Introducing … The Netometer

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The editorial in the previous Signal (Oct ‘07) praised the availability of low cost yet sophisticated test equipment, giving the responsible operator the chance to ensure his/her vintage equipment is operating at its very best, especially when having to cope with modern band conditions. A large net often contains stations many kHz apart making critical receiver tuning difficult, apart from potentially *annoying the neighbours*. This article introduces a unique construction project using modern technology that in some ways has more in common with the BC221 than the frequency counter, offering the reader a quick and, easy way of checking that most fundamental [*sic*] of transmitter parameters – the frequency.

The Art of Frequency Maintenance

For many years now the frequency accuracy and stability of transmitters have been taken as a given. Crystal based frequency synthesisers and DDS signal sources, often temperature controlled, have made such issues a thing of the past.

However, the re-emerging interest in vintage radio, particularly AM radio, takes us back to the days of free running VFOs where net channels were measured to the nearest kilocycle (on a good day).

It seems only proper that vintage equipment, often lovingly and meticulously restored, should not only be cosmetically perfect but also electrically perfect. But electrically perfect means true to the original design for better or worse, often complete with *designed-in* intermodulation distortion, poor spectral purity, and of course frequency drift.

Time though has moved on, and operating such wayward equipment on today’s exacting amateur bands warrants a certain sense of responsibility on the part of the operator.

Stable Relationship

Focusing here on the frequency stability issue, it is unreasonable to expect such classic equipment, liberally sprinkled with miniature furnaces, to hold station as case temperatures rise and every coil, capacitor, nut and bolt expand and contract under the unremitting strain of the laws of thermodynamics.

However, *knowing a transmitter drifts is no excuse for transmitting a signal that drifts.*

The solution is obvious – monitor the transmitter’s frequency, then set and correct as needed. *Step forward the frequency counter*. Such devices are nothing new of course, and most shacks will have one, even if the on/off switch remains shrouded in mystery (*and dust*). Useful instruments, but are they always the best solution?

As with most digital readouts, the digital counter display cannot be taken in at a glance. *Eyes are analogue*. More challenging still is to work out if the frequency is too high or too low. To make matters worse the readout won’t lock properly with an amplitude modulated carrier.

Shall I Compare Thee?

Where the requirement is for an indication of merely being *on-channel*, and where the channel frequency is already known, what is needed is not a frequency *counter*, but rather a frequency *comparator*. Comparing where you *are* with where you *should be* doesn’t need a digital readout, just some sort of indication of being higher or lower. Ideally, a simple display that can be understood at-a-glance. Such a device appears thus far to be unavailable.

Introducing “The Netometer”

And so it was that “The Netometer” came to be. A designed for purpose frequency comparator with a centre-zero style readout comprising nothing more than five LEDs. Choose one of the five pre-settable channels, transmit, then observe the centre-zero display and adjust your VFO accordingly. That’s it, netting done in seconds. The set starts to drift. Netometer displays the offset, tracking the discrepancy. The operator then completes the control loop by manually altering the transmit frequency to cancel the drift and re-balance the LEDs to centre-zero again. Fast, fuss free and instinctive.

So, Netometer represents a more convenient alternative to the normal frequency counter, optimised for AM transmissions in the lower HF bands (40m, 80m and 160m) and designed for battery power, with a single button to control everything.

How much?

Put most of the functionality into the software domain and production costs plummet. The component cost is less than ten pounds, and the project can easily be built in three hours.

Several Netometers have already been successfully constructed, and prospective builders can be confident the design will *do what it says on the tin*.

