How ferrite’s work, and how to use them

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NK7Z
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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?

Common mode:
- $I_{s,\text{outer}}$: Current on outer shield
- $I_g$: Ground return current

Electric interference!
What are differential mode currents?

**Common mode:**
- $I_{s,\text{outer}}$: Current on outer shield
- $I_g$: Ground return current

**Differential mode:**
- $I_i$: Center conductor
- $I_{s,\text{inner}}$: Current on inner shield

Diagram:
- 50Ω load
- Electric interference!

NK7Z, Version 1.00
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.
What types of chokes work best, and why.

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.
What types of chokes work best, and why.
What types of chokes work best, and why.

“The impedance of a ferrite choke below resonance is approximately proportional to the square of the number of turns passing through the core.”

Jim Brown, K9YC
What types of chokes work best, and why.

- 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:
    - Jim’s page is a wealth of information, take the time to visit it, time well spent.
- Other graphics from:
  - https://commons.wikimedia.org/wiki/File:RLC_parallel_circuit.png
  - A host of military handbooks.
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