GAAS MMIC SWITCHES FOR PCS

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Abstract –**A monolithic GaAs SPST (single pole single throw) switch with 3 floating MESFETS is presented. It was designed for 2 GHz operation and have low on-state insertion losses (~1.7dB) and high off-state isolation (50dB). From the comparison between measurements and simulations the best available nonlinear model for the floating bias operation was selected. Several resonant topologies were studied and a new topology is proposed to increase the off-state isolation without degrade the on-state insertion losses.**

I. INTRODUCTION

The switch is a key component of RF transceivers front end. In personal communication systems (PCS) the reduction of size and weight is one of the most important factors. The FET switches present good isolation characteristics. Typical topologies with three active devices use T or π configuration (series and shunt FETs). These topologies have a trade-off between isolation and insertion losses. Larger FETs present lower insertion losses but their off-state isolation degrades due to the FETs capacitances [1]. Isolation can be increased resonating the source and drain capacitance in the off-state, with a parallel inductance [2], [3]. However for low frequency, such as the L Band widely used for PCS, the value of such inductance is too high for monolithic integration. Other type of solution to increase the isolation is presented in [1] using a RC network or in [4] where transmission lines and stubs are used to make a tank resonant shunt filter. This last solution is also not efficient in low frequency applications.

In this paper we will present a MMIC switch for L band using a conventional GaAs MESFET technology [5]. The switch is used to link the antenna to the transmitter and to the receiver MMICs of a 2GHz PCS transceiver [6-8]. All MMICs are fabricated with the same technology. Accordingly, they can be all integrated in the same chip. Experimental and simulated results are presented.

The comparison between experiments and simulations with different nonlinear MESFET models is presented to select the best model for each operation condition. Using the best model a study of alternative switch topologies was performed. New solutions with a good compromise isolation/losses/MMIC area are presented.

For a resonant topology with an inductor between the MESFET Drain and Source, we show that it is possible to reduce the value of the inductance, and so the chip area, introducing a capacitor in parallel without a degradation of the on-state insertion losses at L Band. A new resonant topology with a RC T network with better performances than the inductor one is also introduced.

II. SPST MMIC MESFET SWITCH PERFORMANCE

A SPST MMIC switch with a T topology, consisting on three MESFETs in series-shunt-series (Fig.1) was designed using a 0.5μm GaAs MESFET technology [5] and tested. The switch is DC decoupled. Accordingly, the MESFETs are DC floating (I_{bias}=0).

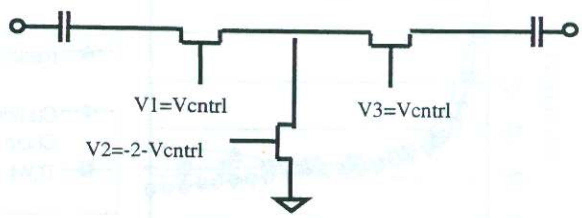

Figure 1: MMIC SPST floating switch circuit

The small signal main characteristics (Pinrf < −10dBm) at 2GHz are insertion losses of 1.7dB (Fig.2), 50dB of isolation (Fig.3) and 18dB of return losses (Fig.4). The noise figure was measured up to 1.6GHz and a minimum of 1.8dB at 1.5GHz was obtained. Since it follows the insertion losses curve a similar value is expected for 2GHz.

Measurements for higher input power show that the performance of the SPST switch is not degraded in large signal operation, presenting a on-state 1dB compression point higher than 15dBm.

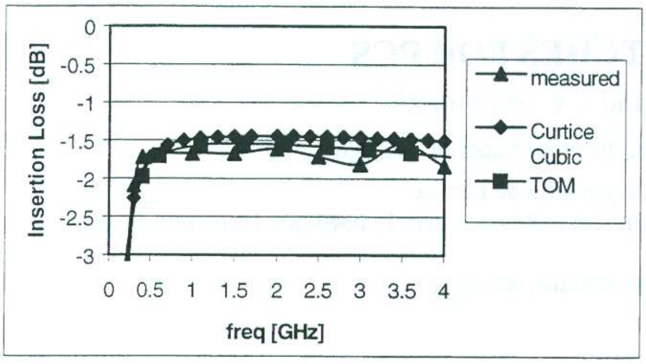

Figure 2: Measured and simulated on-state insertion losses, Pinrf= -10dBm.

