Multiplexer for the Em# Electrometer

P. Sjöblom [a], A. Milan-Otero [a], Andreas G. Persson [a]   [a] MAX IV Laboratory, Lund University, Sweden.

ALBA Em# Electrometer

Small currents need to be measured from a number of devices at a synchrotron and its beamlines. To meet this demand, MAX IV have joined a collaboration with ALBA to develop an electrometer that will ensure low current measurement capabilities and seamless integration into our Tango control system.

The electrometers has 4 independent channels measuring from 1 mA to 100 pA in 8 ranges. Using the 1 nA range, 25 fA resolution has been demonstrated [1]. The 4 channels are measured simultaneously at a rate 400kS/s by a 18 bits SAR ADC.

The front panel of the electrometer presents a touch panel where currents can be read and filters and ranges can be changed together with other parameters.

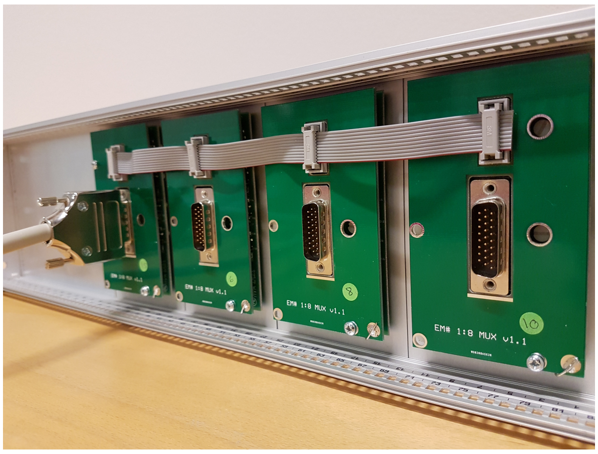
The back panel of the electrometer contains the interconnections such as input current, output voltages, trigger signals, I/O signals, together with the internal NUC computer ports.

Multiplexer

Many devices produce larger currents and only need low sample rate, which the performance of the electrometer exceeds by far. Other channels only need to be measured once in a while. To make the electrometer more flexible and also meet those situations, KITS at MAX IV have developed a multiplexer with 8 independent channels after suggestions from Veritas beamline.

The multiplexer is both powered and controlled by the electrometer through its multipurpose IO interface. At most, an electrometer can control 4 multiplexers simultaneously and read its signals giving a system with 32 channels, but the number of multiplexers can be chosen freely. In case of a beam positioning device, where four currents are to be read simultaneously to calculate location, the four currents can be placed on the same cannel number at different multiplexers, which means the electrometer does not need to change multiplexer channel to get a reading. The position can be calculated by FPGA and presented as a position variable (yet to be implemented).

The multiplexers are mounted in 19" frames and can easily be collocated with other patch panels from MAXIV [2].



The voltage supply, as well as the address, is provided by the electrometer through a HD26 SUBD connector. The bias and address is chained to the rest of the cards by IDC10 flat cable. A second grounded PCB is added on top of the main PCB to reduce EM interference with the surroundings.

Control system integration

The Alba electrometer has been integrated into the control system in different layers. As a first layer, we have the Tango CS [3] integration, for that purpose we are using a generic Tango device server that supports SCPI communication. In that way, we have a Tango device server sending SCPI commands to the equipment and exposing them to the rest of the control system.

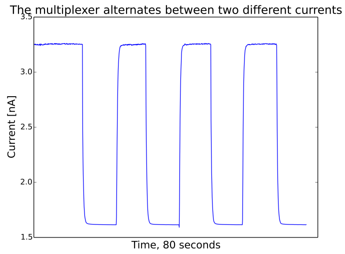
For higher integration and synchronization between equipment's in a system, we are using Sardana [4]. In the case of the Alba electrometer, the integration comes in a form of a Sardana Controller. This controller will handle the operations of the electrometer using the communication exposed to the control system by the Tango device server mentioned before.

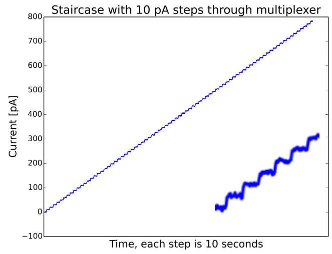
As a final layer, we have developed a set of Sardana macros that help our users to perform some specific actions, for instance, select the operation mode for the multiplexer.

