MICROWAVE FREQUENCY AGILE ACTIVE FILTERS FOR MIC AND MMIC APPLICATIONS

X.H. JIAO - P. GUILLON - B. JARRY - B. MADRANGEAS

I.R.C.O.M. - U.A. 356 C.N.R.S. - UNIVERSITE DE LIMOGES -
123 Avenue Albert Thomas - 87060 LIMOGES Cédex - FRANCE

ABSTRACT

The purpose of this paper is to present newly developped microwave frequency agile active resonators which, in a planar structure, may be realized using MIC or MMIC technologies. Consisting of a modified Hair pin resonator feedback by an amplifier and a phase shifter, these resonators offer extremely low loss and high Q value resonators. The use of varactors permits a tuning of the resonant frequency as well as the bandwidth. Using such resonator, a bandstop filter with a rejection of 45 dB and a lossless band pass filter with a return loss of 35 dB have been obtained at 3.1 GHz.

INTRODUCTION

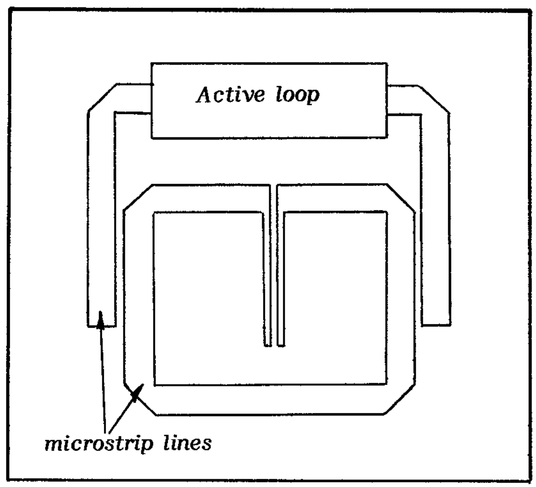
Microwave resonators have been widely used in microwave integrated circuits (MIC) and components. In many applications such as filters or stabilization circuits for oscillators, it is desirable to have a low loss high Q value resonator. For MIC circuits, dielectric resonator making use of low loss high permittivity dielectric materials have been chosen by many microwave circuits designers. However, because of their non planar structure, it is very difficult to implement dielectric resonators in monolithic microwave integrated circuits (MMIC).

In this paper, we report newly developped planar microwave active resonators which may be realized using MIC or MMIC technologies. The microwave active resonators (MAR) proposed in this paper utilize microstrip hairpin resonators feedback by an amplifier and a phase shifter. The resonators thus obtained are lossless and have high Q values. Based on the MAR, another type of active resonators called frequency agile active resonators (FAAR) have been developped. In fact, by using varactor diodes, the MAR may be electronically tuned on both resonant frequency and bandwidth. This paper deals with the developpement of such resonators and their applications to microwave filters. Experimental results obtained from a bandstop filter with a rejection of 45 dB and a lossless bandpass filter with a return loss of 35 dB are presented.

MICROWAVE ACTIVE RESONATORS (MAR) AND FREQUENCY AGILE ACTIVE RESONATORS (FAAR)

The microwave active resonators and frequency agile active resonators presented in this paper utilize both modified microstrip hairpin shaped split ring resonators [1].

As shown in figure 1 which gives a schematical view of a MAR, a modified hairpin resonator is feedback by an active loop composed of an amplifier and a phase shifter. The amplifier and phase shifter are integrated on the same substrate as the hairpin resonator. As in case of the dielectric resonator active filters [2][3], appropriate gain and phase values of the active loop may compensate resonator losses and improve its performances.



- Figure 1 -
Schematic view of a Microwave Active Resonator (MAR)

The MAR are high Q value resonators with extremely low losses. Their configuration is suitable for planar MICs. Unlike the dielectric resonators, the circuits are amendable to monolithic implementation.

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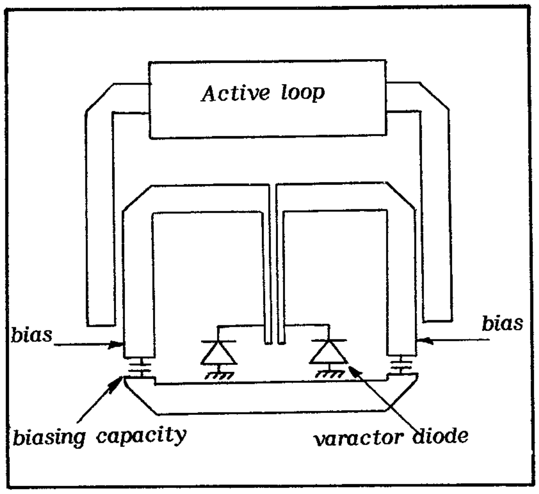
Based on the MAR, FAAR have been developped. In fact, if a varactor diode is mounted at the open circuited end of the parallel coupled lines, the MAR may be electronically tuned. The use of varactor diodes permits to obtain tunability of the MAR on both resonant frequency and bandwidth. Figure 2 shows the configuration of FAAR used in experimental frequency agile filters circuits. These resonators may be very interesting for electronically tunable filters and oscillators.

