



# DC Motor Drive

Power Electronics

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# BY

- Mafaz Ahmed 1882-F12D

# DC DRIVES Vs AC DRIVES

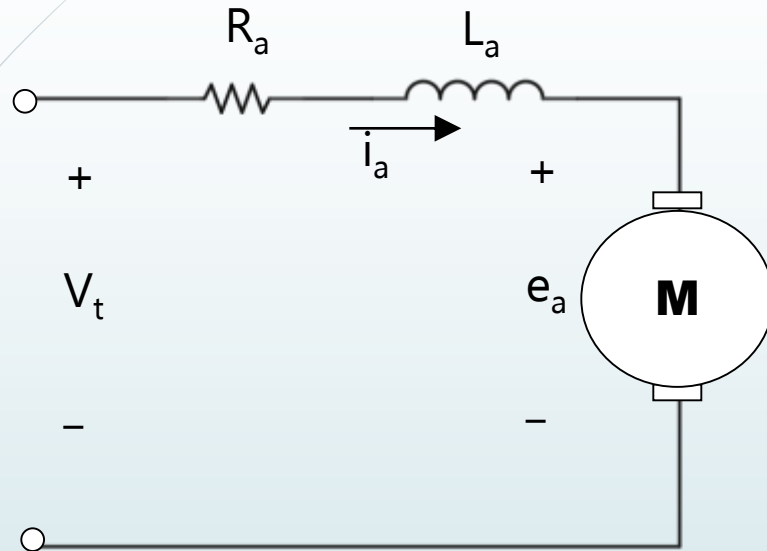
## DC DRIVES

- ▶ Advantage in control unit
- ▶ Disadvantage in motor

## AC DRIVES

- ▶ Advantage in motor
- ▶ Disadvantage in control unit

# Equivalent circuit of DC motor



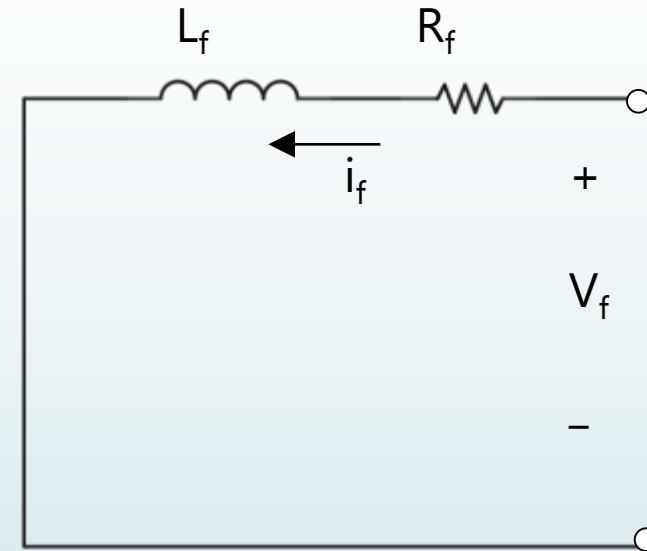
$$v_t = R_a i_a + L \frac{di_a}{dt} + e_a$$

$$T_e = k_t \phi i_a$$

Electromagnetic torque

$$e_a = k_E \phi \omega$$

Armature back e.m.f.



$$v_f = R_f i_f + L \frac{di_f}{dt}$$

# Torque Equation

$$T_e = T_L + J \frac{d\omega}{dt} \quad \text{or} \quad T_e - T_L = J \frac{d\omega}{dt}$$

$T_e$  : motor torque (Nm)     $T_L$  : Load torque (Nm)

