3. Antenna

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3.1 Input Circuit of the Amplifier

There are two goals when designing a small wideband loop - low inductance and large area. The construction of the loop should be made with the following rule in mind: the ratio of loop area to loop inductance should be maximized. That automatically means that a circular shape with 1 turn is the best choice. The material could be copper or aluminum – actually the loop Q-factor is not important. The important factor is the low loop inductance. The conductor must be as fat as possible to reduce the loop inductance.

Most of the commercial small loops on the market are circular in shape with diameter between 0.6 to 1m. The material is aluminum tube of 10-30 mm diameter. To make such a loop is not trivial.

We are suggesting a different approach by using cheap and available parts which are easy to mount. The loop parameters are not compromised because the so called parallel technique is used. The loops will not be described in details but basic configurations and a lot of figures will be given. The loop size is not critical since these loops are aperiodic.

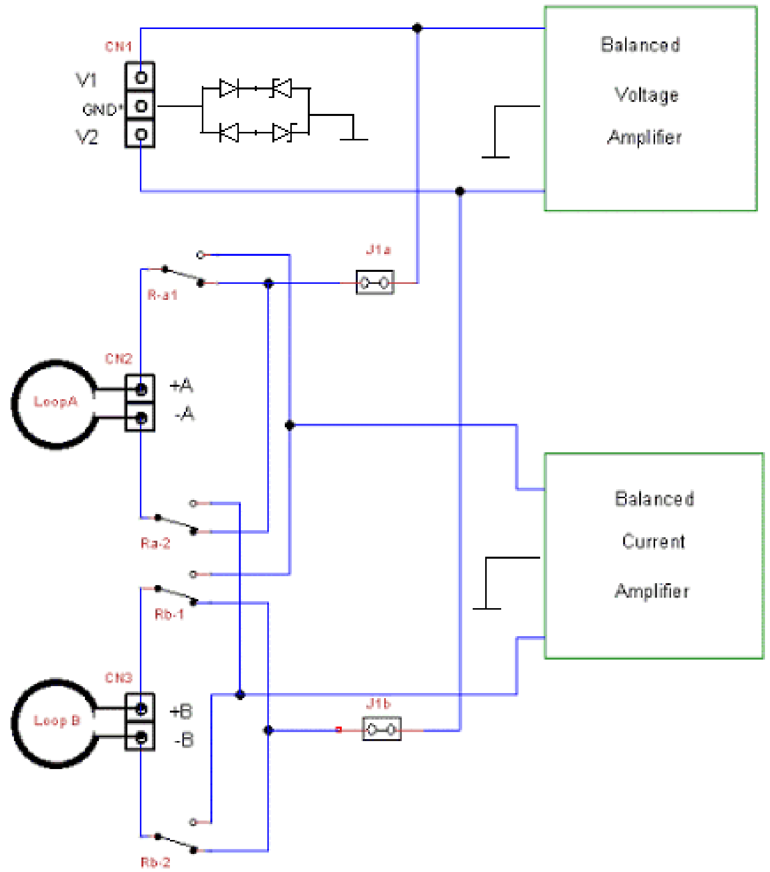


Fig.3.1

The input circuit of the amplifier is shown on ***Fig.3.1*** Three antennas can be connected to the terminals – two loops and a dipole. There are two jumpers which can connect the inputs of the voltage amplifier to the loops which act as arms of a dipole. The relays are shown in off position which is dipole mode. In this mode the loop terminals are short circuited and fed to the corresponding input of the voltage amplifier. If *J1a* and *J1b* are in OFF position a separate dipole can be connected to the connector CN1. Other combinations are possible e.g. *J1a* is ON, *J1b* is OFF - in this case *V1* arm of a dipole is Loop A, another external arm or counterpoise should be connected at terminal *V2*.

The GND terminal is used only for protective ground against lightning discharges. Internally it is connected through a zener diode limiter to the amplifier common point. In normal conditions it is closed and the amplifier common point is left floating. Only when there is a strong EM field the zener diodes open thus limiting the common mode voltage. Connect this terminal only to a good ground point (a rod inserted into the ground or some other point which has a firm ground potential). If there is no such a point (e.g. the user is living in an apartment) it is better to leave this terminal open.

