A 18 GHz MMIC biquad active filter

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A high-Q bandpass biquad filter operating at 18GHz is proposed. It is based on an active parallel resonator and it is suitable for MMIC implementation. A prototype has been implement ed using the Philips ED02AH PHEMT foundry process. A quality factor of 120 at 18GHz with a current consumption of 5mA @ 2V bias has been reported.

GENERAL DESCRIPTION

A very simple solution for the synthesis of a biquad filter is in the use of a LC parallel resonant circuit. Such resonator must be obviously characterized by a very high quality factor, Q. In order to design a high Q resonator two condition have to be fulfilled: first of all the quality factor of the reactive elements composing the resonator must be high enough, and subsequently the real part of the overall resonator admittance has to be as low as possible.

If a monolithic implementation on a standard foundry process is attempted, the first constraint imposes an active realisation for the inductive element. The second one imposes the use of buffer stages to the LC resonator both at the input and output ports (Figure 1). A straightforward consequence is that the resulting filter is unidirectional but, at the same time, can be simultaneously matched at both ports.
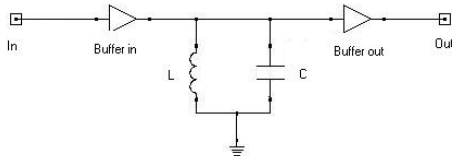

Figure 1: Basic schematic of the biquad filter

ACTIVE RESONATOR DES IGN

Compactness and low power consumption issues impose the selection of a very simple configuration for the active inductor. As in (1), an active inductor with very high Q can be implemented with very limited number of components making use of a common gate PHEMT with the gate dc-connected to ground through a short transmission line with the desired inductive behaviour.

The basic scheme of the selected active inductor topology is reported in Figure 2.
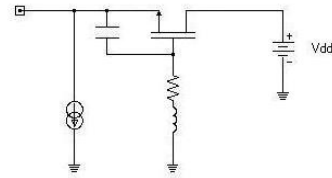

Figure 2: Active inductor topology

For the synthesis of the filter at the selected frequency (18 GHz in this case) such component as to be properly scaled. A capacitor (whose value is simply computed by $C=1/(\omega^2 L)$) in parallel to the above high Q inductor realises the parallel resonant circuit.

Provided that the operating conditions described in (1) are fulfilled, the synthesised active inductor is approximately characterised by the following impedance:

$$Z_{in} \cong \left(R - \frac{L}{C_T} g_m \right) + j\boldsymbol{w}L \qquad (1)$$

Thus a high Q active inductor can be obtained by proper selection of the PHEMT transconductance.

THE COMPLETE BAND PASS FILTER

The input and output buffer stages have to be designed with a sufficiently high output and input impedance respectively, in order to avoid the degradation in the quality factor of the overall filter. Nevertheless, the two buffer stages may also provide a gain level to the filter. In this case such potential gain has been sacrificed preferring a greater filter simplicity and compactness. Thus, the input buffer is simply a common-gate transistor stage and the output buffer is a source follower.
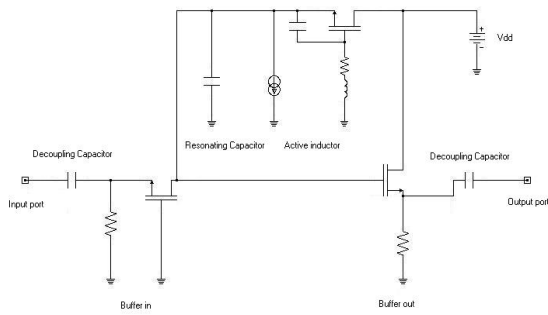
Figure 3: Complete filter topology

Furthermore, direct bias of the two buffer stages has been preferred to minimise overall filter power consumption. The resulting schematic diagram of the complete filter is depicted on Figure 3.

