A 13-GHz YIG-FILM TUNED OSCILLATOR FOR VSAT APPLICATIONS

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Abstract

A 13 GHz tunable oscillator using YIG film grown by LPE has been developed.

A very low phase noise of -90 dBc/Hz at 10 KHz from the carrier has been achieved over the entire tuning range of 500 MHz. With the excellent linear tuning characteristic, this oscillator is ideal for use as a frequency agile synthesyzed local oscillator in VSAT.

Introduction

Today's Ku-band very small aperture terminal (VSAT) offers a new and extended capability for commercial satellite communication services.

We applied our microwave technology utilizing YIG film grown by LPE to develope a compact,low cost and high performance Ku-band tunable oscillator used in VSAT[1, 2,3]. As is noticed widely,local oscillator phase noise is a critical parameter in the bit error rate (BER) performance of a digital earth terminal[4].

From the high unloaded Q of the uniform precession mode of a YIG disk resonator,a very low phase noise of -90 dBc/Hz at 10 KHz from the carrier has been achieved over the entire tuning range of 500 MHz.

A compact magnetic circuit has been constructed of a permanent magnet suppling a dc magnetic field required to resonate the YIG disk at 13 GHz, and a small tuning coil covering the 500 MHz tuning range.

By the appropriate design of the gallium substitution in the YIG film,temperature compensation between the permanent magnet and the YIG disk has been achieved.

This approach enabled us to realize the YIG-tuned oscillator (YTO) of compact size, small power consumption for biasing field and rapid tuning response.

From the excellent low phase noise and the linear tuning characteristic,this oscillator is ideal for use as a frequency agile synthesized local oscillator in VSAT.

As the frequency agile synthesized local oscillator sellects the different chanells in the upconversion and downconversion RF sections, it makes the overall system construction of the earth terminal much simpler than that of the block conversion method using the fixed frequency dielectric resonator local oscillator (DRO).

This paper will first describe the fabrication of the tunable oscillator using YIG film. The design criteria of the YIG disk resonator and the biasing condition of GaAs FET to achieve the low phase noise and to avoid the high power instability will then be discussed. Finally, the tuning characteristic and the oscillator performance over temperature will be present.

Oscillator Fabrication

The schematic structure of the complete YIG film tuned oscillator and its circuit are illustrated in Fig.1 and Fig.2, respectively. The GaAs FET is in the common gate configuration with the source connected to the YIG disk resonator and the drain connected to the output matching circuit[5].

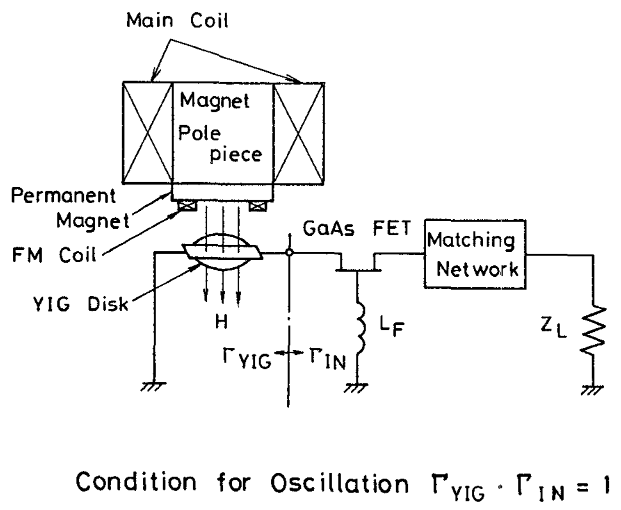

Fig.1 Schematic structure of the complete YTO

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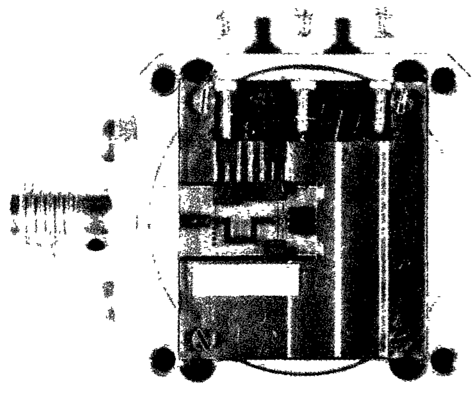

Fig.2 Oscillator MIC

Fig.3 shows trajectory of the inverse of the input small signal reflection coefficient Γ_{in} with frequency, and the typical frequency, and the typical reflection coefficient loop Γ_{yig} resonating at 13 GHz.

