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ISR PERFORMANCE REPORT

Influence of Power Supply Current Spikes on ISR Beams

Introduction

The present investigation was undertaken in an attempt to confirm or disprove a possible correlation between current spikes on different power supplies and phenomena like vertical beam blow-up and partial beam losses. Slow losses of up to 5 Amps associated with a considerable blow-up of the remaining beam have been observed for several years, the great majority in ring 2, without a reason being found. During the last twelve months such current losses have occurred in ring 2 in 38% of all 31 GeV physics runs (LB optics), whilst ring 1 has only been affected by three similar incidents during the same period of time. At 22 GeV/c the statistics show an even worse situation as three out of four runs were affected, again here mainly ring 2. These incidents have a strong impact on the machine performance as they are responsible for a drastic drop in luminosity and a significant deterioration of the background conditions, following the blow-up of the beam. The different subsystems which have a direct influence on the beam (i.e. clearing electrodes, transverse feedback loops, vacuum, power supplies) have therefore been the object of systematic investigation. This report presents the results of the tests carried out on the power supplies.

The Experiment

In order to simulate transients on a power supply, an intervention was made to allow for a controlled perturbation of the control loop. An external source of perturbation, a pulse generator, was connected up to the voltage measurement at the entry of the comparator (see figs. 1 and 2). The pulse generator produces a step function with variable amplitude. A calibration of the step height was made with respect to the amplitude of the output current spike for each power supply in question. The current spikes were measured with the set-up shown on fig. 2 and by means of the program PSMON, which performs fast readings of the DVM and outputs the current spikes in graphical form. The two measurements were in good agreement. The experiment was carried out on those power supplies which were believed to be the best candidates for provocation of the beam perturbations in question: the MOP1's and the FOEL1's, which determine the tune of the machine. 2QT1, 2QT3, 2PFF6 and 2PFD7 were prepared for the simulation of instabilities.

The tests were made on old beams, at the end of physics runs (beam aperture limited, with 'halo'), both with and without previous partial beam losses as well as on new beams (during MP). The influence on the beam was monitored by the transient recorders and the "background" counters.

In addition, the experiment made possible a check of the calibration and reliability of the hard and software involved in our spike detection.
Results

Each of the four power supplies, equipped for spike simulation, was subjected to perturbations giving output spikes of amplitudes ranging from a few ppm to more than 10,000 ppm of full scale output current. The results can be summarised as follows:

- Current spikes of only 20 ppm amplitude (= 1/12 of one bit of DAC) already give appreciable spikes on backgrounds in all intersections, even on new beams without "halo" (collimation as for physics), see fig. 3. This is true for the QT's as well as for the PF's.

- Increasing amplitude of the current spikes results in increasing perturbation of the backgrounds. Saturation of the background spikes occurs at a level which depends on the type of power supply, the location of the magnet and the type of magnetic machine (optics). In general, the beams are slightly less sensitive to fluctuations on QT's than on centre-PF's, and recovery of the background conditions are to some extent slower after a spike on a PF.

- It was not possible to cause any partial beam loss by the provoked current spikes. Even heavy, frequent spiking (amplitude > 5000 ppm) for several minutes at the end of each test never caused particle losses exceeding a total of 1mA. No blow-up of the beam was ever observed.

- On no occasion were the transient recorders triggered by the spikes. No coherent oscillation (coherent motion of the centre of gravity of the beam) was detected.

Complementary tests were made with the Derritrons, powering CR's and H's - using the program OLIV to provide predetermined step-changes to the supplies. These tests revealed that the ISR beams are much less sensitive to fluctuations of those elements: Step changes of 2 bits (~500 ppm) were hardly visible on the "background" of new beams whilst, on old beams, they only caused insignificant spikes (see also ref. 1).

Current spikes exceeding an amplitude of 1400 ppm for the PF's and about 3200 ppm for the QT's were detected by the spike detectors/SPIK program. For spikes above these thresholds, the detection system seemed to work reliably.

CONCLUSION

The present investigation highlights the deplorable absence of possibilities for detection of power supply spikes of smaller amplitudes. Current spikes of only 20 ppm on certain power supplies can, as shown, have a significant impact on the conditions for physics but there exists no simple and efficient tool for the detection of their origin. The actual spike detectors looking at the PF's and QT's are far too insensitive and PSMON which performs fast sampling of the DVM's, is unable to make simultaneous monitoring of more than five power supplies due to lack of CPU time and is therefore not a valuable alternative to the spike detectors.

Based on this experience, it can be assumed that a certain part of the unexplained beam spikes, observed on the ISR beams throughout the years, can be attributed to small power supply instabilities. It is therefore not surprising that only rarely has there been a correlation between such beam spikes and output from the programme SPIK.
On the other hand, the tests showed clearly that the power supplies in question are normally stable to a value better than 20 ppm (1/50 of the original specification !).

Finally, we conclude that it is most unlikely that a power supply fluctuation is the origin of the beam blow-up or the partial beam losses.

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Ref (1) : S. Oliver - Effect on background of controlled power supply fluctuations - ISR-OP/SO/cb 3/8/1982

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Figure 1.

Measurement Chain.

Magnet current measurement, DCCT → Differential voltmeter → Amplification of diff → Numerical memory oscilloscope

Pulse Generator (Wawetek 144). $-30\,\text{dB}$

Figure 2.

Connection of pulse generator in control loop.
Figure 3. Some examples of background spikes.

[Graph showing various background spikes with labels and annotations]