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A REMOTE CONTROL SYSTEM FOR THE LELA EXPERIMENT

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ABSTRACT

A modular system for closed loop computer control of stepping motors has been realized and used for optical component movement of LELA experiment in radiation risk area.

A CAMAC module, controlling up to 15 stepping motors, a NIM dual motor driver and a special purpose circuit for computer interfacing are described.

1. - INTRODUCTION

Since 1977, when the feasibility of a Free Electron Laser (FEL) using an helicoidal undulator magnet on the electron beam of the Stanford Superconducting Linac was demonstrated[1,2], one of the major subjects of interest has been how such a device can be operated on a recirculating beam machine, as an electron storage ring[3-6].

The LELA (Laser ad Elettroni Liberi in Adone) experiment has been designed to study problems involved the interaction between radiation and the recirculating electron beam of a storage ring (Adone of LNF)[7] using a transverse undulator of 20 periods.

Accurate measurements of the angular and spectral distribution of spontaneous radiation from the undulator were perfomed in the first stage of the experiment[8,9].

The results showed good agreement with calculated distributions, with no pattern distortion due to imperfect magnetic field (Fig. 1).

The gain measurements and the construction of a suitable optical cavity for laser oscillation are scheduled starting in 1983. We have already reported(8) gain measurements performed in the late 1982.

In this paper we shall describe the control system used in spontaneous radiation measurements. This system is thought to be the basis of the complete control system of the FEL experiment. The layout of the experimental set-up is shown in Fig. 2. The computer used for control and data acquisition, a PDP 11/40, is installed in a remote control room.

Reliability and reproducibility of movements for alignment and scanning of the spontaneous radiation pattern, and the large amount of data to be collected required a complete computer controlled system.

This system was also planned taking into account the need of remote control for mirrors and beam monitors located in a high radiation risk environment outside the LELA bunker (dashed area in Fig. 2).

Stepping motors and standard CAMAC interface were natural candidates for the setting up of a complete and reliable control system.

2. - GENERAL LAYOUT OF THE CONTROL SYSTEM

A schematic view of the control system is shown in Fig. 3. The computer controls the stepping motor motions through home-made CAMAC circuits, each having a driving capability of 15 motors.

For each motor two distinct pulses for forward and backward movement reach, through coaxial cables, the power driver, a standard NIM module, inside the experimental bunker.

The power driver supplies the current to the four motor phases according to the step command, and contains also a circuitry to control a shaft encoder which can be associated with the motor.

A four digit counter memorizes the motor steps, counting the driving pulses. If the shaft encoder is associated to the motor the counter increment is conditioned by its consent.

The motor counters can be read by the computer. To minimize cables, a multiplexer unit is located inside the experimental bunker. This unit decodes motor addresses from the computer and multiplexes to a single CAMAC input register the addressed counter contents.

