

# **Program for working with vector analyzers**

## **VNA Mouse and NanoVNA V2**

User manual

version 2.0

UR5FFR, Odessa 2019-2021

## Getting started

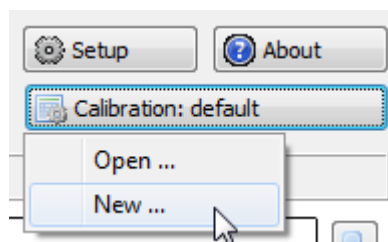
### Instrument connection and calibration

Run vna.exe. Connect the vector analyzer to your computer and select a COM port from the drop-down list. Click the "Open" button.

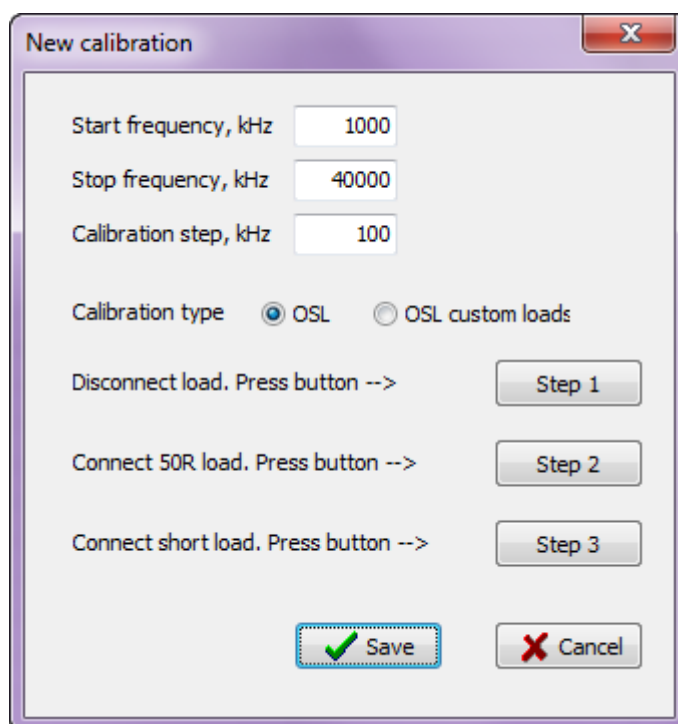


If communication with the device is established, then its version and name will be displayed in the window title.

Before starting measurements, it is necessary to calibrate the device. Calibration allows measurements to be made through a cable with arbitrary parameters. The program saves the calibration to a file on the computer and allows you to quickly switch between different calibrations. To create a new calibration, press the "Calibration" button and select "New"



The calibration window will open.



Each calibration is created for a certain frequency range in which, subsequently, measurements can be made with this calibration. In addition, the calibration is set on the frequency grid with a given step. The default is 100kHz steps. For accurate narrowband measurements, the step value can be reduced down to 1kHz.

For calibration, we need a set of reference loads. In the simplest case, calibration is carried out at 50 ohm load, short-circuit load and no load.

Select the required set of "Calibration type" loads. In the case of "OSL custom loads", you can specify the exact resistances of the loads:

New calibration

Start frequency, kHz 1000

Stop frequency, kHz 40000

Calibration step, kHz 100

Calibration type ☐ OSL ☒ OSL custom loads

Connect load 500 R. Press button --> Step 1

Connect load 50 R. Press button --> Step 2

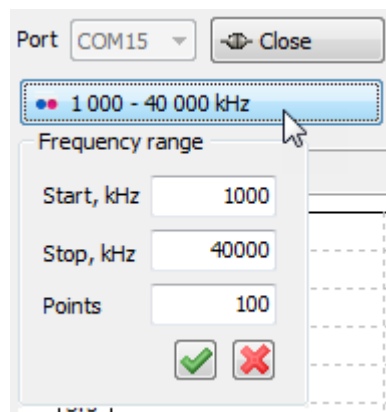
Connect load 5 R. Press button --> Step 3

Save Cancel

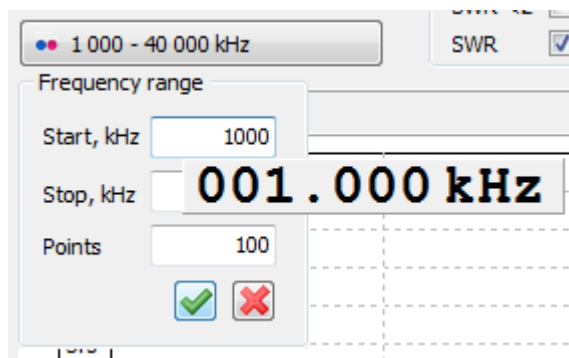
When sequentially connecting the loads, press the corresponding buttons. At the end of each calibration step, a green mark will appear on the corresponding load button. After calibrating on all three loads, click the «Save» button and specify a file name to save the calibration.

## Selection of the measuring range

Press the button for selecting the measurement range. A window opens



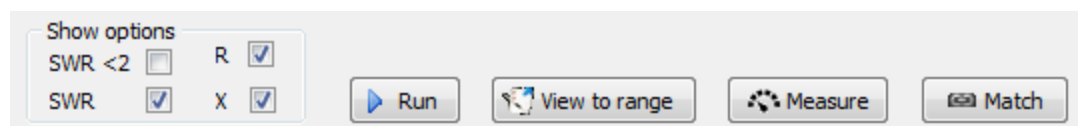
Enter into Start freq field



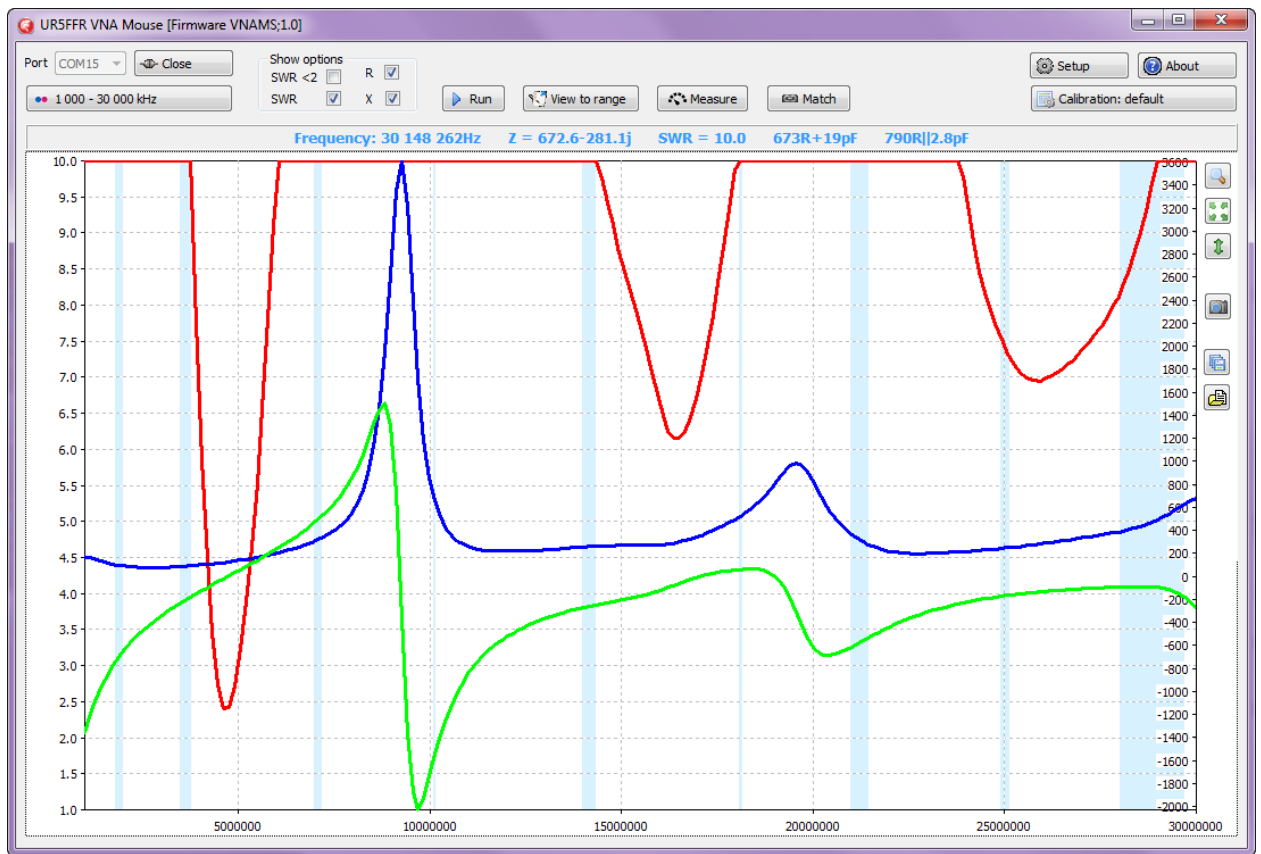
The frequency can be entered directly into the field using the keyboard or using the mouse scroll wheel on the large frequency digits. Double-clicking on a digit will clear the digits on the right.

The **Points** field defines the number of points at which the measurement will be carried out. Increase this parameter for smoother graphs.

