ВИБРО БИТ

SCIENTIFIC PRODUCTION
ENTERPRISE VIBROBIT LCC

EQUIPMENT "VIBROBIT 300"

MK32 Control Module

Setup Instruction

(with module software version from 1.70)

ВШПА.421412.3032 И2

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The MK32 Module Setup Instruction is intended to familiarize users (customers) with main operating principles and setup methods of MK32 variable signals control module of Equipment "Vibrobit 300" with software (SW) version from 1.70.

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

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

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1 General

MK32 universal 4-channel control module (hereinafter the MK32 module) is intended to measure alternating current signals using spectral analysis in real-time mode and also to measure constant and tachometric signals. Exercises the equipment safety shutdown functions.

MK32 is based upon high-performance 32-bit DSP processor, implementing large set of calculated parameters, providing access to measurement results and primary data via high-speed interfaces RS485 and CAN2.0B, organizing convenient user interface, flexibly configurable system of external warning and alarm signaling.

MK32 universal 4-channel control module enables the following measurement types:

- bearing support vibration speed RMS (root mean square);
- vibration speed RMS vector, calculated by rotational components;
- rotor relative vibration displacement excursion;
- rotor relative vibration displacement excursion vector, calculated by rotational components;
- absolute vibration displacement excursion of supports;
- absolute vibration displacement excursion vector of supports, calculated by rotational components;
- rotor absolute vibration displacement, calculated by rotational components;
- rotor absolute vibration displacement resultant vector, calculated by rotational components;
- rotor eccentricity;
- rotor speed;
- mechanical vaues represented by direct current (DC) signals.

Measurement channel main function set includes:

- sensor DC measurement and sensor and communication line serviceability monitoring;
- parameter value calculation (with period of 0.5 s);
- rotational components calculation with resolution ¼ of rotational component (if synchronization pulses are available);
- comparison with setpoints, logic signaling generation;
- measured parameter step monitoring;
- feeding the calculated parameter value to unified current output;
- availability of measurement results and measurement channel status by digital communication interfaces.

MK32 module supports four independent virtual measurement channels. Virtual measurement channel values are calculated basing on rotational components of physical measurement channels;

Available for virtual measurement channel are the following functions: integration, addition, subtraction, scaling.

Provided for every physical measurement channel are four configurable frequency zones. Any one of the frequency zones can be set up for operation with both fixed and floating frequency limits.

MK32 module other features include:

- measurement channels input signals: (0(1) – 5) mA; (0(4) – 20) mA; (0 – 3) V;
- 14 configurable logic outputs to implement signaling and protection circuitry;
- 4 independent unified current outputs;
- supported communication interfaces: two independent RS485, CAN2.0B, diagnostic interface;
- PC (personal computer) service software. Used to visualize current state, module setup and calibration;
- converters (sensors) are powered via resettable fuses 200 mA installed on MK32 module board with +24V DC.
- module single-supply operation by +24V DC, low power consumption.

All MK32 module setup is carried out using personal computer of target setup instrument ПН31. To setup the module using personal computer, started on computer should be a program ModuleConfigurator.exe, MK32 module should be connected to computer via diagnostic interface module MC01 USB (PC USB interface).

Structurally the MK32 module is made as a 3U module for frameworks of “Евромеханика” 19” type.

Table 1 - MK32 control module versions

Version code	Designation	Note
MK32-DC-R2	ВШПА.421412.3032-10	Limited indication system, front panel 20 mm. Module setup, measured values and status viewing can be carried out only via digital communication interfaces;
MK32-DC-20-R2	ВШПА.421412.3032-11	Extended indication and control system, front panel 40 mm. Arranged on front panel are graphical LCD 122x32 pixels, additional indication LEDs and control buttons;
MK32-DC-20-R2-LF3	ВШПА.421412.3032-20	Similar to version MK32-DC-20-R2 Three channels for measuring low-frequency absolute vibration displacement, 16-bit ADC
MK32-DC-20-R2-LF4	ВШПА.421412.3032-21	Similar to version MK32-DC-20-R2 Four channels for measuring low-frequency absolute vibration displacement, 16-bit ADC
MK32-DC-20-R2-MF3	ВШПА.421412.3032-22	Similar to version MK32-DC-20-R2 Three channels for measuring absolute vibration displacement in medium frequency range, 16-bit ADC
MK32-DC-20-R2-M-RAM-PO	ВШПА.421412.3032-30	Similar to version MK32-DC-20-R2 Galvanically isolated unified current outputs (passive mode)

2 Specifications

Table 2 - МК32 module main specifications

Parameter description	Value
Number of measurement channels	4
Number of frequency measurement inputs	2[1)]
Input signal measurement ranges • DC, mA • VDC, V • sinusoidal AC RMS, mA • sinusoidal VAC RMS, V	 1 – 5; 4 – 20 0.56 – 2.80 0 – 1,410; 0 – 5,656 0 – 0.792
Input resistance, Ohm • DC • VDC	 560 ± 2; 140 ± 0,5 10 000 min
Total number of assigned setpoints	32
Total number of the parameter unexpected and irreversible change (step) algorithms	8
Number of discrete (logic) outputs	14
Module output discrete signals • DC, V, max • output current, mA, max	open collector 24 200
Number of additional logic inputs	1
Refresh time of protection and signaling indications and logics operation, s	0.5
Supported digital communication interfaces types	RS485 CAN 2.0B diagnostic SPI
Power supply voltage, V	+(24 ± 1)
Consumed current, mA, max	120[2)]
Ambient air operating temperature range (from and to inclusive), °C	+ 5 – + 45
[1)] For measurement channels 1, 2. [2)] Consumed current is specified without considering consumed current of sensors and other external circuits.	

Table 3 - Constant signals measurement parameters by МК32 control module

Parameter description	Value
Constant signals measurement and signaling ranges	determined according to connected sensor type
Constant signal measurement permissible main relative error limits (offsets), %, max • at unified signal • by digital indicator	 ± 1.0 ± 0.5

Table 4 - Rotor speed measurement parameters by МК32 control module

Parameter description	Value
Rotor speed measurement range, rpm	1 – 12000
Rotor speed permissible main absolute measurement error limit by digital indicator, rpm, max	± 2.0
Rotor speed permissible main relative measurement error limit by unified output, %, max	± 1.0
Parameters of synchronization input signal: • pulse amplitude (from and to inclusive), V • pulse duration, ms, min	 0 – 5 0.001

Table 5 - Vibration velocity RMS measurement parameters by MK32 control module

Parameter description	Value
Vibration velocity RMS measurement range and signaling, mm/s[1)]	0.4 – 15.0 0.8 – 30.0
Measuring frequencies range (from and to inclusive), Hz	2 – 1000 10 – 1000
Base measurement frequency, Hz	80 ± 1
Frequency response (FR) ripple in frequency range (10 – 1000) Hz, % • (10 – 20) Hz • (20 – 500) Hz • (500 – 1000) Hz	 + 2.0; - 10.0 ± 2.0 + 2.0; - 10.0
Frequency response (FR) ripple in frequency range (2 – 1000) Hz, % • (2 – 20) Hz • (20 – 500) Hz • (500 – 1000) Hz	 + 2.0; - 10.0 ± 2.0 + 2.0; - 10.0
Base frequency measurement permissible main relative error limit by display and unified output, %	± 1.0
Signaling actuation permissible relative error limit of the parameter unexpected and irreversible change, %	± 10.0
Level of the parameter unexpected and irreversible change, mm/s	1.0[2)]
Number of configurable additional measurement frequency zones	4
[1)] Measurement range in which the declared metrological accuracy is provided, the actual measurement range is from 0.1 mm/s. [2)] Can be changed at customer's request.	

Table 6 - Relative vibration displacement excursion measurement parameters by MK32 control module

Parameter description	Value
Relative vibration displacement excursion measurement range and signaling, mm	0.01 – 0.25 0.02 – 0.50
Measuring frequencies range (from and to inclusive), Hz	5 – 500
Base measurement frequency, Hz	80 ± 1
Frequency response (FR) ripple in frequency range, % • (5 – 10) Hz • (10 – 250) Hz • (250 – 500) Hz	 + 2.0; - 10.0 ± 2.0 + 2.0; - 10.0
Base frequency measurement permissible main relative error limit by display and unified output, %	± 1.0
Number of configurable additional measurement frequency zones	2
Static clearance measurement between the sensor and control surface	Yes

Table 7 - Absolute vibration displacement excursion measurement parameters by MK32 module

Parameter description	Value
Absolute vibration displacement excursion measurement range and signaling, mm	0.01 – 0.25 0.01 – 0.50
Sensor signal type	Instantaneous vibration velocity
Measuring frequencies range (from and to inclusive), Hz • low-frequency range (LF) • medium frequency range (MF)	 0.8 – 200 2 – 1000
Base measurement frequency, Hz	40 ± 1
Frequency response (FR) ripple in frequency range, % For frequency range of 0.8 – 200 Hz • (0.8 – 2) Hz • (2 – 160) Hz • (160 – 200) Hz For frequency range of 2 – 1000 Hz • (2 – 20) Hz • (20 – 500) Hz • (500 – 1000) Hz	 + 2.0; - 10.0 ± 2.0 + 2.0; - 10.0 + 2.0; - 10.0 ± 2.0 + 2.0; - 10.0
Base frequency measurement permissible main relative error limit by display and unified output, %	± 1.0
Number of configurable additional measurement frequency zones	1
Refresh time of protection and signaling indications and logics operation in 3- and 4-channel measurement mode, s	1.0

Table 8 - Variable signal rotational components measurement parameters by MK32 module

Parameter description	Value
Measurement and signaling range	according to the measurement channel operating mode
Measuring frequencies range (from and to inclusive), Hz	0.05 – 160[1)]
Sinusoidal signal phase measurement range (from and to inclusive), °	0 – 360
Base measurement frequency, Hz	80 ± 1
Frequency response (FR) ripple in frequency range, %	± 2.0
Base frequency measurement permissible main relative error limit by display and unified output, %	± 1.0
Input sinusoidal signal phase measurement permissible main absolute error limit, °	± 4.0
Rotational components measurement spectral resolution	¼ rotational component[2)]

[1)] Frequency range is given for 1st rotational component.

[2)] At low rotor speed it may not be possible to calculate the ¼ and ½ rotational components.

To calculate the variable signal rotational components it is necessary to feed the synchronization signal to MK32 module.

Table 9 - Parameters of unified current outputs of MK32 module

Parameter description	Value
Number of unified DC signals	4
Output unified DC signal, mA	0(1) – 5 0(4) – 20
Output unified signal load resistance, Ohm, max • range (0(1) – 5) mA • range (0(4) – 20) mA	 2000 500
Additional parameters for version MK32-DC-20-R2-M-RAM-PO	
Unified outputs type	Passive regulator with galvanic isolation[1)]
Unified current output power source voltage, V	from 18 to 30
Unified current signal galvanic isolation operation voltage, V, max	400[2)]
[1)] Each output is galvanically isolated from other unified outputs and the module power supply source. [2)] Voltage applied between any galvanically isolated circuits or a ground bus and any galvanically isolated circuit. The values are given for normal conditions, according to ГОСТ Р 53429-2009.	

Table 10 - RS485 interface parameters

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

Table 11 - Diagnostic interface (D.port) parameters

Parameter description	Value
Interface type	SPI slave
MK32 address on SPI interface	0x32
Address format when accessing module registers	16-bit
Data rate, kbit/s, max	400
VDC on diagnostics connector to power matching device, V	5 ± 0.2
Permissible consumption current in power supply circuit on diagnostics connector, mA, max	50
Galvanic isolation from the module power supply source	none

Table 12 - CAN2.0 interface parameters

Parameter description	Value
Number of CAN2.0 interfaces	1
Operating mode	Active
Data format	Special for equipment "Vibrobit 300"
Code for indicating units	0x32 (50)
Data rate (one speed is set), kbit/s	1000; 500; 250; 200; 125; 100; 80; 40
Compliance with CAN bus standard	ISO-11898
Maximum nodes number on bus	120
Driver input resistance, kOhm, min	5
Electrostatic resistance, kV, min	± 16
Galvanic isolation from the module power supply source	none

Table 13 - МК32 module additional parameters

Parameter description	Value
Overall dimensions, mm • МК32-DC-R2 control module • МК32-DC-20-R2(-LF3; -LF4; -MF3; -M-RAM-PO) control module	 20.1 x 130 x 190 40.3 x 130 x 190
Mass, kg, max • МК32-DC-R2 control module • МК32-DC-20-R2(-LF3; -LF4; -MF3; -M-RAM-PO) control module	 0.15 0.20
Warm-up time, min, max	1
Operating mode	continuous
Mean time between failures (design), hours, min	100,000
Average service life, years	10
Permissible relative humidity at temperature of +35 °C, %, max	80
Guarantee service life, months	24
Transportation conditions according to ГОСТ 23216-78	Ж
Storage conditions according to ГОСТ 15150-69	3 (Ж3)

3 Indication and control means

MK32 module front panel differs depending on the version. The MK32 module front panels appearance is shown in the figure 1.

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

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

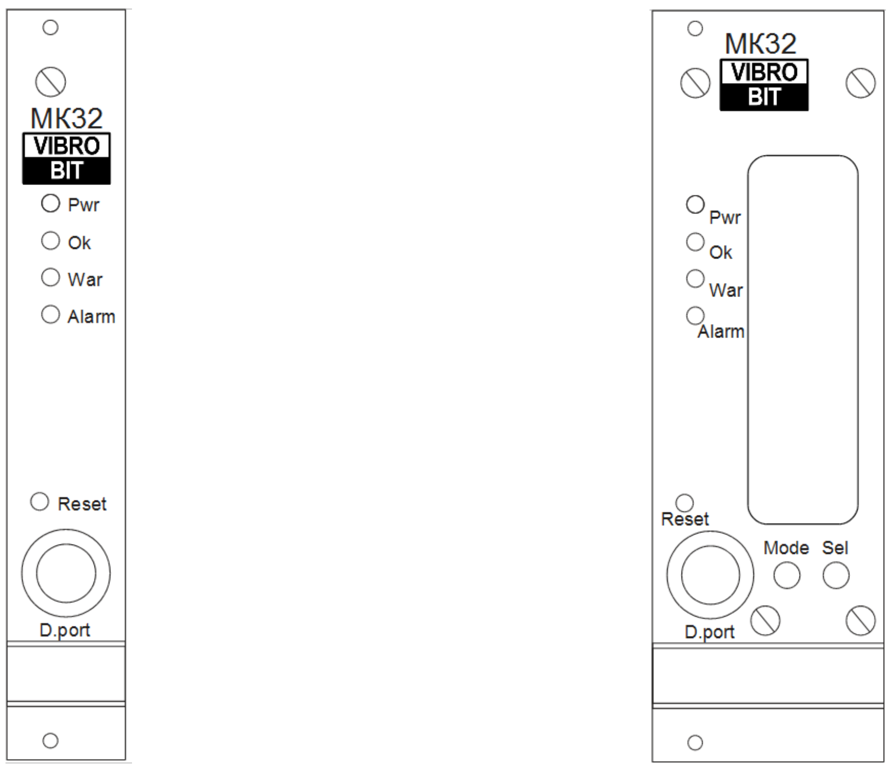
The **Ok** LED color indicate the module status:

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

3.1 MK32-DC-R2 version

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

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



a) MK22-DC-R2

b) MK32-DC-20-R2(-LF3; -LF4; -M-RAM-PO)

Figure 1 - MK32 front panel appearance

3.2 MK32-DC-20-R2 (-LF3; -LF4; ; -MF3; -M-RAM-PO) version

MK32 module front panel with special graphic LCD (liquid crystal display) (32x128 pixels), signal LEDs and control buttons.

Arranged on front panel are:

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

Two control buttons:

- button ***"Mode"*** – indication mode selection;
- button ***"Sel"*** – indicated data selection.

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

Long-term pressing button "***Mode***" in "Channel information" mode resets flags of detected parameters "steps" of the corresponding measurement channel.

The information output to LCD is configurable, it provides two display modes:

- histograms: the information is presented as 4 colored columns, which height is proportional to output parameters values.
- channel information (normal mode): indicated are parameters values referring only to current measurement channel in preliminary setup format.

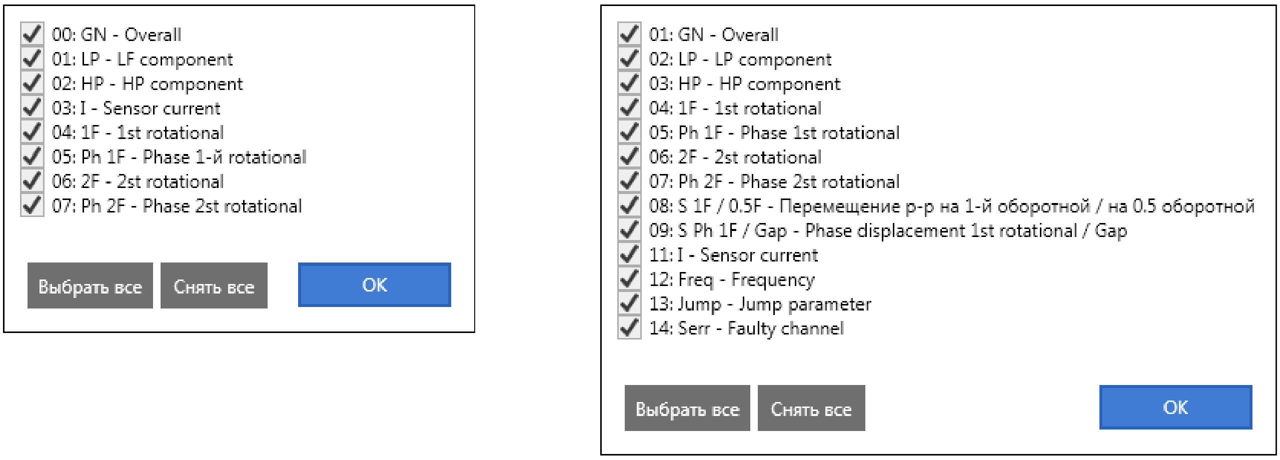
Figure 2 shows an indication setup example of module MK32-DC-20-R2 in ModuleConfigurator software.

Parameter	Value	Address
Compatibility mode permission	✓	0x3400
Histogram page displayed first	GN - General level	0x3414
Histogram page	GN; LP; HP; I; 1F; Ph1F; 2F; Ph2F;	0x3416
Position LCD display №1		
Position 1. Number of measurement channel	Channel 1	0x3404
Position 1. Type of measurement channel	Real	0x3404
Position 1. Channel data format	##.##	0x340C
Position 1. Show data in normal mode	GN; LP; HP; 1F; Ph1F; 2F; Ph2F; S1F_05F; SPh1F_Gap; I; Freq; Jump; Serr;	0x341C
Position LCD display №2		
Position 2. Number of measurement channel	Channel 2	0x3406
Position 2. Type of measurement channel	Real	0x3406
Position 2. Channel data format	##.##	0x340E
Position 2. Show data in normal mode	GN; LP; HP; 1F; Ph1F; 2F; Ph2F; S1F_05F; SPh1F_Gap; I; Freq; Jump; Serr;	0x341E
Position LCD display №3		
Position 3. Number of measurement channel	Channel 3	0x3408
Position 3. Type of measurement channel	Real	0x3408
Position 3. Channel data format	##.##	0x3410
Position 3. Show data in normal mode	GN; LP; HP; 1F; Ph1F; 2F; Ph2F; S1F_05F; SPh1F_Gap; I; Freq; Jump; Serr;	0x3420
Position LCD display №4		
Position 4. Number of measurement channel	Channel 4	0x340A
Position 4. Type of measurement channel	Real	0x340A
Position 4. Channel data format	##.##	0x3412
Position 4. Show data in normal mode	GN; LP; HP; 1F; Ph1F; 2F; Ph2F; S1F_05F; SPh1F_Gap; I; Freq; Jump; Serr;	0x3422

Figure 2 - Indication setup example of module MK32-DC-20-R2 in ModuleConfigurator software

MK32-DC-32-R2 module indication setup includes the following parameters:

- data indication permission on LCD;
- association of measurement channels with display positions on LCD:
  - measurement channel number;
  - measurement channel type (real; virtual);
- histogram pages displayed on LCD (figure 3 a);
- histogram page displayed first when entering the “Histograms” mode;
- measured parameter indication format (table 14) individually for each output position;
- list of displayed parameters in “Channel Information” mode (Figure 3 b), individually for each output position.



a) displayed histograms b) displayed data in normal mode

Figure 3 - Displayed data setup example on MK32 module LCD in ModuleConfigurator software

If none of the histograms is specified for display, then the “Histograms” mode on the LCD will not turn on.

Table 14 - Formats for parameter digital values output on LCD

Format	Maximum value	Minimum value
#.###	9.999	0.000
##.##	99.99	-9.99
###.#	999.9	-99.9
#####	99999	-9999

While attempting to indicate a value, exceeding the limits of permissible values for this format, LCD will display a limiting value.

Figure 4 shows the data output example to LCD as a histogram.

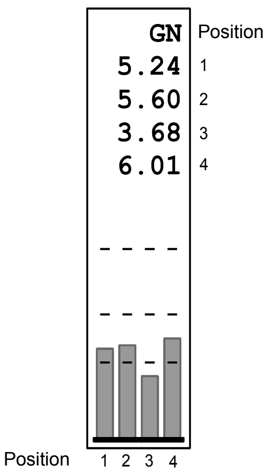


Figure 4 - Data output example to LCD as a histogram

LCD upper line shows histogram description, and under description, starting from 1-st position, displayed are parameters digital values of associated measurement channel. If setpoints are provided for the output parameter, they are displayed as a lines.

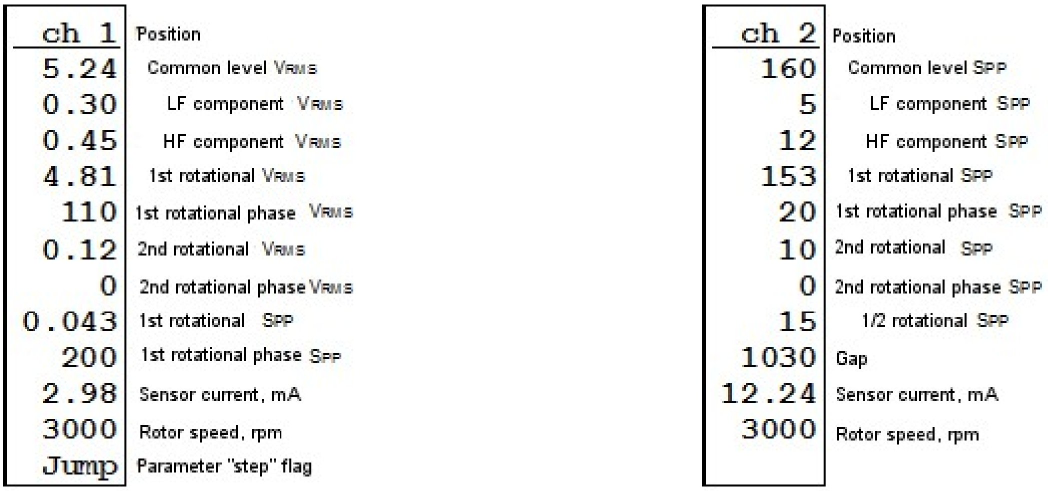
When switching to indication mode “histograms”, LCD will initially display a histogram stated in the MK32 module indication setup. By pressing “***Sel***” button, LCD will cyclically display all recorded histograms.

Example of data output as a histogram is shown on figure 4.

In indication mode “Channel information” LCD displays parameters values referring only to current measurement channel in preliminary setup format.

LCD upper line displays output position number. The rest 14 lines display information on the selected measurement channel according to the measured value type.

Example of data output as a channel information is shown on figure 5.



a) absolute vibration speed RMS b) relative vibration displacement excursion

Figure 5 - Data output example to LCD as a channel information

4 Module operation

4.1 Power-up

Upon power-up, the MK32 module operating parameters are loaded from non-volatile memory Operating parameters are divided into sections:

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

Each operating parameters section in non-volatile memory is accompanied with a check sum, permitting to check authenticity of loaded data. If calculated check sum is not the same as recorded check 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 main section is read with error, then attempt is made to read the data from non-volatile memory reserve area.

If an error is detected in one of operating parameters sections (from main or reserve section), then module operation is blocked LED **“Ok”** on front panel will light up with red color.

During operating parameters normal loading before MK32 module operation start:

- MK32-DC-R2: LED “***Ok***” blinks with yellow color, indicating module starting initialization in progress;
- MK32-DC-20-R2 (-LF3; -LF4; -MF3; -M-RAM-PO): LED “***Ok***” illuminates with yellow color, indicator shows module serial number, then module manufacturing year and then executes MK32 starting initialization.

It is permitted to carry out MK32 module “hot” replacement in section without de-energizing.

After MK32 module power-up (reset), the logic outputs operation is blocked for the established time. If logic outputs operation is blocked, then LED “Ok” illuminated with yellow color.

4.2 Module reset

Carried out during module reset is microcontroller hardware reset and carried out is sequence of actions, corresponding to power-up. Reasons for MK32 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 MK32 module board, user can reset module and carry out module “Cold start”.

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

Module reset can be carried out only after displaying identification information (module number, manufacturing year) and completing MK32 module initialization cycle.

4.2.1 Module “cold start”

“Cold start” is intended to record default settings to module non-volatile memory. This function is useful during module first power-up after assembly or if it is necessary to re-calibrate module.

To switch to “Cold start” mode, press and hold button “***Reset***” during whole cycle of identification information output.

If switching to “Cold start” mode is detected, then during self-diagnostics results output to LCD, the two-colored LED “***Ok***” will engage with yellow color and LED “***War***” will continue blinking. After self-diagnostics results output, confirmation of module “Cold start” is due (Figure 6).

If a non-volatile memory error is detected or memory recording is blocked by jumper on module board, then switching to “Cold start” mode is not executed.

When waiting for “Cold start” confirmation, blinking on LCD is an inscription “`COLD START`” and filled in LCD lower part is waiting indicator. If during 10 seconds “Cols start” is not confirmed, then module is reset. “Cold start” confirmation sequence input correctness is displayed as appeared symbols “*”, one for each correct action.

If confirmation sequence was broken, then repeat whole confirmation sequence anew. This approach prevents accidental data corruption in non-volatile memory.

“Cold start” confirmation sequence: briefly press button “***Reset***”, then press button “***Reset***” and hold it till default settings start recording into memory.

Figures 6, 7 show expecting “Cold start” confirmation and default settings record process to non-volatile memory accordingly.

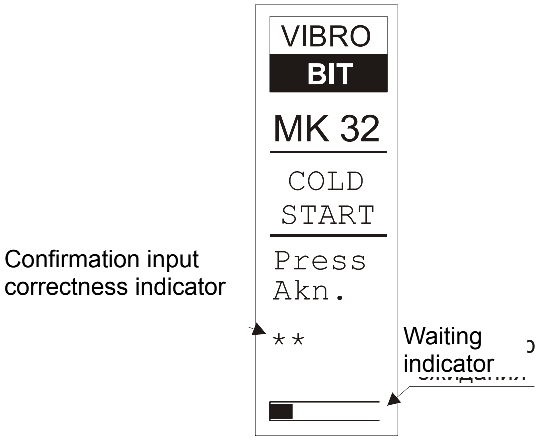


Figure 6 - Waiting for “Cold start” confirmation

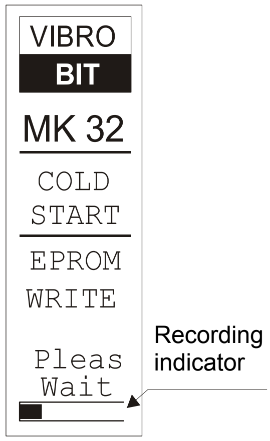


Figure 7 - Default settings record process to non-volatile memory

Immediately after sequence correct input, default settings start recording into non-volatile memory. Data are recorded into both sections, main and reserve with check reading.

