Initial control of CHI plasmas on NSTX

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Control similar to initial ohmic control

Use flux expansion approximation to estimate boundary flux

$$\psi(a) \cong \psi(b) + \left.\frac{\partial \psi}{\partial r}\right|_{r=b} \Delta r = \psi(b) + B_\theta(b) 2\pi b \Delta r$$

Then control inner and outer flux difference to zero

$$\Delta\psi_r = \psi(a_1) - \psi(a_2) = 0 \cong \psi(b_1) + \beta_1 B_\theta(b_1)\Delta r_1 - \psi(b_2) - \beta_2 B_\theta(b_2)\Delta r_2$$

Vertical control

Use simple flux difference plus offset to estimate vertical position

$$\Delta\psi = \left(\psi_{upper} - \psi_{lower}\right) - I_p \frac{dM}{dz} z_{ref}$$

Comparison with camera data indicates that this gives a reasonable estimate of the plasma location

Use PF5 to control radial position and the difference between PF3U and PF3L to control vertical position

PID control and I_p control

Use simple PID control to determine relationship between PF coil currents and the flux errors

$$\delta(I_{vi}) = \frac{f_{vi}}{G}\left(a_1 \Delta\psi_r + a_2 \frac{d\Delta\psi_r}{dt} + a_3 \int_{t-\tau}^{t} \Delta\psi_r dt \right)$$

Also control injector voltage using PID on Injector current error

$$\Delta\left(V_{inj}\right) = \gamma_1 \delta\left(I_{inj}\right) + \gamma_2 \frac{d\left(\delta\left(I_{inj}\right)\right)}{dt} + \gamma_3 \int_{t-\tau}^{t} \delta\left(I_{inj}\right) dt$$

Simple modification to ohmic algorithm

- The algorithm is almost indistinguishable form the ohmic algorithm
- Easy to implement
- Requires ~3 days programming effort
- Will require testing 1-2 run days

Summary

- It will be straightforward to implement a CHI control algorithm
- Success depends on absorber arc suppression