13_031106_CLN_01.doc

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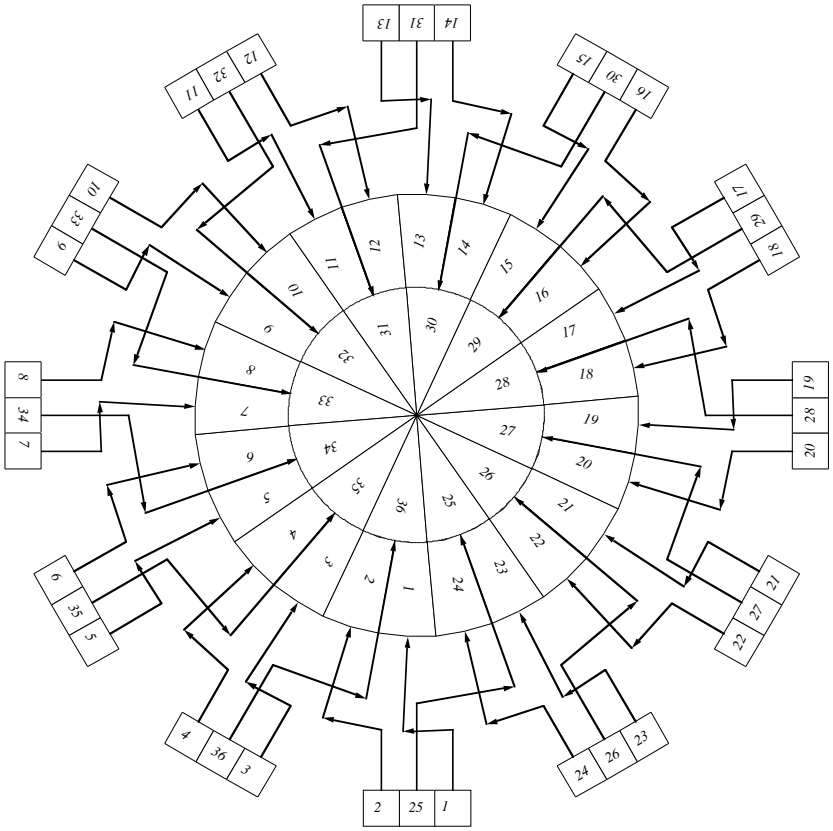
SUBJECT: OPTIMIZATION OF CLOCKING OF TF BUNDLE

Reference: 13_031022_CLN_01.doc

In the reference memo, the pattern of voltages appearing turn-turn in the TF bundle was reported. In this memo, based on the leakage current measurements reported in run copy of D-NSTX-IP-2845, taken on various dates after semi-cure of the quadrants, along with the voltages reported in the reference, a clocking of the bundle is selected which minimizes the sum of the ratios of voltage to leakage resistance, i.e. the sum of the leakage currents. In this way the risk of insulation failure should be minimized.

Winding pattern at the top of the machine, viewed from above, is shown in the following figure. Numbers refer to the series electrical sequence of the turns.



The following table shows the optimum clocking and the basis for same. Nsn refers to the serial number of the turn. R is the measured leakage resistance per the test procedure run copy. V is the highest voltage between the turn and its neighbors when normal operating voltage of 1kV is applied to the coil terminals. I = V/R is the corresponding leakage current. The turns which fell below spec (1000Mohm) are highlighted.

Nsn	R(Mohm)	Ns	V(kV)	I(microAmp)
19	30000	11	0.583	0.019
15	36000	12	0.528	0.015
34	36000	13	0.500	0.014
16	3000	14	0.444	0.148
27	48000	15	0.417	0.009
37	60000	16	0.361	0.006
13	36000	17	0.333	0.009
23	48000	18	0.278	0.006
33	48000	19	0.250	0.005
17	36000	20	0.194	0.005
35	42000	21	0.167	0.004
36	200	22	0.111	0.556
30	30000	23	0.083	0.003
22	1800	24	0.639	0.355
29	30000	1	0.972	0.032
18	42000	2	0.944	0.022
20	42000	3	0.917	0.022
21	30000	4	0.861	0.029
31	30000	5	0.833	0.028
25	35000	6	0.778	0.022
28	40000	7	0.750	0.019
24	45000	8	0.694	0.015
26	45000	9	0.667	0.015
14	40000	10	0.611	0.015
5	45000	32	0.667	0.015
6	45000	33	0.750	0.017
4	45000	34	0.833	0.019
2	42000	35	0.917	0.022
3	48000	36	0.972	0.02
1	600	25	0.667	1.111
7	100	26	0.167	1.667
12	54000	27	0.250	0.005
11	42000	28	0.333	0.008
10	36000	29	0.417	0.012
9	2400	30	0.500	0.208
8	36000	31	0.583	0.016
				4.492

The sum of the leakages from all turns is given in the last row of the last column of the table. The clocking shown above was found to result in the lowest total leakage sum,

which represents the best compromise of voltage and resistance, considering all turns. If only the turns which fell out of spec are considered, the same clocking again gives the best result. If only the worst turn sn#7 is considered then the best result would place that turn in series sequence 23, which has the lowest voltage. However, when the other turns are considered, the optimum shifts as indicated.

Based on the concept of selecting the turn-turn test voltage based on the fraction of operating voltage appearing on the turns, the following table shows the hipot voltage and leakage current for each turn, with the base hipot level set by 2E+1=2*1+1=3kV.

Nsn	R(Mohm)	Ns	Vtest(kV)	I(microAmp)
19	30000	11	1.750	0.058
15	36000	12	1.583	0.044
34	36000	13	1.500	0.042
16	3000	14	1.333	0.444
27	48000	15	1.250	0.026
37	60000	16	1.083	0.018
13	36000	17	1.000	0.028
23	48000	18	0.833	0.017
33	48000	19	0.750	0.016
17	36000	20	0.583	0.016
35	42000	21	0.500	0.012
36	200	22	0.333	1.667
30	30000	23	0.250	0.008
22	1800	24	1.917	1.065
29	30000	1	2.917	0.097
18	42000	2	2.833	0.067
20	42000	3	2.750	0.065
21	30000	4	2.583	0.086
31	30000	5	2.500	0.083
25	35000	6	2.333	0.067
28	40000	7	2.250	0.056
24	45000	8	2.083	0.046
26	45000	9	2.000	0.044
14	40000	10	1.833	0.046
5	45000	32	2.000	0.044
6	45000	33	2.250	0.05
4	45000	34	2.500	0.056
2	42000	35	2.750	0.065
3	48000	36	2.917	0.061
1	600	25	2.000	3.333
7	100	26	0.500	5.000
12	54000	27	0.750	0.014
11	42000	28	1.000	0.024
10	36000	29	1.250	0.035
9	2400	30	1.500	0.625
8	36000	31	1.750	0.049

Finally, it is recommended that another set of leakage resistance readings be taken at a low voltage, e.g. 250V, prior to finalizing the clocking. The reason is to determine whether or not the pattern observed is still in effect after completing the cure of the bundle. If it is substantially different, then the exercise described herein should be repeated.

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