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Magnet Expertise that Makes a World of Difference

Finite Element Analysis

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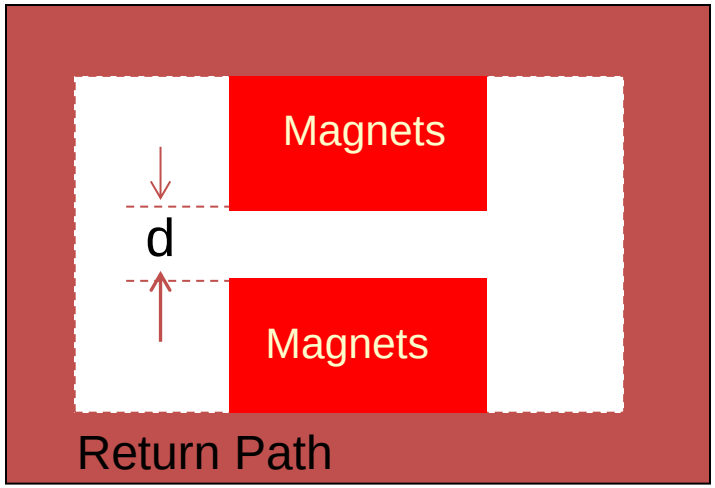
Designing with FEA

Finite Element Analysis can be a cost effective and fast tool to develop and optimize common magnetic systems such as:

- **Magnetic Dipoles**
- **Magnetizing Systems**
- **Surface Couplers**
- **Concentric Coupler**
- **Halbach Arrays**
- **Magnetic Mangles**

FEA Example



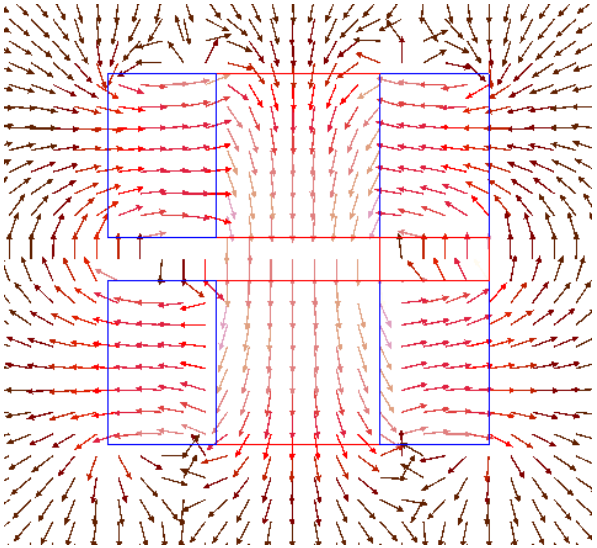
Permanent Magnet Dipoles

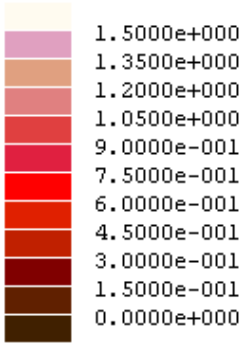
$$B_g = \frac{B_m A_m}{k_1 A_g}$$

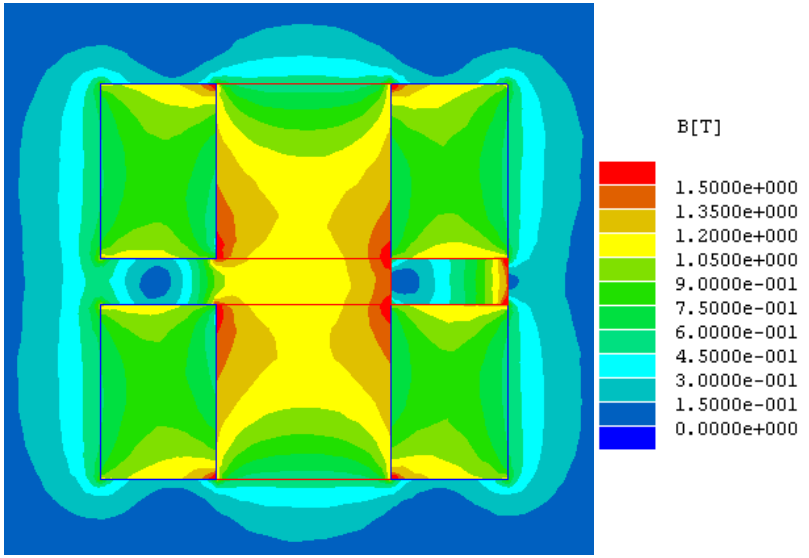
(The air gap flux density is a lot lower than the B_r of the permanent magnets)

