

Small Size, Low Power Consumption Permanent Magnet YIG Based Synthesizers

Introduction

Permanent magnet YIG oscillator (PMYTO) based synthesizers for digital radio applications have been available for a number of years. However, the products available were relatively large in size, consumed power, limited in tuning bandwidth and most of all, susceptible to microphonics (i.e. “phase hits/pops”) and residual FM.

Micro Lambda, Inc. has met these technical challenges with the new MLSL Series of permanent magnet YIG based synthesizers. These synthesizers provide superior phase noise, typically -98 dBc/Hz @ 10 kHz offset, in X-Band (see [MLSL Phase Noise Graph](#)). The MLSL Series are available in >3 GHz tuning bandwidths between 2 GHz and 12 GHz. Frequency doublers are optional through 24 GHz.

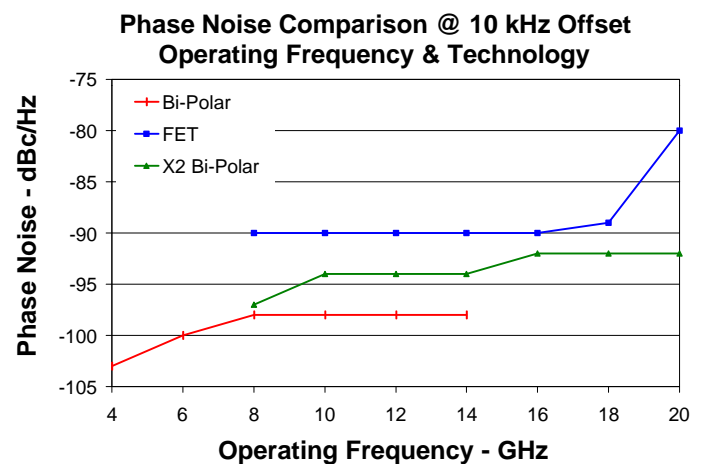
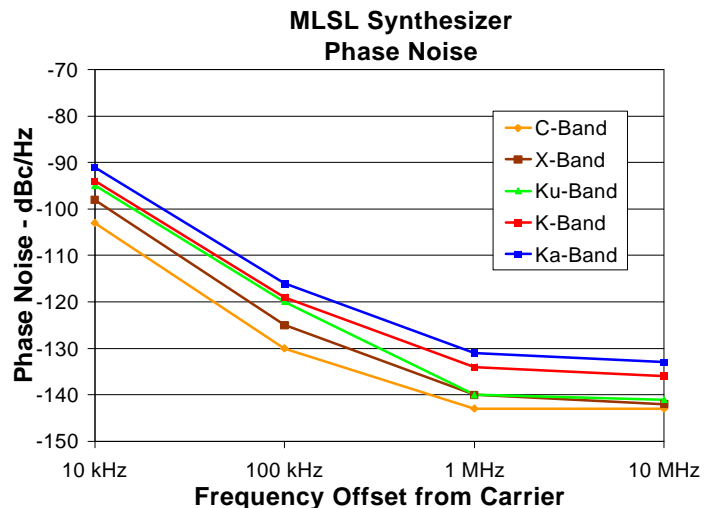
Synthesizer Architecture: DDS, Loops or Microprocessor ?

Tuning step sizes of less than 500 kHz is possible with various architectures. The traditional approach is, the “brute force” method of a frequency sampling circuit and multiple phase locked loops with one or more loops having divide by N ($\div N$) control. Circuit real-estate, cost and power consumption are the obvious drawbacks. A number of years ago, the DDS (direct digital synthesis) chip came to market. They reduced the number of loops required and generally provided good phase noise. However, the DDS created spurious noise. Typical spurious performance for a DDS synthesizer was -60 dBc.

The arrival of inexpensive and low power consumption microprocessors and microwave frequency pre-scalars provide synthesizer engineers numerous design options for reducing the number of phase lock loops and achieving sub-kHz step size. Micro Lambda has patented a microprocessor synthesizer design that has a minimum number of loops. As a result, circuit real-estate and power consumption are minimized, spurious performance (@ -70 dBc) is 10 dB better than traditional DDS designs. Micro Lambda’s MLSL Series synthesizers are $2.5'' \times 2.5'' \times 1.0''$ (see [Outline Drawing](#)), and consume less than 6 watts.

