OKP 43 4531

**Three-phase Programmable
Waveform Generator**

Energoforma 3.3

User's Manual

Edition 8

MC2.211.001 UM

2015

CONTENTS

Introduction

The manual covers Programmable Waveform Generator Energoforma 3.3 (hereinafter referred to as the Generator) and contains the information and instructions for its operation. The aforesaid equipment has been manufactured in compliance with Technical Specifications TS 4345-019-499764972003-2003 and conforms to the Technical Requirements in force.

1. Safety requirements

1.1. When putting the Generator into operation and during operation, "Interbranch Rules for Labor Safety When Operating Electrical Systems" must be observed.

The symbol

on the Generator's panel is intended to alert the user to the presence of important operating instructions. See "Warning" and "Caution" clauses in section 3.3 "Turning on".

1.2. The Generator provides electrical safety according to Russian Standard (GOST) R 51350.

1.3. The Generator provides electrical shock protection according to Russian Standard (GOST) R 51350-99 that corresponds to IEC 61010-1 (Category I).

1.4. Protection provided by the enclosure is per Russian Standard (GOST) 14254–96 — IP20, Mounting Category II, pollution grade 2.

2. General information and operation principle

2.1. Application

2.1.1. Energoforma 3.3 generates single- and three-phase system of current/voltage signals according to a user-specified model that can be used for testing and adjustment of instruments that measure:
- Active, reactive and apparent power/energy;
- Power quality parameters as per 61000-4-30 power quality measurement standard (classes A, S and B) including harmonics (up to 50th) and interharmonics;
- RMS of currents and voltages within commercial frequency range.

2.1.2. The sphere of application includes mobile calibration (testing) laboratories and meter/transformer test systems where the Generator is used together with reference meters, e.g. Energomonitor 3.1K or Energomonitor 3.3T1.

2.2. Description

2.2.1. The generator is supplied as a self-contained hand-held module. The Generator's front panel is shown in Fig. 2.1.
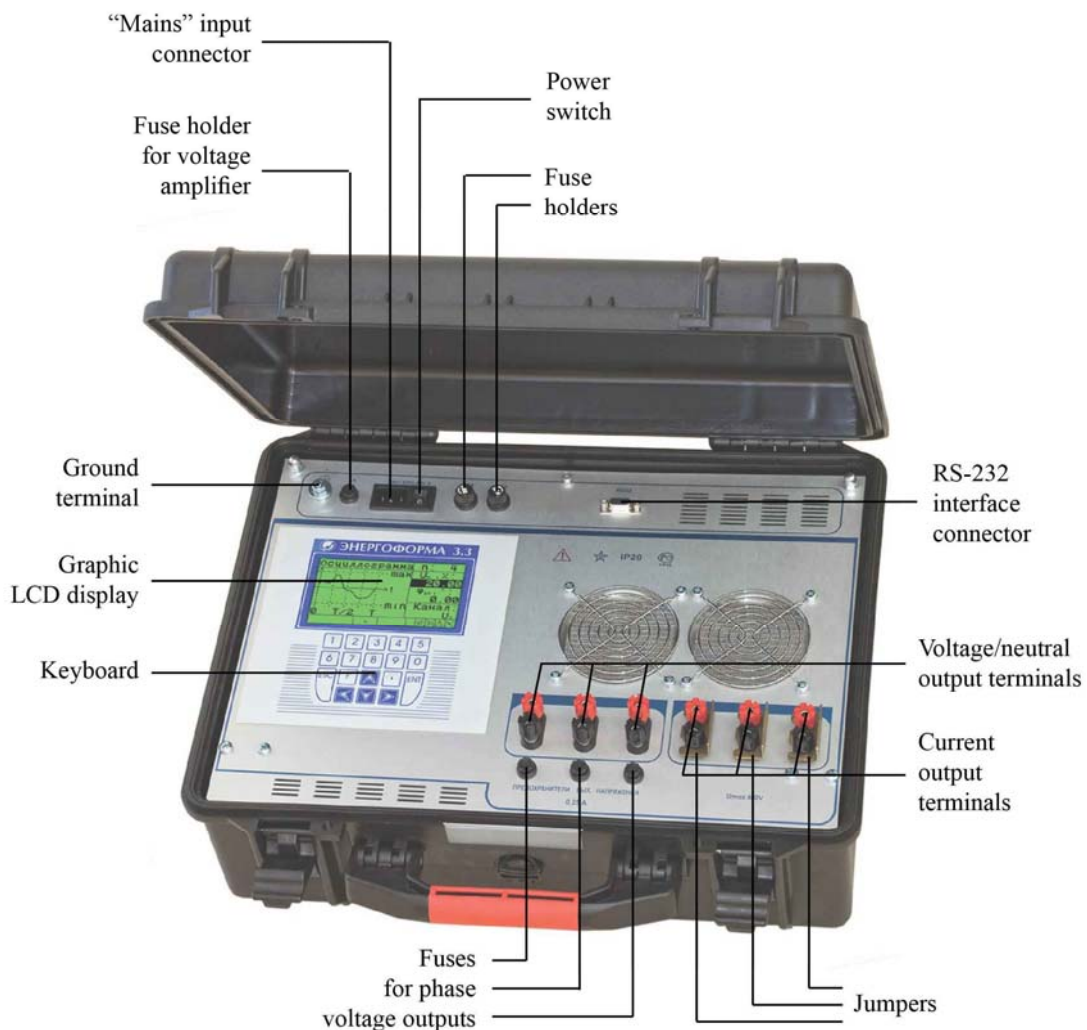

Fig. 2.1. Front panel

2.2.2. The Generator is provided with three channels for generating voltages (phase voltages) as well as with three independent channels for generating currents. There are two ways for the user to specify a signal model in digital form:

- By selecting one of standard signals from the device's internal memory or specifying signal parameters (for a specific signal) using the built-in keyboard;
- By selecting a signal from the Library of standard signals stored on a PC and recording it into the Generator via RS-232 interface running the "Energoform" software;
- By specifying signal parameters manually from the built-in keyboard.

Waveforms and signal parameters are viewed either on the built-in graphic LCD or PC via "Energoform" software.

2.2.3. The generator provides for generating currents and voltages for single- and three-phase AC circuits as required within the parameter ranges and permissible error limits specified in Table 2.1.

