ВИБРО
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SCIENTIFIC PRODUCTION
ENTERPRISE VIBROBIT LLC

EQUIPMENT "VIBROBIT 300"

Module Setup Instruction

ВШПА.421412.300 И1

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2010

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Module Setup Instruction is intended to familiarize users (customers) with main operating principles and setup methods of equipment Vibrobit 300.

VIBROBIT company reserves the right to replace individual parts and components without impairing the item specifications.

Version 4 dated 30.09.2010

CONTENTS

General

Vibrobit 300 equipment is a set of subassemblies intended for measurement and control of DC, AC or voltage periodic signal parameters, pulse signal frequency in stationary control-signaling and information-measurement systems of turbine generators and other equipment.

This document describes МК20, МК21, МК30 modules and БИ24 indication module.

МК20 module is intended for measurement of vibration displacement by means of real-time spectral analysis of sensor signals, performs signaling and equipment safety shutdown functions. Measurable vibration parameters and real-time protective functions:

- Speed F;
- Vibration displacement (5 – 500)Hz, (5z – F/2)Hz, (2F – 500)Hz;
- Vibration displacement of ½, 1-10th of rotational component;
- Phase of ½, 1-5th of rotational component;
- Measurement of amplitude and phase of rotational components from 0.05Hz;
- Constant offset (gap);
- Sensor serviceability control;
- 3 setpoints of (5-500)Hz vibration displacement;
- 1 setpoint of (5 – F/2) low frequency vibration displacement;
- Detection of Vibration displacement amplitude (5-500)Hz step, the 1st rotational component amplitude and phase.

МК21 module is intended for measurement of rotor absolute vibration displacement by means of real-time spectral analysis of sensor signals, performs equipment safety shutdown functions. The rotor relative vibration displacement sensor is connected to the first channel while the support (insert) absolute vibration velocity RMS sensor is connected to the second channel. The third and the fourth channels are the design ones. The third channel is the support (insert) absolute vibration displacement, the result of the second channel vibration velocity signal integration. The fourth channel is the rotor absolute vibration displacement, the result of vector summation of the fist (rotor relative vibration displacement) and the third (the support (insert) absolute vibration displacement) channel signal.

МК21 measurable vibration parameters by vibration displacement channels:

- Vibration displacement (5-500)Hz, (5 – F/2)Hz, (2xF – 500)Hz;
- Vibration displacement of ½, 1-10th of rotational component;
- Phase of 1-10th of rotational component;
- 3 setpoints of (5-500)Hz vibration displacement;
- 1 setpoint of (5 – F/2)Hz low frequency vibration displacement RMS;
- Detection of Vibration displacement amplitude (5-500)Hz step, the 1st rotational component amplitude and its phase.

МК21 measurable vibration parameters by vibration velocity RMS channel:

- Vibration velocity RMS (10 – 1000)Hz, (10 – F/2)Hz, (2xF – 1000)Hz;
- Vibration velocity RMS of ½, 1-10th of rotational component;
- Phase of 1-10th of rotational component;
- 3 setpoints of (10-1000)Hz vibration velocity RMS;
- 1 setpoint of (10 – F/2)Hz low frequency vibration velocity RMS;
- Detection of (5-500)Hz vibration velocity RMS step, RMS of the 1st rotational component and its phase.

The following parameters are additionally measured and controlled:

- Sensor direct current and 1 and 2 measurement channels serviceability control;
- Constant gap between the sensor and monitored surface by the first measurement channel;
- Speed in rpm

MK30 module is intended for measurement of vibration velocity RMS by means of real-time spectral analysis of sensor signals, performs alarm and equipment safety shutdown functions. Measurable vibration parameters and real-time protective functions:

- Speed F;
- Vibration velocity RMS (10 – 1000)Hz, (10 – F/2)Hz, (2F – 1000)Hz;
- Vibration velocity RMS of ½, 1-10th of rotational component;
- Phase of ½, 1-5th of rotational component;
- The 1st rotational component vibration displacement amplitude and phase;
- Peak-to-peak signal excursion and signal form factor;
- Sensor accuracy control;
- 3 setpoints of (10-1000)Hz vibration velocity RMS;
- 1 setpoint of (10 – F/2)Hz low frequency vibration velocity RMS;
- Detection of (5-500)Hz vibration velocity RMS step, RMS and phase of vibration velocity 1st rotational component.

БИ24 indication module is intended for remote display of measured parameter values and independent frequency measurement. The main functions of БИ24 are:

- RS485 interface support with partial ModBus RTU protocol implementation;
- CAN2.0B interface support (expanded messages only);
- I2C slave interface for setting of БИ24 operating parameters;
- Speed measurement (rpm) with selectable display format;
- Setup of information displayed on indicators during start after power-up (reset), when waiting for signal from communication interfaces, absence of signals from communication interfaces and shutdown detection in frequency measurement mode;
- Saving of settings in non-volatile memory;
- Adjustment of display intensity.

Control Modules Power-Up, Reset and "Cold start"

Power-Up

MK20, MK21, MK30 Modules

Module reset due to powering the module up or pushing the Reset button activates the module self-diagnostic test with loading the operating parameters from non-volatile memory.

LCD displays the start window (with blinking of 'War' LED) containing the following data (Figure 1):

- Module type
- Module decimal number;
- Module software version;
- Module number;
- Percent of module self-testing completion.

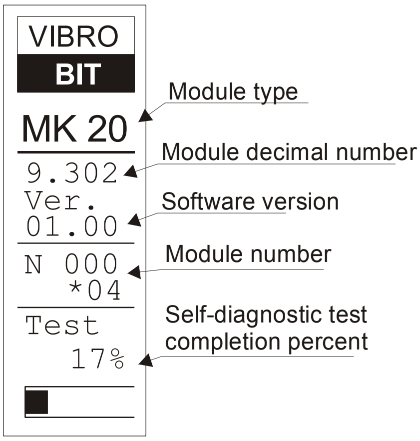


Figure 1. MK20 module start information displayed by LCD

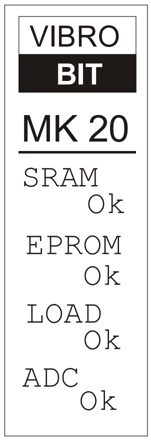


Figure 2. Example of MK20 self-diagnostic test results display on LCD

Each time the module is reset the module self-diagnostic test is performed. Self-diagnostic includes:

- Non-volatile memory test;
- Checksum test when loading operating parameters;
- External RAM test;
- ADC test.

There is 'War' LED blinking during the module self-diagnostic test performance, output logic and analog signaling are disabled. External control interfaces (RS485, CAN2.0B, diagnostic port) are inoperable.

Non-volatile memory test is performed by means of double test request to the non-volatile memory microchip that is to respond with acknowledgment signal indicative of the memory microchip serviceability. Then when loading operating system parameters the non-volatile memory microchip is checked for adequate responses to transmitted requests.

The first non-volatile memory test is accompanied with reading of the module identification data (module number, year of manufacture). If the non-volatile memory test is failed no parameters will be loaded from the non-volatile memory.

All module operating parameters are divided into two groups:

Group 1 – system parameters:

- Identification data including addresses and data rates on external interfaces;
- LCD display settings;
- Output logic signaling;
- Output analogous signaling.
-

Group 2 – measurement channel parameters:

- 1 measurement channel parameters;
- 2 measurement channel parameters;
- 3 measurement channel parameters;
- 4 measurement channel parameters.

Each data block has its own checksums. All datablocks in the groups are recorded into two sections of the non-volatile memory: main and reserve. If any checksum when reading from the main section is incorrect an attempt to read data from the reserve section is made.

Failure to read data from the group 1 (main and reserve section) completely blocks the module operation. If there is a failure to read data from of the group 2 sections, the relevant measurement channel is disabled.

External RAM test is performed by reference recording and reading reference values from each RAM cell. If any error is detected during the reference reading, RAM test is to be deemed failed and the module operation is disabled.

Internal ADC test is performed by means of recurrent (during RAM test) measurement of free channels connected to GND, 1.8V core power supply voltage. ADC average results for these channels should meet the specified levels. If ADC test has been failed the device operation is disabled.

Upon test completion LCD displays self-diagnostic results: (Figure 2).

The module LCD identification of tests and results:

SRAM – external RAM test:
- "ok" – RAM is o.k.;
- "err" – RAM failure.

EPROM – non-volatile memory test:
- "ok" – non-volatile memory is o.k.;
- "err" – non-volatile memory failure;
- "lock" – recording to non-volatile memory is disabled;

LOAD – checksum when loading parameters from non-volatile memory:
- "ok" – all checksums coincide;
- "err" – checksum failure detected when loading parameters;
- "war" – parameters were loaded from the reserve section;
- "--" – no check performed due to non-volatile memory failure;

ADC – ADC test:
- "ok" – ADC is o.k.;
- "err" – ADC failure.

If self-diagnostic test has been successfully completed, the module will switch over to normal vibration parameters measurement mode in 1 second after the test results displayed.

If self-diagnostic test has failed:

- Module will not switch over to normal operation mode;
- LCD always displays the test results;
- Output logic and analogous signaling is disabled;
- There is an active signal on the 12th logic output;
- 'Ok' double LED on the front panel gleams red;
- Red 'Alarm' and yellow 'War' LEDs set by the user are off;
- The user can only reset the module.

To prevent false actuation of the output logic signaling there is a feature of logic output response delay after the module reset (`START_DEVICE`).

The delay time is determined by the parameter:

`start_ready_wait` - delay of output logic signaling response after reset by 10ms.

Start delay enables stabilization of measurement results before safety shutdown is activated.

Module Reset

Module reset is accompanied with hard reset of the microprocessor and execution of sequence of operations corresponding to power-up. The module reset may be caused by:

- Module power-up;
- Reset by the user (using 'Reset' button located on the front panel or by the command from digital interfaces);
- Microcontroller/microprocessor power supply voltage drop (power supply failure);
- Reset by watchdog timer due to microcontroller/microprocessor program hangup.

The user can reset and "cold start" the module pushing 'Reset' hidden board-mounted button through the hole in the module front panel.

The module can be reset upon completion of identification data display only.

To reset the module push 'Reset' button one time and then push and hold 'Reset' button until the module is reset.

Module "Cold start"

"Cold start" is intended for recording of default settings into the module non-volatile memory. This feature is useful in case of initial start-up of the module after unit or in case when the module recalibration is required.

To switch over to "Cold start" mode hold ‘Reset’ button during the whole identification data display cycle.

MK20, MK21, MK30 Modules

If switch over into "cold start" mode is detected, ‘Ok’ bi-color LED will light up yellow and ‘War’ LED will keep on blinking when displaying self-diagnostic test results on LCD. The module "cold start" confirmation is expected upon the display of self-diagnostic test results (Figure 3).

> **Attention:** If any non-volatile memory failure is detected or recording to the memory is disabled "Cold start" mode will not be activated.

There is “COLD START” caption blinking on LCD and standby indicator being filled up in the LCD bottom when expecting the "Cold start" confirmation.

If "Cold start" is not confirmed within 10 seconds the module will be reset.

"Cold start" confirmation sequence correct input is displayed as ‘*’ symbols appearing for each correct operation.

If confirmation sequence is incorrect, it is required to repeat the whole confirmation sequence again. Such approach enables to prevent accident corruption of data recorded in the non-volatile memory.

<u>"Cold start" confirmation sequence</u>: push ‘Reset’ button one time and then push and hold ‘Reset’ button until the process of recording the default settings to the memory starts.

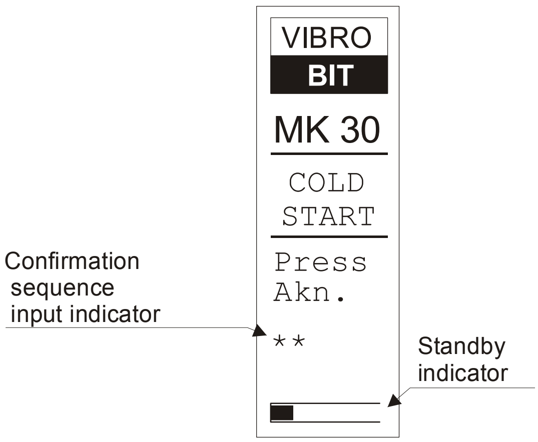


Figure 3. "Cold start" confirmation standby

Figure 4. The process of recording the default settings to the non-volatile memory

Default settings are immediately recorded to the non-volatile memory by correctly input sequence. Data is recorded to both the main and the reserve sections followed by check reading.

LCD displays the message that data recording is in progress and there is recording indicator located in the LCD bottom (Figure 4).

Upon recording completion LCD displays the message on the results of saving the default settings into the non-volatile memory (ERROR – recording has failed; OK – default settings have been successfully recorded).

In 5 seconds after displaying the results of recording into the non-volatile memory, the module is automatically reset.

> **Attention.** No recording to the non-volatile memory shall be executed if recording into EEPROM is physically disabled (with board jumper).

Indication and Control Means

MK20, MK21, MK30 Modules - 'DC'Version

There are 4 LEDs mounted on the front module panel (Figure 5):

- 'Pwr' green LED – normal supply voltage indication;
- 'Ok' bi-color LED – module status indication:
  - Green color – normal module operation, logic signaling is on;
  - Yellow color – normal module operation, output logic signaling is disabled (one or both `START_DEVICE`, `LOGIC_OUT_DISABLE` system flags are on);
  - Red color – critical module operation error, output logic and analogous signaling are disabled, there is an active signal level on the 12th logic output (one of `ERR_EXT_EEPROM`, `ERR_EXT_SRAM`, `ERR_EXT_ADC_DAC` or `ERR_LOAD_SYS_CONF` system flags are set to '1').
- 'War' yellow LED - warning (LED activation conditions are user-defined);
- 'Alarm' red LED - crash (LED activation conditions are user-defined).

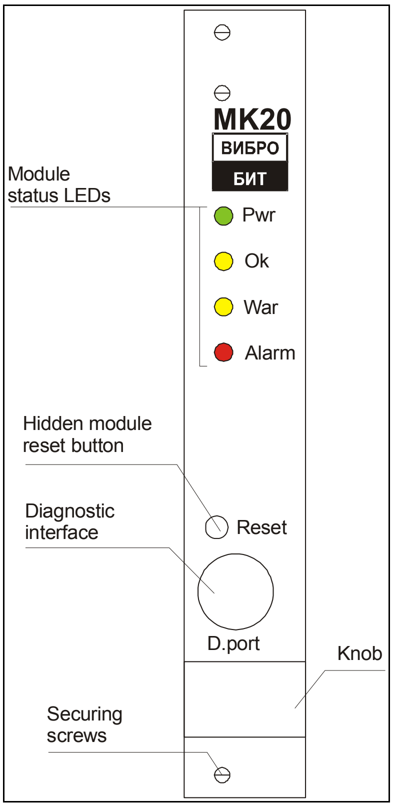


Figure 5. MK20 module front panel'Slim'

In this version the signaling LEDs become the only means of the module status indication except diagnostic device connection or access to the results of measurements on RS485 and CAN2.0B external interfaces.

Yellow 'War' and red 'Alarm' LEDs activation conditions may be defined by the user. To this effect it is required to appropriately set bits No.15 and 14 in `buff_or_dest_matrix_1` of logic signaling "OR" groups.

Bit 15 `buff_or_dest_matrix_1` – red LED control
Bit 14 `buff_or_dest_matrix_1` – yellow LED control

If LED's bit in `buff_or_dest_matrix_1` is set to '1' and event flag is set in '1', the corresponding LED will be enabled.

МК20, МК21, МК30 Modules – 'DC-20' Version

There are graphic LCD 32x122 and two control buttons provided in addition to alarm LEDs to display vibration parameters measurement data (Figure 6).

Data display modes are selected using two buttons 'Mode' and 'Sel' located on the module front panel under LCD.

Control Buttons

There are two buttons provided to control the module and indication modes set at the front panel and one hidden button which is the reset button.

Button assignment:

Button No.1 'Mode' – switching between information "full output" and histogram measurement results display modes. If there are no histograms set in the system, the histogram mode will be disabled.

Button No.2 'Sel' – Pushing the button in histogram mode enables cyclical switching between set histograms to display the data on LCD. Pushing the button in "full output" mode enables switching between measurement channels.

Button No. 3 'Reset' – the button is sunk and cannot be pushed accidentally. The module is reset when pushing the button in certain sequence: push 'Reset' button once, release it, push again and hold until the module is reset.

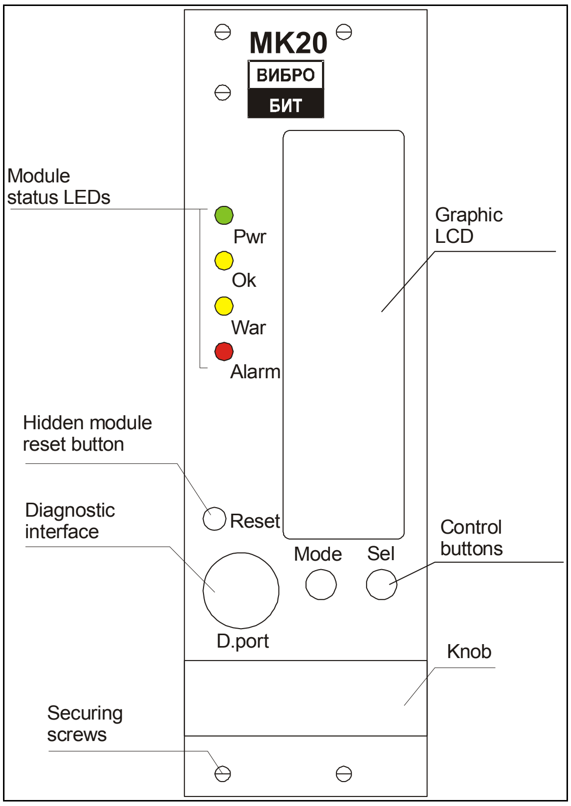


Figure 6. МК20 module front panel 'Full'

The module status can be controlled by provided several combinations of buttons to push:

Continuous holding of 'Mode' and 'Sel' buttons switches LOGIC_OUT_DISABLE bit that is used to disable output logic signaling. Output logic signaling disable feature may be useful when, for example, it is required to inspect the sensor connected to the module without a risk of causing the unit emergency shutdown.

Continuous holding of 'Mode' button in "full output" mode resets the flags of parameter steps detected as well as step detection algorithms for the channel displayed on LCD if necessary.

Continuous holding of 'Sel' button in histogram mode initiates setpoint display mode if there are any setpoints provided for the displayed parameter.

LCD Data Display

Vibration parameters measurement results are displayed in one of two modes:

- As histogram;
- Full information for the channel.

Both indication modes provide for flexible data display format adjustment, enabling to easily change the quantity and format of displayed parameters without the program code correction.

Each measurable vibration parameter is assigned with its unique number (parameter code). This number is used to indicate which information is to be displayed on LCD at the moment (Table 2, Table 3).

There is several display formats provided for display of parameter numerical values (Table 1). In case of displaying any value beyond the range of values permitted for this format, LCD will display a limit value.

Table 1. Reserved formats for output of parameter numerical values on LCD

Format Code	Format	Maximum Value	Minimum Value
0	#.###	9.999	0.000
1	##.##	99.99	-9.99
2	###.#	999.9	-99.9
3	#####	99999	-9999

Table 2. The list of MK20 module measurable parameters and their codes

Parameter Code	Description	Note
0	Sensor current	Two adjacent setpoints
1	Vibration displacement	Three setpoints
2	Low frequency vibration displacement	One setpoint
3	High frequency vibration displacement	
4	Amplitude of the 1st vibration displacement rotational component	
5	Phase of the 1st vibration displacement rotational component	
6	Amplitude of the 2nd vibration displacement rotational component	
7	Phase of the 2nd vibration displacement rotational component	
8	Amplitude of ½ vibration displacement rotational component	
9	Reserve, always 0	
10	Direct component, gap	
11	Reserve, always 0	
12	Speed	Common parameter for all channels, cannot be assigned to be built in the histogram

Table 3. The list of MK30 module measurable parameters and their codes

Parameter Code	Description	Note
0	Sensor current	Two adjacent setpoints
1	Total vibration velocity RMS	Three setpoints
2	Low frequency vibration velocity RMS	One setpoint
3	High frequency vibration velocity RMS	
4	RMS of the 1st vibration velocity rotational component	
5	Phase of the 1st vibration velocity rotational component	
6	RMS of the 2nd vibration velocity rotational component	
7	Phase of the 2nd vibration velocity rotational component	
8	Amplitude of the 1st vibration displacement rotational component	
9	Phase of the 1st vibration displacement rotational component	
10	Peak-to-peak escursion amplitude	
11	Signal form factor	
12	Speed	Common parameter for all channels, cannot be assigned to be built in the histogram

Histogram Display Mode

In histogram data display mode information is represented as 4 colored columns. which height is proportional to the value of displayed parameters. The left column corresponds to the 1st measurement channel and the right column corresponds to the 4th measurement channel (Figure 7).

The top LCD line displays the histogram name while numerical values of parameters are displayed under the name beginning from the 1st channel in set format.

If there are any setpoints provided for the displayed parameter, they are displayed as dashes in each channel separately.

The maximum amount of displayed histograms is defined by the parameter:

`hist_amount` – the amount of recorded histograms, 0 – no histograms to display, maximum amount of histograms is 8.

Each histogram has its own group of adjustable parameters (Table 4).

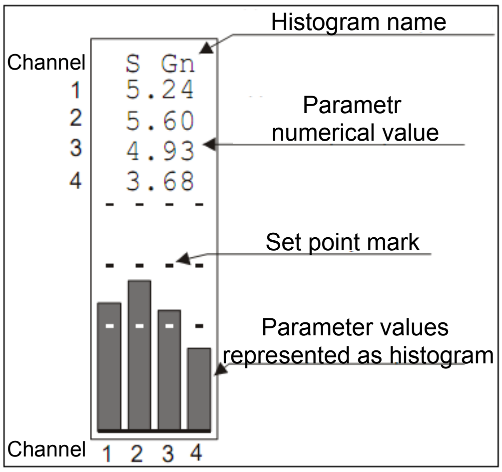


Figure 7. Example of histogram data display for MK20 module

Table 4. The list of adjustable parameters for each histogram type

Designation	Description
`string_name`	Five characters of histogram name that is displayed in the top histogram line (histogram name may not contain any cyrillic symbols).
`data_max`	Maximum value used when calculating the histogram column height and setpoint display position. If any value to be displayed exceeds the maximum value, the column of maximum height is displayed
`data_code`	The code of initial data to be displayed as histogram (Table 2, Table 3)
`data_format`	Numerical value representation format (Table 1)
`flag_mask_no_data`	Bit mask which enables to build histogram based on initial data. If any bit of the channel mask status is set in 1, there will be 0 displayed instead of the data transferred.

Data output mask overlays the channel status register (Table 12, Table 14). If any bit of the channel mask status is set in ‘1’, there will be no histogram built for this channel and 0 displayed instead of numerical value.

When switching to histogram display mode, LCD will display the 1st recorded histogram. Repeated pushing ‘Sel’ button will cyclically display all recorded histograms.

Irrelevant negative value histograms are executed in absolute magnitude while numerical value is displayed negative.

If histogram displays a parameter for which there are any setpoints provided, the set level is shown up as dashes (Figure 7).

Setpoints may be reviewed by pushing and holding ‘Sel’ button. In that case the current parameter values are displayed as histograms, setpoints levels are displayed instead of the parameter numerical value and the relevant setpoints start blinking. Repeated pushing of ‘Sel’ button will switch over to the next setpoints or display the parameter value provided that all setpoints recorded for that parameter have been reviewed.

If the user enabled setpoint display function and have not pushed control buttons for a prolonged time the current parameter values will be automatically displayed in set interval of time.

Setpoint display time-out value is defined with the parameter:

`time_out_test_point` – setpoint display time-out interval

<u>Default histogram display settings for MK20 module</u>

There are 8 histograms recorded by default:

1. Vibration displacement amplitude (5-500)Hz;
2. Low frequency vibration displacement amplitude (5 – F/2)Hz;
3. High frequency vibration displacement amplitude (2F – 500)Hz;
4. Sensor current;
5. Amplitude of the 1st vibration displacement rotational component;
6. Phase of the 1st vibration displacement rotational component;
7. Amplitude of the 2nd vibration displacement rotational component;
8. Phase of the 2nd vibration displacement rotational component.

Table 5. Example of default histogram setting for MK20 module (8 histograms in total)

Parameter	Histogram Number							
	1	2	3	4	5	6	7	8
`string_name`	`"S  Gn"`	`"S  LP"`	`"S  HP"`	`"I    "`	`"S  1f"`	`"Ph 1f"`	`"S  2f"`	`"Ph 2f"`
`data_max`	400	400	400	400	20.0	360	400	360
`data_code`	1	2	3	0	4	5	6	7
`data_format`	3	3	3	3	3	3	3	3
`flag_mask_no_data`	0x000E	0x000E	0x000E	0x0002	0x800E	0x800E	0x800E	0x800E

Total, low frequency and high frequency vibration displacement value display is disabled in default settings if (0x000E (hexadecimal number) = 0000 0000 0000 1110 (binary number)):

- The error of reading the channel operating parameters from non-volatile memory (`ERR_CRC_TWO_BANK`);
- Sensor current is below the set level (`SENSE_ERROR_MIN`);
- Sensor current is above the set level (`SENSE_ERROR_MAX`).

Sensor current display is disabled only when error of reading the channel operating parameters from non-volatile memory occurs (`ERR_CRC_TWO_BANK`).

There is supplementary condition to display rotational components, synchronization pulses are required. Amplitude and phase of the 1st and the 2nd vibration displacement rotational components will not be displayed if:

(0x800E (hexadecimal number) = 1000 0000 0000 1110 (binary number)):

- The error of reading the channel operating parameters from non-volatile memory (`ERR_CRC_TWO_BANK`);
- Sensor current is below the set level (`SENSE_ERROR_MIN`);
- Sensor current is above the set level (`SENSE_ERROR_MAX`).
- Synchronization pulse error (`ERR_FREQUENCY`).

Default histogram display settings for MK30 module

There are 8 histograms recorded by default:

1. Total vibration velocity RMS (10 – 1000)Hz;
2. Low frequency vibration velocity RMS (10 – F/2)Hz;
3. High frequency vibration velocity RMS (2F – 1000)Hz;
4. Sensor current;
5. The 1st vibration velocity rotational component RMS;
6. Phase of the 1st vibration velocity rotational component;
7. The 2nd vibration velocity rotational component RMS;
8. Phase of the 2nd vibration velocity rotational component.

Table 6. Example of default histogram display settings for MK30 module (8 histograms in total)

Parameter	Histogram Number							
	1	2	3	4	5	6	7	8
string_name	"Ve Gn"	"Ve LP"	"Ve HP"	"I "	"Ve 1f"	"Ph 1f"	"Ve 2f"	"Ph 2f"
data_max	20.0	3.0	3.0	30.0	20.0	360	20.0	360
data_code	1	2	3	0	4	5	6	7
data_format	1	1	1	1	1	3	1	3
flag_mask_no_data	0x000E	0x000E	0x000E	0x0002	0x800E	0x800E	0x800E	0x800E

Conditions for data display as histogram are identical to MK20 module default settings

Full information Display Mode

In full information display mode, only parameter values related to the current measurement channel are displayed on LCD in preset format. Data display format is the same for all measurement channels.

The top LCD line displays the measurement channel number. The rest 14 lines are user-definable.

For each line it is possible to select the type of displayed data:

- Parameter numerical value in preset format;
- Text message (5 characters) based on the status of the measurement channel status register signaling flags;
- Blank line.

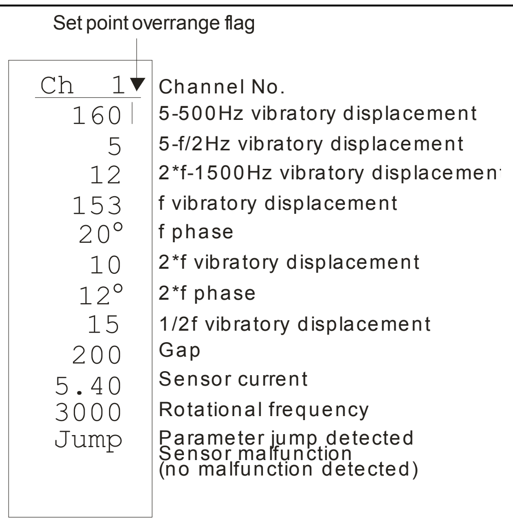


Figure 8. Example of full information mode data display, MK20 module

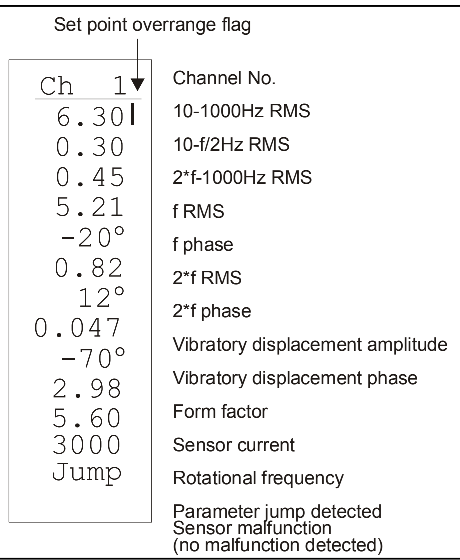


Figure 9. Example of full information mode data display, MK30 module

Table 7. The list of adjustable parameters for each LCD line in full information mode

Designation	Description
data_code	The code of initial data to be displayed in the line (Table 2, Table 3)
data_format	Data format 0– blank line 1– #.### format numerical value 2– ##.## format numerical value 3– #.### format numerical value 4– ##### format numerical value 5– flag_mask_point mask character line
flag_mask_point	For 0 data format No value For 1-4 data format If any status mask bit is set, a vertical dash will be displayed after numerical value that for example may indicate parameter setpoint overrange (Table 12, Table 14). For 5 data format If any status mask bit is set, string_out_flag_set will be displayed otherwise string_out_flag_clear line appears.
flag_mask_no_data	If any status mask bit is set, the null data line '---' will be displayed instead of parameter numerical value. This feature may be used for example to prohibit data output in case of sensor malfunction. (This mask is disabled for formats 0, 5) (Table 12, Table 14)
string_out_flag_clear	Line consisting of 5 characters displayed on LCD with 5 data format if there are no bit masks flag_mask_point set to 1
string_out_flag_set	Line consisting of 5 characters displayed on LCD with 5 data format if there is at least one bit mask flag_mask_point set to 1.

Parameter setpoint overrange flag is 2x8 pixels character box field of user-definable format:

bit_mask_1 – Eight bits of the first line of 1x8 parameter setpoint overrange flag *(1111 1110 by default);*

bit_mask_2 – Eight bits of the second line of 1x8 parameter setpoint overrange flag *(1111 1110 by default).*

If a bit in bit_mask_1, bit_mask_2 is equal to '1' there will be corresponding pixel lighting on LCD. Default setting corresponds to vertical double line of single character height.

'Sel' button switches between the measurement channels. When switching to full information display mode, LCD displays data for the 1st measurement channel.

Full information mode enables to reset detected parameter steps. To this effect it is required to push and hold 'Mode' button until step flags and step detection algorithms being in reset wait condition are reset. Step is reset only for the measurement channel that is displayed on LCD.

Full information display default setting for MK20 module

By default the lines on LCD in full information display mode are set as follows (Table 8):

1. Vibration displacement amplitude (5-500)Hz;
2. Low frequency vibration displacement amplitude (5 – F/2)Hz;
3. High frequency vibration displacement amplitude (2F – 500)Hz;
4. Amplitude of the 1st vibration displacement rotational component;
5. Phase of the 1st vibration displacement rotational component;
6. Amplitude of the 2nd vibration displacement rotational component;
7. Phase of the 2nd vibration displacement rotational component;
8. Phase of 1/2nd vibration displacement rotational component;
9. Vibration displacement gap;
10. Sensor current;
11. Speed;
12. Blank;
13. Message of a step detection ((5 – 500Hz) vibration displacement, amplitude, phase of the 1st vibration displacement rotational component);
14. Sensor malfunction message.

Table 8. Example of full information data display mode setting for MK20 module (by default)

Parameter	String Number						
	1	2	3	4	5	6	7
data_code	1	2	3	4	5	6	7
data_format	4	4	4	4	4	4	4
flag_mask_point	0x0070	0x0080	0x0000	0x0000	0x0000	0x0000	0x0000
flag_mask_no_data	0x000E	0x000E	0x000E	0x800E	0x800E	0x800E	0x800E
string_out_flag_clear	" "	" "	" "	" "	" "	" "	" "
string_out_flag_set	" "	" "	" "	" "	" "	" "	" "

Parameter	String Number						
	8	9	10	11	12	13	14
data_code	8	10	0	12	0	1	1
data_format	4	4	2	4	0	5	5
flag_mask_point	0x0000	0x0000	0x000C	0x8000	0x0000	0x0700	0x000E
flag_mask_no_data	0x800E	0x000E	0x0002	0x0000	0x0000	0x0000	0x0000
string_out_flag_clear	" "	" "	" "	" "	" "	" "	" "
string_out_flag_set	" "	" "	" "	" "	" "	" Jamp"	"S err"

<u>Default settings key:</u>

5- 500Hz vibration displacement flag is displayed if:

- Vibration displacement value is above the 1st setpoint (S_POINT_1);
- Vibration displacement value is above the 2nd setpoint (S_POINT_2);
- Vibration displacement value is above the 3rd setpoint (S_POINT_3).

Low frequency vibration displacement flag is displayed if:

- Low frequency RMS value is above the setpoint (S_LP_POINT).

Sensor current flag is displayed if:

- Sensor current is below the lower setpoint (SENSE_ERROR_MIN);
- Sensor current is above the upper setpoint (SENSE_ERROR_MAX).

Speed flag is displayed if:

- Synchronization error is detected (ERR_FREQUENCY).

(5-500)Hz, low and high frequency vibration displacement display is disabled (“ -- ” is displayed instead of a number) if:

- Sensor operating parameters error is detected when loading from the non-volatile memory (ERR_CRC_TWO_BANK);
- Sensor current is below the lower setpoint (SENSE_ERROR_MIN);
- Sensor current is above the upper setpoint (SENSE_ERROR_MAX).

The 1st and 2nd vibration displacement rotational components display is disabled (“ -- ” is displayed instead of a number) if:

- Sensor operating parameters error is detected when loading from the non-volatile memory (ERR_CRC_TWO_BANK);
- Sensor current is below the lower setpoint (SENSE_ERROR_MIN);
- Sensor current is above the upper setpoint (SENSE_ERROR_MAX);
- Synchronization error is detected (ERR_FREQUENCY).

Sensor current value display is disabled (“ -- ” is displayed instead of a number) if:

- Sensor operating parameters error is detected when loading from the non-volatile memory (ERR_CRC_TWO_BANK).

The 13th line displays “Jamp” message of the parameter step detection if one of the following flags is set:

- Total (5-500)Hz vibration displacement step is detected (JAMP_S);
- The 1st vibration displacement rotational component amplitude step is detected (JAMP_S_1F);
- The 1st vibration displacement rotational component phase step is detected (JAMP_PHASE_1F).

The 14th line displays “S err” message of the measurement channel malfunction if one of the following flags is set:

- Sensor operating parameters error is detected when loading from the non-volatile memory (ERR_CRC_TWO_BANK);
- Sensor current is below the lower setpoint (SENSE_ERROR_MIN);
- Sensor current is above the upper setpoint (SENSE_ERROR_MAX).

Full information display default setting for MK30 module

By default the lines on LCD in full information mode are set as follows (Table 9):

1. Total vibration velocity RMS (10 – 1000)Hz;
2. Low frequency vibration velocity RMS (10 – F/2)Hz;
3. High frequency vibration velocity RMS (2F – 1000)Hz;
4. The 1st vibration velocity rotational component RMS;
5. Phase of the 1st vibration velocity rotational component;
6. The 2nd vibration velocity rotational component RMS;
7. Phase of the 2nd vibration velocity rotational component;
8. Amplitude of the 1st vibration displacement rotational component;
9. Phase of the 1st vibration displacement rotational component;
10. Signal form factor;
11. Sensor current;
12. Speed;
13. Message of a step detection (total RMS, RMS of the 1st vibration velocity rotational component and phase of the 1st vibration velocity rotational component);
14. Sensor malfunction message.

