BODY REFERENCE : SPEC2_GEN_GUIDE_REV F

TITLE :	SPECIFICATION OF IBERDROLA FUNCTIONS: "DETECT PROBABILITY OF FUTURE GENERATION GUIDE BEARING DISTURBANCES (F9)"
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0. OBJECTIVE OF THE FUNCTION

The objective of the function is to detect and report any anomalous event concerning the generator guide bearings that could produce a future malfunction.

This objective is decomposed into another six functions corresponding to the micro needs associated to the macro need described by this function. The final objective of this function will be to detect any malfunction from the results returned by the micro needs functions. Thus, the output of this function will be the six micro needs (incidents) ordered by the certainty factors associated to each incident. The same six incidents are relative to upper and lower guide bearing possible malfunctions .

The incidents relative to generator upper guide bearing malfunction are:

_ Parasite current through generator upper guide bearing

_ Oil leakage in generator upper guide bearing

_ Water leakage to oil in generator upper guide bearing

_ Babbit metal wearing in generator upper guide bearing

_ Lack of cooling in generator upper guide bearing

_ Breaking of coolant coil in generator upper guide bearing

The incidents relative to generator lower guide bearing malfunction are:

_ Parasite current through generator lower guide bearing

_ Oil leakage in generator lower guide bearing

_ Water leakage to oil in generator lower guide bearing

_ Babbit metal wearing in generator lower guide bearing

_ Lack of cooling in generator lower guide bearing

_ Breaking of coolant coil in generator lower guide bearing

This information will be enough for the expert to take any action about the preventive maintenance of the plant in this concrete item (generator guide bearing).

Also, the system will be able to make cause determination for each one of the possible incidents and to give a justification of the results.

1. FUNCTION ENVIRONMENT

The function will evaluate for each incident its own certainty factor showing the expert degree of confidence for that event to occur under the conditions given by the measures.

The information presented to the user will contain the list of incidents associated to the generator guide bearing, ordered by degree of certainty. Also, the degree of certainty will be showed for the user to evaluate the importance of each possible event.

This evaluation will be developed as a user request or cyclically, and will use data collected by the SCADA instrumentation in real time and data collected in periodical tests if they are available (or included by the user).

The sequence of requests and responses of the function is the following:

Event	Request/Response (RQ/RS)	From	To
Forecasting Request (user request)	RQ	Maintenance Operator (M.O.)	Function
Forecasting Request (cyclic execution)	RQ	Function	Function
Collect Data (continuous extern function with a fixed sample interval)	RQ	Function	Data Acquisition System (D.A.S.)
Data Collected (continuous function with a fixed sample interval)	RS	Data Acquisition System (D.A.S.)	Data Base
Select Data (on forecasting request)	RQ	Function	Function
Data Selected (on forecasting request)	RS	Data Base	Function
Perform Forecasting	RQ	Function	Function
Manual Data Request	RQ	Function	M.O.
Manual Data (Manual Tests)	RS	M.O.	Function/ Data Base
Report Results (ordered list of incidents with their associated certainty degree)	RS	Function	M.O.
Report Results (certainty degree incidents)	RS	Function	Data Base.

There are two processes involved in the data handling. There is a process that collects data from the D.A.S. and includes it into the real time data base (D.B). The other process selects the data needed by the function in a range of time. The first function will operate independently from the second and in a continuous way. The second will respond to the maintenance operator requests and when expiring the hibernating period .

2. INPUT DATA DEFINITION

Input data to the function are divided into three types:

1. Digital signals from SCADA system: We will need the last updated value from the SCADA system contained in the real time DB.
2. Analogic signal from SCADA system: We will also need the last updated value from the SCADA system contained in the real time DB.
3. Digital and analogic data, inserted by the user into the real time DB: We will need the last value updated by the maintenance operator as well as the date when it was updated.

All these data must be presented to the user before executing the function and the user must be able to modify any value to adjust the results obtained in the execution. These modifications must not be updated in the DB.

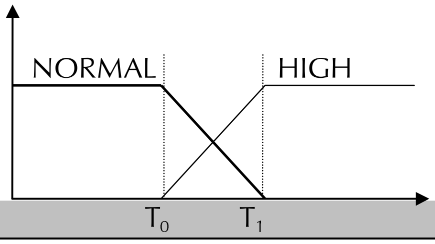
The input data will be the following SCADA signals and maintenance actions that could indicate possible malfunction incidents:

A: Metal heating. Guide bearing metal temperature.

The following data are used in the algorithms for the forecasting function:

CODE:
" LGB_METAL_TEMP "
NAME:
lower guide bearing metal temperature
TYPE:
analogic
RANGE:(limits)
0-100 ºC
ACQUISITION, SOURCE:
SCADA
XA-V0202 LGB_METAL_TEMP , alarms: H 80ºC, HH 90ºC (Francis)
XA-V0205 LGB_METAL_TEMP, alarms: H 80ºC, HH 90ºC (Pelton)
LABELS:
NORMAL
HIGH

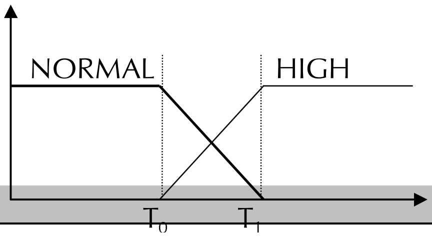
T_0 = **pending**
T_1 = 80 ºC



Default value: NORMAL

CODE:
" UGB_METAL_TEMP "
NAME:
upper guide bearing metal temperature
TYPE:
analogic
RANGE:(limits)
0-100 ºC
ACQUISITION, SOURCE:
SCADA
XA-V0204 UGB_METAL_TEMP , alarms: H 80ºC, HH 90ºC (Francis)
XA-V0207 UGB_METAL_TEMP, alarms: H 80ºC, HH 90ºC (Pelton)
LABELS:
NORMAL
HIGH

T_0 = **pending**
T_1 = 80 ºC



Default value: NORMAL

The following data are not used in forecasting rules, but it could be used if rules are modified in test period. They will be shown by the function.

