Application Note: Co-Generation

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Co-generation is becoming an increasingly important issue in the electricity market.

For some companies it is beneficial always to utilise a certain amount of their own power generating capacity and only import the excess power from the grid. This is also called “base-load”. See fig. 1.

In case of limited grid capacity, companies sometimes have to pay a penalty fee when they exceed a certain agreed amount of power, and then it is beneficial to import only this amount of power from the grid, and produce the excess power with own power generating equipment. This is also called “peak-lopping” or “peak-shaving”.

Another important factor is the increasing liberalisation of the electricity market in many countries. It is now more and more common to be permitted to operate in parallel with the grid, when proper generator control equipment is used. Also many countries now have a policy for exporting excess power to the grid.

SELCO has equipment for control, protection and monitoring generators operating in parallel with each other or with the grid.

The SELCO load sharers provide automatic load sharing for generators running in parallel. When applied with the SELCO B9300 Power Reference Unit, one or several generators in parallel operation with the grid can be controlled.

The SELCO T4900 VAr (Voltage Ampere reactive) Load Sharer provides automatic VAr load sharing for parallel running generators. The VAr Load Sharer can also be used for power factor control (“cos ϕ”) on a generator in parallel operation with the grid.
The SELCO synchronizers perform automatic synchronisation of incoming generators.

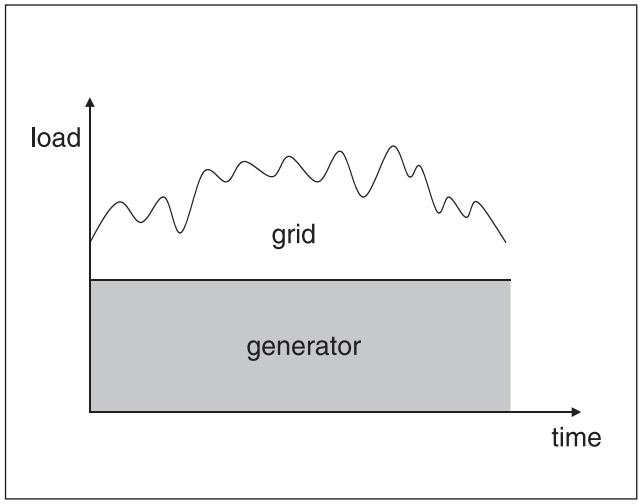

Fig. 1. Illustration of “base-load”

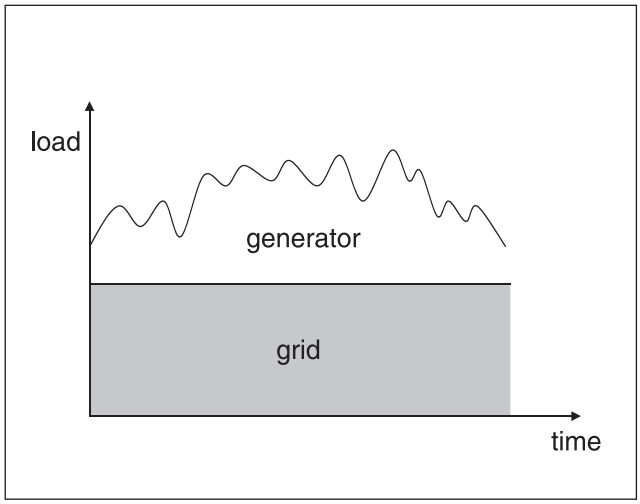

Fig. 2. Illustration of “peak-shaving”

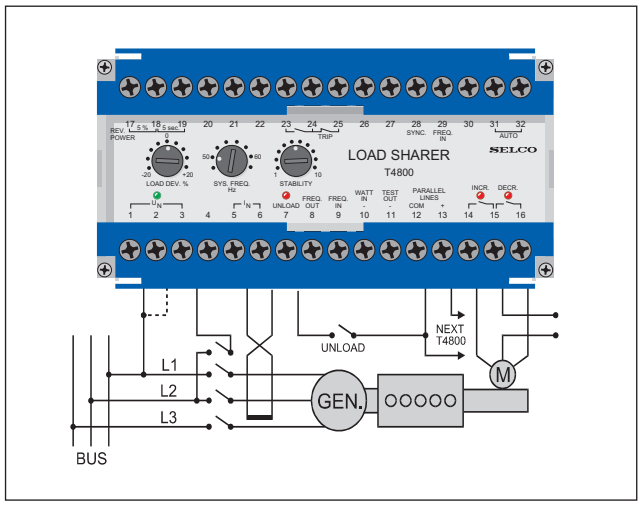

Fig. 3. The SELCO T4800 Load Sharer.

