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## Technical Description of the Autotuner board **ATU-100 Extended board** by N7DDC.

Attention ! There are no restrictions and prohibitions on the use of this material for any purpose, as well as all related materials, the author of which is N7DDC.

Attention! The information published in this document is true only when using a device with firmware version **3.0**. If you are unable to find out which software version is being used, update to firmware version 3.0 using the programmer to ensure that the information from the description matches the device properties.

You can download the latest version of firmware, PCB sources, schematic and documentation here:

[https://github.com/Dfinitiski/N7DDC-ATU-100-mini-and-extended-boards/tree/master/ATU\\_100\\_EXT\\_board](https://github.com/Dfinitiski/N7DDC-ATU-100-mini-and-extended-boards/tree/master/ATU_100_EXT_board)

The schematic in editor:

<https://easyeda.com/rolin791/atu-100-7x7>

### Purpose

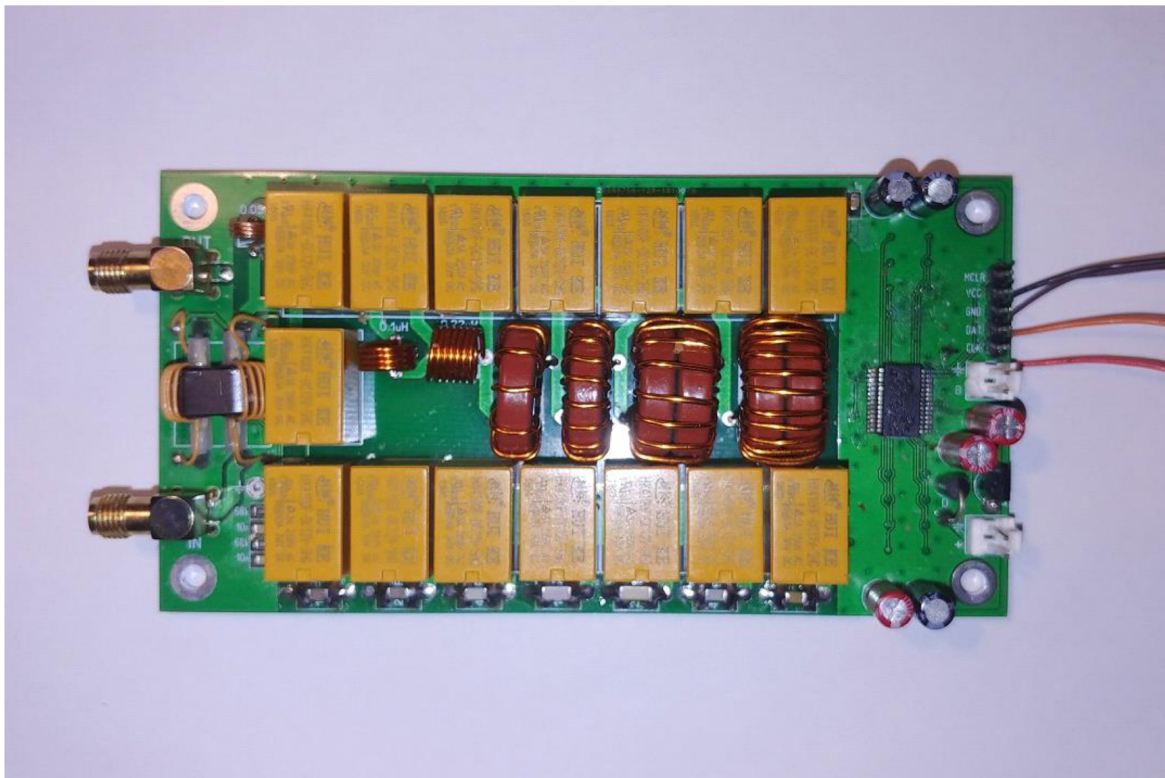
The device is intended for use as an element of amateur radio equipment, as part of amplifiers or transceivers, or as a separate device that performs the function of matching the output impedance of power amplifiers (PA) with antenna feeders.

Unlike the **mini board**, this device can contain a set of from 5 to 7 inductances and from 5 to 7 capacitors, which allows it (in the maximum configuration) to work

effectively in a wide frequency band, overlapping radio amateur HF ranges from 1.8 MHz to 50 MHz.

The numerous settings of the algorithms available to the user allow the use of a microprocessor and a control circuit in other auto-tuner projects in various variations. Nevertheless, there is the concept of a basic scheme, which the author follows.

