Baluns: Good, Bad & Ugly

Steve Sterling, WA7DUH

Current (i)

Voltage (v)

Ohms

Reactance

Balun

RF Choke

Transformer

Impedance z
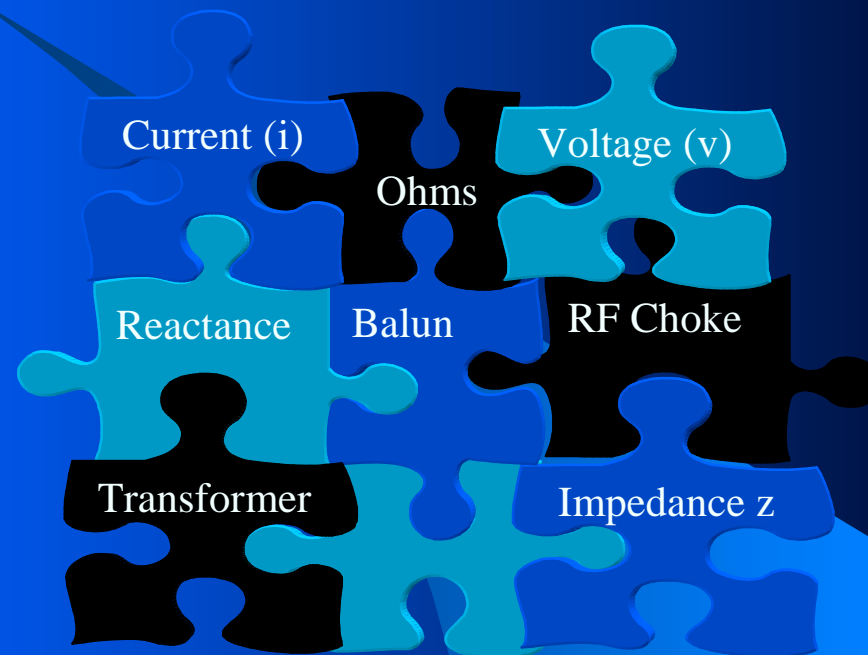
Baluns: The Good, Bad & Ugly

- **Ba**lanced To **Un**balanced = Balun
- Converts balanced feed to unbalanced feed
  - Dipole antennas, twin lead, ladder line are "balanced"
  - Verticals over ground plane, gamma-matched antennas, coaxial feed line are Unbalanced
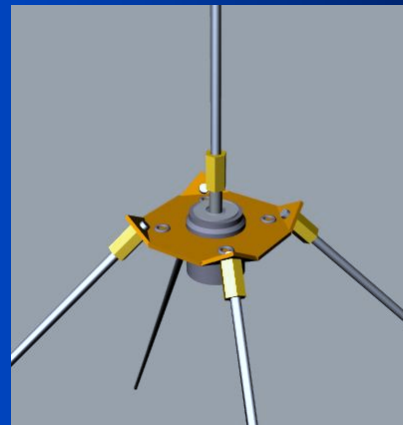
Baluns: The Good, Bad & Ugly

- Without Balun on balanced devices (dipoles) fed with coax – RF on outside of coax and into shack

Current Mode Balun
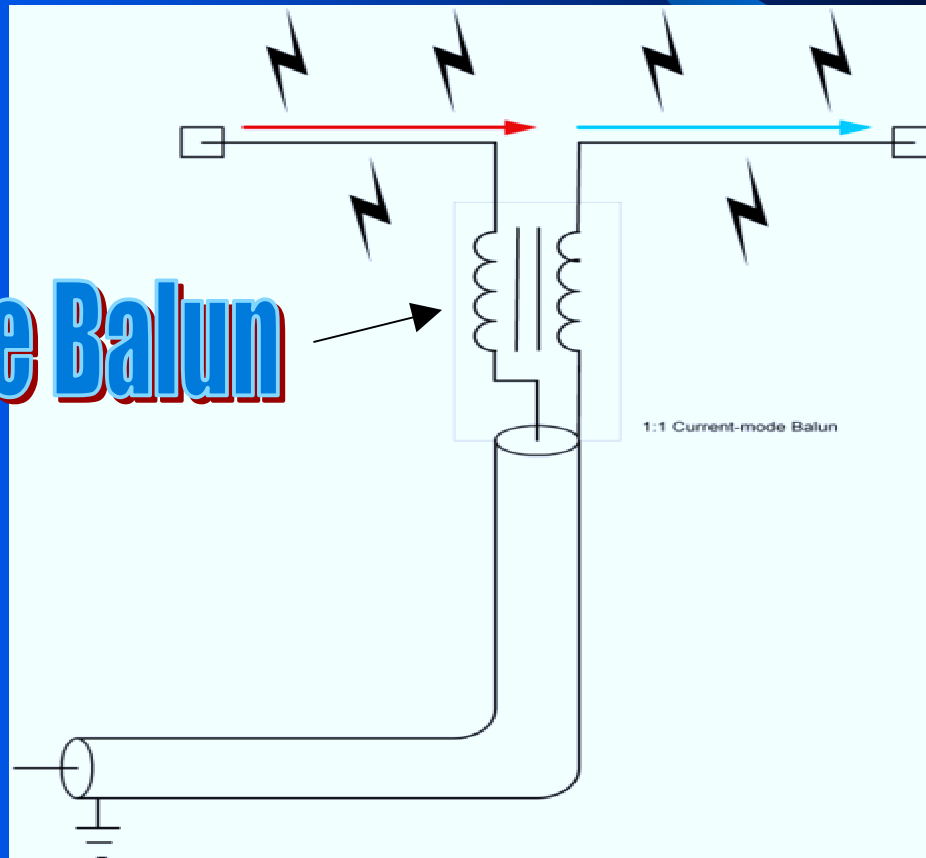
1:1 Current-mode Balun

Baluns: The Good, Bad & Ugly

- Installing G5RV dipole– need Balun between ladder line (balanced) and coax (unbalanced)

- Quick search on internet said an air-wound Balun would work good ….

