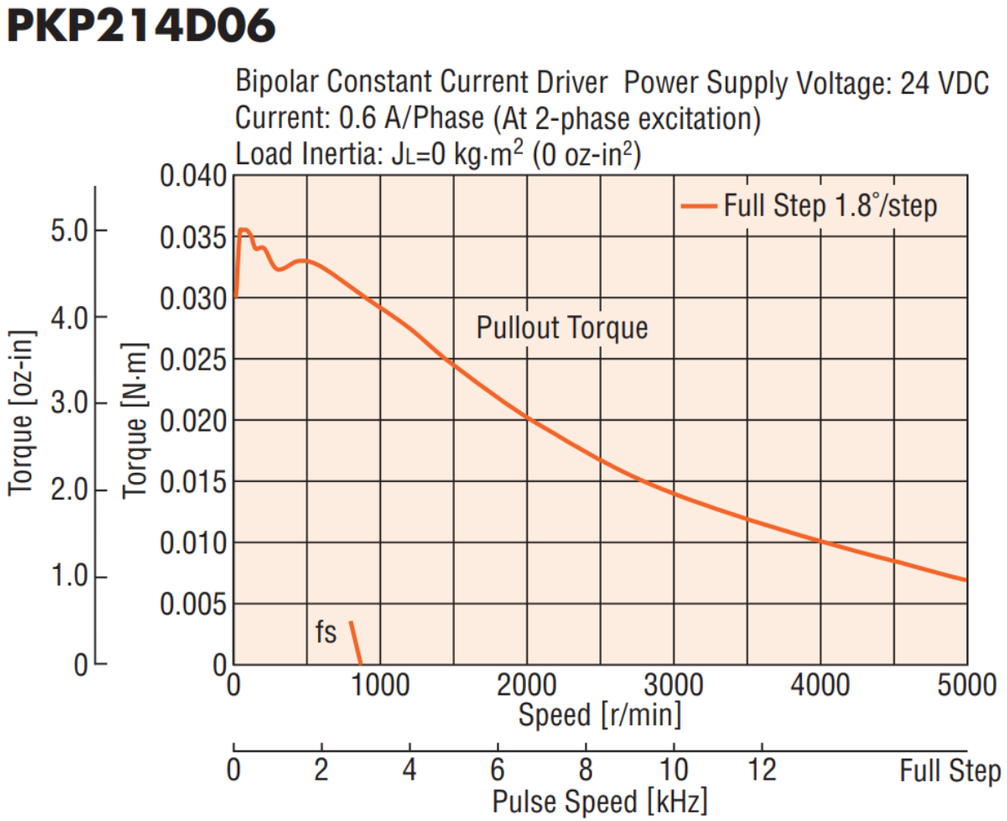
Stepper Motors 10: Stall Detection

TI Precision Labs – Motor Drivers

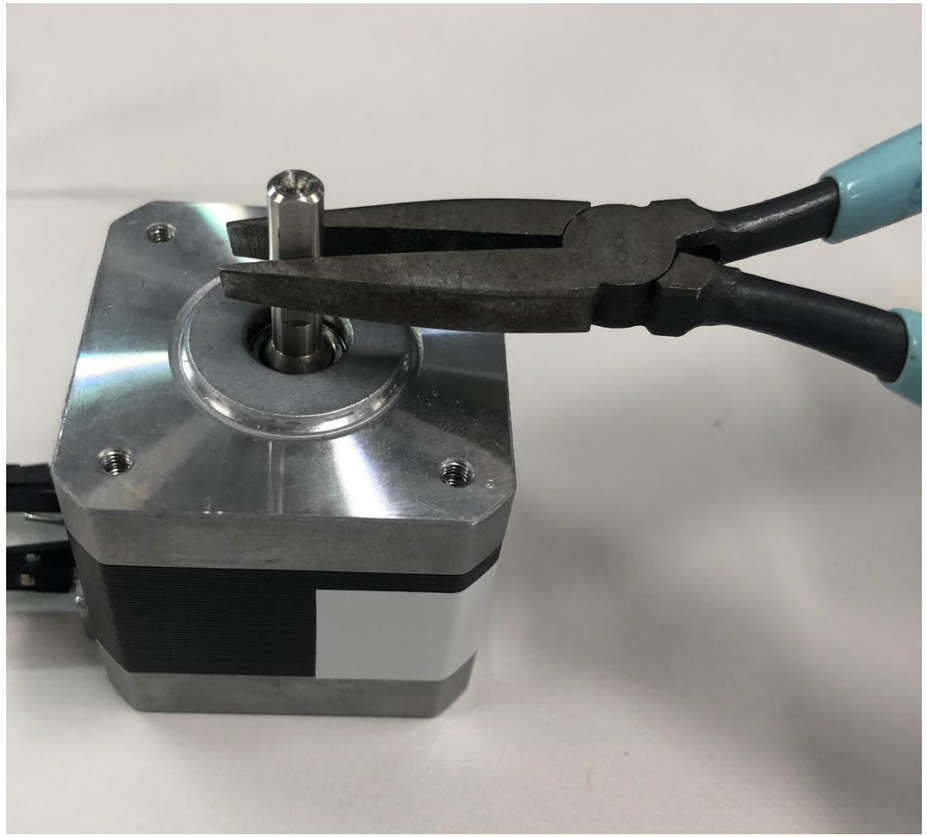
Presented and prepared by Pablo Armet

What is a stall condition?

- Stall condition: load torque exceeds the motor's pull-out torque. [1]



Oriental Motor [2]