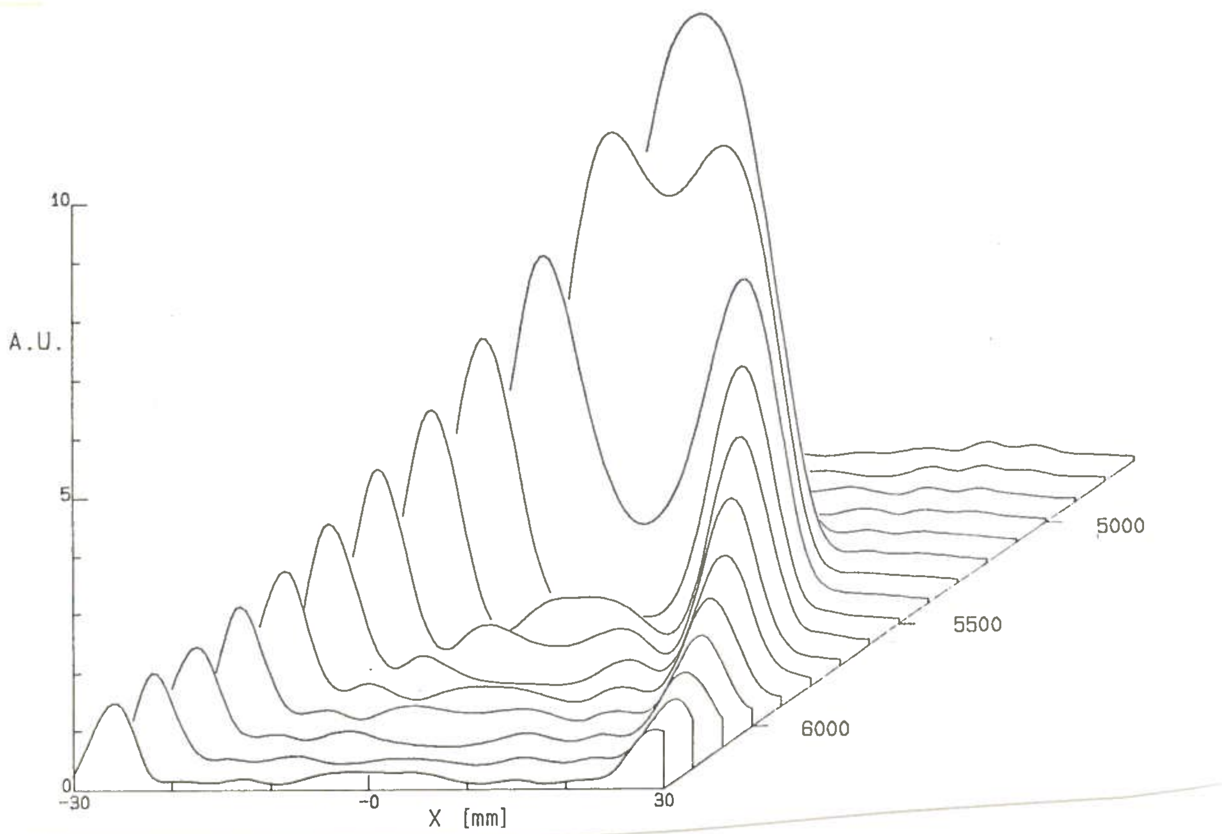

FIG. 1 - Spontaneous radiation pattern measured in the radial dimension. Experimental points are interpolated by means of a cubic spline algorithm.

