EDGES MEMO #301

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To: EDGES Group

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Subject: Study of RFI generated by EDGES-3

1] Detection of RFI with spectrum analyzer

Prior to the inclusion of the inner box the RFI from the switching electronics was easily detected with spectrum analyzer. Following the addition of the inner box based on the details given in memo #300 it was still possible to detect RFI with a spectrum analyzer with the preamp turned on, the antenna box cover removed and in a screen room.

It was even possible to locate the source using a 3" diameter loop antenna close to the inner box fan holes. Following the addition of ferrite "clamp on" cores made of Laird type 28 ferrite the levels were reduced to a level not detectable by a spectrum analyzer.

2] Measurement of RFI using the EDGES-3 spectrometer

The self generated RFI was assessed using three methods:

A) Connecting EDGES-3 antenna input to 1.5 m long wire extended outside the antenna box inside a screen room and making a comparison with the antenna box cover on and off.
B) Connecting antenna input to 1.5 m long wire which loops back into the antenna box and making a comparison with the antenna box cover on and off.
C) Putting a 3" diameter into the box connected back to the receiver input via a Coax cable.

Figure 1 shows the spectrum using method A in the Atmospheric Science Group's (ASG) screen room chamber at Millstone. This is a commercial Lindgren chamber but is located next to a computer room with signal levels -20 dBm on a handheld so the observed levels of about 300 K (when corresponds to -136 dBm for the 6 kHz spectral resolution) implies a chamber isolation of 116 dB which is within the specified isolation of the chamber. Figure 2 shows the spectrum with the antenna box cover removed. It is similar although a little different as the antenna was moved by a small amount.

Figure 3 shows the spectrum using method A in the screen room at Haystack Observatory. This screen room was built in the 1960s. It is limited to an isolation of about 98 dB based on the leakage of FM radio signals which are about -25 dBm outside the screen room. Figure 4 shows that there is little change in the spectrum when the antenna box cover is removed. Figure 3a and 4a show the spectra with the box cover on and off over the frequency range below the FM band.

To accentuate the RFI generated by the EDGES-3 electronics the spectra using method B are shown with and without box cover in Figures 5 and 6 respectively. In this case the spectrum with the box cover in place shows an enhancement, due to a resonance in the antenna cover. This resonance went away when more screws were added to secure the cover. For most of the tests the cover was only placed on the top of the box without screws to save time. Figure 7 shows the spectrum with the antenna in the box and more screws securing the cover. In addition ferrite clamp on cores were added to the connections from the inner box because it was noticed that spectrum at 80 MHz had the characteristic 300 kHz rail spacing of the Laird DC/DC converter which indicated that more filtering of the lines from the inner box was needed.

Figures 8 and 9 show the spectra with box cover off using method C before and after adding ferrites to the cables outside the inner box. Figure 9 shows that the ferrites greatly reduce if not eliminate the RFI from the DC/DC converter.

Conclusions

More tests will be needed for a full verification while it is difficult to get sufficient isolation in the Haystack screen room a trip to the relatively quiet site at West Forks ME will be made to perform similar tests with the antenna box cover on and off.