Table 9. Example of full information data display mode setting for MK30 module (by default)

Parameter	Histogram Number						
	1	2	3	4	5	6	7
data_code	1	2	3	4	5	6	7
data_format	2	2	2	2	4	2	4
flag_mask_point	0x0070	0x0080	0x0000	0x0000	0x0000	0x0000	0x0000
flag_mask_no_data	0x000E	0x000E	0x000E	0x800E	0x800E	0x800E	0x800E
string_out_flag_clear	" "	" "	" "	" "	" "	" "	" "
string_out_flag_set	" "	" "	" "	" "	" "	" "	" "

Parameter	Histogram Number						
	8	9	10	11	12	13	14
data_code	8	9	11	0	12	1	1
data_format	2	4	2	2	4	5	5
flag_mask_point	0x0000	0x0000	0x0000	0x000C	0x8000	0x0700	0x000E
flag_mask_no_data	0x800E	0x800E	0x400E	0x0002	0x0000	0x0000	0x0000
string_out_flag_clear	" "	" "	" "	" "	" "	" "	" "
string_out_flag_set	" "	" "	" "	" "	" "	" Jamp"	"S err"

Default settings key:

Total vibration velocity RMS value flag is displayed if:

- Total RMS value is above the 1st setpoint (VRMS_POINT_1);
- Total RMS value is above the 2nd setpoint (VRMS_POINT_2);
- Total RMS value is above the 3rd setpoint (VRMS_POINT_3).

Low frequency vibration velocity RMS value flag is displayed if:

- Low frequency RMS value is above the setpoint (VRMS_LP_POINT).

Sensor current value flag is displayed if:

- Sensor current is below the lower setpoint (SENSE_ERROR_MIN);
- Sensor current is above the upper setpoint (SENSE_ERROR_MAX).

Speed value flag is displayed if:

- Synchronization error is detected (ERR_FREQUENCY).

Total vibration velocity RMS, low frequency vibration velocity RMS and high frequency vibration velocity RMS display is disabled (" -- " is displayed instead of a number) if:

- Sensor operating parameters error is detected when loading from the non-volatile memory (ERR_CRC_TWO_BANK);
- Sensor current is below the lower setpoint (SENSE_ERROR_MIN);
- Sensor current is above the upper setpoint (SENSE_ERROR_MAX).

The display of the 1st and the 2nd RMS rotational components, vibration velocity phase and amplitude, 1st vibration displacement rotational component display is disabled ("--" is displayed instead of a number) if:

- Sensor operating parameters error is detected when loading from the non-volatile memory (ERR_CRC_TWO_BANK);
- Sensor current is below the lower setpoint (SENSE_ERROR_MIN);
- Sensor current is above the upper setpoint (SENSE_ERROR_MAX);
- Synchronization error is detected (ERR_FREQUENCY).

Signal form factor display is disabled ("--" is displayed instead of a number) if:

- Sensor operating parameters error is detected when loading from the non-volatile memory (ERR_CRC_TWO_BANK);
- Sensor current is below the lower setpoint (SENSE_ERROR_MIN);
- Sensor current is above the upper setpoint (SENSE_ERROR_MAX);
- Total vibration velocity RMS level is too low (VRMS_ABSENT).

Sensor current value display is disabled ("--" is displayed instead of a number) if:

- Sensor operating parameters error is detected when loading from the non-volatile memory (ERR_CRC_TWO_BANK).

- The 13th line displays "Jamp" message of the parameter step detection if one of the following flags is set:
  - Total vibration velocity RMS step is detected (JAMP_VRMS);
  - The 1st vibration velocity rotational component RMS step is detected (JAMP_VRMS_1F);
  - The 1st vibration velocity rotational component phase step is detected (JAMP_PHASE_1F).

The 14th line displays "S err" message of the measurement channel malfunction if one of the following flags is set:

- Sensor operating parameters error is detected when loading from the non-volatile memory (ERR_CRC_TWO_BANK);
- Sensor current is below the lower setpoint (SENSE_ERROR_MIN);
- Sensor current is above the upper setpoint (SENSE_ERROR_MAX).

LCD Data Display, МК21 Module

Vibration parameters measurement data is displayed in one of two modes:

- As histogram;
- Full information for the channel.

Unlike МК20 and МК30 modules, МК21 module display mode cannot be changed. МК21 module display modes are strictly preconfigured. Vibration displacement is displayed in mkm units while vibration velocity RMS is displayed in mm/s.

There are 8 histograms recorded (Figure 10):

1. Vibration displacement amplitude (5-500)Hz (3 setpoints);
2. Low frequency vibration displacement amplitude (5 – F/2)Hz (1 setpoint);
3. High frequency vibration displacement amplitude (2xF – 500)Hz;
4. Sensor current;
5. Amplitude of the 1st vibration displacement rotational component;
6. Phase of the 1st vibration displacement rotational component;
7. Amplitude of the 2nd vibration displacement rotational component;
8. Phase of the 2nd vibration displacement rotational component;

When displaying histograms the vibration displacement data is displayed by columns only:

1. Relative rotor vibration displacement (channel 1);
2. Absolute support (insert) vibration displacement (channel 3);
3. Blank;
4. Absolute rotor vibration displacement (channel 4).

LCD lines in full information display mode are set as follows (Figure 9b):

1. Vibration displacement amplitude (5-500)Hz (vibration velocity RMS for channel 2);
2. Low frequency vibration displacement amplitude (5 – F/2)Hz (low frequency vibration velocity RMS for channel 2);
3. High frequency vibration displacement amplitude (2xF – 500)Hz (high frequency vibration velocity RMS for channel 2);
4. Amplitude of the 1st vibration displacement rotational component (vibration velocity RMS for channel 2);
5. Phase of the 1st vibration displacement rotational component (vibration velocity RMS for channel 2);
6. Amplitude of the 2nd vibration displacement rotational component (vibration velocity RMS for channel 2);
7. Phase of the 2nd vibration displacement rotational component (vibration velocity RMS for channel 2);
8. vibration displacement gap (for channel 1 only);
9. Sensor current (for 1,2 channels only);
10. Speed;
11. Sensor malfunction message (for 1,2 channels only);
12. Message of a step detection (5 – 500Hz vibration displacement, amplitude and phase of the 1st vibration displacement rotational component).

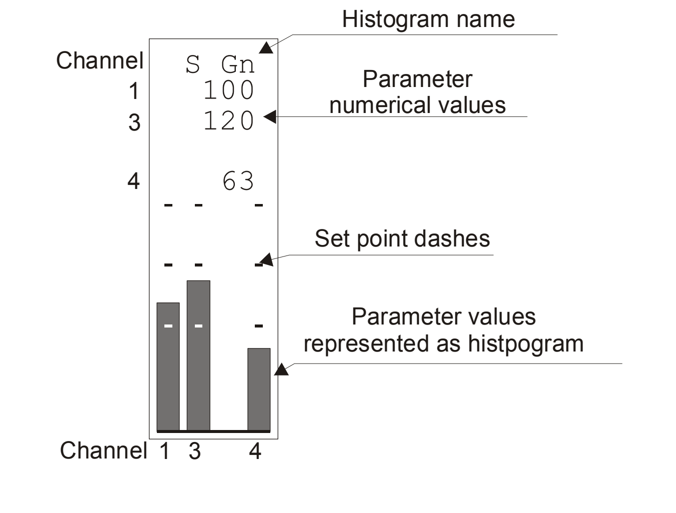


Figure 10. Example of histogram mode information display, MK21 module

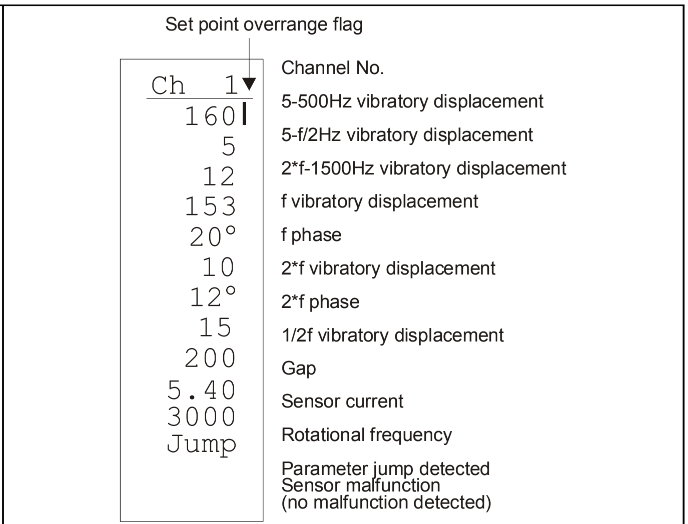


Figure 11. Example of full information mode information display, MK21 module

Equipment Operation

This section describes the basic principles of signal measurement, presents the technique for vibration parameters and other operational parameters calculation and gives recommendations on design factors determination.

MK20 Module – Variable Signal Measurement (vibration displacement)

Vibration parameters are measured synchronously for all 4 channels at results update interval of 0.5 sec according to the same algorithm. Therefore only one measurement channel will be described. The most of the calculations are based on spectral analysis using FFT technique.

There are two types of FFT provided to measure vibration parameters in various modes of the unit operation:

- 2048 samples per second which is the main FFT type with 1Hz to 1024Hz spectrum resolution intended for measurement of the total vibration displacement within the frequency range of (5-500)Hz, (5 – F/2)Hz low frequency vibration displacement and (2F – 500)Hz high frequency vibration displacement;
- 512 samples per 1 unit revolution which is the secondary FFT type with resolution equal to the unit speed. Secondary FFT results are used to calculate vibration displacement amplitude and phase rotational components.

Rotational Frequency Measurement

Based on the determined speed of the unit there is:

1. The unit stationary operation mode detected (the unit speed does not change);
2. FFT ADC selection rate per revolution (512 samplings) adjusted to determine the phase and the amplitude of rotational components.

The unit speed is measured by the leading edge of synchronization pulses fed to synchronization inputs. Measurement interval is the main cycle of the module operation of 0.5 sec required to average the interval of pulses recorded within 0.5 sec. If there is two or less synchronization pulses received within 0.5 sec, speed of the unit is calculated for one synchronization signal interval. The unit speed increase is proportional to the number of synchronization signal intervals used in speed calculations.

The main synchronization channel is synchronization pulse input No.1. If there are no pulses detected at synchronization input No.1 the measurement synchronization will automatically switch to input No.2.

In absence of pulses at both synchronization inputs, low or too high synchronization pulse frequency:

- calculations involving speed of the unit are disabled and the corresponding values go to zero;
- ADC sampling per one unit revolution is not carried out;
- it is assumed that such status is not a stationary mode of operation;
- calculated frequency value does not go to zero except when there are no synchronization pulses;
- the basic speed of the unit is taken for `freq_basic_no_sync`.

The following parameters are provided to detect the absence or invalidity of synchronization pulses in settings of MK20:
`freq_min` – minimum allowable speed of the unit;
`freq_max` – maximum allowable speed of the unit.

If there are no synchronization pulses received within 20 sec, it is assumed that there are no synchronization pulses and `NOT_SYNC_PULSE_1 and NOT_SYNC_PULSE_2` flags are set in '1' respectively. Thus the minimum measurable speed of the unit is 3 rpm.

When measured speed of the unit is above or equal to 3 rpm and below or equal to `freq_max`, ADC sampling per one unit revolution is initiated.

When `ERR_SYNC_PULSE_MIN, ERR_SYNC_PULSE_MAX` error flags are reset to '0', speed stabilization detection algorithm is enabled.

If speed level of the unit is abnormal relative to set parameters, there will be `ERR_FREQUENCY` warning flag set to '1' in each channel status register.

Speed Stabilization Detection

The following parameters are set to enable speed detection algorithm:

`freq_delta` - maximum allowable speed deviation level;

`freq_delta_time` – minimum speed stabilization/destabilization time.

Speed stabilization detection algorithm is enabled only if flags `ERR_SYNC_PULSE_MIN`, `ERR_SYNC_PULSE_MAX` are reset to '0'. By МК20 module reset it is assumed that speed is not stabilized (flag `WORK_STAB_MODE = 0`).

If during `freq_delta_time` speed did not change more than for `freq_delta`, it is assumed that speed has been stabilized and flag `WORK_STAB_MODE` is set to '1'.

The following operations are executed upon detection of speed stabilization:

- Current speed is recorded;
- The numbers of spectral components corresponding to 5Hz, F/2, 2F, 500Hz frequencies are calculated;
- Parameter step algorithm and control of low frequency vibration displacement rotational component setpoint may be enabled.

In stabilized operation mode the current speed is always compared to the one recorded when switching over to the stabilized operation mode. If during `freq_delta_time` the frequency was out of range for `freq_delta`, stabilized operation mode is disabled with following anticipation of frequency stabilization.

By МК20 module reset it is assumed that speed is `freq_basic_no_sync`.

Sensor Current (Voltage)

Sensor current is determined by direct component resulting from averaging of ADC samplings. There are `curr_coff_A`, `curr_coff_B` factors provided to transfer the determined direct component value from ADC dimension to sensor current.

Sensor direct current (voltage) is determined from formula:

I = `curr_coff_A` + `curr_coff_B` x ADC

U = `curr_coff_A` + `curr_coff_B` x ADC

Determined sensor current value passes through moving average algorithm (only N of the last samplings is included in average) which depth is determined by the parameter:

`sense_curr_aver_size` – averaging table size, maximum 10

The determined averaged sensor current value is used to check sensor serviceability and display it on LCD.

Table 10. Recommended testing levels for alternating current (voltage) for МК20 module

Measurement channel operation mode	Input signal level		Module board jumper position
(1- 5)mA current	1mA	5mA	2 - 3
(4 – 20)mA current	4mA	20mA	1 - 2
(0 – 3.0)V voltage	0.56V	2.80V	Removed

Note. For numbers of jumpers for corresponding measurement channels and their location on the module board please refer to Annex B.

Note. `Curr_coff_A`, `curr_coff_B` design factors determination method is similar to determination of parameter factors for МК10 module.

Sensor Test

Sensor test is required to disable calculations for the particular channel and signaling in case of the sensor malfunction.
Sensor test configurable parameters include:

curr_point_min – minimum sensor current level;
curr_point_max – maximum sensor current level;
curr_point_hist – sensor test hysteresis level to prevent trigger effect;
curr_point_time – sensor malfunction detection /normalization time.

There are two flags provided in the measurement channel status register to indicate sensor malfunction:

- SENSE_ERROR_MIN – sensor current is too low;
- SENSE_ERROR_MAX – sensor current is too high.

By the module reset it is assumed that the sensor is in normal condition, flags SENSE_ERROR_MIN, SENSE_ERROR_MAX are equal to zero. If during curr_point_time_reaction the sensor current is above curr_point_max or below curr_point_min, it is assumed that the sensor is faulty and the corresponding flag is set to ‘1’.

Upon the sensor malfunction detection, all measurements for the channel are disabled and parameter values are taken to be equal to zero, all event flags (overrange flags, step detection flags etc.) are reset to zero.

To recover the measurement channel operation it is required that during curr_point_time sensor current is above curr_point_min + curr_point_hist if SENSE_ERROR_MIN flag has been set or below curr_point_max – curr_point_hist if SENSE_ERROR_MAX flag has been set.

Malfunction of a single channel sensor does not affect the rest measurement channels’ operation.

Constant Offset (Gap)

Displacement is calculated similar to the sensor current. The difference is availability of the pair of coefficients gap_coff_A, gap_coff_B for calculation of displacement value. Displacement value is calculated from the formula:

S_c = gap_coff_A + gap_coff_B x ADC;

Integration depth of sense_curr_aver_size by current (voltage) applies to displacement calculation as well.

The method of gap_coff_A, gap_coff_B coefficients determination is similar to the method of sensor current coefficient determination.

Total, Low Frequency and High Frequency vibration displacement

Total peak-to-peak excursion (5-500Hz), low frequency (5 – F/2 Hz) and high frequency ((2F – 500)Hz) vibration displacement is calculated using one pair of linear equation coefficients s_var_coff_A, s_var_coff_B. Vibration displacement value is calculated by the formula (for all frequency bands) with preliminary inverse FFT (for each frequency band individually):

S = s_var_coff_A + s_var_coff_B x ADC.

Check of setpoints for Total and Low Frequency vibration displacement

There are 3 adjustable setpoints for total vibration displacement and 1 adjustable setpoint for low frequency vibration displacement. The following parameters should be set in order to detect setpoint overrange:

- s_5_500_point_1 – The 1st setpoint of total vibration displacement;
- s_5_500_point_2 – The 2nd setpoint of total vibration displacement;
- s_5_500_point_3 – The 3rd setpoint of total vibration displacement;
- s_5_500_point_hist – Total vibration displacement setpoint hysteresis;
- s_5_F2_point – Low frequency vibration displacement setpoint;
- s_5_F2_point_hist – Low frequency vibration displacement setpoint hysteresis;
- s_5_500_point_time – Detection time of total vibration displacement transition over setpoint;
- s_5_F2_point_time – Detection time of low frequency vibration displacement transition over setpoint.

The relevant flags in the measurement channel system register inform of setpoint overrange:

- S_POINT_1 – Total vibration displacement value exceeds setpoint 1;
- S_POINT_2 – Total vibration displacement value exceeds setpoint 2;
- S_POINT_3 – Total vibration displacement value exceeds setpoint 3;
- S_LP_POINT – Low frequency vibration displacement value exceeds the setpoint.

If total vibration displacement (low frequency vibration displacement) value is exceeding the setpoint within s_5_500_point_time (s_5_F2_point_time) the relevant signaling flag is set to ‘1’.

In case of setpoint overrange flag is set, the measurable parameter value should be below the corresponding setpoint minus hysteresis within the set time in order to reset this set setpoint overrange flag to ‘0’. Such approach enables to prevent possible trigger effect in case the measurable parameter value is close to the setpoint value.

Low frequency vibration displacement is checked for setpoint overrange in stationary operation mode only.

Recommendations on Determination of Coefficients

Coefficients `s_var_coff_A, s_var_coff_B` should be determined experimentally based on the total vibration displacement value at base frequency of sine signal. It is recommended to perform alternating voltage tests (direct component level is 1.7V).

In case of the module AC operation (sensors with current outputs) it is required to calculate alternating test voltage based on resistor resistance at the measurement channel transforming current into voltage.

Table 11. Recommended testing levels for alternating voltage (current) 2A for MK20 module

Measurement channel operation mode	Input signal level		Module board jumper position
(1- 5)mA current	0.5mA	4mA	2 - 3
(4 – 20)mA current	2mA	16mA	1 - 2
(0 – 3.0)V voltage	280mV	2,240mV	Removed

Note. For numbers of jumpers for corresponding measurement channels and their location on the module board please refer to Annex B.

Test signal levels correspond to the specific level of measurable vibration parameter. Having recorded ADC value corresponding to set test signal level, one can determine design factor values to obtain the true level of measurable process parameter during the module operation.

To determine `s_var_coff_A, s_var_coff_B` coefficients it is required to conduct at least two tests (at the beginning and the end of measurement range as recommended), record ADC values and resolve the set of equations:

$$\begin{cases} P_1 = \texttt{s\_var\_coff\_A} + \texttt{s\_var\_coff\_B} \times ADC_1; \\ P_2 = \texttt{s\_var\_coff\_A} + \texttt{s\_var\_coff\_B} \times ADC_2; \end{cases}$$

Where: P_1, P_2 – vibration parameter values corresponding to test signal level,

ADC_1, ADC_2 – ADC values corresponding to test signal level

Vibration Displacement Rotational Components

Amplitude of ½ and 1-10th of vibration displacement rotational components is calculated only in case of synchronization pulses presence and allowable speed of the unit. If there are no synchronization pulses (or their frequency is too high/too low), vibration displacement rotational components are not calculated and taken to be equal to zero.

peak-to-peak excursion of vibration displacement rotational components is calculated using the pair of linear equation coefficients `s_circul_coff_A, s_circul_coff_B`. Vibration displacement value is calculated by the formula:

S_O = s_circul_coff_A+ s_circul_coff_B x ADC

Determined instantaneous values of ½, 1st and 2nd vibration displacement rotational components pass moving average algorithm which depth is `s_mag_F2_aver_size, s_mag_1F_aver_size` and `s_mag_2F_aver_size` respectively.

Averaging values of rotational components may be displayed on LCD and the value of the 1st vibration displacement rotational component is involved in step detection.

The method of calculating design factors for vibration displacement rotational components is similar to the method of calculating coefficients for total, low frequency and high frequency vibration displacement.

Vibration displacement rotational components are calculated at the speed of 0.05Hz. ½ vibration displacement rotational components are calculated at 5Hz.

Phases of Vibration Displacement Rotational Components

The phase means time interval in degrees (0-360) from sine signal amplitude zero value to active edge of synchronization pulse when passing from negative to positive value.

Phases of rotational components are calculated only in presence of synchronization pulses. If synchronization pulse rate does not meet the specified criteria, phase values are taken to be equal to zero.

Phase is calculated from the formula: $P = ATAN2\frac{\mathrm{Im}}{\mathrm{Re}}$

If the level of rotational components is too low, the calculated phase values may significantly range (due to quantization noise of ADC and calculations). The following parameter is provided to prevent possible fluctuations:

`s_min_phase_detect` – minimum level of vibration displacement rotational component for rotational component phase calculation.

If the value of rotational component is below `s_min_phase_detect`, the phase value is not calculated but taken to be equal to zero.

Instantaneous calculated value of the phase passes through moving average algorithm of:

`s_phase_1F_aver_size` – the 1st rotational component phase integration depth;
`s_phase_2F_aver_size` – the 2nd rotational component phase integration depth;

Phase Correction

Low-frequency filter application causes significant initial signal phase rotation. There is a feature of frequency-based linear correction of the rotational components' phase provided to correct the phase rotation in the input filter as well as in the measurement channel.

The phase is corrected by the formulas:

$P = P_c$ – N * `frequency * corr_phase_coff`

Where:

P – corrected rotational component phase value;
P_c – calculated rotational component phase value;
`frequency` – speed in Hz;
N – rotational component number;
`corr_phase_coff` – correction coefficient, °/Hz.

The phase correction coefficient is calculated by the formula:

`corr_phase_coff` = P/F

Where:

P – phase value measured by the module when `corr_phase_coff = 0`;
F – sine signal frequency, Hz (recommended base measuring frequency).

Parameter step Detection

There is parameter step detection algorithm implemented to detect instantaneous and irreversible parameter value change. Parameters for which step detection algorithm is effective:

- Vibration displacement (5-500)Hz;
- The 1st rotational component;
- Phase of the 1st rotational component.

Parameter step is detected for rotational components only if there are synchronization pulses available in stationary operation mode.

Parameter step detection algorithm is the same for all measurable vibration parameters however each parameter may have its own step detection settings.

The list of parameters included in step detection settings:

`time_start` – parameter stabilization time out after sensor operation normalization or speed stabilization for rotational components;
`time_stabil` – step detection start parameter stabilization time-out;
`variation_dt` – minimum parameter incremental value for 0.5 sec for step detection start or stabilization time-out;
`variation_max` – minimum parameter variation level relatively to start step detection value and stabilized parameter value.

Step detection algorithm has several conditions:

1. Pause after initialization;
2. Time out for parameter change exceeding `variation_dt` to start step detection;
3. Step stabilization time out;
4. Parameter step detected.

When detecting parameter step even if the step has not been recorded, there is step detection algorithm operation report available on external control interfaces as the following parameters:

`time_count` – time counter by 0.5sec;
`status` – step detection algorithm status;
`values_new` – new parameter value;
`values_old` – old parameter value;
`values_start` – initial parameter value at parameter value stabilization time out start;
`values_jamp` – parameter variation level (character value).

Step detection flags and algorithm are reset by:

- Unit reset;
- Sensor malfunction;
- Command from external control interfaces;
- Pushing of buttons located on the module front panel.

The following flags are provided to indicate step detection in measurement channel system register:

`JAMP_S` – Vibration displacement level step (5-500)Hz;
`JAMP_S_1F` – the 1st vibration displacement rotational component level step;
`JAMP_PHASE_1F` – the 1st vibration displacement rotational component phase step.

General Recommendations for Calculation of Design Factors

Upon the module "cold start" all measurable vibration parameters are in ADC dimension. During the module operation there is ADC value multiplied by 4 used in parameter calculation formulas, which should be taken into consideration when calculating design factors.

ADC value for sensor current is represented in ##.## format with decimal point in the middle.

Factor values may also be obtained by method of calculation (twelve-digit ADC measurement range is (0-3)V), however the best measuring accuracy may be achieved by calibrating the module with test signals.

МК20 module setup program provides for facilities that simplify calculations of factors (for additional information please refer to the relevant software specification).

MK30 Module – Variable Signal Measurement (vibration velocity)

Except for some features described below, MK30 module measuring principles are practically similar to MK20 module.

Speed and sensor current measurements are similar to MK20 module.
No offset (gap) is calculated for MK30 module.

Frequency bands

- Total vibration velocity RMS frequency band (10 – 1000)Hz;
- Vibration velocity RMS low frequency band (10 – F/2)Hz;
- Vibration velocity RMS high frequency band (2F – 1000)Hz;
- Measurement of rotational components from 10Hz speed of the unit.

Total, Low Frequency and High Frequency vibration velocity RMS Measurement

Any frequency band vibration velocity RMS is calculated based on FFT results in 4096 samplings.

Generally, the vibration velocity RMS is calculated for the required frequency band as the square root of the sum of squares of vibration velocity RMS harmonic components.

$$V_{АЦП} = \sqrt{\sum_{f_{\min}}^{f_{\max}} V_n^2}$$

There are numbers of spectral components corresponding to 10Hz, F/2, F, 2F, 1000Hz prepared beforehand and vibration velocity RMS is calculated by frequency limits in ADC units:

- Total vibration velocity RMS (10 – 1000)Hz;
- Low frequency vibration velocity RMS (10 – F/2)Hz;
- High frequency vibration velocity RMS (2F – 1000)Hz.

Determined vibration velocity RMS value in ADC dimension is converted into mm/S by the formula:

V = `Vrms_fixed_coff_A` + `Vrms_fixed_coff_B` x V_{ADC}

Total, low frequency and high frequency vibration velocity RMS passes moving average algorithm of individually set integration depth.

Vibration velocity coefficients are calculated in the same way as vibration displacement for MK20 module.

There are Vrms_var_coff_A, Vrms_var_coff_B coefficients used to calculate rotational components in MK30 module. Rotational components are measured at the unit speed of 10Hz. The calculation method of rotational components and their phases is similar to MK20.

There are 3 setpoints for total vibration velocity RMS level and 1 setpoint for low frequency vibration velocity RMS provided in MK30 module as well as in MK20 module.

MK30 module step detection algorithms are similar to MK20 module (total vibration velocity RMS level, RMS and phase of the 1st vibration velocity rotational component).

Quantization Noise Filtering in FFT during RMS Calculation

For the purpose of FFT calculation speedup, there is fixed-point mathematics applied which in its turn brings an additional noise in the resulting transformation spectrum of 4096 samplings.

ADC and fixed-point calculation quantization noise is expressed as low level energies throughout all harmonic components of the resulting spectrum, though the initial signal lacks those harmonic components.

When summing up the energy of harmonic components to calculate RMS in the desired frequency band, the noise may significantly distort the real parameter value.

There are parameters of minimum allowable level of harmonic component energy square introduced in ADC dimension to correct ADC and calculation quanization noise.

`fft_fixed_mag_error` – minimum allowable level of harmonic component amplitude square in ADC dimension multiplied by 4.

Peak-to-Peak Excursion and Signal Form Factor

4096 ADC samplings prepared for FFT primarily enter peak-to-peak excursion calculation algorithm.

Determined peak-to-peak excursion value is converted from ADC dimension to mm/s by the formula:

V = `peak_peak_coff_A` + `peak_peak_coff_B` x V_{ADC};

Determined instantaneous peak-to-peak excursion value passes through moving average algorithm of `vrms_peak_peak_aver_size`. Only averaged peak-to-peak excursion value is included in signal form factor calculation and may be displayed on LCD.

Signal form factor is calculated from the formula: $K = \frac{Va}{Vrms}$

Where: K – form factor;
Va – peak-to-peak vibration velocity excursion;
Vrms – total vibration velocity RMS (10 – 1000)Hz;

The formula shows that if total RM value is equal to zero (which is theoretically probable), the form factor should go to infinity. To prevent such situations we introduce the parameter:

`vrms_min_peak_peak` – minimum allowable total RMS for signal form factor calculation.

If total vibration velocity RMS is below `vrms_min_peak_peak`, the signal form factor value is taken to be equal to zero and flag `VRMS_ABSENT` is set to ‘1’ which means too low level of total RMS that may be also used to detect the measurement channel and sensor serviceability.

Amplitude and Phase of the 1st vibration displacement Rotational Component

Amplitude and phase of the 1st vibration displacement rotational component is calculated based on determined values of RMS and phase of the 1st vibration velocity rotational component.

Vibration displacement parameters are calculated only if there are synchronization pulses available, otherwise the values are taken to be equal to zero.

Since phase and RMS of the 1st vibration velocity rotational component have been already averaged, the vibration displacement calculation algorithm has no averaging buffer.

Amplitude of vibration displacement is calculated by formula: $S_1 = \frac{Vrms_1 \cdot 0.450158}{f}$

Vibration velocity RMS (mm/s) is converted into peak-to-peak excursion of vibration displacement (mm).

The 1st vibration displacement rotational component phase results from the 1st vibration velocity rotational component plus 90°. Determined vibration displacement phase value is reduced to 0° to 360° format.

Upon the module "cold start", all measurable vibration parameters are in ADC dimension. There is ADC value multiplied by 4 used in parameter calculation formulas during the module operation, which is to be considered when calculating design factors.

ACD value after "cold start" is represented in ##.## format with decimal point in the middle.

MK30 module setup program provides for facilities that simplify calculation of factors (for additional information please refer to the relevant software specification).

МК21 Module – Absolute Rotor Vibration Measurement

МК21 calculation principles are similar to МК20 and МК30 modules.

There should be eddy current sensor of rotor relative vibration displacement connected to channel 1 of МК21 module (ДВТ10 - ИП34 type). Adjustment and operation of the measurement channel 1 (rotor relative vibration displacement) is similar to МК20 module measurement channels.

There should be vibration velocity inertial sensor connected to channel 2 of МК21 module (ДПЭ22МВ type). Adjustment and operation of the measurement channel 2 (insert absolute vibration velocity RMS) is similar to МК30 module measurement channels. Sensors of channel 1 and 2 should be located as close as possible to each other (optimal location is on the same axis).

The third МК21 module channel, rotor absolute vibration displacement, is calculation channel (vibration velocity signal integration). During integration, the frequency response of the vibration velocity measurement channel is equalized against rotor relative vibration displacement channel. The third МК21 channel has the same set of measurable parameters as the rotor relative vibration displacement measurement channel except for gap and sensor current calculation.

The fourth МК21 module channel, rotor absolute vibration displacement, is calculation channel: vector summation of rotor relative vibration displacement (channel 1) and insert absolute vibration displacement (channel 3) signals. The fourth МК21 channel has the same set of measurable parameters as the rotor relative vibration displacement measurement channel except for gap and sensor current calculation.

МК21 module physical measurement channels 3 and 4 are disabled and no sensor is tested for these channels.

Although МК21 module has plenty of mathematical calculations, the update time is 1 sec. The main purpose of МК21 module is diagnostic test of the unit vibration status, though МК21 has power logic outputs provided to implement protective functions.

In МК21 module, the rotational components calculation is similar to the one in МК20 and МК30 modules. In absence of synchronization pulses, the rotational components are not calculated and taken to be equal to zero while other vibration parameters are still calculated.

In case of the measurement channel 2 (insert absolute vibration velocity RMS) failure, the vibration parameters of the support absolute vibration displacement (channel 3) are not calculated and taken to be equal to zero.

In case of failure of the measurement channel 1 (rotor relative vibration displacement) or 2 (insert absolute vibration velocity RMS) failure, the vibration parameters of the rotor absolute vibration displacement (channel 4) are not calculated and taken to be equal to zero.

Frequency response coordination is recommended to be calibrated at vibration stand where simultaneous attachment of relative vibration displacement eddy current sensor and vibration velocity RMS inertial sensor is possible.

Calibrating of frequency response coordination of rotor relative vibration displacement (channel 1) and insert absolute vibration displacement (channel 3) measurement channels requires synchronization pulses from the test stand. Calibration is made at several frequencies (10Hz, 20Hz, 30Hz, 40Hz, 50Hz, 60Hz, 70Hz, 80Hz, 90Hz, 100Hz, 150Hz, 200Hz, 250Hz) for each pair of sensors of different type. Frequency adjustment precision should be at least 0.05Hz.

There is differential of the first vibration harmonic amplitude and phase recorded for each test point of calibration frequency. There is frequency responce calibration table used during the module operation to equalize frequency response between the measurement channels according to piecewise-linear approximation.

Constant correction factor of signal amplitude and constant value of signal phase variation can be adjusted for insert absolute vibration displacement (channel 3) to control design of sensors and method of their attachment on МК21 module bearing insert.

Since frequency response of the insert absolute vibration displacement channel (channel 3) is coordinated with the rotor relative vibration displacement channel (channel 1), the design factors of channel 3 and 4 vibration parameters may be obtained from factor values calculated for channel 1. However it is recommended to determine design factors for channel 3 and 4 using vibration stand as well.

Calculation of factors and calibration of frequency responce coordination is performed using special software supplied with МК21 module.

БИ24 – Remote indication module

Frequency Measurement

There is speed measurement (rpm) feature with stop detection provided in БИ24. Measured speed value may be read on RS485 or I2C interfaces.

The following parameters should be set to measure speed:

1. Enable speed measurement;
2. Select active edge of pulses at the micro-controller input (front/rear);
3. Set speed measurement interval with resolution of 0.5sec (from 0.5 to 99.5 sec);
4. Set time out of stop detection at speed measurement intervals (1 to 255);
5. Select speed display format (rpm or krpm);
6. Set message to be displayed during stop detection.

Speed is measured based on the measurement of time between active edges of synchronization pulses. Actually, there is synchronization pulse interval measured, and then obtained interval value is converted into speed units (rpm). Synchronization pulse interval value (number of count pulses) is averaged for the set interval of time. If one or less synchronization signal interval has been recorded at the measurement interval, then one synchronization signal interval is used in speed calculation without averaging.

If no synchronization signal intervals have been recorded at the set number of measurement intervals, it is assumed that there are no synchronization pulses which means stop mode. In stop mode the display shows ready-made data (e.g. `StOP`).

The minimum measurable speed may be determined based on parameter values: speed measurement interval T_{meas}; stop detection time out T_{stop}.

$$F_{\min} = \frac{60}{Tmeas \cdot Tstop}$$

For example by default the measurement interval is 2 sec and time out is 10. Thus the minimum measurable speed is Fmin = 3 rpm.

To exit stop mode it is required that speed of synchronization pulses exceeds the design minimum measurable speed value.

Regardless of what speed display mode is set, the speed is always measured in rpm. The maximum allowable speed value (mathematical restriction of calculation algorithm) is 65535 rpm.

After each measurement interval, new determined speed value is displayed on LCD (display data update interval is equal to speed measurement interval).

If speed measurement is disabled, the speed value is taken to be equal to zero and the speed measurement (including 16-bit counter operation) is blocked.

When speed measurement feature is enabled, data display by commands from external communication interfaces (RS485, CAN2.0B) is disabled.

Speed Measurement Input Circuit

Speed measurement input circuit has been developed in such a way that pulse signal can be transferred from different sources:

- Active positive current pulse;
- Open collector output, zero active level;
- Voltage pulses.

