Subject: Optimization of the Fast Vertical Control Gains for DIII-D and ITER-like shapes

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Group: Operations

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1. Purpose of Experiments
Include immediate goal of the experiments, scientific importance and/or programmatic relevance. Refer to any relevant program milestones.

The purpose of this run is to test new gains for the fast vertical control channel. The new gains should be able to stabilize plasmas with open-loop vertical growth rates larger than those currently achievable (i.e. more elongated/shaped).

2. Background
Discuss Physics Basis of the proposed research. Prior results at Alcator or elsewhere, and any related work being carried out separately.

Two relevant axisymmetric equilibria have been reproduced with the simulation code Alcasim. The DIII-D-like equilibrium 1050706022 experienced a burst of vertical oscillations around 0.64s. Correspondingly, the critical index reached a minimum Nc=-1.1. A shot with similar programming, but more aggressive shaping, 1050706003, disrupted at about 0.6s. Similar conditions have been reproduced in Alcasim and the control gains have been optimized to avoid instability. The new gains have been tested in simulations to verify their performance for the full duration of the flattop.

The ITER-like equilibrium 1040127005 was terminated by a disruption at about 0.7s. This equilibrium has been reproduced in Alcasim and a new set of optimal gains has been found. Remarkably, the optimal gains for the DIII-D and ITER-like shapes coincide, however the equilibria are rather different.

Our recommendation is to try a proportional gain P=3 and derivative gain D=5.5 on the fast vertical control channel in both cases for the full duration of the flattop. Gains currently programmed are P=4, D=6 in 1050706022 and P=3, D=10 in 1040127005. The slow vertical channel has currently P=0.7, D=0.7 and integral gain I=4.5 in both cases and will stay unchanged. Further optimization of the control gains in between discharges will be possible through Alcasim simulations.

3. Approach
Describe the methodology to be employed; explain the rationale for the choice of parameters, etc. Describe the analysis techniques to be employed in interpreting the data, if applicable. If the approach is standard or otherwise self-evident, this section may be absorbed into the Experimental Plan.

Start with target plasma 1050706022. Change the gains. Seek new condition of marginal stability (max elongation under vertical control).

Second part of the run, try ITER-like shape 1040127005. Change the fast vertical control gains and try for stable discharges. Further tweak the gains if necessary, with the help of Alcasim simulations.

4. Resources

4.1 Machine and Plasma Parameters

Give values or range for:

- Toroidal Field: 6T (DIII-D), 5.4T (ITER)
- Plasma Current: 0.9MA (DIII-D), 1.5MA (ITER)
- Working Gas Species: D2
- Density: NL04 = 1e20/m^2 (DIII-D), NL04 > 0.8e20/m^2 (ITER)
- Equilibrium configuration (if possible, refer to database equilibria): 1050706022 (DIII-D), 1040127005 (ITER)

4.2 Auxiliary Systems

- RF Power, pulse length, phasing: none
- Pellet Injection (species): none
- Impurity blow-off injection: none
- Diagnostic Neutral Beam: none
- Special gas puffing: none
- Non-axisymmetric Coils (Connections, Current): B21_PROJ feedback programming
- Other: maybe Disruption Mitigation with ITER shape

4.3 Diagnostics

List required diagnostics, and any special setup or configuration, e.g. non-standard digitization rate.

Standard magnetics, DPCS

5. Experimental Plan

Both sections must be filled in.

5.1 Run sequence Plan

Specify total number of runs required, and any special requirements, such as consecutive days, no Monday runs, extended run period – 10 hours maximum – etc.

Machine time required for this MP is one run day. Can be done in the startup/pre-physics phase, assuming that plasmas are reproducible enough.

Start with target plasma 1050706022. Change the gains. Seek new condition of marginal stability (max elongation under vertical control).
Second part of the run, try ITER-like shape 1040127005. Change the fast vertical control gains and try for stable discharges. Tweak the gains if necessary, with the help of Alcasim simulations.

5.2 Shot sequence plan
For each run day, give detailed specification for proposed shot sequence: number of shots at each condition, specific parameters and auxiliary systems requirements, etc. Include contingency plans, if appropriate.

Target 1050706022 shouldn’t be difficult to produce, eventually start with lower peak elongation 1.7 and increase to 1.8 (2/3 shots). Change gains to the nominal optimum P=3, D=5.5. Try a few shots to make sure that these gains work for the same target plasma (1/2 shots). Increase elongation to 1.8<k<1.9. Try a few shots, adjust the gains if needed (3/4 shots). If there seems to be margin for pushing more, try k>1.9, adjust the gains if needed (3/4 shots). Return to the original gains and prove they are unstable with these plasmas (2/3 shots). VDEs are expected here, maybe use disruption mitigation procedure. Total 11/16 shots for the first half of the run.

Target 1040127005 is more difficult, it may require a few shots to get the equilibrium right, eventually start with lower current and smaller elongation k=1.7 and increase to the target Ip=1.6MA, k>1.8 (3/4 shots). One problem here is the large current, therefore possible MHD activity. Feedback control of lock modes is essential. After the few initial shots, change the vertical control gains to the nominal optimum P=3, D=5.5. Try a few shots and optimize gains if needed (4/5 shots). If there is time, push to higher elongation or other shaping parameters (3/4 shots). Total 10/13 shots. Final total 21/30 shots.

6. Anticipated Results
Discuss possible experimental outcomes and implications. Indicate if the program may be expected to lead to publications, milestone completions, improved operating techniques, etc. Indicate if the experiments are intended to contribute to a joint research effort, or an external database.

Increase stability margin for standard C-Mod discharges, reduce occurrence of VDEs. Access larger operation space as far as unstable shaping/elongation. Test the accuracy of the simulation code Alcasim.

ITER-shape development is supportive of planned 2007 experiments (Ideas Forum #901 Evaluation of Integrated Performance at High Current and High Power) and is also related to MP#362 (ITER Shape development).

7. References
Include references both to external and internal literature or communications which bear on this proposal. See Section 2.