

PROBLEM: Receiver noise raises when the repeater antenna is connected !

Here are the e-mail exchanges I had with Carl (name fictive) regarding this problem. Many areas for solutions have been explored. I feel it might help other people that have similar problems. Jacques VE2AZX ve2azx.net

My home-brew **VHF duplexer** (Single Loop Series Resonant Notch-Bandpass, about 90dB isolation, based on Aluminium tubes) works well if connected to a dummy load. Squelch threshold and noise level are independent from TX on or off - as it should be.

If I attach my own antenna (below the roof, SWR 1:1) to it, I have to raise the squelch threshold. That's ok, because the antenna is picking up noise. But when I turn TX on, I have to raise the squelch threshold again significantly. And there is a lot of noise and distortion on weak signals, which disappear when I turn off TX.

Is this a problem with my antenna system, or do I still have a problem in the duplexer? What do you think?

Thanks a lot! Carl.

Here are some ideas that come to my mind:

Your antenna may have a small amount of "non linearity" in the form of bad contacts that cause some rectification of the transmitted RF. Also nearby conductors, not being properly bonded together (such a rain gutter), may give the same effect.

This could generate spurious signals that enter into the RX and force you to increase the squelch level.

Can you try another antenna ? Perhaps use your mobile antenna mounted on the car.

If you increase the antenna to receiver distance, and / or change its location (using a longer coax): does it improve the RX sensitivity ?

The transmitted RF could get into the RX and disturb reception, if the RX does not have enough shielding. Moving the antenna away from the RX might improve things.

Check the levels of the TX signal present at the RX port, first with a dummy load and then with the antenna. Do they change more than a few dB's ?

Jacques VE2AZX

Thanks a lot for your feedback. I also thought about some conductive parts on my attic producing some reflections, therefore I think your suggestion using the antenna on my car was very good. I used different cables and a magnet foot aerial, but unfortunately the problem shows up there, too.

By the way, my shack (and therefore the repeater and the duplexer) are in the cellar, so there are two floors between antenna and duplexer.

I also checked the levels of the TX signal present at the RX port, as suggested. It turned out that the level of the main signal at the TX frequency is independently from what is attached. It is about -66 dBm.

I then checked the noise at the RX frequency, first without TX. The dummy load has got a better noise floor (of course) of about -127,4 dBm. Attaching my station antenna rises the floor up to -126,0 dBm. That's ok so far, the antenna is picking up some noise.

But turning on TX on shows the problem: On the dummy load the noise goes up from -127,4 dBm to -127,0 dbm. That's ok I think. On the antenna the noise goes up from -126,0 dBm to -122,5 dbm, about 3,5 dB! (all measurements where done by using the "average" function (100 samples) of the analyzer, a Rigol DSA 815 TR).

I also attached a radio to the RX port of the duplexer to see some S values. It turned out that a signal with S7 still gets hearable noise from the TX. It is a kind of crackle. As stronger the signal gets, as rarer the "peaks" can be heard.

So, with all tests so far, I still don't know where the noise comes from. Is it somehow the antenna system, as the dummy load test suggests? Or is it the duplexer, as the test with my car suggests?

One small oddity I found: My notches are not as deep as the literature states. I got about 25 dB on the RX side and 27 dB on the TX side. The overall performance of the duplexer seems to be ok, about 100 dB isolation at the TX side (RX freq. rejected) and 85 dB isolation at the RX side (TX freq. rejected).

Dear Carl,

Here are my comments:

- The RX port feedthru from the TX is excellent at - 66 dBm.
- Is there any (strong) transmitters nearby that could induce strong signals at your RX frequency coming from intermodulation ?
You could use your spectrum analyzer to check that.
- The measured sensitivity of -122.5 dBm is still good, but it's worth investigating why you are loosing 3.5 dB.

Here are some links to the repeater-builder website that may be helpful. You might find more pages of interest.

