Development of a generator of high-voltage nanosecond squared pulses based on SOS-diode and the high-current cold cathode thyratrons with auxiliary glow discharge for feeding of inflectors IC VEPP-5

S. V. Vasiliev, A. S. Kasaev, D. E. Berkaev

Budker Institute of Nuclear Physics

Russian Federation, 630 090, Novosibirsk, Lavrentev ave. 11

Abstract

An Injection Complex (IC) was designed in Budker Institute of Nuclear Physics in Novosibirsk in frame of a program of super high luminosity electron-positron facility VEPP-5. The stability of its operation is determined, among other things, by an injection-extraction system and, consequently, by generators of inflectors. For stable operation of the Injection Complex, these generators must produce pulses with maximum amplitudes of the output voltage of 50 kV and current in the load of the inflector 2 kA, the instability of the flat top less than 5% and its duration in the range from 20 to 92 ns; temporary stability of the generator should be ± 2 ns and the output pulse's front – less than 50 ns. In addition, it must be able to adjust the output voltage amplitude in the range of 10-100% [1].

This article presents the results of the design sample of a generator of high-voltage nanosecond square pulses based on SOS-diode and the high-current cold cathode thyratrons (pseudospark switches).

Introduction

An Injection Complex (IC) was designed in Budker Institute of Nuclear Physics in Novosibirsk in frame of a program of super high luminosity electron-positron facility VEPP-5 [1, 2]. High intensity bunches producing and forming is realized in two linacs (electron and positron) and in a damping ring. Storage and cooling of the electron and positron bunches occurs in the damping ring in series cycles. At the end of each cycle the bunch is extracted and sent to the consumer - the VEPP-2000 or VEPP-4 colliders [3, 4].

