A NEW N. FETS OSCILLATOR-COMBINER USING TUBULAR DIELECTRIC RESONATORS

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ABSTRACT

A new oscillator-combiner using two tubular dielectric resonators, coupled to N transistors, is presented. An equivalent "TE" representation having N branches is introduced allowing to derive easily the oscillation-condition .

Experimental results obtained with three transistors have given an oscillator with 225 mW output power at 11 GHz without spurious modes. A combiner efficiency of 75% has been measured resulting in an overall oscillator efficiency of 15%.

INTRODUCTION

Combiner-oscillators are widely used at microwaves to add the power of several active-devices [1] [2] [3] [4].

In this paper a new oscillator-combiner is proposed It uses two tubular dielectric-resonators spaced by $\lambda°/4$ This structure allows to obtain a good combining efficiency without spurious oscillating modes.

A simple equivalent representation is proposed valid for all symetrical combiner-oscillators. This equivalent circuit allows to obtain by inspection, the oscillating conditions for the in phase and out of phase modes.

An experimental configuration has been made to combine the power of several transistors by means of two tubular dielectric resonators. Finally results obtained are presented.

I-Combiner-Analysis using a simple equivalent circuit.

A symetrical oscillator-combiner may berepresented as indicated in fig.1.

For sake of clarity let us first suppose an oscillator with two active devices : fig.2 (a).

Since the oscillator circuit is reciprocal and symetrical, a "TE" representation of the network may be obtained as indicated in fig.2 (b).

Kirchoff rules give the two possible modes of oscillation :

- the in phase mode:$I_1=I_2$ and $Z_{NL}=-(Z_s+2Z_p)$.
- the anti phase mode:$I_1=-I_2$ and $Z_{NL}=-Z_s$.

In the first case the oscillation condition is obtained by putting the two branches containing $Z_{NL}+Z_s$ in parallel with Z_p.

In the anti phase mode:the total impedance of each branch $Z_{NL}+Z_s$, is equal to zero, moreover the sum of the currents at points A - A (fig.2 b) is zero:no current flows in Z_p.

This T_e representation is now generalized to an N port combiner-oscillator:fig.3.

- for the in phase mode, we have :

$Z_{NL}=-(Z_s+N\ Z_p)$:all branches in parallel with Z_p

- for the (N-1) out of phase modes, we have :

$Z_{NL}=-Z_s$:impedance of each branch=0

since the amplitudes of the currents are identical in all branches, their phases may be obtained by calculating the complex roots of :

$N\sqrt{1}=e^{j\theta}$ or $N\theta = 2k\Pi (k=1, 2,...N)$, as suggested by the figure 3. Solution obtained for k=N is the in phase mode.

The previous analusis has been applied to the oscillator-combiner described in the following section.

II - Application of the Te representation to a three transistor-combiner

The general structure of this oscillator is shown in fig. 4, where only two transistors have been drawn for sake of clarity.

Fig. 5 shows the electrical equivalent circuit, where the reactances jX_1 and jX_2 are feed back elements.

The combiner network is formed by two TM01 δ tubular dielectric resonators spaced by a fixed lengh : $\lambda°/4$.

The resonateur D_1 which combine the power of the transistors is coupled to the output coaxial line via a coupling probe : C and to the microstrip lines μ_1, μ_2, μ_3 loaded at one end by the transistors and at the other end by 50 Ω damping resistors. Resonator D_2 is coupled only to the microstrip lines, it allows to obtain a good efficiency by short-circuiting the damping resistors at the oscillating frequency. A fine tunable length L_1 and output coupling C allows to obtain an optimized output power at the oscillating frequency, which is imposed by the dielectric resonateur D_1.

Taking into account the previous analysis and the Te representation of the oscillator, we obtain at the resonant frequency of the two dielectric resonators supposed indentical :

$$Z_s = \frac{R_o}{1+\alpha_1 N} \quad ; \quad Z_p = \frac{\beta_1 R_o}{1+\beta_2}$$

where : . β_2 is the coupling factor between the output-coupling Dielectric-Resonator and the output probe.