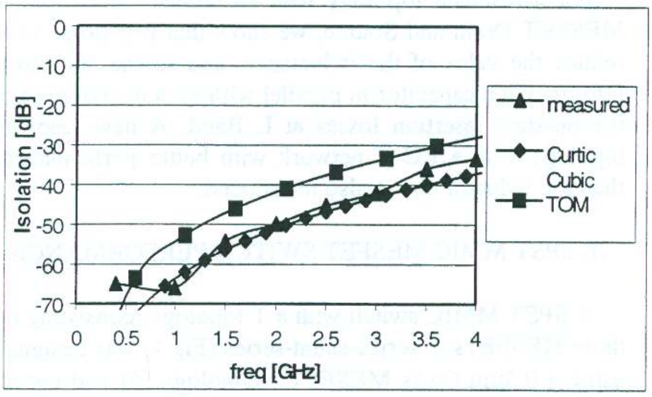

Figure 3: Measured and simulated off-state isolation, Pinrf= -10dBm

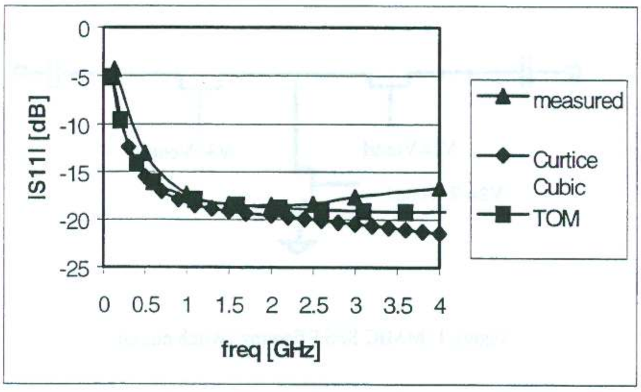

Figure 4: Measured and simulated on-state return losses, Pinrf=-10dBm

The transient behaviour of the SPST switch was measured applying two 50% duty cycle square waves out of phase to V_1=V_3, and V_2. The Fig. 5 curves were obtained with a digital oscilloscope for an input CW signal of 1920MHz with -3dBm and a control signal of 5MHz with 0/2 V of magnitude. The output signal was sub-sampled on the channel 2 for a better visualization. The output signal was simultaneously measured on a spectrum analyzer with a 3dB coupler. Accordingly, the 130mV measured predicts 1.6 dB of insertion losses which is in agreement with the S_{21} small signal measurements (Fig. 2). Due to the oscilloscope characteristics, an offset of -1V and a 30 dB attenuator were introduced in channel 3 (control signal).

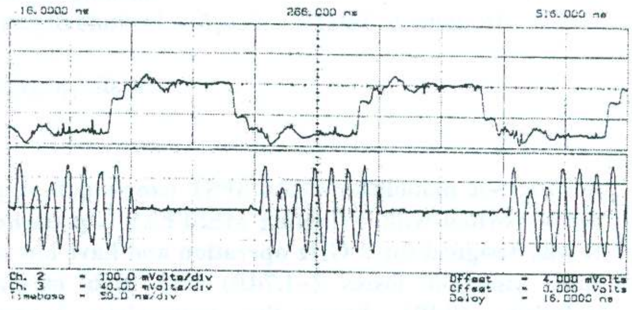

Figure 5: Measured SPST switch transient behaviour (ch.2 output rf signal;ch.3 V2 control signal)

III. NON LINEAR MESFET MODELS ACCURACY

With a MESFET Curtice Cubic model (CC), a TriQuint Own Model (TOM) and a EEFET3 model supplied by the foundry and a Tajima Modified Model obtained from continuous (CTM) or pulsed (PTM) measurements extracted by the authors a comparison between experiments and simulations was performed.

For the on-state operation all the models present similar results predicting better insertion losses than measurements. The TOM model results are slightly closer to the measurements. However, the differences among the different models are not significant (Figs.2 and 4). For the off-state operation the more accurate model is the CC (Fig.3). All the other models had presented results very similar to the TOM model. Accordingly, the CC model was used in the study of resonant topologies presented on next section.

IV. RESONANT SWITCHES

Using the Curtice Cubic model two topologies of resonant switches were studied in order to increase the off-state isolation. The first includes a RC T network (Fig. 6). We have noticed that better results are obtained if we connect the capacitor to the internal node A and not to the ground as proposed in [1]. This circuit has a narrow band on the off-state, but it is enough for many applications.

