Practice 1: PMT signal conditioning circuit

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Abstract

In this work a given pulse emited by a photomultiplier PMT is conditioned to be read by an analog digital converter ADC. The pulse and conditioning circuit was simulated in ltspice. The conditioning circuit consist of inverting amplifier and peak detector.Finally the circuit was tested for different initial pulses.

A PMT is a common transducer in High Energy Particles HEP experiments. This device produce an electric signal proportional to the intensity of te impinging light. This allows to calculate the rate of arriving particle to the detector. The goal of this project is to simulate this signal and prepare it for an ADC lecture. The Project will be devided in 3 subsections given every stage of the simulation consisting of: Source simulation, Amplification and Peak Detection; and a final section of simulation for diferent incoming signals.

Source Simulation:

In ltspice it is possible to simulate pulse using a voltaje source. Specifically for this Project it was used the exponential form with parameters shown in figure3. This peak simulation allows to model a pulsing signal for differents Widths and intensities. To match the expected signal from a PMT the initial pulse was made to fit the provided one figure1,2.

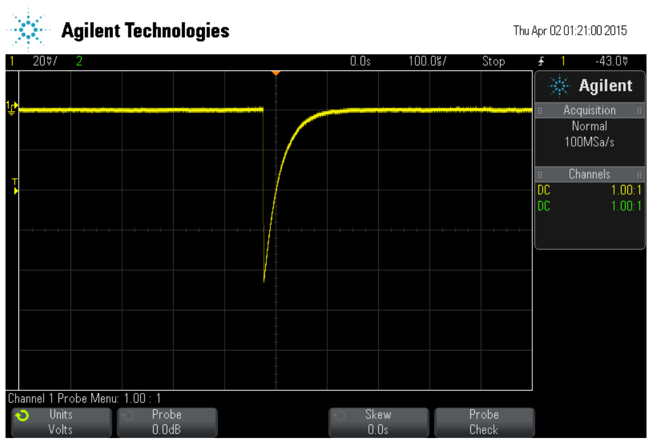

Figure 1: Actual signal from a 9" PMT working at 1200V HV nominal level

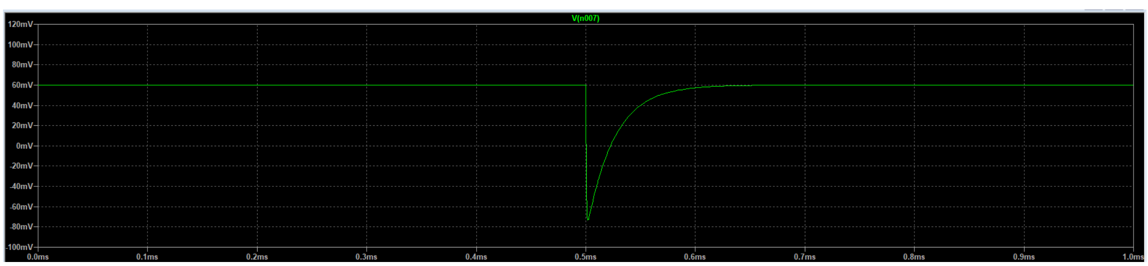

Figure 2: Pulse Simulated in ltspice

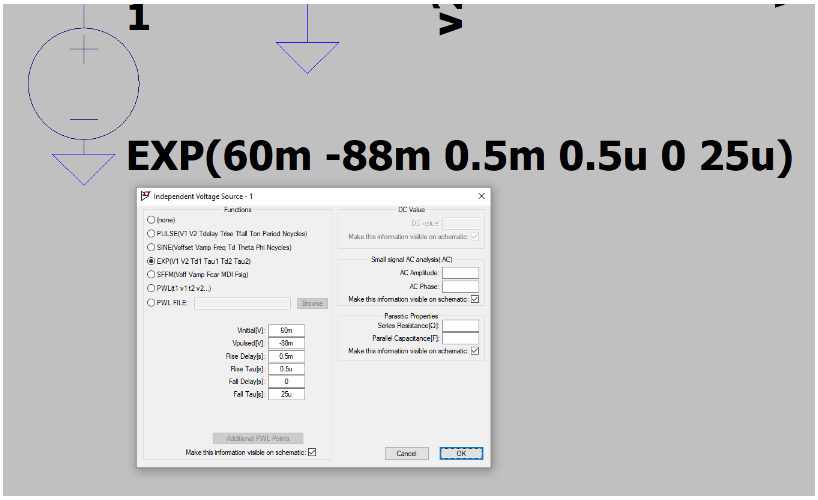

Figure 3: Settings ltspice source configuration for an exponential pulse

Amplification:

In this stage it was used an inverting amplification circuitcircuit and also it was also added a small 60mV source to set the noise to zero Figure 4. The multiplying factor of the amplification is 10 and the resistencias are in the range of 5kΩ - 50kΩ. This Resistances are also slected in order to reduce the negative effects of the slew rate of the Opeational Amplifier OAmp. THe OAmp is a OP777 due to its slew rate conveniently choosen for this circuit.

