**Noise Suppression for the Antenna Feed Line**
by Nick Hall-Patch

**Introduction**

Local electrical noise interfering with the DXer's desired listening is universal. So much so, that many urban DXers have hung up their headphones, even if they have room for outdoor antennas. However, that noise isn't always coming from the neighbor's place. To put it simply, electrical noise generated by our own tech toys can find its way onto the coaxial feed line from our antenna, travel out to the antenna to be picked up there, transferred to the coax feed line, and then become part, perhaps the dominant part, of the signal conveyed back to the receiver.

For receiving antennas, perhaps a model of an antenna and ground with matching transformer will explain why "common mode" current in a coaxial lead in can increase the noise level. (Figure 1) Although simplistic, it can also help to explain the situation in more complex antennas that have one leg capacitively closer to ground than the other.

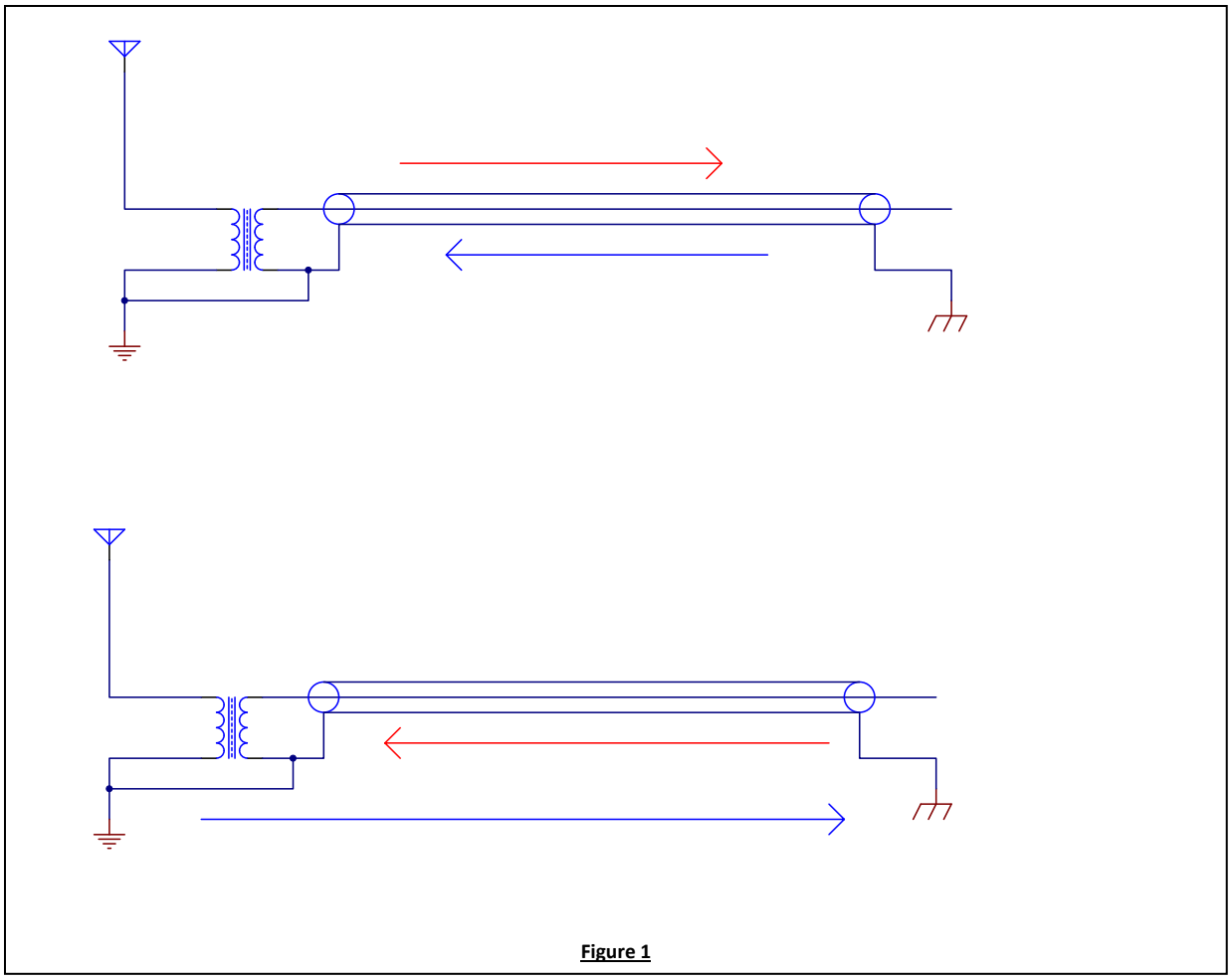

**Figure 1**

1. ideal: The shield of the cable is an electrical conductor, and is the return path for the signal from the antenna that travels down the center conductor of the coax to your receiver (this is "differential mode" current, necessary for hearing your DX)
2. additional reality: The shield of the cable can also act as an electrical path from the ground of your receiving set up (which is usually linked to the noisy AC ground in your receiving set up, or to a noisy computer, even if everything is being run on battery) out to any ground that exists at your antenna. In addition, the shield can act as an antenna itself.
3. The noise signals that are present in your receiver ground will usually have a different electrical potential from that which exists at your antenna's ground rod, so will create a current along the coax shield, which will return through the earth, a path which is also common between your receiver ground and antenna ground. (this is "common mode" current on the coax shield; it doesn't travel in the coax center conductor)
4. That noise current can induce a signal in your antenna via its imperfect (resistive) path to the earth ground. Also, any resistance to the current in the shield or in the splices with coax connectors will tend to induce additional noise into the coax center conductor. (a bad splice is often diagnosed by the additional noise noted at the receiver)

