Port measurements of KEK test model for ATF2 Q-BPM

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Abstract

Test cavity BPMs for ATF2 Q-magnets were fabricated in KEK. We describe the results of the port measurement.

1 KEK test model

Two prototype BPMs were made in KEK machine center. The electrical design of them were exactly the same as the prototype models being made in PAL.

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.

KEK model is not a vacuum tight one. The pieces and SMA connectors are attached by bolts. The inner surface of the cavity was fabricated by a precusion machining (it looks like a mirror). The roughness is expected to be better than 0.1μm, except for the inner surface of the slots and wave guides, which were fabricated by wire discharging.

The machining accuracy will be measured later.

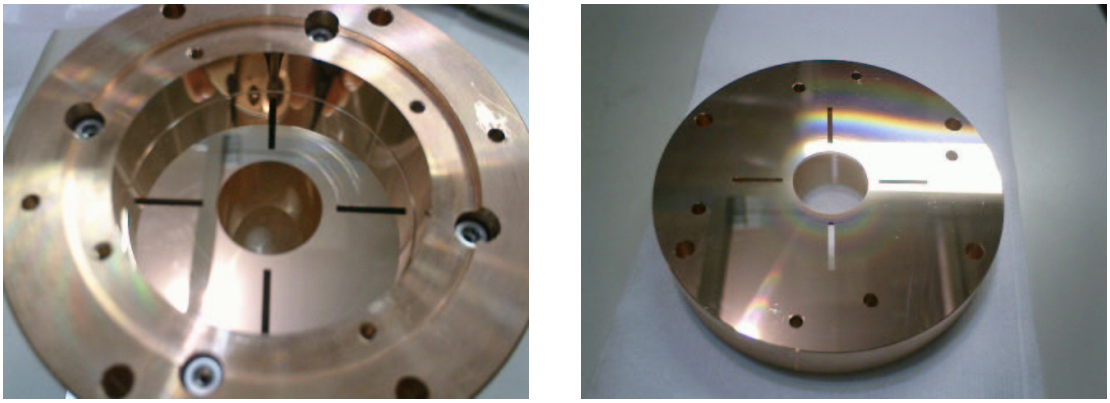

Figure 1: Cavity part.

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$\sim$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).

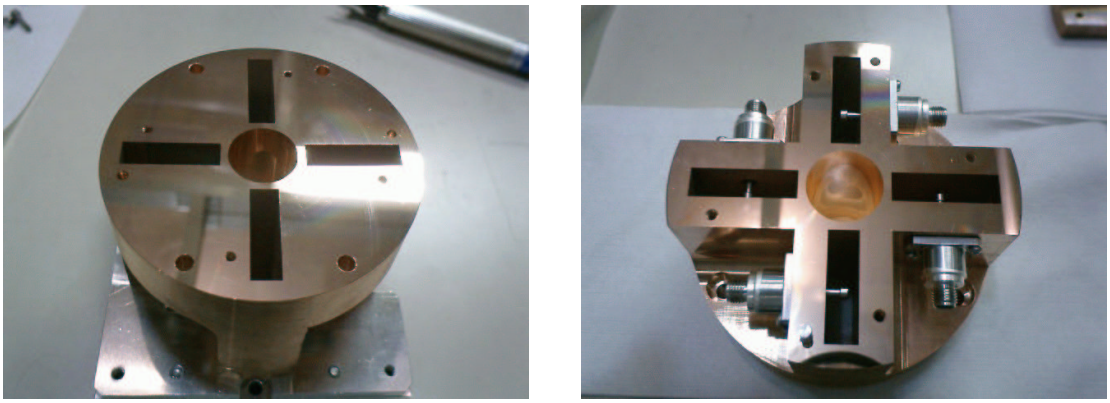

Figure 2: Wave guide part.

