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High Voltage Pulse Generator

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Introduction

The ARION experiment at CIEMAT studies the production of positive ions in argon, both in liquid and gas phase, as well as their drift in these media and transmission across the liquid-gas interface. An essential component of the experiment is the production of high voltage pulses. This note describes the high voltage pulse generator used in ARION. This system allows very high voltage pulses to be introduced into the device at the anode (needle), starting from a constant high voltage, which are subsequently read at the cathode (imbricated grid).

Description

The system consists of:

- The anode (RS-6065 needle) is powered directly by a high voltage.
- The cathode, consisting of two interlocked grids and the readout circuit. It is defined as follows:

  - An imbricated grid (Fig. 1) provides a high field area. The cathode is fabricated with NiCoTINe wire of 0.05 mm diameter.

  - Each mesh is applied a different high voltage by means of the 50 MΩ and 500 MΩ resistors, obtaining a resistance between both ends of 1.1 GΩ (-HVc to HVa). The low voltage section starts at the 1 nF/10kV capacitor (C1). At this point, the signal is read by coupling the circuit to the oscilloscope. The coupling circuit has a ground-connected 10 MΩ resistor (R2) that protects the circuit from overvoltages. The signal is read between the 100 kΩ resistor (R4) and the 0.1 nF protection capacitor (C2) (Fig. 2).

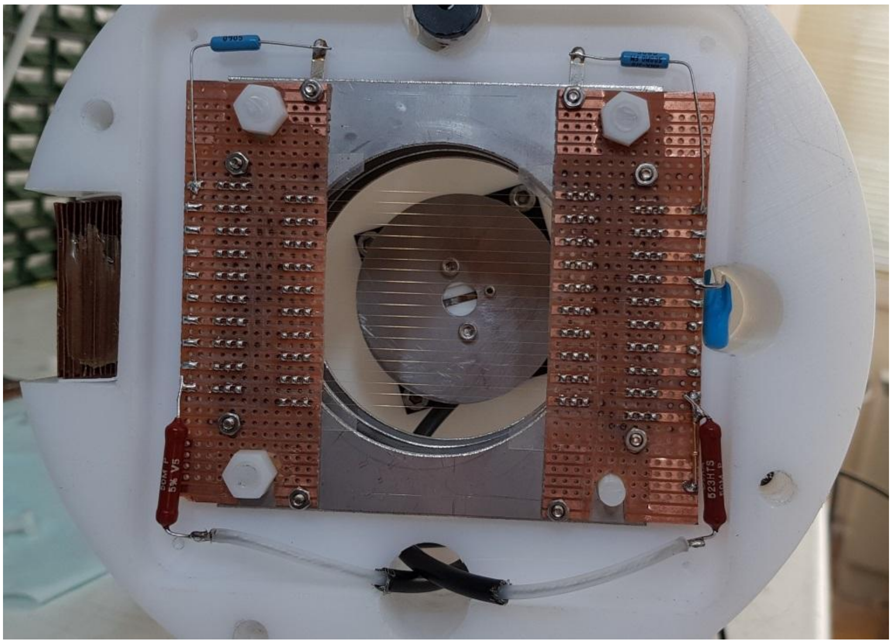

Fig. 1: Double grid cathode.

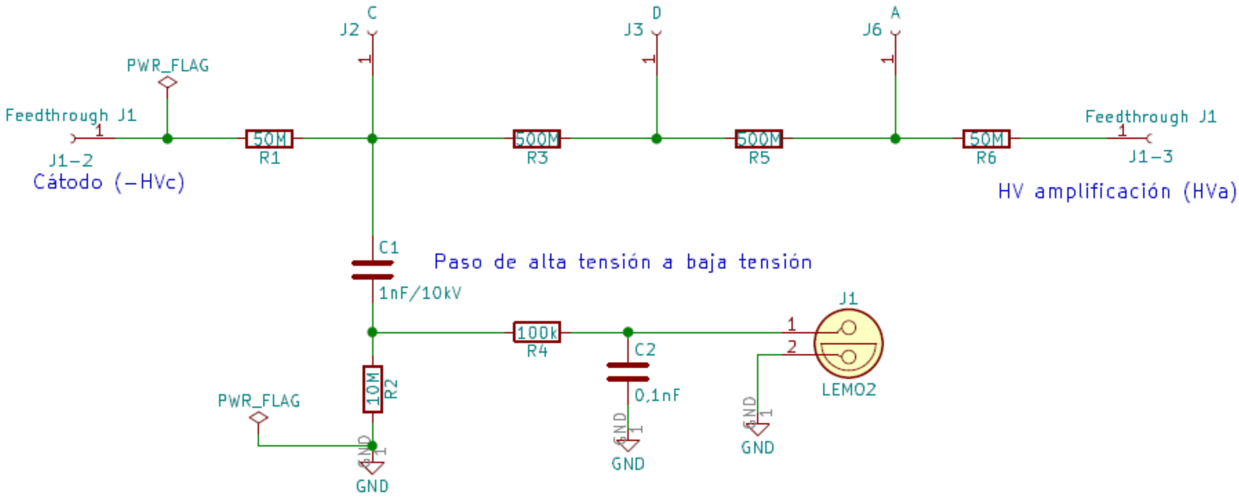

Fig. 2: Diagram of the cathode and the reading system.

An example of induction and drift signals is depicted in Fig. 3. The voltage settings of the system are -1200 V at the cathode and 2000 V at the needle, where the pulse is produced manually. In the figure, two signals are visible:

1. The signal induced by provoking the pulse (spark) in the needle. It is a very fast signal, everytime a pulse is required. In the picture we appreciate the time of charge and discharge caused by the RC of the cathode (measuring point).

