Final Project of Introduction to IC Design

A 6-bit RDAC with a unity-gain amplifier. The unity-gain amplifier is used to drive a capacitive load of 3 pF. The voltage levels on the resistor string are 2.5 V and 5 V. Note: please use PMOS transistors as pass transistors in the RDAC and use NMOS input differential amplifier to fit the input range.

The report includes

(1) Circuit Operation

(2) output waveform of the 6-bit RDAC with a unity-gain amplifier.

(2) Simulation results: refer to the following summary table.

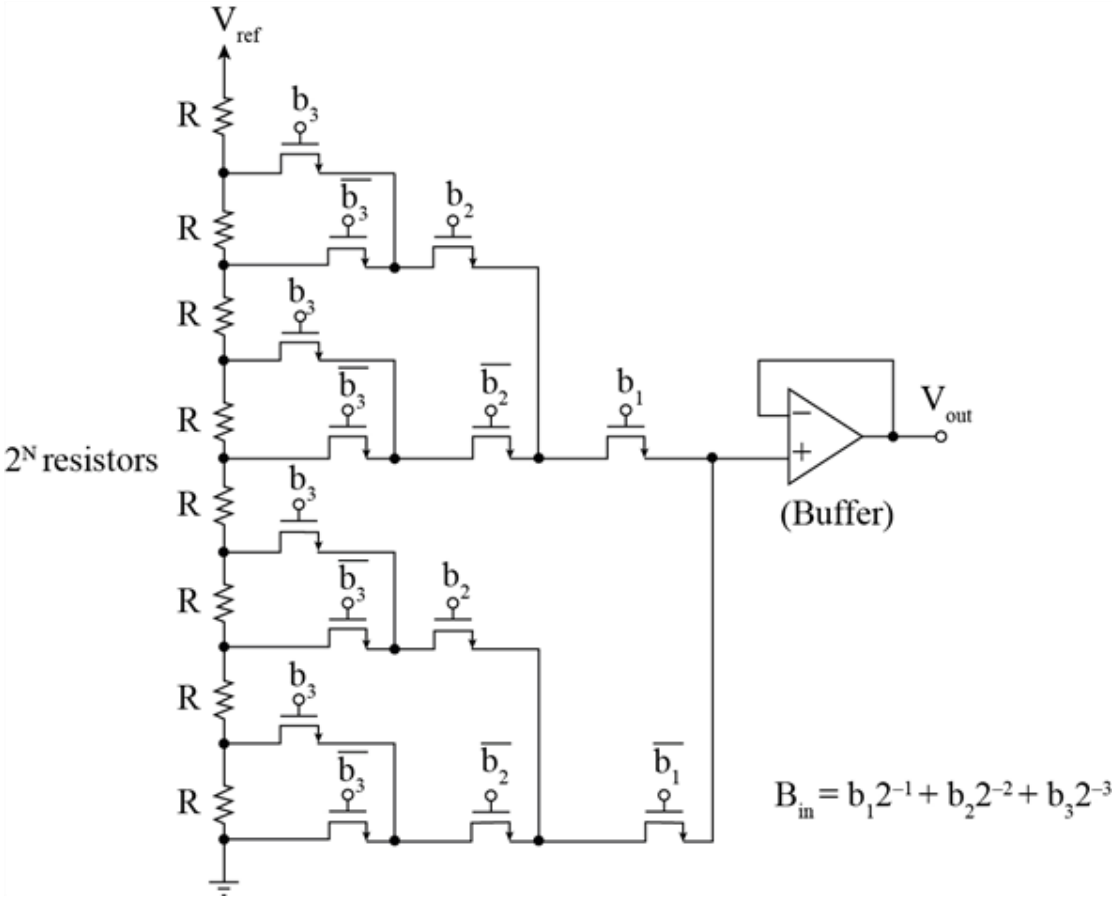
Table 1. Performance summary for Differential amplifier.