" LGB_HIGH_METAL_TEMP ":
XD-V0401 high temp. alarm in lower guide bearing metal (Pelton)
XD-V0611 high temp. Alarm in lower guide bearing metal (Francis).
(integer scalar /boolean)

" LGB_VERY_HIGH_METAL_TEMP ":
XD-V0402 very high temp. alarm in lower guide bearing metal (Pelton)
XD-V0612 very high temp. alarm in lower guide bearing metal (Francis).
(integer scalar /boolean)

" UGB_HIGH_METAL_TEMP ":
XD-V0409 high temp. alarm in upper guide bearing metal (Pelton)
XD-V0703 high temp. Alarm in upper guide bearing metal (Francis).
(integer scalar/boolean)

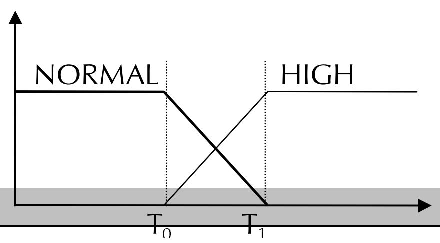
" UGB_VERY_HIGH_METAL_TEMP ":
XD-V0410 very high temp. alarm in upper guide bearing metal (Pelton)
XD-V0704 very high temp. Alarm in upper guide bearing metal (Francis).
(integer scalar/boolean)

B: Oil heating. Oil temperature in carter.

The following data are used in the algorithms for the forecasting function:

CODE:
" UGB_OIL_TEMP "
NAME:
oil temperature in upper carter
TYPE:
analogic
RANGE:(limits)
0-100 ºC
ACQUISITION, SOURCE:
SCADA
XA-V0206 UGB_OIL_TEMP , alarms H 70ºC, HH 80ºC (Francis)
XA-V0209 UGB_OIL_TEMP , alarms H 70ºC, HH 80ºC (Pelton)
LABELS:
NORMAL
HIGH

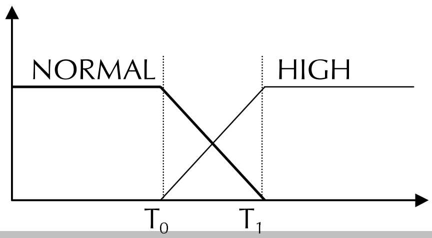
T_0 = **pending**
T_1 = 70 ºC



Default value: NORMAL

CODE:
" LGB_OIL_TEMP "
NAME:
oil temperature in lower carter
TYPE:
analogic
RANGE:(limits)
0-100 ºC
ACQUISITION, SOURCE:
SCADA
XA-V0203 LGB_OIL_TEMP , alarms H 65ºC, HH 70ºC (Francis)
XA-V0206 LGB_OIL_TEMP , alarms H 65ºC, HH 70ºC (Pelton)
LABELS:
NORMAL
HIGH

T_0 = **pending**
T_1 = 65 ºC



Default value: NORMAL

The following data are not used in forecasting rules, but it could be used if rules are modified in test period. They will be shown by the function.

" UGB_HIGH_OIL_TEMP ":
XD-V0413 high oil temperature alarm in upper carter (Pelton)
XD-V0707 high oil temperature alarm in upper carter (Francis).
(integer scalar /boolean)

" UGB_VERY_HIGH_OIL_TEMP ":
XD-V0414 very high oil temperature alarm in upper carter (Pelton)
XD-V0708 very high oil temperature alarm in upper carter (Francis).
(integer scalar /boolean)

" LGB_HIGH_OIL_TEMP ":
XD-V0403 high oil temperature alarm in lower carter (Pelton)
XD-V0613 high oil temperature alarm in lower carter (Francis).
(integer scalar /boolean)

" LGB_VERY_HIGH_OIL_TEMP ":
XD-V0404 very high oil temperature alarm in lower carter (Pelton)
XD-V0614 very high oil temperature alarm in lower carter (Francis).
(integer scalar /boolean)

C: Oil level in carter.
The following data are used in the algorithms for the forecasting function:

CODE:
" UGB_LOW_OIL_LEVEL "
NAME:
Alarm of low oil level in upper carter
TYPE:
boolean, digital
RANGE:(limits)
on-off
ACQUISITION, SOURCE:
SCADA
XD-V0711 UGB_LOW_OIL_LEVEL (Francis)
XD-V0418 UGB_LOW_OIL_LEVEL (Pelton)
LABELS:
on (alarm)
off
Default value: off

CODE:
" UGB_VERY_LOW_OIL_LEVEL "
NAME:
Alarm of very low oil level in upper carter
TYPE:
boolean, digital
RANGE:(limits)
on-off
ACQUISITION, SOURCE:
SCADA
XD-V0710 UGB_VERY_LOW_OIL_LEVEL (Francis)
XD-V0417 UGB_VERY_LOW_OIL_LEVEL (Pelton)
LABELS:
on (alarm)
off
Default value: off

CODE:
" LGB_LOW_OIL_LEVEL "
NAME:
Alarm of low oil level in lower carter
TYPE:
boolean, digital
RANGE:(limits)
on-off
ACQUISITION, SOURCE:
SCADA
XD-V0701 LGB_LOW_OIL_LEVEL (Francis)
XD-V0407 LGB_LOW_OIL_LEVEL (Pelton)
LABELS:
on (alarm)
off Default value: off

CODE:
" LGB_VERY_LOW_OIL_LEVEL "
NAME:
Alarm of very low oil level in lower carter
TYPE:
boolean, digital
RANGE:(limits)
on-off
ACQUISITION, SOURCE:
SCADA
XD-V0700 LGB_VERY_LOW_OIL_LEVEL (Francis)
XD-V0406 LGB_VERY_LOW_OIL_LEVEL (Pelton)
LABELS:
on (alarm)
off
Default value: off

CODE:
" UGB_HIGH_OIL_LEVEL "
NAME:
Alarm of high oil level in upper carter
TYPE:
boolean, digital
RANGE:(limits)
on-off
ACQUISITION, SOURCE:
SCADA
XD-V0712 UGB_HIGH_OIL_LEVEL (Francis)
XD-V0419 UGB_HIGH_OIL_LEVEL (Pelton)
LABELS:
on (alarm)
off
Default value: off

CODE:
" LGB_HIGH_OIL_LEVEL "
NAME:
Alarm of high oil level in lower carter
TYPE:
boolean, digital
RANGE:(limits)
on-off
ACQUISITION, SOURCE:
SCADA
XD-V0702 LGB_HIGH_OIL_LEVEL (Francis)
XD-V0408 LGB_HIGH_OIL_LEVEL (Pelton)
LABELS:
on (alarm)
off Default value: off

The following data are not used in forecasting rules, but it could be used if rules are modified in test period. They will be shown by the function.

