EE2001 - Digital systems lab Applications

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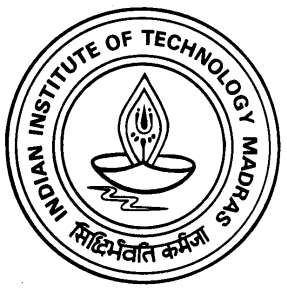
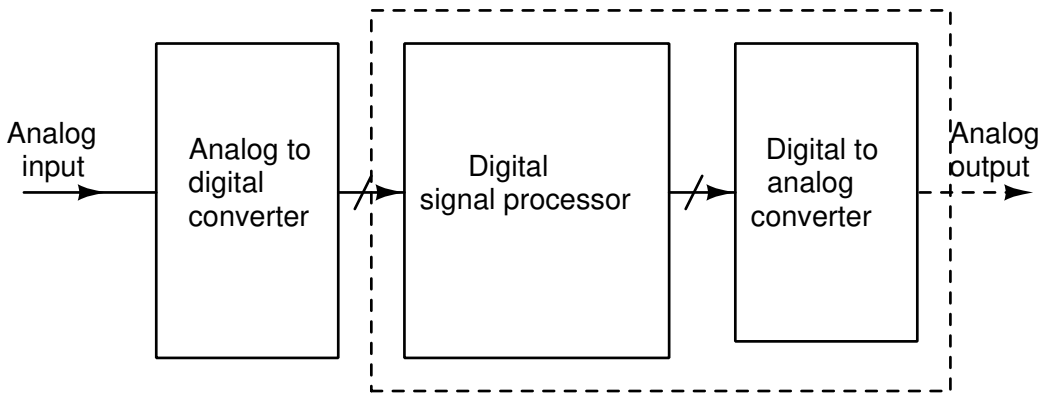
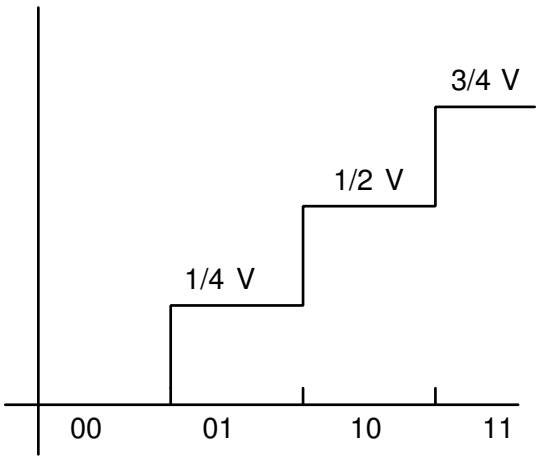


