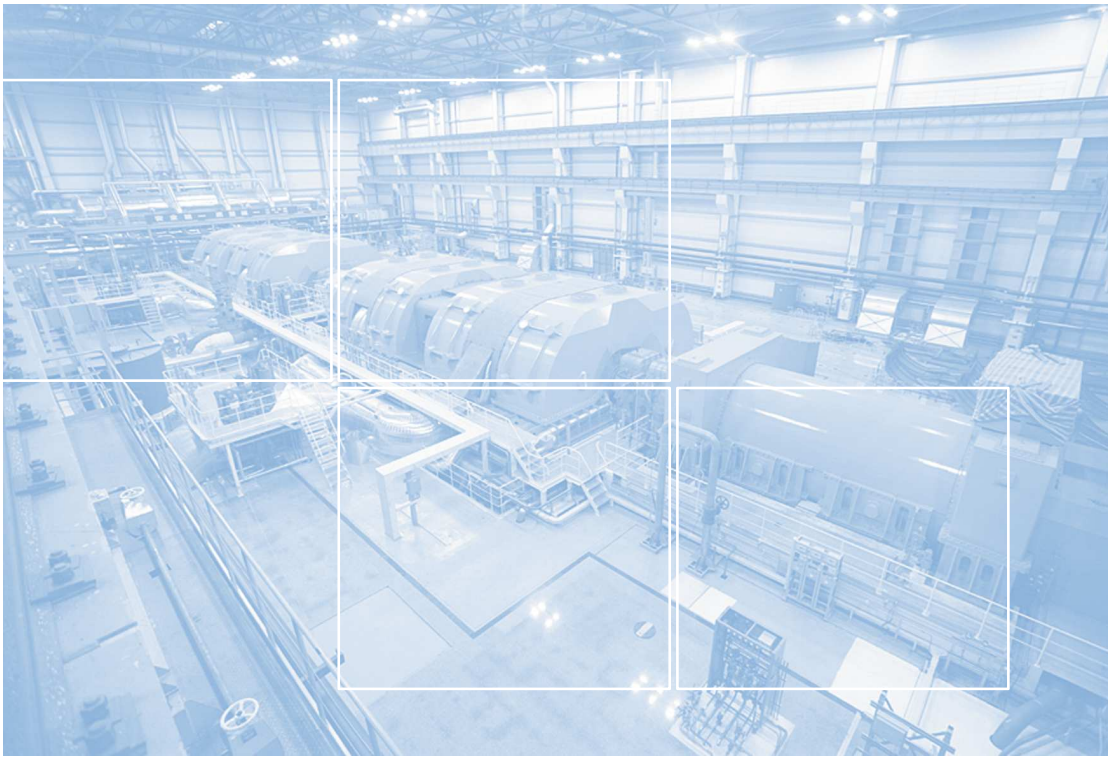
ВИБРО БИТ

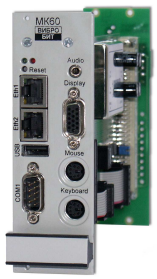
AVCS "VIBROBIT"

TECHNICAL PROPOSAL



INSTRUMENTS AND CONTROL SYSTEMS FOR POWER-GENERATING EQUIPMEN

- Sensors
- Measuring transducers
- Control Modules
- Monitoring



General information

Scope of activity of the Limited Liability Company (LLC) Scientific/Production Enterprise (SPE) “VIBROBIT” includes the following: development, manufacture, field supervision, setup, maintenance of equipment of the systems to measure and control the vibration parameters (AVCS) and mechanical condition of steam and gas turbines, centrifugal pumps, turbine compressors and other industrial equipment. The field of application for the above equipment is thermal and nuclear power plants, industrial enterprises.

On the customer’s instructions, the SPE VIBROBIT undertakes to develop project documentation to install and set up the system, calibrate measuring devices, submit the set to the bodies of State Standard of Russia, draw up the appropriate certificate and prepare a set of technical documents needed for its operation.

The CUSTOMER as per the agreed-on project undertakes to implement the required preliminary and installation work. The list of preliminary activities shall be compiled by the SPE VIBROBIT’s representative jointly with the CUSTOMER’s specialists in keeping with the dates of primary equipment maintenance.

The SPE VIBROBIT shall execute commissioning to start up the AVCS, besides it is possible for the SPE VIBROBIT to perform the installation work.

The AVCS mounted at the controlled object shall be put into experiential/industrial operation, and upon its successful completion it shall be put into industrial operation. Commissioning of the system to the customer shall be formalized with acceptance reports.

SPE VIBROBIT specialists undertake to train the CUSTOMER’s maintenance staff to operate the AVCS VIBROBIT.

The AVCS VIBROBIT shall provide as follows:

- **Effective development of the AVCS upper and lower level;**
- **Connection of the AVCS into the plant or local network with an option of setting up an integrated system of monitoring the turbo-units of hydropower and heat power plants;**
- **Adapting the diagnostic or expert software;**
- **Servicing vibro-adjustments and vibro-trials.**

The AVCS VIBROBIT enables to optimally build the systems of equipment control and protection, and integrate at nearly no cost new equipment into existing ACS of thermal processes, obtain the values of various vibration parameters while starting-up and stationary operating the unit, keep statistics of the unit’s parameters for the purposes of vibro-adjustment and diagnostics.