MK32-DC-R2

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

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

MK32-DC-20-R2 (-LF3; -LF4; -MF3; -M-RAM-PO)

- During recording LCD shows message about data recording and below LCD there is a recording indicator (Figure 7).
- After recording displayed on LCD is a message about results of default settings saving into non-volatile memory (ERROR – recording not executed; OK – default settings recording successfully completed).

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

4.3 MK32 module system parameters

The system parameters influence all measuring channels of MK32 module. The system parameters include:

- logic outputs blocking time;
- synchronization source of rotational components calculation;
- ADC (analog-to-digital converter) sampling frequency;
- availability of additional ADC of extra capacity;
- DAC type (digital-to-analog converter) for unified current outputs;
- rotor speed range to study control surface.

Figure 8 shows the setup example of the logic outputs blocking time and DAC type in ModuleConfigurator software.

Parameter	Value	Address
Time lock logic outputs after module reset, sec	8	0x0C00
Time lock setpoints after normalization of channel, sec	8	0x0C02

Figure 8 - Setup example of the logic outputs blocking time and DAC type in ModuleConfigurator software

The choice of unified current outputs DAC type (parameter `DacExternalType`) depends on the MK32 control module version (implemented in the MK32 module software version 1.80):

- MK32-DC-20-R2 (-LF3; -LF4; -MF3) – One 4-channel DAC AD7398, installed on the module board
- MK32-DC-20-R2-M-RAM-PO – Four single-channel DACs DAC7611, installed on additional board (galvanically isolated current outputs)

MK32 control module version without unified current outputs is available on request.

Description of parameter “Logic outputs blocking time after module reset” is given in section 4.11.3

Description of parameter “Setpoints blocking time after channel operation normalizing” is given in section 4.5.1

4.3.1 ADC sampling discretization parameters

Available in section “Sampling discretization parameters” is setting of the following parameters:

- Selecting the rotational components synchronization source (`SynchronizationMode`):
  - synchronization pulses are not sent to the control module;
  - only the 1st synchronization channel;
  - only the 2nd synchronization channel;
  - 1-st synchronization channel is main, 2-nd is reserve one.

Figure 9 shows an example of ADC sampling discretization parameters setting in ModuleConfigurator software.

Parameter	Value	Address
Measurement channels synchronization mode to calculate rotational component	1st ch. basically., 2nd reserv	0x0C04
Discretization samplings frequency ADC	4096 Hz (spectral resolution 1,0 Hz)	0x0C06
Type of available external ADC	Only internal ADC (12 bits)	0x0C10
Share calculation 1, 2 and 3, 4 channels in separate cycles (update time 1 sec.)	☐	0x0C12

Figure 9 - Example of ADC sampling discretization parameters setting in ModuleConfigurator software

- ADC sampling discretization frequency (`AdcSamplesDivider`):
  - (0 – 4096) Hz (spectral resolution 1.0 Hz);
  - (1 – 2048) Hz (spectral resolution 0.50 Hz);
  - (2 – 1024) Hz (spectral resolution 0.25 Hz);
- Type of available external ADC (`AdcExternalType`) depends on MK32 control module version:
  - MK32-DC-20-R2 (M-RAM-PO) – Only internal ADC (capacity 12 bit);
  - MK32-DC-20-R2-LF3 (-LF4; -MF3) – Additional board with ADC AD7988 (capacity 16 bit).

Calculation dividing of 1, 2 and 3, 4 channels in separate cycles may be necessary when using 64-bit mathematics for FFT and 11th-order inverse FFT. When dividing calculations by cycle, the results update period by measurement channels increases to 1 second.

4.3.2 Control surface form study

When measurement channels operate in the relative vibration displacement mode with compensation of control surface irregularities when calculating the vibration signal rotational components, it is necessary to specify the rotor speed range in which the studies will be carried out.

Figure 10 shows an example of the control surface study frequency range setting in ModuleConfigurator software.

Parameter	Value	Address
Frequency range lower value of control surface form study, rpm	100	0x0C08
Frequency range upper value of control surface form study, rpm	300	0x0C0C

Figure 10 - Example of the control surface study frequency range setting in ModuleConfigurator software

Description of control surface irregularity compensation function when calculating rotational components is given in Section 4.8.7.1.

4.3.3. Test of assumed system settings in MK32 module

In MK32 control module, it is possible to check the assumed system settings: sampling rate of ADC samples, type of available external ADC, type of unified current outputs external DAC, processor processing load, ADC cycles counter (measurement control).

MK32 module system settings take effect after the module is reset.

Figure 11 shows an example of checking the MK32 module assumed system settings in ModuleConfigurator software.

Parameter	Value	Address
01. CPU load status, %	71.35	0x00F4
02. Frequency of sampling ADC samples	1024 Hz (spectral resolution 0,25 Hz)	0x00F8
03. Type of available external ADC	Additional board with ADC AD7988 (16 bits)	0x00FA
04. ADC main cycle counter	7	0x00FC
05. DAC unified current outputs type	One 4-channel DAC AD7398, installed on module board	0x0108

Figure 11 - Example of checking the MK32 module assumed system settings in ModuleConfigurator software

Module status and reasons for blocking its operation can be determined by the control module status flags (`DeviceStatus` register).

Figure 12 shows an example of checking the MK32 module status flags in ModuleConfigurator software.

Parameter	Value	Address
EEPROM error	☐	0x00E0
RAM error	☐	0x00E0
ADC error	☐	0x00E0
Data loading error	☐	0x00E0
Data loading from reserve section	☐	0x00E0
EEPROM recording protection	☐	0x00E0
Module identification information error	☐	0x00E0
Logical outputs formula error	☐	0x00E0
Disabled interface RS485 №2	☐	0x00E0
All measurement channels disabled	☐	0x00E0
Disabled interface RS485 №1	☐	0x00E0
CAN interface disabled	☑	0x00E0
Logical outputs block by module start	☐	0x00E0
Logical outputs block by user	☐	0x00E0
Permission for single write RS485 №1	☐	0x00E0
Permission for single write RS485 №2	☐	0x00E0

Figure 12 - Example of checking the MK32 module status flags in ModuleConfigurator software

4.4. Measurement channel main parameters

For each measurement channel, the following basic parameters should be set:

- channel operation permission (`Enabled`);
- channel operation mode `ModeWork` (main measured parameter):
  - constant signal;
  - rotor speed;
  - signal RMS;
  - signal excursion;
  - signal excursion (vibration velocity integration);
- main measured parameter value integration depth;
- AC parameter range value (informational);
- unit of measurement (8 characters), informational;
- channel description (16 symbols), informational;
- consider the sensor propagation ratio (`UseCoeffOfSensor`);
- actual sensor propagation ratio (`ActualCoeffOfSensor`);

Configure the `Enabled` and `ModeWork` parameters to operate the measurement channel in the necessary mode. If the channel is turned off, then no calculations are performed on this measurement channel, the values of all the measurement results registers are assumed to be zero. The measurement channel operation permission changes and its mode take effect after the measurement channel is reset (module reset).

When measuring parameters represented by AC signals, it is possible to carry out the simplified configuration of the measurement channel to the actually connected sensor.

If the sensor propagation ratio can be accounted, the values of the calculated parameters represented by the AC signals are multiplied by the scaling factor (`CoeffOfSensor`) of the actual sensor propagation ratio (`ActualCoeffOfSensor`) and the nominal sensor propagation ratio (`NominalCoeffOfSensor`).

Figure 13 shows an example of measurement channel No. 1 main parameters setting in ModuleConfigurator software.

Parameter	Value	Address
Enabled channel	☑	0x0800
Channel work mode	Signal RMS	0x0802
Depth averaging primary measured parameter	0 - No averaging	0x08A4
Value range for AC parameter	15	0x0820
Units	мм/с	0x0898
Description channel	Верт.	0x0888
Use sensor transfer coefficient	☐	0x08A6
Actual sensor transfer coefficient	0	0x08AC

Figure 13 - Example of measurement channel No. 1 main parameters setting in ModuleConfigurator software

4.5 Sensor DC measurement

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 (installed using jumper):

- current range (0(4) - 20) mA – resistor 140 Ohm;
- current range (0(1) - 5) mA – resistor 560 Ohm;
- voltage range (0 - 3) V.

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

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

Input signal (voltage) passes via low-pass filter (LPF) (Butterworth, 8-th order) and is supplied to input of 12-bit ADC, built into microcontroller. 4096 samples of ADC values for each measurement channel are used to calculate the ADC average value, which is used in further calculations of the sensor current. Large number of ADC sampling results in ADC DC actual resolution 14-bit due to averaging.

Sensor current is calculated according to the linear equation formula:

$$I_{DC} = A_I + B_I \cdot ADC_{AV};$$

Where:

I_{DC} – calculated sensor current value;

ADC_{AV} – averaged ADC value;

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

Sensor current value I_{DC} can be displayed on indicator and is used in sensor test algorithm to calculate the measured parameter value.

`AI`, `BI` factors are calculated automatically during module operation initialization according to sensor current range data (20 % from `ConstCurrentMax`, `ConstCurrentMax`) and ADC saved values (`ConstAdcMin`, `ConstAdcMax`), corresponding to sensor current input range of calibrated sensor.

If one pair of calibration values (20 % from `ConstCurrentMax`, `ConstCurrentMax` or `ConstAdcMin`, `ConstAdcMax`) 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_{DC} always equals to zero).

Figure 14 shows an example of channel No. 1 DC calibration in ModuleConfigurator software.

Parameter	Value	Address
Lower value of sensor current range, mA	1.00	0x0400
Upper value of sensor current range, mA	5.00	0x0404
Lower calibration value ADC	768	0x043C
Upper calibration value ADC	3877	0x0440

Figure 14 - Example of channel No. 1 DC calibration in ModuleConfigurator software

4.5.1 Sensor serviceability test

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

Monitoring of sensor minimum/maximum permissible current can be disabled in module settings (`CurrentLowCheck`, `CurrentHighCheck` accordingly). If sensor current monitoring is disabled by one of limits, then sensor is considered serviceable regardless of calculated sensor current.

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

If I_{DC} value is above maximum permissible current value `CurrentHigh`, then it is considered that sensor signal level is too high (flags `ErrorSenseHigh`, `ErrorFlag` are set). For measurement channel operation normalizing, I_{DC} value should be less than `CurrentHigh - CurrentCheckHist` (flag `ErrorSenseHigh` is reset).

With any sensor current abnormal level flag set (`ErrorSenseLow`, `ErrorSenseHigh`) measured parameter value is taken as zero.

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

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

Figure 15 shows 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.

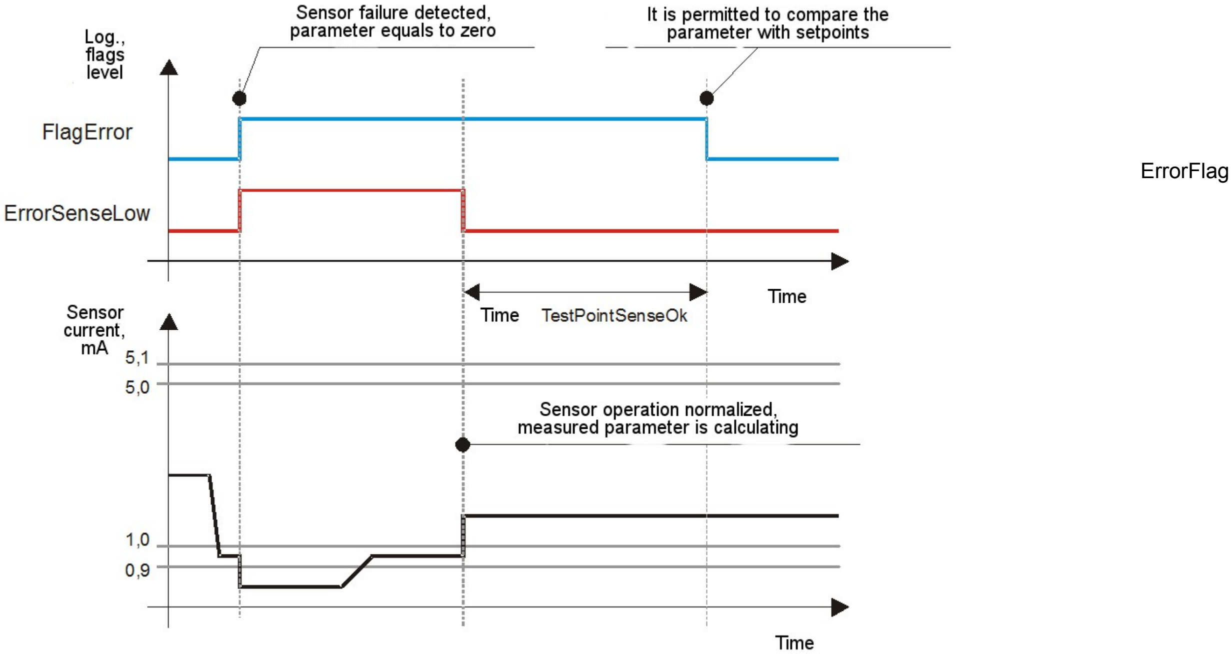


Figure 15 - Sensor test algorithm operation at sensor DC drop below permissible level

After module power-on (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 `ErrorFlag` flag is automatically set after the reset.

Figure 16 shows an example of channel No.1 absolute vibration velocity sensor serviceability setting in ModuleConfigurator software.

Parameter	Value	Address
Control lower limit of current sensor	✓	0x0804
Lower permissible value of sensor current, mA	2.00	0x0808
Control upper limit of current sensor	✓	0x0806
Upper permissible value of sensor current, mA	4.00	0x080C
Hysteresis current sensor, mA	0.10	0x0810

Figure 16 - Example of channel No.1 absolute vibration velocity sensor serviceability setting in ModuleConfigurator software

4.6 Measurement of parameter value represented by DC value

The parameter value is calculated from the sensor measured current value, if measuring channel “Constant signal” operating mode is selected or the parameter “Calculate the constant component” `ConstValueCalculation` value is not zero. The DC parameters calculation for the variable signals may be necessary, for example, for the relative vibration displacement measurement channel, when it is necessary to calculate the static gap between sensor and control surface.

Measured parameter value is calculated according to linear equation formula:

$$P_{DC} = A_P + B_P \cdot I_{DC}$$

Where:

P_{DC} – calculated measured parameter value;

I_{DC} – calculated sensor current value;

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

If channel is set to constant signals measurement mode, P_{DC} value is the main measured parameter. DC parameter calculated value can be:

- compared with setpoints;
- displayed on LCD;
- fed to the unified current output.

A_P, B_P factors are calculated automatically during module operation initialization according to sensor current range data (`ConstCurrentMin`, `ConstCurrentMax`) and measured parameter established range (`ConstValueMin`, `ConstValueMax`).

If one pair of values (`ConstCurrentMin`, `ConstCurrentMax` or `ConstValueMin`, `ConstValueMax`) 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 P_{DC} always equals to zero).

Figure 17 shows an example of channel No. 1 gap measurement setting when measuring relative vibration displacement in ModuleConfigurator softeare.

Parameter	Value	Address
Constant component calculation	✓	0x0814
Lower value of DC parameter range	0	0x0818
High value of DC parameter range	2000	0x081C

Figure 17 - Example of channel No. 1 gap measurement setting when measuring relative vibration displacement in ModuleConfigurator softeare

4.7 Rotor speed measurement

Provided in MK32 module are two channels for rotor speed measurement, to which should be fed the tachometric pulses from the rotor speed sensor. Tachometric pulses can be fed to:

- synchronization inputs - when repeating tachometric pulses from other control modules;
- inputs of measurement channels 1, 2 - with direct connection of sensors to MK32 module.

Synchronization source is selected by jumpers on MK32 control module board. Synchronization inputs have pull-up resistors 1 kΩ (setup by jumper) to a +3.3 V voltage source. Inputs of “open collector” type can be the signal source for synchronization inputs.

If it is necessary to work with current signals (direct connection of sensors) and measurement channel serviceability monitoring, tachometric pulses should be supplied to measurement channels 1 or 2 inputs and measurement channel should be configured for speed measurement.

Frequency measurement channel executes the following main operations:

- calculates the sensor current and monitors the sensor serviceability (only when connected to the measuring inputs);
- measures rotor speed;
- repeats tachometric pulses to synchronize test modules, measuring variable signals (only for control surface “groove”);
- compares parameter calculated values with setpoints and signals about setpoints overrange;
- detects the absence of synchronization pulses ("STOP" mode);
- synchronizes the rotational components measurement.

When measurement channel operation in “Rotor speed measurement” mode, the measurements are taken if no sensor failure is detected (flags `ErrorSenseLow`, `ErrorSenseHigh` are reset). If sensor failure is detected (one of flags `ErrorSenseLow`, `ErrorSenseHigh` is set), the rotor speed is not calculated and is taken as zero.

Rotor speed is determined by synchronization pulses period measurement method, calculating clock signal leading edges number with frequency of 25 MHz between synchronization pulses two active edges. Synchronization pulses period value is averaged for measurement cycle, then rotor speed is calculated in rpm (considering established number of pulses per rotor revolution). If during measurement cycle only one synchronization pulses period was detected, then not averaged period value is used in frequency calculation.

Provided for operation with different control surfaces (groove, pinion) is parameter *Tooth*, determining pulses number per one revolution. For cases of *Tooth* more than 1 (pinion), phase is not calculated.

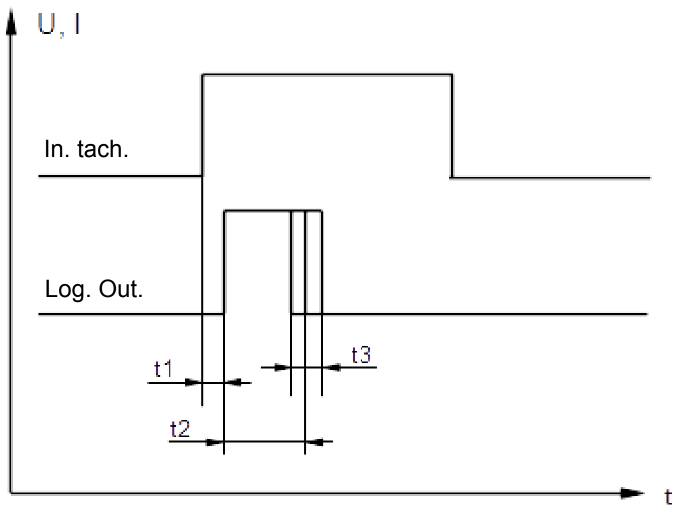
Minimum measured rotor speed is set by parameter MinFrequencyRPM (0.9 rpm min). If rotor speed is less than established value, than synchronization pulses considered to be absent (rotor stopped).

Figure 18 shows an example of speed measurement channel No. 1 setting in ModuleConfigurator software.

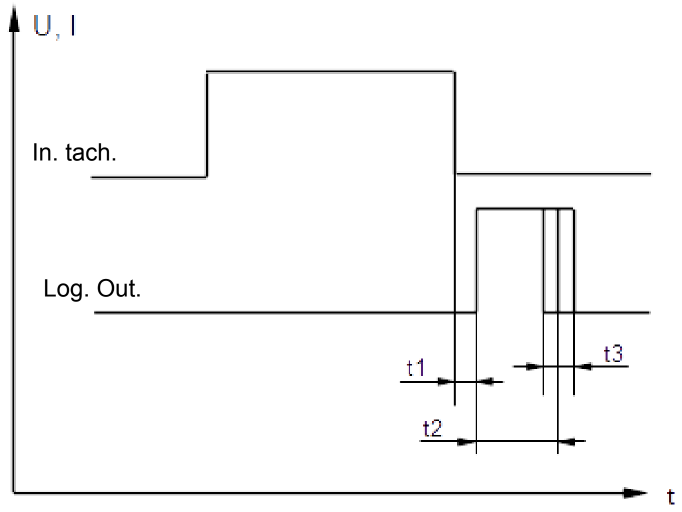
Parameter	Value	Address
Frequency measurement permission	✓	0x0D00
Number of pulses per rotor revolution (from 1 to 300)	1	0x0D02
Minimum measured frequency, Hz	3	0x0D08
Angle of rotor speed sensor installation, gr	0	0x0D0C
Control of frequency stabilization		
Frequency stabilization control permission	✓	0x0D10
Frequency stabilization time, sec	5	0x0D12
Maximum frequency deviation for stabilization algorithm, Hz	10	0x0D14
Synchronization pulses		
Active front input pulses	Front	0x0D04
Repeat synchronization pulses	Do not repeat	0x0D06

Figure 18 - Example of speed measurement channel No. 1 setting in ModuleConfigurator software

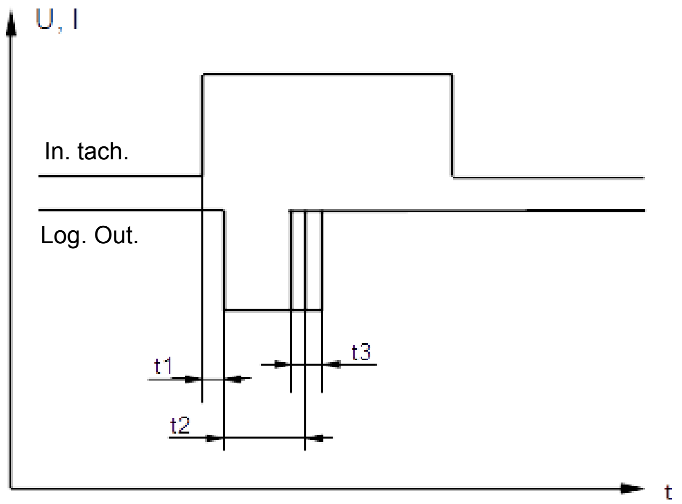
The polarity of the input pulses and repeated synchronization pulses active front is determined in software (`ActiveFront`, `GeneratePulses`). Synchronization pulses are generated only if permitted in module settings (`GeneratePulses` parameter is not zero). Synchronization pulses are generated (if permitted in module settings) even if sensor failure is detected. The graphs of synchronization pulses are shown in the figure 19.



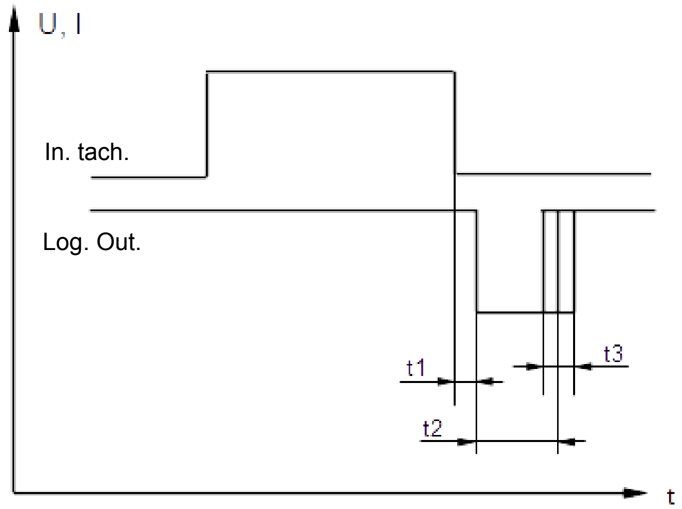
a)
input - leading edge
output - leading edge



b)
input - trailing edge
output - leading edge



c)
input - leading edge
output - trailing edge



d)
input - trailing edge
output - trailing edge

Figure 19 - Polarity of the input and output synchronization pulses depending on the active pulse edges setting

In the figure 19 the time parameters correspond to:

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

MK32 module output synchronization signal has no fixed duration, but it has a fixed time reference (according to the setting) by the “leading” or “trailing” edge relative to the input signal.

The speed stability monitoring is intended to detect the stationary state of the monitored unit. Rotor speed is considered stationary if during the frequency stabilization time (`StableTimeOut`) the frequency did not change more than by the set maximum frequency deviation (`StableFrequencyDelta`). If the rotor speed is not stable, the flag (`NoFrequencyStable`) is set.

4.8 Measurement of parameters represented by AC signals

Physical signals, represented by AC signals are measured basing on the input signal spectral analysis.

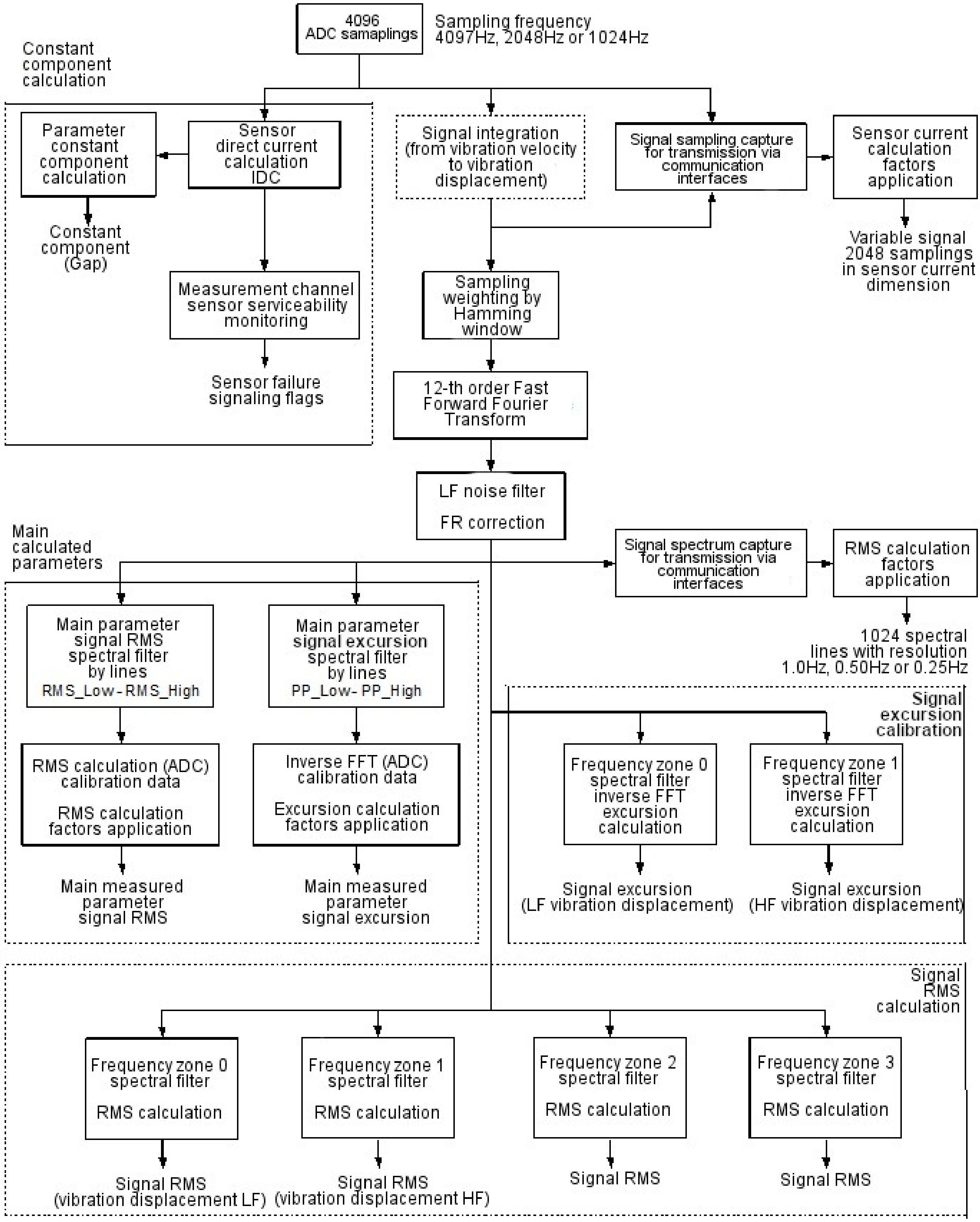


Figure 20 - Block schematic diagram of AC signals calculation by MK32 module one channel

Input signal is processed by two independent algorithms:

- general level calculation of vibration velocity RMS, vibration displacement excursion (regardless of the rotor rotation synchronization pulses presence);
- rotational components calculation (rotor rotation synchronization pulses are required).

