OSCILLATOR APPLICATIONS OF DOUBLE DIELECTRIC RESONATOR

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Oscillator configurations are presented which are based on utilization of a double dielectric resonator. Major advantage of this particular approach is wide, linear tuning of the oscillators. Q-factor degradation associated with metal tuning arrangements is prevented and additional temperature compensation and linearization is possible. The principle of operation and experimental results are shown.

INTRODUCTION.

Use of high Q, temperature stable resonant elements is necessary to stabilize fundamental frequency oscillators. Recently developed dielectric resonators have shown low loss as well as excellent temperature stability. Therefore, use of dielectric resonators in combination with bipolar or GaAs FETs becomes very attractive. Almost all dielectric resonator stabilized oscillators utilize single mode $TE01\delta$ in a cylindrical dielectric resonator, which is for certain D/L ratios considered fundamental. However, one of the drawbacks of structures using this mode is limited tuning range which can be achieved without significant degradation of the Q factor. Metal screws or tuning plates are typically used. Double dielectric resonators offer an excellent solution to this problem. The basic principle of such a resonator is relatively well known (since 1966- [1]), however most of the attention was devoted to accurate calculations of resonant frequencies of this structure (possibly multilayered) [2-4]. Early applications (utilizing rutile resonators) included temperature compensated bandstop filters [5] and slow wave structures [6]. More recent applications started utilization of this interesting concept in dielectric resonator oscillators [7-8]. In this short paper the configurations described in [8] will be explored, which result in easy to build dielectric resonator oscillators which are tunable over a relatively wide range of frequencies.

PRINCIPLE OF OPERATION.

A basic double dielectric resonator operating in $TE01\delta$ mode is shown in Figure 1. Typical tuning curve of such a structure

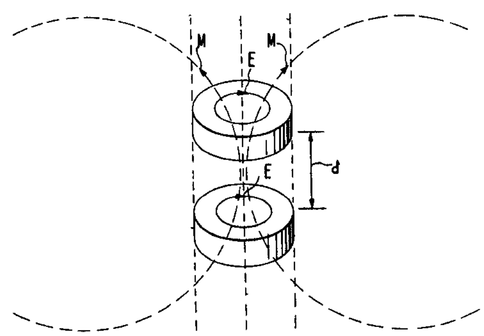

Figure 1. Basic configuration and field distribution of double dielectric resonator.

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is in order of 15% to 20 % and its shape is presented in Figure 2. An excellent paper [5] describes a method of resonant

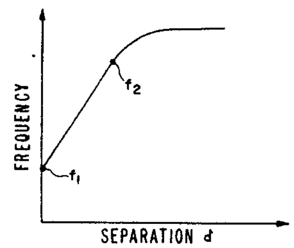

Figure 2. Typical tuning curve of double dielectric resonator.

frequency and Q factor calculations of a double dielectric resonator which can be used to design such a structure. The double dielectric resonator can be utilized in any dielectric resonator stabilized oscillator (TE01δ mode) to enhance tuning range. Typical configurations are shown in Figure 3(a-c). For all three oscillator configurations, the desired degree of coupling between the resonator and transmission lines is best determined experimentally (similar to a single dielectric resonator , which is obviously a special case of the double dielectric resonator when both halves are together). In oscillator applications, in spite of the fact that the double resonator structure is capable of wide band tuning (as a resonator), tuning range is somewhat reduced due to the phasing requirements for oscillator operation and acceptable variation of the oscillator output power. For this reason, the oscillator configuration should be carefully selected to meet oscillation conditions over the tuning range of the double oscillator.

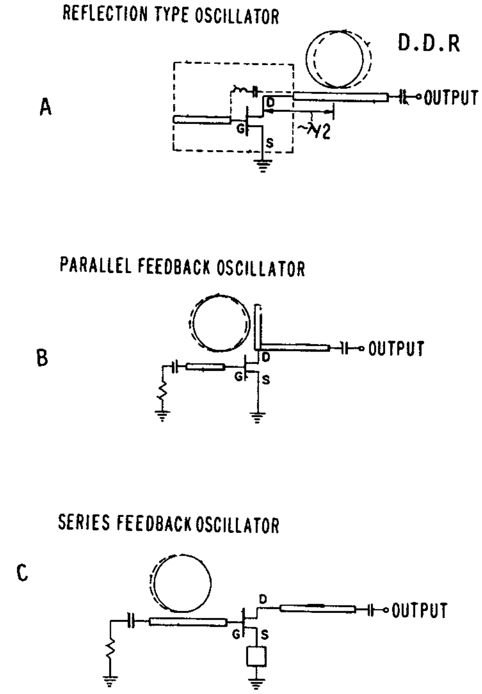

Figure 3. Typical oscillator configurations utilizing double dielectric resonator.

EXPERIMENTAL RESULTS.