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Base-load with one or more Generators

Fig. 4 shows an application diagram for co-generation with constant generator load and optional power factor regulation using SELCO equipment. On the Power Reference Unit B9300 the setting determines the amount of power (in % of generator capacity) to be produced. An output voltage to terminals 12 and 13 on one or more load sharers will cause a constant load on the generators. There is one load sharer for each generator. In case of more than one generator, the load sharers will share the load proportionally. If the load is larger than the produced power, the system imports from the grid. If the load is lower than the produced power, the system exports to the grid.

The load sharer is supplied from two phases of the busbar on terminals 3 and 2 (1). The current from the generator is measured (on the third phase) via a current transformer connected to terminals 5 and 6. From the current and voltage the power from the generator is determined.

If the power is higher than corresponding to the setting on terminals 12 and 13, decrease pulses will be applied to governor. If the power is lower than corresponding to the setting, increase pulses will be applied to the governor. If more than one generator is connected, each generator will produce power according to the setting on terminals 12 and 13 on the corresponding load sharer.

When the grid is off, the supply to the reference unit is off. Terminals 12 and 13 of each load sharer are now used for communicating power and frequency balance between the paralleled generators.

An unloading facility is available on the load sharer. When terminals 7 and 12 are interconnected, the load on the generator is reduced and maintained on a low value (< 5%).

For power factor regulation one VAr load sharer per generator can be added as illustrated in fig. 4. Inputs to the VAr load sharer are similar to the inputs to the load sharer.

When the grid is on, terminals 12 and 28 are interconnected, and this will set the VAr load sharer in power factor mode. The power factor setting is determined by an external potentiometer across terminals 29 and 30. Increase and decrease pulses control a motorized potentiometer, connected to the generators AVR (Automatic Voltage Regulation). This will cause the generator to produce the amount of reactive power according to the power factor setting.

When the grid is off, the VAr load sharers will cause the generators to share the reactive load proportionally. Terminals 12 and 13 of each VAr load sharer are now used for communicating reactive power and voltage balance between the paralleled generators.

An unloading facility is available on the VAr load sharer. When terminals 7 and 12 are interconnected, the reactive power on the generator is reduced to zero. If the grid is on, the unit is in power factor mode. In this mode the power factor will be adjusted to unity.

