KROKS

SCIENTIFIC PRODUCTION COMPANY

2-PORT VECTOR
NETWORK ANALYZER

ARINST VNA-PR1

1-6200 MHz

MANUAL

CONTENT

1. PURPOSE

1.1. Portable 2-port vector network analyzer **ARINST VNA-PR1** (analyzer, device) is designed to measure the elements of the scattering matrix (complex reflection and transmission coefficients) of four-port networks. The device measures parameters S11 and S21, voltage standing wave ratio (VSWR), impedance, admittance, phase, group delay (GD), distance to cable fault.

1.2. The analyzer is designed for setting and matching the characteristics of passive and active radio devices[1] (antennas, cables, filters, attenuators, amplifiers), checking the integrity of high-frequency cables, measuring their parameters, and other amateur radio measurements.

1.3. The device is intended for amateur radio applications, as it is not a professional measuring instrument. The built-in battery allows you to make measurements in the laboratory and in the practical conditions.

2. SAFETY RULES FOR WORKING WITH THE DEVICE

2.1. General safety requirements

2.1.1. Persons who have read this «Manual» and have been instructed in the rules of safe work with electrical appliances are allowed to work with the device.

2.1.2. The risk of injury is possible when the charger is connected or disconnected from the electrical network. Use serviceable power outlets and chargers.

2.1.3. To avoid damage to the wires and connectors of the device, do not hang anything on the wires, paint over and glue the wires and connectors, disconnect the wires by pulling the cord.

2.1.4. Persons using the device are strictly prohibited: pass the device to strangers, disassemble and carry out any repairs not agreed with the manufacturer, use a device with a damaged case.

2.1.5. If you find a fault, stop operation immediately and turn off the device.

2.1.6. If you need to leave your workplace, turn off the device and other devices. Do not leave the working device unattended!

2.1.7. Do not use the device in hospitals. The use of the device near medical equipment is allowed only with the consent of the medical staff.

2.2. Additional safety requirements

2.2.1. Use the device only for its intended purpose. Read the purpose, device, and technical characteristics of the device.

2.2.2. Avoid working in open spaces during snow or rain. High humidity and all types of liquid, getting inside the device, can damage it.

2.2.3. Do not expose the device to very low or very high temperatures, exposure to extreme temperatures can damage the built-in battery.

2.2.4. Do not use the device in areas with a corrosive or explosive environment. Aggressive vapors can destroy the insulation, which can cause the device to fail.

2.2.5. Do not apply excessive force to the device's connectors, controls, or screen. Avoid bumps and falls on the device. If the device falls, it may be damaged.

2.2.6. Do not disassemble or modify the device without the consent of the manufacturer or without the instructions described in this manual. Incorrect self-intervention in the device will result in loss of warranty.

2.2.7. Use chargers, cords, adapters, and other accessories recommended by the manufacturer.

2.2.8. When connecting other tools to the device, carefully read their purpose, technical characteristics. Do not connect incompatible devices.

2.2.9. Maintenance and repair of the device must only be performed by the manufacturer or an authorized service center.

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[1] The devices must allow the possibility of applying a stimulating signal from the analyzer to the test port. The analyzer manufacturer is not responsible for the failure of devices that do not allow the supply of a stimulating signal to the test port.

3. SPECIFICATIONS

3.1. The technical characteristics of the device are shown in Table 1.

Table 1

Parameter		**Value**
Operating frequency range		1-6200 MHz
Frequency resolution	for range 1-100 MHz	100 Hz
	for range 100-6200 MHz	10 kHz
Maximum number of scan points		1000
Scanning rate		1000 points / s
Dynamic range S21 (BW = 250 Hz)	for range 1-1,5 MHz	> 60 dB, 70 dB (typ.)
	for range 1,5-4500 MHz	> 80 dB, 90 dB (typ.)
	for range -6200 MHz	> 70 dB, 75 dB (typ.)
The direction of the bridge, uncorrected throughout the range, not less		12 dB
Directivity effective[2] (after full one-port calibration), not less		55 dB
Input standing wave ratio, not more		2
Phase measurement error[2], not more		0,7°
Magnitude measurement error[2], not more		0,25 dB
Resolution for determining the distance to fault[3]		(C × VF)/2S m
Maximum length of the measured cable[4], when VF=1		3000 m
Compensation electrical length of the cable, when VF=1		±3 m
Maximum DC Input Voltage		25 V
Maximum input power supplied to the ports		+10 dBm
Maximum power of the probing signal [5], not more		-5 dBm
Displayed charts	■ Smith chart; ■ polar chart; ■ phase of the reflection coefficient S11 and transmission coefficient S21; ■ magnitude of S11 and S21 ; ■ logarithmic magnitude of S11 and S21; ■ SWR; ■ distance to fault; ■ cable loss; ■ group delay	
Number of user settings to save		32
Number of traces to save		32
Operating temperature range		0 … +40°C
Screen diagonal		4”
Screen type		touch resistive
Screen resolution		800×480
Test port connectors type		SMA (female)
Maximum current consumption, no more	when charging the battery	≤ 2 A[6]
	when working on battery power	~ 1 A
	when working from USB with battery charging[7]	≤ 2 A[6]
Battery capacity		5000 mAh
Time of continuous battery life[8]		2,5 h
Battery charge time[6]		~ 3,5 h
Overall dimensions (L × W × H)		150×81×27 mm
Weight		0,4 kg