The basic configuration of small loop/dipole antenna which we will suggest is shown on ***Fig.3.6*** and ***Fig.3.7***. In the following sections we will describe different designs with increased complexity so the user can choose the most suitable antenna for the particular environment.

3.2 One Loop and Asymmetric Vertical dipole

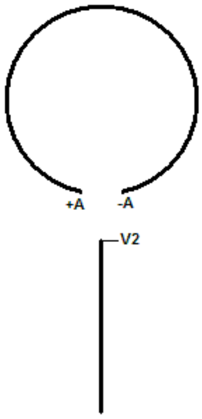


Fig.3.2 *Connect Loop at +A, -A terminals. J1a=ON, J1b=OFF. Connect short counterpoise at V2 terminal.*

This is the simplest configuration. Recommended for quick test or for urban areas where the noise level is too high and better antennas will not give any advantages. Two modes are possible: Loop A and Vertical. The vertical dipole first arm is Loop A and the second arm is a counterpoise. If *V2* is connected to ground then the vertical dipole becomes ground plane. Two basic mechanical loop designs will be described - the simplest "lazy" loop and a "fat" loop.

Simple "Lazy" Loop

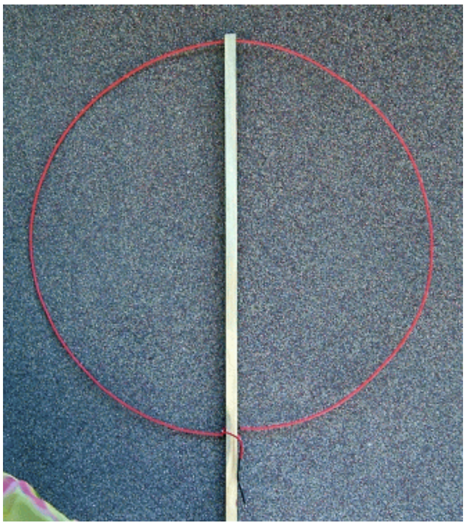


Fig.3.3 S*ingle turn loop with 6mm*^{2} *PVC insulated Cu wire*

A possible construction of the loop is shown on ***Fig.3.3, 3.4, 3.5***. The mast is 20x 20 mm wood (or PVC tube). The loop is made from PVC insulated Cu 6 mm^2 conductor. The diameter of the loop is 0.6m. Three holes are drilled on the mast – one at the top and two at the end of the loop. The conductor ends are inserted there. The loop ends are bent slightly and fixed with cable ties at the other side of the hole (this technique for leads connection is applied to all loops described later).

The lower arm of the dipole (so called *counterpoise*) can be a piece of vertical wire with length around 1 m or a set of several (2 to 4) short horizontal radials with the length equal approximately to the radius of the loop. Theoretically the capacitance to ground of the upper and lower arms of the dipole should be equal to reduce the common mode interferences but in practice it is difficult to perform this measurement. Choose a convenient mechanical construction – the length of the counterpoise is not critical at all.

