52-960321-CLN-01

TO: DISTRIBUTION
FROM: C NEUMEYER
SUBJECT: TF SHUTDOWN SCENARIOS
REFERENCES:

(1) 52-960306-CLN-01, "Preliminary Analysis of TF Performance"

Concern was expressed that a trip of the C-site MG sets might result in an L/R shutdown with ∫i^2(t)dt greater than that associated with a shutdown driven by the inverted MG voltage. The analysis reported herein shows that this is not the case, thanks to a discharge resistor which is inserted during the MG shutdown sequence. Therefore the nominal case should be the worst case.

Per M. Awad the trip shutdown sequence is as follows:

"On emergency shutdown, the generator field contactor (excitation) and the generator high speed breaker trip simultaneously (contacts fully open within 50 mS). This action will add .04Ω (per generator) to the load circuit as a dump resistor to dissipate the stored energy in the coil. The resistor breaker will remain closed for 10 sec to allow removing residual voltage from the generator. Then it will open and disconnect the generator from the load and shunt the generator terminals through the center pole contacts of the resistor breaker. At this moment, the load is connected to half of the dump resistor (.02Ω). After 2 seconds more, the disconnect switch will open and shunt the coil and ground it."

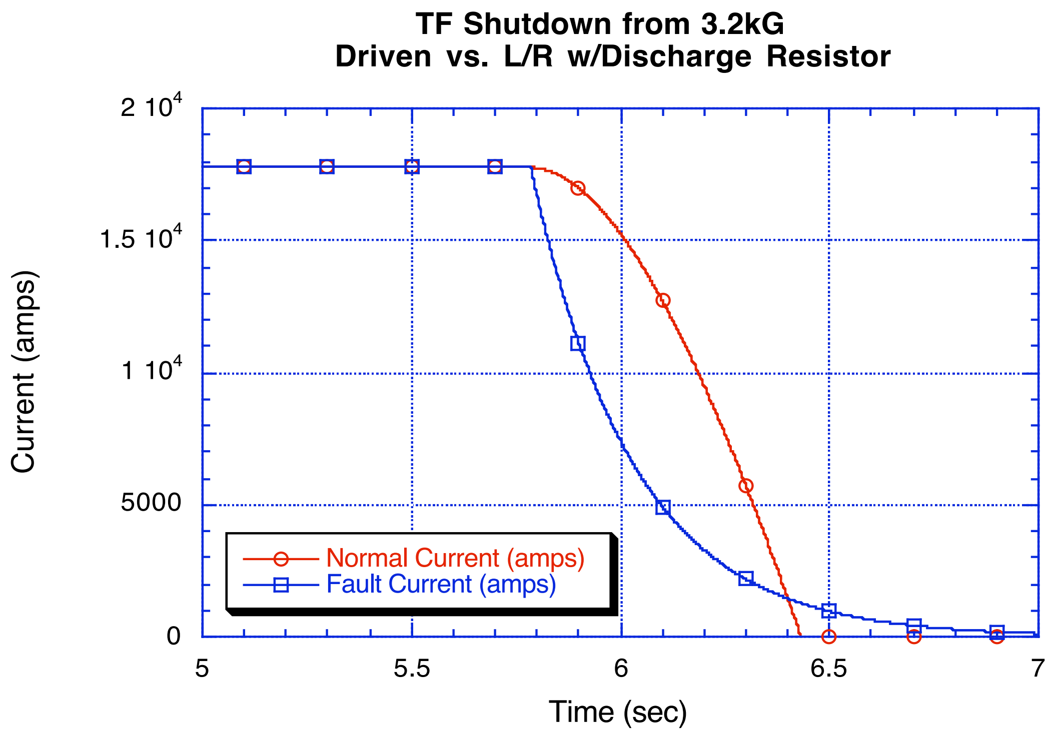
Once the trip is initiated, the generator is excluded from the circuit and the resistor is included. Thus for short periods (≤ 10 sec) it can be anticipated that a 0.04Ω resistor will be inserted in each generator circuit. The net resistance depends on the number of series and parallel generators. Since we are anticipating the use of 2 series and 2 parallel units for 6.4kG, and since this configuration yields a lower net resistance than the case of 2 series and 1 parallel units as is anticipated for the 3.2kG case, the former is assumed.