[2] The measurement is performed after warming up the device for at least five minutes with a full calibration. The change in ambient temperature from the moment of calibration to measurements should not exceed ± 3 ° C.

[3] Where **C** is the speed of light m/s; **VF** – velocity factor (the ratio of the speed of propagation of electromagnetic waves in the cable to the speed of propagation of electromagnetic waves in a vacuum), takes a value from 0.1 to 1 (depending on cable); **S** - scanning frequency range (Hz).

[4] Depends on the amount of attenuation in the cable and is the indication limit on the display.

[5] With the possibility of reducing.

[6] When connecting the device to a charger with an output current of at least 3A.

[7] If your PC has a limit on the maximum current supplied to the USB port, the device will automatically limit the maximum charging current according to the current USB specification.

[8] At an ambient temperature of 20±5°C after the battery is fully charged.

4. COMPLETENESS

4.1. The delivery set of the device is shown in Table 2.

Table 2

Name	Quantity
The vector network analyzer ARINST VNA-PR1 1-6200 MHz	1 pc.
USB 2.0 – Mini-USB cable	1 pc.
SMA (female) – SMA (female) adapter	2 pc.
Manual (product passport)	1 pc.
Package	1 pc.

Due to the continuous improvement of the device and software, the manufacturer reserves the right to make changes to its technical characteristics and completeness.

5. STRUCTURE OF THE DEVICE

5.1. The device structure is shown in Figure 5.1.

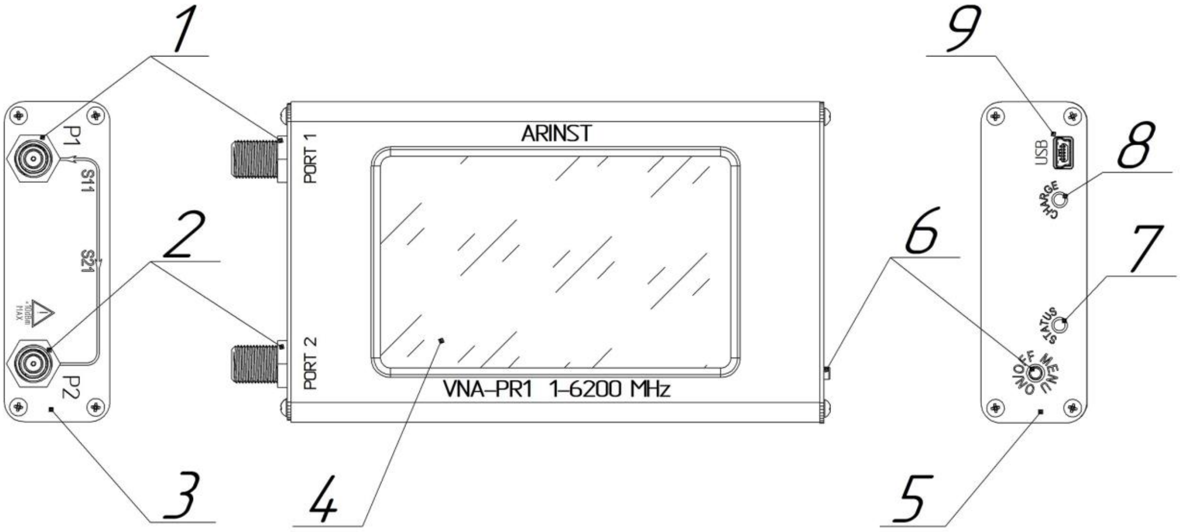


Figure 5.1 - External view of the device

1. Measuring port 1 (PORT 1) is intended for connecting the test devices and acts as a source and receiver of the signal.