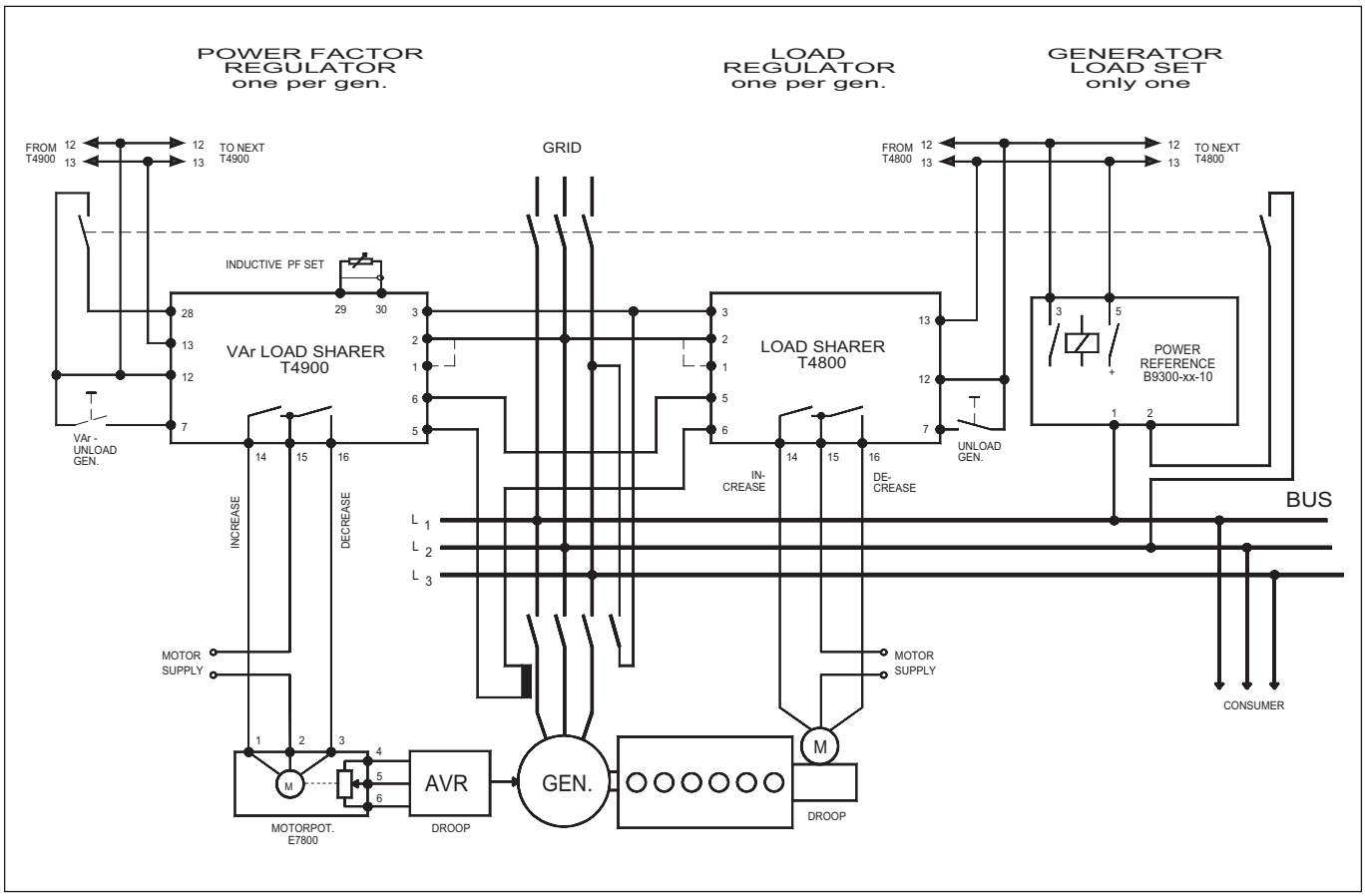

Fig. 4. Co-Generation Application Diagram. One or more generators with constant generator load and generator power factor regulation T0199-51E

Peak-shaving with one Generator

Fig. 5 shows an application diagram for co-generation with constant grid load.

In this case the regulation is based on measuring the current from the grid rather than the current from the generators. Thus we can keep the grid load constant. Due to the fact that the input is now the current from the grid, there is only one measuring current, so in the set-up in fig. 5 we can only regulate one generator.

The guidelines are similar to those of base-load. On the Power Reference Unit the setting determines the amount of power to be imported (or exported if you change terminals 3 and 5). An output voltage to terminals 12 and 13 on the load sharers will cause a constant grid load.

The load sharer is supplied from two phases of the busbar on terminals 3 and 2 (1). The current from the grid is measured (on the third phase) via a current transformer connected to terminal 5 and 6. From the current and voltage the power from the grid is determined.

If the power from the grid is higher than corresponding to the setting on terminals 12 and 13, increase pulses will be applied to the governor. If the power from the grid is lower than corresponding to the setting, decrease pulses will be applied to the governor.

An unloading facility is available on the load sharer. When terminals 7 and 12 are interconnected, the load on the generator is reduced and maintained on a low value (<5%).

If power factor regulation is wanted, a VAr load sharer can be added as illustrated in fig. 5. Inputs to the VAr load sharer are similar to the inputs to the load sharer.

When the grid is on, terminals 12 and 28 are interconnected, and this will set the VAr load sharer in power factor mode. The power factor setting is determined by an external potentiometer across terminals 29 and 30. Increase and decrease pulses control a motorized potentiometer, connected to the generators AVR (Automatic Voltage Regulation). This will cause the generator to produce the amount of reactive power according to the power factor setting.

An unloading facility is available on the VAr load sharer. If the grid is on, the power factor will be adjusted to unity.

