Tutorial 3

02-03 paper

Question 3   Motion Actuators and Drives

(a)   List the advantages and disadvantages of direct-drive linear positioning actuators over convention linear slides driven by rotary motors.   (8 marks)

(b)   Explain why turn-on and turn-off time of the stepping motor will affect the overall performance of the motion system. For a unipolar stepper motor drive, explain how the turn-on and/or turn-off time can be improved by (i) external resistors, (ii) zener diode, (iii) dual-voltage drive, and, (iv) high-voltage PWM chopper drive. Support your answer with appropriate drive circuits.
                                                                                                                   (17 marks)

03-04 paper

Question 4 – Motion Drives

(a)   Explain what is meant by 4-quadrant operation? Explain why 4-quadrant motor drive is required in high performance motion systems. Give an application example for each of the quadrant's operation.   (8 marks)

(b)   Figures Q4a, Q4b, and Q4c show the stepper motor drivers using resistance loading, dual voltage supply, and PWM respectively. Explain the operations of these circuits by referring to the charge/discharge current paths. Compare the performances between these three circuits.
                                                                                                                   (12 marks)
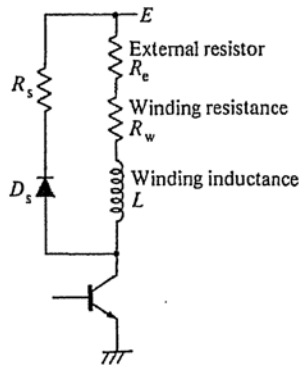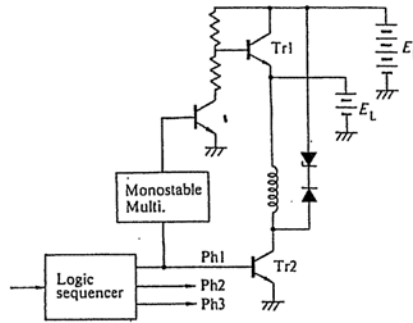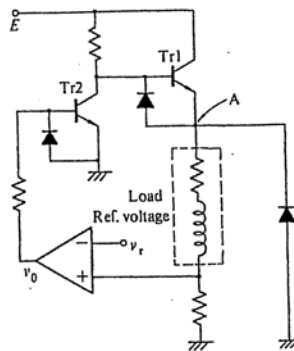

Figure Q4a

Figure Q4b

Figure Q4c

02-03 Q3

Advantages

1. No backlash, high precision
2. No couplings, mechanical translators
3. Lower maintenance cost, set up and alignment cost. Higher reliability
4. Since the motor forms part of the moving device, the space requirement is reduced

Disadvantages

1. No standard component is available. Has to design according to individual applications

2. An external disturbance is directly reflected to the motor controller, due to the absent of reduction gear

3. The controller needs to be more robust, any external interference may make the system unstable

4. The moving platform is virtually free moving once it is powered off.

Dual Voltage Drive

$\rightarrow V_2 + +$
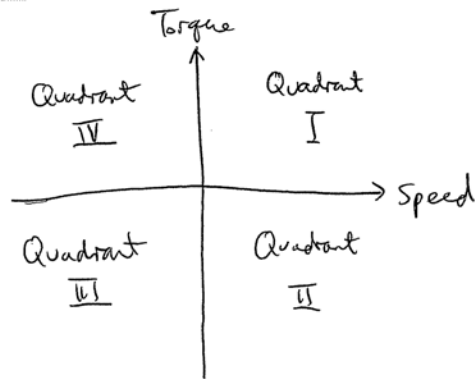
$\rightarrow V_1 +$

Mono
stable
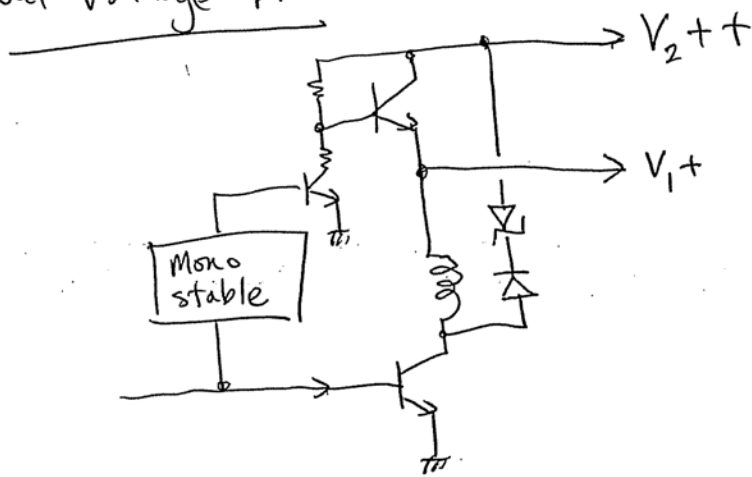
The dual voltage will improve the turn-on time. During turn on, a short duration of very high voltage is injected into the coil.

PWM chopper circuit

PWM has the best all round control for stepper motor drive. Usually the applied voltage is 5 - 10 times the coil voltage of the stepper.