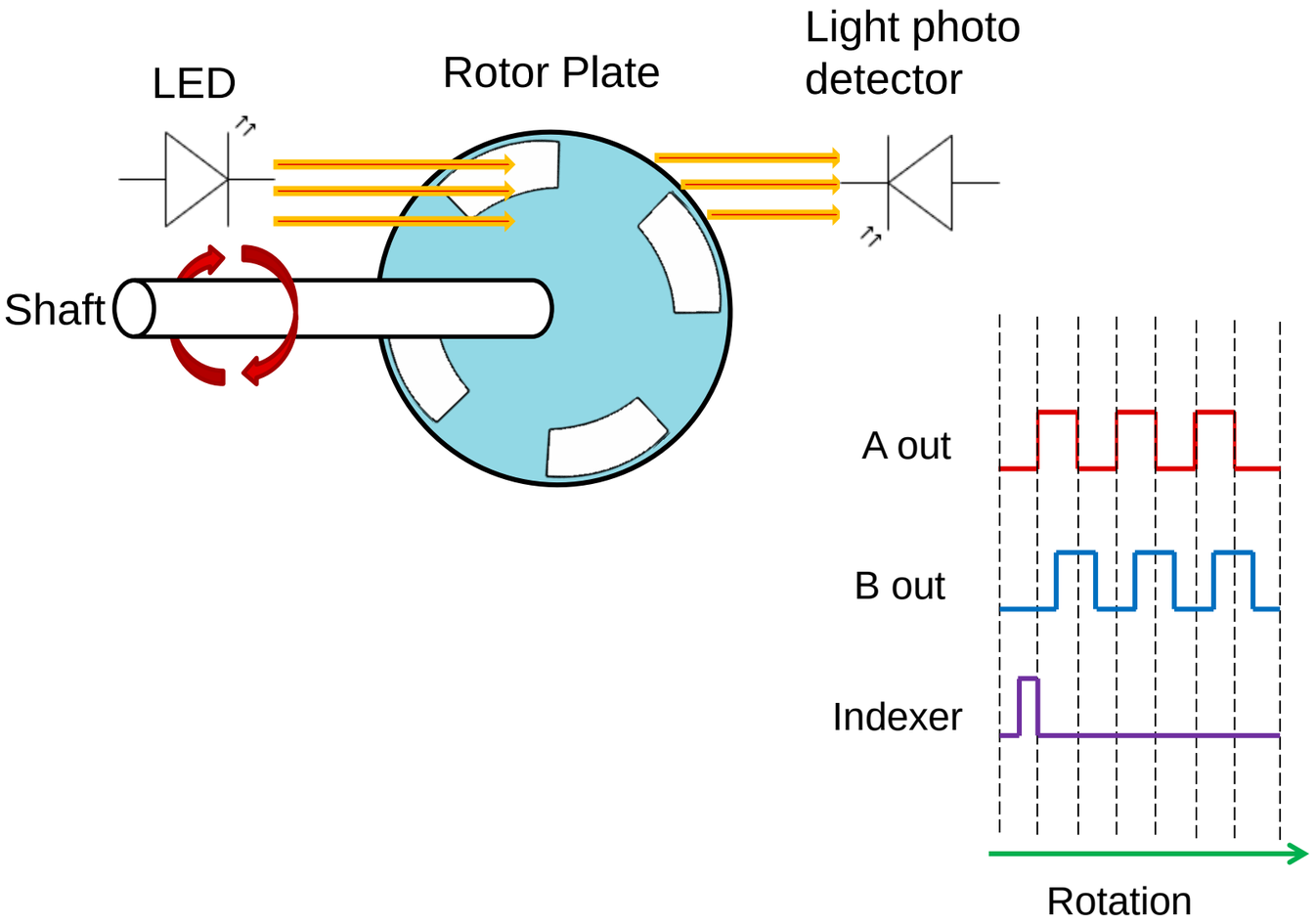


Need for sensor-less stall detection

- Lack of feedback in open-loop motor systems
- End-of-line travel and fixed mechanical stop detection
- Helps lessen the problems that occur when a motor continues to be driven though an obstacle such as:
  - Mechanical failures
