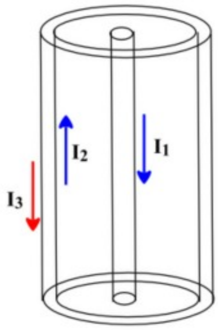
COMMON MODE CURRENT - ITS CAUSE AND CURE

by Terry G4CHD

COAXIAL CABLE

At first sight, coaxial cable (coax) appears to have just two conductors - a central wire and an outer braid.

However, due to the Skin Effect which forces rf current to flow on the outer surface of a conductor, and coax has three surfaces namely - that of the central wire, and the inner and outer surfaces of the outer braid, coax has therefore three conductors.

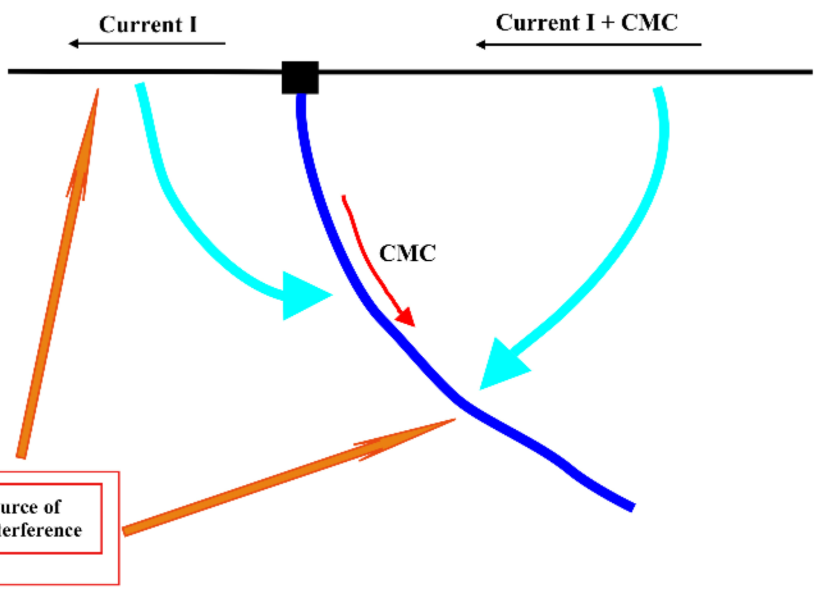


When coax is used to feed an antenna, the feed current uses the surface of the central wire and the return current on the inner surface of the outer braid. These two equal but opposite currents are termed **Differential Currents**.

This leaves the braid outer surface conductor unused unless **Common Mode Current** is produced on it as described in the following section.

COMMON MODE CURRENT - CAUSES

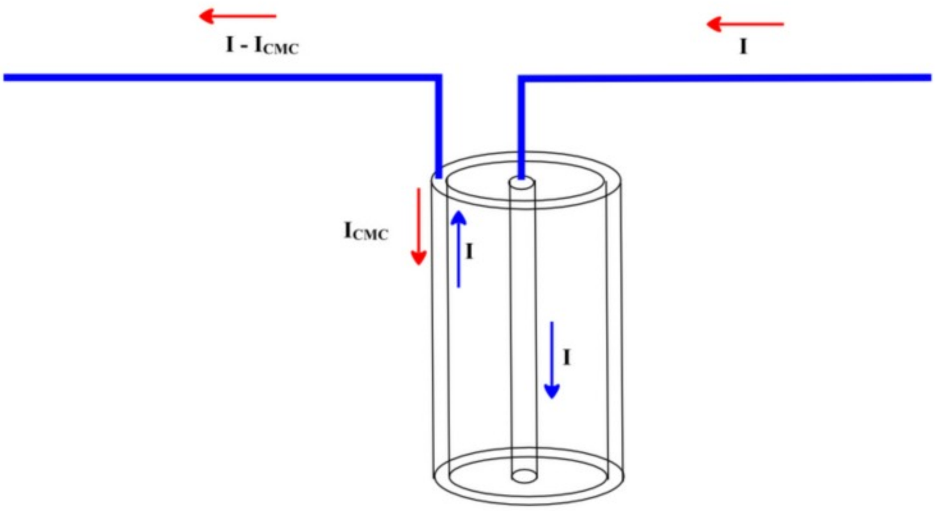
There are basically three ways Common Mode Current can be caused to flow on the braid outer surface as summarised below :-



Cause 1

Consider a dipole centre fed **directly** by coax with the dipole right arm connected to the coax central wire and the dipole left arm connected to the coax outer braid using eg a dipole SO239 centre connector.

