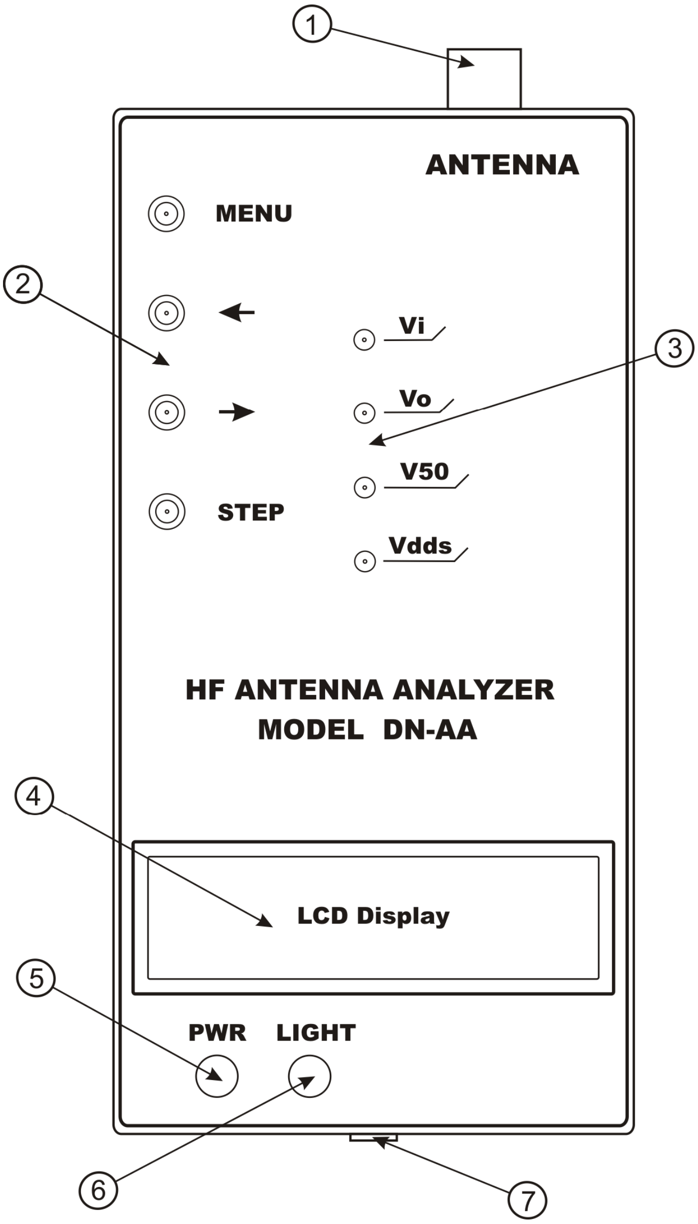
Antenna analyzer DN-AA. User Manual.

Antenna analyzer **DN-AA** (AA) is a portable device. Analyzer provides functions for checking and adjusting antennas and coaxial feeding lines. Device has additional functions to measure small capacitors and coils and can be used as signal oscillator with high stability frequency and amplitude. A 10-bit digital synthesizer is a main module of the DN-AA antenna analyzer.
Because of useful calibration system, device can be used in any temperature ranges. Special diodes in analyzer's detector allow using it in extreme environment, such as static discharges and strong local electromagnetic fields.
Antenna analyzer has a high reliability that mean operation in any field locations.



The device panel shown at left:

- 1.Antenna socket
- 2.Control buttons
- 3.Calibration elements
- 4.LCD
- 5.**PWR** – Power switch
- 6.**LIGHT** – Light switch
- 7.External DC source socket

Specifications

- Frequency range 1-30 MHz
- SWR measurement range 1-20
- R measurement range – 1-900 Ω
- X measurement range – 10-300 Ω *
- Antenna socket type SO-239 (UHF)
- Sinusoidal RF voltage level on antenna socket 3.4V PEP **
- Frequency stability. Frequency drifting not more then 50Hz at power on. After 10 minutes since power on frequency drifting not more then 5Hz **
- Powering – 9 pcs. Alkaline cells 1.5V (AA)***
- Current consumption 160мA (lighting off)
- Dimensions 180x100x50 mm
- Weight 320 g. (without cells)