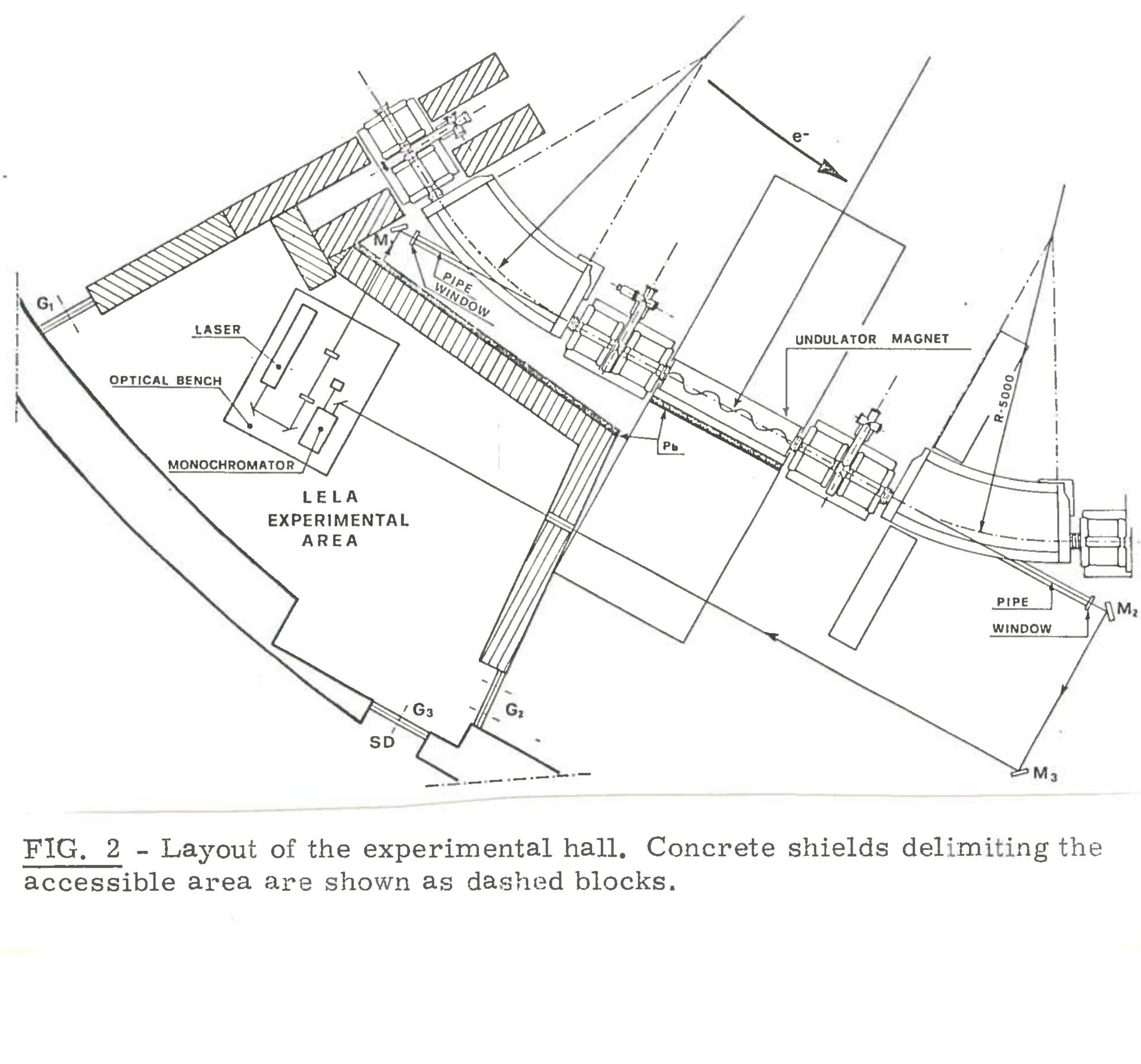

FIG. 2 - Layout of the experimental hall. Concrete shields delimiting the accessible area are shown as dashed blocks.