Optionally there can be a pulse active edge saftware-selected at RC2/CCP1 micro-controller output. Micro-controller output at which synchronization pulses are fed, has Schmidt's input buffer.

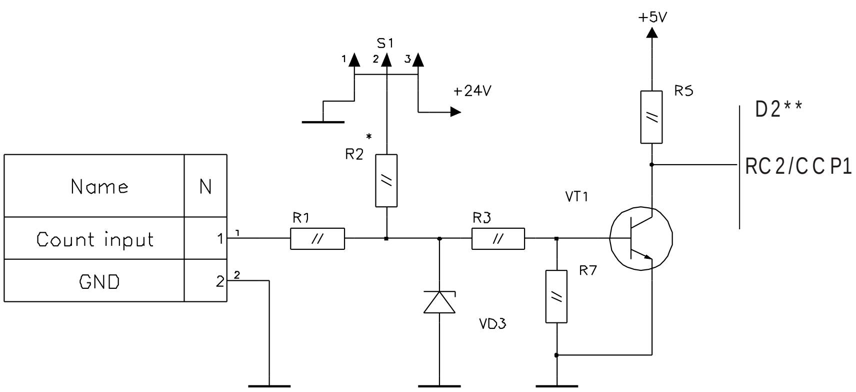


Figure 12. БИ24 pulse input circuit

Position of S1 jumper determines pulse input operation mode.

<u>Operation mode – voltage pulses</u>

In the mode of operation when synchronization pulses are voltage pulses, S1 jumper should be removed and R2 resistor should be off. In that mode VT1 transistor will be reliably opened already at (1-1.5)V input voltage. VT1 transistor will be closed at input voltage below 0.6V.

VD3 safety stabilitron restricts the maximum level of input signal to 27V.

When selecting the active edge, it is necessary to consider signal inversion occurring at VT1 transistor and active edge being set relatively to the microcontroller input.

<u>Operation mode – positive current pulse</u>

In that mode R2 resistor should be grounded (S1 jumper in 1-2 position).

Current signal is transformed into voltage pulses at R2 resistor. It is required to consider the levels of VT1 transistor opening and closing voltage, like for voltage pulse mode.

E.g. Let constant component of current pulses be equal to 1mA and active current pulses are 5mA. In case of R2 resistor resistance of 300Ohm, the constant voltage component is 0.3V which is sufficient to close VT1. With current pulse of 5mA, R2 resistor voltage is 1.5V which is sufficient to open VT1.

<u>Operation mode – zero active level</u>

If synchronization pulse source has open collector output and active low logic level, then R2 resistor should be connected to +24V (S1 jumper in 2-3 position).

R2 resistance should not be too low in order not to load up synchronization pulse source output with excessive current at active signal and also so that communication line had minimum impact on current transformation into voltage.

In case of active signal (for this operation mode) it is desirable that VT1 base voltage level does not exceed 0.3V to ensure reliable closing of VT1.

R2 resistor resistance should not be too high so that no random communication line noise could cause spontaneous opening of VT1 and incorrect frequency calculation. Recommended R2 value for this operation mode ranges between 1kOhm and 10kOhm.

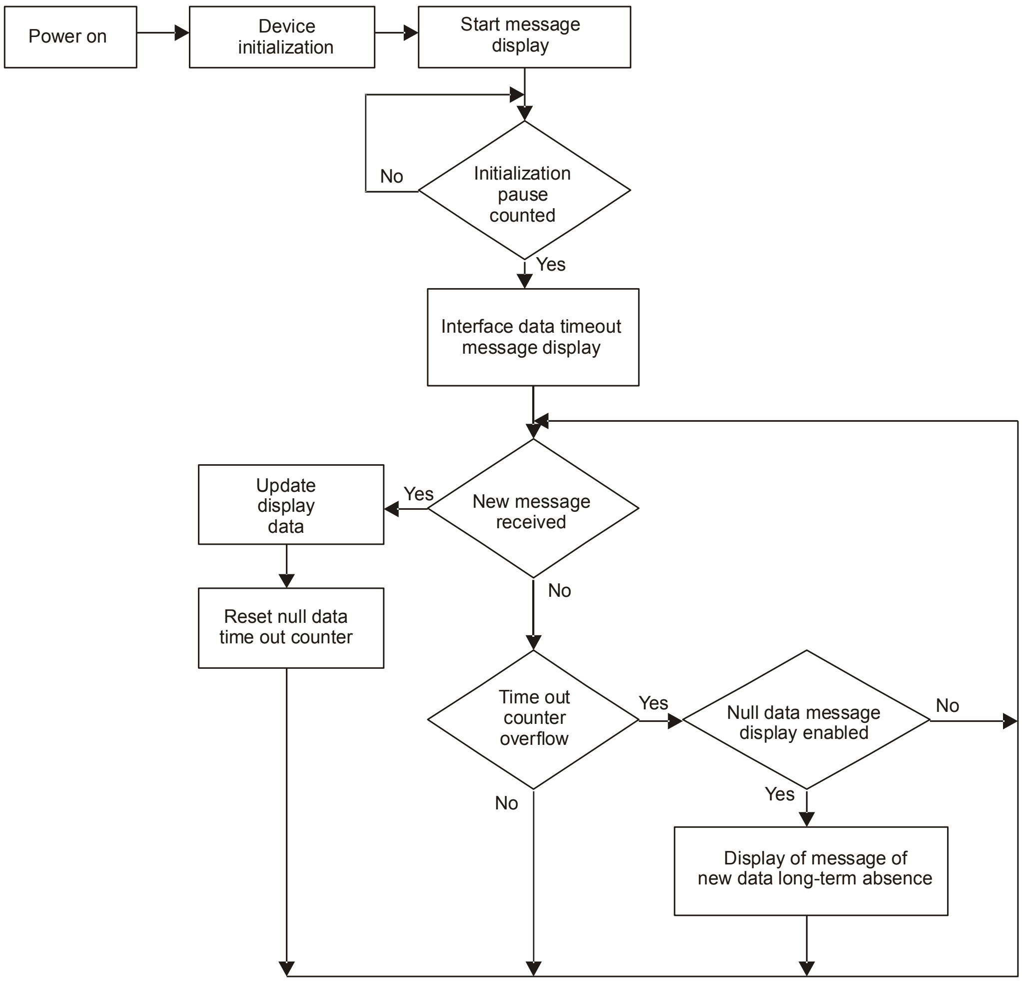


Figure 13. БИ24 board operation algorithm in external commands data display mode

External Indication Outputs

There are high-load capacity OC logic outputs and (4-20)mA unified current outputs provided in Vibrobit 300 equipment modules.

Most of operating parameters of external signaling outputs are set during adjustment of modules which enables optimal equipment protection system build-up.

Power Logic OC Outputs

MK20, MK21, MK30 Modules

There are 80 signaling sources (16 per channel (64) + 16 general system sources) provided in MK20, MK21 and MK30 modules. Each of 80 signaling sources is represented as logic signal transmitted to software-based logic matrix input. Logic matrix output is 11 independent OC power keys.

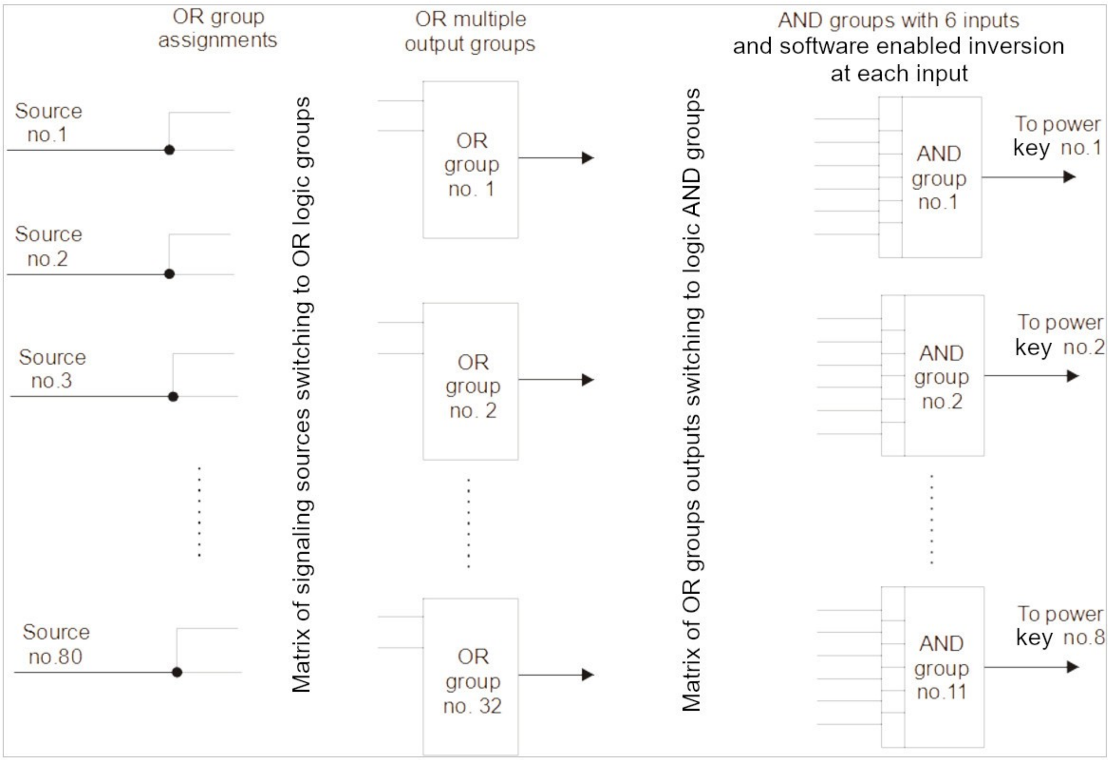


Figure 14. Software logic signaling matrix flow diagram

Each of signaling sources may be assigned to any 2 of 32 available OR groups (it is also possible not to assign any groups to signaling source). Logic OR groups are made so that they can have unlimited number of signaling sources.

If no sources are assigned to OR group inputs, there will be always log 0 at such group input. If any of assigned signals has log 1 at input, there will be log 1 set at this group output.

Power keys are controlled from the output of corresponding AND groups with six inputs and software enabled inversion for each input. Adjustment consists in assignment of each AND group input connection to logic OR group output and switching on/off the signal inversion at AND group input.

If there are no OR groups assigned to AND group inputs, this AND group input does not affect power key control. If there are no OR groups assigned to AND group, there will be always log 0 at the corresponding AND group output (power key is closed).

Power key is enabled provided that there are active signal levels present at all assigned inputs of corresponding AND group (1 for direct inputs and 0 for inverse inputs).

The twelvth logic output is reserved for MK20 and MK30 modules malfunction signaling. If there is any critical error detected during test upon the module reset:

- Module operation is disabled;
- There is active signal level at 12 logic output;
- The rest logic outputs are disabled.

The following parameters are provided for logic signaling adjustment:

`buff_or_dest_matrix_1` – matrix 1 of signaling source assignment to OR groups;
`buff_or_dest_matrix_2` – matrix 2 of signaling source assignment to OR groups;
`buff_and_source_matrix`x – matrix of AND group inputs assignment to OR group outputs.

Matrices `buff_or_dest_matrix_1, buff_or_dest_matrix_2` has 80 elements each; dimension corresponds to the number of signaling sources. If matrix element value is 0 or exceeds 32, this signaling is not assigned to any OR group.

Dimension of matrix `buff_and_source_matrix` is 11x6, which corresponds to 11 AND groups with 6 outputs each. If matrix element value is 0 or exceeds 32 it is assumed that the corresponding AND group input is not connected and does not participate in power key control. Bit 15 of matrix `buff_and_source_matrix` indicates input inversion. If bit 15 is 1, the corresponding AND buffer input is inverse.

Table 12. The list and the numbers of MK20 module measurement channels operation signaling

Channel No.1	Channel No.2	Channel No. 3	Channel No. 4	Designation	Alarm Description
0	16	32	48	ERR_CRC_BASIC_BANK	Error of reading the channel operating parameters from the non-volatile memory main section
1	17	33	49	ERR_CRC_TWO_BANK	Error of reading the channel operating parameters from the non-volatile memory main and reserve sections
2	18	34	50	SENSE_ERROR_MIN	Sensor current is below lower setpoint
3	19	35	51	SENSE_ERROR_MAX	Sensor current is above upper setpoint
4	20	36	52	S_POINT_1	(5-500)Hz vibration displacement is above the 1st setpoint
5	21	37	53	S_POINT_2	(5-500)Hz vibration displacement is above the 2nd setpoint
6	22	38	54	S_POINT_3	(5-500)Hz vibration displacement is above the 3rd setpoint
7	23	39	55	S_LP_POINT	Low frequency vibration displacement is above the setpoint
8	24	40	56	JUMP_S	(5-500)Hz vibration displacement step detected
9	25	41	57	JUMP_S_1F	The 1st vibration displacement rotational component step detected
10	26	42	58	JUMP_PHASE_1F	The 1st vibration displacement rotational component phase step detected
11	27	43	59	WRITE_PARAM	The flag of recording the measurement channel parameters to the non-volatile memory
12	28	44	60	-	Reserve
13	29	45	61	-	Reserve
14	30	46	62	-	Reserve
15	31	47	63	ERR_FREQUENCY	Synchronization pulse error

Table 13. The list and the numbers of MK21 module measurement channels operation signaling

Channel No.1	Channel No.2	Channel No. 3	Channel No. 4	Designation	Alarm Description
0	16	32	48	ERR_CRC_BASIC_BANK	Error of reading the channel operating parameters from the non-volatile memory main section
1	17	33	49	ERR_CRC_TWO_BANK	Error of reading the channel operating parameters from the non-volatile memory main and reserve sections
2	18	34	50	SENSE_ERROR_MIN	Sensor current is below lower setpoint (for channels 1, 2 only)
3	19	35	51	SENSE_ERROR_MAX	Sensor current is above upper setpoint (for channels 1, 2 only)
4	20	36	52	DATA_POINT_1	Total vibration level is above the 1st setpoint
5	21	37	53	DATA_POINT_2	Total vibration level is above the 1st setpoint
6	22	38	54	DATA_POINT_3	Total vibration level is above the 1st setpoint
7	23	39	55	DATA_LP_POINT	Low frequency vibration level is above the setpoint
8	24	40	56	JUMP_DATA	Total vibration level step detected
9	25	41	57	JUMP_DATA_1F	The 1st rotational component vibration step detected
10	26	42	58	JUMP_PHASE_1F	The 1st rotational component vibration phase step detected
11	27	43	59	WRITE_PARAM	The flag of recording the measurement channel parameters to the non-volatile memory
12	28	44	60	FLAG_ERROR	No parameters calculated for this measurement channel
13	29	45	61	-	Reserve
14	30	46	62	DATA_ABSENT	Low vibration level
15	31	47	63	ERR_FREQUENCY	Synchronization pulse error

Table 14. The list and the numbers of MK30 module measurement channels operation signaling

Channel No.1	Channel No.2	Channel No. 3	Channel No. 4	Designation	Alarm Description
0	16	32	48	ERR_CRC_BASIC_BANK	Error of reading the channel operating parameters from the non-volatile memory main section
1	17	33	49	ERR_CRC_TWO_BANK	Error of reading the channel operating parameters from the non-volatile memory main and reserve sections
2	18	34	50	SENSE_ERROR_MIN	Sensor current is below lower setpoint
3	19	35	51	SENSE_ERROR_MAX	Sensor current is above upper setpoint
4	20	36	52	VRMS_POINT_1	Total vibration velocity RMS is above the 1st setpoint
5	21	37	53	VRMS_POINT_2	Total vibration velocity RMS is above the 2nd setpoint
6	22	38	54	VRMS_POINT_3	Total vibration velocity RMS is above the 3rd setpoint
7	23	39	55	VRMS_LP_POINT	Low frequency vibration velocity RMS is above the setpoint
8	24	40	56	JUMP_VRMS	Total vibration velocity RMS step detected
9	25	41	57	JUMP_VRMS_1F	The 1st vibration velocity rotational component RMS step detected
10	26	42	58	JUMP_PHASE_1F	The 1st vibration velocity rotational component phase step detected
11	27	43	59	WRITE_PARAM	The flag of recording the measurement channel parameters to the non-volatile memory
12	28	44	60	-	Reserve
13	29	45	61	-	Reserve
14	30	46	62	VRMS_ABSENT	Too low level of total vibration velocity RMS
15	31	47	63	ERR_FREQUENCY	Synchronization pulse error

Table 15. The list and the numbers of MK20, MK30 modules system signaling

Alarm No.	Designation	Alarm Description
64	ERR_EXT_EEPROM	Non-volatile memory test error
65	ERR_EXT_SRAM	External RAM test error
66	ERR_EXT_ADC_DAC	ADC, DAC microchip error
67	ERR_LOAD_SYS_CONF	Error of reading the system parameters from the non-volatile memory
68	LOAD_SYS_CONF_RESERV_BANK	Loading system parameters from EEPROM reserve bank
69	NOT_SYNC_PULSE_1	No pulses for synchronization channel 1
70	NOT_SYNC_PULSE_2	No pulses for synchronization channel 2
71	ERR_SYNC_PULSE_MIN	Too low frequency of synchronization pulses
72	ERR_SYNC_PULSE_MAX	Too high frequency of synchronization pulses
73	WORK_STAB_MODE	Stabilized operation mode
74	-	Reserve
75	EEPROM_WR_PROTECT	EEPROM recording protection
76	ERR_CAN_BUS	CAN2.0B interface error
77	START_DEVICE	Start device initialization
78	LOGIC_OUT_DISABLE	Output signaling disable command
79	FLASH_BIT	0.5sec flash bit

4-20mA Unified Current Outputs

MK20, MK30 and MK21 modules have several unified current outputs with capability of software-based setting of their operating parameters. Unified outputs of various modules have insignificant differences but the principle of their operation is the same for all modules.

Table 16. Parameters of control module unified outputs

Module type	Number of unified outputs	DAC maximum value	Note
MK20	4	4095	Outputs may be assigned for any measurement channel and any measurable parameter type
MK21	6	3000	
MK30	4	4095	

Note. All unified outputs are designed for maximum 20mA output current.

MK20, MK30 Modules

- `mode work`– operation mode:
  - `bits 7-0` – parameter type;
  - `bits 14-8` – measurement channel number;
  - `bits 15` – permission of analog output operation.
- `zero_offset` - zero offset.
- `coeff_out_a, coeff_out_b` – ADC value coefficients;

Additional information data not involved in output operation:

- `Dmin, Dmax` – desirable parameter value range;
- `Imin, Imax` - desirable output current range;
- `Imax_out` – maximum output current at maximum ADC value, auxiliary value.

Due to the applied components imperfection, the initial current (at DAC value equal to 0) and unified output maximum current (at maximum DAC value) may insignificantly range, therefore an individual setup of each analog output is required.

Analog output circuit technique artificially shifts the initial point below zero (Figure 15, line A) preventing initial displacement above zero due to imperfection of the components applied.

There are two methods of unified output coefficients determination proposed. Unified output should be adjusted using special software run on PC or diagnostic tool connected to control module via digital communication interfaces (for more information refer to the relevant software specification).

Unified Output Zero Offset Method

When setting unified output it is required at first to adjust initial point having experimentally matched `zero_offset` value and determine maximum output current at maximum DAC value, `Imax_out.`

Zero offset and unified output maximum current is determined as follows (`coeff_out_a, coeff_out_b` coefficient values should be equal to zero):

1. Connect milliamperemeter to tested current output switched to the range which is the most suitable for 20mA current measurement.
2. Set `zero_offset` value equal to maximum DAC value for this module.
3. Current shown by milliamperemeter is the maximum analog output current (parameter `Imax out`).
4. Set `zero_offset` value to 0.
5. Switch milliamperemeter to the maximum sensitivity range.
6. Gradually increase `zero_offset` value until milliamperemeter shows presence of current at the analog output.
7. Current `zero_offset` value minus 1 is the true zero offset value (Figure 15, line B).

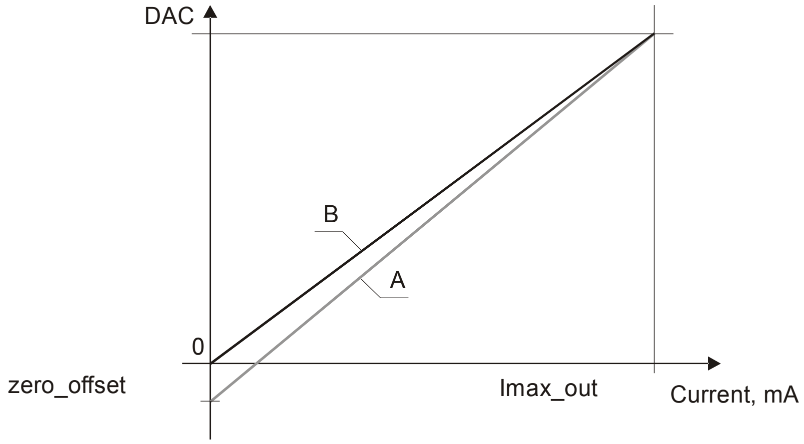


Figure 15. Analog output transfer function

Zero offset decreases the range of unified output DAC values for `zero_offset` value.
After determining analog output physical characteristics, `coeff out a, coeff_out_b` coefficients may be calculated.
DAC value that is transferred to analog output is calculated by the microchip program by the formula:

DAC = zero_offset + coeff_out_a + coeff_out_b · data

If determined DAC value exceeds the maximum value, DAC receives the maximum possible value (Table 16).

Coefficient calculation example
Let us review the example of calculating c`oeff_out_a, coeff_out_b` coefficients for MK10 module.
Let us assume that we have been able to determine experimentally that:

- Maximum analog output current `Imax_out`…………......…………….21mA
- Analog output `zero_offset`………………………………………......20

Analog output current should correspond to:
4mA – 0mm offset;
20mA – 2mm offset.
In calculations it is required to use DAC range reduced for `zero_offset` value (4095 - 20 = 4075).
Let us determine DAC value for 4mA and 20mA currents from the formula:

$$DAC = \frac{(4095 - zero\_offset) \cdot I}{\mathrm{Im}ax\_out}$$

4mA current DAC value is 776;
20mA current DAC value is 3879.

Write down the set of equations:

$$\begin{cases} 776 = \text{coeff\_out\_a} + \text{coeff\_out\_b} \times 0; \\ 3879 = \text{coeff\_out\_a} + \text{coeff\_out\_b} \times 2. \end{cases}$$

Determine the values of coefficients solving the set of equations:
`coeff_out_a` = 776;
`coeff_out_b` = 1551.5.

<u>Experimental method</u>

The essence of this method is that changing `zero_offset` parameter value when `coeff_out_a, coeff_out_b` coefficients are equal to zero, we determine DAC value corresponding to the limits of 4mA and 20mA unified output range (there should be milliamperemeter connected to unified output).

Then `zero_offset` parameter is set to zero and `coeff_out_a, coeff_out_b` unified output coefficients are calculated based on determined DAC values of measurement range limits and corresponding vibration parameter range as shown in example for MK10 module.

Control Interfaces

Vibrobit 300 equipment module supports three independent control interfaces:

- RS485 interface with partial ModBus RTU implementation (sufficient to control modules);
- CAN2.0B interface support (expanded messages only);
- SPI/I2Cslave interface to set the module operating parameters from special tool or PC.

All interfaces can operate simultaneously not interfering with each other.

Attention. Power supply, frequency measurement pulse input, RS485 driver microchip and CAN driver microchip **have no electrical isolation**. Modules with galvanic isolation of communication and supply interfaces are manufactured optionally.

RS485 Interface

There is RS485 semi-duplex bus driver microchip provided on module boards to operate from RS485 interface. Data is exchanged via RS485 interface by ModBus RTU protocol with data rate adjustment (6 standard rates) and module bus address.

To disable any change in the module operating parameters, there is ‘Enable parameter settings by RS485 interface’ flag provided. If the flag is not set to zero, any change in parameters using RS485 bus commands is disabled.

Main data parameters for data exchange via RS485 interface:

Data format..no parity bit, 2 stop bits
Exchange pause to detect message completion ....3.5 bytes
Supported data rates (bit/sec)...4800, 9600, 19,200, 38,400, 57,600, 115,200

Note. There is RS485 bus terminator provided on module boards. If the module is switched on as the last one on RS485 bus and there is no standard 120Ohm terminator on the bus, then to ensure normal RS485 interface operation, install the jumper enabling the bus terminator on the module board.

Setting operating parameters of the module by ModBus Protocol

The module is adjusted with recording the values to the relevant configuration registers provided that recording is enabled. If recording to configuration registers is disabled, the message with error code NEGATIVE ACKNOWLEDGE will be displayed.

Recording to configuration registers is enabled only by Preset Multiple Regs command.

Modules are controlled (recording to control registers) by **Preset Single Registers** command.

When receiving invalid or incorrect command, there is an error message generated if device address is in line and checksum is correct:

Error message format:

Device address
Function code with high bit set to ‘1’
Error code
CRC low byte checksum
CRC high byte checksum

Table 17. Possible error codes

Code	Designation	Description	Notes
0x01	ILLEGAL FUNCTION	Incorrect function code	
0x02	ILLEGAL DATA ADRESS	Unacceptable register address	
0x03	ILLEGAL DATA VALUE	Unacceptable recorded value	
0x07	NEGATIVE ACKNOWLEDGE	Command can’t be executed	Displayed when command cannot be executed
0x09	ILLEGAL SIZE COMMAND	Function code and length of received message are not applicable	Standard ModBus protocol does not include such code. The code is taken from unreserved values.

ModBus Protocol Supported Commands

Table 19. ModBus protocol implemented commands

Code	Name, description	Request	Response	Notes
0x03	**Read Holding Registers** Setup register reading	Device address Function Start address, high byte Start address, low byte Number of reg. high bytes Number of reg. low bytes CRC, low byte CRC, high byte	Device address Function Byte counter Data, high byte Data, low byte CRC, low byte CRC, high byte	
0x06	**Preset Single Registers** Recording to register	Device address Function Address, high byte Address, low byte Data, high byte Data, low byte CRC, low byte CRC, high byte	Device address Function Address, high byte Address, low byte Data, high byte Data, low byte CRC, low byte CRC, high byte	Used in control modules for recording to control registers. Used in БИ24 module for setting of operating parameters
0x10	**Preset Multiple Regs** Recording to multiple registers	Device address Function Start address, high byte Start address, low byte Number of reg. high bytes Number of reg. low bytes Byte counter Data, high byte Data, low byte CRC, low byte CRC, high byte	Device address Function Start address, high byte Start address, low byte Number of reg. high bytes Number of reg. low bytes CRC, low byte CRC, high byte	Used in control modules for recording of parameters. Used in БИ24 module for data display
0x11	**Report Slave ID** ID and event counter reading	Device address Function CRC, low byte CRC, high byte	**For БИ24** Device address Function Byte counter Device ID Start indicator Module type High byte correct communication counter Low byte correct communication counter High byte communication error counter Low byte communication error counter CRC, low byte CRC, high byte	Device ID – 0x11 Start indicator – 0xFF Module type – user-definable (0x50 by default)
			For control module Device address Function Byte counter Device ID Start indicator 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	Device ID: 10 – МК10 20 – МК20 30 – МК30 40 – МК40 Start indicator – 0xFF Manufacturing year, high byte is always zero
0x08	**Diagnostics** Board reset	Device address Function Subfunction, high byte Subfunction, low byte Data, high byte Data, low byte CRC, low byte CRC, high byte	Device address Function Subfunction, high byte Subfunction, low byte Data, high byte Data, low byte CRC, low byte CRC, high byte	БИ24 module supports only 0x0001 subfunction – reset БИ24 module

Diagnostic commands supported by control modules:

- 0x0000 – excho response;
- 0x0001 – ModBus protocol counters reset and Listen Only mode exit;
- 0x0004 – enable Listen Only mode;
- 0x000A – reset of ModBus counters;
- 0x000B – transmit the number of received messages;
- 0x000C – transmit the number of messages with checksum error;
- 0x000D – transmit the number of messages with error.

Checksum 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).

МК10 and МК40 modules control features

Addressing of operating parameters and module status registers is not equalized by 16 bit words. “Number of registers” parameter is indicated in bytes in ModBus commands.

When recording/reading operating parameters and module status, data is transferred according to C language rules for data location in memory (low byte, then high byte) but not according to ModBus standard requirement (high byte, then low byte).

If there is uneven number of bytes requested during reading, the response will contain even number of bytes (one byte more than requested). When recording uneven number of bytes, there should be even number of data bytes always transferred (one byte more than requested) but only the required number of bytes will be actually recorded to parameters.

The maximum recorded/read data size is 64 bytes (32 words) for МК10 module and 50 bytes for МК40 module (25 words).

МК20, МК21 and МК30 modules control features

Addressing of operating parameters and module status registers is always equalized by 16 bit words (start address bit 0 (low byte) is always equal to zero in request). “Number of registers” parameter is indicated in bytes in ModBus commands.

When recording/reading operating parameters and module status data is transferred according to C language rules for data location in memory (low byte, then high byte) but not according to ModBus standard requirement (high byte, then low byte).

The maximum recorded/read data size is 200 bytes (100 words).

БИ24 module control features

Addressing of operating parameters and module status registers is not equalized by 16 bit words (start address bit 0 (low byte) may have any value in request).

When recording/reading operating parameters and module status, data is transferred according to ModBus standard requirements (high byte, then low byte) but high byte is always zero.

The maximum read data size is 10 control registers.

БИ24 module information display by ModBus protocol

Information is displayed by **Preset Multiple Regs** command. Message format is determined by the address of registers transferred in the command. During normal execution of the command, communication interface null data time out counter is reset. БИ24 board supports three message formats:

- Direct recording to indicator segments;
- Sequence of characters (supported characters are ‘0’ – ‘9’, ‘-‘, ‘.’, ‘ ‘);
- Number of unsigned int type (not exceeding 9999) and number of segment to set point in.

Table 18. Data display (message address and format)

Address	Message type	Message format	Note
0x100	Recording of unsigned int number up to 9999 with decimal digit number	Device address Function (0x10) Address, high byte (0x01) Address, low byte (0x00) Number of reg. high bytes (any) Number of reg. low bytes (any) Byte counter (0x04) INT number, high byte INT number, low byte Point number, high byte Point number, low byte CRC, low byte CRC, high byte	If transmitted number exceeds 9999 the value of 9999 is displayed. If decimal digit number is 0 or exceeds 4, no point is displayed. Insignificant zeros are displayed in this message mode.
0x110	Direct recording to indicator segments	Device address Function (0x10) Address, high byte (0x01) Address, low byte (0x10) Number of reg. high bytes (any) Number of reg. low bytes (any) Byte counter (0x04) Digit 1 Digit 2 Digit 3 Digit 4 CRC, low byte CRC, high byte	For order of digits and correspondence of indicator segments to bit data field refer to Fig. 1. Indicator segment is lit up, if the corresponding data bit is 1.
0x120	Line display	Device address Function (0x10) Address, high byte (0x01) Address, low byte (0x20) Number of reg. high bytes (any) Number of reg. low bytes (any) Byte counter (0x0N) Symbol 1 Symbol 2 Symbol N CRC, low byte CRC, high byte	Display of ASCII symbols. Supported characters are ‘0’ – ‘9’, ‘-‘, ‘.’, ‘ ‘ If there are any symbols different of the ones given here, the corresponding indicator digit will be lit off. If there is symbol ‘.’, it is displayed in the previous digit (if ‘.’ is not in the first in line).

Note. Current displayed data cannot be read. When the frequency measurement feature is on, information display by commands from external communication interfaces (RS485, CAN2.0B) is disabled.

CAN2.0B Interface

CAN2.0B interface enables control module status data transfer to БИ24 indication module and statistics gathering module. Control modules do not receive any data via CAN2.0B interface and no modules can be adjusted via CAN2.0B. БИ24 indication module does not transfer any data via CAN2.0B interface but only receives messages from control modules.

Attention. CAN module controller operates in active mode, i.e. it generates received message confirmation dominant and is capable of generating active reset message into CAN bus (e.g. in case of invalid rate). All nodes on CAN bus should have the same data rate.

The following parameters should be set to enable CAN interface operation in control modules:

- Enable CAN interface operation;
- Set data rate;
- Set module address;
- Set message transmission interval;
- Set measurement channels which data is to be transferred by CAN bus.

The following parameters should be set to enable CAN interface operation in indication module:

- Enable CAN interface operation;
- Set data rate;
- Set message transmitter code (8 bit);
- Set message transmitter number (16 bit);
- Set message data code (8 bit);
- Set message initial data offset;
- Select received data type;
- Select data display format.

CAN interface main parameters:

Operation mode ....active data receipt/transmission, with bus reset generation
Message format ....expanded messages only
Supported data rates (kbit/sec)...1000, 500, 250, 200, 125, 100, 40

Note. With data rate increase, the physical maximum length of CAN bus is decreased. Maximum allowable CAN bus length is 40 meters at 1000kbit/sec and 1000 meters at 40kbit/sec.

Module address on CAN bus

CAN2.0B module controller operates only with expanded messages with 29-bit address consisting of:

- 11-bit standard address (SID10 : SID0);
- 18-bit expanded message address (EID1 : EID0).

11-bit standard address includes transmitter module code (8 bit):

- SID10:SID8 - always 110;
- SID7:SID0 - module code 8 bits (reserved and cannot be changed)

18-bit expanded message address includes transmitter module number (16 bit):

- EID17:EID16 - always 10;
- EID15:EID0 - 16 bit transmitter module number

Note. Smaller binary address has higher priority on CAN bus in case of arbitration with simultaneous message transmission from several sources.

Table 19. Control module codes on CAN bus

Module	Transmitter module code on CAN bus
МК20	0x40
МК21	0x41
МК30	0x60

Module initialization on CAN bus

If module operation via CAN interface is enabled and there are no errors in interface configuration parameters, CAN interface controller shall be initialized after identification data display.

If during 4 seconds after initialization CAN bus controller has not switched over to normal operation due to driver malfunction, communication line failure etc., CAN interface operation will be disabled and CAN interface error flag shall be set in status system register.

In case of normal CAN interface initialization and provided that presence pack transmission is enabled, the bus will receive the message containing the module ID information.

Byte No.				
0	**1**	**2**	**3**	**4**
Presence message code	Module number Unsigned int 2 bytes		Year of module manufacture Unsigned int 2 bytes	
0x10 (16)	`board_number`		`board_year`	

Figure 16. Presence message format on MK20 and MK 30 modules CAN bus

Periodic Message Transmission by MK20 module

Data is transmitted by measurement channels at frequency of `can_out_data_sys` (bits 7:0). There is an individual message with unique message code generated for each measurement channel (Table 20).

Table 20. MK20 module transmitted message codes

Message contents	**Length (bytes)**	**Message code (hex)**			
		1	2	3	4
Speed, logic output status, module status flags	8	0x30			
Sensor current, gap	4	0x40	0x50	0x60	0x70
5-500Hz vibration displacement, measurement channel status flags	6	0x41	0x51	0x61	0x71
Low frequency, high frequency vibration displacement	7	0x42	0x52	0x62	0x72
Amplitude and phase of the 1st vibration displacement rotational component	7	0x43	0x53	0x63	0x73
Amplitude and phase of the 2nd vibration displacement rotational component	7	0x44	0x54	0x64	0x74
Amplitude of ½ vibration displacement rotational component	4	0x45	0x55	0x65	0x75

If there are no messages to be sent via CAN bus, no messages will be transmitted to the bus.

When calculating message transmission interval, the messages are sent successively beginning from the speed message. Then all permitted messages are transmitted by measurement channels.

If during 200ms the next message has not been transmitted via CAN bus, the entire pack transmission is delayed till the new transmission interval countdown while current message is deleted from transmission buffer.

