



Fault Recorder

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## ***User manual***

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## Safety information

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*When the device is in operation some of its parts may be connected to a hazardous live voltage.*



*Improper operation of the device or its application to purposes different from the intended use may pose hazards to operators and /or may lead to the equipment damage.*



*National and local electrical safety regulations must always be followed.*



*The user shall be held fully responsible for any safety risk and possible failures of the equipment that may arise due to such an improper operation or misuse.*



*Exploration of damaged device can result in malfunction of protected object and result in threat to life and health.*



*Reliable and defect-free operation of the device needs appropriate transportation, handling, storage, installation and commissioning as well as correct operation and maintenance.*



*The device can be installed and operated solely by accordingly trained personnel.*

## Attention

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*We reserve the right to modify the device.*



*Device is an industrial monitoring and control instrument.*



*Remaining user documentation can be downloaded from [energetyka.itr.org.pl](http://energetyka.itr.org.pl)*



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# 1. Introduction

## 1.1. Symbols



Electrical warning symbol indicates the presence of hazardous energy circuits or electric shock hazards.



The warning symbol indicates the important information related to the threat to life and health.



The information symbol indicates the clarification of relevant features and parameters of the device.

## 2. Technical parameters

Table 1

Parameter	Value
The number of memory sectors for the fault data recordings	1..15
Tr – time of the recording, depends on the division of available memory on sectors: - 1 sector (1 signal A, 1x16 signal D) - 5 sectors (8 signals A, 5x16 signals D) - 15 sectors (8 signals A, 5x16 signals D)	- 196,60 s/sector - 6,04 s/sector - 2,01 s/sector
Tw [s] – length of the recording time before the recorder triggering	Set in a range 0..1 of the time Tr
Recorder state of the operation	blocked active, waiting for a triggerig active, recording of the data full
Recorder mode of the operation	cyclic to fill
Recorder trig modes	single multiple
Recorded analog signals *)	- electrical signals: I1, I2, I3, 2. I1, 2. I2, 2. I3, U1, U2, U3, I0, 2. I0, U0 - optional analog inputs/outputs (PT100, 4-20mA,0-10V)
Recorded digital signals *)	- digital inputs: max. 48 - digital outputs: max. 32 - optical inputs: max. 8 - internal digital signals: max. 40
Sampling frequency / period	2 kHz / 0,5ms
Recorder triggering reasons	- at the request of the operator - from exceeding the upper or lower value of selected analog signals - from rising edges of digital inputs or outputs - from rising edges of internal digital signals, for example an excitation of a selected protection, a request of switch opening, TRIP and ALARM signals - from a programmable logic
Remarks	

\*) Recording of particular signals depend on the current version of the device.



## 3. Principle of operations

### 3.1. Introduction

The fault recorder records analog and digital signals available in the protection device into battery backed memory when triggering conditions occurs for subsequent analysis. Analog and digital data are recorded at a frequency of 2000 Samples/s. The recorder can record following analog signals: the phase voltages U1, U2, U3, phase currents I1, I2, I3, 2. I1, 2. I2, 2. I3, voltage U0, currents I0, 2. I0. Depending on the version of the device up to 6 temperature signals T1 ... T6 and the rotor resistance signal Rrot can also be recorded.

The user can arbitrarily choose signals for a registration. The number of signals selected for registration affect the fault recording time. With a smaller number of selected signals recording time is extended, with more selected signals recording time becomes shorter.

Depending on the current configuration the memory of the recorder can be divided into 1 to 15 blocks of data called sectors. The allocation of memory into sectors determines the time of the registration. The fewer number of sectors recording time is greater, the larger number of sectors recording time is less. Example of memory allocation into five sectors is given in the figure below. Sectors 1 and 2 contain the recorded values. The next fault will be recorded in the sector 3. Sectors 4, 5 are empty.

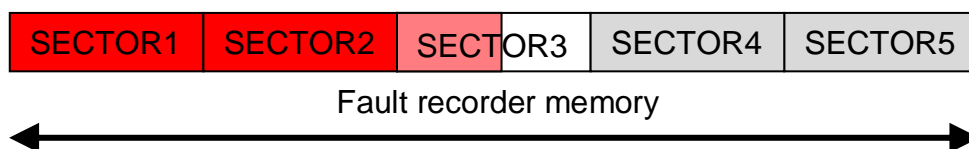


Fig. 3.1. Example of the fault recorder memory allocation into five sectors.