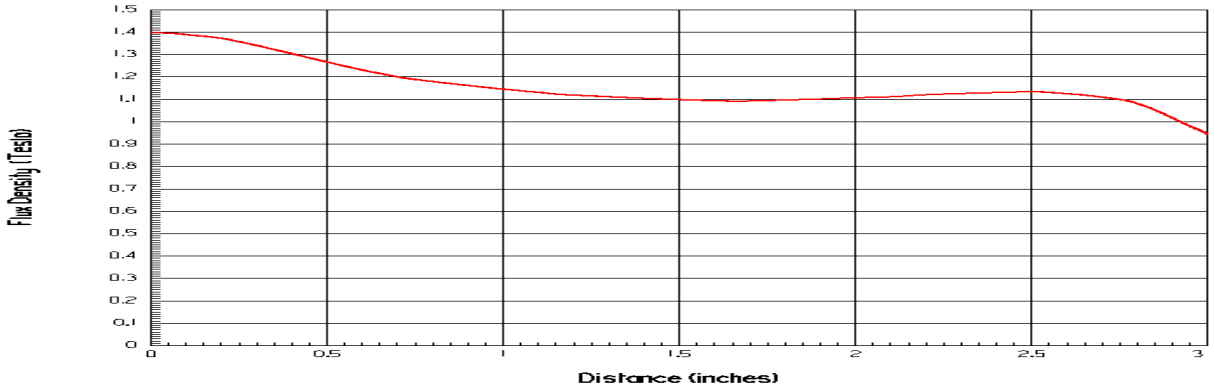
A_m =Magnet area perpendicular to the direction of magnetization;
B_m =Flux density of the magnet corresponding to the operating point of the demagnetization curve;
B_g =Flux density desired in the air gap;
A_g =Cross section area of the air gap perpendicular to the flux lines.

FEA Example: Magnetizing System









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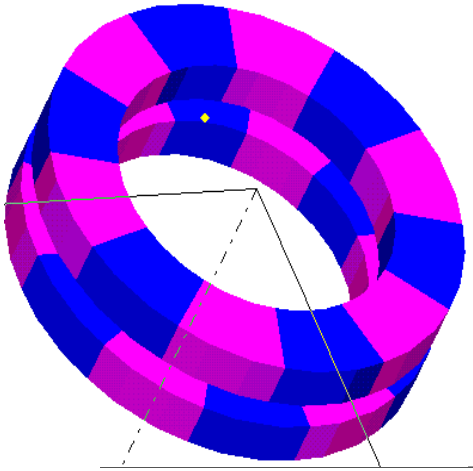
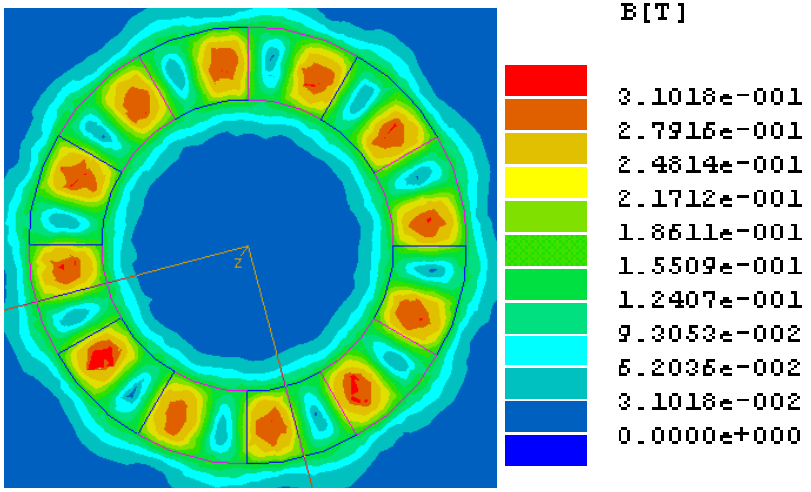
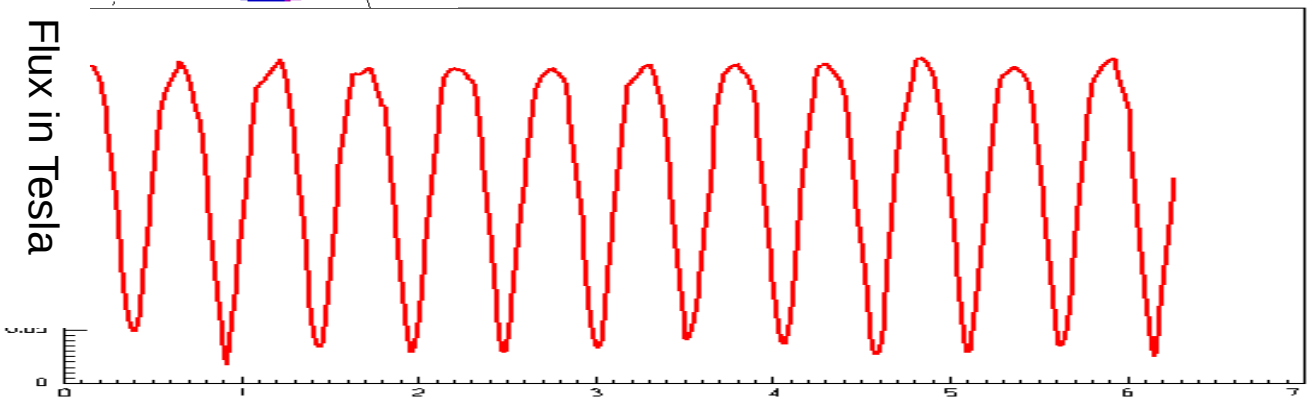
FEA Example: Surface Coupler with 12 Alternating Poles

