

White paper

TN004

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The synchronization of generators in a powerplant can be done by two different ways:

- The classic method commonly named “live bus synchronization”
- The advanced method named “dead bus synchronization”

Dead bus synchronizing is a technique that has been used by KOHLER-SDMO for many years on hundreds of critical plants such as hospitals or data center.

Applications

Deadbus synchronization involves dissociating the start of the diesel engine from the alternator excitation. This technique can be used for four main applications:

- Magnetizing a high voltage loop comprising several step-up/step-down transformers and long cables
- Synchronizing as many generators as possible in less than 15 seconds
- Starting a significant power in the minimum time
- Starting loads with a high inrush current

Dead bus synchronizing sequences

To realize dead bus synchronization, it is necessary to use an advanced genset controller such as the APM802 and to use the same voltage regulator on all the gensets.

The dead bus synchronizing technique is as follows:

- Power plant starting order
- Mains breaker opens
- Stand-by breaker closes
- All generator breakers close
- Diesel engines start with alternator excitation off
- When the last engine reaches its nominal speed, generator excitation order is done simultaneously on all the generators
- Gradual voltage increase in approximately 2 to 3 seconds (adjustable on new digital voltage regulators)

If one or more generators have not reached their nominal speed following a delay, these are uncoupled (their breakers open) and will later be synchronized using the conventional live bus synchronizing.

While the speed is increasing, without excitation, the alternators deliver a remanent voltage corresponding to approximately 10 % of the nominal voltage at nominal speed. With such voltage values, the electrical synchronizing torque is not strong enough to synchronize alternator together.

When the excitation order is executed simultaneously on the generators, the voltage is built up smoothly on all the generators, synchronizing them together naturally.

This smooth synchronization at reduced voltage avoids high current circulation between generators.

Applications justifying dead bus synchronizing

1.1 Transformer magnetization

When magnetizing an HV plant including a large number of step-down transformers, the magnetization current for these transformers depends on several factors:

- The position of the voltage sinusoidal waveform in relation to the zero crossing. The magnetization current is at its maximum when the voltage meets the zero point, and may be 9 to 10 times the nominal current at full load for this transformer.
- The remanent magnetization status of the transformers after the grid voltage has disappeared. This remanent magnetization may be in phase opposition to the magnetization flow and generate currents which may exceed 15 times the nominal current at the transformer's full load.

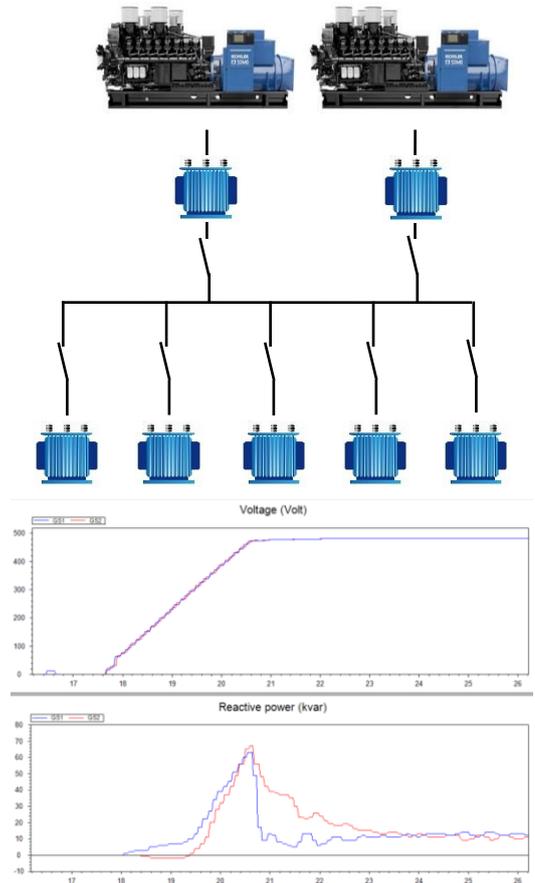
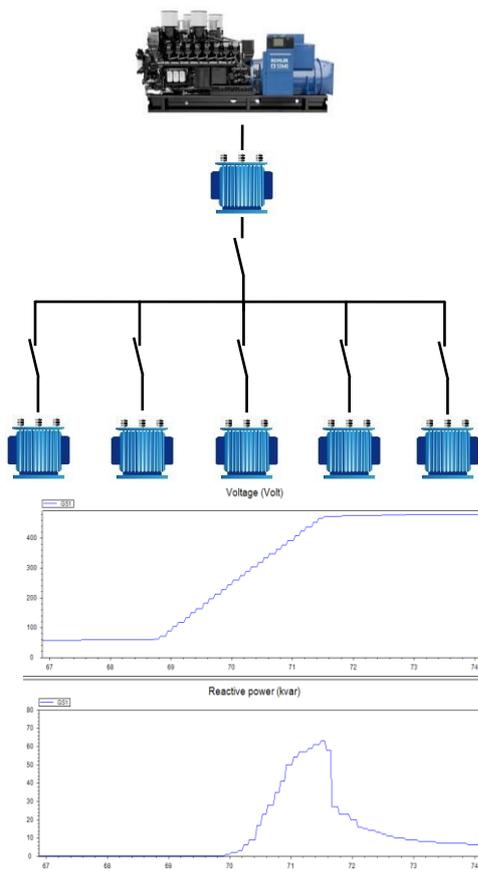
Magnetization under nominal voltage generates high currents in the alternator with high droops on voltage and frequency.

