Baluns: Good, Bad & Ugly

Steve Sterling, WA7DUH
**Baluns: The Good, Bad & Ugly**

- **Balanced To Unbalanced** = 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
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
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
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
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
Types Of Current Baluns

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

1 Turn Clamp-on Mix 31 Ferrite
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
Types Of Baluns
W2DU “String of Beads” Model

[Graph showing Types Of Baluns with different numbers of beads and materials]
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

\[ = 70Z \times (5\text{turns})^2 \times 5 \text{ Mix 31 Toroids} = 5600 \text{ Z} \]

Cost = $7 per Toroid = $35 (plus coax)
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
Capacitance Between Windings Lowers Resonance
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
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 planned 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 efficient way to create an HF balun
Where to Get More Information

- Ref 1- Some Aspects of the Balun Problem; Walter Maxwell
- Ref 2- A Ham's Guide to RFI, Ferrites, Baluns, and Audio Interfacing by Jim Brown K9YC
- Ref 3- Choosing the Correct Balun by Tom W8JI,
  [http://www.dxengineering.com](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](http://www.eznec.com/Amateur/Articles/Baluns.pdf)