Simulating Photodiode Readout Circuit for EIC-DIRC Laser Tests

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Quartz bars in the EIC-DIRC detector will undergo acceptance tests to ensure they reflect at least 99% of light through the bars. For these acceptance tests, a laser will be directed into the bar and photodiodes will be used to quantize the amount of light that passes through the bars. When the light hits a photodiode, it induces a current response proportional to the power of the light. For the test station readout, the current response will be converted to a voltage and read by an ADC. To ensure that the best current-to-voltage conversion circuit is used, one was simulated in Multisim Live.

The current-to-voltage conversion circuit selected is an active transimpedance amplifier. This circuit uses an op-amp and both amplifies and converts the current into an ADC-readable voltage. Taking into consideration the test station photodiodes' physical characteristics, the power of the laser, noise in the laser's power output, and parameters of an op-amp candidate for the circuit, the circuit in Fig. 1 was designed and created in Multisim Live (a free, online version of Multisim with basic circuit components).

The photodiode (portion of Fig. 1 in an orange, dashed box) was modeled as an ideal sine wave current source with 1-mA amplitude, 10-mA DC offset, and 30-kHz frequency (amplitude, offset, and frequency represent expected signal and noise level of photodiode response to laser power), an ideal diode, a capacitor whose value is the photodiode's junction capacitance, and a resistor whose value is the photodiode's shunt resistance. The op-amp used in the simulation is an ideal op-amp model with a feedback resistor appropriately sized to get the desired amplification and a feedback capacitor appropriately sized to stabilize the op-amp's output. After the op-amp, a low-pass filter was designed to filter out effects of the noise in the laser's power (that 1-mA 30-kHz portion of the input current), reducing it's effects to below 186 µV, the resolution of the ADC selected for the test DAQ.

Fig. 2 and 3 are plots of the current input to the circuit (measured at the green probe in Fig. 1) from the photodiode model and the resulting voltages before (blue probe) and after (pink probe) the low-pass filter, respectively. From the plots, it is evident that the circuit converts the input current to a voltage readable by the ADC and it is filtered to reduce the effects of noise in the laser's power on the measured voltage result.

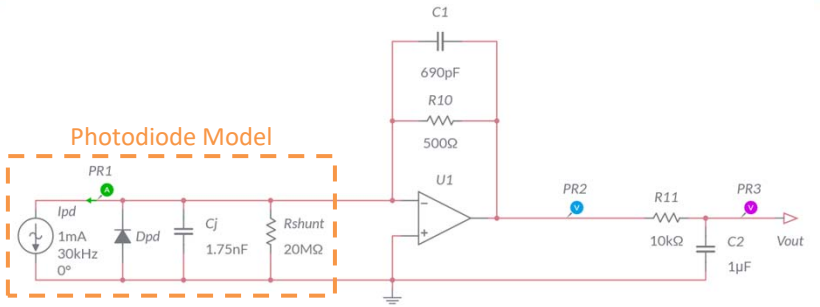

Fig. 1: Circuit schematic used in Multisim Live.

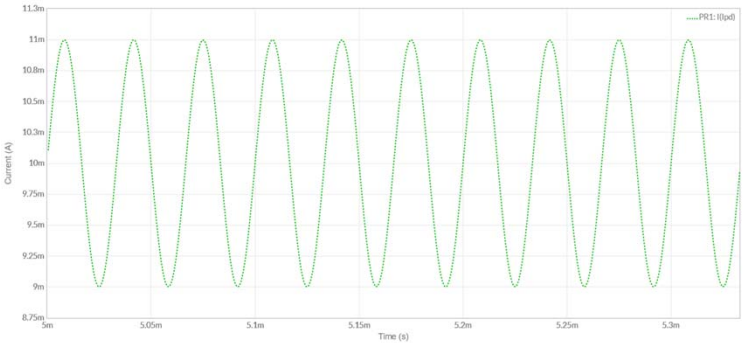

Fig 2: Current input to op-amp from photodiode model.

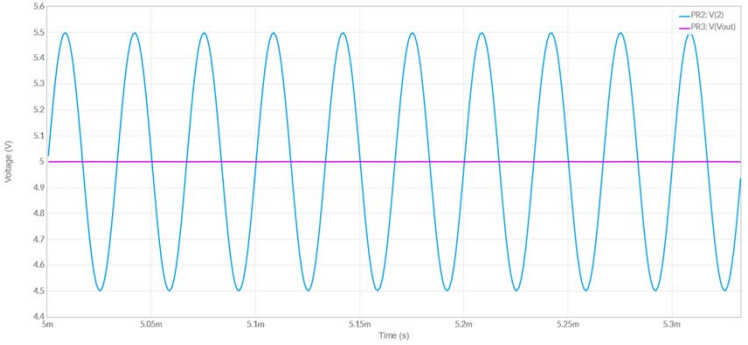

Fig. 3: Voltage output from op-amp before (blue) and after (pink) low-pass RC filter