Joel H. Schultz

Evaluation of NCSX Saddle Coil System using SSC Cable

It's free.

It's high-performance.
(J_{strand} up to 454 A/mm^2, $J_{cablespace}$ up to 290 A/mm^2)

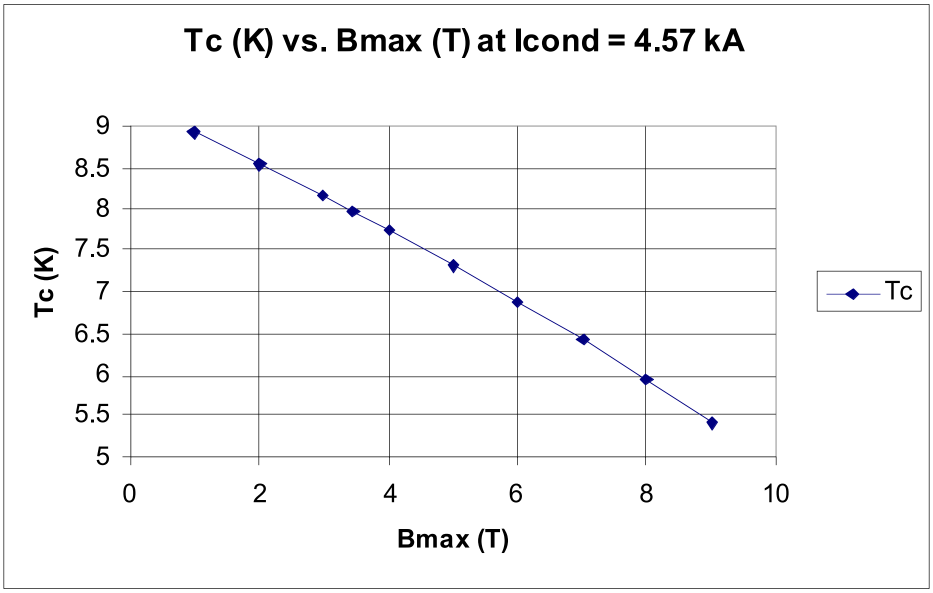
I. Critical and Current-sharing Temperatures of 2-layer SSC Cable Design

SSC Inner Cable Dimensions

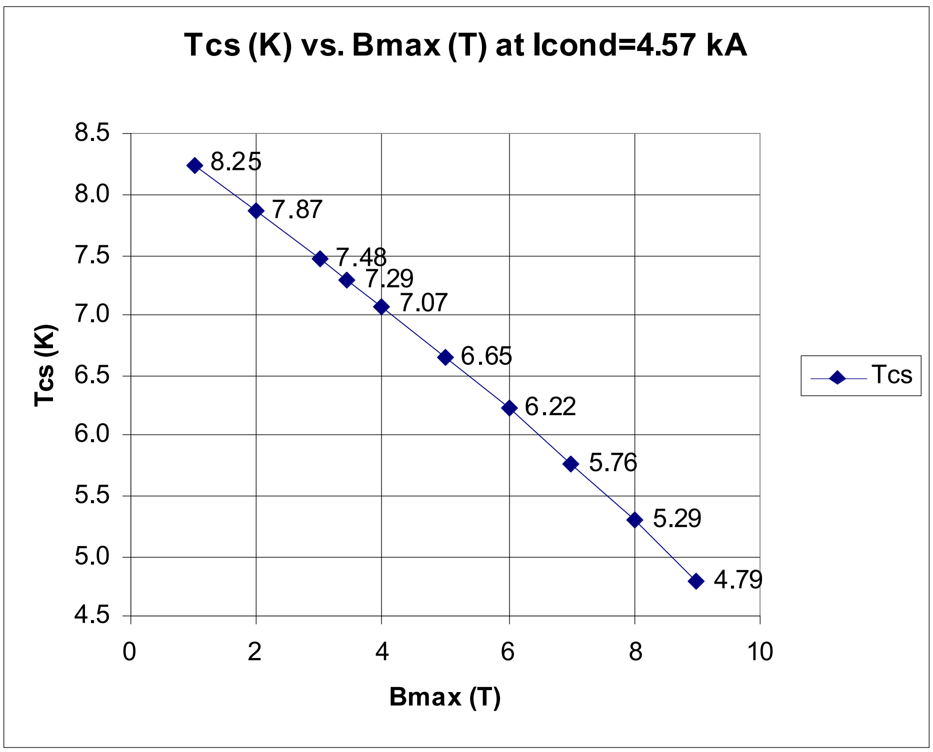
Parameter	Units	Value
Dstrand	(mm)	0.808
nstrands		30
Copper/noncopper		1.3
Astrands	(mm^2)	15.38275
Acopper	(mm^2)	8.441355
Anoncu	(mm^2)	6.49335
Ains	(mm^2)	1.20E+01
hcond, SSCI	(mm)	1.23E-02
wcond, SSCI	(mm)	1.46E-03

Characteristics of NbTi Superconducting Strands

NbTi	**J_{c00}**	**T_{c0}**	**B_{c20}**
	(A/mm^2)	(K)	(T)
SSC	10,000	9.3	15
GEM	9500	9.3	15
45 T Hybrid	9009	11.9	15.4



Critical temperature Tc (K) vs. Bmax (T) at Icond=4.57 kA



Current-sharing temperature Tcs (K) vs. Bmax (T) at Icond=4.57 kA

The current-sharing temperature at 3.46 T is 7.29 K.

