Post Production Check Items for Cavity BPM

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Abstract

Prototype cavity BPMs for ATF2 Q-magnets are under fabrication in PAL. We describe check items to be done before its shipment to KEK. They are basic port measurements using a network analyzer and a check about vacuum tightness.

1 Introduction

1.1 purpose

The purpose of this measurement is to check if there is any serious problem before the shipment. Although we will repeat the measurement in KEK, it should be good to know in advance. We will be able to check accidents in the transport by comparing the results of before the shipment and after the arrival.

Since the purpose of the production of these prototype BPMs is to check the design and to know the quality of the fabrication, we do not determine a strict requirement on the specification. Even if it is found that they do not satisfy the requirements in the useage of ATF2, it is worth knowing and exactly is the purpose of prototyping.

If we find a mistake in the electrical design or a fine tuning is needed (in, for example, the cavity radius, dents depth, etc.), corrections will be reflected in the next production.

1.2 two types of prototype BPM

Two prototype BPMs are being made. The difference of the two is the existence of the dents on the cavity rim. We call them “with dents model” or “without dents model”, here. The dents introduce a small difference in the dipole modes of two polarization. We expect that the difference improves the isolation between x and y position signal.

We will compare the measurement results of the two types, and check the improvement in the isolation between transverse ports.

2 Design value of parameters

The calculated parameters in the design is as follows;

- The frequency of the dipole modes was designed to be 6.426 GHz. Dipole modes of two polarization are degenerated in the “without dents” model. On the other hand, 0.25∼1 MHz frequency differnce was introduced betweeen the two dipole modes in the “with dents” model.
- Q_{ext} of the dipole mode was calculated to be 19000 (MAFIA by Y.Honda) or 14000 (GdfidL by A.Liapine). Since there is a small difference in the two calculation, we use the average, $Q_{ext} = 16500$, here.
- Q_0 of the dipole mode was calculated to be 11000 using the conductivity of copper (5.8×10^7 S/m). However, it was estimated to be 8700 for the existing KEK cavity BPM from the measurement. We use $Q_0 = 8700$ for the new BPM as a realistic number.
- β (coupling) was calculated to be 0.53 using the definition $\beta = \frac{Q_0}{Q_{ext}}$ with the numbers given above.

- Q_L was calculated to be 5700 using the equation $\frac{1}{Q_L} = \frac{1}{Q_0} + \frac{1}{Q_{ext}}$ with the numbers given above.

3 Measurement

A set of simple measurements using a network analyzer is required. Although the new BPMs have four tuning points on the sensor cavity, it should not be used in this moment. We need to know the initial quality of the cavity just after the fabrication.

In this network analyzer measurement, the check items are;

- Resonance frequency (f) of the dipole mode.
- Resonance width (Δf) of the dipole mode.
- Reflection (S_{11}) on the resonance.
- Transmission (S_{21}) on the resonance.

It is required to measure these for all the ports and all the ports combination (in the case of transmission measurement).

3.1 calculated values

As a reference, we give the calculated values from the design corresponding to the ones to be measured.

- Resonance frequency (f) will be lowered by about 1.7 MHz in the air. It will be 6.4243 GHz.
- $Q_L = 5700$ gives the full width of the resonance (Δf). From $\Delta f = \frac{f}{Q_L}$, it will be 887 kHz.
- Reflection (S_{11}) is calculated from the coupling. Using the relation for symmetric two port cavity, $\beta = \frac{1-S_{11}}{S_{11}}$, S_{11} will be 0.654 (-3.69 dB)
- Transmission (S_{11}) is calculated from the coupling. Between the opposite ports, using the relation for symmetric two port cavity, $\beta = \frac{S_{21}}{1-S_{21}}$, S_{21} will be 0.346 (-9.21 dB). Between the transverse ports, it is $-\infty$ dB in the ideal case. Since we hope better than -30 dB isolation, it corresponds to <-39.21 dB in the transmission.

3.2 procedure

The frequency may change a little due to the environment, check the room temperature before/after the measurement so that we can compare the result with the one measured in KEK later.

In the network analyzer measurement, terminate the SMA connectors which are not used by 50 Ω load.

Measurement of f, Δf, S_{11} can be done at the same time by one port measurement. Find the dipole mode peak (minimum position of S_{11}) around 6.4 GHz. Measure the frequency (resolution should be better than 50 kHz), the value of S_{11}, and the full width of the peak (Δf). Repeat the measurement for four ports for each BPM. The transmission can be measured by two port measurement. Find the dipole mode peak and measure the peak value of S_{21}. We can measure f and Δf again. Repeat the measurement for 6 combinations of the ports for each BPM.

With the measured values, we can calculate Q_L, β and Q_0 using the equation above.

4 Other check items

4.1 Vacuum leakage

Naturally, a vacuum leak test is necessary. Using a helium leak detector (or an equivalent device), prove it to be better than 3 $\times 10^{-10}$ Pa·m^3/sec.

4.2 Vacuum reach

We plan to install the caity BPMs in the ATF extraction line. The typical pressure in the beam line is 1×10^{-6} Pa. It have to be proven that the BPM can reach the pressure in a reasonable time. Test the pressure reach with an ion pump monitoring the pressure. It should be better than 1×10^{-5} Pa in a day.

5 Summary

After all, tables like Table 1,2 will be completed for each BPM.

Table 1: list of the results (Reflection measurement)

port	f (GHz)	Δf (kHz)	S_{11}	Q_L	β	Q_0
top						
left						
bottom						
right						

Table 2: list of the results (Transmission measurement)

port	f (GHz)	Δf (kHz)	S_{21}	Q_L	β	Q_0
top-bottom						
left-right						
top-left						
top-right						
bottom-left						
bottom-right						

On the vacuum test, we will be able to state that vacuum leakage is better than XXX Pa·m^3/sec. And we will have a trend of vacuum pressure in the pressure reach test, like Figure 1.

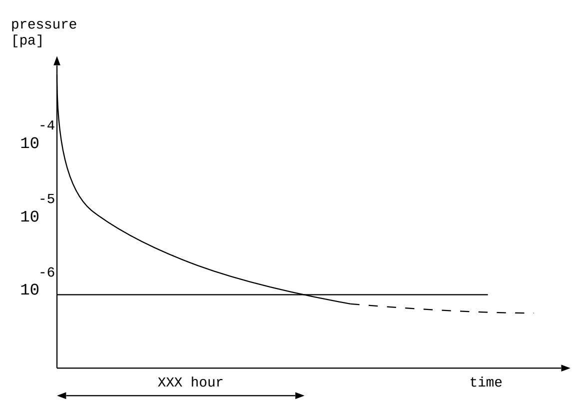

Figure 1: trend of pressure