Princeton Plasma Physics Laboratory

NSTX Experimental Proposal

A solenoid-free current-start-up scenario utilizing outer poloidal field coils including PF 4 – Establish breakdown condition

OP-XP-448	**Revision:**	Effective Date: June--2004 *(Ref. OP-AD-97)* Expiration Date: June--2006 *(2 yrs. unless otherwise stipulated)*

PROPOSAL APPROVALS

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Responsible Division: Experimental Research Operations

Chit Review Board (designated by Run Coordinator)

MINOR MODIFICATIONS (Approved by Experimental Research Operations)

XP 448- A solenoid-free current-start-up scenario utilizing outer poloidal field coils including PF 4 – Establish breakdown condition

1. Overview of planned experiment

#1. Achieve and establish successful breakdown conditions, .
#2. Optimize the breakdown to maximize available poloidal flux for current ramp-up.
#3. Optimize wave forms to achieve plasma current of ~ 100 kA.

2. Theoretical/ empirical justification

To demonstrate a solenoid-free start-up concept using outer PF coils on NSTX by optimizing high loop-voltage, field null quality and available poloidal flux. Addition of PF 4 should improve the field null quality with available poloidal flux of ~ 0.1 Wb. If successful in achieving ~ 100 kA, this induction-based concept should scale well to future devices such as NSST.

3. Operating scenarios

There are four PF waveforms developed (A, B, C, and Base) with incrementally larger PF 4 current and larger available poloidal flux. This was judged prudent as this XP utilizes PF 4 for the first time. The PF 5 current is chosen to be relatively modest ≤ 1.5 kA to insure the structural safety. The PF current notation is that plus is the co-direction. The current should be linearly interpolated.

Case A: Low current:

PF 2 waveform

Time (ms)	-500	-250	-40	10
I (kA)	0	15	15	0

PF3 waveform

Time (ms)	-500	-250	-40	10
I(kA)	0	13	13	0

PF 4 waveform

Time (ms)	0	-10	60	110
I(kA)	0	-6	-6	0

PF 5 waveform

Time (ms)	0	-10	60	110
I (kA)	0	-1.2	-1.2	0

Case B: Medium current:

PF 2 waveform

Time (ms)	-500	-250	-40	20
I (kA)	0	17	17	0

PF3 waveform

Time (ms)	-500	-250	-40	20
I(kA)	0	15	15	0

PF 4 waveform

Time (ms)	-40	0.0	70	120
I(kA)	0	-10	-10	0

PF 5 waveform

Time (ms)	-30	0	70	120
I (kA)	0	-1.2	-1.2	0

Case C: Higher current:

PF 2 waveform

Time (ms)	-500	-250	-40	30
I (kA)	0	19.0	19.0	0

PF3 waveform

Time (ms)	-500	-250	-40	30
I(kA)	0	17	17	0

PF 4 waveform

Time (ms)	-50	0	80	120
I(kA)	0	13	13	0

PF 5 waveform

Time (ms)	-30	0	80	120
I (kA)	0	-1.2	-1.2	0.0

Base Case: High Current:

PF 2 waveform

Time (ms)	-500	-250	5	70
I (kA)	0	19.37	19.37	0

PF3 waveform

Time (ms)	-500	-250	-25	5	25	70
I(kA)	0	19	19	13	9	0

PF 4 waveform

Time (ms)	-90	-35	0	25	60	110	210
I(kA)	0	-9	-15	-15	-2.50	-2.5	0

PF 5 waveform

Time (ms)	-20	0	110	210
I (kA)	0	-1.5	-1.5	0

Summary

	Case A	Case B	Case C	Base
Breakdown time (msec)	0 -10	0 -10 -	0 -10	0 -10
PF 4 Current (kA)	6	10	13	15
PF 5 Current (kA)	1.2	1.2	1.2	1.5
Available loop voltage	13	17	18	15
Available flux (Wb)	0.02	0.04	0.06	0.1
Size of < 0.1 kV/m region	70 x 50 cm^2	70 x 45 cm^2	65 x 45 cm^2	50 x 40 cm^2

