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SCIENTIFIC PRODUCTION
ENTERPRISE VIBROBIT LCC

EQUIPMENT "VIBROBIT 300"

MK11 Control Module Setup Instruction

(with module software version from 2.00)

ВШПА.421412.3011 И2

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The MK11 Module Setup Instruction is intended to familiarize users (customers) with main operating principles and setup methods of MK11 constant signals control module of Equipment VIBROBIT 300 with software (SW) version from 2.00.

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

Version 2 dated 03.06.2019

Contents

General

MK11 control module is intended to measure and monitor linear displacements, DC signals by 2 independent measurement channels, exercise signaling and equipment safety shutdown functions.

MK11 main functions:

- signal constant level measurement by 2 independent measurement channels with sensor serviceability monitoring function;
- automatic indication switching to display main measured parameter (channel 1);
- four setpoints in each measurement channel with individual selection of operating mode for every setpoint;
- two unified current outputs;
- operation check mode of measurement channels, signaling elements and safety shutdown;
- eight logic outputs providing direct connection of signaling relay windings and safety shutdown;
- digital communication interfaces support:
  - two independent interfaces RS485 with Modbus RTU protocol ;
  - CAN2.0B interface;
  - diagnostic interface;
- power supply from DC source +24V and AC 85 - 240 V 50 Hz (depending on module version).

MK11 module is based on high-performance 8-bit microcontroller, providing parallel processing of signals from several measurement channels, incorporation of many functions in one module and support of modern digital control interfaces.

MK11 module operates in real-time mode with measuring results update time of 50 ms. MK11 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;
- supports data exchange via digital communication interfaces;
- supplies measured values to indication and processes buttons pressing by user.

Implemented in MK11 module is a simplified calibration procedure of input measurement channels and unified current outputs, enabling to change the parameter measuring range or unified output range without repeated recalibration (or factor recalculation).

MK11 module design enables to check the operation of entire module measurement section and logic outputs operation. MK11 module measurement channels check is controlled using the module front panel buttons or commands via digital communication interfaces.

Eight logic outputs with open collector (OC: low active level) enable user to configure the function purpose of each output.

All MK11 module operating modes setup is carried out using personal computer of target setup instrument ПН31. To setup MK11 module using personal computer, started on computer should be a program ModuleConfigurator, MK11 module should be connected to computer via diagnostic interface module MC01 USB (USB interface).

List of MK11 control module versions is given in Table 1.

Table 1. MK11 control module versions

Version code	Designation	Note
MK11-DC-R2		Limited indication system, front panel 20 mm. Module setup, measured values and status viewing can be carried out only via digital communication interfaces;
MK11-DC-11-R2	ВШПА.421412.3011-10	Extended indication and control system, front panel 40 mm, module is powered with +24VDC. Arranged on the module front panel is a 7-segment digital indicator, additional indication LEDs and control buttons.
MK11-DC-11-R2-AO2	ВШПА.421412.3011-20	Similar to MK11-DC-11-R2 except for presence of two galvanically isolated unified current outputs
MK11-AC-11-S-R2	ВШПА.421412.3011-11	This version is similar to previous one, except that power is supplied from 85 - 240 V 50 Hz AC circuit, and arranged on module front panel is power toggle switch. This version is particularly advantageous when project requires an individual power supply for each mechanical quantities measurement channel, for example, rotor axial offset control circuit construction
MK11-AC-11-S-R2-AO2	ВШПА.421412.3011-21	Similar to MK11-AC-11-S-R2 except for the presence of two galvanically isolated unified current outputs

Provided is sensors powering from MK11 module via resettable fuse 200 mA.

In version MK11-AC-11-S-R2, MK11-AC-11-S-R2-AO2 the second measurement channel can be used to control +24V power supply voltage of sensor and module itself.

Structurally the MK11 module is made as a 3U modulefor frameworks of “Евромеханика” 19” type.

Table 2. MK11 control module specifications

Parameter description	Value
Number of measurement channels	2
Displacements measurement and signaling range (from and to inclusive), (S), mm	Determined by module settings
Input signal measurement and signaling ranges: - DC, mA - VDC, V	 1 – 5; 4 – 20 0.76 – 3.84
Input resistance, Ohm - DC - VDC	 768 ± 2; 191 ± 0.5 10 000 min
Measurement permissible main relative error limits, % - by digital indicator - by unified signal	 ±1.0 ±1.0
Readings refresh time, sec	0.25
Logic outputs parameter calculation and refresh time, s	0,05
Number of output unified DC signals	2
Output unified DC signal, mA	1 – 5; 4 – 20
Output unified signal load resistance, Ohm, max	500
Unified signal galvanic isolation operation voltage (version AO), V, max:	400[1)]
Number of setpoints by each measurement channel	4
Number of module discrete outputs	8
Module output discrete signals - type - DC, V, max - output current, mA, max	 Open collector (OC) 24 100
Supported digital communication interfaces types	RS485 (Modbus RTU) CAN2.0B diagnostic I2C
Ambient air operating temperature range (from and to inclusive), °C	+5 – +45
Power supply voltage - for versions MK11-AC-11-S-R2, MK11-AC-11-S-R2-AO2 - other versions	 85 – 240/50 Hz +(24 ± 1.0)
MK11 consumption current in circuit +24V, mA, max (without considering consumption current of sensor and other external circuits)	100
Total consumption current in circuit +24V, mA, max (for versions MK11-AC-11-S-R2, MK11-AC-11-S-R2-AO2 considering other connected loads)	320

Notes: 1. Voltage applied between any galvanically isolated circuits or a ground bus and any galvanically isolated circuit. The value is given for normal conditions, according to ГОСТ Р 53429-2009.

Table 3. MK11 additional parameters

Parameter description	Value
Overall dimensions, mm - version MK11-DC-R2 - version MK11-DC-11-R2, MK11-DC-11-R2-AO2 - version MK11-AC-11-S-R2, MK11-AC-11-S-R2-AO2	 20,1 x 130 x 190 40,3 x 130 x 190
Mass, kg, max - version MK11-DC-R2 - version MK11-DC-11-R2, MK11-DC-11-R2-AO2 - version MK11-AC-11-S-R2, MK11-AC-11-S-R2-AO2	 0.15 0.20 0.30
Warm-up time, min, max	1
Operating mode	continuous
Average service life, years	10
Mean time between failures (design), hours, min	100,000
Permissible relative humidity, %	80 at temperature +35 °C
Insulation resistance in circuits 220VAC, MOhm, min - in normal operating conditions - at relative humidity of 80%, temperature of +35 °C	 40 2
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 15150-69	Ж3

Table 4. Displacement measurement channel with sensors and converters of equipment Vibrobit 100

Parameter description	Value
Measurement range, mm	0 – 320[1)]
Measurement permissible main reduced error limit, %	±2.5
Measurement permissible reduced error limit throughout operating temperature range of sensor, converter, control module, %	±6.0

Note: 1. Range of sensors and converters of equipment Vibrobit 100

MK11 module power-up, reset

Power-up

Upon power-up, the MK11 module operating parameters are loaded from non-volatile memory. Operating parameters are divided into sections:

- measurement channels parameters;
- system parameters and 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, then module operation is blocked, signal active level will be available at 7 logic output, LED ‘Ok’ on front panel will light up with red color.

During operating parameters normal loading before MK11 module operation start:

- ***version MK11-DC-R2***: LED ‘Ok’ blinks with yellow color, indicating module starting initialization in progress;
- ***version MK11-DC-11-R2(-AO) and MK11-AC-11-S-R2(-AO)***: LED ‘Ok’ illuminates with yellow color, the module serial number is shown on 7-segment indicator, then module manufacturing year and then MK11 starting initialization executes.

Note: Not recommended, but permitted to carry out MK11 module “hot” replacement in section without de-energizing for all MK11 module versions.

After MK11 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.

For version MK11-AC-11-S-R2(-AO), MK11 module and connected sensors, relays, indication units are powered from built-in AC/DC power supply source. MK11 module is disengaged by toggle switch ‘Power’ on front panel.

Module reset

Carried out during module reset is microcontroller hardware reset and carried out is sequence of actions, corresponding to power-up. Reasons for MK11 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 MK11 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 resets.

Note: Module reset can be carried out only after displaying identification information (module number, manufacturing year) and completing MK11 module initialization cycle.

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:

- ***version MK11-DC-R2*** – ‘Ok’ LED will flash amber in sync with the ‘War’ LED.
- ***version MK11-DC-11-R2(-AO) and MK11-AC-11-S-R2(-AO)*** – ‘Cold’ inscription will flash on 7-segment indicator.

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.

Version MK11-DC-R2

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

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

Version MK11-DC-11-R2(-AO) and MK11-AC-11-S-R2(-AO)

‘Load’ is displayed on indicator during recording. Recording results can be determined by ‘Ok’ LED illumination color (similar to version MK11-DC-R2) and indicator message:

- ‘Good’ – recording completed without errors;
- ‘bad’ - one or several data sections were correctly recorded into non-volatile memory at the second attempt;
- ‘Err’ - one or several data sections were recorded into non-volatile memory with an error.

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

Indication and control means

Version MK11-DC-R2

Module status indication is limited in version MK11-DC-R2. MK11-DC-R2 module front panels appearance is shown in the figure 1. Arranged on MK11-DC-R2 module front panel are:

- four signal LEDs:
  - green LED ***'Pwr'*** - module energized;
  - bi-color LED ***'Ok'*** - module status indication.
    - green color – module normal operation;
    - yellow color – output logic signaling is blocked by user or after the module reset;
    - red color – fatal error in module operation, module operation is blocked;
    - blinking - an error was detected in the sensor test for one of the measurement channels.
  - yellow LED ***'War'*** – warning (LED operation logic is determined by user);
  - red LED ***'Alarm'*** - warning (operation logic is determined by user);
- hole to press hidden reset button ***'Reset';***
- diagnostic interface connector;
- handle for easy module dismantling from framework.

In module version MK11-DC-R2 the signal LEDs are the only module status indication mean apart from ПН31 setup instrument (personal computer) connection to diagnostic interface or access to measurement results using digital interfaces RS485 and CAN2.0B.

