Development of the new circuit to readout MPPCs for the KOTO experiment

Yuta Sato

February 26, 2018

Abstract

Motivation of the J-PARC KOTO experiment is to search for new physics beyond the standard model through the rare decay of the neutral K meson: $K_L \to \pi^0\nu\bar{\nu}$. The branching ratio of the decay is expected to be 3×10^{-11} according to the standard model. This small ratio makes background reduction important for the KOTO experiment.

In this work, I developed a readout circuit for the multi-pixel photon counter (MPPC) to reduce neutron background at the KOTO experiment. I first developed a circuit to connect MPPCs and send signals from MPPCs to an amplifier board. I studied two methods to connect MPPCs. One is called "Parallel" method, which connects MPPCs in parallel and uses resistors and capacitors to shorten the time constant. The other is called "Hybrid" method, which is used at the MEG II experiment. I decided to use the Hybrid method because it has better timing resolution than the Parallel method.

I then confirmed the durability of the coaxial cables to transmit the signals from the MPPCs to the amplifier. This test is important because only one broken cables make severe damage on the readout system.

I also developed the amplifier circuit to readout and process signals from MPPCs. Amplifier boards should not consume high power because they will be placed in vacuum. In addition, in order to readout signals from MPPCs without deformation, the amplifier has to operate up to approximately 30 MHz. I thus selected operational amplifiers and designed the circuit to satisfy also the requirement.

I also checked the performance of the new readout method. Timing resolution of the new readout system is (1.45 ± 0.03) ns, which satisfies the requirement to reduce neutron background by more than 90%.