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Dielectric Resonator Oscillator

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ABSTRACT

This paper describes the detailed theory of design of DRO. The design parameters of Dielectric resonator oscillator (DRO) and the different techniques used to design DRO is illustrated. The use of negative resistance amplifier (NRC) and the dielectric resonator in the design of DRO is explained.

Keywords— *Resonator, Dielectric Resonator, Dielectric Resonator Oscillator, Negative Resistance Amplifier*

1. INTRODUCTION

In design of Oscillator, the negative opposition (NRC) idea is utilized for the advancement of reflection enhancers. The dynamic component in NRC is a transistors, which structures negative opposition hardware. An oscillator that utilizes a Dielectric Resonator as the frequency deciding component, to deliver signals with high Q and low miniature noise is called as Dielectric Resonator Oscillator (DRO). The full frequency of a DRO relies on the actual components of the dielectric material utilized, its shape - square shape or plate and its dielectric consistent.

2. DIELECTRIC RESONATOR

Resonators are used to determine the frequency at which resonance or oscillation occurs. The resonators are used in RF/microwave components like oscillators and amplifiers. The different types of resonators are Coaxial resonator, Dielectric esonator, Crystal resonator, Ceramic resonator, SAW and YIG resonators. These are the different kinds of resonators used for designing oscillators and amplifiers. Some of the resonators as described are also used for determining the lower phase noise but those are limited to some frequency of operation. But the dielectric resonators are used at microwave frequencies and for this reason only the dielectric resonators are using instead of other resonators in the design of oscillators. This prescribed theory can be used at C, Ku, K band frequency of operation for the design of oscillator. A dielectric resonator can be utilized to supplant resounding desolations in parts, like amplifiers and oscillators. It is normally a circle formed material with a high dielectric constant (εr). This high dielectric constant (εr) esteem gives a critical benefit, empowering high Q-factor.

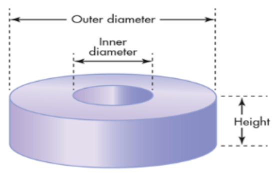

Fig. 1 Dielectric Resonator

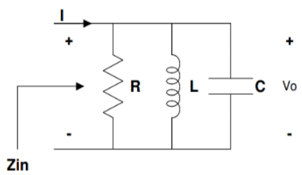

Fig. 2 DR modelled as parallel RLC Circuit

which will be helpful for getting lower phase noise of the oscillator. The main reason in utilizing the dielectric resonator compare to other types of resonators in the design of oscillator is to reduce the phase noise at the output. The quality factor is inversely proportional to the phase noise and as dielectric resonators are having high quality factors up to 5000 to 10000 even more than this.

The above fig. illustrates a typical disc shaped dielectric resonator. While designing disc type resonator we should know the outer diameter and inner diameter, height as shown in the Fig.1. The Dielectric resonator is realized by modelling it to parallel RLC circuit. The values are calculated by using equations and demonstrated by using the Fig.2.

From Fig. 2. The following equations explains the theoretical calculation for the design of dielectric resonator.

$$\mathrm{Zin} = \frac{\mathrm{V0}}{I} = [\mathrm{sC} + (\mathrm{sL})^{-1} + \mathrm{R}^{-1}]^{-1} \quad (1)$$

At resonance,

$$Zin = R \quad (2)$$

The resonator frequency can be defined as,

$$\mathrm{f}_0 = \frac{1}{2\pi\sqrt{LC}} \quad (3)$$

Number of turns in the dielectric resonator can be calculated as,

$$N^2 = \frac{2Z_0\Gamma}{R-\Gamma R} \quad (4)$$

Where,

$$\Gamma = \frac{\beta}{1+\beta} \quad (5)$$

Inductive component of resonator,

$$L = \frac{R}{W_0\, QL} \quad (6)$$

Capacitive component of the resonator,

$$C = \frac{QL}{W_0\, R} \quad (7)$$

The unloaded Q-factor of the resonator,

$$Q_0 = \frac{R}{W_0 L} \quad (8)$$

The relation of Q0 & Qext,

$$\frac{Q0}{Qext} = \frac{R}{2Z0} \quad (9)$$

Where, Qext is external Q-factor.

