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1 DISTURBANCE RECORDER

1.1 Application

The aim of disturbance recording is to provide means for a better understanding of the behaviour of the power network and related primary and secondary equipment during and after a disturbance. An analysis of the recorded data provides valuable information that can be used to improve existing equipment. This information can also be used when planning for and designing new installations.

Most of the built-in disturbance recorders offered by various manufacturers operate only in connection with operation of the protective functions, and they have a very limited capacity for recording times and the number of recordings.

This is not the case with the disturbance recorders built into the REx 500-series protection terminals. These disturbance recorders are characterised by a great flexibility as far as starting conditions and recording times, and large storage capacity is concerned. Thus, the disturbance recorders are not dependent on the operation of protective functions and they can record disturbances that were not discovered by protective functions for one reason or another.

The disturbance recording function in the REx 500-series of protection terminals is fully adequate for the recording of disturbances for the protected object.

Recording capacity

The recording function can record all connected analogue inputs and up to 48 binary signals. In order to maximise the utilisation of the memory, the number of analogue channels to be recorded is user-selectable by programming and can be set individually for each analogue input.
The recorded binary signals can be either true binary input signals or internal logical signals created by the protective functions.

Memory capacity

The memory capacity corresponds to approximately 30 seconds of total recording time with maximum recording capacity. The maximum number of recordings stored in the memory is 10. Thus depending on the set recording times and for recording enabled number of channels the memory can contain minimum 6 and maximum 10 disturbance recordings comprising of both header part and data part. However, the header part for the last 10 recordings will always be available.

Recording times

The recording times for the pre- and post-fault period, tPre and tPost, are user-programmable with wide setting ranges.

In order to avoid uncontrolled recording and subsequent erasing of previous recordings, in case a trigger should not reset within a reasonable time, a limit time tLim can be set to limit the total duration of a recording.

Triggers

Any of the recorded binary signals can be programmed to act as a trigger. The analogue channels have programmable threshold levels for triggering. Both overlevels and underlevels are available.
Manual triggering is also available. This provides a convenient test possibility.

Time tagging

The terminal has a built-in real-time clock and calendar. This function is utilised for time tagging of the recorded disturbances. The time tagging refers to the activation of the trigger that starts the disturbance recording.

1.2 Theory of operation

Disturbance recording is based on the continuous collection of network data, i.e. currents and binary signals, in a cyclic buffer. The buffer operates according to the FIFO principle, i.e. old data will be overwritten as new data arrives when the buffer is full. The size of this buffer is determined by the set pre-fault recording time.

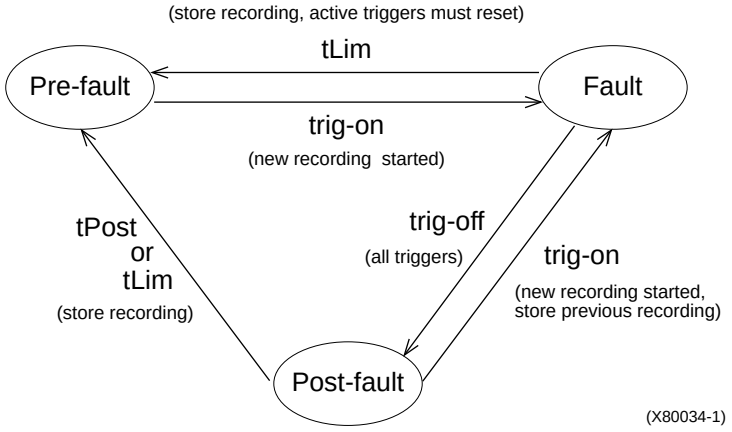

Fig. 1 State transition diagram governing the recording modes.

Upon detection of a fault condition (triggering), the data storage continues in another part of the memory. The storing goes on as long as the fault condition prevails plus a certain additional time. The length of this additional part is called the post-fault time and it can be set in the disturbance recorder. The above mentioned two parts form a disturbance recording. The whole memory acts as a cyclic buffer and when it is full, the oldest recording will be overwritten.

The recordings can be retrieved to the PC with the data collection software RECOM, and analysed and evaluated manually by using the evaluation software REVAL which is also used for print-outs of recorded disturbances. For automatic evaluation of the recordings, the software package RESDA is available.

The recordings can be divided into two parts, the so-called header and the data part. The data part contains the numerical values for the recorded analogue and binary channels. The header contains basic information on the disturbance in clear wording. A part of this information is also used by REVAL to reproduce the analogue and binary signals in a correct and user-friendly way. Such information is e.g. primary and secondary instrument transformer ratings.

The following information is included in the header:

Table 1: Contents of the header

Type of information Parameter	**Stored in parameter database**	**Stored with disturbance**
General		
Station, object & unit id	x	-
Date and time	-	x
Sequence number	-	x
CT earthing	x	-
Time synchronisation source	x	-
Recording times tPre, tPost, tLim	-	x
Trig signal and Test mode flag	-	x
Analogue signals		
Signal name	x	-
Primary and secondary instr. transformer rating	x	-
Under trig: level and operation	x	-
Overtrig: level and operation	x	-
Undertrig status at time of trig	-	x
Overtrig status at time of trig	-	x
Instantaneous Iph-0 at time of trig	-	x
Iph-0 (RMS) before trig (pre-fault)	-	x
Iph-0 (RMS) after trig (fault)	-	x
Binary signals		
Signal name	-	x
Type of contact (trig level)	x	-
Trig operation	x	-
Signal status at time of trig	-	x
Trig status at time of trig	-	x

The above table is a summary. For detailed information, reference is made to the User's Guide for REVAL.

