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A simple approach to YIG oscillators

YIG oscillators have been in use for several decades now, mainly in relation to equipment for professionals from well-known manufacturers. However, we radio amateurs have been prohibited from enjoying their outstanding characteristics for many years, owing to the high prices involved. But for some years now, YIG oscillators have been obtainable at reasonable prices on the surplus market. Most of the equipment available has already been taken out of service, but this poses no problems as a rule, since YIG oscillators have a very long service life and are of excellent quality. This article is intended to provide some practical help regarding a simple approach to these high-quality oscillators.

1

Advantages of YIG oscillators

YIG oscillators have some advantages over normal VCO's. It is above all their good signal quality, with a low level of phase jitter, and their broad band characteristics (with a very linear tuning curve) which make them interesting, or even obligatory, for many measurement applications. Anyone who has become acquainted with the advantages of these oscillators will no longer want to do without them.

The normal frequency ranges are 2 - 4GHz, 4 - 8GHz, 8 - 12GHz, 12 - 18GHz and 2 - 8GHz. However, the usable frequency range usually goes beyond the specified limit frequencies, so that a YIG which is specified for 2 - 4GHz can be used at 1.8 or 1.9GHz, and can frequently also still function at a few 100MHz above 4GHz, but this varies from type to type.

2

YIG resonator

Fig. 1 shows the core of a YIG oscillator. The YIG ball, which sits at the tip of a short ceramic rod, is positioned in the middle of a coupling coil (U bolt). This YIG resonator is influenced by the magnetic field that is generated by the tuning coils. This allows the YIG to be tuned to its frequency.

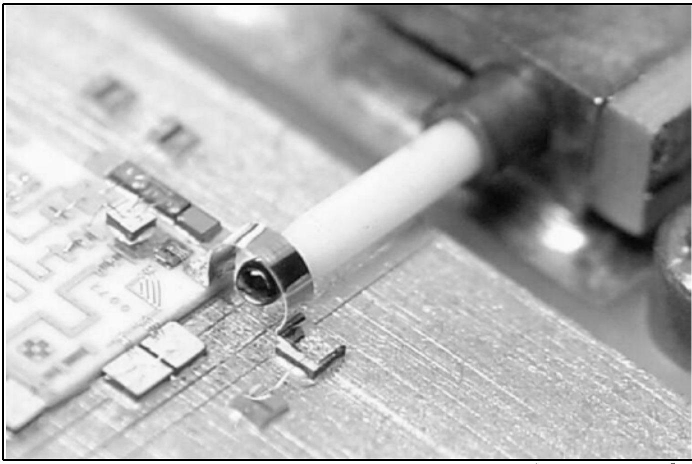

Fig 1: The core of a YIG oscillator.

3

YIG oscillator connections

The connections of a YIG oscillator are shown in the circuit. They have a standard pin configuration, which is almost always the same (Fig. 2).

3.1 Operating voltage

These "standard YIG's" always require + 15V(approximately 150 - 300mA) and frequently also – 5V as operating voltages. But there are also some manufacturers who depart from this norm, and their YIG oscillators need completely different voltages. For example, Hewlett Packard, whose YIG's frequently need + 20.5V and – 5.1V, or + 20V and – 10V.

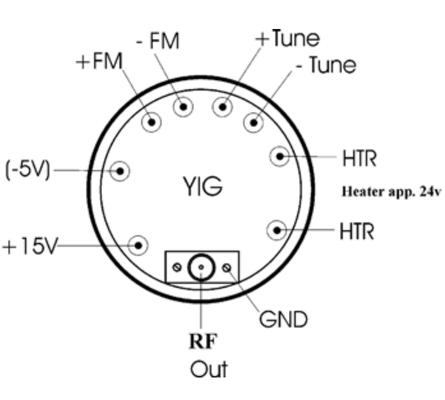

Fig 2: The standard pin connections for a YIG oscillator.

There are also oscillators from Watkin-J that require a negative operating voltage of – 14.2V. But the good thing about this is that these voltage specifications are almost always printed on the oscillator. Fig. 3 shows three YIG's with + 15V and – 5V as operating voltages. Fig. 4 shows three examples from different manufacturers with an operating voltage of + 15V alone. In spite of differences in shape and size, the "standard" pin configuration has been retained.

