

TO: DISTRIBUTION
FROM: C NEUMEYER
SUBJECT: PF COIL PARAMETER UPDATE

This memo presents updated PF coil parameters reflecting the following changes...

- new PF1a coil
- minor corrections to dimensions of OH and PF1b coil
- correction of number of turns in PF1b coil

The change to the PF1a coil is the most significant. However, due to the presence of the external filter inductors, the change in total circuit impedance is relatively small as indicated in Table 1 below. As a result, the change in the harmonic content will be negligible. The rms current harmonic current when driven by single 6-pulse bridge at $\alpha=90$ degrees is estimated to increase to 14.3 amp with new coil from 13.8 amp with prior coil based on the PF1a self and mutual inductances.

TABLE 1 – PF1a Circuit Impedance
Change With New Coil

| | R | L |
|------------------|----------|----------|
| Prior Coil | 2.80E-03 | 3.76E-04 |
| External Circuit | 1.08E-02 | 4.36E-03 |
| Prior Total | 1.36E-02 | 4.74E-03 |
| New Coil | 1.19E-03 | 1.21E-04 |
| External Circuit | 1.08E-02 | 4.36E-03 |
| New Total | 1.20E-02 | 4.48E-03 |
| Change | -12% | -5% |

Revised physical dimensions, resistances, inductances, applied voltages, and induced voltages are given in the following tables.

TABLE 2 – Coil Dimensions

| Coil | R (center) | ΔR | Z (center) | ΔZ | Turns | Fill | Max Curr |
|-------|------------|--------|------------|---------|-------|--------|----------|
| | (in) | (in) | (in) | (in) | | | (kA) |
| OH | 5.2088 | 1.7335 | 41.7490 | 83.4980 | 482 | 0.7403 | 24.0 |
| PF1a | 7.2403 | 1.6265 | 62.6215 | 9.1820 | 20 | 0.6956 | 24.0 |
| PF1b | 11.9768 | 3.3055 | 71.8570 | 7.5030 | 32 | 0.6702 | 20.0 |
| PF2a | 31.4634 | 6.4060 | 76.1225 | 2.6760 | 14 | 0.7409 | 20.0 |
| PF2b | 31.4634 | 6.4060 | 72.9385 | 2.6760 | 14 | 0.7409 | 20.0 |
| PF3a | 58.8370 | 7.3400 | 64.3114 | 2.6760 | 15 | 0.6928 | 20.0 |
| PF3b | 58.8370 | 7.3400 | 61.1274 | 2.6760 | 15 | 0.6928 | 20.0 |
| PF4b | 70.6540 | 3.6040 | 31.7800 | 2.6760 | 8 | 0.7525 | 20.0 |
| PF4c | 71.1210 | 4.5380 | 34.9640 | 2.6760 | 9 | 0.6723 | 20.0 |
| PF5a | 78.5280 | 5.3500 | 25.6840 | 2.6980 | 12 | 0.7689 | 20.0 |
| PF5b | 78.5280 | 5.3500 | 22.7440 | 2.6980 | 12 | 0.7689 | 20.0 |
| PFAB1 | 16.9530 | 0.8565 | 69.1550 | 2.6725 | 48 | 0.5613 | 1.0 |
| PFAB2 | 24.8750 | 0.8565 | 75.8210 | 2.6725 | 48 | 0.5613 | 1.0 |

Notes:

- 1) OH coil dimension given for half plane
- 2) PF1b in lower half plane only
- 3) PFAB1,PFAB2 in upper half plane only
- 4) All dimensions over conductor, not including ground insulation