Table 2.1

Technical Specifications of Energoforma 3.3

Parameter	Value			Notes
	Range	In increments of	Fundamental error of output setting	
1. 1st harmonic frequency of AC current f_1, Hz	45.0…70	0.01	Absolute: ±0.01	
2. Nominal values of phase/phase-to-phase voltages U_n, V	220/(220√3); 60/(60√3)	—	—	
3. Nominal values of current I_n, A	0.5; 5	—	—	
4. RMS of 1st voltage harmonic U_1, V	20…254	0.001	Relative: 1%	At nominal load
	254…264			At a 10% load with respect to nominal load
5. RMS of 1st current harmonic I_1, A	0.05…12	0.0001	Relative: 1%	
	0.005…0.05		Relative: 2%	
6. Harmonic composition				
Harmonics: components with frequencies $f_k = kf_1$ (k from 2 to 50)	2…50	0.01		Q-ty: 49
Interharmonics: components with frequencies $f_k = kf_1/2$ (odd numbers k from 1 to 101)	0.5; 1.5; …, 49.5; 50.5			Q-ty: 51
7. RMS of current or voltage harmonic components, % of U_1 or I_1				
For harmonics from 2nd to 19th	0…100	0.01	—	
For harmonics from 20th to 50th	0…50			
For interharmonics (from 0.5 to 50.5)	0…15			

Parameter	Value			Notes
	Range	In increments of	Fundamental error of output setting	
8. Phase angle between ■ the 1st harmonics of phase voltages in different phases, ■ 1st current and 1st voltage harmonics in the same phase, degrees	−179.99 … +180	0.01	Absolute: ±2°	
9. Phase angle between ■ 1st and nth voltage harmonics (interharmonics) in the same phase, ■ 1st and nth current harmonics (interharmonics) in the same phase, degrees	−179.99 … +180	0.01	—	
10. Total Harmonic Distortion (THD) of voltage, %, or less	—	—	Relative: 1%	$U_1 = 20…254$V, at linear load
11. Total Harmonic Distortion (THD) of current, %, or less	—	—	Relative: 1%	$I_1 = 0.05…12$A[*]
				$I_1 = 0.05…5.0$A,
	—		Relative: 5%	$I_1 = 0.005…0.05$A
12. Instability of RMS of set voltage, no more than, %/min	—	—	Absolute: ±0.03%	
13. Instability of RMS of set current, no more than, %/min	—	—	Absolute: ±0.03%	
14. Instability of set power, no more than, %/min	—	—	Absolute: ±0.05%	
15. Number of dips or swells	0…100 000	1		
16. Voltage dip duration (t), s	0…600	0.001	Absolute: ±0.002	$f_1 = (50 ± 1)$Hz
17. Event repetition period (T; $T ≥ t$), s				
18. RMS of dip voltage (U_{min}), % of U_1	0…9.99	0.01	—	$f_1 = (50 ± 1)$Hz
	10…29.99		Relative: ±[1.0+0.5($U_н/U$−1)]%	
	30…100		Relative: ±1%	
19. RMS of swell voltage (U_{max}), % of U_1	100…200	0.01	Relative: ±0.5%	$f_1 = (50 ± 1)$Hz
20. Power output of current source, VA	5[*]	—	—	At 10A current, $R_n = 0,05$Ohm
21. Power output of voltage source, VA	10	—	—	At a load of 4.8kOhm

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* At 254V output voltage and nominal load in the voltage circuit, maximal current is 7.5A.

2.2.4. Operating ranges for currents and voltages are specified in Tables 2.2 and 2.3.

Table 2.2

Output voltage ranges, V

Output voltage ranges, V	Rated phase (phase-to-phase) voltage values of Current/Voltage amplifier
60.001–268	220 (220√3)
0–71,99	60 (60√3)

Table 2.3

Output current ranges, V

Output current ranges, A	Rated current values of Current/Voltage amplifier
0.5000–7,7	5
0–0.54999	0.5

2.3. Design and operation

2.3.1. Block diagram of the Generator is shown in Fig. 2.2.
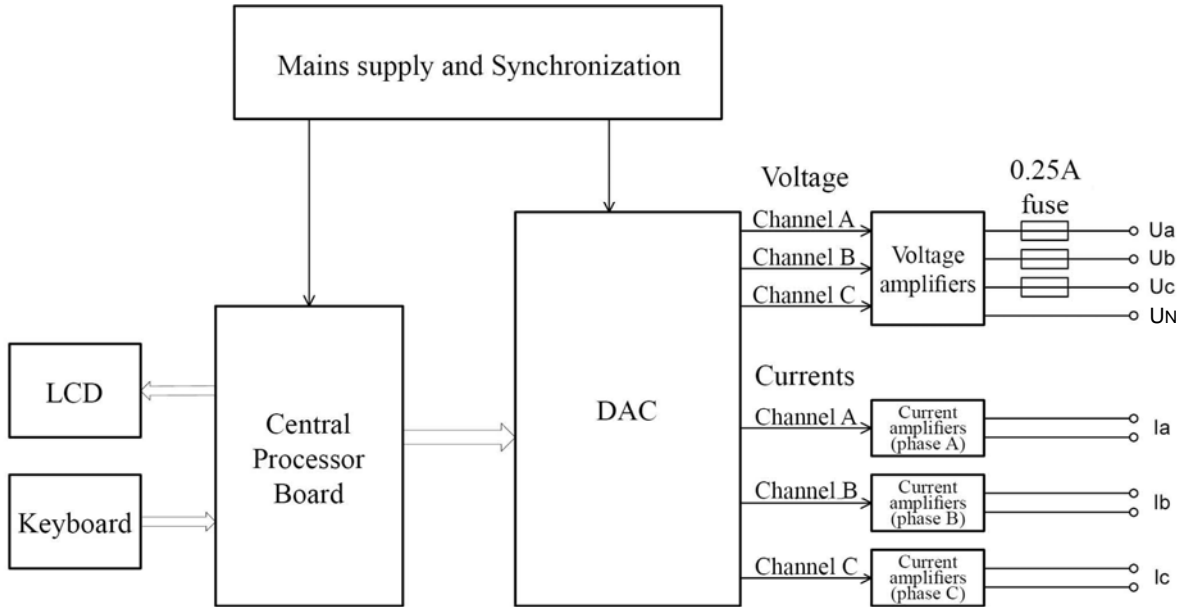
Fig. 2.2. Block diagram

2.3.2. At the hart of the Generator are a Texas Instruments signal processor and FPGA from Xilinx. Such a solution makes possible prompt upgrading of Generator's firmware, keeping its hardware intact.