$-\circ V_{ref}$
in

V

I

Torque

Quadrant IV   Quadrant I

→ Speed

Quadrant III   Quadrant II
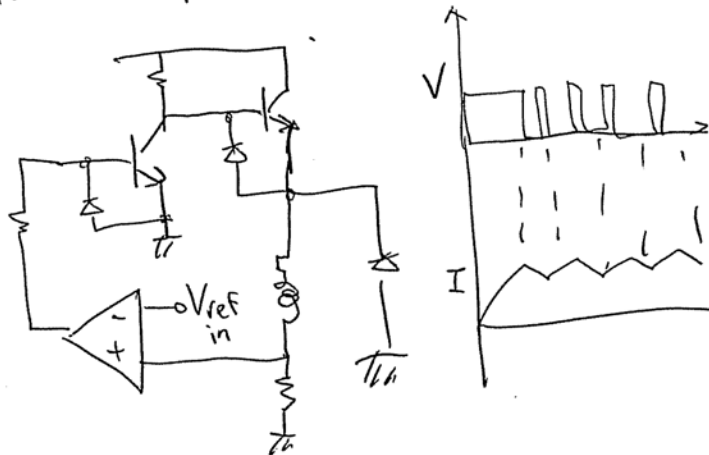
I : torque , speed +ve   (motoring)

II : torque -ve, speed +ve, (generating)

III : torque -ve, speed -ve, (reverse motoring)

IV : torque +ve, speed -ve, (reverse generating)   (8)

I example :   A train accelerating

II example :   A train braking and regenerating energy back to the source

III example :   Electric car in reverse gear.

IV example :   A Crane unloading goods to ground level.

Improve the turn off using dual voltage drive
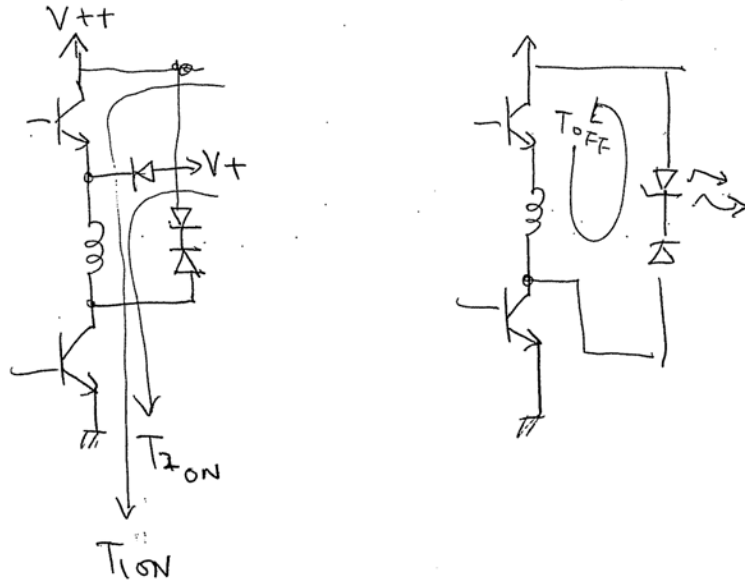
* A momentary High voltage causes the current rise time to increase

* After this period, normal voltage will be applied to prevent overcurret to the coil.

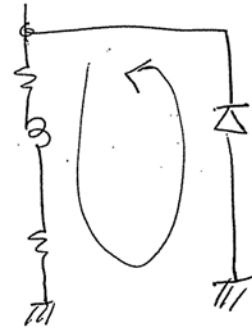* At T_{OFF}, current is discharged through the zener diode and diode.
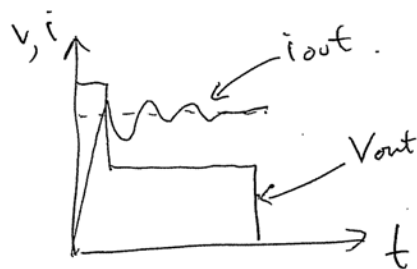
Disadvantage

* Dual voltage will only improve the rise time not the fall time

* Zener diode's rating must be high. It gets very hot during operation

13

Using PWM

T_{ON} — V_{++}, charge i

T_{OFF}

i sense
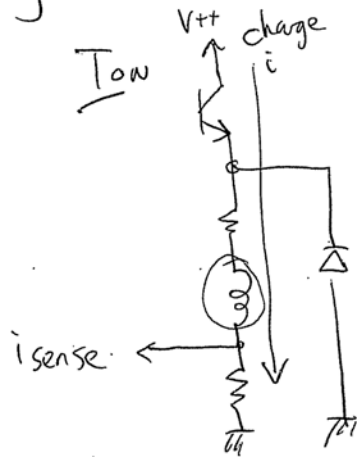
* Max efficiency
* Fastest turn on time
* Best control by using current feedback loop.

Disadvantages

* Complicated circuit
* No improvement on turn off time (for the present cct)
* High chopping frequency causing EMI

V, I

Vout

i out

t