Introduction

This application note is intended to provide the user of YIG oscillators and filters with basic coil driver circuits to facilitate tuning of the YIG component output frequency. Main and FM coil driver circuits are addressed.

This application note assumes that the user is familiar with the fundamentals of YIG oscillator and filter technologies (See YIG Oscillator, and YIG Filter Technical Descriptions).

YIG components require current to "tune" over the operating frequency. The range and amount of tuning current required is determined by the operating frequency and the tuning sensitivity of the YIG device. (A typical 8-18 GHz YIG oscillator has a main tuning coil sensitivity of 20 MHz/mA; the required tuning current at 8 GHz is: [8 GHz/(20 Mhz/mA)] = 400 mA, at 18 GHz it is 900 mA.).

YIG drivers convert control commands to tuning current. There are two control command formats: analog and digital.

Analog Drivers

Analog drivers convert voltage (typically 0-10 Vdc) to tuning current. Figure 1, page 3 (Application Note: 99-002) illustrates a typical YIG driver circuit.

Digital Drivers

Digital drivers convert digital commands (typically 12 to 16 bit parallel) to tuning current. The digital driver is essentially an analog driver with a D/A converter at the input.

Tuning: End Point Versus Center Point

Electromagnet YIG components utilize end point tuning in one direction (f_{MIN} to f_{MAX}) by increasing the tuning current see Figure 1, page 3 (Application Note: 99-002). These are typically used in wideband tuning applications.

Permanent magnet YIG devices can be preset to a center frequency (free run frequency). Therefore, depending on the preset, you can tune up from f_{MIN}, down from f_{MAX}, or up/down from the center of the operating frequency f_{CEN} : $[(f_{MAX} - f_{MIN})/2]$. Tuning up/down from the center frequency requires one half (1/2) the tuning current compared to tuning from endpoint to endpoint. This reduces total power consumption and heat dissipation.

Micro Lambda's BA & BD Series drivers provide center point tuning (end point tuning available) for our permanent magnet YIG components.

Specifications

Common Mode Rejection

Common mode rejection is the attenuation of electromagnetic fields generated by the input/output connection wires between the driver outputs and the YIG component tuning coil inputs. These connect wires are 'twisted" together as a pair, achieving 40 dB attenuation, typical. Grounded shielding improves attenuation.

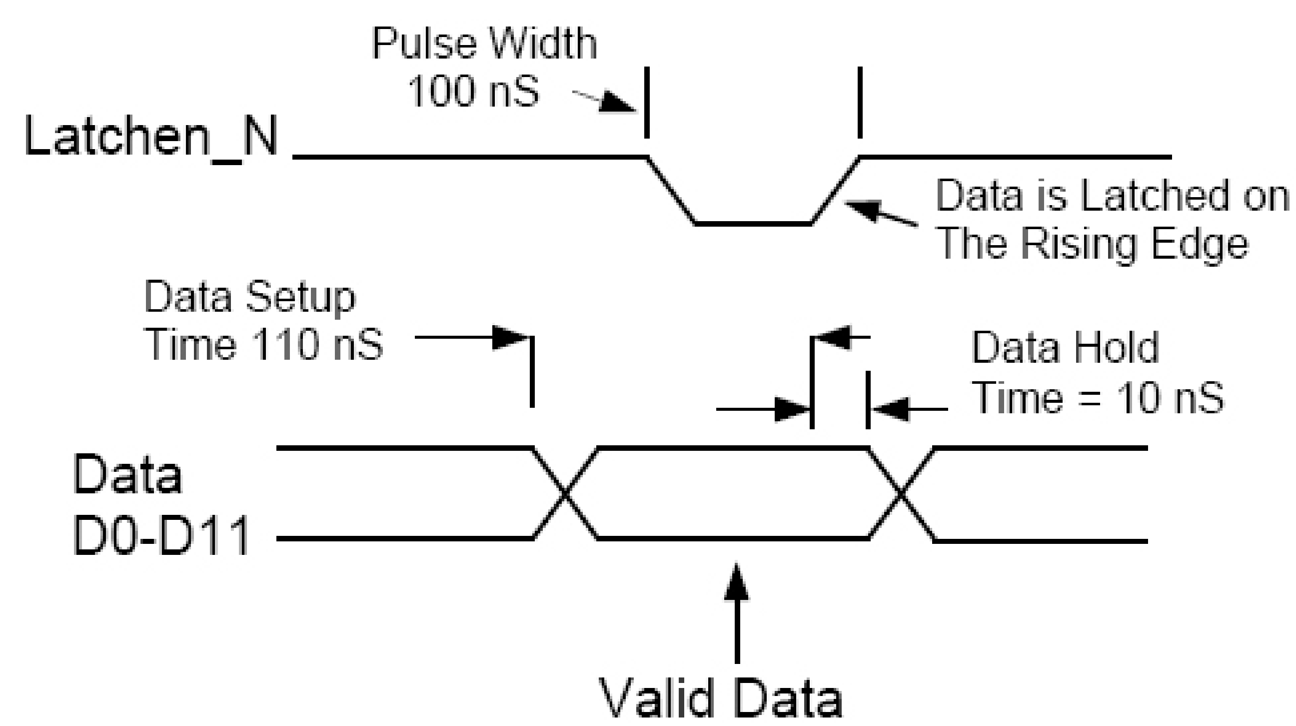
Tuning Command (Analog)

