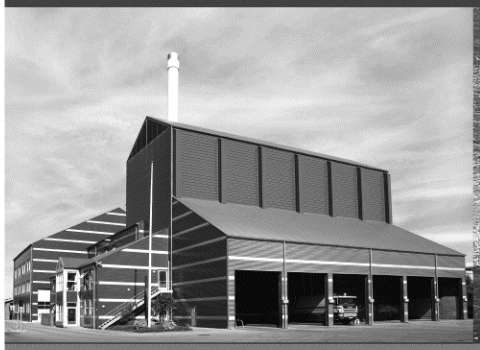
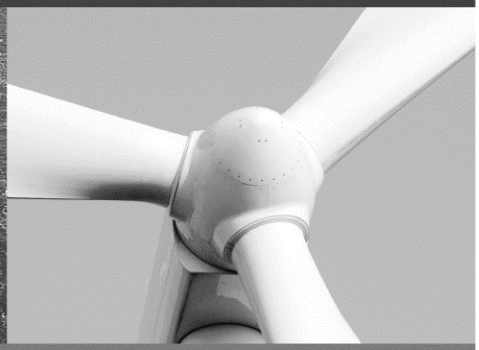
DEIF

-power in control

CE

MULTI-LINE 2
APPLICATION NOTES





Generator Paralleling Controller, GPC-3 Hydro
Start and stop sequences, water level control

- Application description
- Needed options
- Wiring diagrams
- 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.: 4189340647B
SW version 3.0X.X or later

Table of contents

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.

Definitions

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.

Notes

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

Warnings

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

3. Application description

System overview

This document describes how to configure a GPC 3 Hydro for control of a Francis or Kaplan turbine generator with one speed control valve/wicket gate, controllable by relay output UP/DOWN signals. This means that Kaplan turbines with pitch and wicket gate control are not included.

For a Pelton turbine, an example with four nozzles is included.

Also included is control of a main shutoff/bypass valve, but no drain or fill valves.

This application note only covers the functionalities specific for a hydro turbine. For standard functions and options, please refer to the relevant documentation.

The system can be operated manually, semi-automatically or automatically.

Start and stop turbine

The GPC will control the start and stop of the turbine. This is done automatically or controlled by the operator.

Speed control

It is anticipated that speed control is carried out using relay outputs for speed increase/decrease (open/close valve(s)).

If analogue speed control is needed, electronic potentiometers (EPQ96-2) can be used to convert the relay signals to analogue.

Synchronise generator

Synchronisation of the breaker is done automatically, or it can be controlled by the operator.

Fixed power operation

The genset will use internal set point or analogue input for remote set point reference. The analogue input control is activated via a digital input. The signal is 0 to 10 V_{dc} = 0 to 100 % load.

Water level control with automatic start and stop

The genset produced power will be dependent on the level of the water reservoir. Decreasing water level => decreasing generator power. If the water level sinks below “stop level” value, the generator will be stopped. Restart will take place automatically when the water level has risen above the “start level” value.

Needed options

The GPCs must be equipped with the following options in order to carry out the controls and protection described in this application note:

- Option D1 to carry out power factor and voltage synchronisation control (for synchronous generator)
- Option M4 to carry out turbine start/stop and protection

All other available options can be applied as requested. Attention must be paid to governor (AVR) interface and required protections.

Please refer to the data sheet for specific information about the possible options selection.

Digital input settings

Besides the usual settings for AC values (voltage, current, power and so on), a number of settings for inputs and M-Logic are needed to obtain the correct functionality. These settings are listed below.

