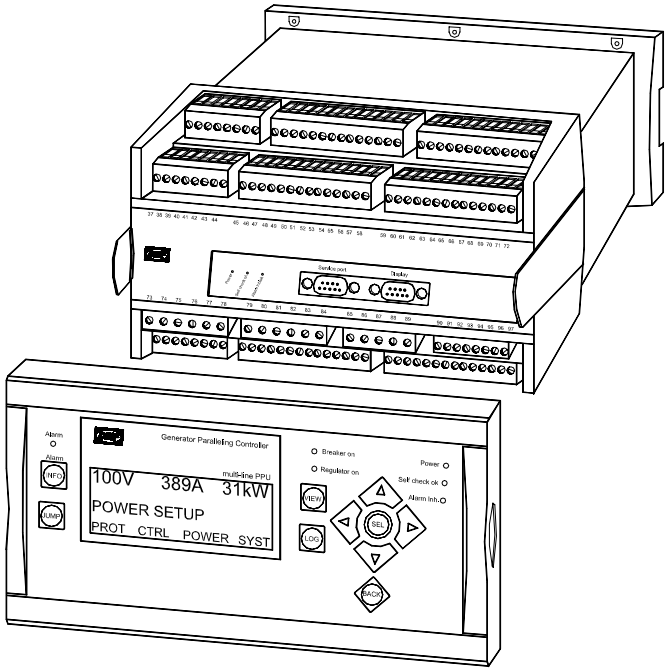
DEIF A/S

Description of options

Option G2, Synchronisation with relay speed governor outputs Multi-line 2 – version 2

4189340274C
SW version 2.4X.X



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This manual is valid for standard multi-line 2 GPU units with firmware version 2.00.0 or later.

1. 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.

2. Description of option

G2 option

This document describes the functionality of the synchronisation option for the GPU.

Function	ANSI no.
Synchronisation	25, 90

Option G2 is available as option for GPU only.
The function is included in GPC/PPU as a standard function.

Terminal description

This terminal description describes the terminals specific to this option.

Slot #1

The PCB in slot #1 is installed in all GPU units. It is shown in this document because the sync. relay and the digital input for start synchronising/control is placed on slot #1.

Term.	Function	Technical data	Description
1	+12/24V DC	12/24V DC -25/+30%	Power supply
2	0V DC		
3	NC	Status relay	Normally closed relay, processor/power supply status supervision
4	Com.	24V/1A	
5	NO	Relay 1 250V AC/8A	Configurable
6	Com.		
7	NC		
8	NO	Relay 2 250V AC/8A	Configurable
9	Com.		
10	NC		
11	NO	Relay 3 250V AC/8A	Configurable
12	Com.		
13	NC		
14	NO	Relay 4 250V AC/8A	Configurable
15	Com.		
16	NC		
17	NO	Relay sync. 250V AC/8A	Sync. relay with option D2/G2
18	Com.		
19	NC		
20	Open collector 1	Transistor out	Pulse output 1, kWh counter
21	Open collector 2	Transistor out	Pulse output 2, kVArh counter
22	Com.	Common	Common terminal for terminals 20 and 21
23	Binary input	Optocoupler	Remote alarm inhibit/configurable
24	Binary input	Optocoupler	Remote alarm acknowledge/configurable

Term.	Function	Technical data	Description
25	Binary input	Optocoupler	Start sync./control functions (only used with option G2/D2)/ configurable
26	Binary input	Optocoupler	Ext. communication control/configurable
27	Binary input	Optocoupler	Block loss of mains (vector jump and df/dt (ROCOF) only) (option A)/configurable
28	Com.	Common	Common for terminals 23-27

