WHITEPAPER

RESILIENT AND RELIABLE POWER MANAGEMENT

Multi-master solutions with DCS and PLC control

Loss of grid power

A matter of money, safety, and security

Loss of grid power can cause significant financial losses as well as safety and security issues in your installation unless a resilient critical power system and control architecture is available. Multi-master power management systems (MM PMS) provide uninterrupted control for applications where power failure is not an option, ensuring supreme resilience through controller redundancy. MM PMS solutions can be designed using distributed control systems (DCSes) or programmable logic controllers (PLCs); for many applications, a combination of the two controller types will be ideal.

In many applications, power failure is simply not an option. In mission-critical facilities and businesses such as life safety, medical, industrial process control, data centres, telecommunications, and television and radio broadcast systems, blackouts are not just about money; they are about safety and security, too

Blackouts are not just about money; they are very often about safety and security, too

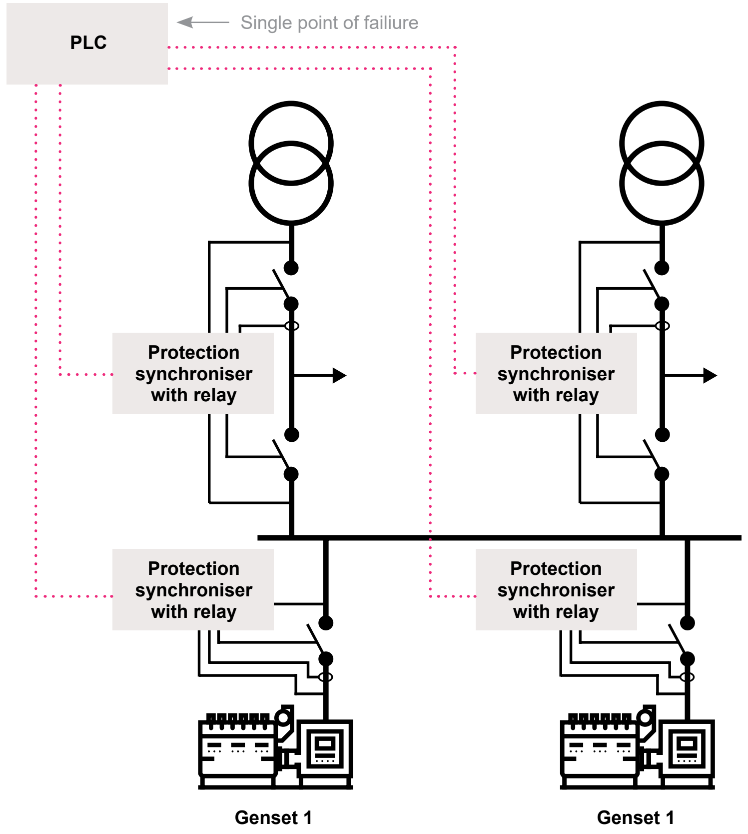
To keep mission-critical equipment running as it should in the event of a blackout, a critical power system must be provided. The system must be able to supply the backup power necessary to keep installations performing to an acceptable level until grid power can be restored.

Avoiding single points of failure

with multi-master power management

Being able to trust the critical power system is crucial, and all components of the system must therefore be designed to be resilient and always deliver – including the control solution which handles the important task of detecting and acting on power issues.

While gensets and batteries are often designed with redundancy, i.e. one or more backup units capable of taking over in the event of equipment failure, this has not always been the case with critical power system control. In the past, control solutions have sometimes been designed as a master-slave setup with one master PLC monitoring the entire power system and switching from grid power to backup power sources in case of grid power failure. The obvious drawback of this solution is that if the master PLC fails, there is no control until the PLC is repaired or replaced. This makes the installation vulnerable to shutdowns due to PLC failure; the controller is a potential **single point of failure** (SPOF) – a component that can disrupt the entire system if it fails.