Function of the AVCS VIBROBIT

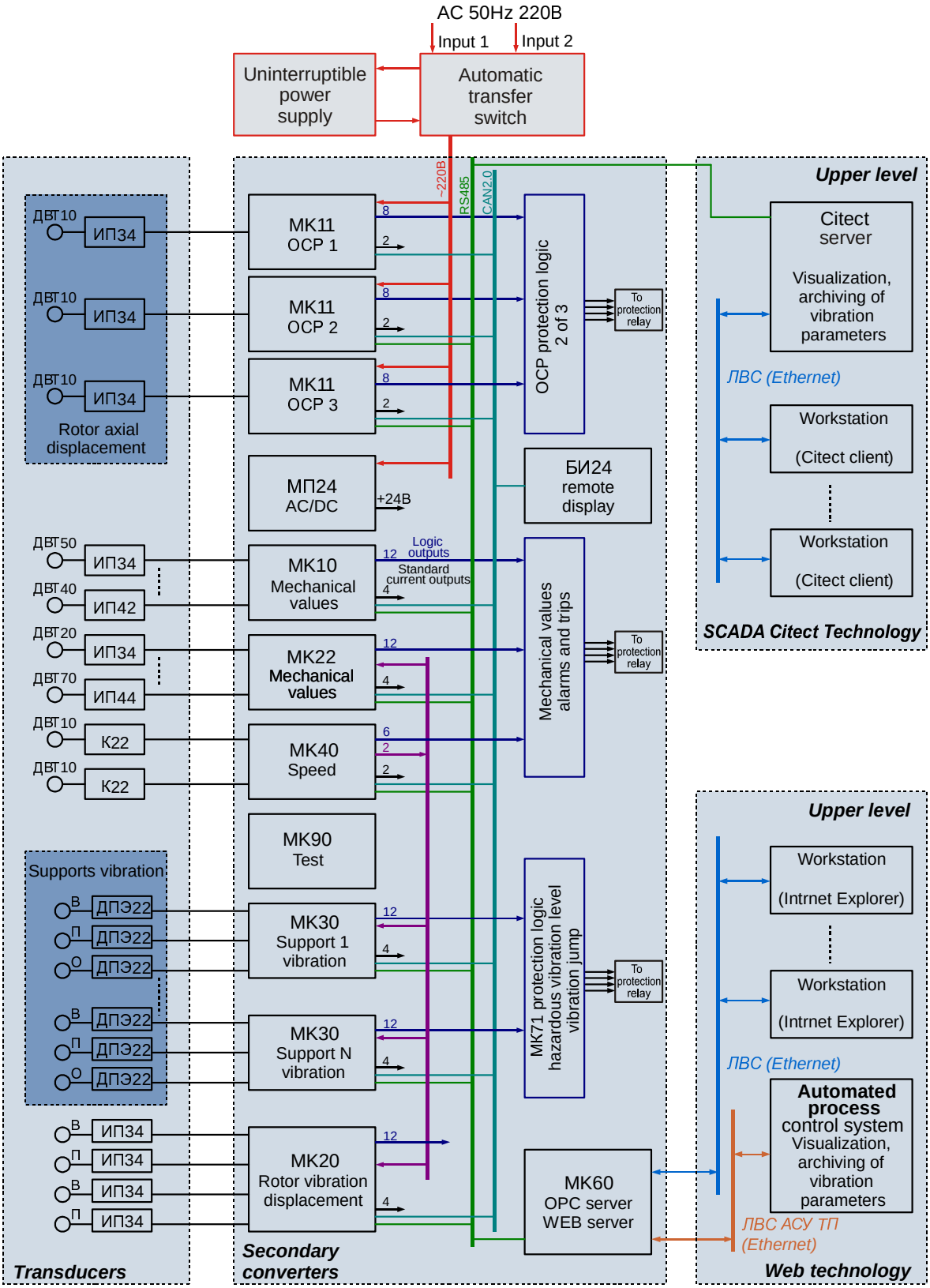
The AVCS VIBROBIT is designed for a continuous stationary measuring, controlling and monitoring the parameters of mechanical condition of steam and gas turbines, turbo-compressors, centrifugal pumps and other machines mounted on bearings when operated.

The AVCS VIBROBIT complies with GOST 25364-97, GOST 27165-97, GOST ISO 2954-97, maintenance rules, ISO 10816-1-95.

Basic functions performed by the AVCS VIBROBIT:

- Measuring the current values of controlled parameters:
  - the mean quadratic value (MQV) of the vibration velocity of bearing supports;
  - the relative vibratory displacement of rotary shaft and other units;
  - the relative displacement of rotary shafts;
  - the relative displacement of bodies of bearings;
  - the position of locking and control elements;
  - the rotor rpm.;
  - the inclination of supports of cylinders, parts and units;
  - other process parameters (capacity, temperature, pressure, etc.).
- Calculation of additional parameters:
  - harmonic vibration components;
  - low-frequency vibration;
  - high-frequency vibration;
  - leaps of parameters;
  - vibration amplitude coefficient, etc.
- Shaping of standard (unitized) current signals proportionate to the parameters measured.
- Matching of parameters against settings and signaling when they are exceeded, generation for the standard system of signaling and protection (including control of “leaps” and trends of MQV for vibration).
- Implementation of algorithms of protection operation as per an extreme value of vibration and axial displacement realized according to normative documents.
- Diagnostics of running order for a measuring channel and communication channel.
- Visualization of current readings of vibratory and mechanical parameters on the operator’s display in a convenient and compact form as well as on the modules’ built-in and remote digital displays.
- Displaying of vibration oscillograms and spectrograms.
- Data achieving with an option to scroll through the archive for a period of a selected depth with a data correlation analysis (displaying of vibratory parameters subject to mechanical values and time).
- Indication, control and documenting of protection signals status.

Control modules connection layout



The AVCS lower level

The AVCS lower level incorporates the primary sensors, remote amplifiers (converters), connecting cables and secondary measuring units with relay, analog and digital outputs.

Items of primary equipment have performance specifications and embodiment assuring their application as designed in accordance with the Instruction Manual 9.100 RE.

For each item of primary equipment the following documents were developed and supplied:

- Installation layout for the object concerned with respective tie-in drawings attached (**Mounting layouts of sensors and converters on a turbo-unit were coordinated by the SPE VIBROBIT with turbines manufacturers).**
- Drawings of wiring accessories (holders to support item assemblies, seals for cable inlets, shields and fixtures for sensor cables).

Information on sensors and converters

Measuring the absolute vibration

The absolute vibration shall be measured relying on the primary pickup mounted on bearing supports. The converter (amplifier) shall transform the mechanical oscillations into electrical signal proportionate to the vibration velocity.

- Ambient operating temperature for the sensor with cable shall be +5 to 180^0C.
- Ambient operating temperature for the converter shall be +5 to +70°C.
- Complementary error due to ambient temperature effect shall not exceed ± 8%.
- The sensor shall be exchangeable within the basic measuring error.

The sensor shall be mounted straight on the bearing support body if the latter is grounded. Should any electric potential be detected on the support body, the sensor shall be mounted using insulating spacers under the sensor and in fastening holes to exclude electric contact between the sensor body and support body.

Measuring the mechanical values

The mechanical values shall be measured using proximity eddy current displacement probes (transducers) generating a high-frequency electromagnetic field which expands in space to generate eddy currents within metal resulting in its weakening. The weakening shall be inversely proportionate to the air-gap between the sensor and (the object under control).

- Ambient operating temperature for the sensor with cable shall be +5 to 180^0C.
- Ambient operating temperature for the converter shall be +5 to +70°C.
- Complementary error due to ambient temperature effect shall not exceed ± 5%.
- The sensor shall be exchangeable within the basic measuring error.

Version of sensors and converters

The sensors protection rate shall be IP-67 (GOST 14254-96). Vibration- and impact-resistance shall comply with GOST 30630.1.2.-99 and GOST R 51371-99.

Converters of all types shall meet the following requirements: protection rate IP-54 (GOST 14254-96), vibration- and impact-resistance shall comply with GOST 30630.1.2.-99 and GOST R 51371-99.