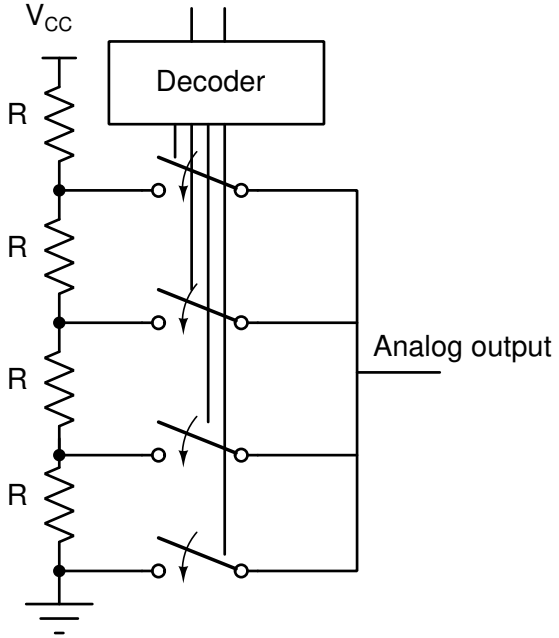
Applications



- Waveform generator
- Stepper motor controller

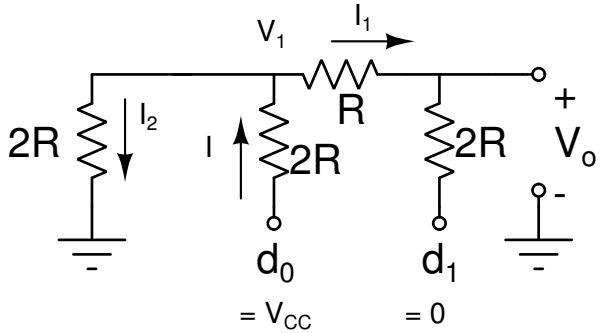
Digital to analog converter

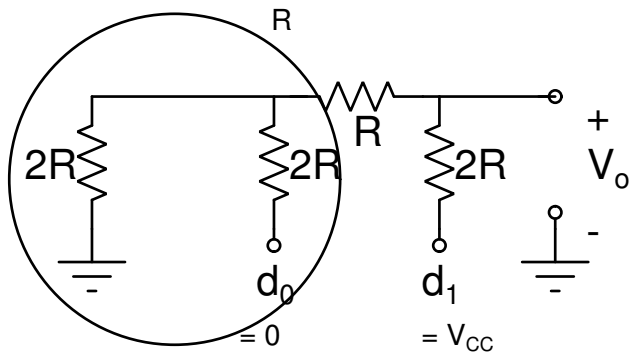




Resolution is $\frac{1}{4}$ V.

R-2R Ladder converter





$$\frac{V_{CC} - V_1}{2R} = \frac{V_1}{2R} + \frac{V_1}{3R}$$

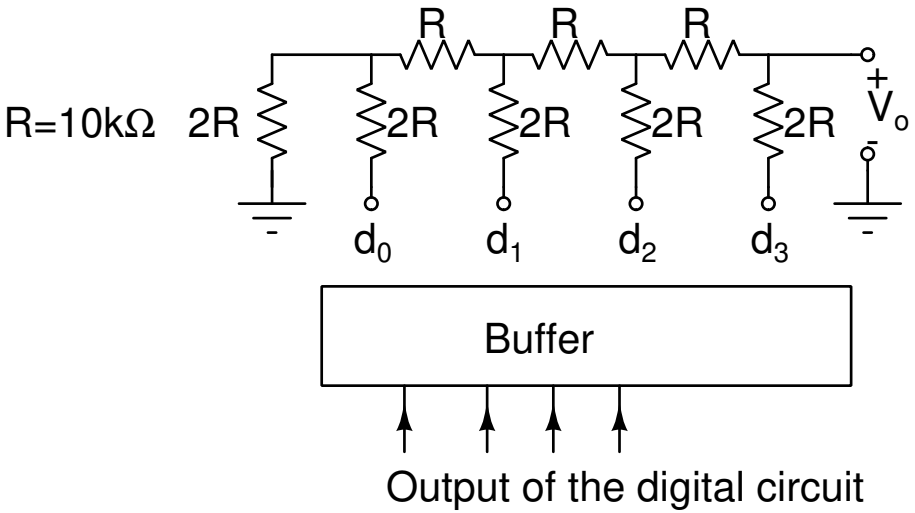
$$V_1 = \frac{3V_{CC}}{8}$$

$$V_{out} = \frac{V_{CC}}{4}$$

$d_0 = 0, d_1 = V_{CC}$
$\implies V_{out} = \frac{V_{CC}}{2}$

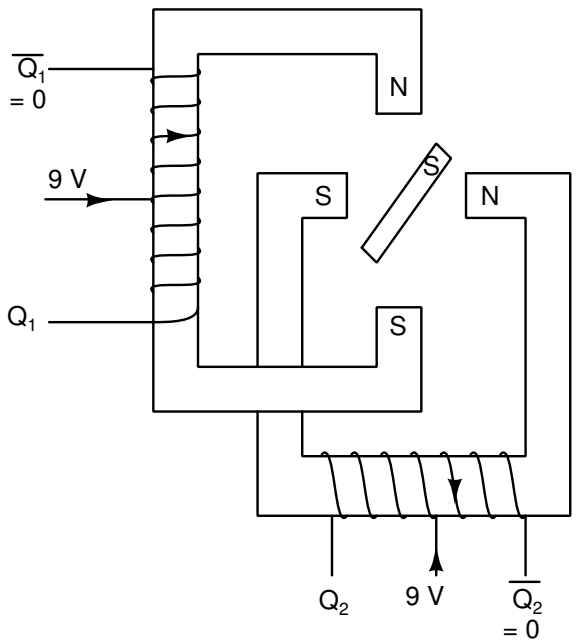
For $d_0 = V_{CC}, d_1 = V_{CC}$, use superposition to get $V_{out} = \frac{3V_{CC}}{4}$

R-2R Ladder converter - 4 bits

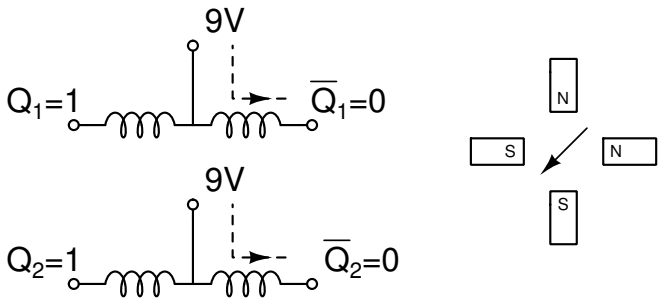


- Accuracy (deviation of the output voltage from the ideal voltage) depends on how well resistors are matched.
- If we connect a counter to this ladder network, can generate a sawtooth waveform.
- Connect a buffer to provide sufficient current to the ladder

