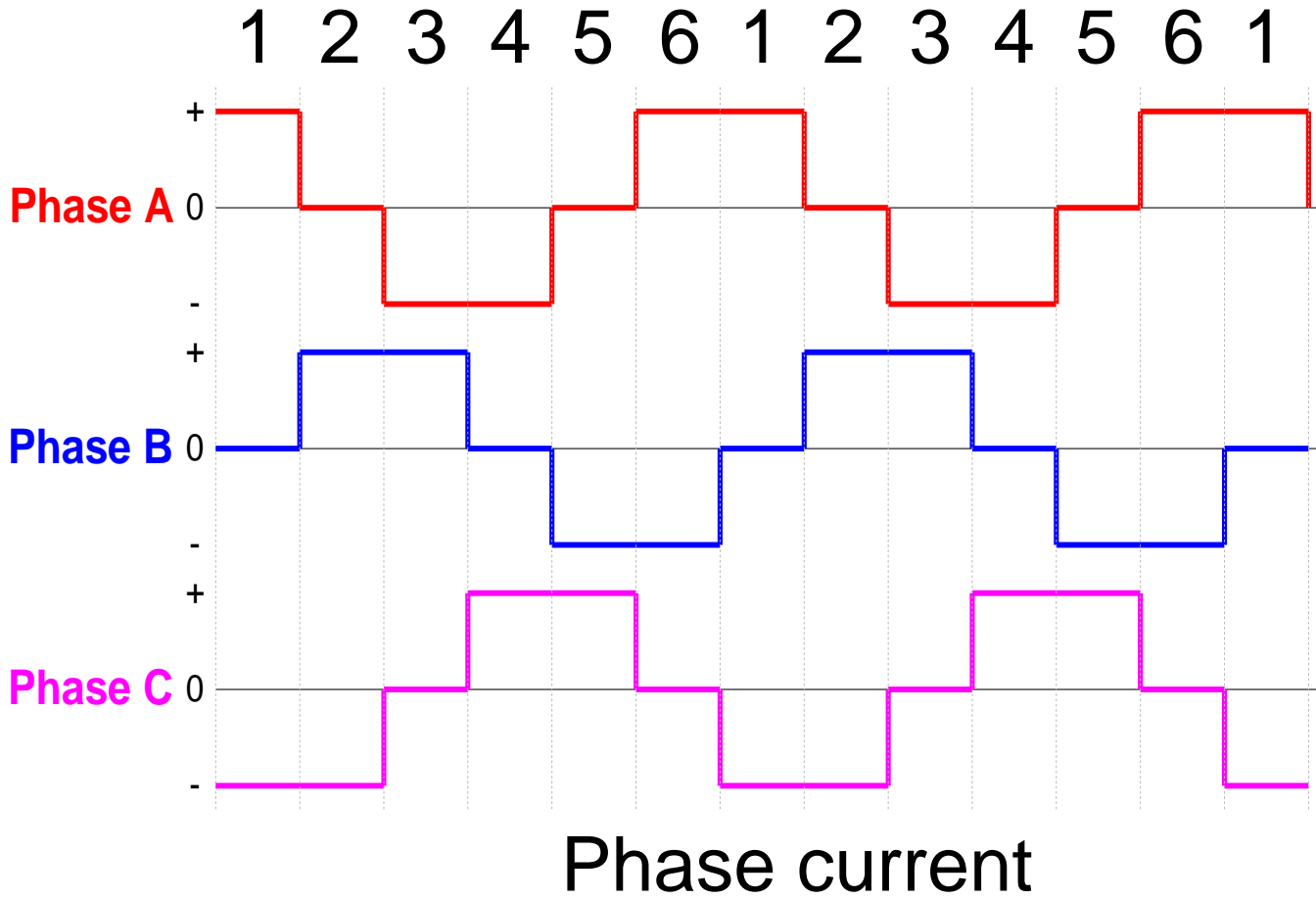
