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The Gas Injection Control and Diagnostic System for the ESTHER shock Tube

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The European Shock-Tube for High Enthalpy Research (ESTHER) is a combustion drive shock-tube that is now being installed at IST/CTN campus where experimental research on plasma radiation of high-speed (>10km/s) shocked flows will be carried to simulate the high pressure and temperature conditions of spacecraft re-entry in different atmosphere conditions. The shock wave will be driven by the deflagration of a stoichiometric H2, O2 and He gas mixture with up to 100 bar filling pressure inside a 50 litre combustion chamber. The ignited mixture rises the pressure up to ˜600 bar which breaks a disposable diaphragm at the end of the combustion chamber creating the resulting wave front. An industrial partner, Air Liquide, installed the gas filling hardware for the combustion chamber including 15 pressure transducers, 22 controlled valves and 3 mass-flow controllers but the respective control system was developed entirely by the IPFN team using the open software EPICS and CS-Studio SCADA environment, embedded Linux computers and standard industrial automation programmable logic controllers (S7-1200 family PLC)) on a configuration similar to the ITER CODAC I&C architecture and software technologies for slow control.

The control system is responsible for handling the gas purge and injection, preparation for ignition, and exhaust burned or unburned mixtures assuring a safe, reliable and reproducible shock tube operation. The system includes an archiving and browsing system for the most important pressure, flows, filling volumes and temperature parameters and also embraces the connections to the independent security gas (H2, O2) alarm system, laboratory door-locking and audible warnings. A number of CS-Studio/BOY graphical user interface (GUI) panels were created both for mimic panels and the gas system operation. Finally a fast acquisition system (up to 125 MSPS) is able to acquire and synchronize the signals from a fast piezoelectric pressure sensor inserted in the camera and from an inductive sensor measuring the current flowing on the copper-nickel ignition wire.

This system allowed a successful operation of ESTHER during the preparation phase, completing already more than 80 deflagration pulses using a reduced volume 3 litre combustion chamber (“bombe”) with filling pressures close to final ESTHER specifications. In addition we present a proposal for a fast triggering system for the ESTHER spectroscopy diagnostic using FPGA fast data processing.

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