The dead bus synchronizing technique avoids these problems by ensuring gradual magnetization of the transformers during the alternator voltage increase. Circulating currents in the alternators are lower than the nominal value, reducing stress on equipments and avoiding modifying electrical protections settings.

Note:

*This magnetization relates to **reactive power**.*

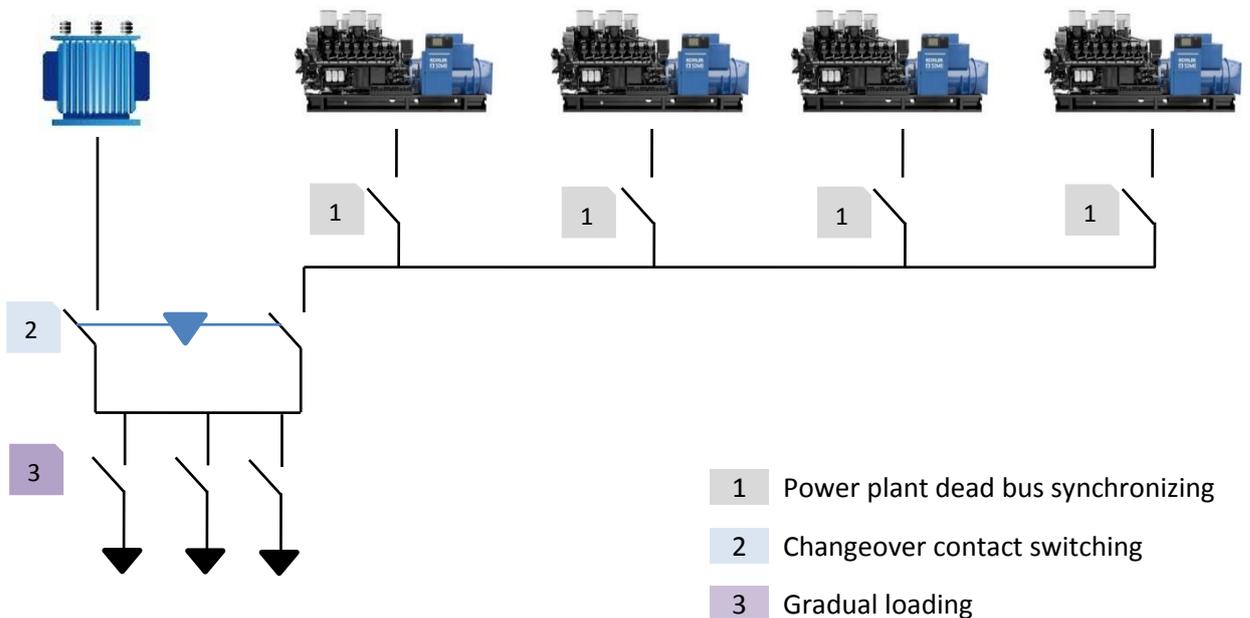
*For **active power**, the loads can be left connected to the power plant (see 1.3 "Starting a significant power in the minimum time" application) or gradually restored.*



1.2 Synchronizing as many generators as possible in less than 15 seconds

For some applications, the voltage must be quickly available on the busbar.