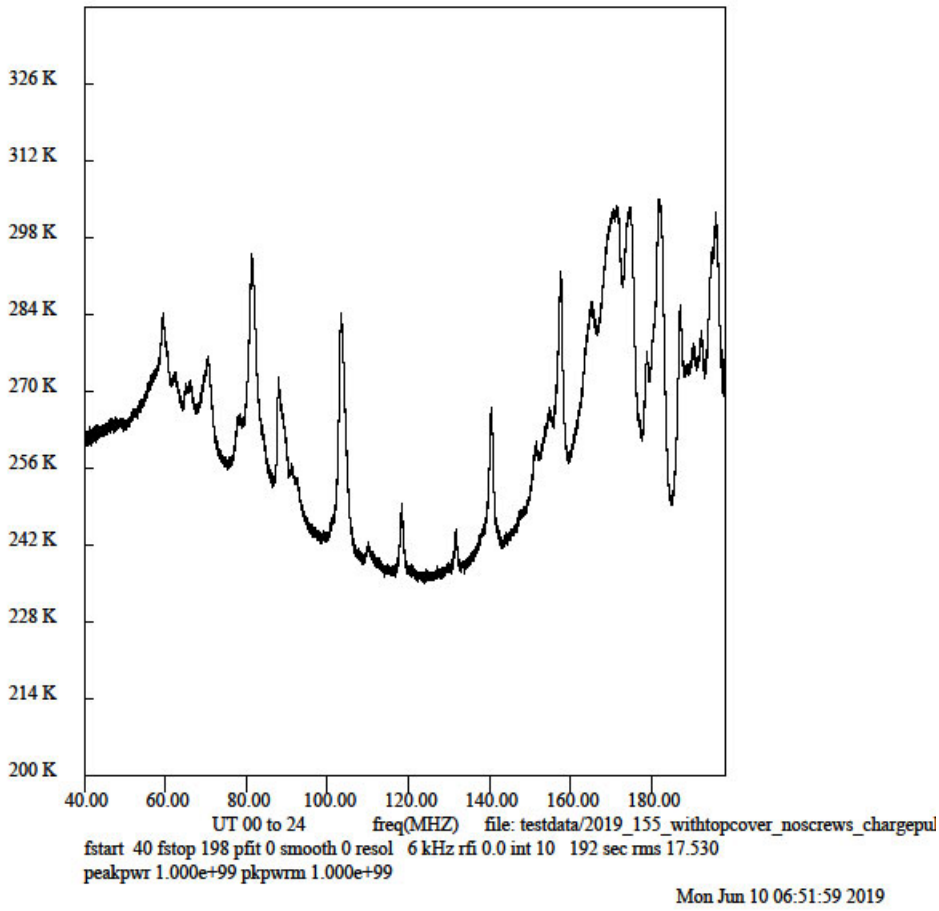

Figure 1. Spectrum of RFI in ASG.

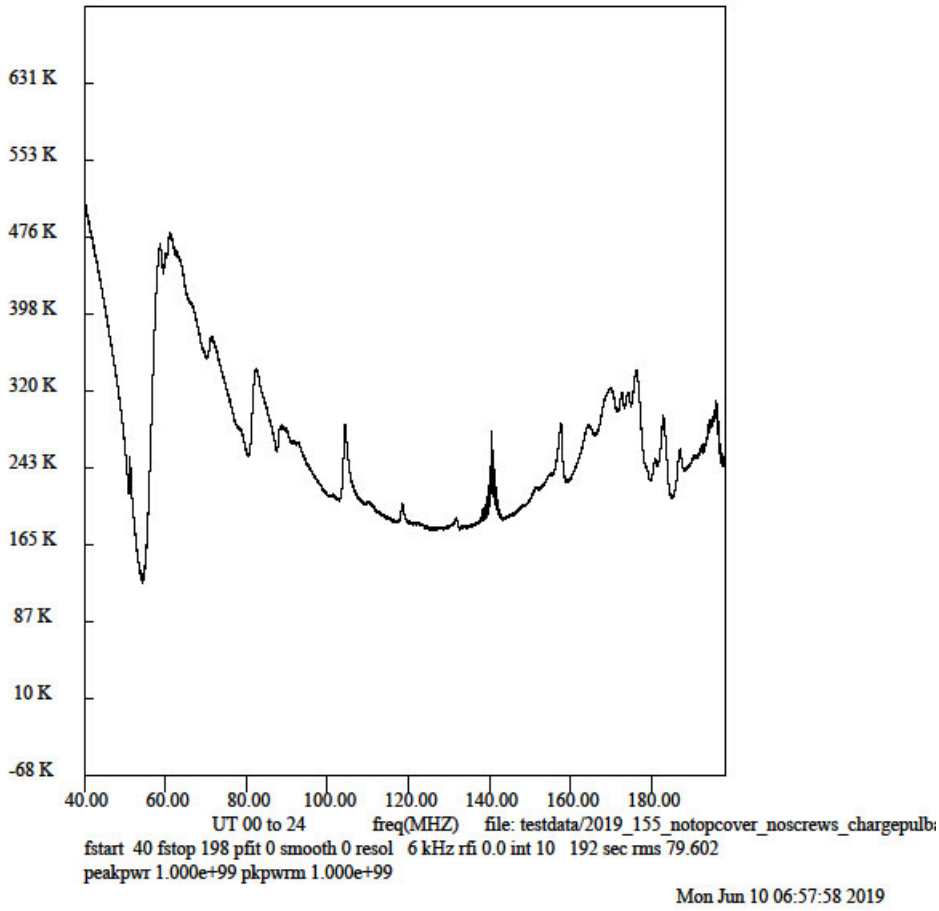

Figure 2. Spectrum with antenna box cover removed.