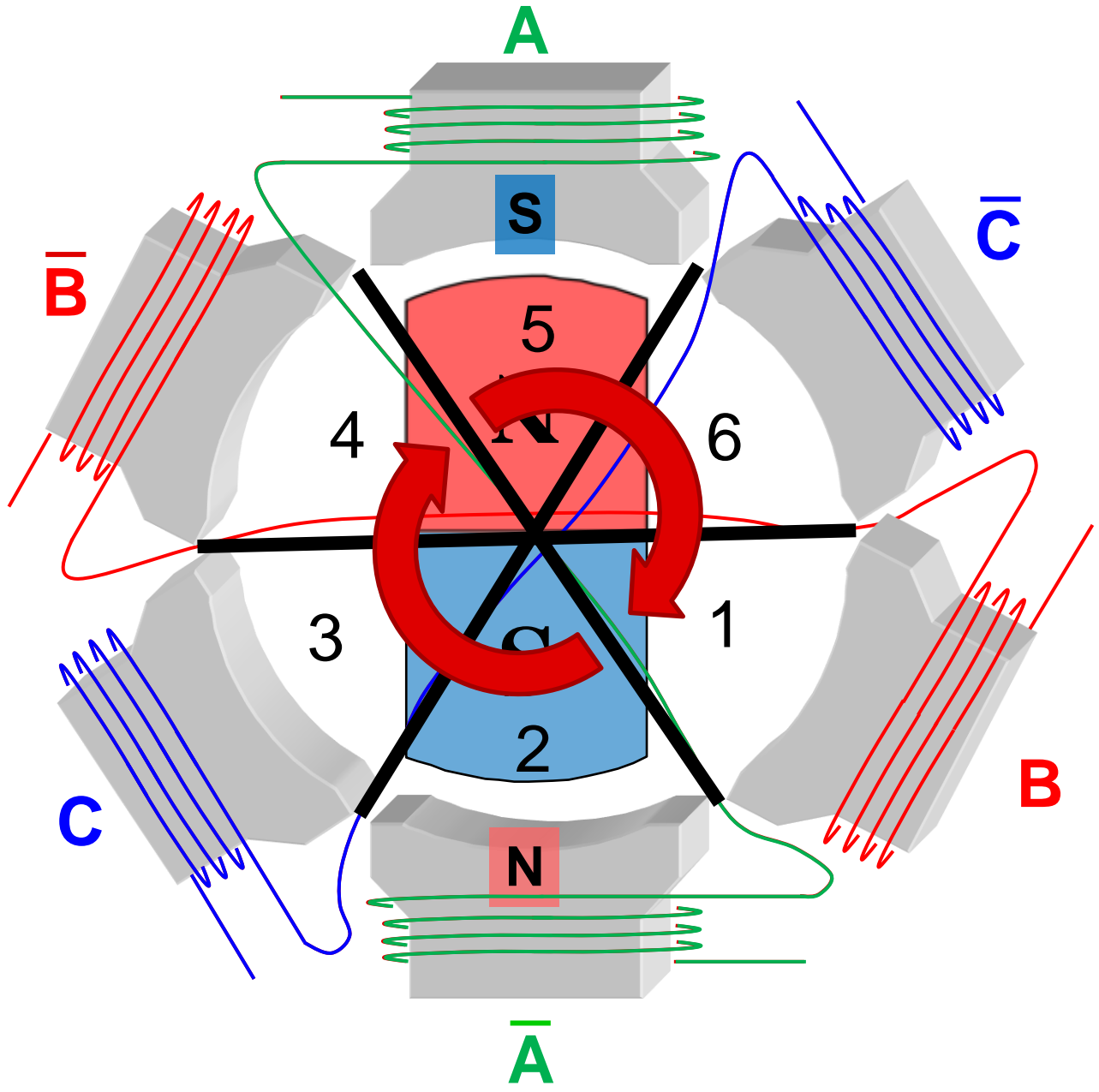


