ROCO222: Intro to sensors and actuators
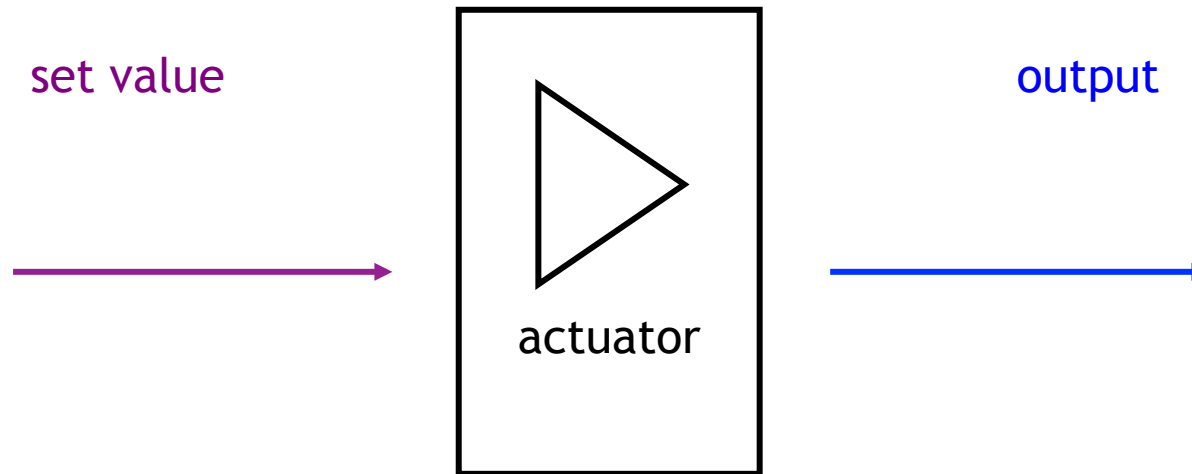
Lecture 1
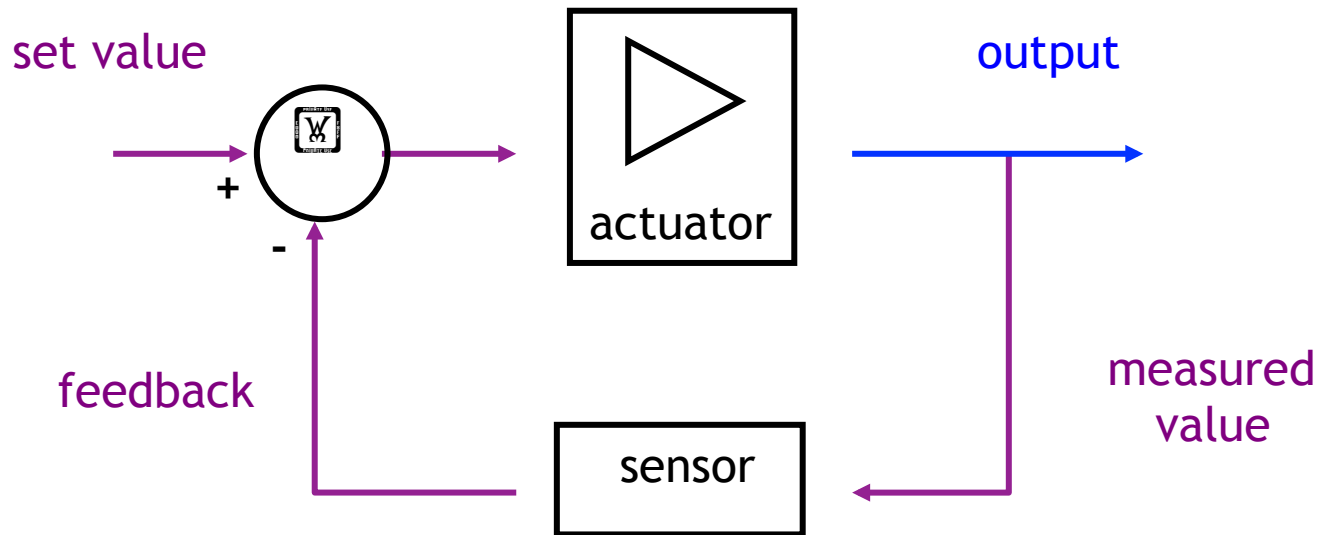
Simple control of motor speed