- Next search said "clamp on" Choke around coax

Baluns: The Good, Bad & Ugly

- Installing G5RV dipole– need Balun between ladder line (balanced) and coax (unbalanced)

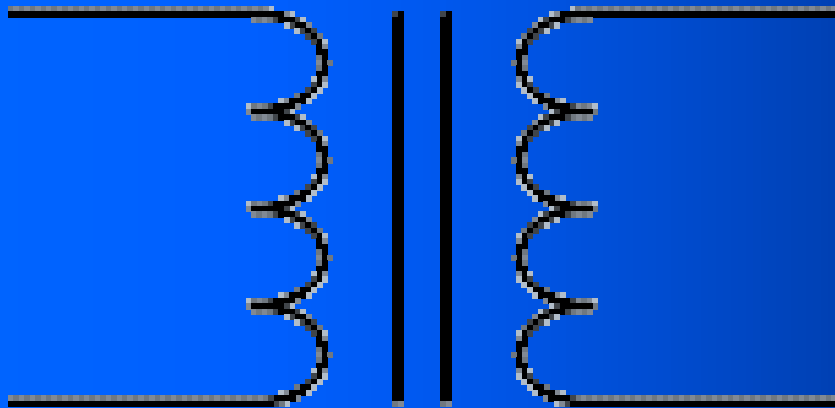- Quick search on internet said an air-wound Balun would work good ….

- Still had RF in shack after installing airwound and clamp on - why?

Types Of Baluns

Voltage or transformer Balun

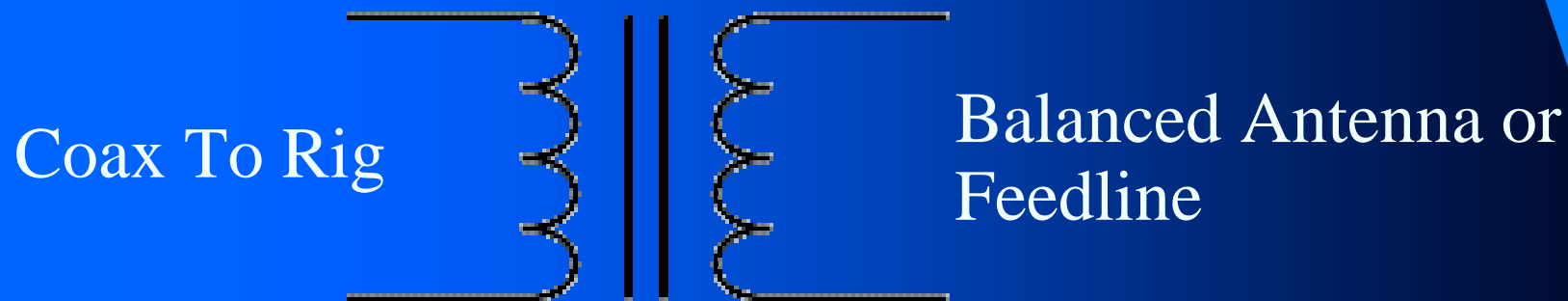- W2AU by Unadilla is a voltage Balun

- Voltage baluns work, but with issues

Types Of Baluns

## Issues With Voltage or Transformer Baluns

- Ferrite core must handle ALL the power being transmitted from the primary to secondary
- Linearity, Saturation & Hysteresis
  - Linear device has the same impedance for all values of applied voltage and current
  - Ferrites will saturate at some high level of current.
  - Ferrite behaves linearly if the field within it is small, but becomes nonlinear as it begins to saturate.