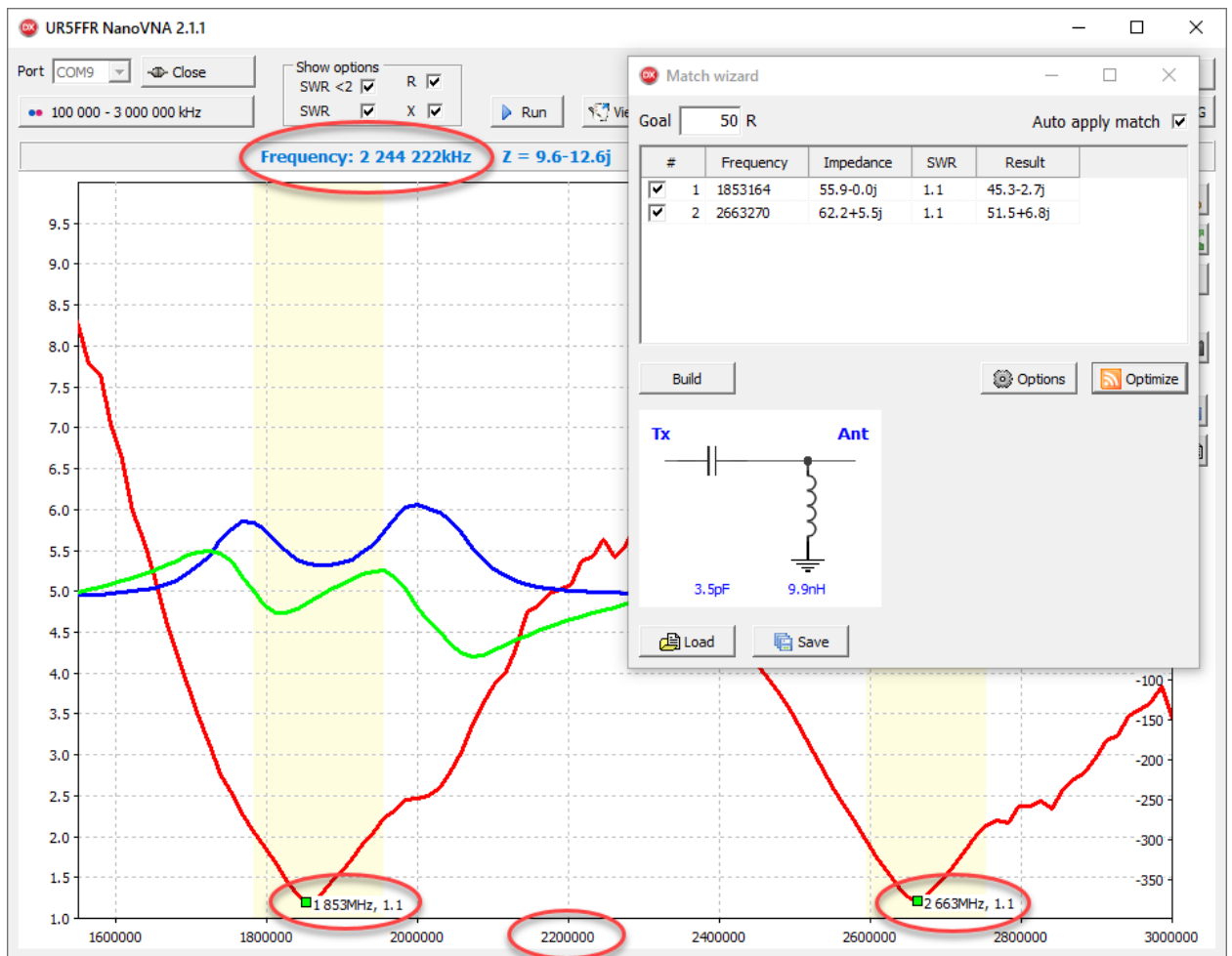
## Panoramic scan



After setting the required frequency range, press the "Run" button. The scan will start and the VSWR and impedance plot of the frequency range is displayed. By choosing different "Show options" you can control the display of graphs on the diagram.



If the scanning range lies above 100 MHz, then the frequency axis and markers are displayed in MHz.



## Working with charts

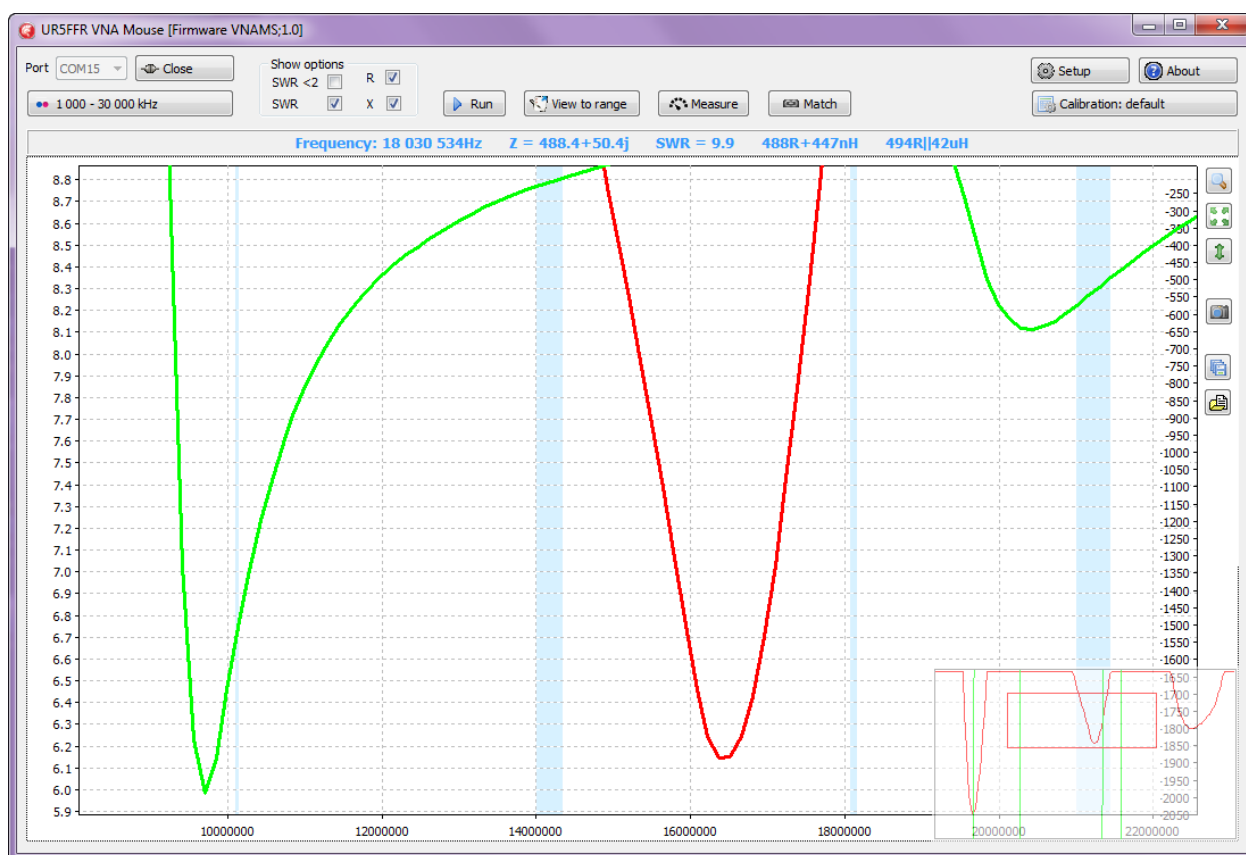
When working with charts, the following control combinations are used

1. Mouse scroll wheel allows you to scale the chart horizontally
2. The scroll wheel of the mouse with the pressed Shift key scales the graph vertically
3. Moving the mouse while holding down the right button - scrolling the chart
4. Moving the mouse with the left button pressed - measuring the range of levels/frequencies. At the same time, a dotted rectangle is drawn on the screen and its dimensions in the status bar
5. To restore the original chart scale, use the restore scale buttons on the right panel



6. To navigate the chart in zoom mode, you can use the navigator, which is called by the button on

the panel on the right



By clicking the mouse in the navigator window (bottom right), you can quickly position yourself on the desired part of the chart.

## Detailing

Pressing the "View to range" button will cause the measurement ranges to be changed to the currently displayed ones. For further measurement, press the Run/New button

## Chart management



Clicking on the right panel of the button allows you to save the image of the graphs as a file in JPEG format.



