DEIF A/S

# MGC-1

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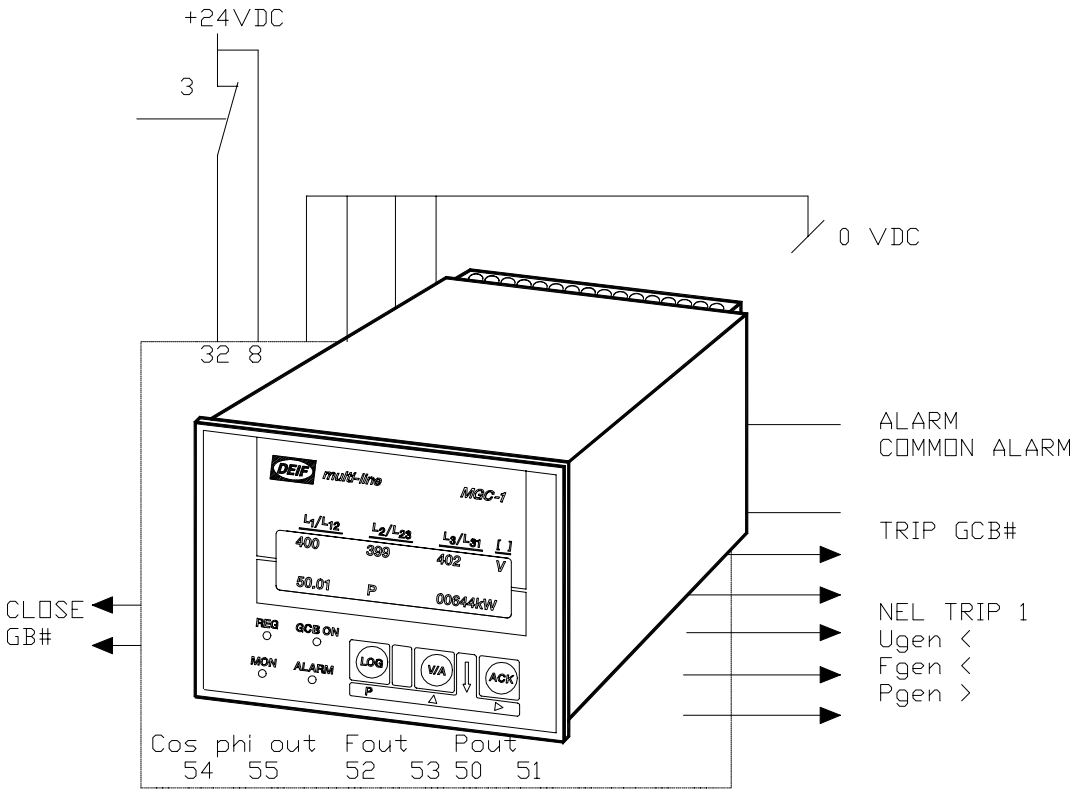


# *Application notes*

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FOR FULL DETAILS ON THE PRODUCTS MENTIONED IN THIS DESCRIPTION, PLEASE SEE:

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| - Multi generator controller | MGC-1 | 4921240088 |
| - Uni-line load sharing unit | LSU-112DG | 4921240118 |
| - Electronic potentiometers | EP-Q96 | 4921240020 |
| - Electronic potentiometers | EPN -110DN | 4921240026 |

## 1. Warnings and legal information

This paper gives guidelines to installation of the DEIF MGC-1 generator control and protection unit. It is, however, not a complete installation instruction. Therefore, even if terminal numbers are shown in some of the drawings, the drawings are to be used as guidance only. To make complete drawings, please refer to the MGC-1 User Manual, ref. No. 4921240088.

Installing and operating the MGC-1 implies work with dangerous currents and voltages, and therefore it should only be done by qualified personnel.

DEIF takes no responsibility for operation or installation of the gen-set. If there is any doubt about how to install or operate the system on which the MGC-1 is measuring, the company responsible for installation or operation must be contacted.

## 2. General description

### 2.1 Introduction

The DEIF electronic units for protection and control of diesel engines can be combined to achieve systems with highly different characteristics.

In the following, a number of applications using the DEIF Multi Generator Controller, MGC-1 is shown including:

- Island operation, marine
- Island operation, land
- Parallel with mains, single generator
- Parallel with mains, multiple generators

MGC-1:

Accurate RMS measurement of generator currents and generator power.

Definite time release characteristics protective functions:

- Reverse power relay
- Overload relay
- Overcurrent relay
- Overvoltage relay
- Undervoltage relay
- Overfrequency relay
- Underfrequency relay
- Voltage asymmetry relay
- Reactive power relay
- Unbalanced load relay
- Busbar voltage relay
- Vector jump relay (option)
- df/dt (ROCOF) (option)

Control functions:

- Load sharing/power and frequency control
- Voltage/cos/var control (option)
- Synchronising relay with voltage matching/control
- Ramp down of generator with opening of breaker at 10% load

3 transducer outputs representing chosen electrical values (option).

The diagrams show details as regards the wiring between MGC-1 and associated equipment, where as details as regards the following are NOT shown:

connection of AC voltages and currents
- connection of output relays (PLC)
- general instrumentation
- manual control of the system
- automatic logical control (PLC)
- stand-by selector (PLC)

This survey thus clarifies which units carry out the necessary functions and how to connect the various units for a typical application.