Coax To Rig

Balanced Antenna or Feedline

Types Of Baluns

Issues With Voltage or Transformer Baluns

- Ferrite core must handle ALL the power being transmitted from the primary to secondary
    - Must be low loss ferrite core or HEAT will destroy
    - Does not deal with off-normal impedances well – causing saturation, high losses and heat
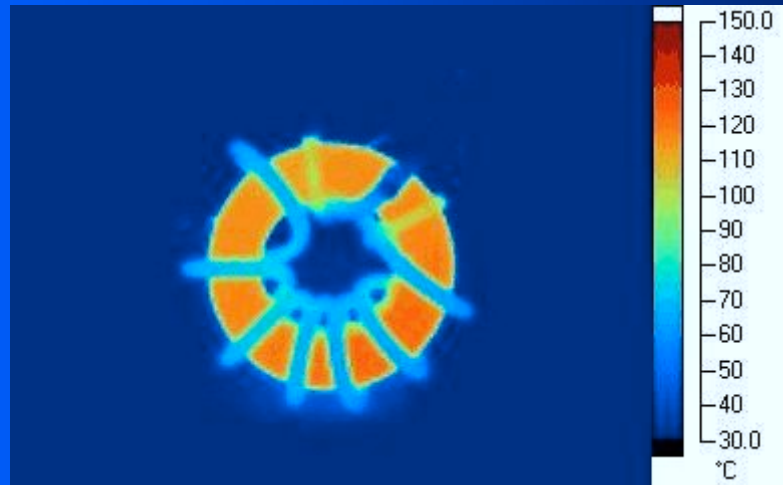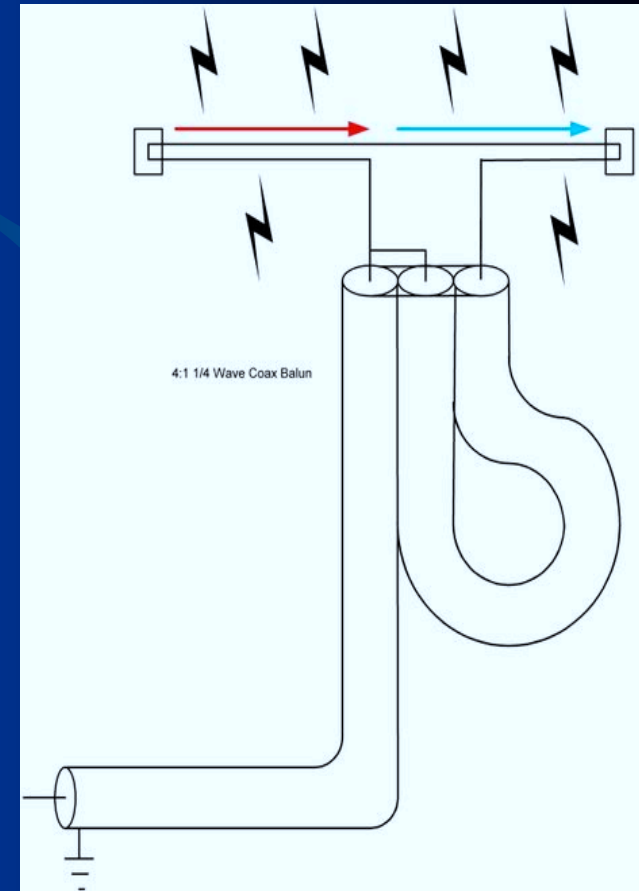
Types Of Baluns

Transmission Line Balun

- Uses transmission line
- Good for one narrow band only
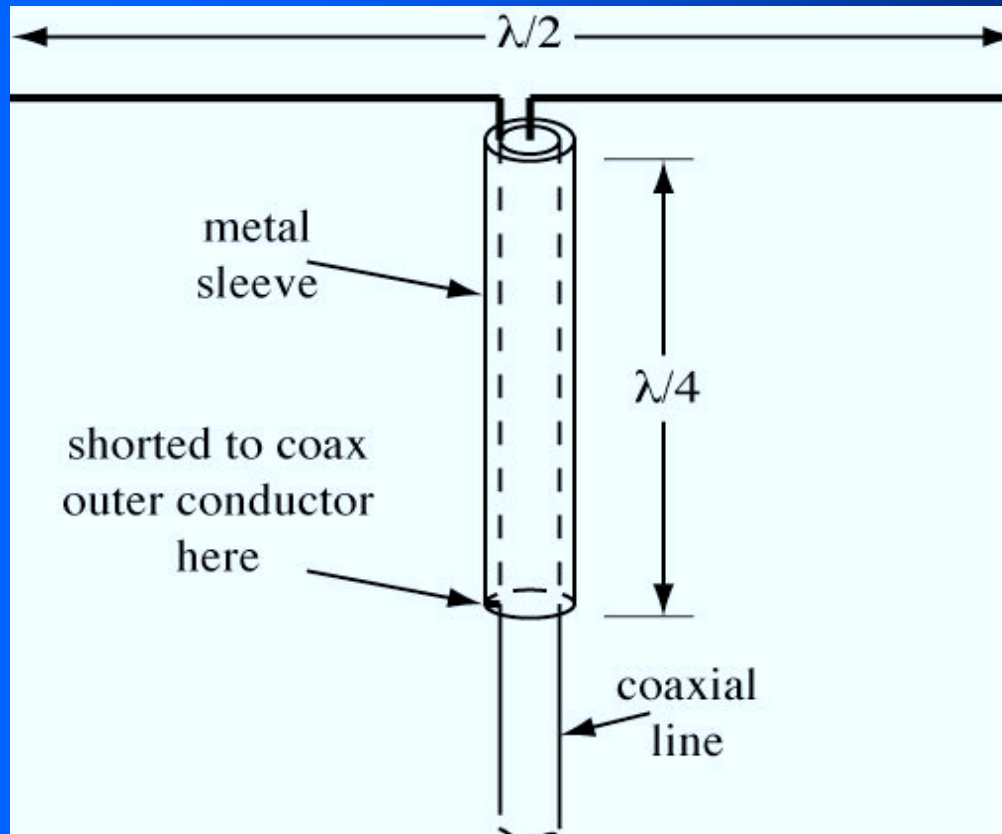- Great for VHF / UHF

4:1 1/4 Wave Coax Balun

Types Of Baluns

Sleeve Baluns

- Great for VHF / UHF
- Complex to fabricate accurately

What Is Our Objective?

Objective

- Stop electromagnetic radiation and reception on unbalanced coax feedline

- In many circuits, RF Choke (inductance) is used.

- RF Choke passes DC and blocks RF using inductive reactance & impedance

- RF Choke ONLY blocking RF on outside of coax should work

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What Is Our Objective?

- What causes RF on outside of coax?

