Precision Frequency Measurement... for under $300...the Heathkit IB-1101

by Ronald F. Schatz

There are several reasons why a DXer would want to know the frequency of a station to the nearest Hertz: The scientifically minded DXer may want to study the frequency "habits" of individual stations, noting their stability, direction and rate of drift if unstable, and normal exact frequencies otherwise. Such knowledge is quite useful when using the EBU TA list, and even more so for keeping track of LAs just straddling the main channels. DXers directly connected with the engineering side of the broadcasting industry can use such precise information to help eliminate interfering heterodynes and inter-station flutter that reduce their station's coverage area. Otherwise, knowing exact frequencies may serve little more than to satisfy the curiosity that makes DXing such an enjoyable hobby in the first place. Finally, there's the usual egotistical reason - outdoing the guy who keeps boasting about the frequency readout of his expensive R-390 (to the kHz, directly), or being among the very few DXers in the world who can determine frequencies to the nearest Hz. But so much for that.

DXers have found several methods useful for determining frequencies to given accuracies: Interpolating between two known frequencies using the logging scale of the receiver bandspread is accurate for getting to the nearest kiloHertz, but is subject to error caused by non-linearities in the tuning capacitors. Matching heterodynes against musical pitches of known frequency gets one to the nearest 0.1 kHz on the average, with accuracy decreasing with higher pitches. Frequency meters are extremely accurate (to 1/10 Hertz or better) but are ghastly expensive, often limited in the range of frequencies they cover, and must be used indirectly with an accompanying table. The military surplus models that some DXers can afford may only be accurate to within 10 Hz, which is not the precision we seek here.

What we have left, then, is a method of frequency measurement that falls within the financial means of most serious DXers yet is accurate to the nearest Hertz! This is the zero-beat method using a frequency counter for readout.

Frequency counters used to be miserably expensive instruments that would visibly count and hold and count and hold until its user got a migraine headache, but not anymore. The count-up readout is gone, a steady numerical figure being held in view for two seconds after which the count is up-dated instantly, then held for two seconds more, etc. Time and progress in the field have reduced the prices of counters considerably also. For our recommendations we call your attention to two fine instruments from Heathkit: The IB-101 reads from 1 Kz to about 15 mHz with an accuracy of ± 1 Hz and sells in kit form for about $220. The new IB-1101 is identical, except its range is extended to over 100 mHz. The latter is also a kit, selling for $295.

At this point the reader may pose the question: "How do I connect the counter to my receiver?" For precision frequency measurements, you don't: First of all, the RF signal of the station in the receiver is rarely strong enough to trigger the counter, though the TRF may be an exception. As you don't want to monitor the steady 455 kHz of the IF, of course, all that is left that the counter can use is the local-oscillator frequency, which is the station's frequency + 455 kHz. This is fine and pretty accurate readout (to within 0.1 kHz at times) as long as one doesn't mind constantly subtracting 455 kHz from the reading on the counter! But in any case there is still no accurate reference available for finding your way exactly on frequency (the shallow "tuned-in" sound is not an accurate reference by any means, nor are BFOs ever stable enough to serve such a purpose).

Thus we must turn to an indirect method of measuring frequencies, and this involves the use of a signal generator, which, unlike counters, are very cheap to own, running $50 or less. At present the author is using a Heathkit IG-102, with an output raning from 100 kHz to 220 mHz in six bands and switchable modulation of about 400 Hz, useful for finding its signal among others on the receiver. It sells for $39.50 in kit form.

The signal generator is the weakest link and the 'problem child' in this method of frequency determination. Cheaper units are noticeably unstable and will "jump" with the slightest tap or jar. Few adjust smoothly enough for easy arrival at the desired frequency, there being a tendency to bind at such precise levels of tuning, then to overshoot the mark with the force needed to break the bind. There is also a problem controlling the amount of signal reaching the rx, since the latter will pick up the stray radiation eminating from the circuitry before the attenuation controls of the generator.

In an effort to "beat the bind" of the signal generator, most users will grasp the tip of the indicator in their fingers and hold it on frequency with a steady hand while they read the counter. We suggest investigating what effect the attenuator control has on the generator's frequency. In the case of the IG-102, moving the fine attenuation control can vary the output frequency over 25 Hz, thus making it an outstanding "fine tuner"! As our experience has shown us that most signal generators possess this idiosyncrasy to an extent, we are employing it in our instructions below. Otherwise, grab and hold the tuning indicator by the tip, unless you've found a better way.

Now to get to the actual procedure for measuring frequencies to the nearest Hz using rx, signal generator, and frequency counter. First, the preliminary set-up:

1) Be certain that the frequency counter has been calibrated against the signal from WWV following a 30-minute (at least) warm-up.

2) Place the signal generator within "reception" distance of the receiver, no closer than a meter apart. The actual distance will vary with convenience, signal strength and other factors.

3) Connect the output of the signal generator directly to the input of the freq. counter. This is the only direct inter-unit connection that will be made.

4) Warm up everything for at least 30 minutes. This is especially important for the signal generator.

5) After the minimal warm-up, place the signal generator attenuation control midway between maximum position (i.e., greatest signal) and the minimum signal that will trigger the frequency counter.

Now you are ready to measure the frequency of your choice:

a) Tune the receiver to the signal to be measured - of course.

b) Tune the signal generator to that frequency so that the heterodyne tone drops and disappears on the receiver. For weak signals you may have to increase the distance between the signal generator and the rx; for strong signals it will be helpful to touch the generator-counter cable to increase radiation to the receiver, among other methods. It is best for both signals to be roughly equal in strength.

c) Carefully adjust the tuning dial of the signal generator until the S-meter on the rx can be seen to vibrate or wiggle. Gentle tapping with the finger will help to overcome the "bind".

d) Now adjust the attenuation control to slow down and finally stop the meter vibration. For good accuracy, the meter indicator should not dip more than once every 4 or 5 seconds, but it should be fairly easy nonetheless to hold things still for a minute or more with this method of tuning.

e) Observe several 2-second readouts on the frequency counter (for as long as the zero-beat hold out), then record the average reading. That is the freq. to the Hertz!

In cases where the rx lacks an S-meter, listen for flutter, then slow it to zero.

When reporting freq's of this accuracy, be sure to include the date, and preferably the time, that the measurement was made, as many freq's change from day to day, or even hour to hour, even in the case of domestic stns. WFUN in Miami has been observed shifting from 789995 Hz to 790012 Hz in the space of 5 hrs, while ECS4 in the Canaries has been rock-steady on 1097080 Hz for weeks! Sometimes it is preferable to report unstable frequencies in reduced form, such as CHHK on 1306.5 kHz; a more precise measurement would not last the night!

-Ronald F. Schatz