

Editorial

Special Issue “Selected Papers from the 2018 IEEE International Conference on High Voltage Engineering (ICHVE 2018)”

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1. An Outlook of the Special Issue

The 2018 IEEE International Conference on High Voltage Engineering and Application (ICHVE 2018) was organized by the National Technical University of Athens, Greece and endorsed by the IEEE Dielectrics and Electrical Insulation Society. The conference, chaired by Professor Ioannis Gonos and co-chaired by Professor Ioannis Stathopoulos, Professor Jian Li and Professor Nicolas Younan, was held in Athens, Greece from 10 to 13 September 2018 and was the fifth of a series of successful conferences (Chongqing, China: 2008; New Orleans, USA: 2010; Shanghai, China: 2012; Poznan, Poland: 2014; and Chengdu, China: 2016). The 406 participants from 31 different countries had the opportunity to attend 32 oral sessions and eight poster sessions and get acquainted with the trending high voltage (HV) research in over 190 presentations. The main research areas covered by the conference papers were:

- Electromagnetic fields;
- Transients and electromagnetic compatibility (EMC);
- Aging, space charge and maintenance;
- Grounding systems;
- Monitoring and diagnostics;
- Power and industrial applications;
- HV insulation systems;
- HV testing and measurement.

Seventeen high quality papers from the 2018 IEEE International Conference on High Voltage Engineering and Application (ICHVE 2018) from all of the above research areas were presented in a Special Issue. The works included in the Special Issue are not the exact papers presented in ICHVE 2018 but enlarged versions of them, enriched with more research outcomes. The Special Issue was welcomed with great interest, as ICHVE attracts the recent advances in all fields of high voltage engineering and applications. We would like to thank all the researchers who made their contribution to this Special Issue and all the reviewers who enabled its publication through their efforts for a prompt and instructive revision procedure.

2. A Review of the Special Issue

The topics of HV testing and monitoring/diagnostics are covered by papers [1,2]. In [1], the authors discuss the use of damped AC voltages (DAC) for after-laying testing and diagnosis of submarine

power cables—both the export and inter-array cables—according to the recommendations of standards IEEE 400 and IEEE 400.4 for partial discharge monitored testing. Within the absence of adequate relevant specifications in the International Electrotechnical Commission (IEC) standards, and the increased need for quality control, the advantages of this testing technique, in combination with actual testing examples, are highlighted.

A novel diagnostic method of measuring water content in transformer oil using multi-frequency ultrasonic, with a back propagation neural network that was optimized by the principal component analysis and genetic algorithm (PCA-GA-BPNN), is reported in [2]. Accurate prediction of water content in oil is important for the stability and security level of power systems as moisture is considered enemy “number one” of insulation. Investigations with 160 oil samples of different water content with multi-frequency ultrasonic detection technology enabled the development and training of a PCA-GA-BPNN model that was proven to be particularly robust. Indeed, the resulting mean squared error of the test sets was 8.65×10^{-5} , with a correlation coefficient of 0.98.

Further discussion on insulating oils is provided in [3,4]. The accumulation of various types of particles and their effect on the DC breakdown voltage of mineral oil is the topic of paper [3]. Simulation results aiming to explore the motion mechanism and accumulation characteristics of different particles are in agreement with experimental measurements of DC breakdown voltages. As a major conclusion, the properties of the impurities determine the bridge shape, conductivity characteristics and variation law of DC breakdown voltages. The increase of current and the electric field distortion which modify the DC breakdown voltage are mainly affected by metal and mixed particles.

The dielectric characteristics of two types of nanofluids modified natural esters were studied in [4]. The addition of colloidal Fe_2O_3 nanoparticles in natural ester oil revealed an increase of the AC breakdown voltage whereas the opposite behavior was observed after the addition of SiO_2 nanoparticles. The conductivity, along with the permittivity, of nanoparticles arises as a key parameter in the performance of the nanofluid. The experimental results point out that specific concentrations of nanoparticles (with electrical conductivity and permittivity different from those of the matrix oil) are required for the enhancement of the breakdown voltage strength.

Papers [5,6] are focused on outdoor HV insulation. The authors of paper [5] investigated the formation of dry bands on insulators as a function of the insulator design and pollution level. Artificial pollution tests were performed on a 4-shed 11 kV insulator with conventional and textured surface designs in a clean-fog test chamber with the application of a voltage ramp-shape source over three pollution levels (extremely high, high and moderate), and the appearance and extension of dry bands were automatically recognized via a newly developed MATLAB based program procedure. The resulting clear distinction between designs and pollution levels regarding the statistical location and extension development over time of the dry bands may serve as a basis of design guidelines to minimize dry band zones.

Trip accidents of transmission lines during forest fires and, specifically, the contribution of vegetation combustion particles to the triggering of discharges within the gap below the transmission line are investigated in [6]. A two-dimensional (2D) axisymmetric simulation model was established by simplifying the flame region and magnitudes, such as fluid temperature and velocity, fluid field and electric field. Moreover, the forces on particles and movement were calculated. The ultimate goal is a future analysis of the electric field distortion and a further study of the discharge mechanism of the gap under the condition of vegetation flames.

Effects regarding HV transmission lines are also presented in [7,8]. In [7], the authors elaborate on the non-uniformities of transmission line parameters that may affect the magnitude of the transferred transients. A frequency domain method was utilized to compute transient voltage and current profiles along nonuniform multiconductor transmission lines, including the effect of time-varying and nonlinear elements. Through the cascade connection of chain matrices, the line was subdivided into segments with different spatial and time-varying properties. The transition to the time domain was performed

with the Laplace transform. The obtained results were compared to respective alternative transients program (ATP) simulations displaying a high accuracy.

