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HIGH Q DIELECTRIC RESONATOR FREQUENCY DISCRIMINATOR.

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ABSTRACT.

A novel , dielectric resonator frequency discriminator utilizing a degenerate, hybrid mode is described. Principle of operation is similar to cavity type discriminator. Advantages of the dielectric resonator approach include simplicity, compatibility with MIC and MMIC structures, low cost, small size, high temperature stability and high Q.

INTRODUCTION.

Stable oscillators are needed in many microwave systems. Modern, solid state fundamental frequency oscillators can be stabilized by phase locking to a stable reference signal, using high Q cavity or a dielectric resonator in an oscillator circuit or by using a discriminator circuit. Cavity type discriminators were introduced as early as 1950 [1] and have been used by several radio link manufacturers for transmitter frequency stabilization (so called AFC cavity) [2]. However, waveguide type, high Q cavities are quite large, heavy (made using temperature stable alloy invar,sealed and filled with e.g.nitrogen) and not compatible with state of the art MIC or MMIC oscillators. For these reasons , miniature, light and temperature stable dielectric resonators are replacing waveguide cavities in most directly stabilized solid state oscillators. To miniaturize a discriminator circuit , a microstrip resonator circuit was proposed by B.Glance and W.W.Snell,Jr. [3]. Small size and compatibility with MIC circuits were achieved,however Q factor of the discriminator was degraded and the frequency stability directly related to temperature stability of the substrate was rather poor (28ppm/degree C). A single mode ,dielectric resonator discriminator was introduced in [4]. A dual mode dielectric resonator frequency discriminator is proposed in this short paper,which offers significant size and weight advantages over waveguide cavity approach and much higher Q and stability than a microstrip resonator circuit.

PRINCIPLE OF OPERATION.

Similar to waveguide cavity configuration,two orthogonal modes are excited in a cylindrical or square dielectric resonator. One of the modes is tuned to a slightly different frequency than the other. Two opposite polarity diodes are coupled to these two modes . Output voltage from these diodes is proportional to frequency and combines into a discriminator curve. This simple concept is illustrated in Fig.1. In the most popular cylindrical dielectric resonator hybrid,degenerate modes such as $HE_{11\delta}$ and $EH_{11\delta}$ can be used to design the discriminator. In this particular discriminator mode HE11o will be used.

EXPERIMENTAL RESULTS.

One of the possible configuration of the dielectric resonator frequency discriminator is shown in Fig.2. A high Q dielectric resonator is placed on low loss support (to maximize Q factor) and is excited by a microstrip line (or electric probe) to resonate in $HE_{11\delta}$ mode. This particular mode can be resolved into two orthogonal modes. Each mode is weakly coupled to a reversed diode pair. Detected signals from the diodes are combined and form desired discriminator output voltage. Typical output voltage from the discriminator is shown, in Fig.3. It can be seen that very narrow bandwidth and good sensitivity are easily achievable(0dBm input signal was used). Return loss of the discriminator is shown in Fig.4. One of the advantages of the dielectric resonator operating in a $HE_{11\delta}$ mode is the flexibility and tuning range. This particular mode can be tuned up and down over a wide range (e.g. 500MHz @ 4 GHz) without significant degradation of the resonator Q. Possible tuning methods are shown in Fig.5. By perturbation of a magnetic field (a) it is possible to tune this mode up in frequency over a similar range to the $TE_{01\delta}$ mode range. In addition, by perturbing electric field (b) wide tuning range down in frequency can be obtained (not possible in TE01o mode). Additional frequency offsets or tuning can be obtained by selectively notching the dielectric disc(c). Discriminator structure can be temperature compensated by a proper selection of dielectric resonator temperature coefficient and stabilities less than 0.5ppm/degree C were obtained(almost perfect compensation is possible). This particular structure is compatible with MIC voltage controlled oscillators, which can be easily stabilized by such a discriminator. In the case of MMIC oscillators, all the components of the stabilized oscillator (including stabilization loop) except discriminator can be incorporated on one GaAs chip forming a very compact structure.

CONCLUSION

It has been shown that a cavity type frequency discriminator can be greatly improved by the use of a dielectric resonator. Excellent electrical performance of the structure is combined with exceptional temperature stability, small size, low weight and cost.