Slot #3

Term.	Function	Technical data	Description
37			Not used
38			Not used
39			Not used
40			Not used
41			Not used
42			Not used
43	Binary input 43	Optocoupler	Deload/open breaker (only if input 25 is ON)
44	Binary input 44	Optocoupler	Manual raise speed (only active when “start sync./control” is OFF)
45	Binary input 45	Optocoupler	Manual lower speed (only active when “start sync./control” is OFF)
46	Binary input 46	Optocoupler	Manual raise voltage (only active when “start sync./control” is OFF)
47	Binary input 47	Optocoupler	Manual lower voltage (only active when “start sync./control” is OFF)
48	Binary input 48	Optocoupler	Configurable
49	Binary input 49	Optocoupler	Configurable
50	Binary input 50	Optocoupler	Configurable
51	Binary input 51	Optocoupler	Configurable
52	Binary input 52	Optocoupler	Configurable
53	Binary input 53	Optocoupler	Configurable
54	Binary input 54	Optocoupler	Generator breaker open
55	Binary input 55	Optocoupler	Generator breaker closed
56	Com.	Common	Common for terminals 43 to 55
57	NO	Relay 5 250V AC 8A	Configurable
58	Com.		
59	NO	Relay 6 250V AC 8A	Configurable
60	Com.		
61	NO	Relay 7 250V AC 8A	Configurable
62	Com.		
63	NO	Relay 8 250V AC 8A	Configurable
64	Com.		

Slot #4

Term.	Function	Description
65	GOV relay up	Relay output for GOV raise speed
66	GOV relay up	
67	GOV relay down	Relay output for GOV lower speed
68	GOV relay down	
69	AVR relay up	*Used for AVR controls (Option D2)*
70	AVR relay up	
71	AVR relay down	
72	AVR relay down	

If option D2 is also selected in the GPU, the AVR control relay outputs can be used for voltage matching.

3. Functional description

The GPU used with option G2 can be used for governor control and synchronising the generator breaker. When the GPU has closed the breaker, the function of the GPU is solely protection of the gen-set since the regulation is switched off during operation with the circuit breaker closed.

The manual 'Description of options: Option D1 and D2' includes the functional description of the AVR control (option D2).

Automatic control

The GPU is controlled with digital inputs (or through communications). The speed governor is controlled with relay outputs from the GPU.

Control inputs

There are three digital inputs that control the synchronising function of the GPU unit. The table shows each input.

Term.	Add. term.	Function	CB position	Comment
25		Start synchronising/control		Starts the regulation/synchronising when the CB is opened. It starts the regulation without synchronisation when the deload input is ON at the same time as this input.
43	25	Deload* input + start sync./control	OFF	Prevents the breaker from closing but the regulation is activated.
			ON	Trips the CB immediately without delay.
26		Enable external communication control		Used when CANopen, Profibus or modbus is used for control.

** the name 'deload input' origins from the GPC and PPU product. There is no deload function in the GPU!*

For detailed information about the combined use of the control inputs, please refer to the flowchart in this handbook.

When the CB opens, there is a 10 sec delay that must expire before the GPU is able to resynchronise.

Fixed frequency operation

When the deload input is left ON after opening the circuit breaker, it will prevent re-synchronisation and the gen-set will operate in fixed frequency control.

Manual control

When the start sync./control input is deactivated, the gen-set can be controlled manually through the GPU.

Manual inputs

There are four digital inputs that ensure the manual control of the GPU unit. The table shows each input.

Terminal	Function	Comment
44	Manual governor UP	Requires that start sync./control is deactivated
45	Manual governor DOWN	Requires that start sync./control is deactivated
46	Manual AVR UP	Requires that start sync./control is deactivated. (Option D2 needed for AVR control)
47	Manual AVR DOWN	Requires that start sync./control is deactivated. (Option D2 needed for AVR control)

Sequences

The following chapter contains information about the sequences of the GPU.

These sequences will be described:

Sequence	Description
CB ON	Synchronising
CB ON	Black out closing
CB OFF	Open breaker

CB ON sequence/synchronising

The CB ON sequence can be started when the generator is running and the terminal 25 (start sync./control) is activated. The regulation will start and control the gen-set in order to synchronise the breaker.

The busbar voltage must be above 70% x U_{NOM} in order to initiate the synchronising.

Interruption of the CB ON (synchronising) sequence	
Input 25 deactivated	
Input 43 activated	25 = ON at the same time
CB close	
U_{BB} measured below 70%	70% x U_{NOM}
Synchronising failure	
General failure	
Alarm + sync block state	

When the CB opens there is a 10 s delay that prevents it from closing immediately after it has opened. This is to ensure that there is sufficient time to change mode and control inputs.

CB ON sequence/black out closing

In order to make a black out closing, terminal 25 must be activated and the measurements from the busbar must be missing. The breaker will close if the voltage is below 30% x U_{NOM}.

The busbar voltage must be below 30% x U_{NOM} in order to initiate the black busbar closing.

