A SINGLE MESFET DOWN-CONVERTER FOR TVRO APPLICATION

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ABSTRACT

In this paper a compact down-converter for use in TVRO receivers is presented. It consists of an image rejection filter and Self-Oscillating Mixer performing as a block which converts RF into IF signal. Its features are fully comparable to those of conventional structures, with the additional advantage that only one MESFET is required, leading to a more compact and reliable design. Average results on a band of 800 MHz (10.95-11.75 GHz with f_{LO}=10 GHz) give a conversion gain of 4.5 dB, 8 dB SSB noise figure and more than 40 dB image rejection.

INTRODUCTION

So far, a number of Self-Oscillating Mixers (SOMs) at microwave frequencies have been reported (2,7,8), but with the exception of Radar Doppler detectors, few practical applications have been found for them. That is probably because of the great difficulty in adjusting so many parameters at the same time on a single device.

The SOM presented here, which is shown in figure 1 solves a great deal of all these problems, providing conversion gain and the high frequency stability of DROs.

A question of prime importance is the election of an appropiate oscillator structure. The use of a Dielectric Resonator in a parallel feedback configuration seems to be the most suitable for several reasons. It avoids low frequency instabilities which could appear otherwise and makes the imput and output matchings easier. In addition, the couplings of the resonator required are considerably lower than in the case of a series feedback configuration, and are therefore easier to obtain in a physical circuit.

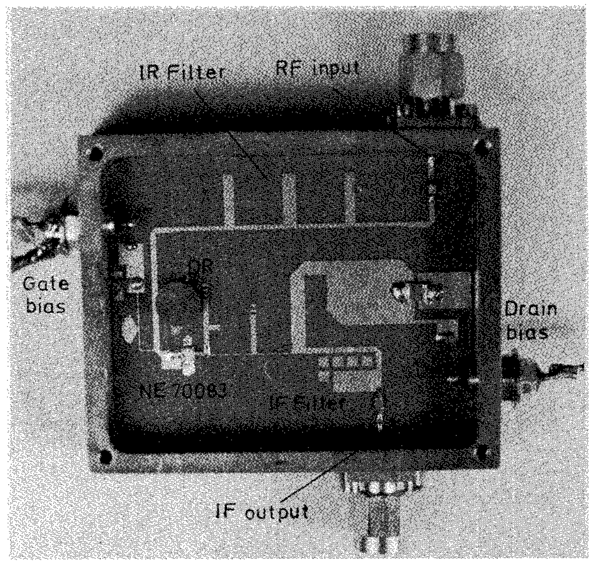

Figure 1. Picture of the TVRO down converter.

The function of the IRF is not only to reject the image band but also to isolate the LO circuit from the RF port. The output is isolated with a simple stub which is a quarter wavelength long at the LO frequency.

SOM DESIGN

The theory of MESFET mixers (1,5,6), shows that for the best performarnce (which means maximum conversion gain and minimum noise figure) the MESFET should be biased close to the pinch-off, where the channel transconductance is a quasi-step function of the gate-to-source voltage. However, this is not the optimal point to obtain high LO power, which normally requires a higher drain current.

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This fact leads to a well known trade-off between the LO power and conversion transconductance, looking for the SOM maximum conversion gain. If we do not take special care this gain will be considerably lower than that obtained through external pumping.

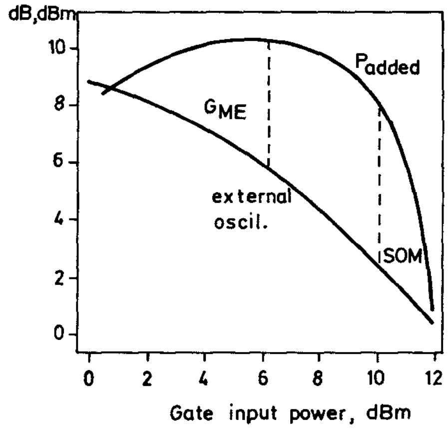

Figure 2. Saturation characteristic of a microwave MESFET, showing operation points is a standard oscillator and in a Self-Oscillating mixer.

Figure 2 shows the typical saturation characteristic of a microwave MESFET in terms of the maximum added power and associated gain, which, for a given set of large signal S parameters, has been shown (3) to follow the expression:

$$G_{ME} = \frac{\left|\frac{S_{21}}{S_{12}}\right|^2 - 1}{2\left(K\left|\frac{S_{21}}{S_{12}}\right| - 1\right)}$$

In standard oscillators we normally try to work in the point where the MESFET delivers the maximum power to the embedding network. In the case of a SOM, however, it is the input power that we are interested in. Increasing the input power means decreasing the power gain of the transistor. Consequently, if we want a high LO level the attenuation of the external network should be as low as possible.

The feedback network in figure 1 attenuates less than 2 dB with moderate values of the coupling coefficients (β in the range 0.5-10).

Concerning the noise, a design for maximum power is again convenient. In the absence of any other external load the whole added power will be dissipated in the resonator and this is expected to enhance the spectral noise.

