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MARSENERGO

INSTRUMENTS FOR POWER INDUSTRY

Making energy visible

VA-3.1

DC/AC Peak Voltmeter

PURPOSE AND FIELDS OF APPLICATION

VA-3.1 Peak Voltmeter was specifically designed for use in high-voltage laboratories where high accuracy of measurements is required.

Functions of VA-3.1 Peak Voltmeter:

- Measurements of amplitude and peak values, as applied to AC voltages of up to 500 Hz frequency, across its three channels (including differential channel);
- Measurements of peak values within:
  - AC voltages,
  - DC voltages,
  - AC voltages with dominant DC component (aperiodic voltages as well);
- Measurements of high voltages as applied to tests, including these complying with local regulations in force.

VA-3.1 fields of application:

- calibration, performance or accuracy tests of
  - voltage transformers,
  - high voltage switches,
  - overvoltage protection circuitry;
- calibration and accuracy tests of Class 0.2 (or less accurate) amplitude and peak voltmeters;
- production quality check of insulation, measurement of breakdown or flashover voltage;
- monitoring of basic parameters within test benches or other installations for high voltages tests;
- tailor-made metrological labs of stationary or mobile type where VA-3.1 (as part of a test and measurement system) can determine parameters of AC and DC voltages, as per local regulations in force;
- research and development projects.

VA-3.1 Peak Voltmeter can be used either as independent device or in conjunction with other equipment, including:

- scaling converters of input voltage (such as CHVT series capacitive high-voltage transducers), that are connected externally and provide for extension of measurement range;
- PC with dedicated software in it (operating as part of specialized or multipurpose test systems) which greatly extends VA-3.1 functionality;
- resistive dividers and differential gages of high DC voltage.

VA-3.1 Peak Voltmeter can be used for equipping metrological labs maintained with major enterprises, power systems and Centres of Standardization and Metrology.

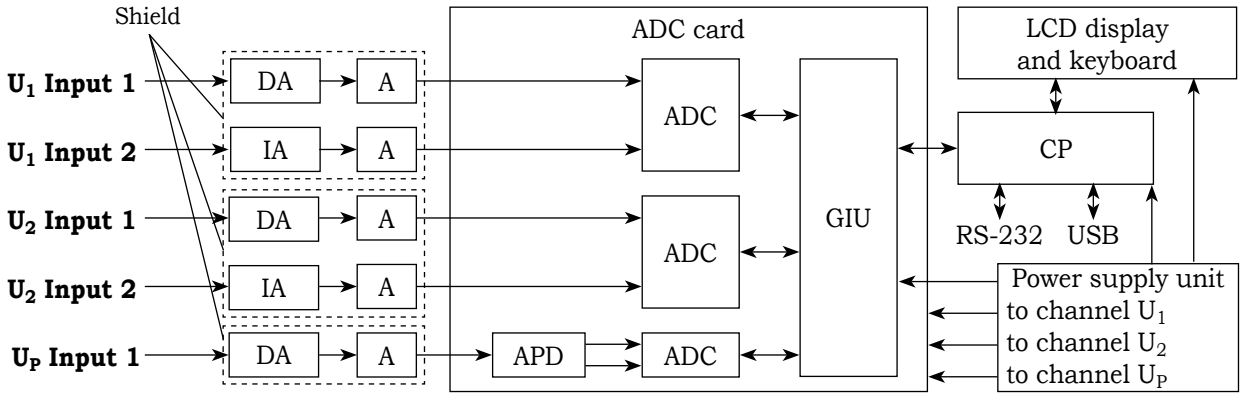
DESCRIPTION

VA-3.1 Peak Voltmeter adheres to 19» standard, as per IEC-60297. It is supplied as modular unit of 3U size.

Measured voltage values are displayed on LCD screen in proper units (V, kV, MV), taking in consideration conversion factors of voltage transducers externally connected to VA-3.1. These factors shall be set programmatically during VA-3.1 configuration.

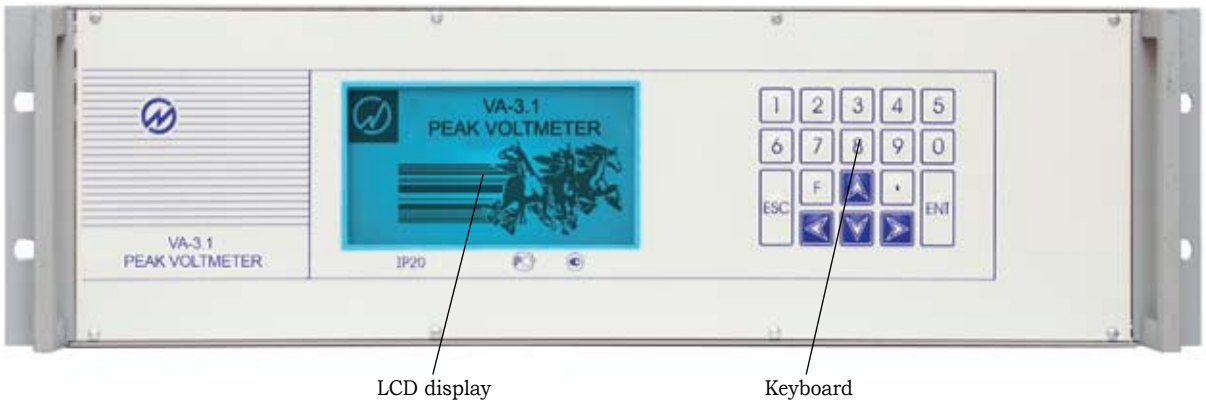
VA-3.1 Peak Voltmeter can operate in various modes subdivided into two groups: “Measurements” and “Peak voltmeter”.

