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A LOW COST HIGH RESOLUTION DAC SYSTEM FOR MAGNET CONTROL

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Summary

Beam switch yard magnets require accurate tracking of the power supplies. Digital to analogue conversion systems with 16 bit resolution are therefore needed. High resolution DAC systems require delicate electronics to preserve the 16 bit monotonocity. However the absolute setting of the magnets is usually restricted to only 0.1%. A system will be described using low noise 10 bit multiplying DAC's. High resolution has been obtained by series connection of two DAC's. The energy setting of the magnetic channel is performed by one central DAC only. The software overhead has been greatly reduced. Substantial savings may be obtained in large magnet systems.

Introduction

The low energy beamtransport system of the 500 MeV 10% d.f. MEA electron linac had been constructed with the components formerly used at the 85 MeV electron linac.[1]. Because the system was to be computer controlled the formerly used magnet reference system had to be replaced. The old system consisted of a main ref. voltage unit with "multiplying" helipots to control each magnet power supply. Setting of the magnetic elements of the beamtransport system could then be easily done by varying the main ref. unit. The main specifications for a new computer controlled system are listed in table 1.

Table 1. Specifications

	Bending magnets	Quad. magnets	
Absolute or calibration Accuracy	10^{-3}	10^{-2}	FSR*
Resolution	10^{-5}	10^{-3}	"
Stability	10^{-4}	10^{-3}	"
Small range tracking	10^{-5}	10^{-3}	"
Construction: A modular system using identical components.			

* FSR = Full Scale Range

As can be seen from table 1 for bending magnets 16 bit resolution is required. However monotonocity is difficult to realise: it required delicate electronics. One can avoid the application of 16 bit DAC's by separating the resolution requirements from the absolute setting of a magnetic element. In our case the absolute setting had to be 10^{-3} (FSR). It is therefore possible to use a 10 bit DAC when stability meets the 10^{-4} (FSR) requirements (see table 1). Resolution can be obtained by adding the output of a second 10 bit DAC to the first one at a ratio of 1%. The quadrupole magnets require only single 10 bit DAC's. Good tracking capability can be obtained by multiplying DAC modules connected to one single main reference DAC. It has been assumed that the applied operational amplifiers are of good quality and do not contribute to offset or stability effects. In this way the main DAC gives the energy setting of the magnetic channel, while the multiplying modules are only scaling factors in the system. In practice it can be done because the magnetic elements have a linear relation with the beam energy over a large range. The obvious advantage of this system is the reduction in software efforts to be made.

Circuit description

The basic circuit of the single multiplying DAC module is given in fig. 1.

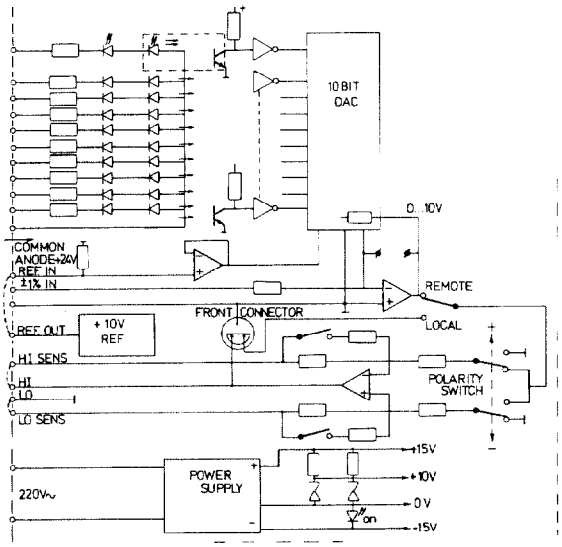

Fig. 1 Circuit diagram of 10 bit DAC unit

The DAC module has been build around a 10 bit low noise standard monolytic multiplying DAC. The module is constructed on an Eurocard (10 x 16 cm) plug in printed circuit board (fig. 2).
Much effort has been paid to avoid ground loop interference. Therefore the digital input is separated by optocouplers and each module is provided with an isolation power supply. An integrated high stability reference unit is provided, low noise, low drift operational amplifiers have been used. A summing input is provided which enables an external signal to be added with a scale factor of 0.01. Gain and polarity switches are provided. The performance obtained is listed in table 2.