The calculation of the RMS values takes some time. The minimum time between the start of two different recordings must be approximately 300 ms in order to obtain correct calculation. If this time is less, the RMS values for the second disturbance will be indicated as 0.

1.3 Design

The disturbance recording function is an optional function in the REx 500-series of protection terminals. The processing of analogue signals is taken care of by a dedicated DSP (Digital Signal Processor). Other functions are implemented in the main CPU. The memory is shared with other functions.

The numerical signals coming from the A/D converter module in serial form are converted to parallel form in a dedicated DSP. The analogue trig conditions are also checked in the DSP.

A check of the start conditions is performed by searching for a maximum value. This is a positive peak. The function will also seek a minimum value, which will be the negative peak.

When this is found, the absolute average value will be calculated. If this value is above the set threshold level for the “overfunction” on the channel in question, an “overfunction” start on that channel will be indicated. The “overfunction” is indicated with “>”.

Similarly, if the average value is below the set threshold level for “underfunction” on the channel in question, an “underfunction” start on that channel will be indicated. The “underfunction” is indicated with “<“.

The procedure is carried out for each channel separately. This method of checking the analogue start conditions gives a function which is insensitive to DC offset in the signal. The operating time for this start is typically in the range of one cycle, i.e. 20 ms in a 50 Hz network.

The numerical data, along with the result of the trigger condition evaluation, are transmitted to the main CPU. The main CPU takes care of the following functions:

- evaluation of the manual start condition
- evaluation of the binary start condition, both for true binary input signals and for internally created logical signals
- storage of the numerical values for the analogue channels

The numerical data for the analogue channels are stored in a cyclic pre-fault buffer in a RAM. When a trigger is activated, the data storage is moved to another area in the RAM, where the data for the fault and the subsequent post-fault period are stored. Thus, a complete disturbance recording comprises the stored data for the pre-fault, fault and post-fault period.

The RAM area for temporary storage of recorded data is divided into sub-areas, one for each recording. The size of a sub-area is governed by the sum of the set pre-fault (tPre) and maximum post-triggering (tLim) time.

There is a sufficient memory capacity for at least four consecutive recordings with a maximum number of analogue channels recorded and with maximum time settings. Should no such area be free at the time of a new triggering, the oldest recording stored in the RAM will be overwritten.

When a recording is completed, a post-recording processing will take place.

This post recording processing comprises:

- merging the data for analogue channels with corresponding data for binary signals stored in an event buffer
- compression of the data, which is performed without losing any data accuracy
- storing the compressed data in a non-volatile memory (flash memory)

The recorded disturbance is now ready for retrieval and evaluation. The recording now comprises the stored and time-tagged disturbance data along with relevant data from the database for configuration and parameter set-up.

Some parameters in the header of a recording are stored together with the recording, and some are retrieved from the parameter database in connection with a disturbance. Table 1 indicates where the various parameters are stored. This means that if a parameter that is retrieved from the parameter database has been changed between the time of recording and retrieval, the collected information will not be correct in all parts. Therefore, all recordings should be transferred to the Station Monitoring System (SMS) workstation and then deleted in the protection terminal before any such parameters are changed.

1.4 Setting

The setting parameters specific for the disturbance recording function are available in the menu tree under:

Settings
- **DisturbReport**
  - **Operation**
  - **RecordingTimes**
  - **BinarySignals**
  - **AnalogSignals**

The list of parameters in the appendix attached to the document “Disturbance report - Settings”, document no 1MRK 580 029-XEN, explains the meaning of the abbreviations used in connection with setting ranges.

It should also be kept in mind that values of parameters set elsewhere in the menu tree are linked to the information on a recording. Such parameters are, for example, station and object identifiers, CT ratios, etc.

The sequence number of the recordings is a specific parameter for the disturbance recorder and is used to identify the different recordings. By combining the date and the sequence number for a recording, the recording can be identified uniquely. The combined setting and service value for the sequence number is found in the menu tree under:

ServRep
DisturbReport
SequenceNo

The read value on the man machine interface (MMI) display is the sequence number that the next recorded disturbance will receive. The number is automatically increased by one for each new recording and is reset to 0 at each midnight. The sequence number can also be set manually.

1.5 Testing

Evaluation of the results from the disturbance recording function requires access to an SMS workstation either permanently connected to the terminal or temporarily connected to the serial port on the front. The following software packages must be installed in the workstation:

SMS-BASE	for common functions
RECOM	for collection of the disturbance data
REVAL	for evaluation and print-outs of the recorded data

It could be useful to have a printer at hand for hard copies.
The behaviour of the disturbance recording function can be checked when protective functions of the terminal are tested.

When the terminal is set to operate in test mode, there is a separate setting for operation of the Disturbance report which also effects the disturbance recorder.

A manual trig can be initiated at any time. This will result in a “snapshot” of the actual values of all recorded channels.

1.6 Technical data

Table 2:

Parameter	**Setting range**
Number of binary inputs	0-48 (programmable)
Number of analogue inputs	0-4 (programmable)
Sampling rate	1 kHz, fixed
Recording bandwidth	(5-250) Hz, fixed
Overcurrent triggering	(0-5000) % I_r in steps of 1%
Undercurrent triggering	(0-200) % I_r in steps of 1%
Pre-fault time	(50-300) ms in steps of 10 ms
Post-fault time	(100-3000) ms in steps of 100 ms
Limit time	(500-4000) ms in steps of 100 ms

Table 3:

Function	**Value**
Current channels, dynamic range without DC offset with full DC offset	 (0,01-110) · I_r (0,01-60) · I_r
Total recording time with maximum recording capacity	≥ 30 s
Built-in calender	for 30 years with leap years