$$T_e - T_L > 0 \quad \text{Acceleration}$$

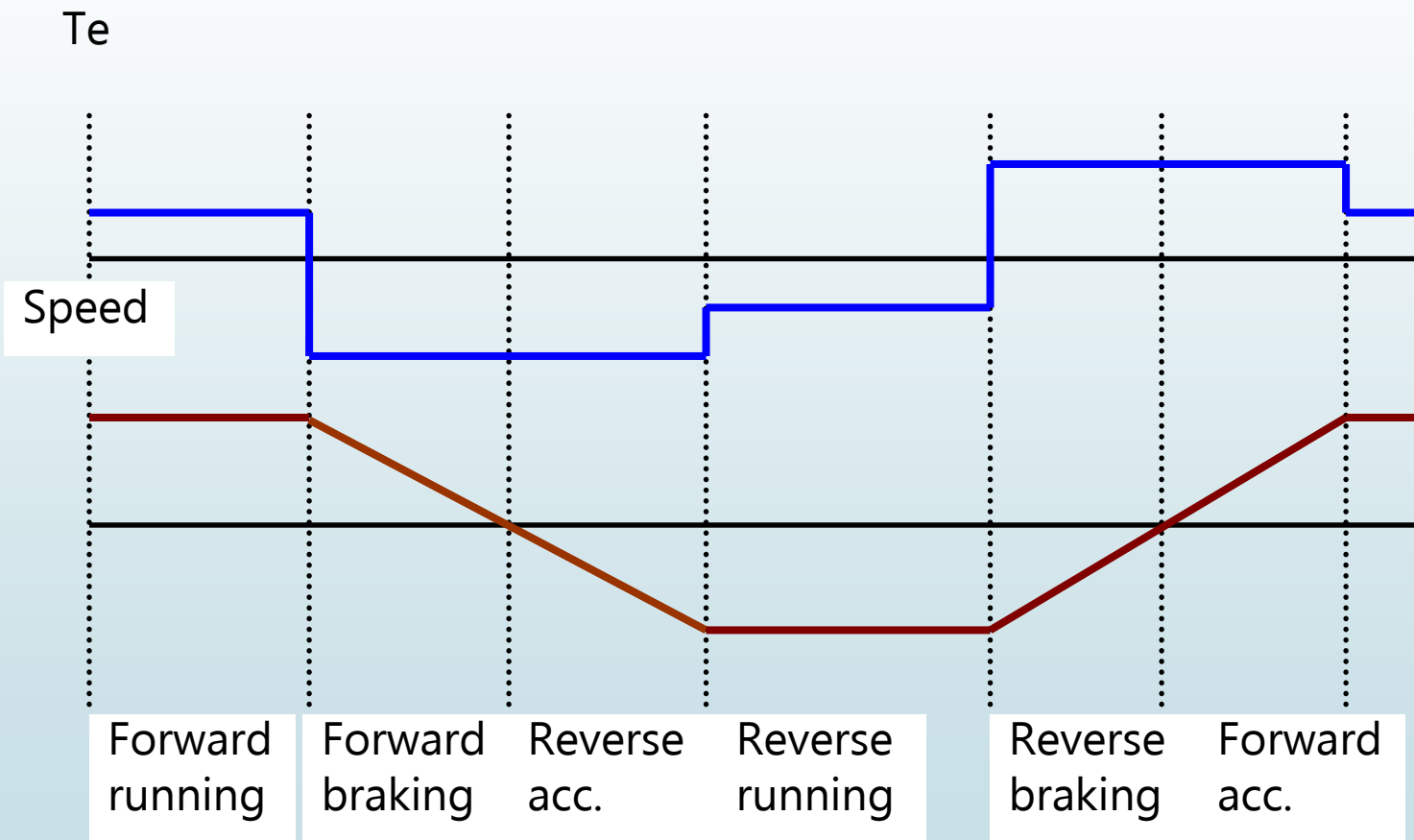
$$T_e - T_L < 0 \quad \text{Deceleration}$$

$$T_e - T_L = 0 \quad \text{Constant speed}$$

# Torque Equation

- ▶ Drive accelerates or decelerates depending on whether  $T_e$  is greater or less than  $T_L$
- ▶ During acceleration, motor must supply not only the load torque but also dynamic torque,  $(Jdw/dt)$
- ▶ During deceleration, the dynamic torque,  $(Jdw/dt)$ , has a negative sign. Therefore, it assists the motor torque,  $T_e$ .

