Frequency Measurement of the Prototype Storage Ring Stainless Steel Single Cell Cavity

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Frequency measurements were made on the stainless steel single cell cavity with various port terminations, using two small loops. The cavity contains six larger ports. The top and bottom ports have a diameter of 144 *mm*, the front and back ports (beam ports) have a diameter of 140 *mm*, and the two side ports have a diameter of 120 *mm*. The cavity also has four smaller ports of diameter 34.8 *mm*, which contain an E-probe, a H-loop, and two field probes.

The frequency measurements for the fundamental mode are as follows:

1. All large ports covered with blank flanges. Frequency is 352.28 *MHz*.
2. Input coupler in side port and all other large ports covered with blank flanges. Frequency is 352.30 *MHz*.
3. Tuner (with plunger in the minimum position) in top port and all other large ports covered with blank flanges. Frequency is 352.39 *MHz*.
4. Tuner (with plunger in the minimum position) in top port, input coupler in side port, and all other large ports covered with blank flanges. Frequency is 352.42 *MHz*.
5. Tuner (with plunger in the maximum position) in top port, input coupler in side port, and all other large ports covered with blank flanges. Frequency is 353.26 *MHz*.

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When the plunger is in the minimum position, it rests 28 *mm* above the inside wall of the cavity. In the maximum position, it rests 33.5 *mm* below the inside wall of the cavity.

As more components are installed in the cavity, the volume of the cavity is reduced, and thus, a slight increase in frequency is observed. These frequency shifts are shown in Table 1, and the frequency plots for the above five cases are shown in Figures 1-5. A decrease in the unloaded Q value for the cavity is also seen as more elements are present in the cavity. The Q values for the different cases described above are shown in Table 1. Furthermore, the unloaded Q value for the stainless steel cavity with all large ports covered with flanges is approximately two and one half times smaller than that previously measured for the copper prototype cavity with a similar setup.

Movement of the tuner plunger into and out of the cavity alters the resonating frequency. Frequency measurements were made with the stainless steel cavity and a 115 *mm* diameter tuner at various plunger depths. The frequency effect due to the movement of the tuner is shown in Figure 6.

A perturbation coefficient, C , relating the frequency and volume change can be calculated where

$$\frac{\Delta\omega}{\omega} = C \frac{\Delta V}{V}.$$

The dimensions of the 352 *MHz* stainless steel cavity are identical to the dimensions of the copper prototype cavity. Thus, the volume (V) of the cavity used in the calculations is 0.116 m^3 and the volume perturbation ($\frac{\Delta V}{V}$) is 8.95×10^{-5} per *mm* of plunger inserted into the cavity.

The perturbation coefficients are as follows:

1. Movement of the plunger from the minimum position at -28 mm (the inside wall of the cavity is used as the reference point of 0 mm) to -24 mm results in a frequency change of 0.019 MHz . The perturbation coefficient, C_1 , is -0.15 .
2. Movement of the plunger from -24 mm to -20 mm results in a frequency change of 0.025 MHz . The perturbation coefficient, C_2 , is -0.20 .
3. Movement of the plunger from -20 mm to 0.5 mm results in a frequency change of 0.199 MHz . The perturbation coefficient, C_3 , is -0.31 .
4. Movement of the plunger from 0.5 mm to 11 mm results in a frequency change of 0.159 MHz . The perturbation coefficient, C_4 , is 0.48 .
5. Movement of the plunger from 11 mm to 18.5 mm results in a frequency change of 0.136 MHz . The perturbation coefficient, C_5 , is 0.58 .
6. Movement of the plunger from 18.5 mm to 27.5 mm results in a frequency change of 0.179 MHz . The perturbation coefficient, C_6 , is 0.63 .
7. Movement of the plunger from 27.5 mm to the maximum position of 33.5 mm results in a frequency change of 0.122 MHz . The perturbation coefficient, C_7 , is 0.64 .

These perturbation coefficients can be averaged to obtain an average inward perturbation coefficient $C^{in} = 0.57$ and an average outward perturbation coefficient $C^{out} = -0.27$.

The average outward perturbation coefficient for the plunger positions above the inside wall is similar to that previously estimated. The average inward perturbation coefficient, however, is 40% lower than that previously estimated. Likewise, the maximum tuning range of the stainless steel cavity and 115 mm diameter tuner combination is 0.84 MHz , 0.60 MHz for 33.5 mm of inward travel and 0.24 MHz

for 28 *mm* of outward travel. This tuning range is half of the previously estimated range. Thus, as evidenced in the lower inward perturbation coefficients and decreased tuning range, the change in frequency per *mm* of plunger inserted into the cavity is not as great as previously expected.

Table 1

	f (MHz)	Δf (MHz)	Q
All ports flanged	352.28	—	17467
Input coupler only	352.30	0.02	16941
Tuner only (-28 mm)	352.39	0.11	17473
Input coupler and tuner (-28 mm)	352.42	0.14	16777
Input coupler and tuner (33.5 mm)	353.26	0.98	11535

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Frequency Effect Due to Tuner Position

Figure 6