

2. Mounting Instructions

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2.1 First Connection

The user must prepare the power supply, crimped FTP cable and mode control switches according to the appropriate sections. Do the first tests without an antenna to check the cable connection.

- Connect the PS output to the 100 ohms load resistor supplied with the kit and check if the voltage is within the prescribed limits.

IMPORTANT !

• The **Control board** must be with removed jumpers J5, J6. Connect to J2 the mode control switches. Connect the PS output to J7. Be sure that the green LED is ON. That means that the polarity connection is right.

IMPORTANT !

• The **Amplifier board** should be with removed jumper J6. Connect the two boards with FTP cable crimped by the user. Be sure that the green LED on the amplifier board is ON. That means that the PS connection is right.

• Connect J6 on amp. board. Insert jumpers J5 and J6 on the control board. Measure the DC voltage between CP8 and CP11 and make sure it is between 11.8 – 15.7 V. Toggle the switches. Slight clicks from the relays should be heard. That is all.

If there is something wrong, do this test with the service cable supplied with the kit to make sure that the board is working properly. Check the crimped cable for errors or bad crimping.

• (Optional) Insert jumper J8=ON (Control board) to limit the maximal output voltage to 4.2 V p-p. This is needed only for some direct sampling digital radios (SDR) in order to fulfill the requirements for maximal allowable input voltage (check their documentation). For other radios leave it open.

• Connect the desired antenna and appropriate jumpers (J1a, J1b) to the amplifier according to the description in **Antenna** section.

• Connect the receiver to the BNC plug of the **Control board** with a coaxial cable and enjoy the wideband antenna world.

The following sections describe in details various parts of the active antenna amplifier. The connection and Control board schematics are shown on **Sch.1** at the end of this document.

2.2 Amplifier Board

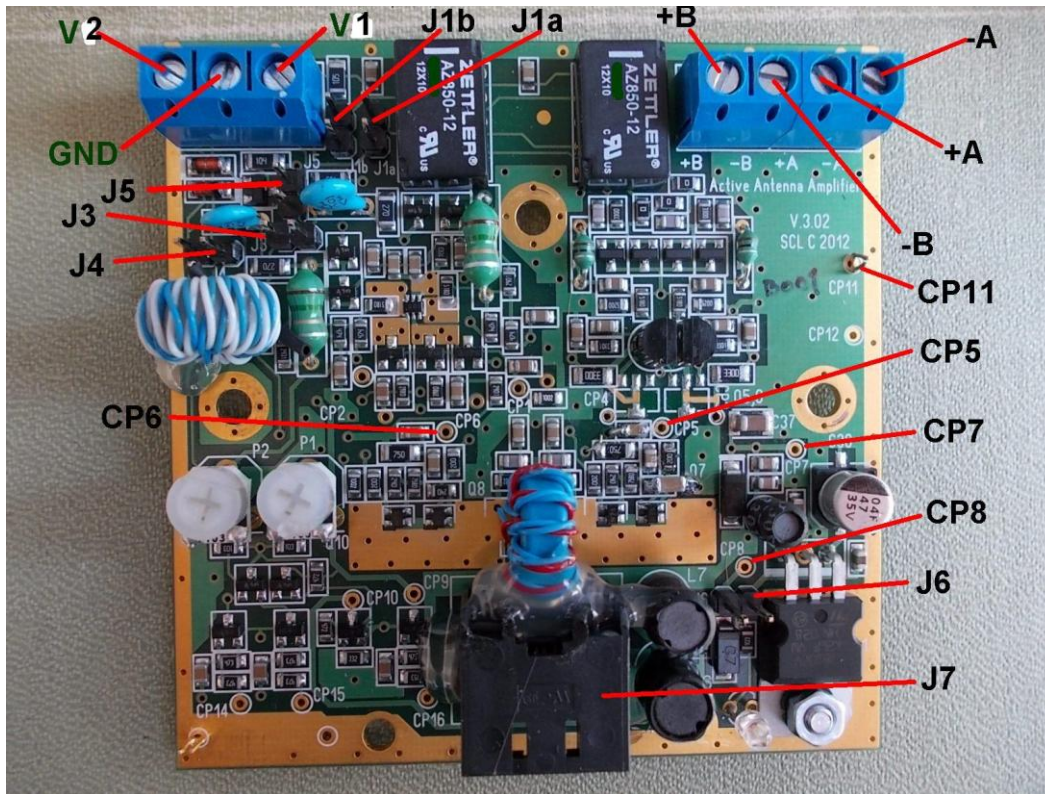


Fig. 2.1 Amplifier board model AAA-1B

The amplifier board (**Fig.2.1**) gets its power supply and mode control through an FTP cable. Here are the terminals and jumpers which the user can use:

- +A, -A** Terminals of Loop A. Polarity is important if crossed loops are used.
- +B, -B** Terminals of Loop B. Polarity is important if crossed loops are used.
- V1, V2** Terminals for separate dipole if loops are not used for dipole arms.
- GND** Lightning protection ground terminal. Connect only to a good electrical ground point. Leave it unconnected if there is no good ground.