The problem isn't new, and at least two solutions were described many years ago in the pages of DX Monitor. These are the isolation transformer and the common mode choke. Both break the path for electrical noise out to the antenna via the feed line's shield, while still allowing DX signals to travel from the antenna to the receiver. In effect, they isolate the receiver ground from the antenna ground, so that there is no longer a return path for the noise.

You'll sometimes hear common mode chokes referred to as "braid breakers", meaning that the braid of a coaxial cable is effectively broken up into two different segments, even if it is not physically broken. Isolation transformers have been frequently marketed as "galvanic isolators"; they actually physically separate the antenna ground from the receiver ground.

**Isolation transformers**

The isolation transformer is simply a radio frequency transformer which has no common ground connection between the input and output windings (Figure 2) compared with the transformer in Figure 1.

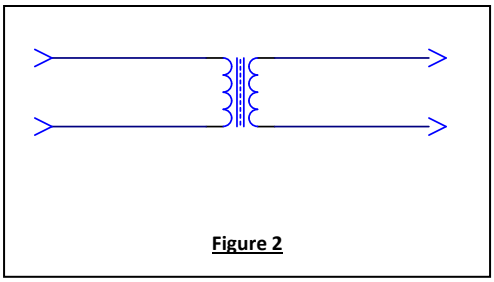

**Figure 2**

Because of its inherent DC isolation, the transformer cannot be used with an external preamplifier or active antenna powered through the coax, but rather should be placed between the bias-T and the receiver. Three articles in IRCA Reprints, from nearly 30 years ago, available at https://www.ircaonline.org , describe isolation transformers, their construction and use:

- A-108 Inverted L Noise Reducing MF/VLF Antenna, by Dallas Lankford,
- A-107 Interference Reducing Antennas for the BCB, by Denzil Wraight
- A-123 Another Look at Noise-Reducing Antenna Systems, by Mark Connelly

These articles are apparently all based on work originally done by F. R. W. Strafford in the 1930s. Lankford's and Wraight's articles emphasize the use of a long wire or vertical antenna with an isolated matching transformer (high impedance to 50 ohms impedance, suitable for input to a receiver), while Connelly's article introduces the idea of additionally using a 1:1 isolated 50 ohm matching transformer for an antenna that has already been optimized for a 50 ohm lead in.