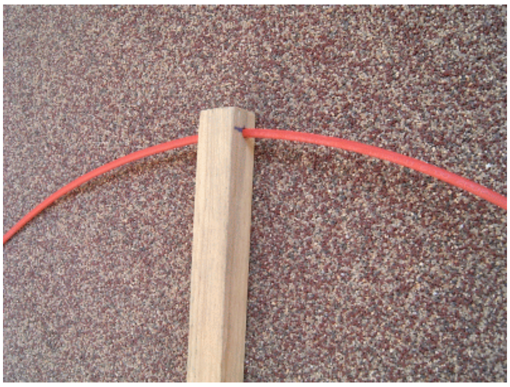


Fig. 3.4 *Top of the loop*

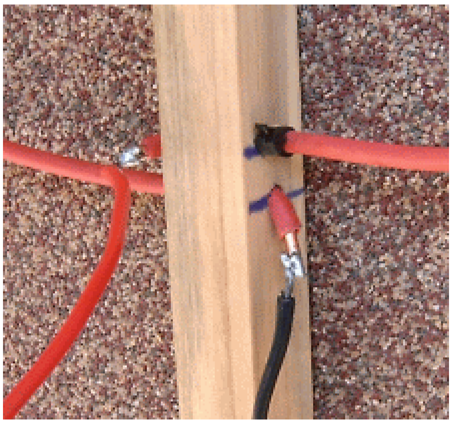


Fig.3.5 *Leads*

This loop is mechanically slightly flexible and might be bent by a very strong wind. A bare aluminum conductor with the diam. 3mm or more is better in this case. Above a diameter of 0.7 m an additional horizontal wooden stick is needed (crest frame).

Large "Fat" Loop

On the market there are tubes for hot water heating systems which are very suitable for making loop antenna. They are made from 3 layers - two polyethylene (PE) and one aluminum layers in the middle. These tubes are very lightweight and perfect thick loops can be made with them. The circular shape is formed easily since the tubes are flexible. A loop with diameter of 95 cm is shown on ***Fig. 3.5.1***

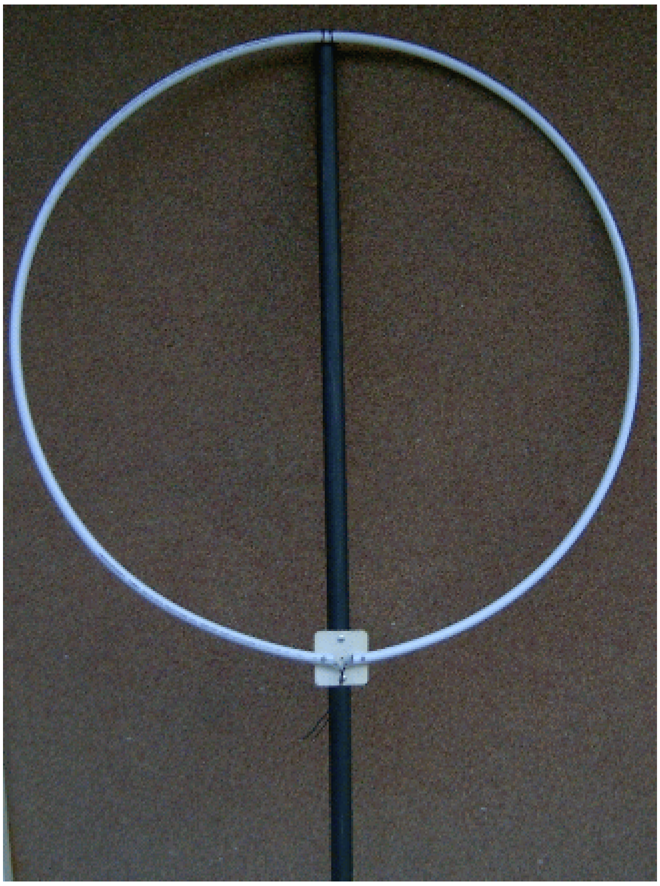


Fig. *3.5.1*

Fig. *3.5.2*

A ½" (12.7 mm) type tube is used but the outer diameter is actually 15 mm. The mast is made from a PVC tube with 40 mm diameter. The connection of the loop leads is shown on ***Fig. 3.5.3, Fig.3.5.4***. The tube can be cut easily with sharp knife.

