SCIENTIFIC - PRODUCTION
ENTERPRISE "VIBROBIT" LCC

INSTRUMENTATION "VIBROBIT 300"

MK22 Control Module Setup Instruction

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The MK22 module setup instructions serve to make users (consumers) aware of The "VIBROBIT" Equipment MK22 Control Module main operation principles and setup methodology.

The present document is a supplement to
The ВШПА.421412.300 РЭ "VIBROBIT 300" EQUIPMENT Operations Manual"

The SPE «VIBROBIT», LLC retains the right to make changes of separate parts and components without sacrifice of performance specifications of the product.

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Overview

The MK22 general-purpose 4-channel control module is designed to measure the sensors constant and tachometric signals, as well as the turbine rotor bowing (eccentricity). The MK22 is based on a high-performance 32-digital DSP processor, the application of which provides an opportunity of the sensors signals real-time processing (determinations interval from 0.1 seconds) in parallel with supporting digital communication interfaces.

The main function of the MK22 module measuring channels is determination of constant signals with a 0.1 second period (the protection algorithms response rate is from 0.1 second). Apart from measuring constant signals, every MK22 module channel can be adjusted to work in an enhanced mode:

- Channel 1 - measurement of the rotor speed (a tachometric signal).
- Channel 2 - measurement of the rotor speed (a tachometric signal).
- Channel 3 - measurement of the turbine rotor bowing (eccentricity) (a variable signal).
- Channel 4 - the sensor signal linearization (a constant signal), parameter computation according to the formula.

The measuring channel standard function package includes:

- Measurement of the sensor direct current, monitoring of the sensor and the communication line integrity.
- Computation of the parameter value (with a -0.1 period), averaging the measurement results, comparing to the setpoints.
- Control of the measured parameter stability, saving the minimum and the maximum parameter values.
- Transmission of the computed parameter value to the unified current output.
- Assigning a meaningful symbolic name to the measuring channels.
- Implementation of complementary algorithms of the parameters measurement (for every channel individually).

Additional functions of the rotor speed measurement include (for Measuring channels 1, 2):

- The rotor speed measurement period from 0.1 to 1.0 second.
- Measuring the rotor speed from 1 rpm with the "Groove" control surface.
- Adjustable gear teeth number (pulse count per one rotor rotation).
- Selection of the sensor signal active edge.
- Reference tachometric pulses repetition to synchronize the control modules, computing the rotational components and their phases (e.g. МК22, МК32 modules).
- Detection of the rotor stop and the opportunity to check the rotor stop warning.

To measure the rotor bowing (eccentricity), the MK22 module is fitted with the following functions (Measuring channel 3):

- Measurement period of 0.2 second (or one rotor rotation).
- Computation of the rotor bowing according to the first rotational component or to a polyharmonic signal of the sensor.
- Computation of the harmonic components of the signals of the sensor, measuring the rotor bowing (2A of the excursion from the half to the fifth harmonic and their phases).
- Selection of the tachometric reference pulses input.
- An opportunity for the Measuring channels 1, 2 to operate in the constant signals mode while the Measuring channel 3 is operating in the "rotor bowing" mode.
- An opportunity to synchronize from tachometric pulses with the "Pinion" control surface (the rotational components phases are not computed).
- Correction of the LF filter module phase shift, of the transducer and of the sensor installation position relating to the "Groove" control surface.
- Lockout of the rotor bowing measuring at the rotor speed limit overrun.

On the fourth measuring channel the sensor constant signal linearization function can be activated.

- Linearization by the method of piecewise linear approximation (current- is the measured parameter value).
- Up to 16 entries (15 segments) in the linearization table.

Other distinctive features include:

- Measuring channels input signals: 0(1) – 5mA; 0(4) – 20mA; 0 – 3V;
- 12 logic outputs with an adjustable operation algorithm to implement signaling and protection schemes.
- Four unified current outputs with an opportunity of program adjustment of the range.
- Supported communication interfaces: RS485, CAN2.0B, a diagnostic interface.
- Service software for the present status PC- visualization and the module adjustment and calibration.
- The module comes in several versions:
  - MK22-DC – a 20 mm 3U narrow front panel, a limited module status signaling system.
  - MK22-DC-11 – a 40 mm 3U front panel, a bright digital 7-segment indicator unit with expanded indication and module control system.
  - MK22-DC-001 – a 40 mm 3U front panel, a special-purpose digital-symbolic LCD with an opportunity of displaying measuring results for all the channels together.
- Unipolar power supply of the module, with direct voltage +24V, low power consumption.
- The transducers (sensors) are fed with direct voltage +24V via 200 mA resettable fuses, allocated on the MK22 module card.

All the MK22 module settings are made via a personal computer or a ПН31 special-purpose adjuster device. To setup the module with the help of a personal computer, one should launch on the computer the ModuleConfigurator.exe program; the module should be connected to the computer via the MC01 USB diagnostic interface card (PC USB interface).

Performance Specifications

Table 1. The MK22 Module Performance Specifications

Parameter Name	Value
Number of constant signals measuring channels	4
Number of rotor speed measuring channels	2[1)]
Number of rotor bowing measuring channels	1[2)]
Direct signals measuring and signaling range	Depends on the connected sensor type
Rotor speed measuring range, rpm	1 – 12000
Rotor bowing measuring range, μm	0 – 500
Input signal measuring ranges - direct current, mA - direct voltage, V	 1 – 5; 4 – 20 0.56 – 2.8
Input resistance, Ohm - direct current - direct voltage	 560 ± 2; 140 ± 0.5 minimum 10 000
Permissible main relative error limits of constant signal measurement, %, maximum - by the unified signal - by the digital indicator	 ± 1.0 ± 0.5
Permissible main absolute error limit of rotor rotations measurement channel, rpm, maximum	± 2.0
Permissible main relative error limits of variable signal measurement, %, maximum - by the unified signal - by the digital indicator	 ± 1.0 ± 1.0
Responses update time and signaling and protection logic functioning time, s - constant signal measurement channels - rotor speed measuring channels - rotor bowing measuring channels	 0.1 0.1 – 1.0 0.2
Number of unified direct current signals	4
Output unified direct current signal, mA	0(1) – 5; 0(4) – 20
Output unified signal load resistance, Ohm, maximum	2000; 500
Number of setpoints for every measuring channel	4
Number of discrete (logic) outputs	12
The module output discrete signals - constant voltage, V, max. - output current, mA, max.	open collector 24 100
Types of the supported communication interfaces	RS485 (ModBus) CAN 2.0B diagnostic SPI
Power supply voltage, V	+(24 ± 1)
Consumption current, mA, max.	100[3)]
Ambient operation temperature range (from to, both inclusive), °C	+5 – +45

Notes:

1. For Measuring channels 1, 2. At activating the frequency measuring function, the constant signal is not measured (the sensor direct current is computed).
2. For Measuring channel 3.
3. The consumption current is indicated without considering the unified outputs source current.

Table 2. MK22 Additional Features

Parameter Name	Value
Overall dimensions, mm - MK22-DC control module - MK22-DC-11, MK22-DC-001 control module	 20.1 x 130 x 190 40.3 x 130 x 190
Mass, kg, max. - MK22-DC control module - MK22-DC-11, MK22-DC-001 control module	 0.15 0.20
Readiness (warm-up) time, min, max.	1
Operation mode	continuous
Mean (estimated) time between malfunctions, hours, min.	100 000
Mean life time	10
Acceptable relative air humidity, %	80 at a temperature +35°C
Insulation resistance in AC circuit 220 V, MOhm, min. - at normal operating conditions - at 80% relative humidity, temperature +35°C	 40 2
Man-made interference voltage, dB·μV, max. - at 0.15 to 0.5 MHz frequencies - at 0.5 to 2.5 MHz frequencies - at 2.5 to 30 MHz frequencies	 80 74 60
Guarantee service life, months	24
Transportation conditions as per GOST (ГОСТ) 23216-78 standard	Ж (Hard)
Storage conditions as per GOST 11550-69 standard	Ж3 (Hard, meeting the requirements of the product description and operating manual)

Displays and Controls

The MK22 module front panels differ, depending on the hardware version. The MK22 module front panels layout is shown in Figure 1.

Any kind of front panel contains the following elements:

- a handle to install/dismantle the module in the bay;
- captive screws;
- a **D.port** diagnostic interface connector;
- a hidden **Reset** button to reset the module;
- the module status **Ok**. LED.

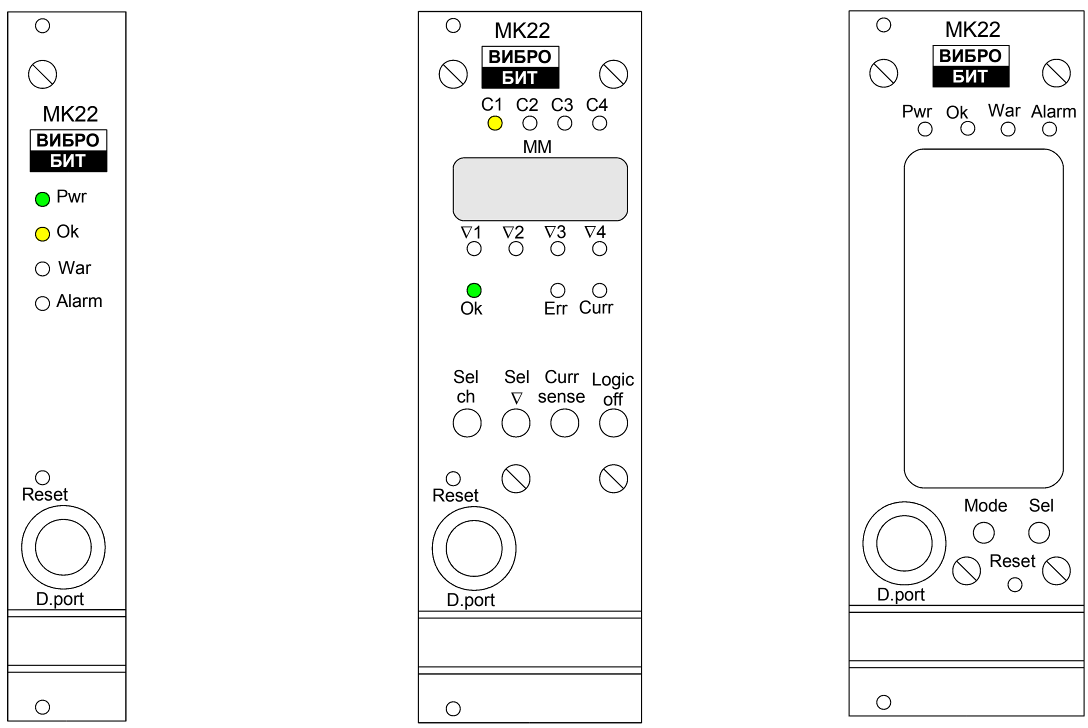
The **Ok** LED color displays the module status:

- _green color_ - normal operation of the module;
- _yellow color_ - the output logic signaling is disabled by the user or after the module reset;
- _red color_ - a fatal error of the module operation, the module operation is locked;
- _blinking green (yellow) color_ - a detected error according to one of the measurement channels test.

The MK22-DC Hardware Version

A narrow front panel (20 mm width) with a limited system of displays and controls. One can browse the measuring results only at their reading via digital communication interfaces. The module front panel as well contains:

- a green ***'Pwr'*** LED – switching on the block power;
- the two-color ***'Ok'*** LED – the module status indication;
- the yellow ***'War'*** LED – warning (the LED operation logics is defined by the user);
- the red ***'Alarm'*** LED – alarm (the LED operation logics is defined by the user).



a) MK22-DC b) MK22-DC-11 c) MK22-DC-001

Figure 1. The MK22 front panel layout

The MK22-DC-11 Hardware Version

The MK22 module front panel with a 7-segment 4-digit LED indicator unit, accessorial signal LEDs and action buttons. This MK22 module version displays on the indicator unit only one measuring channel information at a time.

The front panel contains:

- Four yellow LEDs: ***'C 1', 'C2', 'C3'*** and ***'C4'***, indicating the chosen measuring channel.
- A digital 7-segment 4-digit indicator unit to present the measured parameters values and to display messages.
- Four yellow LEDs ***'∇1'***, ***'∇2'***, ***'∇3'*** and ***'∇4'***, indicating the parameter overrunning the corresponding setpoints of the selected measuring channel. While indicating the setpoint value, the corresponding setpoint LED blinks.
- A two-color ***'Ok'*** LED – the module status indication.
- A red ***'Err'*** LED - indication of the chosen measuring channel failure. If the channel functioning is normalized, but the pause between the normalization and the parameter value test for matching the setpoints has not yet been hold, the ***'Err'*** LED blinks.
- A yellow ***'Curr'*** LED – indication of the effective value of the sensor current (an engineering information). When displaying the sensor current on the chosen channel indicator unit, the ***Curr'*** LED blinks.
- Four action buttons:
  - ***'Sel ch'*** – choosing a measuring channel to display the parameter value and the measuring channel status (inoperative measuring channels are not represented).
  - ***'Sel ∇'*** – indicating the setpoints values (inoperative setpoints are not represented).
  - ***'Curr sense'*** – indicating the sensor current.
  - ***'Logic off'*** – locking the logic outputs operation.
- An opening for pressing the "Reset" hidden button.
- The diagnostic interface connector.
- A handle for comfortable dismantling the module from the frame.

Switching between the measuring channels is performed via pressing the ***"Sel ch"*** button. At choosing a new measuring channel, the indicator unit immediately displays the chosen channel main parameter effective value.

Note: Switching to displaying the information by the measurement channel is not performed, if the measurement channel operation is disabled in the MK22 module settings. If all the measurement channels are disabled in the module settings, the indicator unit displays "OFF".

Setpoints values rolling is performed via pressing the ***'Sel ∇'*** button. The indicator unit displays a setpoint value, at that the corresponding setpoint LED will blink. If, within the set period of time, there is no switch to the next setpoint, the module will come over to the main measured parameter indication.

Note: If a setpoint is disabled in the module settings, this setpoint is not displayed on the indicator unit. If no setpoints functioning is enabled, the setpoints values are not displayed on the indicator unit.

To display the sensor current on the indicator unit, it is required to press the ***'Curr sense'*** button. The indicator unit displays the sensor current in the ##.## format, even in case the sensor failure is detected, at that the ***'Curr'*** LED blinks.

Activation/shutdown of the logic outputs is performed via pressing and holding the ***"Logic off'*** button down until the logic output operation mode switching takes place. When the logic outputs operation is locked, the "Ok" LED lights yellow, and all the logic outputs are in dormant state.

Every measuring channel can be adjusted in its own displaying format of measured parameter values. At an attempt of sending to the indicator unit a value, falling outside the acceptable limits, the indicator unit will display the maximum acceptable value (for negative values - the minimum acceptable value).

Table 3. Picture Formats of the MK22 Module Indicator Unit

The mode code	Picture format	Acceptable values
0	#.###	from 0.000 to 9.999
1	##.##	from –9.99 to 99.99
2	###.#	from –99.9 to 999.99
3	####	from –999 to 9999

The MK22-DC-001 Hardware Version

The MK22 module front panel with a special-purpose symbolic-digital LCD, signal LEDs and action buttons. The indicator unit displays the measuring results and the statuses for all the measuring channels together.

Figure 2. An example of the LCD data display

The front panel contains:

- A special-purpose LCD with built-in lighting.
- Signal LEDs:
  - A green **'Pwr'** LED – switching on the block power supply.
  - A two-color **'Ok'** LED – the module status.
  - A yellow **'War'** LED – warning (the LED operation logics is defined by the user).
  - A red **'Alarm'** LED – alarm (the LED operation logics is defined by the user).