ADC sampling frequency (for parameters independent of rotor speed) is set in the module system settings and applies to all measurement channels of the module:

- 4096 Hz - spectral resolution of 1.00 Hz (frequency range of the measured signal from 1 Hz to 1500 Hz);
- 2048 Hz - spectral resolution of 0.50 Hz (frequency range of the measured signal from 0.50 Hz to 750 Hz);
- 1024 Hz - spectral resolution 0.25 Hz (frequency range of the measured signal from 0.50 Hz to 325 Hz);

To obtain a signal spectrum by each measurement channel, a signal sample with a length of 4096 values passes through the following processing:

- vibration velocity signal integration into the vibration displacement, only for the measuring channel mode “Signal excursion (vibration velocity integration)”;
- Hamming window weighting of the sampling;
- 12th order fast Fourier transform (a 64-bit mode of integer mathematics can be used to measure LF absolute vibration displacement);
- LF noise removal (used to measure LF absolute vibration displacement);
- FR correction.

The resulting spectrum is used for:

- spectrum transmission via digital communication interfaces;
- vibration velocity RMS calculation;
- vibration displacement excursion calculation.

4.8.1 Main calculated parameters

The main parameters are calculated independently of the measurement channel set operating mode in order to perform the channel calibration. The frequency range of the main calculated parameters is determined by the numbers of the lower and upper spectral lines during the module calibration. The main parameters types and their spectral ranges are given in the table 15.

Table 15 - Main measured parameters types and their parameters

Measurement type	Frequency range parameters	Permissible limits	Default value	Calibration factors influence

Signal RMS	`LineRMS_Low`
	
	`LineRMS_High`
		2 min
		
		2047 max
			8
			
			1003
				Signal spectrum capture
				Frequency zones 0 - 3 in RMS mode

Signal excursion	`LinePP_Low`
	
	`LinePP_High`
		2 min
		
		10th order Inverse fast Fourier transform
		511 max
		
		11th order Inverse fast Fourier transform
		1023 max
			4
			
			503
				Frequency zones 0 - 1 in excursion mode

The numbers of the spectral lines for the main calculated parameters should take into account the established spectral resolution and the required frequency ranges of the measured vibration value.

The signal RMS is calculated as a square root of sum of squares of the spectral lines energy included into the measured parameter frequency range. The signal RMS primary result is calculated in the ADC dimension, available for reading via the communication interfaces to calibrate a measurement channel. To obtain the RMS value in the measured physical quantity dimension, the calibration factors are applied to the RMS value in the ADC dimension.

The signal excursion is defined as the difference between the maximum and minimum sample values of the reconstructed signal (ADC dimension). The signal is reconstructed from the spectrum by the inverse fast Fourier (10th or 11th order) transform method, after spectrum preliminary filtering in accordance with the physical parameter frequency measurement range. To obtain the excursion value in the measured physical quantity dimension, the calibration factors are applied to the excursion value in the ADC dimension.

Figure 21 shows an example of channel No. 1 main measured parameters ADC values in ModuleConfigurator software.

Parameter	Value	Address
ADC DC value	13	0x0300
Main parameters measured		
ADC RMS AC value	0	0x0304
ADC AC excursion value	0	0x0308
ADC RMS value/Excursion of rotational component	0	0x031C
In frequency zones		
In frequency zones 0	0	0x030C
ADC value of frequency band 1	0	0x0310
ADC value of frequency band 2	0	0x0314
ADC value of frequency band 3	0	0x0318

Figure 21 - Example of channel No. 1 main measured parameters ADC values in ModuleConfigurator software

4.8.2 AC signals calibration factors

Provided in MK32 module are four calibration data groups for each measurement channel:

- AC signal RMS;
- AC signal RMS, rotational components;
- AC signal excursion;
- AC signal excursion, rotational components;

The need to determine the calibration data of a particular type depends on the measurement channel operating mode, the type of measured physical value and the Condition and Vibration Monitoring System configuration.

To determine the calibration data (calibration) is to obtain the ADC values correspondence to the real physical signal level at 100%, 20% and 5% of the measuring range. It is permitted to omit a calibration at the level of 5% of the measurement range, with the possible measurement accuracy deterioration at low signal levels.

Figure 22 shows the transfer characteristic of parameter value calculation from a dimension.

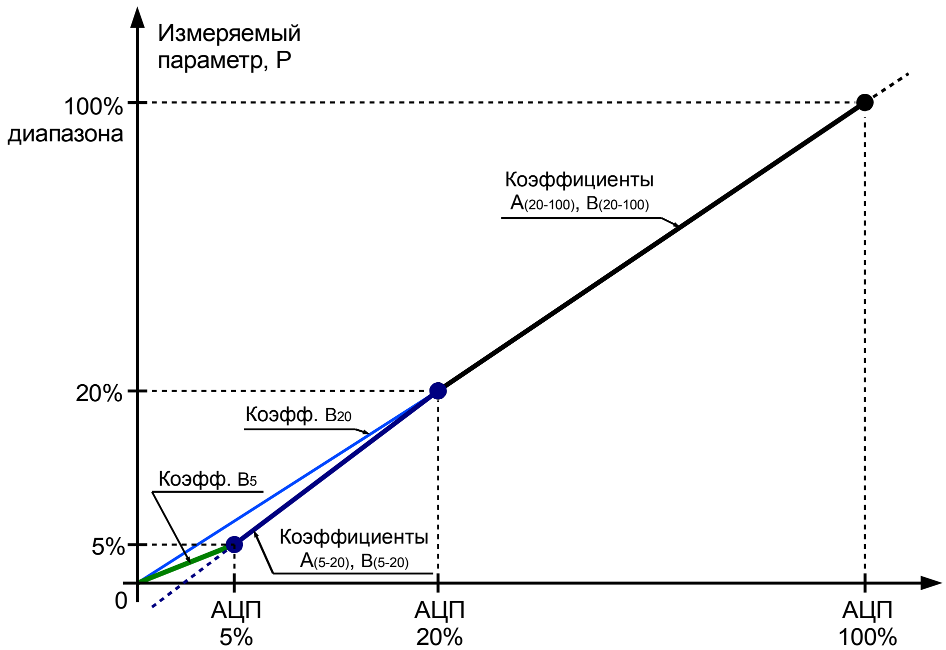


Figure 22 - Transfer characteristic of parameter value calculation from ADC dimension

Generally, parameter value is calculated by the formula:

$$P_{AC} = A + B \cdot ADC_{AC}$$

Where:

P_{AC} – calculated measured parameter value;

ADC_{AC} – parameter value in ADC dimension;

A, B – linear equation factors to calculate measured parameter value.

When measurement channel initializing, determined is a design factors group to calculate variable signals, dividing the total measurement range the into segments. Table 16 shows the selection order of the design factors by priorities (the highest priority is 1).

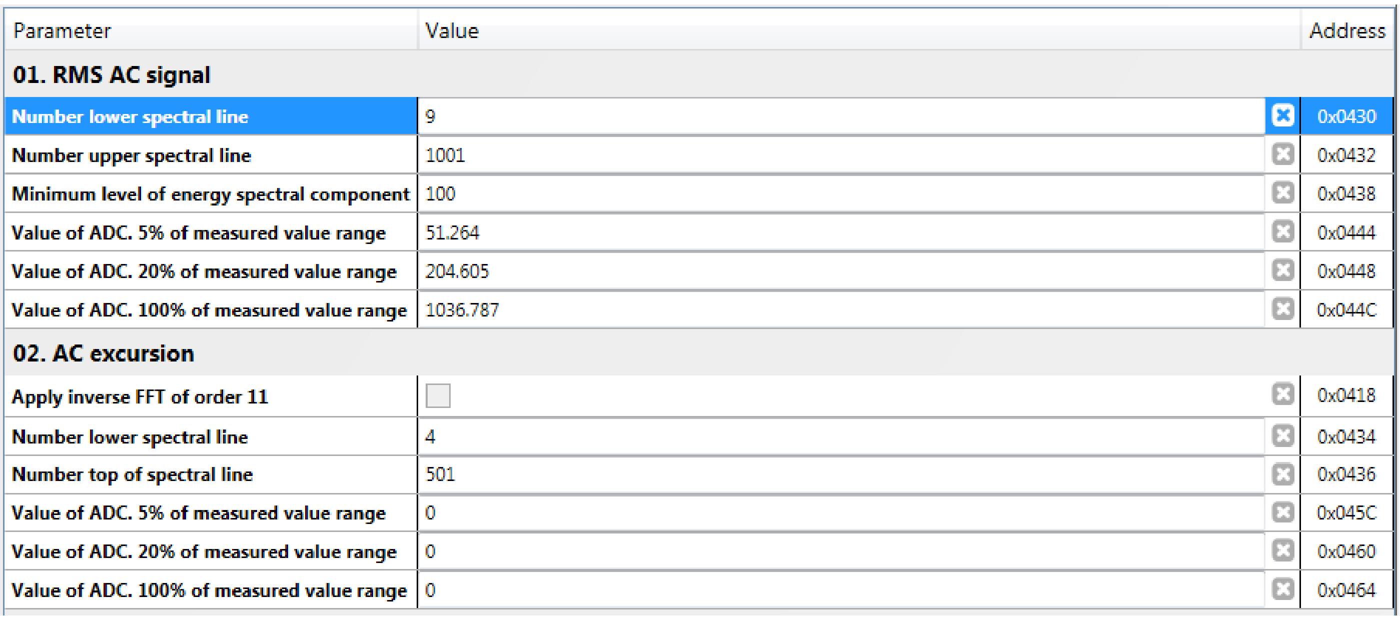
Table 16 - Design factors selection priorities

Priority	Factors group	Measured signal range	Activity condition	Note
1	$A_{20\text{-}100}$, $B_{20\text{-}100}$	from 20 to 100%	1. ADC value exceeds ADC_{20}	and also exceeds 100%
2	$A_{5\text{-}20}$, $B_{5\text{-}20}$	from 5 to 20%	1. Calibration presence at 5% level 2. ADC value exceeds ADC_5	
3	B_5	from 0 to 5%	1. Calibration presence at 5% level 2. ADC value equal to or less than ADC_5	factor A_5 equals to zero
4	B_{20}	from 0 to 20%	1. ADC value equal to or less than ADC_{20}	factor A_{20} equals to zero

In the absence of calibration data at the range 5% level (the ADC_5 value is zero), the factors $A_{5\text{-}20}$, $B_{5\text{-}20}$, and B_5 are not applied.

In order to exclude the parameter value false constant value in the useful signal absence (low signal level) in the measuring ranges ((0-5)% (0-20)%), the only active factors are of type B.

Figure 23 shows an example of channel No.1 main calculated parameters calibration data in ModuleConfigurator software.



Parameter	Value	Address
01. RMS AC signal		
Number lower spectral line	9	0x0430
Number upper spectral line	1001	0x0432
Minimum level of energy spectral component	100	0x0438
Value of ADC. 5% of measured value range	51.264	0x0444
Value of ADC. 20% of measured value range	204.605	0x0448
Value of ADC. 100% of measured value range	1036.787	0x044C
02. AC excursion		
Apply inverse FFT of order 11		0x0418
Number lower spectral line	4	0x0434
Number top of spectral line	501	0x0436
Value of ADC. 5% of measured value range	0	0x045C
Value of ADC. 20% of measured value range	0	0x0460
Value of ADC. 100% of measured value range	0	0x0464

Figure 23 - Example of channel No.1 main calculated parameters calibration data in ModuleConfigurator software

4.8.3 Signal primary sampling integration

If it is necessary to integrate the primary signal (for example, when converting a vibration velocity sensor signal into a vibration displacement), provided in MK32 module computational algorithm is a digital integrator, individually configurable for each measurement channel.

To enable the integrator select measurement channel operating mode “Signal excursion (vibration velocity integration)”;

Figure 23 shows an example of channel No. 1 digital integrator setup in ModuleConfigurator sortware.

Parameter	Value	Address
Default rotor speed (used in absence of synchronization pulses), Hz	50	0x0824
Source capture signal samples	Mode 1 - Signal after integrator	0x08A0
Parameters integrator		
Suppression ratio integration signal (from 0.10 to 5.00), %	0.10	0x08B4
Allowable noise level is relatively constant component	20	0x08A2
Apply adaptive mode integrator	✓	0x08B8

Figure 24 - Example of channel No. 1 digital integrator setup in ModuleConfigurator software

To setup the integrator specify the following parameters:

- `IntegratorDampingFactor` - The integration signal suppression factor, stabilizing the integrator algorithm, however the factor large values suppress the signal low-frequency components;
- `IntegratorNoise` - Permissible noise level relative to a constant component in the ADC dimension;
- `IntegratorUseAdaptive` - Adaptive integration algorithm operation permission that reliminarily detects a sample in the source signal corresponding to the signal zero value after the integrator.

If the integrator is switched on, you can choose the signal sampling capture source (`SamplingSignalSource`):

- 0 - Primary signal, without processing;
- 1 - Signal after integrator.

4.8.4 LF noise spectral filter

The integrator significantly enhances low-frequency spectral components, which can be associated with the sensors operational amplifiers noise, normalizing amplifiers, LPF (low pass filter) of the module or external pickups on the communication line. LF (low frequency) noise presence in the signal can manifest in the measurement results nonstationarity.

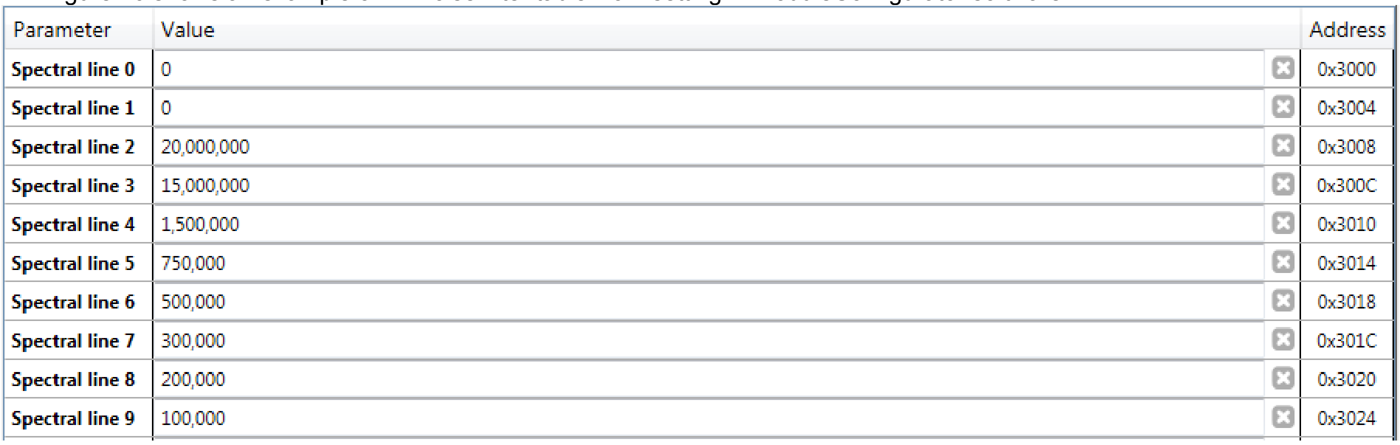
Provided in control module are two tables of the minimum energy level (prior to the square root extraction in ADC dimension) of the useful signal spectral components from 0 to 19 spectral lines. If the spectral component value is below the set level, then it is assumed to be zero.

Figure 25 shows an example of LF noise filter table No.1 assigning to measurement channel No. 1 in ModuleConfigurator software.

Parameter	Value	Address
Nominal coefficient of sensor	0.025	0x0410
Measuring range for RMS AC signal (100%)	500	0x0408
Measuring range for AC signal span (100%)	500	0x040C
Measurement settings		
These ADCs with additional charge, channel selection	Channel 3 external ADC	0x041A
Use 64-bit long calculation	✓	0x041E
Filter LF noise in spectral region	Table №1	0x0424

Figure 25 - Example of LF noise filter table No.1 assigning to measurement channel No. 1 in ModuleConfigurator software

Figure 26 shows an example of LF noise filter table No.1 setting in ModuleConfigurator software.

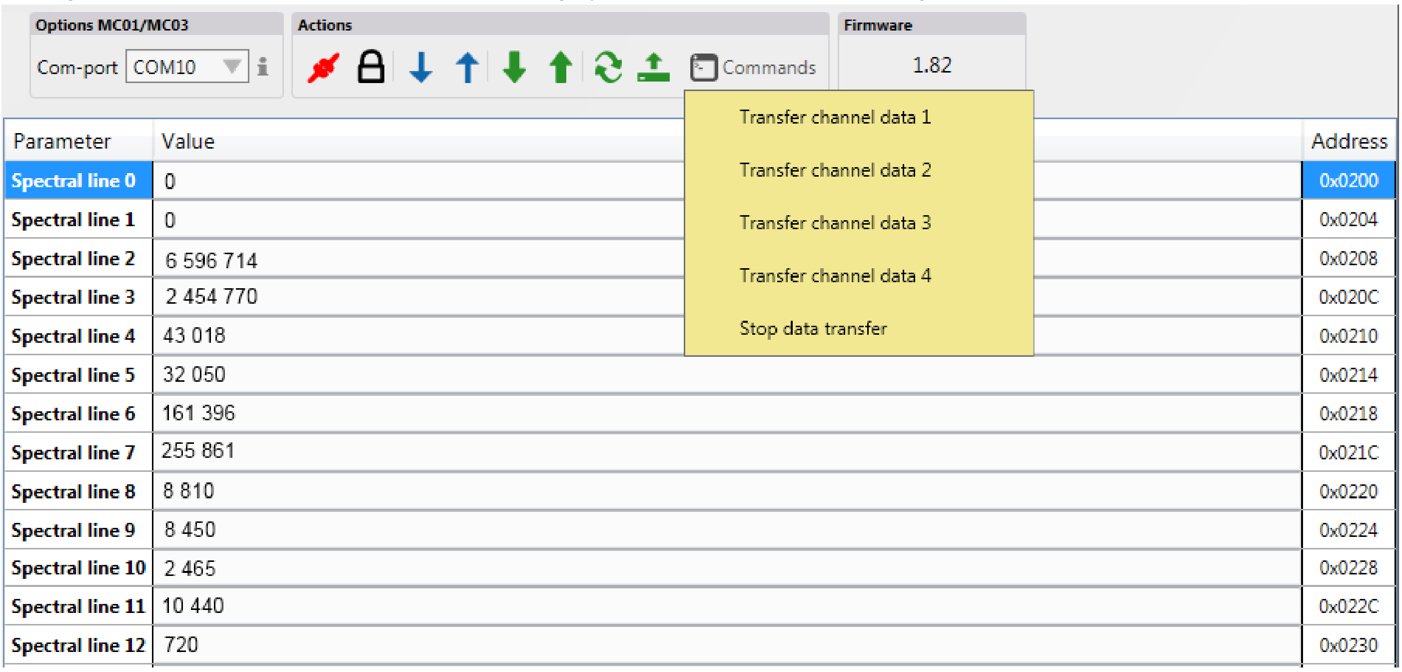


Parameter	Value	Address
Spectral line 0	0	0x3000
Spectral line 1	0	0x3004
Spectral line 2	20,000,000	0x3008
Spectral line 3	15,000,000	0x300C
Spectral line 4	1,500,000	0x3010
Spectral line 5	750,000	0x3014
Spectral line 6	500,000	0x3018
Spectral line 7	300,000	0x301C
Spectral line 8	200,000	0x3020
Spectral line 9	100,000	0x3024

Figure 26 - Example of LF noise filter table No.1 setting in ModuleConfigurator software

LF noise filter spectral lines values are determined experimentally, with the sensor connected at rest (without the vibration signal). Fed to control module is a command to output the spectral lines current energy values by the required measurement channel, current spectral lines values are recorded. It is recommended to increase the experimental data by 1.5 to 2 times when filling in the LF noise filter table.

Figure 27 shows an example LF noise monitoring by channel No.1 in ModuleConfigurator software.



Parameter	Value	Address
Spectral line 0	0	0x0200
Spectral line 1	0	0x0204
Spectral line 2	6 596 714	0x0208
Spectral line 3	2 454 770	0x020C
Spectral line 4	43 018	0x0210
Spectral line 5	32 050	0x0214
Spectral line 6	161 396	0x0218
Spectral line 7	255 861	0x021C
Spectral line 8	8 810	0x0220
Spectral line 9	8 450	0x0224
Spectral line 10	2 465	0x0228
Spectral line 11	10 440	0x022C
Spectral line 12	720	0x0230

Figure 27 - Example LF noise monitoring by channel No.1 in ModuleConfigurator software

4.8.5 FR correction algorithm

Signal frequency response (FR) correction is carried out in the spectral region after LF noise removal, before calculating the measured parameters value and spectrum capturing for transmission over digital communication interfaces.

Module FR correction is carried out on the basis of experimental data of the measurement channel actual FR. It is necessary to:

- Read FR as a pair of values: frequency; amplitude;
- fill in the FR table (up to 30 points);
- specify actual FR data range in table in the measurement channel settings;
- specify the point corresponding to the base frequency;
- permit the FR correction algorithm operation.

The control module automatically calculates the correction factors for each spectral line and brings the spectral line levels to the base frequency. Each measurement channel can be configured with own FR correction.

Table 17 - Example of actual FR data of absolute vibration displacement LF channel

Record No.	1	2	3	4	5	6	7	8	9	10	11	12	13
Frequency, Hz	0.75	1	2	3	5	10	20	40	80	100	160	180	200
Amplitude	68	100	130	120	115	102	101	100	101	100	103	107	113
Correction	1.47	1.00	0.769	0.833	0.870	0.980	0.990	1.000	0.990	1.000	0.971	0.935	0.885

Figure 28 shows an actual FR and FR correction factor according to table 17.

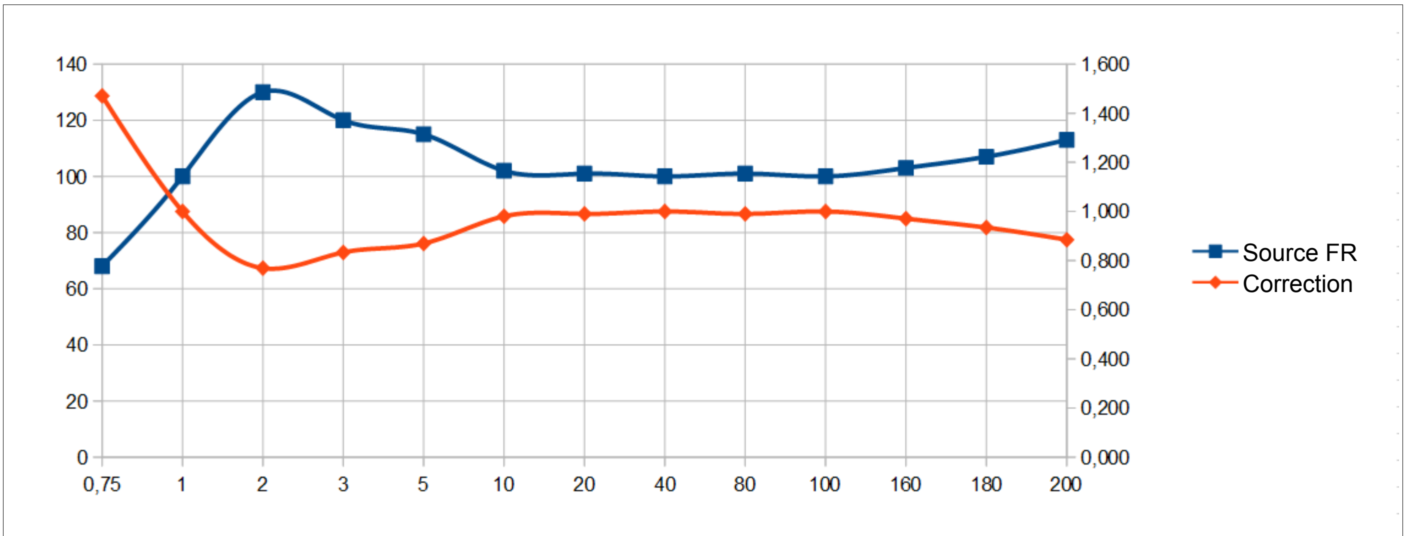


Figure 28 - Actual FR and FR correction factor according to table 17

Between each pair of points, a linear equation is calculated, which is used to correct the amplitude of the corresponding spectral lines.

Figure 29 shows an example of channel No. 1 FR correction setting in ModuleConfigurator software.

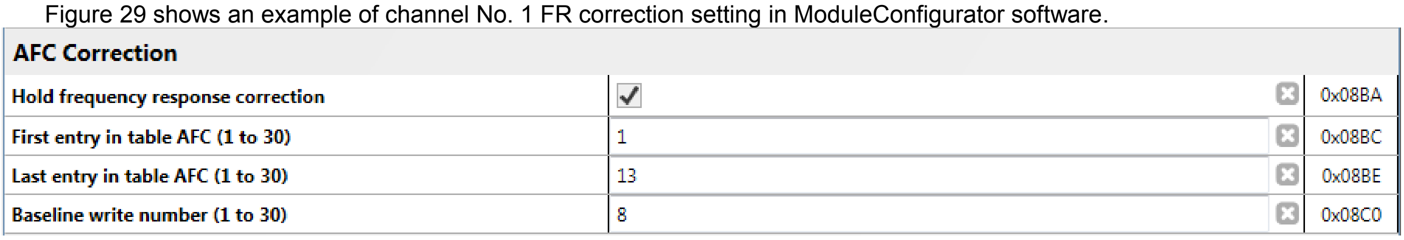


Figure 29 - Example of channel No. 1 FR correction setting in ModuleConfigurator software for module with software version before 1.81

4.8.5.1 Sensor FR correction (module software version 1.82)

In addition to the module FR correction, version 1.82 of the module software adds the ability to specify:

- Sensor FR
- Required (resulting) FR deviation

The control module automatically calculates the correction factors for each spectral line and brings the spectral line levels to the base frequency. Each measurement channel can be configured with own FR correction.

Figure 30 shows the measurement channel No. 1 FR correction setup and Figure 31 shows the filled in table of measurement channel No. 1 FR correction with the data of module FR, sensor FR and the required FR deviation.

