FAST SWITCHING X AND Ku BAND MULTI FREQUENCY DIELECTRIC RESONATOR OSCILLATOR USING A SINGLE GaAs FET.*

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ABSTRACT:

A novel scheme of generating fast-switchable, highly accurate and spurious-free stable signals at widely different frequencies is presented. Using a single GaAs FET oscillator circuit and switching the dielectric resonators through PIN diodes, an efficient and high performance four-switchable-frequency DRO assembly has been realized. Settling times of less than 2 μs, in which the output frequency is within $\pm$ 10 ppm of the final frequency, have been achieved.

INTRODUCTION:

Recent developments in temperature-stable, low-loss ceramic materials have created significant interest in their application in microwave components such as filters, discriminators and oscillators. Various aspects of single-frequency transistor dielectric resonator oscillators have been addressed in a large number of publications in recent years. This paper presents a unique approach for generating rapidly-switchable, stable signals at widely different frequencies using a single transistor oscillator circuit, by switching several dielectric resonators using PIN diodes. Using this technique, a compact, efficient and high performance four-selectable-frequency DRO assembly has been realized.

A number of military/EW systems require spurious-free, fast-switching multiple-frequency sources. These requirements are presently being met by using several, separate dielectric-resonator oscillator (DRO) circuits, selectetd via high-isolation PIN-diode switches (Figure 1). In order to achieve fast settling time using this technique, all oscillators are always operating, and the outputs are switched. This approach calls for well-matched, very-high-isolation PIN switches, to reduce spurious outputs at the unselected frequencies. The isolation required generally exceeds the best isolation of switches available commercially.

The new approach presented in this paper, shown in figure 2, uses a single transistor and a simple single-pole four-throw (SP4T) switch to select the dielectric resonators at the gate terminal[1]. The DRO subassembly thus realized fully meets the switching speed and spurious requirements for most applications. This approach has the inherent advantages of fewer components, smaller size, lower cost and higher DC/RF efficiency.

DESIGN APPROACH:

A series-feedback, drain-output configuration is used for the oscillator. A proprietary high-gain, low-current 0.5 μm Avantek GaAs FET is used as the active device and, for the application, characterized by two-port common-source S-parameters. Source impedance is mapped in the S11 plane by using the converted 3-port S-parameters at different frequencies[2]. The value of the necessary capacitance in the source lead for creating wideband negative resistance in the frequency band of 10 to 18 GHz is calculated.

A simple four-diode SP4T PIN switch is used at the gate terminal of the GaAs FET to select the dielectric resonator (DR) corresponding to the desired frequency. The position of the resonator is determined to satisfy the oscillation conditions at that frequency with the PIN diode in that line in the "ON" condition and other three diodes "OFF". The oscillator oscillates only at the resonant

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frequency of the DR connected through the "ON" PIN, diode while all the other DRs act as passive elements connected to the FET gate through the "OFF" PIN diodes. High quality, low-loss, low-capacitance PIN diodes are required for the purpose. Three of the four frequencies are selected using this technique. The fourth PIN diode, connected to 50 ohms resistance, provides a PIN switch position corresponding to no oscillation and hence no RF output condition.

The fourth stable frequency is generated by using a dielectric resonator as a stabilizing filter at a proper plane in the output of the oscillator[3]. With all four diodes turned "OFF", the transistor oscillates at a frequency determined by the length (L1) of the transmission line at the gate terminal. This length is calculated to achieve oscillations close to the resonant frequency of the DR placed in the drain circuit of the FET. This resonator does not affect any of the three frequencies generated by the selection of resonators in the FET gate circuit.

The main characteristics of this approach are:

No Spurious At Unselected Frequencies:

The problem of spurious signals, especially at the unselected frequencies, is effectively solved. The oscillation conditions are satisfied only at the desired frequency, resulting in generation of only one signal at a time. This is achieved by a simple four-diode SP4T switch to select the resonators.

Fast Switching:

Fast switching between output frequencies is obtained by keeping the GaAs FET always biased on, and using the high-Q resonators to control the frequencies. Special precautions are taken to keep the RF power output and DC/RF efficiencies as close to the same as possible at each frequency, minimizing the thermal changes, and thus reducing the settling time.

Fewer Components and High Efficiency:

Compared to the earlier technique (figure 1) of switching the oscillators, the number of transistors are reduced by 1/n where n is the number of frequencies generated. Additionally, the otherwise-necessary complex, matched PIN switch has been replaced by a simple four-diode SP4T switch. This saving in components directly results in lower cost, higher efficiencies and improved reliability.