Two action buttons:

- The **'Mode'** button - selection of the display mode.
- The **'Sel'** button - selection of the displayed data.

The '**V1**', '**V2**', '**V3**', '**V4**' symbols (framed) send a signal of the measured parameter value overrunning the setpoints.

The '**Er**' symbol (framed) shows, that there is a sensor failure on the channel, the measured parameter value is accepted to be equal to zero (the LCD displays zero), the corresponding measuring channel setpoints signaling is in dormant state.

As soon as the measuring channel operation is normalized, the symbol '**Er**' will start to blink and the block will count the measuring channel operation normalization timeout (set by the user).

To view the sensors direct current on the indicator unit, press and hold down the **Mode** button until the LCD displays the sensors current values (for two channels together). During the sensors current representation, the LCD displays "mA" metric units symbols, and does not display the symbols of the measured parameter value overrunning the setpoints. Resetting to the normal indication mode takes place via reholding down the **Mode** button or automatically by the timeout.

To view the setpoints values on the LCD, press and hold down the **Sel** button until the **K1** symbol of the first measuring channel and the **V1** symbol of the first setpoint start to blink. Briefly pressing the **Sel** button again gives an opportunity to view all the 4 setpoints for the current measuring channel. The setpoints values are displayed instead of the measuring results. If a setpoint is deactivated (in the module settings), dashes are displayed instead of the setpoint value.

One can view another measuring channel setpoints values via pressing the **Mode** button in the setpoints displaying mode. Resetting to the normal indication mode takes place via reholding down the **Sel** button or automatically by the timeout.

Activation/shutdown of the logic outputs is performed via simultaneous pressing and holding down the **Mode**-**Sel** buttons until the logic output operation mode switching takes place. When the logic outputs operation is locked, the **Ok** LED lights yellow, and all the logic outputs are in dormant state.

The Module Operation

Switching the power on

After switching the power on, the MK22 module operation parameters are loaded from the nonvolatile memory. The operation parameters are divided into sections:

- measuring channels parameters;
- system parameters and communication interfaces parameters.

Every operation parameters section in the nonvolatile memory is added with a check sum, enabling to verify the loaded data. If the computed check sum does not coincide with the sum, recorded in the nonvolatile memory, the data are considered to be corrupted and unacceptable for the module operation.

Every section in the nonvolatile memory has its main and reserve allocation. If a parameter section from the nonvolatile memory is read with a mistake, there goes a try to read the data from the reserve area of the nonvolatile memory.

If a mistake is detected in relation to one of the operation parameters sections (from the main and reserve sections), the module operation will be locked, there will be present an active signal level on Logic output 12, the **'Ok'** LED on the front panel will light red.

Under a normal load of the operation parameters before the MK22 module operation commencement:

- ***MK22-DC*** – the "Ok" LED blinks yellow, showing the progress of the module startup initialization;
- ***MK22-DC-11, MK22-DC-001*** - the "Ok" LED lights yellow, the indicator unit displays the module serial number, after which - the module year of manufacture, and then the MK22 startup initialization is performed.

Note: It is not recommended, but considered acceptable to perform a "hot" MK22 module exchange in the section without power off for all the MK22 module hardware versions.

After switching the MK22 module power on (reset), the logic outputs functioning is locked for the set period of time. If the logic outputs functioning is locked, the **'Ok'** LED lights yellow.

The Module Reset

The module reset implies the microcontroller hardware reset and performance of the action sequence, corresponding to switching the power on. Possible reasons of the MK22 module reset:

- switching the module power on;
- reset by the user command (via the "Reset" button on the module front panel or via the command through digital communication interfaces);
- the microcontroller supply undervoltage (power source failure);
- a watchdog timer reset by reason of the microcontroller program hangup.

Through the opening on the front panel via pressing the "Reset" hidden button, installed on the MK22 module card, a user can perform the module reset and the module "Cold start".

To perform the module reset, briefly press the "Reset" button, then press the "Reset' button and hold it down until the module is reset.

Note: The module can be reset only after the identification information is displayed, and the MK22 module initialization cycle is accomplished.

The Module "Cold Start"

A "Cold start" is destined for recording the default operation parameters into the module nonvolatile memory. This function is useful at an initial module start after manufacture or when it is required to perform the module recalibration, to set known operation parameters.

Transition into the "Cold start" mode is performed via holding down the "Reset" button during all the cycle of identification information output and the module initialization after its reset.

If the module has switched to the "Cold start" mode:

- ***MK22-DC*** – the "Ok" LED will blink yellow synchronously with the "War" LED.
- ***MK22DC-11, MK22-DC-001***– the "Cold" caption will blink on the indicator unit.

After transition to the "Cold start" mode, it is required to confirm the module "Cold start". The "Cold start" confirmation is performed via sequential pressing the "Reset" button, analogous to the sequence of the module reset in the normal operating mode (a brief "Reset" button pressing, subsequent pressing the button and holding it down).

At the "Cold start" confirmation, the module settings are initialized as default settings and are saved in the nonvolatile memory, after which the module reset is performed. If the "Cold start" confirmation is not performed, the module proceeds to normal operation.

MK22-DC

During recording to the nonvolatile memory, the "War" LED blinks. The recording results can be identified by the "Ok" LED light color:

- *green* - the recording was accomplished without mistakes;
- *yellow* - one or several sections were correctly recorded to the nonvolatile memory with second shot;
- *red* - one or several sections were recorded to the nonvolatile memory with a mistake.

MK22-DC-11, MK22-DC-001

During recording, the "Load" caption is displayed on the indicator unit. The recording results can be identified by the "Ok" LED light color (analogous to the "Slim" variant) and by the message on the indicator unit.

- "Good" - the recording was accomplished without mistakes;
- "bad" - one or several sections were correctly recorded to the nonvolatile memory with second shot;
- "Err"- one or several sections were recorded to the nonvolatile memory with a mistake.

The results of the operation parameters recording to the nonvolatile memory are displayed for 2 seconds, after which the module is automatically reset.

Parameters Measurement

The MK22 module operates in real-time mode with measuring results update rate of 100 ms. The MK22 module performs the following operations:

- measures constant signal level by measuring channels;
- computes the sensor current and monitors the sensor operability;
- computes the measured parameter real values;
- compares the computed parameter values to the setpoints and signals overrunning setpoints;
- sends the measured values to the unified outputs;
- forms logic signaling;
- updates the indicator units data;

All the measuring channels operate identically and synchronously. There is only a difference in the adjustment parameters and the input signal type, which is set by means of a jumper on the MK22 card (for the jumpers destination and their positions see the appendix):

- current 4 – 20 mA;
- current 1 – 5 mA;
- voltage 0 - 3 V.

The measuring channels inputs are equipped with resettable fuses and protective Zener breakdown diodes (triacs), preventing the module input circuits damaging by pulse disturbances or by a dangerous voltage level.

Measuring the Sensor Current

The input current signal should be transformed into voltage. For that purpose, the measuring channels input circuits are equipped with current resistors, matching the sensor signal current range, and with removable jumpers. Input signals voltage range is from 0 to 3 V.

> ***Note:*** During a measuring channel operating with voltage signals, it is advisable to margin the desired signal range in order to implement the function of the sensor operability testing.

The input signal (voltage) passes through the LF filter and goes to the 12-digit ADC, embedded into the microcontroller. 512 ADC values are sampled for every measuring channel during 100 ms. The ADC average value is used for further sensor current computing. A large number of ADC samples give an opportunity to obtain the actual ADC direct current 14 bit resolution by means of averaging.

The sensor current is computed by the linear equation formula:

$$I_{sense} = A_I + B_I \cdot ADC;$$

Where:

I_{sense} – the sensor current computed value;

ADC - an averaged ADC value;

A_I, B_I – linear equation coefficients to compute the sensor current.

The sensor current value I_{sense} can be displayed on the indicator unit and is used in the sensor test algorithm to compute the measure parameter value.

The A_I, B_I coefficients are automatically computed at the module startup, based on the sensor current range data (20% of `InRangeCurrMax`, `InRangeCurrMax`) and saved ADC values (`AdcInMin`, `AdcInMax`), matching the current input range of the calibrated sensor.

> ***Note:*** If one of the calibrated values pairs (20% of `InRangeCurrMax`, `InRangeCurrMax` or `AdcInMin`, `AdcInMax`) is equal to zero or they are equal to each other, the A_I, B_I coefficients are not computed and accepted to be equal to zero (the sensor current I_{sense} is always equal to zero).

The Sensor Operability Test

The sensor test is performed based on the I_{sense} computed value. The sensor is considered to be operable, if the value is within the `CurrValidMin, CurrValidMax`) acceptable limits, set during the module setup.

The minimum/maximum sensor current control can be disabled in the module settings (`EnaCurrValidMin`, `EnaCurrValidMax` respectively). If the sensor current control is disabled by one of the edges, the sensor is considered to be operable, independent from the computed sensor current.

The sensor current disabling may be useful, for example, during the MK61 module operation as a part of the Automated Vibration Monitoring System (AVMS) and receiving synchronization pulses from the MK22 module.

If the I_{sense} value is below the minimum acceptable current level `CurrValidMin`, the sensor signal level is considered to be too low (the `ErrorSenseLow, FlagError` flags are set). To normalize the measuring channel operation, the I_{sense} value should be higher `CurrValidMin + CurrValidHist` (the `ErrorSenseLow` flag is dropped).

If the I_{sense} value is above the maximum acceptable current level `CurrValidMax`, the sensor signal level is considered to be too high (the `ErrorSenseHigh, FlagError` flags are set). To normalize the measuring channel operation, the I_{sense} value should be lower`CurrValidMax + CurrValidHist` (the `ErrorSenseHigh` flag is dropped).

At every set flag of abnormal level of the sensor current (`ErrorSenseLow, ErrorSenseHigh`), the measured parameter value is accepted to be equal to zero.

It is not recommended to set the sensor current test hysteresis value (`CurrValidHist`) equal to zero, as it may provoke the effect of frequent signaling switching.

After the sensor operation normalization and the `ErrorSenseLow`, `ErrorSenseHigh`flags drop, the `FlagError` flag is dropped after the set period of time `TestPointSenseOk`. After the `FlagError` flag drop, the computed measured parameter value is compared to the setpoints.

The figure displays an example of work of the sensor test algorithm under the sensor direct current below the acceptable level. The sensor acceptable current levels are equal to 0.9 mA and 5.1 mA respectively, the hysteresis is 0.1 mA.

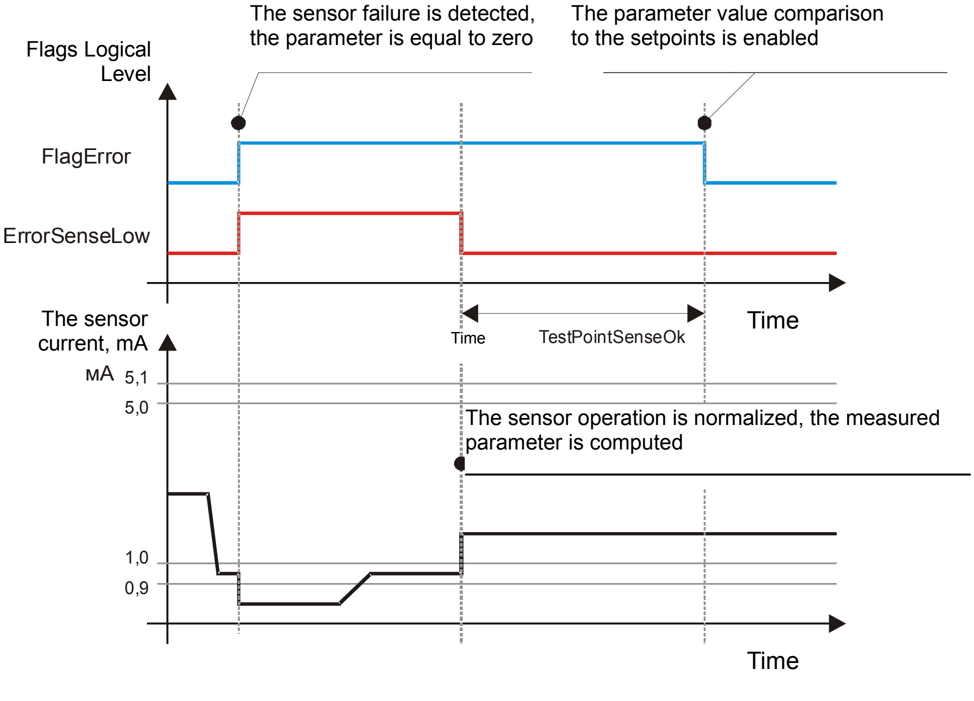


Figure 3. Work of the sensor test algorithm under the sensor direct current below the acceptable level.

After the module reset, the sensor is considered to be intact, but it is required to count the timeout before comparing the parameter value to the setpoints, as soon as after a reset the `FlagError` flag is automatically set.

Measuring the value of the Parameter, Presented by a Direct Current Value

The parameter value is computed from the value of the measured sensor current, if no sensor failure is detected (the ErrorSenseLow, `ErrorSenseHigh` flags are dropped). In case a sensor failure is detected (one of the `ErrorSenseLow`, `ErrorSenseHigh` flags is set), the measured parameter value is not computed and is accepted to be equal to zero.

The measured parameter value is computed by the linear equation formula:

$$D_{Param} = A_P + B_P \cdot I_{sense};$$

Where:

D_{Param} – the measured parameter computed value;

I_{sense} – the sensor current computed value;

A_P, B_P – linear equation coefficients to compute the measured parameter value.

The D_{Param} value is the main measured parameter, used for:

- comparison to the setpoints;
- displaying on the indicator unit as the main parameter;
- computing the DAC value for the unified output.

The A_P, B_P coefficients are automatically computed at the module startup, based on the sensor current range data (`InRangeCurrMin, InRangeCurrMax`) and the measured parameter set range (`RangeParamMin, RangeParamMax`).

Note: If one of the values pairs (20% of `InRangeCurrMin, InRangeCurrMax` или `AdcInMin, AdcInMax`) is equal to zero or they are equal to each other, the A_P, B_P coefficients are not computed and are accepted to be equal to zero (the measured parameter value D_{Param} is always equal to zero).

Averaging the Measured Parameter Value

Before using the parameter computed D_{Param} value (displaying it on the indicator unit, computing to the setpoints, computing the DAC value for the unified output) it is possible to perform the value averaging by means of the moving average method (several latest computed values of the measured parameter are averaged to get the final D_{Param} value).

Averaging depth is set during the module setup (`AverageDepth`) and may vary from 1 to 10 (1 – no averaging; 10 – maximum averaging).

Note: Averaging allows stabilizing of the measured parameter value (during indication, the measured parameter value variation will be minimal), but increasing the averaging depth leads to longer response time during the signaling and protective shutdown operation.

The format of the data output to the indicator unit is defined during the module setup (the `FormatOut` parameter). See the format of the data output to the indicator unit in Table 3.

Additionally, a user can save in the module memory the channel measuring units in symbolic form with the ASCII coding (up to 7 symbols, the `MeasurUnit` parameter) and the measuring channel name (up to 7 symbols, the `MeasurName` parameter).