# Brushless-DC Motor 2: Sensored vs Sensorless Control

TI Precision Labs – Motor Drivers

Presented and Prepared by Michael Walker

# Purpose of sensed and sensorless

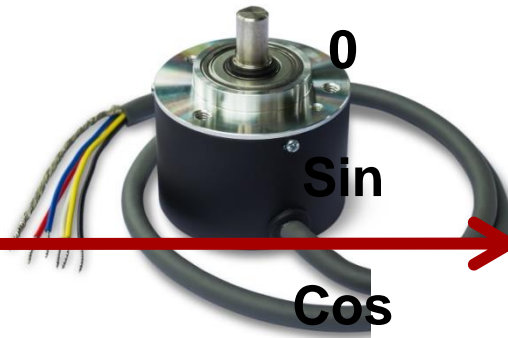


# What is sensed control?

- Stator and rotor positioning sensors:

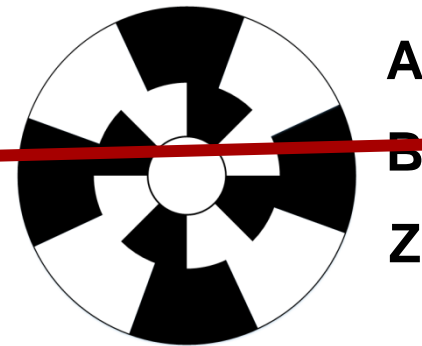
- Resolver

- High resolution
- High system cost
- Needs digital processing



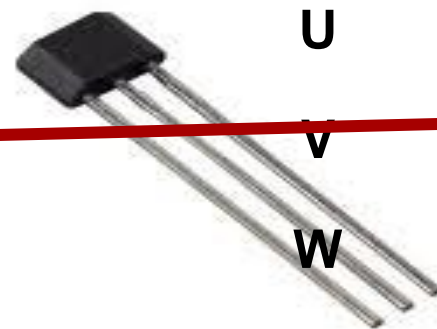
- Encoder

- High resolution
- Needs digital processing



- Hall-Effect Sensors

- Low resolution
- Low cost



360

180

0

Sin

Cos

A

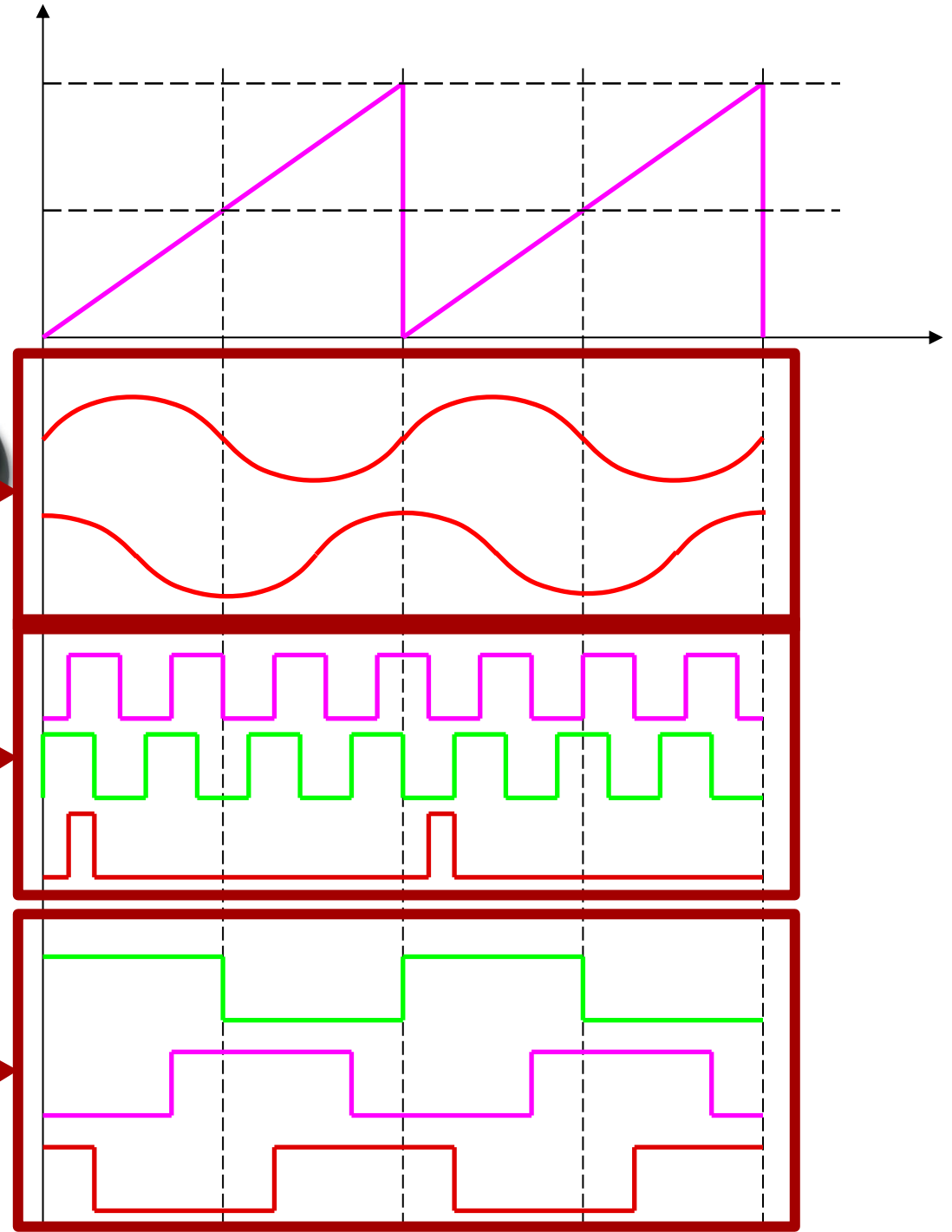
B

Z

U

V

W





# What is sensorless control?

- Uses the “BEMF” of the motor to estimate the position of the rotor.

– What is “BEMF”?