- RF current from xmitter is I1 & I2. Equal and opposite

- I2 splits into I4 (dipole arm) and I3 (outside of coax)

- Magnitude of I3 depends on RF impedance to ground at unbalanced-to-balanced transition

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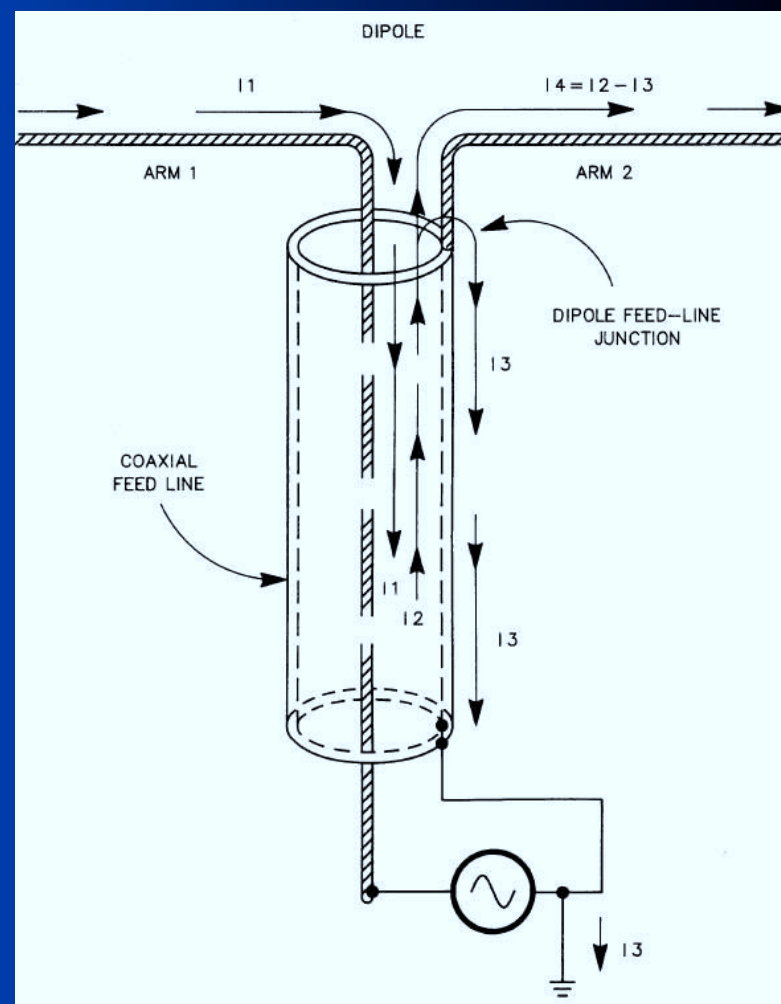
What Is Our Objective?

- RF Choke passes DC and blocks RF using inductive reactance & impedance

- Guanella - RF Choke ONLY blocking RF on outside of coax should work

- Choke is only dealing with the common mode current on outside of coax. Does not handle full Xmitter power
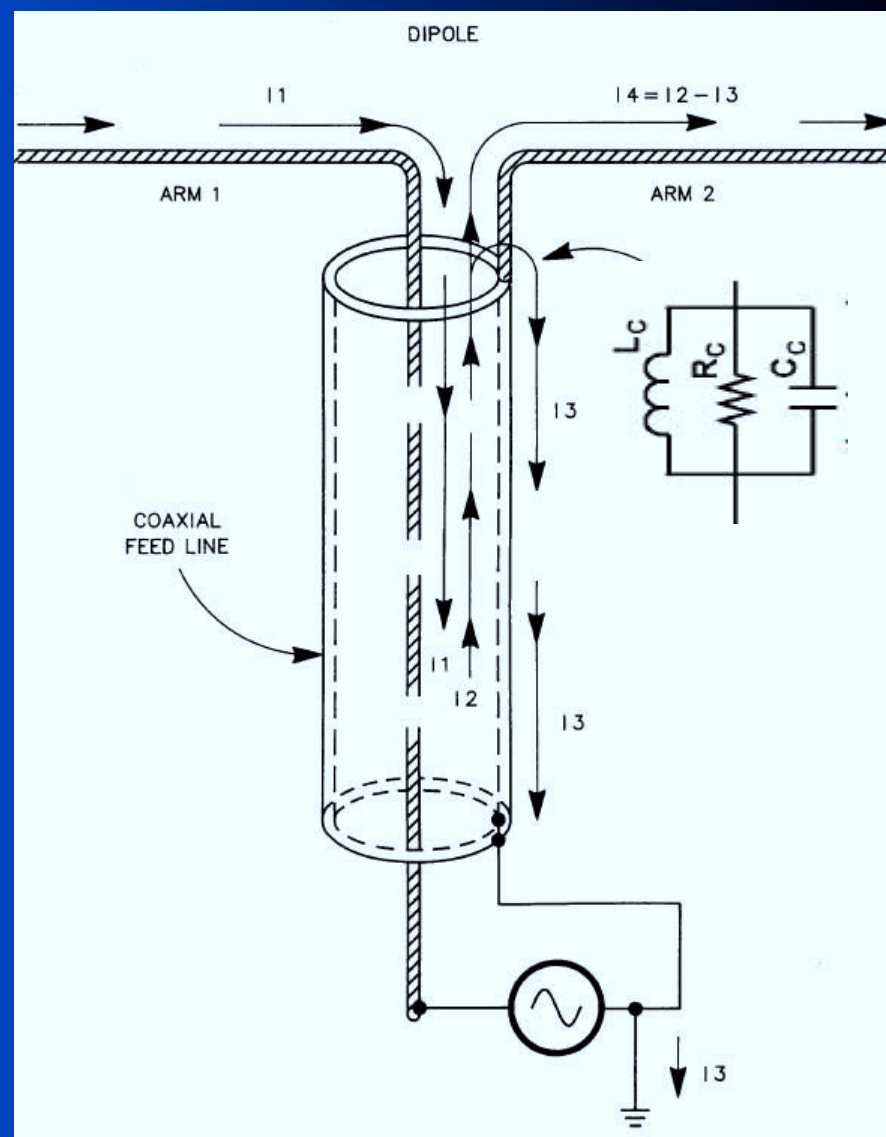
Types Of Current Baluns

Air Core Coax Choke

- Advantage- Cheap and simple to build

- Takes many turns to achieve inductance/ impedance needed at lower frequencies

- Capacitance between ends causes resonance at undesirable freq.

