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3D Magnetic Field Diagnostics for Measurement of Magnetic Diffusion

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A magnetic field diagnostic system has been developed that enables measuring the transient magnetic field diffusing through conductors with wall thickness on the order of the skin depth. Typical commercial magnetic field probes are limited in their ability such that they are only able to measure in a single direction at a time, and they may require multiple measurements in different orientations to account for the external common mode noise.

The magnetic field testbed generates a sinusoidal current with a peak value of ~38 kA, with a ringing frequency of ~5.5 kHz, through a two turn excitation coil. The field diffuses through the walls of a hollow conductive structure placed roughly 5 cm away from the center of the coil. The thickness of side and bottom walls is kept constant, while the top plate thickness is varied to alter the rate at which the magnetic field diffuses through the conductor. Field amplitudes inside the shielded volume are attenuated by multiple orders of magnitude compared to the external field, which complicates measurements. That is, the noise introduced through magnetic interference may easily be on the order of the measured signal unless a proper diagnostic design is chosen.

A 3D differential B-dot probe with sub-µs rise time was successfully developed. The probe consists of three differential pairs of multi-turn pickup coils, which allows accurate capture of tri-axial magnetic fields. Previously developed probes constructed using single-turn differential coils had a lower signal-to-noise ratio and were more susceptible to stray magnetic fields in comparison to the newly constructed probes. The significant common mode noise of the commercially available probe has been virtually eliminated through employing a differential measurement technique. With the existing noise level a minimum dB/dt of 25 times less than the external field of 950 T/s is measured with high fidelity.

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