THE RESULTS OF RF HIGH POWER TESTS OF X-BAND OPEN CAVITY RF PULSE COMPRESSION SYSTEM VPM(JLC).

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Abstract

11.424 GHz "Open" Cavity RF pulse compression system [1,2] was designed and, manufactured under collaboration between Branch INP(Russia) and KEK(Japan). This is a single cavity system with travelling wave regime of operation that provides SLED type shape of the output RF pulse. 134 MW output RF peak power within 31 MW input was obtained in the high power tests with the first VPM 11.424 GHz system.

1.INTRODUCTION

To provide acceleration gradient about 100 MW per meter, future X-band Linear Collider requires RF pulsed power supply with peak RF power about 100 MW and 100 - 200 ns RF pulse duration. One of the most advanced schemes that can producces RF pulsed power with required parameters will consists of conventional klystron which can deliver a 100 MW x 1 μsec range RF pulsed power, and some RF pulse compression system that while shortening of the entire RF pulse by factor of 4 to 6, in several times increases peak RF power. There are some different scheme realizations of such an RF pulsed compression system that are being develop now . Most of them like SLED, SLED II and VPM operate in the same principle, which is discussed in details and can be found elsewhere [3,4,5]. The main difference between them is based on the type of RF energy storing element that is utilized by them and the regime of its RF operation. Two identical high-Q TE_{015} cylindrical cavities (SLED) or TE_{01} low-loss delay lines (SLED II), connected through 3-db coupler to avoid backward reflection of RF power to klystron, and single cavity VPM, where so called Barrel shaped "Open" Cavity operating with "whispering gallery" mode in travelling wave regime is applied.

In this paper, the latest results of the X-band VPM operation at high RF power level in alliance with one of JLC klystron from XB72k series are presented.

2. DESIGN AND PARAMETERS

VPM contains "Open" cavity which is excited from the waveguide laying around the perimeter of the cavity through the coupling slots. Phase velocities both in cavity and waveguide are set at the same frequency array by adjusting the width of waveguide. That provides travelling wave regime of the cavity operation, and hence only one cavity is necessary. Table 1 shows elementary parameters of the two VPM samples, those were measured in low RF power tests.

Table 1. VPM(JLC) parameters

Parameter	VPM #1	VPM #2
Operating mode	TM_{25-1-1}	TM_{25-1-1}
Mode frequency (GHz) at air	11.4222	11.4226
$Q_0 / 10^5$	1.9	1.9
$Q_{loaded} / 10^4$	0.9	1.1
Inserted losses (db) out of res.	< 0.27	<0.27
SWR	<1.15	<1.2
Operating T °C	30-40	30-40

The main feature of the "Open" cavity is that only so called "whispering gallery" modes can be excited, all the others which have weak azimuth dependence have large coupling through the cavity openings. Then extremely high Q-factor (more than 100 000) in X- or higher frequency ranges can be easily achieved with simply increasing of the cavity diameter, while spectrum density still stays low. VPM was designed to operate at 500 ns input and

100 ns output pulses durations. The Fig. 1 presents the results of computer simulations of VPM's efficiency and Peak power v.s. output pulse duration . Both VPM's differ some in their coupling to waveguide, this was done to operate with one of them at lowered peak RF power level, but practically at the same efficiency.

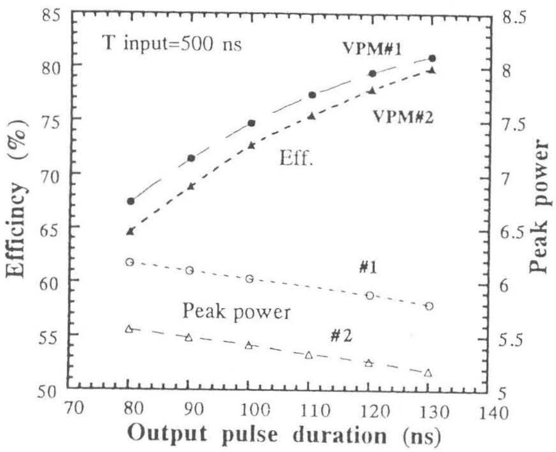

Figure 1. VPM Efficiency and RF Peak power v.s. output pulse duration with 500 ns input pulse.

The present design of the VPM has no mechanical fine frequency tuning. The frequency is adjusted by controlling the temperature of cooling water.

3.HIGH POWER TEST RESULTS

XB72k#2 [6] klystron was used to drive the VPM . Up to 35 MW RF power with pulse-width 500 ns by its flat top was finally applied. This regime was fixed as a highest RF power limit, to avoid the danger of the ceramic windows breakdown. Aging was carried out with repetition rate 25 pps (including 5 hours with 50 pps). A 110 ns phase reversion at the rear of the input pulse was used, as design. In first aging run VPM#2 was installed. VPM high power test set up is shown at Fig. 2.

Inserted losses of the waveguide line from klystron to VPM were about 0.4 db, thus at least 31.5 MW input RF power was applied to VPM. In 18 hours of operation, with 31.3 MW input, 134 MW output RF peak power was finally achieved. This regime was rather stable without any breakdowns within one hour of operation.