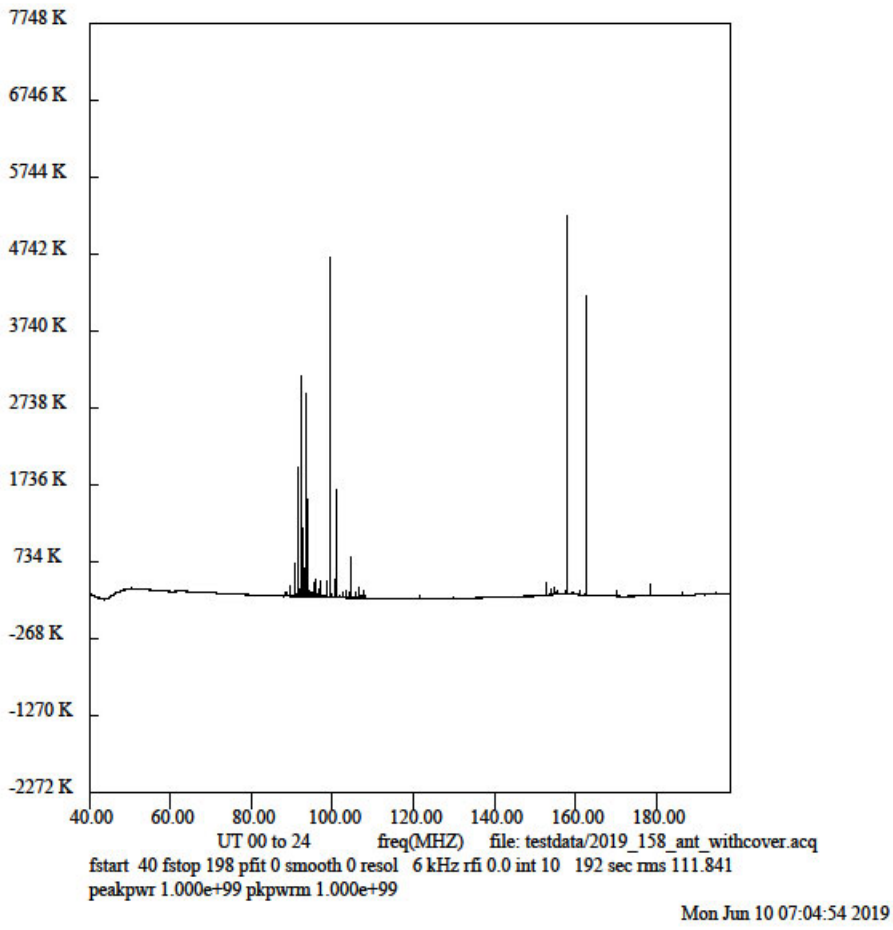

Figure 3. Spectrum in Haystack Observatory screen room.

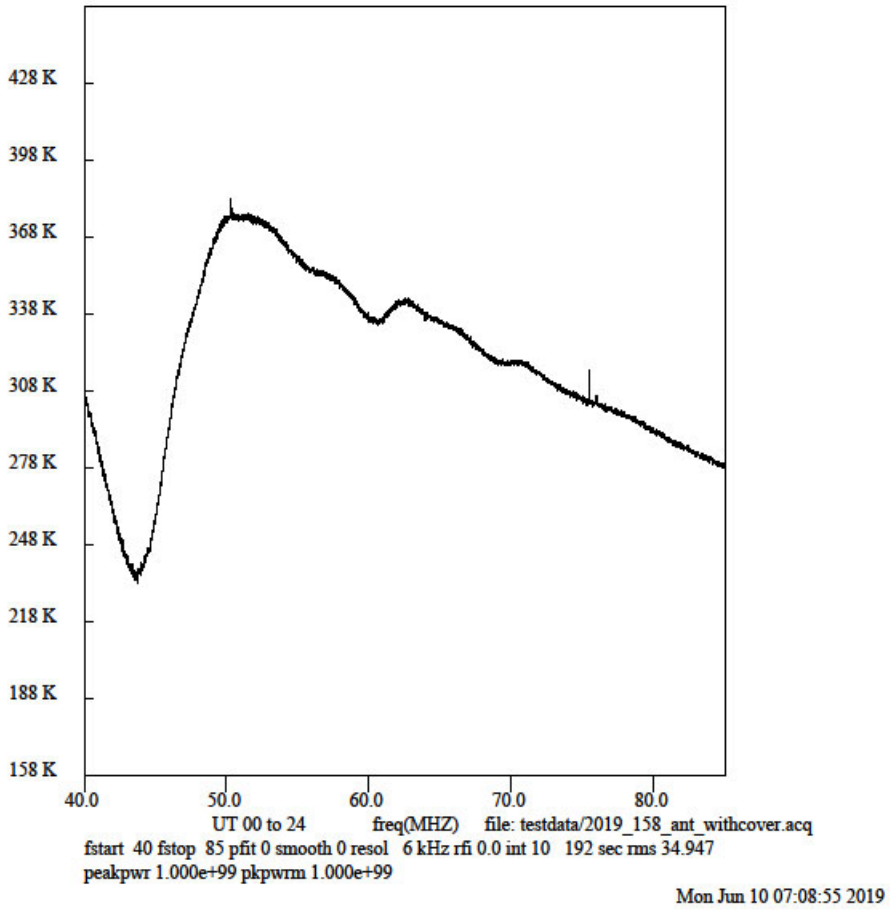

Figure 3a. Spectrum from 40-85 MHz.

