Concept of Control System of Gradient Adjustable Permanent Magnet Quadrupole

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INTRODUCION

Why are permanent magnets interesting?

- ❖Conventional electromagnets consume high energy and need more auxiliary system.
- ❖The new generation accelerator focus on energy efficiency.
- ❖Supports the "green" accelerators drives demand for sustainable alternatives.

Ref : Status of HEPS PPT, Yuhui, Dong, IAC meeting

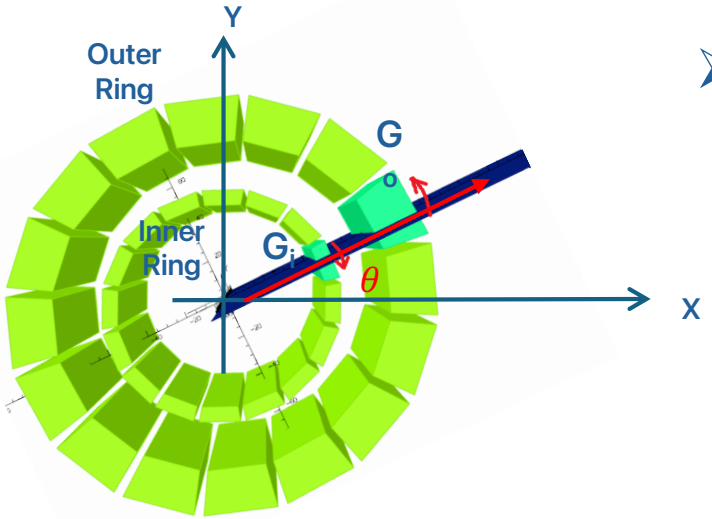
DESIGN PARAMETER

Parameter	Symbol	Unit	Value
Magnet bore diameter	ϕ	mm	≥ 86
Effective magnet length	L_{eff}	mm	≥ 200
Maximum magnetic field gradient	G_{max}	T/m	≥ 10.6
Gradient adjustment range	ΔG	T/m	$1.8 \sim 10.6$
Gradient adjustment accuracy	ΔG_{min}	T/m	≤ 0.002
Inner-outer ring rotational accuracy	$\Delta\theta$	$mrad$	≤ 0.08
Good field region radius	GFR	mm	12
Field quality in good field region @ G_{max}	$Bn/B2$	10^{-4}	< 5

ADVANTAGES

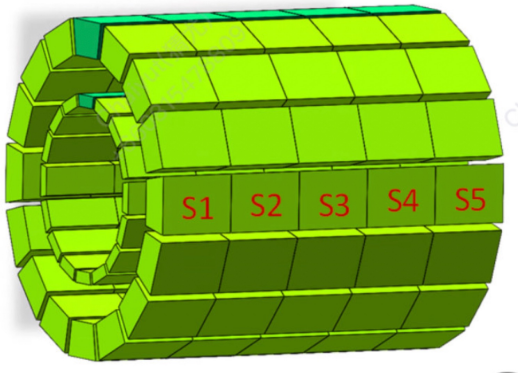
- High precision and real-time control
- Energy-efficient
- User-friendly interface and practical implementation
- Suitable for flexible accelerator applications

MAGNET STRUCTURE



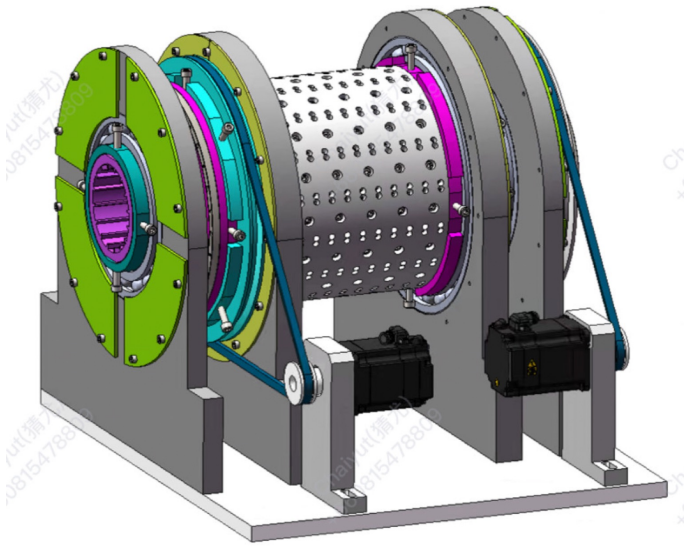
- **Permanent Magnets as a Solution:**
  - ❖ Eliminate electric excitation, reducing energy consumption.
  - ❖ Compact, stable, and efficient magnetic fields.

- **Gradient-Adjustable PMQ:**
  - ❖ Uses double Halbach ring structure for tunable field gradients.