- J1a** Jumper, OFF position if V1 terminal is used for dipole arm.
- J1b** Jumper, OFF position if V2 terminal is used for dipole arm. If loops A and B are used for dipole arms these jumpers must be in ON position.
- J3,J4** Jumpers for the input balun (in dipole mode). The default position is OFF (the balun is disconnected from the input circuit). The balun must be used when there are 2nd order IMD distortions. They might occur when large or asymmetric electric antennas are used. See the Application note “ Adding an Input Balun in AAA-1 in Dipole Mode to Reduce 2nd Order IMD Distortions when Asymmetric Signal Source (antenna) is Used”

- J5** Jumper that connects GND terminal with the amplifier common point. Used for factory adjustments. Default position is OFF.
- J6** Jumper. In OFF position the power supply is disconnected from the board. Used to connect the power for the first time and to protect the amplifier from wrongly crimped cable. With J6 in OFF position make sure that the green LED is ON – that means that the polarity is OK. Then J6 can be left safely in ON position.

- CP5, CP6** DC bias measurements control points
- CP7** 10V stabilized supply voltage control point.
- CP8** Input DC supply voltage control point.
- CP11** Common point of the amplifier. Connect the common point of the measuring equipment here.

J7 RJ45 (8P8C jack modular connector). Connect crimped FTP cable here for connection to Control board.

- Pin 1 -13.8 V
- Pin 2 +13.8 V
- Pin 3 -13.8 V
- Pin 4 Dipole antenna mode; active 0V; For Loop mode must be open circuit.
- Pin 5 Loop A mode; active 0V
- Pin 6 Loop B mode; active 0V; if pins 5 & 6 are 0V cross-loop mode is activated.
- Pin 7 RF Signal
- Pin 8 RF Signal

There are other jumpers and control points which are not documented here but are used for factory adjustments.

2.3 Control Board

The control board (**Fig.2.2**) has the following functions:

- Balun. Transforms the 100 ohms symmetrical impedance of the FTP cable to 50 ohms unipolar.
- Over-current circuit protection with resettable fuse.
- Reverse polarity protection diode (removed by jumper J6=ON)
- 1 ohm shunt resistor to measure remotely the current consumption of the amplifier. (removed by jumper J5=ON)
- On/Off green LED
- Connector for the switches which control the amplifier modes.
- Diode limiter to protect the output RF voltage not to exceed 4.2 V pp. (removed by jumper J8=OFF)

