Ten-Tec 1254 Receiver Upgrade

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Abbreviations used in this article	
AF:	Audio Frequency
AGC:	Automatic Gain Control
AM:	Amplitude Modulation
HF:	High Frequency
IF:	Intermediate Frequency
LED:	Light Emitting Diode
LO:	Local oscillator
RF:	Radio Frequency
RSSI:	Received Signal Strength Indicator
SMD:	Surface Mounted Device
SSB:	Single SideBand
SWL:	ShortWave Listening
USB:	Universal Serial Bus

1. Introduction

A previous article described modifications to the Ten-Tec 1254 receiver that allowed the automatic gain control (AGC) function of the receiver to be turned on or off. [Reeve] With this modification, the 1254 could be used in high frequency (HF) radio astronomy applications such as receiving Jupiter and solar radio emissions. That article also provided a basic description and specifications of the receiver and measurements of the receiver response with the AGC turned on and off. The current article describes an upgrade that improves the receiver's overall performance and operation, and another modification that reduces the receiver's bandwidth to about 2 kHz.

2. Receiver deficiencies and fixes

A frequent complaint in online forums is that the 1254 produces many birdies and display noise. These complaints never include actual measurements, so I measured birdies before and after the upgrade described here and report the results in a later section.

Another complaint is that the tuning resolution of the receiver is too coarse for many applications, being 2.5 kHz in single sideband (SSB) mode and 5.0 kHz in amplitude modulation (AM) mode. The 1254 uses a "Clarifier" control to allow finer tuning when the receiver is used for its intended purpose as a shortwave listening (SWL) receiver. Many users consider the clarifier control unwieldy.

A commercial upgrade is available that improves the tuning resolution as well as birdie performance and adds a serial port interface (or, optionally, a universal serial bus [USB] interface) that allows computer control of the receiver. The upgrade is described in greater detail in the next section and the Appendix shows updated specifications.. The upgrade costs USD68 plus shipping and is available from: http://www.cholakian.com/TT1254upgrade.html. The receiver kit itself is available from Ten-Tec for USD205: http://www.tentec.com/products/Digital-Readout-Superhet-Receiver-Kit.html.

3. Upgrade

The upgrade described in this article provides the following:

- Selectable manual tuning steps from 10 Hz to 100 kHz (see Appendix for actual tuning steps implemented by this upgrade). The supplier claims 98% solutions to the required synthesizer step changes
- Automatic time delay for LED frequency display blanking, selectable from 1 to 255 s, reducing birdies and power consumption
- LED frequency display brightness control
- Expanded frequency memory channels from 15 to 128
- Elimination of the 9 V battery for frequency memory (after upgrade, frequencies are stored on microprocessor flash memory)
- External tuning using software and a serial port interface (or, optionally, USB) with exact tuning within 1 Hz (but with same limitation as manual tuning)
- Received signal strength indicator (RSSI), see text
- Separate analog audio line level output for connection to a PC soundcard or external speaker amplifier

The material for the upgrade was supplied as a kit of pre-built assemblies. Installation consists of replacing the original PIC16C57 microprocessor (circuit designation U2) with a more modern Cypress CY8C29466 microprocessor, installing a serial port interface and connector on the rear panel, and installing the interconnecting cables (figure 1). The new Cypress microprocessor actually is mounted on a pre-built daughter board with other components, and it is the daughterboard that plugs into the existing microprocessor socket. Among other things, this upgrade changes the 7-segment LED display multiplexing and reduces birdies produced by the display. When the display is blanked, the receiver load current drops by about 60 mA (power consumption reduction of about 0.8 W).

