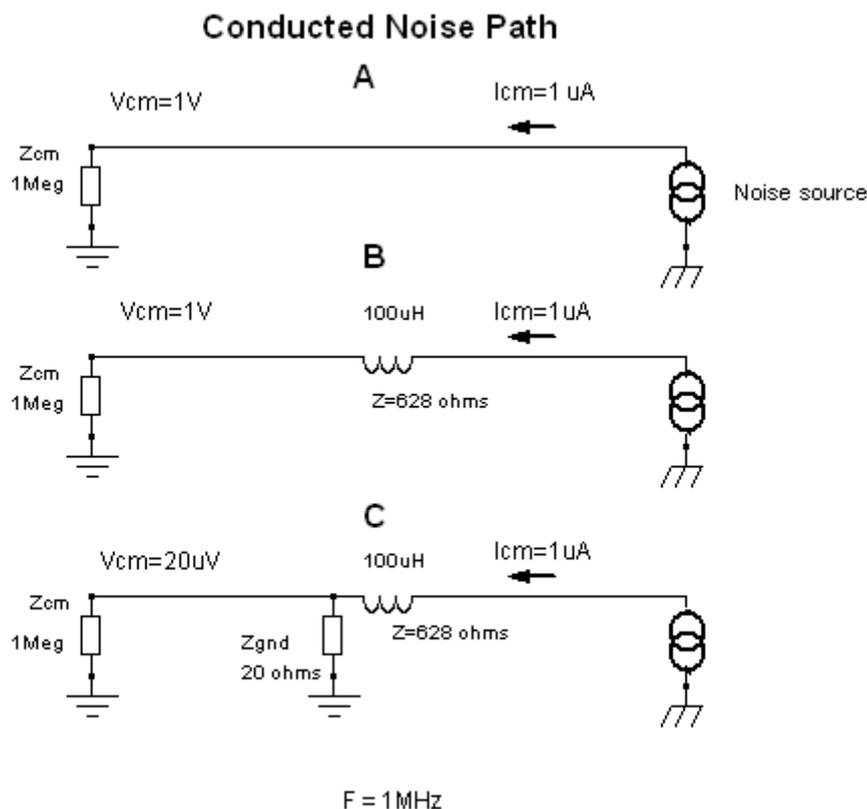


## Reducing the Noise in Dipole Mode with Common Mode Filter

The noise in dipole mode in AAA-1 active antenna is usually higher than in the loop mode. The man can make the wrong conclusion that the short dipole is a very noisy antenna.

Usually the source of this noise is in the house –various electronic equipments with switching power supplies. There are two wireless paths for the noise to reach the antenna. One path is through the electric and the magnetic reactive fields. The intensity of the reactive field reduces very quickly – by  $1/d^2$  or even  $1/d^3$  law (depends from the type of the source and geometry). The other path is through radiated electromagnetic field. The intensity of the radiated field reduces with  $1/d$  law. By the chance the noise sources are with very inefficient antennas so this noise level usually is low. Placing the antenna at sufficient distance  $d$  will reduce wireless path noise to acceptable levels. Be aware that every meter is important.

If the antenna is located outside at least at 6-10 m distance from the house, it is unlikely that the wireless noise influence will be dominant. There is another open door for the noise voltage to enter the amplifier input - the cable to the active antenna acts as an efficient transmission line for the common mode noise source. This is so called conducted common mode noise which travels along the cable to the amplifier input. The common mode voltage is transformed into differential voltage since there is always capacitive asymmetry at the balanced amplifier input instead of the balanced circuit. Simplified schematics of this path are shown on **Fig.1A**.