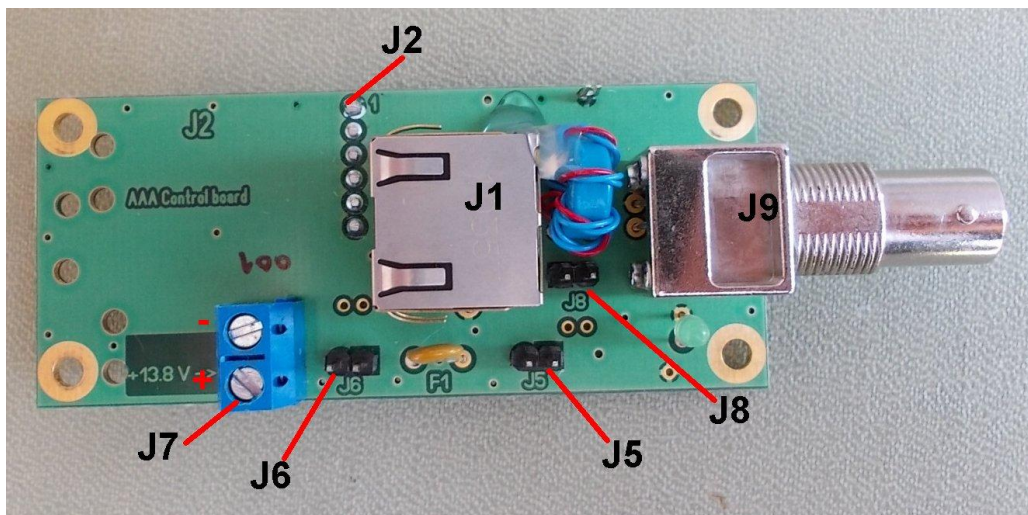


Fig.2.2 Control board model AAA-1B

- J1** RJ45 (8P8C jack modular connector) signal and power
 Pin1 -13.8 V
 Pin 2 +13.8v
 Pin 3 -13.8v
 Pin 4 Vertical antenna mode; active 0V, For the Loop mode the state is open circuit.
 Pin 5 Loop A mode; active 0V
 Pin 6 Loop B mode; active 0V; if pins 5 & 6 are 0V then cross-loop mode is activated.
 Pin 7 RF Signal
 Pin 8 RF Signal
- J2** Mode control connector (mounted on the SMD side of the board)
 Pin 1 Crossed Parallel loops mode; active 0V.
 Pin 2 Loop B mode; active 0V.
 Pin 3 Loop A mode; active 0V.
 Pin 4 Dipole mode; active 0V
 Pin 5 0V
 Pin 6 0V
- J5** Current measuring jumper (1 ohm resistor). Default position is ON.
J6 Reverse polarity protection jumper. Default position is OFF. There is 0.8 V voltage drop on the protection diode. If the supplied voltage is lower than 13 V set J6 permanently to ON position to bypass the diode. Set this jumper always to OFF position when connecting the PS for the first time!
- J7** Power connector for 13.8 V PS; polarity as shown on the **Fig.2.2**
J8 Limiter to 4.2 V p-p maximal output signal. Default position is OFF. Setting this jumper in ON position will reduce the dynamic range of the amplifier. Use it only if the specification of the RX which is used does not allow higher maximal input voltages. Usually this is true for some direct sampling digital radios where the input AD converter is directly connected to the antenna input.
- J9** BNC connector 50 ohms output (to RX).
CP1 Common point of the amplifier. Connect the common point of the measuring equipment here.

2.4 Power Supply

The user must prepare a power supply (PS). The requirements are:

- minimal DC voltage between control points CP8 and CP11 (common point) of the amplifier: 11.8 V
- maximal DC voltage between control points CP8 and CP11 (common point) of the amplifier: 15.7 V
- maximal current consumption: 145 mA.

There is a 7810 IC stabilizer in the **Amplifier** board which needs at least 1.8 V (at 145mA current) difference between input and output to work properly. There are also two chokes at the supply input with additional 0.3 V voltage drop so at the RJ45 terminals (at the amplifier side) the minimal supply voltage is 12.1 V and the maximal is 16 V. The voltage drop in the FTP CAT5 cable is 0.019 V per 1 meter which also must be taken into account :

$$V_{min} = 12.1 + 0.019 * L(\text{cable length in meters}); \quad V_{max} = 16 + 0.019 * L$$

If the cable length for example is 15 meters, then the margins at the cable input become approximately 12.4 to 16.1 V. This voltage must be measured at **Control** board between J5 and CP1 under loaded conditions with connected amplifier and J5 and J6 in ON position. The reverse polarity protection diode is bypassed by J6. If J6 is off there is an additional 0.8 V drop - if the minimal voltage requirements in this position are fulfilled leave J6 OFF. This will reduce the power dissipation of the stabilizer in the amplifier board. These calculations are reliable only if the CAT5 cable is produced according to standards. Cable with smaller wire diameter or conductor different from pure copper might

have much higher DC drop voltage as well as RF losses. See also FTP cable section and **Q&A** document for more details.

Since the current requirements are minimal, the 13.8 V PS of the existing RX or TRX can be used successfully. Another possibility is to use a wall transformer 12V PS which is widely available. We



Fig.2.3 Typical 12V power supply for cordless telephones

will suggest using the iron transformer PS from old cordless telephones. They are widely available everywhere (**Fig.2.3**). They are usually marked 12 V, 0.3 to 0.5 A. At 145 mA current the output voltage is somewhere around 14.5 V. When testing the PS always use the 100 ohms resistor supplied with the kit as a test load. Connect this resistor to the terminals of the tested PS – this resistor will load the PS approximately with the same current as the amplifier. Then measure the output DC voltage to be in the prescribed limits.

The user should make sure that at the output of the PS the voltage is DC, not pulsed. If there is only a rectifier into the transformer box, a 2000 uF/25V electrolytic capacitor filter should be added. For field work a standard lead acid accumulator will give sufficient voltage (12.3-12.8V) if the connecting cable is not too long (see also the FTP cable section).

Do not use switching PS which will create a lot of parasitic noise. The switching PS are very lightweight compared to the iron transformer type.

2.5 Mode Control Switches

The user must provide external switches to the control board for remote control of the antenna modes. The schematic is shown on **Fig.2.4**. Three simple switches are needed – two SPST and one DPDT. When S1 is in the position as shown on **Fig.2.4** the antenna is in dipole mode and the positions of the other switches are irrelevant. When S1 is in the other position then the mode is obtained from the positions of S2 and S3. A 6 pin connector with un-mounted pins is supplied with the kit to connect the switches with the control box. The connector is located at the SMD side of the **Fig.2.5**. Pin 1 of this connector is also shown there - it is also marked on the PCB with figure 1.