" UGB_NORMAL_OIL_LEVEL ":
XD-S0204 Indicator of normal oil level in upper carter (Pelton)
XD-S0503 Indicator of normal oil level in upper carter (Francis).
(integer scalar /boolean)

" LGB_NORMAL_OIL_LEVEL ":
XD-S0202 Indicator of normal oil level in lower carter (Pelton)
XD-S0501 Indicator of normal oil level in lower carter (Francis).
(integer scalar /boolean)

D: Oil refrigeration.

The following data are used in the algorithms for the forecasting function:

CODE:
" LGB_LOW_WATER_FLOW "
NAME:
Alarm of low water flow in lower oil carter heat exchanger
TYPE:
boolean, digital
RANGE:(limits)
on-off
ACQUISITION, SOURCE:
SCADA
XD-V0615 LGB_LOW_WATER_FLOW (Francis)
XD-V0405 LGB_LOW_WATER_FLOW (Pelton)
LABELS:
on (alarm)
off
Default value: off

CODE:
" UGB_LOW_WATER_FLOW "
NAME:
Alarm of low water flow in upper oil carter heat exchanger
TYPE:
boolean, digital
RANGE:(limits)
on-off
ACQUISITION, SOURCE:
SCADA
XD-V0709 UGB_LOW_WATER_FLOW (Francis)
XD-V0415 UGB_LOW_WATER_FLOW (Pelton)
LABELS:
on (alarm)
off
Default value: off

CODE:
" COOLING_SYSTEM_FAULT "
NAME:
Alarm of refrigeration fault
TYPE:
boolean, digital
RANGE:(limits)
on-off
ACQUISITION, SOURCE:
SCADA
XD-V0810 COOLING_SYSTEM_FAULT (Francis)
XD-V0432 COOLING_SYSTEM_FAULT (Pelton)
LABELS:
on (alarm)
off
Default value: off

CODE:
" COOLING_SYSTEM_ON "
NAME:
Refrigeration system working
TYPE:
boolean, digital
RANGE:(limits)
on-off
ACQUISITION, SOURCE:
SCADA
XD-S0513 COOLING_SYSTEM_ON (Francis)
XD-S0214 COOLING_SYSTEM_ON (Pelton)
LABELS:
on
off
Default value: off

The following data are not used in forecasting rules, but it could be used if rules are modified in test period. They will be shown by the function.

" LGB_NORMAL_WATER_FLOW ":
XD-S0201 Indicator of normal water flow in lower carter coil (Pelton)
XD-S0500 Indicator of normal water flow in lower carter coil (Francis)
(integer scalar /boolean)

" UGB_NORMAL_WATER_FLOW ":
XD-S0203 Indicator of normal water flow in upper carter coil (Pelton)
XD-S0502 Indicator of normal water flow in upper carter coil (Francis)
(integer scalar /boolean)

E: Oil analysis.(Periodical maintenance analysis report) (user input).

The following data are used in the algorithms for the forecasting function:

CODE:
" UGB_WATER_IN_OIL "
NAME:
Water detected in upper carter oil analysis
TYPE:
boolean, digital
RANGE:(limits)
yes-not
ACQUISITION, SOURCE:
MANUAL INPUT, periodical maintenance oil analysis reports
UGB_WATER_IN_OIL (Francis)
UGB_WATER_IN_OIL (Pelton)
LABELS:
YES
NOT
Default value: NOT

CODE:
" LGB_WATER_IN_OIL "
NAME:
Water detected in lower carter oil analysis
TYPE:
boolean, digital
RANGE:(limits)
yes-not
ACQUISITION, SOURCE:
MANUAL INPUT, periodical maintenance oil analysis reports
LGB_WATER_IN_OIL (Francis)
LGB_WATER_IN_OIL (Pelton)
LABELS:
YES
NOT
Default value: NOT

CODE:
" UGB_VISIBLE_PART_PEEP_HOLES "
NAME:
Visible babbit metal particles in upper carter oil (peep-holes) and/or filters
TYPE:
boolean, digital
RANGE:(limits)
yes-not
ACQUISITION, SOURCE:
MANUAL INPUT, periodical routes report
UGB_VISIBLE_PART_PEEP_HOLES (Francis)
UGB_VISIBLE_PART_PEEP_HOLES (Pelton)
LABELS:
YES
NOT Default value: NOT

CODE:
" LGB_VISIBLE_PART_PEEP_HOLES "
NAME:
Visible babbit metal particles in lower carter oil (peep-holes) and/or filters
TYPE:
boolean, digital
RANGE:(limits)
yes-not
ACQUISITION, SOURCE:
MANUAL INPUT, periodical routes report
LGB_VISIBLE_PART_PEEP_HOLES (Francis)
LGB_VISIBLE_PART_PEEP_HOLES (Pelton)
LABELS:
YES
NOT
Default value: NOT

CODE:
" UGB_FOREIGN_PART_ANALYS "
NAME:
Apparition of particles in upper carter oil analysis, filters, etc
TYPE:
boolean, digital
RANGE:(limits)
yes-not
ACQUISITION, SOURCE:
MANUAL INPUT, periodical maintenance oil analysis reports
UGB_FOREIGN_PART_ANALYSIS (Francis)
UGB_FOREIGN_PART_ANALYSIS (Pelton)
LABELS:
YES
NOT
Default value: NOT