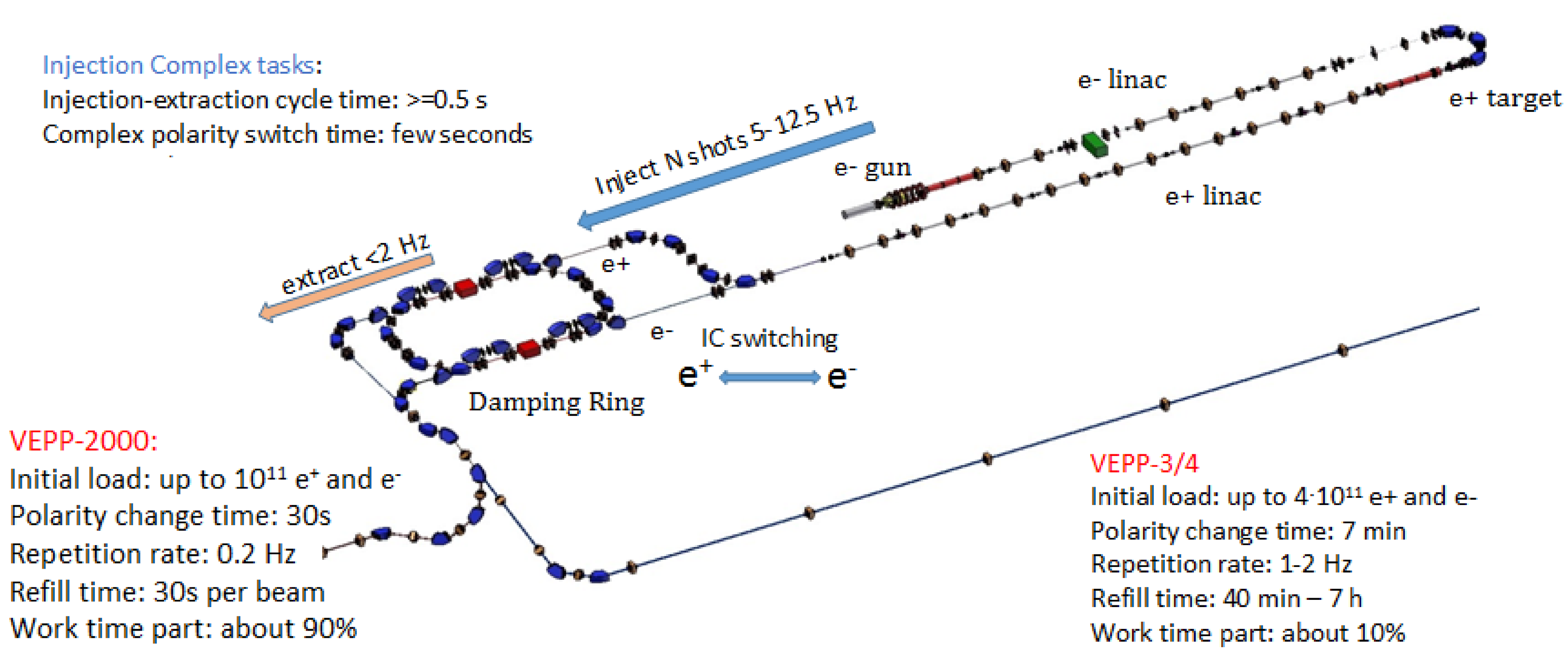

Figure 1: Injection Complex VEPP-5

The damping ring inflectors are executed as a symmetrical strip line pieces, which are used in quasi-traveling wave mode. Every one of the inflectors is fed by a pair of an opposite polarity pulses. The rise time and the decay time of these pulses reach a turn-over period equal to 92 ns [5].

To producing powerful nanosecond pulses, two approaches are most common, differing from one another in the methods of energy storage [6]. The first method is based on the accumulation of electric field energy in capacitive storage devices, which use low-inductance capacitors and forming lines. In such schemes, closing switches are used. The generator of the inflectors, which is used in the IC VEPP-5 at the moment, is based on this principle.

