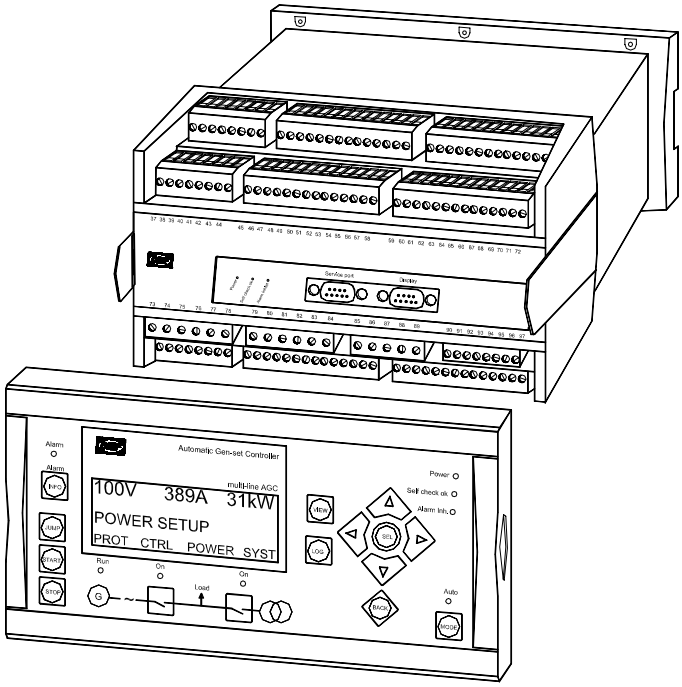
General Guidelines for Commissioning

Multi-line 2 – version 2

4189340317C



- *Settings check*
- *Governor check*
- *AVR check*
- *Protections check*
- *Adjustment*
- *Troubleshooting*

DEIF A/S

***DEIF A/S**, Frisenborgvej 33*
DK-7800 Skive, Denmark

Tel.: +45 9614 9614, Fax: +45 9614 9615
E-mail: deif@deif.com, URL: www.deif.com

Table of contents

1. About this document

General purpose

This document includes general guidelines for commissioning of DEIF's multi-line 2 units. It mainly includes instructions for settings, governor, AVR and protections check and unit adjustment. The general purpose of the document is to supply general guidelines to be used in the commissioning of the multi-line 2.

Please make sure to read this handbook before working with the multi-line 2 controller and the gen-set to be controlled. Failure to do this could result in damage to the equipment or human injury.

Intended users

These guidelines are mainly intended for the person responsible for the commissioning of the unit. In most cases, this would be a commissioning engineer.

Contents/overall structure

The General Guidelines for Commissioning 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.

2. Warnings and legal information

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.

Warning

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

3. Commissioning of the multi-line 2

Step by step

The illustration below indicates the overall steps to be followed in order to carry out a successful commissioning of the multi-line 2 unit.

Step 1	Settings check
Step 2	Governor check
Step 3	AVR check
Step 4	Protections check
Step 5	Adjustment

In addition, the generic troubleshooting in chapter 9 can be used.

4. Settings check

Settings

It is necessary to perform a settings check. This is done following five individual steps:

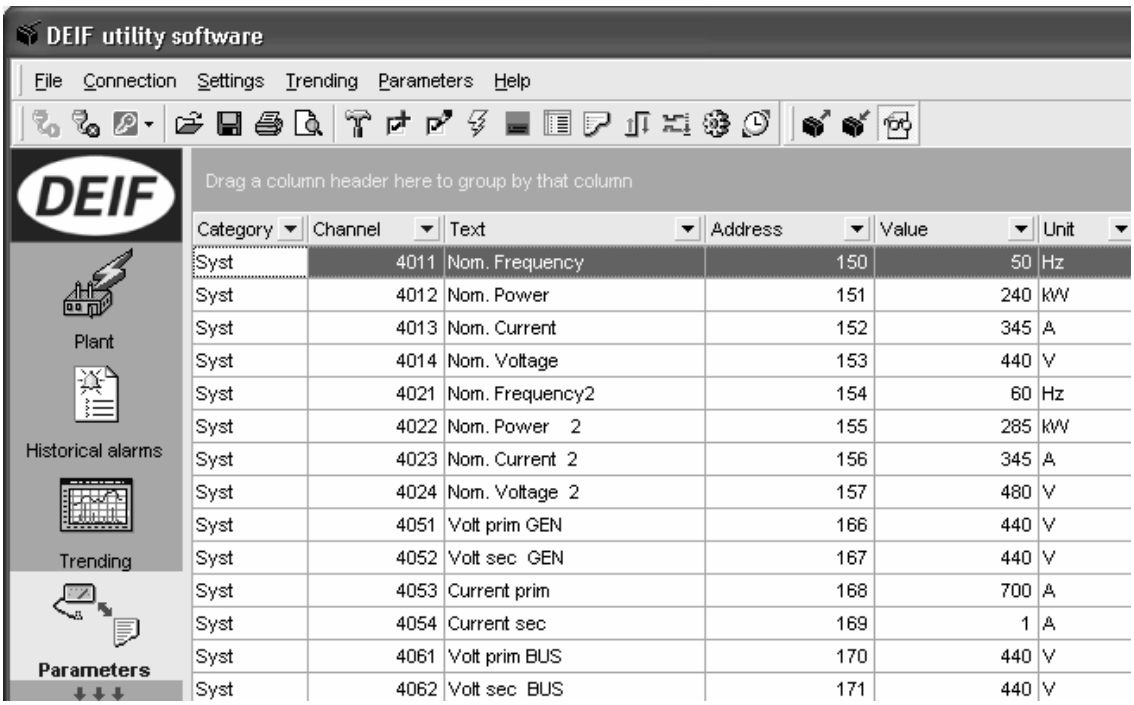
1. Check and adjust the nominal settings.
2. Check and adjust the alarm settings.
3. Check and adjust the function control settings.
4. Check and adjust the speed controller settings.
5. Check and adjust the voltage controller settings.

