

임베디드시스템 기초(#514115)

#3. LCD_A controller

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LCD_A Controller Module

- ▶ LCD (Liquid Crystal Display)
 - ▶ 액정표시장치, 액정 디스플레이
 - ▶ <http://en.wikipedia.org/wiki/LCD>
 - ▶ 저가 제품의 경우 반사형, mono(흑백) 사용
- ▶ MSP430 내장 LCD controller
 - ▶ 단순 흑백 LCD의 경우도 제어해야 하는 세그먼트가 매우 많으므로 이를 편리하고 효과적으로 제어하기 위해 전용 컨트롤러가 이용됨.
 - ▶ 대개 MUX(multiplex) 기법(2,3,4-mux) 적용
 - ▶ 2종류의 LCD controller를 내장(LCD or LCD_A)
 - ▶ LCD_A의 부가 사항: charge pump 내장, contrast control 가능
 - ▶ FG461X series: LCD_A controller 내장

LCD & LCD_A controller 차이점

▶ LCD controller (Ch.24)

- ▶ 모든 MSP430x4xx 장치 내장
- ▶ Features
 - ▶ Display memory
 - ▶ Automatic signal generation
 - ▶ Blinking capability
 - ▶ Support for 4 types of LCDs:
 - Static
 - 2-mux, 1/2 bias
 - 3-mux, 1/3 bias
 - 4-mux, 1/3 bias

▶ LCD_A controller (Ch.25)

- ▶ MSP430x42x0, MSP430FG461x 내장
- ▶ Features
 - ▶ Display memory
 - ▶ Automatic signal generation
 - ▶ Blinking capability
 - ▶ Regulated charge pump
 - ▶ Contrast control by software
 - ▶ Support for 4 types of LCDs:
 - Static
 - 2-mux, 1/2 bias
 - 3-mux, 1/3 bias
 - 4-mux, 1/3 bias

