TWO FREQUENCIES CAVITIES FOR BEAM POSITION MONITOR

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Abstract

Use of the symmetrical SBLC section coupler (hybrid coupler) as well as one of the section cell (BPM cell) for the beam position monitor (BPM) was studied. In both cases the requirements were the high order mode (HOM) power withdrawal of two polarization without changing frequencies at operational mode and HOM. In case of hybrid coupler the protrusions inside the cavity were used. In case of the BPM cell in 15-th cell of SBLC disk loaded waveguide (DLW) four cut-off waveguides at operating frequency were used. Calculations and measurements with initial 30 cells of SBLC DLW results are presented.

1. INTRODUCTION

The trapped modes in initial 30 cells of the SBLC DLW with the symmetric coupler matched with the structure at the operational mode were studied[1]. The first trapped mode (f=4130 MHz) occupies five initial cells, but the field was absent in the coupler cavity. The last mode fully trapped in the structure has the frequency f=4161 MHz and at this frequency the field in the input coupler is just beginning to show up. Hence, it is clear that the coupler frequency on the HOM differs from that of SBLC DLW first cell and supposedly lies at the frequency more than 4161 MHz. The influence of the coupler frequency on the HOM field distribution was studied with the structure having the coupler, which allowed to vary this frequency [2]. By means of changing of the movable plunger (3 at Fig.1) and using the tuning pins 1 and matched loads 2 the coupler frequency was reduced by 30MHz and the Q-factor value was reduced from 8000 to 2000-4000 over the frequency band about 20 MHz.

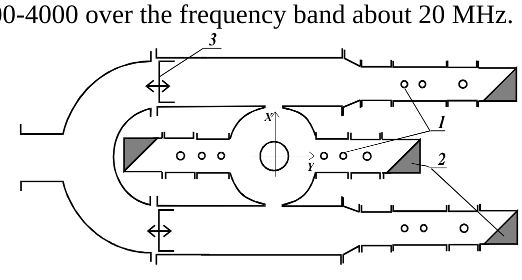

Fig.1 Sketch of the hybrid coupler

2. HYBRID COUPLER

The difference between the coupler frequencies at the operational and first dipole modes in case of SBLC DLW should be in the range of 1150-1230 MHz. The influence of some elements (the choke type grove and the circular protrusions), inserted inside symmetrical coupler on the values of corresponding coupler frequencies was investigated using the method of resonator-analogue [3] and with MAFIA code 3.20 for the coupler with height d_c=28.33mm and variable other dimensions ($2b_c$, $2a_1$, $2a_2$, t_1, t_2). The dimensions of rectangular waveguides (RW) were: A_1=72mm, B_1=28.3mm, A_2=48mm, B_2=24mm. At first, the coupler cell was terminated at both sides by drift tubes with length l_c=100mm and diameter 31.02mm. The calculations were carried out not only for infinite RW, but also for RW1 with movable plunger (m.p.) at one end of every waveguide. The frequencies, calculated using resonator-analogue method and MAFIA code for the coupler with $2b_c$=74mm, $2a_1$=34.8mm, t_1=8.5mm, $2a_2$=27mm, t_2=3.6mm, z=24mm and two ring-type protrusions with diameter 45x55mm and height 2x2mm (1 at Fig.2) are shown in Table1. The influence of movable plunger position z (from 24 mm to 60mm) on the frequencies was about 30MHz at E_{01} mode and 60MHz at E_{11} mode.

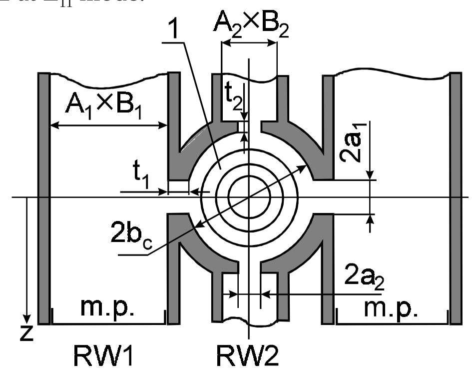

Fig.2. Cross-section of the coupler cells with four RW.

Table 1. The frequencies (in MHz) .

	Resonator-analogue	MAFIA
E_{01} mode	2885	2930
E_{11} mode in RW1	4228	4250-4300
E_{11} mode in RW2	4286	4270-4300

Table.2. The frequencies (in MHz)

	$2b_c$=72mm, h=2x2mm.	$2b_c$=72mm, h=3x3mm.	Δ f=f_1-f_2
E_{01}	2992	2940	52
E_{11} in RW1	4367	4254	113
E_{11} in RW2	4410	4297	113

More substantial changing in frequencies may be obtained, if the cavity diameter and protrusions height were changed (Table2). Obviously, the influence of protrusion height h at the operational frequency is two times more than at the hybrid mode. Using this situation

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and the possibility of changing the dimensions $2b_c$, a_1, a_2, t_1 and t_2 one can obtaine the necessary frequencies for the coupler with four RW and with two drift tubes.