The above-mentioned settings must be checked and adjusted prior to the initial starting of the gen-set.

The settings can be adjusted either through the display or through the PC utility software. For navigating in the menus see the Operator's Manual.

Nominal values

The nominal values of the multi-line 2 are adjusted in the system setup menu.

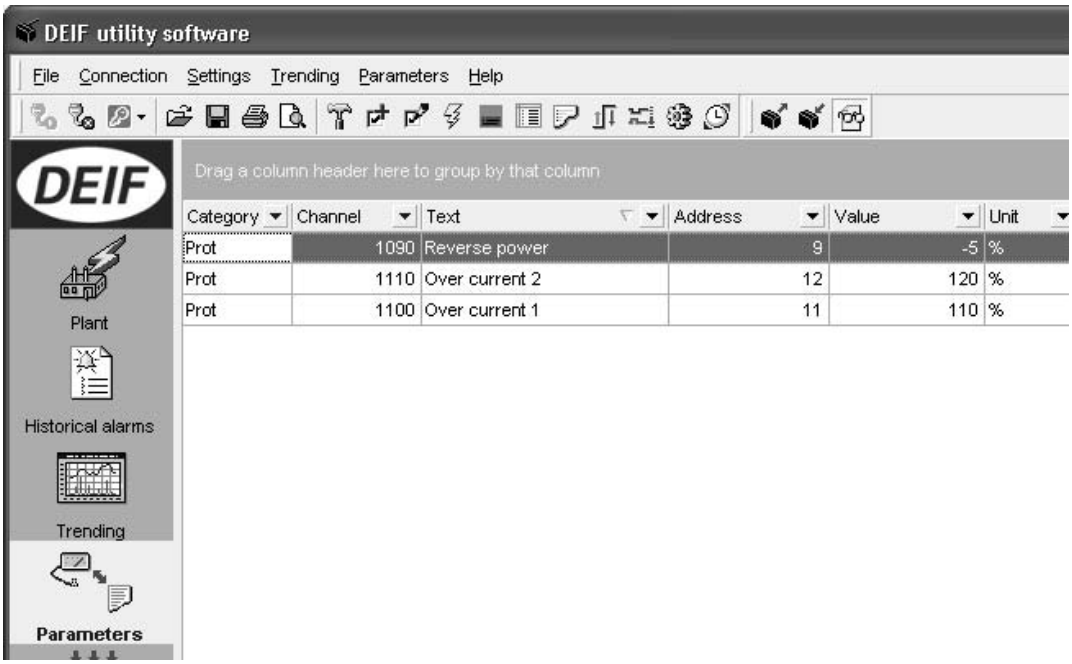


Category	Channel	Text	Address	Value	Unit
Syst	4011	Nom. Frequency	150	50	Hz
Syst	4012	Nom. Power	151	240	kW
Syst	4013	Nom. Current	152	345	A
Syst	4014	Nom. Voltage	153	440	V
Syst	4021	Nom. Frequency2	154	60	Hz
Syst	4022	Nom. Power 2	155	285	kW
Syst	4023	Nom. Current 2	156	345	A
Syst	4024	Nom. Voltage 2	157	480	V
Syst	4051	Volt prim GEN	166	440	V
Syst	4052	Volt sec GEN	167	440	V
Syst	4053	Current prim	168	700	A
Syst	4054	Current sec	169	1	A
Syst	4061	Volt prim BUS	170	440	V
Syst	4062	Volt sec BUS	171	440	V

In the PC utility software it is presented as illustrated on the screen dump above. The correct values are supplied by the switchboard manufacturer.