Types Of Current Baluns

- Maxwell considered 500z impedance was sufficient– current experts say 1500 z minimum, 5000 z best

- Ferrite cores on chokes increase inductance reactance / impedance substantially

- Must be the correct "Mix" of ferrite material for the desired frequencies and impedance
  - Mix 31 ferrites, available only in Fair-Rite ferrite products is considered the best for HF band current choke cores

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Types Of Current Baluns
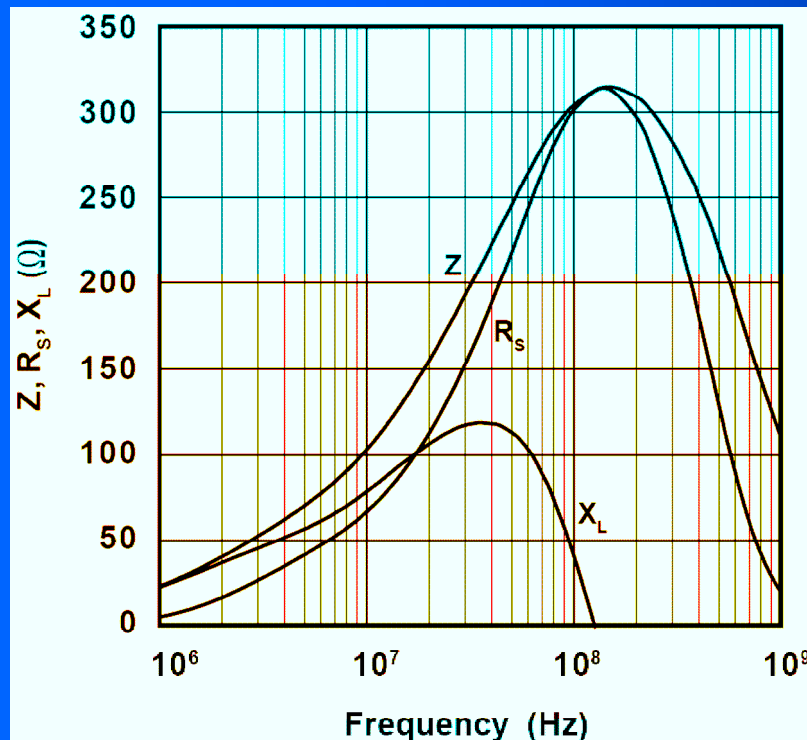
1 Turn Clamp-on Mix 31 Ferrite

- Wideband - Mix 31 has 8:1 effective frequency span
- Compare to Mix 43 with 4:1 effective frequency span
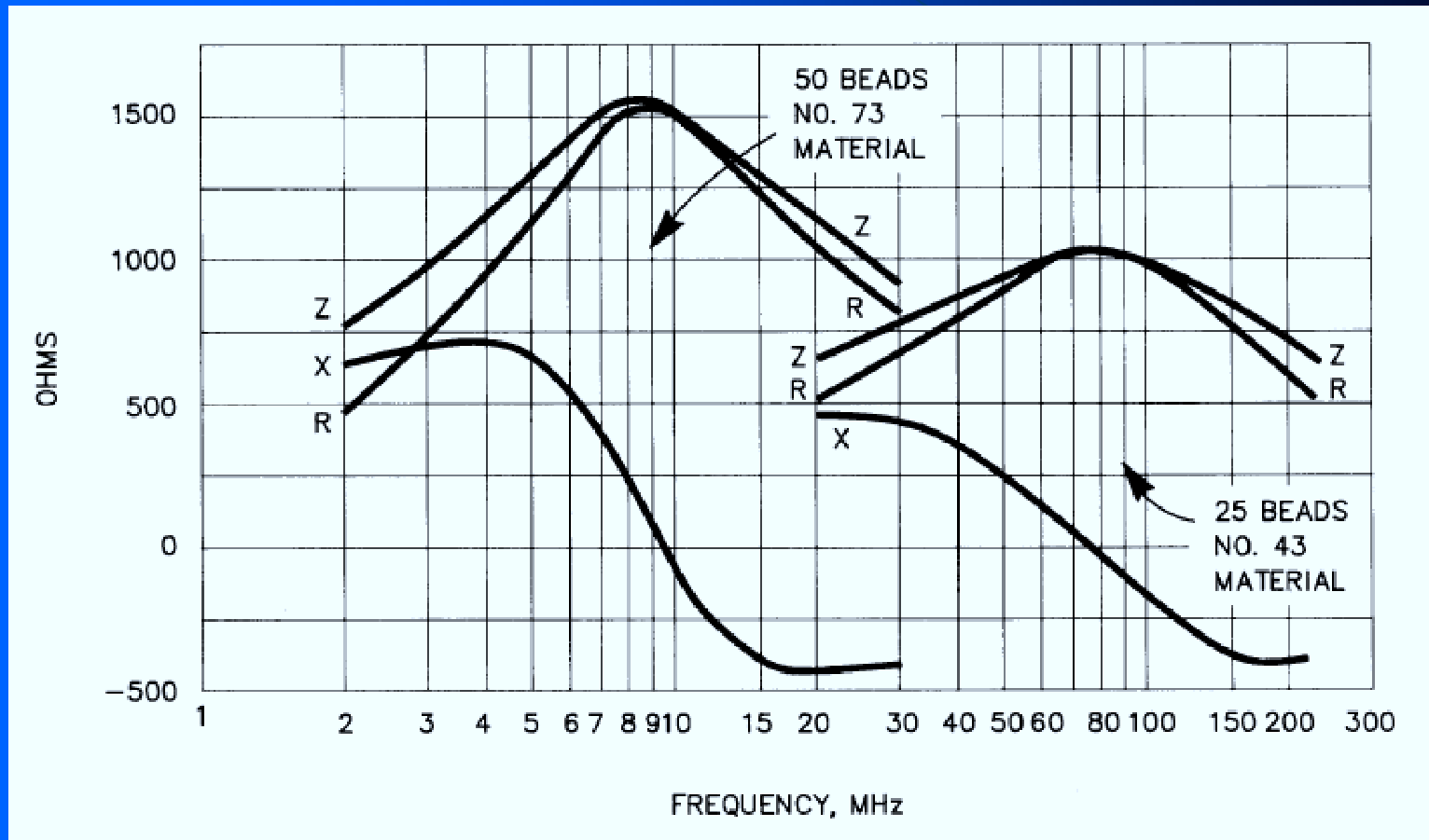
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Types Of Baluns