CODE:
" LGB_FOREIGN_PART_ANALYS "
NAME:
Apparition of particles in lower carter oil analysis, filters, etc
TYPE:
boolean, digital
RANGE:(limits)
yes-not
ACQUISITION, SOURCE:
MANUAL INPUT, periodical maintenance oil analysis reports
LGB_FOREIGN_PART_ANALYSIS (Francis)
LGB_FOREIGN_PART_ANALYSIS (Pelton)
LABELS:
YES
NOT Default value: NOT

CODE:
" UGB_GASES "
NAME:
Apparition of gases in oil analysis, filters, etc of upper carter
TYPE:
boolean, digital
RANGE:(limits)
yes-not
ACQUISITION, SOURCE:
MANUAL INPUT, periodical maintenance oil analysis reports UGB_GASES (Francis) UGB_GASES (Pelton)
LABELS:
YES NOT
Default value: NOT

CODE:
" LGB_GASES "
NAME:
Apparition of gases in oil analysis, filters, etc of lower carter
TYPE:
boolean, digital
RANGE:(limits)
yes-not
ACQUISITION, SOURCE:
MANUAL INPUT, periodical maintenance oil analysis reports LGB_GASES (Francis) LGB_GASES (Pelton)
LABELS:
YES NOT
Default value: NOT

F: Vibrations.

The following data are used in the algorithms for the forecasting function:

CODE:

" LGB_VIBR "

NAME:

lower guide bearing vibration

TYPE:

analogic

RANGE:(limits)

0-10 (mm/s)

ACQUISITION, SOURCE:

SCADA

XA-V0312 LGB_VIBR (Francis)

XA-V0-- LGB_VIBR (Pelton)

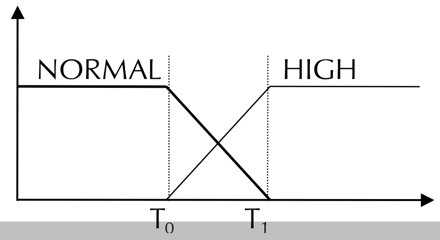
LABELS:

NORMAL

HIGH

T_0 = **pending**

T_1 = pending



Default value: NORMAL

CODE:

" UGB_VIBR "

NAME:

Upper guide bearing vibration

TYPE:

analogic

RANGE:(limits)

0-10 (mm/s)

ACQUISITION, SOURCE:

SCADA

XA-V0313 UGB_VIBR (Francis)

XA-V0-- UGB_VIBR (Pelton)

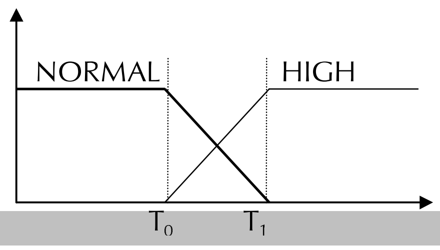
LABELS:

NORMAL

HIGH

T_0 = **pending**

T_1 = pending



Default value: NORMAL

The following data are not used in forecasting rules, but it could be used if rules are modified in test period. They will be shown by the function.

" SET_HIGH_VIBR ":
XD-V0319 hydroelectric set high vibration alarm (Pelton).
XD-V0-- hydroelectric set high vibration alarm (Francis).

" SET_VERY_HIGH_VIBR ":
XD-V0322 hydroelectric set very high vibration alarm (Pelton)
XD-V0-- hydroelectric set very high vibration alarm (Francis)

" LGB_HIGH_VIBR ":
XD-V0407 lower guide bearing high vibration alarm (Francis).
XD-V0-- lower guide bearing high vibration alarm (Pelton).

" LGB_VERY_HIGH_VIBR ":
XD-V0410 lower guide bearing very high vibration alarm (Francis).
XD-V0-- lower guide bearing very high vibration alarm (Pelton).

" UGB_HIGH_VIBR ":
XD-V0408 upper guide bearing high vibration alarm (Francis).
XD-V0-- upper guide bearing high vibration alarm (Pelton).

" UGB_VERY_HIGH_VIBR ":
XD-V0411 upper guide bearing very high vibration alarm (Francis).
XD-V0411 upper guide bearing very high vibration alarm (Pelton).

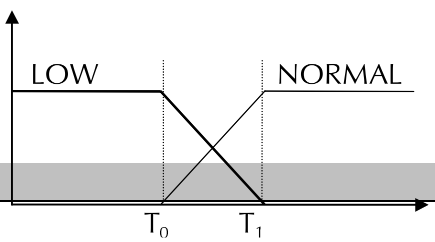
" SET_VIBR ":
XD-V0-- set vibration indicator (Francis).
XD-V0-- set vibration indicator (Pelton).

" SET_AXIAL_VIBR ":
XD-V0-- set axial vibration indicator (Francis).
XD-V0-- set axial vibration indicator (Pelton).

G: Electric insulation.

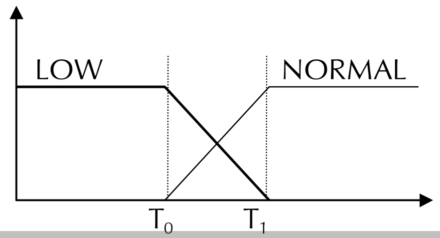
The following data are used in the algorithms for the forecasting function:

CODE:
" UGB_ISOLATION_VALUE "
NAME:
isolation value in upper carter
TYPE:
analogic
RANGE:(limits)
0- (Mohms)
ACQUISITION, SOURCE:
MANUAL INPUT, periodical maintenance test report
UGB_ISOLATION_VALUE (Pelton)
UGB_ISOLATION_VALUE (Francis)
LABELS:
NORMAL
LOW
T_0 = **pending**
T_1 = pending
Default value: NORMAL



