Baluns, Ununs and Chokes

What They Are And When You Need Them

Flathead Valley Amateur Radio Club Presentation

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May 20, 2025

TOPICS

- What is a balun?
- Antenna problems often requiring a balun
- “Balanced” versus “unbalanced”
- When baluns are necessary
- The Current balun
- The Voltage balun
- Selecting a balun
- Balun installation

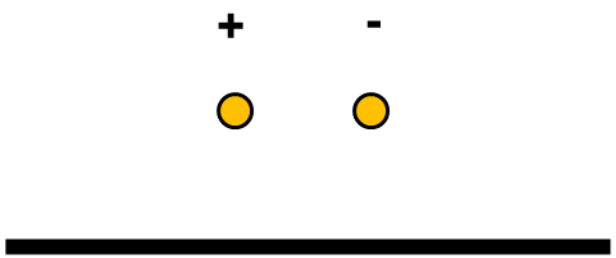
What is a Balun?

- A blended word: **Bal**anced with **un**balanced
- The name for a device such as:
  - Unbalanced to balanced transformers
    - Typical use: mating coax to twin lead
  - Step-up and step-down transformers
    - Typical use: impedance matching
  - Common mode chokes

Antenna Problems Often Requiring a Balun

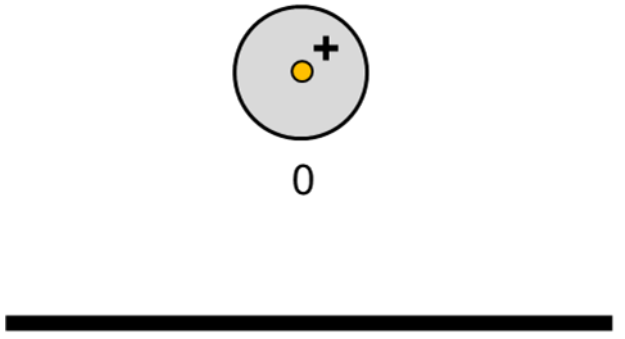
- Problems caused by unbalanced currents on the feedline
  - Radio Interference (RFI) to nearby devices
  - Transmission line radiation
    - Antenna radiation pattern distortions
    - Some antenna designs use the coax as a counterpoise
      - End-fed or asymmetrically-fed antennas
  - RF in the shack
    - “Hot” mic and/or radio chassis
    - Transmit audio distortion
    - Interference with other devices in the shack
  - Loss of power to antenna due to mismatch between the transmission line and antenna
  - Noise coupled into the receiver

“Balanced” vs. “Unbalanced”



Twin Lead

The voltages are usually *balanced* with respect to ground.



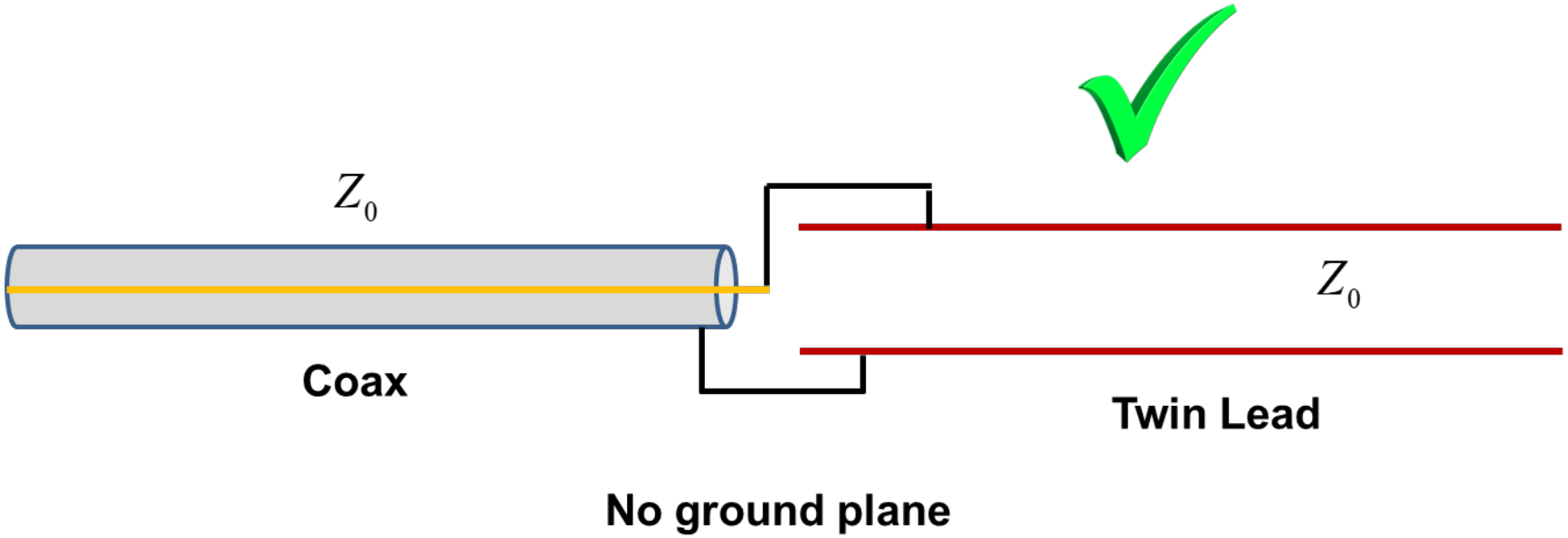
Coax

The voltages are usually *unbalanced* with respect to ground.

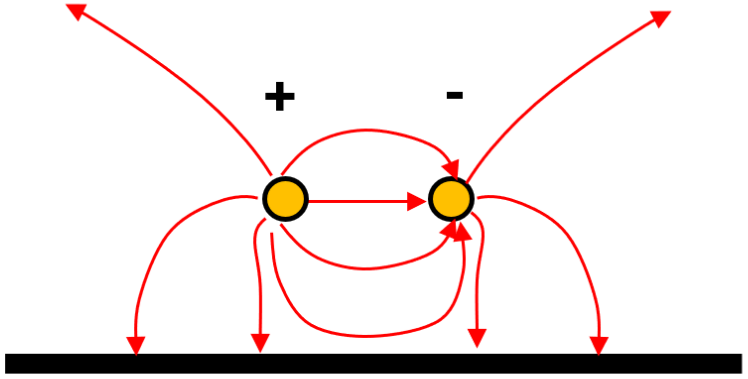
Note:
If the coax outer conductor was not at zero volts, there would be a field between the coax and the ground. There would be charge and current on the outside of the coax.
This would correspond to a “common mode”.

Why Baluns Are Necessary

- Baluns are necessary because, in practice, the two transmission lines are always running over a ground plane (electrical and/or earth)
  - If there were no ground plane, connecting coax to twin lead would not need a balun
    - A matching network would still be required if they had different impedances

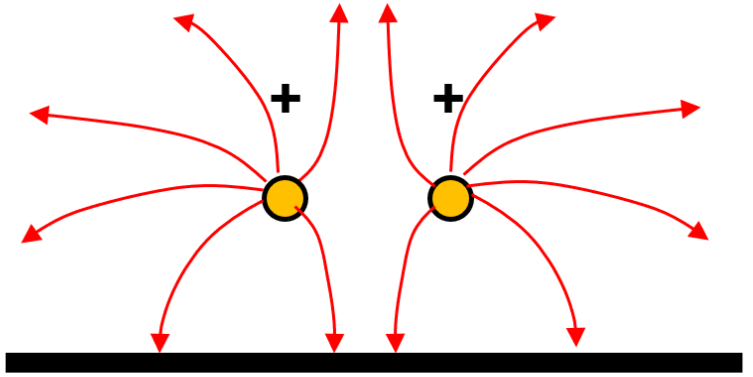


When a ground plane is present, we really have three conductors, forming a multiconductor transmission line, and this system supports two different modes.



Differential mode

(desired)



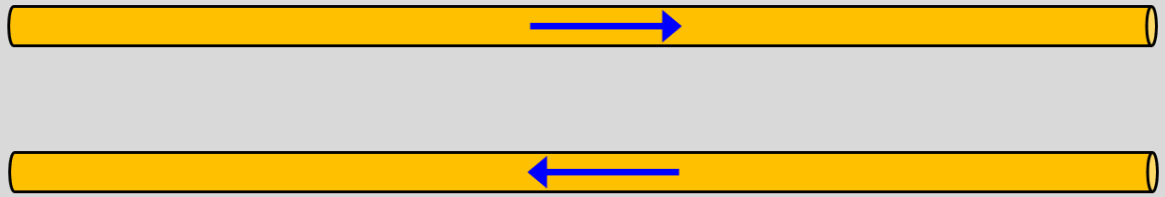
Common mode

(undesired)

The differential and common modes are shown for a twin lead over ground.

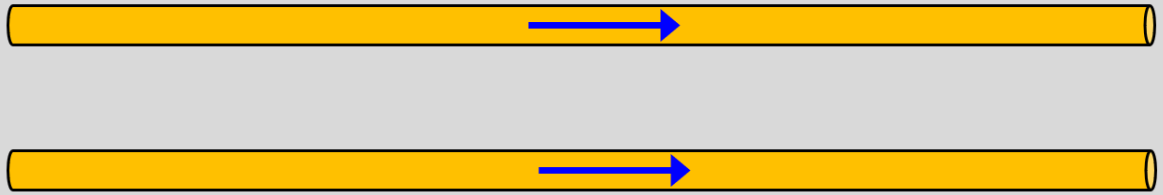
For the common mode, both conductors of the transmission line act as one net conductor, while the ground plane acts as the other conductor (return path for the current).

