Amplifier for Small Magnetic and Electric Wideband Receiving Antennas (model AAA-1B)

1. Description and Specifications

Contents

Fig.1.1 *Amplifier*

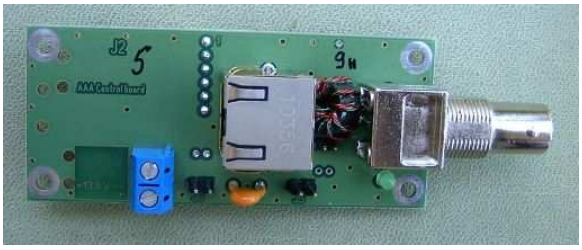

Fig.1.2 *Control board*

1.1 Description

This amplifier is intended for construction of small wideband active receiving antennas from LF to upper HF bands. The mechanical construction of the particular loop/dipole antenna must be performed by the user. This amplifier can use two separate small magnetic loops. These two loops are used also as two arms of a small electric dipole. Thus 3 different antennas can be used. The amplifier has four remote switched modes: Loop A, Loop B, crossed parallel loops A&B and dipole. Each mode can be switched immediately and this enables us to use the best antenna for the moment.

This kit consists of two SMD mounted PC boards – an amplifier board (***Fig.1.1***) and a control board (***Fig.1.2***). The amplifier has low noise, high dynamic range and wideband properties. It has separate current and voltage amplifiers for the different antennas (*Fig. 1.3*). It is a balanced design and uses monolithic pairs of BJT (loop amplifier) and JFET (dipole amplifier). The balanced power amplifier uses medium power BJT with very low IMD and can give approximately 75 mW of output power on a 50 ohms load in order to minimize the non-linear distortions. The small antenna frequency response in all modes is flat in a wide frequency range. Usable frequencies are from 20 KHz up to 55 MHz. The antenna gain in the current and voltage mode is set to be approximately the same to avoid striking differences in the gain when the antennas are switched.

The amplifier is connected to the receiver via a control box and FTP (shielded CAT5) cable with RJ45 connectors which ensure good balance to avoid common mode noise signals. The cable length can be above 100m. There is a possibility to limit the maximal voltage applied to the receiver input which is needed for some direct sampling SDR. The amplifier has jumpers for setting it to the particular environment. It is of SMD design and is mounted in order to be low cost. Every kit set has been tested.

The amplifier input is protected from high electromagnetic field intensities – it can be used with small magnetic and electric antenna in the immediate vicinity (20-30m) of transmitting HF antennas even if the power is 1 - 2 KW. The amplifier has input filters to reject the frequencies above 55 MHz to avoid the influence of strong stations in the broadcast FM bands (80-108MHz).

The amplifier is powered by a nominal 13.8 V (11.8 – 15.7 V margins at control points) DC power supply @ 145 mA nominal current. The standard existing power supplies (PS) for the transceivers or receivers can be used. The amplifier is mounted in an ABS plastic (IP55 protected) box. It can be used by any receiver with sufficient sensitivity and 50 ohms input. This amplifier can be used as a building block for more sophisticated antennas such as phased arrays etc. Minimal additional efforts are needed to complete this active antenna project.