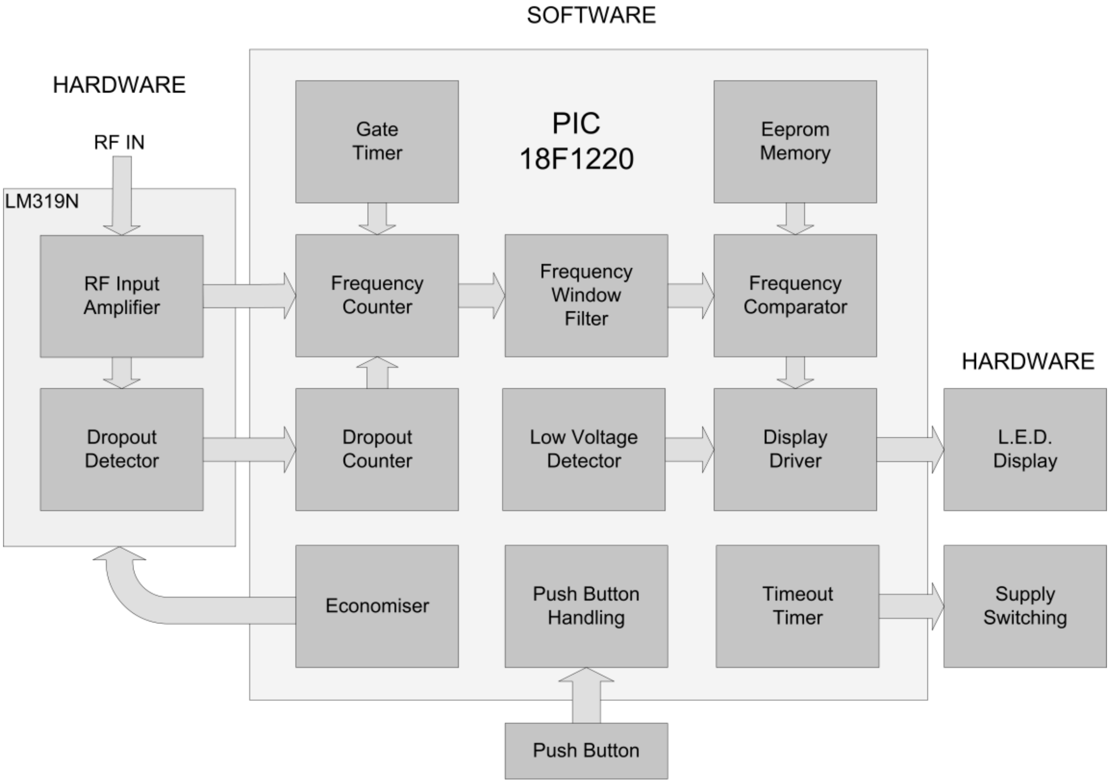

Figure 1. Netometer Block Diagram

Deceptively Simple

Netometer contains very few physical components; the only active devices being two transistors and two small ICs. The heart of the design is the Microchip 18F1220 from the PIC family [1]. This innocent looking 18 pin DIL package is a self-contained computer with program memory, data memory, a central processor, input/output lines and a wealth of specialised peripheral features. A lot is crammed into a small package and many pins have three or four uses, selectable by the software. This project uses two of the four internal counter/timers, the sleep timer, low voltage detector and several I/O lines.

Block Diagram

As Figure 1 above shows, the majority of the functionality is handled by software in the PIC chip, dramatically reducing component count. Don’t be put off by the dreaded “s” word, the software functions can be explained in plain English rather than computer speak, and because the program code is already burnt into the PIC chip, the constructor can treat the PIC as just another component.

Some of the component parts in figure1 will be recognisable from the workings of a typical frequency counter, namely an input amplifier, a gate timer that lets signals through to a counter for a fixed sample period, and the counter itself. Normally at the end of the gate period the counted value would be fed to a seven-segment display via the display driver; job done.

With Netometer, what we want to know is frequency *error* not *actual* frequency, or to put it another way, the *relative difference*. So we need to add a frequency comparator and display the result of that instead. The comparator needs a reference frequency for the comparison, and this is retrieved from non-volatile eeprom memory, having been previously stored by the user. Up to five memories can be recalled. The gate timer is 100ms, giving an accuracy of 10Hz which is perfectly adequate, but more importantly giving a display refresh of about 9.5 times a second making operation smooth and responsive.