In general, the power plant does not directly supply the load: changeovers switch when the power plant voltage is available, or when the power plant is started.



- 1 Power plant dead bus synchronizing
- 2 Changeover contact switching
- 3 Gradual loading

On large-scale power plants, live bus synchronizing can take too much time. Indeed, the conventional live bus synchronizing technique for several generators in parallel involves production equipment deployment time which is difficult to reduce.

For example, consider live bus synchronization for 10 generators:

- Generator starting time after the starting order: 10 seconds
- Time for synchronization between each generator: 1 to 3 seconds

Successively parallel 9 generators to the first one can take an average time of 25 seconds.

This time can be a little bit reduced if the synchronization of all the generators is done simultaneously, provided that no load is applied on the plant during this sequence.

Using the dead bus synchronizing technique, the entire power plant is available in 10 to 12 seconds, since it is not necessary to synchronize the generators individually.

With this method, the voltage will be quickly available on the busbar. However, the power plant will receive a load impact at the changeover, which causes frequency and voltage drop according to the load shedding plan. Because they comply with the G3 application class, KOHLER-SDMO generators can absorb these impacts very quickly.

Note:

On a power plant with dead bus synchronizing, the live bus synchronizing technique for individual generators is still available and can be used for the power management to adjust the number of generators in operation according to the site consumption.

1.3 Starting a significant power in the minimum time

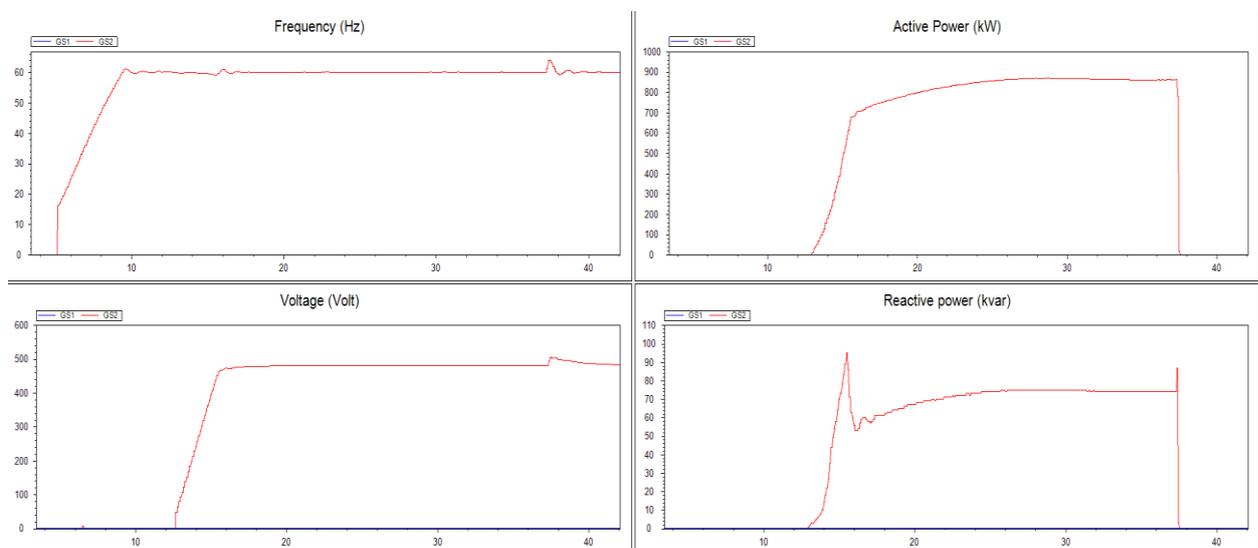
The conventional method, which involves applying a load when the power plant is stabilized, causes a drop in the frequency and/or voltage and a long recovery time which can disturb some equipment.

