**New shorting mechanism for pelletron accelerator**

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A new mechanism to electrically short Pelletron Accelerator modules has been developed to replace the present manually operated system that contains some limitations. Its salient features over the existing system are that the operation will be fully automatic, any module can be independently shorted from control console and its status read back will be available on the control console. Since the new system is not external to the main Accelerator Tank, chance of SF6 leakage is eliminated.

1 Introduction

The 14UD Pelletron Accelerator is an electrostatic tandem accelerator. The potential gradient or the electrostatic field is established by allowing current to pass through corona discharge or resistance path. When lower terminal voltage is needed, it is generally customary to electrically short-circuit a few modules of the accelerator column. It is also sometimes necessary to short-circuit a set of modules for isolating them for diagnostic purpose or for systematic conditioning of the accelerator for withstanding higher voltages. Thus, module short-circuiting mechanism is an important part of these accelerators.

2 Problem Definition

The existing system of short-circuiting modules of this accelerator is achieved by means of a string of rods. The high voltage column is housed in a large pressure vessel which is filled with SF6 gas at 5-6 atmospheric pressure. A motorized driver from outside the tank drives the string of steel rod through a small port. The string is generally formed with nylon and steel rods in a particular combination depending on the position of the column to be shorted.

The major problem encountered with this system is that sometimes the string breaks inside the tank. In such situations, the operation of the accelerator becomes impossible. The entire SF6 gas inside the accelerator tank is required to be transferred to the external reservoirs. It amounts to increased down time of the accelerator. The failure statistics of this shorting rod system was examined and it is found that quite a large break-down time of accelerator can be attributed to the failure/breakage of this shorting system alone. Over and above, the system of rods and drivers, etc. needs careful handling to avoid complications and it requires a large maintenance time.

3 The New Mechanism

The design of new mechanism consists of one-eighth inch braided copper wire used for shorting the one module, a nylon string coupled with the copper wire via a steel coupler, a spring arrangement for positive contact and two micro-switches to know the status. As shown in Fig. 1, the nylon and copper wires are wound on threaded pulleys of 70 mm diameter, which will be housed inside the casting at either end of the module. The pulley will be rotated by stepper motor. The braided copper wire will be inside the casting when module is live, i.e., only the nylon string will be exposed to the high voltage. When module is shorted nylon wire will go inside the casting and braided copper wire will short the module. Special care has been taken from high voltage design point of view while selecting and fabricating the components of this new mechanism. A scheme of shorting for second module is shown in Fig. 2.

4 Stepper Motor Drive and Controller

The controller for the stepper motor is developed around a micro-controller for reliable operation. The whole system can be divided into
Table 1 — Comparative advantages of the new system

<table>
<thead>
<tr>
<th>Proposed shorting mechanism</th>
<th>Existing shorting mechanism</th>
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<tbody>
<tr>
<td>1. The operation is fully automatic.</td>
<td>1. The operation is manual.</td>
</tr>
<tr>
<td>2. Any module or modules can independently be shorted from control console itself.</td>
<td>2. Combinations of steel and nylon rods are required to short a particular module or modules from tank top and/or tank bottom.</td>
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<tr>
<td>3. Status read-back of the module will be available on the control console monitor.</td>
<td>3. No status read-back is available on the control console. A separate logbook has to be maintained.</td>
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<tr>
<td>4. System is not external to the main tank, hence no chance of SF₆ gas leak.</td>
<td>4. System is external to the main tank. In case of failure, there is a chance of SF₆ gas leakage, and physical injury.</td>
</tr>
<tr>
<td>5. Easy to short any module as each module has its own system for shorting.</td>
<td>5. Rods are inserted sequentially, so changing configuration is not easy.</td>
</tr>
<tr>
<td>6. No expertise is needed to short any module.</td>
<td>6. Experience and expertise is necessary, particularly to handle Nylon rods.</td>
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</table>

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In Control Electronics, Intel-89C51 microcontroller has been used. This microcontroller has 4 kbyte of program memory, 256 byte of data memory and 4 I/O ports. The microcontroller uses a 11.059 MHz clock for its operation. The bus port

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P0 is used for driving the stepper motor electronics. The port P2 is used for user input/user control signal. Rest of the ports is unused. The microcontroller, upon receiving user input for forward or reverse rotation of the stepper motor, sends signals to driver electronics for the stepper motor.

The design of stepper motor driver electronics consists of power drivers, which receive control signal patterns in appropriate sequences as decided by the micro-controller.

Thus, the entire circuit has been designed in a compact manner and selection of components as such to improve the reliability. The embedded software has been developed in low-level assembly language. However, no back-up power supply is provided for this system. Therefore, position sensing upon power failure and restoration is achieved by means of two micro-switches.

5 Test Results

Comparative advantages of the new system are presented in Table 1. The system has been tested thoroughly outside the Accelerator tank on the test bench. One such unit has been installed inside the 28th module of the Accelerator, which is working satisfactorily since January, 2000.

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