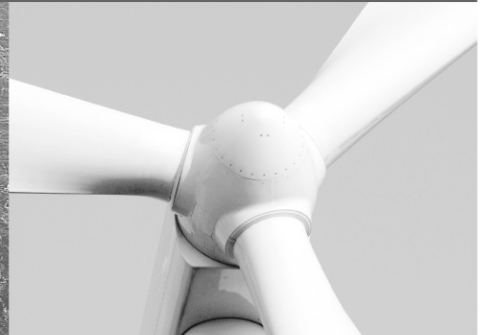




-power in control



MULTI-LINE 2 APPLICATION NOTES



Generator Paralleling Controller, GPC-3 Hydro Special Software

- Description of features
- Functional description



DEIF A/S · Frisenborgvej 33 · DK-7800 Skive
Tel.: +45 9614 9614 · Fax: +45 9614 9615
info@deif.com · www.deif.com

Document no.: 4189341005B
SW version 4198000368

Table of contents

1. ABOUT THIS DOCUMENT	3
GENERAL PURPOSE.....	3
CONTENTS/OVERALL STRUCTURE	3
2. WARNINGS AND LEGAL INFORMATION	4
LEGAL INFORMATION AND RESPONSIBILITY	4
ELECTROSTATIC DISCHARGE AWARENESS.....	4
SAFETY ISSUES.....	4
WARNINGS AND NOTES	4
3. DESCRIPTION OF FUNCTIONS.....	5
GPC-3 HYDRO SOFTWARE 4198000368	5
NEEDED OPTIONS	6
PC PROGRAMMING SOFTWARE	6
4. FUNCTIONAL DESCRIPTION, SOFTWARE 4198000368.....	7
SYSTEM OVERVIEW	7
FAST WATER LEVEL CONTROL.....	8
WATER LEVEL-DEPENDENT START/STOP	10
RELAY SETTINGS.....	12
D-PART FOR RELAY CONTROL	12
FREQUENCY CONTROL, SECONDARY PARAMETERS	13
GOVERNOR ON/PERIOD TIME, SECONDARY SETTING	14
INVERSE PROPORTIONAL GOV/PID OUTPUT	14
GOVERNOR OUTPUT RAMP FUNCTIONS.....	15
RPM REGULATION	16
PROPORTIONAL VALVE CONTROL	17
STOP FUNCTIONS	19
M-LOGIC ADDITIONS.....	21

1. About this document

This chapter includes general user information about this document, concerning the general purpose, the intended users and the overall contents and structure.

General purpose

This document is an application note for DEIF's Generator Paralleling Controller, the GPC. The document mainly includes functional descriptions for the application in question.

Contents/overall structure

The application note is divided into chapters, and in order to make the structure of the document simple and easy to use, each chapter will begin from the top of a new page. The following will outline the contents of each of the chapters.

About this document

This first chapter includes general information about this document. It deals with the general purpose of the application notes. Furthermore, it outlines the overall contents and structure of the document.

Warnings and legal information

The second chapter includes information about general legal issues and safety precautions relevant in the handling of DEIF products. Furthermore, this chapter will introduce note and warning symbols, which will be used throughout the document.

Application description

These chapters will include functional descriptions of the standard functions as well as illustrations of relevant application types. Diagrams and single-line representations will be used in order to simplify the information.

2. Warnings and legal information

This chapter includes important information about general legal issues relevant in the handling of DEIF products. Furthermore, some overall safety precautions will be introduced and recommended. Finally, the highlighted notes and warnings, which will be used throughout this document, are presented.

Legal information and responsibility

DEIF takes no responsibility for installation or operation of the generator set. If there is any doubt about how to install or operate the generator set controlled by the unit, the company responsible for the installation or the operation of the set must be contacted.

The units are not to be opened by unauthorised personnel. If opened anyway, the warranty will be lost.

Electrostatic discharge awareness

Sufficient care must be taken to protect the terminals against static discharges during the installation. Once the unit is installed and connected, these precautions are no longer necessary.

Safety issues

Installing the unit implies work with dangerous currents and voltages. Therefore, the installation should only be carried out by authorised personnel who understand the risks involved in working with live electrical equipment.



Be aware of the hazardous live currents and voltages. Do not touch any AC measurement inputs as this could lead to injury or death.

Warnings and notes

Throughout this document a number of notes and warnings will be presented. To ensure that these are noticed, they will be highlighted in order to separate them from the general text.

Warnings



The warnings indicate a potentially dangerous situation which could result in death, personal injury or damaged equipment, if certain guidelines are not followed.

Notes



The notes provide general information which will be helpful for the reader to bear in mind.

