OVERVIEW OF THE BPM SYSTEM OF THE ESS-BILBAO

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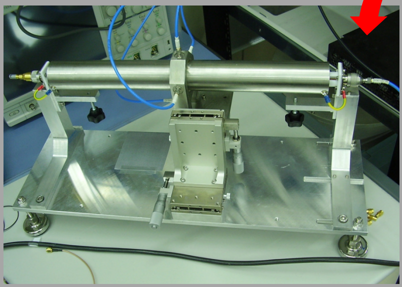

Fig. 2- ESSB test-stand developed for testing the electronics.

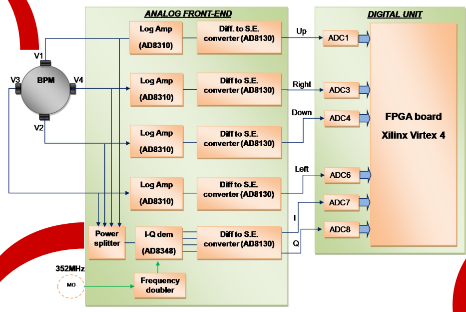

Fig. 1- ESSB BPM system, with the test-stand and the electronics.

BPM SYSTEM OF ESS-BILBAO (ESSB)

1) Test bench: 4 capacitive buttons welded to the beam pipe. The position of the inner tube simulating the beam can be changed with respect to the outer tube within a range of ~20 mm for both X and Y axis.

2) Electronics:

- Analog Front-End (AFE) unit where the BPM signals will be filtered, conditioned and converted to base-band.
- Digital Unit (DU) to sample the base-band signals and calculate the beam position, amplitude and phase.

3) Control: a multipurpose configurable system based on a high performance FPGA, connected to a Host PC which works as an EPICS server using JavaIOC.

ANALOG FRONT-END (AFE)

The AFE unit is based on 2 different boards:

1) A 4-channel logarithmic amplifier (log amp AD8310, high dynamic range of 95 dB and bandwidth from DC to 440 MHz) and differential to single-ended (AD8130) board (Fig. 4) connected to each capacitive button.

To measure the beam position

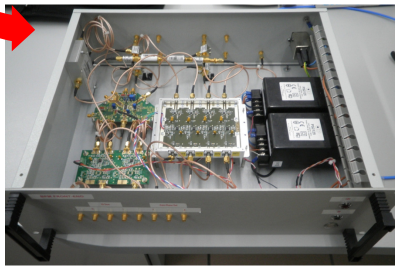

Fig. 3- AFE unit, including log amp and IQ demodulator boards.

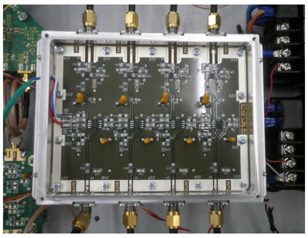

Fig. 4- AD8310 logarithmic amplifier board.

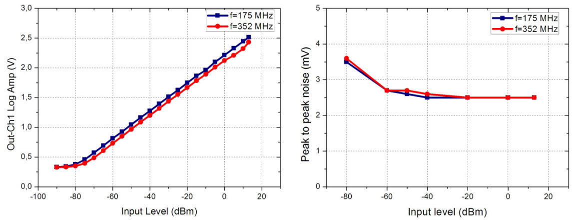

Fig. 5- Left: dynamic range of the log amp board. Right: peak to peak noise of the log amp, both as function of the input level in dBm and for 175 and 352 MHz.

2) An IQ demodulator (AD8348) board fed by the sum of the 4 button signals (Fig. 3, board on the left).

To measure the amplitude and the phase of the beam

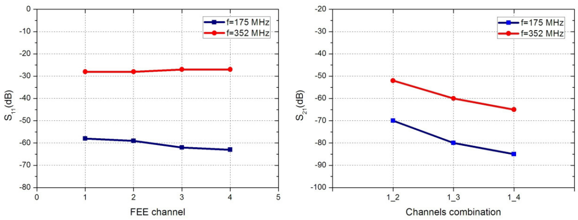

Fig. 6- Left: input impedance matching to 50 Ω of the log amp board. Right: crosstalk between channels of the same board, both for 175 and 352 MHz.

Fig. 7- Digital Unit based on VHS-ADC board from Lyrtech.

