TELEVISION RFI ISSUES and WHAT TO DO ABOUT THEM

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I was not active in VHF ham radio between 2017 and 2019. Some medical problems limited my activity and the old VHF contest station had fallen into dis repair. When I started feeling better, I had significant antenna damage to deal with on 144 and 222 MHz. Yagis were broken in each H frame. In talking with K1OR, he commented on his chase for WAS on 222 MHz and I thought it would be a good way to utilize my 222 contest array if I could repair the broken Yagi that had been snapped in half.

At the time, Maine was a sought after state on 222 due to all the recent excitement of many stations chasing the WAS award. I got the antenna system repaired in August of 2020 and set up a sked with N9HF. We had a good meteor scatter QSO the day after the Perseids peak. When the 222 MHz WAS chasers heard that I was QRV, I was deluged with sked requests and I ran a number of horizon EME skeds over the next week or so. I was using my VHF contest multi-op contest configuration which had much bandpass filtering in front of any active receiving devices. I was immediately made aware that I was not hearing as well as those EME'ers who were calling me. I tended to work the stations right as the Moon was sitting below 1 degree where I had a significant ground gain peak.

This situation got me thinking on how I could improve my receiving capabilities. The 222 MHz station originally had a bathtub sized ICE bandpass filter installed in the shack with great out of band attenuation but with 0.75 dB insertion loss. There was no tower mounted preamp. The filter was a requirement to rid me of Channel 13 overload. Having a 1 5/8" feedline eliminated the need for a preamp at the antenna as feedline loss was under 0.5 dB. With the move to digital TV in 2009, there were all sorts of changes and my Channel 13 RFI source was de activated at some point, and moved to the low UHF channels. I took out the bath tub filter but found that I was getting overload from Channel 11 now. An indoor preamp was overloading the old DEMI transverter. The overload showed up as a perceptible increase in the background noise and amounted to several decibels increase whenever my antenna was aiming southwest. I re configured the station so that the big filter was located in front of the transverter. This helped fix the overload, but I was still under the impression that I was not hearing as well as I should be on the EME route. I was an alligator. How hard can it be to put a tower mounted preamp up at the 222 antenna? It turned out to be very difficult. Digital TV stations present a difficult problem for VHF/UHF hams. The digital signal that is seen on a spectrum analyzer will approximate random noise and those noise peaks can be almost 10 dB above what is seen on a spectrum analyzer. Combine that with the proliferation of densely packed TV stations and you can get rather large amounts of RF energy to overload even "overload proof" preamps! RF power is cumulative within the passband of your preamp. Mixing of TV signals can occur in your receiver. There is also an intermodulation issue.

In 2009, the entire USA switched from an analog TV standard to a new digital format. Before the digital change-over, UHF channels 70-83 were repurposed to cellular use. With the 2009 television edict, USA Television broadcasts are now all ATSC 8 -VSB format, an 8 level vestigial sideband mode. This is a single sideband digital signal that appears as noise across a 6 MHz spectrum. The transmitter filtering

is very stringent and there is almost no signal beyond the band limits. Data speeds are about 19.3 megabits/second. The TV signal looks like a 6 MHz wide rectangle of random noise when viewed on a spectrum analyzer. After the digital switch, there were several large re locations of TV frequencies. The latest, in 2020 affected about 1000 TV stations nationwide. This was again, a result of Federal auctioning of the higher UHF TV channels to cellular telephone companies. The first “re-pack” occurred in the original 2009 digital turn over when channels 52 to 69 were turned over to cellular use. In 2016, there was an FCC auction of TV spectrum amounting to 19.8 billion dollars and where UHF TV stations could cease operation and receive money or get switched to low or high VHF channels . All very confusing, but by 2019/2020, all UHF TV stations occupying the higher channels were forced to move to channels 14 thru 36. The end result is that in most areas here in the northeast, there is a TV station on just about every channel between 14 and 36. That is 470-608 MHz. Power levels are quite high. For example, at my location in Southern Maine, there are nine stations blasting out between 900 and 1000 kilowatts. There are five more transmitting over 100 KW erp.

With my overload situation on 222 MHz I dragged my old HP spectrum analyzer up to the shack and plugged it into my 222 MHz antenna. The biggest signal I located was Channel 11 at 198-204 MHz and it was at about -28 dBm on the scope screen. Remember that peak noise can be much higher. Any gain in your preamplifier that occurs at 204 MHz will increase this signal and overload the next stage, or such a signal level can overload the preamp itself, if there is not enough front end selectivity or dynamic range.

