DRAFT SPECIFICATION

FOR THE BOOSTER

CORRECTOR MAGNET

POWER AMPLIFIERS

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1.0 INTRODUCTION

The following specification describes the requirements for the power amplifiers that will drive the current ramp for the new Booster Corrector Magnet Package. This is a draft version written to assist in the cost and labor estimation phase of the Corrector Magnet Installation project.

There are six separate magnets in the package which need their own individual amplifiers. Forty-eight Corrector Magnet Packages will be installed. Two hundred and eighty-eight power amplifiers will be installed. Each magnet is ramped independently.

The specification of the needed power amplifiers is given as four types based mainly on the voltage and slew rate parameters. The fourth type has a much different requirement than the others. It also has a much lower output current requirement.

2.0 TYPE 1: HORIZONTAL AND VERTICAL TRIM DIPOLES

2.1 MAGNET PARAMETERS

2.1.1 Integrated Field	0.0175 T-m
2.1.2 Maximum Peak Current	50 Amp
2.1.3 Integrated Field per Amp	87.5E–6 T-m / Amp
2.1.4 Maximum Field Slew Rate	3.5 T-m / Sec
2.1.5 Magnet Inductance	7,840 μH
2.1.6 Magnet Resistance	0.27 Ohms
2.1.7 Maximum Magnet Voltage, $V = L (dI/dt) + I R$	+/-92Volts

2.2 AMPLIFIER PARAMETERS

2.2.1 Number of Power Amps of This Type Installed	96 Units
2.2.2 Maximum Input Operating Voltage	200 Volts
2.2.3 Minimum Reference Input Impedance	2000 Ohms
2.2.4 Reference Input Voltage Range	+/- 10 Volts
2.2.5 Reference Input Common Mode Rejection (0 to 360 Hz)	70 dB
2.2.6 Typical Reference Gain	10 Amps / Volt
2.2.7 Continuous Output Current	+/- 50 Amps
2.2.8 Maximum Output Voltage	+/- 92 Volts
2.2.9 Current Regulation (Accuracy)	+/- 2.0 %
2.2.10 Current Regulation (Repeatability)	+/- 1.0 %
2.2.11 Maximum Current Ripple With Given Magnet Load (1)	+/- 1.0 Amps
2.2.12 Maximum Current Slew Rate	10,000 Amp / Sec
2.2.13 Settling Time to Within +/- 100 mA (2)	0.25 mSec
2.2.14 DC Drift Temperature Coefficient	1.0 mA / degC

NOTES:

(1) The given magnet load is expressed as $R + j 2 \pi F_{ripple} L$ where, R is the resistance in ohms, F_{ripple} is the ripple frequency in Hz and L is the inductance in Henries. This also assumes a ripple frequency greater than 25 kHz.

(2) The settling time is measured from the end of the ramp for ramp from 0 to +/-50 Amps and a ramp slope of 10,000 Amps / Sec.

3.0 TYPE 2: NORMAL QUADRUPOLE

3.1 MAGNET PARAMETERS

3.1.1 Integrated Field	0.094 T-m / m
3.1.2 Maximum Peak Current	50 Amp
3.1.3 Integrated Field per Amp	1.88E-3 T / Amp
3.1.4 Maximum Field Slew Rate	160 T / Sec
3.1.5 Magnet Inductance	1,104 μH
3.1.6 Magnet Resistance	0.166 Ohms
3.1.7 Maximum Magnet Voltage, $V = L (dI/dt) + I R$	+/-102 Volts

3.2 AMPLIFIER PARAMETERS

3.2.1 Number of Power Amps of This Type Installed	48 Units
3.2.2 Maximum Input Operating Voltage	200 Volts
3.2.3 Minimum Reference Input Impedance	2000 Ohms
3.2.4 Reference Input Voltage Range	+/- 10 Volts
3.2.5 Reference Input Common Mode Rejection (0 to 360 Hz)	70 dB
3.2.6 Typical Reference Gain	10 Amps / Volt
3.2.7 Continuous Output Current	+/- 50 Amps
3.2.8 Maximum Output Voltage	+/- 105 Volts
3.2.9 Current Regulation (Accuracy)	+/- 2.0 %
3.2.10 Current Regulation (Repeatability)	+/- 1.0 %
3.2.11 Maximum Current Ripple With Given Magnet Load (3)	+/- 1.0 Amp
3.2.12 Maximum Current Slew Rate	85,106 Amp / Sec
3.2.13 Settling Time to Within +/- 100 mA (4)	0.25 mSec
3.2.14 DC Drift Temperature Coefficient	1.0 mA / degC

NOTES:

(3) The given magnet load is expressed as $R + j 2 \pi F_{ripple} L$ where, R is the resistance in ohms, F_{ripple} is the ripple frequency in Hz and L is the inductance in Henries. This also assumes a ripple frequency greater than 25 kHz.

(4) The settling time is measured from the end of the ramp for ramp from 0 to +/-50 Amps and a ramp slope of 85,000 Amps / Sec.

