WP4_009B.DOC

EUROPEAN COMMISSION
DG III INDUSTRY

INDUSTRIAL RTD PROJECT 20874

remafex

REMOTE MAINTENANCE for FACILITY EXPLOITATION

WP4 INTERNAL REPORT

SPECIFICATION OF EFI FUNCTIONS

Trend Analysis on Insulation Systems (S1)

BODY REFERENCE : WP4/009/REV.B

TITLE :	SPECIFICATION OF EFI FUNCTIONS - TREND ANALYSIS ON INSULATION SYSTEMS (S1)
SOURCE :	EFI
STATUS :	FINAL DOCUMENT
EDITOR :	ARNE PETTER BREDE, LARS LUNDGAARD
VERIFIED BY :	EIVIND SOLVANG
DISTRIBUTION :	WP4 TEAM MEMBERS
DATE :	5 SEPTEMBER 1997
NUMBER OF PAGES :	8
INTERNAL REFERENCE :	J:\DOK\13\REMAFEX\WP4\WP4_009B.DOC

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PREFACE

This document contains a description of the remote maintenance function «Trend analysis on insulation systems» (S1). Pilot installations with primary data acquisition systems based on a PC platform (Maintenance Monitoring Tool - MMT) will be developed and implemented at 2-3 test sites.

The preparation of this specification presumes that analogue signals of partial discharges are available from measuring value converters and complementing information can be taken from e.g. the SCADA system.

1. OBJECTIVE OF FUNCTION

The function provides early fault indication for high voltage apparatus (HV apparatus) in power plants by measuring partial discharge trends.

Detection of failure and ageing in insulation systems as soon as possible will allow for optimisation of repair. It may avoid failures or reduce the effect of destruction of insulation strength that can constitute a hazard to operation of a power plant and to human life.

The monitoring system shall present trend values of partial discharge (PD) levels within all three phases for HV apparatus that are to be monitored. The system shall detect changes in the discharge intensity and sudden changes in discharge levels may cause alarms to be activated. Differences in the discharge intensity between the phases shall be used to indicate a failure under evolution.

2. FUNCTION ENVIRONMENT

The function is a part of the condition monitoring system. The purpose of the function is to detect early malfunctions and anticipated failures in HV apparatus, e.g. stator windings of generators, power transformers, measuring transformers, circuit breakers, gas-insulated switchgears and cable terminations.

If trend values exceed the limits specified for the individual HV apparatus the function may address other functions within the condition monitoring system, e.g. the «Monitor stator winding condition (function S2)». In addition the S1-function shall give information to other functions within the maintenance management system.

In order to monitor the electrical discharge conditions in the plant the maintenance operators will use this function. By request to the historical database the function also can be used by the remote maintenance operators.

In the first and preliminary version of the pilot installation it is not possible to automatically determine what particular HV apparatus having excess amount of discharges.

Table 1. Sequence of request and responses necessary to utilise the function.

Event	Request/Response (RQ/RS)	From	To
Perform registration	RQ	Maintenance operator (MO)	Data Acquisition System (DAS)
Collect data			
- Partial discharge values, temperature	RQ	MO	DAS
- load conditions, PD trends			
Store data	RS	DAS	Database (DB)
Performing monitoring	RQ	MO	DB
Present results	RQ	MO	DB
Present curves and diagrams	RS	DB	MO

The data acquisition requires the use of a specific equipment called the Maintenance Monitoring Tool (MMT) in the Remafex project.

The data sources for the MMT are high frequency voltage and current signals from partial discharges within the insulation of HV apparatus. A voltage dividing system mounted between the three phases and local earth potential will detect the high frequency signals. Load currents, temperatures and noise signals will be included in the data sources.

The collected data are analogue signals. The stored data in the MMT are time series obtained from sampling and calculations performed on the analogue signals.

PD sensors:

Broadband LF (low frequency) sensors having long range (within the whole plant), global measurements. HF (high frequency) or VHF (very high frequency) narrow band sensors having short range, local measurements. Calculated values of PD are discharges pr. phase, pr. predefined time interval.

Noise detectors:

Antennas located in the plant in order to pick up rectifier noise, e.g. exciter supply.

Apparatus load:

From dedicated sensors or from other sources, e.g. SCADA.

Temperature conditions:

From dedicated sensors or from other sources.

Operational status:

From dedicated sensors or from other sources, e.g. plant connections to grid.

3. INPUT DATA DEFINITION

Input data to the Remafex-function:

3.1. PROCESS DATA

The partial discharge process data consist of numeric values given by the MMT equipment at a predefined sampling rate (e.g. at 2 minutes interval). Temperature, load currents and operational status of the HV apparatus can be taken from the SCADA. The operational status shows whether the HV apparatus are energised or not.