Open loop control

set value → actuator → output

- Set value is adjusted to specify target output

- No feedback feedforward opertion

- Output is not measured and not use to change input to the plant

- There is an „open loop"

Closed loop control

- Set value is adjusted to specify target output

- Output value is measured

- Feedback from output is used to change the input to the plant

- There is a „closed loop"

Motor operating point voltage dependent
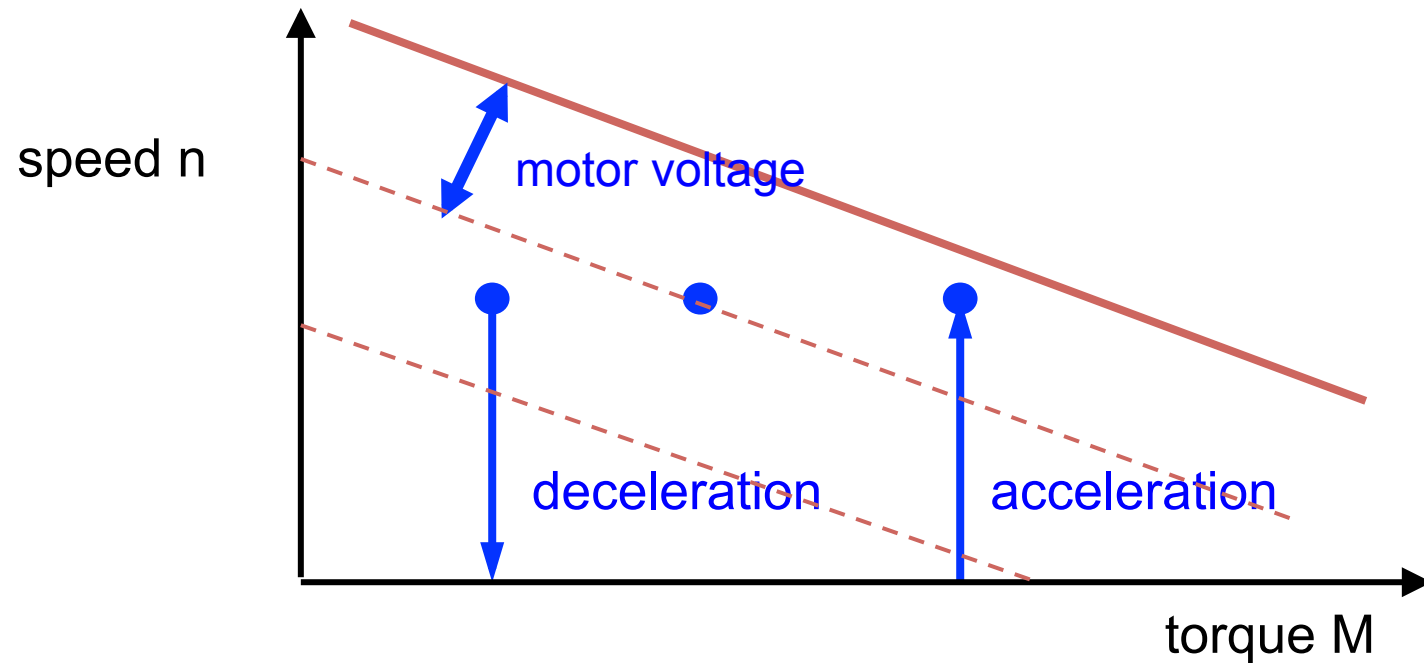
- Load operating points are characterized by a load speed n_L at a given load torque M_L
- Motor operating points lie on the speed-torque-line
- Therefore for a given load we can use motor voltage to control motor speed
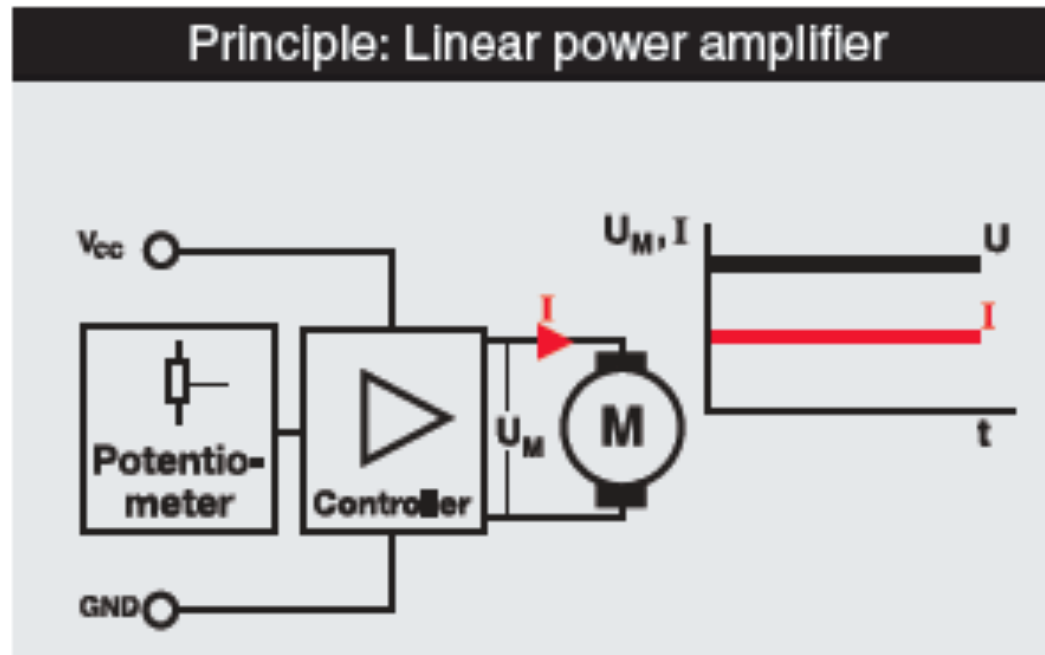
Simple motor speed control

