

# POWER SUPPLIES FOR THE BENDING MAGNETS OF THE BEP AND VEPP-2000 STORAGE RING

S.S. Vasichev, V.F. Veremeenko, K.M. Gorchakov, Yu.A. Evtushenko, V.R. Kozak, A.S. Medvedko, **S.P. Petrov**, R.Z. Pronik, V.P. Prosvetov, O.A. Proskurina,  
Budker Institute of Nuclear Physics SB RAS, Novosibirsk, Russia.

## Introduction

In spring 1999 BINP decided to modernize the complex VEPP-2M in order to increase the brightness and maximal achievable energy up to 2 GeV, which would allow a significant improvement of the experimental resource of the collider.

The beam energy change lead to the necessity to develop new power supplies for the main field of the BEP ( $e^- e^+$  booster) and VEPP-2000 storage ring. The former supplies were manufactured in the seventies of the last century, their element base becoming out of date. That is why both the control system for the supplies and design of the power part has been revised completely.

## POWER SUPPLY FOR THE BENDING MAGNETS OF THE BEP

Below are the parameters of the supply (the supply should be reversible because electrons and positrons are accumulated in turn):

- maximal load current:  $\pm 10\text{kA}$ ,
- output voltage:  $\pm 240\text{ V}$ ,
- admissible error of setting the output current  $\leq 10^{-4}$ ,
- current raise/fall rate up to  $100\text{ A/s}$

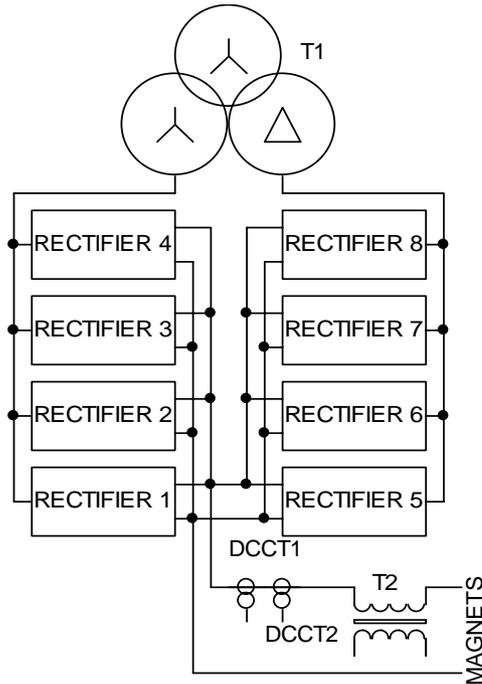


Figure 1: Structure chart of the power supply for the main field magnets of BEP.

The supply is designed as eight modules connected in parallel (fig.1). The modules by groups of four are connected to two groups of output windings of the TDTP-8000 transformer (8000 kVA). The phase shift between the groups of secondary windings of the transformer is  $30^\circ$ .

Transformer T1 is located outside of the building and has its own monitoring system, which is not linked with the similar system to the power supply. That is why we do not consider it in this article.

The direct current current transformers (DCCT1 and DCCT2) and ripple damping transformer (T2) are located closely to the BEP ring.

The power part of each thyristor module (Fig.2) consists of a three-phase bridge rectifier (T253-1000-10 type thyristors), LC filter:  $L=780\ \mu\text{H}$ , C - four capacitors  $12000\ \mu\text{F}\times 450\text{V}$  of the EPCOS B43458-A5129-M type ( $\sim 0,38\text{ F}$  in total power supply, filters frequency  $26\text{ Hz}$ ) and reversing thyristor unit (T153-2500-6 thyristors). Each capacitor of the filter is protected against breakdown (switch SW). Current transformers T1 – T3 are included into the circuits for input current measurement of the each module and protection.

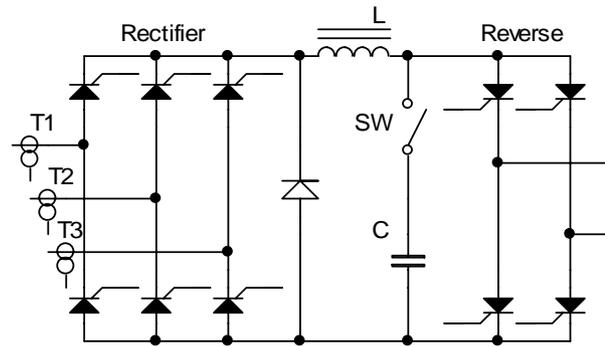


Figure 2: Structure chart of the power part of the thyristor module.

