Homework #4

นายโสภณ สุขสมบูรณ์ 620101163788 sec.3 (PIV)

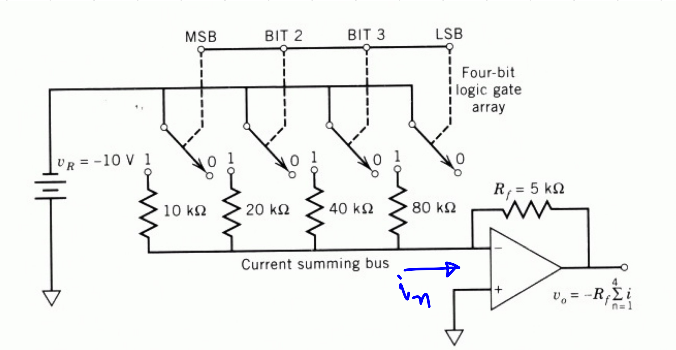


Figure 4.5 Schematic diagram of a simple 4-bit digital-to-analog converter.

4.13 For the 4-bit DAC shown in Fig. 4.5, determine the output voltage v_o for the following digital codes:

(a) 1101 (b) 1010 (c) 0110 (d) 0101 (e) 1001 (f) 1110

(a) 1101

let $i_n = \dfrac{v_R}{R_n}$; $n = 1,2,3,4$; $v_R = -10$V

$i_1 = -\dfrac{10}{10k} = -1\times10^{-3}$ A $= -1$ mA

$i_2 = -\dfrac{10}{20k} = -0.5\times10^{-3}$ A $= -0.5$ mA

$i_3 = 0$ (เนื่องจาก bit3 มีค่า logic = 0)

$i_4 = -\dfrac{10}{80k} = -0.125\times10^{-3}$ A $= -0.125$ mA

formula: $v_o = -R_f \sum_{n=1}^{4} i_n$

$v_o = (-5k)\sum_{n=4}^{4} i_n$

$= (-5k)[-1m - 0.5m + 0 - 0.125m]$

$= (-5\cancel{k})[-1.625\cancel{m}]$

$\therefore v_o = 8.125$ V

(b) 1010

$i_1 = -\dfrac{10}{10k} = -1\times10^{-3}$ A $= -1$ mA

$i_2 = i_4 = 0$ mA

$i_3 = -\dfrac{10}{40k} = -0.25$ mA

จะได้ $v_o = (-5k)[-1m - 0.25m]$

$= (-5\cancel{k})(-1.25\cancel{m})$

$\therefore v_o = 6.25$ V

(c) 0110

$i_1 = i_4 = 0$ mA

$i_2 = -\dfrac{10}{20k} = -0.5$ mA

$i_3 = \dfrac{-10}{40k} = -0.25$ mA

จะได้ $v_o = (-5k)[-0.5m - 0.25m]$

$= (-5k)[-0.75m]$

$\therefore v_o = 3.75$ V

4.13 For the 4-bit DAC shown in Fig. 4.5, determine the output voltage v_o for the following digital codes:

(a) 1101 (c) 0110 (e) 1001
(b) 1010 (d) 0101 (f) 1110

(d) 0101

$i_1 = i_3 = 0$ mA

$i_2 = \frac{-10}{20k} = -0.5$ mA

$i_4 = \frac{-10}{80k} = -0.125$ mA

จะได้ $v_o = (-5\cancel{k})[-0.5-0.125]\cancel{m}$

$\therefore v_o = 3.125$ V

(e) 1001

$i_1 = \frac{-10}{10k} = -1$ mA

$i_2 = i_3 = 0$ mA

$i_4 = \frac{-10}{80k} = -0.125$ mA

จะได้ $v_o = (-5\cancel{k})[-1-0.125]\cancel{m}$

$\therefore v_o = 5.625$ V

(f) 1110

$i_1 = \frac{-10}{10k} = -1$ mA

$i_2 = \frac{-10}{20k} = -0.5$ mA

$i_3 = \frac{-10}{40k} = -0.25$ mA

$i_4 = 0$ mA

จะได้ $v_o = (-5\cancel{k})[-1-0.5-0.25]\cancel{m}$

$\therefore v_o = 8.75$ V

4.17 Prepare an illustration, similar to Fig. 4.7, that demonstrates A/D conversion by the method of successive approximations if the fixed analog input voltage v_u is