Bi-Polar or FET Technology ?

Bi-Polar oscillator circuits are utilized in the MLSL series synthesizers to obtain the lowest close-in phase noise and noise floor possible. Typical Bi-Polar phase noise is approximately 8 db to 12 dB lower than FET circuits (see [Phase Noise Comparison Graph](#)) Bi-Polar transistors for oscillator circuits are limited to 14 GHz. Frequency multiplication of these Bi-polar PMYTO provides superior phase noise to fundamental FET circuits.



It should be noted that FET fundamental YIG synthesizers are more cost effective (no multiplier) between 14 GHz and 18 GHz. Modulation, data rates and cost must be considered. Micro Lambda has FET fundamental synthesizers through 22 GHz and will increase fundamental Bi-Polar synthesizer frequencies as new devices become available.

Perfecting PMYTO Technology !

PMYTOs (& YTOs) are microwave oscillators that are tuned by placing the YIG in a variable magnetic field. This is traditionally achieved by placing the circuit (YIG material) in an air gap in the magnet structure and varying the magnetic field with Main (coarse frequency) & FM (phase lock control) tuning coils (see Figure 1). The magnetic field will vary if there is even the smallest change in the gap size, making the traditional PMYTO (and YTO) susceptible to microphonics and residual FM from shock and vibration .

Traditional PMYTO Structure

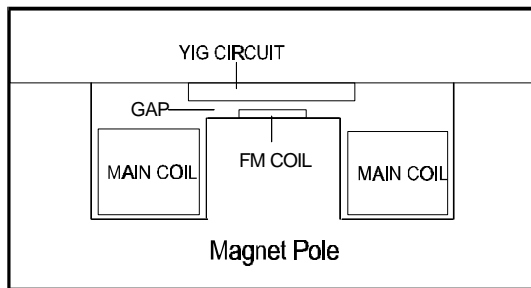


Figure 1

Micro Lambda, Inc. produces over 18,000 PMYTOs annually, and has made significant advancement in eliminating microphonics in PMYTOs. Micro Lambda PMYTOs are ridged, and do not have the traditional gap in the magnetic structure, making them virtually immune to microphonics. This was done by reducing the magnet size (1" x 1" x 1/2") and using proprietary gap structure and magnetic materials. The added benefit of Micro Lambda's gap structure and magnetic materials is frequency tuning bandwidth of > 3 GHz.

Mechanical design & component selection.

Possibly the greatest challenge in microwave synthesizer design is isolating the different functional circuits from each other. Every functional circuit interferes with another: the DC interferes with the RF, the RF interferes with the microwave, and so on. The result is spurious signals at the synthesizer output that are everywhere in the frequency spectrum.

Component selection is the first step in reducing cross interference. The location of components on the PC boards and relative location to other boards requires attention. However, cross interference will continue to be a problem if functional circuits are not physically and electromagnetically isolated from each other.

Another challenge in mechanical design and component selection is the elimination of phase hits (or phase pops) caused by vibration/shock and temperature variations. While component selection is important, PC board assembly and component attachment (solder) is critical. It is also important to "shock mount" components that are affected by vibration/shock.

Micro Lambda's MLSL Series PMYTO synthesizers were designed with all these challenges in mind. Surface mount technology (SMT) boards are used exclusively, as are the lowest power consuming components. These SMT circuits are small, light weight, are essentially immune to vibration/shock and are thermally & electromagnetically efficient. Micro Lambda has developed a proprietary method to "shock mount" the PMYTO.

VXI/VME and external tower mount compatibility was another challenge. However, with SMT boards and the reduction of the PMYTO height to 0.5", Micro Lambda's MLSL Series synthesizers have dimensions of 2.5" x 2.5" x 1.0".

Manufacturing

The PMYTO is the key component in the synthesizer. Micro Lambda has the largest PMYTO manufacturing capacity in the world. This digital radio synthesizer is based upon the Micro Lambda PC board mount PMYTO (MLPB series).

Assembly of the SMT boards is automated with pick & place, operational verification tests are conducted on automated test set-ups; special tests fixtures and interface ports allow diagnostic checks on various points on the SMT board. This provides consistent and reliable circuit performance. Although not as cost effective, SMT boards can also be manually assembled and tested.

The top level synthesizer is assembled manually. The assembled synthesizer requires little or no alignment. Final testing is automated.