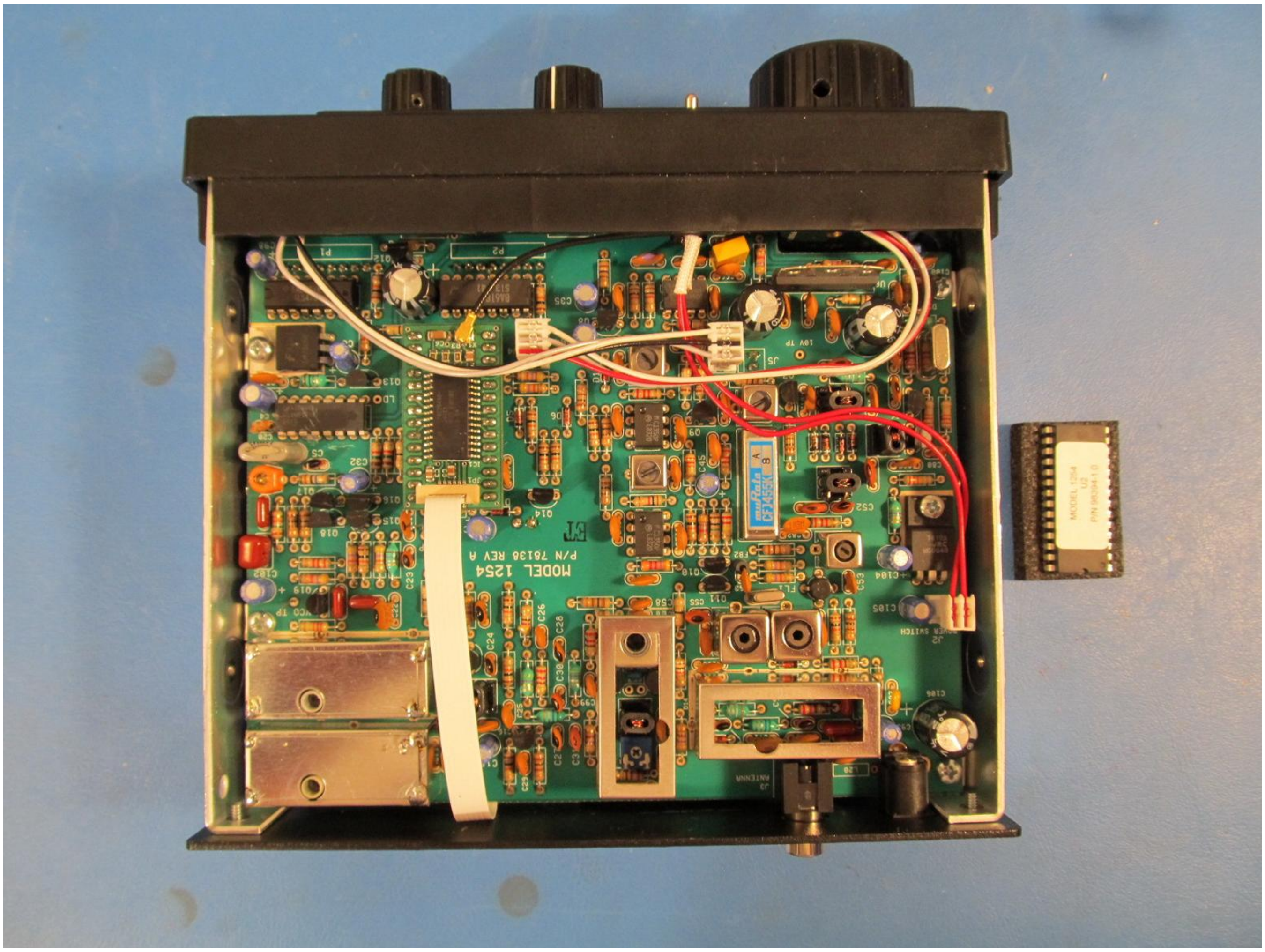


Figure 1 ~ Top (component side) of printed circuit board as viewed from the bottom of the receiver. The new microprocessor daughter board is at the upper end of the ribbon cable about 1/4 the distance from the left side of the chassis. The 2nd IF filter is located about 1/4 of the distance from the middle right side, and the old microprocessor is to the right waiting to be recycled.