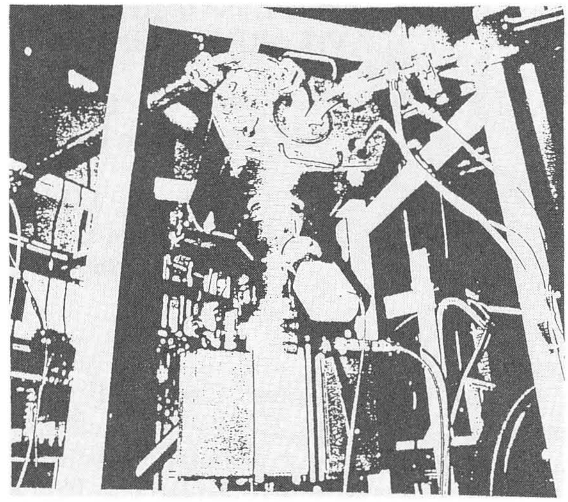

Figure 2. VPM high power test set up.

The history of high power RF conditioning is shown at Fig. 3

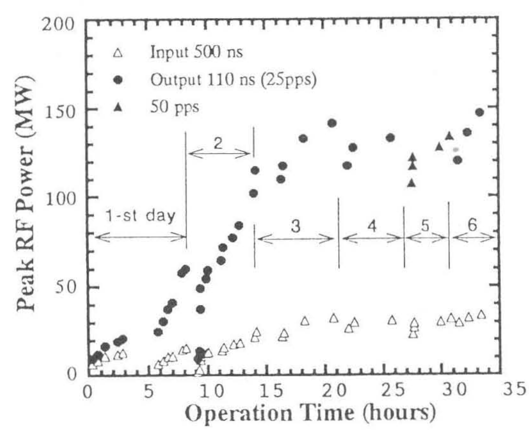

Figure 3. Aging results of the VPM(JLC)

Later there were done some attempts to increase the input power and a few observations of 150 MW output peak power were done, but VPM aging at this power level was impossible, as each breakdown was accomplished with serious worsening of the vacuum conditions around klystron windows area.

Ratio of RF output peak power to input was 4.2 instead of 5.3, that was predicted by simulation . Of course this is a result of time delay of phase switching and also of the RF phase drift during klystron output pulse. To carry out detailed simulation of the process, phase measurements of the klystron were done also. After that the phase behaviour of the klystron pulse was adopted to computer code.

To present the results of simulations in the most close form to experimental data, they were worked up using normalization by input RF power level, measured coupling attenuations to the detectors and detectors calibration curves. Waveforms of signals that were observed in high power tests are presented at Fig.4a) and calculated ones at Fig. 4b) respectively.

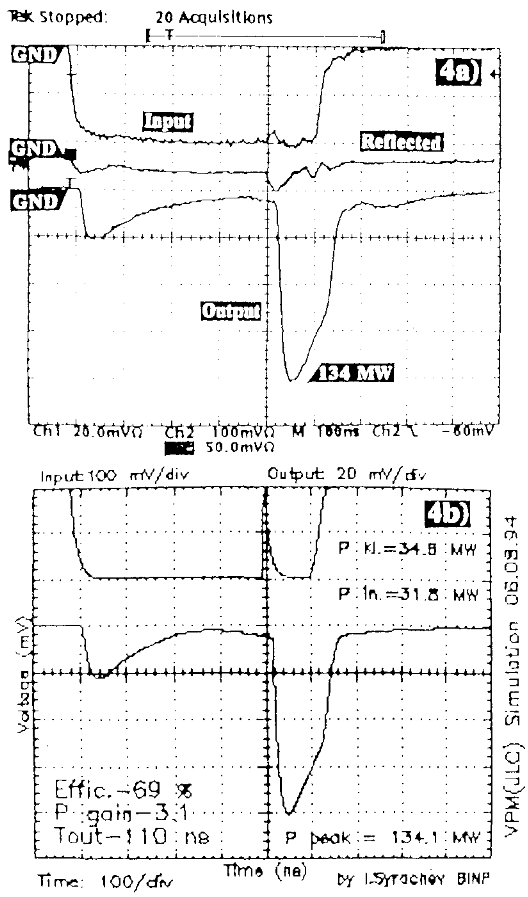

Figure 4. a) Signals waveforms, observed in VPM(JLC) high power tests, b) the same simulated with measured parameters of the input pulse.

Calculated ratio Ppeak/Pinp was almost the same as measured one. Thus we used calculation results to estimate efficiency of the device.It was 69 % with 500 ns input and 110 ns output and an average power gain - 3.1. One can see that deviation of klystron RF phase and phase reversal time decrease efficiency by 6 %.

VPM was pumped by ion pumps in the high power RF test-bench. Vacuum pressure in the VPM chamber 10^{-4} Pa was set as the threshold value to stop the klystron output. Without RF input, the vacuum pressure reached down to 1.6 x 10^{-5} Pa in four days and stay under this range. In the high power aging run the vacuum pressure rose up to 5 x 10^{-5} Pa.

In six days aging was finished. After disassembling of the VPM, a number of discharge marks were observed in the input and output waveguides of the VPM, while the cavity kept surface was rather clean. We suppose that this is a result of some waveguides cleaning process before their brazing to the cavity.

4. CONCLUSION

The first aging run results with VPM compressor showed good adequacy with computer simulations. 134 MW output peak power with efficiency 69 % and average power gain 3.1 (average output power 97 MW) for 500/110 ns compression ratio was achieved. No serious troubles such as an RF discharge or degradation of the cavity were observed in the high power RF tests.

5. ACKNOWLEDGMENTS

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