디지털논리회로설계

전북대학교 전자공학부
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교과목 소개

- 과목명: 디지털논리설계
  - 시간: 3시간 (월6~7, 수6)
- 장소: 공대 3호관 408호
- 교재
  - Digital Design, M. Mano and M. Ciletti, Prentice Hall
- 참고 문헌
  - 모든 논리회로 관련 교재
- 평가방법:
  - 학교 rule에 따라 상대평가 실시
  - 중간 20%, 기말 30%, Quiz 20%, 과제물 20%, 출석 5%
- 시험 일정
  - 중간고사: 4월 21일
  - 기말고사: 6월 9일

교과목 소개

- 다음 경우에 대하여 시험 성적에 관계 없이 무조건 F임
  - 출석미달(1/4 이상 결석): 2회 지각은 1회 결석으로 계산
  - 숙제 전체의 1/4이상 미제출
  - 중간 또는 기말시험 미응시
  - 부정행위
  - 과제물 copy 적발 시
- 문제 풀이 숙제 외에 요약 숙제가 있음
  - 교수의 지시에 따라 각 장이 시작되기 전에 교재를 읽고 그 장의 내용을 A4 용지 4페이지 이상 분량으로 요약하여 제출
  - QUIZ를 통하여 예습 내용 확인할 것임
- 과제물은 일주일 후 강의 시작 전에 제출: 그 외 시간에는 숙제를 받지 않음

기타 사항

- 강의 자료 및 공지 사항은 다음 홈페이지에서 확인
  - http://soclab.chonbuk.ac.kr
- 면담 시간 및 장소
  - 시간: 월요일 오후 4시 ~ 6시
  - 장소: 8호관 202호
- 조교 연구실: 7호관 501호

1. BINARY SYSTEM

BINARY NUMBER

- $a_5a_4a_3a_2a_1a_0.a_{-1}a_{-2}a_{-3}$

  $= a_nr^n + a_{n-1}r^{n-1} + \ldots + a_2r^2 + a_1r + a_0 + a_{-1}r^{-1} + a_{-2}r^{-2} + \ldots + a_{-m}r^{-m}$

  $7392 = 7 \times 10^3 + 3 \times 10^2 + 9 \times 10^1 + 2 \times 10^0$

  $$(11010.11)_2 = 1 \times 2^4 + 1 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 0 \times 2^0 + 1 \times 2^{-1}4 + 1 \times 2^{-2}$$

  $$= 26.75_{10}$$

  2^{10}= 1Kilo
  2^{20}= 1Mega
  2^{30}= 1Giga

Table 1-1
Powers of Two

n	2^n	n	2^n	n	2^n
0	1	8	256	16	65,536
1	2	9	512	17	131,072
2	4	10	1,024	18	262,144
3	8	11	2,048	19	524,288
4	16	12	4,096	20	1,048,576
5	32	13	8,192	21	2,097,152
6	64	14	16,384	22	4,194,304
7	128	15	32,768	23	8,388,608

Binary Number

Augend	101101	Minuend:	101101	Multiplicand:	101
Addend	+100111	Subtrahend:	-100111	Multiplier:	*101
Sum	1010100	Difference:	000110		1011
					0000
					1011
				Product:	10111

Augend: 피가수
Addend: 가수
sum: 합
Minuend: 피감수
subtrahend: 감수
Difference: 차
Multiplicand: 피승수
Multiplier: 승수
Product: 곱

NUMBER CONVERSIONS

- Ex 1-1) Convert decimal 41 to binary

	Integer Quotient		Remainder	Coefficient
41/2 =	20	+	1	a_0
20/2 =	10	+	0	a_1
10/2 =	5	+	0	a_2
5/2 =	2	+	1	a_3
2/2 =	1	+	0	a_4
1/2 =	0	+	1	a_5

Integer	Remainder
41	
20	1
10	0
5	0
2	1
1	0
0	1

answer : $(41)_{10}$ =

Quotient: 몫

Remainder: 나머지

Coefficient: 계수

NUMBER CONVERSIONS

- Ex 1-2) Convert decimal 153 to octal.

