BEAM POSITION MONITORS CHARACTERIZATION FOR ALBA

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Abstract

Beam position monitors (BPM) characterization has been widely studied at ALBA Synchrotron Light Source. Special care has been taken on the analysis of their electrical offset in order to achieve submicron beam stabilities. This paper shows the results of the BPM offset study for Booster and Storage Ring. The electrical effect of the different vacuum vessels housing the BPMs is also reported.

INTRODUCTION

Beam position monitoring at ALBA synchrotron will be performed using a total of 177 button type BPMs, 172 of them dedicated to pure orbit measurements; 3 will be used to do machine studies and 2 for multi-bunch instabilities measurement.

Table 1: BPM Distribution at ALBA

# BPMs	Machine	Purpose
1	Linac	Position
3	LTB	Position
44	Booster	Position
2	Booster	Machine Studies
4	BTS	Position
120	Storage Ring	Position
1	Storage Ring	Machine Studies
2	Storage Ring	Multi-Bunch

Intensive measurements of the feedthroughs during their manufacturing process have been done at the factory on the Booster and Storage Ring BPMs. Electrical tests have been done at ALBA for final manufacturing checking and electrical offset calculation of the BPMs.

BUTTONS CHECKING AND SORTING

Feedthrough capacitance has been measured at different stages during the manufacturing process of the BPM blocks in order to analyze their deviation from specifications. These tests also allow tracking of the BPM quality during the manufacturing. ALBA BPM blocks are directly welded on the vacuum chamber and any defect on the BPM block will require complete chamber replacement. For that reason, intense checking of the feedthrough quality at each stage was almost mandatory.

Measurement of button capacitance

Capacitance was measured using a TDR device [1,2]:

- After button manufacturing
- After button welding on the BPM block
- After BPM block bake-out

The plots in Figure 1 show the results of the capacitance measurement of the 204 buttons of Booster and Booster to Storage Transfer line (BTS) before and after the manufacturing process of the complete vacuum chamber. Design capacitance value was 3.2 pF. The buttons capacitance deviation from specs remained in all cases below +-10% (the tender requirement), with an absolute average value of 3.2%, maximum change on a button of +8% and -5.3%.

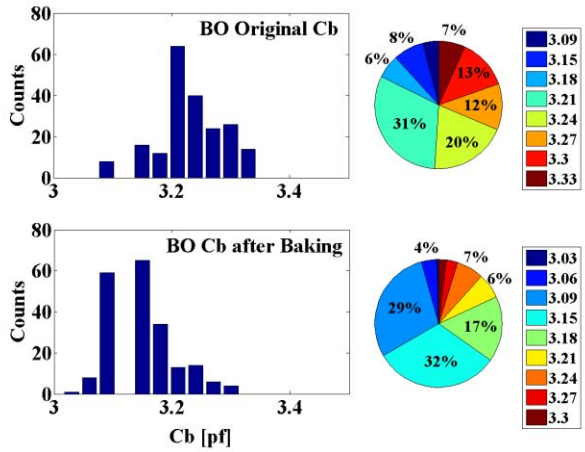

Figure 1: Capacitance deviation on Booster and BTS buttons after vacuum chamber manufacturing.

All these variations of capacitance led to an electrical offset effect on the BPMs (only due to the buttons difference). An extra effect was introduced by the relative positioning of each button on the BPM block (measured later using a network analyzer test).

Button sorting

A sorting of all buttons was done before welding in order to reduce their effect on the electrical offset of the BPMs. Figure 2 shows the calculated offset on the Storage Ring BPMs before and after welding. Buttons were sorted for closer capacitance, so the obtained offset before welding is negligible. Offset after manufacturing remains well below +-50 μm.

ELECTRICAL OFFSET MEASUREMENTS

Once the BPMs were welded and baked on the vacuum chambers and delivered to ALBA, an electrical offset measurement on all of them was performed before installation.

Electrical offset must be known in order to improve the absolute beam position readings, especially on the first days of the accelerator commissioning and operation.

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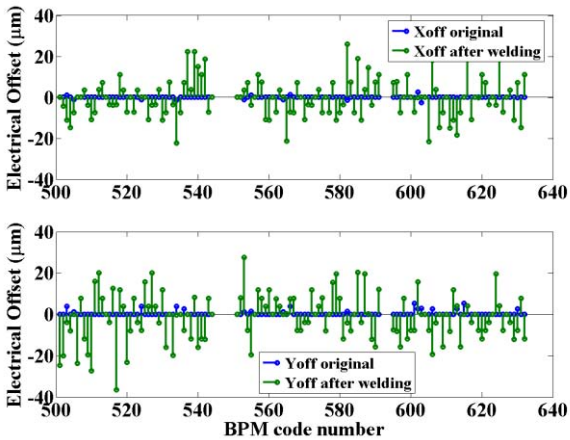

Figure 2: Calculated offset of Storage Ring BPMs before and after welding (only due to buttons imperfections).

