# A Gating Grid Driver for Time Projection Chambers†

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The SπRIT (SAMURAI pion Reconstruction and Ion Tracker) experiment utilizes the SπRIT Time Projection Chamber (TPC)[1)] as the main detector. The TPC operates within the uniform magnetic field of the SAMURAI magnet. Within its field cage, the TPC provides a uniform electric field anti-parallel to the magnetic field. When particles travel through the field cage, they ionize electrons from the counter gas, leaving tracks of electrons. These drift electrons move upwards to the detection region, which consists of wire planes which amplify the electron signal via avalanche process and a 2-D pad plane to readout the amplified signal. The avalanche process produces many positive ions, which can alter the electric fields in the detector. Both the electrons and positive ions cause aging effects on the wires. To avoid space charge problems and aging effects, a gating grid wire plane is used to close the detection region to prevent drift electrons from reaching the avalanche region unless a trigger has been provided. The gating grid operates with an average voltage $V_a$ that matches the electric field from the field cage. In the open state, all wires are maintained at the average voltage $V_a$. In its closed state, the voltages of alternate wires are offset by voltage $\Delta V$ from $V_a$ to voltage $V_h$, which is $\Delta V$ higher than $V_a$, and voltage $V_l$, which is $\Delta V$ lower than $V_a$. Drift electrons will be attracted to the wires at $V_h$ and repelled from the wires at $V_l$, causing them to terminate at $V_h$. The time it takes to transition between closed and open must be minimized, as electrons which reach the detection region before the gating grid opens will not be detected. To control the opening and closing of the gating grid, a gating grid driver was developed at MSU to quickly drive the voltages from closed to open, and then back to closed again.

Key features of this gating grid driver include using a low-impedance transmission line, as well as using two pairs of N-type and P-type MOSFET switches to drive both the opening and closing of the gating grid. For the opening of the gating grid, the $V_h$ and $V_l$ wires are shorted together using an N-type and a P-type MOSFET switch, bringing them to the common voltage of $V_a$. These switches are denoted as $N1$ and $P1$ in Circuit A of Figure 1. To return the gating grid to the closed state, the switches $N2$ and $P2$ are used to quickly recharge the wires to $V_h$ and $V_l$.

In the recent SπRIT experiment, the gating grid driver was used to drive the gating grid of the SπRIT TPC. Both the TPC and the gating grid driver are located inside the SAMURAI magnet. According to GARFIELD calculations, in a magnetic field of 0.5T, $\Delta V$ should be less than 10V to achieve 90% electron transparency, effectively opening the gating grid. This condition is achieved within 350 ns of providing the signal to open. The gating grid with the driver worked succesfully, with only a small pickup correction evidenced by the changing of $V_a$, which can be removed from the data at in offline analysis. The analysis of the performance of the gating grid is ongoing in offline analysis.

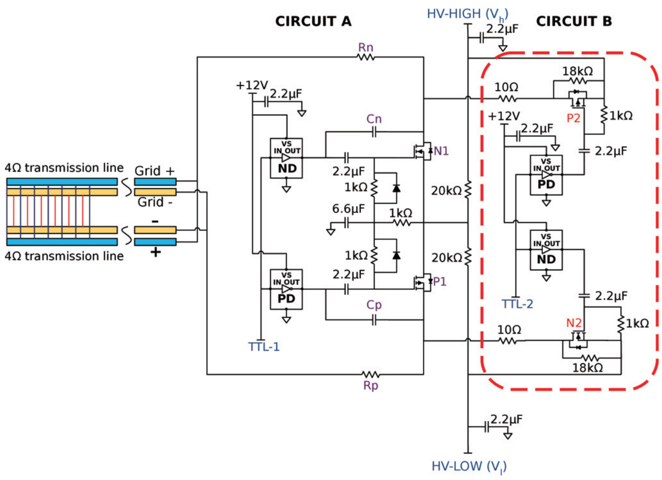


Fig. 1. The gating grid driver circuit design. Circuit A refers to the left side, while Circuit B refers to the circuit inside the red-dashed area.

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Reference

1) R. Shane et al.: Nucl. Instr. Meth. A **784**, 513 (2015).

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