The formation of a transmission line simulation model was also presented in [8] for the calculation of radio interference (RI) lateral profiles generated by corona discharge in high voltage direct current (HVDC) transmission lines. Both the RI and the maximum electric field were calculated as a function of sub-conductor radius, bundle spacing, number of sub-conductors in the bundle, soil resistivity and the radio interference voltage (RIV) frequency for the cases of a 500 kV and a 600 kV bipolar transmission line. Finally, optimal design values to minimize the RI levels were proposed after vector optimization.

In papers [9–11], the authors addressed issues regarding solid insulating materials: creeping discharges on insulating surfaces surrounded by gaseous insulation, electrical treeing in cross-linked polyethylene (XLPE) and partial discharge surface degradation on silicon rubber, respectively.

More specifically, paper [9] dealt with the electrical detection of creeping discharges over disc-shaped insulator samples of different dielectric materials (polytetrafluoroethylene (PTFE), epoxy resin and silicone rubber), using atmospheric gases (dry air, N₂ and CO₂) as insulation mediums in a point-plane electrode arrangement under AC voltage applications. According to the experimental and numerical results, the discharge activity depended highly on the geometrical and material properties of the dielectric and the solid/atmospheric gas interface.

In [10], the authors compared the effectiveness of three specific types of polycyclic compound fillers (compound A: 2-hydroxy-2-phenylacetophenone; compound B: 4-phenylbenzophenone; compound C: 4,40-difluorobenzophenone) in suppressing the electrical treeing growth in XLPE insulation, which can lead to the electrical failure of cables. Experimental results with DC impulse voltage at 30 °C, 60 °C and 90 °C revealed the great application prospects of compound A in HVDC cables as it presented the largest energy level and deep trap density, thus decreasing charge transportation and minimizing electrical tree growth.

An experimental procedure was proposed in [11] to evaluate long-term surface erosion of silicone rubber sheets caused only by partial discharge. The silicone rubber was subjected 50 or 100 times to a 24 h partial discharge cycle. This cycle consisted of an 8 h application of partial discharges using an electrode system with an air gap and a subsequent seizure of the partial discharges for 16 h for the recovery of hydrophobicity. The proposed method presented a satisfying performance in terms of no arc discharge occurrence, good repeatability of results and possible acceleration of erosion. Additionally, the authors stressed out the limited effectiveness of alumina trihydrate (ATH), an additive acting to avoid tracking and erosion by discharge, in the case of partial discharge erosion and the prevalence of the silicon rubber material characteristics.

Space charge accumulation in HV insulating systems was analyzed in papers [12,13]. An accurate description of the time dependent charge distribution within polymeric HVDC cables incorporating complex effects was performed in [12]. An empirical conductivity equation was developed for the accurate description of the stationary space charge and electric field distribution, where the bulk conductivity, found in literature, was extended with two sigmoid functions to represent a conductivity gradient near the electrodes, thus simulating the accumulated bulk space charges and hetero charges. Comparison to space charge measurements taken from the literature showed a good approximation of the space charges prediction with the proposed equation.

A statistical study on the space charge effects and the stages of the needle-plate corona discharge under DC voltage was reported in paper [13]. The statistical rules of repetition rate (n), amplitude (V) and interval time (D_t) were extracted, the corresponding space charge effects and electric field distributions on the PD process were analyzed and the discharge stages of corona discharge under DC voltage were separated.

The fields of HV testing, HV measurements and HV equipment were covered by papers [14–16]. In [14], the authors developed a cable termination model to reduce the electric field at cable ends and prevent surface and external discharges during standardized overvoltage tests. Simulations using the

finite element method (FEM) on a 35 kV sample cable model with 300 kV RMS internal insulation breakdown voltage allowed verifying the sufficient reduction of the electric field at the cable ends.

A novel 363 kV/5000 A/63 kA sextuple-break vacuum circuit breaker (VCB) with a series-parallel structure was presented in [15]. The calculations of the voltage distribution and the electric field of each break at the fully open state via a 3D FEM model highlighted an uneven distribution of the applied voltage, with above 86% stressing the first break. An analysis of the distributed and stray capacitance parameters, along with the equivalent circuit simulation model of the VCB, resulted in an optimal grading capacitor value of 10 nF. The validity of the proposed voltage sharing design was proven through breaking tests of a single-phase unit, where the 363 kV VCB prototype broke both the 63 kA and the 80 kA short circuit currents successfully.

The accuracy and reliability of open-air capacitive sensors in measuring switching transients were demonstrated in [16]. The paper describes a method to calibrate a sensor to line coupling matrix based on assumed 50 Hz symmetric phase voltages. The network simulations indicated good agreement within seven percent with values reconstructed from measurements. Moreover, the comparison of the sensor with measurements of a transient overvoltage by a capacitive divider confirmed the capability of this differentiating/integrating method in interference rejection.

Finally, the scientific subfield of grounding is represented by paper [17], where the authors introduced a new approach to lightning transient studies by incorporating complex grounding grids modelled in MATLAB/Simulink based on the transmission line theory. An interface with electromagnetic transients program-restructured Version (EMTP-RV) allows co-simulation and the facilitation of the component libraries and network design provided by EMTP-RV for more accurate representation of the transmission network.

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