The factory setting of digital input functions do not match a hydro turbine and must therefore be changed:

In the PC utility software (USW), the input settings are selected by clicking the  icon in the top horizontal row of icons. You now have a list of selections and need to set the following:

Function	Input	Function	Input
Shutdown override	Not used	Deload	Not used
Remote start	Not used	SWBD control	Not used
Remote stop	Not used	Alarm inhibit 1	Dig. input 23, term. 23
Remote GB on	Not used	Start sync/contr	Not used
Remote GB off	Not used	Local mode	Not used
Remote alarm ack.	Dig. input 24, term. 24	Remote mode	Not used
Remove starter	Not used	Fixed frequency	Not used
Reset ana gov output	Not used	P Load sharing	Not used
Man Gov UP	Not used	Fixed P	Not used
Man Gov Down	Not used	Frequency droop	Not used
Man AVR UP	Not used	Ext. Gov set point	Not used
Man AVR Down	Not used	Fixed U	Not used
Manual mode	Not used	Q load sharing	Not used
Battery test	Not used	Fixed Q	Not used
GB close inhibit	Not used	Fixed PF	Not used
Low speed	Not used	Voltage droop	Not used
Enable GB black close	Not used	Ext. AVR set point	Not used
Binary running detection	Not used	Start enable	Not used
Access lock	Not used	GB spring loaded	Not used

Functions Deload and Start sync/contr are controlled via M-Logic. Please refer to chapter 5.

Some of the "Not used" may be set to an input if the function is required.

Safe stop alarm

Since a turbine does not stop like a diesel engine (stops immediately when fuel supply is removed), the "Safe stop" fail class function is needed. The "Safe stop" is capable of taking the power off the generator, opening the breaker and stopping the turbine in order to prevent overspeed by tripping the generator breaker (fail class "Trip" or "Trip and stop" or "Shutdown").

This is obtained by:

Setting the alarms in question to "Safe stop" as fail class.

When triggered, the safe stop will deload the generator, open the breaker and stop the turbine.

4. General setup

Relay parameters

- All relays used for speed/excitation control must be set to “Limit”, and the related timers to 0.
- Relays 121 (start) and 123 (stop) are not configurable.

Start timing

The start (crank) on timer setting (parameter 6183) is used for the initial opening of the control valve/guide vane/wicket gate/nozzle (which is dependent on the turbine type). This timer setting must be set so that the turbine starts spinning, but does not overspeed. The time can only be determined by testing. This may be combined with the setting “Remove starter” (parameter 6174).

Stop timing

Stopping of the turbine is based on closing the control valve/wicket gate/nozzle(s) to make the turbine come to a complete stop. The main valve will close also. This is timed based on

1) Using the stop (stop coil) output to close valves
2) Using the RPM input to see if the turbines have stopped
3) Using the “Extended stop time” (parameter 6212) to hold the stop output long enough to make sure that valve/gate/nozzle(s) are really closed.

Magnetic pickup

A pickup connected to terminals 100-101 is needed to detect the turbine speed. This is essential for the setting of the excitation speed output (excitation ON).

Excitation speed

The excitation speed output can be made using the running detection setting (parameter 6173) and then selecting a relay in the run status setting (parameter 6160).

Main valve/deflector

If a main valve and/or deflector is present, it may be controlled via M-Logic:

If no shutdown/trip alarms are present and start input is activated: Open main valve/disengage deflector.

If shutdown/trip alarm is present or start input is not activated: Close main valve/engage deflector.

Water level-dependent running

If water level is measured, this can be used for control of start, stop and output power.

Start

The start water level can be set using one of the two alarm levels present for each analogue input. Combine this with an M-Logic line activating the “Start sync/contr” to start the turbine and synchronise.

