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# NEW VERY HIGH Q MICROWAVE TRANSISTOR OSCILLATORS USING DIELECTRIC RESONATORS.

KHANNA A.P.S.*; OBREGON J. ** ; GUILLON P. * ; GARAULT Y. *

## ABSTRACT

Using the dielectric resonator as the matching as well as the frequency determining element, one port and two port Microwave Transistor oscillators having external quality factors much higher than the unloaded Q of the dielectric resonators, have been presented. A self oscillating mixer has been proposed as the potential application of the two port FET oscillator presented.

## INTRODUCTION

A number of oscillator applications like reference oscillators ; STALO etc. need the oscillator to have high frequency stability and high isolation with respect to load variations. In this paper a simple method to realize, firstly, a highly stable and a very high external Q one port oscillator using a dielectric resonator is presented. The resonator is used simultaneously as a frequency determining element and output matching circuit of the oscillator. Applications like self oscillating mixers also necessitate the use of high external Q in order not to get synchronised with the useful input signal of high level externous spurious signals. Also presented here is a two port oscillator for this potential application using two identical dielectric resonators. Additionally in the approach presented the input/output matching circuits are simplified to 50 Ω lines with dielectric resonators placed at a specified distance and coupling.

## OSCILLATION CONDITION

The oscillation condition for an n-port active device (figure 1) is given by {1}.

$$\left| [S] \quad [S'] - [I] \right| = 0 \qquad (1)$$

where $[S]$ is the S matrix of the transistor
$[S']$ is the S matrix of the passive embedding network and
$[I]$ is the unit matrix.

The small signal oscillation condition can also be represented at any point in the oscillator by

$$\left.\begin{array}{l} \Sigma\, G \leq 0 \\ \Sigma\, B = 0 \end{array}\right\} \qquad (2)$$

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* Laboratoire d'Electronique des Microondes ERA CNRS N°535 123, rue A. Thomas 87060 LIMOGES Cedex France.

** Division Composants Microondes THOMSON-CSF BP.10 91401 ORSAY-France-.

The $TE_{01\delta}$ mode was used. The resonance frequency of the resonator is now determined by its dimensions . {4}

The admittance of a dielectric resonator coupled to the transmission line (fig.4) is then calculated :

$$Y_{in} = G_{in} + j\,B_{in} = Y_o \frac{\cos\theta + j\sin\theta\,(1+Y_oZ_r)}{(1+Y_oZ_r)\cos\theta + j\sin\theta} \quad \ldots.\ (6)$$

where $$Z_r = R_r \,/\, (1+2\,j\,Q_o \frac{\Delta f}{f}) \quad \ldots.\ (7)$$

and $R_r = \beta Z_o$ with $\beta$ as the coupling factor between resonator and microstrip line. $Z_r$ is a function of resonator and microstrip line dimensions and their separation, and has been treated elsewhere {5} .
At resonance frequency :

$$\Gamma_{in} = \frac{R}{R_r + 2Z_o}\, e^{-2j\theta} \quad \ldots.\ (8)$$

### C - Circuit design

a) One port oscillator : (fig. 2).

. $\Gamma_1$ and hence $\theta_1$ are fixed for open circuit stub in the dashed curve of figure 4 (point A). Now the value of $\Gamma_2$ (and hence $d_2$) and $\theta_2$ for the dielectric resonator are obtained from the oscillation condition (2) and the relation (8).

. The output port is now assumed to be loaded respectively with $\frac{jY_o}{2}(s-1/s)$ and $-\,jY_o/2(s-1/s)$ and the new corresponding frequencies of oscillation are calculated at which $\Sigma B = 0$ where B at plane AA' is given by :

$$B = B_{22m} + B_{in}$$

which can be calculated from (5) and (6).

... The difference between these frequencies gives us $\Delta f$ to calculate $Q_{ext}$ from equ. (3).

.... $\Gamma_1$ and hence the length of open circuit stub is now varied within the dashed curve in fig. 4 and using the above procedure the $Q_{ext}$ is optimised.

An oscillator using the above approach was been realized using NEC 56755 bipolar at 6.4 GHz. The principal characteristics of the oscillator are :

Power output : 7 dbm
$Q_{ext}$ (calculated) : 14250
(measured) : 12200
Pushing figure < 200 KHz / volt.

. This oscillator does not give high power. However in a self oscillating mixer it is not the output power but the internal swing voltage which is important.

## CONCLUSION

We have presented simple, highly stable and high $Q_{ext}$ MIC oscillators using one and two dielectric resonators as frequency determining as well as input/output matching circuits for common collector bipolar or reversed channel common source field effect transistors for applications like reference stable oscillators, STALOS and self oscillating mixers etc.

The design can be generalised for any n port active device with no common port, by placing identical dielectric resonators at a specified distance and coupling on the 50 Ω microstrip lines loaded by 50 Ω on all the n ports. By adjusting the distance and the coupling of each cavity the oscillation condition can be optimised.

