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Computer controlled beam profile measurements

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Abstract

The thermionic gun of the LIL (LEP Injector Linac) delivers a 80 keV electron beam. In order to measure beam profiles of the electron beam delivered by the LIL-gun, a computer controlled scan system was designed and used for this purpose.
To obtain beam emittances from measurements of beam radii the beam must be scanned in the x-y-plane [1], [2]. This non-destructive method to deduce the beam emittance is based on a computer controlled movement of the Faraday cup. Simultaneously the analog signals coming from the Faraday cup have to be converted to digital data by the same computer.
This note presents the experimental set-up and describes some technical data.

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1 Experimental setup for profile measurement

From theory [1] profile measurements are required to determine the radius of the beam in the plane of the Faraday cup. The beam radius σ_x is defined by the distance between the maximum value of the profile and the point where the beam intensity is half of the maximum value (FWHM).

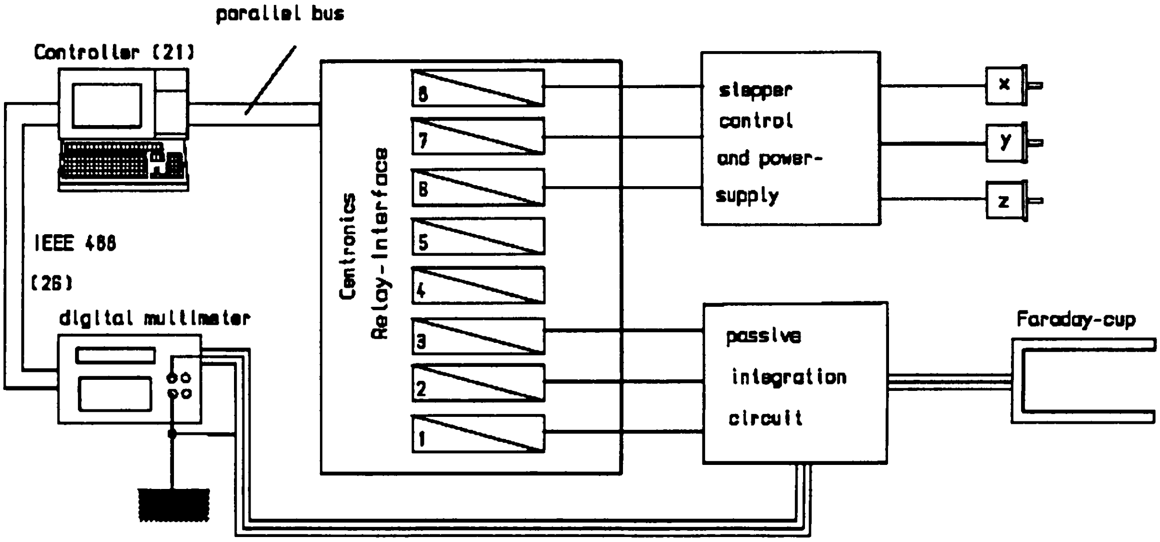

Figure 1: Scheme of the measurement devices and control lines

In order to measure beam intensity profiles, there are a lot of different techniques. In the present paper a scanning method is used. Every scanning method requires a controlling device e.g. a PC. A computer controlled scanning device needs an interface between the controller and the measurement devices. The sort of interface depends on the measurement devices and the method of taking measurements. In case of a pulsed beam a passive integrator and a digital multimeter are required. As one can see in Fig.1 the multimeter is controlled by IEEE488, whereas integrator and stepper-control are controlled by a relay-interface that can be controlled by the parallel bus. That means the steppers and the integrator communicate with the PC by using the printer port. Every ASCII that is sent to printer port results in a special setting of the relay-interface which is equivalent to the binary code of the ASCII. For example:

2 = CHR\$(50) = 00110010_2 = Relays 2, 5 and 6 are switched to state 1 (work).

The Faraday cup is connected with the integrator by coaxial cable. During measurement the Faraday cup is moved over the whole beam diameter in both directions with constant step size. Therefore the Faraday cup is mounted on a cross table of a UHV-manipulator which allows a three axis movement with micrometer screws. The manipulator is driven by stepper motors for moving the cup in well defined steps. Switching Relays 6 - 8 one may change the direction of the movement, the motor number and the moving status (moving, non-moving).

An important feature of the experimental set-up is the integrator which is shown in Fig.2. This unit accumulates the beam charge over a given period of time. The LIL thermionic gun works with a repetition rate of 100 Hz with a pulse length between 10 and 50 nsec. Therefore a sampling device like a scope with "sample and hold"- or an integration cirquit is required. In the present paper a simple passive integration circuit is used and also controlled by the Centronics interface.