Block diagrams of LCD, LCD_A

LCD_A controller

Figure 24-1. LCD Controller Block Diagram

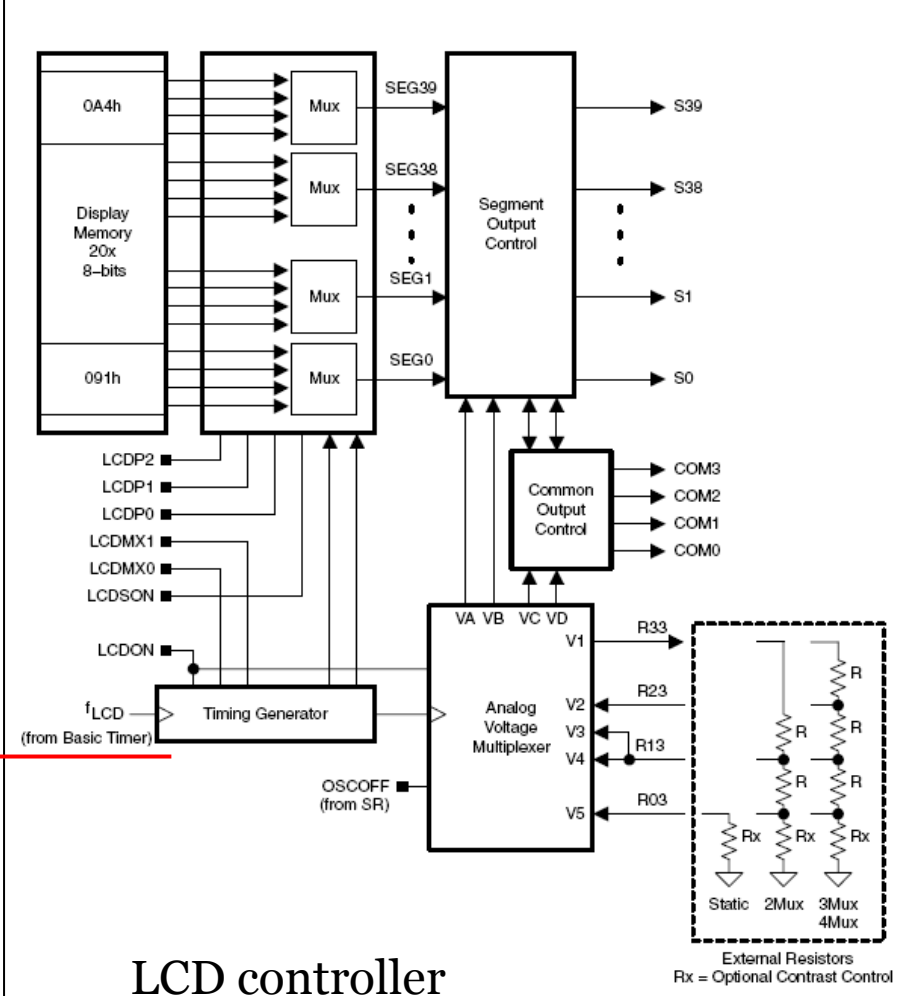
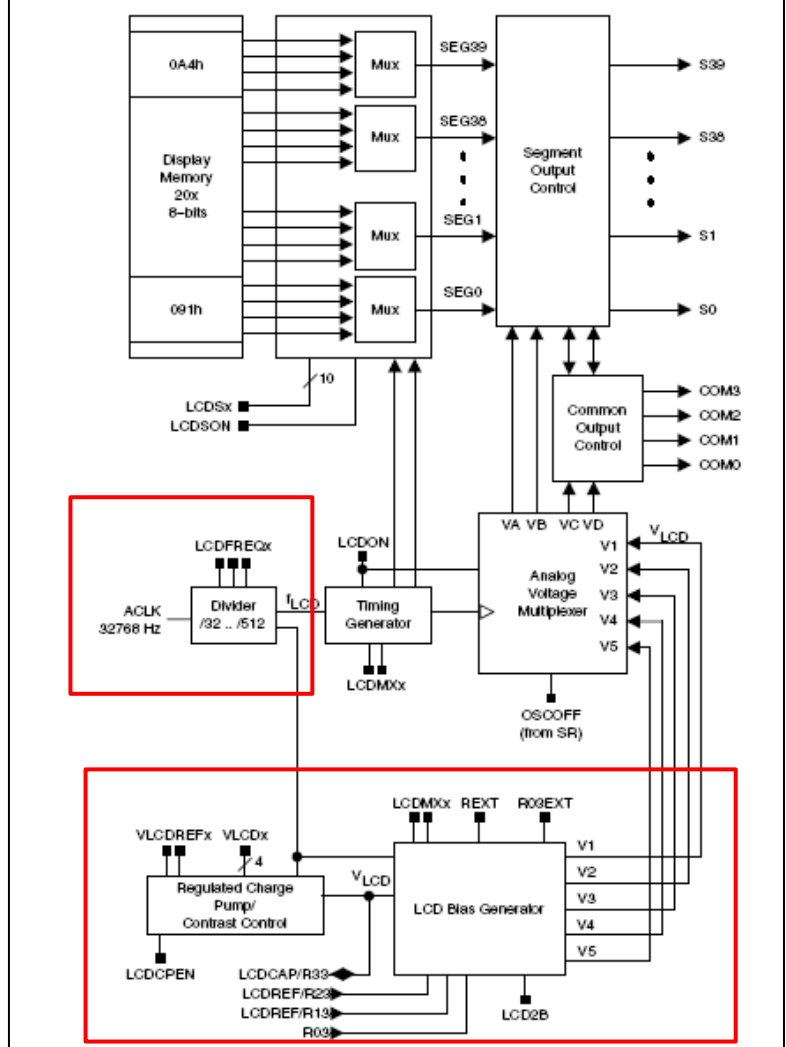
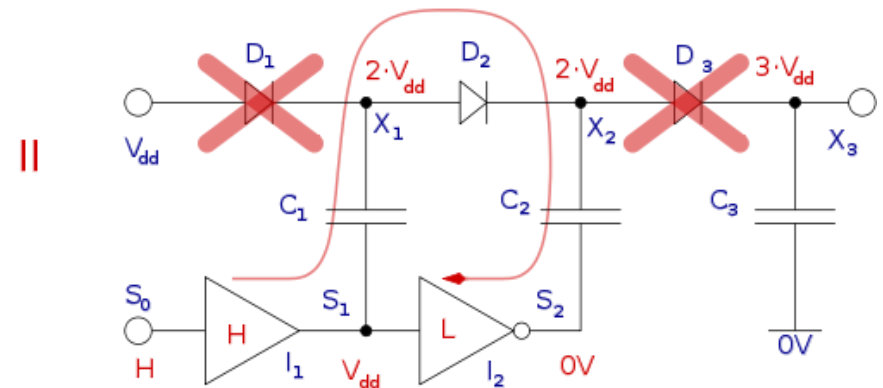
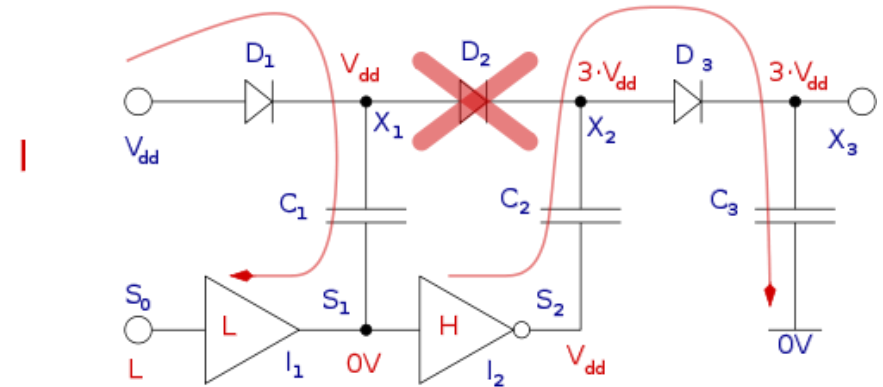