2. Measuring port 2 (PORT 2) is intended for connecting the test devices and is a signal receiver.

3. High frequency connector panel

4. Color resistive screen 4” serves to configure the device through the on-screen menu and display measurement results in the form of user-defined plots and charts.

5. Indication panel

6. Multi-function button. Turns on and off the device when pressed and held for more than 2 seconds. When pressed once, it opens or hides the main menu of the device.

7. Indicator STATUS. Lights up when the device is on.

8. Battery charging indicator CHARGE. Lights up when the battery is charging and when the device is operating from USB. Turns off when charging is complete.

9. Connector Mini-USB. Serves for data transmission and battery charging of the device.

6. DESCRIPTION AND OPERATION OF THE DEVICE

Vector network analyzer **ARINST VNA-PR1** is a technically complex measuring device consisting of a test (probe) signal generator, directional couplers, a multichannel receiver, ADC, a microcontroller, LCD and a Li-Ion battery.

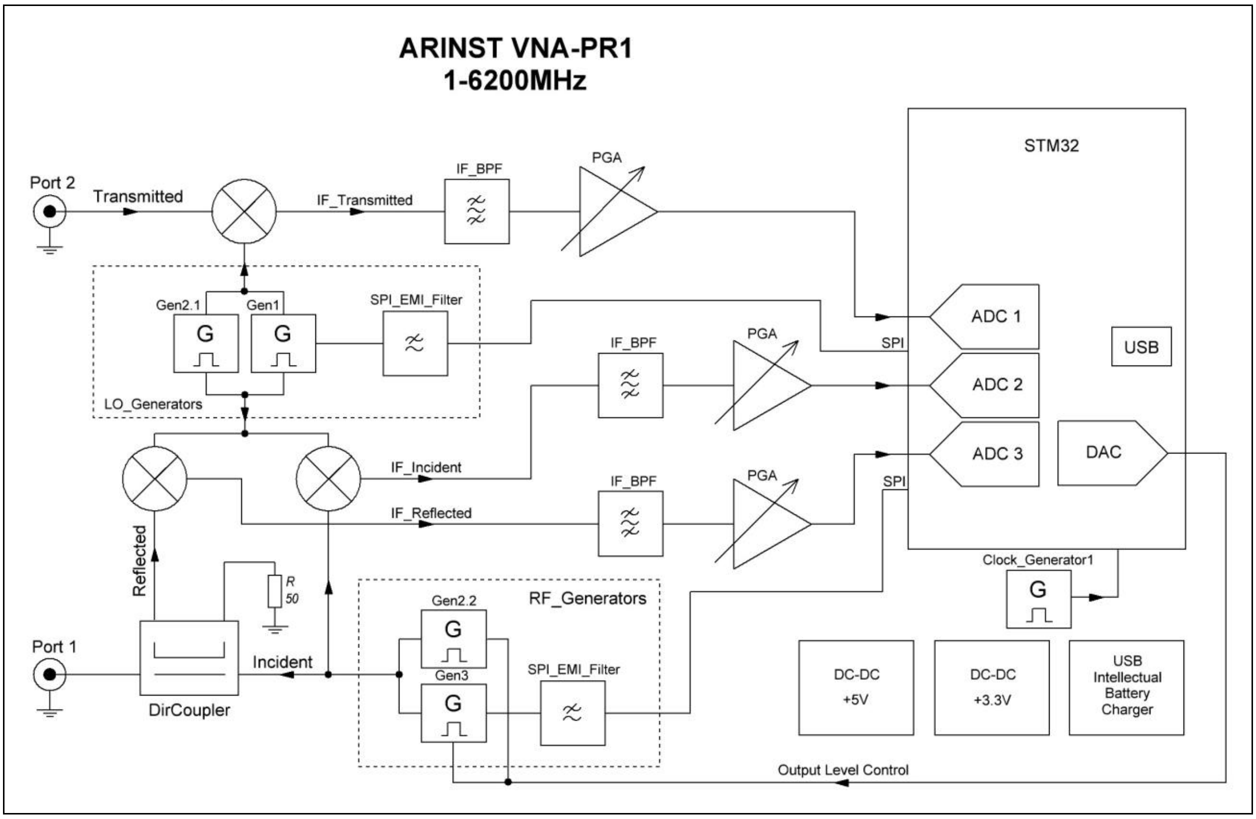


Figure 6.1 - Block diagram of the ARINST VNA-PR1

This is a portable device consisting of the main unit and its accessories (measuring cables, connectors, adapters, calibration tools).

