How ferrite's work, and how to use them

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What will be covered

- What are common mode, (CM) currents and where do they come from?
- What are differential, (DM), mode currents?
- Short Q/A period.
- What causes CM currents in real world antenna systems?
- Short Q/A period.
- Why is Common Mode bad?
- What is a choke?
- Why do ferrite chokes work?
- Short Q/A period.
- What types of chokes work best, and why.
- How to quiet down your receiver using chokes.



What are common mode currents?



I_{s, outer} Current on outer shield I_a Ground return current





What are differential mode currents?

Common mode: I_{s, outer} Current on outer shield

Ground return current

Differential mode:

I_i Center conductor I_{s,inner} Current on inner shield





What causes Common Mode?

- Skin Effect on the outside of the coax.
 - External RF sources see only the outside of the coax.
 - Skin Effect happens on the outside of the coax.
 - Internal RF sources see only the inside of the coax.
 - Skin Effect happens only on the inside of the coax.



What causes CM in Antenna systems?

- Imbalanced antenna design.
- Antenna placement.
- Obstructions near antenna.
- Ground that is not uniform.
- Pretty much anything!



What causes CM in Antenna systems?





What causes CM in Antenna systems?





Why is common mode bad?

- Increases receiver noise.
- Increases transmitted noise.
- Almost uncontrollable.
- Worsens digital.
- Reduces QSOs.
- Lower S/N ratio.
- Lower scores.



What is a choke?

- A choke is anything that removes unwanted currents in a circuit.
- A choke does this by inserting resistance in that circuit.
- Resistance that is frequency dependent is called Impedance.
- Impedance is caused by frequency dependent elements, like coils and capacitors in the choke.



What is a choke?



Why do ferrite chokes work?

- Ferrite chokes are primarily parallel resonant circuits.
- The coil is obvious.
- The capacitor is not so obvious.



Why do ferrite chokes work?

- Parallel resonant circuits present maximum impedance when resonant.
- A ferrite choke is a low Q, parallel resonant circuit, in series with the CM on your coax.
- Impedance is frequency dependent.
- So you end up with a frequency dependent choke in series with your coax, affecting only the signals on the outside of the shield.



Why do ferrite chokes work?



Quick Overview

- We know, what common mode currents are.
- We know what differential mode currents are.
- We know what causes CM in an antenna feedline.
- We know why CM is bad.
- We know what a choke is.
- We know why a choke works.



Ferrite Materials come in "mix" types. A mix is a special mix of metals used to make the ferrite material.

Mix 31:My favorite, good everywhere.Mix 43:Good for 25 MHz and up.Mix 61:Good for UHF.Mix 75:Good for you 160 folks.

Some mix types work better than other mix types based on frequency. It pays to know what mix you want.









"The impedance of a ferrite choke below resonance is approximately proportional to the square of the number of turns passing though the core."

Jim Brown, K9YC





Multi turn chokes work best:

- Always try and use multi turn choking methods.
- Use the "right" number of turns on your choke.
 - Don't just wind cable on a choke, know what you want.
- Never use a snap on or drop on core where you can use a multi turn choke.
- Higher impedance means less choke heating.
- Higher impedance means better CM rejection.
- Higher impedance means less receive noise.
- Choke heating is bad, SWR increases as choke gets warmer.



How to quiet down your receiver using chokes.

By deciding the following:

- Do I have CM problems?
- If so, what items are causing the CM problems?
- What is the best method to choke my CM?
- What mix do I need?
- What type of choke, snap on, drop on, or toroid.
 - Can I wrap, if so, how many turns?
- Where do I put my choke?



How to quiet down your receiver using chokes.

What items cause CM problems:

- Unbalance in antenna systems.
- Ground return currents caused by grounding issues.
- Ground loops.
- RF in the shack.
- Local RF sources like AM radio stations.
- Local RF sources like SMPS.



How to quiet down your receiver using chokes.

• What is the answer?

- Use CM chokes at the feed point of every antenna. This stops the feedline from becoming an antenna.
- Use CM chokes at the transformer end of a wall warts.
- Use CM chokes on anything that might generate RF and feed it into the power lines.
- Clean up everything!



How to quiet down your receiver using chokes.

Before

After







How to quiet down your receiver using chokes.





Questions





Citations

- Background provided by the ARRL.
- Most graphics, and test data provided by Jim Brown, K9YC:
- http://audiosystemsgroup.com/publish.htm
- http://audiosystemsgroup.com/KillingReceiveNoise.pdf
 - Jim's page is a wealth of information, take the time to visit it, time well spent.
- Other graphics from:
 - Tom Thompson, http://www.tomthompson.com/radio/EHam_Articles/CommonMode/CommonMode.html
 - Arron Scher, http://aaronscher.com/
 - https://commons.wikimedia.org/wiki/File:RLC_parallel_circuit.png
 - https://en.wikipedia.org/wiki/File:RLC_parallel_band-stop.svg
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- http://audiosystemsgroup.com/publish.htm









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