Comparing the Parameter Computed Value to the Setpoints

If the `FlagError` flag is dropped (the interval after the sensor operation normalization has been counted) the measured parameter computed D_{Param} value is compared to the setpoints, set during the module setup

If the sensor failure is detected (one of the `ErrorSenseLow`, `ErrorSenseHigh flags is set`) or the `FlagError` is set , the measured parameter computed D_{Param} value is not compared to the setpoints, and all the flags of the measured parameter value overrunning the setpoints are dropped.

Every measuring channel is provided with four setpoints (`TestPointData`) with individually adjusted operation modes (`TestPointMode`), with common hysteresis level (`TestPointHist`) and a setpoint overrun response time (`TestPointTime`).

Table 4. The Setpoints Functioning Modes

The Mode Code	Description
0	The setpoint is disabled, the test is not performed
1	Testing above the setpoint
2	Testing below the setpoint

<u>Operation mode - the setpoint is disabled</u>

The measured parameter D_{Param} value is not compared to the `TestPointData` setpoint, the `OutPoint` flag is always dropped.

<u>Operation mode - testing above the setpoint</u>

If during the `TestPointTime` the D_{Param} value is higher than the `TestPointData`, the parameter value is considered to be too high, and the `OutPoint` flag is set. To drop the `OutPoint` flag (normal level), the measured parameter D_{Param} value should be lower than the `TestPointData - TestPointHist` during the `TestPointTime`.

<u>Operation mode - testing below the setpoint</u>

If during the `TestPointTime` the D_{Param} value is lower than the `TestPointData`, the parameter value is considered to be too low, and the `OutPoint` flag is set. To drop the `OutPoint` flag (normal level), the measured parameter D_{Param} value should be higher than the `TestPointData - TestPointHist` during the `TestPointTime`.

Figure 4 presents an example of the 1.7 mm setpoint signaling (control of the rotor axial offset) with a 0.02 hysteresis.

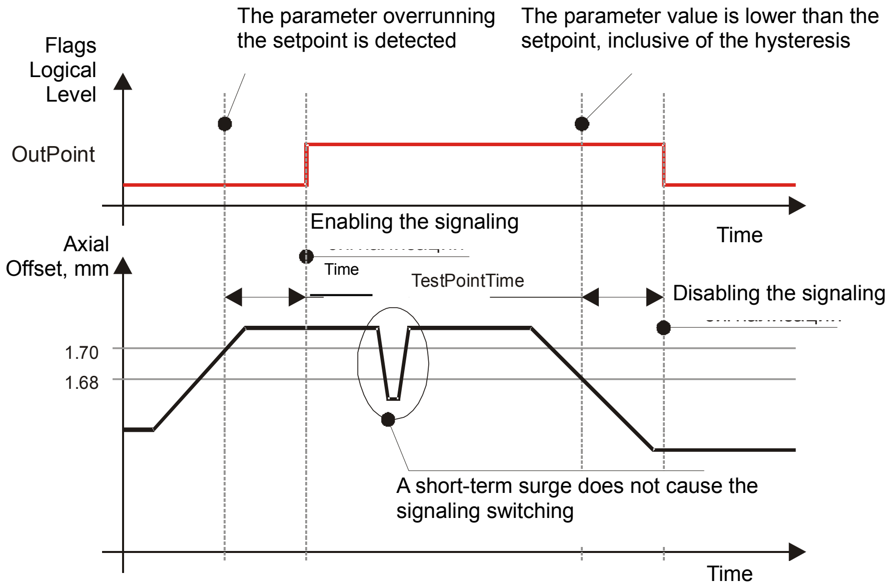


Figure 4. An example of the setpoint algorithm work
(above the setpoint test mode)

Additional Parameters Measurement

Every channel of the МК22 module, apart from the opportunity of constant signals measurement can be adjusted to work in an enhanced mode:

- Channel 1 – measurement of the rotor speed (a tachometric signal).
- Channel 2 - measurement of the rotor speed (a tachometric signal).
- Channel 3 - measurement of the rotor bowing (eccentricity) (a variable signal).
- Channel 4 - the sensor signal linearization (a constant signal), computation of the parameter according to the formula.

The measuring channels enhanced mode operation requires additional functions enabling (`EnabledAdd`).

Measuring the Rotor Speed

In the enhanced mode Channels 1 and 2 measure the rotor speed. The rotor speed measurement period is set during the module setup, and may take values from 0.1 to 1.0 seconds. In case the signal pulse period is longer than the set measuring period, the measuring period value is accepted to be equal to the signal pulses period value.

In the frequency measuring mode, the channel performs the following main operations:

- computes the sensor current and monitors the sensor operability;
- measures the rotor speed;
- repeats tachometric pulses to synchronize the control modules, measuring variable signals (only for the "Groove" control surface);
- compares the computed parameter values to the setpoints and signals setpoints overrun;
- sends the measured values to the unified outputs;
- forms logic signaling;
- updates the indicator units data;
- supports digital communication interfaces.

All the measuring channels operate identically, synchronously and independently of one another. There are several common parameters.

`FreqMeasurTime` - the rotor speed measurement period from 0.1 to 1.0 second.

`TestPointSenseOk` - the setpoints test timeout after the sensor operation normalization.

`TimeOut_TestStop` - The "STOP" mode test timeout.

Measurement of the rotor speed is performed, if no sensor failure is detected (the `ErrorSenseLow`, `ErrorSenseHigh` flags are dropped). In case a sensor failure is detected (one of the `ErrorSenseLow`, `ErrorSenseHigh` flags is set), the rotor speed is not computed and is accepted to be equal to zero.

Note: The synchronization pulses are generated (if enabled in the module settings), even if the sensor failure is detected.

The rotor speed is defined by the method of synchronization pulses period measuring, by means of computing the number of leading edges of the 10 MHz frequency clock signal between two synchronization pulses active edges.

The synchronization pulses period is averaged during a measurement cycle (defined by the `FreqMeasurTime` parameter), and then the rotor speed is computed in rpm (taking into account the adjusted pulse count per one rotor rotation).

If during a measuring cycle there was detected only one synchronization pulses period, the unaveraged period value is used for the frequency computing.

The minimum measured rotor speed is set by the `FrequencyMin` parameter (minimum 0.9 rpm).

If the rotor speed is less the set value, the synchronization pulses are considered to be absent (the rotor is stopped).

The active edge polarity of input pulses and repeated synchronization pulses is determined by means of the software (`PolarityIn,PolarityOut`).

Synchronization pulses are generated only being enabled in the module settings (the `PulseEna` parameter).

The "STOP" signaling test enabling is defined by the `StopTestEna` parameter.

The setpoints test in the "STOP" mode is enabled by the `PointStopEna` parameter.

Note: Starting from the module software version 1.20 (dated 25.07.2012) there was added the "Synchronization pulses period minimum time, ms" (`PulsePeriodMin`), giving the opportunity to perform high-frequency noise program filtration in the rotor speed measuring channel. The parameter range is from 0 to 49.99 ms. A 0 value (more or equal to 50 ms) - the function is disabled.

Thus, starting with version 1.20, there was corrected the error of appearing "Stop" caption (in the rotor speed measuring mode) in case of the measuring channel failure for МИ001 indicator.

Measuring the Rotor Bowing (Eccentricity)

In the enhanced mode, the third channel measures the rotor bowing (eccentricity) amount via the method of the sensor signals spectrum analysis in real-time mode, and performs signaling and the equipment protective shutdown functions. Measured parameters and protective functions in real-time mode:

- Rotational frequency F (available via communication interfaces).
- Rotor bowing (excursion) according to the first rotational component.
- Accumulated rotor bowing (polyharmonic excursion) according to the ½, 1-10-th rotational components.
- Available via communication interfaces, the excursion according to the ½, 1-10-th rotational components.
- Available via communication interfaces, the phase according to the ½, 1-10-th rotational components.
- Constant offset (slack).
- Sensor operability control.

The rotor bowing measuring is performed according to the FFT method. Depending on the rotor speed, there provided two kinds of FFT:

- If the speed is over 90 rpm - 512 samplings are performed during 2 rotor rotations - FFT with resolution, equal to ½ of the rotor speed. The FFT results are used to compute rotational components of the rotor excursion and bowing phase.
- If the speed is below 90 rpm - 512 samplings are performed during 1 rotor rotation - FFT with resolution, equal to the rotor speed. The FFT results are used to compute rotational components of the rotor excursion and bowing phase. Bowing and phase values according to the ½, 1½, 2½ .... 9½ components are not computed and take zero value.

The measuring results are updated at 0.1 sec interval.

The rotor speed measuring for FFT execution is performed similar to channels 1 and 2, as described above.

The bowing measurement synchronization mode is defined by the `SyncMode` parameter:

- If `SyncMode` is set to 0 - the main synchronization channel is the synchronization pulse input No1. In case of pulses absence over the synchronization input No1, computing synchronization automatically switches to input No 2.
- If `SyncMode` is set to 1 - the main synchronization channel is the synchronization pulse input No1.
- If `SyncMode` is set to 2 - the main synchronization channel is the synchronization pulse input No2.

Input pulses polarity is determined by the `SyncPolar` parameter.

To work with different control surfaces (groove, pinion), there provided the `SyncTooth` parameter, which determines pulse count per one rotation. In case the `SyncTooth` is over 1 (pinion), the phase is not computed.

To ensure reliable computing of the phase components, the MK22 module is fitted with the following adjustable parameters:

`PhaseCorrModul` - the LPF module phase shift correction.

`PhaseCorrSense` - the sensor filters phase shift correction.

`PhaseCorrConst` - constant phase shift for the first rotational

`PhaseMinVar` - minimum rotational component excursion to compute the phase.

In case of synchronization pulses absence, low or too high synchronization pulses frequency, all the calculations, involving the device speed, are locked, the corresponding quantities values become equal to zero.

To detest synchronization pulses absence of invalid synchronization pulses, the MK22 settings are provided with the following parameters:
`FreqControl` – enabling the rotor speed control;
`FreqValidMin` – minimum acceptable rotor speed;
`FreqValidMax` – maximum acceptable rotor speed.

The sensor current is computed according to the constant component, acquired as the result of ADC samples averaging. Conversion of the received constant component value from the ADC dimension into the sensor current is performed similarly to the described above channel operation upon direct current measuring.

Constant sensor offset (slack) is computed on the base of the set operation range data and of the sensor averaged current.

For the purpose of FFT computations speedup, fixed point mathematics is applied, which in its turn introduces additional noise in the conversion resultant spectrum. The ADC quantizing and fixed point computing noise manifests itself as low-level energies over all the resultant spectrum harmonic components, though there are no these components in the source signal. When summing up the harmonic components energy to compute the root mean square value (RMS) in the required frequency range, the noise may substantially distort the parameter real value.

To compensate the ADC quantizing and computing noise, there were introduced parameters of minimum acceptable level of harmonic components squared energy in the ADC dimension.

`MagNoice` – the minimum acceptable level of harmonic component squared amplitude in the ADC dimension, multiplied by 4.

The Sensor Signal Linearization

In the enhanced mode, the fourth channel is able to perform the sensor signal linearization. Linearization is required during operation of a measuring channel with nonlinear transfer sensors, as well as for reducing measurement uncertainty.

Linearization mode is enabled via setting the `EnabledAdd` parameter equal to 1.

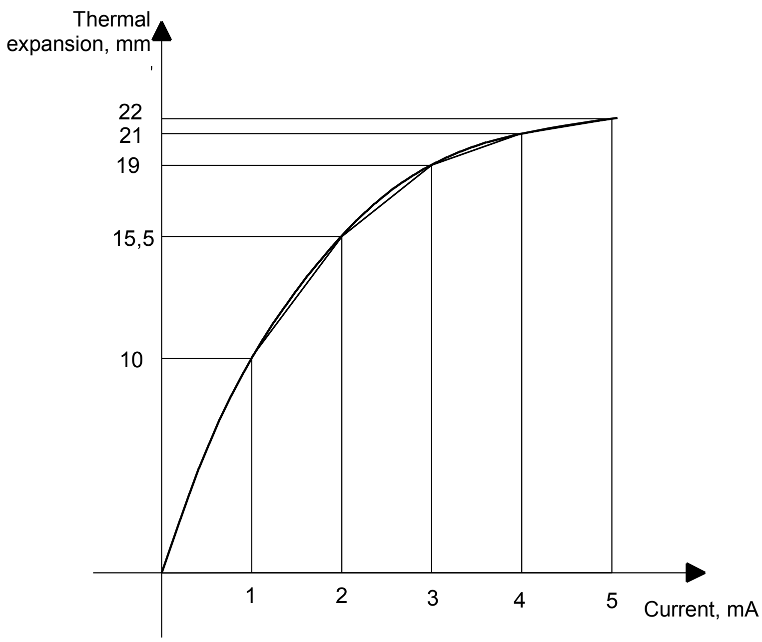
The sensor signal linearization is performed via the piecewise linear approximation method according to the Table of parameters values (`Data_1 … Data_16`) and output currents (`Current_1 … Current_16`) correspondence for the used sensor (table 16).

Table entries number is determined by the `LinearTableSize` parameter, minimum entries number - 2, maximum - 16.

Signal processing sequence of a linearization function sensor:

- the sensor current is computed according to the ADC received data;
- the parameter computing linear coefficients are defined according to the linearization table, in correspondence with the sensor current;
- the measured parameter value is computed;
- the parameter value is compared to the setpoints.

Figure 5 presents an example of a sensor performance and a linearization table.



№	Current, mA	Thermal expansion, mm
1	1	10
2	2	15.5
3	3	19
4	4	21
5	5	22

Figure 5. An example of a sensor performance and a linearization table.

Computing the Parameter by the Formula

Another additional function of the fourth channel in the enhanced mode is the capability of computing the parameter by the formula. Particularly, such function can be used to recompute the parameter with a coefficient, to compute the parameter in accordance with measurement of Channels 1, 2 and 3, and for other mathematic operations with the use of the measuring results and the sensors currents of the first, the second or the third channels.

The mode of computing the parameter by the formula is enabled via setting the `EnabledAdd` parameter equal to 2.

The MK22 control formula for implementation of the parameter computing is provided with the following parameters:

`CheckChannelError` - when computing the Channel 4 value (4 words), consideration must be given to the measuring channels failure flag.

In case of recording a non-zero value into the `CheckChannelError` register fields, corresponding to any of the measuring channels, and upon condition of actuating one (or more) mentioned channels failure flag, the Channel 4 parameter value is not going to be computed and will take a zero value.

`Constant` – the array of constants, used in computing (8 constants "float 4").

`Instruction` – a sequence of operations to compute the parameter value for Channel 4 (32 commands)

A command structure (`Instruction`):

- bits 0-7: the operation code;
- bits 8-11: the operand types (data source), used in the operation;
- bits 12-15: the operand address;

Thus, every command is presented by two bytes: {the operand address:the operand type} {the operation code}, where bytes are recorded in the following order {high byte} {low byte}.

Operations codes:

- 0x00 - no operation;
- 0x01 - final operation, denotes computation end in the formula;
- 0x02 - record the value into the register (accumulator);
- 0x03 - record the register contents into the internal memory (4 cells of the "float 4" type);
- 0x04 - addition;
- 0x05 - subtraction;
- 0x06 - multiplication;
- 0x07 - division;
- 0x08 - unary minus;
- Operand types:
- 0x00 - no data source;
- 0x01 - the channel parameter value;
- 0x02 - the channel current;
- 0x03 - internal memory;
- 0x04 - constant;
- Operand address:
- for the channel parameter value: 0x00 … 0x02 — channels numbers;
- for the channel current value: 0x00 … 0x02 — channels numbers;
- for the internal memory: 0x00 … 0x03;
- for the constants: 0x00 … 0x07.