TABLE 3 – Coil Inductances and Resistances

| L:Henry | OH | PF1AU | PF1AL | PF1B | PF2U | PF2L | PF3U | PF3L | PF4 | PF5 | PFAB1 | PFAB2 |
|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| OH | 1.32E-02 | 3.06E-04 | 3.06E-04 | 4.28E-04 | 2.76E-04 | 2.76E-04 | 2.97E-04 | 2.97E-04 | 3.82E-04 | 5.32E-04 | 6.21E-04 | 4.85E-04 |
| PF1AU | 3.06E-04 | 1.21E-04 | 2.80E-08 | 9.76E-08 | 3.84E-05 | 5.22E-07 | 2.69E-05 | 2.05E-06 | 1.26E-05 | 1.65E-05 | 1.22E-04 | 6.98E-05 |
| PF1AL | 3.06E-04 | 2.80E-08 | 1.21E-04 | 6.96E-05 | 5.22E-07 | 3.84E-05 | 2.05E-06 | 2.69E-05 | 1.26E-05 | 1.65E-05 | 3.08E-07 | 5.59E-07 |
| PF1B | 4.28E-04 | 9.76E-08 | 6.96E-05 | 6.73E-04 | 1.88E-06 | 2.12E-04 | 7.49E-06 | 1.15E-04 | 4.70E-05 | 6.16E-05 | 1.10E-06 | 2.02E-06 |
| PF2U | 2.76E-04 | 3.84E-05 | 5.22E-07 | 1.88E-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 | 5.22E-07 | 3.84E-05 | 2.12E-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 | 2.97E-04 | 2.69E-05 | 2.05E-06 | 7.49E-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 | 2.97E-04 | 2.05E-06 | 2.69E-05 | 1.15E-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 | 3.82E-04 | 1.26E-05 | 1.26E-05 | 4.70E-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 | 5.32E-04 | 1.65E-05 | 1.65E-05 | 6.16E-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 | 6.21E-04 | 1.22E-04 | 3.08E-07 | 1.10E-06 | 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 | 4.85E-04 | 6.98E-05 | 5.59E-07 | 2.02E-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 |
| R:Ohm | 9.64E-02 | 1.19E-03 | 1.19E-03 | 3.15E-03 | 4.17E-03 | 4.17E-03 | 8.34E-03 | 8.34E-03 | 1.14E-02 | 1.74E-02 | 1.30E-01 | 1.90E-01 |

TABLE 4 – External Circuit Inductances and Resistances

| L:Henry | OH | PF1AU | PF1AL | PF1B | PF2U | PF2L | PF3U | PF3L | PF4 | PF5 | PFAB1 | PFAB2 |
|---------|----------|----------|----------|----------|----------|----------|----------|----------|-----|----------|-------|-------|
| OH | 5.30E-04 | | | | | | | | | | | |
| PF1AU | | 4.36E-03 | 2.78E-03 | | | | | | | | | |
| PF1AL | | 2.78E-03 | 4.36E-03 | | | | | | | | | |
| PF1B | | | | 2.65E-04 | | | | | | | | |
| PF2U | | | | | 2.65E-04 | | | | | | | |
| PF2L | | | | | | 2.65E-04 | | | | | | |
| PF3U | | | | | | | 2.65E-04 | | | | | |
| PF3L | | | | | | | | 2.65E-04 | | | | |
| PF4 | | | | | | | | | | | | |
| PF5 | | | | | | | | | | 2.65E-04 | | |
| PFAB1 | | | | | | | | | | | | |
| PFAB2 | | | | | | | | | | | | |
| R:Ohm | 4.59E-03 | 1.08E-02 | 1.08E-02 | 6.52E-03 | 3.53E-03 | 3.18E-03 | 3.61E-03 | 4.31E-03 | | 3.07E-03 | | |

TABLE 5 – Total Circuit Inductances and Resistances

| L:Henry | OH | PF1AU | PF1AL | PF1B | PF2U | PF2L | PF3U | PF3L | PF4 | PF5 | PFAB1 | PFAB2 |
|---------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| OH | 1.38E-02 | 3.06E-04 | 3.06E-04 | 4.28E-04 | 2.76E-04 | 2.76E-04 | 2.97E-04 | 2.97E-04 | 3.82E-04 | 5.32E-04 | 6.21E-04 | 4.85E-04 |
| PF1AU | 3.06E-04 | 4.48E-03 | 2.78E-03 | 9.76E-08 | 3.84E-05 | 5.22E-07 | 2.69E-05 | 2.05E-06 | 1.26E-05 | 1.65E-05 | 1.22E-04 | 6.98E-05 |
| PF1AL | 3.06E-04 | 2.78E-03 | 4.48E-03 | 6.96E-05 | 5.22E-07 | 3.84E-05 | 2.05E-06 | 2.69E-05 | 1.26E-05 | 1.65E-05 | 3.08E-07 | 5.59E-07 |
| PF1B | 4.28E-04 | 9.76E-08 | 6.96E-05 | 9.38E-04 | 1.88E-06 | 2.12E-04 | 7.49E-06 | 1.15E-04 | 4.70E-05 | 6.16E-05 | 1.10E-06 | 2.02E-06 |
| PF2U | 2.76E-04 | 3.84E-05 | 5.22E-07 | 1.88E-06 | 2.24E-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 | 5.22E-07 | 3.84E-05 | 2.12E-04 | 1.03E-05 | 2.24E-03 | 4.11E-05 | 7.31E-04 | 2.64E-04 | 3.45E-04 | 5.92E-06 | 1.10E-05 |
| PF3U | 2.97E-04 | 2.69E-05 | 2.05E-06 | 7.49E-06 | 7.31E-04 | 4.11E-05 | 5.44E-03 | 1.66E-04 | 1.16E-03 | 1.49E-03 | 3.57E-04 | 7.42E-04 |
| PF3L | 2.97E-04 | 2.05E-06 | 2.69E-05 | 1.15E-04 | 4.11E-05 | 7.31E-04 | 1.66E-04 | 5.44E-03 | 1.16E-03 | 1.49E-03 | 2.35E-05 | 4.39E-05 |
| PF4 | 3.82E-04 | 1.26E-05 | 1.26E-05 | 4.70E-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 | 5.32E-04 | 1.65E-05 | 1.65E-05 | 6.16E-05 | 3.45E-04 | 3.45E-04 | 1.49E-03 | 1.49E-03 | 4.81E-03 | 1.26E-02 | 1.93E-04 | 3.66E-04 |
| PFAB1 | 6.21E-04 | 1.22E-04 | 3.08E-07 | 1.10E-06 | 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 | 4.85E-04 | 6.98E-05 | 5.59E-07 | 2.02E-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 |
| R:Ohm | 1.01E-01 | 1.20E-02 | 1.20E-02 | 9.67E-03 | 7.70E-03 | 7.34E-03 | 1.19E-02 | 1.26E-02 | 1.14E-02 | 2.05E-02 | 1.30E-01 | 1.90E-01 |

