Frequency Selectable Parallel Feedback X/Ku Band DRO Using GaAs MMIC

A.P.S.KHANNA & R.T.OYAFUSO

AVANTEK INC.
481 Cottonwood Drive
Milpitas CA. 95035

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 wideband MMIC amplifier and switching the parallel feedback dielectric resonators through the PIN diodes, an efficient and high performance dual DRO assembly has been realized at X/Ku-Band. Settling times of less than 2 us, in which the output frequency settles within ±10 ppm of the final frequency, has been achieved.

INTRODUCTION:

Recent developments in temperature-stable, high Q and convenient size have created significant interest in their application in microwave components such as filters, discriminators and oscillators. Various aspects of the transistor dielectric resonator oscillators have been addressed in a large number of publications in the recent years[1]. This paper presents a unique and simple to realize approach for generating rapidly switchable, stable signals at widely different frequencies using a single GaAs MMIC amplifier and by switching the dielectric resonators using PIN diodes[4](Figure 1). Using this scheme a compact, efficient and high performance dual DRO assembly with no-spurious at unselected frequency has been realized. The new approach is superior than the approach using single GaAs FET device and switching dielectric resonators[2] in view of the wideband characteristics of the circuit, ease of alignment and cost.

A number of military /EW systems require spurious free, fast switching multiple frequency sources. These requirements are presently being met by using separate dielectric resonator oscillator(DRO) circuits,

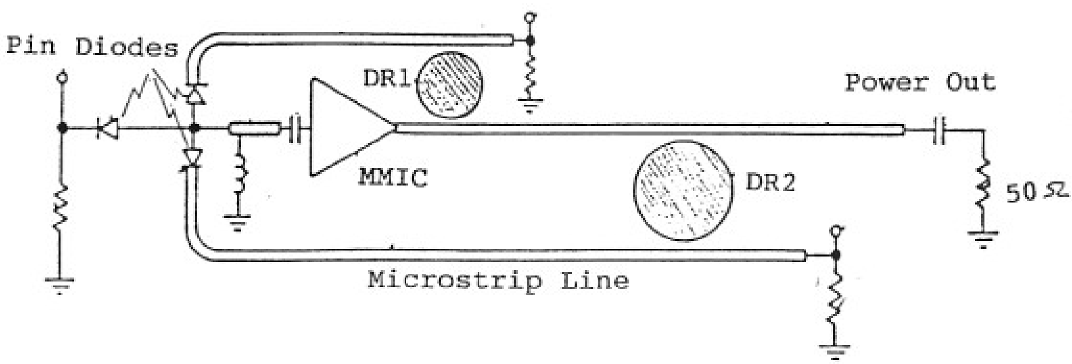

Figure 1. Parallel Feedback Switchable MMIC DRO.

selected via PIN-diode circuits (Figure 2).

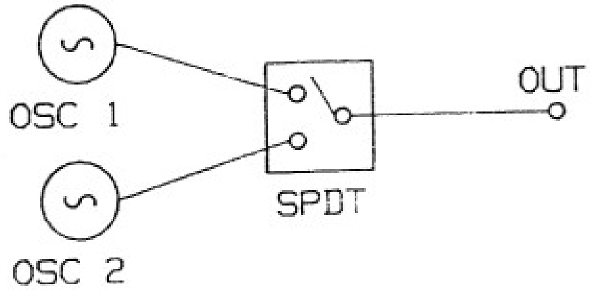

Fig.2 Old Approach

In order to achieve fast settling time using this technique, both 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 frequency. The isolation required generally (>90dBc) exceeds the isolation of the switches available commercially. In the new approach only one oscillator is "ON" at a time thus eliminating the need for PIN switch and fast frequency settling is achieved by keeping the bias "ON" for the device and switching the dielectric resonators. This approach has the inherent advantages of fewer components, smaller size, lower cost and higher DC/RF efficiency.

DESIGN APPROACH:

A parallel feedback configuration[1] is used for the oscillator as shown in figure 1. A wideband GaAs FET MMIC Amplifier, Avantek M21000, using sub-micron technology, is used as an active device. This device has gain of better than 7 dB and P1dB of better than 13 dBm from 2 to 20 GHz. The RF circuit is simple 50 ohm lines which make this design usable over a wide frequency range. The dielectric resonators are placed along the output line resulting in compact sub-assembly. The PIN quad, an Avantek 4PIN diode chip, is used to connect either of the dielectric resonator or 50 ohms to achieve oscillations at f1 or f2 or no-oscillations. This configuration is based on the use of the forward gain of the device. The dielectric resonator is used as a bandpass filter, and connected across the two terminals of the MMIC amplifier possessing the transmission gain greater than the insertion loss of the dielectric resonator filter. To oscillate, the electrical line length between the active device(MMIC) input and output must also provide a phase shift around the feedback loop equal to an integer multiple of 2 π radians at the oscillation frequency.