Writing fault data to the sector is made continuously on the basis of a circular buffer until the triggering condition occurs. After triggering the recorder fault data are written into the current sector to completely fill it and then depending on the triggering mode next sector registration is initiated or the recorder goes into blocked state.

### 3.2. Operating modes

The fault recorder can operate in one of two modes:

- cyclical
- to fill

#### 3.2.1. Mode cyclical

In the cyclical mode faults data are initially written into the subsequent free sectors. After saving the last free sector further faults are written on the position of the oldest sector, destroying his previous content.

#### 3.2.2. Mode to fill

In the operating mode to fill faults data are written into the subsequent free sectors. After writing all sectors the fault recorder indicates the full status and further registration is stopped. Next registrations in this mode are possible after erasing all sectors.



### 3.3. Recorder triggering

The fault registration in a sector starts with the recorder triggering. The user can set the manner of registration triggering via available trigger modes and criteria.

#### 3.3.1. Trigger modes

The fault recorder has two modes of triggering:

- single
- multiple

In a **single trigger** mode only one fault is recorded and the recorder goes inactive.

In a **multiple trigger** mode recorder writes all faults satisfying the recorder trigger conditions.

Within each sector we can distinguish two areas of a data registration:

- before triggering
- after triggering.

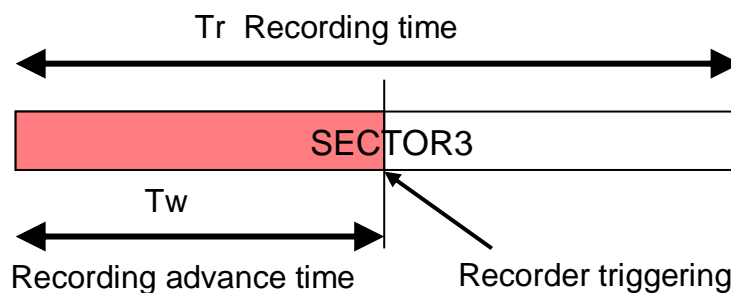


Fig.3.3.1. Fault data recording in a sector.

The time before triggering  $T_w$  (called advance time) is programmable and must satisfy the condition  $T_w < T_r$ . If the time from the activation of the recorder until its triggering is shorter than the programmed time  $T_w$  then the area before the trigger becomes shorter, and the area after triggering is appropriately longer. In the event of a device power failure during data writing, the recording time  $T_r$  is shortened.

#### 3.3.2. Recorder triggering criteria

The criteria for triggering the recorder include a set of conditions which satisfying starts data writing to the sectors. The user can choose the following criteria for triggering the recorder:

- from the increase of the analog signal above the programmed upper limit value:  
>U1, >U2, >U3, >U0, >I1, >I2, >I3, >I0, >2. I1, >2. I2, >2. I3, >2. I0
- from the decrease of the analog signal below the programmed lower limit value:  
<U1, <U2, <U3, <U0, <I1, <I2, <I3, <I0, <2. I1, <2. I2, <2. I3, <2. I0
- from the rising edge of selected digital inputs (also optical inputs)
- from the rising edge of selected digital outputs
- from the rising edge of selected internal digital signals
- on demand of the local or remote operator
- from a programmable logic

### 3.4. Information about the state of sectors

Each of the recorded sectors contains a set of information about the recorded data and the state of the sector. Sectors are described by:

- a sector number
- the format of the data in the sector
- the current state of the sector (written / empty)
- date and time of the recorder triggering



- the real time of the fault data recording (Tr)
- the real time of advance of the recording (Tw)
- the reason of the fault recorder triggering
- the nominal values of voltages and currents recorded in recorder to determine the values of these signals on the primary side

Tr and Tw times given in the sector information may vary from values programmed in settings of the device. The reason for this may be a power failure during a data recording or a recording subsequent faults at time intervals shorter than the time Tw. Full set of information describing the particular sectors is provided to the user via transmission links of the device. Basic information concerning the number of the sector, its status, the date and time of the recorder triggering, the reason of triggering and the time Tw are available from the local menu of the device.