Differential mode: currents are equal and opposite

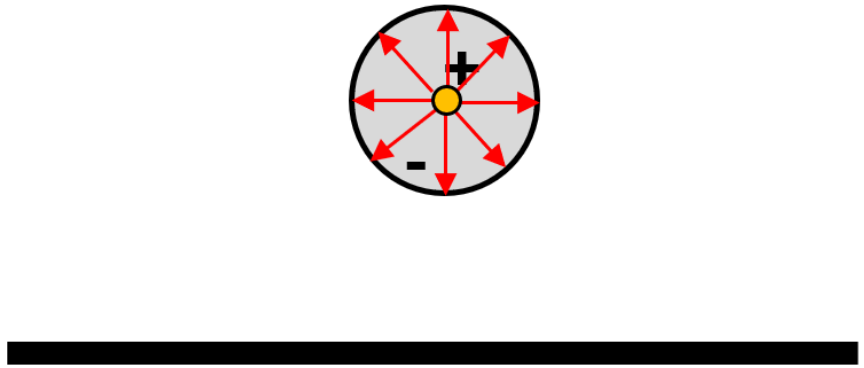


Ground

Common mode: a net current flows on the two conductors

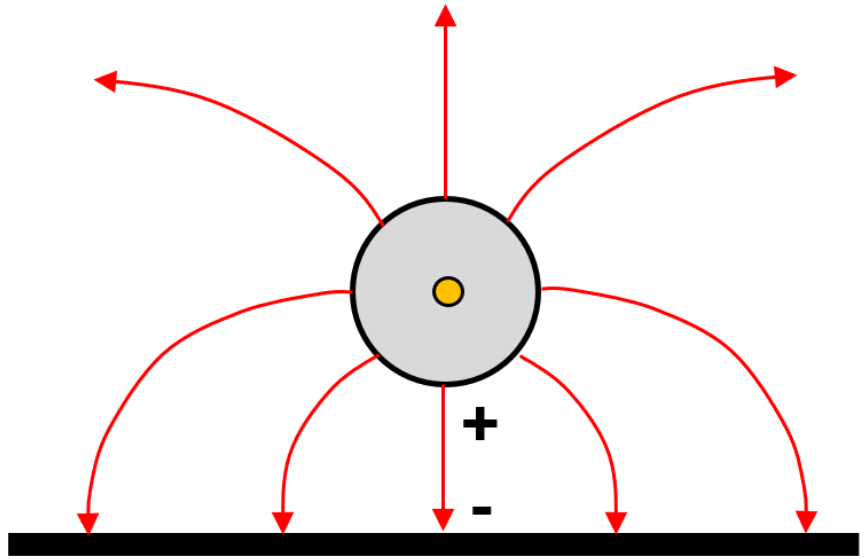


Ground



Differential mode

(desired)



Common mode

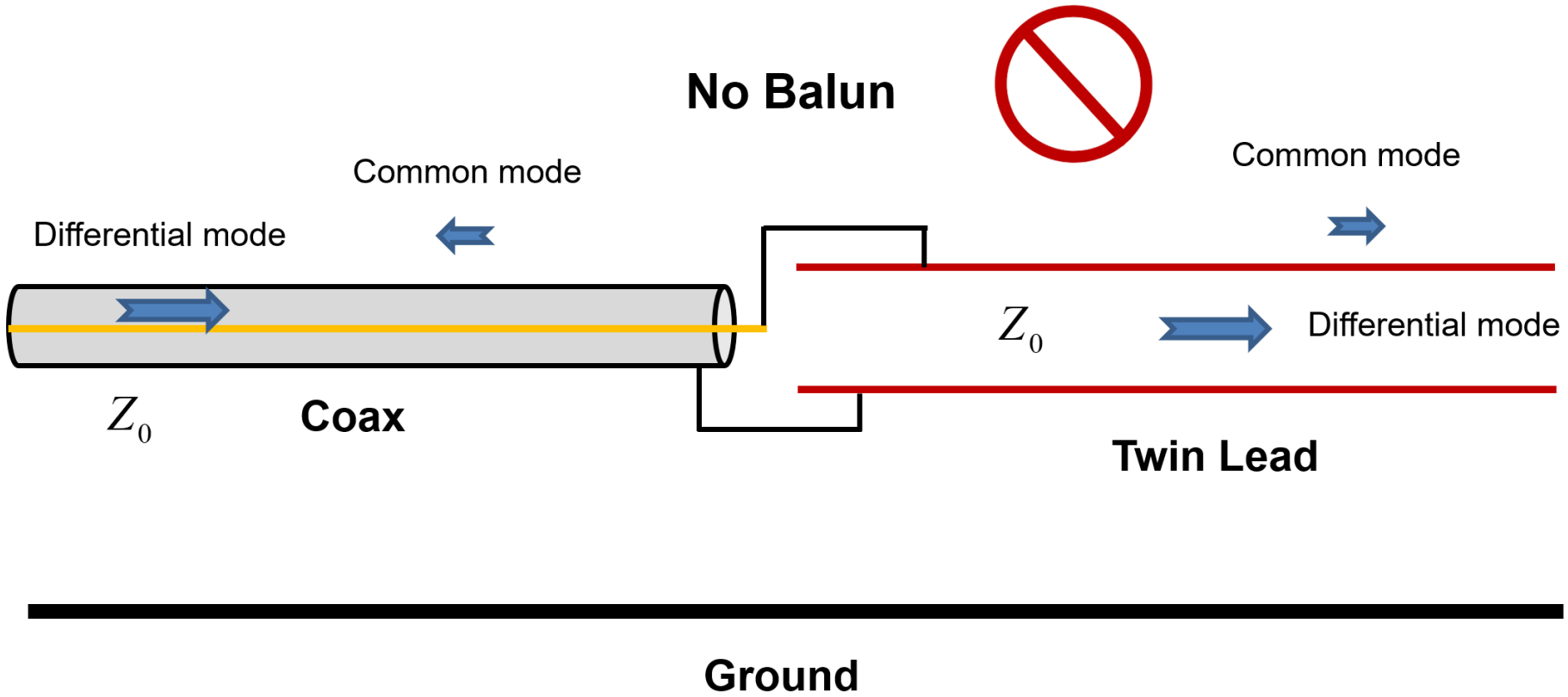
(undesired)

The differential and common modes are shown for a coax over ground.

(The red flux lines show the electric field.)

Baluns for Coax to Twin Lead

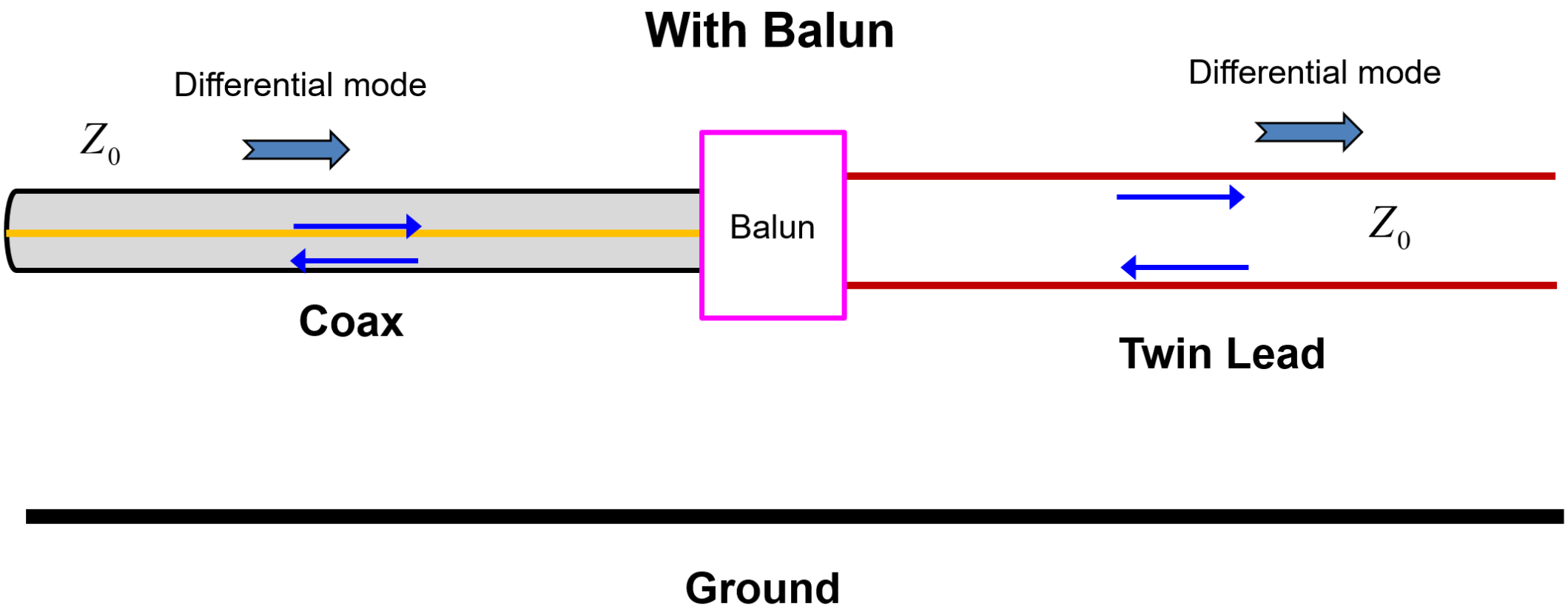
Because of the asymmetry, a common mode current will get excited at the junction between the two lines, and propagate away from the junction.