1	PDA	:	Partial discharge, phase A	(pC)	(real)	
2	PDB	:	Partial discharge, phase B	(pC)	(real)	
3	PDC	:	Partial discharge, phase C	(pC)	(real)	
4	NQSA	:	Discharge current, phase A	(nA)	(real)	
5	NQSB	:	Discharge current, phase B	(nA)	(real)	
6	NQSC	:	Discharge current, phase C	(nA)	(real)	
7	DISPA	:	Scope display, phase A		(bitmaps)	
8	DISPB	:	Scope display, phase B		(bitmaps)	
9	DISPC	:	Scope display, phase C		(bitmaps)	
10	T1	:	Temperature	(°C)	(real)	
11	I1	:	Load current	(A)	(real)	
12	OS1	:	Operational status		(on/off)	(text)

In the case of more than one HV apparatus to be monitored the measurements 1-9 must be performed on each items with the MMT while 10-12 can be taken e.g. from the SCADA.

3.2. PARAMETERS

The threshold levels for partial discharges in each phase as well as the gradient of the discharge levels have to be set manually depending on the specific HV apparatus.

7	THPDA	:	Partial discharge threshold, phase A	(pC)	(real)
8	THPDB	:	Partial discharge threshold, phase B	(pC)	(real)
9	THPDC	:	Partial discharge threshold, phase C	(pC)	(real)
10	GRADA	:	Partial discharge gradient, phase A	(pC/min)	(real)
11	GRADB	:	Partial discharge gradient, phase B	(pC/min)	(real)
12	GRADC	:	Partial discharge gradient, phase C	(pC/min)	(real)

4. OUTPUT DATA DEFINITION

Output from the Remafex function will be curves and graphs of time series of values calculated from the MMT and values given by the SCADA. Typical values will be the number of PD and PD levels pr. hour, day, week, and year. Alarm messages will be produced if specified threshold or gradients are exceeded.

1	PDA	:	Partial discharges, phase A	(pC)	(real)
2	PDB	:	Partial discharges, phase B	(pC)	(real)
3	PDC	:	Partial discharges, phase C	(pC)	(real)
4	NQSA	:	Discharge current, phase A	(nA)	(real)
5	NQSB	:	Discharge current, phase B	(nA)	(real)
6	NQSC	:	Discharge current, phase C	(nA)	(real)
7	DISPA	:	Scope display, phase A		(bitmaps)
8	DISPB	:	Scope display, phase B		(bitmaps)
9	DISPC	:	Scope display, phase C		(bitmaps)
10	T1	:	Temperature	(°C)	(real)
11	I1	:	Load current	(A)	(real)
12	OS1	:	Operational status	(on/off)	(text)
6	ALTHA	:	Alarm, threshold A exceeded		(text)
7	ALTHB	:	Alarm, threshold B exceeded		(text)
8	ALTHC	:	Alarm, threshold C exceeded		(text)
9	ALGRA	:	Alarm, gradient A exceeded		(text)
10	ALGRA	:	Alarm, gradient B exceeded		(text)
11	ALGRA	:	Alarm, gradient C exceeded		(text)

5. DYNAMIC BEHAVIOUR

The local control or maintenance operators have to start and to initiate the MMT equipment. Then the MMT will automatically produce the input data for the S1-function.

The control or maintenance operators can monitor the data acquisition being in progress as well as data previously saved in the database.

If alarm settings are exceeded the maintenance operators can request the S2-function.

6. DATA PROCESSING (ALGORITHMS)

The algorithms are simple threshold conditions for discharge levels and gradients of partial discharge values.

7. INTERFACES

7.1. OPERATOR INTERFACE

Curves:

The maintenance or control operators shall be able to monitor the data acquisition from the MMT to the Remafex function as well as to compare these to the specified thresholds and gradients. In order to go into details of the discharges information the local and remote maintenance operators shall be able to request information from the database.

Alarms:

If the threshold or gradient limits are exceeded an alarm or alarm list shall be produced.

7.2. SYSTEM INTERFACE

The MMT equipment consist of the data acquisition unit, most probably the ICM Monitor from Power Diagnostix Systems GmbH, Germany, and a PC at the first field site. Other MMTs like the ABB Pamos II are also evaluated. The MMT will acquire continuously data from the sensors on the high voltage busbars and perform average calculations of the PD measurements. The PC will communicate with the data acquisition unit and will transfer data from the MMT to the S1-function. Supplementary data will be taken from e.g. the SCADA.

The data from the MMT will not go directly to the CIU unit but to the Ethernet/TCPIP communication string in the local data acquisition application. The software necessary for transferring data from the PC to Ethernet/TCPIP will be a part of the MMT.