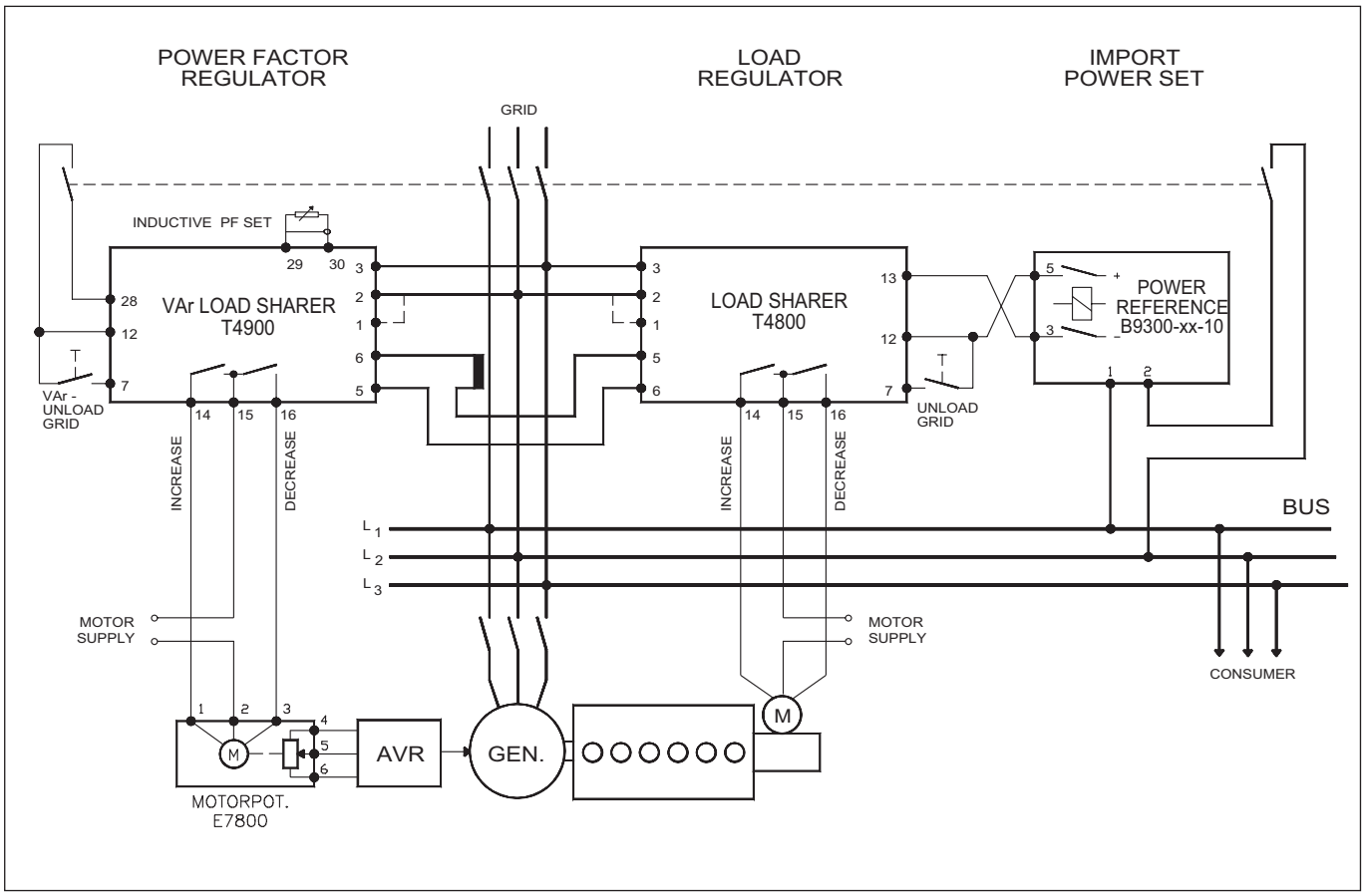

Fig. 5. Co-Generation Application Diagram. Single generator with constant grid load and power factor regulation

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Peak-shaving with Multiple Generators

Fig. 6 shows an application diagram for co-generation with constant grid load using multiple generators. When the grid is on there will be constant grid load (within set limits). When the grid is off, the generators will have active load sharing.

The Load Reference Unit is a special version (-1V to +1V). The setting on this determines the amount of power to import or export (minus for import and plus for export). The current to the grid is measured and fed to terminals 5 and 6 on the upper load sharer. From the current and the voltage the power to the grid is calculated. The increase and decrease signals from this load sharer will adjust a motorized potentiometer.

The output voltage from the motorized potentiometer will tell the lower load sharers how much power to be produced by the generators. The inputs to the lower load sharers are the current from the generators. From the current and voltage the generated power is calculated. With increase and decrease signals to the governor on the generators, the generator output is controlled so that it corresponds to the required power.

Note that there is an adjustment on the motorized potentiometer, where one can adjust the generator maximum limit (in order to protect the generators from overload). The output from the motorized potentiometer can not go below zero (thus avoiding power to the generators from the grid).

