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SCIENTIFIC PRODUCTION
ENTERPRISE VIBROBIT LLC

EQUIPMENT "VIBROBIT 300"

MK22 Control Module

Setup Instruction

(with module software version from 1.40)

ВШПА.421412.3022 И2

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The MK22 Module Setup Instruction is intended to familiarize users (customers) with main operating principles and setup methods of MK22 constant signals control module of equipment VIBROBIT 300 with software (SW) version from 1.40 to 1.69.

This document is a supplement to
ВШПА.421412.300 РЭ Equipment VIBROBIT 300 Operations and Maintenance Manual.

SPE VIBROBIT LLC reserves the right to replace individual parts, components and software without impairing the item specifications.

Version 3 dated 21.01.2019

Contents

1 General

MK22 universal 4-channel control module (hereinafter the MK22 module) is intended to measure sensors constant and tachometric signals, turbine rotor bowing (eccentricity), overspeed protection mechanism trip pin protrusion. MK22 is based on a high-performance 32-bit DSP microprocessor, which allows sensors signals processing in real-time (measurement period from 0.1 seconds) and parallel support for digital communication interfaces.

MK22 module measurement channels main function is to measure constant signals with period of 0.1 sec (protection algorithms response rate is 0.1 seconds). In addition to constant signals measuring, each MK22 module channel can be configured to operate in the extended mode:

Measurement channel No.1

- rotor speed (tachometric signal);
- overspeed protection mechanism mode (tachometric signal, response rate from 5 ms);
- overspeed trip pins position;
- displacement excursion without synchronization pulses.

Measurement channel No.2

- rotor speed (tachometric signal);
- overspeed trip pins position;
- displacement excursion without synchronization pulses.

Measurement channel No.3

- rotor bowing (eccentricity) (variable signal);
- displacement excursion without synchronization pulses.

Measurement channel No.4

- sensor signal linearization (constant signal);
- parameter calculation according to formula;
- displacement excursion without synchronization pulses
- rotor rotational angle

Measurement channel standard function set includes:

- sensor DC measurement, sensor and communication line serviceability monitoring;
- parameter value calculation (with period of -0.1 s), measurement results averaging, comparison with setpoints;
- measured parameter stability monitoring, maintaining minimum and maximum parameter value;
- feeding the calculated parameter value to unified current output;
- assigning descriptive symbolic name to measurement channels;

Rotor speed measurement function (for measurement channels 1, 2) includes:

- rotor speed measurement period from 0.1 to 1.0 s’
- rotor speed measurement from 0.1 rpm with control surface “Groove”;
- pinion teeth adjustable number (number of pulses per rotor revolution);
- selecting sensor signal active edge;
- repeating reference tachometric pulses to synchronize control modules, calculating rotational components and their phases (e.g. MK22, MK32 modules);
- detecting rotor stop and rotor stop signaling check;

Overspeed protection mechanism functions (measurement channel 1):

- speed measurement period and setpoints actuation time from 5 to 100 ms;
- setpoints 1, 2 of measurement channel No.1 are connected to logic outputs 1,2 (accordingly);
- pinion teeth adjustable number (number of pulses per rotor revolution);
- selecting sensor signal active edge.

Overspeed protection mechanism pins positions functions (for measurement channels 1, 2):

- four algorithms to determine pin position;
- setting rotor minimum speed to measure pin position.

The displacement excursion functions without synchronization pulses (for all measurement channels):

- No additional measurement channel calibration by variable signal is required;
- Frequency measurement range from 0.015 to 1000 Hz;
- Two independent algorithms for LF and HF components.

Rotor bowing (eccentricity) measurement functions (measurement channel 3):

- measurement period 0.2 s (or one rotor rotation);
- calculating rotor bowing by 1-st rotor rotational component or sensor polyharmonic signal;
- calculating harmonic components of rotor bowing measurement sensor signal (2 A excursion from ½ to 5 harmonic and their phase);
- reference tachometric pulses input selection;
- measurement channels 1, 2 operation in constant signals mode with 3-rd measurement channel operating in “rotor bowing” mode;
- synchronization from tachometric pulses with a control surface “Pinion” (rotational components phases are not calculated);
- phase shift correction of LPF module, converter and sensor installation position relative to control surface “Groove”;
- rotor bowing measurement blocking when the rotor speed is out of range.

Sensor constant signal linearization function:

- linearization by piecewise linear approximation (current - measured parameter value);
- up to 16 records (15 segments) in linearization table.

Parameter calculation function according to formula:

- record analytical form;
- up to 32 arithmetic operations in the formula;
- data validity check by module measurement channels.

Rotor rotational angle measurement function (channel 4):

- logic pulses software comparator with switching level in current dimension;
- number of pulses per one rotor revolution from 2 to 100;
- rotor speed up to 100 rpm.

MK22 module other features include:

- measurement channels input signals: (0(1) – 5) mA; (0(4) – 20) mA; (0 – 3) V;
- 12 logic outputs with configurable operation algorithm to implement signaling and protection circuitry;
- four unified current outputs with software range setup;
- supported communication interfaces: two independent RS485, CAN2.0B interface, diagnostic interface (connector on module front panel);
- service software for PC to visualize current state, module setup and calibration;
- module manufacturing in several versions (ref. Table 1);
- module single-supply operation by +24V DC, low power consumption;
- converters (sensors) are powered via resettable fuses 200 mA installed on MK22 module board with +24V DC.

All MK22 module setup is carried out using personal computer or target setup instrument ПН31. To setup the module using personal computer, started on computer should be a program ModuleConfigurator.exe, MK22 module should be connected to computer via diagnostic interface module MC01 USB (PC USB interface).

Structurally the MK22 module is made as a 3U module for frameworks of “Евромеханика” 19” type.

List of MK22 control module versions is given in Table 1.

Table 1 - MK22 control module versions

Version code	Designation	Note
MK22-DC-R2	ВШПА.421412.3022-10	Limited indication system, front panel 20 mm. Module setup, measured values and status viewing can be carried out only via digital communication interfaces;
MK22-DC-001-R2	ВШПА.421412.3022-11	Extended indication and control system, front panel 40 mm. Arranged on the module front panel are a digital-character liquid-crystal display (LCD), simultaneously indicating measurement results by all channels, LED's of limited indication system and control buttons.
MK22-DC-11-R2	ВШПА.421412.3022-12	Extended indication and control system, front panel 40 mm. Arranged on the module front panel is a 7-segment digital indicator, additional indication LEDs and control buttons.
MK22-DC-001-R2-M-Base-PO	ВШПА.421412.3022-20	Similar to MK22-DC-001-R2 implementing galvanically isolated unified current outputs (passive mode)
MK22-DC-001-R2-COMP.01	ВШПА.421412.3022-30	Similar to MK22-DC-001-R2 with installed controlled comparators board COMP.01-2CH-MK32-MS for measurement channels 1, 2

2 Specifications

Table 2 - MK22 module main specifications

Parameter description	Value
Number of constant signal measurement channels	4
Number of rotor speed measurement channels	2[1)]
Number of rotor speed measurement channels in overspeed protection mechanism mode	1[2)]
Number of overspeed protection mechanism trip pin position measurement channels	2[1)]
Number of rotor bowing measurement channels	1[3)]
Input signal measurement ranges • DC, mA • VDC, V	1 – 5; 4 – 20 0.56 – 2.8
Input resistance, Ohm • DC • VDC	560 ± 2; 140 ± 0,5 50 000 min
Number of setpoints by each measurement channel	4
Number of discrete (logic) outputs	12
Module output discrete signals • DC, V, max • output current, mA, max	open collector 24 100
Supported digital communication interfaces types	RS485 CAN 2.0B diagnostic SPI
Power supply voltage, V	+(24 ± 1.0)
Consumption current, mA, max	100[4)]
Ambient air operating temperature range (from and to inclusive), °C	+5 – +45

1) For measurement channels 1, 2.
2) For measurement channels 1.
3) For measurement channels 3.
4) Consumption current is specified without considering consumption current of sensors and other external circuits.

Table 3 - Constant signals measurement parameters by MK22 control module

Parameter description	Value
Constant signals measurement and signaling ranges	determined according to connected sensor type
Constant signal measurement permissible main relative error limits, %, max • at unified signal • by digital indicator	± 1.0 ± 0.5
Refresh time of protection and signaling indications and logic operation, s	0.1

Table 4 - Rotor speed measurement parameters by MK22 control module

Parameter description	Value
Rotor speed measurement range, rpm	0.5 – 12000[1)]
Rotor speed permissible main absolute measurement error limit by digital indicator, rpm, max	± 0.5
Rotor speed permissible main relative measurement error limit by unified output, %, max	± 1.0
Refresh time of protection and signaling indications and logic operation, s • in normal operating mode • in overspeed protection mechanism mode (for channel 1)	0.1- 1.0 0.005- 0.100

1) Range with specified metrological accuracy. Actual measurement range from 0.1 rpm
Measurement range from 1 rpm for module software before version 1.67.

Table 5 - Protection mechanism pin positions measurement parameters by MK22 control module

Parameter description	Value
Pin position measurement range, mm	0 – 6[1)]
Measurement permissible main relative error limits, %, max • at unified signal • by digital indicator	 ± 6.0 ± 6.0
Measurement frequencies range, Hz	5 – 10,000
Frequency response (FR) ripple in frequency range, % • 5 – 1,000 Hz • 1,000 – 10,0000 Hz	 ± 2.5 +2.5; -20.0
Refresh time of protection and signaling indications and logic operation, s	0,1
[1)] Determined according to sensor type. Note: Overspeed protection mechanism pin positions monitoring parameters are provided for measurement channels with sensors of equipment Vibrobit 100:	

Table 6 - Rotor bowing (eccentricity) measurement parameters by MK22 control module

Parameter description	Value
Measurement range of relative vibration displacement excursion, eccentricity, mm	0.02 – 0.50
Measurement frequency range of pick-to-pick amplitude and rotational component phase, Hz	0.05 – 160
Variable signal measurement permissible main relative error limits on base frequency, %, max • at unified signal • by digital indicator	 ± 1.0 ± 1.0
Base measurement frequency, Hz	80 ± 1
Frequency response (FR) ripple in frequency range for rotational components, %	± 2.0
Sinusoidal signal phase measurement range, °	0 – 360
Sinusoidal signal phase measurement permissible main absolute error limit, °	± 4.0
Refresh time of protection and signaling indications and logic operation, s	0.2

Table 7 - Displacement excursion measurement parameters by MK22 control module without synchronization pulses

Parameter description	Value
Measurement range of relative displacement excursion, eccentricity, µm	Corresponds to the gap measurement range
Relative displacement excursion measuring frequencies range, Hz	0.015 – 1000
Variable signal measurement permissible main relative error limits on base frequency, %, max • at unified signal • by digital indicator	 ± 2.0 ± 2.0
Base measurement frequency, Hz	80 ± 1
Frequency response (FR) ripple in frequency range for rotational components, %	± 5.0
Refresh time of protection and signaling indications and logic operation, s	0.2
Displacement excursion measurement function without synchronization pulses is available in MK22 control module with software version from 1.68.	

Table 8 - Parameters of unified current outputs of MK22 module

Parameter description	Value
Number of unified DC signals	4
Output unified DC signal, mA	0(1) – 5 0(4) – 20
Output unified signal load resistance, Ohm, max • range 0(1) – 5 • range 0(4) – 20	2000 500
Additional parameters for version MK22-DC-001-R2-PO	
Unified outputs type	Passive regulator with galvanic isolation[1)]
Unified current output power source voltage, V	from 18 to 30
Unified current signal galvanic isolation operation voltage, V, max	400[2)]

[1)] Each output is galvanically isolated from other unified outputs and the module power supply source.
[2)] Voltage applied between any galvanically isolated circuits or a ground bus and any galvanically isolated circuit. The values are given for normal conditions, according to ГОСТ Р 53429-2009.

Table 9 - RS485 interface parameters

Parameter description	Value
Number of RS485 interfaces	2
Exchange protocol	ModBus RTU (partial implementation)
Data format	without parity bit, 2 stop bits
Pause between messages, byte, min	3.5
Data rate (one speed is set), bit/s	4800; 9600; 19200; 38400; 57600; 115200; 230400
Driver operating mode	semiduplex
Maximum nodes number on bus	256
Driver input resistance, kOhm, min	12
Electrostatic resistance, kV, min	± 16
Galvanic isolation from the module power supply source	none

Table 10 - CAN2.0 interface parameters

Parameter description	Value
Number of CAN2.0 interfaces	1
Operating mode	Active
Data format	Special for equipment Vibrobit 300
Code for indicating units	0x22 (34)
Data rate (one speed is set), kbit/s	1000; 500; 250; 200; 125; 100; 80; 40
Compliance with CAN bus standard	ISO-11898
Maximum nodes number on bus	1200
Driver input resistance, kOhm, min	5
Electrostatic resistance, kV, min	± 16
Galvanic isolation from the module power supply source	none

Table 11 - Diagnostic interface (D.port) parameters

Parameter description	Value
Interface type	SPI slave
MK22 address on SPI interface	0x38
Address format when accessing module registers	16-bit
Data rate, kbit/s, max	400
VDC on diagnostics connector to power matching device, V	5 ± 0.2
Permissible consumption current in power supply circuit on diagnostics connector, mA, max	50
Galvanic isolation from the module power supply source	none

Table 12 - MK22 additional parameters

Parameter description	Value
Overall dimensions, mm • control module MK22-DC-R2 • control module MK22-DC-11-R2, MK22-DC-001-R2, MK22-DC-001-R2-M-Base-PO	 20,1 x 130 x 190 40,3 x 130 x 190
Mass, kg, max • control module MK22-DC-R2 • control module MK22-DC-11-R2, MK22-DC-001-R2, MK22-DC-001-R2-M-Base-PO	 0.15 0.20
Warm-up time, min, max	1
Operating mode	continuous
Mean time between failures (design), hours, min	100,000
Average service life, years	10
Permissible relative humidity, %	80 at temperature +35°C
Industrial radio interference voltage, dB mkV, max - on frequency from 0.15 to 0.5 MHz - on frequency from 0.5 to 2.5 MHz - on frequency from 2.5 to 30 MHz	 80 74 60
Guarantee service life, months	24
Transportation conditions according to ГОСТ 23216-78	Ж
Storage conditions according to ГОСТ 11550-69	3 (Ж3)

3 Indication and control means

MK22 module front panel differs depending on the version. The MK22 module front panels appearance is shown in the figure 1.

The following elements are arranged on all types of front panels:

- handle to install/dismount the module in the section;
- module to section attachment screws;
- **D.port** diagnostic interface connector;
- hidden reset button **Reset**;
- module status LED **Ok.**

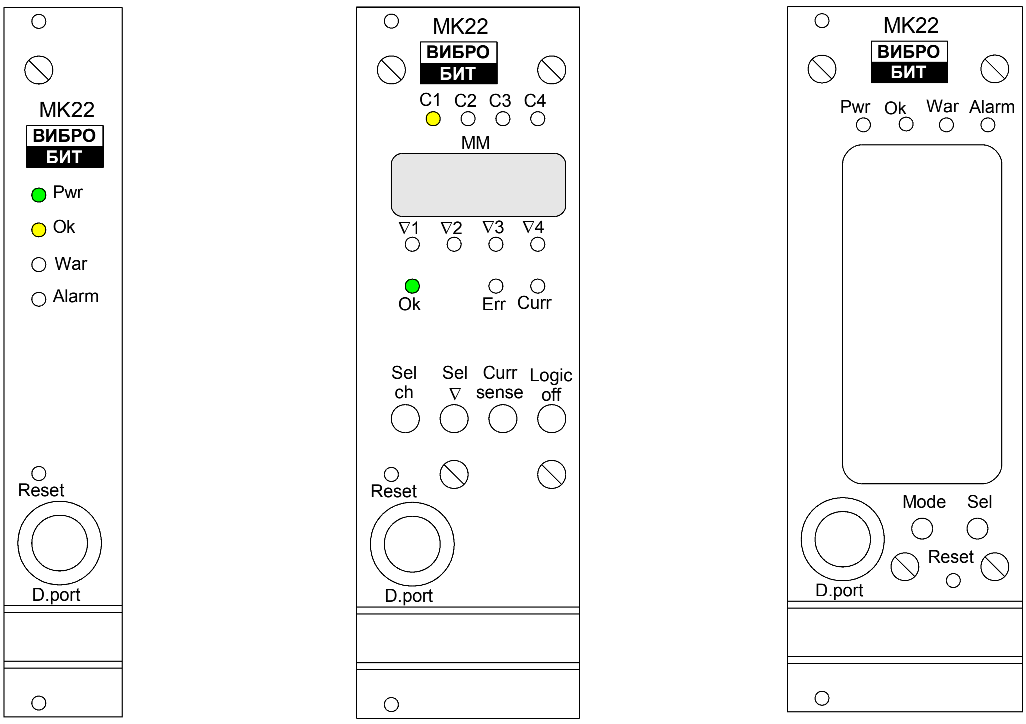
The **Ok** LED color indicates the module status:

- green color – module normal operation;
- yellow color – output logic signaling is blocked after the module switching off (reset) or by the user’s command;
- red color – fatal error in module operation, module operation is blocked;
- blinking green (yellow) color - an error was detected in the sensor test for one of the measurement channels.

3.1 Version MK22-DC-R2

Narrow front panel (width 20 mm) with limited indication and control system. Measurement results can be viewed only at reading by digital communication interfaces. Additionally on the module front panel are arranged:

- green LED ‘***Pwr***’ - module energized;
- bi-color LED ***‘Ok’*** - module status indication;
- yellow LED ***‘War’*** – warning (LED operation logic is determined at the module setup);
- red LED ***‘Alarm’*** – alarm (LED operation logic is determined at the module setup);



a) MK22-DC-R2 b) MK22-DC-11-R2 c) MK22-DC-001-R2, MK22-DC-001-R2-PO

Figure 1 - MK22 front panel appearance

3.2 Version MK22-DC-11-R2

MK22 module front panel with a 7-segment 4-bit LED indicator, auxiliary signal LEDs and control buttons. In this MK22 module version the indicator simultaneously display only one measurement channel information.

Arranged on front panel are:

- four yellow LEDs ***'C1', 'C2', 'C3'*** and ***'C4'*** of the selected measurement channel indication.
- digital 4-bit 7-segment indicator to display parameters measured values and messages output.
- four yellow LEDs ***'∇1'***, ***'∇2'***, ***'∇3'*** and ***'∇4'*** of the parameter overrange indication of the selected measurement channel (when the setpoint value is displayed, the corresponding setpoint LED flashes).
- bi-color LED ***'Ok'*** - module status indication.
- red LED ***'Err'*** - fault indication of the selected measurement channel (LED ***'Err'*** flashes if the measurement channel operation is normalized, but the pause has not been counted down between the channel operation normalization and the parameter setpoints value test).
- yellow LED ***'Curr'*** - indicates the indicator output of sensor actual current value (LED ***'Curr'*** flashes when indicator shows the sensor current of the selected measurement channel).
- four control buttons:
  - ***'Sel ch'*** - select the measurement channel to display the parameter value and the measurement channel status (the disengaged measurement channels are not displayed).
  - ***'Sel ∇'*** - displays the setpoints values on the indicator (disengaged setpoints are not displayed).
  - ***'Curr sense'*** - displays the sensor current on indicator.
  - ***'Logic off'*** - blocking the logic outputs operation.
- hole to press hidden reset button ***'Reset'.***
- diagnostic interface connector.
- handle for easy module dismantling from framework.

Measurement channel are switched by pressing the ***'Sel ch'*** button. When selecting new measurement channel, the indicator immediately displays the selected channel main parameter current value. Switching to the information indication by measurement channel is not carried out if this measurement channel operation is blocked in the MK22 module settings. If all measuring channels are disengaged in the module settings, the indicator shows 'OFF'.

Cyclic viewing of the setpoints value is carried out by pressing the ***'Sel ∇'*** button. The indicator shows the setpoint value, and the corresponding setpoint LED will flash. If during the set time the indicator didn't switch to the next setpoint, the module will indicate the main measured parameter value. If setpoint is disabled in the module settings, this setpoint is not displayed on the indicator. If all setpoints operation is forbidden, the setpoints value is not displayed on the indicator.

To display the sensor current on the indicator, press the ***'Curr sense'*** button. The indicator shows the sensor current in the format ##. ## even if a sensor fault is detected, in this case the ***'Curr'*** LED flashes.

Logic outputs are enabled/disabled by pressing and holding button ***'Logic off'***, until logic outputs operating mode switches. When the logic outputs operation is blocked, the '***Ok***' LED lights up in yellow, and all logic outputs are inactive.

Custom display format of the measured parameter values can be set for each measurement channel. When trying to display a value beyond the acceptable limits, the indicator will show the maximum permissible value (for negative values, the minimum permissible value).

Table 13 - Data displaying formats on the indicator

Mode code	Display format	Permissible values for MK22-DC-11-R2	Permissible values for MK22-DC-001-R2(-M-Base-PO)
0	#.###	from 0.000 to 9.999	from 0.000 to 19.999
1	##.##	from -9.99 to 99.99	from -9.99 to 199.99
2	###.#	from -99.9 to 999.9	from -99.9 to 1999.9
3	####	from -999 to 9,999	from -999 to 19,999

3.3 Version MK22-DC-001-R2

MK22 module front panel with special digital-character LCD (liquid crystal display), signal LEDs and control buttons. The indicator simultaneously display measurement results and status of all measurement channels.

Figure 2 - Sample of data displaying on LCD DC-001

Arranged on front panel are:

- special LCD with built-in LED backlight
- signal LEDs:
  - green LED ‘***Pwr***’ - module energizing;
  - bi-color LED - ***‘Ok’*** -- module status;
  - yellow LED ***‘War’*** – warning (LED operation logic is determined at the module setup);
  - red LED ***‘Alarm’*** – alarm (LED operation logic is determined at the module setup);

Two control buttons:

- button “Mode” – indication mode selection;
- button “Sel” – indicated data selection.

Symbols ***'∇1'***, ***'∇2'***, ***'∇3'***, ***'∇4'*** (in frame) signal about monitored parameter value overrange.

The ‘***Er***’ symbol (in frame) indicates that a sensor fault has been detected on this measurement channel, the measured parameter value is assumed to be zero (LCD displays dashes), the setpoints alarm of the corresponding measurement channel is inactive.

As soon as the measurement channel operation is normalized, the ’***Er***’ symbol starts blinking, the module counts the time-out for the measurement channel operation normalization (determined during module setup).

To display the sensors DC on indicator, press and hold the ***‘Mode’*** button until the sensors current value (two channels at a time) appears on the LCD. When the sensors current is displayed on LCD, the units of measurement ***‘мА’*** symbol will appear, and the measured parameter overrange symbols will not be displayed. Return to the normal display mode by repeated holding the ***‘Mode’*** button or automatically by timeout.

To view setpoints value on LCD press and hold the ***’Sel’*** button until the symbol of 1-st measurement channel ***‘K1’*** and first setpoint symbol ***‘∇1”*** start flashing. To view all 4 setpoints by the current measurement channel, repeatedly (briefly) press the ***’Sel’*** button. Setpoints values are displayed instead of measurement results. If setpoint is disabled (in the module settings), the dashes are displayed instead of the setpoint value.

To view the setpoints values of another measurement channel, press the ***‘Mode’*** button in the setpoint displaying mode. Return to the normal display mode by repeated holding the ***'Sel'*** button or automatically by timeout.

Logic outputs are enabled/disabled by simultaneous pressing and holding buttons **‘Mode’-’Sel’**, until logic outputs operating mode switches. When the logic outputs are blocked, the ‘***Ok***’ LED lights up in yellow, and all logic outputs are inactive.

