

Basic Antennas

Part 2

Common Mode Current

Common Mode Current

Special thanks to John Keith (W5BWC) and Jerry Ritchie (WA5OKO) for the following information; and

Baluns: Choosing the Correct Balun

and

https://www.w8ji.com/common_mode_current.htm

By Tom, W8JI;

and the 2017 ARRL Handbook chapter on
Transmission Lines

Common Mode Current

- In Review
 - All transmission lines must be terminated properly to prevent radiation
 - A proper termination must allow the currents in a transmission line to cancel out completely
 - And the voltages if using balanced lines
 - Neither conductor of a parallel conductor line can be grounded
 - Coaxial shields can be grounded to earth, a chassis ground, or an RF ground, at the source

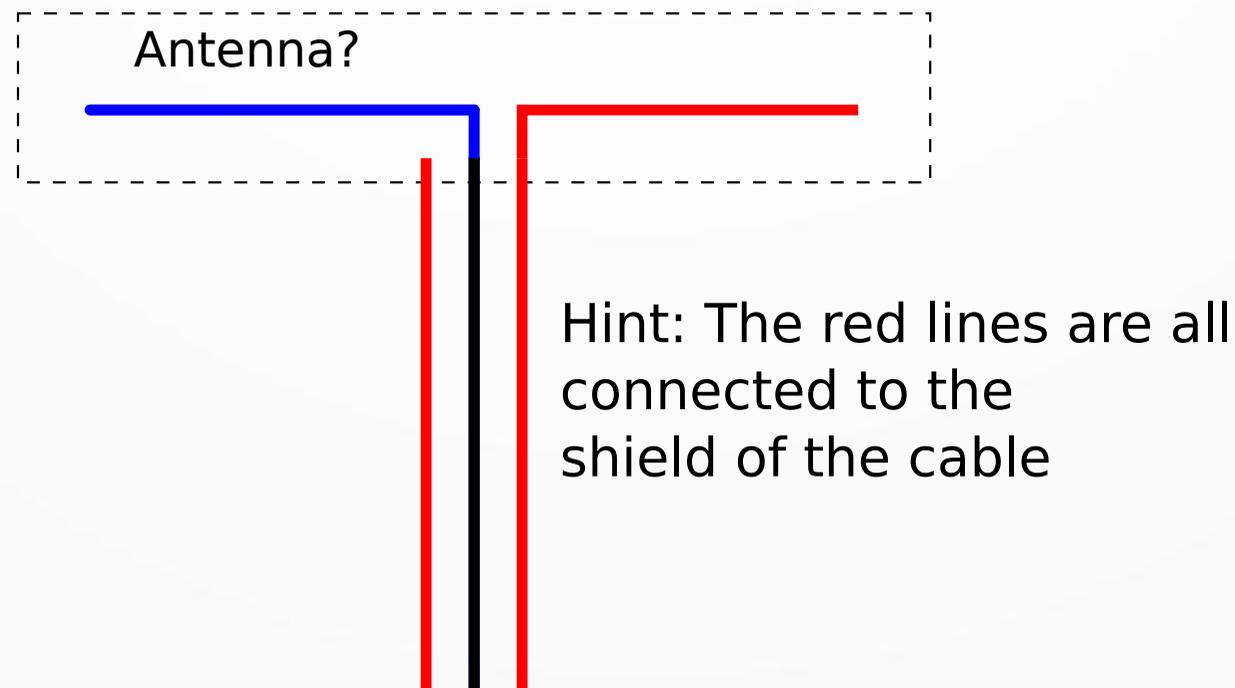
Common Mode Current

- Keeping it all BALUNced...
 - An imbalanced flow of current between parallel conductors causes the transmission line to radiate
 - Transmission line termination is critical; in most cases either the antenna or the feed line is not properly connected
 - Coaxial cabling isolates the center conductor with a shield and causes it to become invisible