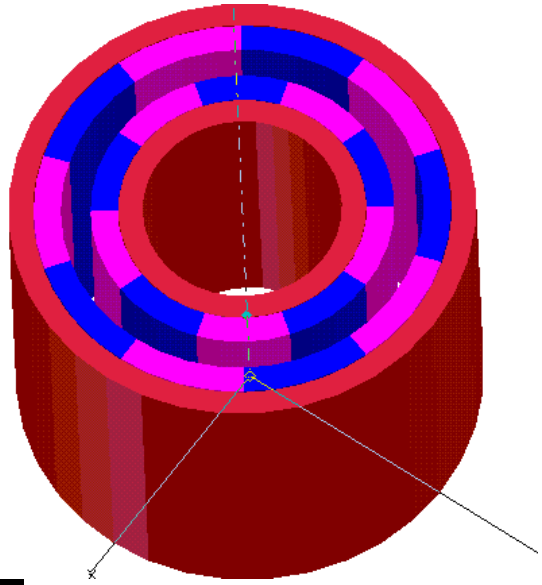


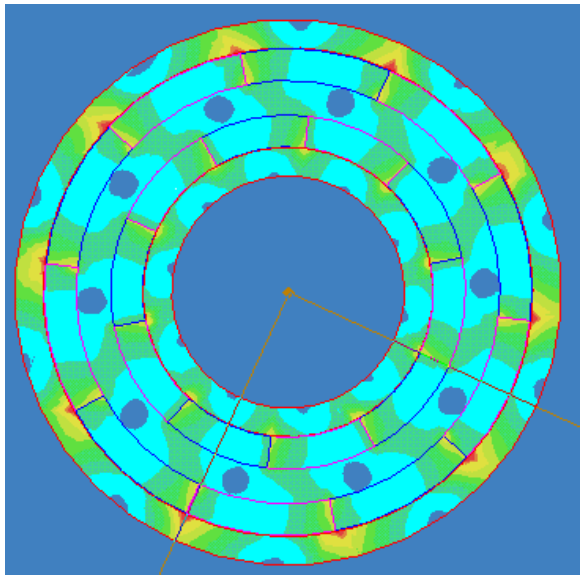


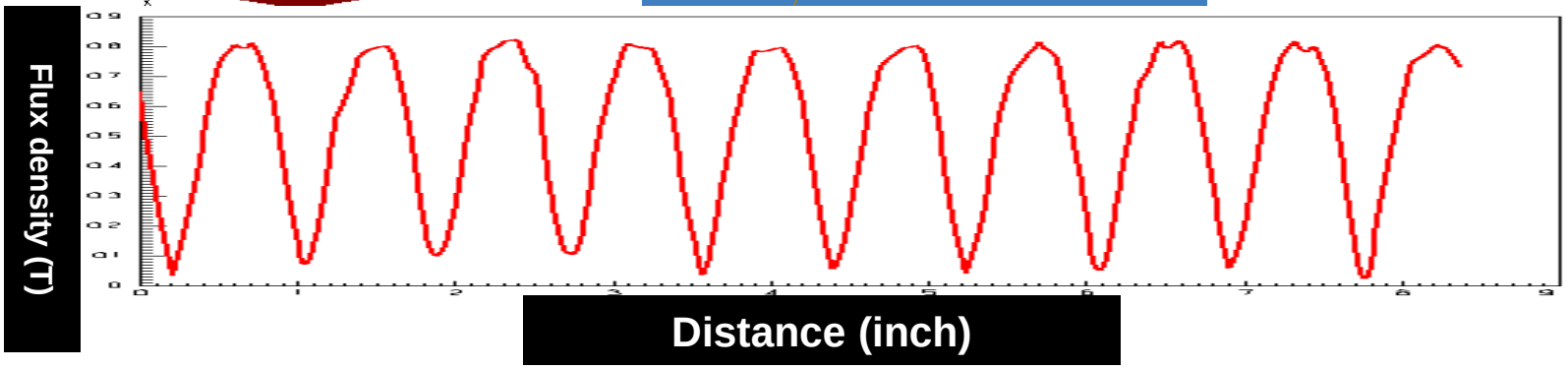


Flux density along the center line of the air gap

FEA Example: Concentric Coupling System