Frequency response (FR) Correction		
Carry out FR correction for module	✓	0x08BA
Carry out FR correction for sensor	✓	0x08BA
Carry out FR correction	✓	0x08BA
First entry in FR table (1 to 30)	1	0x08BC
Last entry in FR table (1 to 30)	14	0x08BE
Baseline write number (1 to 30)	6	0x08C0

Figure 30 - Example of the channel No. 1 FR correction setup in ModuleConfigurator software for module with software version from 1.82

	Frequency, Hz	Module	Sensor	Required deviation FR, %
Record 1	2.00	3.9	9.7	-6.0
Record 2	3.00	6.6	10.3	-3.0
Record 3	5.00	8.23	10.25	-1.0
Record 4	10.00	9.5	10.1	0.0
Record 5	20.00	9.89	10.05	0.0
Record 6	40.00	10	10	0.0
Record 7	80.00	10	9.96	0.0
Record 8	160.00	9.922	9.9	0.0
Record 9	315.00	10	9.85	0.0
Record 10	500.00	10	9.81	0.0
Record 11	630.00	10	9.79	0.0
Record 12	800.00	10.04	9.74	0.0
Record 13	900.00	10.15	9.72	-1.0
Record 14	1000.00	10	9.68	-3.0

Figure 31 - Example of the channel No. 1 FR correction table in ModuleConfigurator software for module with software version from 1.82

When configured in the ModuleConfigurator software, the required FR deviation is entered in%, it is stored in module as a division ratio. The value corresponding to the deviation absence (0%) corresponds to the value 1.

4.8.6 Measurement by frequency zones

In addition to the main measurement parameters in the control module, the additional frequency ranges can be defined in which the calculations will be made according to algorithms corresponding to the established mode for the measurement channel.

The lower and upper frequency area boundaries are determined by the linear equation associated with the rotor speed calculated value in Hz.

Frequency area boundaries:

$$F_L = A_L + B_L \cdot F_{Hz}$$
$$F_U = A_U + B_U \cdot F_{Hz}$$

Where:

F_L – frequency area lower boundary;
F_U – frequency area upper boundary;
F_{Hz} – rotor speed value in Hz;
A_L, B_L, A_U, B_U– design, configurable factors.

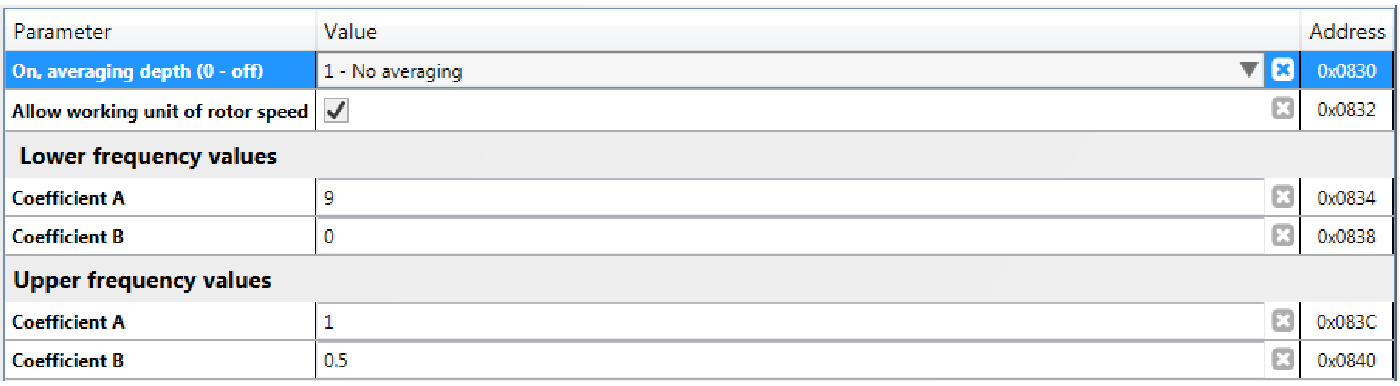
If synchronization pulses are not received, then the nominal unit rotor speed specified in the measurement channel settings can be used.

If, as a result of the calculation F_L is more than F_U, the result over the frequency area is assumed as zero.

Provided for every measurement channel are four (from 0 to 3) frequency areas. However, taking into account the calculations duration in the “Excursion Measurement” mode, only two frequency zones (0, 1) are available for the 10th order IFFT. With IFFT (Inverse Fast Fourier Transform) of the 11th order, only one frequency zone (0) is available.

For each frequency zone, it is possible to indicate the results integration depth from 1 to 10 by the moving average method. Assigned to the calculation results by frequency zones can be the setpoints, the parameter “step” algorithms.

Figure 32 shows an example of frequency zone 0 setup for absolute vibration velocity LF measuring in the frequency range 10-F/2 Hz of channel No.1 in ModuleConfigurator software.



Parameter	Value	Address
On, averaging depth (0 - off)	1 - No averaging	0x0830
Allow working unit of rotor speed	✓	0x0832
Lower frequency values		
Coefficient A	9	0x0834
Coefficient B	0	0x0838
Upper frequency values		
Coefficient A	1	0x083C
Coefficient B	0.5	0x0840

Figure 32 - Example of frequency zone 0 setup for absolute vibration velocity LF measuring in the frequency range 10-F/2 Hz of channel No.1 in ModuleConfigurator software

4.8.7 Rotational components calculation

To calculate the rotational components that are multiples of the rotor speed, the synchronization pulses (phase mark) should be sent to the control module. The synchronization mode is determined by the parameter *SynchronizationMode* and applies to all measurement channels:

- 0 – There is no synchronization, the rotational components are not calculated;
- 1 – Synchronization only on the 1st input;
- 2 – Synchronization only on the 2nd input;
- 3 - the main synchronization channel is input No.1, in the absence of pulses at input No. 1, the calculations synchronization is automatically switched to input No. 2.

The rotational components are calculated by the signal sampling spectral analysis method (512 samples) for 1, 2 or 4 rotor rotations depending on the current speed:

- up to 60 rpm - signal sampling for one rotor revolution, ½ and ¼ rotational components are not calculated;
- from 60 to 120 rpm - signal sampling for two rotor revolutions, ¼ rotational components are not calculated;
- above 120 rpm - signal sampling for rotor four revolutions.

The rotational components measurement can be limited by the rotor speed range, individually for each measurement channel. When the rotor speed is out of specified range, the rotational components are not calculated and assumed to be zero.

Figure 33 shows an example of rotational components measurement setting of channel No.1 in ModuleConfigurator software.

Parameter	Value	Address
Perform calculation rotational component	Compute	0x0816
Minimum allowable speed, rpm	600	0x0880
Maximum allowable speed, rpm	4000	0x0884
Minimum value of parameter for calculating phase	0.05	0x0828
Constant phase shift for 1st part of back, gr	0	0x082C

Figure 33 - Example of rotational components measurement setting of channel No.1 in ModuleConfigurator software

The rotational components calculating algorithm has adjacent calibration data sets to determine the rotational components RMS and excursion.

Figure 34 shows an example of rotational components calibration data of channel No.1 set in ModuleConfigurator software.

Parameter	Value	Address
Phase correct, gr/Hz	-0.213	0x0414
Minimum calculated value back part	0.001	0x0420
01. RMS AC signal		
Value of ADC. 5% of measured value range	42.413	0x0450
Value of ADC. 20% of measured value range	163.798	0x0454
Value of ADC. 100% of measured value range	804.763	0x0458
02. AC excursion		
Value of ADC. 5% of measured value range	0	0x0468
Value of ADC. 20% of measured value range	0	0x046C
Value of ADC. 100% of measured value range	0	0x0470

Figure 34 - Example of rotational components calibration data of channel No.1 set in ModuleConfigurator software

If the rotational component calculated value is less than the parameter “Rotational component minimum calculated value”, then the value of the rotational component and its phase are assumed to be zero.

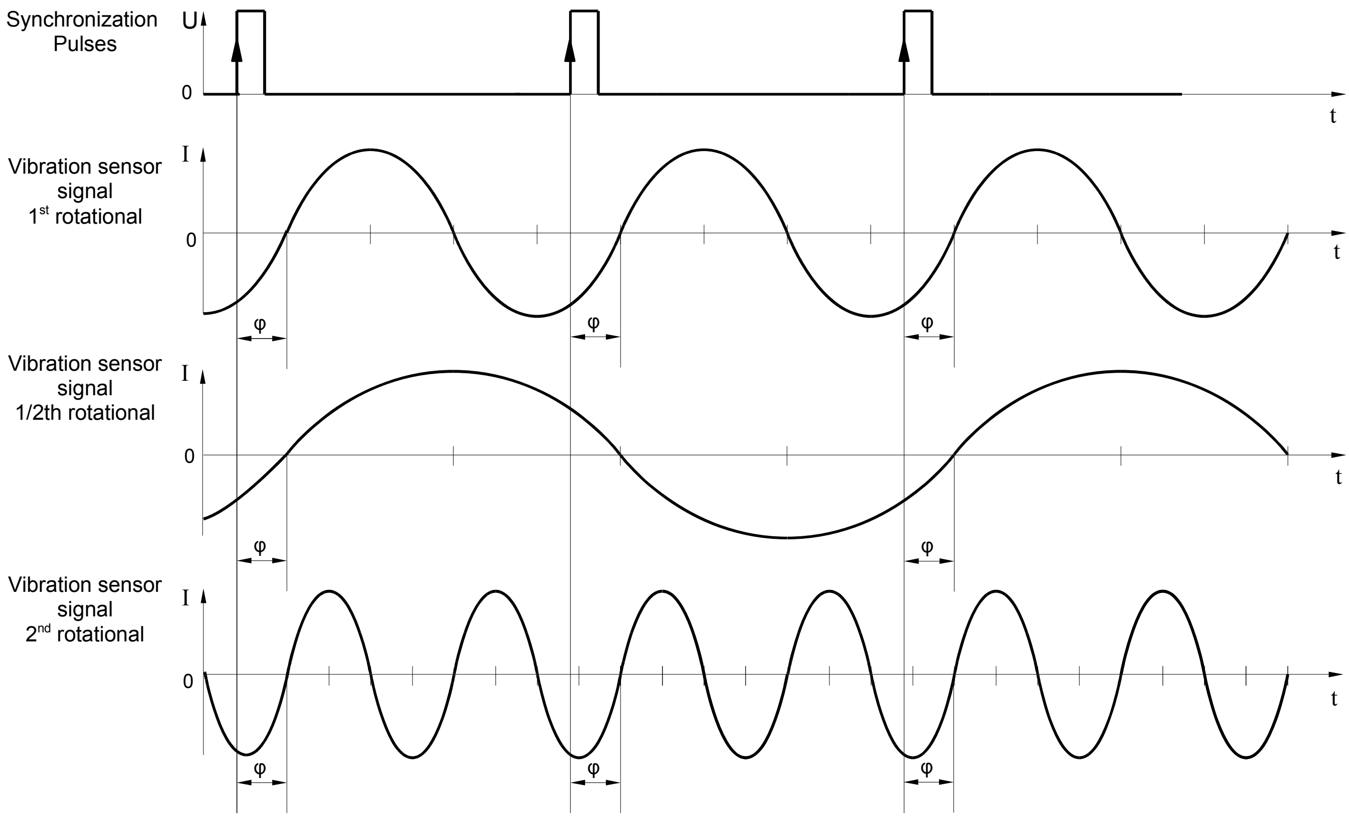
4.8.7.1 Control surface irregularity compensation

When excursion measuring relative to the vibration displacement, it is possible to compensate for the rotor surface irregularity when calculating the rotational components. In the established frequency range (valid for all measurement channels), a control surface is examined: the rotational components determination in the absence of the control surface physical vibration.

In the operating mode the rotational components values obtained during the control surface examination are subtracted from the obtained rotational components. Subtraction is carried out considering the rotational components phase.

4.8.7.2 Rotational components phase calculation

The phase is the time interval in degrees (φ = 0-360) from the positive (active) pulse amplitude edge at the synchronization input (pulse input) to the sinusoidal signal amplitude zero value when transferred from negative to positive. Figure 35 graphically shows the phase measurement for the 1st, 2nd and ½th signal rotational frequency.



Rotational 35 - Time diagrams to calculate the rotational components phase by MK32 module

If the rotational component calculated value is less than the parameter “Minimum parameter value for the phase calculation”, then the rotational component phase value is not calculated and is assumed to be zero.

If calculation synchronization of rotational components is carried out from the control surface of the “Pinion” type (the number of synchronization pulses per rotor rotation is more than 1), the rotational components phases are not calculated and are assumed to be zero.

When calculating the rotational components phase value, the following configuration data is taken into account:

- S_{PH1F} - Constant phase shift for the 1st rotational component, is multiply considered for other rotational components;
- An - Rotor speed sensor installation angle (individually for each synchronization channel);
- C_{PH} - Phase shift correction deg/Hz.

First rotational component phase correction is carried out according to the formula:

$$Ph_{1F} = Pc_{1F} + S_{PH1F} + An + C_{PH} \cdot F_{Hz}$$

Where:

Ph_{1F} – 1st rotational component phase value of vibration signal;

Pc_{1F} – 1st rotational component phase value of the electrical signal at the module input;

F_{Hz} – rotor speed value in Hz.

The similar formula is used to calculate the phase of the other rotational components, multiplying the correction values.

4.8.8 Virtual measurement channels

MK32 control module has four independent virtual measurement channels. Virtual measurement channel values are calculated basing on rotational components of physical measurement channels; Participated in calculations are 22 complex spectral components (each spectral component is divisible by 1/2 rotational component).

Available for virtual measurement channel are the following functions:

- argument 1 integration;
- argument 1 and argument 2 addition;
- argument 2 subtraction from argument 1;
- calculation considering scaling factor.

Where argument 1 and argument 2 are parameter measuring rotational components of physical or virtual measurement channel.

Configurable parameters for every virtual channel:

- measurement channel operation permission (`Enabled`) (1 - channel enabled);
- operating mode (`ModeWork`):
- argument 1 (`Argument1`);
- argument 2 (`Argument2`);
- failures mask (`ParameterCheckErrors`) according to measurement results tables, bit sequence corresponds to parameter `CommonError`;
- apply scaling factor (`UseScaleFactor`) (0 - don't apply);
- AC parameter range upper value (`ValueMax`);
- measurement units (`Units`);

Virtual channels calculations results can be setup for output to LCD and are also available for reading by communication interfaces.

Figure 36 shows an example of virtual channel No.1 setting to calculate support vibration velocity vector in ModuleConfigurator software.

Parameter	Value	Address
Enable channel	☑	0x3500
Work mode	Argument 1 and 2 addition	0x3502
Value range for AC parameter	15	0x3510
Units	mm/s	0x3514
Main settings		
Fault mask	ErCh1; ErCh2;	0x3508
Apply scaling factor	☐	0x350A
Scaling factor	1	0x350C
Argument 1		
Measuring channel	Channel 1	0x3504
Type of measurement channel	Real	0x3504
Argument 2		
Measuring channel	Channel 2	0x3506
Type of measurement channel	Real	0x3506

Figure 36 - Example of virtual channel No.1 setting to calculate support vibration velocity vector in ModuleConfigurator software

Virtual measurement channels can be used to measure rotor absolute vibration displacement by rotational components.

4.8.9 Sampling and signal spectrum request

MK32 module can capture sampling and signal spectrum simultaneously by four measurement channels. At the same time only one capturing type can be executed.

Source signal types available for capturing:

- 4096 samples per 1 second (discretization 4096 Hz);
- 512 samples per 2 rotor revolutions (discretization depends on speed).

Resulted sampling can be converted to sensor instantaneous current.

Available for spectrum request are 1024 spectral lines with resolution (depending on sampling frequency), without phase value.

- 1 Hz – range from 1 to 1023 Hz;
- 0.5 Hz – range from 0.5 to 511.5 Hz;
- 0.25 Hz – range from 0.25 to 255.75 Hz;

Resulted spectra can be preliminary converted to one of physical parameters: vibration velocity RMS, vibration displacement excursion. Approximate warm-up time of spectra/sampling for reading, after request is 1 to 4 seconds.

Available for virtual measurement channels capturing is spectrum of 22 spectral lines with resolution of ½ rotational component.

Broadcast commands support on digital communication interfaces (RS485, CAN2.0B) enables to simultaneously capture sampling/spectrum by all measurement channels of all modules, operating for one unit.

MK32 module software version 1.82 adds the FR correction shape request by spectral lines as multiplier values.

4.9 Measurement channel status monitoring

Provided in MK32 module are registers to monitor measurement channels status, preliminary calculations results:

- measurement channel status flags;
- preliminary calculations results;
- rotational components calculation.

Figure 37 shows an example of measurement channel No. 1 status monitoring in ModuleConfigurator software.

Parameter	Value	Address
Measurement channel status		
Channel enables	[x]	0x0020
Works channel measurement mode	RMS measurement signal	0x0020
Duration of discharge, ms	85	0x0024
Operating check measurement channel		
Sensor current below the allowable level	[x]	0x0020
Sensor current above permissible level	[ ]	0x0020
Initialization of measurement channel settings lock	[x]	0x0020
AC signal overload	[ ]	0x0020
Performing measurements		
Use coefficient of sensor	[ ]	0x0022
Sample signal with additional payment of ADC	[ ]	0x0020
Use of 64-bit integer math algorithms in DSP	[ ]	0x0020
Calculation of constant component	[ ]	0x0020
Inverse FFT of order 11 in calculating magnitude of signal	[ ]	0x0020
Calculation of working capital components	[x]	0x0020
Studies forms reference surface		
Study forms reference surface	[ ]	0x0020
Waiting for study forms reference surface	[x]	0x0020
Performing for study forms reference surface	[ ]	0x0020
AFC correction		
Performing AFC correction	[ ]	0x0022
Error in AFC correction settings	[ ]	0x0022

Figure 37 - Example of measurement channel No. 1 status monitoring in ModuleConfigurator software

4.10 Unified outputs

Provided in MK32 module are 4 assignable unified outputs. All unified outputs have individual settings and operate independently from one another.

Signal level on unified output is in proportion to measured parameter value. Unified output current range corresponds to measured parameter range, can be selected during module setup. Each unified output can be set to monitor one of MK32 module parameters.

Current on unified output is set using 12-bit DAC and active or passive current amplifier (depending on module version). MK32 module is provided with protective stabilitron (breakdown voltage 27 V) and resettable fuse 200 mA to protect unified output circuits.

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

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

Where:

ADC_{OUT} – calculated ADC value;

D_{Param} – calculated measured parameter value;

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

A_O, B_O factors are automatically calculated during module operation initialization according to unified output current range data (`OutCurrentMin`, `OutCurrenMax`), parameter range fed to unified output (`ParameterMin`, `ParameterMax`) and DAC saved values (`OutDacMin`, `OutDacMax`), corresponding to current range of calibrated unified output (20% from `OutCurrenMax`, `OutCurrenMax`).

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

If one pair of calibration values (`20% from OutCurrenMax – OutCurrenMax` or `ParameterMin – ParameterMax`, `OutDacMin – OutDacMax`) equals to zero or they are equal to each other, then factors A_O, B_O are not calculated and are set to zero (DAC_{OUT} value always equals to zero).

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

Unified output is connected to measured parameter by setting the parameter address `ParameterAddress` according to register address table for communication interfaces. The unified output parameter type should be Float.

Failures mask (`ParameterCheckErrors`) according to measurement results tables, bit sequence corresponds to parameter `CommonError`.

Implemented in module version MK32-DC-20-R2-M-RAM-PO are galvanically isolated (between themselves and the power supply module) unified current outputs with a passive current regulator. Specified in the module system settings should be the DAC type used in module MK32 (parameter `DacExternalType`), module software version 1.80.

Figure 38 shows an example of unified output No.1 setting in ModuleConfigurator software.

Parameter	Value	Address
Unified output operation permission	✓	0x0F00
Sending parameters		
Parameter address	Main measur. param. channel 1	0x0F02
Lower range of parameter value	0	0x0F0C
Upper range of parameter value	15	0x0F10
Control fault measurement channel		
Fault mask	ErCh1;	0x0F04
Set fault current if detected fault channel measured	✓	0x0F06
Current fault measurement channel, mA	2.00	0x0F08
Calibration data		
Lower value of current output range, mA	4.00	0x0F14
Upper value of current output range, mA	20.00	0x0F18
Lower value of the DAC output	799	0x0F1C
Upper value of the DAC output	4000	0x0F1E

Figure 38 - Example of unified output No.1 setting in ModuleConfigurator software

4.11 Module logic functions

MK32 control module can generate warning signaling and unit emergency shutdown logic signals. Implemented for parameters monitoring in module are measured parameter value control functions (setpoints check by measured parameter level) and parameter “step” detection algorithms.

4.11.1 Parameter calculated value comparison with setpoints

Provided in MK32 module are 32 assignable setpoints. All setpoints have individual settings and operate independently from one another. Each setpoint can be set to monitor one of MK32 module parameters.

All setpoints have the following settings:

- setpoint operating mode (`CheckMode`);
  - 0 – disabled;
  - 2 – control “up”;
  - 2 – control “down”.
- parameter address (`ParameterAddress`) according to measurement results tables;
- failures mask (`ParameterCheckErrors`) according to measurement results tables, bit sequence corresponds to parameter `CommonError`.
- detection time of transition over setpoint by 0.5 s (`TimeOut`);
- setpoint value (`CheckValue`);
- setpoint hysteresis (`CheckValueHist`).

If monitored parameter value was above (lower) than setpoint “up” (”down”) during time (TimeOut), then corresponding parameter setpoint overrange flag (`ControlPoint`) is set to “1”.

In case of set parameter setpoint overrange flag, measured parameter value should be less (more) than corresponding setpoint, minus (plus) hysteresis (`CheckValueHist`) during established time, to reset parameter setpoint overrange flag to “0”. This approach prevents possible trigger effect at measured parameter value close to setpoint value.

Figure 39 shows example of signaling operation by setpoint of 1.7 mm (rotor axial shift monitoring) with hysteresis of 0.02 mm.

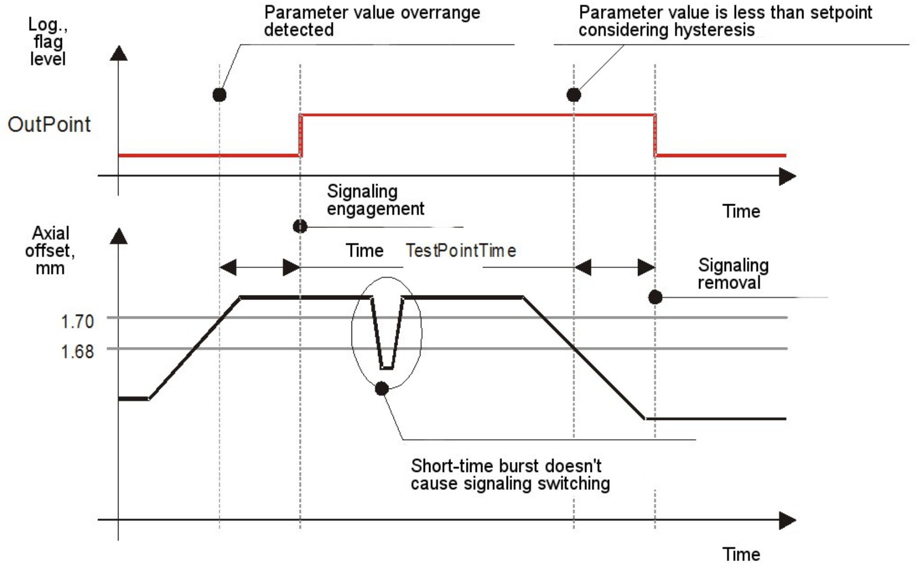


Figure 39 - Example of setpoint algorithm operation (mode – check above setpoint)

Figure 40 shows an example of setpoint No.1 setting in ModuleConfigurator software.

Parameter	Value	Address
Setpoint operating mode	Control «up»	0x1800
Parameter address	Main measur. param. channel 1	0x1802
Failures mask	ErCh1;	0x1804
Detection time of transition over setpoint, sec	1	0x1806
Setpoint value	4.5	0x1808
Setpoint hysteresis	0.1	0x180C

Figure 40 - Example of setpoint No.1 setting in ModuleConfigurator software

4.11.2 Parameter “step” detection

To detect parameter value instantaneous and irreversible change, implemented are 8 independent algorithms of parameter “step” detection. Each algorithm can be set to monitor one of MK32 module parameters. “Step” detection algorithm is the same for all measured parameters but each parameter can have its own “step” detection settings.

All algorithms have the following settings:

- step operating mode (`Enabled`):
  - 0 – disabled;
  - 1 – control “up”, “down”;
  - 2 – control “up” only;
- initialization time out by 0.5 s (`TimeOutInit`) – parameter stabilization waiting time after normalizing sensor operation or speed stabilization for rotational components;
- stabilization time out by 0.5 s (`TimeOutStable`) – parameter stabilization waiting time if parameter change is less than `ValueSense` per one measurement cycle (0.5 s);
- step detection flag active status time by 0.5 s (`TimeOutActive`);
- parameter address according to measurement results tables (`ParameterAddress`);
- failures mask (`ParameterCheckErrors`) according to measurement results tables, bit sequence corresponds to parameter `CommonError`.
- step algorithm sensitivity (`ValueSense`) – parameter minimum value increment per measurement cycle (0.5 s);
- step minimum level (`CheckValueHist`) – parameter minimum change level relative to “step” detection initial value and parameter value after stabilization.

Step detection algorithm has several statuses (explanations on Figure 43):

- pause after initialization;
- waiting for parameter change for more than `ValueSense` to start “step” detection;
- waiting for “step” stabilization;
- parameter “step” detected.

Parameter “step” algorithm actuation versions are shown in the figure 41, not actuation - in the figure 42.

Flags and step detection algorithm are reset by:

- device reset;
- sensor failure;
- command from external control interfaces;
- pressing buttons on module front panel.

Two types of step detection flags are available for reading by communication interfaces:

- step detection flags – active status;
- step detection flags – latch;

“Step” algorithm actuation flags are available for reading by communication interfaces:

Figure 44 shows the parameter value change versions when the parameter “step” is detected.