Although the upgrade kit included a new rear panel, as supplied it was not painted or silkscreened, so I chose to cut the necessary holes in the existing panel and reuse it (figure 2). The upgrade also has provisions for RSSI that is used with the included control software but it does not function when the AGC is turned off if the AGC modification has been implemented.

Figure 2 ~ Rear panel with new cutouts for the serial port interface and associated activity LEDs and auxiliary audio output jack on upper right side. The AGC on/off switch from the previous AGC modification is at top-left.

4. Birdies and display noise

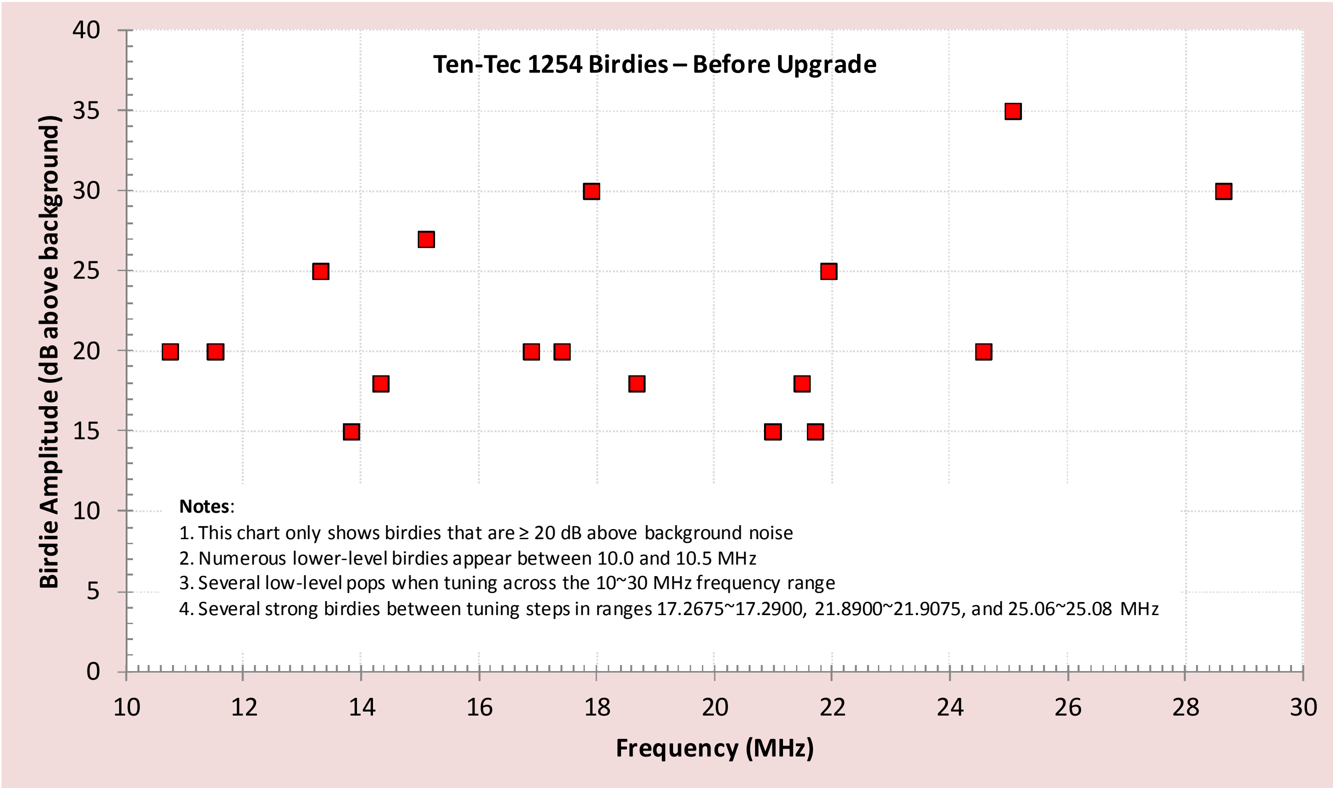
Birdies are false signals or undesired tones produced by unfiltered and unshielded local oscillators (LO) and mixers that are coupled into the radio frequency (RF), intermediate frequency (IF) and audio frequency (AF) amplifier circuits. The name birdies comes from the sounds they make as a receiver is tuned – audio tones – but they also can sound like unmodulated carriers – decreases in background noise or even silence.