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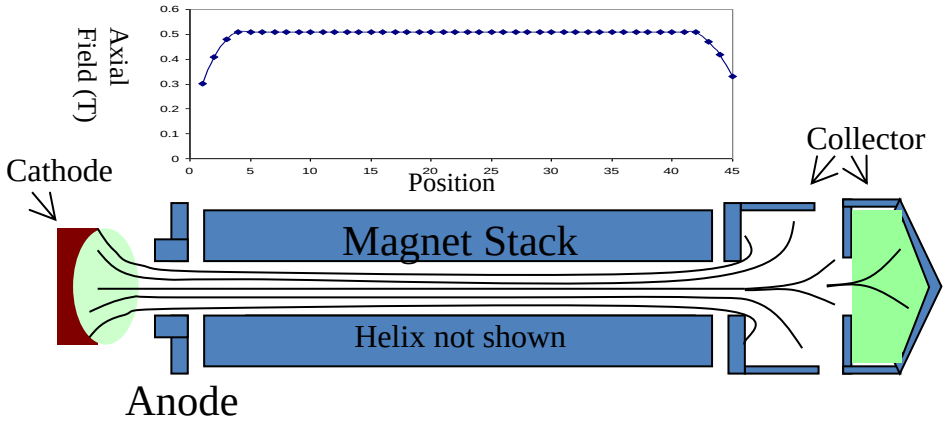
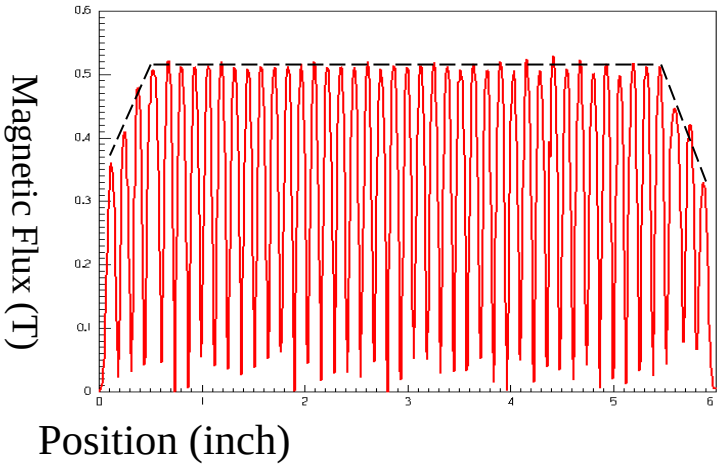
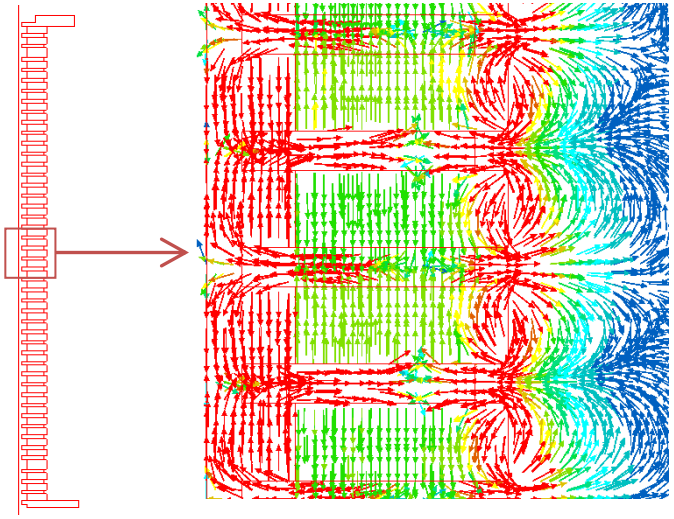
FEA Example: Traveling Wave Tubes