An example of computing the Channel 4 parameter by the formula: Ch4 = I1*K1 + Ch2*K2, where

Ch4 — the fourth channel parameter,

I1 — the fourth channel current,

K1 — constant 1,

Ch4 — the Channel 2 parameter,

K2 — constant 2.

Previously, record K1 and K2 constants into the `Constant` array, successively, starting with zero index.

Command sequence to compute the fourth channel parameter (`Instruction`):

- via the (0x02 0x02) command, put the first channel current value into the accumulator;
- via the (0x04 0x06) command, multiply the accumulator value by K1;
- via the (0x03 0x03) command, record the accumulator contents into the internal memory (the cell with the "0" index);

- via the (0x11 0x02) command, put the second channel parameter value into the accumulator;
- via the (0x14 0x06) command, multiply the accumulator value by K2;
- via the (0x03 0x04) command, add the contents of the memory cell with the "0" index to the accumulator;
- via the (0x01) command, inform the module about the computation completion.

Upon computation completion, the accumulator content is considered to be the Chanel 4 parameter value.

Further parameter value computing operations are performed similar to the rest of the measuring channels.

The operation sequence, loaded into the module, is performed at every measuring cycle. The previous measuring cycles results are not saved.

To save the loaded computation sequence into EEPROM, it is required to perform the corresponding sequence of commands, saving the parameters into the nonvolatile memory.

Unified Outputs

Every measuring channel in the MK22 module is provided with a unified current output. The unified output signal level is proportional to the measured parameter value. The unified output current range corresponds to the measured parameter range and can be selected during the module setup.

Setting the unified output current is performed with the help of 12-digit DAC and an active current amplifier, designed to be connected to an earthed load. The MK22 module is equipped with a protective Zener breakdown diode (breakdown voltage - 27V) and a 200 mA resettable fuse to protect the unified output circuits.

A unified output DAC value is computed by the linear equation formula:

$$DAC_{OUT} = A_O + B_O \cdot D_{Param};$$

Where:

DAC_{OUT} – the computed DAC value;

D_{Param} – the measured parameter computed value;

A_O, B_O – linear equation coefficients to compute a unified output DAC value.

The A_O, B_O coefficients are automatically computed at the module startup according to the data of the unified output current range (`OutRangeCurrMin`, `OutRangeCurrMax`), the data of the measured parameter range (`RangeParamMin`, `RangeParamMax`), the data of the range of the parameter, dumped to the unified output (`OutRangeParamMin`, `OutRangeParamMax`) and according to the saved DAC values (`DacOutMin`, `DacOutMax`), corresponding to the range of the calibrated unified output (20% of `OutRangeCurrMax`, `OutRangeCurrMax`).

In case of a measuring channel failure, the unified output current value can be set in `OutCurrentError`, if setting of the mentioned current in the unified output is enabled at a channel failure (`CurrentErrorEnabled`).

Note: If one of the calibrated values pairs (20% of `OutRangeCurrMax`,`OutRangeCurrMax` or `RangeParamMin`, `RangeParamMax`, `DacOutMin`, `DacOutMax`, `OutRangeParamMin`, `OutRangeParamMax`) is equal to zero, or they are equal to each other, the A_O, B_O coefficients are not computed and accepted to be equal to zero (the DAC_{OUT} value is always equal to zero).

Logic Outputs

The MK22 module is equipped with 12 logic outputs with an open collector (active level - zero). The logic inputs circuit engineering provides for possible direct connection of the relay windings.

Each of 12 logic output operation is adjusted by a user via communication interfaces.

If a check sum error is detected by one of the module operation parameters sections, an active level of the signal will be present on the Logic output 12, the rest of the MK22 module logic outputs will remain in dormant state.

After the block reset, the logic outputs operation is locked for the `LogicOffStartUp` time, counted after completion of the MK22 module initialization.

There is an opportunity of logic outputs lockout by the user, which may be required during the block operation parameters adjustment or its functional check without anticipation of the alarm actuation or of a safety shutdown.

The MK22 module parameter includes two "OR" matrices (`LogicMatrix`) of status flags switching (measuring channels and the module at large) to the logic outputs. The appointed status flags may be inverted before the "OR" matrix input. In case, at least, one appointed to a logic output flag is set, there will be present an active signal level on the corresponding logic output, if the logic outputs operation is not locked.

The `LogicOutMode` parameter can be used to invert a logic signal on the corresponding logic output (part from Logic output 12).

Every flag is supplied with the number of the logic output, to which it is going to be assigned. Every flag can be assigned to two different logic outputs. If, for any flag, the number of the assigned logic output is equal to zero or is over 12, the status of the corresponding flag does not influence any of the logic outputs.

Note: If for Logic outputs 1 and 2 there was appointed synchronization pulses generation from the corresponding measuring channels, the logic signaling settings for these outputs are not taken into account.

Table 5. Measuring channels flags `Status` and their position in the logic outputs matrix `LogicMatrix`.

Bit No	Indication	Description	Code	Position in the matrix			
				Ch. 1	Ch. 2	Ch. 3	Ch. 4
0	`OffMode`	The channel is disabled	xChO	16	32	48	64
1	`ErrorSenseLow`	The sensor current is below the acceptable level	xSeH	17	33	49	65
2	`ErrorSenseHigh`	The sensor current is above the acceptable level	xSeL	18	34	50	66
3	`FlagError`	The parameter is not compared to the setpoints	xChE	19	35	51	67
4	`OutPoint_1`	The parameter overrunning the setpoint 1	xOp1	20	36	52	68
5	`OutPoint_2`	The parameter overrunning the setpoint 2	xOp2	21	37	53	69
6	`OutPoint_3`	The parameter overrunning the setpoint 3	xOp3	22	38	54	70
7	`OutPoint_4`	The parameter overrunning the setpoint 4	xOp4	23	39	55	71
8	`DataStable`	The parameter is stabilized	xDst	24	40	56	72
9	`DataUnstable`	The parameter is not stabilized	xDust	25	41	57	73
10	`FreqMeasurement`	Channel 1, 2 – the frequency measuring mode Channel 3 - the bowing is being measured Channel 4 - always equal to zero	xMf	26	42	58	74
11	`ModeStop`	Channel 1, 2 - the "STOP" mode Channel 3, 4 - always equal to zero	xMs	27	43	59	75
12	`ModeStopTest`	Channel 1, 2 - the "STOP" mode test Channel 3, 4 - always equal to zero	xMst	28	44	60	76
13	`ModeResetMeasur`	Channel 1, 2 – the frequency measuring algorithm in the reset status Channel 3, 4 - always equal to zero	xMr	29	45	61	77
14	`ModeWaitPulse`	Channel 1, 2 — the frequency measuring algorithm while waiting for the "STOP" mode exit Channel 3, 4 — always equal to zero	xMw	30	46	62	78
15	`NoPulse`	Channel 1, 2 - no synchronization pulses Channel 3 - always equal to zero Channel 4 - the formula error, when Channel 4 operates in the computation mode	xMnp	31	47	63	79

Note: Instead of "x" symbol in the signaling code, one should specify the channel number (e.g. 1SeH).

Table 6. The module flags `StatusSys` and their position in the logic outputs matrix `LogicMatrix`.

Bit No	Indication	Description	Code	Position in the matrix
0	`ErrorLoadData`	Operation parameters reading from the nonvolatile memory error	ErrLD	0
1	`LoadDataReserv`	One or several operation parameters groups are read from the reserve section of the nonvolatile memory.	ResLD	1
2	`LogicOffStartUp`	Lockout of the logic outputs operation after the module reset	LgOffSt	2
3	`LogicOffUser`	Lockout of the logic outputs operation by the user command	LgOffUs	3
4	`InterfRS485_Off`	The RS485 interface is turned off	RS_Off	4
5	`InterfCAN_Off`	The CAN2.0B interface is turned off	CAN_Off	5
6	`AllowOneWrite`	A single entry access was obtained	OneWr	6
7	`AllChannelOff`	All the measuring channels are disabled	AllChOff	7
8	`RequstSignalReady`	The third channel signal sample capture has been executed, the data is ready for reading	rsRD	8
9	`RequstSignalWait`	Waiting for the third measuring channel signal sample capture	rsWT	9
10	`EEPROM_Error`	Nonvolatile memory microchip error	eepERR	10
11	`EEPROM_Lock`	Recording into the nonvolatile memory microelectronic circuit is locked	eepLC	11
12	`SaveExecut`	Recording into the nonvolatile memory microelectronic circuit is in progress	svEx	12
13	`SaveGood`	Recorded successfully	svG	13
14	`SaveFailure`	Recorded with errors	svF	14
15	`SaveNoSection`	The requested for recording section does not exist in the module.	svNS	15

Table 7. The module flags `StatusSysAdd` and their position in the logic outputs matrix `LogicMatrix`.

Bit No	Indication	Description	Code	Position in the matrix
0	`LigicMode`	Logic outputs operation mode	LgMD	0
1	`LogicExpressionError`	Logic outputs formula error	LgExEr	1

Every logic output can be adjusted in an analytical form with the help of logical rules. Similarly, the "War" and "Alarm" LEDs operation can be adjusted in an analytical form on the module front panel.

Logical operations use Boolean functions above the module status flags.

The logical rules command structure is presented in Table 25.

To set and edit the logical rules, the ModuleConfigurator.exe program is provided with a special feature, giving an opportunity to lay down logical rules in an easy and simplified form, eliminating the necessity of direct commands entry.

The indication system, used in the configuration program (ModuleConfigurator.exe) to lay down logical rules in an analytical form, is presented in Tables 5, 6, 7 (indication, description, code).

Logical operations, used in the program for laying down logical rules:

"X**->** Mg.Nbit" - recording the logical rules computations results into the global memory;

" | " - logical operation "OR";

" | " - logical operation "exclusive OR";

" & " - logical operation «AND»;

" ! " - logical operation "NOT";

" ( ) " - acceptable parentheses to set the equation order;

where X - the status flag (e.g. ErrLD).

Logical operations performing priorities (from the top downwards in sequence)

1) " ! ";

2) " & ";

3) " | " and " ^ " are equivalent;

4) " **->** ".

An example of The "Alarm" LED logical rule entry in the analytical form:
logical rule: (1Op1 & 2Op1 & 3Op1) | RS_Off | LgExEr, where:

1Op1, 2Op1, 3Op1 – flags of an overrun of the setpoint 1 by Channels 1, 2 and 3 correspondingly;
RS_Off - the RS485 interface is disabled;
LgExEr - logic outputs formula error;

Thus, the "Alarm" LED will light in case of the parameter overrunning the Setpoint 1 on all the three channels, either in case of disabled RS_Off interface, or at an error in the logic outputs formula.

Note: To change the module operation parameters, it is required to lock the logic outputs operation or to get single entry access into the operation parameters.

The Module Calibration Guidelines

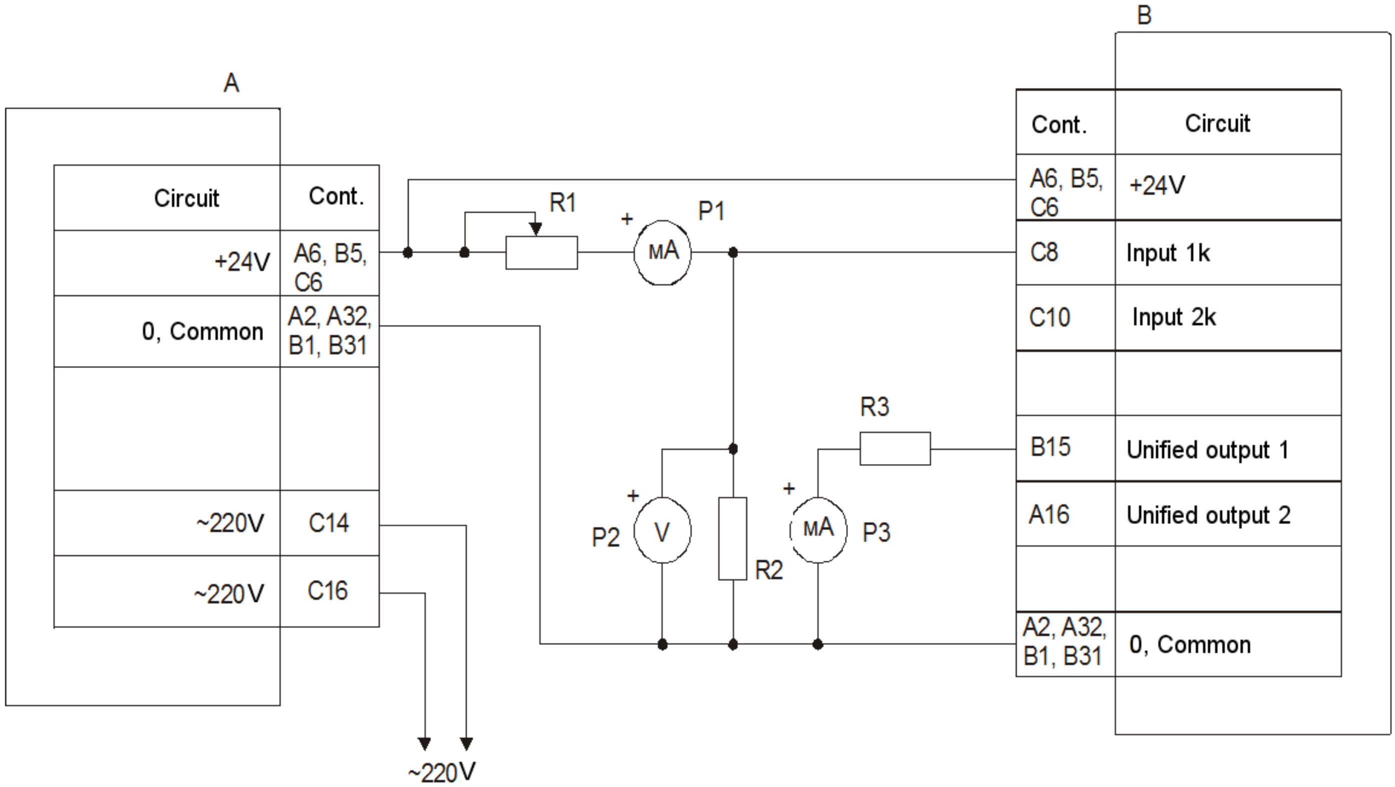
The MK22 module calibration technology gives an opportunity to perform recalibration without performing the module cold start, and to perform a measuring channel range change without the measuring channels and the unified outputs recalibration. If a channel current range or a unified output change is performed, it is required to execute a recalibration.

After the module calibration, it is required to import the data to the module, save them in the nonvolatile memory and to reset the module.

Direct Current Calibration

The MK22 module connection diagram for direct current calibration and check is displayed in Figure 6. It is recommended to calibrate the MK22 module via the СП43 bench, enabling to set up the displayed diagram.

Note: The module calibration is performed via commands over digital communication interfaces with the help of special-purpose software.



A – МП24 or БП17　***B*** – MK22　***R1*** – resistance box 100 kOhm

R2, R3 – resistors 500±10 Ohm 0.5 W　***P1, P3*** – direct current milliammeter 0-20 mA, cl. 0.2

P2 – direct current voltmeter, cl. 0.1

Note: P2, R2 are used upon voltage measuring channels check.