3.2 Heating

There are usually two connections for heating. These lead to a small PTC plate inside the oscillator, which serves to keep the YIG element at a uniform temperature. The voltage for heating is not critical, and is normally about 24V. A relatively high starting current of several hundred mA falls off markedly after a few seconds, and then oscillates around a value of < 100mA. Fig. 5 shows a small heating plate of this kind on the YIG ball

Fig 3 Examples of YIG oscillators with operating voltages of +15v and -5v.

mounting.

3.3 Main tuning coil

The main tuning coil is usually indicated by “+ tune” and “– tune”. In contrast to a VCO, where the frequency is controlled using a tuning voltage, a YIG is “current controlled” i.e. the frequency of the YIG oscillator depends on the current which flows through the tuning coil. The great thing about this is that the frequency response curve is very linear in relation to the current fed in. 20MHz/mA is a typical value.

The main tuning coil consists of thick enamelled copper wire and is very powerful. Even currents exceeding 1A can be coped with for a short time. Incidentally, the tuning current should always be fed in to the correct pin. This coil’s resistance is approximately 10Ω, but it can lie in a range between 5 and 15Ω. The thick main tuning coil can easily be recognised in Fig. 6. It runs around the metal plate

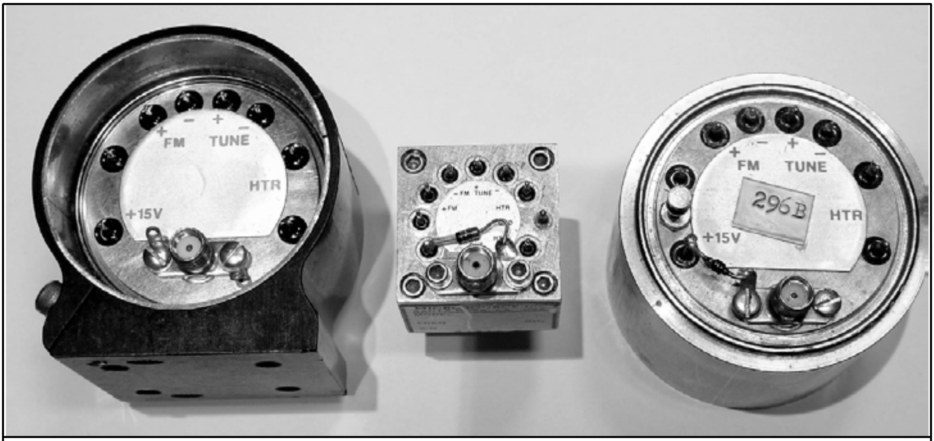

Fig 4: Examples of YIG oscillators with operating voltages of +15v.

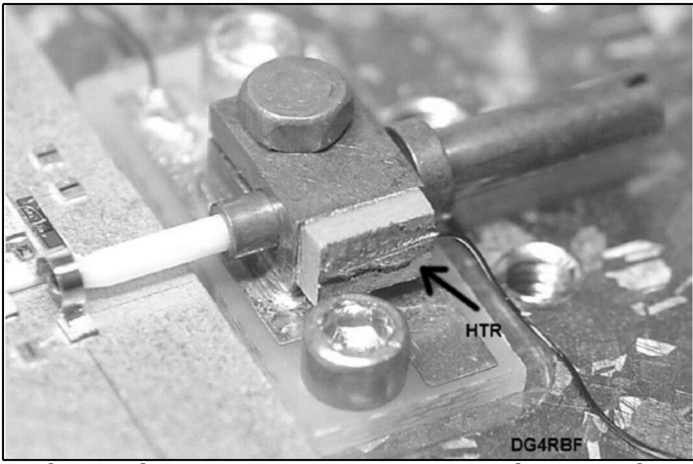

Fig 5: The PTC heating plate in a YIG oscillator.

on the outside.

3.3 FM coil

A second tuning coil is used for fine tuning or the FM modulation of the oscillator. It is indicated by "+ FM" and "– FM".

This small coil consists of very thin wire, has a resistance of only approximately 1Ω, and could be destroyed by currents exceeding 200mA. So care must be exercised here.

The small coil on the plate is the FM coil and can be seen in the middle of Fig. 6. But there are also models without an FM coil. Fig. 7 shows a unit of this type. Although this YIG has no connections for the FM coil, the other pins correspond to the standard layout.