The analyzer performs the functions of forming a probing signal, measuring, calculating and displaying the measured parameters of the test device.

The analyzer provides adjustment of the output power level of the probing signal generator. Power adjustment extends the measurement capabilities of active devices and reduces the probability of exceeding the maximum power of the input signal of the P2 port specified in the technical characteristics of the device.

where,

ARINST VNA-PR1 – network analyzer;
DUT – device under test;
P1 and **P2** – port 1 and port 2 of the analyzer;
$\mathbf{U_{rwa}}$ – reflected wave amplitude;
$\mathbf{U_{iwa}}$ – incident wave amplitude;
$\mathbf{U_{twa}}$ – transmitted wave amplitude.

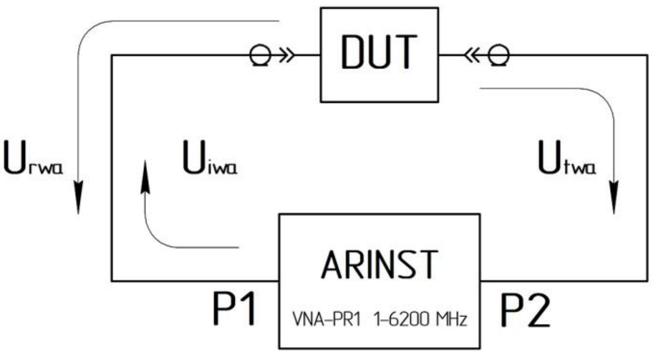


Figure 6.2 - Schematic diagram of measurements of the reflection and transmission coefficient

The device generates a probing signal based on the frequency range set by the user.

In measurement mode S11 the probing signal (incident wave) is sent to the first port P1, to which the test device or calibration standards are connected. A reflected wave is formed, which is separated by a directional coupler and enters the reflected signal receiver. From the output of the receiver, the intermediate frequency (IF) signal is converted into digital form using a high-speed ADC. The digitized data contains information about the amplitude and phase of the reflected signal. Similarly, information about the amplitude and phase of the incident signal is obtained.

At each frequency, the IF signal of the direct and reflected waves is sampled with further calculation of the amplitude and phase of each signal using the maximum likelihood method.

The obtained values make it possible to calculate the reflection coefficient (RC), which is a complex number that carries information about both the phase and the amplitude of the reflected and incident waves.

$$RC = \frac{U_{rwa}}{U_{iwa}} \times exp\left[j\left(\varphi_{rwp} - \varphi_{iwp}\right)\right]$$

where, U_{rwa} – Reflected wave amplitude;

U_{iwa} – Incident wave amplitude;

Φ_{rwp} – Reflected wave phase;

Φ_{iwp} – Incident wave phase;

j – √-1 – Imaginary unit.

In measurement mode S21 the probing signal (incident wave) is sent to the first port P1. The test device is connected to port P1 on one side and to port P2 on the other. In this mode, the analyzer can simultaneously measure the parameters S11 (according to the algorithm described above) and S21. When measuring S21, the incident wave passes through the test device, the resulting signal enters port P2 and enters the processing path of the transmitted signal, is transferred to IF and converted to digital form using an ADC.

The obtained values make it possible to calculate the transmission coefficient (TC), which is a complex number that carries information about both the phase and the amplitude of the transmitted wave.

$$TC = \frac{U_{twa}}{U_{iwa}} \times exp\left[j\left(\varphi_{twp} - \varphi_{iwp}\right)\right]$$

where, U_{twa} – Transmitted wave amplitude;

U_{iwa} – Incident wave amplitude;

φ_{twp} – Transmitted wave phase;

φ_{iwp} – Incident wave phase;

j – √-1 – Imaginary unit.

After calculating the RC and TC, the microcontroller displays the result of scanning over the frequency range in the form of plots and charts selected by the user: Smith chart, phase chart, magnitude plot of RC / TC, SWR plot and others.

7. START ON

⚠ Do not use the device outdoors during snowfall or rain. If the device is brought in during the cold season from a cold room or from the street into a warm room, do not turn it on for enough time to allow condensation to evaporate from the device.