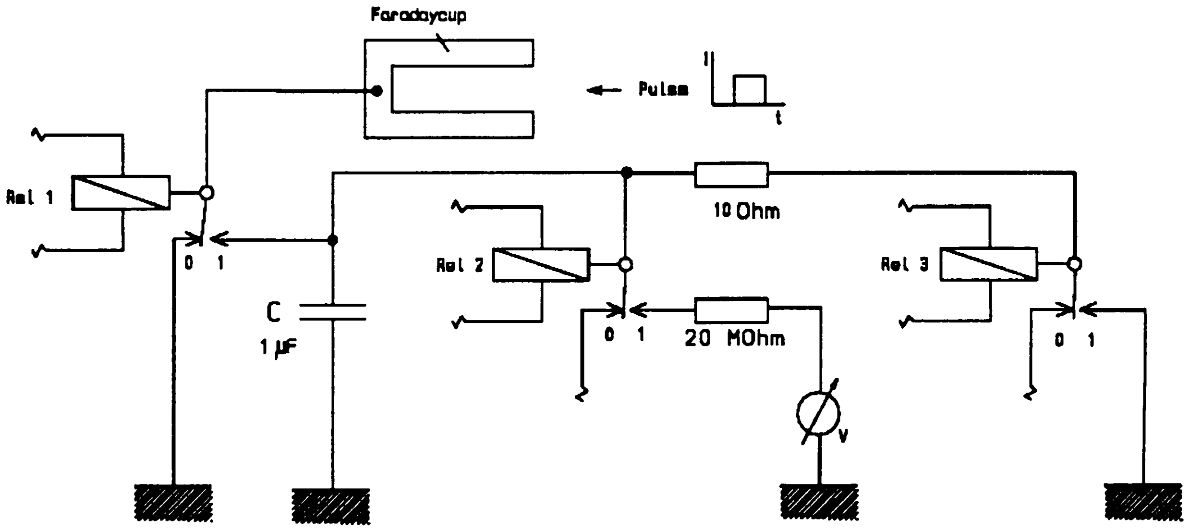

Figure 2: Passive integration circuit

The relays shown in Fig.2 are mounted on the integrator card. They are switched by the relays 1 - 3 of the Centronics relay-interface. The voltmeter in Fig.2 is a digital multimeter with a 16 Bit AD-converter. The integrator card is plugged in the voltage ports of the multimeter. The layout of the integrator shows a RC-link as mean part.

In order to measure the beam profile a quantity is required which is proportional to the beam intensity at a given position of the cup. Thus the voltage at a capacitor, which is charged over a well defined period of time by a part of the beam that is collected by the Faraday-cup, is a well suited quantity. The capacitor is dependent on the beam current and on the relaxation time τ = RC. The AD-converter of the multimeter needs 100 msec for digitizing the value of the capacitor voltage. Also the relaxation time has to be long enough to prevent discharging of the capacitor while voltage measurements happened. Fig.2 shows following choice: C = 1 μF and R = 20 MΩ. This means a relaxation time of 20 sec which is long enough to prevent discharging.

Discharging of the capacitor for next measurement is possible by grounding the capacitor via relay 3. The resistance of 10 Ω avoids high discharging currents. The different steps of the process at every mesh point are shown in Fig.3. It is a flux diagram of the program the computer run with. Registration of data, control of the different devices and the display of the measured profiles were done by the computer. After several initialisation steps the computer will loop until the Faraday-cup will reach the end position.

First at all the Faraday-cup is moved to the mesh point at position (x,y). The time the