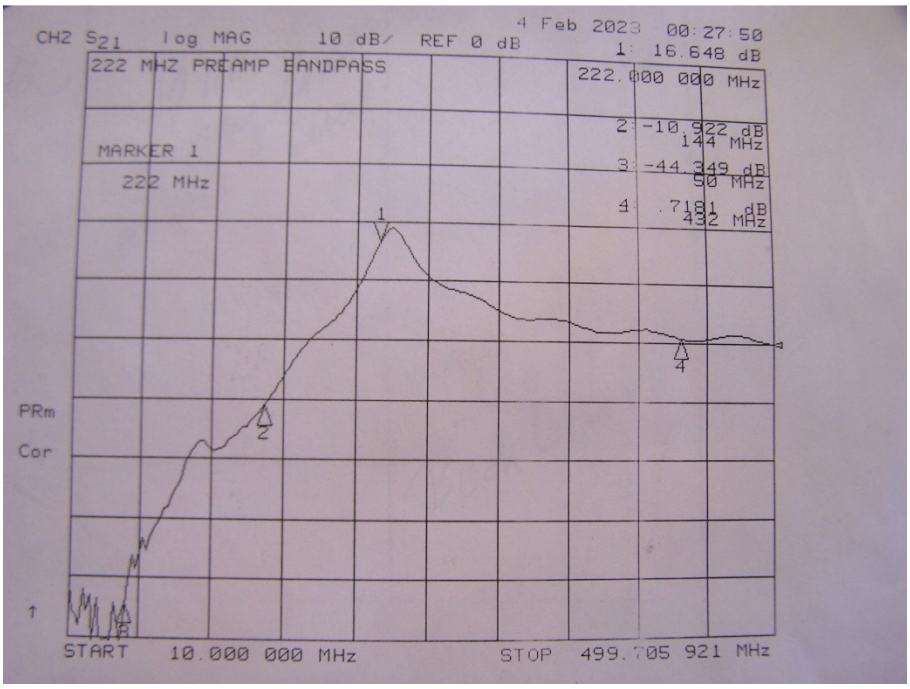

FIGURE 1

This is a typical amateur preamp with a silver plated input coil and a high quality piston trimmer coupling cap on 222 MHz. It has been adjusted for best noise figure.The middle graticule line is 0 dB gain and you can see MARKER 2 is 144 MHz and is only 11 dB down. Channel 11 at 204 MHz has about

12 dB of gain. The output of the preamp would be almost -6 dBm on noise peaks. This is a very strong signal and can easily overload a preamp or second stage transverter input. Then note that a 470 MHz signal will also go through the preamp at about unity gain as well.

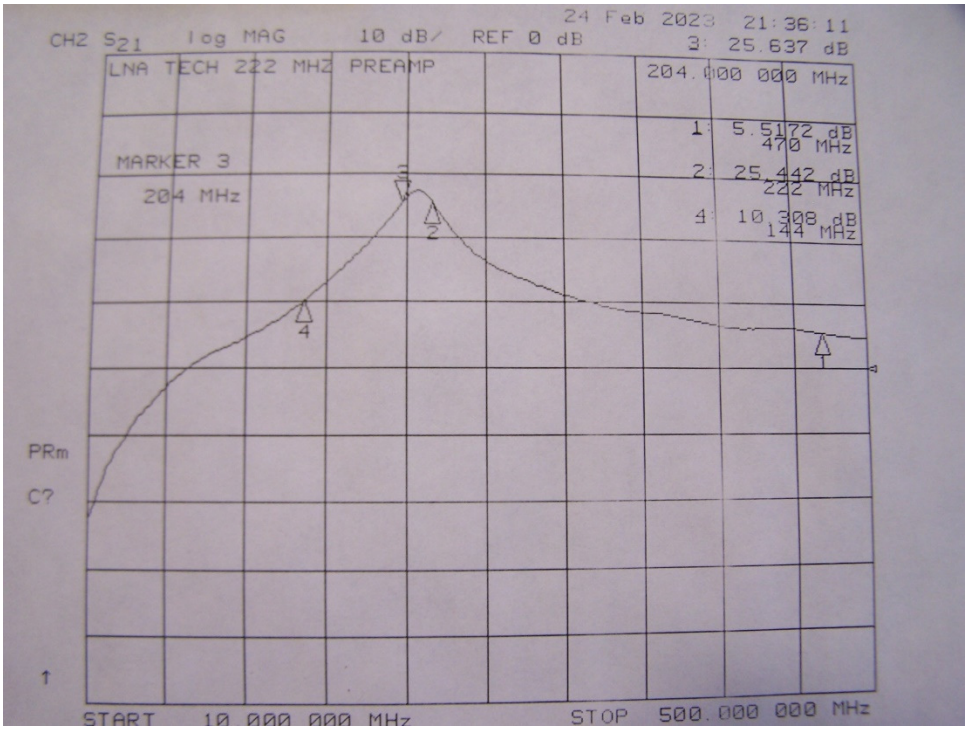

FIGURE 2.

