Brushless-DC Motor 1: Basics

TI Precision Labs – Motor Drivers

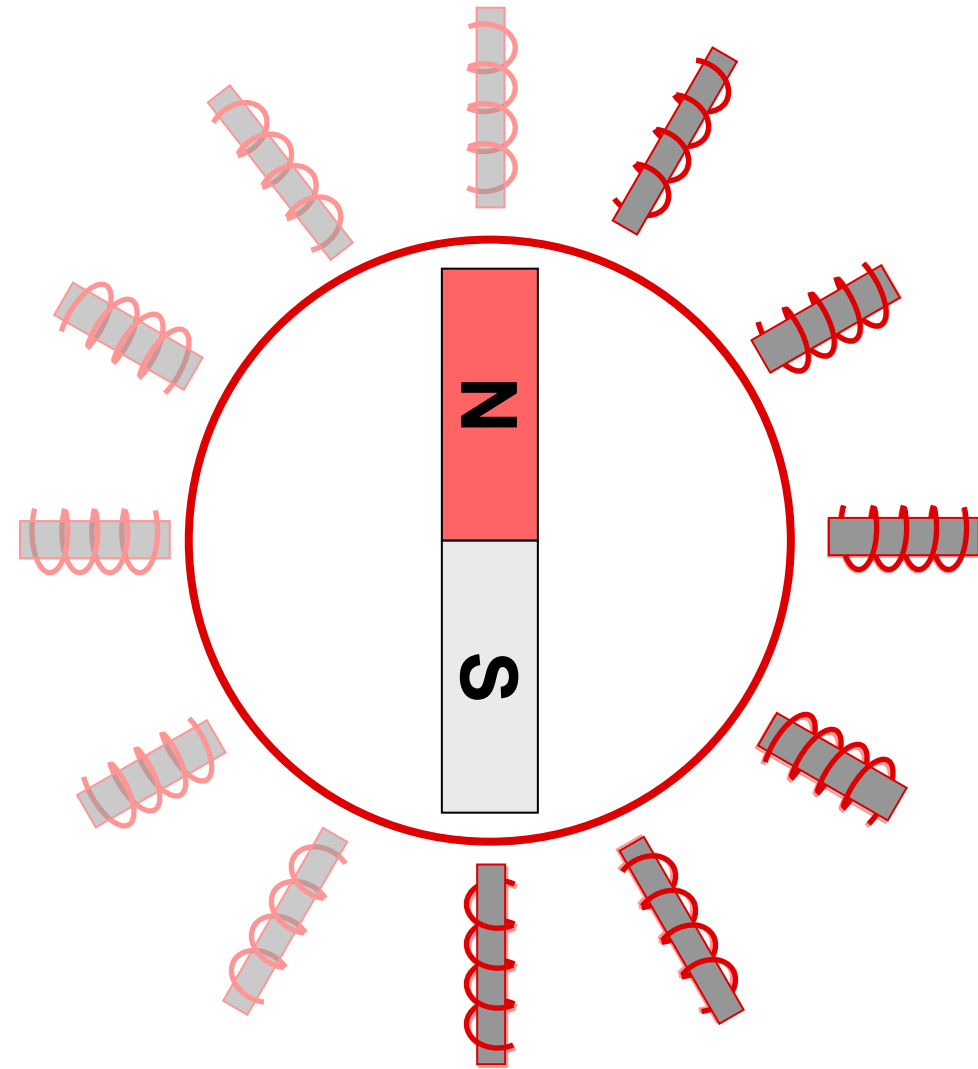**Presented