Later, the Beam Based Alignment (BBA) technique will better determine the final settings for the correction of the offsets [3].

One of the main obstacles to overcome on the offset measurements was the fact that the BPM blocks welded on the chamber didn't allow for an antenna or wire-through based measurement. The so-called Lambertson method was used instead [4].

Laboratory setup

Pictures in Figure 3 show the measurement setup for Booster and Storage Ring BPM offset characterization.

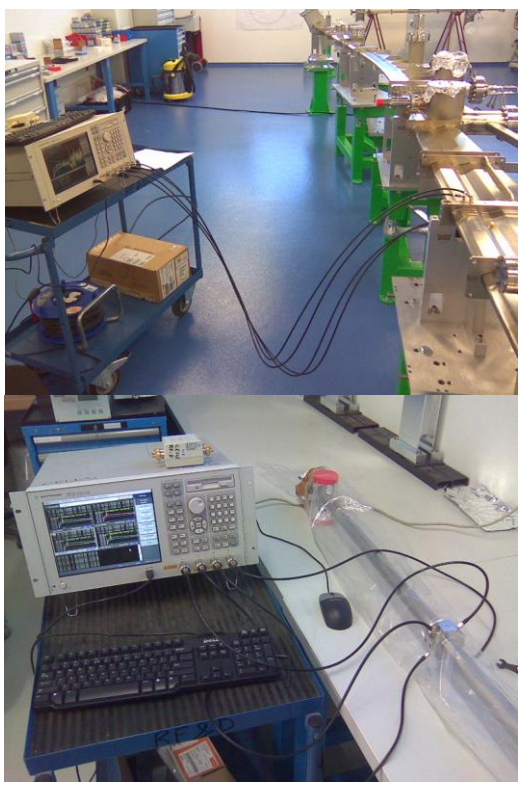

Figure 3: Measurement setup for Storage Ring (top) and Booster (bottom) BPM electrical offset.

The easurement method is based on the use of a network analyzer (NA) for scattering parameters calculation on the 4 buttons of a BPM. Output signal from the NA is injected through one button and the S-parameters to the other buttons are measured. Repeating the process on all buttons an S-parameters matrix is obtained. Ideally the reflection coefficients should be 0 and the transmission ones should be symmetric (S12=S21, S13=S31...). Transmission coefficients will determine the electrical offset value, while their non-equal value gives a figure of the differences in the feedthroughs' quality. Figure 4 shows a snapshot of the S-parameters measurement on a Booster BPM. As the BPM has a 45º symmetry, the distance from buttons 1-to-4 and 1-to-2 is the same and so S41 curve (green) is hidden by S21 (blue).

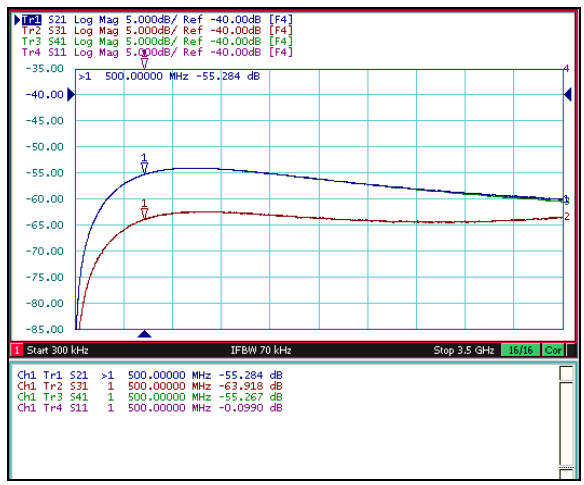

Figure 4: Snapshot of a Booster BPM S-parameters measurement

ALBA BPMs electrical offset

The electrical offset of a BPM will be determined by two effects: the non-equal electrical behaviour of the feedthroughs and the buttons positioning in the BPM block during the welding process. Due to the sorting performed prior the welding, the asymmetry of the resulting BPM block is the dominant contributor to the offset.

The electrical offset of the BPMs is computed on a Matlab based application according to the S-parameters measured in the laboratory [5]. Figures 5 and 6 show the obtained electrical offset on the BPMs finally installed in Booster and Storage Ring respectively. Comparing the results shown in Figures 2 and 6 it can be seen that main contribution to the BPM offset is determined by the errors in the positioning of the feedthroughs and the asymmetry of the resulting BPM block.

Effect of the vacuum vessel

During the measurements of the electrical offset performed on the Storage Ring BPM blocks it was seen that the ante-chamber had a high influence on the data obtained by the network analyzer device.