The analog tuning command is the voltage range applied to the control input that controls the frequency of the YIG device. It is typically 0 Vdc for the low frequency of operation, and +10 Vdc for the high frequency. However, this voltage can be set for smaller ranges (e.g. 0 to +5 Vdc), and/or the polarity can be reversed.

Tuning Command (Digital)

The digital tuning command is the bit control word (i.e. "0" or "1") applied to the control input that controls the frequency of the YIG device. It is typically all "0's" for the low operating frequency and all "1's" for the high operating frequency. Micro Lambda offers drivers with 12 bit to 16 bit input. Figure 2 is a timing diagram for a typical Micro Lambda digital driver.

Figure 2: Timing Diagram



Tuning Resolution (Digital)

Digital tuning resolution is defined as the total operating frequency range ($f_{MAX} - f_{MIN}$) divided by the total number of possible tuning commands (2^N, where N equals the number of input bits). Hence, a 2-8 GHz, 12 bit oscillator would have a tuning resolution of approximately 1.5 MHz: [(8-2) GHz / 2^{12} bits]. Tuning resolution can be modified to larger integers (e.g. 2 MHz/bit) by setting the tuning end points to an imaginary frequency (i.e. out of operating frequency range) at either the low or high frequency side of the operating frequency range.

Tuning Accuracy
Tuning accuracy is the overall accuracy of the YIG component AND the driver circuit over frequency and temperature. Tuning accuracy is expressed as a "frequency window" covering the worst case: usually at the high frequency of operation and over temperature. Tuning accuracy does not include the YIG component's hysteresis (see Oscillator and Filter Technology Descriptions); however, hysteresis can be minimized by tuning to the low operating frequency prior to tuning the YIG component to the next desired operating frequency.

Tuning Input Impedance
Tuning input impedance is the impedance (typically 10 k¿) at the tuning command input of the control connector.

Tuning Speed
Tuning speed (sometimes referred to as switching speed) is the time required for a YIG component and driver to tune to within a specified frequency widow (e.g. ±10 MHz) centered on the final frequency of a specified frequency step (e.g. 1 GHz).

Sweep Speed
Sweep speed is the time required for a YIG component and driver to tune from the low operating frequency to the high operating frequency, or high to low. It should be noted that sweep speed is fastest tuning down in frequency as opposed to tuning up in frequency.

Supply Voltage & Current
Supply voltage & current includes power required for the driver AND the YIG component. However, it does not include the YIG component's YIG sphere heater power requirements (see Oscillator and Filter Technology Descriptions). Normally, the positive supply (e.g. +15 Vdc) provides the majority of the required current (i.e. the YIG components main tuning coil); however, Micro Lambda offers the option of supplying the majority of the required tuning current from the negative supply (e.g. –15 Vdc). This is referred to as "Negative Current Draw".

Reverse Voltage and Over Voltage Protection
Reverse voltage and over voltage protection typically consists of a set of diodes located at the power supply voltage input connectors (e.g. control connector). These diodes protect the YIG component and driver from accidental misconnection of the power supplies.