Stop

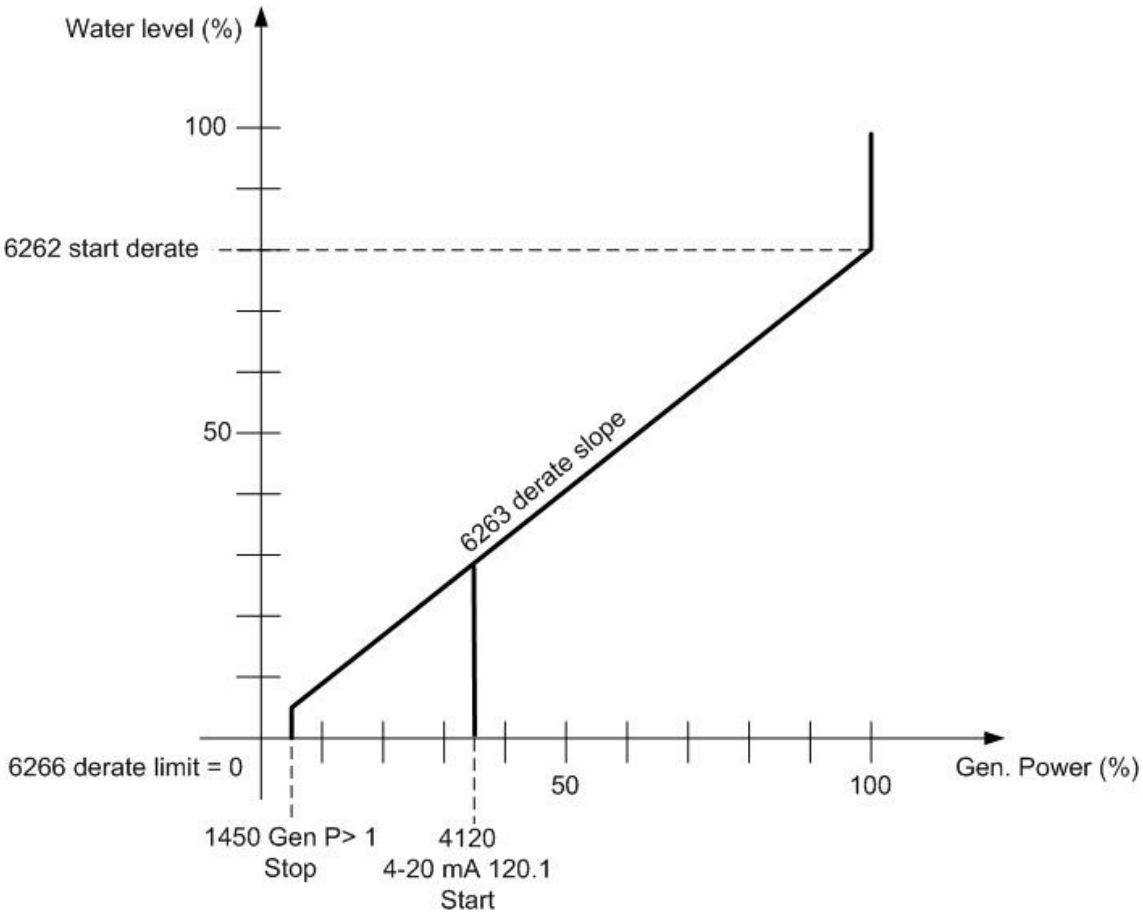
The stop point can be made with the other alarm level for the water level input in question, but in order to save this for a low level alarm/shutdown, it is better to use one of the overload alarms (parameters 1450 to 1490) where the setting range is -200...0...+200 % load. Remove the “high alarm” tick box setting to make the alarm trigger on a low value.

Water level-dependent power

To make the generator output power be dependent on the water level, the power derate function can be used (parameter 6260).

This function creates a straight line relation between an analogue input value and generator power output.

Example, start, stop and water level dependent power:



The turbine will start at water level 35 % and stop at generator power 5 %. 100 % output is reached when the water level reaches 80 %.

Set parameter 6264 proportional to ON (increase power by increasing signal).

Parameter 6263 derate slope is set in %(P)/mA.

The example uses multi-functional input 120 set to 4 to 20 mA, and the alarm no. 1 (120.1) to start the generator and generator overload 1, set to low alarm, to stop the generator.