Byte No.							
1	2	3	4	5	6	7	8
Code	Speed Float (3 bytes)			Logic output status Unsigned int 2 bytes		Module common flags Unsigned int 2 bytes	
0x30	`frequency`			`logic_out_satus (15:0)`		`sys_status`	

Figure 17. Message format: speed, logic output status and MK20 module common status flags

Byte No.							
1	2	3	4	5	6	7	8
Code	Sensor current Float (3 bytes)			Gap Float (3 bytes)			
0x_0	`sense_curr`			`s_const`			

Figure 18. Message format: sensor current, MK20 module gap

Byte No.							
1	2	3	4	5	6	7	8
Code	(5-500)Hz vibration displacement Float (3 bytes)			Channel flags Unsigned int 2 bytes			
0x_1	`s_5_500`			`status_ch`			

Figure 19. Message format: (5-500)Hz vibration displacement, MK20 module measurement channel status flags

Byte No.							
1	2	3	4	5	6	7	8
Code	Low frequency vibration displacement Float (3 bytes)			High frequency vibration displacement Float (3 bytes)			
0x_2	s_5_F2			s_2F_500			

Figure 20. Message format: Low frequency and high frequency vibration displacement of МК20 module

Byte No.							
1	2	3	4	5	6	7	8
Code	Amplitude of the 1st vibration displacement rotational component Float (3 bytes)			Phase of the 1st vibration displacement rotational component Float (3 bytes)			
0x_3	s_mag_1F			s_phase_1F			

Figure 21. Message format: amplitude and phase of the 1st vibration displacement rotational component for МК20 module

Byte No.							
1	2	3	4	5	6	7	8
Code	Amplitude of the 2nd vibration displacement rotational component Float (3 bytes)			Phase of the 2nd vibration displacement rotational component Float (3 bytes)			
0x_4	s_mag_2F			s_phase_2F			

Figure 22. Message format: amplitude and phase of the 2nd vibration displacement rotational component for МК20 module

Byte No.							
1	2	3	4	5	6	7	8
Code	Amplitude of ½ vibration displacement rotational component Float (3 bytes)						
0x_5	s_mag_F2						

Figure 23. Message format: amplitude of ½ vibration displacement rotational component for МК20 module

Periodic Message Transmission by MK21 module

Data is transmitted by measurement channels at frequency of `can_out_data_sys` (bits 7:0). There is an individual message with unique message code generated for each measurement channel (Table21).

Table 21. MK21 module transmitted message codes

Message contents	Length (bytes)	Message code (hex)			
		1	2	3	4
Speed, logic output status, module status flags	8	0x30			
Sensor current	4	0x40	0x50	0x60	0x70
Total vibration, measurement channel status flags	6	0x41	0x51	0x61	0x71
Low frequency, high frequency vibration	7	0x42	0x52	0x62	0x72
Amplitude (RMS) and phase of the 1st vibration rotational component	7	0x43	0x53	0x63	0x73
Amplitude (RMS) and phase of the 2nd vibration rotational component	7	0x44	0x54	0x64	0x74

If there are no messages to be sent via CAN bus, no messages will be transmitted to the bus.

When calculating message transmission interval, the messages are sent successively beginning from the speed message. Then all permitted messages are transmitted by measurement channels.

If during 200ms the next message has not been transmitted via CAN bus, the entire pack transmission is delayed till the new transmission interval countdown while current message is deleted from transmission buffer.

Byte No.							
1	2	3	4	5	6	7	8
Code	Speed Float (3 bytes)			Logic output status Unsigned int (2 bytes)		Module general flags Unsigned int (2 bytes)	
0x30	`frequency`			`logic_out_satus (15:0)`		`sys_status`	

Figure 24. Message format: speed, logic output status and MK21 module common status flags

Byte No.							
1	2	3	4	5	6	7	8
Code	Sensor current Float (3 bytes)						
0x_0	`sense_curr`						

Figure 25. Message format: MK21 module sensor current

Byte No.							
1	2	3	4	5	6	7	8
Code	Total vibration Float (3 bytes)			Channel flags Unsigned int (2 bytes)			
0x_1	`DataGeneral`			`status_ch`			

Figure 26. Message format: total vibration, MK21 module measurement channel status flags

Byte No.							
1	2	3	4	5	6	7	8
Code	Low frequency vibration Float (3 bytes)			High frequency vibration Float (3 bytes)			
0x_2	`DataLP`			`DataHP`			

Figure 27. Message format: Low frequency and high frequency vibration of MK21 module

Byte No.							
1	2	3	4	5	6	7	8
Code	Amplitude of the 1st vibration rotational component Float (3 bytes)			Phase of the 1st vibration rotational component Float (3 bytes)			
0x_3	`DataMag1F`			`DataPhase1F`			

Figure 28. Message format: amplitude and phase of the 1st vibration rotational component for MK21 module

Byte No.							
1	2	3	4	5	6	7	8
Code	Amplitude of the 2nd vibration rotational component Float (3 bytes)			Phase of the 2nd vibration rotational component Float (3 bytes)			
0x_4	`DataMag2F`			`DataPhase2F`			

Figure 29. Message format: amplitude and phase of the 2nd vibration rotational component for MK21 module

Periodic Message Transmission by MK30 module

Data is transmitted by measurement channels at frequency of `can_out_data_sys` (bits 7:0). There is an individual message with unique message code geerated for each measurement channel (Table 22).

Table 22. MK30 transmitted message codes

Message contents	**Length (bytes)**	**Message code (hex)**			
		1	**2**	**3**	**4**
Speed, logic output status, module status flags	8	0x30			
Sensor current	4	0x40	0x50	0x60	0x70
Total RMS, measurement channel status flags	6	0x41	0x51	0x61	0x71
Low frequency, high frequency RMS	7	0x42	0x52	0x62	0x72
RMS and phase of the 1st vibration velocity rotational component	7	0x43	0x53	0x63	0x73
RMS and phase of the 2nd vibration velocity rotational component	7	0x44	0x54	0x64	0x74
Amplitude and phase of the 1st vibration displacement rotational component	7	0x45	0x55	0x65	0x75
Peak-to-peak excursion and vibration velocity signal form factor	7	0x46	0x56	0x66	0x76

If there are no messages to be sent via CAN bus, no messages will be transmitted to the bus.

When calculating message transmission interval, the messages are sent successively beginning from the speed message. Then all permitted messages are transmitted to measurement channels.

If during 200ms the next message has not been transmitted via CAN bus, the entire pack transmission is delayed till the new transmission interval countdown while current message is deleted from transmission buffer.

Byte No.							
1	2	3	4	5	6	7	8
Code	Speed Float (3 bytes)			Logic output status Unsigned int (2 bytes)		Module common flags Unsigned int (2 bytes)	
0x30	`frequency`			`logic_out_satus (15:0)`		`sys_status`	

Figure 30. Message format: speed, logic output status and MK30 module common status flags

Byte No.							
1	2	3	4	5	6	7	8
Code	Sensor current Float (3 bytes)						
0x_0	`sense_curr`						

Figure 31. Message format: MK30 module sensor current

Byte No.							
1	2	3	4	5	6	7	8
Code	Total RMS Float (3 bytes)			Channel flags Unsigned int (2 bytes)			
0x_1	`vrms_10_1000`			`status_ch`			

Figure 32. Message format: total RMS, MK30 module measurement channel status flags

Byte No.							
1	2	3	4	5	6	7	8
Code	Low frequency vibration velocity RMS Float (3 bytes)			High frequency vibration velocity RMS Float (3 bytes)			
0x_2	`vrms_10_F2`			`vrms_2F_1000`			

Figure 33. Message format: Low frequency and high frequency vibration velocity RMS of MK30 module

Byte No.							
1	2	3	4	5	6	7	8
Code	RMS of the 1st vibration velocity rotational component Float (3 bytes)			Phase of the 1st vibration velocity rotational component Float (3 bytes)			
0x_3	`vrms_mag_1F`			`vrms_phase_1F`			

Figure 34. Message format: RMS and phase of the 1st vibration velocity rotational component for MK30 module

Byte No.							
1	2	3	4	5	6	7	8
Code	RMS of the 2nd vibration velocity rotational component Float (3 bytes)			Phase of the 2nd vibration velocity rotational component Float (3 bytes)			
0x_4	`vrms_mag_2F`			`vrms_phase_2F`			

Figure 35. Message format: RMS and phase of the 2nd vibration velocity rotational component for MK30 module

Byte No.							
1	2	3	4	5	6	7	8
Code	Amplitude of the 1st vibratory displacement rotational component Float (3 bytes)			Phase of the 1st vibratory displacement rotational component Float (3 bytes)			
0x_5	`balan_mag_1F`			`balan_phase_1F`			

Figure 36. Message format: amplitude and phase of the 1st vibration displacement rotational component for MK30 module

Byte No.							
1	2	3	4	5	6	7	8
Code	Vibration velocity peak-to-peak excursion Float (3 bytes)			Vibration velocity signal form factor Float (3 bytes)			
0x_6	`vrms_peak_peak`			`vrms_peak_factor`			

Figure 37. Message format: vibration velocity peak-to-peak excursion and signal form factor for MK30 module

Received data format setting for БИ24 indication module

To display the relevant information in the desirable form it is required to setup the received data format and message data packing parameters.

One CAN message is capable of transmitting of up to 8 bytes of information which is not sufficient when it is required to transmit multiple parameters from the single module. Therefore the first byte in the message is always reserved for data code that may change the transmitter based on information packed in the message. For instance the message code is 0x20 when transmitting the information on the current module status and measured frequency from MK40 tachometer module.

If the received message data code is not the same as indicated in БИ24 unit settings, the message will be rejected and communication line null data time out counter will not change.

Received data may be in one of 4 formats (configuration register address is 0x26):

- Code 0x00 – unsigned int, unsigned integral number (size is 2 bytes)
- Code 0x01 – signed int, signed integral number (size is 2 bytes)
- Code 0x02 – truncated float, real number with floating-point coefficient of 2 bytes (size is 3 bytes)
- Code 0x03 – float, real number with floating-point coefficient of 3 bytes (size is 4 bytes)

Note. If data format number exceeds 0x03, CAN controller shall not be initialized. Controller is disabled.

Data is displayed in one of 4 formats (configuration address is 0x27):

- 0x00 – #### (–999 to 9999)
- 0x01 – ###.# (–99.9 to 999.9)
- 0x02 – ##.## (–9.99 to 99.99)
- 0x03 – #.### (0.000 to 9.999)

If received value is above or below the one allowable for this format, the corresponding maximum/minimum possible number will be displayed.

Note. If data format number exceeds 0x03, CAN controller shall not be initialized. Controller is disabled.

One message transmitted via CAN interface may contain several parameter values. There is initial data offset capability provided to setup the relevant parameter (parameter 0x25). Permissible offset range is between 0 and 6 apart from the message data code.

Note. If offset exceeds 6, the CAN controller will not be initialized. Controller is disabled. If there are less bytes in the message than it is required, such message shall be rejected.

Example

To display data from MK40 module it is required to select data type - unsigned int (0x00) and data format #### (0x00). The data display offset value should be 0 for the 1st measurement channel and 3 for the 2nd measurement channel.

Note. It is required to reset the module so that CAN bus data rate, module address and CAN interface on/off functions could be enabled.

Note. The module cannot be setup by CAN bus commands.

Note. There is CAN bus terminator provided on the module board. If the module is switched on as the last one on RS485 bus and there is no standard 120Ohm terminator on the bus, then to ensure normal CAN interface operation, install the jumper enabling the bus terminator on the module board**.**

SPI, I2C Slave Interfaces

SPI and I2C slave interfaces are designed for module operation control and setting of operating parameters. Diagnostic interface port is located on the module front panel.

SPI and I2C slave interface parameters are strictly preset therefore diagnostic interface is always available for module control regardless of the current module status.

Modules can be adjusted via special tool or personal computer (PC). To setup modules using PC there should be the relevant program running on the computer and the module should be connected to PC via MC01 diagnostic interface board.

MC01 is powered from the module. There should be standard power supply provided for the module during adjustment.

Table 23. Diagnostic interface parameters of modules

Module	Interface	Bus address	Module parameter addressing
МК20 МК21 МК30	SPI	0x40 (8-bit) 0x36 (8-bit) 0x34 (8-bit)	16-bit
БИ24	I2C	0x80 (7-bit)	8-bit

Note. Modules provide capability of hot MC01 adapter connection/disconnection without power-off.

Configuration Parameters and Current Status of Modules

МК20, МК21, МК30 Modules

Table 24. The list of МК20 module measurement channel parameters

Description	Designation	Type (bytes)	Parameter address by channels (hex)			
			1	2	3	4
ADC to mkm conversion coefficient for total, low frequency and high frequency vibration displacement	s_var_coff_A	Float (4)	600	700	800	900
	s_var_coff_B	Float (4)	604	704	804	904
ADC to mkm conversion coefficient for vibration displacement rotational components	s_circul_coff_A	Float (4)	608	708	808	908
	s_circul_coff_B	Float (4)	60C	70C	80C	90C
(5-500)Hz vibration displacement calculation averaging buffer depth	s_5_500_aver_size	Uint (2)	610	710	810	910
Low frequency vibration displacement calculation averaging buffer depth	s_5_F2_aver_size	Uint (2)	612	712	812	912
High frequency vibration displacement calculation averaging buffer depth	s_2F_500_aver_size	Uint (2)	614	714	814	914
The 1st vibration displacement rotational component calculation averaging buffer depth	s_mag_1F_aver_size	Uint (2)	616	716	816	916
The 1st vibration displacement rotational component phase calculation averaging buffer depth	s_phase_1F_aver_size	Uint (2)	618	718	818	918
The 2nd vibration displacement rotational component calculation averaging buffer depth	s_mag_2F_aver_size	Uint (2)	61A	71A	81A	91A
The 2nd vibration displacement rotational component phase calculation averaging buffer depth	s_phase_2F_aver_size	Uint (2)	61C	71C	81C	91C
Sensor current calculation averaging buffer depth	sense_curr_aver_size	Uint (2)	61E	71E	81E	91E
½ vibration displacement rotational component calculation averaging buffer depth	s_mag_F2_aver_size	Uint (2)	620	720	820	920
Reserve	reserv_1(2)	Uint (2)	622	722	822	922
Reserve	reserv(2)	Ulong (4)	624	724	824	924
First setpoint of (5-500)Hz vibration displacement	s_5_500_point_1	Float (4)	628	728	828	928
Second setpoint of (5-500)Hz vibration displacement	s_5_500_point_2	Float (4)	62C	72C	82C	92C
Third setpoint of (5-500)Hz vibration displacement	s_5_500_point_3	Float (4)	630	730	830	930
Hysteresis for (5-500)Hz vibration displacement setpoints	s_5_500_point_hist	Float (4)	634	734	834	934
Low frequency vibration displacement setpoint	s_5_F2_point	Float (4)	638	738	838	938
Hysteresis for low frequency vibration displacement setpoint	s_5_F2_point_hist	Float (4)	63C	73C	83C	93C
Minimum allowable sensor current	curr_point_min	Float (4)	640	740	840	940
Maximum allowable sensor current	curr_point_max	Float (4)	644	744	844	944
Hysteresis for sensor current setpoints	curr_point_hist	Float (4)	648	748	848	948
Minimum vibration displacement rotational component for rotational component phase calculation	s_min_phase_detect	Float (4)	64C	74C	84C	94C
Reserve	reserv_2(2)	Float (4)	650	750	850	950
Time of response to vibration displacement value transition over 0.5sec setpoints	s_5_500_point_time	Uint (2)	654	754	854	954
Time of response to low frequency vibration displacement value transition over 0.5sec setpoint	s_5_F2_point_time	Uint (2)	656	756	856	956
Time of response to sensor current value transition over 0.5sec setpoints	curr_point_time	Uint (2)	658	758	858	958
Reserve	reserv_3(2)	Uint (2)	65A	75A	85A	95A
Sensor current (voltage) calculation coefficients	curr_coff_A	Float (4)	65C	75C	85C	95C
	curr_coff_B	Float (4)	660	760	860	960
Constant offset (gap) calculation coefficients	gap_coff_A	Float (4)	664	764	864	964
	gap_coff_B	Float (4)	668	768	868	968
Phase correction coefficient	corr_phase_coff	Float (4)	66C	76C	86C	96C
Resistance of resistor converting current into voltage	data_resist(1)	Float (4)	670	770	870	970
Minimum sensor current range	data_curr_min(1)	Float (4)	674	774	874	974
Maximum sensor current range	data_curr_max(1)	Float (4)	678	778	878	978
Minimum parameter range	data_param_min(1)	Float (4)	67C	77C	87C	97C
Maximum parameter range	data_param_max(1)	Float (4)	680	780	880	980

The list of MK20 module measurement channel parameters (continued)

Description	Designation	Type (bytes)	Parameter address by channels (hex)			
			1	2	3	4
Time after algorithm reset prior to vibration displacement 0.5sec step detection	Jump_S_5_500. time_start	Uint (2)	684	784	884	984
Vibration displacement value stabilization time out for 0.5sec step detection	Jump_S_5_500. time_stabil	Uint (2)	686	786	886	986
Vibration displacement value variation within 0.5sec	Jump_S_5_500. variation_dt	Float (4)	688	788	888	988
Minimum vibration displacement value step to enable signaling	Jump_S_5_500. variation_max	Float (4)	68C	78C	88C	98C
Time after algorithm reset prior to the 1st vibration displacement rotational component 0.5sec step detection	Jump_S_1F. time_start	Uint (2)	690	790	890	990
The 1st vibration displacement rotational component stabilization time out for 0.5sec step detection	Jump_S_1F. time_stabil	Uint (2)	692	792	892	992
The 1st vibration displacement rotational component value variation within 0.5sec	Jump_S_1F. variation_dt	Float (4)	694	794	894	994
Minimum step of the 1st vibration displacement rotational component value to enable signaling	Jump_S_1F. variation_max	Float (4)	698	798	898	998
Time after algorithm reset prior to the 1st vibration displacement rotational component phase step detection, 0.5 sec	Jump_Phase_1F. time_start	Uint (2)	69C	79C	89C	99C
The 1st vibration displacement rotational component phase stabilization time out for 0.5sec step detection	Jump_Phase_1F. time_stabil	Uint (2)	69E	79E	89E	99E
The 1st vibration displacement rotational component phase variation within 0.5sec	Jump_Phase_1F. variation_dt	Float (4)	6A0	7A0	8A0	9A0
Minimum step of the 1st vibration displacement rotational component phase to enable signaling	Jump_Phase_1F. variation_max	Float (4)	6A4	7A4	8A4	9A4

Notes:

1. Reference data, not included in module operation.
2. Reserve register, should be equal to zero.

Table 25. The list of MK20 module measurement results registers

Description	Designation	Type (bytes)	Parameter address by channels (hex)			
			1	2	3	4
Sensor current, mA	sense_curr	Float (4)	000	004	008	00C
(5-500)Hz vibration displacement, mkm	s_5_500	Float (4)	010	014	018	01C
Low frequency vibration displacement, mkm	s_5_F2	Float (4)	020	024	028	02C
High frequency vibration displacement, mkm	s_2F_500	Float (4)	030	034	038	03C
The 1st vibration displacement rotational component, mkm	s_mag_1F	Float (4)	040	044	048	04C
The 1st vibration displacement rotational component phase, degrees	s_phase_1F	Float (4)	050	054	058	05C
The 2nd vibration displacement rotational component, mkm	s_mag_2F	Float (4)	060	064	068	06C
The 2nd vibration displacement rotational component phase, degrees	s_phase_2F	Float (4)	070	074	078	07C
½ vibration displacement rotational component, mkm	s_mag_F2	Float (4)	080	084	088	08C
Reserve	reserv_1	Float (4)	090	094	098	09C
Gap, mkm	S_const	Float (4)	0A0	0A4	0A8	0AC
Reserve	reserv_2	Float (4)	0B0	0B4	0B8	0BC
Speed, rpm	frequency	Float (4)	0C0			
Logic output status flags	logic_out_satus	Ulong (4)	0C4			

Table 26. The list of MK20 module measurement channel status registers

Description	Designation	Type (bytes)	Parameter address by channels (hex)			
			1	2	3	4
Time counter of transition over the 1st setpoint of (5-500)Hz vibration displacement	s_5_500_count_time_1	Uint (2)	100	200	300	400
Time counter of transition over the 2nd setpoint of (5-500)Hz vibration displacement	s_5_500_count_time_2	Uint (2)	102	202	302	402
Time counter of transition over the 3rd setpoint of (5-500)Hz vibration displacement	s_5_500_count_time_3	Uint (2)	104	204	304	404
Time counter of transition over the low frequency vibration displacement setpoint	s_5_F2_count_time	Uint (2)	106	206	306	406
Time counter of transition over the lower sensor test setpoint	curr_point_count_min	Uint (2)	108	208	308	408
Time counter of transition over the upper sensor test setpoint	curr_point_count_max	Uint (2)	10A	20A	30A	40A
Reserve, always equal to zero	pre_status	Uint (2)	10C	20C	30C	40C
Measurement channel status flags (Table 12)	status_ch	Uint (2)	10E	20E	30E	40E
(5-500)Hz vibration displacement step detection algorithm time counter	Jump_S_5_500. time_count	Uint (2)	110	210	310	410
(5-500)Hz vibration displacement step detection algorithm status 0 - start pause 1 - Parameter variation time out 2 - Parameter stabilization time out 3 - step detected	Jump_S_5_500. status	Uint (2)	112	212	312	412
New value of (5-500)Hz vibration displacement	Jump_S_5_500. values_new	Float (4)	114	214	314	414
Old value of (5-500)Hz vibration displacement	Jump_S_5_500. values_old	Float (4)	108	208	308	408
Start value of (5-500)Hz vibration displacement	Jump_S_5_500. values_start	Float (4)	10C	20C	30C	40C
(5-500)Hz vibration displacement step level	Jump_S_5_500. values_jamp	Float (4)	120	220	320	420
The 1st vibration displacement rotational component step detection algorithm time counter	Jump_S_1F. time_count	Uint (2)	124	224	324	424
The 1st vibration displacement rotational component step detection algorithm status	Jump_S_1F. status	Uint (2)	126	226	326	426
New value of the 1st vibration displacement rotational component	Jump_S_1F. values_new	Float (4)	128	228	328	428
Old value of the 1st vibration displacement rotational component	Jump_S_1F. values_old	Float (4)	12C	22C	32C	42C
Start value of the 1st vibration displacement rotational component	Jump_S_1F. values_start	Float (4)	130	230	330	430
The 1st vibration displacement rotational component step level	Jump_S_1F. values_jamp	Float (4)	134	234	334	434
The 1st vibration displacement rotational component phase step detection algorithm time counter	Jump_Phase_1F. time_count	Uint (2)	138	238	338	438
The 1st vibration displacement rotational component phase step detection algorithm status	Jump_Phase_1F. status	Uint (2)	13A	23A	33A	43A
New value of the 1st vibration displacement rotational component phase	Jump_Phase_1F. values_new	Float (4)	13C	23C	33C	43C
Old value of the 1st vibration displacement rotational component phase	Jump_Phase_1F. values_old	Float (4)	140	240	340	440
Start value of the 1st vibration displacement rotational component phase	Jump_Phase_1F. values_start	Float (4)	144	244	344	444
The 1st vibration displacement rotational component phase step level	Jump_Phase_1F. values_jamp	Float (4)	148	248	348	448

Table 27. The list of MK21 module measurement channel parameters

Description	Designation	Type (bytes)	Parameter address by channels (hex)			
			1	2	3	4
ADC to mkm (channel 1,3,4) and mm/s (channel 2) conversion coefficient for total, low frequency and high frequency vibration level	MainCoff_A	Float (4)	600	700	800	900
	MainCoff_B	Float (4)	604	704	804	904
ADC to mkm (channel 1,3,4) and mm/s (channel 2) conversion coefficient for vibration rotational components	VarCoff_A	Float (4)	608	708	808	908
	VarCoff_B	Float (4)	60C	70C	80C	90C
Total vibration calculation averaging buffer depth	DataGeneral_AverSize	Uint (2)	610	710	810	910
Low frequency vibration calculation averaging buffer depth	DataLP_AverSize	Uint (2)	612	712	812	912
High frequency vibration calculation averaging buffer depth	DataHP_AverSize	Uint (2)	614	714	814	914
The 1st vibration rotational component calculation averaging buffer depth	DataMag1F_AverSize	Uint (2)	616	716	816	916
The 1st vibration rotational component phase calculation averaging buffer depth	DataPhase1F_AverSize	Uint (2)	618	718	818	918
The 2nd vibration rotational component calculation averaging buffer depth	DataMag2F_AverSize	Uint (2)	61A	71A	81A	91A
The 2nd vibration rotational component phase calculation averaging buffer depth	DataPhase2F_AverSize	Uint (2)	61C	71C	81C	91C
Sensor current calculation averaging buffer depth (for channels 1,2 only)	sense_curr_aver_size	Uint (2)	61E	71E	81E	91E
Gap calculation averaging buffer depth (for channel 1 only)	DataGap_AverSize	Uint (2)	620	720	820	920
Reserve	reserv_1 (2)	Uint (2)	622	722	822	922
Minimum spectral component level in ADC dimension (for channels 1,2 only)	SpectrMagError	Ulong (4)	624	724	824	924
First total vibration setpoint	DataGeneralPoint_1	Float (4)	628	728	828	928
Second total vibration setpoint	DataGeneralPoint_2	Float (4)	62C	72C	82C	92C
Third total vibration setpoint	DataGeneralPoint_3	Float (4)	630	730	830	930
Hysteresis for total vibration setpoints	DataGeneralPointHist	Float (4)	634	734	834	934
Low frequency vibration setpoint	DataLPPoint	Float (4)	638	738	838	938
Hysteresis for low frequency vibration setpoint	DataLPPointHist	Float (4)	63C	73C	83C	93C
Minimum allowable sensor current	curr_point_min	Float (4)	640	740	840	940
Maximum allowable sensor current	curr_point_max	Float (4)	644	744	844	944
Hysteresis for sensor current setpoints	curr_point_hist	Float (4)	648	748	848	948
Minimum rotational component level for rotational component phase calculation	DataMin_CalcPhase	Float (4)	64C	74C	84C	94C
Low vibration setpoint	DataGeneralMin	Float (4)	650	750	850	950
Time of response to total vibration value transition over 0.5sec setpoints	DataGeneralPointTime	Uint (2)	654	754	854	954
Time of response to low frequency vibration value transition over 0.5sec setpoint	DataLPPointTime	Uint (2)	656	756	856	956
Time of response to sensor current value transition over 0.5sec setpoints	curr_point_time	Uint (2)	658	758	858	958
Reserve	reserv_3 (2)	Uint (2)	65A	75A	85A	95A
Sensor current (voltage) calculation coefficients	curr_coff_A	Float (4)	65C	75C	85C	95C
	curr_coff_B	Float (4)	660	760	860	960
Constant offset (gap) calculation coefficients (channel1 only)	GapCoff_A	Float (4)	664	764	864	964
	GapCoff_B	Float (4)	668	768	868	968
Phase correction coefficient	VarCorrPhaseCoff	Float (4)	66C	76C	86C	96C
Resistance of resistor converting current into voltage	data_resist (1)	Float (4)	670	770	870	970
Minimum sensor current range	data_curr_min (1)	Float (4)	674	774	874	974
Maximum sensor current range	data_curr_max (1)	Float (4)	678	778	878	978
Minimum parameter range	data_param_min (1)	Float (4)	67C	77C	87C	97C
Maximum parameter range	data_param_max (1)	Float (4)	680	780	880	980

The list of MK21 module measurement channel parameters (continued)

Description	Designation	Type (bytes)	Parameter address by channels (hex)			
			1	2	3	4
Time after algorithm reset prior to vibration 0.5sec step detection	`Jump_DataGeneral.time_start`	Uint (2)	684	784	884	984
Vibration value stabilization time out for 0.5sec step level calculation	`Jump_DataGeneral.time_stabil`	Uint (2)	686	786	886	986
Vibration value variation within 0.5sec	`Jump_DataGeneral.variation_dt`	Float (4)	688	788	888	988
Minimum vibration value step level to enable signaling	`Jump_DataGeneral.variation_max`	Float (4)	68C	78C	88C	98C
Time after algorithm reset prior to the 1st vibration rotational component 0.5sec step detection	`Jump_Data1F.time_start`	Uint (2)	690	790	890	990
The 1st vibration rotational component stabilization time out for 0.5sec step detection	`Jump_Data1F.time_stabil`	Uint (2)	692	792	892	992
The 1st vibration rotational component value variation within 0.5sec	`Jump_Data1F.variation_dt`	Float (4)	694	794	894	994
Minimum step level of the 1st vibration rotational component value to enable signaling	`Jump_Data1F.variation_max`	Float (4)	698	798	898	998
Time after algorithm reset prior to the 1st vibration rotational component phase step detection, 0.5 sec	`Jump_Phase_1F.time_start`	Uint (2)	69C	79C	89C	99C
The 1st vibration rotational component phase value stabilization time out for 0.5sec step detection	`Jump_Phase_1F.time_stabil`	Uint (2)	69E	79E	89E	99E
The 1st vibration rotational component phase value variation within 0.5sec	`Jump_Phase_1F.variation_dt`	Float (4)	6A0	7A0	8A0	9A0
Minimum step level of the 1st vibration rotational component phase value to enable signaling	`Jump_Phase_1F.variation_max`	Float (4)	6A4	7A4	8A4	9A4

Notes:

1. Reference data, not included in module operation.
2. Reserve register, should be equal to zero.

Table 28. The list of MK21 module measurement results registers

Description	Designation	Type (bytes)	Parameter address by channels (hex)			
			1	2	3	4
Sensor current (for channel 1, 2 only), mA	`sense_curr`	Float (4)	000	004	008	00C
Total vibration Channels 1, 3, 4 – vibration displacement Channel 2 – vibration velocity RMS	`DataGeneral`	Float (4)	010	014	018	01C
Low frequency vibration	`DataLP`	Float (4)	020	024	028	02C
High frequency vibration	`DataHP`	Float (4)	030	034	038	03C
The 1st vibration rotational component	`DataMag1F`	Float (4)	040	044	048	04C
The 1st vibration rotational component phase, degrees	`DataPhase1F`	Float (4)	050	054	058	05C
The 2nd vibration rotational component	`DataMag2F`	Float (4)	060	064	068	06C
The 2nd vibration rotational component phase	`DataPhase2F`	Float (4)	070	074	078	07C
Reserve	`reserv_0`	Float (4)	080	084	088	08C
Reserve	`reserv_1`	Float (4)	090	094	098	09C
Gap, mkm	`DataGap`	Float (4)	0A0	0A4	0A8	0AC
Reserve (for channel 1 only)	`reserv_2`	Float (4)	0B0	0B4	0B8	0BC
Speed, rpm	`frequency`	Float (4)	0C0			
Logic output status flags	`logic_out_satus`	Ulong (4)	0C4			

Table 29. The list of MK21 module measurement channel status registers

Description	Designation	Type (bytes)	Parameter address by channels (hex)			
			1	2	3	4
Time counter of transition over the 1st total vibration setpoint	DataGeneralTimeCount_1	Uint (2)	100	200	300	400
Time counter of transition over the 2nd total vibration setpoint	DataGeneralTimeCount_2	Uint (2)	102	202	302	402
Time counter of transition over the 3rd total vibration setpoint	DataGeneralTimeCount_3	Uint (2)	104	204	304	404
Time counter of transition over the low frequency vibration setpoint	DataGeneralTimeCount_LP	Uint (2)	106	206	306	406
Time counter of transition over the lower sensor test setpoint	curr_point_count_min	Uint (2)	108	208	308	408
Time counter of transition over the upper sensor test setpoint	curr_point_count_max	Uint (2)	10A	20A	30A	40A
Reserve, always equal to zero	pre_status	Uint (2)	10C	20C	30C	40C
Measurement channel status flags (Table 12)	status_ch	Uint (2)	10E	20E	30E	40E
Total vibration step detection algorithm time counter	Jump_DataGeneral.time_count	Uint (2)	110	210	310	410
Total vibration step detection algorithm status 0 - start pause 1 - Parameter variation time out 2 - Parameter stabilization time out 3 - Step detected	Jump_DataGeneral.status	Uint (2)	112	212	312	412
New total vibration value	Jump_DataGeneral.values_new	Float (4)	114	214	314	414
Old total vibration value	Jump_DataGeneral.values_old	Float (4)	108	208	308	408
Start total vibration value	Jump_DataGeneral.values_start	Float (4)	10C	20C	30C	40C
Total vibration step level	Jump_DataGeneral.values_jamp	Float (4)	120	220	320	420
The 1st vibration rotational component step detection algorithm time counter	Jump_Data1F.time_count	Uint (2)	124	224	324	424
The 1st vibration rotational component step detection algorithm status	Jump_Data1F.status	Uint (2)	126	226	326	426
New value of the 1st vibration rotational component	Jump_Data1F.values_new	Float (4)	128	228	328	428
Old value of the 1st vibration rotational component	Jump_Data1F.values_old	Float (4)	12C	22C	32C	42C
Start value of the 1st vibration rotational component	Jump_Data1F.values_start	Float (4)	130	230	330	430
The 1st vibration rotational component step level	Jump_Data1F.values_jamp	Float (4)	134	234	334	434
The 1st vibration rotational component phase step detection algorithm time counter	Jump_Phase_1F.time_count	Uint (2)	138	238	338	438
The 1st vibration rotational component phase step detection algorithm status	Jump_Phase_1F.status	Uint (2)	13A	23A	33A	43A
New value of the 1st vibration rotational component phase	Jump_Phase_1F.values_new	Float (4)	13C	23C	33C	43C
Old value of the 1st vibration rotational component phase	Jump_Phase_1F.values_old	Float (4)	140	240	340	440
Start value of the 1st vibration rotational component phase	Jump_Phase_1F.values_start	Float (4)	144	244	344	444
The 1st vibration rotational component phase step level	Jump_Phase_1F.values_jamp	Float (4)	148	248	348	448