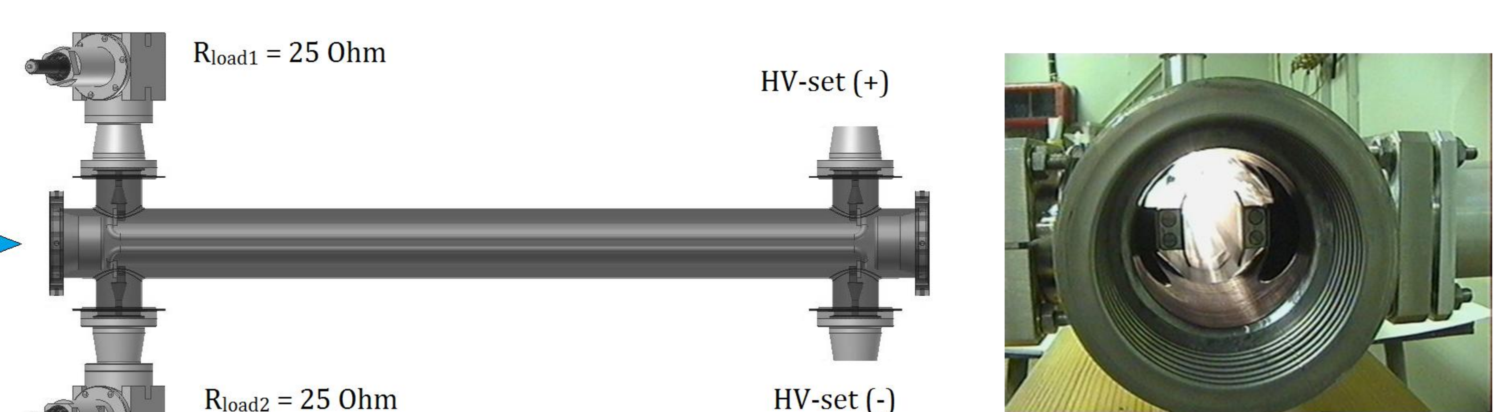

Figure 2: Inflectors of IC VEPP-5

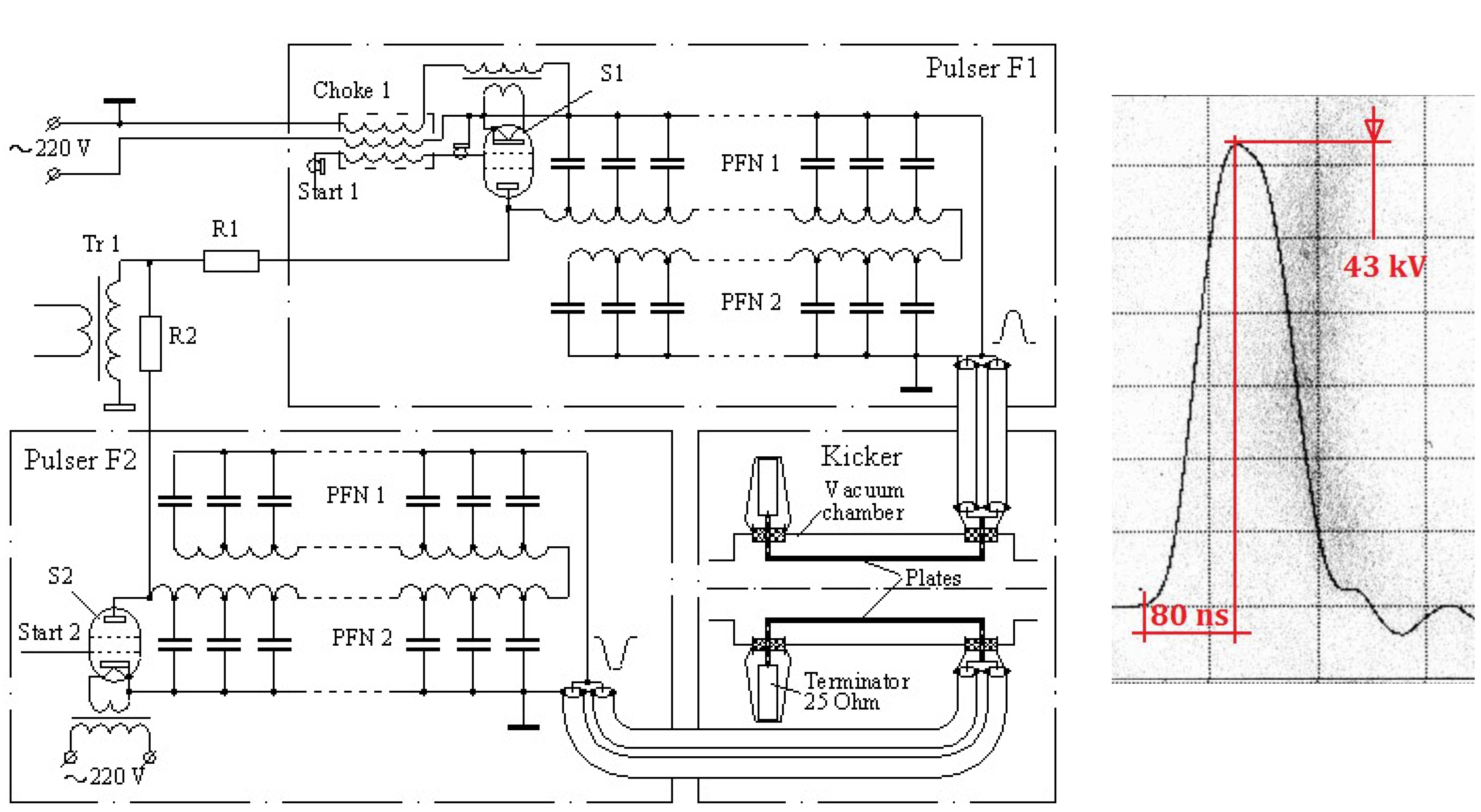

Figure 3: Scheme of generator and its typical produced voltage pulse

A generator of a pair of negative and positive polarity pulses bases on two double pulse forming network (DPFN). Both DPFN are charged up to 50 kV using a common pulse transformer. Every DPFN is commutated by single high-voltage hydrogen thyratron TGI1-2500\50.

Disadvantages of this generator is the problem of obtaining short pulse fronts and the short lifetime and inaccessibility of these types of thyratrons at the present time.

In the second method, the accumulation of energy takes place in the magnetic field of the inductive circuit with the current. In this case current breakers are used. The main difficulty in using inductive energy storage devices is the problem of fast breaking of a large pulse current, which is more difficult from a technical point of view than the respectively commutation. As current breaker in such cases it is possible to apply SOS-diodes [7].

The sample of a generator of high-voltage nanosecond square pulses based on SOS-diode was design for feeding inflectors of the IC VEPP-5. In this work we are used a SOS-diode manufactured by the Institute of Electrophysics of the Ural Branch of the Russian Academy of Sciences [8]. This devices is submitted in the Figure 4.