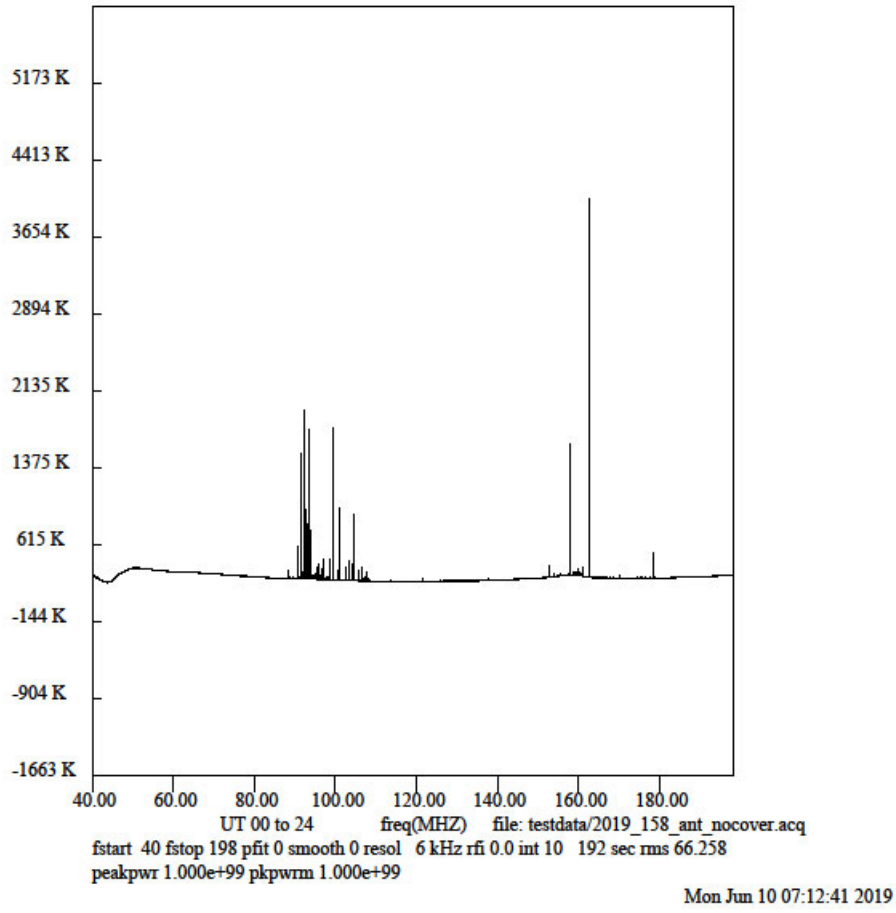

Figure 4. Spectrum with antenna box cover removed.