# Torque Speed Relation



# Speed control using Armature Voltage Control

## Armature voltage control

Variable voltage source

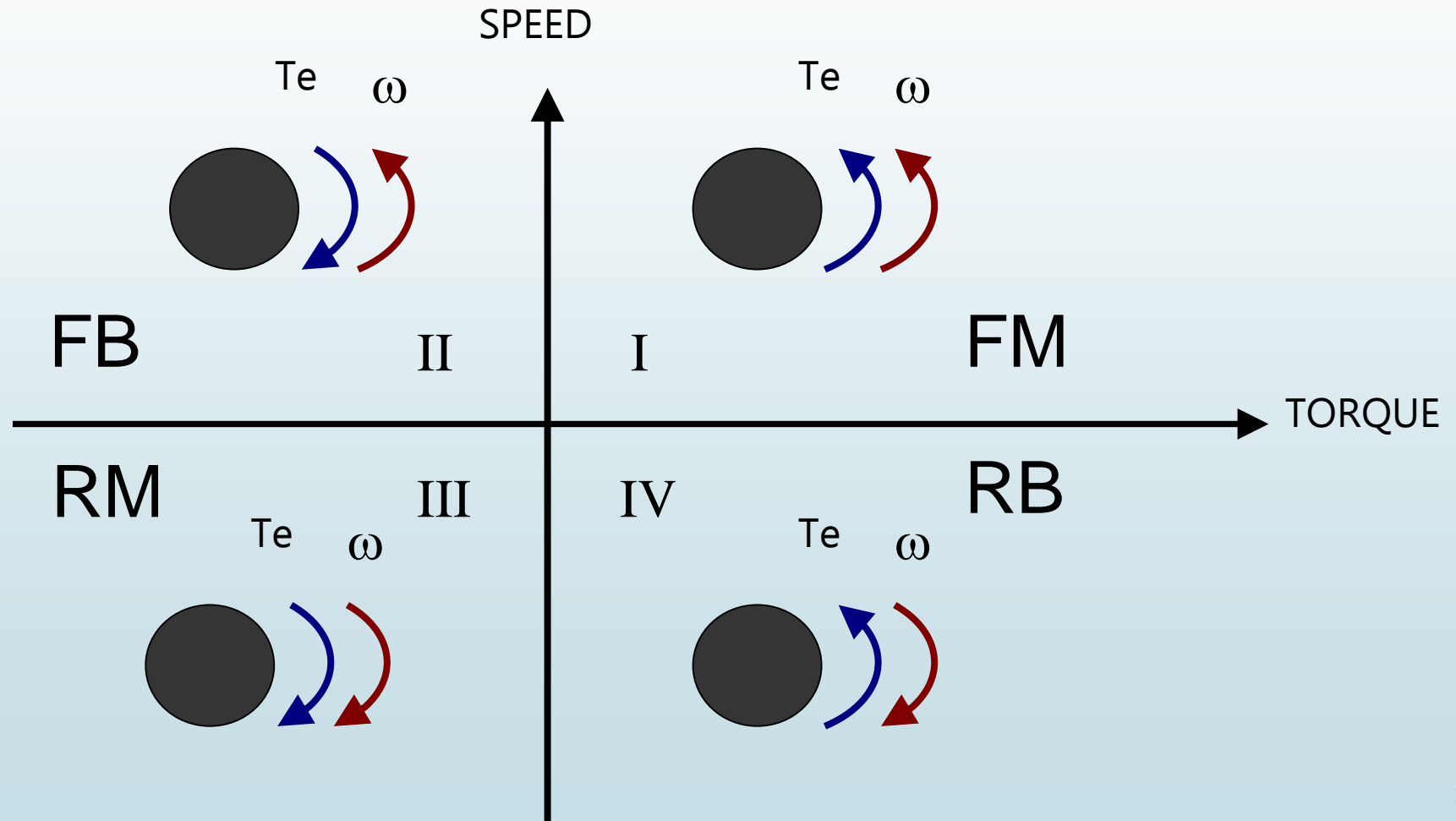
Phase-controlled Rectifier

Switch-mode converter (Chopper)

- 1Q-Converter
- 2Q-Converter
- 4Q-Converter

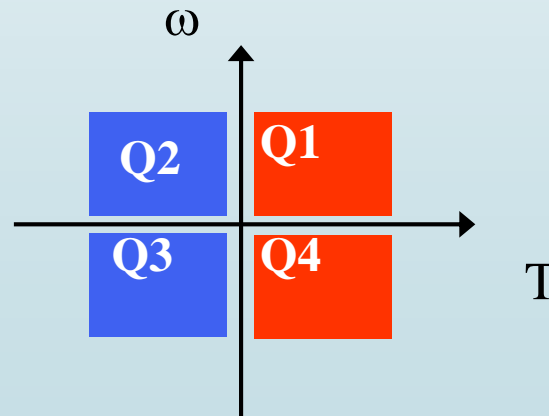
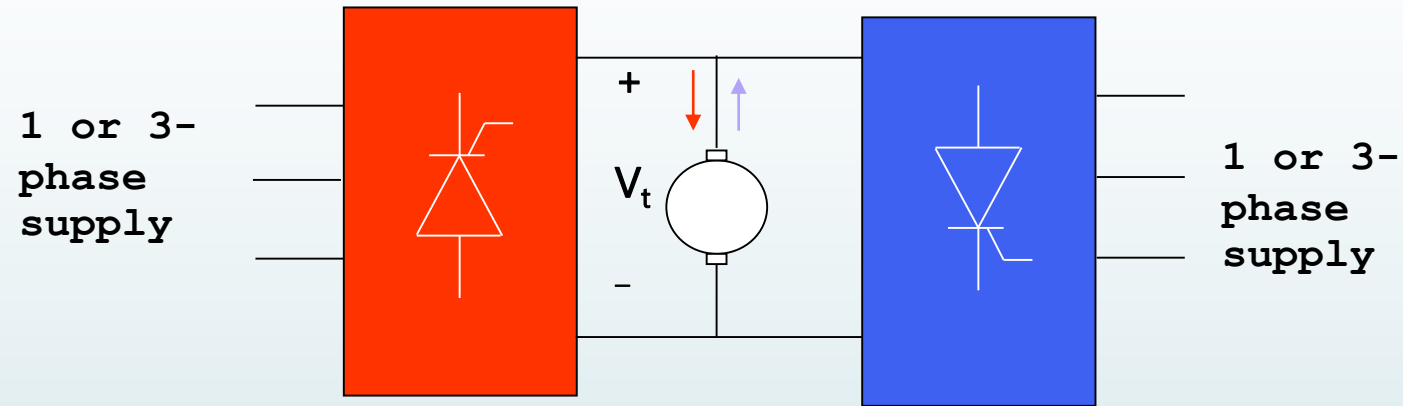


