WHITE PAPER

Optimisation of protection and transfer in Data Centre applications

Power availability

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Glossary

ATS	Automatic Transfer Switch
ATSE	Automatic TSE
BB	Busbar
CB	Circuit Breaker
I/L	Interlocking
MSWBD	Main Switchboard
RBD	Reliability Block Diagram
SLD	Single Line Diagram
SPF	Single Point of Failure
TSE	Transfer Switching Equipment

Contents

Case study of a campus of 4 IT buildings

Environment and preliminary solution

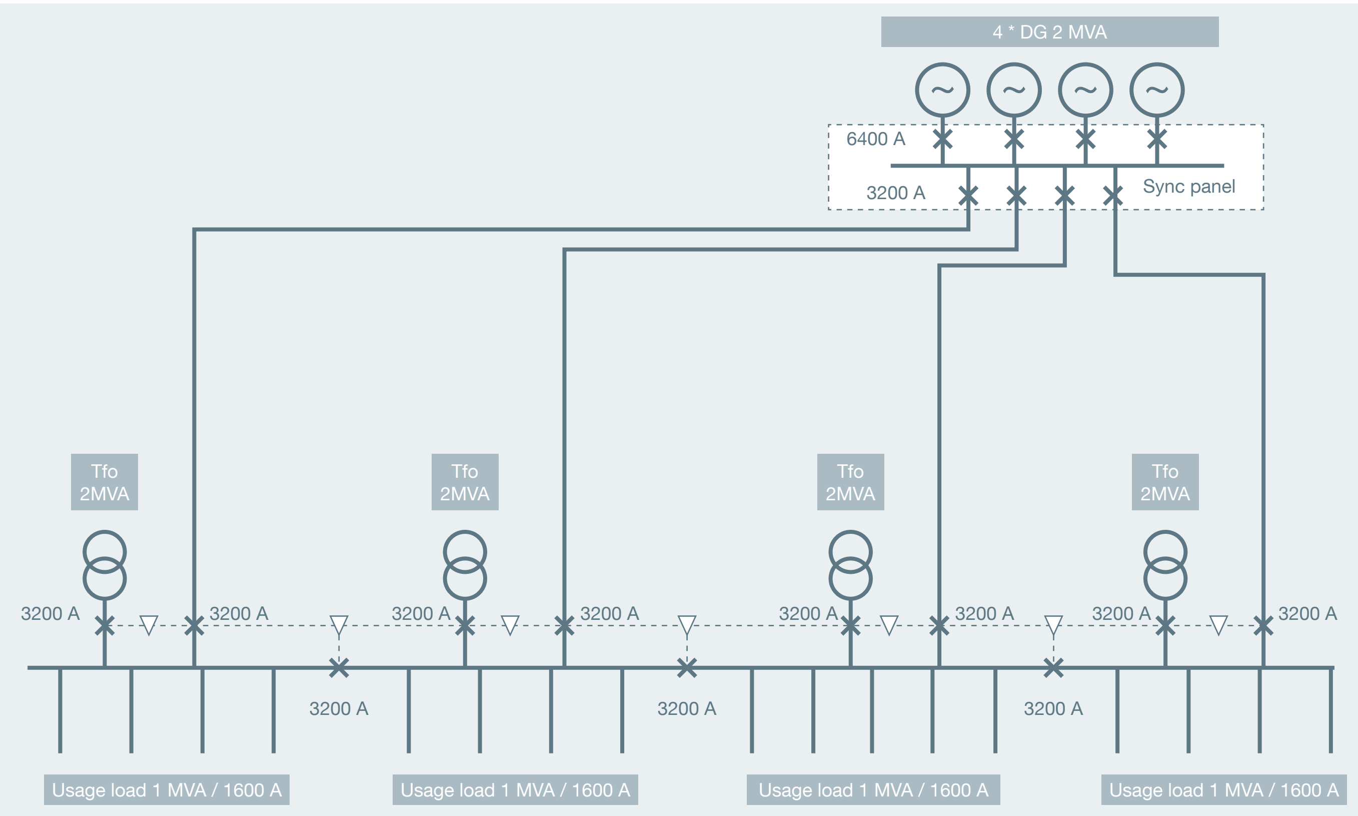
This case study takes a look at a campus comprising 4 IT-enabled buildings separated by a fairly large distance.
The designer works for the EPC which has won the contract for a "Build-Operate-Transfer" (BOT) project over a period of only one year.
Power supply continuity is a vital function for Data Centres as a power outage can have adverse consequences (e.g. financial losses, loss of credibility, etc.). The availability of a quality power supply is therefore essential to achieving this aim.
In this specific example, the need for high availability was the most important topic. This point was emphasised by the fact that the buildings are located in a country where the grid cannot be trusted as there are several outages per day as well as some fluctuations in voltage and frequency.

