We take care of it.

LVRSys

Pilot project on a motorway parking lot

Autobahndirektion Nordbayern was facing serious problems due to voltage dips which were causing failures of electric motor driven pumps

There are currently around 2050 rest stops in Germany, consisting of more than 1,600 parking spaces, including 600 parking spaces with toiletry facilities.[1] The power consumption of parking lots is relatively low. In addition to lighting equipment, pumps must be operated for water and wastewater. The car park with WC (PWC) „Auergründel" on the A6 motorway is one of many places with its own toiletry facility. In 2018, there were more and more frequent failures of the fresh water and sewage pumps at this station, which forced the Autobahndirektion Nordbayern, in particular Mr. Kellermann, to continuously carry out repair operations. The repair costs for the pumps and the cleaning operations were very high over a very short time. For the repair on site, the control of the pump must be reset and operation can only be resumed when the system is without errors. After the incidents became more frequent, manufacturers of the frequency converters and pumps were consulted. The manufacturers reported back that there were no problems with their equipment. Mr. Kellermann monitored the electrical network and noted that the short-circuit power of the network at the parking station might not be sufficient for stable pump operation.

Special Publication

Figure 1: Parking station Auergründel on the A6 motorway

Description of Electrical Supply to site:

The connected loads changed since the commissioning of the parking lot. At the beginning only 2 pumps were in operation and lighting was only available at the toilet house, now several pumps are in operation and the entire parking lot is equipped with LED lighting. The pumps were also equipped with inverter based electric drives and their associated control for better efficiency.

The consulted network operator stated that the nearest local grid transformer has been set with a lower output voltage due to the increased reserve power flow following the increased generation by additional photovoltaic systems. The supply voltages are within the limits set in the EN 50160 standard ('Voltage Characteristics in Public Distribution System'). EN 50160 applies at the point of connection between the customer and the supply network. If the prescribed limit values are met, the network operator is not obliged to take measures to solve problems.

A power quality measurement illustrated that the 10 minute averages of the voltages were slightly below the nominal voltage but still within the EN 50160 standard.

Figure 2: Course of the supply line (Google)

Figure 3: Measurements with PQ-Box 150

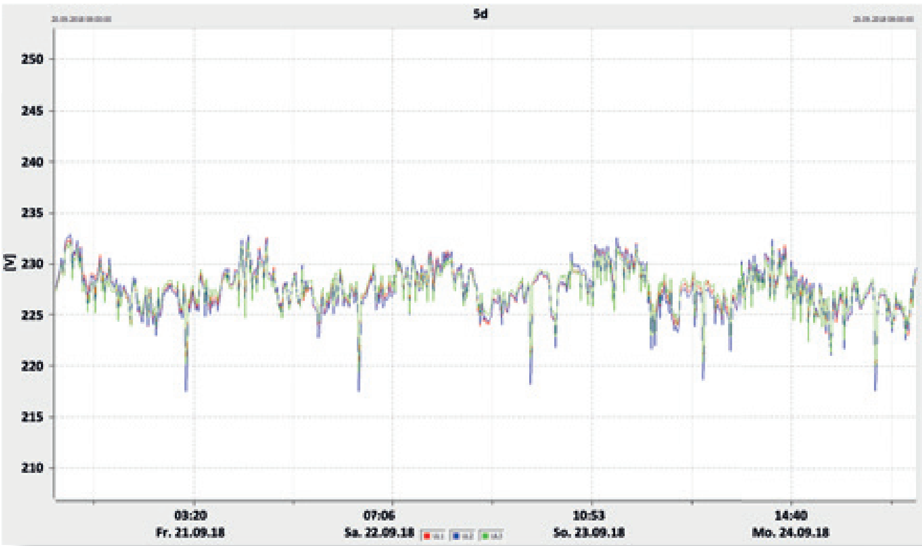

Figure 4: 10 minutes medium values of the measured voltages

In July 2018 Mr. Kellermann consulted the PQ experts of the company A. Eberle. After a more detailed analysis of the measurement data and comparison of the time data at which the faults occurred, it could be identified that at the start of the pumps, the voltages at the connection point dropped so low that the frequency inverter switched to fault mode and reported 'under-voltage' as its cause.