3. Description of functions

GPC-3 Hydro software 4198000368

The special hydro software gives, when compared to the standard software, the following additional functions:

- Fast water level control based on a 4-20 mA water level measurement using a separate PID controller for the purpose.
- 6 configurable level switches with free selection of the related analogue input, intended for a.o. water level based automatic start and stop.
- Expanded scaling of the regulators and start time for better adjustability.
- Derivative part added to relay control output for speed/frequency/power control.
- 2 parameter sets for frequency control, for example one for synchronising (no load) and one for single generator island mode (load applied).
- 2 sets of governor ON time and PERIOD time, for example for switching between settings for synchronising (no load) and for single generator island mode (load applied).
- Inverse proportional analogue output for speed governor and PID in case of dump load control of turbine generator speed.
- RPM regulation, to be used if generator frequency is not available (excitation OFF).
- Selection between relay control, analogue output control and proportional valve control of turbine speed.
- Activating stop button during start sequence will interrupt the start and stop the turbine
- Stop coil output does not activate between start attempts.
- M-Logic added features for hydro turbine control.



Unlike standard software, the special 4198000368 software cannot be downloaded from the internet. Contact DEIF to obtain the software.



If you require the functions of the special 4198000368 software, it must be specified when ordering. Failing to do so will give you the standard GPC-3 software which does not contain the above functions.

Needed options

The option M4 (prime mover/engine interface) is required for water level, RPM control and start/stop sequences. If you interface to a proportional valve for speed control, the option E1 is required. All other options can be chosen as needed.

PC programming software

The PC utility software (USW-3) is a special variant, which has to be required specifically. Before installing it, the standard USW-3 must be installed. This can be downloaded from www.deif.com.

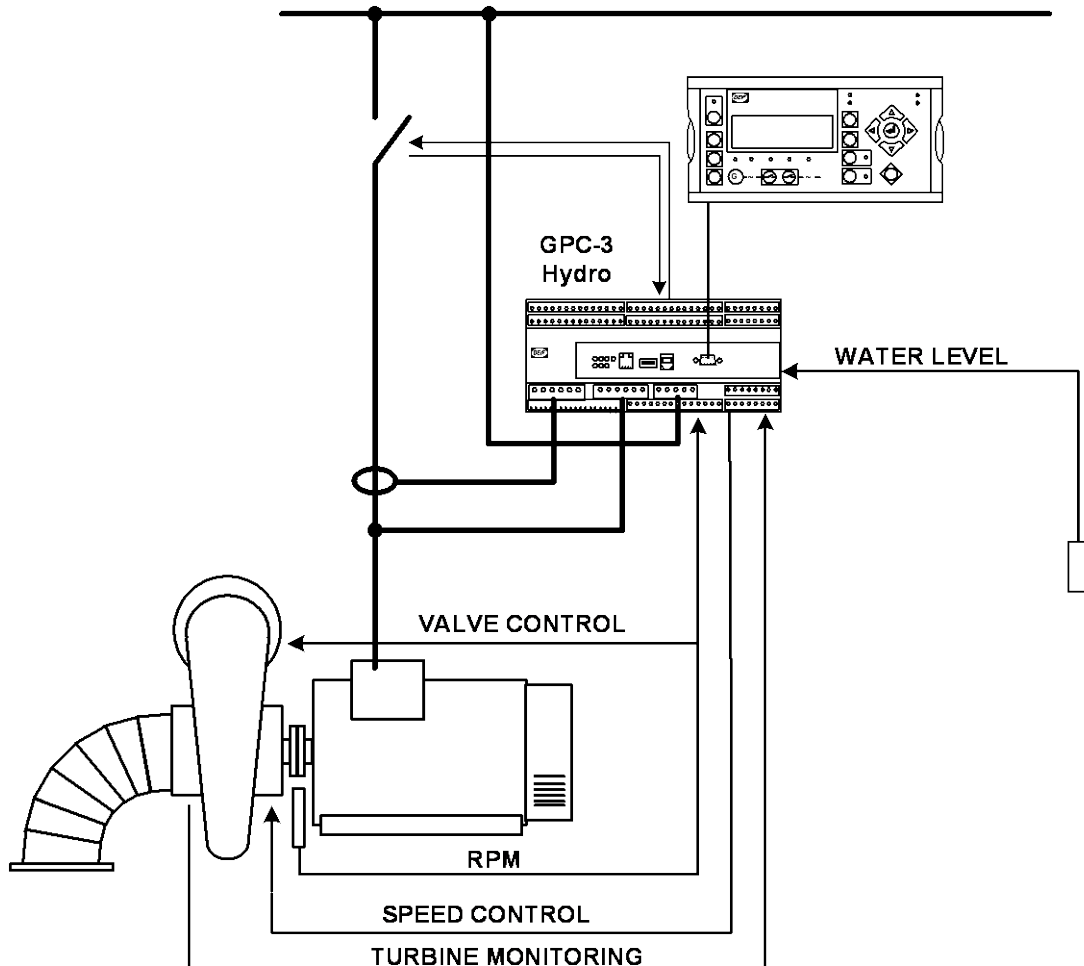


**Unlike standard USW, the special USW for 4198000368 cannot be downloaded from the internet. Contact DEIF to obtain the USW software.
The standard USW is not capable of handling the special features for hydro.**

4. Functional description, software 4198000368

System overview

The system is intended for a hydro turbine-driven generator set.