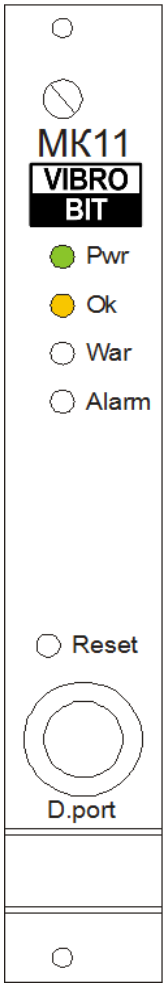


Figure 1 .MK11-DC-R2 front panel appearance (width 20 mm)

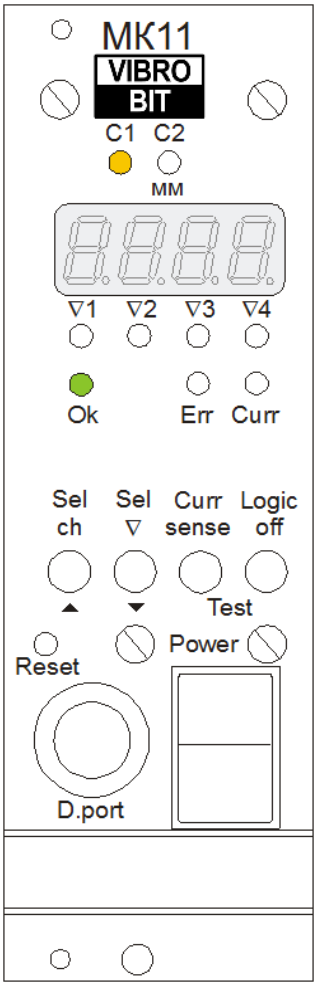


Figure 2.MK11-AC-11-S-R2(-AO) front panel appearance (width 40 mm)

Version MK11-DC-11-R2(-AO) and MK11-AC-11-S-R2(-AO)

Implemented in module version MK11-DC-11-R2(-AO) are extended indication and control means. MK11-AC-11-S-R2(-AO) module front panel appearance is shown on Figure 2. Arranged on MK11-DC-11-R2(-AO) module front panel are:

- two yellow LEDs ***'C1' and 'C2'*** of the selected measurement channel indication. The selected measurement channel LED will flash in measurement channel `'Test'` mode.
- 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. LED ***'Ok'*** operation in version MK11-DC-11-R2 is similar to version MK11-DC-R2.
- 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 starting of the parameter setpoints value test.
- yellow LED '**Curr**' - indicates the indicator output of sensor actual current value (engineer information). LED '**Curr**' flashes when the sensor current is displayed on the indicator of the selected measurement channel.
- four control buttons:
  - ***'Sel ch'*** - selects the measurement channel to display the parameter value and the measurement channel status.
    In `'Test'` mode it is used for DC increase at the selected measurement channel input (only for versions MK11-DC-11-R2, MK11-AC-11-S-R2).
  - ***'Sel ∇'*** - displays the setpoints values on the indicator.
    In `'Test'` mode it is used for DC decrease at the selected measurement channel input (only for versions MK11-DC-11-R2, MK11-AC-11-S-R2).
  - ***'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.

In version MK11-AC-11-S-R2(-AO) additionally arranged on MK11 module front panel is a toggle switch ***'Power'*** – to power-up MK11 module (switches input supply voltage).

Measurement channels are switched by pressing the ***'Sel ch'*** button. When selecting new measurement channel, the indicator immediately displays the selected channel main parameter current value.

If 1st measurement channel in MK11 module is a primary one, and the 2nd channel is an auxiliary, then module can be configured to automatically switch output to the 1st measurement channel information indicator by the user's idle timeout (within the established time during information output by the second measurement channel, user has never pressed any button on the module front panel).

Note: Switching to the information indication by 2nd measurement channel is not carried out if 2nd measurement channel operation is blocked in the MK11 module settings.

Cyclic viewing of the setpoints values 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.

Note: 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, at this time 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 (ref. Table No.5). 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 5. Data displaying formats on MK11 module indicator

Mode code	Display format	Permissible values
0	#.###	from 0.000 to 9.999
1	##.##	from -9.99 to 99.99
2	###.#	from -99.9 to 999.9
3	####	from -999 to 9999

"Test" mode

In MK11 module user can check operation of the module measurement channels, unified and logic outputs. When 'Test' mode is turned on, sensor connected to the module input is disconnected from the module input circuits. Module measurement signals receive signals from internal controlled current generator or external test signals (determined by jumper on MK11 board).

To activate the test mode, simultaneously press and hold the ***'Curr sense'*** and ***'Logic off'*** buttons until the current measurement channel switches to the 'Test' mode. In the 'Test' mode, the selected measurement channel LED (***'C1'***, ***'C2'***) will flash. To exit the 'Test' mode, press and hold the ***'Curr sense'*** and ***'Logic off'*** buttons until you exit the 'Test' mode.

Note - The 'Test' mode for each module channel should be permitted when configuring the MK11 module. If the 'Test' mode is forbidden, transition to the 'Test' mode does not occur.

If board jumpers are used to select the test signal internal generator mode, user can use ***'Sel ch'*** button to increase and ***'Sel ∇'*** button to decrease the test signal constant level. When holding these buttons, the test signal level continuously increases/decreases.

Note: In the 'Test' mode it is impossible to switch to another measurement channel and view the selected measurement channel setpoints values.

Calculated current value in 'Test' mode is compared with the permissible sensor current level set in module, so the module can enter the 'Sensor Failure' mode. Parameter calculated value is compared with setpoints and logic signaling is generated about parameter overrange. User can view the current sensor current calculated value (by pressing ***'Curr sense'*** button), enable/disable the logic outputs blocking (by pressing ***'Logic off'*** button) and change test signal level (with the ***'Sel ch'*** and ***'Sel ∇'*** buttons) .

Note: Test signal level change should be permitted for each measurement channel separately when module setup.

When 'Test' mode is turned on, the test signal reaches the level set during the module setup. 'Test' mode can be enabled for both channels simultaneously only by commands via the digital communication interfaces.

Module operation

MK11 module operates in real-time mode with measuring results update time of 250 ms. MK11 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.

Both measurement channels operate in the same way and synchronously. Only the settings and the input signal type, set by jumper on the MK11 board differ (the jumpers purpose and their positions is shown in the appendix):

- current 4 - 20 mA;
- current 1 - 5 mA;
- voltage (0 - 4.096) V.

Measurement channels input is provided with resettable fuses and protective stabilitrons (triacs), preventing module input circuits damage by pulse interferences or dangerous voltage level.

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 and removable jumper. Input signals voltage range from 0 to 4.096 V.

Note: 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 and is supplied to input of 10-bit ADC, built into microcontroller. Conducted are 128 analog-to-digital converter (ADC) values sampling by every measurement channel during 50 ms. ADC mean value is used in further sensor current calculations. Large number of ADC sampling results in ADC DC actual resolution 12-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;

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

Sensor current value I_{sense} can be displayed on indicator (by pressing ***'Curr sense'*** button) and is used in sensor test algorithm to calculate the measured parameter value.

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

Typically, the sensor current lower calibration level (`CurrMinCalibr`) and sensor current lower range (`RangeCurrMin`) are equal. If sensor current lower range (`RangeCurrMin`) is zero, then it is recommended to calibrate the lower value at 20% of the sensor current maximum value, with the sensor current minimum calibration value indicated separately (`CurrMinCalibr`).

Note: If one pair of calibration values (`CurrMinCalibr, RangeCurrMax` 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).

Sensor serviceability test

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

If I_{sense} value is less than minimum permissible current value `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 value `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).

Control permission above/below the permissible current level is set by `CurrControlMax`/ `CurrControlMin` registers, respectively. Zero value of `CurrControlMax`/`CurrControlMin` registers blocks the corresponding sensor current monitoring direction (above/below).

If the `NotLockChannel` register is zero, with any set flag of sensor current abnormal level (`ErrorSenseLow, ErrorSenseHigh`), the measured parameter value is assumed to be zero.

If `NotLockChannel` register is not zero, the measuring channel operation is not blocked (measured parameter is calculated, value is compared with setpoints), but the fault flags are set in accordance with the operation algorithm.

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 3 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.

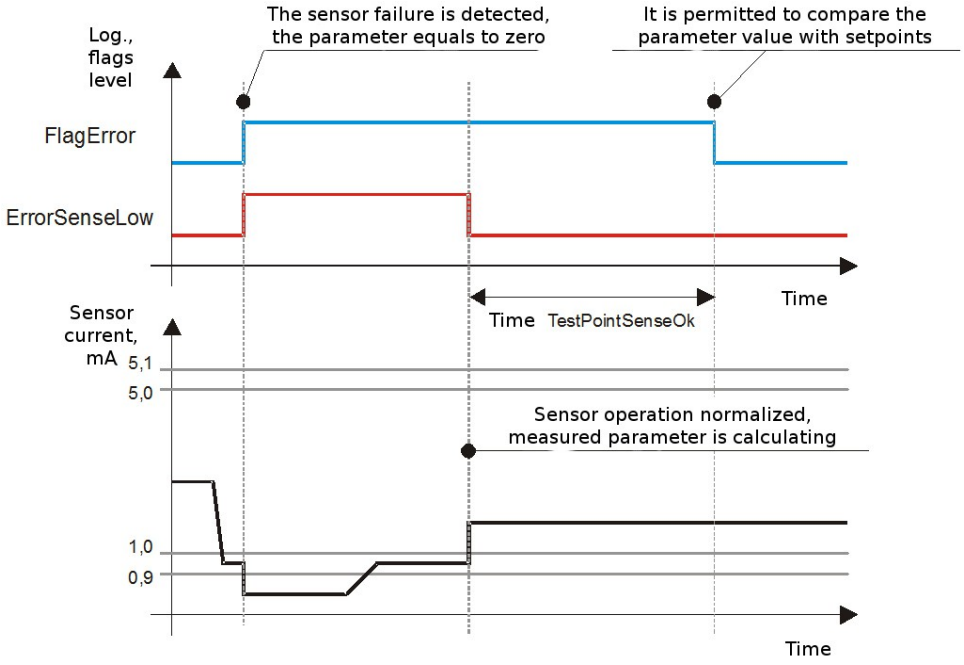


Figure 3. Sensor test algorithm operation at sensor DC drop below permissible level (`NotLockChannel = 0`)

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.

Parameter value measurement

Parameter value is calculated from sensor measured current value if channel operation is not blocked.

Measured parameter value is calculated according to linear equation formula:

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

Where:

D_{Param} – measured parameter calculated 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 used for:

- comparison with setpoints;
- displaying on indicator as main parameter;
- DAC value calculation for unified output.

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

Note: If one pair of values (`RangeCurrMin, RangeCurrMax` 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).

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 (several last calculated valuesof the measured parameter are averaged to obtain the final D_{Param} value).

Integration depth is set during module setup (`AverageData`) and can vary from 1 to 10 (1 - no averaging, 10 - maximum averaging).

Note: 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.

Format of data output to indicator is established during module setup (parameter `FormatOut`). Codes of data output formats to indicator are given in Table 5.

Additionally, user can save channel measurement units in module memory in symbolic representation with ASCII encoding (up to 7 symbols, parameter `MeasurUnit`).

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.