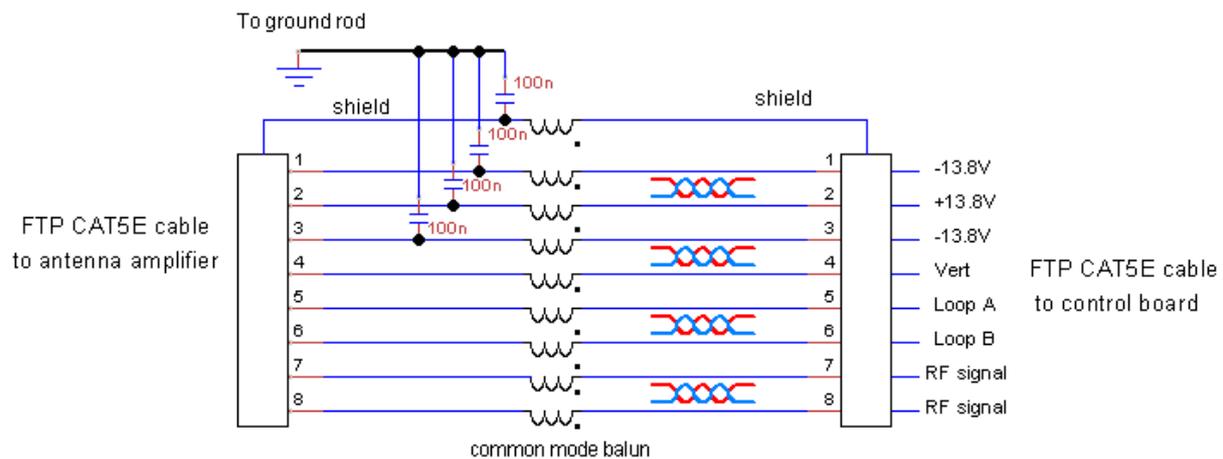


**Fig.1** A very simplified model of conducted noise path through the cable to the amplifier input. For the simplicity the amplifier common mode impedance  $Z_{cm}$  is assumed resistive.

The usual remedy is to insert a common mode choke balun with sufficient inductance into the cable path – this technique is well known and widely used.

The problem with the small dipole amplifier is that it has very high common mode as well as differential input impedances and simple calculations show that the choke balun impedance must also be very high to have some noticeable effect on the noise. Putting a simple balun with 50 – 300  $\mu\text{H}$  inductance will not work for the dipole mode! **Fig.1B**. A more sophisticated model is the transmission line model. The cable works as an open line at the antenna end for the common mode and there will be standing waves along it. The efficiency of the balun will be better, but will depend very much from the position of the point where it is inserted. The results will be unpredictable and also frequency dependant.

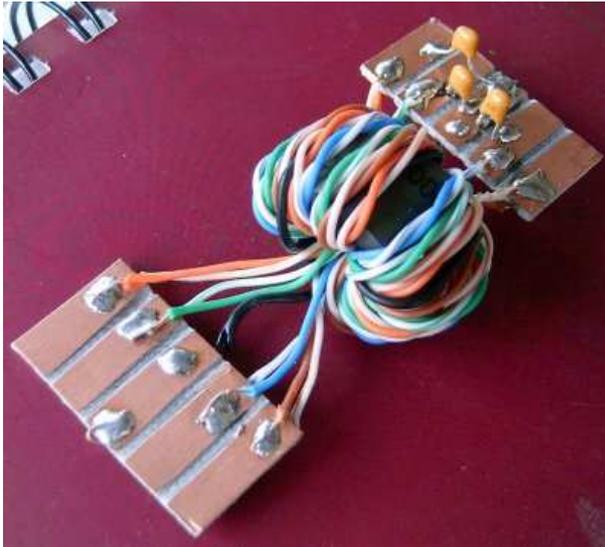
To solve this problem some manufacturers of electrical active antennas recommend to bury the cable into the ground or to connect the shield to the earth ground for noise free operation. Burying the cable means that a common mode filter is formed which consists of the cable shield impedance to the ground (which is low) and balun impedance (as shown on **Fig.1C**). This technique is widely applied for the case of coaxial cable feeders - here I will show how to make common mode filter for the FTP CAT5E cable.



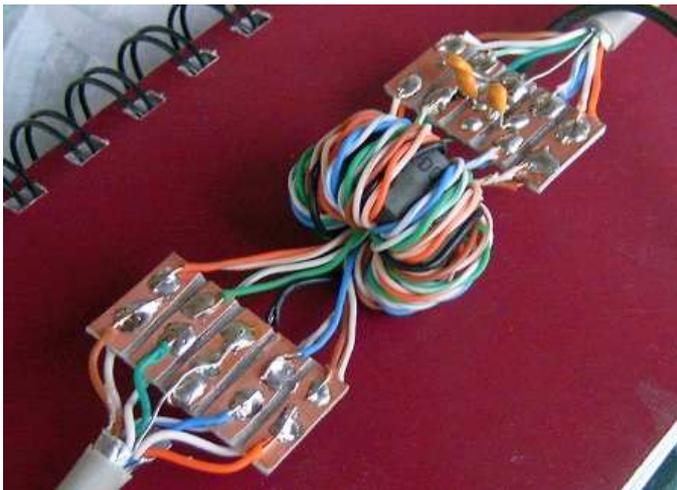
**Fig.2** Common mode balun filter schematics