Figure 25-1. LCD_A Controller Block Diagram



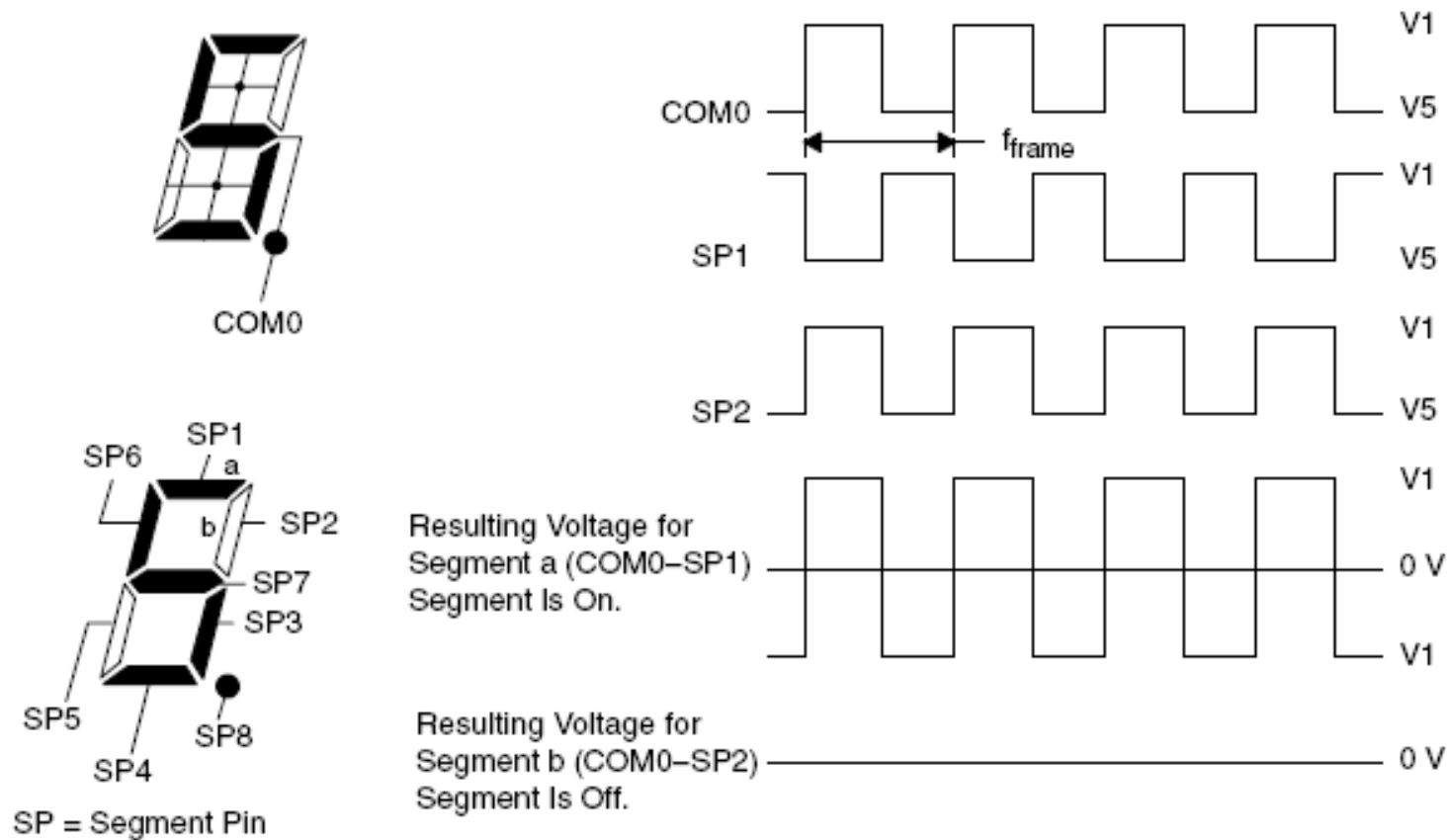
*Charge pump

- ▶ What is charge pump?
 - ▶ http://en.wikipedia.org/wiki/Charge_pump
 - ▶ A kind of DC to DC converter that uses capacitors as energy storage elements to create either a higher or lower voltage power source.
- ▶ How to work?
 - ▶ Use some form of switching device(s) to control the voltage of the capacitor.
 - ▶ 오른쪽 그림 참조.
- ▶ Applications
 - ▶ RS-232 level converters
 - ▶ LCD/LED drivers
 - ▶ Flash memory erasing circuit



