Accepted abstract

TITLE: *EXPLORING DC POWER QUALITY MEASUREMENT AND CHARACTERIZATION TECHNIQUES*

Key words: *LVDC grids ; Ripple DC ; Measurement chain ; Accuracy*

- Scientific and technical field: **Uncertainties & Data Analysis & Virtual Experiments**

Abstract content:

In recent years, the electric community has been actively engaged in steering the world away from traditional fossil fuel reliance toward a more sustainable energy landscape. In line with this commitment to reshape the energy framework, distribution networks are witnessing widespread adoption of electric vehicles, distributed renewable energy sources, and storage systems. However, these technologies, operating naturally in direct current (DC), require conversion from alternating current (AC) to DC to be connected to AC-designed existing grids. This increase in the number of converters in the grid, reducing its energy efficiency, gave rise to the concept of hybrid networks including sections designed in DC to which DC-native sources and loads will be connected, thereby decreasing the number of converters.

Upon recognizing the potential of low-voltage DC grids (LVDC) as a promising solution, important theoretical and experimental efforts were dedicated to validating its feasibility under acceptable conditions. However, significant challenges remain in the integration of DC in LVDC: the thorough characterization and assessment of DC power quality (DCPQ) and the analysis of disruptive phenomena within DC networks. Furthermore, there is a critical need for the development of advanced measurement methodologies and systems capable of accurately identifying these disturbances to set regulatory frameworks similarly to those established for AC. Despite ongoing initiatives by international standardization bodies, the IEC and European projects, additional research on measurement techniques, methodologies, and equipment is crucial to tackle metrological complexities such as the identification and measurement of current and voltage DC ripples.

Indeed, several phenomena affect the LVDC network. In this study, we focus on investigating DC ripple as a steady-state phenomenon due to its effect on DC distribution voltage quality and the safe operation of the grid. The primary sources of DC ripple are power electronic converters, the instability of DC power sources, and the connection of various dynamic loads to the network.

Therefore, we have undertaken an investigation into the potential measurement equipment, signal processing tools, and methodologies capable of accurately identifying the DC ripple for a voltage level up to 1000 V, a current level up to 30 A, a frequency range up to 500 kHz, and an uncertainty in the measurement chain of 0.5%. The proposed chain is composed of voltage and current probes characterized considering: their transfer function, calibration uncertainty associated with their division ratio, non-linearity of the input voltage with this ratio, temperature-related uncertainty, and uncertainty related to input and output impedances. Additionally, the chain incorporates signal acquisition devices, whose accuracy and noise levels are quantified to verify their capability to detect the DC ripple within

the measured signals. It also includes protections against electromagnetic compatibility issues when characterizing the whole system from a metrological point of view. Furthermore, this work presents the measurement methodology, and signal processing tools employed, including the choice of measurement window types, DFT analysis, spectral assessment, and ripple distortion evaluation.

This study will allow us to advance our comprehension of DC ripple, power quality challenges in LVDC grids and to progress on future DCPQ international standardization works.

EDF R&D

Accepted abstract

TITLE: NV QUANTUM SENSORS FOR NON-DESTRUCTIVE TESTING

***Key words**: NV centre in diamond ; Non-destructive testing ; Quantum sensing ;*

- Scientific and technical field: **Quantum technologies**

Abstract content:

The nitrogen-vacancy (NV) centre in diamond has emerged in the past two decades as a unique multi-modal sensor, combining the excellent sensitivity and accuracy of quantum sensors in a solid diamond, small and easy-to-integrate while offering extremely high spatial resolution. NV centres in diamond are especially good magnetometers, providing an absolute vectorial measurement of the magnetic field. Founded in 2020, Kwan-tek is a start-up company pioneering in the development of NV-based sensors for industrial application. By leveraging the stability of NV sensors, Kwan-tek has for example been developing a metrology product for stabilizing magnetic fields below nT per day in the 1-30 mT range.

In the context of non-destructive testing (NDT), several techniques rely on the magnetic field for controlling the state of a metal, either with static measurement (magnetoscopy, magnetic flux leakage) or with dynamic measurements (Eddy current testing, Barkhausen noise, incremental permeability). All these techniques have specific limitations linked to the sensors used for the implementation and could benefit from the use of absolute sensors with high resolution and sensitivity like NV sensors.

In this talk, we will recall the underlying principle of NV physics before presenting the recent experimental advances of Kwan-tek in the field of NDT. We will especially aim at illustrating cases where the NV can improve detection of defects and discuss the improvements and current limitations of the technique.

Kwan-Tek

Accepted abstract

TITLE: *ANALYSIS OF DISTRICT HEATING SENSOR DATA FOR UNCERTAINTY-AWARE, NETWORK-WIDE SENSOR-CORRECTION*

Key words*: Sensor network ; Kalman filtering ; offset correction ; mathematical modelling*

- Scientific and technical field: **Uncertainties & Data Analysis & Virtual Experiments**

Abstract content:

District heating (DH) will play a vital role in the transition towards a fossil-fuel free heating infrastructure in many countries. With the implementation of 4th generation DH, temperatures in the utility network are getting so low that it might not fulfil the requirements of the end-user.

To avoid this scenario, it is important for utilities to monitor the temperature in the network continuously. However, sensor data in the utility network is limited to a few temperature sensors at critical points. This is due to high installation costs, and locations where power and data connectivity is often unavailable.