### 3.5. Remote access to the recorded data

Remote service of the recorder is done via serial ports available in the device (RS485, fiber optic, Ethernet, USB). Using software ELF it is possible:

- viewing the status of the recorder and the state of sectors
- editing recorder settings
- activating or blocking the recorder
- reading written sectors and archiving
- removing of sectors.

Fault data read from the device are stored in the computer disk storage in the Comtrade format. For their visualization the computer programs ELF or FaultViewer can be used.

## 4. Notes on the use of the recorder

1. The number of analog and digital signals selected for recording and the number of registered sectors affect the structure of the data in the sector. Changing the value of any of these parameters in the recorder settings causes a loss recently registered data in sectors.
2. The minimum number of sectors in the cyclical mode is 2, in the mode to fill is 1. The work with one memory sector is possible only after setting triggering mode to single.
3. Settings must satisfy the following requirements:
  - at least one data format to record in the sector must be selected,
  - at least one reason of recorder triggering must be selected,
  - after setting the recorder triggering from digital inputs the input number should be selected. The same must be done in the case of triggering from digital outputs and internal signals,
  - after setting the triggering from increase or decrease the value of analog signal the threshold of the triggering must be set.
4. Remote reading of the recorded data is possible only in an inactive state of the recorder.
5. In the device event logger (after configuring recorder in the Settings window) the following operations can be annotated:
  - settings change
  - removal of the sectors
  - the recorder state change
  - the recorder triggering
6. In a case of a power loss and return the recorder behaves as follows:
  - if it was in an inactive state, after power return the state will also be inactive,

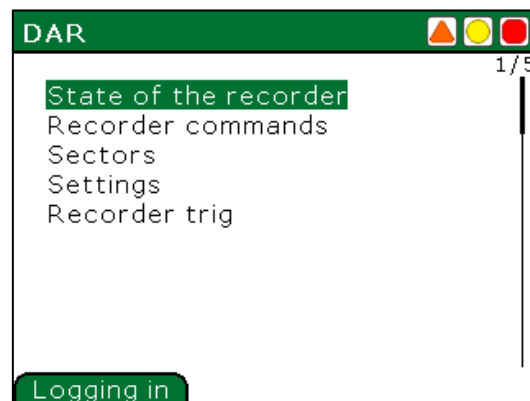


- if it was in an active state and waiting for a trigger (registration of phase Tw), after a power return it will continue in this state. Tw registration phase starts from the beginning,
- if it was in the registering process - after a power return the last recording will be completed with reduced time Tr. Then, depending on the current operating mode, next sector recording is initiated or the recorder is blocked.

## 5. Using Fault Recorder from the device local keyboard

The main window of the fault recorder is invoked from the main menu by using the local keyboard buttons ↑, ↓, OK. Full path to the main window of the fault recorder is as follows:

Management ⇒ Extension ⇒ DAR - Fault recorder



In the main window of the fault recorder there are the following items of menu:

- State of the recorder
- Recorder commands
- Sectors
- Settings
- Recorder trig

### 5.1. State of the recorder

In the State of the recorder window there are displayed information about actual operating mode of the fault recorder, time and data of the recording in the sector, sampling frequency of the recorded data. The recorder may be in one of the following modes:

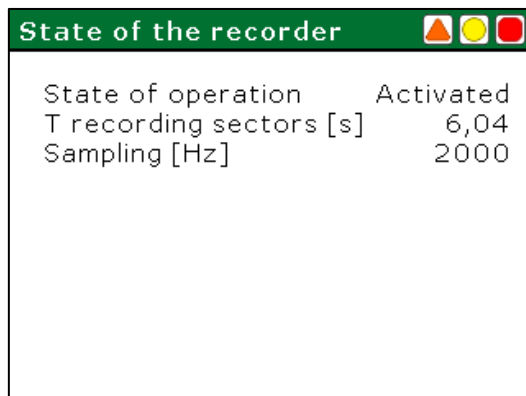
- Blocked
- Active – waiting for a recorder triggering
- Data recording – during data writing to the sector
- Filled – for the mode to fill after saving all available sectors

