4Pa36

高速点火核融合実験における中性子計測用 多チャンネルゲートシステムの開発

Development of Multichannel Gating System of Neutron Detector Array in Fast-Ignition Laser Fusion Experiment

中島希[1]，安部勇輝[1]，有川安信[1]，水谷亮介[1]，高橋将太[1]，小坂匠[1]，
余語覚文[1]，西村博明[1]，中井光男[1]，白神宏之[1]，兒玉了祐[1]

Nozomi Nakajima[1], Yuki Abe[1], Yasunobu Arikawa[1], Ryosuke Mizutani[1], Shota Takahashi[1], Takumi Kosaka[1], Akifumi Yogo[1], Hiroaki Nishimura[1], Mitsuo Nakai[1], Hiroyuki Shiraga[1], Ryosuke Kodama[1],

[1]大阪大学レーザー科学研究所
[1]Institute of Laser Engineering, Osaka University

The interaction of high-power laser pulse with matter has demonstrated a new potential to produce bright neutron source with a compact system that can be employed in various scientific, medical, and industrial applications. The recent progress in laser particle acceleration technique has allowed to use a number of nuclear reactions to produce neutrons including nuclear fusion ($D(d,n)^3He$, $D(t,n)^4He$), photonuclear reaction, and breakup and stripping reaction such as Be(d,n)B.

Time-of-flight (ToF) is an effective measurement technique for neutron spectroscopy in laser-plasma experiments. However, the current laser-driven neutron sources are in many cases accompanied with intense hard X-rays, which precede neutrons in ToF arrangement and make neutron measurement difficult. Neutron detectors composed of a photomultiplier tube (PMT) and an organic scintillator suffers from long-lived dynode voltage depletion, persistent anode currents, and amplifier gain saturation (we call these effects simply as “overloading”) upon exposure to an intense scintillation flash due to the hard X-ray event. This overloading of PMT results in a nonlinear response to the subsequent neutron signal. Furthermore, an intense optical event on PMTs causes serious signal-induced background noises known as “afterpulses”, which could in principle dominate the output signal in the microsecond scale time even if the PMT is deactivated during the optical event by an electrical time gating (ETG) system.

We have developed a simple ETG circuit that is capable of driving hundreds of PMTs at the same time with very low afterpulse rate so that the ToF measurement can be performed in multiple directions around the neutron source even in the presence of hard X-rays. Our gating circuit is not only able to disable the PMTs with reasonable cutoff ratio (the ratio of PMT gain between ON and OFF state, > 10^3) but also able to drive the PMT back to the normal working condition in a very short time (< 100 ns) at any required timing. In addition, the circuit configuration is quite simple (see Fig. 1) and it can be easily installed into any multichannel detector system.

In our presentation, we will show the design and performance of the multichannel gating system and discuss future prospects of neutron diagnostics in the super-intense laser-plasma interaction experiments in the fields of research such as fast ignition ICF and laser-driven neutron sources.

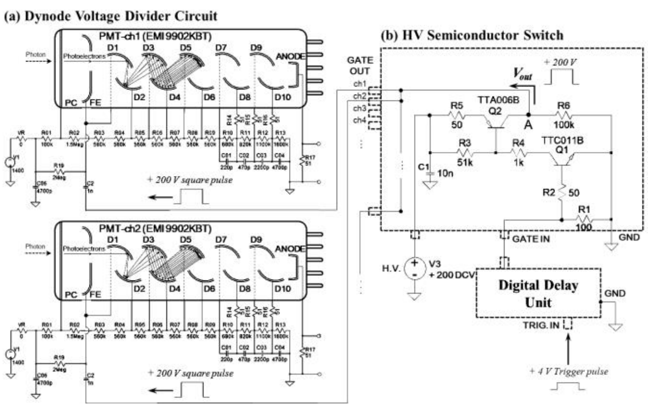

Figure 1: Circuit diagram of the multichannel gated PMT. Cathode-D1 voltages of all the PMTs are simultaneously switched by only one switching circuit module coupled with a digital delay pulse generator and a DC power supply.