Parameter 6266 derate limit is set to 0 % (power).

5. M-Logic settings

M-Logic is used to create functions otherwise not obtainable. The settings are done via the PC utility software.

Water level-dependent start/stop with main valve control

The following inputs are used:

Digital input 25:	AUTO start command
Digital input 52:	Main valve open/deflector disengaged
Multi-input 120 alarm 120.1:	Water level for start

Logic 15:
Set start sync/control (activates regulators), based on digital input 25.

Logic 16:
When start activates (no matter why), the open main valve command is set. Here it is important to note that the first part of start, the start prepare, must have a timer run (setting 6168) that is longer than the time it takes to open the main valve to ensure that the main valve is open before the start sequence commences.

The relay 5 is used in this example to control the main valve. The logic holds the main valve open until the cooling time starts. Here the cooling time (setting 6211) can be set to 1 sec., the detection is only there to break the self-hold of relay 5.

Logic 17:
Monitors that the main valve actually opens when the command is set. If no start is active, or if terminal 54 is ON, the alarm inhibit 2 is activated. This can be used for digital input 54 alarm (setting 3220) inhibit, so that it only triggers if the start sequence is in progress. The alarm timer must be set to the same value as for start prepare (logic 16). The alarm must be set to “not high alarm” (high alarm tick box not ticked off).

Logic 18:
REMOTE start based on water level. The logic 18 only triggers if the unit is in REMOTE control, that is if the operator selects LOCAL, logic 18 is ignored. In this example, the water level limit is set in alarm 102.1. Remember to set outputs A and B to “Limit”, otherwise an alarm will be triggered.

Logic 19:
REMOTE stop based on generator low power output. This can also be based on an analogue input limit, for example Alarm 102.2. Remember to set outputs A and B to “Limit”, otherwise an alarm will be triggered.


Logic 15
AUTO regulators ON
Event A
Operator
Event B
Operator
Event C
NOT
Dig. Input No25: Inputs
OR
NOT
Not used
OR
NOT
Not used
Enable this rule
Output
Start sync./control: Comman
Delay (sec.)
0
Logic 16
Open main valve and hold (main valve opening time must be lower than start prepare (setting 6168))
Event A
Operator
Event B
Operator
Event C
NOT
Start activated: Events
OR
NOT
Relay 5: Relays
AND
NOT
Cool down active: Events
Enable this rule
Output
Relay 5: Relays
Delay (sec.)
0
Logic 17
Main valve open monitoring: Inhibit 2 blocks input 52 alarm (setting 3220) = mains valve not open)
Item description (optional and saved in project file only)
Event A
Operator
Event C
NOT
Start activated: Events
OR
NOT
Dig. Input No52: Inputs
OR
NOT
Not used
Enable this rule
Output
Inhibit 2: Inhibits
Delay (sec.)
0
Logic 18
REMOTE start on water level high
Event A
Operator
Event B
Operator
Event C
NOT
Remote: Modes
AND
NOT
Multi input 102.1: Limits
OR
NOT
Not used
Enable this rule
Output
Remote start and close GB:
Delay (sec.)
0
Logic 19
REMOTE stop on water level low (power output low)
Event A
Operator
Event B
Operator
Event C
NOT
G P> 1: Limits
AND
NOT
Remote: Modes
AND
NOT
Running: Events
Enable this rule
Output
Remote open GB and stop: C
Delay (sec.)
0

M-Logic for Pelton turbine

The Pelton turbine control is in this example for a turbine with four nozzles arranged in cascade (activates one by one).