Birdies can occur as a result of the receiver being tuned to a frequency that is a harmonic of the local oscillator frequency or IF or harmonics of the sum and difference of these frequencies. Birdies are inevitable in superheterodyne receivers, but the receiver design usually places them outside the normal operating range or includes shielding and filtering to reduce their effects.

The stock 1254 suffers from a strong birdie at the 455 kHz 2nd IF but it also suffers from birdies at other frequencies both related and unrelated to the RF, LO and IF circuits. The 7-segment light emitting diode (LED) frequency display multiplexing circuits produce various birdie frequencies and noise due to their switching actions and lack of shielding. In fact, the 1254 kit builder is instructed to use these display birdies in an early test of the partially built receiver. The question is how bad are the birdies in the 1254?

I measured birdies before and after the upgrade by terminating the antenna input with a 50 ohm resistor, tuning the receiver (SSB mode) over the range of 10 to 30 MHz and noting birdie locations indicated by an a tone in the speaker. Although the receiver tunes down to 100 kHz, I made no measurements below 10 MHz because in my applications, I never tune below 10 MHz.

To make comparable measurements of the stock and upgraded receiver, I used the 2.5 kHz tuning steps even though the upgraded receiver allowed much finer tuning resolution. For these tests, I set the Clarifier control to mid-range and left it there. The frequency was recorded as well as the peak level of the tone as indicated on a PC-based audio spectrum analyzer. A plot shows the strongest birdies (figure 3). The upgrade clearly improved the receiver's overall birdie performance, particularly between 10.0 and 10.5 MHz, where there originally were many low-level birdies.