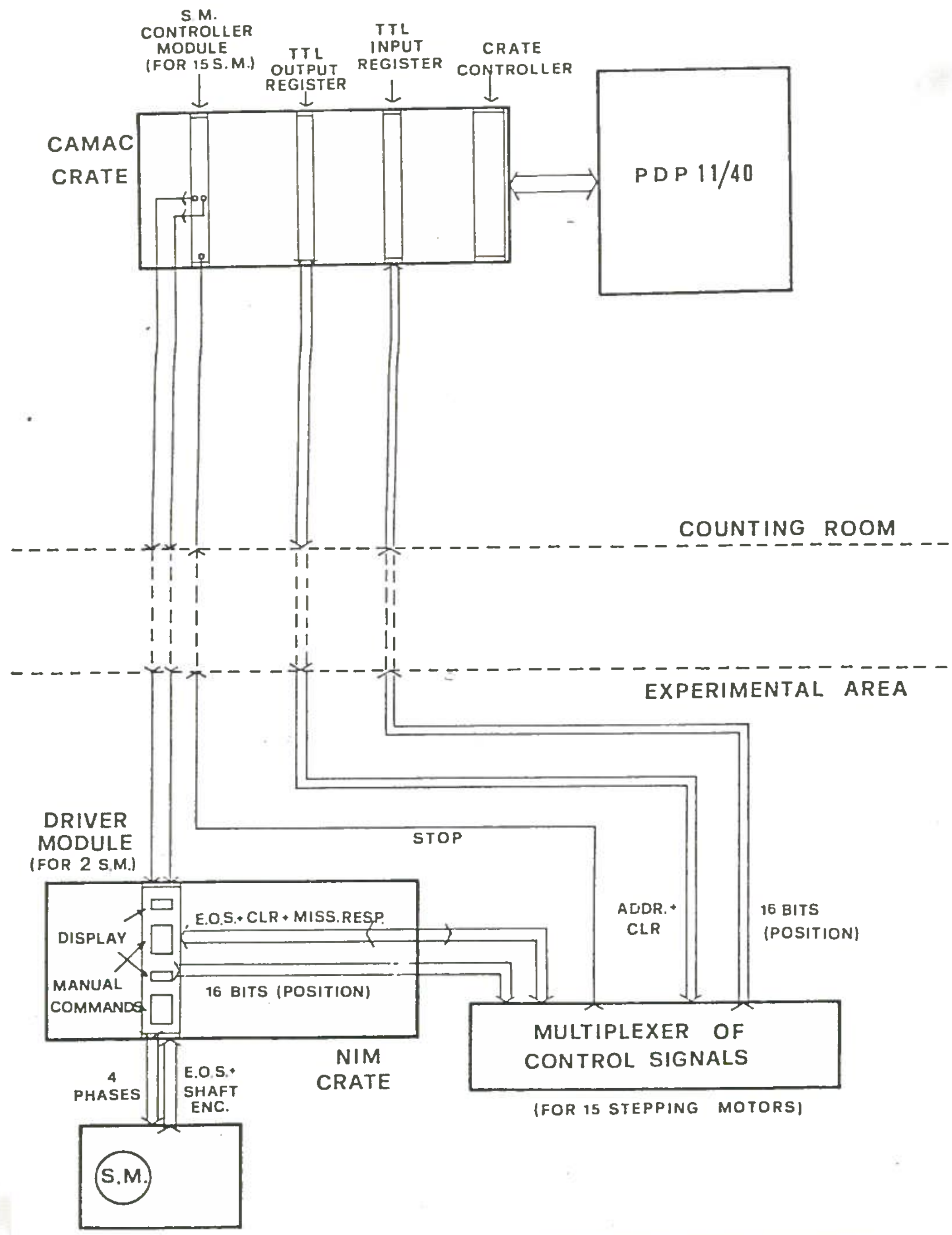

FIG. 3 - Schematic view of the control system.

The same unit takes also care of all possible end-of-stroke signals generated by the movements and of the no-movement pulses generated by the shaft encoder electronics. A stop pulse is then sent to the computer, and a status register is strobed enabling it to reconstruct the stop source.

In the following we will describe the circuits and their performances.

3. - CIRCUITS DESCRIPTION

3. 1. - The stepping motors control module

This circuit, housed in a double unit CAMAC module, controls the movements of up to 15 stepping motors. For each motor two LEMO connectors are provided for clock wise and anticlockwise movement commands.

The number of steps and the movement direction of each motor can be programmed, and a pulse for each step is generated from the respective output.

The pulse train frequency is programmable on a wide range (0.1 Hz to 1 KHz). The circuit, whose logic diagram is shown in Fig. 4, is microprogrammed. The sequence of microinstructions, memorized in three SN74S288 PROMs, is controlled by an AM 2909 sequencer.

