MSE diagnostic signal processing using software Phase Locked Loop and Empirical Mode Decomposition

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Plasma diagnostics are essential for the reconstruction of important plasma radial profiles, such as the safety factor q(R). One of the best known techniques to obtain the radial q-profile, probing directly inside the plasma, is the Motional Stark Effect (MSE) diagnostic. In this paper, we focus on a novel, digital signal processing technique associated with this diagnostic. A software implementation of a Phase Locked Loop scheme, based on the Hilbert transform and instantaneous phase concept, is used to determine the signal amplitudes of each of the MSE signal relevant components DC, 23, 40 and 46 kHz, robustly minimising frequency jitter effects. In addition, through a Matlab graphical user interface, user interaction is minimised, in particular regarding the rotation angles necessary for the PLL setup. The core processing uses the Local Area Multicomputing/Message Passing Interface (LAM/MPI) implementation for Matlab and is split between 28 nodes taking the most advantage of the Jet Analysis Cluster. Furthermore, Empirical Mode Decomposition (EMD) is used successfully as a filter bank tool for analysing local time variations of the pitch angle. This technique has proven very useful for filtering high frequency components especially when the available amount of samples is limited or one wants to narrow down the analysis to a short time window. Globally, this technique is applied to determine the local pitch angle in a time scale of one millisecond for the full MSE time window in JET plasmas. The measured radial profile of the local pitch angle reveal minor difference over the standard MSE processing techniques, showing the possibility of using this technique in a faster time scale, avoiding in this way the conventional smoothing of data points to reduce noise. Comparison between the EMD and standard moving average analysis is presented, showing good agreement between the two. Moreover, MSE signals processed with EMD techniques are used as constraint for equilibrium reconstruction using EFIT code. In this case we present the example of a JET reversed shear discharge, where the reconstructed q-profile is verified with MHD analysis.

[1] *See the Appendix of J.Pamela et al., Fusion Energy 2004 (Proc. 20th Int. Conf. Vilamoura, 2004) IAEA, (2004)*