4 Module operation

4.1 Power-up

Upon power-up, the MK22 module operating parameters are loaded from non-volatile memory Operating parameters are divided into sections:

- measurement channels parameters;
- system parameters;
- communication interfaces parameters.

Each operating parameters section in non-volatile memory is accompanied with a check sum, permitting to check authenticity of loaded data. If calculated check sum is not the same as recorded sum in non-volatile memory, then data are considered damaged and unfit for module operation.

Each section in non-volatile memory has main and reserve allocation. If parameters section from non-volatile memory is read with error, then attempt is made to read the data from non-volatile memory reserve area.

If an error is detected in one of operating parameters sections (from main or reserve section), then module operation is blocked, signal active level will be available at 12-th logic output, LED ***'Ok'*** on front panel will light up with red color.

During operating parameters normal loading before MK22 module operation start:

- MK22-DC-R2 : LED "***Ok***" blinks with yellow color, indicating module starting initialization in progress;
- MK22-DC-11-R2, MK22-DC-001-R2 – LED "Ok" illuminate with yellow color, indicator shows the module serial number, then module manufacturing year and then executes MK22 starting initialization.

After MK22 module power-up (reset), the logic outputs operation is blocked for the established time. If logic outputs operation is blocked, then LED "Ok" illuminates with yellow color.

Not recommended, but permitted to carry out MK22 module "hot" replacement in section without de-energizing for all MK22 module versions.

4.2 Module reset

Carried out during module reset is microcontroller hardware reset and carried out is sequence of actions, corresponding to power-up. Reasons for MK22 module reset include:

- module power-up;
- reset according to user command (by button "***Reset***" on module front panel or by command via digital communication interfaces);
- microcontroller power supply voltage drop (power source malfunction);
- Reset according to watchdog timer due to microcontroller program "hang-up".

Using hole on module front panel to press hidden button ***'Reset'***, installed on MK22 module board, user can reset module and carry out module "Cold start".

To reset module – briefly press button "Reset", then press button "Reset" and hold it until module is reset.

Module reset can be carried out only after displaying identification information (module number, manufacturing year) and completing MK22 module initialization cycle.

4.2.1 Module “cold start”

“Cold” start is intended to record default operating parameters into the module non-volatile memory. This function is useful during module first power-up after manufacture or if it is necessary to recalibrate the module, establish predetermined operating parameters.

To switch to “Cold start” mode, press and hold button ***‘***Reset’ during whole cycle of module identification information displaying and initialization after its reset.

If module switched to “Cold start” mode, then:

- MK22-DC-R2 – ***‘Ok’*** LED will flash amber in sync with the ***‘War’*** LED.
- MK22-DC-11-R2, MK22-DC-001-R2 – inscription ‘Cold’ will flash on display.

After switching to cold start mode, it is necessary to confirm the module “Cold start”. “Cold start” confirmation is a sequence of ***‘Reset’*** button pressing similar to reset sequence in normal operating mode (brief pressing, pressing and holding the ***‘Reset’*** button).

Upon “Cold start” confirmation, module settings are initialized with default values and are saved in non-volatile memory, then module is reset. If “Cold start” was not confirmed, module switches to normal operation.

MK22-DC-R2

‘***War***’ LED blinks during recording into non-volatile memory. Recording results can be determined by ‘***Ok***’ LED illumination color:

- *green* - recording completed without errors;
- *yellow* – one of data sections was correctly recorded into non-volatile memory at the second attempt;
- *red* - one of data sections was recorded into non-volatile memory with an error.

MK22-DC-11-R2, MK22-DC-001-R2 (-M-Base-PO)

- During recording, the ‘`Load`’ inscription is displayed on indicator. Recording results can be determined by ‘***Ok***’ LED illumination color (similar to version MK22-DC-R2) and indicator message:
- ‘`Good`’ – recording completed without errors;
- ‘`bad`’ – one of data sections was correctly recorded into non-volatile memory at the second attempt;
- ‘*`Err`*’ - one of data sections was recorded into non-volatile memory with an error.

Results of operation parameters recording into non-volatile memory are indicated in 2 seconds, then module is reset automatically.

4.3 Parameters measuring

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

- measures signal constant level by measurement channels;
- calculates sensor current and monitors sensor serviceability;
- calculates measured parameter real values;
- compares parameter calculated values with setpoints and signals about setpoints overrange;
- sends the measured values to unified outputs;
- generates logic signaling;
- refreshes data on indication means.

Measurement channels input circuits contain resettable fuses and protective stabilitrons, preventing module damage by pulse interferences or dangerous voltage level.

4.3.1 Sensor current measuring

Input current signal should be converted to voltage. To this end provided in the measurement channels input circuit are precise resistors corresponding to sensor signal current range depending on the required current range.

Input signals voltage range from 0 to 3 V. During measurement channel operation with voltage signals it is recommended to maintain useful signal range reserve to implement function – sensor serviceability test.

Input signal (voltage) passes via LPF (low-pass filter) and is supplied to input of 12-bit ADC (analog-to-digital converter), built into microcontroller. Conducted are 512 analog-to-digital converter (ADC) values sampling by every measurement channel during 100 ms. ADC mean value is used in further sensor current calculations. Large number of ADC sampling results in ADC DC actual resolution 14-bit due to averaging.

Sensor current is calculated according to the linear equation formula:

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

Where:

I_{sense} – calculated sensor current value;

ADC – averaged ADC value (`AdcConst`);

A_I, B_I – linear equation factors to calculate sensor current.

Sensor current value I_{sense} can be displayed on indicator and is used to calculate the value of measured parameter, provided by DC signals.

A_I, B_I factors are calculated automatically during module operation initialization according to sensor current range data (20 % from `InRangeCurrMax`, `InRangeCurrMax`) and ADC saved values (`AdcInMin`, `AdcInMax`), corresponding to current input range of calibrated sensor.

If one pair of calibration values (20 % from `InRangeCurrMax`, `InRangeCurrMax` or `AdcInMin`, `AdcInMax`) equals to zero or they are equal to each other, then A_I, B_I factors are not calculated and are set to zero (sensor current I_{sense} always equals to zero).

Figure 3 shows an example of MK22 module measurement channel No.1 input setting in ModuleConfigurator software.

Parameter	Value		Address
01. Sensor current range lower level, mA	4	☒	0x0600
02. Sensor current range upper level, mA	20	☒	0x0604
03. Minimum ADC	726	☒	0x0628
04. Maximum ADC	3817	☒	0x062A

Figure 3 - Example of measurement channel No.1 input setting in ModuleConfigurator software

4.3.2 Sensor serviceability test

Sensor test is carried out according to calculated value I_{sense} (`Current`). Sensor is considered serviceable if value is within permissible limits (`CurrValidMin`, `CurrValidMax`), established during module setup.

Monitoring of sensor minimum/maximum permissible current can be disabled in module settings (parameters `EnaCurrValidMin`, `EnaCurrValidMax` accordingly).

If I_{sense} value is less than minimum permissible current level `CurrValidMin`, then it is considered that sensor signal level is too low (flags `ErrorSenseLow`, `FlagError` are set). For measurement channel operation normalizing, I_{sense} value should exceed `CurrValidMin + CurrValidHist` (flag `ErrorSenseLow` is reset).

If I_{sense} value is above maximum permissible current level `CurrValidMax`, then it is considered that sensor signal level is too high (flags `ErrorSenseHigh`, `FlagError` are set). For measurement channel operation normalizing, I_{sense} value should be less than `CurrValidMax – CurrValidHist` (flag `ErrorSenseHigh` is reset).

With any sensor current abnormal level flag set (`ErrorSenseLow`, `ErrorSenseHigh`) measured parameter value is taken as zero, flag (`FlagError`) is set if measurement channel blocking is permitted (`OutRangeCurrMode`) during sensor fault detection.

It is not recommended to set sensor current test hysteresis value (`CurrValidHist`) as zero, because frequent signaling switching effect may occur.

After normalizing sensor operation and resetting flags `ErrorSenseLow`, `ErrorSenseHigh`, reset is flag `FlagError` in established time interval `TestPointSenseOk`. After flag `FlagError` reset, measured parameter calculated value is compared to setpoints.

Figure 4 shows an example of sensor test algorithm operation at sensor DC drop below permissible level. Sensor current permissible levels are 0.9 mA and 5.1 mA correspondingly, hysteresis 0.1 mA.

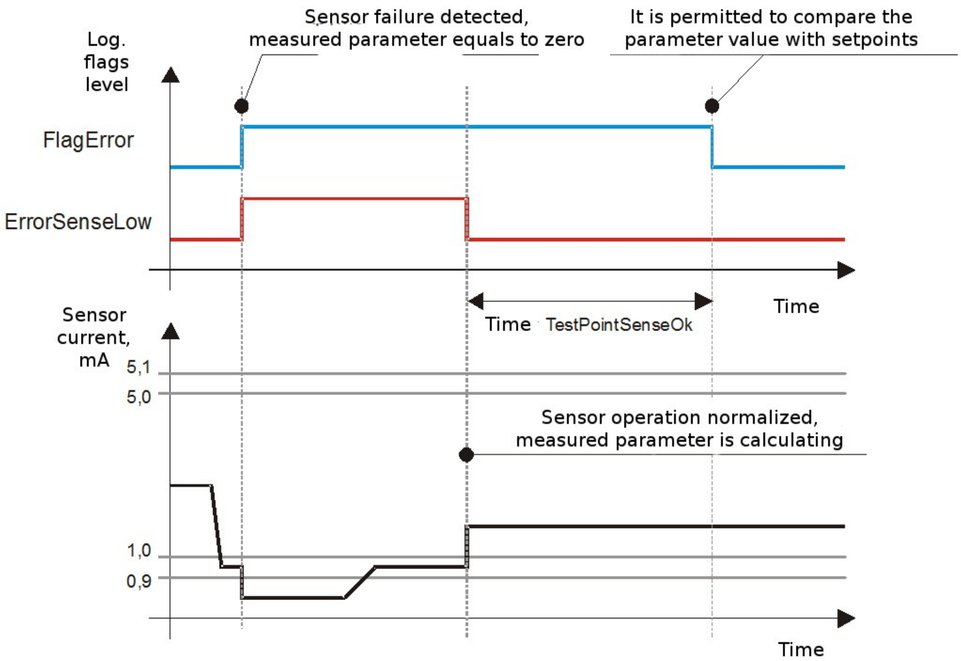


Figure 4 - Sensor test algorithm operation at sensor DC drop below permissible level

After module reset, the sensor is assumed serviceable, but it is necessary to count the time-out before comparing the parameter value with the setpoints, because the `FlagError` flag is automatically set after the reset.

Figure 5 shows an example of MK22 module measurement channel No.1 input setting in ModuleConfigurator software.

Parameter	Value	Address
01.1 Enabling the sensor test by the lower limit	✓	0x0608
01.2 Sensor current lower acceptable limit, mA	3.6	0x060C
02.1 Enabling the sensor test by the upper limit	✓	0x060A
02.2 Sensor current upper acceptable limit, mA	21	0x0610
03. Hysteresis according to the sensor test, mA	0.1	0x0614
04. Sensor current control operation mode	block channel work	0x0630

Figure 5 - Example of MK22 module measurement channel No.1 input setting in ModuleConfigurator software

4.3.3 Measurement of parameter value represented by DC value

Parameter value is calculated from sensor current measured value if sensor failure is not detected (flag `FlagError` is reset). If sensor failure is detected, the measured parameter value is not calculated and is taken as zero.

Measured parameter value is calculated according to linear equation formula:

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

Where:

D_{Param} – calculated measured parameter value;

I_{sense} – calculated sensor current value;

A_P, B_P – linear equation factors to calculate measured parameter value.

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

- comparison with setpoints;
- displaying on indicator as main parameter;
- DAC (digital-to-analog converter) value calculation for unified output.

A_P, B_P factors are calculated automatically during module operation initialization according to sensor current range data (`InRangeCurrMin, InRangeCurrMax`) and measured parameter established range (`RangeParamMin, RangeParamMax`).

If one pair of values (`InRangeCurrMin, InRangeCurrMax` or `RangeParamMin, RangeParamMax`) equals to zero or they are equal to each other, then A_P, B_P factors are not calculated and are set to zero (measured parameter value D_{Param} always equals to zero).

Figure 6 shows an example of MK22 module measurement channel No.1 main parameters setting in ModuleConfigurator software.

Parameter	Value	Address
01. Channel enable	☑	0x0A00
02.1 Measuring parameter name	ЧВФ (П)	0x0A0C
02.2 Addition information (48 symbols)		0x0A70
03. Measuring parameter lover range	0	0x0A04
04. Measuring parameter upper range	5000	0x0A08
05. Measuring units	rpm	0x0A14
06.1 Measuring results displaying format	####	0x0A1C
06.2 Adaptive mode output to the screen	☐	0x0A1D
07. Measuring results averaging depth	0	0x0A1E
08. Current output. Lower value range	0	0x0A48
09. Current output. Upper value range	5000	0x0A4C

Figure 6 - Example of measurement channel No. 1 main parameters setting in ModuleConfigurator software

Additionally, it is possible to specify for each measurement channel:

- parameter name, 8 characters `MeasurName` (informational purpose);
- units of measurement, 8 symbols `MeasurUnit` (information purpose);
- Indicator output format `FormatOut` (number of digits after the decimal point, ranges of the displayed values are shown in the table 13);
- indicator output format adaptive mode `AdaptiveOut` (implemented from MK22 module software version 1.67), `FormatOut` register sets the maximum displaying accuracy, switching between formats occurs automatically depending on the displayed value;
- measurement results integration depth `AverageDepth`;
- measured parameter range at unified output (usually is the same as measurement range).

4.3.4 Measured parameter averaged value

Before using the calculated D_{Param} parameter value (displaying on indicator, comparison with setpoints, DAC value calculation for unified output), it is possible to average the value by the moving average method (the last several calculated valuesof the measured parameter are averaged to obtain the final D_{Param} value).

The averaging depth is set during module setup (AverageDepth) and can vary from 1 to 10 (1 - no averaging, 10 - maximum averaging). Averaging stabilizes the measured parameter values (the measured parameter value variation will be minimum during indication), however the integration depth increase cause a greater inertia during signaling and safety shutdown operation.

4.3.5 Parameter calculated value comparison with setpoints

If FlagError flag is reset (a pause is counted after sensor operation normalization), the measured parameter calculated value D_{Param} is compared with setpoints set during module setup.

If a sensor fault is detected and FlagError flag is set, the parameter calculated value D_{Param} is not compared with setpoints, and all measured parameter value overrange flags are reset.

Provided for every measurement channel are four setpoints (TestPointData) with individually configurable operating modes (TestPointMode), hysteresis level (TestPointHist) and setpoint transition response (TestPointTime).

Table 14 - Setpoints operating mode

Mode code	Description
0	Setpoint disabled, check is not carried out
1	Check above setpoint
2	Check below setpoint

Operating mode – Setpoint disabled

Measured parameter value D_{Param} is not compared with setpoint TestPointData, OutPoint flag is always reset.

Operating mode – Check above setpoint

If during TestPointTime the D_{Param} value is more than TestPointData, the parameter level is considered too high and OutPoint flag is set. To reset OutPoint flag (normal level), measured parameter D_{Param} value should be less than TestPointData - TestPointHist during TestPointTime time.

Operating mode – Check below setpoint

If during TestPointTime the D_{Param} value is less than TestPointData, the parameter level is considered too low and OutPoint flag is set. To reset OutPoint flag (normal level), measured parameter D_{Param} value should be more than TestPointData + TestPointHist during TestPointTime time.

Figure 7 shows an example of signaling operation by setpoint of 1.7 mm (rotor axial shift monitoring) with hysteresis of 0.02 mm.

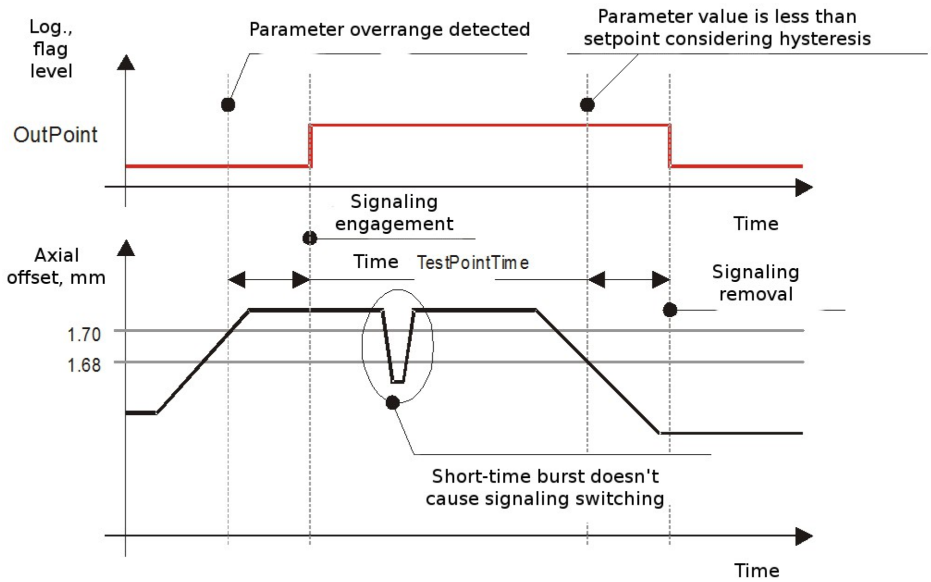


Figure 7 - Example of setpoint operation algorithm (mode – check above setpoint)

Implemented in MK22 module software from version 1.60 are individual hysteresis levels for each setpoint.

Figure 8 shows an example of MK22 module measurement channel No.1 RAO setpoints setting in ModuleConfigurator software.

Implemented in module software from version 1.68 is the TestPointDisplayOut parameter, used to set the setpoints value display formation on modules MK22-DC-001-R2 indicator.

Parameter	Value	Address
00.1 Setpoint transition response time, sec	0.5	0x0A3C
00.2 Setpoints display format	##.##	0x0A3A
01. Setpoint 1		
01.1 Mode	Low	0x0A20
01.2 Value	-0.8	0x0A28
01.3 Hysteresis	0.1	0x0A50
02. Setpoint 2		
02.1 Mode	High	0x0A22
02.2 Value	0.4	0x0A2C
02.3 Hysteresis	0.1	0x0A54
03. Setpoint 3		
03.1 Mode	Low	0x0A24
03.2 Value	-1.1	0x0A30
03.3 Hysteresis	0.1	0x0A58
04. Setpoint 4		
04.1 Mode	High	0x0A26
04.2 Value	0.8	0x0A34
04.3 Hysteresis	0.1	0x0A5C

Figure 8 - Example of measurement channel No. 1 RAO setpoints setting in ModuleConfigurator software

4.4 Additional parameters measuring

In addition to constant signals measuring, each MK22 module channel can be configured to operate in the extended mode:

Measurement channel No.1

- rotor speed (tachometric signal);
- overspeed protection mechanism mode (tachometric signal, response rate from 5 ms);
- overspeed trip pins position.

Measurement channel No.2

- rotor speed (tachometric signal);
- overspeed trip pins position.

Measurement channel No.3

- rotor bowing (eccentricity) (variable signal).

Measurement channel No.4

- sensor signal linearization (constant signal);
- parameter calculation according to formula.

In module software from version 1.68, it is possible to enable the “Displacement excursion calculation without synchronization pulses” operating mode for any measurement channel.

Additional functions operation should be permitted for measurement channels to operate in extended mode (`EnabledAdd`). Additional functions codes values by measurement channels are shown in table 24.

Figure 9 shows an example of MK22 module measurement channels additional functions setting in ModuleConfigurator software.

Figure 9 - Example of MK22 module measurement channels additional functions setting in ModuleConfigurator software

4.4.1 Rotor speed measurement

Only channels 1 and 2 measure rotor speed in extended mode. Rotor speed measurement period is set during module setup and can be from 0.1 to 1.0 s. If signal pulse period is more than established measurement period, the measurement period value is assumed equal to the signal pulse period.

MK22 module channel in frequency measurement mode executes the following main operations:

- calculates sensor current and monitors sensor serviceability;
- measures rotor speed;
- repeats tachometric pulses to synchronize test modules, measuring variable signals (only for test surface “groove”, one pulse per rotor revolution);
- compares parameter calculated values with setpoints and signals about setpoints overrange;
- sends the measured values to unified outputs;
- generates logic signaling;
- refreshes data on indication means;
- supports digital communication interfaces.

All frequency measurement channels work in the same way, in-sync, independently of each other. Several parameters are common:

- `FreqMeasurTime` - rotor speed measurement period from 0.1 to 1.0 s;
- `TestPointSenseOk` - setpoints test time-out after sensor operation normalizing;
- `TimeOut_TestStop` - “STOP” mode check time-out.

Rotor speed is measured if no sensor failure is detected (flag `FlagError` is reset). If sensor failure is detected, the rotor speed is not calculated and is taken as zero.

Rotor speed is determined by synchronization pulses period measurement method, calculating clock signal leading edges number of frequency 10 MHz between synchronization pulses two active edges.

Synchronization pulses period value is averaged for measurement cycle (determined by parameter `FreqMeasurTime`), then rotor speed is calculated in rpm (considering established number of pulses for rotor revolution `Tooth`). If during measurement cycle only one synchronization pulses period was detected, then not averaged period value is used in frequency calculation.

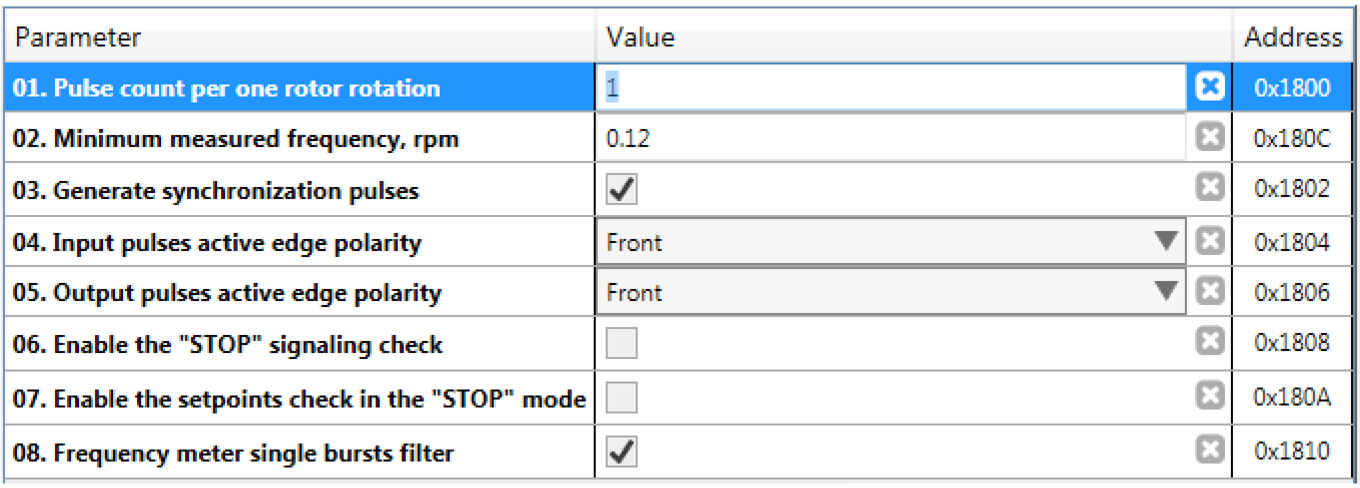
Minimum measured rotor speed is set by parameter `FrequencyMin` (0,9 rpm min). If rotor speed is less than established value, then synchronization pulses considered to be absent (rotor stopped).

