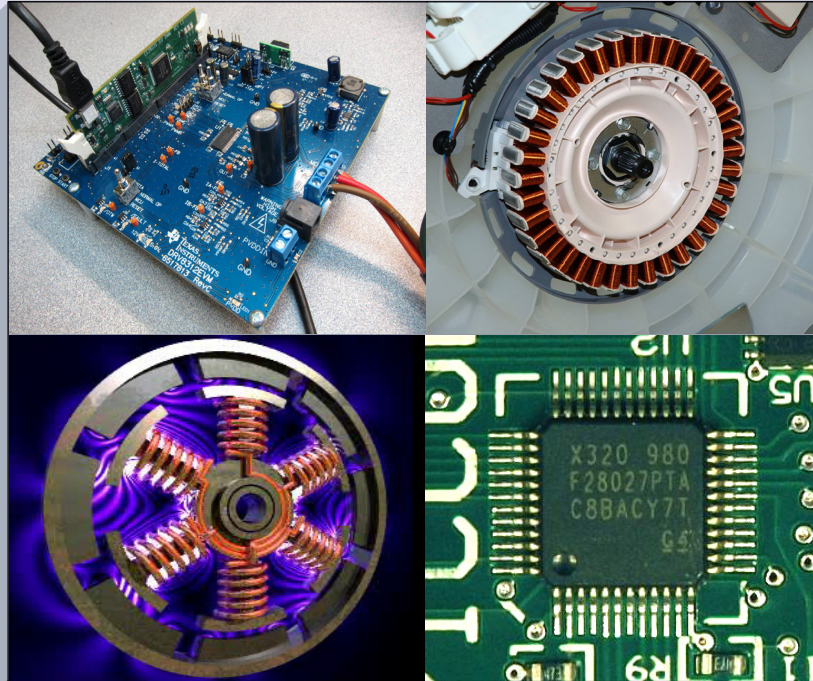
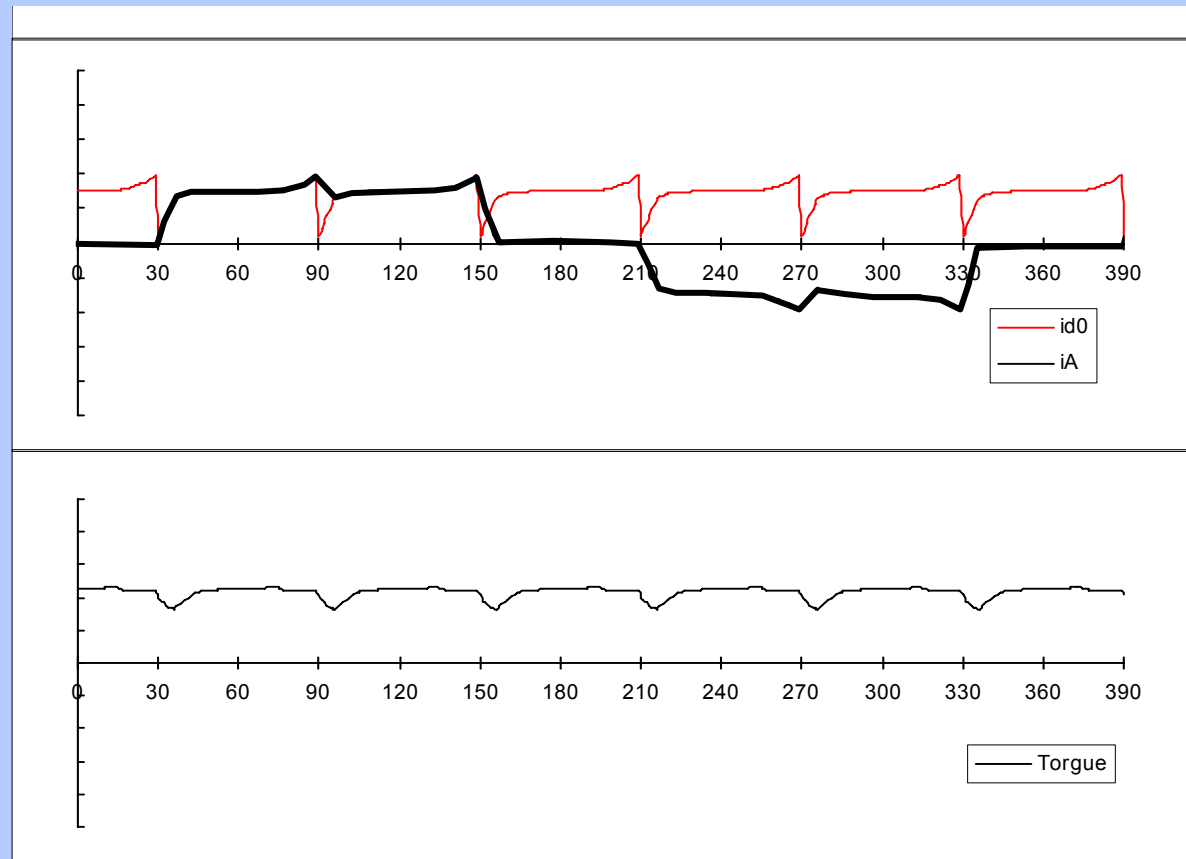
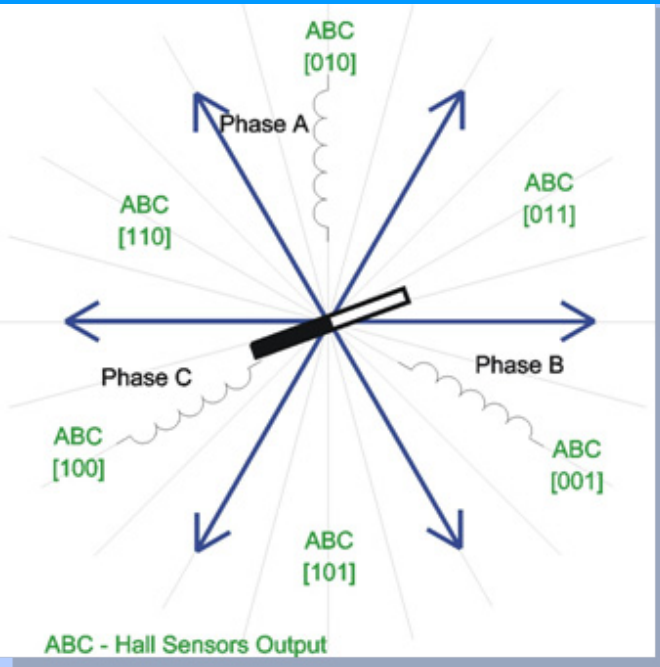


