

General Guidelines for Commissioning



Multi-line 2

4189340447A

SW version 3.0X.X

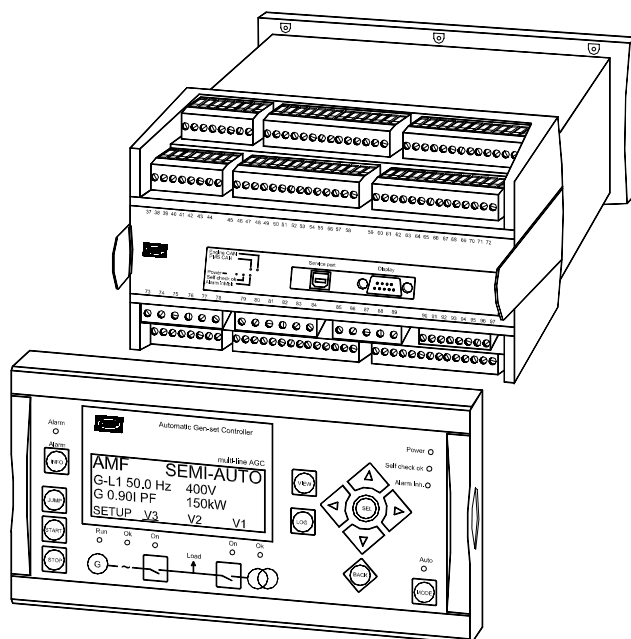


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1. About this document

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.

<i>Step 1</i>	Settings check
<i>Step 2</i>	Governor check
<i>Step 3</i>	AVR check
<i>Step 4</i>	Protections check
<i>Step 5</i>	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

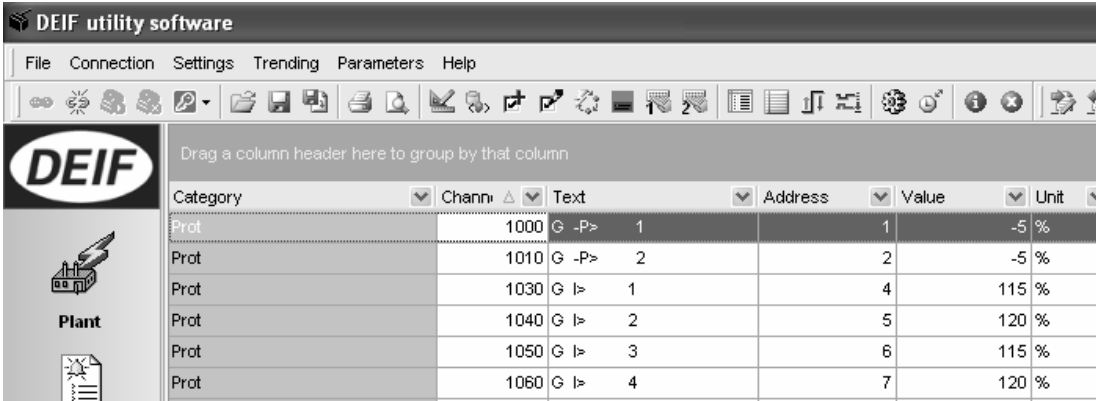
The nominal values of the multi-line 2 are adjusted in the general part of the system setup menu.

DEIF utility software							
File Connection Settings Trending Parameters Help							
Drag a column header here to group by that column							
Category	Chann	Text	Address	Value	Unit		
Gen	6001	Nom. f 1	407	50	Hz		
Gen	6002	Nom. P 1	408	480	kW		
Gen	6003	Nom. I 1	409	867	A		
Gen	6004	Nom. U 1	410	400	V		
Gen	6005	Nom. RPM 1	411	1500	RPM		
Gen	6006	Enable nom. set	412	0			
Gen	6011	Nom. f 2	413	60	Hz		
Gen	6012	Nom. P 2	414	285	kW		
Gen	6013	Nom. I 2	415	345	A		
Gen	6014	Nom. U 2	416	480	V		
Gen	6015	Nom. RPM 2	417	1500	RPM		
Gen	6021	Nom. f 3	418	60	Hz		
Gen	6022	Nom. P 3	419	285	kW		
Gen	6023	Nom. I 3	420	345	A		
Gen	6024	Nom. U 3	421	480	V		
Gen	6025	Nom. RPM 3	422	1500	RPM		
Gen	6031	Nom. f 4	423	60	Hz		
Gen	6032	Nom. P 4	424	285	kW		
Gen	6033	Nom. I 4	425	345	A		
Gen	6034	Nom. U 4	426	480	V		
Gen	6035	Nom. RPM 4	427	1500	RPM		
Gen	6041	G primary II	428	400	V		

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

Alarm settings

The alarm settings are adjusted in the protection setup menu.