Note:
If the height above the ground plane goes to infinity, the characteristic impedance of the common mode goes to infinity, and there is no common mode current – we would not need a balun.

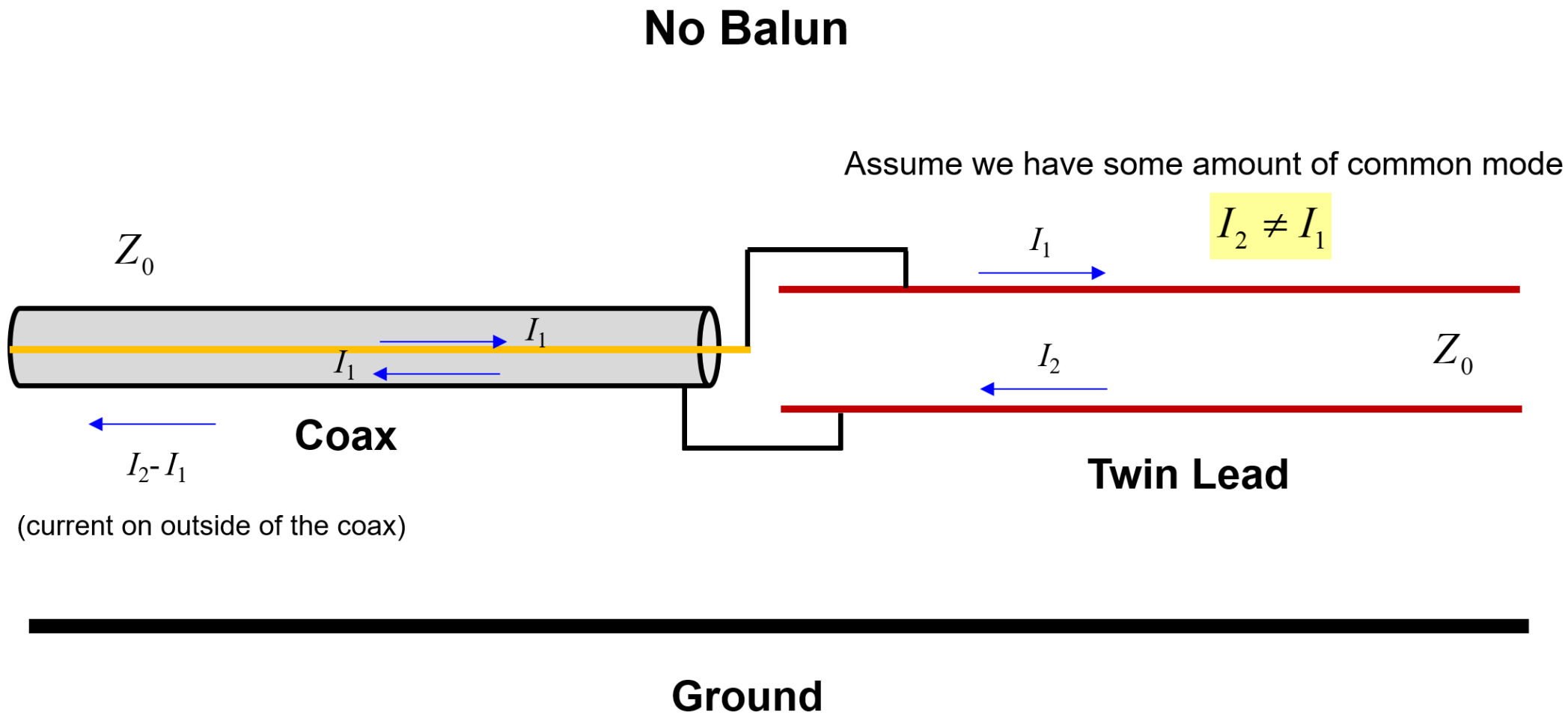
Baluns for Coax to Twin Lead (cont.)

A balun prevents common modes from being excited at the junction between a coax and a twin lead.



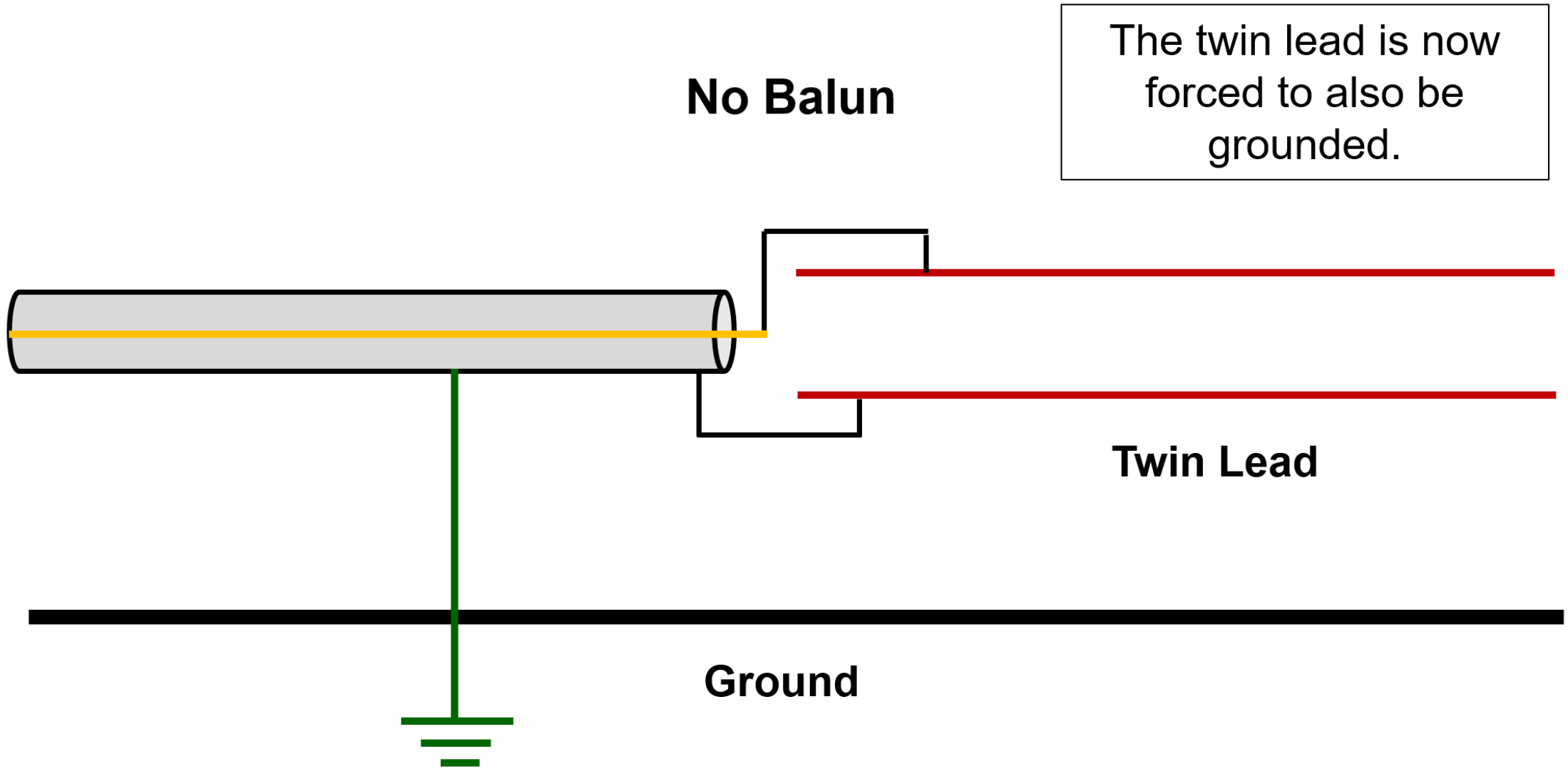
Baluns for Coax to Twin Lead (cont.)

From another point of view, a balun prevents currents from flowing on the outside of the coax.