The second topology studied uses inductors in parallel with the MESFETs drain-source and can only be implemented at higher frequencies, due to the MMIC inductors maximum values. If it is used an additional capacitor in parallel with the inductor we can reduce the value of the inductance to a feasible value and reducing the chip area without degradation of the on-state insertion losses (Fig.7). It can be seen in Fig.3 that the simple SPST switch isolation is degraded with frequency. Accordingly, at low frequencies the advantage of using a resonance is not significant.

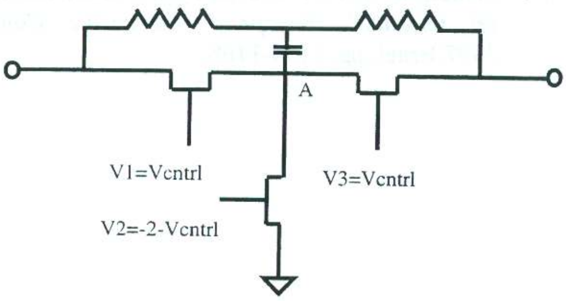

Figure 6: Resonant RC switch circuit.

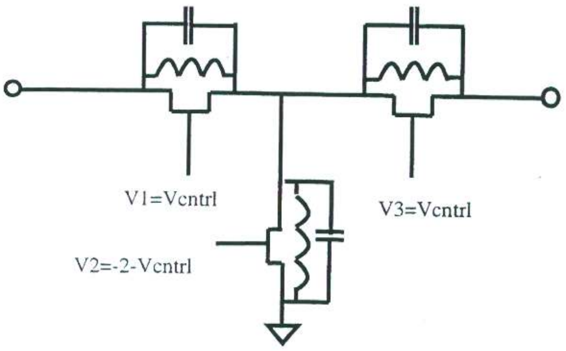

Figure 7: Resonant LC switch circuit.

From Figs.8 and 9 we can conclude that the RC resonant switch not only presents lower insertion losses and higher isolation than the inductor resonant switch, but also a higher bandwidth. The only advantage of the inductor resonant switch is the higher isolation.

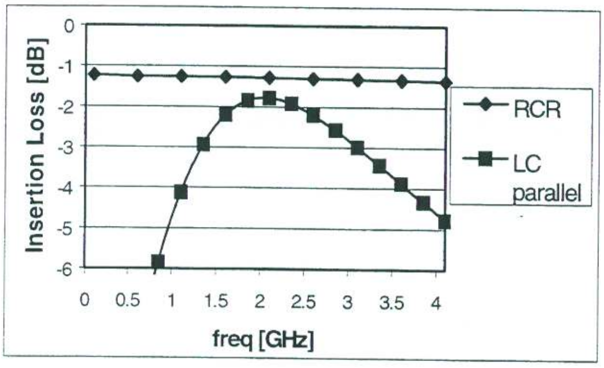

Figure 8: Simulated on-state insertion losses of resonant switches.

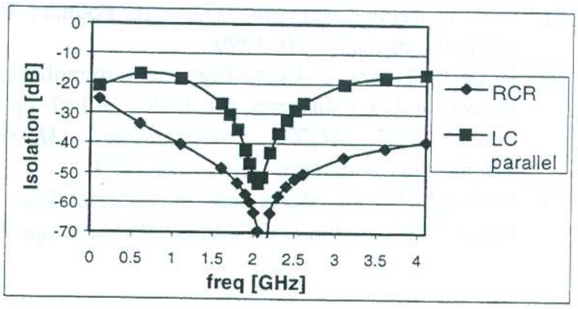

Figure 9: Simulated off-state isolation of resonant switches.

V. CONCLUSIONS

A SPST floating GaAs monolithic switch with 1.7dB of insertion losses and 50 dB isolation at 2 GHz was presented. Several nonlinear models were used to simulate its behaviour and better accuracy was obtained with a Curtice Cubic model. Based on this model a solution to reduce the inductor value in LC resonant switches was studied and a new topology of RC resonant switch was introduced. The LC resonant switch presents higher isolation. However, the RC switch has lower insertion losses and wider bandwidth.

ACKNOWLEDGEMENTS

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VI. REFERENCES

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