Interruption of the CB ON (black close) sequence	
Input 25 deactivated	
Input 43 activated	25 = ON at the same time
U gen not OK	Limit set in menu 2042
f gen not OK	Limit set in menu 2041
Black closing not enabled	Enabled in menu 2040
CB close	
U_{BB} measured above 30%	
General failure	
Alarm + sync block state	

When the CB opens there is a 10 s delay that prevents it from closing immediately after it has opened. This is to ensure that there is sufficient time to change mode and control inputs.

CB OFF/open breaker

The CB can be opened instantly by the GPU. The sequence is started by this selection of the control inputs:

Terminal	**Description**	**Input state**
25	Start sync./control	ON
43	Deload	ON

The CB open signal will be issued immediately when the combination of the control inputs are as mentioned in the table above.

Protections

The protections in the GPU are activated at all times. The option described in this manual does not affect the protections.

The protection functions as well as the alarm inhibit functions are described in the Designer's Reference Handbook and other option manuals.

Text in status line

If the display is installed it will show various messages depending on the running condition. To see these messages, the view menu system must be selected (press 'BACK' three times) and move the cursor to V3. Typically, the messages are self-explanatory so the operator knows what state the generator is in.

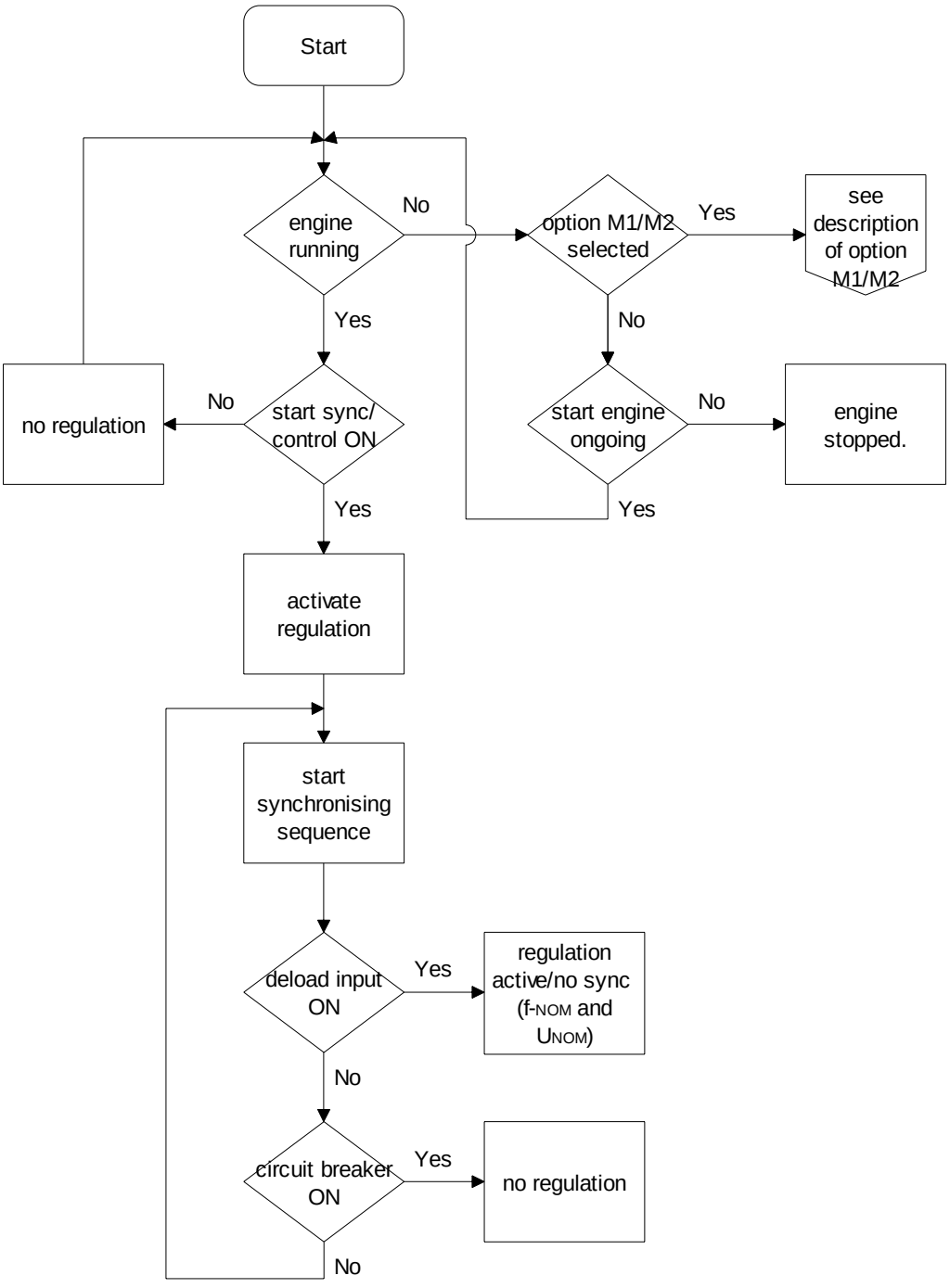
Use the status texts for daily operation and troubleshooting.