LCD_A Controller 작동 원리: Static

Figure 25-4. Example Static Waveforms



Static LCD Example

Figure 25-5. Static LCD Example

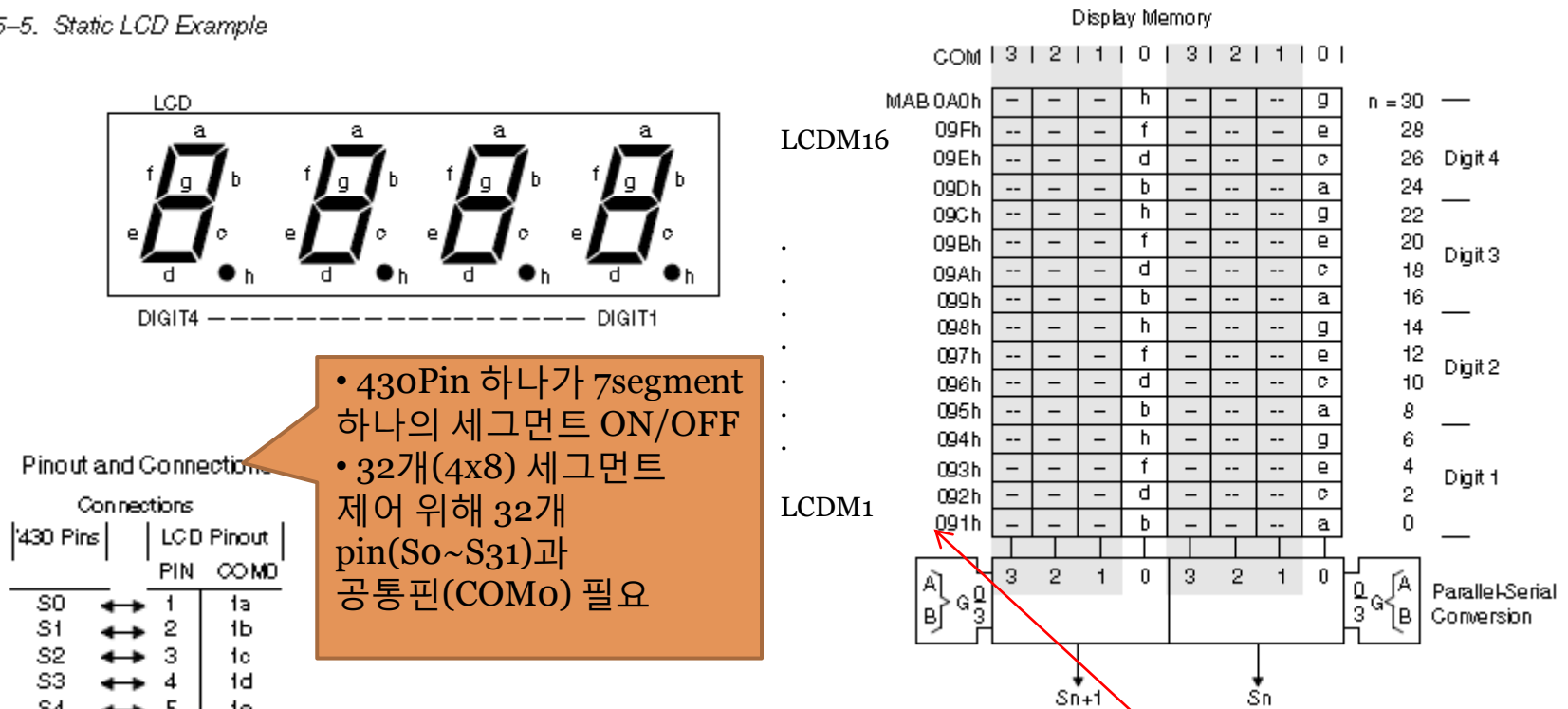
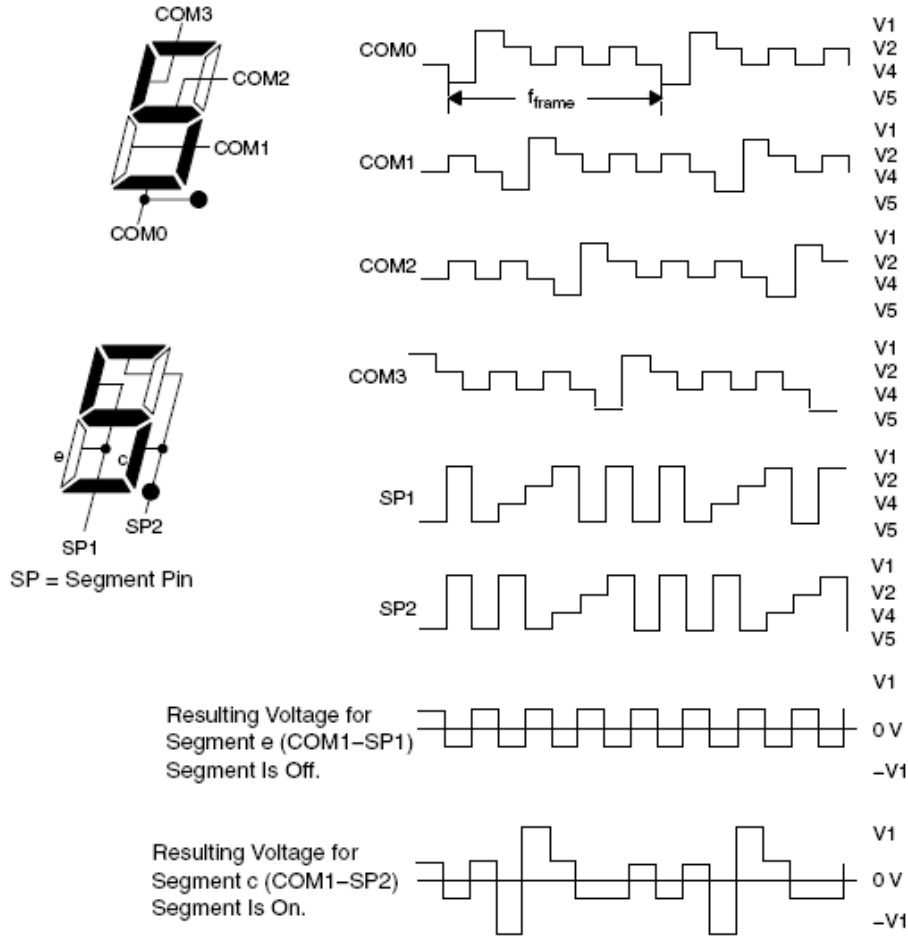