# 4Quadrant OPERATION



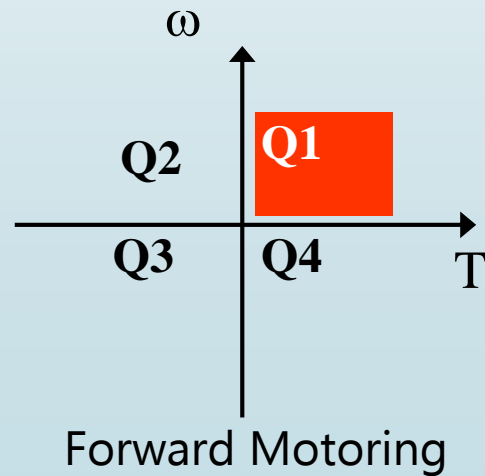
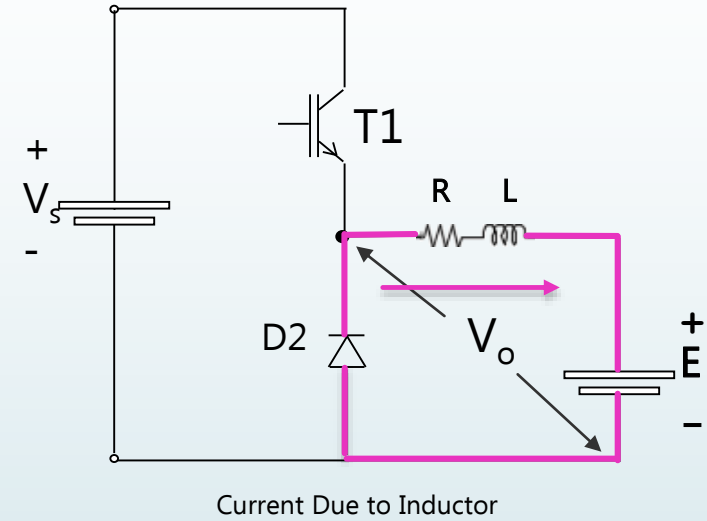
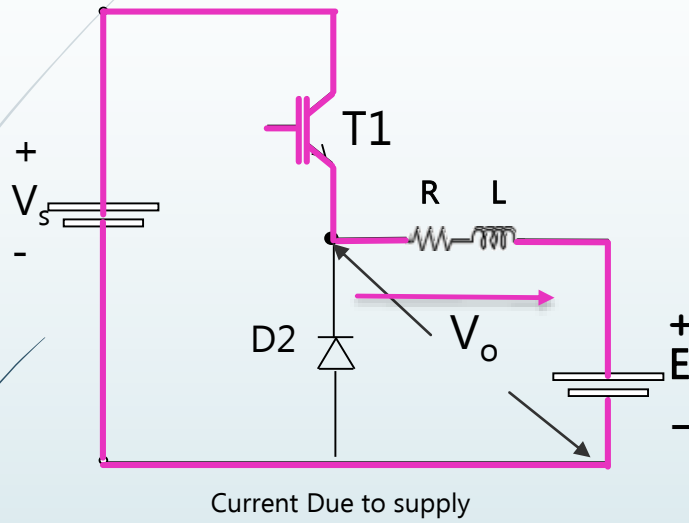
F: FORWARD R: REVERSE M: MOTORING B: BRAKING