The condition for the onset of oscillation is that Γ_{in}^{-1} is encircled by Γ_{yig}, and the stable oscillation is realized when the condition $\Gamma_{in}^{-1}(\mathbf{A}) = \Gamma_{yig}$ is satisfied with the increase of signal level **A** of the GaAs FET. Suspended substrate stripline was adopted in order to avoid the spurious oscillation due to the feedback from the source line.

The YIG disk resonator was normally magnetized by the magnetic circuit.

A dc magnetic field of about 5600 Oe required to resonate YIG disk at 13 GHz was supplied by the permanent magnet, and a tuning magnetic field of about 180 Oe required to cover 500 MHz was supplied by the coil current.

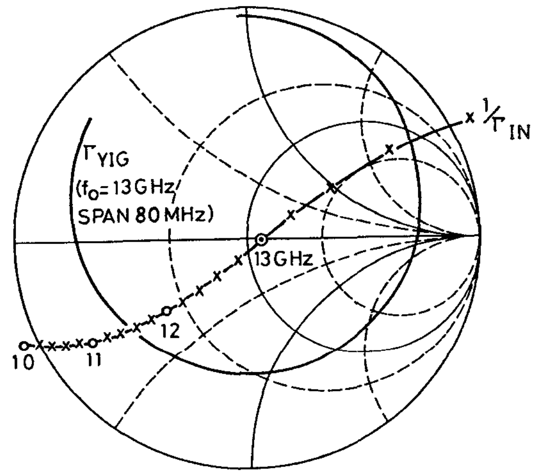

Fig.3 Reflection coefficient Γ_{yig} and the trajectory of Γ_{in}^{-1}

Design of YIG Disk Resonator

In order to obtain the low phase noise oscillator, the YIG disk resonator which shows the large change of the reflection coeffiecient Γ_{yig} with frequency is required. In this case, the electromagnetic energy stored in the YIG disk resonator becomes very large, and the YIG disk resonator suffers the high power instability [6].

In the practical realization of the YTO, we have to determine the YIG resonator compromising the low phase noise and the high power instability.

The phase noise performance and the high power instability were carefully evaluated between the oscillators with the different YIG resonators.

The YIG resonator, which has the following characteristics, was chosen as the best compromise.

The unloaded Q, loaded Q and the loop diameter of the resonator were 2900, 670 and 1.54, respectively, and the high power instability starts from the power level of 13 dBm.

Phase Noise Dependence on Bias Condition

The SSB phase noise and the high power instability were measured against the different bias conditions of the GaAs FET.

Fig.4 shows the change of the output power versus Vds under the constant Ids of 25 mA. The meshed region in the figure shows where the high power instabilities were observed. The output grows as the increase of Vds and finally enters in the instability region.

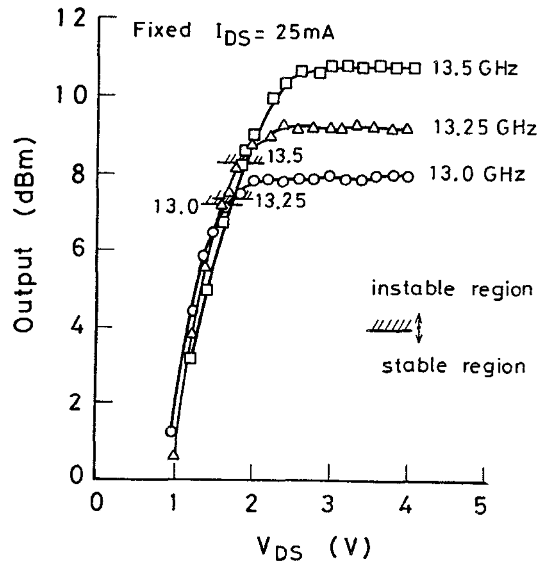

Fig.4 Power output versus Vds

From the results shown in Fig.4, Vds has been chosen at 1.7 volts where the oscillation shows the moderate output power of 6.6 dBm and does not suffer the high power instability.

