Frequency Measuring Test 2006 — Back to Basics, Plus

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With the return of the Frequency Measuring Test (FMT) in 2002, hams were given a series of new challenges — technical and operating. Technically, how well can you measure the frequency of transmitted signals? Operationally, do you know the frequency of the signals you are transmitting? The FMT provides a grindstone on which to sharpen both sides of the knife!

The Basics

"Back to Basics" means just that. Last year and in 2004, the FMT challenged hams to measure the frequency of an audio tone that modulated a steady carrier. In 2006, we return to the original format of the FMT by asking for measurements of the transmitted carrier's frequency.

Let's get one thing straight, though — accurate frequency measurement is within reach of nearly all hams with modern equipment. You don't have to own a rack full of sophisticated test equipment. You don't even have to wear a lab coat! (although it might make you *feel* more accurate). The frequency accuracy of most radios sold in the past decade is specified as ±10 parts per million (ppm) or better (see the sidebar "Precision, Accuracy and Stability"). By calibrating your radio (see the sidebar "Calibrating Your Receiver") to a known frequency reference such as WWV or CHU (you don't even have to take the cover off) and letting the radio reach an even, stable temperature, your measurements can be within 1 ppm or even better!

The basic techniques for making the carrier frequency measurements are the same as they were in 2002. The FMT announcement for that year gives detailed instructions on how to make them. You can download the 2002 article at **www.arrl.org/w1aw/fmt/0210051.pdf**.

The Plus

During the time at which FMT transmissions are made from W1AW, propagation does not favor the West Coast. This was reflected in the locations from which measurement reports were submitted, mostly east of the Mississippi. While the ARRL couldn't do much about propagation, the ham community did respond and a volunteer station was selected to make the West Coast "run." Hopefully, more reports from W6 and W7s will be received in this year's exercise.

Mike's FMT transmissions will be powered by Heathkit, but the stable source of the signals is Hewlett-Packard instruments, synchronized to GPS satellite time.

Finding a station whose transmitter's oscillators were of adequate stability was a bit of a challenge, but thanks to volunteer Mike Fahmie, WA6ZTY, the FMT measuring transmissions will be heard loud and clear from his location in San Francisco's East Bay.

The West Coast run will be on 40 meters only and will follow the W1AW transmissions (see "West Coast Format" on the next page). It was decided that at this time of day in November, 40 meters would offer the best reception for the West Coast and western interior states.

Mike's FMT station consists of an HP-5100 synthesizer referenced to an HP-107BR Quartz Standard, which is manually disciplined to the US Naval Observatory standard via GPS. He expects that his transmissions will be accurate to within 1 part in 10^{11} with even better stability during the test. As shown in the photo, the synthesizer will drive a DX-60 Heath transmitter driving an SB-200 amplifier. The antenna is a 40 meter dipole for broad area coverage.

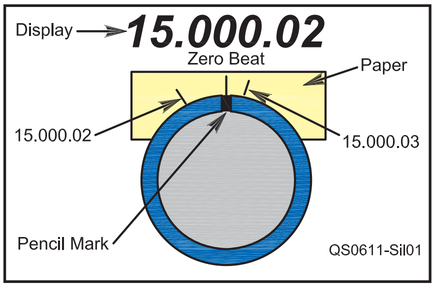
As a check, John Staples, W6BM, is just a mile from Mike's station and has agreed to

Precision, Accuracy and Stability

Precision is the smallest difference in frequency that can be displayed or measured. Above 10 MHz, a radio with a 7 digit display (10.000.00) has a precision of 10 Hz. At 28 MHz, 10 Hz is equivalent to 0.36 ppm (0.000036) percent, and at 3.5 MHz, 2.9 ppm (0.00029) percent.

Accuracy is a measure of how close the displayed frequency is to the actual frequency. For example, an operating manual might specify that the displayed frequency will be ±7 ppm from the actual frequency. It's important to know the displayed frequency accuracy when operating near the limits of your license privileges.

Stability is the ability to remain at a specific frequency over time. Even after a warm-up period, vacuum tube radios tended to drift — sometimes up to several dozen Hz per minute. Solid state radios, with low heat dissipation that minimizes temperature changes inside the radio, are much more stable. Stability is specified as a frequency error over a range of temperature, such as ±10 ppm from –10 to +50° Celsius.



By creating your own "fine-tune" scale, the precision of your frequency measuring capabilities can be increased by a factor of four to 10.

Calibrating Your Receiver

You can turn your rig into a precision FMT machine with just a few minutes of work, a pencil and a sticky note! You'll use one of the on-the-air time and frequency references, such as WWV, WWVH (**www.boulder.nist.gov/timefreq/stations/wwv.html**) or CHU (**www.nrc.ca/inms/time/chu.html**). WWV and WWVH modulate their AM signals with a 500 Hz tone, while CHU uses an FSK data signal.