# Phase-controlled rectifier: 4Q Operation

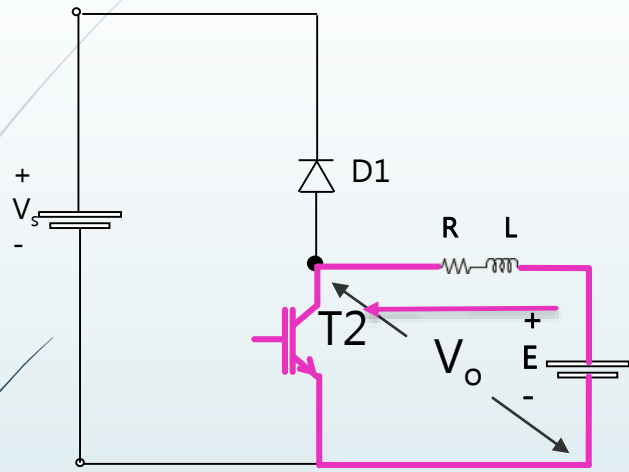


➤ Plugging type Braking

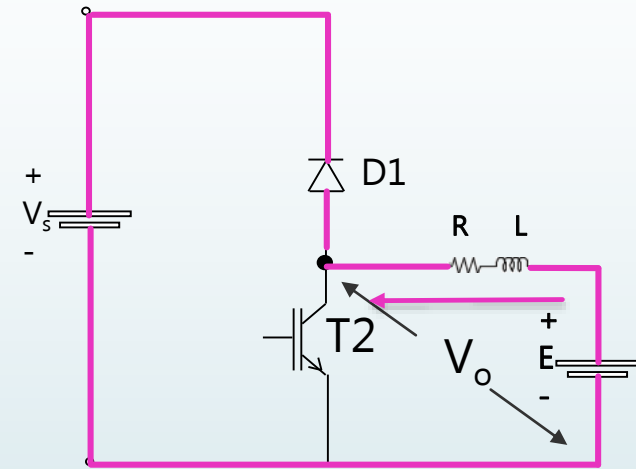
# 1<sup>st</sup> Quadrant Converter



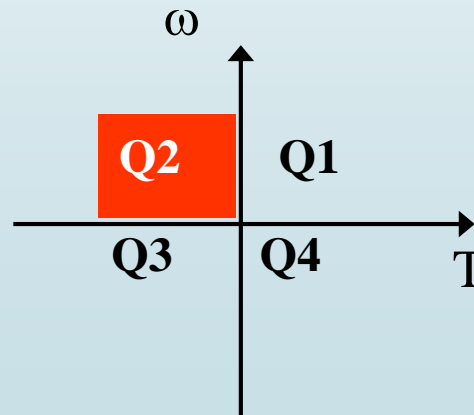