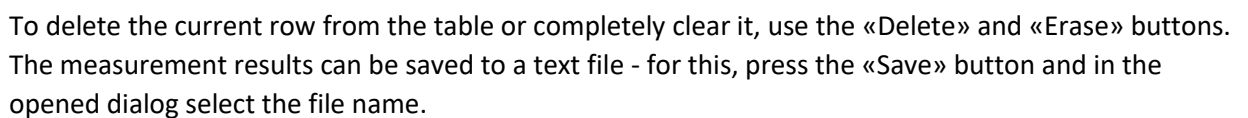
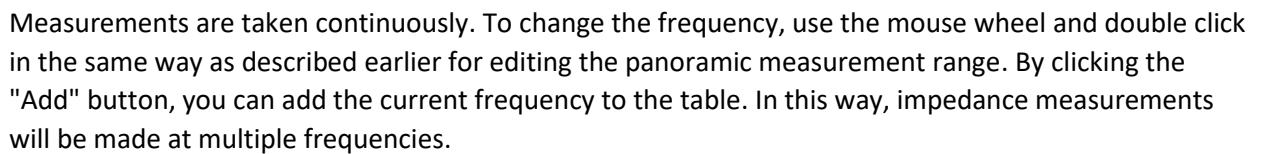
Using the save



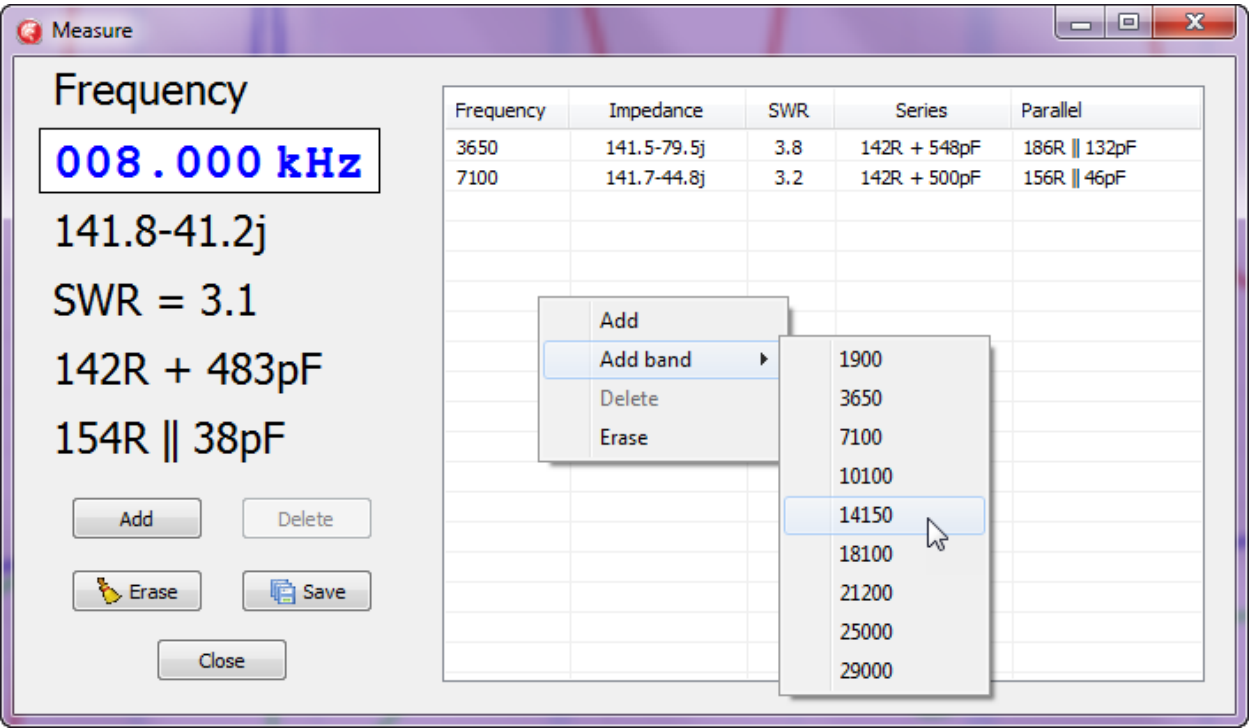
and load

buttons, you can save measurements to disk for further analysis.

Press button "Measure"



On the measurement table, you can call the context menu by right-clicking. It duplicates the main actions, and it is also possible to select frequencies corresponding to the middle of the amateur bands.

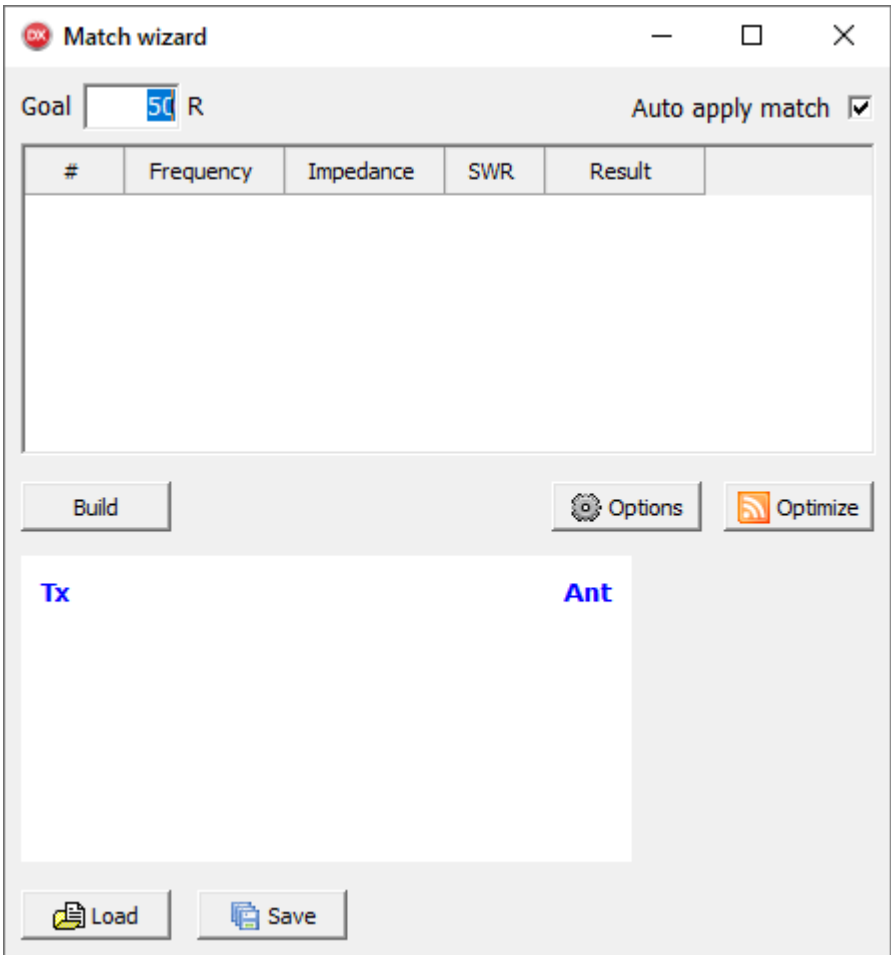


### Impedance matching

Press button "Match"

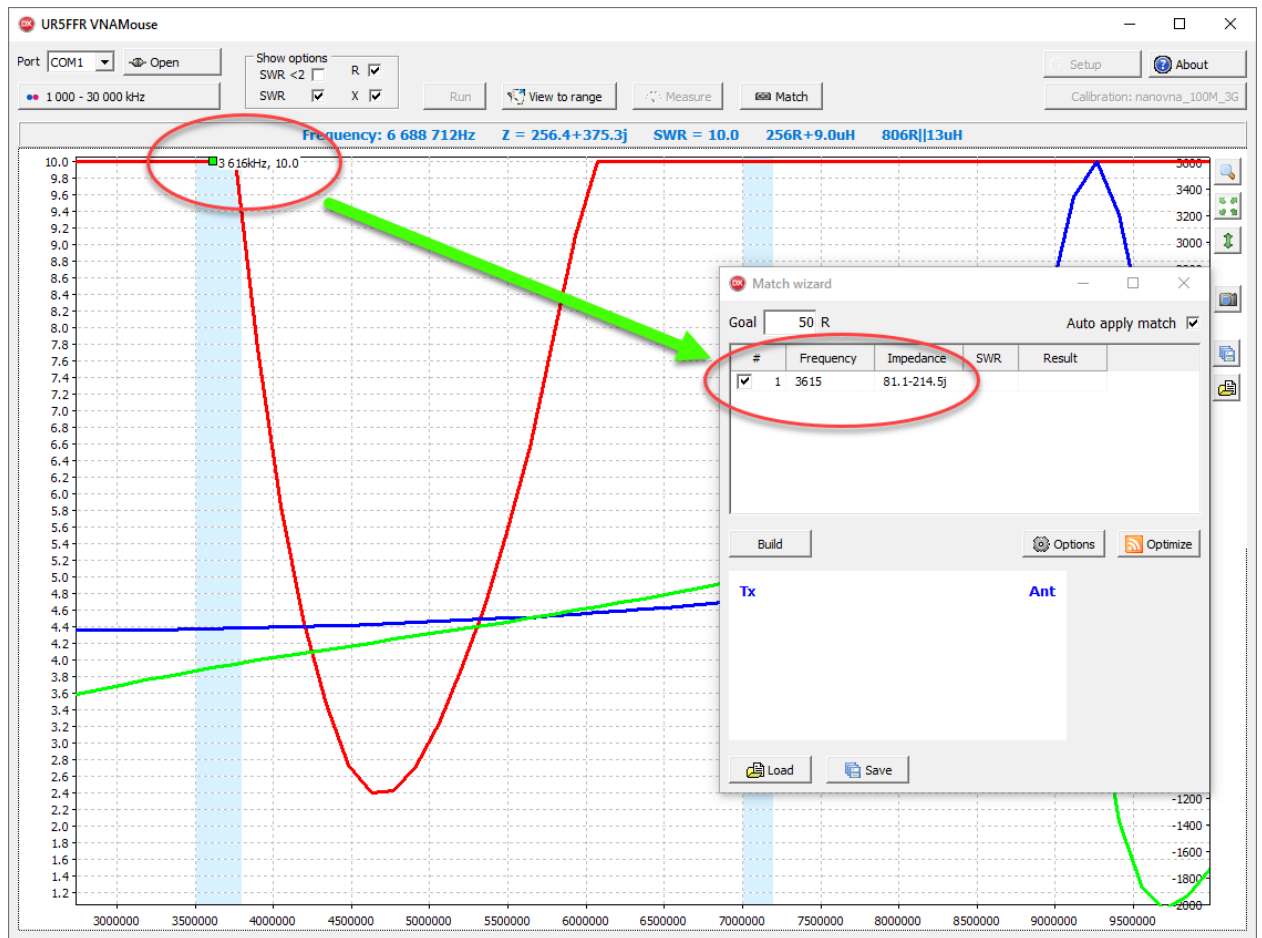


The window for calculating the complex impedance matching network will open.