The units shown on the diagram will carry out the following functions:

- Protection of generators
- Automatic synchronisation
- Automatic load sharing in isochronous mode
- Automatic load dependent start/stop of generators
- Automatic tripping of non-essential load
- Automatic blocking of heavy loads/start of stand-by generator

*NOTE: The principle diagrams for load sharing show two generators of identical size, however, the system can, without principal changes, be amended to control up to 6 generators of any size, provided none of the connected generators are smaller than 15% of the total plant power.*

## 3. Protection of generators

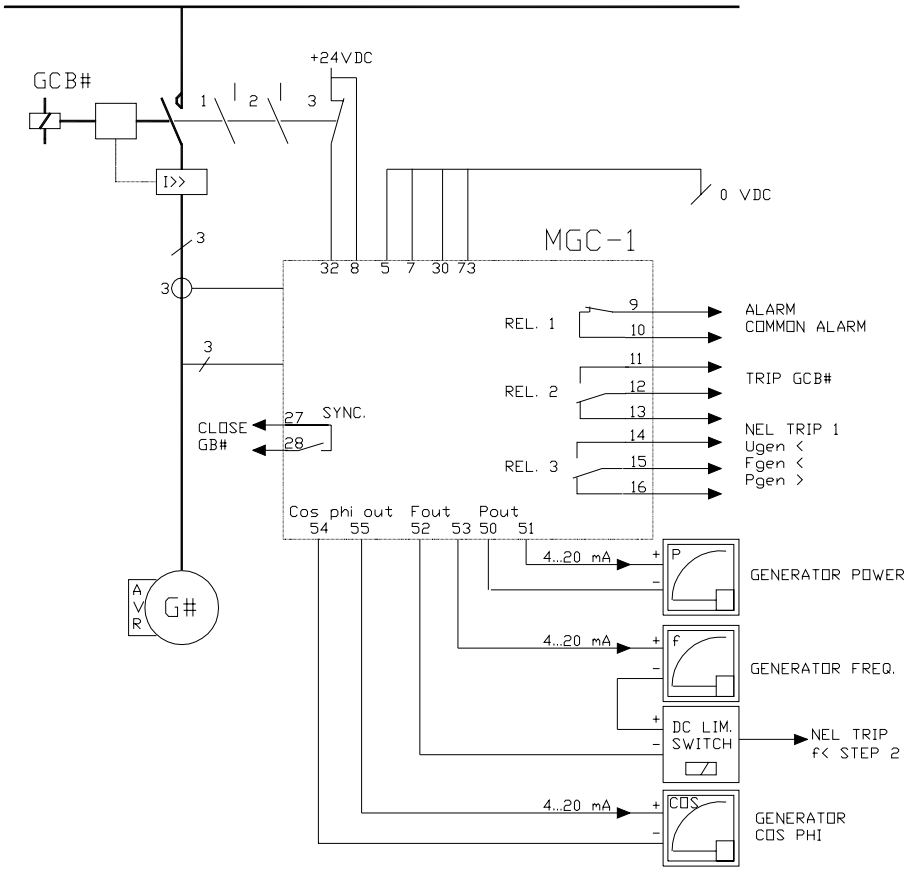


**Fig. 1: Connection/tripping by means of generator circuit breaker**

NOTE: The analog outputs shown on fig. 1 are options.
The Non Essential Load (NEL) trip functions are related to marine use and are possible but not required for land-based generator sets. If relay 3 is not used for NEL trip, it may be freely configured for alarm indication purposes.

If a P> NEL step 2 is required, a limit switch (4...20mA) can be connected to the generator power output (if available) or a limit switch (0..5VDC) can be connected to the load sharing line (terminals 52 (+) and 4 (-).

## 4. Measurements carried out on the generator

### 4.1 Measurement of generator power

An accurately calibrated 3-phase watt transducer is integrated in the MGC-1, measuring the RMS value of the active power, irrespective of the wave form of the actual generator current and voltage.

The power is converted into a DC current ($P_{out}$) signal (4..20mA at normal direction of power).

### 4.2 Indication of generator power

A standard moving coil instrument (0...20mA DC) is connected to the terminals 50(-) and 51(+) for indication of reverse power as well as generator power (available only if the analog output option is present). This value is also shown on the MGC-1 display.

### 4.3 Measurement of generator currents

For current measurements we recommend using moving iron instruments calibrated for the current transformer secondary side values. These values are also shown on the MGC-1 display.

### 4.4 Tripping functions

All protective functions (see section 1.1) can be programmed to activate the "GCB trip" relay output. In this manner all the required trip functions can be utilised. It is recommended to programme all protective functions not used for trip to activate the "Alarm" output relay. In this manner all protective functions are active.