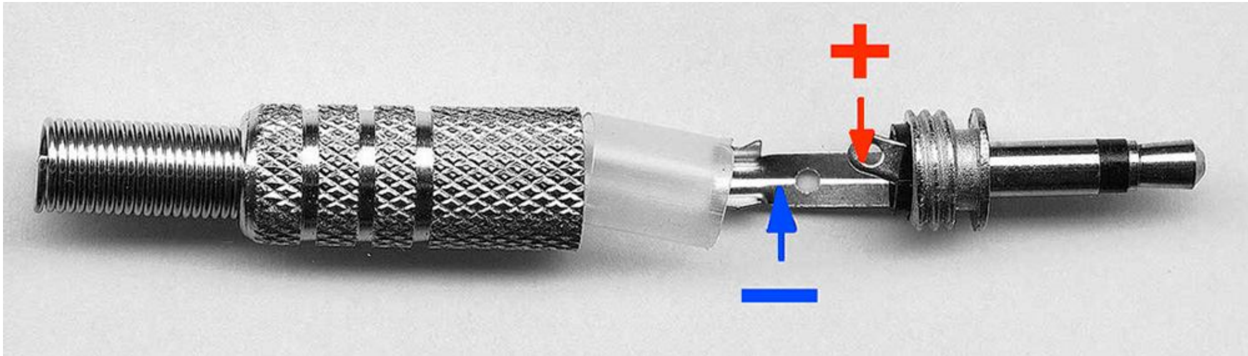
* Expansion method of measurement limits will be described later
** Measured at 7,05 MHz
*** Alkaline cells should be purchased additionally.

Safety tips

- Be sure that your antenna has no stored electrostatic charge before trying to connect feeder line to antenna analyzer. Electrostatic discharge can be very dangerous for user and damage your device. DO NOT connect you antenna analyzer to antenna in a thunderstorm.
- DO NOT left device connected to antenna. Electrostatic discharge can damage analyzer even if it powered off.
- DO NOT connect analyzer to transmitter. Power RF signal from transmitter immediately damage DN-AA device.
- Close a center pin to shield of antenna feeder line for short time, before connect it to analyzer. It can help to discharge an electrostatic voltage stored in antenna feeder line.
- Take out alkaline cells from antenna analyzer before storing it for long time. Simple alkaline cells can leak during long storing and electrolyte can damage a device's schemes.
- Please observe a correct polarity when powering DN-AA from external DC source.

Prepare to operation

Remove 4 screws and open back panel cover. Install eight alkaline cells AA type, observing a polarity. You can use an external DC source 12-14 V DC to powering antenna analyzer. Current capacity should be not less then 300mA. External power source should provide a 12-14 V DC voltage with powered on antenna analyzer. External DC connector shown on diagram as item #7. Device not required a stabilized power voltage but it could not be less than 11 V DC. If power voltage drops below 11V level, analyzer will not work correctly. Pin assignment for external DC power source shown on photo below =>



Connector for external DC power source included with analyzer. **PWR** switch should be used to powering on and powering off device. To save alkaline cells power switch on lighting only when needed by **LIGHT** switch.

Operation

LCD of antenna analyzer is shows:

1. Current frequency in kHz,
2. **S** - SWR,
3. **R** – Active impedance,
4. **X** – Reactive impedance. Reactivity sign could be defined by frequency changing buttons. If reactive resistance on upper frequency is higher, then it has inductive value. If reactive resistance on upper frequency is lower, then it has capacitive value.

Antenna analyzer DN-AA controlled by 4 buttons.

1. **«MENU»** button - enter menu mode to calibrate device.

<= Device’s LCD in MENU mode.

2. Arrows buttons: 1. Arrow right **–>** increase frequency. 2.Arrow left **<–** decrease frequency. Press and hold button to change a frequency in required way.

3. **«STEP»** button **–** tuning step.

Tuning step can be selected from 1kHz, 10kHz, 100kHz and 1MHz. Pres this button to enter tuning step selection menu. Press arrows buttons to select required tuning step and then press STEP button once more to confirm and save selection.

<= Device’s LCD in tuning step selection mode.

Resistors **Vi, Vo, V50, Vdds** is used for device calibration. Device calibration procedure will be described below.

LCD lighting

Device has additional LCD lighting for nighttime operation. You can witch on LCD lighting by **LIGHT** switch. Device's power consumption is increased with LCD lighting on. Pay attention to it and switch LCD lighting only for short time. When LCD lighting constantly on, battery will be exhausted for 70% faster. If an external DC source connected to device, LCD lighting can be constantly on.