Fig.5 shows the change of SSB phase noise versus Ids under the constant Vds of 1.7 volts. When the Ids was 25mA, SSB phase noise was below -90 dBc/Hz at 10 KHz offset over the entire tuning renge from 13 GHz to 13.5 GHz.

Fig.6 shows the measured SSB phase noise when the oscillator was tuned to 13 GHz, 13.25 GHz and 13.5GHz under the bias condition of Vds=1.7 volts and Ids=25mA.

Performance

The tuning characteristic of the oscillator is shown in Fig.7. The variation of the output power over the tuning range from 13 GHz to 13.5 GHz was less than 0.3 dB, and the hysteresis of the oscillation frequency was less than 1MHz.

Fig.8 shows the change of the oscillation frequency with temperature.

A small temperature drift of 10 MHz has been achieved from the temperature range from -30°C to +60°C.
The characteristics of the oscillator are summarized in Table 1.

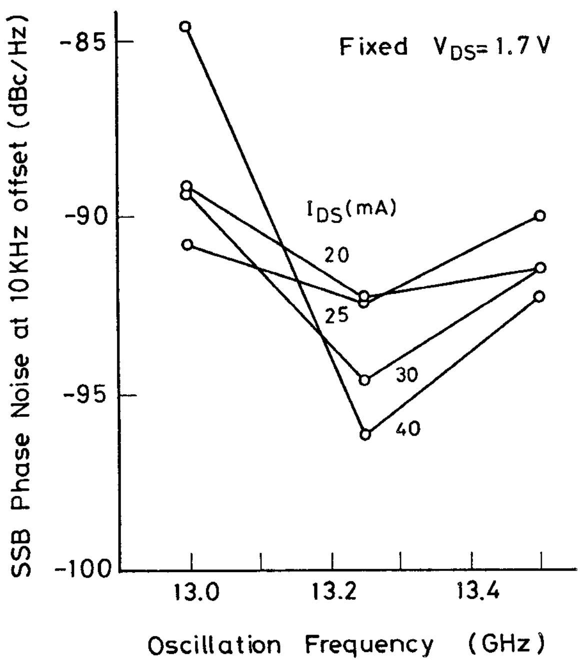

Fig.5 Ids dependence of SSB phase noise at 10 KHz offset for the 13 - 13.5 GHz band