The following is assumed for control of four nozzles with increase/decrease relay speed signals to the nozzles:

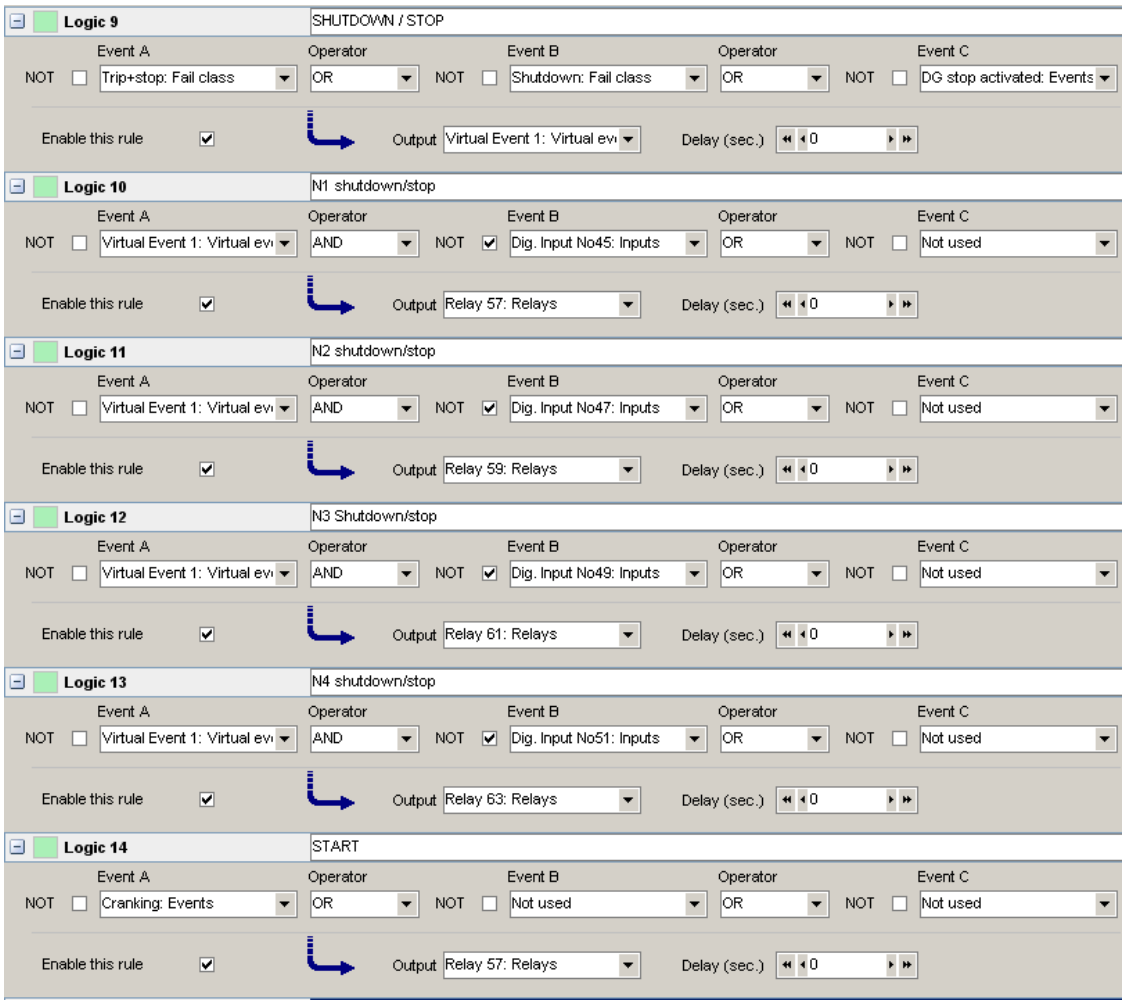
Relay	Function
57	Activate nozzle 1
59	Activate nozzle 2
61	Activate nozzle 3
63	Activate nozzle 4
65	Speed increase
67	Speed decrease

Dig IN	Function
44	Nozzle 1 open feedback
45	Nozzle 1 closed feedback
46	Nozzle 2 open feedback
47	Nozzle 2 closed feedback
48	Nozzle 3 open feedback
49	Nozzle 3 closed feedback
50	Nozzle 4 open feedback
51	Nozzle 4 closed feedback

The M-Logic setup for four nozzle Pelton turbine can be seen on the next page.