The polarity of the input pulses and repeated synchronization pulses active front is determined in software (`PolarityIn`, `PolarityOut`). Synchronization pulses are generated only if permitted in module settings (parameter `PulseEna`). Synchronization pulses are generated (if permitted in module settings) even if sensor failure is detected. The graphs of synchronization pulses are shown in the figure 11.

“STOP” signaling check permission is determined by `StopTestEna` parameter. Setpoints check in “STOP” mode is permitted by `PointStopEna` parameter.

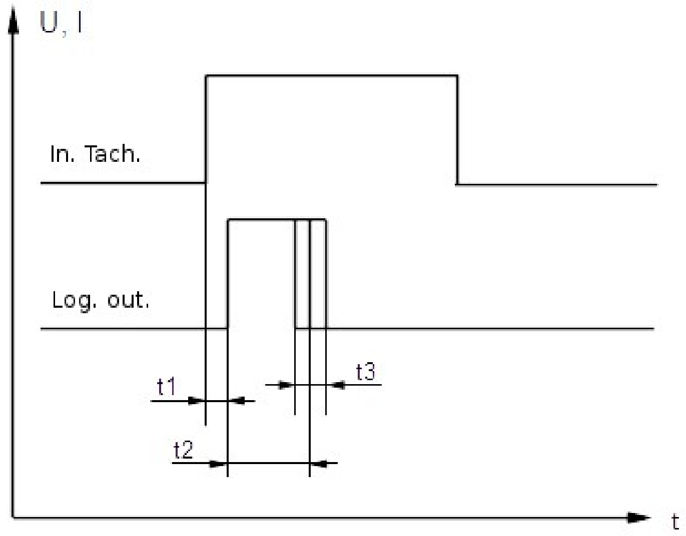
High-frequency noise filtering in rotor speed measuring channel is carried out by setting the parameter (`PulsePeriodMin`) - “Synchronization pulses period minimum time, ms” in the range from 0 to 49.99 ms. Value 0 (more than or equal to 50 ms) - function disabled.

Figure 10 shows an example of rotor speed measurement setting by channel No. 1 in ModuleConfigurator software.

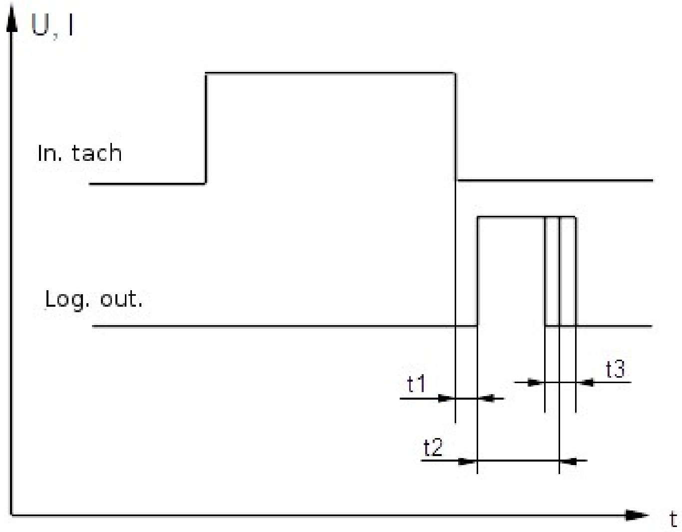


Parameter	Value	Address
01. Pulse count per one rotor rotation	1	0x1800
02. Minimum measured frequency, rpm	0.12	0x180C
03. Generate synchronization pulses	✓	0x1802
04. Input pulses active edge polarity	Front	0x1804
05. Output pulses active edge polarity	Front	0x1806
06. Enable the "STOP" signaling check	☐	0x1808
07. Enable the setpoints check in the "STOP" mode	☐	0x180A
08. Frequency meter single bursts filter	✓	0x1810

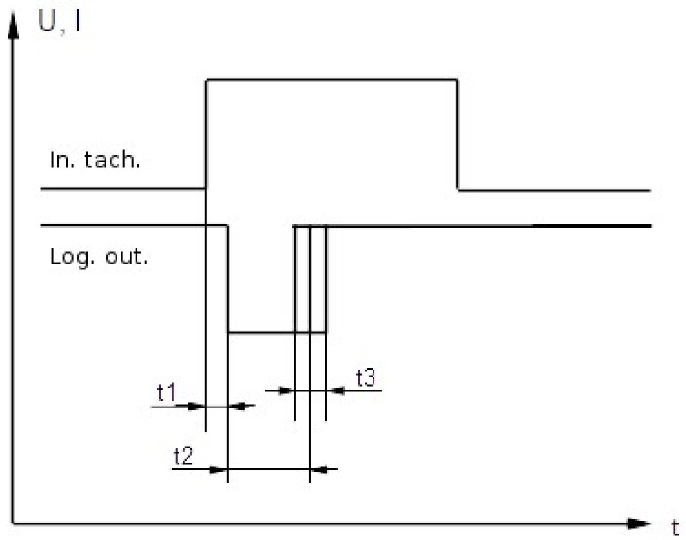
Figure 10 Example of rotor speed measurement setting by channel No. 1 in ModuleConfigurator software.



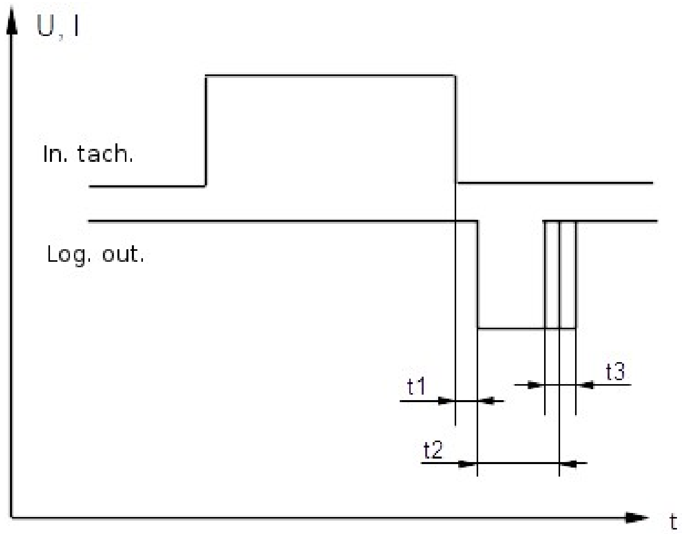
a)
input - leading edge
output - leading edge



b)
input - trailing edge
output - leading edge



c)
input - leading edge
output - trailing edge



d)
input - trailing edge
output - trailing edge

Figure 11 - Polarity of the input and output synchronization pulses depending on the active pulse edges setting

In the figure 11 the time parameters correspond to:

- t1 - fixed time delay 40 µs, which corresponds to 0.72º at speed of 3000 rpm;
- t2 - the output pulse signal average duration of 870 µs (at the logic output);
- t3 - “Jitter” (or drift) of the output pulse duration of 250 µs.

MK22 module output synchronization signal has no fixed duration, but it has a fixed time reference (according to the setting) by the “leading” or “trailing” edge relative to the input signal.

Implemented in MK22 module software version 1.67 is a single bursts filter of rotor speed measurement, which can be linked to “skip”, “creating a false” pulse by the frequency measurement channel primary sensor (converter). Filter function engagement: `FilterOnePulse` register value is not the zero. The filter function only affects the frequency measurement result displayed on the module indicator, transmitted via the communication interfaces and does not affect the synchronization pulses repetition.

4.4.2 Comparator board COMP.01-2CH-MK32-MS (software version 1.68)

Comparator board COMP.01-2CH-MK32-MS is intended to isolate tachometric pulses through measurement channels 1, 2 when measuring rotor speed. It is advisable to use a comparator board with an input signal proportional to the instantaneous gap to the control surface (for example for ДВТ10 sensor, ИП34 converter of Vibrobit 100 equipment).

Comparator board COMP.01-2CH-MK32-MS enables to:

- Measure gap to control surface (CS) during the rotor stop
- Measure gap to CS during rotor rotation, considering tachometric marks presence.
- Set comparison levels to isolate tachometric signal
- Automatically adjust the comparison levels when changing gap to CS during rotor rotation
- Isolate tachometric pulses for the subsequent rotor speed measurement

MK22 control module is equipped with a comparator board in version MK22-DC-001-R2-COMP.01. In this module version the LPF input filter cut-off frequency by measurement channels 1, 2 is 15 kHz. Extension of the LPF filter bandpass is necessary to reliably measure the gap to CS during rotor rotation.

The comparator board control is enabled in the MK22 module system parameters by selecting the “Comparator board COMP.01-2CH-MK32-MS” as the expansion board type (example in the figure 25). After changing the “Expansion board type” parameter, control module should be assembled to initialize the control function.

Measurement channels 1, 2 work with comparator board in the same way, independently of each other. Each measurement channel has its own additional parameter group. If there are no settings (zero values of the comparator board control parameters) or erroneous parameters, the comparator switching levels correspond to:

- For current range 1-5mA: logical ’0’ - 2.75mA; logical ’1’ - 3.25mA.
- For current range 4-20mA: logical ’0’ - 11mA; logical ’1’ - 13mA.

Comparator switching levels are set using a 12-bit DAC. Figure 12 shows the measurement channel 1 block schematic diagram with expansion card COMP.01-2CH-MK32-MS installed in MK22 module. DAC is controlled by SPI interface. Analog comparators of lower / upper switching level control the RS trigger, at which output generated is a logic tachometric signal (CH1-S). Analog signal (CH1-A) after LPF filter is supplied to the control module ADC input to measure static (with rotor stopped) and dynamic (with rotor rotation) gap.

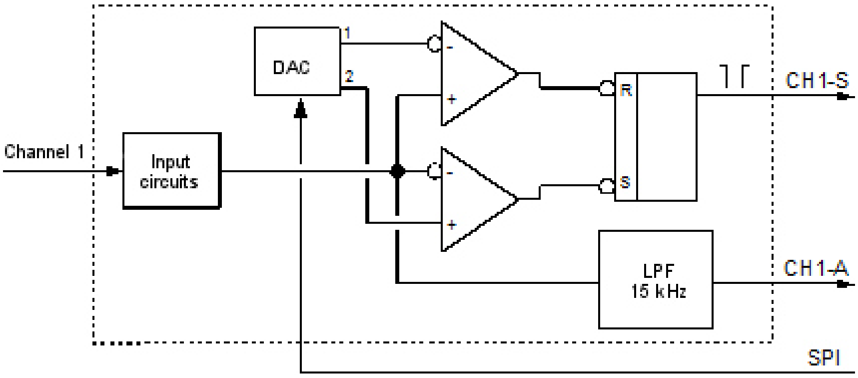


Figure 12 - Block schematic diagram of measurement channel 1 input circuits with comparator board COMP.01-2CH-MK32-MS

4.4.2.1 Comparator setup

Measurement channel 1 comparator settings list is given on Figure 13. Setup of all gaps, switching levels and displacements is carried out in μm.

Main parameters for comparator static setting:

- Gap measurement range (G_{LOW}), lower value, μm
- Gap measurement range (G_{HIGH}), upper value, μm
- Initial preset gap (G_{INIT}), μm
- Comparator switching medium level displacement relative to gap (TG_{OFFSET}), μm
- Comparator switching hysteresis, excursion (TG_{HIST}), μm

Because measurement channel basic settings specify the frequency measurement, it is also necessary to specify the gap measuring range corresponding to the measurement channel sensor DC range. Sensor current gap calculation is carried out similar to p.4.3.3 .

Parameter	Value	Address
01. Gap measurement range, lower value, µm	0	0x3000
02. Gap measurement range, upper value, µm	2000	0x3004
03. Initial setup gap, µm	500	0x3008
04. Comparator switching average level displacement relative to gap, µm	400	0x3010
05. Comparator switching hysteresis (excursion), µm	100	0x3014
06. Limit comparator switching levels by gap measurement range	✓	0x300C
07. Calculate GAP during rotor rotation	✓	0x3028
08. Number of rotor revolutions to calculate gap (from 1 to 100)	4	0x302A
09. Comparator levels setup adaptive mode		
09.01 Comparator switching levels adaptive correction	By gap, calculated from sen	0x300E
09.02 Limit comparator switching average levels, µm	✓	0x3024
09.03 Average switching level lower limit, µm	1000	0x3018
09.04 Average switching level upper limit, µm	1900	0x301C
09.05 Minimum rotor speed for adaptive mode, rpm	100	0x3020

Figure 13 - Example of channel No.1 comparator setting in ModuleConfigurator software

Figure 14 shows the comparator operation considering measurement channel settings. For the comparator static setting, the tachometric signal switching levels of logical’0’ and logical ’1’ are calculated by the formulas:Average comparison level

$TG_{AVR} = G_{INT} + G_{OFFSET}$

Switching level of logical '0' $TG_{LOW} = TG_{AVR} - TG_{HIST}/2$

Switching level of logical '1' $TG_{HIGH} = TG_{AVR} + TG_{HIST}/2$

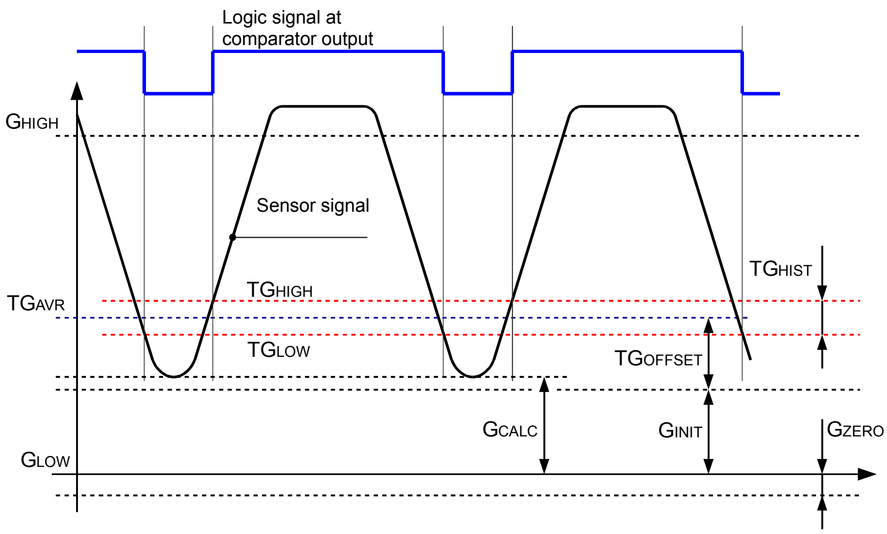


Figure 14 - Logic tachometric signal generation

Minimum permissible value of TG_{HIST} is 5 µm. The module automatically sets the minimum limit value if TG_{HIST} setting does not meet the requirements.

Figure 14 G_{ZERO} - eddy current sensor operating gap.

When limiting comparator switching levels TG_{LOW}, TG_{HIGH}, the gap measurement range uses the limits G_{LOW}, G_{HIGH}.

ModuleConfigurator software provides comparator status and operation monitoring, example is given in Figure 15.

Parameter	Value	Address
01. Status flags		
00. Enable function	☑	0x3300
01. Gap measurement during rotor rotation	☐	0x3300
02. Rotor is stop	☑	0x3300
03. Gap measured during rotor rotation	☐	0x3300
04. Adaptive mode. Rotor rotation frequency below the set level	☐	0x3300
05. Adaptive mode. Lower level restriction.	☐	0x3300
06. Adaptive mode. Upper level restriction.	☐	0x3300
31. Settings Error	☑	0x3300
02. Gap measuring		
02.1 1. Gap, calculated from sensor DC, µm	0	0x3304
02.2 Gap, calculated during rotor rotation, µm	0	0x3308
03. Comparator switching level		
03.1 Average level, µm	0	0x3310
03.2 Lower comparison level, µm	0	0x3314
03.3 Upper comparison level, µm	0	0x3318
04. Status data		
04.1 Switching level lower value, DAC	1540	0x3320
04.2 Switching level upper value, DAC	1820	0x3322
04.3 Gap calculation. Factor A	0	0x3328
04.4 Gap calculation. Factor B	0	0x332C
04.5 DAC calculation. Factor A	0	0x3330
04.6 DAC calculation. Factor B	0	0x3334
04.7 Gap during rotor rotation, ADC	0	0x3348

Figure 15 - Example of channel No.2 comparator operation monitoring in ModuleConfigurator software
Measuring gap to CS during rotor rotation

4.4.2.2 Measuring gap to CS during rotor rotation

MK22 control module supports the real CS gap measurement during rotor rotation, considering tachometric marks presence. To enable real gap measurement proceed as follows:

- permit gap calculation during rotor rotation;
- specify rotor speed for measurement results averaging.

Gap (G_{CALC}) calculation algorithm during rotor rotation:

1. Minimum gap is determined for each tachometric pulse (the nearest CS position);
2. The obtained minimum gap values for each tachometer pulse are averaged considering the number of CS marks per rotor revolution and the specified rotor speed for gap measurement.

Gap can change, for example, when the rotor floats up. When changing the CS gap it is recommended to adjust the comparator switching levels in automatic mode.

When calculating gap during rotor rotation, the factors used to convert the sensor current into the gap are obtained in p. 4.4.2.1 . No additional calibration is required.

CS gap measurement during rotor rotation is monitored by flags (Figure 15):

- Gap measurement during rotor rotation;
- Gap calculated during rotor rotation.

Also available are gap measurement results by the sensor DC and determined during rotor rotation.

4.4.2.3 Адаптивный режим настройки уровней компаратора

Comparator levels setup adaptive mode

Adaptive mode enables comparator switching levels correction considering CS gap change. Two types of algorithms are supported:

1. By gap, calculated from sensor DC;
2. By gap, calculated during rotor rotation.

Adaptive mode operation is possible only in case of rotor speed exceeding the established value: parameter “Minimum rotor speed for adaptive mode, rpm”

Switching levels in adaptive mode are calculated according to the formula:

Average comparison level	$TG_{AVR} = G_{CALC} + G_{OFFSET}$
Switching level of logical '0'	$TG_{LOW} = TG_{AVR} - TG_{HIST}/2$
Switching level of logical '1'	$TG_{HIGH} = TG_{AVR} + TG_{HIST}/2$

When using the sensor current for gap calculation, it is necessary to consider that the obtained gap value is a constant component of the initial tachometric signal (actually the comparator average switching level), G_{OFFSET} value must be zero (or have a minimum value).

Average comparison level TG_{AVR} can have the following limits:

- The average switching level lower limit, μm;
- The average switching level upper limit, μm.

To limit the average comparison level TG_{AVR} the operation should be permitted in the measurement channel settings: parameter «Limit the comparator average switching level ».

Comparator switching levels TG_{LOW}, TG_{HIGH} can be limited with the gap measurement range G_{LOW}, G_{HIGH}.

4.4.3 Displacement excursion measurement without synchronization pulses (software version 1.68)

In MK22 control module software version 1.68, it is possible to measure the vibration displacement excursion without synchronization pulses for any of 4 channels. Select “Displacement excursion (without synchronization)” as the measurement channel operating mode.

DC range is used as a measuring range. Measurement channel should be calibrated by direct current only.

Two algorithms are used to calculate the displacement excursion:

- HF components in frequency range from 0.6 to 1000 Hz with sampling frequency of 50 kHz
- LF component in frequency range from 0.015 to 3 Hz with sampling frequency of 10Hz

LF measurement range lower limit is determined by parameter “Minimum rotor speed (from 1 to 100), rpm” (see the Figure 16). The lower the minimum rotor speed, the longer the measurement time.

Algorithm separation into two frequency zones provides a fast response to the high frequency signals change.

10. Displacement excursion mode (without synchronization pulses)		
10.1 Minimum frequency of rotor speed (from 1 to 100), rpm	3	0x0A60
10.2 HF excursion meter noise level, μm	5	0x0A62

Figure 16 - Example of channel No.1 displacement excursion measurement setting in ModuleConfigurator software

The resulting displacement excursion is the maximum value of the displacement excursion in HF and LF area.

Due to the HF algorithm increased sampling frequency, single bursts of signal may appear as a noise. To determine the noise level, proceed as follows:

1. Set the parameter “Noise level of the excursion measurement by HF algorithm, μm” value equal to zero;
2. Supply a constant component of 12 mA (5 mA) to the measurement channel input without a variable component;
3. Use module indicator to determine the noise level (the displacement excursion value in the signal absence);
4. Set the parameter “Noise level of the excursion measurement by HF algorithm, μm” value equal to obtained noise value;

The noise value is subtracted from the HF algorithm displacement excursion measured value.

4.4.4 Overspeed protection mechanism mode (software version 1.60)

The overspeed protection mechanism mode (PM) is intended for rotor speed high-speed measurement, setpoints overrange signaling generation.

The overspeed PM mode can be engaged as an additional function for measurement channel No. 1. The rotor speed measurement initial parameters in overspeed PM mode are the parameters specified for channel No.1 rotor speed measurement.

Main differences of rotor speed measurement in overspeed PM mode are:

- synchronization pulses are not generated on logic output 1;
- period of speed measurement and setpoints check is determined by parameter (`OSP_MeasurPeriod`) in module system settings within range from 5 to 100 ms;
- setpoints 1, 2 are checked in speed high-speed measurement (setpoints operating mode “Above”);
- status of setpoints 1, 2 is supplied to logic outputs 1, 2 without any additional setting of logic outputs considering logic signaling block, present in the module.

Active status of flag `OverSpeedProtection` in additional status register `StatusSysAdd` confirms the overspeed PM mode engagement.

The overspeed PM function is implemented in the MK22 module software from version 1.60.

4.4.5 PM pin position change (software version 1.50)

PM pin position measurement mode can be engaged for measurement channels 1, 2. To measure PM pin position, rotor speed sensor pulses should be supplied to MK22 module.

Up to a certain rotor speed (`FrequencyMin`) it is considered that PM pin is in zero position. By analyzing the signal amplitude by PM pin protrusion measurement channel, obtained is the zero position parameter which is the reference value for all rotor PM pin displacement calculations till measurement cycle end. When determining the PM pin zero position, pin protrusion value is not shown on LCD, and digital communication interfaces read the zero value.

As soon as rotor speed exceeds the set limit, the current signal amplitude from the PM pin protrusion sensor is assumed to be zero.

A mandatory condition for measurement cycle start is the absence of recorded sensor fault. If rotor speed exceeded the set limit, and the sensor fault has been detected by PM pin position measurement channel, the PM pin protrusion will not be calculated after measurement channel operation is normalized, until rotor speed drops below the set limit (`FrequencyMin`).

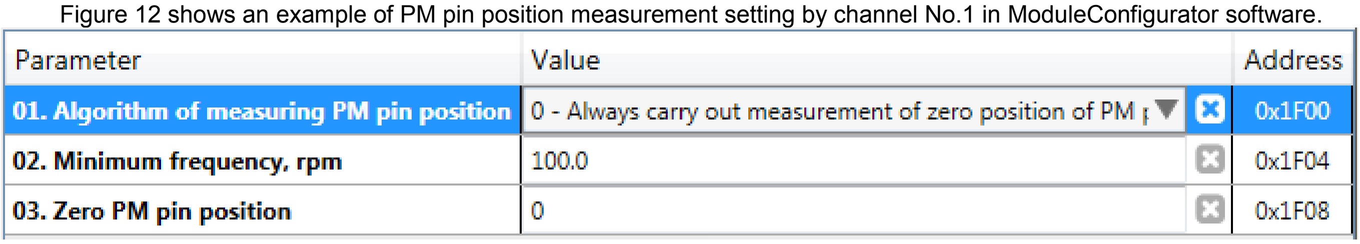
Depending on the PM pin position measurement channel version, provided are several algorithms to measure the PM pin zero position (parameter `ModeWork`):

- 0 - Always measure the PM pin zero position;
- 1 - It is permitted to use the PM pin zero position obtained in the previous measurement cycle (this mode can be used during the measurement channel operation restoration and repeated PM pin zero position measurement is impossible because there is no way to restart the equipment);
- 2 - Do not measure the PM pin zero position (PM pin zero position should be set during the unit configuring, parameter `DeltaConst`);
- 3 - Sensor range incomplete, PM pin zero position is not measured (the non-sensitive zone should be specified during the unit configuring, parameter `DeltaConst`).