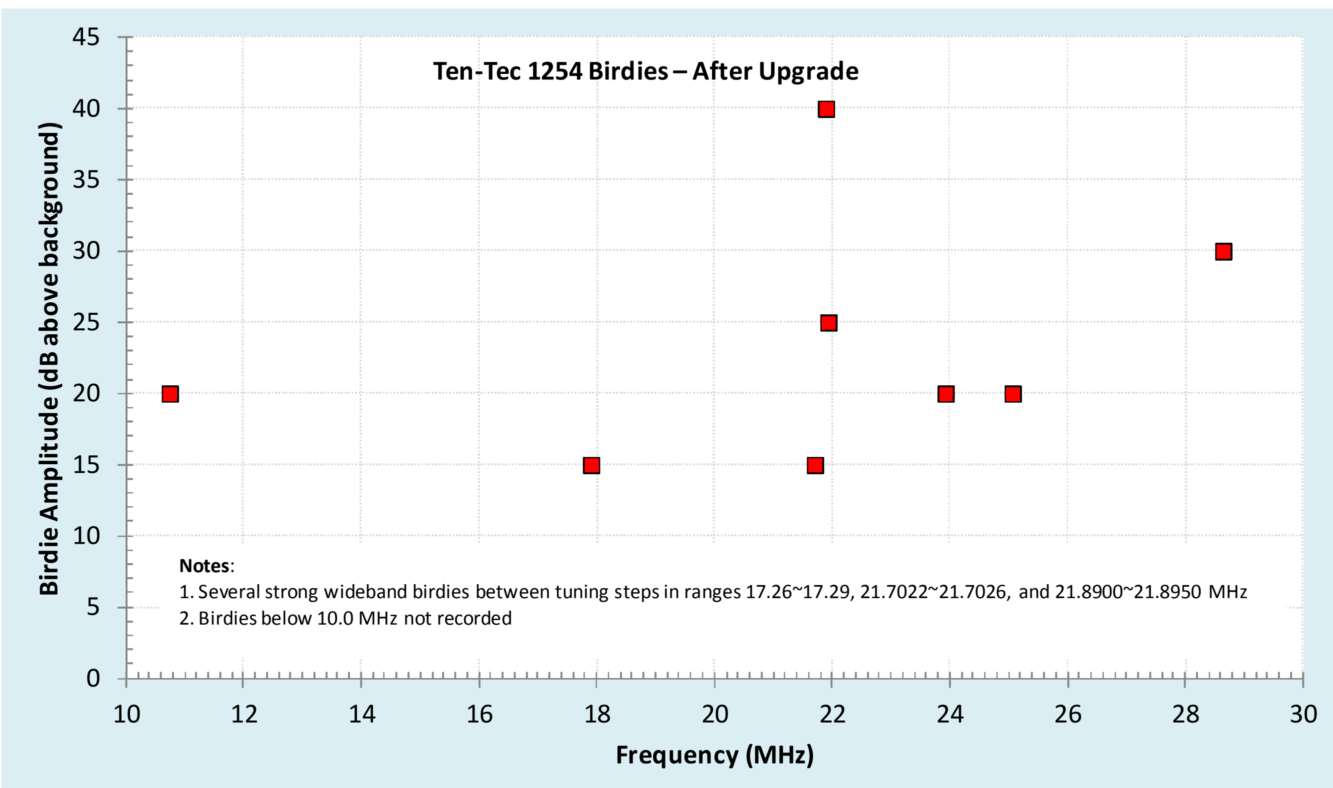


Figure 3 ~ Birdie measurements before the upgrade described in this article (upper), and after upgrade (lower). Birdies less than 15 dB above the background noise were not recorded.

5. Bandwidth modifications

In addition to the AGC modifications and upgrade already discussed, I also replaced the factory-supplied 2nd IF filter, a plastic encased 4 kHz ceramic filter (CQ p/n S455IT), with a much higher quality 1 kHz metal encased ceramic filter (Murata p/n CFJ455K-8) (figure 4). The plastic filter is cheaply made and I found them to be unreliable (I had two failures when building and testing the receiver). I measured the audio spectrums by connecting a noise source to the receiver input and a PC soundcard to the audio output. I then monitored the spectrum with Goldwave audio editing software (figure 5).