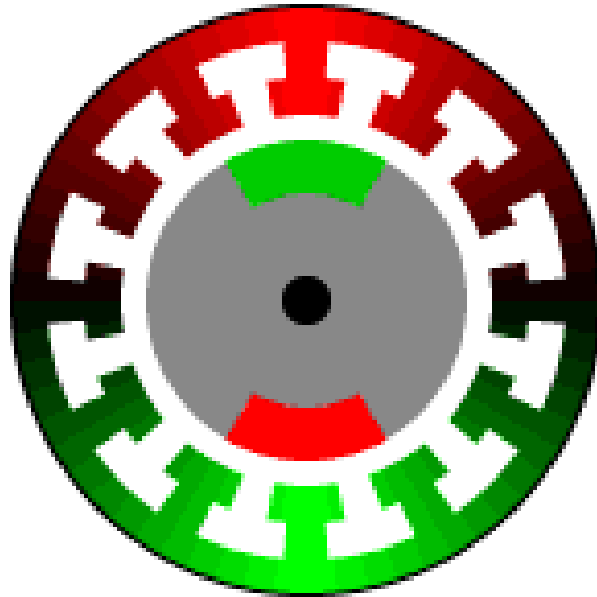
# PM Synchronous Motors



# Torque Ripple from Commutation

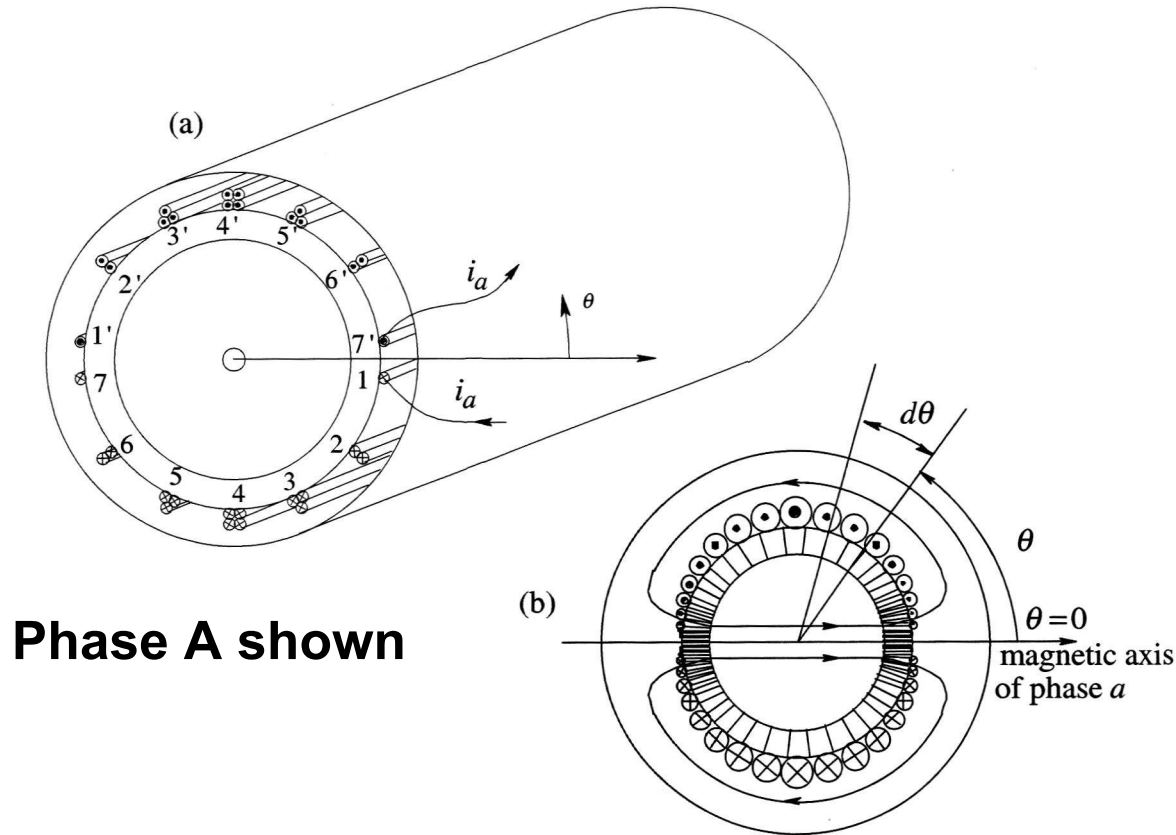


# Permanent Magnet AC Motor



- This motor exhibits a smoothly rotating magnetic field where the magnetic gradient of the stator flux is illustrated by the color shading. There is no commutation to cause motor jerking. But how do you create such a smoothly rotating magnetic field????