Assumed PM pin zero position excursion is saved to result No.1 additional register.

PM pin position is measured by measurement channel DC (parameter) calibration data.

Figure 12 shows an example of PM pin position measurement setting by channel No.1 in ModuleConfigurator software.



Parameter	Value	Address
01. Algorithm of measuring PM pin position	0 - Always carry out measurement of zero position of PM p	0x1F00
02. Minimum frequency, rpm	100.0	0x1F04
03. Zero PM pin position	0	0x1F08

Figure 17 - Example of PM pin position measurement setting by channel No.1 in ModuleConfigurator software

The PM pin position function is implemented in the MK22 module software from version 1.50.

4.4.6 Rotor bowing (eccentricity) measurement

In the extended mode the 3rd channel measures the rotor bowing (eccentricity) value by sensor signals spectral analysis method in real time, carry out signaling and equipment safety shutdown functions. Measured parameters and protective functions in real time mode:

- rotational frequency F (available via communication interfaces);
- rotor bowing (excursion) by 1st rotational component;
- total rotor bowing (polyharmonic excursion) by ½, 1-10-th rotational components;
- excursion by ½, 1-5-th rotational components are available by communication interfaces;
- phase by ½, 1-5-th rotational components are available by communication interfaces;
- permanent offset (gap):
- sensor serviceability monitoring.

Rotor bowing value is measured by FFT method (Fast Fourier Transform). Provided are two FFT types depending on the rotor speed:

- If rotor speed is greater than 90 rpm, 512 samples per 2 rotor rotations are carried out, FFT with a resolution equal to ½ of the rotor speed. FFT results are used to calculate the excursion rotational components and rotor bowing phase;
- If rotor speed is less than 90 rpm, 512 samples per 1 rotor rotations are carried out, FFT with a resolution equal to the rotor speed. FFT results are used to calculate the excursion rotational components and rotor bowing phase. Bowing and phase values by ½, 1½, 2½ .... 4½ rotationals are not calculated and assume zero value.

Measuring results are refreshed with periodicity of 0.1 s.

To carry out FFT, the rotor speed is measured similar to channels 1 and 2, as described above.

The bowing measurement synchronization mode is determined by the parameter *SyncMode:*

- if *SyncMode* is set to 0: main synchronization channel is synchronization pulses input No. 1. If there are no synchronization pulses by input No. 1, calculation synchronization automatically switches to input No. 2;
- if *SyncMode* is set to 1: main and only synchronization channel is synchronization pulses input No. 1;
- if *SyncMode* is set to 2: main and only synchronization channel is synchronization pulses input No. 2.

If the synchronization input is not initialized by rotor speed measurement for measurement channels 1.2, the frequency measurement settings specified in the rotor bowing parameters are applied:

- input pulses polarity is determined by parameter *SyncPolar*;
- number of pulses per one rotor rotation *SyncTooth*.

Implemented for rotational components phase authentic calculations in MK22 module are the configurable parameters:

- *PhaseCorrModul* - module LPF phase displacement correction;
- *PhaseCorrSense* - sensor filters phase displacement correction;
- *PhaseCorrConst* - costant phase displacement for 1st rotational;
- *PhaseMinVar* - rotational component minimum excursion for phase calculation.

In case of synchronization pulses absence, too low or too high synchronization pulses frequency, the rotational components are not calculated, rotational components amplitude and phase values are assumed equal to zero. If control surface of the “Pinion” type is used as the synchronization pulses source (the number of pulses per rotor rotation is not 1), the rotational components phases are not calculated and are assumed to be zero.

To detect the absence or unreliable synchronization pulses, the following parameters are provided in the MK22 module settings :

- `FreqControl` – permission to monitor the rotor speed;
- `FreqValidMin` – minimum permissible rotor speed;
- `FreqValidMax` – maximum permissible rotor speed;

Sensor current is calculated according to constant component resulted from ADC sampling. Constant component resulted value is converted from ADC dimension to sensor current similar to channel operation when DC measuring described above. Sensor permanent offset (gap) is calculated according to established operating range data and averaged sensor current.

To speedup FFT calculations, the mathematics with a fixed comma is used, which in turn introduces additional noise into the resulting conversion spectrum. The noise of ADC quantization and calculations with a fixed comma is manifested as a small energy level over all harmonic components of the resulting spectrum, although these harmonic components are absent in the original signal. To compensate for noise of ADC quantization and calculations, introduced are parameters of energy square minimum permissible level of the harmonic components in the ADC dimension, squared: `MagNoice` – amplitude square minimum permissible level of the harmonic component.

Rotor bowing value calculation (vibration displacement excursion) by 1st rotational component:

$$S_{PP\ 1F} = A_{PP\ 1F} + B_{PP\ 1F} \cdot ADC_{PP\ 1F}$$

Where:

$S_{PP\ 1F}$ – vibration displacement excursion calculated value by 1st rotational component;

$ADC_{PP\ 1F}$ – vibration displacement excursion ADC value by 1st rotational component (Adc1F);

$A_{PP\ 1F}$, $B_{PP\ 1F}$ – linear equation factors to calculate measured parameter value.

$A_{PP\ 1F}$, $B_{PP\ 1F}$ factors are calculated automatically during measurement channel initialization according to measurement range data (20 % from RangeVarMax, RangeVarMax) and ADC saved values (AdcVar1fMin, AdcVar1fMax), corresponding to calibrated measurement input range.

If one pair of calibration values (20 % from RangeVarMax, RangeVarMax or AdcVar1fMin, AdcVar1fMax) equals to zero or they are equal to each other, then $A_{PP\ 1F}$, $B_{PP\ 1F}$ factors are not calculated and are set to zero (vibration displacement excursion by 1st rotational component is not calculated).

Rotor bowing value calculation (vibration displacement excursion) by polygonometric signal:

$$S_{PP} = A_{PP} + B_{PP} \cdot ADC_{PP}$$

Where:

S_{PP} – vibration displacement excursion calculated value by polygonometric signal;

ADC_{PP} – vibration displacement excursion ADC value by polygonometric signal (AdcPoly);

A_{PP}, B_{PP} – linear equation factors to calculate measured parameter value.

A_{PP}, B_{PP} factors are calculated automatically during measurement channel initialization according to measurement range data (20% from RangeVarMax, RangeVarMax) and ADC saved values (AdcVarPolyMin, AdcVarPolyMax), corresponding to calibrated measurement input range.

If one pair of calibration values (20 % from RangeVarMax, RangeVarMax or AdcVarPolyMin, AdcVarPolyMax) equals to zero or they are equal to each other, then A_{PP}, B_{PP} factors are not calculated and are set to zero (vibration displacement excursion by polygonometric signal is not calculated).

Saved to measurement results additional registers are:

- Additional measurement result No.1 (DataAdd_1) - constant gap to control surface;
- Additional measurement result No.2 (DataAdd_2) - rotor speed assumed for rotor bowing measurement (vibration displacement excursion), rpm.

Figures 13, 14 show an example of rotor bowing main measurement parameters setting and rotor bowing measurement synchronization setting in ModuleConfigurator software, respectively.

Parameter	Value	Address
01.Measured parameter lover range	0	0x1A00
02. Measured parameter upper range	500	0x1A04
03. Measuring mode	By 1st harmonic back	0x1A08
04. Gap measurement integration depth	0	0x1A0A
05. Data source selections for the unified output	Deflection of rotor	0x1A12

Figure 18 - Example of rotor bowing main measurement parameters setting in ModuleConfigurator software

Parameter	Value	Address
01. Synchronization mode	1st main, 2nd standby input sy	0x1A0C
02. Control the rotor speed	☐	0x1A1C
03. Minimum acceptable rotor speed, rpm	1.0	0x1A14
04. Maximum acceptable rotor speed, rpm	4000.0	0x1A18
05. Pulse count per one rotor rotation	1	0x1A10
06. Polarity of input synchronization pulses	Front	0x1A0E
07. Calculate displacement excursion (without synchronization pulses)	☐	0x1A38

Figure 19 - Example of rotor bowing measurement synchronization setting in ModuleConfigurator software

4.4.7 Sensor signal linearization

4th channel can linearize the sensor signal in extended mode. Linearization is necessary when operating measurement channel with sensors having a nonlinear transfer characteristic, and also to reduce the measurement error.

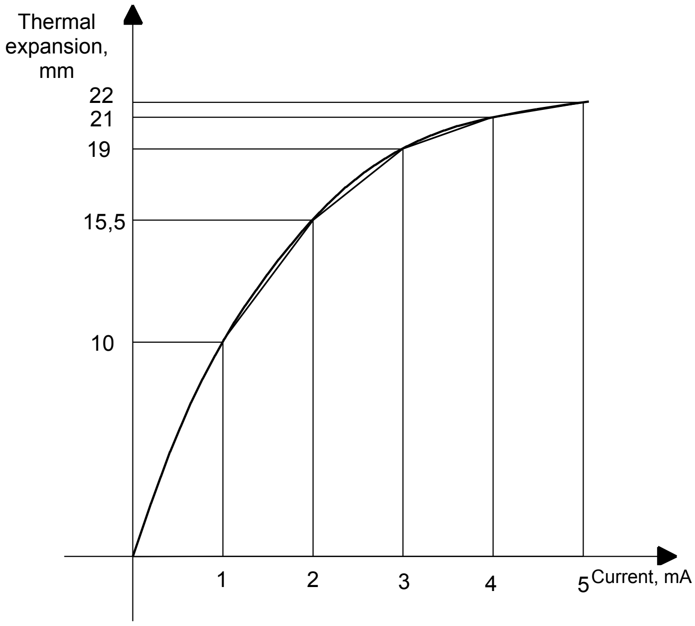
Sensor signal linearization is carried out by the piecewise linear approximation method according to the correspondence table of parameter values (`Data_1 … Data_16`) and output currents (`Current_1 … Current_16`) for the used sensor (Table 16).

The number of table records is determined by the parameter `LinearTableSize`, minimum number of records is 2, maximum is 16.

Processing sequence of the sensor signal with linearization function:

- sensor current is calculated according to the obtained ADC value;
- linear coefficients for parameter calculation are determined from the linearization table in accordance with the sensor current;
- measured parameter value is calculated;
- parameter value is compared with setpoints.

Figure 20 shows an example of sensor parameter and linearization table.



No.	Current, mA	Thermal expansion, mm
1	1	10
2	2	15,5
3	3	19
4	4	21
5	5	22

Figure 20 – Example of sensor parameter and linearization table.

4.4.8 Parameter calculation according to formula

An additional function of the 4th channel in extended mode is the parameter calculation by the formula. Such function can be used in particular for parameter conversion with a factor, for parameter calculation by measurement results of channels 1, 2 or 3 and other mathematical operations using measurement results and sensor currents of 1st, 2nd or 3rd channels.

The following parameters to calculate parameter by the formula are provided in MK22 control module:

`CheckChannelError` - Consider the measurement channels fault flag when calculating the channel 4 value. If a nonzero value is written to CheckChannelError register fields corresponding to any measurement channels, and if the fault flag is triggered by one (or more) of the specified channels, the channel 4 parameter value is not calculated and will assume a zero value.

`Constant` - The array of constants used in calculations (8 constants float 4).

`Instruction` - Sequence of operations to calculate the channel 4 parameter value (32 commands).

Structure of one command (`Instruction`):

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

Thus, each command is represented by two bytes: {operand address:operand type} {operation code}, where bytes are written in the following order {upper byte} {lower byte}.

Operation codes:

- 0x00 - no operation;
- 0x01 - final operation, indicates calculation end in the formula;
- 0x02 - record value into register (storage battery);
- 0x03 - record register content into the internal memory (4 cells of type float 4);
- 0X04 - addition;
- 0x05 — subtraction;
- 0x06 - multiplication;
- 0x07 — division;
- 0x08 - unary minus;

Operand types:

- 0x00 - no data source;
- 0x01 - channel parameter value;
- 0x02 - channel current;
- 0x03 - internal memory;
- 0x04 — constant.

Operand address:

- for channel parameter value: 0x00 … 0x02 — channel numbers;
- for channel current value: 0x00 … 0x03 — channel numbers;
- for internal memory: 0x00 … 0x03;
- for constants: 0x00 … 0x07.

Example of 4th channel parameter calculation according to formula: Ch4 = I1*K1 + Ch2*K2, where:

Ch4 — 4th channel parameter;
I1 — first channel current;
K1 — constant 1;
Ch2 — 2nd channel parameter;
K2 — constant 2.

Preliminary record K1 and K2 constants into the Constant array, one after another starting from the zero index.

Commands sequence for 4th channel parameter calculation (`Instruction`):

- command (0x02 0x02) to place the first channel current value to storage battery;
- command (0x04 0x06) to multiply storage battery value by K1;
- command (0x03 0x03) to record storage battery content into internal memory (cell with index 0);
- command (0x11 0x02) to place the second channel parameter value to storage battery;
- command (0x14 0x06) to multiply storage battery value by K2;
- command (0x03 0x04) to add contents of memory cell with index 0 to storage battery;
- command (0x01) informs module about calculations completion.

Upon calculations completion contents of the storage battery is considered as channel 4 parameter value. Further operations with the calculated parameter value are carried out similar to other measurement channels.

Operations sequence loaded into the module is carried out at each measurement cycle. Results of the previous measurement cycles are not saved.

4.4.9 Rotor rotational angle measurement (software version 1.69)

The rotor rotational angle measurement can be engaged as an additional function for measurement channel No. 4. Pinion teeth serve as a control surface for the rotor rotational angle measurement channel. The module counts the pulses received at the measurement channel input and calculates the rotational angle, considering the number of pulses per one revolution of the rotor.

Presence of synchronization pulses (phase mark) is necessary for the rotor rotational angle measurement channel operation. Every active edge of the synchronization pulse resets the pulse number counter to zero (the rotation angle is set to 0 degrees).

Rotor rotational angle is calculated by the formula

$$A_{DG} = 360 \cdot N / N_{TOOTH}$$

Where:

A_{DG} – rotor rotational angle calculated value, deg;

N – current value of the pulse counter;

N_{TOOTH} – number of pulses per one revolution of the rotor.

The following parameters are provided to configure the rotor rotational angle measurement channel setting (Figure 21):

- Switching level to logical '0', '1';
- Maximum measurement frequency (rotor speed), max 100 rpm;
- Selection of the synchronization pulses source (synchronization mode);
- Number of pulses per one rotor rotation

Parameter	Value	Address
01. Switching level of logical '0', mA	2	0x3400
02. Switching level of logical '1', mA	4	0x3404
03. Minimum measuring frequency, rpm	100.00	0x3408
04. Synchronization mode	1st main, second standby input synchroni	0x340C
05. Pulse count per one rotor rotation	60	0x340E
06. Allow measuring of rotor speed without synchronization	☐	0x3410

Figure 21 - Example of rotor rotational angle measurement setting in ModuleConfigurator software

Switching level to logical '0', '1' is recalculated to the ADC value by the measurement channel calibration data. The switching level value of logic '0' should be less than the switching level of logic '1'.

Provided are registers for the rotor rotational angle measurement channel operation monitoring (Figure 22):

- Channel status flags (ref. the registers description for the bits assignment);
- Established number of pulses per one rotor revolution;
- Current rotor speed;
- Pulse counter value;
- Rotational angle calculated value;
- Switching levels in ADC dimension.

Parameter	Value	Address
01. Status flags (Hex)	0601	0x3500
02. Number of pulses per rotor rotation	60	0x3502
03.1 Synchronization input number	0	0x3512
03.2 Rotation frequency, rpm	0.0	0x3508
04.1 Pulse counter (register)	0	0x3510
04.2 Angle of rotation, degree	0.0	0x3504
05.1 Switching level to logical '0', ADC	419	0x3514
05.2 Switching level to logical '1', ADC	810	0x3516

Figure 22 - - Example of rotor rotational angle measurement setting in ModuleConfigurator software

4.5 Unified outputs

Unified current output is provided for each measurement channel in MK22 module. Signal level on unified output is in proportion to measured parameter value.

Current on unified output is set using 12-bit DAC and active or passive current amplifier (depending on module version). MK22 module is provided with protective stabilitron (breakdown voltage 27 V) and resettable fuse 200 mA to protect unified output circuits.

Unified output ADC value is calculated according to linear equation formula:

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

Where:

ADC_{OUT} – calculated ADC value;

D_{Param} – calculated measured parameter value;

A_O, B_O – linear equation factors to calculate unified output ADC value.

A_O, B_O factors are calculated automatically during module operation initialization according to unified output current range data (`OutRangeCurrMin`, `OutRangeCurrMax`), parameter range fed to unified output (`OutRangeParamMin`, `OutRangeParamMax`) and DAC saved values (`DacOutMin`, `DacOutMax`), corresponding to current range of calibrated unified output (20 % from `OutRangeCurrMax`, `OutRangeCurrMax`).

In case of measurement channel failure, unified output current value can be set to `OutCurrentError`, if specified current set is permitted on unified output in case of measurement channel failure (`CurrentErrorEnabled`).

If one pair of calibration values (20 % from `OutRangeCurrMax`, `OutRangeCurrMax` or `OutRangeParamMin`, `OutRangeParamMax`, `DacOutMin`, `DacOutMax`) equals to zero or they are equal to each other, then A_O, B_O factors are not calculated and are set to zero (DAC_{OUT} value always equals to zero).

To calibrate the current output, provided are DAC direct control registers (`AnalogDirectData`) for each channel individually. They do not participate in measurement channels normal operation and are automatically reset to 0 if register value hasn't changed for 30 s.

Implemented in module version MK22-DC-001-R2-M-Base-PO are galvanically isolated (between themselves and the power supply module) unified current outputs with a passive current regulator. DAC type used in module MK22 (parameter `DacExternalType`) should be specified in the module system settings, module software version 1.65:

- 0 - Current outputs not implemented;
- 1 - One 4-channel DAC AD7398 (MK22-DC-R2, MK22-DC-11-R2, MK22-DC-001-R2);
- 2 - Four single-channel DACs DAC7611 (MK22-DC-001-R2-M-Base-PO).

Figure 23 shows an example of MK22 module measurement channel No.1 unified current output setting in ModuleConfigurator software.

Parameter	Value	Address
01. Unified output current range lower level, mA	4	0x0618
02. Unified output current range upper level, mA	20	0x061C
03. Enable setting referred current on unified output at measuring channel failure	✓	0x0624
04. The current, set on the unified output at a measuring channel failure, mA	2	0x0620
05. Unified output calibration lower level DAC value	806	0x062C
06. Unified output calibration upper level DAC value	4025	0x062E

Figure 23 - Example of measurement channel No.1 unified current output setting in ModuleConfigurator software

4.6 Logic outputs

Provided in MK22 module are 12 logic outputs with open collector (active level - zero). Logic inputs circuit engineering enables direct connection of relay windings. Operation of each of 12 logic outputs is configured by user using digital communication interfaces.

If check sum error is detected by one of module operation parameters section, logic output 12 will have signal active level, other logic outputs of MK22 module will remain inactive.

Logic outputs operation is blocked after module switching power on (reset) for a time `LogicOffStartUp`, counted after completing MK22 module initialization cycle. User can block logic outputs operation which can be necessary during block operation parameters correction or check of its operation, without fear of signaling actuation or safety shutdown.

Logic outputs can be configured in two ways (`LogicMode` system parameter):

- 0 - logic matrix;
- 1 - logic formula;

Configuring method is defined for all logic outputs, it is impossible to use different configuring methods for different logic outputs.

If synchronization pulses generation is assigned for logic outputs 1, 2 from the corresponding measurement channels, then logic signaling settings for these outputs are not considered.

If measurement channel No.1 operates in overspeed PM mode then logic outputs 1,2 receive status of measurement channel No.1 setpoints 1, 2, logic signaling settings for these outputs are not considered.

To change module operation parameters, it is necessary to block logic outputs operation or get permission for single recording into operation parameters.

4.6.1 Outputs setup by logic matrix

MK22 module parameter includes two matrices “OR” (`LogicMatrix`) of status flags switching (status of measurement channels and module as a whole) to logic outputs. Assigned status flags can be inverted before entering the “OR” matrix. If at least one flag assigned to logic output is set then corresponding logic output will have signal active level, if logic outputs operation is not blocked.

`LogicOutMode` parameter can be used to invert logic signal at the corresponding logic output (except for logic output 12).

Specified for each flag is logic output number to which it will be assigned. Each flag can be assigned to two different logic outputs. If any flag has assigned logic output number of zero of more than 12, then corresponding flag status doesn’t effect any logic output.

Table 15 - StatusSys module flags and their position in logic outputs matrix LogicMatrix

Bit No.	Designation	Description	Code	Matrix position
0	`LoadDataError`	Operation parameters read error from non-volatile memory	ErrLD	0
1	`LoadDataReserv`	One or several operating parameters groups read from non-volatile memory reserve section	ResLD	1
2	`LogicOffStartUp`	Logic outputs operation block after module reset	LgOffSt	2
3	`LogicOffUser`	Logic outputs operation block by user command	LgOffUs	3
4	`InterfRS485_Off`	RS485 interface No.1 is disabled	RS_Off	4
5	`InterfCAN_Off`	CAN2.0B interface disabled	CAN_Off	5
6	`AllowOneWrite`	Permission received for single recording by RS485 interface No.1	OneWr	6
7	`AllChannelOff`	All measurement channels disabled	AllChOff	7
8	`RequstSignalReady`	Signal sampling capture of 3rd channel is complete, Data ready for reading	rsRD	8
9	`RequstSignalWait`	Waiting for signal sampling capture of 3rd measurement channel	rsWT	9
10	`EEPROM_Error`	Non-volatile memory microchip error	eepERR	10
11	`EEPROM_Lock`	Recording to non-volatile memory microchip is blocked	eepLC	11
12	`SaveExecut`	Recording to non-volatile memory microchip in process	svEx	12
13	`SaveGood`	Recording completed successfully	svG	13
14	`SaveFailure`	Recording completed with errors	svF	14
15	`SaveNoSection`	Module has no section, requested for recording	svNS	15

Table 16 - Measurement channels flags `Status` and their position in logic outputs matrix LogicMatrix

Bit No.	Designation	Description	Code	Matrix position			
				Chan. 1	Chan. 2	Chan. 3	Chan. 4
0	`OffMode`	Channel disabled	xChO	16	32	48	64
1	`ErrorSenseLow`	Sensor current below permissible level	xSeL	17	33	49	65
2	`ErrorSenseHigh`	Sensor current above permissible level	xSeH	18	34	50	66
3	`FlagError`	Parameter is not compared with setpoints	xChE	19	35	51	67
4	`OutPoint_1`	Setpoint 1 parameter overrange	xOp1	20	36	52	68
5	`OutPoint_2`	Setpoint 2 parameter overrange	xOp2	21	37	53	69
6	`OutPoint_3`	Setpoint 3 parameter overrange	xOp3	22	38	54	70
7	`OutPoint_4`	Setpoint 4 parameter overrange	xOp4	23	39	55	71
8	`DataStable`	Parameter stabilized	xDst	24	40	56	72
9	`DataUnstable`	Parameter not stabilized	xDust	25	41	57	73
10	`FreqMeasurement`	Channel 1,2 – frequency measurement mode Channel 3 – bowing measurement Channel 4 – always equals to zero	xMf	26	42	58	74
11	`ModeStop`	Channel 1,2 – mode “STOP” Channel 3.4 – always equals to zero	xMs	27	43	59	75
12	`ModeStopTest`	Channel 1,2 – mode “STOP” test Channel 3.4 – always equals to zero	xMst	28	44	60	76
13	`ModeResetMeasur`	Channel 1,2 – frequency measurement algorithm in reset state Channel 3.4 – always equals to zero	xMr	29	45	61	77
14	`ModeWaitPulse`	Channel 1,2 – frequency measurement algorithm when waiting for exit from “STOP” mode Channel 3.4 – always equals to zero	xMw	30	46	62	78
15	`NoPulse`	Channel 1, 2 - no synchronization pulses Channel 3 – always equals to zero Channel 4 – formula error when channel 4 operates in calculation mode	xMnp	31	47	63	7

Note - Specify channel number (for example 1SeH) in signaling code instead of ‘x’ symbol.