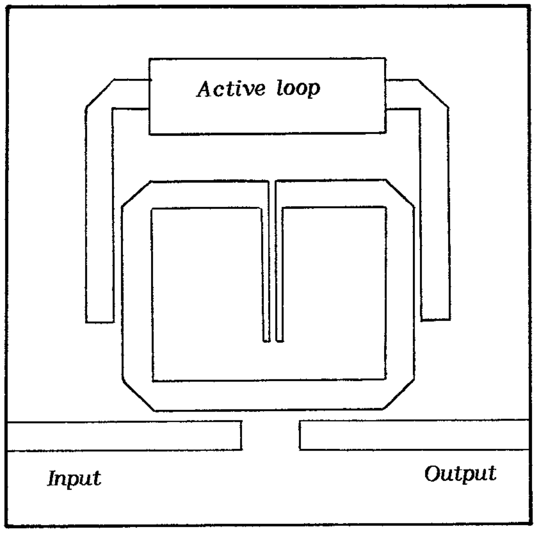


- *Figure 2* -
Frequency Agile Active Resonator (FAAR)

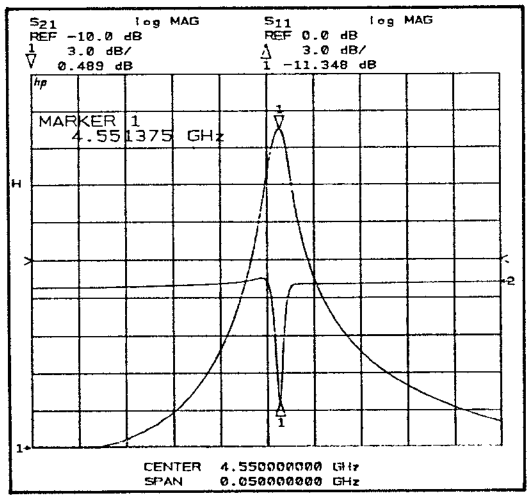
APPLICATION TO MICROWAVE ACTIVE FILTERS

To demonstrate the feasibility of the MAR and the FAAR, bandstop filters and bandpass filters have been realized and measured. The circuits were built on Duroid 5870 substrate with a thickness of 0.503 mm and dielectric constant of 2.32. The filters were measured with an HP 8510 network analyser. For these first experimental works, an external active loop was utilized which was composed of a FET amplifier, an attenuator and a phase shifter. In order to reduce coupling losses, dielectrically loaded microstrip technique was used [4]. By utilizing a dielectric overlaid layer, the couplings between the resonators and the transmission lines can be enhanced.

The first realized is a bandpass filter using a MAR. The configuration and the measured response of the filter are given in figure 3. Using an external loop of 4.7 dB, we obtained a lossless filter with a gain of 0.49 dB (figure 4), while for the corresponding passive filter, the transmission losses were about 21.3 dB. The return losses have been improved from 2.6 dB to 11.3 dB. For this active resonator, a loaded Q factor was measured to be about 2070 at 4.5 GHz.



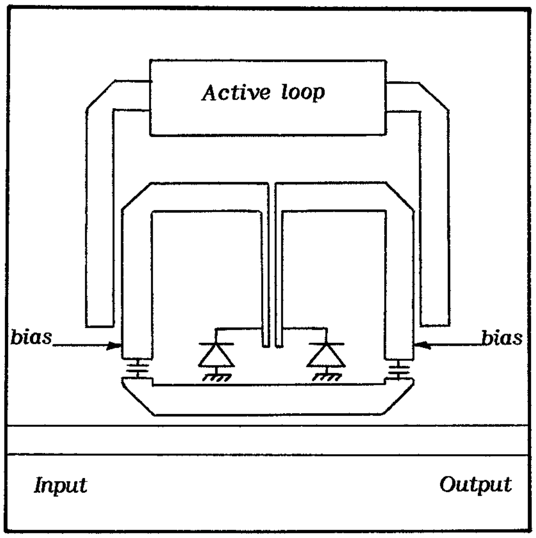
- *Figure 3* -
Bandpass filter using a MAR



