DAFNE HORIZONTAL FEEDBACK UPGRADE

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Abstract

In this paper the horizontal feedback upgrade for the positron DAFNE ring is presented. After having completed the analysis of the e+ current limit behavior, a feedback upgrade turned out to be necessary. A fast implementation was required for the success of the crab waist experiment in 2008. It was considered if a simple power increase would have been the best solution. The lack of power combiners and space for other two power amplifiers has brought to a different approach, doubling the entire feedback system. The advantages of this implementation with respect to a more traditional power amplifier doubling are evident: two feedback kicks for every revolution turn, more efficient use of the power amplifiers, greater reliability, and less coherent noise in the system. Measurements of the performance for each of the two feedbacks have shown a perfect equivalence between the new and the old system. In fact the resulting damping rate is exactly twice the rate of each system taken individually. A description of the implementation is presented together with the performance of the system.

INTRODUCTION

A strong beam current limit in the positron ring was threatening the success of the crab waist experiment in DAFNE during the runs in 2008 [1]. The analysis of the e+ current limit behavior [2] suggested an upgrade of the horizontal feedback system in the positron ring as the best way to store larger beam currents. Instead of increasing the power of the existing system, also due to lack of power combiners and available space, a much more powerful approach, doubling the entire feedback system, has been chosen.

In the original system, two 250 W power amplifiers were connected to the two striplines of the horizontal kicker and there were three options for adding other two 250 W amplifiers to the system.

The first one would consist in joining two 250W amplifiers by a power combiner to feed a 500W signal to each stripline, with a total 1kW on one kicker.

The second option would be to connect the additional two power amplifiers to a second horizontal kicker, close to the first one needing the same betatron phase response or at least keeping a well known and stable betatron phase relation with respect to the first kicker. This option would give a better use of the power amplifier than the first one, but it would be too difficult to realize because of lack of space in the machine lattice.

The third option was the implementation of a completely new feedback system and this one has been the final choice.

SYSTEM DESCRIPTION

As shown in Fig. 1, each one of the two horizontal injection kickers of the DAFNE positron ring, after an upgrade of the pulsers, have left free one stripline out of two. In order to use more power amplifiers for the horizontal feedback system, a hybrid use of these kickers has been tested, with one stripline connected to the injection pulsers and the other to the horizontal feedback power amplifiers. The tests have given satisfactory results. No significant crosstalk from the feedback to injection system has been found while, in the opposite direction, a ~100V pulse during the injection pulse (two each second and only during beam injection) has been detected. This pulse can be tolerated by the feedback system. Due to injection requirements, the two hybrid kickers are at 180 degrees betatron phase advance, therefore allowing kicking in opposite directions. Using the injection kickers for the feedback gives also the advantage to kick the bunches every half turn because they are located exactly on the opposite side with respect to the old ones.

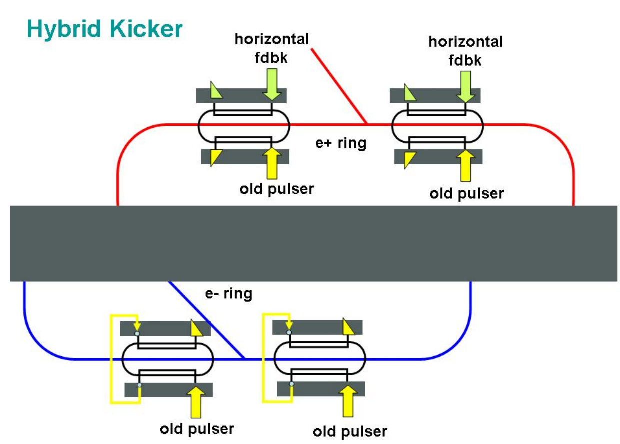

Figure 1: Hybrid kickers for injection and feedback.

Pickup

In order to have a less noisy pickup, a four-buttons monitor, usually connected to the orbit control system, has been dedicated to the horizontal feedback. The DAFNE main ring are less than 100 m long and the new feedback pickup has been chosen farther from the RF system than the other one to have cleaner signals as well as less coherence in the signal noise.

