THE HETERODYNE VCO

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Abstract

Using synchronously controlled varactor tunable oscillators into both the RF and LO ports of a mixer produces a resulting VCO output which is extremely linear and wideband. A deviation from best straight line of ±25MHz has been achieved over a frequency range of 2-8GHz, tunable in only 4.77V. This high modulation sensitivity is accompanied by a fast set-on time of <20ns.

Introduction

The bandwidth of a VCO is primarily limited by the capacitance swing of varactors. Octave bandwidth in 10V tuning can now be attained with relative ease,[1] but further increase in bandwidth requires either a new generation of hyperabrupt varactors or a change in circuit concept. Present day technology allows such an increase in bandwidth by mixing an octave bandwidth VCO with a fixed LO (Fig. 1). Furthermore, by departing from the conventional heterodyne technique by using a variable frequency LO instead of a fixed LO, a highly linear voltage/frequency output is attained in addition to being broadband.

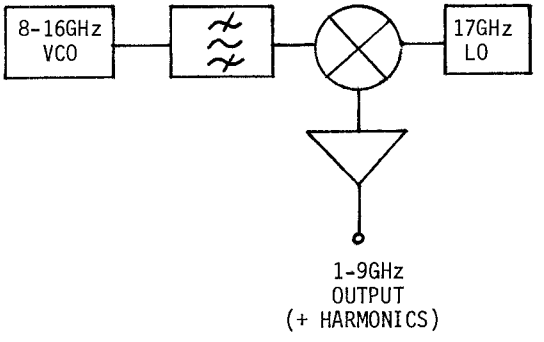

Fig.1 Schematic Of Conventional Broadbanding By Downconverting.

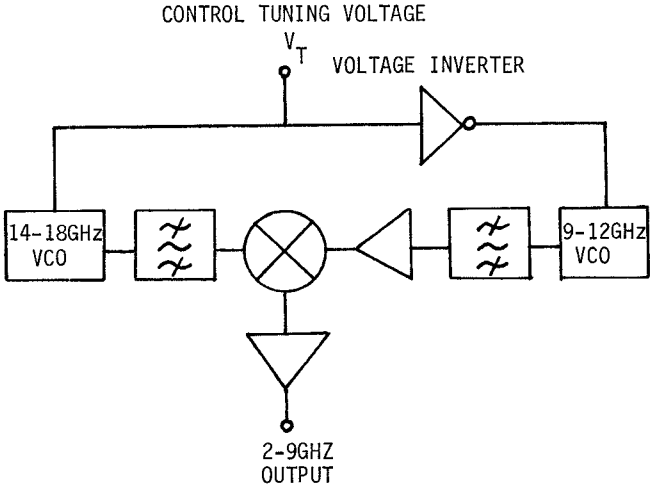

Fig. 2 The Subsystem.

The Subsystem Design

Fig. 2 shows a schematic of the components used in this subsystem. The two VCOs have frequencies tunable from 14-18GHz (25%) and 9-12GHz (28.6%). The same input voltage is used to control each oscillator. A 5GHz bandwidth operational amplifier used as a voltage inverter is incorporated between the control and the 9-12GHz oscillator so that as the 14-18GHz tunes up in frequency with a 0 to 5V control input, the 9-12GHz oscillator tunes from 12GHz down to 9GHz. The resulting difference frequency (IF output) is 2-9GHz (127%).

In addition to wide bandwidth, relatively high linearity is achieved as follows. Fig. 3 illustrates the typical deviation from straight line curves for each oscillator. Clearly, on subtraction a cancellation occurs, resulting in a very linear output.