The Generator employs 16-bit Digital-to-Analog Conversion (DAC). The DAC block has six identical channels in it. They operate independently, each converting 16-bit binary input data into analog form. 2048 points are produced every 20 milliseconds, which gives 2048 samples per period at 50Hz frequency. The DAC board produces 6 analog signals: 3 currents and 3 voltages. The current signals are galvanically isolated from each other and from other circuits, and the voltage signals are galvanically isolated from other circuits and connected by a common wire.

The Central Processor board exercises full control over the Generator.
- It produces the arrays of samples (representing point by point each of the six waveforms).
- The array data are fed into the DAC board and converted into 3 current and 3 voltage curves. Conversion results are stored in non-volatile memory and displayed on LCD screen.
- The Central Processor board is responsible for:
  - keeping of time and marking of intervals as per real-time clock;
  - supporting of data exchange with external devices (PCs);
  - receiving of data and commands from operator's keyboard.

The keyboard is mounted on the front panel and connected to the Central Processor board. Operator uses the keyboard to specify how the information should be displayed, to enter

the parameters of signals to be generated (waveform, amplitude, phase shifts for currents and voltages) etc.

2.3.3. The Power Supply unit generates voltages +5V, +3.3V, and +1.6V for the Central Processor Board and +5V (independent power supply) for RS-232 port. It also contains a circuit that keeps output signals synchronized with power supply network (synchronization signal represented as a 50x2048Hz meander comes to the Central Processor board).

2.3.4. Analogue current and voltage signals are taken out of the DAC board and applied to the outputs of current and voltage amplifiers respectively.

To provide short circuit protection, a 0.25A fuse is mounted on the output of each voltage channel.

Output ranges of the current and voltage amplifiers are processor-controlled. The processor transmits its commands to select a current or voltage output range to the relays. Ranges of the amplifiers are also operated by commands coming from the processor.

3. Preparing for operation

3.1. Operating restrictions

If the Generator has been moved from a cold environment (with ambient temperature below 20°C) into a warm one, it shall be left to stand for at least 4 hours at room temperature before applying power, to make sure that no condensation remains inside.

Caution! The Generator shall not be used under the ingress of moisture inside its body.

Caution! Current outputs not connected to a load must be short circuited (they must not be left without a load).

3.2. Unpacking

Check that the delivery package contains all parts specified in the Supply Agreement. Check that the manufacturer's seal is intact. Should anything in the package be found damaged, contact the supplier immediately.

The delivery package is specified in Table 2.1 of the Equipment Certificate (MS2.211.001 PS).

3.3. Turning on

Caution! To avoid electric shock, it is strongly recommended to connect (disconnect) the Device to the measured circuits when they are de-energized. Otherwise, connection (disconnection) to the measured circuits shall be carried out by qualified service personnel in compliance with local safety regulations in force.

The Generator's voltage circuits have 6 terminals (U_A, U_B, U_C) for connection to phase voltages (and neutral); six terminals are provided for phase currents (I_A, I_B, I_C). Current circuits are galvanically isolated from each other and from voltage circuits. The voltage circuits are symmetrical and have one common point (neutral conductor). All connections to measured circuits are made via terminals located on Generator's front panel (see Fig. 2.1).

Caution! Inspect the cables. Ensure all joints are made properly to avoid overheating and excessively high resistance.

Power the Generator from mains in the following order:
1) Connect the Generator to the device under test and reference device;
2) Plug the mains cable of the device under test and reference device to mains socket;
3) Turn on the Generator.

Caution! Before turning the Generator on, make sure that its current outputs are short circuited (short-circuit straps are placed) or a device with the input impedance below 0.3MOhm has been connected to the Generator.

The Generator performs warm-up and initialization procedures as it is turned on. At the conclusion of the procedure, the "power up" screen (Fig. 3.1) appears. It shows manufacturer's name and logo, Generator's type and its firmware version.
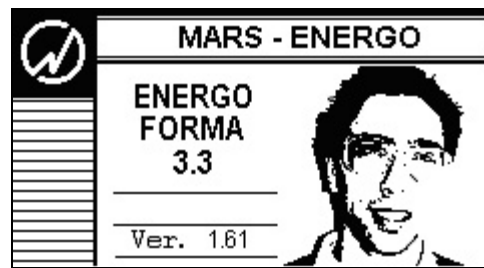
Fig. 3.1. "Power up" screen

Pressing any key will bring up the main menu (see Fig. 4.1).
To set the Generator for stable operation, it shall be kept powered for at least 30 minutes.

4. Operation procedure

Energoforma 3.3 three-phase programmable waveform generator operates in two modes:
- Controlled from a PC via RS-232 running "Energoform" program;
- Controlled from its membrane keyboard.

4.1. PC-controlled mode

To operate the Generator in the on-line mode, "Energoform" software package shall be installed on a PC. The "Energoform" software works under operation systems MS Windows 98, 2000, XP, Vista and Windows 7 (32- or 64-bit architecture) supporting the Cyrillic alphabet.

When working in "Energoform" program, it is recommended to use the Generator together with Energomonitor 3.3T1 (or Energomonitor 3.1K) reference instrument.

The following PC configuration is recommended for proper functioning of the program:
- Processor: Pentium III at 500MHz or more powerful;
- At least 64Mb RAM;
- At least 3Mb of disc space to install the program;
- Video adapter of 1024x768 resolution;
- CD drive for software installation;
- Mouse or compatible pointing device;
- Two free COM-ports (RS-232).

For a more convenient work with large volumes of data a more powerful computer may be requisite.

To make the program run properly, connect serial ports of the PC to RS-232 ports of the Generator and Energomonitor 3.3T1 (Energomonitor 3.1K) reference instrument.

On starting "Energoform" program, the Generator automatically goes to the PC-controlled mode.

For how to work with the Energomonitor 3.3T1 (or Energomonitor 3.1K) instruments, see the user manual for the corresponding instrument.

For how to work with "Energoform" program, see "Energoform program, User's Manual" document.

4.2. Off-line mode (control from membrane keyboard)

In the off-line mode, the Generator is operated via its membrane keyboard.

For how to work with the Energomonitor 3.3T1 (or Energomonitor 3.1K), see the user manual for the corresponding instrument.

Operation of the Generator in the off-line mode is described below.

4.2.1. Operator interface

Operator interface of the Generator includes an 18-button membrane keyboard and graphic 240x128 dot matrix Liquid Crystal Display (LCD). The interface makes it possible to select operation modes and configure signal parameters. Table 4.1 describes the keys located on the front panel.