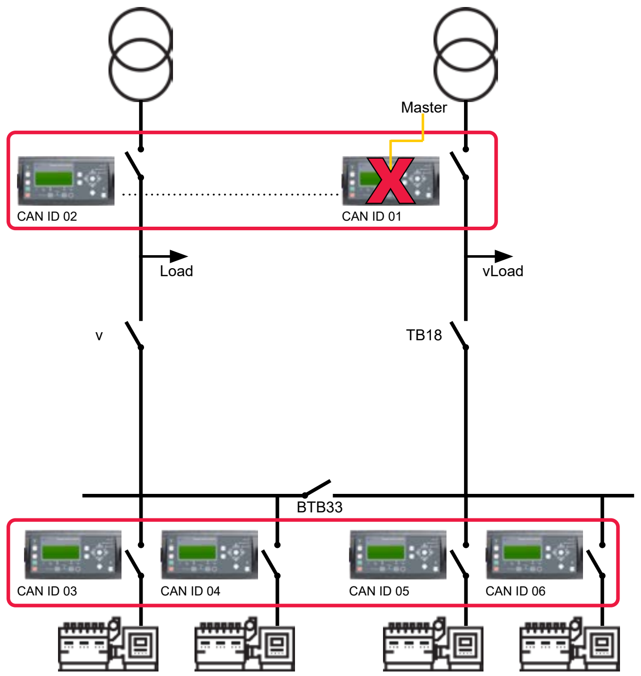
The traditional approach of having one master PLC control the critical power system makes the system vulnerable to master controller failure. The controller, like the rest of the critical power system, needs to be safeguarded against single points of failure

In order to safeguard against SPOFs, critical power systems must be designed with full redundancy for all important components such as cables, IO units – and controllers. A critical power system designed with controller redundancy, in other words with a number of interconnected controllers capable of assuming control if another controller fails, is called a **multi-master power management system** (MM PMS).

A key feature of the MM PMS is the use of several interconnected controllers. There is one controller for every power source and associated breaker, and optionally one controller for every additional important switch such as the bus tie breaker (BTB). Each controller is capable of acting as master controller in the system, as all controllers are interconnected over a communication network. If one controller breaks down, the control system will not fail. It is only the individual controller and associated breaker that does not work.

DEIF AGC-4 generator controllers, for example, can be interconnected over a CAN bus, automatically assigning the master controller role to the available controller with the lowest CAN ID on the network (for example, 01). This controller is appointed command unit. All controllers constantly exchange availability information over the CAN bus. If the command unit (CAN ID 01) fails and no longer responds over the CAN bus, the command unit role is instantly and automatically moved to the available controller with the next-lowest CAN ID (in this case, 02) which then becomes the new master.

The term **power management system** is often associated with marine applications. On a ship, it is responsible for monitoring and controlling the power generation systems, matching supply and demand, switching between power sources as needed, and alerting the crew in case of power problems. With multiple master controllers, the power management system is a resilient and safety-critical feature that helps prevent shipwrecks and other hazardous situations by ensuring that there is always propulsion power, even if one controller fails.



With a multi-master power management system (MM PMS), the master controller role can be passed on to another controller on the communication network, ensuring that no controller constitutes a single point of failure. In this example, a number of controllers are interconnected over a CAN bus; if one controller fails, the controller with the next-lowest CAN ID takes over

PLC and DCS:
controller types explained

A critical power system can be designed using DCSes or PLCs, or a combination; in fact, combining the two controller types will often be a good solution for a complete critical power system.

The key difference between DCSes and PLCs is the question of programmability versus configurability. PLCs are custom programmed whereas DCSes come with off-the-shelf software that can be configured to application needs. This difference is important when selecting controller types for an MM PMS.

A key difference between PLCs and DCSes is the question of programmability versus configurability

In recent years, the distinction between PLCs (and PACs) and DCSes has become muddled because different manufacturers use different terminologies, and because recent generations of PLCs/PACs often include features that make them very similar to DCSes. Yet the key difference of **programmability versus configurability** remains, and it is this issue that you should consider when selecting controller types.

PLC and DCS – definition

A **programmable logic controller (PLC)** is a rugged industrial computer developed to control processes with high reliability. Originally invented in the late 1960s to replace relays and other analogue automation devices in the automotive industry, PLCs are configured and reconfigured through software programming instead of rewiring, greatly simplifying process alterations. PLCs have continued to develop over the years; a PLC with advanced features such as multi-domain functionality, flexible software tools, and compatibility with enterprise networks is sometimes referred to as a programmable automation controller (PAC). Both PLCs and PACs need to be programmed for each specific application, often using software tools that adhere to the IEC 61131-3 control systems programming standard.

