DEVELOPMENT OF PROTOTYPE BUMP MAGNET POWER SUPPLY FOR PROTON SYNCHROTRON

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Abstract

The authors has designed, constructed and tested prototype bump magnet power supply (BPS) for proton synchrotron. The BPS is capable of generating two types of current waveform, trapezoidal and controlled-decay. The later approximates decaying function, which will be used for beam painting horizontally in the aperture. Typical trapezoidal current waveform parameters to 30micro-H dummy coil are flat-top current of 5 kA, duration of 500micro-s and rep rate of 25Hz.

1 BACKGROUND

Together with the High Energy Accelerator Research Organization (KEK), Japan Atomic Energy Research Institute (JAERI) has proposed "High Intensity Proton Accelerator Project", which includes development of 3-GeV proton synchrotron (3GeVPS). [1] For the proton beam injection to the 3GeVPS, planned lattices of bending and focusing magnets allow few variations of bump magnet system, where waveform of magnetic fields are designed to be trapezoidal, or controlled-decay. As R&D of rather difficult decay-control and fast parallel switching of high current, the prototype BPS was constructed. Formerly, bump waveform was reported, that was composed of two decaying sections switched by thyratron. [2] Now the authors have introduced IGBT semiconductor switch and more complicated switching scheme.

2 DESIGN OF POWER SUPPLY

The authors designed and determined the specification, electrical schematic and mechanical construction.

2.1 Specification

Rep rate:	25[Hz]
Source frequency:	50[Hz]
Load inductance:	30[microH]
Load resistance:	0.8[mOhm]
Output peak current:	5[kA]
Trapezoidal waveform:	
rise time	less than 500[micro-s]
flat-top	longer than 500[micro-s]
fall time	less than 50[micro-s]
flatness in flat-top	within +-1[%]
Controlled-decay waveform:	
rise time	less than 500[micro-s]
decay function	Io*(1-sqrt(t/T))
where Io: peak current, T: pulse width	
tracking accuracy	within +-1[%]

(normalized by peak current)

2.2 Electrical Schematic

The schematic of main circuit is shown in Fig. 1.

Current driving capacitor C1 is used in any case. Current sustaining capacitor C2 and current absorbing capacitor C3 are used for trapezoidal waveform.

For controlled decay waveform, switches S2, S3 and S4 are connected horizontally, and appropriate resistors being switched by IGBTs Q2 and Q3 control the decaying waveform to approximate desired function (1-sqrt(t/T)).

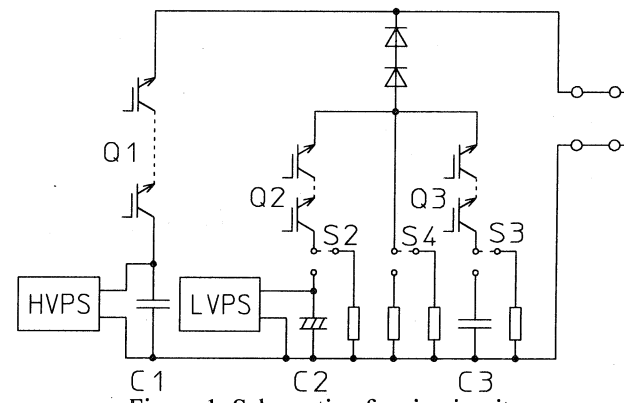

Figure 1: Schematic of main circuit.

2.3 Mechanical construction

In order to test parallel operation of IGBTs, that should be required for much greater currents of the accelerator, all circuitry is devided in two parts. Asymmetry of capacitor location has caused current unbalance particularly at the beginning of flat top in trapezoidal waveform, but allowable 5% of the total cuurent.

3 TEST RESULTS

The constructed prototype BPS has been operating well as designed. Fig.3 shows typical trapezoidal waveform, and Fig.4 controlled-decay. In the 5hours heat-run test, temperature at measured points did not rise over the safety area of each device.

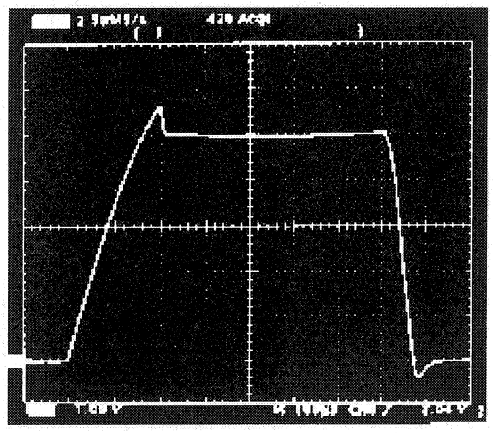

Figure 2: typical trapezoidal waveform.
1kA/div.
100 micro-s/div.

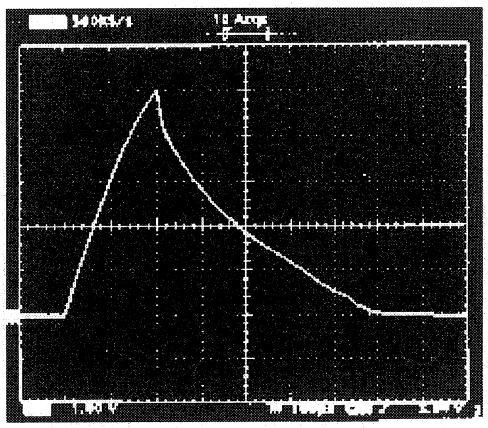

Figure 3: typical controlled-decay waveform.
1kA/div.
100 micro-s/div.

4 CONCLUSION

Prototype bump magnet is under construction. Magnetic field measurement and heat-run test are planned. On the basis of test results of both prototype BPS and magnet, the authors will progress to design and construct those for the accelerator.

5 REFERENCES

[1] The Joint Project for High-Intensity Proton Accelerators
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[2] Positive-Ion Multi-Turn Injection with Bi-Waveform Fast Orbit-Bump Magnets
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