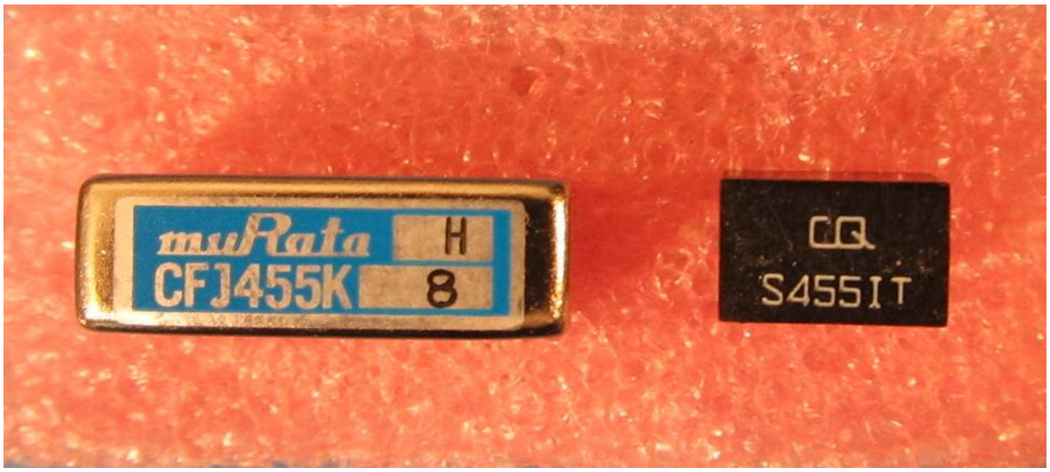
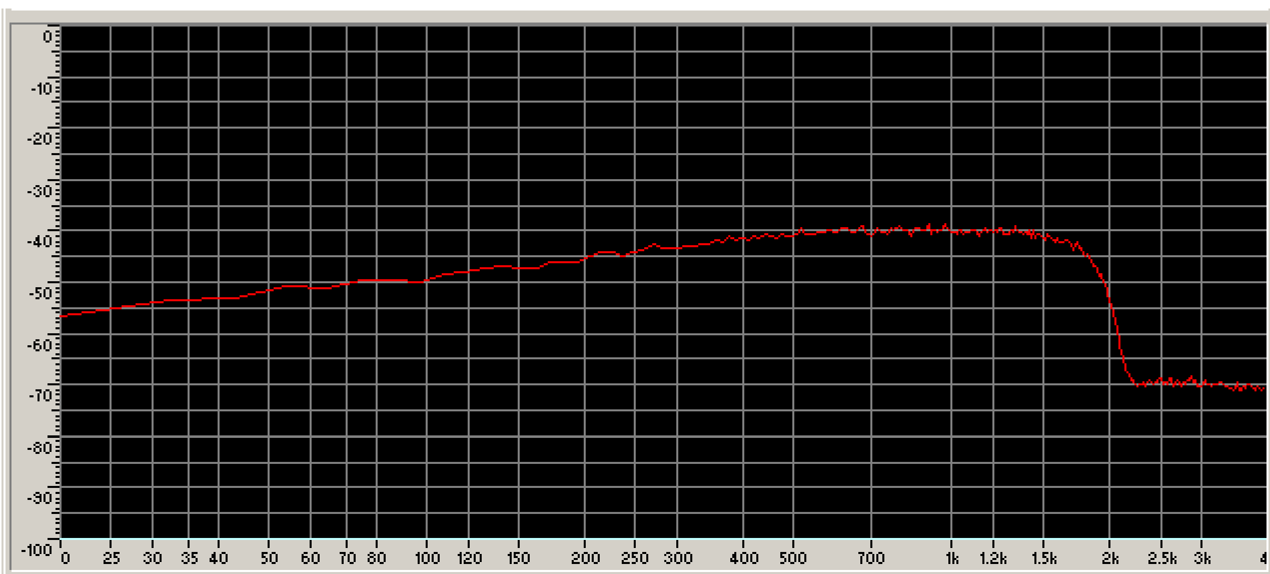


Figure 4 ~ New ceramic filter (left) has a nominal operating bandwidth of 1 kHz and original filter (right) has a 4 kHz bandwidth. The printed circuit board has solder pads for both configurations.



