Design and fabrication of a MHz scaler module

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Introduction

Digital scaler modules are used to count pulses. Various types of scaler modules are available for this purpose. However, commercially available scaler modules are very expensive. So, at Bose Institute, Kolkata we have taken an initiative to develop a scaler module that would be cheap, without any compromise in performance. This scaler module described here can count pulses upto 8 MHz. The device is still in it's developmental phase and only one channel is designed. This article described the detail building process and to the results obtained from the device.

Working principle

This scaler module is a microcontroller based design. There are two iterations of the module so far to cope up the high frequency (∼MHz). In the following sections, both the iterations is described in details.

First iteration

The first prototype of the device comprised of two microcontrollers, one acting as the Master, while the other is acting as the Slave [1, 2]. Both microcontrollers are Atmega328p, running at 16 MHz and 5 V power supply. Since timing is very crucial in order to measure high frequency pulses, hardware interrupts are used in the design. The Master microcontroller is used to communicate with the user and for timing control. At the beginning the number of seconds (which can also be changed to miliseconds) during which the scaler should count, is given to the Master via the serial port. Then, a HIGH (5 V) pulse is sent to the Slave, which enables the hardware interrupts on the slave. After the stipulated time, the signal goes LOW and counting on the Slave stops and the final 32 bit count information is sent to the Master via I^2C protocol. The device is capable of counting upto 2^{32} - 1 pulses. Human interaction to the microcontrollers is done via PC using the UART (Universal Asynchronous Receiver Transmitter) communication protocol. However, the "live-view" of the counter was not present in the first version, as the data was transferred only after the counting completed. The module is then calibrated with a commercial NIM scaler taking signals from a random pulse generator after discriminator. The discriminator gives NIM signal of - 800 mV where as the designed scaler can take TTL signal. So the discriminated NIM signal is converted to a TTL signal using a NIM-TTL adopter. The calibration curve for the first iteration is shown in FIG. 1. It is clear from the calibration curve that the first version of the scaler proved to be good only upto 150 kHz.

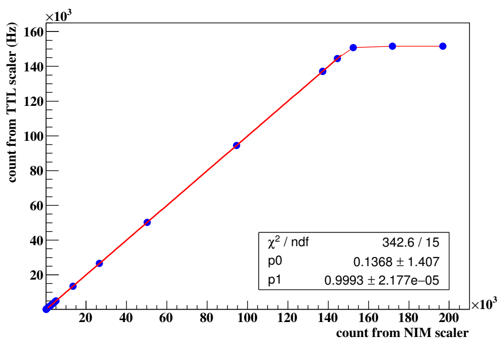

FIG. 1: Calibration curve for the first version.

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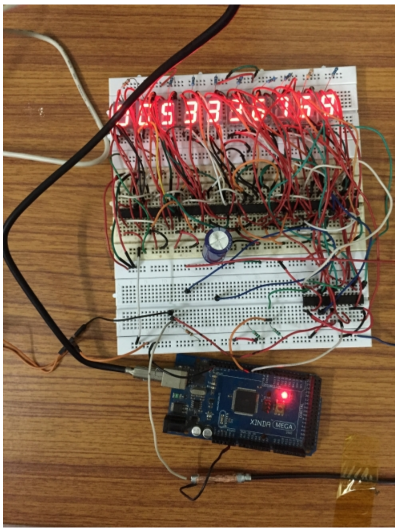

FIG. 2: Second version prototype.

second iteration

Since the first prototype couldn't meet the frequency requirements, a second version is introduced. In this case, the counting circuitry is replaced by dedicated high speed counting IC's, capable of counting frequencies $\sim$ a few MHz. However, the Master part is still a microcontroller based system, controlling the counting circuitry, and interfacing with a human user via PC. In this version, 7-segment displays are used, making the final countable number to be 10^{10} - 1. The use of 7-segment displays also introduced the live-view of the counter. The prototype is built on a bread board and then it is interfaced with the microcontroller via jumper cables. The second version prototype is shown in FIG. 2. This prototype is again calibrated using the method as described in the last paragraph. The used pulse generator can produce frequency upto 1.2 MHz. Since the second version is constructed to count more than 2 MHz, a microcontroller is used to generate square waves upto 8 MHz. The calibration curve for the second version is shown in FIG. 3. This curve shows linearity upto 8 Mhz.

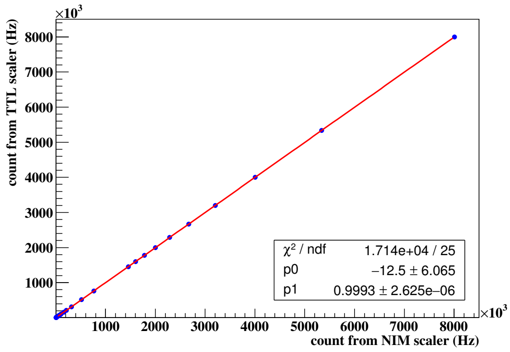

FIG. 3: Calibration curve for the second version.

Summary and future plans

A scaler has been designed to count signal upto a few MHz. The calibration curve of the second iteration clearly shows that the scaler can count signals upto 8 MHz. The main advantage of the scaler described here is that it is a edge triggered system. So when a digital signal changes its state then only the scaler counts. During a spark when the signal sustained for a longer time the scaler will not count it as more than one signal pulse.

To make the scaler a stand alone one an LCD will be attached to the system, which in turn will also make it more portable and user friendly. Since the test on one channel is conducted successfully, the future plan is to make a four channel scaler and also in a box which will fit in a conventional NIM crate.

Acknowledgement

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References

[1] S. Sahu et al., Proceedings of the DAE Symp. on Nucl. Phys. 60 (2015) 958.

[2] S. Sahu et al., RD51-NOTE-2016-003, [arXiv:1608.00563].