Common Mode Current

- Examples of Imbalanced Systems

- A dipole, fed at the center, with one leg attached to the coax center conductor and the other attached to the shield looks like this electrically:



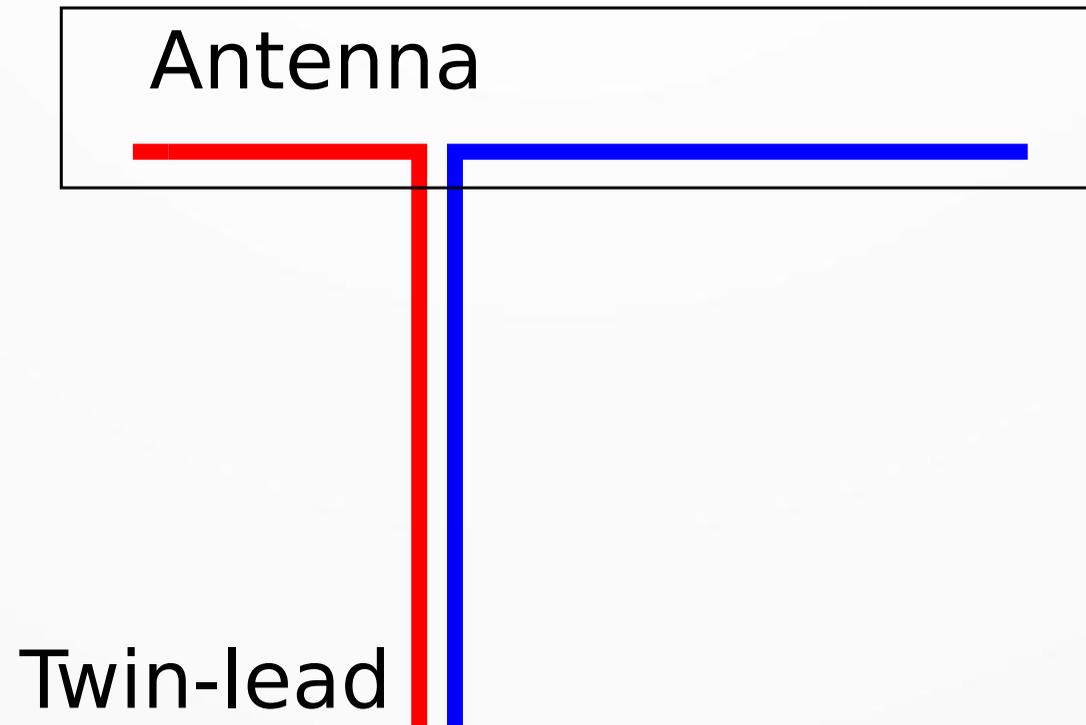
Common Mode Current

- Unbalanced System Explained
 - The previous graphic was not exaggerated
 - The entire length of the coax shield is now carrying current along with the antenna
 - The transmission line carries common mode current on its shield and differential mode within its dielectric

NOT A VERY GOOD SITUATION!

Common Mode Current

- Another Example of an Unbalanced System
 - Twin-lead and an off-center-fed dipole looks like this:



Common Mode Current

- Antenna or Transmission Line: Which is it?
 - In these examples, the antenna and the transmission lines are one and the same! These are two worst-case scenarios that are common in amateur radio antenna systems

THIS IS BAD BECAUSE THE OTHER END OF THE TRANSMISSION LINE (NOW AN ANTENNA) IS IN YOUR SHACK!