and Prepared by Sanmeshkumar Udhayakumar**
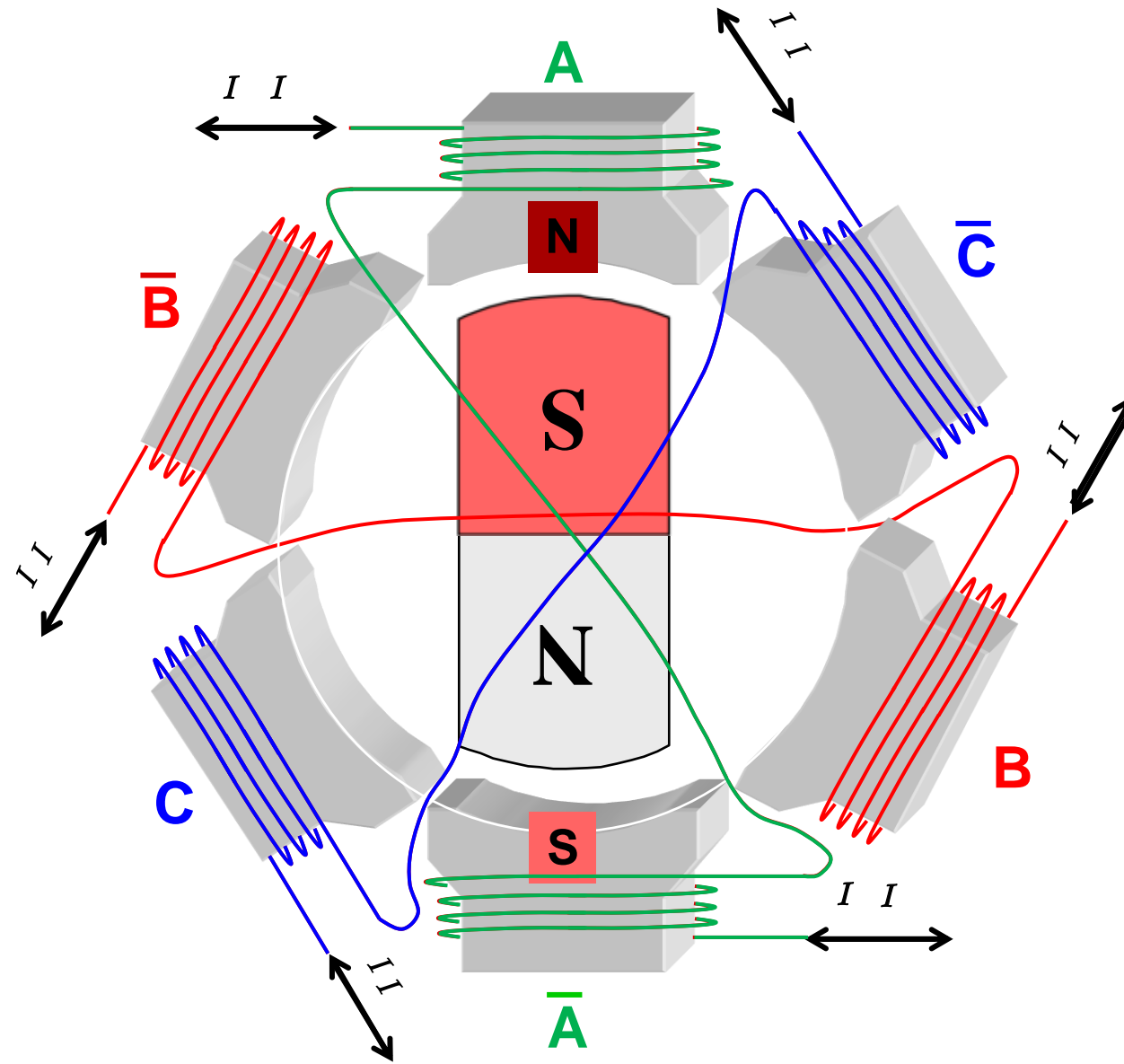
Easy model of BLDC motor

