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TELEMETRY COMPONENT TESTS IN THE FN TANDEM TERMINAL*

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When an electrostatic tandem accelerator is used primarily for heavy ion acceleration numerous communication channels with the high voltage terminal are desirable. The ANL FN tandem operates at a tank pressure of 100 psi SF_6 at terminal voltages up to 9.5 MeV. A low powered He-Ne laser with 15% modulation has been successfully tested in the terminal under normal operating conditions. Such a system allows the transmission of information without the use of light guides. Multistranded light guides did not withstand voltage gradients as low as 0.4 MV/m. Single core light guides with a diameter of 0.5 mm have been successfully operated at voltage gradients in excess of 1.7 MV/m. In addition to the laser a microprocessor has also been tested in the tandem terminal. With suitable protection an 8080 microprocessor and a programmable ROM operated successfully for several weeks under normal operating conditions.

An Intel 8080 microprocessor, which can address up to 256 input and output ports and which can support up to 64 K bytes of mixed programmable read only memory (ROM) and random access memory (RAM) elements was tested in the terminal of the Argonne FN tandem. During these tests a single 2048 byte ROM and a RAM were used. The tandem operated with a tank pressure of 100 psi SF_6 and terminal voltage up to 9.3 MV. During conditioning above 8.5 MV sparks occur rather frequently. The tests were conducted for periods as long as 6 weeks. Since the RAM is a volatile element machine sparks are expected to erase information contained in it. The ROM is a non-volatile element and for successful operation of the microprocessor as a component of the telemetry system the program should be fully retained even during heavy sparking periods.

The microprocessor was powered by a 400 Hz 110 V generator driven by the Pelletron charging chain. The power cable from the generator to the copper box containing the microprocessor was doubly shielded and grounded about every 15 cm. The ground connection between the microprocessor board and the copper box is made with a single line. Multiple ground connections of the microprocessor board results in loops which may erase parts of the ROM program. Tank sparks can result in large voltage fluctuations and a broad RF spectrum transmitted over the power line. To protect the microprocessor and the memory an overvoltage protection consisting of 3 317 A gas diodes which effectively limit the voltage at the processor to 115 V and a filter which attenuates all frequencies in excess of 400 Hz were located in the copper box.

The program counter of the microprocessor has to be reset to zero at start up and following a power failure. Since the reset is in an inaccessible location a time delay relay is used to automatically reset the program counter.

The arrangement which was used is illustrated in Fig. 1. To be compatible with other equipment the communication with ground through the I/O channel uses a two-tone mark-space signal with frequencies of 1225 Hz and 1675 Hz.

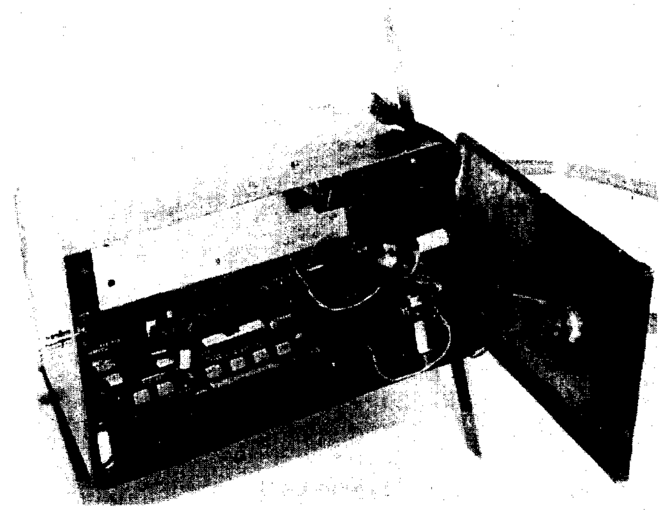

Fig. 1. The 8080 Intel microprocessor installed in its copper box.

In the final test the output of the Intel 8080 microprocessor was used to modulate a low-power Helium-Neon laser with 15% modulation. The laser system is shown in Fig. 2. The laser and encoder were powered with the 400 Hz 110 V generator driven by the Pelletron charging chain. The power cable grounding was identical to the system used for the

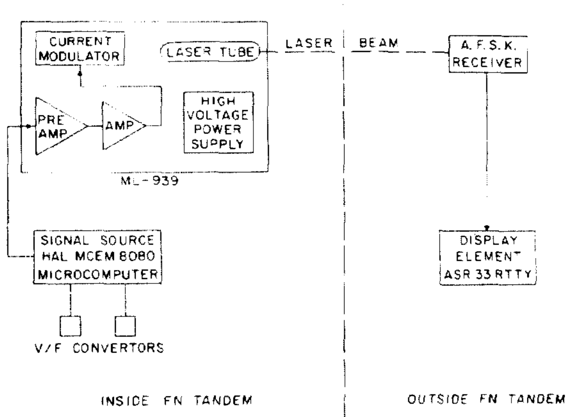

Fig. 2. Schematic diagram of the microprocessor and laser transmission station in the tandem terminal and the receiver station outside the tandem tank.

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Intel 8080 microprocessor. In initial experiments the laser was boxed to allow operation at atmospheric pressure. Subsequent experiments did show that the laser could be operated successfully at 100 psi gauge and in the final test it was used that way. The laser beam was directed to a small glass port in the base of the tandem tank. In adjusting the laser position in the terminal corrections were made for the tank deformation and terminal displacement which occur when the tank is pressurized. The light loss in the SF_6 and base port are negligible. The receiver and decoder transform the signal into the standard teletype signals.

The laser beam allows data transmission from the terminal to the ground station without the use of light guides. Tests with multistranded light guides were made and complete destruction of the light guides occurred at voltage gradients as low as 0.4 MV/m. This destruction results in large amounts of fine powder dispersed over the tank. The cleaning of the accelerator structure is time consuming and even after thorough cleaning the maximum attainable terminal voltage may be lower and less stable than it was before the destruction of the light guide. In one instance a 0.5 mm diameter single core light guide withstood successfully voltage gradients in excess of 1.7 MV/m. However the light guide diameter makes it difficult to couple the light source and the detector with sufficient efficiency to permit reliable operation. Tests with a single core light guide with a diameter of 1 mm are being planned. Light guides with substantially larger diameters with a single core are difficult to handle over the required length.

If the 1 mm diameter light guide can be used and allows adequate coupling of the light source and the receiver the use of light emitting diodes in conjunction with the 8080 microprocessor would become an attractive alternative since such a source requires less space than the laser. On the other hand for communication with the dead sections in the accelerator structure where space is severely limited the use of a laser to drive power supplies for Ti sublimation pumps and electromagnets is a very attractive possibility. In this case one would use a dual tone rather than a two tone signal to modulate the laser at the ground station and have the receiver, decoder and a few sealed relays in the dead section of the accelerator powered by a small generator to control the necessary functions.

In the operation of devices in the terminal it is necessary to retain the position number of stripper foils, the in-out position of the collector cup and the position of leak valves even if the accelerator sparks or when the accelerator charging chains are temporarily turned off. Since storage of such numbers on a volatile RAM would be useless this information has to be contained in the hardware of the interface between the microprocessor and the device. If Ti sublimation pumps are used to pump the terminal box to the levels required for successful operation of heavy ion beams it is desirable to power these pumps with a direct shaft driven generator since frequent power interruptions tend to recrystallize the Ti spheres and make the pumps ineffective. If the control system is powered from the chains the system will have to maintain the sublimators at the fixed current selected by the controller even when the chains are turned off.