The State of the recorder window is invoked from the Fault recorder menu, by pushing local keyboard buttons ↑, ↓, OK and choosing State of the recorder item. Full path to the State of the operation window is as follows:





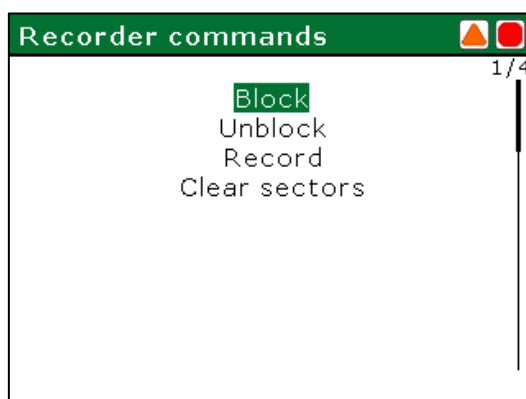
Management ⇒ Extension ⇒ DAR - Fault recorder ⇒ State of the recorder



## 5.2. Control commands of the fault recorder

There are four control command to control the fault recorder. The Control command window is invoked from the Fault recorder menu, by pushing local keyboard buttons  $\uparrow$ ,  $\downarrow$ ,  $\text{OK}$  and choosing Recorder commands item. Full path to the control command window is as follows:

Management ⇒ Extension ⇒ DAR - Fault recorder ⇒ Recorder commands



In the Control commands window following commands are available:

- Block – blocking of the recorder
- Unblock - unblocking of the recorder
- Record – triggering of the recorder at the operator request
- Clear sectors – deleting all of the saved sectors

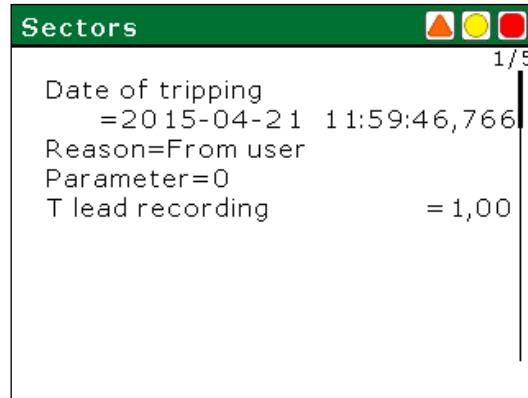
To invoke the specified command, it should be selected by using local keyboard buttons  $\uparrow$ ,  $\downarrow$ , and next confirmed by pushing button  $\text{OK}$ . Only the logged user – which has the appropriate privileges – can invoke control commands of the fault recorder.



### 5.3. Information about the sectors

In the Sectors window information about the state of a recorded sector are displayed. The Sectors window is invoked from the Fault recorder menu, by pressing local keyboard buttons ↑, ↓, OK and choosing Sectors item. Full path to the Sectors Window is as follows:

Management ⇒ Extension ⇒ DAR - Fault recorder ⇒ Sectors

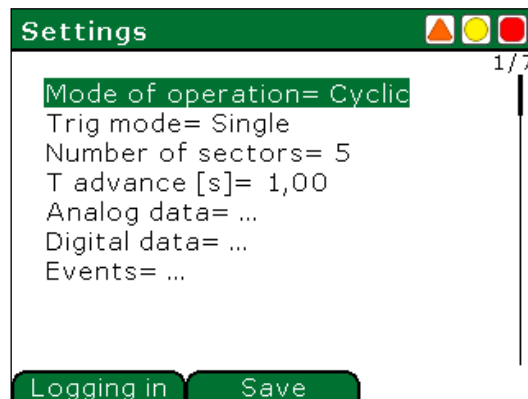


Invoking Information windows about the sectors is done by using the local keyboard ↑, ↓. If the specified sector contains stored data, the following information is displayed: date and time of the recorder triggering, the reason of triggering with appropriate parameter, registration advance time. If the specified sector doesn't store fault data, there is displayed information „Empty”.