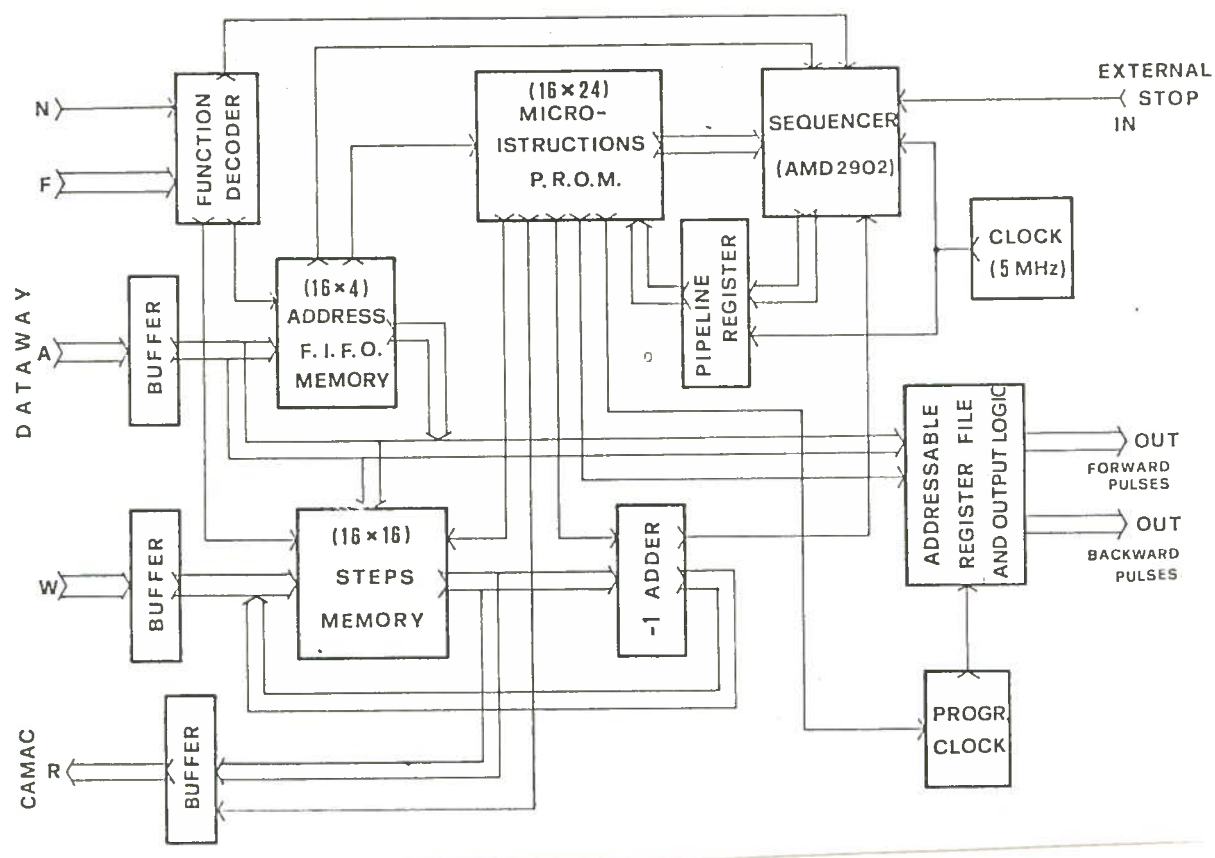

FIG. 4 - Logic diagram of the stepping motor control module.

The programming of a motor movement is obtained writing, with CAMAC subad dress A as motor address, a 16 bit word in the 16x16 RAM of the module, the most significative bit being the movement direction. The motor address is also inserted in to 16x4 FIFO memory. When all movements of interest have been programmed, the subaddress ∅ has to be inserted into the FIFO. This subaddress does not correspond to a motor address and is used as separation word in the FIFO itself.

When a start command is issued by the computer, motor addresses are sequentially extracted from the FIFO, the addressed RAM content is decremented by 1 and the relative output flip-flop is set. If the decremented RAM content is greater than ∅ the number is rewritten into the RAM and the address inserted into the FIFO.

This operation is repeated until the separation word is extracted from the FIFO. A pulse is then generated and sent to all outputs, which are gated by the output flip-flop. A step is thus simultaneously executed by all programmed motors.

FIFO's scanning is then repeated, and pulses generated, until no more addresses are contained in the FIFO.

The end-of-movement flip-flop is set in the status register and a CAMAC LAM to the computer is issued.

The 200 ns microinstruction cycle makes the variable delay introduced between successive pulses completely negligible.

3.2. - The power driver module

The power driver module is a two unit NIM module (Fig. 5). It drives two independent four phase stepping motors and monitors their position and status through a multiplexed interface to the remote control system.