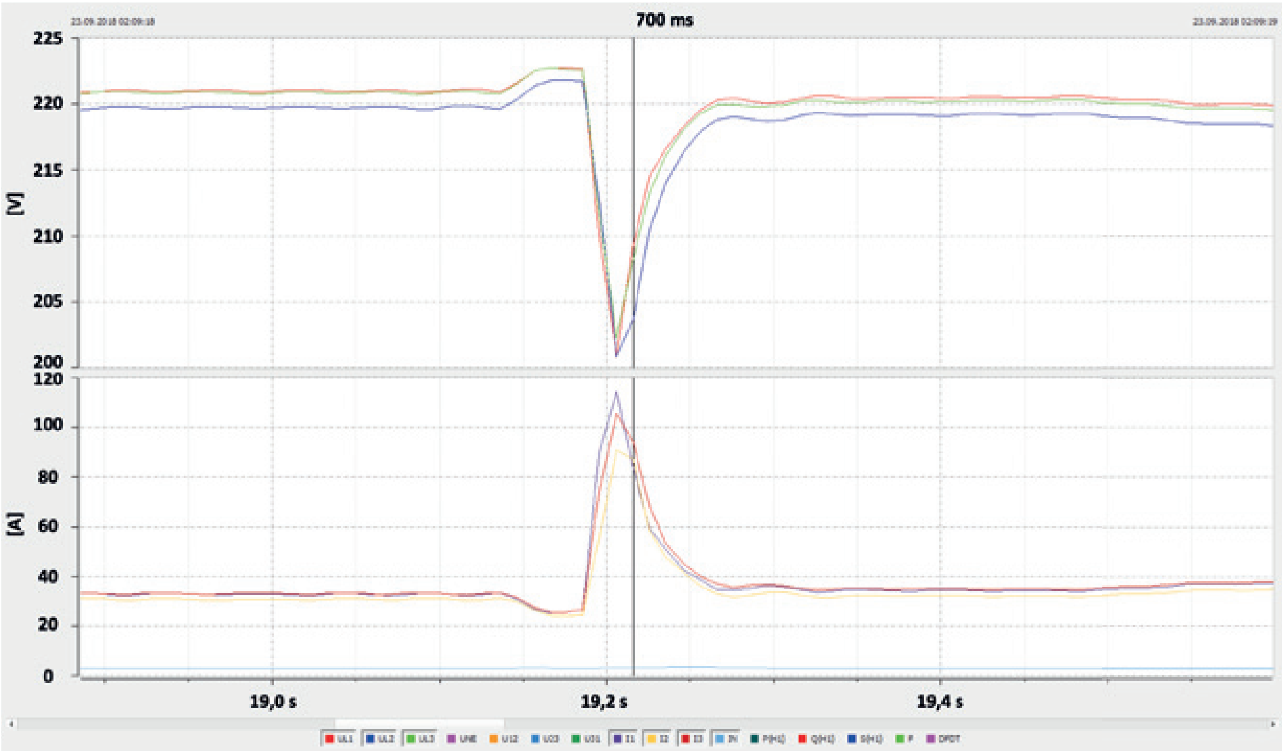

Figure 5: 10 ms RMS values during start-up of the wastewater pump

During startup, the pumps require higher reactive and active power until the rated speed is reached. This power is demanded from the electrical network. Since the voltage can be considered as a given quantity, the increased power demand causes an increased current flow. Consequently the high current flow causes an increased voltage drop along the entire line.

To solve the problem, several approaches were considered:

- Increase of the short-circuit power by adding a parallel cable to reduce the voltage dips during the start-up process of the pumps.
- Installation of a UPS system to avoid voltage dips.
- Stabilizing and raising the voltage through the low voltage regulation system (**LVRSys™**).

After a general cost calculation, the **LVRSys™** was found to be the most cost effective solution over a period of several years. Although a UPS system is comparable in terms of acquisition costs, the UPS system, unlike the **LVRSys™**, has also annual maintenance costs. In addition, due to the relatively high power loss, the operating costs are very high. Although the parallel cable reduces power dissipation, it is an extremely expensive solution to the voltage stability problem.

