THE PULSERS OF THE DAMPING INJECTION OSCILLATION SYSTEMS FOR THE UNK I-STAGE

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Summary

The hard requirement to the emittance of the beam is a characteristic feature of the designed and constructed accelerators for high and super-high energy. It is determined by working regime of an accelerator as a collider or buster for the next acceleration stage. The I-stage of the IHEP UNK[1] is a proton synchrotron accelerating the beam with a common particle number $5\cdot10^{14}$ in the beam at the energy from 70 GeV to 400 GeV. The beam consists of the 12 trains each of 4.6 μsec length with intervals between trains 0.6 μsec. At the full pack of the ring the interval between the 12th and 1st trains is 5.2 μsec. Each train is modulated by frequency 200 MHz. The I-stage is a buster for the 2nd accelerator stage at 3 TeV. The both stages occupy one tunnel together. The long distance from the injector to the I stage UNK (the order $\approx$ 6.5 km) may be followed by the maximum amplitude of injection oscillations to the consequent error of 5 mm.

I. THE CHOICE OF DESIGN.

The linear theory gives the increasing time about 120 μsec (the time of one turn is approximately 70 μsec). In these conditions it is necessary to damp injection oscillations as soon as possible till the amplitude could keep against resistive instability in creasing by damping system during all the accelerator cycle. For the UNK the initial oscillation amplitude reduce is supposed to be from 5 mm till 0.5 mm during 1-3 turns and damp resistive instability in the frequency region from the most dangerous low one (about 4 kHz) up to the upper freguency, where Landau damping is expected for the given energy spread. In our case this freguency is 500 kHz.

Due to this the solution was taken to perform separate systems for injection oscillation damping and limitation of resistive instability increasing. Every of these systems uses 2 kickers in X- and Z- directions. Every pair of kickers is placed on the accelerator ring in such a way, to make the phase advance of betatron oscillations between them close to $\pi/2$. The supply system for injection oscillation damping includes the pulsers, which must provide necessary time characteristics and accuracy requirements to the current pulses in the kickers. In our case the maximum oscillation of the generator pulse top must be less than ±3%. At such a pulser design, in principle, two approches are possible:

i) to design a pulser, which provides to damp the oscillation during one turn only;
ii) to design a pulser which permits to influence the beam during turns.

II. KICKER

We agree that the kicker constructed in IHEP for the 1 UNK[2] stage may satisfy us. The theorethical data have shown that the intergral magnetic field at the level of 0.014 Tm is required. The kicker is a vacuum box with current lines surrounded by ferrit yokes inside. The aperture of the kicker is 60x60 mm. The current lines are divided into two parts, each of them has got an independent high voltage exit. It gives a possibility to provide the magnetic field pulse of the different sign within each kicker. The inductivity of the every half of kicker current lines is 2-3 μH. It means that the maximum

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current of 500 A corresponds to the necessary magnetic field.

The kickers are connected by cable lines of the supply systems placed in a special building on the ground (the total connection lines length ⩾ 300 m).

III. ONE TURN DAMPING PULSER[3]

The general idea of this generator is as follows: the U_0 summary capacity form line charged preliminary till the constant voltage is discharged during the time ⩽ 50 μsec (that time is determined by the time one turn minus the time for control system work) to the necessary level corresponding to the pick-up signal. The scheme of the generator is represented in Fig.1.

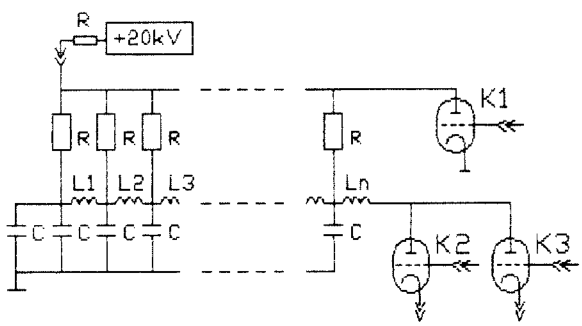

Fig.1 One turn pulser scheme.

The effective meaning of the resistances R1-RN is chosen to reduce the voltage up to the level of 0.03 Uo during 50 μsec while the commutator K1 is switched on (the line is discharged like a concentrated capacity) The commutator K2 starts functioning in time To after the measuring moment. While switching on the K1 the law of the transformation is chosen to have the voltage by the moment of K1 working at the line corresponding to the current necessary for A_{meas} damping. The higher A_{meas} - the later K1 is switched on.

The curves illustrating the principle of the scheme work are shown in Fig.2, and the current on the loading has satisfieted the beam time characteristics in Fig.3.

The usage of the third commutator K3 switched on at the kicker with different current line allows one to get magnetic field pulses of different polars from one generator with one polar charged voltage.