Numerous oscillators in various configurations (Figure 3) were built and tested. Power output, phase noise performance and temperature stability were similar to the realized oscillators utilizing a single dielectric resonator, however , significant improvement in tuning range was achieved. Some selected examples of the achieved performance are shown in Figures 4-6. In some of the configurations so called reverse bias power FETs were used. A nominally 6 GHz oscillator utilizing a power device exhibited power output of +24 dBm and tuning range from 5800 MHz to 6300 MHz (Figure 5) with output power variation of less than 1.5 dB and no degradation of phase noise (Figure 4). Murata's Resomics R-04 was used to manufacture a double dielectric resonator and temperature stability better than 3 ppm/degree C was obtained. Higher Q factor Resomics R-03 can be also used, and for lower frequencies dielectric materials with dielectric constant on the order of 80 (manufactured by Trans-Tech) were successfully used. A photograph of one of the lower

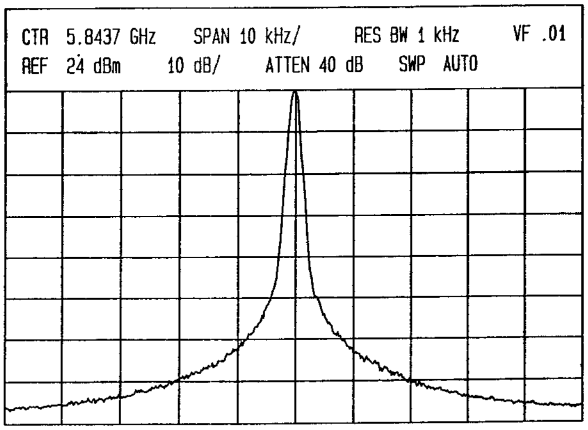

Figure 4. Phase noise performance of 6 GHz double dielectric resonator stabilized oscillator.

frequency oscillators with a tuning range greater than 100 MHz is shown in Figure 6. One of the additional advantages of the double dielectric resonator is flexibility in selection of temperature coefficients for each half of the resonator. By proper selection of the resonator materials and supports, the temperature coefficient of the composite resonator can be made linear and temperature performance better than 1 ppm/degree C can be achieved.

CONCLUSIONS.

A refinement of dielectric resonator oscillator configurations was described which removes one of the drawbacks of these devices, namely limited, nondegrading Q tuning range. Tuning ranges on order of 20% are theoretically possible. However, careful selection of the oscillator circuit and the active device is required to take full advantage of the double dielectric resonator. Another degree of flexibility is related to proper selection of the resonator's two halves materials for temperature compensation and temperature coefficient linearization.

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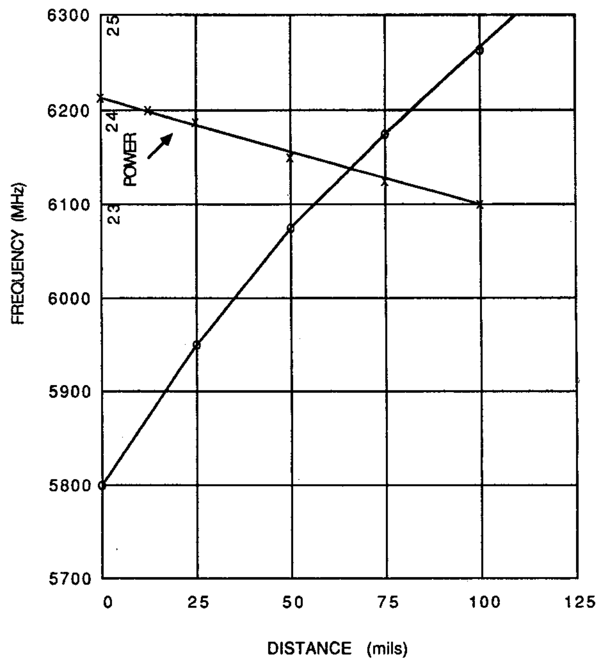

Figure 5. Tuning range and output power variation of 6 GHz double dielectric resonator stabilized oscillator.

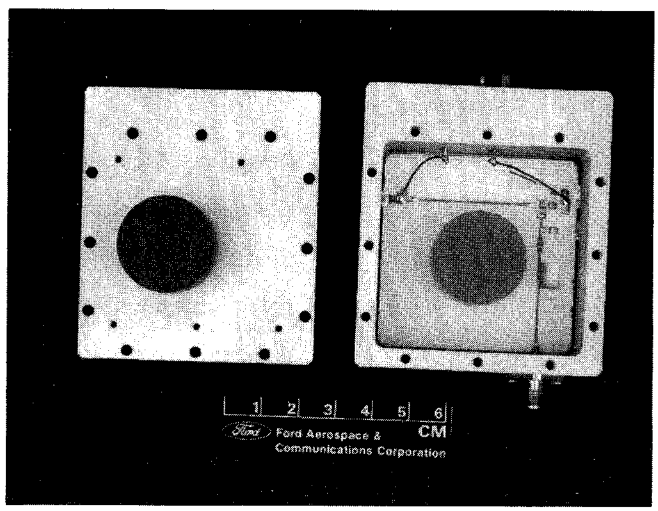

Figure 6. 2.2 GHz double dielectric resonator stabilized oscillator.