INJECTION SYSTEM TO DAMPING RING OF AN ELECTRON-POSITRON INJECTION COMPLEX VEPP5

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Abstract

In this paper elements of an injection system to a damping ring of an injection complex VEPP-5, and a status of work for today also are briefly described. For last year the large work on assembly of the injection system has been done: trial switching on and tests of the system element wise, and work of all elements in common also are made.

INTRODUCTION

An injection complex is designed in Budker Institute of Nuclear Physics in Novosibirsk within the confines of a program of super high luminosity electron – positron facility VEPP-5 for energy up to 15 GEV constructions [1]. [2]. High intensity bunches producing and forming is realized in two 10 cm 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.

INJECTION SYSTEM

One turn single bunch injection with pre-kick of a storage beam is used in the damping ring. One of two long strait sections with nearby bending magnets is occupied for installation of the kickers and a septum magnet for electrons. Another straight section is used for positrons. The same kickers are used for both the pre-kick and the extraction. Both the injection and the extraction are made in vertical direction by kicking in the horizontal plane in the same straight section.

To match optical functions both of canals and of the damping ring special “bridges” have included to a magnet structure of the last one.

Accepted injection and extraction scheme proposes to use vertical DC Lambertson type septum magnet biased from an equilibrium orbit in the radial direction. Such scheme seems to be more economical in comparison with a vertical kick scheme because of it does not demand of a bending magnet vertical aperture increase.

At the injection with the pre-kick both a storage bunch and a bunch to be injected are moving synchronously in the median plain at different sides of a septum magnet wall. The storage beam is shifted to the aperture border due to an influence of the pre-kicker. Both the pre-kicker and the kicker are installed middle in a distant of half betatron wavelength symmetrically relatively to the septum magnet. The storage beam returns to the equilibrium orbit without residual coherent oscillations practically after a blow by the kicker, residual coherent oscillations of an injected beam damp. This procedure is reiterated at 50 Hz repetition rate until a required particles number in the beam will be reached.

The same septum magnet is used as for the extraction also for the injection; the pre-kicker is used as a deflector.

Just before the extraction pair pulse correctors fulfill a local distortion of the equilibrium orbit in the horizontal plane during about 25 ms to shift the storage and damping beam to the septum magnet wall. After the blow by the pre-kicker the beam moves along a new trajectory and gets to the septum magnet aperture.

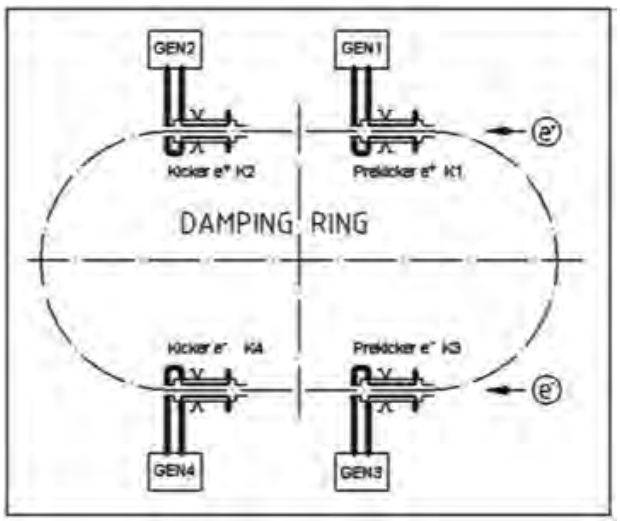

Figure 1: Injection scheme.

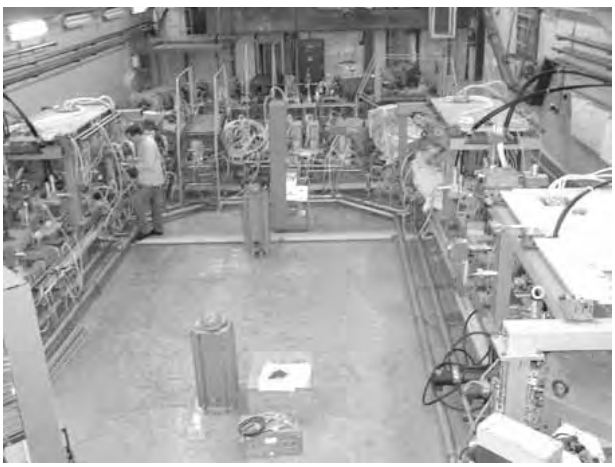

Figure 2: Damping ring with installed kickers.

