

# An integrated biasing power supply, control and acquisition system for large Langmuir probe arrays in cold plasmas

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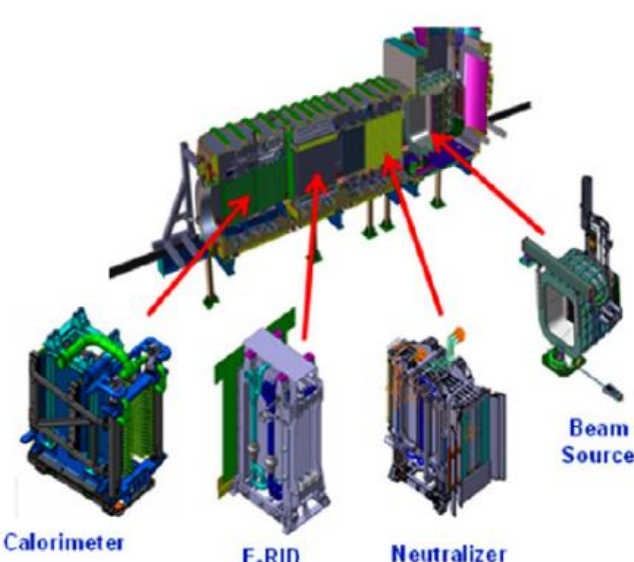
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## 1. Introduction

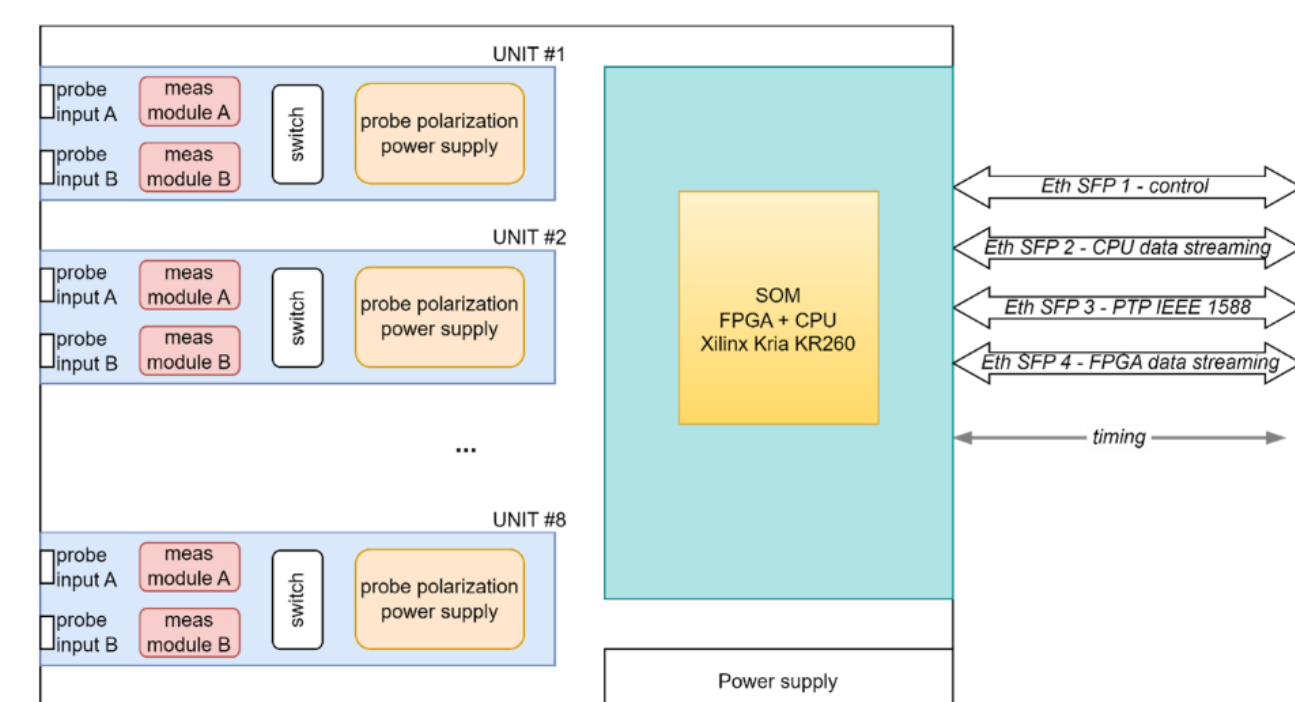
The Electrostatic Probe Integrated Conditioning and data Acquisition module – **EPICA** – is an acquisition system designed to manage the acquisition and data transfer of the electrostatic measurements required in ITER's NBI prototype, MITICA.