Table 25-2. LCD Controller Registers

Register	Short Form	Register Type	Address	Initial State
LCD_A control register	LCDACTL	Read/write	090h	Reset with PUC
LCD memory 1	LCDM1	Read/write	091h	Unchanged
LCD memory 2	LCDM2	Read/write	092h	Unchanged
LCD memory 3	LCDM3	Read/write	093h	Unchanged
LCD memory 4	LCDM4	Read/write	094h	Unchanged

LCD_A Controller 작동 원리: 4-mux waveform

Figure 25-10. Example 4-Mux Waveforms



- $V_{RMS,OFF}$: OFF 신호일 때의 평균적(RMS; root mean square) 전압 값 → 완전한 0이 아님!
- $V_{RMS,ON}$: ON 신호 값
- Contrast Ratio: ON/OFF 비율, 이 값이 클 수록 구별이 잘 됨.

Mode	Bias Config	$V_{RMS,OFF}/V_{LCD}$	$V_{RMS,ON}/V_{LCD}$	Contrast Ratio $V_{RMS,ON}/V_{RMS,OFF}$
Static	Static	0	1	1/0
2-mux	1/2	0.354	0.791	2.236
2-mux	1/3	0.333	0.745	2.236
3-mux	1/2	0.408	0.707	1.732
3-mux	1/3	0.333	0.638	1.915
4-mux	1/2	0.433	0.661	1.528
4-mux	1/3	0.333	0.577	1.732