CODE:
" LGB_ISOLATION_VALUE "
NAME:
isolation value in lower carter
TYPE:
analogic
RANGE:(limits)
0- (Mohms)
ACQUISITION, SOURCE:
MANUAL INPUT, periodical maintenance test report
LGB_ISOLATION_VALUE (Pelton)
LGB_ISOLATION_VALUE (Francis)
LABELS:
NORMAL
LOW

T_0 = **pending**
T_1 = pending



Default value: NORMAL

CODE:
" GENERATOR_DIFFERENTIAL_PROTECT "
NAME:
generator differential protection activation alarm
TYPE:
boolean
RANGE:(limits)
on- off
ACQUISITION, SOURCE:
SCADA
XD-V0727 GENERATOR_DIFFERENTIAL_PROTECT (Pelton)
XD-V1500 GENERATOR_DIFFERENTIAL_PROTECT (Francis)
LABELS:
ON
OFF
Default value: off

CODE:
" STATOR_GROUND_RELAY_PROTECT "
NAME:
Stator grounding relay activation alarm
TYPE:
boolean
RANGE:(limits)
on- off
ACQUISITION, SOURCE:
SCADA
XD-V0728 STATOR_GROUND_RELAY_PROTECT (Pelton)
XD-V1501 STATOR_GROUND_RELAY_PROTECT (Francis)
LABELS:
ON
OFF
Default value: off

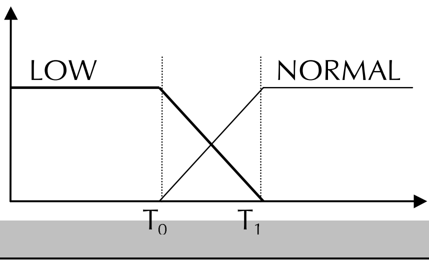
CODE:
" BAD_GROUNDING "
NAME:
Bad conditions of generator grounding brushes
TYPE:
boolean
RANGE:(limits)
yes-not
ACQUISITION, SOURCE:
MANUAL INPUT, periodical maintenance test report
BAD_GRUNDING_BRUSHES (Pelton)
BAD_GRUNDING_BRUSHES (Francis)
LABELS:
YES
NOT
Default value: NOT

Q: water pressure in coil.

The following data are used in the algorithms for the forecasting function:

CODE:
" UGB_COIL_WAT_OUTLET_PRESS "
NAME:
Outlet water pressure in upper guide bearing heat exchanger
TYPE:
analogic
RANGE:(limits)
0-15 (bar)
ACQUISITION, SOURCE:
SCADA, missing by SCADA
UGB_COIL_WAT_OUTLET_PRESS (Pelton)
UGB_COIL_WAT_OUTLET_PRESS (Francis)
LABELS:
NORMAL
LOW

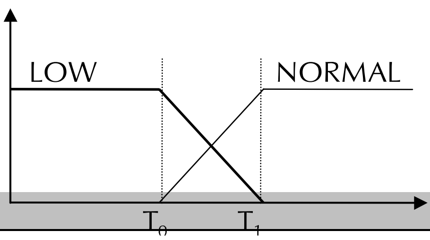
T_0 = **pending**
T_1 = pending



Default value: NORMAL

CODE:
" LGB_COIL_WAT_OUTLET_PRESS "
NAME:
Outlet water pressure in lower guide bearing heat exchanger
TYPE:
analogic
RANGE:(limits)
0-15 (bar)
ACQUISITION, SOURCE:
SCADA, missing by SCADA
LGB_COIL_WAT_OUTLET_PRESS (Pelton)
LGB_COIL_WAT_OUTLET_PRESS (Francis)
LABELS:
NORMAL
LOW

T_0 = **pending**
T_1 = pending



Default value: NORMAL

CODE:

" UGB_COIL_DIRT_LEVEL "

NAME:

dirt level in upper guide bearing heat exchanger

TYPE:

analogic

RANGE:(limits)

0-200 (%)

ACQUISITION, SOURCE:

SCADA, missing by SCADA (from function S23)

UGB_COIL_DIRT_LEVEL (Pelton)

UGB_COIL_DIRT_LEVEL (Francis)

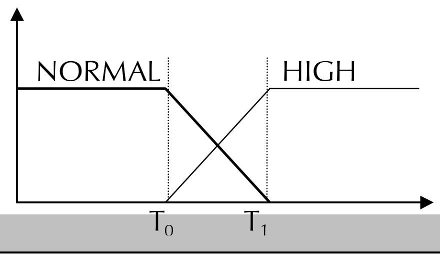
LABELS:

NORMAL

HIGH

T_0 = **pending**

T_1 = pending



Default value: NORMAL

CODE:

" LGB_COIL_DIRT_LEVEL "

NAME:

dirt level in lower guide bearing heat exchanger

TYPE:

analogic

RANGE:(limits)

0-200 (%)

ACQUISITION, SOURCE:

SCADA, missing by SCADA (from function S23)

LGB_COIL_DIRT_LEVEL (Pelton)

LGB_COIL_DIRT_LEVEL (Francis)

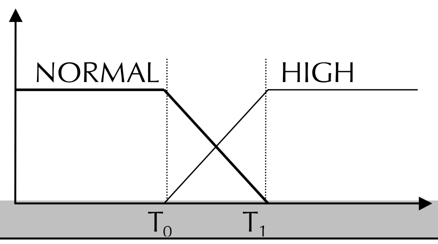
LABELS:

NORMAL

HIGH

T_0 = **pending**

T_1 = pending



Default value: NORMAL

R: power generated

The following data are not used in forecasting rules, but it could be used if rules are modified in test period. They will be shown by the function.

