Coil Inductances
Modular and Saddle Systems

NCSX Project Meeting

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What are the Inductive Voltage Requirements for the Saddle and Modular Configurations? A first Cut

- Start with a simplified set of Current Waveforms
  - Use coil currents from Free Boundary Optimization for S1, S2 and S3
  - Assume Linear Ramps
- Estimate the Coil System Inductance Matrix
- Evaluate L * dI/dt

Estimate of Coil System Inductances

- Use Michael Drevlak's code "ENERGIES"
  - Calculates Ncoil by Ncoil inductance matrix
  - Uses single filament representation
  - Assumes all coils have equal cross-sections
- Reduce Ncoil by Ncoil matrix to Ncircuit by Ncircuit matrix
- Scale Matrix based on actual #turns/coil

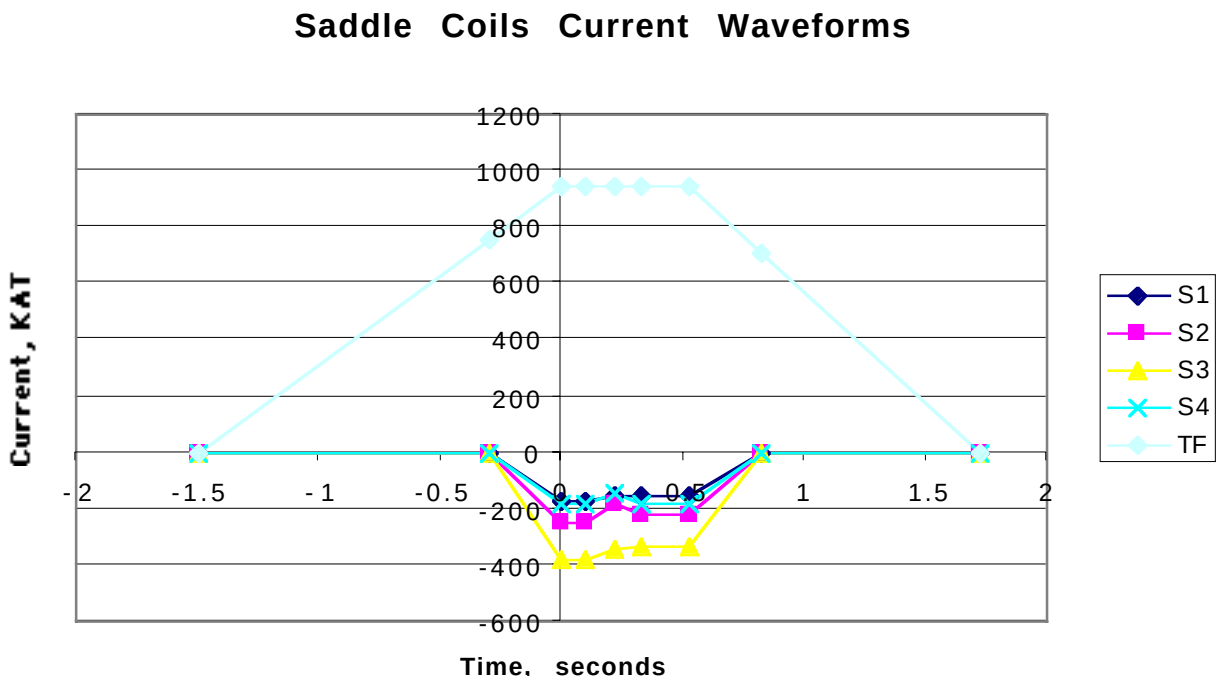
Saddle Coils Inductance Matrix

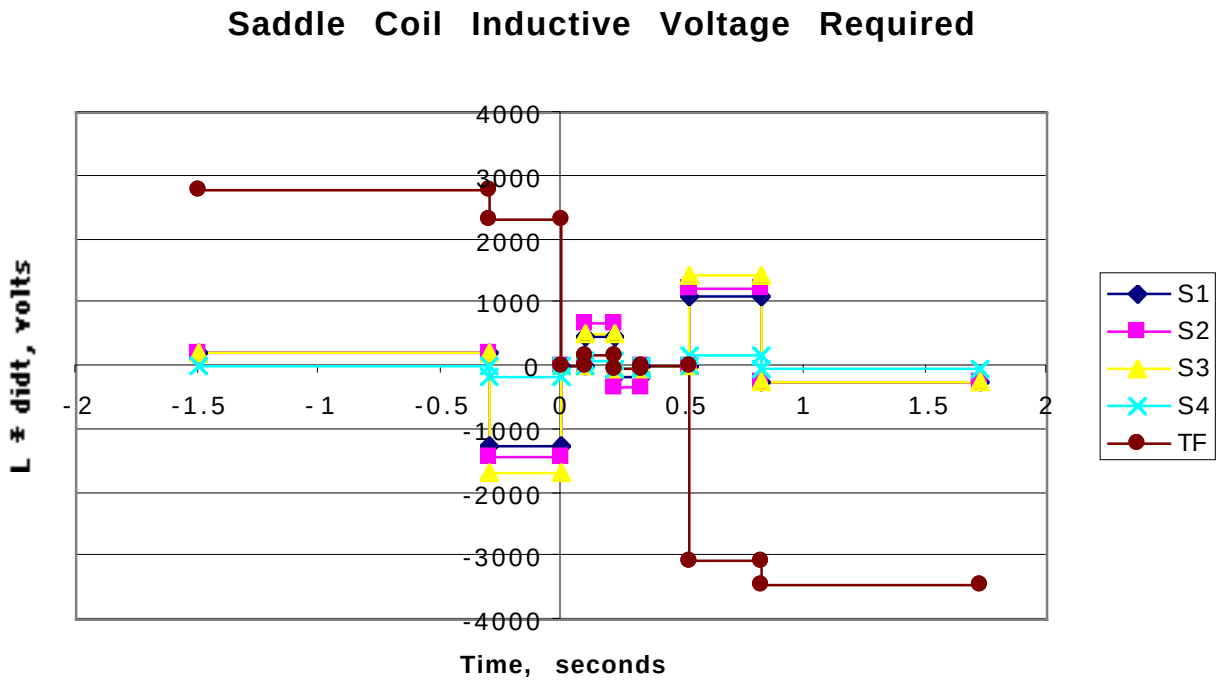
Coil Set	Saddles				PF						TF	Plasma
#Coils	6	6	6	6	2	2	2	2	2	2	18	1
#Turns	16	20	32	20	1	1	7	1	2	9	12	1
	22021	10034	6449	580	-2	-4	-15	3	19	-92	3615	46
	10034	20613	9421	751	-2	-2	-7	3	6	-6	3819	47
	6449	9421	30613	1492	-3	-3	-17	-2	44	338	4031	55
	580	751	1492	2449	-5	-2	1	2	10	51	383	4
	-2	-2	-3	-5	12	4	16	1	3	16	0	2
Inductance	-4	-2	-3	-2	4	11	22	2	3	16	0	1
Matrix	-15	-7	-17	1	16	22	504	16	25	111	0	9
(micro-henries)	3	3	-2	2	1	2	16	15	7	27	0	2
	19	6	44	10	3	3	25	7	138	228	0	7
	-92	-6	338	51	16	16	111	27	228	3753	0	42
	3615	3819	4031	383	0	0	0	0	0	0	52943	-2
	46	47	55	4	2	1	9	2	7	42	-2	11