Measurement

To create and adjust antenna correctly, need to know some minimal basic rules and laws for antenna and feeder line systems. Read some book specially written for amateur radio. We recommend read books of **K. Rothammel**, **Z. Benkowski**, **E. Lipinski** and **ARRL Handbooks**. Do not trust to some articles in a popular magazines or Internet. If you ignore some basic rules, it will grant you only wrong results and wasting your time.

1.Preliminary antenna testing.
Real resonant frequency of antenna may be measured **only in antenna feed point**. If you do not know antenna resonant frequency even approximately, it will be very difficult to evaluate it through feeder line. Antenna analyzer's reading will be degrading by own feed line parameters. Moreover whole antenna and feed line system be effected by close metal objects. So, device will show parameters of entire complex object – antenna plus coaxial feeder line plus local metal object. Press arrows buttons to change a frequency around required ranges and analyzer will show real parameters whole system.
If you know approximately resonant frequency of antenna, then re-tune frequency within predictable range and look for point with minimal **S** and **X** values. This minimum value may be not noticeable at resonant frequency, if antenna impedance does not match with feeder line impedance.

2.Antenna impedance measurement.
Antenna impedance can be measured remotely via so-called "half-wave repeater". It is a piece of coaxial cable with length of one half wave on desired frequency. How to prepare such cable will be described below. If you know a length of coaxial cable and it velocity factor, then you can find frequencies, where this piece of cable will be a "half-wave repeater". This piece of cable will be transform antenna impedance exactly on these frequencies. But remember that more differences between cable and coaxial cable impedance give more error in measurements.

3.Cable resonance measurement.
Connect one end of coaxial cable to analyzer and other one leave open. Active impedance value **R** will be minimal on frequencies with quarter-wave resonance. Active impedance value **R** will be maximal on frequencies with half-wave resonance.
To find frequencies with half-wave resonance of coaxial cable, short circuit a central wire with braid and find minimal value of active impedance **R**. These frequencies with minimal values are half-wave resonance.
Reactive impedance **X** with these measurements should be 0 Ohms. If reactive impedance **X** has some value this mean than cable quality is poor.

4.Cable impedance measurement.
To measure unknown cable impedance, connect graduated non-inductive variable resistor to the free end of cable. Resistor value should be little bit higher then supposed impedance of coaxial cable. For example, if supposed impedance of coaxial cable is 50-70 Ohms, then need to connect variable resistor with 100 Ohms maximum. Connect cable with resistor on the other end to antenna analyzer. Change a variable resistor value and find point where active impedance value **R** equal to variable resistor while X=0. Now you have coaxial cable impedance value. All measurements should be performed on quarter-wave resonant frequency of tested cable. If variable resistor value set correctly then all measured values **S**,**R**,**X** on device's LCD should not change while frequency retuning. Constant values of **S**,**R**,**X** means that resistor value is equal impedance of the tested cable.

5.Manufacturing piece of coaxial cable with required length.
First of all need to calculate supposed cable length. Use simple expression to convert frequency to wavelength: **λ=300\f**, where **λ** - wave length in meters, **f** – frequency in megahertz. For example: need to manufacture a piece of coaxial cable with one half wavelength for 7,05MHz - **L=300\7,05\2=21,275м**. If you require a quarter-wave piece of cable, then use following expression: **L=300\7,05\4=10,368м**. But manufacturer usually indicate a velocity factor for each type of coaxial cable. The velocity factor for RG-58 cable, as example, is 0,66. Multiply obtained length value by velocity factor – 21,275x0,66=14,04м. Cut your coaxial cable with length little bit longer then obtained value. Connect other end of cable to antenna analyzer. There are two ways to find exact required cable length:
1. Cut very small pieces of cable, until analyzer will show **R**=0 on required frequency 7,05MHz. Don't forget to short-circuit central wire of cable to braid before performing a measurement.
2.Find a frequency, where analyzer show value **R**=0. It will be a half-wave resonance. Let it be a 7.01MHz for example. Calculate an electrical length of cable L=300\7,01\2=21,4м. Because a physical cable length is known, as example cable was cut to 15м, calculate a real velocity factor - 15\21,4=0,7. Now measure and cut exact cable length: 21,275x0,7=14,89м.

