Super Wide Band Cavity With An All-Pass Network

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A tuning-free cavity with a bridged-T type all-pass network has been developed for an ion synchrotron [1][2] as shown in Fig.1. As for the characteristic of this cavity with an all-pass network, output impedance is equal to input one. The sufficient condition values of parameter are as follows

$$Z_2 = \frac{R^2}{2Z_1},\quad Z_3 = 4Z_1 \tag{1}$$

LC expression as follows

$$L_2 = \frac{C_1 R^2}{2},\quad C_2 = \frac{2L_1}{R^2},\quad L_3 = 4L_1,\quad C_3 = \frac{C_1}{4} \tag{2}$$

The acceleration voltage of this cavity has the characteristic curve which looks like a band pass filter. Since the circuits of bridged-T type all-pass network are divided low and high pass filter, the values of f_{min} and f_{max} are roughly estimated to $f_{\min} \cong R/(4\pi L_1)$, $f_{\max} \cong 1/(\pi R C_1)$. The accurate values are as follows

$$f_{\min} = \frac{1}{2\pi\sqrt{L_1 C_1}}\{\sqrt{1+\frac{L_1}{R^2 C_1}} - \frac{1}{R}\sqrt{\frac{L_1}{C_1}}\} \tag{3}$$

$$f_{\max} = \frac{1}{2\pi\sqrt{L_1 C_1}}\{\sqrt{1+\frac{L_1}{R^2 C_1}} + \frac{1}{R}\sqrt{\frac{L_1}{C_1}}\} \tag{4}$$

$$f_0 = \frac{1}{2\pi\sqrt{L_1 C_1}} \tag{5}$$

Comparing the acceleration gap voltage phase to input phase, a phase difference change continuously between f_{min} and f_{max} from +90 for the -90 degrees as shown in Fig.2.

We selected parameters with values of $L_1 = 16.83\mu H$, $C_1 = 240pF$ so that an acceleration gap voltage could generate between 0.1 and 60MHz. Then, this cavity voltage was generated between 0.1 and 32MHz as shown in Fig.3.

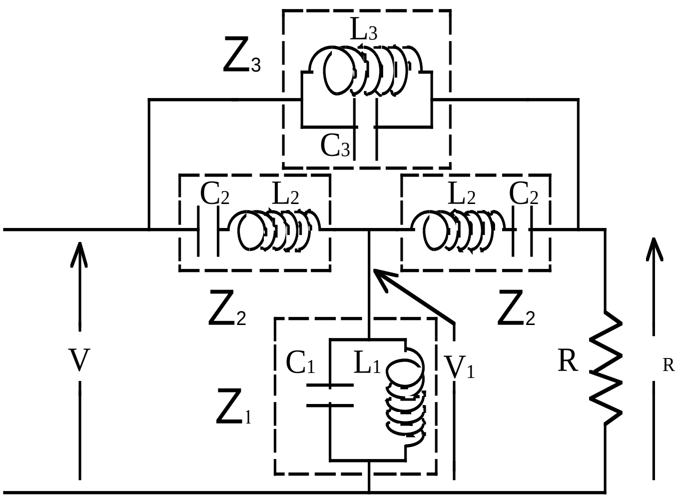

Fig.1; A bridged-T type all-pass network (Z_1 is basic cavity.)