The control system of the supply is divided into two parts. The main part consists of circuits for measurement of output current, feedback, thyristors control pulse generation and supply protection monitoring system. Eight subsidiary parts are located in close vicinity to each of the thyristor modules and contain circuits for amplification of thyristors control pulse and interlocks system.

The interlocks system of the thyristor module monitors the following parameters:

- input current of the rectifying bridge (for protection against short circuits and breakdown of thyristors);
- output current of the rectifier (protection against overload);
- overheating of power parts that operated without water cooling;
- water flow in the system of thyristor cooling;
- state of filtering capacitors protection switches.

The system for monitoring and protection of the main part of the control system collects status signals of each of the thyristor modules, global interlocks (auxiliary supply and total water flow) and permission for operation.

The system has two precise DCCTs. One of them is used in the feedback loop and the other serves for independent measurement of current.

All status signals of the interlocks as well as the values of input and output current are sent to the control computer.

Particularities of the supply design do not allow realizing complete symmetry of power circuits. The current unbalance that has been revealed during the adjustment was up to 1 kA, which is not critical since the thyristors have a large allowance in nominal current. That is why no special steps to choose thyristors for the circuits to be symmetrical have been taken.

## POWER SUPPLY FOR THE BENDING MAGNETS OF THE VEPP-2000 STORAGE RING

The supply is intended to power the main field electromagnets of the VEPP-2000 storage ring. Below are its main parameters:

- maximal load current: 10 kA;
- output voltage: 120 V,
- admissible error of output current stability  $\leq 10^{-5}$ .

The supply for the bending magnets of the VEPP-2000 storage ring is two thyristor rectifiers connected in parallel (Fig.3).

The rectifiers are connected to two groups of secondary windings of the TMNPU-4000 transformer (4000 kVA). The transformer is located outside of the building. The rest components of the supply are placed in one room. The rectifiers are assembled on T173-4000-8 thyristors type.

The filter consists of chokes L1 and L2 (200  $\mu$ H each) and capacitor bank C (40 EPCOS capacitors of the B43458-A5129-M type, 12000 $\mu$ F $\times$ 450V). The filter frequency is 23 Hz. Each capacitor has its own protection switch (SW).

The measured current unbalance between the rectifiers was less than 10% over the whole operating current range.

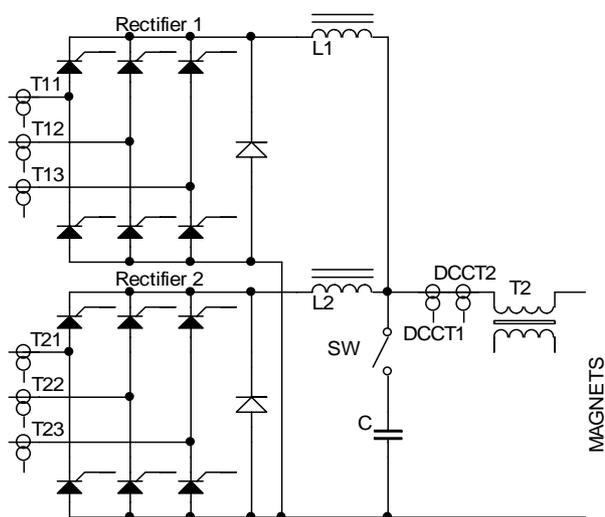


Figure 3: Structure chart of the power supply for the bending magnets of the VEPP-2000 storage ring.

The supply control system is similar to that for power supply of the BEP. The system consists of the main part and two subsidiary ones, having the same functions as those of the control system of the power supply for BEP.

Similarly to the power supply for the BEP magnets, the protection system monitors the following parameters: the input and output current of the modules, overheating, water flow, state of capacitors protection switches of the filter, total water flow and auxiliary supply.

The ripple damping system (ripple damping amplifier and transformer T2) is applied in order to improve output characteristics of the supply.