### 5.4. Editing of the recorder settings

The Settings window is invoked from the Fault recorder menu, by pushing local keyboard buttons ↑, ↓, OK and choosing Settings item. Full path to the Settings Window is as follows:

Management ⇒ Extension ⇒ DAR - Fault recorder ⇒ Settings



In the Settings window the user can change the following recorder settings in accordance with their range shown in the Table 1:

- Mode of operation
- Triggering mode
- Number of sectors
- Recording advance time
- Analog data
- Digital data
- Events



The choice of setting to edit and editing individual settings is made by using the local keyboard buttons  $\uparrow$ ,  $\downarrow$ , OK and context buttons *Select* and *Save*. In the Analog and Digital Data Settings it is possible to select signals that will be recorded in the sectors after triggering of the recorder. The various recorder settings editing windows are showed below.

Mode of operation	Trig mode
<input checked="" type="radio"/> Cyclic <input type="radio"/> Filling up	<input checked="" type="radio"/> Single <input type="radio"/> Multiple
Select	Select

Editing window of the operational mode    Editing window of the triggering mode

Selection of the operational mode and triggering mode id done by using buttons  $\uparrow$ ,  $\downarrow$ . Setting of the selected item is done by means of a context button *Select*, and the confirmation is done by pressing button OK.

Number of sectors	T advance [s]
min= 1 max= 15	min= 0,00 max= 655,35
05	001,00
<    >	<    >

Editing window of sectors number    Editing window of advance time of recording

Editing of the numeric fields of sectors number and advance time is done as follows: editing field positions are selected by using the  $<$ ,  $>$  buttons, appropriate value is set by using  $\uparrow$ ,  $\downarrow$  buttons. OK button confirms set setting.

Analog data	Digital data
<input checked="" type="checkbox"/> U1 [V] <input checked="" type="checkbox"/> U2 [V] <input checked="" type="checkbox"/> U3 [V] <input checked="" type="checkbox"/> U0 [V] <input type="checkbox"/> I1 [A] <input type="checkbox"/> I2 [A] <input type="checkbox"/> I3 [A] <input type="checkbox"/> I0 [A]	<input checked="" type="checkbox"/> Inputs 1-16 <input checked="" type="checkbox"/> Inputs 17-32 <input checked="" type="checkbox"/> Outputs 1-16 <input checked="" type="checkbox"/> Outputs 17-32 <input checked="" type="checkbox"/> Optical inputs 1-8
Select	Select

Editing window of analog data

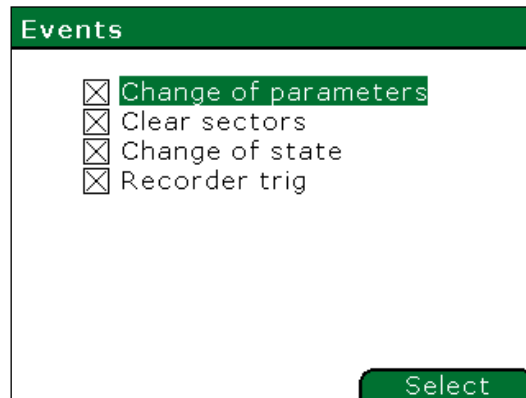
Editing window of digital data



Selection of the recorded analog and digital data is done as follows: by using buttons  $\uparrow$ ,  $\downarrow$  select signal for recording, then mark with a cross by using context button **Select**. OK button confirms the setting.

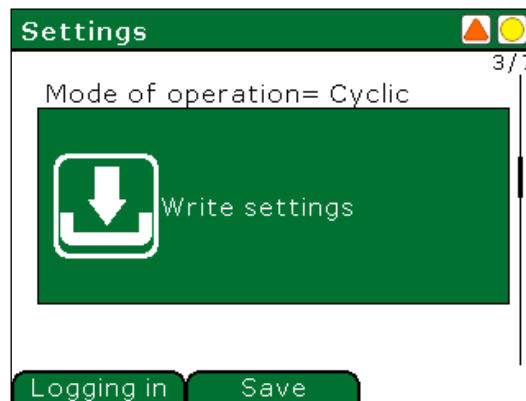
By means of setting Events available in the Settings window the user can choose, which events coming from the recorder will be recorded in the events log. In the events log of the device following fault recorder events can be recorded:

- Change of parameters
- Clear sectors
- Change of state
- Recorder trig



Selection of events for recording is done by using buttons  $\uparrow$ ,  $\downarrow$  and context button **Select**. OK button confirms the setting.