# 2<sup>nd</sup> Quadrant Converter



Current Due to emf

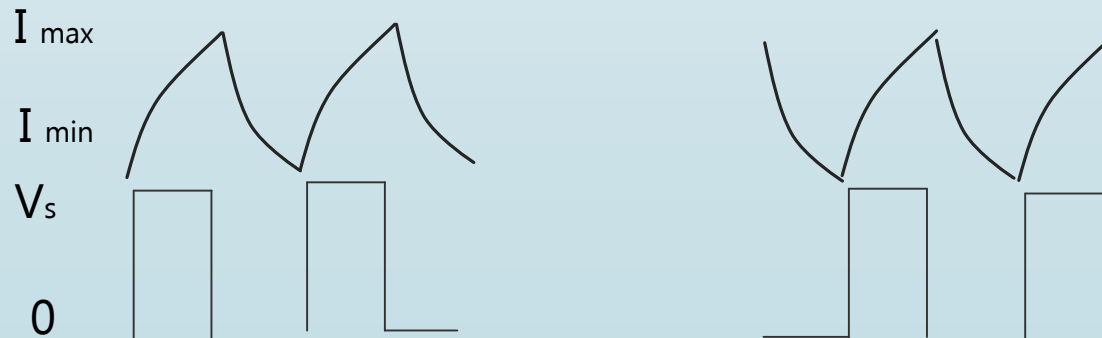
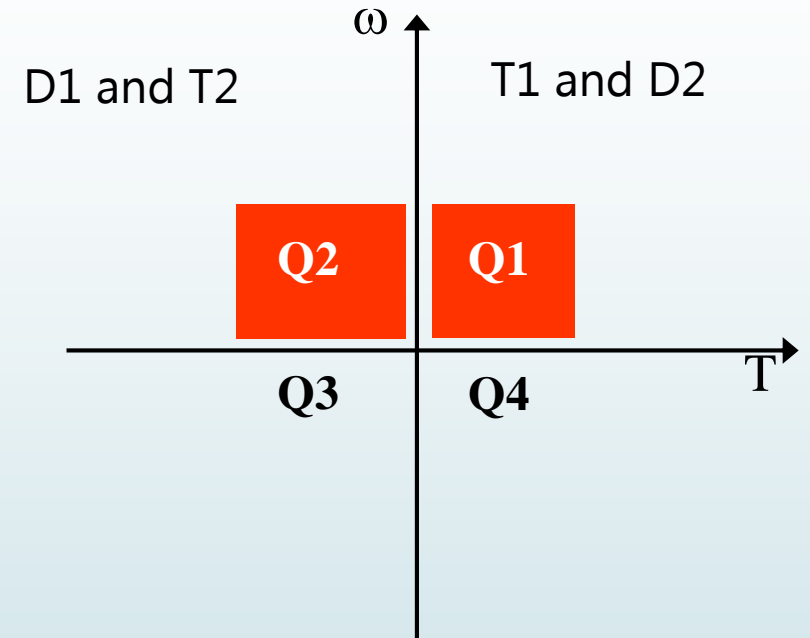
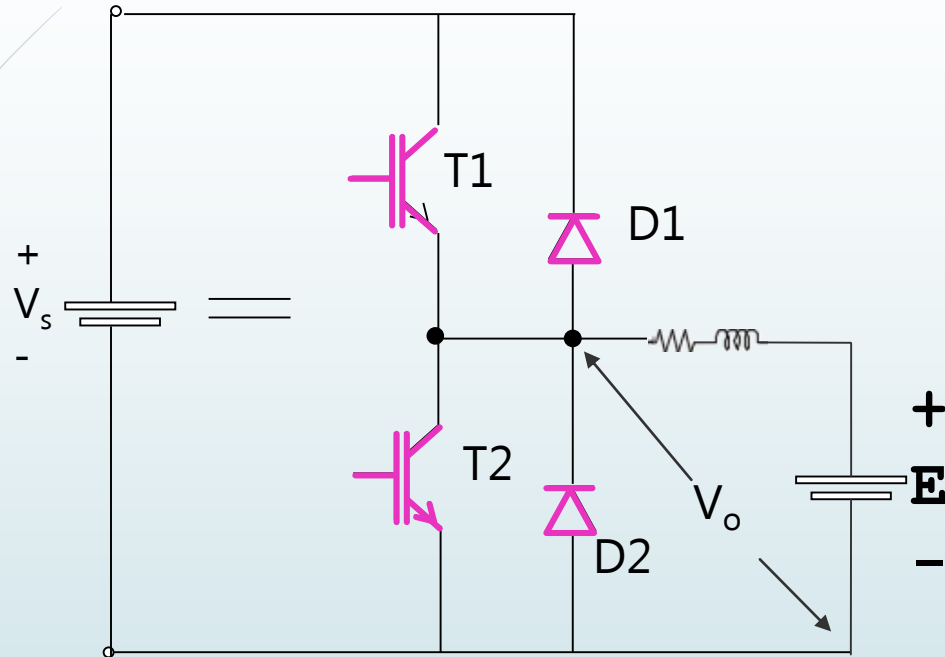


