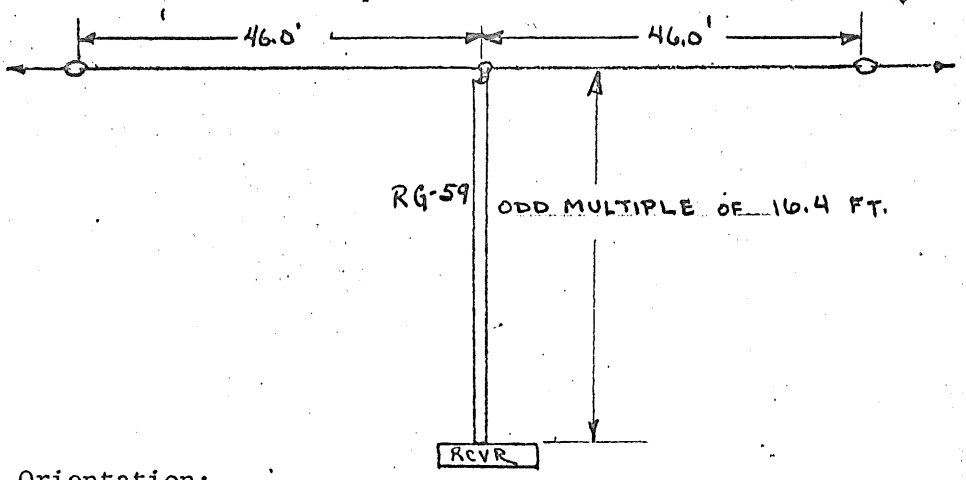
# Frequency Calibration Using a WWV Receiver

INSTALLATION:

The most important part of reception is a good antenna installation. It can make the difference between a usable signal and none at all. Points to remember are:

1. Resonant Antenna:

An antenna whose total length is 92 feet will be one-half wave length at 5 mc, one wave length at 10 mc, and 3/2 wave length at 15 mc. Center feeding with RG-59 matches 72 ohms at 5 mc and 15 mc. If the feed line is cut to an odd multiple of 16.4 feet, the antenna system will match the receiver input at 10 mc also.




2. Orientation:

Antenna should be approximately broadside to signal. (Using great circle bearing,[1] face Washington D.C.. Arms outstretched from sides will give direction antenna should run.) Trial adjustments can be made to find major lobes for higher frequencies.[2]

3. Location:

Avoid locating near metal objects, power lines or other conductors running parallel to antenna. Antenna should be 46' or higher above ground. Major obstacles preferably should be below 3° elevation in direction of reception.

4. Receiver:

The Gonset GR212 receiver is a dual conversion receiver that has been modified with two BNC connectors on the front panel. The MARKERS input injects signal from the local frequency standard (Tektronix 180) into the antenna circuit. The SCOPE output is tied to the avc line to provide low frequency to dc response. Receiver antenna input impedance is 50-75 ohms. In extremely poor signal areas it may be desirable to add a tuned pre-amp to the receiver.

## Comparison Techniques

Two comparison techniques are available when using a receiver and a 545 scope. They are (1) Beat Frequency and (2) Time Interval Comparison. Each has advantages and limitations.

In the Beat Frequency method, the frequency to be measured is injected along with the WWV signal into the receiver antenna. Both frequencies are converted to the IF frequency and detected. At the detector the difference in frequency of the two RF signals is developed and appears in the AVC circuit. A DC coupled scope is connected to the AVC and the beat frequency can be measured on the scope. The ratio of beat frequency to received frequency is the accuracy of the frequency under test. The advantage of this method

Comparison Techniques: (continued)

is the simplicity of operation, and the result is a measure of instantaneous (short term) stability. Extremely low level WWV signals, even below audible level, can be used accurately. Due to the ionisphere raising and lowering (Doppler shift) the instantaneous accuracy of a received WWV sky wave may be as poor as 1 part in $10^6$. Observations using a total daylight path during low ionospheric storm activity may be as good as 1 part in $10^8$, however.[3]