153	
19	1
2	3
0	2

- Ex 1-3) Convert (0.6875)10 to binary.

	Integer		Fraction	Coefficient
0.6875*2 =	1	+	0.3750	a
0.3750*2 =	0	+	0.7500	a
0.7500*2 =	1	+	0.5000	a
0.5000*2 =	1	+	0.0000	a

Answer: $(0.6875)_{10}$ =

octal: 8진수

OCTAL AND HEXADECIMAL NUMBERS

Table 1-2
Numbers with Different Bases

Decimal (base 10)	Binary (base 2)	Octal (base 8)	Hexadecimal (base 16)
00	0000	00	0
01	0001	01	1
02	0010	02	2
03	0011	03	3
04	0100	04	4
05	0101	05	5
06	0110	06	6
07	0111	07	7
08	1000	10	8
09	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

$$(\underline{10}\ \underline{110}\ \underline{001}\ \underline{101}\ \underline{011}\ .\ \underline{111}\ \underline{100}\ \underline{000}\ \underline{110})_2 = (26153.7460)_8$$

2 6 1 5 3 7 4 0 6

$$(\underline{10}\ \underline{1100}\ \underline{0110}\ \underline{1011}\ .\ \underline{1111}\ \underline{0010})_2 = (2C6B.F2)_{16}$$

2 C 6 B F 2

hexadecimal: 16진수

COMPLEMENTS – DIMINISHED RADIX COMPLEMENT

- (r-1)'s complements of N is $(r^n - 1) - N$
- r=10, r-1=9, 9'complements of N is $(10^n - 1) - N$
- Ex)
  - the 9's complements of 546700 is 999999-546700 = 453299
  - the 9's complements of 012398 is 999999-012398 = 987601
- For binary number, r=2, r-1=1 $(2^n - 1) - N$
- 1'complements of N is
- Ex)
  - the 1's complements of 1011000 is 0100111
  - the 1's complements of 0101101 is 1010010

0은 1로, 1은 0으로 변경

COMPLEMENTS – RADIX COMPLEMENT

- The r's complements of an n-digit number N is $r^n - N, N \neq 0$.
- The r's complements of an n-digit number 0 is 0.
- $r^n - N = [(r^n - 1) - N] + 1$
  - The r's complements is obtained by adding 1 to the (r-1)'s complements
- Ex)
  - The 10's complements of 012398 is 987602
  - The 10's complements of 246700 is 753300
  - The 2's complements of 1101100 is 0010100
  - The 2's complements of 0110111 is 1001001

Complements – Subtraction with Complements

r's complement of B $= \boldsymbol{B} = r^n - B$

$$
\begin{aligned}
A + \boldsymbol{B} &= A + r^n - B \\
&= A - B + r^n
\end{aligned}
$$

$$A - B = A + \boldsymbol{B} - r^n$$

$$
\begin{aligned}
A + \boldsymbol{B} &= A + r^n - B \\
&= A - B + r^n \\
&= r^n - (B - A)
\end{aligned}
$$

$$B - A = r^n - (A + \boldsymbol{B}) = \text{r's complement of } (A + \boldsymbol{B})$$

$$A - B = -\text{r's complement of } (A + \boldsymbol{B})$$

Complements – Subtraction with Complements

- Ex1-5) using 10's complement, subtract 72532-3250. (r = 10, n = 5)

M =	72532
10's complement of 3250 =	+ 96750
Sum =	169282
Discard end carry 10	-100000
Answer =	69282

Complements – Subtraction with Complements

- Ex1-6) Using 10's complement, subtract 3250-72532.

M =	03250
10's complement of 72532 =	+27468
Sum =	30718

- There is no end carry
- Therefore, the answer is –(10's complement of 30718)=-69282

Complements – Subtraction with Complements

- Ex1-7) X=1010100, Y=1000011, (a) X-Y, (b) Y-X

X = 1010100

2's complement of Y = +0111101

Sum = 10010001

Discard end carry 2 -10000000

Answer: X-Y =

Y = 1000011

2's complement of X = +0101100

Sum = 1101111

There is no carry.