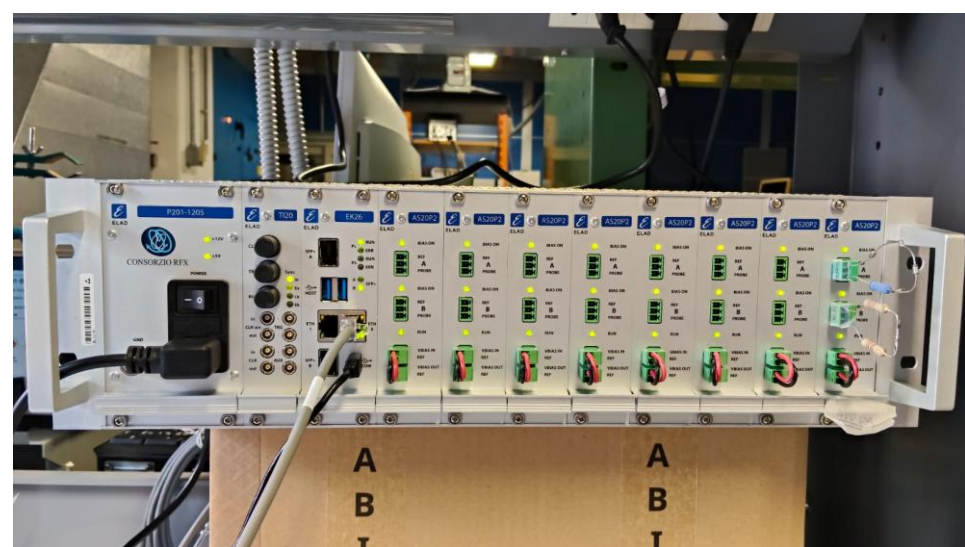
- **High volume of simultaneous measurements (218).**
- **Isolation** between the analogue front-end and the subsequent processing electronics.
- **Integration** of the biasing power supply
- ITER CODAS integration

Development of a **tailored modular system**:

- **Great flexibility**
- **Scalability**
- **Ease of integration.**



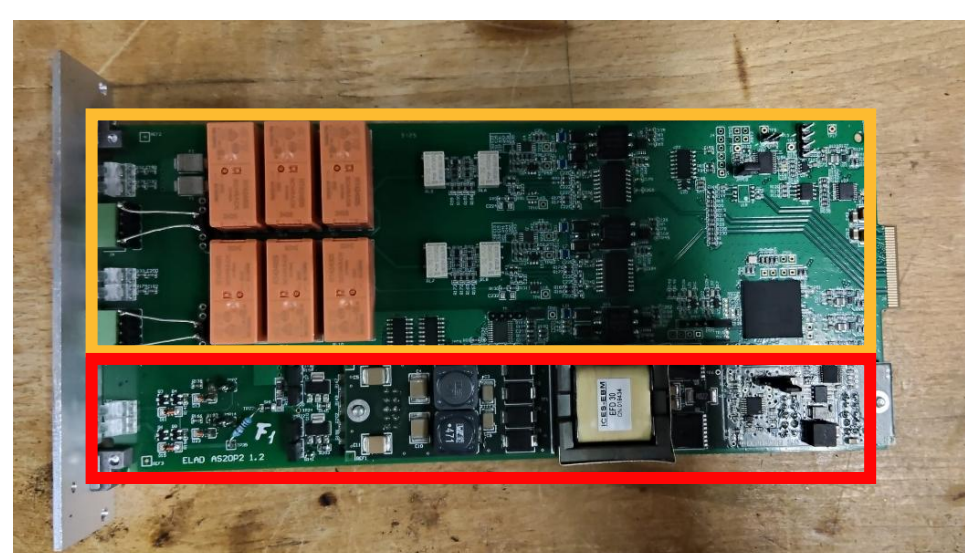
## 2. EPICA – System Description



The system is housed in a **3U Eurocard Standard, 84 TE rack**. It is composed by various modules: power unit, timing unit, **controller module** and **probes module**.