## 5. Load sharing between the generators

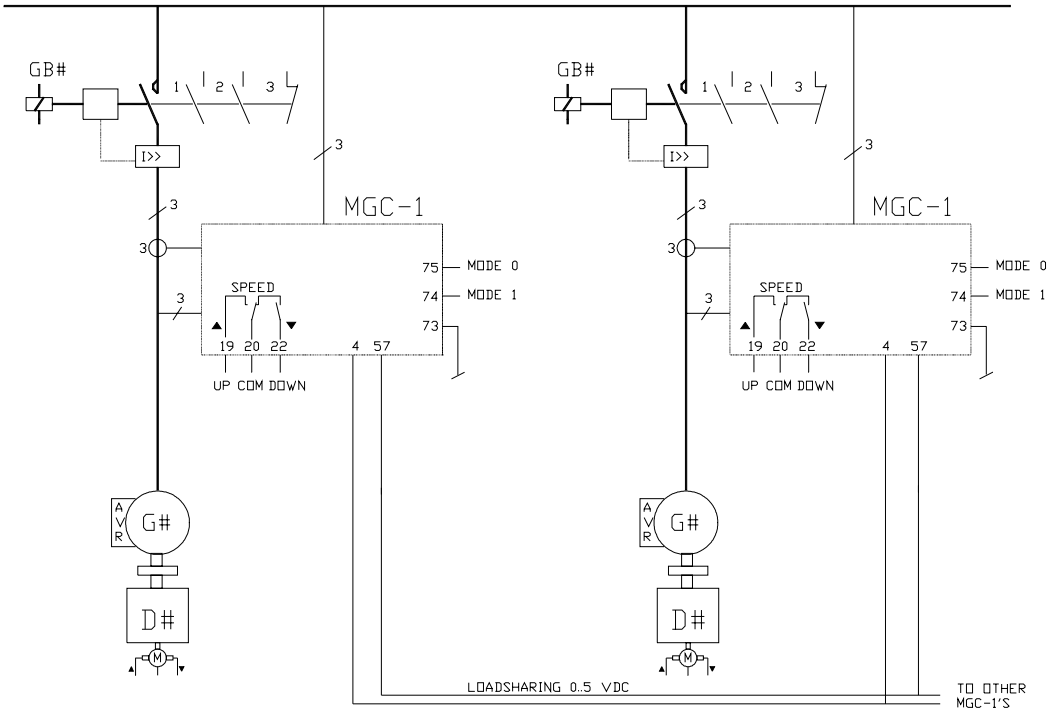


**Fig. 2: Isochronous load sharing or base load**

The load sharing line is a 0...5 VDC analog line representing 0..125% of the nominal plant power.

NOTE: If a generator is to deliver fixed power to the busbar (base load), the MGC-1 for this generator must be disconnected from the load sharing line.

### 5.1 Control of speed governor

If the diesel engine is provided with a mechanical speed governor, this must be equipped with a pilot motor ("M") for manual/automatic remote control of the diesel engine. The 2 output relays of the MGC-1 may then, in conjunction with a supply voltage for the "M", control the mechanical speed governor.

If the diesel engine is provided with an electronic speed governor, the MGC-1 can be delivered with an analog output, -5..0..5VDC (option), or an "electronic potentiometer" (EPQ96 or EPN-110DN) is applied to manual/automatic remote control of the diesel engine. The 2 output relays of the MGC-1 can then control the electronic governor through the EPQ96/EPN110DN.

Re EPQ96/EPN-110DN : See section 11.2.

### 5.2 Adjustment of speed governors

Mechanical/electrical speed governors must ALWAYS be adjusted to an INTERNAL speed droop, irrespective of the applied connection (fig. 2) to ensure stability at manual as well as automatic control! A speed droop of 4% is the rule of thumb setting.

### 5.3 Connection of the MGC-1

The supply voltage for the MGC-1 is connected to terminals 7 (0 VDC) and 8 (+24 VDC).

### 5.4 Load sharing – Isochronous mode (fig. 2)

The most commonly used method.
The term "isochronous" refers to load independent frequency control, i.e. the frequency is kept constant at 50/60Hz at 0...100% load.

Each MGC-1 unit receives the following signals:

| | |
|---|---|
| "Mode 0": | Not connected |
| "Mode 1": | Connected to +24 VDC |

When the first generator is connected, the frequency is controlled to 50/60Hz only.

When connecting more generators in parallel, the load is shared equally between the generators and the frequency is simultaneously controlled to 50/60Hz.

### 5.5 Load sharing – Base load (fig. 2)

The term "base load" refers to frequency independent load control, i.e. the generator load is kept constant at a pre-set load regardless of the system frequency.

The MGC-1 unit for the generator in question receives the following signals:

| | |
|---|---|
| "Mode 0": | Connected to +24 VDC |
| "Mode 1": | Connected to +24 VDC |
| "Load sharing line": | Disconnected |

Note that the frequency **must** be kept constant by one or more other parallel running generator(s).

It is also possible to run the system in "SPEED DROOP" (frequency dependent on load), but it is not commonly used. We refer to the MGC-1 manual for settings.

### 5.6 Automatic start/stop of generators

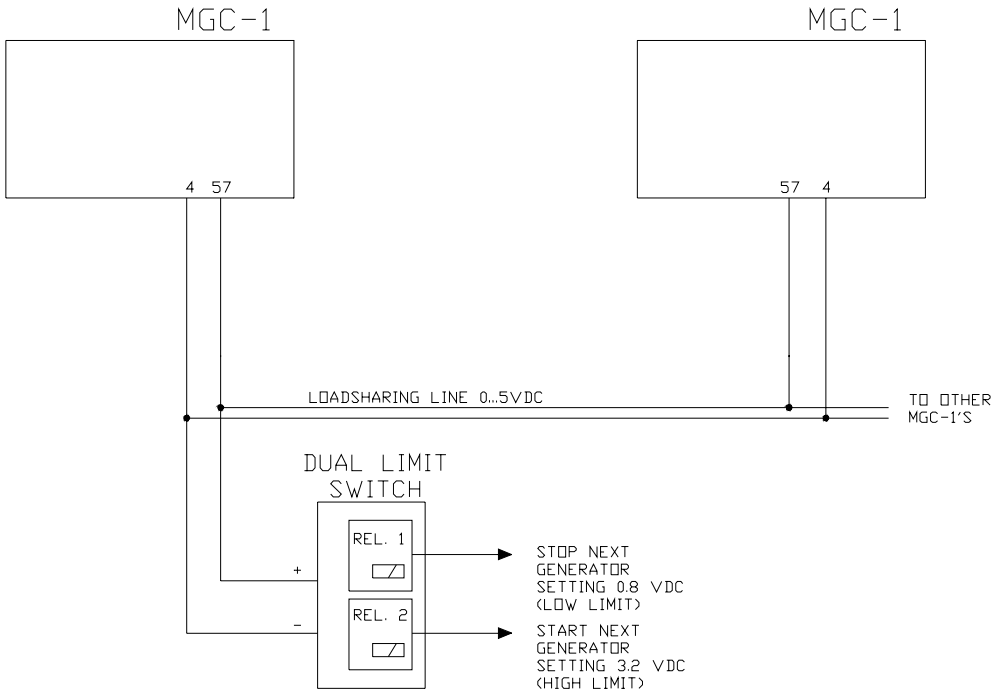


**Fig. 3: Start/stop of generators**

As the load of the busbars are normally mechanically connected to many points, the measurement of the total load is carried out by measuring the voltage on the load sharing line in practice.