## ACKNOWLEDGEMENT

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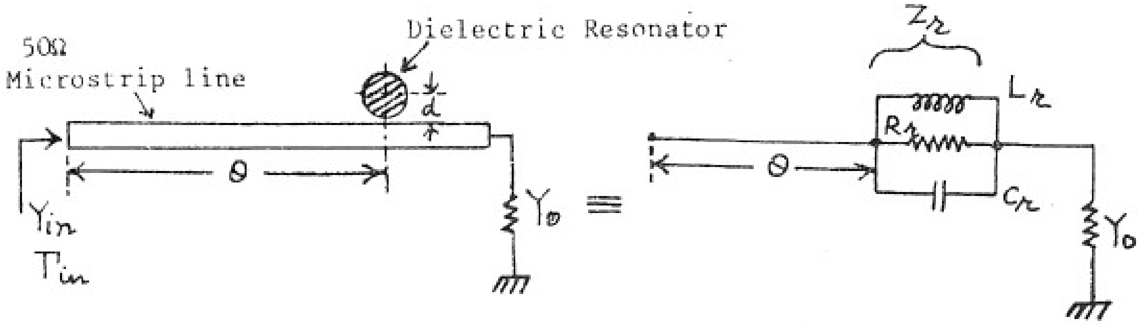

Fig.5 Dielectric resonator coupled to a microstrip line

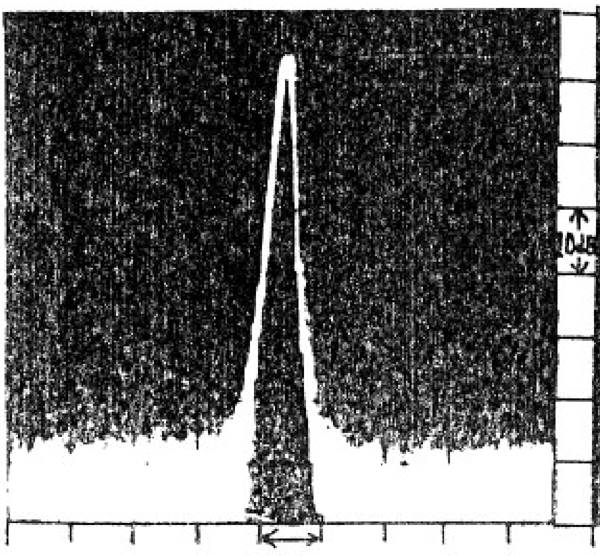

Figure:6

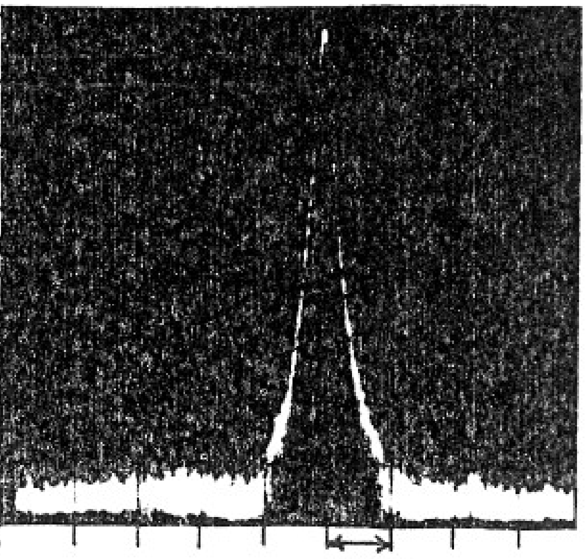

Figure:7

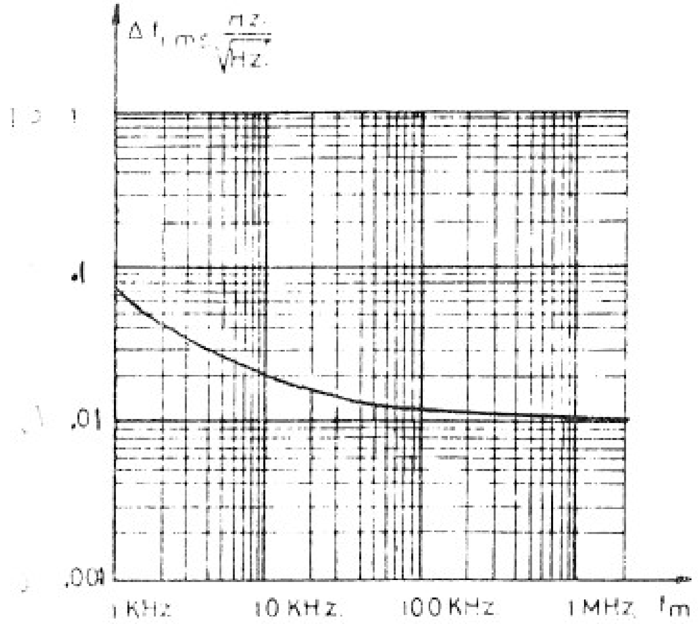

Figure:8