- **Back ElectroMotive Force**

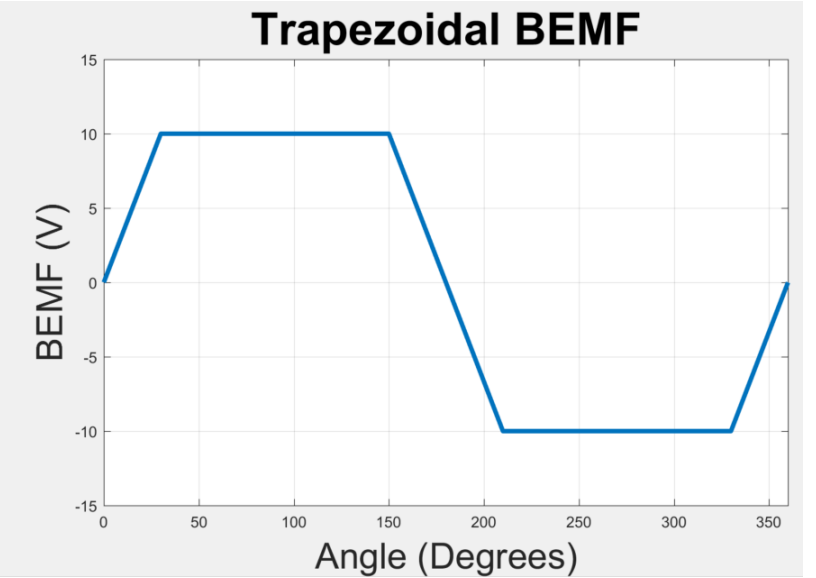
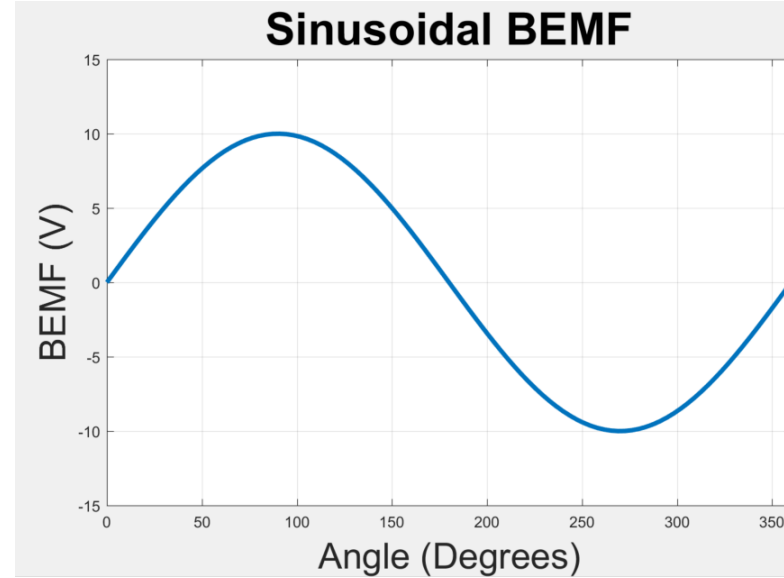
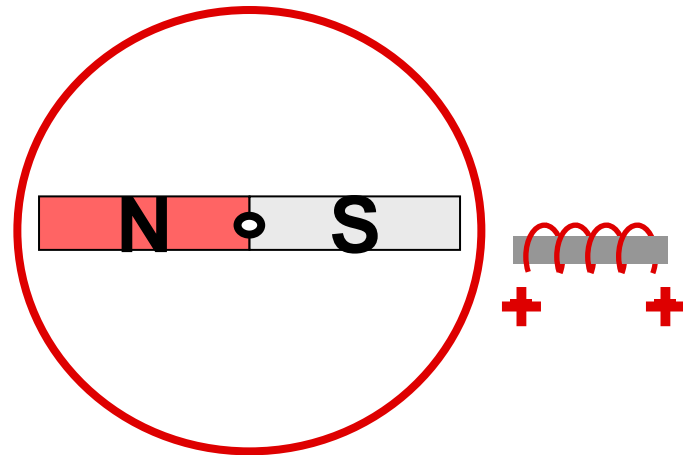
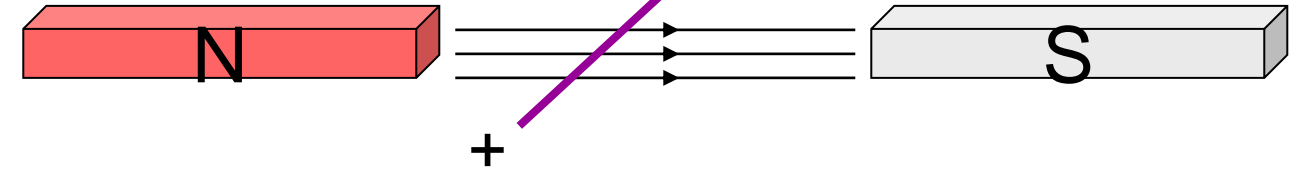
- Faraday’s Law  $V_{BEMF} = -N \frac{\Delta(B \cdot A)}{\Delta t}$