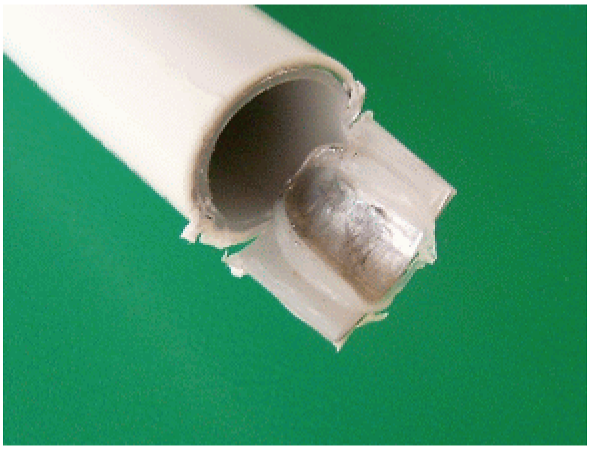


***Fig.** 3.5.3*

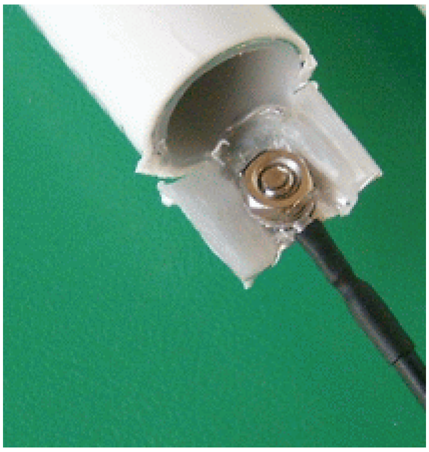


***Fig.** 3.5.4*

***Fig.** 3.5.5*

The PE layers can be removed to some extent with hot soldering iron as shown on ***Fig.3.5.3***. Then the aluminum surface of both sides must be carefully cleaned with sharp instrument. The terminal lug between aluminum and copper lead must be tinned to avoid electrochemical corrosion. Stainless steel screws with shake proof washers must be used for the same reason (***Fig.3.5.4***). A plastic plate is used to fix the loop ends with 3mm screws (***Fig.3.5.5***). The plate is fixed to the mast with two 5 mm screws. The tube openings might be choked mechanically with caps or with hot melt adhesive. Be aware that PE cannot be stuck with standard glues! The inductance of this loop is 2.6 uH and the area is 0.71 m^2. The loop is mechanically very stable and even bigger loops can be made from the same material. The total cost of the materials for this loop is about 3 – 4 Euro.

3.3 Two loops in one plane and symmetrical vertical dipole

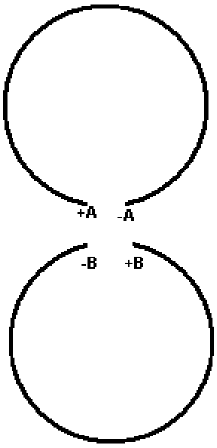


Fig.3.6

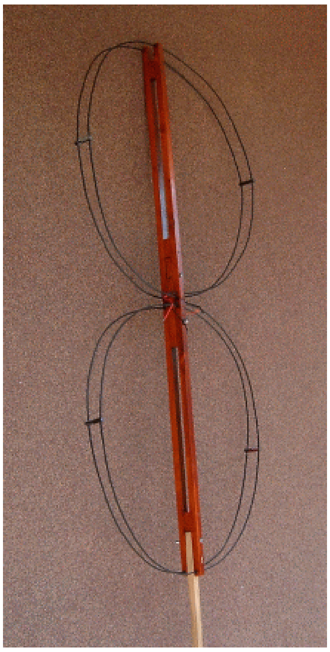


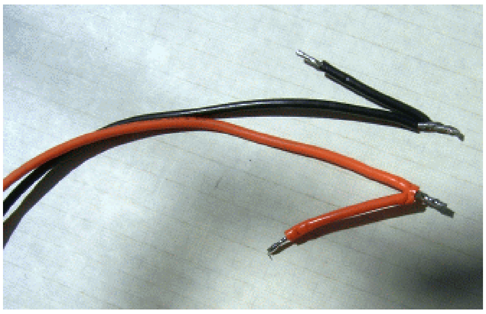
Fig.3.7 *This is the basic loop/dipole design*

This is the basic suggested configuration. Loop A and Loop B are connected to the corresponding terminals CN2 and CN3 as shown on the ***Fig.3.6***. *J1a* = *J1b* = ON. This is the basic recommended configuration . We have the following modes: Loop A, Loop B , Loop A & B in crossed parallel connection and vertical dipole where Loop A and B are the arms. The first two modes will give identical results since the loops are in the same plane. Loops are made again from PVC insulated 6 mm^2 Cu conductor. The diameter of each loop is 0.7m. To reduce the inductance of each loop, two parallel connected conductors are used (***Fig. 3.7***). The measured inductance of each loop is 2.2 uH.