Alarm settings

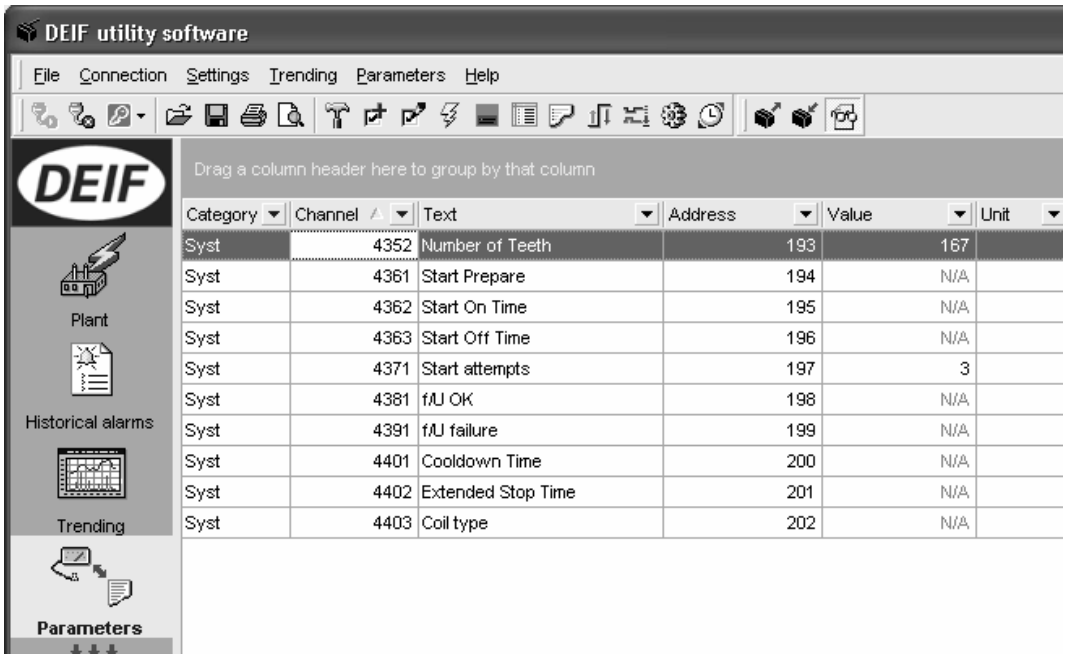
The alarm settings are adjusted in the protection setup menu.



In the PC utility software it is presented as illustrated on the screen dump above or similar. The screen dump includes the protection alarms of the standard multi-line 2. The number of alarms depends on the options selection of the individual unit. The actual alarm parameters are adjusted according to customer requirements and application requirements.

Function control settings

The function control settings are adjusted in the system setup and the power setup menu.



In the screen dump above, the adjustments for the start and stop sequences are illustrated. Since the function control settings include parameters for the entire functionality of the multi-line 2, they

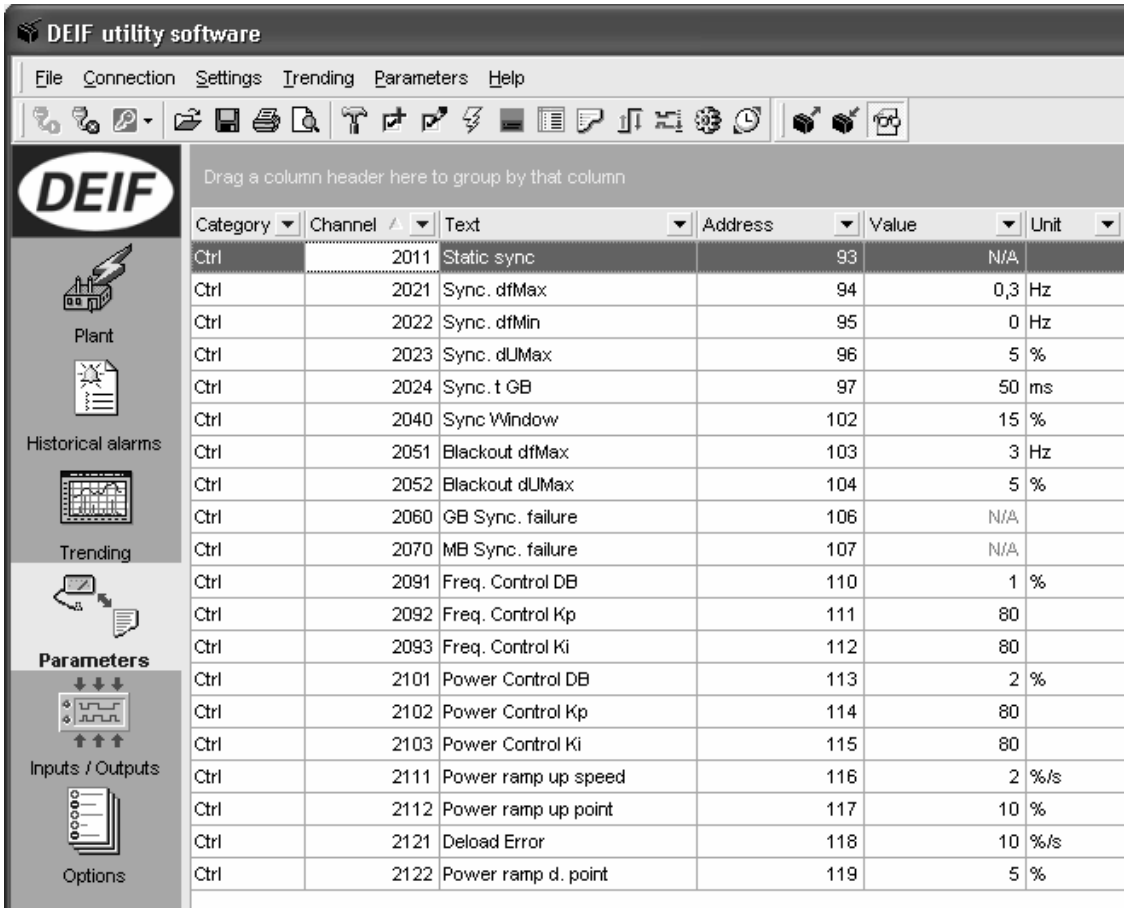
must be stepped through carefully. The function control settings are adjusted according to the desired unit control.