**Common Mode Chokes**

The common mode choke may not have such a venerable history as the isolation transformer, at least not for suppressing noise in antenna feed lines. However, common mode chokes have been used for many years for noise suppression in AC power lines. Without going into the physics, the common mode choke can be seen as a device that impedes "common mode" signals, such as the noise signals from our receiver ground out to the ground rod via the coax shield, but present no impedance to "differential mode" signals, such as the DX from our antenna. The choking effect can be perceived on the received signal just by coiling up a hundred feet of coaxial cable as part of the antenna lead-in; the coil looks like an inductor to the common mode signals, reducing their amplitude, but looks just like a length of cable to the DX signals. It is much more convenient however to run a few turns of the coax around an appropriate ferrite core, creating a large inductance, and therefore an impedance to common mode signals. (Figure 3)

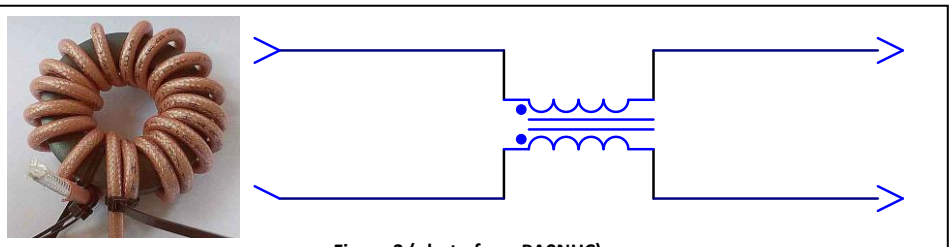

**Figure 3 (photo from PA0NHC)**

Is Your Coaxial Lead-In Actually an Antenna?? by John Bryant and Bill Bowers, was an early (2003) description of the use of coaxial chokes to suppress unwanted signals in the antenna feedline, at least in in the MW DXing world. The article is available as IRCA reprint A-151 and also online at http://www.dxing.info/equipment/coax_leadin_bryant.pdf It was inspired by the 3rd Edition of John Devoldere's Low Band

DXing, a book aimed at the radio amateur, but which contains a wealth of information about receiving down to 1.8MHz, and by extension, into the medium and long wave bands. The fifth edition of this book is available from ARRL (http://www.arrl.org/shop/ON4UN-s-Low-Band-DXing/). In this case, the authors were "choking" undesired signals that were being picked up on the coax shield, but the same device reduces noise traveling on the shield also.

Devoldere's book and the Bryant/Bowers article recommended the use of two coaxial chokes on the antenna feedline, one near the antenna itself, and one near the input to the receiver. In addition they recommended attaching the shield of the coaxial cable to a ground rod in the center of the cable run between antenna and receiver (Figure 4). However, significant degrees of noise suppression have been found by users with just one choke at the receiver, and with no ground rod.

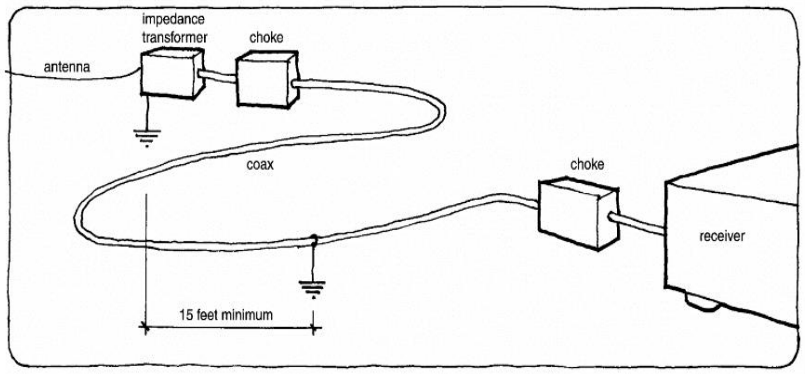


**Figure 4 from Bryant / Bowers**

**Discussions on the IRCA Group**

If this subject is such old news, what can be added to it now? A few months ago, the IRCA groups.io list contained quite a lot of discussion about "galvanic isolators" and "common mode chokes", because some DXers had used one or the other on their antenna lead ins, and found reduction in what some had previously thought was received electrical noise from their antenna, rather than their own noise being fed to their antenna. In spite of the information available in the technical archives, there appeared to be some confusion between the two items, which was hopefully cleared up by other contributors to the list.