The time interval measurement utilizes the 545 delayed sweep feature to compare the one second "ticks" of WWV against one second markers of the 180. The 180 triggers "B" sweep and "A" is delayed until the arrival of the "tick". "A" sweep is then positioned to display the 5 cycle tick referenced to some portion of the graticule. A "CA" unit can be used to also display faster markers from the 180 so that any drift in B sweep can be noted and corrected. In a period of several minutes or hours the "tick" will be observed to drift across the CRT so many milliseconds. The drift divided by total observed time (both in MS) is the accuracy of 180. This method gives the average frequency of the 180 and does not show rapid fluctuations due to crystal heater action. Accuracy of WWV time intervals as received is on the order of ±2 parts in $10^8$ + 1 millisecond. Variations of several milliseconds may be noted due to propagation variations, but when averaged over a few hours, contributes little to inaccuracy.

## Beat Frequency Procedure

1. Connect equipment appropriately:
   a. Antenna to BNC in rear of receiver.
   b. Scope vertical to BNC "SCOPE" on receiver.
   c. 180 1 μs markers to "MARKERS" on receiver.

2. Spot WWV by removing antenna and tuning to either 2.5, 5, 10, 15, 20, 25 mc.

3. Reconnect antenna and look for beat note on scope with vertical sensitivity at approximately .2 V/CM. Beat note may be observed even if WWV cannot be heard. (DC coupled but repositioned on screen).

4. Trigger scope INT. but not AUTO..

5. Turn trigger level to stop sweep. Brighten intensity slightly. Rotate trigger level to cause single sweep.

6. Count cycles per 10 cm, and determine cps of observed beat note.
   Example: Sweep speed = 50 ms/cm. 7 cycles counted in 10 cm.
   10 cm x 50 ms/cm = 500 ms. $\frac{1000 \text{ ms}}{500 \text{ ms}}$ = 2 displays per second.
   7 x 2 = 14 cps.

7. Calculate accuracy by dividing beat frequency by received frequency.
   Example: $\frac{14 \text{ cps}}{15 \text{ mc}} = \frac{14}{15 \times 10^6}$ = .93 ppm or approximately 1 ppm error.

8. Determine sense of error. With cover of 180 removed bring grounded screw-driver near trimmer capacitor of oscillator. If beat frequency increases the 180 is low in frequency. If beat frequency decreases 180 frequency is high.

9. Zero beat 180 oscillator against WWV by observing scope on auto triggering.

10. Check local 180 used as a standard against WWV every month to assure that it's accuracy is within ±2 ppm. Maintain log of dates, observed drift, and whether reset or not, to show history of frequency standard.

## Time Interval Comparison - - (Alternate Method)

1. If signal is strong enough to hear "ticks" well, this method may be used to obtain long term precision.

2. Connect 545 or 535 to external speaker jack on rear of receiver.

3. Put 1 sec trigger markers of 180 to EXT. "B" trigger. Set "B" sweep at .1 sec/cm, "A" at 2 ms/cm. If "Tick" appears in right half of CRT, turn 180 off for 5 or 10 seconds to "rephase" "tick" in the left half. Then advance "B" to 50 ms/cm.

4. With "B" intensified by "A" locate tick with intensified portion.

5. Switch to "A" delayed by "B" and observe 5 cycles of tick (6 cycles for WWVH, Hawaii).[4] Move delayed trigger to position start of tick near center of screen.

6. Observe shift over several minutes or hours.

7. Calculate Accuracy: $\frac{\text{milliseconds shift}}{\text{milliseconds observed}}$ = Accuracy.

8. Put 100 or 10 ms markers in "B" channel and relate to "A" delayed by "B" display. (Horizontal position one marker on graticule line). If delayed triggering has shifted at end of observation reposition same marker and graticule with Horizontal Control.

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## FOOTNOTES

1. Reference Data for Radio Engineers, 4th Edition ITT, Pg. 733.

2. Radio Engineer's Handbook, Terman, McGraw-Hill, Pg. 788.

3. Reference Data for Radio Engineers, 4th Edition, ITT, Pg. 25.

4. Standard Frequencies and Time Signals from NBS Stations WWV and WWVH NBS. Misc. Pub. 236 (Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., 10 cents).