Mathematical Modelling of Phenomena in Resonance Scattering and Generation of Oscillations for Nonlinear Layered Media

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Abstract:
Nonlinear dielectrics with controllable permittivity are subject of intense studies and begin to find broad applications, for instance in device technology and electronics. Based on a model of resonance scattering and generation of waves on an isotropic nonmagnetic nonlinear layered dielectric structure, which is excited by a packet of plane waves, we compare two numerical algorithms - the preset field approximation and the self-consistent method for simulating various effects of the fields at multiple frequencies. The mathematical model consists of a system of boundary-value problems of Sturm-Liouville type and of an equivalent system of one-dimensional nonlinear Fredholm integral equations of the second kind. Various effects caused by the nonlinearity of the structure were investigated using analytical and numerical techniques \([1]\) - \([3]\). It could be observed that only the self-consistent approach ensures the physically important law of the balance of energy. The results principally indicate how to control the generated field by means of the intensity of the exciting field. In particular, they offer the possibility of designing a frequency multiplier and other electrodynamic devices containing nonlinear dielectrics with controllable permittivity.

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References


Non-contact High Voltage Measurements: Modeling and On-site Evaluation

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In the high voltage grid, voltage measurements are made in dedicated voltage-transformers. These devices are expensive and insulation failures could impact directly on the system, and even cause a power outage. A non-contact measurement technique, on the other hand, does not require a connection to the conductors, and the sensors can therefore be much cheaper by avoiding the need for high voltage insulation.

A capacitive coupling between three measurement electrodes, close to ground, and a high voltage three phase conductor system is used to model and measure the electric field and thereby determine the potentials of the conductors. A 2D-model is used for simulations, where the sensors are modeled as ideal, the conductors are modeled in an infinite wire approximation, and the ground plane is approximated as a perfect conductor. For non-ideal sensors a transfer function from the potentials on the measurement equipment to the potentials on the conductors is derived as a lumped-circuit model.

The L2-norm errors for the amplitude and the phase in the reconstructed signals are calculated and measured for various sensor distances. Simulations show that the sensor distance should not be larger than the conductor distance to mitigate the erroneous effects from distance uncertainties. The optimal sensor distance depends on the quota between the height from the sensors to the conductors and the conductor distance.

Measurements show, in accordance with the theory, that the sensor distance should not be larger than the conductor distance. To reduce the amplitude and phase shift errors the sensors should be placed close to the ground. For applied load resistances there is a tradeoff between amplitude- and phase shift errors. Additionally, higher load resistances attenuate higher frequencies. Measurements have verified that this technique is capable of detecting high harmonics and transients.

The relatively low cost and the movability makes this method highly applicable for quick diagnostics on many locations in a grid, where the data can be evaluated on-site using computer based scripts.
Smart Grid technologies for Detecting Electrical Equipment Faults, Defects and Weaknesses

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Abstract

Joint Stock Company “Federal Grid Company of United Energy System” is the operator of the United National Electrical Network of Russia. Extent of the electrical power transmission lines is 121,7 thousand km, a quantity of substations is 805, the class of voltage 220-750 kV.

The realized by Federal Grid Company passage to “clever power engineering” (Smart Grid) will make it possible to the development of electrotechnical industry, to monitoring the parameters of electrical equipment, to increase the reliability of electrical power supply.

The most important element of “intellectual of networks” (Smart Grid) are the systems of monitoring the parameters of electrical equipment. Information-measuring systems (IMS) were proposed to use together with rapid digital protection against short-circuit regimes in transformer windings. At the beginning of winding deformations, and also in the case of winding turn-to-turn internal short-circuit the value of inductance L is developed to increase, or to decrease.

The residual winding’s deformations of power transformers during short circuits will be appear practically instantly, without leaving time on the analysis the results of the diagnostic measurements, and requiring as it is possible rapid switch off with the purpose averting or reduction in the scales of future repairing of electrical equipment.

Information-measuring system and connected with it protection block were stopped the process of winding destruction. Also this paper presents an application's experience of Low Voltage Impulse testing (LVI-testing), some results of the use of Frequency Response Analysis (FRA) to check the condition of transformer windings of electrical equipment. The LVI method and short-circuit inductive reactance measurements are sensitive for detecting such faults as radial, axial winding deformations, a twisting of low-voltage or regulating winding, a losing of winding’s pressing and other.

LVI oscillograms of 110 kV winding, including turns of regulating winding, and oscillograms of 6 kV winding of 250 MVA/220 kV transformer (ΔXk=+20%) are presented.

Diagnostics experience was showed that application of LVI-testing, Frequency Response Analysis (FRA) and short-circuit reactance measurements (Zk) was be very effective to check the condition of transformer windings of electrical equipment.