Kicker

The damping ring kickers are executed as a symmetrical strip line pieces. Every one of the kickers is fed by a pair of an opposite polarity pulses. Because of the kickers are installed partially in the bending magnets ferrite type kickers could not be used.

Main parameters of the kickers are shown in Table 1.

Table 1. Main parameters of the kickers

Plate length, cm	110
Wave resistance of each plate, Ohms	50
Kick direction	radial
Plate feeding scheme	paraphase
Voltage on the kicker plates, kV:	
counter-traveling wave mode:	± 60
accepted scheme*	± 40
Kick rise/fall time, ns	≤ 80

*Quasi-traveling wave mode is applied in the kickers

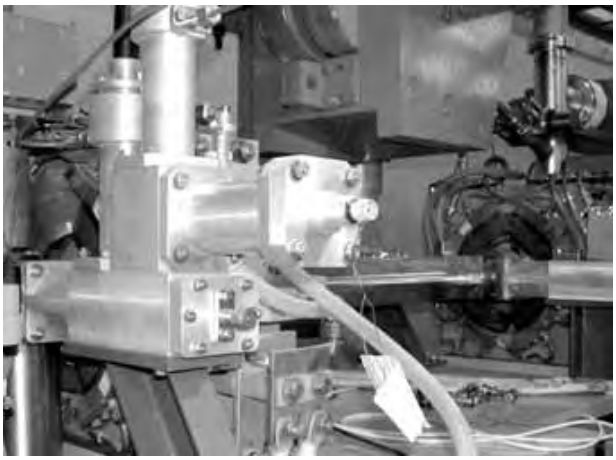

Figure 3: One of the installed kicker.

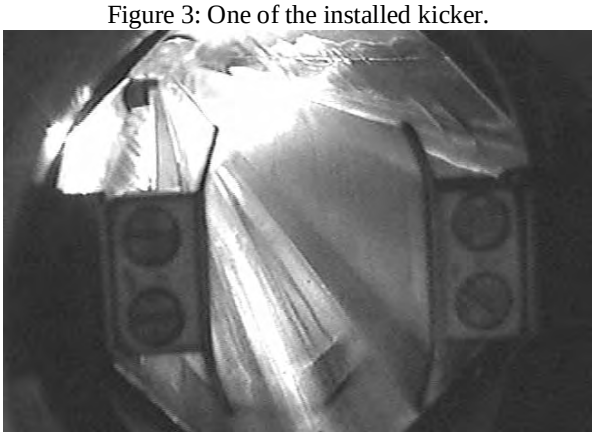

Figure 4: Kicker plates inside damping ring chamber.

Because of the injected beam has a small length and single bunch operation mode is chosen for the damping ring both the rise time and the fall time of the kick almost could achieved the circulating period is equal of about 90 ns. As it follows from the Table 2, it is necessary to feed ± 60 kV to the kicker in the counter-traveling wave. (It should be remarked that a matched operating mode or the same as the traveling wave mode they name a regime when voltage V, current I and wave resistance ρ are connected with expression: I=V/ρ.) As it was mentioned above it is possible to work at rather long rise and fall time of the kick due to the small bunch duration. It allows choosing the regime, which we call quasi-traveling wave mode. At that the kicker feeding voltage could be reduced sufficiently.

In our case every plate of the kicker has wave resistance of about 50 Ohm, is fed by 25-Ohm generator and loaded by 25-Ohm terminator. As a result, 50-Ohm kicker plates turns out to be put into a brake of a matched 25-Ohm circuit. Relatively small reflections only arise here since a wave traveling time through the kicker is match less than the pulse rise/fall time and the wave resistances of the kicker exceeds one of the circuit two times only. The strip could be considered as a not great additional inductance where is excited a current equal to a traveling wave current of the generator:

$$Ig = Vtr / \rho g \text{ , where}$$

Vtr – the traveling wave voltage,

ρg – the wave resistance of the generator and the terminator.

This magnitude exceeds a current value corresponding to the matching mode operation at the voltage Vtr.

An influence of both an electric and a magnetic field components of the kicker to the beam are summarized for the counter wave and subtracted for an accompanying wave. The influences of the both components are equal for relativistic particles. In our case the beam is deflected 1.5 times more strongly in comparison with the counter-traveling mode at equal voltage due to two times more current. That is why ± 40 kV should be enough in the accepted feeding scheme of the kickers. That reduces requirements to the generators very sufficiently. Capacitors Ccor are installed in parallel to inputs and outputs of the kickers to improve transient processes.

At present to the damping ring all kickers are installed.