Information on measuring modules

The AVCS VIBROBIT shall be completed with the following modules:

- Modules to measure and control constant, variable and tachometer signals;
- Modules of remote indication for the parameters measured, the assembly performance statistics record-keeping modules;
- Software for diagnostics and adjustment of modules.

The modules shall be assembled into 3U Euromechanics frames as per process criteria (bearings vibration, mechanical values, etc.). The frame shall be fitted with power packs, output relays of signaling and protection, output connectors and transient cords to the electrical cabinet terminal blocks.

All the modules of AVCS VIBROBIT shall support the following interfaces:

- CAN2.0B – for remote displaying of parameters measured and off-line gathering and storing the measuring results;
- RS485 with ModBus protocol – for integrating the AVCS VIBROBIT 300 into produced or existing ACS of thermal processes or PC connecting;
- Diagnose interface which connector is located on the modules' front panel, and designed to set up the module, to collect full information on the module performance with the help of a diagnostic device or computer as well as for the on-line correction of the module performance parameters.

The mechanical values, vibration parameters (or other process parameters) presented by direct current or voltage shall be measured using MK10 four-channel module. Each measuring channel shall be matched with a 4-20mA lead-out with adjustable range of the measurable value, as well as with 4 independent settings with a possibility to route the operation. Twelve logic outputs have a flexible performance algorithm adjustment with an option for grouping, signaling the parameter going beyond the settings or the measuring channel sensor malfunctioning.

Alternate current (voltage) signals shall be measured by modules MK20, MK30. Modules MK20, MK30 are based on high-performance microprocessor DSP processing variable signals through the four independent measuring channels using the spectral analysis method (spectral resolution being 1Hz) with an updating frequency of 0.5 sec.

Module MK20 is oriented to measure the vibrodisplacement parameters:

- Double amplitude (2A) of the vibrodisplacement general level in the frequency range of 5-500Hz;
- 2A LF vibrodisplacement in the frequency range of 5 – F/2Hz (F – rotational frequency);

- 2A HF vibrodisplacement in the frequency range of 2F – 500Hz;
- 2A rotational components 1/2F, 1F – 10F, Phase of rotational components 1/2F, 1F – 5F in the range of the unit rotational frequency 0.05 – 160Hz;
- Fixed bias (clearance) between the shaft and bearing;
- The unit rotational velocity.

Module MK30 is designed to measure the vibration velocity parameters:

- Total MQV of the vibration velocity in the frequency range 10-1000Hz;
- LF component of MQV for the vibration velocity in the frequency range 10 – F/2 Hz;
- HF component of MQV for the vibration velocity in the frequency range 2F – 1000 Hz;
- MQV of rotational components 1/2F, 1F – 10F, Phase of rotational components 1/2F, 1F – 5F in the range of the unit rotational frequency 10 – 160Hz;
- Amplitude of vibrodisplacement on the 1st rotational component and its phase;
- 2A of total vibrodisplacement signal and signal form factor;
- The unit rotational velocity.

In addition, modules MK20, MK30 perform signaling and protecting functions:

- Three settings (separately for each measuring channel) for the vibro-signal general level;
- One setting (separately for each measuring channel) for the vibro-signal LF level;
- Leap detection (an instant, irreversible change in the parameter value) as per vibro-signal general level, 1st rotational component and its vibro-signal phase;
- Monitoring of the unit running order.

Modules MK20, MK30 are designed to have 6 unified lead-outs of 4-20mA with a software option to select the type and scale of the vibration parameter displayed. Twelve logic outputs have a software option to adjust the commutation matrix as per signaling from measuring channels.

Vibration parameters values are displayed on a graphic LCD (32x122 pixels) mounted on the module front panel. The information is displayed in two modes: Complete Information referring to a measuring channel; Data Display Mode of all the measuring channels in the form of a histogram.

Module MK40 is designed to measure tachometric signals from two independent sensors in the range 0 to 10 000 rpm. For each measuring channel there are 3 settings (with an option to route the operation) matching individual logic outputs. In module MK40 there realized a detection algorithm to stop the unit and to store the maximum value of rpm. The unified lead-out of 4-20mA (individual for each channel) with a programmable option to set up the performance range can be used for connecting a plotter or other devices.

Module MK70 integrates the logic signaling formed by control modules to generate a signal of protective shutdown. Module MK70 is based on the Programmable Logical Integrated Circuit of Altera. The basic functions of mMK70 are the following:

- 16 logic inputs from the Common Collector (CC);

- 4 outputs of protective shutdown from CC: any pair “I”; any of 16; 2 any of 16 with an input of operation grant; any pair “I” with a validity function as to the time of input operation (response) (for MK70 J version only).
- Outputs dwell (delay);
- Indication of logic inputs condition;
- Indication of the input number which was the first one for the signal active level to appear;
- Resetting the module status with a key on the front panel or with an external signal;
- Generation of a test signal – a meander of 61Hz with an adjustable amplitude and constant component.

Control module MK90 is designed to check the performance of the unit signaling and protection through any measuring channel. While checking no commutations with the channel under control shall be performed. Check-up can be accomplished in any mode of the equipment operation. Control module MK90 is an adjustable source of signals imitating the signals from sensors (converters).

A remote display of parameters readings becomes possible with the help of module BI24. Module BI24 supports interfaces CAN2.0B, RS485, and also is able of independent measuring the unit’s rpm. BI24 is connected to control modules MK10, MK20, MK30, MK40 through a common interface CAN2.0B. The control modules periodically dispatch messages about measurement results, and module BI24 receives them and displays on a 4-digit 7-segment indicator.

Modules of VIBROBIT equipment are set up with specialized software loaded onto PC and adapter module MC01 or MC01 USB connected to the control module through the unified diagnostic interface.

Power packs are fitted with pulse voltage converters designed for the input voltage of 176…242V AC, 47…63Hz or 246…350V DC. At the output a stabilized voltage of +24V is generated. Power packs’ monitoring circuit gives a signal of the voltage overrunning the preset limits, and provides blocking output signaling relays during the unit switching on/off, power packs’ failures, ups and downs or failures of supply-line voltage. Urgent replacement of power sources is acceptable.

See modules’ detailed specifications in the Instruction Manual 9.300 RE.

Hardware cabinet

Frames with measuring modules are placed into the cabinet. When supplied the cabinet is completed with all the devices and fittings to mount the items of secondary hardware in it. In the cabinet there mounted connectives, cables, cords for bonding the frames mounted inside the cabinets with instruments and cables from the primary hardware. The Rittal hardware cabinet has protection of IP54 against environmental attacks.

The characteristics of fixture to connect cables from the primary hardware are as follows:

- Cable make-up: KVVGE, conductor cut: ≥ 0,5 to 2,5 mm^2;
- Cable input from the primary hardware is located in the cabinet lower part and has a sealing.

