An introduction to YIG Tuned Oscillators

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The YIG Tuned Oscillator (YTO) is the only direct signal source to provide multi octave tuning bandwidths in excess of 10 GHz. Common tuning ranges are from 2-10 GHz, 8-18 GHz and 10-20 GHz. YTO's are also known for their superior phase noise and exceptional tuning linearity.

The heart of the YIG Tuned Oscillator is the YIG sphere. YIG (Yttrium, Iron and Garnet) spheres are manufactured from a synthetic crystalline structure, which is grown in platnumum crucibles. These batches of crystal are then diced, tumbled, ground and polished into very small spheres. For most applications the nominal diameter of YIG spheres is 10 to 30 thousands of an inch. The sphere is normally mounted to a rod, thus becoming a YIG sphere assembly. A single YIG sphere assembly can be bought for the price of a nice lunch, but looking at it another way; YIG sphere assemblies sell for several million dollars per pound.

Due to the ferrite properties of YIG spheres, they resonate at microwave frequencies when immersed in a magnetic field. The frequency of resonance is very linear and increases at a rate of 2.8 MHz per gauss of applied field.

A coupling structure, often referred to as the "coupling loop", is utilized to couple RF energy to the YIG sphere forming a high Q microwave tank circuit. This "YIG resonator" is tied to the negative resistance of an active device to form an oscillator. It is the YIG resonator that controls the frequency of oscillations for the YTO.

The YTO is tuned using the "Main Coil", which creates an electromagnet from the oscillator housing. Within this housing is a pole gap, where the YIG resonator resides. The oscillator housing is carefully designed to focus the magnetic field in the pole gap. Re-capping from above, the frequency output is directly proportional to the applied magnetic field. To achieve 2.8 GHz a magnetic field of 1000 gauss is required, 2000 gauss for 5.6 GHz, and so on. It can now be seen that by increasing the current through the main coil, we increase the magnetic field and the frequency of the YIG resonator. This relationship will continue until the magnetic structure approaches and then magnetically saturates, limiting the upper frequency limit of the YTO housing.

A typical main coil is made of copper wire and may have 500 to 1000 turns. As the resistance of this coil will vary over temperature, a "Current Source" (Vs a Voltage Source) is required to maintain a

constant control current for tuning the oscillator. The relationship between frequency and current is the YTO's tuning sensitivity. This is expressed in MHz per mA (milli amp). Example: If the oscillator has a 20 MHz/mA tuning sensitivity, then 100 mA will tune the oscillator to 2,000 MHz (2 GHz) and 500 mA will provide a 10,000 MHz (10 GHz) output frequency.

A secondary "FM" coil is normally provided to frequency modulate or phase lock the oscillator. This coil is quite small when compared to the main coil, with 10 to 15 turns being typical. With very low inductance and low resistance, the FM coil allows a much faster tuning rate than the main coil. FM tuning bandwidths are nominally from mid to very high KHz range and can be pushed to the low MHz region. The sensitivity of the FM coil is usually between 300 and 450 KHz per mA. Low frequency deviations for the FM port is limited to approximately 100 MHz due to current limitations of the FM coil wire.

YTO's will exhibit frequency drift, which is usually inversely proportional to temperature. The frequency drift is specified as the maximum amount of drift that will occur over the temperature range for the oscillator. Example: We start with a YIG oscillator tuned to 5,000 MHz at 30 degrees Celsius. Nominally the oscillator will drift up in frequency to a maximum of 5,015 MHz when at 0 degrees Celsius and conversely, the oscillator may drift down to a minimum frequency of 4,985 MHz at 60 degrees Celsius. This performance would equate to a 30 MHz drift specification and a 0 to 60 degrees operating temperature.

For excellent phase noise and very accurate frequency output, YIG oscillators are often phase-locked. Microsource's Synthesizer product line (link to synth) is based on the phase-locked YTO.