Synchronized Ramping of Magnet Power Supplies for Streamlined Operation

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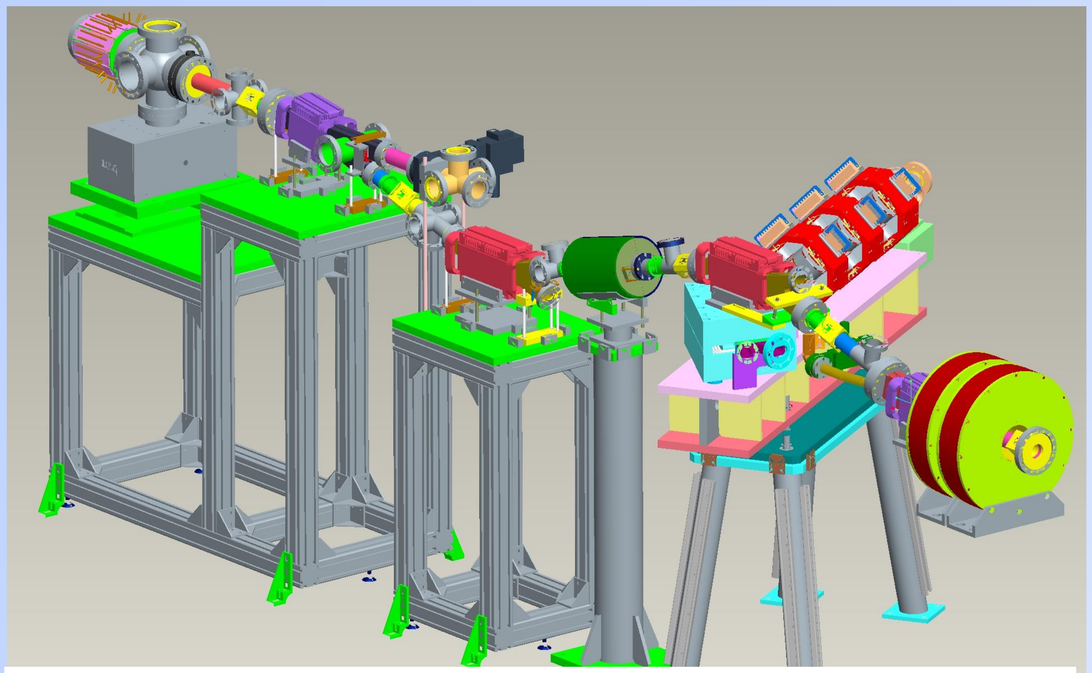
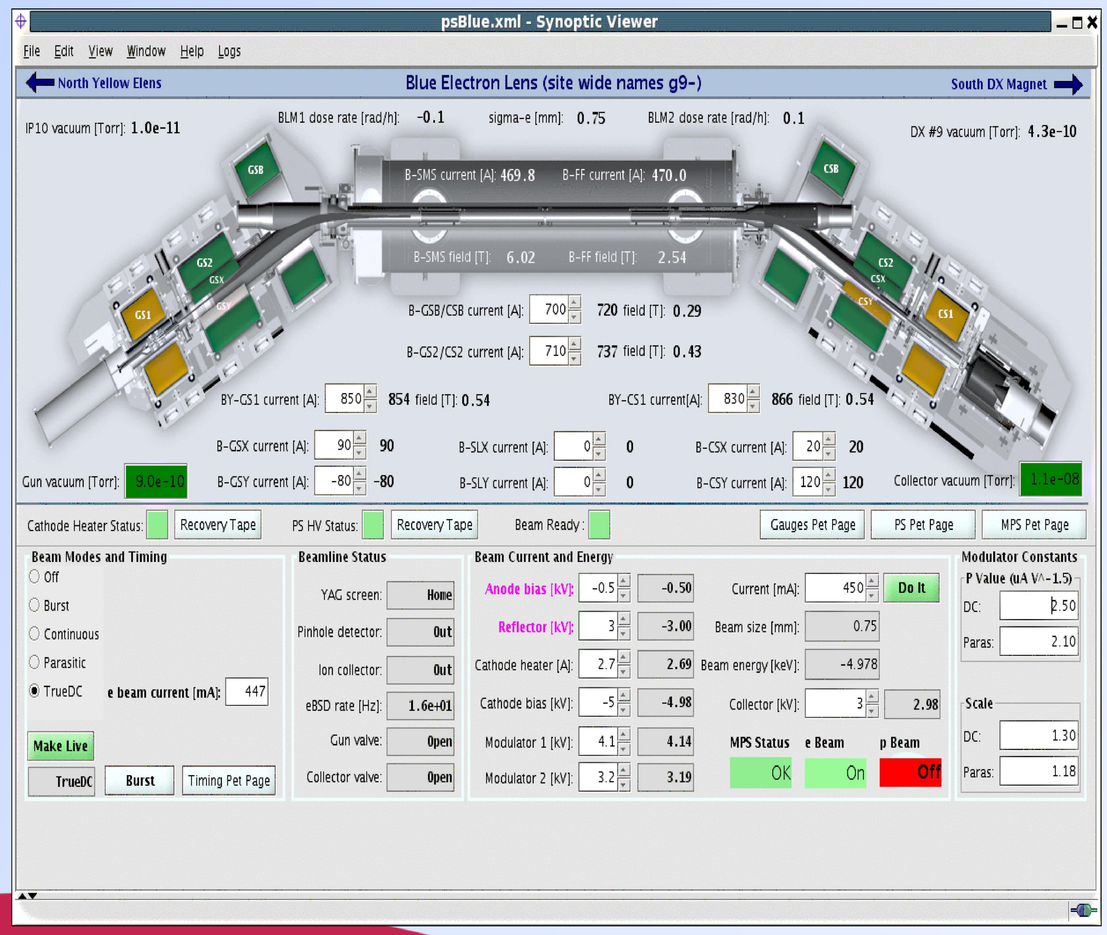
Abstract :*Synchronous ramping of an assembly of magnets is critical for operation of beam in an accelerator. Magnet currents must remain within the operational limits to avoid misalignment of electron beam. In order to comply with the design specifications of ERL and ELENS project , two different software control mechanisms have been developed. The ramp profile is automated and maintained by tracking current in all dipole magnets at ERL and superconducting solenoid magnets at ELENS. This mechanism speeds up operations and adds a level of protection. The purpose of this application is to reduce unnecessary interlocks of the personnel protection system. This paper will describe the power supply arrangement, communication mechanism and the state machine algorithm used for feedback and control. A report on operating experience will be presented.*