The GPC Hydro will:

- Measure AC values (voltages, frequency, currents, power, power factor etc.)
- Measure water level
- Measure turbine RPM using magnetic pickup
- For synchronous generator: synchronise the generator to grid, with voltage matching (option D1)
- For asynchronous generator: adjust RPM to nominal speed and close the breaker
- Carry out generator protections
- Carry out mains grid failure protections (dependent on options chosen)
- Display values and alarms

Fast water level control

The water level control for a hydro turbine can be carried out in 2 ways:

- Slow for lakes and ponds with large surfaces. This is described in the hydro power application note for GPC-3 Hydro
- Fast for small surface reservoirs. This is described below.



If “slow” water level is needed (large pond or lake), please refer to the document “GPC-3 Hydro appl. notes Start-stop seq. – water level ctrl 4189340647 UK”.

Water level input

The water level sensor must provide a 4-20 mA signal, the range is freely selectable.

Any analogue input present can be used, in this example it is the first multi-input on the M4 option.

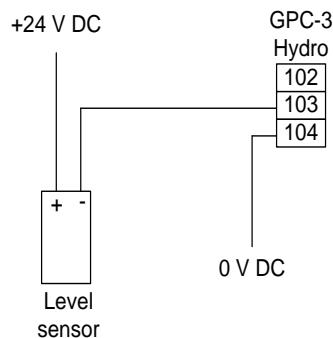
Setting up the multi-input:

- 1) If multi-input is used: select input type 4-20 mA (setting 10980 for multi-input 102)
- 2) To reach a better scale of the input: select and enable two decimals (setting 11010 for multi-input 102).
- 3) Upload the parameter list again to get settings for 4-20 mA inputs available.
- 4) Select scaling for the input (setting 4120 in PC Utility Software for multi-input 102).
Click the dots on either side of the slider to change measuring range:



- 5) Set up water level alarms if needed (settings 4120 and 4130 for multi-input 102).

Connections:



Separate PID controller

The separate PID controller can be used for water level dependent power control.

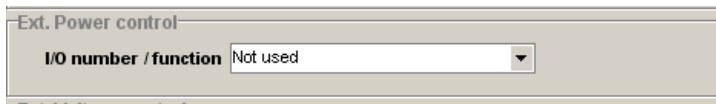
The basic function is that the PID controller output is used to manipulate the fixed power set point of the GPC-3.

This means that if fixed power without water level control is required at some point, the power set point needs to be checked to see if it matches required power output.

Alternatively, the analogue input for fixed power (0-10 V DC = 0-100 %) can be used.

This input is on terminals 41 (Gnd) and 42 (+ signal).

The input needs to be activated. This can be done by selecting binary input “external power control” in the input/output settings:

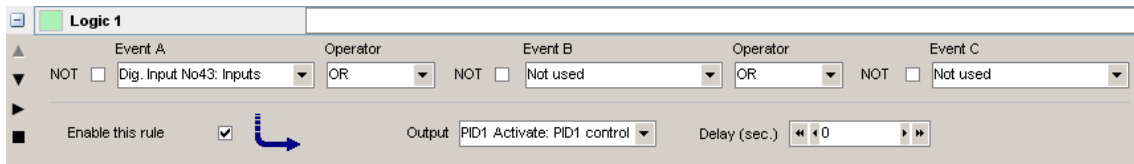


or via M-Logic:

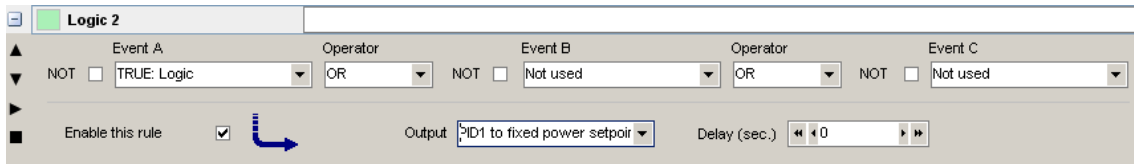
- Fixed P
- P load sharing
- Frequency droop
- **Ext. GOV set point**
- Start sync./control enable
- Force Dynamic sync
- Force Static sync

The PID controller is activated in M-Logic. In this example, a binary input is used for the purpose.

When the “PID1 to fixed power” is deactivated, then the fixed power set point will return to the value it was at the moment where the “PID1 to fixed power” was activated.