2. The drift signal is the charge signal collected at the cathode some time after the pulse is triggered. The charge corresponds to the ions produced in the needle. The time is slow because the ions take longer to arrive and collect at the cathode than the electrons. We have a bipolar signal which is explained by the integration of the RC circuit.

Fig. 3: Induction and drift signals produced at the needle and the cathode.

Fig. 4: Signal registered with the cathode at 0 V. The drift signal disappears and a discharge is visible.

Another operation example is presented in Fig. 4. In this case, the voltage in the cathode is set to 0 V and only the induced signal is expected. In the figure we appreciate the induced signal and a small discharge signal.

As indicated above, the induced signal follows a pattern in all the pulse shots, and it is the same in both images. Several other measurements confirm this behavior.

This pulse generator is a circuit of resistors and very high voltage capacitors that allows the introduction of very high voltage pulses to an already high DC voltage. The operation mode is as follows:

- A high DC voltage is applied to the needle (SHV_A_Point). The pulses provided through the circuit of Fig. 5, using specifically a coaxial cable (SHV_Coaxial_Power), are added to the voltage already existing in the system. The capacitors in parallel of 10 nF increase the capacity to 20 nF and make the pulse wide enough to be detected. The differentiator is formed by these capacitors and the 10 MΩ and 100 kΩ resistors.

- The schematic presented in Fig. 5 is implemented in the box of Fig. 6. The voltage enters through a SHV connector (bottom left), reaching the 100 kΩ resistor (top left), passing through the capacitors and the 100 MΩ resistor and high power. The pulse is generated by connecting manually the output of C10/C11 to SHV_A_Punta (bottom right) by means of a manual actuator. The smaller resistors R11 and R12 create a voltage divider, permitting to measure the pulse on the oscilloscope that is supplied to the needle.

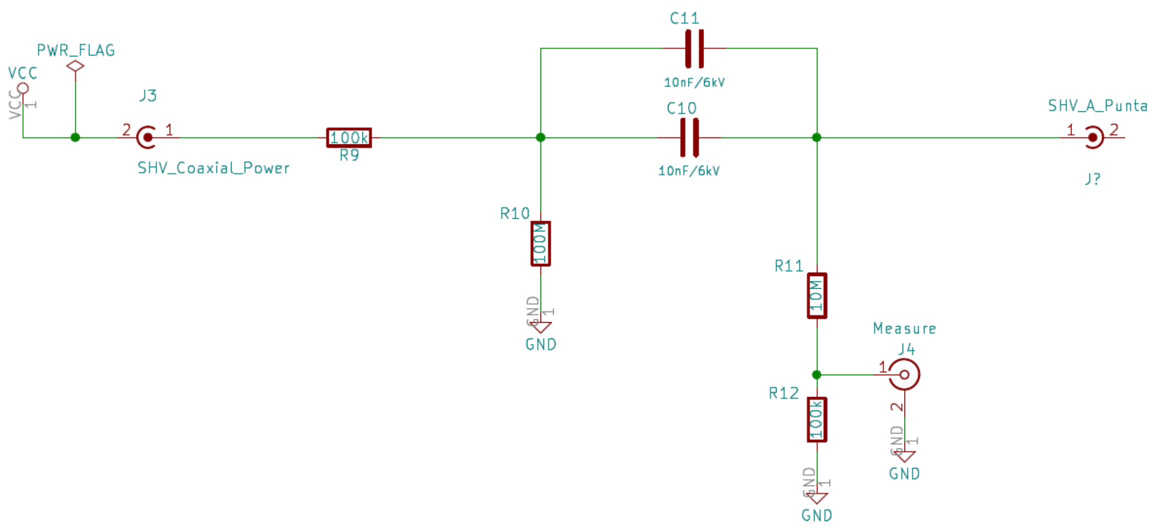

Fig. 5: Pulse generator circuit diagram.

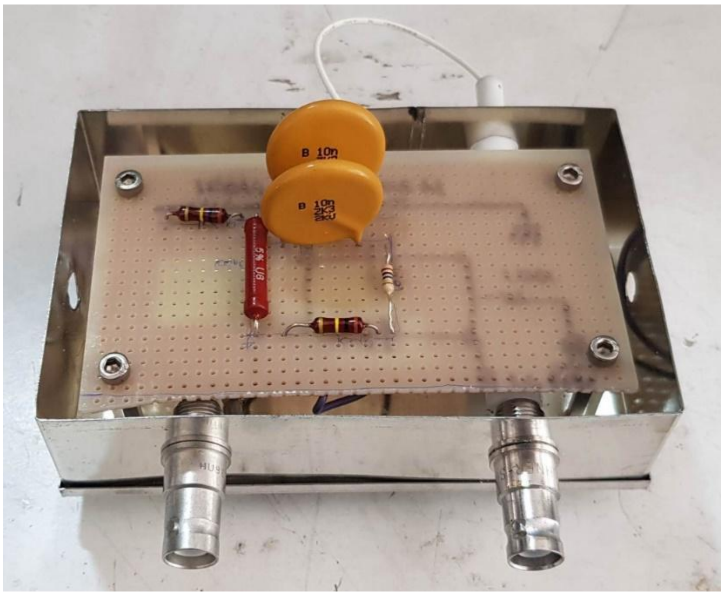

Fig. 6: High voltage pulse generator.

Conclusion

We have successfully designed and built a high voltage pulse generator generator. The device has been extensively used in the ARION experiment at CIEMAT to study the production and drift properties of positive ions in gas and liquid argon.