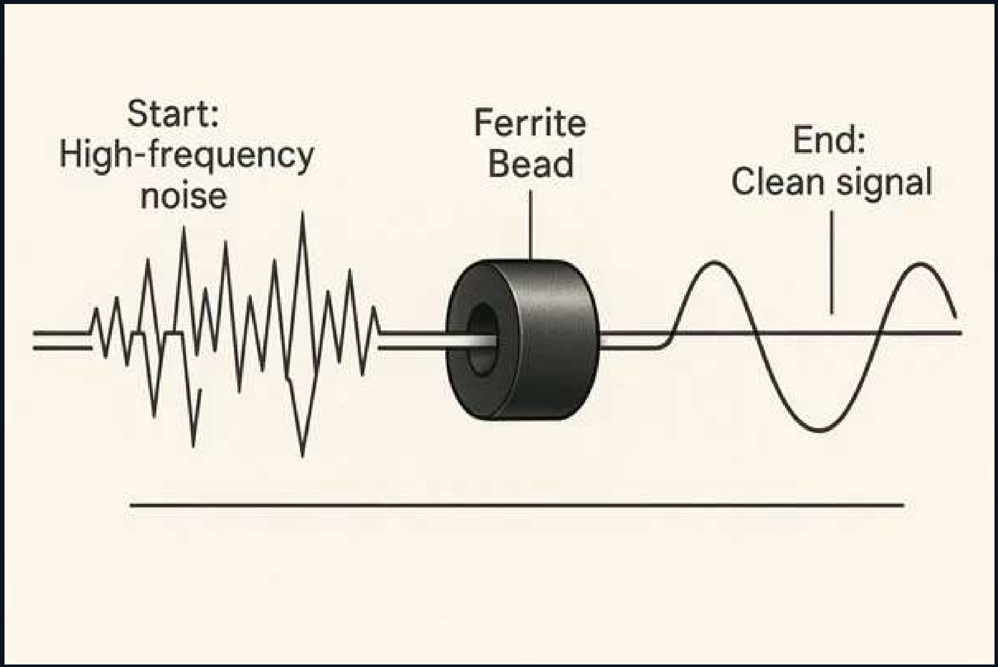
Ferrite Beads and Toroids in Amateur Radio



Rick Fletcher, W7YP
Flathead Valley Amateur Radio Club

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Ferrite Beads and Toroids in Amateur Radio

Using ferrites for HF and VHF RFI/EMI control, common-mode choking, mix selection, and measurement.

HF + low VHF

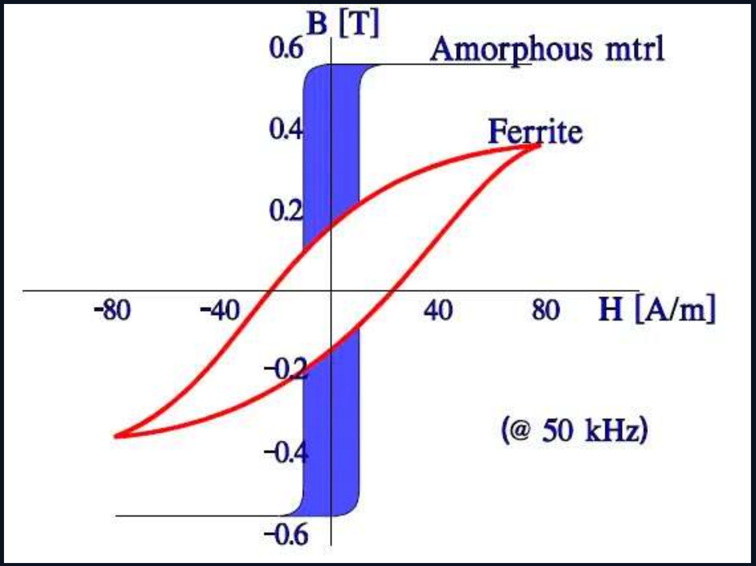
Mix selection

Chokes & baluns

- What common-mode current is and why ferrites 'see' it
- Which mixes fit HF, 6 m, 2 m, and cable-suppression jobs
- How beads and turns add impedance in practical builds