Table 30. The list of MK30 module measurement channel parameters

Description	Designation	Type (bytes)	Parameter address by channels (hex)			
			1	2	3	4
ADC to mkm conversion coefficients for total, low frequency and high frequency vibration velocity RMS	Vrms_fixed_coff_A	Float (4)	600	700	800	900
	Vrms_fixed_coff_B	Float (4)	604	704	804	904
ADC to mkm conversion coefficients for vibration velocity RMS rotational component	Vrms_var_coff_A	Float (4)	608	708	808	908
	Vrms_var_coff_B	Float (4)	60C	70C	80C	90C
Total vibration velocity RMS calculation averaging buffer depth	vrms_10_1000_aver_size	Uint (2)	610	710	810	910
Low frequency vibration velocity RMS calculation averaging buffer depth	vrms_10_F2_aver_size	Uint (2)	612	712	812	912
High frequency vibration velocity RMS calculation averaging buffer depth	vrms_2F_1000_aver_size	Uint (2)	614	714	814	914
The 1st vibration velocity RMS rotational component calculation averaging buffer depth	vrms_mag_1F_aver_size	Uint (2)	616	716	816	916
The 1st vibration velocity rotational component phase calculation averaging buffer depth	vrms_phase_1F_aver_size	Uint (2)	618	718	818	918
The 2nd vibration velocity RMS rotational component calculation averaging buffer depth	vrms_mag_2F_aver_size	Uint (2)	61A	71A	81A	91A
The 2nd vibration velocity rotational component phase calculation averaging buffer depth	vrms_phase_2F_aver_size	Uint (2)	61C	71C	81C	91C
Sensor current calculation averaging buffer depth	sense_curr_aver_size	Uint (2)	61E	71E	81E	91E
vibration velocity peak-to-peak excursion calculation averaging buffer depth	vrms_peak_peak_aver_size	Uint (2)	620	720	820	920
Reserve	reserv_1(2)	Uint (2)	622	722	822	922
Minimum allowable spectral component amplitude square level in ADC dimension	fft_fixed_mag_error	Ulong (4)	624	724	824	924
First total vibration velocity RMS setpoint	vrms_10_1000_point_1	Float (4)	628	728	828	928
Second total vibration velocity RMS setpoint	vrms_10_1000_point_2	Float (4)	62C	72C	82C	92C
Third total vibration velocity RMS setpoint	vrms_10_1000_point_3	Float (4)	630	730	830	930
Hysteresis for total vibration velocity RMS setpoints	vrms_10_1000_point_hist	Float (4)	634	734	834	934
Low frequency vibration velocity RMS setpoint	vrms_10_F2_point	Float (4)	638	738	838	938
Hysteresis for low frequency vibration velocity RMS setpoint	vrms_10_F2_point_hist	Float (4)	63C	73C	83C	93C
Minimum allowable sensor current	curr_point_min	Float (4)	640	740	840	940
Maximum allowable sensor current	curr_point_max	Float (4)	644	744	844	944
Hysteresis for sensor current setpoints	curr_point_hist	Float (4)	648	748	848	948
Minimum vibration displacement rotational component RMS for rotational component phase calculation	vrms_min_phase_detect	Float (4)	64C	74C	84C	94C
Minimum total vibration velocity RMS level for signal form factor calculation	vrms_min_peak_peak	Float (4)	650	750	850	950
Time of response to total vibration velocity RMS transition over 0.5sec setpoints	vrms_10_1000_point_time	Uint (2)	654	754	854	954
Time of response to low frequency vibration velocity RMS transition over 0.5sec setpoint	vrms_10_F2_point_time	Uint (2)	656	756	856	956
Time of response to sensor current value transition over 0.5sec setpoints	curr_point_time	Uint (2)	658	758	858	958
Constant rotational component phase correction	var_phase_correct	Int (2)	65A	75A	85A	95A
Sensor current (voltage) calculation coefficients	curr_coff_A	Float (4)	65C	75C	85C	95C
	curr_coff_B	Float (4)	660	760	860	960
Peak-to-peak excursion calculation coefficients	peak_peak_coff_A	Float (4)	664	764	864	964
	peak_peak_coff_B	Float (4)	668	768	868	968
Phase correction coefficient	corr_phase_coff	Float (4)	66C	76C	86C	96C
Resistance of resistor converting current into voltage	data_resist(1)	Float (4)	670	770	870	970
Minimum sensor current range	data_curr_min(1)	Float (4)	674	774	874	974
Maximum sensor current range	data_curr_max(1)	Float (4)	678	778	878	978
Minimum parameter range	data_param_min(1)	Float (4)	67C	77C	87C	97C
Maximum parameter range	data_param_max(1)	Float (4)	680	780	880	980

The list of MK30 module measurement channel parameters (continued)

Description	Designation	Type (bytes)	Parameter address by channels (hex)			
			1	2	3	4
Time after algorithm reset prior to total vibration velocity RMS 0.5sec step detection	Jump_Vrms_10_1000. time_start	Uint (2)	684	784	884	984
Total vibration velocity RMS value stabilization time out for 0.5sec step detection	Jump_Vrms_10_1000. time_stabil	Uint (2)	686	786	886	986
Total vibration velocity RMS value variation within 0.5sec	Jump_Vrms_10_1000. variation_dt	Float (4)	688	788	888	98A
Minimum total vibration velocity RMS step to enable signaling	Jump_Vrms_10_1000. variation_max	Float (4)	68C	78C	88C	98C
Time after algorithm reset prior to the 1st vibration velocity rotational component RMS 0.5sec step detection	Jump_Vrms_1F. time_start	Uint (2)	690	790	890	990
The 1st vibration velocity rotational component RMS stabilization time out for 0.5sec step detection	Jump_Vrms_1F. time_stabil	Uint (2)	692	792	892	992
The 1st vibration velocity rotational component RMS variation within 0.5sec	Jump_Vrms_1F. variation_dt	Float (4)	694	794	894	994
Minimum step of the 1st vibration velocity rotational component RMS to enable signaling	Jump_Vrms_1F. variation_max	Float (4)	698	798	898	998
Time after algorithm reset prior to the 1st vibration velocity rotational component phase step detection, 0.5 sec	Jump_Phase_1F. time_start	Uint (2)	69C	79C	89C	99C
The 1st vibration velocity rotational component phase stabilization time out for 0.5sec step detection	Jump_Phase_1F. time_stabil	Uint (2)	69E	79E	89E	99E
The 1st vibration velocity rotational component phase variation within 0.5sec	Jump_Phase_1F. variation_dt	Float (4)	6A0	7A0	8A0	9A0
Minimum step of the 1st vibration velocity rotational component phase to enable signaling	Jump_Phase_1F. variation_max	Float (4)	6A4	7A4	8A4	9A4

Notes:

1. Reference data, not included in module operation.
2. Reserve register, should be equal to zero.

Table 31. The list of MK30 module measurement results registers

Description	Designation	Type (bytes)	Parameter address by channels (hex)			
			1	2	3	4
Sensor current, mA	sense_curr	Float (4)	000	004	008	00C
Total vibration velocity RMS, mm/s	vrms_10_1000	Float (4)	010	014	018	01C
Low frequency vibration velocity RMS, mm/s	vrms_10_F2	Float (4)	020	024	028	02C
High frequency vibration velocity RMS, mm/s	vrms_2F_1000	Float (4)	030	034	038	03C
The 1st vibration velocity rotational component RMS, mm/s	vrms_mag_1F	Float (4)	040	044	048	04C
The 1st vibration velocity rotational component phase, degrees	vrms_phase_1F	Float (4)	050	054	058	05C
The 2nd vibration velocity rotational component RMS, mm/s	vrms_mag_2F	Float (4)	060	064	068	06C
The 2nd vibration velocity rotational component phase, mm/s	vrms_phase_2F	Float (4)	070	074	078	07C
The 1st vibration displacement rotational component amplitude, mm	balan_mag_1F	Float (4)	080	084	088	08C
The 1st vibration displacement rotational component phase, degrees	balan_phase_1F	Float (4)	090	094	098	09C
Vibration velocity peak-to-peak excursion, mm/s	vrms_peak_peak	Float (4)	0A0	0A4	0A8	0AC
Vibration velocity signal form factor	vrms_peak_factor	Float (4)	0B0	0B4	0B8	0BC
Speed, rpm	frequency	Float (4)	0C0			
Logic output status flags	logic_out_satus	Ulong (4)	0C4			

Table 32. The list of MK30 module measurement channel status registers

Description	Designation	Type (bytes)	Parameter address by channels (hex)			
			1	2	3	4
Time counter of transition over the 1st total RMS setpoint	vrms_10_1000_count_time_1	Uint (2)	100	200	300	400
Time counter of transition over the 2nd total RMS setpoint	vrms_10_1000_count_time_2	Uint (2)	102	202	302	402
Time counter of transition over the 3rd total RMS setpoint	vrms_10_1000_count_time_3	Uint (2)	104	204	304	404
Time counter of transition over the low frequency RMS setpoint	vrms_10_F2_count_time	Uint (2)	106	206	306	406
Time counter of transition over the lower sensor test setpoint	curr_point_count_min	Uint (2)	108	208	308	408
Time counter of transition over the upper sensor test setpoint	curr_point_count_max	Uint (2)	10A	20A	30A	40A
Reserve, always equal to zero	pre_status	Uint (2)	10C	20C	30C	40C
Measurement channel status flags (Table 14)	status_ch	Uint (2)	10E	20E	30E	40E
Total vibration velocity RMS step detection algorithm time counter	Jump_Vrms_10_1000. time_count	Uint (2)	110	210	310	410
Total vibration velocity RMS step detection algorithm status 0 - start pause 1 - Parameter variation time out 2 - Parameter stabilization time out 3 - step detected	Jump_Vrms_10_1000. status	Uint (2)	112	212	312	412
New total vibration velocity RMS value	Jump_Vrms_10_1000. values_new	Float (4)	114	214	314	414
Old total vibration velocity RMS value	Jump_Vrms_10_1000. values_old	Float (4)	108	208	308	408
Start total vibration velocity RMS value	Jump_Vrms_10_1000. values_start	Float (4)	10C	20C	30C	40C
Total vibration velocity RMS step level	Jump_Vrms_10_1000. values_jamp	Float (4)	120	220	320	420
The 1st vibration velocity RMS rotational component step detection algorithm time counter	Jump_Vrms_1F. time_count	Uint (2)	124	224	324	424
The 1st vibration velocity RMS rotational component step detection algorithm status	Jump_Vrms_1F. status	Uint (2)	126	226	326	426
New value of the 1st vibration velocity RMS rotational component	Jump_Vrms_1F. values_new	Float (4)	128	228	328	428
Old value of the 1st vibration velocity RMS rotational component	Jump_Vrms_1F. values_old	Float (4)	12C	22C	32C	42C
Start value of the 1st vibration velocity RMS rotational component	Jump_Vrms_1F. values_start	Float (4)	130	230	330	430
The 1st vibration velocity RMS rotational component step level	Jump_Vrms_1F. values_jamp	Float (4)	134	234	334	434
The 1st vibration velocity RMS rotational component phase step detection algorithm time counter	Jump_Phase_1F. time_count	Uint (2)	138	238	338	438
The 1st vibration velocity RMS rotational component phase step detection algorithm status	Jump_Phase_1F. status	Uint (2)	13A	23A	33A	43A
New value of the 1st vibration velocity rotational component phase	Jump_Phase_1F. values_new	Float (4)	13C	23C	33C	43C
Old value of the 1st vibration velocity rotational component phase	Jump_Phase_1F. values_old	Float (4)	140	240	340	440
Start value of the 1st vibration velocity rotational component phase	Jump_Phase_1F. values_start	Float (4)	144	244	344	444
The 1st vibration velocity rotational component phase step level	Jump_Phase_1F. values_jamp	Float (4)	148	248	348	448

Table 33. The list of rotational component registers and main parameters of MK20, MK21, MK30 modules

Description	Type (bytes)	Parameter address by channels (hex)			
½ rotational component excursion/RMS	Float (4)	1000	1100	1200	1300
1st rotational component excursion/RMS	Float (4)	1004	1104	1204	1304
2nd rotational component excursion/RMS	Float (4)	1008	1108	1208	1308
3rd rotational component excursion/RMS	Float (4)	100C	110C	120C	130C
4th rotational component excursion/RMS	Float (4)	1010	1110	1210	1310
5th rotational component excursion/RMS	Float (4)	1014	1114	1214	1314
6th rotational component excursion/RMS	Float (4)	1018	1118	1218	1318
7th rotational component excursion/RMS	Float (4)	101C	111C	121C	131C
8th rotational component excursion/RMS	Float (4)	1020	1120	1220	1320
9th rotational component excursion/RMS	Float (4)	1024	1124	1224	1324
10th rotational component excursion/RMS	Float (4)	1028	1128	1228	1328
½ rotational component phase	Float (4)	102C	112C	122C	132C
1st rotational component phase	Float (4)	1030	1130	1230	1330
2nd rotational component phase	Float (4)	1034	1134	1234	1334
3rd rotational component phase	Float (4)	1038	1138	1238	1338
4th rotational component phase	Float (4)	103C	113C	123C	133C
5th rotational component phase	Float (4)	1040	1140	1240	1340
Reserve, always equal to zero	Float (4)	1044	1144	1244	1344
	Float (4)	1048	1148	1248	1348
	Float (4)	104C	114C	124C	134C
	Float (4)	1050	1150	1250	1350
	Float (4)	1054	1154	1254	1354
Sensor current, mA	Float (4)	1058	1158	1258	1358
Reserve, always zero	Uint (2)	105C	115C	125C	135C
Measurement channel status flags MK20 - Table 12, MK21 - Table 13, MK30 - Table 14	Uint (2)	105E	115E	125E	135E
(5-500)Hz vibration displacement, mkm (MK20; 1,3,4 channel of MK21) Total vibration velocity RMS, mm/s (MK30; 2 channel of MK21)	Float (4)	1060	1160	1260	1360
Low frequency vibration displacement, mkm (MK20; 1,3,4 channel of MK21) Low frequency vibration velocity RMS, mm/s (MK30; 2 channel of MK21)	Float (4)	1064	1164	1264	1364
High frequency vibration displacement, mkm (MK20; 1,3,4 channel of MK21) High frequency vibration velocity RMS, mm/s (MK30; 2 channel of MK21)	Float (4)	1068	1168	1268	1368
Gap, mkm (MK20, MK21 - reserve) 1st vibration displacement rotational component amplitude, mm (MK30)	Float (4)	106C	116C	126C	136C
Reserve, always zero (MK20, MK21) 1st vibration displacement rotational component phase, degrees (MK30)	Float (4)	1070	1170	1270	1370
Reserve, always zero (MK20, MK21 – gap, channel 1) Vibration velocity peak-to-peak excursion, mm/s (MK30)	Float (4)	1074	1174	1274	1374
Reserve, always zero (MK20, MK21) Vibration velocity signal form factor (MK30)	Float (4)	1078	1178	1278	1378

Table 34. The list of logic signaling parameters of MK20, MK21 and MK30 modules

Description	Designation	Type (bytes)	Parameter address (hex)
1st logic matrix of OR buffers (80 elements)	`buff_or_dest_matrix_1` (1)	Uint (2)	A00 (160 bytes)
2nd logic matrix of OR buffers (80 elements)	`buff_or_dest_matrix_2`	Uint (2)	B00 (160 bytes)
Logic matrix of AND output buffers	`buff_and_source_matrix`	Uint (2)	C00 (132 bytes)

Note 1. Bit 15 – ‘War’ LED enable conditions. Bit 14 – ‘Alarm’ enable conditions.

Table 35. The list of unified output parameters of MK20, MK21 and MK30 modules

Description	Designation	Type (bytes)	Parameter address (hex)					
			1	2	3	4	5	6
Operation mode: Bits 7:0 – parameter Bits 14:8 – measurement channel number Bit 15 – output operation permission	`mode_work`	Uint (2)	D00	D20	D40	D60	D80	DA0
Output zero offset in PWM dimension	`zero_offset`(1)	Uint (2)	D02	D22	D42	D62	D82	DA2
Maximum output current	`Imax_out`(2)	Float (4)	D04	D24	D44	D64	D84	DA4
Output current range, lower limit	`Imin`(2)	Float (4)	D08	D28	D48	D68	D88	DA8
Output current range, upper limit	`Imax`(2)	Float (4)	D0C	D2C	D4C	D6C	D8C	DAC
Parameter range, lower limit	`Dmin`(2)	Float (4)	D10	D30	D50	D70	D90	DB0
Parameter range, upper limit	`Dmax`(2)	Float (4)	D14	D34	D54	D74	D94	DB4
Coefficient A of PWM value	`coeff_out_a`	Float (4)	D18	D38	D58	D78	D98	DB8
Coefficient B of PWM value	`coeff_out_b`	Float (4)	D1C	D3C	D5C	D7C	D9C	DBC

Notes:
1. Transferred to analog output PWM even if the output is disabled (bit 15 `mode_work` is 0).
2. Reference data, not involved in the module operation

Table 36. The list of sampling registers of initial signal and its spectrum (for MK30/MK20 with software version 1.15), MK21

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 interval (0 – 1000ms (MK20),500ms (MK30); (1 – 50ms) has no value in case of spectrum request bit 4 – run data request bit 5 – cancel current task (has higher priority than data request) bits 15:6 – reserve (should be equal to 0)	`SampleTask`	Uint (2)	FF3F
Status register (read only): bits 1:0 – Measurement channel number bit 2 – request type (0 – signal; 1 - spectrum) bit 3 – signal request interval (0 – 1000ms (MK20),500ms (MK30); (1 – 50ms) has no value in case of spectrum request bit 4 – task running, reset to 0 upon data availability bit 5 – data capture time out bit 6 – data calculation time out bit 7 – task completed, data can be read (automatically reset to zero in case of new data request) bit 8 – Cancel current task bit 9 – New task rejected as the previous one is running (current task is not reset) bit 10 – data calculation status (service bit) bits 15:11 – reserve, always 0	`SampleStatus`	Uint (2)	3F00
Data request result (read only) Initial signal is in mA: Module MK20 – 2048 samplings per sec or 50ms Module MK21 – not executed Module MK30 – 2048 samplings per 0.5sec or 50ms Signal spectrum: Module MK20 – 512 spectral components, 1Hz resolution, excursion in mkm Module MK21, MK30 – 1024 spectral components, 1Hz resolution, RMS in mm/s	`SampleData`	float(4)	4000 – 5F00

Notes:
1. Recording to control register is executed by control command rules (bit 7 `SampleStatus` is automatically reset).
2. Zero and first harmonic of the requested spectrum is recommended to be reset to zero prior to diagram construction and not to be considered in the analysis.
3. At spectrum request, direct component is located at address 0x4000 etc. Unused data capture buffer pool is set to zero and may be not read by the control system.
4. Data is stored in data capture buffer until the next request.

Table 37. The list of system parameters and communication interfaces of MK20, MK21 and MK30 moduled

Description	Designation	Type (bytes)	Parameter address (Hex)
Module number from 0 to 9999	board_number	Uint (2)	E00
Year of the module manufacture from 0 to 99	board_year	Uint (2)	E02
Reserve	reserv_1[1]	Uint (2)	E04
Logic signaling activation delay after the module reset (power-up)	start_ready_wait	Uint (2)	E06
Minimum allowable speed of the unit, rpm	freq_min	Float (4)	E08
Maximum allowable speed of the unit, rpm	freq_max	Float (4)	E0C
Speed tolerance in stabilization mode, rpm	freq_delta	Float (4)	E10
Reserve	reserv_2[1]	Uint (2)	E14
Speed stabilization/destabilization detection time at 0.5 sec interval	freq_delta_time	Uint (2)	E16
Base frequency in absence of synchronization pulses, rpm	freq_basic_no_sync	Uint (2)	E18
Reserve	reserv_3[1]	Uint (2)	E1A
Enable RS485 interface: 0 – interface operation is disabled not zero – interface is enabled	rs485_enable[2]	Uint (2)	E1C
Enable parameter change via RS485 interface: 0 – changes enabled not zero – changes disabled	rs485_change	Uint (2)	E1E
Data rate via RS485 interface: 0 – 4800 bit/sec 1 – 9600 bit/sec 2 – 19,200 bit/sec 3 – 38,400 bit/sec 4 – 57,600 bit/sec 5 – 115,200 bit/sec	rs485_speed[2]	Uint (2)	E20
Module address on RS485 interface (from 1 to 247)	rs485_adres[2]	Uint (2)	E22
Enable CAN interface: 0 – interface operation is disabled not zero – interface is enabled	can_enable[2]	Uint (2)	E24
Data rate via CAN interface: 0x00 – 1000 kbit/sec 0x01 – 500 kbit/sec 0x02 – 250 kbit/sec 0x03 – 200 kbit/sec 0x04 – 125 kbit/sec 0x05 – 100 kbit/sec 0x06 – 40 kbit/sec	can_speed[2]	Uint (2)	E26
Module address on CAN interface (from 0 to 65535)	can_adres[2]	Uint (2)	E28
Interval of data transfer via CAN interface (bits 8:0), 0.5sec; Presence message transmission (bit 12) Message transmission: Frequency, log. signaling, system flags (bit 13)	can_out_data_sys	Uint (2)	E2A
Flags enabling periodic data transfer by measurement channels for MK20 module: Bit 0 – Sensor current, gap Bit 1 – Vibration displacement, measurement channel status flags Bit 2 – Low frequency and high frequency vibration displacement Bit 3 – Amplitude and phase of the 1^{st} vibration displacement rotational component Bit 4 – Amplitude and phase of the 2^{nd} vibration displacement rotational component Bit 5 – Amplitude of ½ vibration displacement rotational component			
Flags enabling periodic data transfer by measurement channels for MK30 module: Bit 0 – Sensor current Bit 1 – Total RMS, measurement channel status flags Bit 2 – Low frequency and high frequency RMS Bit 3 – RMS and phase of the 1^{st} vibration velocity rotational component Bit 4 – RMS and phase of the 1^{2nd} vibration velocity rotational component Bit 5 – Amplitude and phase of the 1^{st} vibration displacement rotational component Bit 6 – Peak-to-peak excursion and vibration velocity signal form factor	can_out_channel_1	Uint (2)	E2C
	can_out_channel_2	Uint (2)	E2E
	can_out_channel_3	Uint (2)	E30
	can_out_channel_4	Uint (2)	E32

Notes:
1. Reserve register should be equal to zero
2. Become effective upon module reset only

Table 38. The list of common status registers of MK20, MK21 and MK30 modules

Description	Designation	Type (bytes)	Parameter address (Hex)
Module software version	`version`	Uint (2)	500
Module status flags (Table 15)	`sys_status`	Uint (2)	502
Spectrum resolution, Hz	`fixed_spectr_resolution`	Float (4)	504

Table 39. The list of frequency response correction registers for MK21 module

Description	Designation	Type (bytes)	Parameter address (Hex)
Correction table record count (maximum 30)	`CalibrPoint`	Uint (2)	1800
Constant phase rotation, 0.1 degrees (0 to 3600)	`PhaseConstCorrect`	Uint (2)	1802
Amplitude correction constant multiplier	`MagConstCorrect`	Float (4)	1804
Offset table records (addresses are given for the first record)			
Calibration frequency, Hz	`SpLine`	Uint (2)	1808
Main harmonic phase difference, 0.1 degrees (0 to 3600)	`Phase`	Uint (2)	180A
Main harmonic amplitude ratio	`Mag`	Float (4)	180C

Table 40. The list of registers of current measurement results of MK21 module in ADC dimension

Description	Type (bytes)	Parameter address by channels (hex)			
Direct signal component (channel 1, 2)	long (4)	1900	1904	1908	190C
Total vibration level (channels 1,3,4 – excursion; channel 2 - RMS)	long (4)	1910	1914	1918	191C
Low frequency vibration (channels 1,3,4 – excursion; channel 2 - RMS)	long (4)	1920	1924	1928	192C
High frequency vibration (channels 1,3,4 – excursion; channel 2 - RMS)	long (4)	1930	1934	1938	193C
The 1st vibration rotational component (channels 1,3,4 – excursion; channel 2 - RMS)	long (4)	1940	1944	1948	194C
Main harmonic ratio of channels 1, 3 prior to correction	Float (4)	`RationMag`		1950	
Main harmonic phase difference of channels 1, 3 prior to correction	Float (4)	`DifferPhase`		1954	
Main harmonic ratio of channels 1, 3 after correction	Float (4)	`RationMagCorr`		1958	
Main harmonic phase difference of channels 1, 3 after correction	Float (4)	`DifferPhaseCorr`		195C	
Flag of compliance with synchronization frequency requirements	Uint (2)	`FreqDeviationOk`		1960	

Control Registers

There are several reserved registers provided to execute control commands in MK20, MK21 and MK30 modules. Reading control registers gives back zero result. Control command may be executed only if recording to control registers is bitewise and not in stream.

Table 41. The list of MK20, MK21 and MK30 modules control registers

Register address (Hex)	Recorded value (Hex)	Action
0xFF10	0x33	Disable logic signaling
	0xCC	Enable logic signaling
	0x47	Convert frequency response coordination coefficients (for MK21 only)
0xFF44	0x55	Module reset
0xFF68	 0x00 0x01 0x02 0x03	Reset of parameters step for the measurement channel: Channel 1 Channel 2 Channel 3 Channel 4
0xFFD0	 0x00 0x01 0x02 0x03	Recording measurement channel parameters to non-volatile memory: Channel 1 Channel 2 Channel 3 Channel 4 Recording parameters to EEPROM is possible if only: 1. Logic outputs are disabled; 2. Recording to EEPROM is enabled. When saving parameters to EEPROM, the measurement of sensor signal for all module channels is suspended (200ms). Upon completion of parameters saving, the measurements are automatically recovered.
0xFFE0	0x21	Saving the current module settings in non-volatile memory. Recording parameters to EEPROM is possible if only: 3. Logic outputs are disabled; 4. Recording to EEPROM is enabled. When saving parameters to EEPROM, the module operation is suspended, recording progress is displayed on LCD (for Full option). Upon saving completion the module is forcibly reset.

БИ24 indication module

Table 42. БИ24 module operating parameters

Address	Designation		Range	Default value	Notes
0x00	Enable parameter setting via RS-485 interface: 0x00 – recording disabled not zero – recording enabled		-	0x01	Read only via RS485
0x01	Digit 1	Display status after power-up (initialization pause – display test).	0x00 - 0xFF	0xFF	Corresponds to code “8.8.8.8.”
0x02	Digit 2		0x00 - 0xFF	0xFF	
0x03	Digit 3		0x00 - 0xFF	0xFF	
0x04	Digit 4		0x00 - 0xFF	0xFF	
0x05	Digit 1	Display status when waiting for the first data reception from communication interface after power-up	0x00 - 0xFF	0x40	Corresponds to code “----”
0x06	Digit 2		0x00 - 0xFF	0x40	
0x07	Digit 3		0x00 - 0xFF	0x40	
0x08	Digit 4		0x00 - 0xFF	0x40	
0x09	Digit 1	Display status in too long absence of data from communication interface	0x00 - 0xFF	0x00	Corresponds to code “ Err”
0x0A	Digit 2		0x00 - 0xFF	0x79	
0x0B	Digit 3		0x00 - 0xFF	0x50	
0x0C	Digit 4		0x00 - 0xFF	0x50	
0x0D	Communication interface display data absence time out (0.5sec)		4 - 255	10	Default time out is 5.5sec
0x0E	initialization pause duration (30. ms)		0 - 255	10	Default pause is 0.30sec
0x0F	Enable display of communication interface data absence message: 0x00 – display disabled, indicators show the last received information not zero – display enabled		0x00 – 0xFF	0x01	
0x10	Display light intensity 0 – lowest intensity		0 - 8	5	
0x11	Device address		1 - 247	0x40	
0x12	Code of data rate via RS-485 interface: 0x00 = 4800, 0x01 = 9600, 0x02 = 19,200, 0x03 = 38,400		0 - 3	1	Reset board to accept changes
0x13	Module number (module type)		0x00 – 0xFF	0x50	
0x14	Enable pulse frequency measurement function: 0x00 – frequency measurement disabled not zero – frequency measurement enabled, measured frequency value is updated on the display at preset measurement interval. LCD data display with external commands is disabled.		0x00 – 0xFF	1	Reset board to accept changes
0x15	Active pulse edge 0x00 – front edge not zero – trailing edge		0x00 – 0xFF	0	Reset board to accept changes
0x16	Frequency measurement interval of 0.5sec (0 corresponds to 0.5sec)		0x00 – 0xFF	3	Default measurement interval is 2sec
0x17	Time interval of stop detection at measurement intervals (0 corresponds to one measurement interval)		0x00 – 0xFF	9	20 seconds Minimum measurement frequency is 3 rpm
0x18	Speed display format 0x00 – rpm (XXXX) not zero – krpm (XX.XX)		0x00 – 0xFF	0	Rpm (XXXX)
0x19	Digit 1	Display status when detecting stop	0x00 - 0xFF	0x6D	Corresponds to “Stop” code
0x1A	Digit 2		0x00 - 0xFF	0x78	
0x1B	Digit 3		0x00 - 0xFF	0x3F	
0x1C	Digit 4		0x00 - 0xFF	0x73	
0x1D	Measured frequency low byte		-	0x00	Read only
0x1E	Measured frequency high byte		-	0x00	

БИ24 module operating parameters (continued)

Address	Designation	Range	Default value	Notes
0x1F	Data receipt permission via CAN2.0B interface: 0x00 – receipt disabled not zero – receipt enabled	-	0x00	Reset board to accept changes
0x20	Data rate by CAN bus: 0x00 – 1000 kbit/sec 0x01 – 500 kbit/sec 0x02 – 250 kbit/sec 0x03 – 200 kbit/sec 0x04 – 125 kbit/sec 0x05 – 100 kbit/sec 0x06 – 40 kbit/sec	0x00 – 0x06	0x00	
0x21	Transmitter module code	0x00 – 0xFF	0x00	
0x22	Transmitter module number low byte	0x00 – 0xFF	0x00	
0x23	Transmitter module number high byte	0x00 – 0xFF	0x00	
0x24	Sent data code	0x00 – 0xFF	0x00	
0x25	Sent data offset	0x00 – 0x06	0x00	
0x26	Data type 0x00 – unsigned int (unsigned integral number, 2 bytes) 0x01 – signed int (signed integral number, 2 bytes) 0x02 – float 3 (real number, 3 bytes) 0x03 – float 4 (real number, 4 bytes)	0x00 – 0x03	0x00	
0x27	Data display format 0x00 – #### (–999 to 9999) 0x01 – ###.# (–99.9 to 999.9) 0x02 – ##.## (–9.99 to 99.99) 0x03 – #.### (0.000 to 9.999)	0x00 – 0x03	0x00	
0x28	БИ24 software version low byte	0x00 – 0xFF	Depends on БИ24 version	Read only
0x29	БИ24 software version high byte	0x00 – 0xFF		

Notes:

- Reading of non-existing registers gives 0.
- Recording to non-existing registers or read-only registers causes no effect.
- Display digits arrangement and correspondence of data bytes to display segments is shown on Figure 1. Display segment is lit up if corresponding data byte is equal to 1.

Attention. Control module parameters can only be changed if logic outputs are disabled otherwise transferred data is ignored.

Note. Recording to non-existing addresses causes no effect except when recording to special addresses is perceived as control commands (refer to control interface specification).

Note. Reading of data from non-existing addresses gives 0.

Module Setup PC Software

Special module setup program has friendly interface and access to all module parameters. To enable setup program it is required to connect the module to PC via MC01 diagnostic interface module.

PC program enables:

- Setting of all operating parameters of the module;
- Saving setup templates as files;
- Saving current settings in the module non-volatile memory;
- Reset the module;
- Read current module configuration;
- Read current value of measurable parameters and measurement channel status.

Connect the module to PC via MC01 diagnostic interface board.

For МК20 module – МК20_setup.exe
For МК21 module – МК21_setup.exe
For МК30 module – mk30_setup.exe
For БИ24 module – БИ24_setup.exe.

In “Connection” menu select COM port to which MC01 adapter is connected and choose “Connect” command.

During connection, MC01 and module adapter availability is tested. In case of an error there will be the message displayed corresponding to the error occurred.

If connection has been normally established, data update indicator will blink synchronously with data requests executed.

MK20, MK21, MK30 Modules

Most of MK20, MK21 and MK30 module setup program windows are very similar, therefore this section describes program windows for MK20 or MK30 module. Differences of MK21 setup program will be described separately.

The main setup program window (Figure 38) shows current values of measured parameters and status of signaling and logic outputs. Signaling status by measurement channels and general module status is shown as round indicators. The function of specific indicators is shown in pop-up tooltip when pointing the corresponding indicator with cursor bar.

If logic outputs are enabled, active level of signal at logic outputs will be indicated in red. If logic outputs are disabled the user can see the preliminary logic signaling status. Logic outputs which should be active when enabled are lit in yellow.

The module status information update may be controlled by the user via blinking green indicator in the top left corner of the program window.

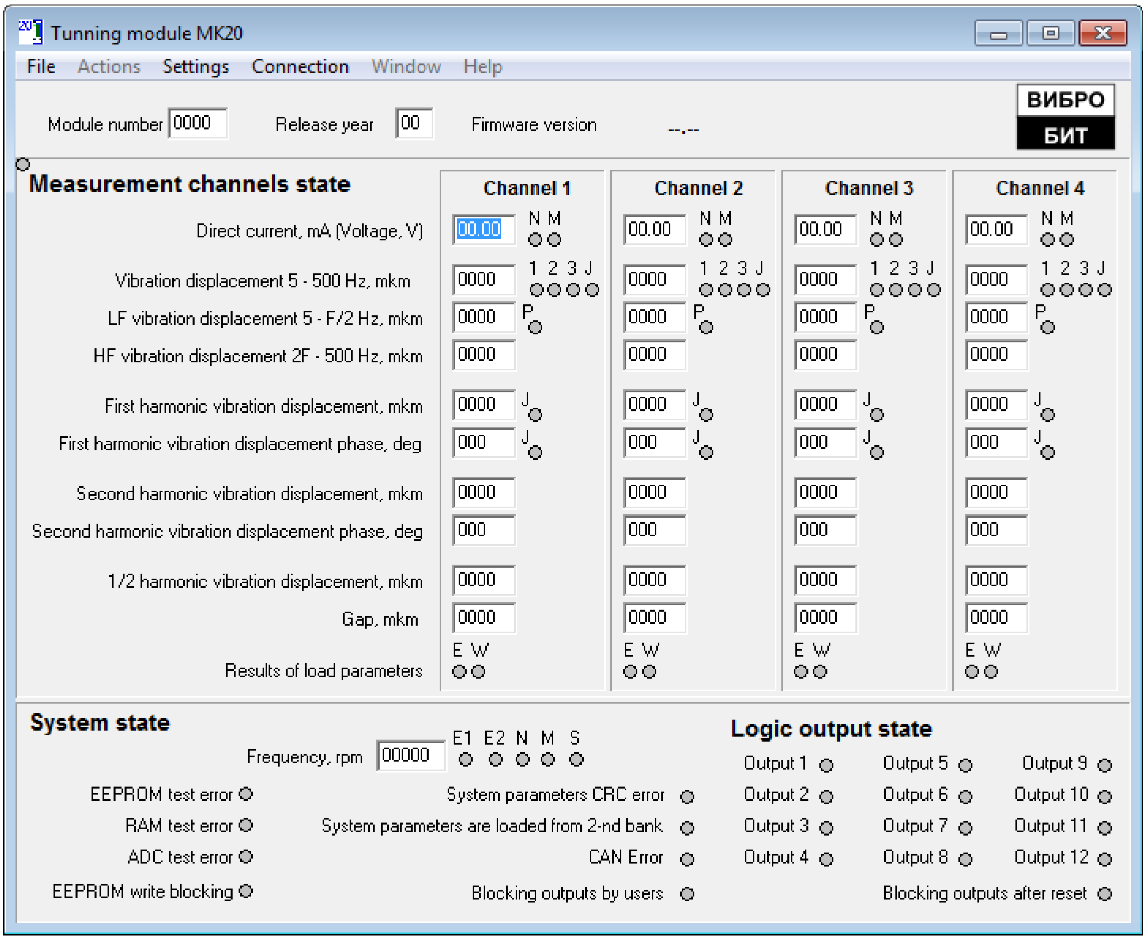


Figure 38. The main module setup program window

For MK20 module operation mode setting, it is required to enable the relevant window in “Module Setup” menu comprising the following options:

- Measurement channels, measurement channels configuration;
- Logic outputs, logic signaling setup;
- Analog outputs, unified analog output setup;
- System settings and communication interfaces.

Each configuration window has a local loading of parameters for each group of settings.

The module operating parameters may be saved and recovered on the computer hard drive from “File” menu:

- Load settings from the file;
- Save settings to the file;
- Module setting text report, automatic module logbook generation;
- Form reset: program windows are reset to status corresponding to the initial program start.

The following options are provided in “Action” menu to control the module:

- Disable logic signaling. If the selection flag is set over this option, the logic signaling is disabled. When logic signaling is disabled, the menu options enabling the settings loading to MK20 module are activated.
- Reset module. The module connection is preserved when resetting the module.
- Read all settings from module.
- Load all settings to module.
- Save current settings in EEPROM. This action is possible if only logic outputs are disabled and recording to EEPROM is enabled.

The main module operation parameters are set in the window “Module measurement channel parameters” (Figure Figure 39).

The measurement channel for which parameters are being set, can be selected with buttons located in the top left corner of the program window.

When changing parameters values, the changes are to be confirmed with pushing “Accept changes” button.

The following coefficients are automatically calculated based on the initial data in “Calculations” menu item:

- Vibration displacement;
- Sensor current;
- Phase correction;
- Unified output.

“Action” menu commands enable reading/transfer of the selected measurement channel settings.