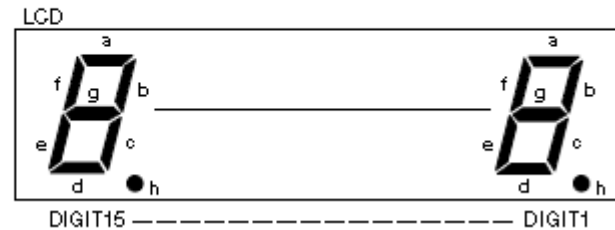
LCD_A Controller 작동 원리: 4-mux example

Figure 25-11.4-Mux LCD Example

Pinout and Connections

Connections		LCD Pinout			
1430 Pins	PIN	COM0	COM1	COM2	COM3
S0	↔ 1	1d	1e	1g	1f
S1	↔ 2	1h	1c	1b	1a
S2	↔ 3	2d	2e	2g	2f
S3	↔ 4	2h	2c	2b	2a
S4	↔ 5	3d	3e	3g	3f
S5	↔ 6	3h	3c	3b	3a
S6	↔ 7	4d	4e	4g	4f
S7	↔ 8	4h	4c	4b	4a
S8	↔ 9	5d	5e	5g	5f
S9	↔ 10	5h	5c	5b	5a
S10	↔ 11	6d	6e	6g	6f
S11	↔ 12	6h	6c	6b	6a
S12	↔ 13	7d	7e	7g	7f
S13	↔ 14	7h	7c	7b	7a
S14	↔ 15	8d	8e	8g	8f
S15	↔ 16	8h	8c	8b	8a
S16	↔ 17	9d	9e	9g	9f
S17	↔ 18	9h	9c	9b	9a
S18	↔ 19	10d	10e	10g	10f
S19	↔ 20	10h	10c	10b	10a
S20	↔ 21	11d	11e	11g	11f
S21	↔ 22	11h	11c	11b	11a
S22	↔ 23	12d	12e	12g	12f
S23	↔ 24	12h	12c	12b	12a
S24	↔ 25	13d	13e	13g	13f
S25	↔ 26	13h	13c	13b	13a
S26	↔ 27	14d	14e	14g	14f
S27	↔ 28	14h	14c	14b	14a
S28	↔ 29	15d	15e	15g	15f
S29	↔ 30	15h	15c	15b	15a
COM0	↔ 31	COM0			
COM1	↔ 32		COM1		
COM2	↔ 33			COM2	
COM3	↔ 34				COM3

Pin 하나가
4개 세그먼트
제어 → 4-
Mux 의미



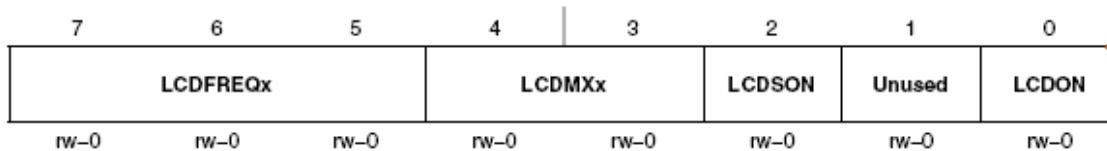
Display Memory

COM	3	2	1	0	3	2	1	0	
MAB 09Fh	a	b	c	h	f	g	e	d	n = 30 Digit 16
09Eh	a	b	c	h	f	g	e	d	28 Digit 15
09Dh	a	b	c	h	f	g	e	d	26 Digit 14
09Ch	a	b	c	h	f	g	e	d	24 Digit 13
09Bh	a	b	c	h	f	g	e	d	22 Digit 12
09Ah	a	b	c	h	f	g	e	d	20 Digit 11
099h	a	b	c	h	f	g	e	d	18 Digit 10
098h	a	b	c	h	f	g	e	d	16 Digit 9
097h	a	b	c	h	f	g	e	d	14 Digit 8
096h	a	b	c	h	f	g	e	d	12 Digit 7
095h	a	b	c	h	f	g	e	d	10 Digit 6
094h	a	b	c	h	f	g	e	d	8 Digit 5
093h	a	b	c	h	f	g	e	d	6 Digit 4
092h	a	b	c	h	f	g	e	d	4 Digit 3
091h	a	b	c	h	f	g	e	d	2 Digit 2
	a	b	c	h	f	g	e	d	0 Digit 1

LCDM1:[01100000]
→ Digit1
7세그먼트의 b,c
ON → 숫자 1 표시.
LCDM2:[11000111]
→ Digit2에 숫자 2
표시.

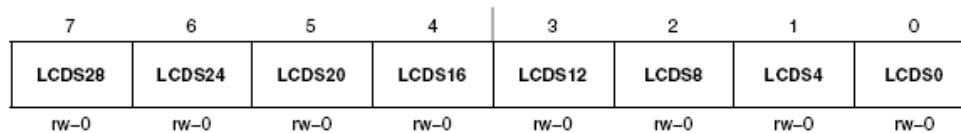
LCD_A related control registers

LCDACTL, LCD_A Control Register



- Main control
- LCDFREQx: freq. select
 - LCDMXx: Mux rate
 - LCDSON: Seg. on (flashing)
 - LCDON: LCD module on/off control

LCDAPCTL0, LCD_A Port Control Register 0



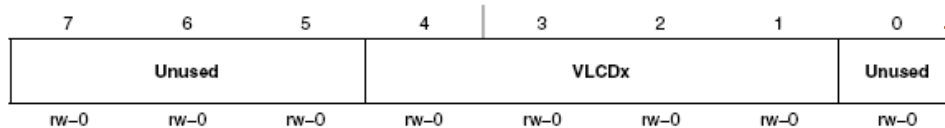
- Port control reg. 0/1
- 4개씩 묶인 세그먼트들에 대해 LCD 기능 사용 여부 결정.