DIGITAL UNIT (DU)

DU is a VHS-ADC board from Lyrtech, including a high performance cPCI FPGA based on Xilinx Virtex-4 connected to an Analog to Digital Converters (ADC) → 8 channels, 14 bits resolution sampling up to 105 MHz.

Signals linearization and calibration to compensate the errors of the measurements → offset compensation, CORDIC blocks to obtain the amplitude and beam phase (arctan(Q/I)) and an estimation of the current ($\sqrt{I^2+Q^2}$) and a Δ/Σ algorithm for the position.

BPM CONTROL SYSTEM

It is a multipurpose configurable system based on a high performance FPGA connected to a Host PC working as an EPICS server using JavaIOC for the networked control to allow a distributed and fast control. The communication between both parts is made by a register bank implemented in the FPGA for storage of parameters and calculations (accessible by the PC through a cPCI bus).

A MySQL database is integrated in EPICS via RDBArchiver and Control System Studio (SCC), created by the Spallation Neutron Source (SNS, Oak Ridge).

PRACTICAL RESULTS

Resolution → ESSB BPM system has been tested continuously for several days in an unregulated temperature environment, showing some drifts as the result of these temperature variations.

To simulate the beam a 14 dBm and 175/352 MHz signal was used → $\mathbf{I_{beam}=14.14\ mA}$. The signals were connected to the log amp board and added as the input of the IQ demodulator (Fig. 1).

Linearity → the BPM mechanical center does not correspond to the electrical one, due to mechanical distortions and impedance mismatch of the buttons, being more linear in the center (Fig. 9). The horizontal (x) and vertical (y) beam positions are represented by the map functions up to a 4-order polynomial:

$$x_{real} = \sum_{i,j=0}^{4} a_{ij} \cdot X^{i}_{measured} \cdot Y^{j}_{measured}$$

$$y_{real} = \sum_{i,j=0}^{4} b_{ij} \cdot X^{i}_{measured} \cdot Y^{j}_{measured}$$

a_{ij}, b_{ij} coefficients of the map functions derived by fitting the map data to the map functions.

Table 1- Measured and required resolution and accuracy position and phase for ESSB BPM system.

Parameter	Level	Requirement	Unit
X Position resolution	9.77	10	μm
Y Position resolution	9.14	10	μm
X Position precision (absolute)	48.84	100	μm
Y Position precision (absolute)	50.27	100	μm
Phase resolution	0.2	0.3	º
Phase precision (absolute)	1.3	2	º

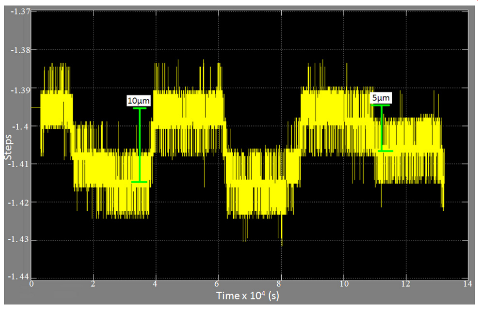

Fig. 8- Sensitivity of the BPM electronics, measured at the level of 5 μm.

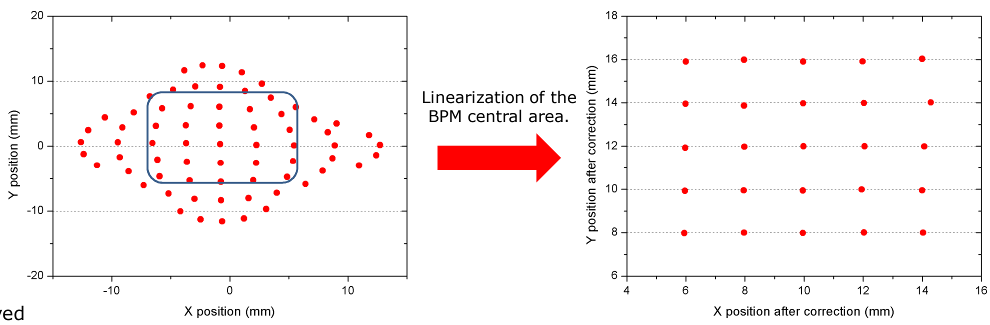

Fig. 9- Positions measured before (left) and after linearization (right) applied to the BPM central area.