  - Audible noise
- Replaces expensive motor position modules

Applications

Existing solution: encoder



- Benefits:
  - Multifunctional
  - Robust
- Drawbacks:
  - High cost
  - Increase in system area

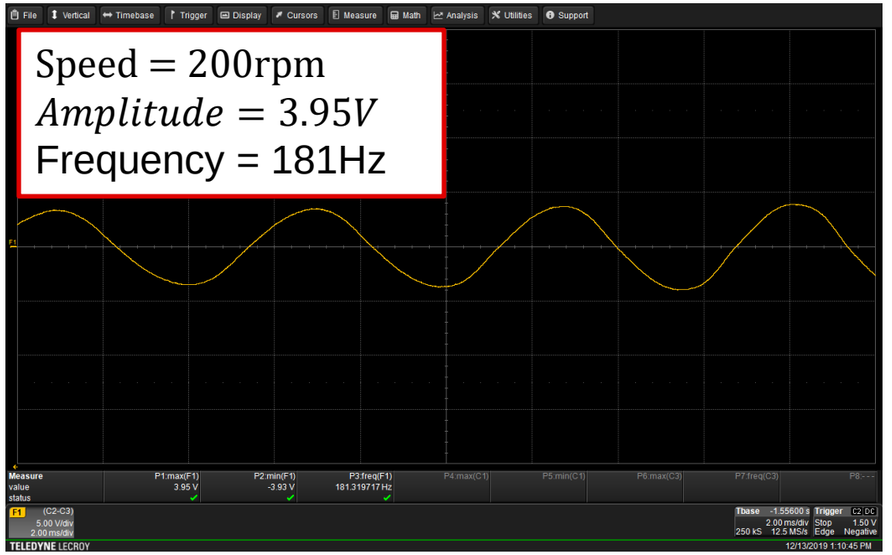
Existing solution: sensor-less back-emf measurement