. β_1 : the coupling factor between the output-coupling D.R and the microstrip-lines.

. α_1 : the coupling factor between the D.R. decoupling the damping resistors and the microstrp-lines.

. R_o = 50 Ω

. N : number of transistors.

From those equations, it is clear that the equivalent damping resistor :

$$Z_s = \frac{R_o}{1+\alpha_1 N}$$

seen in series with each transistor must be very smaller than the output resistance, to obtain a good efficiency ; So α_1 must be as high as possible.

Same calculations can be made if the two resonators are not identical, detailed results will be given elsewhere.

III - Experimental set-up - results

MGF-1802 mitsubishi transistors are used. First, each transistor is tested alone in a test oscillator circuit, which allows to define the best feedback reactances and load resistance values, to obtain the optimum output power for fixed bias conditions : V_{ds} = 5 V; V_{gs} = - 0.8 V.

The optimized output power is : 98 mw ; 100 mw and 103 mw for the three transistors.

The combining oscillator-modulus, is a metallic tube containing 3 microstrip - 50 ohms - lines on duroïd substrat (h = 0.254 mm ; ε_r = 2.32) equably spaced in the tube.

Each microstrip line is loaded by a 50 Ω resistor chip at one end and by a feedbacked transistor at the other end.

The two tubular-dielectric-resonators spaced by a fixed $\lambda_o/4$ length may slide in the tube. The D.R. nearest of the transistor is also coupled the the coaxial output probe. The space between the microstrip lines and the dielectric resonators is equal to 0.1 mm. It must be as low as possible to realize a high coupling factor.

Then the transistors are mounted in the oscillator-combiner ; the length L_1 and coupling C_{out} are then optimized.

Final results after optimization of L_1, and coupling C are the following :

- output power : 225 mW (for the fixed bias conditions)
- output frequency : 11 GHz
- output efficiency : 75 %
- overall efficiency : 15 %
- FM noise measured : 105 dB/C/Hz at 100 KHz.

Conclusion

A new oscillator-combiner using two dielectric resonators has been proposed. An equivalent "Te" representation has been introduced allowing to derive easily the oscillation conditions. Experimental results on a three transistors oscillator, show a combiner efficiency of 75 %.

Results obtained allow us to think that this simple structure will be able to compete with others existing systems.

Acknowledgments

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References

[1] M. DYDYK "Efficient power combining". MTT 28 July 1980.

[2] P. KNOCHEL, K. SCHUMEMAN "An approach to the ideal circuit for power combining". E.M.C. 1982.

[3] D.F. PETERSON "Harmonic power combining of microwave solid state active devices". M.T.T. 30 March 1982.

[4] D.M. KINMAN, D.J. WHITE, M.A. AFENDYKIV "Symetrical combiner analysis using S parameters" M.T.T. 30 March 1982.

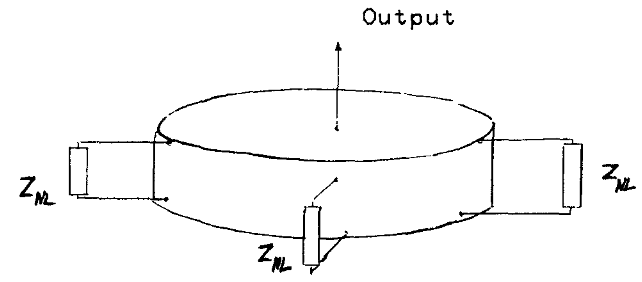

Fig 1: general configuration of a symetrical oscillator combiner.