Help!! I have a crackling noise in my repeater

<http://www.repeater-builder.com/antenna/cracking.html>

HELIAX Coaxial Cable for Low Intermodulation Generation

<http://www.repeater-builder.com/antenna/andrew/andrew-braid-over-foil-imd.pdf>

Dear Jacques,

well, the problem disappears if I turn off the transmitter. Therefore I don't think strong transmitters are a problem (and I don't have them in my cellar ...).

The 3.5 dB indeed wouldn't probably be a real problem, if it would be a fixed signal. But I get some random crackle with average (!) 3,5 dB , and that really disturbs the FM signal.

My suspicion is, that the connection between the lid and the tube of each cavity is not good enough. Please find attached an image of my homebrew duplexer, lids and tubes are only screwed together. So a small portion of the signal from the antenna can get back into the RX part. The dummy load doesn't radiate anything, and therefore the problem disappears when using one.

If I use a screwdriver and tap on the place where lid and tube are screwed together, I can hear a loud crackle in the RX if the TX is running. If I put some Aluminium foil onto the duplexer, the RX completely get's mad ...

I already ordered Aluminium conduct paste to improve the connection. If that doesn't help, welding lid and tube together should solve the problem. Unfortunately I will not be able to open the cavities any more then, for example if something goes wrong with the tuning rod ...

Carl

Dear Carl,

I have seen an intermod problem where two outside transmitters would mix in the repeater TX PA stage (or mix in a close by TX) with the TX frequency to give an intermod frequency right on the RX frequency. Of course this occurred only when the two outside TX were on at the same time. Something to keep in mind.

As you say, the crackle may come from improper/insecure/oxydized contacts. The contacts between the lid and the tube of each cavity are probably the most critical, since the current density is highest at the junction. Also the oxyde at the aluminium contacting surfaces probably makes things worse. I would carefully sand the mating surfaces before applying the conductive grease. Can you try aluminium tape to cover the lid to cylinder joints to add more shielding ?

Jacques VE2AZX

Dear Jacques,

thanks for your input. Aluminium is very reactive and oxidates during a few seconds, so every piece of aluminium you see is "rusted". The aluminium conduct paste simply destroys the (non-conducting) oxide film permanently, but is not conducting itself. The paste I ordered is called "Wago 249-130", in case you want to get some more infos about it.

You even can solder aluminium by using motor oil - scrape off the oxide film, the oil prevents the re-oxidation and you can solder with normal tin solder. The paste hasn't arrived yet, I'll keep you up to date how things are going on. I'll give the aluminium tape a try this weekend!

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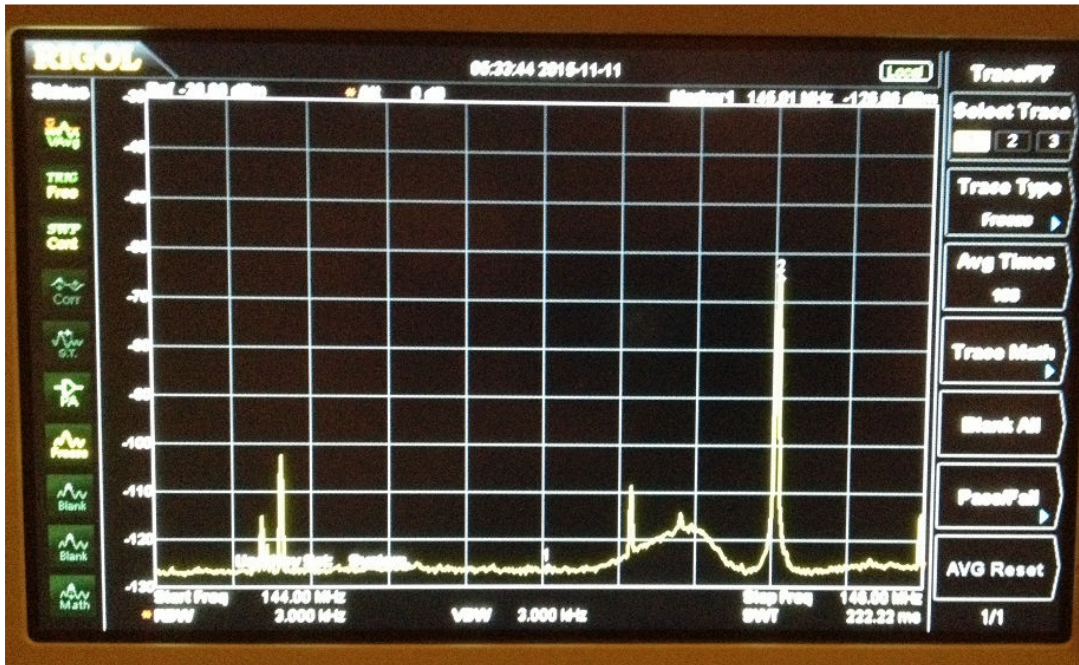
to keep you up to date:

- Neither using the paste nor the tape did help anything.
- Welding lid and tube together also did not help anything. I did that for three of the six cans, so that I'm still able to open three cans now.

I must admit, that I'm a bit clueless now. I played around with the spectrum analyser to track down the problem a bit. And I did some screen shots for you:

DummyLoad-TXON.JPG:

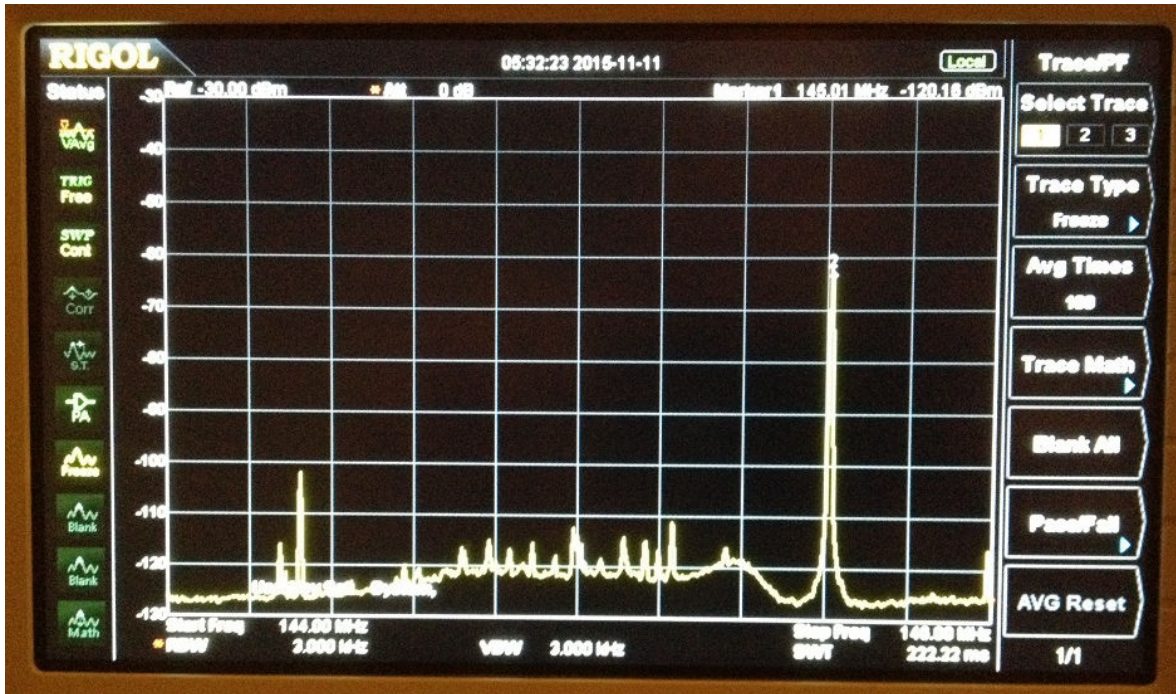
If I use a dummy load, everything is fine. You see the TX signal on the right (at "Marker2", 145.6125 MHz), well attenuated to about -64 dBm. Next to the left, you see part of the phase noise of the TX signal, which gets well attenuated when it comes to the RX frequency (at "Marker1", 145.0125 MHz). (Center Frequency is 145.0000 MHz)



So far, so good.

