CHAPTER 4

630M LOCAL NOISE:

HOW TO MINIMIZE AND CONTROL IT

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9/21/16 SHACK NOISE TIPS
Laurence, KL7L / WE2XPQ, recently posted on the RSGB-LF reflector about a noise experience in his shack that has come up from time to time so his experience is sage advice that is worth sharing:

> "One interesting thing about cleanup of radio shacks and moving equipment around is that you suddenly learn something is going on you really didn't know about.
>
> Aces high E probe (L400b) has always had the best or concurrently equal performance of all the arrays here but for the past 24 hours it had been down a dB or two s/n wise
>
> Thinking it was a decoupling issue I checked feeders, performance of amp, splitters etc – and it wasn't till I realized I had put the die cast **aluminum fully sealed box** which houses the power injector and cap/transformer **atop my computer** that if I moved the box over the pressed steel lid of the computer we were getting **induced magnetic noise coupled into the box** causing a reduction of s/n.
>
> I could actually hear the difference on the R75 as I slide the box over the top of the computer lid – the noise wasn't coming in common mode on coax or via the power injector cables.
>
> The box had to be lying flat atop the computer press steel cover to induce noise – move it just 1 cm above and the coupling noise stopped.
>
> So – lesson learned that Die Cast Aluminum boxes aren't perfect at magnetically induced fields – it's not shielded Mu metal!
>
> **Keep any coupling box or perhaps not perfectly screened/matched cables** (mine didn't couple), **away from sources of potential mag coupling noise generators** –
>
> …and don't clean up the shack as your radio performance will likely suffer (just kidding!) Laurence KL7L WE2XPQ

11/4/16 STOP BROADCAST STATION INTERMODULATION NOISE ON 630m
" I noticed my feedline loop resistance was varying last evening by a few ohms and had to apply DC sealing current 3 or 4 times for it to settle down. Must be time to clean and oil all the ground and F-connector conductor surfaces….seems like it only takes an ohm or so of feedline loop resistance for the low level intermod to creep into the rx antenna and feedline system (especially with a handfull of 10KW to 50KW AM BC stations nearby) …..then I start seeing an increase in false decodes under strong WSPR2 signal handling situations. 73 Mike wa3tts"

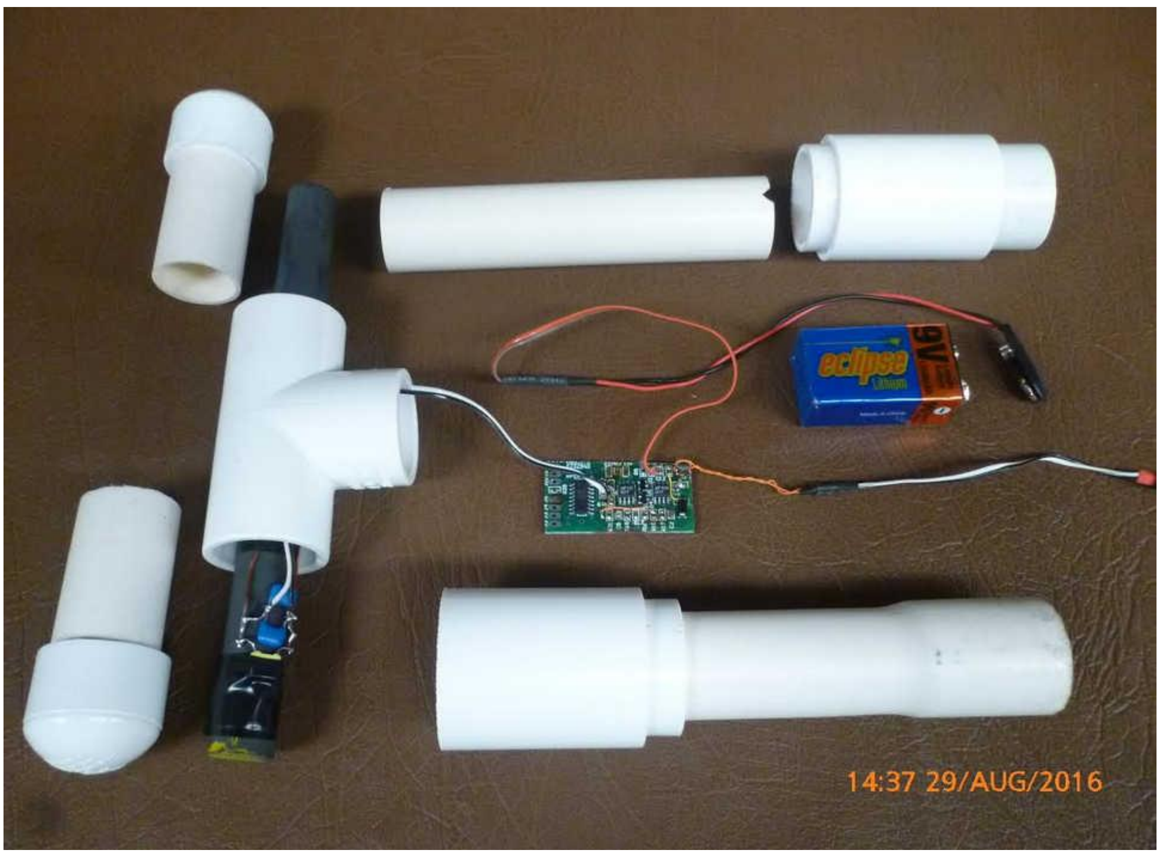
12/23/16 AIR CONDITIONER CAUSES SIGNIFICANT NOISE ON-AIR
Ron, NI7J / WH2XND, reported that a friend recently installed a new air conditioner that was causing significant noise on-air. The friend recently followed a QST article that recommended **twisting the power leads and using choke**, solving the noise problem. Ron performed the same modification, using **snap-on type-W cores** inside of an **eight-circuit outdoor type utility box**