(a) 1/8 FSV (c) 3/4 FSV
(b) 7/16 FSV (d) 13/16 FSV

formula: $$v_b = v_u + \frac{1}{2^{n+1}}\text{FSV}$$

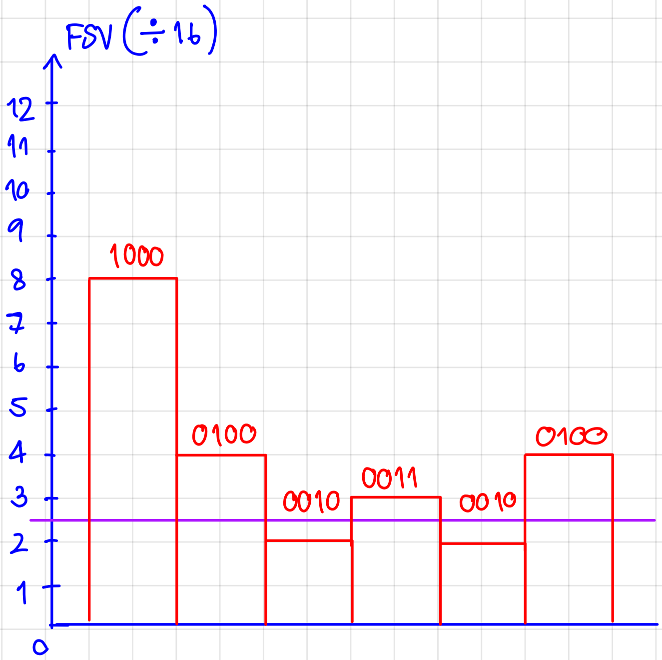
let n = 4 (number of Digits)

ดังนั้นค่าดิจิตอลที่ได้คือ 0010

(a) 1/8 FSV

; $v_b = \frac{1}{8}\text{FSV} + \frac{1}{2^5}\text{FSV} = \frac{5}{32}\text{FSV} = \frac{2.5}{16}\text{FSV}$

Register	D/A FSV	comparator
1000	8/16	$v_o > v_b$
0100	4/16	$v_o > v_b$
0010	2/16	$v_o < v_b$
0011	3/16	$v_o > v_b$
0010	2/16	$v_o < v_b$
0100	4/16	$v_o > v_b$



the advantages and disadvantages

4.17 Prepare an illustration, similar to Fig. 4.7, that demonstrates A/D conversion by the method of successive approximations if the fixed analog input voltage v_u is

(a) 1/8 FSV
(b) 7/16 FSV
(c) 3/4 FSV
(d) 13/16 FSV

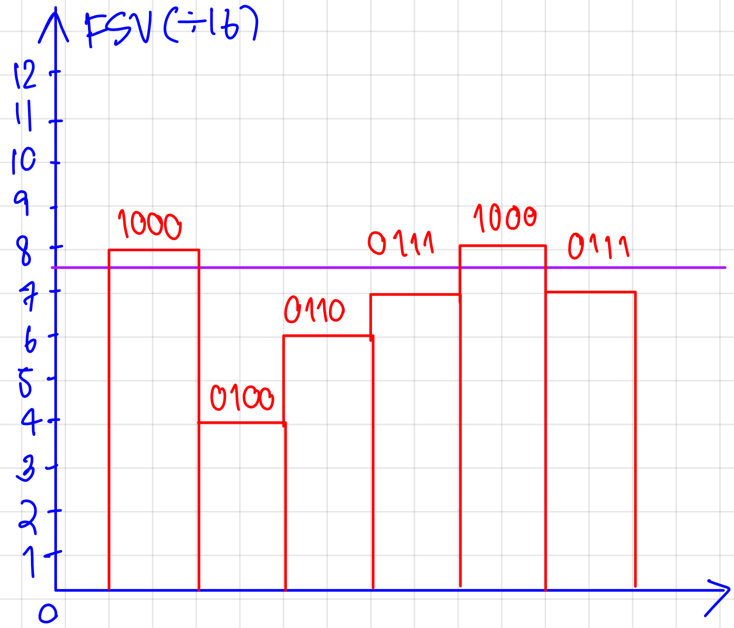
Formula: $$v_b = v_u + \frac{1}{2^{n+1}}\text{FSV}$$