Power supply	5 V
Capacitance load	3 pF
Power consumption	275.1623uW
Phase margin	252.3665
Slew rate	28.7M

Table 2. Performance summary for 6-bit RDAC with unity-gain amplifier

Power supply	5 V
Capacitance load	3 pF
Power consumption	1.0259mW
VREFH/VREFL of Resistor string	5 V/2.5 V
INL	請見附表
DNL	請見附表

Schematic circuit:

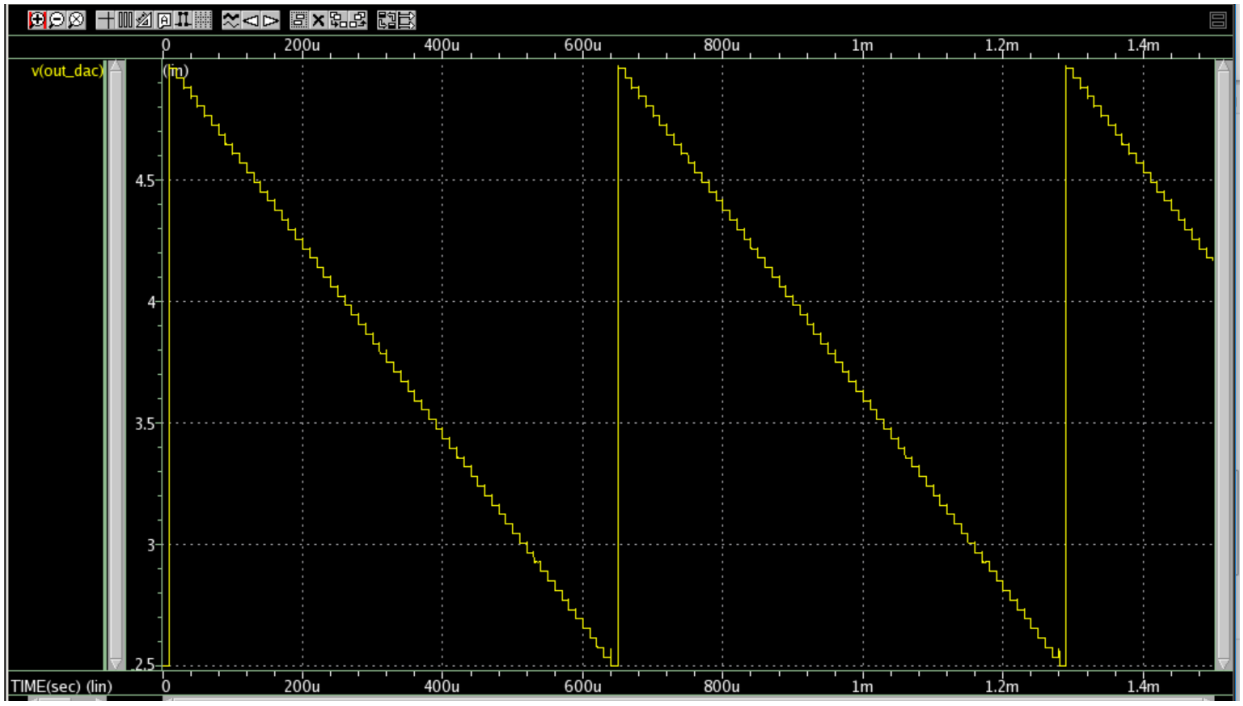


這張圖是 3 bits 的電路，但是 6bits 也可以以此類推，分六層，從最左邊開始，第一層 64 個 MOS，第二層 32 個 MOS，第三層 16 個 MOS，第四層 8 個 MOS，第五層 4 個 MOS，第六層 2 個 MOS，輸入為 b0 $\overline{b0}$ ，b1 $\overline{b1}$ ，b2 $\overline{b2}$ ，b3 $\overline{b3}$， b4 $\overline{b4}$ ，b5 $\overline{b5}$