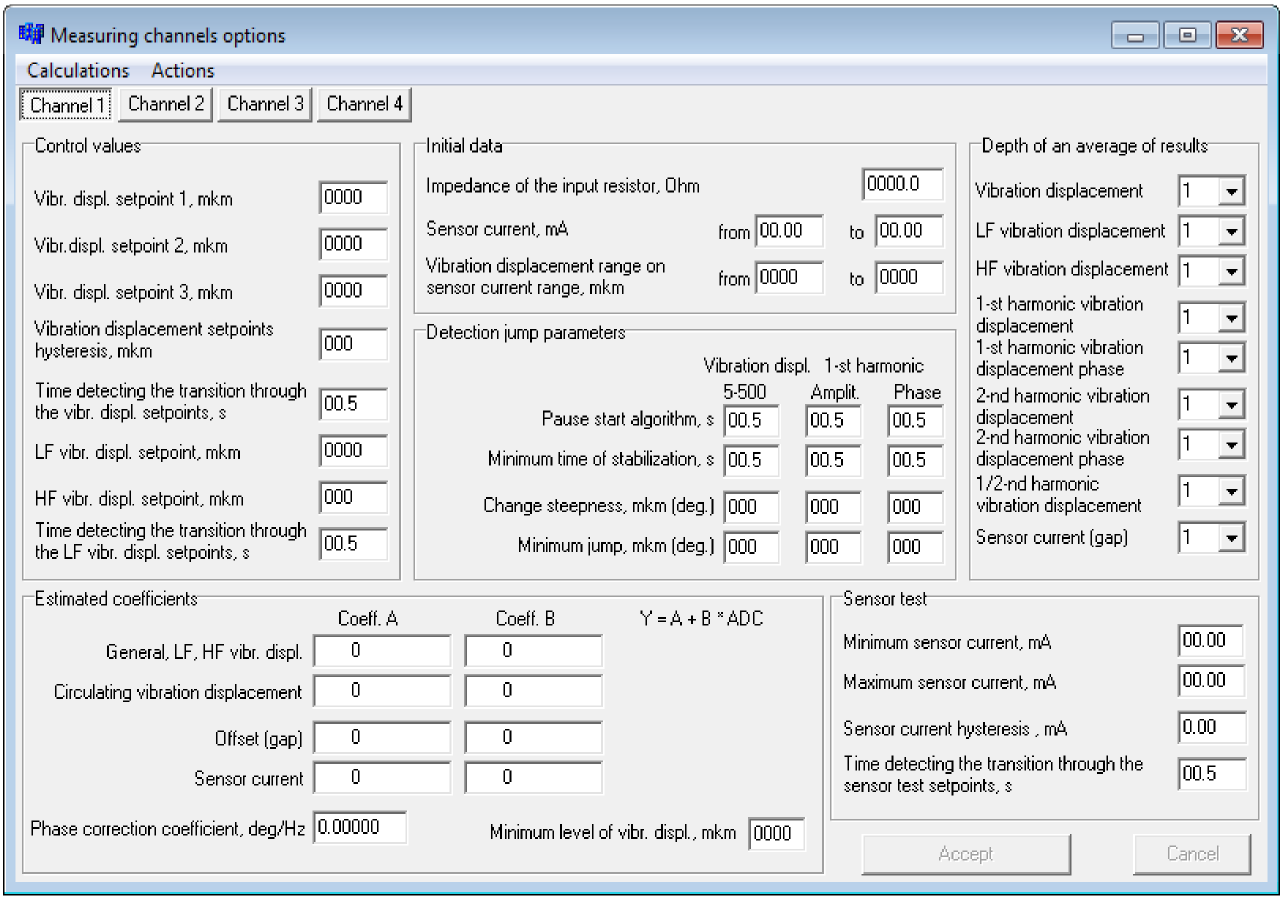


Figure 39. Module measurement channel parameters window

Calculation window incorporates the form (Figure 40), which filling enables automatic determination of design factors. By the module "cold start" LCD displays parameter values in ADC dimension. This window fields should be filled by transmitting test signals to the module inputs. Pushing “Calculate” button enables to calculate the design factors for the relevant measurement channel.

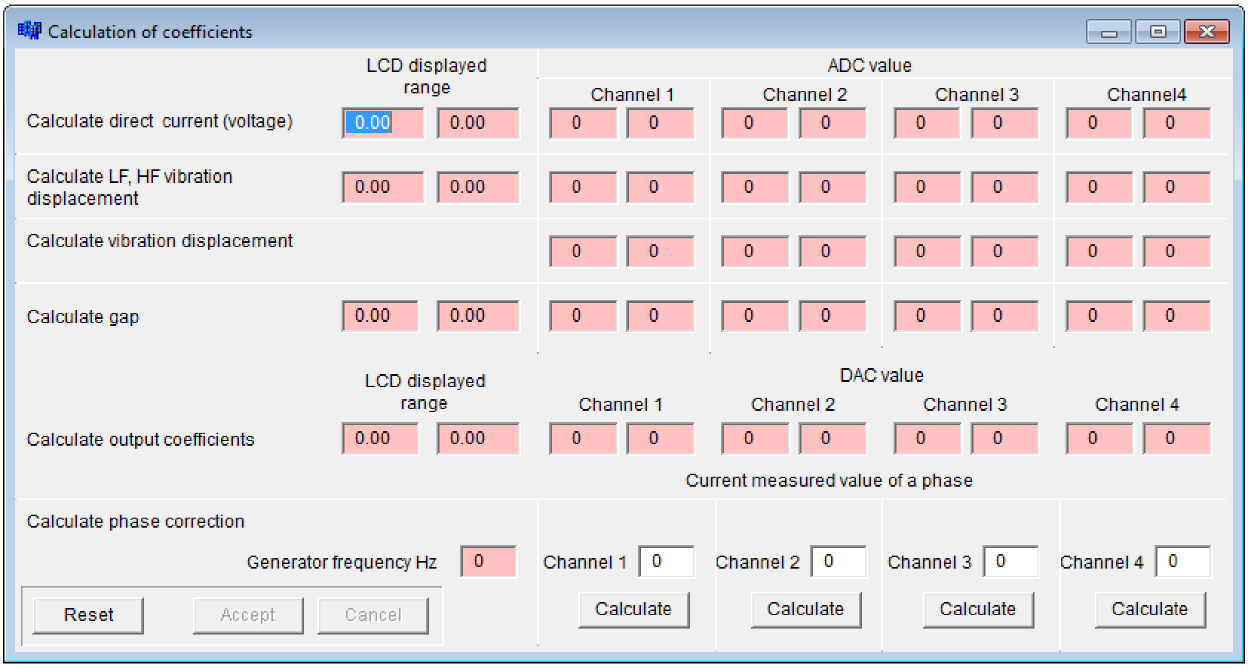


Figure 40. Module coefficients calculation window

The form fields highlighted in red indicate that this value is incorrect and not used in calculations.

When determining coefficients of analog (unified outputs), it is assumed that data will be transferred from channel 1 to the 1st analog output etc. though analog output settings provide free data source assignment.

Analog output setup window (Figure 41) contains all necessary tools for determination of parameters and setting of unified outputs operation mode.

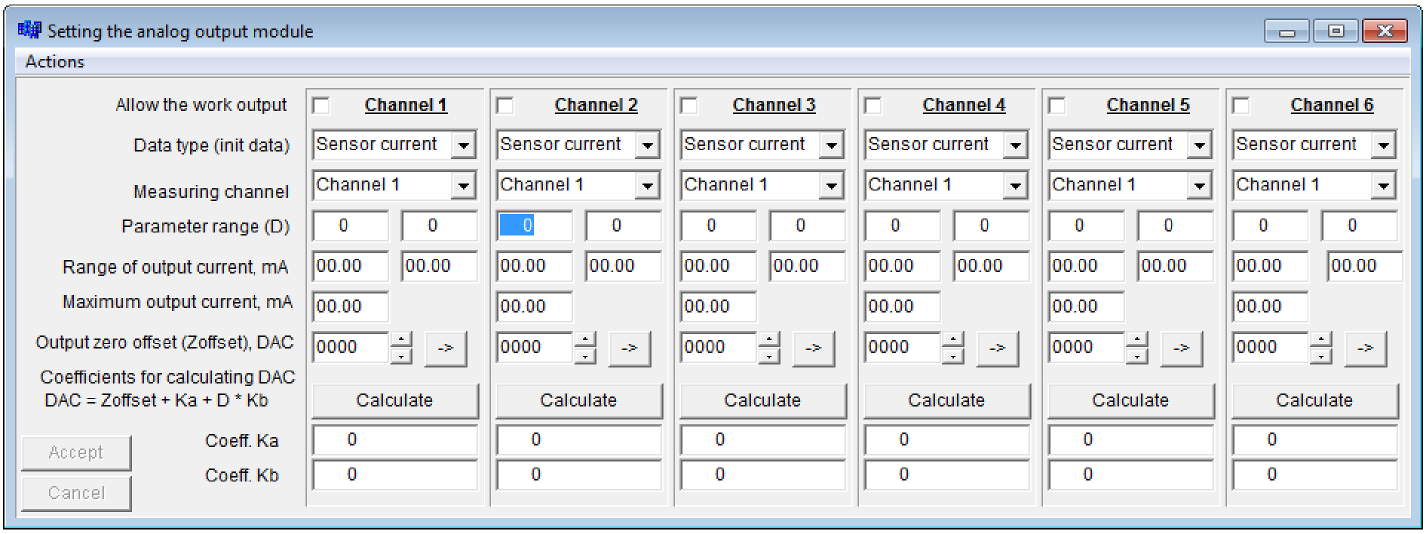


Figure 41. Analog output setup window

There are buttons to transfer current offset value to the module located near “Zero Offset” value parameter (only available if logic signaling is disabled).

Pushing “Calculate” button enables automatic calculation of PWM factors for the particular analog output based on preset data by unified output zero offset method (refer to unified output operation description).

Changes made in logic output setup window (Figure 42) become effective immediately and do not require any confirmation (the changes are transferred to the module by the user's command only).

This window allows for setting logic signaling and lighting conditions of 'War' and 'Alarm' LEDs located on the module front panel.

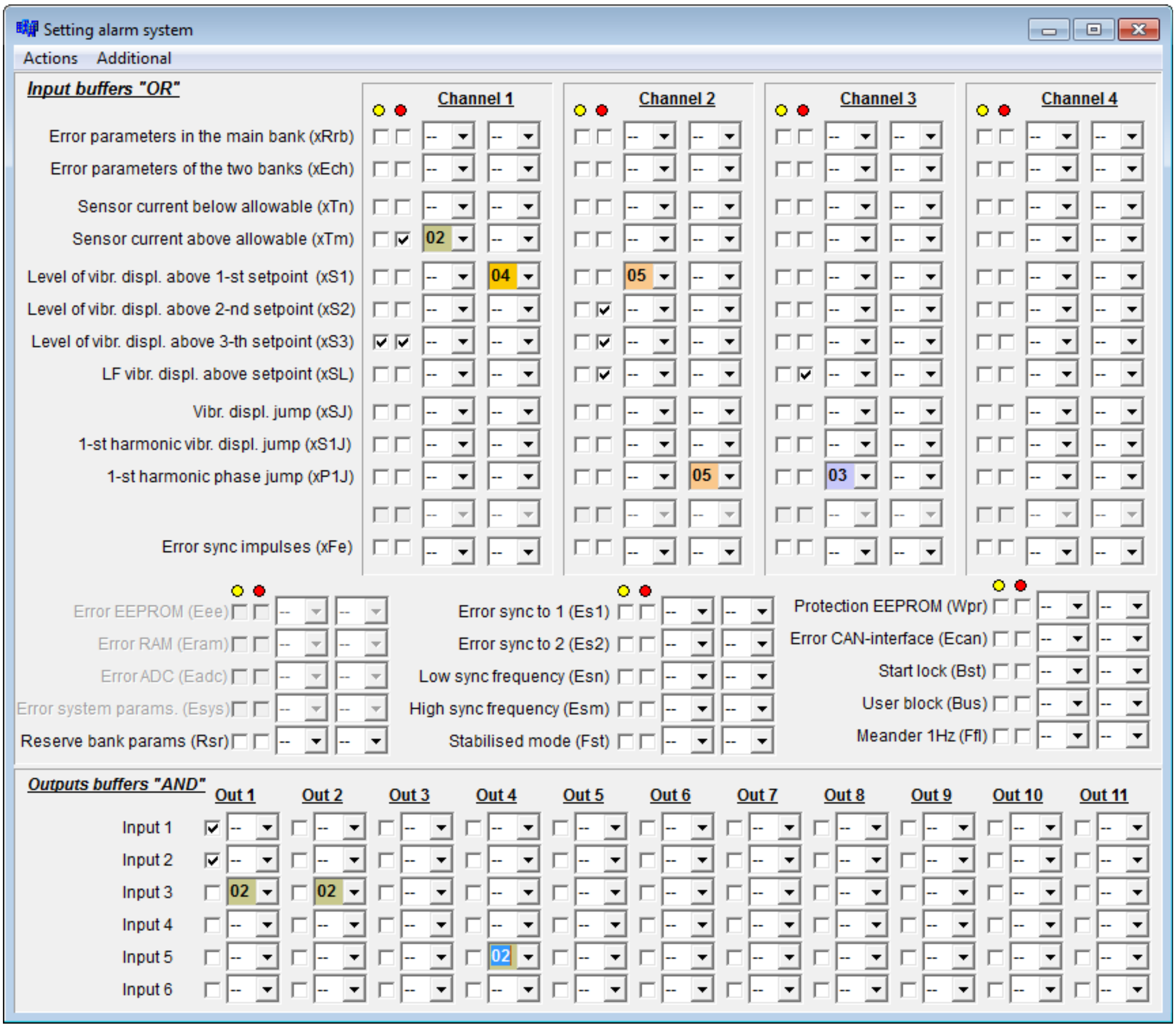


Figure 42. Module logic output setup window

For the user's convenience, assignments to similar logical groups are highlighted in the same color.

It is possible to generate the logic signaling configuration text report. To this effect it is required to select “Text signaling recording format” option in “Extras” menu. New window containing logic output setup report will appear (Figure 43).

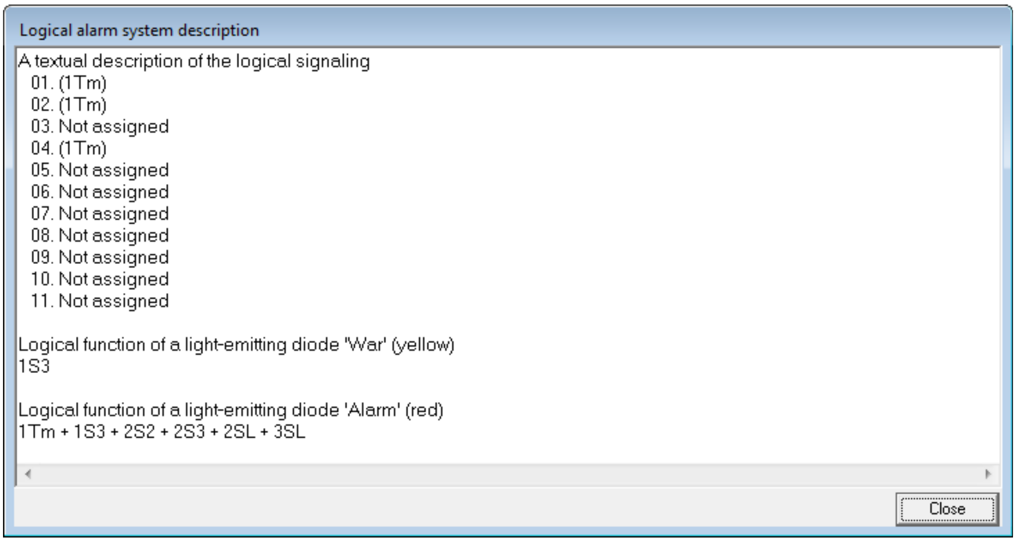


Figure 43. МК20 module logic output setting text box

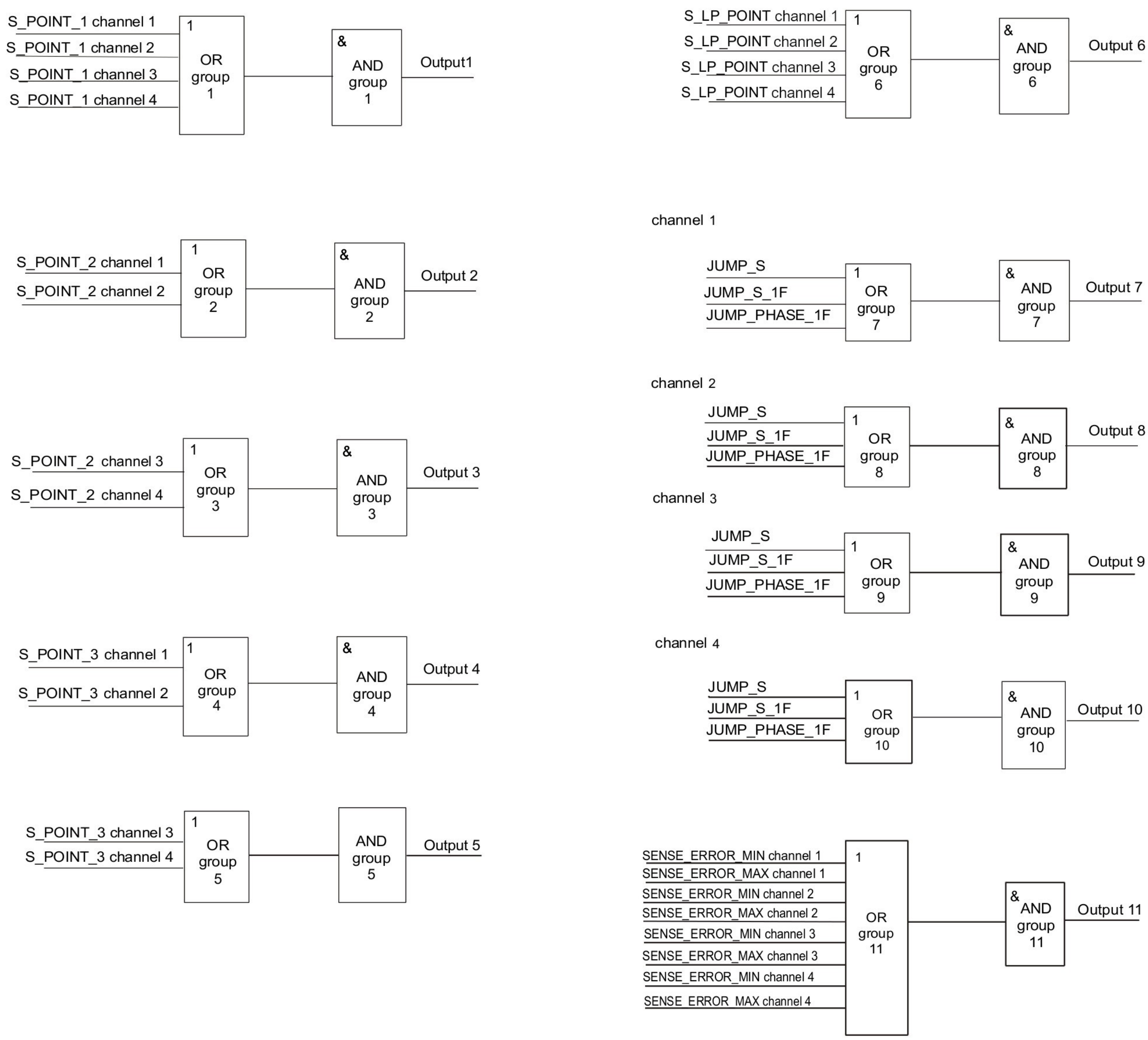


Figure 44. Logic signaling circuit for setup shown on Figure 51.

The following parameters can be set in system and communication interface configuration window (Figure 45):

- Synchronization;
- RS485 and CAN2.0B interfaces;
- Identification data (module number, year of manufacture)

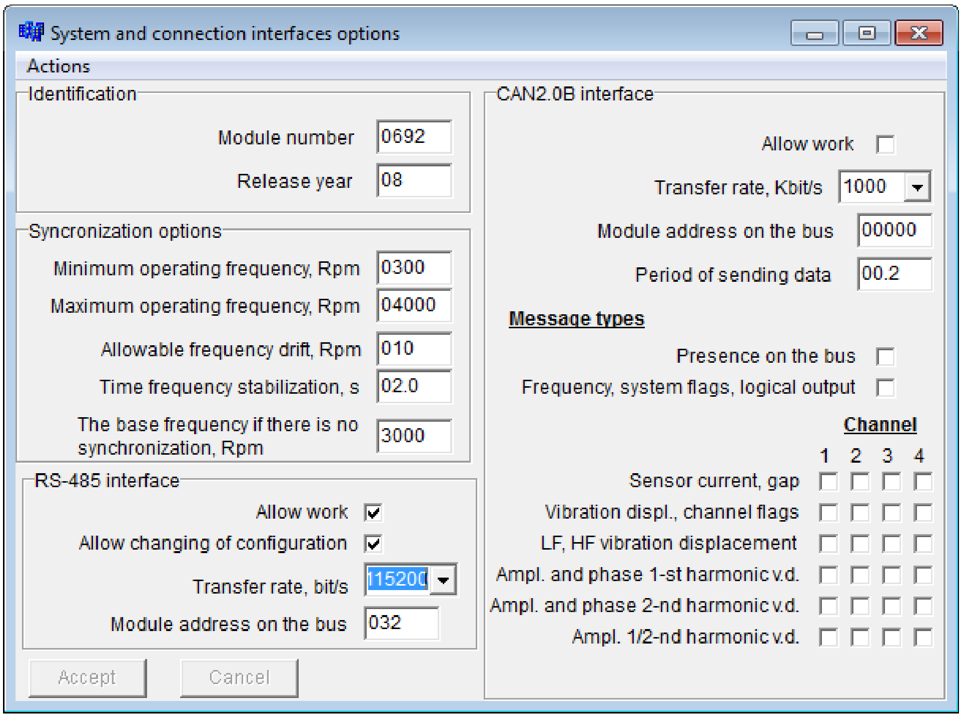
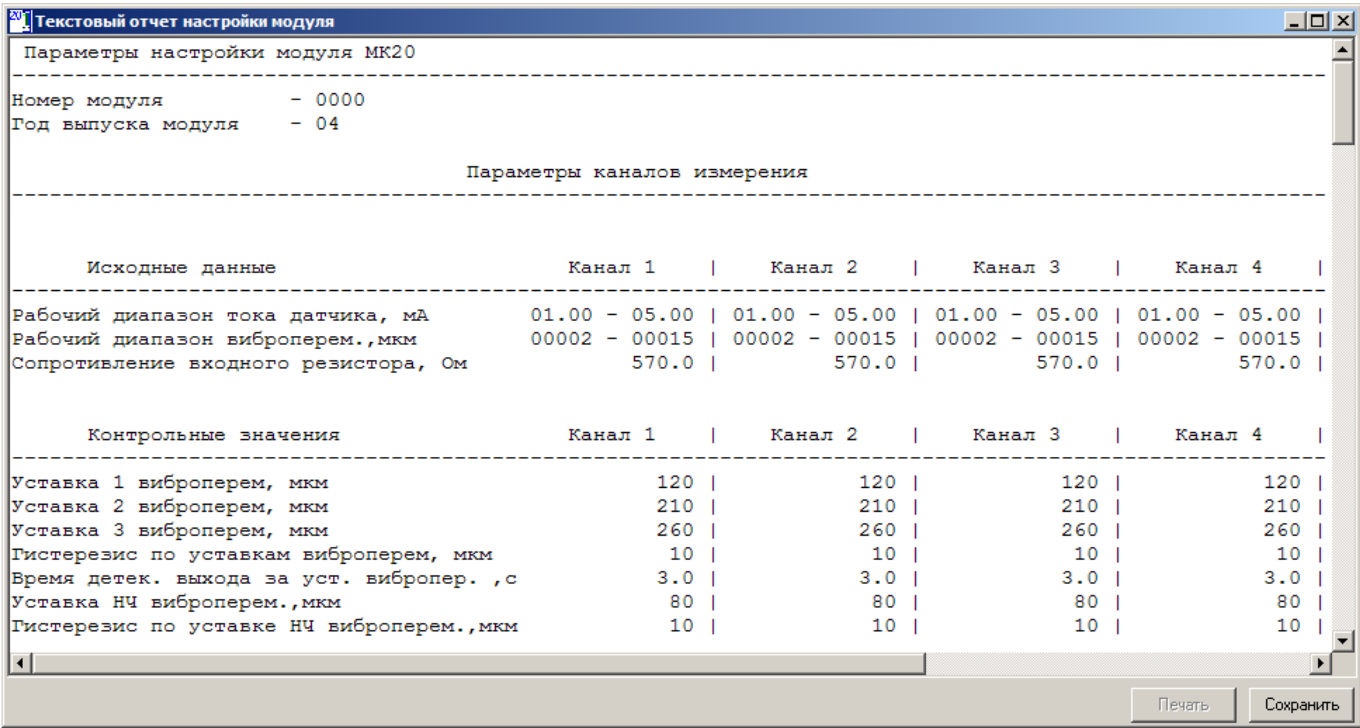


Figure 45. MK20, MK30 modules system and communication interface configuration window

There is text report generation function provided for the purpose of generating text document on the module operating parameters (Figure 46). The text report includes the entire module parameters. This text report may be used as the module passport supplementary sheet. The report text should be saved on the hard drive.



Текстовый отчет настройки модуля

Параметры настройки модуля МК20

Номер модуля - 0000
Год выпуска модуля - 04

Параметры каналов измерения

Исходные данные	Канал 1	Канал 2	Канал 3	Канал 4
Рабочий диапазон тока датчика, мА	01.00 - 05.00	01.00 - 05.00	01.00 - 05.00	01.00 - 05.00
Рабочий диапазон виброперем.,мкм	00002 - 00015	00002 - 00015	00002 - 00015	00002 - 00015
Сопротивление входного резистора, Ом	570.0	570.0	570.0	570.0

Контрольные значения	Канал 1	Канал 2	Канал 3	Канал 4
Уставка 1 виброперем, мкм	120	120	120	120
Уставка 2 виброперем, мкм	210	210	210	210
Уставка 3 виброперем, мкм	260	260	260	260
Гистерезис по уставкам виброперем, мкм	10	10	10	10
Время детек. выхода за уст. вибропер. ,с	3.0	3.0	3.0	3.0
Уставка НЧ виброперем.,мкм	80	80	80	80
Гистерезис по уставке НЧ виброперем.,мкм	10	10	10	10

Печать Сохранить

Figure 46. MK20 module setup text report window.

There is an extra option to preview the input signal oscillogram and spectrogram for MK20/MK30 software version 1.15 and higher. Figure 64 shows an example of channel 2 signal oscillogram window while the same signal spectrum is shown in Figure 65.

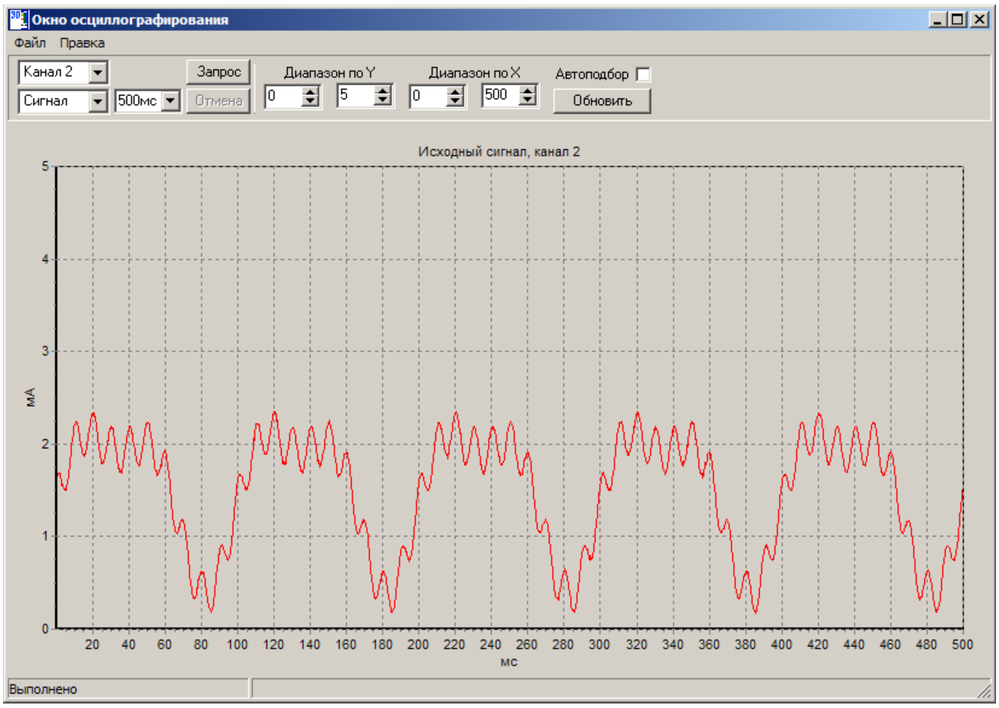


Figure 47. Oscillogram window, channel 2 signal oscillogram

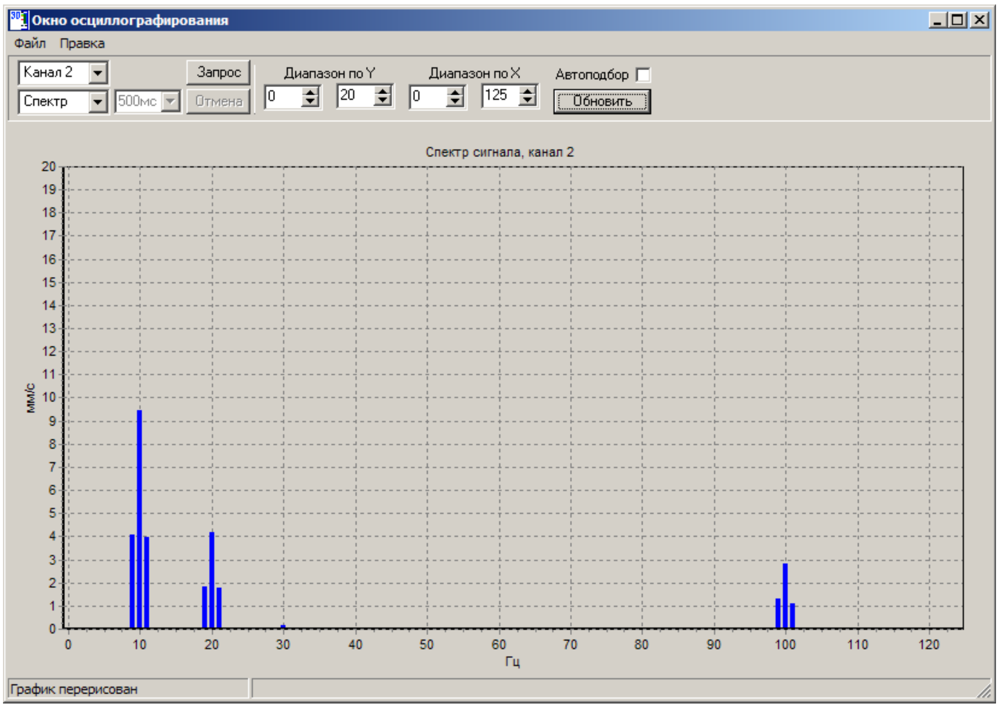


Figure 48. Oscillogram window, channel 2 signal spectrogram (set range is (0 – 125)Hz)

There is relative rotor vibration displacement and absolute support vibration displacement frequency response channels coordination window provided in MK21 setup program.

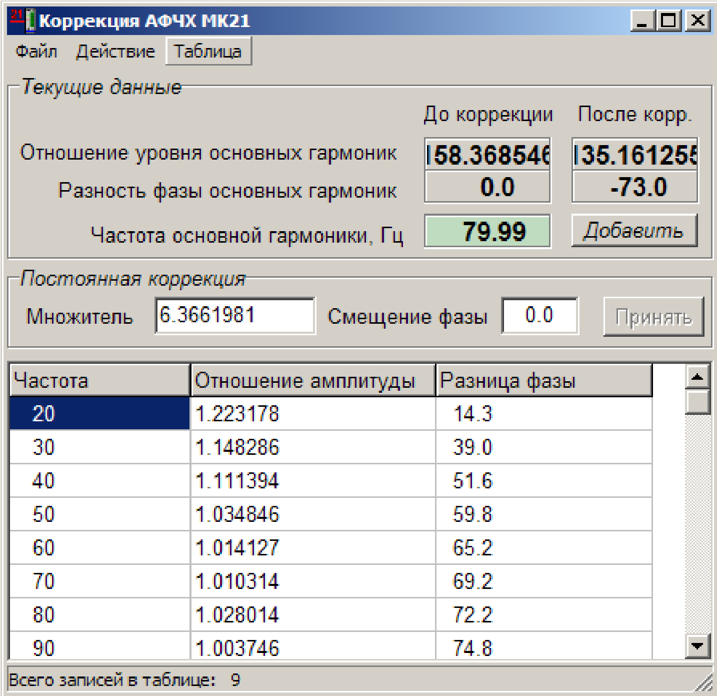


Figure 49. MK21 module frequency response correction window

The window contains all necessary tools for convenient frequency response coordination. The following actions can be executed from the window main menu:

"File" menu

- Open frequency response correction parameters for MK21 module from file;
- Save current frequency response correction parameters as a file;

"Action" menu – enabled only in case of MK21 module connection:

- Read current correction data from the module;
- Load correction data to the module (available only if logic outputs are disabled);
- Convert correction coefficients (available only if logic outputs are disabled).

"Table" menu

- Add new data to correction table;
- Delete selected line from correction table.

There is current main harmonic ratio and phase difference prior and after correction and current synchronization frequency in Hz displayed in *"Current Data"* section when connecting with the module. If no correction has been made previously, the values in *"Prior to Correction"* and *"After Correction"* fields will be identical.

Phase difference and main harmonic ratio is displayed only in case of synchronization frequency multiplicity of 1 Hz with accuracy of up to 0.05Hz. If synchronization frequency requirements are met, the frequency value field will be green and *"Add"* button will be enabled.

When amending the correction table with a frequency record, that has been already recorded, the old data will be replaced by the new one. Table records are automatically sorted in the order of correction frequency rate increasing.

"Constant Correction" section allows for entry of coefficients based on sensor parameters and their setpoints. *"Multiplier"* parameter affects the main harmonic amplitude ratio prior to correction. It should be set and transmitted to the module prior to correction calibration. *"Phase Offset"* parameter enables to consider design and mutual arrangement of sensors during their installation. This parameter does not affect *"Prior to Correction"* mismatch values.

Upon calibration completion, the correction data should be loaded to the module and *"Convert Coefficients"* command is to be executed. If calibration is correct, the main harmonic amplitudes ratio should be proximal to 1 while phase difference should be close to zero.

To save calibration parameters in the module non-volatile memory, it is required to give the relevant command from "Action" menu of the setup program main window.

When powered-up MK21 module independently calculates necessary correction coefficients based on the data saved in its non-volatile memory.

БИ24 Module

Special БИ24 setup program has friendly interface and access to all БИ24 parameters (Figure 50).