Condition that `NotLockChannel` register equals to zero:

- If a sensor fault is detected (one of `ErrorSenseLow`, `ErrorSenseHigh` flags is set) or `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`), common hysteresis level (`TestPointHist`) and setpoint transition response (`TestPointTime`).

Table 6. 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`, flag `OutPoint` 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 4 shows an example of signaling operation by setpoint of 1.7 mm (rotor axial offset monitoring) with hysteresis of 0.02 mm.

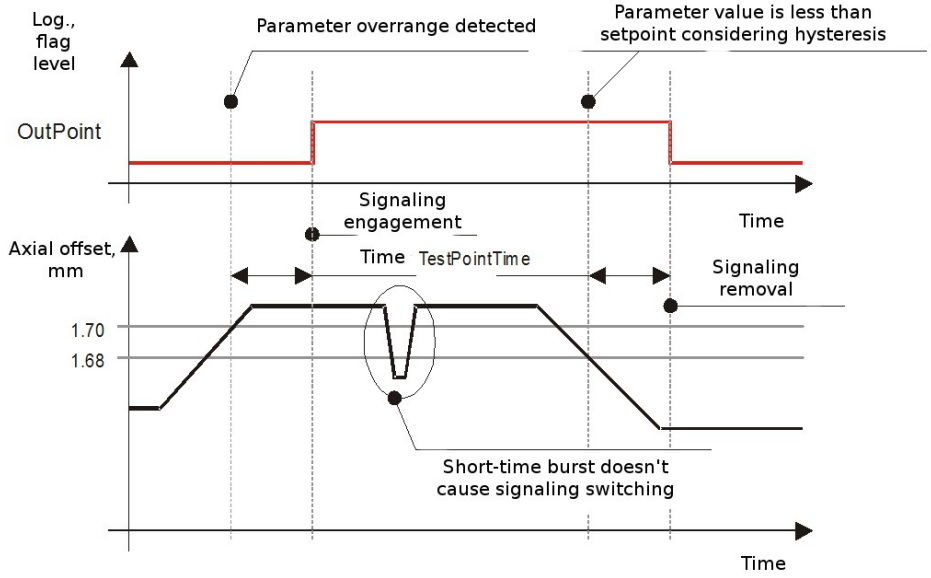


Figure 4. Example of setpoint operation algorithm (mode – check above setpoint)

Sensor signal linearization (software version 2.02)

Measurement channel can be configured to the sensor signal linearixation mode. Linearization is necessary when operating measurement channel with sensors having a nonlinear transfer characteristic, and also to reduce the measurement error.

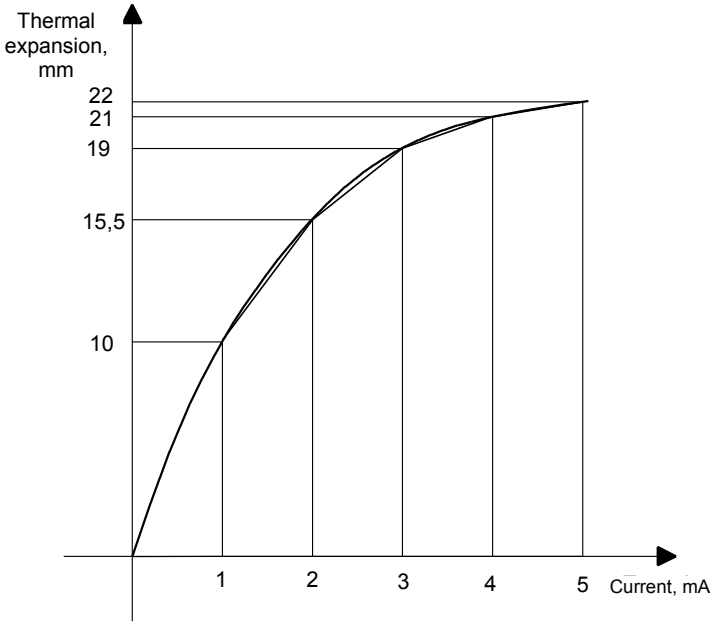
Sensor signal linearization is carried out by the piecewise linear approximation method according to the correspondence table of parameter values (`Data_1 … Data_12`) and output currents (`Current_1 … Current_12`) for the used sensor (Table 26).

The number of table records is determined by the parameter `LinerItems`, 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 5 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 5. Example of sensor parameter and linearization table.

Unified output

Unified current output is provided for each measurement channel in MK11 module. Signal level on unified output is in proportion to measured parameter value. Unified output current range corresponding to measured parameter range, can be selected at random during module setup.

Current on unified output is set using 12-bit DAC and active current amplifier designed for connection of grounded load. MK11 module is provided with protective stabilitron (breakdown voltage 27 V) and resettable fuse 200 mA to protect unified output circuits.

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

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

Where:

DAC_{OUT} – calculated DAC value;

D_{Param} – measured parameter calculated value;

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

A_O, B_O factors are calculated automatically during module operation initialization according to unified output current range data (`CurrOutMin`, `CurrOutMinCalibr`, `CurrOutMax`), unified output parameter range (`RangeParamOutMin`, `RangeParamOutMax`) and DAC saved values (`DacOutMin`, `DacOutMax`), corresponding calibrated unified output range (`CurrOutMinCalibr`, `CurrOutMax`).

Note: If `RangeParamOutMin`, `RangeParamOutMax` parameters values are not set or equal to zero (by default they have zero values), A_O, B_O factors are calculated automatically according to `RangeParamMin`, `RangeParamMax` parameters values.

Typically unified output lower calibration level (`CurrOutMinCalibr`) and unified output lower range (`CurrOutMin`) are equal. If unified output lower range (`CurrOutMin`) is zero, then it is recommended to calibrate the lower value at 20% of the unified output maximum value, with unified output minimum calibration value indicated separately (`CurrOutMinCalibr`).

Notes If one pair of calibration values (`CurrOutMinCalibr`, `CurrOutMax` or `RangeParamMin`, `RangeParamMax` or `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).

In case of measurement channel fault (`FlagError` flag active status), current of 0 mA is set on the corresponding analog output.

"Test" mode

Ony for versions MK11-DC-11-R2, MK11-AC-11-S-R2.

To implement 'Test' mode, provided in MK11 module for each measurement channel are separate current generators, connected to measurement channel input instead of sensor. Current test generators are controlled by 12-bit DAC.

Board jumper (ref. Appendix A) can be used to select the type of signal, supplied to the measurement channel input, internal current/voltage generator or external test signal.

Table 7. Test" mode operation versions (`TestEnabled` parameter)

Mode code	Description
0	"Test" mode forbidden
1	'Test' mode is permitted, internal test signal level change is forbidden
2	'Test' mode is permitted, internal test signal level change is permitted

When test mode is enabled, the `TestMode` flag is set and signal level on the test output is set to `CurrTestON`. Exit from 'Test' mode occurs at the user command or automatically, after time countdown `TimeOut_TestMode`: user permissible inactivity time in 'Test' mode.

Test signal current value is calculated according to linear equation formula:

$$DAC_{TEST} = A_T + B_T \cdot I_{TEST};$$

Where:

DAC_{TEST} – calculated DAC value;

I_{TEST} – test signal established current (voltage);

A_T, B_T – linear equation factors to calculate test signal DAC value.

A_T, B_T factors are calculated automatically during module operation initialization according to sensor current range data (`CurrMinCalibr, RangeCurrMax`) and DAC saved values (`DacTestMin, DacTestMax`), corresponding to current input range of calibrated sensor.

Typically, the sensor current lower calibration level (`CurrMinCalibr`) and sensor current lower range (`RangeCurrMin`) are equal. If sensor current lower range (`RangeCurrMin`) is zero, then it is recommended to calibrate the lower value at 20% of the sensor current maximum value, with the sensor current minimum calibration value indicated separately (`CurrMinCalibr`).

Note: If one pair of calibration values (`CurrMinCalibr, RangeCurrMax` or `DacTestMin, DacTestMax`) equals to zero or they are equal to each other, then A_T, B_T factors are not calculated and are set to zero (DAC_{TEST} value always equals to zero).

Test signal level is changed by changing `CurrTest` variable value. `CurrTest` parameter can be changed by pressing the ***'Sel ch'***, ***'Sel ∇'*** buttons to increment/decrement test signal level, and also by recording the test signal level value by commands via digital communication interfaces.

Permissible range of `CurrTest` test signal change is set during module configuration (`CurrTestMin`, `CurrTestMax` parameters).

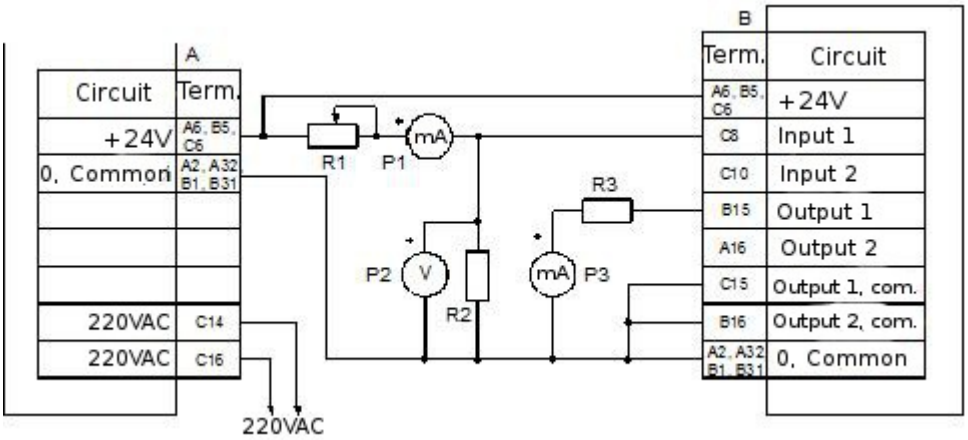
Module calibration recommendations

MK11 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 the repeated calibration.

After module calibration it is necessary to load calibration data into module, save into module non-volatile memory and reboot module (or execute command: repeated calculation of factors).

MK11 module connection diagram for calibration and check is given in Figure 6. It is recommended to calibrate MK11 module using stand СП43 enabling to connect the stated diagram.

Note: Module calibration is carried out using commands by communication digital interfaces with software ModuleConfigurator.



A – МП24 or БП17 ***B*** – МК11 ***R1*** – resistance box 100 kOhm

R2, R3 – resistors 500±10 Ohm 0.5W ***P1, P2*** – 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 6. MK11 module connection diagram for calibration and check

Measurement channel input calibration

Measurement channel input calibration sequence is simple:

1. specify measurement channel current range values (`CurrMinCalibr`, `RangeCurrMin`, `RangeCurrMax`);
2. specify measured parameter range (`RangeParamMin`, `RangeParamMax`);
3. at measurement channel input set current `CurrMinCalibr`;
4. overwrite `AdcData` value into `AdcInMin`;
5. at measurement channel input set current `RangeCurrMax`;
6. overwrite `AdcData` value into `AdcInMax`;
7. send calibration results into MK11 module;
8. re-calculate factors.