Figure 6. The MK22 module connection diagram for direct current calibration and check

The measuring channel input calibration sequence is fairly easy:

1. Specify the measuring channel current range value (`InRangeCurrMin`, `InRangeCurrMax`).
2. Specify the measured parameter range (`RangeParamMin`, `RangeParamMax`).
3. Set the 20% of `InRangeCurrMax` current on the measuring channel input.
4. Overwrite the `AdcConst` value into `AdcInMin`.
5. Set the `InRangeCurrMax` current on the measuring channel input.
6. Overwrite the `AdcConst` value into `AdcInMax`.
7. Communicate the calibration results into the MK22 module.
8. Perform the coefficients recomputation.

The measured parameter range change involves changing the `RangeParamMin`, `RangeParamMax` values. The measured parameter range change may require a change of the data output to the indicator unit format (`FormatOut`).

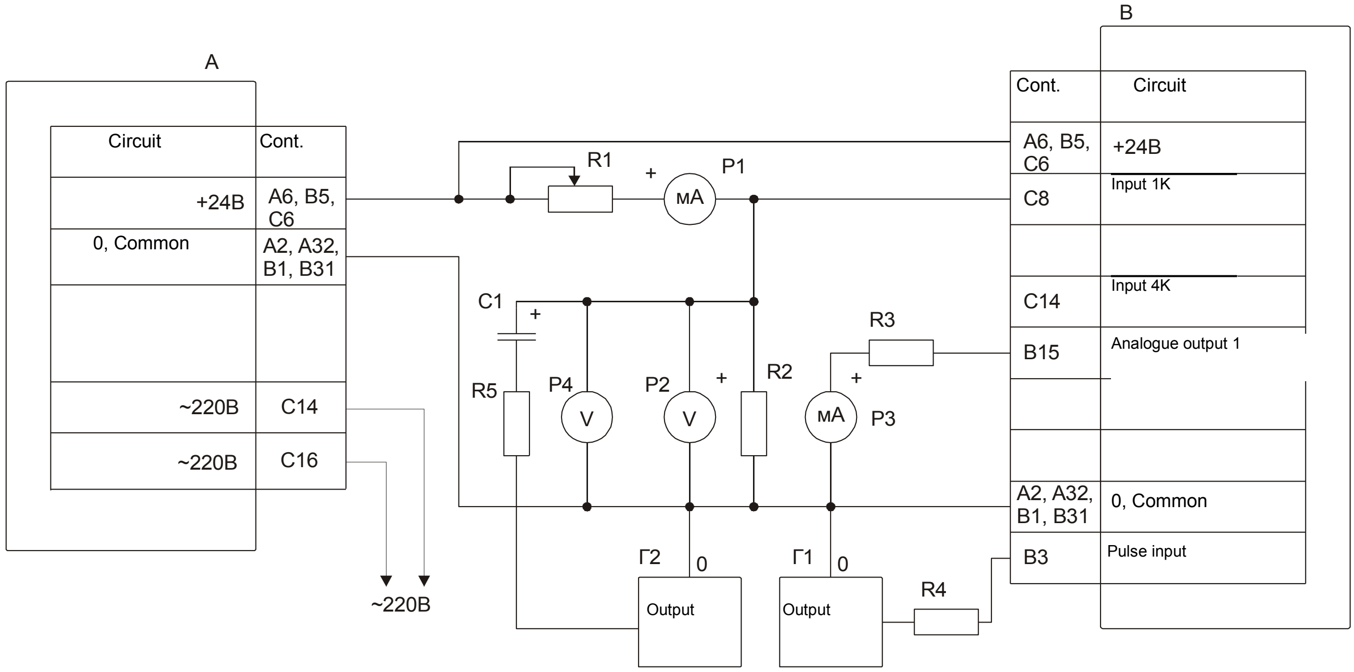
The special-purpose MK22 module configuration program is provided with the measuring channel input calibration master, substantially simplifying the calibration process.

Alternating Current Calibration

The MK22 module connection diagram for alternating current calibration and check is displayed in Figure 7.

It is recommended to calibrate the MK22 module via the СП43 bench, enabling to set up the displayed diagram.

Note: The module calibration is performed via commands over digital communication interfaces with the help of special-purpose software.



A – МП24 or БП17 ***B*** – МК22 ***R1*** – resistance box 100 kOhm

R2, R3, R4, R5 – resistors 500±10 Ohm 0.5 W ***P1, P3*** – direct current milliammeter 0-20 mA, cl. 0.2

P2 – direct current voltmeter, cl. 0.1 **P4** – alternating current voltmeter Rвх ≥ 1.0 MOhm, cl. 0.6

Г1 – square-pulse oscillator Г6-33 **Г2** – low frequency oscillator Г3-110

C1 – capacitor 1000 µF, 16 V (over measurements at a 0.05 Hz frequency minimum 50000 µF)

Note: P2, R2 are used upon voltage measuring channels check.

Figure 7. The MK22 module connection diagram for alternating current calibration and check

The measuring channel input alternating current calibration sequence:

1. Before the measuring channel input alternating current calibration it is required to perform the measuring channel input direct current calibration, as described above.
2. Set via the R1 resistor, according to the P1 milliammeter, the 3±0,2(12±0,8) mA direct current for the alternating current channel or, according to the P2 voltmeter, the 1,7±0,1 V direct voltage for the alternating voltage channel.
3. Set the 80 Hz base frequency and the +5 V square pulse amplitude on the Г1 generator.
4. Specify the measured parameter range (`RangeVarMin`, `RangeVarMax`).
5. Set the harmonic signal RMS with a value, corresponding to the 20% `RangeVarMax` bowing.
6. Overwrite the `Mag` value into `AdcVar1fMin`.
7. Set the harmonic signal RMS with a value, corresponding to the `RangeVarMax` bowing.
8. Overwrite the `Mag` value into `AdcVar1fMax`.
9. Communicate the calibration results into the MK22 module.
10. Perform the coefficients recomputation.

The measured parameter range change involves changing the `RangeVarMin`, `RangeVarMax` values. The measured parameter range change may require a change of the data output to the indicator unit format (`FormatOut`).

The special-purpose MK22 module configuration program is provided with the measuring channel input calibration master, substantially simplifying the calibration process.

The Unified Output Calibration

The unified output range over the measured parameter corresponds to the `OutRangeParamMin`, `OutRangeParamMax` range. The unified output calibration consists of the following steps:

1. Specify the unified output current range value (`OutRangeCurrMin`, `OutRangeCurrMax`).
2. Via recording the value into `AnalogDirectData`, select on the unified output the current (according to the milliammeter), equal to 20% of `OutRangeCurrMax`.
3. Overwrite the `AnalogDirectData` value into `DacOutMin`.
4. Via recording the value into `AnalogDirectData`, select on the unified output the current (according to the milliammeter), equal to `OutRangeCurrMax`.
5. Overwrite the `AnalogDirectData` value into `DacOutMax`.
6. Record zero into `AnalogDirectData` (disable the calibration mode).
7. Communicate the calibration results into the MK22 module.
8. Perform the coefficients recomputation.

The MK22 module configuration program is provided with the unified output calibration master, simplifying the calibration process.

Note: Recording of the calibration results into the MK22 module and the coefficients recomputation may be performed once, after all the calibration steps (input, unified output).

Digital Control Interfaces

The MK22 module supports three independent control interfaces:

- The RS485 interface with partial ModBus RTU protocol implementation (ample for control).
- The CAN2.0B interface (communication is performed only with expanded messages).
- The SPI slave interface for the module operation parameters adjustment.

All the interfaces can work synchronously; not interfering with each other's functioning.

Warning The power source, the RS485 drivers and the CAN2.0B interfaces microchips, and the diagnostic interface **do not have a galvanic isolation**. The MK22 module with a galvanic isolation of the communication and power interfaces is manufactured according to an additional agreement.

The RS485 Interface

To work via the RS485 interface, the MK22 card is equipped with a microchip of the RS485 bus half-duplex driver. Data communication via the RS485 interface is performed according to the ModBus RTU protocol with the option of choosing a data rate from several standard speeds, and of the module address on the bus.

Table 8. The RS485 Interface Parameters

Parameter Name	Value
Communications protocol	ModBus RTU (partial implementation)
Data format	without a parity bit, 2 stop bits
A space between messages, byte, minimum	3.5
Data rate (one of the speeds is set), bps	4800; 9600; 19200; 38400; 57600; 115200; 230400
Driver operation mode	half duplex
Maximum nodes number on the bus	256(1)
The driver input resistance, kOhm, minimum	12(1)
Electrostatic resistance, kV, minimum	$\pm$16(1)
Galvanic isolation	no(1)

Note 1: Upon condition of using the SN65HVD11 driver.

The Module Operation Parameters Adjustment According to the ModBus Protocol

The module setup is performed via recording the settings into the corresponding configuration registers upon condition of enabled recording. When recording is disabled, the NEGATIVE ACKNOLEDGE message returns to configuration registers.

Recording into the configuration registers is performed only by the **Preset Multiple Regs** command of the ModBus protocol.

The module control commands are run by the **Preset Single Registers** command of the ModBus protocol.

When receiving a wrong (incorrect) command, an error message is formed, in case of matching the request address and the module address, and the checksum is correct.

An error message format (5 bytes):

The device address

The function code with the high byte set to "1"

The error code

Check sum, low byte

Check sum, high byte

Table 9. The ModBus Protocol Errors Possible Codes

Code	Indication	Description	Notes:
0x01	ILLEGAL FUNCTION	Invalid function code	
0x02	ILLEGAL DATA ADRESS	Invalid register address	
0x03	ILLEGAL DATA VALUE	Invalid recorded value	
0x07	NEGATIVE ACKNOWLEDGE	Non-executable command	
0x09	ILLEGAL SIZE COMMAND	The function code and the received message length do not match	Nonstandard ModBus code

The ModBus Protocol Supported Commands

Table 10. The ModBus Protocol Run Commands in the MK22 Module

Code	Name, description	Request	Response	Note:
0x03	Read Holding Registers Reading the configuration registers	The device address Function (0x03) Start address, high byte Start address, low byte Nr. of reg., high byte Nr. of reg., low byte CRC low byte CRC high byte	The device address Function (0x03) Byte counter Data, high byte Data, low byte CRC low byte CRC high byte	Used for reading the measuring results and the module operation parameters
0x06	Preset Single Registers Register entry	The device address Function (0x06) Address, high byte Address, low byte Data, high byte Data, low byte CRC low byte CRC high byte	The device address Function (0x06) Address, high byte Address, low byte Data, high byte Data, low byte CRC low byte CRC high byte	Used for making the control registers entries (commands execution)
0x10	Preset Multiple Regs Several registers entries	The device address Function (0x10) Start address, high byte Start address, low byte Nr. of reg., high byte Nr. of reg., low byte Byte counter Data, high byte Data, low byte CRC low byte CRC high byte	The device address Function (0x10) Start address, high byte Start address, low byte Nr. of reg., high byte Nr. of reg., low byte CRC low byte CRC high byte	Used for recording the operation parameters into the module
0x11	Report Slave ID Identifier reading	The device address Function (0x11) CRC low byte CRC high byte	The device address Function (0x11) Byte counter Identifier (0x0B) Start indic. (0xFF) Software version, high byte Software version, low byte Module number, high byte Module number, low byte Year made, high byte Year made, low byte CRC low byte CRC high byte	
0x08	Diagnostics Diagnostic commands	The device address Function (0x08) Subfunction, high byte Subfunction, low byte Data, high byte Data, low byte CRC low byte CRC high byte	The device address Function (0x08) Subfunction, high byte Subfunction, low byte Data, high byte Data, low byte CRC low byte CRC high byte	See the supported diagnostic commands list in Table 11.

Table 11. Supported ModBus Protocol Diagnostic Commands List

Command code	Description
0x0000	Echo reply
0x0001	The ModBus protocol counters reset and exiting the Listen Only mode
0x0004	Enable the Listen Only mode
0x000A	The ModBus protocol counters reset
0x000B	Communicate the number of messages, received without errors
0x000C	Communicate the number of messages, received with check sum errors
0x000D	Communicate the number of messages, received with errors (besides check sum errors)

Computation of the Check Sum in the Messages

The CRC check sum consists of two bytes: The CRC check sum is computed by the transmission device and is added to the end of every message. The receiving device computes the check sum during the reception process and compares it to the CRC field of the received message. The CRC counter is initialized in advance with the 0xFF value. Only 8 data bits are used to compute the check sum (start, stop and parity bits are not used for the check sum computing).

The ModBus Protocol Control Characteristics

Operation parameters registers addressing and the module status is justified by 16-digit words. The "Registers number" parameter in ModBus commands is indicated in bytes.

During the operation parameters and the module status reading/writing, the data are communicated in accordance with the C language of data arrangement in the memory (a low byte, than - a high byte), and not in accordance with the ModBus standard.

If during reading/writing there were requested an odd number of bytes, a report with a corresponding error will be drawn.

Maximum volume of written/read bytes for one transaction is 256 bytes.

The MK22 module supports the 0x00 broadcast address for synchronous operation of several modules. The reply to a broadcast request is not communicated.

Note: The MK22 module card is equipped with the RS485 bus terminator. If the module is last to be activated on the RS485 bus, and there is no standard 120 Ohm terminator on the bus, normal RS485 interface functioning will demand installing on the module card a jumper, activating the bus terminator.

The CAN2.0B interface

The CAN2.0B interface gives an opportunity to communicate the MK22 module status data to indication blocks and to the collected statistics module. The MK22 module supports module control via the CAN2.0B interface.

Table 12. The CAN2.0B Interface Parameters

Parameter Name	Value
Operation mode	data communication in an active mode with an opportunity of the bus reset generation
Messages format	only expanded
Communications protocol,	unified to work within the "VIBROBIT 300" equipment
The code for the indication blocks	0x22 (34)
Data rate (one of the speeds is set), bps	1000; 500; 250; 200; 125; 100; 80; 40
Compliance with the CAN bus standard	ISO-11898(1)
Maximum nodes number on the bus	120(1)
The driver input resistance, kOhm, minimum	5(1)
Electrostatic resistance, kV, minimum	±16(1)
Galvanic isolation	no(1)

Note 1: Upon condition of using the SN65HVD235 driver.

The module CAN controller operates in an active mode, i.e. it produces a dominant confirmation of the received messages and can generate into the CAN bus active reset messages (for example, in case of wrong indicated data rate).

All the nodes on the CAN bus should have the same data rate. Under increasing the data rate, the CAN bus physical maximum length is decreased. Maximum acceptable CAN bus length at the 1000 kbit/s data rate is 40 meters, and at the 40 kbit/s speed - 1000 meters.

Note: The MK22 module card is equipped with the CAN2.0B bus terminator. If the module is last to be activated on the CAN2.0B bus, and there is no standard 120 Ohm terminator on the bus, normal CAN2.0B interface functioning will demand installing on the module card a jumper, activating the bus terminator.

Standard Operation Mode

To enable the CAN2.0B interface standard mode operation, it is required to set the following parameters:

- enabling the CAN2.0B interface operation (`CanEnabled`);
- data rate (`CanSpeed`);
- the module address (`CanBasicAddress`);
- message sending frequency (`CanBasicTime`);
- enabling communication by measuring channels (`CanBasicDataOut`).

Measuring results data are communicated with the `CanBasicTime` frequency. For every measuring channel there is generated its own message with a unique message code:

Table 13. The SPI Slave Interface Parameters

Data name	Messages codes by measuring channels			
	Channel 1	Channel 2	Channel 3	Channel 4
The measured parameter value	0x30	0x40	0x50	0x60
The measured parameter minimum value	0x31	0x41	0x51	0x61
The measured parameter maximum value	0x32	0x42	0x52	0x62
Additional parameter 1 value	0x33	0x43	0x53	0x63
Additional parameter 2 value	0x34	0x44	0x54	0x64

Every message is communicating the module status bites values, as well as the status bites of the corresponding measuring channel.

