morEnergy

ONIS Low Voltage

the grid impedance measurement tool

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1 WITH THE ONIS-TECHNOLOGY YOU CAN MEASURE THE GRID IMPEDANCE AND THE POWER QUALITY

Grid impedance - A short excursion

The grid impedance (also called complex grid resistance) is the sum of all impedances in a public electrical power supply system or an on-board power supply system. In addition to current and voltage, the grid impedance depends largely on the frequency.

1.1. Determination of the exact grid impedance

Measurements show that neither the location nor the type of network have a direct influence on the grid impedance. Although the courses measured at network connection points differ greatly in their location, they show very similar patterns in their course. The electrical properties of a grid connection point (GCP) to the electrical power supply system can be described in a simplified way according to the Thévenin theorem with a voltage source as well as a complex network impedance. Both parameters are frequency-dependent and vary over time within certain limits. The mains voltage is usually known and can also be measured relatively easily. In some cases, the network impedance at an GCP can be analytically estimated at the nominal grid frequency with the aid of equipment characteristics. However, an exact determination of the grid impedance can only be made by a measuring identification. This applies in particular to frequencies above the nominal grid frequency, since analytical approaches are subject to major errors and do not correctly reflect the actual frequency response of the grid impedance. For this reason there have been various research initiatives in recent years to be able to determine the grid impedance accurately, since knowledge of the grid impedance is essential for safe and reliable operation of a decentralized power supply.

The measuring of the frequency-dependent grid impedance currently requires a spectral excitation of the grid with current curves. These cause measurable voltage drops at the measuring point depending on the respective grid impedance. The grid impedance is determined by the corresponding current and voltage curves as well as the measured open-circuit voltage. This current method of measuring or determining the network impedance is based on the principle of active excitation of the network under investigation.

1.2. Grid impedance and repercussions on equipment

With the knowledge of frequency-dependent network impedance, repercussions of emitted harmonic currents on harmonic network voltages can be explained. Thus the network impedance is an important basis for converting harmonic voltages into corresponding currents. This allows resonance points to be detected ex-ante and countermeasures to be initiated to protect equipment and the network. The latest research results have produced measuring instruments that can determine both power quality measurements and frequency-dependent network impedance. Active methods, such as switching loads on and off, have proven their worth. Excitation signals are generated, the voltage response is measured and the frequency-dependent network impedance is calculated

1.3. Outlook and increased significance

Since many consumers and producers are connected to the electrical power grid via power electronic circuits, knowledge of the network impedance is becoming increasingly important. In particular, so called green power units such as photovoltaic and wind power plants or even electromobility are contributing to this trend. The grid integration of these decentralized units is mainly carried out in distribution grid structures on the low and medium voltage level. The grid impedance at the respective connection point is of great importance for the grid connection of plants with power electronic grid coupling. The network impedance not only determines the short-circuit power of the connection point, but is also an important parameter for the filter and controller design as well as for the evaluation of network repercussions of the systems in the form of flicker and harmonics. Up to now, the determination of the network impedance has almost exclusively been carried out by analytical or numerical calculations with network simulation programs based on equipment characteristics. If detailed network data are available, the network impedance at the nominal network frequency can be estimated with good approximation. However, the grid voltage and grid impedance at a connection point are time-dependent variables due to changes in the grid state, which makes a correct calculation difficult. In particular, the frequency response of the grid impedance cannot be modelled and calculated with sufficient accuracy in simulation programs. An exact determination of the time- and frequency-dependent network impedance can therefore only be carried out by a measurement at the respective connection point.

2 TECHNICAL SPECIFICATIONS

ONIS-690V Technical Data

Voltage range at Load- and Sense-connection (phase-phase-voltage)	±70 to 1000 V_{peak}
Measurement category of Load- und Sense-connections	CAT IV 600 V
Nominal network frequency	50 Hz
Maximum current at Load-connections	12,12 A_{peak}
Frequency range of impedance measurements	DC to 50 kHz
Measurement tolerance of impedance measurements	± 5 %
Measurement accuracy of voltage measurements	class A, 0.1%
Sampling rate of voltage measurements	up to 1 MHz
Supply voltage	110-240 V~ 50/60 Hz
Operating environment	IP 20, 0-40 °C, ≤ 75 % rH
Operating height	≤ 2000 over sea level
Dimensions (L x B x H)	54 cm x 45 cm x 14,5 cm
Weight ONIS-690V	12,5 kg
Weight ONIS-690V in transport case	23 kg

3 FIELDS OF APPLICATION

Modern high-performance inverter systems can be found in fast charging systems for electric cars, in high-rise elevators, on server farms and in photovoltaic and wind power plants. They normally function reliably even under the most difficult conditions. This highly efficient frequency converter technology not only precisely controls the charging speed or the speed of elevators, but also takes care of energy regulation on the power grid. The reliability of the systems requires that the interactions between the frequency converter and the power grid have been well estimated by the engineers when designing the controller. If this is not the case, due to complex power grids on site, instabilities often occur during operation, resulting in system failures. With our ONIS technology, we prevent problems in the system integration of energy producers and consumers and proactively prevent system and revenue losses.