"String Of Beads" Balun

- Multiple ferrite beads around the coax
- Each bead only contributes a small impedance

- Must be the correct "mix"

- Takes many beads (30-50 or more) at lower frequencies

8231, 8232

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Types Of Baluns
W2DU "String of Beads" Model
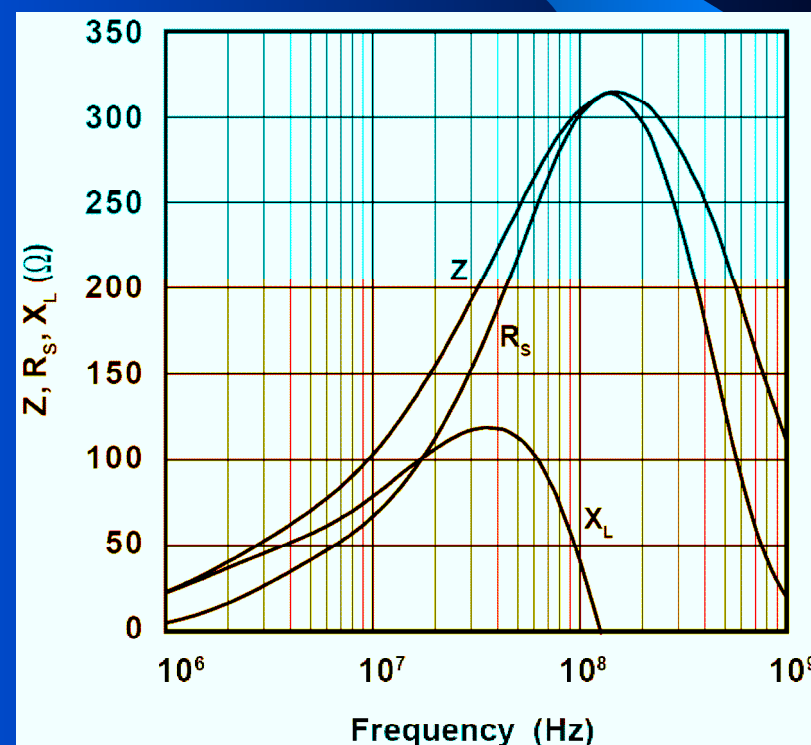
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Types Of Current Baluns

- Multiple Winding Ferrites
  - Each pass through the center of a ferrite increases the impedance by the square of the passes
  - Multi-turn Impedance = 1 Pass Impedance x (No of Turns)^2

Using graph on left

- Z @ 4Mhz = 70

- 5 Passes thru core

Total Z= 70 * 5^2=1750z

Types Of Current Baluns

- Multi-turn Coax Using Ferrite Toroids
  - Each pass through the center of a ferrite increases the impedance by the square of the passes

$= 70Z * (5turns)^2 * 5$ Mix 31 Toroids $= 5600$ Z

Cost $= \$7$ per Toroid $= \$35$ (plus coax)