The dielectric resonator used is a high Q, temperature stable ceramic material with dielectric constant of 37. The material is 8514 by trans-tech Inc. having a temperature coefficient of 3ppm/deg C.The unloaded quality factor of the dielectric resonator was measured using[3] to be 3010 at 9.8 GHz and 2540 at 12.5 GHz. The dielectric resonator coupled simultaneously to the two microstrip lines can be modeled using known techniques[1]. The coupling of the dielectric resonator to microstrip lines can be optimized for the desired insertion loss and quality factor of the transmission filter.

The four diode SP4T PIN switch,in chip form, is used at the input of the MMIC to select either of dielectric resonators or 50 ohms. 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 PIN diodes in the "OFF" condition. The oscillator oscillates only at the resonant frequency of the DR connected through the "ON" PIN diode, while the other Dielectric resontors stand disconnected from the MMIC. High quality, low loss, low capacitance PIN diodes are required for this purpose. The PIN diode connected to 50 ohms provides a PIN switch position corresponding to no oscillations and hence no RF output condition.

The main characteristics of the approach are:

1. No Spurious at Unselected Frequency:

The oscillation conditions are satisfied only at the desired frequency, resulting in generation of only one signal at a time. The input of the MMIC being loaded with 50 ohm resistance at all frequencies other than the desired resonant frequency, the possibility of spurious oscillations is eliminated.

2. Fast Switching:

Fast switching between the frequencies is obtained by keeping the MMIC always biased "ON" and using the high Q resonators to control the frequencies.

3. Fewer Components/ lower cost:

Compared to the old approach(figure 2) the number of active devices is reduced to one. Additionally the otherwise-necessary complex, matched PIN switch has been replaced by a simple SPMT switch. The fact that the RF circuit is reduced to simple 50 ohm lines, makes it easier to align and allows for a wide band operation of a given circuit. This saving in components and testing time directly results in lower cost, higher efficiency and improved reliability.

4. The approach presented is easily extendable to more than two frequencies[4].

EXPERIMENTAL RESULTS:

A dual frequency X/Ku band DRO assembly has been realized using the above detailed approach consisting of the switchable oscillator and the digitally controlled driver. All circuits are realized in MIC hybrid form on 15 mil alumina substrate. The MMIC is biased at 6V and 70 ma. The "ON" PIN diode is biased at 10 ma. and the "OFF" PIN diodes are biased with 5V reversed bias. The Important measured results are:

Parameter	Osc.1	Osc.2
Frequency (GHz)	9.8	12.5
Po Output (dBm)	13.2	13
DC Bias	6V, 70	
Phase Noise (dBc) @ 10KHz	-85	-83
Temperature Stability(ppm/ C)	2	2.5
SPURIOUS AT UNSELECTED FREQ.	<90 dBc*	<90 dBc*

* measurement limit

Settling time:
Settling time was measured using a delay line discriminator approach shown in figure 3. A synthesizer was used to calibrate the set-up. The results were displayed on a digital storage scope. The settling times for the frequencies to be within ±10 ppm were measured to be between 1 and 1.5 microseconds.

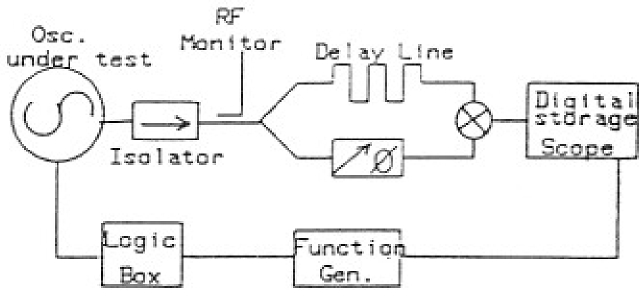

Fig.3 Measurement Set-up

Figure 4 shows a typical settling time measurement result.

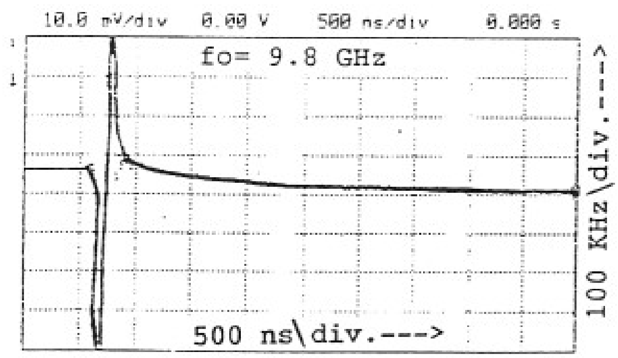

Fig.4 Typical Settling Time (12.5GHz to 9.8GHz)

REFERENCES:

1. A.P.S.Khanna "Introduction To DROs", Application note AN-M003, Avantek Inc. December 1989.

2. A.P.S.Khanna & R.Soohoo "Fast switching X and Ku Band Multi frequency Dielectric resonator Oscillator Using a single GaAs FET", IEEE MTT-S Int. Microwave Symposium Digest, pp. 189-191, Las Vegas,1987.

3. A.P.S.Khanna "Q Measurement of Microstrip-coupled dielectric resonators" Microwaves & RF, pp.81-86, January 1984.

4. A.P.S.Khanna "Multi-Frequency Dielectric Resonator Oscillator Using Parallel Feedback" U.S. Patent 4,733,199 March 1988.