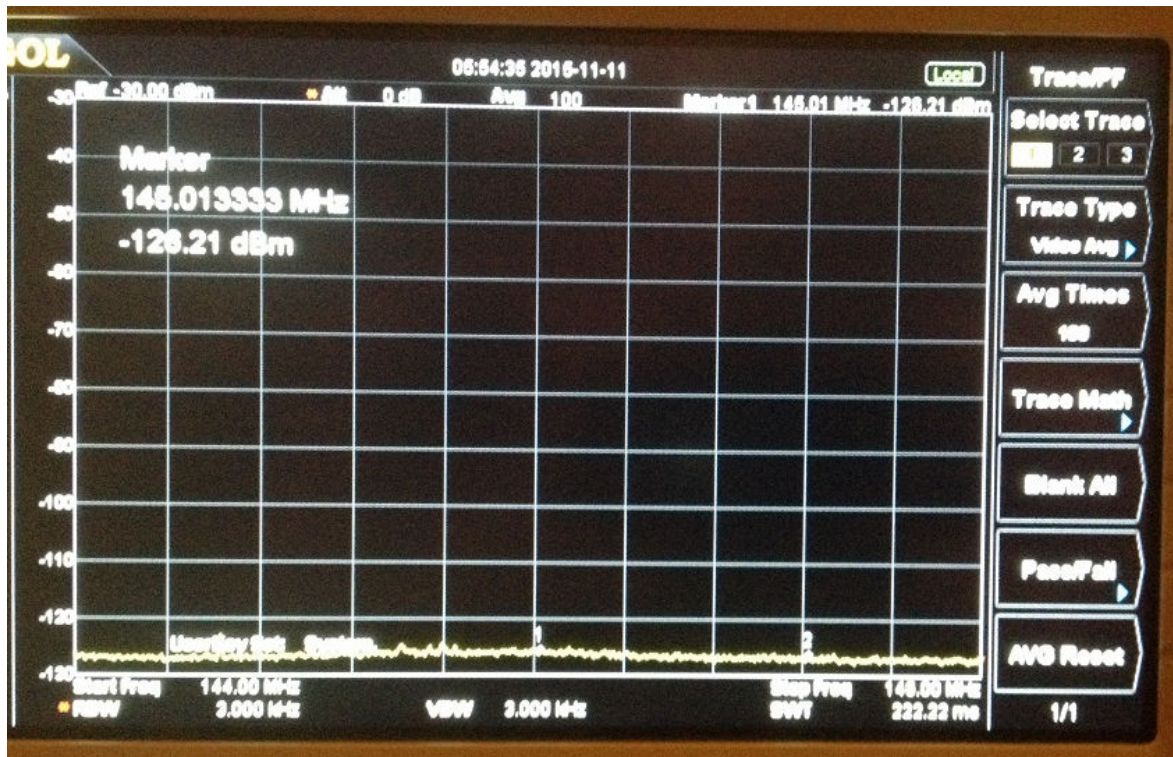
Antenna-TXON.JPG:

If I then attach the antenna, things get worse. The noise floor rises from 144.4000 to about 145.2500, and you see some peaks. These peaks are always at the same frequency. But they are not carriers, they are kind of noise accumulations.



Now you will say, there is some noise at your attic (where the antenna is mounted). But please look at:

Antenna-TXOFF.JPG: Turning off the TX signal completely removes the noise floor and also the fixed peaks



Where does this effect come from? Is "reflections at the attic" the answer? Do you have any ideas or suggestions I could try out now?

Carl

Dear Carl,

Thank you for the photos.

Here are some ideas:

1- Notch-bandpass duplexers do not provide much selectivity far away from the TX/RX frequencies.

A bandpass (dual loop) cavity at the TX output will restrict the phase noise and prevent outside noise picked up by the antenna from generating intermod at the TX PA output stage. I would adjust the loop coupling for about 15 dB attenuation 600 KHz away from its center frequency.