The schematic is shown on **Fig. 2**. It is not practical to wind the FTP cable on toroidal core as is the case for the coaxial cables. Here the balun is made from 4 bare pairs taken from a piece of CAT5E cable along with one additional conductor for the cable shield. In this particular case the core consists of 2 toroids with 20x12x6 mm size with  $\mu=2000$ . On these cores I managed to wind 6 turns - the measured inductance was 90  $\mu\text{H}$ . The balun construction is shown on **Fig. 3,4,5,6**. Other cores and magnetic materials might be used – the usual recommendations for choke baluns can be applied here. The recommended inductance of one of the windings should be between 50 and 150  $\mu\text{H}$ .

As can be seen on the schematics the amplifier power supply lines and the cable shield are RF grounded through 100 nF capacitors since the common mode currents can flow through all lines. I do not recommend to ground the shield galvanically - there is always a potential difference between earth ground and the neutral conductor of the mains and sometimes substantial 50 Hz current can flow through this ground loop. Do not ground the control lines of the antenna mode switches since some strange effects can occur due to the same reasons.



**Fig.3** The FTP cable balun. Small double sided PCBs are used to connect the cable pairs. Notice that each pair uses the opposite board pads. The central pad is for the cable shield.



**Fig.4** The cable is connected to the balun. Cable shield is connected to the center pad.



**Fig.5** A cheap and quick solution. A wasted plastic bottle from PET material is used.



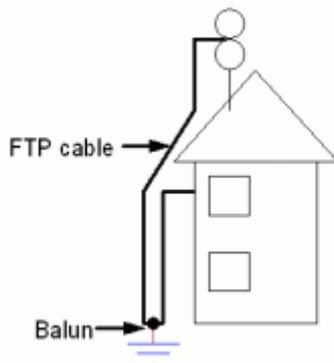
**Fig.6** Final assembly. The bottles are fixed with adhesive tape. The ground lead is short.

Sometimes the balun might be omitted and to ground only the shield. This might work but you should bear in mind that the cable is also a transmission line for the common mode signals and grounding at an arbitrary point might be not efficient. It is safer to use balun to have predictable results.

Where to insert the balun? I have tested two cases - the balun is inserted and the cable is grounded at the immediate vicinity of the active antenna and also at the other end where the cable enters the house. Both work well. There are some theoretical assumptions that the better place is near the house (near the noise origin) but up to now I do not have sufficient data to prove that. Probably for difficult noise cases two baluns and grounding points might be used at the both cable ends. The grounding points must be always between the active antenna and the balun! It is not necessary to bury the cable but if you do that it will not hurt.

For good results the RF earth ground should be prepared carefully as described in numerous books. But even improvised ground is better than nothing. Usually more than 1 m earth depth is needed in order to reach the moister parts of the soil. If the soil is dump even a short copper rod made from thick conductor is quite efficient.

The grounding lead should be as short as possible - that means that the balun box should lie on the ground or to be buried. On **Fig.7** is given an example how should the balun be placed in the case where the antenna is on the roof and the radio shack is at the second floor. It is always better to use longer FTP cable and short ground lead.



**Fig. 7**

So the most practical place to insert balun is at the place where the cable passes near the earth ground.

This common mode filter is very efficient. Now the LF portions of the spectrum can be received in dipole mode without problems with equipment powered by mains power supplies (at least in my country house). The loop mode also benefits from the filter.

This method can not be applied for the cases where there is no good earth ground! I do not know how to make efficient conducted noise filter for the inhabitant of the city apartment. If the man can find electrically quiet point where to connect the grounding lead it might work. Otherwise use the loop mode where the conducted noise is much lower due to the very low input impedance of the loop amplifier.