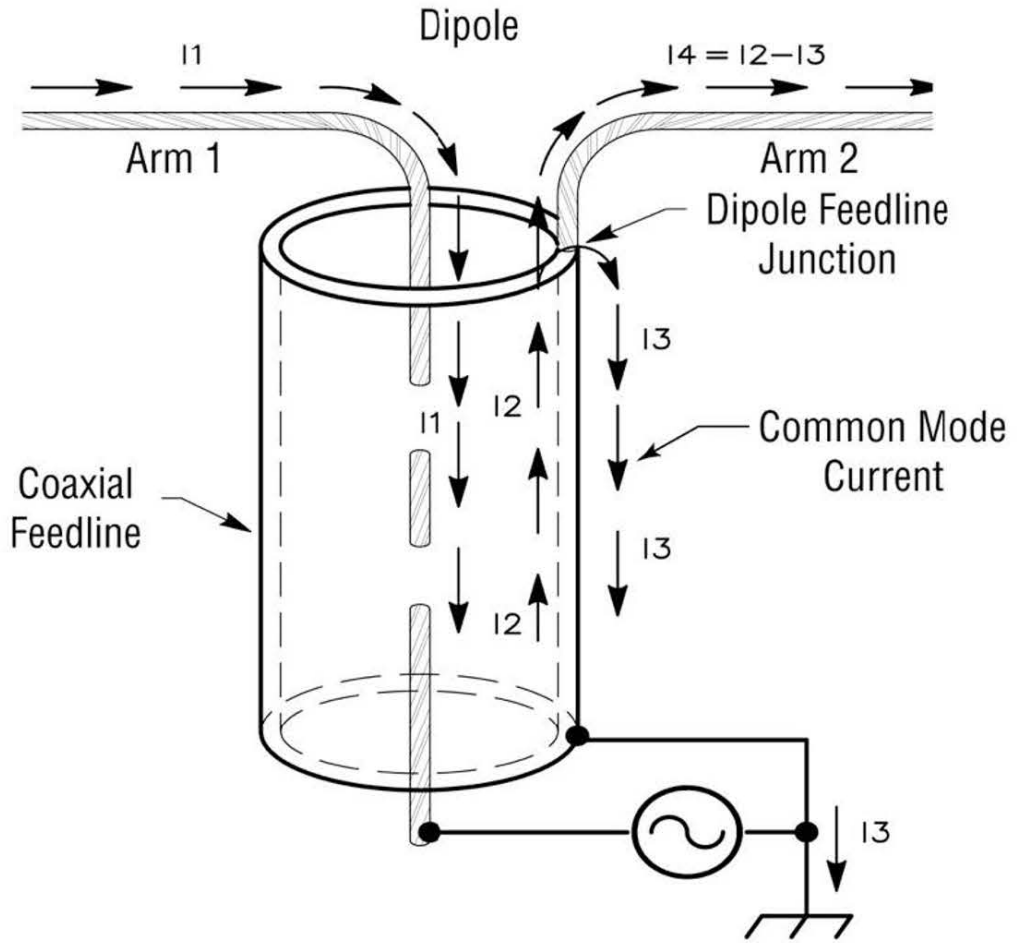
Baluns and Grounding

Baluns are also useful whenever one transmission line is grounded and the other one isn't.



Baluns for Antennas

If you try to feed a dipole antenna directly with coax, there will be a common mode current on the coax.



$I_1 = I_2$

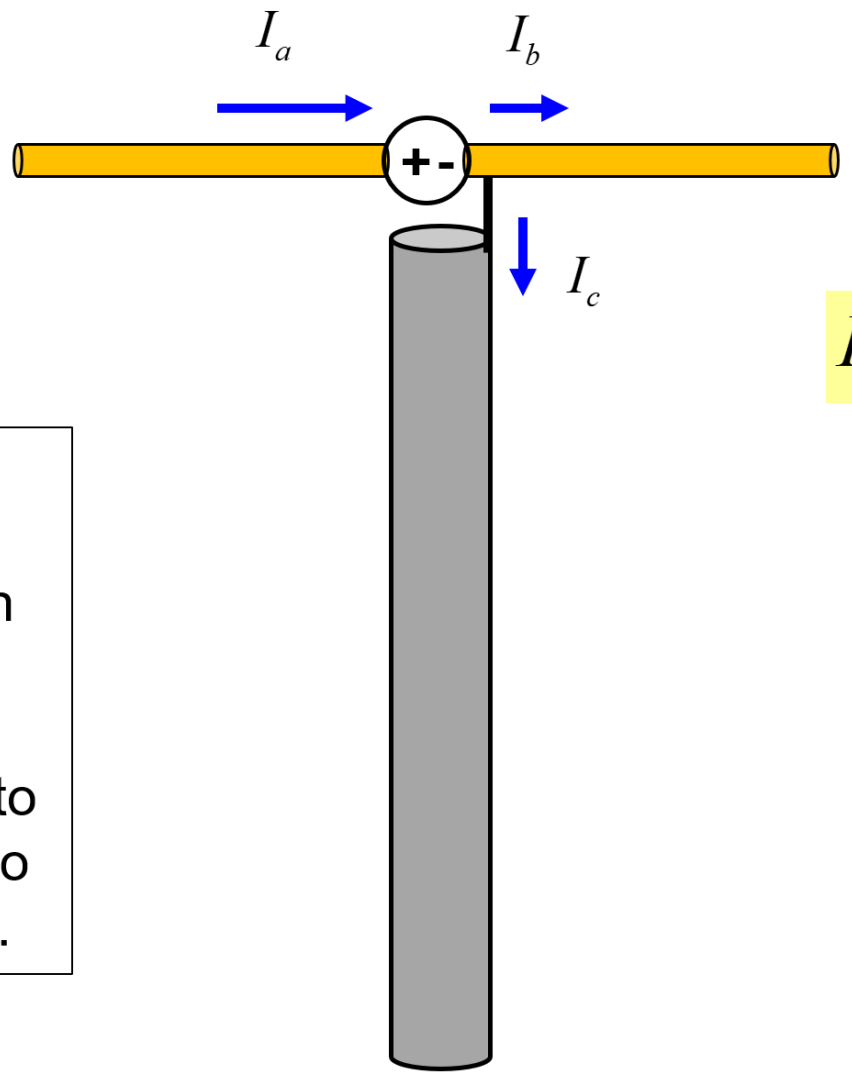
$I_3 \neq 0$

$I_4 \neq I_1$

No balun

Baluns for Antennas (cont.)

The equivalent circuit explains why there is a common mode on the coax.



$$I_a = I_b + I_c$$

$$I_a \neq I_b$$

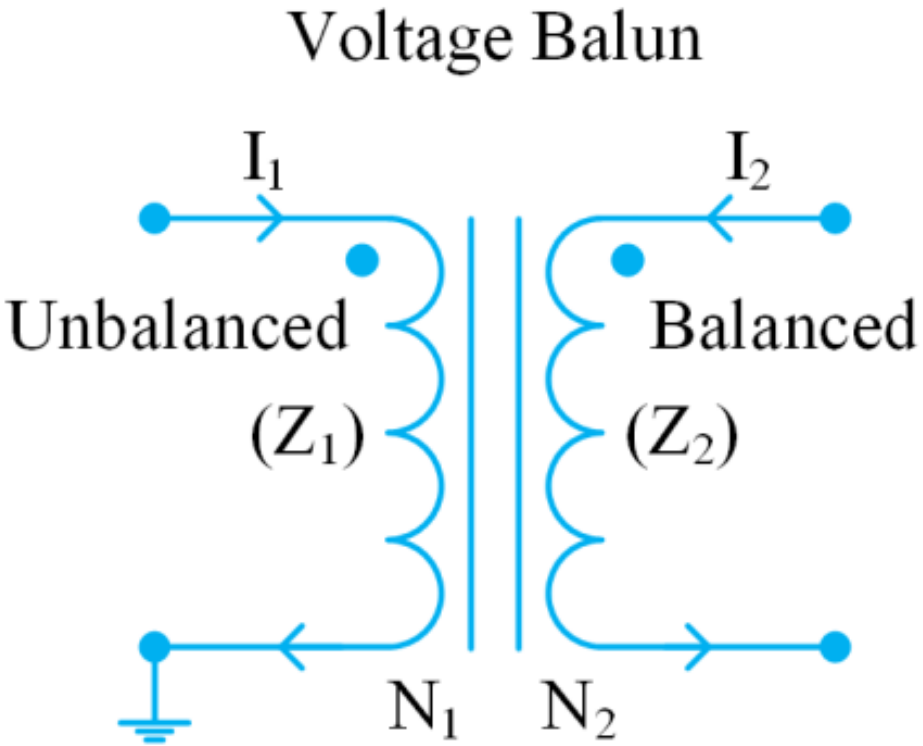
No balun

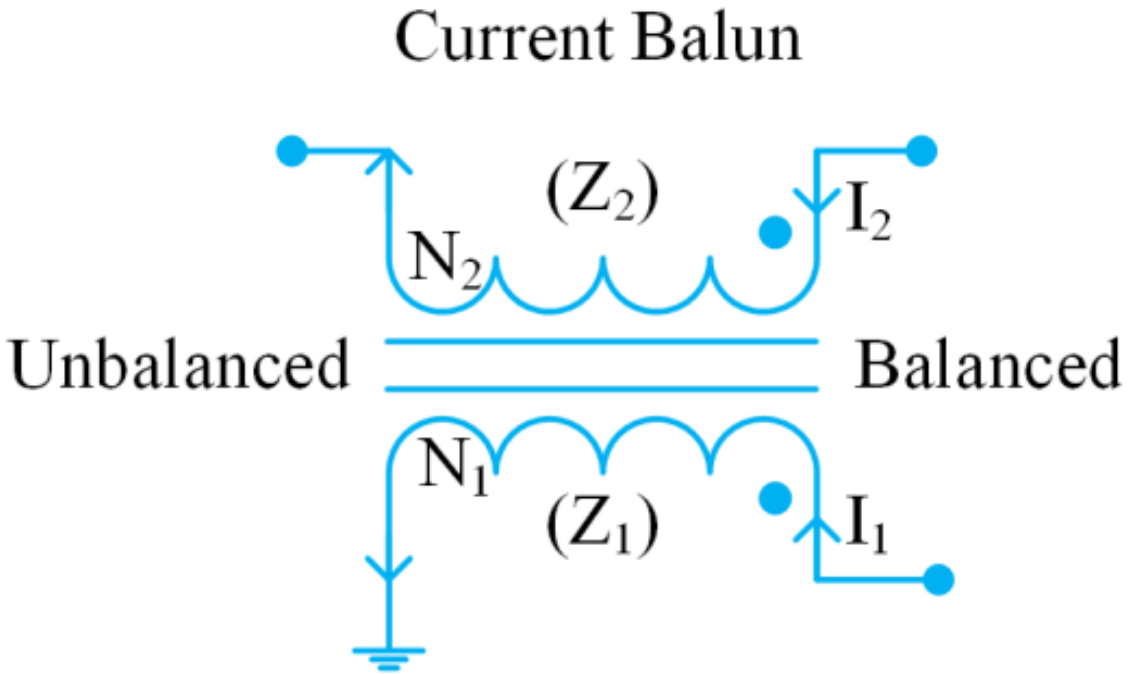
Note:
The voltage source sees an asymmetric structure. The current flowing to the right has two possible paths.

