***DOI*: 10.5937/TID25037R**

APPLICATION OF THE NONLINEAR KERNEL PRINCIPAL COMPONENT ANALYSIS IN DETECTING DISK TO-DISK FAULTS ALONG A TRANSFORMER WINDING

Ebrahim Rahimpour, THWS, Germany
ORCID: 0000-0002-7493-2666
Mohammed Bilal Ghorbal, University of Zanjan (ZNU), Iran
ORCID: 0009-0005-5865-0078
Hassan Reza Mirzaei, University of Zanjan (ZNU), Iran
ORCID: 0000-0002-2498-314X

Abstract: Transient overvoltages within a power grid may lead to electrical faults in power transformers. Moreover, short circuit currents passing through the transformer may cause mechanical deformations in its windings. Engineers typically use Frequency Response Analysis (FRA) to identify defect characteristics in transformers. The severity of defects varies based on the extent of the short circuit current and power flowing through the fault. Among electrical faults, disk-to-disk faults in the disk windings are particularly significant, as they can reduce transformer efficiency and increase repair costs. In this study, a nonlinear Kernel Principal Component Analysis Algorithm (KPCAA) is employed to estimate the location and severity of these faults. In the present work, a 1.2 MVA, 10 kV non-interleaved double-disk winding is used and subjected to various artificial faults. Firstly, the high-dimensional Transfer Functions (TF) of this winding are obtained using the Low Voltage Impulse (LVI) method under both healthy and faulty conditions. Next, the KPCAA is applied to the obtained TFs to extract significant features in a lower-dimensional space. Afterwards, the parameters of the selected kernel functions associated with KPCAA are adjusted to achieve optimal results. Finally, the advantages of the proposed technique in determining the characteristics of faults are presented.

Keywords: transformer fault detection, disk to disk fault, Kernel PCA, low voltage impulse (LVI) method, dimension reduction.

Biographies



Ebrahim Rahimpour (SM'10) received a B.Sc. degree in electrical engineering from Tabriz University in 1993 and M.Sc. and Ph.D. degrees in electrical power engineering from the Faculty of Engineering of Tehran University, Tehran, Iran, in 1995 and 2002, respectively. He was an Associate Professor at the University of Zanjan, working on modeling and monitoring of electrical machines, especially transformers, from 2002 to 2007. He acquired a Georg Forster Research Fellowship of the Alexander von Humboldt Foundation (AvH) Scholarship in 2007 and performed some research involving the transfer function method at the Institute of Power Transmission and High Voltage Technology of Stuttgart University until 2008. He has had several positions, including Director of the Electrical Engineering Department at the University of Zanjan, Program Chairman of the 13th Iranian Conference on Electrical Engineering, the project leader of transformer transients, and responsible for Hitachi transient tools at Hitachi Energy, Transformers, Bad Honnef, Germany. Additionally, he is a member of CIGRE WG A2/C4.39, CIGRE WG A2/C4.52 and Convenor of CIGRE WG A2.63. Currently, he is a professor in the field of electric power systems and network components at the Technical University of Applied Sciences Würzburg-Schweinfurt.



Mohammed Bilal Ghorbal was born in Homs, Syria, in 1990, He received his B.Sc. degree in electrical engineering in 2014 from Al-Baath University, Homs, Syria, and his M.Sc. degree in 2021 from Sahand University of Technology, Tabriz, Iran. He is presently working toward a Ph.D. degree at Zanjan University. His main fields of research are high voltage, electrical insulation, and frequency response analysis.



Hassan Reza Mirzaei was born in Zanjan, Iran, in 1983. He received his B.Sc. degree in electrical engineering in 2005 from University of Zanjan, Zanjan, Iran, and M.Sc. and Ph.D. degrees in 2008 and 2013 from K. N. Toosi University of Technology, Tehran, Iran. He is currently an associate professor at the faculty of engineering, department of electrical engineering, University of Zanjan, Iran. He has worked also as a researcher at Iran-Transfo company HV test field and R&D institute. His research interests include high voltage tests and monitoring of the power transformers, partial discharge evaluation, and frequency response analysis.