Table 4.1

Functions of the keys

Key	Name and Function
"0", ..., "9"	Numeric keypad: Press to type in numeric values of the field currently active
⊡	- Decimal point: press this key before entering the desired magnitude of a fractional part; - Press this key to enter a negative value before specifying its magnitude
⋀, ⋁	- Up and down arrow keys: press to scroll through various menu items; - Press this key to scroll through the fields within a parameter setting window
◂, ▸	- Left and right arrow keys: press to increment/decrement the value of an active field; - Press to scroll through the active status line and select a field in it
"ENT"	- Enter: Press to activate a menu item or status line field; - Press to save changes
"ESC"	- Press to return to an upper-level menu without saving changes; - Press to leave the status line
"F"	- Press to activate the status line

As it is turned on, the Generator displays the screen shown in Figure 3.1. Pressing any key will bring up the main menu (Fig. 4.1).

Fig. 4.1. Main menu

The main menu has four options:
- "Standard signal";
- "Special signals";
- "Settings";
- "Signal Library".

Whatever menu/window is on the screen, its bottom is always occupied by Generator status line informing operator on basic modes currently in force.

Note: The operator interface may be modified with respect to the order of displaying information. The changes do not affect metrological and technical characteristics of the Generator.

Menu navigation (i.e. selection of an item) is supported by ⋀, ⋁ keys (the menu item currently active is highlighted by color inversion). To enable an item (and skip to its subordinate menu or parameter setting window), press "ENT". Return to the upper-level menu is made by pressing "ESC". On enabling the selected menu item, it is possible either to skip to its subordinate menu or parameter setting window.

The parameter setting windows (hereinafter referred to as "the windows") graphically and/or textually display various parameters of the signal produced by the Generator. Each window has one or more modifiable fields in it ("the fields"). When there are several fields in the window, ⋏, ⋎ keys can be used to skip from field to field. The menu item currently active is highlighted by color inversion.

Observe the following rules when you use keyboard to change values of active modifiable fields within the current window:

1) Key ➤ increases and key ◀ decreases, respectively, the value of an active field. The longer the key remains depressed, the faster the active field changes its value. Suppose the active field can be changed cyclically (like phase shift expressed in angular degrees). When its growing value reaches maximum with ➤ key still hold down, minimum value appears in the field and starts growing again. When you depress and hold ◀ key, the value goes the other way round: having dropped to its minimum, it becomes maximum and starts decreasing again. When a value in the active field is not of cyclic nature, it can only be changed in both directions within its permissible interval.

2) By pressing number keys 0 to 9 you can immediately type in the desired value within permissible interval established for the currently active field.

3) Suppose you modify the value of an active field formatted to have integer and fractional parts. By pressing ⊡ (decimal point) key you terminate integer part of the number and change "number entry mode" accordingly. Then you specify the fractional part by pressing number keys.

4) To enter a negative value into a currently active field, press ⊡ (decimal point) key BEFORE specifying the desired magnitude, provided that permissible values established for the parameter may be negative. As soon as the decimal point key is pressed, the field assumes a negative value with the smallest possible magnitude (i.e. "−1" for integer fields, "−0.01" for the fields specified in 1/100 increments, etc). Then modify the field (as described in previous paragraphs) to set a target value in it.

Having pressed "ENT", you see ⧖ ("sand glass") icon in the Generator status line on the bottom of the screen. This notifies you that modification is in progress, and further operation is suspended till the end of recalculation process. To return to the upper-level menu, press "ESC" key.

Status line
Whatever menu/window is on the screen, its bottom is always occupied by the Generator status line (Fig. 4.2) informing operator on basic modes currently in force.
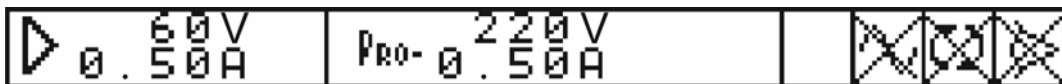
The leftmost position reflects nominal values of sub-ranges selected in the current and voltage amplifiers. The adjacent position marked "PRO" indicates nominal values of sub-ranges that will be enabled when the Generator starts producing new (modified) signals

The meaning of each icon is described below (from right to left)

Fig. 4.2. Status line

You may activate status line by pressing "F" key in any Generator's mode of operation. This will give you access to change basic modes of operation. Keys ◀, ➤ are used to scroll through the active status line and select a field in it (while selected, the field is highlighted with inverse video). When active, the active status line can be de-activated with "ESC" key.

The meaning of each icon is described below (from right to left):

"Generation" mode:
- ⎍ — generation of output signals is turned on at the moment.
- ⊠ — generation of output signals is turned off, and the outputs have zero potentials.
  To change the mode, select the corresponding icon and press "ENT".

"Regenerate" mode (accessible only with ⎍ icon):
- ⟳ — Pressing the "regenerate" icon brings output signals of the Generator in accordance with their modified parameters. At this time, "Sand glass" icon ⧗ lets you know that modification/recalculation of the parameters is in progress, and further operation is suspended till this comes to the end. Without the icon, the Generator is ready to respond to your further actions, such as modification of some other parameter.
- ⊠ — is displayed with ⊠.

Mode of synchronization with mains frequency (accessible only with ⊠ icon):
- ▷ — mains synchronization mode is enabled, and the Generator monitors mains frequency and produce its output signals accordingly.
- ⊠ — no monitoring of mains frequency is maintained at the moment. The Generator produces its output signals in accordance to the frequency specified by the "frequency" parameter (Fig. 4.8)).
  To enable a mode, select the corresponding icon and press "ENT".

The position marked ▷ reflects nominal values of sub-ranges selected in the current and voltage amplifiers. The adjacent position marked P_{RO}. indicates nominal values of sub-ranges that will be enabled when the Generator starts producing new (modified) signals. As soon as the "generation" ⎍ or "regeneration" ⟳ command is executed, the current nominal values become equal to these "programmed" values.

"Sand glass" icon ⧗ displayed in the inverse video (Fig. 4.3) informs you that modification/recalculation of the parameters is in progress. Further operation is suspended till this comes to the end. Without the icon, the Generator is ready to respond to your further actions.
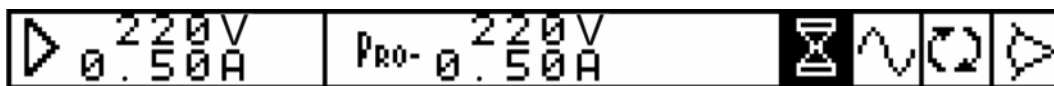

Fig. 4.3 Generator status line
(modification/recalculation in progress)

If an additional context-dependent function is included in the current menu/window, the function name appears on the active status line and gives access to that function (Fig. 4.4). Press "ENT" to enable the function.

Fig. 4.4. Generator status line with additional function in it.