Messages are communicated sequentially: the first channel message, then - the second. A new message is not communicated to the bus, until the previous one has been communicated. If a current message cannot be communicated within 200 ms, its communication cancels.

If the `CanBasicDataOut` flag is not equal to zero, the corresponding measuring channel message is communicated via the CAN2.0B interface. If all the CanBasicDataOut flags are equal to zero, the module does not communicate any messages via the CAN2.0B interface, but the module generates confirmation of normal communication of messages of other modules, connected to the CAN2.0B bus.

The byte number in the message							
0	1	2	3	4	5	6	7
The message code	The module status	The parameter value (float f bytes)				The measuring channel status	
	StatusSys<7:0>					StatusCH<15:0>	

Figure 8. The CAN Message Format

The SPI Slave Interface

The SPI Slave Interface is destined for the module operation control and its operation parameters adjustment. The SPI interface connector is located on the module front panel (diagnostic connector). The SPI Slave Interface parameters are strictly predetermined, so, irrespective of the MK22 module current status, the SPI interface is always accessible for the module control.

The MK22 module setup can be performed by means of the ПН31adjuster device or a personal computer. A setup via a personal computer requires launching special software and connecting the block to the personal computer by means of the MC01 diagnostic interface card (the RS232 PC interface) or the MC01 USB (the USB PC interface).

Note: The block setup with the help of the MC01 USB requires installation on the computer of a virtual COM port driver.

Table 14. The SPI Slave Interface Parameters

Parameter Name	**Value**
The MK22 address on the SPI interface	0x38
The address format at the module registers appeal	16 bit
Data rate, kb/s, max.	400
Direct voltage on the diagnostic connector for the matching device power, V	5 ± 0.2
Acceptable consumption current in the power-supply circuit on the diagnostic connector, mA, maximum	50
Galvanic isolation	no

Note: The MK22 module provides the opportunity of "hot" connecting/disconnecting an adjuster device and the MC01, MC01 USB diagnostic interface cards.

Setup Parameters and the Module Present Status (Addresses Tables)

Measuring Channels Parameters and the Module System Settings

Table 15. List of the measuring channels calibration registers

Name	Indication	Type (byte)	Address (Hex)				Value by default	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
The sensor current range lower level	`InRangeCurrMin`	Float (4)	0x600	0x700	0x800	0x900	1.0	
The sensor current range upper level	`InRangeCurrMax`	Float (4)	0x604	0x704	0x804	0x904	5.0	
Enabling the sensor test by the lower limit (0 - the sensor test is not performed)	`EnaCurrValidMin`	Uint (2)	0x608	0x708	0x808	0x908	0	
Enabling the sensor test by the upper limit (0 - the sensor test is not performed)	`EnaCurrValidMax`	Uint (2)	0x60A	0x70A	0x80A	0x90A	0	
The sensor current lower acceptable limit	`CurrValidMin`	Float (4)	0x60C	0x70C	0x80C	0x90C	0.7	
The sensor current upper acceptable limit	`CurrValidMax`	Float (4)	0x610	0x710	0x810	0x910	5.3	
The hysteresis according to the sensor test	`CurrValidHist`	Float (4)	0x614	0x714	0x814	0x914	0.1	
The unified output current range lower level	`OutRangeCurrMin`	Float (4)	0x618	0x718	0x818	0x918	4(0)	
The unified output current range upper level	`OutRangeCurrMax`	Float (4)	0x61C	0x71C	0x81C	0x91C	20(0)	
The current, set on the unified output at a measuring channel failure	`OutCurrentError`	Float (4)	0x620	0x720	0x820	0x920	2(0)	
Enable setting the referred current on the unified output at a measuring channel failure (0 - disable the failure current setting)	`CurrentErrorEnabled`	Uint (2)	0x624	0x724	0x824	0x924	0	
Reserve (should always be set equal to zero)	`Reserv`	Uint (2)	0x626	0x726	0x826	0x926	0	
Sensor current calibration lower level ADC value	`AdcInMin`	Uint (2)	0x628	0x728	0x828	0x928	0	1
Sensor current calibration upper level ADC value	`AdcInMax`	Uint (2)	0x62A	0x72A	0x82A	0x92A	0	1
Unified output calibration lower level DAC value	`DacOutMin`	Uint (2)	0x62C	0x72C	0x82C	0x92C	0	1
Unified output calibration upper level DAC value	`DacOutMax`	Uint (2)	0x62E	0x72E	0x82E	0x92E	0	1

Table 15 continued

Name	Indication	Type (byte)	Address (Hex)				Value by default	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
The sensor current control operation mode (0 - lock the channel operation, reset the parameter value to zero; 1- do not lock the channel operation, do not reset the parameter value to zero, only overrange signaling)	OutRangeCurrMode	Uint (2)	0x0630	0x0730	0x0830	0x0930	0	
Reserve, should always be equal to zero	Reserv	Uint (2)	0x0632	0x0732	0x0832	0x0932	0	

Notes:

1. The calibration information is missing, all the measured parameters will have a zero value.
2. The value by default – the value, assigned to the parameter after a "Cold start".

Table 16. List of the measuring channels main registers

Name	Indication	Type (byte)	Address (Hex)				Value by default	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
Enabling a measuring channel functioning (0 - the channel is disabled)	Enabled	Uint (2)	0xA00	0xB00	0xC00	0xD00	0	1
Enabling additional functions (0 - additional functions are disabled) For Channel 4 1 - linearization function is enabled 2 - computing by the formula function is enabled	EnabledAdd	Uint (2)	0xA02	0xB02	0xC02	0xD02	0	1
The measured parameter lover range	RangeParamMin	Float (4)	0xA04	0xB04	0xC04	0xD04	0	
The measured parameter upper range	RangeParamMax	Float (4)	0xA08	0xB08	0xC08	0xD08	0	
The measured parameter name	MeasurName	Char (8)	0xA0C	0xB0C	0xC0C	0xD0C		2
The parameter measuring units	MeasurUnit	Char (8)	0xA14	0xB14	0xC14	0xD14		2
The measuring results displaying format (0 – ####, 1 – ###.#; 2 – ##.##; 3 – #.###)	FormatOut	Uint (2)	0xA1C	0xB1C	0xC1C	0xD1C	0	
Measuring results averaging depth from 0 to 9. (0 - no averaging)	AverageDepth	Uint (2)	0xA1E	0xB1E	0xC1E	0xD1E	0	
Setpoint 1 operation mode	TestPointMode_1	Uint (2)	0xA20	0xB20	0xC20	0xD20	0	
Setpoint 2 operation mode	TestPointMode_2	Uint (2)	0xA22	0xB22	0xC22	0xD22	0	
Setpoint 3 operation mode	TestPointMode_3	Uint (2)	0xA24	0xB24	0xC24	0xD24	0	
Setpoint 4 operation mode	TestPointMode_4	Uint (2)	0xA26	0xB26	0xC26	0xD26	0	
Setpoint 1 value	TestPointData_1	Float (4)	0xA28	0xB28	0xC28	0xD28	0	
Setpoint 2 value	TestPointData_2	Float (4)	0xA2C	0xB2C	0xC2C	0xD2C	0	
Setpoint 3 value	TestPointData_3	Float (4)	0xA30	0xB30	0xC30	0xD30	0	
Setpoint 4 value	TestPointData_4	Float (4)	0xA34	0xB34	0xC34	0xD34	0	
The setpoints hysteresis	TestPointHist	Float (4)	0xA38	0xB38	0xC38	0xD38	0	
The setpoint overrunning reaction time	TestPointTime	Uint (2)	0xA3C	0xB3C	0xC3C	0xD3C	0	3

Table 16 continued

Name	Indication	Type (byte)	Address (Hex)				Value by default	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
Enabling functioning of the measured parameter stability algorithm (0 - the algorithm is disabled)	`StabEnabled`	Uint (2)	0xA3E	0xB3E	0xC3E	0xD3E	0	
The measured parameter destabilization detection time	`StabTimeOut`	Uint (2)	0xA40	0xB40	0xC40	0xD40	0	3
The measured parameter stabilization detection time	`StabTimeIn`	Uint (2)	0xA42	0xB42	0xC42	0xD42	0	3
Maximum measured parameter deviation for the stabilization algorithm	`StabDataDelta`	Float (4)	0xA44	0xB44	0xC44	0xD44	0	
The lower value of the parameter, dumped to the unified output	`OutRangeParamMin`	Float (4)	0xA48	0xB48	0xC48	0xD48	0	
The upper value of the parameter, dumped to the unified output	`OutRangeParamMax`	Float (4)	0xA4C	0xB4C	0xC4C	0xD4C	0	

Notes:

1. The measuring channel is disabled; the additional measuring channel function is disabled.
2. Empty line.
3. Time by 0.1 second (0=0.1 second)
4. The value by default - the value, assigned to the parameter after a "Cold start".

Table 17. Unified output control registers list

Name	Indication	Type (byte)	Address (Hex)				Value by default	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
The DAC value for direct control of the measuring channel unified output	`AnalogDirectData`	Uint (2)	0x500	0x502	0x504	0x506	0	

Notes:

1. Used at unified outputs calibration DAC converter range from 0 to 4096
2. Are not engaged in measuring channels normal operation.
3. Automatically reset to 0 if the register value was not changed for 30 seconds.
4. Available for recording in any of the module operation modes.

Table 18. List of *additional* frequency measuring registers (for Channels 1, 2)

Name	Indication	Type (byte)	Address (Hex)		Value by default	Note
			Channel 1	Channel 2		
Pulse count per one rotor rotation (from 1 to 1000)	`Tooth`	Uint (2)	0x1800	0x1900	1	
Generate synchronization pulses (0 - synchronization pulses are not generated)	`PulseEna`	Uint (2)	0x1802	0x1902	0	1
Input pulses active edge polarity (0 - leading edge; not zero - trailing edge)	`PolarityIn`	Uint (2)	0x1804	0x1904	0	
Output pulses active edge polarity (0 - leading edge; not zero - trailing edge)	`PolarityOut`	Uint (2)	0x1806	0x1906	0	
Enable the "STOP" signaling test (0 - the test is disabled)	`StopTestEna`	Uint (2)	0x1808	0x1908	0	
Enable the setpoints test in the "STOP" mode (0 - the test is disabled)	`PointStopEna`	Uint (2)	0x180A	0x190A	0	
Minimum measured frequency, rpm	`FrequencyMin`	Float (4)	0x180C	0x190C	1	
Minimum time of synchronization pulses period, ms (The parameter range is from 0 to 49.99. Values 0, 50 and more - the function is disabled)	`PulsePeriodMin`	Float (4)	0x1810	0x1910	0	

Notes:

1. Synchronization pulses are communicated to the first and the second logic outputs for the first and the second measuring channels correspondingly.
2. The value by default - the value, assigned to the parameter after a "Cold start".

Table 19. List of Additional Rotor Bowing Measurement Registers (for Channel 3)

Name	Indication	Type (byte)	Address (Hex)	Value by default	Note
The measured parameter lover range	`RangeVarMin`	Float (4)	0x1A00	0	
The measured parameter upper range	`RangeVarMax`	Float (4)	0x1A04	500	
Measuring mode (0 - by the first rotational harmonic, not zero - by the polyharmonic	`ModeMeasur`	Uint (2)	0x1A08	0	
The slack measuring averaging depth from 0 to 9.	`AverageDepth`	Uint (2)	0x1A0A	0	
The distortion measurement synchronization mode 0 - the main synchronization input 1 the reserve synchronization input 2 1 - synchronization over the first input only 2 - synchronization over the second input only	`SyncMode`	Uint (2)	0x1A0C	0	1
Polarity of input synchronization pulses (0 - leading edge; not zero - trailing edge)	`SyncPolar`	Uint (2)	0x1A0E	0	1
Pulse count per one rotor rotation (from 1 to 1000)	`SyncTooth`	Uint (2)	0x1A10	1	1
Selection of the data source for the unified output (0 - rotor bowing, not zero - slack)	`SelectOutData`	Uint (2)	0x1A12	0	
Minimum acceptable rotor speed, rpm	`FreqValidMin`	Uint (2)	0x1A14	1	2
Maximum acceptable rotor speed, rpm	`FreqValidMax`	Uint (2)	0x1A16	10,000	2
Control the rotor speed (0 - do not control)	`FreqControl`	Uint (2)	0x1A1C	0	2
The FFT algorithm acceptable nose in the resolution	`MagNoice`	Uint (2)	0x1A1E	100	
The LPF module phase shift correction, gr/Hz	`PhaseCorrModul`	Float (4)	0x1A20	0	
The sensor filters phase shift correction, gr/Hz	`PhaseCorrSense`	Float (4)	0x1A24	0	
Permanent phase shift for the first rotational., gr	`PhaseCorrConst`	Float (4)	0x1A28	0	
Minimum rotational component excursion for the phase computing	`PhaseMinVar`	Float (4)	0x1A26	0	

Table 19 continued

Name	Indication	Type (byte)	Address (Hex)	Value by default	Note
The lover calibration level ADC value according to the rotational component	AdcVar1fMin	Uint (2)	0x1A30	0	3
The higher calibration level ADC value according to the rotational component	AdcVar1fMax	Uint (2)	0x1A32	0	3
The lover calibration level ADC value according to the polyharmonic	AdcVarPolyMin	Uint (2)	0x1A34	0	3
The higher calibration level ADC value according to the polyharmonic	AdcVarPolyMax	Uint (2)	0x1A36	0	3

Notes:

1. The priority is given to the the settings for Channels 1, 2 in the frequency measuring mode
2. The acceptable rotor bowing measuring frequency is force-limited by the range from 0.9 to 12000 rpm.
3. The calibration information is missing, all the measured parameters will have zero value.
4. The value by default - the value, assigned to the parameter after a "Cold start".

Table 20. List of Additional Linearization Registers (for Channel 4 when EnabledAdd = 1)

Name	Indication	Type (byte)	Address (Hex)	Value by default	Note
Number of entries in the linearization table	LinearTableSize	Uint (2)	0x1B00	0	1
Reserve, should always be equal to zero	Reserv	Uint (2)	0x1B02	0	
Entry 1, current value	Current_1	Float (4)	0x1B04	0	
Entry 1, parameter value	Data_1	Float (4)	0x1B08	0	
Entry 2, current value	Current_2	Float (4)	0x1B0C	0	
Entry 2, parameter value	Data_2	Float (4)	0x1B10	0	
Entry 16, current value	Current_16	Float (4)	0x1B7C	0	
Entry 16, parameter value	Data_16	Float (4)	0x1B80	0	

Notes:

1. The linearization algorithm functioning needs minimum 2 entries. In case of less than 2 entries in the table, the parameter value is accepted to be equal to zero. Maximum number of entries - 16.
2. The value by default - the value, assigned to the parameter after a "Cold start".