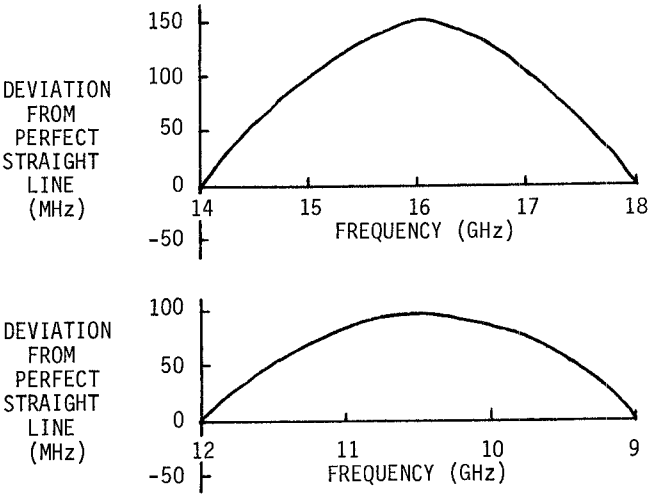

Fig. 3 Typical Deviation From Linear Curves For each VCO.

The two bandpass filters were included to minimize mixer product amplitudes. The amplifier following the LO presented the LO to the mixer at the 10mW level required to drive the mixer with minimal loss. The amplifier on the output raised the mixer output by ~20dB.

The Components

The oscillators used in this subsystem are bipolar transistor doubling oscillators using silicon hyperabrupt junction diodes.[2] The devices used could have been GaAs FETs and GaAs hyperabrupt diodes, but here is an example where GaAs has no advantage over silicon. On the contrary, the higher thermal resistance of GaAs causes the mid-term post tuning drift (μs to ms) to be at least a factor of three worse when presently available GaAs FETs and diodes are used instead of silicon bipolars and diodes. The contribution to PTD from transistor devices arises from device power dissipation changing as the operating point varies with diode tuning voltage. Also, the diodes themselves dissipate

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power which varies as a function of the bias dependent R_S.

The filters are microstrip designs. The 9-12GHz bandpass is a 6-section combline and the 14-18GHz bandpass an 8-section shorted stub design. The LO amplifier is a simple single stage balanced design providing 6dB gain over 9-12GHz. The output amplifier is a 5 stage feedback amplifier. Although a standard balanced amplifier could cover this frequency range, the feedback amplifier was used with a view to wider bandwidth VCOs being developed.

The mixer is an Avantek DBX 18212M having a 2-18GHz RF bandwidth, 2-26GHz LO bandwidth and 1-12GHz IF bandwidth.

Results and Conclusion

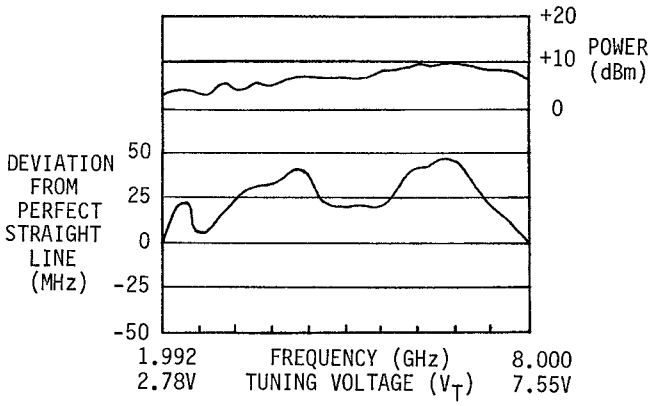

Fig. 4 Frequency Response And Linearity Plot.

Fig. 4 shows the frequency response and the linearity plot. Across 2-8GHz the deviation from perfect straight line is $< \pm 25$MHz. This result is obtained without the aid of a linearizer circuit. Furthermore, within this 2-8GHz range from 3.05-6.34GHz, the linearity is ± 10MHz from perfect straight line.

This novel mixing technique has produced a VCO which has advanced the state-of-the-art with respect to the simultaneous achievement of wide bandwidth, high linearity and fast set-on.

References

1. B.N. Scott et al, "Octave band varactor-tuned GaAs FET oscillators", IEEE International Solid State Circuits Conference, 1981, p. 138.

2. R.G. Winch, "Very broadband bipolar VCO", Electron. Lett., 1981, 17, pp. 296-298.