Coaxial Wire Impedance Measurements of BPM Buttons for the PEP-II B-Factory

J.N. Corlett

September 1995
DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor The Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or The Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof, or The Regents of the University of California.

Ernest Orlando Lawrence Berkeley National Laboratory
is an equal opportunity employer.
DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.
COAXIAL WIRE IMPEDANCE MEASUREMENTS OF BPM BUTTONS FOR THE PEP-II B-FACTORY*

John N. Corlett

Lawrence Berkeley National Laboratory
University of California
Berkeley, California 94720

Submitted to the Proceedings of the International Workshop on Collective Effects and Impedance for B-factories, KEK, Tsukuba, Japan, June 12-17, 1995

* This work was supported by the Director, Office of Energy Research, Office of High Energy and Nuclear Physics, High Energy Physics Division, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.
The coaxial wire impedance measurement uses a conducting rod placed along the beam axis in the vacuum chamber, forming the center conductor in a coaxial line system [1]. Tapers at either end of this section allow for smooth impedance transformation from the 50 Ω lines used in common microwave measurement equipment, to the characteristic impedance of the vacuum chamber and center conductor, typically around 200 Ω. RF and microwave absorptive material placed in the ends of the vacuum chamber and in the impedance matching tapers minimizes reflections which cause trapped modes within the apparatus, allowing measurements to be made above the traveling-wave cut-off frequency of the vacuum vessel (typically 2.5 - 3.0 GHz for PEP-II). A smooth vessel of the same cross-section as that containing the device under test is used in a reference measurement. Resonances within the apparatus are difficult to avoid completely and require careful placing of absorptive material, manufacture of test and reference chambers, and assembly of apparatus.

![Figure 1. Coaxial wire impedance measurement.](image_url)

Current $I_0$ is applied upstream of the impedance to be determined, $Z$. The coaxial wire forms a line of characteristic impedance $R$ with the vacuum chamber. A voltage $V$ is generated at the impedance, inducing currents $V/2R$ traveling equally upstream and downstream. For a localized impedance (small in extent compared to the wavelength of the applied current), the current that excites the voltage $V$ in the impedance is $I_e = I_0 - I_r$. The perturbation in wire current $\Delta I = I_0 - I_c = V/2R = I_eZ/2R$, and $Z = 2R(1 - I_c/I_e) = 2R(I_0/I_e - 1)$. $S_{21}$ measurements without the impedance $Z$ (reference measurement) and with the impedance $Z$ (object measurement) give

$$Z = 2R \left( \frac{S_{21}^{\text{reference}}}{S_{21}^{\text{object}}} - 1 \right)$$

* This work is supported by the Director, Office of Energy Research, Office of High Energy and Nuclear Physics, High Energy Physics Division, of the U.S. Department of Energy under contract No. DE-AC03-76SF00098.
BPM button measurements

BPM button measurements were made with a single button mounted in a short section of vacuum chamber of appropriate cross-section (elliptical for the LER, octagonal for the HER, and circular for the straights of both rings). For a reference measurement, the button assembly was replaced with a tightly fitting solid metal plug, flush with the vacuum chamber inner wall. The first BPM design was for a 2 cm diameter button, which showed a TE$_{11}$ resonance, located at the button circumference, at approximately 6 GHz. Figure 2 shows the real part of the impedance in this region. Since we have approximately 1160 buttons in each ring, the contribution to the total impedance from the buttons is not negligible [2]. The resonance may be suppressed by cutting a flat across the button, breaking the symmetry of the structure, figure 3 shows the measured impedance in this case [2].

![Figure 2. TE$_{11}$ mode in 2.0 cm circular BPM button, straight vacuum chamber.](image)

![Figure 3. TE$_{11}$ mode suppressed with flat cut 6 mm from the edge of a 2 cm BPM button.](image)
In order to simplify manufacture and installation and to minimize costs, the final design uses a 1.5 cm diameter circular button. The TE$_{11}$ resonance is still present, but at 7.7 GHz, and the effective impedance of this mode is reduced as a result of the roll-off of the single-bunch spectrum. Coupled bunch motion driven by this impedance is well within the capabilities of the feedback systems. Figure 4 shows the measured beam impedance of the 1.5 cm button. The measurements are qualitatively in good agreement with computations, but with a lower impedance than predicted by MAFIA, likely due to the finite conductivity of the real button and feedthrough assembly [3].

![Figure 4. 1.5 cm BPM button in HER arc chamber.](image)

The transfer impedance measurement uses the coaxial wire and takes the output signal from the button in an $S_{21}$ measurement. The impedance is given by

$$Z_{\text{transfer}} = \sqrt{R_{\text{button}}} \frac{|S_{\text{pickup}}|}{|S_{21}|} \frac{|S_{\text{through}}|}{|S_{21}|}$$

where $R_{\text{button}}$ is the output impedance of the button (50 Ω), $S_{21}^{\text{pickup}}$ is the transmission from the vacuum chamber coaxial line to the button output, and $S_{21}^{\text{through}}$ is the transmission through the vacuum chamber line. Figure 5 shows the transfer impedance for the 1.5 cm button, which is in good agreement with MAFIA computations [3].
Figure 5. 1.5 cm BPM button in HER arc chamber.

References


[3] C. Ng, private communication. See also these proceedings.