Change in magnetic field

Area

Number of turns

Change in time

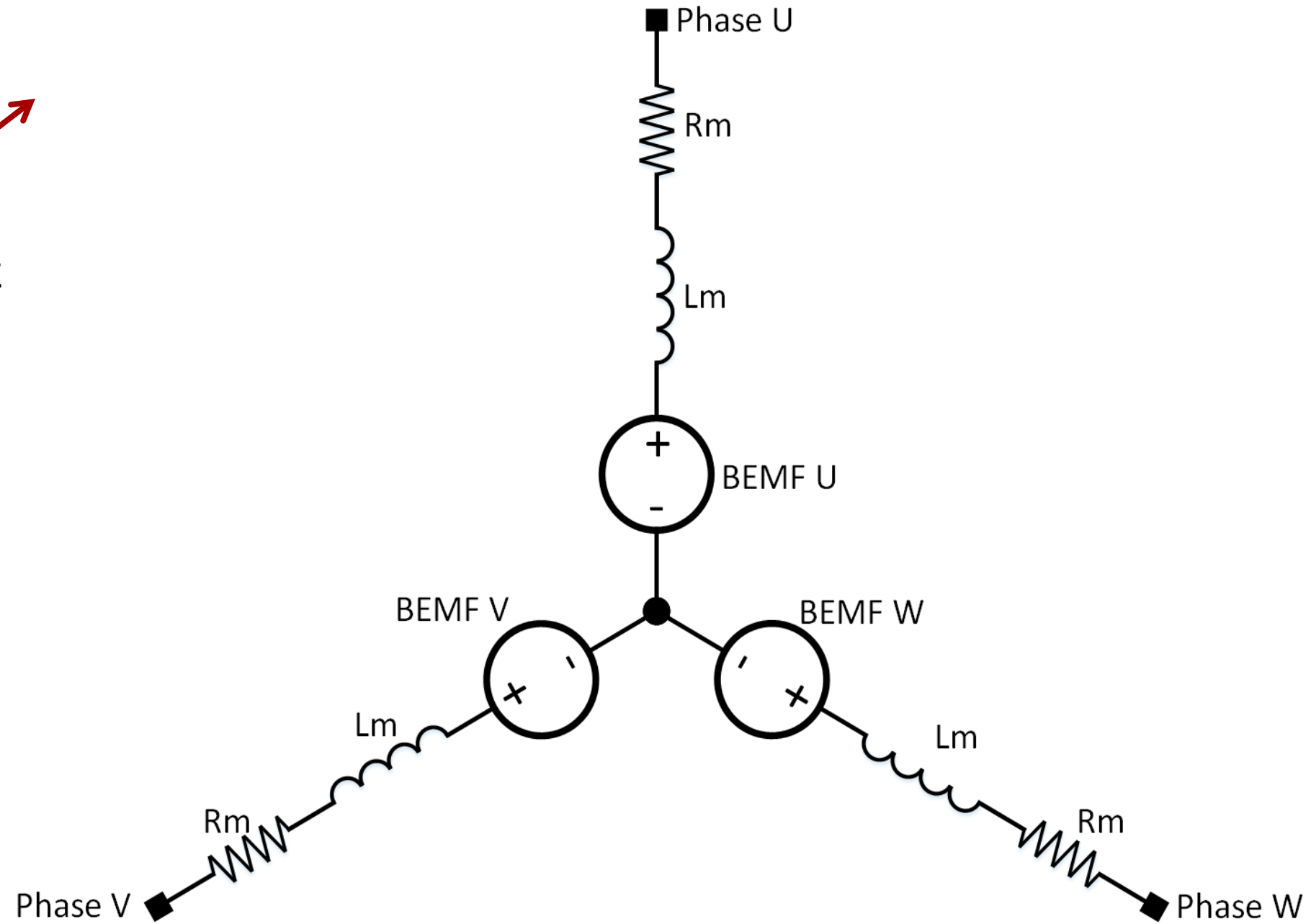
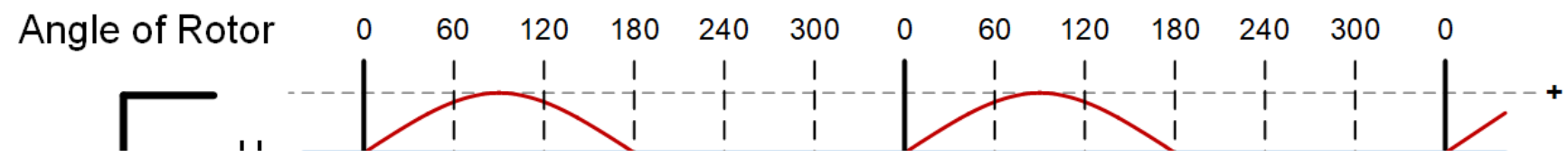
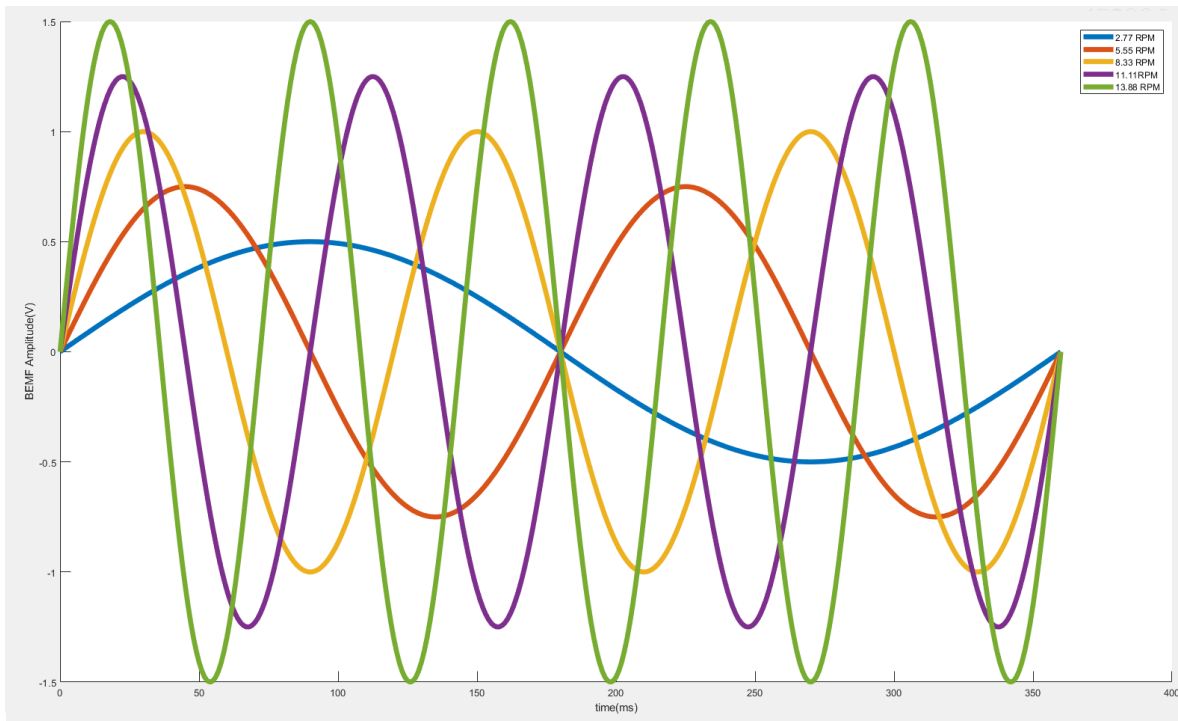