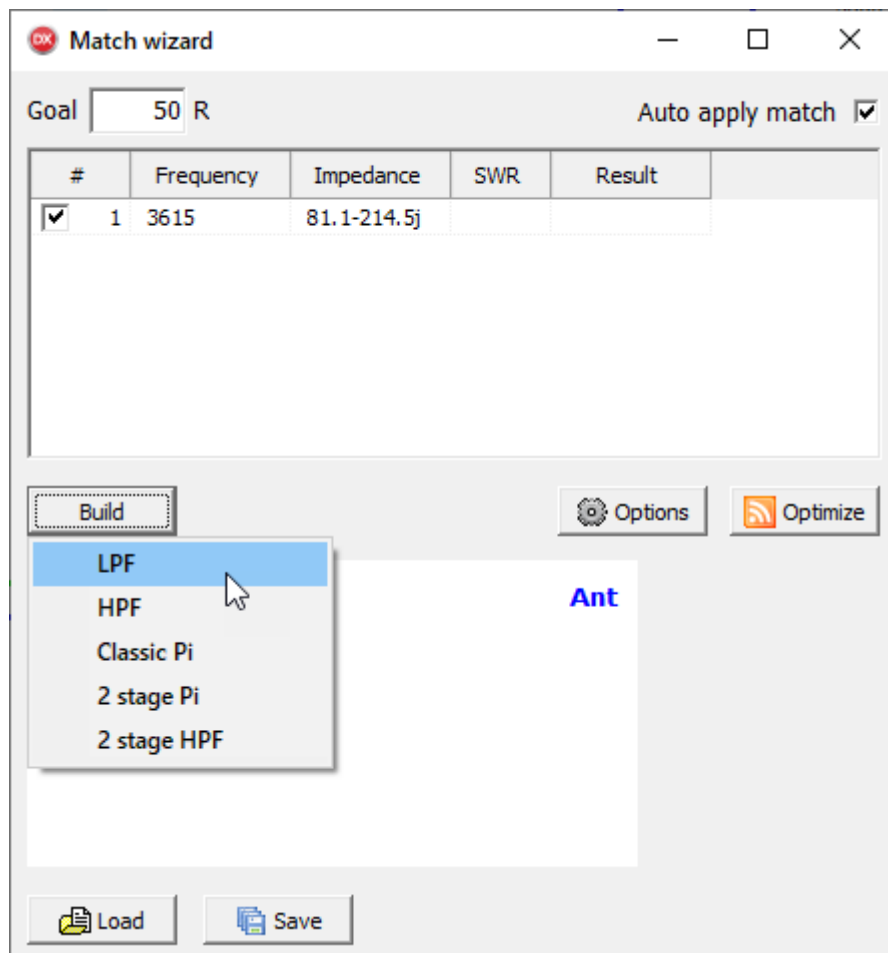




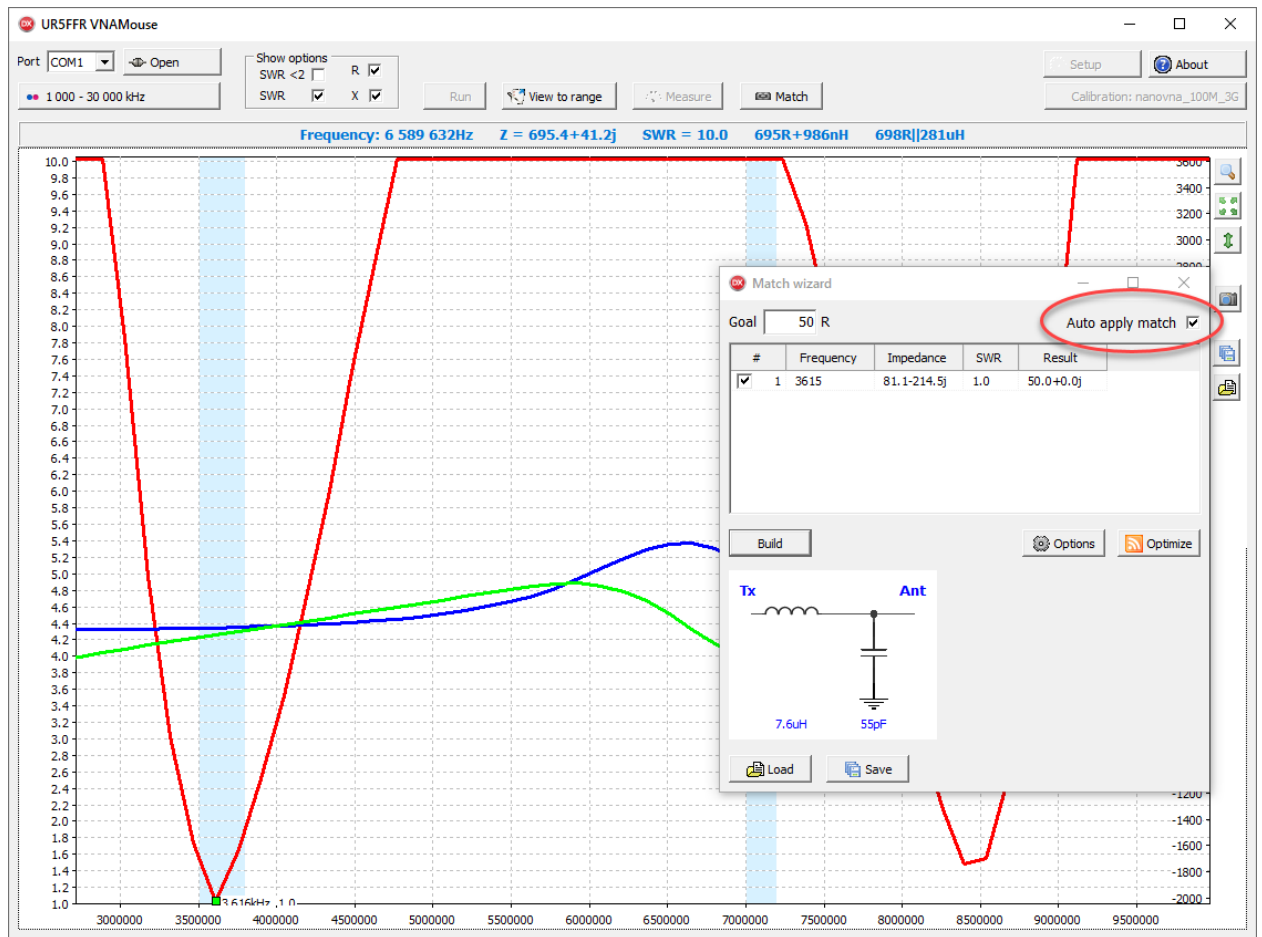
To set the frequency (one or several) at which it is necessary to calculate the matching network, put a marker on the measurement graph by double-clicking the left mouse button



