Klystrons and Modulators for the SPring-8 Linac

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As the SPring-8 is a commercial operating machine, it is to be desired that shutdown or maintenance time is shorter as possible. So even if one or two klystrons failed, beams of which energy is more than 1GeV has to be provided, to the SPring-8 Synchrotron. For this reason, we selected TOSHIBA E3712's, of which peak output power are 80MW, for main klystrons. Modulators for these klystrons are line-type, and the peak output power is 200MW. They are now under construction by Toshiba Corporation. The modulator itself is controlled by a sequencer unit, and communicates to the upper control system through VME boards, which are mounted near the modulator body. So it is very important to reduce noise level of the modulator.

In our system, there are two another klystron and modulator sets. One is PV-3035 made by Mitsubishi Electric Corporation, which peak output power is 35MW, for positron focusing section. And the other is MITSUBISHI PV-2012 (7MW) for a booster-klystron which feeds drive power to other klystrons and also feeds rf to pre-bunchers and a buncher. In the positron focusing section, an accelerator structure is mounted in strong magnetic field for focusing positron, so it is difficult to input a large rf power to the accelerator structure. For this reason, we adopted lower power klystron.

E3712 klystron has two drive modes. One is 80MW operation mode, where an rf pulse width is 5 μsec. The other is 100MW mode with pulse width of 1 μ sec.

These klystrons have been adopted at JLC(KEK), PLS(POSTEC), and FEL lab. for several years. In JLC, 10 klystrons have been used with both modes since March 1989, and in PLS, 11 klystrons have been driven since May 1992 with the 80MW operation mode. In FEL lab., two E3729s which are remodellers of E3712 have been used since February 1994. The output power of E3729 is 24MW with rf pulse width of 24 μsec, and 70MW with 0.5 μsec. Now, none of the E3712 or E3729 klystrons has been broken down.

In the SPring-8, both short pulse beams (~40nsec) and long pulse beams (~1 μsec) are requested. From a view point of filling-time of accelerator structures or flatness of the klystron beam current, the 80MW mode is adopted in the Linac. Our design parameters and absolute ratings of the E3712 klystron are shown in TABLE.1. 13 klystrons were ordered to TOSHIBA, and first klystron has already constructed. Output power of 80MW were achieved with the rf pulse width of 3 μsec. All klystrons will be delivered to the SPring-8 site by autumn, 1995.

TABLE.1 E3712 klystron parameters

	Absolute ratings	SPring-8 operation
Frequency	-------	2856MHz
Peak Beam Voltage	470kV	391kV
Peak Beam Current	630A	474A
Peak OutputPower	84MW	80MW
Drive Power	-------	255W
Pulse Width (beam)	6.7 μsec	5 μsec
Pulse Width (rf)	5 μsec	4 μsec
Repetition Rate	60pps	60pps
Efficiency	-------	44%

The first modulator for the E3712 is now under construction and will be accomplished by May, 1995. Its design parameters are shown in TABLE.2. An input power is 95kVA, and a peak output power is 200MW, the pulse width of flat top will be more than 2 μsec with fluctuation of less than $\pm$0.5%. The Pulse-Forming-Network (PFN) has 4 parallel networks, and each network has 14 pill-box type oil condensers, of which leakage inductance are less than 250nH (This includes value of circuit between the condenser and an analyzer). Moreover, pares of adjoining coils have mutual inductances which decrease leakage inductance of the condenser

TABLE.2 modulator parameters

Input Power	95KVA
Output Voltage	25kV
Output Current	8.0kA
Pulse Width (FWHM)	5 μsec
Pulse Width (flat top)	2 μsec
Repetition Rate	60pps

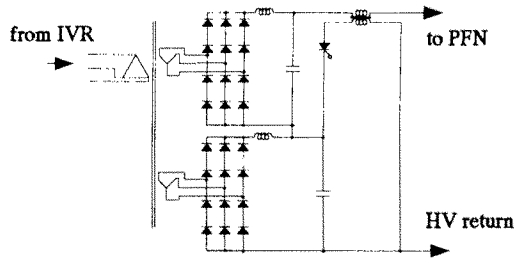

FIG.1 Outline of DeQ'ing circuit section

equivalently. Simulation data of the PFN cleared the fluctuation level. A thyratron is ITT, F-157, which maximum rating voltage is 75kV and current is 20kA. A De'Qing circuit shown in FIG.1 is a re-chargeable type circuit, and has a range of 7% regulation. Assemblies of modulator output cable are tri-axial, made by STANGENES, where two cables are connected parallel to a pulse-transformer tank. A pulse transformer and the tank are also made by STANGENES.

Signal cables connect from modulator to control section, where sequencer and VME boards are mounted. So, the earth potential regulation will be appeared as one of problems. Three kinds of filters, isolators, passive filters or bypass condensers, will be inserted in cable lines. A test of the control section against noise or potential regulation will be held on May, 1995. If the protection of the noise is not good enough, we will re-design filters, or earth systems.

The design of the 200MW modulator has finished in 1994. And all 13 modulators will accomplished by the end of 1995. The other modulator design will also be finished in spring 1995, and delivered by autumn. Tests of modulators and klystrons in the Linac building will start at the beginning of next year.