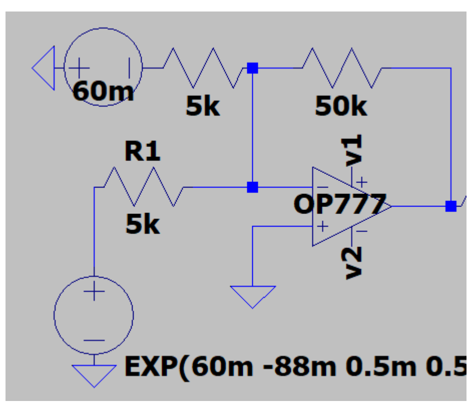

Figure 4: Inverting amplifierand sumation of the pulse

Peak Detection:

In the peak detection it was used a Two-Stage Active Peak Detector Figure 5. OAmp, resistamce, capacitors and diodes where choosen to better fit the aim of the project. The most important remarks in the conformation of this circuit are the slecction of the capacitance $0.01\mu F$ to allows a fast charging time and the discharge resistance $50k\Omega$ to prolonge this process as long as possible. Another oimportan remark of th circuit is the slection of the diode, in this case a zener diode which only attribute considered was that the reverse Voltage tolarance were high enougth to allow a well behaved peak detector notice that the with of the output signal is wider than the time resolution of an ADC.

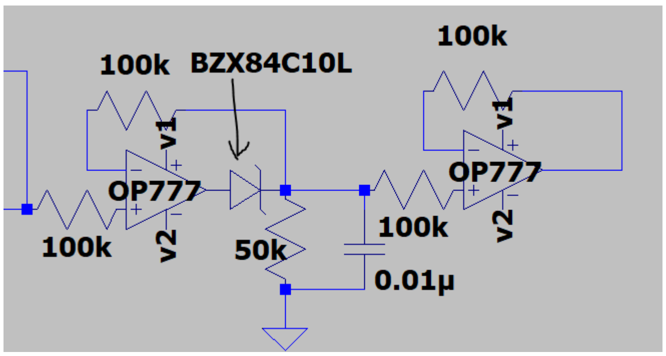

Figure 5: Two-Stage Active Peak Detector with 50kΩ discharge resistance and 0.01μ capacitance

Using this finel set up the simulation was runned and the varying signals are presented in Figure 6.

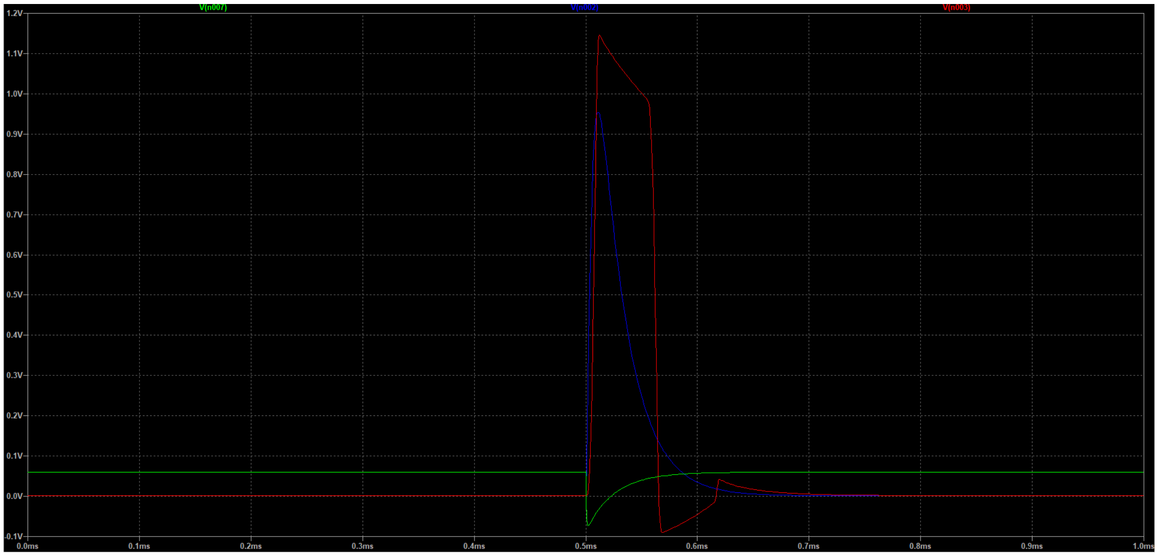

Figure 6: In green incoming simulated pulse, in blue amplified and inversed signal, in red output conditioned signal