Dropouts

The reader may be intrigued by the dropout detector and counter. Unlike normal counters, Netometer is designed to cope with AM transmissions. Usually a counter will under-read when troughs of the modulation envelope fall below its input threshold. The envelope dropout detector solves this problem by catching the troughs, which are then fed as pulses to the dropout counter. At the end of each gate period any stored dropout counts result in the main count being aborted, leaving the display unaffected.

Battery Toy

Netometer is designed for battery operation (4 x AAA /AA NiMH or 3 x Alkaline) and several features have been added to the software to maximise battery life.

- The economiser saves power in Standby Mode by taking 1ms samples every 100ms until a valid signal is detected.
- The Low Voltage Detector triggers a display change to indicate low battery volts when the supply falls below 4V.
- To save battery life the Timeout Timer automatically powers the unit off after 30 minutes on standby.

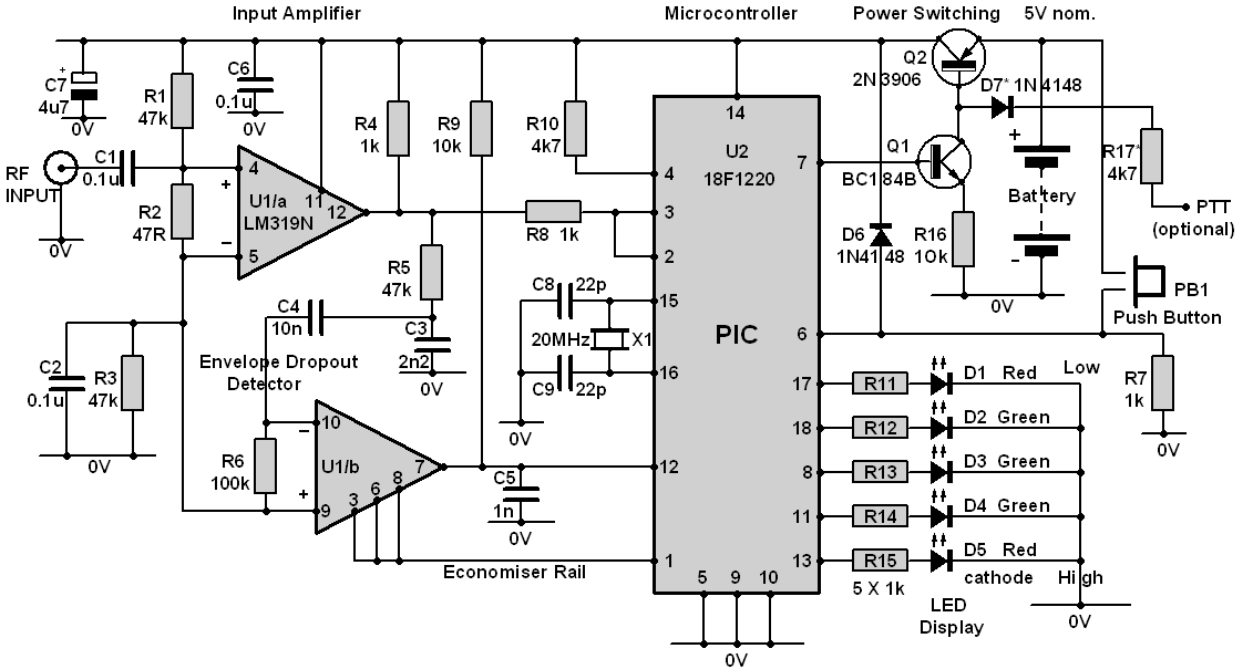

Figure 2. Circuit Diagram

Circuit Description

The LM319N (U1) is a dual high speed comparator, chosen because it is cheap, simple to use, and available in a DIL package for easy construction. U1/a amplifies and squares the input signal to 5V p-p to drive pin 3 of the PIC which is internally connected to counter0. R2 defines the input impedance as 50 Ohms, also giving U1/a high sensitivity as the differential voltage across R2 is only a few millivolts.