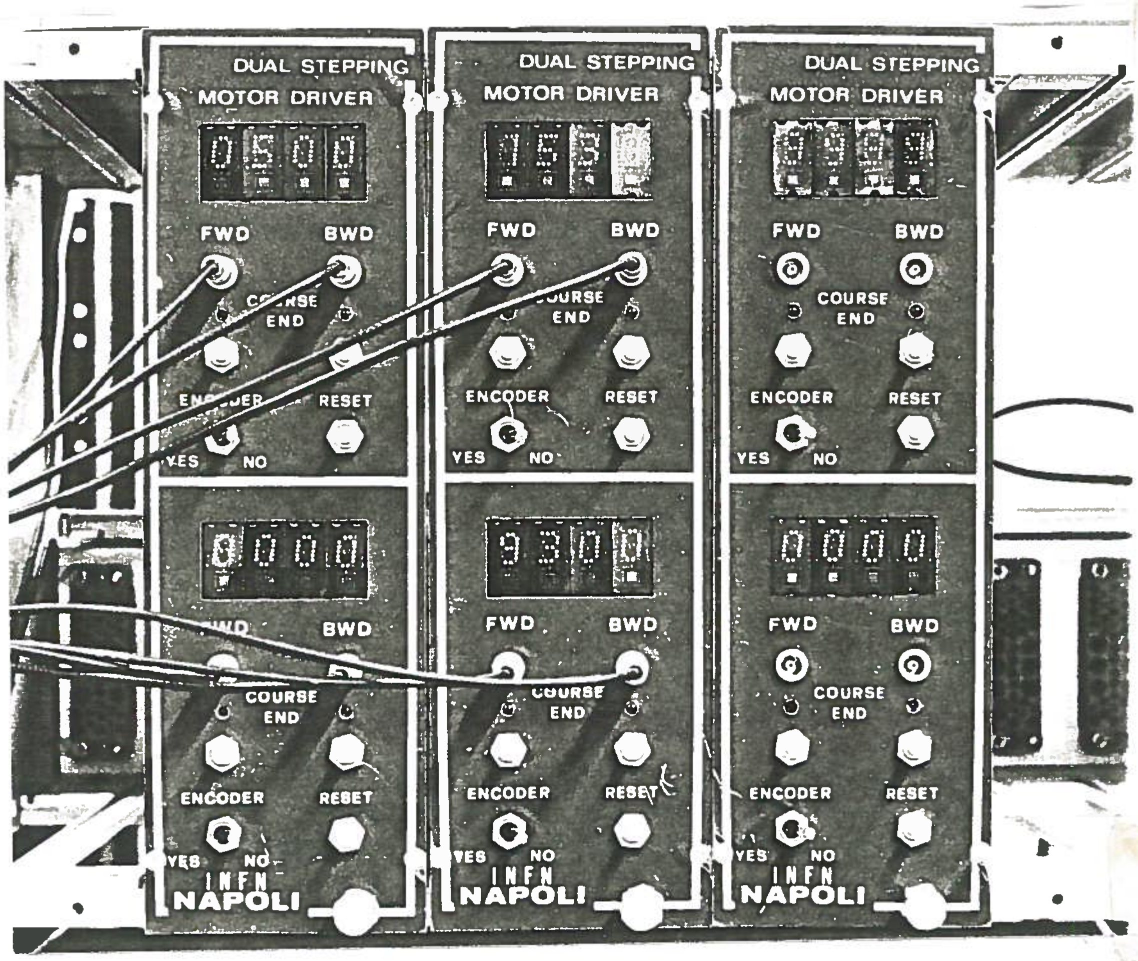

FIG. 5 - Frontal view of NIM dual motor driver module

Each driver, whose logic diagram is shown in Fig. 6, receives clockwise or anticlockwise motion commands, TTL levels low true, through two coaxial LEMO connectors.