In order to the final approval of recorder settings in the Settings window the context button **Save** should be pressed.



If the settings values was written correctly, on the screen will be displayed message **Command accepted**. Otherwise it will be displayed message **Operation error**.

## 5.5. Trigger mode

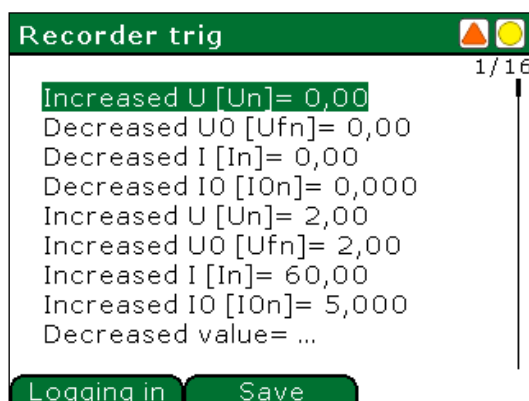
The recorder triggering window is invoked with menu Fault Recorder and next Recorder trig using keyboard keys  $\uparrow$ ,  $\downarrow$ , OK and context button **Save**. Full path to the window of the settings edition is:

**Management  $\Rightarrow$  Extension  $\Rightarrow$  DAR - Fault recorder  $\Rightarrow$  Trigger mode**

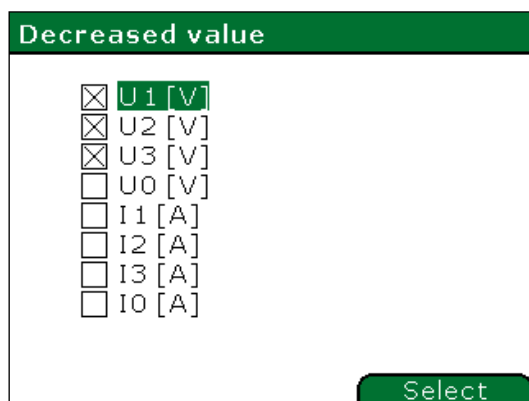
In the trigger mode widow the change of currents and voltages thresholds is available beyond which recorder is released and the data are saved to the sector. Triggering of the recorder may occur as a result of the increase



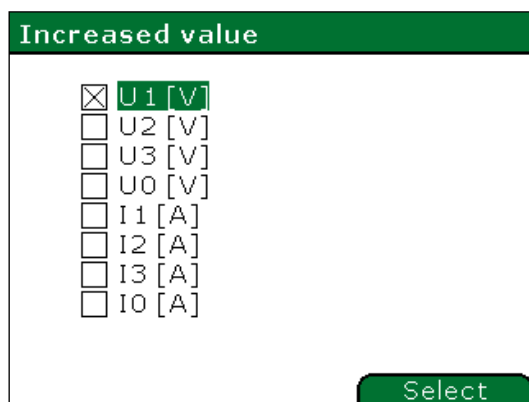
above or fall below the set threshold. The threshold values for the rise and fall signals are set independently in nominal units.



In the window of recorder triggering mode analog and digital signals are chosen, as a source of triggering. Select the appropriate analog signal using the  $\uparrow$ ,  $\downarrow$  and OK buttons, set its threshold using  $\uparrow$ ,  $\downarrow$  and context buttons  $\leftarrow$ ,  $\rightarrow$  and accept changes by OK button. Then changes should be saved by context button Save. Message **Command accepted** will appear.



In the window Decreased using  $\uparrow$ ,  $\downarrow$  keys desired signal should be chosen and selected or deselected using Select button. Then confirm edition using OK button. Similarly signals which increase the value above the programmed threshold value triggers recorder are selected. To do this choose parameter Increased value and select appropriate analog signals.



To select the digital signals which rising edge triggers the recorder, user should select appropriate option using the  $\uparrow$ ,  $\downarrow$ , for example From digital inputs 1-16 and accept it by OK button. Window From digital inputs 1-16 will appear.