Two Basic Types of Baluns

- Current balun
  - Forces equal currents to flow through the two sides of a balanced load
    - A resonant dipole is a balanced load
    - Often 1:1, but can have other ratios
  - Used to connect unbalanced transmission lines (e.g., coax) to a balanced load
  - Also effective at suppressing common-mode currents
    - **NOTE: The presence of these currents will not be detected by an SWR meter**
  - Typical construction is ferrite beads over coax or wires on ferrite core
  - Many loops of coax wound upon itself without use of a ferrite core is another kind of current balun and is always 1:1
- Voltage balun
  - Forces equal voltages on its output
  - Popular for impedance matching
  - Doesn’t suppress common-mode currents
  - Typical construction uses coax or wires on a ferrite core

Voltage Balun vs. Current Balun



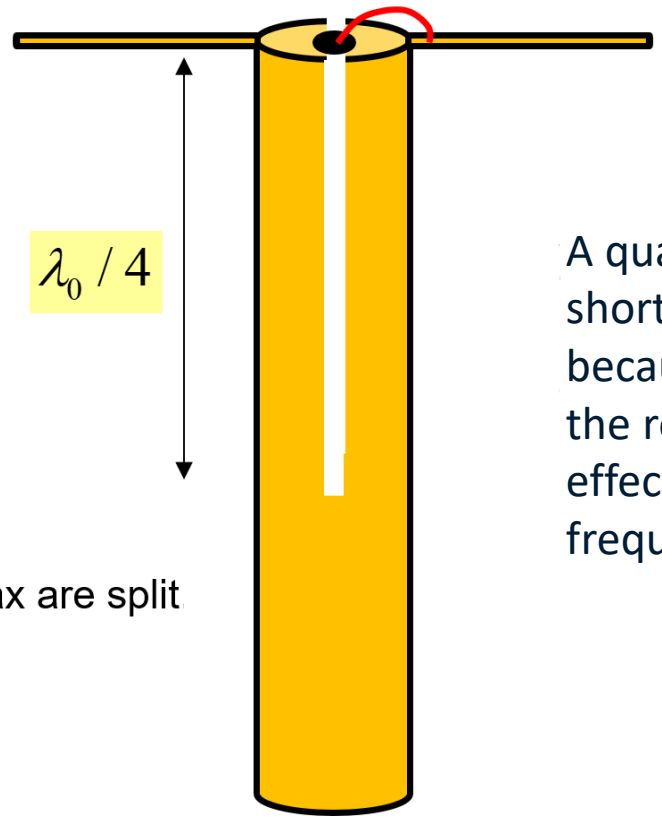


Impedance ratio is the square of its turn ratio.
So, twice as many turns on the output would
Increase the impedance by 4

Baluns for Antennas (cont.)

Another balun for feeding a dipole antenna from coax

"Split Coax Balun"



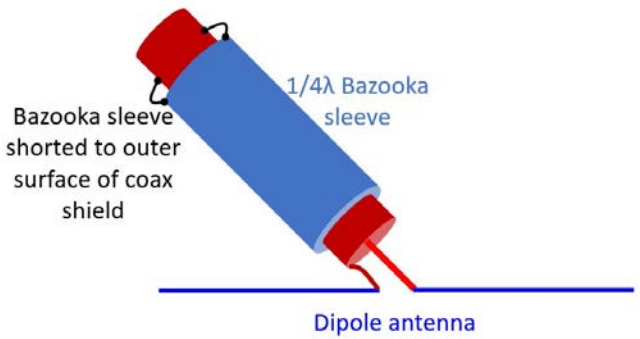
Both sides of the coax are split

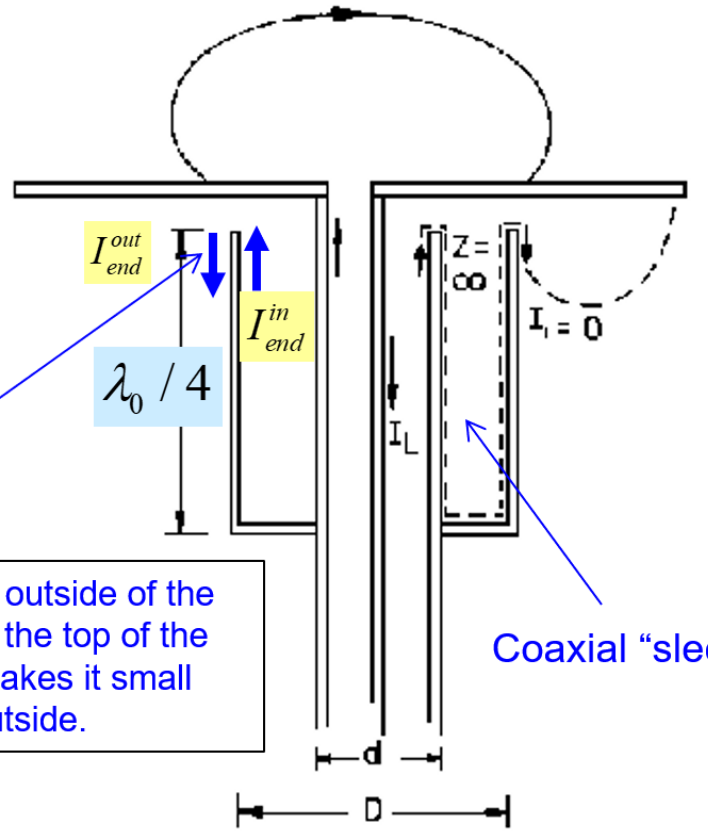
A quarter-wave shorted stub will appear as a short circuit at the resonant frequency. This is because the electrical length of the stub causes the reflected signal to cancel out the original signal, effectively creating a short circuit at that frequency.

Baluns for Antennas (cont.)

Another balun for feeding a dipole antenna from coax.

"Bazooka Balun"





$$I_{end}^{in} = 0 \quad (\lambda_0 / 4)$$

$$I_{end}^{in} = I_{end}^{out} \quad (\text{KCL})$$

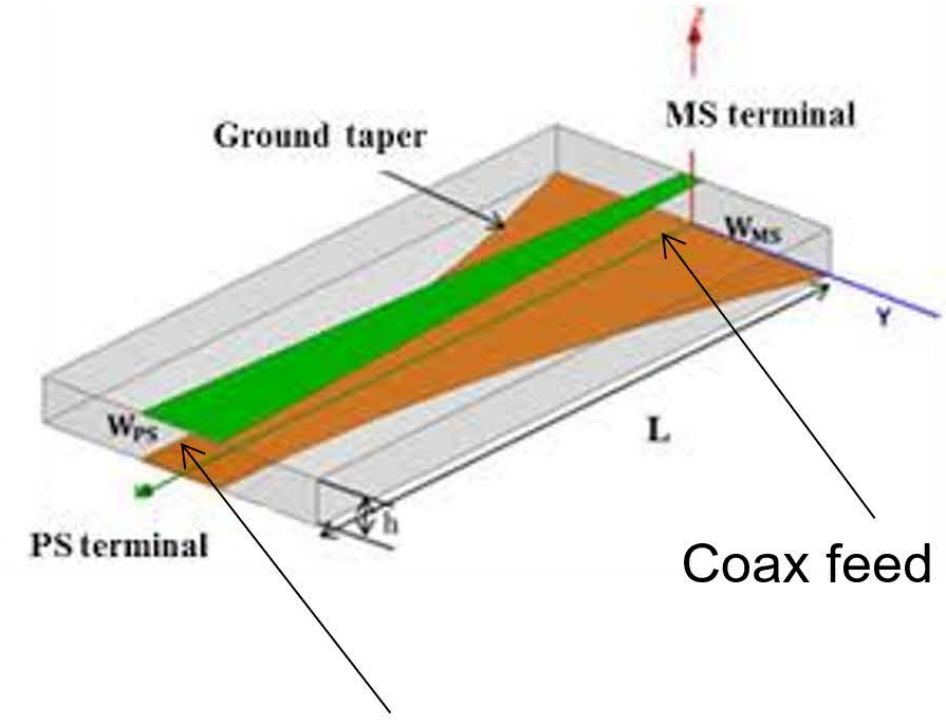
$$\Rightarrow \quad I_{end}^{out} = 0$$

The current on the inside and outside of the sleeve is forced to be zero at the top of the sleeve (open circuit). This makes it small everywhere on the outside.