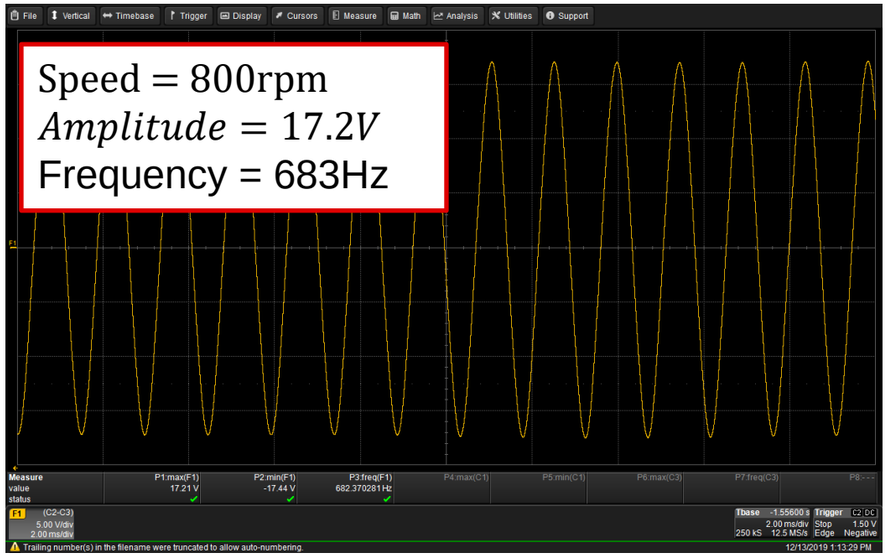
- Back-emf in stepper motors:

$$BEMF = -p * \Psi_m * \omega * \sin(p * \omega * t)$$

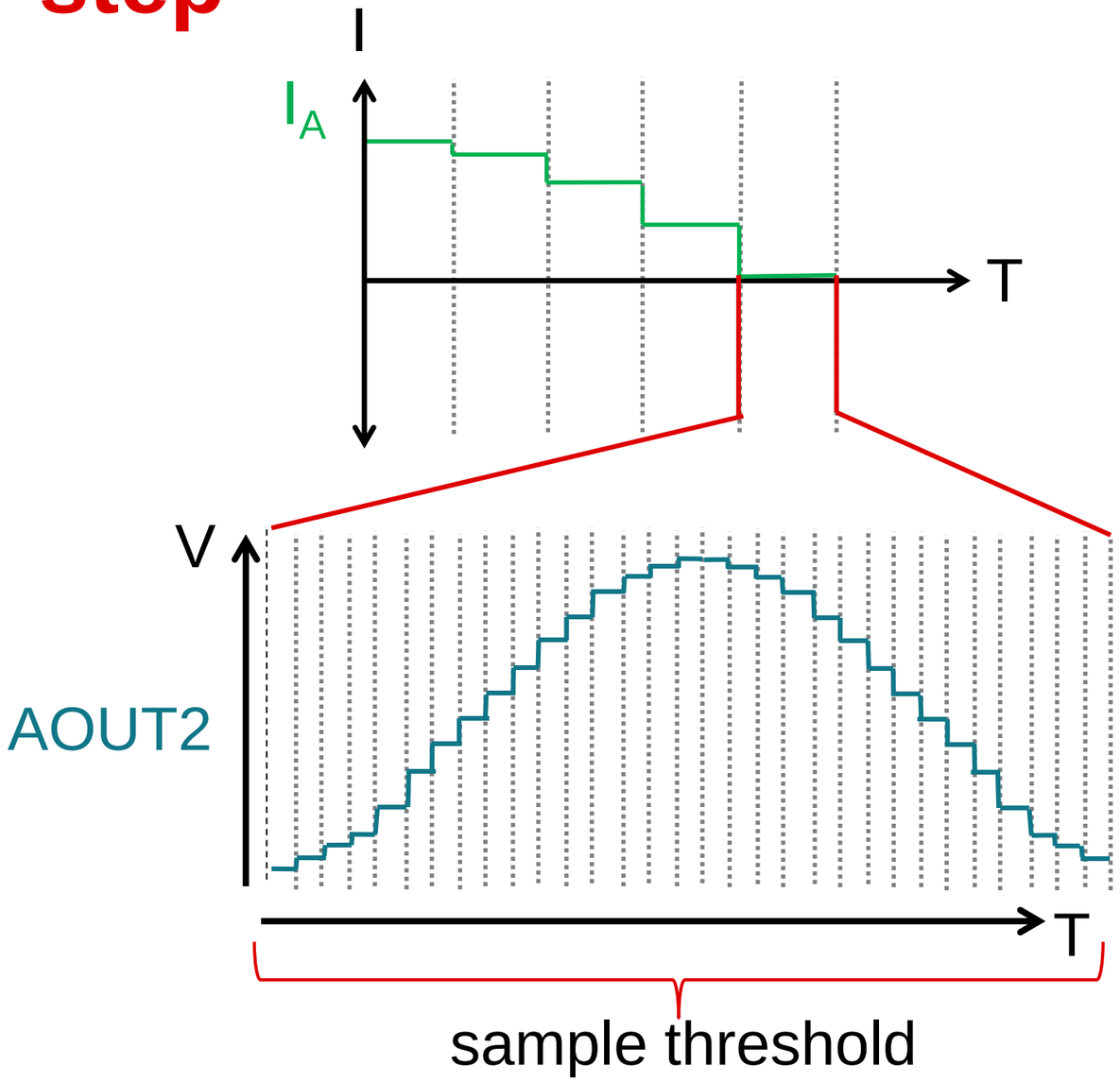
  - p: number of pole pairs
  - Ψ_m: maximum magnetic flux
  - ω: motor angular speed