The load sharing line is a combined transmit/receive line on the MGC-1 unit, 0...5VDC representing 0...125% load.

If the size of the generators varies, this is corrected simply by the fact that all values are represented in percentage of the generator's nominal power.

The limit switch used must be a high-impedance input (min. 1MΩ) combined high/low limit switch with adjustable time delay. Typical start delay is 10 sec., typical stop delay is 2 min.

NOTE: If NEL trip (relay 3) is not required, the option H (start signal to next unit on power demand) can be used instead of the limit switch.

## 6. Connection of a shaft generator

A shaft generator is normally not controlled as the frequency of the shaft generator is controlled by the main engine speed only. This means that parallel running a (non-controlled) shaft generator with (controlled) diesel generator(s) is not advisable.

It is, however, necessary to parallel for a short period, in order to transfer load to and from the shaft generator without creating a blackout.

In other words, the shaft generator has to be synchronised and load transfer has to take place before opening the diesel generator GCB's.

As the shaft generator is not controlled, synchronisation has to take place controlling the diesel generator(s) instead. This is done by controlling the load sharing line via and EPN-110DN as shown in fig. 4.

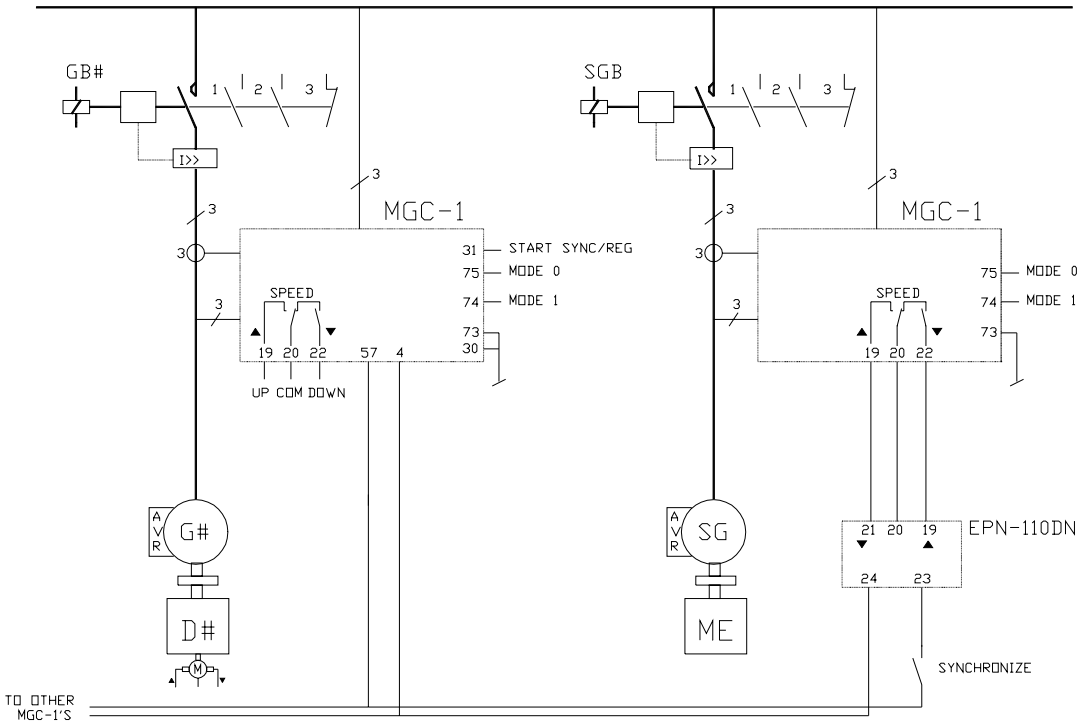


**Fig. 4: Connection of a shaft generator**

NOTE: The EPN-110DN has to be a special version for this application. The internal resistance in the output has to be 5kΩ to match the impedance in the MGC-1 load sharing line.

NOTE: Ramping down with opening of breaker is initiated by taking away the ”start sync./regulating” signal.

## 7. Connection of mains breaker

Seen from a control point of view, a mains breaker is very similar to a shaft generator. It is a power supply unit running a fixed frequency and voltage, of which we do not have control.

### 7.1 Short-time parallel with load transfer

This system will synchronise one or more running generators to the mains, transfer load and stop the generators. This is very similar to the case of a shaft generator (see fig. 5).

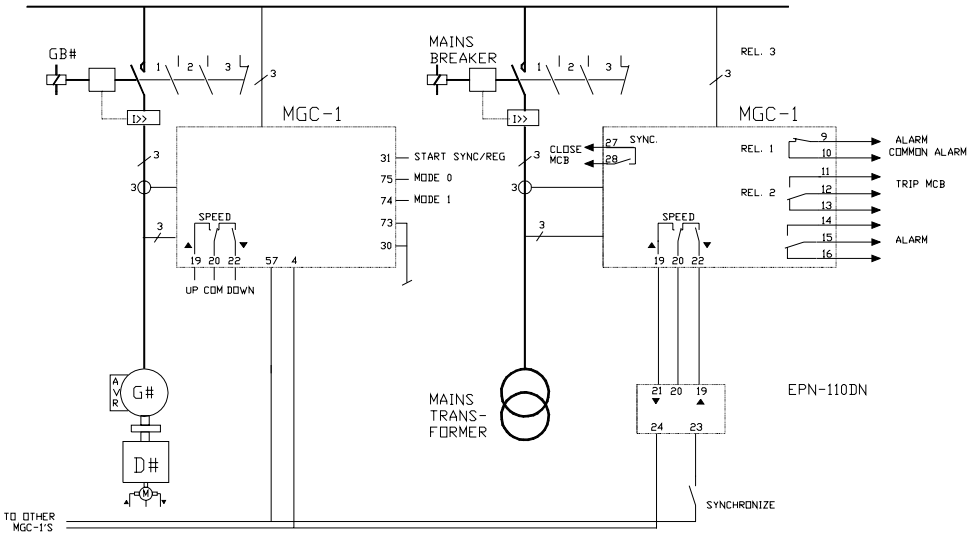


**Fig. 5: Connection of a mains breaker**

The system shown in fig. 5 includes mains breaker protection. If this is not needed, a fully automatic synchroniser (FAS) may be chosen instead of the MGC-1 to do synchronisation only.