FILTER PERFORMANCES

The filter implementation using Philips ED02AH foundry process results in the layout reported in Figure 4. Die area is about 600 x 900 μm^2, including the conspicuous contribution of the two coplanar probe pads and dc blocking capacitors. The filter exhibits an extremely selective transfer function as can be noted in Figure 5. As previously mentioned, a 0 dB center band gain is obtained, and the filter is non reciprocal (an attenuation of about 23dB is results on the S_{12} parameter).
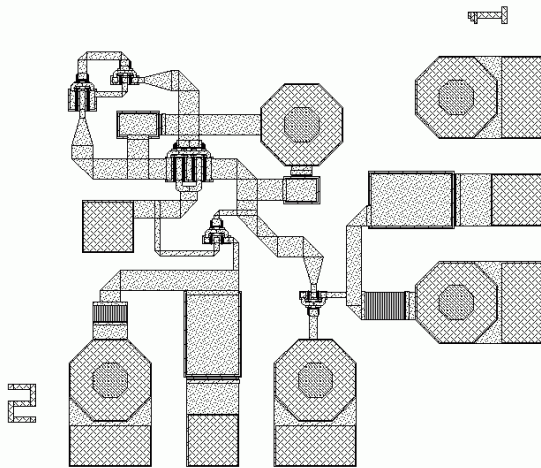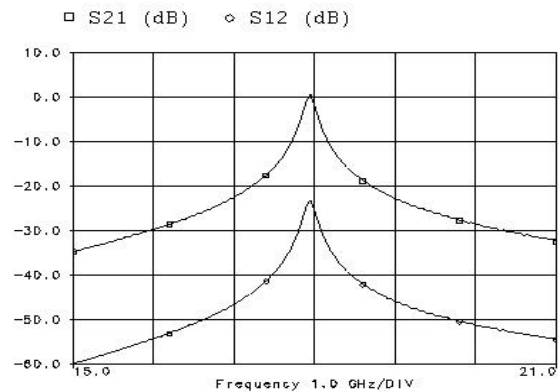

Figure 4: Filter layout

Figure 5: Trasmisison parameters of the filter

Measured Input and output matching performances of the filter are reported in Figure 6.
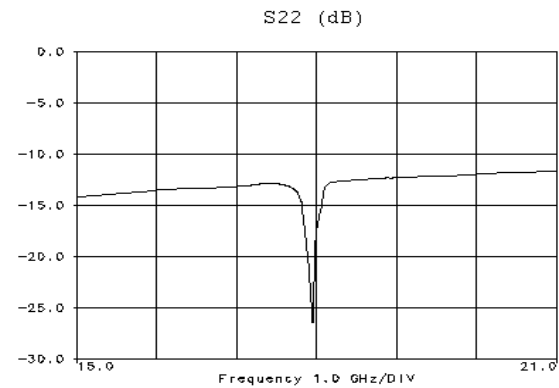

Figure 6: Output reflection parameter of the filter

The source follower output buffer ensures a good matching to a 50 ohm load especially at center frequency. The common base input buffer performs very poorly, when compared to the output stage. This effect is mainly to be ascribed to the poor biasing circuitry used for the common base transistor in order to simplify the implementation.

CONCLUSIONS

A high Q bandpass biquad filter has been presented operating at 18GHz. The resulting 3dB band pass width is about 150MHz (Q=120). The power consumption is about 10mW at 2Vdc bias.

REFERENCES

(1)   G.Avitabile, B.Chellini, F.Giannini, E.Limiti, *A novel high Q active inductor for millimeter wave applications*, Proceedings of the 30th European Microwave Conference, vol. 1, pp. 198-201, October 2000

(2)   S.Hara, T.Tokumitsu, T.Tanaka, M.Aikawa, *Lossless broadband monolithic microwave active inductors*, IEEE Transactions on Microwave Theory and Techniques, vol. 37, pp. 1979-1984, Dec. 1989

(3)   H.Hayashi, M.Muraguchi, Y.Umeda, T.Enoki, *A novel loss compensation technique for high-Q broadband tunable active inductors*, IEEE Microwave and Millimeter-Wave Monolithic Circuits Symposium Digest, pp. 103-106, 1996

(4)   E.M.Bastida, G.P.Donzelli, L.Scopelliti, *GaAs monolithic microwave integrated circuits using broadband tunable active inductors*, Proceedings of the 19th European Microwave Conference, pp. 1282-1287, 1989

(5)   F.E. van Vliet, F.L.M. van den Bogaart, J.L.Tauritz, R. G. F.Baets, *Systematic analysis, synthesis and realization of monolithic microwave active inductors*, IEEE MTTs Digest, pp. 1659-1662, 1996

(6)   G.F.Zhang, J.L.Gautier, *Broad-band, lossless monolithic microwave floating active inductor*, IEEE Microwave and Guided Wave Letters, vol. 3, pp. 98-100, Apr. 1993

(7)   S.Lucyszyn, I.D. Robertson, *Monolithic narrow-band filter using ultrahigh-Q tunable active inductors*, IEEE Transactions on Microwave Theory and Techniques, vol. 42, pp. 2617-2622, Dec. 1994

(8)   R.G.Arnold, S.P.Marsh, *A microwave active bandstop filter with tunable center frequency*, IEEE MTTs Digest, pp.1313-1316, 1993

(9)   F.Giannini, E.Limiti, G.Orengo, P.F.Sanzi, *A monolithic active notch tunable filter based on the gyrator principle*, IEEE MTTs Digest, pp. 809-812, June 1997