Figure 4: SOS-diode and pseudospark switch (TPI-10k\50)

The working principle of the circuit with the SOS diode (Figure 5): initially the capacitor C1 is charged to the voltage U_0, at the instant t = 0 the switch Sw is triggered and the capacitor discharged through the inductance L1 and the diode VD. During this discharge, a direct pumping of the diode occurs during the time t_+. During the reverse pumping of the diode t_-, a current break occurs, as a result of which a voltage pulse appears on the load R_{load}, exceeding the value of the charging voltage U_0. This pulse is bell-shaped.

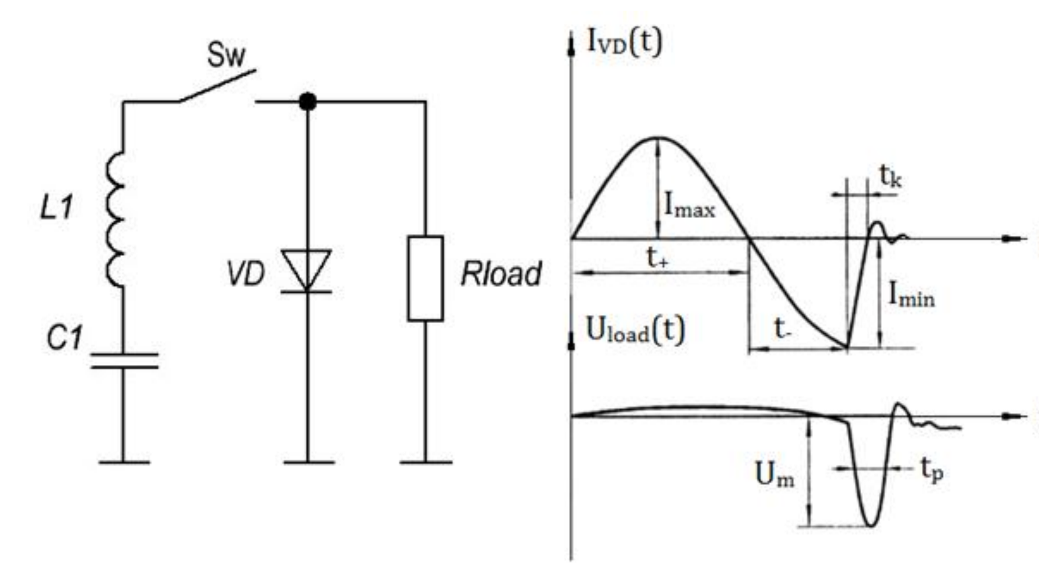

Figure 5: Working principal of the circuit with the SOS-diode

The sample of a generator of high-voltage nanosecond square pulses based on SOS-diode for feeding inflectors of the IC VEPP-5 is submitted in the Figure 6.

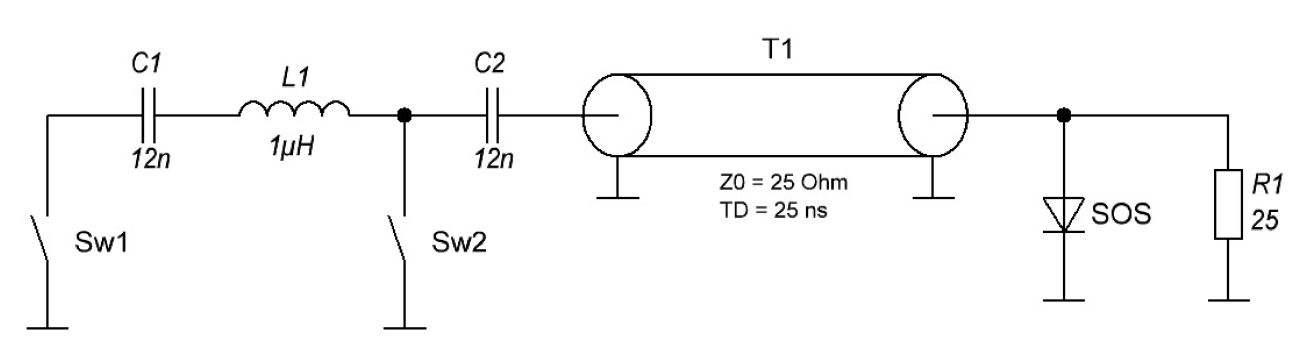

Figure 6: Principal scheme of the generator

Initially the capacitor C1 is charged to the operating voltage U0. At time t = 0, the key Sw1 is triggered and the capacitor C1 is discharged through inductance L1, capacitor C2 and transmission line T1 into SOS-diode. During this discharge, a direct pumping of the diode occurs during the time t+.