Table 17 - Module flags `StatusSysAdd` and their position in logic outputs matrix LogicMatrix

Bit No.	Designation	Description	Code	Matrix position
0	`LigicMode`	Logic outputs operating mode 0 - logic matrix 1 - logic formula	LgMD	
1	`LogicExpressionError`	Logic outputs formula error	LgExEr	
2	`AllowModbusR2`	RS485 No.2 interface is available	-	
3	`InterfRS485_R2_Off`	RS485 interface No.2 disabled	-	
4	`AllowOneWrite_R2`	Permission received for single recording by interface RS485 No.2	-	
5- 13	`Reserv`	Reserve, equal to zero		
14	`OverSpeedProtection`	Overspeed protection mechanism mode	-	
15	`NotResetWDT`	Do not reset watchdog timer WDT (WDT test mode)	-	

4.6.2 Outputs setup by logic formula

Every logic output can be setup in analytical form using logical rules, including LEDs “War” and :Alarm” on module front panel. Used in logical operations are boolean functions on module status flags.

Logical rules command structure is given in Table 37.

To setup and edit logical rules provided in ModuleConfigurator software is a special mean enabling to form logical rules in convenient and simplified form making it unnecessary to directly enter the command codes. Notation system used in setup program ModuleConfigurator to generate logical rules in analytical form is given in tables 16, 15, 17 (designation, description, code).

Logical operations used in the program to generate logical rules:

"X**->** Mg.Nbit" - recording logical rules calculation results to global memory;
“ | “ - logical operation “OR”;
“ ^ “ - logical operation “exclusive OR”;
“ & “ - logical operation “AND”;
“ ! “ - logical operation “NOT”;
“ ( ) “ - parentheses are permissible to define calculation order;
where X - status flag (e.g. ErrLD).

Logical operations execution order (top down in order):

1) " ! “ - logical operation “NOT”;
2) “ & “ - logical operation “AND”;
3) “ | “ and “ ^ “ are equivalent, logical operation “OR”, logical operation “exclusive OR”;
4) “ **->** “ - calculation results recording.

Figure 24 shows an example of logic outputs setting in ModuleConfigurator software.

Parameter	Value	Address
01. Logical rule of output 1		0x1C00
02. Logical rule of output 2		0x1C20
03. Logical rule of output 3	1Ms | 2Ms	0x1C40
04. Logical rule of output 4	1Op2 | 2Op2	0x1C60
05. Logical rule of output 5	1Op4 | 2Op4	0x1C80
06. Logical rule of output 6		0x1CA0
07. Logical rule of output 7	3Op2 & 1Op1	0x1CC0
08. Logical rule of output 8	(2Op3 | 1Op3) & 3Op4	0x1CE0
09. Logical rule of output 9	3Op2 & 2Op1	0x1D00
10. Logical rule of output 10		0x1D20
11. Logical rule of output 11		0x1D40
12. Logical rule of output 12	1SeL | 1SeH | 2SeL | 2SeH	0x1D60
15. 'War' LED logical rule	1Op2 | 2Op2	0x1DC0
16. 'Alarm' LED logical rule	1Op4 | 2Op4	0x1DE0

Figure 24 - Example of logic outputs setting in ModuleConfigurator software

4.7 Module system setup

MK2 module system settings include parameters affecting operation of all measurement channels:

- `LogicOffStartUp` - logic outputs block time after module power switching on (reset);
- `TestPointSenseOk` - setpoints test time-out after sensor operation normalizing;
- `TimeOut_TestStop` - STOP” mode check time-out.
- `FreqMeasurTime` - frequency measurement period for channels 1, 2 (discretisation 0.1 s);
- `LogicOutMode` - logic outputs operating mode setup;
- `OSP_MeasurPeriod` - overspeed PM. Measurement period, ms (software version 1.60);
- `DacExternalType` - unified current outputs DAC type (software version 1.65);
- InputExpBoardType - extension board type (software version 1.68).

When configuring MK22 control module, it is recommended first of all to configure the system parameters.

Figure 25 shows an example of system parameters setting in ModuleConfigurator software.

Parameter	Value	Address
01. The logic outputs lockout time after the module reset, sec	8	0x0E00
02. The setpoints test timeout after the sensor operation normalization, sec	8	0x0E02
03. "STOP" mode test timeout, sec	300	0x0E04
04. Frequency measuring period for channels 1, 2, sec	1	0x0E06
05. Logic outputs operation mode adjustment	by matrix	0x0EC0
06. Overspeed protection mechanism. Measurement period, ms	5	0x0EC2
07. DAC type of standard current output	One 4-channel DAC AD7.	0x0EC4
08. Expansion board type	Comparator board COMI	0x0EC6

Figure 25 - Example of system parameters setting in ModuleConfigurator software

4.8 Module calibration recommendations

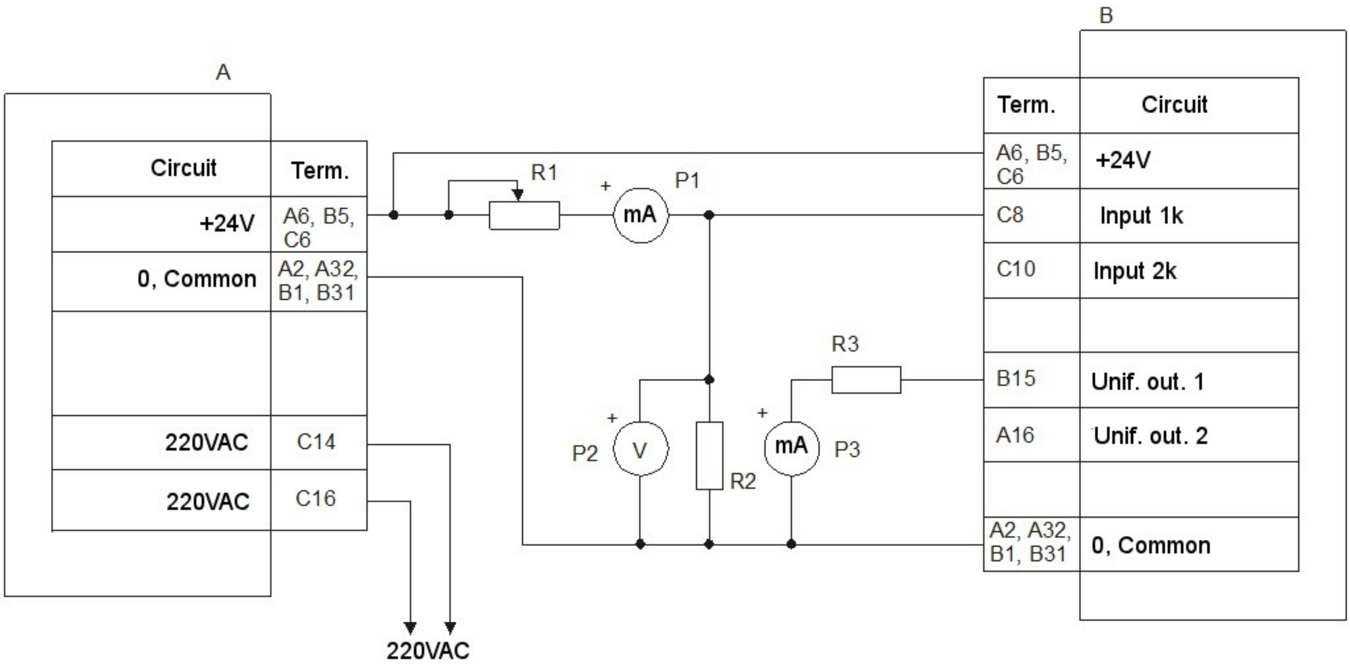
MK22 module calibration procedure permits repeated calibration without module cold start and measurement channel range change – without repeated calibration of measurement channels and unified outputs. In case of measurement channel or unified output current range change, it is necessary to carry out repeated calibration.

After module calibration it is necessary to load calibration data into module, save into module non-volatile memory and reboot module. Calibration results recording into MK22 module and factors repeated calculation can be carried out once after all calibration steps (input, unified output).

4.8.1 DC calibration

MK22 module connection diagram for calibration and DC check is given in Figure 26. It is recommended to calibrate MK22 module using stand СП43 enabling to connect the stated diagram.

For module version MK22-DC-001-R2-M-Base-PO, the connection diagram of milliammeter P3, resistor R3 to galvanically isolated current output is shown in figure 30.



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

R2, R3 – resistors (500±10) Ohm, 0.5 W ***P1, P3*** – DC milliammeter (0-20) mA, grade 0.2

P2 – DC voltmeter grade 0.1

Note - P2, R2 are used during voltage measurement channels check.

Figure 26 - MK22 module connection diagram for calibration and DC check

Measurement channel input DC calibration sequence:

1. specify measurement channel current range values (`InRangeCurrMin`, `InRangeCurrMax`);
2. specify measured parameter range (`RangeParamMin`, `RangeParamMax`);
3. at measurement channel input set current 20 % from `InRangeCurrMax`;
4. overwrite `AdcConst` value into `AdcInMin`;
5. at measurement channel input set current `RangeCurrMax`;
6. overwrite `AdcConst` value into `AdcInMax`;
7. send calibration results into MK22 module;
8. save parameters into module non-volatile memory;
9. execute measurement channel repeated initialization.

Measured parameter range change involves change of values `RangeParamMin`, `RangeParamMax`. When changing measured parameter range it might be necessary to change the format of data output to indicator (`FormatOut`).

Figure 27 shows an example of MK22 module measurement channel N.1 DC calibration data setting in ModuleConfigurator software.

Parameter	Value	Address
01. Sensor current range lower level, mA	4	0x0600
02. Sensor current range upper level, mA	20	0x0604
03. Minimum ADC	726	0x0628
04. Maximum ADC	3817	0x062A

Figure 27- Example of measurement channel N.1 DC calibration data setting in ModuleConfigurator software

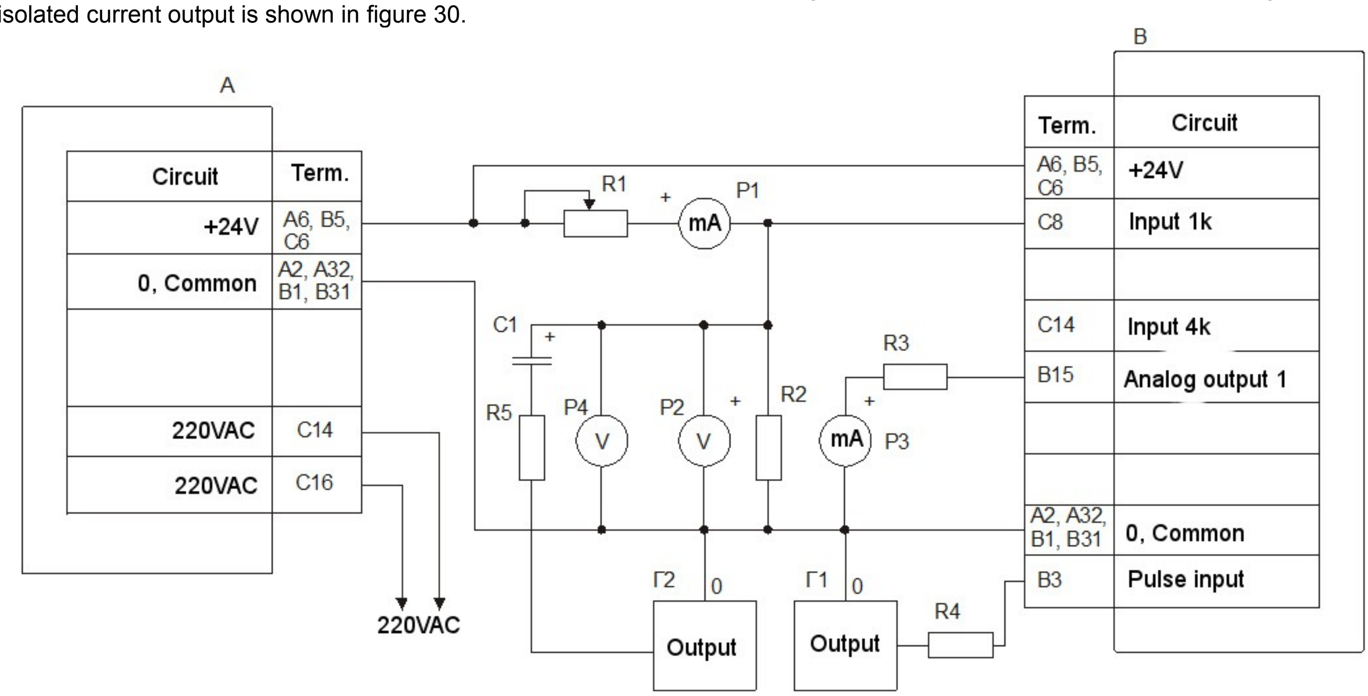
Implemented in ModuleConfigurator software is a visual plug-in, simplifying measurement channels DC calibration process.

4.8.2 AC calibration

AC calibration is required for measurement channel No. 3 if the optional function of rotor bowing (vibration displacement excursion) measurement is activated.

MK22 module connection diagram for calibration and AC check is given in Figure 28. It is recommended to calibrate MK22 module using stand СП43 enabling to connect the stated diagram.

For module version MK22-DC-001-R2-M-Base-PO, the connection diagram of milliammeter P3, resistor R3 to galvanically isolated current output is shown in figure 30.



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

R2, R3, R4, R5 – resistors (500±10) Ohm, 0.5 W ***P1, P3*** – DC milliammeter (0-20) mA, grade 0.2

P2 – DC voltmeter grade 0.1 **P4** – AC voltmeter Rin ≥ 1.0 MOhm, grade 0.6

G1 – square-pulse generator Г6-33 **G2** – LF generator Г3-110

C1 – capacitor 1000 μF, 16 V (during measurements at 0.05 Hz frequency not less than 50000 μF)

Note - P2, R2 are used during voltage measurement channels check.

Figure 28 - MK22 module connection diagram for calibration and AC check

Measurement channel input AC calibration sequence:

1. before measurement channel input AC calibration it is necessary to carry out measurement channel input DC calibration as described in section 4.8.1 ;
2. use resistor R1 to set DC of 3±0.2(12±0.8) mA by milliammeter P1 for AC channel or by voltmeter P2 VDC of (1.7±0.1) V for VAC channel.
3. set base frequency of 80 Hz and squared pulses amplitude +5V at Г1 generator output.
4. specify measured parameter range (`RangeVarMin`, `RangeVarMax`;
5. set harmonic signal RMS value corresponding to bowing 20 % `RangeVarMax`;
6. overwrite `Adc1F` value into `AdcVar1fMin`;
7. overwrite `AdcPoly` value into `AdcVarPolyMin`;
8. set harmonic signal RMS value corresponding to bowing `RangeVarMax`;
9. overwrite `Adc1F` value into `AdcVar1fMax`;
10. overwrite `AdcPoly` value into `AdcVarPolyMax`;
11. send calibration results into MK22 module;
12. save parameters into module non-volatile memory;
13. execute measurement channel repeated initialization.

Measured parameter range change involves change of values `RangeVarMin`, `RangeVarMax`. When changing measured parameter range it might be necessary to change the format of data output to indicator (`FormatOut`).

Figure 29 shows an example of MK22 module measurement channel No.3 AC calibration data setting in ModuleConfigurator software.

Parameter	Value	Address
01. FFT algorithm acceptable nose in resolution	100	0x1A1E
02.1 Rotational component. Lover calibration level ADC value according	625	0x1A30
02.2 Rotational component. Higher calibration level ADC value according	3144	0x1A32
03.1 Lover calibration level ADC value according	644	0x1A34
03.2 Polyharmonic. Higher calibration level ADC value according	3203	0x1A36

Figure 29 - Example of measurement channel No.3 AC calibration data setting in ModuleConfigurator software

Implemented in ModuleConfigurator software is a visual plug-in, simplifying measurement channel No.3 AC calibration process.

4.8.3 Unified output calibration

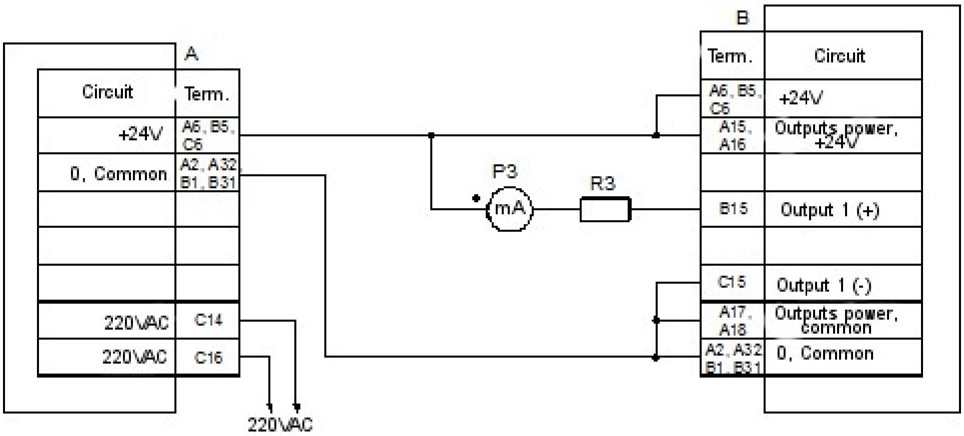
Unified output range by measured parameter corresponds to range of `OutRangeParamMin`, `OutRangeParamMax`.

For MK22 module with software version 1.65 it is necessary to specify the unified current outputs type in system settings (`DacExternalType`).

Unified output calibration consists of the following steps:

1. specify unified output current range value (`OutRangeCurrMin`, `OutRangeCurrMax`);
2. record value in `AnalogDirectData` to select unified output current (by milliammeter) equal to 20 % of `OutRangeCurrMax`;
3. overwrite `AnalogDirectData` value into `DacOutMin`;
4. record value in `AnalogDirectData` to select unified output current (by milliammeter) equal to `OutRangeCurrMax`;
5. overwrite `AnalogDirectData` value into `DacOutMax`;
6. record zero into `AnalogDirectData` (disable calibration mode);
7. send calibration results into MK22 module;
8. save parameters into module non-volatile memory;
9. execute measurement channel repeated initialization.

Figure 30 shows milliammeter connection diagram to calibrate unified current outputs with galvanic isolation (module version MK22-DC-001-R2-M-Base-PO).



A – МП24 or БП17 ***B*** – MK22

R3 – resistors (500±10) Ohm, 0.5 W ***P3*** – DC milliammeter (0-20) mA, grade 0.2

Figure 30 - MK22 module connection diagram for unified current output calibration and check for module version MK22-DC-001-R2-M-Base-PO

Example of measurement channel No.1 unified current output setting in ModuleConfigurator software is shown in Figure 23. Implemented in ModuleConfigurator software is a visual plug-in, simplifying unified current output calibration process.

5 Digital control interfaces

MK22 module supports four independent control interfaces:

- to RS485 interfaces with partial implementation of ModBus RTU protocol (enough for control);
- CAN2.0B interface (transfer of measurement results and control module status);
- slave interface SPI to set up module operation parameters.

All interfaces can operate simultaneously without interfering one another.

Warning. Power supply source, driver microchips of RS485 and CAN2.0B interfaces, diagnostic interface **have no galvanic isolation**. MK22 module with galvanic isolation of communication interfaces and power supply is manufactured upon separate agreement.

5.1 RS485 interface

MK22 module is provided with RS485 bus semiduplex driver microchips for operation by RS485 interfaces. Data exchange by RS485 interfaces is carried out according to ModBus RTU protocol with data rate choice from several standard speeds and bus module address for each interface.

For RS485 interface No.2 it is possible to specify that it is necessary to implement settings of the first RS485 interface (detailed information is given in table 39).

5.1.1 Module operation parameters setup by ModBus protocol

Module is set up by recording values into the corresponding configuration registers if recording is permitted. If recording into configuration registers is prohibited, a message is returned with error code NEGATIVE ACKNOLEDGE.

Configuration registers recording is carried out only using ModBus protocol command **Preset Multiple** Regs.

Module control commands are executed by ModBus protocol command **Preset Single Registers**.

Upon receiving incorrect command, generated is an error message, if request address matched to module address and check sum is correct.

Error message format (5 bytes):

Device address
Function code with high bit set to “1”
Error code
Check sum, low byte
Check sum, high byte

Table 18 - ModBus protocol possible error codes

Code	Designation	Description	Notes
0x01	ILLEGAL FUNCTION	Incorrect function code	
0x02	ILLEGAL DATA ADRESS	Unacceptable register address	
0x03	ILLEGAL DATA VALUE	Unacceptable recorded value	
0x07	NEGATIVE ACKNOWLEDGE	Command can’t be executed	
0x09	ILLEGAL SIZE COMMAND	Function code and length of received message are not applicable	Unusual ModBus code

Figure 31 shows an example of RS485 interface No.1 setting in ModuleConfigurator software.