Permanent magnet rotor

Stationary coils on stator

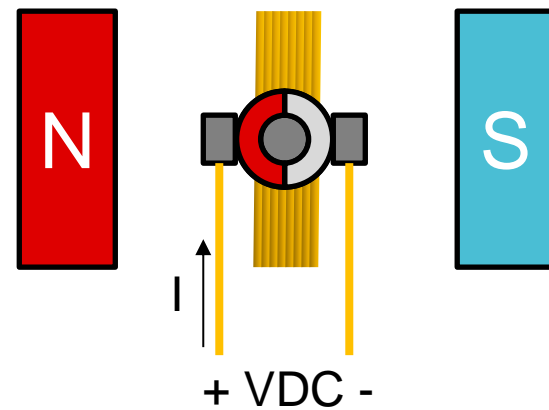Moving magnetic field
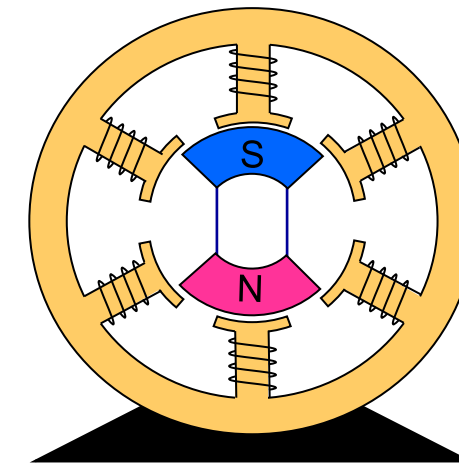continuously drags the rotor
along the circle