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

Provided in ModuleConfigurator software is MK11 control module measurement channel input calibration wizard, significantly simplifying calibration process.

Unified output calibration

Unified output range by measured parameter corresponds to input range (`RangeParamMin`, `RangeParamMax`). Unified output calibration consists of the following steps:

1. specify unified output current range value (`CurrOutMinCalibr`, `CurrOutMin`, `CurrOutMax`);
2. enable unified output calibration mode (`CalibrateMode` flag is set);
3. record value in `DacDirectData` to select unified output current (by milliammeter) equal to `CurrOutMinCalibr`;
4. overwrite `DacDirectData` value into `DacOutMin`;
5. record value in `DacDirectData` to select unified output current (by milliammeter) equal to `CurrOutMax`;
6. overwrite `DacDirectData` value into `DacOutMax`;
7. disengage unified output calibration mode
8. send calibration results into MK11 module;
9. re-calculate factors.

Input measured parameter range change (`RangeParamMin`, `RangeParamMax`) automatically changes the unified output parameter range. To calibrate MK11 control module provided in ModuleConfigurator program is a unified output calibration wizard, simplifying the calibration process.

Test signal output calibration

Test signal is calibrated by measurement channel current range (`CurrMinCalibr`, `RangeCurrMin`, `RangeCurrMax`). Test signal is calibrated in the following sequence:

1. specify test signal parameters (`CurrTestON`, `CurrTestMin`, `CurrTestMax`, `TestEnabled`);
2. enable test signal calibration mode (`CalibrateMode` flag is set);
3. record value in `DacDirectData` to select test output current (by milliammeter) equal to `CurrMinCalibr`;
4. overwrite `DacDirectData` value into `DacTestMin`;
5. record value in `DacDirectData` to select test output current (by milliammeter) equal to `RangeCurrMax`;
6. overwrite `DacDirectData` value into `DacTestMax`;
7. disengage test output calibration mode;
8. send calibration results into MK11 module;
9. re-calculate factors.

Note: Calibration results recording into MK11 module and factors repeated calculation can be carried out once after all calibration steps (input, unified output, test output of both measurement channels).

Logic outputs

Provided in MK11 module are 8 logic outputs with open collector (active level - zero). Logic inputs circuit engineering enables direct connection of relay windings.

Logic outputs operation is configured by user using digital communication interfaces.

If check sum error is detected by one of module operation parameters section, logic output 7 will have signal active level, other logic outputs of MK11 module will remain inactive.

Logic outputs operation is blocked after module reset for a time `LogicOffStartUp`, counted after completing module initialization cycle.

User can block logic outputs operation which can be necessary during module operation parameters correction or check of its operation, without fear of monitored equipment signaling actuation or safety shutdown.

State inversion (`LogicInvert` register) can be assigned for each logic output (except output 7). Signal inactive level is set on inverted logic outputs when the logic outputs blocking and module failure.

MK11 module parameter includes matrix “OR” (`LogicMatrix`) of status flags switching (status of measurement channels and module as a whole) to logic outputs. If at least one fag assigned to logic output is set then corresponding logic output will have signal active level, if logic outputs operation is not blocked.

Specified for each flag is logic output number to which it will be assigned. If any flag has assigned logic output number of zero or more than 8, then corresponding flag status doesn’t effect any logic output.

Table 8. Measurement channels flags `StatusCh` and their position in logic outputs matrix `LogicMatrix`

Bit No.	Designation	Description	Code	Matrix position	
				Channel 1	Channel 2
0	`ErrorSenseLow`	Sensor current below permissible level	xSH	0	8
1	`ErrorSenseHigh`	Sensor current above permissible level	xSL	1	9
2	`TestMode`	“Test” mode enabled	xTM	2	10
3	`FlagError`	Measurement channel common failure flag	xFE	3	11
4	`OutPoint_1`	Setpoint 1 parameter value overrange	xS1	4	12
5	`OutPoint_2`	Setpoint 2 parameter value overrange	xS2	5	13
6	`OutPoint_3`	Setpoint 3 parameter value overrange	xS3	6	14
7	`OutPoint_4`	Setpoint 4 parameter value overrange	xS4	7	15

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

Table 9. Module status flags `StatusSys` and their position in logic outputs matrix `LogicMatrix`

Bit No.	Designation	Description	Code	Matrix position
0	`ErrorLoadData`	Operation parameters read error from non-volatile memory	ErrLD	16
1	`LoadDataReserv`	One or several operating parameters groups read from non-volatile memory reserve section	ResLD	17
2	`LogicOffStartUp`	Logic outputs operation block after module reset	LgOffSt	18
3	`LogicOffUser`	Logic outputs operation block by user command	LgOffU	19
4	`InterfRS485_Off`	RS485 No.1 interface is disabled	RS_Off	20
	`TimeOutTxRS485_1`	No CVMS requests via RS485 No.1 interface (version 2.02)		
5	`InterfCAN_Off`	CAN2.0B interface disabled	CAN_Off	21
	`TimeOutTxRS485_2`	No CVMS requests via RS485 No.2 interface (version 2.02)		
6	`AllowOneWrite`	Permission received for single recording	OneWr	22
7	`CalibrateMode`	Calibration mode is engaged for one of unified outputs	Calibr	23

Note: To change module operation parameters, it is necessary to block logic outputs operation or get permission for single recording by communication interfaces.

Digital control interfaces

MK11 module supports three independent control interfaces:

- two independent RS485 interfaces with partial implementation of Modbus RTU protocol (enough for control);
- CAN2.0B interface (only extended messages exchange);
- I2C slave interface to setup 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**.

RS485 interface

Implemented in MK11 module are two independent RS485 interfaces. Provided on MK11 board are RS485 bus semiduplex driver microchips for each interface. Data exchange by RS485 interface is carried out according to Modbus RTU protocol with data rate choice from several standard speeds and bus module address.

Table 10. RS485 interface parameters

Parameter description	Value
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	4,800; 9,600; 19,200; 38,400; 57,600; 115,200; 230,400
Driver operating mode	semiduplex
Maximum nodes number on bus	128(1)
Driver input resistance, kOhm, min	12(1)
Electrostatic resistance, kV, min	±15(1)
Galvanic isolation	no(1)

1) Assuming MAX487ESA driver is used.

Module operation parameters setup by Modbus RTU protocol

Module is setup 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 11. 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

Modbus RTU protocol supported commands

Table 12. Implemented commands of Modbus RTU protocol in MK11 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 Table13

Table13. 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)

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 0xFF. Only 8 data bits are used to calculate check sum (start, stop and parity bits are not used when calculating check sum).

ModBus protocol MK11 module control features

Addressing of operation parameters registers and module status is not aligned by 16-bit words.

Maximum number of recorded/read bytes per one transaction is 64 bytes.

Additional deviations from ModBus RTU protocol in VibrobitRTU communication interface operating mode:

- 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 requested is odd number of bytes, the response will contain even number of bytes (one byte more than requested). When recording odd number of bytes, transmitted should always be even number of bytes (one more than necessary), actually recorded into module parameters will be specified number of bytes.

Note. Provided on MK11 module board is RS485 bus terminator for interface No. 1. If module is the last to be engaged on RS485 bus and bus has no standard terminator 120 Ohm, then RS485 interface normal operation requires installation of jumper on module board, engaging bus terminator.

Time-out of requests absence from interface wizard (software version 2.02)

The requests absence time-out from the ModbusRTU protocol wizard can be used to signal a communication interface failure.

The `TimeOutTx_s` register determines the maximum time for the module data transmission absence via the RS485 interface (no module access from the server side).

If during the `TimeOutTx` time there was not a single request for information transfer (including service messages for data reception) from the server (protocol wizard), then the `TimeOutTxRS485` flag is set. The flag is reset at any message first send via the RS485 interface.

Each RS485 interface has its own `TimeOutTx` registers and `TimeOutTxRS485` flags.

Flags `TimeOutTxRS485_1`, `TimeOutTxRS485_2` can participate in generating the logic signaling of the MK11 module.

CAN2.0B interface

CAN2.0B interface enables MK11 module status data transmission to indicating units and statistics gathering module. MK11 module doesn't receive any data by CAN2.0B interface, and also module can not be setup using CAN2.0B interface.

Table 14. CAN2.0B interface parameters

Parameter description	Value
Operating mode	data transmission in active mode with ability to generate bus overloading
Messages format	only extended
Exchange protocol	unified for operation as part of equipment VIBROBIT 300
MK11 module code for indicating units	0xC1 (193)
Data rate (one speed is set), kbit/s	1000; 500; 250; 200; 125; 100; 80; 40
Compliance with CAN bus standard	ISO-11898(1)
Maximum nodes number on bus	112(1)
Driver input resistance, kOhm, min	5(1)
Electrostatic resistance, kV, min	±6(1)
Galvanic isolation	no(1)
Note 1. Assuming MCP2551 driver is used.	

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.

Note: Provided on MK11 module board is CAN2.0B bus terminator. If module is the last to be engaged on CAN2.0B bus and bus has no standard terminator 120 Ohm, then CAN2.0B interface normal operation requires installation of jumper on module board, engaging bus terminator.

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

- CAN2.0B interface operation resolution (`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:

0X30(48) — 1st measurement channel message;

0X30(49) — 2nd measurement channel message.

Messages are sent in series: 1-st channel message, then – second. New message is not sent to bus 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.

Byte number in message						
0	1	2	3	4	5	6
Code	Measured parameter value (Float 4 bytes)				Measurement channel status register	Module status register
0x30, 0x31	ParamData				StatusCh	StatusSys

Figure 7. message format on MK11 module CAN bus

I2C slave interface

I2C slave interface is intended to control module operation and setup its operation parameters. I2C interface connector is arranged on module front panel (diagnostics connector). I2C slave interface parameters are rigidly predetermined, therefore regardless of module current status, the I2C interface is always available for module control.

Module can be setup by setup instrument ПН31 or personal computer. To setup using personal computer, started should be the software ModuleConfigurator, and module should be connected to personal computer via diagnostic interface board MC01 USB (PC USB interface).

Note: When module setup using MC01 USB, installed on personal computer should be drivers of virtual COM port (ref. Appendix D).

Table 15. I2C slave interface parameters

Parameter description	Value
MK11 address on I2C interface	0x28
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	none

Note: Module provides “hot” connection/disconnection of setup instrument and MC01 USB diagnostic interface module.