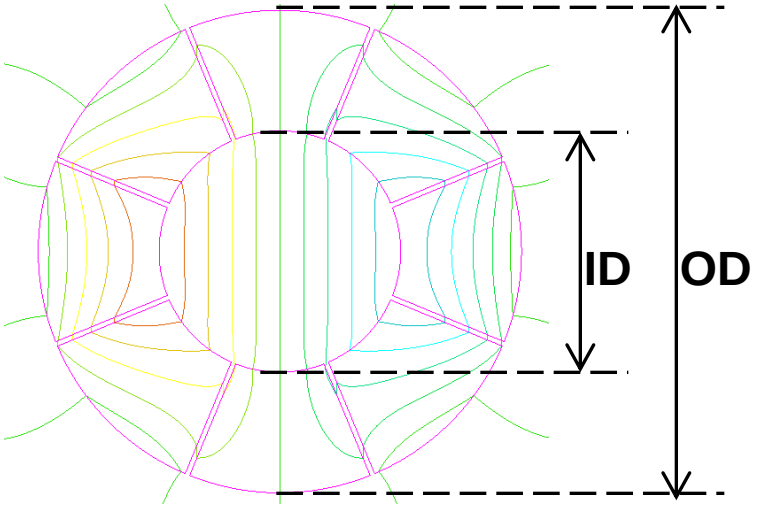






- Requires high resistance to demagnetization
- Requires high temperature stability up to 300°C
- Requires small RTC of B_r
- Requires high precision of magnetic properties
- SmCo magnets are the best choice

FEA Example



Halbach PM Dipole Structures:

$B_g = B_r \ln(OD/ID)$

There is no upper limit for air gap flux density in Halbach dipole structures according to equation.

Reality limited by:

(1) The realistic size

(2) The demagnetization effect

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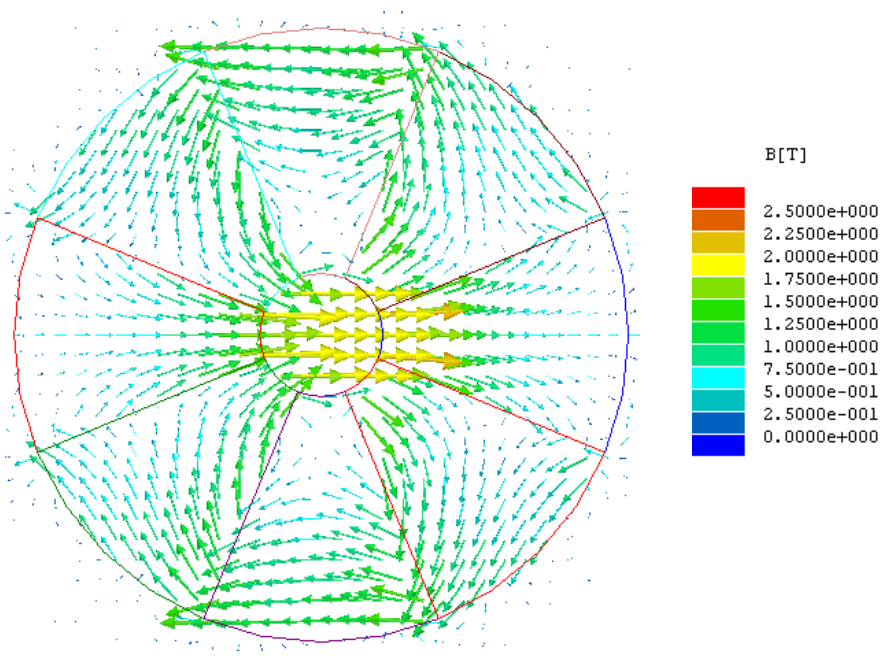
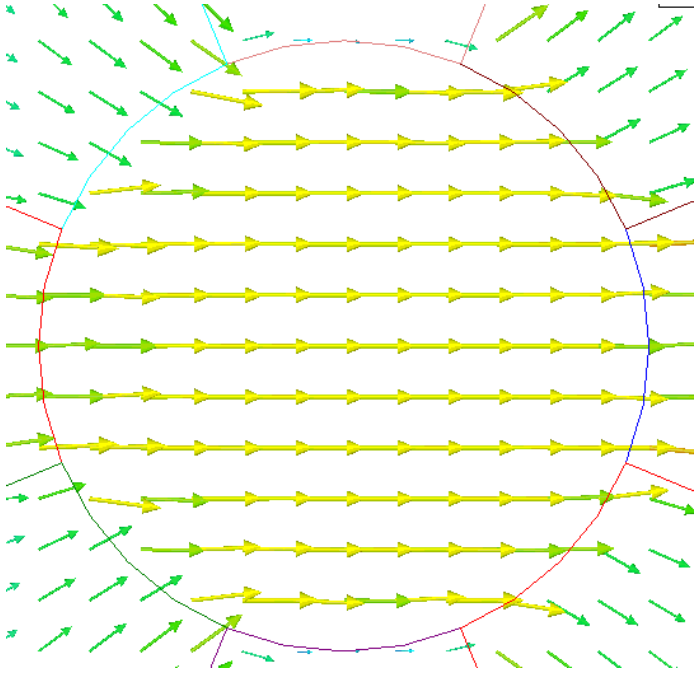
FEA Example: High Field Halbach Cylinders





