A Magnetic Diagnostic Suite for the Pegasus-III Experiment

J.A. Reusch, M.W. Aslin, M.W. Bongard, C. Rodriguez Sanchez, S.J. Diem, J.A. Goetz, M.D. Nornberg, A.S. Rajendra, S. Redd, R.K. Sassella, A.C. Sontag, J.D. Weberski, G.R. Winz

University of Wisconsin-Madison, Madison, WI 53706, USA

Corresponding Author Email: jareusch@wisc.edu

Pegasus-III is a new ultralow-A ST providing a dedicated US experiment for comparative solenoid-free startup studies. This new solenoid-free ST ($A \geq 1.22$, $I_p \leq 0.3$ MA, $B_T \leq 0.6$ T, $t_{pulse} \sim 0.1$ s) has recently begun operations utilizing local helicity injection (LHI) startup, with deployment of: a coaxial helicity injection (CHI) startup system; a 28 GHz radiofrequency (RF) system for heating and current drive; and enhanced diagnostics planned for the near future. An important part of the new diagnostic set is the magnetics measurements for equilibrium magnetic field and low frequency (< 200 kHz) MHD analysis. The new magnetic diagnostic set consists of: 33 poloidally distributed flux loops inside the vessel; 16 flux loops outside the vessel; a poloidal array of 34 b-dot coils; a high-field-side and a low-field-side toroidal array consisting of 6 non-uniformly distributed coils each; 3 diamagnetic loops; and two plasma Rogowskis. These new diagnostics address significant challenges to measuring the magnetic field in Pegasus-III. That is, all of the diagnostics must be shielded against electrostatic switching noise generated by the 14 independent current feedback-controlled power supplies for the toroidal and equilibrium fields and the helicity injection startup systems. Immunity to this switching noise is accomplished through end-to-end differential signal runs and signal processing, along with continuous EMI shielding from diagnostic to digitizer. Ex-vessel calibrations of NA_{eff} for the b-dot coils were completed using a three axis Helmholtz cube to a nominal uncertainty of $< 0.5\%$. Measurements of the coil and flux loop locations were performed in-vessel with typical uncertainties of 0.5 mm. The residual tilt angle of the coils has been quantified such that toroidal field pickup and NA corrections can be made in post shot processing. While this angle is small (typically $< 1.5^{o}$) the HFS magnetic field is over 3.5 T compared to O(0.1 T) poloidal fields, and therefore must be accounted for. The plasma Rogowskis were calibrated using a 20 turn coil wound in place in the vessel. This coil was pulsed to 300 kA-turns and 60 MA-turns/s, validating the calibration across the Rogowski coils' expected operational range. Differential magnetic signals are conditioned by a precision 8 pole Butterworth filter with a corner frequency at 200 kHz and simultaneously digitized at 1 MHz. This setup provides switching-noise-free signals that are suitable for equilibrium and stability analysis.

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