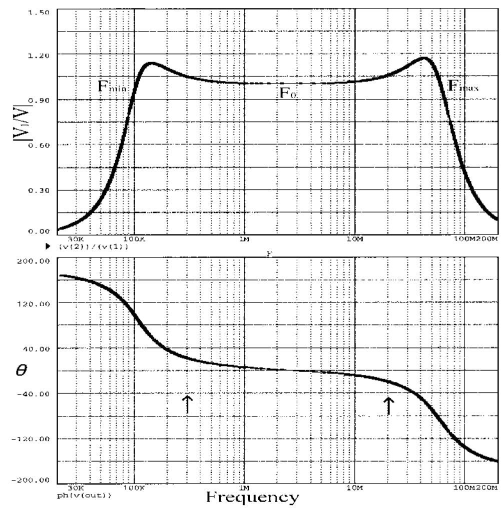

Fig.2; Low-level RF test results$|V_1/V|$ and phase

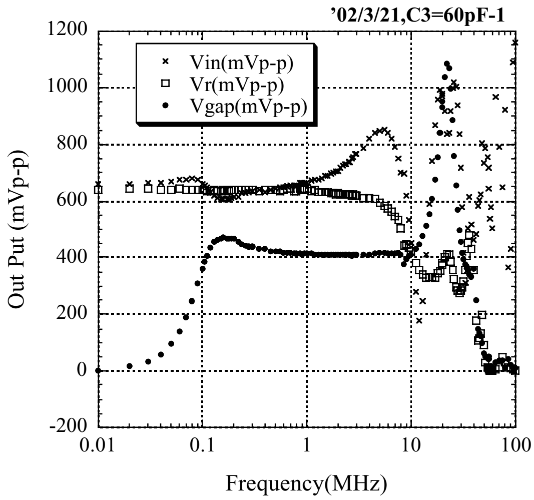

Fig.3; Low-level RF test results of the cavity (Source V/ Terminal Resister V_R/ Cavity voltage

The f_{min} value from equation (3) is almost the same as measured 0.1MHz. But, the f_{max} value from (4) is different from measured 32MHz. The parameter L_2 values that it wasn t measured may be wrong. And L_2 value is very little one. As for the measurement of L_1, C_1 of the circuit parameters, accurate value $L_1 = 15.9\mu H$ can be calculated from the measurement value by using a Vector Impedance Meter, and C_1 value was adjusted $C_1 = 240pF$. But, the measurement of the L_2 of the component seems to be very difficult. Then, it influence of the value of f_{max} if the value of L_2 is different from the design value (L_2=57.9nH). The measured L_2 value is less than 362nH. F_{max}=29.3MHz is calculated by L_2=362nH. A frequency band width of accelerator gap voltage is smaller than design value.

This cavity can generate sawtooth-wave rf-field. A sawtooth-wave is suitable for production of short bunched beam compared with a sine wave. A short-bunched beam with 370 ns at FWHM (full width at half maximum) was gotten in using the sawtooth-wave ($500V_{p-p}$), while that with 480 ns in the sine wave ($500V_{p-p}$). As shown in Fig.4, 5 (Horizontal scale is 400 ns/div at f=1.042180MHz.)

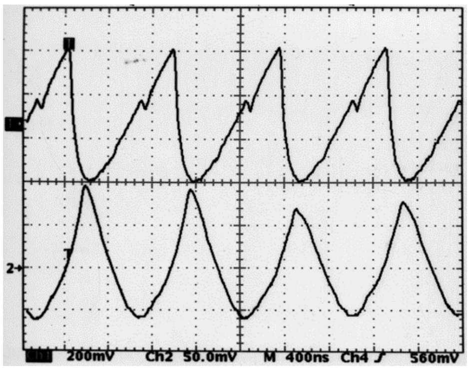

Fig.4; Sawtooth-wave and bunched beam

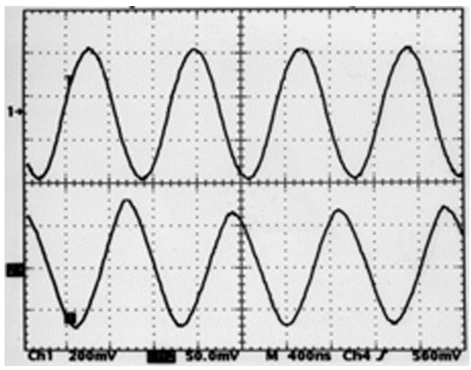

Fig.5; Sine wave and bunched beam

Reference

[1] H.Tamura et al., RCNP Annual Report 2000 p.104

[2] H.Tamura et al., Procs. of the 12th Symposium on Accelerator Science and Technology,