In need of detailed information about the requirements, contact the switchboard manufacturer.

Speed controller settings

The multi-line 2 speed controller settings are adjusted in the control setup menu.

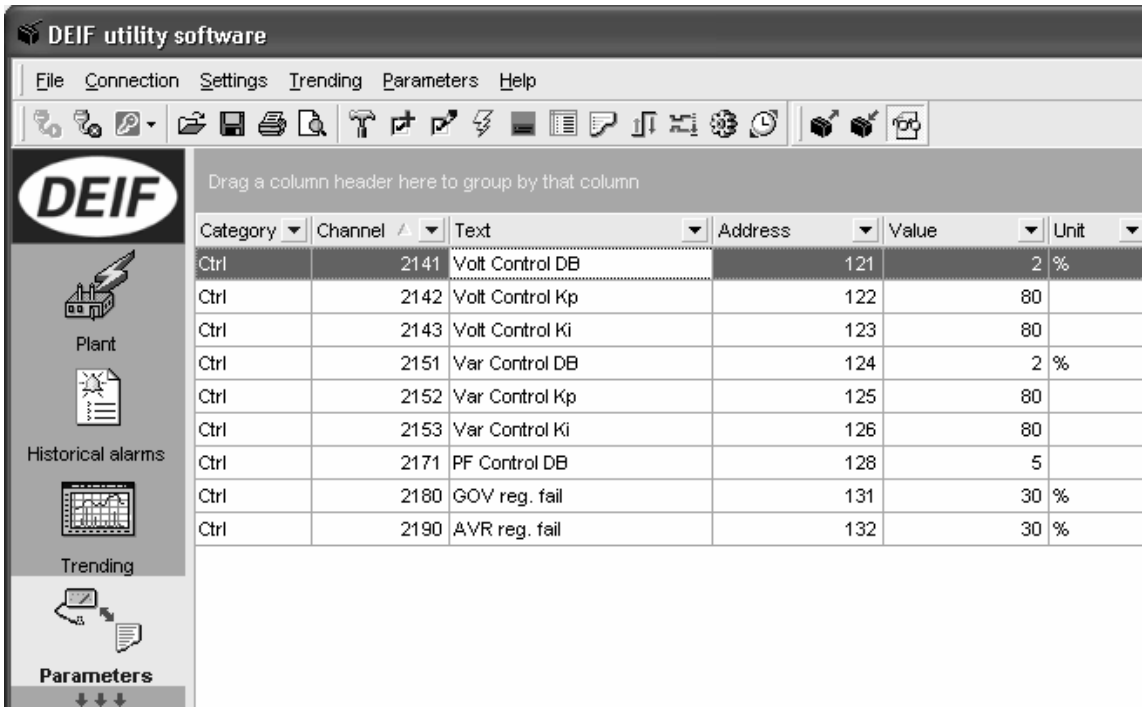
The screen dump below illustrates the controller settings related to the speed governor. As an initial setting before the first start up, the K_P and K_I of the frequency and power controllers are set to a low value.