- Example simple methods of motor speed control

- Using rheostat (or voltage drop across a transistor) in series with motor to limit applied voltage will realize a primitive kind of open loop control

- This will realize a primitive kind of open loop control

+5 VDC

+

M M1
DC Brush

R1
200 Ω
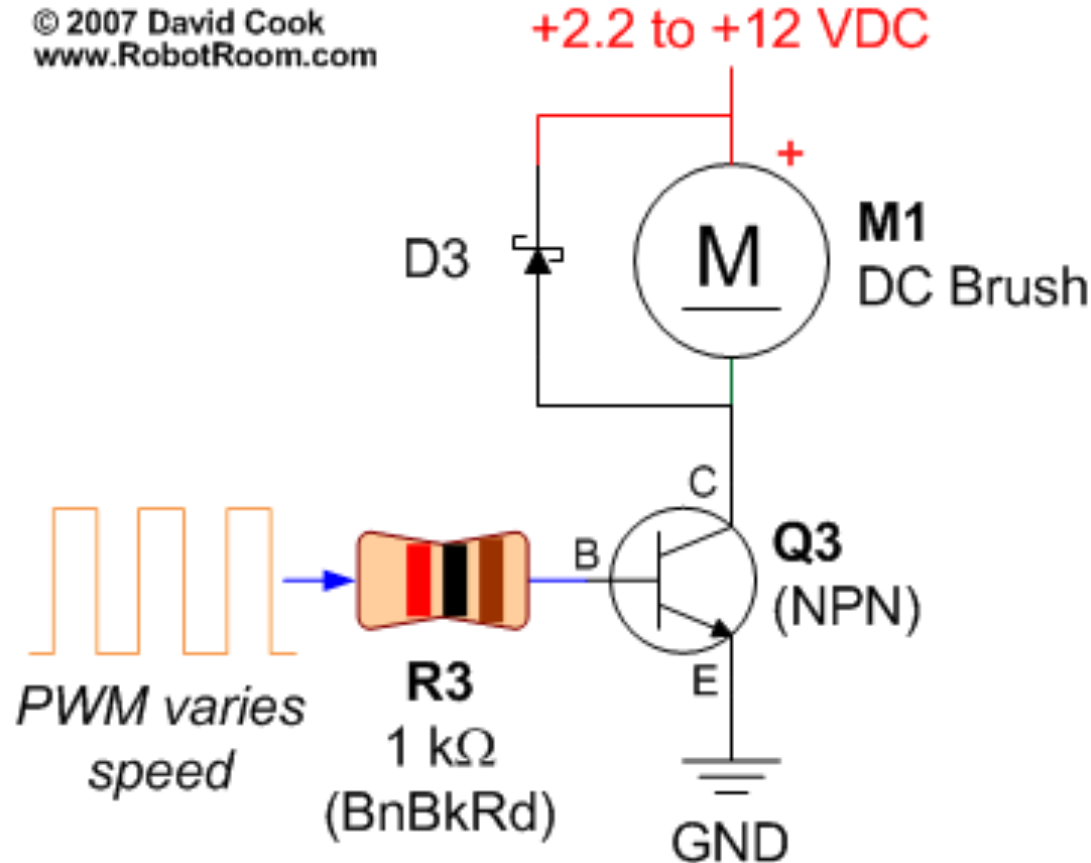variable

**LAME!
DO NOT USE**

GND
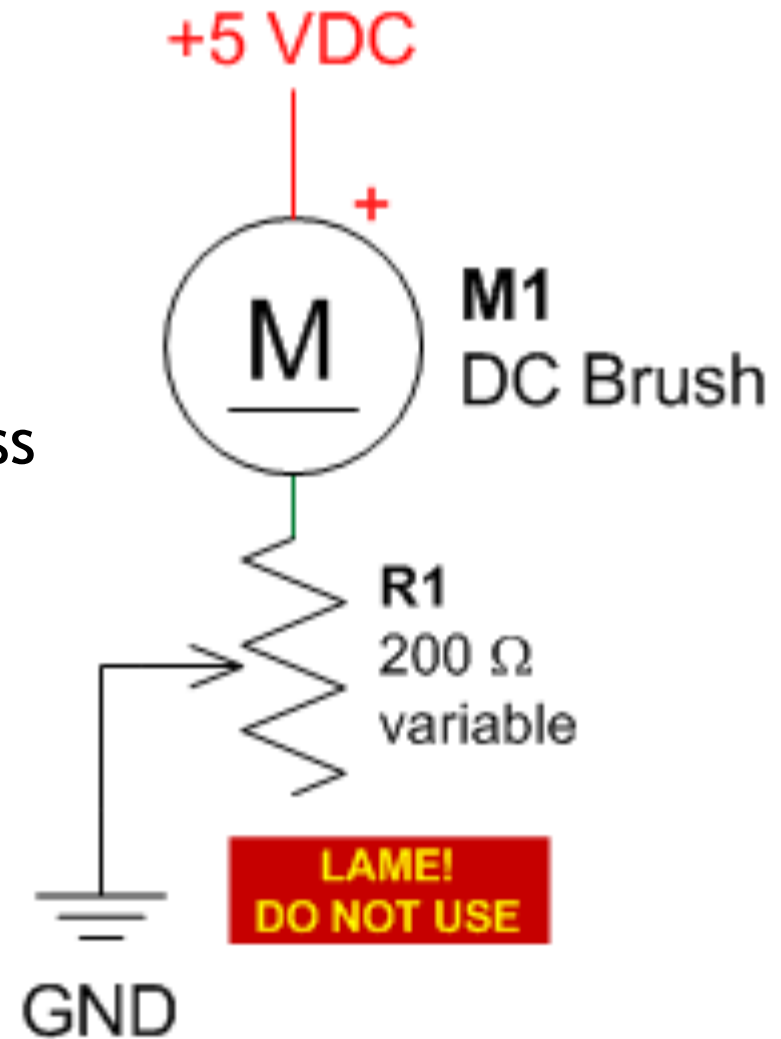
Linear power stage

- Linear power amplifier to control motor
- Operating voltage is divided between the motor and amplifier.
- Voltage drop across amplifier output stage causes power dissipation
- High currents and low motor voltages cause significant power dissipation
- Simple and favorably priced design of the power amplifier

Principle: Linear power amplifier

Better motor speed control

+2.2 to +12 VDC

D3

M — M1 DC Brush

+

C

B — Q3 (NPN)

E

PWM varies speed

R3
1 kΩ
(BnBkRd)

GND

- Speed of the motor can be controlled by the duty cycle of the square wave
- Transistor either fully on or fully off
- Therefore little power dissipation in control circuitry
- This can achieve high efficiently motor control

Pulsed power stage (PWM)

