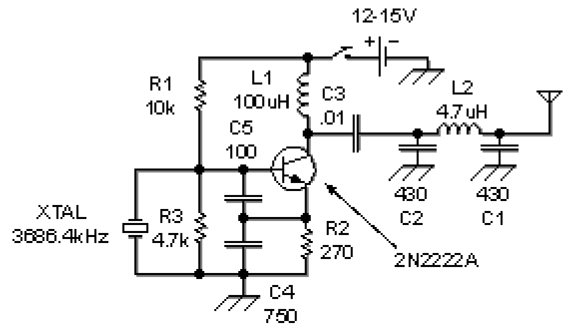
QRV, April, 2000

The NOGA QRP Club is a bunch of hams in the Atlanta area that love building stuff, love operating QRP and really love talking about it! Whenever we get together, we always have FUN! For grins last summer, a few of us decided to kit together a project for the Atlanta Hamfest. The idea was to stir interest in construction and to get more folks involved in our weekly net (Tuesdays, 9:30pm ET, 3686.4 kHz). I called the project the "NOGAnaut" since it was fashioned after Dave Ingram, K4TWJ's, Micronaut transmitter. It was definitely a fun project, but I sure did gain a new respect for the work that the folks at NORCAL, Small Wonders Labs, Kanga and others do for the hobby! (Details can be found in the Projects section of the NOGA website, http://www.qsl.net/nogaqrp).

The Micronaut was a one-transistor transmitter that put out 20 to 30 mW of power, originally described in *CQ Magazine* in 1997. The NOGAnaut is an adaptation of this circuit, with modifications for operation on 80 meters, increased output, and increased stability. It is the simplest kind of transmitter possible—the crystal oscillator—in this case a Colpitts crystal oscillator.

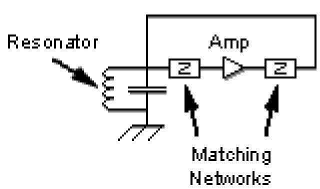


NOGAnaut Transmitter

In putting this kit together, quite honestly, I took a lot for granted. But in the subsequent months, I've wondered, "*Exactly how does this thing work?*"

Have you ever stood looking into a mirror with a mirror directly behind you? What you see is a reflection of a reflection of a reflection of a reflection, etc. This experiment demonstrates one of the two things that are necessary in order to achieve oscillation—*feedback.* Here, the reflectivity of each mirror to the other provides the feedback, and the repeating reflections visibly demonstrate oscillation.

In electrical terms, *feedback* means that some of the output signal of a circuit is *fed back* into its input (a good example of electrical feedback is the howl you get when you hold a microphone connected to the input of an PA in front of a speaker connected to the PA's output). The output signal applied as feedback should be higher in amplitude than the original input signal, that is, the signal must be *amplified*. If the signal is not amplified, losses in the circuit will eventually cause the signal to *dampen* (e.g., the reflected mirror images "fade into the distance").



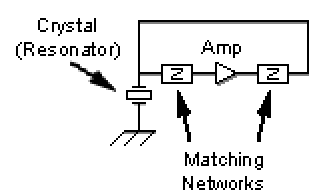
LC Oscillator from *Solid State Design for the Radio Amateur*

The second condition required for oscillation is that the phase of the output signal should be exactly the same as that of the input signal. This sort of makes sense, since two sine waves exactly in phase added together result in a sine wave, whose amplitude is the sum of the amplitudes of the two waves. In the LC oscillator shown here, the two matching networks (labeled "Z") ensure that the input and output signals are in phase.

When an inductor and a capacitor are connected in parallel, they form a resonant circuit, or resonator. The resonator shunts signals not at the resonant frequency to ground. This ensures that the oscillator operates on a single frequency.

The two conditions for oscillation in an electrical circuit (in phase feedback with gain) are known as the Barkhausen criterion. Note that too much gain, or too much feedback leads to runaway oscillation—how many times have we had to tame an unwieldy audio amplifier under such conditions? The amount of gain in the amplifier is just that amount needed to overcome the losses in the electrical circuit, which come primarily from the resonator and the matching networks.

The NOGAnaut is a crystal-controlled oscillator. Crystals used in amateur radio oscillators are usually made from quartz. Quartz has the characteristic that when it is subjected to an electric field, the crystal structure changes mechanically, i.e. it moves slightly. Interestingly, not only does an electric field cause mechanical stress in the crystal, mechanical stress to the crystal also generates an electric field. This is known as the *piezoelectric effect*.



Crystal Oscillator

As an experiment, hook up a battery, a telegraph key and a piezoelectric buzzer from your local Radio Shack store. The buzzer is actually a crystal, *resonant* on a particular audio frequency. The crystal used in the NOGAnaut is just

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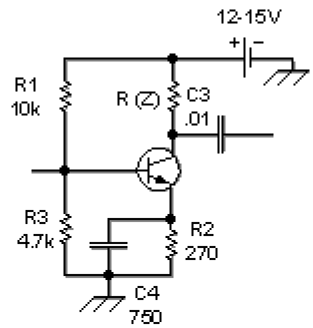
a piece of quartz, with two electrical connections, that is resonant (i.e. it behaves just like a *tuned circuit*) on the NOGA net frequency, 3686.4 kHz.

You might wonder, how does the oscillation get started? Or, put another way, which came first, the chicken or the egg? If all of the components in an oscillator were perfect, then a signal would somehow have to be injected into the circuit to begin oscillation. However, real components generate *noise* when current flows through them (for example, from heating of the components). In the NOGAnaut, noise is amplified by the transistor and then fed back to the input via capacitor C5, starting the oscillation.



NOGAnaut without C5

Where is all this headed? Well, take a look at the NOGAnaut with feedback capacitor C5 removed. In this diagram, I've also changed L1 to a resistor, representing the impedance of L1. This is a common circuit for biasing a transistor into operation as an amplifier (I'll go into amplifiers in more detail in the next QRV, but if you are curious, check out *Solid State Design for the Radio Amateur*, by Doug DeMaw, W1FB, and Wes Hayward, W7ZOI, called "SSD" by fans).

So in the NOGAnaut, C5 actually performs three separate functions—it serves as the input and output matching networks, as well as providing a path for feeding back the output signal into the amplifier input (actually C5 and C4 form a RF voltage divider helping to control the amount of signal feedback).

In this discussion, I've left out one important detail—the circuit formed by C1, C2 and L2. This circuit is called a pi network and serves a dual purpose in the NOGAnaut. It helps to match the impedance of the collector circuit to a 50 Ohm load. Its low pass response also helps to attenuate some of the harmonic energy that might be generated by the oscillator. Note that this pi filter is not sufficient to meet FCC spectral purity requirements. However, at the power levels generated by the NOGAnaut, it is unlikely that you will create interference from harmonics. If you plan to use this transmitter on the air, though, you should probably add a half-wave filter—more about this next time.

Even though Doug DeMaw, W1FB (SK) published several one-transmitter circuits (such as the "Mighty Mite"), he and Wes Hayward, W7ZOI, say in *Solid State Design for the Radio Amateur*, "It is *not* recommended that a single oscillator be used as a simple transmitter. The addition of an amplifier is so straightforward, and the system efficiency is so much better, that the minimal simplicity is not of value." Well, the NOGAnaut is a fun little project, can be built fairly quickly, and can be used to communicate with nearby stations. So for now, have fun, and next time, we'll talk more about amplifiers, and build a power amplifier for the NOGAnaut.

72 de Mike, KO4WX

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