DYNAMIC TESTS ON THE NEW FRONT-STEERING EC H&CD LAUNCHER FOR FTU

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The electron cyclotron resonance heating and current drive launcher for real time control experiments on FTU consists of two fast-steering antennas capable to track the MHD instabilities. The working space of the two antennas is limited by mechanical constraints of the port aperture which bounds the possible toroidal and poloidal movements of the steerable antennas facing the thermonuclear plasma. Each antenna is steered by a couple of brushless motors for toroidal and poloidal axes of rotation [1].

The identification of the antenna dynamics, for the design of both an optimized antenna controller and a model predictive protection system [2], is the main objective of this paper. Using a set of hardware and signal conditioning electronic circuits, the response of each antenna system (including the antenna mass, gears, shafts, motors and drive inverters) has been acquired in laboratory for different working conditions, in order to identify the state space model of the launcher.

Based on the antenna dynamics, the proportional, integral and derivative gains of the PID controller of each motor have been set to the optimized values which meet the constraints of the rising time, overshoot and settling time for each motor movement. The laboratory tests which will be presented in the full paper show that the dynamics of the prototype antenna is capable to meet the design specifications.

The gears between motor and antenna are modeled as an algebraic relation which links the antenna angles θ and ϕ to the angular positions of the two motor shafts, which are called γ and δ, with a transmission ratio due to the coupling between the motors and the antenna. Each motor is controlled by a drive inverter, which contains a PI speed controller. The reference speed signal is calculated externally and sent to the drive inverter, whereas the speed feedback is obtained from a resolver which is mounted on the motor shaft [2].

The paper also describes the proposed hardware for implementation of the real-time antenna control system which consists of a set of industrial reliable FPGA and DSP based platforms. FPGA technology is indispensable wherever capability of parallel processing or harsh industrial environments is involved. The antenna control algorithm has been implemented on the FPGA in NI Compact-RIO system which is a small, rugged embedded control and data acquisition system that provides graphical, data flow and VHDL programming tools of FPGA in LabVIEW [3]. The computations needed for PID control of toroidal and poloidal positions of each antenna are classified in two sets that execute in parallel. The VHDL code of antenna control algorithm is optimized for using fewer resources and faster execution.

[1] A. Bruschi et al., Fusion Science and Technology, **55**, 94-107 (2009).

[2] G.D'Antona, M.Davoudi, R.Ferrero, H.Giberti, *A Model Predictive Protection System for Actuators Placed in Hostile Environments*, accepted for publication on Proc. IEEE Instrumentation and Measurement Conference (I2MTC), USA, 2010.

[3] http://www.ni.com/compactrio/