and now cannot observe any difference between the AC compressor running or not. Leads to the AC compressor are simply re-routed via a conduit to the box, returning through the conduit and located adjacent to the compressor. If you are having problems, research this mod as it may improve noise conditions at your station.

AC unit power line filtering

8/29/16 LOCAL NOISE PROBE

Roger, VK4YB, reports that he has been chasing a noise source that is present day and night over the past few weeks. It is believed that the noise is coming from power lines and he has built a **portable ferrite loop stick probe** tuned to **475 kHz** in order to search for it. The **preamp** draws only 1.5 mA and he uses his **Elecraft KX3** as a receiver:



5/28/16 LOCAL NOISE CANCELLATION

“It’s a jungle out there,” and you live nearby! PCs, TVs, wall warts, light bulbs, fluorescent lights, motors, AC power lines, cable TV coax, DSL, etc. Imagine each such local noise source reaching out with *tendrils of displacement current* to grow noise and reduce SNR in your LF/MF antenna system as illustrated here. [*More in Chapter 11.]*

Suppose a tall vertical antenna A1 is the receiving antenna. Local noise often originates at points in the *near field* region. The near field region almost entirely features reactances and works like an extended circuit. Accordingly, the schematic illustration shows a hypothetical capacitor network circuit model where stray capacitances variously couple one or more sources of local noise into the system A1 and noise antenna A2.

After local-noise cancellation in a noise canceller, best-case SNR approximates:

$$\mathbf{SNR = (S\text{-}kS) / (N_{band} + N_{local} - N_{local})}.$$

The improvement in dB is roughly

$$\mathbf{Improvement = 10\log_{10} [(1\text{-}k)\ (1+ N_{local} / N_{band})]}.$$

Some signal power **kS** may unfortunately cancel, as represented by factor *k*. If local noise power $\mathbf{N_{local}}$ is large compared to band noise power $\mathbf{N_{band}}$, noise cancellation of local noise power $\mathbf{N_{local}}$ can dramatically improve SNR without reducing signal power **S** very much. In a pathologically noisy location you might see 20dB or more SNR improvement this way on 630m!

If you do noise canceling, and your canceler arrangement yields more than 5-10dB SNR improvement, it's probably canceling local noise, not band noise. Even if your canceller were set to a *phase* that could cancel band noise, the *amplitude* setting that cancels local noise will probably diverge markedly from amplitude scaling that would cancel band noise.

Noise canceling of local noise, as displayed on a spectrum analyzer when you adjust the canceler dials, looks like draining a bathtub and seeing kids' bathtub toys emerge! Remember the canceler settings then may have almost nothing to do with the ones that would cancel band noise. Using a noise canceller to fight serious local noise may deliver adequate SNR performance in your region or even your continent but probably not transoceanic DX path-conquering performance.

Radiation resistance and corresponding signal **S** reception capability of each antenna A1 and A2 is proportional to the *square* of its respective height h_1 and h_2. By contrast, capacitance of each antenna increases directly with its height and amount of top hat and closeness to noise sources. So a small noise antenna A2 picks up mostly local noise, which is readily cancelled by a canceller circuit. Also, you can more flexibly situate a small noise antenna closer to a local noise source to attain more noise pickup into noise antenna A2 than the main antenna A1 suffers relative to that local noise source.

