MicrodsPIC Features for Lidar Measurements

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Abstract - Flexible and programmable components have been playing a key role in many electronic systems. Lidar systems can be improved by means of component and electronic progress, especially in data collection, acquisition and processing. The objective of present paper is to show the design of an electronic unit capable of substituting Raman lidar - based discriminator and multichannel scaler. For this experiment, a Hamamatsu H7732P-01 photomultiplier has been used.

I. Introduction

A photomultiplier tube, in the usual configuration, is used to detect light (photons). It consists of a cathode (negative) and an anode (positive) which are separated by a vacuum. When light hits the cathode, electrons are emitted from it into the vacuum. These electrons are then multiplied by "electron multipliers" and collected as an output signal. Photomultipliers are very sensitive and have fast response and low noise. However, the output signal from PMT contains noise that must be removed in order to know the true values of measured atmospheric parameters. PMT output is digital but it does not represent a photon counting. We can only get atmospheric parameters through a photoncounting got by means of a MCS (Multichannel Scaler) that operates as an accumulator. A small amount of current flows in a photomultiplier tube even when the tube is operated in a completely dark state. This output current, called the anode dark current, and the resulting noise are critical factors in determining the detectivity of a photomultiplier tube. As figure 1 shows, dark current is greatly dependent on the supply voltage [1].

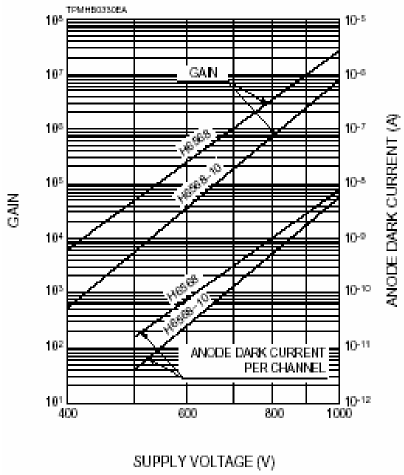

Fig.1 Typical dark current vs. Supply voltage

II. Rationale

If we consider a Raman lidar dedicated for water vapour measurements, a no correct accomplishment of data acquisition and data analysis can determine a miscalculation in the estimation of the aerosol coefficient and of the statistical error. For this reason, huge care is necessary in handling data in order to retrieve the extinction coefficient profile coming from Raman signals. Previous researches have demonstrated the need of filtering signals recovered from MultiChannel Scaler (MCS). The results reported in this paper reflect the noctitime operations using the above XeF excimer laser. Many simulations have been performed in order to characterize the output signal from MCS. Digital filters have been used to get best (the same) results than those obtained with Poisson statistics. Window design of FIR filters [2] has been implemented to remove noise from useful signal containing water vapour.

Figure 2 and figure 3 illustrate recovered signals in time domain and frequency one respectively. The above representations do not deceive some body since the actual reasons are to remove noise by characterizing the lidar output as an alternate way by respect to Poisson average. In figure 3 different FIR windows, not only Kaiser's one, have been shown in order to represent their impact in lidar recovering data. While in figure 2 we have illustrated just one FIR window; We did so to simplify the representation. It is clear that the NED approach is the best one for the present lidar signal since it allows a maximum reduction of noise. That is one of the advantages of adjustable windows. On the one hand, in NER case, the resulting and designed filter has a frequency response characteristic that is very nearly equal ripple about unity in the passband, $0 < f < \beta-\delta/2$, and about zero in the stopband, $\beta+\delta/2 < f < 1.0$. The gain at zero frequency is slightly different than unity, but within $\pm\ \varepsilon$ of unity. We noticed that the reduction in passband ripple and the increase in stop-band attenuation is achieved at the expense of a widening transition band. To narrow the transition band a greater number of terms has been used; on the other hand, the NERD derivative filter design is characterized by approximately equal passband and stop-band magnitude errors. The resulting designs are very nearly the most efficient possible consistent with the filter performance specifications.