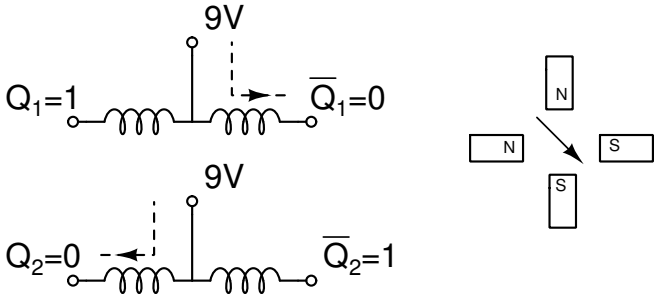
Stepper Motor



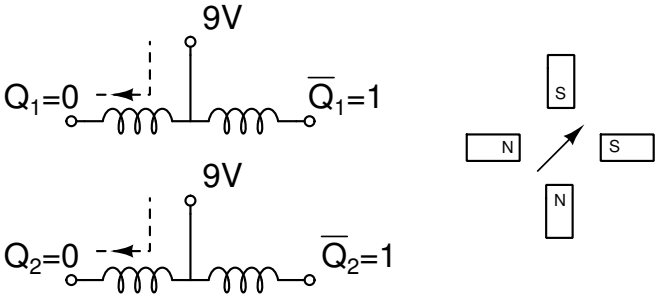
- Has two magnets - Stator(electromagnet) and Rotor (permanent magnet)
- Unipolar motors has a centre tap and stator coils are energized in sequence
- Magnetic field due to the stator rotates, moving the rotor. Torque on rotor is proportional to current in stator.
- In practice, it has many more poles for smaller steps


9V
$Q_1=1$
$\overline{Q}_1=0$
9V
$Q_2=1$
$\overline{Q}_2=0$
N
S
N
S

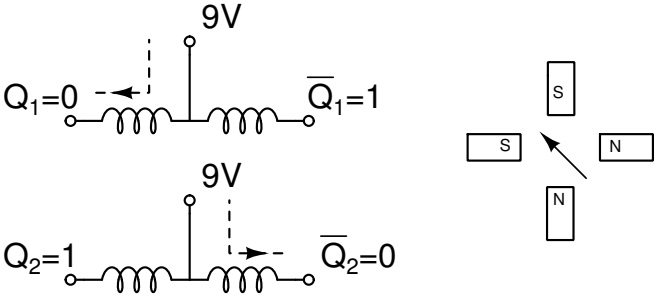
(1)


9V
$Q_1=1$
$\overline{Q}_1=0$
9V
$Q_2=0$
$\overline{Q}_2=1$
N
N
S
S

(2)