VA-3.1 Peak Voltmeter pictured as part of reference measurement bench. Picture was taken in Mars-Energo high voltage lab

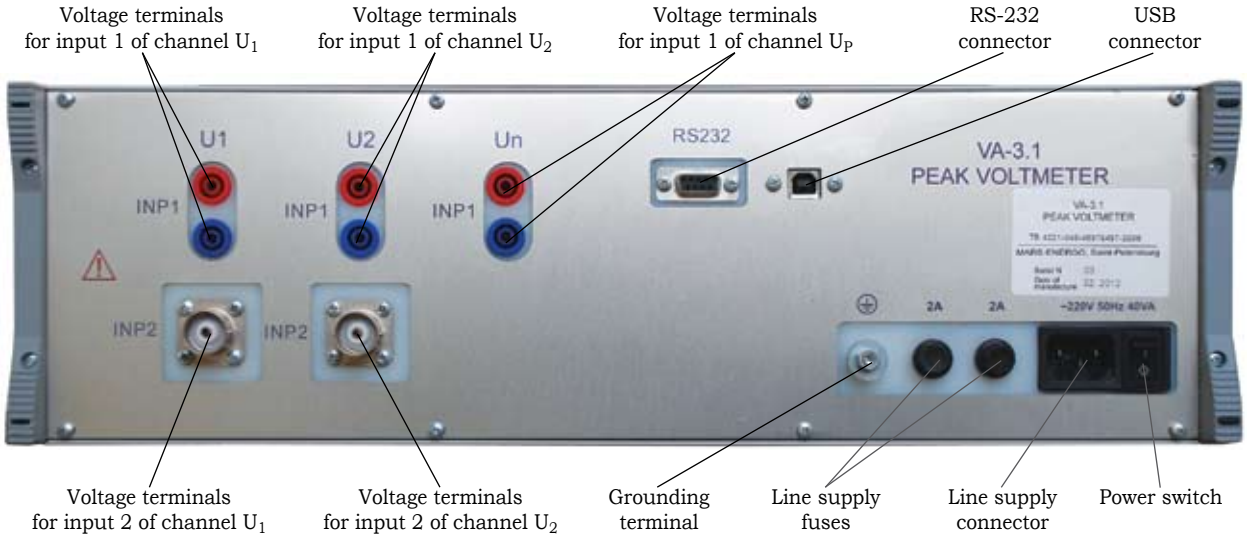


Block-diagram of VA-3.1 Peak Voltmeter:
DA – differential amplifier with gain factor of 0.01; **IA** – instrument amplifier with gain factor of 1; **A** – inverting controllable amplifier (two different gain factors); **APD** – analogue peak detector built around two active rectifiers; **ADC** – two-limit ADCs with 204.8 kHz sampling rate; **GIU** – galvanic isolation unit; **CP** – central processor card; **"U_1 Input 1"** and **"U_2 Input 1"** – voltage inputs (0÷1200 V, R_{INP} ≥ 10 MOhm); **"U_1 Input 2"** and **"U_2 Input 2"** – voltage inputs (0÷12 V, R_{INP} ≥ 100 MOhm); **"U_P Input 1"** – input of analogue peak detector (0÷1200 V, R_{INP} ≥ 10 MOhm)

Front panel of VA-3.1 Peak Voltmeter



Rear panel of VA-3.1 Peak Voltmeter



BASIC TECHNICAL CHARACHTERISTICS

Parameter	Range	Note
Amplitude (peak) value of input voltage, V	0 to ±1200	Upper limits of ranges: 1200; 600; 240; 120; 12; 6; 2.4 and 1.2 V
RMS value of input voltage, V	0 to 840	Upper limits of ranges: 840; 420; 168; 84; 8.4; 4.2; 1.68 and 0.84 V
Frequency range, Hz	0 to 2000	
Frequency range (fundamental harmonic), Hz	0 to 500	
Input impedance, MOhm	at least 10 at least 100	Measurement ranges (RMS values in brackets): 1200 (840); 5600 (420); 240 (168) и 120 (84) V 12 (8.4); 6 (4.2); 2.4 (1.68) и 1.2 (0.84) V
Input capacitance, pF	50 or less	
Number of channels	3	
Range of conversion factor setting	0.001 to 100 000	
Individual voltage harmonic ratio	10 % or less 5 % or less	Frequency range 500 to 1000 Hz 1000 to 2000 Hz
Total harmonic ratio, %	25 % or less 10 % or less	Frequency range 500 to 1000 Hz 1000 to 2000 Hz