REFERENCES. 1. W.W.Hansen et al " Ultra High Frequency Discriminator and Apparatus" U.S.Patent 2,502,456, April 4,1950.
2.F.Ivanek " Oscillator Alternatives Examined" Microwave Systems News November, 1979.
3.B.Glance, W.W.Snell Jr. " A Discriminator Stabilized Microstrip Oscillator" , IEEE Transactions on MTT ,pp.648-650,October 1976.
4.M.J.Bianchini et al. " A Single Resonator GaAs FET oscillator With Noise Degeneration " 1984 IEEE MTT-S Digest pp.270-273, June 1984, San Francisco.

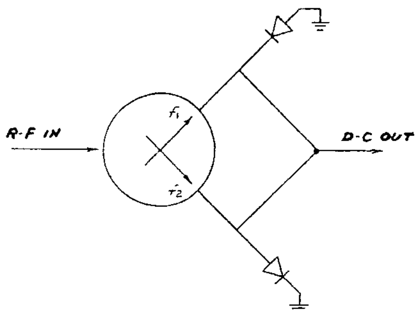

FIGURE 1. BASIC DIAGRAM OF CAVITY DISCRIMINATOR.

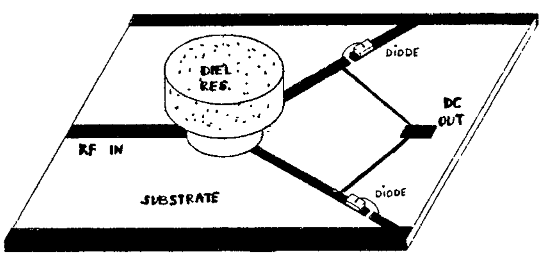

FIGURE 2. DIELECTRIC RESONATOR FREQUENCY DISCRIMINATOR CONFIGURATION.

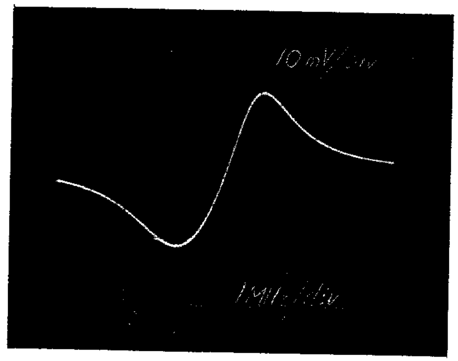

FIGURE 3 . DETECTED OUTPUT SIGNAL OF THE DISCRIMINATOR (0 DBM IN).

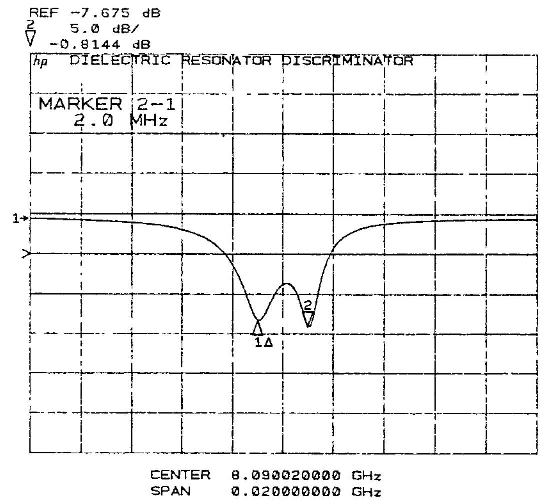

FIGURE 4. INPUT RETURN LOSS OF THE DISCRIMINATOR.

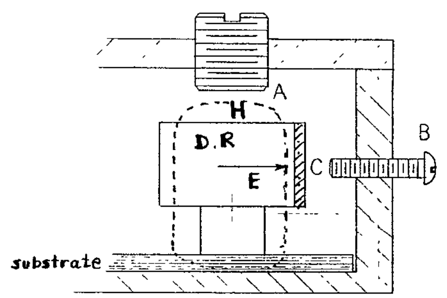

FIGURE 5. FREQUENCY TUNING OF HE11δ MODE. (A) LARGE SCREW PERTURBING MAGNETIC FIELD. (B)SCREW PERTURBING ELECTRIC FIELD. (C) NOTCH OR FLAT.