Design of an eight input dual channel remote controllable NIM coincidence module

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Introduction

Coincidence measurement is an important technique in nuclear physics experiments [1]. A remote controllable coincidence module had been designed and developed previously[2]. In that module, there were four inputs and only the coincidence level selection was done remotely but not the width alteration of the output pulse. Nuclear physics experiments using large detector array need modules with large number of inputs for coincidence operation. Online controlling of a module always provide advantages during experiment. Here, we present the considerable modifications made to up-grade the previously developed coincidence module by introducing eight inputs per channel in place of four inputs and remote operation of the output pulse width.

Working principle of the module

The module consists of five sections; input section, comparator section, pulse width generator section, output section and remote control section.

The input section accepts NIM inputs and generates a sum output voltage according to the number of coincident inputs. The sum output is fed to a comparator section to compare the sum output with a predefined threshold voltage. When sum output voltage crosses the predefined threshold voltage, comparator generates an output. The output of the comparator section is fed to pulse width generator section which is finally fed to output section. As our aim is to increase the number of inputs per channel and control the output pulse width remotely, so we shall only discuss the details of the input section and the remote control section. All the remaining sections are same as described in our previous work[2].

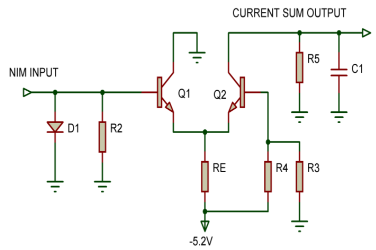

FIG. 1: Schematic circuit diagram of input section. Only one pair of transistors are shown.

Summing section: Schematic circuit of summing section is shown in figure 1. A NPN matched transistor pair is used in this section for each NIM input. A collector of a transistor in the pair is grounded and the other collector in the pair is shorted with the respective collectors of the other pairs, which gives the current sum output. This current sum output is grounded through a 50 ohm resistor and the voltage developed accross it is fed to the comparator section.

Control section: Two parameters viz., coincidence level selection and width of output pulse are controlled in this module both remotely and manually. For manual operation, a coincidence level selector rotary switch and a output width adjuster trimpot are provided. For remote operation, a webpage is developed. This webpage contains a set of eight radio buttons for selecting coincidence level and a range slider for adjusting output width. The heart of the control system, the Arduino

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Mega 2560 is coded to generate suitable pulse width modulated (PWM) output according to the client request. These PWM outputs are passed through a RC-low pass filter to get DC voltage level and then passing through a voltage buffer. The buffered control voltage level is fed to the comparator circuit for coincidence selection and to the pulse width generator section for output.

Simulation of sum output

It is obeserved in our earlier work that, the sum output increases almost linearly with number of coincident inputs for first four inputs and then the sum output voltage starts saturating. Thus makes it difficult to identify the number of coincident inputs beyond four. To incorporate eight inputs, the most essential criterion is that, the sum output should not saturate with eight coincident inputs rather the step voltage should be ideally large enough to be compared by the comparator section. The bias of the transistor pair must be proper to get a voltage pulse which increases uniformly with a well separated votage amplitude step. To search for the proper bias of the the transistor pair, simulation was done using Proteus8.1 software and the result was compared with actual prototype circuit.

In simulation, a fast NIM level pulse of rise and fall time 2ns having width of 200ns at a frequency of 1MHz was applied to the input. The input and sum output were seen in the virtual oscilloscope of Proteus (figure 2). The sum output voltage as a function of number of coincident inputs is plotted in figure 3 for different values of emitter resistor (R_E). It is observed that, for R_E = 680 ohm, the sum output voltage starts saturating before adding all eight inputs. The sum output voltage does not saturate even with eight inputs for emitor resistor values of 3 kohm and 2 kohm. The step voltage size is low in the order of 50 mV when R_E = 3kohm while the step voltage size is about 100 mV with R_E = 2 kohm. Hence, the emitter resistor is chosen to be 2 kohm as optimal. The simulated sum output voltage and waveform with these emitter resistor values are checked with actual prototype circuit and found nearly same.

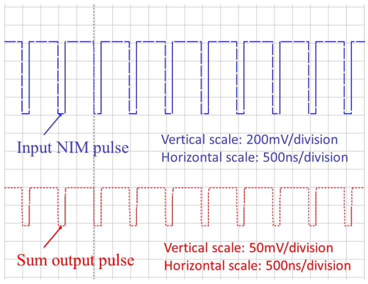

FIG. 2: Input (blue) and sum output (red) waveforms as seen in the virtual oscilloscope for single input.

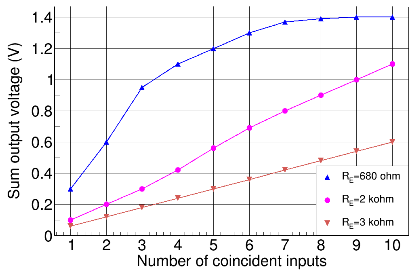

FIG. 3: Plot of sum output voltage versus number of inputs for different values of emitter resistor R_E.

Conclusion

Design study of eight input fully remote controlled coincidence module is presented. The emitter resistance value of the transistor pair used in the input section is optimised using the Proteus simulation.

References

[1] I. Bikit et al. Physics Procedia **31**, 84 (2012).
[2] S. Dalal et.al, JINST **16** P01008 (2021).