NOTE: The mode inputs for the "generator(s) MGC-1" must be set to "load sharing" (see section 4.4). For the "mains MGC-1", the mode setting is of no importance.

NOTE: The EPN-110DN has to be a special version for this application. The internal resistance in the output has to be 5kΩ to match the impedance in the MGC-1 load sharing line.

NOTE: Ramping down of generators is initiated by taking away the “start sync./regulating” signal.

### 7.2 Long-time parallel with fixed generator power and cosφ/var control

This way of running is using the power setpoint (see section 7) for each generator. If the mains breaker protection is not needed, the mains protection may be carried out in each MGC-1 generator or via external equipment. In this case, the mains breaker MGC-1 can be replaced by a fully automatic synchroniser (FAS).

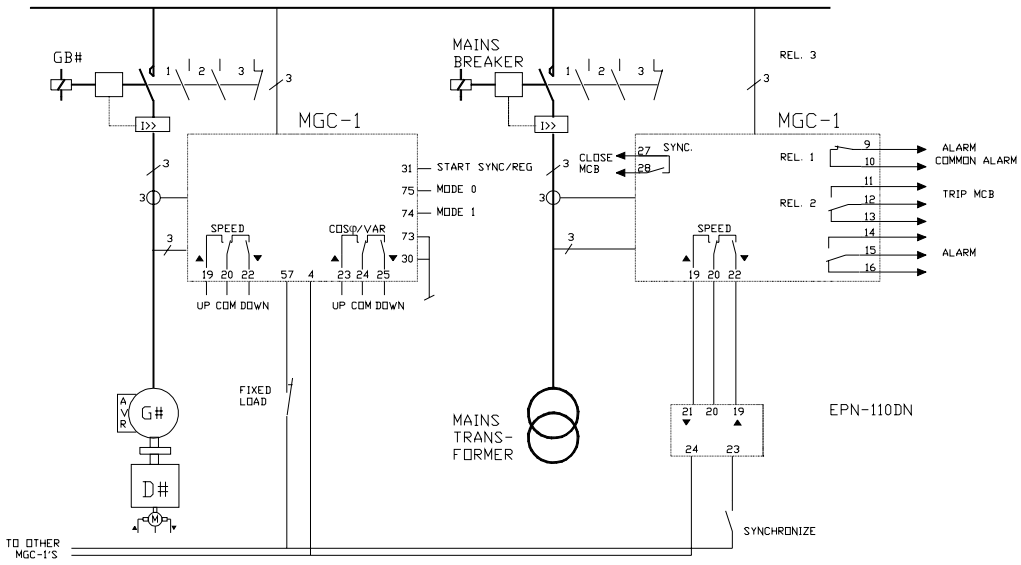


**Fig. 6: Parallel with mains running**

NOTE: Right after synchronisation, the mode inputs for the running generator(s) has to be switched to "fixed power" mode, and the load sharing line(s) has to be disconnected.

NOTE: The EPN-110DN has to be a special version for this application. The internal resistance in the output has to be 5kΩ to match the impedance in the MGC-1 load sharing line.

To control the power production, the running generators can be set to a "fixed set point" which is a power set point keyed in during programming, or the "external setpoint" can be used. See section 7 for further explanations.

If option A “cosφ/var controller” is implemented, a generator running parallel with mains can be preset at a fixed cosφ or var value (selected during programming). This means that the MGC-1 will compensate for changes in voltage in order to maintain a fixed cosφ value/var production.

### 7.3 Long time parallel, ”Peak lopping”

Peak lopping (also in some cases called "peak shaving") is a special parallel with mains operation mode, which controls the mains power transport (import or export) in such a manner that it is kept at a constant level.

#### 7.3.1 Peak lopping using PLC control

A PLC (or similar control device) requires an analog input for mains power transport. This signal can come from the mains breaker MGC-1 or, if this is not used, a power transducer TAP-210DG. This signal is the present value of the mains power.

The present value is used as feedback to a PI regulator, and the output (setpoint) from this regulator is used to control the generator(s) power production, using the "external setpoint" input and "fixed power" running mode.