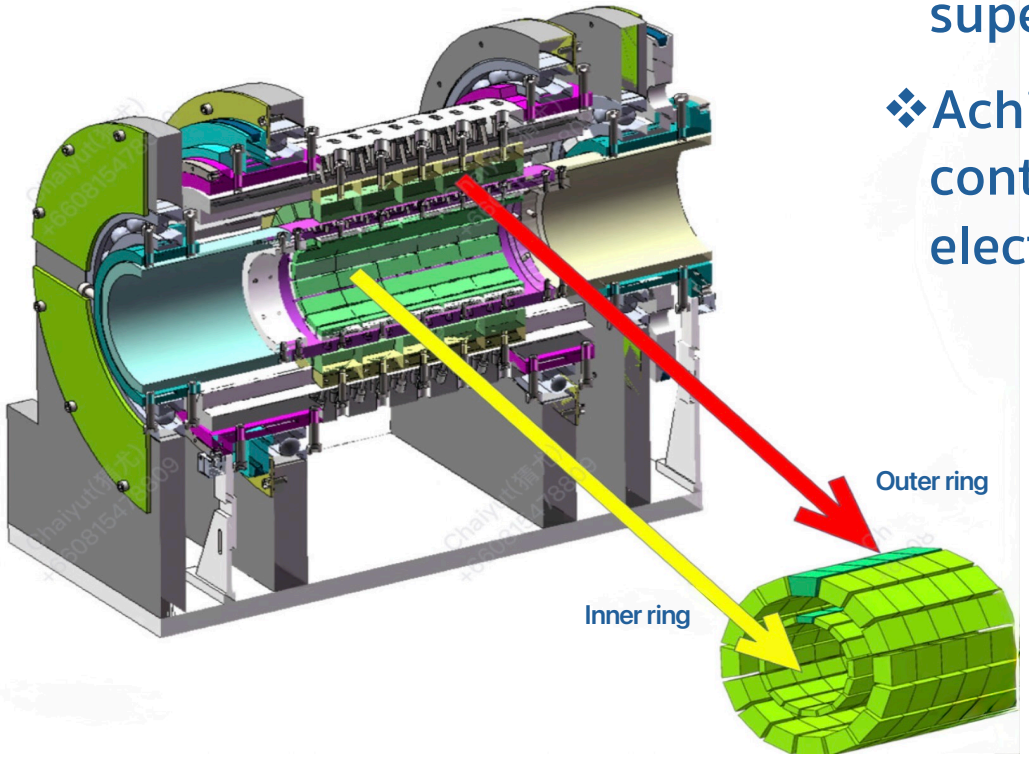


METHODOLOGY

- Synchronizing dual motorized controls involves controlling two motors to move with each other.
- The system typically operates in a closed-loop feedback control, where the sensor provides real-time feedback to the controller, allowing for continuous adjustments.
- Inner & outer ring independently rotation enables real-time magnetic field adjustment.



MECHANICAL



- Relative angular adjustment between rings modifies the superposition value.
- Achieves dynamic gradient control without energy-intensive electromagnets.