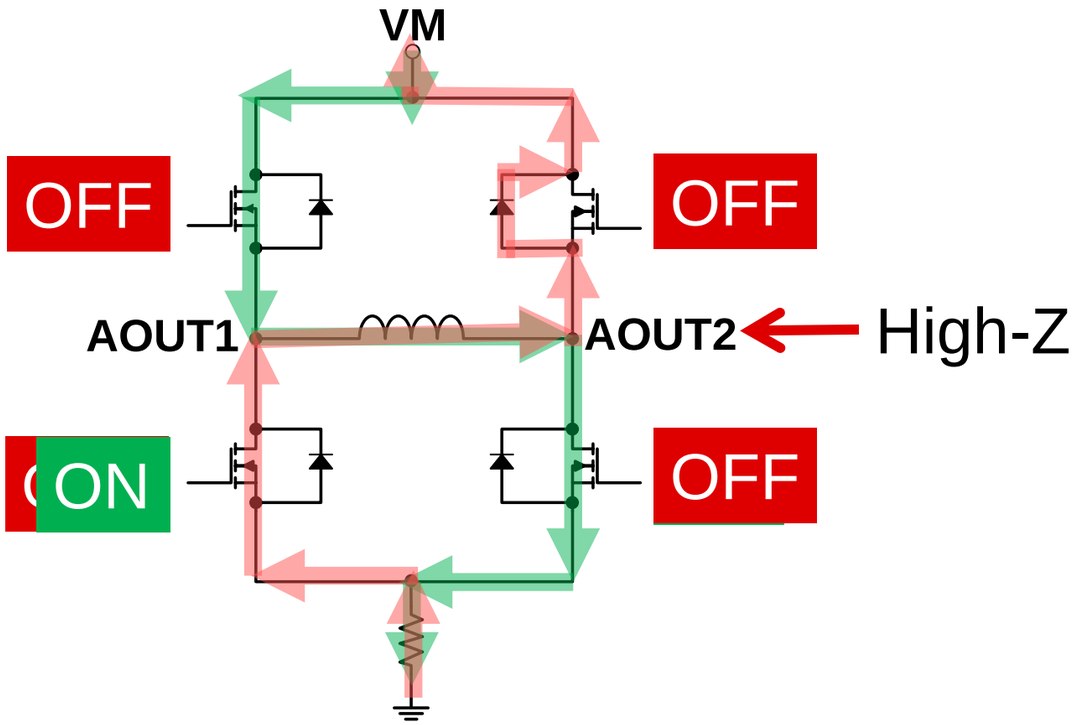
- Benefits:
  - Sensor-less solution
  - Reduces design cost and size
- Drawbacks:
  - Minimum motor running speed