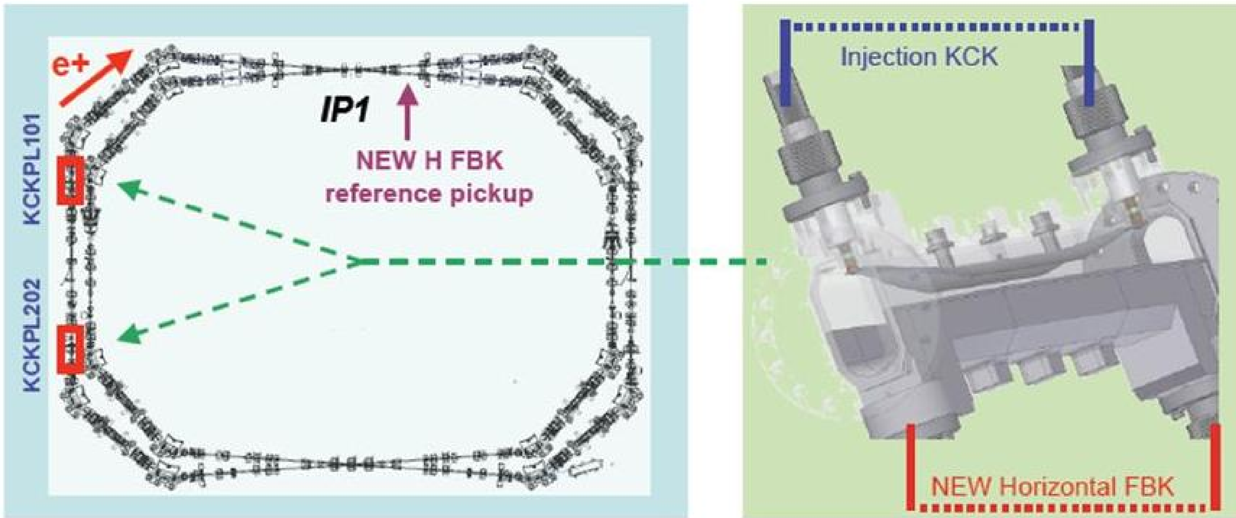

Figure 2: DAFNE main rings layout with new horizontal pickup and hybrid kicker positions.

Feedback Processing Unit

The DAFNE transverse feedback systems are based on the so called "Gproto" or "iGp" systems [3], [4], [5]. This powerful processing unit has been developed in a large collaboration by KEK, SLAC and INFN/LNF and it is now sold by Dimtel, Inc. [6]. It is a very compact system and basically is composed by an 8-bits ADC, a Xilinx Virtex-II FPGA and a DAC, together with a commercial personal computer with LINUX as operating system for interfacing with the external environment. Digital delay lines are also includes in the box. The "iGp" synthesizes in real time the correct betatron phase advance (using filter coefficients chosen by the operator) and it doesn't need anymore two pickups as used in many old transverse feedback systems.

In conclusion, the simplest way to manage a second pickup and a second power section, with a betatron phase advance different from the other horizontal feedback, has been the installation of a second complete processing unit.

FEEDBACK PERFORMANCE

To evaluate the performance on the new scheme with two feedback systems in the horizontal plane of the positron ring, each one has been switched on separately. Different timings and digital gains as well as filter responses have been quickly set as usual with these systems [7].

All the performances of each system can be measured using the offline diagnostics tools designed for the longitudinal feedback collaboration (between SLAC, ALS@LBNL and LNF) in the mid-nineties [8], [9]. The grow rate analysis is a powerful technique to evaluate the beam behaviour, but it is also the best method to measure the feedback correct response with the beam.

The single horizontal feedback damping rate is shown in Fig. 3 and it is 128 ms^{-1}, equivalent to ~24 beam revolution turns. The two systems yield the same damping rate.

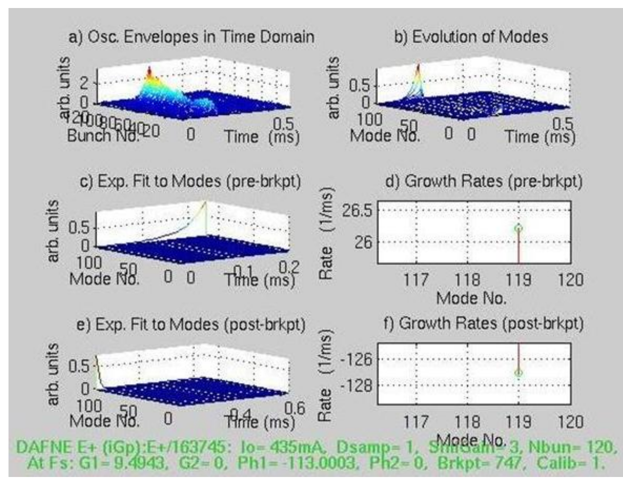

Figure 3: Single feedback damping rate [128 ms^{-1}].

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Data records can be produced by a simple software trigger given by the operator keyboard. The trigger turns off the feedback for a while and when it turns it on again, it is possible to evaluate the feedback capability and speed to damp the unstable beam.

Grow Damp Data from Two Feedbacks

With two feedback systems in the same oscillation plane, the software trigger is no more adequate to record grow-damp data because the two systems should be turned off and on simultaneously and this is clearly difficult to do. Therefore the measurements have been carried out by means of hardware generated triggers from the DAFNE Timing System [10].