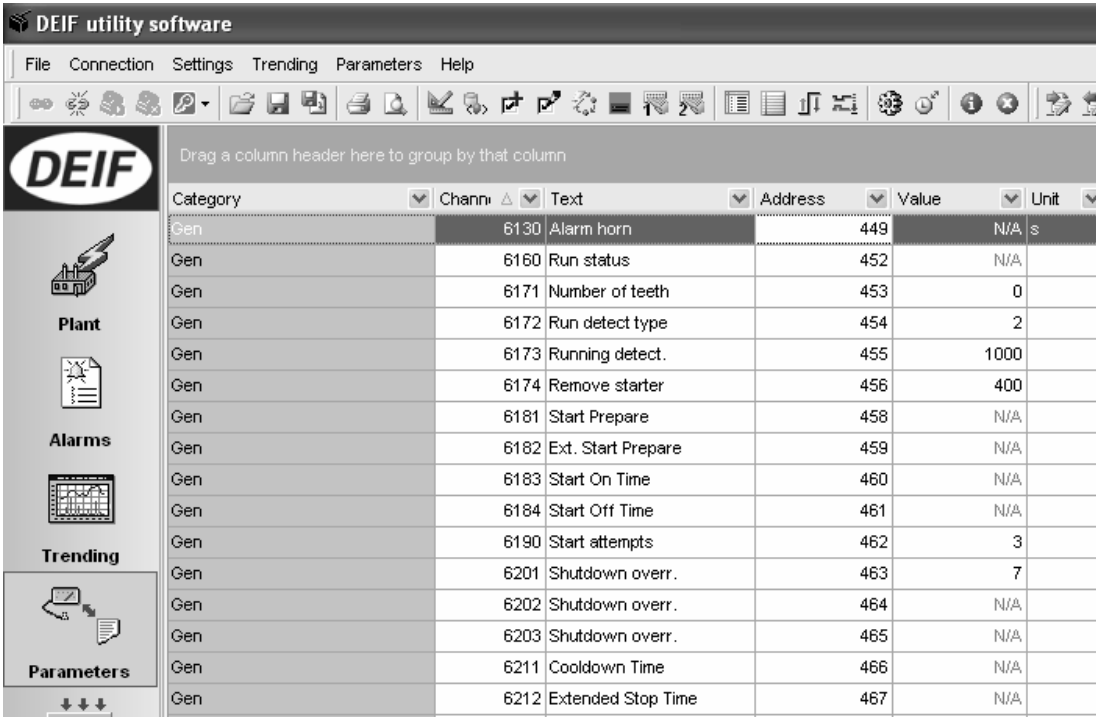


Category	Chann	Text	Address	Value	Unit
Prot	1000	G -P> 1	1	-5	%
Prot	1010	G -P> 2	2	-5	%
Prot	1030	G > 1	4	115	%
Prot	1040	G > 2	5	120	%
Prot	1050	G > 3	6	115	%
Prot	1060	G > 4	7	120	%

In the PC utility software it is presented as illustrated on the screen dump above or similar. 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 general part of the system setup menu.



Category	Chann	Text	Address	Value	Unit
Gen	6130	Alarm horn	449	N/A	s
Gen	6160	Run status	452	N/A	
Gen	6171	Number of teeth	453	0	
Gen	6172	Run detect type	454	2	
Gen	6173	Running detect.	455	1000	
Gen	6174	Remove starter	456	400	
Gen	6181	Start Prepare	458	N/A	
Gen	6182	Ext. Start Prepare	459	N/A	
Gen	6183	Start On Time	460	N/A	
Gen	6184	Start Off Time	461	N/A	
Gen	6190	Start attempts	462	3	
Gen	6201	Shutdown overr.	463	7	
Gen	6202	Shutdown overr.	464	N/A	
Gen	6203	Shutdown overr.	465	N/A	
Gen	6211	Cooldown Time	466	N/A	
Gen	6212	Extended Stop Time	467	N/A	

In the screen dump above only some of the settings 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.

