FR-4U Heterodyne Frequency Meter, part of AN/URM-79

This is one of the most interesting frequency meters. One of the latest analog instruments, it was designed to ensure unsurpassed accuracy when early digital meters were already on the scene. It can well be seen as forerunner of frequency synthesizers which would appear in the late fifties. Since resolution down to hertz level was not practically feasible, the entire measuring range was divided in 5 kc segments, within the lowest measuring band, 100 to 250 kc. Higher frequencies, between 250 kc and 20 mc, were measured in six additional bands which were converted down into the fundamental band.

Segments are all derived from a thermostated quartz crystal reference operating at 1250 kHz. A divide by 125 chain scales the internal reference down to 10 kHz. A spectrum generator followed by a tuned amplifier select the harmonic closest to the frequency to be measured. Harmonic beats with input signal and the output of the mixer goes through an amplifying chain including a 15 to 20 kc selective filter, up to the horizontal deflection plates of the CRT indicator. A precision interpolation oscillator, tunable from 15 to 20 kHz, drives the vertical deflection plates. Lissajous patterns on the CRT make possible exact tuning of the interpolation oscillator which now indicates the least significant digits of the unknown frequency down to hertz.

Worth of note is the frequency divider chain used to scale down the internal reference. The basic circuit performs all analog divide-by-5 scaling, handling sinusoidal waveforms. It is based upon quite unique circuits, containing a loop with a subtractive mixer and a frequency multiplier, never encountered before The simplified block diagram is shown below.

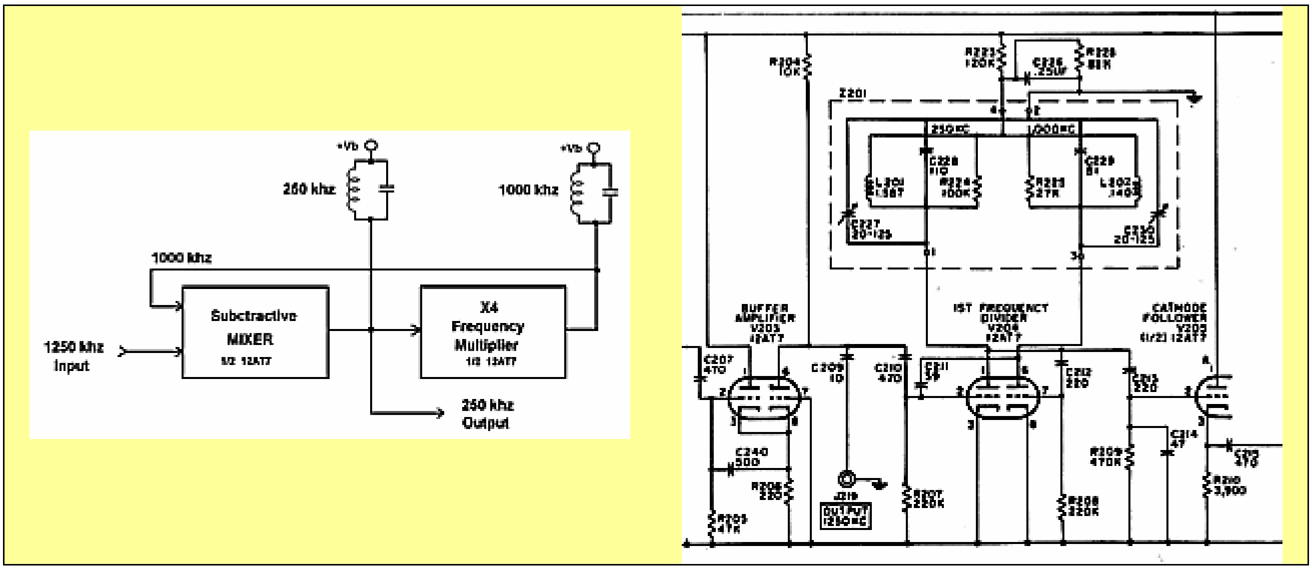

Fig. 1 - Simplified block diagram of the first divider and actual circuit. Click on images to enlarge.

The input reference frequency is fed to a subtractive mixer, whose output is tuned to one fifth of the input frequency. The output of the mixer also drives the feedback control loop, a frequency multiplier tuned to the fourth harmonic of its input. The frequency generated by the multiplier, 4/5 of the reference input, is fed back to the second input of the mixer and then subtracted from the reference. The circuit cancels by subtraction any error generated and its output locks exactly at one fifth of the input reference frequency. Three cascaded divide-by-5 circuits are used to scale the 1250 kHz crystal reference down to 10 kHz.

Fig. 2 - The 10 kHz generator subchassis. The 1.250 kHz crystal reference is in the oven at top right.

Since divider circuits are regenerative, both the grid signal amplitudes and the plate operating voltages are limited to prevent oscillation build-up even in absence of input signals. The stability of the chain is improved by slightly detuning the thank circuits of the three mixers.