Simulation:

In the simulation stage the initial pulse was varied in width and intensity and the beheavior of the circuit was studied y doing so. First, the output signal is compared for direrent widths $\tau = 25, 10, 5, 1, 0.75\mu s$. For 25μsee figure 6 and for the rest od the wisths se figure 7.

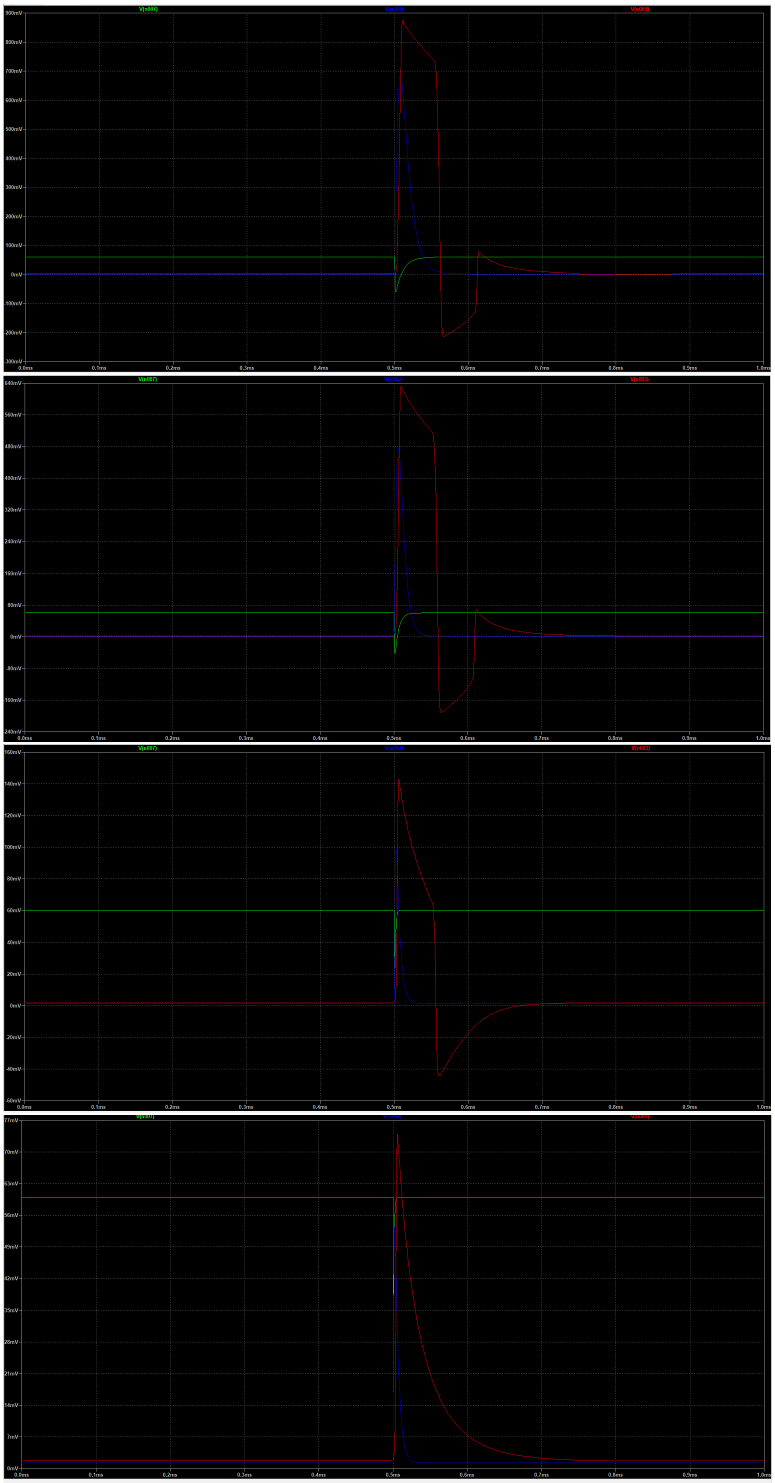

Figure 7: From top to botom comparison of diferent conditioning outputs for different width of the initial pulse $\tau = 10, 5, 1, 0.75\mu s$

As may be seen the effectiveness of the circuit decreases for narrower pulses reaching a non amplification for $\tau = 0.75\mu s$.