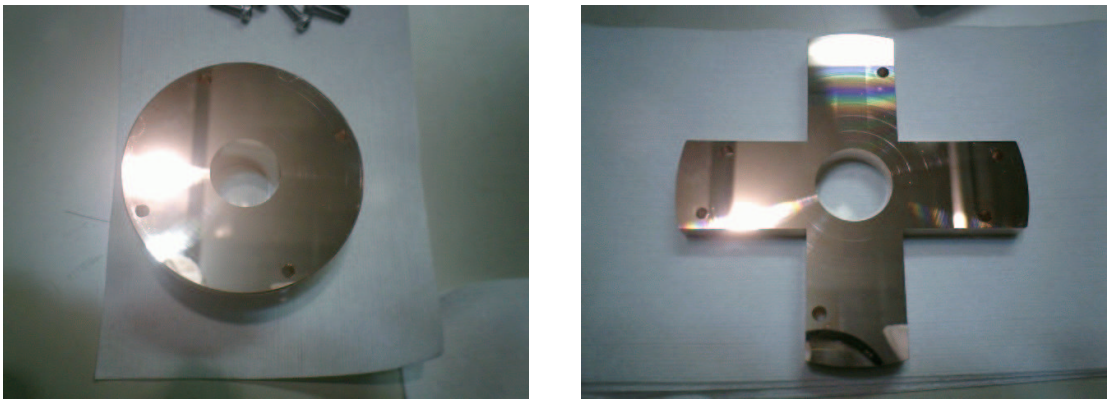

Figure 3: Endcap part.

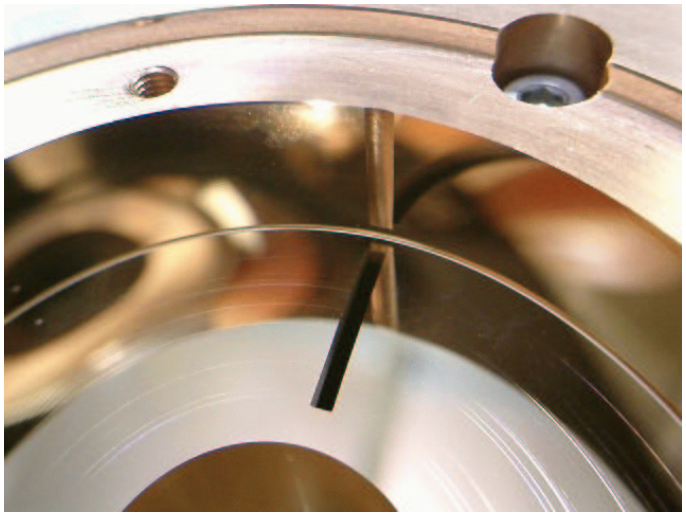

Figure 4: Asymmetry dent.

- Q_0 of the dipole mode was calculated to be 11000 using the conductivity of copper (5.8×10^7 S/m). Since the pieces of the test model were attached by bolts, the Q_0 must be lower than this value.

3 Measurement

The definition of the port numbers are shown in Figure5.

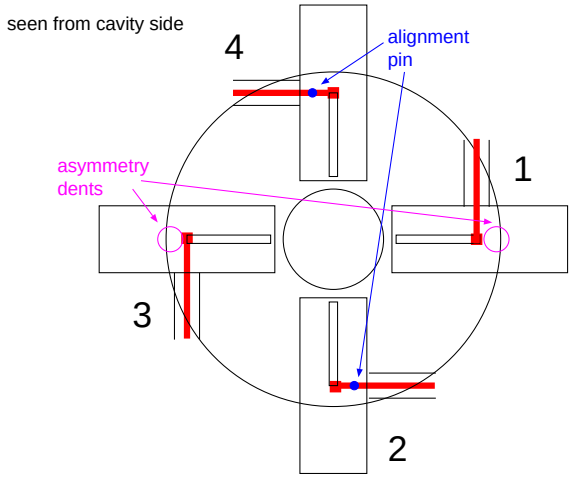

Figure 5: Definition of the port numbers.

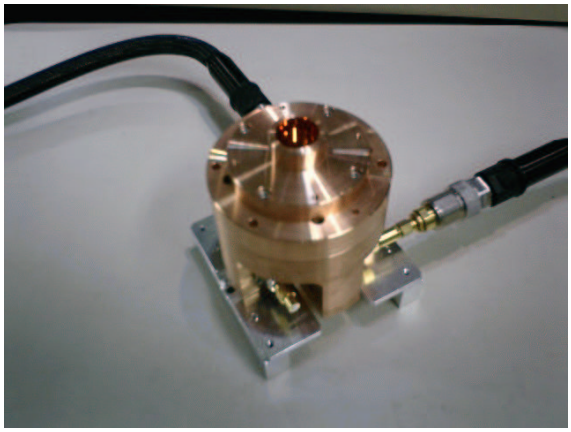

Figure 6: Setup of the measurement (two port).