4.2.2. "Standard signal" mode

The mode makes Generator produce pure sine waveforms on its outputs. Angles between phase voltages are set to 120°.

You can use the window shown in Fig. 4.5 to specify:
- Fundamental (1st harmonic) frequency — from 42.50 to 70.00Hz in 0.01Hz steps;
- Phase shifts between currents and voltages for each phase — from –179.99° to +180.00° in 0.01° steps);
- Values of voltage — from 0 to 268V in 0.001V steps);
- Values of current— from 0 to 8A in 0.00001A steps).

Checkboxes ☒ below I_A, I_B, I_C fields allow you to toggle switches that are used to set off (zero) phase currents as desired. A switch is selected by ◄, ► keys, then toggled by "ENT" key.
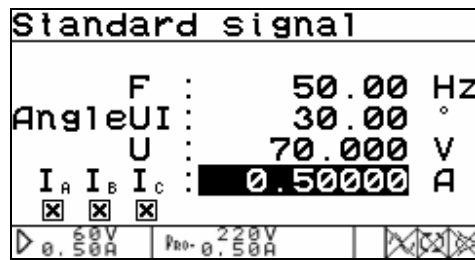
Fig. 4.5. Parameter setting window for Standard signal

New wave shapes are recalculated by pressing "ENT". It may take long time to recalculate the parameters (up to 5s). The time of recalculation is determined by the selected wave shapes and the number of channels for which the parameters are recalculated. When recalculation is in progress, the status line displays ⧗ icon.

Note: All changes made in the "Standard signal" mode are automatically extended to the "Subharmonics" (section 4.2.3.2) and "Phase Control" (section 4.2.3.3) modes and vice versa.

4.2.3. "Special signals" menu

"Specific signals" menu (Fig. 4.6) has six options:
- Programmed waveform;
- Subharmonics;
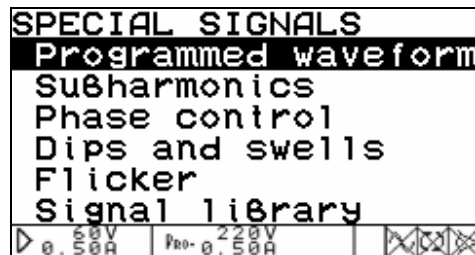- Phase control;
- Dips and swells;
- Flicker;
- Library.

Fig. 4.6. "Specific signals" menu

4.2.3.1. "Programmed waveform" menu

This option (Fig. 4.7) makes it possible to set signals on Generator outputs to any desired parameter values (within permissible limits established for each parameter):

- Frequency;
- Phase angles;
- Wave shape;
- RMS values.

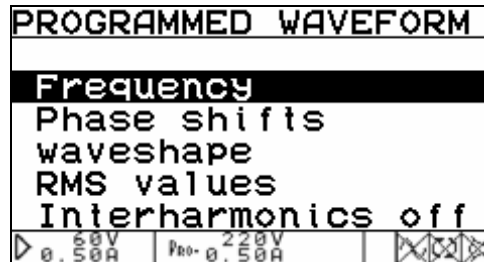Additionally, the "Interharmonics" mode is turned on/off here.

Fig. 4.7. "Programmed waveform" menu

Setting frequency

The "Frequency" item, when enabled, opens the window (Fig. 4.8) where you can set fundamental frequency (i.e. frequency of the first harmonic) of the desired three-phase voltage/current system (⊠). When the mains synchronization mode is enabled (▷), output frequency is determined by mains frequency. Otherwise (with "eye" icon), the Generator ignores frequency specification entered in this window.
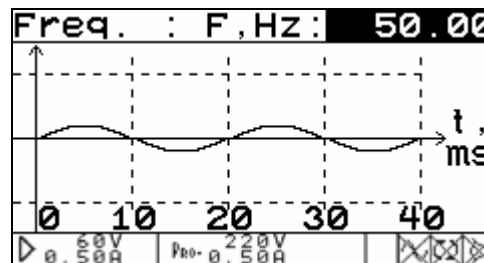

Fig. 4.8. Parameter setting window for signal frequency

"Frequency" is the only modifiable field within this window. It can accept values of 42.50 to 70.00Hz specified in 0.01Hz increments. As you adjust frequency, the window displays the value just entered, and sample oscillogram immediately below.

Setting phase angles

By enabling "Phase shifts" item you open the window (Fig 4.9) where you can set phase shifts between voltages of different phases as well as between currents and voltages within each phase (by definition, phase angles between channels are considered to be these between respective first harmonics).
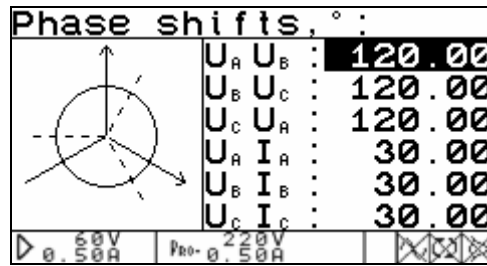
Fig. 4.9. Parameter setting window for phase angles

Six modifiable fields of the above window correspond to various angles, as applied to the first harmonics of signals to be generated. The fields are modified within the range of –179.99° to +180.00° in 0.01° increments. The values can be set by cycling through the range.

All settings currently selected are pictured on a vector diagram in the left part of the screen. Vectors on the diagram reflect each modification. Arrows (pointed heads) only appear on the vectors that form the angle selected at the moment, while other vectors remain headless.

Setting signal shapes

Screens representing wave shapes of desired signals may be of 4 types:
- Oscilloscope;
- Spectrum (linear);
- Spectrum (logarithmic);
- Harmonics phases.

To skip to an alternative representation, use additional function of this window named "Change view". The function is enabled via its highlighted name in the status line.

By enabling "Waveshape" item you can set the desired shape of a signal in each of six Generator's channels.