The cabinet is fitted with a vent panel and UPS unit assuring backup of the assembly performance for at least 30 minutes while cut off from outer power supply.

The computer and other hardware are supplied from individual (exchangeable) sources of uninterrupted power supply.

Scope of measurements

The bearing support absolute vibration shall be measured in 3 inter-perpendicular directions as per requirements of GOST 25364-97, GOST ISO 2954 – 97, maintenance rules.

The vibrodisplacement of the shaft in relation to bearing inserts shall be measured in compliance with GOST 27165-97. The shaft static position in bearing bore shall be determined through measuring the gaps between the sensors' heads and spindle in vertical and horizontal direction.

The AVCS VIBROBIT makes it possible to measure and control the following mechanical values:

- Rotor axial displacement;
- Rotors relative expansion;
- Cylinder bodies' absolute expansion;
- Rotors distortion (spread of the shaft relative vibratory displacement on the spot of sensor mounting);
- Displacement of pilot valves and servomotors;
- Angular displacements of bearing bodies and foundation elements.

The rotation speed (tachometric channel) in the AVCS shall be measured with a reference surface "notch" on the rotor shaft.

The scope of heat/mechanic parameters to be controlled shall be determined by the CUSTOMER.

Functions of the lower level

The basic functions of the AVCS VIBROBIT lower level are the following:

- Sensors of primary hardware of lower hardware are resistant to mineral and synthetic oils within the range of operating temperatures including OMTI liquid;
- The body of the primary hardware of the system lower level is resistant to spirit-based and decontaminating substances to be used in difficult environment;
- Variation of process variables and their control with reference to preset values (settings);
- An option to view the measured data in the operator-friendly form. To display each of the measured process variables, one has to use digital indicators and liquid-crystal displays with an updating frequency of at least 0,5 sec.
- Availability of nonvolatile memory to store modules settings excluding loss of information;
- Availability of digital communication interfaces (RS485, CAN2.0B, Ethernet) to transfer data to the AVCS upper level.

On-line monitoring

The AVCS VIBROBIT lower level hardware processes signals from sensors in real-time operation mode throughout all the measuring channels.

The hardware provides monitoring of the levels of measurable vibratory parameters, and in case of going beyond the preset limiting values, produces warning and alarm signals.

To ensure a high level of reliability for the formation of warning and alarm signals, the AVCS VIBROBIT provides as follows:

- Monitoring of the system lower level irrespective of operability of the upper level prime computer;
- In case of the upper level prime computer failure, the last preset measuring configuration for the lower level hardware is realized;
- Self-diagnosis of each measuring channel together with the sensor and connecting cables with signaling on failures (overrunning the preset ranges of values for supply voltages of primary hardware, values of operating clearance for sensors of vibratory displacement and tachometric sensors, short circuits and break in signal circuits of the primary hardware and connecting cable);
- Overload (short circuit) protection for feed circuits of the primary hardware.

*Data archiving and log keeping**

Upon reaching agreement with the CUSTOMER, the AVCS VIBROBIT can be additionally completed with a module of short-term statistics of process parameters measured fulfilling the following functions:

- Storing depth of uninterrupted archive information of at least 10 days old with protection against memory overfilling (older data are deleted automatically);
- Updating of instantaneous values of measurable parameters with a frequency of at least 0,5 sec., and archiving with a frequency of at least 1 sec.;
- Event log keeping (protection triggering, messages about hardware failures, operator's actions);
- Possibility of viewing history graphs and event log on the module display;
- Access to instantaneous values of parameters and archive information through Ethernet interface;
- System time (timer) synchronization with external (network) time through the system of upper level.

*Supplied under a separate supplementary agreement.

Basic technical characteristics

Parameter	Value
Measuring range of rotor speed, rpm	2-10000
Measuring range of bearing support vibratory velocity MQV, mm/s	0,4-15; 0,8-30
Measuring range of rotor spindles relative vibration, mic	25-500
Measuring range of rotor distortion, mic	25-500
Measuring range of rotor axial displacement, mm	-2,5...0...+2,5
Measuring range of rotor relative expansion, mm	-10,0...0...+40,0
Measuring range of rotor absolute expansion, mm	0-60
Measuring range of servomotor stroke, mm	up to 320
Measuring range of angular displacements, mm/m up to	-5...0...+5
Output current on contacts of the slot PLOTTER in the measuring range, mA	0-5; 1-5; 4-20
Tolerance limit for the given measuring error	±5 %
Alternating current supply voltage 50Hz, V	175 to 242V
Standard length of a cable connecting the sensor with converter, m	3; 5; 7 and other
Availability for service upon power-up, minutes not more	10
Operating mode	non-stop

The AVCS upper level

General information

The AVCS upper level software is license, russified and built on the basis of MS Windows 2000/XP operational system. Functionally the AVCS VIBROBIT upper level is realized as a distributed client-server system with possibilities of its flexible expansion and hot sparing of the system components. The Server and workstation application software is run by SCADA Citect.

The system upper level basic functions

The system upper level software provides fulfillment of the following basic functions:

- Measuring database maintenance (archive);
- Stand-alone processing of measurement results;
- Presentation of results of measurements and their processing;
- Control of current parameters as against settings in all operating modes as per requirements of GOST 25364-97, GOST 27165-97, GOST ISO 2954-97, Maintenance Rules, and signaling in case of their exceeding.

Data monitoring

The system software provides monitoring of vibratory parameters and mechanical values in the following size:

- Turbo-unit aggregated condition;
- Table of the turbo-unit basic vibratory parameters;
- Turbo-unit mechanical values;
- Position of the drive shafting rotor spindles in bearing bores;
- Harmonics of the bearing supports vibratory velocity;
- Harmonics of the bearing supports vibratory displacement;
- Harmonics of the rotor spindles relative vibratory displacement.

Functions of vibratory diagnostics

The AVCS VIBROBIT incorporates all essential aids to run the vibratory diagnostics of TG condition. Application of the AVCS VIBROBIT with the software by LLC RPA “Grad” using the display-client system allows to process on-the-fly the results and give out recommendations to prevent and rectify defects.

The vibratory diagnostic software enables to accomplish the following:

- Calculation of TG operation safety factor;
- Calculation of TG efficiency factor;
- Analysis of the vibratory and heat/mechanic condition of the primary and auxiliary equipment;
- Analysis and optimization of alignment for the drive shafting and supports;
- Enhancement of tasks for multiplanar balancing of multirotor-bearing system;
- Analysis of quality of starting operations and operating modes, start-up optimization for the purpose of avoiding catching the setting;
- Analysis of quality of power equipment maintenance;
- Analysis of the rate of wear for bearing seating and thrust face.