Principle: Pulsed power amplifier
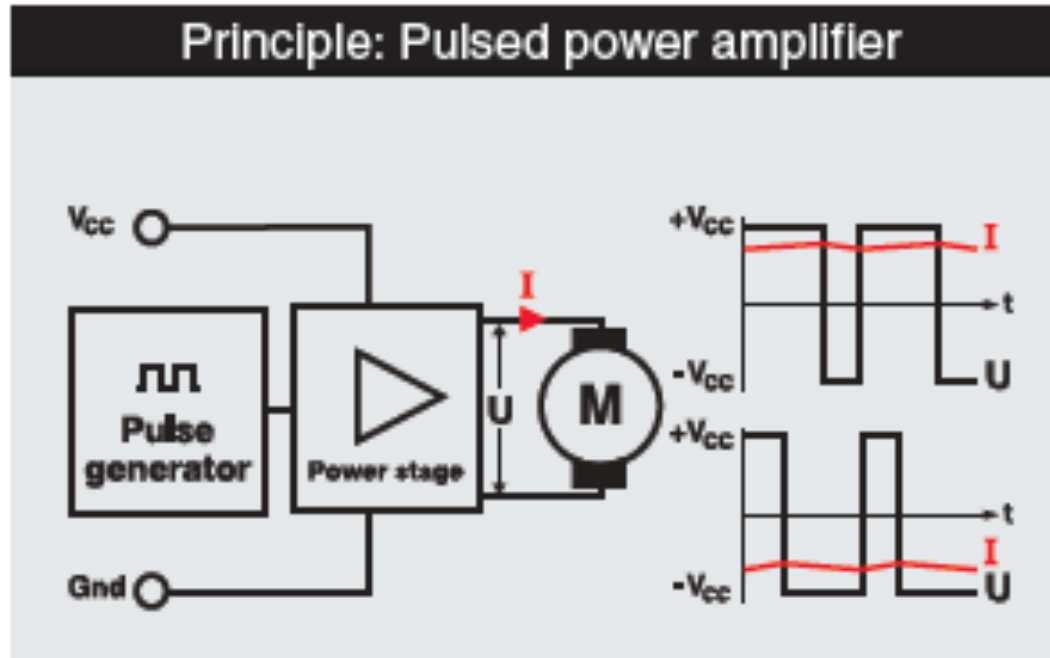
- In PWM the controller switches the motor on and off in short intervals (pulses/cycles)

- Average value of voltage changes in relation to the on-to-off time.

- If the off intervals longer, the motor drips in speed.

- Therefore little energy is converted into heat.

- Was more expensive than linear control (at least until recently)

Pulse width modulation waveforms

- The output of most controllers are almost entirely PWM

- Output square wave is manipulated by the controller into shorter and longer pulses

- The average of the wave gives the effective applied voltage to the motor

- This way the controller has precise control of the voltage supplied to the motor
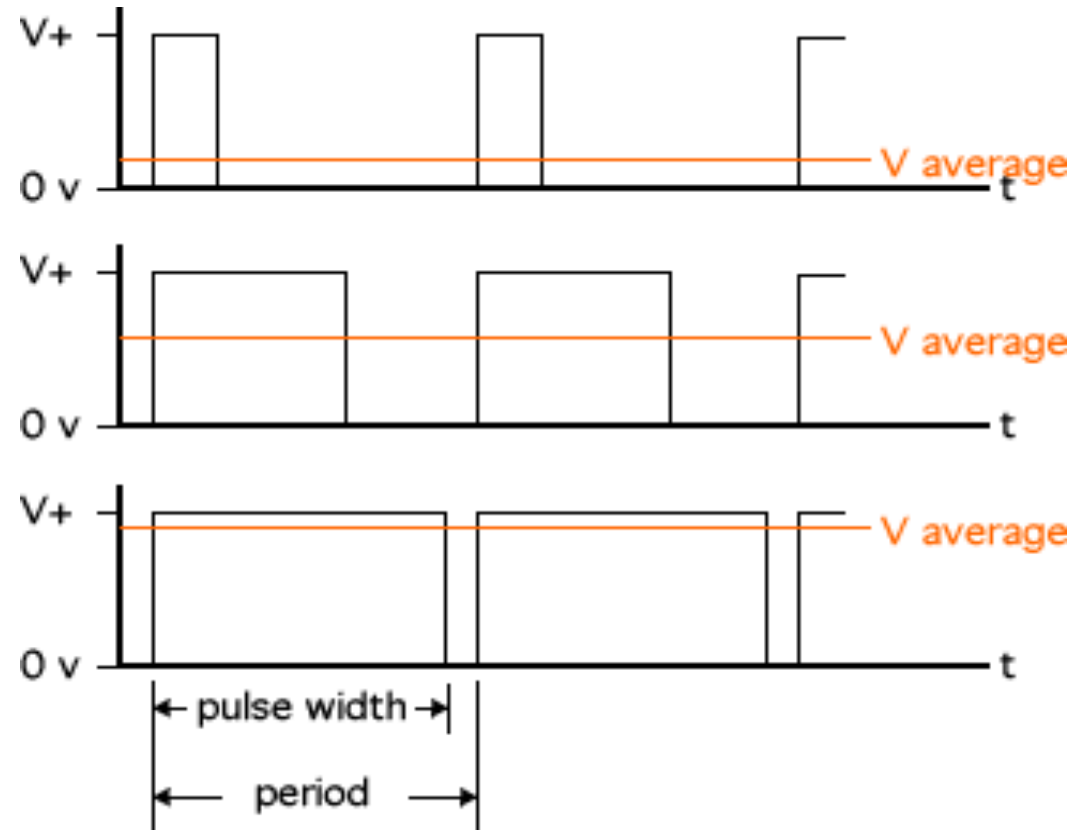
PWM and current ripple