From digital inputs 1-16

- bit 0
- bit 1
- bit 2
- bit 3
- bit 4
- bit 5
- bit 6
- bit 7
- bit 8
- bit 9

Select

In the From digital inputs 1-16 window, using  $\uparrow$ ,  $\downarrow$  buttons select the desired signals. Then using context button **Select**, select or deselect it and confirm by **OK**. Save should be made by **Save** context button. Message **Command accepted** will appear.

In order to select the user, who can trigger the recorder, option From user should be selected using  $\uparrow$ ,  $\downarrow$  buttons and accepted by **OK** button. The window From user will appear.

From user

- Local
- Remote

Select

In the From user window using  $\uparrow$ ,  $\downarrow$  keys select user box to edit. Then using context button **Select** select or deselect it and confirm edition by **OK** button. Save should be done by **Save** context button. Message **Command accepted** will appear.



## 6. Reading stored sectors

Stored sectors can be read by using ELF application. To do this disable the recorder. Next in the ELF application, open the Fault Recorder window (Tabs/Fault Recorder) and open the window with commands from menu Data/Commands. Then select the sector number to read and push the Read sector button.

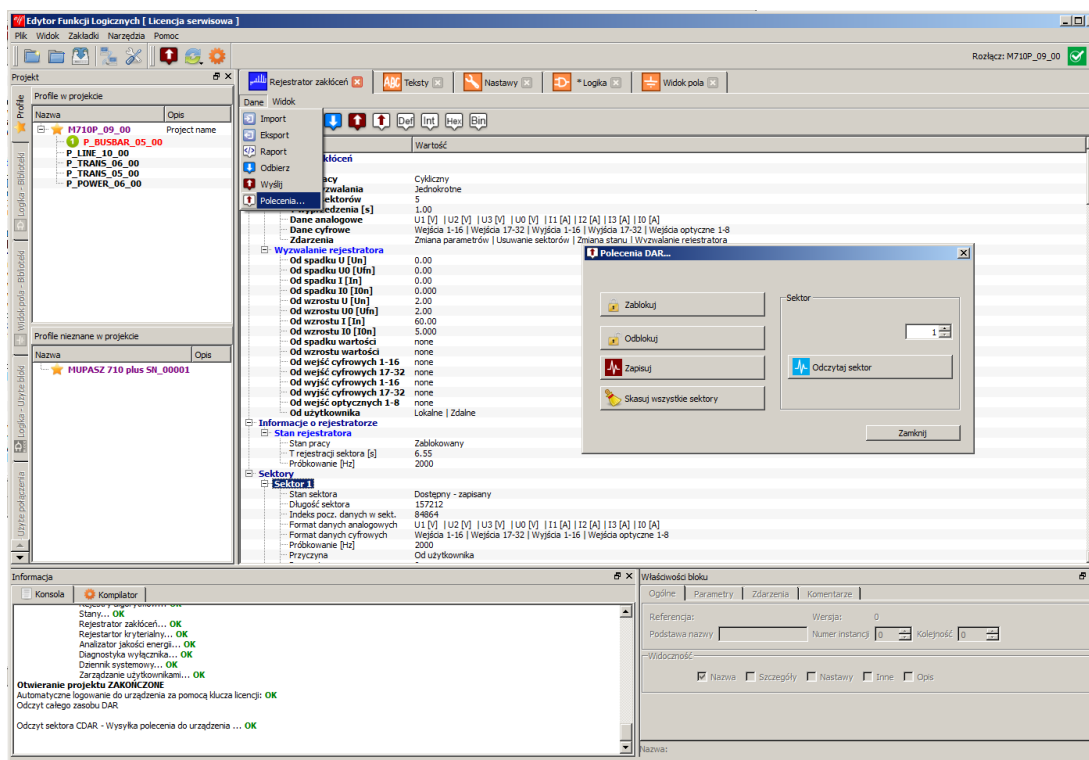


Fig. 6.1. Reading the recorded sector using ELF application.

Read sector is saved in \*.dat, \*.cfg files in Comtrade format. The visualization of the saved waveforms can be done by FaultViewer application or by the ELF software.



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## 7. Contact



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