All the buildings have the same usage (IT-Enabled building for Internet process outsourcing), therefore the same usage profile. There is a heavy load in servers, workstations, HVAC and lighting.

The power usage is fairly stable during the year and during the day:
- the HVAC load is fairly constant over the year (i.e. no big difference between the seasons in this area),
- there are few non-working hours at night (owing to worldwide customer demand, constant consumption of servers), the HVAC load remains almost at its daily level, and only the lighting is significantly reduced during this period,
- it does not seem to represent a sufficiently important issue to justify a specific transformer / DG configuration dedicated to the HVAC loads.

The transformers' power is doubled in order to supply the adjacent busbar with back-up power for reasons of Continuity of Service (CoS). Thus in the original configuration this made for a complicated truth table and I / L system:
- the maximum demand is 4 MVA (1 MVA for each building),
- the installed power is 16 MVA.

A central DG set with a Sync panel is used to stage the power ramp-up over the first 8 to 12 months of operation (progressive occupation). The advantage advanced was to be able to purchase the DGs over the initial 8-12 month ramp-up period.
The original configuration is represented in Fig. 1 below:



WP 205 A GB

Fig. 1 - Preliminary design with Sync panel.

The analysis of the preliminary drawing showed serious drawbacks:
- after a reliability analysis four major weaknesses appeared:
  - the interlocking system as single point of failure, with interlocking (I/L) MTBF estimated to be only 50 000 H, less than a good quality DG,
  - the electrical I/L can be easily circumvented. The I/L system involves several components which increase the level of complexity. Moreover, as this concerns an external system (not built-in) there is still the possibility of bypassing it and of operating without it, which means the risk will increase as the I/L system degrades over the years,
  - the "wear & tear" of the protection used for the transfer in a country with an average of 4 to 10 outages/day. After a few years of operation, the initial reliability of the CBs may decrease considerably,
  - up to 3 CBs rated at 3200 A in series in the same circuit. We cannot be sure how the protection system will perform in case of a short-circuit on the busbar. For further details see the document "Selection of switchboard incomers"(1) to understand the design flaw.
- an additional cost: the transformers and DGs are doubled in order to supply the adjacent busbar (BB) in back-up:
  - this feature is useless given the high level of unreliability provided by this rather complex solution,
  - the main issue is not a transformer failure (average MTBF ~100 y) but the utility incomer outage (average equivalent MTBF ~ a few hundred hours in this area). Doubling the transformers with all the HV lines coming from the same substation does not offer any advantage in the event of a power outage,
- a central DG set with a Sync panel:
  - the cost of this solution is very high due to a 6400 A busbar, the cabling of the 4 CBs rated 3200 A, and busways to the buildings,
  - the maintenance of such a solution is quite complex,
  - The Sync panel is a single point of failure here.

The Sync panel has been implemented in this initial configuration based on the EPC's experience in previous projects. It appeared to be more of a "contractor" issue (saving money on the project duration, minimising the CAPEX only) than an end-user one (optimising the total cost of ownership, minimising the CAPEX + OPEX, etc.). However, the drawbacks are permanent and have to be compared with the costs involved in purchasing the DG over the 8-12 months ramp-up period on the entire operating life of the building (~10 years minimum).

The installation layout is fixed: the SLD makes it compulsory to have the 4 MSWBD in the same building in a central location with the difficulty and cost of extending the busbar parts to the actual buildings. Multiple disconnections are necessary to maintain one MSWBD. This means that during maintenance operations several devices will need to be operated at the same which increases the associated risk of error.

(1) Consult the document: www.socomec.com/resourcesTSE

The alternative solution is based on the following principles

1. Include transformers, DG and Sync panel in the scope of analysis.
2. Remove all possible SPFs. Tackle the remaining SPF with high MTBF devices or bypass solutions.
3. Give preference to independence of circuits and systems to increase availability.