Current Due to Inductor



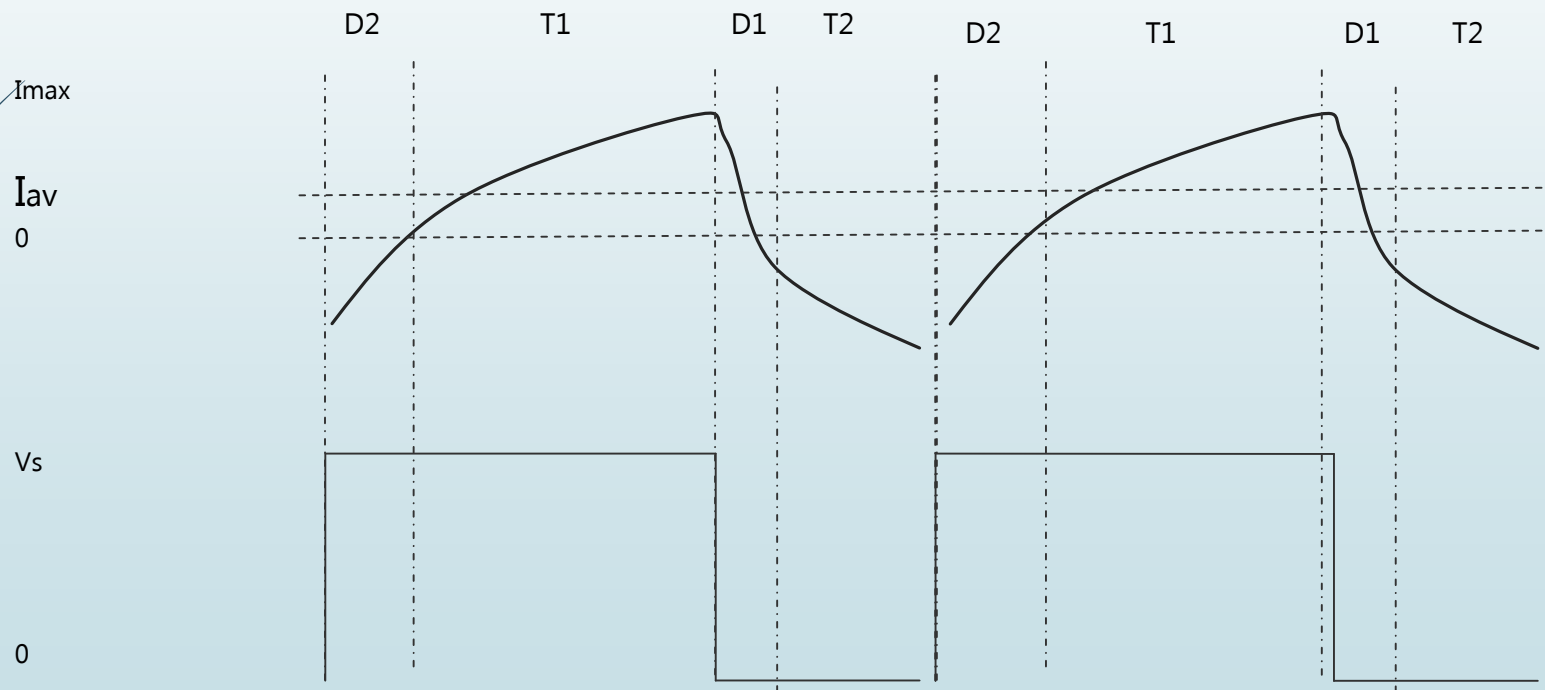
Forward Braking

# 2Quadrant Converter

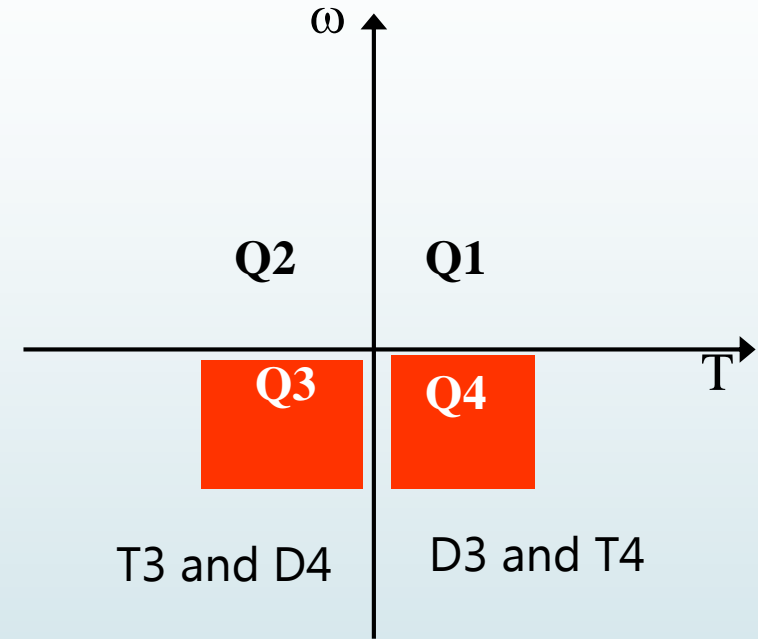
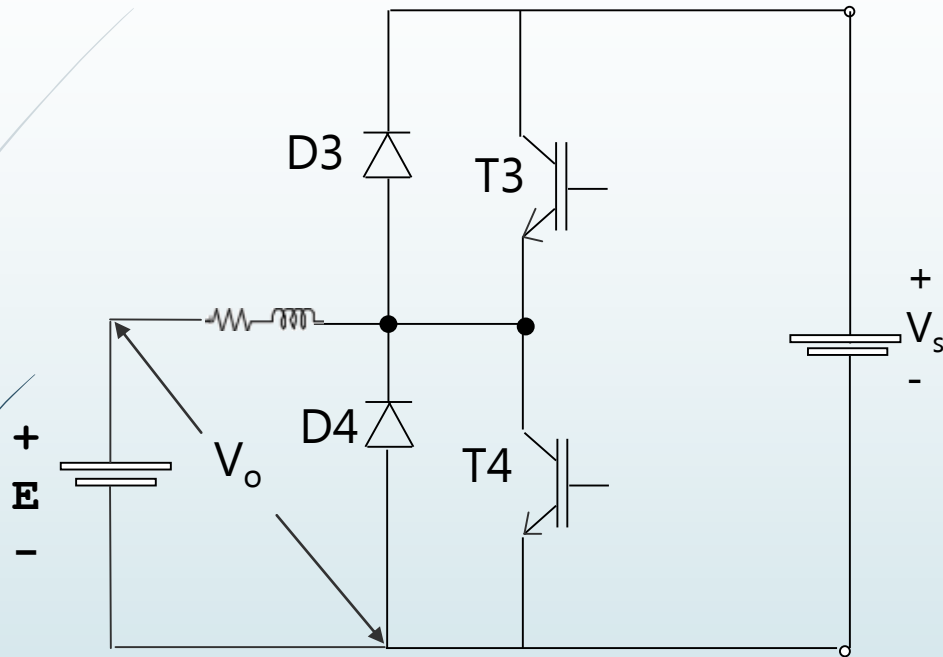