The 10 kHz buffered output of the generator suchassis is fed to the harmonic selector subchassis. Here the rising edges of the signal trigger a blocking oscillator which generates fast pulses, exactly synchronized to the 10 kHz reference.

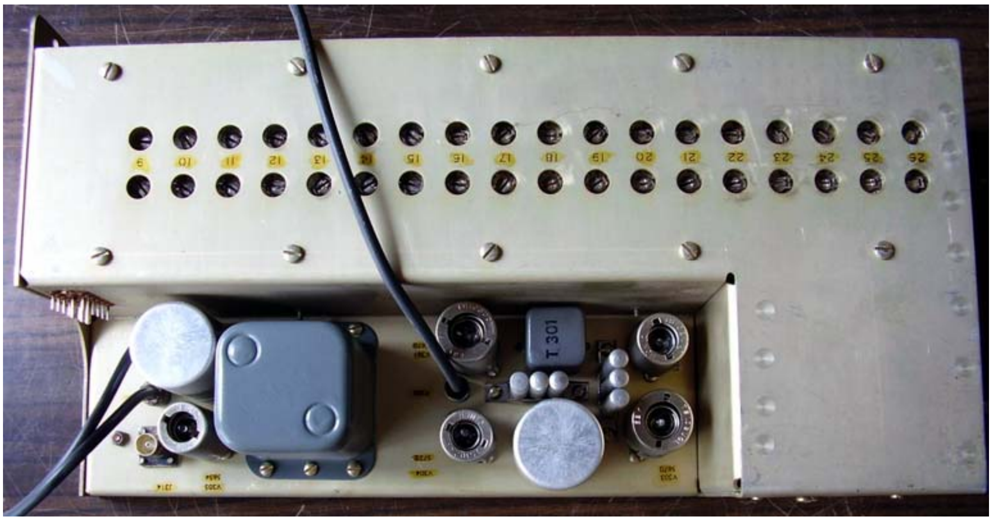

Fig. 3 - 10 kHz harmonic selector subchassis

Pulses are amplified by a shaper-amplifier and shock excite the plate circuit which is tuned to one of the switch-selectable harmonic, from 10th to 26th. Depending upon the selected function the output is fed to the horizontal amplifier of the CRT, to calibrate the interpolation oscillator, or to the measure mixer, to beat with unknown input signal. The precision interpolation oscillator drives the vertical axis amplifier of the measurement oscilloscope.

Depending upon the unknown frequency either direct or indirect measuring modes are used, the second one relying on an additional proxy oscillator tuned to the zero-beat with input signal.

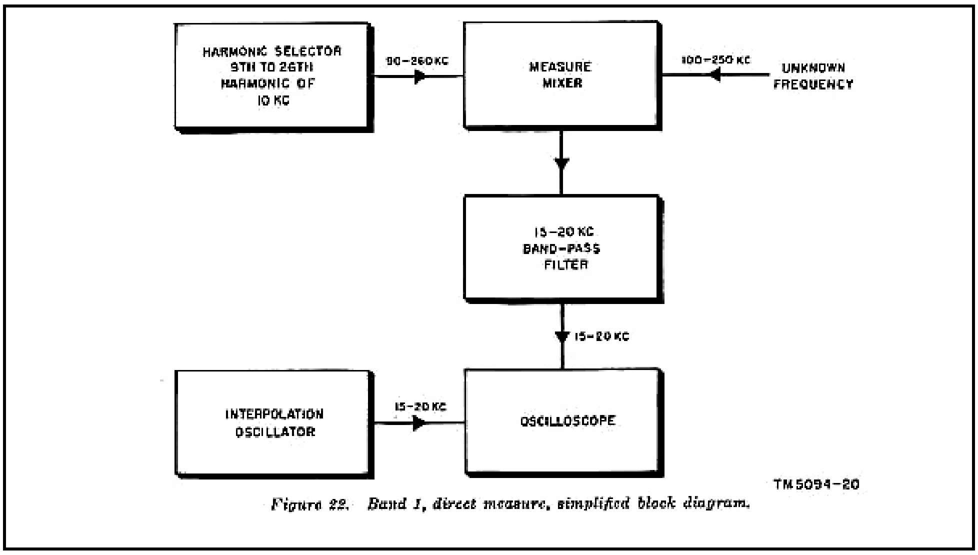

Fig. 4 - Block diagram in the lowest band, with input signal beating with the nearest harmonic of the 10 kHz reference. Click to enlarge.

In the lowest measuring band, 100 to 250 kc, input signal beats with the nearest useful harmonic of the 10 kc internal reference. The filtered mixer output is compared against the signal of the precision interpolation oscillator. The interpolation oscillator must be calibrated against the internal reference before each measurement.