Table 21. List of Additional Formula-Computing Registers (for Channel 4 when EnabledAdd = 2)

Name	Indication	Type (byte)	Address (Hex)	Value by default	Note
When computing the Channel 4 value (4 words), consideration must be given to the measuring channels failure flag.	CheckChannelError	Uint (8)	0x2300	0	
Array of constants, used in the computations (8 constants)	Constant	Float (32)	0x2308	0	
Sequence of operations to compute the parameter value for Channel 4 (32 commands) A command structure: bits 0-7: operation code bits 8-11: type of the memory, used in the operation bits 12-15: the register address	Instruction	Uint (64)	0x2328	0	

Notes:

1. The value by default - the value, assigned to the parameter after a "Cold start".

Table 22. System registers list

Name	Indication	Type (byte)	Address (Hex)	Value by default	Note
The logic outputs lockout time after the module reset	LogicOffStartUp	Uint (2)	0xE00	15	1, 3
The setpoints test timeout after the sensor operation normalization	TestPointSenseOk	Uint (2)	0xE02	15	2, 3
"STOP" mode test timeout	TimeOut_TestStop	Uint (2)	0xE04	0	2, 3
Frequency measuring period for Channels 1, 2	FreqMeasurTime	Uint (2)	0xE06	0	2.3
Logic signaling matrix (80 words): bits 0:3 - number of the output, to which signaling is assigned (Group 1) bits 4:7 - number of the output, to which signaling is assigned (Group 2) bit 8 - signaling inversion for Group 1 bit 9 - signaling inversion for Group 2 bits 10:13 - reserved, should be equal to zero bit 14 – the 'War' LED activation for the variant bit 15 – the 'Alarm' LED activation for the variant	LogicMatrix	Uint (160)	0xE08	0	
A signal inversion on the logic output (12 words) (not zero - output inversion)	LogicOutMode	Uint (24)	0xE80	0	4
Logic outputs operation mode adjustment	LogicMode	Uint (2)	0x0EC0	0	6
Reserve, should always be equal to zero	Reserv	Uint (2)	0x0EC2	0	

Notes:

1. In case of an error of reading the data from the nonvolatile memory, is always equal to 79 (8 seconds).
2. At the value, equal to 0, the function is disabled.
3. Time by 0.1 s (0=0.1 s).
4. This parameter does not apply to Logic output 12.
5. The value by default - the value, assigned to the parameter after a "Cold start".
6. 0 - adjustment with the help of the matrix, 1 - adjustment with the help of the equation (formula). The adjustments require the module reset.

Table 23. Logic Outputs Symbolic Names

Name	Indication	Type (byte)	Address (Hex)	Value by default	Note
Logic output 1 symbolic name (code)	LogicName_1	Char (16)	0x1700	0	1
Logic output 2 symbolic name (code)	LogicName_2	Char (16)	0x1710	0	1
Logic output 12 symbolic name (code)	LogicName_12	Char (16)	0x17B0	0	1

Notes:

1. The name is not assigned, empty line.
2. The value by default - the value, assigned to the parameter after a "Cold start".

Table 24. List of logic signaling configuration registers

Name	Indication	Type (byte)	Address (Hex)	Value by default	Note
Output 1 logical rule (16 commands)	LogicRules[0]	Uint(2)x16	0x1C00		
Output 2 logical rule	LogicRules[1]	Uint(2)x16	0x1C20		
Output 3 logical rule	LogicRules[2]	Uint(2)x16	0x1C40		
Output 4 logical rule	LogicRules[3]	Uint(2)x16	0x1C60		
Output 5 logical rule	LogicRules[4]	Uint(2)x16	0x1C80		
Output 6 logical rule	LogicRules[5]	Uint(2)x16	0x1CA0		
Output 7 logical rule	LogicRules[6]	Uint(2)x16	0x1CC0		
Output 8 logical rule	LogicRules[7]	Uint(2)x16	0x1CE0		
Output 9 logical rule	LogicRules[8]	Uint(2)x16	0x1D00		
Output 10 logical rule	LogicRules[9]	Uint(2)x16	0x1D20		
Output 11 logical rule	LogicRules[10]	Uint(2)x16	0x1D40		
Output 12 logical rule	LogicRules[11]	Uint(2)x16	0x1D60		
'War' LED logical rule	LogicRules[14]	Uint(2)x16	0x1DC0		
'Alarm' LED logical rule	LogicRules[15]	Uint(2)x16	0x1DE0		

Table 25. Logical Rules Command Structure

Name	Indication	Bits
Operation code 0x00 - empty operation 0x1F - end of the logical formula 0x01 - place the memory value to the accumulator 0x02 - save the accumulator value in the memory 0x03 - reset the accumulator to zero 0x04 - invert the accumulator value 0x05 - the accumulator and the memory logical OR 0x05 - the accumulator and the memory logical AND 0x05 - the accumulator and the memory logical exclusive OR	Operation	11 : 15 (5)
Memory (register) code 0x00 - no memory reference 0x01 - local memory (16 bit) personal for every logic output (cleared before execution) 0x01 - global memory (16 bit) common for all the logic outputs (cleared before execution) 0x03 - no memory reference 0x04 - Channel 1 status register 0x05 - Channel 2 status register 0x06 - Channel 3 status register 0x07 - Channel 4 status register 0x08 - no memory reference 0x09 - no memory reference 0x0A - the module status register (StatusSys) 0x0B - the module additional status register (StatusSysAdd) 0x0C - no memory reference 0x0D - no memory reference 0x0E - no memory reference 0x0F - no memory reference	Memory	6 : 10 (5)
Memory location (the bit number in the register)	Address	0 : 5 (6)

Communication Interfaces

Table 26. The RS485 Interface Registers List

Name	Indication	Type (byte)	Address (Hex)	Value by default	Note
Enable the interface (not zero - the interface is enabled)	`Enabled`	Uint (2)	0xF00	0	
Enable the module operation parameters changes via the RS485 interface (not zero - enabled)	`ChangeEna`	Uint (2)	0xF02	0	
Enable a write once operation (not zero - enabled)	`OnWriteEna`	Uint (2)	0xF04	0	
Enable the broadcast address support (not zero - enabled)	`CommAddrEna`	Uint (2)	0xF06	0	
The device address on the RS485 bus (from 1 to 247)	`Address`	Uint (2)	0xF08	1	
Data rate, bps 0 – 4800; 1 – 9600; 2 – 19200; 3 – 38400; 4 – 57600; 5 – 115200; 6 – 230400	`Speed`	Uint (2)	0xF0A	0	

Note: The RS485 interface parameters become operational only after the interface reinitialization.

Table 27. List of the CAN2.0B Interface Standard Registers

Name	Indication	Type (byte)	Address (Hex)	Value by default	Note
Enable the interface (not zero - the interface is enabled)	`Enabled`	Uint (2)	0x1000	0	
Data rate, kb/s 0 – 1000; 1 – 500; 2 – 250; 3 – 200; 4 – 125; 5 – 100; 6 – 80; 7 – 40	`Speed`	Uint (2)	0x1002	0	
The module address on the bus	`Address`	Uint (2)	0x1004	0	
A 0.1 s messaging period	`PeriodSend`	Uint (2)	0x1006	0	1
Data communication by Measuring channel 1 bit 0 - measuring results bit 1 - the measured parameter minimum bit 2 - the measured parameter maximum bit 3 - additional parameter 1 bit 4 - additional parameter 2 bits 5-15 - reserve, should be equal to zero	`DataSend_1`	Uint (2)	0x1008	0	
Data communication by Measuring channel 2 (the bits assignment is the same with Channel 1)	`DataSend_2`	Uint (2)	0x100A	0	
Data communication by Measuring channel 3 (the bits assignment is the same with Channel 1)	`DataSend_3`	Uint (2)	0x100C	0	
Data communication by Measuring channel 4 (the bits assignment is the same with Channel 1)	`DataSend_4`	Uint (2)	0x100E	0	

Notes:

1. Time by 0.1 s (0=0.1 s).
2. The CAN2.0B interface parameters become operational only after the interface reinitialization.
3. The value by default - the value, assigned to the parameter after a "Cold start".

Table 28. List of the CAN2.0B Interface Additional Registers

Name	Indication	Type (byte)	Address (Hex)	Value by default	Note
Enable the interface operation in the enhanced mode (not zero - enabled)	`Enabled`	Uint (2)	0x1100	0	
The module address for the enhanced mode (from 0 to 255)	`Address`	Uint (2)	0x1102	0	
Enable the module operation parameters changes via the CAN interface commands (not zero - enabled)	`ChangeEna`	Uint (2)	0x1104	0	
Enable a write once operation (not zero - enabled)	`OnWriteEna`	Uint (2)	0x1106	0	
A 0.1s period of Message 1 sending	`Period_1`	Uchar (1)	0x1108	0	1
Number of bytes in Message 1	`LenSend_1`	Uchar (1)	0x1109	0	
The data address in the Message 1 module	`AddressData_1`	Uint (2)	0x110A	0	
A 0.1s period of Message 2 sending	`Period_2`	Uchar (1)	0x110C	0	1
Number of bytes in Message 2	`LenSend_2`	Uchar (1)	0x110D	0	
The data address in the Message 2 module	`AddressData_2`	Uint (2)	0x110E	0	
A 0.1s period of Message 32 sending	`Period_32`	Uchar (1)	0x1184	0	1
Number of bytes in Message 32	`LenSend_32`	Uchar (1)	0x1185	0	
The data address in the Message 32 module	`AddressData_32`	Uint (2)	0x1186	0	

Notes:
1. Time by 0.1 s (0=0.1 s).
2. The CAN2.0B interface parameters become operational only after the interface reinitialization.
3. The value by default - the value, assigned to the parameter after a "Cold start".

Identification Information

Table 29. List of the Module Identification Information Registers

Name	Indication	Type (byte)	Address (Hex)	Value by default	Note
The module serial number	`Number`	Uint (2)	0x1200		
The module production year	`Year`	Uint (2)	0x1202		
Order number	`Order`	Uint (2)	0x1204		
Assembler number	`Assembler`	UChar (1)	0x1206		
Adjuster number	`Adjuster`	UChar (1)	0x1207		
Additional text information	`TextString`	Char (32)	0x1208		

Note: The Identification information, read-only, is not initialized with the "Cold start".

Table 30. List of the Module Software Identification Information Registers

Name	Indication	Type (byte)	Address (Hex)	Value by default	Note
The microprocessor software version line	`Version`	Char (6)	0x1300		
The microprocessor software compilation date	`Date`	Char (12)	0x1306		
The microprocessor software compilation time	`Time`	Char (10)	0x1312		

Note: The identification information is read-only.

Measurements Results

Table 31. List of the measurement results main registers

Name	Indication	Type (byte)	Address (Hex)				Note
			Channel 1	Channel 2	Channel 3	Channel 4	
The main measured parameter value	`Data`	Float (4)	0x0000	0x001C	0x0038	0x0054	
The main measured parameter minimum value	`DataMin`	Float (4)	0x0004	0x0020	0x003C	0x0058	
The main measured parameter maximum value	`DataMax`	Float (4)	0x0008	0x0024	0x0040	0x005C	
Additional measurement results Channels 1, 2 - always equal to zero Channel 3 - Slack Channel 4 - The parameter value without linearization	`DataAdd_1`	Float (4)	0x000C	0x0028	0x0044	0x0060	1
Additional measurement results Channels 1, 2, 4 - always equal to zero Channel 3 - the rotor speed, used during the bowing measuring	`DataAdd_2`	Float (4)	0x0010	0x002C	0x0048	0x0064	1
The sensor direct current, mA	`Current`	Float (4)	0x0014	0x0030	0x004C	0x0068	
The measuring channel status flags	`Status`	Uint (2)	0x0018	0x0034	0x0050	0x006C	2
The ADC value of the sensor signal constant component	`AdcConst`	Uint (2)	0x001A	0x0036	0x0052	0x006E	4
The module status flags	`StatusSys`	Uint (2)	0x0070				3
The logic output status: bits 0-11 - Logic outputs 1 to 12 status bits 12-13 - reserve, are always equal to zero bit 14 - the "War" LED status bit 15 - the "Alarm" LED status	`LogicOutStatus`	Uint (2)	0x0072				
An additional status register: bit 0 - LogicOutMode the logic outputs operation mode (0 - matrix, 1 - equation) bit 1 - LogicExprErr the equation error bits 2-15 - reserve, always equal to zero	StatusSysAdd	Uint (2)	0x007C				6
Reserve, should always be equal to zero	Reserv	Uint (2)	0x007E				

Notes:

1. On the condition of enabling additional functions for corresponding measuring channels.
2. See the measuring channels status flags in Table 5.
3. See the module status flags in Table 6.
4. Used during the measuring channels calibration.
5. the measuring results registers are read-only.
6. The default value is equal to zero.

Table 32. List of Spectral Components of the Third Channel during the Rotor Bowing Measurement

Name	Indication	Type (byte)	Address (Hex)	Note
The half rotational component excursion (2A)	`Mag`	Float (4)	0x0100	
The half rotational component phase, gr.	`Phase`	Float (4)	0x0104	
The rotational component excursion	`Mag`	Float (4)	0x0108	
The rotational component phase, gr.	`Phase`	Float (4)	0x010C	
The one and a half rotational component excursion	`Mag`	Float (4)	0x0110	
The one and a half rotational component phase, gr.	`Phase`	Float (4)	0x0114	
The fifth rotational component excursion	`Mag`	Float (4)	0x0148	
The fifth rotational component phase, gr.	`Phase`	Float (4)	0x014C	

Notes:

1. The rotation components values and their phases are equal to zero, if the rotor bowing measurement function is disabled.
2. The half rotational components values and their phases are equal to zero, if the rotor bowing measurement are performed during one rotor rotation.
3. The rotation components phases values is equal to zero, if the corresponding rotation component level is below the set limit.
4. The measuring results registers are read-only.

Table 33. List of Additional Registers of the Third Channel during the Rotor Bowing Measurement

Name	Indication	Type (byte)	Address (Hex)	Note
Speed, used at a signal sample capture, rpm	`RequestFreq`	Float (4)	0x221C	
A sample capture mode (0 - 2 rotor rotations, 1 - 1 rotor rotation)	`ReqestMode`	Uint (2)	0x220E	
The data, dumped to the third unified output (0 - rotor bowing, not zero - slack)	`OutData`	Uint (2)	0x2206	
The first rotational component ADC excursion value	`Adc1F`	Uint (2)	0x2208	1
The polyharmonic ADC excursion value	`AdcPoly`	Uint (2)	0x220A	1

Notes:

1. Used during the measuring channels calibration.
2. The measuring results registers are read-only.

Table 34. List of the Third Measuring Channel Signal Capture Registers

Name	Indication	Type (byte)	Address (Hex)	Note
Signal capture results, mA	`Data_0`	Float (4)	0x2800	
	`Data_1`	Float (4)	0x2804	
	`Data_511`	Float (4)	0x2FFC	

Notes:

1. Perform reading after setting the corresponding flag in the module status register.
2. The measuring results registers are read-only.

Control Commands

To execute operating commands, there provided several reserved registers. Control commands are executed only under individual entry in every of the registers (execution of several commands during one data transaction is impossible).