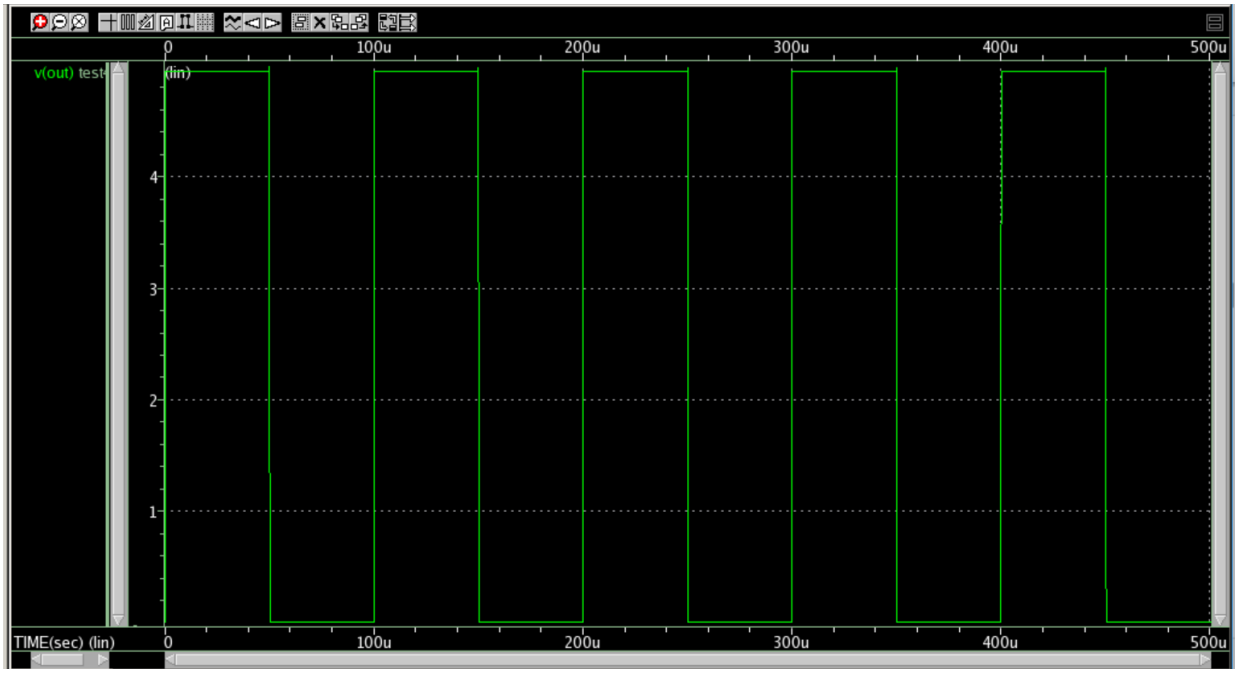
當輸入為 000000 時，b0b,b1b,b2b,b3b,b4b,b5b 導通，輸出最低伏，以此類推