Similarly to the supply for BEP, two precise DCCTs are installed in this supply. One of them is used in the feedback loop and the other serves for independent measurement of current.

## CONTROL SYSTEM OF THE SUPPLIES

For the sake of simplification of development and manufacture of the control electronics, the control systems of the supplies base on the same principles and control cards.

The control electronics are assembled in "Euromechanics" chassis and rack.

As it was mentioned above, the control system is divided into two parts:

- the main chassis, containing cards of the electronics of the total output precise current measurers (DCCT electronics), feedback (Feedback Controller), interlocks (Interlock), thyristor control pulse generators (Phase Controller) and control DAC/ADC (Fig.4);

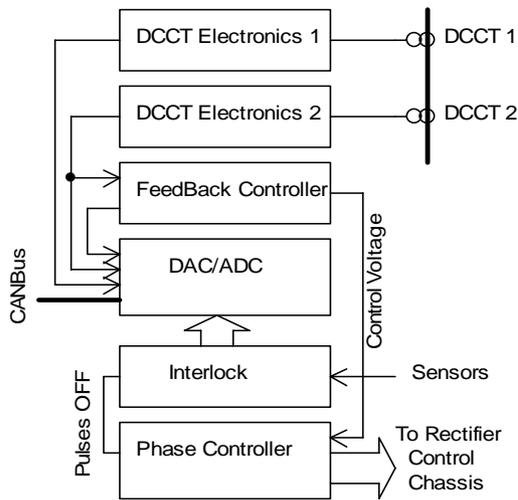


Figure 4: Chart of the main chassis of supply control.

- supplementary chassis in the close position of the each thyristor modules, with cards of thyristors control pulse amplifiers (Control Pulse Amplifier) and interlocks (Interlock) and a DAC/ADC card to transfer the state of the interlock system to the control computer (Fig.5).

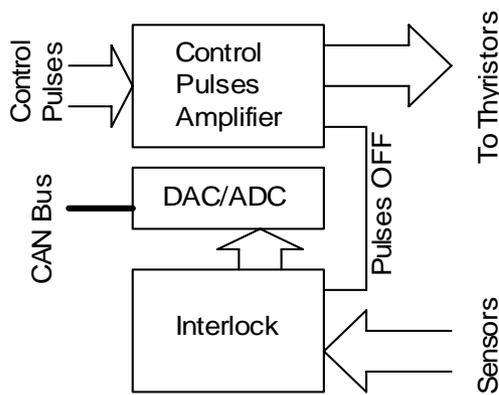


Figure 5: Chart of the supplementary chassis.

In order to reduce the influence of electromagnetic interference, we have introduced a galvanic isolation of signals passed between the main and supplementary chassis.

The both supplies are controlled with special precision DAC/ADC (CEDAC20), placed both in the main and in each of the supplementary chassis. They are used to transmit interlock status signals and parameters of the supply – input current of each module, output current and voltage of the supply and the error signal – to the control computer, by the CANBUS. The signal of the DAC, located in the main chassis, determines the value of the supply output current. No DAC channel is used in the DAC/ADC cards in the supplementary chassis.

For the more reliability, the current measurement circuit is equipped with precise DCCTs, two on each

supply. One of them is used in the feedback loop and the other serves for independent measurement.

## CONCLUSION

The supplies have been assembled and tested by now. The following currents from the supplies have been achieved:

- in the bending magnets of the BEP : 6kA,
- in the bending magnets of the VEPP-2000 storage ring: 2 kA.

Works on the supplies are going on and the full range of parameters will be obtained in the nearest future.

## REFERENCES

- [1]. D.E. Berkaev, A.A. Valishev, V.V. Volkov et al. VEPP-2000 collider project. Budker Institute of nuclear Physics SB RAS, Novosibirsk, 1999.
- [2]. V.R. Kozak, E.A. Kuper, A.N. Fisenko. Set of devices with the CANBUS interface for automation systems for physical facilities. //BINP preprint 2003-70, 2003.
- [3]. Yu.M. Velikanov, V.F. Veremeenko, N.A. Vinokurov et al. High-power free electron laser for the Siberian Center for Photochemical Research: Control system for power supplies of the electromagnets//BINP preprint 2003-69, 2003.