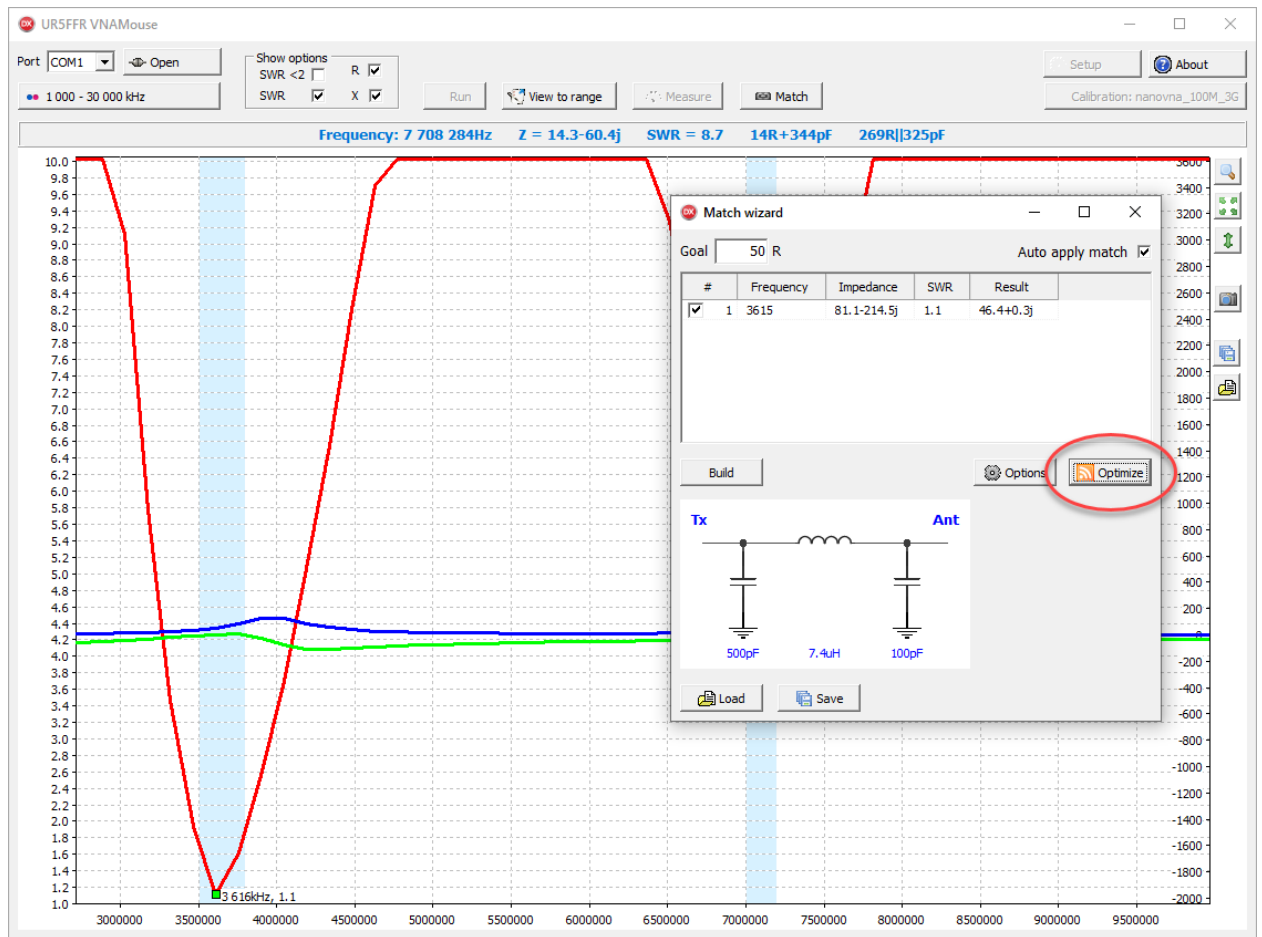
Then click the "Build" button and select the required matching network circuit



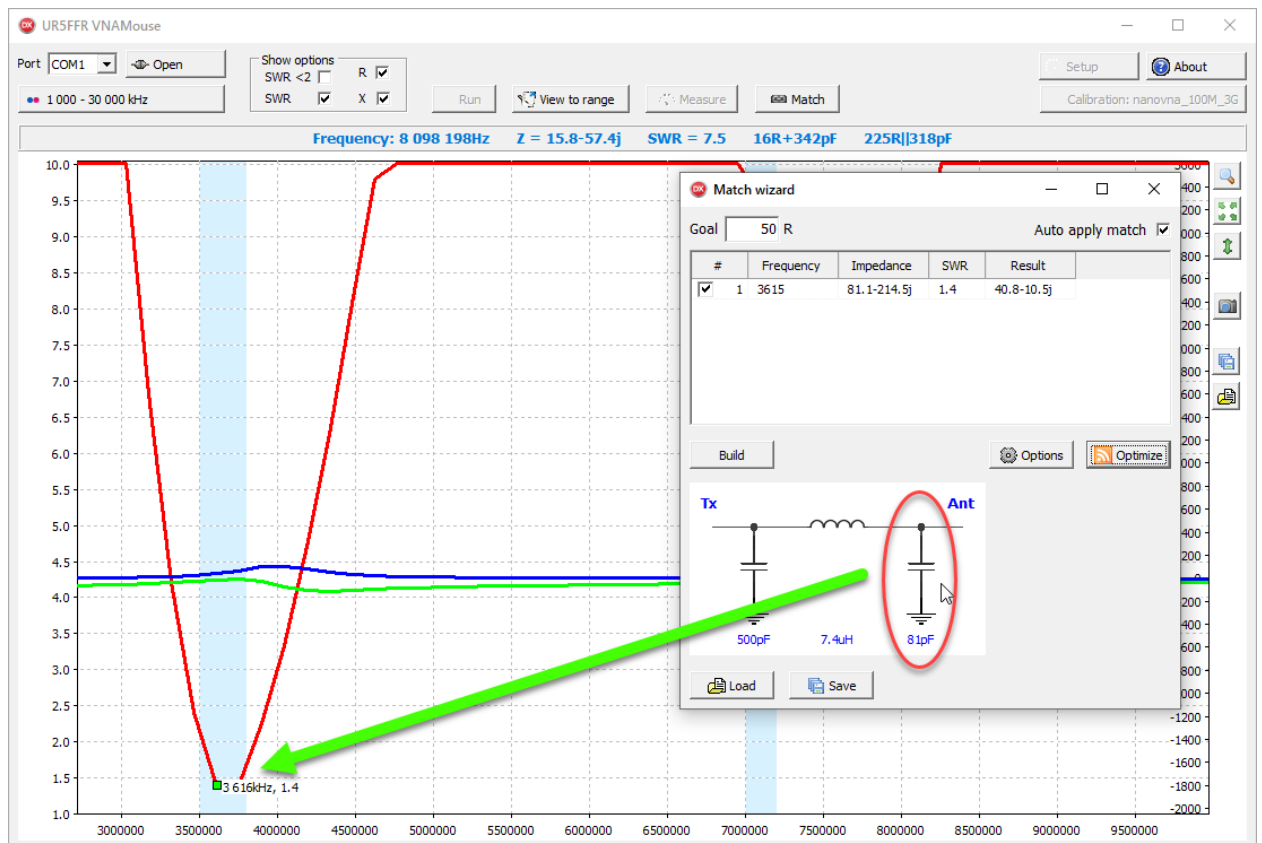
The matching network will be built and the results of its application will be displayed in the main window. To automatically display the results of changing the network chain in the panorama, "Auto apply match" must be enabled.



Automatic calculation of the network during its construction is performed only for simple network of the LPF / HPF type. For more complex circuits, it is necessary to press the "Optimize" button for the program to optimize the parameters of the matching circuit.

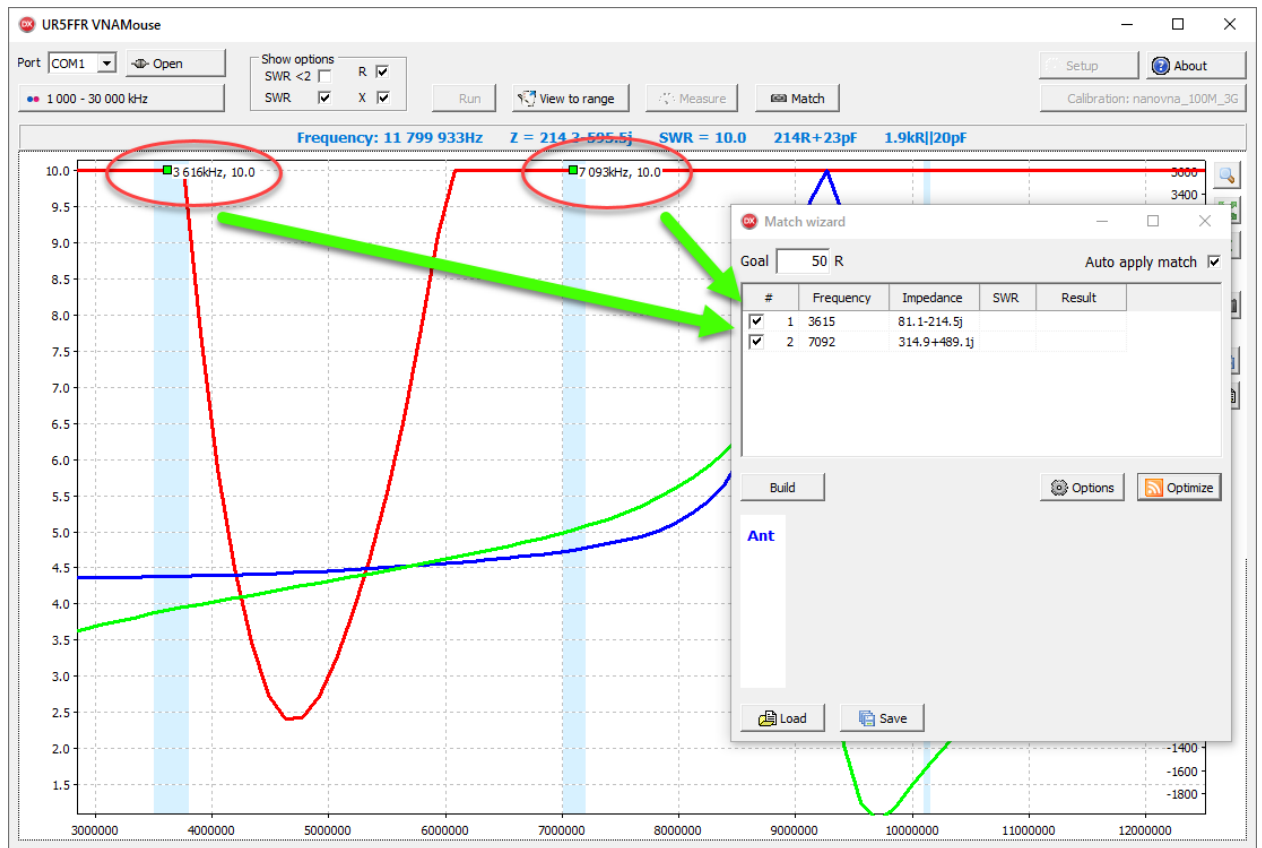


Using the mouse scroll wheel on the elements of the matching circuit, you can change their values and immediately watch how the matching will change in the panorama.