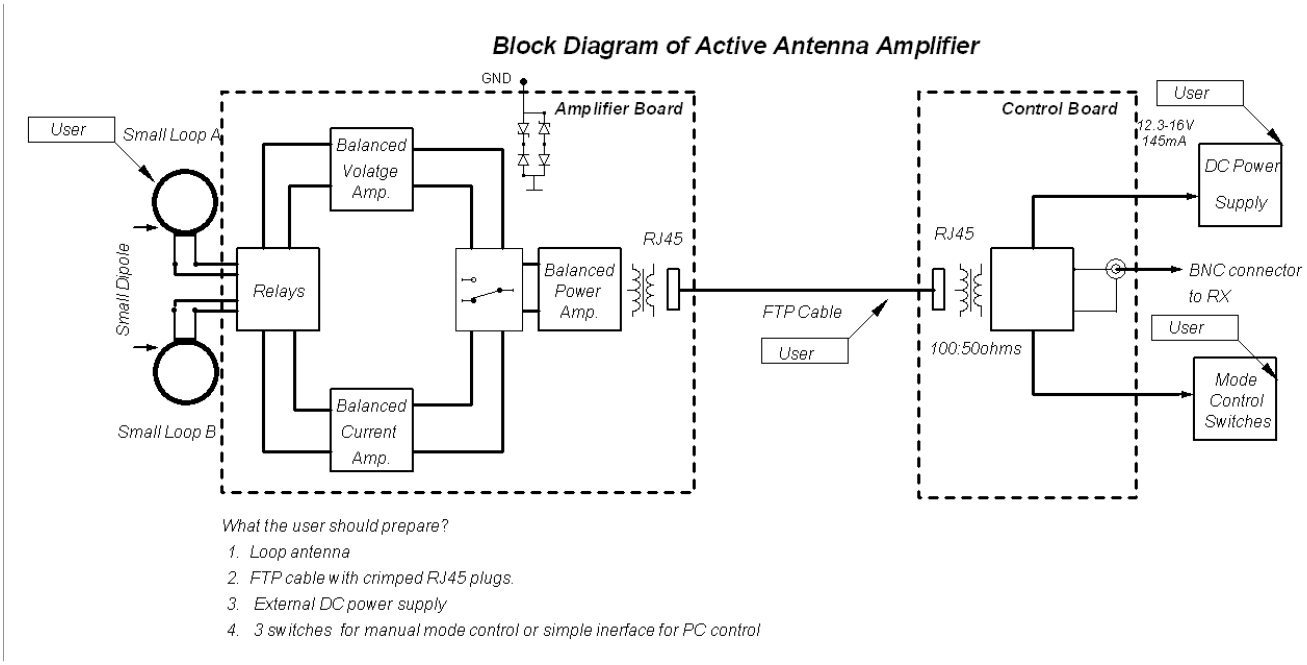

Fig. 1.3 *Block diagram. Two small loops act also as arms of a small vertical dipole*

1.2 Specifications for Model AAA-1[11]

General

Output impedance	50 Ohms, BNC connector on control board
Power supply[1]	External, 13.8 V, =< 145 mA
	Polarity protection & recoverable fuse are on the control board
Maximal output voltage[10]	6V p-p or 4.2 V p-p
Physical size	76 x 76 mm Amplifier board; 32mm x76mm Control board

Current amplifier with 1m diam. loop

Loop :	diam. 1 m, 1 turn, conductor with 25 mm diameter, 2.4 uH
Antenna Factor K_a[2]	2 dB meters^{-1} @ 10 MHz
	(1 uV/m input signal will give 0.8 uV output voltage)
K_a Frequency response[2]	0.35 – 51 MHz; (within 3dB)
Usable frequency range [3]	0.02 – 55 MHz
MDS @ 10MHz [2]	0.7 uV/m , Noise bandwidth =1KHz
Output noise power at 10MHz[4,5]	-113 dBm
1 dB output compression point[9]	+19dBm (5.6 V p-p), equal to +125 dB(uV/m) at input
Second harmonic OIP2[7]	+88dBm to +94dBm
Third harmonic OIP3[8]	+41dBm to +42dBm

Voltage amplifier with dipole arms of 2 x 1 m

Antenna Factor K_a[2]	2 dB meters^{-1} @ 10 MHz
	(1 uV/m input signal will give 0.8 uV output voltage)
K_a Frequency response[2]	0.35 – 55 MHz; (within 3dB)
Usable frequency range [3]	0.02 – 55 MHz
MDS @ 10MHz [2]	0.25 uV/m, Noise bandwidth =1KHz
Output noise power at 10MHz [4,6]	-118 dBm
1 dB output compression point[9]	+19dBm (5.6 V p-p) equal to +125 dB(uV/m) at input
Second harmonic OIP2[7]	+94dBm to +103dBm
Third harmonic OIP3[8]	+40dBm to +42dBm

