A High-Repetition-Rate Bounded-Wave EMP Simulator Based on Hydrogen Thyratron and Transmission Line Transformer

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Abstract—**Transmission line transformers (TLTs) are usually used for impedance match and pulse transformers, which have received gradual attention due to their excellent frequency response characteristics over conventional wire-wound transformers. This transformer basically consists of equal lengths of transmission line normally used by coaxial cables connected in parallel at the input side of the transformer and in series at the output side so that the output voltage can be boosted in proportion. For high-voltage and high-current pulsed system, a gas spark switch is usually used because of its large state current and high hold-off voltage. However, it is hard to get high repetition rate with gas spark switch, because of recombination of the ionized gas. Owing to the high working voltage, high pulse current, quick and steady fire lighting, low trigger voltage, reliable triggering, long life, light weight, small size, and ease of use, hydrogen thyratron, which selected hydrogen or deuterium as arc discharge dielectric, is widely used in the fields of scientific research, military, medical treatment, industry, etc. In this paper, we propose a high-power pulsed system based on TLT and hydrogen thyratron. The system is likely to work at higher voltage as well as higher repetition rate than what are for a conventional system made of wire-wound transfer and gas spark switch.**

Index Terms—**Bounded-wave simulator, hydrogen thyratron, impedance match, repetition rate, transmission line transformers (TLTs).**

I. INTRODUCTION

BOUNDED-WAVE electromagnetic pulse simulator is widely used in many EMP protection systems. A bounded-wave EMP simulator, in its simplest form, consists of two electrically conducting triangular plates separated by a parallel-plate region [1], [2]. A capacitor, charged to high voltage, is discharged through a fast closing switch into the front triangular plate. The current flows through the middle parallel plate to the rear triangular plate and then ends with an absorption resistance.

Recently, the design of a compact pulsed-power generator is becoming important. Transmission line transformers (TLTs) have been used in high-voltage pulse generators with great success [3], as they can produce high-voltage pulses with fast rise time (typically less than 100 ns), which is impossible with traditional pulse transformers. Some systems have been constructed successfully with TLTs, which can produce hundreds of kilovolts of pulses at hundreds of hertz [4], [5]. However gas spark switches limit their lifetime and higher repetition rate, which could be overcome with hydrogen thyratron switches.

Although hydrogen thyratron has been widely used in pulsed-power techniques and, moreover, the TLTs attract increasing attention because of its good response toward the high rate pulse, the pulse generation and the setup technology created by a combination of hydrogen thyratron and TLTs have not been reported yet [6]–[8].

In this paper, we are exploring the possibility of developing a high-voltage pulsed-power system with very fast rising time (< 20 ns) and very high repetition rate (> 100 kHz). The outline of this paper is as follows: The system is introduced in Section II, design and simulation results in Section III, and discussion and summary in Section VI.

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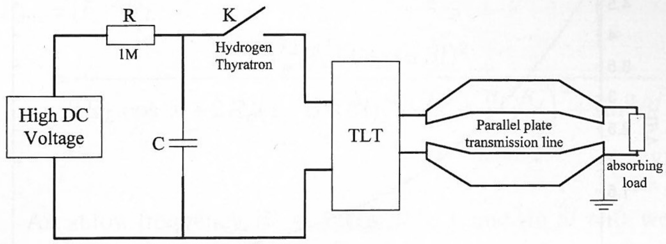

Fig. 1. Diagram of the high-voltage system.

II. SYSTEM CONSTRUCTIONS

A high-repetition-rate EMP simulator in Fig. 1 mainly consists of three parts: high-repetition-rate pulsed-power supply, plate-type bounded-wave simulator, and absorbing load. The pulsed-power supply has a charging source for powering the circuit, a double exponential waveform modulation, a trigger circuit, and a TLT. We will only discuss the last three parts in this paper.

A. Double Exponential Waveform Output

Fig. 2 shows a circuit diagram of double exponential waveform generator, where L, R, C, and K are the inductor including lead inductor and switch turn-on inductor, impedance, energy-storage capacitor (where the capacitance of the energy-storage