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| **Princeton Plasma Physics Laboratory**  **NSTX Machine Proposal** | | | | | | | |
| Title: **Commission rtEFIT, ISOFLUX** | | | | | | | |
| **OP-XMP-115** | | Revision**: 0** | | | Effective Date:  Expiration Date:  *(2 yrs. unless otherwise stipulated)* | | |
| **Proposal Approvals** | | | | | | | |
| Responsible author: **Dan Boyer** | | | | | | Date | |
| ATI (NSTX Physics Ops): **Dennis Mueller** | | | | | | Date | |
| RLM (NSTX Expt. Research Ops): **S. Gerhardt** | | | | | | Date | |
| Responsible Division: **Experimental Research Operations** | | | | | | | |
| **Procedure Requirements**  designated by RLM | | | | | | | |
|  | NSTX Work Permit | |  | T-MOD (OP-AD-03) | | |
|  | Independent Review | |  | ES&H Review | | |
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| **RESTRICTIONS AND MINOR MODIFICATIONS**  Approved by RLM | | | | | | | |

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| **REVIEWERS** (designated by RLM) | | |
| Organization/Position | Name | Signature |
| ATI | D. Mueller |  |
| Test Director |  |  |
| Independent Reviewer |  |  |
| NB system |  |  |
| RF systems |  |  |
| FCPC systems |  |  |
| Diagnostics |  |  |
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| **TRAINING** (designated by RLM)  Training required: No ⬛ Yes ⬜ Instructor \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | | |
| Personnel (group, job title or individual name) | Read Only | Instruction | Hands-On |
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| RLM \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ | | | |

**NSTX MACHINE PROPOSAL**

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| TITLE: **Commission rtEFIT, ISOFLUX** | No. **OP-XMP-** |
| AUTHORS: **D. Boyer,** S. Gerhardt, D. Gates, S. Sabbagh, E. Kolemen, C. Myers | DATE: **4/22/2015** |

## 1. Overview:

The purpose of this XMP is to commission the rtEFIT and ISOFLUX algorithms, excluding X-point and strike-point control.

## 2. Justification:

rtEFIT and ISOFLUX will enable precise control over the plasma boundary. Data from rtEFIT reconstruction will also be used for betaN, li, and q profile control in later XPs.

## 3. Plan:

**Offline testing:**

1. Development computer testing in piggyback with other XMPs to compare with EFIT and test calculation time (will determine if vessel needs to be simplified or # of diagnostics used needs to be reduced).

Shot number

1. Piggyback testing with PCC doing shape control, compare with offline calculations (to verify that no issues arise when running ‘live’.

Shot number

**Live testing:**

Live testing will be done in two phases:

1. *Limiter configuration* using the ISOFLUX limiter algorithm isoelong.
2. *Double null configuration* using the ISOFLUX algorithm isodnull. This configuration may require H-mode access.

Each phase will have three goals/approaches in the following priority order:

1. *Demonstrate ISOFLUX control using proportional gain only.* Begin from gains used in NSTX, adjust empirically to optimize performance.
2. *Assess performance with integral gain included.* Tune empirically, based on simserver simulations, or use relay feedback as needed.
3. *Demonstrate target tracking.* Modify the control point locations along the control segments.

**Goal 1 Phase 1**

Note: The following will be done in a limiter configuration using the ISOFLUX limiter algorithm (isoelong). The target shape should be one achieved (at least transiently) under PCC control. After each test, if performance is reasonable, adjust gains empirically as needed to optimize performance. If performance is poor, relay feedback may be used for tuning.

1. Set gains on PF5 in ISOFLUX to match those used in NSTX. Use fuzzy logic to introduce ISOFLUX control of PF5 for a short time during flattop. If successful, increase time window until entire discharge (from Ip=300kA).

Shot number

Shot number

Shot number

1. Set gains on PF3U/L control of SEG03/11 in ISOFLUX to match those used in NSTX. Use fuzzy logic to introduce ISOFLUX control of PF3U/L for a short time during flattop. If successful, increase time window until entire discharge (from Ip=300kA). PF5 settings should remain unchanged from last shot in Step 3. Adjust gains empirically as needed to achieve good performance.

