

2022년 IoT기반 스마트 솔루션 개발자 양성과정



Embedded Application

5-LED/FND Output

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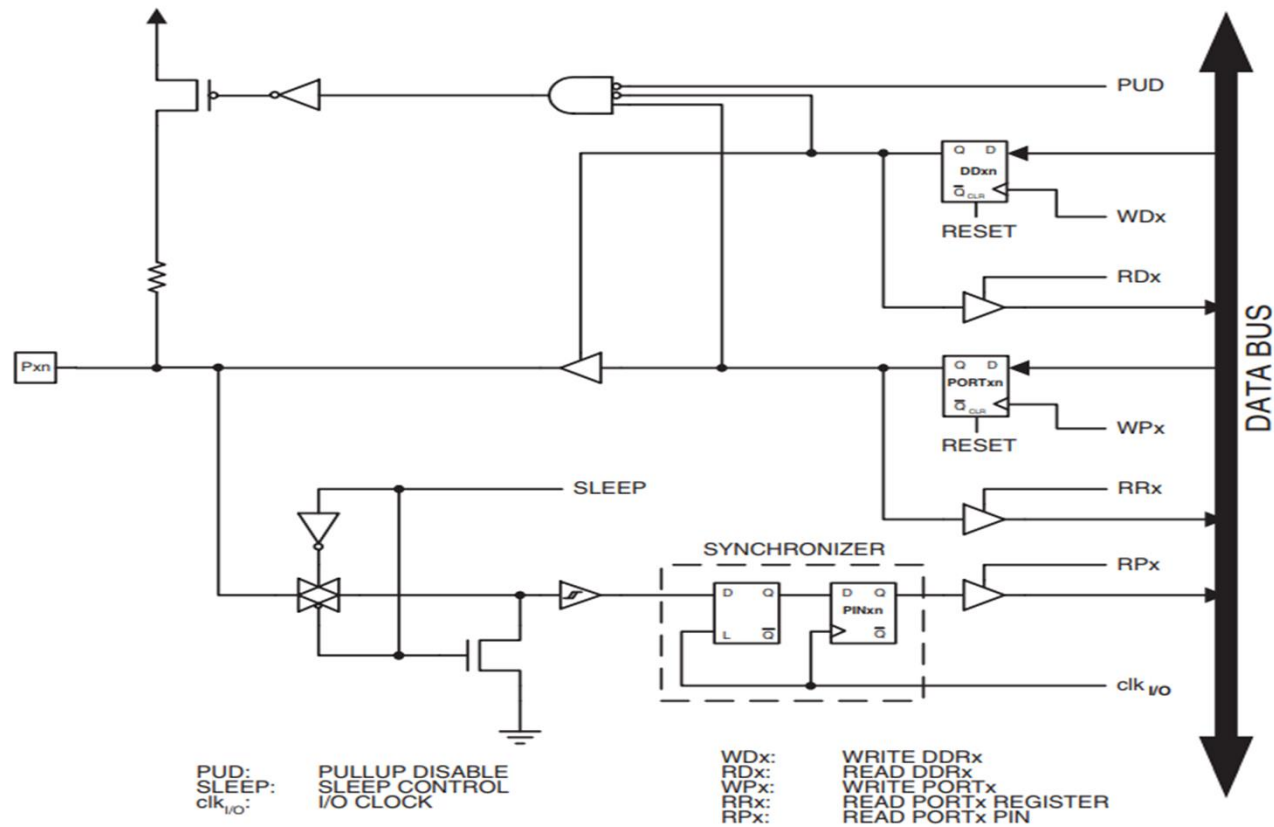
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I/O 관련 레지스터