Parallel cabling poses another risk from a long-term perspective. If the voltage drops at the connection point of the cables, the voltage at the parking area shall drop as well. New innovations, such as heat pumps and electro mobility, will further lower the voltage in the low-voltage grid in the future. The problem as it currently exists would thus only be postponed and not solved. Since the **LVRSys™** system provides real-time voltage regulation, unless the low-voltage grid voltage drops down to unacceptable low values, it would still be able to function under such conditions.

Due to the previous measurement data and load analysis, the low-voltage regulation system was optimally designed for this application. For future requirements, the control system was designed with a double power reserve. The transmission power is 44 kVA. The integration of the system could be made through the modular design in existing cabinets.

Figure 6: Toilet house

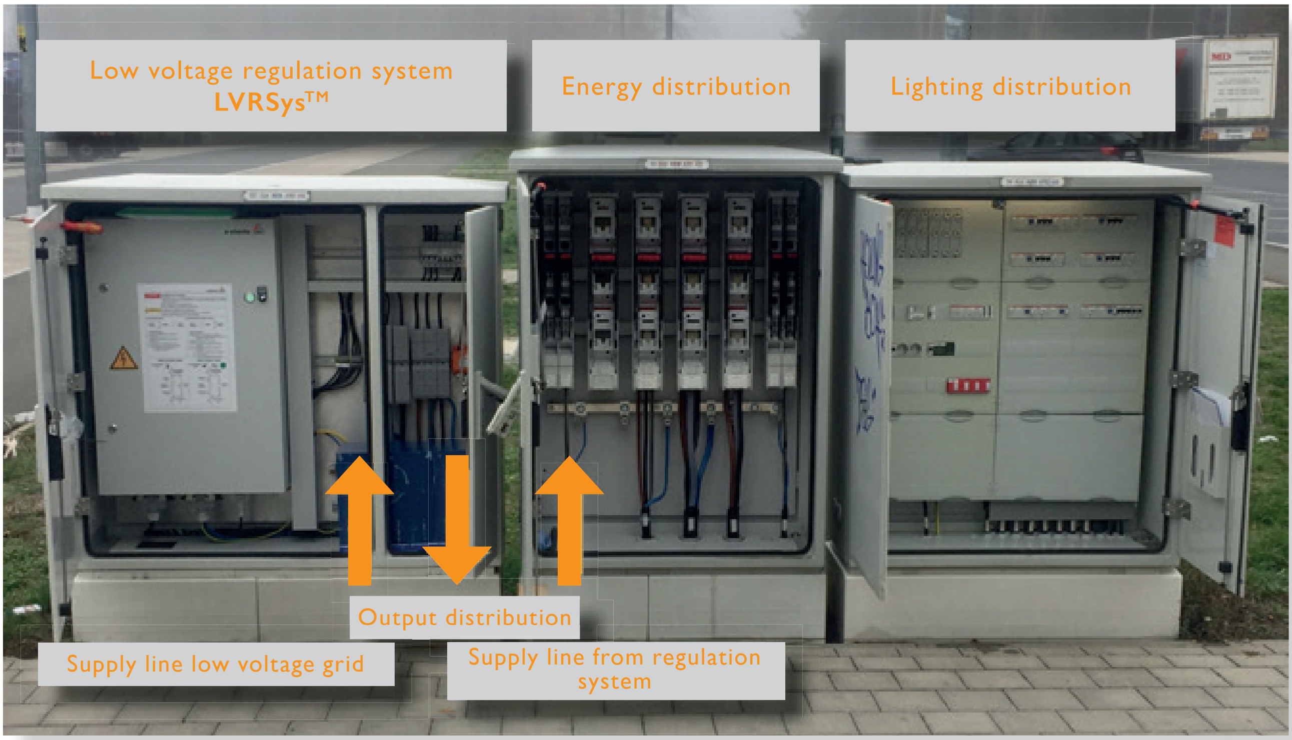

Figure 7: Low voltage regulation system LVRSys™, *energy distribution and lighting distribution*

