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Development of a solid-state high-voltage switch device for an insulation oil-filled klystron modulator

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Although many high-voltage pulse modulators for high-power pulse klystrons use thyratrons as a high voltage switch device, their instability and short lifetime are headache for large accelerator facilities including the X-ray free electron laser facility SACLA (Spring-8 Angstrom Compact free electron LAser). In SACLA, 78 klystron modulators for an 8 GeV linac are operated as high-power rf sources. Since the typical lifetime of the thyratron is short for about 4 years, its high-maintenance cost are serious problem. In order to overcome this problem, we have developed a solid-state high voltage switch having a long lifetime for thyratron replacement. The high-voltage switch device of our modulator should run at a 60 pps repetition rate and conducts a large current of 5 kA with a 5 us pulse width from the pulse forming network circuit charged at 50 kV in maximum. We employ the static-induction (SI) thyristor as the high-voltage switch, because it has suitable characteristics for the thyratron replacement; a high off-state voltage, large pulse current capacity, a fast switching time, and a low conduction loss. In total, the 192 SI-thyristors (24 series, 8 parallel) are used in a 50 kV switch module. Since our modulator is filled with an insulation-oil, water cooling of the device is not so easy. Hence, we attach the SI-thyristors on aluminum heat sinks forcibly cooled by oil circulation. Performance check in high-voltage operation for the switch was carried out by connecting it to the actual klystron and modulator. The switch stably run at a 50 kV charging voltage, a 5 kA pulse current and a 60 pps repetition rate. A temperature rise of the SI-thyristor is about 7 degree, which is low enough. Validity of employing the module for the high-voltage switching is well confirmed.

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