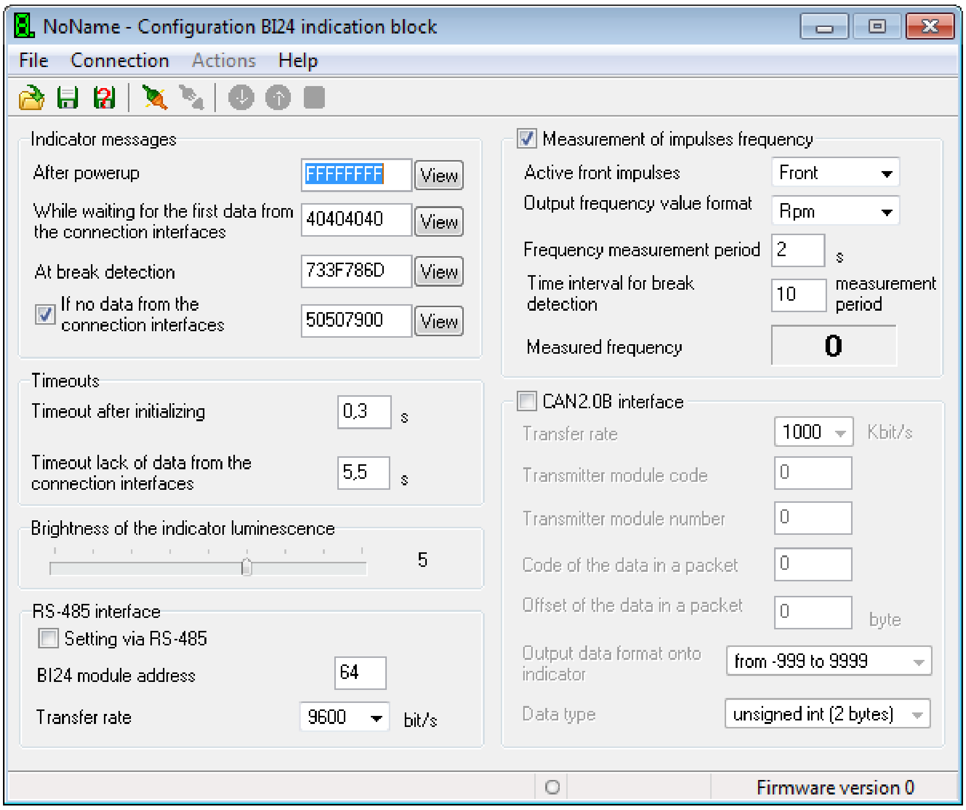


Figure 50. БИ24 setup program window

Upon successful connection, “Action” menu is enabled. “Action” menu comprises the following commands:

- “Read settings from module” – reading all settings from БИ24. In this case the current settings in the form are replaced with the ones read from БИ24.
- “Load settings to module” – settings are transferred from the form to БИ24 unit. Parameters are checked for allowable values prior to loading. In case of an error the relevant message appears and cursor is set to the error area.
- “Reset module” – БИ24 reset command is transmitted. Connection with БИ24 is preserved.
- “Save current setting” – setting loaded to БИ24 is preserved in БИ24 non-volatile memory. During saving, connection with БИ24 is preserved and БИ24 is not automatically reset upon saving completion.

Current form status may be saved as a file on the PC hard drive. Further these files may be used as templates and settings are loaded into the form upon the program new start.

The following commands are provided in “File” menu to be used when working with the form:

- “Open” – loads configuration from the file to the form. When opened file select dialog box appears and opened file validity is checked during loading. In case of an error the relevant message appears.
- “Save” – saves current form status on the local hard drive. When saving file select window appears. If selected file exists on the drive, it will be automatically updated with new data without warning. Parameters are checked for valid values prior to saving. In case of an error the relevant message appears and cursor is set to the error area.
- “New” – setting form is reset to default state.

Numerical parameters that require entry of some number have pop-up tooltips with permissible value limits. Put the cursor over the required parameter input box and the message of permissible limits will appear after a while.

Configuration of display status in case of reset, communication interface signal time out, long-term absence of data from communication interfaces and stop mode during frequency measurement is set in extra window (Figure 51).

The main form (Figure 50) displays only unchangeable hexadecimal message code. Input message can be changed by pushing “View” button near the corresponding parameter.

Figure 51. БИ24 module display status setup window

The screen shows four seven-segment displays which status corresponds to the current code.

Left-clicking the indicator segment switches the relevant segment with automatic display status code modification. Digital code can be entered manually. Click “OK” button to confirm changes and “Cancel” button to cancel changes.

To view the detailed БИ24 setup program operation manual select menu item Help->Operation Manual… or push F1 key.

Annex A. Functions of Connector terminals

This Annex specifies purpose of the main module connector terminals.

Table 43. Module МК20, МК21, МК30

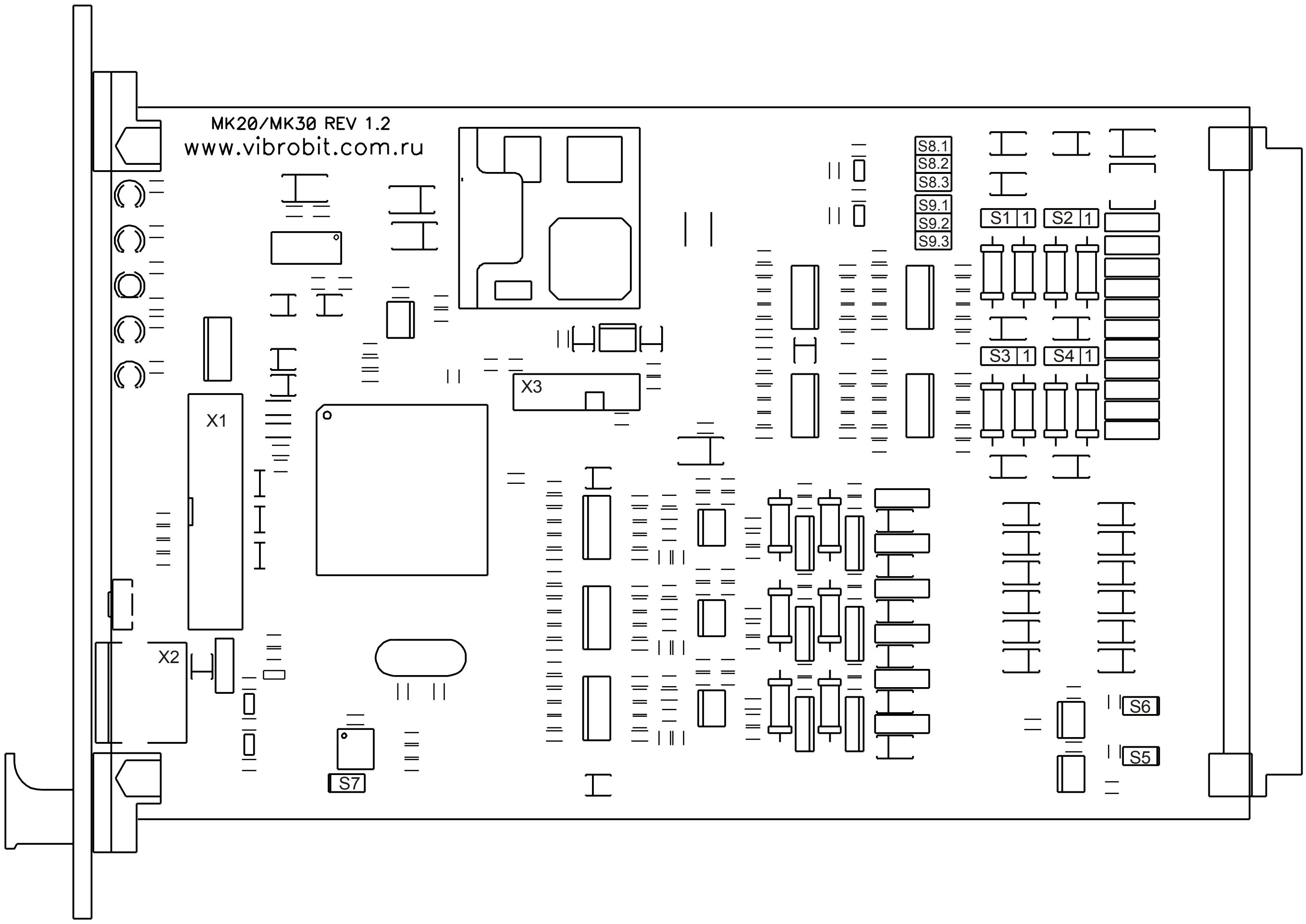
Terminal number	Designation	Purpose
A2	GND	Common
A4	GND	Common
A6	+24V	Module power supply voltage
A16	Aout 5	Analog output 5
A18	Aout 6	Analog output 6
A20	Lout 1	Logic output 1
A22	Lout 2	Logic output 2
A24	Lout 3	Logic output 3
A26	Lout 4	Logic output 4
A28	CAN GND	CAN interface common
A30	RS485 GND	RS485 interface common
A32	GND	Common
B1	GND	Common
B3	Fin 1	Main pulse input
B5	+24V	Module power supply voltage
B7	Spw 1 +24 V	Channel 1 sensor supply voltage
B9	Spw 2 +24 V	Channel 2 sensor supply voltage
B11	Spw 3 +24 V	Channel 3 sensor supply voltage
B13	Spw 4 +24 V	Channel 4 sensor supply voltage
B15	Aout 1	Analog output 1
B17	Aout 3	Analog output 3
B19	Lout 5	Logic output 5
B21	Lout 6	Logic output 6
B23	Lout 7	Logic output 7
B25	Lout 8	Logic output 8
B27	CAN H	CAN interface H connector
B29	RS485 B(-)	RS485 interface B(-) connector
B31	GND	Common
C2	GND	Common
C4	Fin 2	Reserve pulse input
C6	+24 V	Module power supply voltage
C8	Sin 1	Channel 1 input
C10	Sin 2	Channel 2 input
C12	Sin 3	Channel 3 input (not used in МК21)
C14	Sin 4	Channel 4 input (not used in МК21)
C16	Aout 2	Analog output 2
C18	Aout 4	Analog output 4
C20	Lout 9	Logic output 9
C22	Lout 10	Logic output 10
C24	Lout 11	Logic output 11
C26	Lout 12	Logic output 12
C28	CAN L	CAN interface L connector
C30	RS485 A(+)	RS485 interface A(+) connector
C32	GND	Common

Table 44. БИ24 Unit

Terminal number	Designation	Function
1	RS485-B/CAN-H	Connector B(-) RS485 / H CAN
2	RS485-A/CAN-L	Connector A(+) RS485 / L CAN
3	COUNT	Pulse input
4	GND	Common
5	+24В	Supply voltage +24V
6	GND	Power supply general
7	RS485/CAN-GND	RS485/CAN interface common

Annex B. Controls Arrangement

B.1 MK20, MK21, MK30 control modules (based on MK20/MK30 board)



S1, S2, S3, S4 jumpers – selection of measurement channel 1, 2, 3, 4 operation mode respectively

Removed	Voltage operation
1-2	(4…20)mA current operation
2-3	(1…5)mA current operation

S5 jumper – RS485 bus 120Ohm terminator

Removed	Terminator is disconnected from bus
Installed	Terminator is connected to bus

S6 jumper – CAN bus 120Ohm terminator

Removed	Terminator is disconnected from bus
Installed	Terminator is connected to bus

S7 jumper – EEPROM recording protection

Removed	Recording to EEPROM is disabled
Installed	Recording to EEPROM is enabled

S8, S9 jumpers – operation mode of pulse input 1 (main), 2 (reserve) respectively

Removed	Voltage operation
1	OK signal source, e.g. MK40 synchronization outputs
2	(4…20)mA current operation
3	(1…5)mA current operation

B.2 MK20, MK30 control modules (based on MK32 board)

X1, X2, X3, X4 jumpers – selection of measurement channel 1, 2, 3, 4 operation mode respectively

Removed	Voltage operation
1-2	(4…20)mA current operation
2-3	(1…5)mA current operation

X8 jumper – RS485 bus 120Ohm terminator

Removed	Terminator is disconnected from bus
Installed	Terminator is connected to bus

X9 jumper – CAN bus 120Ohm terminator

Removed	Terminator is disconnected from bus
Installed	Terminator is connected to bus

X10 jumper – EEPROM recording protection

Removed	Recording to EEPROM is disabled
Installed	Recording to EEPROM is enabled

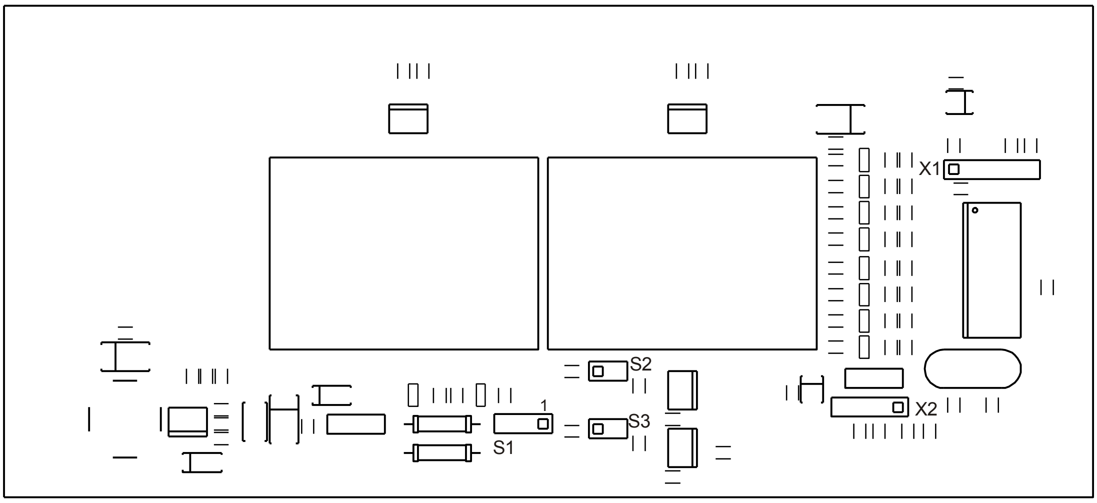
X11, X12 jumpers – source of synchronization signals 1 and 2 respectively

Removed	No synchronization source selected
1-2	Connection to measurement channel 1 (2)
2-3	Connection to X17 connector (normal mode)

X12, X14, X15 jumpers – connection of pull-up resistor to additional logic input, synchronization channels 1 and 2 respectively

Removed	Pull-up resistor is disconnected
Installed	Pull-up resistor is connected

B.3 БИ24 indication unit



S1 jumper – pulse input operation mode selection

Removed	Voltage input
1-2	Positive current pulse
2-3	Zero active level

S2 jumper – RS485 bus 120Ohm terminator

Removed	Terminator is disconnected from bus
Installed	Terminator is connected to bus

S3 jumper – CAN bus 120Ohm terminator

Removed	Terminator is disconnected from bus
Installed	Terminator is connected to bus

Annex C. Communication Interface Parameters

MK20, MK21, MK30 modules

RS485 Interface

Exchange protocol........ModBus RTU (partial implementation)
Data format........no parity bits, 2 stop bits
Pause between messages........min 3.5 bytes
Data rate........4800, 9600, 19200, 38400, 57600, 115200 bit/sec(1)
RS485 driver operation mode........semi-duplex(2)
Maximum number of nodes on the bus........256(2)
Driver input resistance, min........12kOhm(2)
Electrostatic resistance........±16kV(2)
Galvanic isolation........none(2)

Note:

1. *One of the fixed rates may be selected.*
2. *If SN65HVD11 driver is used.*

CAN2.0B Interface

Exchange protocol........unified, for operation as part of Vibrobit equipment
Message format........extended messages only
Supported data rates (kbit/sec)........1000, 500, 250, 200, 125, 100, 40(1)
Maximum number of connectable nodes........120(2)
Compliance with CAN bus standard........ISO-11898(2)
Driver input resistance, min........5kOhm(2)
Electrostatic resistance........±16kV(2)
Galvanic isolation........none(2)

Note:

1. *One of the fixed rates may be selected.*
2. *If SN65HVD235 driver is used.*

SPI Interface

Addressing format........8-bit
Maximum allowable data rate on the bus........400 kbit/sec
Format of addressing the bus setting registers........16-bit
Power supply voltage on X2 connector........5V ±0.2V
Maximum permissible consumption current in power supply circuit on X2 connector........50mA
Galvanic isolation........none

Protocol of data exchange with MK20, MK21, MK30 modules via SPI interface

SPI interface supports three control commands (Figure 52):

- Testing module presence on SPI bus;
- Reading data from module;
- Recording data to module.

Command	Control device	Module
Presence test	Module address (1 byte) 0x34	
	Presence test command (1byte) 0x80	
		Presence confirmation (1 byte) 0xD5
Reading data from module	Module address (1 byte) 0x34	
	Reading data command (1byte) 0x10	
		Presence confirmation (1 byte) 0xD5
	Address low byte	
	Address high byte	
	Number of requested data bytes	
		Data from MK30 module
Recording data to module	Module address (1 byte) 0x34	
	Recording data command (1byte) 0x40	
		Presence confirmation (1 byte) 0xD5
	Address low byte	
	Address high byte	
	Number of recorded data bytes	
	Data recorded to module	

Figure 52. Module operation protocol on SPI bus

During flow recording/reading, the internal address counter is automatically increased by 1.
Recording to non-existing registers has no effect. Reading non-existing registers gives back 0xFF value.

Annex D. Module Setup Recommendations

МК20 Module

In order to setup, the МК20 module should be connected to PC via MC01 diagnostic interface board or MC01 USB (refer to MC01 and MC01 USB description respectively). There should be mk20_setup.exe program installed on PC. It is assumed that МК20 module is serviceable and its setting corresponds to "cold start" (all parameters displayed on LCD and in setup program windows are measured in module ADC capacity).

Connect to МК20 module. To this effect in ***"Connection"*** menu select COM port to which MC01 is connected (when using MC01 USB there is a virtual COM port created in Window OS) and give ***"Connect"*** command. In case of connection error the relevant message appears. In case of normal connection МК20 module data request indicator will start blinking.

Prior to module setup it is required to read all settings from МК20, to do that select ***"Action"->"Read all settings from module".***

МК20 module setup includes:

- Calibration of measurement channels and unified output;
- Setting of measurement channel parameters;
- Setting of output logic signaling;
- Setting of communication interface parameters and serial number;
- Saving of operating parameters in the module.

Calibration of measurement channels and unified output

Calibration of measurement channels consists in calculation of five pairs of linear equation coefficients:

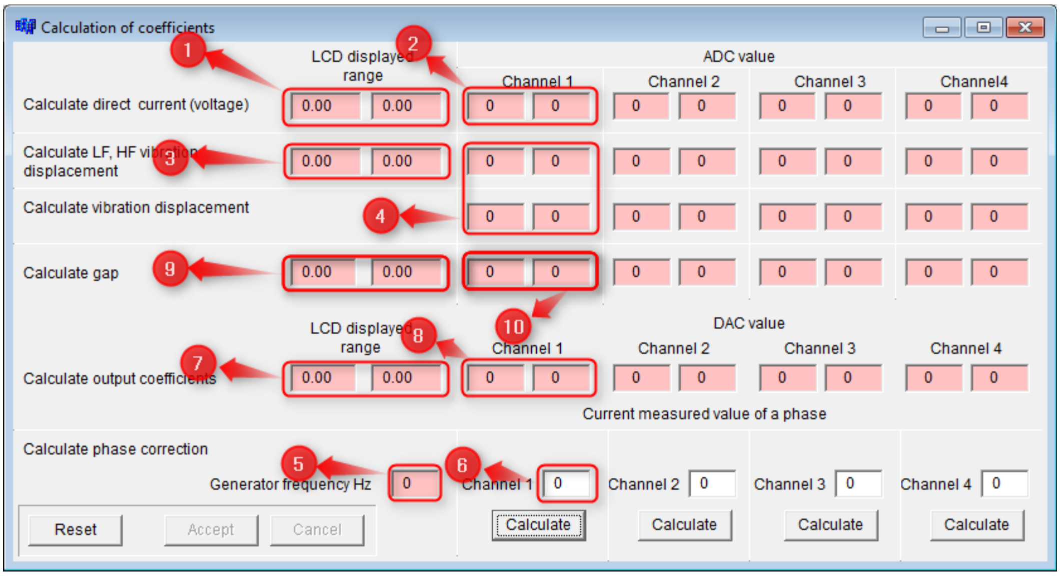
- Sensor current coefficients;
- Gap coefficients;
- Total, low frequency, high frequency and 2A vibration displacement coefficients;
- Coefficients of 2A vibration displacement rotational components;
- Unified output coefficients.

Rotational component phase measurement correction coefficient is calculated optionally.

Example of measurement channel calibration is given for ДВТ10 sensor with ИП34 converter:

Sensor output signal range, mA 1-5
Vibration displacement measurement range, mm 0-2
Vibration displacement to output current conversion coefficient, mA/mm 0.707

Open measurement channel parameters window ***"Setting->Measurement channels".*** Then open calibration window selecting ***"Calculations->Calculate parameter coefficient"*** in the measurement channel parameters setting window. Enter the desired parameter range on the left side of ***"Calculate Coefficients"*** window and ADC values when transmitting test signal – on the right side of the window.



Example of МК20 module coefficient calculation window

The first measurement channel direct current calibration sequence (calibration of the rest measurement channels is identical):

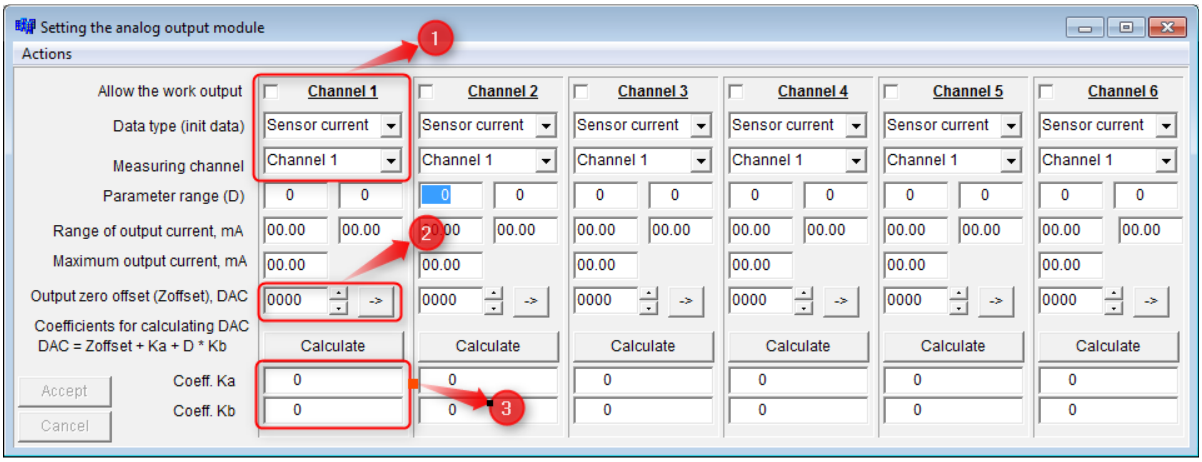
1. Connect circuit shown on Figure 22 of ВШПА.421412.300 РЭ Operation and Maintenance Manual.
2. Remove jumpers S1, S8, X1 (Annex B1, B2).
3. Disable Г generator.
4. Enter sensor range of (1-5)mA to ***“Calculate coefficients”*** box (field 1).
5. Enter gap range of (0-2000)mkm to ***“Calculate coefficients”*** box (field 9).
6. Using resistor R2 and voltmeter P2 set direct voltage of 0.56V at the measurement channel input (U = R×I = 560Ohm × 1mA = 0.56V). Enter sensor current ADC value to field 2 and field 10 (left part of the field, lower value).
7. Using resistor R2 and voltmeter P2 set direct voltage of 2.80V at the measurement channel input (U = R×I = 560Ohm × 5mA = 2.80V). Enter sensor current ADC value to field 2 and field 10 (left part of the field, lower value).
8. Push ***“Apply”*** button.

The first measurement channel alternating current calibration sequence (calibration of the rest measurement channels is identical):

1. Connect circuit shown on Figure 23 of ВШПА.421412.300 РЭ Operation and Maintenance Manual.
2. Remove jumpers S1, S8, X1 (Annex B1, B2).
3. Enter 100 and 500mkm vibration displacement values to which transmitted test signals will correspond (field 3) to ***“Calculate coefficients”*** box.
4. Using resistor R3 and voltmeter P3 set the direct component of 1.7V.
5. Set generator frequency of 80Hz.
6. Set harmonic signal RMS of 39.6V, corresponding to vibration displacement of 100 mkm (U = R×S×K = 560 Ohm ×0.1 mm × 0.707 mA/mm = 39.6 mV).
7. Enter ADC values for the following parameters (field 4, lower value):
   a. total vibration displacement 2A;
   b. 1st vibration displacement rotational component 2A.
8. Enter harmonic signal frequency of 80Hz to ***“Calculate coefficients”*** window (field 5).
9. Enter current value of the 1st vibration velocity rotational component phase (field 6).
10. Set 197.96mV harmonic signal RMS corresponding to 500mkm vibration displacement (U = R×S×K = 560Ohm ×0.5mm × 0.707mA/mm = 197.96mV).
11. Enter ADC values for the following parameters (field 4, lower value):
    a. total vibration displacement 2A;
    b. 1st vibration displacement rotational component 2A.
12. Push ***“Apply”*** button.

Note. If there are any fields highlighted in red in calculate coefficients form, such field values do not comply with certain requirements, coefficients are not calculated for these parameters and not modified in the measurement channel setup window.

To calibrate unified current outputs select “**Setting->Analog outputs”** from the main program window.

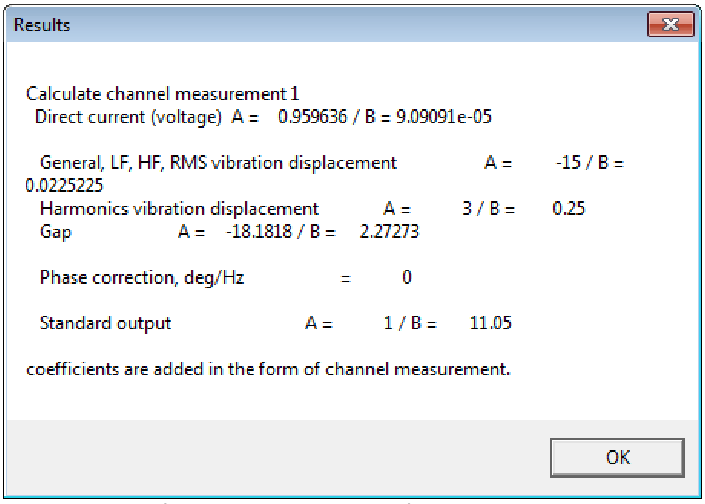


MK20 module analog output setup window

The first unified output calibration sequence (calibration of the rest unified outputs is identical):

1. Connect circuit shown on Figure 23 of ВШПА.421412.300 РЭ Operation and Maintenance Manual.
2. Disable logic outputs (***”Action->Disable logic outputs”***).
3. DAC value calculation coefficients (field 3) should be equal to zero.
4. Changing output zero offset (field 2) achieve P4 milliamperemeter readings of 4mA.
5. Enter determined DAC value to ***“Calculate coefficients”*** window (field 8, upper value).
6. Changing output zero offset (field 2) achieve P4 milliamperemeter readings of 20mA.
7. Enter determined DAC value to ***“Calculate coefficients”*** window (field 8, upper value).
8. Enable unified output, select parameter type “Total RMS”, “Channel 1”.
9. Enter unified output vibration displacement range of (0-500)mkm to ***“Calculate coefficients”*** window (field 7).
10. Push ***“Apply”*** button.

Push ***“Calculate”*** button to automatically determine design factors.

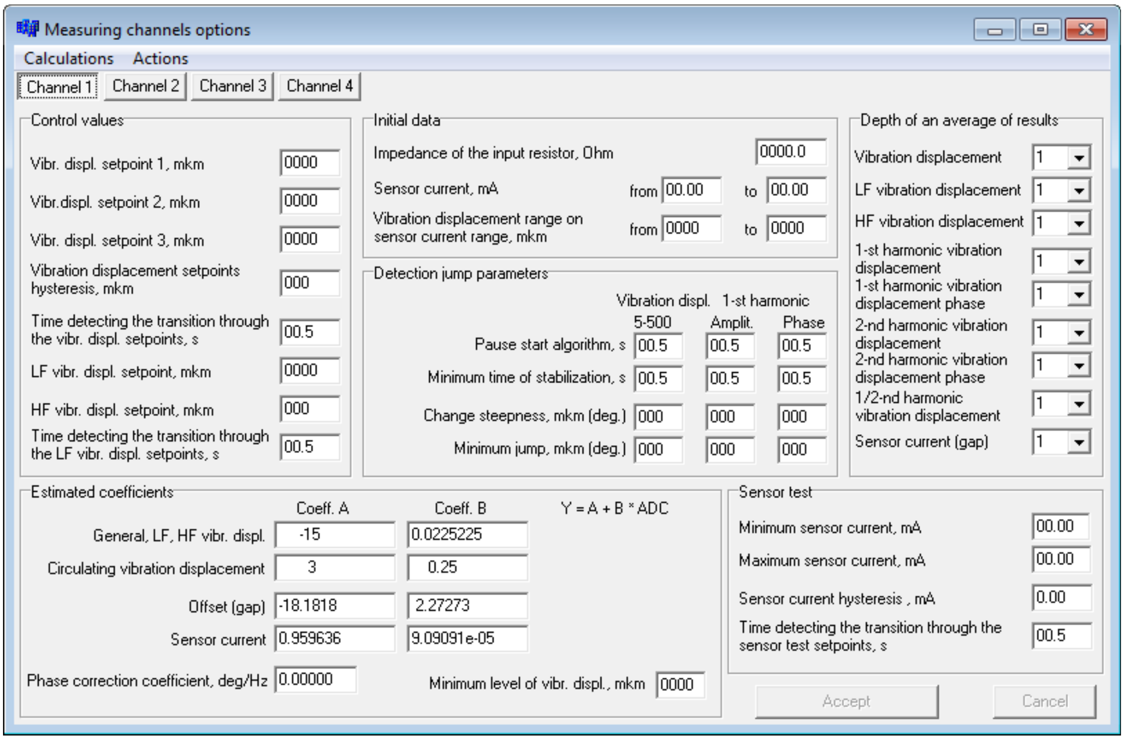


Window of MK20 module design factors calculation results

Calculated coefficients are automatically recorded to the corresponding positions of ***“Measurement channel parameters”*** window.

Setting of measurement channel parameters

Upon calibration of measurement channels it is required to check settings of each channel. Module setup form data is transferred to measurement channel setup window. If there is no data in setup form it is required to set recommended parameters by default (see below).



MK20 module measurement channel 1 setup window

The following should be set in this window:

- setpoint values and mode of the module operation controlling measurable parameter transition over the setpoints;
- 2A total vibration displacement, 2A 1st vibration displacement rotational component and 1st vibration displacement rotational component phase step detection parameters;
- Sensor test parameters;
- Averaging buffer depth for each parameter;
- Measurement channel information data.

Upon setting all the measurement channel parameters transfer data to the module selecting ***"Action->Load setting to module".***

Setting of logic signaling, communication interfaces and serial number

If logic signaling parameters are not indicated in the module setup form, they should be set in accordance with default recommended parameters.

If parameters of communication interfaces are not indicated in the module setup form, the corresponding communication interfaces should be disabled.

Open setup window of system parameters and communication interfaces (***"Setting->System settings and communication interfaces"***). Enter the module serial number and year of manufacture (two last digits of the year), then push ***"Apply"*** button.

Saving of operating parameters in the module

Prior to saving operating parameters in the module, all settings should be transferred to the module. Successively open and transfer settings from the following program windows to the module (***“Action->Load settings to module”***) checking input data validity:

- Measurement channel parameters:
    - 1st measurement channel;
    - 2nd measurement channel;
    - 3rd measurement channel;
    - 4th measurement channel.
- Analog output parameters.
- Logic signaling parameters.
- System parameters and communication interface parameters. There should be the module unique number and year of manufacture entered in system parameter window.

Save loaded parameters in the module selecting ***“Action->Save current settings in EEPROM”*** from the main program window.

Save module settings on PC hard drive as a file: ***“File->Save settings as a file”.***

Generate module setting text report: ***“File->Text report”***.

Recommended parameter values

The list of system parameters and communication interfaces

Description	Value
Logic signaling activation delay after the module reset (power-up), sec	5
Minimum allowable speed of the unit, rpm	600
Maximum allowable speed of the unit, rpm	10000
Speed tolerance in stabilization mode, rpm	10
Speed stabilization/destabilization detection time, 0.5sec	2
Base speed in absence of synchronization pulses, rpm	3000
Enable RS485 interface:	Disabled
Enable CAN interface:	Disabled

Measurement channel parameters

Description	Value
(5-500)Hz vibration displacement calculation averaging buffer depth	4
Low frequency vibration displacement calculation averaging buffer depth	4
High frequency vibration displacement calculation averaging buffer depth	4
The 1st vibration displacement rotational component calculation averaging buffer depth	4
The 1st vibration displacement rotational component phase calculation averaging buffer depth	4
The 2nd vibration displacement rotational component calculation averaging buffer depth	4
The 2nd vibration displacement rotational component phase calculation averaging buffer depth	4
Sensor current calculation averaging buffer depth	4
½ vibration displacement rotational component calculation averaging buffer depth	4
First (5-500)Hz vibration displacement setpoint, mkm	120
Second (5-500)Hz vibration displacement setpoint, mkm	165
Third (5-500)Hz vibration displacement setpoint, mkm	260
Hysteresis for (5-500)Hz vibration displacement setpoints, mkm	10
Time of response to vibration displacement value transition over 0.5sec setpoints	1
Low frequency vibration displacement setpoint, mkm	100
Hysteresis for low frequency vibration displacement setpoint, mkm	10
Time of response to low frequency vibration displacement value transition over 0.5sec setpoints	1
Minimum allowable sensor current, mA	1.25
Maximum allowable sensor current, mA	4.75
Hysteresis for sensor current setpoints, mA	0.1
Time of response to sensor current value transition over 0.5sec setpoints	1
Minimum vibration displacement rotational component for rotational component phase calculation, mkm	10
Time after algorithm reset prior to vibration displacement 0.5sec step detection	10
Vibration displacement value stabilization time out for 0.5sec step level calculation	10
Vibration displacement value variation within 0.5sec	4
Minimum vibration displacement value step to enable signaling	40
Time after algorithm reset prior to the 1st vibration displacement rotational component 0.5sec step detection	10
The 1st vibration displacement rotational component stabilization time out for 0.5sec step level calculation	10
The 1st vibration displacement rotational component value variation within 0.5sec	4
Minimum step level of the 1st vibration displacement rotational component value to enable signaling	40
Time after algorithm reset prior to the 1st vibration displacement rotational component phase step detection, 0.5 sec	10
The 1st vibration displacement rotational component phase stabilization time out for 0.5sec step level calculation	10
The 1st vibration displacement rotational component phase variation within 0.5sec	4
Minimum step of the 1st vibration displacement rotational component phase to enable signaling	40
Resistance of resistor transforming voltage into current, Ohm	560
Minimum sensor current range, mA	1
Maximum sensor current range, mA	5
Minimum vibration displacement range, mkm	0
Maximum vibration displacement range, mkm (variants)	250 500 1000 2000

Logic signaling parameters

Output No.	Logic formula
1.	(1Se1 + 2Se1 + 3Se1 + 4Se1)
2.	(1Se2 + 2Se2)
3.	(3Se2 + 4Se2)
4.	(1Se3 + 2Se3)
5.	(3Se3 + 4Se3)
6.	(1SeL + 2SeL + 3SeL + 4SeL)
7.	(1SeJ + 1S1J + 1P1J)
8.	(2SeJ + 2S1J + 2P1J)
9.	(3SeJ + 3S1J + 3P1J)
10.	(4SeJ + 4S1J + 4P1J)
11.	(1Tn + 1Tm + 2Tn + 2Tm + 3Tn + 3Tm + 4Tn + 4Tm)

Signaling codes designation:

Codes for measurement channels (enter the channel number instead of 'x'):

xRrb – error of reading parameters from the main section
xEch – error of reading parameters
xTn – low sensor current
xTm – high sensor current
xSe1 – 1st setpoint overrange
xSe2 – 2nd setpoint overrange
xSe3 – 3rd setpoint overrange
xSeL – low frequency vibration displacement setpoint overrange
xSeJ – total level step
xS1J – 1st rotational component RMS step
xP1J – 1st rotational component phase step

System codes:

Rsr – reading parameters from reserve section
Es1 – pulse synchronization error, input 1
Es2 – pulse synchronization error, input 2
Esn – low pulse synchronization frequency
Esm – high pulse synchronization frequency
Fst – stabilized operation mode
Wpr – setting memory recording protection
Ecan – CAN interface initialization error
Ffl – 1Hz square wave

Operations:

'()' – OR group dropping
'+' – logic OR operation
'&' – logic AND operation between OR groups
'!' – OR group inversion

Example:

(1VL + 2VL + 3VL + 4VL) & (Fst) — Alarm of low frequency setpoint overrange on one of the measurement channels in stabilized operation mode

Front panel signal LED operation

LED	Logic formula
War	(1Se1 + 2Se1 + 3Se1 + 4Se1) + (1SeL + 2SeL + 3SeL + 4SeL)
Alarm	(1Se3 + 2Se3 + 3Se3 + 4Se3) + (1SeJ + 1S1J + 1P1J)+(2SeJ + 2S1J + 2P1J)+(3SeJ + 3S1J + 3P1J)+(4SeJ + 4S1J + 4P1J)

Note: for signaling codes it is permitted to use logic OR operation only.