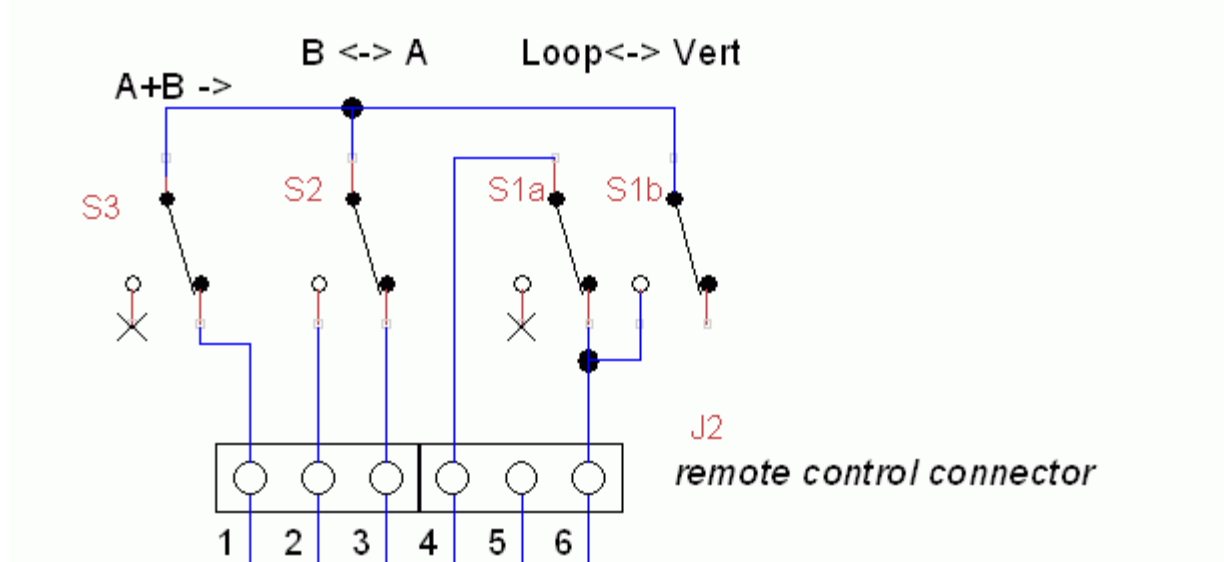


Fig. 2.4 Remote control switches schematic diagram

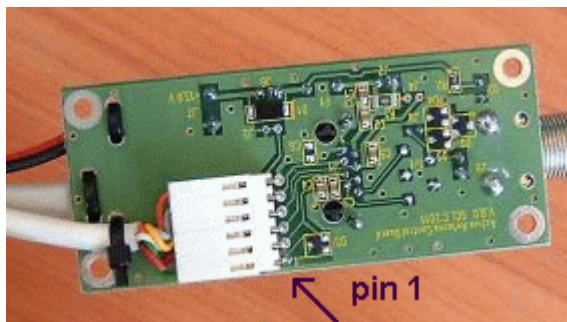


Fig.2.5 Switch plug connection

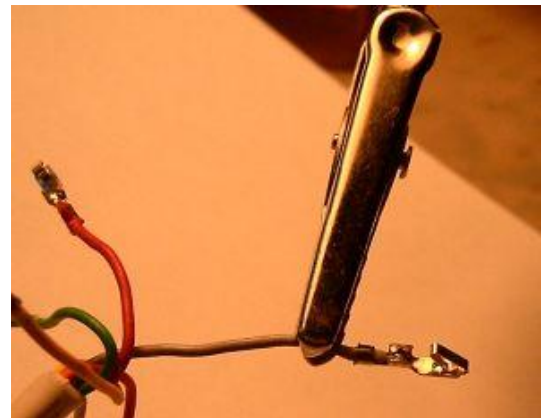


Fig.2.6 Soldering plug pins

The pins are for crimping but they can be soldered successfully as shown on **Fig.2.6**. On the board there are holes to secure all cables with cable ties. The switches can be mounted in a plastic box with the control board as shown on, **Fig. 2.7, 2.8**.

A metal box can also be used but the control board is small in size, screened connectors are used, and there is no need for additional metal screening.



Fig.2.7 A Control board box



Fig.2.8 Inside view



Fig. 2.9 Mounting the control board without box.

Another option is to mount the control board on another cable without any box. An example is shown on **Fig.2.29** where the control board is secured with cable ties to the main antenna coaxial cable. A short coaxial cable connects the amplifier output to the receiving antenna input of the transceiver. The switches can be mounted on a separate plate and connected to the box with a long 6-wire cable. This solution is very convenient since the small switch plate is very flexible and can be mounted anywhere. On the figure two wooden pieces are used as the base of a plastic plate where the switches are mounted.

2.6 FTP Cable

The FTP cable is a screened CAT5 or CAT5E cable. It consists of 4 twisted pairs. There are numerous producers of this type of cable, but the user should be aware that there are some very low quality cables on the market. The most common problems are that the cables have non standard wire diameter. The standard wire diameter should be AWG 24 (0.51mm). If it is different then the crimping to the connector might not be reliable. Also, if the conducting material is not pure copper the losses will be

higher. On the other hand there are more expensive cables specially designed for external environment (**Fig2.10**). A normal good quality single braid FTP cable will last for several years in external environment without any problems.