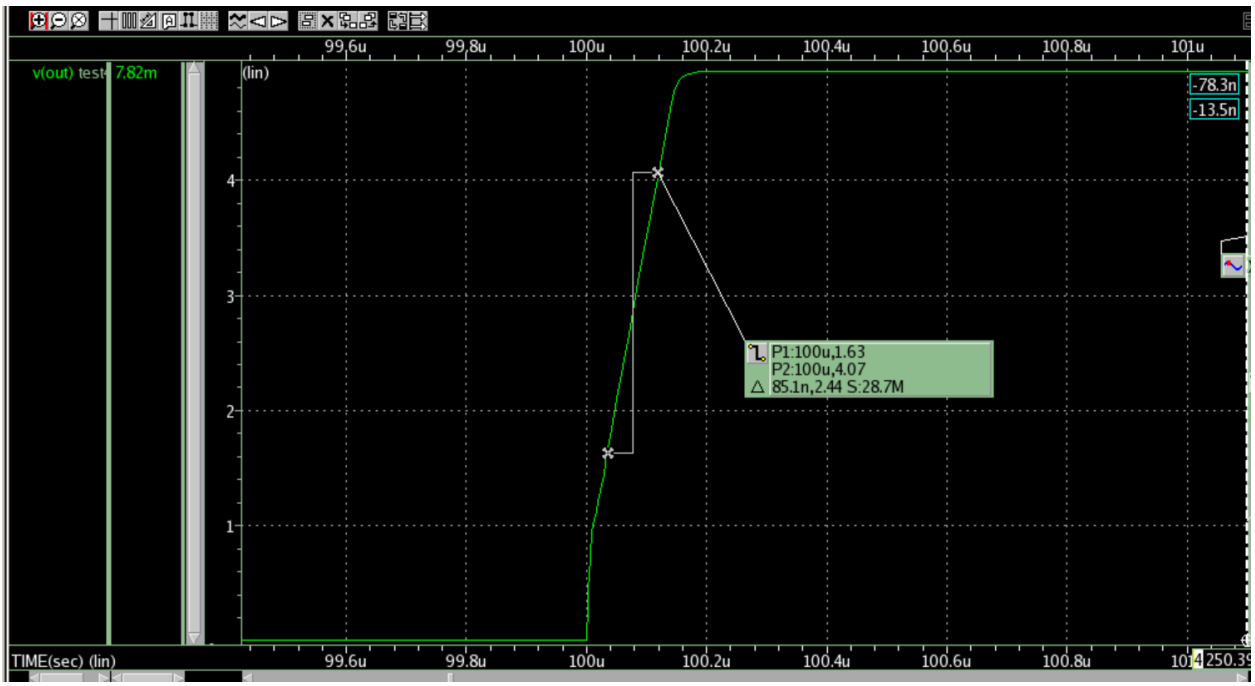
Output waveform：

6bits-RDAC



unity-gain amplifier

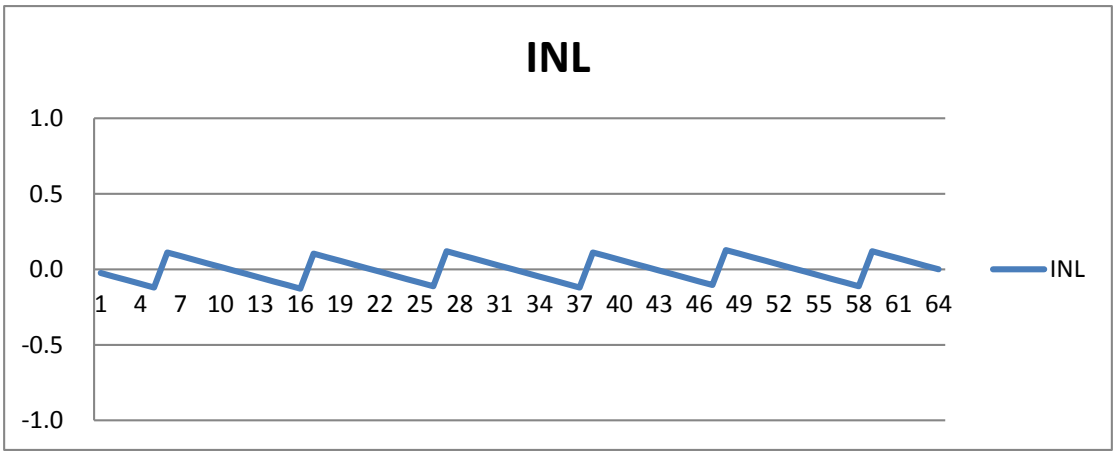


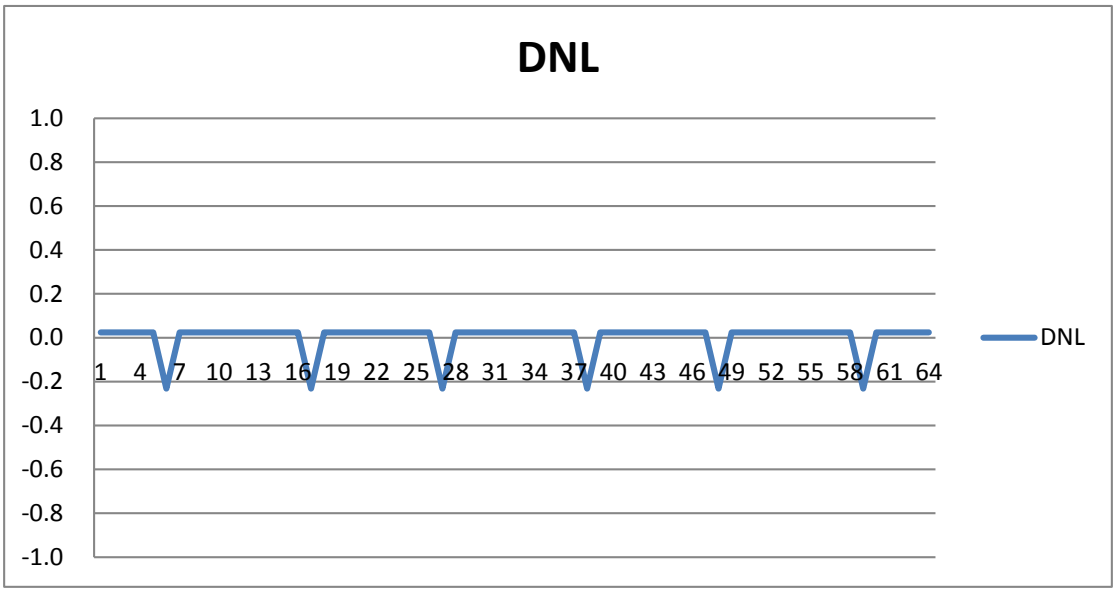

99.6u
99.8u
100u
100.2u
100.4u
100.6u
100.8u
101u
v(out) test
7.82m
(lin)
-78.3n
-13.5n
4
3
2
1
P1:100u,1.63
P2:100u,4.07
△ 85.1n,2.44 S:28.7M
TIME(sec) (lin)
99.6u
99.8u
100u
100.2u
100.4u
100.6u
100.8u
250.3

INL、DNL

VHIGH	5.0000000000		code	5.0000000000	INL	DNL	ideal
VLOW	2.5000000000	0	63	4.960000000000	-0.024000000000	0.024000000000	2.46
	0.0390625000	1	62	4.920000000000	-0.048000000000	0.024000000000	2.42
		2	61	4.880000000000	-0.072000000000	0.024000000000	2.38
		3	60	4.840000000000	-0.096000000000	0.024000000000	2.34
		4	59	4.800000000000	-0.120000000000	0.024000000000	2.30
		5	58	4.770000000000	0.112000000000	-0.232000000000	2.27
		6	57	4.730000000000	0.088000000000	0.024000000000	2.23
		7	56	4.690000000000	0.064000000000	0.024000000000	2.19
		8	55	4.650000000000	0.040000000000	0.024000000000	2.15
		9	54	4.610000000000	0.016000000000	0.024000000000	2.11
		10	53	4.570000000000	-0.008000000000	0.024000000000	2.07
		11	52	4.530000000000	-0.032000000000	0.024000000000	2.03
		12	51	4.490000000000	-0.056000000000	0.024000000000	1.99