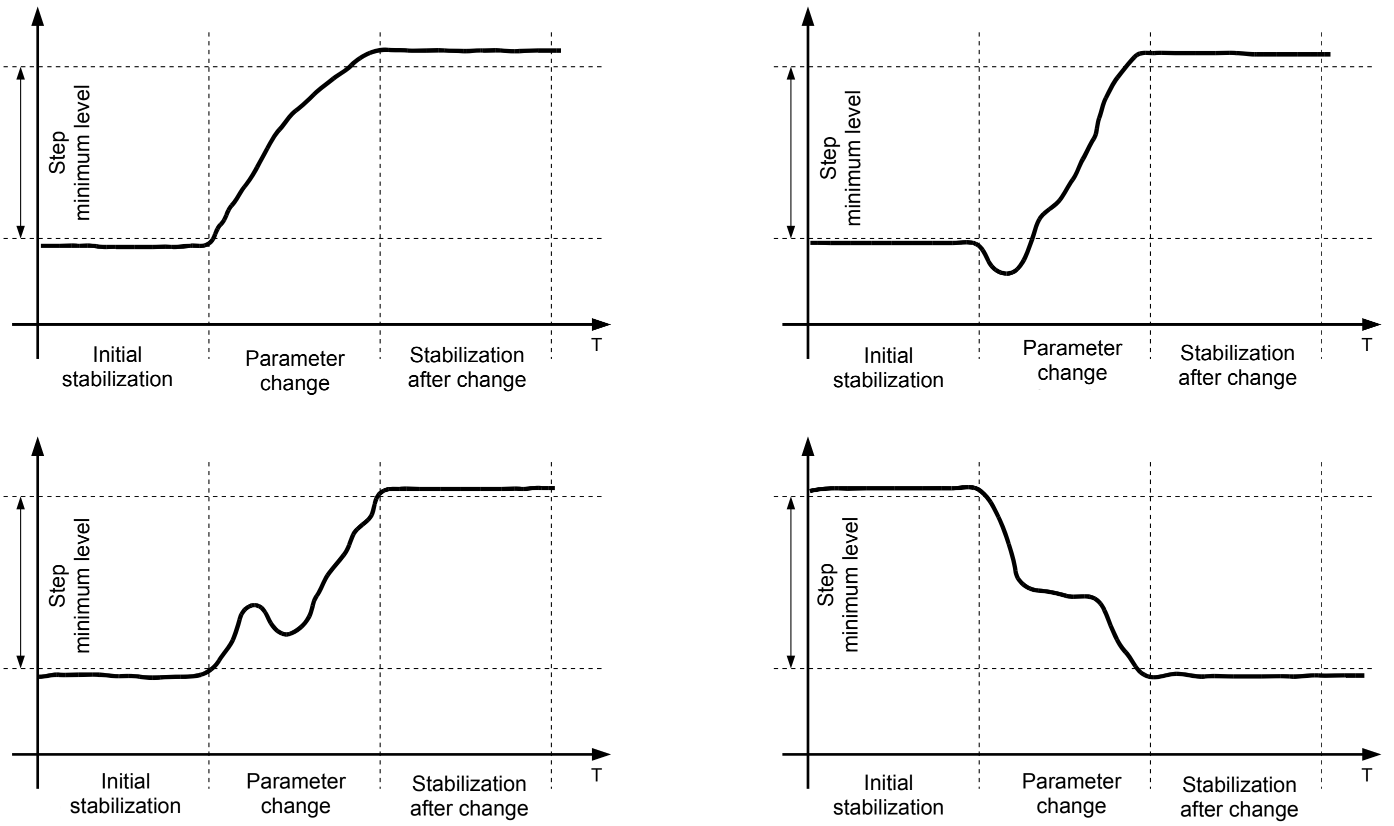


Figure 41 - Parameter value change versions when the parameter “step” is detected

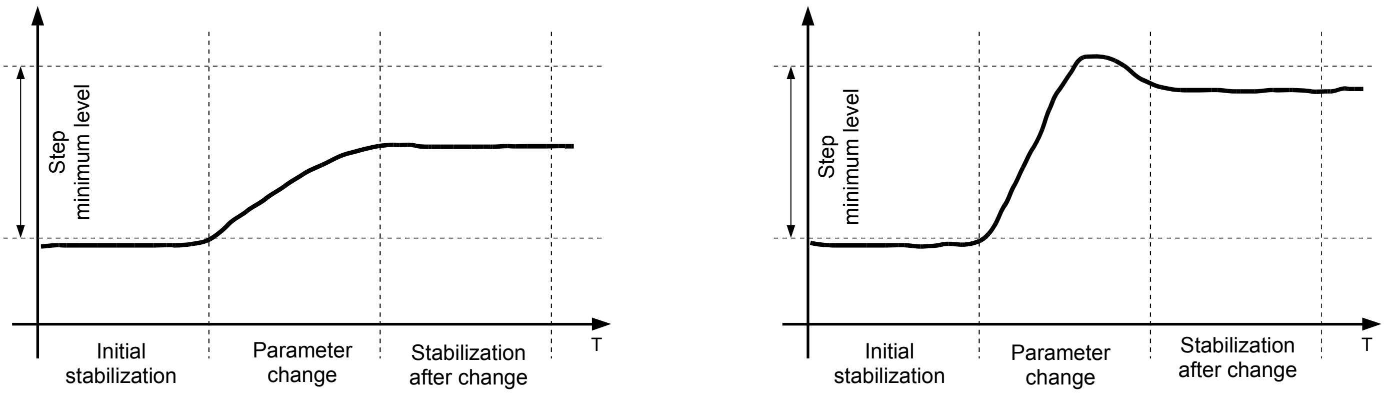


Figure 42 - Parameter value change versions when the parameter “step” is not detected

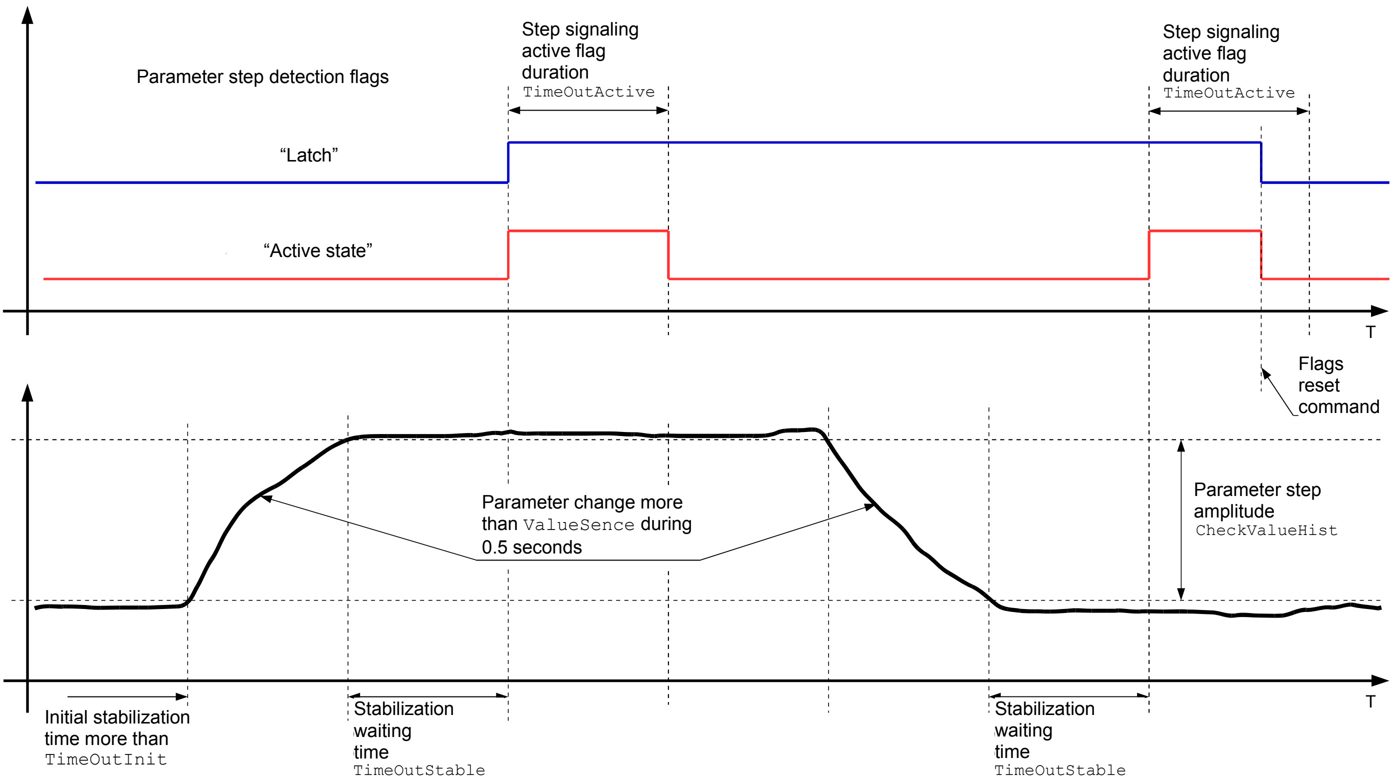


Figure 43 - Parameter "step" detection algorithm operation explanations

Parameter	Value	Address
Setpoint operating mode	Increasing, decreasing value	0x1B00
Initialization time out, sec	10	0x1B02
Stabilization time out, sec	10	0x1B04
Active status time by 0.5 s, sec	10	0x1B06
Parameter address	Main measur. param. channel 1	0x1B08
Failures mask	ErCh1; ErSync; ErStab;	0x1B0A
Step algorithm sensitivity	0.1	0x1B0C
Step minimum level	1	0x1B10

Figure 44 - Example of step No.1 algorithm setting in ModuleConfigurator software

4.11.3 Logic outputs

Provided in MK32 module are 14 logic outputs with open collector (active level - zero). Logic inputs circuit engineering enables direct connection of relay windings.

Operation of each of 14 logic outputs is configured by user using communication digital interfaces.

If check sum error is detected by one of module operation parameters section, logic output 12 will have signal active level, other logic outputs of MK32 module will remain inactive.

Logic outputs operation is blocked after reset for a time `InitModulTimeOut`, counted after completing MK32 module initialization cycle.

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

Each logic output is setup in analytical form using logical rules. Also configured in analytical form is operation of LEDs “War” and :Alarm” on module front panel.

Used in logical operations are boolean functions on module status flags.

Logical rules command structure is given in Table 37.

To setup and edit logical rules provided in program ModuleConfigurator.exe, provided is a special mean to form logical rules in convenient and simplified form making unnecessary to directly enter the command codes.

4.11.3.1 Registers notation system

Notation system used in setup program ModuleConfigurator to generate logical rules in analytical form:

- Mg.Nbit - Global memory (16 bit) common for all logic outputs. Available during one calculation cycle of logic outputs status. Cleared before executing new cycle.
- Rch{Nch}.Nbit - Measurement channel status register;
- Rchf{Nchf}.Nbit - Frequency measurement channel status register;
- Rvr.Nbit - Rotational components measurement status register;
- Rdv.Nbit - Control module status register;
- Rer.Nbit - Errors status register;
- Rjl.Nbit - Step (latch) algorithm status register;
- Rja.Nbit - Step (active statuses) algorithm status register;
- Rtp.Nbit - Setpoints control algorithm status register.

where:

Nbit - bit number in corresponding register (0...15),

{Nch} - measurement channel number (1...4),

{Nchf} - frequency measurement channel number (1, 2).

Logical operations used in the program to generate logical rules:

"X**->** Mg.Nbit" - recording logical rules calculation results to global memory;

“ | “ - logical operation “OR”;

“ ^ “ - logical operation “exclusive OR”;

“ & “ - logical operation “AND”;

“ ! “ - logical operation “NOT”;

“ ( ) “ - parentheses are permissible to define calculation order;

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

Logical operations execution order (top down in order):

1) " ! “ - logical operation “NOT”;

2) “ & “ - logical operation “AND”;

3) “ | “ and “ ^ “ are equivalent, logical operation “OR”, logical operation “exclusive OR”;

4) “**->** “ - calculation results recording.

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

Figure 45 shows an example of logic outputs algorithm setting in ModuleConfigurator software. Figure 46 shows an example of logic outputs status monitoring in ModuleConfigurator software.

Parameter	Value	Address
Output 1 logical rule	Rtp.0 | Rtp.8 | Rtp.16	0x1C00
Output 2 logical rule	Rtp.1 | Rtp.9 | Rtp.17	0x1C20
Output 3 logical rule	Rtp.2	0x1C40
Output 4 logical rule	Rtp.10	0x1C60
Output 5 logical rule	Rtp.18	0x1C80
Output 6 logical rule	Rja.0	0x1CA0
Output 7 logical rule	Rja.2	0x1CC0
Output 8 logical rule	Rja.4	0x1CE0
Output 9 logical rule	Rtp.3 | Rtp.11 | Rtp.19	0x1D00
Output 10 logical rule		0x1D20
Output 11 logical rule		0x1D40
Output 12 logical rule	Rch1.4 | Rch1.5 | Rch2.4 | Rch2.5 | Rch3.4 | Rch3.5 | Rch4.4 | Rch4.5 | Rtp.25	0x1D60
Output 13 logical rule		0x1D80
Output 14 logical rule		0x1DA0
LED 'War' logical rule	Rtp.0 | Rtp.8 | Rtp.16 | Rtp.3 | Rtp.11 | Rtp.19	0x1DC0
LED 'Alarm' logical rule	Rtp.2 | Rtp.10 | Rtp.18 | Rja.0 | Rja.2 | Rja.4	0x1DE0

Figure 45 - Example of logic outputs algorithm setting in ModuleConfigurator software

Parameter	Value	Address
Logic output 1	☐	0x00F0
Logic output 2	☐	0x00F0
Logic output 3	☐	0x00F0
Logic output 4	☐	0x00F0
Logic output 5	☐	0x00F0
Logic output 6	☐	0x00F0
Logic output 7	☐	0x00F0
Logic output 8	☐	0x00F0
Logic output 9	☐	0x00F0
Logic output 10	☐	0x00F0
Logic output 11	☐	0x00F0
Logic output 12	☑	0x00F0
Logic output 13	☐	0x00F0
Logic output 14	☐	0x00F0
Logic output 'War'	☐	0x00F0
Logic output 'Alarm'	☐	0x00F0

Figure 46 - Example of logic outputs status monitoring in ModuleConfigurator software

Logic outputs status is available even when user blocks the logic signaling.

4.12 Module calibration recommendations

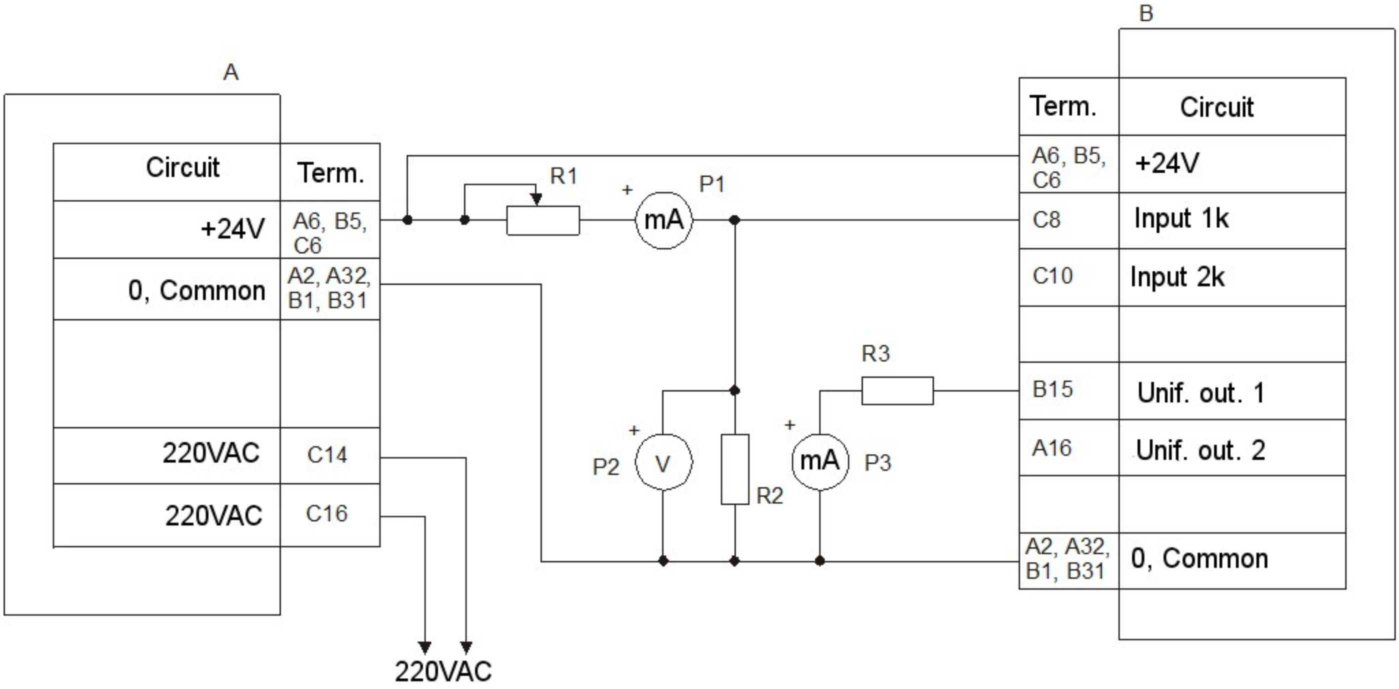
MK32 module calibration procedure permits repeated calibration without module cold start and measurement channel range change – without repeated calibration of measurement channels and unified outputs. In case of measurement channel or unified output current range change, it is necessary to carry out repeated calibration.

After module calibration it is necessary to load calibration data into module, save into module non-volatile memory and reboot module. Module calibration is carried out using commands by digital communication interfaces with target software. Calibration results recording into MK32 module and factors repeated calculation can be carried out once after all calibration steps (input, unified output).

4.12.1 DC calibration

MK32 module connection diagram for DC calibration and check is given in Figure 47. It is recommended to calibrate MK32 module using stand СП43 enabling to connect the stated diagram.

For module version MK32-DC-20-R2-M-RAM-PO the connection diagram of milliammeter P3, resistor R3 to galvanically isolated current output is shown in figure 51.



A – МП24 or БП17 ***B*** – МК32 ***R1*** – resistance box 100 kOhm

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

P2 – DC voltmeter grade 0.1

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

Figure 47 - MK32 module connection diagram for DC calibration and check

Measurement channel input DC calibration sequence:

1 specify measurement channel current range values (`ConstCurrentMin`, `ConstCurrentMax`);

2 specify measured parameter range (`ConstValueMin`, `ConstValueMax`);

3 at measurement channel input set current 20 % from `ConstCurrentMax`;

4 overwrite `Constant` value into `ConstAdcMin`;

5 at measurement channel input set current `ConstCurrentMax`;

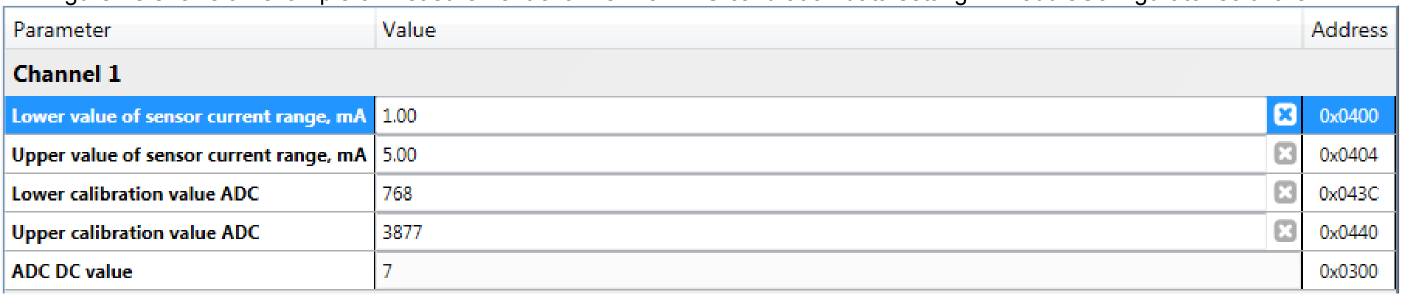
6 overwrite `Constant` value into `ConstAdcMax`;

7 send calibration results into MK32 module;

8 re-calculate factors.

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

Figure 48 shows an example of measurement channel No.1 DC calibration data setting in ModuleConfigurator software.



Parameter	Value	Address
Channel 1		
Lower value of sensor current range, mA	1.00	0x0400
Upper value of sensor current range, mA	5.00	0x0404
Lower calibration value ADC	768	0x043C
Upper calibration value ADC	3877	0x0440
ADC DC value	7	0x0300

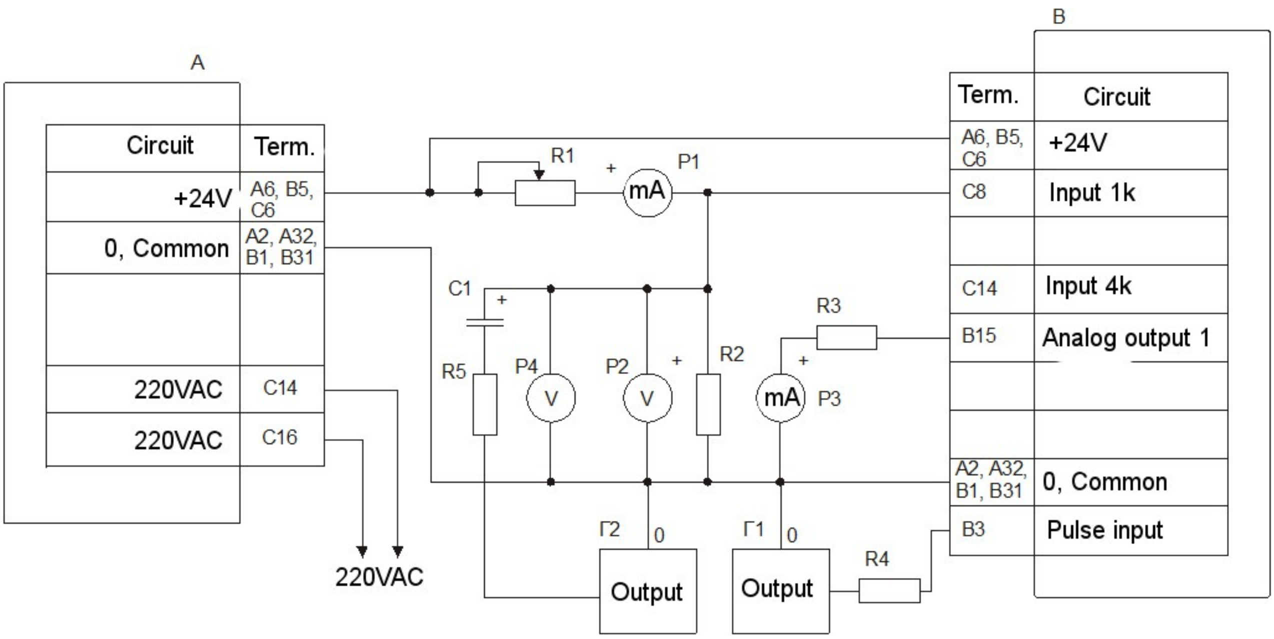
Figure 48 - Example of measurement channel No.1 DC calibration data setting in ModuleConfigurator software

4.12.2 AC calibration

MK32 module connection diagram for AC calibration and check is given in Figure 49.

It is recommended to calibrate MK32 module using stand СП43 enabling to connect the stated diagram.

For module version MK32-DC-20-R2-M-RAM-PO the connection diagram of milliammeter P3, resistor R3 to galvanically isolated current output is shown in figure 51.



A – МП24 or БП17 ***B*** – MK32 ***R1*** – resistance box 100 kOhm

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

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

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

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

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

Figure 49 - MK32 module connection diagram for AC calibration and check

Measurement channel input AC calibration sequence (signal RMS):

1 Before measurement channel input AC calibration it is necessary to carry out measurement channel input DC calibration as described in p. 4.12.1;

2 Use resistor R1 to set DC of (3±0.2) mA or (12±0.8) mA by milliammeter P1 for AC channel of by voltmeter P2 VDC of (1.7±0.1) V for VAC channel;

3 Set base frequency of 80 Hz and squared pulses amplitude +5V at Г1 generator output.

4 State AC parameter range upper value:

- `RangeRMS` - Variable signal RMS measurement range (100 %);

5 Set harmonic signal RMS value corresponding to 100 % of `RangeRMS`:

5.1 Overwrite `VariableRms` value into `AdcRMS_100`;

5.2 Overwrite `ValueRMS1F` value into `AdcRMS1F_100`;

6 Set harmonic signal RMS value corresponding to 20 % of `RangeRMS`:

6.1 Overwrite `VariableRms` value into `AdcRMS_20`;

6.2 Overwrite `ValueRMS1F` value into `AdcRMS1F_20`;

7 Set harmonic signal RMS value corresponding to 5 % of `RangeRMS`:

7.1 Overwrite `VariableRms` value into `AdcRMS_5`;

7.2 Overwrite `ValueRMS1F` value into `AdcRMS1F_5`;

8 Send calibration results into MK32 module;

9 Re-calculate factors.

Variable signal excursion calibration is carried out in the same way as variable signal RMS calibration using registers `RangePP`, `AdcPP_5`, `AdcPP_20`, `AdcPP_100`, `AdcPP1F_5`, `AdcPP1F_20`, `AdcPP1F_100`, `ValuePP`, `ValuePP1F`.

Figure 48 shows an example of measurement channel No.1 AC calibration data setting (signal RMS) in ModuleConfigurator software.

Parameter	Value	Address
Channel 1		
Measuring range for RMS AC signal (100%)	500	0x0408
Value of ADC. 5% of measured value range	51.264	0x0444
Value of ADC. 20% of measured value range	204.605	0x0448
Value of ADC. 100% of measured value range	1036.787	0x044C
ADC RMS alternating current (AC)	0	0x0304

Figure 50 - example of measurement channel No.1 AC calibration data setting (signal RMS) in ModuleConfigurator software

4.12.3 Unified output calibration

Unified output range by measured parameter corresponds to range of `ParameterMin`, `ParameterMax`.

For MK32 module with software version 1.80 it is necessary to specify the unified current outputs type in system settings (`DacExternalType`).

Unified output calibration consists of the following steps:

1 Specify unified output current range value (`OutCurrentMin`, `OutCurrentMax`);

2 Record value in `AnalogDirectData` to select unified output current (by milliammeter) equal to 20% of `OutCurrentMax`;

3 Overwrite `AnalogDirectData` value into `OutDacMin`;

4 Record value in `AnalogDirectData` to select unified output current (by milliammeter) equal to `OutCurrentMax`;

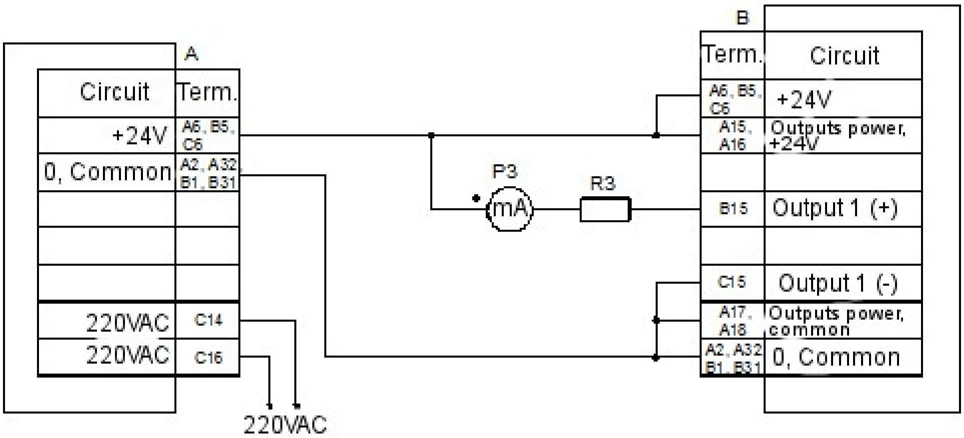
5 Overwrite `AnalogDirectData` value into `OutDacMin`;

6 Record zero into `AnalogDirectData` (disable calibration mode);

7 Send calibration results into MK32 module;

8 Re-calculate factors.

Figure 51 shows milliammeter connection diagram to calibrate unified current outputs with galvanic isolation (module version МК32-DC-20-R2-RAM-PO).



A – МП24 or БП17

B – МК22

R3 – resistors (500±10) Ohm, 0.5 W

P3 – DC milliammeter (0-20) mA, grade 0.2

Figure 51 - МК32 module connection diagram for unified current output calibration and check module version МК32-DC-20-R2-RAM-PO

Figure 52 shows an example of unified current output No.1 calibration data setting in ModuleConfigurator software.

Parameter	Value	Address
Calibration data		
Lower value of current output range, mA	4.00	0x0F14
Upper value of current output range, mA	20.00	0x0F18
Lower value of DAC output	799	0x0F1C
Upper value of DAC output	4000	0x0F1E
Direct control of DAC		
DAC value for direct output control	0	0x0E00

Figure 52 - Example of unified current output No.1 calibration data setting in ModuleConfigurator software

5 Digital control interfaces

MK32 module supports four independent control interfaces:

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

All interfaces can operate simultaneously without interfering one another.

Warning. Power supply source, driver microchips of RS485 and CAN2.0B interfaces, diagnostic interface **have no galvanic isolation**. MK32 module with galvanic isolation of communication interfaces and power supply is manufactured upon separate agreement.

5.1 RS485 interface

MK32 module is provided with RS485 bus semiduplex driver microchip for operation by RS485 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 for each interface.