Fig. 2.10 Double braid FTP

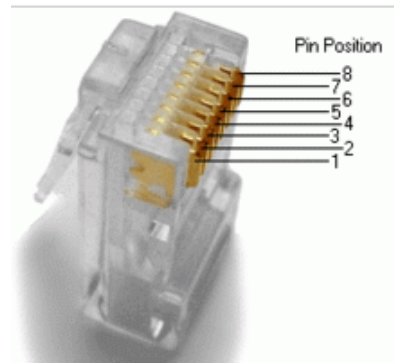


Fig.2.11 RJ45 (8P8C modular plug)

Fig. 2.11 shows RJ45 (8P8C modular plug) which must be crimped to the cable. There are some very cheap crimping tools on the market which do not last too long but usually several hundred crimpings can be performed without problems. These plugs are so popular that any technician dealing with the computer nets has such a tool. Very good examples how to crimp plugs can be found on numerous movies on YouTube [1],[2].

The cable wiring is the so called straight cable and a wire diagram is shown on **Fig. 2.12**

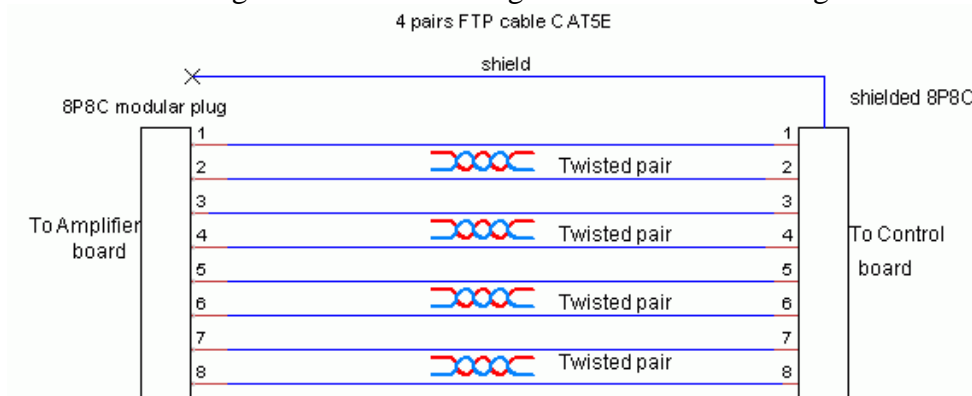


Fig. 2.12 Cable wiring

RJ45 (8P8C jack modular connector) cable connection on both ends:

Pin 1 -13.8 V

Pin 2 +13.8v

Pin 3 -13.8v

Pin 4 Vertical antenna mode; active 0V, For the Loop mode active state is open circuit.

Pin 5 Loop A mode; active 0V

Pin 6 Loop B mode; active 0V; if pins 5 & 6 are 0V then cross-loop mode is activated.

Pin 7 RF Signal

Pin 8 RF Signal

It does not matter which color pairs to which pins are connected. The only requirement is that the two RF wires (Pin 7 and 8) should be part of a single twisted pair.

The RJ45 plug connected to the amplifier board is unshielded and it is better to crimp it first.

Fig.2.13. Do not forget to put the rubber cap for the box before crimping the other connector! The opposite plug must be screened. **Fig. 2.14** and **Fig.2.15** show how the screened plug is mounted. The internal screen wire should be soldered to the plug screen and this makes an excellent secure connection.



Fig.2.13

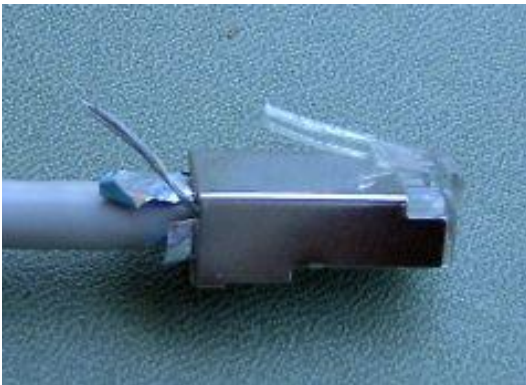


Fig.2.14



Fig. 2.15

At the amplifier side the screen wire should be left open but there must be a small tail left for possible connection to the ground if necessary.

Ready made straight cables for computer networks can be used as well. Pins 1 & 2 and pins 7 and 8 on ready made Ethernet network straight cable are always part of one pair so they are suitable for this purpose. Do not forget to carry out the polarity protection instructions (see **2.1 First Connection**) when changing the FTP cable with a new one!