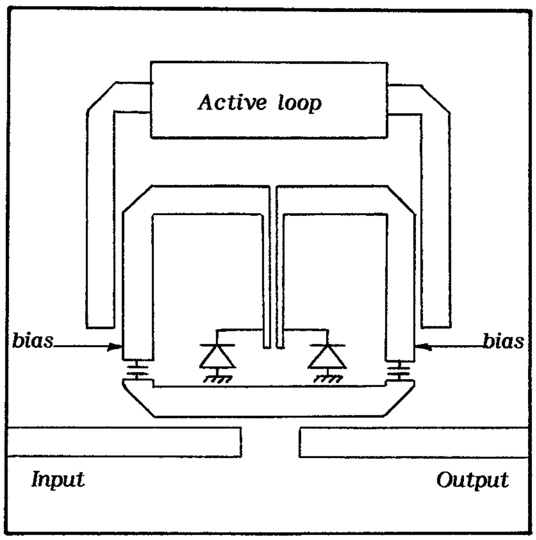
- *Figure 4* -
Measured response of the bandpass filter

APPLICATION TO MICROWAVE AGILE ACTIVE FILTER

A bandstop filter and a bandpass filter using a FAAR have been respectively realized and measured. The configurations of these filters are shown in figures 5 and 6.

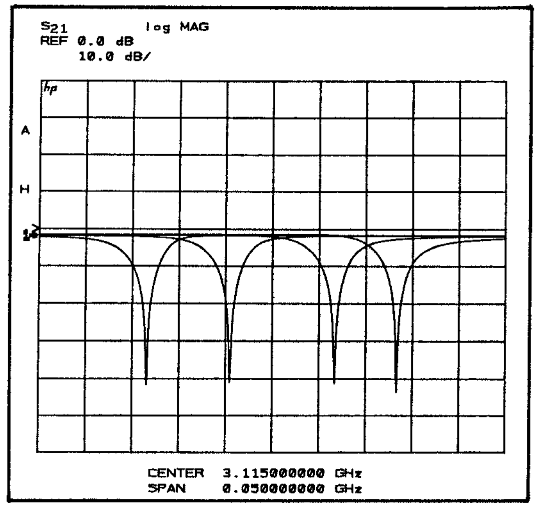


- Figure 5 -
Bandstop filter



- Figure 6 -
Bandpass filter

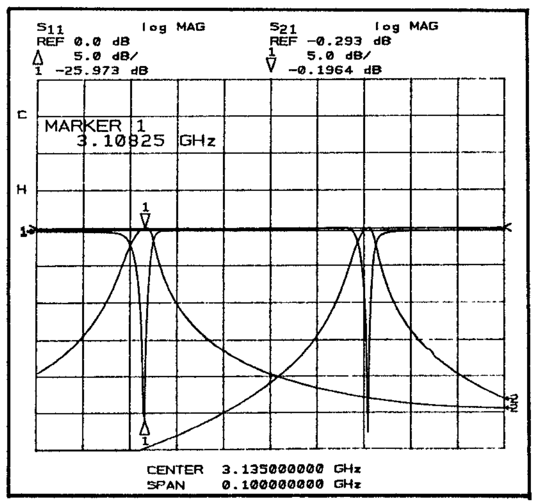
In figure 7, we present the measured responses of the bandstop filter when varactors diodes were tuned. At center frequency (3.1 GHz) a rejection of 45.3 dB has been obtained. For this filter the frequency tuning range is about 27 MHz.



- Figure 7 -
Responses of a bandstop filter when varactors are tuned

In the same manner, measured characteristics of the bandpass filter are presented. In figure 8, we present the measured filter responses when varactors are tuned. At center frequency (3.1 GHz), the filter has 0,03 dB losses and a return losses of 35.9 dB.

For this filter, the frequency tuning range is about 47 MHz. Over this range, the 3 dB bandwidth has been reduced from 5.13 MHz to 3.17 MHz. It is well known that by reducing the distance between the parallel coupled lines of the hairpin resonator, a wider tuning range may be obtained.



- Figure 8 -
Responses of a bandpass filter when varactors are tuned

CONCLUSION

Planar frequency agile active resonators using duroid microstrip lines were developped. Such resonators, offering low lossless characteristics and high Q value, may be implemented to monolithic circuits. Applications to microwave filters were also demonstrated and encouraging experimental results have been obtained. It is believed that such resonators should have many applications in high performance electronically tunable filters and oscillators. These resonators should also provide a way for stabilization of MMIC oscillators.

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