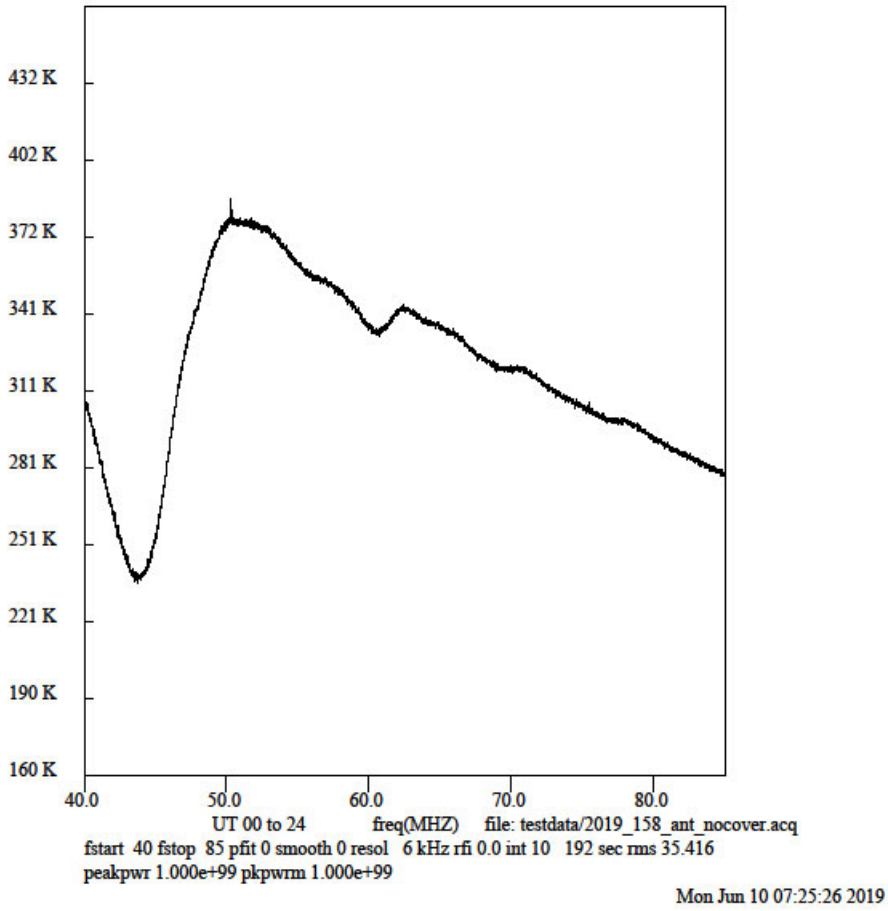

Figure 4a. Spectrum below FM band with box cover removed.

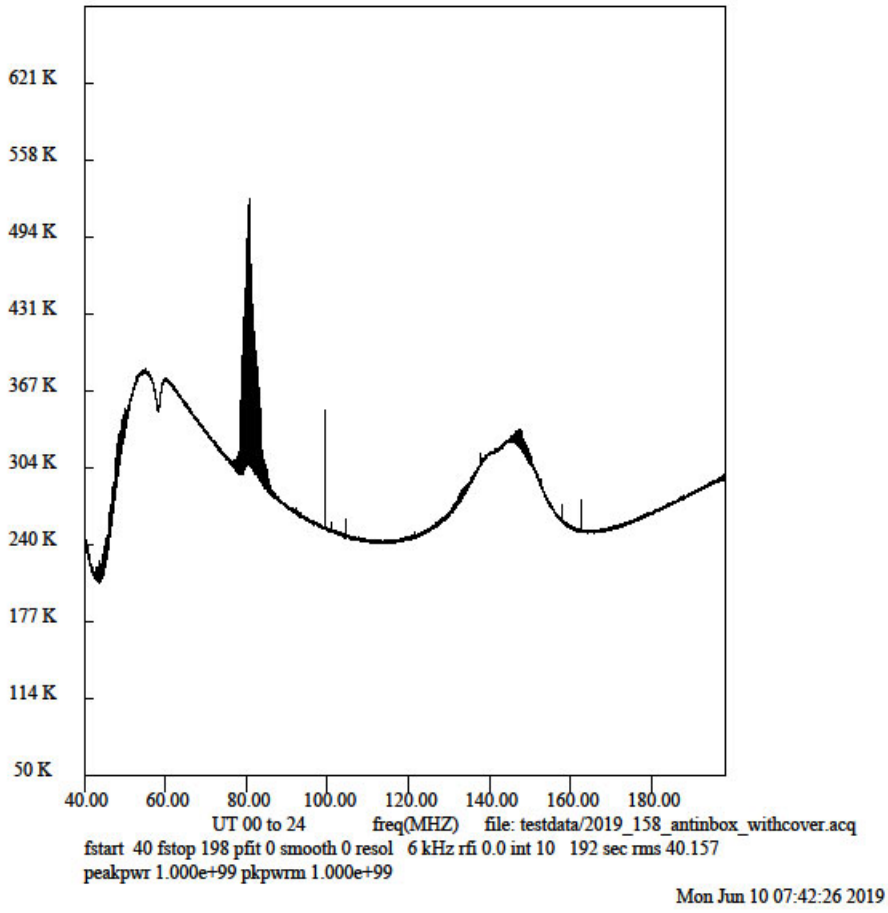

Figure 5. Spectrum with wire antenna in antenna box with box cover in place without screws.

