

Validation and comparison of FPGA-based real-time Thomson Scattering data processing against offline analysis methods

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A real-time signal processing unit based on FPGA has been developed for electron temperature (T_e) evaluation in a Thomson scattering (TS) diagnostic system. The FPGA module is independent of the polychromator and is integrated with ADC and DAC components as a compact real-time processing unit. It receives five analog input channels directly from the spectral outputs of the polychromator and digitizes scattered signal pulses (~40 ns width) using a 16-bit, 1 GS/s ADC.

After background subtraction, each channel's waveform is integrated, consuming 1.01 μ s in simulation. The resulting integrals are then standardized across the five channels, a process taking 4.26 μ s. These standardized values are matched against a precomputed 5001 $\times$ 5 spectral response database using a minimum-variance search algorithm. The database lookup takes 12.4605 μ s in simulation, yielding the T_e estimate. A 16-bit DAC converts the result to a 0–10 V analog voltage, linearly corresponding to 1–5000 eV. Preliminary validation has been performed for T_e ; the electron density (n_e) algorithm is under development. The system demonstrates sub-15 μ s processing latency and provides a viable foundation for future real-time plasma diagnostics and control applications.

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