Application Note

Understanding Synthesizer Designs and Specifications

A frequency synthesizer is a device capable of providing a stable output frequency that can be programmed by the user over some range of frequencies. Specifically, Spinnaker Microwave designs and manufactures frequency synthesizers that generate frequencies in the rf spectrum between 100 MHz and 40 GHz.

The specifications of a frequency synthesizer fall into two categories: those which deal with the electrical aspects of the system, and those which describe its mechanical / environmental attributes.

Some important electrical specifications of a frequency synthesizer are:

- Frequency range: the rf spectrum over which the system will operate.
- Frequency resolution or 'Step Size': the minimum possible frequency change that can be programmed.
- Switching speed or 'Settling Time': the time it takes for the output signal to shift to a new frequency.
- Phase Noise: describes spectral purity of the output signal relative to itself, usually measured in dBc/Hz
- Spurious: describes the spectral purity of the output signal relative to harmonics or other spectral components, usually measured in dBc.
- Output Power: usually measured in dBm

Important mechanical / environmental parameters include:

- Package Size, RF interface, programming connector
- Operating Temperature Range
- Vibration / Shock survivability requirements

Frequency synthesizers can be designed using many different types of techniques. Three of the most common are described below.

The simplest and lest expensive is referred to as the 'single loop indirect type'. This consists of a traditional Phase Locked Loop (PLL) circuit controlling a VCO with a programmable divider (with count value 'N') used to determine the output frequency. The bandwidth is set by the limits of the VCO and the PLL's ability to provide a stable lock voltage. The PLL's 'loop bandwidth' sets the frequency range over which the phase detector is able to correct for phase deviations of the VCO with respect to the reference frequency. The main advantage of the single loop type is that they are the least complex designs to build and thus offer the lowest cost to the customer. Disadvantages include worse phase noise, step size, and switching speed performance when compared to more elaborate types of synthesizers.

The dual loop (or multiple loop) type synthesizer consist of a VCO/PLL system, but with a mixer / Local Oscillator (LO) in between the VCO output and N-divider. This has the effect of lowering the maximum divider count N, thus enhancing phase noise and resolution capabilities of the synthesizer. Typically, phase noise can be enhanced by up to 20 dB and resolution increased by 10 times by using a 'dual loop' system. But the cost of the increased performance is the additional components necessary to construct the second loop, i.e. the mixer, LO and filtering. Obviously these systems can cost more to produce and take up more space when compared to a single loop type.

The 'Direct' type frequency synthesizer can offer the best phase noise, resolution, and switching speed possible. The most common direct synthesizers use a large number of LO's generated either by harmonic multiplication of a lower frequency reference signal, or by indirect type phase locked loops. Since the highest value of 'N' (multiplication or division ration with respect to the reference) is kept very low, phase noise of all possible frequencies is correspondingly low too. The multiple LO signals are then routed to a single output by means of switching networks which can settle in much less than 1 us. Resolution can be enhanced by frequency dividing the LO's to a lower frequency and then mixer translating them back up to higher frequencies. The amount of hardware required to build these systems can become enormous, thus they are generally the largest and most expensive types of frequency synthesizers.

For a more detailed discussion of any topic covered above, please contact Spinnaker Microwave directly and ask to speak with an engineer.

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