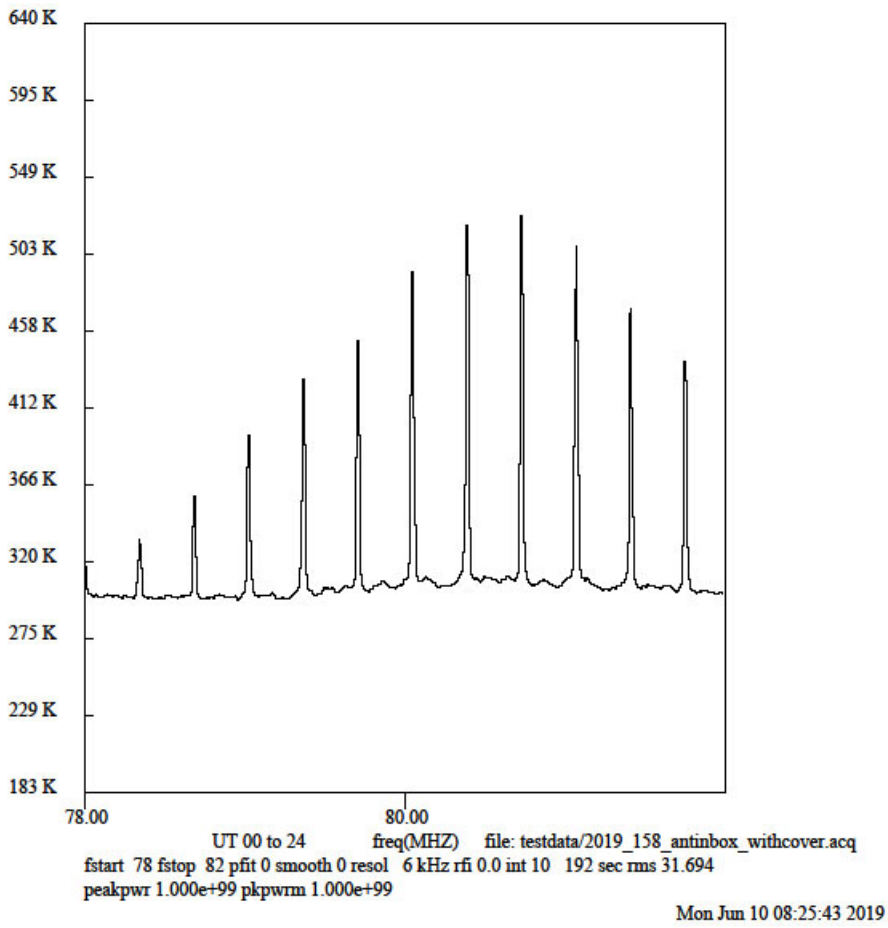

Figure 5a. Expanded spectrum shows harmonics of 300 kHz DC/DC converter switching frequency.