The output of the PID controller must be for power set point (PID1 to fixed power set point):



Parameters

The following set points are used for fast water level control:

Parameter	Function	Notes
7051	Fixed power set point (active power)	Is being manipulated by PID 1
2784	PID reg output type	Selection of analogue or relay output
2821	PID input selection	Selection of analogue input used for water level control
2822	PID minimum	Min. and max. defines the working range of the PID controller
2823	PID maximum	
2824	PID reference	
2825	PID offset	
2831	Reg 1 Kp (Proportional factor)	These settings are only available if “analogue” is chosen in parameter 2784
2832	Reg 1 Ti (Integrator time)	
2833	Reg 1 Td (Derivative time)	
2841	Reg 1 DB (deadband)	These settings are only available if “relay” is

2842	Reg 1 Kp (Proportional factor)	chosen in parameter 2784
2843	Reg 2 Td (Derivative time)	
2851	PID relay ON time	These settings are only available if "relay" is chosen in parameter 2784
2852	PID relay period time	
2853	PID relay Increase relay output	
2854	PID relay Decrease output	



When used for fast water level, the setting 2784 must be set "to analogue".

Water level-dependent start/stop

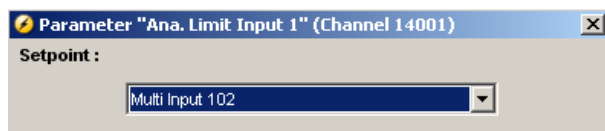
The water level start/stop control is based on the built-in analogue limit switches and the M-Logic function.

There are 6 analogue limit switches.

In the following, limit switch #1 (start) and #2 (stop) are used.

In this example, the limit switch refers to multi-input 102.

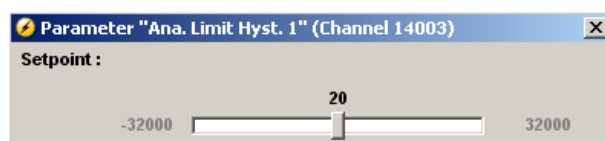
Input:



Limit setting (the value relates to the scaled value of multi input 102)



Hysteresis (reset of limit switch)



Start/stop logics

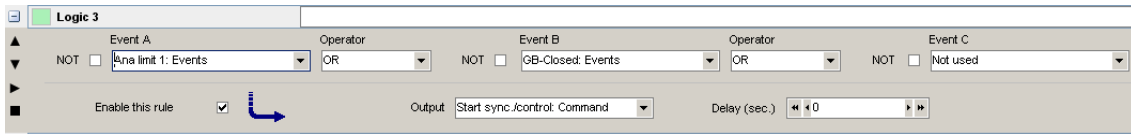
Once the start and stop limit switches are made, the M-Logic control needs to be made.

The following functions are based on the unit being in REMOTE AUTO control.

START:

If the water level rises above the start limit value, the command "start sync/control" must be set.

The command must remain, also if the water level sinks below the start level. This is obtained by looking at the breaker feedback (feedback ON="start sync/control" ON).



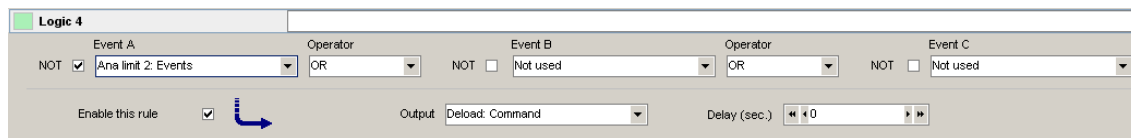
Use the delay to prevent flicker if needed.

STOP:

If the water level sinks below the stop limit value, the turbine must be stopped.

This is obtained by:

- Setting the command “de-load” to take the power down and open the breaker.
- When the breaker is open, set “start sync/control” to OFF.



The turbine is now stopped and waiting for the water level to be high enough to start again.



Event A is set to “not” Ana. Limit 2. This is due to the fact that the analogue limit switches are always triggering on “high” signal. Use the delay to prevent flicker if needed.

Parameters

The following set points are used for analogue limit switches:

14000 Limit switch #1

Parameter	Function	Notes
14001	Ana Limit 1 Input selection	Multi-inputs (option M4) or 4-20 mA inputs (option M15)
14002	Ana Limit 1 limit	These settings relate to the scaling made for the input in question. If Pt100 input is used, the setting range is limited to -49...+482 °C
14003	Ana Limit 1 Hysteresis	
14004	Ana Limit 1 Output	Relay output selection

Settings for limit switch #2 to #6 are identical:

- 14010 Limit switch #2
- 14020 Limit switch #3
- 14030 Limit switch #4
- 14040 Limit switch #5
- 14050 Limit switch #6

Relay settings

For relay speed control, the following settings have been changed:

Relay kP

Due to the slow reaction of a hydro turbine when using relay outputs, the original GPC-3 Hydro settings for Kp values (0—100) may not be sufficient, since it only gives you 100 steps to select.

For that reason, the relay Kp values are changed to 0-10000. The impact (amplification) remains the same, which means that the new range of 0-10000 gives the same amplification as the old range (0-100). Only the resolution is improved.

Starter ON time (relay output)

The starter output is used to open the control valve in steps until the regulation takes over (running state reached). To do this, it has been necessary to increase the resolution of the starter ON time from 1 s to 0.1 s.