BLDC commutation

Brushed vs brushless DC motor

Brushed-DC motor

+ VDC -

Commutation automatically handled by mechanical design
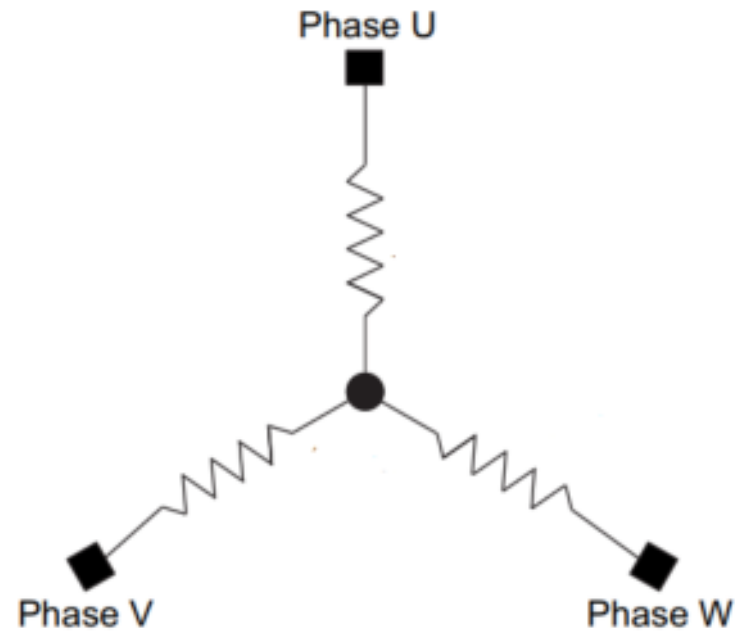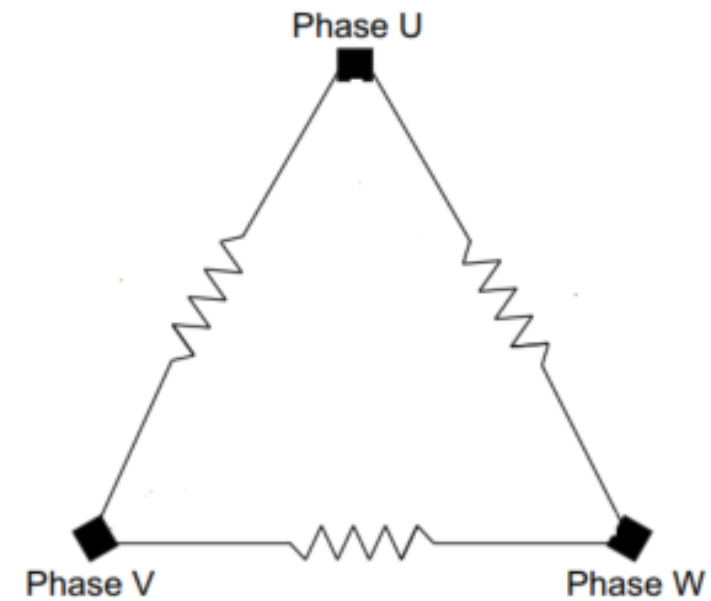
Brushless-DC motor