" ACTIVE_POWER ":

XA-V0114 Indicator of active power generated by set (Pelton group)
XA-V0107 Indicator of active power generated by set (Francis group)
(MW, real scalar/ analogic)

3. OUTPUT DATA DEFINITION

The output of this function will be used to report directly to the user the evaluation results of the different incidents relative to the generator guide bearing malfunction. These results are the ordered list of the related incidents with the certainty factor associated to each one. The output will be then for example (for each one of the upper and lower guide bearings):

UPPER GUIDE BEARING
1. Lack of cooling (0.8) VERY HIGH
2. Breaking of coolant coil (0.7) HIGH
3. Carter oil leakage (0.3) LOW
4. Babbit metal wearing in generator guide bearing (0.3) LOW
5. Water leakage to oil (0.1) VERY LOW
6. Isolation loss in generator guide bearing (0.1) VERY LOW
LOWER GUIDE BEARING
1.Lack of cooling (0.8) VERY HIGH
2. Breaking of coolant coil (0.7) HIGH
3. Carter oil leakage (0.3) LOW
4. Babbit metal wearing in generator guide bearing (0.3) LOW
5. Water leakage to oil (0.1) VERY LOW
6. Isolation loss in generator guide bearing (0.1) VERY LOW

As in the input, the output interface for the function will be a file, that must be created by the function when finishing execution and will contain the name of the incident, the certainty factor and the label associated to the certainty factor.

As mentioned earlier, the list of the possible causes for each incident must be displayed if the user requests it. This information will be also given by the function in the output file.

The list of possible causes is the following:

<u>Lack of cooling in lower/upper carter:</u>

Lack of cooling water:
- -loss of flow in input water admission
- -grid and/or general filter obstruction
- -sudden closing of manual and/or motorised valves
- -air in lines
- -obstruction in coil circuit
- -breaking in coolant system (over pressure, thermal change, etc.)

Lower/upper carter oil leakage:

Lack of seal in the carter
Lack of seal in bearing junctions
Defect in upper cover obturator
Leakage through peep-holes, oil level and temperature indicators and other devices

Parasite current through lower/upper guide bearing:

Loss of characteristics by ageing
Flats
Contamination
- -oil
- -water
- -metallic residues

Bad material
Successive disassembles
Bolts for bench-bridge attachment bad isolated
Bridging caused by other devices bad isolated
- -temperature and oil level sensor connections
- -oil injection pipes
- -other conductor devices (obturators, etc.)

Babbit Metal wearing in lower/upper guide bearing:

Unstuck of babbit metal (lack of adherence)
Shaft oscillations (several causes)
Abrasive particles
Lack of self-lubrication (low oil level)
Fissures (vibrations or temperature)
Unfitting (measured)
Increment of time running at low r.p.m.
Looseness of support
Loss of oil characteristics
Damage when the machine is suspended
Bridging or bad isolation

Water Leakage in lower/upper carter:

Breakage inside the bearing carter in:

- input of cooling water collector
- output of cooling water collector
- coolant pipes

Accidental water input from outside to the carter

Breaking of coils in lower/upper carter:

Mechanic stress in coil pipes
Over-pressure
- air bubbles in water circuit
- quick closing of motorised valve

Sudden thermal changes
Abrasion and adherence of suspended particles
Bad maintenance (cleaning) \ low quality material
Junction between pipes and tubular plate has been carried out badly

The output file will also contain a justification text of the deductions made by the fuzzy module to obtain the conclusions.

4. DYNAMIC BEHAVIOUR

As mentioned in section 1. , there are two processes involved in the forecasting functions. The first of them is the responsible of gathering data at sample intervals (given by the availability of SCADA signals) and inserting them into the D.B. in real time. This function allows us to dispose of all the data needed to carry out the forecasting and cause determination needs.

As mentioned above, we will have 2 types of executions:

1. As a user request.
2. Cyclically.

For the configuration of the cyclic execution, the system must provide the way to define:

- The event/s (a group of SCADA signals that satisfy some conditions) that starts the execution of the functions under a certain type of cycle.
- The period of activation for each type of cycle.

Thus, when the event defined by the user for a type of cycle is true, the functions will be executed cyclically within a period of activation. This period could be null, in the case of the group stop event, for example.

5. DATA PROCESSING (ALGORITHMS)

For the data processing, we have to consider the deduction mechanism used to determine the possibility of any generator guide bearing malfunction due to a concrete incident of the six listed previously in section 0.

This mechanism uses the certainty associated to each event of the system to make deductions for each incident. That is, we will have a deduction tree for each incident going from lower to upper nodes, evaluating the rules and spreading the certainty to upper levels. In those cases where we have independent variables for a common conclusion, we will accumulate the certainty for the conclusion. Where we have dependent variables (for example: A defined as A1 AND A2) we must not.

The implementation of the function is based on the deduction rules and their probabilities. The deduction must be made with forward chaining going from the signals to the incidents certainty. All the rules for an incident will be applied accumulating the resulting certainty because they represent independent events.
The rules to apply are listed below grouped by incidents:

<u>Lack of cooling in lower carter:</u>

IF (“ **COOLING_SYSTEM_ON** “) IS ON AND (“**LGB_LOW_WATER_FLOW**“) IS ON THEN
LACK OF COOLING IN LOWER CARTER
(CERTANTY=HIGH, RELIABILITY=HIGH)

IF (“ **COOLING_SYSTEM_ON** “) IS ON AND
(“ **COOLING_SYSTEM_FAULT** “) IS ON THEN
LACK OF COOLING IN LOWER CARTER
(CERTANTY=VERY HIGH, RELIABILITY=HIGH)

IF (“ **COOLING_SYSTEM_ON** “) IS ON AND
(“ **LGB_OIL_TEMP** “) IS HIGH THEN
LACK OF COOLING IN LOWER CARTER
(CERTANTY=MEDIUM, RELIABILITY=HIGH)

IF (“ **COOLING_SYSTEM_ON** “) IS ON AND
(“ **LGB_COIL_DIRT_LEVEL** “) IS HIGH THEN
LACK OF COOLING IN LOWER CARTER
(CERTANTY=HIGH, RELIABILITY=HIGH)

<u>Lack of cooling in upper carter:</u>

IF (“ **COOLING_SYSTEM_ON** “)IS ON AND
(“ **UGB_LOW_WATER_FLOW** “) IS ON THEN
LACK OF COOLING IN UPPER CARTER
(CERTANTY=HIGH, RELIABILITY=HIGH)