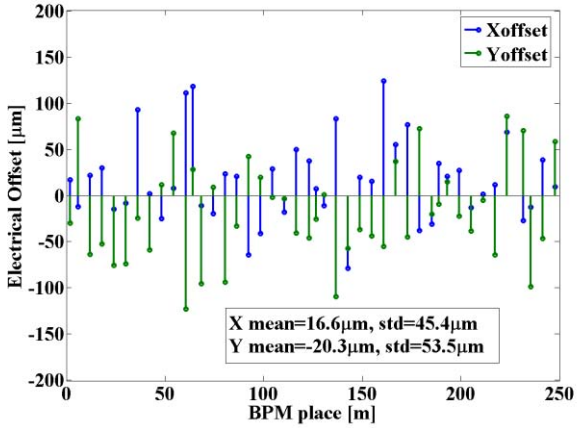

Figure 5: Electrical offset distribution for ALBA Booster BPMs.

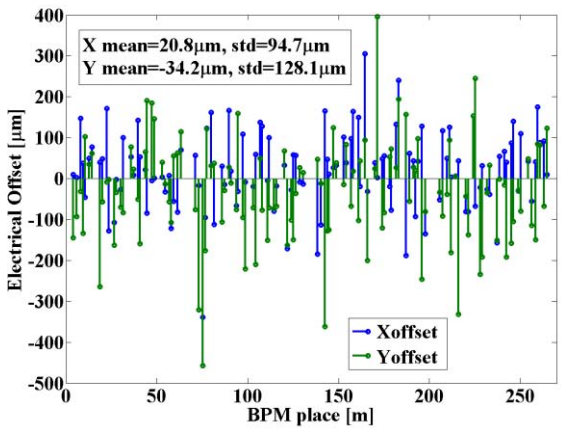

Figure 6: Electrical offset distribution for ALBA Storage Ring BPMs.

Storage Ring BPM blocks have 6 different cross sections because of the antechamber, depending on the place in the machine (see Figure 7). Cross section at the feedthroughs side is kept the same in the entire machine.

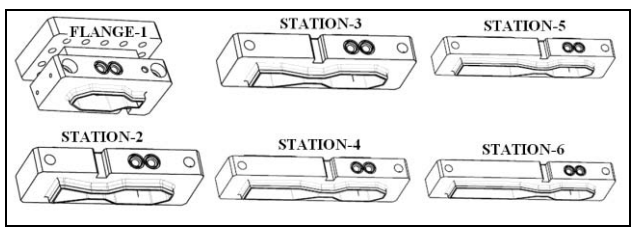

Figure 7: ALBA Storage Ring BPMs cross sections.

Figure 8 shows the data obtained when measuring the electrical offset on 4 different BPM blocks of the same vacuum chamber sector (S05 in this case).

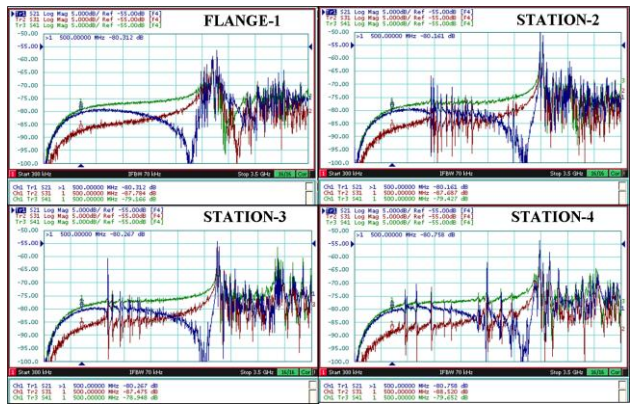

Figure 8: S-parameters on 4 different types of BPMs.

There is no ante-chamber on the Flage-1 type, whereas the length of the antei-chamber of Station type BPMs changes from one to the other, and so the transmission signals from one to another button is affected.

Increase of peaks on the S-parameters spectra is due to the extra resonance modes created by the ante-chamber of the BPM block.

Higher noise in the transmission curves compared to the ones showed for Booster (see Figure 4) is due to the smaller size of the feedthroughs electrodes. Storage Ring buttons are closer to each other than the Booster ones, but they are almost half the diameter (7 mm for Storage versus 14.3 mm for Booster).

CONCLUSIONS

Characterization of all the buttons and BPMs during manufacturing and later test on the laboratory gave us a good tracking of BPMs quality control. Electrical offset measurement was also performed on all machine BPMs in order to have a first estimation of the offset correction needed on day one. Offsets will stay between ±150 μm and ≠±400 μm for Booster and Storage Ring, respectively.

REFERENCES

[1] G. Decker, Y. Chung, “Progress on the Development of the APS Beam Position Monitoring System”, Proceedings of 1991 PAC.

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[4] Y. Chung, G. Decker, “Offset calibration of the Beam Position Monitor Using External Means”, Proceedings of 1991 Accelerator Instrumentation Workshop.

[5] http://www.cells.es/Divisions/Accelerators/RF_Diagnostics/Diagnostics/OrbitPosition/Tools/Offset.