What makes a RF Feedline ‘Balanced’ or ‘Unbalanced?’

‘Balanced’ *and* ‘**Unbalanced’** *describes a certain circuit behavior with* **'Two-Terminal'** *Signal Sources, RF Feedlines, and Loads used in most RF Communication – Electronics applications.* Feedlines include Coaxial Cable, Twin-Lead Ribbon Cable, Ladder Line, and Open Wire Line. This circuit behavior also includes systems working against earth ground or a ground plane (counterpoise) as the ‘second conductor’.

Any two-terminal item (Signal Source, RF Feedline and Load) operating in ‘ideal’ fashion will have exactly equal and opposite currents flowing through each terminal. Current flowing out one terminal will be matched or duplicated by exactly equal current flowing in the other terminal at any instant of time.

1. Two-Terminal Item examples:
    a. Signal Source
        1. The Transmitter stage of a Transceiver during transmission.
        2. An antenna during reception.
    b. RF Feedline (During Transmission and Reception)
        1. 50-Ohm Characteristic Impedance (Zo) Coaxial Cable.
        2. 75-Ohm Characteristic Impedance (Zo) Coaxial Cable.
        3. 300-Ohm Characteristic Impedance (Zo) Twin-Lead Ribbon Cable.
        4. 450-Ohm Characteristic Impedance (Zo) Ladder Line.
        5. 600 Ohm Characteristic Impedance (Zo) Open Wire Line.
    c. Load
        1. An antenna during transmission.
        2. The Receiver stage of a Transceiver during reception.

With **‘any’** RF Feedline If the current is not equal and opposite on each conductor, it will radiate and receive unwanted signals. This is true no matter how good a shield is, or how many layers of shielding a cable has. Even the grounded shield of a coaxial cable has the same current as the center conductor (in a perfect system).

The difference between ideally operating* ‘Balanced’ *and* ‘Unbalanced’ *RF Feedlines lies in the system voltages, rather than currents. "Balance is referenced to voltage, not current, in an ideal system."

50-Ohm and 75-Ohm Coaxial Cable are 'Unbalanced’ RF Feed Lines and they have significantly different voltage from each conductor to ground. In a "perfectly" working unbalanced (coaxial) line, the amount of voltage unbalance is infinite. One terminal (the shield) has zero voltage to the outside world, even while currents are equal and opposite. Current on the center conductor is balanced by an equal but opposite flowing current on the INSIDE of the innermost shield. No matter how we feed or connect a coaxial line, all current on the center conductor is always matched by an equal and opposite current on the inside of the innermost shield. If the two terminals of the load or source do not carry equal

currents, some current will flow in a loop through the ground or along the OUTSIDE of the shield. The outside of the shield or shields is isolated by skin effect in the conductor wall. At Radio Frequencies (RF) the outside of the shield can be treated as an “independent conductor” connected to the “inside shield” at the ends of the coax.

300-Ohm Twin-Lead Ribbon Cable, 450-Ohm Ladder Line, and 600-Ohm Open Wire Line are ‘Balanced’ RF Feed Lines and if "perfectly" operating they have equal and opposite voltages, as well as equal and opposite currents, all along the length of the line. Any difference in opposing voltages along the line can cause the line to radiate, since that often means currents will become unbalanced. All operating balanced lines are surrounded by an external magnetic and electric fields. This effect is caused by the necessary separation of conductors in the line. “To minimize radiation, balanced lines should be twisted or transposed at fractional wavelength intervals.” If you look at older open-wire telephone or signaling lines, they are periodically transposed.

With **‘any’** RF Feedline the portion of current not equal in amount and opposite in phase is called the “Common-Mode Current”. The amount of opposing phase current is the “Differential-Mode Current”. Differential mode operation, is the normal desired method of operating a transmission line, and has impedance. This is the characteristic impedance we talk about when we say a line is 50-Ohm, 75-Ohm, 300-Ohm, 450-Ohm, or 600-Ohm characteristic impedance. This impedance is different than the common mode impedance.

Most RF Feedlines fall somewhere short of perfect examples, but the closer to perfect the less energy lost as unwanted radiation. Perfection also means that the feedline does not pick up unwanted signals and noise, and Radio Frequency Interference (RFI) will not appear on equipment near the transmitter unless it is from antenna or equipment radiation. In short, your antenna becomes the point of most signal reception and radiation. Most of us want the antenna to be an antenna, and the feedline, which often runs near computers, radios, TV sets, and noise sources to NOT be an antenna!

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