5.Coaxial cable velocity factor detection.
Manufacturer usually indicates a velocity factor of produced coaxial cable. But this is an average value and it has some differences between different manufacturers. Sometimes the type of coaxial cable is unknown and need to define its velocity factor. Measure a physical and electrical length of cable and then calculate a real velocity factor. For example, we have a piece of cable with 25 meters length. Connect it to antenna analyzer and short-circuit the other end of cable. Tune the frequency in antenna analyzer and find a first half-wave resonance – for example it on 3,840MHz. Now use expression to convert frequency to wavelength - **λ=300\3,84=78,125м**. If velocity factor will not take to account, then piece of coaxial cable with electrical half-wave length on that frequency will be 78,125\2=39,0625м. So, The velocity factor of coaxial cable is 25\39,0625=0,64.

6.Balanced feeder line measurement.
Balanced feeder line measurement is almost identical with unbalanced feeder line measurement but have some differences. Balanced feeder line measurement required powering antenna analyzer from internal battery. Moreover, need to hold DN-AA device away from current-conducting objects and ground. Antenna analyzer should not have any wires connected, except measuring balanced feeder. Two-wired balanced feeder line should be stretched without bends as far as possible from metal objects and ground. Analyzer will show real values with balanced lines only with these conditions.

7.Antenna adjusting.
The main antenna parameter is a resonant frequency. Reactive impedance of antenna on resonant frequency has a 0 value. Antenna adjusting goal is get minimal possible reactive impedance on required frequency. The values S ≠ **1.00** and **R ≠ 50 Ω** on resonance frequency. Antenna impedance depends of either its design or some other additional factors, for example, height of antenna and surrounded objects. To tune antenna to required resonant frequency, need to change physical dimensions of it. After that need to find decision which type of feeder line to be used, depending of measured **R** value. The simplest type of antenna feeder line is coaxial cable but active impedance of antenna should be equal to impedance of coaxial cable. If antenna feeder line is unbalanced but antenna itself has a balanced design, then additional device required between them – RF BALUN. Such devices could also covert impedances. What type of matching system needed to install between your antenna and feeder line is unique decision for each situation.

8.Matching antenna and feeder line.
To check matching quality between antenna and feeder line need to connect feeder line to antenna analyzer and find supposed resonant frequency of the antenna. Then, add some feet to feeder line using a same type of coaxial cable. If antenna analyzer does not show any changes of **S**, **R** values, this mean that antenna and feeder line has a good matching quality.

9.Testing RF Transformers.
Connect RF transformer to antenna analyzer with short wires. Other winding of the transformer need to connect to non-inductive resistor with required value. Sweeping DN-AA within required frequency range. **S**, **R** readings on device LCD within working frequency range should be constant.

10.Testing BALUN's
Connect 50Ω-output of BALUN to antenna analyzer. Two resistors in serial connected to the antenna side of BALUN. Whole resistance should be equal to required load impedance. Measure **S** value, connecting a ground point of antenna analyzer to antenna outputs of BALUN and to point between two resistors. If those three **S** readings have large differences it means that quality of the BALUN is poor.

11.Adjusting tuners.
Connect tuner to antenna analyzer. Tune antenna analyzer to required frequency. Rotate tuner controls until AA will show value S=1.00. These positions of tuner controls will be suited for best match.

12.Testing a matching unit of power amplifier.
Be careful while performing such testing procedures. There are some risks to damage AA device or get an electrical shock. **All power amplifiers, powering from AC outlet 110-220V has dangerous voltage!** Remember, currents about 0.1A and voltages higher then 36V are dangerous for human and could be a reason of death. Tube working mode simulated by non-inductive resistor connected to testing circuit. Resistor connected parallel to tube outputs with a short wires. When testing a matching unit of power amplifier, resistor connected between tube anode and closest point of ground. The resistor's value calculated from tube working mode. Antenna analyzer AA connected to unit from antenna side and tuned working frequency. The capacity of closest to antenna capacitor's need to be set according calculated Q-factor. Change capacity of closest to tube capacitor and inductance of windings until device's reading will not be S=1.00; R=50 Ω; X=0 Ω.

13.Testing power amplifiers on solid-state elements.
Antenna analyzer DN-AA is very useful when testing solid-state power amplifiers. Because of calibration elements on front panel of analyzer, you could raise RF output power by **Vdds** control up to 18dBm. It will be described below. Antenna analyzer AA has enough RF power output to measure input parameters of solid-state amplifier with very small error. Connect dummy load to power amplifier antenna socket. Analyzer DN-AA connected to power amplifier input. Power amplifier switched to transmit mode. Switch on an antenna analyzer and retune working frequency. Check parameter's reading on device's LCD. Do not forget to switch on suitable band pass filter if power amplifier has such units on input.