How they work – permeability (µ) matters

- µ ("myoo") represents a materials ability to concentrate magnetic flux and allow magnetic fields to pass through it more easily
- Ferrites suppress undesired common-mode currents by presenting a mostly resistive high impedance to the undesired frequencies
  - Unwanted RF energy is dissipated as heat
  - Higher initial permeability (µi) gives more inductance per turn/length at lower frequencies
    - Provides higher choking impedance where you need it
    - Very high µ materials tend to have their impedance peak shift to lower frequencies
      - At higher frequencies, their permeability drops off and they become less effective
  - Lower µ materials (e.g., NiZn types) maintain better performance at VHF/UHF
    - Present less impedance in the lower HF range



"B-H characteristic" describes how the material responds to a magnetic field. B = magnetic flux density and H = magnetic field strength.

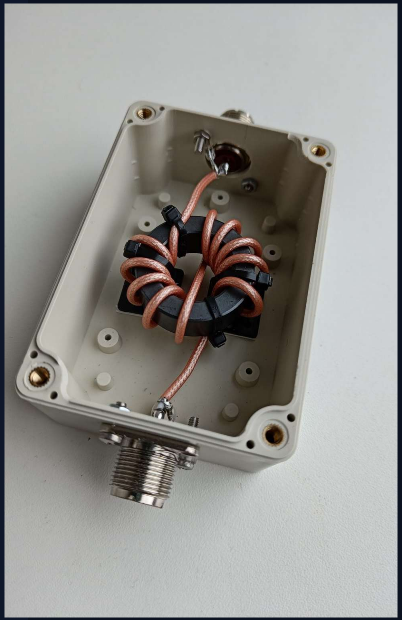
Area inside the loop = energy lost as heat

Why ferrites matter in a ham station

Most problems are feedline or cable currents finding their way into equipment.

Typical symptoms:

- RF in the shack: hot mic, keyer glitches, touch-current surprises
- Feedline radiates and changes the antenna pattern or SWR behavior
- Noise picked up on power, USB, Ethernet, rotor, and control cables
- RFI to nearby audio gear, monitors, speakers, and network devices
- Symptoms often become apparent only when using higher TX power



A choke does one job well:

- Add a large impedance only to the unwanted outside-of-the-coax current
- Leave the wanted differential signal mostly untouched
- Turn cable radiation and coupled noise into heat in the ferrite

Rule of thumb:

Below 30 MHz, serious feedpoint chokes are often designed toward about 5 kΩ choking impedance, not just a few hundred ohms.

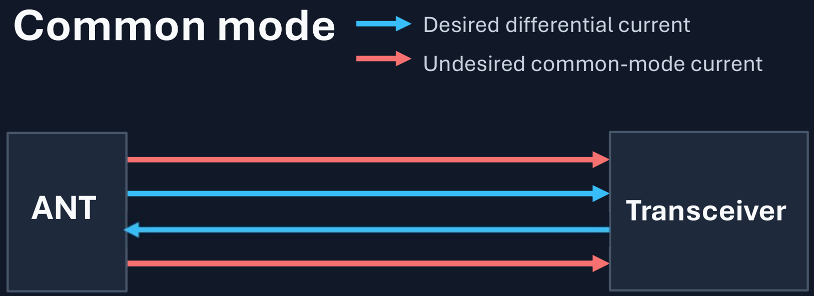
Differential current vs. common-mode current

Ferrites work because coax shield current is split: inside for the wanted signal, outside for the unwanted one.

Differential mode

- Equal current, opposite direction
- Fields mostly stay between conductors
- Little distant radiation from an ideal line