A **distributed control system (DCS)** is a microprocessor-based process controller generally agreed to have been invented in 1975. DCSes come with built-in, standardised software that allows them to be configured for logic, sequential, and process control, HMIs, custom applications, and business integration – all in one platform. They enable system designers and users to set up a distributed IO and control architecture with digital communication between distributed controllers, workstations, and other computing equipment. As they rely on built-in software that has been developed based on the experience from many similar applications, DCSes do not need to be programmed.

DCS solutions were initially more expensive than PLCs, but rapid advances in computing power and the availability of low-cost processors mean that this is no longer the case.

Mixing and matching:

a good solution

PLCS: THE PROGRAMMING APPROACH

If you use PLCs, you can customise the control logic to your application according to your exact requirements. Custom-programmed PLC solutions are often used for one-off projects or for controlling specific applications such as auxiliary equipment. Within the limits imposed by the application, the programming language, and the programmer's skills, there is not much that you cannot program a PLC to do. Some PLC manufacturers allow you to choose which programming language to use, and you retain full control and ownership of your PLC logic; an important consideration if you need to protect business assets.

Custom-programmed PLC solutions are often used for one-off projects or for controlling specific applications

However, programming a PLC to carry out central power management functions as part of an MM PMS (for example, communicating with other controllers, and ensuring controller redundancy by transferring the master controller role if a controller fails) takes high-level programming skills. If the control logic needs to be changed, upgraded, or extended after a time, this can only be done by someone with in-depth knowledge of the original solution, preferably the original programmer. *"Two PLC programmers may use completely different programming approaches to reach the same target"*, comments Technical Director Darius Woitalla of DEIF. *"This makes it difficult if one technician then needs to support a programme developed by another technician because it was done in a different way"*.

DCSES: THE CONFIGURATION APPROACH

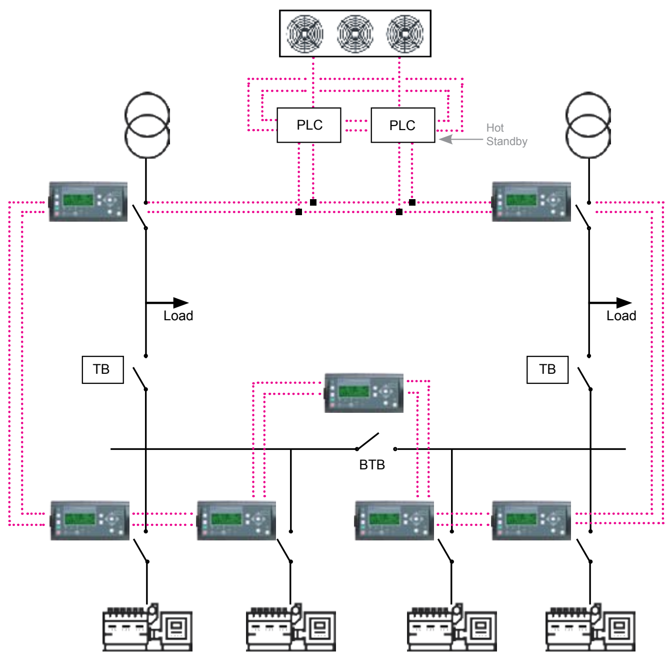
If you use DCSes, the necessary software for handling central power management tasks and ensuring controller redundancy will already be available in the DCS units. No programming is needed; the DCSes can be configured according to application requirements. With sufficient documentation from the DCS vendor, even non-specialists with application knowledge may be able to configure, reconfigure, change, or extend the MM PMS, making a DCS solution comparatively flexible and time-saving. Modern DCSes may also offer value-added features in addition to central MM PMS functionality; something that would require high-level programming skills if you were to achieve something similar with a PLC.

With sufficient documentation from the DCS vendor, even non-specialists with application knowledge may be able to configure, reconfigure, change, or extend the MM PMS

However, the software of a DCS solution designed for MM PMS applications is usually optimised for central power management tasks such as ensuring controller redundancy and controlling gensets; transformer and genset protection is also normally applied in such a controller. It may not be able to adequately control all aspects of the critical power system as a whole. DCS units may not, for example, be suitable for interfacing directly with auxiliary equipment such as cooling systems, which can be an important consideration, for example in data centres where server rack temperature is a critical parameter. Also, if full ownership of controller logic is important to you, a DCS may not be the ideal solution as it relies on standardised software developed and owned by the DCS vendor.