When measuring frequencies from 250 kc to 20 mc, an indirect reading technique is used. Input signal beats against the nearest useful harmonic of a variable proxy oscillator. Proxy oscillator is tuned to zero-beat using first the audio amplifier and then the blinker circuit. The fundamental of the proxy oscillator, that is anyway between 100 and 250 kc, is then fed into the unknown frequency input of the above direct reading circuit.

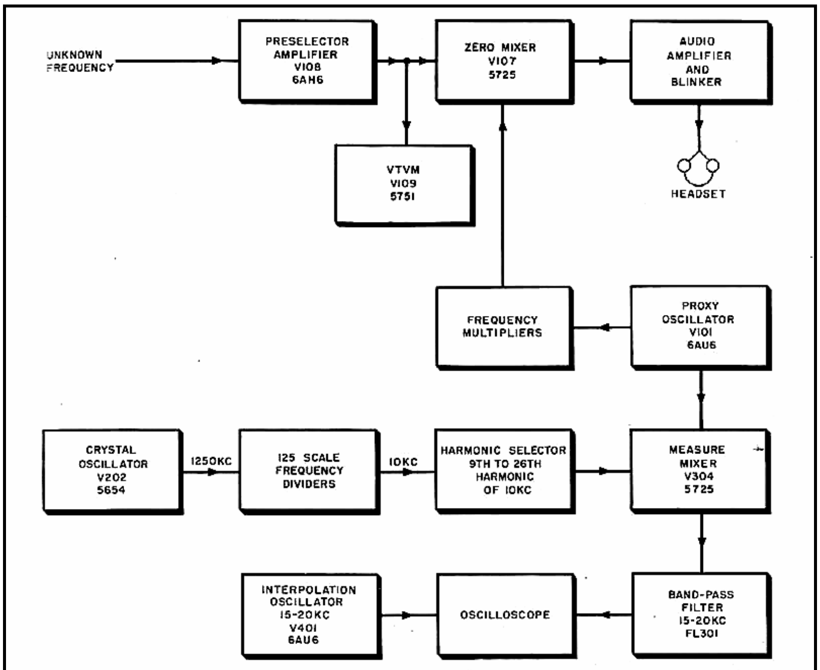

Figure 23. Indirect measure, simplified block diagram.

Fig. 5 - Block diagram for measuring higher frequencies. Input signal beats with the nearest harmonic of a precision proxy oscillator, whose fundamental is also fed into the above direct measure path.

The construction is all modular, with front panel and a middle frame holding the subassemblies.

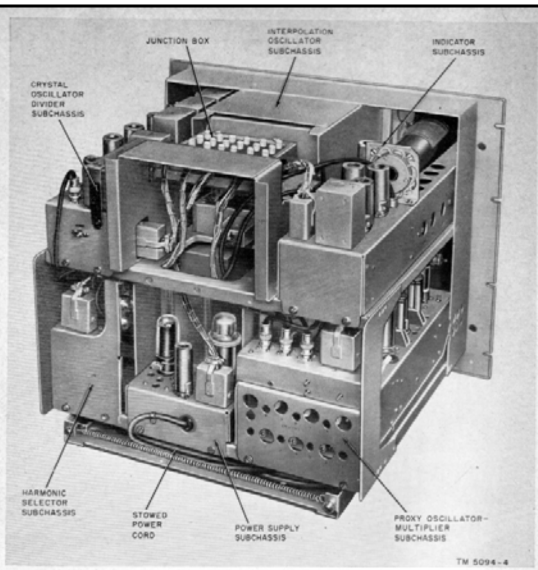

Figure 8. Frequency Meter FR-4/U, with dust cover removed.

Fig. 6 - Inside view. (Click to enlarge)

The calibration book, hosted in the bottom drawer, lists the settings of the proxy oscillator, of the interpolation oscillator and the crystal check points. 5000 dial settings, spaced 1 cycle apart, are listed for band 1.

FR-4/U was supplied to Signal Corps and to Air force in a transportable aluminum case under the nomenclature AN/URM-79. The same frequency meter was supplied to Navy with side brackets under the nomenclature AN/URM-82.

Crystal oscillator frequency 1,250 MHz
Tube complement, 30 tubes, including CRT:

Xtal oscillator:	1 ea 5654, 5 ea 12AT7
Spectrum selector:	2 ea 5654, 2 ea 5670, 2 ea 5725
Interpol. oscillator:	6AU6, 5670
Band selector:	6 ea 6AU6, 12AT7, 5751, 5725
Oscilloscope:	1 ea 12AT7, 2 ea 5751, 2BP1 CRT
Power supply:	5Y3WGTA, 0A2, 6Y6G

Power requirements:	115 or 230 V, 50 to 1000 Hz, 136 W nominal
Weight	86 pounds (about 39 kg)

Documentation	TM 11-5094, Dec. 1954	Army
	TO 16-35FR4-6	Air Force

Last edited on February 4, 2015 by Emilio Ciardiello