⚠ Match the signal strength and voltage applied to ports P1 and P2 to the maximum device specifications shown in Table 1.

7.1. Make sure that the device is not damaged externally and that the battery is charged. Charge the discharged battery in accordance with item 11.2.

7.2. Press and hold button (6) for 2 seconds. The device turns on. When the device is turned on for the first time, it is necessary to set the frequency range, the type of plots displayed on the screen (4) and carry out calibration. User settings will be saved in the device memory and will be automatically installed on subsequent switching on.

7.3. To turn off the device, press and hold the button (6) for 2 seconds. The display (4) of the device will go out, the device will turn off. Each time the device is turned off, the main user settings are recorded in the nonvolatile memory, which allows avoiding the device setting at the next turn on.

8. SCREEN INTERFACE

The device displays the results of scanning the frequency range specified by the user in the form of plots and charts. The current device settings and interactive buttons for controlling the device interface are located at the bottom of the screen.

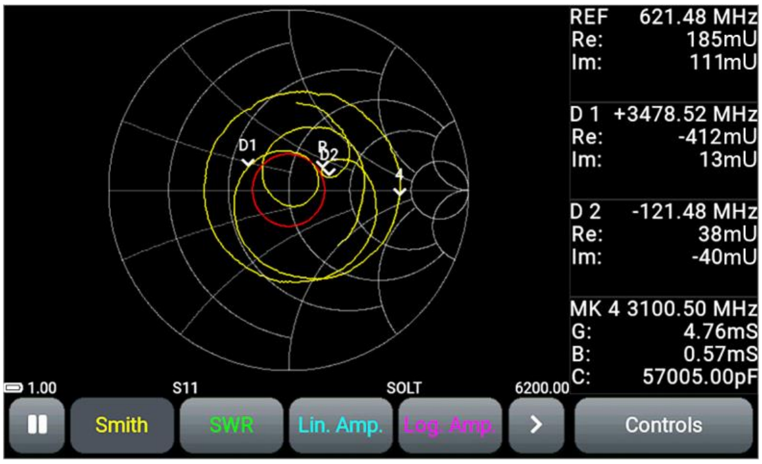


Figure 8.1 - Device screen

8.1. The information bar of the screen displays information about the current state of the device.

8.1.1. Built-in battery status indicator:

- indicator in the form of a spark (lightning) – the battery is charging;
- the battery indicator symbol is completely filled in white – the battery is fully charged;
- indicator symbol in the form of a white battery outline – the battery is low and needs to be charged;
- the device displays a message about the critical charge level – the battery is fully discharged, the device will automatically turn off.

8.1.2. Frequency range:

• Numerical values of the beginning and end of the frequency range. In our example, the frequency range is 1-6200 MHz.

In the mode of measuring the distance to fault, instead of the frequency range, the distance in meters or time in nanoseconds is displayed.

8.1.3. Measurement mode:

- **S11** – the mode of measuring the reflection coefficient, cable loss and distance to damage;

- **S21** – transmission coefficient measurement mode.

8.1.4. Calibration type designation:

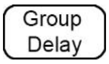
- **Factory** – factory calibration;
- **SOL** – one-port calibration;
- **SOL+T** – full two-port calibration;
- **T** – direct connection.

8.2. The interface control buttons are located under the information bar (figure 8.1):

8.2.1. The «pause» button. Pressing the button pauses the measurement process and «freezes» the plot on the screen. Pressing the button again resumes the measurement process.

-  – pause off, measurement in progress;
-  – pause on, measurement is paused.

8.2.2. Buttons for switching charts. The device screen displays buttons for quick access to four plots with measurement results simultaneously. The chart types and their order in the row are set by the user.

-  – Smith chart or impedance chart;
-  – polar chart;
-  – the phase plot of the measured S-parameter, presented in the range from -180 to + 180º;
-  – S-parameter modulus (amplitude) plot on a linear scale;
-  – S-parameter modulus (amplitude) plot in logarithmic scale (in dB);
-  – voltage standing wave ratio (VSWR) plot;
-  – plot showing the distance to fault or discontinuity in the cable;
-  – plot of signal attenuation in the cable;
-  – group delay plot.

8.2.3. Function buttons

-  – expands the plot to the full screen.
-  – turn off the plot to access additional settings
-  – opens access to settings for plots and measurement modes displayed on the screen.