Generator

The kicker-feeding generator is executed as a linear modulator based on double pulse forming network (DPFN) Blumline type. It is well known DPFN consists of two identical pulse forming networks PFN. Russian high voltage hydrogen thyratrons TGI1-2500/50 type are used as switches. Every generator includes a charging unit and two pulsers, which produce the pair of opposite polarity pulses to feed single kicker.

Now all 4 generators are mounted and installed.

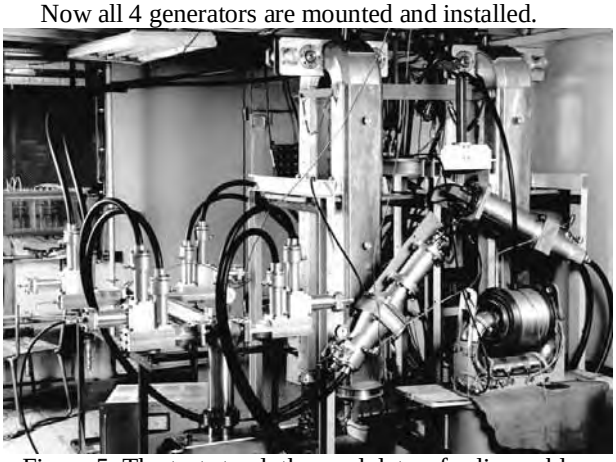

Figure 5: The test stand: the modulator, feeding cables, kicker, loads, high-voltage pulse transformer of DPFN charging scheme.

Figure 6: Installed generators.

Feeding Cables

As it shown on fig. 6, generators are installed in a separate room, therefore special cable lines are laid from the generators to the kickers. The length of the cables is equal of about 40 m. Radio-frequency coaxial cables type RK50-24-17, filled by SF_6 gas at superfluous pressure, and are used here.

DPFN Charging Scheme

The charge of pulse forming lines is carried out by a resonant process due to the discharging of a capacitor store through a step-up high-voltage pulse transformer and an additional separating resistor. The maximal charging voltage on the forming lines is amount of 50 kV at a store voltage of about 500 V. At present a next generation of the charging scheme unit, which will be installed on the injection complex, is developed.

Gas System

The big working voltage has demanded of gas isolation SF6 using. One of engineering features of the injection system consists in the fact that gas isolation are demanded such elements of injection system as the feeding high-voltage cables, inputs of the cables to the kickers and the high-voltage loads. Preliminary high-voltage tests of the cables without SF_6 have shown their enough electrical strength in operating conditions. However the too much repetition rate and the fact that the operating voltage fall outside the limits, specified in the manufacturer data for the cable, prompt us to use SF_6.

Gas is lead to the kicker inputs and to the loads through the center conductor of the cables. It allows to refuse a special tubes use between the generator room and the damping ring hall and to avoid a badly controllable contours over "grounds". Gas gets to the loads through by-pass from the kicker inputs.

At present the gas system has mounted and tested.

High Voltage Loads

At present time there are two completely tested loads. The loads appeared an enough complex product, but presently there is a finished technical decision, and the basic complete set of the load is in manufacture [3], [4].

Control System

A control system is under development now. The control system will allow both, independent work and work in structure of the injection complex. About this system it will be separately reported during subsequent time.

Results of Commissioning

Presently the high-voltage signal has been passed through the entire circuit from the modulator through the cables and kickers to the load. In figure 7 the pulse from the load built-in divider is shown below.

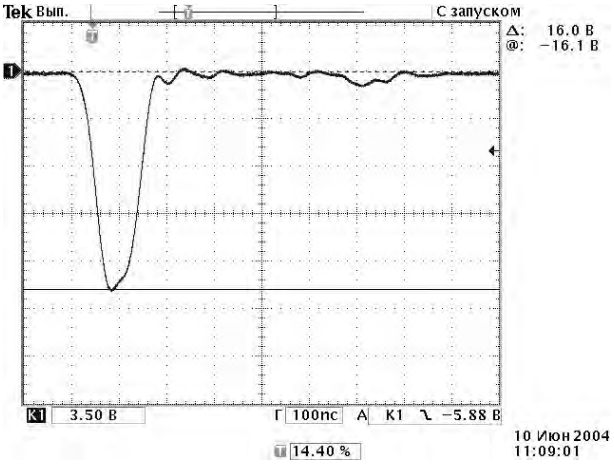

Figure 7: Pulse from kicker.

PERSPECTIVES

In the nearest future it is planned to start a control system. After industrial works finishing the injection system of the complex will be ready to operate with bunches.

ACKNOWLEDGEMENTS

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