Module settings and current status (address tables)

Measurement channels parameters and module system settings

Table 16. List of measurement channels calibration parameters

Description	Designation	Type (bytes)	Address (Hex)		Note
			Channel 1	Channel 2	
Sensor current range lower level	RangeCurrMin	Float (4)	0x0600	0x0700	
Sensor current range upper level	RangeCurrMax	Float (4)	0x0604	0x0704	
Calibrated sensor current lower level	CurrMinCalibr	Float (4)	0x0608	0x0708	
Sensor current lower permissible level	CurrValidMin	Float (4)	0x060C	0x070C	
Sensor current upper permissible level	CurrValidMax	Float (4)	0x0610	0x0710	
Sensor test hysteresis	CurrValidHist	Float (4)	0x0614	0x0714	
Unified output parameter range lower level	RangeParamOutMin	Float (4)	0x082B	0x092B	
Unified output parameter range upper level	RangeParamOutMax	Float (4)	0x082F	0x092F	
Unified output current range lower level	CurrOutMin	Float (4)	0x0618	0x0718	
Unified output current range upper level	CurrOutMax	Float (4)	0x061C	0x071C	
Calibrated unified output lower level	CurrOutMinCalibr	Float (4)	0x0620	0x0720	
Current level established on test signal when enabling “Test” mode	CurrTestON	Float (4)	0x0624	0x0724	1
Test signal current adjustment lower permissible level	CurrTestMin	Float (4)	0x0628	0x0728	1
Test signal current adjustment upper permissible level	CurrTestMax	Float (4)	0x062C	0x072C	1
Current sensor lower calibration level ADC value	AdcInMin	Uint (2)	0x0630	0x0730	
Current sensor upper calibration level ADC value	AdcInMax	Uint (2)	0x0632	0x0732	
Unified output lower calibration level DAC value	DacOutMin	Uint (2)	0x0634	0x0734	
Unified output upper calibration level DAC value	DacOutMax	Uint (2)	0x0636	0x0736	
Internal test signal lower calibration level DAC value	DacTestMin	Uint (2)	0x0638	0x0738	1
Internal test signal upper calibration level DAC value	DacTestMax	Uint (2)	0x063A	0x073A	1
“Test” mode operation permission	TestEnabled	Uchar (1)	0x063C	0x073C	1, 2
Sensor current lower limit monitoring: 0 – disabled 1 - enabled	CurrControlMin	Uchar (1)	0x063D	0x073D	
Sensor current upper limit monitoring: 0 – disabled 1 - enabled	CurrControlMax	Uchar (1)	0x063E	0x073E	
Measurement channel operation block when fault detection: 0 - measurement channel is blocked, measurement result is assumed to be zero 1 - measurement channel is not blocked, measurement result is compared with setpoints	NotLockChannel	Uchar (1)	0x063F	0x073F	

Notes

1 Test signal generator is not implemented in versions MK11-DC-11-R2-AO2, MK11-AC-11-S-R2-AO2.

2 For TestEnabled parameter values description ref. in Table 7.

Table 17. List of measurement channels main parameters

Description	Designation	Type (bytes)	Address (Hex)		Note
			Channel 1	Channel 2	
Measured parameter range, lower value	RangeParamMin	Float (4)	0x0800	0x0900	
Measured parameter range, upper value	RangeParamMax	Float (4)	0x0804	0x0904	
Measurement units text line	MeasurUnit	Char (8)	0x0808	0x0908	
Measurement results output format to indicator	FormatOut	UChar (1)	0x0810	0x0910	1
Measured parameter integration depth	AverageData	UChar (1)	0x0811	0x0911	2
Setpoint transition response time	TestPointTime	UChar (1)	0x0812	0x0912	3
Reserve, should be equal to zero		UChar (1)		0x0913	
Number of linearization table records from 1 ro 12 0 – linearization function disabled	LinerItems	UChar (1)	0x0813		5
Setpoint 1 operating mode	TestPointMode_1	UChar (1)	0x0814	0x0914	4
Setpoint 2 operating mode	TestPointMode_2	UChar (1)	0x0815	0x0915	4
Setpoint 3 operating mode	TestPointMode_3	UChar (1)	0x0816	0x0916	4
Setpoint 4 operating mode	TestPointMode_4	UChar (1)	0x0817	0x0917	4
Setpoint 1 value	TestPointData_1	Float (4)	0x0818	0x0918	
Setpoint 2 value	TestPointData_2	Float (4)	0x081C	0x091C	
Setpoint 3 value	TestPointData_3	Float (4)	0x0820	0x0920	
Setpoint 4 value	TestPointData_4	Float (4)	0x0824	0x0924	
Setpoints hysteresis	TestPointHist	Float (4)	0x0828	0x0928	
Parameter range on unified output, lower value	RangeParamOutMin	Float (4)	0x082C	0x092C	
Parameter range on unified output, upper value	RangeParamOutMax	Float (4)	0x0830	0x0930	

Notes

1 For FormatOut parameter values description ref. in Table 5.

2 - Value from 0 to 9. If AverageData equals to zero, averaging is absent, at AverageData equals to 9, integration depth is 10 (maximum).

3 Time by 0.05 s (0 = 0.05 s).

4 Parameter description ref. in Table 6.

5. Implemented in module software version 2.02,

Table 18. List of module system settings

Description	Designation	Type (bytes)	Address (Hex)	Note
Channel 2 operating permission 0 – channel 2 disabled 1 – channel 2 enabled	ActivChannel	UChar (1)	0x0A00	1,5
Indication output switching time-out from channel 2 (auxiliary) to channel 1 (main) by 1 second	TimeOut_ChannelTwo	UChar (1)	0x0A01	2
“Test” mode time-out by 1 second	TimeOut_TestMode	UChar (1)	0x0A02	2
Logic outputs block time after module reset	LogicOffStartUp	UChar (1)	0x0A03	3
Setpoints test time-out after sensor operation normalizing	TestPointSenseOk	UChar (1)	0x0A04	3
DAC type for unified current outputs 0 - not implemented 1 - DAC7614, outputs without galvanic insulation 2 - DAC7611, outputs with galvanic insulation	DacExternalType	UChar (1)	0x0A05	6
Logic signaling matrix: bits 0:3 – input number to which signaling is assigned bits 4:5 – reserved, should be zero bit 6 - LED ‘War’ engagement bit 7 - LED ‘Alarm’ engagement	LogicMatrix	UChar (24)	0x0A06	4
Logic outputs inversion bits 0...5 - inversion engagement on logic outputs from 1 to 6 correspondingly bit 7 - inversion engagement on 8th logic output	LogicInvert	UChar (1)	0x0A1E	5
Reserve, should be equal to zero		UChar (1)	0x0A1F	

Notes

1 Takes effect only after module reset.

2 If value is zero, function is disabled.

3 Time by 0.05 s (0 = 0.05 s).

4 For logic signaling bytes assignment refer to tables 8, 9.

5 Default value: 0. Sensor serviceability does not affect the parameter measurement and logic signaling operation.

6 Implemented in MK11 module SW with version above 2.01.

Communication interfaces

Table 19. List of RS485 No.1 interface parameters

Description	Designation	Type (bytes)	Address (Hex)		Note
			No.1	No.2	
Interface operating mode: 0 – Disabled 1 – Vibrobit RTU 2 – Modbus RTU	RSEnabled	UChar (1)	0x0B00	0x0D00	1
Module operation parameters change by commands and RS485 interface 0 – Prohibited 1 – Permitted	RSChangeEnabled	UChar (1)	0x0B01	0x0D01	
Single recording operations: 0 – Prohibited 1 – Permitted	RSOneWriteCommand	UChar (1)	0x0B02	0x0D02	
Device address on RS485 bus (from 1 to 247)	RSAddress	UChar (1)	0x0B03	0x0D03	
Data rate, bit/s: 0 – 4800; 1 – 9600; 2 – 19,200; 3 – 38,400; 4 – 57,600; 5 – 115,200; 6 – 230,400	RSSpeed	UChar (1)	0x0B04	0x0D04	
Broadcast address support: 0 – Prohibited 1 – Permitted	AllowCommonAddress	UChar (1)	0x0B05	0x0D05	
Detection time of CVMS requests absence, sec	TimeOutTx_s	UChar (1)	0x0B06	0x0D06	3

Notes

1 Register value for interface No.2 can be set to 2: interface No.1 setting acceptance.

2 RS485 interface operation parameters take effect only after interface repeated initialization.

3. Implemented in MK11 module with software version above 2.02.

Table 20. CAN2.0B interface parameters list

Description	Designation	Type (bytes)	Address (Hex)	Note
Permit interface operation: 0 – interface disabled 1 – interface enabled	CANEnabled	UChar (1)	0x0C00	
Data rate, kbit/s: 0 – 1000; 1 – 500; 2 – 250; 3 – 200; 4 – 125; 5 – 100; 6 – 80; 7 - 40	CANSpeed	UChar (1)	0x0C01	
Reserve, should be equal to zero		UChar (1)	0x0C02	
Message sending period by 0.25 s	CANBasicTime	UChar (1)	0x0C03	
Module address on bus	CANBasicAddress	Uint (2)	0x0C04	
Send data by channel 1 (0 – do not send)	CANBasicDataOut_1	UChar (1)	0x0C06	
Send data by channel 2 (0 – do not send)	CANBasicDataOut_2	UChar (1)	0x0C07	

Note. CAN2.0B interface operation parameters take effect only after interface repeated initialization.

Identification information

Table 21. List of module identification information registers

Description	Designation	Type (bytes)	Address (Hex)	Note
Module factory number	Number	Uint (2)	0x1400	
Module manufacturing year	Year	Uint (2)	0x1402	
Order number	Order	Uint (2)	0x1404	
Assembler's code	Assembler	UChar (1)	0x1406	
Adjuster's code	Adjuster	UChar (1)	0x1407	
Additional text information	TextString	Char (32)	0x1408	
Note. Identification information is available read-only.				