The answer is Y-X =

SIGNED BINARY NUMBERS

- Ex) The number 9 represented in binary with eight bit
  - +9 : 00001001
  - -9 : 10001001 (signed-magnitude representation)
  - 11110110 (signed-1’s-complement representation)
  - 11110111 (signed-2’s-complement representation)

Table 1-3
Signed Binary Numbers

Decimal	Signed-2’s complement	Signed-1’s complement	Signed magnitude
+7	0111	0111	0111
+6	0110	0110	0110
+5	0101	0101	0101
+4	0100	0100	0100
+3	0011	0011	0011
+2	0010	0010	0010
+1	0001	0001	0001
+0	0000	0000	0000
−0	—	1111	1000
−1	1111	1110	1001
−2	1110	1101	1010
−3	1101	1100	1011
−4	1100	1011	1100
−5	1011	1010	1101
−6	1010	1001	1110
−7	1001	1000	1111
−8	1000	—	—

SIGNED BINARY NUMBERS

- Ex) The number 9 represented in binary with eight bit
  - -9 : 10001001 (signed-magnitude representation)

sign

magnitude

Table 1-3
Signed Binary Numbers

Decimal	Signed-2's complement	Signed-1's complement	Signed magnitude
+7	0111	0111	0111
+6	0110	0110	0110
+5	0101	0101	0101
+4	0100	0100	0100
+3	0011	0011	0011
+2	0010	0010	0010
+1	0001	0001	0001
+0	0000	0000	0000
−0	—	1111	1000
−1	1111	1110	1001
−2	1110	1101	1010
−3	1101	1100	1011
−4	1100	1011	1100
−5	1011	1010	1101
−6	1010	1001	1110
−7	1001	1000	1111
−8	1000	—	—

SIGNED BINARY NUMBERS

- Ex) The number 9 represented in binary with eight bit
  - -9 : 11110110 (signed-1's-complement representation)

-9 is represented by the 1's complement of +9 (00001001).

Table 1-3
Signed Binary Numbers

Decimal	Signed-2's complement	Signed-1's complement	Signed magnitude
+7	0111	0111	0111
+6	0110	0110	0110
+5	0101	0101	0101
+4	0100	0100	0100
+3	0011	0011	0011
+2	0010	0010	0010
+1	0001	0001	0001
+0	0000	0000	0000
−0	—	1111	1000
−1	1111	1110	1001
−2	1110	1101	1010
−3	1101	1100	1011
−4	1100	1011	1100
−5	1011	1010	1101
−6	1010	1001	1110
−7	1001	1000	1111
−8	1000	—	—

SIGNED BINARY NUMBERS

- Ex) The number 9 represented in binary with eight bit
    - -9 : 11110111 (signed-2's-complement representation)

-9 is represented by the 2's complement of +9 (00001001).

Table 1-3
Signed Binary Numbers

Decimal	Signed-2's complement	Signed-1's complement	Signed magnitude
+7	0111	0111	0111
+6	0110	0110	0110
+5	0101	0101	0101
+4	0100	0100	0100
+3	0011	0011	0011
+2	0010	0010	0010
+1	0001	0001	0001
+0	0000	0000	0000
−0	—	1111	1000
−1	1111	1110	1001
−2	1110	1101	1010
−3	1101	1100	1011
−4	1100	1011	1100
−5	1011	1010	1101
−6	1010	1001	1110
−7	1001	1000	1111
−8	1000	—	—

Signed Binary Numbers

- Arithmetic Addition
  - signed-magnitude system follows the rules of ordinary arithmetic.
  - signed-complement system requires only addition.

+6	00000110	-6	11111010
+13	00001101	+13	00001101
+19	00010011	+7	00000111

+6	00000110	-6	11111010
-13	11110011	-13	11110011
-7	11111001	-19	11101101

SIGNED BINARY NUMBERS

- Arithmetic Subtraction
  - (±A)-(+B) = (±A)+(-B)
  - (±A)-(-B) = (±A)+(+B)

-B is either 1's complement or 2's complement of B.

A-B is A + 2's complement of B.

We don't need to perform subtraction.