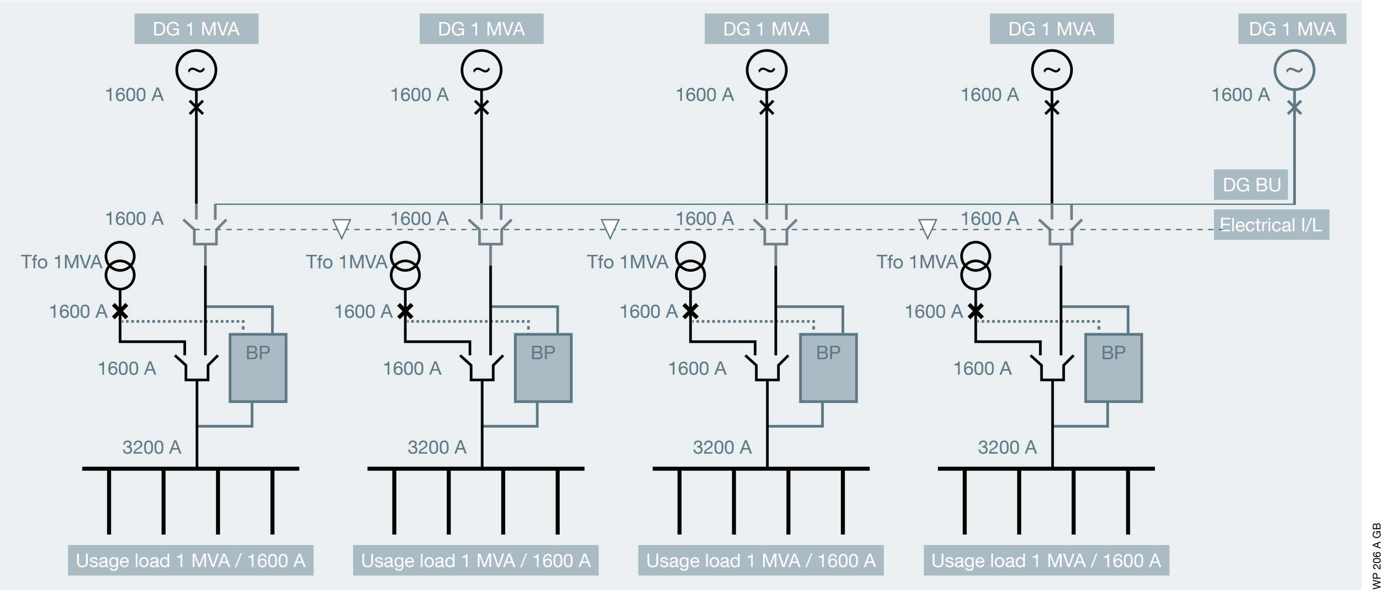


Fig. 2 - Optimised SLD.

Analysis of the optimised solution

The principle of separating protection and transfer led to the following results:

1. **no more protection issues,** with simple, robust and reliable protection even after 15 years of operation. There are no longer several CBs with the same rating in series,
2. **a simple, robust and reliable transfer function:** all TSE are mechanically interlocked (and no longer electrically interlocked), no circumventing is possible,
3. **simple operation:** no more 14-key truth table and I/L mechanisms to maintain, and operations are now automatic. Each building has its own supply system. Therefore the principles of **independence** have been applied (for example, each TSE can be operated independently from the position of other TSE, therefore avoiding a SPF on the communication needed between all the TSE),
4. **simple maintenance:** the SLD is easily understandable, and the isolation of the panels is much clearer when upstream TSE is in 0 position. Furthermore, the ATSE Bypass improves maintainability,
5. **the total installed power is reduced by 40%:** the back-up by the adjacent busbars was removed, which was made inoperative by the poor reliability of the I/L system needed for that. The installed transformer power ranges from 4x2 MVA to 4x1 MVA, and the installed DG power ranges from 4x2 MVA to 5x1 MVA.
6. using the Reliability Block Diagram (RBD) method shows that **the downtime is divided by 100, and the MTBF protection is improved by a factor of 10,**
7. **each DG has a 100% back-up,**
8. **the installation can be decentralised:** the transformers and DG can be installed independently, either close to their own building or in a central location, according to the cost analysis and operational restrictions.
   This will have a positive impact on both the CAPEX (as cable lengths will be shortened) and OPEX (as energy losses are reduced): an interesting initial layout is with the transformer and DG close to each building, with the back-up DG in a central location,
9. each MSWBD can be easily maintained, completely independent from the other panels,
10. **no more Sync panel** and the DG back-up is still in place,
11. the I/L schematic of the ATSE can be used to supply 2 or more buildings by the same DG during the ramp-up period: it should be noted at this point that the electrical I/L of the various TSE is not hazardous. A failure in this I/L would only cause the overloaded DG to stall,
12. the remaining SPF (ATSE on each main busbar) can be replaced by an ATSE Bypass, again improving reliability and maintainability.

About the author

Jérémie Pleynet received an MSc Engineering degree from the French Arts et Métiers Paris Tech School of Engineering in 2008.
He started his career at Socomec Italy in 2008 in Technical Sales Support for Power Switching and Power Monitoring. In 2010 he was promoted to the post of Specification Engineer in Power Conversion.
He later took over responsibility for the Italian Specification and Technical Support teams, and in 2016 he transferred to Socomec headquarters in France to be part of the Specification and Segment Development team with specific focus on the Healthcare and Data Centre sectors.
He is currently in charge of coordinating specification activities for the Socomec Group's commercial and industrial sites around the world, providing training, technical and commercial support and business development for major projects.

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