- Wafer magnetic annealing
- Magnetic field strength greater than 4 Tesla
- Choose sintered SmCo or high H_{ci} NdFeB magnets

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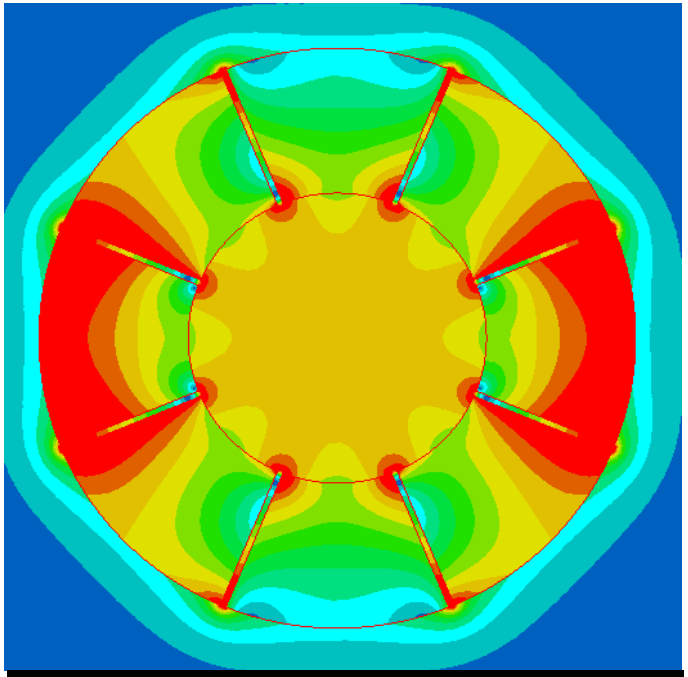
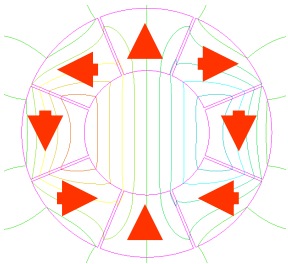
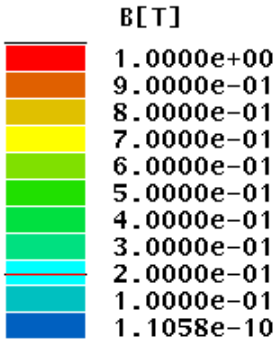
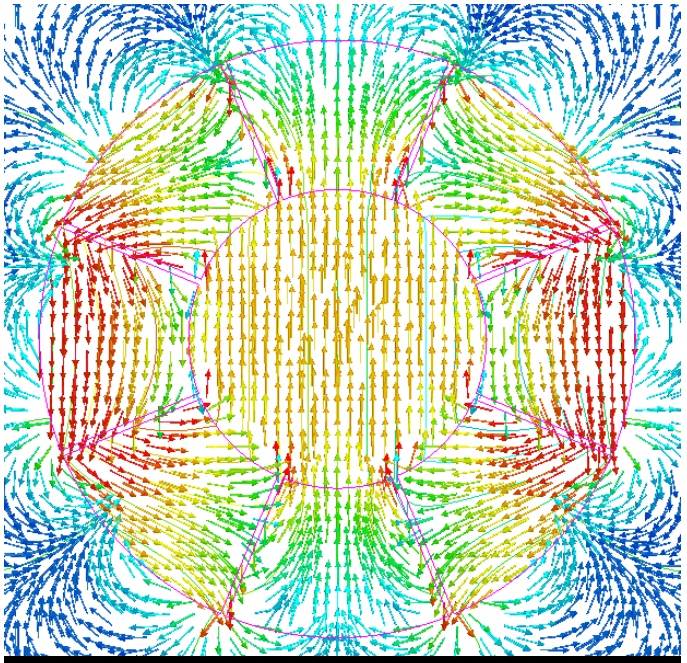
FEA Example: Halbach Dipole Example