MK30 Module

In order to setup, the MK30 the module should be connected to PC via MC01 diagnostic interface board or MC01 USB (refer to MC01 and MC01 USB description respectively). There should be mk30_setup.exe program loaded on PC. It is assumed that MK30 is serviceable and its setting corresponds to "cold start" (all parameters displayed on LCD and in setup program windows are measured in ADC capacity).

Connect to MK30 module. To this effect in ***"Connection"*** menu select COM port to which MC01 is connected (when using MC01 USB there is virtual COM port created in Window OS) and give ***"Connect"*** command. In case of connection error, the relevant message appears. In case of normal connection, MK30 module data request indicator will start blinking.

Prior to module setup it is required to read all settings from MK30, to do that select ***"Action"->"Read all settings from module".***

MK30 module setup includes:

- Calibration of measurement channels and unified output;
- Setting of measurement channel parameters;
- Setting of output logic signaling;
- Setting of communication interface parameters and serial number;
- Saving operating parameters in the module.

Calibration of measurement channels and unified output

Calibration of measurement channels consists in calculation of four pairs of linear equation coefficients:

- Sensor current coefficients;
- Gap coefficients;
- Total, low frequency, high frequency vibration velocity RMS coefficients;
- Coefficients of vibration velocity RMS rotational components;
- Vibration velocity peak-to-peak excursion coefficients.

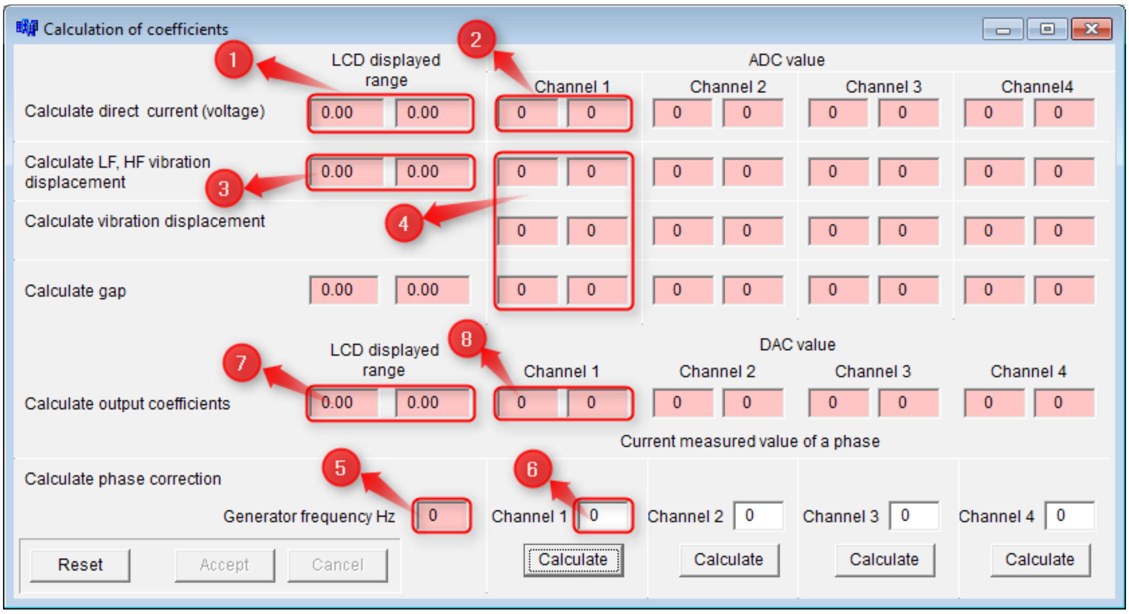
Rotational component phase measurement correction coefficient is calculated optionally.

Example of measurement channel calibration is given for ДПЭ22МВ sensor:

Sensor output signal range, mA 1-5
Vibration displacement measurement range, mm/s 0-15
Vibration velocity to output current conversion factor, mAxc/mm 0.05

Open measurement channel parameters window ***"Setting->Measurement channels".*** Then open calibration window selecting ***"Calculations->Calculate parameter coefficient"*** in the measurement channel parameters setting window. Enter the desired parameter range on the left side of ***"Calculate Coefficients"*** window and ADC values when transmitting test signal – on the right side of the window.

> ***Note.*** ADC value is presented in ##.## format (point between two digits) for all MK30 module measurable parameters. Point should not be considered when recording ADC values. E.g. ADC value `38.22` displayed on LCD should be read as `3822`.



Example of MK30 module coefficient calculation window

The first measurement channel direct current calibration sequence (calibration of the rest measurement channels is identical):

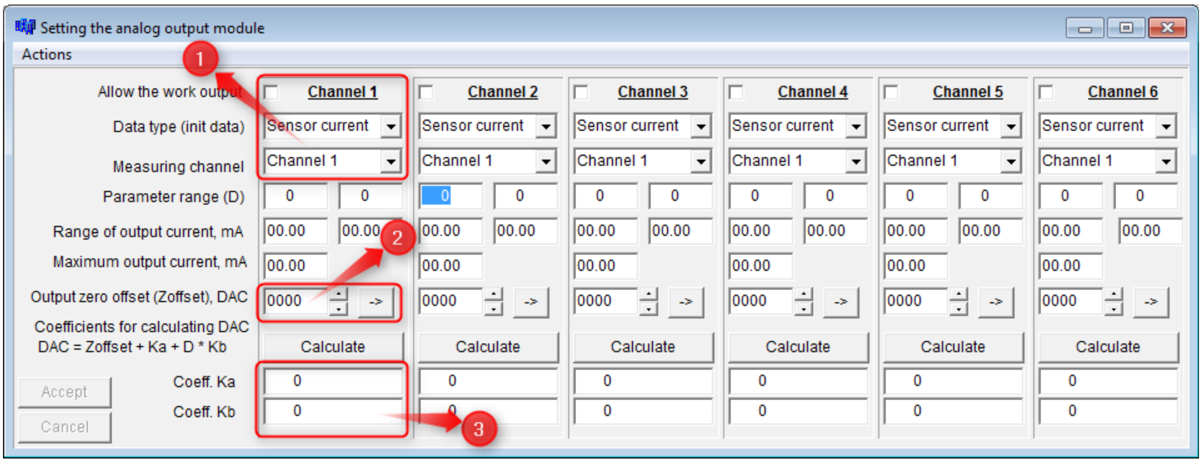
1. Connect circuit shown on Figure 22 of ВШПА.421412.300 РЭ Operation and Maintenance Manual.
2. Remove jumpers S1, S8, X1 (Annex B1, B2).
3. Disable Г generator.
4. Enter sensor range of (1-5)mA to ***"Calculate coefficients"*** window (field 1).
5. Using resistor R2 and voltmeter P2 set direct voltage of 0.56V at the measurement channel input (U = R×I = 560Ohm × 1mA = 0.56V). Enter ADC value (sensor current) to field 2 (left part of the field, lower value).
6. Using resistor R2 and voltmeter P2 set direct voltage of 2.80V at the measurement channel input (U = R×I = 560Ohm × 5mA = 2.80V). Enter ADC value (sensor current) to field 2 (left part of the field, lower value).
7. Push ***"Apply"*** button.

The first measurement channel alternating current calibration sequence (calibration of the rest measurement channels is identical):

1. Connect circuit shown on Figure 23 of ВШПА.421412.300 РЭ Operation and Maintenance Manual.
2. Remove jumpers S1, S8, X1 (Annex B1, B2).
3. Enter 3 and 15mm/s vibration velocity RMS to which transmitted test signals will correspond (field 3) to ***"Calculate coefficients"*** window. Vibration velocity peak-to-peak excursion is calculated automatically after pushing ***"Apply"*** button.
4. Using resistor R3 and voltmeter P3 set the direct component of 1.7V.
5. Set generator frequency of 80Hz.
6. Set 84mV harmonic signal RMS corresponding to 3mm/s vibration velocity (U = R×V×K = 560Ohm ×3mm/s × 0.05mA × s/mm = 84mV).
7. Enter ADC values for the following parameters (field 4, lower value):
   a. total vibration velocity RMS;
   b. 1st vibration velocity rotational component RMS;
   c. vibration velocity peak-to-peak excursion.
8. Enter harmonic signal frequency 80Hz to ***"Calculate coefficients"*** window (field 5).
9. Enter current value of the 1st vibration velocity rotational component phase (field 6).
10. Set 420mV harmonic signal RMS corresponding to 15mm/s vibration velocity (U = R×V×K = 560Ohm ×15mm/s × 0.05mA × s/mm = 420mV).
11. Enter ADC values for the following parameters (field 4, lower value):
    a. total vibration velocity RMS;
    b. 1st vibration velocity rotational component RMS;
    c. vibration velocity peak-to-peak excursion.
12. Push ***"Apply"*** button.

Note. If there are any fields highlighted in red in calculate coefficients form, such field values do not comply with certain requirements, coefficients are not calculated for these parameters and not modified in the measurement channel setup window.

To calibrate unified current outputs select "**Setting->Analog outputs"** from the main program window.

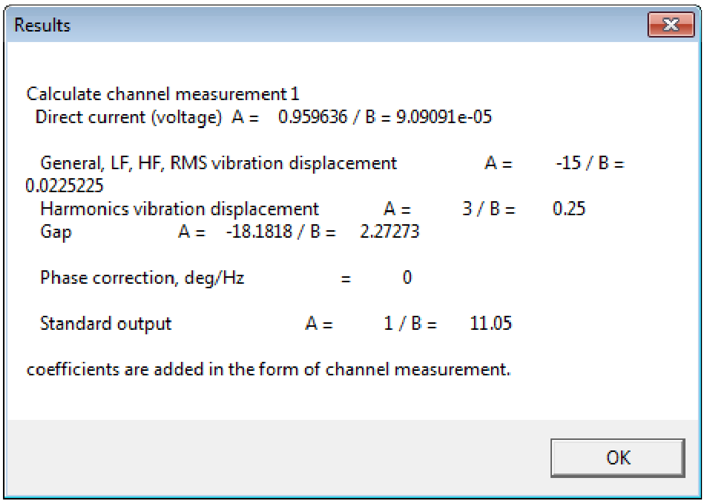


MK30 module analog output setup window

The first unified output calibration sequence (calibration of the rest unified outputs is identical):

1. Connect circuit shown on Figure 23 of ВШПА.421412.300 РЭ Operation and Maintenance Manual.
2. Disable logic outputs (***"Action->Disable logic outputs"***).
3. DAC value calculation coefficients (field 3) should be equal to zero.
4. Changing output zero offset (field 2) achieve P4 milliamperemeter readings of 4mA.
5. Enter determined DAC value to ***"Calculate coefficients"*** window (field 8, lower value).
6. Changing output zero offset (field 2) achieve P4 milliamperemeter readings of 20mA.
7. Enter determined DAC value to ***"Calculate coefficients"*** window (field 8, upper value).
8. Enable unified output, select parameter type "Total RMS", "Channel 1".
9. Enter unified output vibration velocity RMS of (0-15) mm/s to ***"Calculate coefficients"*** window (field 7).
10. Push ***"Apply"*** button.

Push ***"Calculate"*** button to automatically determine design factors.

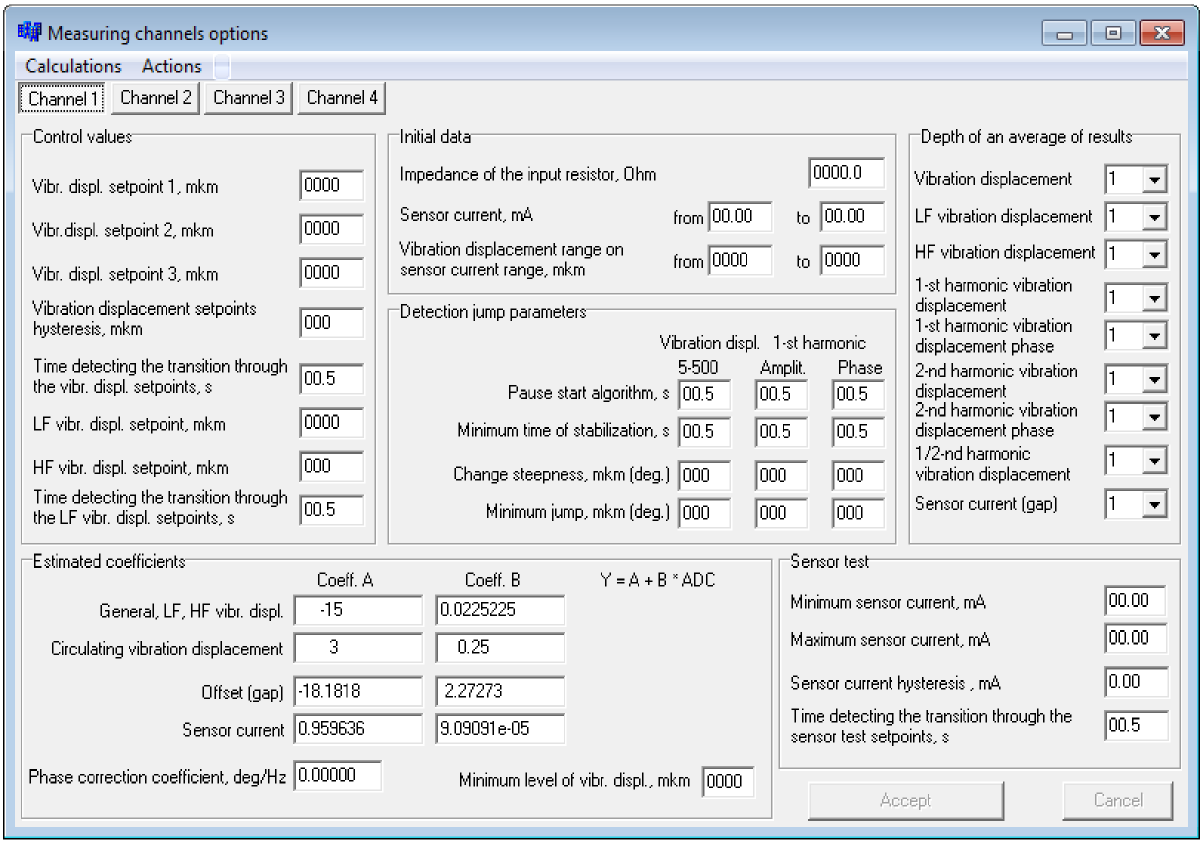


Window of MK30 module design factors calculation results

Calculated coefficients are automatically recorded to the corresponding positions of ***"Measurement channel parameters"*** window

Setting of measurement channel parameters

Upon calibration of measurement channels, it is required to check settings of each channel. Module setup form data is transferred to measurement channel setup window. If there is no data in setup form it is required to set recommended parameters by default (see below).



MK30 module measurement channel 1 parameter setup window

The following should be set in this window:

- Setpoint values and mode of the module operation controlling measurable parameter transition over the setpoints;
- Total RMS, 1st vibration velocity rotational component RMS and 1st vibration velocity rotational component phase step detection parameters;
- Sensor test parameters;
- Averaging buffer depth for each parameter;
- Measurement channel information data.

Upon setting all the measurement channel parameters, transfer data to the module selecting ***“Action->Load setting to module”.***

Setting of logic signaling, communication interfaces and serial number

If logic signaling parameters are not indicated in the module setup form, they should be set in accordance with default recommended parameters.

If parameters of communication interfaces are not indicated in the module setup form, the corresponding communication interfaces should be disabled.

Open setup window of system parameters and communication interfaces (***“Setting->System settings and communication interfaces”***). Enter the module serial number and year of manufacture (two last digits of the year), then push ***“Apply”*** button.

Saving of operating parameters in the module

Prior to saving operating parameters in the module, all settings should be transferred to the module. Successively open and transfer settings from the following program windows to the module (***"Action->Load settings to module"***) checking input data validity:

- Measurement channel parameters:
    - 1st measurement channel;
    - 2nd measurement channel;
    - 3rd measurement channel;
    - 4th measurement channel.
- Analog output parameters.
- Logic signaling parameters.
- System parameters and communication interface parameters. There should be the module unique number and year of manufacture entered in system parameter window.

Save loaded parameters in the module selecting ***"Action->Save current settings in EEPROM"*** from the main program window.

Save module settings on PC hard drive as a file: ***"File->Save settings as a file".***

Generate module setting text report: ***"File->Text report".***

Recommended parameter values

The list of system parameters and communication interfaces

Description	Value
Logic signaling activation delay after the module reset (power-up), sec	5
Minimum allowable speed of the unit, rpm	600
Maximum allowable speed of the unit, rpm	10000
Speed tolerance in stabilization mode, rpm	10
Speed stabilization/destabilization detection time, 0.5sec	2
Base speed in absence of synchronization pulses, rpm	3000
Enable RS485 interface:	Disabled
Enable CAN interface:	Disabled

Measurement channel parameters

Description	Value
Total vibration velocity RMS calculation averaging buffer depth	4
Low frequency vibration velocity RMS calculation averaging buffer depth	4
High frequency vibration velocity RMS calculation averaging buffer depth	4
The 1st vibration velocity RMS rotational component calculation averaging buffer depth	4
The 1st vibration velocity rotational component phase calculation averaging buffer depth	4
The 2nd vibration velocity RMS rotational component calculation averaging buffer depth	4
The 2nd vibration velocity rotational component phase calculation averaging buffer depth	4
Sensor current calculation averaging buffer depth	4
Vibration velocity peak-to-peak excursion calculation averaging buffer depth	4
Minimum spectral component amplitude square in ADC dimension	400
First total vibration velocity RMS setpoint, mm/s	4.5
Second total vibration velocity RMS setpoint, mm/s	7.1
Third total vibration velocity RMS setpoint, mm/s	11.2
Hysteresis for total vibration velocity RMS setpoints, mk/s	0.1
Low frequency vibration velocity RMS setpoint, mm/s	0.5
Hysteresis for low frequency vibration velocity RMS setpoints, mm/s	0.05
Minimum allowable sensor direct current, mA	2
Maximum allowable sensor direct current, mA	4
Hysteresis for sensor current setpoints, mA	0.1
Minimum vibration velocity rotational component RMS for rotational component phase calculation, mm/s	0.5
Minimum total vibration velocity RMS for signal form factor calculation, mm/s	1
Time of response to total vibration velocity RMS transition over 0.5sec setpoints	1
Time of response to low frequency vibration velocity RMS transition over 0.5sec setpoints	1
Time of response to sensor current value transition over 0.5sec setpoints	1
Constant rotational component phase correction, degrees	0
Time after algorithm reset prior to total vibration velocity RMS 0.5sec step detection	10
Total vibration velocity RMS stabilization time out for 0.5sec step detection	10
Total vibration velocity RMS variation within 0.5sec, mm/s	0.1
Minimum total vibration velocity RMS step to enable signaling, mm/s	1
Time after algorithm reset prior to the 1st vibration velocity RMS rotational component 0.5sec step detection	10
The 1st vibration velocity RMS rotational component stabilization time out for 0.5sec step calculation	10
The 1st vibration velocity RMS rotational component variation within 0.5sec, mm/s	0.1
Minimum step of the 1st vibration velocity RMS rotational component to enable signaling, mm/s	1
Time after algorithm reset prior to the 1st vibration velocity rotational component 0.5sec step detection	10
The 1st vibration velocity rotational component phase stabilization time out for 0.5sec step calculation	10
The 1st vibration velocity rotational component variation within 0.5sec, mm/s	4
Minimum step of the 1st vibration velocity rotational component phase to enable signaling, mm/s	40
Resistance of resistor transforming voltage into current, Ohm	560
Minimum sensor current range, mA	1
Maximum sensor current range, mA	5
Minimum vibration velocity RMS range, mm/s	0
Maximum vibration velocity RMS range, mm/s (variants)	15 20 30

Logic signaling parameters

Output No.	Logic formula
1.	(1Ve1 + 2Ve1 + 3Ve1)
2.	(1Ve2)
3.	(1Ve3)
4.	(2Ve2)
5.	(2Ve3)
6.	(3Ve2)
7.	(3Ve3)
8.	(1VeL + 2VeL + 3VeL)
9.	(1VeJ + 1V1J + 1P1J) + (2VeJ + 2V1J + 2P1J) + (3VeJ + 3V1J + 3P1J)
10.	(4VeS + 4Ve2)
11.	(1Tn + 1Tm + 2Tn + 2Tm + 3Tn + 3Tm + 4Tn + 4Tm)

Signaling codes designation:

Codes for measurement channels (enter the channel number instead of ‘x’):

xRrb – error of reading parameters from the main section
xEch – error of reading parameters
xTn – low sensor current
xTm – high sensor current
xVe1 – 1st total RMS setpoint overrange
xVe2 – 2nd total RMS setpoint overrange
xVe3 – 3rd total RMS setpoint overrange
xVeL – low frequency RMS setpoint overrange
xVeJ – total RMS step
xV1J – 1st rotational component RMS step
xP1J – 1st rotational component phase step
xVes – low RMS

System codes:

Rsr – reading parameters from reserve section
Es1 – pulse synchronization error, input 1
Es2 – pulse synchronization error, input 2
Esn – low pulse synchronization frequency
Esm – high pulse synchronization frequency
Fst – stabilized operation mode
Wpr – setting memory recording protection
Ecan – CAN interface initialization failure
Ffl – 1Hz square wave

Operations:

‘()’ – OR group dropping
‘+’ – logic OR operation
‘&’ – logic AND operation between OR groups
‘!’ – OR group inversion

Example:

(1VL + 2VL + 3VL + 4VL) & (Fst)
Signaling of low frequency setpoint overrange on one of the measurement channels in stabilized operation mode

Front panel signal LED operation mode

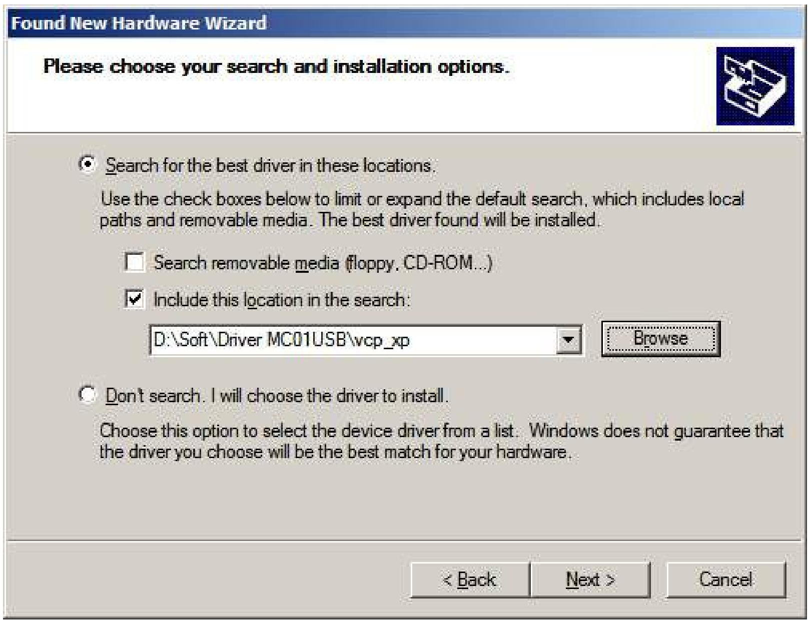
LED	Logic formula
War	(1Ve1 + 2Ve1 + 3Ve1) + (1VeL + 2VeL + 3VeL)
Alarm	(1Ve3 + 2Ve3 + 3Ve3) + (1VeJ + 1V1J + 1P1J) + (2VeJ + 2V1J + 2P1J) + (3VeJ + 3V1J + 3P1J)

Note: for signaling codes it is allowed to use logic OR operation only.

Annex E. MC01 USB Driver Installation on Windows XP PC

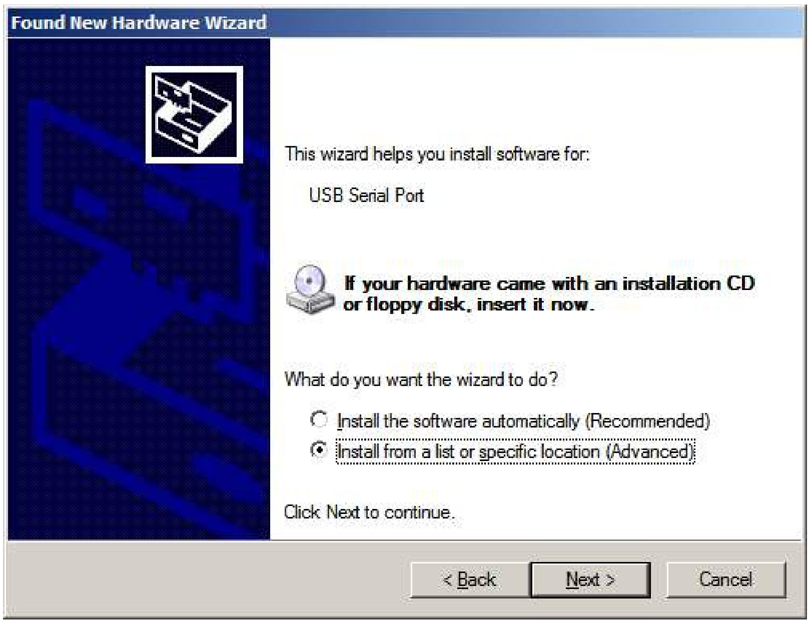
When connecting MC01 USB to PC via USB port, the operating system will detect new devices on USB bus and offer to install the software for it. MC01 USB drivers are included in the software set supplied with Vibrobit 300 equipment. For contents, purpose and location of documents and programs on CD-disk, refer to readme.txt file of Vibrobit 300 software CD.

Choose “Install from a list or specific location” and click “Next” button. The window appears where you should specify the path to the folder containing MC01 USB drivers.

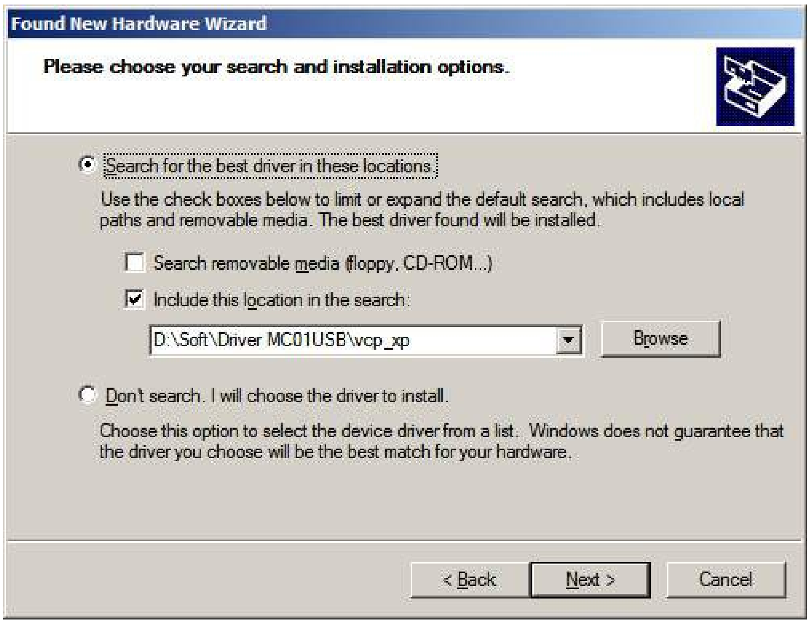


Select “Include this location in the search”, click “Browse” button to specify the path to MC01 USB driver. Then click “Next” button.

Windows XP OS will install the required USB Serial Converter drivers. Upon completion push “Finish” button.
Then virtual COM port drivers will be installed. The window informing of driver installation necessity will appear.



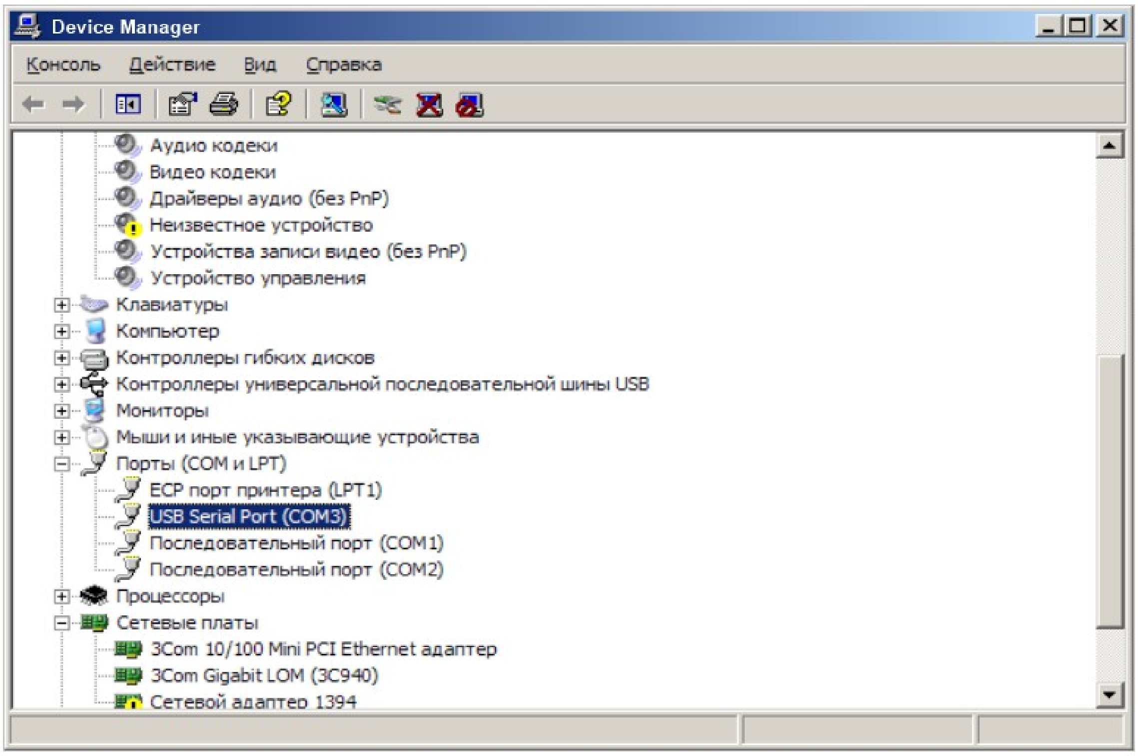
Select “Include this location in the search”, click “Browse” button to specify the path to MC01 USB drivers. Then click “Next” button.



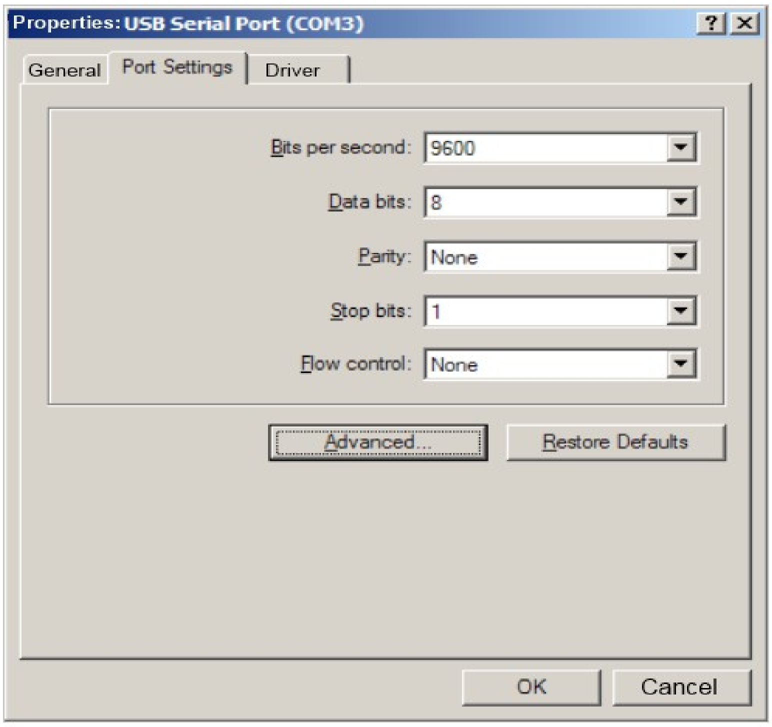
Select “Include this location in the search”, click “Browse” button to specify the path to MC01 USB drivers. Then click “Next” button.

The required files will be copied and OS will be setup for virtual COM port operation. Click “Finish” button upon completion.

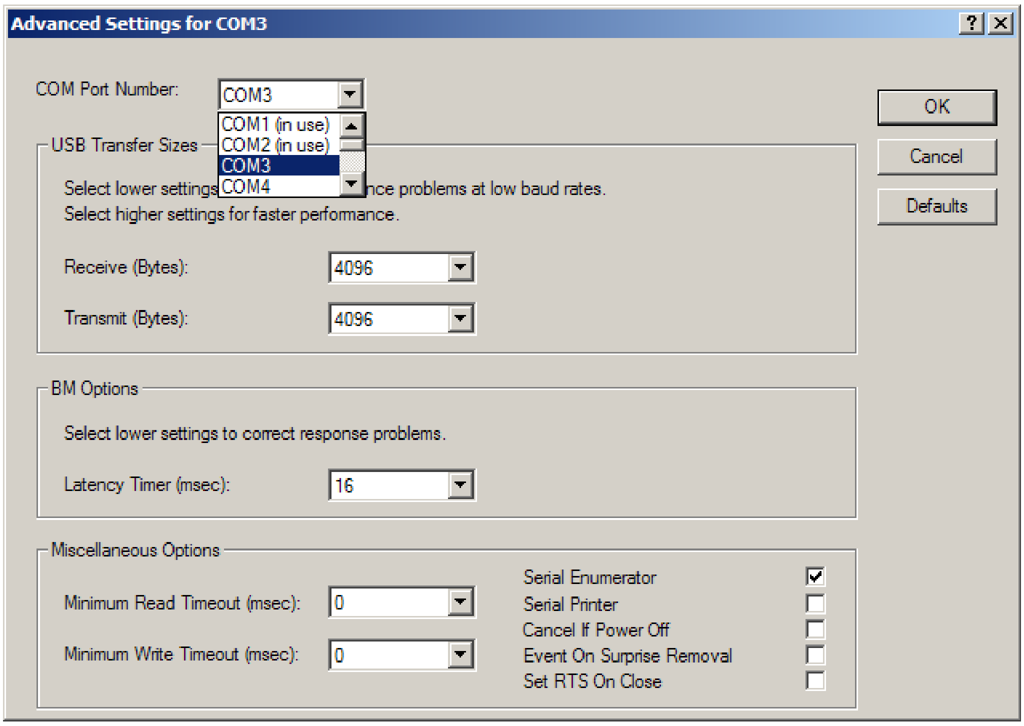
Vibrobit 300 software operates with COM ports with numbers from 1 to 4. It is necessary to make sure which number is occupied by virtual COM port. Open Windows OS device manager window (Control panel->System->Equipment).



Virtual COM port should be in the list of devices “Ports (COM and LPT)”. Open USB Serial Port properties.



Select ‘Port Settings’ tab and push “Advanced…” button. Advanced settings window will appear.



In ‘COM Port Number:’ select the desired free port number from COM1 to COM4, click “OK” button. Close all windows.

Usually installation of MC01 USB drivers does not require rebooting PC.

MC01 USB driver installation for other Windows OS versions is identical and the only requirement is to specify the driver location on hard drive for corresponding OS.

Notes