Synchronisation settings

The ML-2 synchronisation settings are adjusted in the synchronisation part of the control setup menu.

The screenshot shows the DEIF utility software interface. The title bar reads 'DEIF utility software'. The menu bar includes 'File', 'Connection', 'Settings', 'Trending', 'Parameters', and 'Help'. Below the menu is a toolbar with various icons. On the left is a sidebar with the DEIF logo and icons for 'Plant' and 'Alarms'. The main area displays a table of synchronisation settings. Above the table, there is a header row with columns: 'Category', 'Chann', 'Text', 'Address', 'Value', and 'Unit'. A prompt 'Drag a column header here to group by that column' is visible above the table. The table contains 10 rows of settings, all with 'Sync' in the Category column.

Category	Chann	Text	Address	Value	Unit
Sync	2022	Sync. dfMin	66	0	Hz
Sync	2023	Sync. dUMax	67	5	%
Sync	2024	Sync. t GB	68	50	ms
Sync	2025	Sync. t MB	69	50	ms
Sync	2031	Maximum df	70	0,1	Hz
Sync	2032	Maximum dU	71	5	%
Sync	2033	Closing window	72	10	deg
Sync	2034	Static sync	73	N/A	s
Sync	2041	f sync. Kp	74	0,5	

Speed controller settings

The multi-line 2 speed controller settings are adjusted in the regulation part of 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 of the frequency and power controllers are set to a low value giving a slow regulation.

DEIF utility software						
File Connection Settings Trending Parameters Help						
 Drag a column header here to group by that column						
Category	Chann	Text	Address	Value	Unit	
Reg	2560	GOV reg. fail	134	30	%	
Reg	2571	f deadband	135	1	%	
Reg	2572	f Kp relay	136	10		
Reg	2581	P deadband	137	2	%	
Reg	2582	P Kp relay	138	10		
Reg	2591	P LS f deadband	139	1	%	
Reg	2592	P Is. f Kp rel.	140	10		
Reg	2593	P LS P deadband	141	2	%	
Reg	2594	P LS P weight	142	10	%	
Reg	2601	GOV ON time	143	500	ms	
Reg	2602	GOV period time	144	2500	ms	

Analogue controller

As an initial setting before the first start up, the K_p , T_i and T_d of the frequency and power controllers are set to a value giving a slow regulation. This means that K_p and T_d should be set to a low value, and T_i should be set to a high value.

Voltage controller settings

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

DEIF utility software						
File Connection Settings Trending Parameters Help						
 Drag a column header here to group by that column						
Category	Chann	Text	Address	Value	Unit	
Reg	2680	AVR reg. fail	162	30	%	
Reg	2691	U deadband	163	2	%	
Reg	2692	U Kp relay	164	10		
Reg	2701	Q deadband	165	2	%	
Reg	2702	Q Kp relay	166	10		
Reg	2711	Q LS U deadband	167	1	%	
Reg	2712	Q Is. U Kp rel.	168	10		
Reg	2713	Q LS Q deadband	169	2	%	
Reg	2714	Q LS Q weight	170	100		
Reg	2721	AVR ON time	171	100	ms	
Reg	2722	AVR period time	172	500	ms	

The screen dump above illustrates the controller settings of the voltage and reactive power controller. As an initial setting before the first start up, the K_p of the voltage and reactive power controllers are set to a low value giving a slow regulation.

Analogue controller

As an initial setting before the first start up, the K_p , T_i and T_d of the frequency and power controllers are set to a value giving a slow regulation. This means that K_p and T_d should be set to a low value, and T_i should be set to a high 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 is depending 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 +/-25mA or 0-20mA (depending on option) 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, 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.

- 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).

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 safety reasons 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, so it is possible to operate at full load. Typically, this is $f_{\text{NOM}} + 3\text{Hz}$. 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.