# BEMF

$$V_{BEMF} = -N \frac{\Delta(B * A)}{\Delta t}$$

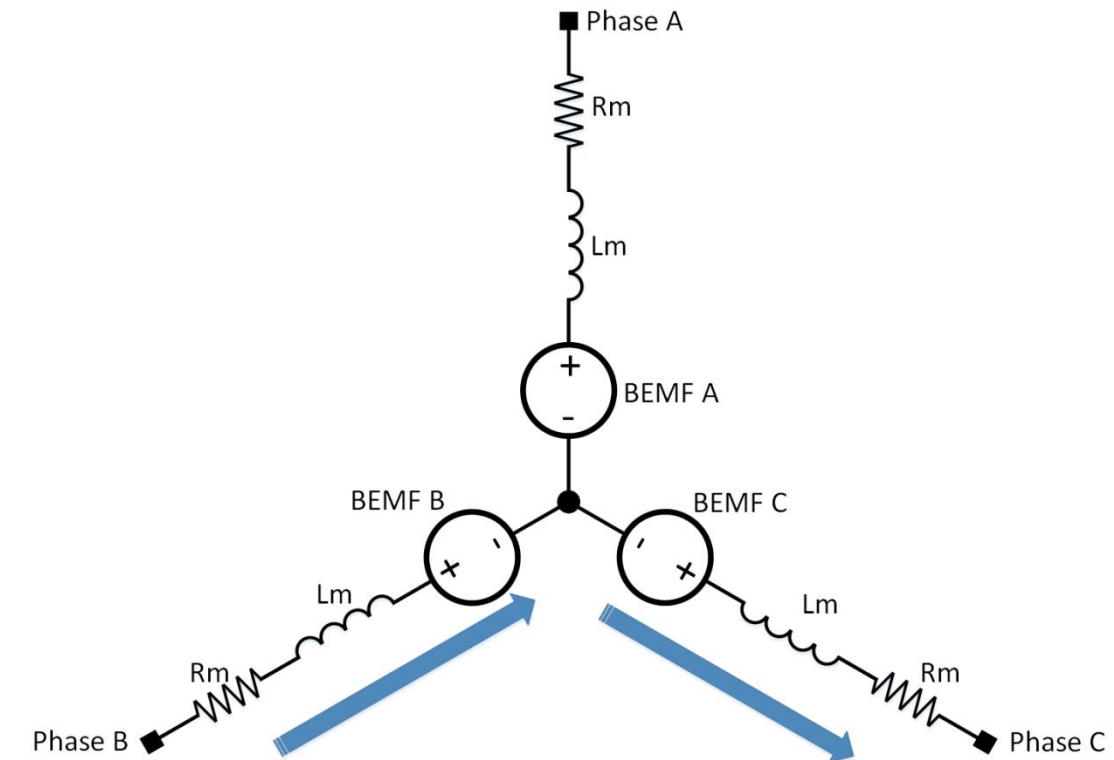
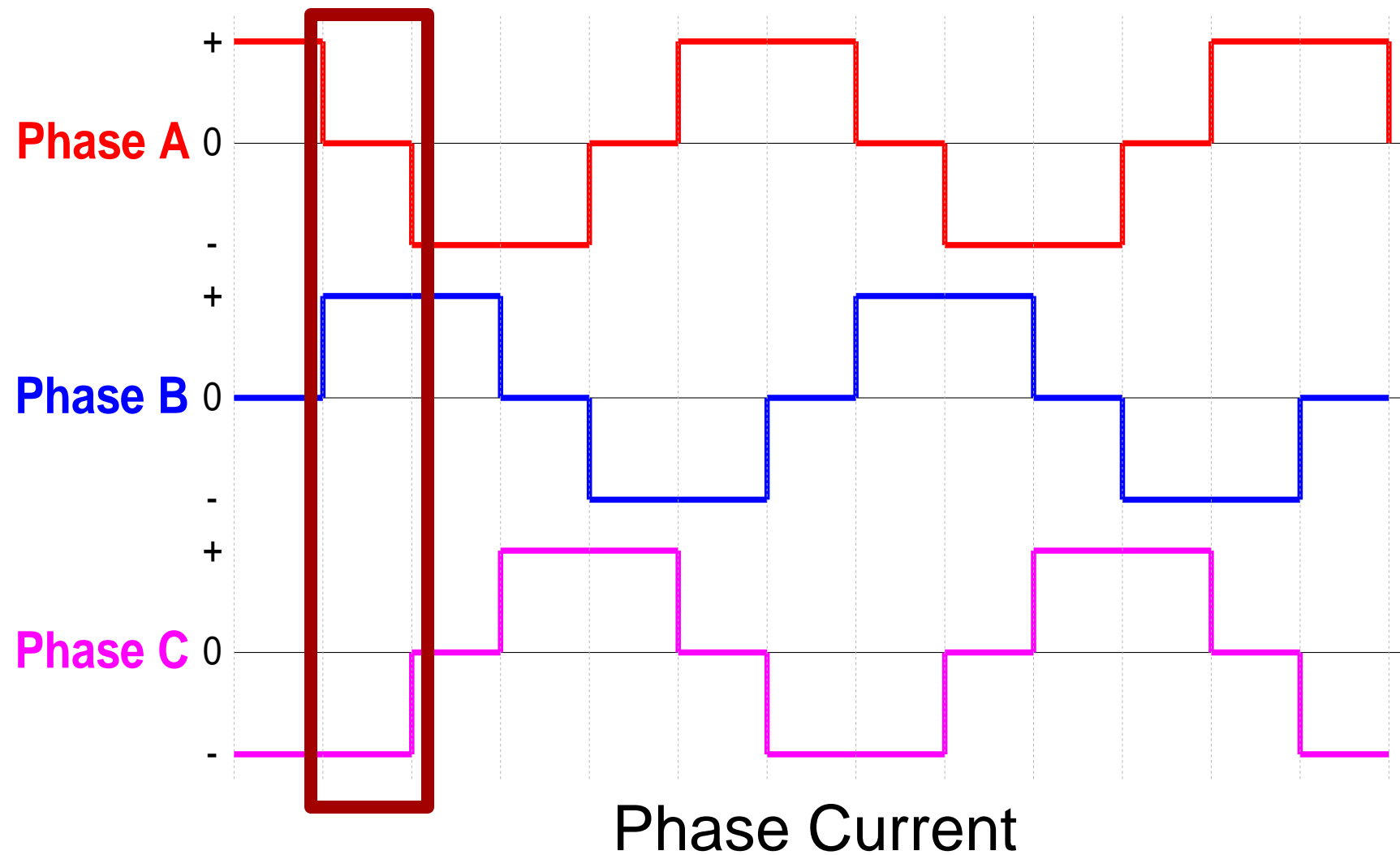
$$V_{BEMF} = \omega * k_e * \sin(\theta + \varphi)$$