The table below indicates the texts in the status line.

The plant overview in the PC utility software also shows the status message (shown below the gen-set symbol).

Status text	Condition	Comment
Manual	No regulation	
No regulation	No regulation	The “start sync./reg” input term 25 may be ON, requiring the regulators to operate, but the condition is not fulfilled (e.g. generator not running)
Gov Static Sync	Static synchronisation in progress	Attempting to reach phase angle difference = 0 and frequency difference = 0
Gov Dynamic Sync	Dynamic synchronisation in progress	Attempting to synchronise with generator frequency slightly higher than busbar/ mains
Ramp down	Generator power is being lowered and breaker opens at a preset low power value	
Ramp up	Generator power increasing after synchronising of breaker	Only in load sharing and fixed power mode. Ramp up stops when power set point is reached
Gov fixed f int	Fixed frequency running mode	Using internal set point (f nom)
Gov fixed f ext	Fixed frequency running mode	Using external set point (analogue input)
Start Prepare	Pre-start heating or oil pressure build up for engine	Options M1/M2 only
Start relay on	Cranking	Options M1/M2 only
Start relay off	Crank pause	Options M1/M2 only
Cooling down ###.# s	Engine cooling down timer running	Options M1/M2 only
Gen-set stopping	Stop command has been issued but running feedback is still present	Options M1/M2 only
Ext. stop T. ###.#s	Engine has stopped and the extended stop timer is running. During this the stop coil (if selected) will be activated	Options M1/M2 only. Gen-set cannot be started before the extended stop timer runs out

Flowchart



If the deload input is activated before the start sync./control input, the GPU will go into fixed frequency control and the synchronising will not be initiated.

4. Synchronising

The unit can be used for synchronisation of generator and mains breaker (if installed). Two different synchronisation principles are available, namely static and dynamic synchronisation (dynamic is selected by default).

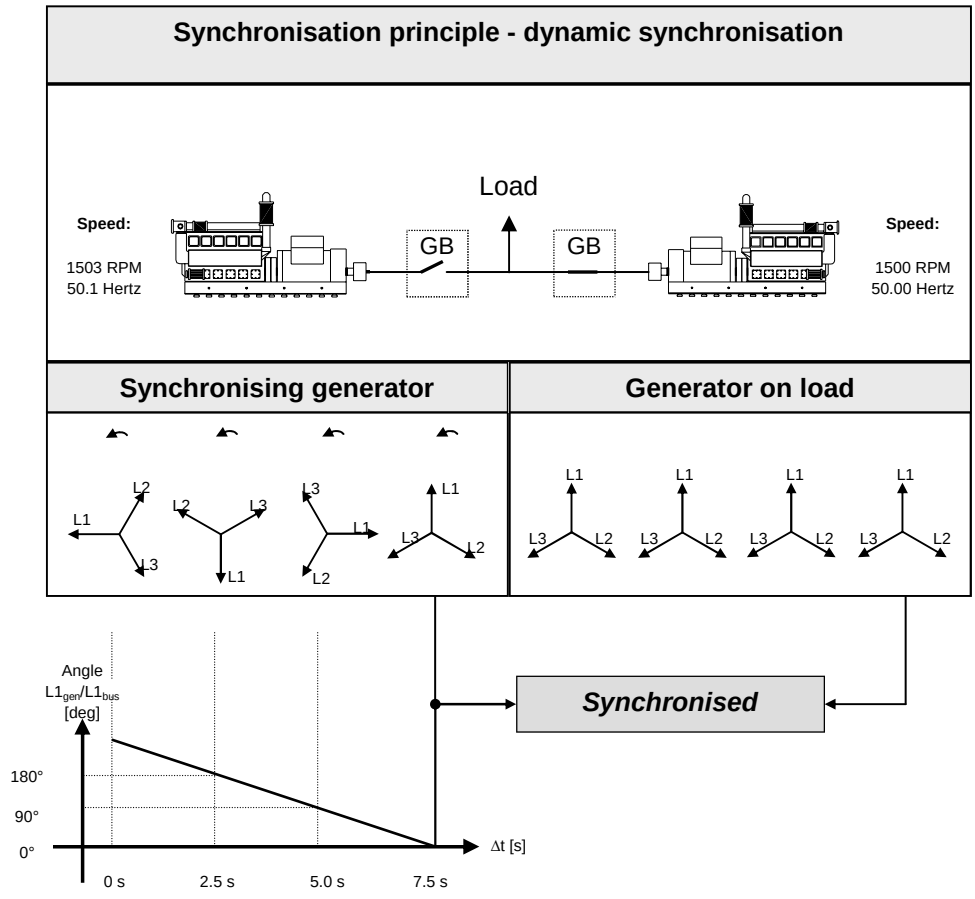
This chapter describes the principles of the dynamic synchronisation functions and the adjustment of them. The static synchronisation function is not preferred to use in the GPU product because the GPU – G2 is delivered with relay outputs for governor control. In principle, static synchronising can only be used when analogue outputs are used for relay control.