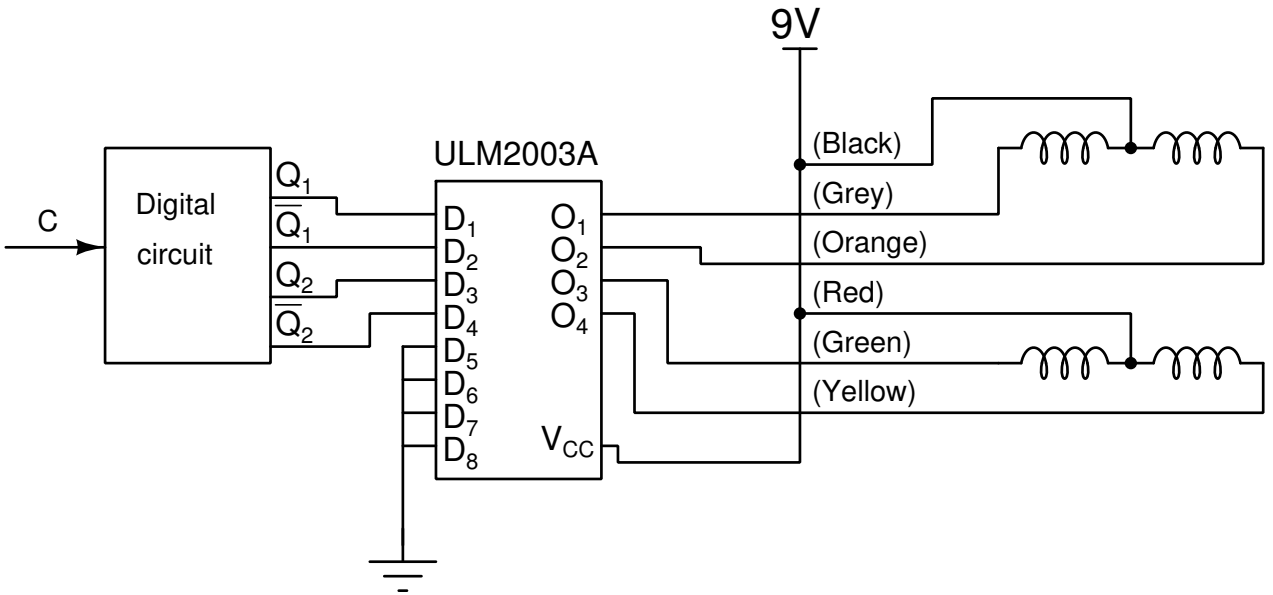

9V
$Q_1=0$
$\overline{Q}_1=1$
9V
$Q_2=0$
$\overline{Q}_2=1$
S
N
S
N

(3)


9V
$Q_1=0$
$\overline{Q}_1=1$
9V
$Q_2=1$
$\overline{Q}_2=0$
S
S
N
N

(4)

Stepper motor interface

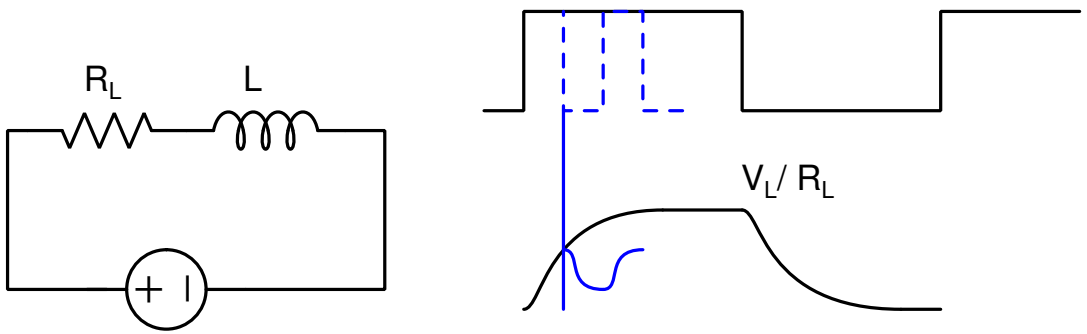


C = 1

Step	Q_1	Q_2
1	0	1
2	0	0
3	1	0
4	1	1

C = 0

Step	Q_1	Q_2
1	1	1
2	1	0
3	0	0
4	0	1



- Due to inductance of the winding, current takes time to build up
- If the clock frequency is too high, current will not build up to final value
- Torque is proportional to the current - As frequency is increased, at some point the motor will stop responding.

Experiment 9

Objective: Applications of digital circuits

- Figure out how the R-2R ladder D/A converter works. Wire up the circuit and measure the output voltage corresponding to each digital input. Find the step sizes between two successive digital inputs. Are all the step sizes the same? If not, explain why.
- Use the counter and the DAC to construct an (approximate) sawtooth waveform generator. Since the TTL gates cannot supply much current when the output is high, use a buffer(74245) to drive the resistors.

Experiment 10

- Design a circuit using D Flipflops and any other gates required, so that the states step through the table shown in the slide. The colours indicated at the output of the motor driver (ULN2003) are the colours of the stepper motor wires - so for example connect $Q_1(O1)$ to the grey wire of the motor. The DC resistance of the motor is about 24Ω/winding. At any given point, only two of the windings will be ON. They are effectively in parallel.
  (a) Before connecting the circuit to the power supply, turn on the supply and short the two terminals of the $30V$ source. Adjust *Iset* so that the current limit is set to $600mA$. Do not touch *Iset* after this.
  (b) Remove the short and connect V_{CC} of ULN2003 to the $30V$ source and adjust the voltage setting so that it supplies $9V$. The digital circuit should be connected to the $5V$ source as usual. Use the signal generator as the clock for the digital circuit and set the frequency to 100Hz.

(c) Slowly decrease the supply voltage of the motor until the motor stops rotating. What happens to the current drawn (and hence the available torque) by the motor?

(d) Increase the clock frequency from 100Hz to 400Hz in steps of 50Hz. Each time, before you increase the frequency, turn off the power supply. What is your observation?

(e) Plot current drawn versus frequency. What are your conclusions about available torque?