Motor driver circuitry needs to handle commutation

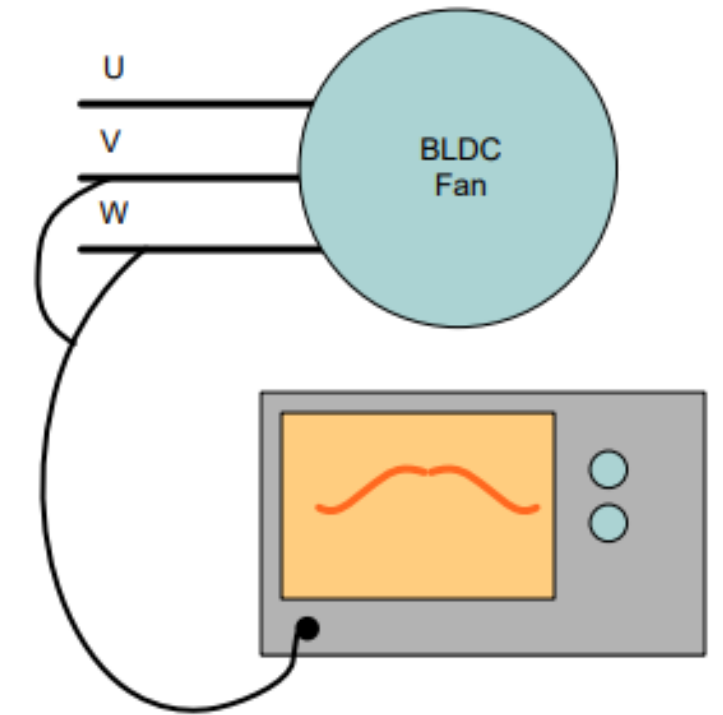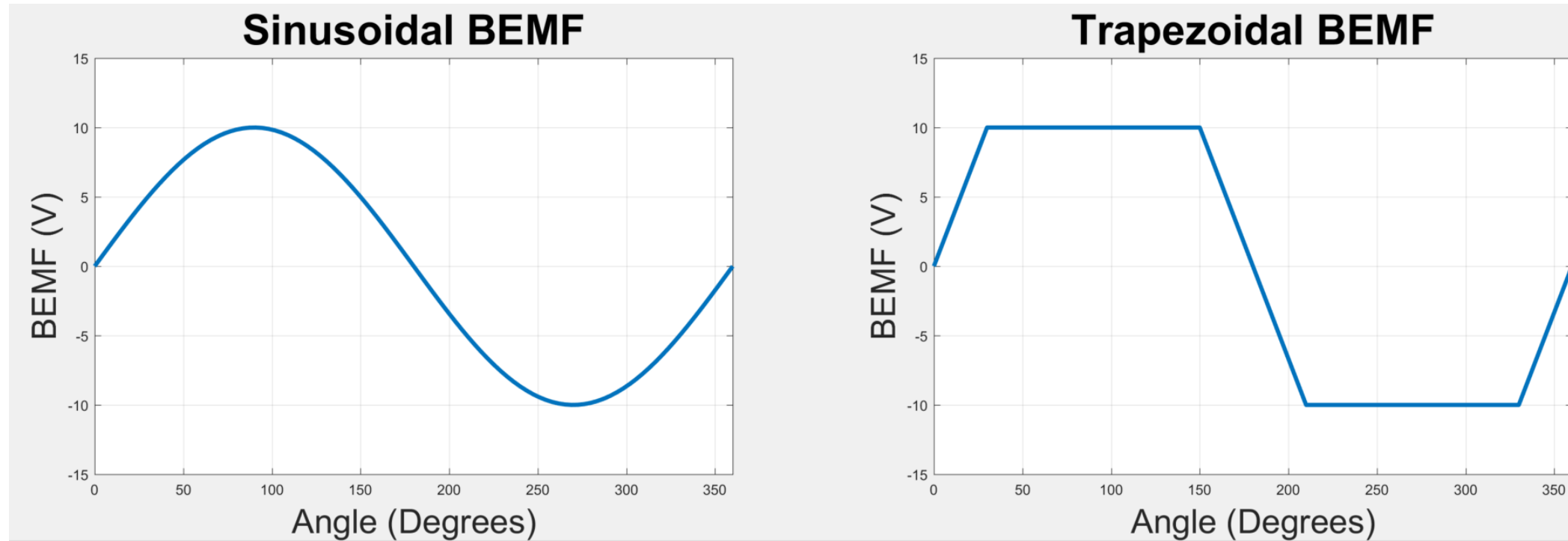# Motor winding configuration