The basic model, according to the author, contains a set of 7 switched inductances with an uneven pitch, from 0.05  $\mu\text{H}$  to 4.5  $\mu\text{H}$ , a set of 7 capacitors with uneven pitch, from 10 pF to 1 nF. The parameters used by default guarantee reliable operation of the device in the basic version and are the main parameters for testing during software development by the author. Many parameters can be changed by the user on their own, which can change the behavior of the device and even make it unusable. Please read the description carefully before making any changes.



## Using the «base model»

The author assumes that the device can be used in two scenarios: as an additional module as part of a transceiver or amplifier, or as a standalone device in a separate case, with or without indication. There is no need to redo something. Both the button for manual start of tuning and the output of the control signal from the control processor of the transceiver or amplifier can be connected to the control connector.

A short impact on the control line of less than **250 ms**, whether with a button or a control signal, will cause the tuner elements to reset to their original state, when all

inductances and capacitances are turned off. A longer hold on the control signal will trigger the start of the setup process. The result of each configuration process is stored in the non-volatile memory of the device and is restored after turning off and on the power.

Additional signals for better integration with existing equipment can be taken from the RA7 and RA6 microprocessor connectors. This is the Tx\_request signal (carrier request for tuning) in direct and inverse form. This signal is issued by the device's processor for the time necessary for tuning, during which the transmitter must provide a continuous carrier of suitable power. This can be used to automate

the configuration process when the user does not need to perform additional actions, except for how to press the TUNE button. This is not necessary, since the device allows tuning with any input signal of sufficient power, be it speech, modulated with an RF signal by any type of modulation, telegraphic packets, and even a noise-like signal. Tuning will stop when the input signal is low and resume when it appears. That is, the tuning can occur directly in the normal operation of the equipment.

However, for reliable operation of the device, it is advisable to use this signal to reduce the signal power of the transmitter to safe for the device values during tuning, for example by acting on the ALC loop.

The **Tx\_request** signal can also be used to connect a LED that will indicate the activity of the adjustment process in the case when using the LCD indicator is undesirable or impossible.

## Indication

In general, the device can be used without display elements, while for monitoring the operation of the device you can use, for example, the scale of the SWR meter built into the transceiver or a separate external SWR meter. Of course, when using an autotuner as a separate device in your own case, it would be very convenient to have your own display for monitoring the operation and this device allows you to implement it in different ways.

The easiest way is to connect a two-color red-green LED with a common anode to the pins of the connector for programming the processor. In order for this method of display to work, you need to change some of the default values, which will be discussed below. The common anodes must be connected to the VCC pin of the connector (+5 V power), the cathode of the green LED through the current limiting resistor to the pin CLK of the connector, the cathode of the red LED through the current limiting resistor to the DAT connector. Thus, the LED will be able to generate three colors of light, green, orange and red, depending on the SWR in the line with which the matching process was completed.

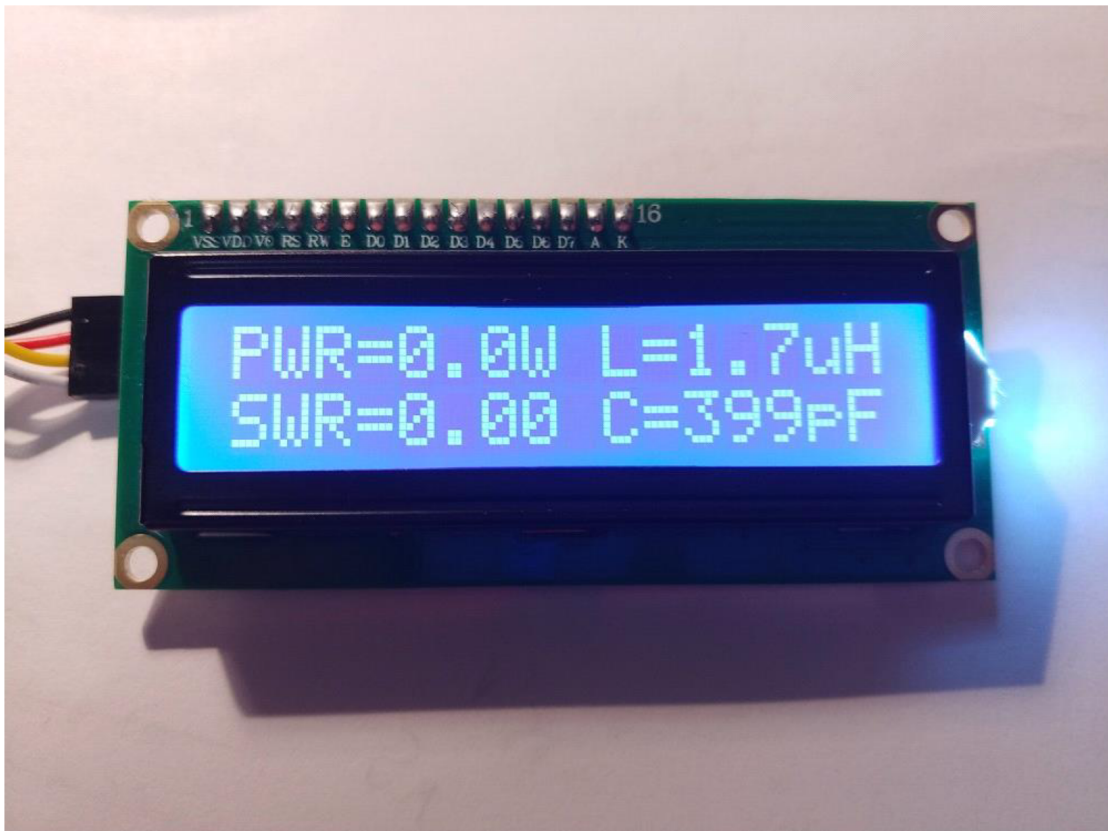
Green color of a luminescence will speak about SWR in a line less than 1.5, orange - less than 2.5 and red at SWR more than 2.5. The LED will go out at the moment of the start of the adjustment and will glow immediately after its completion.