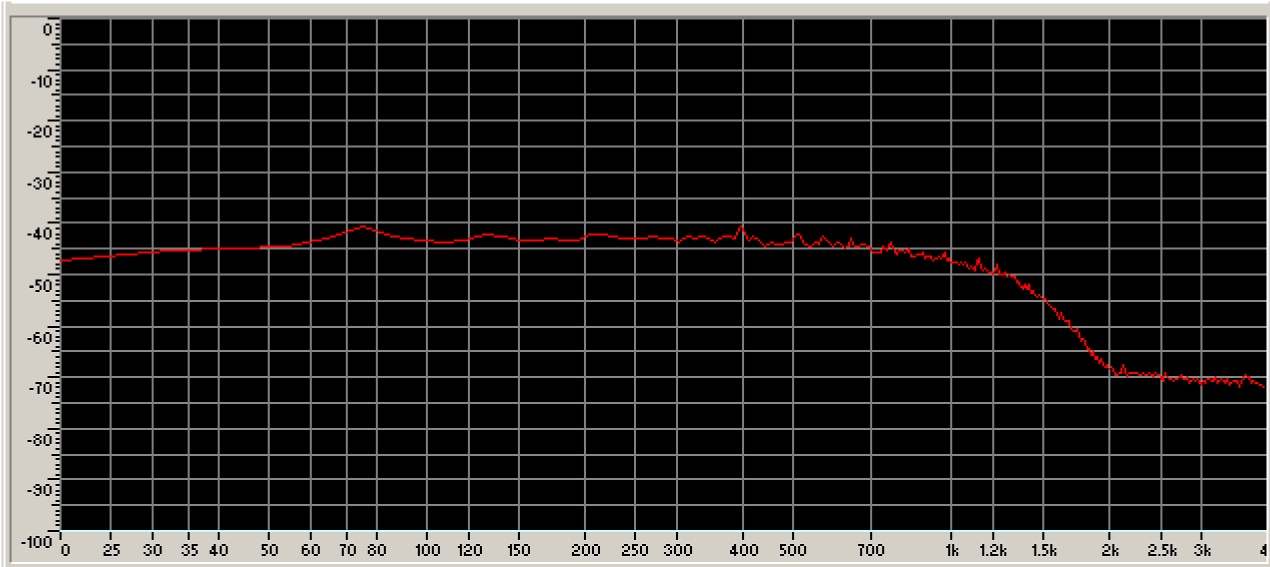


Figure 5 ~ Peak audio spectrum responses for SSB (upper) and AM (lower) modes with a 1 kHz 2nd IF filter and a noise source connected to the antenna input. The noise source level was set just high enough to provide a clear spectrum shape. The vertical scale is dB with respect to the fully loaded power of the soundcard analog-digital converter, and the horizontal scale is frequency in Hz. The slight difference between SSB and AM spectrums is due to the respective detection methods but both spectrums indicate an approximate noise bandwidth of 2 kHz.

6. PC software control

The PC software interface is called ComCAT and is supplied as a free download. For the amateur radio astronomer wishing to control the radio from a remote location, the program would be very useful. It can control all receiver functions except the audio Volume and Clarifier. The user interface is simple and easy to setup and use (figure 6). Interestingly, I noticed repetitive low-level noise on the auxiliary audio output port when the program is active.