In short, both PLCs and DCSes have their strengths and weaknesses. The choice between PLCs and DCSes should be made based on present and future application requirements, and on the present and future capabilities and requirements of your organisation.

For many critical power applications, a solution that makes use of both PLCs and DCSes will be a good solution. The two controller types do not rule out one another, and it is possible to combine their strengths in a solution that addresses all needs in your critical power system.



Managing central power management tasks using DCSes and interfacing with auxiliary equipment using PLCs is a good solution in many applications

"For most applications, DCSes are the best choice for MM PMS controller", says Critical Power System Specialist and Accredited Tier Designer René Kristensen of DEIF. *"Their onboard software is designed to handle all critical power management tasks in an MM PMS, and they can easily be reconfigured if the need arises – even by non-specialists with basic application knowledge. The software is based on extensive experience with various unforeseen cases, and usually it's updated by the developer so that users get access to software updates. Programming PLCs to achieve the same thing is time-consuming and costly, and it requires extensive expertise. This is even more important if the MM PMS needs to be changed. PLCs are often programmed to only handle one single application; the IF-THEN scenarios of the PLC logic provide little robustness or flexibility in case that scenario changes. And if the original programmer is no longer with the company, or the consultant who wrote the logic has gone out of business, what do you do?"*

By contrast, PLCs are well suited for controlling specific components that are not central parts of the MM PMS. For example, as described above, cooling systems are often important to the critical power system as a whole, but a DCS-based MM PMS may not be able to control them directly. In such cases, the MM PMS may also include one or more custom-programmed PLCs that interface with auxiliary equipment like the cooling systems. *"For specific control tasks that do not require advanced power management like operation and protection of gensets in parallel with Close Before Excitation, PLCs are a good, tried and tested solution, for example for providing the gateway between the BMS and the emergency power system"*, adds René Kristensen. *"It's definitely possible to include both types of controllers in an MM PMS and make use of their relative strengths in the system design"*.

Another example of a solution combining DCSes and PLCs is an application with a building management system (BMS). The MM PMS will often have to interface with the BMS, and this can be handled through a PLC providing the gateway connection. At genset level, the MM PMS can then use DCSes to provide central power management features and ensure resilience in the critical power system (and optionally interface with other PLCs for controlling auxiliary equipment).

A PLC providing the gateway connection between a building management system and a DCS-based MM PMS is a good example of a combination of controller types

A final reason for combining controller types is that it may prove too expensive to replace all PLCs at once in an existing application that already relies on PLCs for component control and basic power management. Instead of a complete redesign of the critical power system, in such cases it may be possible to upgrade the critical power solution by developing a customised, DCS-based MM PMS solution that integrates the existing PLCs and only adds DCSes to handle central power management tasks and provide complete controller redundancy.

"The important thing is to ensure that the critical power system is always available, and both DCSes and PLCs can be used to achieve this in an MM PMS." – René Kristensen, DEIF

"There isn't one right way of designing a critical power system", remarks René Kristensen. *"It all boils down to what your installation needs, and how you prefer to approach the project. Having said that, I'd recommend taking full advantage of the features offered by each controller type, and combine them in a solution that delivers the resilience needed. The important thing is to ensure that the critical power system is always available, and both DCSes and PLCs can be used to achieve this in an MM PMS"*.

Value-added features

The off-the-shelf software found in DCSes may come with features that add value to your operation. It is possible to program a PLC to offer similar features, but as with PLCs in general, this requires high-level programming skills as well as in-depth knowledge of the MM PMS, the critical power system as a whole, and the installation it interfaces with. Value-added extra features found in DCSes may include the following:

AUTOMATIC LOAD SHEDDING

A DCS may also be configured to handle the load side of the system. Traditionally, PLCs have been used to carry out load side power management, for example disconnecting and reconnecting non-critical loads as needed to ensure sufficient power capacity. By using DCSes on the load side, it is possible to design an integrated system in which power and load side controllers communicate without the need for PLC programming. Controllers can provide a configurable load control logic where the designer only needs to set load levels for disconnection and reconnection. The integrated solution means that the designer often does not need separate measurement devices.

