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#04-109 Development of a wideband current amplifier dedicated to Fission Chamber measurement

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Fission chambers are widely used in nuclear reactors, either to occasionally probe the neutron flux maps in nuclear power plants or as part of the nuclear instrumentation used in research reactors to characterize neutron flux levels in irradiation locations. In the frame of the Jules Horowitz Reactor (JHR) under construction at the CEA CADARACHE site, the Instrumentation Sensors and Dosimetry Lab (LDCI) is designing and manufacturing instrumentation (electronics and detectors) for the monitoring of experiments as well as for the reactor start-up protocol. For this purpose, instrumentation capable of high dynamics is required.

Wide dynamic range acquisition systems are very limited on the nuclear instrumentation market. Thus, since 2012, the LDCI is developing the MONACO system, which allows a measurement in pulse, fluctuation and current mode running simultaneously on the same channel. The latest prototype of this measurement system has reached TRL7 [1-2] and is now being industrialised. [1-2] considered now at a validated TRL7 level.

The simultaneous use of three measurement modes places high requirements on the amplification stage. Indeed, the current mode exploits a bandwidth between 0 and a few kHz, while the fluctuation mode is based on the frequency range 100 kHz - 1MHz. Finally, for the pulse mode, it is necessary to identify current pulses of a few uA in amplitude and with a duration of about ten nanoseconds, which implies a bandwidth that extends up to 10 or 20 MHz.

LDCI is then pursuing the industrialization process of the MONACO system in collaboration with the INSTRUMENTATION TECHNOLOGIES (I-TECH) company. In this paper, the first step, development an industrialized current preamplifier, is presented. The main goal of this redesign is to to improve the measurement of the DC current and extend its bandwidth. CEA miniature fission chambers require a wideband current transimpedance preamplifier to retrieve the current signals from detectors and convert them into a voltage signal compatible with a digitizer. The I-TECH designed preamplifier contains two modules, the first one corresponds to a trans-impedance amplifier built with operational amplifiers, which allows to measure AC current in the frequency band 10 kHz - 50 MHz. It is suitable both for negative and positive pulses, specific solutions and shieldings were implemented to reduce the parasitic cable capacitance as well as to increase its immunity to electromagnetic noise: The output noise level is ±25 mVpp The second module measures the DC part of the current by using a shunt and an isolated circuit operating at the potential of the fission chamber.

LDCI and I-TECH performed very promising bench tests in October 2020. Tests with synthetic signals corresponding to pulse and fluctuation mode showed very good performance of the electronics. The positive and negative current pulses are correctly amplified and the measurement noise was estimated at 0.1 uA pp thanks to a proper electronic shielding. The DC current measurement is also satisfactory in the tested range with an accuracy of less than nA and a bandwidth of 1kHz. Preamplifier qualifications are planned within realistic experiments using a fission chamber placed in a neutron field.

This preamplifier will be integrated as frontend in a complete new industrialized version of the MONACO system developed jointly by CEA and I-TECH (foreseen in 2022).

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