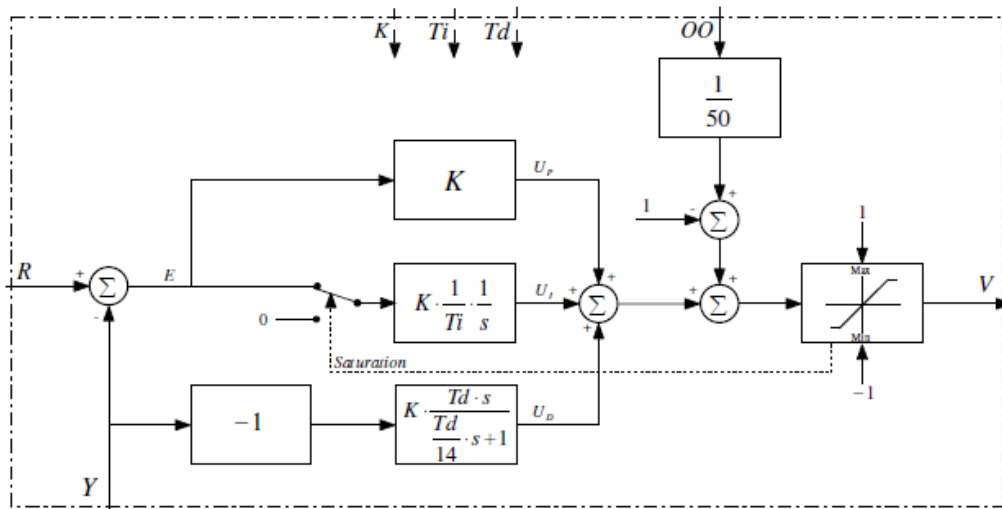
Parameters

Parameter	Function	Notes
2051	F Sync Kp Relay	
2071	Phase Kp Relay	
2091	RPM Sync Kp Relay	
2572	F Kp Relay	
2582	P Kp Relay	
2592	P LS Kp Relay	
6183	Starter ON time	

D-part for relay control

In order to overcome the slow reaction of the turbine and the following “overshoot”, especially during acceleration, a D- part has been added to relay control.

Function block diagram





Only changes in the actual value are differentiated, not reference value change.

Relation to dead band

Dead band handling remains. This means that if a dead band is set and the actual value is within the dead band, output activation is OFF, even if a D-part action is required.

In the synchronising phase, dead band is always OFF.

Parameters

The D-part relates to the following parameters:

Parameter	Function	Notes
2050	Dynamic synchronisation	
2070	Static synchronisation	
2090	RPM sync (asynchronous generator)	
2570	Frequency	
2580	Power	
2590	load share	
2823	Td setting for PID 01	Fast water level



Derivative time Td scaling is 0...20.00 sec. If set to 0, the D-part is ignored.

Frequency control, secondary parameters

A secondary parameter set for frequency regulation is added. The parameter set is activated when the GCB feedback indicates a closed GCB and deactivated when GCB feedback indicates an open GCB.

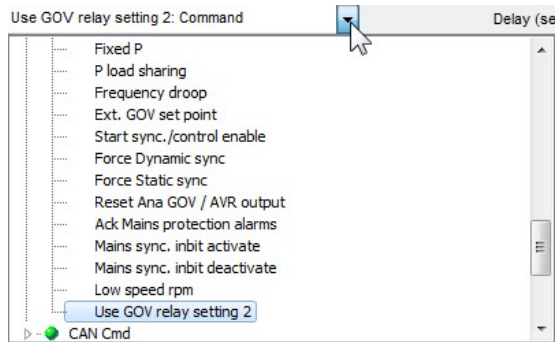
This function can be used to change the behaviour of the frequency regulation when load is added to the generator, which is different from the behaviour during idle running.

Parameters

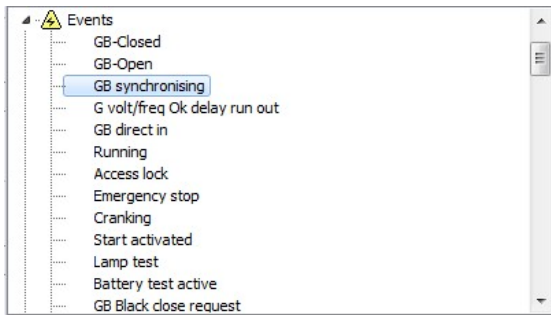
Parameter	Function	Notes
2521	f Kp Parallel	Min 0 Max 40
2522	f Ti Parallel	Min 0 s. Max 120 s.
2523	f Td Parallel	Min 0 s. Max 30 s.

Governor ON/Period time, secondary setting

By use of M-Logic, it is possible to jump between *GOV on time*/*GOV period time* and *GOV on time 2*/*GOV period time 2*.



As an example, the feature can be used if another setting is needed for the governor configuration during synchronising of GCB:



Or if a longer *GOV on time* is needed to make a better change over between spear valve 1 and spear valve 2, when running in fixed power mode on a Turgo or Pelton turbine.