BINARY CODE-BCD CODE

- the 4-bit code for one decimal
  - $(185)_{10}$ = (0001 1000 0101)BCD = (10111001)2
- BCD Addition

4	0100	4	0100	8	1000
+5	+0101	+8	+1000	+9	+1001
9	1001	12	1100	17	10001
			+0110		+0110
			10010		10111

Table 1-4
Binary Coded Decimal (BCD)

Decimal symbol	BCD digit
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

If the binary sum is greater or equal to 1010, we add 0110 to obtain the correct BCD

BINARY CODE-OTHER DECIMAL CODES

Table 1-5
Four Different Binary Codes for the Decimal Digits

Decimal digit	BCD 8421	2421	Excess-3	8 4-2-1
0	0000	0000	0011	0 0 0 0
1	0001	0001	0100	0 1 1 1
2	0010	0010	0101	0 1 1 0
3	0011	0011	0110	0 1 0 1
4	0100	0100	0111	0 1 0 0
5	0101	1011	1000	1 0 1 1
6	0110	1100	1001	1 0 1 0
7	0111	1101	1010	1 0 0 1
8	1000	1110	1011	1 0 0 0
9	1001	1111	1100	1 1 1 1
	1010	0101	0000	0 0 0 1
Unused	1011	0110	0001	0 0 1 0
bit	1100	0111	0010	0 0 1 1
combi-	1101	1000	1101	1 1 0 0
nations	1110	1001	1110	1 1 0 1
	1111	1010	1111	1 1 1 0

BINARY CODE-GRAY CODE

Table 1-6
Gray Code

Gray code	Decimal equivalent
0000	0
0001	1
0011	2
0010	3
0110	4
0111	5
0101	6
0100	7
1100	8
1101	9
1111	10
1110	11
1010	12
1011	13
1001	14
1000	15

BINARY CODE- ASCII CHARACTER CODE

Table 1-7
American Standard Code for Information Interchange (ASCII)

	$b_7 b_6 b_5$							
$b_4 b_3 b_2 b_1$	**000**	**001**	**010**	**011**	**100**	**101**	**110**	**111**
0000	NUL	DLE	SP	0	@	P	`	p
0001	SOH	DC1	!	1	A	Q	a	q
0010	STX	DC2	“	2	B	R	b	r
0011	ETX	DC3	#	3	C	S	c	s
0100	EOT	DC4	$	4	D	T	d	t
0101	ENQ	NAK	%	5	E	U	e	u
0110	ACK	SYN	&	6	F	V	f	v
0111	BEL	ETB	‘	7	G	W	g	w
1000	BS	CAN	(	8	H	X	h	x
1001	HT	EM	)	9	I	Y	i	y
1010	LF	SUB	*	:	J	Z	j	z
1011	VT	ESC	+	;	K	[	k	{
1100	FF	FS	,	<	L	\	l	|
1101	CR	GS	−	=	M	]	m	}
1110	SO	RS	.	>	N	∧	n	~
1111	SI	US	/	?	O	—	o	DEL

BINARY CODE

- Error-Detecting Code

	With even parity	With odd parity
ASCII A = 1000001	01000001	11000001
ASCII T = 1010100	11010100	01010100

Binary Storage and Registers

- Registers – A register with n cells can store any discrete quantity of information that contains n bits.
- Register Transfer