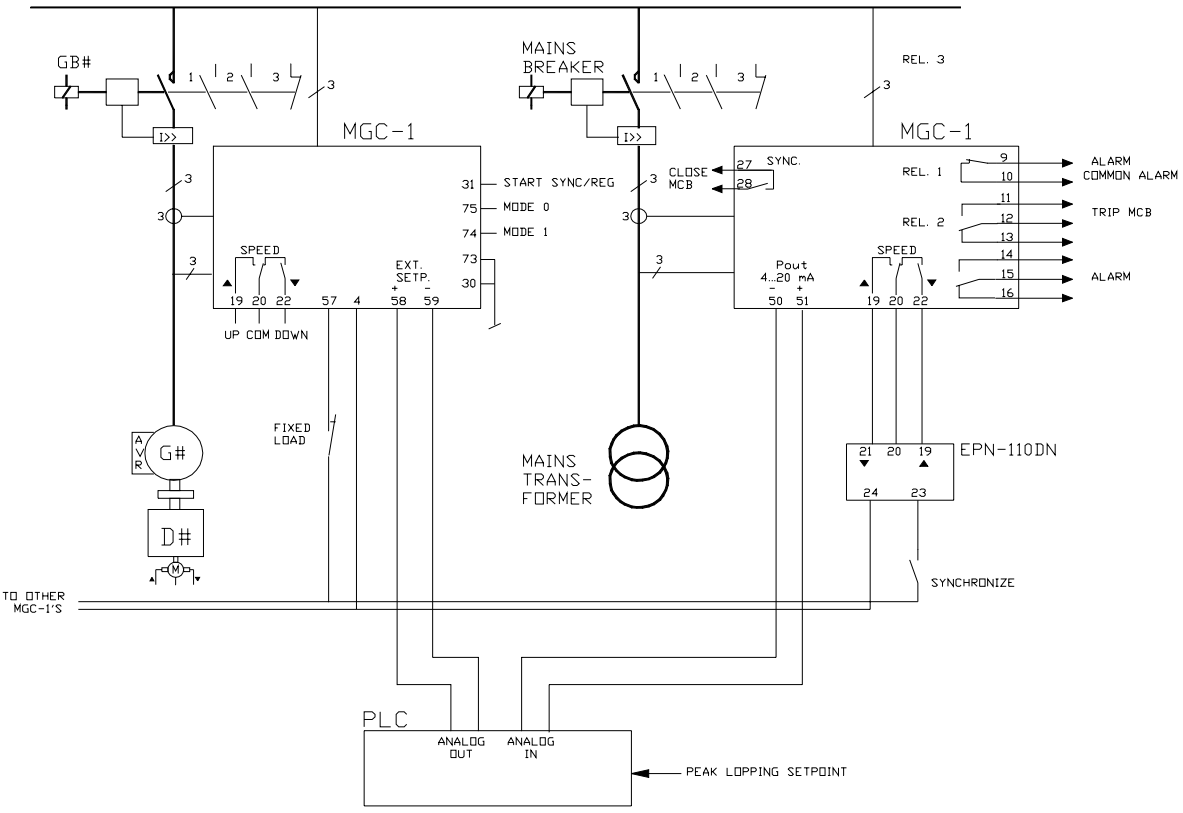


**Fig. 7: Peak lopping using PLC**

### 7.3.2 Peak lopping using MGC-1 control

If a MGC-1 is used for mains breaker protection, it may be used for peak lopping control as well, if peak lopping is required.

The mains breaker MGC-1 has to be set in "fixed power" mode. This is done by activating "mode 0" and "mode 1" simultaneously and keeping them activated during peak lopping.

As previously mentioned, the setpoint can be internal "fixed power" or external "external setpoint" 0...20mA. The mains breaker MGC-1 will control the EPN-110DN during synchronisation **and** during peak lopping.

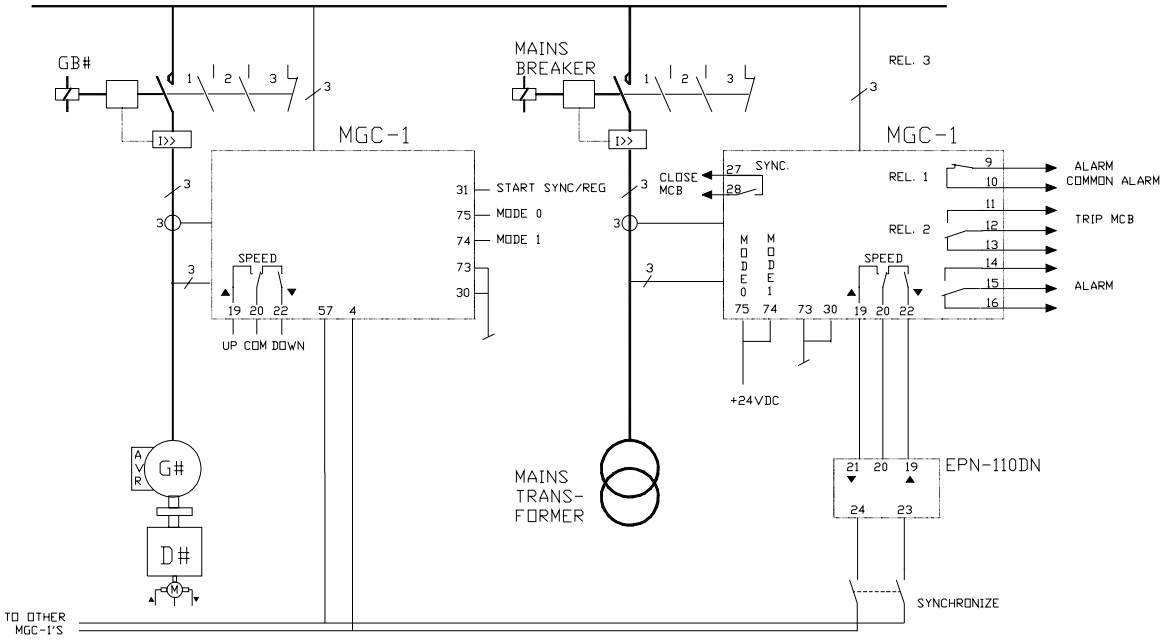


**Fig. 8: Peak lopping**

### 7.3.3 Single generator peak lopping using uni-line LSU-112DG

If a simple peak lopping system is required for a single generator, an attractive solution is to use a uni-line load sharing unit LSU-112DG.

The LSU-112DG is, as indicated in the name, a load sharing unit. It can, however, be configured to do power control, using a potentiometer (2KΩ) as external setpoint.

The LSU-112DG relay output is converted to 0…20 mA (special output) by the EPN-110DN, and this output is used as a signal to the MGC-1 external setpoint input.

The MGC-1 must be set in "fixed power" mode (inputs mode 0 and mode 1 activated), and an external power setpoint must be chosen in the programming.