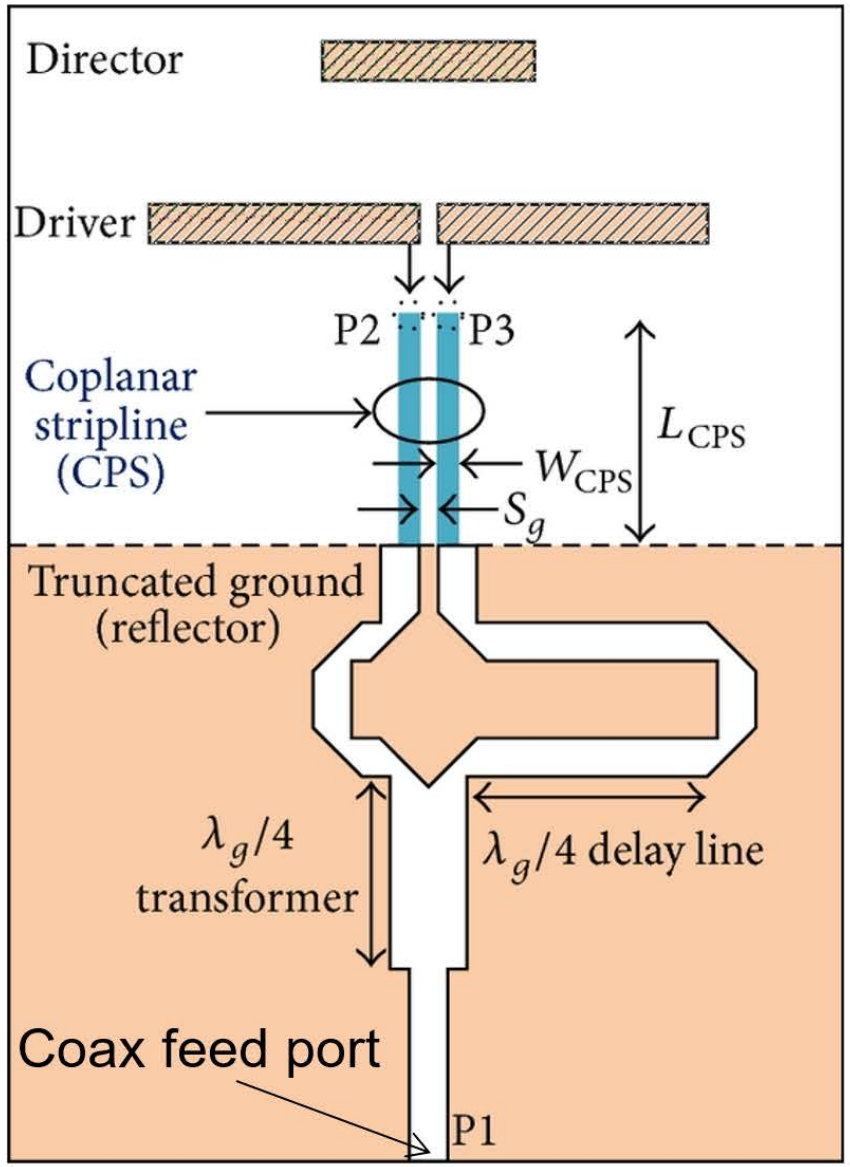
Coaxial "sleeve" region

A "sleeve balun" directly connects a coax to a dipole.

Microstrip balun:

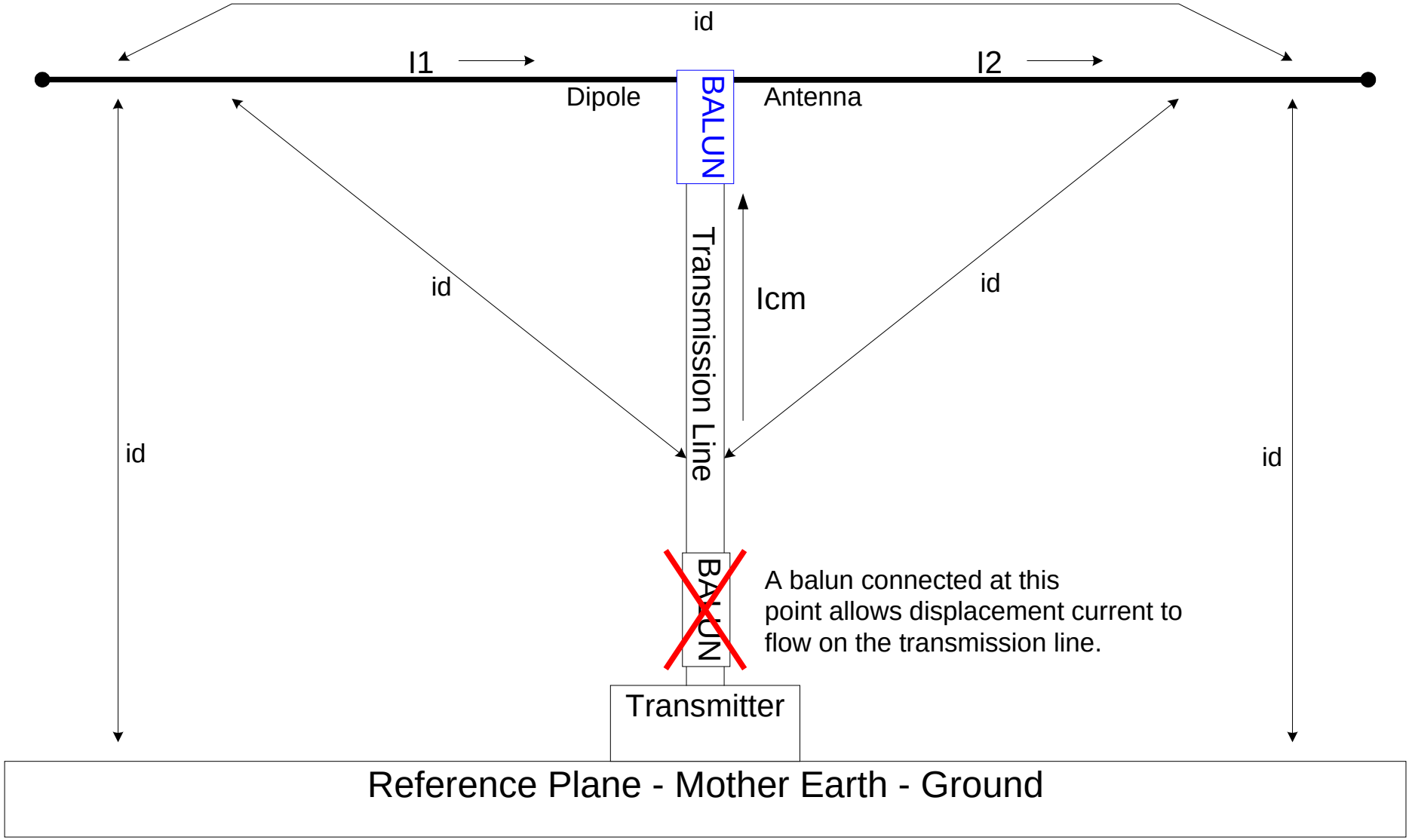


Tapered balun



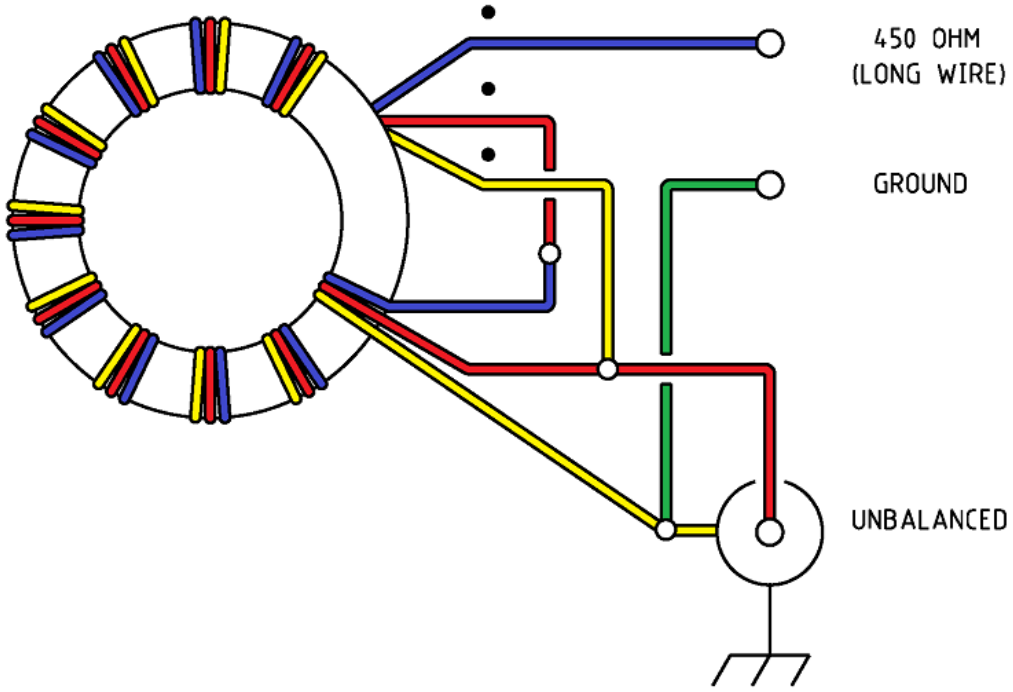
Balun feeding a microstrip Yagi-Uda antenna

Balun Installation



Ununs – Unbalanced to Unbalanced

- Used when an unbalanced feedline is driving an unbalanced antenna and there's an impedance mismatch
  - Whip antenna
  - Vertical antennas with a ground plane
  - Windom
  - Short end-fed single wire antenna
    - 9:1 unun transformer is often used for the popular 33' and 66' "portable" wire antennas
    - This makes the range of impedances seen in multiband use manageable by an ATU
    - Any antenna where one side of the feed system is connected to ground