Saddle Configuration

Saddle Coils:
1.7 KV @ .3s ramp
I_{max} = 12 KA

TF Coils:
2.8 KV @ 1.5s ramp
I_{max} = 78 KA





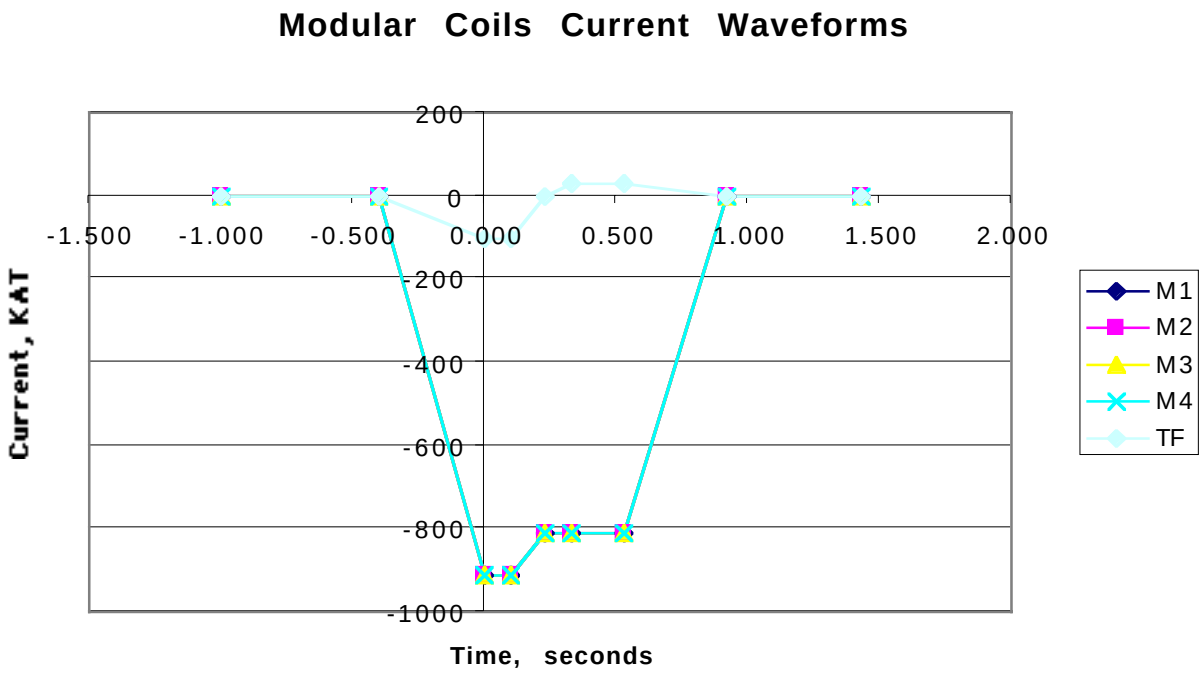
Modular Coils Inductance Matrix

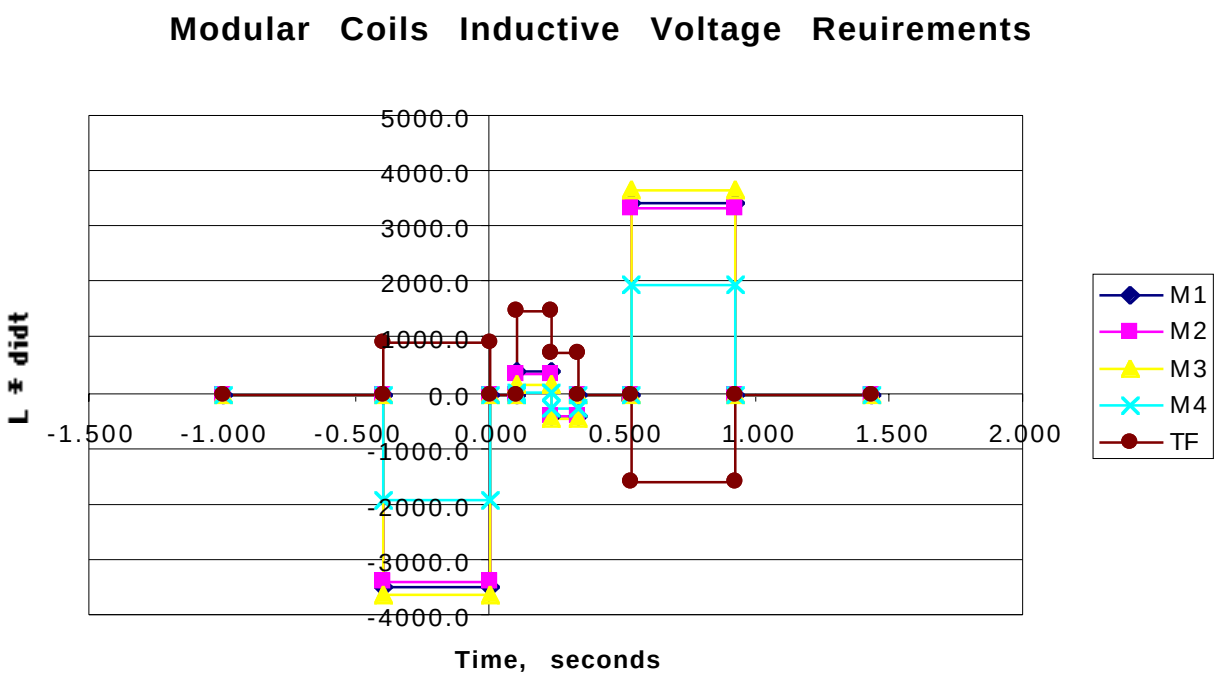
Coil Set	Modulars				PF							TF	Plasma
#Coils	6	6	6	3	2	2	2	2	2	2	2	21	1
#Turns	44	44	44	44	63	61	28	87	78	45	22	6	1
	49218	13906	6994	2836	340	125	-28	-860	-1525	-494	400	-7443	-21
	13906	40828	12207	4284	86	9	-19	-242	-119	579	209	-7922	-24
	6994	12207	46671	11592	-121	-48	13	309	559	-67	-165	-9245	-30
	2836	4284	11592	22396	-84	-52	-1	268	632	173	-27	-5477	-14
	340	86	-121	-84	5982	1240	136	550	557	498	309	0	13
Inductance	125	9	-48	-52	1240	4921	355	796	636	486	291	0	11
Matrix	-28	-19	13	-1	136	355	1023	785	404	224	125	0	4
(micro-henries)	-860	-242	309	268	550	796	785	32590	9573	3564	1803	0	45
	-1525	-119	559	632	557	636	404	9573	59246	10409	4623	0	84
	-494	579	-67	173	498	486	224	3564	10409	57701	13438	0	132
	400	209	-165	-27	309	291	125	1803	4623	13438	16916	0	95
	-7443	-7922	-9245	-5477	0	0	0	0	0	0	0	14837	1
	-21	-24	-30	-14	13	11	4	45	84	132	95	1	8

Modular Configuration

Modular Coils:
3.7 KV @ .4s ramp
I_{max} = 21 KA

TF Coils:
1.6 KV @ .4s ramp
I_{max} = 17 KA





Summary

- Inductive Voltage Requirements appear feasible for both Modular and Saddles, although
  - Modular coils require roughly twice the voltage and carry roughly twice the current as the Saddles
  - Modulars coils require slightly longer ramp time

- Detailed simulation of coils with available power supplies remains to be done including
  - Resistive effects
  - Multi-filament inductance coil model