Figure 6 shows the **LVRSys™** installed on site. Since commissioning, the **LVRSys™** solves the low voltage problems and also compensates the unbalance of the line voltages. Now a stable voltage is ensured at the station at an established set point ± set tolerance band, even if the voltage can fluctuate between ± 10 % in the upstream network as per grid operator network code. Although very rapid voltage dips cannot be compensated, they can be significantly reduced. The control parameters have been set so that the output voltages of the regulator are stabilized at 238 V instead of 230 V. Moreover the under voltage limit of the frequency converter has been considerably increased. In addition, the higher input voltages on the frequency converter, lower current will flow assuming constant power output from the inverter.

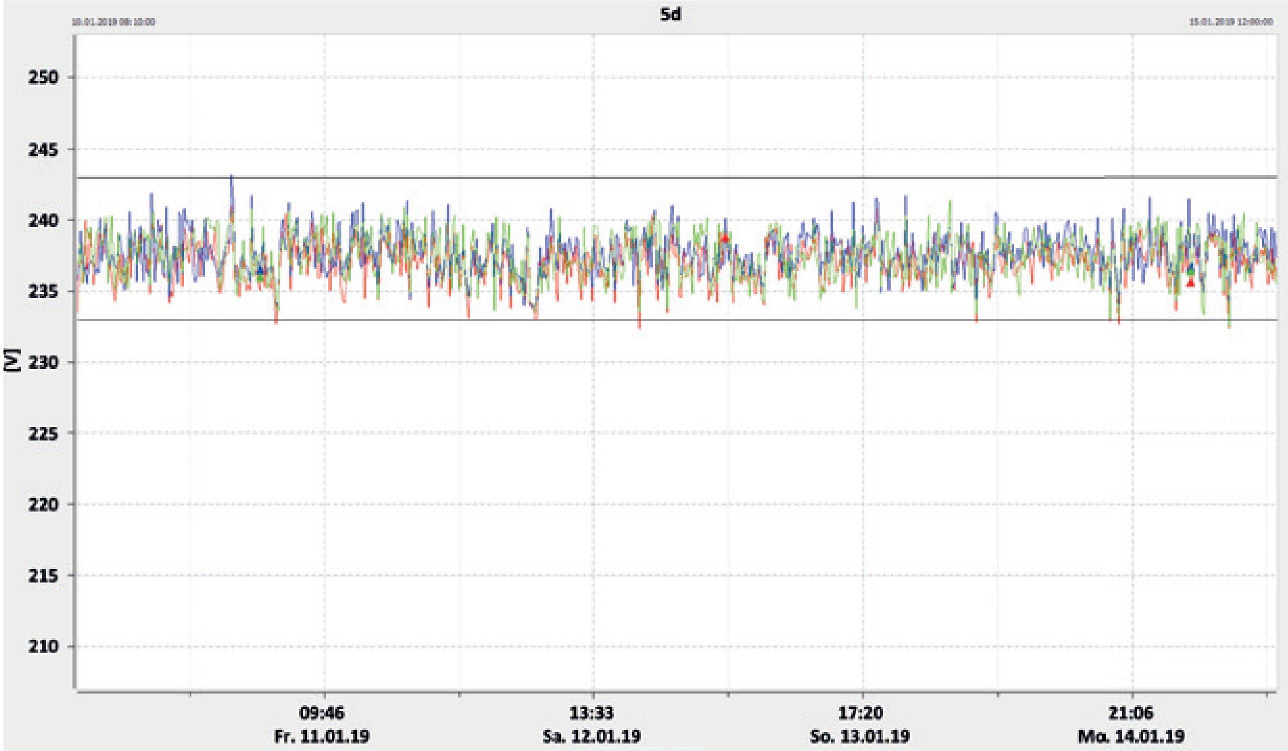

Figure 8: Stabilized output voltage at the output of the regulation system nominal voltage ± 2 %