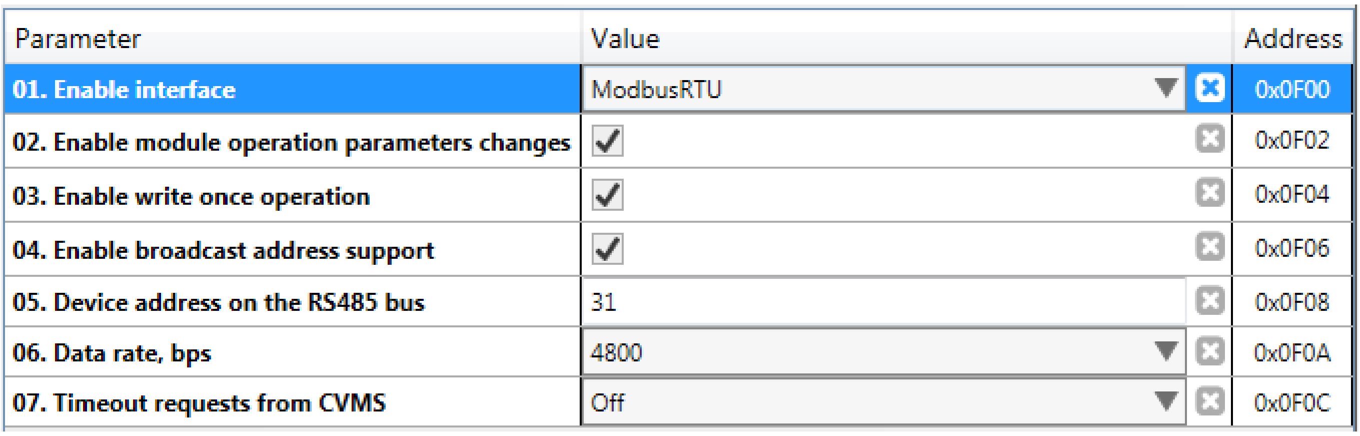


Figure 31 - Example of RS485 interface No.1 setting in ModuleConfigurator software

5.1.2 ModBus protocol supported commands

Table 19 - Implemented commands of ModBus protocol in MK22 module

Code	Description	Request	Response	Note
0x03	Read Holding Registers Setup registers reading	Device address Function (0x03) Start address, high byte Start address, low byte Register number, high byte Register number, low byte CRC, low byte CRC, high byte	Device address Function (0x03) Bytes counter Data, high byte Data, low byte CRC, low byte CRC, high byte	Used to read measurement results and module operation parameters
0x06	Preset Single Registers Register recording	Device address Function (0x06) Address, high byte Address, low byte Data, high byte Data, low byte CRC, low byte CRC, high byte	Device address Function (0x06) Address, high byte Address, low byte Data, high byte Data, low byte CRC, low byte CRC, high byte	Used to record into control registers (commands execution)
0x10	Preset Multiple Regs Several registers recording	Device address Function (0x10) Start address, high byte Start address, low byte Register number, high byte Register number, low byte Bytes counter Data, high byte Data, low byte CRC, low byte CRC, high byte	Device address Function (0x10) Start address, high byte Start address, low byte Register number, high byte Register number, low byte CRC, low byte CRC, high byte	Used to record operation parameters into module
0x11	Report Slave ID Identifier reading	Device address Function (0x11) CRC, low byte CRC, high byte	Device address Function (0x11) Bytes counter Identifier (0x0B) Start indicator (0xFF) Software version, high byte Software version, low byte Module number, high byte Module number, low byte Manufacturing year, high byte Manufacturing year, low byte CRC, low byte CRC, high byte	
0x08	Diagnostics Diagnostic commands	Device address Function (0x08) Subfunction, high byte Subfunction, low byte Data, high byte Data, low byte CRC, low byte CRC, high byte	Device address Function (0x08) Subfunction, high byte Subfunction, low byte Data, high byte Data, low byte CRC, low byte CRC, high byte	List of supported diagnostic commands is given in Table 20

Table20 - List of ModBus protocol supported diagnostic commands

Command code	Description
0x0000	Echo response
0x0001	ModBus protocol counters reset and Listen Only mode exit
0x0004	Engage Listen Only mode
0x000A	ModBus protocol counters reset
0x000B	Send number of received messages without errors
0x000C	Send number of received messages with check sum errors
0x000D	Send number of received messages with errors (excluding check sum errors)

5.1.3 Check sum calculation in messages

Check sum CRC consists of two bytes. Check sum CRC is calculated by transmitting device and added into each message end. Receiving device calculates check sum during reception and compares with received message CRC field. CRC counter is preliminary initialized with value of 0xFFFF. Only 8 data bits are used to calculate check sum (start, stop and parity bits are not used when calculating check sum).

5.1.4 ModBusRTU protocol control features

Addressing of operation parameters and module status registers is aligned by 16-bit words. Parameter “Number of registers” in ModBus commands is stated in registers (by two bytes).

Maximum number of recorded/read bytes per one transaction is 256 registers (512 bytes).

MK22 module supports broadcast address 0x00 to simultaneously control several modules. Response for broadcast request is not sent.

5.1.5 VibrobitRTU protocol control features

Addressing of operation parameters and module status registers is aligned by 16-bit words. Parameter “Number of registers” in ModBus commands is stated in bytes.

When recording/reading operation parameters and module status, the data are sent according to C language rules of data allocation in memory (low byte, then - high byte), not according to ModBus standard requirements.

If during reading/recording requested is odd number of bytes, then a response with corresponding error will be generated.

Maximum number of recorded/read bytes per one transaction is 512 bytes.

MK32 module supports broadcast address 0x00 to simultaneously control several modules. Response for broadcast request is not sent.

5.2 CAN2.0B interface

CAN2.0B interface enables MK22 module status data transmission to indicating units and other system modules. MK22 module doesn’t support module control by CAN2.0B interface.

Module CAN controller operates in active mode, i.e. generates dominant confirmation of received messages and can generate active reset messages into CAN bus (e.g. In case of incorrect data rate).

All nodes on CAN bus should have the same data rate. When data rate increasing, CAN bus physical maximum length decreases. Maximum permissible CAN bus length at data rate of 1000 kbit/s is 40 meters, and for speed 40 kbit/s – 1000 meters.

5.2.1 Format of messages transmitted by CAN2.0B interface

For CAN2.0B interface operation it is necessary to set up the following parameters:

- CAN2.0B interface operation permission (`CanEnabled`);
- data rate (`CanSpeed`);
- module address (`CanBasicAddress`);
- messages sending periodicity (`CanBasicTime`);
- permission to send information by measurement channels (`CanBasicDataOut`).

Measuring results data are sent with periodicity `CanBasicTime`. Generated for every measurement channel is its own message with unique message code. List of messages codes in given in Table 21.

Sent in each message is module status bits value and also status bits of corresponding measurement channel.

Messages are sent in series: 1-st channel message, then – second. New message is not sent to but until previous message is sent. If current message can’t be sent during 200 ms, its sending is canceled.

If flag `CanBasicDataOut` is not zero, then corresponding measurement channel message is sent by CAN2.0B interface. If all flags `CanBasicDataOut` equal to zero, then module sends no messages by CAN2.0B interface, but module generates messages normal transmission confirmation of other modules, connected to CAN2.0B bus.

Figure 32 shows CAN message format.

Byte number in message							
0	1	2	3	4	5	6	7
Message code	Module status	Parameter value (float 4 byte)				Measurement channel status	
	`StatusSys<7:0>`					`StatusCH<15:0>`	

Figure 32 – CAN message format

Table 21 - Codes of messages transmitted by CAN2.0B interface

Data description	**Message codes by measurement channels**			
	Channel 1	**Channel 2**	**Channel 3**	**Channel 4**
Measured parameter value	0x30	0x40	0x50	0x60
Measured parameter minimum value	0x31	0x41	0x51	0x61
Measured parameter maximum value	0x32	0x42	0x52	0x62
Additional parameter 1 value	0x33	0x43	0x53	0x63
Additional parameter 2 value	0x34	0x44	0x54	0x64

Figure 33 shows an example of CAN2.0B interface setting in ModuleConfigurator software.

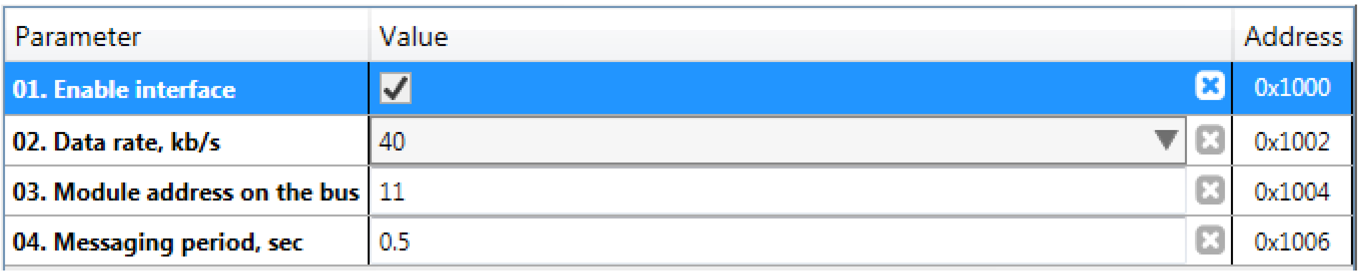


Figure 33 - Example of CAN2.0B interface setting in ModuleConfigurator software

5.3 SPI slave interface

SPI slave interface is intended to control module operation and setup its operation parameters. SPI interface connector is arranged on module front panel (D.Port). SPI slave interface parameters are rigidly predetermined, therefore regardless of MK22 module current status, the SPI interface is always available for module control.

MK22 module can be set up by setup instrument ПН31 or personal computer. To setup using personal computer, started should be ModuleConfigurator software, and module should be connected to personal computer via diagnostic interface module MC01 USB (PC USB interface), installed on personal computer should be drivers of virtual COM port.

MK22 module provides “hot” connection/disconnection of setup instrument and MC01 USB diagnostic interface boards.

5.4 Module settings and current status (address tables)

5.4.1 Measurement channels parameters

Table *22* - List of measurement channels calibration registers

Description	Designation	Type (bytes)	Address (Hex)				Default value	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
Sensor current range lower level, mA	`InRangeCurrMin`	Float (4)	0x600	0x700	0x800	0x900	1.0	
Sensor current range upper level, mA	`InRangeCurrMax`	Float (4)	0x604	0x704	0x804	0x904	5.0	
Sensor test permission by lower edge 0 – sensor is not tested	`EnaCurrValidMin`	Uint (2)	0x608	0x708	0x808	0x908	0	
Sensor test permission by upper edge 0 – sensor is not tested	`InRangeCurrMin`	Uint (2)	0x60A	0x70A	0x80A	0x90A	0	
Sensor current lower permissible level, mA	`CurrValidMin`	Float (4)	0x60C	0x70C	0x80C	0x90C	0.7	
Sensor current upper permissible level, mA	`CurrValidMax`	Float (4)	0x610	0x710	0x810	0x910	5.3	
Sensor test hysteresis, mA	`CurrValidHist`	Float (4)	0x614	0x714	0x814	0x914	0.1	
Unified output current range lower level, mA	`OutRangeCurrMin`	Float (4)	0x618	0x718	0x818	0x918	4.0	
Unified output current range upper level, mA	`OutRangeCurrMax`	Float (4)	0x61C	0x71C	0x81C	0x91C	20.0	
Current set on unified output in case of measurement channel failure, mA	`OutCurrentError`	Float (4)	0x620	0x720	0x820	0x920	2.0	
Permit specified current setup on unified output in case of measurement channel failure (0 - do not set failure current)	`CurrentErrorEnabled`	Uint (2)	0x624	0x724	0x824	0x924	0	
Reserve (should always be set to zero)	`Reserv`	Uint (2)	0x626	0x726	0x826	0x926	0	
Current sensor lower calibration level ADC value	`AdcInMin`	Uint (2)	0x628	0x728	0x828	0x928	0	1
Current sensor upper calibration level ADC value	`AdcInMax`	Uint (2)	0x62A	0x72A	0x82A	0x92A	0	1
Unified output lower calibration level DAC value	`DacOutMin`	Uint (2)	0x62C	0x72C	0x82C	0x92C	0	1
Unified output upper calibration level DAC value	`DacOutMax`	Uint (2)	0x62E	0x72E	0x82E	0x92E	0	1

Table (continued) 22

Description	Designation	Type (bytes)	Address (Hex)				Default value	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
Sensor current monitoring operating mode 0 - block channel operation, zero parameter value 1 - do not block channel operation, do not zero parameter value	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 Calibration information is absent, all measured parameters will equal to zero.

2 Default value – value assigned to parameter after “Cold start”.

Table 23 - List of measurement channels main registers

Description	Designation	Type (bytes)	Address (Hex)				Default value	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
Measurement channel operating permission 0 – channel disabled	Enabled	Uint (2)	0x0A00	0x0B00	0x0C00	0x0D00	0	1
Additional functions operating permission 0 - additional functions disabled	EnabledAdd	Uint (2)	0x0A02	0x0B02	0x0C02	0x0D02	0	2
Measured parameter lower range	RangeParamMin	Float (4)	0x0A04	0x0B04	0x0C04	0x0D04	0	
Measured parameter upper range	RangeParamMax	Float (4)	0x0A08	0x0B08	0x0C08	0x0D08	0	
Measured parameter name	MeasurName	Char (8)	0x0A0C	0x0B0C	0x0C0C	0x0D0C		3
Parameter measuring units	MeasurUnit	Char (8)	0x0A14	0x0B14	0x0C14	0x0D14		3
Measurement results output format to indicator (0 – ####, 1 – ###.#; 2 – ##.##; 3 – #.###)	FormatOut	Uint (2)	0x0A1C	0x0B1C	0x0C1C	0x0D1C	0	7
Measurement results output format to indicator (0 – ####, 1 – ###.#; 2 – ##.##; 3 – #.###)	FormatOut	Uchar(2)	0x0A1C	0x0B1C	0x0C1C	0x0D1C	0	8
Adaptive mode of information output to indicator (0 - disabled, 1 - enabled)	AdaptiveOut	Uchar(2)	0x0A1C	0x0B1C	0x0C1C	0x0D1C	0	8
Measurement results integration depth from 0 to 9 0 - no averaging	AverageDepth	Uint (2)	0x0A1E	0x0B1E	0x0C1E	0x0D1E	0	
Setpoint 1 operating mode	TestPointMode_1	Uint (2)	0x0A20	0x0B20	0x0C20	0x0D20	0	
Setpoint 2 operating mode	TestPointMode_2	Uint (2)	0x0A22	0x0B22	0x0C22	0x0D22	0	
Setpoint 3 operating mode	TestPointMode_3	Uint (2)	0x0A24	0x0B24	0x0C24	0x0D24	0	
Setpoint 4 operating mode	TestPointMode_4	Uint (2)	0x0A26	0x0B26	0x0C26	0x0D26	0	
Setpoint 1 value	TestPointData_1	Float (4)	0x0A28	0x0B28	0x0C28	0x0D28	0	
Setpoint 2 value	TestPointData_2	Float (4)	0x0A2C	0x0B2C	0x0C2C	0x0D2C	0	
Setpoint 3 value	TestPointData_3	Float (4)	0x0A30	0x0B30	0x0C30	0x0D30	0	
Setpoint 4 value	TestPointData_4	Float (4)	0x0A34	0x0B34	0x0C34	0x0D34	0	
Setpoints hysteresis	TestPointHist	Float (4)	0x0A38	0x0B38	0x0C38	0x0D38	0	4
Reserve should be equal to zero	Reserv	Uint (2)	0x0A38	0x0B38	0x0C38	0x0D38	0	9

Table (continued) 23

Description	Designation	Type (bytes)	Address (Hex)				Default value	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
Setpoints display format (0 - corresponds to measurement channel settings 1 – ####, 2 – ###.#; 3 – ##.##; 4 – #.###)	TestPointDisplayOut	Uint (2)	0x0A3A	0x0B3A	0x0C3A	0x0D3A	0	9
Setpoint transition response time	TestPointTime	Uint (2)	0x0A3C	0x0B3C	0x0C3C	0x0D3C	0	5
Measured parameter stability monitoring algorithm operating permission (0 - algorithm disabled)	StabEnabled	Uint (2)	0x0A3E	0x0B3E	0x0C3E	0x0D3E	0	
Measured parameter destabilization detection time	StabTimeOut	Uint (2)	0x0A40	0x0B40	0x0C40	0x0D40	0	5
Measured parameter stabilization detection time	StabTimeIn	Uint (2)	0x0A42	0x0B42	0x0C42	0x0D42	0	5
Maximum measured parameter deviation for stabilization algorithm	StabDataDelta	Float (4)	0x0A44	0x0B44	0x0C44	0x0D44	0	
Parameter range lower value sent to unified output	OutRangeParamMin	Float (4)	0x0A48	0x0B48	0x0C48	0x0D48	0	
Parameter range upper value sent to unified output	OutRangeParamMax	Float (4)	0x0A4C	0x0B4C	0x0C4C	0x0D4C	0	
Setpoint 1 hysteresis	TestPointHist_1	Float (4)	0x0A50	0x0B50	0x0C50	0x0D50	0	6
Setpoint 2 hysteresis	TestPointHist_2	Float (4)	0x0A54	0x0B54	0x0C54	0x0D54	0	6
Setpoint 3 hysteresis	TestPointHist_3	Float (4)	0x0A58	0x0B58	0x0C58	0x0D58	0	6
Setpoint 4 hysteresis	TestPointHist_4	Float (4)	0x0A5C	0x0B5C	0x0C5C	0x0D5C	0	6

Table (continued) 23

Description	Designation	Type (bytes)	Address (Hex)				Default value	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
Vibration displacement excursion algorithm without synchronization pulses Mnimum rotor speed, rpm	`VariablePP RotorRpmMin`	Uint (2)	0x0A60	0x0B60	0x0C60	0x0D60	0	9
Vibration displacement excursion algorithm without synchronization pulses HF excursion meter noise level, µm	`VariablePP NoiseAmplHF`	Uint (2)	0x0A62	0x0B62	0x0C62	0x0D62	0	9
Reserve should be equal to zero	`Reserv`	Uchar (12)	0x0A64	0x0B64	0x0C64	0x0D64	0	9
Additional Information	`InformationString`	Char (8)	0x0A70	0x0B70	0x0C70	0x0D70	0	9

Notes

1. Measurement channel enabled, measurement channel additional function enabled
2. Codes of additional functions are given in Table 24.
3. Corresponds to empty string
4. Not implemented in MK22 module software version 1.65. Reserve, should be equal to zero.
5. Time by 0.1 s (0 = 0.1 second).
6. Implemented in MK22 module software version 1.65.
7. Implemented in MK22 module software up to version 1.65 inclusive.
8. Implemented in MK22 module software version 1.67.
9. Implemented in MK22 module software version 1.68.

Table 24 - Additional functions codes by measurement channels (EnabledAdd parameter)

Additional function	Channel 1	Channel 2	Channel 3	Channel 4	Implemented in MK22 module software from version
Additional function disabled	0	0	0	0	
Rotor speed measurement	1	1	X	X	1.40
PM pin position change	2	2	X	X	1.50
Rotor speed measurement in overspeed PM mode	3	X	X	X	1.60
Rotor bowing measurement	X	X	1	X	1.40
Sensor signal linearization	X	X	X	1	1.40
Parameter calculation according to formula	X	X	X	2	1.40
Vibration displacement excursion measurement without synchronization pulses	4	4	4	4	1.68
Note - ‘X’ - the function is not implemented for this channel					

Table 25 - List of unified output control registers

Description	Designation	Type (bytes)	Address (Hex)				Default value	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
DAC value for measurement channel unified output direct control	`AnalogDirectData`	Uint (2)	0x500	0x502	0x504	0x506	0	
Notes 1 Used for unified outputs calibration. DAC range from 0 to 4095. 2 Do not participate in measurement channels normal operation. 3 Automatically reset to 0 if register value hasn’t change for 30 seconds. 4 Available for recording in any operating mode of module.								

Table 26 - List of frequency measurement additional registers (for channels 1, 2)

Description	Designation	Type (bytes)	Address (Hex)		Default value	Note
			Channel 1	Channel 2		
Number of pulses 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	
Permit “STOP” signaling check (0 – check prohibited)	`StopTestEna`	Uint (2)	0x1808	0x1908	0	
Permit setpoints check in “STOP” mode (0 – check prohibited)	`PointStopEna`	Uint (2)	0x180A	0x190A	0	
Minimum measured frequency, rpm	`FrequencyMin`	Float (4)	0x180C	0x190C	1	
Frequency meter single bursts filter (0 - disabled; 1 - enabled)	`FilterOnePulse`	Uint (2)	0x1810	0x1910	0	2
Reserve, should be equal to zero		Uint (2)	0x1812	0x1912	0	

Notes

1 Synchronization pulses are sent to logic outputs 1 and 2 for measurement channels 1, 2 respectively.

2 Implemented in MK22 module software version 1.67.

3 Default value – value assigned to parameter after “Cold start”.

Table 27 - List of PM pin position measurement additional registers (for channels 1, 2)

Description	Designation	Type (bytes)	Address (Hex)		Default value	Note
			Channel 1	Channel 2		
PM pin position measurement algorithm 0 - Always measure the PM pin zero position 1 - Permission to use the saved PM pin zero position value 2 - Do not measure zero position, always use entered value 3 - Incomplete sensor range	`ModeWork`	Uint (2)	0x1F00	0x1F20	0	
Reserve, should be equal to zero	`Reserv`	Uint (2)	0x1F02	0x1F22	0	
PM pin protrusion measurement minimum speed, rpm	`FrequencyMin`	Float (4)	0x1F04	0x1F24	0	
PM pin zero position, preset value	`DeltaConst`	Float (4)	0x1F08	0x1F28	0	

Notes

1 Implemented in module software version 1.50.

2 Default value – value assigned to parameter after “Cold start”.

Table 28 - List of comparator board COMP.01-2CH-MK32-MS control registers (for channels 1, 2)

Description	**Designation**	**Type (bytes)**	**Address (Hex)**		**Default value**	**Note**
			Channel 1	**Channel 2**		
Gap measurement range, lower value, µm	GapRangeMin	Float (4)	0x3000	0x3100	0	
Gap measurement range, upper value, µm	GapRangeMax	Float (4)	0x3004	0x3104	0	
Initial preset gap, µm	GapInitial	Float (4)	0x3008	0x3108	0	
Limit comparator switching levels by gap measurement range (0 - do not limit)	ComparatorLevel Control	Uint (2)	0x300C	0x310C	0	
Comparator switching levels adaptive correction 0 – disabled 1 - by gap from sensor DC 2 - by actual gap during rotor rotation	ToggleAdaptive Mode	Uint (2)	0x300E	0x310E	0	
Comparator switching average level displacement relative to gap, µm	ToggleLevel Offset	Float (4)	0x3010	0x3110	0	
Comparator switching hysteresis (excursion), µm	ToggleLevelHist	Float (4)	0x3014	0x3114	0	
Average switching level lower limit, µm	ToggleLevelMin	Float (4)	0x3018	0x3118	0	
Average switching level upper limit, µm	ToggleLevelMax	Float (4)	0x301C	0x311C	0	
Minimum rotor speed for adaptive mode, rpm	ToggleAdaptive FreqMin	Float (4)	0x3020	0x3120	0	
Limit comparator switching average levels (0 - do not limit)	ToggleGapLevel Control	Uint (2)	0x3024	0x3124	0	
Reserve, should be equal to zero	Reserv	Uint (2)	0x3026	0x3126	0	
Calculate gap during rotor rotation (0 - do not calculate)	GapUponRotation	Uint (2)	0x3028	0x3128	0	
Number of rotor revolutions to calculate gap (from 1 to 100)	GapUR_RpmMin	Uint (2)	0x302A	0x312A	0	

Notes

1 Implemented in MK22 module software version 1.68.

2 Default value – value assigned to parameter after “Cold start”.

Table 29 - List of rotor bowing measurement additional registers (for channel 3)

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Measured parameter lower range	`RangeVarMin`	Float (4)	0x1A00	0	
Measured parameter upper range	`RangeVarMax`	Float (4)	0x1A04	500	
Measurement mode (0 – by first rotational harmonics not zero - by polyharmonics)	`ModeMeasur`	Uint (2)	0x1A08	0	
Gap measurement integration depth (from 0 to 9)	`AverageDepth`	Uint (2)	0x1A0A	0	
Bending measurement synchronization mode 0 - main synchronization input 1 reserve synchronization input 2 1 – synchronization only on the 1st input 2 – synchronization only on the 2nd input	`SyncMode`	Uint (2)	0x1A0C	0	1
Input synchronization pulses polarity (0 – active leading edge; not zero – trailing edge)	`SyncPolar`	Uint (2)	0x1A0E	0	1
Number of pulses per one rotor rotation (from 1 to 1000)	`SyncTooth`	Uint (2)	0x1A10	1	1
Data source selection for unified output (0 – rotor bowing; not zero – gap)	`SelectOutData`	Uint (2)	0x1A12	0	
Minimum permissible rotor speed, rpm	`FreqValidMin`	Uint (2)	0x1A14	1	2
Maximum permissible rotor speed, rpm	`FreqValidMax`	Uint (2)	0x1A16	10 000	2
Monitor rotor speed 0 - do not monitor	`FreqControl`	Uint (2)	0x1A1C	0	2
Permissible FFT algorithm noise in ADC capacity	`MagNoice`	Uint (2)	0x1A1E	100	
Module LPF phase shift correction, deg/Hz	`PhaseCorrModul`	Float (4)	0x1A20	0	
Sensor filter phase shift correction, deg/Hz	`PhaseCorrSense`	Float (4)	0x1A24	0	
Phase permanent offset for 1-st rotational, deg	`PhaseCorrConst`	Float (4)	0x1A28	0	
Rotational component minimum excursion for phase calculation	`PhaseMinVar`	Float (4)	0x1A26	0	
Lower calibration level ADC value by rotational component	`AdcVar1fMin`	Uint (2)	0x1A30	0	3
Upper calibration level ADC value by rotational component	`AdcVar1fMax`	Uint (2)	0x1A32	0	3
Lower calibration level ADC value by polyharmonics	`AdcVarPolyMin`	Uint (2)	0x1A34	0	3
Upper calibration level ADC value by polyharmonics	`AdcVarPolyMax`	Uint (2)	0x1A36	0	3

Notes

1 Channels 1, 2 in frequency measurement mode has priority.

2 Rotor bowing permissible measurement frequency is limited forcibly by range from 0.9 to 12000 rpm.

3 Calibration information is absent, all measured parameters will equal to zero.

4 Default value – value assigned to parameter after “Cold start”.

Table 30 - List of additional linearization registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Number or records in linearization table	`LinearTableSize`	Uint (2)	0x1B00	0	1
Reserve, should always be equal to zero	`Reserv`	Uint (2)	0x1B02	0	
Record 1, current value	`Current_1`	Float (4)	0x1B04	0	
Record 1, parameter value	`Data_1`	Float (4)	0x1B08	0	
Record 2, current value	`Current_2`	Float (4)	0x1B0C	0	
Record 2, parameter value	`Data_2`	Float (4)	0x1B10	0	
Record 16, current value	`Current_16`	Float (4)	0x1B7C	0	
Record 16, parameter value	`Data_16`	Float (4)	0x1B80	0	

Notes

1 For linearization algorithm to work at least 2 records are required. If table has less than 2 records, the parameter value is assumed to be zero. Maximum number of records is 16.

