MODULATOR FOR KLYSTRON 5045

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Abstract

The first modulator for a forinjector klystron of VEPP – 5 is being tested now in BINP in Novosibirsk. The forinjector of VEPP – 5 will involve a 510 MeV Linac consisting of four accelerating modules. The Klystron 5045 manufactured at SLAC [1] was chosen to drive the accelerating modules. This paper presents a design and some testing results of this modulator.

I. INTRODUCTION

The modulator is a conventional line type modulator with some supplementary characteristics. A simplified electrical layout of this modulator is shown in Fig. 3. The voltage value in a filter capacitor $C_F$ is determined by a phase-control system with six SCRs. The $C_F$ charging current is limited by three 500 μH inductors connected to the primary winding of the rectifier transformer. In addition, this system provides “soft-start” capability and fast protection. The PFN is resonantly charged through a charging high-voltage SCR-switch (HV-switch), a charging inductor, and de-spiking circuits. The resonant PFN charge goes only after starting the HV-switch. A de-Qing system provides precise setting of the PFN voltage by stopping the charge when a required voltage is reached. When the thyatron is fired, the PFN is discharged through a coaxial cable to the klystron pulse transformer or to the load resistor. The 1:15 pulse transformer delivers a 350 kV pulse to the cathode of the klystron. The thyatrons TGI-2500/50 are used in the modulator. Output pulse waveform at the Klystron 5045 shown in Fig. 1 was obtained in the process of modulator adjustment.

Table 1. Modulator specification

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Required</th>
<th>Tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak output power</td>
<td>150MW</td>
<td>150MW</td>
</tr>
<tr>
<td>Peak output voltage</td>
<td>23.5kV</td>
<td>5 to 22.5kV</td>
</tr>
<tr>
<td>Pulse width</td>
<td>5μS</td>
<td>5μS</td>
</tr>
<tr>
<td>Flat-top width (tol.±0.5%)</td>
<td>4μS</td>
<td>3.5μS</td>
</tr>
<tr>
<td>Repetition rate</td>
<td>50pps</td>
<td>0 to 50pps</td>
</tr>
<tr>
<td>Peak klystron voltage</td>
<td>350kV</td>
<td>360kV</td>
</tr>
<tr>
<td>Peak RF power</td>
<td>67MW</td>
<td>60MW</td>
</tr>
</tbody>
</table>

A. Rectifier assembly

The rectifier assembly designed earlier [2] consists of 18 1.5 kV sections connected in series and placed on the common core. Each section is protected with fuses; that’s why if one or two of them would fail, it would not be necessary to take off and repair the whole rectifier.

II. High voltage switch

A high-voltage charging commutator consisting of 64 thyristors connected in series makes possible to charge the PFN immediately before pulse generating. In addition, such commutator is a convenient and reliable protection element. It allows us also to change the repetition rate 0 to 50 pps. To turn on simultaneously 64 thyristors, the circuit shown in Fig. 2 is used.

![Figure 2. Control HV-SCR circuit](image)

The capacitor and thyristor form a 2 μS leading edge of the HV-switch pulse control, then a 1 μS flat-top is formed by the transistor switching-on. The control pulse current is more than 0.1 A. To suppress unwanted oscillation of the charging circuit, the special measures are undertaken. After the charging current
has stopped, the de-Qing thyristor is kept in the ON-state till the oscillation caused by the thyatron switching dies down.

III. Pulse Forming Network

The modulator comprises two PFNs in parallel. Each of them consists of 13 sections with a fixed capacitor and a tunable inductor. It is placed in an oil-filled tank. The total characteristic impedance of each PFN is $8\Omega$. The inductors may be regulated from the outside of the tank.

IV. EOLC system

EOLC system comprising a diode and a resistor is used to remove the excessive negative voltage swing and to protect the klystron in the case of a break-down. The EOLC diode is composed of 60 rectifying elements connected in series and alternating with washers used as radiators with forced air cooling. A small size of diode assembly (total length is 370 mm) provides low inductance of EOLC.

V. Dummy load

The dummy load with the characteristic impedance $4\Omega$ is designed and installed to test the modulator without the klystron in a required range of output power. The dummy load is composed of 8 high-voltage resistors $S5 - 41$ connected in parallel. The introduction of water cooling allows us to raise the dissipated power of the load from 4 kW to 40 kW.

VI. Conclusion

Since the modulator is rigged with computer control and measurement, the protection system, the dummy load, and with a wide range of working voltage and repetition rate, it is possible to use it as the stand for testing and studying of both the modulator components and klystrons.

References

Figure 3. Simplified electrical layout of the modulator

Figure 4. Position of the main components in the cabinet (sizes are in mm).

Figure 5. View of the modulator