		13	50	4.450000000000	-0.080000000000	0.024000000000	1.95
		14	49	4.410000000000	-0.104000000000	0.024000000000	1.91
		15	48	4.370000000000	-0.128000000000	0.024000000000	1.88
		16	47	4.340000000000	0.104000000000	-0.232000000000	1.84
		17	46	4.300000000000	0.080000000000	0.024000000000	1.80
		18	45	4.260000000000	0.056000000000	0.024000000000	1.76
		19	44	4.220000000000	0.032000000000	0.024000000000	1.72
		20	43	4.180000000000	0.008000000000	0.024000000000	1.68
		21	42	4.140000000000	-0.016000000000	0.024000000000	1.64
		22	41	4.100000000000	-0.040000000000	0.024000000000	1.60
		23	40	4.060000000000	-0.064000000000	0.024000000000	1.56
		24	39	4.020000000000	-0.088000000000	0.024000000000	1.52
		25	38	3.980000000000	-0.112000000000	0.024000000000	1.48
		26	37	3.950000000000	0.120000000000	-0.232000000000	1.45
		27	36	3.910000000000	0.096000000000	0.024000000000	1.41
		28	35	3.870000000000	0.072000000000	0.024000000000	1.37
		29	34	3.830000000000	0.048000000000	0.024000000000	1.33
		30	33	3.790000000000	0.024000000000	0.024000000000	1.29
		31	32	3.750000000000	0.000000000000	0.024000000000	1.25
		32	31	3.710000000000	-0.024000000000	0.024000000000	1.21
		33	30	3.670000000000	-0.048000000000	0.024000000000	1.17