2 Default value – value assigned to parameter after “Cold start”.

Table 31 - List of additional registers of calculation by formula

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Consider the measurement channels fault flag when calculating the channel 4 value (4 words)	`CheckChannelError`	Uint (8)	0x2300	0	
Array of constants used in calculations (8 constants).	`Constant`	Float (32)	0x2308	0	
Sequence of operations to calculate the channel 4 parameter value (32 commands). Structure of one command: bits 0-7: operation code bits 8-11: type of memory used in the operation bits 12-15: register address	`Instruction`	Uint (64)	0x2328	0	

Note: Default value – value assigned to parameter after “Cold start”.

Table 32 - List of additional registers of calculation by formula

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Switching level to logical '0'	`ToggleCurrent_ToLow`	Float (4)	0x3400	2	
Switching level to logical '1'	`ToggleCurrent_ToHigh`	Float (4)	0x3404	4	
Maximum rotor speed for measurements (not more than 100), rpm	`FrequencyMax_RPM`	Float (4)	0x3408	10	
Synchronization mode 0 - not specified (measurements disabled) 1 - synchronization input 1 2 - synchronization input 2 3 - main synchronization input 1, reserve - 2	`InputSynchPulse`	Uint (2)	0x340C	3	
Number of pulses per one revolution (from 2 to 100)	`Tooth`	Uint (2)	0x340E	60	

Notes

1 Implemented in MK22 module software version 1.69.

2 Default value – value assigned to parameter after “Cold start”.

5.4.2 Module system setup

Table 33 - List of system registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Logic outputs block time after module power switching on (reset)	`LogicOffStartUp`	Uint (2)	0xE00	15	1, 3
Setpoints test time-out after sensor operation normalizing	`TestPointSenseOk`	Uint (2)	0xE02	15	2, 3
“STOP” mode check time-out	`TimeOut_TestStop`	Uint (2)	0xE04	0	2, 3
Frequency measurement period for channels 1, 2	`FreqMeasurTime`	Uint (2)	0xE06	0	2,3
Logic signaling matrix (80 words) bits 0:3 – output number to which signaling is assigned (group 1) bits 4:7 – output number 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 zero bit 14 - LED ‘War’ engagement for version bit 15 - LED ‘Alarm’ engagement for version	`LogicMatrix`	Uint (160)	0xE08	0	
Signal inversion on logic output (12 words) (not zero – output inversion)	`LogicOutMode`	Uint (24)	0xE80	0	4
Logic outputs operating mode setup 0 - logic matrix 1 - logic formula	`LogicMode`	Uint(2)	0x0EC0	0	
Overspeed PM Measurement period, ms	`OSP_MeasurPeriod`	Uint(2)	0x0EC2	5	5
DAC type of unified current outputs 0 - Current outputs not implemented 1 - One 4-channel DAC AD7398 (MK22-DC-R2, MK22-DC-11-R2, MK22-DC-001-R2) 2 - Four single-channel DACs DAC7611 (MK22-DC-001-R2-M-Base-PO)	`DacExternalType`	Uint(2)	0x0EC4	0	6
Extension board type 0 - no extension board 1 - comparator board COMP.01-2CH-MK32-MS	`InputExpBoardType`	Uint(2)	0x0EC6	0	7
Reserve, should always be equal to zero	`Reserv`	Uchar(4)	0x0EC8	0	

Notes
1. In case of reading error from non-volatile memory always equals to 79 (8 seconds)
2. If value is 0, function is disabled.
3. Time by 0.1 s (0 = 0.1 s).
4. This parameter does not apply to logic output 12.
5. Implemented in module software from version 1.60.
6. Implemented in module software from version 1.65.
7. Implemented in module software from version 1.68.
8. Default value – value assigned to parameter after “Cold start”.

Table 34 - Information line

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Information on installed jumpers	`JumpersInfoString`	Uchar(64)	0x1600	0	

Notes
1 Filled in no particular form, not required parameter.
2 Default value – value assigned to parameter after “Cold start”.

Table 35 - Logic outputs symbol names

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Logic output 1 symbol name (code)	LogicName_1	Char (16)	0x1700	0	1
Logic output 2 symbol name (code)	LogicName_2	Char (16)	0x1710	0	1
Logic output 12 symbol name (code)	LogicName_12	Char (16)	0x17B0	0	1
Notes 1 Name not assigned, empty line. 2 Default value – value assigned to parameter after “Cold start”.					

Table 36 - List of logical signaling setup registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Output 1 logical rule (16 comands)	LogicRules[0]	Uint(2)x16	0x1C00	0	
Output 2 logical rule	LogicRules[1]	Uint(2)x16	0x1C20	0	
Output 3 logical rule	LogicRules[2]	Uint(2)x16	0x1C40	0	
Output 4 logical rule	LogicRules[3]	Uint(2)x16	0x1C60	0	
Output 5 logical rule	LogicRules[4]	Uint(2)x16	0x1C80	0	
Output 6 logical rule	LogicRules[5]	Uint(2)x16	0x1CA0	0	
Output 7 logical rule	LogicRules[6]	Uint(2)x16	0x1CC0	0	
Output 8 logical rule	LogicRules[7]	Uint(2)x16	0x1CE0	0	
Output 9 logical rule	LogicRules[8]	Uint(2)x16	0x1D00	0	
Output 10 logical rule	LogicRules[9]	Uint(2)x16	0x1D20	0	
Output 11 logical rule	LogicRules[10]	Uint(2)x16	0x1D40	0	
Output 12 logical rule	LogicRules[11]	Uint(2)x16	0x1D60	0	
LED “War” logical rule	LogicRules[14]	Uint(2)x16	0x1DC0	0	
LED “Alarm” logical rule	LogicRules[15]	Uint(2)x16	0x1DE0	0	
Notes: - Default value – value assigned to parameter after “Cold start”.					

Table 37 - Logical rules command structure

Description	Designation	Bits
Operation code 0x00 - empty operation 0x1F - logical formula completion 0x01 - place memory value to storage battery 0x02 - save storage battery value to memory 0x03 - reset storage battery to zero 0x04 - invert storage battery value 0x05 - storage battery and memory logical OR 0x06 - storage battery and memory logical AND 0x07 - storage battery and memory logical exclusive OR	`Operation`	11 : 15 (5)
Memory (register) code 0x00 - no memory reference 0x01 - local memory (16 bit) individual for each logic output (cleared before execution) 0x02 - global memory (16 bit) common for all 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 - module status register (StatusSys) 0x0B - 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 address (bin number in register)	`Address`	0 : 5 (6)

5.4.3 Communication interfaces

Table 38 - List of RS485 interface No.1 registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Permit interface operation 0 – Disabled 1 – VibrobitRTU mode 2 - ModbusRTU mode	`Enabled`	Uint (2)	0xF00	0	
Permit module operation parameters change by RS485 interface commands (not zero - permitted)	`ChangeEna`	Uint (2)	0xF02	0	
Permit single recording operation (not zero - permitted)	`OnWriteEna`	Uint (2)	0xF04	0	
Permit broadcast address support (not zero - permitted)	`CommAddrEna`	Uint (2)	0xF06	0	
Device address on RS485 bus (from 1 to 247)	`Address`	Uint (2)	0xF08	1	
Data rate, bit/s 0 – 4800; 1 – 9600; 2 – 19200; 3 – 38400; 4 – 57600; 5 – 115200; 6 – 230400	`Speed`	Uint (2)	0xF0A	0	

Notes

1 RS485 interface parameters take effect only after interface repeated initialization.

2 Default value – value assigned to parameter after “Cold start”.

Table 39 - List of RS485 interface No.2 registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Permit interface operation 0 – Disabled 1 – VibrobitRTU mode 2 - ModbusRTU mode 10 - Apply RS485 interface No.1 setting	`Enabled`	Uint (2)	0x1500	0	
Permit module operation parameters change by RS485 interface commands (not zero - permitted)	`ChangeEna`	Uint (2)	0x1502	0	
Permit single recording operation (not zero - permitted)	`OnWriteEna`	Uint (2)	0x1504	0	
Permit broadcast address support (not zero - permitted)	`CommAddrEna`	Uint (2)	0x1506	0	
Device address on RS485 bus (from 1 to 247)	`Address`	Uint (2)	0x1508	1	
Data rate, bit/s 0 – 4800; 1 – 9600; 2 – 19200; 3 – 38400; 4 – 57600; 5 – 115200; 6 – 230400	`Speed`	Uint (2)	0x150A	0	

Notes

1 RS485 interface parameters take effect only after interface repeated initialization.

2 Default value – value assigned to parameter after “Cold start”.

Table 40 - List of CAN2.0B interface standard registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Permit interface operation (Not zero - interface operation permitted)	`Enabled`	Uint (2)	0x1000	0	
Data rate, kbit/s 0 – 1000; 1 – 500; 2 – 250; 3 – 200; 4 – 125; 5 – 100; 6 – 80; 7 – 40	`Speed`	Uint (2)	0x1002	0	
Module address on bus	`Address`	Uint (2)	0x1004	0	
Message sending period by 0.1 s	`PeriodSend`	Uint (2)	0x1006	0	1
Data transfer by measurement channel 1 bit 0 - measurement results bit 1 - measured parameter minimum bit 2 - measured parameter maximum bit 3 - additional parameter 1 bit 4 - additional parameter 2 bits 5-15 – reserve, should be zero	`DataSend_1`	Uint (2)	0x1008	0	
Data transfer by measurement channel 2 (bits purpose similar to channel 1)	`DataSend_2`	Uint (2)	0x100A	0	
Data transfer by measurement channel 3 (bits purpose similar to channel 1)	`DataSend_3`	Uint (2)	0x100C	0	
Data transfer by measurement channel 4 (bits purpose similar to channel 1)	`DataSend_4`	Uint (2)	0x100E	0	
Notes 1 Time by 0.1 s (0 = 0.1 s). 2 CAN2.0B interface parameters take effect only after interface repeated initialization. 3 Default value – value assigned to parameter after “Cold start”.					

5.4.4 Identification information

Table 41 - List of module identification information registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Module factory number	`Number`	Uint (2)	0x1200		
Module manufacturing year	`Year`	Uint (2)	0x1202		
Order number	`Order`	Uint (2)	0x1204		
Assembler’s code	`Assembler`	UChar (1)	0x1206		
Adjuster’s code	`Adjuster`	UChar (1)	0x1207		
Additional text information	`TextString`	Char (32)	0x1208		
Note - Identification information is available read-only, not initialized by “Cold start”.					

Table 42 - List of module software identification information registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Microprocessor software version line	`Version`	Char (6)	0x1300		
Microprocessor software compilation date	`Date`	Char (12)	0x1306		
Microprocessor software compilation time	`Time`	Char (10)	0x1312		
Note - Identification information is available read-only.					

5.4.5 Measurement results

Table 43 - List of measurement results main registers

<table>
<tr><th rowspan="2">Description</th><th rowspan="2">Designation</th><th rowspan="2">Type (bytes)</th><th colspan="4">Address (Hex)</th><th rowspan="2">Note</th></tr>
<tr><th>Channel 1</th><th>Channel 2</th><th>Channel 3</th><th>Channel 4</th></tr>
<tr><td>Main measured parameter value</td><td><code>Data</code></td><td>Float (4)</td><td>0x0000</td><td>0x001C</td><td>0x0038</td><td>0x0054</td><td></td></tr>
<tr><td>Main measured parameter minimum value</td><td><code>DataMin</code></td><td>Float (4)</td><td>0x0004</td><td>0x0020</td><td>0x003C</td><td>0x0058</td><td></td></tr>
<tr><td>Main measured parameter maximum value</td><td><code>DataMax</code></td><td>Float (4)</td><td>0x0008</td><td>0x0024</td><td>0x0040</td><td>0x005C</td><td></td></tr>
<tr><td>Additional measurement result No.1</td><td><code>DataAdd_1</code></td><td>Float (4)</td><td>0x000C</td><td>0x0028</td><td>0x0044</td><td>0x0060</td><td>1</td></tr>
<tr><td>Additional measurement result No.2</td><td><code>DataAdd_2</code></td><td>Float (4)</td><td>0x0010</td><td>0x002C</td><td>0x0048</td><td>0x0064</td><td>1</td></tr>
<tr><td>Sensor DC, mA</td><td><code>Current</code></td><td>Float (4)</td><td>0x0014</td><td>0x0030</td><td>0x004C</td><td>0x0068</td><td></td></tr>
<tr><td>Measurement channel status flags</td><td><code>Status</code></td><td>Uint (2)</td><td>0x0018</td><td>0x0034</td><td>0x0050</td><td>0x006C</td><td>2</td></tr>
<tr><td>Sensor signal constant component ADC value</td><td><code>AdcConst</code></td><td>Uint (2)</td><td>0x001A</td><td>0x0036</td><td>0x0052</td><td>0x006E</td><td>3</td></tr>
<tr><td>Module status flags</td><td><code>StatusSys</code></td><td>Uint (2)</td><td colspan="4">0x0070</td><td>4</td></tr>
<tr><td>Logic outputs status
bits 0-11 - logic outputs status from 1 to 12
bits 12-13 – reserved, always are zero
bit 14 - LED ‘War’ status
bit 15 - LED ‘Alarm’ status</td><td><code>LogicOutStatus</code></td><td>Uint (2)</td><td colspan="4">0x0072</td><td></td></tr>
<tr><td>Additional status register</td><td><code>StatusSysAdd</code></td><td>Uint(2)</td><td colspan="4">0x007C</td><td>5</td></tr>
<tr><td>DAC type of unified current outputs</td><td><code>DacExternalType</code></td><td>Uint(2)</td><td colspan="4">0x007E</td><td>6</td></tr>
<tr><td>Extension board type</td><td><code>InputExpBoardType</code></td><td>Uint(2)</td><td colspan="4">0x0080</td><td>7</td></tr>
<tr><td colspan="8">Notes
1. Purpose depends on additional functions for the corresponding measurement channels.
2. Measurement channels status flags are described in Table 16.
3. Used during measurement channels calibration.
4. Module status flags description is given in Table 15.
5. Module status additional flags description is given in Table 17.
6. Register value corresponds to the description, given in Table 33.
7. Register value corresponds to the description, given in Table 33.
8. Measurement results registers are available read-only.</td></tr>
</table>

Table 44 - List of 3rd channel spectral components registers when rotor bowing measurement

Description	Designation	Type (bytes)	Address (Hex)	Note
Excursion (2A) ½ rotational component	Mag	Float (4)	0x0100	
Phase ½ rotational component, °	Phase	Float (4)	0x0104	
Rotational component excursion	Mag	Float (4)	0x0108	
Rotational component phase, °	Phase	Float (4)	0x010C	
Rotational component 1.5 excursion	Mag	Float (4)	0x0110	
Rotational component 1.5 phase, °	Phase	Float (4)	0x0114	
Rotational component 5 excursion	Mag	Float (4)	0x0148	
Rotational component 5 phase, °	Phase	Float (4)	0x014C	

Notes

1 Value of rotational components and their phases are zero if rotor bowing measurement function is disabled.

2 Values of half rotational components and their phases are zero if rotor bowing measurement is carried out per one rotor rotation.

3 Rotational component phase values are zero, if corresponding rotational component level is less than established limit.

4 Measurement results registers are available read-only.

Table 45 - List of 3rd channel additional registers when rotor bowing measurement

Description	Designation	Type (bytes)	Address (Hex)	Note
Frequency used when signal sampling capture, rpm	RequestFreq	Float (4)	0x2200	
Sampling mode 0 - 2 rotor revolutions 1 - 1 rotor revolution	ReqestMode	Uint (2)	0x2204	
Data supplied to 3rb unified output 0 - rotor bowing 1 – gap	OutData	Uint (2)	0x2206	
1-st rotational ADC excursion value	Adc1F	Uint (2)	0x2208	1
Polyharmonics ADC excursion value	AdcPoly	Uint (2)	0x220A	1
Synchronization source 0 - not selected 1 - Channel 1 2 - Channel 2	InFreqSelect	Uint (2)	0x2216	
Number of pulses per rotor rotation	Tooth	Uint (2)	0x2218	

Notes

1 Used during measurement channels calibration.

2 Measurement results registers are available read-only.

Table 46 - List of 3rd measurement channel signal capture registers

Description	Designation	Type (bytes)	Address (Hex)	Note
Sampling value 0	Data_0	Float (4)	0x2800	
Sampling value 1	Data_1	Float (4)	0x2804	
...	...	...	...	
Sampling value 511	Data_511	Float (4)	0x2FFC	

Notes

1 Read after setting the corresponding flag in module status register.

2 Measurement results registers are available read-only.

Table 47 - List of comparator board COMP.01-2CH-MK32-MS status registers (for channels 1, 2)

Description	Designation	Type (bytes)	Address (Hex)		Note
			Channel 1	Channel 2	
Status flags bit 0 - Function is active b it 1 - Gap measurement during rotor rotation bit 2 - Rotor stopped bit 3 - Gap calculated during rotor rotation Adaptive mode bit 4 - Speed below established level bit 5 - Lower level limit bit 6 - Upper level limit bit 7-30 - Service bit 31 - Settings error	`Status`	Ulong (4)	0x3200	0x3300	
Sensor DC gap, μm	`GapAverage`	Float (4)	0x3204	0x3304	
Gap calculated by CS protrusions, μm	`GapUponRotation`	Float (4)	0x3208	0x3308	
Reserve, equal to zero	`Reserv`	Ulong (4)	0x320C	0x330C	
Average level, μm	`ToggleGapLevel_Avr`	Float (4)	0x3210	0x3310	
Lower comparison level, μm	`ToggleGapLevel_Low`	Float (4)	0x3214	0x3314	
Upper comparison level, μm	`ToggleGapLevel_High`	Float (4)	0x3218	0x3318	
Reserve, equal to zero	`Reserv`	Ulong (4)	0x321C	0x331C	
Switching level. Lower value, DAC	`ToggleGapDAC_Low`	Uint (2)	0x3220	0x3320	
Switching level. Upper value, DAC	`ToggleGapDAC_High`	Uint (2)	0x3222	0x3322	
Reserve, equal to zero	`Reserv`	Ulong (4)	0x3224	0x3324	
Gap calculation. Factor A	`CoeffCurrentToGap_A`	Float (4)	0x3228	0x3328	
Gap calculation. Factor B	`CoeffCurrentToGap_B`	Float (4)	0x322C	0x332C	
DAC calculation. Factor A	`CoeffGapToDAC_A`	Float (4)	0x3230	0x3330	
DAC calculation. Factor B	`CoeffGapToDAC_B`	Float (4)	0x3234	0x3334	
Algorithm service registers		Uchar (16)	0x3238	0x3338	
Gap during rotor rotation, ADC	`GapUR_Adc`	Ulong (4)	0x3248	0x3348	

Notes

1. Implemented in MK22 module software version 1.68.
2. Measurement results registers are available read-only.

Table 48 - List of 4th channel additional registers when rotor rotation angle measurement

Description	Designation	Type (bytes)	Address (Hex)	Note
Measurement channel status flags (bits): 0 - measurements enabled 1 - measurement results are authentic 2-6 - reserve, equal to 0 7 - logic level 8 - signal sampling is active 9 - synchronization available on channel 1 10 - synchronization available on channel 2 11 - service 12-13 - reserve, equal to 0 14 - error of the measurement channel estimated factors 15 - incorrect settings	`Flags`	Uint (2)	0x3500	
Established number of pulses per rotor revolution	`Tooth`	Uint (2)	0x3502	
Rotor rotational angle, deg	`Value_Dg`	Float (4)	0x3504	
Rotor speed, rpm	`Frequency_RPM`	Float (4)	0x3508	
Reserve, equals to zero	`ReservFL`	Float (4)	0x350C	
Pulse counter (operating register)	`PulseCounter`	Uint (2)	0x3510	
Synchronization input number	`InFreqSelect`	Uint (2)	0x3512	
Switching level to logical '0', ADC 16	`ToggelAdc_ToLow`	Uint (2)	0x3514	
Switching level to logical '1', ADC 16	`ToggelAdc_ToHigh`	Uint (2)	0x3516	

ПримеNotes

1 Implemented in MK22 module software version 1.69.

2 Measurement results registers are available read-only.

5.4.6 Control commands

Several reserved registers are provided for control commands execution. Control commands are executed only during individual recording into each register (it is impossible to execute several control commands per one data transaction).