The relation between the loaded and unloaded quality factor is given as,

$$Q0 = (1+\beta)QL \quad (10)$$

Where, QL is loaded Q-factor. From the above relation the coupling co-efficient of the resonator,

$$\beta = \frac{R}{Rext} \quad (11)$$

3. NEGATIVE RESISTANCE CIRCUIT

The idea of the negative obstruction gadget is straightforwardly identified with the idea of the power gain which is significant for oscillator to work. In regrettable opposition, the voltage and current are 180 degrees out of phase. Subsequently, an expansion in voltage in adverse opposition gadget leads to diminish in current and result of voltage and current gets negative. This relates to the idea of power gain. In the two-port oscillator, the for the most part comprises of complex and that with the semiconductor gives the vital negative protection from the circuit. Though the Generator tuning network decides the swaying frequency utilizing a resonator. These are utilized in electronic oscillator, enhancers at microwave frequency (i.e., 1 GHz to 1000 GHz).

Negative opposition intensifier is reciprocal (has 2 terminals), it intensifies in the two ways, so it experiences affectability to stack impedances and feedback issues, so we use Circulators to isolate the information and yield the power in the middle of resonator and transistor. The Fig. 3 shows the negative resistance circuit. The theoretical calculations used for the design of negative resistance circuit are explained from the Fig. 4.

From the Fig. 4 we can write,

$$Zin = Rin + jXin \quad (12)$$

and

$$ZL = RL + jXL \quad (13)$$

From KVL,

$$(Zin + ZL) \times I = 0 \quad (14)$$

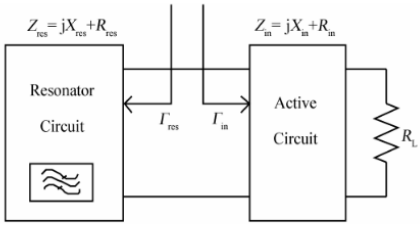

Fig. 3 Negative resistance circuit

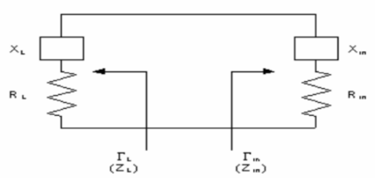

Fig. 4 NRC

For oscillation,

$$RL = -Rin \quad (15)$$

And

$$XL = -Xin \quad (16)$$

Since the load is passive RL > 0 so Rin < 0,

$$\Gamma L = \frac{ZL+Z0}{ZL-Z0} = \frac{-Zin-Z0}{-Zin+Z0} = \frac{Zin+Z0}{Zin-Z0} = \frac{1}{\Gamma in} \quad (17)$$

So, Rin become negative as the oscillation starts, important to select RL so that RL + Rin < 0 to start condition.

$$RL = -\frac{1}{3}\,Rin \quad (18)$$

4. DIELECTRIC RESONATOR OSCILLATOR

This circuit normally comprises of an enhancer, a resonator, and a feedback organization. The feedback might be inside i.e., a piece of energy from the dynamic gadget is taken care of back to the resonator or it could be an outside feedback circuit. The dynamic gadget in the oscillator takes in DC power from a managed supply and for an information power gives a particular yield power which is a few times higher in extent. It very well may be a bipolar intersection semiconductor (BJT), or a field impact semiconductor (FET) or a Gain block which is generally wideband. The details influencing the nature of activity of the entire system relies upon the neatness of the oscillator signal i.e., low phase noise and low deceptive, which comprise noise in systems. The ideal qualities for oscillators are adequate yield RF power level, low phase noise, proficiency, and strength of the sign and so on A few noises add to the all-out noise of the oscillator. These remember misfortunes for the resonator, semiconductor noise, noises regulated in power supply and noise due to the varactor diode tuning.

Furthermore, appropriate choice of the dynamic gadget to create the ideal yield wavering power while limiting phase noise is fundamental which is likewise attached to the right DC biasing of the dynamic gadget and legitimate segregation of DC inclination parts versus RF signal way.

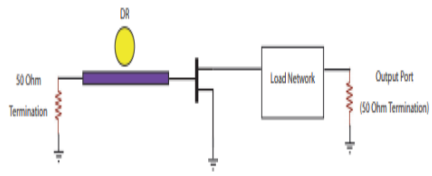

Fig. 5 Series feedback DRO

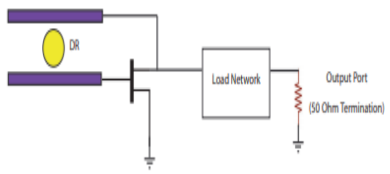

Fig. 6 Parallel feedback DRO

Qualities that are wanted from an effective DRO are an exceptionally low phase noise, high yield wavering power, high temperature steadiness, and a generally high DC to RF productivity. In most oscillator designs, designing to boost each of the four of these boundaries isn't down to earth and a few concessions should be made in the designs. The following segment talks about many distributed DRO's and other resonator oscillator designs that have attempted to expand one or these boundaries by presenting contrasts in dynamic gadgets, dielectric materials, taking care of systems, and techniques for supporting motions. There are two techniques to design DRO as shown in Fig. 5 and 6, the series (dielectric resonator is arranged series to the active device) and the parallel (dielectric resonator is arranged parallel to the active device i.e., transitor or negative resistance circuit) feedback dielectric resonator oscillator (DRO).