		34	29	3.630000000000	-0.072000000000	0.024000000000	1.13
		35	28	3.590000000000	-0.096000000000	0.024000000000	1.09
		36	27	3.550000000000	-0.120000000000	0.024000000000	1.05
		37	26	3.520000000000	0.112000000000	-0.232000000000	1.02
		38	25	3.480000000000	0.088000000000	0.024000000000	0.98
		39	24	3.440000000000	0.064000000000	0.024000000000	0.94
		40	23	3.400000000000	0.040000000000	0.024000000000	0.90
		41	22	3.360000000000	0.016000000000	0.024000000000	0.86
		42	21	3.320000000000	-0.008000000000	0.024000000000	0.82
		43	20	3.280000000000	-0.032000000000	0.024000000000	0.78
		44	19	3.240000000000	-0.056000000000	0.024000000000	0.74
		45	18	3.200000000000	-0.080000000000	0.024000000000	0.70
		46	17	3.160000000000	-0.104000000000	0.024000000000	0.66
		47	16	3.130000000000	0.128000000000	-0.232000000000	0.63
		48	15	3.090000000000	0.104000000000	0.024000000000	0.59
		49	14	3.050000000000	0.080000000000	0.024000000000	0.55
		50	13	3.010000000000	0.056000000000	0.024000000000	0.51
		51	12	2.970000000000	0.032000000000	0.024000000000	0.47
		52	11	2.930000000000	0.008000000000	0.024000000000	0.43
		53	10	2.890000000000	-0.016000000000	0.024000000000	0.39
		54	9	2.850000000000	-0.040000000000	0.024000000000	0.35
		55	8	2.810000000000	-0.064000000000	0.024000000000	0.31
		56	7	2.770000000000	-0.088000000000	0.024000000000	0.27
		57	6	2.730000000000	-0.112000000000	0.024000000000	0.23
		58	5	2.700000000000	0.120000000000	-0.232000000000	0.20
		59	4	2.660000000000	0.096000000000	0.024000000000	0.16
		60	3	2.620000000000	0.072000000000	0.024000000000	0.12
		61	2	2.580000000000	0.048000000000	0.024000000000	0.08
		62	1	2.540000000000	0.024000000000	0.024000000000	0.04
		63	0	2.500000000000	0.000000000000	0.024000000000	0.00


INL
1.0
0.5
0.0
-0.5
-1.0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64
INL


DNL
1.0
0.8
0.6
0.4
0.2
0.0
-0.2
-0.4
-0.6
-0.8
-1.0
1 4 7 10 13 16 19 22 25 28 31 34 37 40 43 46 49 52 55 58 61 64
DNL