Experiment 0 – Oscilloscopes and Nuclear Electronics

The first lab of the quarter is designed to acquaint you with the use of analogue oscilloscopes, processing signals and use of NIM modules. You will use the following equipment:

1. Tektronix analogue oscilloscope making use of both internal and external triggers.

2. Coaxial cables, terminating resistors and attenuators to examine techniques of signal transmission.

3. A small box containing a variable resistor capable of the range 0-500 ohms with a toggle switch that makes the cable open-ended (infinite impedance) or shorted to ground (zero impedance).
4. Units called “pulse generators” that generate short voltage pulses of tunable peak voltage, time duration and frequency. There are three BNC 8010 units that mount in a NIM bin and one HP8011A that is not a NIM unit. The repetition rate should be chosen to give an easily visible image but not so high that you get multiple pulses on the screen. Typically setting it at 100 KHz for the BNC8010 and the range 2m-1m for the HP8011A works well.

5. NIM (Nuclear Instrument Module) discriminators and Logic units. (see W. R. Leo Chapter 12).

6. Photomultiplier-Plastic scintillator

There will be four stations each containing a rack in which a NIM power bin is installed. Pulse generators, NIM units and terminating resistors are located on a near by table. Each station also has two loops of cable with BNC connectors at each end. One cable is RG58 (50 Ω) and one other mystery cable whose characteristic impedance you are to determine. A cable rack behind the movable chalkboard contains many 50 Ω coaxial cables that you should use as needed. At the end of the day please return everything where it was found.

Items to examine

1. **Effect of terminating and not terminating a pulse.**
   Connect the output of the pulse generator (square wave) and set up a negative square wave pulse of a few hundred mV amplitude. Observe this on the scope
using the external and internal trigger. Using the external trigger observe the signal on channel 1 by connecting to channel 1 via a T-connector. 

A) Put a 50 Ω terminator at one end of the T. Next remove the terminating resistor and attach a 10 or so foot cable to the T, leaving it open-ended. It is important to choose a pulse width compatible with the cable length. Begin with a width of about 30 ns and then widen pulse to about 100 ns is two increments of 30 ns. Note pulse shape characteristics for each of the three pulse widths. Observe and record your observations; then attach a 50 Ω terminating resistance to the open end of the cable and again observe results. Repeat with the long, 50 Ω cable. In lab report describe your observations and explain quantitatively.

2. **Determine the characteristic impedance of the “mystery cable”**
   
   Using the long unidentified cable and the terminator box that contains a variable resistor determine the impedance of the mystery cable. Each person in the group should independently determine a Z₀ and in your lab report you will report each measurement and calculate an average Z₀. Explain clearly the procedure used for making this measurement in your lab report.

3. **Delay line pulse clipping.**
   
   Using the tail-pulse generator set up a pulse that has a tail of a few hundred nanoseconds; record the pulse shape. The tail can be cut off by using a delay line that returns a reflected pulse of opposite polarity that overlaps the incident pulse after a time δt, which is the desired pulse width. This is accomplished by having the unshaped pulse go into the oscilloscope through a T-connector and a clipping cable of suitable length that defines the desired δt attached to the other side of the T-connector. Should the end of the clipping-cable be shorted, open or terminated in 50 Ω in order to “clip” the pulse and how long should it be if you want to have a pulse width of about 50 ns? There are only two tail pulse generators so two groups will jump to item 6 while the other two are doing 3 to 5.

4. **Use of discriminators and Logic Units.**
   
   Put NIM discriminator and logic units in your crate. Observe the effects of the discriminator threshold setting by inputting a negative pulse with long tail and observing the output or the discriminator at various thresholds. Look at both input and output simultaneously on the scope. Note effect of triggering on the output while varying the threshold. Record values to the threshold setting and compare output with input pulse widths.

5. **Evaluate coincidence circuits.**
   
   Create two pulses using two outputs of the discriminator and obtain a coincidence using the NIM logic units. Next use the 50Ω delay boxes determine the maximum delay between the pulses that will still give a coincidence trigger. Explain observations in your lab report.
6. **Observe output of phototube**
   Connect the anode output of a scintillation counter provided to the oscilloscope; terminate the cable at the scope. Next connect the high voltage input (using a **high voltage cable**) to the provided HV supply and set it to a positive output. At this point you should increase the high voltage slowly to about $+750 - 800$ volts. Observe and note the PM output as you reach the final set voltage. Note, as you increase the voltage on the PM you will need to adjust the trigger level on the scope. Next take a $^{22}_{\text{Na}}$ source from the source locker and bring it near the plastic cookie at the end of the PM. Observe and note the characteristics of the signal.

During all of your observations please record every observation by sketching in your lab note book the shapes on a scale that shows time and voltage accurately.

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