Cascade control outputs for Pelton turbine

Stop and start control outputs for Pelton turbine

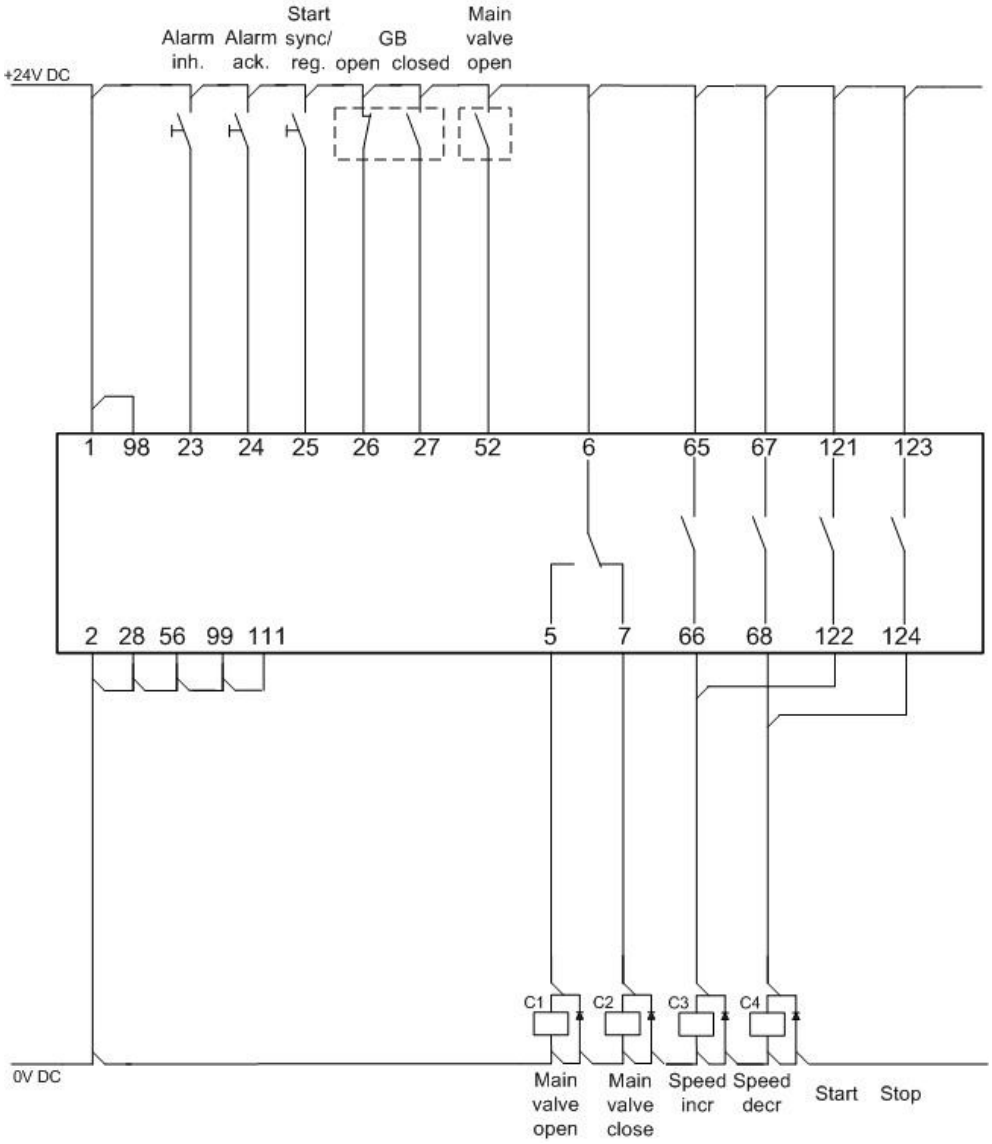


6. Wiring

These wirings only comprise the DC lines. The AC lines are described in the GPC installation instructions.