Table 2. DAC module performance

	multiplying mode	single DAC mode
Accuracy	10^{-3}	10^{-3}
Resolution	10^{-3}	10^{-3}
Stability	1 x 10^{-5}/°C	4 x 10^{-5}/°C
Output voltage	+ or - 10V or 1V	
Output current	1 mA max.	

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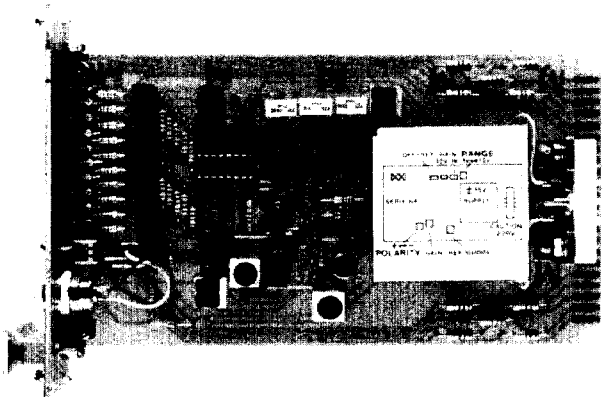
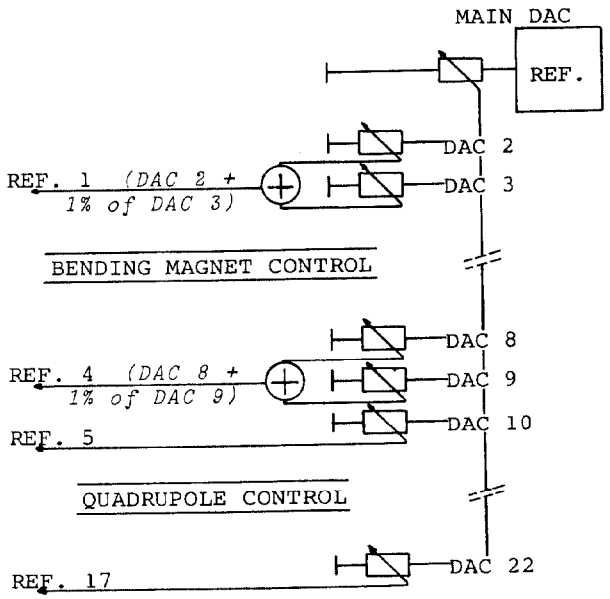


Fig. 2 DAC module

System description

The layout of the magnet power supply reference system is given in figure 3.



DAC's are represented by a potentiometer symbol

Fig. 3. Layout reference system

It consists of a main DAC unit with multiplying units to control the magnet power supplies. The plug in units are mounted in standard 19" racks (see fig. 4). The racks are housed with other instrumentation in a standard air cooled 19" cabinet. The temperature will not vary more than 5°C resulting in better than 2×10^{-4} stability. The temperature difference between the units is even less. The tracking requirement could be met, which has been demonstrated by stable beam performance in the low energy experimental electron scattering facility.

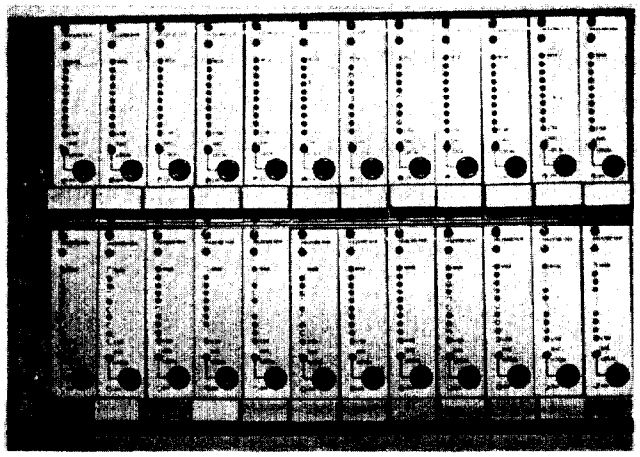


Fig. 4. Magnet reference system

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