Initially, there was a discussion about common mode chokes, mentioning the commercially available products that were being sold to the radio amateur market, for example, https://www.insight-eng.net/products/cmx/cmx.html and https://myantennas.com/wp/product-category/cmc-2/ The latter company has at least one product that is specified to as low as 0.5MHz, while the former's products are useful primarily for the HF amateur bands, so may not be of much use to the medium wave DXer.

This exchange then devolved into a rather detailed discussion of home brew common mode chokes by Everett Sharp and Chuck Hutton, which is referenced in the final section of this article. Then, another commercial product, specified for 40kHz to 30MHz, the GT-1 Galvanic Isolator Transformer , (http://www.aorusa.com/accessories/gt1.html) was mentioned by Vince Ferme (Figure 5) along with pointing out alternative home brew solutions, which are also described below .


**Figure 5**

**Figure 6**

Finally, Vince mentioned the availability of a "Coaxial Video Ground Loop Isolator Balun BNC Male to Female for CCTV Camera" offered by various Ebay sellers, for example, https://www.ebay.ca/itm/Coaxial-Video-Ground-Loop-Isolator-Balun-BNC-Male-to-Female-for-CCTV-Camera-E8P6/122656420263?ssPageName=STRK%3AMEBIDX%3AIT&_trksid=p2060353.m2749.l2649 He tried them and was pleased with the reduction of noise on longwave in particular.

Les Rayburn pointed out that these devices were “designed to remove annoying "hum bars" from CCTV video cameras. These show up as slowly moving "bars" of noise on monitors—anyone who has worked much with CCTV has experienced them. To be effective, they really only need to function (to) a little above 1 MHz.” (so may be useful at medium wave frequencies)

Steve Ratzlaff opened up a couple of the CCTV ground loop isolators and found them to contain either an isolation transformer (GB001), or a combination of isolation transformer and common mode choke (GL101) (Figure 7). He found that the GL101 model had considerable insertion loss above a few MHz, 20dB down by 10MHz, compared with the GB001 which was only a couple of dB down by 30MHz.

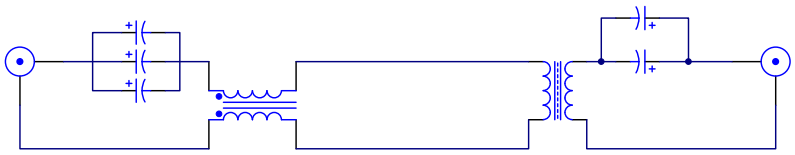

**Figure 7 - GL101 coaxial video ground loop isolator with built-in video balun**

The discussion died out shortly after these evaluations, and there does not seem to have been the detailed analysis of the noise cancelling response of these CCTV isolators similar to that which was done by Everett Sharp for his homebrew common mode chokes. However, the average DXer is not a homebrewer, and will likely be pleased by the improvement in response to local noise found by using one of these inexpensive devices.

**More detailed discussion**

For those who are not afraid of doing a little homebrewing (or know someone who will do it for them), there was quite a bit of more detailed information provided during the list discussions which might allow the user to consistently knock down local noise over a broad band of frequencies.

More about isolation transformers:

As an update to the 30 year old articles on creating isolation transformers, here is what was mentioned. Everett Sharp has used a BN73-202 binocular core, with a bifilar pair of #30 magnet wire, each with different colored enamel coating (to indicate each winding). The pair of wires is then wound six times through the binocular core (Figure 8). (The BN73-202 binocular core is Fair Rite part number 2873000202, available from Mouser as # 623-2873000202).

**Figure 8 (Sylvain Naud photo)**

Vince Ferme also mentioned I2PHD's design: "You can build a simple 1:1 RF transformer- for use as a galvanic isolation transformer by twisting two wires together and running the pair through a toroid core just two or three times. Then connect both ends of one of the wires to the coax going to the receiver and both ends of the other to the two balanced antenna wires or to the antenna coax.
The ferrite must be of high permeability (e.g. -75 or -77 material). The two windings are galvanically insulated, usable from LF to 30 MHz.
Not aesthetically pretty, but works". Vince specified the possible toroid part numbers as Digikey: #240-2524-ND or #240-2522-ND for #75 Mix, or Mouser #623-5977001101 or #623-5977000301for #77 Mix.