Measured parameter	Range of measurement	Type and limit of permissible fundamental error of measurement	Note
Peak value of voltage (channels U_1 and U_2), V	$0.1U_{up}$ to U_{up}	relative: $\pm[0.05 + 0.02(U_{up}/U - 1)]$ %	U_{up} = 1200; 600; 240; 120; 12; 6; 2.4 and 1.2 V
Peak value of voltage (channel U_P), V			U_{up} = 1200; 600; 240 and 120 V
Amplitude value of voltage (channels U_1 and U_2), V		relative: $\pm[0.05 + 0.02(U_{up}/U - 1)]$ %	U_{up} = 1200; 600; 240; 120; 12; 6; 2.4 and 1.2 V; Input signal is periodical; Time constant equals 100 s
Amplitude value of voltage (differential channel), V		relative: $\pm[0.1 + 0.05(U_{up}/U - 1)]$ %	
Average amplitude value of voltage (channels U_1 and U_2), V		relative: $\pm[0.05 + 0.02(U_{up}/U - 1)]$ %	U_{up} = 1200; 600; 240; 120; 12; 6; 2.4 and 1.2 V; Input signal is periodical; Averaging time equals 1.25 s
Average amplitude value of voltage (differential channel), V		relative: $\pm[0.1 + 0.05(U_{up}/U - 1)]$ %	
RMS value of AC voltage U (channels U_1 and U_2), V		relative: $\pm[0.01 + 0.005(U_{up}/U - 1)]$ %	U_{up} = 840; 420; 168; 84; 8.4; 4.2; 1.68 и 0.84 V
RMS value of 1st voltage harmonic U_1 (channels U_1 and U_2), V		relative: $\pm[0.02 + 0.01(U_{up}/U - 1)]$ %	
DC voltage U_{DC} (channels U_1 and U_2), V		relative: $\pm[0.01 + 0.005(U_{up}/U - 1)]$ %	UU_{up} = 1200; 600; 240; 120; 12; 6; 2.4 and 1.2 V
Total harmonic distortion of voltage (K_U) (channels U_1 and U_2), %	0 to 49.9	absolute: ±0.05 % relative: ±5 %	$0.2U_{up} < U < U_{up}$; U_{up} = 840; 420; 168; 84; 8.4; 4.2; 1.68 и 0.84 V; $K_U < 1.0$ $K_U > 1.0$
Ratio of nth voltage harmonic (n = 2 to 40), $K_{U(n)}$ (channels U_1 and U_2), %		absolute: ±0.05 % relative: ±5 %	$K_U < 1.0$ $K_U > 1.0$
AC frequency f (channels U_1 and U_2), Hz	40 to 70	absolute: ±0.003 Hz	$0.1U_{up} < U < U_{up}$; U_{up} = 840; 420; 168; 84; 8.4; 4.2; 1.68 и 0.84 V;

Note. U_{up} — upper limit of measurement range.

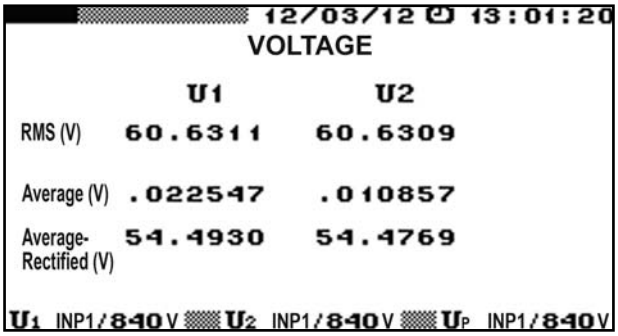
The following modes of operation are available within the group named "Measurements":

- Voltage measurement;
- Harmonics;
- Waveforms.

AC and/or DC voltages across two channels (U_1 and U_2) are measured in "Voltage measurement" mode, the results being displayed as RMS voltage, average rectified voltage and average (DC component) voltage.

"Voltage" screen displays:

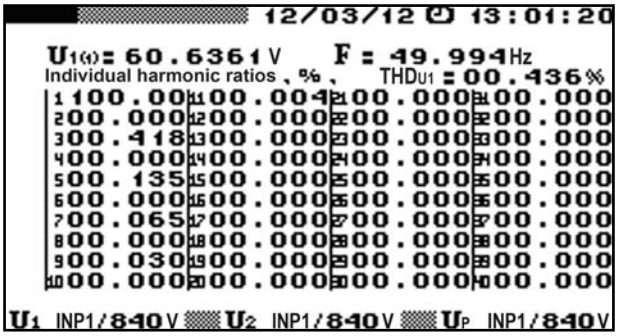
- measured RMS values of voltage;
- average rectified values of voltage;
- average (DC component) voltage measured across channels U_1 and U_2.

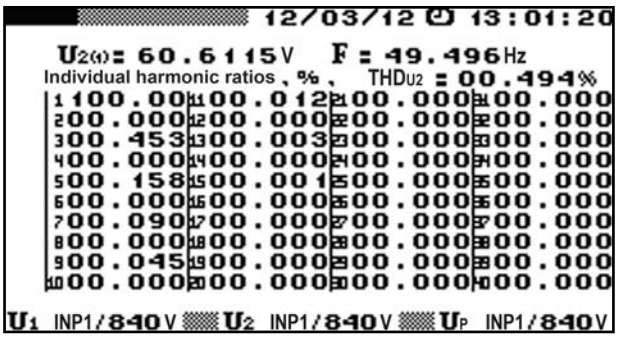


In "Harmonics" mode the following is measured and displayed separately for channels U_1 and U_2 RMS value of 1st voltage harmonic, total harmonic distortion of voltage, frequency of 1st voltage harmonic and ratios of voltage harmonics from 1st to 40th.

