

Calibration of Booster Extraction Bump Magnet Readbacks

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AGS STUDIES REPORT	
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EXPERIMENT

The extraction bump magnets (F2, F4, F7, A1) were powered individually at various currents and three readings were taken at each current. This note compares the three sets of readings. At each current, the three readings are:

1. The command setting - I_c
2. The readback signal - I_r
3. The analogue voltage - V

The command setting and the readback signal are the numbers that appear on spreadsheet; the analogue voltage is the voltage measured on a digital scope looking at a signal from a current transformer. In AGS Studies Report No. 267 we established that the analogue signal was directly proportional to the amplitude of the bump angle produced by the magnet on the beam. In particular:

$$K = [0.904 (\pm 0.018)] * V. \quad (\text{Eq. 1})$$

This equation is the key physical relationship. The further discussion in this note is just about some electronic calibrations to establish parameters for evaluating the run just finished and to suggest improvements that can be implemented for the next run. Equation 1 should remain true, the other numbers developed here may well change for the next run.

ANALYSIS OF I_r vs. V

Since the analogue signal has been established to be directly proportional to the current, we use it as our basic signal. Figure 1 shows a plot of the readback signal, I_r , versus the analogue signal, V , for bump A1. Similar plots could be shown for the other magnets. A straight line gives a very good fit to the data. The fitting results are given in Table 1. Note that the correlation coefficients, R^2 , are very good and that the slopes are essentially identical. The only problem is that the intercepts are different for each magnet.

We strongly urge that prior to the next run the system should be adjusted so that the intercepts are all set to zero.

Apart from this, the readback signal, I_r , can be used as a good measure of the strength of the bump, when it is properly interpreted. Table 1 gives the parameters for I_r versus V , and for completeness, the parameters for V versus I_r and K versus I_r .

COMPARISON OF MEASURED AND PREDICTED I_r

The bend angle of a magnet is given by:

$$K = 299.8 * \{B * L\} / P, \quad (\text{Eq. 2})$$

where K is in milliradians, $\{B * L\}$, the integrated field strength, is in Tesla-meters, and P , the momentum, is in GeV/c.

Extraction takes place at a frequency of 4.011 MHz, which gives a momentum of:

$$P = 2.027 \text{ GeV/c.}$$

The extraction momentum will depend on the extraction radius, but for our present purposes, that is a small effect.

Dropping the intercept term, we get:

$$\{B * L\} / I_r = 0.59 \text{ E-4 T * m/A.}$$

From the dc measurements on the dipoles, we would expect:

$$\{B * L\} / I = 0.73 \text{ E-4 T * m/A.}$$

The observed field is 20% less than the dc field expected; since this is a fast pulse, the difference may be possible.