4. Experimental run plan: 10 minutes cycle – 7 hours x 5 = 35 shots

a. Start with low current Case A as shown in the table above. Determine an optimum condition for break-down: **(10 shots)**

i. Start with nominal pre-fill pressure of 1.5×10^{-5} Torr. (2 shots)

ii. Adjust the gas injection timing and HHFW timing to optimize the break down (4 shots)

iii. Try 1.75×10^{-5} Torr and 1.25×10^{-5} Torr. (4 shots)

iv. If no observable problem with operation, proceed to Case B.

b. Medium Current Case B: **(5 shots)**

i. Start with the optimum setting from Case A

ii. Adjust the gas injection timing and HHFW timing by noting the difference in the breakdown timing. If needed adjust the gas pressure.

ii. If no observable problem with operation, proceed to Case C.

iii.

c. Higher Current Case C: **(5 shots)**

i. Start with the optimum setting from Case B

ii. Adjust the gas injection timing and HHFW timing by noting the difference in the breakdown timing. If needed adjust the gas pressure.

iii. If no observable problem with operation, proceed to Base case.

d. Base case: **(5 shots)**

i. Start with the optimum setting from Case C

ii. Adjust the gas injection timing and HHFW timing by noting the difference in the breakdown timing. If needed adjust the gas pressure.

e. Extend current ramp and density build-up: **(10 shots)**

i. Choose the most promising case from A, B, C, and Base.

ii. Adjust the PF 4 ramp down rate to optimize the current ramp up. If the plasma is shifting inward, increase the PF 4 ramp down rate. If plasma is shifting outward, reduce the PF 4 ramp down rate.

5. Required machine, NBI, RF, CHI and diagnostic capabilities

Completion of PF 4 commissioning. See below for the heating and diagnostics requirements.

6. Planned analysis

LRDFIT and EFIT will be used for reconstructions of the vacuum field patterns and flux surfaces of any plasma generated. TSC and/or DINA codes will be used to analyze the plasma evolution.

7. Planned publication of results

Results will be published in Nuclear Fusion, Physics of Plasmas, or other suitable journal depending on the success of the experiment within 1 year of experiment completion.

PHYSICS OPERATIONS REQUEST

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Machine conditions (specify ranges as appropriate)

I_{TF} (kA): **53** Flattop start/stop (s): **-0.2 / 0.2s**

I_P (MA):**>0** Flattop start/stop (s): **0/0.1s**

Configuration: **Inner wall or outer wall.**

Outer gap (m): Inner gap (m):

Elongation κ: , Triangularity δ:

Z position (m): **0.00**

Gas Species: **D**, Injector: **Midplane**

NBI - Species:**D**, Sources:**A+B+C**, Voltage (kV): **60kV**, Duration (s): **50 ms**

ICRF – Power (MW): **2 MW**, Phasing: **in-phase.** Duration (s): **100 msec**

ECH- On

CHI: **Off**

Either: List previous shot numbers for setup:

Or: Sketch the desired time profiles, including inner and outer gaps, κ, δ, heating, fuelling, etc. as appropriate. Accurately label the sketch with times and values.

See the PF waveforms above.

DIAGNOSTIC CHECKLIST

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Diagnostic	Need	Desire	Instructions
CHERS		X	
Edge rotation spectroscopy		X	
Filterscopes	X		
FIReTIP	X		
Magnetics - Flux loops	X		
Magnetics - Locked modes	X		
Magnetics - Pickup coils	X		
Magnetics - Rogowski coils	X		
Magnetics - RWM sensors	X		
Mirnov coils – toroidal array	X		
Plasma TV	X		
Reflectometer – core		X	
Reflectometer - SOL		X	
RF antenna camera	X		
RF antenna probe		X	
SPRED	X		
Thomson scattering	X		
Ultrasoft X-ray arrays	X		