Fig. 3.8 *The loops are fixed with cable ties on both sides*

Fig.3.9

The parallel conductors are connected together with a short wire and only one lead is passed to the box (Fig.3.9). The leads are prepared as shown on ***Fig.3.10*** and then soldered to the loops. Before soldering slightly bend the loop ends to fix them.



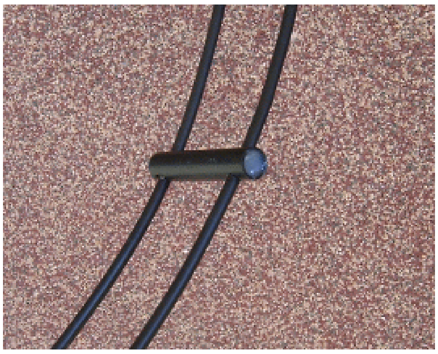


Fig. 3.11

Fig.3.10

The length of the leads should be at least 200 mm. Cut them to the exact length after mounting the amplifier into the box. Keep them as short as possible not to increase the inductance unnecessarily. Use heat shrinkable tubes to cover the soldering.

The spreader is made from the body of a plastic pen (10mm diameter) drilled with 2 holes (***Fig.3.11***). Silicone glue is applied to fix the spreader.

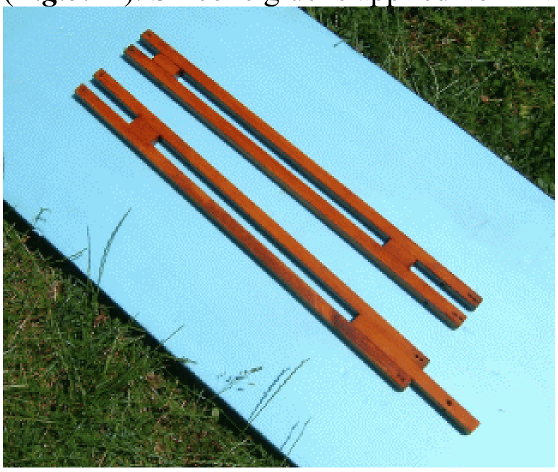


Fig.3.12

The wooden loop frame is shown on ***Fig. 3.12***. It is made from 4 pieces of wood sized with 20 x 20 mm. The length of the sticks is 750 mm. The distance between the parallel conductors is 40 mm. This construction permits the mounting of loops in the same or orthogonal plane. This is modular construction and can be disassembled in minutes to carry the loop in a car for field day.

Sequence of the assembly: Cut the cable for the loops and mark the center point. Insert the cables in the far end holes of the frame. Insert the spreaders. Insert the cables in near end holes and bend their ends slightly for fixing. Adjust the center point of the cable to be at the center of upper holes. Put the cable ties at both sides of the holes to fix the loops. Adjust spreaders to be at symmetrical positions on both sides and fix them with glue. Let the glue set. Solder the leads and cover them with heat shrinkable tubes. In crossed loop mode this loop has an equivalent area of 0.7 m^2 and an inductance of 1 uH.

This basic design can be build also with PE/Alum. tubes as shown on ***Fig.5.3.1***. Two 1 m diam. crossed loops will give excellent sensitivity in both modes. This is a DX construction and is suitable for places with low electromagnetic pollution.