Parameters

Parameter	Function	Notes
2604	GOV on time 2	Min 10 ms. Max 6500 ms.
2605	GOV period time 2	Min 250 ms. Max 32500 ms.

Inverse proportional GOV/PID output

Parameters

Parameter	Function	Notes
5981	Governor output	
5691	PID output	

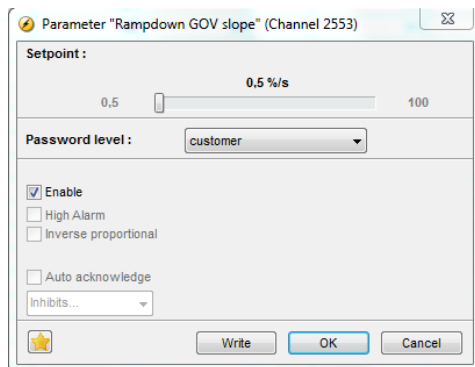
Governor output ramp functions

Governor output ramp up and down of analogue signal function can be used to open and close the guide vane of a turbine during the start and stop sequences.

Governor output ramp down

Parameter 2553 "Ramp down GOV slope" is the slope of the ramp down curve. A higher value of the slope means the closing speed of the guide vane will be increased.

To activate the ramp down function, the "Ramp down GOV slope" must be enabled.

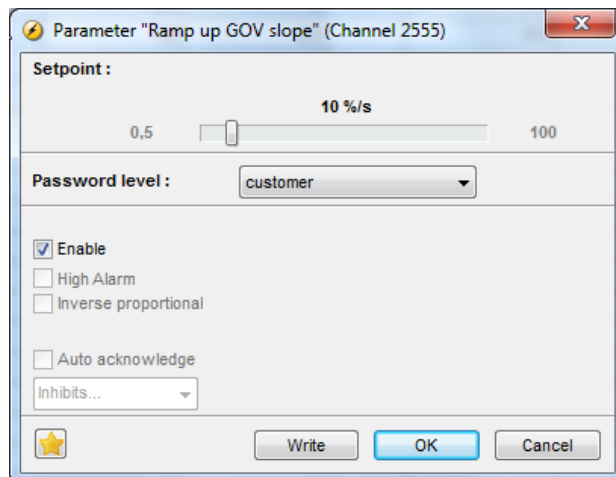


Governor output ramp up

Parameter 2554 "Ramp up GOV offset" is the start value GOV output where the ramp up function is started.

Parameter 2555 "Ramp up GOV slope" is the slope of the ramp up curve. A higher value of the slope means the opening speed of the guide vane will be increased.

To activate the ramp up function, the "Ramp up GOV slope" must be enabled.



Parameters

Parameter	Function	Notes
2553	Ramp down GOV slope	Min 0.5 %. Max 100 %.
2554	Ramp up GOV offset	Min 0 %. Max 100 %.
2555	Ramp up GOV slope	Min 0.5 %. Max 100 %.

RPM regulation

From M-Logic, it is possible to switch on/off the RPM regulation.

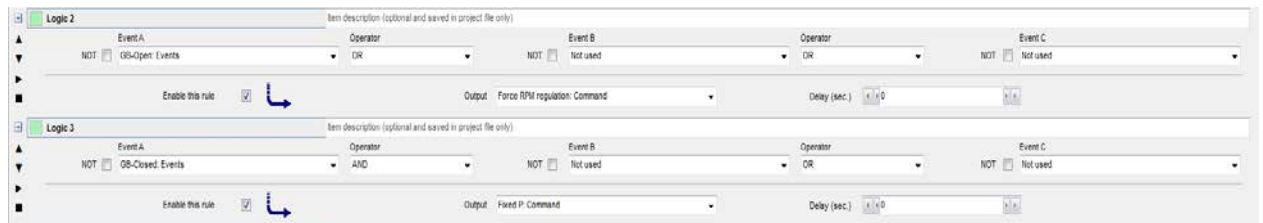
Option M4 is needed in the configuration, and a magnetic pick-up MPU must be connected to MPU input.

The RPM regulation will become active when the run signal appears, and the governor will regulate to obtain the nominal RPM.

When synchronisation of the GCB is started, the governor will jump into frequency regulation.

Example:

The GB-open: Event is used to force on the RPM regulation. As soon as the GCB is synchronised and closed, the RPM regulation is off. Fixed power or fixed frequency can now be selected as a regulation mode.



When using Fixed RPM regulation, please consider to activate parameter 4550 "MPU wirebreak" as a shutdown and parameter 4540 "Run feedback fail" as a shutdown too.

Parameters

Parameter	Function	Notes
2081	RPM Sync Kp	For analogue output
2082	RPM Sync Ti	
2083	RPM Sync Td	
2091	RPM Sync Kp rel	For relay output
2092	RPM Sync Td rel	

Proportional valve control

A proportional valve is an electrically controlled analogue hydraulic valve, common in the hydraulic industry for any purpose where position control takes place. The valve has (in principle) 2 magnetic coils, moving the valve in the “opening” or “A” direction or the “closing” or “B” direction.