(1) The voltage measured between control points CP8 and CP1 of the amplifier should be > = 11.8 V. The maximal voltage should not exceed 15.7 V.
(2) The value is not measured but based upon spice model calculations.
(3) The amplifier can be used down to 20 KHz lower limit since the degradation of the gain is not so important on these frequencies (the atmospheric and man-made noise levels are high).
(4) The noise power is measured with Perseus SD RX at 10MHz at 1KHz noise bandwidth. The amplifier is placed into a shielded box and powered by battery. The inputs are connected to antenna equivalents. Careful shielding is needed to measure the amplifier output noise eliminating the noise of external sources.
(5) Measured with antenna equivalent of 2.4uH. Symmetric signal source at +A, -A terminals. Typical value.
(6) Measured with antenna equivalent of 10 pF. Symmetric signal source at V1, V2 terminals. Typical value.
(7) Measured with single tone method at 3.69MHz / 7.38 MHz at +2 dBm output level. Symmetric signal source. Data are from 5 randomly chosen production samples.
(8) Measured with single tone method at 2.46MHz / 7.38 MHz at +2 dBm output level. Symmetric signal source. Data are from 5 randomly chosen production samples.
(9) Measured at 10MHz, typical value
(10) *Clipping level. Typical value. 4.2 V is for diode limiter jumper in ON position.*
(11) *Specifications subject to change without notice. Current version* AAA-1B. *PCB identifications: ampl. board v.3.02, control board v.1.04*

Notations:

K_a *- Antenna factor is a measure of the antenna gain.*

$$K_a = 20 \lg (E / U_{out})$$

where E[uV/m] is the input field intensity, U_{out}[uV] is the output voltage . The output is loaded with 50 ohms. The dimension of K_a is meter $^{-1}$

MDS *is minimal discernible signal.*

OIP *is output intercept point*

1.3 Tested parameters in production stage

- DC operating points
- Frequency response at 7 points. 0.1, 0.3, 1, 10 , 30, 50 , 100 MHz
- Output noise power
- 1 dB output compression point at 10MHz
- Second harmonic OIP2 at 3.680/7.360 MHz

This set of measurements assures that the amplifier has normal gain, frequency response, noise floor and dynamic range.

