Additional Environment Protection of the AAA-1 and VDL-1 Devices

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The AAA-1 amplifier is inserted in a box which is marked as IP55 protection class. According to the standard it is dust and water protected. The standard says: "water projected by a nozzle (6.3 mm) against enclosure from any direction shall have no harmful effects. Test duration: at least 15 minutes with water volume: 12.5 liters per minute at pressure: 30 kPa at distance of 3 m."

We made a simple test – a new box with two thin wire leads coming out from the upper side of the box (antenna terminals) and a piece of FTP cable coming out from the lower side of the box. The punched holes in the rubber caps were with 0.7 of the diameter of the cables. The device was put under a strong shower from 1 m distance in the bathroom for 15 minutes. The box was in vertical position as it is usually mounted on the mast. After the test, the box was opened to examine the water content. There was a water leakage into the box - very thin water layer was found at the bottom side of the box and several water drops at the box walls! We carefully examined the cause of the leakages. The main reason was the poor adhesion between the ABS box and rubber caps. Some caps do not have any water leakage but some of them show some water permeability. Additional examination was made which showed that very small imperfections in the caps and also in the box coming from the production technology are the reason of this leakage. There is also possibility for water leakage from the rubber belt of the cover and also from the openings for fixing bolts of the box cover. A probable reason is the thermal cooling which gives immediate pressure difference between internal and external sides of the box. In our experiment the water never leaks from the cable junctions through the rubber caps.

This experiment was quite heavy – it probably corresponds to a severe tropical storm but the nature can always surprise us. But we must also bear in mind that during the operation life of the device, it is expected that the rubber will stiffen thus reducing the water insulation. Additional protection of the device is advisable.

1. Sealing

The rubber caps must be sealed with proper stuff. We began with grease (technical Vaseline). It is better to nothing but does not cure the problem. Also in hot days it will become liquid andprobably will flow out. Then we bought from the local store some sealing materials and tested them (***Fig.1***).

Fig. 1

Tested sealants: (A) Universal white silicone, type 100E from Akfix, (B)high temperature red silicone type 300H from Akfix , (C) polyurethane automotive sealant type P645 from Akfix, (D) special grey polymer sealant - type FT101 from Henkel, and (E) clear hot glue adhesive sticks – no name. We did not use strong adhesives which are available on the market since we wanted to keep the rubber junctions intact which will permit to change or repair the whole setup at later time. All these materials must be able to be removed in the case of maintenance.

We seal all caps with different sealants (***Fig. 2 to 12***) and tested them. The sealing was only on the surface. The results when we open the sealed caps are also shown. The adhesion is not strong and the sealants can be removed completely from the ABS box and rubber.

Fig.2, 3, 4 *High temperature red silicone B and grey polymer sealant D (sealed and un-mounted).*

Fig. 5, 6, 7 *Universal white silicone A*

Fig. 8, 9, 10 *Polyurethane sealant C*

Fig.11, 12 *Hot glue clear type*

After sealing the waterproof was 100%. Here is the ranking of different materials sorted to their adhesion to ABS and rubber.

Weak adhesion -- > B-A-C-D-E –> strong.

The weakest adhesion has the red silicone B and the best was to hot glue E. The same seal can be used for the cable entrances (***Fig.17***)

Sealing technology is quite simple – we should carefully put some sealant around the cap and then form with finger a smooth layer. Do not forget to dip your finger in a soap water.

2. Protecting of vertically mounted AAA-1

Usually the amplifier is mounted vertically as shown on ***Fig.13.*** In this case we will suggest to do the following:

Fig.13 *The box is mounted vertically*

- Seal all rubber caps as shown on upper pictures. The only exception is the lower rubber cap for the FTP cable.
- Put a rubber gasket (***Fig.14***) for the screw that fix the box to the mast.
- Add a drainage tube (***Fig. 15, 16***) to make a path for the water to flow out.
- Seal the antenna leads. (***Fig.18***)
- Punch a small hole (***Fig.16***) in the FTP cable rubber cap for water drain.
- Put a small amount of grease (Vaseline or silicone) on the rubber gasket which is on the cover of the box.
- Seal the openings for the cover screws after the box is closed (***Fig. 20***).