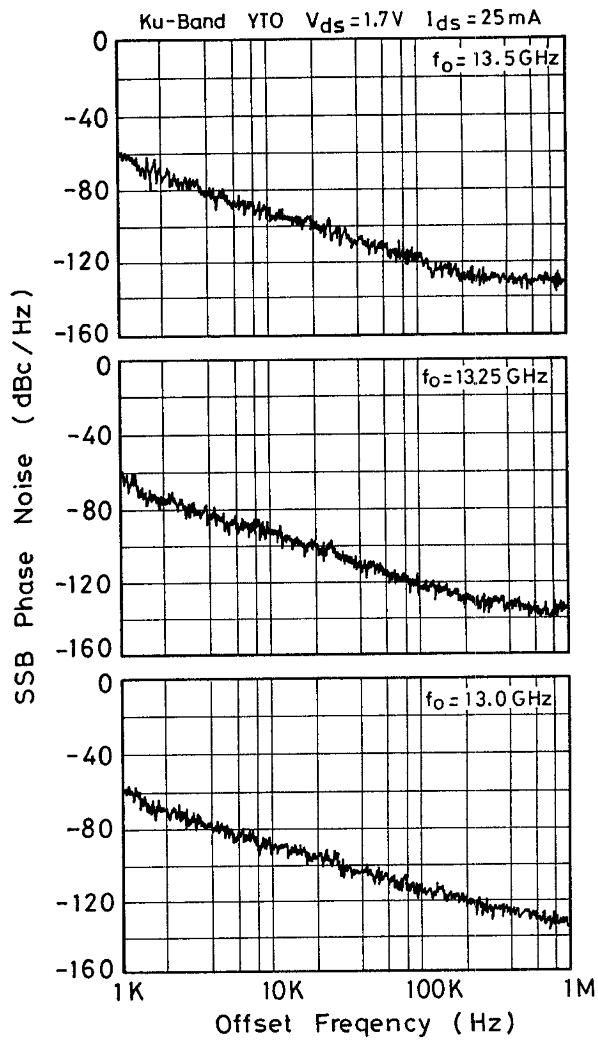

Fig.6 SSB phase noise for the 13 - 13.5 GHz band

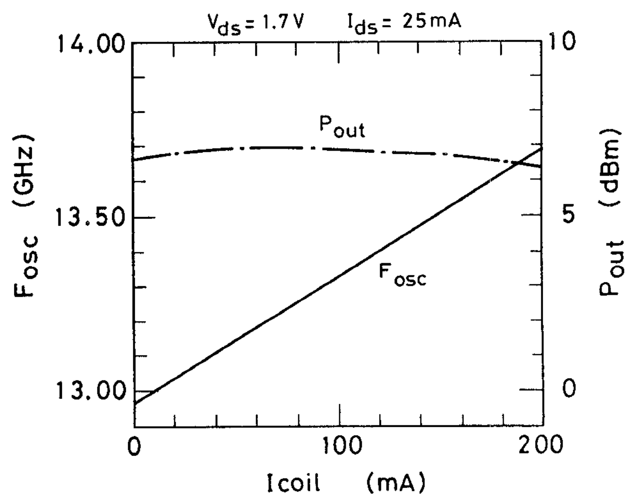

Fig.7 Tuning characteristic of the YTO

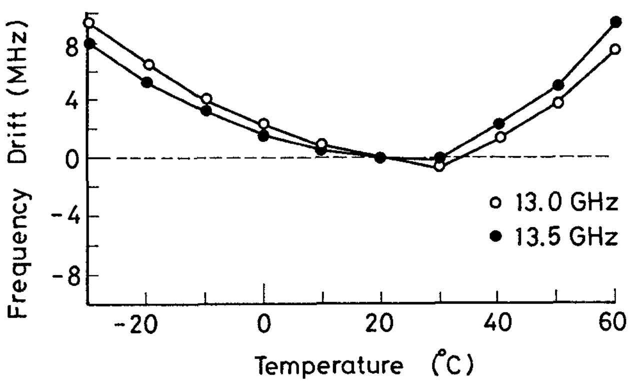

Fig.8 Temperature dependence of the YTO at 13 GHz and 13.5GHz

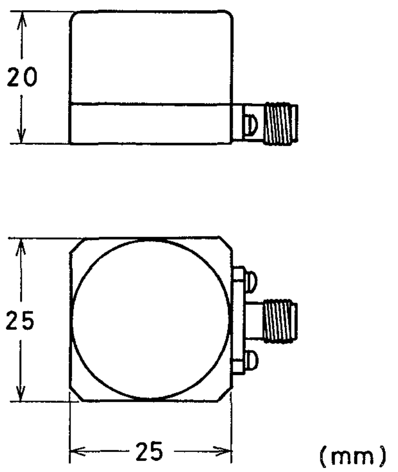

Fig.9 Outline drawings of the YTO

The outline drawings of the oscillator are shown in Fig.9. The case dimensions are 25x25x20 mm^3.

Conclusion

A 13 GHz tunable oscillator using YIG film grown by LPE has been developed.

A very low phase noise of -90 dBc/Hz at 10 KHz from the carrier has been achieved over the entire tuning range from 13 GHz to 13.5 GHz. The output power of the oscillator was over 6.6 dBm without using the output buffer amplifier.

The compact, low cost YTO with the excellent low phase noise and the linear tuning characteristic is ideal for use as a frequency agile synthesized local oscillator in VSAT.

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Frequency Range	13.0 - 13.5	GHz
Output Power	6.6 - 6.9	dBm
Output Power Variation	0.3	dB
SSB Phase Noise at 10 KHz offset	-90	dBc/Hz
Frequency Drift Over Temperature (-30° C to +60° C)	10	MHz
Main Tuning Port Characteristics		
Sensitivity	3.5	MHz/mA
3 dB Bandwidth	45	KHz
Hysterisis	1	MHz
Input Impedance(1 KHz)	6 Ohm with series 20 mH	

Table 1