EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH
ORGANISATION EUROPEENNE POUR LA RECHERCHE NUCLEAIRE

CERN – PS DIVISION

PS/PO/Note 99-26 (Tech)

IMPROVEMENTS FOR THE NEW B-TRAIN SYSTEMS

P Dreesen, J. Morales Arostegui

Geneva, Switzerland
December 1999

1. INTRODUCTION

The new B-Train system has been installed and tested in the PS Booster recently, with promising results, as the beam was successfully accelerated with the new approach. Apart from this, previous tests show that the system performs according to specifications.

The new B-Train system has also been installed in the PS Antiproton-Decelerator (AD) where it works fully satisfactorily as a magnetic field monitor. The AD machine is, for the moment, still steered by a synthetic B-Train.

However, in view of an eventual PS Main Ring B-Train system, some modifications and new features can be introduced to significantly improve it. The main issues to be improved are those of system performance, testability and integration in the digital control electronics of the power supplies in the PS/PO group. An explanation of each of these qualities follows.

2. SYSTEM PERFORMANCE

The key parameters in the behaviour of the new B-Train system are its linearity, reproducibility and stability. After the experience gained from tests in the Booster and AD, each of them can still be improved.

2.1 Linearity: the system linearity is strongly related to that of the 16-bit A/D Converter (ADC) in the Analog Front-End Card. The B-Train Generator can not have a better linearity than that of the ADC it is based upon. Moreover, the selected ADC shows poor behaviour in the negative range when approaching full-scale values. This effect has no influence in the PS Booster, where only the ramping-up stage of the magnetic field is of importance, but limits the system performance in AD, where the ramping-down stages have to be taken into account.

For these reasons, the use of a better ADC is suggested. An 18-bit ADC would probably improve the system characteristics in terms of linearity by a factor of four.

2.2 Reproducibility: the system reproducibility is strongly related to the quality of the autocalibration. Currently, the autocalibration is based on two 8-bit digital potentiometers inside the feedback loop of the ADC offset and gain adjustments.

As the B-Train Generator behaves as an integrator, any offset error is integrated during a full magnetic cycle. In consequence, the quality of the autocalibration is defined not only by its resolution, but also by the duration of a magnetic cycle. In the Booster, the system behaves well within specifications. In AD, with cycles originally foreseen to last no more than 60 seconds, the current cycle lasts over 120 seconds, posing more strict requirements. For such a cycle, the system is at its very limit in terms of reproducibility.

Therefore, a new solution for the autocalibration feedback loop is recommended. The use of 12-bit D/A converters (DAC) instead of the 8-bit digital potentiometers would improve the autocalibration resolution, reducing dispersion in the measurements.

2.3 Stability: the Head Amplifier has not been included in the autocalibration loop. Any change in the characteristics of its electronic components will not be detected by the autocalibration. Therefore, the current system configuration cannot guarantee long-term system stability.

A redesign of the Head Amplifier is therefore strongly recommended. The new electronics would include 0 and 5 Volt references, thus allowing the autocalibration to correct any drift in the characteristics of any component, not only inside the Analog Front-End Card but also inside the Head Amplifier.

Apart from this, after studying the characteristics of the reference voltage components and its design, some doubts about its long-term stability remain. Since the reference voltage is crucial for the quality of the autocalibration, the authors recommend a better design.

3. TESTABILITY

The actual system design makes it difficult to be tested in an easy way. As the system performance is critical for the correct operation of the accelerators, any modification leading to increase its testability should be considered. Amongst some others, the main suggested improvements are the following:

3.1 Modification of the B-Train crate to house a high-resolution measurement of the current in the Main Power Supply. A second Analog Front-End Card can be used for this measurement. In this way, the correlation between the current in the Main Power Supply and the integrated magnetic field can be obtained, allowing the maintenance team to distinguish between a problem in the B-Train system and a change in the Main Power Supply operating conditions.

