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EX/P4-35: Current Profile Control Using the Ohmic Heating Coil in TCV

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The economy of future tokamaks may have to rely on having large bootstrap current fractions and/or pulsed operation, with limited power available from non inductive current drive actuators. The transformer primary coil can assist in reducing the power requirements of the non inductive current drive sources needed for current profile control, since the general shape of the current profile can be easily manipulated by the transformer, at least transiently. Thus, a natural extension of the existing magnetic control systems (plasma current, shape and position control using the PF coil system) is to add the control of the magnetic field structure inside the plasma using the transformer primary coil. The scheme will be particularly useful for the start up and termination phases of future pulsed reactors such as ITER, of ignition designs relying on a fast plasma current ramp, such as Ignitor, as well as of present day tokamak research facilities.
To test these ideas, we have designed and developed a control system on TCV. Two main objectives have guided the design. First the wish to regulate or control the plasma current, inductance or any other current profile related variable with a control law as independent as possible of the machine model parameters, so the design can easily be applied to any tokamak . Second, the possibility to use the full capability of the OH coil power supplies using a switching control law. We have used a non-linear control strategy known as sliding mode control because it fulfils these two main requirements.
First system tests have been very encouraging; internal inductance has been controlled for the whole pulse by acting directly on the OH coil voltage, starting from as early as 30ms after plasma breakdown.
The resulting control architecture is simple enough to be implemented in any present or future reactor with a standard set of magnetic sensors, so it has the potential to become a routine and standard control system with the same rank as plasma current, position or shape control.

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