Table 35. Control registers list

Register Address (Hex)	Recorded value (Hex)	Action	Note
0xFF00	0x55	The module reset (analogous to switching the module power on)	
0xFF01	0x60	Perform the frequency measurement reinitializing.	1.3
	0x61	Recompute the Channel 1 coefficients	1, 3
	0x62	Recompute the Channel 2 coefficients	1, 3
	0x63	Recompute the Channel 3 coefficients	1, 3
	0x64	Recompute the Channel 4 coefficients	1, 3
	0x51	The first measuring channel minimum/maximum reset	3
	0x52	The second measuring channel minimum/maximum reset	3
	0x53	The third measuring channel minimum/maximum reset	3
	0x54	The fourth measuring channel minimum/maximum reset	3
	0x93	Perform the RS485 interface reinitializing.	2, 3
	0x98	Perform the CAN2.0B interface reinitializing.	2, 3
0xFF02	0x33	Logical signaling lockup	
	0xCC	Logical signaling normal functioning	
0xFF03	0x3C	A single entry request	
0xFF04	0x51	Channel 1 "STOP" mode test	5
	0x52	Channel 2 "STOP" mode test	5
	0x50	Disable Channels 1, 2 "STOP" mode test	5
0xFF05	0xA3	Measuring channel 3 sample capture	6

Table 35 continued

Register Address (Hex)	Recorded value (Hex)	Action	Note
0xFF06		Recording operation parameters into the module nonvolatile memory	3, 4
	0x80	Channel 1 calibration data	
	0x81	Channel 2 calibration data	
	0x82	Channel 3 calibration data	
	0x83	Channel 4 calibration data	
	0x84	Channel 1 main parameters	
	0x85	Channel 2 main parameters	
	0x86	Channel 3 main parameters	
	0x87	Channel 4 main parameters	
	0x88	The module system parameters	
	0x89	The RS485 interface parameters	
	0x8A	The CAN2.0B interface parameters	
	0x8B	The CAN2.0B additional interface parameters	
	0x8C	Logic outputs symbolic names	
	0x8E	Channel 4 formula-computing additional parameters	
	0x90	Channel 1 additional parameters	
	0x91	Channel 2 additional parameters	
	0x92	Channel 3 additional parameters	
	0x93	Channel 4 additional parameters, linearization	
0xFF07	0x21	Recording all the module setup parameters into the nonvolatile memory	3, 7

Notes:

1. Can be used after the calibration to check adjustments without the module reset.
2. If a command came during data communication, the data are fully communicated, then a reinitialization is performed.
3. The logical operation should be locked.
4. After recording the module is not reset.
5. Only for Channels 1, 2 in the rotor speed measuring mode.
6. Only in the rotor bowing measuring mode.
7. During recording the module operation is stopped. After recording the module reset is automatically performed.

Maintenance

See maintenance information in the following document: "ВШПА.421412.300 РЭ "VIROBIT 300" Equipment Operations Manual":

- the equipment maintenance;
- routine maintenance;
- the equipment check.

Transportation and Storage

Transportation should be performed via any means of transport upon condition of protection from exposure to atmospheric precipitation and splashing water, in correspondence with transportation regulations, valid for all the means of transport.
Being transported by air, the equipment should be allocated in heated pressurized compartments.
Transportation conditions – "Ж" (Hard) as per GOST (ГОСТ) 25804.4-83 standard

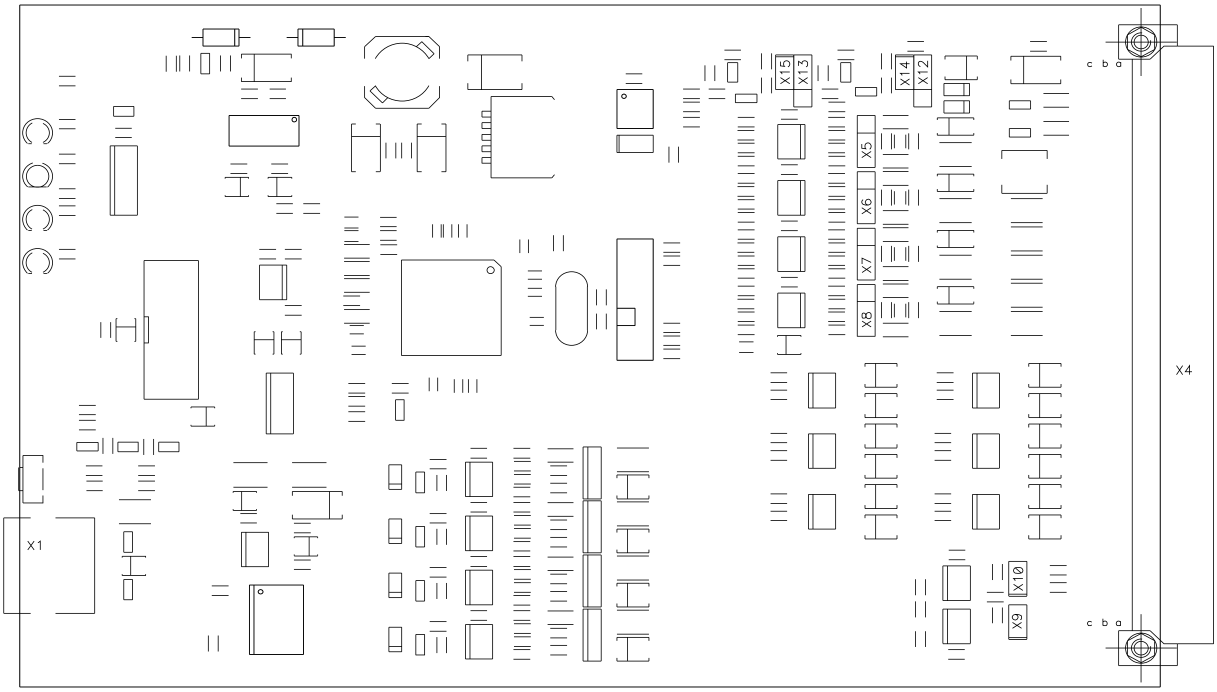
The equipment storage, as related to exposure to climatic factors, should correspond to Group 3 (Ж3) (Hard 3) as per GOST (ГОСТ) 15150-69.
The warranty period is, maximum, 24 months from the production date.

Manufacturer's Warranty

The Manufacturer guarantees the equipment compliance with the technical requirements under meeting the conditions of operation, storage, transportation and installation.
Guarantee service life is 24 months from the date of operational commissioning, but not over 48 months from the production date.
In case of sending the module to the manufacturer for repair, it is necessary to specify the detected malfunction.

Appendices

A. Control Elements Layout on the MK22 Module Card



The X5, X6, X7,X8 jumpers - selection of the operation mode for Measuring channels 1, 2, 3, 4 (respectively).

Position	Mode
Removed	Voltage operation mode 0...3 V.
1-2	Current operation mode 1...5 mA.
2-3	Current operation mode 4...20 mA.

The X9, X10 jumpers - a 120 Ohm bus terminator for RS485, CAN2.0B (respectively).

Position	Mode
Removed	The terminator is disconnected from the bus.
Applied	The terminator is connected to the bus.

The X12, X13 jumpers - selection a synchronization pulses source for Channel 1 (2).

Position	Mode
1-2	Synchronization from the Input CH1 input (2)
2-3	Synchronization from the Fin 1 input (2)

The X14, X15 jumpers - a 1 kOhm resistor connection of the pulse input to +3.3 V

Position	Mode
Removed	The pullup is disabled (operation with the comparator)
Applied	The pullup is enabled (operation within the AVMS)

Figure 9. Elements Layout on the MK22 Module Card

B. The X4 Connector Contacts Assignment

The contact number	Indication	Assignment	Note
A2, B1, C2 A32, B31, C32	GND	COM	
A6, B5, C6	Power +24V	+ 24 V power supply voltage input/output	
B3	Fin 1	The main pulse input	
C4	Fin 2	The reserve pulse input	
B7	+24V sense CH1	+ 24 V voltage output for Chanel 1 transducer power supply	
B9	+24V sense CH2	+ 24 V voltage output for Chanel 2 transducer power supply	
B11	+24V sense CH3	+ 24 V voltage output for Chanel 3 transducer power supply	
B13	+24V sense CH4	+ 24 V voltage output for Chanel 4 transducer power supply	
C8	Input CH1	Measuring channel 1 input	1
C10	Input CH2	Measuring channel 2 input	1
C12	Input CH3	Measuring channel 3 input	1
C14	Input CH4	Measuring channel 4 input	1
B15	Analog out 1	Measuring channel 1 unified output	
C16	Analog out 2	Measuring channel 2 unified output	
B17	Analog out 3	Measuring channel 3 unified output	
C18	Analog out 4	Measuring channel 4 unified output	
A20	LG_OUT_1	Logic output 1	2
A22	LG_OUT_2	Logic output 2	2
A24	LG_OUT_3	Logic output 3	2
A26	LG_OUT_4	Logic output 4	2
B19	LG_OUT_5	Logic output 5	2
B21	LG_OUT_6	Logic output 6	2
B23	LG_OUT_7	Logic output 7	2
B25	LG_OUT_8	Logic output 8	2
C20	LG_OUT_9	Logic output 9	2
C22	LG_OUT_10	Logic output 10	2
C24	LG_OUT_11	Logic output 11	2
C26	LG_OUT_12	Logic output 12	2, 3
A28	CAN-GND	The CAN2.0B interface	
B27	CAN-H		
C28	CAN-L		
A30	RS485-GND	The RS485 Interface	
B29	RS485-B(-)		
C30	RS485-A(-)		

Notes:

1. If the channel is out of use, the output can be left disconnected, the given channel operation should be disabled in the module settings.
2. The behavior is determined during the module setup.
3. Upon an error of parameters reading from the nonvolatile memory, there will be present an active level. It is advisable to assign all the module failure signals (the sensors test etc.) to the given output.
4. The A4, A8, A10, A14, A16, A18 contacts are out of use and should be left without connection for the sake of compatibility with MK22 future versions.

D. The Module Marking

The module marking includes:

- the MK22 module type and hardware version (DC, DC-11, DC-001);
- serial number and the module year of manufacture;
- the unified outputs operation mode (A – 1-5 mA; B – 4-20 mA);
- the assembler number;
- the adjuster number;
- the order number.

An example of the MK22 module marking:

МК22 DC-11	The module No -	Mode	Assembler	Adjuster	Order

The module setup complete information (measurement ranges, the measuring channels setpoints levels, communication interfaces parameters, the logical signaling setting etc.) is indicated in the corresponding module setting record.

In addition, the module card is labeled with the module main parameters table.

An example of a module card label with the main configuration settings:

Канал	1	2	3	4
Пар.	ОРР ВД	ОРР НД	Wa	Выкл.
Един.	мм	мм	МВт	
Диап.	-5-0-+5	-5-0-+5	0-60	
Уст.1	-1.5	-1.5		
Уст.2	+2.5	+2.5		
Уст.3	-2	-2		
Уст.4	+3	+3		
RS485	Адр.	014	Скор.	115200
CAN2.0B	Адр.		Скор.	

Chan.	1	2	3	4
Par.	OPP UR	OPP LR	Wa	Off
Units	mm	mm	MW	
Range	-5-0-+5	-5-0-+5	0-60	
Stpt.1	-1.5	-1.5		
Stpt.2	+2.5	+2.5		
Stpt..3	-2	-2		
Stpt.4	+3	+3		
RS485	Addr.	014	Speed	115200
CAN2.0B	Addr.		Speed	

E. The MK22 Module Order (Setup) Form Example

The module hardware version (DC, DC-11, DC-001) ______ a number of modules with this setup ______

1. The measuring channels parameters.

Parameter / Channel No		1		2		3		4	
Sensor, transducer									
The channel operation mode (on/off; dir. curr. measur.; bowing measur.; freq. measur.; linearization; comput. by form.)									
The parameter name									
Measuring units									
The parameter range									
The setpoints parameters	№	upper/lower	value	upper/lower	value	upper/lower	value	upper/lower	value
	1								
	2								
	3								
	4								
Picture format									
Averagings depth									
Setpoints hysteresis									
Time of the setpoints overrunning									
Unified Outputs	№	param. range	current range	param. range	current range	param. range	current range	param. range	current range
	1								
	2								
	3								
	4								
The sens. curr. hyster. (test.)									
Stabil. control	Detect. Destab.								
	srabil. detetect.								
	max. add. adjust.								

2. The RS485, CAN communication interfaces parameters

Parameter	RS485	CAN
Enable the interface functioning (yes/no)		
The module address (RS485 – from 1 to 247; CAN – from 0 to 65535)		
Data rate RS485 – 4800, 9600, 19200, 38400, 57600, 115200, 230600 bit/s CAN – 40, 80, 100, 125, 200, 250, 500, 1000 kbit/s		
Enable parameters adjustment via communication interfaces (yes/no)		
Enabling a single entry command support (yes/no)		
Enable the broadcast address support (yes/no)		
Messages sending period, s (for CAN only)		
Data communication by measuring channels (specify) *		

Note* — Codes of the enumerated types of the data, communicated over the measuring channels:
measuring results — Rx; minimum — minx; maximum — maxx; add. param.1 — 1dx; add. param.2 — 2dx
(instead of "x" , one should specify the channel number)

3. Additional parameters of Channels 1, 2 measurement

Parameter / Channel No	1	2
Enable frequency change		
Generate synchronization pulses		
Enable the "STOP" signaling test		
Enable the setpoints test in the "STOP" mode		
Polarity of input pulses (leading edge/trailing edge)		
Polarity of output pulses (leading edge/trailing edge)		
Minimum measuring frequency		
Pulse count per one rotation		

4. Additional parameters of Channel 3 measurement

Parameter / Channel No		3
Enable the rotor bowing measurement		
The bowing measurement range		
Measuring mode (acc. to the first rotational / acc. to the polyharmonic)		
The slack measuring averaging (0 ,,, 7)		
Synchronization mode (main - first, reserve - second / first / second)		
Input pulses polarity (leading edge / trailing edge)		
Pulse count per one rotation		
The unified output parameter (bowing / slack)		
Enable the rotor rotation speed control	yes / no	
	acceptable frequencies range	
The FFT acceptable noise		
Correction of the module LPF phases shift		
Correction of the sensor phases shift		
Permanent phase shift for the first rotational		
The rotational component minimum excursion		

5. Additional parameters of Channel 4 measurement

Parameter / Channel No		4
Linearization is on	Yes / no	
	Number of entries in the linearization table	
Computing the Parameter by the Formula	Yes / no	
	Consider the channels failure flag during computing (no / yes (the channels numbers))	
	The analytical formula*	

Note* - use the following indication codes when writing the analytical formula:
instead of "x" , one should specify the channel number and instead of "y" one should specify the constant number in the array)
Chx — the channel parameter; Ix — the channel current; Ky — the constant in the array
* multiplication / division + addition - subtraction

6. The module common parameters

Parameter	Value
The log. signal locking after the module reset, sec.	
The setpoints locking after the channel operation normalization, sec.	
The "stop" test timeout, sec.	
Frequency measuring period for Channels 1, 2, sec.	

7. Logical signaling and the "War" and "Alarm" LEDs on the module front panel.

logic. outp.	Logical formula	Output inversion	Name
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
War			
Alarm			

Measuring channels codes (instead of "x" , one should specify the channel number):

xChO – the channel is disabled	xSeL – low level of the sensor current	xSeL – high level of the sensor current
xFE - the setpoints test is not performed	xOp1 –overrunning the first setpoint	xOp2 –overrunning the second setpoint
xOp3 –overrunning the third setpoint	xOp4 –overrunning the fourth setpoint	xchE – the measuring channel is faulty
xDst – the parameter is stabilized	xDust – the parameter is not stabilized	xMf – the frequency measuring mode
xsm – the "STOP" mode	xsmt – The "STOP" mode test	xMr – frequency measur. algor. in reset
xMw – frequency measur. algor. in the STOP mode	xMnp – no synchronization pulse	
System codes:	ErrLD – parameters reading error	ResLD – reading param. from a reserve section
RS_Off - the RS485 interface is disabled;	CAN_Off - the CAN2.0 interface is disabled;	eepERR – the nonvolatile memory error
Operations:	‘()’ – selection of the "OR" group	‘+’ – logical "OR" operation

Prepared by ________________ Dated _____________________