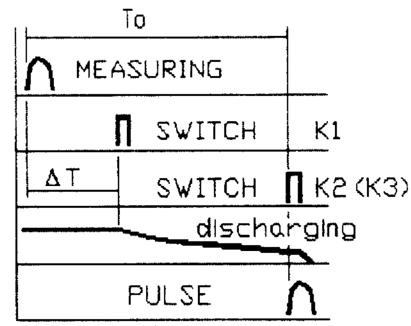

Fig.2 Time diagram of one turn pulser work

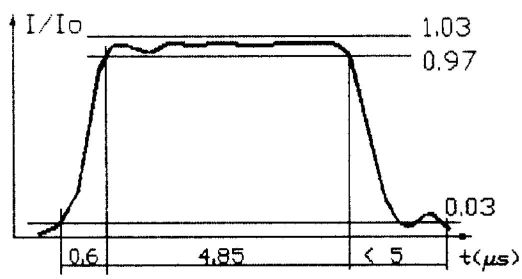

Fig.3 Current curve on the loading

The constructed line possesses the effective wave resistance 17 Om and provides its sequence with a feeder. The sequence of the feeder with the kicker was done by including it into LC-chain with the same wave resistance. Model experiments have shown the correspondence between the real time, amplitude, accuracy parameters of the output pulse and the calculations in all the range of changes (current pulse is changed in the loading for 32 times due to the change of switching delay for 50 μsec).

IV. THE PULSER FOR MULTI TURN ACTION AT THE BEAM.

Developing the one turn damping system for the UNK initial betatron oscillations we cannot but take in account the reasons due to which it could turn out not effective enough. The main reasons are error amplitude oscillation measuring and partial instability rising during one turn. So, we must provide the possibility of multi turn action at the beam.

On this purpose the scheme of fast form line generator with a regulated amplitude of charging is being designed. The repetition frequency of the same pulses should not be less than 14 kHz, the rest parametrs of the pulse are similar to the one turn damping generator. The current on the loading at the level of 500-100 A. At the ETA accelerator[4] a MAG tipe generetor work with repetition frequency of the pulses 5 kHz but it is not supposed for the wide region of regulated voltage. The investigated principle scheme of the generator is represented in Fig.4.

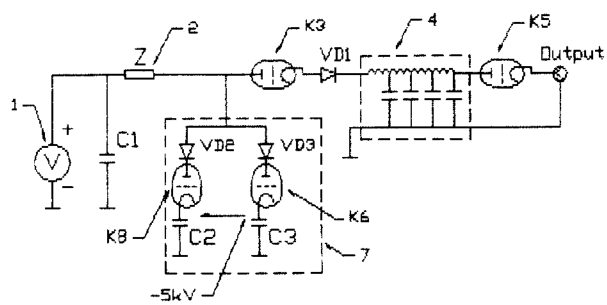

Fig.4 The principle scheme of a multi turn pulser.

The artificial form line 4 is charged by commutator K3 and one-port 2 from the constant voltage source 1. The commutators K6 and K7 are included into a symmetrically double-pole switch 7. The length of charging and, therefore, the magnitude of the voltage on the line 4 is determined by the time interval between commutator K3 and K6 (or K8) switching. A double-pole switching scheme was taken to decrease reguirements to the commutator K6 and K8 recovery time. The availability time for work of each arm switch 7 must include the recharging time the storage capacities C_2, C_3 in thyratron catode chain. One-port 2 accelerates the current break in commutators K3, K6, K8. It provides the principle posibility of the scheme work with necessary frequency repetition pulses 14 kHz. The voltage on the storage capacity line curve is shown in Fig.5.

The total time of line charging up to 15 kV is not more than 30 µsec. On the back front of the voltage curve one can see the leap, connected with the discharging line for the sequence loading. The investigations on the generator have shown the principle possibility of work with high frequency repetition

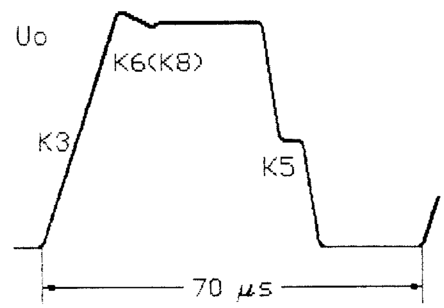

Fig.5 The line voltage

of bursts containing several tens pulses. The limitation for a number of pulses is the middle current of a thyratron. Every generated pulse may be regulated inside the 0-15 kV amplitude region. The amplitude setting must be done not later than 30-40 µsec before the pulse starting.

V. CONCLUSION

The study on accuracy characteristics received at the pulse loading and work reliability should determine the final architecture of kicker supply system for injection oscillation damping.

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