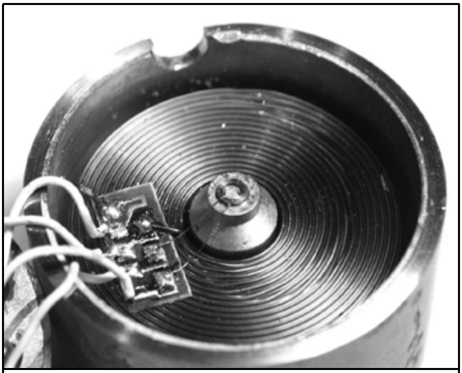

Fig 6: The tuning coils.

So there's no need to be scared of YIG oscillators! Using them is really quite simple and not critical. If you have a YIG that has the connections laid out in the circuit as described, everything is really clear, even if the pins are not labelled. As a precaution, you can check the connections for the two tuning coils with an ohmmeter. Zener diodes are frequently fitted as a protection against an over voltage on the pins caused by the operating voltages.

Care must be exercised with YIG oscillators from HP, as most have unlabelled connections which do not correspond to the "standard" and often also need decidedly unusual voltages. The connections here should be known, or you should obtain a connection diagram. Figs. 8 and 9 show two examples from Hewlett Packard.

3.4 Output of YIG oscillators

The output to be expected lies in the range between + 10dBm and + 15dBm. For many examples, it can even extend to + 20dBm. Depending on the frequency range, the output can vary by a few dB's.

Fig 7: A YIG oscillator with no FM mode.

Fig 8: An example of a HP YIG oscillator with non standard operating voltages.

4

Simple putting into operation of YIG oscillators

What's a simple way of putting a YIG oscillator into operation?

Fig 9: Another example of an HP YIG oscillator.

A mW meter with a suitable attenuator, or better, a spectrum analyser, is connected to the RF output. After feeding in the correct operating voltage, connect an adjustable power supply (approximately 0 – 20V / 1A) via an output resistance (Fig. 10).

Then slowly increase the tuning current until a measurable signal level is obtained at the output (lower frequency limit). Carry on increasing the current until the output signal fades again. This is the upper frequency limit of the oscillator. The operating range can therefore be determined using a frequency counter.

It should be taken into account that this frequency limit is somewhat dependent on temperature. So heating should be connected up if possible. It should also be taken into account that a considerable tuning current sometimes has to flow through oscillators for relatively high frequencies before oscillation sets in. Thus, for example, in a YIG which is specified for up to 18GHz, 420mA is already flowing through the main tuning coil before it begins to operate at approximately 8GHz.

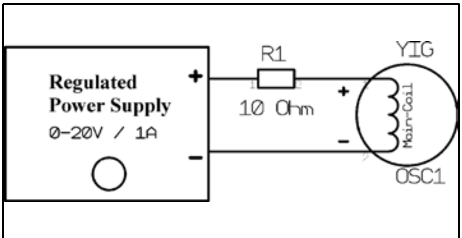

Fig 10: Circuit for operating a YIG oscillator.

4.1 Triggering of YIG oscillators

To be able to trigger a YIG at a voltage, you need a YIG driver, a voltage/current transformer. An appropriately wired operational amplifier with an output transistor normally carries out this task. A suitable circuit can be seen in [1].

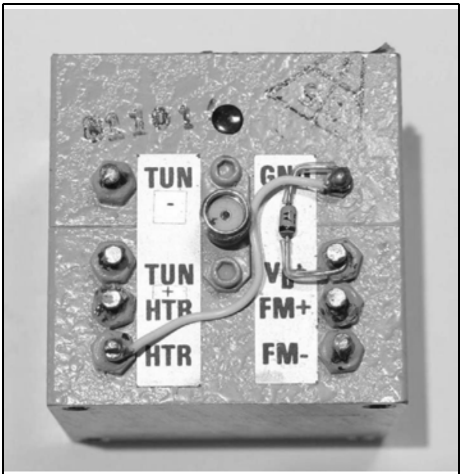

Fig 11: An example of a square format YIG oscillator.

5 Other models

Square format units can also pop up. Figs. 11 and 12 show two specimens of this type. Luckily, the connections are mostly labelled here as well.

Fig 12: A second example of a square format YIG oscillator.

5.1 YIG oscillators with integrated driver

There are also types of equipment that already incorporate the YIG driver. Figs. 13 and 14 show oscillators like this. These are then usually tuned with a tuning voltage of between 0 and 10V. A connection diagram should acquired for these types, since no rules are applicable here. Finally, I'd like to mention two other types, although they are rare.

Fig 13: An example of a YIG oscillator with built in YIG driver.

Fig 14: A second example of a YIG oscillator with a built in driver.