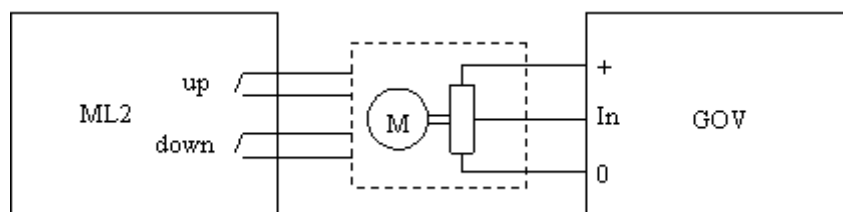
Terminals

The governor can either be prepared for analogue interfacing or digital interfacing. When analogue interfacing is used, a +/-25mA or 0-20mA 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.

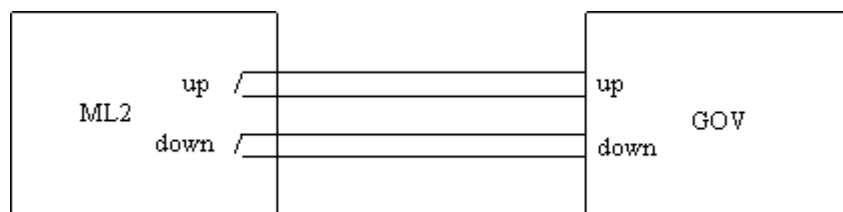
The terminals must be identified depending on the necessary interfacing. Some general examples are shown in the illustrations below.

Digital interfacing

Motor potmeter

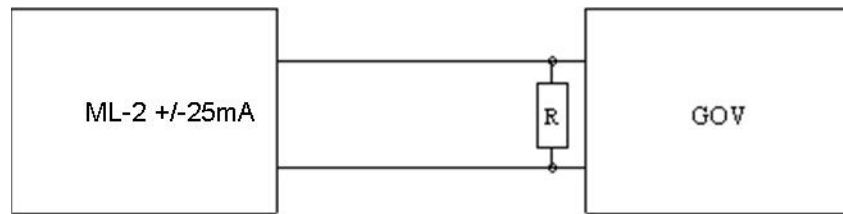


Direct digital signals

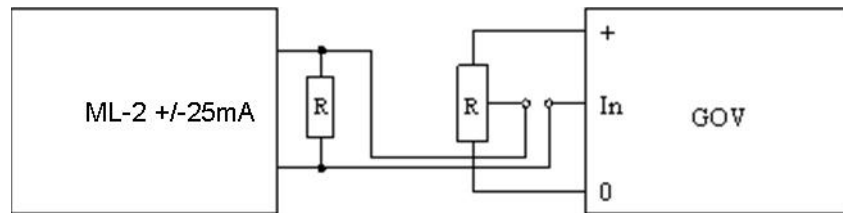


Analogue interfacing

Direct analogue signal



External potmeter



For additional information about interfaces, see Interfacing DEIF Equipment to Governors and AVR's 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 is depending 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 +/-25mA or 0-20mA (depending on option) 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.

- 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.

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 $\pm 10\% \cdot U_{\text{NOM}}$. 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 $\pm 25\text{mA}$ or $0\text{--}20\text{mA}$ 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
- Inhibits



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

Considerations

Several issues must be taken into consideration when doing the configuration of 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.

Parameter "G -P> 1" (Channel 1000)

Setpoint :

-50 -5 % 0

Timer :

0,1 10 sec 100,0

Fail class : Trip of GB

Output A : Not used

Output B : Not used

Password level : Customer

☒ Enable
☐ High Alarm
☐ Inverse proportional
☐ Auto acknowledge
Inhibits...

Commissioning

Actual value : 0 %
Time elapsed : 0 sec (0 %)
0 sec 10 sec

Write OK Cancel



In the 'commissioning' field above, the horizontal blue line indicates the elapsed time since the alarm set point was exceeded. In this example the generator reverse power set point is -5%. If the commissioning is done without the PC utility software, then the timers can be seen in the service menu 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 PID controller.

The unit includes different controllers which must be tuned in at the correct running situations (see the 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.	Tune in when the generator is running parallel to the mains.
P load share controller	Controls the power when the multi-line 2 is running in load sharing mode.	Tune in when the generator is running 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.
Reactive power 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.
Q load share controller	Controls the reactive power when the multi-line 2 is running in load sharing mode.	Tune in when the generator is running in reactive load sharing mode.

Adjusting PID controller

Before the PID controllers of the multi-line 2 are tuned in, the values of the K_p , T_i and T_d of all controllers must be decreased to a low value.