In this application, the mains protection is carried out by the generator MGC-1. This means that the generator will trip if a mains failure occurs. If the generator is to be used as a emergency generator as well, the system described in 7.3.2. must be used.

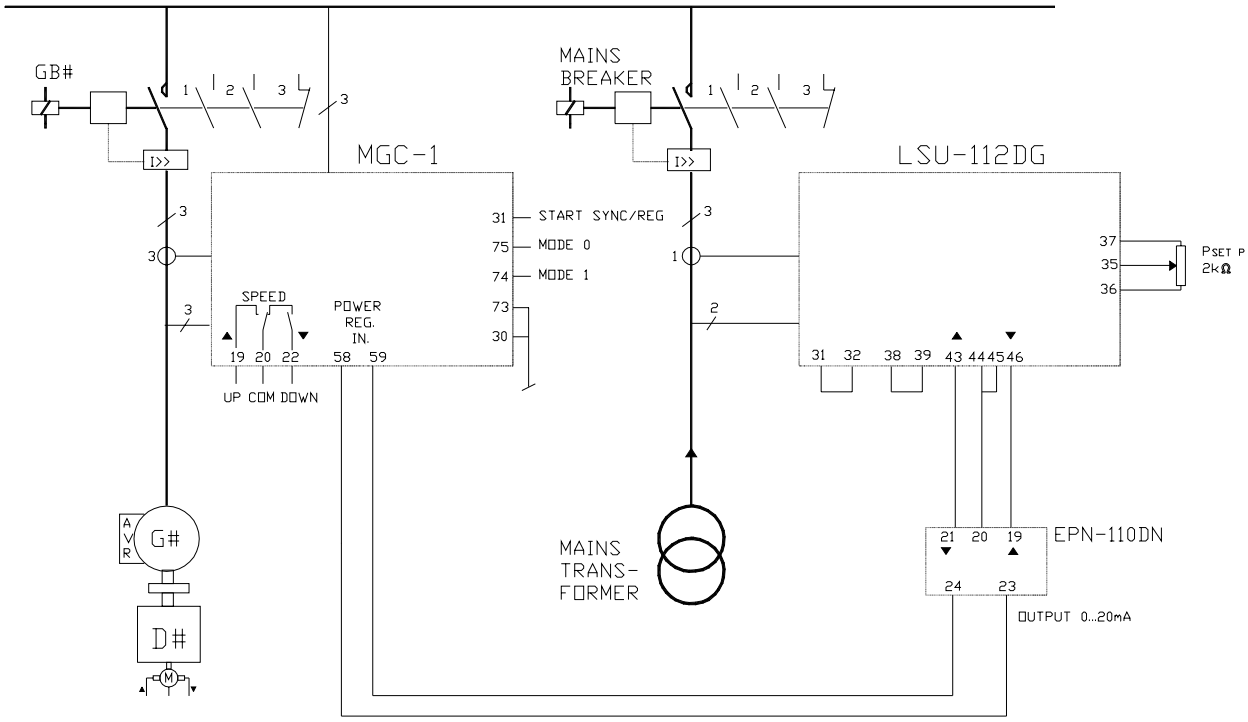


**Fig. 9: Peak lopping, single generator**

## 8. Remote load control

The MGC-1 contains an opportunity for remote control of the generator load. There is an "external setpoint" 0...20mA input (terminals 58(+) and 59(-). Using this input enables you to use an external mA source (e.g. a PLC or a potmeter-controlled transmitter) to control the actual load of the generator to any value (0...100%) desired.

If you use a PLC and at the same time let the PLC receive the P signal form all the generators, you will possess a powerful tool for complete control of the plant power, with base load, ramp up/down and available / consumed power calculations for control of consumers.

## 9. Blocking of heavy loads

Blocking signals can be emitted by a limit switch connected to the power output of the MGC-1(s) to block heavy loads when sufficient power is not available.

If a PLC is used, a more precise way is to let the PLC receive the power signals from the MGC-1(s) and calculate the available power of the system. If sufficient power is not available, the PLC can also give start signal to the next stand-by generator before allowing the heavy consumer(s) to start.

## 10. Enabling/blocking of control functions

The control functions of the MGC-1 (synchronising and load sharing) are only active when the "start reg./synchronising" input on terminal 31 is activated.

To start regulating, most commonly you can use the "engine running" signal from the diesel engine control system.

If blocking/disabling of the regulating function is needed (e.g. by an external breaker trip, typically shortcircuit or undervoltage trip of the breaker), deactivate the input.

Deactivating terminal 31 does not affect the measuring and protective functions of the MGC-1.

If the “de-load” function is activated (during programming), deactivating term 31 will make the MGC-1 ramp down a running generator and open the breaker at 10% load.

## 11. Control of speed governors

Each diesel generator must be provided with a speed governor with the following characteristics:

It can be adjusted to a 2...4% speed droop
It can be remote controlled

The main diagram shows control of mechanical speed governors only, however, it is immediately applicable to control of electronic speed governors when adding only a single unit per engine as shown in fig. 10.

### 11.1 Mechanical speed governor

The governor is mechanically controlled by means of a pilot motor (PM), mounted on the governor (supplied from the voltage source mrk. SUPPLY).

Manual control: The START SYNC/REG input is deactivated.
The pilot motor (PM) is controlled by means of two push-buttons mrk. (UP and DOWN) on the panel front.

*NOTE: Switch and push-buttons are NOT shown on the diagram and are NOT supplied by DEIF.*

Automatic control: The START SYNC/REG input is activated.

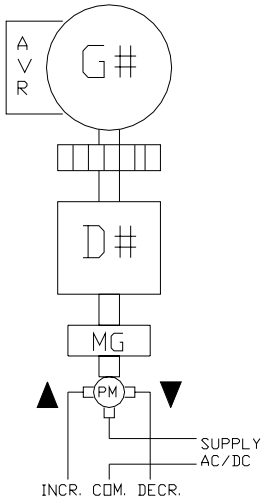


**Fig. 10: Mechanical speed governor**

During synchronisation the pilot motor (PM) is controlled by the output relays of the MGC-1 unit.
During load sharing the pilot motor (PM) is controlled by the output relays of the MGC-1 unit.