3.4 Two loops in orthogonal planes and symmetric vertical dipole

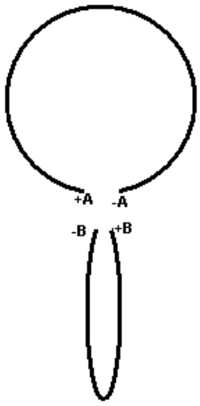


Fig.3.12

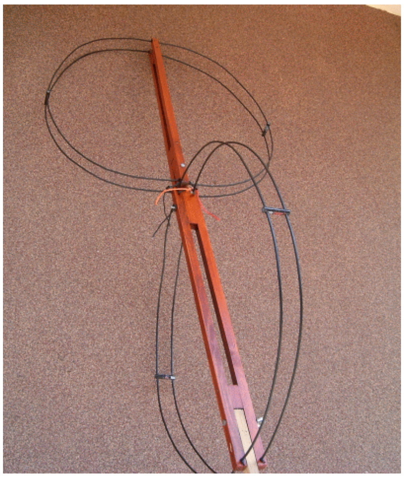


Fig.3.13

The connection and the jumpers settings is the same as in ***Fig.3.5***. The same construction is used – the only difference is that the loops are orthogonal (***Fig.3.13***). Switching between Loop A and B will give different direction patterns which is important on LW and MW bands. On SW bands due to random polarization of the incoming wave the directivity will be minimal or nonexistant. In this configuration the crossed loop mode will not increase the sensitivity since the loops are orthogonal. Sometimes this mode might give some advantages, usually exhibited as decreased fading. The vertical dipole mode works in the same way as is in the previous example.

3.5 Two loops in orthogonal planes and asymmetric vertical dipole

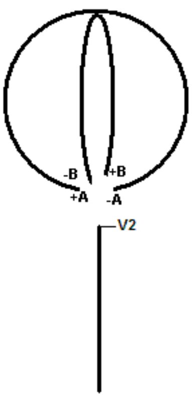


Fig. 3.14

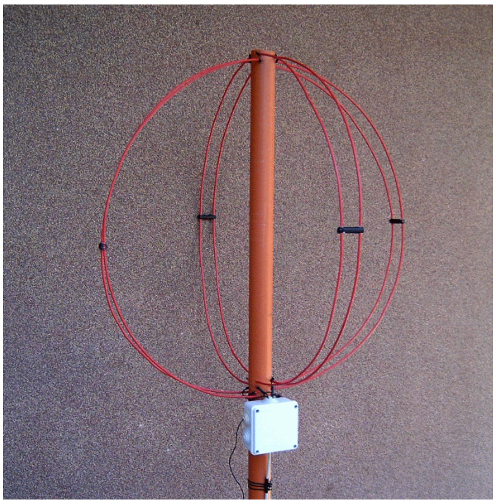


Fig.3.15

The leads are connected as shown on ***Fig. 3.14***. Jumpers are set to *J1a*= ON, *J1b*= OFF. The requirements for the counterpoise are the same as is in section ***3.2***. The loops are again orthogonal but the needed volume space is smaller. Crossed loop mode is not available. Loops are made from PVC insulated 6 mm^2 Cu conductor. The diameter of each loop is 0.7m. To reduce the inductance 2 parallel connected conductors are used in each loop with a distance of 38mm. The loop mast is made from 50 mm diam. PVC tube.