TABLE 6 – Applied and Induced Voltages

| V _{max} :kV | OH | PF1AU | PF1AL | PF1B | PF2U | PF2L | PF3U | PF3L | PF4 | PF5 | PFAB1 | PFAB2 |
|----------------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| OH | 6.000 | 0.137 | 0.137 | 0.912 | 0.123 | 0.247 | 0.109 | 0.109 | 0.148 | 0.127 | 0.158 | 0.075 |
| PF1AU | 0.133 | 2.000 | 1.242 | 0.000 | 0.017 | 0.000 | 0.010 | 0.001 | 0.005 | 0.004 | 0.031 | 0.011 |
| PF1AL | 0.133 | 1.242 | 2.000 | 0.149 | 0.000 | 0.034 | 0.001 | 0.010 | 0.005 | 0.004 | 0.000 | 0.000 |
| PF1B | 0.186 | 0.000 | 0.031 | 2.000 | 0.001 | 0.190 | 0.003 | 0.042 | 0.018 | 0.015 | 0.000 | 0.000 |
| PF2U | 0.120 | 0.017 | 0.000 | 0.004 | 1.000 | 0.009 | 0.269 | 0.015 | 0.102 | 0.083 | 0.165 | 0.284 |
| PF2L | 0.120 | 0.000 | 0.017 | 0.453 | 0.005 | 2.000 | 0.015 | 0.269 | 0.102 | 0.083 | 0.002 | 0.002 |
| PF3U | 0.129 | 0.012 | 0.001 | 0.016 | 0.326 | 0.037 | 2.000 | 0.061 | 0.450 | 0.355 | 0.091 | 0.115 |
| PF3L | 0.129 | 0.001 | 0.012 | 0.245 | 0.018 | 0.653 | 0.061 | 2.000 | 0.450 | 0.355 | 0.006 | 0.007 |
| PF4 | 0.167 | 0.006 | 0.006 | 0.100 | 0.118 | 0.235 | 0.427 | 0.427 | 2.000 | 1.149 | 0.038 | 0.043 |
| PF5 | 0.232 | 0.007 | 0.007 | 0.131 | 0.154 | 0.308 | 0.546 | 0.546 | 1.864 | 3.000 | 0.049 | 0.057 |
| PFAB1 | 0.271 | 0.055 | 0.000 | 0.002 | 0.290 | 0.005 | 0.131 | 0.009 | 0.057 | 0.046 | 1.000 | 0.205 |
| PFAB2 | 0.211 | 0.031 | 0.000 | 0.004 | 0.820 | 0.010 | 0.273 | 0.016 | 0.108 | 0.087 | 0.338 | 1.000 |

Notes:

- 1) Diagonal elements are applied voltages
- 2) Column entries are induced on row coils due to excitation of column coil
- 3) PF2U limited to 1kV to avoid overvoltage on PFAB2 coil

cc:

M Bell D Gates R Hatcher J Menard D Mueller M Ono
 S Ramakrishnan A Von Halle M Williams