Much more information about the operation of the device can be provided by

much more information about the operation of the device can be provided by connecting to the connector for programming a standard two-line 1602 LCD display. You will also need a small I2C port expander card to convert the parallel LCD control code to an I2C serial bus. These are widely used boards using the PCF8574T chip and having an access address on the 4E bus. This is the indication that the author uses by default, and the default firmware is already configured to work with such an

indicator. Some port extension cards use PCF8574 chips with an "AT" index and they have a different bus access address. They can also be used by specifying the desired address (which will be described below).

The pins of the programming connector when the LCD is connected are used for their intended purpose, VCC is 5 Volt power supply, GND is ground, DAT and CLK are data and clocking lines respectively.



The left side of the indicator displays the power throughput and SWR. The peak detector mode is used, which allows to accurately measure the signal power of the transmitter when using various types of modulation.

The right side shows the inductance and capacitance values set by the device as a result of the last tuning process. Indication is carried out in the first and second lines, and indications L and C can be interchanged. This is used to display the connection point of capacitors according to the classical L-shape scheme. So, if the inductance is on the top line, it is assumed that the capacitor of the tuner is connected after it, that is, to the output. If the inductance value is displayed on the bottom line below the capacitance value, then the capacitance is connected before inductance, that is, to the input.

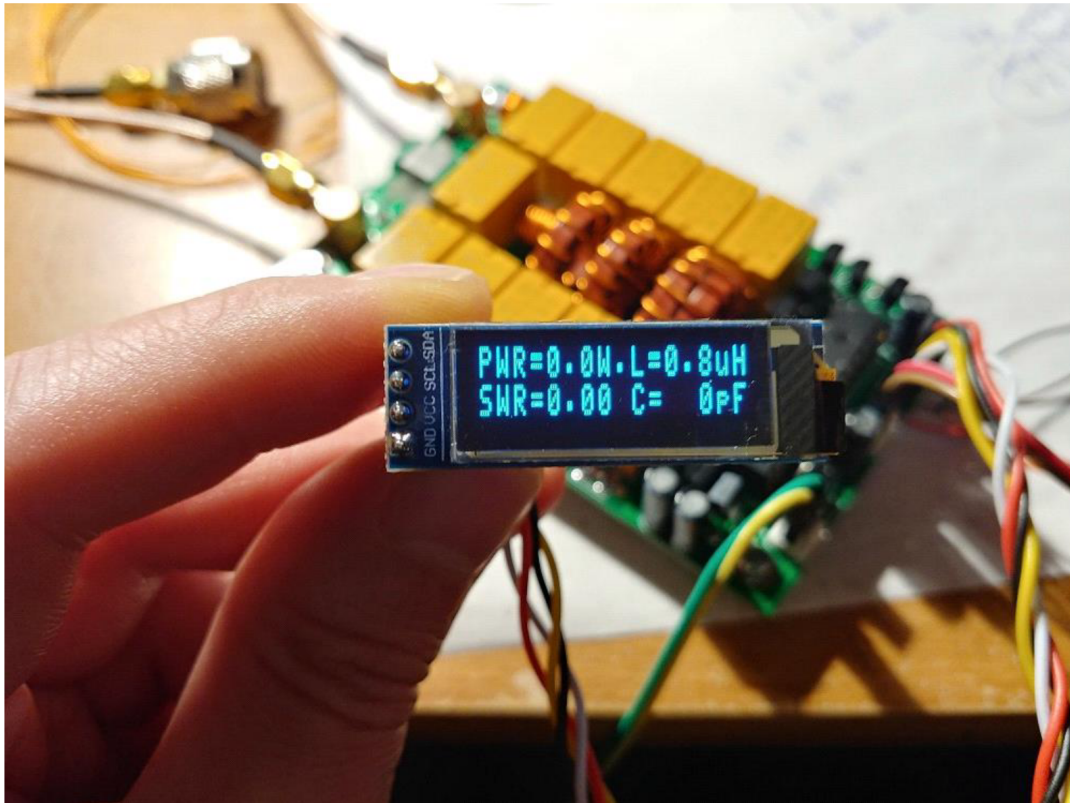
impedance, that is, to the input.