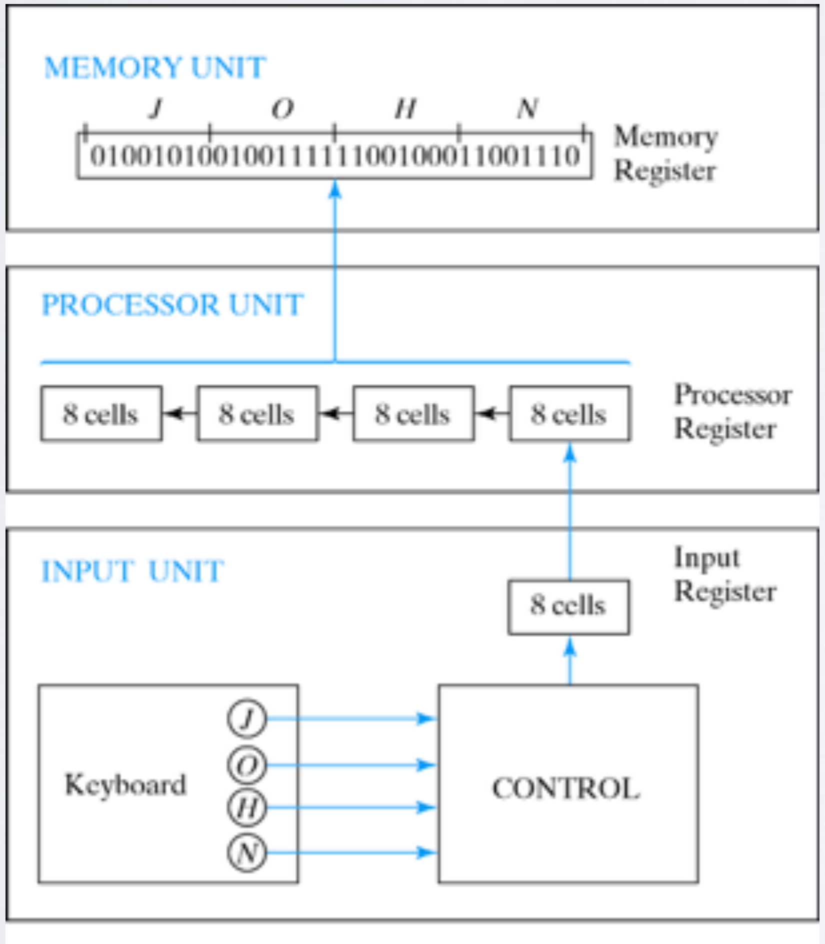

Fig. 1-1 Transfer of information with registers

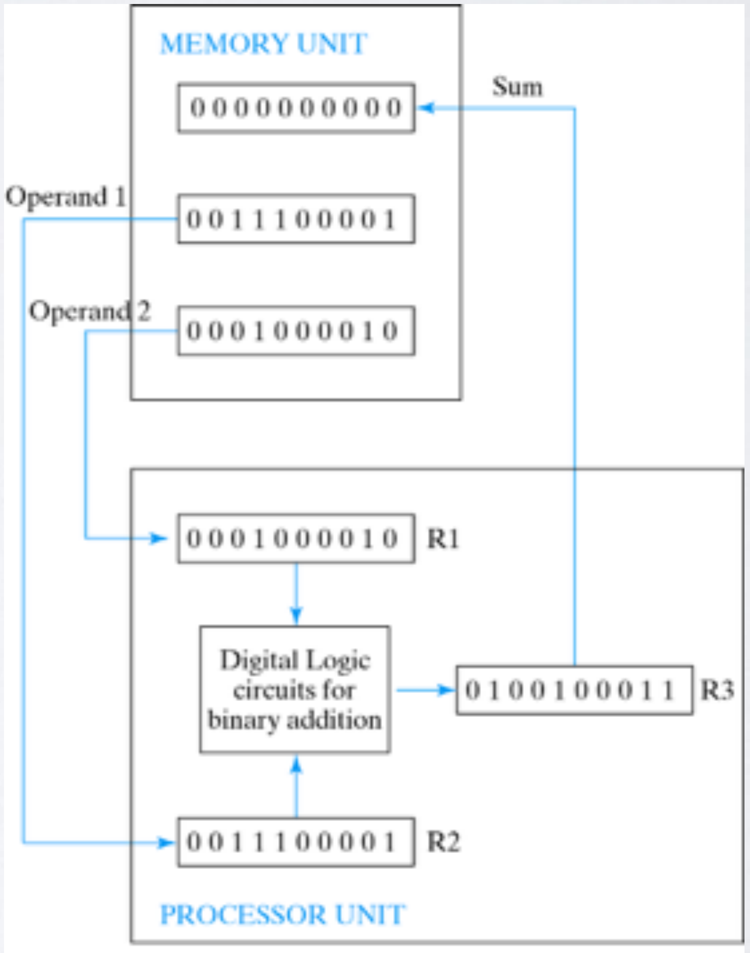

Fig. 1-2 Example of binary information processing