DESIGN OF A PROTOTYPE DISK AND WASHER STRUCTURE FOR A HIGH INTENSITY ELECTRON LINAC

P.Fernandes, R.Parodi, A.Schenone
INFN-Genova Via Dodecaneso 33
16146 Genoa ITALY

ABSTRACT

The design of a Disk and Washer structure for an High current linac for electron accelerators is introduced.
The RF structure operating at 3600 Mhz is optimized for a BETA =1 electron beam, trying to avoid the overlap between the band of the accelerating modes and the bands of the dangerous beam deflecting modes.
The cavity geometry was not optimized for the maximum shunt impdance, but nevertheless a characteristic shunt impedance Z/Q of 463 ohm was obtained.
Measurements on a short prototype section built following our design shown a perfect agreement (in frequency and field distribution) with our computation.
The measured characteristic shunt impedance Z/Q of our prototype was 460 ohm in agreement with our computations.
The dangerous dipole modes inducing beam break-up were (as computed) 400 MHz apart from the operating frequency of the structure showing the correctness of our design.

INTRODUCTION

The possibility of using a Disk and Washer structure for an High intensity High gain R.F. linac was studied in many laboratories [1,2,3] due to the benefit of high shunt impedance and large bandwidth of the accelerating mode.Nevertheless the structure is not widely used for practical applications due to the major drawback of the overlap of the accelerating and coupling TMlike monopolar bands with the Hybrid dipolar bands.

This band overlap could induce serious beam unstabilities leading to beam break-up at a current lower than the design current of the accelerator.

Due to our interest for a compact, high gradient and efficient Standing Wawe linac structure to be used to build a low energy test accelerator for high energy detectors, we started a research programme on the DAW structure.

Our goal was to state whether the band overlap is a general feature of the DAW linac or that drawback can be overcome by a suitable choice of the parameters of the elementary cells of the linac structure.

We focused our attention mainly on the mode pattern of the resonant structure without attempting any optimization of the shunt impedance and efficiency of the structure itself.

We succeeded to design a DAW structure free from band overlap in the accelerating mode region, and with a reasonable shunt impedance (Z/Q) value of 463 ohm at a frequency of 3500 Mhz.

METHOD OF DESIGN

For the design of the structure we widely used computer codes for the computation of RF fields in SW-resonant structures.

We computed the first ten TE and TM monopolar modes of a linac unit cell by our OSCAR2D [4]code and the multipolar modes by the URMELT code[5] (courtesy of T.Weiland DESY).

in that way , by using a single cell of the linac and changing the boundary condition on suitable segments of the cell, we where obtain the values of the resonant frequency of the ZERO, PI and PI over TWO modes of the band pass under examination.

From those values we easily reconstructed the dispersion relation of that band pass of the structure[6]and checked whether for that geometry we have band overlap or not.

Once the right cavity shape had been found, the geometry was slightly changed till the perfect coalescence on the PI mode of the coupling mode bandpass and accelerating mode bandpass was obtained closing the stop band between the two pi modes.

After that a new complete search for the monopolar and multipolar modes was done to eventually detect a band overlap introduced by the previous geometry changes

the process converged after three iterations leading to the coalescent band overlap free cell shown in figure 1.

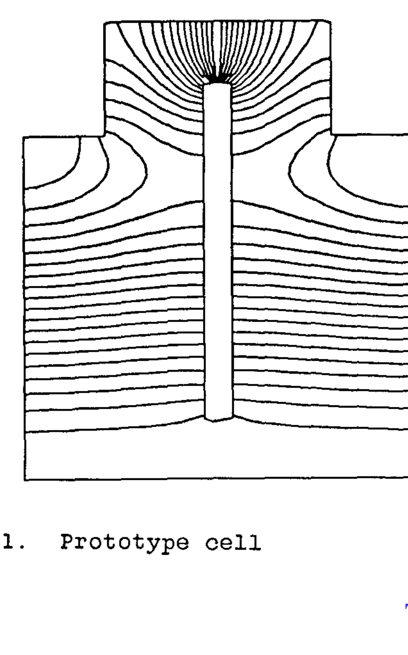

Figure 1. Prototype cell

The relevant RF properties of the cavity are reported in TABLE I.

TABLE I

GEOMETRY AND CAVITY PARAMETERS

f [MHz]	1053.	R [cm]	16.
Z [MΩ/m]	69.	Rw [cm]	13.8
Q	38000.	Rd [cm]	12.
T	0.725	tw [cm]	1.
ZT^2 [MΩ/m]	36.	td [cm]	5.8
Z/Q [ohm]	251.	r [cm]	2.

In figure 2 is reported the plot of the dispersion relation for the different band-pass showing no overlap between any multipolar mode and the accelerating one.

From that figure is straightforward to see that the accelerating mode is 400 Mhz below the frequency of the nearet dipolar mode.