Table 22. List of module software identification information registers

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

Information on jumpers arrangement on module board

Table 23. List of information registers on jumpers arrangement on MK11 board

Description	Designation	Type (bytes)	Address (Hex)	Note
Information on jumpers arrangement (text line)	Jumpers	Char (60)	0x1600	

Measurement results

Table 24. List of measurement results registers

Description	Designation	Type (bytes)	Address (Hex)	Note
Measurement results by channel 1	ParamData_1	Float (4)	0x0000	
Channel 1 sensor current	Current_1	Float (4)	0x0004	
Channel 1 status flags	StatusCh_1	UChar (1)	0x0008	1
Reserve, equals to zero		UChar (1)	0x0009	
Channel 1 ADC value (used during calibration)	AdcData_1	Uint (2)	0x000A	
Measurement results by channel 2	ParamData_2	Float (4)	0x000C	
Channel 2 sensor current	Current_2	Float (4)	0x0010	
Channel 2 status flags	StatusCh_2	UChar (1)	0x0014	1
Reserve, equals to zero		UChar (1)	0x0015	
Channel 2 ADC value (used during calibration)	AdcData_2	Uint (2)	0x0016	
Module status flags	StatusSys	UChar (1)	0x0018	2
Module status additional flags bit 0 - Second channel disabled bit 1 - RS485 interface No.2 disabled bit 2-7 - Service	StatusSysAdd	UChar (1)	0x0019	
Logic outputs status bits 0-7 - logic outputs status bits 13-8 – reserved, equal to zero bit 14 - LED ‘War’ status bit 15 - LED ‘Alarm’ status	LogicOutStatus	Uint (2)	0x001A	3
Operation parameters reading errors flag	ErrorLoad	UChar (1)	0x001C	
Operation parameters read flags from non-volatile memory reserve section	ReservLoad	UChar (1)	0x001D	
Accepted DAC type for unified current outputs 0 - not implemented 1 - DAC7614, outputs without galvanic insulation 2 - DAC7611, outputs with galvanic insulation	DacExternalType	UChar (1)	0x001E	
Reserve, equals to zero		UChar (1)	0x001F	
Communication interfaces status flags (service)	Falgs			5

Notes

1 Flags purpose ref. in Table 8.

2 Flags purpose ref. in Table 9.

3 When blocking logic outputs by LogicOutStatus parameter, it is possible to determine logic outputs status after blocking removal.

4 Measurement results registers are available read-only.

5 Implemented in MK11 module with software version above 2.02.

Table 25. Test signal and unified outputs control registers

Description	Designation	Type (bytes)	Address (Hex)	Note
Test signal current level for channel 1	CurrTest_1	Float (4)	0x0500	1, 2
Test signal current level for channel 2	CurrTest_2	Float (4)	0x0504	1, 2
DAC value for channel 1 unified output direct control	DacDirectData_1	Uint (2)	0x0508	3
DAC value for channel 2 unified output direct control	DacDirectData_2	Uint (2)	0x050A	3
DAC value for channel 1 test signal direct control	DacDirectData_1T	Uint (2)	0x050C	3
DAC value for channel 2 test signal direct control	DacDirectData_2T	Uint (2)	0x050E	3

Notes

1 Assumes CurrTestON value when “Test” mode engagement.

2 Maintained in CurrTestMin, CurrTestMax range even when recording by digital communication interfaces.

3 Used during calibration. DAC range from 0 to 4095. Do not participate in channels normal operation.

4 All group registers are available for recording in module any operating mode.

5 Test signal generator is not implemented in versions MK11-DC-11-R2-AO2, MK11-AC-11-S-R2-AO2.

Table 26. Measurement channel 1 linearization

Description	Designation	Type (bytes)	Address (Hex)	Note
Record 1, current value	Current_1	Float (4)	0x0F00	
Record 1, parameter value	Data_1	Float (4)	0x0F04	
Record 2, current value	Current_2	Float (4)	0x0F08	
Record 2, parameter value	Data_2	Float (4)	0x0F0C	
Record 12, current value	Current_12	Float (4)	0x0F58	
Record 12, parameter value	Data_12	Float (4)	0x0F5C	

Notes:

1. Linearization algorithm operation requires at least 2 records. If table has less than 2 records, then parameter value is assumed to be zero. Maximum number of records is 12.
2. Implemented in MK11 module with software version above 2.02.

Control commands

Several reserved registers are provided for control commands execution in MK11 module. Control commands are executed only during individual recording into each register (it is impossible to execute several control commands per one transaction).

Table 27. List of control registers

Register address (Hex)	Recorded value (Hex)	Action	Note
0xFF00	0x55	Module reset (similar to module power-up)	
0xFF01	0x61	Recalculate channel 1 factors	1, 4
	0x62	Recalculate channel 2 factors	1, 4
	0x93	Execute RS485 interface repeated initialization	2, 4
	0x98	Execute CAN2.0B interface repeated initialization	3, 4
0xFF02	0x33	Logic signaling block	
	0xCC	Logic signaling normal operation	
0xFF03	0x3C	Request for single recording	
0xFF04	0x10	Enable “Test” mode on both channels	4
	0x11	Enable “Test” mode on channel 1	4, 5
	0x12	Enable “Test” mode on channel 1	4, 5
0xFF05	0x40	Enable calibration mode of all unified outputs and test signals	4
	0x41	Enable unified output 1 calibration mode	4
	0x42	Enable channel 1 test signal calibration mode	4, 8
	0x43	Enable unified output 2 calibration mode	4
	0x44	Enable channel 2 test signal calibration mode	4, 8
0xFF06	Operation parameters recording into module non-volatile memory		4, 6
	0x81	Calibration data by channel 1	
	0x82	Calibration data by channel 2	
	0x83	Main parameters by channel 1	
	0x84	Main parameters by channel 2	
	0x85	Module system parameters	
	0x86	RS485 No.1 interface parameters	
	0x87	CAN2.0B interface parameters	
	0x88	RS485 No.2 interface parameters	
	0x89	Measurement channel 1 linearization table	9
0xFF07	0x21	Recording all module settings into non-volatile memory	7

Notes

1 Can be used after module calibration to check measurements without module reboot.

2 If command was received during response transfer, response is transferred in full, then repeated initialization is carried out.

3 If command was received during message transfer, the message is transferred in full, then repeated initialization is carried out.

4 Signaling logic outputs should be blocked.

5 Mode should be permitted in module settings

6 Module is not rebooted after recording.

7 Module operation is stopped during recording. Module automatically resets after recording.

8 Test signal generator is not implemented in versions MK11-DC-11-R2-AO2, MK11-AC-11-S-R2-AO2

9. Implemented in MK11 module with software version above 2.02.

Parameters values after module “cold start”

Module parameters are set to initial state after module “cold start”:

- calibration information removed;
- logic signaling is not assigned;
- RS485, CAN2.0B interfaces disabled;
- some parameters are initialized by default;

Table 28. Measurement channels calibration parameters values after “cold start”

Parameter	Designation	Value	Note
Sensor current range lower level	RangeCurrMin	1.0	
Sensor current range upper level	RangeCurrMax	5.0	
Calibrated sensor current lower level	CurrMinCalibr	1.0	
Sensor current lower permissible level	CurrValidMin	0.8	
Sensor current upper permissible level	CurrValidMax	5.2	
Sensor test hysteresis	CurrValidHist	0.1	
Unified output current range lower level	CurrOutMin	4.0	
Unified output current range upper level	CurrOutMax	20.0	
Calibrated unified output lower level	CurrOutMinCalibr	4.0	
Current level established on test signal when enabling “Test” mode	CurrTestON	1.0	
Test signal current adjustment lower permissible level	CurrTestMin	0.6	
Test signal current adjustment upper permissible level	CurrTestMax	5.4	
Current sensor lower calibration level ADC value	AdcInMin	0	1
Current sensor upper calibration level ADC value	AdcInMax	0	
Unified output lower calibration level DAC value	DacOutMin	0	2
Unified output upper calibration level DAC value	DacOutMax	0	
Internal test signal lower calibration level DAC value	DacTestMin	0	3
Internal test signal upper calibration level DAC value	DacTestMax	0	
“Test” mode operation permission	TestEnabled	2	
Sensor current lower limit monitoring	CurrControlMin	0	
Sensor current upper limit monitoring	CurrControlMax	0	
Measurement channel operation block when fault detection	NotLockChannel	0	

Notes

1 Sensor current and measured parameter values are not calculated.

2 Unified output is disabled, output always has current 0 (or minimum possible).

3 Test signal is disabled, test signal always has level 0 (or minimum possible).

Table 29. Measurement channels main parameters values after “cold start”

Parameter	Designation	Value	Note
Measured parameter range, lower value	RangeParamMin	0	
Measured parameter range, upper value	RangeParamMax	0	
Measurement units text line	MeasurUnit	Empty	
Measurement results output format to indicator	FormatOut	3	####
Measured parameter integration depth	AverageData	5	
Setpoint transition response time	TestPointTime	5	1.5 s
Setpoint 1 operating mode	TestPointMode_1	0	
Setpoint 2 operating mode	TestPointMode_2	0	
Setpoint 3 operating mode	TestPointMode_3	0	
Setpoint 4 operating mode	TestPointMode_4	0	
Setpoint 1 value	TestPointData_1	0	
Setpoint 2 value	TestPointData_2	0	
Setpoint 3 value	TestPointData_3	0	
Setpoint 4 value	TestPointData_4	0	
Setpoints hysteresis	TestPointHist	0	
Parameter range on unified output, lower value	RangeParamOutMin	0	
Parameter range on unified output, upper value	RangeParamOutMax	0	
Number of linearization table records (version 2.02)	LinerItems	0	Off

Table 30. Module system parameters values after “cold start”

Parameter	Designation	Value	Note
Channel 2 operating permission	ActivChannel	1	Both
Indication output switching time-out from channel 2 (auxiliary) to channel 1 (main)	TimeOut_ChannelTwo	5	
“Test” mode time-out	TimeOut_TestMode	0	Off
Logic outputs block time after module reset	LogicOffStartUp	31	8c
Setpoints test time-out after sensor operation normalizing	TestPointSenseOk	31	8c
Logic signaling matrix	LogicMatrix	0	1
DAC type for unified current outputs	DacExternalType	0	Off
Logic outputs inversion	LogicInvert	0	
Notes: 1. Logic signaling not determined, all logic outputs are inactive.			

Table 31. RS485 interfaces parameters values after “cold start”

Parameter	Designation	Value	Note
Permit interface operation	RSEnabled	0	Off
Module operation parameters change permission by commands and RS485 interface	RSChangeEnabled	0	
Permit single recording operation	RSOneWriteCommand	0	
Device address on RS485 bus (from 1 to 247)	RSAddress	1	
Data rate, bit/s:	RSSpeed	0	4800
Detection time of CVMS requests absence, sec (version 2.02)	TimeOutTx_s	0	Off

Table 32. CAN2.0 interface parameters values after “cold start”

Parameter	Designation	Value	Note
Permit interface operation	CANEnabled	0	Off
Data rate, kbit/s:	CANSpeed	0	1000
Module address on bus	CANBasicAddress	0	
Message sending period by 0.25 s	CANBasicTime	0	0.25 s
Send data by channel 1 (0 – do not send)	CANBasicDataOut_1	0	none
Send data by channel 2 (0 – do not send)	CANBasicDataOut_2	0	none

Software

Software ModuleConfigurator is a specialized program to setup MK11 control module with convenient interface and access to all module parameters. For program operation it is necessary to connect MK11 module to personal computer via diagnostic interface module MC01 USB or via RS485 interfaces.