Table 49 - List of control registers

Register address (Hex)	Recorded value (Hex)	Action	Note
0xFF00	0x55	Module reset (similar to module power-up)	
0xFF01	0x60	Execute frequency measurement repeated initialization	1,3
	0x61	Recalculate channel 1 factors	1, 3
	0x62	Recalculate channel 2 factors	1, 3
	0x63	Recalculate channel 3 factors	1, 3
	0x64	Recalculate channel 4 factors	1, 3
	0x51	1-st measurement channel minimum/maximum reset	3
	0x52	2-nd measurement channel minimum/maximum reset	3
	0x53	3-rd measurement channel minimum/maximum reset	3
	0x54	4-th measurement channel minimum/maximum reset	3
	0x93	Execute RS485 No.1 interface repeated initialization	2, 3
	0x94	Execute RS485 No.2 interface repeated initialization	2, 3
	0x98	Execute CAN2.0B interface repeated initialization	2, 3
0xFF02	0x33	Logical signaling block	
	0xCC	Logical signaling normal operation	
0xFF03	0x3C	Request for single recording	
0xFF04	0x51	Channel 1 “STOP” mode check	5
	0x52	Channel 2 “STOP” mode check	5
	0x50	Disengage channels 1, 2 “STOP” mode check	5
0xFF05	0xA3	Measurement channel 3 sampling capture	6

Table 49(continued)

Register address (Hex)	Recorded value (Hex)	Action	Note
0xFF06		Operation parameters recording into module non-volatile memory	3, 4
	0x80	Calibration data by channel 1	
	0x81	Calibration data by channel 2	
	0x82	Calibration data by channel 3	
	0x83	Calibration data by channel 4	
	0x84	Main parameters by channel 1	
	0x85	Main parameters by channel 2	
	0x86	Main parameters by channel 3	
	0x87	Main parameters by channel 4	
	0x88	Module system parameters	
	0x89	RS485 No.1 interface parameters	
	0x8A	CAN2.0B interface parameters	
	0x8C	Logic outputs symbol names	
	0x8D	RS485 No.2 interface parameters	
	0x8E	Channel 4 additional parameters - Calculations by formula	
	0x90	Channel 1 additional parameters - Frequency measurement	
	0x91	Channel 2 additional parameters - Frequency measurement	
	0x92	Channel 3 additional parameters - Rotor bowing	
	0x93	Channel 4 additional parameters - Linearization	
	0x98	Save comparator board COMP.01-2CH-MK32-MS parameters	9
	0x98	Channel 4 additional parameters – Rotor rotational angle	10
	0x9A	Channel 1, 2 additional parameters - PM pin position	7
	0x9B	Jumpers information line	
	0x9C	Logic formula 0 - 3	
	0x9D	Logic formula 4 - 7	
	0x9E	Logic formula 8 - 11	
	0x9F	Logic formula 12 - 15	
0xFF07	0x21	Recording all module settings into non-volatile memory	3, 8

Notes:

1. Can be used after calibration to check changes without module reboot.
2. If command was received during data transfer, data are transferred in full, then repeated initialization is carried out.
3. Logical signaling should be blocked.
4. Module is not rebooted after recording.
5. Only for channels 1, 2 in rotor speed measurement mode.
6. Only in rotor bowing measurement mode.
7. Implemented in module software from version 1.60.
8. Module operation in stopped during recording. Module automatically reboots after recording.
9. Implemented in module software from version 1.68.
10. Implemented in module software from version 1.69.

6 Software

ModuleConfigurator software is a specialized program to setup MK22 control module with convenient interface and access to all module parameters. For program operation it is necessary to connect MK22 module to personal computer via diagnostic interface modules MC01 USB, MC03 Bluetooth or via RS485 interfaces.

Main program features:

- real-time observing current readings of MK11 current indicator readings and signaling;
- setup of measurement channels all parameters, communication interfaces and module general parameters;
- text report generation of logic signaling settings and module as a whole;
- settings loading/saving into file;
- input calibration;
- unified output and test signal calibration.

ModuleConfigurator software is available for download from SPE Vibrobit LLC official web-site www.vibrobit.ru, section “Support”.

ModuleConfigurator software operation detailed description is given in ВШПА.421412.300.001 34 Vibrobit Module Configurator. Operator Manual.

Before connecting with MK22 module, select MK22 setting in ModuleConfigurator software.

ModuleConfigurator software appearance with loaded MK22 setting is given on Figure 34.

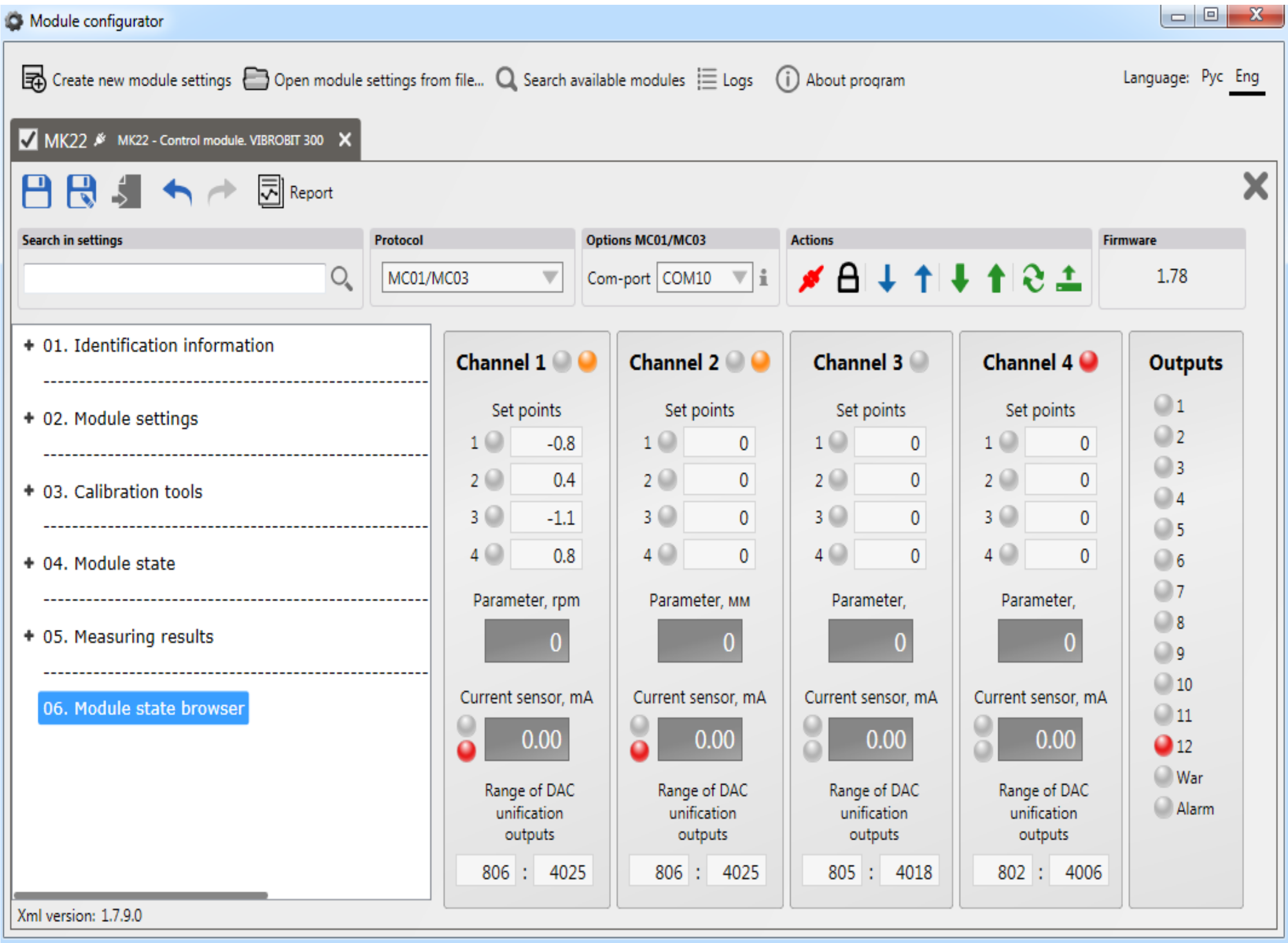


Figure 34 - MK22 module observer appearance in ModuleConfigurator software

7 Maintenance

For maintenance information refer to document ВШПА.421412.300 РЭ Equipment Vibrobit 300 Operations and Maintenance Manual:

- equipment maintenance;
- routine repair;
- equipment check method.

Appendix A

(mandatory)

Controls arrangement

Versions
МК22-DC-R2, МК22-DC-001-R2, МК22-DC-001-R2

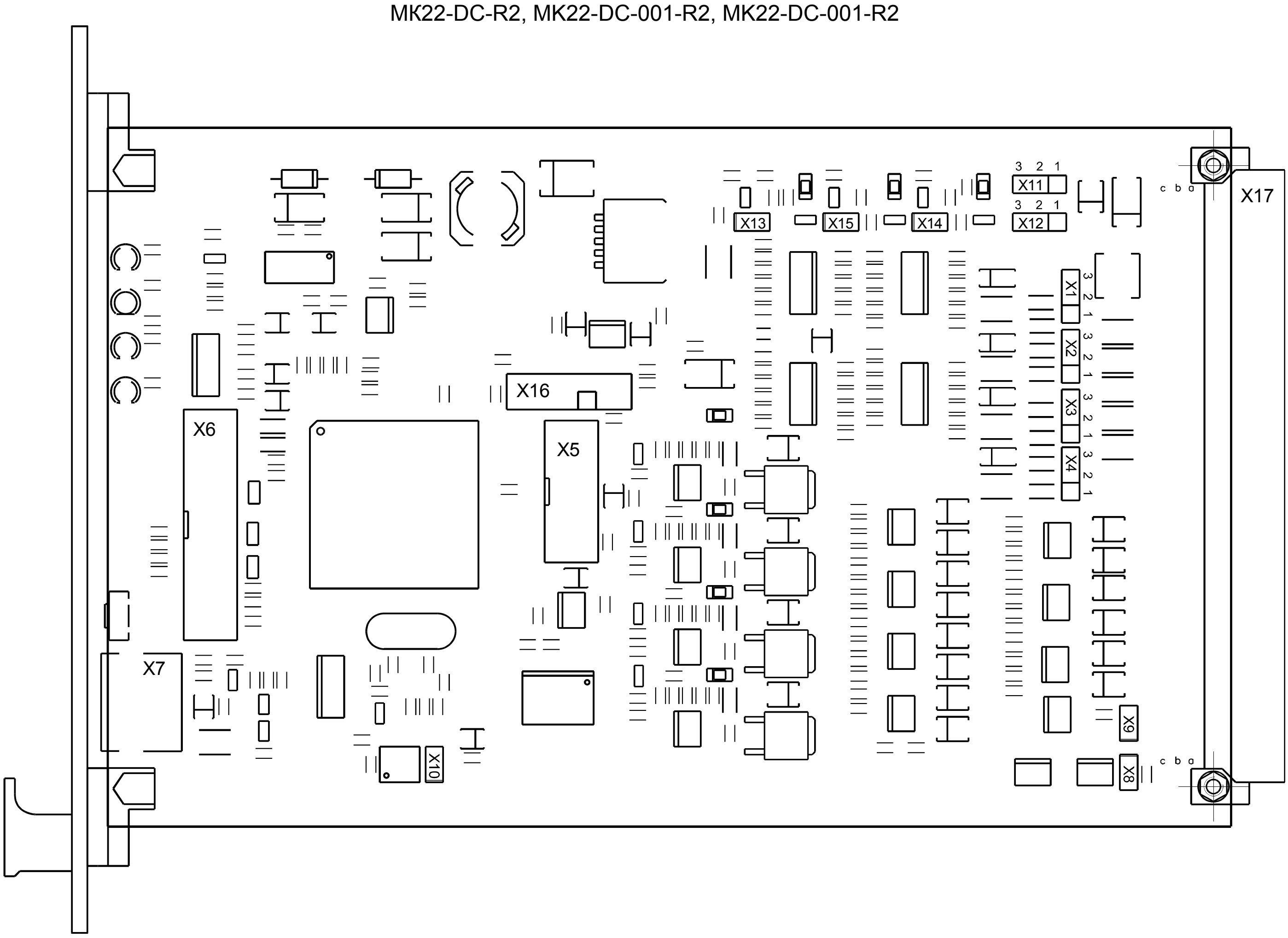


Figure A.1 - Controls arrangement

Connectors purpose

Designation	Purpose
X17	Main switching connector
X5	Module front panel indicator connection serial interface
X6	Parallel interface, reserve
X7	Diagnostic interface, D.port
X16	Microcontroller programming, service

Jumpers X1, X2, X3,X4

Measurement channels 1, 2, 3, 4 (correspondingly) operating mode selection

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

Jumpers X8, X9

Terminator 120 Ohm of bus RS485 No.1, CAN2.0B (correspondingly)

Position	Mode
Removed	Terminator disconnected from bus
Installed	Terminator connected to bus

Jumpers X11, X12

Synchronization pulses source selection for measurement channel 1,2 correspondingly

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

Jumpers X13

Pull-up resistor connection to logic input

Position	Mode
Removed	Pull-up resistor disabled
Installed	Pull-up resistor connected

Jumper X14, X15

Pull-up resistor connection to synchronization channels 1, 2 correspondingly

Position	Mode
Removed	Pull-up resistor disabled (synchronization pulses from measurement channel)
Installed	Pull-up resistor enabled (synchronization pulses from input with OC)

Jumper X10

EEPROM recording protection

Removed	EEPROM recording prohibited
Installed	EEPROM recording permitted

Jumper X20, X21

Internal power supply connection to current outputs board

Position	Mode
Removed	External power supply
Installed	Internal power supply

Version
МК22-DC-001-R2-M-Base-PO

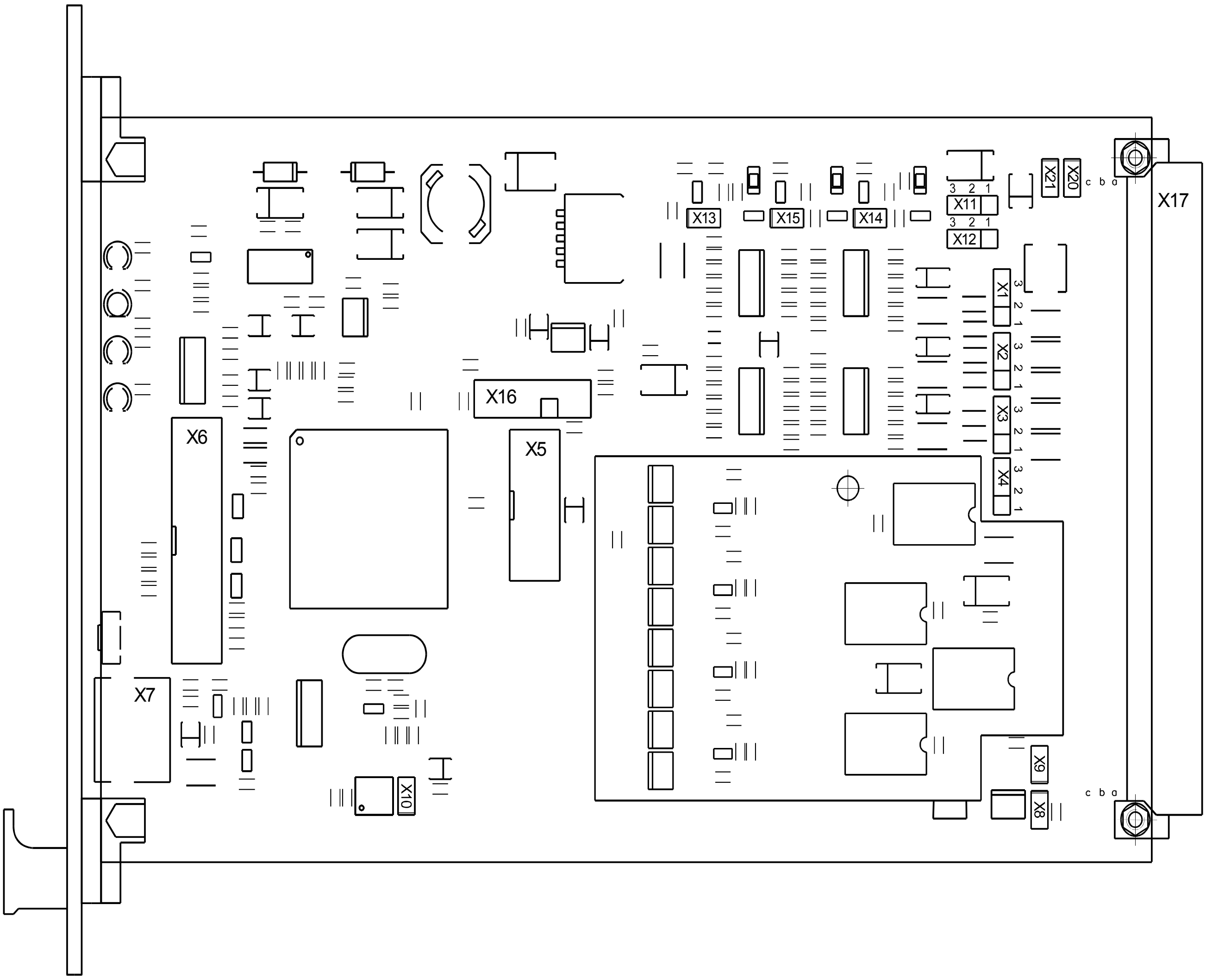


Figure A.2 - Controls arrangement

Purpose of connectors and jumpers corresponds to the module versions МК22-DC-R2, МК22-DC-11-R2, МК22-DC-001-R2.

Version
MK22-DC-001-R2-COMP.01

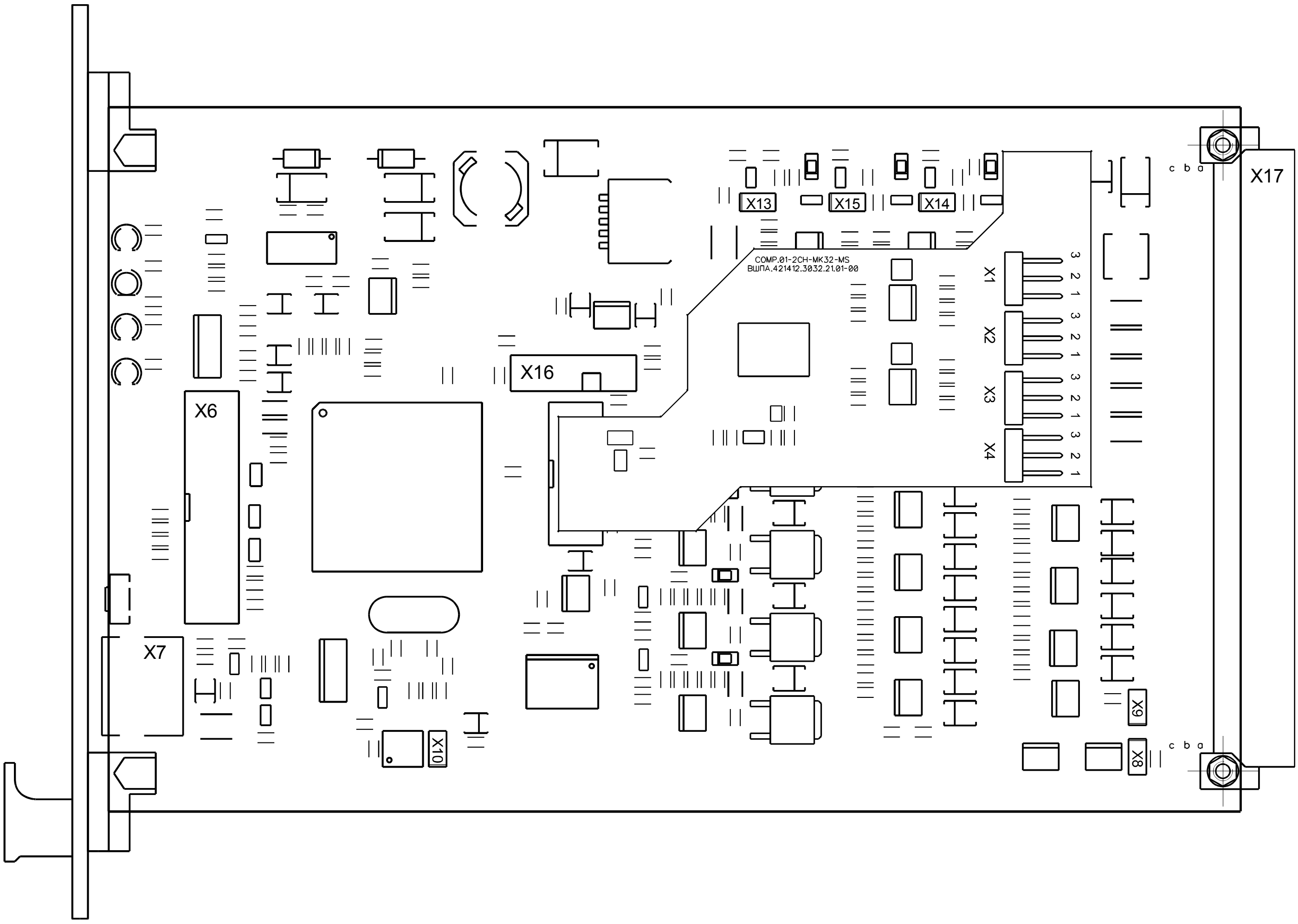


Figure A.3 - Controls arrangement

Purpose of connectors and jumpers corresponds to the module versions MK22-DC-R2, MK22-DC-11-R2, MK22-DC-001-R2.

Appendix B

(mandatory)

Purpose pf mModule switching connector terminals

Table B.1 - List of control registers

Terminal number	Designation	Purpose	Note
A2, B1, C2 A32, B31, C32	GND	Common	
A6, B5, C6	Power +24V	Power supply voltage input/output +24V	
B3	Fin 1	Main pulse input	
C4	Fin 2	Standby pulse input	
B7	+24V sense CH1	Voltage input +24V to power channel 1 converter	
B9	+24V sense CH2	Voltage input +24V to power channel 2 converter	
B11	+24V sense CH3	Voltage input +24V to power channel 3 converter	
B13	+24V sense CH4	Voltage input +24V to power channel 4 converter	
C8	Input CH1	Measurement channel 1 input	1
C10	Input CH2	Measurement channel 2 input	1
C12	Input CH3	Measurement channel 3 input	1
C14	Input CH4	Measurement channel 4 input	1
B15	Analog out 1	Measurement channel 1 unified output	
C15	Analog out 1 (-)	Measurement channel 1 (-) unified output	4
C16	Analog out 2	Measurement channel 2 unified output	
B16	Analog out 2 (-)	Measurement channel 2 (-) unified output	4
B17	Analog out 3	Measurement channel 3 unified output	
C17	Analog out 3 (-)	Measurement channel 3 (-) unified output	4
C18	Analog out 4	Measurement channel 4 unified output	
B18	Analog out 4 (-)	Measurement channel 4 (-) unified output	4
A15, A16	Analog Pwr +24V	+24V power supply of galvanically isolated unified output	4
A17, A18	Analog Pwr GND	Common power supply of galvanically isolated unified output	4
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	CAN2.0B interface, common	
B27	CAN-H	CAN2.0B interface, line H	
C28	CAN-L	CAN2.0B interface, line L	

Table B.1 continued

Terminal number	Designation	Purpose	Note
A30	RS485-GND	RS485 interface, common	
B29	1-RS485-B(-)	RS485 No.1 interface, line B	
C30	1-RS485-A(+)	RS485 No.1 interface, line A	
B30	2-RS485-B(-)	RS485 No.2 interface, line B	
C29	2-RS485-A(+)	RS485 No.2 interface, line A	

Notes

1 If the channel is not used, then the output can be left unconnected, this channel operation should be disabled in the module settings.

2 Operation logic is determined during module configuration.

3 In case of parameters reading failure from non-volatile memory, the active level will be present. It is recommended to assign all module failure signals (sensors test, etc.) to this output.

4 In module version MK22-DC-001-R2-M-Base-PO for galvanically isolated current outputs.