U1/b shares the same bias chain as U1/a i.e. R1,R2,R3 but relies on R6 and the input impedance of pin 10 to develop a static differential voltage.

As mentioned earlier, when using amplitude modulation there will be occasions when the troughs of the modulation envelope will not fully drive U1/a resulting in gaps in the pulse stream fed to the PIC. R5/C3 form a low pass filter which detects the first sign of envelope dropout. U1/b amplifies and squares this signal to produce pulses to drive counter1 inside the PIC via pin 12. At the end of the gate period any counts here cause the main count to be discarded, thus avoiding feeding inaccurate values to the rest of the system. Because there are 9.5 refreshes a second these *missed* counts go unnoticed and the display remains stable.

The PIC uses a 20MHz crystal as its clock source. A 20 ppm version is recommended over the usual 30 ppm type for better stability, but as the unit produces zero heat, when used in a stable room temperature environment there are no drift issues.

Push My Button

There is only one user control, push button PB1. This is used to change channel (there are up to five available), to store reference frequencies, and to power the device on and off. On-off switching is done by Q1, Q2, D6, and pin7 of the PIC. The operation is simpler than it may at first look. From a powered off condition, pressing PB1 feeds 5V to the main power rail via D6, powering up the PIC, U2. The PIC is programmed to test pin6 on first power-up and if it sees 5V it puts 5V onto pin7 as well. When pin7 goes high Q1 and thus also Q2 are cut on, maintaining power even after PB1 is released. D6 is now reverse biased and PB1 is free to signal to the PIC via pin 6 without disturbing the supply. The optional parts D7/R17 can also power up the unit. In this case when the PIC is powered up it would see 0V on pin 6 and would therefore leave pin7 at 0V. In this mode Netometer is only powered up when the PTT line is earthed as there is no keep-alive voltage on pin7.

The Economy

The economiser rail is simply another I/O line from the PIC (pin1), programmed to go low for 1ms every 100ms in standby mode – just to switch U1 on long enough to detect RF. (Not unlike how Pye Pocketfones used to do it). For the rest of the time there are only microamps of drain from the circuit as the PIC places itself in sleep mode. In count mode the economiser rail stays low.

Keep it Green

There are five low-current LEDs D1-D5 driven directly from the PIC via current limiting resistors R11-R15. All the user need do is keep the LED display central, assisted by the fact that the three centre LEDs are green and the outer two red. The range of off-channel indication is from greater than 2.5kHz below reference to greater than 2.5kHz above reference. The online documentation [2] gives full details about the display pattern. In standby mode the LEDs become channel indicators 1-5 and one LED flashes for the channel selected. When low battery is detected the channel LED gives a double flash.