Here is another 222 MHz preamp, originally sold by LNA Technologies as a very low noise and selective design that had a cavity input section made out of a quarter wave copper pipe filter. When tuned for best NF, the results are not good and you can see that the gain is very high and selectivity is not much different from the homebrew silver plated coil design. In fact it is noticeably worse on the low side of resonance. Marker 2 is at the high end of Channel 11 and gain is 25.6 dB! There is still 10 dB of gain at 144 MHz as compared to -11 dB loss on preamp number one! 470 MHz shows 5.5 dB gain as well. Clearly, additional selectivity is needed. The high gain is not helping anything either.

I tried tower mounting some preamps, but the few types of modern high dynamic range amplifiers that I tried could not totally eliminate overload from the Channel 11 station. The background noise would rise by about 5 dB when the 222 MHz antenna was aiming within about +/- 20 degrees of the Channel 11 azimuth at 219 degrees. If you were not looking at the noise floor, you would not know that you were being overloaded. And here lies the problem. If I am getting overload in Maine, and W1GHZ is being overloaded in northern Vermont, there is a good chance that you will get overloaded if you are closer to a metropolitan area. To make matters worse, the effect of overload resembles the constant background

noise that we always hear. Your only tip-off is to monitor background noise levels as you rotate your antenna. Bear in mind that your antenna pattern might be different at the television frequency. Frequencies well above your yagi's range will be better copied off the rear portion of the yagi, so be aware of that.

The solution to the dilemma might require two filters, one before and another after the preamp to protect the transverter. You might find that your preamp works well, but it causes overload in the transverter as a result of the added gain up front. Downeast Microwave makes a great preamp that has a SAW filter on the output that is very sharp and can protect the transverter quite well.

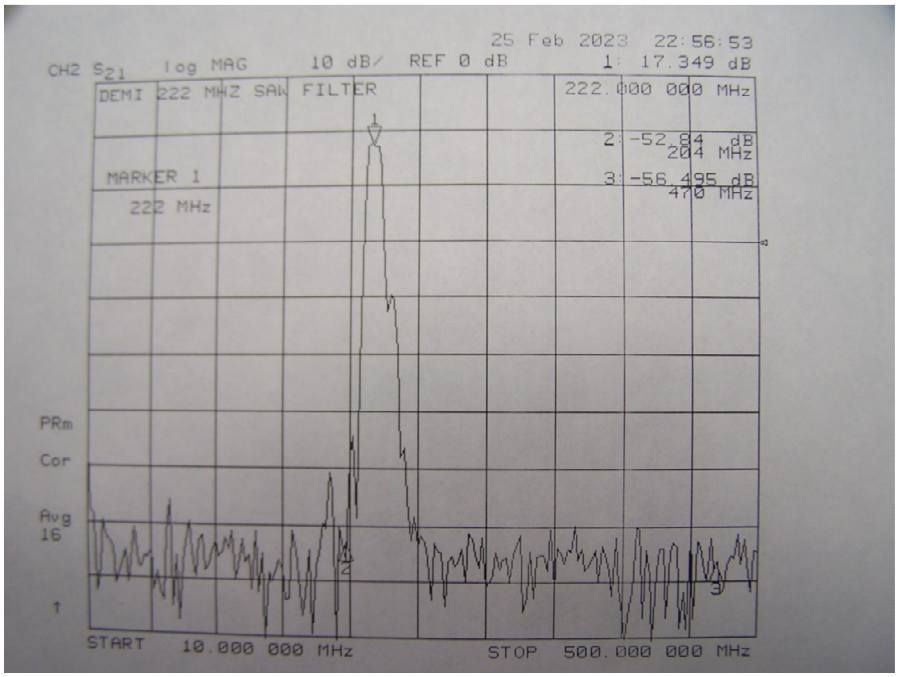

FIGURE 3.