# Sinusoidal Winding Distribution



Phase A shown

**Stator winding density is sinusoidally distributed,  
thus creating a sinusoidally distributed flux density**

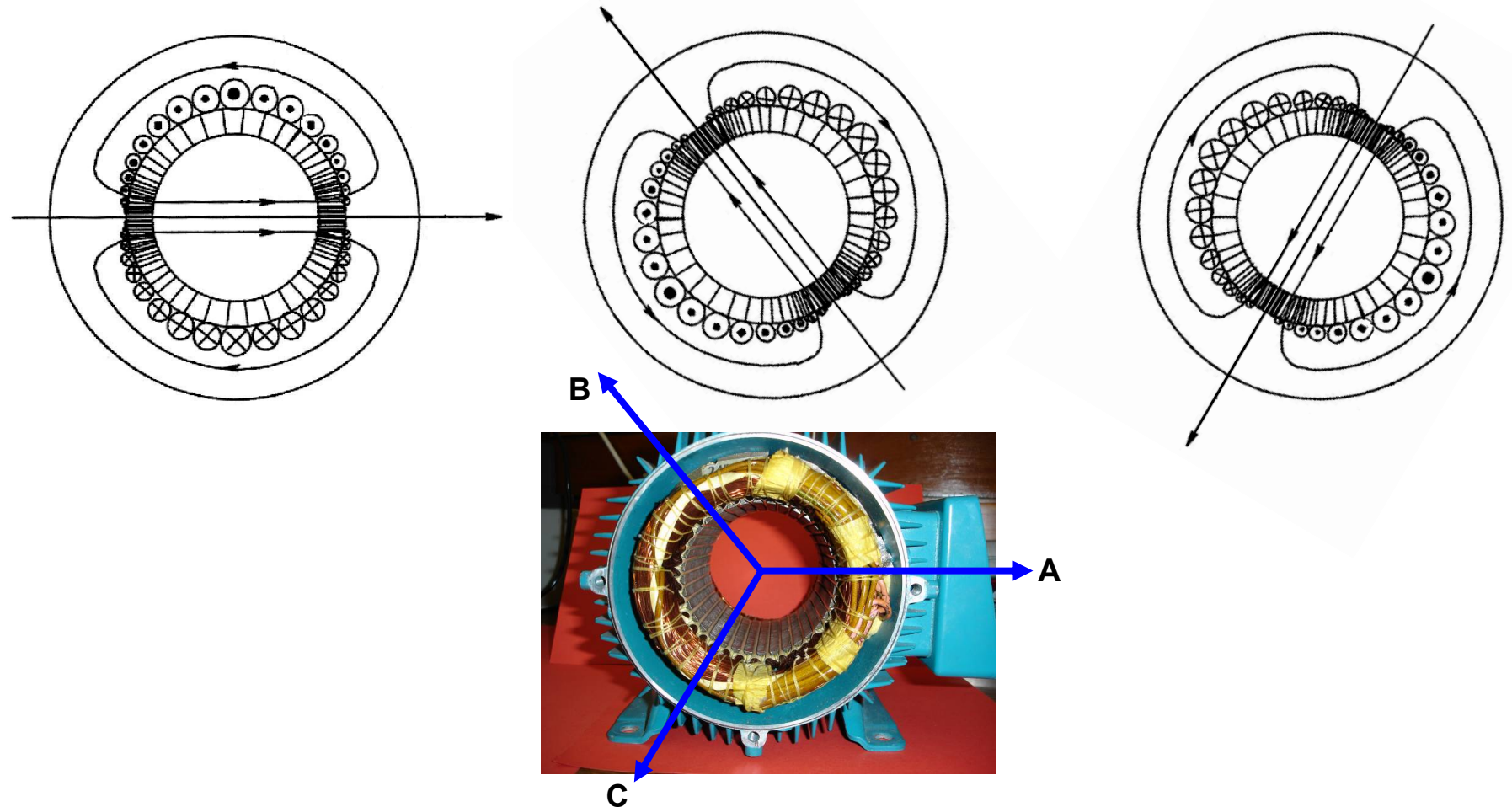
*Source: Electric Drives, an Integrative Approach,  
by Ned Mohan, University of Minn. Printing Services, 2000*

