Transmission Line Transformers (TLT's) – Part 4 - Common Mode (CM) Chokes

Common mode (CM) chokes: Reisert Coax Crossover Toroid, Guanella Bifilar Toroid, How Not To Wind One, Maxwell Sheath (Beads), Coax Wound Split Bead, Coax Air Core (Big Ugly), Parallel Conductor Air Core

Definition: A Guanella common mode choke can best be described as a transmission line that selectively acts as a choke for common mode signals. It behaves as a transmission line for differential mode signals, but acts as a choke for common mode signals.

What Is Common Mode Current? In RF, here is a phenomenon called 'skin effect'. Skin effect is where almost all of the current flows on the surface of a conductor and thru the insulation, with a very small portion flowing in the conductor barely below the surface. Because of this phenomenon, when connected to a balanced load like a dipole, the connection where the braid and one arm of the dipole meet, it makes the inside and outside of the braid appear like two parallel conductors that originate from the transmitter. The inside surface of the coax carries all the common mode or signal current and then, at the dipole, the current divides; half goes to one arm of the antenna and half goes back to the transmitter on the outside surface of the coax.

When current flows on the outer surface of a coaxial cable, it radiates like a vertical antenna and will skew the desired radiation pattern of the dipole. A mismatch further increases the amplitude of CM currents and unwanted radiation. A more detailed explanation is here: Common Mode Chokes

Interestingly, antennas like the Off Center Fed New Carolina Windom, a portion of that unwanted, vertically polarized radiation is actually used to augment the radiation pattern. At a specific distance from the feedpoint, it is then suppressed using a CM choke.

Figure 1a.

Figure 1b.

Figure 1c.

Figure 1a., shows a coaxial-wound choke with 10-turns of RG-316 on an FT240-43 ferrite core that uses the 'Reisert Crossover' developed by W1JR in 1978; that style serves mainly to place the input and output connections at opposite sides of the core for easier connection.

Figure 1a. When forming CM chokes or 1:1 baluns using coax wound on a core, check the composition of the inside insulating material. There's a parameter listed in data sheets called *'minimum bending radius.'* Generally, this radius is about five times the outer diameter of the cable, but specific values can vary by cable type and manufacturer. If exceeding that minimum radius, and bent too sharply, the inner conductor may migrate thru the dielectric, come in contact with the shield and short out. If the inner dielectric is solid Teflon (PTFE) and the center conductor is stranded, migration is less of a concern. If the dielectric is foam PTFE and the center is solid, pay attention to the minimum bending radius. When running power, this may become serious due to heating. RG-316 Teflon insulated coax is used in Figure 1a and has a small minimum radius.

Figure 1b & 1c. shows a bifilar-wound Guanella 1:1 current balun or CM choke. It is identical in operation to the coax-wound choke in Figure 1a. It consists of two parallel conductors closely wound that forms a transmission line segment. Ideally they should create a characteristic impedance of 100-ohms but work well using any pair of well insulated conductors in parallel; Teflon (PTFE) insulated solid or stranded wire or Teflon sleeving over enameled copper are preferred. Enameled wire without sleeving can easily be nicked during construction and may eventually cause arcing if high a SWR is present; sleeving also greatly raises arc-over voltage.

For both chokes both core mix for the frequency of use; usually #43 for HF or #61 mix for VHF and size (usually an OD of 1.40 - 2.40) will determine the maximum wire size that can be used. The choking impedance is the single turn impedance times the turns squared. At VHF frequencies, the number of turns depends on the maximum frequency and length of the windings. When the total length of the winding approaches λ/8, it may have a detrimental effect the overall operation of the choke.

Figure 2a.

Figure 2b.

Maxwell sheath or bead chokes. This is also a 1:1 current balun or CM choke. To get the same level of choking impedance as that of either wound choke in **Figure 1.,** it would take a high number of beads because each bead is only a single turn strung in series-aiding **Figure 2a.**; whereas wound chokes **Figure 2b.**, benefits from the turns-squared impedance multiplication factor. Bead chokes are useful when limited space necessitates their use. For cables with connectors, clip-on or split beads are available. **Figure 2b.** is a large, clip-on bead made by Fair Rite and has a 3/4-inch inner diameter; 5-turns (4-loops) of RG-58A/U wound on a split ferrite #43 mix bead gives approximately 3K-ohms of choking impedance.




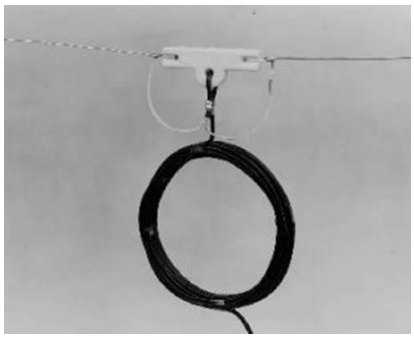

Figure 3a. **Figure 3b.** **Figure 3c.** **Figure 3d.**

Air-wound Coaxial Cable Choke or Big Ugly Balun. BUILD AN AIR WOUND 1:1 CHOKE BALUN FOR HF – THE UGLY BALUN!

For maximum effectiveness, a single-layer, winding style must be adhered to; the number of turns is not as important as the length of the coiled coax used which is generally around 18 to 21 feet. That choke was wound on a gallon milk jug, taped up then the jug removed.

As shown in **Figure 3a.,** it is advisable that when mounting to a metal pole to use standoffs.

Figure 3b. uses a large diameter PVC pipe as a former. In **Figure 3c.,** 21-feet of LMR-400, low loss, coax cable was used and later replaced with a broad-banded coax-wound ferrite choke (Figure 2b.). 18-21 feet of coax is the recommended length of coax for an effective BUB.

Figure 3d. A coil is formed in the coax and located close to the feed point – usually found on a beam antenna. If formed into a tight, single layer as shown, they are effective – those that are loosely coiled or scramble-wound may actually worsen the CM currents and would be better left off; as shown, they are either left dangling in the air, or zip tied to the metal boom. Attaching them directly to a metal support negatively affects choking action and should be placed on insulated standoffs away from the boom. One drawback is that they are narrow-banded and have low choking impedance as compared to ferrite chokes. But, if properly wound, are better than nothing.

Figure 4. Courtesy of G8JNJ

Even these two designs in Figure 4 work as air-core 1:1 chokes and approximate Guanella's original air-core design.

"It will soon be possible to transmit wireless messages around the world so simply that any individual can carry and operate his own apparatus." *~ Nikola Tesla*