LCDAVCTL0, LCD_A Voltage Control Register 0



- Voltage control reg. 0
- LCD voltage 관련 특성 설정
 - 내부 charge pump 사용 여부, bias 종류 등

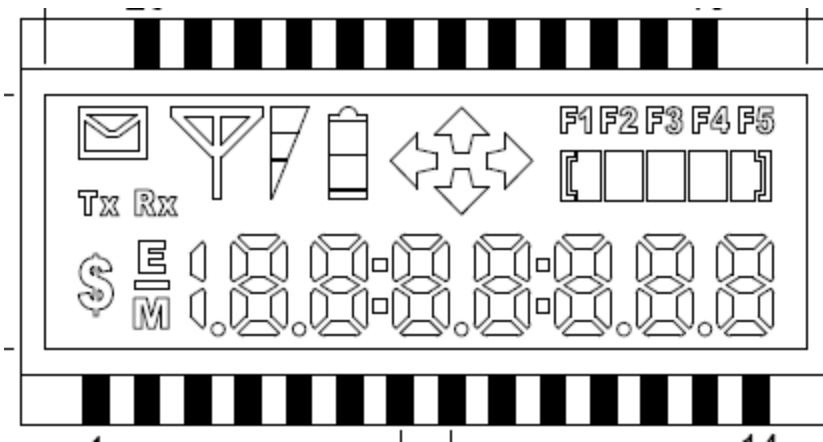
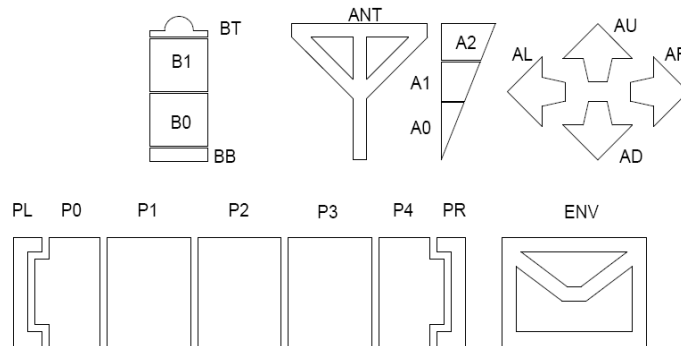
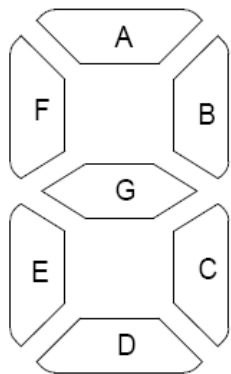
LCDAVCTL1, LCD_A Voltage Control Register 1



- Voltage control reg. 1
- 내부 charge pump 출력 전압 크기 설정 (2.6~3.44V)