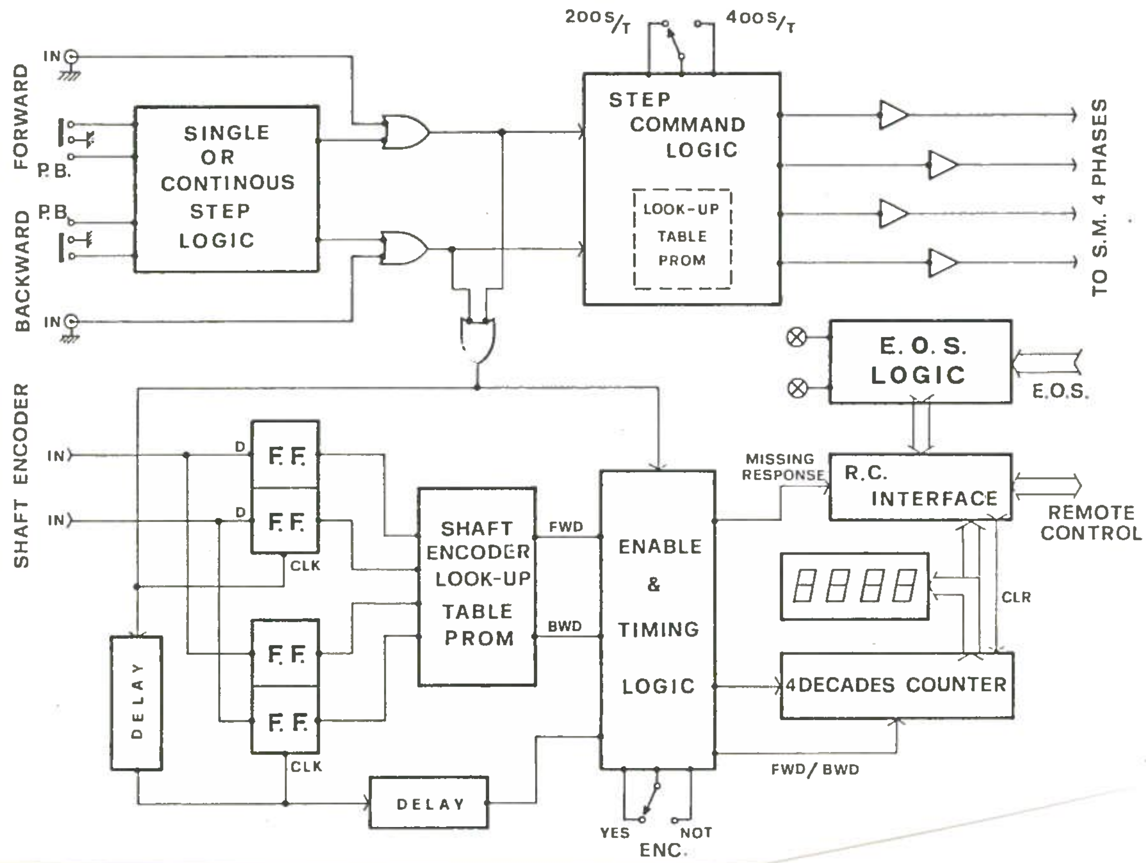

FIG. 6 - Logic diagram of motor driver module

The driver can also be manually operated by means of two front panel pushbuttons which, if shortly pressed, cause the motor to execute a single step in either direction, and, if continously pressed, give way to a 100 Hz oscillator which drives the motor to a fixed speed run. In this way it can be fully operated as a stand-alone module.

The step generation logic is based on a 32x8 PROM. Four PROM bits drive the motor phases currents. Three more bits are used as less significative bits of the 5 bits next address to the PROM itself.

The next address most significative bit, controlled by a switch on printed circuit, selects an half or full step movement (0.9 or 1.8 degrees respectively). The second one is derived from step command and determines the clockwise or anticlockwise step direction.

Currents to the four motor phases are derived from an external source, so to adapt it to specific voltage or current requirement. The driver itself can be set on current or voltage mode by a suitable choice of a resistor in the final power stage.

A differential square wave type shaft encoder can be associated to each unit. The two bit status of the encoder, before and after the step execution, is used as a 4 bit address to a look-up table PROM. A forward or backward consent to step counter or a missing response signal to alarm system is then generated.

If the encoder electronic is disabled by a front panel switch, the step counter is incremented or decremented directly by the step command.

The step counter content is visualized on a four digit display on the front panel and can be read by the computer through a rear panel CANNON connector.