This plot shows the effect of the SAW filter on the passband. Note that the gain is 17 dB at 222 MHz and loss is over 50 dB at 204 MHz and 470 MHz. The bandwidth of the preamp itself is similar to the silver plated coil design of FIGURE 1. A strong TV signal can overload the high dynamic range preamp and you are stuck! In my case I still had some slight overload with this preamp combination. I tried all sorts of filter tricks after the preamp, but could not eliminate the overload. My tower mounted preamp was not able to handle the -28 dBm measured Channel 11 signal plus all the other big signals in the passband. Having that overload appear only at 219 degrees was a killer for me, as 219 degrees is the heading for New York City from here! I ended up using a custom made WD5AGO cavity filter preamp with a transmitting FET as the active device. It has enough input selectivity and any ill effects are now not visible when it is in line. P1 is at -5 dBm, and it has about 5 dB of loss at 204 MHz. My 222 MHz system is now quite capable, and I routinely see a few dB of improvement when I elevate above the warm 290 degree K horizon and look at cold outer space. It is also interesting that I can switch the

tower mounted preamp in and out to compare an indoor preamp with the tower mounted one. Even with a 165 ft run of 1 5/8" feedline and 0.45 dB loss, there is a slight improvement with the tower mounted preamp with signals located on the horizon. I estimate about 2 dB. S/N ratio improvement. When the antenna is elevated the difference is quite large. I see about 5.3 dB of Sun noise on 222 MHz.

On the 432 MHz band, I suffered the same problem. My tower mounted preamp that had worked well for years now was suffering from all sorts of excess noise in many directions. The 2020 FCC TV re-packing had caused me problems. A check with the spectrum analyzer showed a disturbing sight. At first glance I thought I was seeing CATV leakage from a defective coax line nearby. There was a big strong signal on every UHF channel. Upon closer examination, it turned out that I was seeing the lower UHF broadcast channels and all of them were in use! There were no guard channels as in times past during the analog era. Those digital noise generators were stacked up and looked like a solid wall of noise peaking at about the -30 to-25 dBm level for the strongest ones on my 432 antenna. After the last FCC re-packing in 2019/2020, the bottom of the UHF band has become glutted with high power transmitters on every channel! All those 1000 kilowatt stations can kill just about any preamp. The biggest offender for me was the old Channel 13 transmitter that has now moved to UHF channel 15. It is about 40 miles away but line of sight to my 432 antenna. Having multiple TV transmitter signals brings up the spectre of notable intermodulation products as well, and that complicates the situation.

Intermod is a result of non linear mixing of the frequencies: 2F1-F2 and 2F2-F1. You can see that there can be combinations of 6 MHz wide UHF signals that will put intermod products in or close to the 432 ham band. The combination of a very strong CH 14 or 15 station with a CH 21 or 23 station will put the distortion products within the 432 band. They will appear as an increase in your noise floor. Other combinations of higher channels such as CH 19 and CH 31 can also produce intermod at 432. Small amounts of intermod distortion can raise the noise floor a few decibels. The only solution is a good filter in front of the preamp. You must remove the mixing signals! I used a homebrew re entrant cavity built from a 4" chunk of copper pipe about 6 inches high. It provides adequate filtering and only about 0.2 dB insertion loss in front of the preamp. It has been installed on the tower in a wx proof box. The filter has removed all of the overload symptoms on 432 MHz. I can now make EME contacts on 432 when on the horizon with the filter in place, so I think the system noise figure has not been seriously degraded. I never got to measure the two units together in the shop, but I feel that my hearing on 432 is adequate.

To figure out what towers are located in your vicinity, you can check for information at:
https://otadtv.com/tvtower/index.html
https://www.rabbitears.info
These websites will list TV transmitters in your area. I have found that the data is not 100% correct, as channels are often in flux, but it will give you an idea of what stations are there and how much power they are running. All you need to do is enter your location and it will give you the data for your area. You can then compile a list of strong stations, and then plan for a solution should you have receiving issues on any VHF band.

In summary, be aware that our receiving situation on the VHF bands can change at any time. Between home installed digital power supplies, lighting, digital TVs etc. It is hard to maintain a quiet RF environment. Add to that problem, the apparent constant change in digital TV station allocations and you have a constant threat to your weak signal detection process. Always be aware that digital TV signals now sound the same as background noise, and monitoring your background noise level is imperative to maintain an effective station. Your tools to correct any overload from strong television stations include proper gain distribution and robust filtering before any active devices. For regular VHF contacts on the horizon, a 0.5 dB loss filter in front of any preamp is a good solution. For EME and tropo contacts on the same system, achieving the lowest system noise is a bit more difficult. Any improvements that you make in either case will pay off handsomely with increased hearing capability.