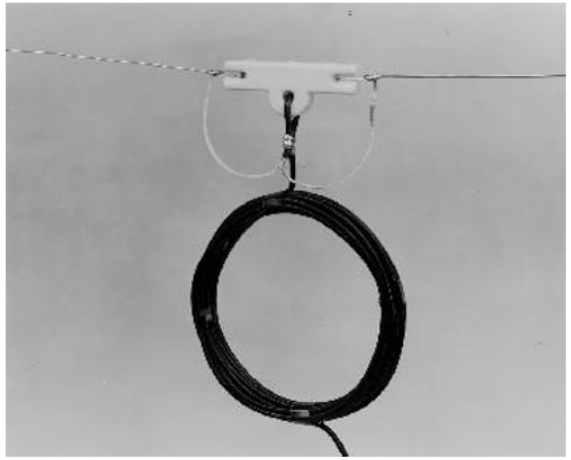
Examples


DX
ENGINEERING
DXENGINEERING.COM
MAXI-CORE® 20
DXE-MC20-C4-1
4:1 Balun
Dual Core
1.8 to 54 MHz

Selecting A Balun

- ALWAYS use a current balun to eliminate common mode current and, if matching is needed, current baluns can also have a ratio (e.g., 4:1 or 9:1) as required to match the antenna
- Use a voltage balun only for impedance matching of antenna to transmission line
  - It will not block common mode currents
- The description of commercial baluns may or may not include whether it is a current or voltage balun
  - For example, the catalog description of the W2AU ferrite balun usually does not indicate that it is a voltage balun
- A 1:1 current balun is sometimes called a choke balun

Make A Simple Choke Balun



A choke balun can be made by winding several turns of coax to form an inductor

Another option for making a choke balun is to place a number of ferrite beads over coax.

Making A 1:1 Current Balun on a Ferrite Core

Click the link below for the video:

https://www.youtube.com/watch?v=nmtRsHmLGsM

“Trick” Question: What kind of balun should be used to feed an Off-Center Fed Dipole (OCFD)?

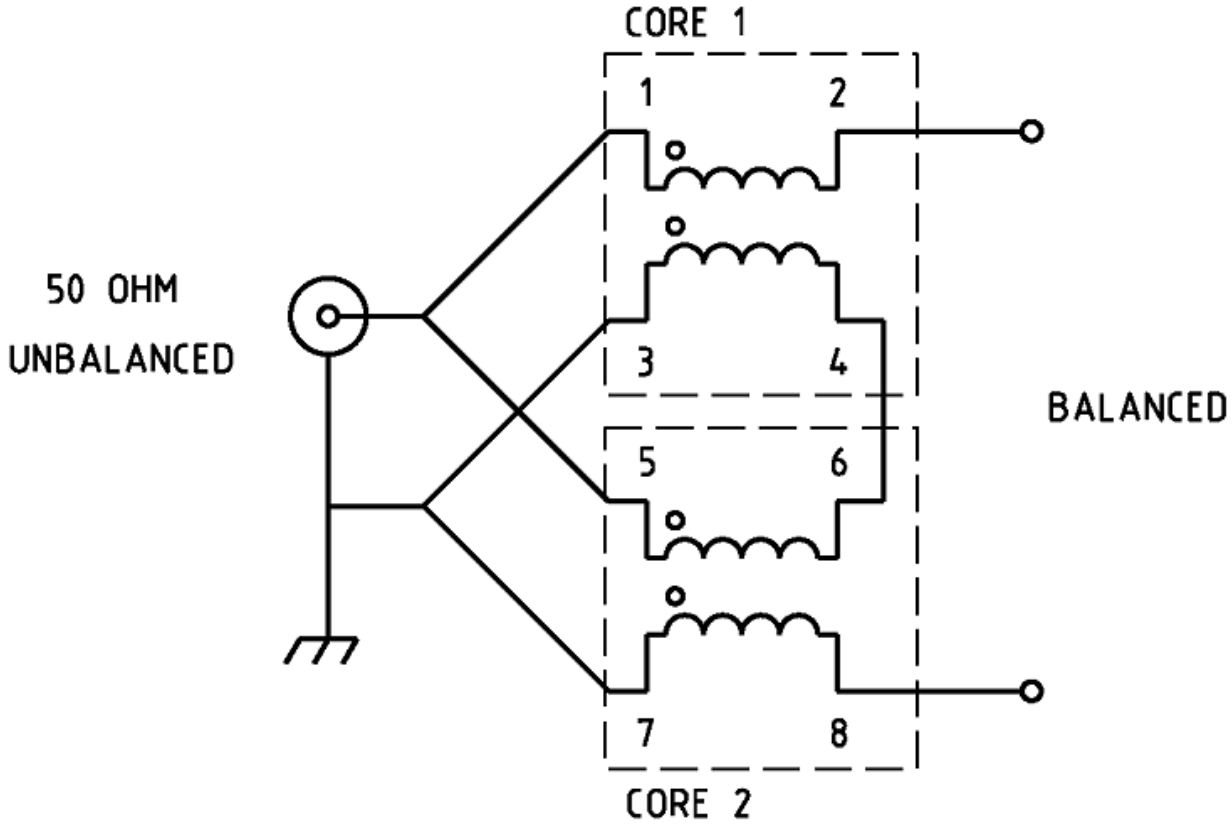
1. A 1:4 Guanella balun
2. A 1:4 voltage balun
3. A 1:4 voltage balun with a choke balun below it
4. A choke balun only

ANSWER: A 1:4 Guanella balun

If you selected #3, that would work; but, a 1:4 Guanella balun is more compact and can be more effective at blocking common mode currents

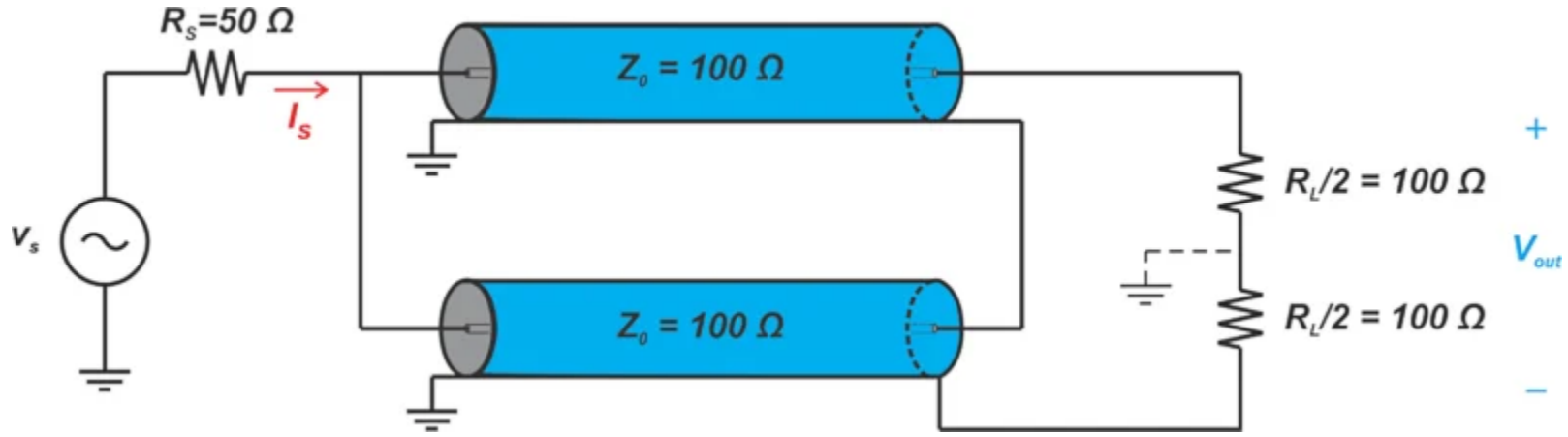
The Guanella Balun

- The 1:4 Guanella balun is derived from two identical 1:1 current baluns, with each consisting of bifilar windings, evenly spaced around their ferrite toroid core
  - “Transmission line effect” increases the output impedance by 4, even though 1:1 current baluns are used
- Matches the OCFD’s feed point impedance of 200 ohms
- Significantly reduces common mode currents



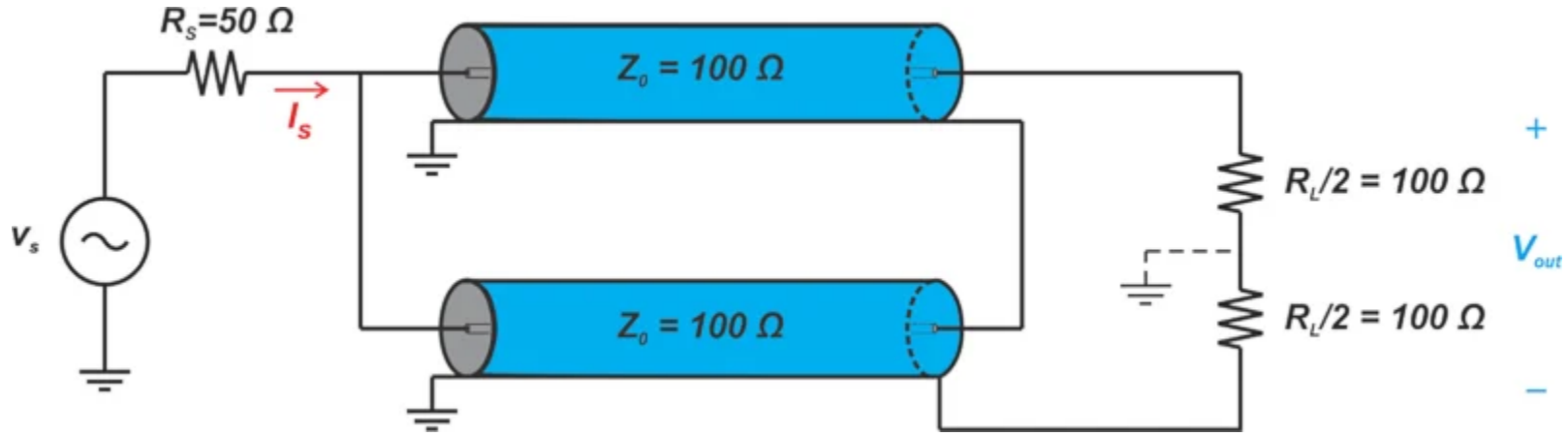
The Guanella Balun (cont.)

