New Single Shot Beam Position Monitor of the GSI High Energy Transfer Line

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ABSTRACT

In the near future, single bunch handling with intensities from \(10^7\) up to \(3 \cdot 10^{12}\) charges/bunch and minimum lengths of 30ns (FWHM) are expected at the GSI high energy transfer line. Thus, the demand of an accurate real-time position monitoring is mandatory. At the moment, a recently developed amplifier optimised for the best common mode amplification covers a dynamic range from nearly -80dBm up to +20dBm and a bandwidth of 200MHz. To gain the required dynamic range of around 130dB, an improvement of the amplifiers will be necessary. The data acquisition shall be done by commercial DSOs which have a sample rate of 2GS/s on each of the four channels for every PU. This DSO based solution is cheap in comparison to the usage of other available sampling units. The data transfer from the DSOs to the operating stuff is foreseen via Ethernet. Amplifier controlling and position calculation happens at the control centre with LabVIEW. First results measured at the GSI synchrotron will be presented.

INTRODUCTION

The purpose of the new single shot BPM electronics is to monitor the position of the injected beam in the high energy beam transfer line (HEBT) and help tuning of machine parameters like the right kicker-timing for fast extraction. Due to the wide dynamic range the development of a complete new PU-electronics was necessary to fulfil the following requirements:

- Dynamic range \(10^7\) to \(3 \cdot 10^{13}\) charges/bunch
- Bandwidth 1MHz-200MHz
- Common mode gain matching better than 0.1dB for each PU-plate pair
- Utilisation of commercially available hardware

A well matched common mode gain for each PU plane is very important for accurate position estimation. Within the scope of the rf-amplifier development it was necessary to find a solution for gain matching. The chosen amplifier concept enables the possibility of digital adjustment of the gain in retracted condition. At the moment there are nine broadband position pick-ups, distributed over the HEBT (and one in the SIS18), installed to supply position information, see Fig.1 for the setup. PUs and infrastructure (rf-signal cables and control-signal-cables) are taken over from a former system that did not fit the needs. The system worked only in a master-mode, an individual parameter based range switching was not possible. Due to the use of electro-mechanical-relays the system did not work reliably for longer times. The next section reports the new system concept and the further development of the remaining hardware. First measurements with a new rf-amplifier will be presented.

SINGLE BPM-SYSTEM

The basic principle (see Fig.2) of the new system is the use of digital storage oscilloscopes for data acquisition instead of conventional A/D-converter-cards. This concept was taken over from the NEWSUBARU-accelerator in Japan [1].
are expected, a signal conditioning before data acquisition is necessary. The operator at the control room (HKR) sets the gain range depending on the beam intensity. With the help of a clipping detector an overdrive of the amplifier input can be detected. Each of the ten PUs will be equipped with the following electronics (see Fig.3):

- four rf-amplifiers- modules
- combiner-module
- testsignal-generator-module
- digital I/O
- attenuator-control
- fibre-optic links (optional) for the sum-signal
- TDS 2024

Measurements show noise equals -80dBm i.e. a peak voltage of \( V_p = 32 \mu V \). For such low PU-signal levels amplification of 60dB is applied to get the signal in a reasonable mV range of the DSO. This is done by a cascade of the commercial MMIC's GALI 52 and GALI 4 from minicircuits [2]. The upper limit of the amplifier electronics depends on the design parameters of the used building blocks. In this case, +20dBm i.e. a peak voltage of \( V_p = 3.2V \) is the maximum input-level for a linear amplifier work-mode. Hence, an internal accessory attenuator of about 40dB is needed and installed to assure the +20dBm upper limit of the amplifier cascade. Figure 4 shows the usable dynamic range. This means that the PU-signal may vary from 32µV up to 3.2V peak voltage. This equals 32mV up to 2V for the DSO-range. All up a dynamic range of 100dB is reached.

**DYNAMIC RANGE**

As mentioned before the data acquisition is based on by DSOs. But with the utilisation of the scope-internal range switching, it also works as an additional amplifier.

![Figure 4: Dynamic range of the BPM-system](image)

This assembly enables the individual adjustment of each measurement range. As figure 6 and table 1 shows, more gain than necessary is available. This is the playground
for the gain matching. A PIC controller and a DAC manage the matching in the required range. In combination with a temperature sensor it is also possible to compensate the temperature drift of the PIN-diodes. Measurements with a network-analyzer demonstrate a only a slight gain versus frequency.

The reason is a mismatch between the GALI amplifiers and additional parts like directional coupler, attenuators etc.. Since the nonlinearity is a generally attribute of this amplifier, a calibration process enables the compensation.

MEASUREMENTS

The lower limit of the amplifier resolution is reached with about $1.8 \times 10^7$ charges per bunch (see Fig.7). In this case $(S/N)/N \approx 2$ is essential. This means that the worst case of the lower limit with $10^7$ charges per bunch is nearly reached.

CONCLUSION

The rf-electronics achieve nearly the requirements. With a gain greater than 60dB over a bandwidth of 200MHz, a big gain reserve is given. It is also succeeded to provide common mode gain matching for each position plane. An individual gain adjustment is possible to stay in the tolerance range of 0.1dB. This enables by the PIN-diode-attenuator. To get an improvement for the lower limit, an additional low-pass-filtering close to the PU can produce relief. But this is not tested yet. The next necessary step will be testing the interaction between the DSOs, software and electronics. The project will be finished end of 2005 after installation of all components.

REFERENCES