# Polyphase Topology

Phase A

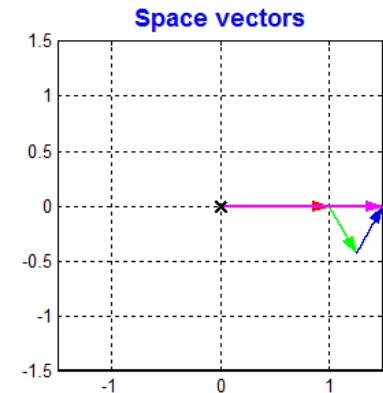
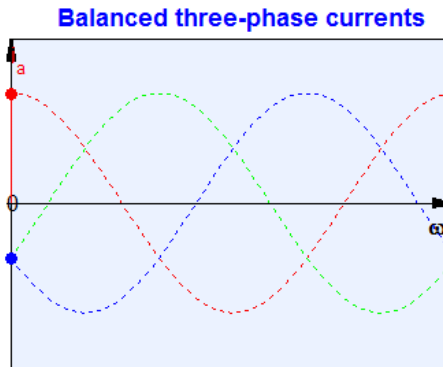
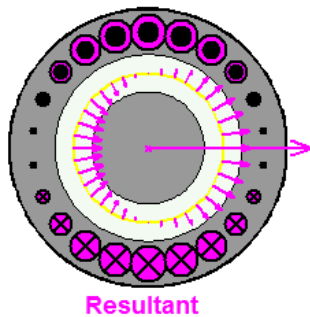
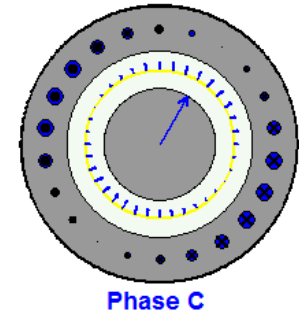
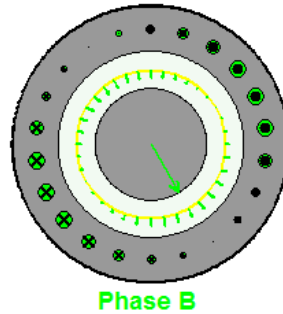
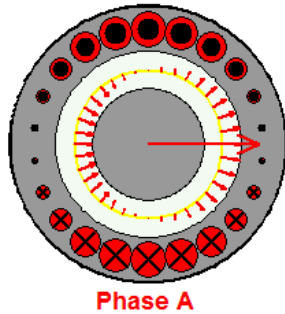
Phase B

Phase C



TI Spins Motors...Smarter, Safer, Greener.