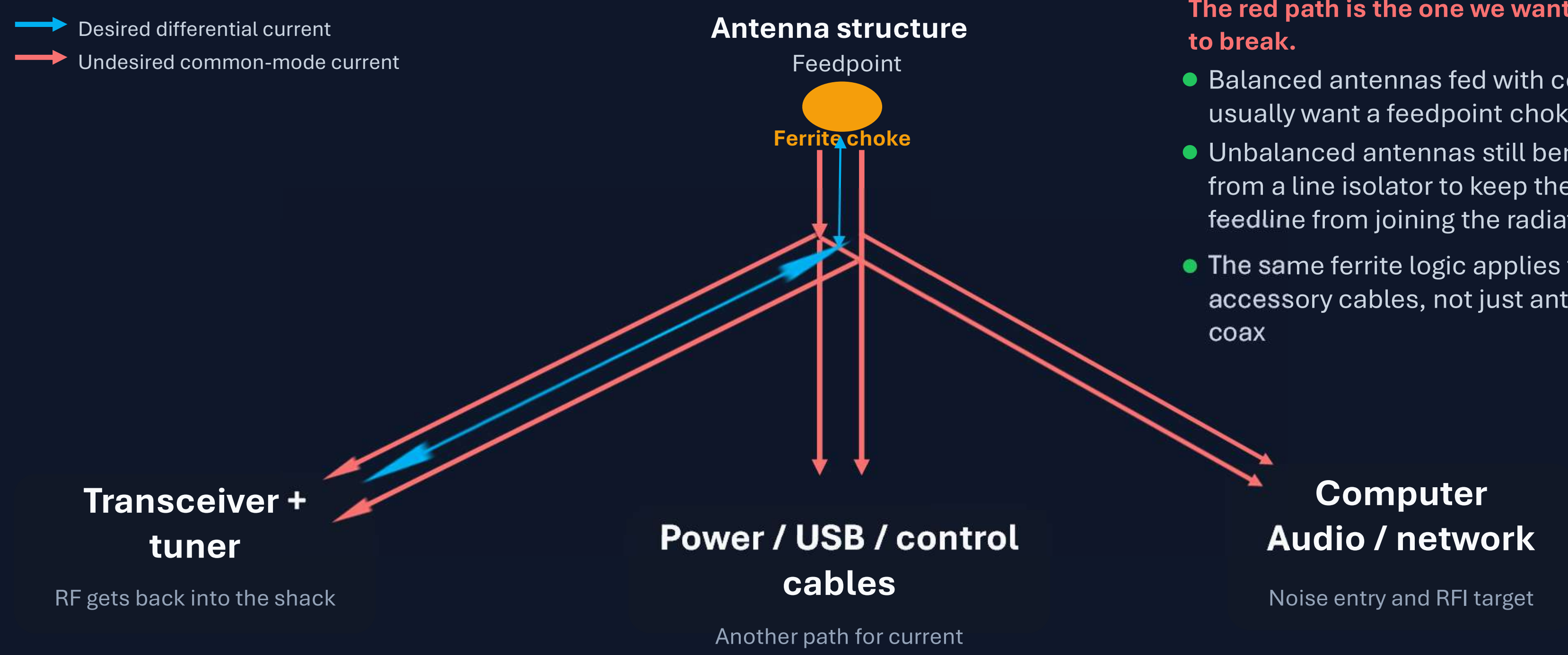
Common mode



- Current flows in the same direction on the cable exterior
- The line radiates like part of the antenna
- A ferrite around coax sees this outside current — not the wanted inside current

Where common-mode current shows up

A station problem is often a system problem, not just an antenna problem.



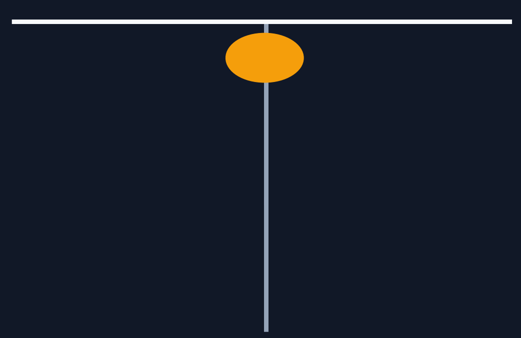
The red path is the one we want to break.

- Balanced antennas fed with coax usually want a feedpoint choke
- Unbalanced antennas still benefit from a line isolator to keep the feedline from joining the radiator
- The same ferrite logic applies to accessory cables, not just antenna coax

Choke placement: where ferrites do the most good

Put the impedance where the unwanted current wants to flow.