With dead bus synchronizing, most of generators can supply the full power in less than 15 seconds. The power increases gradually with the voltage reducing the frequency drop.

Combined together, the advantages of dead bus synchronizing are:

- ▶ Magnetize many transformers
- ▶ Have all the generators available quickly
- ▶ Immediately supply high loads on the power plant at one time

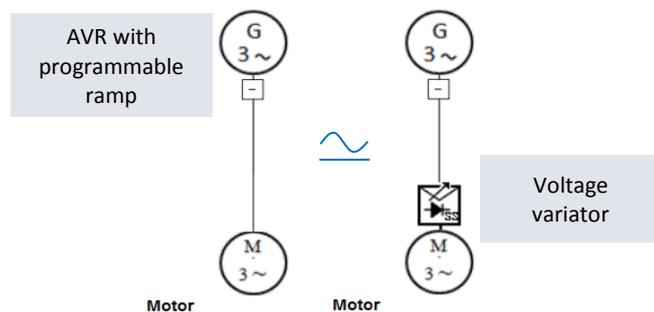
Example with a KD900-UF supplying a 900 kW load through a step-up transformer:



1.4 Starting loads with a high inrush current

Dead bus synchronizing can be used to directly start a load with a very high inrush current, such as an asynchronous motor (6 to 7 times the nominal current).

This application is specific since it requires to supply only this load. Otherwise, all the other connected loads would have to be shut down if the asynchronous machine needed to be restarted later.



Dead bus synchronizing is similar to starting with a soft starter with a fixed frequency (generator frequency) and a voltage ramp provided by the voltage regulator. The current impact on the generator is much lower than for direct starting with nominal voltage.

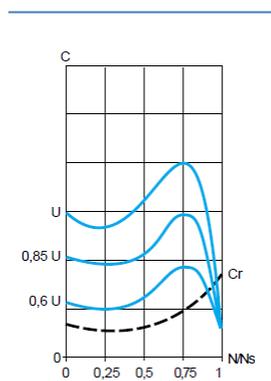


Figure 1

Figure 1 shows the torque/speed characteristics for an asynchronous machine depending on the voltage supply.

For driven mechanical loads with a parabolic resistive torque (fans, pumps), the torque supplied by the asynchronous motor at nominal voltage is very high compared to the torque required to drive this load. The current impact is therefore very large.

A reduced voltage supply lowers the motor torque and therefore the current absorbed at start-up. This technique prevents oversizing of the alternator to support the peak current when the asynchronous machine is started.

Applications where dead bus synchronizing is optional

The dead bus synchronizing option is sometimes used on sites where it is not really necessary. It's often the case when the loads or the starting sequence are not established during the project phase.

Examples of power plants on which dead bus synchronization is optional:

- LV power plant with changeover: if the changeover time is not a matter, the dead bus synchronizing option is not necessary since the time will be sufficient for live bus coupling of the power plant before the changeover switches, thanks to the reactivity of our regulation modules.
- Production power plants (for any number of generators).
For many production power plants, the generators are started individually with gradual increase of the load.

There is no restriction on the starting time for production power plants: dead bus synchronizing is therefore not mandatory.

Power plant extension and dead bus synchronizing

For power plant extensions, all of the voltage regulators must be identical to enable dead bus synchronizing.

In fact, different regulators have different excitation ramp time, which causes exchanges in reactive power between the machines and can lead to activate electrical protections.

For dead bus synchronizing with alternators of different brands and power ratings, it is preferable to have the same digital regulator to get the same ramp for all the generators. The same regulator allows to get uniform ramp more easily.

To realize dead bus synchronizing with digital regulators of different brands, tests must be carried out to determine whether it is possible to obtain identical ramps.

If these solutions cannot be provided, the machines must be coupled with live bus synchronizing.

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