1.4 Charts

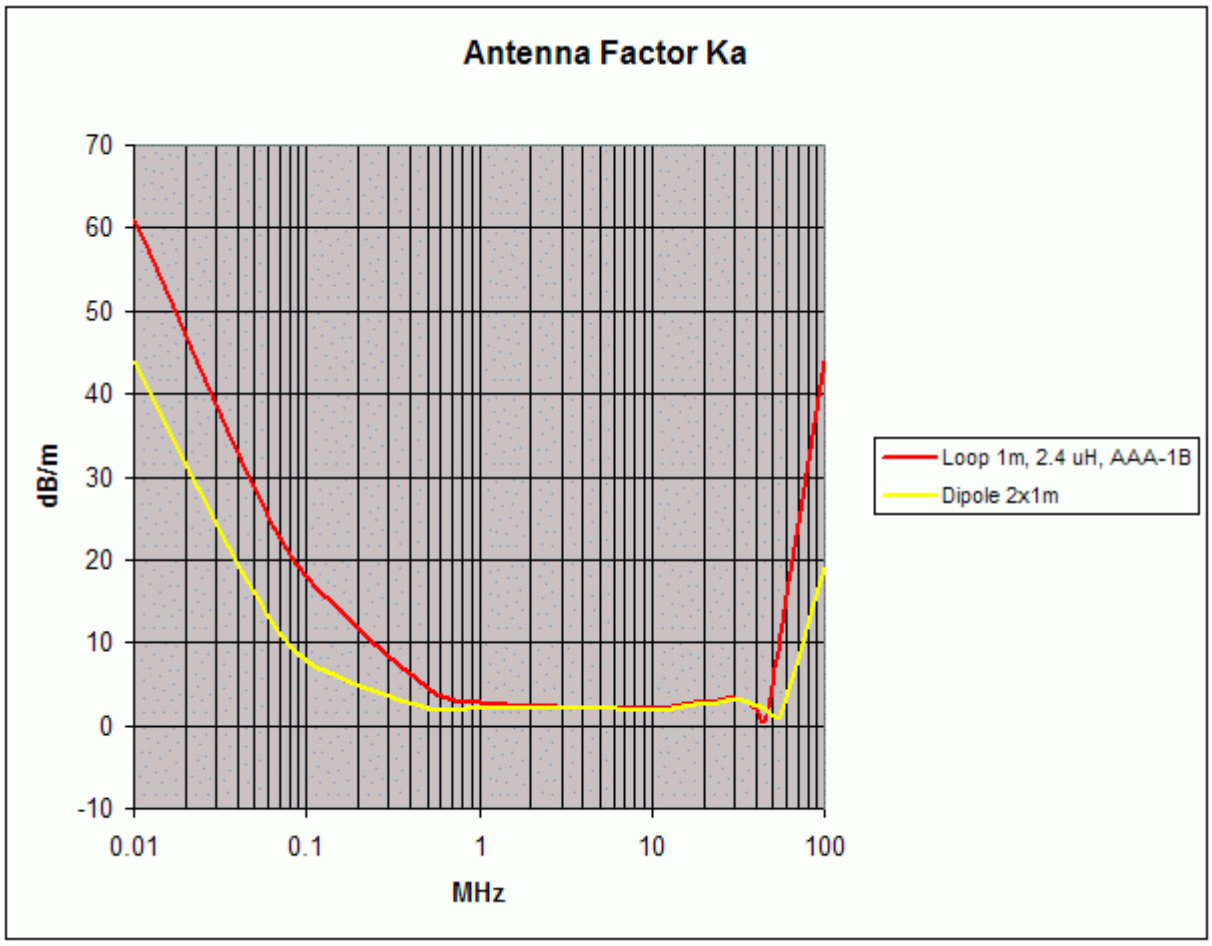

Fig.1.4 *Spice simulated antenna factor K_a for loop and dipole. The circular loop is with single turn 1m diam. made with 25mm diam. alum. tube with 2.4 uH inductance. The dipole has two 1 m long arms – effective height is 1 m. .*