In addition the following could be done relying on the analysis of the vibratory and geodetic data:

- Determination of space-time parameters for deformations and displacements of the turbo-unit against foundation in two planes (vertical and cross-horizontal) in all operating modes;
- Determination of thermal alignment for the drive shafting supports during turbo-units start-up, prediction of their modifications from seasonal and long-term impacts onto the system “turbine-support-foundation”;
- Determination of ethe turbo-unit (TU) load effect onto vibratory condition, quality of rigidity for the system of rotor – support – foundation, critical rotor speed, rotor dynamic and static imbalance, establishing the reasons of higher vibration for the system of rotor – support – foundation;
- Development of recommendations to eliminate these causes, adjustment and alignment (balancing in proper bearings and machine tools).

Scheduled vibratory examinations are performed according to the approved schedule. Reports are made to give out recommendations.

The measures taken allow to create a database for the actual technical condition of equipment which considerably lightens the work of operating and maintenance personnel.

Data archiving

The upper level system provides the following:

- Storing depth of the uninterrupted archive information of at least three years;
- Option to view/print out history graphs and event logs;
- Automatic storing of the on-line information into archive continuously, archive files are created during the first start-up which makes it possible to avoid the archive overfilling.

Database management

The system synchronizes the system time on all the information sites of the vibratory monitoring system as to the signals from ACS of thermal processes or the operator from the Citect server keyboard.

The system has a feature of storing the hard disc image on CD-R for fast recovery (upon CUSTOMER's request).

Logs

Logs are intended to register the operator's actions and arising alarms. The following types of logs are supported:

- ***User's actions log.*** This window displays all users' actions made in the system: login/signoff, modification of setups and some other modifications of the system parameters.
- ***Alarm log.*** The alarm log window displays messages about modules' and channels' faults, affirmed alarms as well as alarms related to the values of variables exceeding the alarm and warning setups.
- ***Leaps and trends log.*** This window displays leaps and trends occurred in respect of the turbo-unit vibration. The leaps and trends are registered as they arise.

Access to archives

The upper level system provides access to instantaneous values of parameters and archives:

- To on-line data, through OPC Data Access;
- The archive information could be accessed only from the Server or Citect workstations;
- It is possible to store an archive sample in Excel database format.

Compiling reports and statements

The upper level system:

- Enables to manually compile a statement of the turbo-unit performance;
- Ensures data safety, prevents unauthorized access as well as differentiation of access to forms of presentation.

Setup of measuring parameters and forms of the system data presentation

The system software enables to set up the system parameters with the help of the following functions:

- Delimitation of the TU operating modes frontiers as per rotor speed;
- Correction of the system parameters setup values;
- Setting the period of data archiving into DB;
- Setting the initial shaft clearances in the TU bearing bores;
- Scaling of parameters values;
- Viewing time dependences of the turbo-unit operating and vibratory parameters in any operating modes;
- Analysis of time dependences for any number of the turbo-unit operating and vibratory parameters;
- Formation of the fixed sets to view and dump parameters graphs;
- Visual control of all vibration parameters and mechanical values of the user's interest;
- Possibility to make calibration and testing.

Personal computer of the technologist-operator's workbench

The technologist-operator's workbench incorporates as follows:

- System block of industrial make Intel Pentium 4 (2.8 GHz), RAM 512 Mb DDR, HDD 250 Gb RAID, Ethernet card 10/100 Mbit/s, CD-ROM, FDD;
- Monitor: 19" TFT LCD;
- Standard keyboard, mouse;
- Laser printer to print out reports;
- OS: Windows 2000 or Windows XP;
- Software of the AVCS installed in the computer and on CD.

Data retention in an emergency

Information retention is provided with installation of the RAID controller in the mode of mirror backup for hard discs.

To protect against loss of information in case of power failures, the system features power supply for the computer and hardware of lower level from the UPS.

Instrumentation modules and software provide automatic self-testing and software restarting upon restoring power supply of the system.

Protection of information against unauthorized access

Hard- and software ensure protection against accidental or purposeful unauthorized access. To be protected from unauthorized access, the hardware cabinets are fitted with lock-up glass front doors. The software has a password protection as well as protection against unauthorized access to computer networks which could be integrated with the AVCS.

Operating conditions, maintenance and repair

The AVCS should be serviced by technical staff aware of operating rules for electronic equipment, admitted for servicing and responsible for the quality of performed work.

The system shall be installed onto the object, commissioned, operated and routinely maintained (calibration and verification) by the personnel of LLC SPE VIBROBIT and the CUSTOMER qualified enough in the field of vibratory and mechanical measurements.

Measurement assurance

The equipment for vibratory monitoring and mechanical values measuring is certified by the Russian bodies of State standard (Gosstandart).

The system metrological provision includes as follows:

- Nomenclature of basic measurable values;
- Specification of accuracy standards for measurable parameters;
- Nomenclature of measuring instruments incorporated in the system;
- Nomenclature of references and accessory instruments needed for the system verification;
- Verification technique for the system.

The AVCS reliability

System lifetime, not less than ..... 10 years

Mean-time-between-failures, not less than ..... 100 000 hours

Technical documentation

All the technical documentation supplied for the system shall be in Russian.

Technical specifications of all the system components with instructions for installation, maintenance, and repair and serviceability control are included in the Operational Manuals 9.100 RE and 9.300 RE which contain the following:

- Scheme of installation, mounting and operation;
- Pre-starting procedure;
- Operation procedure;
- Maintenance check;
- Possible troubles and troubleshooting;
- Maintenance service;
- Storage rules and details;
- Transportation rules and other essential data;
- Verification technique.

Procedure and technique of the modules setting-up are featured in the Modules Setup Manual 9.300I1.

The connection project contains required basic and setup electrical diagrams (including connection layouts for cabinets, wiring circuits to connect sensors to a terminal block or converter in a connecting box, circuit diagrams for connecting cables between connecting boxes and cabinets, etc.).

All required manuals to operate the workbench are included into the Operation Manual for the Operator’s Workbench 9.300.000 ARM.

Standardization and unification

The AVCS component parts have been developed using modules. The AVCS software is based on standard display and information input elements, communication protocol for programs and physical devices.

Ergonomics and technical aesthetics

The AVCS complies with the up-to-date requirements of technical ergonomics and provides the personnel with visualization of information on the controlled object’s current condition.

Procedure of the AVCS implementation and commission

The AVCS shall be implemented in the following two stages:

Preparatory stage

Work to be done by the CUSTOMER

- Preparation of seats for vibration sensors;
- Marking, placement of revolution sensors;
- Preparations for cable routing;
- Installation of mounting boxes for converters;
- Manufacture of required supports and adapters to fasten the sensors.

Work to be done by LLC SPE VIBROBIT:

- Manufacture of the system component parts and blocks;
- Development of the CUSTOMized software;
- Complex testing at large.