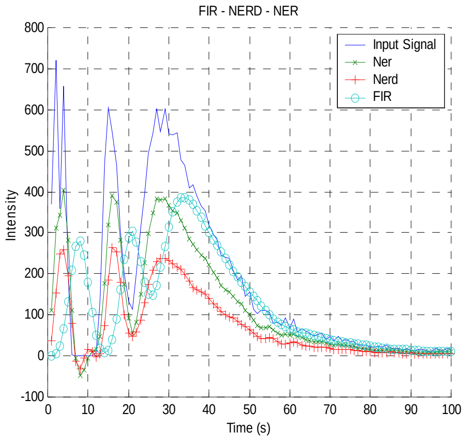

Fig. 2 Retrieved signals in time domain

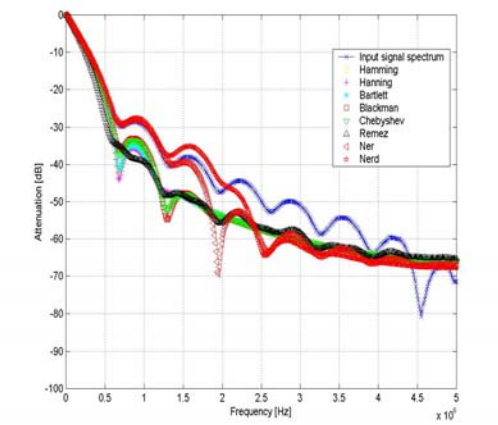

Fig. 3 Retrieved signals in frequency domain

A new flexible configuration is appropriate to overcome many troubles [3] introduced by hardware components. Performance of Raman lidar can be improved in terms of: reliability, low contribution to overall noise, signal processing speed, easy installation, and reduction of construction costs.

III. Proposed system description

The above technique, used for processing signal, in order to retrieve atmospheric components, is applied at the end of data acquisition block. If signals contain noise and undesired information in the previous blocks, their removal process will not achieve the correct and complete role. To avoid that, a model of a special and innovating electronic unit is proposed in order to intervene after signal has passed across PMT. The new unit substitutes MCS and discriminator as shown in fig. 4

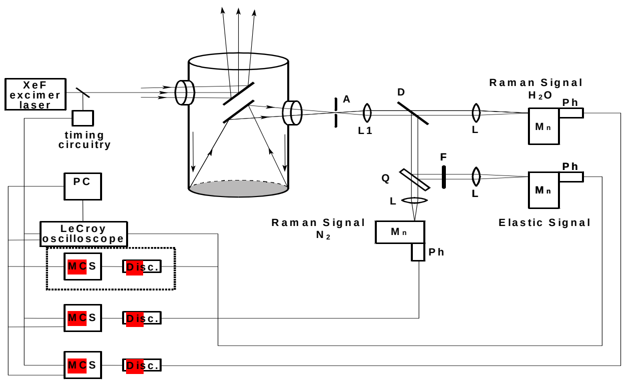

Fig. 4 Raman lidar description scheme

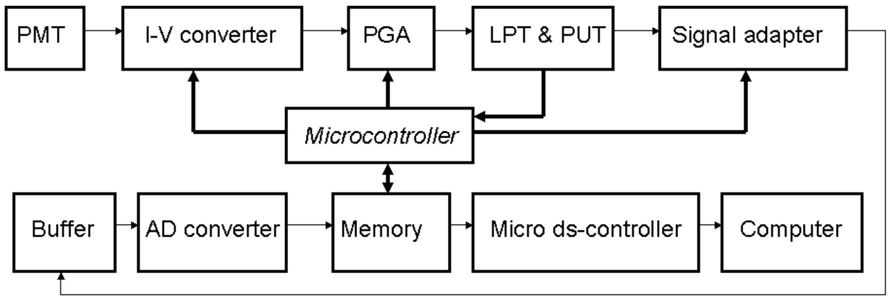

Fig. 5 Electronic signal processing unit general architecture

On the contrary, fig.5 illustrates the general architecture of the electronic unit that can works on signal, controlling it from PMT blocks up to computer without alterate signal frequency. After PMT output there is an I-V converter in order to adapt a current signal to the requested voltage signal at successive block which is a *Programmable Gain Amplifier* – PGA. Through this block (AD624), signal is amplified up to 1000 times than that in input. A MAX274 as low pass filter is used to reduce noise. Filter input is connected to a comparator that warns everytime threshold value is exceeded. A counting is performed by means of a PUT(*Programmable Unijunction Transistor*) capable of supporting Voltage Control Oscillator (VCO) function, by operating a choice between Relaxation Oscillator (RO) and Phase-Locked Loop (PLL). From fig. 6 up to fig. 9, description and features of PUT in dual-transistor configuration is underlined.