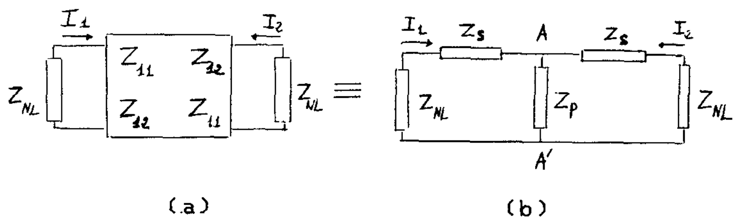

Fig 2:equivalent "TE" representation of an oscillator-combiner.

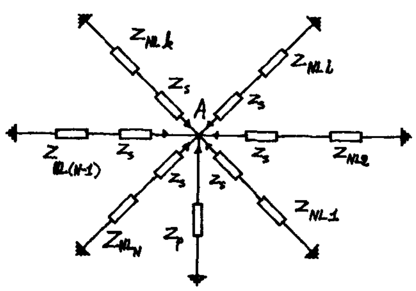

Fig 3: N-port symetrical oscillator-combiner.

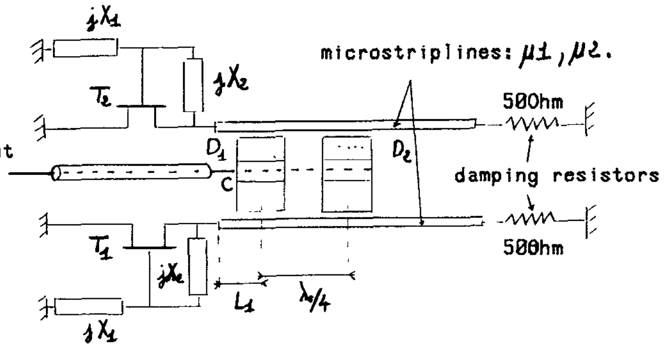

Fig 4: Schematic representation of the D-R combiner-oscillator.

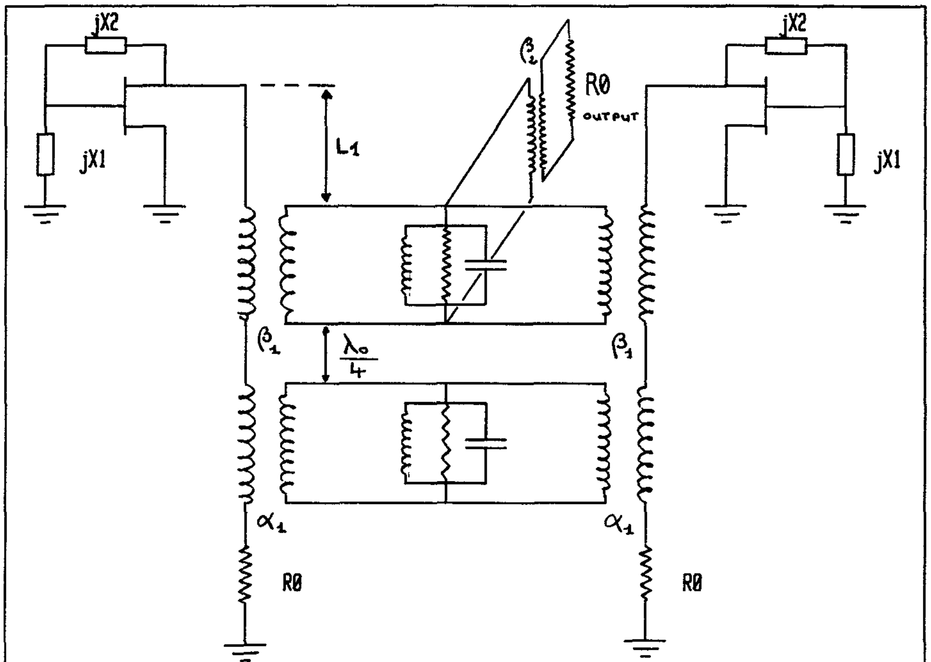

Fig 5: Equivalent circuit of the Dielectric–resonators oscillator–combiner