In fact, the "iGp" system allows both internal (software from keyboard) and external (hardware connection with NIM logic level) triggers. To make a grow damp data record, a hardware trigger signal is sent to both feedback systems. Data are recorded by both "iGp" units simultaneously. The results for this case are shown in Fig. 4. The double feedback damping rate is shown by the offline software tools to be 234 ms^{-1} equivalent to ~13 DAFNE beam turns, demonstrating that the use of two systems has effectively halved the damping time.

Besides the measurement of the performances, the horizontal feedback upgrade has successfully permitted to exceed the positron beam current limit, storing more than 1.1 Amperes under stable conditions. This helped to achieve the "crab waist" luminosity goal of about three times the previous peak luminosity.

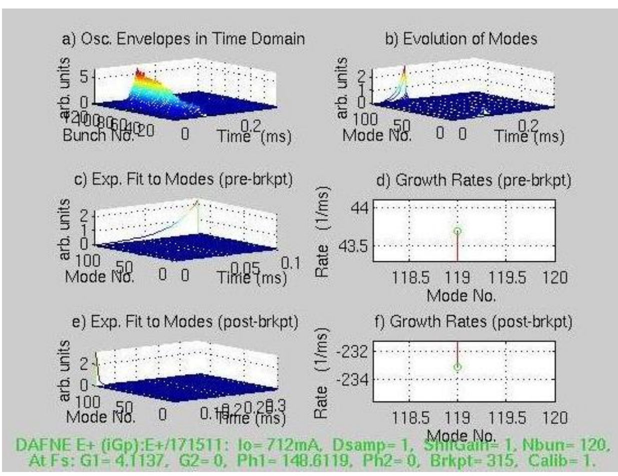

Figure 4: Two feedbacks damping rate [234 ms^{-1}].

CONCLUSIONS

The lack of power combiners and space for other two power amplifiers has brought to a different approach, doubling the entire feedback system.

The advantages of this implementation with respect to a more traditional power amplifier doubling are evident: two feedback kicks at every revolution turn, more efficient use of the amplifiers power, better reliability and less coherent noise in the system.

Measurements of the performance for each of the two feedbacks have shown a substantial equivalence between the new and the old system. In fact the resulting damping rate is exactly twice that of each system taken individually.

With this feedback upgrade, it has been possible to exceed the positron beam current limit due to a strong horizontal instability and achieve the goals of the 2008 DAFNE runs: adequate peak and integrated luminosity for the Siddharta detector and test of the Crab Waist collision scheme.

The double feedback damping rate is of 234 ms^{-1} equivalent to ~13 revolution turns (i.e. 4.3 us), a very important result.

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REFERENCES

[1] C. Milardi, "Experience with DAΦNE upgrade including crab waist", this conference, MO4RAI01.

[2] A. Drago, "Fast Horizontal e+ Instability Measurements in DAFNE", TH5RFP057, this conference.

[3] D. Teytelman, R. Akre, J. Fox, A.K. Krasnykh, C.H. Rivetta, D. Van Winkle, A. Drago, J.W. Flanagan, T. Naito, M. Tobiyama, "Design and Testing of Gproto Bunch-by-bunch Signal Processor", THPCH103, contributed to European Particle Accelerator Conference (EPAC 06), Edinburgh, UK, 26-30 Jun 2006. Published in *Edinburgh 2006, EPAC* 3038-3040.

[4] Dmitry Teytelman, "iGp-120F Signal Processor-Technical User Manual", Rev.1.6. Dimtel, Inc., Sept. 19, 2008. S. José, CA, USA. http://www.dimtel.com/support/manuals/igp

[5] A. Drago, "Trends in Fast Feedback R&D", TUACH12, Proceedings of The 40th ICFA Advanced Beam Dynamics Workshop on High Luminosity e+e- Factories, Novosibirsk, Russia. Budker INP, April 14-16, 2008.

[6] http://www.dimtel.com/

[7] Alessandro Drago, John Fox, Dmitry Teytelman, Makoto Tobiyama, "Commissioning of the iGp feedback system at DAFNE", THPC116, EPAC'08, Genova, Italy.

[8] Shyam Prabhakar, "New Diagnostics and Cures for Coupled-Bunch Instabilities", PhD Thesis, SLAC-Report-554, pp. 191, August 2001.

[9] Dmitry Teytelman, "Architectures and Algorithms for Control and Diagnostics of Coupled-Bunch Instabilities in Circular Accelerators", PhD Thesis, SLAC-Report-633, pp. 181, June 2003.

[10] A. Drago, G. Di Pirro, A. Ghigo, F. Sannibale, M. Serio, "The DAFNE Timing System", 5th European Particle Accelerator Conference (EPAC96), Sitges, June 10-14 1996. Published in *Sitges 1996, EPAC 96* 1775-1777. LNF-96/033(P).