3.1 Measured values

In this network analyzer measurement, the items measured were;

- 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.

These items were measured for all the ports and all the ports combination.

3.2 Extracted values

Using the measured values, the following values were calculated.

- Loaded Q value (Q_L) of the dipole mode. It was calculated using the equation $Q_L = \frac{f}{\Delta f}$
- Coupling (β) of the dipole mode. It was calculated using the equation $\beta = \frac{1-S_{11}}{S_{11}}$ (from reflection measurement) or $\beta = \frac{S_{21}}{1-S_{21}}$ (from transmission measurement)
- Unloaded Q value (Q_0) of the dipole mode. It was calculated using the equation $Q_0 = (1+\beta)Q_L$
- External Q value (Q_{ext}) of the dipole mode. It was calculated using the equation $Q_{ext} = \frac{Q_0}{\beta}$

3.3 Procedure

The room temperature and humidity were measured before and after the measurement. The temperature was 24°C and the humidity was 50 %. The measurement took about 2 hours, the environment did not change during the measurement.

In the network analyzer measurement, those SMA connectors which were not used were terminated by 50 Ω load.

Measurement of f, Δf, S_{11} were done at the same time by one port measurement. S_{21} was measured by two port measurement.

With the measured values, we calculated Q_L, β, Q_0 and Q_{ext}.

3.4 Results

The results were summarized in the Tables.

Table 1: Without dents model (Reflection measurement)

port	f (GHz)	Δf (MHz)	S_{11}	Q_L	β	Q_0	Q_{ext}
1	6.41843	1.67	0.861	3843	0.16	4458	27863
2	6.41832	1.59	0.817	4037	0.22	4925	22386
3	6.41846	1.71	0.852	3753	0.17	4391	25829
4	6.41829	1.56	0.827	4114	0.21	4978	23705

Table 2: With dents model (Reflection measurement)

port	f (GHz)	Δf (MHz)	S_{11}	Q_L	β	Q_0	Q_{ext}
1	6.41640	2.54	0.910	2526	0.099	2776	28040
2	6.41566	2.20	0.897	2916	0.115	3251	28270
3	6.41643	2.43	0.915	2641	0.093	2887	31043
4	6.41562	2.25	0.894	2875	0.119	3190	26807

4 Summary

Frequency was found to be about 8 MHz lower than the calculation, we need to modify the cavity radius.

Q_L and Q_0 values were smaller, and hence β is smaller, than the calculation. Since the pieces of the test model are attached by bolts, this is an expected bahavior.

Q_{ext} is a little higher than the calculation, but it seems to be acceptable.

Q_0 of the with dents model is lower than the without dents model. This might be the power loss at the dents part. We should check the surface quality of the dents.

Table 3: Without dents model (Transmission measurement)

port	f (GHz)	Δf (MHz)	S_{21}	Q_L	β	Q_0	Q_{ext}
1-3	6.41844	1.94	0.155	3308	0.183	3913	21383
2-4	6.41827	1.81	0.180	3546	0.220	4326	19664
1-2	6.41840	1.18	0.0078				
2-3	6.41830	1.18	0.0091				
3-4	6.41832	1.15	0.0085				
4-1	6.41840	1.20	0.0076				

Table 4: With dents model (Transmission measurement)

port	f (GHz)	Δf (MHz)	S_{21}	Q_L	β	Q_0	Q_{ext}
1-3	6.41642	3.08	0.100	2083	0.111	2314	20847
2-4	6.41563	2.47	0.114	2597	0.129	2932	22729
1-2	6.41596	1.96	0.023				
2-3	6.41604	1.96	0.023				
3-4	6.41597	1.96	0.022				
4-1	6.41597	1.95	0.023				

The asymmetry dents split the frequency of the two polarization about 800 kHz as we designed.

The x-y isolation can be estimated by the ratio of the transmission of opposite ports and transverse ports. For without dents model, it was calculated to be -26 dB. On the other hand for with dents model, it was -14 dB. This is not what we expected.