The "Oscilloscope" option (Fig. 4.10) displays the signal under review in the form of traditional oscillogram. The view of the oscillogram depends on whether the "Interharmonics" mode is turned on or off.
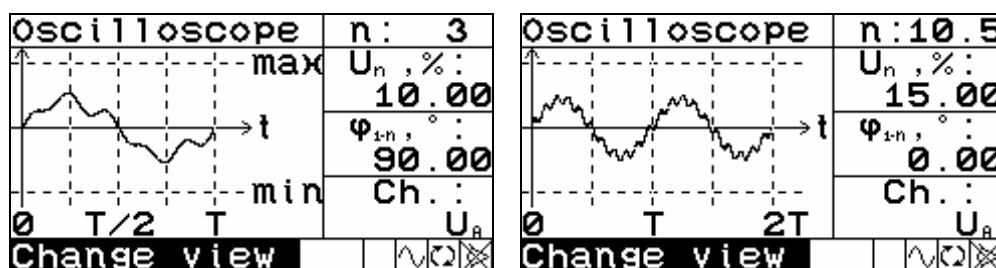

Fig. 4.10. "Waveshape" window in the form of oscillogram
(left part — "Interharmonics" mode is off; right part — "Interharmonics" mode is on)

The window has 4 editable fields:
- Number of the harmonic selected ("n" field):
  - *"Interharmonics" mode is off*. Possible values are selected from the sequence: 1, 2, …, 49, 50.
  - *"Interharmonics" mode is on*. Possible values are selected from the sequence: 0.5; 1; 1.5; 2; …; 50; 50.5.

The required value is selected with ◄, ► keys;

- amplitude ratio of the harmonic ("U_n" or "I_n" field, the value is set as a percentage of the 1st harmonic):
  - *"Interharmonics" mode is off*. Values are set within the range of 0 to 100.00 % in 0.01 % increments.
  - *"Interharmonics" mode is on*. Values are set within the range of 0 to 15.00 % in 0.01 % increments.
- relative phase of the harmonic ("φ_{1-n}", the value is set as a percentage of the 1st harmonic within the range of –179.99° to 180.00° in 0.01° increments);
- symbolic name of the channel (to switch over 6 channels).

The "Spectrum (linear)" option (Fig. 4.11) represents spectrogram of the signal in the channel under review drawn in linear scale.
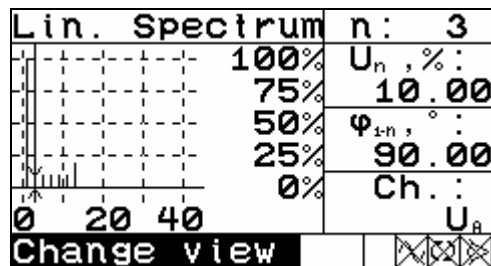

Fig. 4.11. "Waveshape" window
with linear spectrum of amplitudes

The "Spectrum (logarithmic)" option (Fig. 4.12) displays the spectrogram of the signal in the channel under review drawn in logarithmic scale (in decibels, dB), this only affects graphical part of the window. The value in its modifiable field named "amplitude ratio of the harmonic" (Un or In) are still displayed and edited in linear scale (as a percentage of the 1st harmonic).
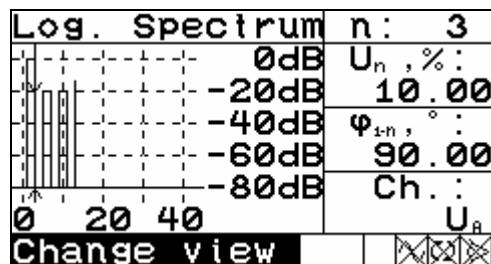

Fig. 4.12. "Waveshape" window
with logarithmic spectrum of amplitudes

The "Harmonics Phase Shift" option (Fig. 4.13) displays the spectrum of phase shift angles, each determined relative to the first (fundamental) harmonic of the signal in the active channel.
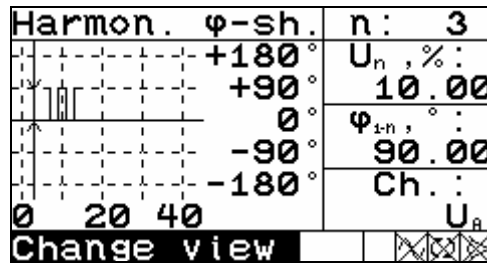
Fig. 4.13. "Harmonics Phase Shift" window
with spectrum of phase shift angles

"Linear spectrum", "Logarithmic spectrum" and "Harmonics phase shift" windows contain 2 editable fields:
- number of the harmonic selected ("n", setting is made with ⋀, ⋁ keys, which makes the cursor move to the spectral line corresponding to the harmonic selected;
- "amplitude ratio of the harmonic" ("U_n" or "I_n" fields in the "Spectrum (linear)" and "Spectrum (logarithmic)" windows; "relative phase of the harmonic" ("φ_{1-n}" in the "Harmonics phase shift" window.

The channel under review can only be selected in the "Oscilloscope" window.

Setting RMS values

The "RMS values" item, when enabled within "Special signals" submenu, opens the window (Fig. 4.14) where you can set the desired RMS value for the first harmonic of each output signal.

The window header is self-explanatory: "RMS values of 1st harmonics". Six modifiable fields at the centre of the window correspond to six channels of the Generator. The fields dedicated to voltage channels can accept values 0 to 268V; these standing for current channels have 0 to 8A for permissible range. When being modified, all fields are incremented with step equal to one unit of least significant decimal place (0.001V for voltage channels and 0.00001A for current channels).
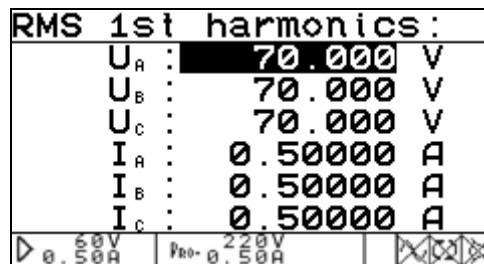

Fig. 4.14. "RMS values" window

Turning "Interharmonics" on/off

To toggle between the "Interharmonics" mode on and off, select the corresponding option in the "Programmed waveform" menu and press "ENT": "ON" or "OFF" status will appear to the right of the field.

Note: When the mode is "ON", recalculation time will be extended.

4.2.3.2. "Subharmonics" mode

In the "Subharmonics" mode, it is possible to set parameters for signals on Generator's current outputs I_A, I_B, I_C. One period of such a signal is outlined on the diagram (Fig 4.15).
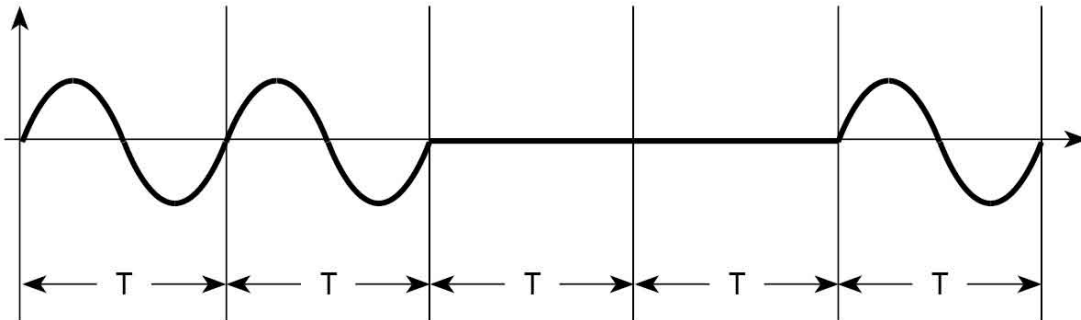

Fig. 4.15. Shape of a signal generated in "Subharmonics" mode
(with period T)

You can use the window pictured on Fig. 4.16 to specify:
- fundamental frequency (i.e. the frequency of the first harmonic);
- phase shift between current and voltage, one and the same for each phase;
- current and voltage values.

