Prebys & Harms
Colorado State University

Laboratory Session – Beam Position Monitor & Toroid/Wall Current Monitor

Three key factors, among others, in knowing how well an accelerator is performing are:

- What is the intensity?
- Is the beam where it belongs?
- Are there localized areas of beam loss?

This session has two parts: investigation and measurements of a *split plate* Beam Position Monitor (BPM) followed by a similar exercise on a combination Wall Current Monitor/Beam Current Toroid. These devices help us to address two of the factors referred to above. Be prepared to plot and fit the data in this session.

1 Beam Position Monitor

For this exercise a BPM assembly, wire (to simulate the passing beam), oscilloscope, function generator, end caps, and necessary cabling are provided. ***Use caution handling the BPM and manipulating it during measurements as the connections and internal wire are delicate!***

1. By virtue of being a split plate detector, the BPM has two outputs, referred to in this case as 'A' and 'B'. Set up the apparatus so that you can measure both the incident signal to the wire and both output channels of the BPM simultaneously.

2. Perform a visual inspection of the BPM. Can you draw any conclusions on why this design would be chosen? What about its planar orientation?

3. Align the slot in horizontal orientation. Note the distance between graduations; measure their separation.

4. With a Sine wave output of the Function Generator and a fixed input amplitude, say 0.5V, measure the BPM outputs as a function of input frequency using the full range of the signal generator. What is the optimum frequency for the input signal?

5. Record and plot the outputs as a function of input amplitude. Comment on the linearity of the response.

6. Measure and plot the response as a function of ‘x’. Typically the response is best recorded by measuring (A-B)/(A+B). Why would this be? Explain your method for measuring (A-B)/(A+B).

    a. What is the sensitivity (amplitude vs. radial position of the wire)?

    b. What do you observe about the linearity of the BPM’s response?

7. How does the apparent physical center of the device compare to the ‘electrical’ center?

8. Experiment with other settings for the frequency and amplitude and wave shape.

    a. Are BPM’s useful devices for measuring DC (continuous) beam?

2 Toroid/Wall Current Monitor

A pulsed beam current can be measured with a transformer type current monitor. A wide variety exists, many commercially available. The beam functions as the primary coil of the transformer. Sending a pulsed signal from a signal generator through the current monitor, using coaxial cable where the beam would be, generates a signal in the secondary coils of a few windings which is observed with an oscilloscope. For this exercise a Fermilab-built combination toroid and Wall Current monitor, digital oscilloscope, function generator and necessary cabling are supplied.

1. Take a few moments to get familiar with the apparatus. Develop and sketch your layout to send a pulsed signal through the apparatus and sense the incident signal and output on the oscilloscope.

2. Set up the Function Generator with a Pulse output with Frequency = 25 kHz and Duty factor = 21%.

    a. Record the shape of the **Toroid** output.

    b. Measure and plot the **Toroid** output as a function of the amplitude of the input signal. What is the response?

    c. Vary the Duty factor. What happens?

3. Vary the signal’s amplitude, frequency, and signal shape. Note the Toroid’s response.

   a. At what frequency(ies) is the Toroid's output no longer 'useful'?

   b. What conclusions can you make as to this device's sensitivity as a function of the above variables?

4. Now set up the Function Generator Function Generator with an Arb(itrary) output with Frequency = 1.5 MHz.

   a. Record the shape of the Wall Current Monitor output.

   b. Measure and plot the **Wall Current monitor** output as a function of input signal amplitude. What is the response?

5. Vary the signal's amplitude, frequency, and signal shape. Note the Wall Current monitor's response.

   a. At what frequency is the output of the Wall Current Monitor a maximum? How does the signal shape compare to that of the input?

   b. What conclusions can you make as to this device's sensitivity as a function of the above variables?

6. Compare the output of the two devices. What conclusions can you draw regarding their utility?

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