of the different kinds of transmission lines.

3)Bare chip bonding or surface mount bonding on the coplanar waveguides are almost perfectly, then the circuit structure is very suited for high frequency oscillation.

The oscillator incorporates electromagnetic coupling between top and bottom sides of substrate with no via holes. Since the circuit structure is very simple and also has much design flexibility, voltage-controlled oscillators and sub-harmonic injection locked oscillators can be easily realized up to millimeter wave band.

II. OSCILLATOR DESIGN

Fig.1 shows the circuit pattern of the oscillator, as well as the cross sections. The microstrip lines are arranged on a dielectric substrate, coplanar waveguides on a reverse side. The amplifier is mounted on the coplanar waveguides. There are three points of electromagnetic coupling (A, B, C part in Fig.1) between microstrip lines and coplanar waveguides. The amplified signal is transmitted through the electromagnetic coupling A to looped microstrip line as shown in fig.1. The signal is transferred to point B, back to the input of amplifier. In order to realize the positive feedback for the oscillation, the frequency is designed by the electrical length of coplanar waveguide, microstrip lines and the amplifier, which is designed to be ($2\pi \times n$) at the oscillating frequency. The tight coupling at coupling B is needed for the stable oscillation, and then the coplanar waveguides at the amplifier input port has a quarter open-ended wavelength. To adjust the feedback gain, a microstrip open-stub is connected at the point B. The oscillating signal is available at C through the electromagnetic coupling between coplanar waveguides and microstrip line. The characteristics of this circuit are described as follow.

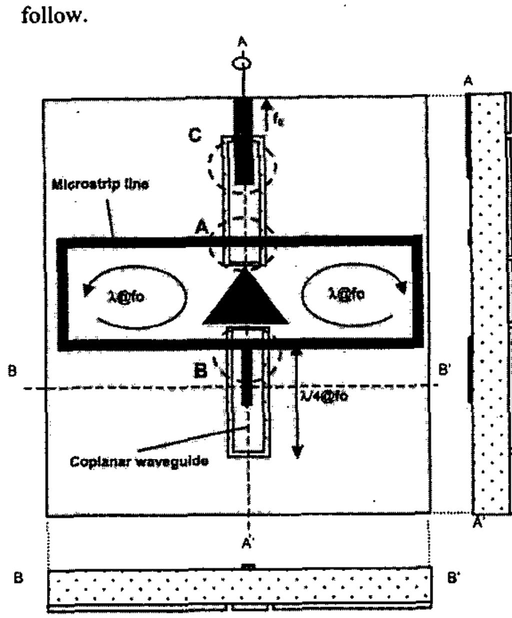

Fig.1. Circuit pattern of the proposed oscillator using double-sided MIC technology.

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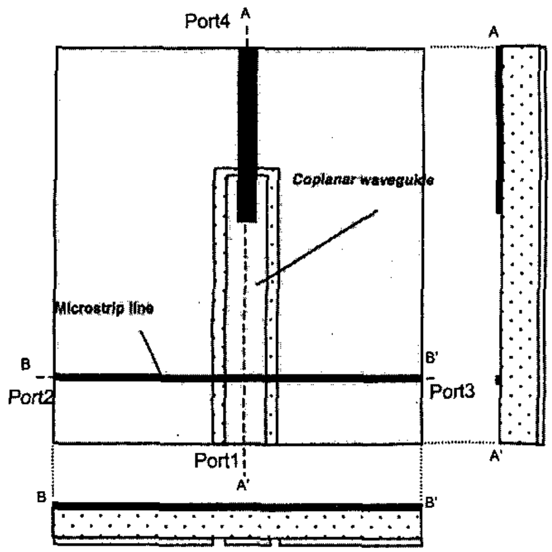


Fig.2. Simulation model of the electromagnetic coupling

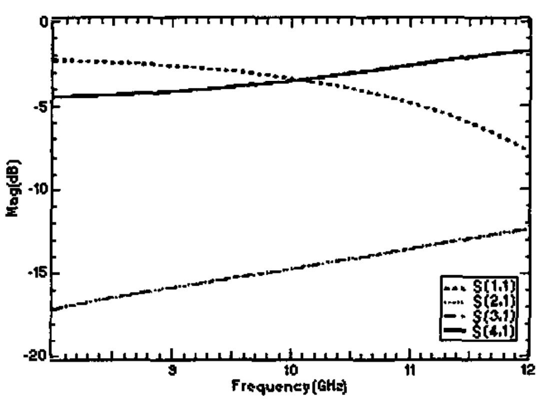


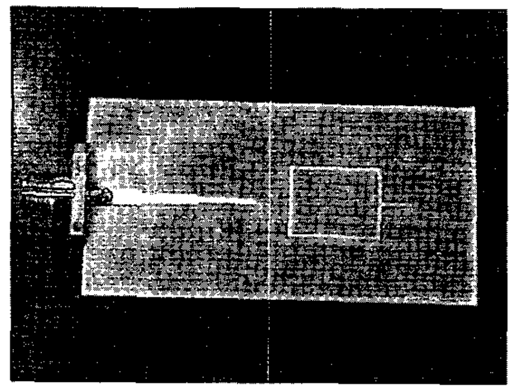
Fig.3. The characteristics of the circuit shown in Fig.2.