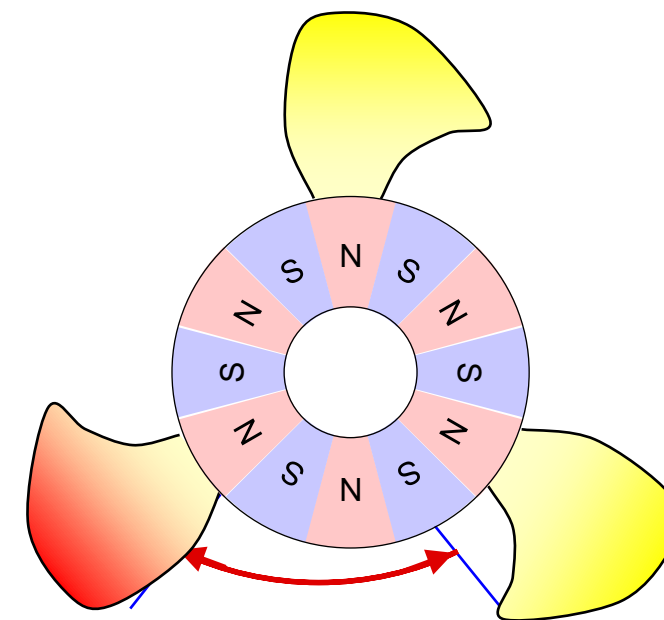**Wye (Y) winding
star connection**

Delta (Δ) winding connection

Both are driven the same way

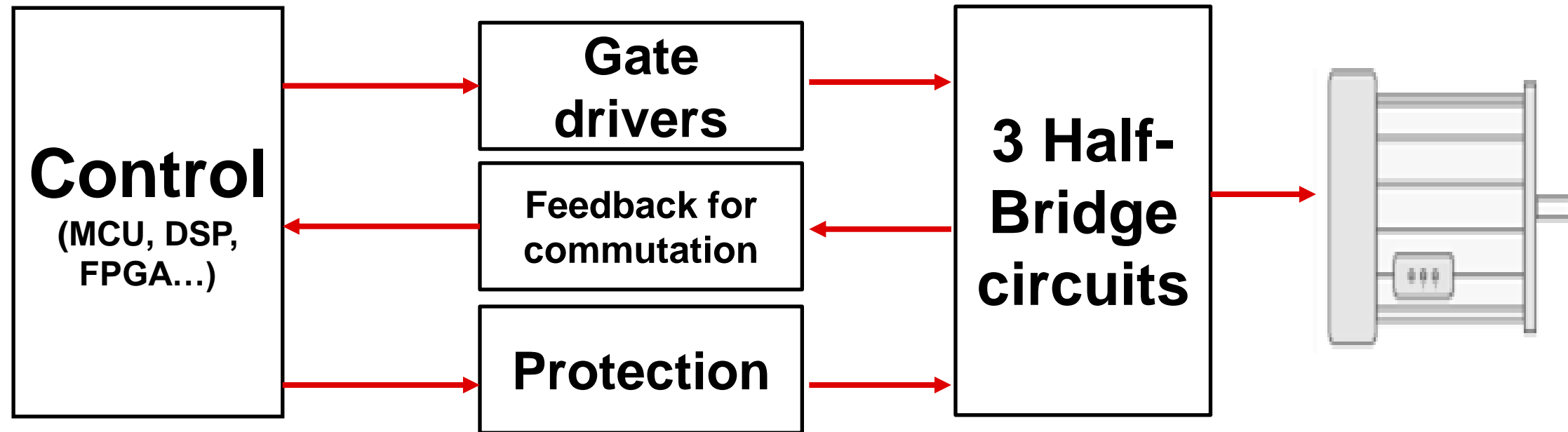# Sinusoidal vs trapezoidal back-electromotive force (BEMF)

Electrical vs mechanical cycle

- Mechanical cycle:

  Time for the motor to travel one full revolution

- Electrical cycle:

 Time for the rotor to pass a pair of poles.

$$mechanical\ speed = \frac{electrical\ speed}{\#\ of\ pole\ pairs}$$

# Motor control circuitry

TEXAS INSTRUMENTS

3 Half-Bridge circuits and gate drivers

- 3 Half-bridge circuits indicated by dotted boxes

- Half-bridge circuits connect motor phases to Vcc or GND

- Gate drivers turn on/off MOSFETs in half-bridge circuits to connect to Vcc or GND