"Harmonics" screens display (separately for channels U_1 and U_2):

- RMS values of 1st voltage harmonics;
- total harmonic distortion of voltage;
- frequency of 1st voltage harmonic;
- ratios of voltage harmonics from 1st to 40th.

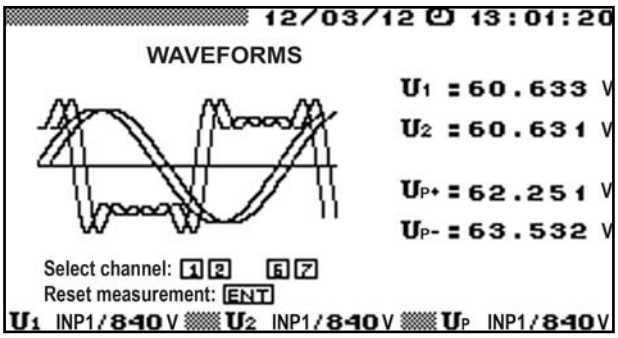




Waveforms of voltage signals across channels U_1 and U_2 are measured and displayed in "Waveforms" mode, while peak values for channel U_P are displayed separately for positive and negative half-waves. RMS values of measured signals are displayed as well.

"Waveforms" screen displays:

- Voltage signal waveforms across channels U_1 and U_2;
- Waveforms of peak values across channel U_P (separately for positive U_{P+} and negative U_{P-} half-waves);
- RMS values of the signals displayed.



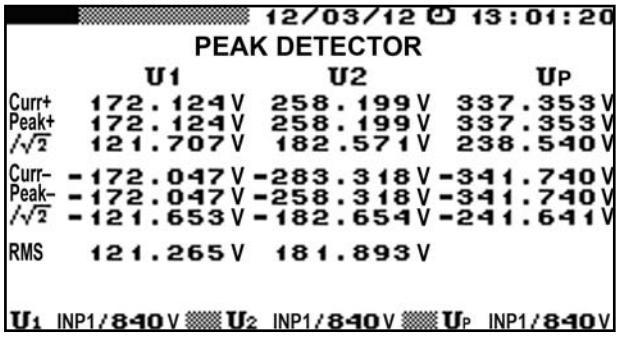
The following modes of operation are available within the group named "Peak voltmeter":

- Peak detector;
- Amplitude detector / Differential amplitude detector;
- Average amplitude / Differential average amplitude;
- Ripple parameters;
- Breakdown clamping.

"Peak detector" mode detects maximum and minimum values of the signal for the duration of user-defined period.
Time interval for next peak detection is set by the parameter named "Averaging time". For the duration of this interval LCD screen maintains peak values of voltage detected during previous "Averaging time" period.

The following is displayed on LCD screen in "Peak detector" mode:

- current peak values of voltage (both polarities) across three channels;
- peak values of voltage (both polarities) across three channels, as detected during previous time interval;



- peak values of voltage (both polarities) across three channels, divided by $\sqrt{2}$, as detected during previous time interval;
- RMS values of voltage across two channels.

In "Ripple parameters" mode ripple ratios are determined using two different approaches:

- as ratio of RMS value of AC component (ripple) to the level of DC component of the signal;
- as ratio of half-swing of signal ripple to the level of DC component of the signal.

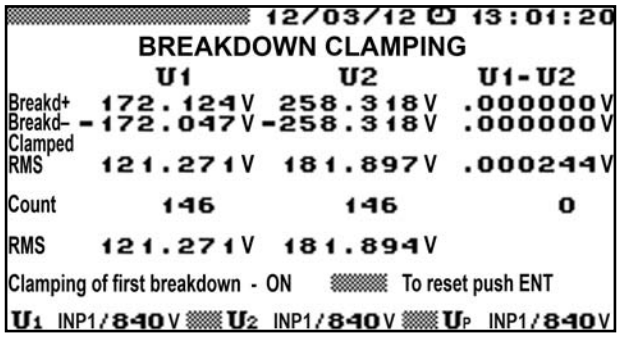
"Breakdown clamping" mode is meant to detect the facts of rapid voltage drops ("breakdowns") that typically reflect partial or total breakdown of insulation.

Principle of "breakdown" detection

Two parameters shall be set to configure "Breakdown clamping" mode:

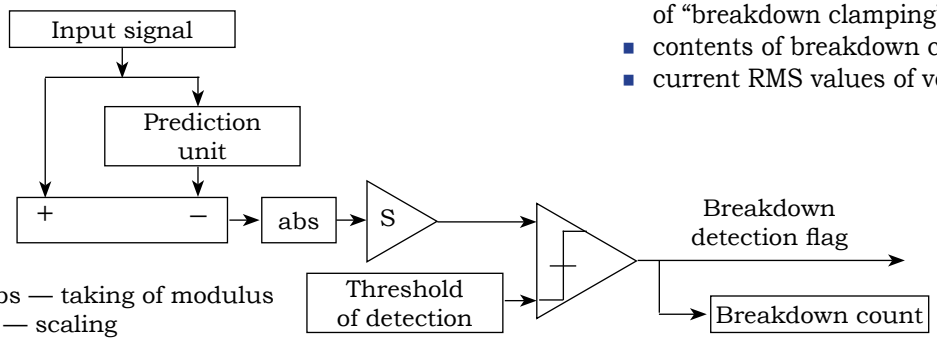
- breakdown detection threshold (various criteria are set to determine the fact of breakdown detection);
- clamping flag to indicate parameters of first breakdown.