TVRO DOWN-CONVERTER

The performance of our SOM in the TVRO band is shown in figure 3. Due to the low conductance of the MESFET channel, it was found impossible to obtain a good IF matching over the whole band with a simple structure. The solution adopted was to equalize the response through a uniform mismatch. The result is a rather a flat gain (4-5.5 dB), and noise figure (7.5-8.5) over the whole band, including losses of 1 dB of the IRF and about 1 dB due to the IF mismatch. In figure 4 the conversio gain in the signal and image bands is plotted for a wider frequency range.

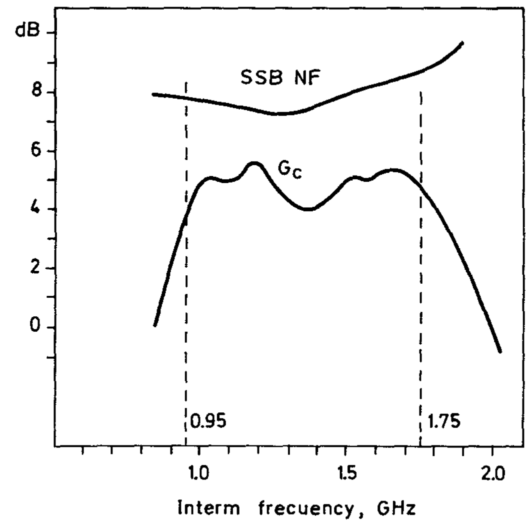

Figure 3. Conversion gain and Single-sideband noise figure in the band.

The current bias dependence of LO power, IF mismatch losses and overall conversion gain is shown in figure 5. The LO level at the IF port is taken as an indicator of the oscillator power. Increasing the drain bias current the channel conductance becomes higher, producing an increase in the LO power and a better output matching. On the other hand, the conversion transconductance decreases with increasing current. These two opposite effects produce a broad maximum of the overall conversion gain.

The oscillator circuit behaves as a typical MESFET DRO, showing 90 dBc/Hz at 20 KHz off carrier. The sensitivity of the oscillation frequency to the input and output loads is fairly good. Table I shows the frequency deviations when the RF and IF ports are loaded with open and short circuits. The oscillation frequency when both ports are loaded with 50 Ohms is taken as the reference.

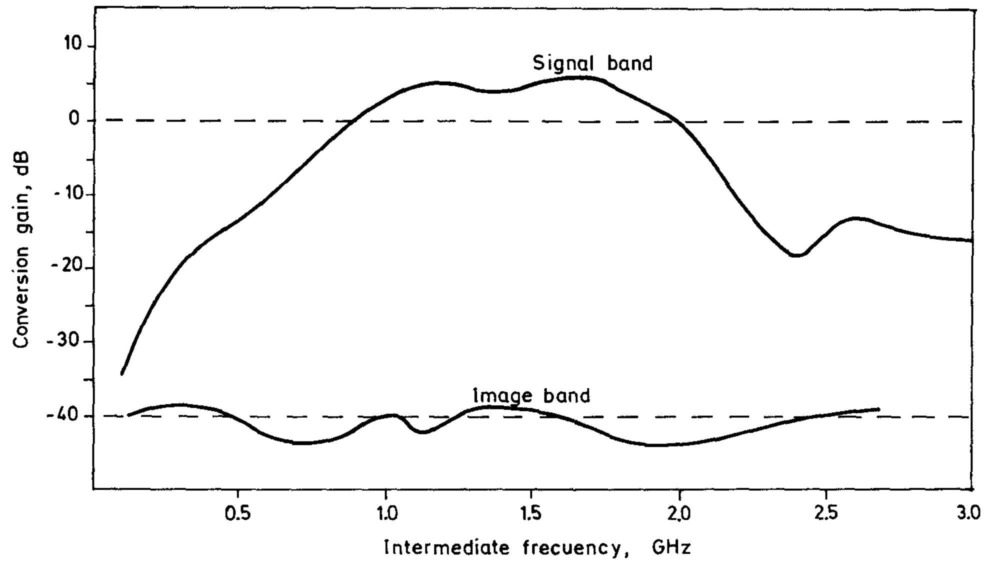

Figure 4. Conversion gain in the signal and image bands.

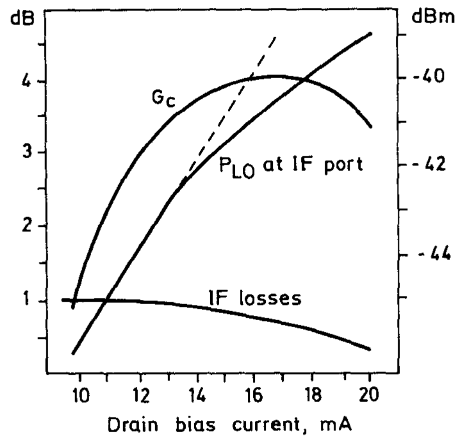

Figure 5. Dependence of the conversion gain, local oscillator power, and output matching on bias current. f_{lo} = 10 GHz, f_{if} = 1.3 GHz and V_{ds} = 3 V.

CONCLUSIONS

A SOM down-converter has been presented suitable for TVRO receivers. Its performance is comparable to that of the conventional structures which make use of an independent oscillator. The use of only one MESFET has the additional advantages of a more compact design, lower cost, and higher reliability of the receiver.

TABLE I

Sensitivity of the local oscillator frequency to input and output loads.

Load	RF port	IF port
Short circ.	+ 140 KHz	—
Open circ.	- 540 KHz	—

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