CLOSE BEFORE EXCITATION

In many applications, getting full backup power quickly is an important consideration. For hospitals, for example, EU regulations require full backup power to be available within 15 seconds of a grid blackout while the NFPA 110 stipulates a 10 second limit. And in data centre applications using rotary UPS solutions, backup power needs to be restored before the UPS stops spinning, and the faster you get backup power online, the less power you need to restore in the system. The Close Before Excitation (CBE) feature found on some DCS controllers (also known as black bus sync or run up sync) enables you to start any number of gensets quickly.

"With CBE, the breakers are closed for all gensets when the gensets start", explains Darius Woitalla. *"When the gensets are running, excitation is activated in a delayed manner. This takes approximately two seconds, and you have the nominal voltage, e.g. 400 V, 50 Hz on the bus bar. You save a lot of time because there is no synchronisation anymore; you just start the gensets! You can have full backup power on the bus bar within approximately 10 seconds, and not just with one genset. You could have 5, 6, 10 gensets – it doesn't matter"*.

APPLICATION EMULATION

DCSes may include emulation features that help the system designer save time and money when developing the MM PMS. The DEIF AGC-4, for example, includes a software emulation feature that lets the designer carry out a virtual test of the system from the set-up software utility. The designer can use the feature to simulate operational issues such as overload or overvoltage, loss of grid power, or site-specific conditions such as sensor readouts or the presence of input signals on specific terminals. The PC screen shows how the system reacts to changes such as these (for example if the grid voltage suddenly drops from 400 V to 100 V) so that the designer can check that the critical power system control set-up is working as expected, or make any necessary adjustments.

The emulation feature can be used to carry out an FAT (Factory Acceptance Test) on specific controllers before installing them in the operating environment. It cannot replace physical tests, and it does not safeguard against installation errors. It can, however, help identify and resolve programming errors and therefore greatly reduces the number of physical test runs needed with real backup power sources such as gensets. This can significantly reduce the time and cost of commissioning a critical power system, and it helps the designer build a reliable solution.

Pros and cons of PLC and DCS solutions

The table below sums up the pros and cons of using customised PLCs or DCSes with standard software when designing an MM PMS.

Controller type	PLC	DCS
Setup	Programming from scratch	Configuration of standard software
Suitable for	• One-off projects • Specific or non-central applications with highly specialised specifications, such as controlling auxiliary equipment • Gateway between BMS and emergency power system	• Central power management applications • Redundant applications • Fast start-up of multiple gensets
Limitations	• Redundant controller setup in an MM PMS requires high-level programming skills • Reconfiguring, changing, or extending the solution requires in-depth knowledge of the existing logic	• Unsuitable for interfacing with auxiliary equipment like cooling systems
Other benefits	• Can be programmed for many different applications • Full ownership of controller logic	• Can easily be reconfigured, changed, and extended • Standard software is continuously maintained with access to software updates and may offer value-added PMS features such as CBE and fuel optimisation • Well-proven control logic through extensive field experience with various unforeseen cases

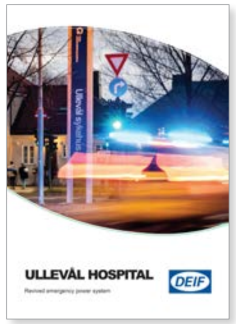
As explained above, the two controller types can be combined, and for many applications and organisations, this may be the optimal solution as it provides the best combination of performance and serviceability.

TALK TO THE EXPERTS

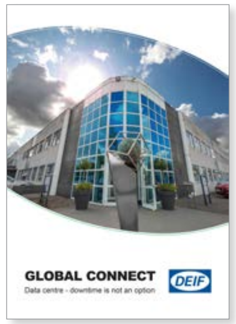
We recommend partnering with experienced system designers and solution vendors who can assist you in defining, designing, developing, testing, and commissioning a system that meets your requirements.

For more information on critical power system control, MM PMSes, and designing for redundancy, contact DEIF. We have the experience and know-how to help you avoid single points of failure and develop a solution that fulfils your requirements.

FIND MORE INFORMATION ON DEIF.COM



Case study:
See how a Norwegian hospital upgraded its backup power system and got higher reliability.
www.deif.com/land-power/cases/oslo-hospital-brings-new-life-to-emergency-power-on-campus



Case study:
See how Denmark's biggest co-location provider built a resilient critical power system using DEIF AGC-4 controllers
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