- Tune to the highest frequency reference that you can receive clearly. Set your rig's display for its highest precision if there is more than one setting.
- Place the sticky note behind the rig's main tuning knob and make a light pencil mark on the edge of the tuning knob near the center of paper (see Figure 1).
- Switch back and forth between USB and LSB while adjusting frequency until the audio tone is the same pitch. You are now *zero beat* with the transmitted carrier. (The steady tones transmitted by WWV and WWVH are easier to compare by ear.)
- The difference between the displayed frequency and the carrier frequency is the displayed frequency error. Record this value.
- Make a mark on the paper aligned with the mark on the knob.
- Tune the rig higher until the right-most digit of the frequency display changes. Make another mark at the position of the knob's mark.
- Tune the rig down through the zero beat frequency until the right-most digit of the display changes again and make another mark here.
- Record the frequency at both marks — you now have a fine-tune scale! Interpolate between these two marks at specific frequencies to estimate the frequency of the zero-beat mark.

For example, if you zero beat the 15 MHz WWV transmission and your display reads "15.00002" your rig is 20 Hz high, or 1.33 ppm. For superheterodyne receivers (most modern receivers), this represents the sum of the frequency errors of all of the local oscillators in the mixing chain. Subtract the difference from any displayed frequency. Although any of the receiver's oscillators may be slightly off-frequency, this procedure assumes the error is due to the tunable VFO.

In this example, the two marks on either side of the zero-beat mark would be at 15.00003 and 15.00002 MHz (the "2" changes to "1" at 15.000019999… MHz). If the zero beat mark were three-quarters of the distance from .00002 to .00003, then the implied frequency would be 15.0000275 MHz. Subtracting the display error of 20 Hz, the zero beat frequency would be 15.0000075 MHz, within 0.5 ppm of the true carrier frequency!

make an independent measurement using a Cesium frequency standard as the reference. John and Mike will have made several test runs before the actual FMT.

Mike was first licensed in 1961 as WV6ZTY, and after a tour of duty in the US Navy, moved to the East Bay to work at the Lawrence Radiation Lab; he is currently working on the laboaratory's Advanced Light Source, a 200 meter electron cyclotron, among other things. He also maintains a pair of UHF voice repeaters, a packet BBS and assists with the northern California packet network. When not in the lab, he's an avid skier and enjoys bluegrass music, hiking, backpacking and putting up big antennas with the WB6W Field Day team.

Schedule

The W1AW FMT will run on November 16 at 0245 UTC (November 15 at 9:45 PM EST). It will replace the W1AW Phone Bulletin normally scheduled at that time. It is recommended that participants listen to W1AW's CW/digital transmissions prior to the event to get an idea of conditions to see which band (or bands) will be best for measurement purposes.

W1AW Format

The FMT will begin with a general W1AW (QST) call beginning exactly at 0245 UTC sent simultaneously on three amateur frequencies. The test will consist of three 60-second key-down transmissions for each band, each followed by a series of dits and station identification.

The test will last for a period of approximately 15 minutes total. The test will end with a series of Vs, followed by station identification. W1AW will identify before, during and after the transmissions. The approximate frequencies are as follows:

- 160 meters — 1853 kHz
- 80 meters — 3586 kHz
- 40 meters — 7039 kHz

During the course of the FMT, W1AW will indicate the band on which participants should measure. For example, after the initial call-up, W1AW will begin sending NOW 160 METERS via Morse code. During the 160 meter measuring time frame, W1AW will continue to indicate the band first by IDing, and then indicate the band in the following way: QST DE W1AW 160 METERS.

West Coast Format

The West Coast FMT transmissions will follow the W1AW transmissions, beginning at 0330 UTC (7:30 PM PST). The test will begin with a general call of QST DE WA6ZTY. The measurement period begins with NOW 40 METERS (at 10 wpm), followed by one minute of continuous carrier and 10 seconds of continuous CW dits. The measurement transmissions are repeated twice more. The test concludes with 15 seconds of V, followed by DE WA6ZTY WA6ZTY SK SK. The approximate frequency will be 7029 kHz.

Reporting and Results

Your submitted report should include the time of reception, frequency measured and signal report, along with your name, call and QTH. If possible, participants should submit reports on as many bands for which measurements were made.

A Certificate of Participation will be available to all entrants. Those entrants that come closest to the measured frequency will be listed in the test report and will also receive special recognition on their certificate.

All entries, including West Coast entries, should be postmarked by December 16, 2006 to be eligible. Send entries to W1AW/FMT, 225 Main St, Newington, CT 06111.

If you'd like more information about the equipment that will be in use at W1AW to generate the test signals, take a look at **www.arrl.org/w1aw.html**. For more information about the FMT, including a Frequently Asked Questions list and updates to test schedules, the FMT Web page is **www.arrl.org/fmt**.

Reference

H. W. Silver, NØAX, "The ARRL Frequency Measuring Tests," *QST*, Oct 2002, p 51.