The versions of local noise received by antennas A1 and A2 can only be cancelled if they are correlated—scaled versions of each other, for which phasing and scaling can bring them into cancellable antiphase. If either antenna fails to pick up a local noise source, that source will be uncorrelated and not cancelled. If the noise antenna A2 picks up a local noise source that does not reach the main antenna A1, then that noise will be undesirably included in the canceler output.

Multiple sources may inject different local noises into antennas A1 and A2. Each local noise source N1, N2, N3 induces a noise voltage N11, N21, N31 in antenna A1 and another noise voltage N12, N22, N32 in antenna A2. That means antenna-specific sets of noise voltage ratios may differ, so N11: N21: N31 is different from N12: N22: N32.

In that case, each noise pair N11, N12; N21, N22; and N31, N32 in the noise canceller is still probably a correlated noise pair. Nevertheless, the noise pairs can't all be fully cancelled with any one noise canceller setting because a setting that cancels one noise pair doesn't fully cancel another noise pair.

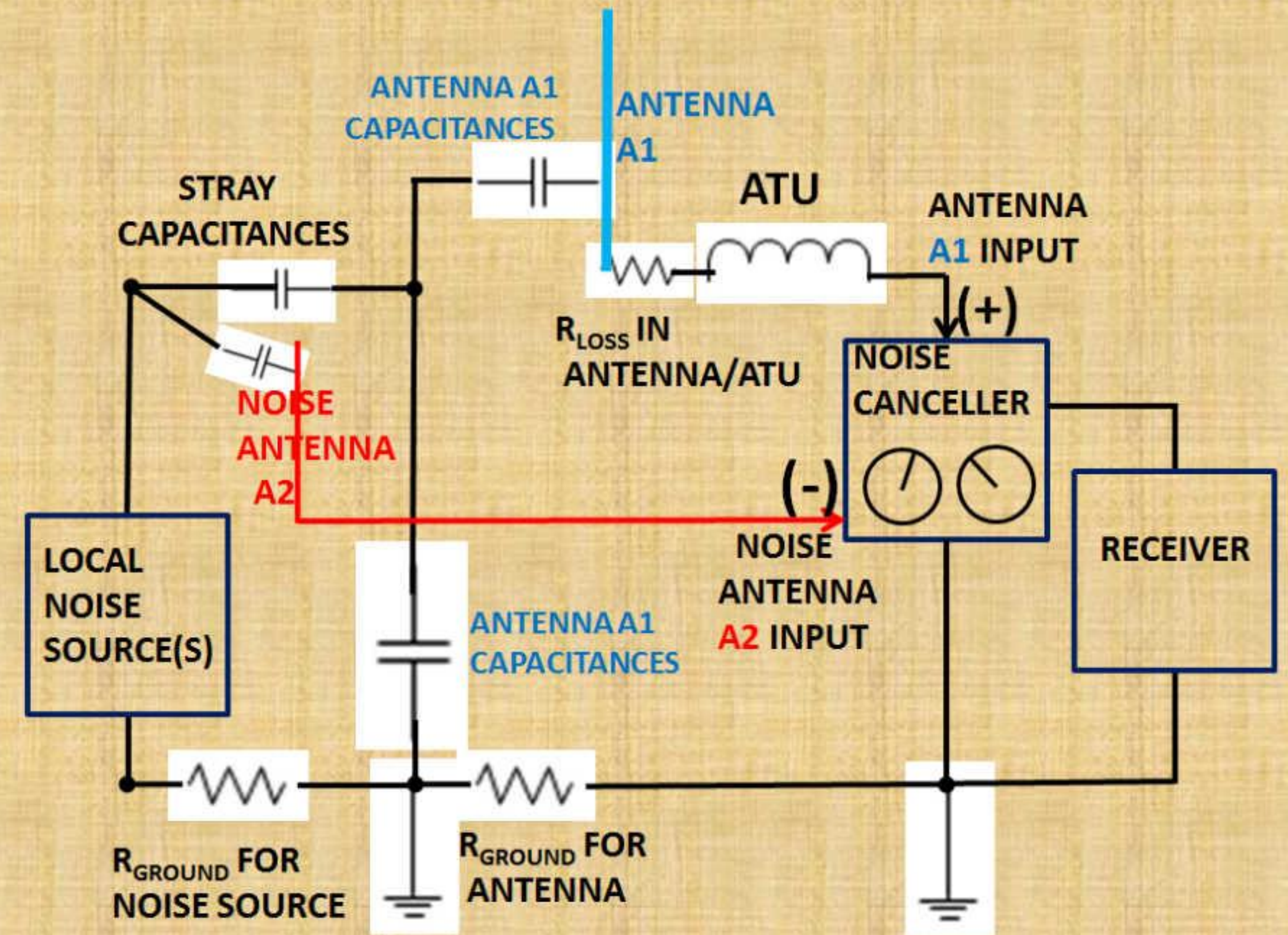
It should be possible to manipulate the canceller dials to increase SNR somewhat, though. If the improvement is inadequate, relocating the noise antenna A2 by trial and error may better align its aggregated local noise pickup with the constellation of local noises being coupled into the main antenna A1. Understanding that the ratios of noises need to align can give you some intuition where a good noise antenna A2 location may be found.