### 11.2 Electronic speed governor (EG)

(Note: Not shown in main diagram)

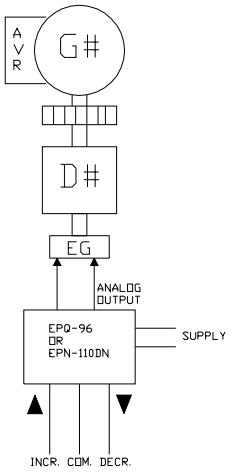


**Fig. 11: Electronic speed governor**

The governor is electrically remote controlled by means of an "electronic potentiometer" (EPQ96 or EPN-110DN or MGC-1 with analog governor control (option B1). This unit controls the electronic speed governor by means of a -5...0...5V DC signal, connected to those terminals of the speed governor that are normally applied to connect a 5KΩ potentiometer for fine adjustment of the frequency. If an EPQ96 is used, it is mounted in the panel front and connected to a supply voltage of 24V DC.

Manual control: The START SYNC/REG input is deactivated.
The functions of the EPQ96 are now controlled by the two push-buttons mounted in the front plate.
If an EPN-110DN are used, a separate switch/potentiometer for this function is necessary.
If the analog output from MGC-1 is used, manual control is not possible.

Automatic control: The START SYNC/REG input is activated.
During synchronisation/load sharing the EPQ96/EPN-110DN is controlled by the output relays of the MGC-1 unit.
If the analog output from MGC-1 is used, no electronic potentiometer is needed.

## 12. Complete layout for island operation

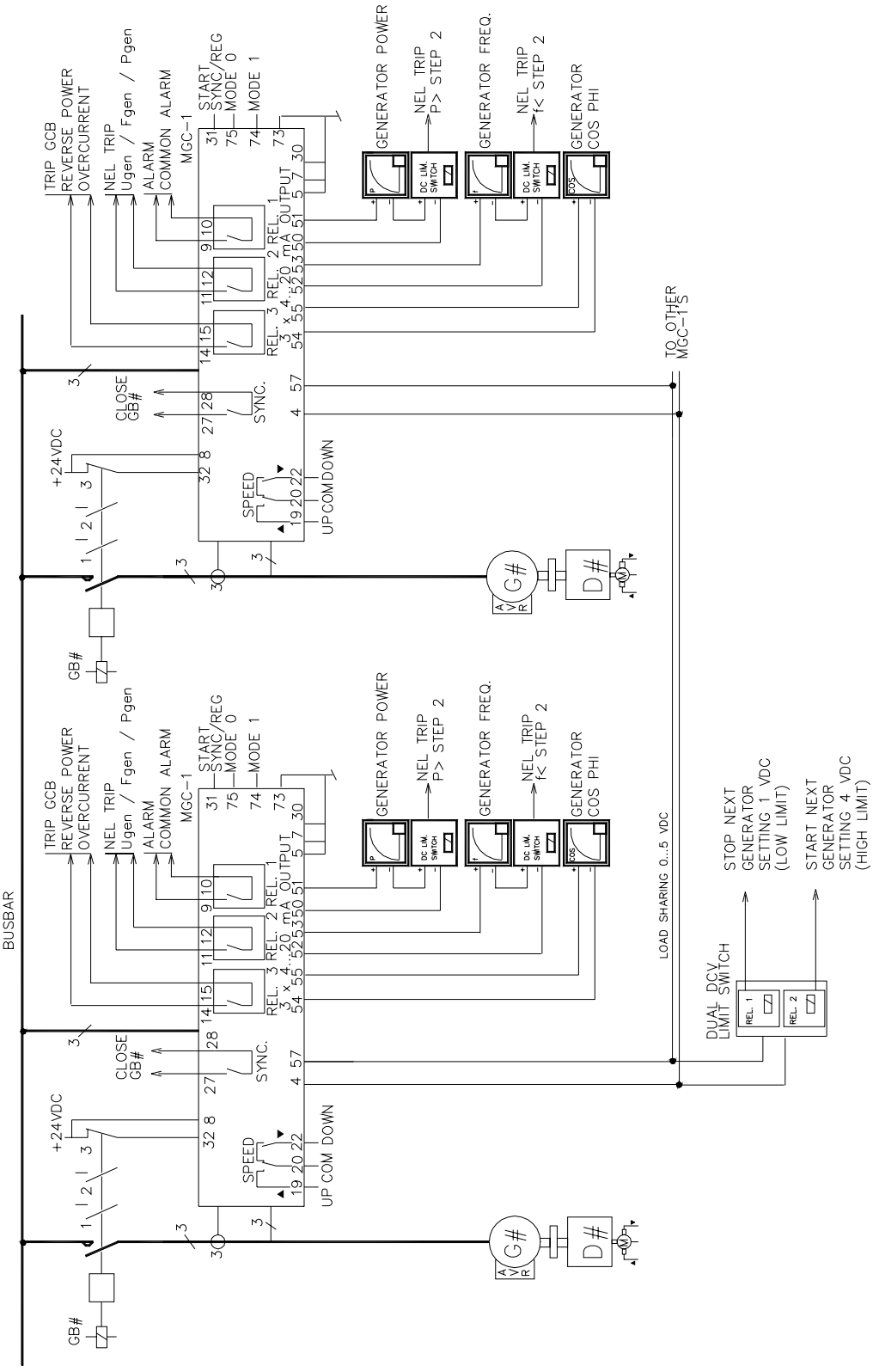


**Fig. 12: Diagram for island operation**

Errors and changes excepted