Fig.14 *Use rubber gasket for the screw that fix the box to the mast.*

Fig.15, 16 *Drainage tube is placed at the bottom side of the box. A plastic tube with external diameter 5 mm and internal diameter is 3 mm is used for this purpose. A thin wire (0.4 mm diam.) is inserted into it to reduce the effects of the water surface tension. Thus it is possible to remove also the condensed water due to very fast changes of the temperature. The drainage tube and the wire are fixed with hot glue gun. The tube can be choked if not needed.*

Fig.16 *There is no need to seal the lower cap were the FTP cable is passing through. One small hole can be punched into the rubber cap next to the cable hole for a water drainage.*

Fig.17 *A test example of the antenna terminals sealing. Polymer sealant D (grey) and universal silicone A are tested. Both are good for this purpose but the polymer adhesion is better.*

Fig.18 *Sealing of the antenna terminals and top cap. This box was inspected immediately after water shower test.*

Fig.19 *Side caps are sealed with white universal silicone.*

Fig.20 *The holes on the cover of the box can be sealed with the same sealants. Do not fill the hole but just make a surface layer. This layer will be removed easily when the box must be opened.*

The only weak point in vertically mounted AAA-1 is the gasket of the cover of the box. It is possible to use there the same sealing technique but it is not so easy to be applied if the amplifier is mounted. We will suggest to put small amount of grease (Vaseline or silicone) on the rubber gasket of the cover .

3. Protecting of horizontally mounted AAA-1

An example of horizontally placed amplifier is shown on ***Fig. 21***. Here the great advantage is that the cover of the box is naturally waterproofed (acting as a roof) and there is no need to seal it. Also the antenna terminals rubber cap is placed vertically which reduces the possibility of water leakage. But there is also a need to seal all rubber caps including that at the FTP side.



Fig. 21 *Horizontally mounted AAA-1. There is also water drainage tube as in previous case. All rubber caps must be sealed.*
Fig. 22 *The clamp is fixed asymmetrically to leave the place for the antenna leads.*
Fig. 23 *The FTP rubber cap and the cable are sealed with sealant.*

4. Protecting with additional box

This is the best way to protect the amplifier. There is no need for any sealing. There are boxes for food (***Fig. 24***) which are widely available on the market. The material is probably polyethylene (PE). These boxes can withstand temperatures from -25 to +80 deg (as written on the box bottom). The PE material is not very UV resistant. Probably black painting will help but the box is so cheap that it can be replaced after several years of sunlight exposure.

Fig. 24 Polyethylene *(PE) boxes for food.*

The price of such a box is 1-2 Euro. The box used in our example is approximately 140 x 190x 90 mm. Minimal efforts are needed to prepare the protecting box.


Fig.25 *Several holes must be drilled in the box – for antenna terminals with 0.9 of diameter of the antenna leads. The antenna leads must pass with difficulty through these holes. Also one hole with 20 mm diameter for the FTP cable. The RJ45 plug and the rubber cap must pass freely through the hole. Another two holes (5 mm diameter) must be drilled at the lowest part of the box for water drainage.*

Fig.26 *The protection box is fixed to the mast with 3 screws.*

Fig.27 *The antenna leads*

Fig.28 *The AAA-1 box is mounted into protection box. It is fixed with one screw at the center of the box with rubber gasket. There is a drainage tube in the ABS box for water condense drain.*

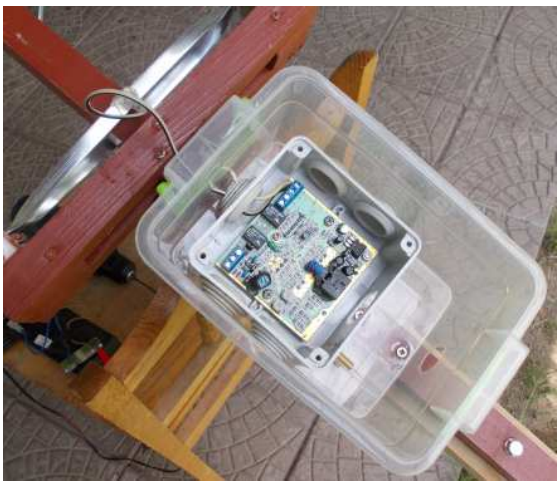

Fig.29 *The amplifier is mounted.*
Fig.30 *FTP cable and lower dipole arm (the black wire) are mounted.*

Fig.31 *The cover of the protection box is secured with nylon fishing cord.*

Fig.32, 33 *AAA-1 mounted with additional protection box. The amplifier is protected from any rain.*

Protection with second external box has many additional advantages . For example it protects the rubber caps and the box from aging.

5. Protecting the VDLine module

The box used by the VDline device (Variable delay line for phased arrays) is of the same type as AAA-1 . The same problems exist and the best solution is to use additional protection box of the same type as shown on ***Fig.24*** . Here we will present one possible solution. The size of the box is approximately 190 x 270 x 100 mm.