Category	Channel	Text	Address	Value	Unit
Ctrl	2011	Static sync	93	N/A	
Ctrl	2021	Sync. dfMax	94	0,3	Hz
Ctrl	2022	Sync. dfMin	95	0	Hz
Ctrl	2023	Sync. dUMax	96	5	%
Ctrl	2024	Sync. t GB	97	50	ms
Ctrl	2040	Sync Window	102	15	%
Ctrl	2051	Blackout dfMax	103	3	Hz
Ctrl	2052	Blackout dUMax	104	5	%
Ctrl	2060	GB Sync. failure	106	N/A	
Ctrl	2070	MB Sync. failure	107	N/A	
Ctrl	2091	Freq. Control DB	110	1	%
Ctrl	2092	Freq. Control Kp	111	80	
Ctrl	2093	Freq. Control Ki	112	80	
Ctrl	2101	Power Control DB	113	2	%
Ctrl	2102	Power Control Kp	114	80	
Ctrl	2103	Power Control Ki	115	80	
Ctrl	2111	Power ramp up speed	116	2	%/s
Ctrl	2112	Power ramp up point	117	10	%
Ctrl	2121	Deload Error	118	10	%/s
Ctrl	2122	Power ramp d. point	119	5	%

Voltage controller settings

The voltage controller settings are adjusted in the control setup menu.



Category	Channel	Text	Address	Value	Unit
Ctrl	2141	Volt Control DB	121	2	%
Ctrl	2142	Volt Control Kp	122	80	
Ctrl	2143	Volt Control Ki	123	80	
Ctrl	2151	Var Control DB	124	2	%
Ctrl	2152	Var Control Kp	125	80	
Ctrl	2153	Var Control Ki	126	80	
Ctrl	2171	PF Control DB	128	5	
Ctrl	2180	GOV reg. fail	131	30	%
Ctrl	2190	AVR reg. fail	132	30	%

The screen dump above illustrates the controller settings of the voltage and var controller. As an initial setting before the first start up, the K_P and K_I of the voltage and var controllers are set to a low value.

5. Governor check

Even if the engine manufacturer has adjusted the governor, it is necessary to carry out the following adjustments to be sure that the multi-line 2 can successfully operate with the speed governor.

The governor should be tuned in according to the governor/engine manufacturer's instructions. It is important that the engine is able to run smoothly and without hunting before the control function of the multi-line 2 is activated.

Speed setting

An initial speed setting must be made.

The speed setting procedure depends on the interfacing.

Relay output

- Disable the outputs from the multi-line 2.
- Run the generator with no load (open generator breaker).
- Adjust the frequency (on the speed governor) to be base frequency (50 or 60Hz).

Analogue output

The analogue output is a +/- 20mA signal which in most cases must be converted into a voltage using a resistor across the terminals (150Ω gives 3V DC at 20mA, etc).

Given the fact that especially the governors are sensitive to the external circuit impedance, it is essential to carry out the initial setting of speed governor while the multi-line 2 is connected and the control function disabled.

Putting the multi-line 2 in manual operation disables the control function. This will 'disable' the control outputs, but the generator protection is still active. If you fail to do this, you may experience control problems later on.

AGC/BGC:

- Go to MAN mode.
- Reboot the unit or activate the input 'reset analogue controller outputs'.
- Run the generator with no load (open generator breaker).
- Set the frequency (on the speed governor) to be base frequency (50 or 60Hz).

GPU/GPC/PPU:

- Deactivate terminal 25.
- Reboot the unit or activate the input 'reset analogue controller outputs'.
- Run the generator with no load (open generator breaker).
- Set the frequency (on the speed governor) to be base frequency (50 or 60Hz).

With multi-line 2 PPU/GPC/AGC PWM output for Caterpillar®

Since the PWM initial setting has an influence on the start-up speed of the engine, the first thing to do is to set this (setting 2272 for multi-line, 2662 for AGC):

- Make sure that the generator cannot start.
- Turn the PPU/GPC/AGC OFF and ON again (to make sure that the PWM output is reset).
- Start the generator (no load).
- Adjust setting 2272/2662 until the correct speed (and frequency) is achieved.

Speed droop

The speed governor must have a speed droop of 3-4% (speed dropping 3-4% from no load to full load, when the multi-line 2 is **not** in control). In order to ensure equal load sharing on parallel running machines, all governors must have the same droop setting.

DEIF recommends adjusting the speed droop on the speed governor for stability purposes. It is necessary in all cases when relay outputs for governor control is used.

When analogue interfacing is used, it is possible to operate with a speed droop adjustment of 0%, but for stability and safety purposes it is recommended to use the speed droop adjustment.

Speed range

When using the analogue interfacing, the resistor installed across the output terminals is selected to obtain the necessary speed range. When finding the correct resistor, several aspects must be considered.

The necessary speed range must be selected to make operation at full load possible. Typically, this is f_{NOM} + 3Hz. If the speed range is too high, then the resistor size must be decreased. If the speed range is too low, then the resistor size must be increased.

The speed range must allow for the full load of the gen-set. If full load cannot be reached, then the resistor size must be increased.