The length of the cable is limited by the attenuation of the cable. FTP shielded CAT5E cables have the following typical parameters per 100 m length:

Attenuation: 1MHz 2 dB, 10 MHz 6.5 dB, 50 MHz 12 dB

Ohmic resistance: 9.0 ohms/100m

If the receiver noise floor is low, a substantial length of cable can be used. For example, if the MDS of RX is -140 dBm @ 500Hz BW, then 100 m of cable will reduce the signal and noise level with 6.5 dB at 10MHz and the noise of the amplifier will still be 10 dB above the RX noise floor. For 50 MHz this length is still acceptable with very slight degradation of sensitivity.

The resistive losses should also be taken into account. As said earlier, the DC supply voltage at the RJ45 terminals at the amplifier side should not be lower than 12.1 V (or 11.8 V at CP8 control point) in the worst case conditions. At a current of 140 mA there will be $0.14A * 9 \text{ ohms} = 1.3 \text{ V} / 100 \text{ m}$ DC voltage drop per single wire. In our case we have one wire for positive polarity and two parallel wires for negative polarity. Which means $9 + 4.5 = 13.5 \text{ ohms} / 100\text{m}$ or $1.82 \text{ V} / 100 \text{ m}$ voltage drop. When choosing PS voltage these requirements should be taken into account.

2.7 Mounting the Amplifier into the Box

The amplifier is mounted in the plastic box (**Fig.2.16**). There is no need to use a metal shielded box. The box that is supplied with the kit is a standard electrical box for external wiring. This particular box is IP55 protected, made from UV resistant ABS and has rubber caps for the cables. There are 3 screws (3.5 mm) to mount the amplifier board. The places of the screws are marked on the bottom of the box. When mounting, insert screw # 1 first, screw down it slightly and then move the board to match the universal holes of the box with holes in the board. Then insert screws #2 and 3. Be careful not to twist and bend the board. The board is SMD design and bending might break some component! Do not screw the bolts very tightly into the plastic since the thread might be damaged.

The antenna leads can run through the holes as shown on the **Fig.2.17**. Separate holes for each lead must be punched in the rubber cap. The diameter of the hole must be approximately 80-90% of the outer diameter of the antenna lead. One of the rubber caps has a ready-made 5 mm hole for the FTP cable. There are 5 rubber caps so if for some reason the user has punched the holes wrongly, he can take another cap. The wrongly punched one can be choked with some silicone glue and mounted in an unused hole of the box. The leads for the separate dipole antenna and protection ground can run through another cap.



Fig. 2.16 Mounting the amplifier board into the box

For extreme environments the user might want to use another type of box so there are three 3.7 mm and two 3.3 mm holes on the amplifier board for easy board mounting.

How to mount easily the board and cables? First of all fix the board with the 3 screws. Then insert and fasten the leads into the terminal blocks. The ends of the antenna leads must be tinned and with diameter not more than 2mm and then put the rubber cap. The RJ45 connector is plugged first then the rubber cap is adjusted in the box hole. When unplugging first remove the cap and then the connector can be unplugged easily.

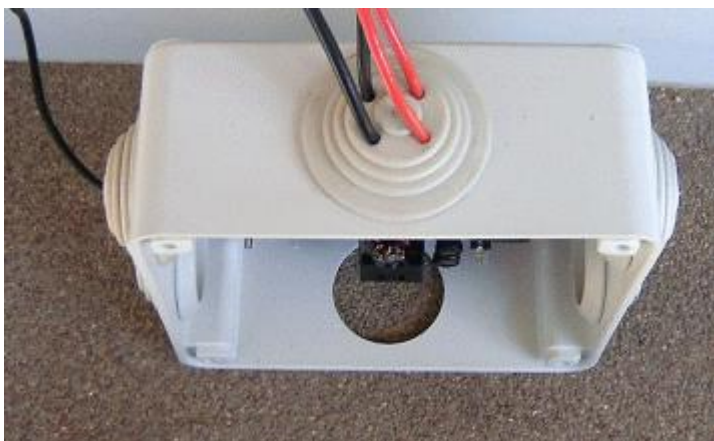


Fig.2.17 Leads connections

2.8 Mounting the Box to the Mast

The users can choose the proper antenna construction according to their needs. See *Antenna* section. There are many ways to mount the box to the mast. There are 4 places on the bottom of the box where holes for bolts can be drilled.



Fig.2.18



Fig.2.19

The easiest way to mount the box is with one screw only (**Fig.2.18**, **Fig. 2.19**). The center of the box is drilled and a single 5 mm diam. screw is inserted there. It is fixed with a hot glue gun from both sides. One hole is drilled in the mast (PVC tube in this case) – **Fig.2.20**. Only one screw is used but the box is well fixed because it is held also by the antenna leads and the FTP cable. This cable must be fixed to the mast to avoid bending and stress to the RJ45 plug. A lazy solution is shown on **Fig. 2.21** - the cable is fastened with cable ties. The cable is wrapped with several turns of insulation tape to reduce the pressure from the ties. Do not fasten the ties strongly since the braid can be damaged.

