STABILIZATION OF AN ORBIT OF PARTICLES FOR VEPP-4M ELECTRON-POSITRON COLLIDER

I. I. Morozov, BINP SD RAS & Novosibirsk State University, Novosibirsk, Russia

Abstract

To one of defining factors of work collider VEPP-4M is efficiency of injection of bunches from store-preaccelerator VEP-3. It depends on many parameters, including stability of an orbit of particles in the injection region. The system of correction including the control not only a current, but also magnetic fields has been developed for orbit stabilization at injection time in corrector magnets. A proportional-integral-derivative controller (PID controller) is applied to increase of accuracy and speed of installation of a orbit.

INTRODUCTION

The VEPP-4 accelerating-storage complex is the unique Russian particle collider in the 2-11 GeV energy range (center-of-mass reference system) [1]. Moreover, owing to some characteristics, this complex is the unique facility on a global scale. The VEPP-4 is designed for high-energy physics experiments. Now, the basic instrument to study elementary particles and fundamental properties of matter is the colliding beams method. The main principles of particle colliders have been formulated and realized first in Budker Institute of Nuclear Physics and in a few of other laboratories. Using more than 40-years expirience of BINP in the area of colliding beams and accelerator physics, the VEPP-4 team carries out high-energy physics experiments of global scientific interest.

The method of particle energy calibration gives a possibility to measure masses of elementary particles with extremely high precision. Masses of the *J/psi* and *psi'* mesons measured at the VEPP-4 are among 10 most precisely known particles masses.

Now, the VEPP-4M electron-positron collider is operating for high-energy physics experiments in the 1.5-2.0 GeV energy range. The most important of them is precise measurement of the tau-lepton mass at the producing threshold. The tau-lepton mass is used to test the lepton universality principle which is one of the postulates of the Standard Model, the most complete theory describing fundamental properties of matter and elementary particles.

The VEPP-4 accelerating-storage complex includes: the linear accelerator with the maximal beam energy of 50 MeV, the booster synchrotron (350 MeV), the VEPP-3 storage ring (2 GeV) and the VEPP-4M collider (6 GeV).

A requirements of beams orbits stabilization at the collider VEPP- 4M operation exist not only during experiment, but also at beam injection from VEPP-3 to VEPP- 4M .

Bunches separation and change of orbits is carried out by an electrostatics and correction dipole magnets. If the electrostatics precisely enough and quickly establishes a preset value of electric fields with installation of a magnetic field all is much more difficult. Value of a magnetic field depends not only on a current in coils of correction magnets, but also from the previous value of a magnetic field, in consequence of presence hysteresis. Its has memory. This means that it is necessary to know the path that the input followed before it reached its current value.

For elimination of this problem the direct control of magnetic-field strength is used. Correction is made by using Hall probes measurements. A proportional-integral-derivative controller (PID controller) is applied to increase of accuracy and speed of correction magnetic field. The similar way was used for stabilization of VEPP-4M RF- cavities temperature [2].

STABILIZATION SYSTEM FOR THE MAGNETIC FIELD OF CORRECTOR MAGNET

Always there is a difficulty of accommodation of a measuring instrument of a magnetic field inside a magnet because of lack of a place. But at use Hall probe thickness of 0.6 mm, it was possible to place inside corrector dipole magnet with a 90 mm and 120 mm gaps.

Main Corrector Magnets Parameters

- X-direction
- Gap - 120 mm,
- *H/I*=75.4 Oe /A,
- *HL/I*=1.055 kOe·cm/A,

- Z-direction
- Gap - 90 мм,
- *H/I*=100 Oe/A
- *HL/I*=1.41 kOe·cm/A;

Main Hall Probes Parameters

• Length (total/ operating)	2/0.4 mm
• Width (total/ operating)	2 mm/0.125
• Thickness	0.6 mm
• Resistance (input/ output)	6.2/5.7 Ω
• Nominal drive current	100 mA
• Residual voltage	10 mkV
• Magnetic sensitivity	70.4 mV/T
• Temperature coefficient	<0.0021%/K
• Upper limit for magnetic induction	2 T
• Nonlinearity factor at 2T	< 1.9%

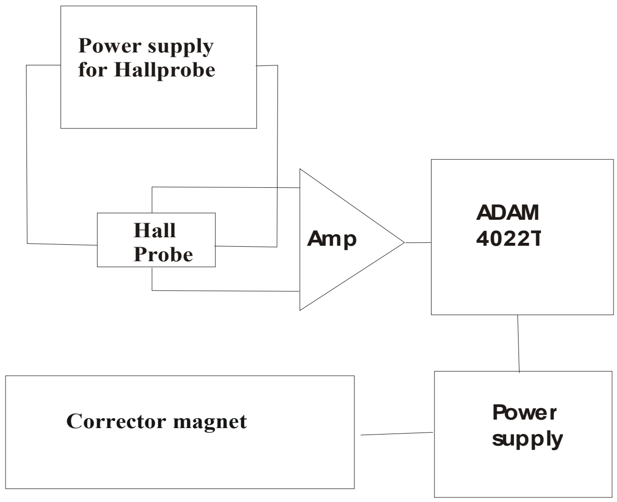

Figure 1: Magnetic field PID-regulator.

The circuitries are presented at Fig. 1. The amplified signal from the Hall probe input to PID regulator ADAM 4022T. PID-regulator allows set required value of a magnetic field with accuracy of 0.5 % for three steps of measurement.

That is 5 s in this case. The current in a magnet was changed from 0.5 up to 1 A.

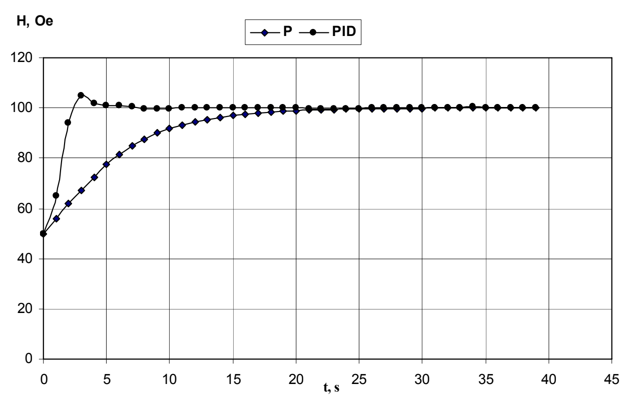

Figure 2: Magnetic field strength (P – ordinary current regulator, PID – PID current regulator).

For connection ADAM with control room of VEPP-4M is used interface RS-485. Transition with RS on USB is carried out with the uLink isolated RS485 – USB adapter USOLT4. It allows increase number of controlled elements many times.

PID-regulators will be used on five vertical and five horizontal corrector magnets. Further it is supposed to install same system on all corrector magnets and to develop same system of correction quadrupole magnets.

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