Supply Voltage Pushing
Supply voltage pushing defines the amount of output frequency change of the YIG component AND the driver due to small variations in supply voltage changes (e.g. ± 100 kHz for ±5 V variations, from 2-3000 kHz).

Installation Instructions

Mounting & Heat Sinking the YIG Driver
All Micro Lambda's outline drawings identify mounting hole configurations. These mounting holes and associated hardware should be used when mounting the unit. The surface which the YIG device is to be mounted should be at least as large as the baseplate of the YIG device. The mounting surface's heat sink/thermal dissipation capacity MUST be greater than total amount of power dissipated in the YIG device & driver at the highest operating frequency. For example: the MLOS-0818PA 8-18 GHz YTO draws 1050 mA (@18 GHz) and 50 mA from +15 V and –15V respectively, or 16.5 watts; plus 0.6 watts for the heater (24 V @ 25 mA). Therefore, the heat sink must be capable of dissipating at least 17.1 watts @ all operating temperatures. It is a good idea to include a 10% to 20% margin (i.e. 18.8 watts to 20.5 watts dissipation).

Control Connector Connections
All Micro Lambda outline drawings have tables identifying what should be connected to each pin of the control connector. NO SOLDERING OR ALLIGATOR CLIPS ARE TO BE USED TO CONNECT DIRECTLY TO THE CONTROL CONNECTOR PINS. Please use the recommended mating connector. Soldering to the mating connector should be done while it is removed from the YIG driver's control connector. This eliminates potential damage to the control connector due to excessive soldering heat.

CHECK THE CONNECTION WIRES/PINS OF THE MATING CONNECTOR WITH A VOLT METER, **TWICE** BEFORE CONNECTING IT TO THE YIG DRIVER CONTROL CONNECTOR. This requires additional time, but greatly reduces the possibility of damaging the driver.

Power Supply Connection
All Micro Lambda Drivers require positive and negative biasing (e.g. ±15 Vdc) of the driver circuitry. IT IS VERY IMPORTANT THAT THE "COMMONS" OF THE POWER SUPPLIES ARE CONNECTED TO EACH OTHER. THIS APPLIES FOR BOTH DUAL POWER SUPPLIES AND SEPARATE POWER SUPPLIES. Unconnected "commons" of the biasing power supplies is the largest cause of damage to driver circuits. Please contact Micro Lambda if you have ANY questions on connecting the power supplies to the YIG driver!

Calibration
Field/customer calibration is not recommended, and may void the Warranty. Contact Micro Lambda for direction BEFORE accessing calibration pots.