Balanced antenna feedpoint



1:1 current balun / choke

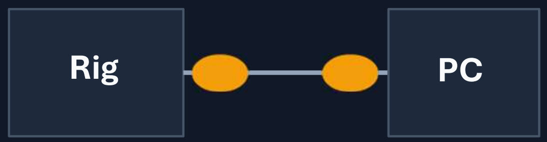
- Best first choice for dipoles, loops, Yagis
- Stops pattern distortion and shack RF

Vertical / end-fed feed

Line isolator at feed / base

- Useful on verticals, end-feds, OCFDs, J-poles
- Keeps the feedline from becoming a counterpoise

Shack entry and device cables



- Ferrites close to the noisy device or cable entry point often work better than random mid-cable placement.
- Use snap-ons for quick fixes
- Use at both ends if the cable couples noise both ways

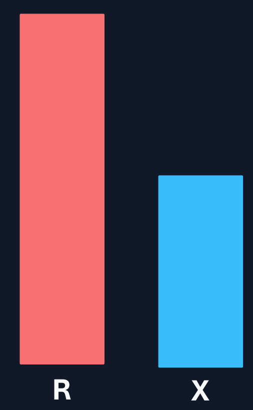
Ferrite impedance: resistance is the useful part

A choke that is mostly resistive dampens current. A choke that is only reactive can resonate with the line.

Simple model

- At low frequency the part looks more inductive
- As frequency rises, ferrite loss grows and R becomes large
- That lossy region is what makes a good suppression choke

What we want



High R lowers current, even when cable length changes. In a TX line with standing waves, impedance varies with length, as do currents. This is why RF problems can change when you move a cable or with small length changes.

Why air-coil chokes are narrowband

- A simple coil of coax is mainly inductive
- Its stray capacitance creates a resonance peak
- Great for one band sometimes; risky as a broadband fix

Ferrite chokes are preferred because they add useful resistance over the target range.

When a choke is mostly inductive, the added capacitance from the cable causes behavior to be that of an L-C circuit. This can cause some degree of resonance which actually causes impedance to drop, undesired current flow to actually increase, and performance to depend strongly on cable length.

Mix selection by frequency

Use the mix that places the ferrite loss peak where you need choking or cable suppression.

