BYPASS SYSTEM FOR SHUNTING OF ELECTROMAGNETS FOR ACCELERATORS AND STORAGE RINGS

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Abstract

The bypass module was developed for correction of magnetic field in the bending magnet gap through partially taking current away from the coil. The SHUNT-20 bypass module that is presented in this work is able to take a current of up to 20A away from the coil of electromagnet. The device developed allows both recuperation of the taken energy to the main power source of the electromagnet and energy dump to a ballast load. The bypass module is remotely monitored and controlled through a CAN-bus. The SHUNT-20 modules are made by the Switch Mode Technology with application of the up-to-date components in the "Euromechanics" standard.

INTRODUCTION

Designing of compact accelerators and charge particle storage rings faces the problem of placement of detached elements for magnetic field correction. Placing a trim coil inside the bending magnet would complicate the design and, besides, it is sometimes impossible. Correction with a special bypass module for each of the magnets is alternative solution. Such way of correction is presented in Fig.1. Такой способ коррекции изображён на Fig. 1. An adjustable bypass module, which takes part of current away from the magnet, is connected to the magnet coil. The bypass circuit is shown in Fig.2. A serial switching regulator with the switching sampler S is used here as the bypass module. The samplers L and C make a second-

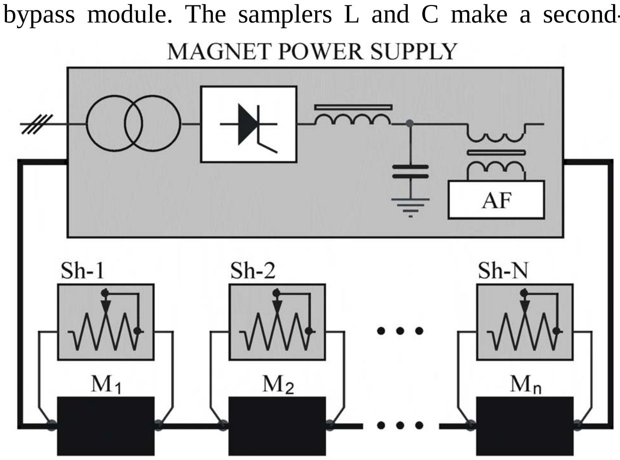

Figure 1: System for correction of the fields of of bending magnets.
AF is the active filter; Sh-1, Sh-2, Sh-N are the bypass modules; M_1, M_2, …M_n are the bending magnets.

order receiving filter that provides continuity of the bypass current. Power that is taken away from the magnet is released on the load Z. The main difference of the bypass module circuitry from the power supply is that

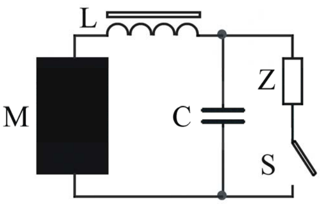

Figure 2: Bypass module circuit.
M is the magnet; L is the choke; C is the capacity; Z is the load; S is the switch.

adjustment is done against an input parameter (the input current of the bypass module).

SCHEMATIC CIRCUIT OF THE BYPASS MODULE SHUNT-20

The choice of the circuitry was determined by the possible bypass module operation in the regime of taken-away-energy recuperation to the main power supply of the magnet. That imposes the following requirements: the load of the bypass module should be a 1F capacitance battery for the main magnet; voltage across the magnet to be bypassed is in an ambiguous dependence on the main supply voltage. We took the schematics of single-ended flyback converter as a basis (Fig. 3). The phases of energy

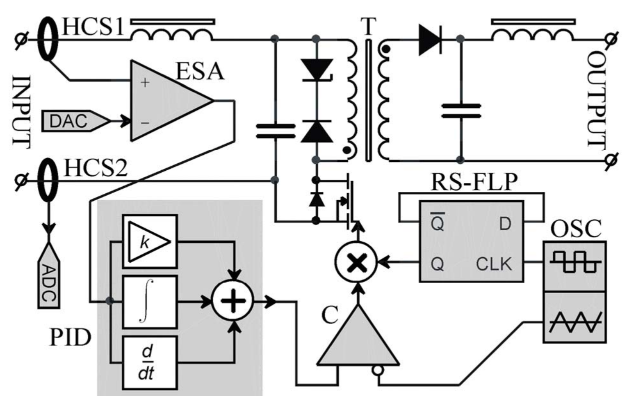

Figure 3: Structural schematic of the SHUNT-20 module. HCS is for the Hall current sensors; PID is the proportional-integral-derivative **c**ontroller; T is the transformer; RS-FLP is the RS-flip-flop; OSC is the oscillator; C is the comparator; ESA is the error-signal amplifier; ADC is the analog-to-digital converter; DAC is the digital-to-analog converter.