Easy determination of the system parameters of frequency converters and of the power grid

Detection of faulty filters, components and prediction of system and network failures

Grid stability control

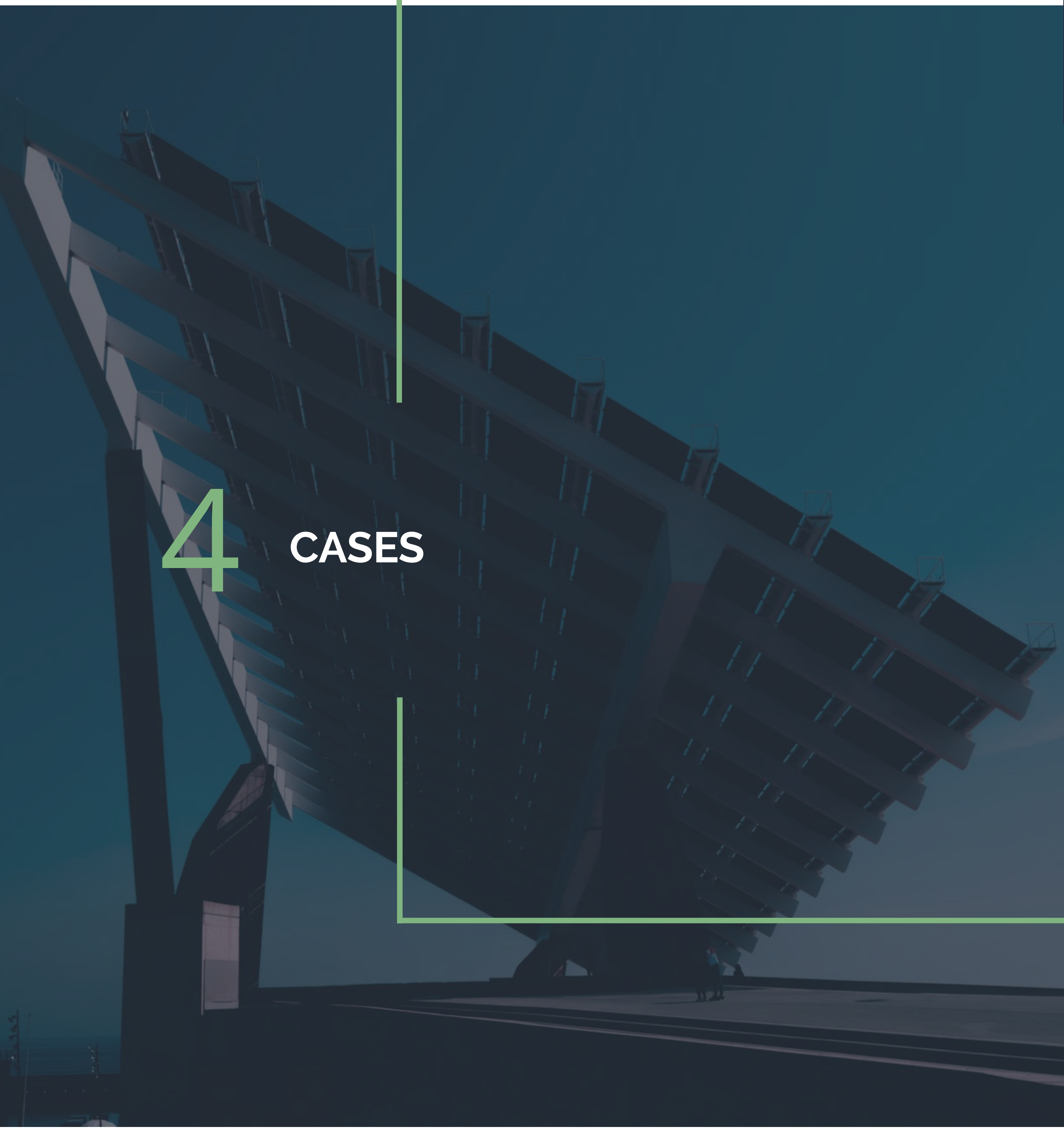
Power Quality Measurements

Easy embedding of ONIS technology into the power grid (ready to use)

Predictive and preventive maintenance of Solar and Windparks

Easy integration of e-mobile loading stations into the the power grid

Making the Smart Grid Einstein Smart



4 CASES

PHOTOVOLTAIC POWER PLANTS

PREVENTIVE MAINTENANCE AND TROUBLESHOOTING

Challange:

Most inverters used in today's photovoltaic power plants operate without internal transformers. The lack of galvanic decoupling of the transformer can lead to higher loads on the EMC filters as well as coping between the DC and AC sides. With increasing age there can be restrictions in the filter effect and in the worst case filters are damaged or fail completely. The reduced or no longer existing filtering of harmonic and supraharmonic currents can lead to increased voltages depending on the local grid impedance, which can damage components of the inverter or other component groups. Thus, filter failure is very often the beginning of a chain of errors that often ends in system failure. This system failure requires troubleshooting, which can lead to considerable loss of revenue and costs for high-performance solar systems.

