A.7: Faraday cup electrometer for linac beam pulsed current measurement

In an industrial linac, real time monitoring of important parameters, namely, peak pulse current, charge content in each pulse, integrated charge for a set duration, and the number of beam pulses produced every second is used for characterization and qualification of a pulsed electron linac. Online measurement of peak current and integrated charge over a set period provides useful correlation of linac output in terms of dose rate and dose. An isolated Faraday cup intercept the electron beam coming from the linac and the electrometer measures and displays all the above parameters. Commercially available imported electrometers need additional interface circuits. Such indirect solutions become inconsistent to use in high EMI environment and also are costly solutions. We have indigenously developed an integrated system Faraday cup electrometer data acquisition system (FCE-DAS) consisting of in-built current integrator, precision switched peak detect and hold synchronized with external trigger and efficient data acquisition system for real time monitoring of per pulse beam current. FCE-DAS shown in Figure A.7.1, is designed for the measurement of the peak beam current (1 mA - 300 mA), PRR (pulse repetition rate 1-300 Hz), integrate charge value for the pre-set time duration (presently fixed at 3 min) and the charge per pulse.

Fig. A.7.1: Faraday cup electrometer (FCE-DAS).

FCE-DAS is used for the measurement of beam parameters of linac installed at ARPF, RRCAT with beam energy 9 MeV, peak current 300 mA, pulse width 10 µs and PRR of 1 - 250 Hz, respectively.

Block schematic of the system is shown in Figure A.7.2. Voltage proportional to the charge collected by Faraday cup is generated across the 50 Ω termination. The charge is calculated by expression: $Q = \frac{1}{R}\int V dt$.

Peak voltage corresponding to the charge pulse is kept hold for specified period of time and digitized by a fast 16-bit digitizer. The droop time constant of peak hold is kept much larger than conversion time of ADC so that its effect on measurement accuracy is negligible. The measurement is synchronized with trigger received from linac. PRR, pulsed current and total charge are measured, and can also be transferred to master PC.

Experiments were carried out to check the response of FCE-DAS when beam scanning at various currents and different PRRs. The beam was intercepted by isolated Faraday cup as shown in Figure A.7.3 and generated charge is measured by FCE-DAS.

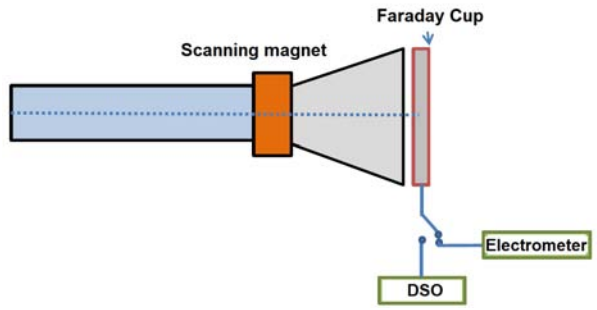

Fig. A.7.2: Block schematic of FCE-DAS.

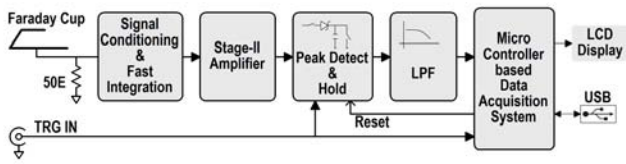

Fig. A.7.3: Experiment setup at ARPF, RRCAT.

The plot of integrated charge vs. time for low (14 mA), and high current (280 mA) are shown in Figure A.7.4(a) and (b), respectively for different PRR from 10-250 Hz.

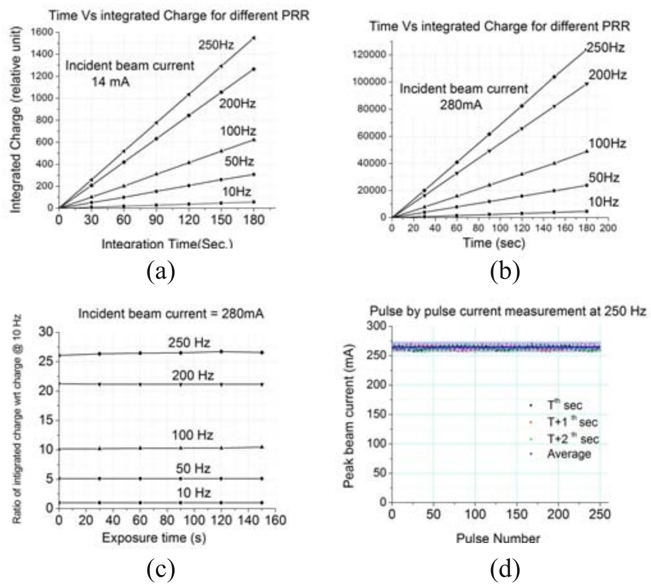

Fig. A.7.4: Different measurements of charge and beam current. (a) At 14 mA beam current. (b) At 280 mA beam current. (c) Plot normalized wrt 10 Hz. (d) Pulse current at 250 Hz rep rate.

It is concluded from these observations that the linearity in all ranges is better than 1%. In Figure A.7.4(c), data is normalized w.r.t. 10 Hz, which verifies integrated charge increase in proportion with PRR. Peak beam current for every individual pulse at PRR of 250 Hz was measured and also transferred serially in real time to the master PC. The pulse to pulse variation in beam current is found satisfactory, within 3% as shown in Figure A.7.4(d).

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