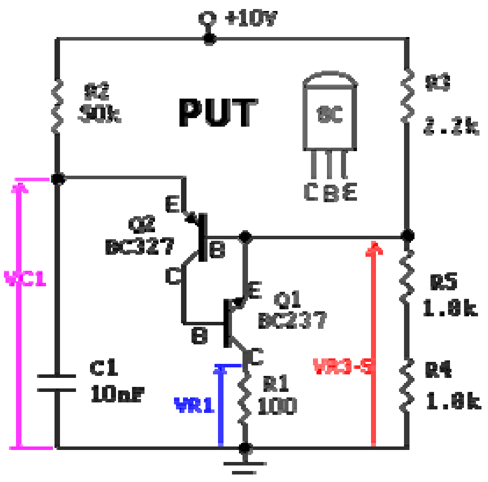

Fig. 6 Two transistors operating as PUT

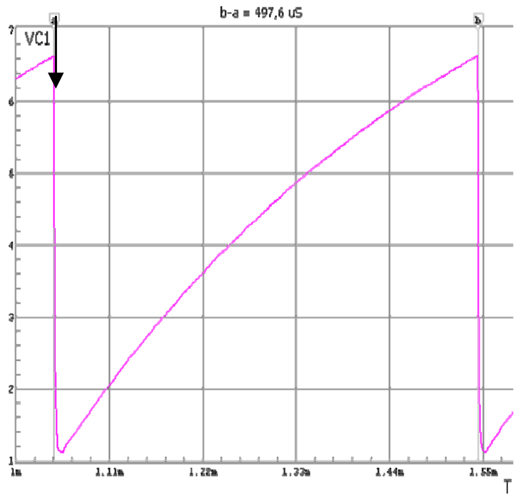

Fig.7 Voltage trend on capacitor C_1

From this block, two outputs are provided: one for adapting, buffering and digitalizing in a signal adapter and the other is collected by a microcontroller that indicates to PGA how to increase amplification. Further role that microcontroller can play is to regulate current flux at PMT output since the total resistance of dynode resistors (included in PMT) should be such that the current flowing through the series resistance is at least 100 times than the expected anode current of the tube:

$$R_T = \frac{Voltage, Anode - to - Cathode}{100xAnode\,Current} \qquad (1)$$

Once signal is out of filtering and counting subunit, it is ready for adapting and buffering operations and hence converted in digital form and stored in a memory connected to the above microcontroller and to a micro-ds-controller that processes all data and transmit them to computer.

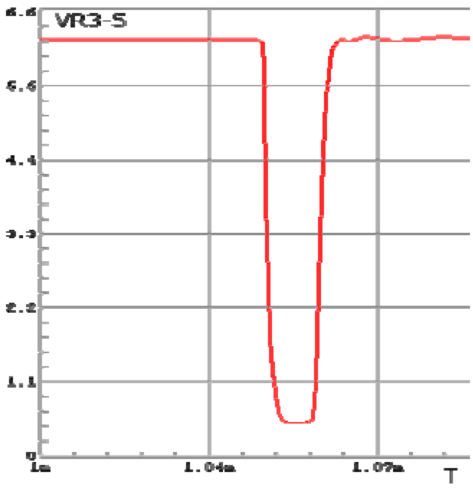

Fig. 8 Signal trend on voltage divider $V_{R3\text{-}5}$

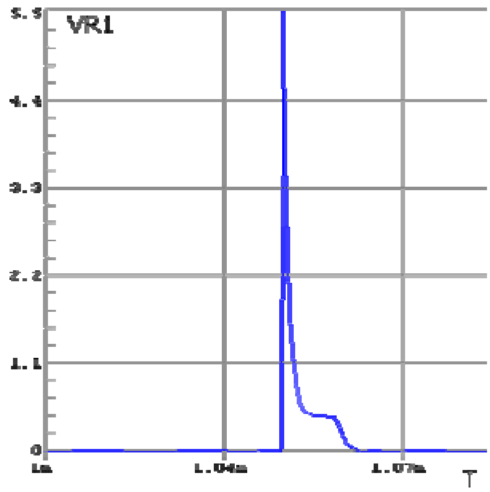

Fig.9 Voltage trend on resistance R_1

IV. Design criteria and simulations

Before focusing on the overall electronic scheme developed for the purposes of this research, it is suitable to recall the main blocks of the lidar unit and to see how they have been design, which criteria have been used in order to reach the preserve signal in nonlinear conditions. Three main blocks has been designed in order to avoid tedious considerations upon the unit, that is, PGA, lowpass filter, and pulse counter - photocounting circuit. A Multisim designing software (ver. 8.0) is utilized to perform all circuits.