4.0 TYPE 3: NORMAL AND SKEW SEXTUPOLES

4.1 MAGNET PARAMETERS

4.1.1 Integrated Field	1.48 T-m / m^2
4.1.2 Maximum Peak Current	50 Amp
4.1.3 Integrated Field per Amp	29.6E-3 T / m / Amp
4.1.4 Maximum Field Slew Rate	2,279 T / m / Sec
4.1.5 Magnet Inductance	1,760 μH
4.1.6 Magnet Resistance	0.187 Ohms
4.1.7 Maximum Magnet Voltage, V = L (dI/dt) + I R	+/-145 Volts

4.2 AMPLIFIER PARAMETERS

4.2.1 Number of Power Amps of This Type Installed	96 Units
4.2.2 Maximum Input Operating Voltage	200 Volts
4.2.3 Minimum Reference Input Impedance	2,000 Ohms
4.2.4 Reference Input Voltage Range	+/- 10 Volts
4.2.5 Reference Input Common Mode Rejection (0 to 360 Hz)	70 dB
4.2.6 Typical Reference Gain	10 Amps / Volt
4.2.7 Continuous Output Current	+/- 50 Amps
4.2.8 Maximum Output Voltage	+/- 145 Volts
4.2.9 Current Regulation (Accuracy)	+/- 2.0 %
4.2.10 Current Regulation (Repeatability)	+/- 1.0 %
4.2.11 Maximum Current Ripple With Given Magnet Load (5)	+/- 1.0 Amp
4.2.12 Maximum Current Slew Rate	77,000 Amp / Sec
4.2.13 Settling Time to Within +/- 100 mA (6)	0.25 mSec
4.2.14 DC Drift Temperature Coefficient	1.0 mA / degC

NOTES:

(5) The given magnet load is expressed as $R + j\,2\,\pi\,F_{ripple}\,L$ where, R is the resistance in ohms, F_{ripple} is the ripple frequency in Hz and L is the inductance in Henries. This also assumes a ripple frequency greater than 25 kHz.

(6) The settling time is measured from the end of the ramp for ramp from 0 to +/-50 Amps and a ramp slope of 80,000 Amps / Sec.

5.0 TYPE 4: SKEW QUADRUPOLE

5.1 MAGNET PARAMETERS

5.1.1 Integrated Field	0.0275 T-m / m
5.1.2 Maximum Peak Current	5 Amp
5.1.3 Integrated Field per Amp	5.5E-3 T / Amp
5.1.4 Maximum Field Slew Rate	0.8 T / Sec
5.1.5 Magnet Inductance	6400 μH
5.1.6 Magnet Resistance	0.35 Ohms
5.1.7 Maximum Magnet Voltage, V = L (dI/dt) + I R	2.7 Volts

5.2 AMPLIFIER PARAMETERS

5.2.1 Number of Power Amps of This Type Installed	48 Units
5.2.2 Maximum Input Operating Voltage	+/-15 Volts
5.2.3 Minimum Reference Input Impedance	2000 Ohms
5.2.4 Reference Input Voltage Range	+/- 10 Volts
5.2.5 Reference Input Common Mode Rejection (0 to 360 Hz)	70 dB
5.2.6 Typical Reference Gain	1 Amps / Volt
5.2.7 Continuous Output Current	+/- 5 Amps
5.2.8 Maximum Output Voltage	+/- 2 Volts
5.2.9 Current Regulation (Accuracy)	+/- 2.0 %
5.2.10 Current Regulation (Repeatability)	+/- 1.0 %
5.2.11 Maximum Current Ripple With Given Magnet Load (7)	+/- 1.0 Amp
5.2.12 Maximum Current Slew Rate	145.5 Amp / Sec
5.2.13 Settling Time to Within +/- 10 mA (8)	0.25 mSec
5.2.14 DC Drift Temperature Coefficient	1.0 mA / degC

NOTES:

(7) The given magnet load is expressed as $R + j\,2\,\pi\,F_{ripple}\,L$ where, R is the resistance in ohms, F_{ripple} is the ripple frequency in Hz and L is the inductance in Henries. This also assumes a ripple frequency greater than 25 kHz.

(8) The settling time is measured from the end of the ramp for ramp from 0 to +/-5 Amps and a ramp slope of 150 Amps / Sec.

6.0 REMOTE MONITORING AND CONTROL

The power amplifiers need to have the following remote monitoring and control features.

Current Monitor : +/- 1V per 10 Amps, or +/- 1V per 5 Amps.
Voltage Monitor : +/- 1V per 20 V
Remote Enable : TTL or contact closure.
Remote Inhibit : TTL or contact closure.

Status Outputs : Output Enabled
Amp Normal
Amp Fault
Over Voltage
Over-Current
Over-Temperature

Amplifier Protection :
Input reference voltage limiter
Over-Temperature Shutdown
Over-Current Shutdown
Over-Voltage Shutdown
Under-Voltage Shutdown