(b) 7/16 FSV

จาก $v_b = v_u + \frac{1}{2^{n+1}} FSV$; $v_b = \frac{7}{16} FSV + \frac{1}{2^5} FSV$

$= \frac{15}{32} FSV = \frac{7.5}{16} FSV$

Register	D/A FSV	comparator
1000	8/16	$v_o > v_b$
0100	4/16	$v_o < v_b$
0110	6/16	$v_o < v_b$
0111	7/16	$v_o < v_b$
1000	8/16	$v_o > v_b$
0111	7/16	$v_o < v_b$

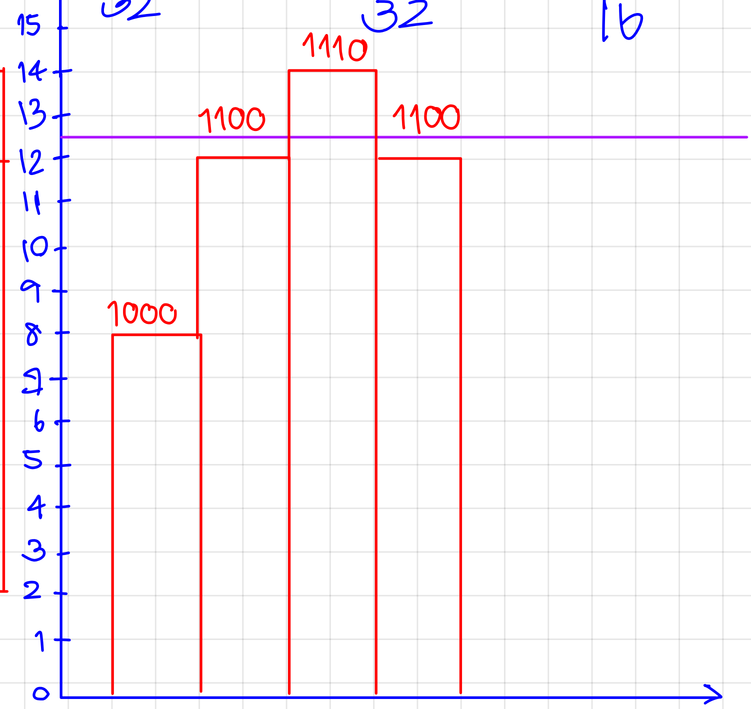


ดังนั้น ค่าดิจิตอลที่ได้คือ 0111 ##

(c) 3/4 FSV

จาก $v_b = v_u + \frac{1}{2^{n+1}} FSV$; $v_b = \frac{3}{4} FSV + \frac{1}{32} FSV = \frac{25}{32} FSV = \frac{12.5}{16} FSV$

Register	D/A FSV	Comparator
1000	8/16	$v_o < v_b$
1100	12/16	$v_o < v_b$
1110	14/16	$v_o > v_b$
1100	12/16	$v_o < v_b$