# 2Quadrant Converter

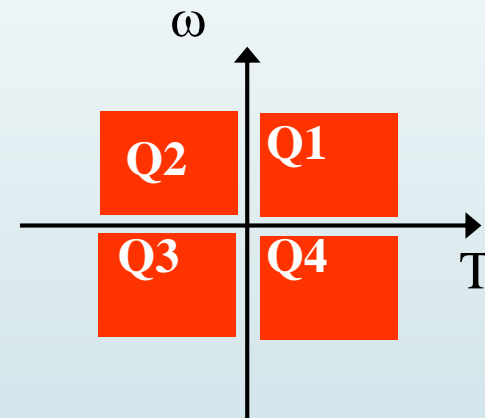
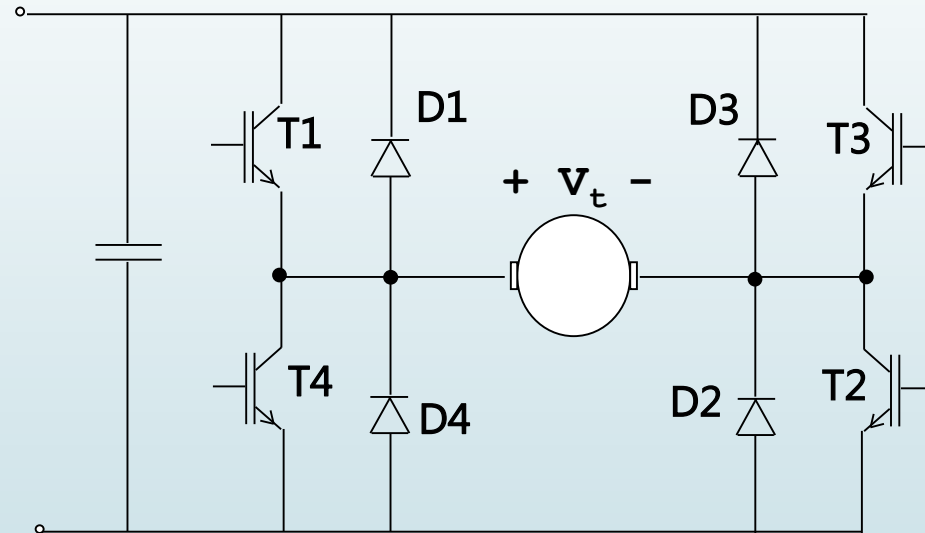
Both speed and torque can be controlled by involving 2 quadrants (1<sup>st</sup> quadrant and Second Quadrant)



# 2Quadrant Converter

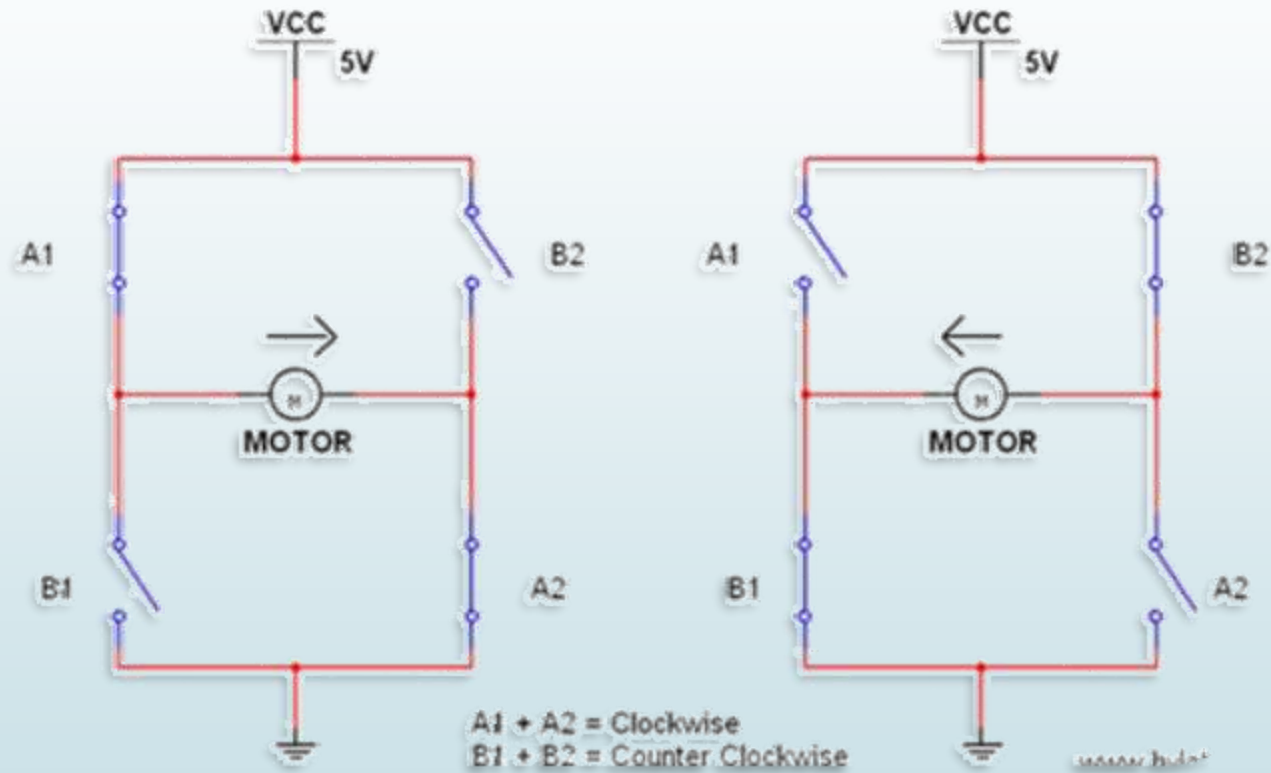


# Switch-mode converters: 4Q Converter





# Forward and Reverse Motoring



# Switch-mode converters

- Switching at high frequency
  - Reduces current ripple
  - Increases control bandwidth
- Suitable for high performance applications

The END