The antenna currents are shown in the diagram opposite :-



The same current I flows in both the dipole right arm and the coax central wire.

However, the current I on the braid inner which is equal and opposite to that on the central wire, splits between feeding the dipole left arm with the remainder flowing onto the braid outer as Common Mode Current (CMC). The current split is determined by the relative impedance of each route. In fact someone compared this to feeding a tripole and not a simple dipole!!

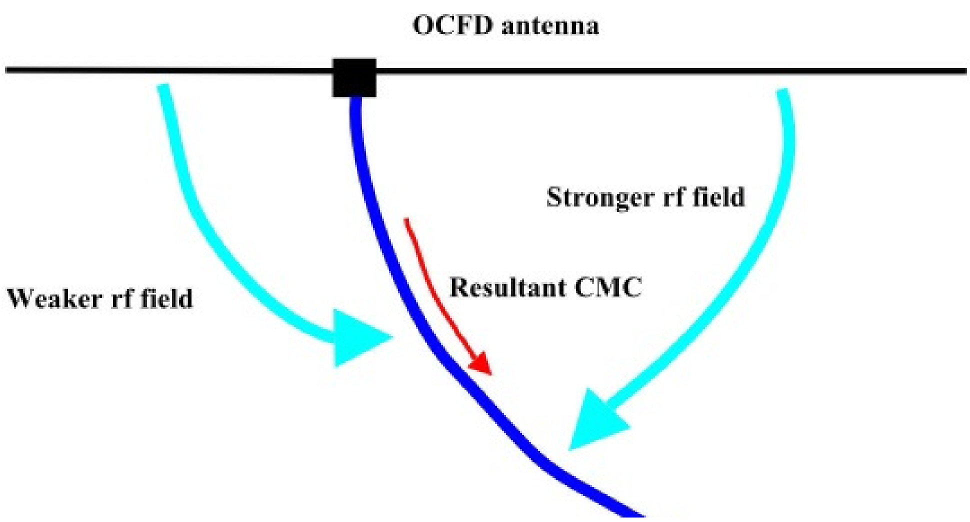
The impedance to current flowing in the dipole left arm is approx 30 - 40 ohms whereas the impedance to Common Mode Current flowing on the braid outer depends on the length of coax from the antenna feed point to the far end where it should be terminated at the rf earth point. If this length is an even number of half wavelengths, the impedance offered to Common Mode Current will be very low leading to virtually all the current I flowing on the braid outer as common Mode Current. However, typically it will generally be higher than 30 - 40 ohms and hence normally the dipole left arm will receiver virtually the same current as the right arm with any difference being Common Mode Current flowing on the braid outer.

This may well explain why many amateurs who directly feed a centre fed dipole experience few problems or have just been lucky!

To summarise, Common Mode Current on the braid outer only occurs when **different currents** flow in each arm of the antenna.

Cause 2

The braid outer surface conductor acts as a wire in the radiation field of the antenna and so there will be rf currents induced in it. The current induced by one half of the antenna will be in the opposite direction to that induced by the other.



Hence any resulting Common Mode Current is the difference between these two induced currents. So, if the coax feeder leaves the antenna at an angle other than ninety degrees or the antenna arms produce different levels of radiation, then the difference in induced currents will be much greater. It is for this reason that Common Mode Current produced is much more common with Off Centre Fed Dipoles see diagram below and even more so with End Fed Dipoles.

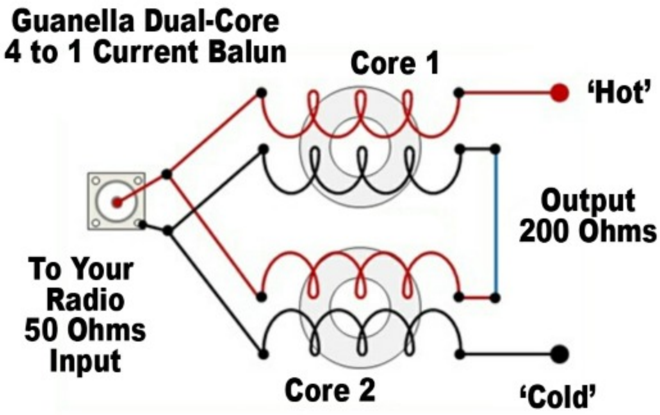
Cause 3

Finally, in a similar way to cause 2, any other source of rf eg from a neighbour etc will induce current onto the braid outer even when not transmitting. This can explain why you get a high S meter reading on receive in some locations.