The system mounting and setting-up

Work to be done by the CUSTOMER:

- Cable routing;
- Mounting of sensors, boxes for converters, instrumentation blocks.

Work to be done by LLC SPE VIBROBIT:

- Supervised installation;
- Setup of equipment to be installed;
- Personnel training.

Upon fitting-out each unit, the AVCS shall be put into trial operation for the period of 2 months. This fact shall be endorsed in the appropriate act. In case of any failures in the system, the trial operation may be extended. Upon successful completion of the trial operations, the system shall be put into commercial operation which fact to be endorsed in the appropriate act.

Supervised installation, testing and commissioning of the AVCS

Upon mounting the system equipment in the TPS, a thorough checkout of the AVCS shall take place as per program developed by the user in line with procedures of preoperational and functional trials provided in advance by the supplier.

LLC SPE VIBROBIT undertakes to train the CUSTOMER's personnel in the AVCS structure, performance and operation.

The supervised installation shall include as follows:

- Inspection of installation;
- System checkout;
- Acceptance tests;
- Putting the system into trial operation;
- Putting the system into commercial operation.

The supervised installation fees are included into the total value of supply of the AVCS.

Project schedule times

Delivery time for the AVCS equipment shall be coordinated with the CUSTOMER.

The system can be started before completing the turbine maintenance, but the system can be put into trial operation only upon finishing the turbine maintenance and connection of all the measuring channels.

Certification and licensing

To supply the system onto the object, the following documents are to be submitted:

- Certificate of the type of measuring devices authorization;
- Certificate of serial production conformance;
- License for manufacturing and repairing measuring devices.

Warranty

Irrespective of the agreement period, LLC SPE VIBROBIT warrants the system at large and all components to function faultlessly within 36 months of the commissioning date.

Over the warranty service period LLC SPE VIBROBIT undertakes to repair the supplied system free of charge except for the cases when the equipment failure is caused by improper actions on the part of the CUSTOMER's staff.

On the expiry of the warranty service period, the equipment maintenance shall be provided by LLC SPE VIBROBIT under a supplementary agreement.

Packing, transportation

The AVCS equipment must be transported in packing ensuring its safety while being delivered by any mode of transportation.

Supplements

Comments to the AVCS VIBROBIT construction

The AVCS VIBROBIT is a system of continuous stationary measurement, control and monitoring the mechanical state of steam and gas turbines, turbine compressors, centrifugal pumps and other machines mounted on bearings.

The AVCS VIBROBIT is a configurable system in its soft- and hardware part for a specific type of controlled equipment.

Functionally the AVCS VIBROBIT can be subdivided into the following three levels:

- ***The first level*** – at this level some physical quantity is transformed into a proportionate current signal entering the digital control modules. In digital control modules the signal strength is converted (recalculated) into a value of physical measurable parameter. The values received are matched against the setups, and signals of protecting shutdown are generated, etc. The parameters computed values are transferred onto the system upper level through the digital communication interfaces. In its turn the system first level could be subdivided into two parts as follows:
  - Sensing (primary) devices – include sensors, converters (remore amplifiers), connecting cables;
  - Secondary devices – are control modules, logic modules of process protection, modules to check measuring channels and protection circuits running order, power sources (including UPS), and remote indication modules. Control modules (and other functional modules of secondary converters) are mounted into 19” 3U Euromechanics frames. The frames with modules are mounted into the cabinet of Rittal with a glass lockable front door.
- ***The second level*** – is functionally built as a distributed client-server system with capacities of flexible buildup. The Server’s and workstations’ application software is executed with SCADA Citect aids. The system software ensures monitoring the vibratory parameters and mechanical values: the turbo-unit aggregate condition; on-line diagnostics of the turbo-unit’s condition running in real-time operation mode and others. The upper level connected with the AVCS lower level through digital communication interfaces (Ethernet, RS485) with standard data communications protocols.
- ***The third level*** – the AVCS VIBROBIT third level incorporates remote workstations (personal computers) having access to the database and the unit’s current condition for their viewing and analyzing.

In each particular case the AVCS VIBROBIT shall be completed as requested by the CUSTOMER with the respective set of sensors, measuring and service modules as well as there might be some variations in setup procedures and circuits turning the control modules on, and the upper level software configuration. It is reasonable that while supplying the AVCS VIBROBIT we have some ready-made patterns measuring various vibratory/mechanical parameters and building protection circuits. Hereunder there are considered some typical techniques of measuring basic parameters as well as measuring protection circuits as on these parameters which are used in the AVCS VIBROBIT.

Rotor axial displacement

The rotor axial displacement is controlled with three independent sensors DVT20*7, converters IP34A, control modules MK10 or MK11 (measuring the steady signal). The sensors' measuring range is 2 – 0 – 2mm. The sensors are placed at the setter MU10, and converters are located in the box KP23V protecting the converters and connecting cable terminal clamps from mechanical damages, dirt, etc.

Along the connecting cables power is supplied onto converters +24V, and the current signal is transferred from sensors in proportion to the axial displacement measured to enter the individual control modules mounted in the section of the hardware cabinet of the AVCS VIBROBIT.

Each control module MK10 measures the axial displacement from one sensor and is completed with its own power source AC 220V/DC 24V MP24 or MP25. If control modules MK11 are used, the additional power sources are not needed since the AC/DC converter is embedded into control module MK11. Individual power sources for the control modules and sensors (or a power source integrated into the measuring module) substantially enhance reliability of protection as to the rotor axial displacement.

Each measuring module calculates the value of axial displacement of the relevant sensor continuously controlling the operable condition of the sensor and communication line. The calculated value of axial displacement is matched against the warning and emergency setups (setups as to directions of axial displacement could be asymmetric).

A warning signal of the rotor axial displacement is formed along the circuit of any of 3 measuring channels and transferred at the cabinet terminal clamps in the form of "dry contact" (normally dead/live relay contacts). The alarm signaling follows the logic 2 out of 3, and is also transferred onto the cabinet terminal clamps in the form of "dry contact".

Should any failure be detected in the sensor, communication line or control module (the control modules are provided with a function of self-diagnostics), the relevant measuring channel shall not be involved in the formation of the warning and emergency signaling, and the active signal ("dry contact") will be present at the cabinet terminal clamps "AVCS VIBROBIT fault".

The control module front panel displays the current value of axial displacement on 7-segment 4-digit numerical indicator. Referring to setup individual LEDs one can on-the-fly detect availability of a dangerous axial displacement of the rotor. With the help of key buttons on the control module front panel one can browse the setup values, actual value of the sensor current.

The results of axial displacement measurement and information on protection condition are transferred onto the upper level through RS485 interface with ModBus protocol. It is possible to remotely display the values of rotor axial displacement on indication modules BI24 connected with CAN2.0B interface.

