A Wideband Voltage-Tunable Dielectric Resonator Oscillator Controlled by a Piezoelectric Transducer*

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Abstract — **A new voltage-controlled dielectric resonator oscillator (VCDRO) is described. A piezoelectric transducer (PET) is used to vary the oscillation frequency by perturbing the electromagnetic fields of the DR. The measured frequency tuning is from -2.0 to +1.7 % about the center frequency of 11.78 GHz. The tuning bandwidth is slightly less than that of a mechanical tuning using a micrometer-head controlled tunable DRO with a tuning range of -3.1 to +1.6 %. To our knowledge, this is the largest electronic tuning range reported to date for a VCDRO.**

I. INTRODUCTION

The dielectric resonator oscillator (DRO) is used for stable microwave sources because of its temperature stability, small size, compactness, low price, etc. In addition, the electronically tunable DROs or voltage-controlled DROs (VCDRO) have many applications in phase-locked loop (PLL) circuits, frequency modulated continuous wave (FMCW) radar systems, and frequency hopping spread spectrum circuits. Several methods have been used to tune the resonant frequency of DR [1] and DRO: mechanical [2], ferrite, varactor [3]-[4], PIN diode, optical [5]. The mechanical method using a dielectric disc perturbation was able to maintain good performance over a wide tuning range [2]

The oscillation frequency of DRO can be tuned by perturbing the DR's electromagnetic fields. This tuning can be achieved by varying the air gap between the DR and the dielectric (or metallic) disc above DR. In this paper, to electronically control this mechanical movement, a piezoelectric transducer (PET) or actuator is used. The PET is a piezoelectric ceramic, deflected by an applied voltage [6]. PET-controlled tuning has been demonstrated on the recently reported phase shifter [7], tunable resonator [8], and phased array antenna [9]. Here, the PET controlled VCDRO is demonstrated to obtain the largest tuning range up to date.

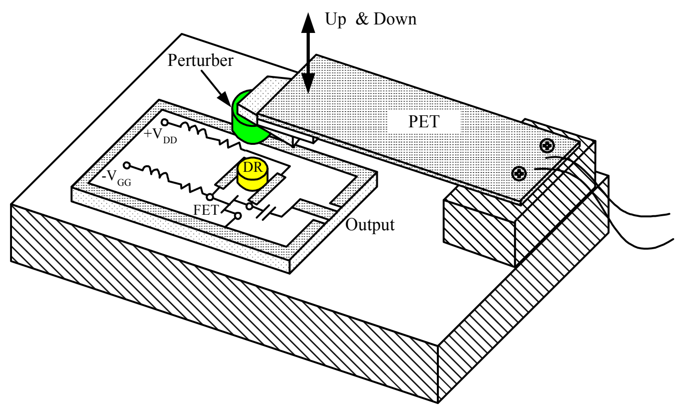

Fig. 1 Configuration of the PET controlled VCDRO.

II. DESIGN AND EXPERIMENTS

As shown in Fig. 1, the DRO consists of a MESFET feedback type oscillator with a DR. To perturb electromagnetic fields of the DR and thereby tune the oscillation frequency, a dielectric or metal perturber disc attached to the PET moves vertically above the DR puck as the DC bias voltages is varied from 0 to 90 V. The deflection of the PET may be varied linearly under the applied voltage [6]. The PET is composed with a Lead Zirconate Titanate (PZT) and can be deflected over $\pm$1.325 mm at $\pm$90 V. With its supporter, it has a size of 2.75x1.25x0.085 in^3. This size makes a large capacitance of 290 nF and a relatively slow response time of 5 ms. Smaller size can be used to make a compact unit and improve the tuning time. A commercial DR (Trans-Tech) of ε_r = 30.09 and a MESFET (Agilent, ATF-26836) are used. To obtain an optimum power level and a more stable oscillation, the location of DR between two microstrip-

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lines and bias conditions are adjusted. DC biases of V_{GG} = -0.8 V, V_{DD} = 12 V, and I_{DS} = 30mA are applied. A drain resistor of 100 Ω is used. The dielectric perturber has a dielectric constant of 10.8, diameter of 0.3 in, and thickness of 0.1 in. The perturber's size affects the tuning bandwidth. So as not to change the normal circuit operation, the perturber diameter is chosen very similarly with the DR puck diameter.

