COMPUTER SIMULATION OF MULTI-GIGAWATT MAGNETIC COMPRESSION LINES

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Non-linear transmission lines (NLTL) filled with saturated ferrite are promising solid-state sources of high-power microwave radiation. At present such gyromagnetic NLTLs can provide microwave generation in GHz range with typical pulsed RF power on the order of 100 MW [1]. The main principle of generation of these high-power microwave oscillations is the precession of the magnetization vector $\boldsymbol{M}$ around the lines of the effective magnetic field (the sum of driver pulse $\boldsymbol{H}$-field and external bias $\boldsymbol{H}$-field). This precession induces voltage across NLTL conductors and thus leads to pulse transformation and to the generation of oscillations.

In recent years NLTLs also have been utilized to increase the peak power of unipolar pulses in the multi-gigawatt power range [2-4]. This NLTL type is called Magnetic Compression Line (MCL). To date, the highest reported pulse power achieved with the MCL approach is 77 GW at 48-Ohm load, with the pulse amplitude of 1.93 MV and pulse duration of 105 ps (FWHM) [4]. The device uses a semiconductor opening switch (SOS) generator as the input pulse driver, and four consecutive MCL stages as power amplifiers, thus making the generator an extension of all solid-state pulsed power approach.

In this study, a numerical model of MCL operation was created and tested. The electrodynamic part of the model is described by Maxwell's equations reduced to one $\boldsymbol{A}$-potential-dependent equation, i.e., the "full-wave" formulation. The precession of magnetization vector $\boldsymbol{M}$ is described by Landau-Lifshitz-Gilbert equation. The resulting coupled system is solved using COMSOL Multiphysics numerical modeling software [5]. System geometry can be specified in 2D-axisymmetric or full 3D definition. The model also accounts for the nonlinearity of ferrite magnetization by adding non-linear relative permeability μ_r.

The model shows good agreement with existing experimental data [3] in amplitude, overall shape, and delay of the main peaks of the output pulse (figure 1). Optimal ferrite filling length can be determined, and field distribution in the line cross-section can be analyzed. The created model allows to design and analyze MCL power amplification systems, as well as microwave NLTL systems.

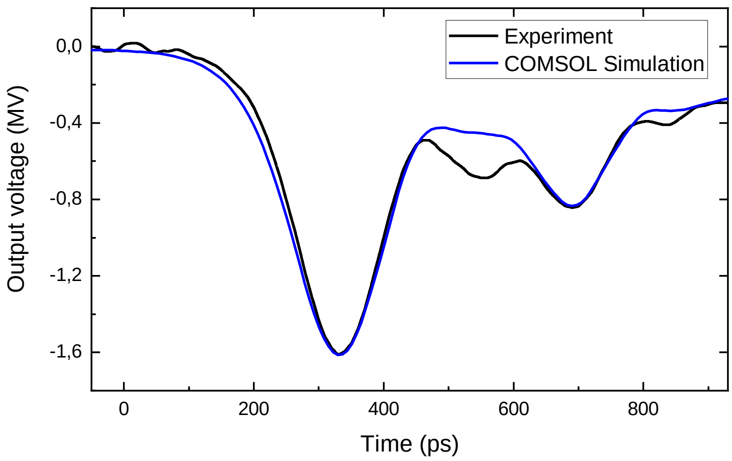

Fig.1. Comparison of experimental output pulse waveform [3] and simulated output pulse waveform for third MCL stage

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