Highly-linear signal antenna and noise canceller preamplifiers beneficially employ active devices such FETs and/or other active devices in circuits at the antenna or elsewhere. Residual nonlinearities may multiply out-of-band QRM signals together and produce mixing products that have frequencies equal to the sum and difference of the original frequencies of each pair of QRM signals (and/or noises) that become multiplied together.

Since broadcast band stations offer many different arithmetical possibilities involving BCB strong carriers and modulation frequencies lying 475KHz apart, active antennas with such preamps require careful design. Some noise cancellers add an adjustable BCB trap. MF/LF ops and SWLs appreciate all-passive well-matched antenna and noise canceller circuits for their inherently high linearity. But the lack of signal power gain calls for careful design in the all-passive arena too.

While noise cancellation of local noise may not be a perfect solution, it can be quite useful on 630m when implemented after all other noise reduction measures have been taken.

LOCAL NOISE CANCELLATION



Symbols from https://www.edrawsoft.com/electrical-symbols.php

10/17/16 NOISE CANCELLING: GETTING THE LAST BIT OF NOISE OUT!

Generally a noise canceller varies each of the noise phase and noise amplitude approximately linearly to effectively achieve a subtraction from noise accompanying the signal. Local noise cancellation is discussed at: http://njdtechnologies.net/052816/

Unfortunately, a noise antenna may not often deliver an exact scaled replica of the noise that needs to be canceled from your primary RX antenna. Even if the noise antenna and a noise canceler circuit may null the vast majority of the local noise power content from the primary RX antenna, a small residue of noise power is likely to remain.

SNR(dB) responds logarithmically to the declining noise. In percentages, as shown in **Figure 1**, that means if all the noise in the main antenna were theoretically cancelable, then canceling 90% and leaving just 10% of the noise power gives you 10dB SNR improvement.

Canceling 9% more to leave 1% of the original noise power yields another 10dB SNR. Local noise cancellation, say 25dB more or less, is very beneficial, but it may be about all your noise canceler employing a noise antenna can deliver. (In the SNR improvement process, some unavoidable moderate cancellation of the signal itself by the noise canceller may also occur. So this discussion is approximate.)

If you could just eliminate as little as 0.9% more noise power, you could get still another 10dB SNR! At some point, you are tantalized like a dog chasing its tail! Any amount of effort you expend on repositioning and improving the noise antenna to eliminate some more noise power simply fails to employ some other scintilla of noise power that before had been included in the nulling process.

When this point is reached, the noise antenna is delivering sufficient noise power for cancellation purposes, but the noise antenna's noise is not sufficiently *correlated* with the noise in the primary RX antenna. If it were perfectly correlated, the noise waveforms could be phased and scaled to perfectly cancel out the noise from the primary RX antenna using the noise antenna.