Ham-focused view of ferrite use

160/80m | 40/20m | 17–10m | 6m | 2m+

31

1–500 MHz

Best general HF choice; also good into low VHF

75

100 kHz–30 MHz

Low-band HF / LF work; split cores lose more from small gaps

43

20–250 MHz

Useful from upper HF into VHF; classic clamp-on material

61

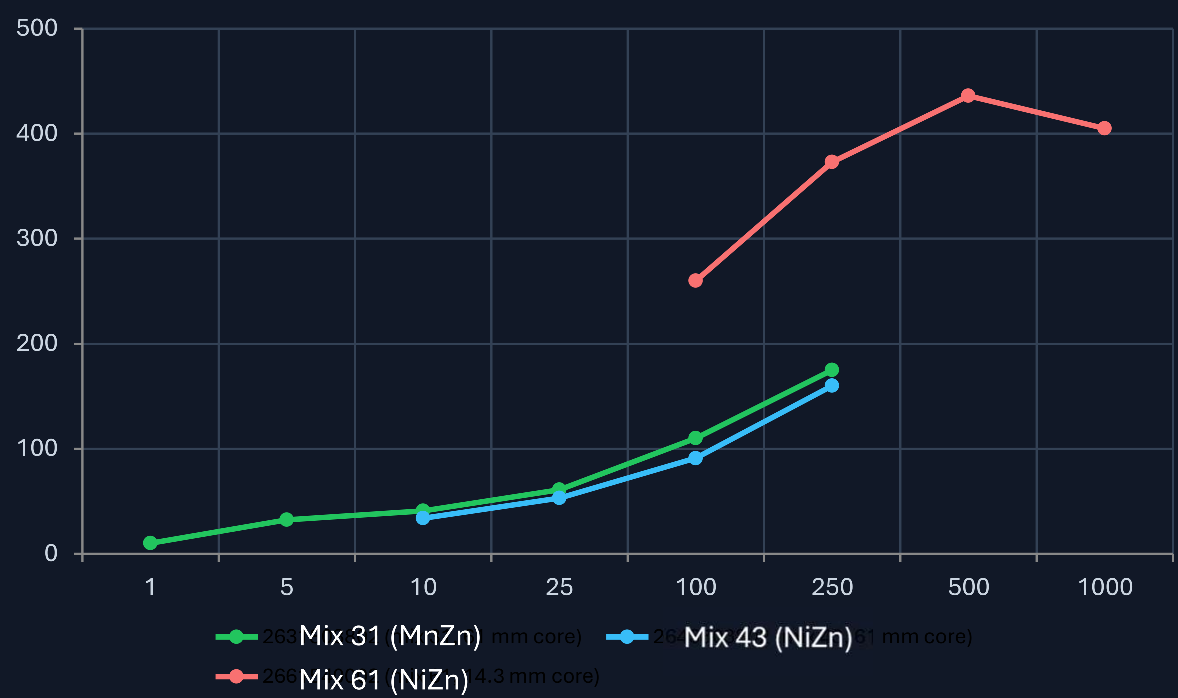
200 MHz+ EMI

Useful when the problem is VHF/UHF cable noise or 2 m and above

Practical shortcut: for HF station troubleshooting, start with mix 31. For clamp-ons on data or control cables around 2 m and higher, look hard at mix 43 or 61.

Example impedance vs. frequency for real Fair-Rite parts

Single-pass cable-through data are useful for comparing what one core can do before you add more cores or turns.



What the chart says

- Mix 31 starts being useful very low in frequency and stays relevant through HF
- Mix 43 is comfortable from upper HF into VHF cable suppression
- Mix 61 shines when the problem is already well into VHF/UHF territory

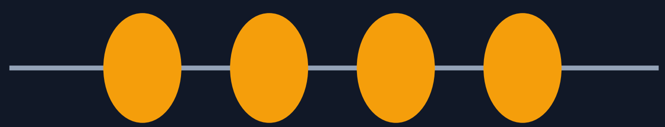
These are single-core, single-pass numbers. A finished choke can be far higher by using more cores or turns.

These are not metallic alloys. They are ceramic ferrites – sintered materials made primarily from iron oxide combined with other metal oxides.

How impedance adds: more beads and more turns

Two different levers: series core material and turns through a core.

1) Multiple beads / cores in series



$Z_{total} \approx Z_1 + Z_2 + Z_3 + \ldots$

A W2DU-style bead string simply stacks single-core impedance along the cable.

2) Multiple turns on one toroid

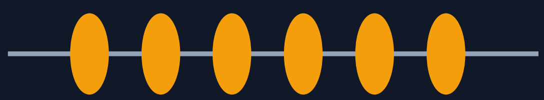
Turns multiply choke effectiveness quickly, which is why toroidal chokes are the efficient choice below about 30 MHz.

GOAL: 1,000 to 5,000 ohms of impedance to undesired current flows

Bead string vs. toroidal choke

Both work; the better choice depends on frequency, space, weight, and how much impedance you need.

W2DU / bead string



- Easy to retrofit on finished coax
- Good where cable cannot be rewound
- Can be quite effective on 6 m and 2 m with enough material

Toroidal choke

- Best ferrite efficiency for HF
- Turns let you shape the useful impedance region
- Usually the first choice for a serious feedpoint choke

Decision rule

- HF feedpoint choke → toroid(s)
- Accessory cable fix → snap-on or bead chain
- VHF/UHF cable suppression → small beads or snap-ons often win

If you need 5 kΩ at the low end of HF, a single snap-on is not the answer.

HF build recipes that usually work

Use these as starting points; exact turns depend on core size, cable type, and target band coverage.

Target use	Good starting mix	Typical form	Comment
160/80 m feedpoint choke	31 or 75	Large toroid, often stacked	Prioritize lots of resistive impedance at the low end
40–10 m broadband choke	31	Single or stacked toroid with coax turns	Common all-around HF solution
Upper HF / 6 m line isolator	31 or 43	Toroid or bead string	Need less material than 160–80 m work
Accessory cable cleanup	31 near HF rigs	Snap-ons / clamp-ons	Place at the noisy device, cable entry, or both

Good practice: make the finished choke broad and resistive, not just resonant on one band.

A compact toroidal choke

Build cues

The PA9X example uses multiple turns around an FT240-style toroid to get broad HF common-mode suppression.

- Avoid sharp coax bending beyond the cable spec
- Use stacked cores when low-band HF needs more material
- For high power, larger wire or coax and more core volume help

HF is not VHF: how the strategy changes

At VHF and above, smaller ferrites and cleaner cable routing matter more than big multi-turn HF chokes.

Snap-ons and clamp-ons

Ideal for mic, USB, Ethernet, speaker, rotor, and control cables when the problem is above HF or when retrofitting is easier than rebuilding.