General ways to reduce current ripple:

- Reduce motor voltage

- Increase total inductance

- Motor choke in controller

- Additional motor choke

- Increase PWM frequency

50% 50%

low motor inductance

With additional motor choke

30% 70%

U_{mot},
I_{mot}
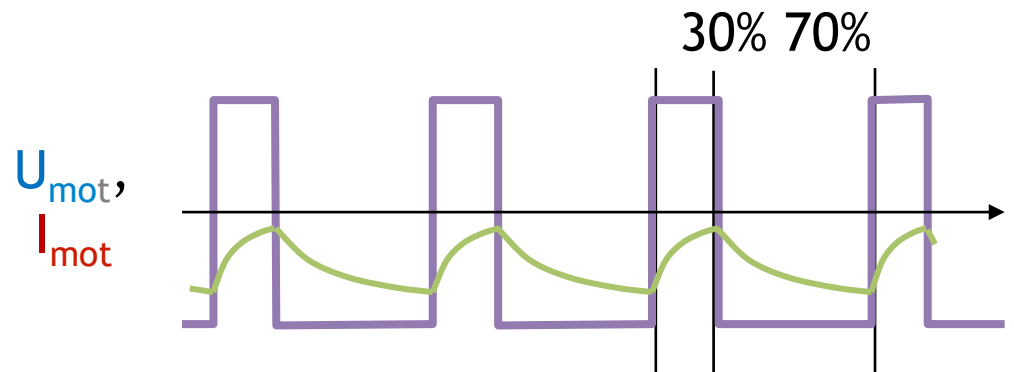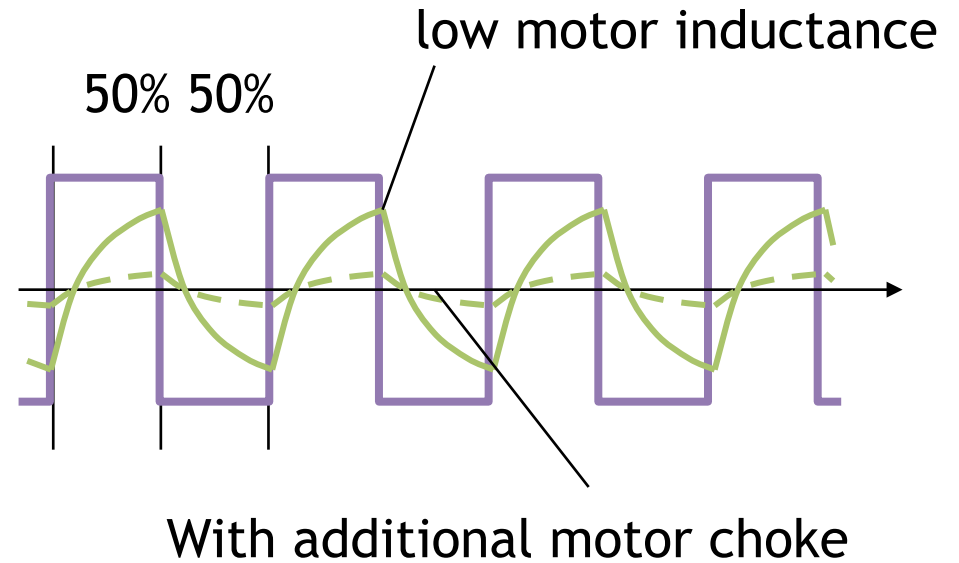
PWM and electronic commutation