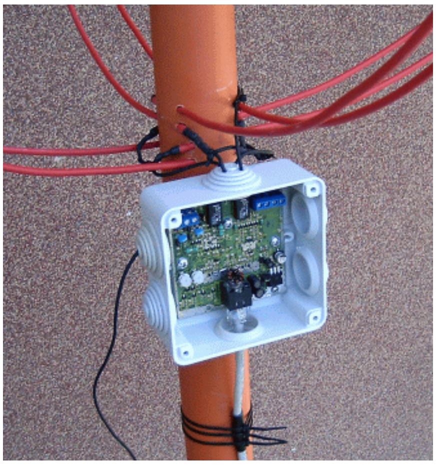


Fig.3.16

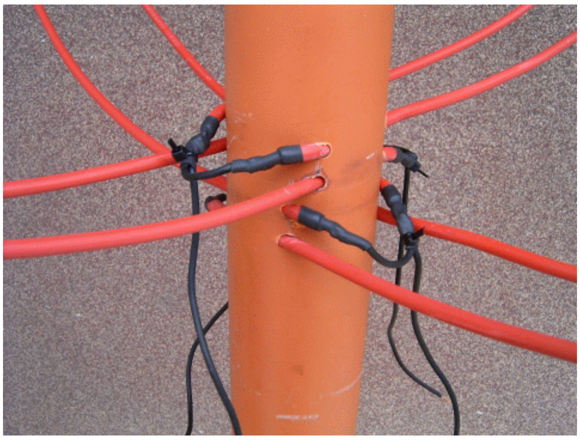


Fig.3.17

The box is fixed with 1 screw. The cable is fixed with 3 black cable ties. On the photo the counterpoise is hanging freely but it must be fixed. Loop ends are bent slightly and soldered to the leads. Leads are covered with shrinkable tubes ***(Fig.3.17)***.

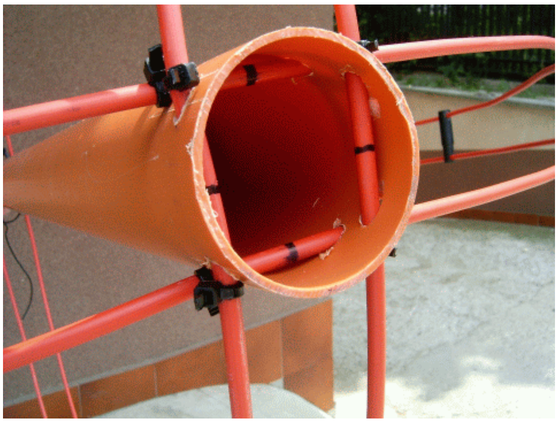


Fig.3.18

The top of the loop is shown on ***Fig.3.18***. The loops are fixed with cable ties on both sides of the tube

3.6 Two loops in one plane and symmetrical horizontal dipole

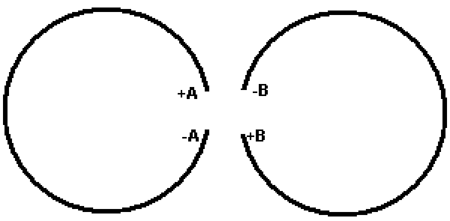


Fig.3.19

The leads are connected as shown on ***Fig. 3.19***. Loop A and Loop B modes will be identical since the loops are in the same plane. Crossed parallel mode will work. The dipole mode now is with horizontal polarization. Placed near the ground this dipole will be very inefficient but placed higher (above ¼ wavelength) will give excellent results.

3.7 2/4 crossed parallel loops and symmetrical vertical dipole

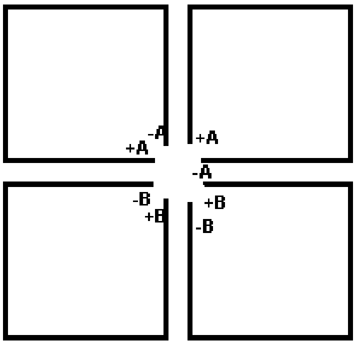


Fig.3.21

Fig.3.20

Connect the loops to the amplifier terminals as shown on the ***Fig.3.20***. *J1a* and *J1b* must be ON. The loop shape is square since it is easier to make the mechanical frame. In Loop A mode the two upper loops are working in crossed parallel connection. In Loop B mode the lower two loops are active. In crossed loop mode all 4 loops are cross-connected and the efficiency is very high. In dipole mode the two upper loops are short-circuited and form the upper arm of the vertical dipole. The same applies to lower loops. This configuration becomes a very fat vertical dipole.

This antenna was built with side of the smaller quad of 1 m (***Fig.3.21***). The distances between the inner conductors of the loops are 4 to 8 cm. The loop has a total area of 4 m^2. Its equivalent inductance in 4-crossed loops mode is 1 uH. This antenna has a small loop radiation pattern up to 60 MHz. This is a very good antenna with very low noise floor. The antenna was made from 4 mm^2 PVC insulated stranded Cu wire on a wooden frame **[1].**

3.8 Links

[1] ***Wideband Active Small Magnetic Loop Antenna*** *http://www.lz1aq.signacor.com/docs/wsml/wideband-active-sm-loop-antenna.htm*