IF (“ **COOLING_SYSTEM_ON** “) IS ON AND
(“ **COOLING_SYSTEM_FAULT** “) IS ON THEN
LACK OF COOLING IN UPPER CARTER
(CERTANTY=VERY HIGH, RELIABILITY=HIGH)

IF (“ **COOLING_SYSTEM_ON** “) IS ON AND
(“ **UGB_OIL_TEMP** “) IS HIGH THEN
LACK OF COOLING IN UPPER CARTER
(CERTANTY=MEDIUM, RELIABILITY=HIGH)

IF (“ **COOLING_SYSTEM_ON** “) IS ON AND
(“ **UGB_COIL_DIRT_LEVEL** “) IS HIGH THEN
LACK OF COOLING IN UPPER CARTER
(CERTANTY=HIGH, RELIABILITY=HIGH)

Lower carter oil leakage:

IF (“ **LGB_LOW_OIL_LEVEL** “) IS ON THEN
LOWER CARTER OIL LEKAGE
(CERTAINTY=HIGH, RELIABILITY=HIGH)

IF (“ **LGB_VERY_LOW_OIL_LEVEL** “) IS ON THEN
LOWER CARTER OIL LEKAGE
(CERTAINTY=VERY HIGH, RELIABILITY=HIGH)

IF (“ **LGB_METAL_TEMP** “) IS HIGH OR
(“ **LGB_OIL_TEMP** “) IS HIGH THEN
LOWER CARTER OIL LEKAGE
(CERTAINTY=MEDIUM, RELIABILITY=MEDIUM)

Upper carter oil leakage:

IF (“ **UGB_LOW_OIL_LEVEL** “) IS ON THEN
UPPER CARTER OIL LEAKAGE
(CERTAINTY=HIGH, RELIABILITY=HIGH)

IF (“ **UGB_VERY_LOW_OIL_LEVEL** “) IS ON THEN
UPPER CARTER OIL LEAKAGE
(CERTAINTY=VERY HIGH, RELIABILITY=HIGH)

IF (“ **UGB_METAL_TEMP** “) IS HIGH OR
(“ **UGB_OIL_TEMP** “) IS HIGH THEN
UPPER CARTER OIL LEAKAGE
(CERTAINTY=MEDUIM, RELIABILITY=MEDIUM)

Parasite current through lower guide bearing:

IF (“ **LGB_GASES** “) IS YES THEN

PARASITE CURRENT THROUGH LOWER GUIDE BEARING
(CERTAINTY=HIGH, RELIABILITY=MEDIUM)

IF (“ **GENERATOR_DIFFERENTIAL_PROTECT** “) IS ON OR
(“ **STATOR_GROUND_RELAY_PROTECT** “) IS ON OR
(“ **BAD_GROUNDING** “) IS YES OR
(“ **LGB_ISOLATION_VALUE** “) IS LOW THEN
PARASITE CURRENT THROUGH LOWER GUIDE BEARING
(CERTAINTY=HIGH, RELIABILITY=HIGH)

IF (“ **LGB_METAL_TEMP** “) IS HIGH THEN
PARASITE CURRENT THROUGH LOWER GUIDE BEARING
(CERTAINTY=MEDIUM, RELIABILITY=LOW)

Parasite current through upper guide bearing:

IF (“ **UGB_GASES** “) IS YES THEN
PARASITE CURRENT THROUGH UPPER GUIDE BEARING
(CERTAINTY=HIGH, RELIABILITY=MEDIUM)

IF (“ **GENERATOR_DIFFERENTIAL_PROTECT** “) IS ON OR
(“ **STATOR_GROUND_RELAY_PROTECT** “) IS ON OR
(“ **BAD_GROUNDING** “) IS YES OR
(“ **UGB_ISOLATION_VALUE** “) IS LOW THEN
PARASITE CURRENT THROUGH UPPER GUIDE BEARING
(CERTAINTY=HIGH, RELIABILITY=HIGH)

IF (“ **UGB_METAL_TEMP** “) IS HIGH THEN
PARASITE CURRENT THROUGH UPPER GUIDE EARING
(CERTAINTY=MEDIUM, RELIABILITY=LOW)

Babbit Metal wearing in upper guide bearing:

IF (“ **UGB_METAL_TEMP** “) IS HIGH THEN
BABBIT METAL WEARING IN UPPER GUIDE BEARING
(CERTAINTY=HIGH, RELIABILITY=HIGH)

IF (“ **UGB_FOREIGN_PART_ANALYS** “) IS YES THEN
BABBIT METAL WEARING IN UPPER GUIDE BEARING
(CERTAINTY=HIGH, RELIABILITY=HIGH)

IF (“ **UGB_VISIBLE_PART_PEEP_HOLES** “) IS YES THEN
BABBIT METAL WEARING IN UPPER GUIDE BEARING
(CERTAINTY=VERY HIGH, RELIABILITY=HIGH)

IF (“ **UGB_VIBR** “) IS HIGH THEN
BABBIT METAL WEARING IN UPPER GUIDE BEARING
(CERTAINTY=MEDIUM, RELIABILITY=HIGH)

Babbit Metal wearing in lower guide bearing:

IF (“ **LGB_METAL_TEMP** “) IS HIGH THEN
BABBIT METAL WEARING IN LOWER GUIDE BEARING
(CERTAINTY=HIGH, RELIABILITY=HIGH)

IF (“ **LGB_FOREIGN_PART_ANALYS** “) IS YES THEN
BABBIT METAL WEARING IN LOWER GUIDE BEARING
(CERTAINTY=HIGH, RELIABILITY=HIGH)

IF (“ **LGB_VISIBLE_PART_PEEP_HOLES** “) IS YES THEN
BABBIT METAL WEARING IN LOWER GUIDE BEARING
(CERTAINTY=VERY HIGH, RELIABILITY=HIGH)

