General Purpose, Modular and Customizable Integrated Data Acquisition and Control System (IDACS) For Charged Particle Instrumentation

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Synopsis We present the design of a general-purpose, modular data acquisition and control system that replaces the independent interfaces of individual charged-particle instruments with a single PC-controlled platform. Built around a dual-core TI microcontroller, it links isolated ADC, DAC, TDC, RF, function-generator, power-supply and digital I/O modules through separate high-speed and low-speed buses, allowing instruments to be controlled and read out from one graphical interface.

Charged-particle experiments, from electron-impact ionisation and ion spectroscopy to plasma and electric propulsion diagnostics, require many electrode potentials to be set, swept and synchronised while detector signals are recorded. In most laboratories, instruments operate independently, each relying on its own interface for control and data acquisition. This makes experiments difficult to synchronise, slow to reconfigure and hard to combine. We are therefore building a universal, modular data acquisition and control system through which various instruments can be controlled, and their signals fetched for processing, visualisation and analysis. The system is being developed to support various mass spectrometry, plasma diagnostics and charged particle optics applications at IIST.

Architecture: The system is built around a Texas Instruments (TI) dual-core 200 MHz real-time microcontroller that coordinates all modules (Fig. 1). A host PC communicates with it over USB, Ethernet or Wi-Fi, and a graphical user interface sets instrument parameters and displays the acquired data. Modules are grouped by their timing needs: time-critical modules share a high-speed SPI bus with dedicated synchronisation lines, while slow-control modules share an RS-485/232 and I^2C bus.

Signal generation and acquisition: The high-speed bus serves 20-channel, 16-bit ADC and DAC modules, a time-to-digital converter (TDC), and RF and function-generator modules required by specific experiments. A programmable clock generator (100 MHz–2.2 GHz) provides the common reference against which the TDC timestamps discriminator-generated detector pulses, enabling event synchronisation and time-resolved measurements alongside the ADC amplitude data [1].

Biasing and isolation: Low-voltage (LV) unipolar, LV bipolar and high-voltage (HV) power-supply modules on the low-speed bus bias the probes, electrodes and detectors, and are set through digital I/O modules. Because many instruments are biased with respect to floating potentials, each module is interfaced through digital isolation and powered by an isolated DC/DC converter with fuse, TVS (Transient Voltage Suppressor) and filter input protection. A hardware safety interlock acts on the power-supply modules, protecting users, instruments and the controller.

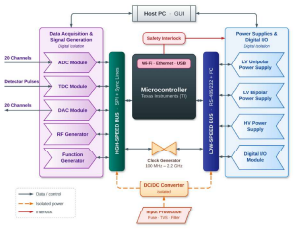

Figure 1. DAQ block diagram.

Status: The system architecture, bus layout and isolation scheme have been defined, and the ADC, DAC and TDC modules are being selected. The data acquisition chain, comprising ADC readout, data transfer to the PC and real-time processing, is under development. Once complete, the platform will be deployed, replacing their separate control and acquisition setups with a single reconfigurable system. Details of the test board and system performance results will be presented.

References

[1] Abbasi R *et al.* 2009 *Nucl. Instrum. Methods A.* **601** 294

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