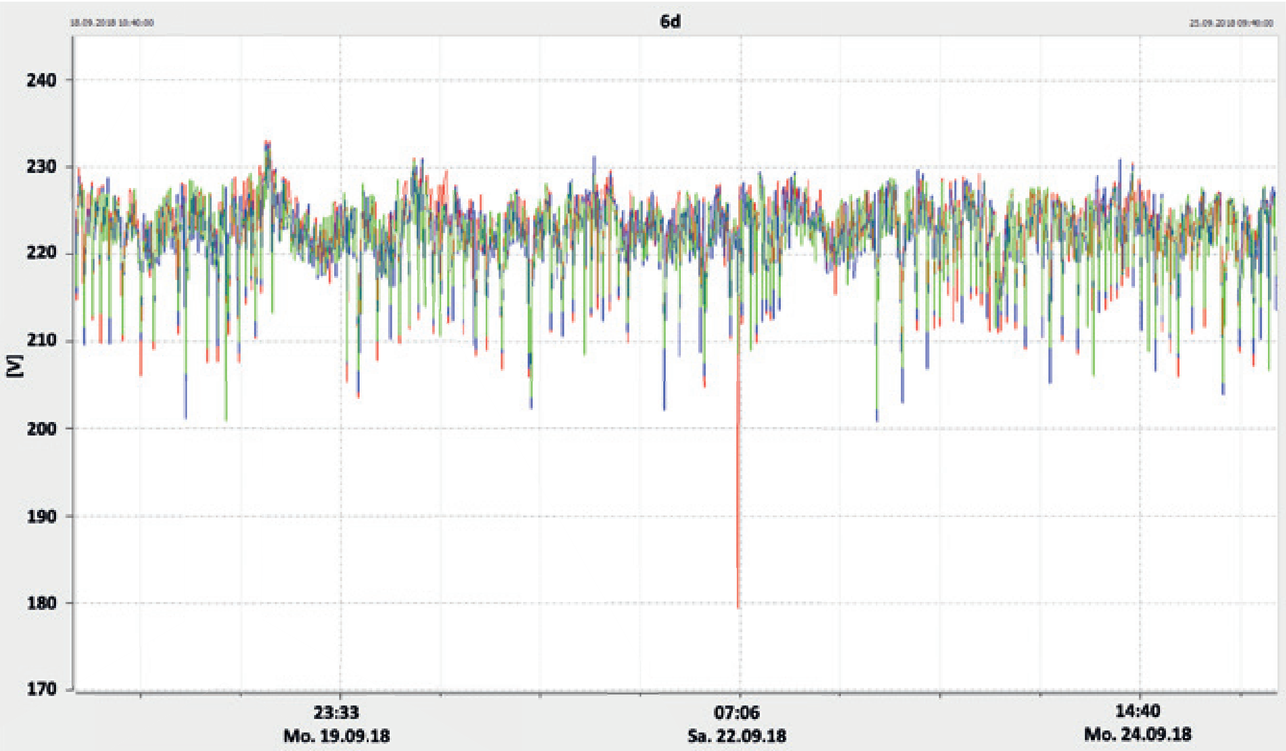

Figure 9: Voltage dips and 10 ms RMS minimum values

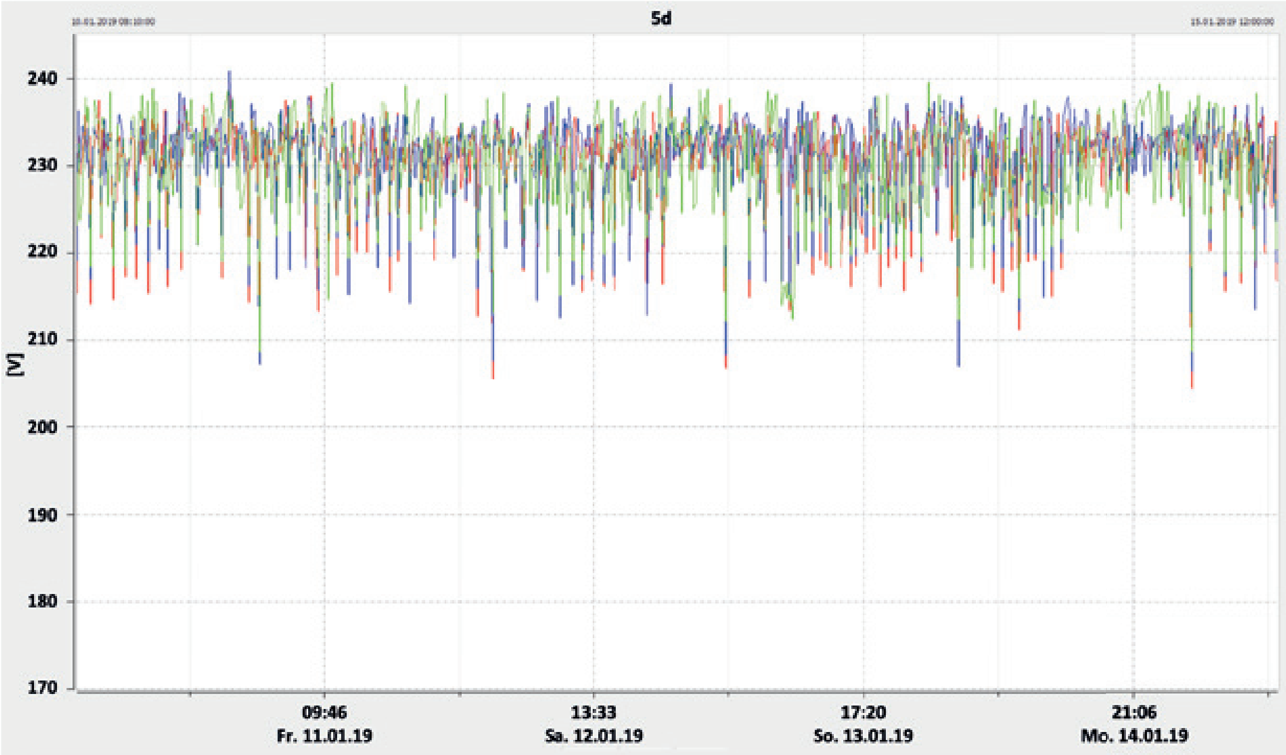

Figure 10: Reduced voltage dips and 10 ms RMS minimum values at the output of the regulation system

Conclusion and feedback

Since the **LVRSys™** low-voltage-regulation-system was installed, there have been no failures of the control electronics and no failures of the water pumps. With the knowledge gained from this successful pilot project, the Autobahndirektion Nordbayern now generally consider the use of **LVRSys™** as the first solution for voltage stability problems. Many of the problems reported by Mr. Kellermann, such as failures of sign gantries, water pumps and lighting equipment can be solved with the **LVRSys™** system. The extremely long supply lines of the connected loads are often the cause of power quality issues. Of course, not every load of the Autobahndirektion can be provided with a medium voltage supply and own local network station. The investment costs would be extremely high and economic unfeasible. In the future, the connection points to the low voltage grids will be even more affected by voltage fluctuations since, on one hand, it is predicted that the electrical loads shall increase (electro mobility, heat pumps) and on the other hand also the feed-in generation (PV systems, wind turbines) shall increase making the source of energy more unreliable due to their intermittent nature The provision of real-time regulated voltage, taking into consideration the future of the electrical network, shall have a positive effect which will also extend the service life of electronic loads.

Sources:

1) http://www.eautobahn.de/html/zahlen_und_daten.html

Authors

Stefan Hoppert

Produktmanager Smart Grid
A. Eberle GmbH & Co. KG
Frankenstraße 160, 90461 Nürnberg
stefan.hoppert@a-eberle.de
www.a-eberle.de

Heinz Kellermann

Autobahndirektion Nordbayern
Infrastruktur Starkstromtechnik
www.abdnb.bayern.de

A. Eberle GmbH & Co. KG
Frankenstraße 160
D-90461 Nürnberg
Tel +49(0)911 628108-0
Fax +49(0)911 628108-99
info@a-eberle.de
www.a-eberle.de

06/2019