Energy Recovery Linac Magnets



Quadrupole, Solenoid, and Precision Steering Supplies – 23 main quadrupoles, some small dipoles /solenoids. – 10 Amps, 15 Volts, 100 ppm, Bipolar, DC supplies

Electron LENS



Key Software Features

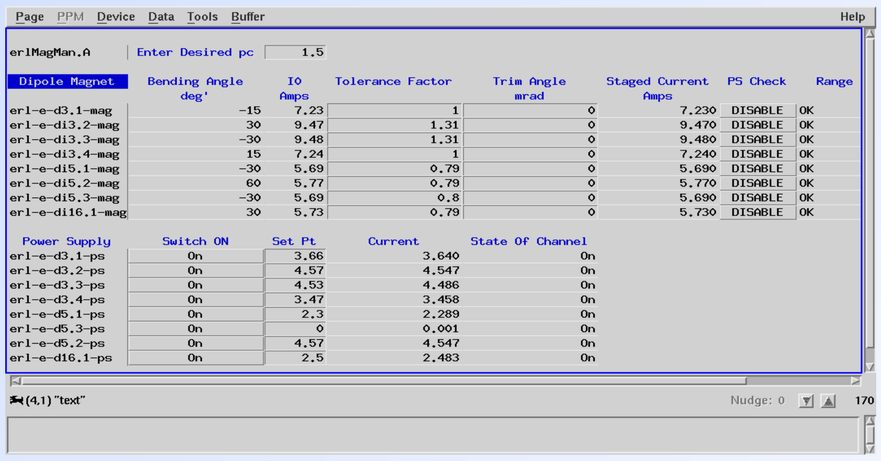
• erlMagMan is a program written to co-ordinate DC ramps of several dipole , quadrupole and solenoid magnets at ERL's gun to dump beam line

• Each magnet is represented as a software object with configurable parameters such as correction angles, relationship coefficient with reference dipole magnet, maximum output current threshold

• Output currents of each supply in the system is compared against a threshold value which is set to be at 4% of PASS system maximum. An alarm is raised at violation of this threshold

• This software is also used as underlying link between orbit correction application and magnets

• Work is under progress for implementing a magnet hysteresis compensation algorithm



