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論 文 内 容 の 要 旨
Abstract of Dissertation

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Pulse power technology has been widely applied in the fields of industries. Compactness, solid-state and high repetition rate are the most important development trends A compact and solid-state Marx generator using saturable pulse transformer (SPT) is proposed to verify the feasibility of the method to reduce the rise time. A compact and solid-state LC-Marx generator using SPT is proposed and investigated to get high voltage with the same rise time by stages superposition. The generation of high square voltage pulse wave based on Blumlein pulse forming network (PFN) using SPT with the same rise time by stages superposition. The three main contents are as follows.

1. Solid-state Marx generator using saturable pulse transformer

A solid state Marx generator using saturable pulse transformer (SPT) has been developed. The primary circuit is switched by a switching unit consisting of three MOS-gated thyristors connected in parallel. The SPT functions both as a transformer to increase the voltage and as a closing switch for the secondary circuit. Meanwhile, all the SPTs use the same one transformer core can not only make the structure compact, but also ensure the synchronization of discharge to avoid the influence of switch jitter on rise time. The energy storage capacitors on the secondary side is charged by the transformer and switched by the SPT. Then, a pulsed output is generated on a load. The rise time is almost same under different stages, as it is mainly decided by the turn-off speed of the diode. In the demonstration experiment, the output with peak voltage of ~ 10.80 kV, FWHM of ~ 150 ns and rise time of ~ 11 ns (10％-90％) was obtained on a resistive load of 100 Ω with a 4-stage Marx generator. The total energy efficiency is ~ 49.08 %. This pulsed power generator has been tested at repetition rate of 20 kHz in burst mode.

2. Solid-state LC-Marx generator using saturable pulse transformer and magnetic switch

An all solid-state compact LC-Marx generator based on saturable pulse transformer (SPT) has been proposed and analyzed. It could be operated by 1 semiconductor switch in primary circuit. The SPT functions both as a transformer to increase the voltage and as a closing switch for the secondary circuit. All the SPTs share the same one magnetic core to avoid the influence of switch jitter on rise time. Meanwhile, the inductance of SPT is outside the discharging circuit to reduce the influence of inductance on rise time. The capacitors are connected end to end not only minimize the inductance connected to the discharge circuit, but also make the structure as compact as possible. In the demonstration experiment, 3-stages LC-Marx generator could generated peak output voltage of ~ -20 kV with pulse width at half-maximum of ~ 300 ns and rise time of ~ 70 ns on the resistance load of 600 Ω with charging voltage of 900 V. The total energy efficiency is ~ 41.25％. This pulsed power generator has been tested at repetition rate of 30 kHz in burst mode.

An all-solid-state LC-Marx generator based on magnetic switch has been proposed and analyzed by theory, simulation and experiment. This system is controlled by 1 MOSFET and magnetic switches that are made by 1 magnetic core. It has dimensions of 130 mm (diameter) and 60 mm (height), which almost not change with the stage increase. The capacitors could be charged to 1.82 source voltage according to the principle of resonant charging. Five-stage LC-Marx generator could obtain a peak output voltage of -10.9 kV with rise time of 80 ns when the source voltage of 950V is applied, and the energy efficiency is 30.43 % . The generator has been tested under 30 kHz that could work steadily. It could output higher voltage when applying n atmospheric discharge.

3. Solid-state pulsed power generator based on Blumlein PFN using saturable pulse transformer

A solid state pulsed power generator has been developed. It is based on Blumlein pulse forming network (PFN) combined with saturable pulse transformer (SPT). The primary circuit is switched by a switching unit consisting of three MOS-gated thyristors connected in parallel. The SPT functions both as a transformer to increase the voltage and as a closing switch for the secondary circuit. The PFN on the secondary side is charged by the transformer and switched by the SPT so that a pulsed output is generated on a matched load. In the demonstration experiment, an output with peak voltage of ~ 10.4 kV and pulse width of ~ 160 ns was obtained on a resistive load of 52 Ω. Furthermore, three identical modules, sharing the common primary circuit, have been connected in series to demonstrate voltage adding, where a peak output voltage of ~ 30.0 kV was obtained on a load of 156 Ω with energy efficiency of ~ 54.37 %. This pulsed power generator has been tested at repetition rate of 20 kHz in burst mode.