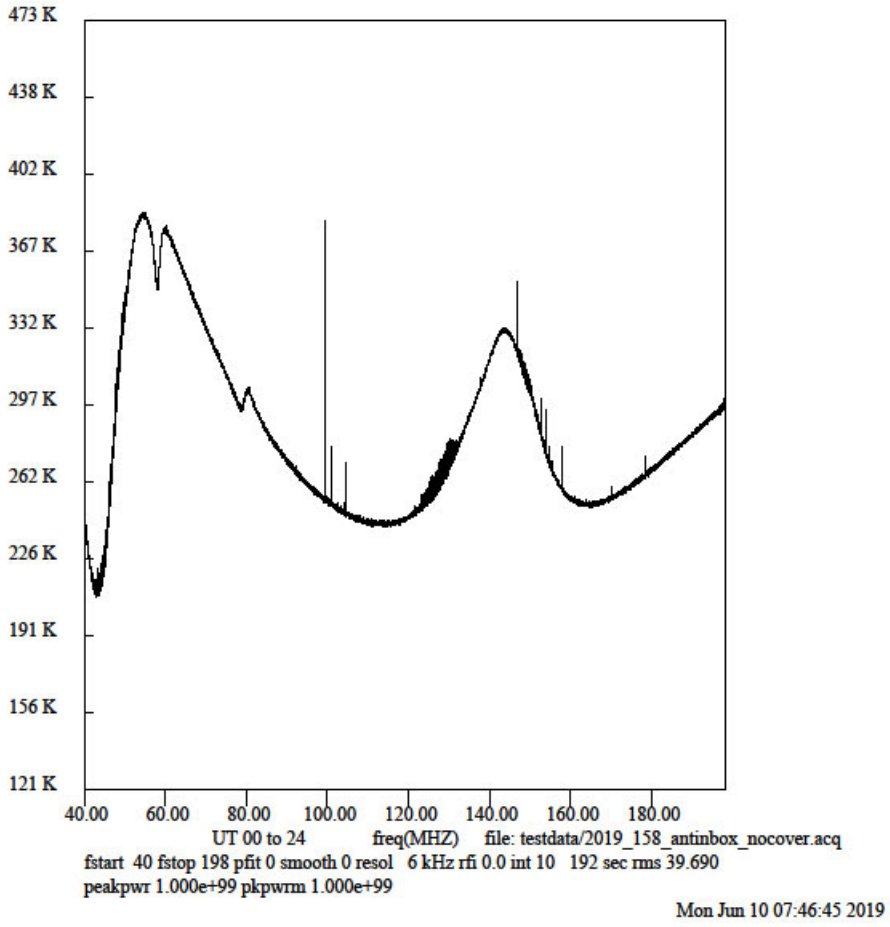

Figure 6. Spectrum without antenna box cover in place.

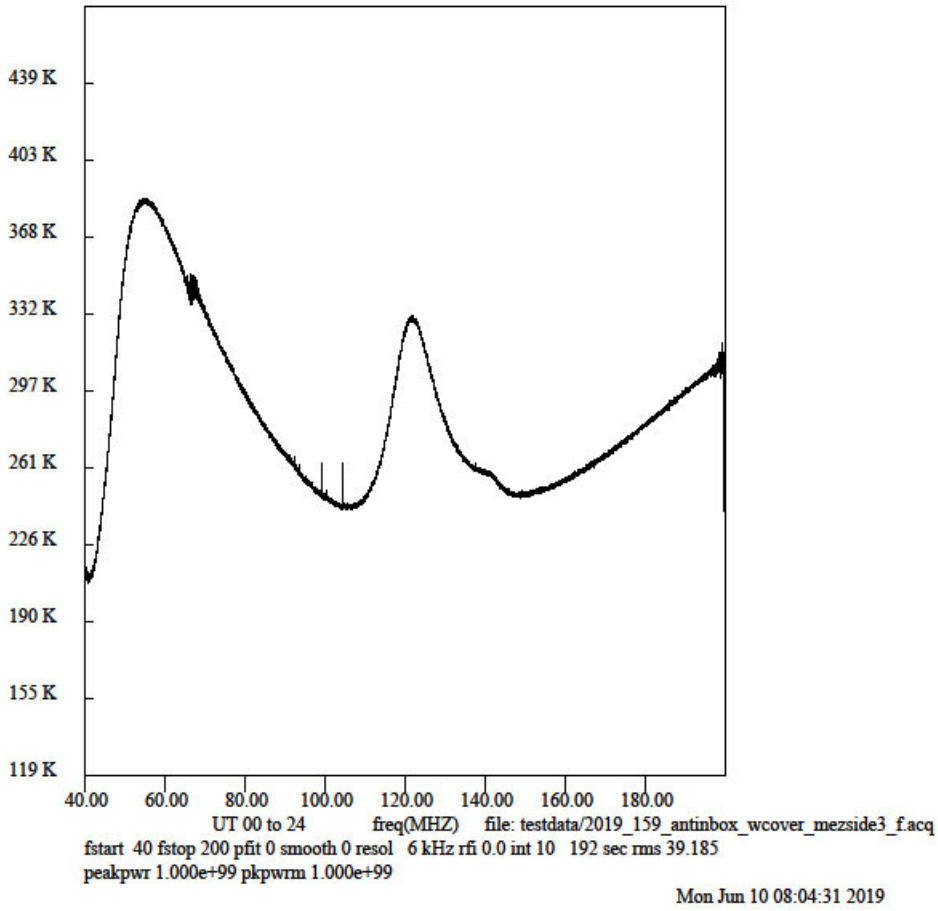

Figure 7. Spectrum with added screws to remove the resonance at 80 MHz seen in Figure 5.