Shot number

Shot number

Shot number

1. Set gains on PF2U/L control of SEG04/10 in ISOFLUX to match those used in NSTX (if not available, use values obtained from simserver testing or relay feedback). Use fuzzy logic to introduce ISOFLUX control of PF2U/L for a short time during flattop. If successful, increase time window until entire discharge (from Ip=300kA). PF5 and PF3U/L settings should remain unchanged from last shot in Step 4. Adjust gains empirically as needed to achieve good performance.

Shot number

Shot number

Shot number

**Goal 1 Phase 2:**

Note: The following will be done in a double null configuration using the ISOFLUX algorithm isodnull. This may require H-mode access to complete. After each test, if performance is reasonable, adjust gains empirically as needed to optimize performance. If performance is poor, relay feedback may be used for tuning.

1. Set gains on PF5 control of outergap in ISOFLUX to match those used in NSTX. Attempt control through entire discharge. Adjust gains empirically as needed to achieve good performance.

Shot number

1. Set gains on PF3U/L control of upper/lower squareness in ISOFLUX to match those used in NSTX. Attempt control through entire discharge. PF5 settings should be the same as in step 6. Adjust gains empirically as needed to achieve good performance.

Shot number

1. Set gains on PF3U/L control of symmetry in ISOFLUX to match those used in NSTX. Using the whichMmatrix waveform, introduce control for a short time period during flattop. If successful, increase time window until controlling symmetry through entire discharge (from Ip=300kA). Adjust gains empirically as needed to achieve good performance. PF5 and PF3U/L settings should be the same as in step 7.

Shot number

Shot number

Shot number

**Goal 2 Phase 1:**

Note: The following will be done in a limiter configuration using the ISOFLUX limiter algorithm (isoelong). The target shape should be one achieved (at least transiently) under PCC control.

1. Starting from gains determined in Step 5, add integral gain to the outer gap error calculation (controlled by PF5). If performance is reasonable, empirically adjust to optimize. Otherwise, use relay feedback and test derived controller gains.

Shot number

Shot number

Shot number

1. Starting from gains determined in Step 5, add integral gain to the SEG03/11 error calculations. If performance is reasonable, empirically adjust to optimize. Otherwise, use relay feedback and test derived controller gains.

Shot number

Shot number

Shot number

1. Starting from gains determined in Step 5, add integral gain to the SEG04/10 error calculations. If performance is reasonable, empirically adjust to optimize. Otherwise, use relay feedback and test derived controller gains.

Shot number

Shot number

Shot number

**Goal 2 Phase 2:**

Note: The following will be done in a limiter configuration using the ISOFLUX double null algorithm (isodnull). The target shape should be one achieved (at least transiently) under PCC control.

1. Starting from gains determined in Step 9, add integral gain to the outer gap error calculation (controlled by PF5). If performance is reasonable, empirically adjust to optimize. Otherwise, use relay feedback and test derived controller gains.

Shot number

Shot number

Shot number

1. Starting from gains determined in Step 9, add integral gain to the SEG03/11 error calculations. If performance is reasonable, empirically adjust to optimize. Otherwise, use relay feedback and test derived controller gains.

Shot number

Shot number

Shot number

**Goal 3 Phase 1:**

Note: The following will be done in a limiter configuration using the ISOFLUX limiter algorithm. (isoelong).

1. Using best settings established after Goals 1 and 2 (with or without integral gains depending on outcome of Goal 2), attempt to track an alternative target shape, defined at the operator’s discretion.

Shot number

Shot number

**Goal 3 Phase 2:**

Note: The following will be done in a limiter configuration using the ISOFLUX double null algorithm (isodnull).

1. Using best settings established after Goals 1 and 2 (with or without integral gains depending on outcome of Goal 2), attempt to track an alternative target shape.

Shot number

Shot number

1. Adjust drsep target to achieve upper and lower biased discharges.

Shot number

Shot number

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

Normal plasma ops requirements. EFIT reconstructions with calibrated vessel current modeling so data is useful for offline comparison of rtEFIT results.

## 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.

Cognizant Physicist/Test Director