The centre position equals closed valve.

As an example, if the turbine is a Francis, typically a hydraulic cylinder is used to move the wicket gate position. The cylinder movement is controlled by the proportional valve.

The output (option E1, E2 (0(4)-20 mA only), EF2 or EF4) from the ML-2 product is used to control the opening % of the proportional valve. This means:

- Activating the “A” coil (50...100 % output) moves the wicket gate (turbine regulation valve) in the opening direction.
- Activating the “B” coil (50...0 %) moves the wicket gate in the closing direction.
- Not activating any coil (50 % output, centre of range) keeps the wicket gate in the present position.

So:

- If the turbine actual speed/power is in balance with the needed power, the wicket gate should not move. Output signal 50 %.
- If the turbine actual speed/power is too low, the wicket gate must be moved in the opening direction. Output signal > 50 %
- If the turbine actual speed/power is too high, the wicket gate must be moved in the closing direction. Output signal < 50 %

The degree of opening of the proportional valve is proportional with the analogue signal (hence the name “proportional”), and thereby the rate (or speed) of opening of the wicket gate is proportional with the mA signal.

Or in other words:

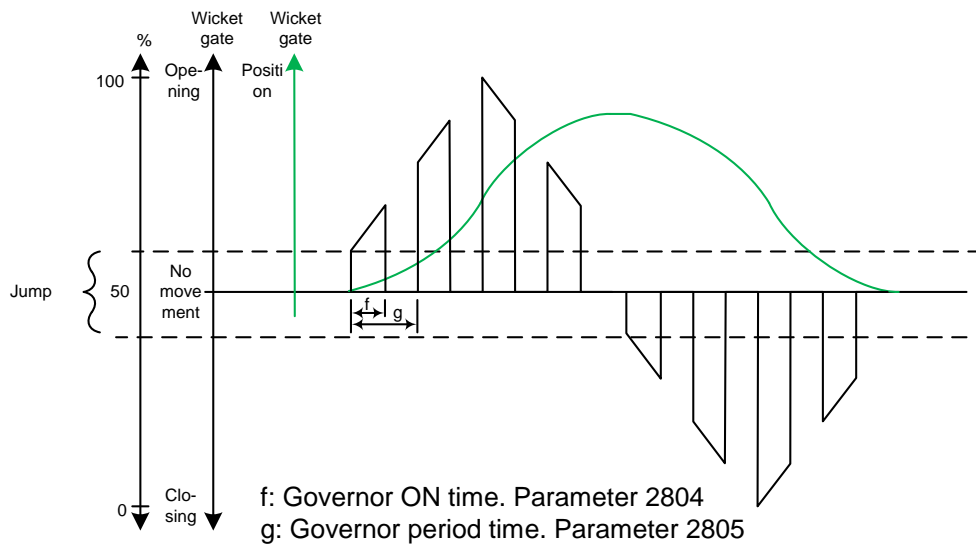
50 % (Centre of output range): no change of wicket gate opening.

Close to 50 %: slow change of wicket gate opening.

Far away from 50 %: fast change of wicket gate opening.

If an analogue signal like 0 – 20 mA or 4 – 20 mA is required to the proportional valve, then option E2 can be used as a hardware configuration of the ML-2 product. The GOV output offset (parameter 2551) must be set to 50 % and the AOUT Limit must be set to either 4 mA and 20 mA or 0 mA and 20 mA as minimum and maximum.

Furthermore, to overcome possible “sticking” of the proportional valve, a certain mA output must be given to start the movement of the proportional valve. This value, “Jump” must be equal to or bigger than the needed mA to make the valve move.



Parameters

Parameter	Function	Notes
2511	Kp	Standard setting
2513	Td	Standard setting
2515	Dead band	+ / %
2801	Proportional valve ON/OFF	Function ON/OFF
2802	Jump	+ mA
2803	Jump	- mA
2804	GOV On time	
2805	GOV period time	

The deadband is comparable to the relay control deadband, for example if frequency or power is within the deadband, no action will be taken. Deadband is 0 for synchronising.

The jump value relates to the % output, minimum % change output in either direction to make the proportional valve move

Selecting proportional valve ON activates the function. Selecting OFF gives you the standard analogue output.

The GOV ON time and GOV period time is to configure the PWM signal of the analogue output.