**Control module** - Capable of managing up to 8 units, is based on a System-on-Module (SoM) integrating an **FPGA fabric** and an **ARM processing core** on a **single chip**.

- Provides both high flexibility and **strong computational performance**.
- Ensures **alignment with industrial standards** for seamless integration.
- Can operate using either a timing module or the **Precision Time Protocol (PTP)**.
- **Custom Linux distribution** enabling real-time, high-performance system operation.



**Probes board** - capable of managing two probes in different configurations. Each board can measure different current magnitudes, enabling a wide range of applications.

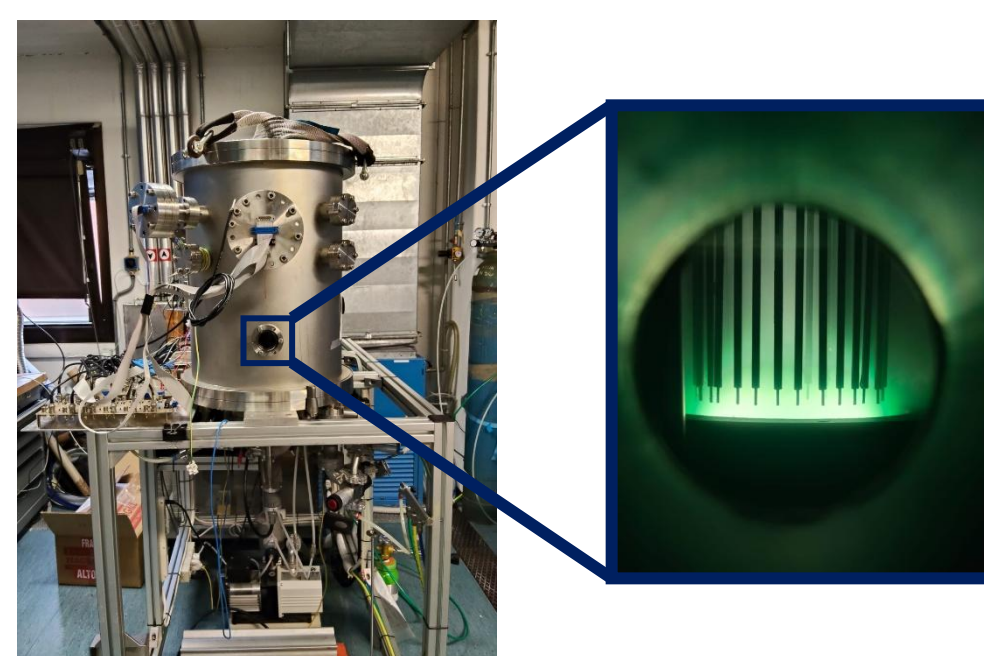
### Control, acquisition & configurable front-end:

- **FPGA** for fast parallel acquisition and **microcontroller** for front-end configuration and slow control.
- **16-bit isolated ADC** providing up to 1.5  $kV_{RMS}$  isolation between front-end and processing electronics.
- **Configurable front end** supporting different probe configurations and current ranges.