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II. Pulsed Field Thermal Loads on the SSC Cable in NCSX

Major Magnet System Dimensions

Parameter	Units	Value
System Ampere-m	(MA-m)	20
Icond	(kA)	4.53
Lcond, system	(km)	4.38
ncoils		6
nlayers, 1 coil		2
npancakes, 1 coil		32
Vcable	(m^3)	0.0673
Vnoncu	(m^3)	0.0284
Bmax	(T)	3.46

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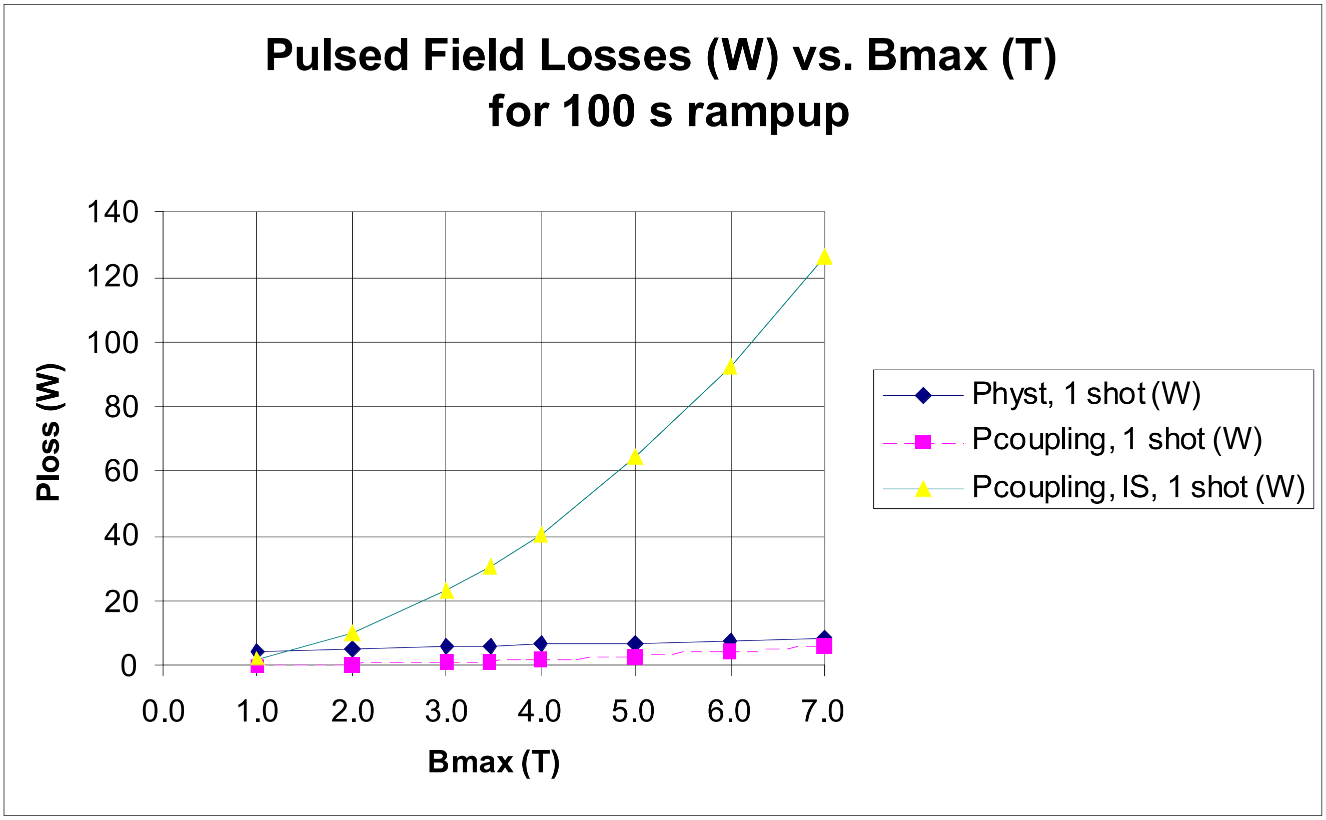
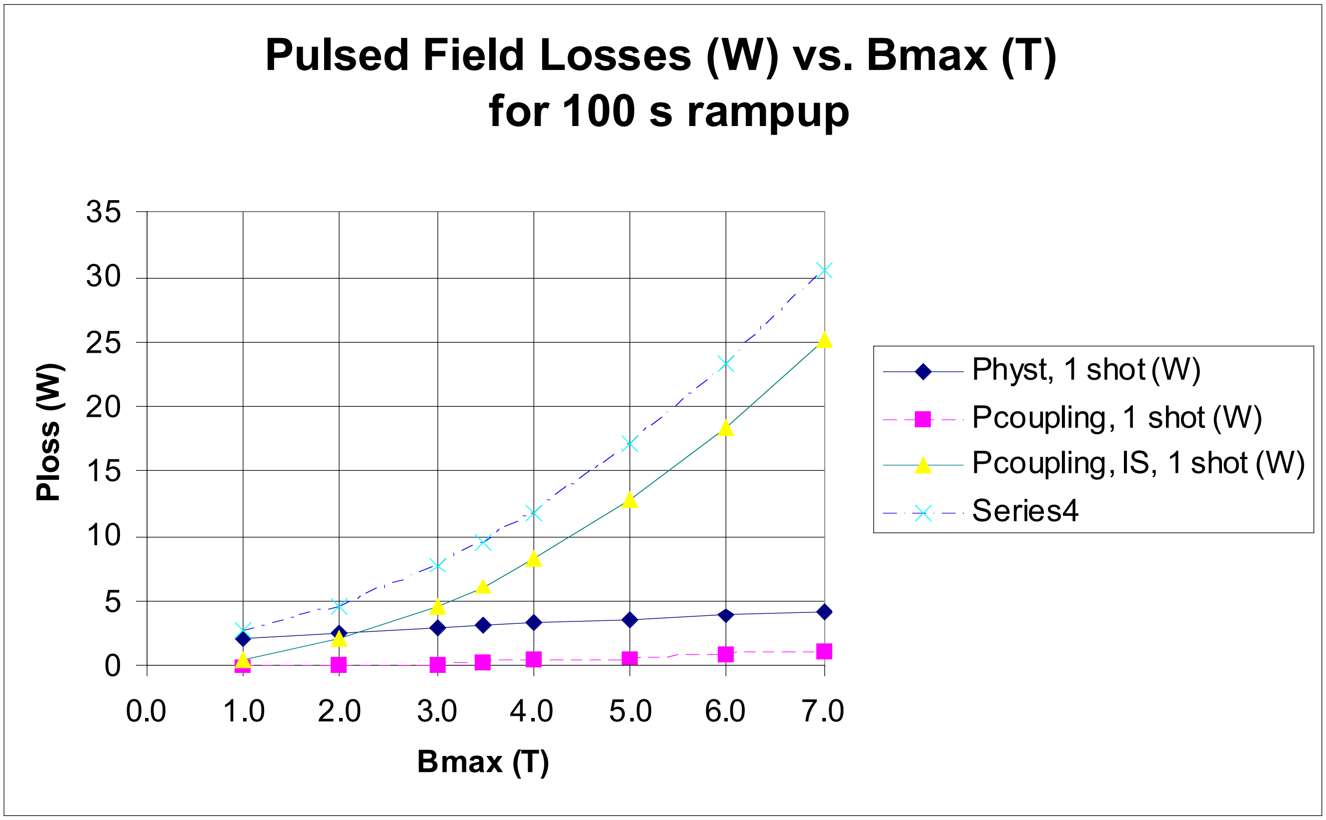
Pulsed Loss Scenario Description

Parameter	*Units*	*Value*
trampup	**(s)**	**100**
tflattop	**(s)**	**50**
trampdown	**(s)**	**100**
tdwell	**(s)**	**50**
tcycle	**(min)**	**5**
Deff	**(μm)**	**5**
$n\tau_{if}$	**(ms)**	**33**
$n\tau_{is}$	**(s)**	**1.2**



Loss power (W) vs. Bmax (T) for 100 s rampup, 50 s flattop, and 100 s rampdown



Loss power (W) vs. Bmax (T) for 250 s rampup, 50 s flattop, and 250 s rampdown

The total pulsed losses over a pulse are reduced by nearly a factor of four when the pulse length is doubled to slightly under 10 W.

Conclusions

Conservative loss calculations predict ~ 50 W for "shot every 5 minutes",
10 W for "shot every 10 minutes"

The pulsed losses are dominated by interstrand losses.

Radiation, conduction and lead losses haven't been evaluated.

The losses are too high for conduction cooling through cryocoolers, unless the pulse length is increased to 10 minutes between experiments. There will have to be circulating helium in the system.