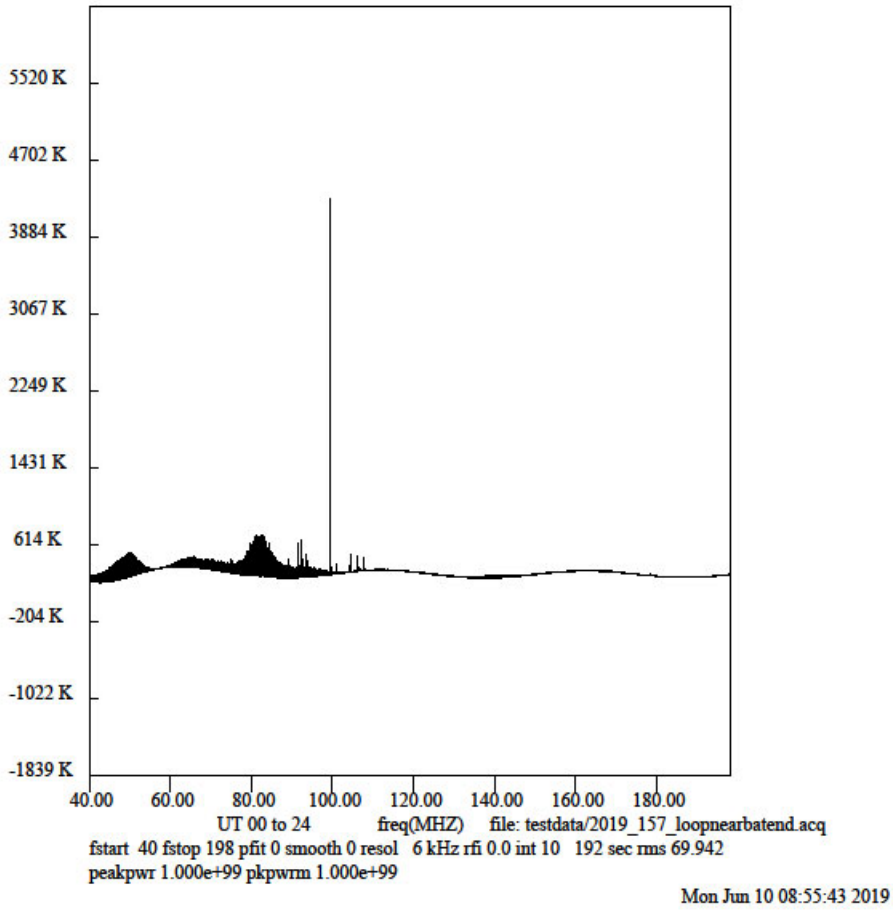

Figure 8. Spectrum using loop antenna in box before adding ferrites.

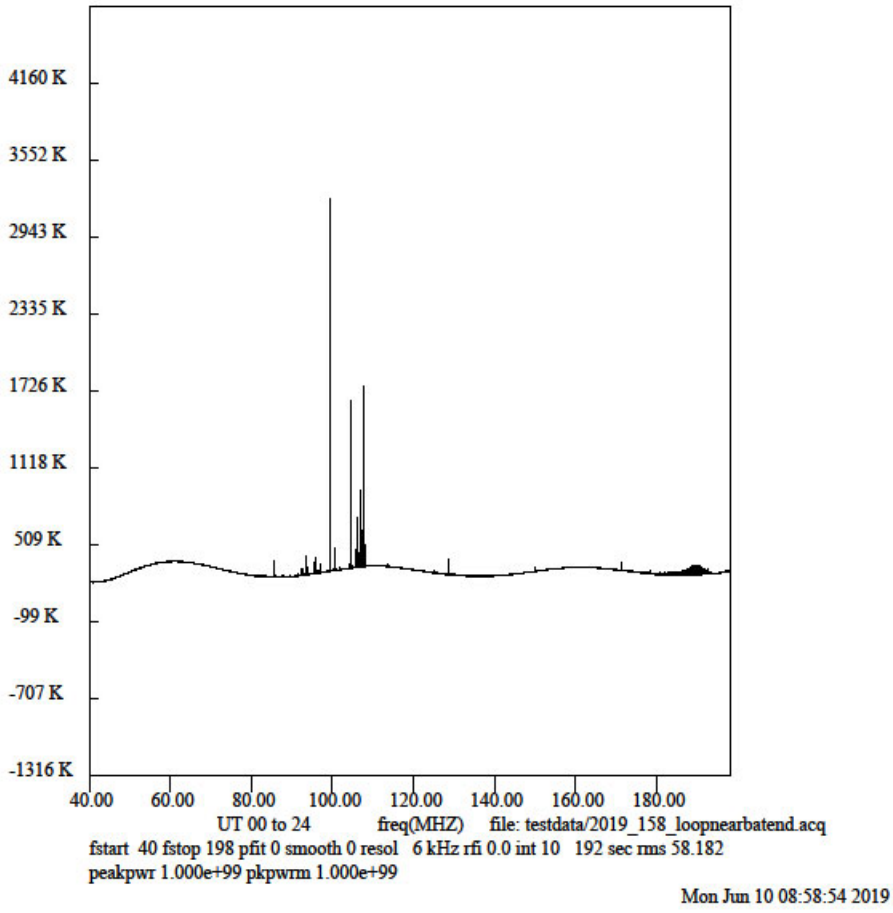

Figure 9. Spectrum using loop antenna after adding ferrites.