EXPERIMENTAL RESULTS:

A four-frequency X and Ku band DRO asssembly has been realized using the above detailed approach. The complete assembly consists of the switchable oscillator, a digitally controlled driver and an amplifier. All circuits are realized in MIC hybrid form on 15 mil alumina. The oscillating GaAs FET is biased at 4.5 volts and 50% Idss. A commercial PIN quad used as the RF switch was biased at about 10 ma in the "ON" diode. The frequency selection is digitally controlled by using a digital decoder chip to drive the PIN switch drivers. An Avantek proprietary high gain, low VSWR and wideband GaAs MMIC is used as a buffer amplifier. This device has 1dB compression power of 13dBm. The important measured results are in Table No. 1:

TABLE NO. 1

Parameter	Osc. 1	Osc. 2	Osc. 3	Osc. 4
Frequency	10.8 GHz	12.9 GHz	14.5 GHz	16.8 GHz
Power	13.5 dBm	13 dBm	13 dBm	12.0 dBm
DC/RF Efficiency	8%	8%	7.5%	7%
Phase Noise @ 10 KHz	-90 dBc	-85 dBc	-85 dBc	-80 dBc
Temperature Stability	2.5ppm/^{o}C	2.4ppm/^{o}C	3ppm/^{o}C	3.8ppm/^{o}C

Spurious at unselected frequencies:

Less than our measurement limit of- 90 dBc.

Settling Time:

Settling time was measured using a delay line discriminator approach shown in figure 3. High-stability electrically tunable DRO's were used to calibrate the system. The results were displayed on a HP model 54100A storage scope. The settling times were measured to be between 1.4 to 1.8 µs. Figure 4 shows a typical settling time measurement.

ACKNOWLEDGEMENT:

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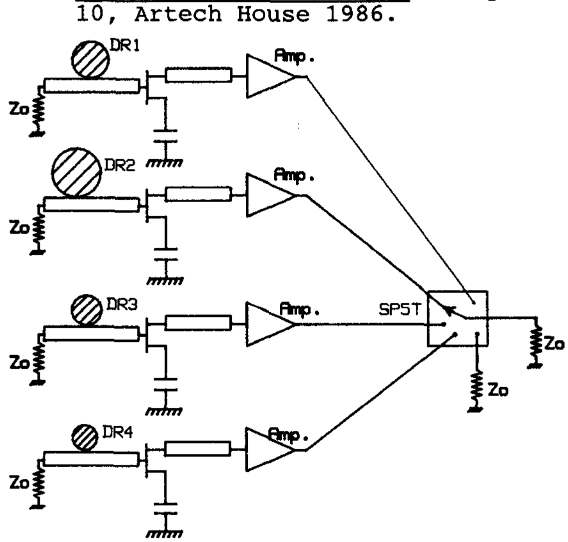

Fig. 1 Selectable Freq. DRO: Old Approach

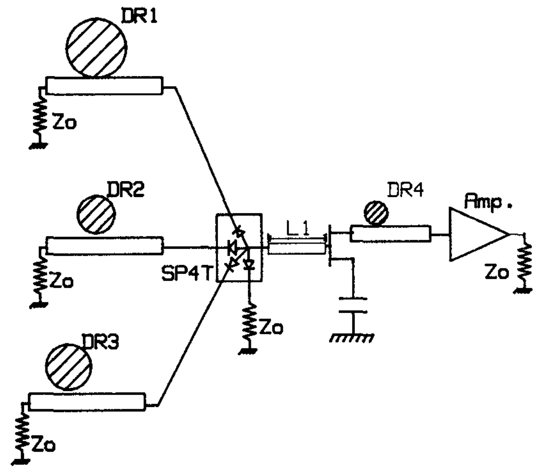

Fig. 2 Selectable Freq. DRO: NEW APPROACH

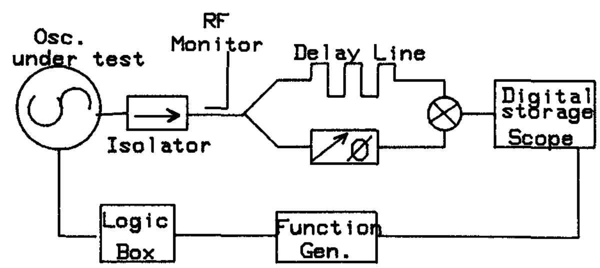

Fig. 3 Setling Time Measurement Setup

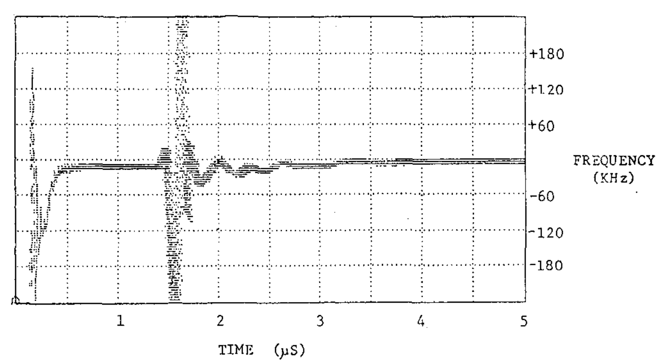

Fig. 4 - TYPICAL SETTLING TIME MEASUREMENT (12.9 TO 10.8 GHz)