As soon as first breakdown is detected in the channel, the following is memorized for respective observation interval (160 ms period): current RMS value of voltage and peak voltages (both polarities). Breakdown count is set to 1.



The following is displayed on LCD screen in "Breakdown clamping" mode:

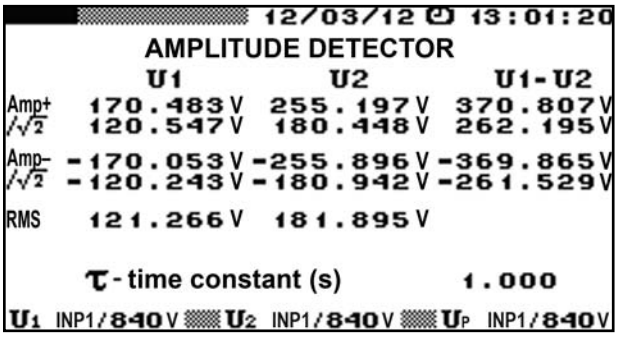
- peak values of breakdown voltage (both polarities) by channel for the duration of "breakdown clamping" interval;
- RMS values of voltage by channel for the duration of "breakdown clamping" interval;
- contents of breakdown counts by channel;
- current RMS values of voltage for two channels.

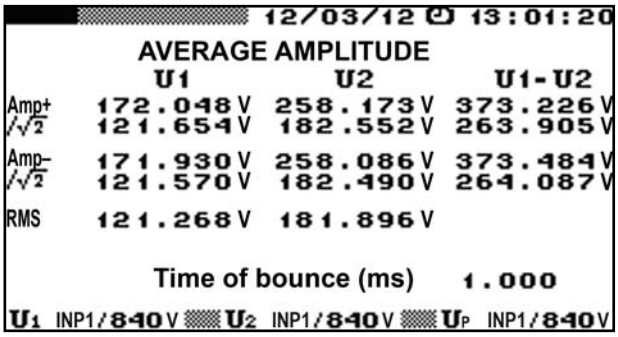


abs — taking of modulus
S — scaling

In "Amplitude detector" mode amplitude value of signal is determined by emulating the method used in peak voltmeters built around active rectifier.

In "Average amplitude" mode amplitude value of signal is determined by averaging its maximum and minimum values for the period of 1.25; 2.5 or 5 seconds.

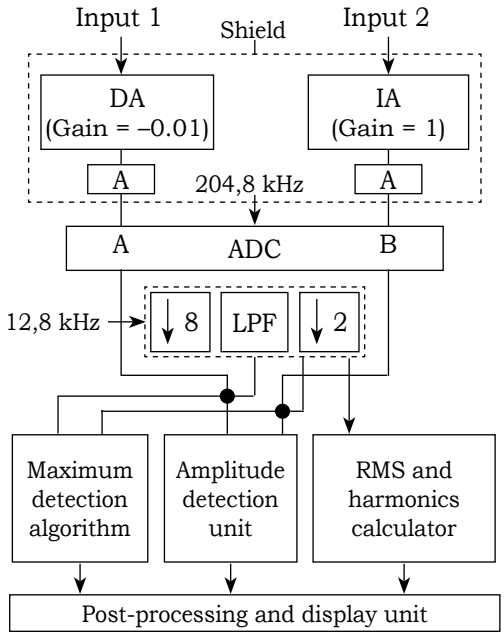




In the modes named "Amplitude detector" and "Average amplitude" LCD screen displays the following:

- amplitude values of voltage (both polarities) across two channels;
- amplitude values of voltage (both polarities) across two channels, divided by $\sqrt{2}$;
- RMS values of voltage across two channels;
- amplitude values of voltage (both polarities) across differential channel 1-2;
- amplitude values of voltage (both polarities) across differential channel 1-2, divided by $\sqrt{2}$.

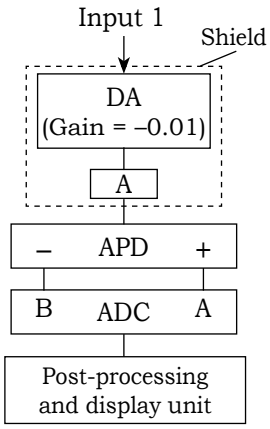
In the modes named "Amplitude detector" and "Average amplitude" ADC uses 204.8 kHz sampling rate to convert instantaneous values of input signals fed into channels U_1 and U_2. Differential channel $U_1 - U_2$ is calculated accordingly from two input channels.



Flowchart of signal processing in channels U_1 and U_2 in the modes named "Amplitude detector","Average amplitude" and "Peak detector"

Measurement in "Peak detector" mode involves three input channels:

- For input channels U_1 и U_2 ADC conversion is made with 204.8 kHz sampling rate to process instantaneous values of input signals.
- Peak detection circuitry operates on the third channel U_P.