(a further note, not mentioned on the list. In reprint A-123, Mark Connelly mentions using Mini-Circuits transformers as ready-made isolation transformers. Coilcraft is another company that makes a number of wideband RF transformers at inexpensive prices, for example, their 1:1 transformer, WB1-6TL, available from Mouser as # 994-WB1-6TL, as are many others with different winding ratios.)

More about common mode chokes:

Generally, for use at medium and long wave frequencies, a high permeability, physically fairly large, ferrite toroidal core or clamp-on core should be used with multiple turns of coaxial cable (or twisted pair if that is your choice) around it. Over the years since the Bryant/Bowers article was written, DXers have done exactly that, sometimes with impressive results, sometimes with results that are good at some frequencies but not at others. It's been a "whatever works" strategy, for example, by getting a clamp-on core such as Fair-Rite #0475176451, using a cable assembly of thin RG-174 coax, and winding as many turns as possible around the core. (Figure 9)

core open core closed

**Figure 9**

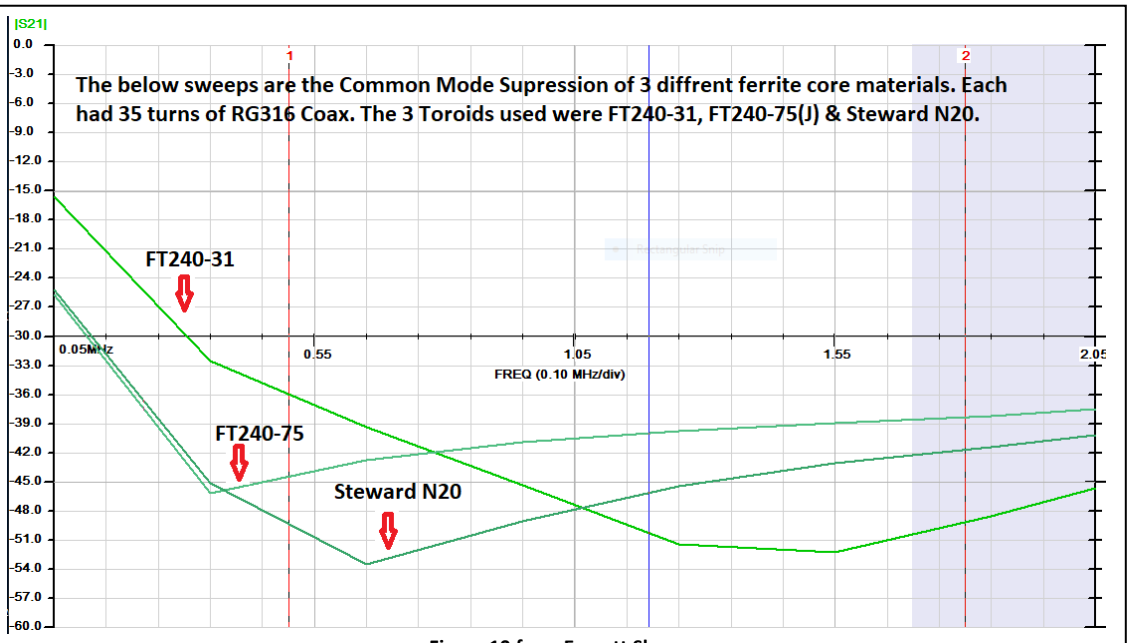


**Figure 10 from Everett Sharp**

However, to create a common mode choke that is optimum over the frequency range for which a DXer wishes to attenuate noise is not always easy, and can involve poring over data sheets, developing an understanding about the difference between reactive and resistive impedance, making inductance measurements, and using a vector network analyzer (VNA). Fortunately, a couple of contributors to the IRCA list had done exactly that.

