

# Undertones

## — a fractional frequency oscillator

Last time I wrote a ham magazine article, Wayne Green and company misspelled my name (April, 1957, CQ) so I've been hesitant about trying again. Oh well, after 22 years he deserves another chance.

Now, all of you have heard of crystal oscillators. Almost all of you have heard of overtone oscillators, where the circuit oscillates on an approximate whole integer, odd harmonic of the crystal fundamental frequency. But how many have heard of the "Undertone Oscillator"? (My name; gotta call it something!) This one oscil-

lates on some fraction of the crystal fundamental such as  $\frac{1}{2}$ ,  $\frac{1}{3}$ ,  $\frac{1}{4}$  ...  $\frac{1}{100}$ , etc. Well, read on, my friend, it is very simple.

This circuit is a by-product of work on a crystal-controlled vfo with a 1000-kHz range. (Works very well, thank you.) Fig. 1 shows the very simple circuit. U1c is an optional buffer to isolate the oscillator from load capacitances. U1 is any TTL NAND gate, 7400, etc. If the NAND gate has more than two inputs, e.g., a 7410, tie all unused inputs to +5 V dc. 74Sxx ICs, have been tried but aren't quite as stable and

draw too much current. 74LSxx ICs might work well. CMOS NAND gates, e.g., 4011, might work OK at lower frequencies. The circuit has been tested from fundamental oscillations through  $\frac{1}{350}$ th of fundamental. Almost any crystal will work except some very low frequency rocks such as a 200-kHz one that I tried.

The oscillation frequency is set by C1 and R1/R2. C3 is optional for trimming the oscillator to an exact frequency. C2 is optional for help in locking the frequency to a function of the crystal frequency. R1/R2 and R3 bias U1a into its linear region. The output is a TTL-compatible square wave. Larger division factors (lower frequencies) are limited because it is too difficult to select the desired division factor.  $\frac{1}{100}$  is about the maximum I have found practical.

R1 gives a wide range, as Table 1 shows. Different undertones can be selected by small R1 changes, so a 10-turn trimmer pot helps in picking the desired one. At

small division factors (higher frequencies), R1 adjustment is not so critical, so R1/R2 and C1 can be fixed components selected experimentally. Also, at small division factors, better operation is obtained with C1 selected so that R1 is near the higher end of its range (1000 Ohms) for the desired frequency. At higher frequencies, the load capacitance affects the setup of the circuit. Therefore, it is better to have the circuit connected to the next stage or load when adjusting. If the 7400 IC is used and the other two gates are uncommitted, one of them used as a buffer (unused input to +5 V dc) eliminates this problem.

The table shows some ranges for different values of C1 obtained from a 11,000-MHz crystal. A frequency counter or a general coverage receiver are helpful for establishing the oscillation frequency. The circuit will oscillate even without a crystal. Between selected division factors, it oscillates on random, unstable frequencies.

A strange thing is that some division factors lock in better than others. For instance, with a given crystal and C1 value,  $\frac{1}{15}$ ,  $\frac{1}{16}$ ,  $\frac{1}{17}$  and  $\frac{1}{18}$  might lock in

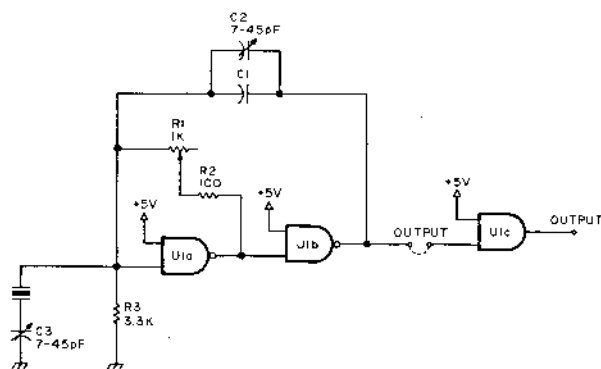
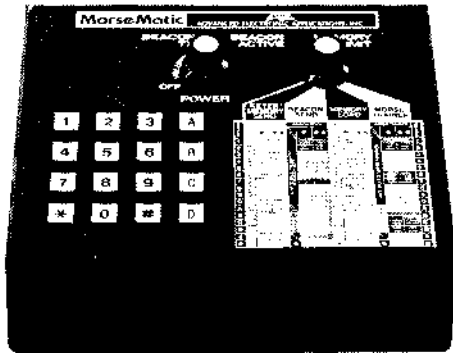


Fig. 1.

C <sub>1</sub>	50pF	300pF	560pF	1120pF	002 μF	.0047 μF	.0067 μF	01 μF
DIVISION FACTORS	+1--+5	+2--+6	+3--+3	+5--26	-8--40	+18--94	+23--132	-55--350

Table 1.

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nicely. Then 1/19 might not lock, but 1/20, 1/21, etc., might lock well. Some factors lock with poor stability. If the factor you want doesn't lock well, try a slightly different value of C1. Division factors greater than about 1/30 become fairly critical to set and aren't very practical. One-half through 1/10 are easy, and very stable operation can be obtained. After a division factor has been selected, remove the power, wait a few seconds, then turn it back on. Readjust R1 until it always starts oscillation on the desired frequency. This is more critical at larger division factors (lower frequencies). There is a little drift in the first 30 seconds the oscillator is on. (This is minimal at small division factors such as 1/10.)

What can this circuit be used for? Use your imagination. Let's say you want a 1000-kHz reference, and in

your junk box is an old 40-meter, 7-MHz rock. Set up the circuit with C1 at 1000 pF and set R1 for divide-by-7, and presto, there is a 1000-kHz crystal oscillator. The 11-MHz crystal is set up to divide by 110 (C1 at 6700 pF) and makes a nice 100-kHz reference rich in harmonics.

I would be interested to hear of applications that others might find for this circuit, and of any new developments in the circuit. Also, if anyone knows where this type of oscillator is covered in any literature, I would appreciate hearing about it.

A note: Be careful; sometimes the circuit can be made to lock on unusual division factors such as 1/3.5! Operation in this case is unreliable. Although it will work, this is not a particularly good circuit for fundamental frequency oscillation. ■

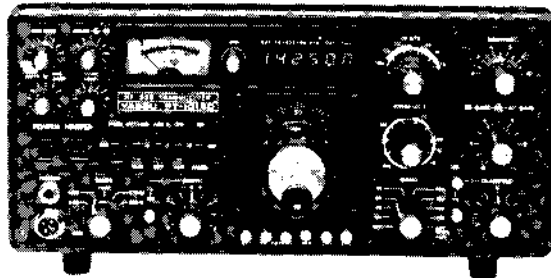
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