The wiring shows the necessary control circuits to carry out the task. It is assumed that all controls (except breaker commands) are carried out using 24 V_{dc}.

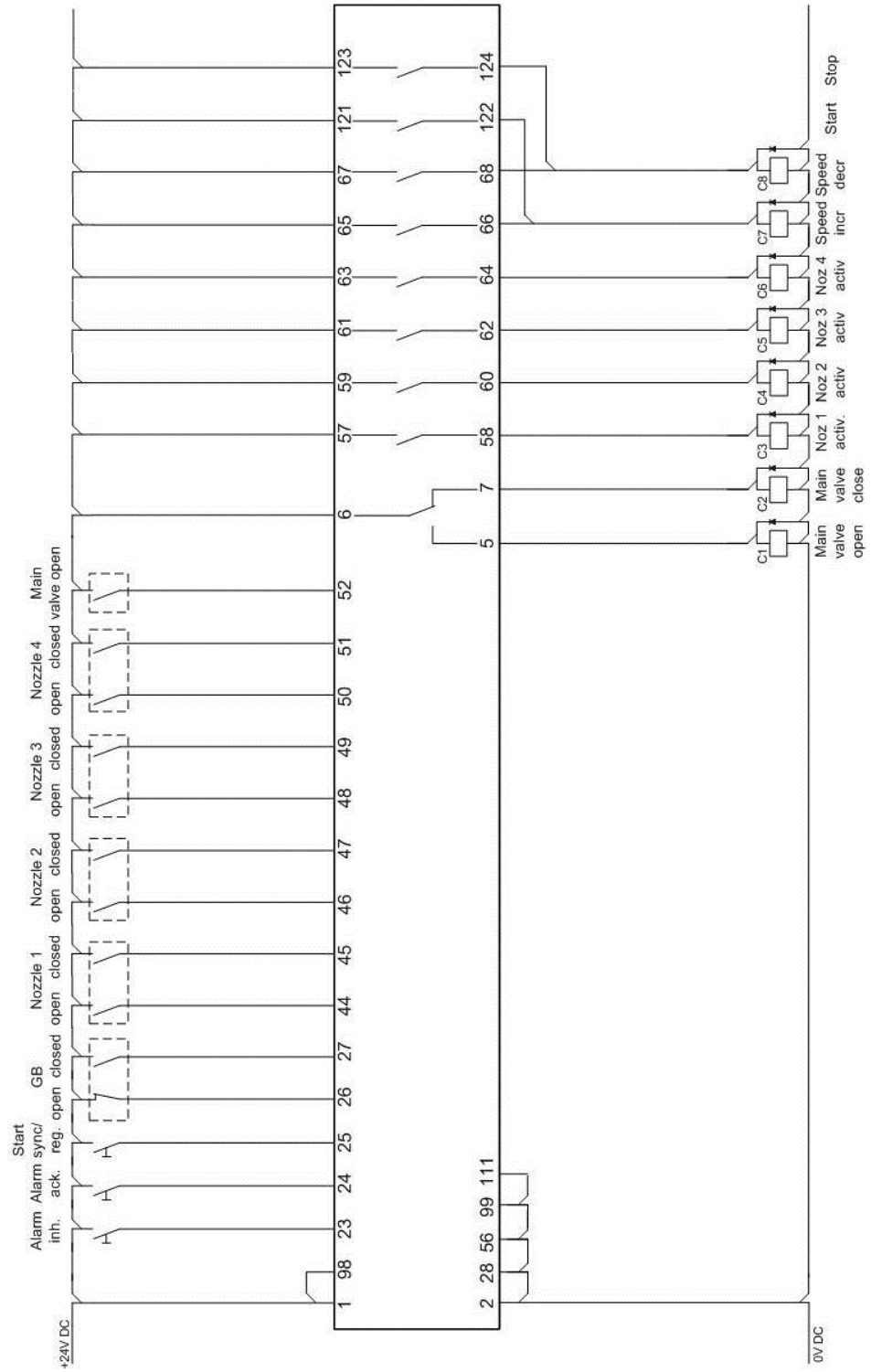
Francis/Kaplan turbine plant control wiring

