# Wire Setup Calibration of Beam Position Monitors

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## ABSTRACT

Many button type and strip line type beam position monitors are employed in the South Hall Ring (SHR) at MIT-Bates. It is desired to calibrate and routinely check the readouts of those monitors by simulating the beam. A wire setup was built to serve this purpose. It consists of a button type beam position monitor body with a wire running through it. To eliminate end-effects both ends are extended with 10 inch long uniform beam pipes. RF matching is carefully performed with ECCOSORB AN 75 microwave absorber forms. The wire is positioned 3 mm offset with respect to the X-pair buttons and symmetric with respect to the Y-pair buttons. Thus the same setup can be used to check both sensitivity and zero-offset.

## INTRODUCTION

A number of stripline and button beam position monitors are used in the SHR. The readouts of those beam position monitors change due to zero-drifting of electronic circuits (thermal and/or aging), radiation effects on electronic components, inadequately matched 3-dB hybrids, cable bends, etc., To get reliable data, it is necessary to perform periodic field calibrations and routinely check the zero-offsets and sensitivities of those beam position monitor electronics using rf to simulate the beam.

The normal rf test of the electronics does not calibrate the entire system. We have built a calibration setup with an actual beam position monitor and a wire, excited by rf, to actively simulate the beam.

The SHR is a 0.3-1 GeV, multi-bunch (containing 1812 buckets) electron beam storage ring[1]. The rf frequency of the ring is equal to the rf frequency of the linear accelerator, that is 2856 MHz. Consequently, all beam position monitors operate on this frequency[2][3].

The setup is basically straight forward: a wire running through a button type beam position monitor. The beam position monitor is stimulated through the wire by a 2856 MHz rf source. The displacement of the wire is a simulation of the beam in an offset position.

## DESCRIPTION OF THE FIXTURE

The construction of the wire setup is shown in Fig. 1. The fixture consists of a button type beam position monitor body with 25 cm long uniform extension pipes at both ends. The inner diameter of the monitor and pipes is 60 mm. The function of these pipes is to eliminate the end-effects (local modes' effects). A wire with diameter of 0.5 mm runs through the beam position monitor and the uniform pipes with a displacement of 3 mm from the axial center in the horizontal plane. The wire is tightly stretched to minimize sag and vibration. A dielectric plate with a clearance hole is at both ends to assure good alignment.

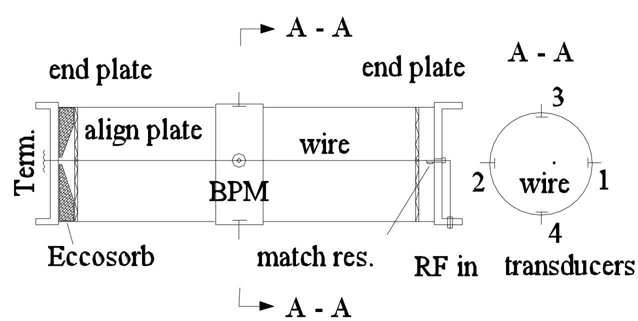


Fig. 1 Construction of the wire setup

An SMA bulkhead feedthrough jack receptacle is mounted on each end-plate, and the wire is soldered to the inner conductor of the SMA bulkhead. One end is the rf input, the other end is terminated with an rf terminator. Because the characteristic impedance of the wire-pipe system is $60*\ln(30/0.5)=287\ \Omega$, parallel and serial resistance matching is needed in order to match to the outside 50 Ω system. Also, we placed some microwave absorber forms, ECCOSORB AN 75, inside to further improve matching.

## RF RELATED CONSIDERATIONS

The beam position monitor rf signal processing block diagram is shown in Fig. 2. The beam induced signals on the transducer pairs (horizontal and vertical) are transmitted to the 90° hybrids. The amplitude difference of these pairs of beam induced signals, which is a function of beam position, is converted to a phase difference by the 90° hybrids. The electronics box processes this phase difference information. The output of the phase detector, which is transmitted to the Central Control Room, is the measurement of the beam position.

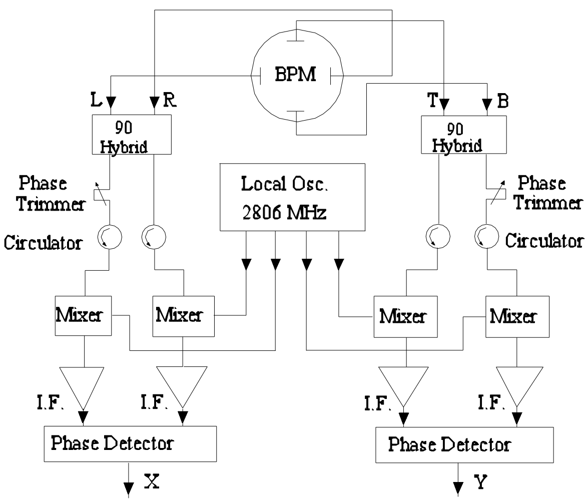


Fig. 2 BPM electronics block diagram

A very important characteristic of the system is the dynamic range, which is determined by the mixers used in the circuits (Mini-Circuits ZEM-4300MH). From the bench measurements, shown in Fig. 3, we note the following: when the rf signal power level to the hybrid is within the range of -40 dBm to 0 dBm, the output of the electronics circuit is only dependent on the phase difference of the input signals to the mixers, and independent of signal amplitude. In other words, the beam position information will not be deteriorated by the beam intensity if the beam induced rf signal power level transmitted to these hybrids is within the above mentioned range.