Main program features:

- real-time observing of MK11 indicator and signaling current readings;
- set up 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 to MK11 module with software version 2.00 and above, select MK11-R2 setting in ModuleConfigurator software.

ModuleConfigurator software appearance with loaded MK11-R2 setting is given on Figure 8.

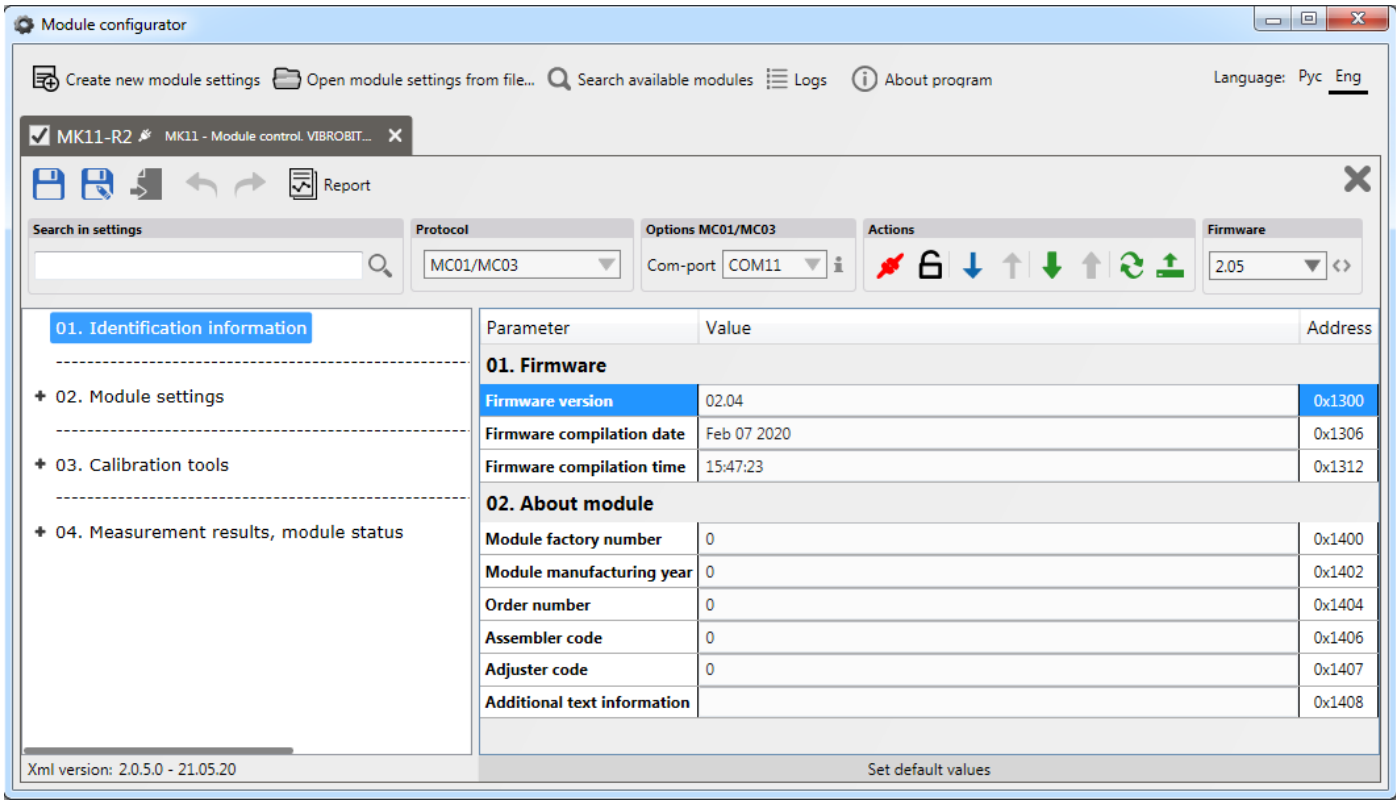


Figure 8. ModuleConfigurator software appearance

Maintenance

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

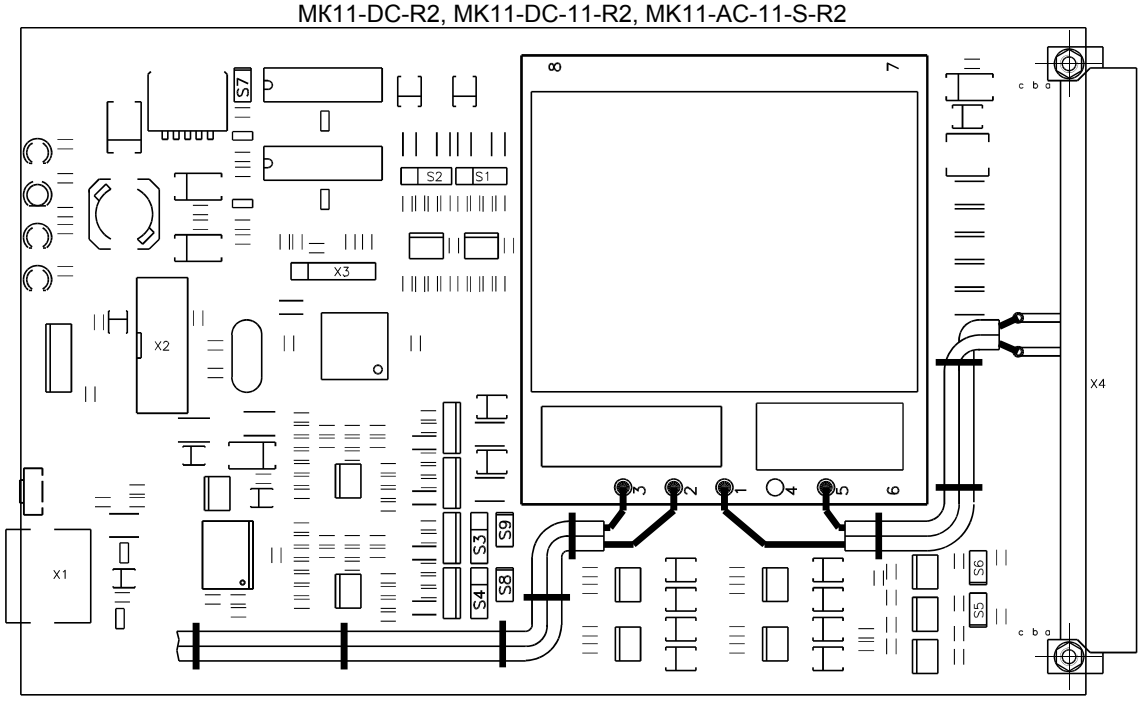
- equipment maintenance
- routine repair;
- equipment check.

Appendicies

A. Controls arrangement

Versions

MK11-DC-R2, MK11-DC-11-R2, MK11-AC-11-S-R2



Note: Module front panel is not shown

Jumpers S1, S2 – measurement channels 1, 2 operating mode selection (correspondingly)

Position	**Mode**
Removed	Voltage operating mode 0 - 4.096 V
1-2	Current operating mode 4 - 20 mA
2-3	Current operating mode 1 - 5 mA

Jumpers S3, S4 – measurement channels 1, 2 test signal operating mode selection (correspondingly)

Position	Mode
Removed	Disabled
1-2	Current operating mode 0 - 20 mA
2-3	Voltage operating mode 0 - 4.096 V

Jumpers S5, S6 – terminator 120 Ohm of bus RS485 No.1, CAN2.0B (correspondingly)

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

Jumper S7 – pull-up resistor 7.23 kOhm to input +24V of second measurement channel
(can be used to measure power supply voltage at module version ‘AC + МИ11’)

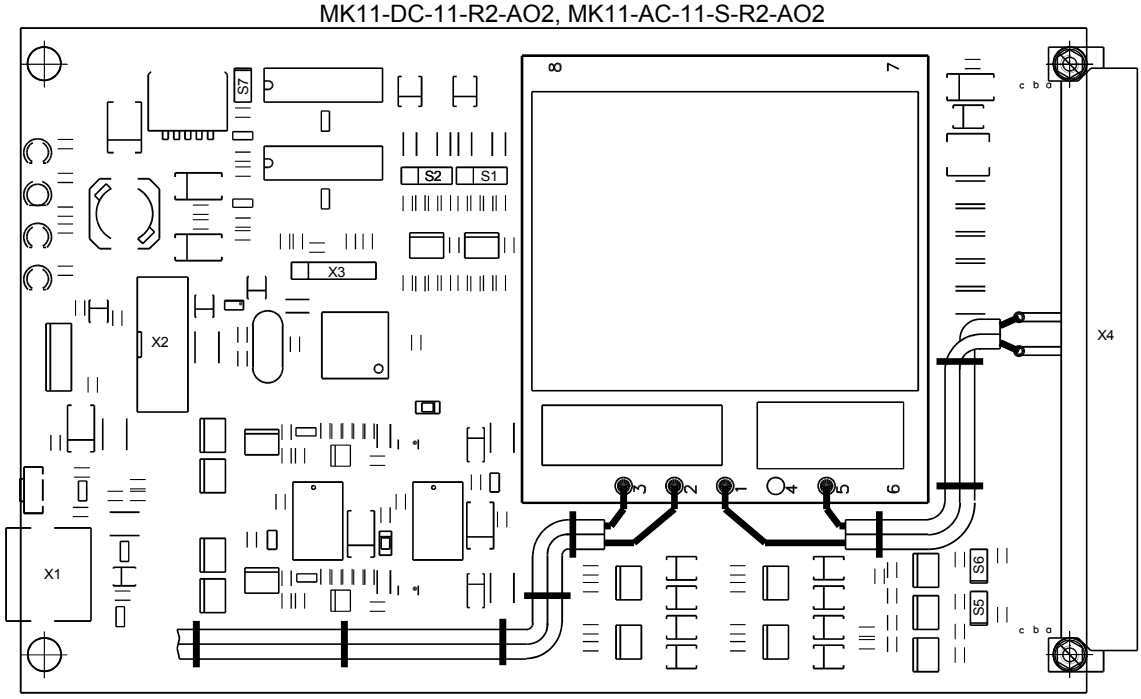
Position	Mode
Removed	Not connected
Installed	Connected

Jumpers S9, S8 – channels 1, 2 test signal connection to X4 connector terminals

Position	Mode
Removed	Not connected
Installed	Connected

Versions

MK11-DC-11-R2-AO2, MK11-AC-11-S-R2-AO2



Note: Module front panel is not shown

Jumpers S1, S2 – measurement channels 1, 2 operating mode selection (correspondingly)

