A.20: Precision ion chamber electrometers for x-ray detection in Indus 2 beam lines

Ionization Chamber (IC) is widely used for the measurement of flux of the ionizing radiations in synchrotron radiation sources. Its output current is proportional to the radiation flux, which depends on the chamber design, media filled inside the chamber and applied voltage. Commercially available IC system uses external HV power supply and dedicated electrometers to measure the current or charge. We have developed indigenously an integrated system (named as E-DAS) consisting of in-built HV power supply for biasing, high dynamic range electrometers and associated data acquisition system. The developed system measures charge or ionization current in the range of 10 pA to 10 μA. The E-DAS has uniform interface and portability across ICs of various size and geometry, which caters the dynamic range of 120 dB and internal programmable HV supply (0 - 2 kV) to bias IC.

To handle such a large dynamic range in E-DAS, a novel multi stage gain scheme is incorporated in which two independent channels of amplifiers are used. Channel 1 uses Gated Integrator based charge Amplifier (GIA) for low current signal i.e. 10 pA to 100 nA and channel 2 is used as trans-impedance amplifier (TIA) for 100 nA to 10 μA range. Further a digitally programmable gain amplifier with gain 10 is used for ultra-low currents. A micro-controller is used to digitize the analog signal, which also controls different modes of amplification, programmable gains, integration time and HV. The unit can be used as a standalone or as remote slave inside a beam line hutch which can communicate to master PC over serial optical fiber for loss-less data transmission up to 50 meters for data logging and networking. Block schematics of the IC E-DAS is shown in Fig.A.20.1.

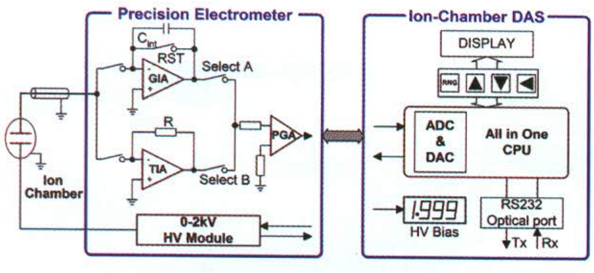

Fig. A.20.1: Block schematic of IC E-DAS.

System Description:

Electrometer module is designed to handle large dynamic range using independent amplifiers working in gated integrating mode (GIA) for 10 pA-100 nA and trans-impedance mode (TIA) for 100 nA to 10 μA. For the ultra-low range, to enhance S/N ratio, current from ion chamber is integrated by a GIA over predetermined period. Further care was taken to have the area beneath the amplifier chip free of power lead/plane and to surround all the high impedance nodes with guarding to avoid current leakage. Inherent integrating behavior of GIA provides good power line noise rejection capability as integration time, which is set to integer multiple value of time period of 50 Hz mains power. Maximum uncertainty measured in integration time is less than 100 ppm which corresponds to output noise of 100μV or less.

To accommodate large dynamic range current is being measured using trans-impedance amplifier (TIA) with gain of 10^6. Errors observed due to bias- current, resistor noise and gain error are negligible. This configuration can also be used for pulsed current measurements. Use of GIA for lower range avoided the use of large value feedback resistor and associated drawbacks. Buffered output with short-circuit protection was applied to analog input of CPU card for data acquisition and control. Fig.A.20.2 shows the photograph of the developed system.

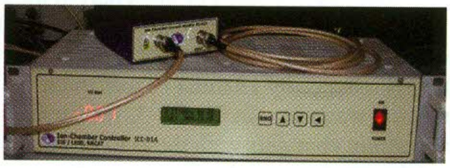

Fig. A.20.2: Ion chamber electrometer & DAS.

Salient features / specifications of the unit:

(1) Input: 10 pA - 10 μA.
(2) Integration time: 100 ms / 1 s
(3) Input offset and leakage current : <1 pA.
(4) Output drifts: < 200 fA / °C / hour
(5) Accuracy :< 0.05% of FS.
(6) HV bias: 0 - 2 kV

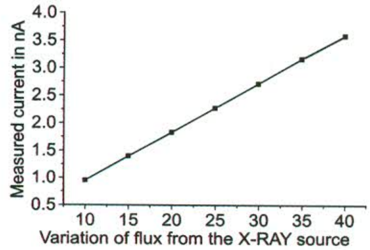

Fig. A.20.3: Measurement of X-ray flux using E- DAS.

The linearity of amplifier was evaluated using Keithley current source. For each current range, corresponding output voltage was measured and the end-point linearity was calculated and found better than 1% of full scale. Finally the E-DAS was tested with the x-ray source. Fig. A.20.3 depicts the linearity curve with fixed energy X-ray generator source Model PW 3830 and ion chamber saturation voltage of 1 kV. X-ray flux was varied and corresponding output was measured. From these data, end-point linearity was calculated, which was better than 1%.

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