In the following, the term 'synchronisation' means *'synchronising and closing of the synchronised breaker'*.

Dynamic synchronisation

In dynamic synchronisation, the synchronising gen-set is running at a different speed than the generator on the busbar. This speed difference is called *slip frequency*. Typically, the synchronising gen-set is running with a positive slip frequency. This means that it is running with a higher speed than the generator on the busbar. The objective is to avoid a reverse power trip after the synchronisation.

The dynamic principle is illustrated below.



In the example above, the synchronising gen-set is running at 1503 RPM ~ 50.1Hz. The generator on load is running at 1500 RPM ~ 50.0Hz. This gives the synchronising gen-set a positive slip frequency of 0.1Hz.

The intention of the synchronising is to decrease the phase angle difference between the two rotating systems. These two systems are the three-phase system of the generator and the three-phase system of the busbar. In the above illustration, phase L1 of the busbar is always pointing at 12 o'clock, whereas phase L1 of the synchronising gen-set is pointing in different directions due to the slip frequency.

Of course, both three-phase systems are rotating, but for illustrative purposes the vectors for the generator on load are not shown to be rotating. The reason is that we are only interested in the slip frequency for calculating when to release the synchronisation pulse.

When the generator is running with a positive slip frequency of 0.1Hz compared to the busbar, then the two systems will be synchronised every 10 seconds.

$$t_{SYNC} = \frac{1}{50.1 - 50.0} = 10\,\text{sec}$$

In the illustration above, the difference in the phase angle between the synchronising set and the busbar decreases and will eventually reach zero. When this happens, the gen-set is synchronised to the busbar, and the breaker will be closed.

Close signal

The unit always calculates when to close the breaker to find the most accurate synchronisation. This means that the close breaker signal is actually issued before being synchronised (read L1 phases exactly at 12 o'clock).

The breaker close signal will be issued depending on the breaker closing time and the slip frequency (response time of the circuit breaker is 250 ms, and the slip frequency is 0.1Hz):

$$\deg_{CLOSE} = 360 * t_{CB} * f_{SLIP}$$
$$\deg_{CLOSE} = 360 * 0.250 * 0.1$$
$$\deg_{CLOSE} = 9\,\deg$$

The synchronisation pulse is always issued, so the closing of the breaker will occur at the 12 o'clock position.

The length of the synchronisation pulse is the response time + 20 ms.

Load picture after synchronising

When the incoming gen-set has closed its breaker, it will take a portion of the load depending on the actual position of the fuel rack. Illustration 1 below indicates that at a given *positive* slip frequency, the incoming gen-set will *export* power to the load. Illustration 2 below shows that at a given *negative* slip frequency, the incoming gen-set will *receive* power from the original gen-set. This phenomenon is called *reverse power*.