At the moment when the direct pumping current reaches zero, the switch Sw2 is triggered and a current of reverse polarity begins to flow through the SOS-Diode. The switch SOS is turn-off at the maximum reverse current moment. As a result of the squared high voltage pulse appears on the load. Duration of the reverse current is t-.

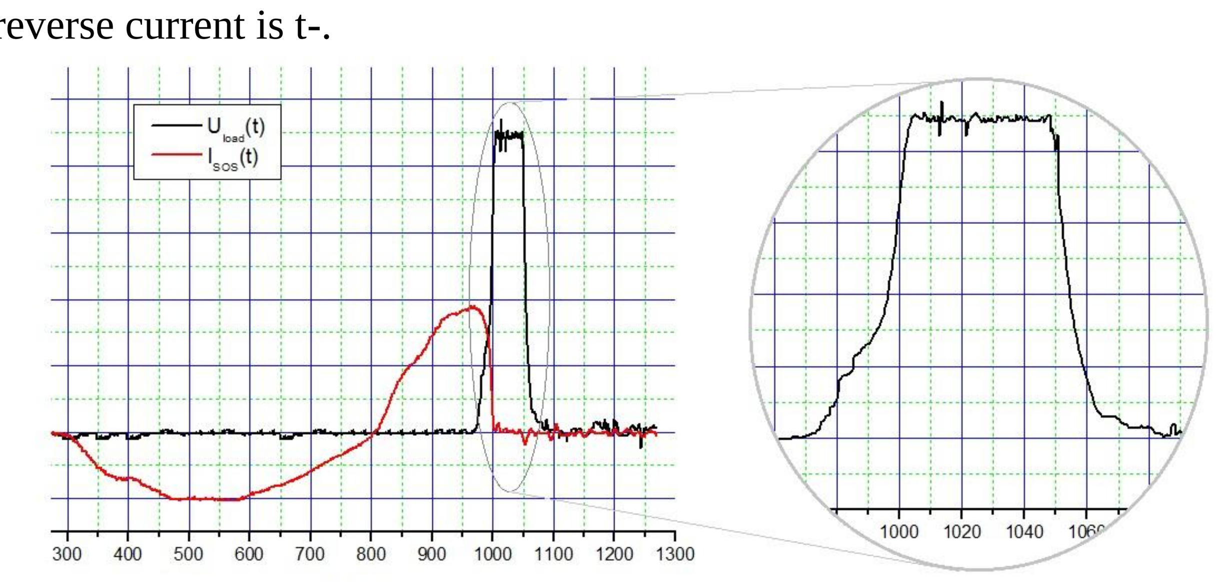

Figure 7: Diagram of the pulse of the generator

Results

Results of our experiments with the 2-kA-SOS-diode have shown in the Figure 7. The generator can produce squared voltage pulses with an amplitude of up to 50 kV and a current of up to 2 kA in a 25-Ohm load. The maximum value of the direct pumping current reaches $I_{+MAX} = 1\ kA$, and the maximum value of the reverse pumping current reaches I_{-MAX} = 1.92 kA. The duration of the front t1-9 = 20 ns, the duration of the flat top t_{flat_top} = 45 ns. The direct pumping of the SOS-diode occurs for a time t+ = 500 ns, and reverse pumping occurs for a time t- = 150 ns. The uniformity of the flat top of the voltage pulse on the load is ± 4%, with single peaks reaching ± 10%.

Conclusion

In this work was simulated a scheme of a generator of high-voltage nanosecond squared pulses, based on the using of an intermediate inductive energy storage device and an SOS-diode.Then was development project of the generator of squared voltage pulses and experiment was carried out. The received experimental results are the base for design of a working variant of the inflector feeding generators for the Injection Complex VEPP-5.

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