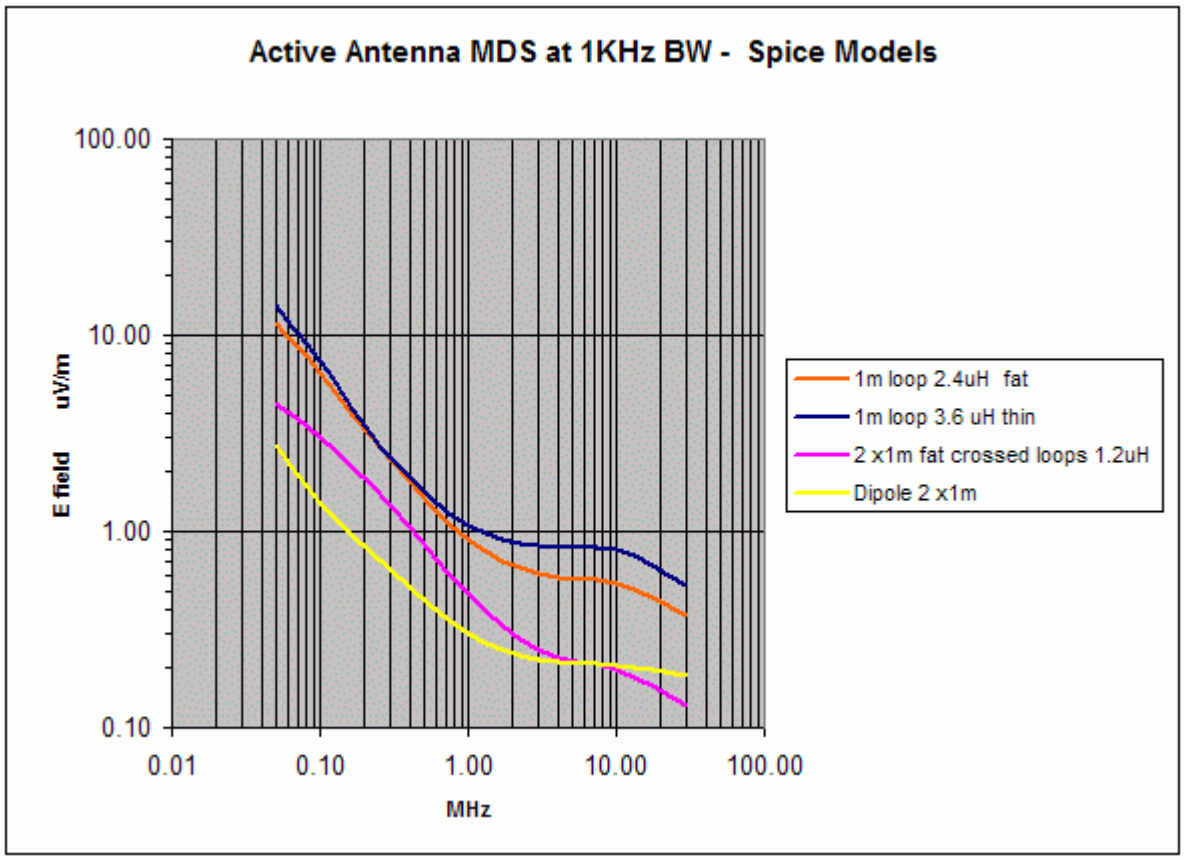

Fig.1.5 *Spice simulated input minimal discernible signal (MDS) in [uV/m] for different antennas. The noise bandwidth is 1KHz. First two loops are 1m diam. single turn (thin and fat conductor). 2-crossed loops are loops with 1m diam. circular shape (1.56 m^2 total area), each with fat conductor. The dipole is with 2 arms of 1 m. See* ***Antenna*** *section for details. A small loop and dipole models are used which is acceptable up to 10 MHz. For higher frequencies the MDS values might be not reliable.*

Rem.: Low inductance of the loop is needed for the frequencies where its corresponding inductive impedance is higher than the input impedance of the amplifier. For low frequencies where this impedance is low (<3 ohms) there will be no difference in sensitivity between "fat" and "thin" loops with equal areas. See upper two curves of Fig.1.5.