Several words about additional protection from external environment. There are silicone seals of different kinds (spray, paste etc.) on the market. They can be used for additional protection from moisture and UV erosion. All rubber caps can be covered with the spray especially the places where the wires are entering the box. This procedure will increase the life and reliability of the whole setup and will keep the rubber more flexible. This must be performed at least once per year. The 4 supplied with the kit screws for the box cover are not made from inox steel so it is good to cover them with some grease to avoid corrosion. In very extreme environment the user can use another box with higher degree of protection.



Fig.2.20 Fixing to the mast



Fig.2.21 FTP cable fixing

2.9 Simple Measurements

Some simple DC measurements can be performed to check the amplifier state:

DC Supply voltage at the input of the cable:

The supply voltage at the cable input is measured between *J5* (with jumper ON) and *CP1* of the Control board. Under loaded condition when the amplifier is connected, the voltage should be between 12.1 and 16 V for zero length of the FTP cable and must be increased with 0.019 V per each meter of the cable.

Power consumption:

Remove *J5* on the control board. Connect a DC voltmeter between the two pins of the jumper and measure the voltage. There is 1 ohm shunt resistor on the board. The voltage in mV equals the current in mA. The current should be approximately 130 mA (Loop A or B mode), 140 mA (Loop X mode) and 120 ma (Dipole mode). These measurements permit to check the amplifier current remotely.

DC operating point on the amplifier board:

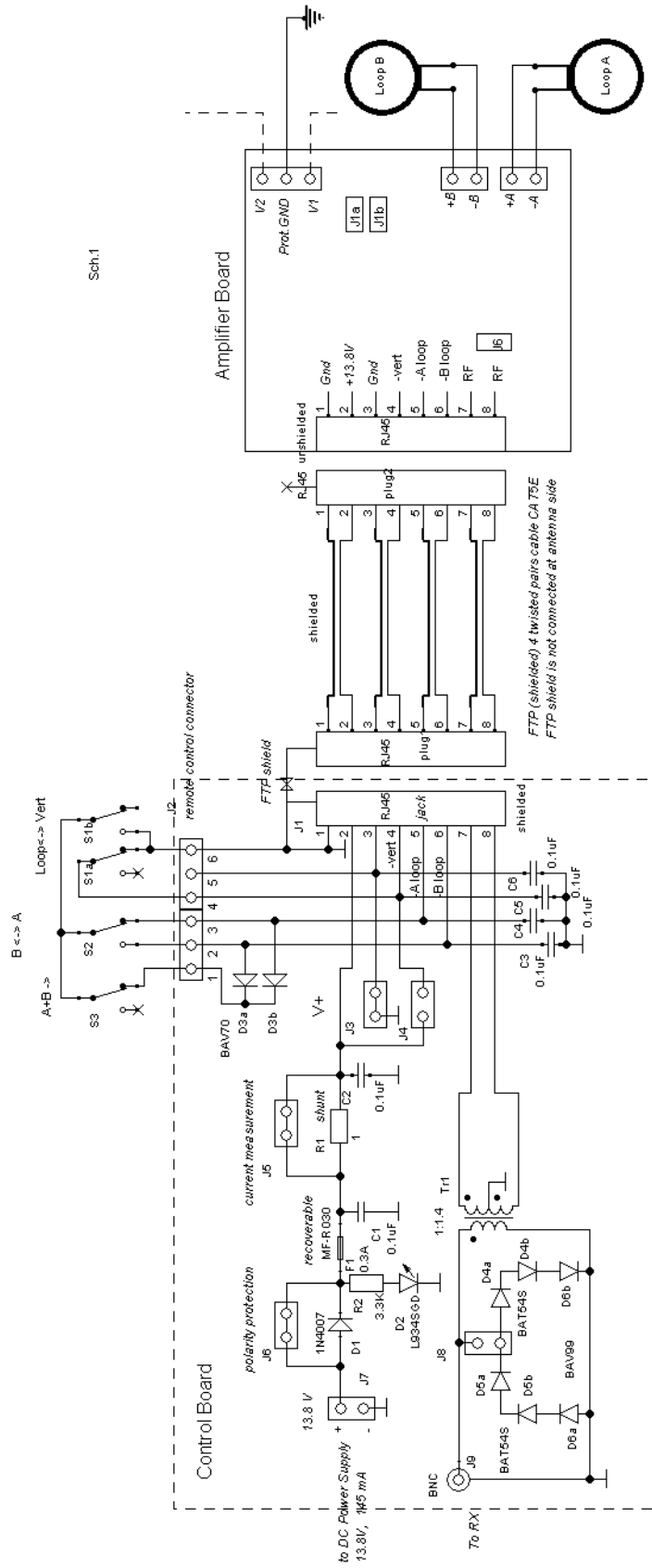
Connect the DC voltmeter between the common point *CP11* and the corresponding control point:

CP5, CP6: 2.85 V +- 20 mV ; the voltage should be equal at the two control points. This is the voltage across emitter resistor at the output power amplifier. Switching between voltage and current amplifier should not change significantly this voltage. All stages of the amplifier are DC connected and this single measurement assures that the operating points of all stages are correct.