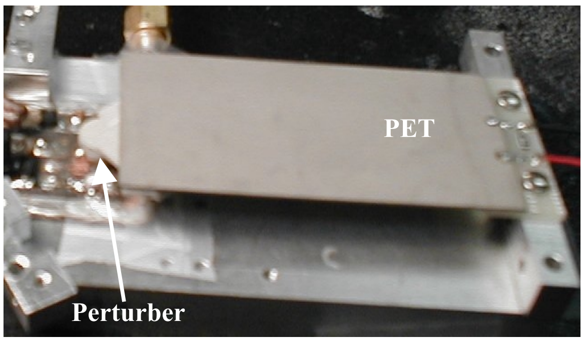


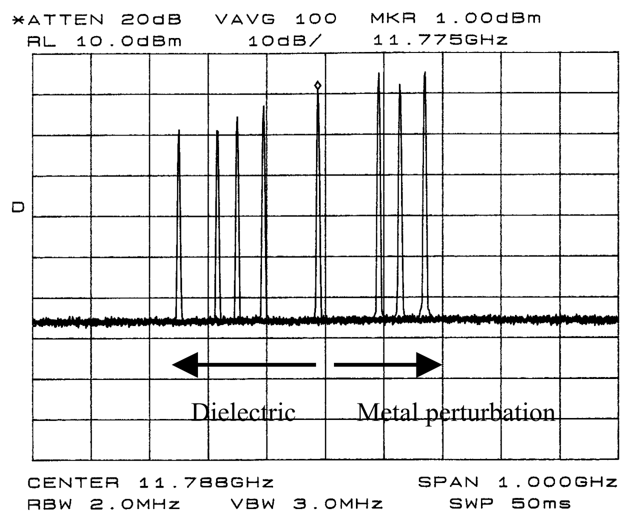
Fig. 2 A photograph of the PET controlled VCDRO.

Fig 2 shows a photograph of the PET controlled VCDRO. Measured results are shown in Fig. 3. A bottom-up alignment method was used, which means the minimum perturbation and deflection at 0 V and the maximum perturbation and deflection at 90 V. The use of dielectric and metal perturbation results in the tuning of the oscillation frequency from 11.54 to 11.97 GHz (–2.0 and +1.7 %) about the center frequency of 11.78 GHz. The metal perturbation may increase the stored magnetic energy in DRO with respect to the electrical energy, which results in increasing the oscillation frequency. It can be also explained with a metal cavity wall movement inward. The dielectric perturbation effect can oppositely be explained [1]. Higher dielectric constant material than 10.8 for the perturber may produce a wider tuning range [2]. Ideally the VCO output power level remains a constant, but practically the PET and metal or dielectric perturber make the output power level fluctuated from –5 to +2.9 dBm. The output power level without perturbation is +1.45 dBm.

For comparison, a mechanical tuning using a micrometer-head was set up as shown in Fig. 4, and the results are given in Fig. 5. The micrometer-head controlled DRO produces more ideal perturbation results due to better alignment and the smaller effect on circuit by the micrometer-head movement. A tuning bandwidth of -3.1 to +1.6 % with a power level variation of 4.5 dB has been achieved. The results are slightly better than the electronic tuning.

III. CONCLUSIONS

A new voltage-controlled dielectric resonator oscillator (VCDRO) using a piezoelectric transducer (PET) has been demonstrated. The PET was used to perturb electromagnetic fields of the DR and tune the oscillation frequency. The results were favorably compared with the mechanical tuning using a micrometer-head. With the largest electronic tuning range up to date, the new PET controlled VCDRO should be useful for many applications.



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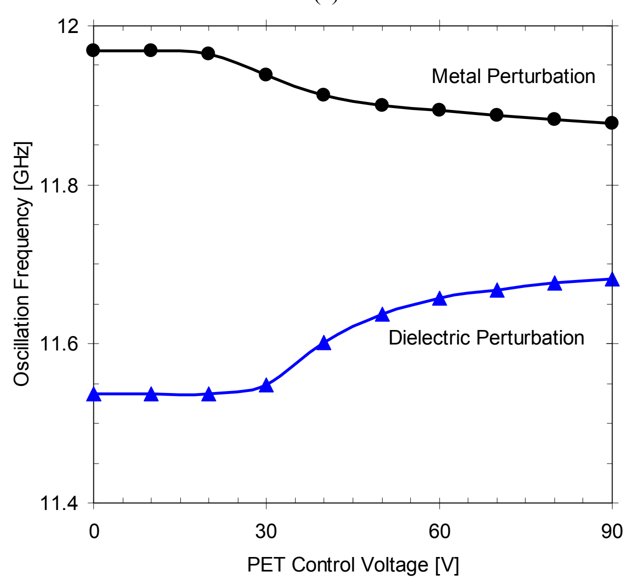

(b)

Fig. 3 PET controlled VCDRO results with the dielectric and metal perturbation: (a) the spectrum analyzer display of tuning

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the oscillation frequency and (b) oscillation frequencies vs. PET control voltages.