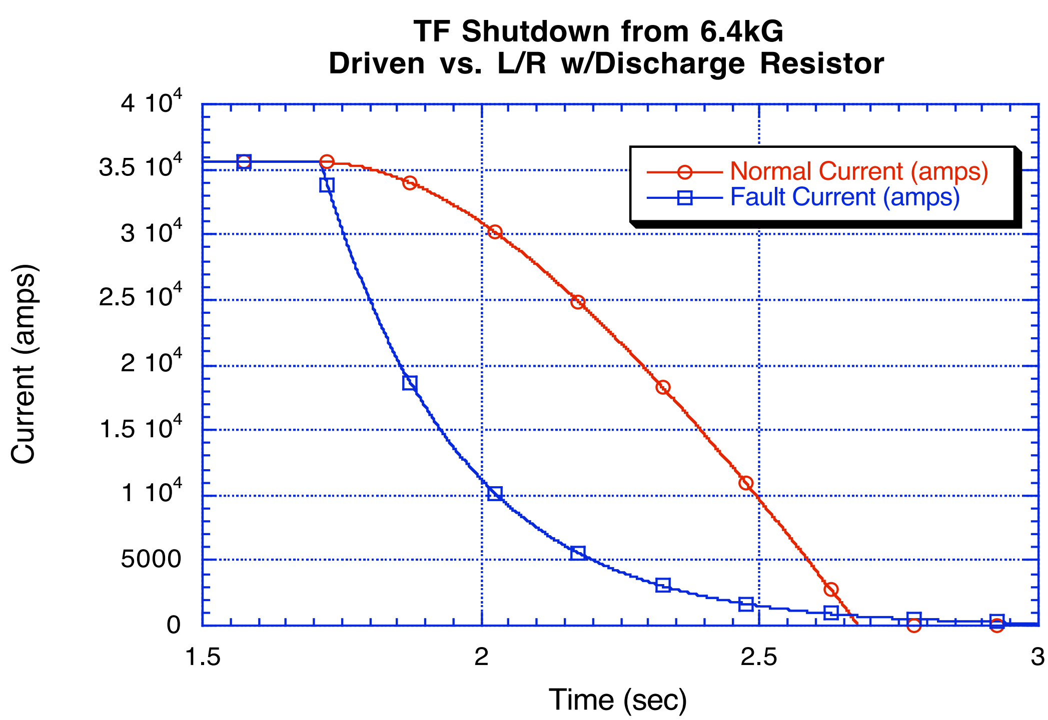
Per the following table the estimated* ESW attributable to the L/R decay is small (0.134 sec) thanks to the inserted resistor.

Armature Inductance	8.90E-05	henries
Armature Resistance	0.0039	Ω
Dump Resistance	0.04	Ω
#Series	2	
#Parallel	2	
TF Inductance	0.017	henries
TF Inner Leg Res @ 20C	0.0177	Ω
TF Outer Leg Res @ 20C	0.002256	Ω
Net Resistance	0.063856	Ω
Net Inductance	0.017089	henries
L/R	0.267617765	sec
L/R Decay ESW	0.133808882	sec
I @ 3.2kG	17777.7	amp
L/R Decay ∫i^2(t)dt	4.23E+07	A^2-sec
I @ 6.4kG	35555.4	amp
L/R Decay ∫i^2(t)dt	1.69E+08	A^2-sec

* constant coil resistance is assumed in the above table.

To determine the relative ∫i^2(t)dt contributions of the generator driven vs. L/R shutdown with resistor insertion, the simulations described in ref. 1 were repeated with the L/R case. The normal and fault scenarios for the 3.2kG and 6.4kG cases are depicted in the following figures.


TF Shutdown from 3.2kG
Driven vs. L/R w/Discharge Resistor
Current (amps)
Time (sec)
Normal Current (amps)
Fault Current (amps)
2 10^4
1.5 10^4
1 10^4
5000
0
5
5.5
6
6.5
7


TF Shutdown from 6.4kG
Driven vs. L/R w/Discharge Resistor
Current (amps)
Time (sec)
Normal Current (amps)
Fault Current (amps)
4 10^4
3.5 10^4
3 10^4
2.5 10^4
2 10^4
1.5 10^4
1 10^4
5000
0
1.5
2
2.5
3

Based on the simulation results the final ∫i^2(t)dt was actually found to be slightly less in the fault cases as compared to the normal case. The results are summarized in the following table.

	3.2kG	6.4kG	
Flat Top Current	17777.8	35555.6	amp
Flat Top Time	5.0	0.6	sec
Normal ∫i^2(t)dt	1.769E+09	1.802E+09	A^2-sec
Fault ∫i^2(t)dt	1.706E+09	1.376E+09	A^2-sec

Although the coil parameters used in the above are now being updated, it is unlikely that the conclusion would be different with slightly different coil parameters. Therefore this work need not be repeated.

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