### Integrated biasing power supply:

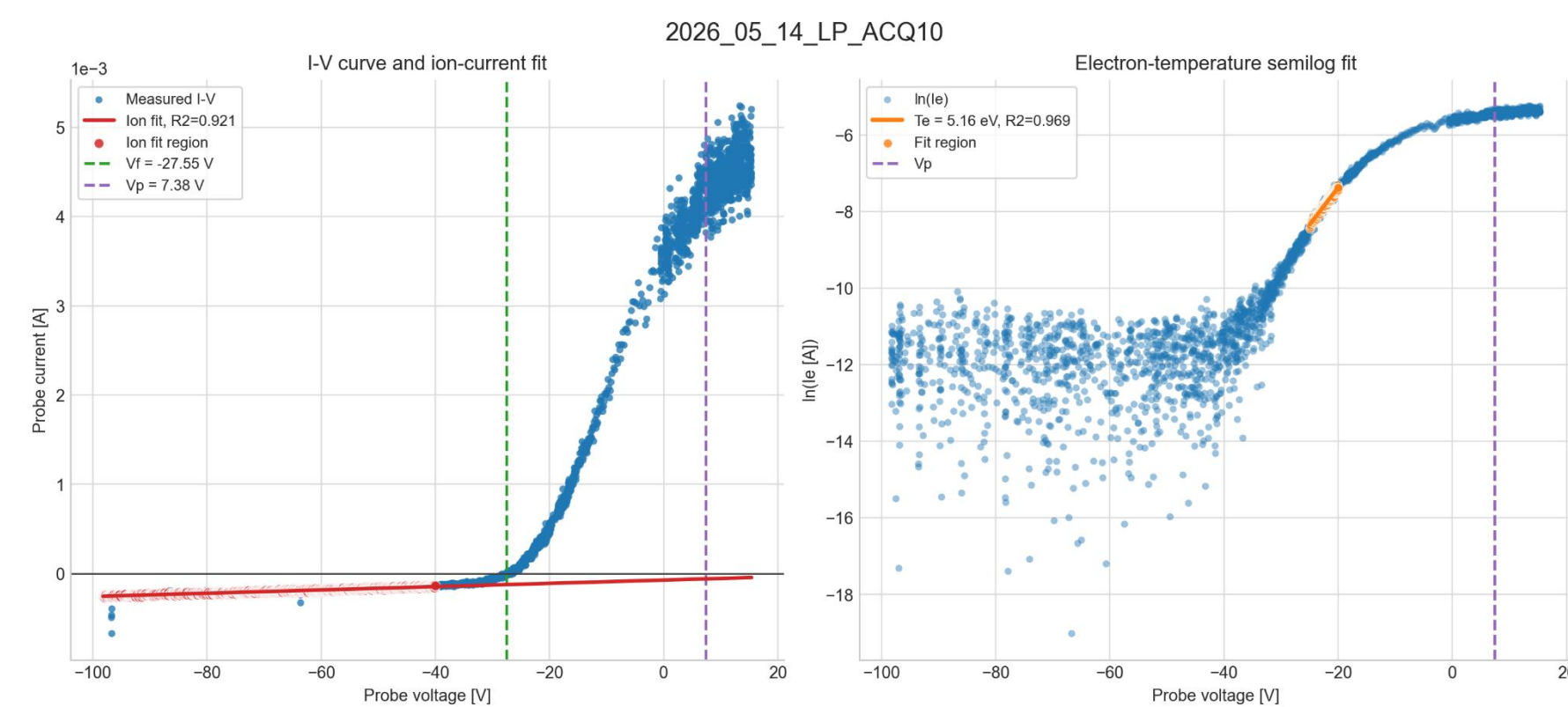
- **Bipolar push-pull DC/DC converter** with configurable reference voltage.
- $\pm 100V$  output swing and  $\pm 0.5A$  drive capability.
- **Fully isolated** from the processing electronics.
- **Supports bypass operation** for COTS power supplies.