Everett Sharp detailed his strategy to the list, first by using a VNA to evaluate several different toroidal cores wound with coaxial cable, showing clearly the depth of attenuation of common mode noise on the y-axis of his graph, and how that attenuation varied with frequency (Figure 10). Type #31 ferrite material has been frequently suggested as a useful choke for the ham bands, while type #75 material had been more widely used by MW and LW DXers. "Steward N20" noted in Figures 10 and 11 was apparently a misidentification, and it was later corrected to TDK #B64290A0040X830, available as Mouser part # 871-B64290A0040X830.

Then Everett placed two of his chokes in series to smooth out and deepen the common mode attenuation response across a broad range of frequencies (Figure 11). This would be an extremely effective common mode choke from below the longwave broadcast band to 160 meters.

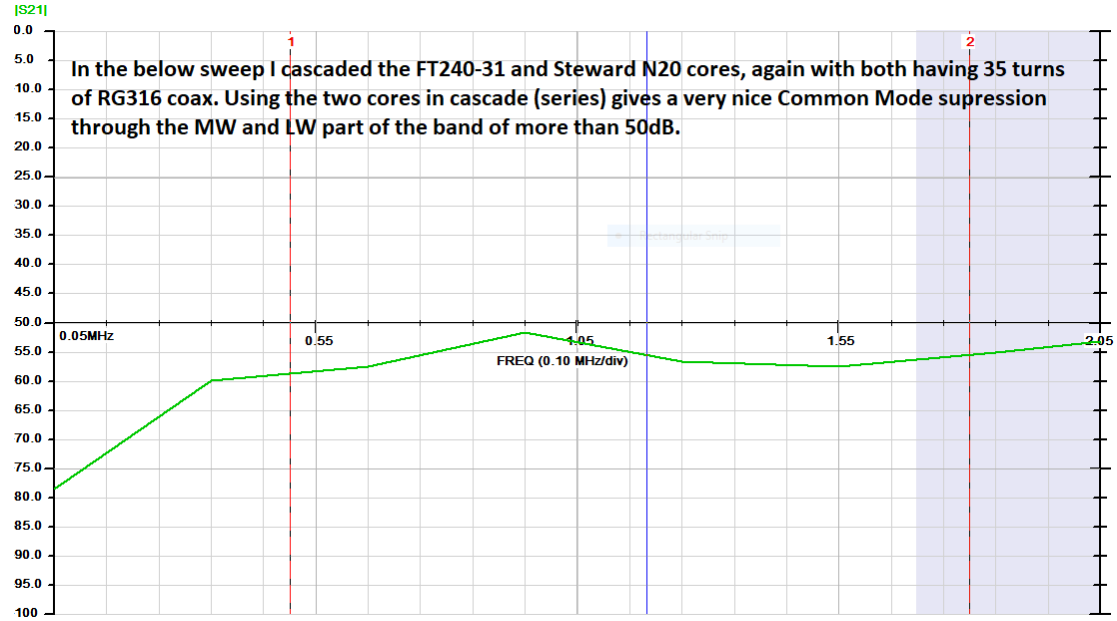


**Figure 11 from Everett Sharp**

**References for further study**

Sources of ferrite cores

https://palomar-engineers.com/ferrite-products/
https://partsandkits.com/toroids.php
http://www.amidoncorp.com/ferrites/

https://www.mouser.com/ (search for Fair-Rite parts; https://www.arrow.com/, https://www.digikey.com/, https://www.newark.com/ also carry a number of different manufacturer's cores)

(https://palomar-engineers.com/ferrite-products/ferrite-cores/toroid-cross-reference is a good cross reference for different manufacturer's ferrite cores

Further reading

https://www.pa0nhc.nl/RXloop_PN2222/indexE.htm
http://www.pa0nhc.nl/CommonModeChokes/indexE.htm
http://www.yccc.org/Articles/W1HIS/CommonModeChokesW1HIS2006Apr06.pdf
http://k9yc.com/RXChokesTransformers.pdf
http://audiosystemsgroup.com/NCDXACoaxChokesPPT.pdf
http://www.karinya.net/g3txg/chokes/
(many of the above are aimed at radio amateurs, and their need for common mode chokes in transmitting, but include plenty of worthwhile theoretical and practical information not found elsewhere)

plus a video from W1VLF concerning his experiments:
https://www.youtube.com/watch?v=b0Jx-oN3YlA&feature=youtu.be