Dipole Magnet	Bending Angle deg'	Io Amps	Tolerance Factor	Trim Angle mrad	Staged Current Amps	PS Check	Range
erl-e-d3.1-mag	-15	7.23	1	0	7.230	DISABLE	OK
erl-e-di3.2-mag	30	9.47	1.31	0	9.470	DISABLE	OK
erl-e-di3.3-mag	-30	9.48	1.31	0	9.480	DISABLE	OK
erl-e-di3.4-mag	15	7.24	1	0	7.240	DISABLE	OK
erl-e-di5.1-mag	-30	5.69	0.79	0	5.690	DISABLE	OK
erl-e-di5.2-mag	60	5.77	0.79	0	5.770	DISABLE	OK
erl-e-di5.3-mag	-30	5.69	0.8	0	5.690	DISABLE	OK
erl-e-di16.1-mag	30	5.73	0.79	0	5.730	DISABLE	OK

Power Supply	Switch ON	Set Pt	Current	State Of Channel
erl-e-d3.1-ps	On	3.66	3.640	On
erl-e-d3.2-ps	On	4.57	4.547	On
erl-e-d3.3-ps	On	4.53	4.486	On
erl-e-d3.4-ps	On	3.47	3.458	On
erl-e-d5.1-ps	On	2.3	2.289	On
erl-e-d5.3-ps	On	0	0.001	On
erl-e-d5.2-ps	On	4.57	4.547	On
erl-e-di6.1-ps	On	2.5	2.483	On

• Input energy is converted into magnet current for all supplies based on the relationship:

Io / (PC * PCref)

Io , Normal Bending Angle Current

PC , Momentum per particle in MeV/c

PCref, 3MeV for ERL

Key Software Features

• elensWfgMan is a program to ramp four superconducting solenoids simultaneously for blue and yellow ELENS or individually. This software interfaces with The RHIC Wave Form Generator is described in detail elsewhere [1]

• ELENS magnet profile is broken down into various states such as IDLE, RAMP, SLOWRAMP, STOP, and RESUME

• These states are implemented in C++ in form of a state machine

• Software allows easy transition between staggering ramps fig1 and smooth ramps fig2

• The user interface allows for selection of multiple magnetic fields (from Zero to Six Tesla) for the system and relevant parameters are automatically loaded from a lookup table

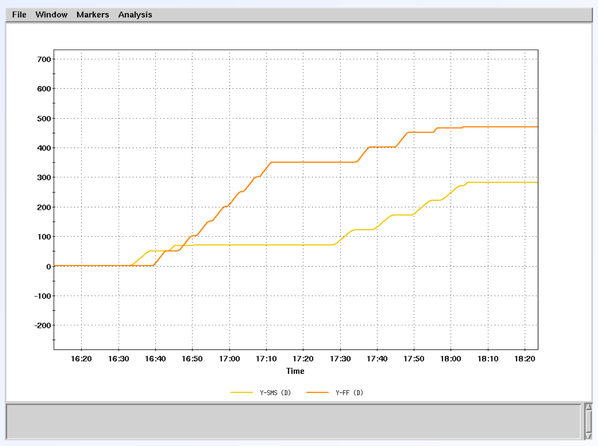


Fig 1. Yellow ELENS ramp in steps of 50 amps between main and fringe solenoids.

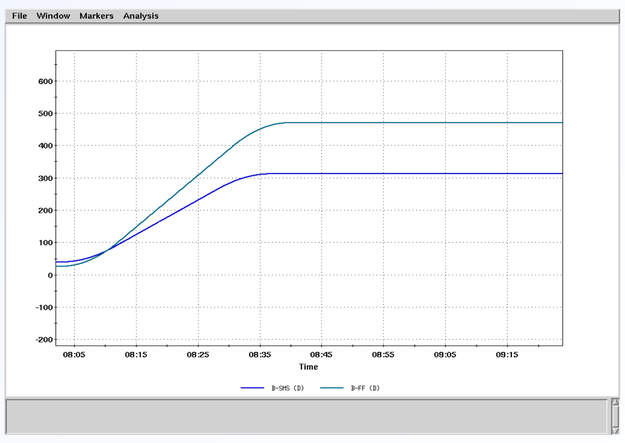


Fig 2. Blue ELENS ramping from 0 to 5.8 Tesla field main and fringe ramped simultaneously.

References

1. T. Kahn, "Power Supply Waveform Generator Module Design Specification"

ICALEPCS 2015, Melbourne Australia

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