These results would be changed in case when one drift tube is replaced by DLW cells. Some calculations were carried out for the coupler with $2b_c$=74mm, two circular protrusions 45x55mm with height h=2mm, $2a_1$=34.8mm, t_1=8.5mm, $2a_2$=27mm, t_2=3.6mm, z=24mm and two DLW cells with 2b=82.664mm, 2a=30.68mm. With magnetic wall in symmetrical plain the power was observed at the frequencies 2945MHz and 2998MHz at E_{01} mode in DLW and at H_{10} in RW1. In this case we also observed the power at the frequencies 4120MHz and 4153MHz at E_{11} mode in DLW and at H_{10} in RW2. In case with electric wall we had the power at the frequencies 4140MHz at E_{11} mode in DLW and at H_{10} (H_{20}) modes in RW1. The electromagnetic field was calculated only at the pointed out frequencies. At these frequencies we had the maximum signal. But the power was observed in wider frequency band. Hence the hybrid coupler with these dimensions may be used for BPM.

Another scheme for the withdrawal of two polarization hybrid modes may be realized by means of using RW1 of the coupler for one polarization and first DLW cell with RW2 for the second polarization. In this case we may tune the hybrid coupler easier at the operational and hybrid modes. In Table3 one can see the calculation results with MAFIA code for the case of the coupler with $2b_c$=76mm and only RW1 with two protrusions h=2x2mm and without them. Similar coupler with two DLW cells (cell N1 of SBLC DLW) was calculated too and the power in RW1 was observed at frequency 4130-4140MHz.

Table.3. The frequencies (in MHz)

	With protrusions	Without protrusions
E_{01} mode	2915	2975
E_{11} mode	4410	4550

3. BPM CELL

The possibility of restoring the preliminary frequencies at the operational and hybrid modes in the BPM cell was tested with the constant impedance structure having dimensions of the last cell of SBLC DLW. The tuning of the cell at the operational mode was made by means of cell diameter changing and also by means of tuning pins, inserted into the cell. The changing of the HOM frequency of this cell was realised by introducing the reactive conductivity in the cell, using the RW with movable plungers or mismatched loads. As the dimensions of RW were chosen as cut-off for fundamental mode we may neglect their influence at these frequencies. The equivalent circuit of the device, consisting of some cells is presented in Fig.3. L,C,G are the parameters of equivalent circuit at some mode, l is the rectangular waveguide length, G_a is conductance of theload. There is the following expression for the n mode frequency

$$f_n = f_{0n}\left[1-\frac{\sin\frac{4\pi l}{\lambda_w}}{2Q_{ext}\left(\cos\frac{4\pi l}{\lambda_w}+\frac{1+\Gamma^2}{2\Gamma}\right)}\right]$$

where f_{0n} is the own frequency at n mode, Q_{ext} is the external Q-factor being determined by the coupling between the cell at n mode and waveguide with load, Γ is the load reflection coefficient.

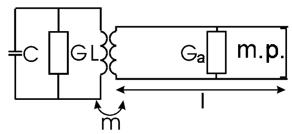

Fig.3 Equivalent circle.

The frequencies versus the movable plunge position l were measured the structure, consisting of one cell (0-mode), three and six cells (modes 0,π/3 and 2π/3). The BPM cell dimension wasn't equal that of to last cell, because there was two slots in the cell and therefore it was corrected. The experiments were carried out with two movable plungers and with the mismatched load with standing wave ratio (SWR) of 5.6. The BPM cell was tuned at the calculated frequency of the operation 0 mode using four tuning screws 4 (see Fig.4). It is clear from these experiments that with increasing of cell number in the stock under investigations (in 6 times) the frequency change decreases (about in 6-7 times).

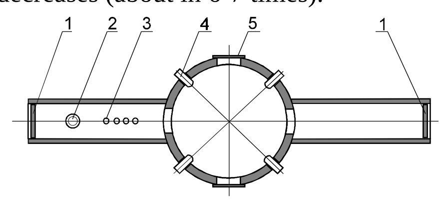

Fig.4. BPM cell

The next experiments were performed with the device where the matched load was connected to one slot and the movable plunger to another one (see Fig.4.). The matched load was made on the basis of RW with cross section dimensions 37.5x5 mm and had the movable plunger (1), some tuning screws (3) and coaxial output with the absorbing load (2). SWR was achieved less than 1.1 in the frequency range 4130-4175 MHz. Using four tuning screws in a cell we have obtained the 0-mode frequency equal to the calculated one 2965MHz. Then the frequencies $0, \pi/3$ and $2\pi/3$ modes in the resonant stock consisting of tree cells were measured and their values appeared to be equal to the calculated values: 2965, 2975 and 2998 MHz correspondingly. In Table 4 one can see the hybrid mode frequencies(f_1) measured after tuning by means of the movable plunger and calculated one (f_2) for the structure consisting of six cells. From these data and the similar data with three cells we may conclude that with increased number of cells in the resonant structure after tuning the BPM cell by means of movable plunger the hybrid frequencies became close to calculated values. At the setup consisting from six cells the transmission coefficient K_{tr} at HOM from DLW into RW was measured. The cell with input loop and screws was tuned at the frequency of $2\pi/3$ mode with SWR 1.05. The transmission coefficient was equal 3dB.