14.Testing throttles.
Antenna analyzer could be used to testing anode tube's throttles in power amplifiers. There are some frequencies where such throttles have serial resonance with low impedance formed by their capacity and inductance. There are very high current and voltages between coils. It may be reason of damaging a throttle.
Throttle's serial resonance could be found by measuring throttle's parameters with antenna analyzer. Throttle should be set in a working condition to take to account capacity of whole circuit. Connect AA with throttle's contacts by short piece of 50Ω cable. Tune antenna analyzer's working frequency very slowly. If device's reading decrease very sharp, it mean that serial resonant of the throttle is found. Close a screwdriver blade to throttle's winding and find a point where impedance is constant whatever you do. This is a high voltage area and any capacity variation will put a maximum detuning effect. Shift a resonance point from working frequency range by adding some more windings to throttle. Shifting a throttle's resonant frequency also may be done by variation of its installation place or adding some shields object nearby.

15.Capacitors and coils measurement.
Antenna analyzer AA allow small capacitors and coils measurements. This feature is additional and required to fulfill some rules to keep minimum device's errors. The higher capacity and inductance value, the lower frequency tuned antenna analyzer for measurement. Inductance 20-300μH should be measured on frequency 1,5-2MHz. Inductance lower then 20μH should be measured on 2-3MHz frequency range. Capacitors lower then 100pF should be measured on 5-7MHz frequency range. Capacity values 100-1000pF should be measured on 3-5 MHz frequency ranges, while capacitors more then 1000pF value should be measured on frequency range 1,5-3MHz. Measured element should be connected to device with short wires. Do not hold an element by your fingers or forceps it will put some additional errors. Device calibration required before performing such measurements. Connect a non-inductive resistor 50 Ω to antenna analyzer. Enter **MENU** mode and set: Vi=1022; V50=510(511); Vo=510(511). Now exit **MENU** mode and disconnect a resistor. Connect a measuring element. Value **X** reading on device's LCD should be converted to **pF** or **μH** using following expressions: **C=159200\X·f** or **L=X\2π·f,** where: **C** – capacity in pF; **L** – inductance in μH; **f** – frequency in MHz; **X** - measured reactive impedance;

Technical part

Special feature of antenna analyzer is simple user calibration procedure. Usually this feature is not accessible for user and should perform in a service centers with special testing devices and equipment. Simplicity of calibration allows expanding devices functionality but lay responsibility on user for sensible of his actions. To gain maximum from your antenna analyzer read carefully and completely technical part of operation manual and observe the rules for device operation.
Antenna analyzer's design used special RF diodes, which could hold up to 50V voltage and current 200mA. It is quite powerful diodes that allow achieve a very high stability against electrostatic discharge. Previous models of antenna analyzer also used these diodes and several years' operation experience did not show any damaging of diodes from electrostatic discharge. Weak place of used diodes is nonlinear specification while frequency and temperature variations. That's why user should check a calibration values from time to time. This is particularly important on border values of frequencies and at high variations of ambient temperature. Simple calibration procedure is allow to use antenna analyzer in almost any temperature conditions and powerful diodes in analyzer's detector assumed to use device in extremely high local electromagnetic fields and electrostatic discharges.

Device operation rules

Calibration procedure.
Calibration elements are placed on front panel of antenna analyzer for user conveniences. It is multi turn variable resistor pots: **Vi**, **V50**, **Vo**, **Vdds** and rotation borders marked by click. Use a small screwdriver and do not rotate more then ten turns from default position. Rotate resistor pot clock wise to increase value and rotate counter clock wise to decrease value.
The main parameter is RF signal level in antenna socket. Variable resistor **Vdds** controls it. This level should be corrected with RF (tube) voltmeter. Voltmeter's probe resistance should be not less then 100kΩ. Connect voltmeter to analyzer's **ANTENNA** socket and rotate variable resistor pot Vdds until device's reading will be Urms=1,2V. Antenna analyzer delivered to customer fully operational and ready to use and this important control originally closed by plastic film on front panel.