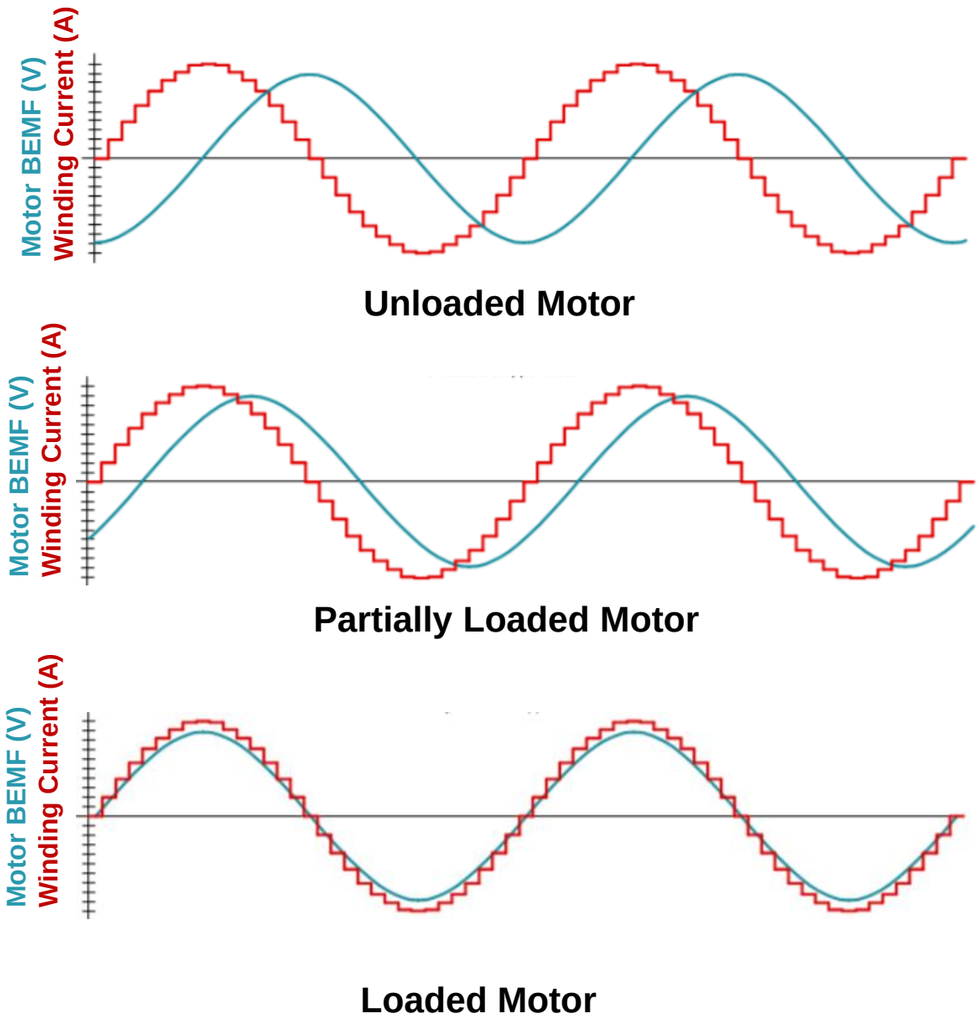


Direct back-emf measurement during zero current step



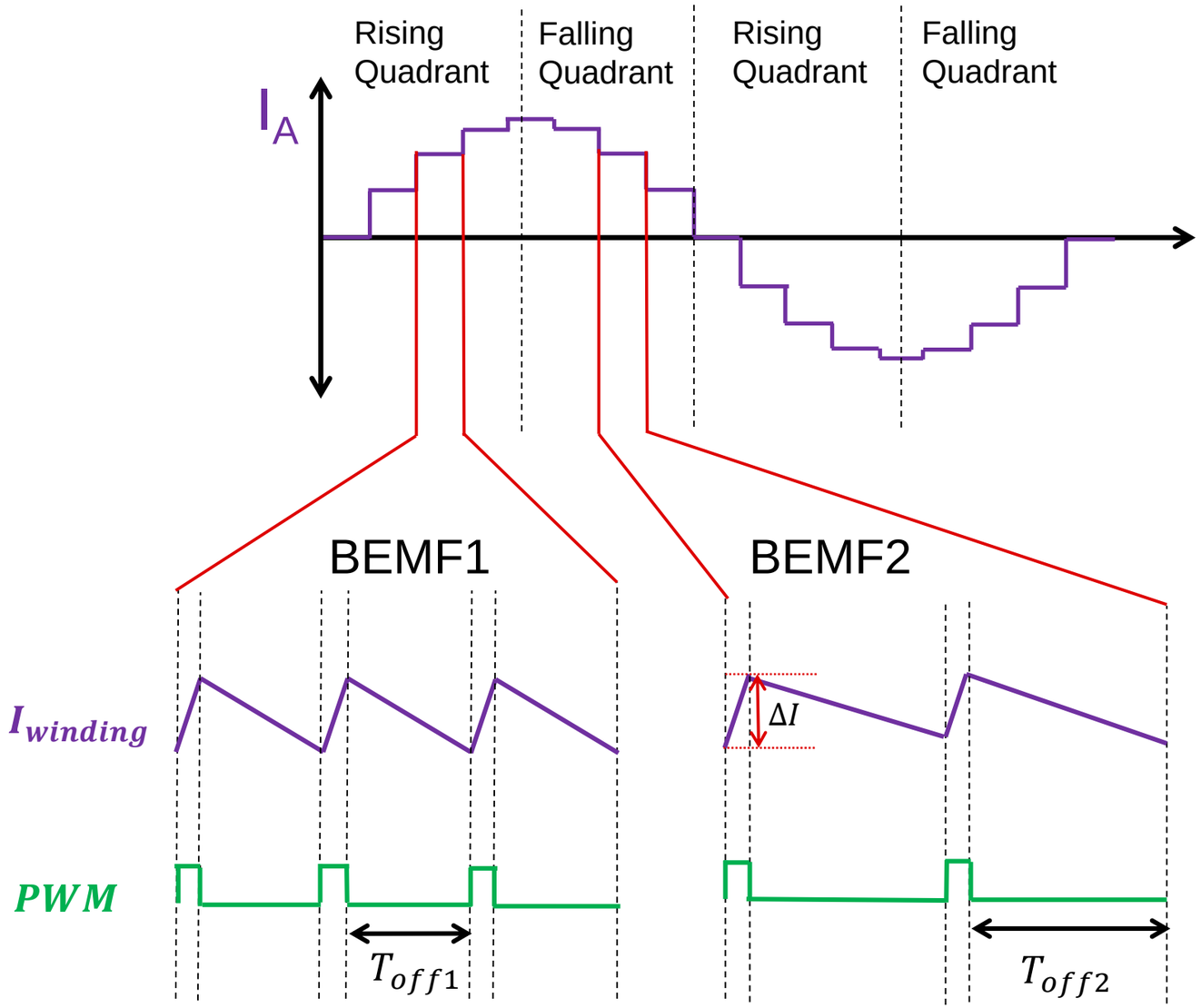


Indirect back-emf measurement



- Benefits:
  - Constant back-emf monitoring.
- Drawbacks:
  - Current regulation waveform dependencies on supply voltage, motor current, and motor resistance

TI solution: fixed current ripple method



$$T_{off} = \frac{L*\Delta I}{I*R-BEMF}$$

$$\frac{1}{T_{off1}} - \frac{1}{T_{off2}} = \frac{\Delta BEMF}{L*\Delta I}$$

$$\Delta BEMF = BEMF2 - BEMF1$$

Normal operation: $\Delta BEMF > 0$

Stall Condition: $\Delta BEMF = 0$

Summary

	Advantages	Disadvantages
Encoder	• Precise motor position monitoring • Can work at very low speeds	• Higher cost • Larger system area size
Direct back-emf measurement	• Reduce design system cost and size	• Minimum motor speed required • Does not work in full-step mode.
Indirect back-emf measurement	• Reduce system cost and size • Works for all micro-step settings	• Minimum motor speed required • Can be affected by supply voltage, motor current, and motor resistance variations

To find more stepper driver technical resources and search products, visit http://www.ti.com/motor-drivers/stepper-driver/overview.html

Resources

- [1] Acarnley, Paul P. *Stepping motors: a guide to theory and practice.* 4th ed., Institution of Engineering and Technology, 2007.
- [2] “PKP Series Product Catalog”, orientalmotor.com