8. ERROR MANAGEMENT

If there is no output from the MMT the local control or maintenance operators have to be called. They must be able to manage the adjustments of the MMT and to be familiar with the software that transfer data from the PC to the Ethernet/TCPIP. The adjustments of the MMT can also be made remotely by the PC and a modem.

9. CONSTRAINTS

In order to acquire proper discharge data the PD sensors have to be installed on the busbars and properly connected to the MMT, e.g. the ICM Monitor. The monitor should be configured to transfer averaged data to the PC at a sampling rate of approximately 1-2 minutes. The software required for data transfer to the Ethernet/TCPIP must work properly.

10. HARDWARE AND SOFTWARE REQUIREMENTS

Hardware constraints:

In order to detect partial discharges it is necessary to install HV line-side couplers like moulded ceramic capacitors, mica capacitors etc. to limit the power frequency voltage derived from a coupler to a harmless level. Included in the setup are preamplifiers that cover the frequency range of 2-20 MHz. The signal energy of a PD pulse found in this frequency band is converted down to the acquisition bandwidth of the system (40 kHz-800 kHz). It is necessary to have remote access from the PC to the ICM Monitor in order to control the primary data acquisition either by a fibre optic link or by communication via modem.

Software constraints:

In order to optimise the data output from the ICM unit several subroutines for the PC have to be written. In addition a program for transferring data from the PC to the Ethernet/TCPIP has to be prepared. All these software are an integral part of the MMT.

11. TEST PLAN

The first test site will most probably be equipped with instrumentation from Power Diagnostix, GmbH, Germany. The “ICM Monitor “ is designed for monitoring and diagnosing of discharge activity in the insulation system of rotating machines. The modification of the ICM Monitor unit will suite well within the concept of the Remafex function S1 by performing the software modifications for transport of data from the monitor to the local PC.

The first prototype of installation will be at the France-Covas site in Portugal. The time schedule is to make an installation during October 1997.

The MMT units will be tested at EFI before the site installation can take place.

12. ANNEX - FUNCTIONS INPUT DATA

Item	**Hydroelectric set**
Domain	**Supervision/Monitoring**
User Need	**To request insulation system condition trend**
Function	**Trend analysis on insulation systems**

No.	System, Subsystem	Component, Subcomp.	Parameter	State	Type	Unit of measure	Range	Alarm value	Trip value	Remarks	Data label
1.	Hydroel. set, Generator	Stator, Stator winding	Discharge level		Numeric	pC	$[10, 10^6]$	1)		Dedicated measurem. Also on busbars. 2)	_HS_GE_ST_SWI_#PDA
2.	Hydroel. set, Generator	Stator, Stator winding	Discharge level		Numeric	pC	$[10, 10^6]$	1)		2)	_HS_GE_ST_SWI_#PDB
3.	Hydroel. set, Generator	Stator, Stator winding	Discharge level		Numeric	pC	$[10, 10^6]$	1)		2)	_HS_GE_ST_SWI_#PDC
4.	Hydroel. set, Generator	Stator, Stator winding	Discharge current		Numeric	nA	$[10^3,10^9]$				_HS_GE_ST_SWI_#NQSA
5.	Hydroel. set, Generator	Stator, Stator winding	Discharge current		Numeric	nA	$[10^3,10^9]$				_HS_GE_ST_SWI_#NQSB
6.	Hydroel. set, Generator	Stator, Stator winding	Discharge current		Numeric	nA	$[10^3,10^9]$				_HS_GE_ST_SWI_#NQSC
7.	Hydroel. set, Generator	Stator, Stator winding	Scope display		Bitmaps						_HS_GE_ST_SWI_#DISPA
8.	Hydroel. set, Generator	Stator, Stator winding	Scope display		Bitmaps						_HS_GE_ST_SWI_#DISPB
9.	Hydroel. set, Generator	Stator, Stator winding	Scope display		Bitmaps						_HS_GE_ST_SWI_#DISPC
10.	Hydroel. set, Generator	Stator, Stator winding	Winding temperature		Numeric	°C	[0,200]			From other sources 3)	_HS_GE_ST_SWI_#T1
11.	Hydroel. set, Generator	Stator, Stator winding	Load current		Numeric	A	$[0,10^5]$			From other sources 3)	_HS_GE_ST_SWI_#I1
12.	Hydroel. set, Generator	Stator, Stator winding	Operational status		Text						_HS_GE_ST_SWI_#OS1

1) Depends on the machine. The values have to be specified individually for each generator.
2) Measurements can also be performed on the main busbars.
3) Data can, if necessary, be acquired by the function itself.