Simultaneously, an EU-directive requires that all new consumer meters are remotely read from 2027, creating thousands of low-quality measurements all over the network.

The consumer meters in the network are not aimed at being used as a thermometer, but for measuring the yearly energy consumption, allowing the utility to send out invoices. They are normally used for more than a decade without re-calibration, making their absolute temperature readings dubious.

Despite the above, DH meters still have the potential of delivering added value to the utility. By exploiting the fact that all these meters are interconnected in a known physical network, allows for a network-wide analysis, combining a physical model of the network with Kalman Filtering to identify the offset of the individual sensor.

Traceability towards the SI-system can be established by temporarily installing battery driven reference sensors in the network, allowing for a short-term (7-days) adjustment of the remaining sensors towards the reference.

Uncertainties on the meter offsets, using the above method, have been modelled to be as low as 0.13 K (k=2), compared to the potentially 2 K, unknown offset on the temperature measurement as-is on the consumer meter, when no adjustments are made.

Danish Technical Institute

Accepted abstract

TITLE: Quantification of trace NH3 as an impurity in emerging applications: CCUS, Biomethane and Hydrogen

***Key words**: Optical Gas Standard ; NH3 ; impurity ; TDLAS*

- Scientific and technical field: **Chemistry**

Abstract content:

A mid-infrared quantum cascade laser (Mid-IR QCL) coupled with a Single Pass Cell and a Multi Pass Cell, was utilized to measure ammonia (NH3) absorption spectroscopic parameters and quantify trace NH3 amount fraction. The uncertainties of line intensities have been significantly reduced from 20% in the HITRAN database to below 3%.

As we transition towards alternative energy sources, new challenges related to gas impurities have emerged due to evolving objectives and limitations. For example, the impurity of ammonia is commonly concerned which can corrode materials, pollute the air, and endanger human health. For CCUS, the impurity limit of NH3 in CO2 listed in the standard ISO 27913:2016 specifies a limit of 10 ppm. For the utilization of biomethane in transportation, as well as the injection of biomethane into the natural gas network, the EN 16723:2016 standard outlines specifications for NH3 impurity at 10 mg/m3 (15 ppm at 20 °C and atmospheric pressure). The stringent requirement on NH3 impurity in H2 outlined in ISO 14687:2019 specifies the high-quality H2 used in Proton-exchange membrane (PEM) fuel cells with a limit of 0.1 µmol/mol (100 ppb). Based on the concept of optical gas standard (OGS), the newly measured NH3 line parameters are used to examine NH3 as an impurity outlined in three standards: CCUS (ISO 27913:2016), Biomethane (EN 16723:2016), and H2 (ISO 14687:2019). With this NH3-OGS, it can meet the NH3 impurity detection requirements in all three standards. The uncertainty of the NH3 mole fraction is 1.35%. The precision of the NH3-OGS is 800 ppt with an integration time of 100 s. The repeatability of the NH3-OGS is 130 ppt for a continuous measurement time of 48 min. Strong adsorption-desorption dynamics of NH3 have been observed during the measurements. The adsorption and desorption processes are highly nonlinear and exhibit much stronger effects at the early stage. The newly developed NH3-OGS effectively overcomes this challenge (for sticky and reactive gases) compared to the conventional 'Primary Reference Gas' approach for gas calibration. The case studies in this work show the capability of using SI-traceable and calibration-free OGS as a metrological gas analysis instrument to establish gas standards.

PTB

Accepted abstract

TITLE: *ALGORITHMS FOR SURFACE TEXTURE CHARACTERIZATION OF FREEFORM SURFACES AND COMPONENTS PRODUCED BY ADDITIVE MANUFACTURING*

Key words: *Surface texture ; Additive manufacturing ; AST parameters ; Surface fitting*

- Scientific and technical field: **Mechanics**

Abstract content:

Surface texture on complex surfaces presents significant challenges in manufacturing and quality control. Complex shapes, often produced through additive manufacturing, exhibit intricate geometries that make it difficult to accurately measure and characterize their surface textures. Traditional methods may not be sufficient, as they struggle to capture the detailed nuances of freeform surfaces. Advanced techniques, such as parametric modeling and B-spline reconstructions, are required to address these challenges. These methods provide a more accurate representation of the surface, ensuring precise analysis and quality assurance in industrial applications.

One of the primary issues with traditional surface texture characterization methods is their limitation in handling non-standard, irregular shapes. These methods often rely on assumptions of regularity and symmetry, which do not apply to complex, freeform surfaces. The advanced techniques take into account the parametric nature of these surfaces, allowing for a more detailed and accurate analysis.

In this work, a novel methodology has been introduced to compute surface texture parameters specifically tailored for complex shapes derived from freeform surfaces and components produced through additive manufacturing technologies. This new method, designed for industrial applications in mechanical engineering and mechanics, employs an extended definition of areal surface texture (AST) parameters as specified in ISO 25178. Unlike traditional methods, it uses an expanded conceptualization of surface texture parameters to enhance applicability to complex profiles. The method relies on a parametric representation of the shape, represented by a parametric function. By utilizing B-spline reconstructions, GB-spline reconstructions, and triangular mesh reconstructions, it accommodates a wide range of shape complexities, ensuring versatility across various applications. The effectiveness of the proposed method is demonstrated through comprehensive testing on several organized and unorganized data sets, with comparative analysis against parameter values obtained from different methods highlighting its robustness and reliability.

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