VHF / UHF tactics

- Use 43 or 61 when the noise is well above HF
- Keep cable pigtails short — the cable itself becomes the problem
- Place ferrites at the source or at the victim device first
- May need to place ferrites at both ends of cable/coax

More smaller pieces near the source often beat one big ferrite in the middle of the cable.

Band-specific hint

- 6 m often still behaves like HF in ferrite choice
- 2 m, 70 cm, and digital-noise issues push you toward 43/61-style parts
- Small snap-ons can be very effective on handheld and mobile accessory leads
- Typically, fewer beads/turns required than for HF

Practical Example: RF feedback in microphone on 20 m

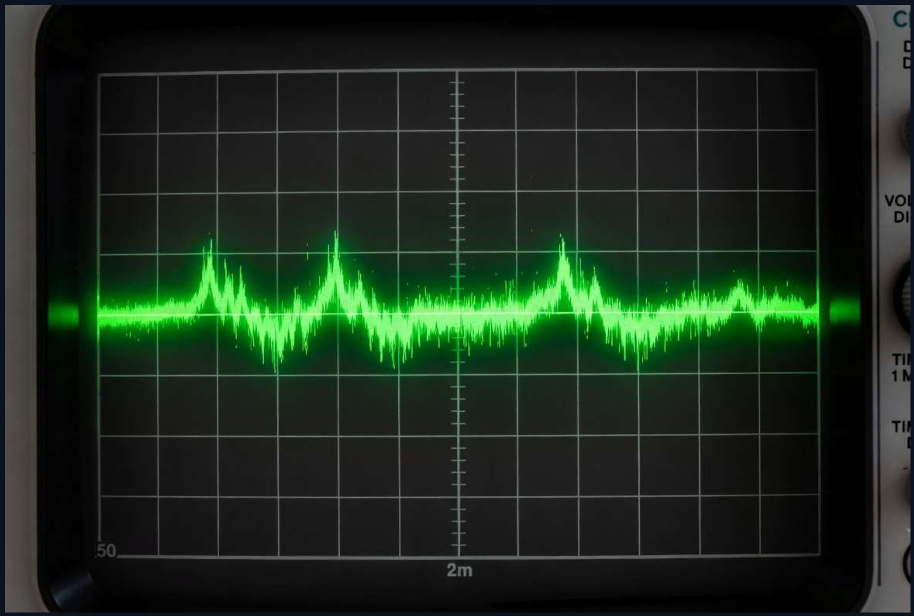
Natural SSB speech:
- Narrow bandwidth results in ‘thin’ audio quality
- “Communication grade” audio

When RF overlays the audio component:
- Adds a harsh, raspy, buzzy or hissy distortion
- Oscilloscope display of the demod audio shows:
  - Higher frequency ripple on the audio
  - Makes the audio trace look fuzzy/hairy

Solution:

Add:
- 5–10 Mix 31 beads to mic cable
- Common-mode choke at feedpoint

Result:
- Clean audio
- Stable operation



The "Pin 1 Problem"

Incorrect grounding of Pin 1 on XLR connectors in audio gear – connected to PCB ground, not chassis ground

This allows RF and noise currents to flow into the audio circuitry, causing:

- Buzz, hum and distortion
- RF in the audio during transmit

Field Fixes

Add ferrites to:

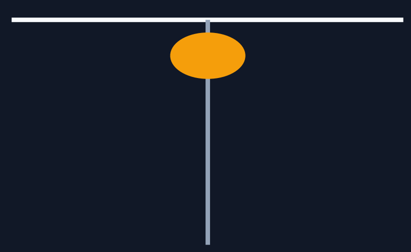
- Mic cable
- Audio leads

Related problem in other audio gear

Baluns, ununs, and line isolators

Not every ferrite choke is used in the same place, even when the core physics are similar.

1:1 current balun

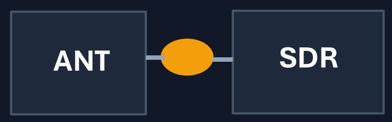


- Balanced antenna to unbalanced coax
- Common at dipoles, loops, and many beams
- Often implemented as a ferrite current choke

1:1 unun / line isolator

- Unbalanced antenna to unbalanced coax
- Useful on verticals, end-feds, OCFDs, J-poles
- Goal is still to stop the feedline from radiating

Isolation on receive & accessories



- Reduce cable-borne noise on receive antennas
- Also useful on USB, Ethernet, and power paths
- Same ferrite principle, lighter-duty power handling

Real product examples: Fair-Rite starting points

These are example parts to anchor the design conversation — check current stock and dimensions before building.

