DESIGN OF THE ITER HIGH-FREQUENCY MAGNETIC DIAGNOSTIC COILS

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The ITER high-frequency (HF) in-vessel magnetic diagnostic has to provide essential measurements of MHD modes. The Project Requirements [1] impose the measurement of oscillating fields $|\delta B_{MEAS}/B_{POL}|\sim10^{-4}$ up to 2MHz to resolve toroidal (n) mode numbers in the range |n|=10-50.

The ITER reference design of the HF coil system has two main arrays for n-number identification, each one with 36 equally spaced sensors located at the corners of the equatorial ports, and one array for poloidal (m) mode number identification, comprising 16 un-evenly spaced sensors over the full poloidal cross-section excluding the divertor region, repeated on six machine sectors. The current reference 1D HF pick-up coil [2] has an effective area of $\sim0.06m^2$. It is made with 33 turns each on 2 separate layers, wound over ceramic spacers acting as insulating formers and centered on a hollow slotted stainless steel body.

The manufacture of HF mock-up and prototype coils has revealed difficulties regarding the winding process and the routing of the tungsten wire. The simulated thermo-mechanical behavior of the mechanically preloaded coil assembly is likely to lead to fatigue failure by cyclic differential thermal expansion [3]. Different improved variants of such coils have been built with alternative types of guiding grooves and materials for the wire. However, the proposed tungsten wire appears to us to be too brittle. Our test results have demonstrated that the reference design for the HF coil could usefully be revised.

Various exploratory designs, presented in this paper, have been investigated, prototyped and characterised: (a) non-conventional Mirnov-type coil with the winding made by laser-cutting a tube; (b) stacking of plane windings manufactured from a tungsten plate by electrical discharge machining; (c) monolithic 1D magnetic flux sensors based on the low temperature co-fired ceramic (LTCC) technology; (d) monolithic 3D magnetic flux sensors based on the same LTCC technology. The design and prototyping of 1D LTCC sensors with winding patterns for low frequency measurements used for magnetic reconstruction is reported at this conference in [4].

The proposed manufacturing processes are applicable and scalable to the production of a large number of coils with high reliability and reproducibility of the electromagnetic properties.

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[1] ITER Project Requirements, ITER_D_27ZRW8 v4.5.
[2] ITER Magnetic Diagnostics Design Status, Appendix 1 to the Overview of the ITER Diagnostics System, N 55 DDD 12 04-07-09 W 0.1.
[3] ITER System Requirement Document SRD-15-IV (In-Vessel Coils), ITER_D_2MFYMW v1.4.
[4] A.Gallo et al., ITER In-Vessel Magnetic Sensors Prototyping and Tests, this conference.
[5] D. Testa, Assessment of the ITER High-Frequency Magnetic Diagnostic Set, this conference.