Rotor relative expansion

To measure the rotor relative expansion, the sensor DVT40.10*7 with converter IP42A (the measuring range: 5 – 0 – 5mm) is used. The sensor is fixed at setter MU10, and the converter is mounted in box KP13.

To measure the rotor relative expansion, 4-channel module measuring steady signals MK10 is used. At the CUSTOMER's request, it is possible to connect several sensors to one module or to arrange an individual control module for each measuring channel.

Thermal cylinder expansion

The thermal cylinder expansion is measured with the help of sensors DVT50*5 and converters IP34A (the converter to be mounted into box KP13). The control module of steady signals MK10 is used as a secondary converter.

Other parameters of the unit conditions represented by the DC signal

A variety of parameters of the unit conditions represented by DC could be measured and transferred onto the AVCS VIBROBIT upper level with the help of 4-channel modules measuring steady signals MK10, e.g.: active power, servomotors' position, inclinations, temperature, pressure, etc., provided that the sensors are connected through the relevant normalizing converters.

Checkup of the mechanical values measuring channels

To check up the mechanical values measuring channels (and measuring channels with DC signals), modules MK90 are used. MK90 outputs are connected to the measuring channel signal circuit. With the help of MK90 one can check up the measuring channel running order and performance of the equipment protection circuit.

Rotor rpm

To measure the rotor rpm, two actually independent measuring channels are realized. Two pairs of sensors DVT10*5 and comparators K22A are normally mounted next to the generator exciter. The channel measuring rotor rpm is sensitive to the "notch" type mark. Comparator K22 is mounted in box KP23V.

Two rpm measuring channels enter one module of tachometric signals MK40. The module measures the rpm values through the two channels independently (the first channel being prime, and the second one being reserve). Module MK40 replicates synchronization impulses onto the modules measuring the support vibration, drive shafting relative vibration and shaft deformation. Should any fault in the basic rpm measuring channel be detected, then the control modules would be synchronized through the reserve channel.

Through each measuring channel the sensor's good order is controlled, the calculated rotor rpm value is matched against setups (3 setups) to form signaling about the calculated rpm value exceeding the setups. Additionally in module MK40 there are functions to store the rotor ultimate rpm value and detect the rotor stop block with formation of appropriate signaling.

The results of the rotor rpm measurement is transferred onto the upper level through RS485 interface with ModBus protocol. There are provided two remote display units BI24 to represent the rotor rpm (the rpm values are transferred onto display units BI24 from module MK40 through CAN2.0B interface). One module BI24 is mounted at the turbine front seat, another one – on the control switchboard panel.

Rotor deformation

The rotor deformation is measured with the help of sensor DVT10*7 mounted on the setter. Then there are two options to measure the rotor deformation differing in the type of converter and measuring module. In either case the converter is mounted in box KP13.

Application of IP34A converter

A signal from converter IP34 contains both a constant component and a variable one. Referring to the constant component you determine clearance between the sensor and rotor, and referring to the variable component you determine the rotor deformation. To make these measurements one uses module MK20 implemented on the basis of a high-performance processor. The rotor deformation is measured with the help of harmonic analysis referring to the first rotational component (in addition the rotational component phase is calculated). Allocation of this technique enables to properly measure the rotor deformation at the rotating velocity starting from 2.5 rpm. To activate module MK20 the synchronization impulses from the rpm measuring module are required.

Application of IP37A converter

Converter IP37A gives out two signals: the first one refers to clearance between the sensor and rotor; the second one refers to the rotor deformation represented by DC. To measure the rotor deformation with converter IP37A, module measuring steady signals MK10 is used. The 1st channel receives the signal of rotor deformation, and the second channel receives the signal of clearance between the sensor and rotor. The synchronization impulses are not needed to measure rotor deformation by this strategy.

Relative vibration of shaft on bearing

The shaft vibration is measured with the help of sensor DVT10*100*0.5 mounted on the bearing top insert. In addition, with the help of shaft vibration sensor one can measure the air gap in the bearing. The control of gap in the bearing enables to estimate the babbitt wear and to monitor the rotor's position.

Sensor DVT10*100*0.5 operates with converter IP34A mounted in box KP23V. As a rule, one rotor is fitted with two pairs of the shaft vibration sensors (in a vertical and transverse plane on each support).

The signal goes from the shaft vibration sensor converters to the input of the 4-channel shaft relative vibration measuring module MK20. Thus one turbine rotor is serviced by one control module MK20.

Module MK20 measures the shaft relative vibration (the frequency range: 5-500Hz), LF and HF shaft relative vibration, clearance, spread (swing) and phases of the rotational components (up to 10 rotational components). Module MK20 is regulated with 3 setups of the shaft relative vibration general level and one setup of the shaft LF relative vibration. The sensor and measuring channel running order is permanently controlled by the converter DC.

The results of shaft relative vibration measurement are displayed on the graphical LCD in the form of detailed information on each measuring channel or in the form of histograms of one-type parameter (total vibration, LF or HF vibration, sensor's current, etc.) through the four channels at once (the parameter digital values are also displayed on the LCD as a histogram).

There is a possibility to request the detailed oscillograms and spectrograms of the shaft relative vibration signal.

Bearings vibration

To measure bearings vibration one uses sensors DPE22MV A15*7 consisted of the sensor per se (accelerometer) and converter mounted in box KP23P.

The bearing vibration is measured in three perpendicular planes (vertical, transverse and axial). One bearing's vibration is serviced by one 4-channel vibration measuring module MK30. The first three channels of MK30 are connected with the bearing vibration sensors (in a vertical, transverse and axial plane). The fourth channel (test) is supplied with an AC testing signal to control module MK30 running order.

For each measuring channel module MK30 calculates the general level of vibratory velocity MQV (10-1 000Hz); LF and HF components of vibratory velocity MQV; rotational components of vibratory velocity MQV and their phases (up to 10 rotational components); vibratory velocity signal form factor to determine the non-level of signal nonsinusoidality. In addition, the module exercises control over "the leap" of the vibration general level and rotational component.

Module MK30 is provided with 3 setups of the general level of vibratory velocity MQV and one setup of the vibration LF components. To create a protection circuit for the vibration dangerous level on two supports of one rotor or adjacent supports of two rotors one has to use the protective shutdown logic module MK70 integrating the signaling from several bearing vibration measuring modules MK30. Module MK70 is fitted with a generator of 61Hz variable signal with an adjustable amplitude level and steady component. This signal is connected to the testing inputs of modules MK30.

Merging of signaling as to the detected "leaps" of vibratory velocity MQV level from control modules MK30 is also merged with the help of module MK70. In addition, while merging protection as to the vibratory velocity MQV "leaps", in module MK70 there controlled simultaneity of "the leap" emerging on two supports of one rotor, on adjacent supports of two rotors or two components of one support.