Flux Density Map

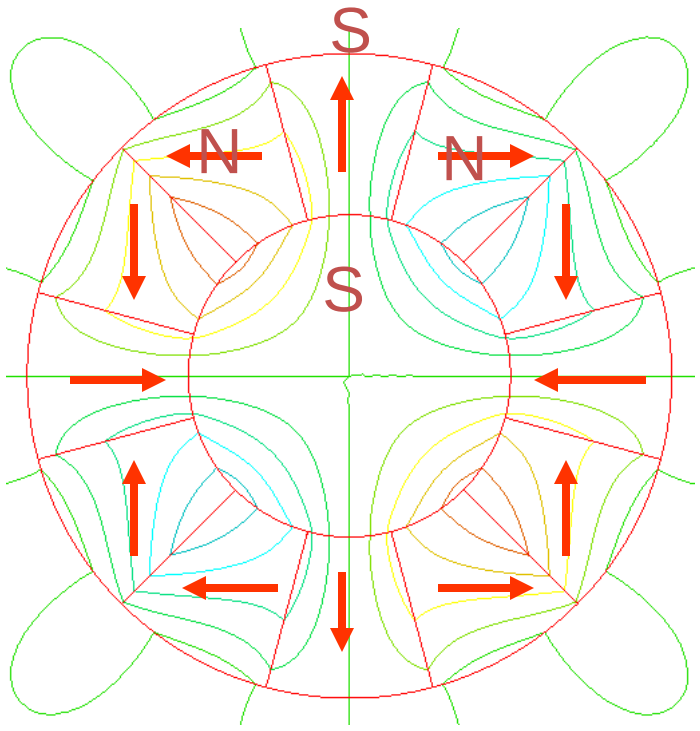


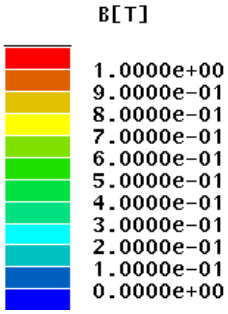


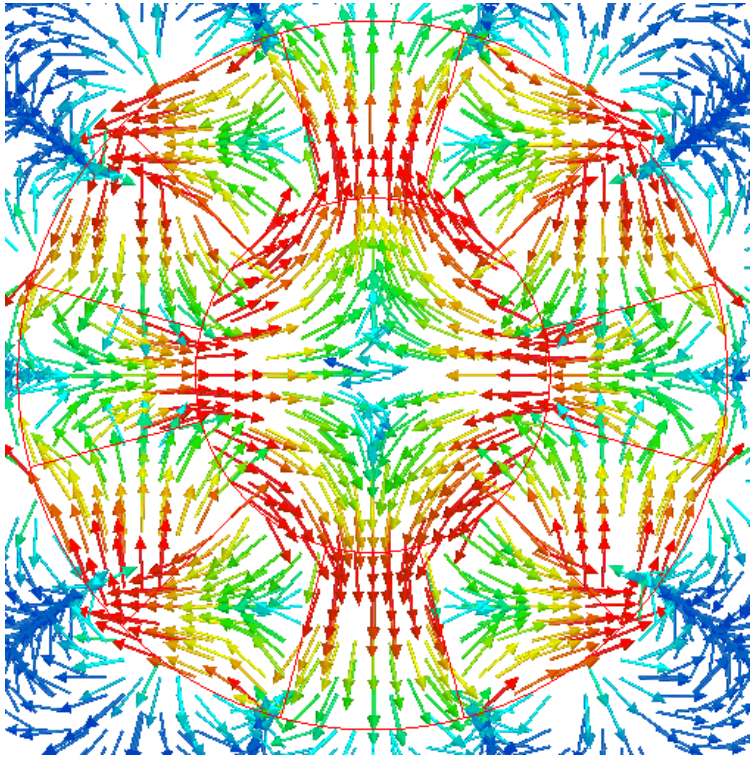


Vector Map

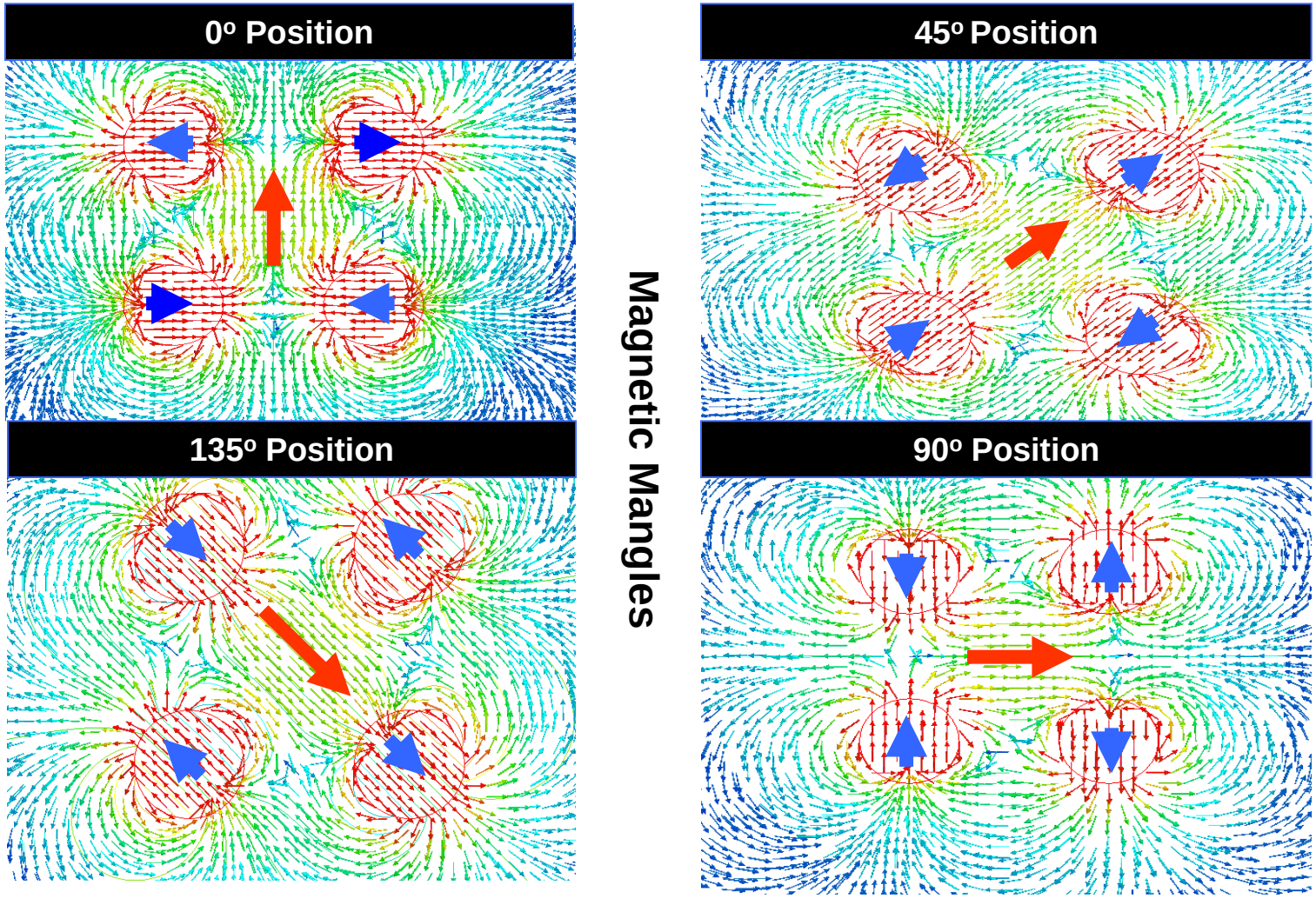
FEA Example: Halbach PM Quadrupole







FEA Example


0º Position
45º Position
135º Position
90º Position
Magnetic Mangles
Vector Plot
5.0000e-01
4.5000e-01
4.0000e-01
3.5000e-01
3.0000e-01
2.5000e-01
2.0000e-01
1.5000e-01
1.0000e-01
5.0000e-02
0.0000e+00

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