(i) Grounding the amplifier is almost perfect, because the amplifier is mounted on the coplanar waveguides.
(ii) The electromagnetic couplings are employed in this oscillator so that there is no need of via holes, which has not undesired parasitic effect.
(iii) The oscillator consists of microstrip lines, coplanar waveguides and an amplifier for microwave and millimeter wave, which can be easily realized. Besides, this circuit structure is suited to achieve voltage-controlled oscillators or sub-harmonic injection locked oscillators. For instance, by mounting a varactor diode on the feedback loop, a voltage-controlled oscillator can be easily realized.

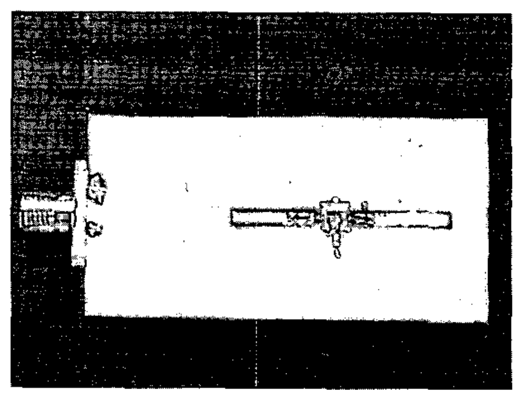
The characteristics of the oscillator depend on feedback gain. As an example of electromagnetic coupling, the performance at A point described below. Figure 2 and 3 show the electromagnetic coupling characteristics. S_{21}, S_{31} in Fig.3 is coupling between coplanar waveguides and microstrip line. S_{41} in Fig.3 is the coupling from coplanar waveguides to the microstrip line at the output port. The coupling to the looped microstrip line is less than –10 dB, which is comparatively sparse.

III. EXPERIMENT RESULT

The oscillator using double-sided MIC technology at X-band is designed and fabricated. The dielectric substrate is Teflon (dielectric constant ε_r=2.15). The substrate thickness is 0.8 mm. The amplifier used here is µPG110B (NEC Corp.). Fig.4 shows photographs of microstrip surface and coplanar waveguides pattern on the reverse side. The circuit size is 35 x 50 mm^2.

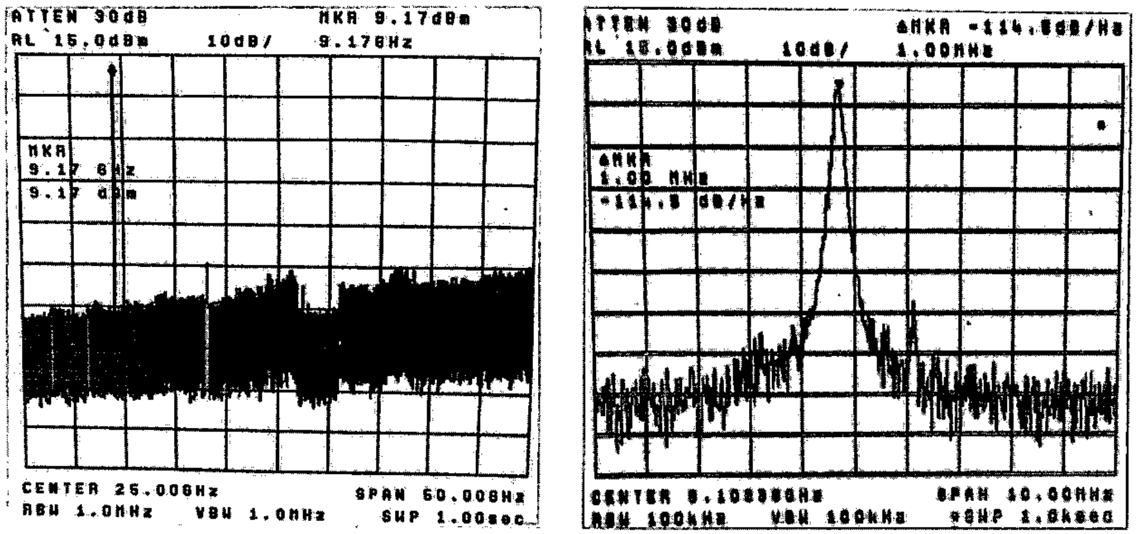


(a)



(b)

Fig.4. X-band oscillator (a) microstrip line surface, (b) coplanar waveguides surface on the reverse side.



(a) (b)

Fig.5 Output power spectrum of the oscillator (a) full range of 50GHz, (b) power spectrum for phase noise estimation

Fig.5 (a) is the output spectrum in the full range of 50 GHz, and Fig.5 (b) is the power spectrum to estimate the phase noise. HP8565EC spectrum analyzer is used for the measurement. Bias voltage of this oscillator is 5.0 V. The oscillator frequency is 9.17 GHz with the output power of 9.17 dBm. The phase noise is –114.5 dBc/Hz at the offset frequency of 1 MHz, which is comparatively excellent phase noise at X-band.

It should be noted that undesired harmonic signals are excellently suppressed, less than –45 dBc. This is the remarkable feature of this oscillator.

IV. Conclusion

A novel microwave oscillator is proposed, which utilized the feature of double-sided MIC technology. This circuit is very simple and employs electromagnetic coupling between both sides of substrate. As a result, there is no via holes, and it is very suited for high frequency band oscillator. The oscillator is designed and fabricated at X-band. The experimental result shows very excellent oscillating performance. In particular, undesired harmonic signals are sufficiently suppress in a very wide frequency band. The harmonic signal is less than –45 dBc. The phase noise is also very good, which is –114.5dBc/Hz at the offset frequency of 1 MHz.

The circuit structure is suited for realizing voltage-controlled oscillators as well as sub-harmonic injection locked oscillators. Moreover, this circuit can be monolithic- integrated using the three-dimensional MMIC technology [7] .

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