For each movement two end-of-strokes are foreseen. In order to have maximum flexibility, any logical function of two independent signals can be implemented by jumpers on printed circuit for each end-of-stroke, and used to generate an alarm to the multiplexer unit. The end-of-stroke status is also displayed by two front panel LEDs.

For all linear movements used in spontaneous radiation measurements, a coincidence between two optical switches has been used to generate end-of-stroke signals. One of the switches is connected to the linear movement, the second one to the circular movement of the stepping motor axis to ensure an absolute position reference within one motor step (Fig. 7).

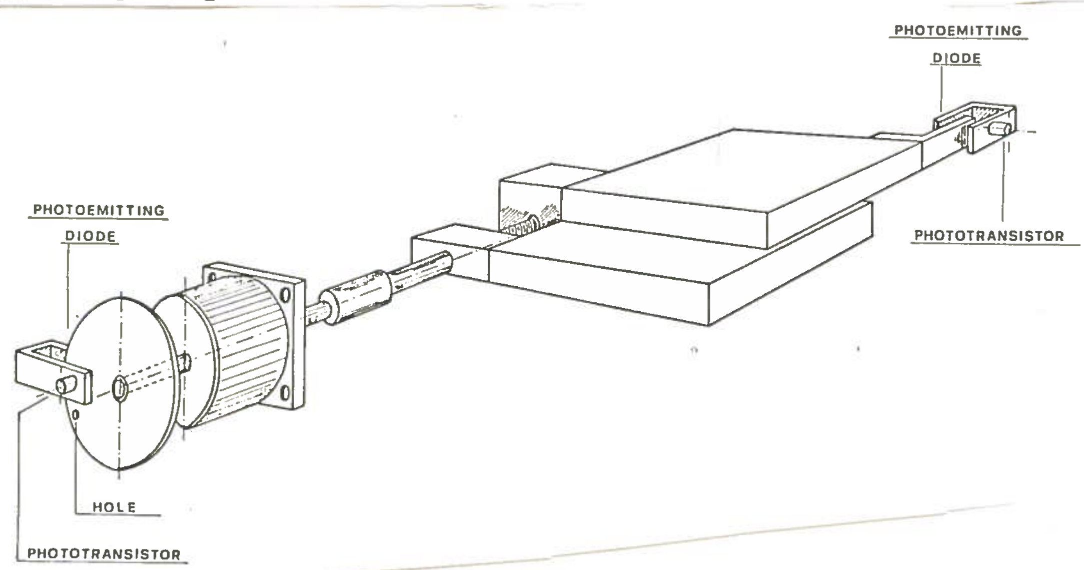

FIG. 7 - Schematic view of a linear movement with LEDs and phototransistor for end-of-stroke logic.

3. 3. - The multiplexer unit

In each power driver module the counters and the end-of-stroke status are displayed on front panel to allow safe operation when used in manual mode. The multiplexer unit ensures interrupting and polling capability when operating in remote computer controlled mode. This unit is linked to a CAMAC I/0 register from which it receives four motor address and two control bits, and to which it sends 16 data bits. No communication handshake with the computer is foreseen.

Each double power driver module is linked to the multiplexer unit via 16 data lines, multiplexed between the two counters, 6 fault signals and 4 control lines.

All fault signals from the drivers are ORed together to promptly detect a wrong condition and to send a stop pulse to the motor control module. Their status is also strobed in a register so that, by means of a polling routine, the computer can reconstruct the fault source and undertake the correct recovery action.

The step counters of the drivers can be independently read or reset, allowing a reproducible starting point to be created, moving forward or backward up to an end--of-stroke signal, and resetting the counter.

4. - CONCLUSIONS

A modular computerized system for remote control of stepping motor based high precision movements has been realized.

The use of standard CAMAC interface allowed an easy integration of the control and data acquisition system of LELA experiment.

The system has been successfully operated during the undulator spontaneous radiation measurement, in which a highly repetitive frequency and bidimensional position scanning with a high degree of reproducibility was required.

The modularity and the separation of different functions allows a straightforward extention to the complete LELA control system, including optical cavity tuning and diagnostics.

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