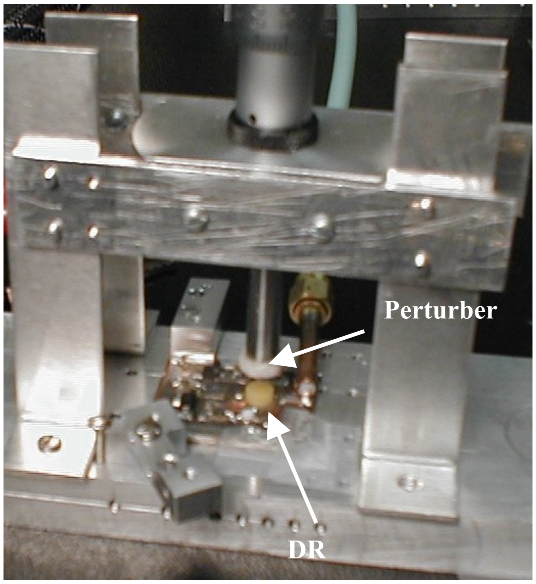

Fig. 4 A photograph of mechanical tuning using a micrometer-head controlled DRO.

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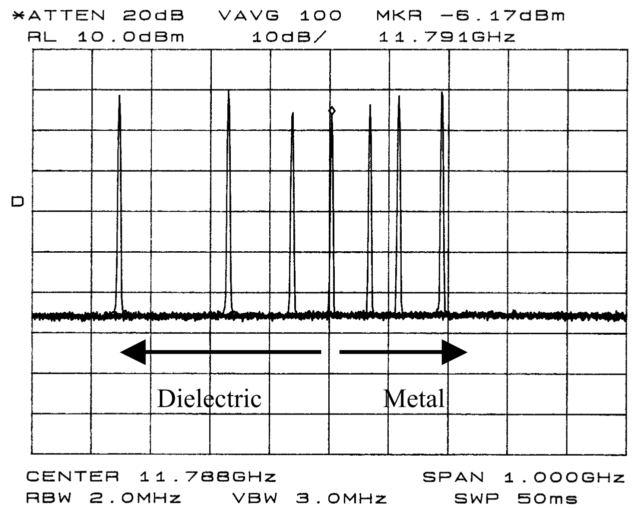

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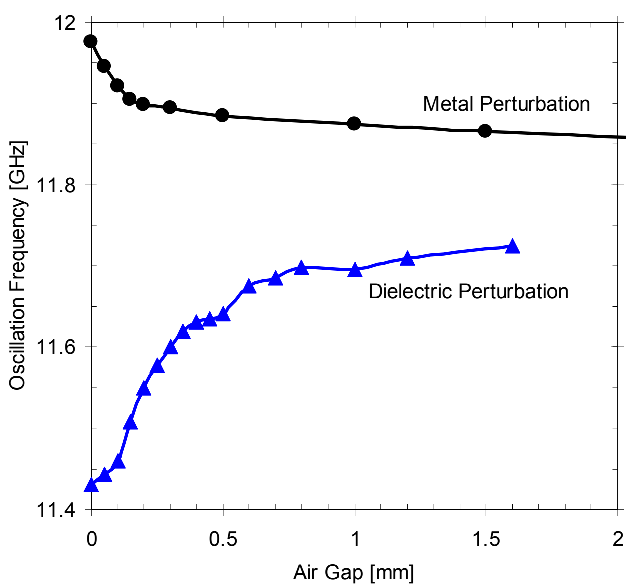

(b)

Fig. 5 Mechanically micrometer-head controlled DRO results with the dielectric and metal perturbation: (a) the spectrum analyzer display of tuning the oscillation frequency and (b) oscillation frequencies vs. PET control voltages.