$$QL = \frac{F0}{F2-F1} \quad (19)$$

Where, F2 & F1 are 3 dB cut-off frequency of the resonator.

$$Qu = \frac{QL}{1-S21(linear)} \quad (20)$$

For the design of DRO or any microwave oscillator we need biasing circuit and it is described as below.

4.1 DC Biasing

A DC inclination circuit should be built to predisposition the dynamic component at the right working point to have the option to support motions. Likewise, dc obstructing capacitors should be fixed on the yield line to hinder dc.

4.2 Stub

Spiral stubs are frequently utilized in these predisposition circuits. The motivation behind spiral stub is to give a thunderous short out. The outspread stub generally utilized as a detour capacitor in the predisposition circuit of micro-strip speakers and oscillators.

4.3 Matching

The coordinating is done so that the reflection taking a gander at the info and the yield, ought to be more than solidarity (S11 and S22 > 1).

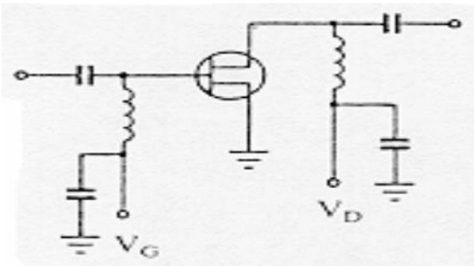

Fig. 7 DC Biasing

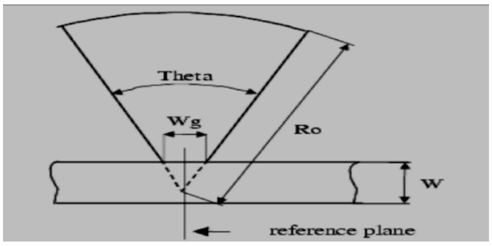

Fig. 8 Stub

5. CONCLUSION

In this paper the design techniques series feedback and parallel feedback dielectric resonator oscillator (DRO) are explained. The concept of circulator used in the negative resistance circuit. The full frequency of a DRO relies on the actual components of the dielectric material utilized, its shape - square shape or plate and its dielectric consistent.

6. ACKNOWLEDGMENT

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7. REFERENCES

[1] Mahyuddin, Nor Muzlifah, et al. "A 10GHz PHEMT dielectric resonator oscillator." *2006 International RF and Microwave Conference*. IEEE, 2006.

[2] Régis, Myrianne, Olivier Llopis, and Jacques Graffeuil. "Nonlinear modeling and design of bipolar transistors ultra-low phase-noise dielectric-resonator oscillators." *IEEE Transactions on Microwave Theory and Techniques* 46.10 (1998): 1589-1593.

[3] Khanna, A. P. S. "Review of dielectric resonator oscillator technology." *41st Annual Symposium on Frequency Control*. IEEE, 1987.

[4] Pavio, Anthony M., and Mark A. Smith. "A 20-40-GHz Push-Push dielectric resonator oscillator." *IEEE Transactions on Microwave Theory and Techniques* 33.12 (1985): 1346-1349.

[5] Mahyuddin, Nor Muzlifah, et al. "Modeling of a 10GHz dielectric resonator oscillator in aDS." *2006 International RF and Microwave Conference*. IEEE, 2006.

[6] Lan, G., et al. "Highly stabilized, ultra-low noise FET oscillator with dielectric resonator." *1986 IEEE MTT-S International Microwave Symposium Digest*. IEEE, 1986.

[7] Pavio, A. M., and Mark A. Smith. "Push-push dielectric resonator oscillator." *1985 IEEE MTT-S International Microwave Symposium Digest*. IEEE, 1985.

[8] Warburton, A. "A phase tuned, fixed frequency dielectric resonator oscillator design." *2005 European Microwave Conference*. Vol. 1. IEEE, 2005.

[9] Manjunatha, R.H. and Manjunath, R.K., 2018, April. Design and Simulation of Ku-Band Voltage Tuned Dielectric Resonator Oscillator. In *2018 International Conference on Communication and Signal Processing (ICCSP)* (pp. 0299-0304). IEEE.