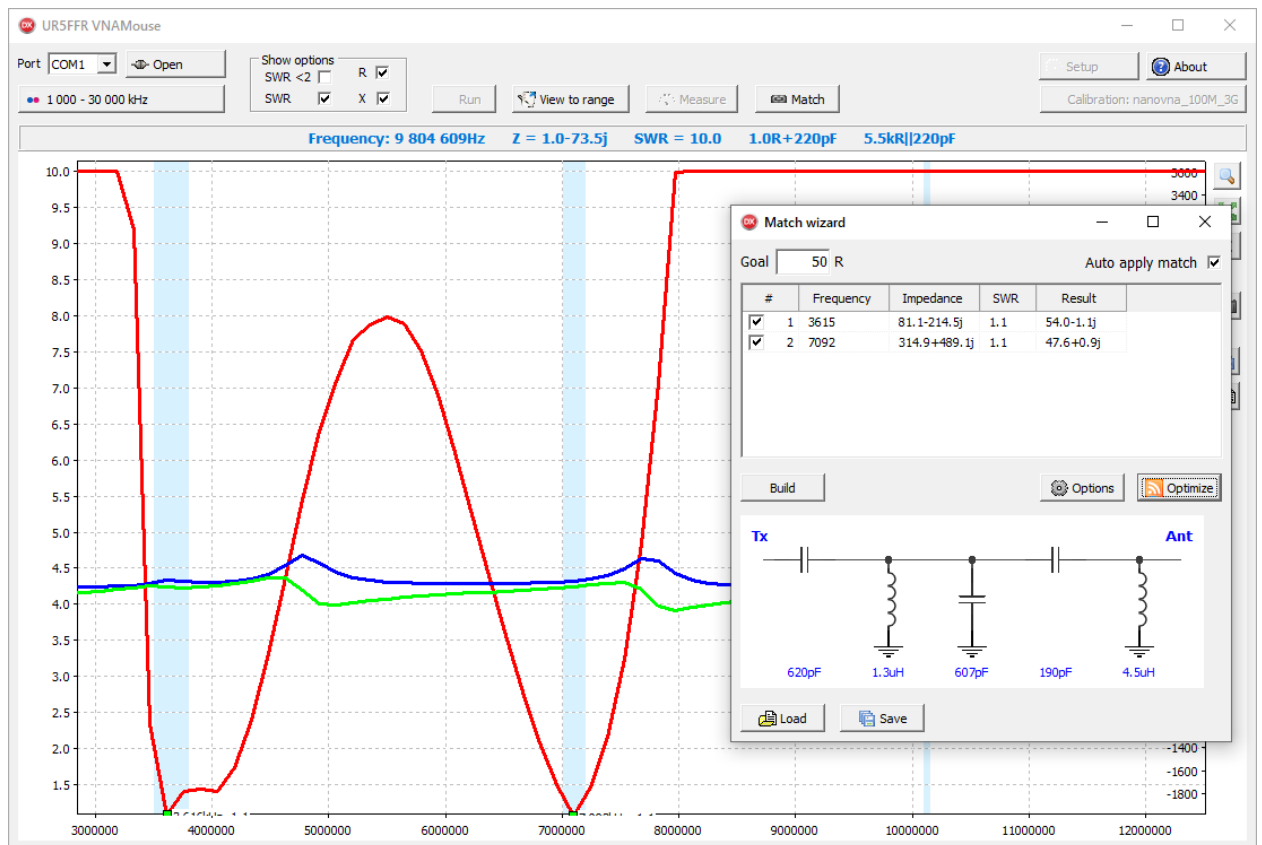


## Build impedance matching for multiple frequencies

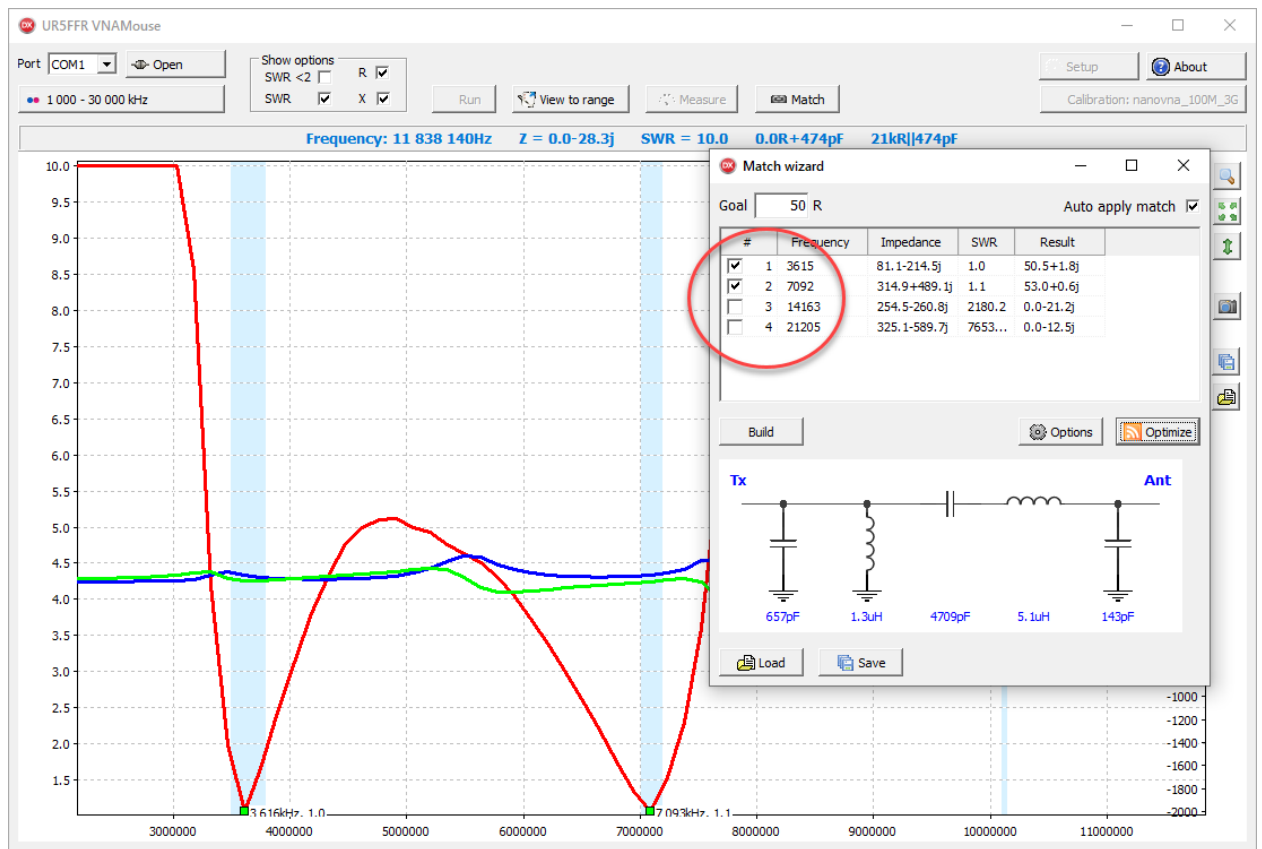
Using a double click of the mouse, place markers on the frequencies you are interested in - they will be added to the list of frequencies in the matching calculation window.



Click the "Build" button and select a complex network such as "2 stage Pi". Click the "Optimize" button for the program to optimize the matching network.



You can add many frequencies, but only calculate the matching network for the selected ones. For example, the calculation of matching for 20m and 15m.



## Settings

Press button "Options". A window will open with the adjustment optimization settings.

Matching options

Min capacitance  pF

Max capacitance  10000 pF

Min inductance  10 nH

Max inductance  30000 nH

Allow change series/parallel ☒

Allow change L/C ☒

Max count of inductance  0

☐ Inductor physical model

Inductor Q  200

☐ At frequency  MHz

☐ Capacitor physical mode

Capacitor Q  500

☐ At frequency  MHz

OK Cancel

The min/max capacitance/inductance parameters define the limits within which the optimizer can vary the ratings of the matching network.