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Types Of Current Baluns

- Multi-turn Coax Using Ferrite Toroids

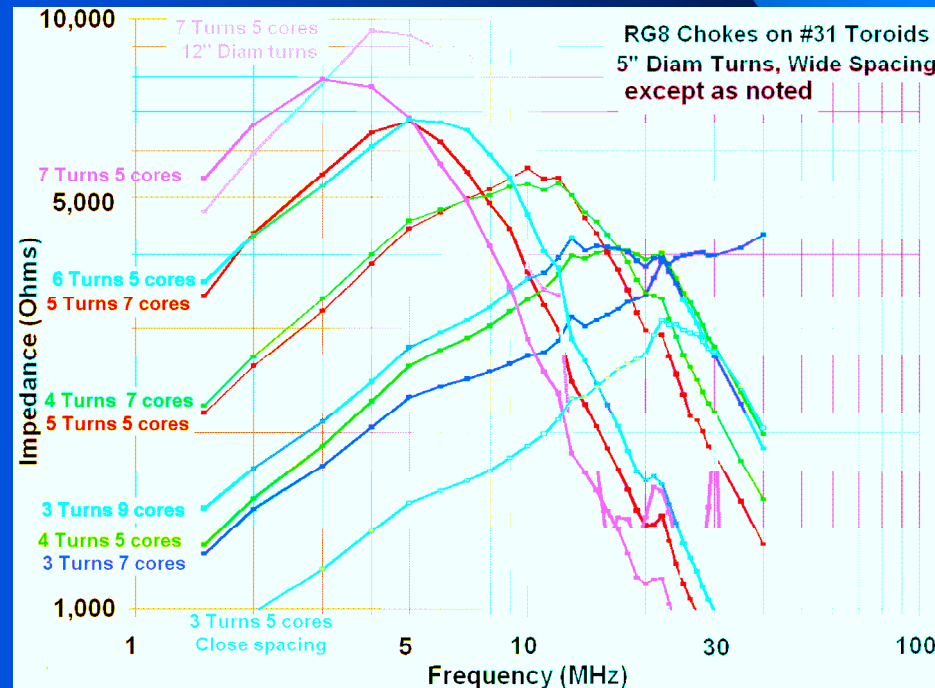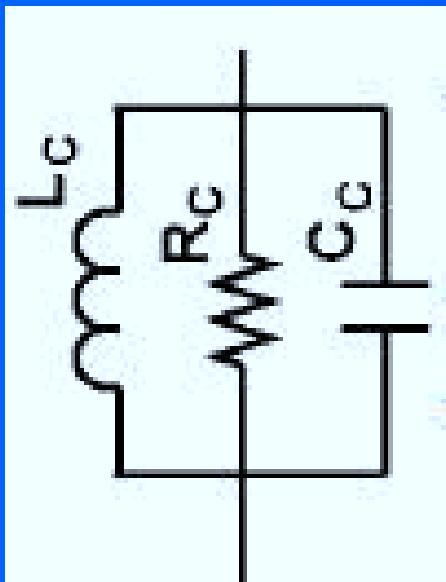 - Each pass through the center of a ferrite increases the impedance by the square of the passes
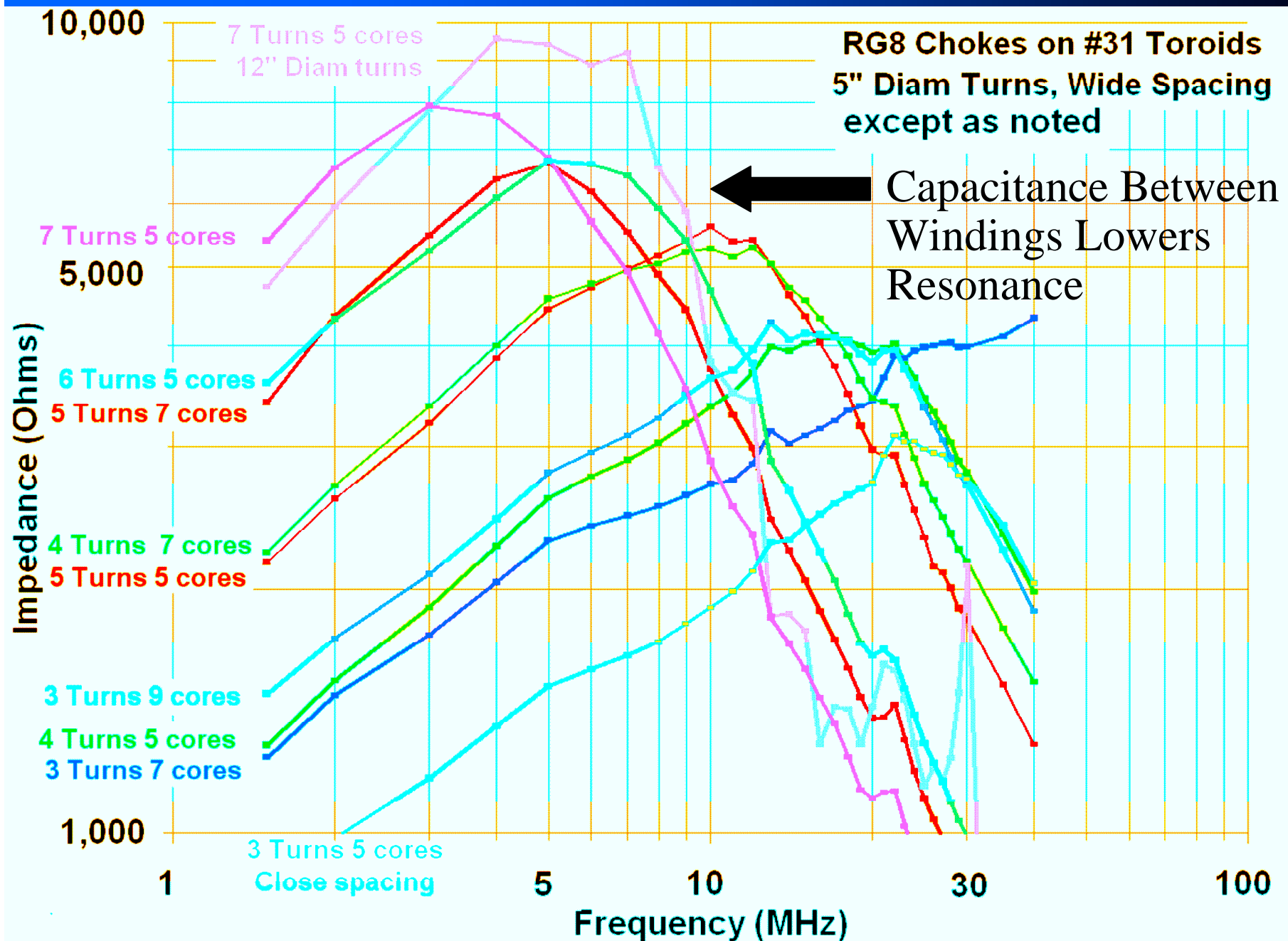
  - Also increases the capacitance, lowering the resonance of our equivalent tuned circuit