The display may also briefly show some inscriptions explaining the current modes

of operation of the device. These are TUNE, RESET, OVERLOAD (when a signal with a power of more than 150 watts is applied to the device).

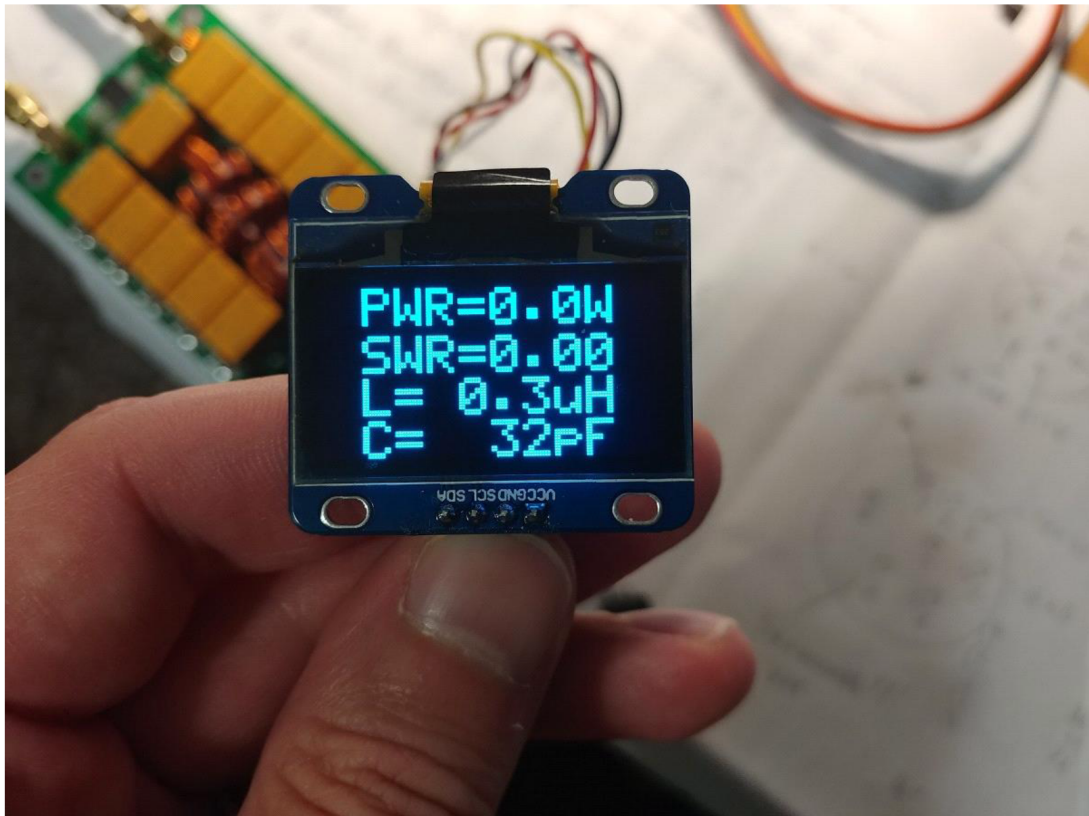
To reduce the size of the device, it is possible to connect small-sized OLED displays that use the same I2C bus to control.

These are monochrome OLED displays with a SSD1306 controller and with a resolution of 128x32 pixels with a diagonal of 0.91 inches, with a resolution of 128x64 pixels with diagonals of 0.96 and 1.3 inches. These displays are connecting in the same way, but in order for them to work correctly, the firmware parameters should be changed (to be described below).