# Space Vector Addition

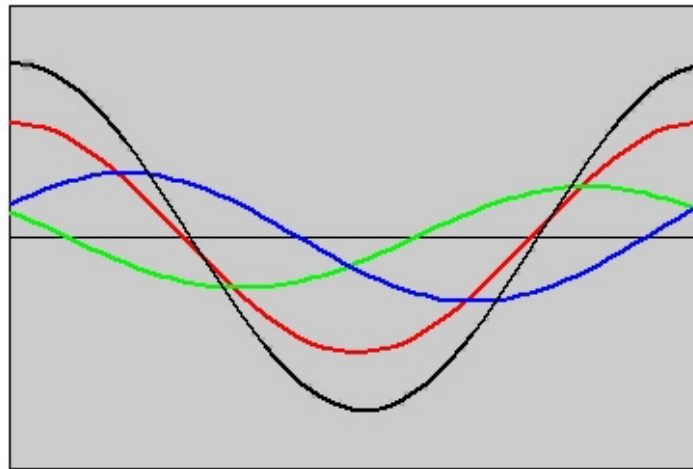


Source: Mahmoud Riaz, Sc.D., Professor of Electrical Engineering, Department of Electrical and Computer Engineering, University of Minnesota

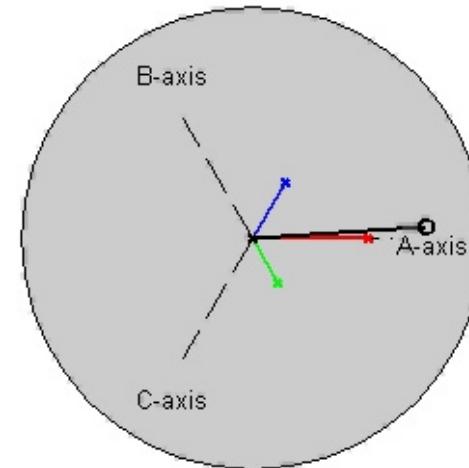


# Multi-Phase Currents and Resulting Airgap Flux

WAVE SPACE DISTRIBUTION



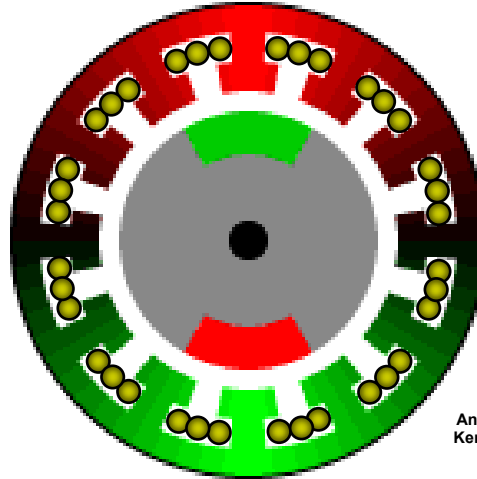
SPACE VECTORS



Phase A  
Phase B  
Phase C  
Resultant

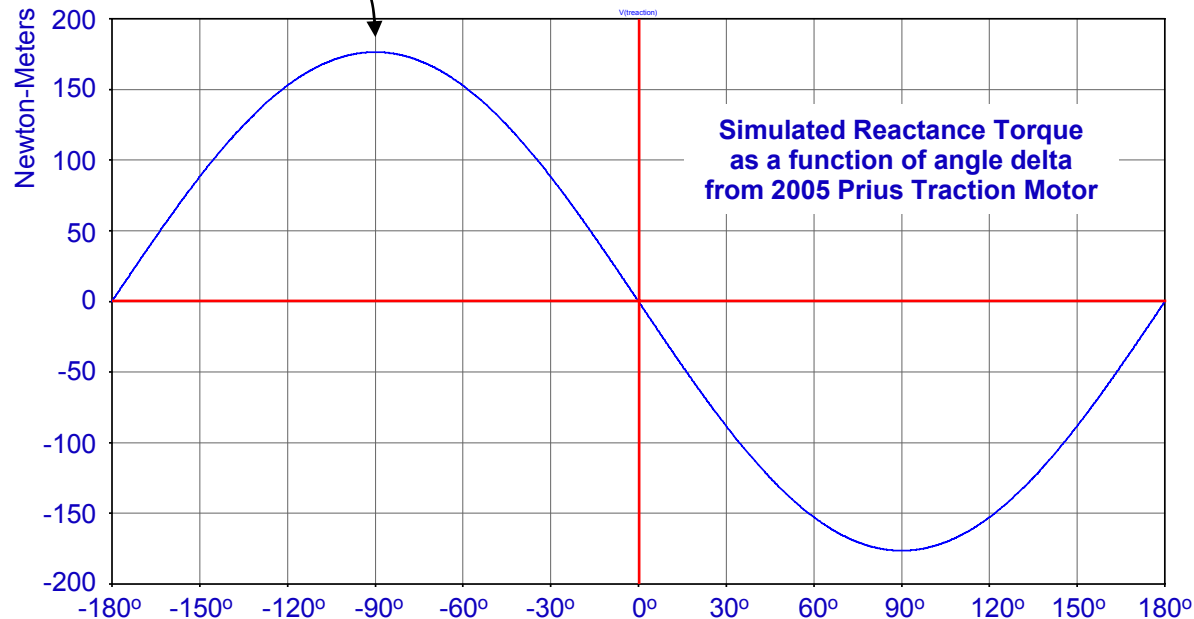
*Source: Mahmoud Riaz, Sc.D., Professor of Electrical Engineering, Department of Electrical and Computer Engineering, University of Minnesota*

# PMSM Load Angle



Animation by  
Ken Berringer

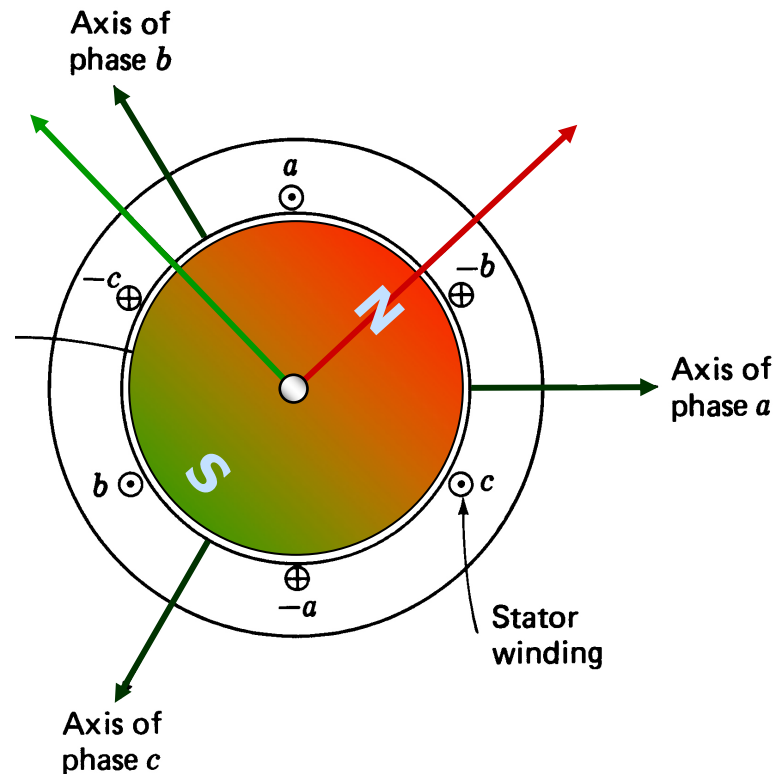
Maximum torque per amp



TI Spins Motors...Smarter, Safer, Greener.



# Orientation of Field for Max Torque



**Axis of rotor flux is fixed with respect to the rotor, i.e., it is “synchronous”.**

**(Reluctance torque assumed to be zero)**

*Source: Electric Drives, an Integrative Approach, by Ned Mohan, University of Minn. Printing Services, 2000*

# PMSM Motors Summary

## Advantages

- High power output per frame size
- High efficiency due to small rotor losses
- Low profile designs possible
- Very low torque ripple
- Structure inherently allows heat to be easily removed
- Zero speed sensorless operation possible with IPM motors

## Disadvantages

- More elaborate control required compared to BLDC
- High rotor angle accuracy required vs. BLDC trapezoidal
- Field weakening requires additional current
- Permanent magnetic field causes viscous drag
- Permanent magnets can be demagnetized at high temp.  
(not as much of a problem with IPM motors)