Checkboxes below I_A, I_B, I_C ☒ allow you to toggle switches that you can use to set off (zero) phase currents as desired. A switch is selected by ◄, ► keys, then toggled by pressing "ENT" key.

Angles between phase voltages are set to 120°.

Fig. 4.16. Parameter setting window for "Subharmonics" mode

4.2.3.3. Phase control mode

In the "Phase Control" mode, it is possible to set parameters for specially-shaped signals on current outputs I_A, I_B, I_C. One period of such a signal is outlined on the diagram (Fig 4.17).
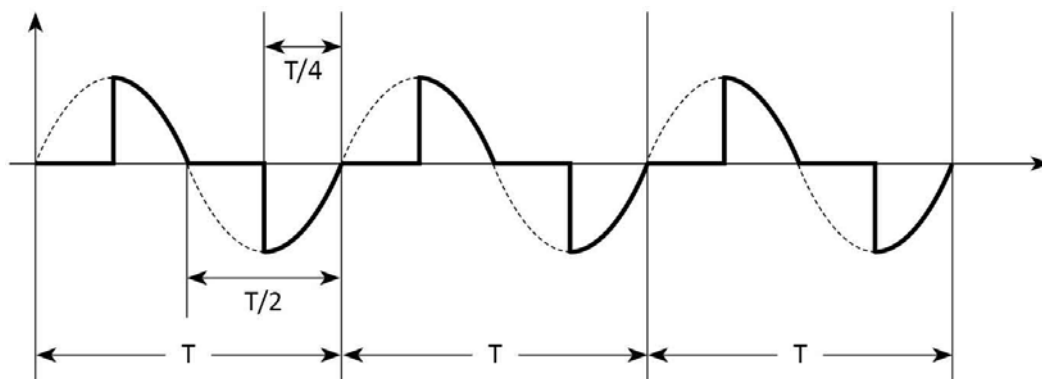

Fig. 4.17. Shape of a signal generated in "Phase Control" mode
(with period T)

21

You can use the window pictured on Fig. 4.18 to specify:
- fundamental frequency (i.e. the frequency of the first harmonic);
- phase shift between current and voltage, one and the same for each phase;
- current and voltage values.

Checkboxes below IA, IB, IC ☒ allow you to toggle switches that you can use to set off (zero) phase currents as desired. A switch is selected by ◄, ► keys, then toggled by pressing "ENT" key.

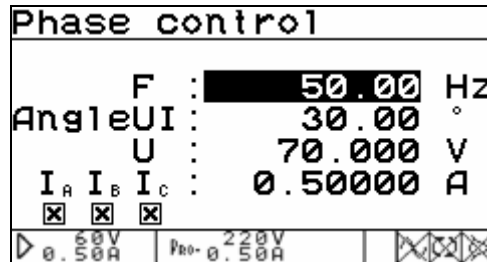Angles between phase voltages are set to 120°.

Fig. 4.18. Parameter setting window for "Phase control" mode

4.2.3.4. "Dips and swells" mode

You can use the window pictured on Fig. 4.19) to set a number of parameters that define dips and/or swells (referred to as "the events") to be introduced in output signal generated by voltage channels:
- total number of events n = 0 to 100 000;
- duration of one event t = 0 to 600s;
- event repetition period T = 0 to 600s (0.001s increment); T cannot be less than t);
- first event shift in time, relative to the moment of triggering (time delay between issuing the command to generate the output signal, and the occurrence of first event) t_n = 0 to 600s, 0.001s increment);
- phase shift of the event (φ_n = –179.99° to 180.00° in 0.01° increments; this parameter is only valid when half-cycle referencing (1/2T base) option is enabled;
- half-cycle referencing (1/2T base). This characteristic of the event means that each event is triggered in step with nearest half-cycle of fundamental frequency. *This kind of synchronization is recommended in conjunction with aforesaid "phase shift of the event" (φ_n other than zero)*;
- dip depth value (Un < 100%) or swell height value (Un > 100%) for each phase (UA, UB, UC) within the range of 0 to 200% in 0.01% increments).
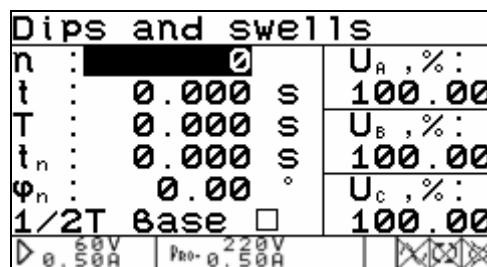

Fig. 4.19. Parameter setting window for "Dips and swells" mode

In the "Dips and swells" mode, voltage range is always set to 220V.

4.2.3.5. Flicker Mode

In the "Flicker" mode, meander-like changes in voltage are maintained on Generator outputs. These fluctuations depend on the settings in the window (see the table below):

Number	Number of variations per minute	Relative change in voltage $\Delta U/U$, %
1	1	2.720
2	2	2.210
3	7	1.460
4	39	0.905
5	110	0.725
6	1620	0.402

Signal parameters are set by selecting (Fig. 4.20) the number identifying one of six options of the above table; and the multiplier applied to $\Delta U/U$. The multiplier can be set within the range of 0.01 to 25.00 in 0.01 increments.

Fig. 4.20. Parameter setting window for "Flicker" mode

4.2.3.6. Signal Library Menu

See section 4.2.5.

4.2.4. Settings menu

The "Settings" menu (Fig. 4.21) includes two options:
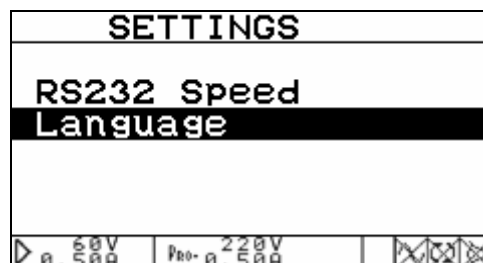- RS-232 Speed;
- Language.