To avoid nuisance trips caused by reverse power, the synchronising settings can be set up with a positive slip frequency.

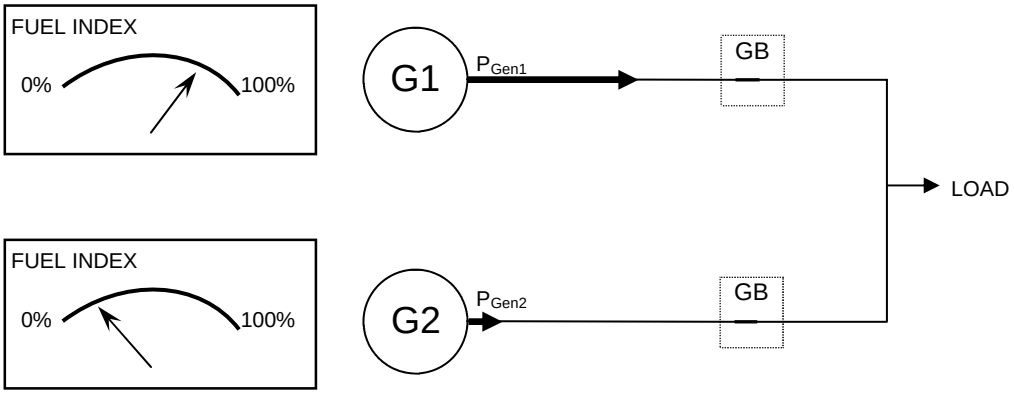


Illustration 1, POSITIVE slip frequency

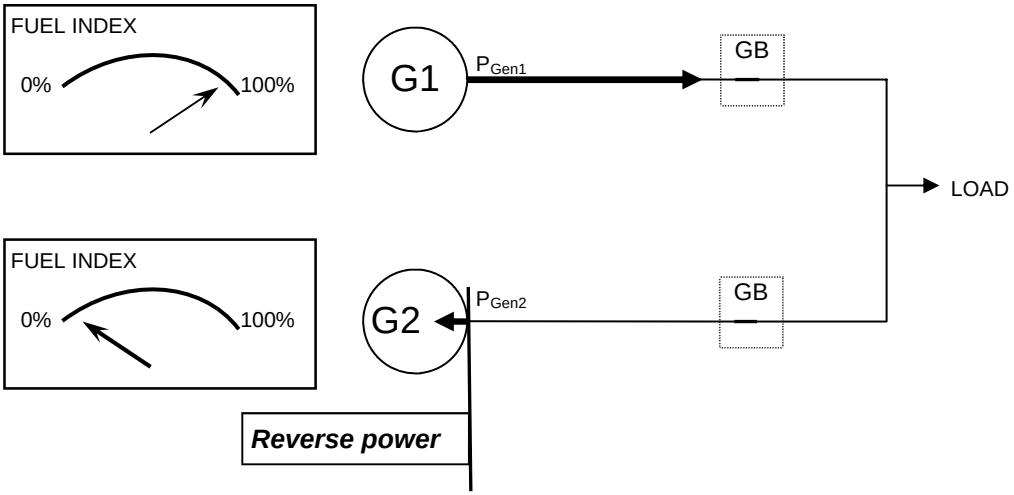


Illustration 2, NEGATIVE slip frequency

Adjustments

The dynamic synchroniser is selected in menu 2010 in the control setup and is adjusted in menu 2020.

Setting	Description	Comment
2021 f_{MAX}	Maximum slip frequency.	Adjust the maximum positive slip frequency where synchronising is allowed.
2022 f_{MIN}	Minimum slip frequency.	Adjust the maximum negative slip frequency where synchronising is allowed.
2023 U_{MAX}	Maximum voltage difference (+/- value).	The maximum allowed voltage difference between the busbar/mains and the generator.
2024 t_{CB}	Circuit breaker closing time.	Adjust the response time of the circuit breaker.

It is obvious that this type of synchronisation can synchronise relatively fast because of the adjusted minimum and maximum slip frequencies. This actually means that when the unit is aiming to control the frequency towards its set point, then synchronising can still occur as long as the frequency stays within the limits of the slip frequency adjustments.

Dynamic synchronisation is recommended where fast synchronisation is required, and where the incoming gen-sets are able to take load just after the breaker has been closed.