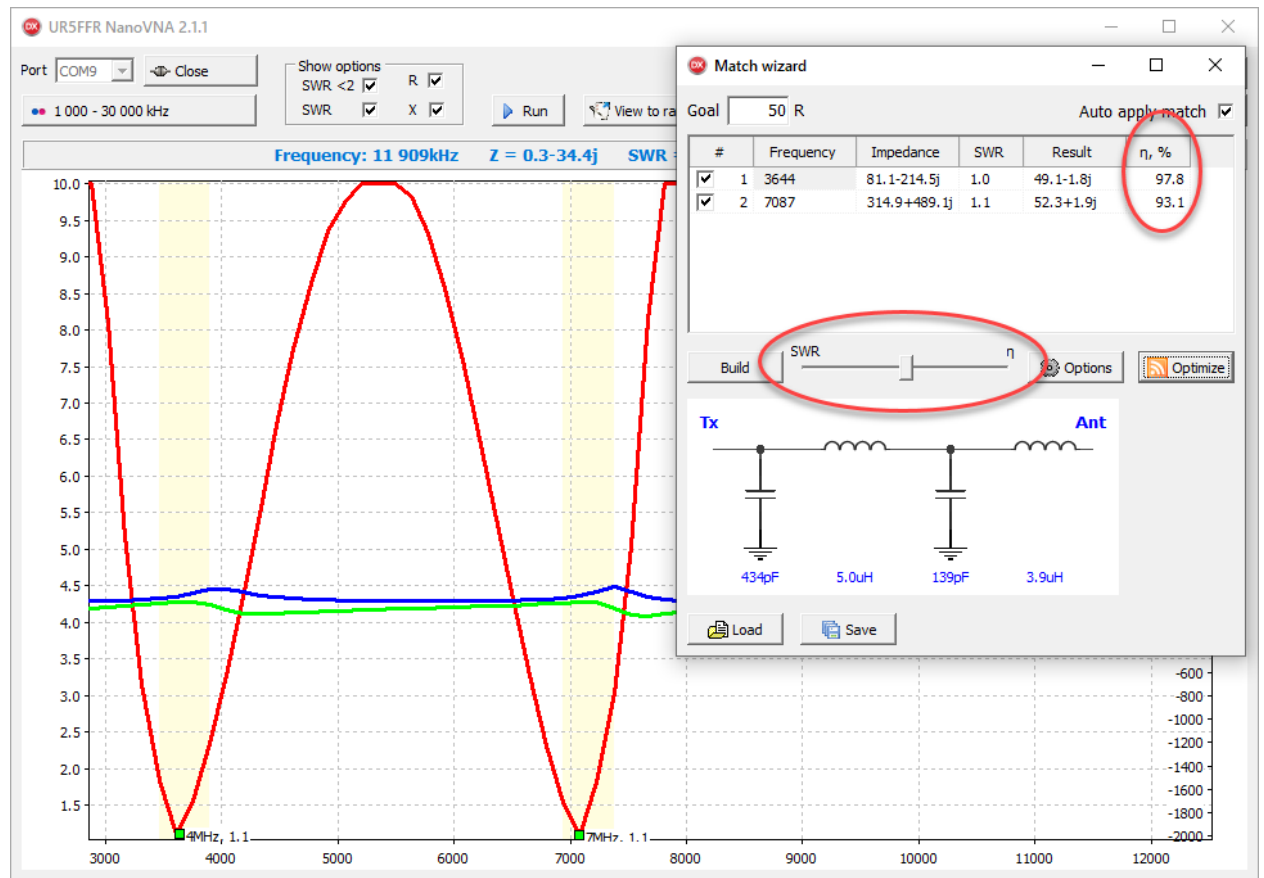
"Allow change series/parallel" allows the optimizer to change the topology of the circuit using parallel and serial connecting of elements.

"Allow change L/C" allows the optimizer to swap capacitors to inductors in the circuit and vice versa.

"Max count of inductance" sets the maximum number of inductors. This restriction makes sense if the optimizer is allowed to independently choose the types of network elements. A value of 0 indicates no restrictions.

The program allows you to take into account the physical properties of the elements of the matching chain. For this, the quality factors of the elements are set.

When calculating taking into account physical properties, an additional column appears in the table, displaying the efficiency. In addition, a slider is displayed that allows you to set the balance between SWR and efficiency when optimizing the matching circuit.



## Build matching network with defined topology

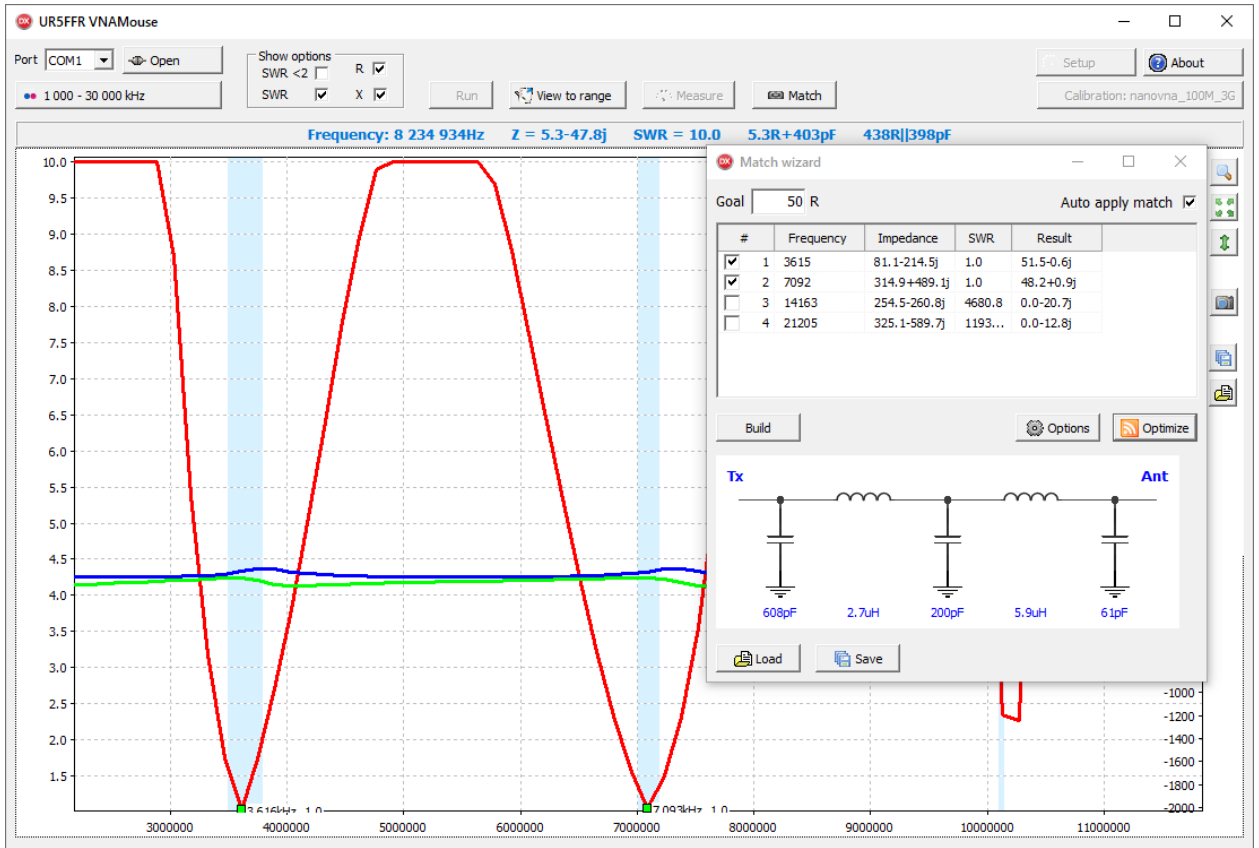
If you need to calculate the matching chain of a fixed topology, you must prohibit the optimizer from changing it. We will indicate this in the options.

The 'Matching options' dialog box contains the following settings:

- Min capacitance: 1 pF
- Max capacitance: 10000 pF
- Min inductance: 10 nH
- Max inductance: 30000 nH
- Allow change series/parallel: ☐
- Allow change L/C: ☐ (circled in red)
- Max count of inductance: 0
- Inductor physical model: ☐
  - Inductor Q: 200
  - At frequency: ☐ MHz
- Capacitor physical mode: ☐
  - Capacitor Q: 500
  - At frequency: ☐ MHz

Buttons: OK, Cancel

Press button "Build" and select "2 stage Pi". Press button «Optimize»



## Build matching network with custom topology

Call the context menu by right-clicking on the matching circuit diagram.