ดังนั้น ค่าดิจิตอลที่ได้ คือ 1100 ##

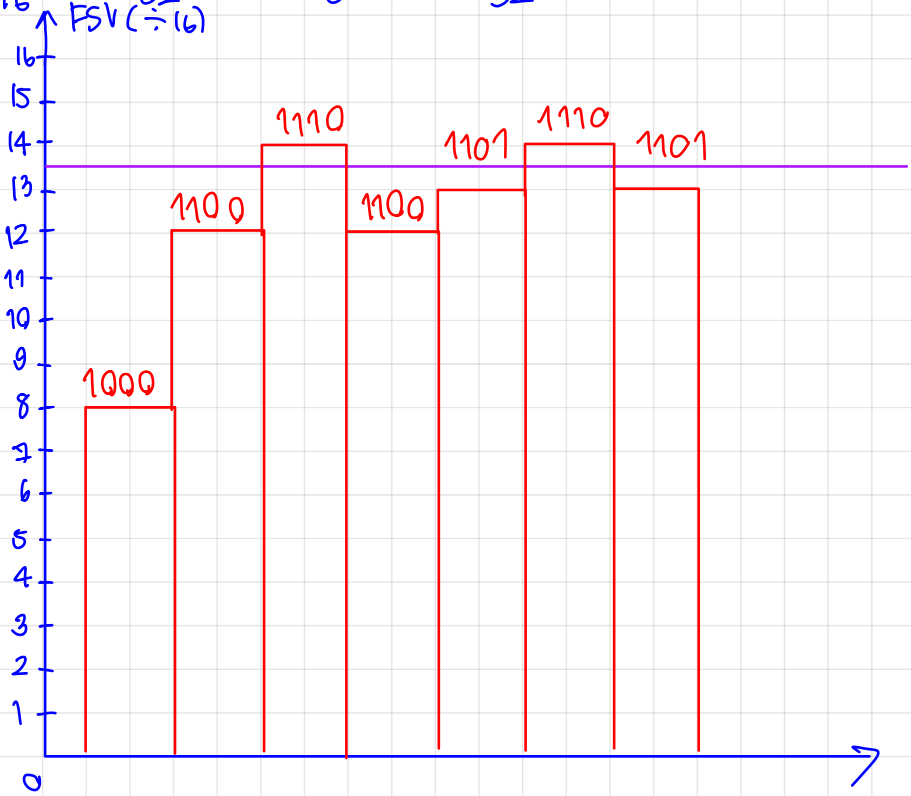
4.17 Prepare an illustration, similar to Fig. 4.7, that demonstrates A/D conversion by the method of successive approximations if the fixed analog input voltage v_u is

(a) 1/8 FSV (c) 3/4 FSV
(b) 7/16 FSV (d) 13/16 FSV

(d) 13/16 FSV

จาก $v_b = v_u + \frac{1}{2^{n+1}}$ FSV ; $v_b = \frac{13}{16}$ FSV $+ \frac{1}{32}$ FSV $= \frac{27}{32}$ FSV $= \frac{13.5}{32}$ FSV

Register	D/A FSV	comparator
1000	8/16	$v_o < v_b$
1100	12/16	$v_o < v_b$
1110	14/16	$v_o > v_b$
1100	12/16	$v_o < v_b$
1101	13/16	$v_o < v_b$
1110	14/16	$v_o > v_b$
1101	13/16	$v_o < v_b$



ดังนั้น ค่าดิจิตอลคือ 1101

4.23 Verify Eq. 4.16 beginning with Eq. ...
4.24 Determine the frequency limit of a 12-bit unipolar dual-slope integrating A/D converter capable of 20 readings per second.
... if the A/D converter of Exercise 4.24 is bipolar ...

formula : $f < \frac{2^{-n}}{\pi T}$

จาก $f < \frac{2^{-n}}{\pi T}$ โจทย์กำหนด $n = 12$-bit และ $f_{A/D} = 20\ s^{-1}$

; $f < \frac{2^{-12}}{\pi\left(\frac{1}{10}\right)}$

$\boxed{f = \frac{1}{T}}$

* เนื่องจากเป็น Dual-slope

$\boxed{f = \frac{2}{T}}$

$f < \frac{10 \times 2^{-12}}{\pi} = 0.777 \times 10^{-3}$ Hz

$\therefore$ $f < 0.777$ mHz

4.25 Determine the frequency limit if the A/D ... polar,

4.26 Determine the slew rate of the A/D converter in Exercise 4.24 if the FSV is

(a) 1 V
(b) 2 V
(c) 5 V
(d) 10 V

From eq. 4.14; $\left(\frac{dv_u}{dt}\right)_{\max} = \pi f v_u^*$

The term $(dv_u/dt)_{\max}$ is called the slew rate of the signal.