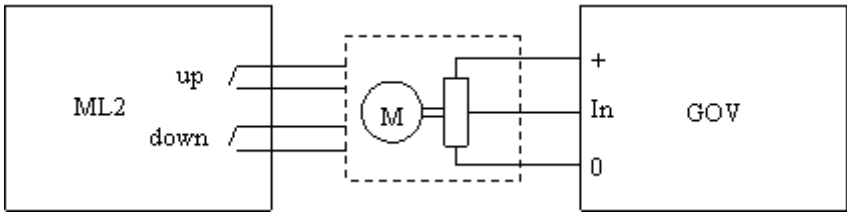
Terminals

The governor can either be prepared for analogue interfacing or digital interfacing. When analogue interfacing is used, a +/- 20mA signal from the multi-line 2 is applied. This signal can be converted to the necessary voltage level. When digital interfacing is used, two relays are used as increase/decrease outputs.

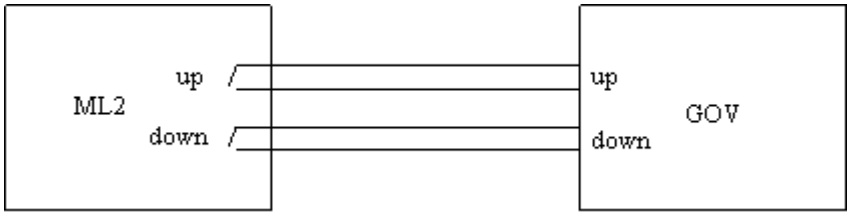
The terminals must be identified depending on the necessary interfacing. Some general examples are shown in the illustrations below.

Digital interfacing

Motor potmeter



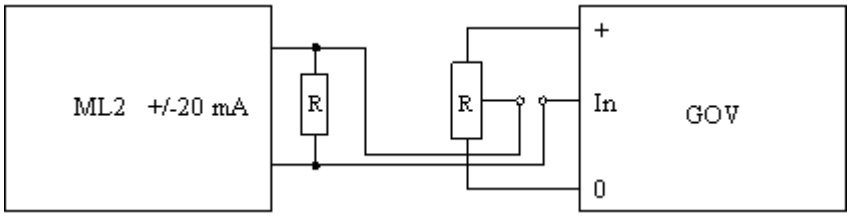
Direct digital signals



Analogue interfacing

Direct analogue signal

External potmeter



For additional information about interfaces, see Interfacing DEIF Equipment to Governors and AVRs available on www.deif.com.

6. AVR check

Even if the AVR is adjusted by the gen-set manufacturer, it is necessary to go through the following adjustments in order to be sure that the multi-line 2 can operate with the AVR.

The AVR should be tuned in according to the AVR/generator manufacturer's instructions. It is imperative that the gen-set is able to operate smoothly before the control function of the multi-line 2 is activated.

Voltage setting

An initial voltage level setting must be made.

The voltage level setting procedure depends on the interfacing.

Relay output

- Disable the outputs from the multi-line 2.
- Run the generator with no load (open generator breaker).
- Adjust the voltage (on the AVR) to be nominal voltage.

Analogue output

The analogue output is a +/- 20mA signal which in most cases has to be converted into a voltage using a resistor across the terminals (150Ω gives 3V DC at 20mA, etc).

Given the fact that especially the AVRs are sensitive to the external circuit impedance, it is essential to carry out the initial setting of the AVR while the multi-line 2 is connected and the control function disabled.

Putting the multi-line 2 in manual operation, MAN, disables the control function. This will 'disable' the control outputs, but the generator protection is still active. If you fail to do this, you may experience control problems later on.

AGC/BGC

- Go to MAN mode.
- Reboot the unit or activate the input 'reset analogue controller outputs'.
- Run the generator with no load (open generator breaker).
- Set the voltage (on the AVR) to be nominal voltage.

GPU/GPC/PPU:

- Deactivate terminal 25.
- Reboot the unit or activate the input 'reset analogue controller outputs'.
- Run the generator with no load (open generator breaker).
- Set the voltage (on the AVR) to be nominal voltage.

Voltage droop

The AVR controls the generator voltage in a way which is comparable to the speed governor controlling the prime mover speed.

This means that the generator AVR must have a voltage droop of 3-4% (voltage dropping 3-4% from no load to full reactive load when the multi-line 2 has no control). In order to ensure equal var sharing on parallel running generators, all generators must have the same voltage droop setting.

Voltage range

When using the analogue interfacing, the resistor installed across the output terminals is selected to obtain the necessary speed range. The voltage range must be defined similar to the speed range for the governor.

The voltage range must be wide enough for the voltage droop and for the full loading of the gen-set. A typical value is +/- 10% * U_{NOM}. The necessary control signal level is often specified depending on the AVR type.

Terminals

The AVR can either be prepared for analogue interfacing or digital interfacing. When analogue interfacing is used, a +/- 20mA signal from the multi-line 2 is applied. This signal can be converted to the necessary voltage level. When the digital interfacing is used, two relays are used as increase/decrease outputs.

The terminals must be identified depending on the necessary interfacing. Some general examples are shown in the illustrations in the chapter about ‘governor check’.

7. Protections check

As a part of the commissioning, the protections should be checked.

The following points must be considered for each alarm:

- Alarm set point.
- Alarm delay.
- Relay output.
- Activation.
- Fail class.