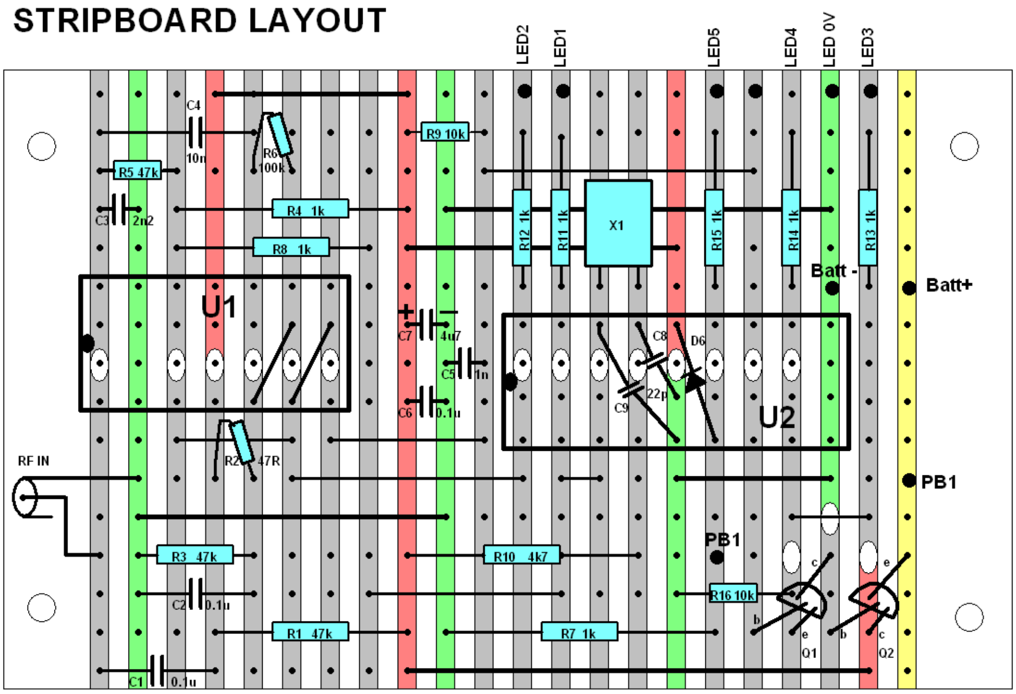

Figure 3. Layout Plan using 16 x 22 matrix stripboard

On What Shall I Build It?

Figure 3 above shows a suggested layout, with a built example shown in figure 4. There are no difficult to obtain parts and layout is not over-critical. The design does of course require the correct firmware to be programmed into the PIC chip. The builder is not required to perform this task.

Count the Ways

How to obtain a programmed PIC: 1/ The author is happy to program and test PIC chips free of charge if sent with an s.a.e. 2/ A brand new, pre-programmed PIC can be supplied at cost 3/ A full kit of parts including the programmed PIC can be supplied, again at cost. The website [2] gives full details.

The Full Works

There is a lot more to say about Netometer than space here permits, and the complete documentation set is downloadable from the Netometer support website [2] This includes large size copies of the circuit diagram (figure 2) and stripboard layout (figure 3), a complete parts list, full construction and testing details, the operating manual, and more detailed technical information. Please also check the website [2] for possible updates before building.

Conclusion

Netometer demonstrates once again that the world of the *old* can benefit from the world of the *new*. It should prove a useful addition to the vintage AM shack, making frequency adjustment second nature. There is no equivalent device available commercially. *The only way to get one is to build one!*

Brief Specification:

Frequency range: 1MHz – 9MHz.
Input Sensitivity: -25dBm (12.5mV PD)
Input Impedance: 50 Ohms
Gate Time: 100ms
Resolution: 10Hz
Stability: Based on crystal spec. 20ppm recommended.
Readout: 5 LEDs in centre-zero format
Channels: Five. User programmable, non volatile
Power Requirements: 5V @ 25mA max.
Low Voltage indication: LED flash rate alters on standby.
Auto Power-off: After 30 minutes continuous standby.

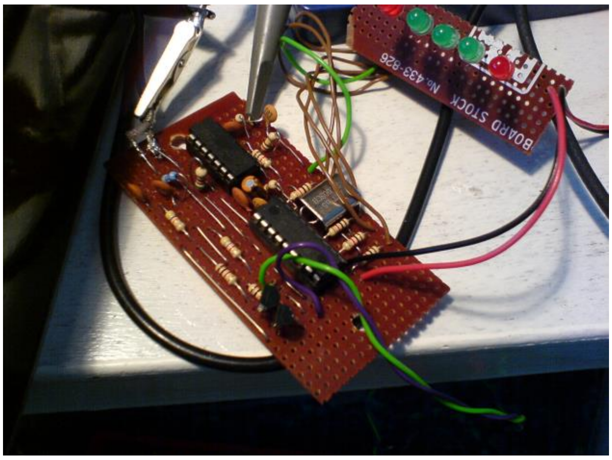

Figure 4. Completed Circuit Board

References:

[1] http://www.microhip.com (*search for 18F1220*)

[2] http://www.netometer.co.uk (Full Information