5.1.1 Module operation parameters setup by ModBus 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.

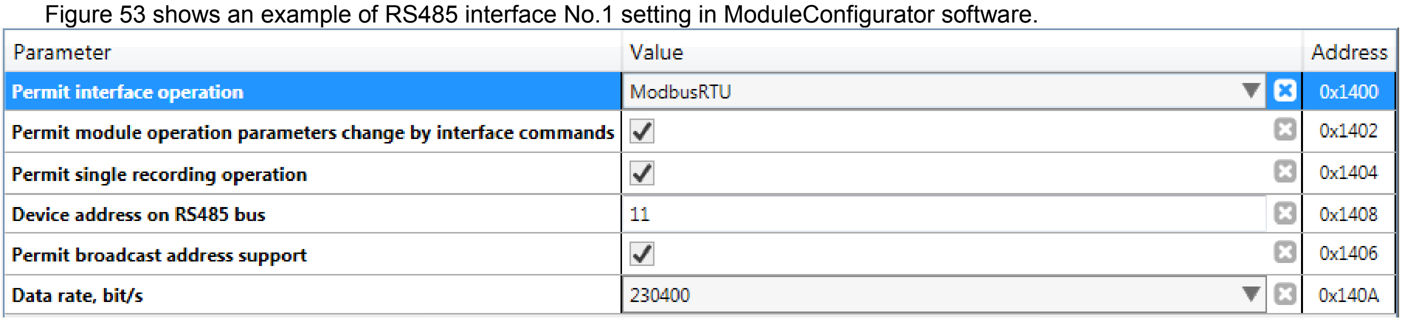
Error message format (5 bytes):

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

Table 18 - ModBus protocol possible error codes

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

Figure 53 shows an example of RS485 interface No.1 setting in ModuleConfigurator software.



Parameter	Value	Address
Permit interface operation	ModbusRTU	0x1400
Permit module operation parameters change by interface commands	✓	0x1402
Permit single recording operation	✓	0x1404
Device address on RS485 bus	11	0x1408
Permit broadcast address support	✓	0x1406
Data rate, bit/s	230400	0x140A

Figure 53 - Example of RS485 interface No.1 setting in ModuleConfigurator software

5.1.2 ModBus protocol supported commands

Table 19 - Implemented commands of ModBus protocol in MK32 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	
0x0B	Diagnostics Diagnostic commands	Device address Function (0x08) Subfunction, high byte Subfunction, low byte Data, high byte Data, low byte CRC, low byte CRC, high byte	Device address Function (0x08) Subfunction, high byte Subfunction, low byte Data, high byte Data, low byte CRC, low byte CRC, high byte	List of supported diagnostic commands is given in Table 20

Table20 - List of ModBus protocol supported diagnostic commands

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

5.1.3 Check sum calculation in messages

Check sum CRC consists of two bytes. Check sum CRC is calculated by transmitting device and added into each message end. Receiving device calculates check sum during reception and compares with received message CRC field. CRC counter is preliminary initialized with value of 0xFFFF.

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

5.1.4 ModBusRTU protocol control features

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

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

5.1.5 VibrobitRTU protocol control features

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

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

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

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

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

5.2 CAN2.0B interface

CAN2.0B interface enables MK32 module status data transmission to indicating units and MK71 logic modules. MK32 module doesn’t support module control by CAN2.0B interface.

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

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

5.2.1 Format of messages transmitted by CAN2.0B interface

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

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

Measuring results data are sent with periodicity `CanBasicTime`. Generated for every measurement channel is its own message with unique message code:

Table 21 - CAN2.0B interface message codes when transmitting main measured parameter

Data description	Message codes bu measurement channels			
	Channel 1	Channel 2	Channel 3	Channel 4
Main measured parameter value	0x30	0x40	0x50	0x60

Sent in each message is module status bits value and also status bits of the corresponding measurement channel. 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 send no messages by CAN2.0B interface, but module generates messages normal transmission confirmation of other modules, connected to CAN2.0B bus.

Figures 54 and 55 show CAN message format of main measured parameter and signaling CAN message format.

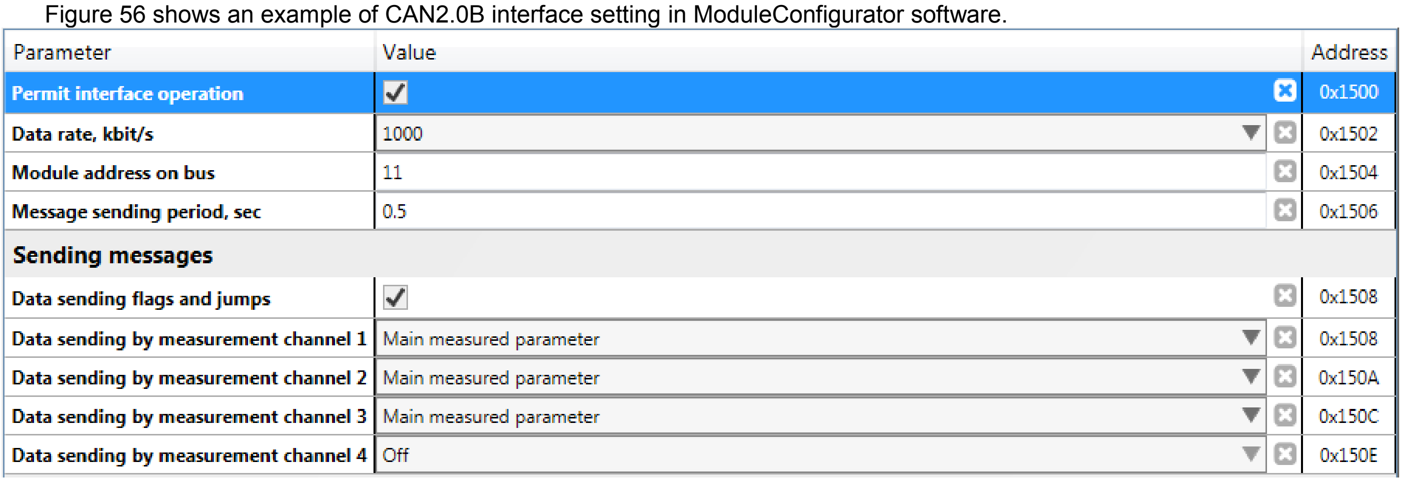
Byte number in message							
0	1	2	3	4	5	6	7
Message code	Module status	Parameter value (Float 4 bytes)				Measurement channel status	
Ref. Table 21	DeviceStatus <7:0>					Status<15:0>	

Figure 54 - CAN message format of main measured parameter

Byte number in message							
0	1	2	3	4	5	6	7
Message code	Standby	Step algorithm status flags		Setponts status flags			
0x80	0x00	ControlJumpLatch	ControlJumpActive	ControlPoint			

Figure 55 - Signaling CAN message format

Figure 56 shows an example of CAN2.0B interface setting in ModuleConfigurator software.



Parameter	Value	Address
Permit interface operation	✓	0x1500
Data rate, kbit/s	1000	0x1502
Module address on bus	11	0x1504
Message sending period, sec	0.5	0x1506
Sending messages		
Data sending flags and jumps	✓	0x1508
Data sending by measurement channel 1	Main measured parameter	0x1508
Data sending by measurement channel 2	Main measured parameter	0x150A
Data sending by measurement channel 3	Main measured parameter	0x150C
Data sending by measurement channel 4	Off	0x150E

Figure 56 - Example of CAN2.0B interface setting in ModuleConfigurator software

5.3 SPI slave interface

SPI slave interface is intended to control module operation and setup its operation parameters. SPI interface connector is arranged on module front panel (D.Port). SPI slave interface parameters are rigidly predetermined, therefore regardless of MK32 module current status, the SPI interface is always available for module control.

MK32 module can be setup by setup instrument ПН31 or personal computer. To setup using personal computer, started should be ModuleConfigurator software, and module should be connected to personal computer via diagnostic interface module MC01 USB (PC USB interface), installed on personal computer should be drivers of virtual COM port.

MK32 module provides “hot” connection/disconnection of setup instrument and MC01 USB diagnostic interface modules.

5.4 Settings and module current status (address tables)

5.4.1 Measurement channels parameters and module system settings

Table 22 - List of measurement channels calibration data registers

Description	Designation	Type (bytes)	Address (Hex)				Default value	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
DC sensor current range lower value	`ConstCurrentMin`	Float (4)	0x0400	0x0500	0x0600	0x0700	0	
DC sensor current range upper value	`ConstCurrentMax`	Float (4)	0x0404	0x0504	0x0604	0x0704	0	
Variable signal RMS measurement range (100%)	`RangeRMS`	Float (4)	0x0408	0x0508	0x0608	0x0708	0	
Variable signal excursion measurement range (100%)	`RangePP`	Float (4)	0x040C	0x050C	0x060C	0x070C	0	
Nominal sensor propagation ratio	`NominalCoeffSensor`	Float (4)	0x0410	0x0510	0x0610	0x0710		
Phase shift correction, deg/Hz	`PhaseCorrect`	Float (4)	0x0414	0x0514	0x0614	0x0714	0,2375	
Use inverse FFT of 11th order to calculate excursion 0 - 10th order Inverse FFT 1 - 11th order Inverse FFT	`UseIFFT11`	UInt (2)	0x0418	0x0518	0x0618	0x0718	0	
ADC data from additional board, channel selection 0 - External ADC is not used 1 - Channel 1 of external ADC 2 - Channel 2 of external ADC 3 - Channel 3 of external ADC 4 - Channel 4 of external ADC	`ExternalAdcChannel`	UInt (2)	0x041A	0x051A	0x061A	0x071A	0	
Reserve, should be equal to zero	`Reserv`	UInt (2)	0x041C	0x051C	0x061C	0x071C	0	
Use 64-bit integer mathematics 0 - 32-bit FFT mathematics 1 - 64-bit FFT mathematics	`Use64bitLongCalc`	UInt (2)	0x041E	0x051E	0x061E	0x071E	0	
Rotational component maximum calculated value	`ValueRpmMin`	Float (4)	0x0420	0x0520	0x0620	0x0720	0	
LF noise filtering in spectral area 0 - do not execute 1 - Execute according to Table No.1 2 - Execute according to Table No.2	`FilterNoiseLP`	UInt (2)	0x0424	0x0524	0x0624	0x0724	0	
Reserve, should be equal to zero	`Reserv1`	UInt (2) x 5	0x0426	0x0526	0x0626	0x0726	0	

Table 22(continued)

Description	Designation	Type (bytes)	Address (Hex)				Default value	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
Variable signal RMS lower spectral line number	LineRMS_Low	UInt (2)	0x0430	0x0530	0x0630	0x0730	8	
Variable signal RMS upper spectral line number	LineRMS_High	UInt (2)	0x0432	0x0532	0x0632	0x0732	1003	
Variable signal excursion lower spectral line number	LinePP_Low	UInt (2)	0x0434	0x0534	0x0634	0x0734	4	
Variable signal excursion upper spectral line number	LinePP_High	UInt (2)	0x0436	0x0536	0x0636	0x0736	503	
Minimum spectral component energy level	RmsMinPower	Ulong (4)	0x0438	0x0538	0x0638	0x0738	100	
ADC DC lower calibration value	ConstAdcMin	Ulong (4)	0x043C	0x053C	0x063C	0x073C	0	1
ADC DC upper calibration value	ConstAdcMax	Ulong (4)	0x0440	0x0540	0x0640	0x0740	0	1
ADC Value. 5% of measured parameter RMS range	AdcRMS_5	Float (4)	0x0444	0x0544	0x0644	0x0744	0	1
ADC Value. 20 % of measured parameter RMS range	AdcRMS_20	Float (4)	0x0448	0x0548	0x0648	0x0748	0	1
ADC Value. 100 % of measured parameter RMS range	AdcRMS_100	Float (4)	0x044C	0x054C	0x064C	0x074C	0	1
ADC Value. 5% of measured parameter RMS range 1st rotational component	AdcRMS1F_5	Float (4)	0x0450	0x0550	0x0650	0x0750	0	1
ADC Value. 20 % of measured parameter RMS range 1st rotational component	AdcRMS1F_20	Float (4)	0x0454	0x0554	0x0654	0x0754	0	1
ADC Value. 100 % of measured parameter RMS range 1st rotational component	AdcRMS1F_100	Float (4)	0x0458	0x0558	0x0658	0x0758	0	1
ADC Value. 5% of measured parameter excursion range	AdcPP_5	Float (4)	0x045C	0x055C	0x065C	0x075C	0	1
ADC Value. 20 % of measured parameter excursion range	AdcPP_20	Float (4)	0x0460	0x0560	0x0660	0x0760	0	1
ADC Value. 100 % of measured parameter excursion range	AdcPP_100	Float (4)	0x0464	0x0564	0x0664	0x0764	0	1
ADC Value. 5% of measured parameter excursion range 1st rotational component	AdcPP1F_5	Float (4)	0x0468	0x0568	0x0668	0x0768	0	1
ADC Value. 20 % of measured parameter excursion range 1st rotational component	AdcPP1F_20	Float (4)	0x046C	0x056C	0x066C	0x076C	0	1
ADC Value. 100 % of measured parameter excursion range 1st rotational component	AdcPP1F_100	Float (4)	0x0470	0x0570	0x0670	0x0770	0	1
Reserve, should be equal to zero	Reserv2	UInt (2) x 8	0x0474	0x0574	0x0674	0x0774	0	
Note - If calibration information is absent, all measured parameters will equal to zero.								

Table 23 - List of measurement channels main parameters registers

Description	Designation	Type (bytes)	Address (Hex)				Default value	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
Measurement channel operation permission (0 - channel disabled)	`Enabled`	Uint (2)	0x0800	0x0900	0x0A00	0x0B00	0	
Channel operating mode 0 - Constant signal 1 - Rotor speed 2 – Signal RMS 3 - Signal excursion 4 – Signal excursion (vibration velocity integration)	`ModeWork`	Uint (2)	0x0802	0x0902	0x0A02	0x0B02	0	1
Control sensor current lower limit (0 - disabled)	`CurrentLowCheck`	Uint (2)	0x0804	0x0904	0x0A04	0x0B04	0	
Control sensor current upper limit (0 - disabled)	`CurrentHighCheck`	Uint (2)	0x0806	0x0906	0x0A06	0x0B06	0	
Sensor current lower permissible value	`CurrentLow`	Float (4)	0x0808	0x0908	0x0A08	0x0B08	0	
Sensor current upper permissible value	`CurrentHigh`	Float (4)	0x080C	0x090C	0x0A0C	0x0B0C	0	
Sensor current hysteresis	`CurrentCheckHist`	Float (4)	0x0810	0x0910	0x0A10	0x0B10	0	
Calculate constant component (0 – do not calculate)	`ConstValueCalculation`	Uint (2)	0x0814	0x0914	0x0A14	0x0B14	0	
Calculate rotational components 0 - do not calculate 1 - calculate (for modes 2, 3, 4) 2 - calculate with rotor surface irregularity compensation (only for mode 3)	`RpmValue`	Uint (2)	0x0816	0x0916	0x0A16	0x0B16	0	
DC parameter range lower value	`ConstValueMin`	Float (4)	0x0818	0x0918	0x0A18	0x0B18	0	
DC parameter range upper value	`ConstValueMax`	Float (4)	0x081C	0x091C	0x0A1C	0x0B1C	0	
AC parameter range value	`VariableValueMax`	Float (4)	0x0820	0x0920	0x0A20	0x0B20	0	
Monitored unit rotor operation speed (used in absence of synchronization pulses), Hz	`FreqDefaultHz`	Float (4)	0x0824	0x0924	0x0A24	0x0B24	0	
Minimum permissible parameter value to calculate rotational components phase	`MinValueForCalcRpm`	Float (4)	0x0808	0x0908	0x0A08	0x0B08	0	
Phase permanent offset for 1-st rotational component, deg (from 0 to 360)	`PhaseCorrectionFor1F`	Float (4)	0x082C	0x092C	0x0A2C	0x0B2C	0	

Table 23(continued)

Description	Designation	Type (bytes)	Address (Hex)				Default value	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
Frequency zone 0	FZ0	STR (20)	0x0830	0x0930	0x0A30	0x0B30		
Permit calculation, integration depth: 0 – disabled 1 – no averaging 2-9 – averaging level 10 – maximum averaging	Enabled	Uint (2)	0x0830	0x0930	0x0A30	0x0B30	0	
Permission to use rotor operation speed: (0 - not permitted)	UseDefaultFreq	Uint (2)	0x0832	0x0932	0x0A32	0x0B32	0	2
Frequency lower value. Factor A	MinFreqCoff_A	Float (4)	0x0834	0x0934	0x0A34	0x0B34	0	
Frequency lower value. Factor B	MinFreqCoff_B	Float (4)	0x0838	0x0938	0x0A38	0x0B38	0	
Frequency upper value. Factor A	MaxFreqCoff_A	Float (4)	0x083C	0x093C	0x0A3C	0x0B3C	0	
Frequency upper value. Factor B	MaxFreqCoff_B	Float (4)	0x0840	0x0940	0x0A40	0x0B40	0	
Frequency zone 1	FZ1	STR (20)	0x0844	0x0944	0x0A44	0x0B44		
Frequency zone 2	FZ2	STR (20)	0x0858	0x0958	0x0A58	0x0B58		
Frequency zone 3	FZ3	STR (20)	0x086C	0x096C	0x0A6C	0x0B6C		
Minimum permissible rotor speed to calculate rotational components, rpm	VariableFreqLow	Float (4)	0x0880	0x0980	0x0A80	0x0B80	0	
Maximum permissible rotor speed to calculate rotational components, rpm	VariableFreqHigh	Float (4)	0x0884	0x0984	0x0A84	0x0B84	0	
Channel description	Description	Uchar (16)	0x0888	0x0988	0x0A88	0x0B88	0	
Measuring units	Units	Uchar (8)	0x0898	0x0998	0x0A98	0x0B98	0	
Signal sampling capture source 0 - Primary signal without processing 1 - Signal after integrator	SamplingSignalSource	Uint (2)	0x08A0	0x09A0	0x0AA0	0x0BA0	0	
Permissible noise level relative to integrator constant component	IntegratorNoise	Uint (2)	0x08A2	0x09A2	0x0AA2	0x0BA2	0	

Table 23(continued)

Description	Designation	Type (bytes)	Address (Hex)				Default value	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
Main measured parameter integration depth (from 0 to 9)	AveragDepth	Uint (2)	0x08A4	0x09A4	0x0AA4	0x0BA4	0	
Consider the sensor propagation ratio (0 - do not consider)	UseCoeffOfSensor	Uint (2)	0x08A6	0x09A6	0x0AA6	0x0BA6	0	3
Monitor AC overload (0 - do not monitor)	OverloadControlEnabled	Uint (2)	0x08A8	0x09A8	0x0AA8	0x0BA8	0	3
Limit result with maximum permissible value (0 - do not limit)	OverloadValueLimit	Uint (2)	0x08AA	0x09AA	0x0AAA	0x0BAA	0	3
Actual sensor propagation ratio	ActualCoeffOfSensor	Float (4)	0x08AC	0x09AC	0x0AAC	0x0BAC	0	3
Maximum permissible parameter value	OverloadLevel	Float (4)	0x08B0	0x09B0	0x0AB0	0x0BB0	0	
Integration signal suppression factor (from 0.10 to 5.00)	IntegratorDampingFactor	Float (4)	0x08B4	0x09B4	0x0AB4	0x0BB4	0	
Use integrator adaptive operating mode (0 - do not use)	IntegratorUseAdaptive	Uint (2)	0x08B8	0x09B8	0x0AB8	0x0BB8	0	
Carry out FR correction (0 - do no carry out)	AFC_Enabled	Uint (2)	0x08BA	0x09BA	0x0ABA	0x0BBA	0	
FR correction. First record in FR correction table	AFC_LineStart	Uint (2)	0x08BC	0x09BC	0x0ABC	0x0BBC	0	4
FR correction. Last record in FR correction table	AFC_LineEnd	Uint (2)	0x08BE	0x09BE	0x0ABE	0x0BBE	0	4
FR correction. Base value record number	AFC_LineBase	Uint (2)	0x08C0	0x09C0	0x0AC0	0x0BC0	0	4,5
Reserve, should be equal to zero	Reserv	Uint (2)	0x08C2	0x09C2	0x0AC2	0x0BC2	0	

Notes

1 Rotor speed measurement mode only for measuring channels 1, 2.

2 Measurement channel setup frequency, if there is no rotor speed measurement.

3 Only when measuring variable signals.

4 The range is from 1 to 30.

5 Should be between the first and last record (inclusive).

Table 24 - List of virtual measurement channels setup registers

Description	Designation	Type (bytes)	Address (Hex)				Default value	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
Measurement channel operation permission (0 - channel disabled)	`Enabled`	Uint (2)	0x3500	0x3520	0x3540	0x3560	0	
Operating mode 0 – argument 1 integration (argument 1 – signal RMS) 1 – argument 1 and argument 2 addition 2 – argument 2 subtraction from argument 1	`ModeWork`	Uint (2)	0x3502	0x3522	0x3542	0x3562	0	
Argument 1 bits 7:0 – measurement channel number bit 8 – measurement channel type (0 – real; 1 – virtual) bits 15:9 – reserve, should be zero	`Argument1`	Uint (2)	0x3504	0x3524	0x3544	0x3564	0	
Argument 2	`Argument2`	Uint (2)	0x3506	0x3526	0x3546	0x3566	0	1
Failures mask	`MaskErrors`	Uint (2)	0x3508	0x3528	0x3548	0x3568	0	2
Apply scaling factor (0 – do not apply)	`UseScaleFactor`	Uint (2)	0x350A	0x352A	0x354A	0x356A	0	
Scaling factor	`ScaleFactor`	Float (4)	0x350C	0x352C	0x354C	0x356C	0	
AC parameter range value	`ValueMax`	Float (4)	0x3510	0x3530	0x3550	0x3570	0	
Measuring units	`Units`	Uchar (8)	0x3514	0x3534	0x3554	0x3574	0	
Reserve, should be equal to zero	`Reserv`	Uchar (4)	0x351C	0x353C	0x355C	0x357C	0	
Notes 1 Bits assignment similar to argument 1. 2 For bit field description ref. to Table 45 register `CommonError`.								

Table 25 - List of frequency measurement channels registers

Description	Designation	Type (bytes)	Address (Hex)				Default value	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
Frequency measurement permission (0 - disabled)	`Enabled`	Uint (2)	0x0D00	0x0D20			0	
Number of pulses per rotor revolution (from 1 to 300)	`Tooth`	Uint (2)	0x0D02	0x0D22			0	
Input pulses active edge 0 - leading 1 - trailing	`ActiveFront`	Uint (2)	0x0D04	0x0D24			0	
Repeat synchronization pulses (active only when number of pulses per revolution is 1) 0 - do not repeat 1 - active leading edge 2 - active trailing edge	`GeneratePulses`	Uint (2)	0x0D06	0x0D26			0	
Minimum measured frequency, rpm	`MinFrequencyRPM`	Float (4)	0x0D08	0x0D28			0	
Rotor speed sensor installation angle (from 0 to 360)	`AngleOfTheSensor`	Float (4)	0x0D0C	0x0D2C			0	
Frequency stabilization control permission (0 - disabled)	`SatbleControl`	Uint (2)	0x0D10	0x0D30			0	
Frequency stabilization time (by 0.5 s)	`StableTimeOut`	Uint (2)	0x0D12	0x0D32			0	
Maximum frequency deviation for stabilization algorithm, rpm	`StableFrequencyDelta`	Float (4)	0x0D14	0x0D34			0	
Reserve, should always be equal to zero	`Reserv`	Uchar (8)	0x0D18	0x0D38			0	

Table 26 - List of unified setup registers

Description	Designation	Type (bytes)	Address (Hex)				Default value	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
Unified output operation permission (0 - disabled)	`Enabled`	Uint (2)	0x0F00	0x0F20	0x0F40	0x0F60	0	
Parameter address (according to measurement results tables)	`ParameterAddress`	Uint (2)	0x0F02	0x0F22	0x0F42	0x0F62	0	
Failures mask	`ParameterCheckErrors`	Uint (2)	0x0F04	0x0F24	0x0F44	0x0F64	0	
Set failure current at measurement channel failure detection (0 - do not set)	`CurrentErrorEnabled`	Uint (2)	0x0F06	0x0F26	0x0F46	0x0F66	0	
Measurement channel failure current	`CurrentError`	Float (4)	0x0F08	0x0F28	0x0F48	0x0F68	0	1
Parameter range lower value	`ParameterMin`	Float (4)	0x0F0C	0x0F2C	0x0F4C	0x0F6C	0	
Parameter range upper value	`ParameterMax`	Float (4)	0x0F10	0x0F30	0x0F50	0x0F70	0	
Output current range lower value	`OutCurrentMin`	Float (4)	0x0F14	0x0F34	0x0F54	0x0F74	0	2
Output current range upper value	`OutCurrentMax`	Float (4)	0x0F18	0x0F38	0x0F58	0x0F78	0	2
DAC output lower value (20% of current range upper value)	`OutDacMin`	Uint (2)	0x0F1C	0x0F3C	0x0F5C	0x0F7C	0	2
DAC output upper value	`OutDacMax`	Uint (2)	0x0F1E	0x0F3E	0x0F5E	0x0F7E	0	2

Notes

1 For bit field description ref. Table 45 register `CommonError`.

2 Calibration information not available, to unified output is disabled.

Table 27 - List of unified output control registers

Description	Designation	Type (bytes)	Address (Hex)				Default value	Note
			Channel 1	Channel 2	Channel 3	Channel 4		
DAC value for measurement channel unified output direct control	`AnalogDirectData`	Uint (2)	0x0E00	0x0E02	0x0E04	0x0E06	0	

Notes

1 Used for unified outputs calibration. DAC range from 0 to 4095.

2 Do not participate in measurement channels normal operation.

3 Automatically reset to 0 if register value hasn’t change for 30 seconds.

4 Available for recording in any operating mode of module.

Table 28 - FR correction records table (frequency, module FR)

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Record No.1	`AFC_Line_01`	STR(8)	0x3200		
Frequency, Hz	`Frequency`	Float(4)	0x3200	0	
Module effect amplitude	`Module`	Float(4)	0x3204	0	
Record No.2	`AFC_Line_02`	STR(8)	0x3208		
Record No.3	`AFC_Line_03`	STR(8)	0x3210		
...	...	...	...	...	...
Record No.30	`AFC_Line_30`	STR(8)	0x32E8		

Table 29 - FR correction records table (sensor FR, required FR deviation)

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Record No.01	`AFC_ExtLine_01`	STR(8)	0x3300		
Sensor effect amplitude	`Sensor`	Float(4)	0x3300	0	
Required FR diviation	`Required`	Float(4)	0x3304	0	
Record No.02	`AFC_ExtLine_02`	STR(8)	0x3308		
Record No.03	`AFC_ExtLine_03`	STR(8)	0x3310		
...	...	...	...	...	...
Record No.30	`AFC_ExtLine_30`	STR(8)	0x33E8		
Note — implemented in MK32 module software version 1.82.					

Table 30 - LF noise filters table

Description	Designation	Type (bytes)	Address (Hex)		Default value
			No.1	No.2	
Spectral line No.0	`FilterNoiseLP_0`	Float(4)	0x3000	0x3100	0
Spectral line No.1	`FilterNoiseLP_1`	Float(4)	0x3004	0x3104	0
...	...	...	...	...	...
Spectral line No.19	`FilterNoiseLP_19`	Float(4)	0x304C	0x314C	0

Table 31 - Information registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
ModuleConfigurator software data	`InformationModuleConfig`	UChar(64)	0x3600	0	1
Note - Used for jumpers location information on MK22 module board.					