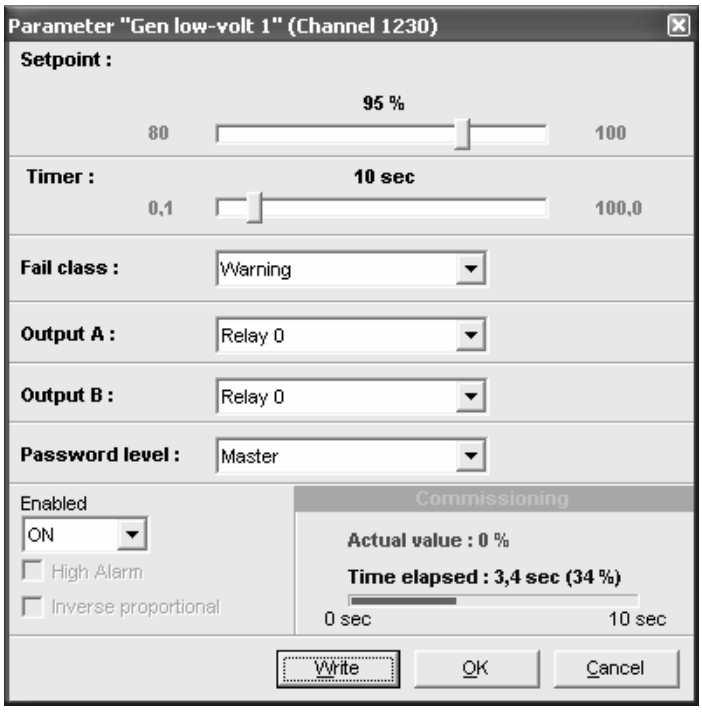
For further information about the above-mentioned, see the Designer's Reference Handbook.

Considerations

Several issues must be taken into consideration when configuring the alarms. These are e.g. national rules and requirements, additionally installed protection equipment, required use of the protections (trip of non-essential load, breaker tripping and engine stopping). *The switchboard manufacturer and the end customer must take these considerations.*

Configuration of the protections

The dialogue box shows a typical alarm.



In the 'commissioning' field above, the horizontal line indicates the elapsed time since the alarm set point was exceeded. In this example, the generator low voltage set point is 95%. If the commissioning is done without the PC utility software, then the timers can be seen in the service menu 4980/9120.

8. Adjustment

The adjustment of the unit can be carried out when the initial settings of the governor and the AVR are made.

The controller of the unit is a PI controller.

The unit includes different controllers which must be tuned in at the correct running situations (see table below):

Controller	Purpose	Tune in conditions
Frequency controller	Controls the frequency when the multi-line 2 is in island mode (stand-alone or load sharing).	Tune in when the generator is running with the generator breaker open.
Power controller	Controls the power when the multi-line 2 is running parallel to the mains and when running in load sharing mode.	Tune in when the generator is running parallel to the mains or in load sharing mode.
Voltage controller	Controls the voltage when the multi line 2 is in island mode (stand-alone or load sharing).	Tune in when the generator is running with the generator breaker open.
var controller	Controls the vars when the multi-line 2 is running parallel to the mains and when running in var sharing mode.	Tune in when the generator is running parallel to the mains or in load sharing mode.

Adjusting PI controller

Before the PI controllers of the multi-line 2 are tuned in, the values of the K_P and K_I of all controllers must be decreased to a low value.

Start by tuning in the K_P factor, and then tune in the K_I factor. Normally, the controllers are tuned in following a few general rules as given below.

Step 1, adjustment of the K_P

Only the P regulator is to be active, and the operation of the gen-set must be stable. Now increase the K_P factor step by step, until the gen-set becomes unstable. Adjust the K_P factor to 50% of the value found above.

Step 2, adjustment of the K_I

Step by step increase the K_I value, until the gen-set becomes unstable. Adjust the K_I factor to 50…70% of the value found above.

Step 3, readjustment of controller settings

It can be necessary to make a readjustment of the controller settings, if during testing the gen-set turns out to be unstable to some extent. If this is the case, then adjust the K_P and/or K_I, until the operation is satisfactory.

To see the effect of the new adjustments when tuning in the multi-line 2, remember to make a regulation deviation, e.g. by applying a load jump.

Adjustment hints for AGC

This concerns the AGC only!

In many cases it is difficult to tune in the controller using load jumps (no load bank available). When this is the situation, the manual incr/decr inputs can be used in semi-auto mode. The inputs are digital inputs that must be configured in the utility software.

The number of digital inputs is option dependent.

When the manual increase/decrease input is activated, the regulator is switched off and an offset will be given to the governor or AVR. The governor/AVR outputs will be activated as long as the manual input is activated. When the input is deactivated again, the regulation will be switched on, and the AGC will control gen-set towards the set point.

This is an easy way to make regulation deviations during the commissioning.