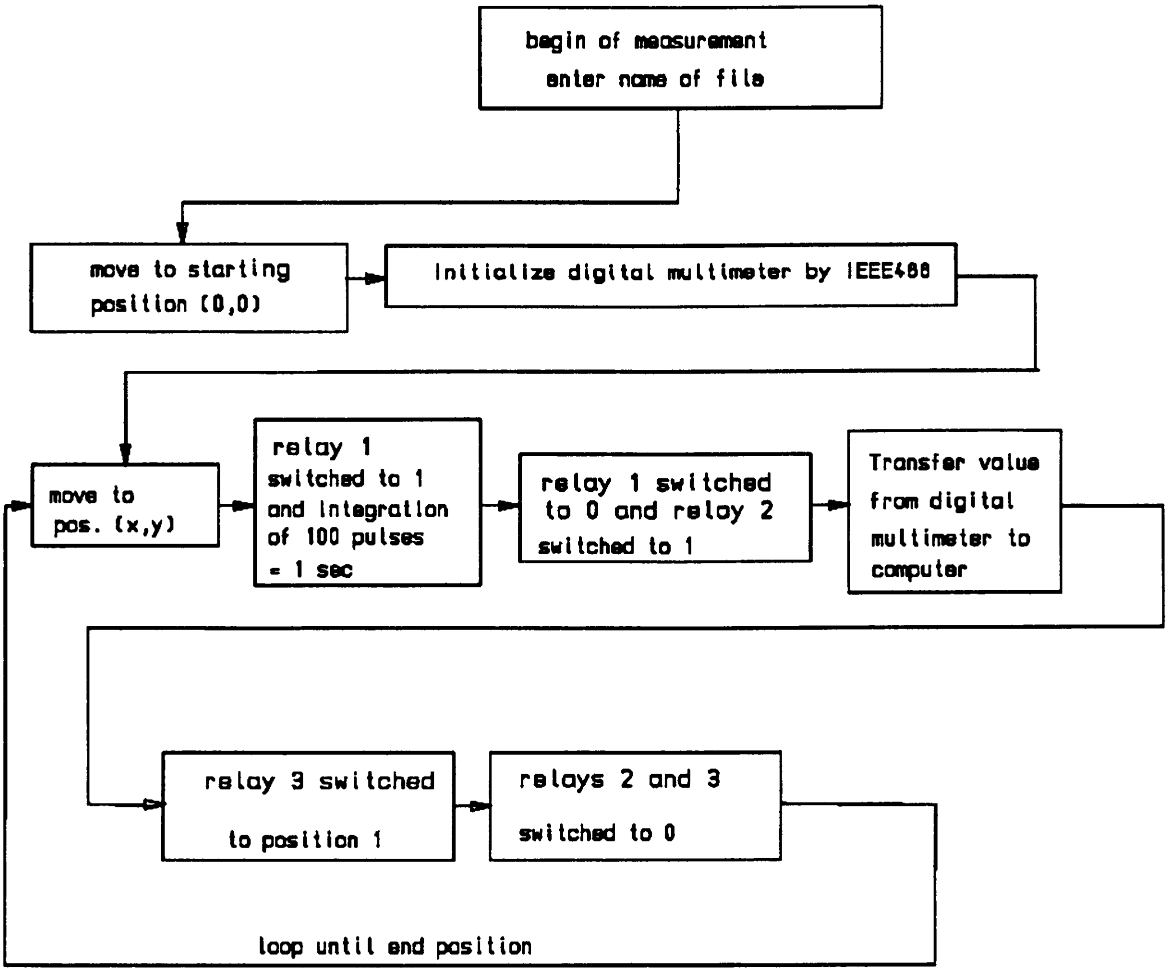

Figure 3: Scheme of the different measurement steps

steppers will need for moving to the next mesh point is dependend on the step size. In the next step relay 1 is switched to 1 (see Fig.2) and the capacitor will be charged. After one second or after 100 pulses relay 1 is switched to 0. That disconnects the capacitor and the Faraday-cup. Immediately relay 2 switches to 1, connecting capacitor and multimeter. After triggering the multimeter and after a measurement time of 0.1 sec, the value of the capacitor voltage is transferred from the multimeter to the computer via IEEE488-bus. Then relay 3 switches to 1 for grounding the capacitor. Finally relay 2 and 3 are switched to 0 and the next loop can start.

The sequence the relays are switched is illustrated in Fig.4. The times which the several steps need are also shown in that scheme.

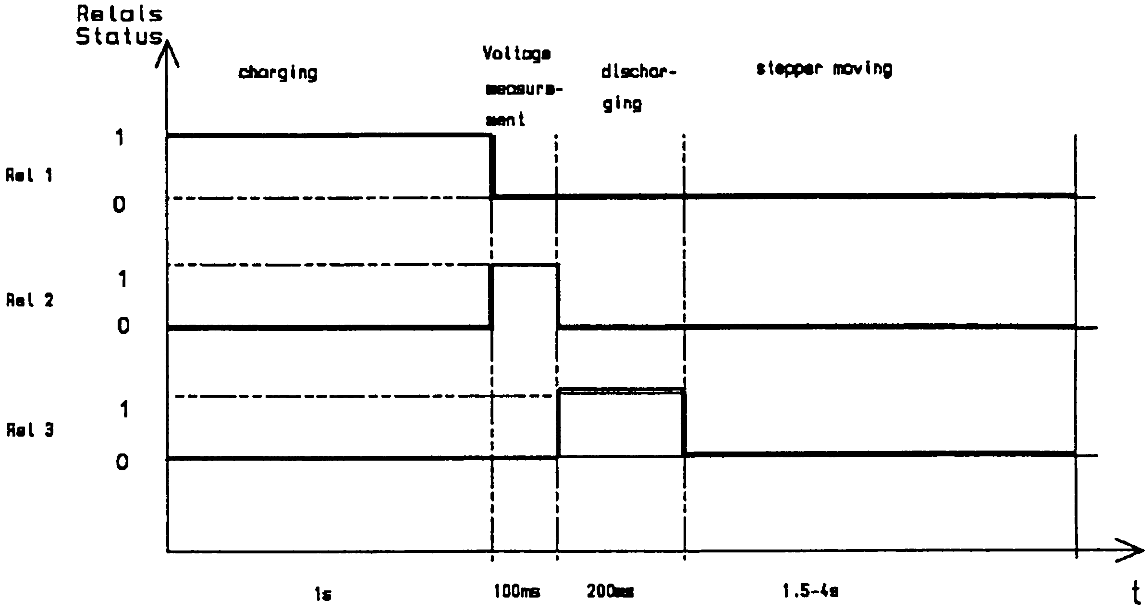

Figure 4: Scheme of the sequence the relays are switched

References

[1] R.Rao, L.Rinolfi
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