Flowchart of signal processing in channel U_P in "Peak detector" mode

DA – differential amplifier with gain factor of 0.01;
IA – instrument amplifier with gain factor of 1;
A – controllable amplifier (two different gain factors);
APD –peak detector built around two active rectifiers; **ADC** – two-limit ADC (channels "A" and "B" are used)

Reference-class lab complexes for high-voltage measurements

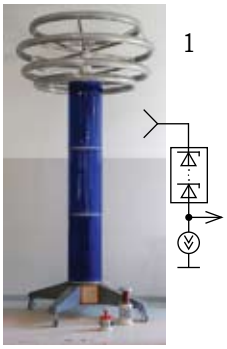
As metrological support of power industry becomes an urgent need, increasing attention is directed to the development of a reference-class complex applicable to both high-voltage AC measurements of commercial frequency and high-voltage measurements in DC circuits.

Particular solution of the problem is the use of VA-3.1 Peak Voltmeter that can operate as part of high-voltage measurement systems complete with primary transducers and dividers of voltage.

4

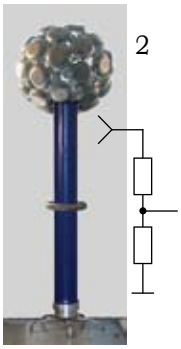
VA-3.1
Peak Voltmeter

1



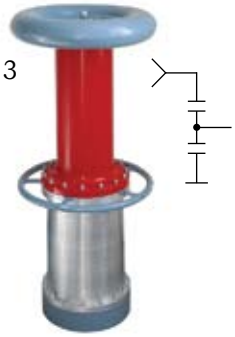
IDN-100÷500
differential gage
of high DC voltage

2



DNI-100÷300
resistive-capacitive high voltage
divider of AC/DC voltage

3



KIV-100÷300
capacitive high voltage
divider of AC voltage

Specification. Functionality. Fields of application

Reference-class complex for measurements of DC high voltage (hereinafter referred to as Complex) incorporates the following equipment:

- differential gage of DC voltage 1;
- peak voltmeter 4.

Complex is meant for use as primary standard of high DC voltage in national metrological institutions.

Complex incorporating

- reference class resistive-capacitive divider of voltage 2;
- peak voltmeter 4.

The complex is meant for use in metrological labs to conduct investigation of metrological characteristics, testing and adjustment of high-voltage dividers and certification of DC test benches.

Complex for measurements of high AC voltage incorporates:

- capacitive divider of AC voltage 3;
- peak voltmeter 4.

A chain of working standards maintained with regional units can be built around the complex. It can be used as well to create the means of metrological support for high-voltage reference standard.

Basic technical characteristics

Voltage measurement range

1÷500 kV (DC voltage of positive and negative polarity)	100÷300 kV (DC and AC voltage)	100÷300 kV (AC voltage of commercial frequency)

Limits of permissible relative error of measurement

±0.02 %	±0.1 %	±0.05 %

RESEARCH AND DEVELOPMENT

Movable working standards for high-voltage measurement of voltage (DC and AC)

Scientific research involving international comparison of standards is an important line in development of Russian fleet of standards.

Work is now underway with Mars-Energo towards the development of measurement equipment set involving:

- standards of basic units of electric quantities;
- means of reproducing derivative units; and
- means of transmitting the sizes of units.

This includes the sets of measuring instruments to be used for comparisons as movable standards.

IDN-100 reference-class differential gage of high DC voltage

IDN-100÷500 reference-class differential gage of high DC voltage

The reference installation is built around differential measure that provides for real-time compensation of major part of high DC voltage under review (1 to 500 kV), while its minor part (1 kV or less) is measured with peak voltmeter.

VA-3.1 Peak Voltmeter measures the output of reference-class gage of DC voltage, taking in consideration the amplitude of ripple.

The following equipment can be involved into inter-lab comparisons:

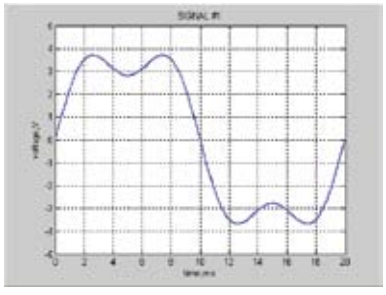
1. Measuring complex for AC voltage, including:
   - KIV-200 capacitive high voltage divider of AC voltage;
   - VA-3.1 Peak Voltmeter;
   - Energoforma-3.0 calibrator.

The set complete with reference-class capacitive high voltage divider of AC voltage and VA-3.1 Peak Voltmeter can be involved into comparisons as movable standard of amplitude volt unit, as well as RMS values of electric AC voltage of commercial frequency within the range of 1 to 200 kV.

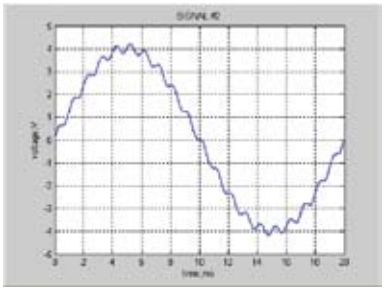
2. Measuring complex for DC voltage, including:
   - IDN-100 reference-class differential gage of high DC voltage;
   - VA-3.1 Peak Voltmeter;
   - Energoforma-3.0 calibrator.

