AN INSTRUMENT FOR LOW LEVEL MEASUREMENTS OF THE LEAKAGE CURRENT FROM HIGH VOLTAGE BIASED DETECTORS

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Resitive Plates Chambers are detectors biased at High Voltage, HV, in excess of 4 KV. When fired by a particle they develop a large signal current that can be read across a small resistance, 100 $\Omega$ or so. A characterization has been made of their ageing as a function of the behaviour of their leakage current with time. An array of 10 detectors has been developed for this purpose. We present the instrument designed and built to perform a continuous and automatic monitoring of the leakage current from each detector of the array. The current has been measured in series to the terminal connected to the HV of every channel. Since the small value of the current, order of nA, a special circuit solution and special precaution has been adopted, that will be described in detail.
The requirement is the monitoring of the leakage current of an array of detectors biased at high voltage (4500 V) using a single voltage supply.

The aim is the study of the ageing, temperature behavior and the like.

Leakage current is from a few hundreds of pA up to hundreds of nA.
Minimization of disturbances from the measuring setup lead us to monitor the current from the high side of the detector.
The Leakage current develops a voltage across resistor $R_{\text{Sense}}$.

The voltages present at both terminals of $R_{\text{Sense}}$ are attenuated a factor of 750 with a pair of resistive splitters.

The difference $V_r-V_a$ is therefore 750 smaller than the voltage developed across $R_{\text{Sense}}$.

$R_A, R_{M1}, \ldots, R_{Mn} = 30 \text{ G\Omega, 1 ppm/V, 100 ppm/°C}$

$R_B, R_{AT1}, \ldots, R_{ATn} = 40 \text{ M\Omega, 100 ppm/°C}$

$R_{\text{Sens}_1}, \ldots, R_{\text{Sense}_n} = 22 \text{ M\Omega, 100 ppm/°C}$
Instead of performing the difference $V_r - V_a$ the 2 voltages, $V_r$ and $V_a$, are read, with an instrumentation amplifier, one at a time, closing the corresponding switch.

From each voltage its common mode is subtracted by proper adjustment of the DAC $V_{REF}$ ($V_{REF}$ is determined once, at the beginning of the measurement).

After each reading the offset is measured by short-circuiting switch $SW_{off}$.
Temperature is also monitored.

Voltage $V_r$ depends on the voltage drift of the splitter and of the HV only.

Its characterization allows to know the time dependence of the drift of the system against the environment one.

From this, assuming similar behavior for the drift all the other splitters, a good suppression is obtained.

An even larger degree of rejection of the temperature drift of each probe can be obtained if the system is run for enough time without the detectors connected. This allows to obtain knowledge of the ratio of any probe from $V_r$.  

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A computer with a commercial 16 bits ADC and Digital I/O is able to manage the system by regulating $V_{\text{REF}}$, setting the switches and performing the measurements.

The automatic setup is able to monitor the system for long time, while detectors are taking data. No influence has been verified thanks to the large impedances used for the splitters.

An accurate layout has been set to minimize ground loops between the computer and the array.
System setup and detector array (1)

Measurement setup. The PC is on the back, far from the probes.

Front view of the RPC 10 channels array.
System setup and detector array (2)

Probes

Switch box and amplifier

Inside view of the switch box with the amplifier and the digital circuit section.
The measurement shows the trend of the leakage current due to ageing. The black line is the reference channel, \( V_r \), after temperature compensation.