Module MK30 is permanently controlling the sensor and communication line running order as referred to the DC signal level. In case of any fault detected, the relevant signaling is formed, and the control of setups for this channel is blocked.

The bearing vibration measuring channel running order is checked up with the help of module MK90. Moreover, the variable testing signal from module MK90 passes through the accelerometer crystal which makes it possible to control not only the running order of converter and communication line, but straight that of the sensor itself.

As in the shaft vibration measuring channel, in module MK30 there applied a graphic LCD with a detailed displaying mode through the measuring channels as well as in the form of histograms.

Realized options of requesting detailed oscillograms and spectrograms (spectral resolution: 1Hz) of the bearing vibration signal through the measuring channels open up vast possibilities for vibratory diagnostics.

Data are transferred onto the upper level through RS485 interface with standard ModBus protocol. CAN2.0B interface is provided for remote indication of the calculated vibration parameter values.

The power supply for the bearing vibration measuring channels is performed, as a rule, by two feeding modules MP24.

Second, third level

It is possible to build an integrated system to control and monitor power units' vibratory, mechanical and heat/mechanic parameters on the basis of the AVCS VIBROBIT upper level.

Building-block systems of vibratory control and monitoring are integrated into the plant Ethernet local network to be able of exchanging information through standard protocols (OPC, ModBus) with block ACS of thermal processes.

The AVCS VIBROBIT upper level provides maximum convenient aids for the on-line access to any information stored in any block server of the vibratory control and monitoring system for various users:

- Power plant managing, operating and technical staff relying on the application software by the SPE VIBROBIT installed on users' personal computers connected to the plant local network;
- Specialists in the field of vibratory setup and vibratory diagnostics relying on the software by the SPE VIBROBIT and other diagnostic software.

In the AVCS VIBROBIT there applied the trusted unified license soft- and hardware ensuring compatibility through interfaces with various ACS of thermal processes. Application of open technologies enables the plant's specialists to check out and upgrade the system (development aids, strategy and algorithms are supplied).

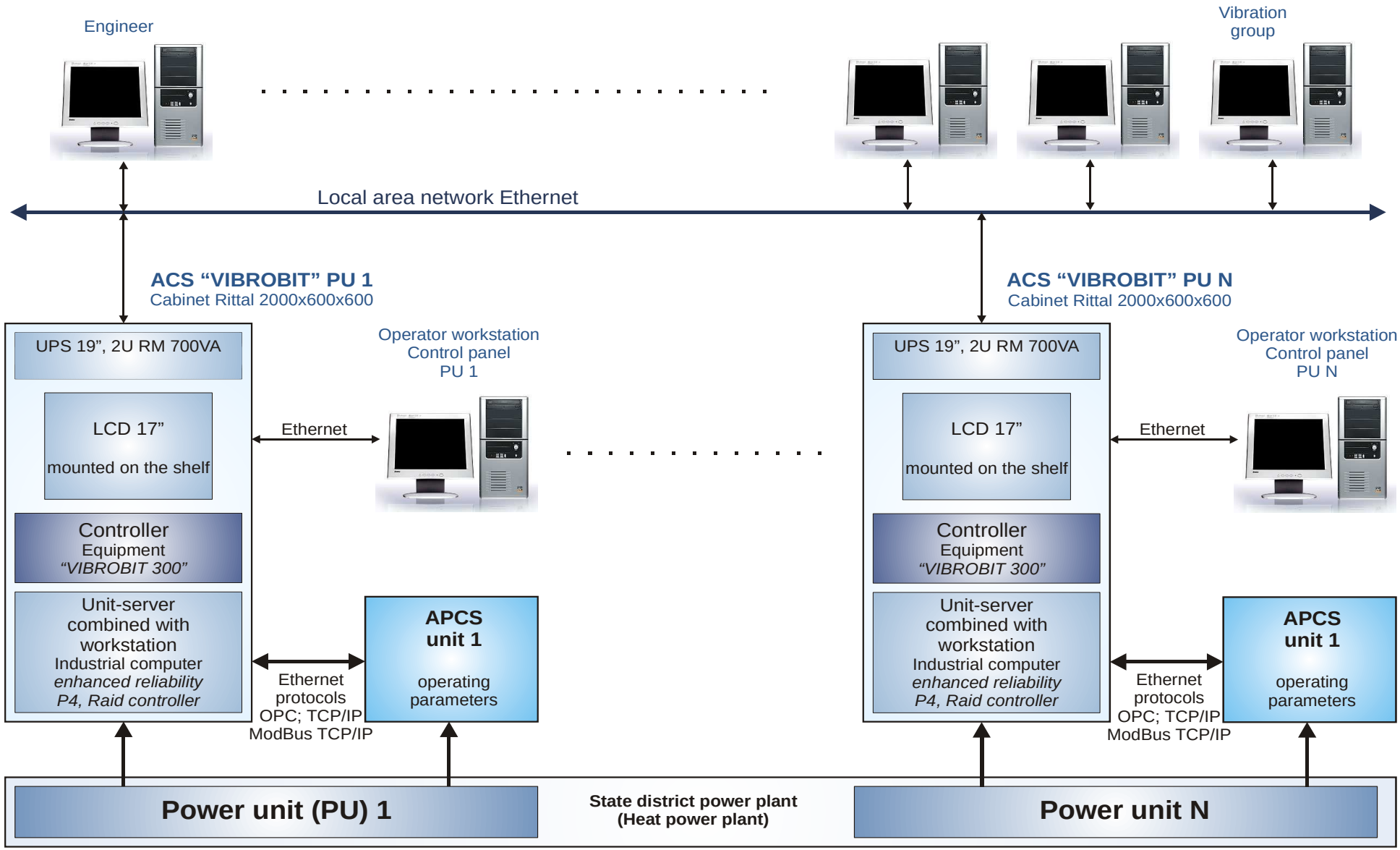
The human-engineered interface of application software by the SPE VIBROBIT makes it possible to browse on-the-fly the information of nay kind:

- Videograms of the turbo-unit on-line inspection;
- Amplitude-phase-frequency-characteristic Diagrams and tables;
- Parameter spectrograms and oscillograms;
- Parameter correlation;
- Trends;
- Orbits of support and shaft vibratory displacements;
- Archive data in form of tables and graphs.

While constructing the AVCS VIBROBIT we use standard personal computers installed in the studies of top executives and specialists and connected to the plant local network Ethernet. As an application software these computers are provided with draft block systems implemented in SCADA Citect. Manager Client LPT-key must be installed in every computer as the SCADA Citect license.

While developing the integrated system, it is possible to integrate the vibratory control and monitoring block systems' databases and block ACS of thermal processes into the plant database on the plant server.

The general architecture of the integrated system of control and monitoring mechanical and thermotechnical parameters of the state district power plant (heat power plant) power units.



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