Reference stage (with U_{NOM} = 100 kV) of differential gage of high DC voltage, in conjunction with VA-3.1 Peak Voltmeter, can be used as movable standard of volt unit for DC voltage within the range of 1 to 100 kV.

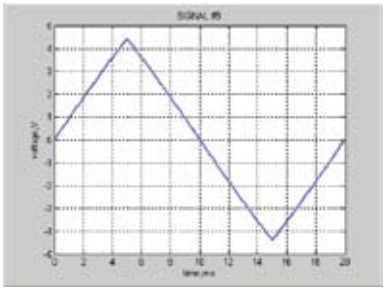
Examples of test signals used in comparison procedures.
Signals of the kind may be produced by a waveform generator/calibrator, such as Energoforma-3.0



Distortion (3th harmonic, 30 %)



High frequency noise in high-voltage signal (20th harmonic, 5 %)



Triangular waveform

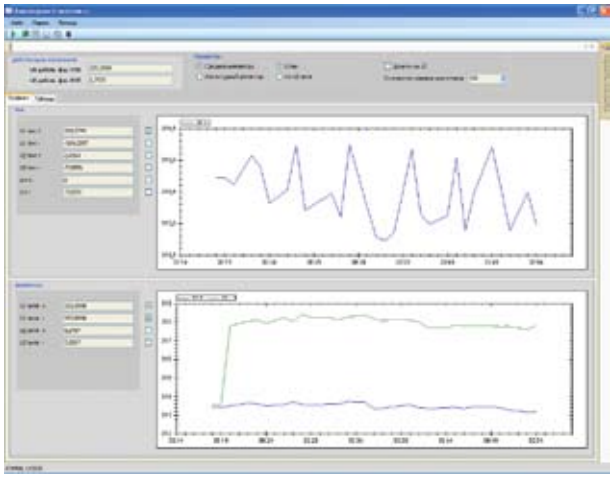
DEDICATED SOFTWARE

"Energomonitoring VA"

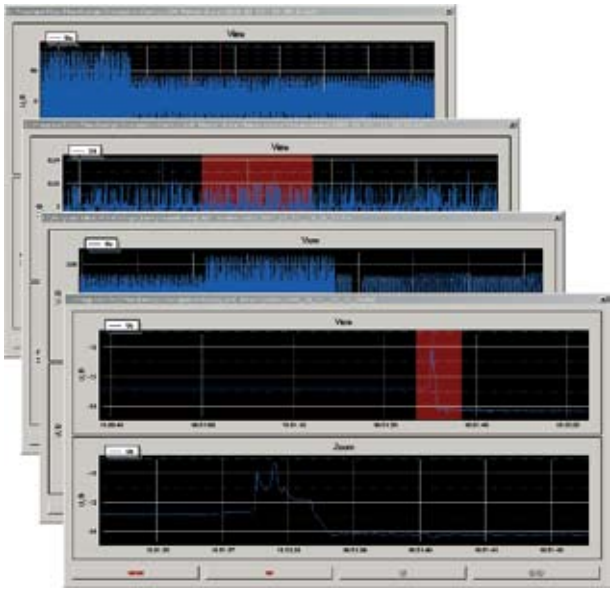
This PC software is oriented at the user of VA-3.1 Peak Voltmeter and makes it possible:

- to read into PC via RS-232 or USB serial interfaces the data measured by VA-3.1 Peak Voltmeter (amplitude or peak values of AC voltage and peak values of DC voltage);
- to view the data in graphical or tabular form;
- to store an maintain the acquired data on hard disk, and
- to export the data in MS Excel format.

User interface follows Windows standard model.



Main window of "Energomonitoring VA" software



Cascaded windows of oscillogram files under review

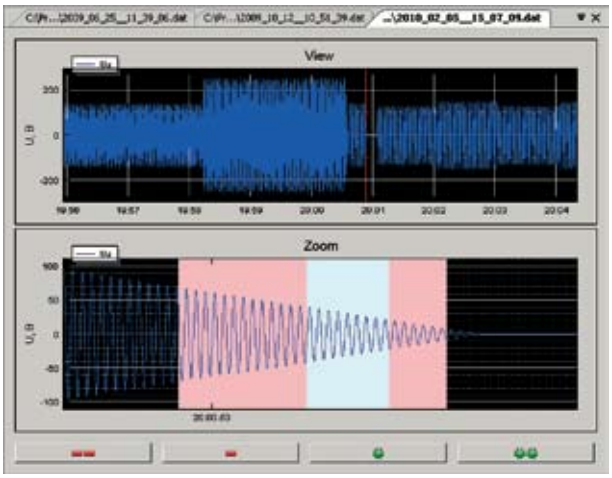
"Oscilloscope VA"

"Oscilloscope VA" program operates in conjunction with VA-3.1 Peak Voltmeter and makes it possible to view and archive the records of voltage signals. It reflects the course of real time and therefore can be of assistance to these who investigate the operation under stationary, transient and emergency conditions.

Oscillogram recording mode supports user analysis of signals containing harmonics up to 40th. Oscillograms constitute samples of instantaneous values acquired each 78 mcs from 16-bit ADC instrument (which corresponds to sampling rate of 12.8 kHz). This makes it possible to analyze recorded samples in detail.