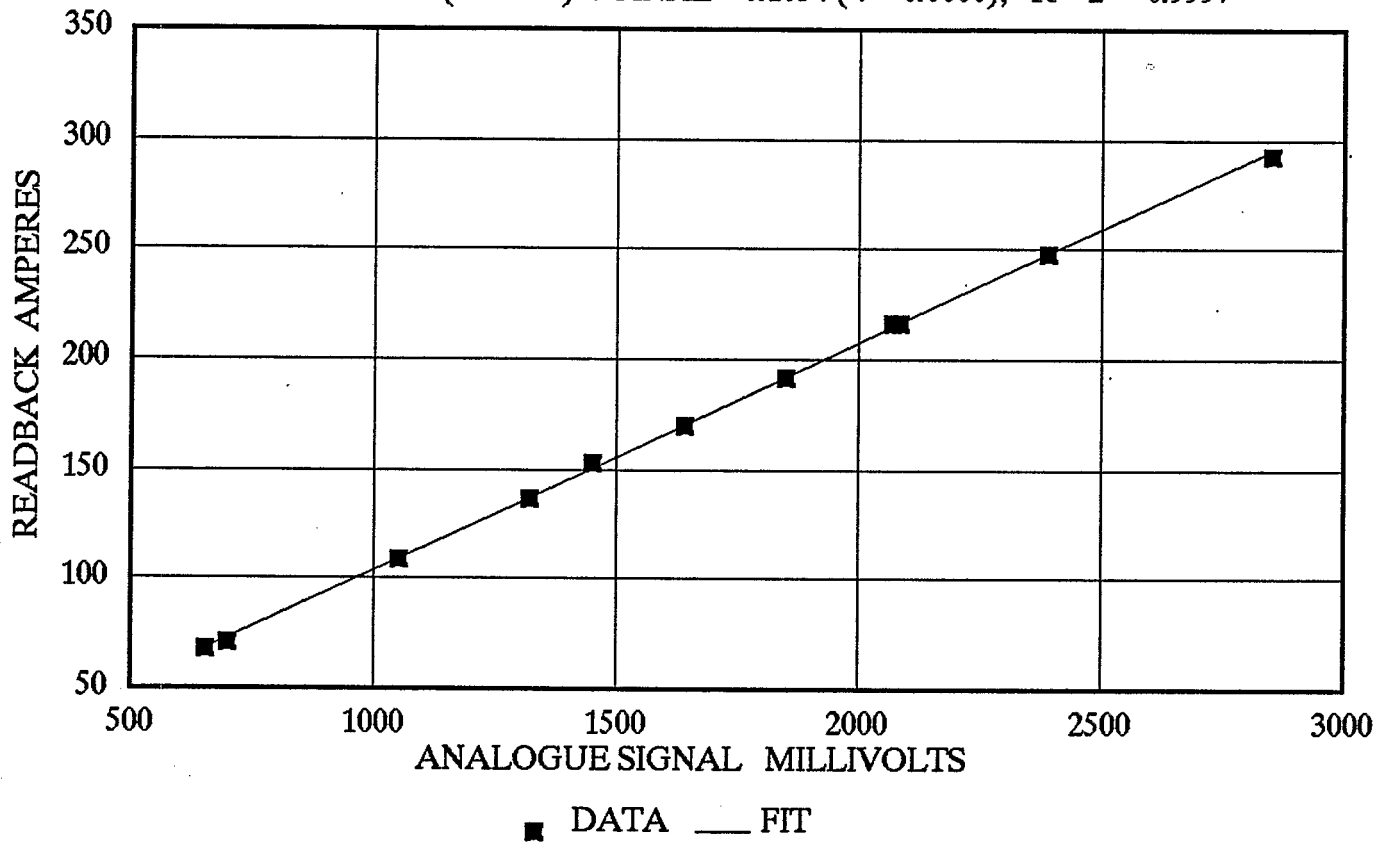
THE COMMAND SETTING

The command setting has a complicated relationship to the readbacks due to the induced voltages. Sophisticated fits can be made to the data to parameterize the relationship, but since those fits depend on the ramp rate, they are of no universal interest.

A serious effort should be made before the next run to either solve this problem or at least to come up with a practical operating mode.

EXTRACTION BUMP MAGNET – A1

$$RDBK = 0.58(+\text{--}1.39) + \text{ANAL} * 0.1034(+\text{--}0.0006); R^2 = 0.9997$$



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Figure 1.

TABLE 1. FITTED RESULTS

$$I_r = a + b * V$$

MAGNET PARAMETERS	F2	F4	F7	A1	UNITS
a	3.25	-9.07	10.43	0.58	Amperes
da	1.08	0.85	0.88	1.39	Amperes
b	103	103.1	103.2	103.4	Amp/V
db	0.4	0.4	0.4	0.6	Amp/V
R^2	0.9998	0.9999	0.9999	0.9997	
V = c + d * I_r					
c	-31	88	-101	-5	milliV
dc	10	8	8	13	milliV
d	9.705	9.702	9.691	9.672	milliV/Amp
dd	0.04	0.035	0.033	0.059	milliV/Amp
R^2	0.999759	0.999895	0.999906	0.999662	
K = e + f * I_r					
e	-0.02802	0.079552	-0.0913	-0.00452	milliradian
f	0.008773	0.008771	0.008761	0.008743	milliradian/Amp