To test the imput range of the peak detector the ampification factor resistance was varried $R = 50, 40, 30, 25, 20k\Omega$. Resitance 50k$\Omega$is presented in Figure 6 and for the rest of resistance check figure 8.

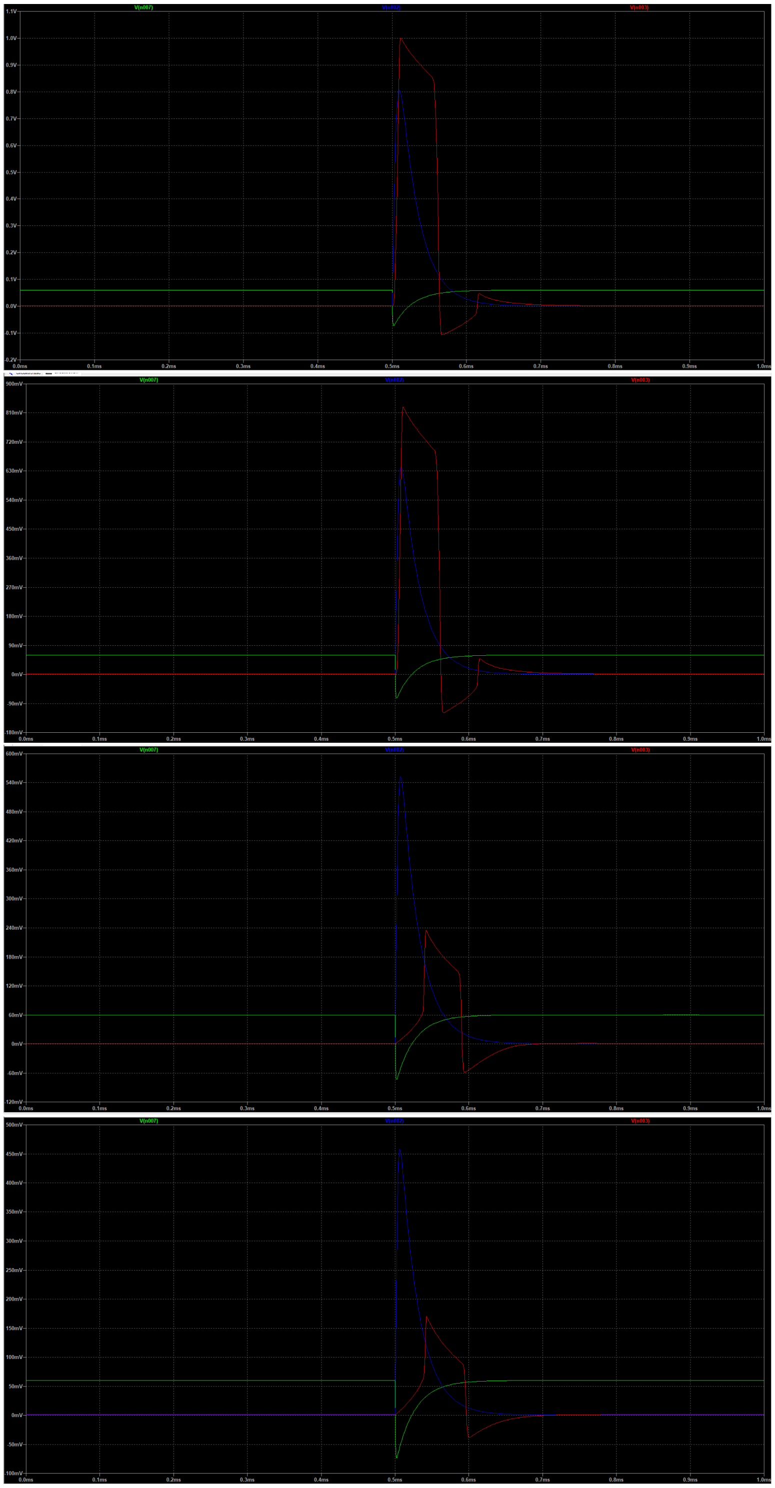

Figure 8: From top to botom comparison of diferent conditioning outputs for different amplification resistances of the initial pulse $R = 40, 30, 25, 20 k\Omega$

As may be seen the inputo range of the peak detector is given by a resistance between 30-25kΩ that is equivalent to a vointensity range between 540-630mV.