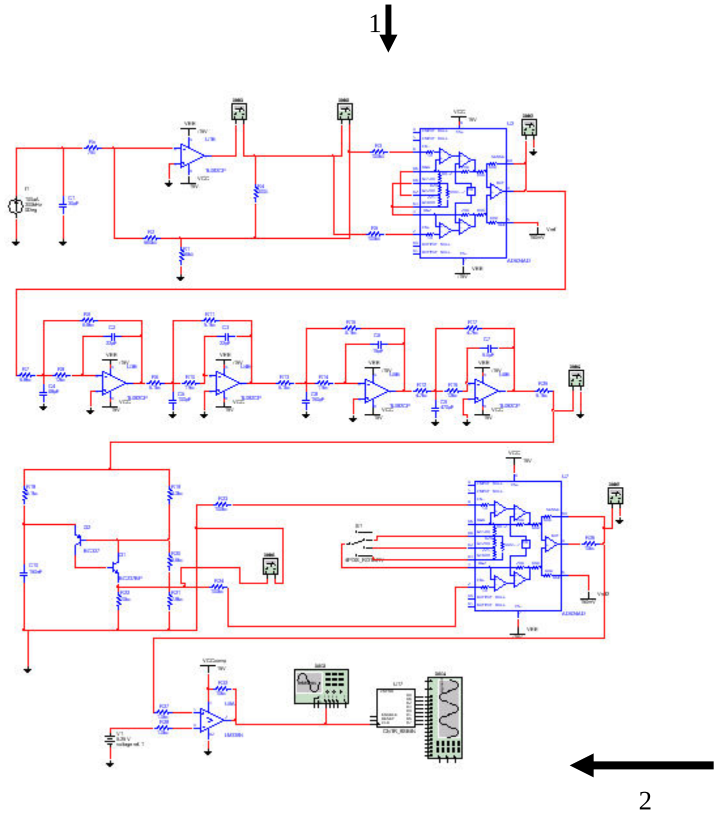

Fig.10 Overall unit

Fig. 10 represents the final version of the designed unit capable of improving lidar signal processing by using flexible components as declared above. Fig. 11 shows the signal at reference 1 of fig.10 while fig.12 indicates the final result, in terms of waveforms, at reference 2 of overall unit. The digital response is given in fig. 13 that demonstrates the correct design of the system [4].

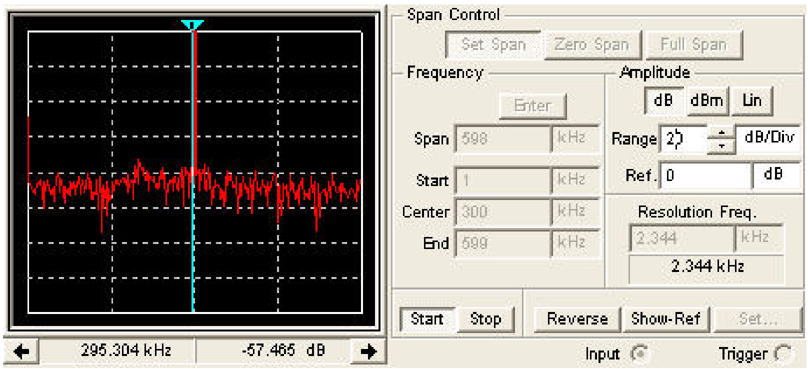

Fig.11Signal at reference 1

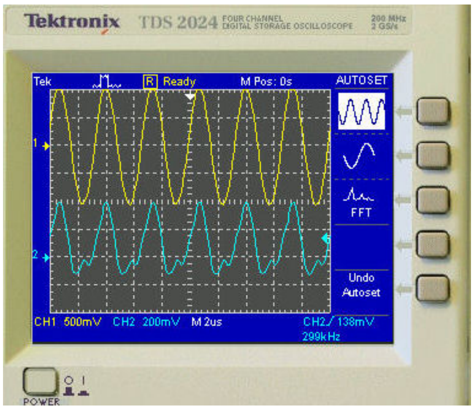

Fig.12 Signal at reference 2

Fig.13 Result example on micro-ds-PIC exit

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