Performance

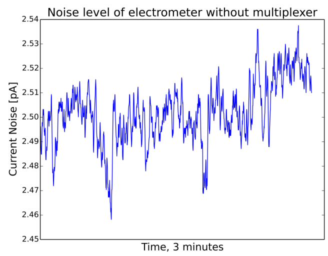
The multiplexer shifts between signals without providing any glitches or spikes of its own as can be seen in the plot where a 1.6 nA and 3.3 nA signal are present on two channels and the multiplexer is switching between those two signals. The shift takes, in this case, 500 ms, which is due to the charging of the cables and cut-off frequency of filter on the electrometer inputs as signals not under measurements are grounded by the multiplexer. A 10 pA staircase shows that the multiplexer can be used if current levels are a few pA and stronger. Testcurrents are generated by a Keithley 2635B source meter.

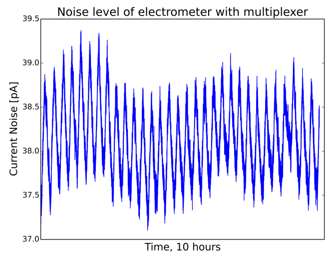
A reference setup with equipment found at beamlines was used to collect a noise spectrum with and without the multiplexer to investigates its influence. Without multiplexer, the noise was ±30 fA over a time period of 3 minutes and with a multiplexer ±50 fA during the same time period. A measurement over 10 hours shows ±1.2 pA variance, including long and short time drifting of the system. During noise and drift measurements, the input connector was shorted with a termination.





Switching between different inputs are made without spikes and staircase measurements resolve a few pA signals with the multiplexer.





Noise measurements over long time indicate that the multiplexer setup introduce more noise than what is possible to achieve when just the electrometer is present, but that the performance is anyhow in many cases well beyond what is needed.

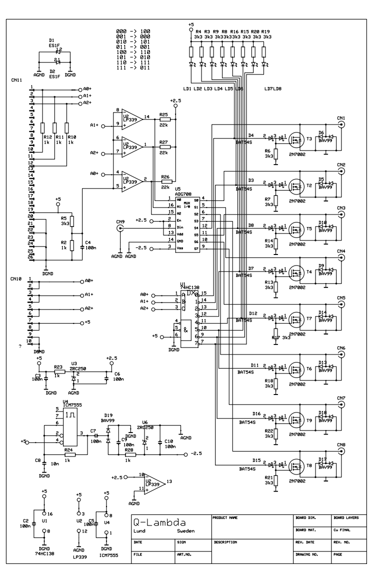
Circuit Design

The designs major components are the ADG708 channel multiplexer from Analog Devices that routes the current on the input to the output and the 174HC138 demultiplexer, which allows the MOSFET 2N7002 to ground the other signals that should not be measured.

The inputs are protected by BAV99 diodes from FAIRCHILD with 1.5 pF total capacitance. LEDs indicates which channel is in use.

The ICM555 is connected as a oscillator and runs for a half clock cycle before getting stuck on negative voltage, which is used in the rest of the circuit.

The multiplexer uses an address with three bits. Analog and digital grounds are separated.



The soft x-ray beamline projects Species, Arpes, Veritas, and Hippie project are funded by:

Knut och Alice Wallenbergs Stiftelse

Vetenskapsrådet

References

[1] J. Avila-Abellan, M. Broseta, et. al., *"Em# Electrometer Comes to Light"* TUAPL04, ICALEPCS 2017, Barcelona, Spain, 2017

[2] P. Sjöblom, M Lindberg, et.al. , *"Motion control system of MAX IV Laboratory soft x-ray beamlines"*. AIP Conference Proceedings, doi: 10.1063/1.4952868, Poster Verison, 2016 07 27.

[3] http://www.tango-controls.org

[4] http://www.sardana-controls.org

The MAX IV Laboratory

The MAX IV Laboratory opened for operation in 1987 (under the name MAX-lab) and is a national laboratory operated jointly by the Swedish Research Council and Lund University. The laboratory supports three distinct research areas: Accelerator Physics, Research based on the use of Synchrotron Radiation, and Nuclear Physics using high energy electrons.

At present three synchrotron storage rings are in operation MAX I-III and each year close to 1000 researchers visit the laboratory to perform experiments. The MAX IV laboratory is also responsible for the build up of the MAX IV facility situated in the Brunnshög area just outside of Lund and approximately 2 km from the present facility.