The longitudial electric field distributions were measured with this structure with and without the BPM cell by means of the small needle with 0.05 mm radius and 12 mm length. It is being placed 3mm of axis. The formfactor of this bead was equal $2.5\text{x}10^{-19}\text{m}^2/\text{c}\cdot\text{Ohm}$ and direction coefficient was equal 16. It was shown, that the longitudinal electric field distribution depends on resonant structure length, frequency and slot sizes.

Table 4. The frequencies (in MHz).

MODE	f_1, MHz	f_2, MHz	Q-factor
0	4597	4600	1840
$\pi/6$	4580	4583	1650
$\pi/3$	4546	4546	5600
$\pi/2$	4507	4508	1500
$2\pi/3$	4580	4479	1000
$5\pi/6$	4462	4462	1600

The investigations of the initial part of SBLC DLW consisting of 30 cells were carried out with the BPM cell instead of cell #15. This BPM cell has two pairs of narrow slots with dimensions $2\times15\text{mm}^2$, $2\text{x}25\text{mm}^2$ or $2\text{x}37\text{mm}^2$. The BPM cell was connected with RW through these coupling slots. Rectangular wavequides were ended by the loads having SWR less than 1.2 in investigating frequency band. At first the BPM cell was tuned with the resonant structure, consisting of cells #14, #15, #16. Dimension 2b of the BPM cell was less than 2b of real 15-th cell in order to compensate the influence of four coupling slots with connected RW and matched loads at the operational frequency. The radial electric field component distribution versus longitudinal coordinate was measured by mean of the perturbating shim having the diameter 6mm and the thickness 0.3mm being moved along the structure axis (formfactor was equal $6.05\text{x}10^{-19}\text{m}^2/\text{c}\cdot\text{Ohm}$ and direction coefficient was equal 25). The measurements were performed in the frequency range 4135MHz-4171MHz. The upper frequency value was chosen from condition RF power filling of all section 30 cells. In Fig.5 one can see the frequency changes for structure without the BPM cell and with the BPM cell at different slot sizes. The position z of the first cell at these pictures is equal to 1000mm. The analysis of these experimental results show that the BPM cell influences on the field structure. At some frequencies and slot dimensions the resonant structure seems to be divided into two slightly coupled parts, the field excitement in one part is being smaller than in the other one. This effect is the result of the difference between BPM cell impedance and that of other cells. Using these data it is possible to calculate the transverse shunt impedance function structure length for different frequencies and slot sizes compare it with that of the structure without the BPM cell. The necessary slot size of the BPM cell is to be chosen with accounting for small influence of these slots at the transverse shunt impedance over the frequency range and the required the transmission coefficient between DLW and RW. The measured transmission coefficient versus slot length (the height 2mm) is shown in Fig.6. The data for every slot length were averaged over the frequency range 4131-4171MHz.

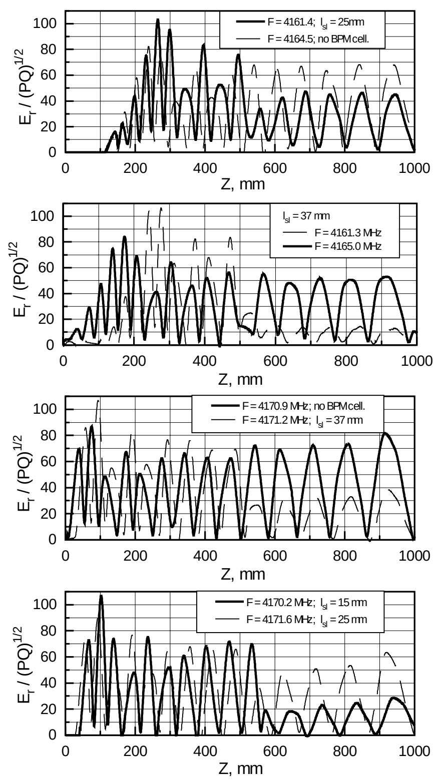

Fig.5. Radial electric field on the DLW axis with cell number

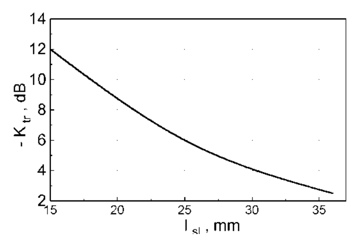

Fig.6. Transmission coefficient at HOM depends on slot length.

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