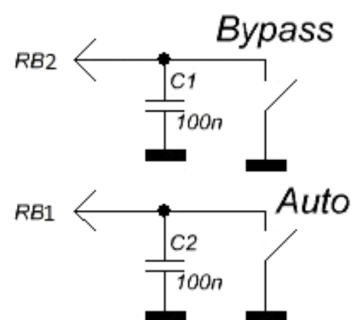
The indication on the 0.91 128x32 display looks like on a regular 1602 display, while having tiny dimensions.

The indication on 128 \* 64 displays looks a little different, in four rows and with larger characters.



## Additional buttons

The device also allows you to connect two additional buttons that extend the basic functionality. These are the Bypass and Auto buttons. The buttons are connected respectively to the ports of the RB1 and RB2 processor. It is recommended to use ports blocked by capacitors to avoid interferences, which may hinder the processor operation.



Pressing the Bypass button causes a temporary shutdown of all capacitances and inductances on the path signal from the input to the output. This mode has the corresponding indication on the LCD display in the form of an underscore. If Auto mode has been activated, its operation will be temporarily stopped while the Bypass mode is in effect. Pressing the button again turns off Bypass mode and the device reconnects the capacitances and inductances that were installed at the end of the last tuning process. Auto mode will also resume if it has been activated previously.

Pressing the Auto button activates the automatic mode of the device, which is displayed on the display as a dot sign. The device will remember to turn on the automatic mode, and will remain with it even after turning off the power, until it is turned off again by pressing it again. Automatic mode can also be activated by changing the parameters during the firmware installation (will be described below).

## **Automatic mode**

The automatic mode of operation provides a unique opportunity for the user to use the device without the need to press buttons and connect any external control.

The device can be designed without buttons, without indication and at the same time will perform its function of matching the resistance of the antenna power supply line.

The algorithm uses the following: if the current SWR exceeds 1.3 and it has changed to  $(1.3 - 1)$  relative to the value recorded after the previous tuning process, the tuning mode is activating. Usually, this condition is easily met when the bands are changing, which causes an immediate triggering of the new tuning process.

If necessary, the trigger threshold of the tuning can be changed by changing the parameters during the firmware installation (described below).

## **Special modes of operation**

The device has several special modes of operation, designed to facilitate the process of assembling, debugging or troubleshooting.

When power is applied to the device with all three pressed buttons Tune, Bypass

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and Auto, the Fast Test mode is activated. In this mode, the device provides power to all relays, which allows you to quickly identify faults associated with transistor

switches or soldering faults.

When power is applied to the device with the Bypass and Auto buttons pressed, the device enters the simple Test Mode. In this mode, you can manually, step by step, use the Bypass and Auto buttons to change the value of capacitance or inductance. A long press on the Tune button allows you to select which elements will be moved at the moment, and a short press changes the point of connection of the capacitor. In this mode, it is possible to measure input power and SWR in line. The whole process is accompanied by a clear indication.

## Possible device modifications

The microprocessor and its software allow you to control a series from 5 to 7 inductances and from 5 to 7 capacitance, with a linearly increasing step, or nonlinearly. Component ratings can be arbitrary, their values can be specified in the firmware parameters during processor programming to correctly display the values on the display.

When choosing the number of elements less than the maximum (7), the lower bits of the control bus work.

Incorrect configuration of the firmware or errors in the sequence of control elements may lead to failures during setup or to the complete inability to configure. At the same time, an exact indication of the values may affect only the accuracy of their display on the display, but not the operation of the tuning algorithm.

## Technical Characteristics, «Base model»

The range of permissible supply voltages: 10 - 15 V DC

Maximum current consumption: 400 mA\*

Maximum working throughput: 100 watts

Maximum possible measured power: 150 watts

Minimum power required to start tuning: 5 watts \*\*

The minimum possible measured power: 0.1 watts

Measurement step at power up to 10 Watts: 0.1 Watt

Measurement step with power above 10 watts: 1 watt

Accuracy of power measurement: 10%

Maximum installed inductance: 8.53  $\mu$ H

The minimum installation step of inductance: 0.05  $\mu$ H

Maximum installed capacity: 1869 pF

Minimum capacitance installation step: 10 pF

\* Typical consumption 150-200 mA

\*\* Some parameters may be changed if necessary.



## **Change of default settings**

During programming of the microprocessor, in addition to writing directly to the control code (program), it is also proposed to record a small number of cells of the rewritable memory EEPROM. The information in these cells can be changed by the user before programming. During each start of the processor, its program first reads data from the cells of long-term memory in order to further use this information for work. Thus, the user can easily change many parameters of the device without understanding the much more complex software development processes.









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