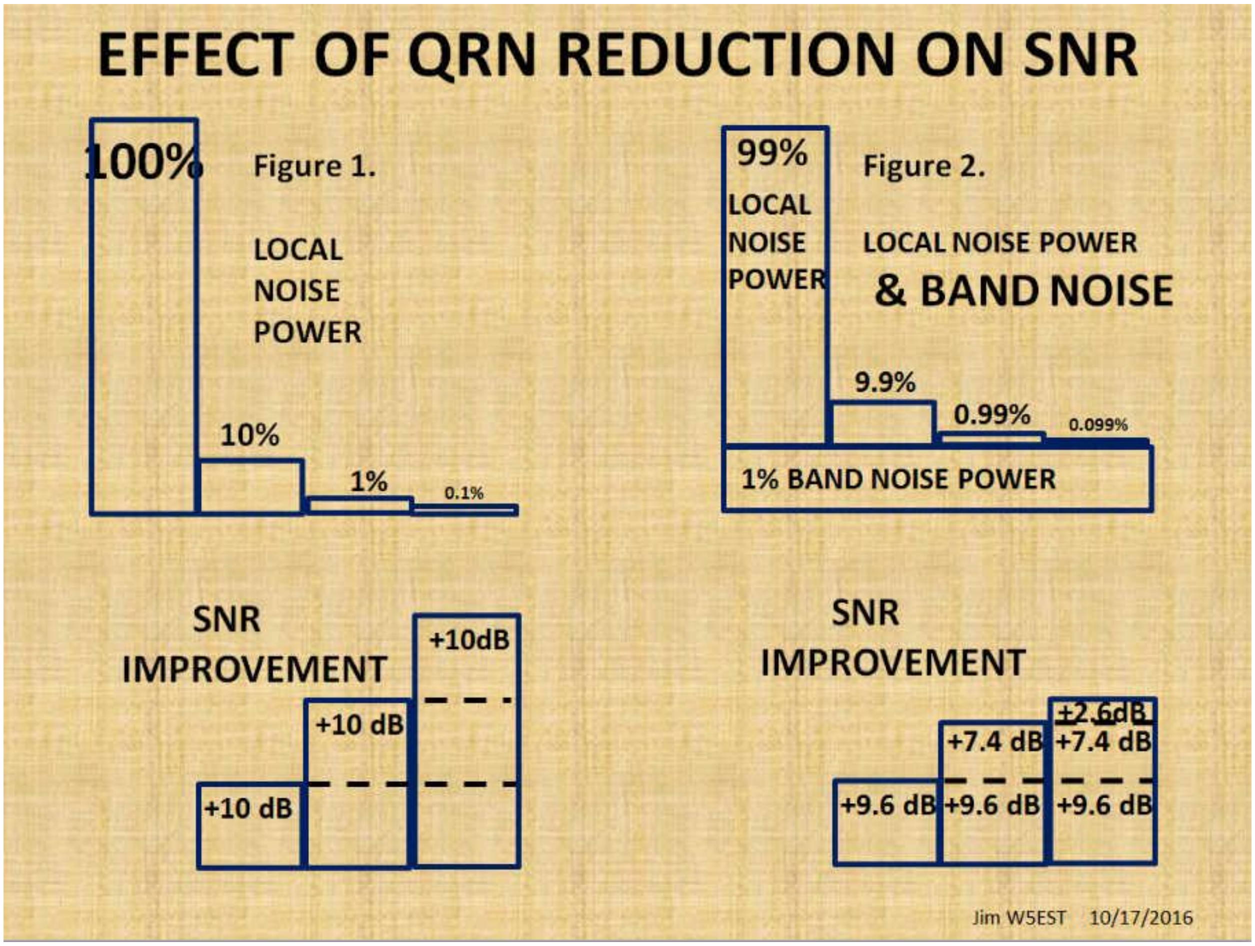
The only ways to entirely get rid of local QRN seem to be: Stop it at its source or locate the main RX antenna sufficiently far from the QRN source to avoid it. If you can't do any more than you already have done on either of those QRN projects, then what? You can still do plenty of useful 630m work and have lots of fun—indeed, a few dB of 630m nighttime band noise may show up after sundown and cover up some of your uncanceled local QRN. But beyond your reach may remain the weaker stations on cross-continent paths and the stronger stations on the most advanced long-paths.

That's the bad news. Fortunately, some local QRN sources may do you a favor and turn themselves off at night. Also, WSPR and JT9 are digital modes. Even if SNR is not as favorable as you'd like, digimodes do decode a station at those times its SNR rises above the decode threshold.

Moreover, the 630m band provides a level of noise power in the signal bandwidth arriving from and with the same azimuth, elevation and polarization as the signal. Even in the absence of local noise, most receiving antennas unavoidably receive 630m sky wave noise from a substantial fraction of the sky.

Suppose you can cancel local noise power to about one tenth of the 630m band noise power relative to signal level, which may concurrently decline somewhat as you cancel noise. At that point, you don't need to cancel further because the SNR is as high as it can be for that particular signal. **Figure 2** shows how some example noise power cancellation percentages work in that situation. You can see the process reaching a point of diminishing returns.

If your local noise power is so strong and intractable that you just can't cancel the local noise down below the sky wave 630m band noise, then you face the tantalizing conundrum described in this post. (*More: 10/18/16 in Chapter 6*.)



8/23/16 W7RNB TRYING X-PHASER
Rick, W7RNB / WI2XJQ, has built a "**XX-Phaser / noise enhancer**" and provided **this article** to discuss the build. See schematic at:
http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0ahUKEwifjKGp7PbRAhUD7CYKHQ1WB_AQFggaMAA&url=http%3A%2F%2Fwww.dd1us.de%2FDownloads%2FInside%2520a%2520X-phaser%25200v2.pdf&usg=AFQjCNHerYb5WpxSPMKk3kv1FzFfMpdgFQ&bvm=bv.146094739,d.eWE