จากข้อ 4.24 จะได้ว่า $f = 0.777 \text{ mHz}$

หรือ $f = \frac{10 \times 2^{-12}}{\pi} \text{ Hz}$

(a) 1 V

จาก $\left(\frac{dv_u}{dt}\right)_{\max} = \pi f v_u^*$

; $\left(\frac{dv_u}{dt}\right)_{\max} = \cancel{\pi} \times \left(\frac{10 \times 2^{-12}}{\cancel{\pi}} s^{-1}\right) \times 1 \text{ V}$

$\therefore \left(\frac{dv_u}{dt}\right)_{\max} = 2.441 \text{ mV/s}$

(b) 2 V

จาก eq. 4.14; $\left(\frac{dv_u}{dt}\right)_{\max} = \pi \times \frac{10 \times 2^{-12}}{\pi} s^{-1} \times 2 \text{ V}$

$\therefore \left(\frac{dv_u}{dt}\right)_{\max} = 4.882 \text{ mV/s}$

(c) 5 V

จาก eq. 4.14; $\left(\frac{dv_u}{dt}\right)_{\max} = \pi \times \frac{10 \times 2^{-12}}{\pi} s^{-1} \times 5 \text{ V}$

$\therefore \left(\frac{dv_u}{dt}\right)_{\max} = 12.207 \text{ mV/s}$

(d) 10 V

จาก eq. 4.14; $\left(\frac{dv_u}{dt}\right)_{\max} = \pi \times \frac{10 \times 2^{-12}}{\pi} s^{-1} \times 10 \text{ V}$

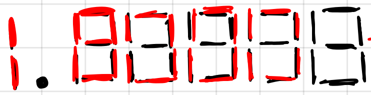
$\therefore \left(\frac{dv_u}{dt}\right)_{\max} = 24.414 \text{ mV/s}$

4.40 You are to measure a voltage v_i with a $5\frac{1}{2}$-digit DVM capable of 100% over-ranging. If the meter is specified with an accuracy of ± 0.002 % and ± 2 counts, determine the maximum and minimum readings anticipated if v_i is

(a) 1.80000 V (b) 2.50000 V (c) 9.99996 V

Measurement Error $= \pm(0.002\%\,\text{rdg} + 2d)$

(a) 1.80000 V



$\Rightarrow 5\frac{1}{2}$ Digit

$\Rightarrow d = 5$ digits.

จาก Measurement Error $= \pm(0.002\%\,\text{rdg} + 2d)$

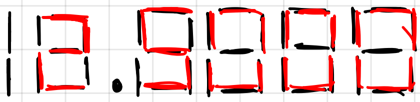
; Measurement Error $= \pm(0.002\%(1.80000) + 2(0.00001))$

$= \pm 5.6 \times 10^{-5}$ V

จะได้ว่า ค่า Maximum readings anticipated is $1.80000\text{ V} + 5.6\times10^{-5}\text{ V} = 1.800056$ V

ค่า Minimum readings anticipated is $1.80000\text{ V} - 5.6\times10^{-5}\text{ V} = 1.799944$ V #

(b) 2.50000 V



$\Rightarrow d = 4$ digits.

จาก Measurement Error $= \pm(0.002\%\,\text{rdg} + 2d)$

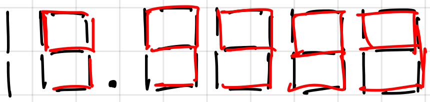
; Measurement Error $= \pm(0.002\%(2.50000) + 2(0.0001))$

$= \pm 0.25 \times 10^{-3}$ V

จะได้ว่า ค่า Maximum readings anticipated is $2.50000 + 0.25\times10^{-3} = 2.50025$ V

ค่า Minimum readings anticipated is $2.50000 - 0.25\times10^{-3} = 2.49975$ V #

(c) 9.99996 V



$\Rightarrow d = 4$ digits

จาก Measurement Error $= \pm(0.002\%\,\text{rdg} + 2d)$

; Measurement Error $= \pm(0.002\%(9.99996) + 2(0.0001))$

$= \pm 3.999 \times 10^{-4}$ V

จะได้ว่า ค่า Maximum readings anticipated is $9.99996 + 3.999\times10^{-4} = 10.00036$ V

ค่า Minimum readings anticipated is $9.99996 - 3.999\times10^{-4} = 9.99956$ V #