IEEE Transactions on Nuclear Science, Vol. NS-28, No. 3, June 1981

A NOVEL POWER SUPPLY FOR HIGH DUTY FACTOR KICKER MAGNETS

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Introduction

The combination of high duty factor accelerators and multiple beam lines open up the possibility of beamsharing on a pulse-to-pulse basis. The beam-switch yard will then be equipped with fast switching kicker magnets. Power supply designs for pulsed magnets have been described extensively in literature. However in high duty factor applications the absence of sufficient time between pulses imposes severe restrictions on the power supply. The MEA 500 MeV electron accelerator [1] is capable of 50 microsecond beams spaced 400 microseconds apart. Pulse-to-pulse operation will be possible on a cyclic pattern with 0.1 sec. max. duration, therefore magnet switching times less than 1 msec. will not degrade the high duty factor aspect.

A design will be described which will permit rapid setting of a bipolar kicker magnet for two experimental and one tune-up beam lines. Operation is possible with different beam currents and energy into each line. Due to the use of DC magnets in the beam transport lines, only one beam energy per beam line will be supported. Table 1 presents the main design parameters.

Table 1: Main design parameters

magnet inductance:	0.3 mH
magnet current :	375 A
current rise time:	0.8 msec.
pulse duration :	0.8 msec. min.
	0.1 sec. max.
repetition rate :	50 pps max.

Design considerations

Power supplies for kicker magnets usually contain one or more energy storage elements, inductors or capacitors. During the transfer of energy from one element to another a transient phenomena takes place, which is often used to control the shape of the magnet current pulse. However in the NIKHEF-K design the magnet current is controlled by a standard current regulated DC power supply. Transient effects take place between beam current pulses. Power SCR's will be used as the switching elements. Therefore the current and voltage levels have been selected on the basis of available standard components.

An energy storage capacitor has been used for rapid removal of the stored magnet energy. The circuit will also permit fast reflow of the energy back into the magnet, The component values determine the transient time: Ls = 0.3 mH, Cs = 50 micro F, so t = 0.38 msec. Considering circuit losses, approximately 80% of the energy may be recuperated which will bring the magnet current up to 90% of its previous value. The power supply will provide the remaining 10% (k = 0.1) from the main storage element, the inductor L1. I_o denotes the DC power supply and kI_o the magnet current before opening of the shorting switch S. It can be shown (fig. 1) that the steady state magnet current after opening S will be $Im = I_o(1-k*Lm/(Ls+Lm))$. With k = 0.1 and Ls >> Lm the DC power supply current will deviate only slightly from I_o as set by the current regulator.

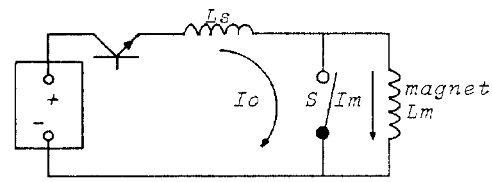


FIG. 1. SIMPLIFIED CIRCUIT DIAGRAM.

The regulator will supply this amount of energy by decreasing the voltage (V) across the series transistor bank during a period T. Assuming Ls = 10 mH, Lm = 0.3 mH, k = 0.1, I_o = 375 A and a voltage decrease of 3 V the response time T will be < 0.2 msec.

Circuit description

Figure 2 represents the simplified circuit diagram. It consists of two identical parts, one for each beam line, indicated by subscripts l and r respectively. SCR snubbers ans noise suppresion circuits have not been indicated, since they represent standard engineering practice. Isolation of the two circuits has been obtained by SCR's S7 and S8. The dc power supply current will be switched from aux load R1 into the magnet by means of SCR's S1 and S2. The storage capacitor will be changed by diodes D4 and D5 and discharged by SCR's S4 and S5. The commutation circuit Cc, D3 and S3 will provide reliable turnoff operation of the SCR's S1 and S2. The auxilary load resistors R1 will be made equal to the magnet resistance, because this will improve the transient current wave form.

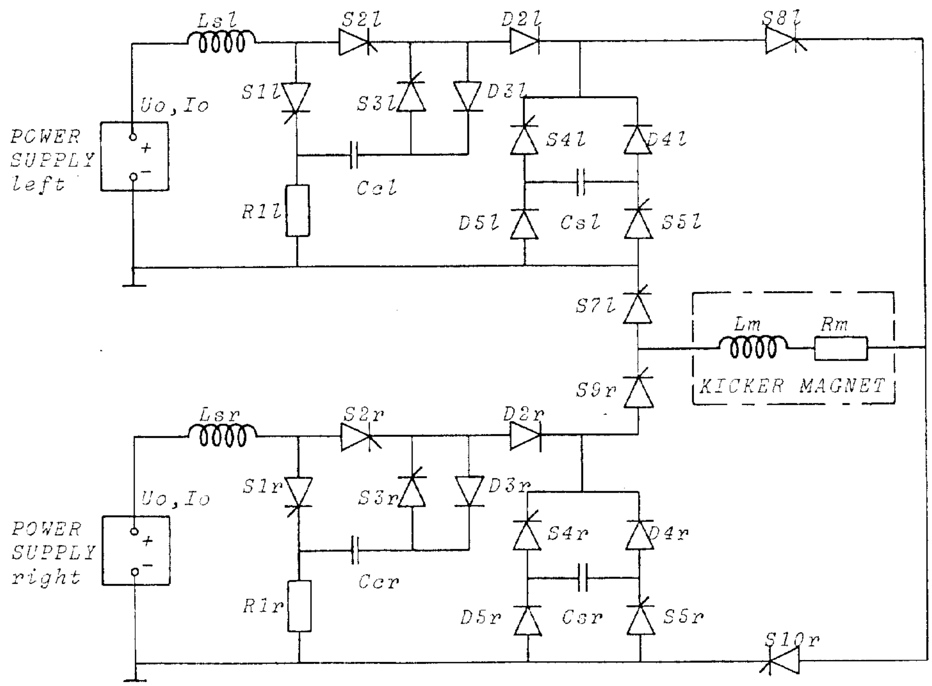
Performance

Several scale models have been constructed. All relevant parameters have been demonstrated sucessfully. The storage choke Ls represents a major cost item however. A successfull high current attempt has been made to utilize a bending magnet as the main storage element. The circuit will be modified slightly in order to use the first bending magnet of each beam transport line as storage inductors. A small power supply, one for each beam line, with an auxilary choke will now be needed for individual adjustment of bending and kicker magnets. It will be connected to A and B in the circuit diagram.

Actual beam operation has been scheduled by the end of 1981.

Acknowledgement

The work described in this paper is part of the research program of the National Institute for Nuclear and High Energy Physics, section Nuclear Physics (NIKHEF-K), made possible by financial support from the Foundation for Fundamental Research on Matter (F.O.M.) and the Netherlands Organization for the Advancement of Pure Research (Z.W.O.).



R1 = 0,03 Ω	Lm = 0,3 mH	Cs = 50 μF/1000 V	Uo = 20 V max.
Rm = 0,03 Ω	Ls = 10 mH	Cc = 2500 μF/30 V	Io = 400 A max.

FIG. 2. CIRCUIT DIAGRAM.

References

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