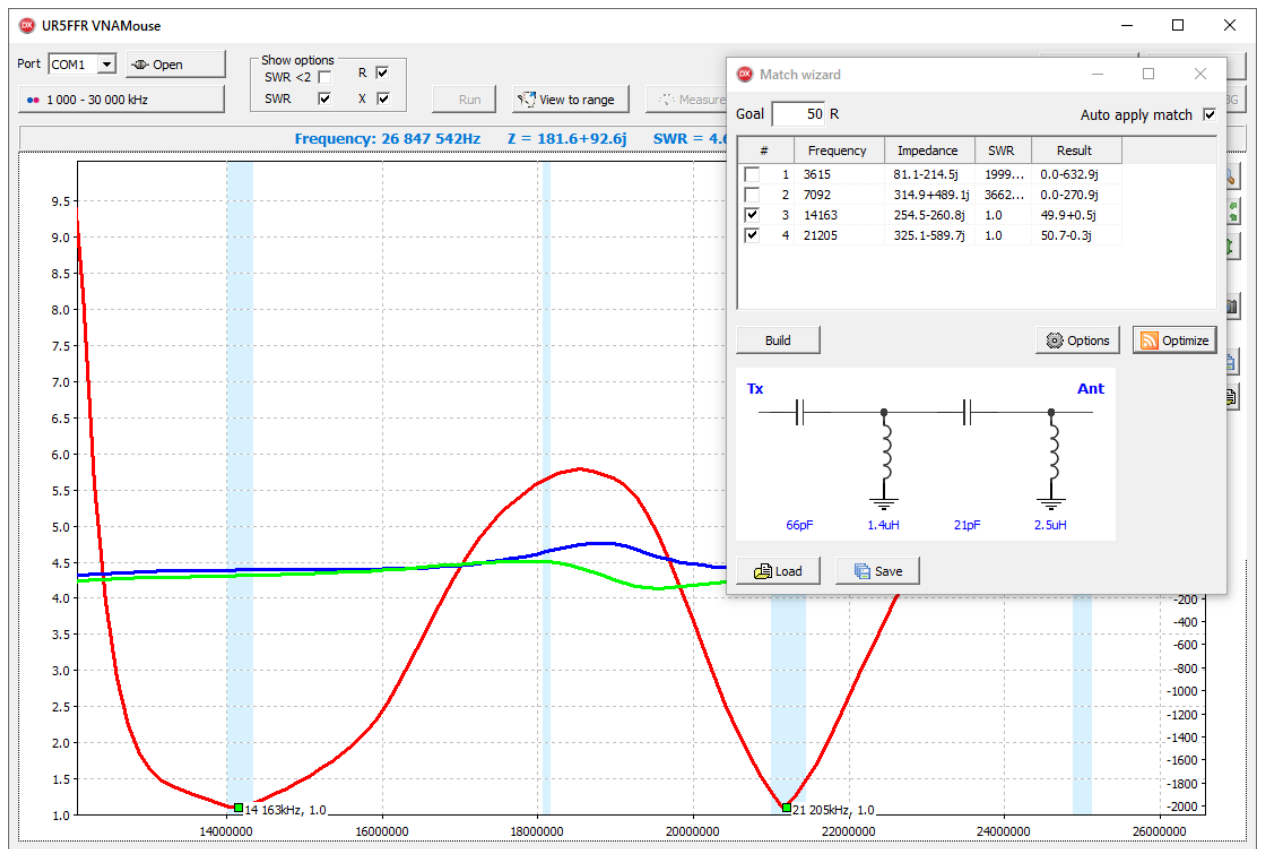
The screenshot shows the 'Match wizard' window. At the top, the 'Goal' is set to 50 R, and 'Auto apply match' is checked. Below this is a table with the following data:

#	Frequency	Impedance	SWR	Result	
<input checked="" type="checkbox"/>	1	3615	81.1-214.5j	1.0	51.5-0.6j
<input checked="" type="checkbox"/>	2	7092	314.9+489.1j	1.0	48.2+0.9j
<input type="checkbox"/>	3	14163	254.5-260.8j	4680.8	0.0-20.7j
<input type="checkbox"/>	4	21205	325.1-589.7j	1193...	0.0-12.8j

Below the table are buttons for 'Build', 'Options', and 'Optimize'. The circuit diagram shows a transmission line between 'Tx' and 'Ant' ports. It contains a series inductor of 2.7uH and two shunt capacitors: 608pF near the Tx port and 61pF near the Ant port. A context menu is open over the 61pF capacitor, showing options: 'Add node', 'Edit value', 'Delete', 'Erase', 'Series', 'Parallel', 'L', 'C', and 'Locked'. A sub-menu is also visible with 'First', 'Last', and 'Insert' options.

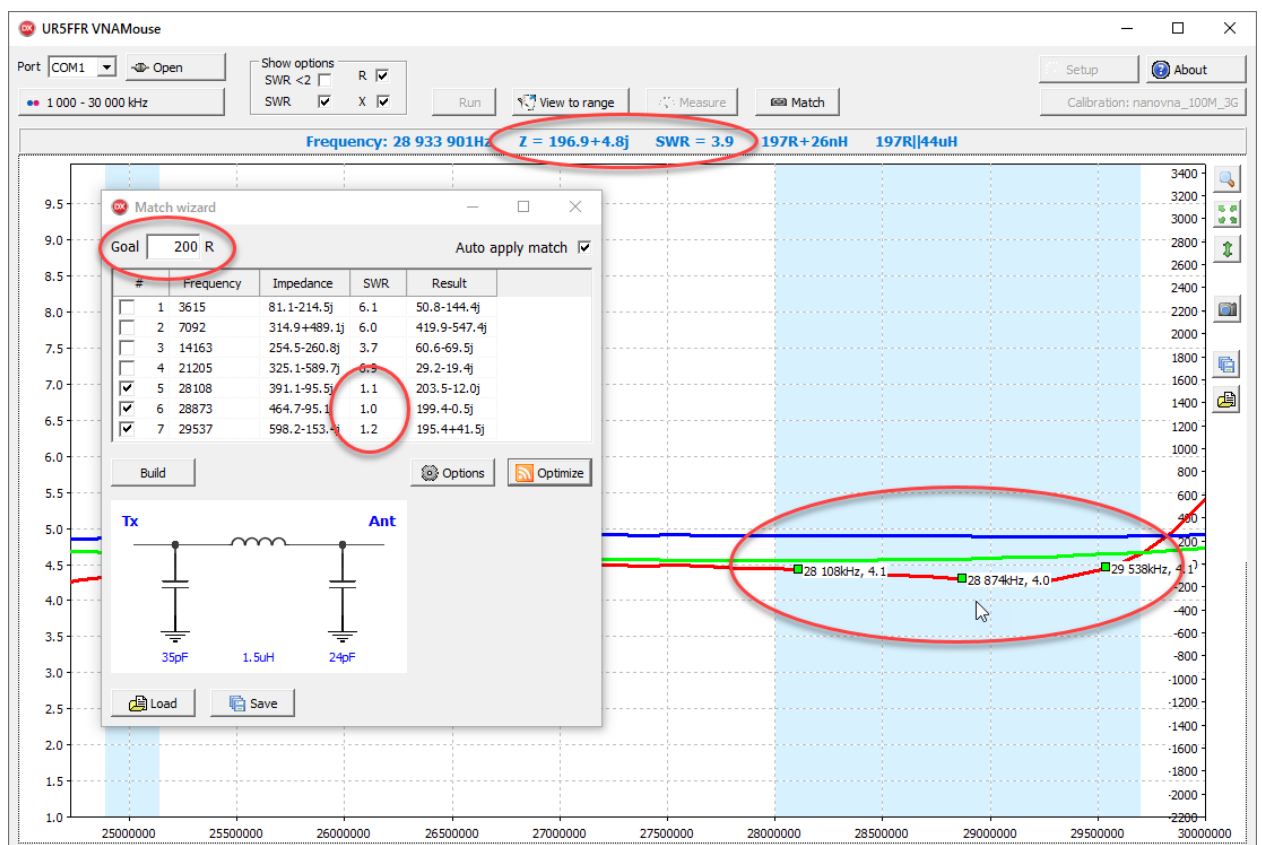
It is possible to add/remove elements, change their type and include. By double-clicking on an element in the diagram, you can change its inclusion from parallel to serial and vice versa. After specifying the topology of the matching network, click the "Optimize" button.





The program stops searching for matching options if VSWR is not worse than 1.1 at all points, or if the search lasts more than 10 minutes. In some cases, the program cannot find the optimal value of the matching circuit parameters. This usually happens if the chain contains too few nodes and the number of matching points is large. To stop the search, press the "Abort" button in the optimizer window, increase the number of nodes in the circuit, or change its topology, or decrease the number of selected points (frequencies) to build the matching circuit.

Matching network can be calculated to obtain a net impedance other than 50 ohms. Enter the required impedance in the "Goal" field and click the "Optimize" button. Below is an example of calculating a matching network for a 10m range and a target impedance of 200 ohms.



The coordination chain can be saved or loaded from a file using the "Load" and "Save" buttons at the bottom of the window.

Match wizard

Goal

50 R

Auto apply match

☒

#	Frequency	Impedance	SWR	Result	$\eta$ , %
<input checked="" type="checkbox"/> 1	3644	81.1-214.5j	1.0	49.1-1.8j	97.8
<input checked="" type="checkbox"/> 2	7087	314.9+489.1j	1.1	52.3+1.9j	93.1

Build

SWR

$\eta$

Options

Optimize

Tx

Ant

434pF

5.0uH

139pF

3.9uH

Load

Save