COMPONENT

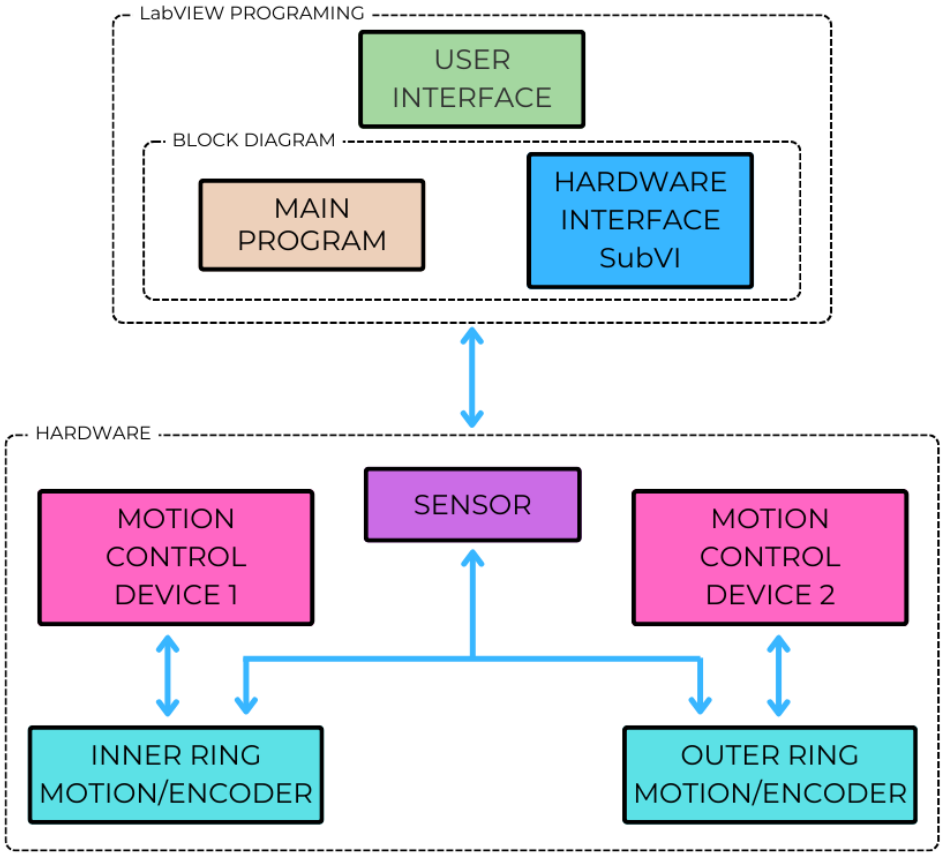
➢ Motor

The motorized system is a crucial component for adjusting the magnetic gradient.

➢ Rotational encoder:

This device is used to measure angular position, with rotational encoders being common instruments that provide precise feedback on angular displacement.

SYSTEM STRUCTURE



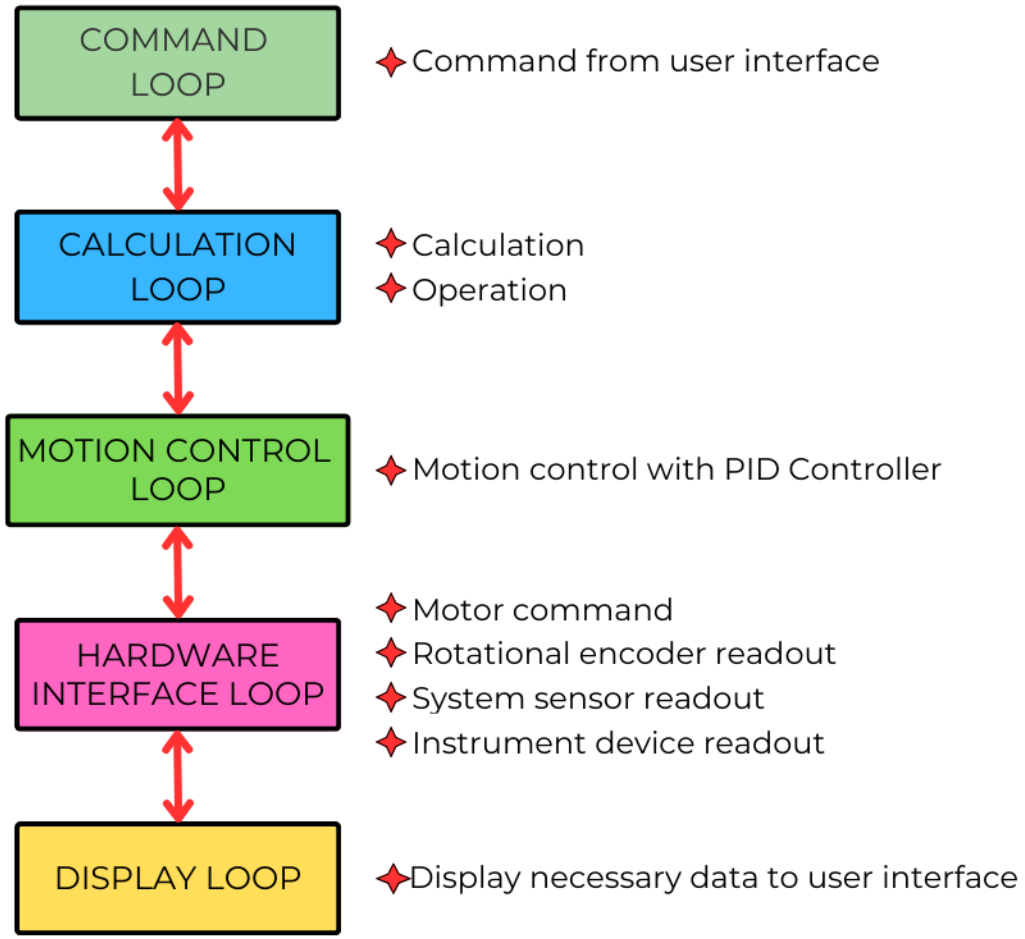
This figure illustrates the structure of the magnetic gradient adjustment system.

PROGRAMMING

- Programing based on LabVIEW

In this research, LabVIEW will be used to implement the overall control, interfacing with the hardware (motors, sensors, etc.) and providing a user-friendly interface for setting target positions, monitoring current positions, and controlling the system in real time.

PROGRAMMING



Programming-loop structure configuration

REFERENCE

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THANK YOU FOR YOUR ATTENTION

谢谢您!