IF (“ **LGB_VIBR** “) IS HIGH THEN
BABBIT METAL WEARING IN LOWER GUIDE BEARING
(CERTAINTY=MEDIUM, RELIABILITY=HIGH)

Water Leakage in lower carter:

IF (“ **LGB_HIGH_OIL_LEVEL** “) IS ON THEN
WATER LEAKAGE IN LOWER CARTER
(CERTAINTY=VERY HIGH, RELIABILITY=HIGH)

IF (“ **LGB_WATER_IN_OIL** “) IS YES THEN
WATER LEAKAGE IN LOWER CARTER
(CERTAINTY=VERY HIGH, RELIABILITY=HIGH)

Water Leakage in upper carter:

IF (“ **UGB_HIGH_OIL_LEVEL** “) IS ON THEN
WATER LEAKAGE IN UPPER CARTER
(CERTAINTY=VERY HIGH, RELIABILITY=HIGH)

IF (“ **UGB_WATER_IN_OIL** “) IS YES THEN
WATER LEAKAGE IN UPPER CARTER
(CERTAINTY=VERY HIGH, RELIABILITY=HIGH)

Breaking of coolant coil in lower carter:

IF (“ **LGB_HIGH_OIL_LEVEL** “) IS ON THEN
BREAKING OF COOLANT COIL IN LOWER CARTER
(CERTAINTY=HIGH, RELIABILITY=HIGH)

IF (“ **COOLING_SYSTEM_ON** “) IS ON AND
(“ **LGB_COIL_WAT_OUTLET_PRESS** “) IS LOW AND
(“ **UGB_COIL_DIRT_LEVEL** “) IS NORMAL THEN
BREAKING OF COOLANT COIL IN LOWER CARTER

(CERTAINTY=HIGH, RELIABILITY=HIGH)

Breaking of coolant coil in upper carter:

IF (“ **UGB_HIGH_OIL_LEVEL** “) IS ON THEN
BREAKING OF COOLANT COIL IN UPPER CARTER
(CERTAINTY=HIGH, RELIABILITY=HIGH)

IF (“ **COOLING_SYSTEM_ON** “) IS ON AND
(“ **UGB_COIL_WAT_OUTLET_PRESS** “) IS LOW AND
(“ **UGB_COIL_DIRT_LEVEL** “) IS NORMAL THEN
BREAKING OF COOLANT COIL IN UPPER CARTER
(CERTAINTY=HIGH, RELIABILITY=HIGH)

6. INTERFACES

6.1 OPERATOR INTERFACES

The operator interface is defined by the input and output data listed in the previous sections:

•Input:

- The user must be able to view and modify all input data.
- Also, the user must be able to define and modify the different types of cycles for the cyclic execution.
- The user must be able to define and modify the thresholds for the resulting certainty factors that will produce the triggering of an alarm in the monitoring system. So, the result of every incident must be defined and used in the DB as SCADA inputs.

• Output: The user must be able to view the list of possible incidents, related certainty factors and certainty labels. Also the list of possible causes for each incident, and justification of the deductions must be listed is the user requests it. This information must be displayed :

- When the user executes the function.
- When the user retrieves an alarm report or a certainty factor evolution graph.
- When the highest certainty incident is greater than its associated threshold (alarm detected).

The implementation of this function can be done in C or C++. This would allow us to incorporate to the program some libraries already implemented by IBERDROLA. We can also use an inference engine for the resolution of the rule handling and any tools to build the knowledge base and to fuzzyficate variables.

The simulation of the system for testing purposes can be done easily by including in the D.B. some historical incident data. So, the mechanisms to update the DB with simulation values must be provided by the system.

6.2 SYSTEM INTERFACES

The system interface will be the mentioned input and output files and the parameters given in the function call.

• The parameters will indicate the number of the function to be executed and the type of turbine (Pelton/Francis).

• The input file will contain the data listed in the input data section.
• The output file always contains the incidents, certainty factors of the incidents, labels associated with the certainty factors, lists of possible causes and justification of the deductions.
• The certainty factors must always be inserted into the DB by the system.
• The rest of the information must only be inserted when an alarm is detected.

So, the system must provide the way to access to the forecasting data stored in the DB to study the tendencies of the incidents.

7. ERROR MANAGEMENT

• Input data into normal limits (for analogic data it's specified in the fuzzy sets, for alarms 0/1).
• The resulting certainty accumulated or inferred from the application of any rule must be into normal values [0,1] during the inference process.
• Errors must be included in separate files/tables and identified by a key.
• Control null values or not existent (for a given period) in D.B.
• The tuning of the fuzzy sets and the adjusting of the certainty factors associated to each rule will be done according to the special conditions of the equipment in the plant.
• The grouping , partition or including of any rule could be done while testing if the results are not the most accurate to the working conditions of the plant, so the system must be flexible in this aspect.
• All kind of error signals from the computer must be captured in the function.

8. CONSTRAINTS

The only time constraint is the availability of data into the D.B. for the chosen period of time. This means that the process for the data gathering from SCADA must insert data into the D.B. almost continuously (with a sample rate to determine)

9. HARDWARE AND SOFTWARE REQUIREMENTS

The mentioned above for the building of the Knowledge Base and the inference engine, C,C++ (Borland), Oracle, PC architecture, Windows-NT.

10. TEST PLAN

The testing of this function will be specified in the WP6 IBERDROLA documents for the Adaptation and Experimentation Specifications of the System.

Some of the features we will try to test are the following:

- Control of incorrect input data.
- To prove that for a set of symptoms related to an incident the probability of the incident is high enough.
- To prove that for a set of symptoms related to an incident the probability of the incident is higher than the rest (conclusion is clear).
- To prove that for a set of symptoms related to several incidents the probability is higher for the all the incidents implicated.
- To prove that for a set of symptoms indicating normal working there are not high probability values for any incident.
- To prove that exists any symptoms set that returns a high probability for a given incident.
- To prove that the fuzzyficated symptoms describe precisely the existence of a fault in that item.