5. Parameter list

The setup of parameters is done via the display or the PC utility software (USW).

For further information about the structure of the parameter descriptions, please see the Designer's Reference Handbook.

Control setup

The following parameters will be available through the control setup.

2010 Synchronisation type

No.	Setting		First setting	Second setting	Factory setting
2011	Sync. type	Sync. type	Static sync.	Dynamic sync.	Dynamic sync.

2020 Dynamic synchronisation

No.	Setting		Min. setting	Max. setting	Factory setting
2021	Dynamic sync.	Df max.	0.0 Hz	0.5 Hz	0.3 Hz
2022	Dynamic sync.	Df min.	-0.5 Hz	0.5 Hz	0.0 Hz
2023	Dynamic sync.	DU max.	2%	10%	5%
2024	Dynamic sync.	Breaker delay	40 ms	300 ms	50 ms

2030 Static synchronisation

No.	Setting		Min. setting	Max. setting	Factory setting
2031	Static sync.	Maximum df	0.00 Hz	1.00 Hz	0.25 Hz
2032	Static sync.	Maximum dU	2%	10%	5%
2033	Static sync.	Close window	0.1 deg.	20.0 deg.	10.0 deg.
2034	Static sync.	Phase K_P	0	400	250
2035	Static sync.	Phase K_I	0	400	160

2040 Sync. blackout

No.	Setting		Min. setting	Max. setting	Factory setting
2041	Sync. blackout	Df max.	0.0 Hz	5.0 Hz	3.0 Hz
2042	Sync. blackout	DU max.	2%	10%	5%
2043	Sync. blackout	Enable	OFF	ON	OFF

2050 Sync. window

No.	Setting		Min. setting	Max. setting	Factory setting
2051	Sync. window	Set point +/-	2.0%	20.0%	15.0%
2052	Sync. window	Delay	0.1 s	2.0 s	0.5 s
2053	Sync. window	Output A	R0 (none)	Option dependent	R0 (none)
2054	Sync. window	Output B	R0 (none)		R0 (none)
2055	Sync. window	Enable	OFF	ON	OFF

2060 Sync. failure

No.	Setting		Min. setting	Max. setting	Factory setting
2061	Sync. failure	Delay	30.0 s	300.0 s	60.0 s
2062	Sync. failure	Relay output A	R0 (none)	Option dependent	R2 (relay 2)
2063	Sync. failure	Relay output B	R0 (none)		R0 (none)
2064	Sync. failure	Activate	OFF	ON	ON

2070 General failure

No.	Setting		Min. setting	Max. setting	Factory setting
2071	General failure	Relay output A	R0 (none)	Option dependent	R2 (relay 2)
2072	General failure	Relay output B	R0 (none)		R0 (none)
2074	General failure	Activate	OFF	ON	ON

2120 Frequency controller

No.	Setting		Min. setting	Max. setting	Factory setting
2121	Freq. control	Deadband	0.2%	10.0%	1.0%
2122	Freq. control	F K_P	0	1000	250
2123	Freq. control	F K_I	0	1000	160
2124	Freq. control	Droop	0.0%	10.0%	4.0%

2180 Governor regulation failure

No.	Setting		Min. setting	Max. setting	Factory setting
2181	Governor reg. failure	Deadband	1.0%	100.0%	30.0%
2182	Governor reg. failure	Timer	10.0 s	360.0 s	60.0 s
2183	Governor reg. failure	Output A	R0 (none)	R4 (relay 4)	R2 (relay 2)
2184	Governor reg. failure	Output B	R0 (none)	R4 (relay 4)	R2 (relay 2)
2185	Governor reg. failure	Enable	OFF	ON	ON

2250 Relay control

No.	Setting		Min. setting	Max. setting	Factory setting
2250	Relay control	Selection display	-	-	-
2251	Relay control	GOV ON time t_N	10 ms	6500 ms	500 ms
2252	Relay control	GOV per. time t_P	50 ms	32500 ms	2500 ms

2290 Delayed regulation

No.	Setting		Min. setting	Max. setting	Factory setting
2291	Delay regulation	Timer	0.0 s	9900.0 s	0.0 s
2292	Delay regulation	Relay output A	R0 (none)	Option dependent	R0 (none)
2293	Delay regulation	Relay output B	R0 (none)		R0 (none)
2294	Delay regulation	Enable	OFF	ON	OFF