- $k_e$  = motor BEMF constant in mV/Hz
- $\theta$  = rotor angle
- $\omega$  = motor speed in Hz



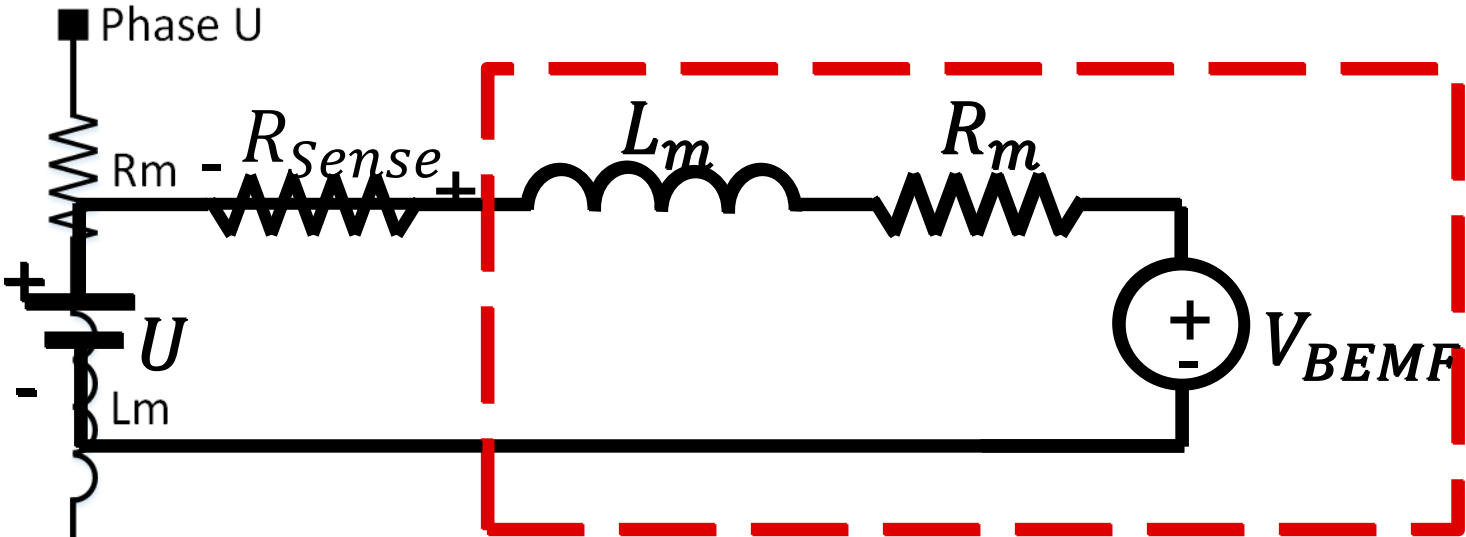
# How do you detect BEMF and position?