- Bifilar windings, of identical length, behave as transmission lines
  - They provide identical frequency-dependent phase shifts
    - The circuit produces a pair of signals at its output, with the same amplitude, but opposite polarity
      - The output voltage is therefore twice the input voltage
    - This voltage gain of 2 corresponds to an impedance transformation ratio of 4
- Here's another way of picturing the circuit:



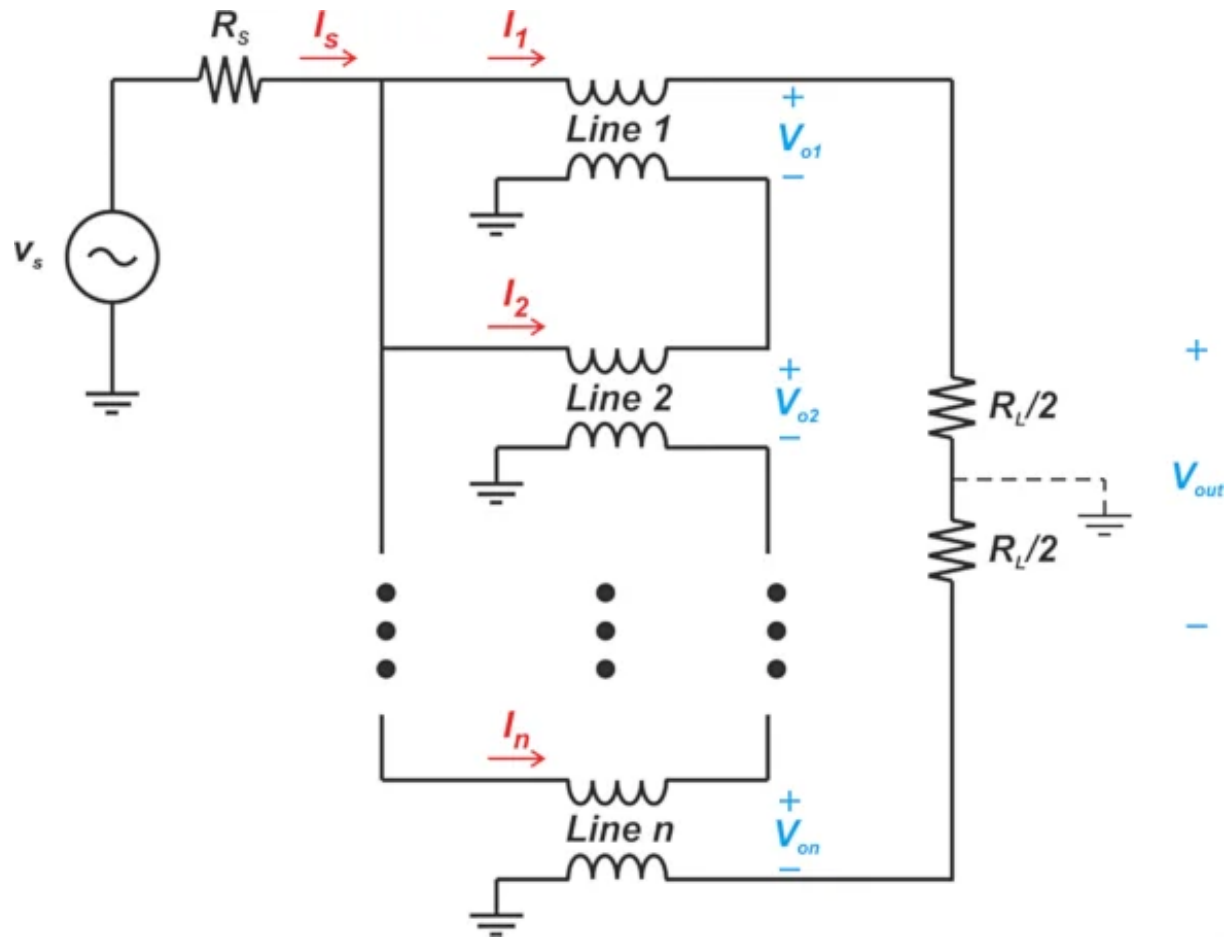
The Guanella Balun (cont.)

- On the input side:
  - Transmission lines are connected in parallel
  - In-phase currents are added
  - Impedance is lower than on the output side
- On the output side:
  - Transmission lines are connected in series
  - In-phase voltages are added
  - Impedance is higher than on the input side



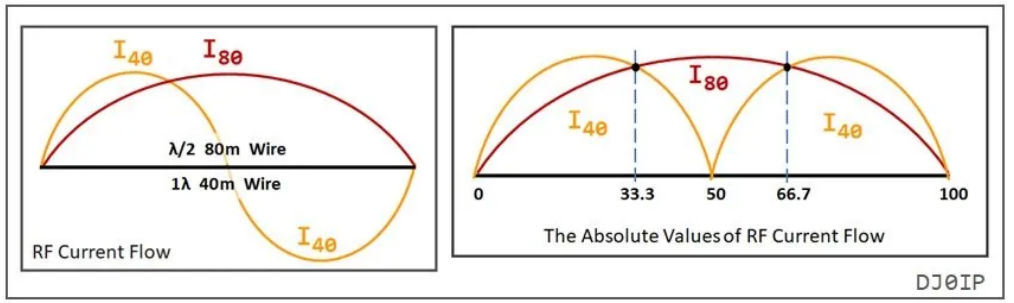
Building the 1:N^2 Current Balun

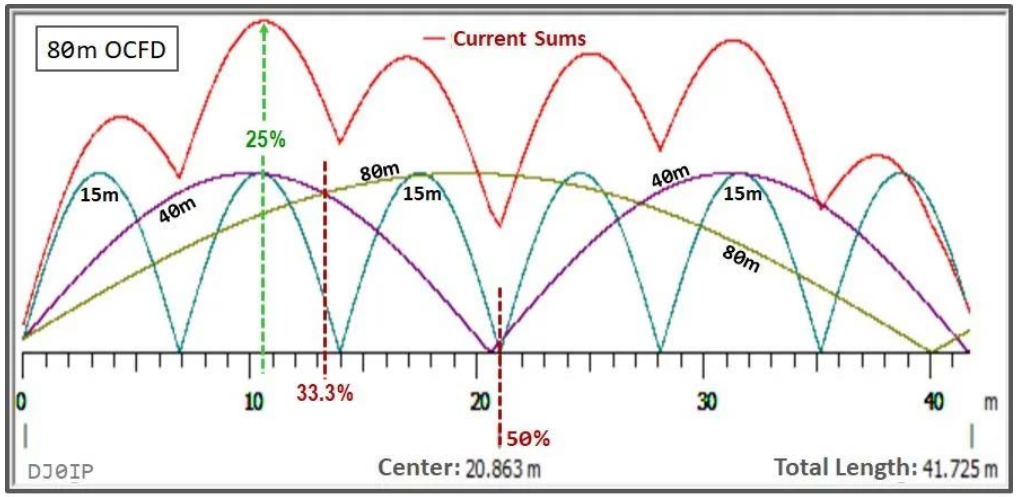
By extending the idea of driving windings in parallel and taking outputs in series, we can create 1:N^2 baluns, where N is an integer equal to the number of bifilar coils used



OCFD Discussion

- While the OCFD is a great multiband HF antenna, it is NOT a balanced antenna
  - It is asymmetrical and has unbalanced currents
- So why don't we use a voltage balun?
  - You can, but then you'll also need a choke balun to block common mode currents
  - Some OEMs provide both in one assembly
- The dual core Guanella does a great job of impedance matching and common mode current rejection for this hybrid dipole design





REFERENCES

- file:///C:/Users/rick/Downloads/Making_Baluns.pdf
- Making a 1:1 Current Balun on a Ferrite Core
  - https://www.youtube.com/watch?v=nmtRsHmLGsM
- Baluns: Choosing the Correct Balun, by W8JI
  - https://static.dxengineering.com/pdf/choosing%20the%20correct%20balun.pdf
- Demystifying Transformers: Baluns and Ununs Jul 9, 2020 | Engineering Resources, RF Transformers
- Baluns: What They Do And How They Do It, by Roy W. Lewallen, W7EL. Article in “The ARRL Antenna Compendium” Vol 1

Q & A

DX
ENGINEERING
DXENGINEERING.COM
MAXI-CORE® 20
DXE-MC20-C4-1
4:1 Balun
Dual Core
1.8 to 54 MHz