Stop functions

Stop function

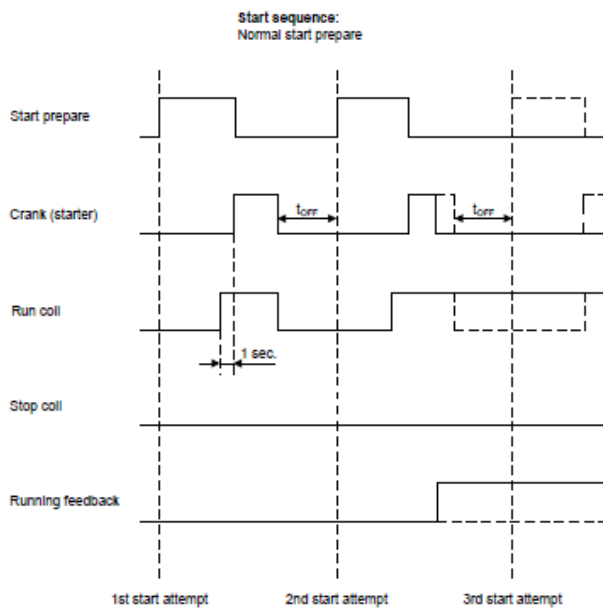
The stop button makes it possible to enter the stop sequence. When the stop button in front of the display is pushed, when in Local Mode, the extended stop sequence is activated even if the stop button is pushed before the Run signal has appeared.

Stop coil

To make it possible to use the stop coil relay from option M4 to stop the turbine (close the guide vane or the spear valves), the stop coil relay is not energised between the start on pulses.

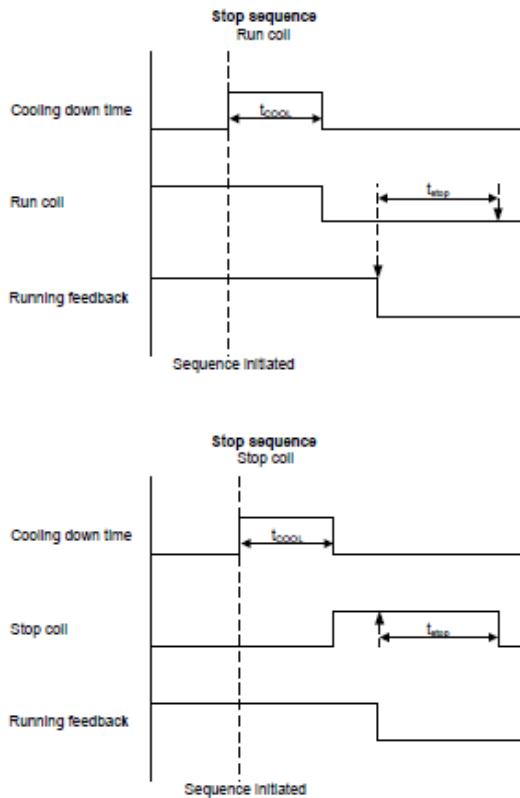
The stop coil relay will always be energised after the last start pulse if the run signal does not appear and also in case a failure class is activated.

The stop coil is activated as long as the extended stop timer is active.



Stop sequence

The drawings illustrate the stop sequence.



Stop sequence, description

The stop sequence will be activated if a stop command is given. The stop sequence includes the cooling down time if the stop is a normal or controlled stop.

Description	Cooling down	Stop	Comment
Remote mode stop	X	X	Deactivate "Start sync./control" to stop or activate "Remote stop"
Stop button on display	X	X	Local mode
Trip and stop alarm	X	X	Alarm sequence
Emergency stop		X	GB opens and engine shuts down

"tstop" is the extended stop time (parameter 6212). The value of the timer must be high enough to be sure that the guide vane or spear valves always reach the fully closed position when the stop sequence is activated.



The cooldown time function can be eliminated by setting the value of parameter 6211 to 0 sec.

M-Logic additions

Governor UP/DOWN events (relay control)

“Governor up activated” and “governor down activated” feedback can be selected as an event in M-Logic. This can be used when doing an M-Logic configuration to control spear valves without digital end stop feedbacks. On some turbine applications, the feedback from the spear valves is based on a spear valve DC motor over-current feedback measurement.

When combining a current measurement with the feedback, an “end stop reached” function can be made to stop the attempt to move the valve further in the direction in question.

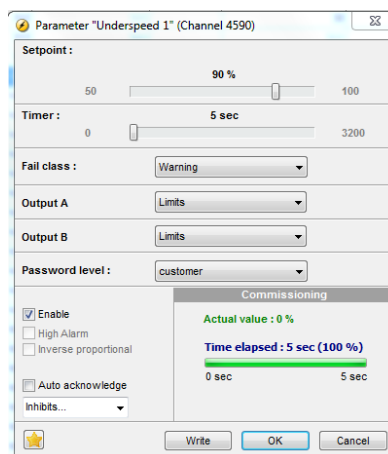
Freeze AVR output command

If the generator voltage regulator (AVR) is turned on/off by use of the GPC-3 hydro, then the M-Logic offers an opportunity to select when the AVR regulation must become active.

The following example shows an M-Logic configuration where relay 57 is used to switch on/off the AVR depending on the turbine speed. The AVR regulation in the GPC-3 Hydro is deactivated until the AVR is activated. “Freeze AVR output” will eliminate the risk of generator voltage overshooting when the AVR is activated.



The time delay before switching the AVR off again is determined by the value of the timer in parameter 4590 (Under-speed).



DEIF A/S reserves the right to change any of the above.