accumulation and energy dumping to the load are separated in time, which allows stable operation with a low-impedance load. The input current is adjusted via pulse-duration modulation of input voltage. At the input

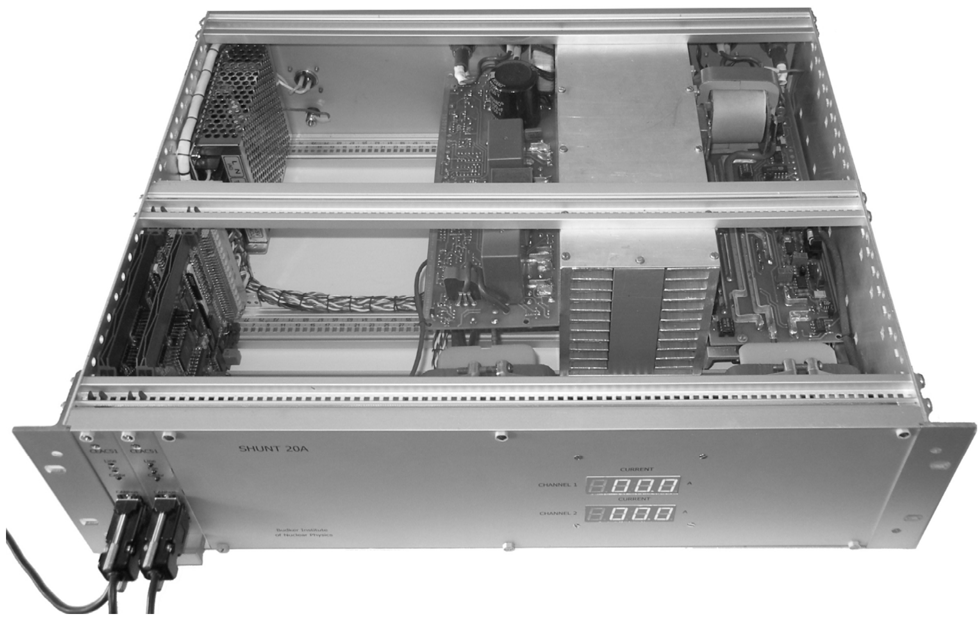

Figure 4: Two-channel bypass module SHUNT 20A

to the flyback converter there is a second order filter to ensure suppression of the carrier frequency of 60 db. The feedback circuit provides the required accuracy of conversion with a current error of the order of 1000. A PID controller ensures stable automatic adjustment.

The SHUNT-20 device has two protections: by overheating of the power part and by excess of the ultimate value of recuperation voltage, which can occur in the absence of output load. In this case, the converter operation is locked and then, when the operation state is restored, the SHUNT-20 is automatically re-started. The control system gets a signal about the protection operation.

The two-channel bypass module SHUNT-20 is made as a 3U subunit (432×355×133mm) in the "Euromechanics" standard. It includes two CEAC51 controllers [1] (an individual controller for either channel) and an auxiliary power supply (Fig.4). The electronics of the module is fed from a 100÷240V, 50/60Hz mains. It is seen from the schemes that the output circuits are fed from the coil of the magnet to be bypass.

Parameters of the bypass module SHUNT-20 are presented in Table 1. The input and output parts of the SHUNT-20 are isolated up to a voltage of 1 kV. The bypass modules can be connected in series.

Table 1:

Maximum current of bypass	20A
Current accuracy	≤0,1%
Maximum input voltage	30V
Maximum output voltage	200V
Control	DAC/ADC
Cooling	Air forced
Conversion frequency	50kHz

TESTS AND RESULTS

The bypass modules SHUNT-20 are working successfully on the small storage ring booster of the Technological storage ring complex (TSC) at Lukin Research Institute of Physical Problem in Zelenograd, Russia. The maximal bypass current, at a low voltage across the magnet, is defined mainly by the cable path resistance (Fig.5). The instability of bypass module current does not exceed the stated error and the dynamic range of conversion is 500 or greater.

Figure 5: Current-voltage characteristic of the SHUNT 20A. I_{MAX} is the maximum current of bypass; U_{IN} is the input voltage.

REFERENCES

[1] V. Kozak. Euromechanical device set with CANbus interface, Preprint Budker INP 2008-18, Novosibirsk (2008).