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TO: DISTRIBUTION
FROM: C NEUMEYER
SUBJECT: VOLTAGE CONSTRAINTS DUE TO ABSORBER COILS

Reference: "CHI Absorber Field Nulling Coil Description, Revised", 22-020816-CLN-01.

The two new CHI Absorber field nulling coils are subject to mutual coupling to the other PF coils on NSTX. For interactions between pairs of coils, where coil 1 is the driving coil starting at I_1=0 and coil 2 is the coupled and open circuited coil:

$$V_1=L_1 dI_1/dt$$
$$V_2=M_{12}\, dI_1/dt$$
$$V_2=V_1*M_{12}/L_1$$

The mutual inductance matrix for NSTX, including the new CHI Absorber coils, is as follows.

PF Coil Inductances (Henry)

	OH	PF1AU	PF1AL	PF1B	PF2U	PF2L	PF3U	PF3L	PF4	PF5	PFAB1	PFAB2
OH	1.30E-02	7.31E-04	7.31E-04	3.74E-04	2.76E-04	2.76E-04	2.95E-04	2.95E-04	3.79E-04	5.28E-04	6.18E-04	4.86E-04
PF1AU	7.31E-04	3.76E-04	1.95E-07	2.25E-07	7.23E-05	1.35E-06	6.04E-05	5.29E-06	3.16E-05	4.16E-05	1.95E-04	1.22E-04
PF1AL	7.31E-04	1.95E-07	3.76E-04	9.01E-05	1.35E-06	7.23E-05	5.29E-06	6.04E-05	3.16E-05	4.16E-05	8.07E-07	1.45E-06
PF1B	3.74E-04	2.25E-07	9.01E-05	5.36E-04	1.66E-06	1.86E-04	6.61E-06	1.01E-04	4.15E-05	5.43E-05	9.69E-07	1.78E-06
PF2U	2.76E-04	7.23E-05	1.35E-06	1.66E-06	1.98E-03	1.03E-05	7.31E-04	4.11E-05	2.64E-04	3.45E-04	6.50E-04	1.84E-03
PF2L	2.76E-04	1.35E-06	7.23E-05	1.86E-04	1.03E-05	1.98E-03	4.11E-05	7.31E-04	2.64E-04	3.45E-04	5.92E-06	1.10E-05
PF3U	2.95E-04	6.04E-05	5.29E-06	6.61E-06	7.31E-04	4.11E-05	5.18E-03	1.66E-04	1.16E-03	1.49E-03	3.57E-04	7.42E-04
PF3L	2.95E-04	5.29E-06	6.04E-05	1.01E-04	4.11E-05	7.31E-04	1.66E-04	5.18E-03	1.16E-03	1.49E-03	2.35E-05	4.39E-05
PF4	3.79E-04	3.16E-05	3.16E-05	4.15E-05	2.64E-04	2.64E-04	1.16E-03	1.16E-03	5.16E-03	4.81E-03	1.48E-04	2.79E-04
PF5	5.28E-04	4.16E-05	4.16E-05	5.43E-05	3.45E-04	3.45E-04	1.49E-03	1.49E-03	4.81E-03	1.23E-02	1.93E-04	3.66E-04

PFAB1	6.18E-04	1.95E-04	8.07E-07	9.69E-07	6.50E-04	5.92E-06	3.57E-04	2.35E-05	1.48E-04	1.93E-04	3.93E-03	1.33E-03
PFAB2	4.86E-04	1.22E-04	1.45E-06	1.78E-06	1.84E-03	1.10E-05	7.42E-04	4.39E-05	2.79E-04	3.66E-04	1.33E-03	6.46E-03

Using the above inductance and the maximum design voltage for each circuit, one can estimate the maximum induced voltage due to each PF coil as follows.

Induced Voltages (Volts)

	OH	PF1AU	PF1AL	PF1B	PF2U	PF2L	PF3U	PF3L	PF5
Vmax	6000.0	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0	3000.0
VindAB1	285.2	1037.2	4.3	3.6	656.6	6.0	137.8	9.1	47.1
VindAB2	224.3	648.9	7.7	6.6	1858.6	11.1	286.5	16.9	89.3

Since the new coils are only rated for 1000V, it will be necessary to reduce the maximum allowable voltage in PF1AU AND PF2U from 2kV down to 1kV. Resultant induced voltages are as follows.

Induced Voltages (Volts) with PF1AU and PF2U reduced to 1kV

	OH	PF1AU	PF1AL	PF1B	PF2U	PF2L	PF3U	PF3L	PF5
Vmax	6000.0	1000.0	2000.0	2000.0	1000.0	2000.0	2000.0	2000.0	3000.0
VindAB1	285.2	518.6	4.3	3.6	328.3	6.0	137.8	9.1	47.1
VindAB2	224.3	324.5	7.7	6.6	929.3	11.1	286.5	16.9	89.3

With multiple coils in operation the situation becomes more complex. One can imagine a scenario where all PF power supplies come fully on to $V=V_{max}$ starting from I=0. Then [V]=[M][dI/dt], and one can solve for the current derivatives according to the matrix equation $[dI/dt] = [M]^{-1}[V]$, and then compute the voltages induced on the absorber coils due to the net influence. In this case, with PF1AU and PF2U reduced as recommended above the maximum voltages on AB1 and AB2 are 762V and 1016V, which is considered to be acceptable.

Future issues of ISTP-001, which includes declaration of the latest operating limits, will be in accordance with the above voltage limits.

Cc:

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