DECADE BANDWIDTH FET FUNCTIONS

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ABSTRACT

Decade bandwidth FET functions have been designed, using an analytical approach followed by a computer optimization. Two experimental functions have been built using commercially available FETS :

- a YIG tuned oscillator monotonically tunable from 2 to 20 GHz with 1 mW minimum output power.
- an ultrabroadband amplifier covering the frequency range from 150 MHz to 16 GHz with 12 dB flat gain and a V.S.W.R lower than 2.5.

This paper presents the theoretical analysis and experimental results on two active functions :

- a decade bandwidth YIG tuned oscillator, monotonically tunable from 2 to 20 GHz, and few milliwatts output power.
- a three stage low level amplifier with 12 dB flat gain and V.S.W.R < 2,5 from 150 MHz to 16 GHz.

These functions have been designed for broadband microwave applications, with commercially available FETS.

I - DECADE BANDWIDTH FET-YIG TUNED OSCILLATOR

Broadband tunability of FET-YIG oscillators has been demonstrated [1], [2], published results show one or two octaves bandwidth. However a field effect transistor allows to obtain a negative conductance in a very large bandwidth (Fig.1) if the load resistance is small. Moreover this negative conductance bandwidth (N.C.B) depends directly on the reactive positive feedback.

Taking the FET model of the Fig. 2 in commongate configuration, it can be shown that the negative conductance bandwidth is limited by a minimum and maximum pulsations ω min and ω max given approximately by :

$$\omega^2 min = \frac{1}{Lg_T C_g}$$

and

$$\omega^2 max = \frac{1 + Rd\ gmo}{Lg_T\ Cg + Ld\ Cd\ Rd\ gmo}$$

if the load is small.

This N.C.B can be moved to the higher or lower frequencies by changing the gate inductance Lg_T.

This variation can be realized electronically with a YIG sphere magnetically coupled to the gate circuit. The oscillator is then tuned at the desired frequency by another YIG sphere coupled to the source circuit.

Since the two spheres are placed in the same magnetic field, their resonant frequencies are synchronised. However to obtain a monotonically tunable oscillator over a decade bandwidth, the load impedance must be computer optimized, to eliminate parasitic resonances.

An experimental oscillator based on this design has been built with FETS having 0,5 µm gate length. The best result obtained, shows a monotonically tunable frequency from 2 GHz to 20 GHz without jumps ; the output power is between one and five milliwatts; the tuning linearity is good. Fig.3 indicates the circuit and the experimental result.

II - TWO DECADES BANDWIDTH LOW LEVEL FET AMPLIFIER

Second order matching circuits without feedback are used in conjunction with commercially available FETS to realize an ultrabroadband, matched amplifier.

With our simplified model, an FET used in common source configuration, can be described by the product of three transfer functions, one of them being constant. The two others, describing the input and output circuit of the FET, are of second order versus frequency.

Theoretically, each circuit must be tuned at ωmax and transformers must be placed so that the input and output circuits have Q factors equal to unity at ωmax, to obtain a flatgain response from ω = o to ω = ωmax. But the FET so tuned, is not matched to 50 Ω.

In order to match the amplifier, a simple resistance in series with an inductance is placed at the input and output of each transistor, in parallel with the second order circuits previously described.

Finally the circuits are optimized by computer. Figure 4 shows the overall diagram of the amplifier. It should be noticed that this does not include any transformer or distributed circuit. Moreover the Lp inductances are parasitics and must be lowered.

An experimental amplifier have been built following this design. The transistors are self biased.

Figure 5 shows the gain obtained with a three stage amplifier : 12 dB ± 1,5 dB from 150 MHz to 16 GHz, the input and output V.S.W.R are lowe than 2.5. The noise figure measured between 1 and 12,4 GHz was found lower than 8,5 dB in this bandwidth.

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0149-645X/81/0000-0141$00.75

[1] LETRON - BARVET - OBREGON
Broadband YIG tuned FET oscillators
E.M.C. 1979

[2] LETRON - BARVET - OBREGON
Multioctave FET-oscillators double tuned by a single YIG
ISSCC 1979

[3] NICLAS - WILSER - GOLD - HITCHENS
The matched Feedback Amplifier
MTT 28 N° 4

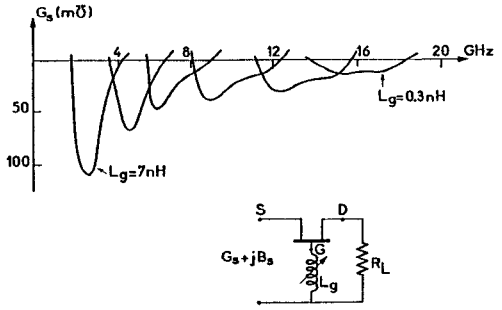
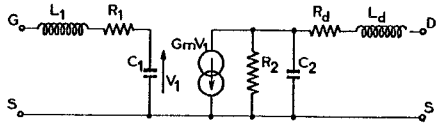
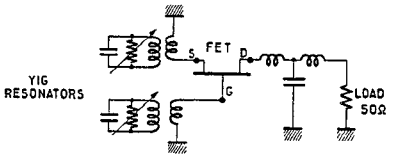


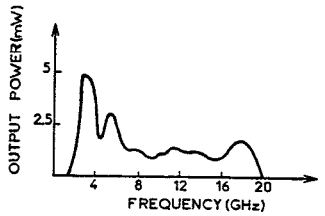
FIG:1



FET MODEL

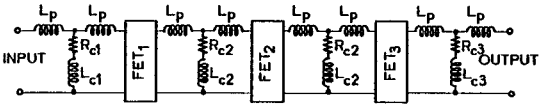
FIG 2.





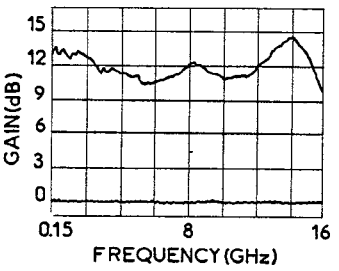
2-20GHz FET-YIG OSCILLATOR

FIG.3



3 STAGES AMPLIFIER DIAGRAM

FIG:4



GAIN OF THE 3 STAGES AMPLIFIER

FIG:5