Table 32 - List of system registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Logic outputs block time after module reset	`InitModulTimeOut`	Uint (2)	0x0C00	15	1, 3
Setpoints test time-out after sensor operation normalizing	`InitChannelTimeOut`	Uint (2)	0x0C02	15	2, 3
Measurement channels synchronization mode to calculate rotational components 0 - no synchronization 1 - only by 1-st channel 2 - only by 2-nd channel 3 - 1-st channel main, 2-nd - reserve	`SynchronizationMode`	Uint (2)	0x0C04	0	
Sampling frequency of ADC sampling 0 – 4096 Hz (spectral resolution 1.0 Hz) 1 – 2048 Hz (spectral resolution 0.50 Hz) 2 – 1024 Hz (spectral resolution 0.25 Hz)	`AdcSamplesDivider`	Uint (2)	0x0C06	0	
Frequency range lower value of control surface form study, rpm	`FrequencyStudyMin`	Float (4)	0x0C08	0	4
Frequency range upper value of control surface form study, rpm	`FrequencyStudyMax`	Float (4)	0x0C0C	0	4
Type of available external ADC 0 – Only internal ADC (capacity 12 bit) 1 – Additional board with ADC AD7988 (capacity 16 bit)	`AdcExternalType`	Uint (2)	0x0C10	0	
Divide calculations of 1, 2 and 3, 4 channels in separate cycles, refresh time 1 sec. (0 - do not divide)	`UseSeparateMainLoop`	Uint (2)	0x0C12	0	5
DAC unified current outputs type 0 - Absent, current outputs not implemented 1 – One 4-channel DAC AD7398, installed on the module board 2 – Four single-channel DACs DAC7611, installed on additional board	`DacExternalType`	Uint (2)	0x0C14	0	6
Reserve, should be equal to zero	`Reserv`	Uint (2)x3	0x0C16	0	

Notes

1 In case of reading error from non-volatile memory always equals to 15 (8 seconds).

2 If value is 0, function is disabled.

3 Time by 0.5 s (0 = 0.5 s).

4 If lower value is more or equal to upper one, control surface form study to calculate rotational components is not carried out.

5 Dividing may be necessary when implementing 64-bit mathematics in measurement channels.

6 Implemented in MK32 module software version 1.80.

Table 33 - List of indication setup registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
LCD indication permission (0 - disabled)	`Enabled`	Uint (2)	0x3400	0	
Reserve, should be equal to zero	`Reserv`	Uint (2)	0x3402	0	
Associative measurement channel with output position to LCD 1 bits 7:0 – measurement channel number bit 8 – channel type (0 – physical; 1 – virtual)	`ChannelOut_1`	Uint (2)	0x3404	0	
Associative measurement channel with output position to LCD 2	`ChannelOut_2`	Uint (2)	0x3406	0	1
Associative measurement channel with output position to LCD 3	`ChannelOut_3`	Uint (2)	0x3408	0	1
Associative measurement channel with output position to LCD 4	`ChannelOut_4`	Uint (2)	0x340A	0	1
Position 1 data displaying main format 0 - #.### (from 0 to 9.999) 1 - ##.## (from -9.99 to 99.99) 2 - ###.# (from -99.9 to 999.9) 3 - #### (from -999 to 9999)	`FormatOut_1`	Uint (2)	0x340C	0	
Position 2 data displaying main format	`FormatOut_2`	Uint (2)	0x340E	0	2
Position 3 data displaying main format	`FormatOut_3`	Uint (2)	0x3410	0	2
Position 4 data displaying main format	`FormatOut_4`	Uint (2)	0x3412	0	2
Histogram page displayed first	`HistogrammMainPage`	Uint (2)	0x3414	0	
Displayed histogram pages: bit 0 – GN: General level bit 1 – LP: LF component bit 2 – LHP: HF component bit 3 – I: Sensor current bit 3 – 1F: 1-st rotational bit 5 – Ph 1F: 1 rotational phase bit 6 – 2F: 2-st rotational bit 7 – Ph 2F: 2 rotational phase bits 8-15 – reserve, should be zero	`HistogrammShow`	Uint (2)	0x3416	0	
Reserve, should be equal to zero	`Reserv`	Ulong (4)	0x3418	0	
Data output in normal mode, position 1 bit 0 – GN: General level bit 1 – LP: LF component bit 2 – LHP: HF component bit 3 – 1F: 1-st rotational bit 4 – Ph 1F: 1 rotational phase bit 5 – 2F: 2-st rotational bit 6 – Ph 2F: 2 rotational phase bit 7 – S 1F / 0.5F: Transition p-p on 1st/0.5 rotational bit 8 – S Ph 1F/Gap: 1st rotational phase transition / Gap bits 9-10 – reserve, should be zero bit 11 – I: Sensor current bit 12 – Freq: Frequency bit 13 – Jump: Parameter step bit 14 – Serr: Channel failure bits 15 – reserve, should be zero	`NormalShow_1`	Uint (2)	0x341C	0	
Data output in normal mode, position 2	`NormalShow_2`	Uint (2)	0x341E	0	3
Data output in normal mode, position 3	`NormalShow_3`	Uint (2)	0x3420	0	3
Data output in normal mode, position 4	`NormalShow_4`	Uint (2)	0x3422	0	3

Notes

1 Register bit fields purpose is similar to `ChannelOut_1`.

2 Register value is similar to `FormatOut_1`.

3 Register bit fields purpose is similar to `NormalShow_1`.

4 Default values correspond to LCD disabled indication.

Table 34 - List of setpoints setup registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Setpoint 1	`TestPoint_01`	STR(16)	0x1800		
Setpoint operating mode 0 – disabled 2 – control “up” 2 – control “down”	`CheckMode`	Uint (2)	0x1800	0	
Parameter address (according to measurement results tables)	`ParameterAddress`	Uint (2)	0x1802	0	
Failures mask	`ParameterCheckErrors`	Uint (2)	0x1804	0	1
Detection time of transition over setpoint by 0.5 s	`TimeOut`	Uint (2)	0x1806	0	
Setpoint value	`CheckValue`	Float (4)	0x1808	0	
Setpoint hysteresis	`CheckValueHist`	Float (4)	0x180C	0	
Setpoint 2	`TestPoint_02`	STR(16)	0x1810		
Setpoint 3	`TestPoint_03`	STR(16)	0x1820		
...	...	...	...	...	...
Setpoint 32	`TestPoint_32`	STR(16)	0x19F0		
Note – For bit field description ref. Table 51 register `CommonError`.					

Table 35 - List of parameters step control setup registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Step 1 control	`JumpPoint_01`	STR(24)	0x1B00		
Algorithm operating mode 0 – disabled 1 – increase, value decrease 2 – only value increase	`Enabled`	Uint (2)	0x1B00	0	
Initialization time-out by 0.5 s	`TimeOutInit`	Uint (2)	0x1B02	0	
Stabilization time-out by 0.5 s	`TimeOutStable`	Uint (2)	0x1B04	0	
Active status time by 0.5 s	`TimeOutActive`	Uint (2)	0x1B06	0	
Parameter address (according to measurement results tables)	`ParameterAddress`	Uint (2)	0x1B08	0	
Failures mask	`ParameterCheckErrors`	Uint (2)	0x1B0A	0	1
Step algorithm sensitivity	`ValueSense`	Float (4)	0x1B0C	0	
Step minimum level	`CheckValueHist`	Float (4)	0x1B10	0	
Reserve, always equals to zero	`Reserv`	Ulong(4)	0x1B14	0	
Step 2 control	`JumpPoint_02`	STR(24)	0x1B18		
Step 3 control	`JumpPoint_03`	STR(24)	0x1B30		
...	...	...	...	...	...
Step 8 control	`JumpPoint_08`	STR(24)	0x1BA8		
Note – For bit field description ref. Table 51 register `CommonError`.					

Table 36 - List of logic signaling setup registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Output 1 logical rule (16 comands)	`LogicRules[0]`	Uint(2) x 16	0x1C00		
Output 2 logical rule	`LogicRules[1]`	Uint(2) x 16	0x1C20		
Output 3 logical rule	`LogicRules[2]`	Uint(2) x 16	0x1C40		
Output 4 logical rule	`LogicRules[3]`	Uint(2) x 16	0x1C60		
Output 5 logical rule	`LogicRules[4]`	Uint(2) x 16	0x1C80		
Output 6 logical rule	`LogicRules[5]`	Uint(2) x 16	0x1CA0		
Output 7 logical rule	`LogicRules[6]`	Uint(2) x 16	0x1CC0		
Output 8 logical rule	`LogicRules[7]`	Uint(2) x 16	0x1CE0		
Output 9 logical rule	`LogicRules[8]`	Uint(2) x 16	0x1D00		
Output 10 logical rule	`LogicRules[9]`	Uint(2) x 16	0x1D20		
Output 11 logical rule	`LogicRules[10]`	Uint(2) x 16	0x1D40		
Output 12 logical rule	`LogicRules[11]`	Uint(2) x 16	0x1D60		
Output 13 logical rule	`LogicRules[12]`	Uint(2) x 16	0x1D80		
Output 14 logical rule	`LogicRules[13]`	Uint(2) x 16	0x1DA0		
LED “War” logical rule	`LogicRules[14]`	Uint(2) x 16	0x1DC0		
LED “Alarm” logical rule	`LogicRules[15]`	Uint(2) x 16	0x1DE0		

Table 37 - Logical rules command structure

Description	Designation	Bits
Operation code 0x00 - empty operation 0x1F - logic formula completion 0x01 - place memory value to storage battery 0x02 - save storage battery value to memory 0x03 - reset storage battery to zero 0x04 - invert storage battery value 0x05 - storage battery and memory logical OR 0x06 - storage battery and memory logical AND 0x07 - storage battery and memory logical exclusive OR	`Operation`	11 : 15 (5)
Memory (register) code 0x00 - no memory reference 0x01 - local memory (16 bit) individual for each logical output (cleared before execution) 0x02 - global memory (16 bit) common for all logical outputs (cleared before execution) 0x03 - no memory reference 0x04 - channel 1 status register 0x05 - channel 2 status register 0x06 - channel 3 status register 0x07 - channel 4 status register 0x08 - frequency measurement status register, channel 1 0x09 - frequency measurement status register, channel 2 0x0A - rotational components measurement status register 0x0B - control module status register 0x0C - errors status register 0x0D - step (latch) algorithm status register 0x0E - step (active statuses) algorithm status register 0x0F - setpoints control algorithm status register	`Memory`	6 : 10 (5)
Memory address (bin number in register)	`Address`	0 : 5 (6)

Table 38 - Main registers and their designation to generate logical rules

Parameter	Channel 1	Channel 2	Channel 3	Channel 4	Module common registers
Measurement channel enabled	Rch1.0	Rch2.0	Rch3.0	Rch4.0	
Sensor current below permissible level	Rch1.4	Rch2.4	Rch3.4	Rch4.4	
Sensor current above permissible level	Rch1.5	Rch2.5	Rch3.5	Rch4.5	
Measurement channel initialization	Rch1.6	Rch2.6	Rch3.6	Rch4.6	
Frequency measurement channel enabled	Rchf1.0	Rchf2.0			
No synchronization pulses (STOP)	Rchf1.4	Rchf2.4			
Frequency stable	Rchf1.7	Rchf2.7			
Data loading from reserve section					Rdv.4
Module information identification error					Rdv.6
Logic outputs formula error					Rdv.7
All measurement channels disabled					Rdv.9
RS485 interface disabled					Rdv.10
CAN interface disabled					Rdv.11
Channels failure	Rer.0	Rer.1	Rer.2	Rer.3	
No synchronization pulses by frequency measurement channel 0					Rer.4
No synchronization pulses by frequency measurement channel 1					Rer.5
Rotor speed not determined					Rer.6
Rotor speed not stable					Rer.7
Logic input 1 status					Rer.8
Logic input 1 inverse status					Rer.9
Virtual channels failure	Rer.12	Rer.13	Rer.14	Rer.15	

Table 39 - Designation of parameter setpoint overrange flags, step detection flags

Parameter setpoint overrange flags		Step detection flags (latch)		Step detection flags (active status)	
1	Rtp.0	1	Rjl.0	1	Rja.0
2	Rtp.1	2	Rjl.1	2	Rja.1
3	Rtp.2	3	Rjl.2	3	Rja.2
4	Rtp.3	4	Rjl.3	4	Rja.3
5	Rtp.4	5	Rjl.4	5	Rja.4
6	Rtp.5	6	Rjl.5	6	Rja.5
7	Rtp.6	7	Rjl.6	7	Rja.6
8	Rtp.7	8	Rjl.7	8	Rja.7
9	Rtp.8				
...	...				
31	Rtp.30				
32	Rtp.31				

5.4.2 Communication interfaces

Table 40 - List of RS485 interface registers

Description	Designation	Type (bytes)	Address (Hex)		Default value
			No.1	No.2	
Permit interface operation 0 – disabled 1 – VibrobitRTU 2 - ModbusRTU	`Enabled`	Uint (2)	0x1400	0x3700	0
Permit module operation parameters change by RS485 interface commands (0 – changes prohibited)	`ChangeEna`	Uint (2)	0x1402	0x3702	0
Permit single recording operation (0 – operation prohibited)	`OnWriteEna`	Uint (2)	0x1404	0x3704	0
Permit broadcast address support (0 – no support)	`CommAddrEna`	Uint (2)	0x1406	0x3706	0
Device address on RS485 bus (from 1 to 247)	`Address`	Uint (2)	0x1408	0x3708	1
Data rate, bit/s 0 – 4800; 1 – 9600; 2 – 19200; 3 – 38400; 4 – 57600; 5 – 115200; 6 – 230400	`Speed`	Uint (2)	0x140A	0x370A	0
Note - RS485 interface parameters take effect only after interface repeated initialization.					

Table 41 - List of CAN2.0B interface standard registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Permit interface operation (Not zero - interface operation permitted)	`Enabled`	Uint (2)	0x1500	0	
Data rate, kbit/s 0 – 1000; 1 – 500; 2 – 250; 3 – 200; 4 – 125; 5 – 100; 6 – 80; 7 – 40	`Speed`	Uint (2)	0x1502	0	
Module address on bus	`Address`	Uint (2)	0x1504	0	
Message sending period by 0.5 s	`PeriodSend`	Uint (2)	0x1506	0	1
Data transfer by measurement channel 1 bits 0-8 0 - Data not transferred 1 - Main measured parameter 2 - 1st rotational component bits 9-14 – reserve, should be zero bit 15 - Setpoints and steps flags	`DataSend_1`	Uint (2)	0x1508	0	
Data transfer by measurement channel 2	`DataSend_2`	Uint (2)	0x150A	0	2
Data transfer by measurement channel 3	`DataSend_3`	Uint (2)	0x150C	0	2
Data transfer by measurement channel 4	`DataSend_4`	Uint (2)	0x150E	0	2
Notes 1 Time by 0.5 s (0 = 0.5 s). 2 Similar to channel 1, except for bit 15 – reserve, should be zero. 3 CAN2.0B interface parameters take effect only after interface repeated initialization.					

5.4.3 Identification information

Table 42 - List of module identification information registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Module factory number	`Number`	Uint (2)	0x1600		
Module manufacturing year	`Year`	Uint (2)	0x1602		
Order number	`Order`	Uint (2)	0x1604		
Assembler’s code	`Assembler`	UChar (1)	0x1606		
Adjuster’s code	`Adjuster`	UChar (1)	0x1607		
Additional text information	`TextString`	Char (32)	0x1608		
Note - Identification information is available read-only, not initialized by “Cold start”.					

Table 43 - List of module software identification information registers

Description	Designation	Type (bytes)	Address (Hex)	Default value	Note
Microprocessor software version line	`Version`	Char (6)	0x1700		
Microprocessor software compilation date	`Date`	Char (12)	0x1706		
Microprocessor software compilation time	`Time`	Char (10)	0x1712		
Note - Identification information is available read-only					

5.4.4 Measurement results

Table 44 - List of ADC measurement results registers (used for calibration)

Description	Designation	Type (bytes)	Address (Hex)				Note
			Channel 1	Channel 2	Channel 3	Channel 4	
ADC DC value	`Constant`	Ulong (4)	0x0300	0x0324	0x0348	0x036C	
ADC AC RMS value in range (10-1000) Hz	`VariableRms`	Float (4)	0x0304	0x0328	0x034C	0x0370	
ADC AC excursion value in range (5-500) Hz	`VariableVpp`	Float (4)	0x0308	0x032C	0x0350	0x0374	
Zone 0 ADC AC RMS (excursion) value	`FZ0_Variable`	Float (4)	0x030C	0x0330	0x0354	0x0378	
Zone 1 ADC AC RMS (excursion) value	`FZ1_Variable`	Float (4)	0x0310	0x0334	0x0358	0x037C	
Zone 2 ADC AC RMS (excursion) value	`FZ2_Variable`	Float (4)	0x0314	0x0338	0x035C	0x0380	
Zone 3 ADC AC RMS (excursion) value	`FZ3_Variable`	Float (4)	0x0318	0x033C	0x0360	0x0384	
1-st rotational ADC RMS (excursion) value	`VariableRpm1F`	Float (4)	0x031C	0x0340	0x0364	0x0388	
ADC DC value – minimum sampling value	`ConstantTestSenseMin`	Uint (2)	0x0320	0x0344	0x0368	0x038C	1
ADC DC value – maximum sampling value	`ConstantTestSenseMax`	Uint (2)	0x0322	0x0346	0x036A	0x038E	1
Note – 1 Used to monitor the measurement channel serviceability.							

Table 45 - List of results registers by measurement channels

Description	Designation	Type (bytes)	Address (Hex)				Note
			Channel 1	Channel 2	Channel 3	Channel 4	
Sensor current	`CurrentSense`	Float (4)	0x0000	0x0030	0x0060	0x0090	
Parameter constant component	`Constant`	Float (4)	0x0004	0x0034	0x0064	0x0094	
Main measured parameter	`MainValue`	Float (4)	0x0008	0x0038	0x0068	0x0098	
Reserve, always equals to zero	`Reserv`	Float (4)	0x000C	0x003C	0x006C	0x009C	
Frequency zone 0 value	`FZ0_Value`	Float (4)	0x0010	0x0040	0x0070	0x00A0	
Frequency zone 1 value	`FZ1_Value`	Float (4)	0x0014	0x0044	0x0074	0x00A4	
Frequency zone 2 value	`FZ2_Value`	Float (4)	0x0018	0x0048	0x0078	0x00A8	
Frequency zone 3 value	`FZ3_Value`	Float (4)	0x001C	0x004C	0x007C	0x00AC	

Table 45(continued)

Description	Designation	Type (bytes)	Address (Hex)				Note
			Channel 1	Channel 2	Channel 3	Channel 4	
Measurement channel status	Status:32	Ulong (4)	0x0020	0x0050	0x0080	0x00B0	
Measurement channel enabled	*Enabled*	bit 0					
Measurement channel operating mode	*Mode*	bit 1-3					
Sensor current below permissible level	*CurrentSenseLow*	bit 4					
Sensor current above permissible level	*CurrentSenseHigh*	bit 5					
Measurement channel initialization, setpoints block	*FlagInitialization*	bit 6					
Control surface form was studied	*VariableCompensationReady*	bit 7					
Control surface form study anticipation	*VariableStadyWait*	bit 8					
Control surface form study in process	*VariableStadyExecute*	bit 9					
Inverse FFT of 11th order when calculating signal excursion	*UseIFFT11*	bit 10					
Variable signal overload	*OverloadAC*	bit 11					
Signal sampling from ADC additional board	*UseAdcExternal*	bit 12					
Application of 64-bit integer mathematics in DSP algorithms	*Use64bitLongCalculation*	bit 13					
constant component calculation	*CalculationConstValue*	bit 14					
Rotational components are not calculated	*NoCalcRpmValue*	bit 15					
Consider sensor propagation ratio	*UseCoeffOfSensor*	bit 16					
FR correction in process	*AFC_Enabled*	bit 17					
FR correction setting error	*AFC_SettingsError*	bit 17					
Reserve, equal to zero	*Unused*	bit 18-31					
Calculation duration, ms	TimeCalculation_ms	Uint (2)	0x0024	0x0054	0x0084	0x00B4	
Reserve, equals to zero	Reserv	UChar (10)	0x0026	0x0056	0x0086	0x00B6	

Table 46 - List of additional information registers by measurement channels

Description	Designation	Type (bytes)	Address (Hex)				Note
			Channel 1	Channel 2	Channel 3	Channel 4	
Main parameters RMS	ValueRMS	Float (4)	0x3800	0x3900	0x3A00	0x3B00	1
1 rotational component RMS	ValueRMS1F	Float (4)	0x3804	0x3904	0x3A04	0x3B04	1
Variable signal excursion	ValuePP	Float (4)	0x3808	0x3908	0x3A08	0x3B08	1
1 rotational component excursion	ValuePP1F	Float (4)	0x380C	0x390C	0x3A0C	0x3B0C	1
Sensor propagation ratio correction multiplier	CoeffOfSensor	Float (4)	0x3810	0x3910	0x3A10	0x3B10	
Sensor current design factor A	CurrentCoff_A	Float (4)	0x3814	0x3914	0x3A14	0x3B14	
Sensor current design factor B	CurrentCoff_B	Float (4)	0x3818	0x3918	0x3A18	0x3B18	
Parameter DC design factor A	ConstCoff_A	Float (4)	0x381C	0x391C	0x3A1C	0x3B1C	
Parameter DC design factor B	ConstCoff_B	Float (4)	0x3820	0x3920	0x3A20	0x3B20	
Measurement channel blocking time counter (service)	InitTimeOutCount	Uint (2)	0x3824	0x3924	0x3A24	0x3B24	
Surface study algorithm counter (service)	VariableStudyCount	Uint (2)	0x3826	0x3926	0x3A26	0x3B26	
Variable signal RMS lower spectral line number	LineRMS_Low	Uint (2)	0x3828	0x3928	0x3A28	0x3B28	
Variable signal RMS upper spectral line number	LineRMS_High	Uint (2)	0x382A	0x392A	0x3A2A	0x3B2A	
Variable signal excursion lower spectral line number	LinePP_Low	Uint (2)	0x382C	0x392C	0x3A2C	0x3B2C	
Variable signal excursion upper spectral line number	LinePP_High	Uint (2)	0x382E	0x392E	0x3A2E	0x3B2E	
Main measured parameter integration depth	AveragDepth	Uint (2)	0x3830	0x3930	0x3A30	0x3B30	
Next record index in averaging table	AveragTableIndex	Uint (2)	0x3832	0x3932	0x3A32	0x3B32	
Main measured parameter averaging table	AveragTable	Float (4) x 10	0x3834	0x3934	0x3A34	0x3B34	
Variable signal RMS estimated factors	Coeff_RMS	STR(40)	0x385C	0x395C	0x3A5C	0x3B5C	2
Signal rotational components RMS estimated factors	Coeff_RMS1F	STR(40)	0x3884	0x3984	0x3A84	0x3B84	2
Variable signal peak-peak excursion estimated factors	Coeff_PP	STR(40)	0x38AC	0x39AC	0x3AAC	0x3BAC	2
Signal rotational components peak-peak excursion estimated factors	Coeff_PP1F	STR(40)	0x38D4	0x39D4	0x3AD4	0x3BD4	2
External ADC channel number	ExternalAdcChannel	Uint (2)	0x38FC	0x39FC	0x3AFC	0x3BFC	
Number of applied LF noise filter table	FilterNoiseLP	Uint (2)	0x38FE	0x39FE	0x3AFE	0x3BFE	

Notes

1 Parameter is calculated without considering measurement channel failure flags.

2 Estimated factors field structure information is available at request.

Table 47 - List of measurement channels rotational components registers with pace ½ rotational

Description	Designation	Type (bytes)	Address (Hex)				Note
			Channel 1	Channel 2	Channel 3	Channel 4	
Rotational components RMS/excursion of physical measurement channels (20 components from 1/2 rotational to 10 rotational with pace of 1/2 rotational)	`HardwareMag`	Float (4) x 20	0x2000	0x2100	0x2200	0x2300	
Rotational components phase of physical measurement channels (20 components from 1/2 rotational to 10 rotational with pace of 1/2 rotational)	`HardwarePhase`	Float (4) x 20	0x2400	0x2500	0x2600	0x2700	
Rotational components RMS/excursion of virtual measurement channels (20 components from 1/2 rotational to 10 rotational with pace of 1/2 rotational)	`VirtualMag`	Float (4) x 20	0x2800	0x2900	0x2A00	0x2B00	
Rotational components phase of virtual measurement channels (20 components from 1/2 rotational to 10 rotational with pace of 1/2 rotational)	`VirtualPhase`	Float (4) x 20	0x2C00	0x2D00	0x2E00	0x2F00	

Table 48 - List of measurement channels rotational components registers with spacing ¼ rotational

Description	Designation	Type (bytes)	Address (Hex)				Note
			Channel 1	Channel 2	Channel 3	Channel 4	
Rotational components RMS/excursion of physical measurement channels (40 components from ¼ rotational to 10 rotational with pace of ¼ rotational)	`VariableQuarterMag`	Float (4) x 40	0x6000	0x6100	0x6200	0x6300	
Rotational components phase of physical measurement channels (40 components from ¼ rotational to 10 rotational with pace of ¼ rotational)	`VariableQuarterPhase`	Float (4) x 40	0x6400	0x6500	0x6600	0x6700	

Table 49 - List of speed measurement results registers

Description	Designation	Type (bytes)	Address (Hex)		Note
			Channel 1	Channel 2	
Frequency value, Hz	ValueHz	Float (4)	0x00C0	0x00D0	
Speed value, rpm	ValueRPM	Float (4)	0x00C4	0x00D4	
Maximum speed value, rpm	ValueMaxRPM	Float (4)	0x00C8	0x00D8	
Speed measurement algorithm flags	Status:16	Uint (2)	0x00CC	0x00DC	
Frequency measurement channel enabled	*Enabled*	bit 0			
Repeat synchronization pulses	*GeneratePulses*	bit 1			
Synchronization pulses polarity	*PolarityPulses*	bit 2			
Frequency stabilization detection enabled	*StableEnabled*	bit 3			
No synchronization pulses (STOP)	*NoInputPulses*	bit 4			
Service	*WaitNextPulses*	bit 5			
Service	*WaitNormalWork*	bit 6			
Frequency stable	*StableFrequency*	bit 7			
Reserve, equal to zero	*Unused*	bit 8-15			
Reserve, equals to zero	Reserv	Uint (2)	0x00CE	0x00DE	
Established number of pulses per rotor revolution	Tooth	Uint (2)	0x3C00	0x3D00	

Table 50 - List of rotational components measurement registers

Description	Designation	Type (bytes)	Address (Hex)	Note
Frequency value, Hz	FrequencyHz	Float (4)	0x3E00	
Speed value, rpm	FrequencyRpm	Float (4)	0x3E04	
Speed measurement algorithm flags	Status:16	Uint (2)	0x3E08	
Rotor speed not determined	NoFrequencyCalc	bit 0		
Rotor speed not stable	NoFrequencyStable	bit 1		
Synchronization channel	ChannelSynchro	bit 2		
Reserve, equals to zero	Unused	bit 3		
Gathering data	ExecRpmSampling	bit 4		
Expecting synchronization signal from channel 1	WaitSynchro_CH0	bit 5		
Expecting synchronization signal from channel 2	WaitSynchro_CH1	bit 6		
Calculation support of ¼ rotational	RpmMode_025F	bit 7		
Capture mode 000 – no sampling 001 - 1 rotor revolution 010 - 2 rotor revolutions 011 - 4 rotor revolutions	RpmSampling	bit 8-10		
Reserve, equal to zero	Unused	bit 11-15		
	Reserv	Uint (2)	0x3E0A	
	SampleFrequencyHz	Float (4)	0x3E0C	

