Intro to Measurement Systems

LA-CoNGA physics

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PRACTICE 1: PMT signal conditioning circuit

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1 Introduction

A photomultiplier (PMT) is the most popular transducer in High Energy Particle (HEP) detection application. A PMT produce an electric pulse proportional to the intensity of light produced by the interaction of a HEP particle with matter (water for a Water Cerenkov detector for example). The basic task in detecting HEP particle is to calculate the rate, i.e. count the amount of particles arriving at the detector in a certain time. Rate is measured in Hertz and depends of several factors, see ref(1).

In this activity you have to design and simulate a peak detector circuit which be used to convert the PMT signal to an impulse suitable for a digital system which will perform the counting task.

Some of the contents needed to this work you already know, others must be studied during this activity

2 Objectives

- Main Objective: Design and simulate a PMT signal conditioning circuit
- Activities:
  - To design a signal amplifier with op amps
  - Learn about a peak detection techniques
  - To design an amplifier and peak detection circuit
  - To simulate the circuit and show results

3 Activities

3.1 Signal amplifier

PMT signal is a negative pulse of few tenths of milivolts height and microseconds wide, an example is shown in the following figure:

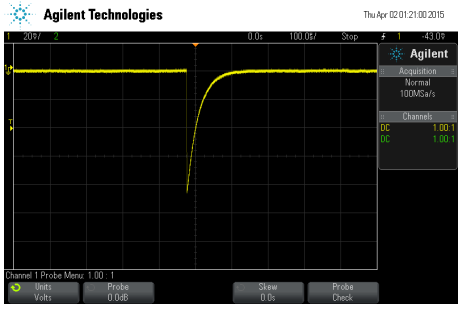

Figure 1: Actual signal from a 9" PMT working at 1200V HV nominal level

This "original" signal must be inverted and amplified to a hundred of milivolts range to be compatible with a analog to digital converter ADC or any digital circuit used to record and post process this signal. Take into account that a typical PMT signal voltage range cpuld from 20mV to 200mV

A replica of this signal must be created and stored in a voltage source (function generator) in LTSpice, see ref(2).

Design a circuit that inverts and amplify the signal, choose the right op-amp model, factors as *slew rate* could be important, see ref (3)

3.2 Peak detector

A signal diode is the key component of a peak detector, a simple rectifier circuit could act as a peak detector but it has limitations.

For this activity you have to explore active peak detector circuits based on a combination of diodes and op amps, see ref(4).

The parameters of this circuit depends of the output characteristics of the signal amplifier designed earlier.

3.3 Simulations

Simulate the whole circuit and test it for different levels of signals, try to change the pulse width and height of the PMT signal to determine:

- What is the narrowest signal your circuit can detect
- What is the input range of your peak detector

4 Report

Write a detailed report of this activities focusing in how you can use this circuits to build a cosmic ray particle detector, see ref(5)

5 References

1. Cosmic Ray Detectors: Principles of Operation and a Brief Overview of (Mostly) U.S. Flight Instruments
2. LTspice: Piecewise Linear Functions for Voltage & Current Sources
3. Understanding Operational Amplifier Slew Rate
4. Op Amp Rectifiers, Peak Detectors and Clamps
5. The desktop Muon Detector: A simple, physics-motivated machine- and electronics-shop project for university students, S.N. Axani, J.M. Conrad and C. Kirby, 2017