Common Mode Current

- Making the Connections
 - Off-center-fed dipoles and center-fed dipoles are two real-world examples of unbalanced and balanced antennas, respectively—with respect to current balance at the feed point
 - Every antenna design is either balanced or unbalanced with respect to current at the feed point
 - Antennas such as end-fed zeps or G5RV's need a radiating transmission line to work—but it isn't the main transmission line

Common Mode Current

- Center-fed dipoles are balanced
 - Directly feeding these antennas using a coaxial line without a balun will cause the cable to be part of the antenna
 - Similar to a G5RV and twin-lead
 - Feeding them with twin-lead or open-wire line will not result in feed line radiation since the load is balanced
 - A balanced load (and generator) allow the currents in each conductor to cancel each other because they are equal but opposite

Common Mode Current

- Off-center-fed dipoles (OCFD) are unbalanced
 - Directly feeding these antennas using coaxial cable without isolation will result in the feed line becoming part of the antenna
 - Feeding them with twin-lead or open-wire line will *also* make the transmission line part of the antenna since it is an imbalanced load
 - Just because an antenna looks symmetrical doesn't guarantee a balanced flow of current, so a CFD (center-fed dipole) can act like an OCFD in some instances

Common Mode Current

- **BUT WAIT!** There are exceptions
 - Looks can be deceiving: just because it “looks” balanced doesn’t mean you don’t need a balun; the inverse is also true
 - Examples include hourglass antennas, coaxial dipoles, $\frac{1}{4}$ wave ground plane antennas (with radials), etc.
 - “Balanced” and “Unbalanced” isn’t the only important detail
 - Antenna modeling and real-world testing is the only way to analyze current flow on a feed line

Common Mode Current

- What is “Bal-un-ce” again?
 - Balance in an antenna system refers to the way currents interact between multiple conductors
 - A balanced antenna is made imbalanced by feeding it directly with a coaxial line
 - An unbalanced antenna can cause a balanced line to become imbalanced
 - Other antennas can be fed with balanced or unbalanced lines and cause no problems for either one

Common Mode Current

- So What is Radiation?
 - RF Radiation is a result of both current (magnetic) and voltage (electric) on a conductor
 - Coax should have no current or voltage on the shield— if there is, its radiating with common mode current
 - Remember, if it is doing it's job, the current is contained in the dielectric
 - Parallel conductor lines will not have any current flowing on them because both lines must cancel each other

Common Mode Current

- The Main Point
 - The key element to making antennas work and transmission lines fail is Common Mode Current
 - Certain antenna designs (read *terminations*) cause a current to flow on the shield of a coaxial cable or along BOTH conductors of a parallel conductor transmission line
 - Common mode current can be measured

Common Mode Current

- Stopping (or choking) Common Mode Current
 - Balun's (BALanced-to-UNbalanced) are used to prevent the coaxial cable shield from acting like a radiating element when feeding a balanced antenna
 - UN-UN's (UNbalanced-to-UNbalanced) are used prevent coaxial cable from radiating when feeding an unbalanced antenna—like an off-center-fed dipole
 - Both are essentially the same—they both terminate the cable to prevent common mode current
 - Remember: not every antenna needs one in the same place

Common Mode Current

- The Balun's Easy Job

- Current baluns (choke baluns, bead baluns, choke coils) present a high impedance to current on the shield of a coaxial line, preventing (or reducing) common mode current
 - Voltage baluns are unique—these may balance voltages only
 - Some baluns or un-uns also help with impedance matching....
- A balun “isolates” the cable from the antenna
 - Kind of....

Common Mode Current

- A Few Caveats

- Using a balun/choke/etc will not necessarily prevent a feed line from being a parasitic radiator/reflector
- Balun placement is critical for proper antenna operation
 - Remember, some antennas need a transmission line in order to work

Common Mode Current

- Common Mode Current vs. SWR
 - A **properly connected** coaxial cable can have standing waves
 - Standing waves are caused by an impedance mismatch and are within the shielded dielectric; common mode current is a result of an **improper connection** that produces common mode current on the outer surface of the shield
 - A balun will not magically cure a high SWR—common mode current and SWR are two different things

Common Mode Current

- In Summary
 - Transmission lines must not have any common mode current flowing on them
 - Coax must not have a voltage or current on the shield
 - Both conductors in parallel conductor lines must cancel each other out completely
 - Current flowing on a transmission line—shielded or not—is common mode current
 - Common mode current is antenna; differential mode is transmission line

Questions? Comments?

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