COMMON MODE CURRENT - CURES

Cause 1 - the Cure

Since Common Mode Current on the braid outer only occurs when the current fed to each arm of an antenna is different, then if an antenna can be fed in such a way as to **ensure equal currents are fed to both arms** then there will be no Common Mode Current.



This can easily be achieved by feeding the antenna through a **Current Balun** (NOT a Voltage Balun).

Hence use a 1:1 Current Balun to feed a centre fed dipole and since the OCFD has a feed impedance of approx 200 ohms, feed the OCFD with a 4:1 Current Balun as shown in the diagram opposite from the web site :-

https://q82.uk/41balun-transformer

which recommends using either FT240-43 or FT240-52 ferrite rings and gives full construction details.

Causes 2 and 3 - the Cure

Here Common Mode Current is induced onto the coax outer braid between the shack and antenna. Hence the cure is to introduce a high attenuation (in excess of 20dB) in the coax feed preferably just before where the coax enters the shack. In this way the Coax in the shack should be relatively free of any Common Mode Current which if present would cause rf feedback and erratic SWR readings and possibly a high noise level on receive. This attenuation should be applied only to the Common Mode Current flowing on the braid outer and **NOT** to the differential antenna feed currents within the coax.

This can be readily be achieved by inserting a **Current Choke** - shown opposite - in the dipole or OCFD antenna coax feed.

A Current Choke can be easily made by winding eg 11 turns of RG58 onto either a FT240-43 or FT240-52 ferrite ring with a crossover half way to minimise self capacitance and terminated with eg PL259 plugs - see excellent article on RF Choke design by Steve Hunt (G3TXQ).

Cure - End Fed Dipole

There are many who prefer the long wire to be resonant ie exactly half a wavelength since this leads to the feed current being very very low resulting in less Common Mode Current problems but operation being restricted to harmonically related bands. The high impedance feed needs to be fed via a 64:1 Unun.

Alternatively, using a non resonant length of wire, leads to a lower feed impedance and can be fed via a 49:1 Unun and provides access to more bands with the aid of an ATU. However, the higher feed current leads to a higher Common Mode Current.

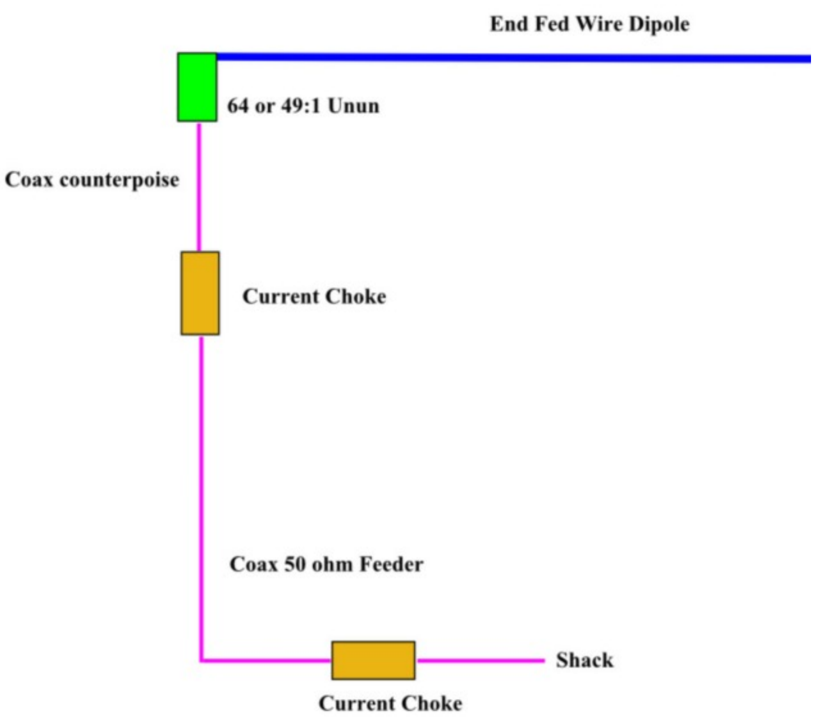
With an end fed dipole, only one coax connector eg the central wire, is connected to the end of the antenna wire via an Unun with no connection to the braid inner which therefore needs a return route to complete the circuit..