Relay output adjustments

If the relay outputs are used for the speed governor/AVR, then it will be necessary to adjust the relay minimum pulse time and the period time.

There are 2 settings: ON time, which is the shortest relay ON signal time.
PER time, which is the period time.

The shortest acceptable pulse time is depending on the reaction of the governor/AVR and connection type. Slow reaction requires a long time pulse.

As a starting point, use the following settings for the relay ON time and relay period time:

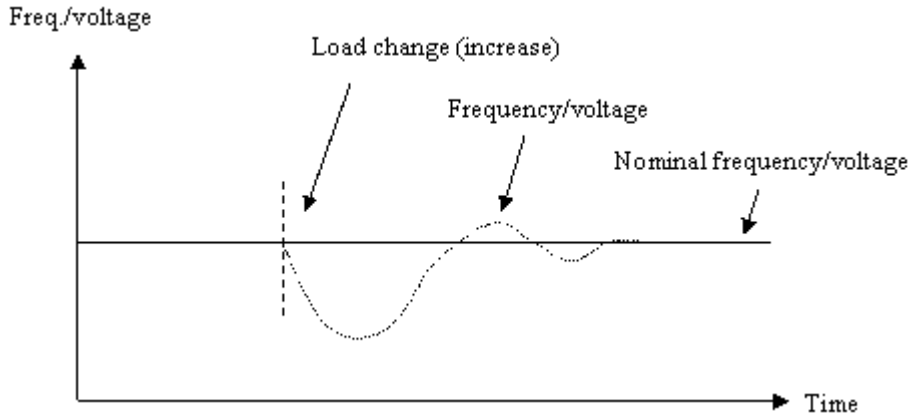
Menu text	AGC	GPC/PPU/GPU	Setting	Comment
Governor ON time	Menu 2251	Menu 2641	500…1000ms	
Governor period time	Menu 2252	Menu 2642	2500…5000ms	It is recommended that the period time is approximately 5*ON time.
AVR ON	Menu 2253	Menu 2643	100ms	
AVR period time	Menu 2254	Menu 2644	500ms	It is recommended that the period time is approximately 5*ON time.

It is still necessary to tune in the PI controllers.

Resulting speed/voltage curve upon load change

Testing is easily done by using (if possible) a load bank applying 'jumps' in the generator load, thus testing the speed/voltage control.

The optimum result is indicated by this curve:



As indicated, 2-3 'overshoots' before stabilising after a sudden change is OK. If more 'overshoots' are present, then decrease the K_P factor and try again.

9. Troubleshooting

The troubleshooting table can be used for the uni-line and the multi-line 2 products.

Problem indication	Problem cause	Remedy
Load sharing or parallel with mains power control unstable. Synchronisation OK. Single generator running frequency control OK.	No speed droop on generators.	Apply 3-4% speed drop on prime mover governor.
Load sharing or parallel with mains voltage (var) control unstable. Synchronisation OK. Single generator running voltage control OK.	No voltage droop on generators.	Apply 3-4% voltage drop on generator AVR.
Uni-line active power load sharing units only: Load sharing or parallel with mains power control unstable. Synchronisation OK. Single generator running frequency control OK. Speed droop OK.	Faulty connection of measuring voltage and/or current transformer input.	Correct connections. Voltage on L1 and L2, current transformer in L1.
Uni-line active power load sharing units only: Load sharing stable but not equal. Synchronisation OK. Single generator running frequency control OK. Speed droop OK.	Load sharers have been mounted to control the wrong size generators (can happen in systems with different size of generators).	Re-mount the load sharers to match the generators. The load sharers are pre-configured for a specific generator.
Uni-line reactive power load sharing units only: Load sharing or parallel with mains var control unstable. Synchronisation OK. Single generator running voltage control OK. Voltage droop OK.	Faulty connection of measuring voltage and/or current transformer input and/or voltage transducer.	Correct connections. Voltage on L1 and L2, current transformer in L1, voltage transducer to US-line (term. 38 (+) and 39 (-)).
Uni-line reactive power load sharing units only: var load sharing stable but not equal. Synchronisation OK. Single generator running voltage control OK. Voltage droop OK.	var load sharers have been mounted to control the wrong size generators (can happen in systems with different size of generators).	Re-mount the var load sharers to match the generators. The var load sharers are preconfigured for a specific generator.
Generator not able to take load to 100%.	Initial setting of speed governor not correct.	See chapters regarding governor/AVR checks.
Generator not able to take load to 100%.	Analogue output from DEIF equipment has too low output range.	Increase the full scale value. This is mostly a case when using electronic potentio-meters.
Speed decreases when increase was expected (relay outputs).	Relay outputs 'up' and 'down' reversed.	Swap connections.
Speed decreases when increase was expected (analogue output).	Outputs '+' and '-' reversed.	Swap connections.
Engine overspeeds when starting up.	Regulator output is too high.	Decrease the analogue output signal by decreasing the resistor.

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