Table 51 - List of system registers

Description	Designation	Type (bytes)	Address (Hex)	Note
Control module status	DeviceStatus:16	Uint (2)	0x00E0	
EEPROM error	*ErrorExternalEEPROM*	bit 0		
RAM error	*ErrorExternalSRAM*	bit 1		
ADC error	*ErrorInternalADC*	bit 2		
Data loading error	*ErrorLoadDataCRC*	bit 3		
Data loading from reserve section	*WarningLoadData*	bit 4		
EEPROM recording protection	*LockExternalEEPROM*	bit 5		
Module identification information error	*BadIdDeviceData*	bit 6		
Logic outputs formula error	*ErrorLogicFormula*	bit 7		
RS485 interface No.2 disabled	*OffInterfaceRS485_2*	bit 8		
All measurement channels disabled	*OffAllChannel*	bit 9		
RS485 interface No.1 disabled	*OffInterfaceRS485_1*	bit 10		
CAN interface disabled	*OffInterfaceCAN*	bit 11		
Logic outputs block by module start	*FlagStartLoad*	bit 12		
Logic outputs block by user	*FlagUserLogicBlock*	bit 13		
Permission for RS485 No.1 single recording	*FlagAllowOneWrite_1*	bit 14		
Permission for RS485 No.2 single recording	*FlagAllowOneWrite_2*	bit 15		
Control module errors register	CommonError:16	Uint (2)	0x00E2	
Measurement channel 1 failure	*Channel_0*	bit 0		
Measurement channel 2 failure	*Channel_1*	bit 1		
Measurement channel 3 failure	*Channel_2*	bit 2		
Measurement channel 4 failure	*Channel_3*	bit 3		
No synchronization pulses by frequency measurement channel 1	*NoFreqency_0*	bit 4		
No synchronization pulses by frequency measurement channel 1	*NoFreqency_1*	bit 5		
Rotor speed not determined	*NoFrequencyCalc*	bit 6		
Rotor speed not stable	*NoFrequencyStable*	bit 7		
Logic input 1 status	*InputLogic*	bit 8		
Logic input 1 inverse status	*InputLogicInvert*	bit 9		
RS485 No.2 interface is available	*AllowModbusR2*	bit 10		
Calculation duration exceeds measurement cycle duration	*OverTimeMainCycle*	bit 11		
Virtual channel 1 failure	*VChannel_0*	bit 12		
Virtual channel 2 failure	*VChannel_1*	bit 13		
Virtual channel 3 failure	*VChannel_2*	bit 14		
Virtual channel 4 failure	*VChannel_3*	bit 15		
Step detection flags (latch) bits 0-7 - step algorithms 1-8 bits 8-31 – reserve, equal to zero	ControlJumpLatch	Ulong (4)	0x00E4	
Step detection flags (active status) bits 0-7 - step algorithms 1-8 bits 8-31 – reserve, equal to zero	ControlJumpActive	Ulong (4)	0x00E8	
Parameter setpoint overrange flags bits 0-31 - setpoints algorithms 1-32	ControlPoint	Ulong (4)	0x00EC	

Table 51(continued)

Description	Designation	Type (bytes)	Address (Hex)	Note
Logic outputs status bits 0-13 - logic outputs 1-14 bit 14 - LED 'War' bit 15 - LED 'Alarm'	`LogicOutStatus`	Ulong (4)	0x00F0	1
Processor load, %	`UtilizationCPU`	Float (4)	0x00F4	
Sampling frequency of ADC sampling 0 – 4096 Hz (spectral resolution 1.0 Hz) 1 – 2048 Hz (spectral resolution 0.50 Hz) 2 – 1024 Hz (spectral resolution 0.25 Hz)	`AdcSamplesDivider`	Uint (2)	0x00F8	
Type of available external ADC 0 – Only internal ADC (capacity 12 bit) 1 – Additional board with ADC AD7988 (capacity 16 bit)	`AdcExternalType`	Uint (2)	0x00FA	
ADC main cycle counter	`AdcMainCounter`	Uint (2)	0x00FC	
Measurement cycle status register (service)	`MeasurStatus`	Uint (2)	0x00FE	
Error flags of data sections reading from non-volatile memory (service)	`ReadSectionError`	Ulong (4)	0x0100	
Flags of data sections reading from non-volatile memory reserve area (service)	`ReadSectionWarning`	Ulong (4)	0x0104	
DAC unified current outputs type 0 - Absent, current outputs not implemented 1 – One 4-channel DAC AD7398, installed on the module board 2 – Four single-channel DACs DAC7611, installed on additional board	`DacExternalType`	Uint (2)	0x0108	
Reserve, equals to zero	`Reserv`	Uint (2)	0x010A	
Note - 1 Logic signaling block flags effect is not extended over logic outputs status register.				

Table 52 - List of LF noise filter registers, spectral lines current energy value

Description	Designation	Type (bytes)	Address (Hex)	Note
Spectral line No.00	`Line_00`	Float (4)	0x0200	
Spectral line No.01	`Line_01`	Float (4)	0x0204	
...	...	...	...	...
Spectral line No.19	`Line_19`	Float (4)	0x024C	
Notes 1 Spectral lines energy in ADC dimension before square root extraction. 2 In normal state the values are equal to zero. 3 To transfer spectral lines of necessary measurement channel it is necessary to execute the corresponding command. 4 Data output duration by selected measurement channel is 10 minutes.				

Table 53 - List of source signal sampling and its spectrum registers

Description	Designation	Type (bytes)	Address (Hex)
Control register (record-only) bits 1:0 – Measurement channel number bit 2 – request type (0 – signal; 1 – spectrum) bit 3 - signal request period (0 - 500 ms, 1 - 50 ms), irrelevant during spectrum request bit 4 - request data bit 5 - cancel current task (has higher priority than data request) bit 6 – FR correction request (from module software version 1.82) bits 15:7 – reserve (should be zero)	`SampleTask`	Uint (2)	0xFF0F
Status register (read-only): bits 1:0 – Measurement channel number bit 2 – request type (0 – signal; 1 – spectrum) bit 3 - signal request period (0 - 500 ms, 1 - 50 ms), irrelevant during spectrum request bit 4 - task in progress, reset to 0 by data readiness bit 5 - waiting for data capturing bit 6 - waiting for data calculation bit 7 - task executed, data can be read (automatically reset to zero at new data request) bit 8 - Cancel current task bit 9 - New task declined because previous one not executed (current task execution not interrupted) bit 10 - data calculation status (service bit) bit 15:11 – reserve, always are zero	`SampleStatus`	Uint (2)	0x3F00
Data request result (read-only) Source signal supplied in mA: 2048 sampling for 0.5 sec or 50 ms Signal spectrum: Spectrum components 0-1024 Hz (resolution 1 Hz), RMS mm/s or μm	`SampleData`	Float(4)	from 0x4000 to 0x5FFC

Notes

1 Recording to control register is carried out according to control command rules (bit 7 - `SampleStatus` is reset automatically).

2 Before plotting diagram it is recommended to reset the requested spectrum zero and first harmonics to 0 and do not consider in analysis.

3 When requesting spectrum, the constant component is arranged at address 0x4000 and further. Unused data capturing buffer area is reset to zero and may not be read.

4 Data in data capturing buffer are kept till next request.

5.4.5 Control commands

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

Table 54 - List of control registers

Register address (Hex)	Recorded value (Hex)	Action	Note
0xFF00	0x55	Module reset (similar to module power-up)	
0xFF01	0x60	Execute frequency measurement repeated initialization	1,3
	0x61	Recalculate channel 1 factors	1, 3
	0x62	Recalculate channel 2 factors	1, 3
	0x63	Recalculate channel 3 factors	1, 3
	0x64	Recalculate channel 4 factors	1, 3
	0xA1	Reset control surface study carried out for channel 1	3
	0xA2	Reset control surface study carried out for channel 2	3
	0xA3	Reset control surface study carried out for channel 2	3
	0xA4	Reset control surface study carried out for channel 2	3
	0x91	Execute unified outputs repeated initialization	3
	0x93	Execute RS485 No.1 interface repeated initialization	2, 3
	0x94	Execute RS485 No.2 interface repeated initialization	2, 3
	0x98	Execute CAN2.0B interface repeated initialization	2, 3
0xFF02	0x33	Logical signaling block	
	0xCC	Logical signaling normal operation	
0xFF03	0x3C	Request for single recording	
0xFF04	0x10 - 0x17	Parameter step flags acknowledgment by algorithms 1-8 accordingly	
0xFF08	0xA1	Engage measurement channel 1	4
	0xA2	Engage measurement channel 2	4
	0xA3	Engage measurement channel 3	4
	0xA4	Engage measurement channel 4	4
0xFF09	0x31	Disengage measurement channel 1	4
	0x32	Disengage measurement channel 2	4
	0x33	Disengage measurement channel 3	4
	0x34	Disengage measurement channel 4	4
0xFF0A	0x40	Do not output spectral component energy data	5
	0x41	Measurement channel 1 spectral components energy output	5
	0x42	Measurement channel 2 spectral components energy output	5
	0x43	Measurement channel 3 spectral components energy output	5
	0x44	Measurement channel 4 spectral components energy output	5
0xFF0B	0xD0	Repeated initialization of all parameter step control algorithms	3
	0xE0	Repeated initialization of all setpoints control algorithms	3

Notes

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

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

3 Logical signaling should be blocked.

4 Executed is register `Enabled` change of the corresponding measurement channel, saving into non-volatile memory and measurement channel repeated initialization.

5 Data output is carried out into registers of table 52.

Table 54(continued)

Register address (Hex)	Recorded value (Hex)	Action	Note
0xFF06		Operation parameters recording into module non-volatile memory	1, 2
	0x40	Channel 1 calibration values	
	0x41	Channel 2 calibration values	
	0x42	Channel 3 calibration values	
	0x43	Channel 4 calibration values	
	0x44	Channel 1 main parameters	
	0x45	Channel 2 main parameters	
	0x46	Channel 3 main parameters	
	0x47	Channel 4 main parameters	
	0x48	Table No.1 of LF noise filter	
	0x49	Table No.2 of LF noise filter	
	0x4A	FR correction table (frequency, module)	
	0x4B	FR correction table (sensor, required deviation)	3
	0x4C	Module main parameters	
	0x4D	Synchronization channels parameters	
	0x4E	RS485 No.1 interface parameters	
	0x4F	CAN2.0 interface main parameters	
	0x50	Algorithm parameters of setpoints with numbers 1-8	
	0x51	Algorithm parameters of setpoints with numbers 9-16	
	0x52	Algorithm parameters of setpoints with numbers 17-24	
	0x53	Algorithm parameters of setpoints with numbers 25-32	
	0x54	Algorithm parameters of parameter step control with numbers 1-8	
	0x55	RS485 No.2 interface parameters	
	0x56	Virtual measurement channels parameters	
	0x58	Information registers	
	0x5A	Unified outputs parameters	
	0x5B	Compatibility parameters with MK20/MK30 modules	
	0x5C	Logical rules for logic outputs with numbers 1-4	
	0x5D	Logical rules for logic outputs with numbers 5-8	
	0x5E	Logical rules for logic outputs with numbers 9-12	
	0x5F	Logical rules for logic outputs with numbers 13, 14, LEDs “War” and “Alarm”	
0xFF07	0x21	Recording all module settings into non-volatile memory	1, 4

Notes

1 Logical signaling should be blocked.

2 Module is not rebooted after recording.

3 Implemented from MK32 module software version 1.82

4 Module operation in stopped during recording. Module automatically reboots after recording.

6 Software

ModuleConfigurator software is a specialized program to setup MK32 control module with convenient interface and access to all module parameters. For the program operation it is necessary to connect MK32 module to personal computer via diagnostic interface module MC01 USB or via RS485 interfaces.

Main program features:

- real-time observing current readings of MK32 current indicator and signaling readings;
- setup of all parameters of measurement channels, communication interfaces and module general parameters;
- settings text report generation of logic signaling and module as a whole;
- settings loading/saving into file;
- input calibration;
- unified output and test signal calibration.

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

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

Before connecting with MK32 module select MK32 V1.70 setting in ModuleConfigurator software.

7 Maintenance

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

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

Appendix A

(mandatory)

Controls arrangement

Versions
MK32-DC-R2, MK32-DC-20-R2

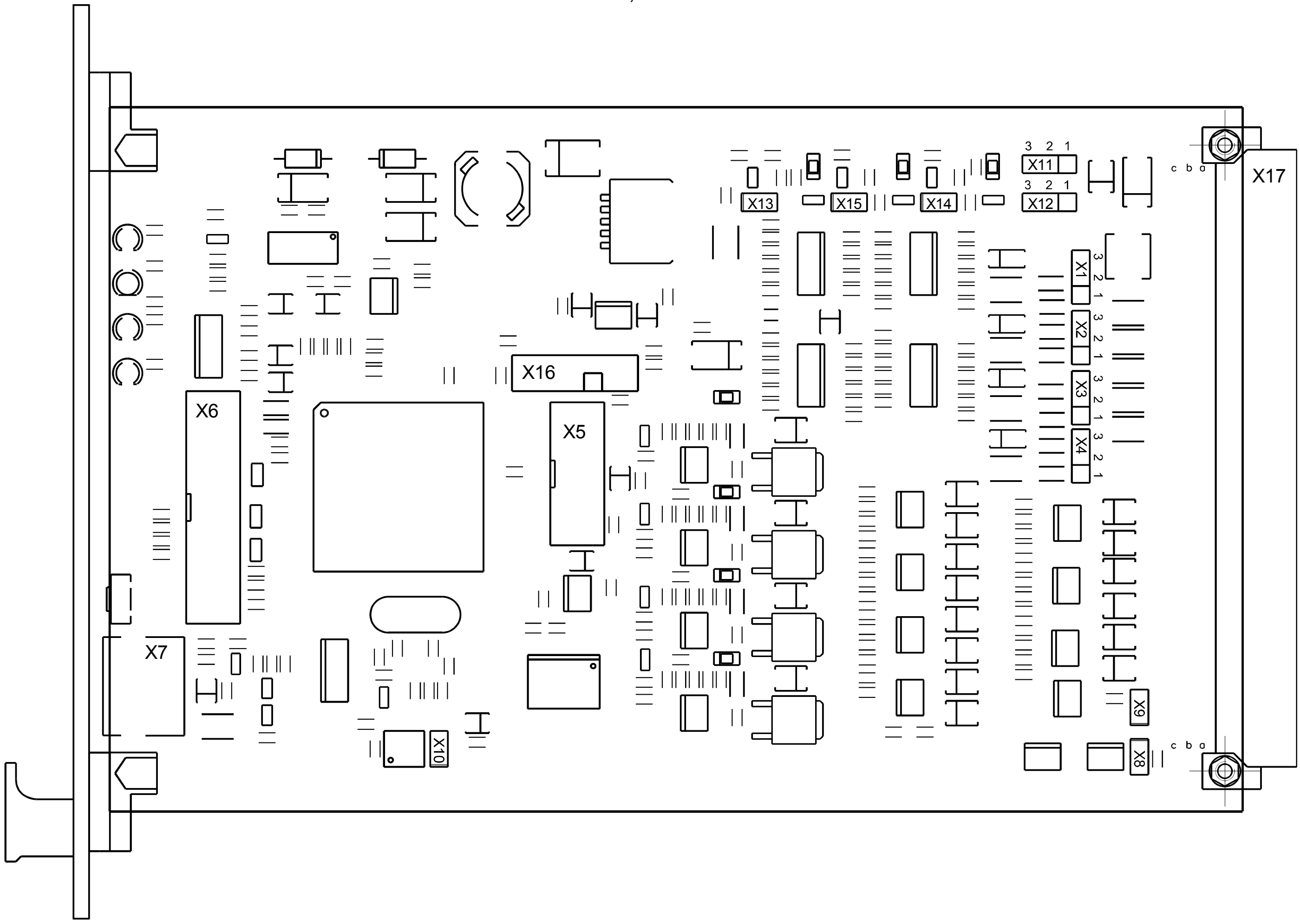


Figure A.1 - Elements arrangement on module board

Connectors purpose

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

Jumpers X1, X2, X3, X4

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

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

Jumpers X8, X9

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

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

Jumpers X11, X12

Synchronization pulses source selection for measurement channel 1,2 correspondingly

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

Jumpers X13

Pull-up resistor connection to logic input

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

Jumper X14, X15

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

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

Jumper X10
EEPROM recording protection

Removed	EEPROM recording prohibited
Installed	EEPROM recording permitted

Jumper X20, X21
Internal power supply connection to current outputs board

Position	Mode
Removed	External power supply
Installed	Internal power supply

Versions
MK32-DC-20-R2-M-RAM-PO

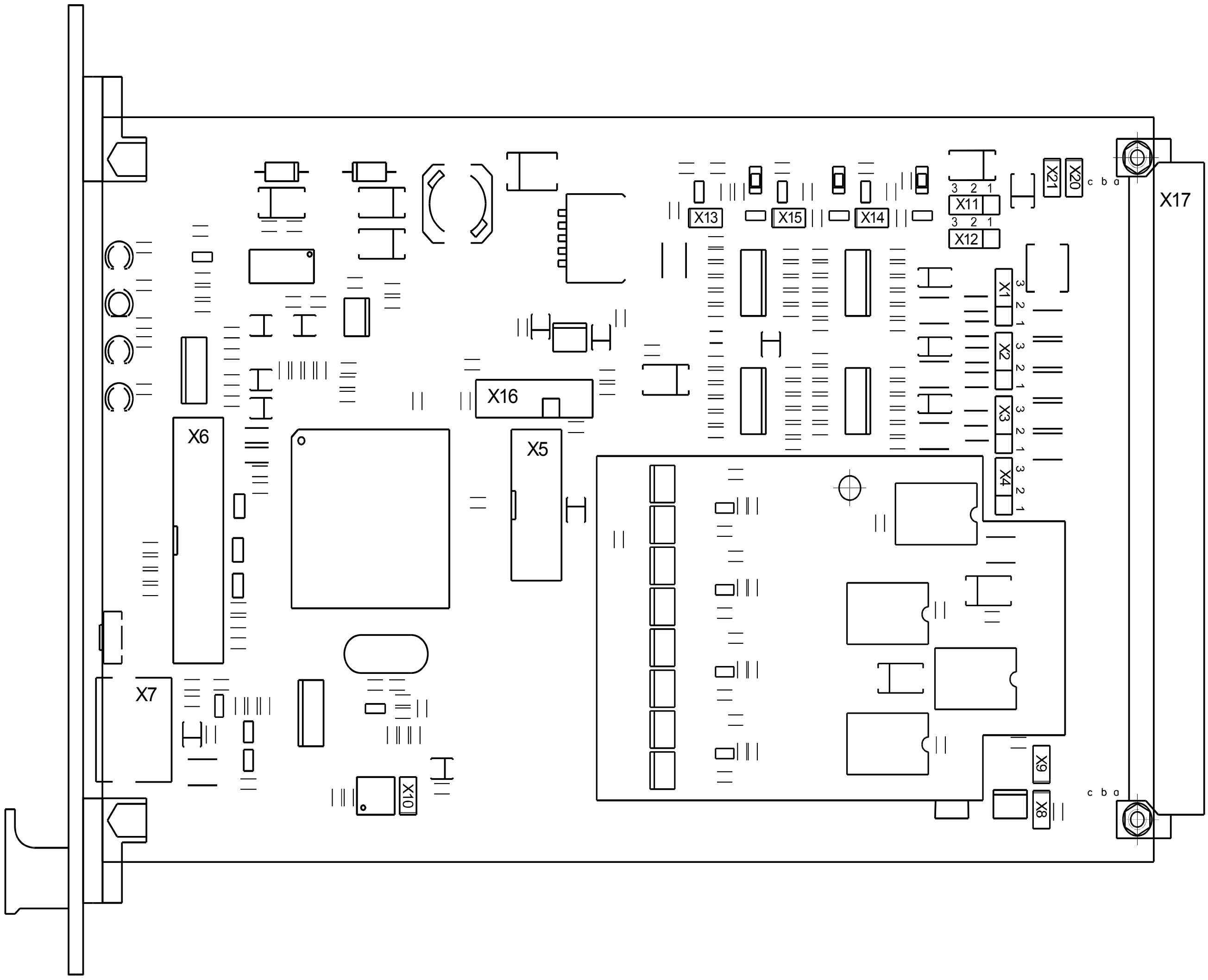


Figure A.2 - Elements arrangement on module board

Purpose of connectors and jumpers corresponds to the module versions MK32-DC-R2, MK32-DC-20-R2 (ref. Figure A.1).

Versions
МК32-DC-20-R2-LF3(-LF4; -MF3)

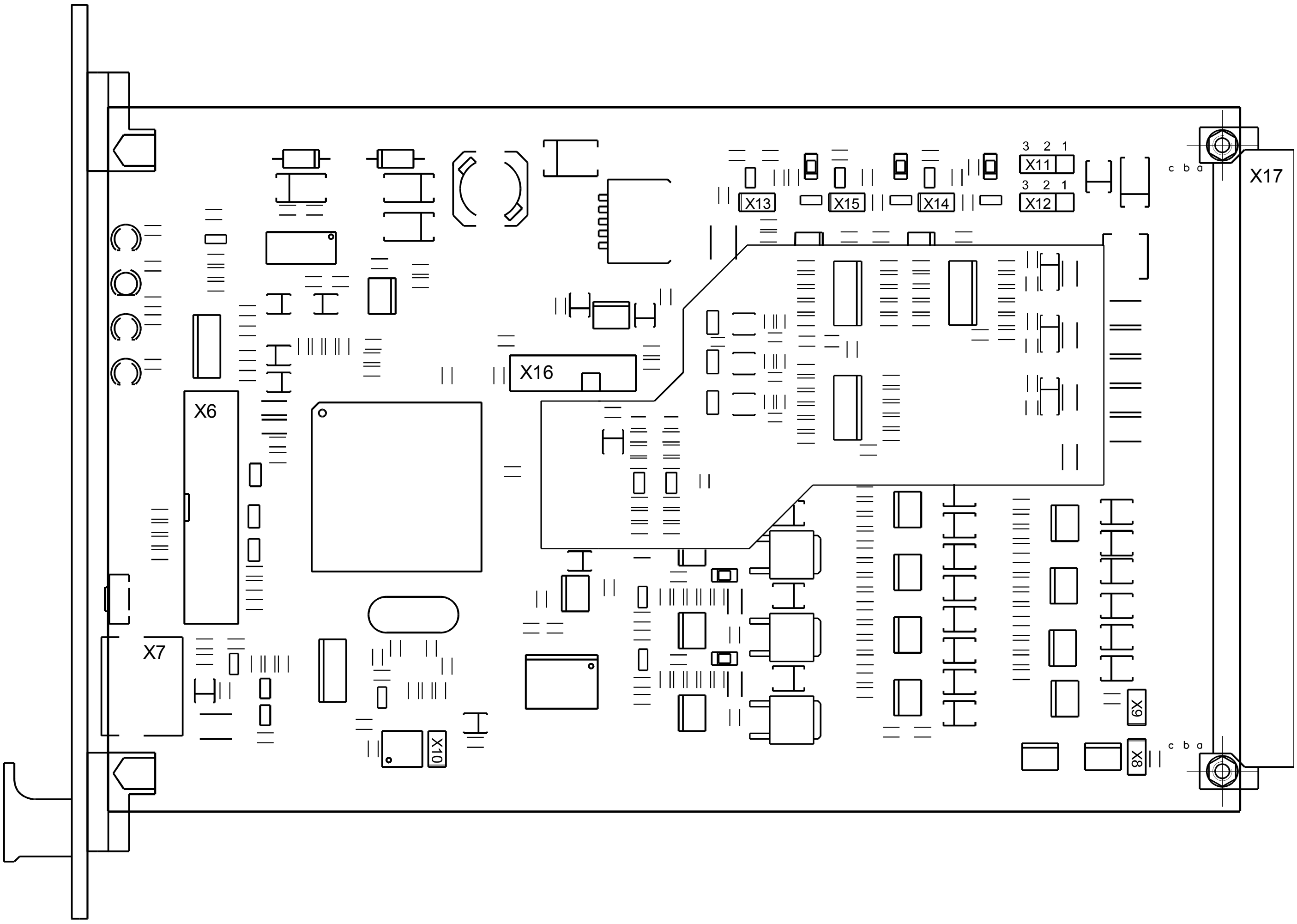


Figure A.3 - Elements arrangement on module board

Purpose of connectors and jumpers corresponds to the module versions МК32-DC-R2, МК32-DC-20-R2 (ref. Figure A.1) except for jumpers X1-X4, connector X5.

Appendix B

(mandatory)

Module switching connector terminals purpose

Table B1 – Purpose of module switching connector terminals

Terminal number	Designation	Purpose	Note
A2, B1, C2 A32, B31, C32	GND	Common	
A6, B5, C6	Power +24V	Power supply voltage input/output +24V	
B3	Fin 1	Main pulse input	
C4	Fin 2	Standby pulse input	
B7	+24V sense CH1	Voltage input +24V to power channel 1 converter	
B9	+24V sense CH2	Voltage input +24V to power channel 2 converter	
B11	+24V sense CH3	Voltage input +24V to power channel 3 converter	
B13	+24V sense CH4	Voltage input +24V to power channel 4 converter	
C8	Input CH1	Measurement channel 1 input	1
C10	Input CH2	Measurement channel 2 input	1
C12	Input CH3	Measurement channel 3 input	1
C14	Input CH4	Measurement channel 4 input	1
B15	Analog out 1	Measurement channel 1 unified output	
C15	Analog out 1 (-)	Measurement channel 1 (-) unified output	4
C16	Analog out 2	Measurement channel 2 unified output	
B16	Analog out 2 (-)	Measurement channel 2 (-) unified output	4
B17	Analog out 3	Measurement channel 3 unified output	
C17	Analog out 3 (-)	Measurement channel 3 (-) unified output	4
C18	Analog out 4	Measurement channel 4 unified output	
B18	Analog out 4 (-)	Measurement channel 4 (-) unified output	4
A15, A16	Analog Pwr +24V	+24V power supply of galvanically isolated unified output	4
A17, A18	Analog Pwr GND	Common power supply of galvanically isolated unified output	4
A20	LG_OUT_1	Logic output 1	2
A22	LG_OUT_2	Logic output 2	2
A24	LG_OUT_3	Logic output 3	2
A26	LG_OUT_4	Logic output 4	2
B19	LG_OUT_5	Logic output 5	2
B21	LG_OUT_6	Logic output 6	2
B23	LG_OUT_7	Logic output 7	2
B25	LG_OUT_8	Logic output 8	2
C20	LG_OUT_9	Logic output 9	2
C22	LG_OUT_10	Logic output 10	2
C24	LG_OUT_11	Logic output 11	2
C26	LG_OUT_12	Logic output 12	2, 3
A28	CAN-GND	CAN2.0B interface, common	
B27	CAN-H	CAN2.0B interface, line H	
C28	CAN-L	CAN2.0B interface, line L	
A30	RS485-GND	RS485 interface, common	
B29	1-RS485-B(-)	RS485 No.1 interface, line B	
C30	1-RS485-A(+)	RS485 No.1 interface, line A	
B30	2-RS485-B(-)	RS485 No.2 interface, line B	
C29	2-RS485-A(+)	RS485 No.2 interface, line A	

Notes

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

2 Operation logic is determined during module configuration.

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

4 In module version МК22-DC-20-R2-M-RAM-PO for galvanically isolated current outputs.