## 3. Prototype Validation



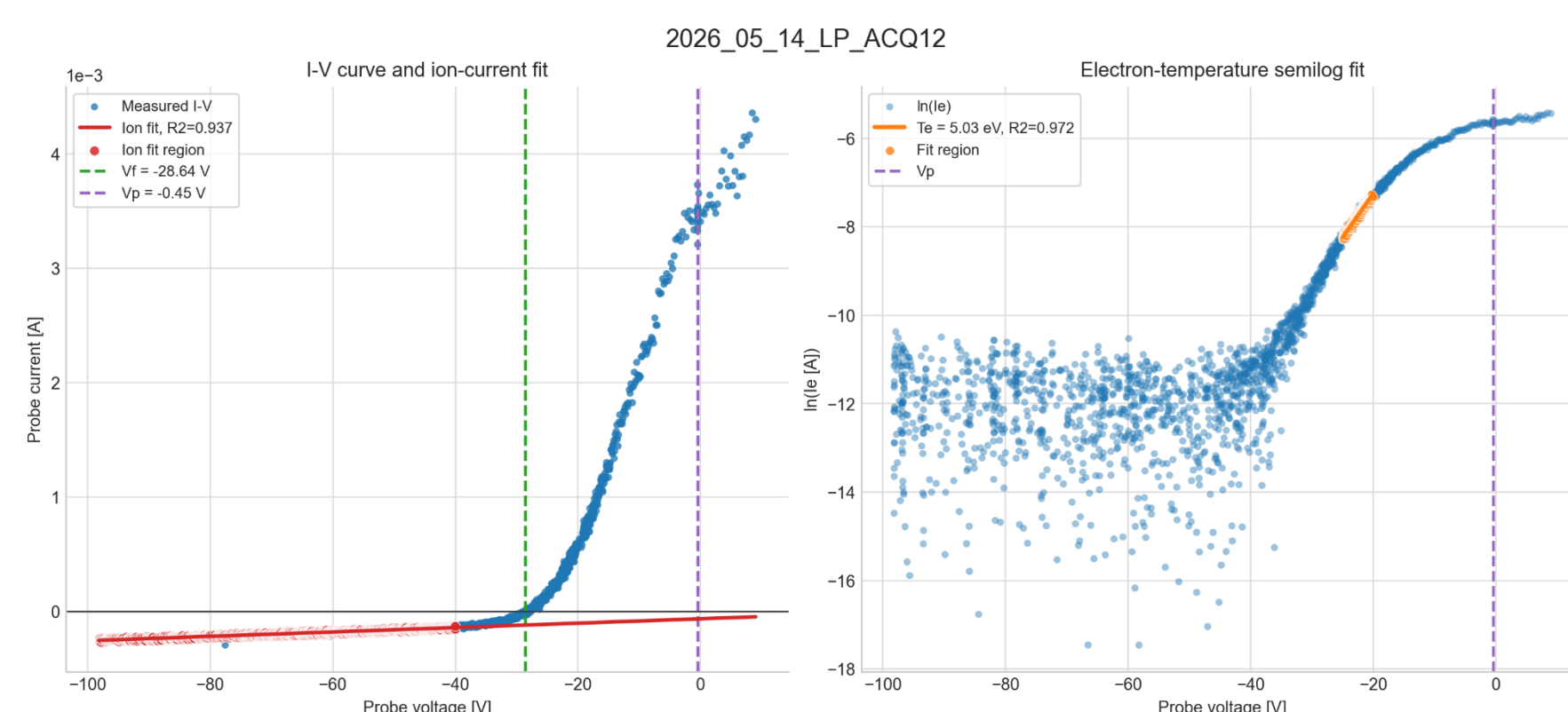
Prototype validation was conducted in a vacuum chamber environment, where weak plasma discharges can be generated.

Various waveforms were generated and multiple acquisition tests were performed.



$$V_p = 7.37V \quad V_f = -27.55V \quad N_e = 3.71 \cdot 10^{16} m^{-3}$$

$$N_i = 4.47 \cdot 10^{16} m^{-3} \quad T_e = 5.16eV$$



$$V_p = -0.45V \quad V_f = -28.64V \quad N_e = 2.9 \cdot 10^{16} m^{-3}$$

$$N_i = 4.46 \cdot 10^{16} m^{-3} \quad T_e = 5.03eV$$

## 4. Conclusions & Future Works

### Conclusions:

- EPICA was **successfully developed** for **scalable Langmuir probe diagnostics** in MITICA/ITER-related applications.
- Vacuum chamber validation confirmed reliable probe acquisition and plasma parameter extraction.

### Future works:

- System **validation on small-scale experiments**.
- Studying, characterization and development of a **controller for the integrated biasing power supply**.