CP7: + 10V stabilized supply voltage control point.

CP8: Input DC supply voltage control point. Should be between 11.8 V and 15.7V.

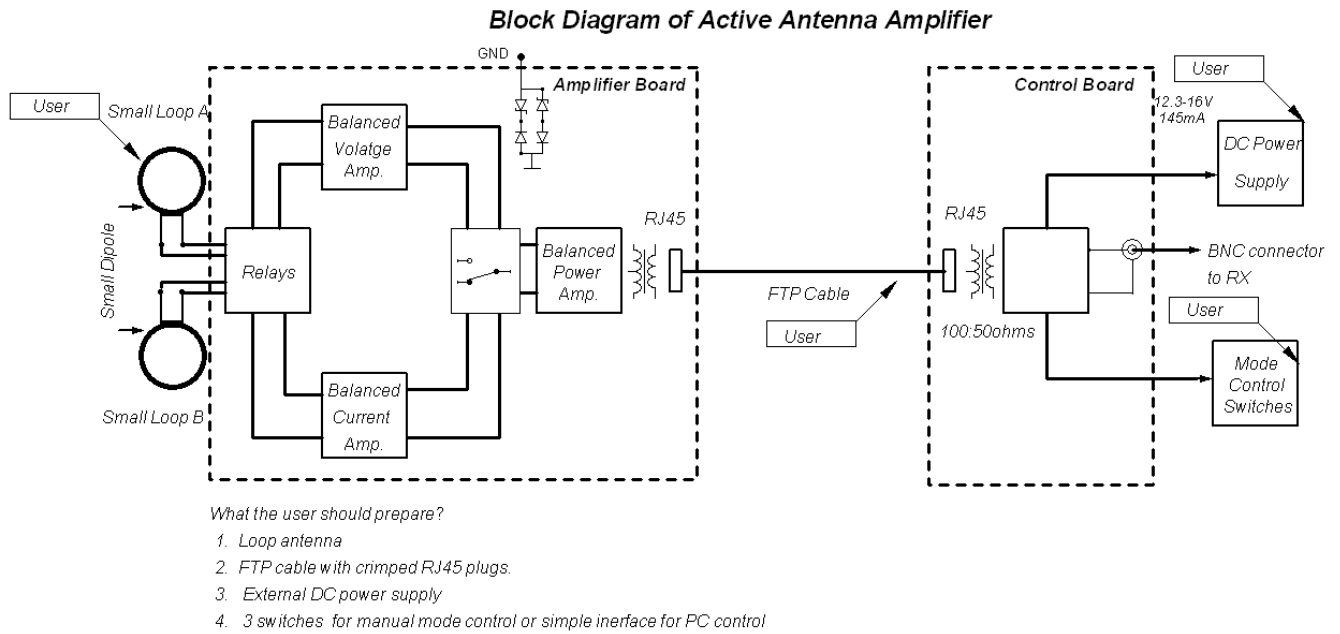
On **Sch. 1** a wiring diagram of **Control** board and connections to the **Amplifier** board are given. On **Sch. 2** the block diagram of the Amplifier is given.



Sch.1

Title	AAA-1 Control box & Amplifier block		
Author	© LZ1AQ & Signacor EOOD		
File	LMModul_CBox\Sch\CBox_v56aAMP_block_2.dsn		
Revision	5.6a	Date	5 June 2011
Document	Sheets		1 of 1

Sch.1



Sch. 2 Block diagram of the amplifier

2.9 Links

How to crimp RJ45 plug videos:

[1] <http://www.youtube.com/watch?v=k4B4Sep3Qpg&feature=related>

[2] <http://www.youtube.com/watch?v=482VtesZwZ8&feature=related>

Used Abbreviations

ABS	type of styrol plastic
AD	analog to digital
BC	broadcasting
BJT	bipolar junction transistor
BNC	bayonet coaxial type of connector
BW	bandwidth
CP	crossed parallel (loop) or compression point
DC	direct current
DX	far located station
EM	electromagnetic
FM	frequency modulation
FTP	4 pairs screened communication cable type CAT5 or CAT5E
HF	high frequency 2 - 50 MHz
IP	abbreviation for mechanical protection level or intercept point
JFET	junction field effect transistor
LAN	local area network
LED	light emitting diode
LF	low frequency (bellow 500 KHz)
LW	long waves
MDS	minimal discernible signal
MW	medium waves
OIP	output intercept point
PC	printed circuit or personal computer
PCB	printed circuit board
PE	polyethylene
PVC	polyvinyl chloride
pp	peak to peak value
PS	power supply
RX	receiver
SD, SDR	software defined (radio)
SMD	surface mounted device
S/N	signal to noise ratio
SW	short waves
TRX	transceiver
VHF	very high frequency