In fig. 6 it is also indicated on the load sharers how an optional trip for reverse power and unload can be used.

The system can also be equipped with VAr load sharers in a similar manner to that shown in fig. 7.

When the grid is on, power factor regulation is obtained according to the setting of the potentiometer on terminals 29 and 30 on the upper VAr Load Sharer. The lower VAr load sharers will control the generators to produce the required reactive power. When the grid is off, the lower VAr load sharers will perform reactive load sharing and voltage control.

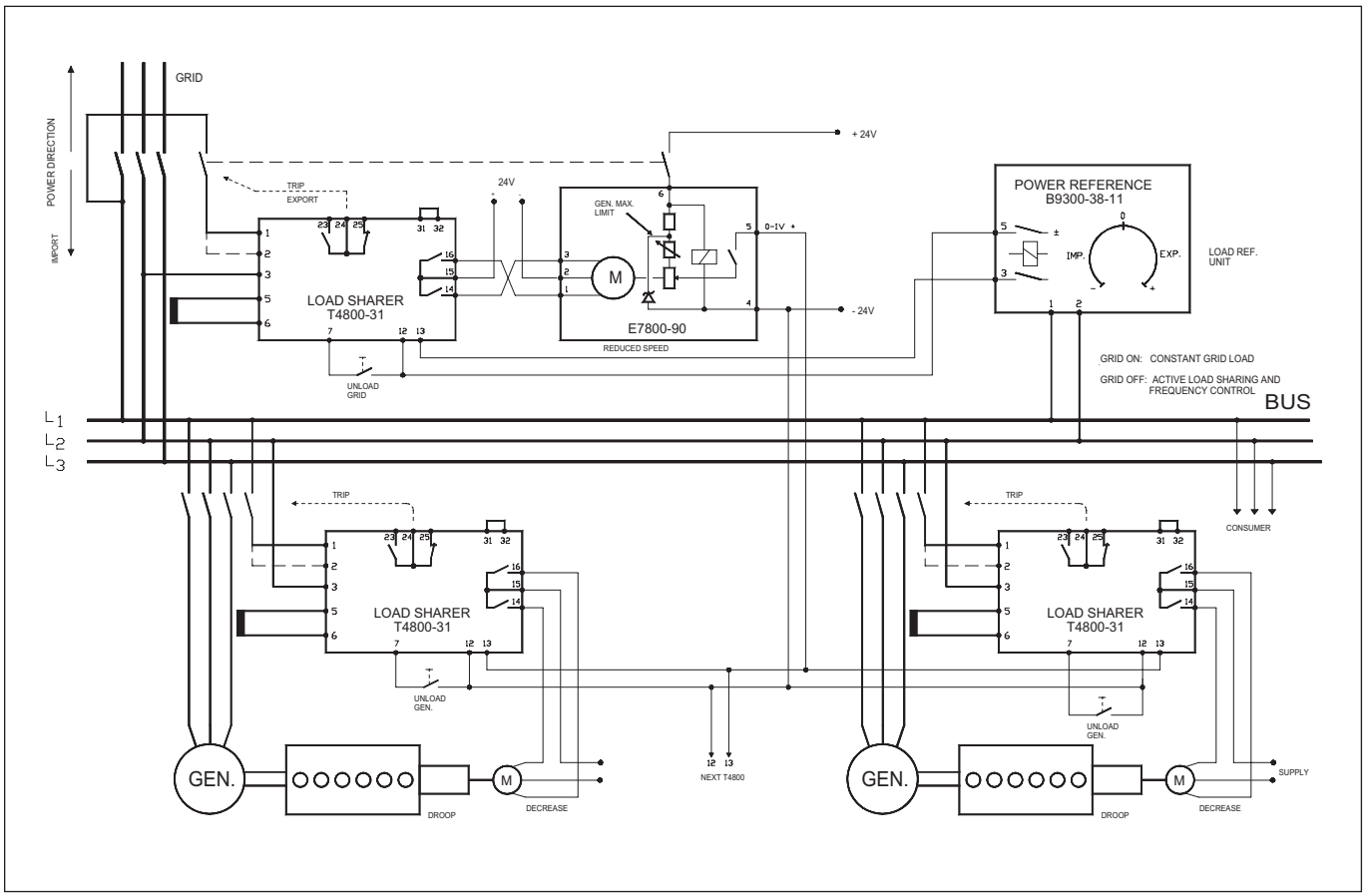

Fig. 6. Co-Generation Application Diagram. Multiple generators with constant grid load.