To calibrate antenna analyzer connect a non-inductive 50Ω-resistor to **ANTENNA** socket. It may be two usual low power resistors connected in parallel. Required connection has to be as short as possible.
Press a **MENU** button to enter analyzer's calibration mode. If device is correctly calibrated the LCD reading on working frequency has to be: **Vi=1022**; **V50=500**; **Vo=500**. Press a **MENU** button once more to exit calibration mode. Please follow to these rules during calibration: 1.Value **Vi** has to be higher then 1022. 2.Values **V50** and **Vo** has to be equal, i.e. **V50=Vo**. 3. Sum of values **V50** and **Vo** could not be higher then **Vi**, i.e. - 1022.

Special calibration techniques for different applications.
Some variation is calibration procedure allows minimizing a measurement error in different applications.
<u>Calibrating for measuring in strong local electromagnetic fields area</u>.
To prepare analyzer to be less sensitive to strong local RF signals in antenna, need to decrease values **V50**, **Vo** in proportion. While decreasing these values measurement accuracy of **S** and **R** values is saved but lower limit of measured **X** values goes high. For example, while V50=Vo=430 analyzer will show X=0 if antenna reactive impedance is less then 10Ω. If strong RF fields generated by broadcast station i.e. signal with amplitude modulation, then it lead to permanently changing readings of **S**, **R**, **X** values. The higher electromagnetic field's level in antenna - the higher variation range of device's readings. Reduce a V50 and **Vo** values to use analyzer in such RF conditions.

<u>Calibrating for measuring very low X values.</u>
To measure very low values of antenna reactive impedance need to increase **V50** and **Vo** values. For example, to find a exact value of tuned antenna resonance increase a **V50**=**Vo to** 505-510. In this case analyzer will show few Ohms of antenna reactive impedance.

<u>Calibrating for measuring capacity and inductance.</u>
Set values **V50**=**Vo** to 510-511 for that type of measuring. Analyzer must show **R=0** while measuring a capacitor. If **R** readings not equal to zero, it means a poor quality of capacitor or bad calibration of the device.

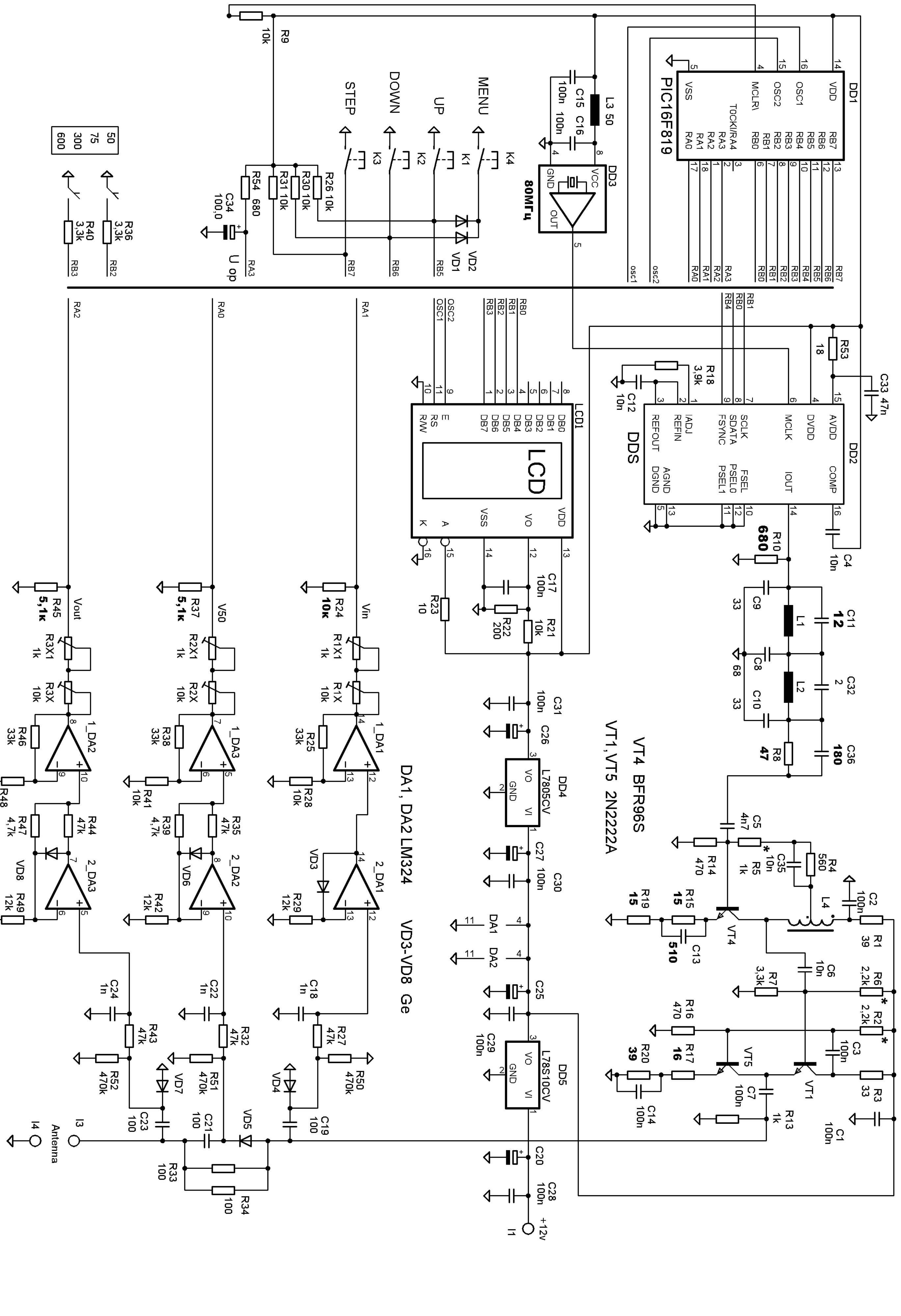
Package content:

1. Antenna analyzer
2. External power supply plug
3. User manual
4. CD with additional information.

Manufacturer leaves all rights for it to change design, particular units and elements with modest analogues and modify device without decreasing operational specifications.
Manufacturer does not keep responsibility for any device's modification made by customer. **Warning!** Manufacturer's warranty will be lost in case of damaging device's enclosure or violation rules of operation.
Warranty period last a one-year since date of purchasing but customer must pay any expenses for delivering device for repair to/from service center.

Troubleshooting.

Problem	Possible reason	Problem solution
Device does not switching on while powering from internal alkaline cells.	1. Alkaline cells installed with wrong polarity. 2. Contact lost in alkaline cells case. 3. Contact lost in external power supply plug.	1. Check alkaline cells polarity and install it correctly. 2. Check correct installation alkaline cells. 3. Check contact in external power supply plug.
Device's readings are not constant while antenna measuring. All readings are inadvertently changing while calibrating process.	Too low power voltage.	Measure a power voltage while switched on state. If voltage drops lower then 11V - replace cells. If power voltage is higher then 11 V DC check a voltage on automatic voltage regulator's output – DD5, DD4. The voltage on DD5 output must be – 10V and on DD4 output must be 5V. If these voltage values are lower replace respective automatic voltage regulator.
Device does not measuring. Frequency on LCD is tuned but S, R, X readings almost constant.	1. Automatic voltage regulator DD5 failure. 2. Frequency synthesizer DD2 failure.	1. Check voltage on automatic voltage regulator's output DD5. If this voltage is lower then 10V, replace automatic voltage regulator. 2. Check signal level on frequency synthesizer's DD2 output. Signal level from DD2 must be 80-100mV. You can check signal level by your receiver. Be careful – do not close a DD2 output to ground! Frequency value on LCD and in your receiver must be the same. If no signal received from synthesizer DD2, replace synthesizer IC.