Fig 15: An example of a YIG oscillator requiring variable operating voltages.

5.2 YIG oscillators with variable operating voltage

In these types, the operating voltage must also be varied if they are to be able to operate in all possible frequency ranges.

Here, for example, is an oscillator for 8.0 – 12.0GHz, which has an operating voltage of 15.5 – 9.7V. At the lowest frequency of 8.0GHz, an operating voltage of 15.5V should be set, and at the highest frequency of 12.0GHz the operating voltage should be only 9.7V. So for these types the operating voltage must be altered inversely to the tuning current. But it can also suffice to switch the operating voltage in two ranges. Thus this oscillator can be operated at 15.5V from 8 to 10GHz and at 10.5V from 10 to 12GHz. Fig. 15 shows this oscillator.

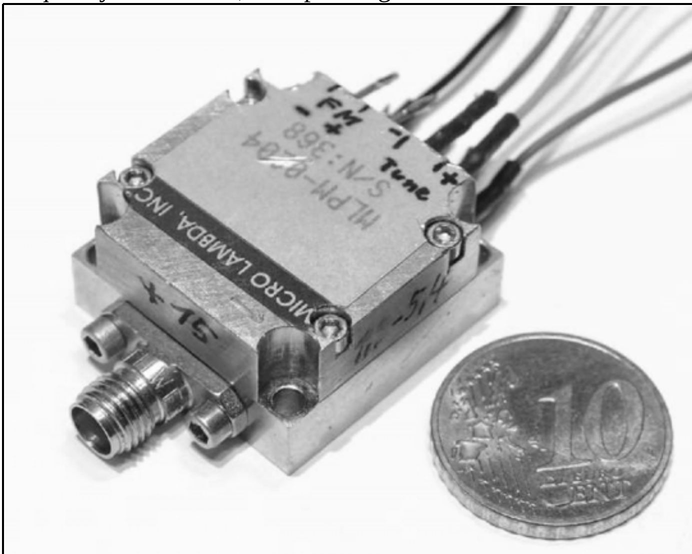

Fig 16: An example of o YIG oscillator with a permanent magnet.

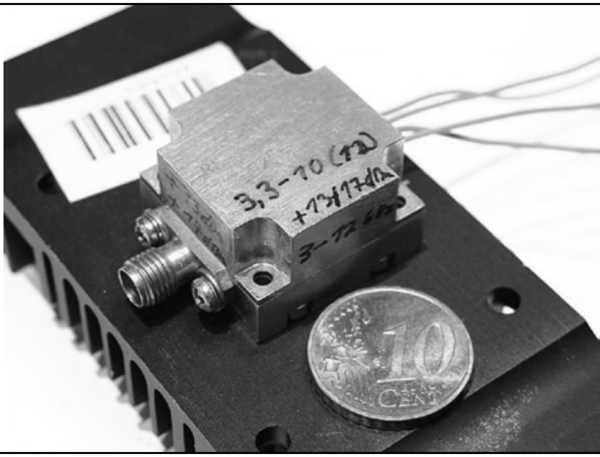

Fig 17: An example of a miniature YIG oscillator that operates up to 10GHz.

5.3 YIG oscillators with permanent magnet

YIG oscillators with permanent magnets represent a decidedly special and very recent development. These YIG's oscillate even without a tuning current, and they do this at their centre frequency, the "free run frequency".

Thus a YIG for 2 - 4GHz operates at 3GHz and can, depending on the polarity of the tuning current, be tuned to 1GHz up or down. Fig. 16 shows such an oscillator.

6 Cooling

However strange the idea may seem at first, a YIG should be heated and cooled. Heated so that the YIG pellet reaches its operating temperature rapidly, and cooled so that the heat building up in the main tuning coil can be used to heat the YIG up really well. Cooling is necessary, above all, at relatively high operating frequencies, since here there can be a considerable current of up to 1A, and so a considerable heat loss is generated.

Fig. 17 shows a miniature YIG oscillator, which operates at up to 10GHz and becomes very hot. This YIG was experimentally mounted on this heat sink, but it was somewhat too small.

7 Conclusion

I couldn't find much on the Internet on the subject of YIG oscillators and their connections. So I just hope that these remarks (without a lot of theory) help to make it easier to use these interesting components.

8 Literature references

[1] Synthesiser signal generator for 10 to 1,800MHz Bernd Kaa, DG4RBF, VHF Communications 2/2004 pp 66 – 94.