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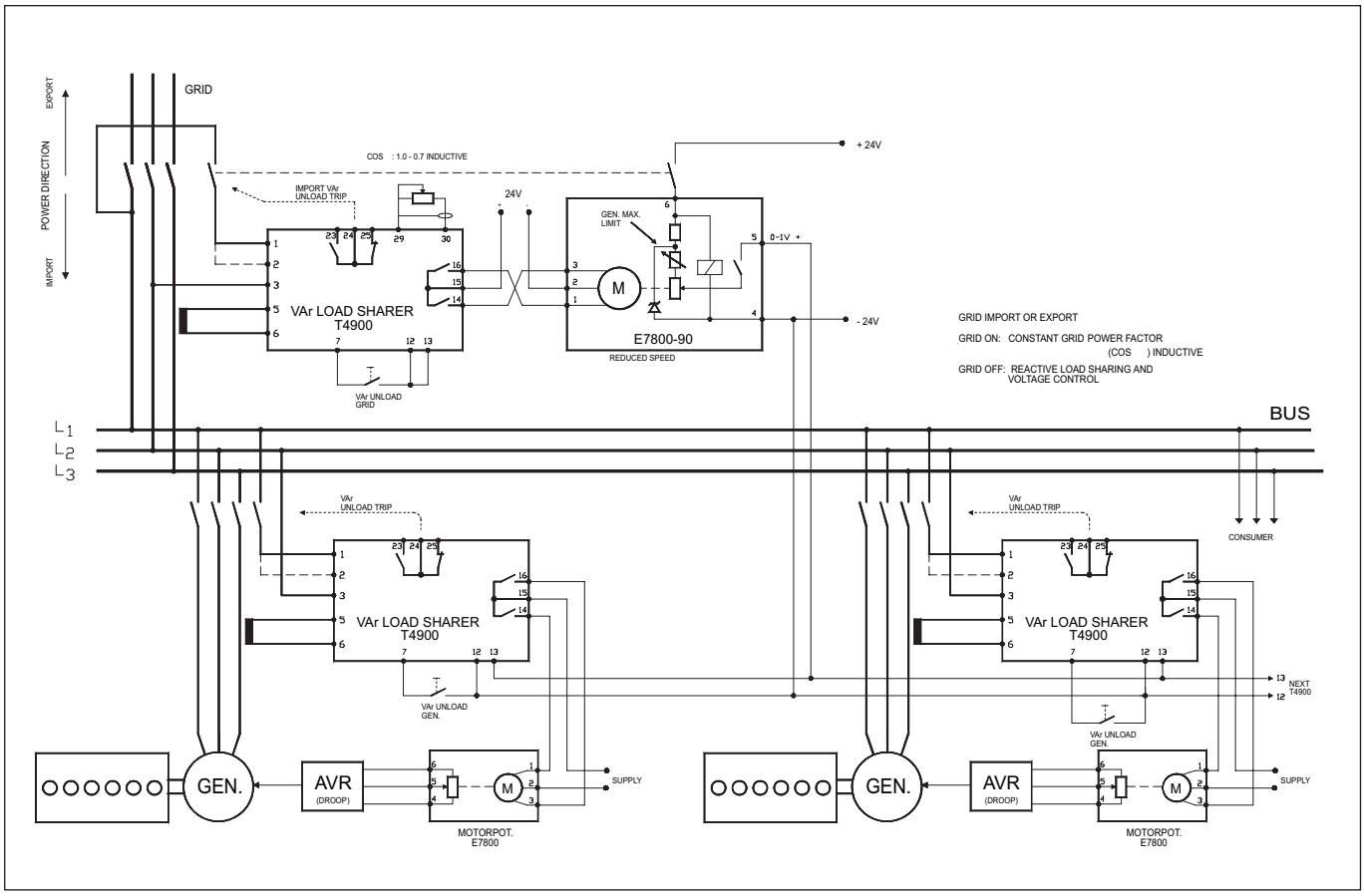

Fig. 7. Co-Generation Application Diagram. Multiple generators with constant grid power factor regulation.

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Type Approvals and Certificates

The SELCO equipment has been thoroughly tested by certified laboratories with regard to high vibration levels, heat, cold, humidity, salt mist, EMC emission and immunity as well as other parameters.

SELCO products are in accordance with all significant international standards and have been approved and certified by the major marine classification societies.

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