Position	Mode
Removed	Voltage operating mode 0 - 4.096 V
1-2	Current operating mode 4 - 20 mA
2-3	Current operating mode 1 - 5 mA

Jumpers S5, S6 – terminator 120 Ohm of bus RS485 No.1, CAN2.0B (correspondingly)

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

Jumper S7 – pull-up resistor 7.23 kOhm to input +24V of second measurement channel
(can be used to measure power supply voltage at module version ‘AC + МИ11’)

Position	Mode
Removed	Not connected
Installed	Connected

B. Connector X4 terminals purpose

Terminal number	Designation	Purpose	Note
A2, B1, C2 A32, B31, C32	GND	Common	
A6, B5, C6	Power +24V	Power supply voltage input/output +24V	1
B7	+24V sense CH1	Voltage output +24V to power measurement channel 1 converter	
B9	+24V sense CH2	Voltage output +24V to power measurement channel 2 converter	
C8	Input CH1	Measurement channel 1 input	
C10	Input CH2	Measurement channel 2 input	2
A12, B11, C12, C18	FG	AC/DC pulse power supply source Faraday ground ***It is necessary to connect to grounding bus***	3
C14	~L220V	Mains voltage AC 220 V 50 Hz	3
C16	~N220V		
A16	Analog out 2	Measurement channel 2 unified output	
B15	Analog out 1	Measurement channel 1 unified output	
A18	Test 2	Channel 2 test signal	4, 9
B17	Test 1	Channel 1 test signal	4, 9
A20	LG_OUT_1	Logic output 1	5
A22	LG_OUT_2	Logic output 2	5
A24	LG_OUT_3	Logic output 3	5
A26	LG_OUT_4	Logic output 4	5
B19	LG_OUT_5	Logic output 5	5
B21	LG_OUT_6	Logic output 6	5
B23	LG_OUT_7	Logic output 7	5, 6
B25	LG_OUT_8	Logic output 8	7
A28	CAN-GND	CAN2.0B interface	
B27	CAN-H		
C28	CAN-L		
A30	RS485-GND	RS485 interface No.1	
B29	RS485-B		
C30	RS485-A		
C29	RS485-B	RS485 interface No.2	
B30	RS485-A		

Notes

1 In module version MK11-AC-11-S-R2(-AO) is a voltage output +24V. Can be used to connect external load (indication units) and signaling and protection logic relay windings.

2 If channel 2 is not used, then the output can be left unconnected, channel 2 operation should be disabled in the module settings.

3 Only for version MK11-AC-11-S-R2(-AO), in other versions outputs are not connected.

4 Used to calibrate test signal diagram in output mode. Connected to measurement channel input in “Test” mode. When this output is in input mode, test signal operating mode selection jumper should be removed.

5 Operation logic is determined during module configuration.

6 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.

7 Signal is inverted relative to logic output 7. Output can be used as module serviceability active signaling.

8 Terminals A4, A8, A10, A14, B3, B13, C4, C20, C22, C24, C26 are not used.

9 Outputs are external test signal inputs for versions MK11-DC-11-R2-AO, MK11-AC-11-S-R2-AO.

C. Example of module setting for rotor axial offset measurement

Generally, rotor axial offset is measured by three independent measurement channels, generating safety shutdown signaling by logic two out of three. To implement this requirement, the continuous vibration monitoring system design should provide the individual secondary converters (control modules) with individual power supplies of the module itself and sensor with primary element.

Application of 2-channel constant signals measurement module in version МК11-AC-11-S-R2(-AO) enables to efficiently implement the protection circuit by rotor axial offset with minimum space occupied in the section. In version МК11-AC-11-S-R2(-AO), the module contains a digital indicator displaying measurement results, and AC/DC power supply source with a wide range of input voltages. Considering that МК11 module is equipped with the check function for measurement channels, signaling actuation and safety shutdown, it is possible to implement a complete measurement and protection circuit by rotor axial offset using only three МК11 modules.

Consider an example of МК11 module setting for rotor axial offset measurement Primary sensor ДВТ20 with converter ИП34А (measuring range 2 - 0 - 2 mm, sensor current range 1 - 5 mA).

МК11 module first measurement channel is setup to measure the rotor axial offset. Measurement channel 1 recommended settings are given in the table.

Measurement channel 1 calibration parameters (rotor axial offset measurement)

Parameter	Value	Note
Sensor current range lower level	1,0	1
Sensor current range upper level	5,0	1
Calibrated sensor current lower level	1,0	1
Sensor current lower permissible level	0,7	1
Sensor current upper permissible level	5,3	1
Sensor test hysteresis	0,1	1
Unified output current range lower level	4,0	1
Unified output current range upper level	20,0	1
Calibrated unified output lower level	4,0	1
Current level established on test signal when enabling “Test” mode	3,0	
Test signal current adjustment lower permissible level	0,6	1
Test signal current adjustment upper permissible level	5,4	1
Sensor current lower/upper calibration level ADC value		2
Unified output lower/upper calibration level DAC value		2
Internal test signal lower/upper calibration level DAC value		2
“Test” mode operation permission	2,0	1
Sensor current lower limit monitoring	Yes	
Sensor current upper limit monitoring	Yes	
Measurement channel operation block when fault detection	No	3

Notes

1 Value corresponds to module “Cold start”

2 Determined during module calibration.

3 Measurement channel operation is not blocked when sensor overrange (RAO protection logic chart requirements).

Measurement channel 1 main parameters (rotor axial offset measurement)

Parameter	Value	Note
Measured parameter range, lower value	-2	
Measured parameter range, upper value	2	
Measurement units text line	mm	
Measurement results output format to indicator	1	##.##
Measured parameter integration depth	1	
Setpoint transition response time	3	1.0 s
Setpoint 1 operating mode	2	Lower
Setpoint 2 operating mode	1	Upper
Setpoint 3 operating mode	2	Lower
Setpoint 4 operating mode	1	Upper
Setpoint 1 value	-1,5	War.
Setpoint 2 value	1	War.
Setpoint 3 value	-1,7	Alarm
Setpoint 4 value	1,2	Alarm
Setpoints hysteresis	0,05	
Parameter range on unified output, lower value	-2	
Parameter range on unified output, uper value	2	
Note: Setpoints values should be set according to setpoints log.		

For 1st measurement channel, it is necessary to set jumper S1 to position 2-3 (current operating mode (-5 mA), jumper S3 to position 1-2 (test signal current operating mode 0-20 mA) and jumper S9 should not be set (external test signal is not used).

Second measuring channel is used to monitor +24 V voltage (power supply of module and sensor primary element) generated by AC/DC converter (AC/DC converter is installed on MK11 board). To monitor +24 V supply voltage, set jumper S2 to position 2-3 (current operating mode 1-5 mA), set jumper S7 (offset connection to measuring channel 2 input), remove jumpers S4 and S8 (test signal disabled).

With supply voltage of +24 V, the second measurement channel input current is approximately 3 mA. Input current deviation from 3 mA can be used to determine power supply voltage quality.

Measurement channel 2 calibration parameters (power supply voltage +24V monitoring)

Parameter	Value	Note
Sensor current range lower level	8,09	1
Sensor current range upper level	40,44	1
Calibrated sensor current lower level	8,09	1
Sensor current lower permissible level	20	2
Sensor current upper permissible level	24	2
Sensor test hysteresis	0,2	2
Unified output current range lower level	0	3
Unified output current range upper level	0	3
Calibrated unified output lower level	0	3
Current level established on test signal when enabling “Test” mode	0	3
Test signal current adjustment lower permissible level	0	3
Test signal current adjustment upper permissible level	0	3
Sensor current lower/upper calibration level ADC value		4
Unified output lower/upper calibration level DAC value	0	3
Internal test signal lower/upper calibration level DAC value	0	3
“Test” mode operation permission	0	Off

Notes:
1. Special range to set the channel operation settings to power supply voltage measurement mode.
2. Permissible power supply voltage range when its step change. Sensor test algorithm does not contain averaging and response delay.
3. Functions are not used and should be disabled.
4. Determined during calibration. Lower value is determined during current calibration of 1 mA, upper value at a current of 5 mA.

Measurement channel 2 main parameters (power supply voltage +24V monitoring)

Parameter	Value	Note
Measured parameter lower range	8,09	1
Measured parameter upper range	40,44	1
Measurement units text line	V	
Measurement results output format to indicator	1	##.##
Measured parameter integration depth	3	
Setpoint transition response time	3	1.0 s
Setpoint 1 operating mode	0	Off
Setpoint 2 operating mode	2	Lower
Setpoint 3 operating mode	1	Upper
Setpoint 4 operating mode	0	Off
Setpoint 1 value	0	
Setpoint 2 value	22	2
Setpoint 3 value	26	2
Setpoint 4 value	0	
Setpoints hysteresis	0,2	2

Notes

1. Special range to set the channel operation settings to power supply voltage measurement mode.
2. Permissible power supply voltage range when its smooth change. Setpoints algorithm does not contain averaging and response delay.

Second measurement channel is auxiliary one, therefore module should automatically switch to displaying the rotor axial offset measurement results (channel 1). Recommended module system settings are shown in the table.

Parameter	Value	Note
Channel 2 operating permission	1	Both
Indication output switching time-out from channel 2 (auxiliary) to channel 1 (main)	5	
“Test” mode time-out	0	Off
Logic outputs block time after module reset	31	8 s
Setpoints test time-out after sensor operation normalizing	31	8 s

Note: All table values correspond to module “Cold start”

Logic signaling can be setup in the following way:

- assign rotor axial offset warning setpoints (channel 1 setpoints 2, 3) to first logic output;
- assign rotor axial offset alarm setpoints (channel 1 setpoints 1, 4) to second logic output;
- all types of malfunctions to seventh logic output (module abnormal state signal):
  - abnormal sensor current by rotor axial offset measurement channel (channel 1);
  - abnormal power supply voltage by sensor test algorithm (channel 2);
  - abnormal power supply voltage by setpoints test algorithm (channel 2);
- Eighth logic output is always inverted relative to 7 logic output and signals the serviceability of module and measurement channels.

Signaling is not assigned to unused logic outputs, they are always inactive.

For version МК11-AC-11-S-R2(-AO) it is not required to assign operation logics of ‘War’ and ‘Alarm’ LEDs.

Output number	Purpose	Logic formula
1	Rotor axial offset exceeds one of warning setpoints	1S1 + 2S1
2	Rotor axial offset exceeds one of alarm setpoints	3S1 + 4S1
7	Module failure	ErrLD + 1FE + 2FE + 2S2 + 2S3

Note: ErrLD signal is always assigned to 7 logic output

RS485 and CAN2.0B communication interfaces settings are determined by the project requirements and CVMS upper level. RS485, CAN2.0B interfaces are disabled after module “Cold start”.