Fig. 35, 36, 37 *A wooden plank is prepared which length must be equal to the with of the protective box. A wooden plank is fixed to the VDLine box with two screws.*

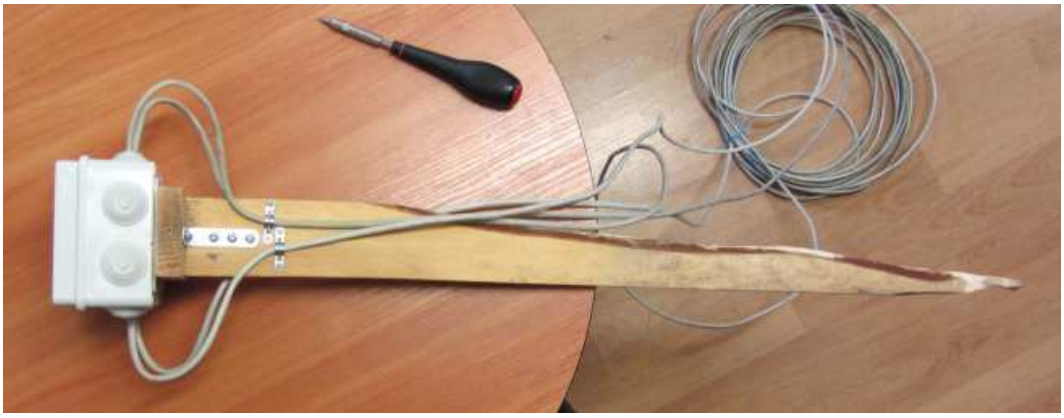

Fig. 38 *The box is fixed to a wooden stake which will be inserted into the ground.*

Fig.39 *The plank is fixed to the stake by means of two universal clamps. Another clamps are used to fix the FTP cables.*

Fig.40 *Bolts with nuts are used to fix the stake in order to ease the mounting and un-mounting. At the beginning the stake must be inserted into the ground by means of hammer and then to mount the plank with the box.*

Fig.41 *The protection box is fixed upside down with 2 screws to the wooden plank. There is no need to close the box from the lower side. The handles are removed. The possibility for water to enter into the VDLine box is almost zero.*

Fig.42 *VDLine mounted in the field.*

Fig.43 *" Under the hood"*

Some useful rules:

- Use soap water and finger to remove excessive sealant and to obtain a smooth surface.
- Hot glue is the absolute adhesive for PE since they are almost the same plastics. It is equivalent to thermal sewing of PE. Sealing of PE with other sealants is not possible.

6. Protecting the RJ45 plug

There are specific plastic hats that can be inserted into the RJ45 male plug but more reliable way is to use self-amalgamating silicon rubber tape as shown on ***Fig. 44***.

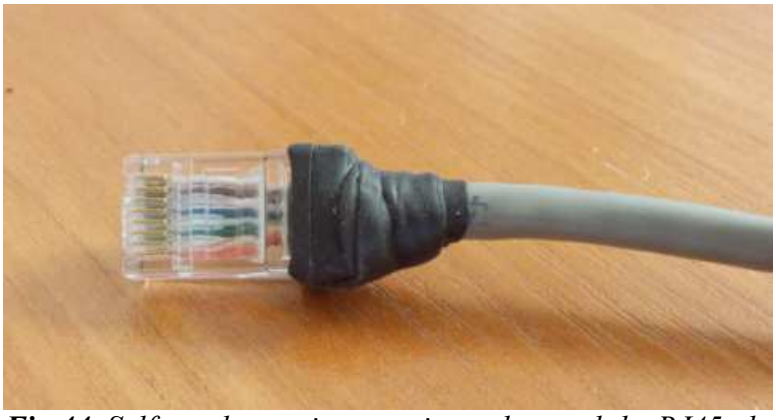

Fig.44 *Self-amalgamating tape is used to seal the RJ45 plug*

7. Using boxes with higher degree of protection

On the market there are boxes with higher degree of protection e.g. IP65 or 66. (the first figure is for dust protection and the second is for water protection). ***Fig. 45, 46*** . The main difference between them and the existing boxes are:

- There are no rubber caps for the cable terminals. The cables must pass through the box wall with special cable glands (***Fig.47***)
- The bolts of the cover are screwed in metal nuts embedded into the box wall (***Fig.48***). This permits the cover to be fixed more tightly and thus to increase the insulation to dust and water. Also the walls of the box are more thick for the same reason.
- The bolts that fix the cover are outside the protected area (***Fig.48)*** .

Fig. 45 , 46

Fig. 47 , Fig.48

It is possible to mount AAA-1 or VDL-1 in such boxes but the user should again take measures for additional protection. These boxes are not 100 % waterproof also and there is always possibility for water condense to appear due to sudden thermal difference between external and internal sides. For AAA-1 board the problem is also the insertion of the RJ45 plug which must be inside the protected area of the box.

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