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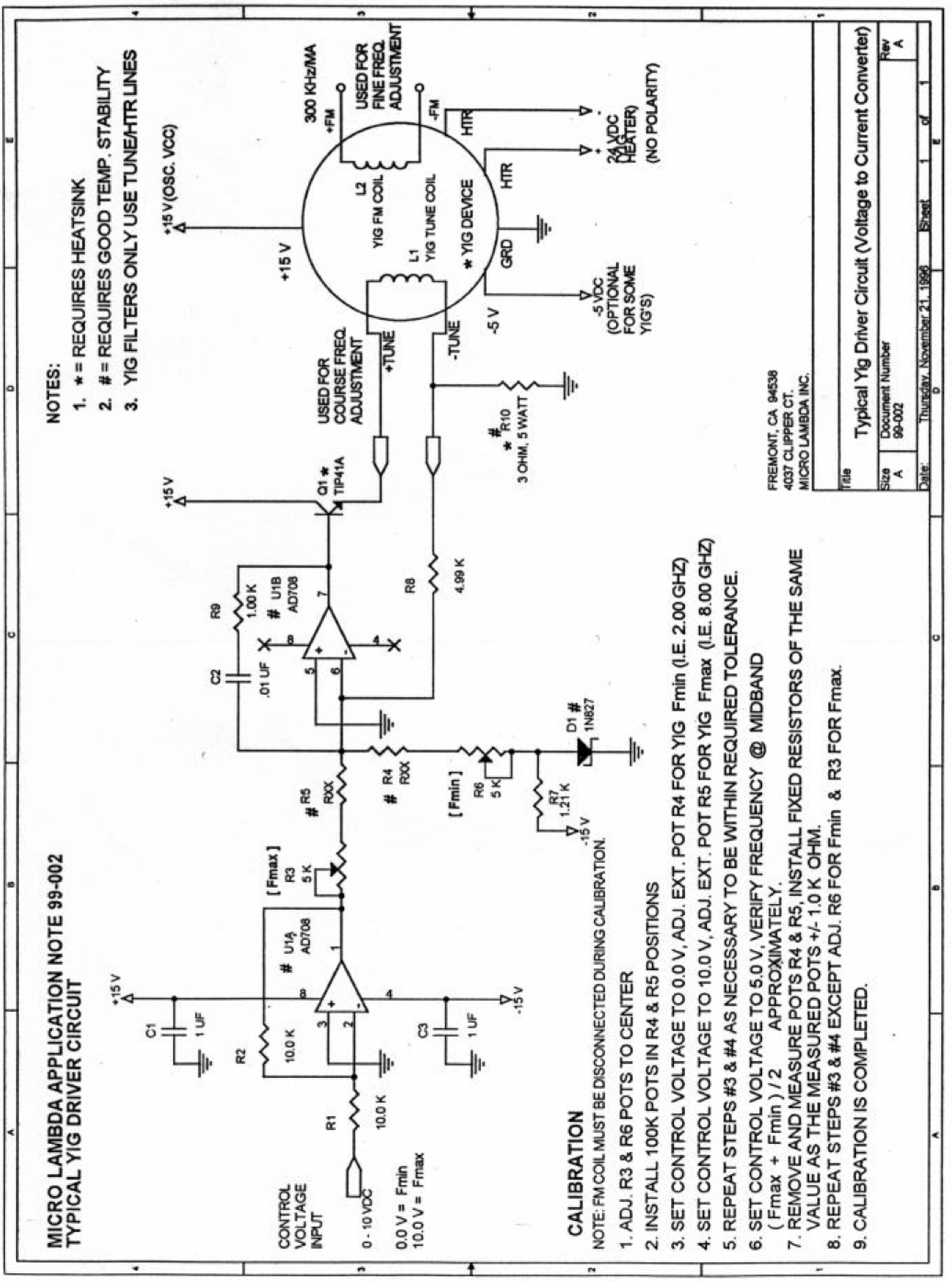
Figure 1 : Typical YIG Driver Circuit



Introduction

This application note is intended to provide the user of YIG tuned oscillators with a basic FM coil driver circuit to facilitate fine tuning, modulation, or phase locking of the output frequency. The circuit and actual performance data is provided.

YIG Tuning Fundamentals

To provide a fine tuning/modulation/phase-locking capability, a small secondary coil is included in the magnetic circuit, with lower sensitivity (as compared to the main tuning coil), typically 300-500 kHz per mA. Due to design limitations (small gage wire), the FM coil is generally limited to ± 250 mA of tuning current. (FM coils with higher currents are available.)

With a bipolar current source, the frequency deviation at ± 250 mA ranges between ± 75 and ± 125 MHz. With an input impedance of approximately 0.33 to 1.0 ohms in series with 1 to 2 mH, typical 3 dB bandwidths of the FM coil range from 50 kHz to 1.0 MHz. The 3 dB bandwidth can be increased by removing the RF filtering capacitors from the FM coil ports. The 3 dB bandwidth is defined as the frequency at which the current delivered by the driver circuit decreases by 3 dB (0.707) relative to a static, DC input. It is important to note that the 3 dB bandwidth is a function of not only the YIG oscillator, but also the driver.

Circuit Design Considerations

Figure FM-1 illustrates a general purpose FM coil driver, providing the basic voltage-to-current conversion. Easy to find components and standard PCB layout are utilized. Performance can be enhanced by design and component optimization.

Circuit Description

The circuit as designed provides ± 100 mA to the FM coil with an input of ±10 V and supply voltages of ±15 Vdc. The 3 dB bandwidth of this circuit is > 50 MHz. Input impeadance is 10K Ω

Figure FM-1: Basic FM Coil Driver Circuit