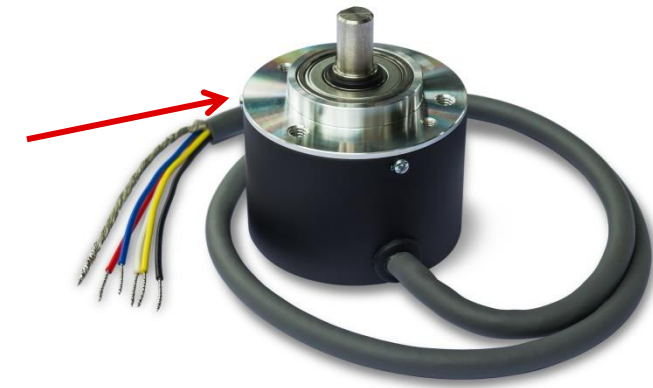

Half-Bridge Circuits
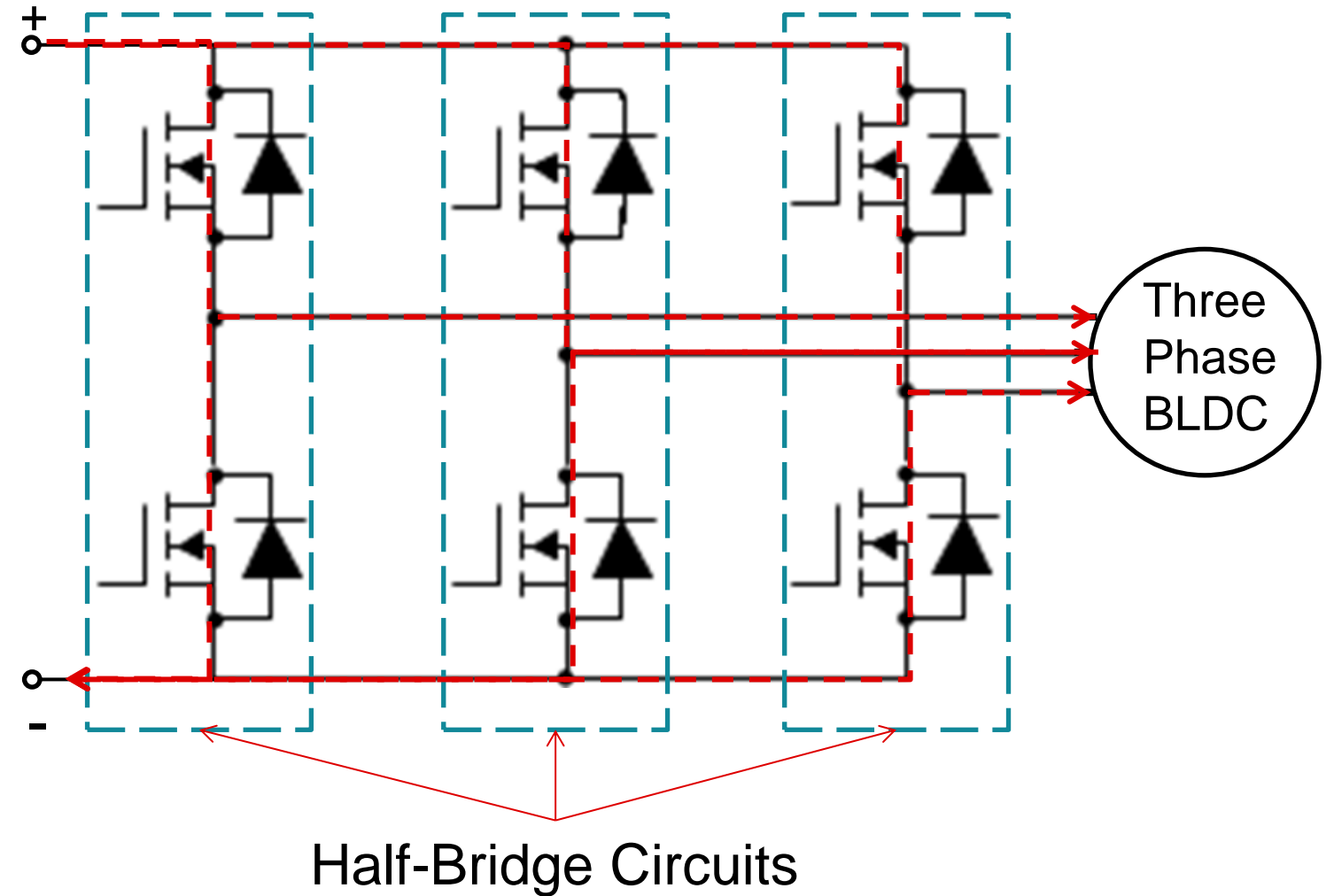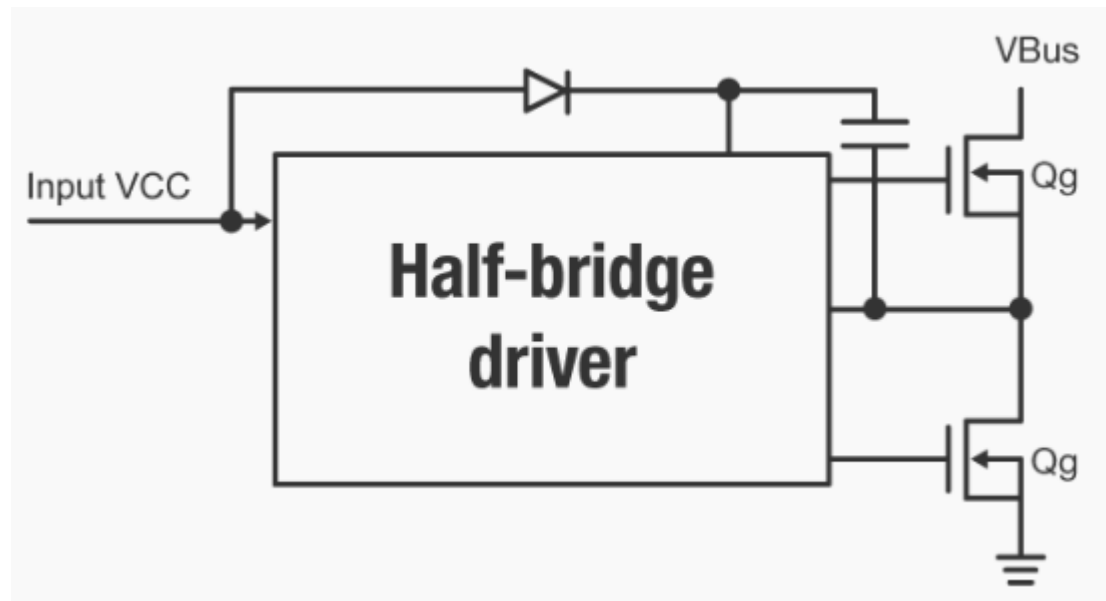
Control Block