Recording time of an oscillogram is 3 minutes. When oscillograms are produced in cyclic mode, their memory reflects last 3 minutes. In case of single-shot oscillogram first 3 minutes are memorized.

Main window of "Oscilloscope VA" software



Selection of time interval to display (zoom)

VA-1.3 TESTING

Accuracy tests of VA-1.3 shall comply with document "Peak Voltmeter VA-1.3. Test procedure" (MC2.271.001 TP).

Basic equipment used:

- national standard of electric power unit GET153-86;
- multipurpose test system **"MTS ME 3.1K"**;
- multipurpose generator/calibrator of AC/ DC waveforms **"Energoforma-3.0"**.

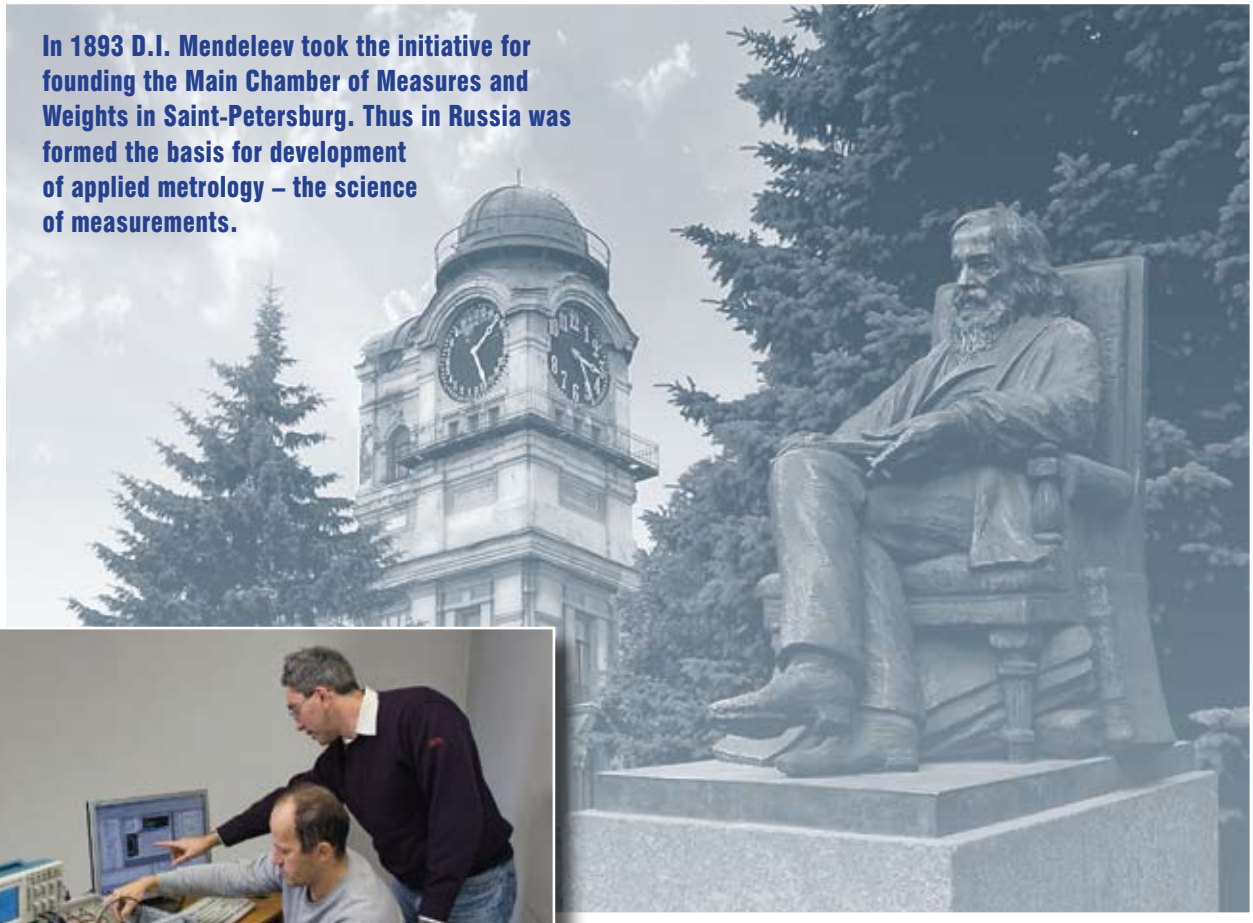
Multipurpose generator/calibrator of AC/ DC waveforms "Energoforma-3.0"

Multipurpose test system "MTS ME 3.1K"

Making energy visible

Mars-Energo
V.O. 13 Line, 6-8, office 41H
Saint-Petersburg, Russia 199034
Tel/Fax: +7 812 327-21-11
Tel: +7 812 309-03-56
E-mail: mail@mars-energo.ru

INNOVATIONS AND TRADITIONS



In 1893 D.I. Mendeleev took the initiative for founding the Main Chamber of Measures and Weights in Saint-Petersburg. Thus in Russia was formed the basis for development of applied metrology – the science of measurements.

At present time, in Mars-Energo a team of engineers – mathematicians, programmers and metrologists – creates genuine measuring instruments based on the extensive research experience in innovations and scientific capabilities.