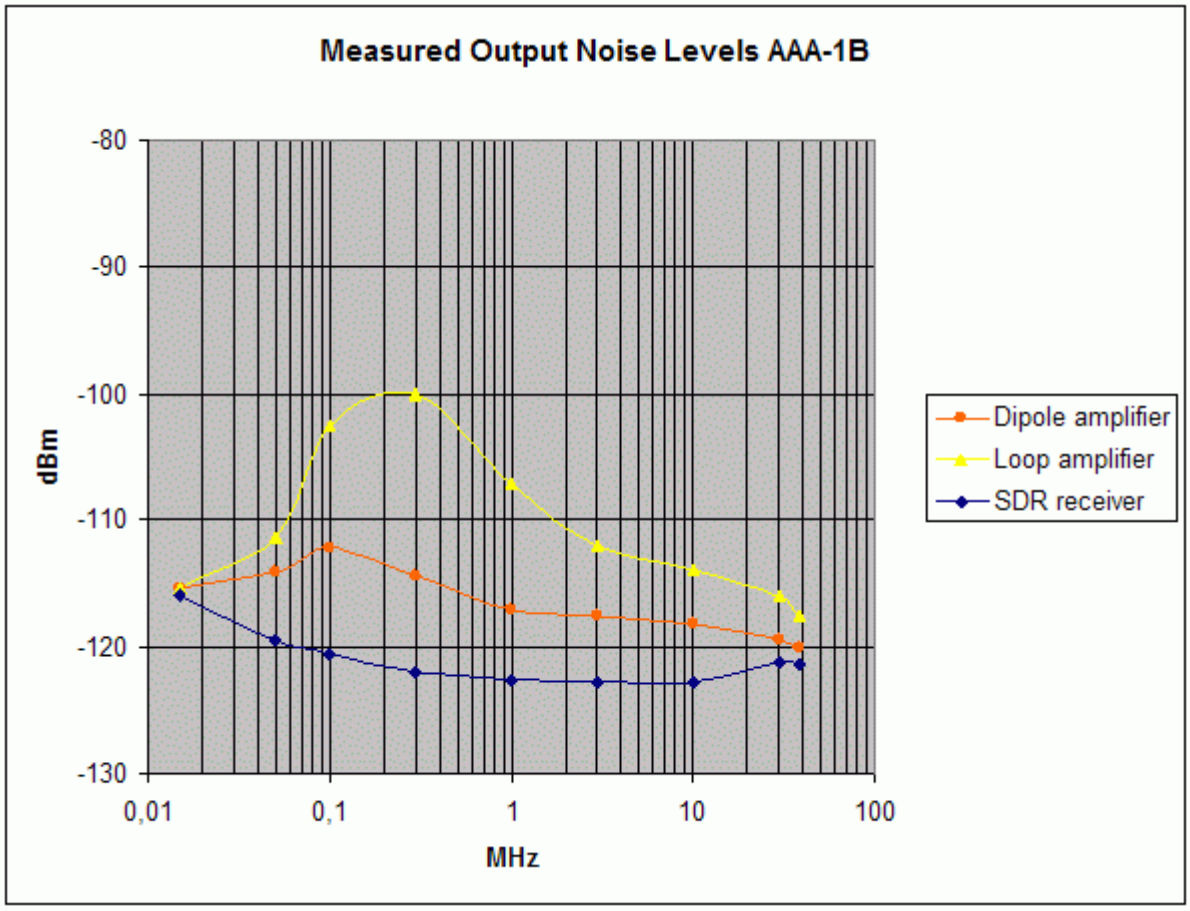

Fig. 1.6 *Output noise levels of the active antenna amplifier measured at 1 KHz bandwidth without antenna. The loop amplifier is measured with 2.4 uH loop inductance connected to the input. The dipole amplifier is measured with 10 pF equivalent dipole capacitance. The equivalent input noise level of a direct sampling SD receiver is given for comparison. Usually the commercial RX and TRX have similar or lower noise floor. This chart is useful to obtain information for the needed noise floor of the receiver which will be used with this active antenna. A practical rule is that the receiver noise floor should be at least 6 dB bellow the output noise level of the antenna amplifier.*

1.5 Kit

The amplifier kit consists of the following parts:

- Amplifier board (mounted and tested)
- Control board (mounted and tested)
- 6-pin female connector for remote control switches
- Plastic ABS IP55 protected box
- 3 mounting screws diam. 3.5 mm
- 9 jumpers (2.54 mm)
- Short service cable crimped with two RJ45 connectors
- Spare RJ45 shielded plug connector
- Spare RJ45 unshielded plug connector
- Load resistor 100 ohms/2W

1.6 Links

More detailed description of the theory, schematics and principle of operation of this active antenna amplifier can be found in other publications:

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

[2] *Wideband Active Small Magnetic Loop Antenna. Protection from Strong Electromagnetic Fields.* http://www.lz1aq.signacor.com/docs/Wide_Mag_loop_prot_v1/wideband_mag_loop_protection.htm

[3] *Very Weak Signal Reception with Small Magnetic Loop Antenna.* http://www.lz1aq.signacor.com/docs/fa-eng/Weak_signals-mag_loop_engl.htm

1.7 Documentation

This project refers to the following PDF format documents:

1. ***Description and Specifications***
2. ***Mounting Instructions***
3. ***Antenna***
4. ***Questions and Answers***

1.8 Used Abbreviations

ABS	type of styrol plastic
AD	analog to digital
BC	broadcasting
BJT	bipolar junction transistor
BNC	bayonet coaxial type of connector
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

1.9 Disclaimer

This amplifier kit (referred to as the Product) is not intended for professional use or other responsible applications. It is a hobby project and it is intended to be used by the amateur radio society. The specifications data are based only on measurements in the designer's laboratory and model calculations. They are made on random production samples. The designers and producers of this Product will make all the necessary efforts to ensure that the production fulfills the above mentioned specifications. We do not guarantee that the documentation of this Product is free from unintentional errors. Any damages or losses direct or indirect caused to any third party by using the Product and its documentation are entirely the user's responsibility. The antenna, the cable and the power supply built or supplied by the user should fulfill the requirements of the respective safety standards and regulations.