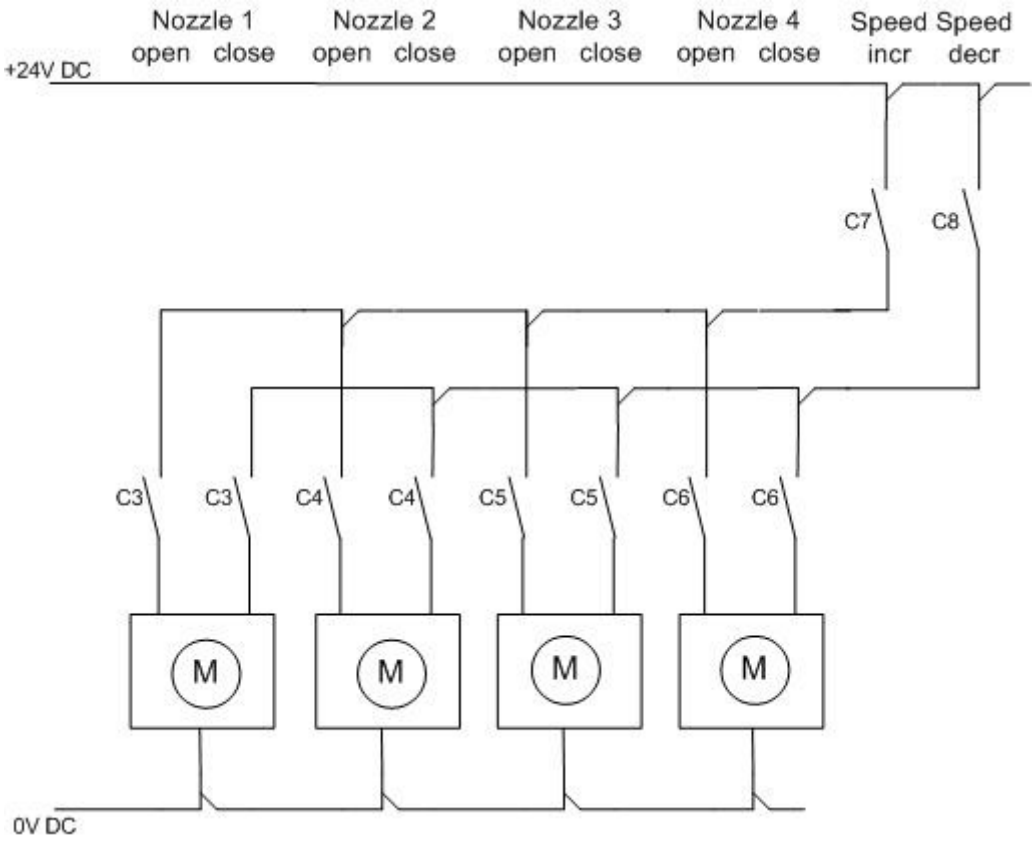


For Kaplan turbine: The relation between turbine wicket gate (guide vane) opening and runner pitch is not controlled by the GPC.

Pelton turbine plant control wiring

The wiring is mainly to enable the cascade control made in M-Logic to operate, distributing the signals between the nozzles.





In the above example, the four nozzles are driven by 24 V_{dc} pilot motors. The drive can also be 230 V_{ac} motors or hydraulic pilot valves for hydraulically controlled nozzles. The important thing is to choose relays, whose contacts can carry the voltage/current needed.