GENERATION OF HIGH-POWER ULTRAWIDEBAND ELECTROMAGNETIC PULSES IN A SYSTEM WITH A COAXIAL TEM HORN

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A coaxial TEM horn was designed on the basis of results from nonstationary computer modeling using code KARAT. With its high dielectric strength, this antenna is capable of radiating high-power ultrawideband nanosecond pulses. The pulse source used was a compact generator built around a coaxial forming line with a built-in Tesla transformer, which shapes pulses up to 1 GW high at repetition frequencies up to 1 kHz. The amplitude of the pulses on a matched load was 20 kV at a duration of 4 nsec. Returns of ultrawideband signals from objects with simple geometric shapes were studied in laboratory experiments using this radiator.

INTRODUCTION

Radar systems that use high-power nanosecond and picosecond pulses have several advantages over radars with quasi-continuous signals. Most important are their high spatial resolution and contrast in target detection. The various types of pulsed radars include ultrawideband (UWB) radars [1] whose pulses have no microwave fill (video pulses). UWB radars with pulse durations from the tens of picoseconds into the nanosecond range have come into use. The broad continuous spectrum of the UWB signal makes it possible to detect objects that are radar-protected in certain frequency bands, for example by absorbing coatings. The use of short ultrawideband signals opens broad opportunities for highly informative diagnosis of targets [2]. For example, UWB devices have an advantage in the relative simplicity with which powerful short electromagnetic pulses are generated [3].

A priority objective for UWB radar is the development of sources that combine high pulse powers with high pulse repetition frequencies. This imposes certain requirements on the basic components of the radiator — the pulse shaper (stability of pulse parameters and longevity) and the antenna system (dielectric strength at gigawatt power levels).

The designs of the "SINUS" range of pulse-periodic nanosecond pulse shapers, which are based on coaxial forming lines with built-in Tesla transformers, have been under development at the Institute of High-Current Electronics of the Siberian Division, Russian Academy of Sciences since the 1970s. They have been used in high-current nanosecond electron accelerators [4, 5]. This paper describes an experiment in the use of such a device in a powerful, compact UWB radiation source.

Since the "SINUS" pulse generators work on the coaxial principle, it is helpful to use antennas that also have axisymmetric configurations to facilitate matching of the UWB antenna to the generator. The advantages of the coaxial antenna over the traditional two-lobe TEM horn include a smoother shape without "sharp corners" and, consequently, higher dielectric strength. The wide annular directional pattern is a disadvantage.

1. COMPUTER MODELING OF THE COAXIAL TEM HORN

Nonstationary computer modeling of the antenna system was done using an axisymmetric version of the 2.5- and 3-dimensional fully electromagnetic KARAT code [6, 7]. The program returns finite-difference solutions of the Maxwell equations

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in a computing region that is closed from the boundary-condition standpoint. The calculations were run on a Pentium-chip 166-MHz microcomputer, which took about an hour to compute a process 60 nsec in duration.

The configuration of the computing region is represented schematically in Fig. 1. It was established by successive approximations that a coaxial antenna designed to radiate nanosecond UWB pulses must have a solid internal electrode and a smoothly expanding external electrode, with the maximum thickness of the internal electrode and the curvature radius of the outer electrode (in cross-section planes) of the order of the electrical length of the radiated pulse. Trapezoidal nanosecond pulses were fed to the coaxial-antenna input in the simulation. The pulse generator was not modeled in combination with the antenna.