Toroids for serious HF chokes

2631803802 — mix 31, 61 mm OD, 35.55 mm ID, 12.7 mm thick

2643803802 — mix 43, same size class
These are large enough for practical coax-wound feedpoint chokes.

Snap-on example

0431164181 (Mix 31) is one Fair-Rite Snap-It example, a hinged ferrite for a 0.5” cable class.

Typical Impedance (Ω)	
1 MHz	19
5 MHz	67
10 MHz+	91
25 MHz+	147
100 MHz+	265
250 MHz	318

How to pick a part

- First pick the mix for the frequency problem
- Then check cable diameter / core window size
- For feedpoint chokes, ask whether the cable can make the turns you need
- For split cores, remember the air gap hurts low-frequency mixes more

Products change; the design logic does not.

How to measure whether a ferrite fix helped

Measurements do not have to be exotic - even simple station symptoms are data

Quick station checks

- Did the RF-in-the-shack symptom vanish?
- Did receive noise floor drop?
- Did antenna pattern or SWR stop changing with feedline position?

Better tools

- Clamp-on RF ammeter for common-mode current
- VNA / antenna analyzer to compare finished choke impedance
- Receiver A/B tests with and without the choke in line

Interpretation tips

- A choke that improves 20 m but worsens 80 m is probably too reactive or too narrowband
- If one cable still misbehaves, add ferrites to the accessory path too
- Measure at the symptom frequency — a perfect 100 MHz part may do almost nothing at 3.5 MHz

Additional considerations: power, DC bias, heat, and split-core gaps

A choke can fail electrically even when the ferrite choice looked right on paper.

Power & heat

Undersized chokes overheat when common-mode voltage/current is high. More resistance and more core volume reduce risk.

DC bias

If current with DC content passes through a suppression core, impedance falls due to DC magnetic bias field (H) which pushes the ferrite material toward saturation, where its effective permeability (μ) drops sharply.

Split-core gap

Hinged or split parts are convenient, but the air gap hurts low-frequency, high-permeability mixes more than solid toroids, since air has very low permeability. This gap becomes a magnetic “bottleneck”.

Stacking cores

Stacking identical toroids increases ferrite volume and usually broadens a serious HF choke without forcing impossible bend radii.

This is why the “right mix” alone is not enough — geometry and operating conditions matter.

Troubleshooting workflow

Use ferrites as part of a repeatable process instead of guessing randomly.

1. **Identify the path** — Feedline? power? USB? rotor? mic?
2. **Match the frequency** — HF = start with 31; VHF/UHF = consider 43/61
3. **Pick the geometry** — Toroid for HF choke, snap-ons for cable cleanup
4. **Add enough material** — More beads or more turns until the symptom clearly changes
5. **Measure and refine** — Keep what works; move ferrites closer to source/victim if needed

The fastest win is usually at the worst offender, not by sprinkling ferrites everywhere equally.

If a cable changes the symptom when you move it by hand, it probably deserves ferrite attention.

Common mistakes

- Using wrong ferrite mix
- Too few beads/turns (e.g., not enough impedance)
- Placing ferrites in wrong location(s)
- Ignoring common-mode currents entirely

Best practices

- Use Mix 31 for most HF work
- Aim for ≥ 1000Ω
- Combine beads plus turns were possible
- Treat every cable as a potential antenna
- Test and iterate to confirm suppression

Takeaways

- Ferrites solve current-path problems — not just generic noise.
- For HF, start with mix 31. For higher VHF/UHF issues, consider 43 or 61.
- Feedpoint chokes come from core volume plus turns.
- Accessory fixes come from smart placement near the source or victim.
- Hundreds of ohms may help. Thousands of ohms change a station.

Suggested next step for your own station

Pick one known problem cable or one transmitting antenna feedpoint. Add ferrite deliberately, measure before/after, then scale the same method to the rest of the station.

NEXT MONTH: How to measure unknown ferrites and actual suppression achieved

References

7QP - the 7th Call Area QSO Party - http://7qp.org/new/Page.asp?Content=START&Page=1

Fair-Rite - https://fair-rite.com/

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Q & A