RG8 Chokes on #31 Toroids
5" Diam Turns, Wide Spacing
except as noted

Capacitance Between Windings Lowers Resonance

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Types Of Current Baluns

- Multi-turn Bifilar Wound Wire Using Ferrite Toroids
  - Each pass through the center of a ferrite increases the impedance by the square of the passes
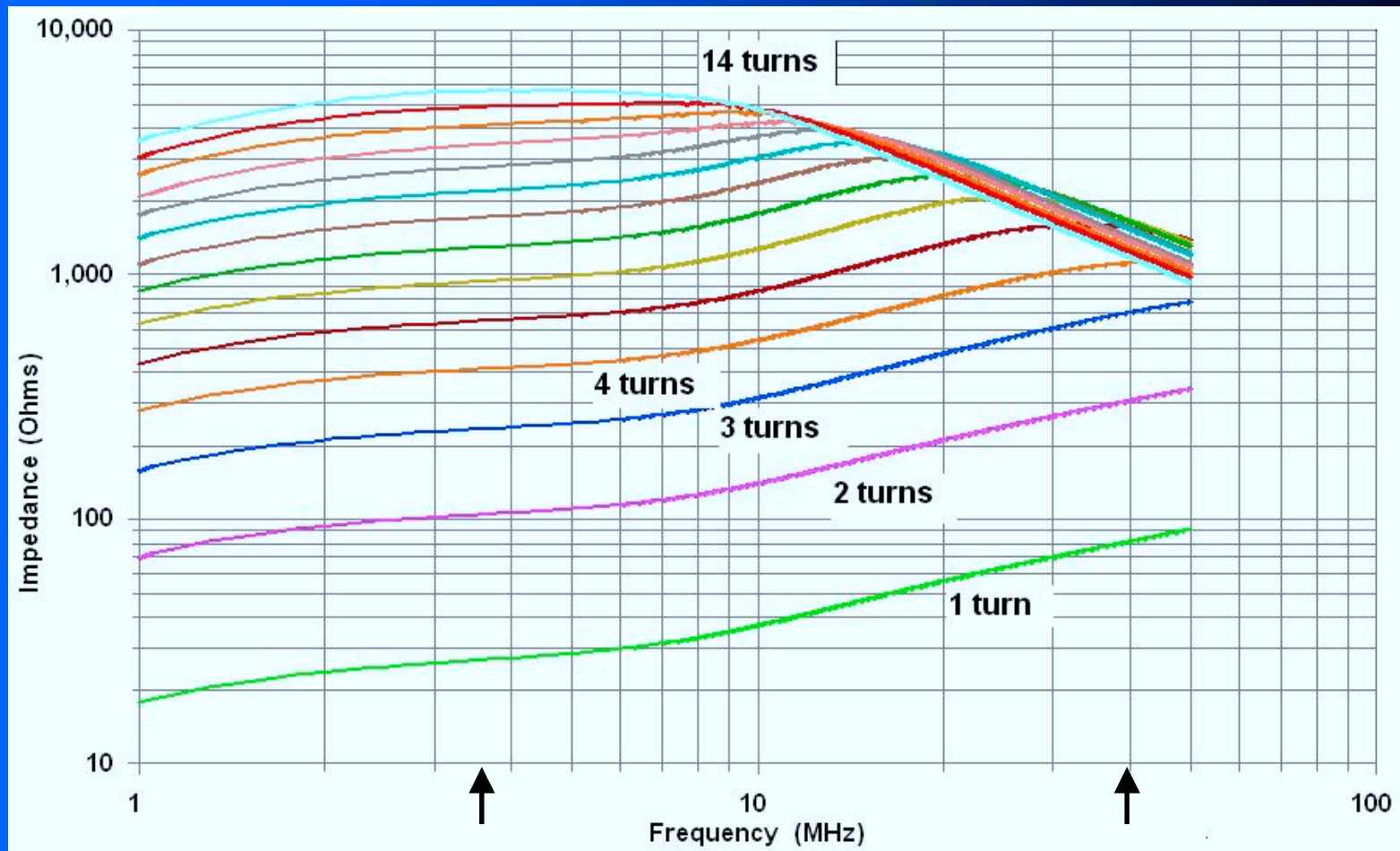 - #12 to #16 Coated Magnet Wire, or THHN electrical

-Magnet wire close to 50 Z

-THHN close to 100 Z

Types Of Current Baluns

- Stray capacitance between windings less with bifilar wound vs coax

Mix 31 2.25 inch toroid

Take Away

- Transformer (aka voltage) baluns have issues and are rarely the best balun approach
- Stop the RF on the outside of coax with a ferrite-based current choke balun
- Getting the correct ferrite material for the planed operating frequency is essential. Mix 31 is currently the best for the HF bands.
- The W2DU "string of beads" current choke works OK but it takes a lot of beads, typically > 50 depending on size and mix
- Winding a "transmission line" around a 2 ¼" mix 31 balun is the most cost effective and efficent way to create an HF balun

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Where to Get More Information

- Ref 1- Some Aspects of the Balun Problem; Walter Maxwell
  http://w2du.com/r2ch21.pdf

- Ref 2- A Ham's Guide to RFI, Ferrites, Baluns, and Audio
  Interfacing by Jim Brown K9YC

- Ref 3- Choosing the Corect Balun by Tom W8JI,
  http://www.dxengineering.com

- Ref 4- ARRL Antenna Book

- Ref 5- Baluns: What They Do And How They Do It By Roy
  Lewallen, W7EL
  http://www.eznec.com/Amateur/Articles/Baluns.pdf