- Window method



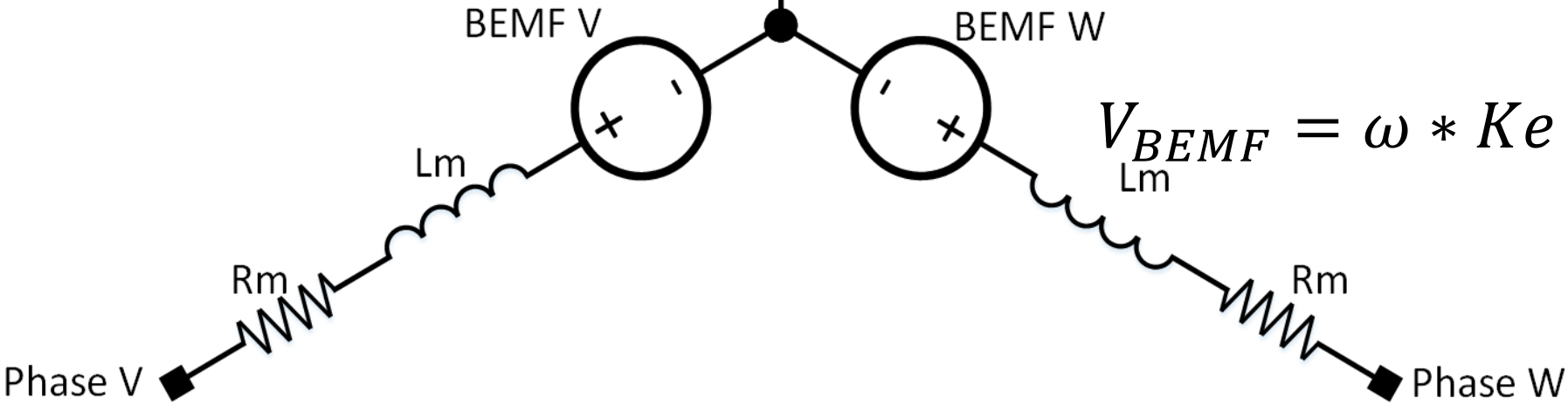
# How do you detect BEMF and position?

- What we know:
  - Phase voltage  $U = Duty\ cycle * V_m$
  - Motor Inductance  $L$
  - Motor Inductance  $R$
  - Motor BEMF constant  $K_e$
  - $\omega$
  - $I$






- What we don't know
  - $V_{BEMF}$
  - $\theta$
  - $I$

$$V_{BEMF} = U - I * R - L * \frac{di}{dt}$$






$$V_{BEMF} = \omega * K_e * \sin(\theta)$$

# Types of BLDC motor applications




		Desired Output	
<b>Torque</b>	Uses a motor to apply a force	$N^*m$	
<b>Speed</b>	Uses a motor to maintain a speed	RPM	
<b>Position</b>	Uses a motor to move to and hold a position	$\theta$	



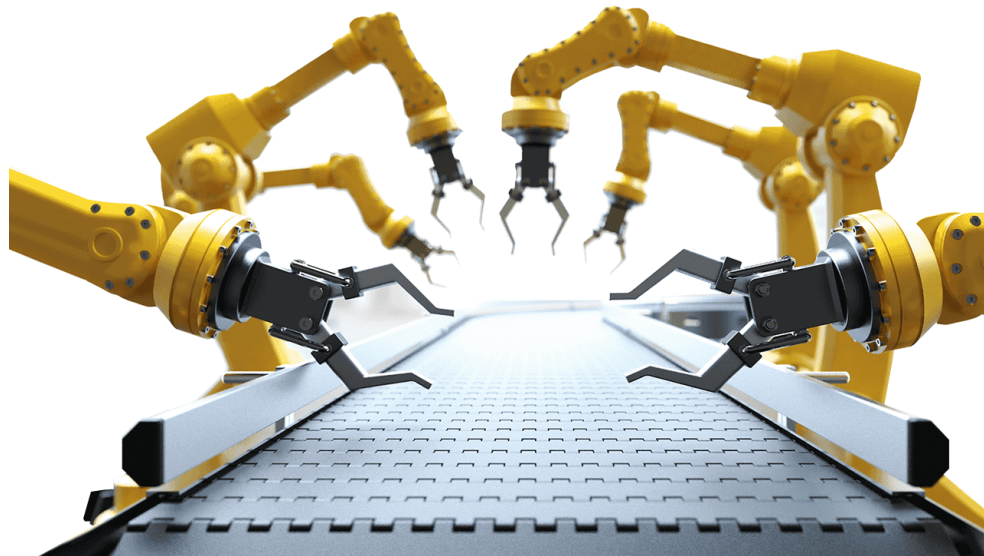
# Challenges of BLDC motor applications

	Challenges	
<b>Torque</b>	Zero/Slow speed torque	
<b>Speed</b>	Withstand changes in torque	
<b>Position</b>	Position tracking	
	Zero/Slow speed torque	

# Control of BLDC motor applications

<b>Torque</b>	Typically require sensored control	
<b>Speed</b>	Can use either sensorless control or sensored control	
<b>Position</b>	Almost always require sensored control	

# Sensored vs Sensorless Control



**To find more motor driver technical resources and search products, visit [ti.com/motordrivers](https://www.ti.com/motordrivers)**