Keywords — Intellectual of networks, Smart Grid, Monitoring system, Electrical equipment, Information-measuring system, Frequency Response Analysis, Transformer winding fault diagnostic, Low voltage impulse method, Short-circuit inductive reactance measurement.
Wiener-Hopf operator methods applied to wave diffraction

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In this talk, I will try to present a review of operator methods to treat boundary value problems in connection to diffraction of waves. The applications include different geometries of diffraction screens that range from half-planes to gratings. The boundary conditions can be of different kind: Dirichlet, Neumann, mixed type, or even oblique derivative type.

We start to seek for weak solutions of the Helmholtz equation, together with boundary-transmission conditions on the screen and translate the boundary value problem into a linear operator equation. From the mathematical point of view, we deal mostly with Wiener-Hopf and Toeplitz operators with Fourier symbols that constitute matrix functions defined in certain classes.

The next step is to give an overview of useful factorization methods of matrix functions relative to a curve with emphasis on explicit Wiener-Hopf factorization and a factorization issued from the solution of a Riemann-Hilbert problem. The first factorization applies to some boundary value problem on the half-plane, and the latter works in the case of certain boundary value problem on a two-dimensional grating. Both factorizations allow, under certain conditions, to construct explicit inverses for the Wiener-Hopf and Toeplitz operators, respectively, and therefore solve the corresponding boundary value problem.
We give a short introduction to the spectral theory of open structures including some mathematical aspects of modeling the interaction of oscillations and waves in electromagnetics and acoustics. The problems in question are considered in terms of the analysis of the spectral and various critical points (CPs) of multi-parameter operator-valued functions (OVFs), in particular, integral and infinite-matrix (summation) OVF s, when some of the operator parameters are varied. Interaction of oscillations in a cylindrical slotted resonator whose cross section is formed by two rectangular domains is taken as an example. We reduce the initial boundary eigenvalue problem for the Helmholtz equation or Maxwell equations to Fredholm integral equations with logarithmic singularity or to infinite systems with respect to the unknown Fourier coefficients of the solution. It turns out that some CPs of the OVF are associated with the points where one or several eigenvalues of partial domains merge. We demonstrate that interaction of oscillations occur in this case; namely, the electromagnetic field distributions become unstable with respect to small variations of certain parameters of the structure (geometric, permittivity etc.) in the vicinities of critical values.
DECOMPOSITION PROPERTIES OF OPERATORS, AND
SCHATTEN CLASSES

JOACHIM TOFT

Abstract. It is well-known that any integral operator $T_K$ with its kernel $K$ in the Schwartz space $\mathcal{S}(\mathbb{R}^{2d})$ can be written as $T_{K_1} \circ T_{K_2}$, where both $K_1$ and $K_2$ belong to $\mathcal{S}(\mathbb{R}^{2d})$. We give a proof of this. Furthermore, we show that similar facts hold if $\mathcal{S}$ is replaced by the smaller Gelfand-Shilov space $\mathcal{S}_s$, $s \geq 1/2$, i.e. if $T_K$ with $K \in \mathcal{S}_s(\mathbb{R}^{2d})$, then we prove that $T_K = T_{K_1} \circ T_{K_2}$, for some $K_1, K_2 \in \mathcal{S}_s(\mathbb{R}^{2d})$. We use this to prove that for any (quasi-)Banach spaces $B_1$ and $B_2$ such that

$\mathcal{S}_s(\mathbb{R}^d) \subseteq B_1, B_2 \subseteq \mathcal{S}_s(\mathbb{R}^d)$ \quad (\mathcal{S}(\mathbb{R}^d) \subseteq B_1, B_2 \subseteq \mathcal{S}'(\mathbb{R}^d)),$

and $K \in \mathcal{S}_s(\mathbb{R}^{2d})$ ($K \in \mathcal{S}(\mathbb{R}^{2d})$), then $K$ belongs to $\mathcal{S}_p(B_1, B_2)$, the set of Schatten-von Neumann operators from $B_1$ to $B_2$ of order $p \in (0, \infty]$.

Finally, by similar technique we show that if

$$\frac{1}{p_0} = \frac{1}{p_1} + \frac{1}{p_2}, \quad p_0, p_1, p_2 \in (0, \infty],$$

and $K$ belongs to the modulation space $M^{p_0}(\mathbb{R}^{2d})$, then $T_K = T_{K_1} \circ T_{K_2}$, for some $K_1 \in M^{p_1}(\mathbb{R}^{2d})$ and $K_2 \in M^{p_2}(\mathbb{R}^{2d})$. We use this to prove that if $a \in M^p(\mathbb{R}^{2d})$ with $p \in (0, 2]$, then $T_K \in \mathcal{S}_p(L^2(\mathbb{R}^d), L^2(\mathbb{R}^d))$.

The present talk is based on two scientific project. The first one is a joint project between J. Toft, A. Khrennikov, B. Nilsson and S. Nordebo. The second one is a joint project between K. Gröchenig and J. Toft.

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