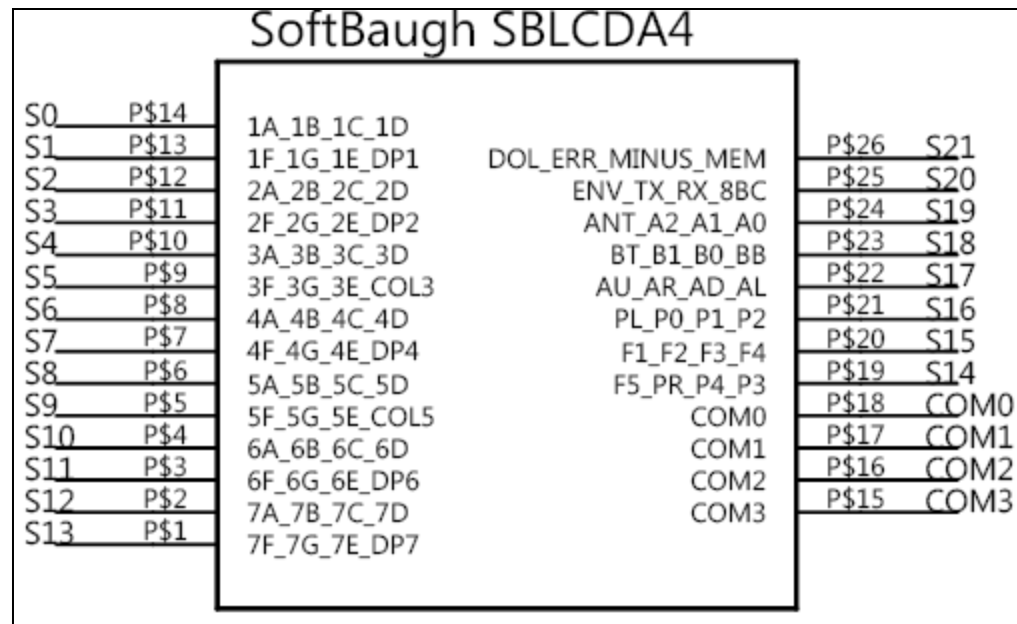
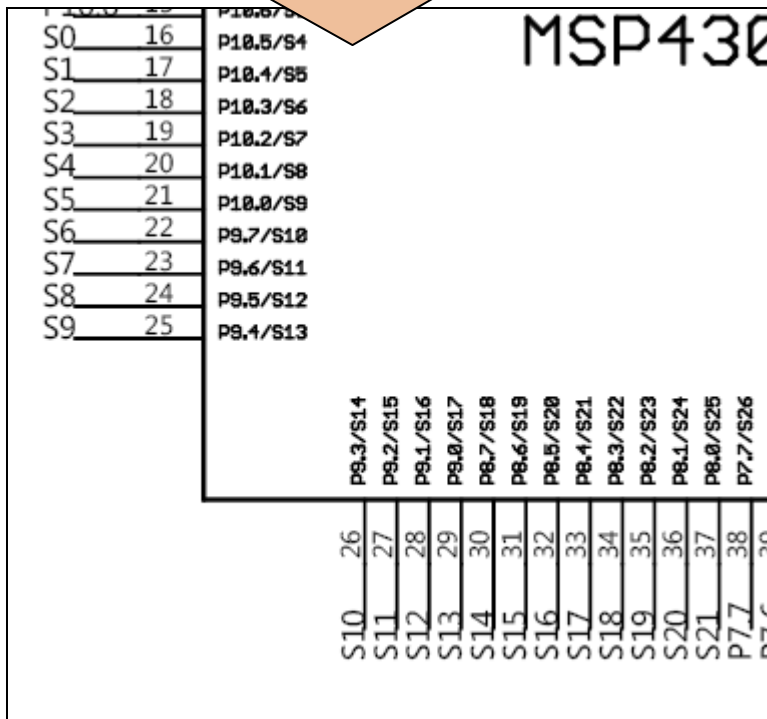
MSP-EXP430FG4618 보드 내장 LCD

- ▶ Softbaugh사의 SBLCDA4 display 장착
 - ▶ 총 88개 표시장치 (7.1 7-segments, +/- sign, 상하좌우 화살표, 안테나, 배터리 등)
 - ▶ 4-mux operation
 - ▶ MSP430FG4618과는 S4~S25(22개 제어 라인)과 연결



MSP-EXP430 보드와 SBLCDA4와의 연결

***주의사항: So label이 LCD A controller의 So가 아니라 S4부터 시작됨! → 따라서 Port 설정 및 LCDMEM[x] setting에 주의해야 함.**



LCD_A Coding 방법

```
void main(void)
{
    //port setup
    P10SEL |= 0x3F;
    P9SEL = 0xFF;
    P8SEL = 0xFF;
    P5SEL |= BIT4 + BIT3 + BIT2 ; //COM3~1

    //setup LCD_A
    LCDAPCTL0 = 0x7E; //make S4~S27 enable
    LCDAPCTL1 = 0;
    LCDAVCTL0 = VLCDREF_0 + LCDCPEN ; //use
    internal charge pump
    LCDAVCTL1 = VLCD_3_02; //Vlcd = 3.02V ??
    LCDACTL = LCDFREQ_64 + LCD4MUX +
    LCDON;

    //LCDMEM 제어
    //ex, 모든 세그먼트 ON

    for(i=0;i<11;i++)
        LCDMEM[2+i] = 0xFF;
}
```

왜 2를
더할까?

LCD 관련 핀 설정

- 모든 핀은 2개 이상의 기능을 담당. 따라서 반드시 각 핀의 사용 목적에 따라 GPIO로 쓰지, 주변장치 핀으로 쓰지 정해야 함.

LCD_A 설정

- LCDAPCTL0/1: S0~S39까지 40개의 제어 선들 중에서 몇 개를 사용할지를 결정.
- LCDAVCTL0: voltage 설정을 위한 것으로 대개 internal charge pump 모듈 이용하도록 설정.
- LCDAVCTL1: 최대 전압값 설정 (2.60~3.44V)
- LCDACTL: f_{LCD} , mode, module ON/OFF 등 제어