If the feed point is at ground level, then connect a short lead (eg a twentieth of the longest wavelength) from the Unun earth terminal to a ground stake to provide the return path.

Alternatively use a horizontal counterpoise again approximately one twentieth of the longest wavelength used connected to the Unun earth terminal.

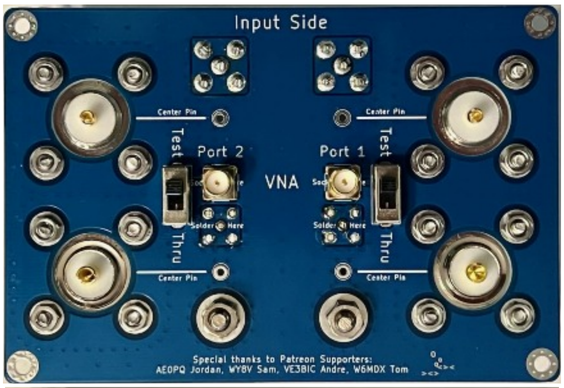
However, to prevent the coax also outer acting as a counterpoise, fit a Current Choke in the coax feed very close to the Unun - this precaution also applies when using the rf ground option.

Perhaps an even simpler method is to use the outer braid of coax feed as the counterpoise (ie approx one twentieth of the longest wavelength used) with a Current Choke inserted in the coax to terminate the counterpoise section as shown opposite :-.



Measurement of the effectiveness of a Current Choke

A good indicator is a plot of Common Mode Current attenuation over the operating range of frequencies. This will need a scanning rf generator and amplitude measuring instrument which can be readily achieved with a NanoVNA.

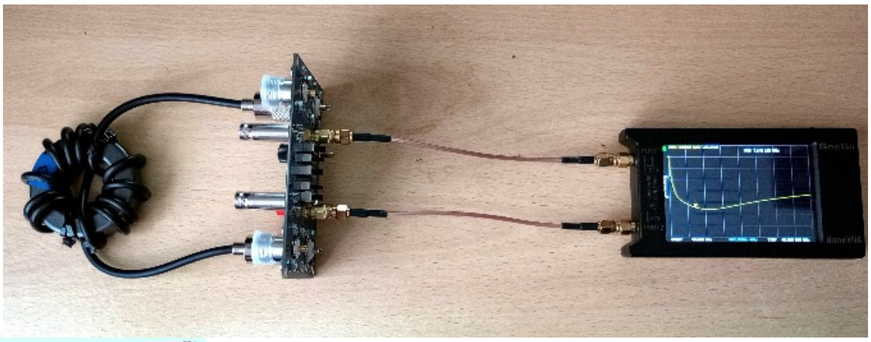


But there is a problem - the NanoVNA rf out feed is within the coax as Differential Current and not on the coax outer where Common Mode Current flows and the attenuation is applied.

Fortunately there is a solution which is an excellent product available from the States - the Halibut Common Mode Current Choke Test Rig - (CMCC Test Rig) - available either ready made or in kit form.

This double sided PCB accepts rf on its input side from a NanoVNA and swaps the rf signal from the coax inner to the coax outer which is then available on the output side to feed the Current Choke under test. The board also contains through calibration standard loads for calibrating the NanaVNA.

Below is a plot showing attenuation against frequency with the magenta line for 11 turns of RG58 on a FT240-52 ferrite ring and the blue trace for 11 turns of RG58 on a FT240-43 ferrite ring (ignore the top blue line).



Attenuation increases downwards and the horizontal frequency scale is from 50kHz to 40 MHz.

As can be seen, the FT240-43 Current Choke offers attenuation in excess of 20dB from 1 MHz to beyond 40 MHz.

Conclusion

Hopefully this article makes sense and answers some of the questions associated with feeding antennas.