Solution:

With the ONIS 690V measuring instrument, currents and voltages as well as impedances of renewable power plants and their grid connection points can be measured and analyzed at high frequency. Status information of relevant component groups as well as of the grid connection can be determined. In addition, recommendations for action can be developed for the controller parameters and filter design of the installed inverters in order to optimally adapt the plants to the local connection point and thus exclude failures due to inadequate control or filtering of the generating plants.

Result:

Insufficient, reduced filtering or filter failures are clearly identified by the impedance measurement results

Adaptation of control parameters and filter design to local network requirements

Predicting and preventing system and revenue outages

4.2. Detection of wrong inverters

Revenue declined about 15 percent

In a solar power plant in southwest Germany, transformerless central inverters are used for grid connection. In some central inverters, EMC filters failed. Measurements on site revealed a strong superimposition of the DC voltage with AC components in almost every second inverter used. The DC PV power was reduced by approx. 30%. ONIS Technology was commissioned to find the cause of the reduced power and to solve it.

Grid impedance and power quality

Measurements were carried out on site to determine the frequency-dependent grid impedance and the power quality for an inverter without significant AC components in the DC voltage and an inverter with high AC components in the DC voltage during feed-in operation. There were no high AC components, so that a problem with the regulation and control of the inverter could be excluded. During the measurement of the impedance it was noticeable that the parallel resonances showed a different quality over a wide frequency band. These deviations could only be explained by differences in the filters, which were then examined during further.

Filters

Considerations have led to the assumption that the AC components on the DC side couple into the DC side through filter capacitances above ground. The measurement results showed that the capacitance between two external conductors is similar for all inverters. However, the capacitance between the outer conductor and earth differed by a factor of 1000 from problematic to nonproblematic inverters. This explained the different grid impedance curves. From these different earth capacitances an explanation was found why some inverters can be operated without problems and others cannot - their age.

Inverters and their characteristics

Inverters are electrical circuits that can turn direct current into alternating current. However, this alternating current is strongly distorted compared to the 50 Hz alternating current in the grid. This reduces the voltage quality of the grid, which is why filters are used in every inverter. State of the art are passive filters, which consist of an electrical network with capacitors and coils. These components are subject to an ageing process. If, for example, capacitors age, in most cases the capacity decreases until there is no more capacity and the capacitors have a completely insulating effect. These aging processes can be dangerous for installations, as over the years the filter parameters shift and as a result the installations are no longer properly protected.

The morEnergy solution

To prevent AC components from coupling to the DC side of inverters, the AC main filter and an AC auxiliary filter should be modified or replaced with new filters. It should be noted that filters were used which have no or only very low capacitance to earth. A short-term immediate measure was to disconnect one filter. This reduced the capacitive earth currents and thus the increased coupling of EMC interference from the AC side to the DC side. However, the earth capacitances of the AC main filter also had to be removed in order to completely eliminate the problem.

According to morEnergy's recommendations the solar park was able to operate at 100% power again, which resulted in a significant increase in revenues.

morEnergy offers its customers preventive measurements within obligatory accident prevention measurments (DGUV V3) or other control measurements to detect faulty components. This can be done easily even during the power plant is operating with the ONIS technology developed by morEnergy and is currently unique worldwide.

ELECTRIC DRIVE OF ELEVATOR SYSTEMS

TESTING AND TROUBLESHOOTING

Challange:

Modern elevator systems are perfectly adapted to customer needs. They function reliably under the most difficult conditions and are now highly efficient thanks to modern high-performance frequency inverter technology. These not only precisely control the speed of the elevators, but also feed energy back into the power grid during braking.

The reliability of the system presupposes that the interaction between the frequency inverter and the power grid has been well estimated by the engineers during the controller design phase. If this is not the case, due to complex power grids on site, instabilities during operation can result in system failures. To date, there is no technology that can detect problems in the system integration of pull-outs and proactively prevent system failures.

Solution:

With our ONIS technology, we can determine whether the control system is stable or whether a component in the electric drive system is defective. Here we determine the causes of the malfunction and can make recommendations based on our measurements to make the system stable and reliable.

Result:

- Simple determination of system parameters from the frequency inverter and from the power grid
- Adaptation of the control parameters to the network requirements locally
- Determination of faulty filters, components and predictions of system failures

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