2- A bandpass cavity at the RX might help, although the RX normally has its own filtering. You may try a bandpass cavity only on the RX port or on both TX and RX ports.

3- Decrease the TX power by 3 dB or so. What happens to the noise at the RX, as measured by the spectrum analyzer ?

Does it decrease by 3 dB, or more, like 6 or 18 dB ?

If it decreases by more than 3 dB, this indicates that a non linear process is going on. If it's easier, you may increase the power by 3 dB...

4- Try another transmitter and see if the noise spectrum is the same. (at the RX port like you did)

Well... these are my Sunday morning ideas.

Jacques

Dear Jacques,

Unfortunately I currently don't have a dual loop cavity available. I would have to build one first, so suggestion 1 and 2 are a bit difficult to carry out for me.

For suggestion 3 I used my handheld transceiver, which has three power settings (0.05W, 0.5W and 5W). Here are the results (antenna in the same room, not at the attic):

0.05W (17 dBm) : 112.24 dBm

0.5W (27 dBm) : 106.57 dBm

5W (37 dBm) : 103.17 dBm

Surprisingly decreasing the TX power by about 10 dB decreases the noise only about less than 3 dB. Decreasing the power by 10 dB again the noise decreases by about less than 6 dB. I used the average function of the SA with 100 samples again to get the results.

So there seems to be a non linear process here. Using a different transmitter produces the same noise spectrum (I used my TS-2000 to produce the same 20W as the repeater does).

I did another test:

I placed an antenna in the garden, duplexer and repeater still in the cellar. And then I moved it around. The noise was strongest when the antenna was placed directly in front of my cellar window. Moving it behind the house wall produced the lowest noise level. Cable length was always the same.

So it seems to be a kind of direct radiation into the duplexer.

I read somewhere in the Internet that the distance between antenna and duplexer should be at least 4 Lambda ... do you know the reason for that? If I use my antenna at the attic I have more or less that distance (and the cable got about 10 Lambda), but I'm wondering what might be the reason for that rule. Perhaps this could give us a hint for the problem. Have you ever tried to hold an antenna next to a duplexer in the past?

Carl

Dear Carl,

Can you try to turn off ALL electronic equipments in the house ?

Excepted the repeater itself... and perhaps the spectrum analyzer.

Now a days there are lots of switching power supplies operating in the house that can generate radio frequency interference. (TV, Computer...)

This could mix with the TX signal acting as local oscillator, in nearby conductors that behave as rectifier junctions.

I don't believe that the duplexer is at fault, unless the coax cables connecting to it do not provide enough shielding.

This might explain why you read that the antenna should be located some distance away.

You might try the repeater/duplexer/antenna in a different environment/house. Somewhere in the country side perhaps.

Let me know the results,
Jacques

Dear Jacques,

That did the trick! After removing the main fuse (and using battery driven radios) the noise disappeared. I then started hunting for the source, and finally found a (probably defective) power supply of a monitor in a room next to my shack.

When using an antenna in the cellar, there is no noise at all any more now. Using my main antenna in the attic, a bit of noise gets audible again, probably picked up from other sources in the neighbourhood.

So Serial Loop duplexers really seem to be vulnerable for out-of-band noise, as you said before. I will wait until the repeater gets installed at its final location. If we have a noise problem there, too, I'll know what to do: Build a band pass filter with two coupling loops, as you suggested.

Thanks a lot for your support! It was very helpful, especially when you suggested to look for noise sources in the house!

Best 73, and thanks again!
Carl

Dear Jacques,

I just want to let you know that indeed the duplexer worked fine from the beginning. I could eliminate two additional noise sources in my house (an old digital telephone line adapter and a bad junction in a power joint box). After that everything was as expected.

Somehow the RF of the TX seems to amplify the noise of such sources. They are audible using AM and get much stronger when RF is around. This behaviour can be reproduced by a separate TX and RX (two handhelds), which are not connected to a duplexer or whatever.

We installed the repeater and duplexer today at it's final location in a tower of a fire station, and luckily no noise is showing up there so far.

Thanks again for all of your help!

Best wishes

Carl