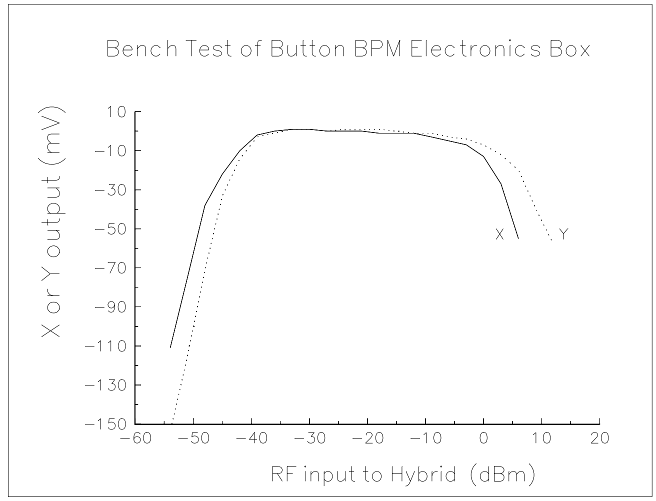


Fig. 3 Dynamic range of the BPM electronics circuit

After the fixture was built we measured the transition, $S_{21}$, of this wire setup from the input (rf stimulating port) to the output (BPM pickup), which was around -50 dB. Thus, the stimulating rf signal power level should be within the range of 10 dBm to 50 dBm. We set the stimulating rf power level at about 20 dBm, which is easily available.

## BENCH TEST AND FIELD OPERATION

To investigate the overall response of the beam position monitor to the displacements of the wire, we did bench measurements using a HP8510B Network Analyzer. Table 1 shows the results.

Table 1: Bench measurements of position sensitivity

| displacement of wire (mm) | signal diff. on pair-transducers(dB) | phase diff. converted after hybrid (°) |
|---|---|---|
| 3 | 3.7 | 23.4 |
| 6 | 7.2 | 43.0 |
| 9 | 10.7 | 57.1 |
| 12 | 15.4 | 70.5 |
| 15 | 19.2 | 77.8 |

From Table 1 we can see that over the range of half radius of the beam pipe, 1 mm displacement of the wire corresponds with 1.23 dB on average.

One of the advantages of the wire setup calibration over the normal electrical-zeroing by using rf only is that you can determine if the signal polarity is correct. For example, in our case we want a positive signal when the beam (wire) goes right or up, and negative when the beam (wire) goes left or down.

Because the wire is positioned 3 mm off center with respect to the horizontal (X) transducers and approximately centered with respect to the vertical (Y) transducers, by swapping X and Y connections we obtain both the sensitivity and the zero-offset of the beam position monitor electronics box under test (see Fig. 1 and 2).

Table 2 lists some sample data on the field operation. Fig. 4 is a scope display of the wire setup field calibration as viewed in the Central Control Room.

Table 2. Sample data of the wire setup calibration

| BPM # | *LPM17 | *LPM18 |
|---|---|---|
| Test date | 09/27/94 | 09/27/94 |
| R to 1 (L to 2) | 298 | 335 |
| R to 2 (L to 1) | -325 | -274 |
| R to 3 (L to 4) | 35 | 94 |
| R to 4 (L to 3) | -63 | -12 |
| Zero-offset(mV) | -14 | 41 |
| Sens. (mV/mm) | 104 | 102 |
| T to 1 (B to 2) | 304 | 319 |
| T to 2 (B to 1) | -296 | -282 |
| T to 3 (B to 4) | 54 | 50 |
| T to 4 (B to 3) | -52 | -30 |
| Zero-offset(mV) | 1 | 10 |
| Sens. (mV/mm) | 100 | 100 |

* LPM17 and LPM18 are the two most important position monitors for SHR operation

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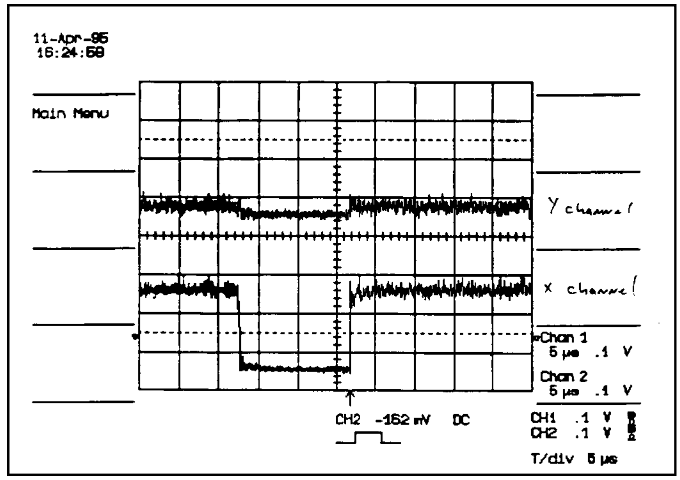


Fig. 4 Wire calibration signal viewed in CCR

## REFERENCES

[1] J. B. Flanz, et al., Proceedings 1989 Particle Accelerator Conference pp34-36 (1989)
[2] J. B. Flanz, et al., Proceedings 1993 Particle Accelerator Conference pp2331-2333 (1993)
[3] A. Zolfaghari, C. Sibley, et al., Bates internal reports