Princeton Plasma Physics Laboratory
NSTX-U Machine Proposal

Title: **I_p and R control**		
OP-XMP-126	Revision**: 0**	Effective Date: **11-22-2015** Expiration Date: **11-22-2017** *(2 yrs. unless otherwise stipulated)*

Proposal Approvals

Responsible author: **Dennis Mueller** Dennis Mueller Digitally signed by Dennis Mueller Date: 2015.11.25 13:39:48 -05'00'	Date
ATI (NSTX-U Physics Ops): **Dennis Mueller** Dennis Mueller Digitally signed by Dennis Mueller Date: 2015.11.25 13:40:33 -05'00'	Date
RLM (NSTX-U Expt. Research Ops): **Stefan Gerhardt** Stefan Gerhardt Digitally signed by Stefan Gerhardt DN: cn=Stefan Gerhardt, o=Physics, ou=PPPL, email=sgerhard@pppl.gov, c=US Date: 2015.12.03 10:08:04 -05'00'	Date

Responsible Division: **Experimental Research Operations**

Procedure Requirements
designated by RLM

	NSTX Work Permit		T-MOD (OP-AD-03)
X	Independent Review		ES&H Review

RESTRICTIONS AND MINOR MODIFICATIONS
Approved by RLM

REVIEWERS (designated by RLM)		
Organization/Position	Name	Signature
ATI	D. Mueller	Dennis Mueller Digitally signed by Dennis Mueller Date: 2015.11.25 13:42:23 -05'00'
Test Director		
Independent Reviewer	D. Battaglia	
NB system		
RF systems		
FCPC systems		
Diagnostics		
Vertical Control	M.D. Boyer	Dan Boyer Digitally signed by Dan Boyer Date: 2015.11.25 14:35:38 -05'00'

TRAINING (designated by RLM)

Training required: No ■ Yes ☐ Instructor ____________________

Personnel (group, job title or individual name)	Read Only	Instruction	Hands-On

RLM ______________________________

NSTX-U MACHINE PROPOSAL

TITLE: **I_p and R control** No. **OP-XMP-126**

AUTHORS: **Dennis Mueller** DATE: **11-22-2015**

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1. Overview:

After breakdown, the plasma current ramp must be controlled to avoid excessively high dI_p/dt and the plasma radius must be controlled to keep the plasma approximately centered in the vacuum vessel.

2. Justification:

Finer control is required for many discharges, and isoflux control using rtEFIT is the choice for that, but at low I_p the fidelity of rtEFIT is questionable. I_p and R control enables establishment of plasmas with sufficient I_p and R in an acceptable range to hand-off control to isoflux control.

3. Plan:

After breakdown, the plasma current and position are determined by open-loop programming of OH, PF currents, PF/OH values, PF/Ip values and by gas injection. At 20 ms, the open loop Ip is about 150 kA and the signals used to perform feedback control on Ip and R are sufficiently robust for use in a feedback control loop.

A. Use the plasma breakdown scenario determined from XMP101 with 8 kA ohmic precharge.

B. Setup the PCS Ip/OH control to use Ip feedback beginning at 20 ms with the same I_p request, gains, and handoff as was used on NSTX shot 124893 (a 600 kA, He discharge using D2 prefill). Setup I_{pmin} and OH Loss of Control.Note: It is best if the I_p request at 20 ms exceeds the measured I_p to ensure a positive loop Voltage, also this shot used rtEFIT-isoflux for flattop control, but was under Discharge Shape control until about 400 kA at 75 ms; the R request will need to be adjusted after that time as it will at 20 ms to reflect the value we get at that time. OH P gain = 3

Time	0.02	0.051	0.120	0.220
I_p P Gain	0.007		0.012	
I_p I Gain	0.0	0.03		0.4

C. Chose which diagnostics to use for gap control based on discussions with the magnetics diagnostician.

D. Setup the PCS in Discharge Shape Category PCC Algorithm to use the same R control loop as was used in Discharge Shape on NSTX, again use shot 124893 as a starting point for R and Gains, but note that R from the new PCC algorithm is different than on NSTX so it will need to be programmed by comparing the open-loop plasma R from XMP101 at 20 ms and the Plasma TV images to provide the first estimate of R request. . The P gain goes into top left corner of the "Gap

Matrix." The top right element (PF45 SP GAP) is zero. Ramp PF45 Gap Handoff from 0 to 1 from 20 ms to 35 ms.

E. Produce a plasma with this setup. Adjust the I_p gains if needed (probably not). Adjust the R request to grow the plasma quickly to an outer gap of 5 – 10 cm as indicated by the TV and EFIT analysis. Adjust the R gains if required (but the similarity between NSTX-U and NSTX would suggest that this will not be needed).

F. If the plasma is vertically unstable increase the magnitude of PF3 (make more negative) to provide a stabilizing field. If this is not successful, perform the first part of XMP-105 to provide the simplest vertical control feedback.

G. When the plasma current flattop reaches 600 kA for 100 ms, replace the He gas puffing with D2; as an initial guess use the gas puff from 124800 until 60 ms then ramp to 0Tl/s at 100 ms. Adjust D2 gas puff as necessary to get a good discharge with similar flattop density in D2.

H. Repeat steps A-G with the initial OH precharge of the largest value available (21 kA), and the D2 gas flow rate found in G.

I. Try controlling PF3 coils after 20ms using SOL gap control. This requires populating the 2x2 gap matrix. Confirm that gap control works at different OH precharge levels.

4. Required machine, beam, ICRF and diagnostic capabilities:

The required diagnostics are the magnetics, Thomson, filter scopes, plasma TV. All other diagnostics are invited to use these plasmas for an early test of their status.

5. Sign off at run time:

5.1 Permission to Proceed: ______________________________

Physics Operations Head

5.2 Documentation of results:

Documentation of the results completed, attached to proposal and sent to Ops. Center with copies to Cognizant Physicist and Head of Physics Operations. (A copy of Physics Operators' logbook is sufficient.)

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Cognizant Physicist/Test Director