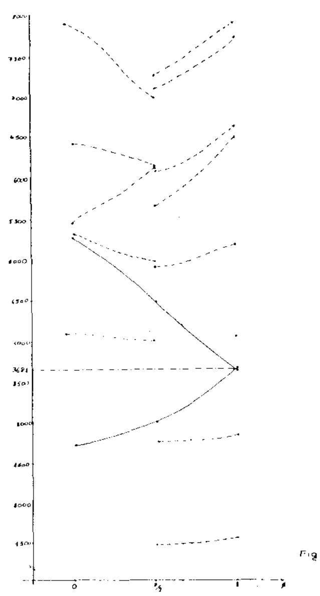

Figure 2, Dispersion plot for the infinite sructure.

EXPERIMENTAL

On the basis of our computation we built a small two cell prototype operating at 3.5 GHZ shown in figure 3.

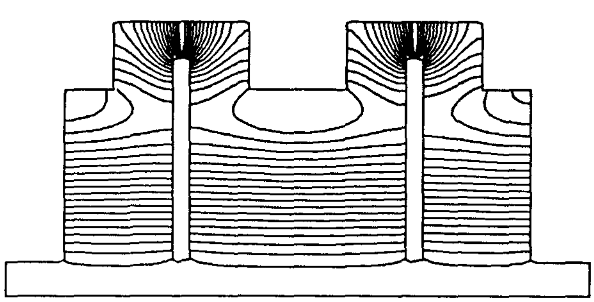

Figure 3, Two cell ptototype structure.

For that section we measured the resonant frequencies up to eight gigahertz and using a suitable set of rf probes we identified the bandpass of the dipolar quadrupolar and sextupolar modes.

The measured frequencies and the computed ones for the model structure are reported in TABLE II together with the mode band identification.

TABLE II

Computed Frequency [MHz]	Measured Frequency [MHz]	Error %	
2743.	2738.	0.3	
3018.	2995.	0.7	
3682.	3640.	1.1	TM monopolar
4517.	4464.	1.1	Modes
5479.	4438.	0.7	
6170.	6133.	0.9	
1645.	1644.	.06	
4011.	4021.	0.2	
4133.	4134.	.02	
4956.	4951.	0.1	
5236.	5252.	0.3	Hybrid Dipolar
5698.	5700.	.03	Modes
6576.	6500.	1.1	
7119.	7175.	0.8	
7759.	7760.	.01	
2786.	2775.	0.4	
2880.	2872.	0.3	
5029.	5048.	0.4	
5323.	5330.	0.1	Hybrid Quadrupolar
6135.	6143.	0.1	Modes
6685.	6670.	0.2	
7035.	7045.	0.2	
7962.	8000.	0.5	
4021.	4041.	0.5	
4089.	4100.	0.3	
6163.	6116.	0.8	Hybrid Sextupolar
6461.	6490.	0.5	Modes
7297.	7273.	0.3	
7945.	7925.	0.3.	

We also measured for the monopolar modes the axial field distribution and the characteristic impedance Z/Q for the accelerating one. the plot of the measured axial field is shown in figure 4; the value of the measured characteristic impedance was Z/Q=460 Ohm in very good agreement the value of 463 Ohm found by our computations.

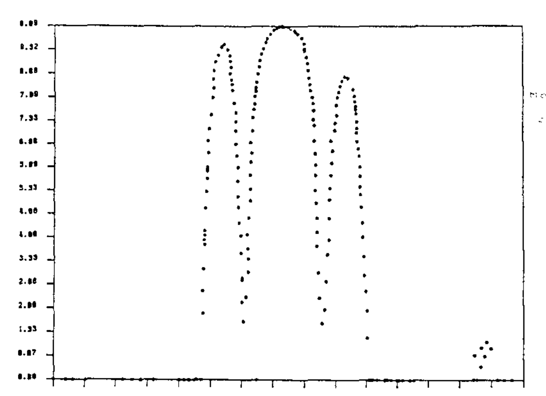

Figure 4 Axial field of the prototype cavity on the accelerating mode

REFERENCES

[1] J.J.Manca, E.A.Knapp, D.A.Swenson; "High energy accelerating structures for High gradient proton linacapplications"; IEEE Trans. Nucl. Sci., NS-24, 3, June 1977.

[2] S.Inagaki, T.Higo, K.Takata, H.Nakanishi, S.Noguchi, T.Furata, K.Kitagawa, E.Ezura, Y.Kojima, T.Takashima, "Developement of a disk and Washer cavity in KeK ", IEEE Trans. Nuc. Sci., NS-30,(4), 3752(1983).

[3] V.G.Andreev, V.M.Belugin, S.K.Esin, L.V.Kravchuk,V.V.Paramunov,"parasitic modes Removal out of operating mode neibourough in the DAWaccelerating Structure" IEEE- Trans .Nucl. Sci., NS-30(4) 3575(1983).

[4] P.Fernandes, R.Parodi,"Higher order modes computation in RF cavities" IEEE Trans. on Mag mag-24 (1) 154 (1988)

[5] U.van Rienen, T.Weiland, "Triangular discretization method for evaluation of RF fields in cylindrically symmetric cavities". IEEE Trans. Mag. Mag.21, (6)Nov 1985.

[6] P.Fernandes, R.Parodi, "On compensation of axial electric field unflatness in multicell accelerating structures", Particle accelerators Vol 14, (1984).