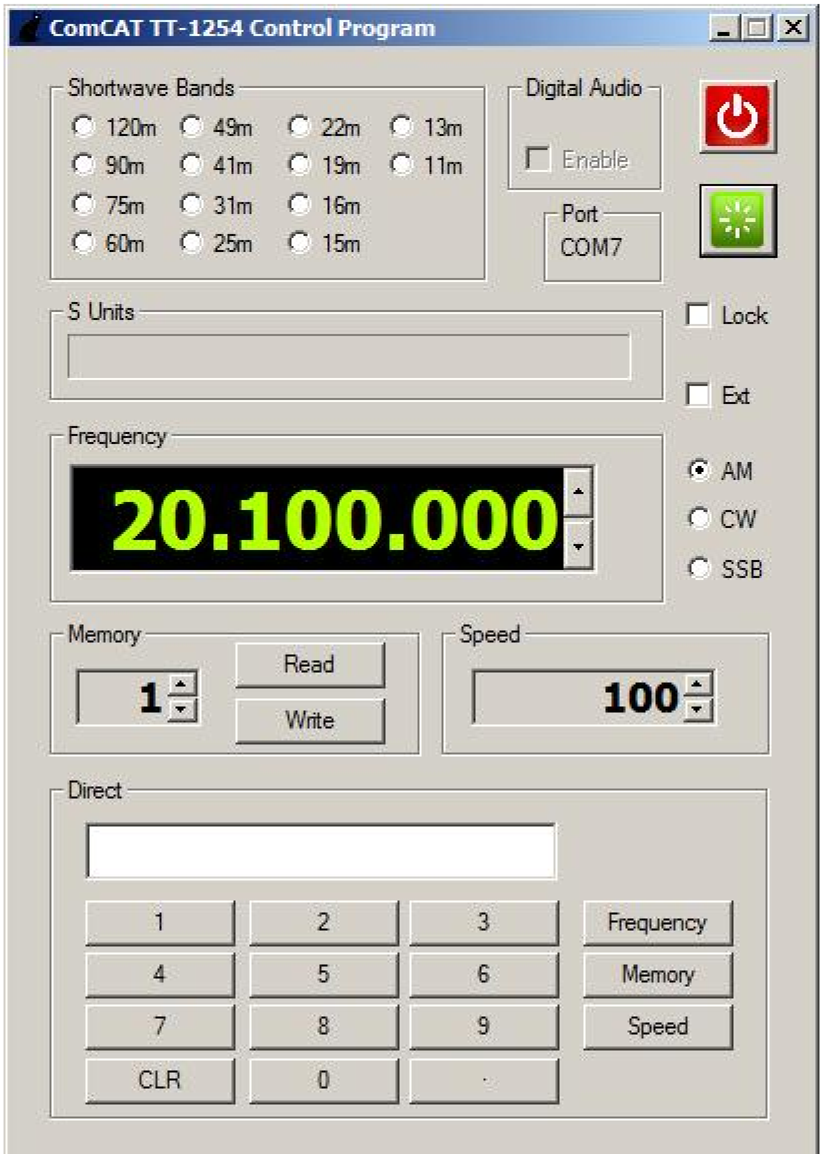


Figure 6 ~ The ComCAT program uses a serial or USB port to control the radio frequency, mode, tuning step (speed) and memories.

7. Future work

Yet another commercial upgrade will be available to replace the 7-segment LED frequency display with a high-resolution liquid crystal display (LCD) module. This new display eliminates the LEDs and LED multiplexing circuits. It also provides an RSSI bar graph display similar to that on cellphone handsets (as previously mentioned, the RSSI does not work when the AGC is turned off). As of this writing (August 2012) this upgrade is not yet available, but when it is it will be described in a future article.

8. Conclusions

The upgrade has no effect on the receiver's RF sensitivity and overload performance, but it does enhance its overall performance in terms of tuning and display noise (birdies). It required a couple hours work, which, for me, included cutting additional holes in the existing rear panel for the serial port interface, activity LEDs and auxiliary audio output jack. If a user decides to use the supplied panel and not paint it, the work would require less than 15 minutes. The installation instructions required a few minutes study because the pictures are not annotated and the new component locations are not obvious or well marked; however, the upgrade requires only two solder joints on the PCB. Once the upgrade is installed, the instructions on their use are quite simple and clear.

9. References

[Reeve] Reeve, W., Ten-Tec 1254 Receiver AGC Modifications, Radio Astronomy, December 2012.

10. Appendix – Ten-Tec 1254 Specifications (shade indicates upgrade)

Parameter	**Specification**	**Remarks**
Original purpose	Shortwave listening (SWL)	
Frequency range	100 kHz to 30 MHz	
Tuning steps	10, 100, 1000 2500, 5000, 9000, 10 000 and 100 000 Hz	
Frequency control	Microprocessor controlled frequency synthesizer	Cypress CY8C29466
Frequency tuning method	Manual or computer control	
Frequency display	7-segment LED (green)	
1st IF	45 MHz	
2nd IF	455 kHz	
Bandwidth	4 kHz at –6 dB (determined by 2nd IF filter)	1 kHz in test receiver
RF sensitivity	2.5 µV (AM), 0.5 µV (SSB) for 10 dB SNR	Not verified
RF input	Unbalanced (RCA phono jack)	Impedance not specified
Audio output	Built-in speaker, 4~8 ohm output (3.5 mm mono jack)	
Audio output power	1.5 W	
Auxiliary audio output	Line level (3.5 mm mono jack)	
Frequency memory	128 storage locations	
Computer interface	EIA-232 DCE (DB-9F)	Optional USB
Compatible software	ComCAT	Free
Power requirements	12~15 Vdc, 260 mA	Current at low audio volume
Dimensions	165 mm wide x 165 mm deep x 57 mm high	
Weight	1 kg	Not including ac adapter
PCB components	Through-hole (no SMD)	
Construction difficulty	Intermediate	