Fig. 4.21. Settings menu

4.2.4.1. RS-232 Speed

By enabling "Settings" item in the main menu you open the window where you can specify the desired characteristic of RS-232 interface (Fig. 4.22). The Device can support data transfer to/from a PC via RS-232 interface at a speed of 115 200, 38 400, 19 200, and 9600bit/s.

Use ⋏, ⋎ keys to select data rate and "ENT" to enable. The value you have entered appears on the upper line of the screen.
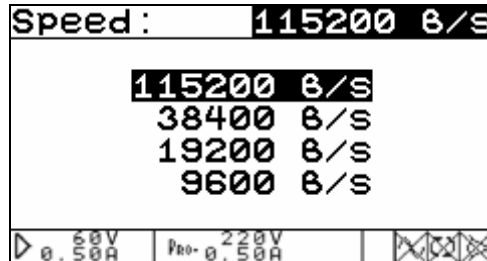

Fig. 4.22. "Data rate" selection menu for RS-232 interface

4.2.4.2. Language

Selecting "Language" will take you to the window pictured below (Fig. 4.23). The option gives the possibility to choose the language (Russian or English) for messages and alphanumeric fields on the screens. The language is selected with ⋏, ⋎ keys confirmed by "ENT".
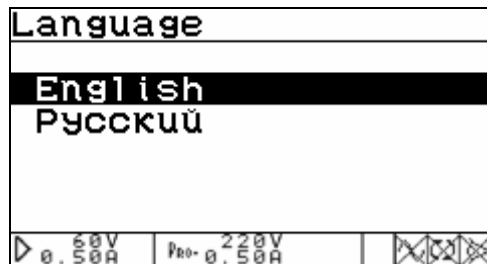

Fig. 4.23. "Language" window

4.2.5. Signal Library Menu

Signal Library menu (Fig. 4.24) includes two options:
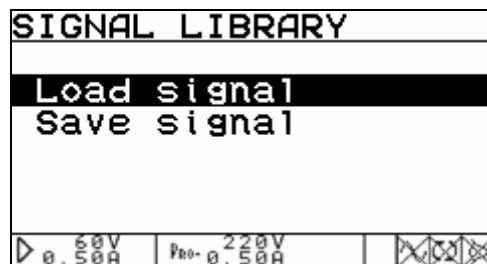- Load signal;
- Save signal.

Fig. 4.24. "Signal library" menu

By enabling either option you make a branch to another submenu named "Select library" (Fig. 4.25). There are 12 libraries with the capacity of 10 test signals per each. The submenu

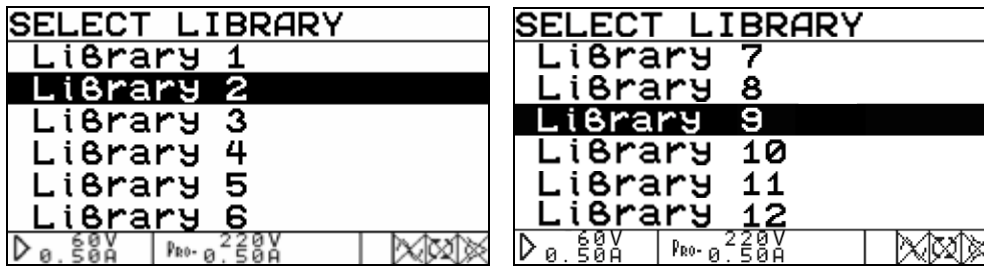occupies two pages pictured below. Use ▲, ▼ keys to turn them over, and ◄, ► keys to select a library name.

```
SELECT LIBRARY          SELECT LIBRARY
 Liбrary 1               Liбrary 7
 Liбrary 2               Liбrary 8
 Liбrary 3               Liбrary 9
 Liбrary 4               Liбrary 10
 Liбrary 5               Liбrary 11
 Liбrary 6               Liбrary 12
```

Fig. 4.25. "Select library" submenu (pages 1 and 2)

By enabling a library you open its submenu named "Select signal" that lists the names of 10 signals stored in that library (Fig. 4.26). Vacant positions (that store no signals at the moment) show "No data" instead of signal name. Use ▲, ▼ keys to turn the pages over , and ◄, ► keys to select a signal position.
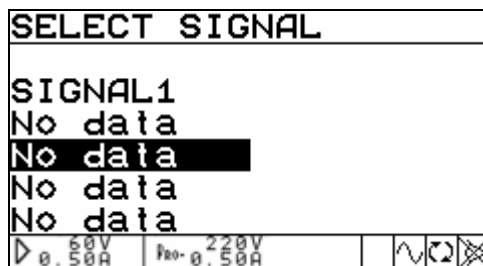
```
SELECT SIGNAL

SIGNAL1
No data
No data
No data
No data
```

Fig. 4.26. "Select signal" submenu (page 1)

If "Load signal" has been selected, the requested signal is loaded, and its profile data is displayed on the screen pictured on Fig. 4.27.

```
Load signal
SIGNAL1
       I,A        U,V
A   0.50000    70.000
B   0.50000    70.000
C   0.50000    70.000
  Freq.   :  50.00  Hz
```

Fig. 4.27. Signal profile window

If "Store signal" has been selected, on opening "Signal library" option, the screen with alphanumeric keyboard is displayed (Fig. 4.28).
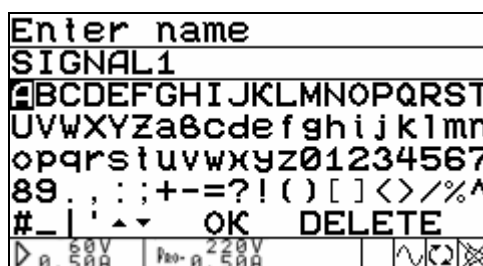
```
Enter name
SIGNAL1
ABCDEFGHIJKLMNOPQRST
UVWXYZaбcdefghijklmn
opqrstuvwxyz01234567
89.,:;+-=?!()[]<>/%^
#_|'▲▼  OK  DELETE
```

Fig. 4.28. Signal name entry window

The signal name must contain 20 characters or less.

Use ⋀, ⋁, ◄, ➤ keys to select a character on the screen keyboard.

Press "ENT" to enter a character of a new signal name.

If you select "DELETE" on-screen option with ⋀, ⋁, ◄, ➤ keys, and then press "ENT", the last character will be deleted.

As soon as the desired signal name has been entered, select "OK" on-screen option, and then press "ENT" to save the name in the memory.