

Booster Corrector BPM Measurement Summary

BOOSTER CORRECTOR BPMs:

The Booster Corrector (BC) BPMs are four-electrode devices with straight arc shaped strip line pickups. The BPM uses SMA connectors connected to the electrodes with a short stainless steel loop for strain relief. The BPMs are located inside the downstream end of the Booster Corrector Magnets, protruding only enough to access the output connectors. The BPMs are marked with a Serial Number and a letter "T" near one connector to indicate the proper installed "Top" orientation. The Top indication also provides a reference to the BPM test stand orientation and the test stand measurement data. For more complete BC BPM information refer to the included Document titled "Booster Correctors Specs".

SYSTEM SIGN CONVENTION:

The sign convention for the Booster Corrector (BC) Magnet and BPM Assembly was chosen so that measured positions delivered by the data acquisition system to Acnet will be signed positively for beam positions radially outside at horizontal locations and above center at vertical locations. POSITIVE measurement values correspond to beam UP or OUT. NEGATIVE measurement values correspond to beam DOWN or IN. This convention is generally true of all the accelerator rings. However note that the personnel aisle is on the OUTSIDE of the beam line in the booster tunnel. For pictures of BC magnet and BPM assembly showing sign conventions refer to the included Document titled "Booster Corrector BPM Coordinates"

BPM and JUNCTION BOX CABLING:

The BC BPM output cables are routed to a junction box located nearby on the top of the downstream end of the Magnet. The junction box provides a transition from RG-8 cables connected to the BPM feedthrus to the larger helix transmission routed upstairs to the RF modules. The junction box has four Type N connectors on each side which are labeled outside- inside and top-bottom for the respective horizontal and vertical pickups. This provides for a clear method of connection consistent with the convention noted above.

The Junction box also provides two HV type BNC connectors to allow for an Ion Clearing Field voltage to be applied to the BPM electrodes.

CALIBRATION VALUES FOR THE BOOSTER CORRECTOR BPMs

The BC BPMs were measured on the test stand with a 35 x 35 mm grid in 5mm increments. Using a Network Analyzer BPM output values A and B are recorded for every position. Using MS Excel these values can be directly used to provide an A/B log ratio values and a Sensitivity values in mm/dB. Using the standard BPM formulas and a few trig identities these values can be converted to equivalent output volts, and then to an equivalent AM-PM or Diff/Sum Sensitivity values in mm/Volt. The Booster Corrector BPM data was evaluated these three methods. Calculating the

position using the AM to PM conversion produces the best linearity. Comparison values and plots are shown in the individual BPM data, listed by serial no.

For AM to PM Conversion the relevant equations are:

$$V_{out} = V_o [\tan^{-1}(A/B)-p/4] = V_o [\tan^{-1}(A-B/A+B)]$$

R. E Shafer
(Beam Position Monitors, 1990)

In particular for the Booster Corrector BPMs:

$$V_{out} = -2.3168+2.9499*ATAN\{e^{[(A/B)dB/-7.6192]}\}$$

J. Crisp

Calculating the position using a polynomial fit to the data also contributes to a worthwhile improvement in linearity. The BPM position using the polynomial coefficients are shown below.

USING THE POLYNOMIAL FIT TO THE BPM MEASUREMENTS

M = Measured beam position from the BPM electronics in dB or volts.

P_n Thru P₀ = Calculated values for the Polynomial fit coefficients.

Polynomial Coefficients P_n thru P₁ determines the gain value, in mm/dB or mm/V, P₀ is the offset value in mm. Coefficients of 3 to 5 are listed, higher orders are insignificant

$$\text{Position} = P_n (M)^n + P_{n-1} (M)^{n-1} + P_{n-2} (M)^{n-2} + P_{n-3} (M)^{n-3} \dots + P_0$$

Or

$$\text{Position} = ((P_3)M+P_2)M+P_1)M+P_0 \quad (\text{mm})$$

For the Booster calibration depending on the AM-PM module and digitizing outputs it may be necessary to add a gain and offset corrections to the above formula.

Summary of BC Measurement

The measurement data was statistically analyzed and is presented as a summary showing the Mean, Standard Deviation, Max, and Min of the Polynomial Coefficients. The first of the coefficients is the BPM Offset Value, the remaining evaluate the Sensitivity. The least squares fit to the data are also listed for reference. For the Statistical Summary refer to the documents titled "BC BPM 38M PolySum.pdf" and "BC BPM 53M PolySum.pdf" included in this listing.

For a summary showing measurement values for individual BPM refer to "BC BPM 38M PolySum.xls" Excel "and "BC BPM 53M PolySum.xls" on the Accelerator Div Document Server link shown below.

For a complete detailed measurement information and plots of each Booster Corrector BPM by serial number also follow the link below.

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