- Control block: Controls gate drivers to dictate commutation through the half-bridge circuits
  - MCU
  - FPGA
  - DSP
  - Digital state machine
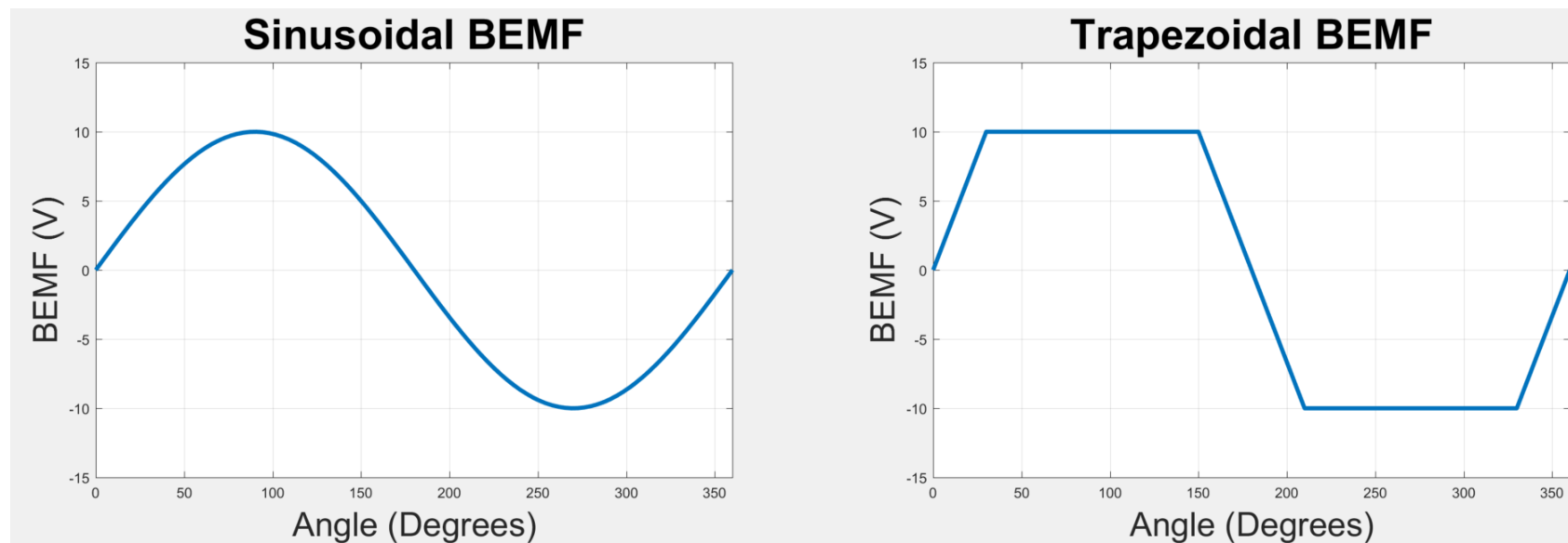 - Pure analog implementation
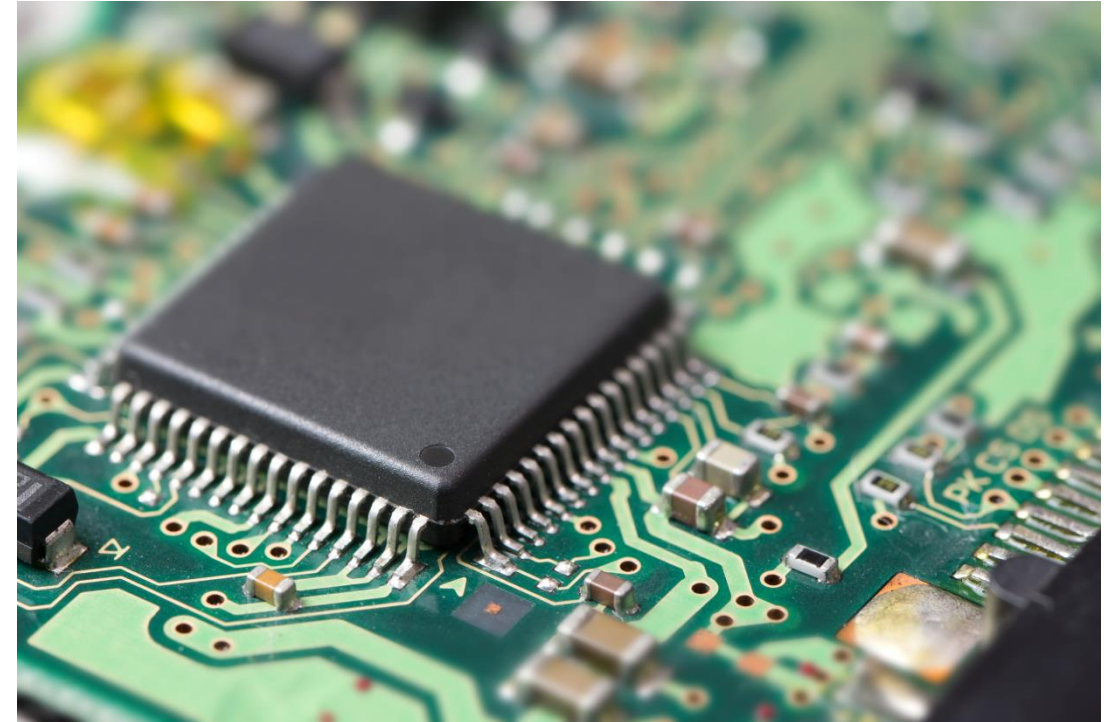
Feedback for Commutation

- Feedback of rotor position for commutation:
  - Encoders
  - Hall-effect
  - BEMF

Encoder

Hall-Effect Sensors

Sinusoidal BEMF

Trapezoidal BEMF

Motor Circuitry Protection

Over current protection (OCP)

Thermal shutdown

Under-Voltage lock-out (UVLO)

Shoot-Through

Lock detect

Anti-Voltage surge (AVS)

To find more motor driver technical resources and search products, visit ti.com/motordrivers