Start by tuning in the K_p factor, and then tune in the T_d and T_i . 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 (T_d and T_i set to 0 s), 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 T_i

With the K_p setting set to the value found in step 1, raise the T_i to a high value, e.g. 30 s, and decrease T_i step by step, until the gen-set becomes unstable. Adjust the T_i to approx. 1.5 to 1.7 times the value where instability begins.

Step 3, adjustment of the T_d

Step by step increase the T_d until the gen-set becomes unstable. Adjust the T_d to 50...70% of

the value.

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 , T_d and T_i until the operation is satisfactory.



The T_i and T_d settings are only available when analogue controller output is used.



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.

Manual governor and AVR control



This is possible in 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 control can be used as an easy way to make regulation deviations during the commissioning.

This function can be activated by pressing  more than 2 seconds, or by activating the digital inputs or AOP buttons for governor or AVR control in semi-auto mode. The intention of this function is to give the commissioning engineer a helpful tool for adjustment of the regulation.

The function of the regulation window depends on the selected mode:

G	0	0	0V
f-U Setp		100%	100%
f-U Reg.		50%	60%
		<u>GOV</u>	AVR

Manual mode

In manual mode, the regulation is deactivated. When activating the up or down arrows, the output value to GOV or AVR is changed, this is the Reg. value in the display. The up and down arrows have the same function as the digital inputs or AOP buttons for governor and AVR control when the window is open. To exit the regulation window, press 'back'.

Semi-auto mode

As in manual mode, the up and down arrows have the same function as the digital inputs or AOP buttons for governor or AVR control when the window is open.

The value setp can be changed by pressing the arrow up or down. When GOV is underlined, the governor set point will be changed, and vice versa when the AVR is underlined. When changing the setp value, an offset will be added to or subtracted from the nominal value. The reg. value is the output value from the regulator. If the gen-set is running in parallel, the active or reactive nominal power set point value will be changed. If it is a stand-alone gen-set not parallel to the mains, the nominal frequency or voltage set point will be changed and also displayed. When the 'back' button is activated, the regulation set point returns to nominal.



If the digital inputs or AOP buttons are activated in semi-auto, the regulation window is automatically opened.

Auto and test mode

Similar to semi-auto except from the fact that activating the digital inputs or AOP buttons for governor or AVR control will change the regulation set point but not open the regulation window. When the digital inputs or AOP buttons are deactivated, the regulation set point returns to nominal.



AVR set point manipulation requires option D1.



Regarding AOP setup, please refer to 'Help' in the PC utility software.

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:

Governor ON time	Menu 2601	500...1000ms	
Governor period time	Menu 2602	2500...5000ms	It is recommended that the period time is approximately 5*ON time.
AVR ON time	Menu 2721	100ms	
AVR period time	Menu 2722	500ms	It is recommended that the period time is approximately 5*ON time.

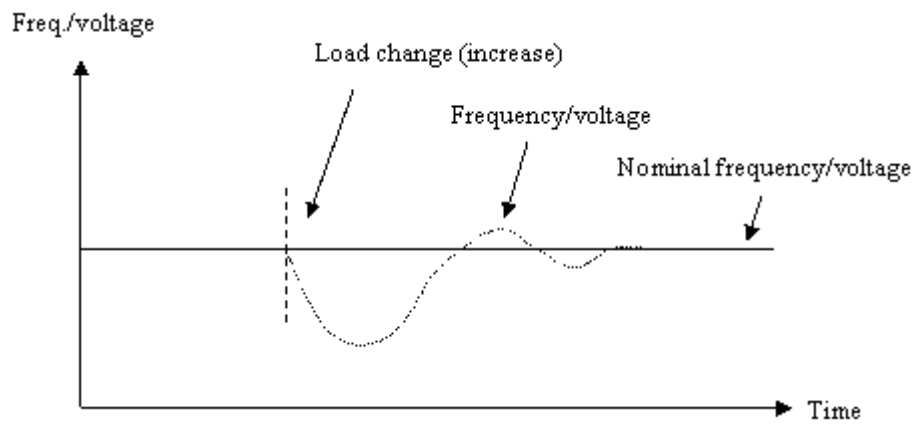


It is still necessary to tune in the P controllers.

Resulting speed/voltage curve upon load change

Testing is easily done by using (if possible) a load bank applying 'jumps' in the generator load, hereby 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.
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 potentiometers.
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