3.2 Addition of a high-resolution DAC to the Analog Front-End Card. This would allow monitoring the integrated magnetic field with just an oscilloscope. This signal is missing for the moment. At a later stage, the analog magnetic field signal could be distributed to the control electronics of the Main Power Supply and included in a feedback loop. The same set-up can be used for the necessary determination of the relationship between current and magnetic field.

3.3 Addition of a Function Generator on the Analog Front-End Card or on the Digital Control Card (to be studied). Tests of the system require a high-quality function generator. Every time simulated cycles have to be fed into the system, a complex test bench including a VME crate, a DAC, a pulse generator and a terminal is needed. As an alternative, an on-board function generator can be built to input some predefined cycles to the system. In this way, no heavy add-on devices are needed every time the system is tested.

3.4 Partial new layout of the Analog Front-End Card. The signal from the Head Amplifier, for the moment, is fed in the Analog Front-End Card from its rear connector. This multiplication of electric contacts and wiring reduces reliability. Every time the card is tested, an extension card is needed. The ohmic resistance of both the connectors and tracks in the extension card falsifies the analog measurements, making correct testing awesome. Therefore, the analog signal should be fed directly into the Analog Front-End Card from its front panel.

Apart from this, every time the overall gain of the B-Train Generator has to be modified, the card has to be unplugged to access a 24-bit DIP switch. Time is needed to allow the card to warm up for correct operation.

3.5 Partial redesign of the ADC Test Card. This card was originally defined as a test card to verify the main characteristics of the analog electronics in the Analog Front-End Card. However, it became very useful during system debugging in the Booster. The signal from the Pickup Coil was sampled and stored on-line during a magnetic cycle and later downloaded off-line so the integrated magnetic field could be calculated from this data. A redesign would be useful to allow sampling and storing of a complete AD cycle. At the same time, the reviewed ADC Test Card could be integrated within the Noise Monitor on a single card, allowing all the auxiliary cards to be grouped together and eliminating connections inside the crate.

3.6 NMR timing signals. The marker pulses coming from the NMR equipment do not fully persuade. If the situation is acceptable for the Booster, it is not yet for AD. We have to investigate more into multiplexing, shielding and transmission of these signals.

4. INTEGRATION IN THE DIGITAL POWER SUPPLY CONTROL ELECTRONICS

The system was conceived as a stand-alone measurement system. However, members of the PS/PO group have already shown interest in a high-resolution sampling system with an autocalibration feature, to be used inside the regulation loops of high power converters. An excellent general sampling system can be derived from the B-Train system by adding a few features to the Analog Front-End Card, corresponding to the particular needs of the digital regulation loops.

A fully functional crate could then easily be built, containing just the Analog Front-End Card, the Noise Monitor and the Liquid Crystal Display on the front panel. The rest of the electronics needed for the B-Train system would not be necessary for such a high-resolution sampling system.

5. CONCLUSIONS

Despite the promising results that the B-Train system for the Booster has obtained in the first tests with beam, some of its features should be redesigned to improve its performance and to ease testability and maintenance in the long term.

From the authors' point of view, the actual main limitation of the system is that it does not guarantee long-term stability. Therefore a partial redesign of the Analog Front-End Card and Head Amplifier is recommended. At the same time, all the suggestions inside this note can be included to ease system maintenance and testing.

The authors also recommend making the review compatible with the needs of digital control loop developments within the PS/PO group. In this way, the knowledge gained during the development of the B-Train system can be most helpful to every member involved in instrumentation and control tasks.

Distribution

PS/PO Group and Section Leaders:
J. Gruber
J. Buttkus
J.-P. Royer
H. Ullrich
F. Völker

PS/PO/MP Section:
E. Aldaz Carroll
G. Brulhart
P. Dreesen
H. Fiebiger
I. Garcia Alfonso
F. Gendre
A. Lévrier
J. Morales Arostegui
D. Rivalli

/ed