DD1
PIC16F819
DD2
DDS
DD3
80МГц
LCD1
LCD
DD4
L7805CV
DD5
L78S10CV
VT4 BFR96S
VT1,VT5 2N2222A
DA1, DA2 LM324
VD3-VD8 Ge
MENU
UP
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U op
50
75
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600
Vin
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Antenna
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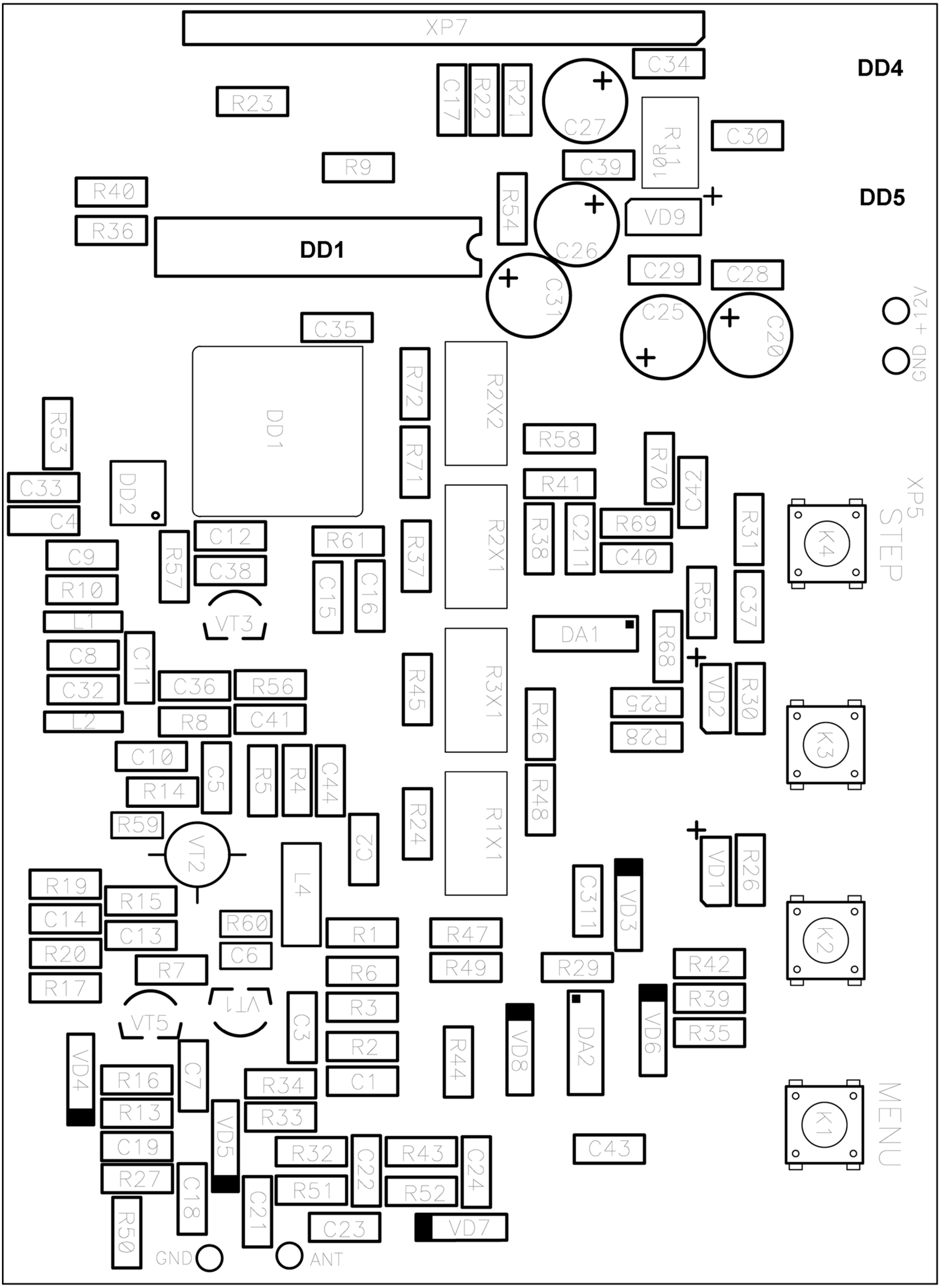
XP7
C34
DD4
R23
C17
R22
R21
C27
R11
10R
C30
R9
C39
R40
R54
C26
VD9
DD5
R36
DD1
C29
C28
C31
C35
C25
C20
GND +12V
R72
R2X2
DD1
R53
R71
R58
R41
R70
C42
C33
DD2
C4
XP5
STEP
C12
R61
R37
R2X1
R38
C211
R69
R31
K4
C9
R57
C38
C15
C16
C40
R10
R55
C37
L1
VT3
DA1
R68
C8
C11
R45
R3X1
VD2
R30
C36
R56
R25
C32
R46
K3
L2
R8
C41
R28
C10
C5
R5
R4
C44
R14
R24
R48
R59
C2
R1X1
VT2
L4
VD1
R26
R19
C3I1
VD3
R15
C14
R60
K2
C13
R1
R47
R20
C6
R6
R49
R29
R42
R7
R17
VT1
R3
R39
C3
VT5
VD8
DA2
VD6
R35
R44
VD4
C7
R2
R16
R34
C1
MENU
R13
VD5
R33
K1
C19
C43
R32
R43
C22
C24
R27
C18
C21
R51
R52
R50
C23
VD7
GND
ANT