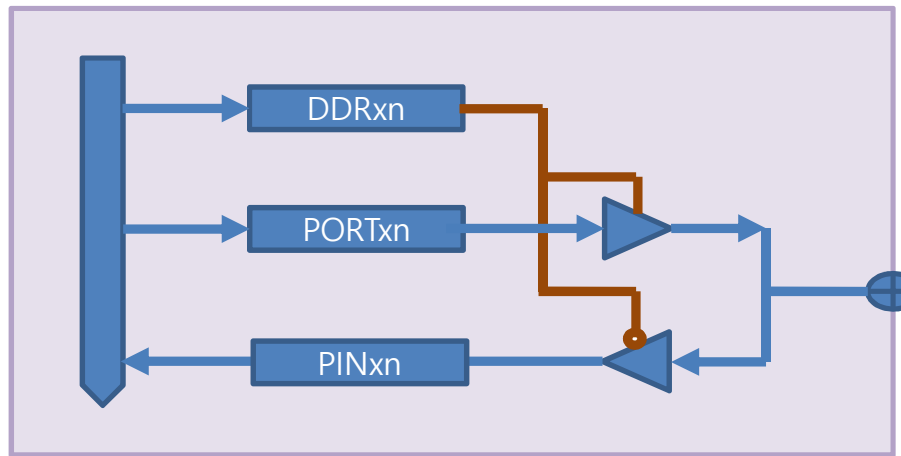
- ❑ DDRxn : PORT 입출력 방향 설정
X :PORTA-PORTG
1 (출력), 0 (입력)
- ❑ PORTxn : PORT 출력 버퍼 레지스터
데이터 출력
- ❑ PINxn : PORT 입력 버퍼 레지스터
포트 입력



General Digital I/O pin



DDR,PORT,PIN

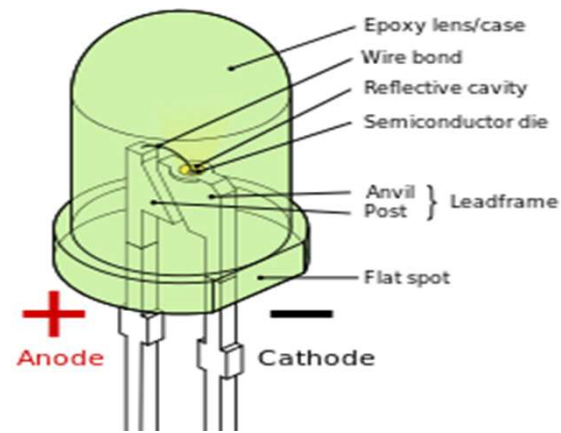


DDRxn	PORTxn	I/O	Comment
0	0	Input	Hi-Z
0	1	Input	Hi-Z
1	0	Output	Output Low(Sink)
1	1	Output	Output High(Source)



LED

- Light Emitting Diode : 발광 다이오드
- PN접합 반도체로 에너지 밴드 겹에 의한 발광현상을 이용
- 수명이 반 영구적, 절전 형 발광, 다양한 색상
- 표시장치나 조명장치로 사용함
- 극성이 있음(Anode, Cathode)

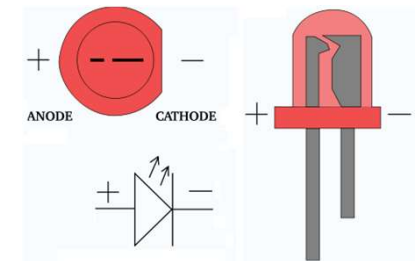
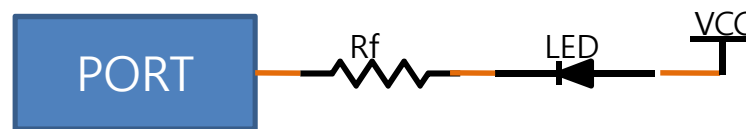


LED의 사용

- Anode에 + 전압이 연결되고 Cathode에 -전압이 연결됨
- 전류 제한 저항 : LED에 정격 전류가 흐르도록 함
 - LED 전후에 관계 없음
- 정방향 연결 : 논리적으로 포트가 1일때 켜짐



- 역방향 연결 : 논리적으로 포트가 0일때 켜짐



전류제한 저항값 구하기

- 옴의 공식 : $R = V / I$
- LED에 흐르는 정격 전류 : $10\text{mA} = 0.01\text{A}$
- LED의 순방향전압 : Forward Voltage = 1.4V
- LED의 공급전압 : 5V

- $R_f = (5\text{V} - 1.4\text{V}) / 0.01\text{A}$
 $= 360 \Omega \Rightarrow 390 \Omega (< 1\text{K} \Omega)$

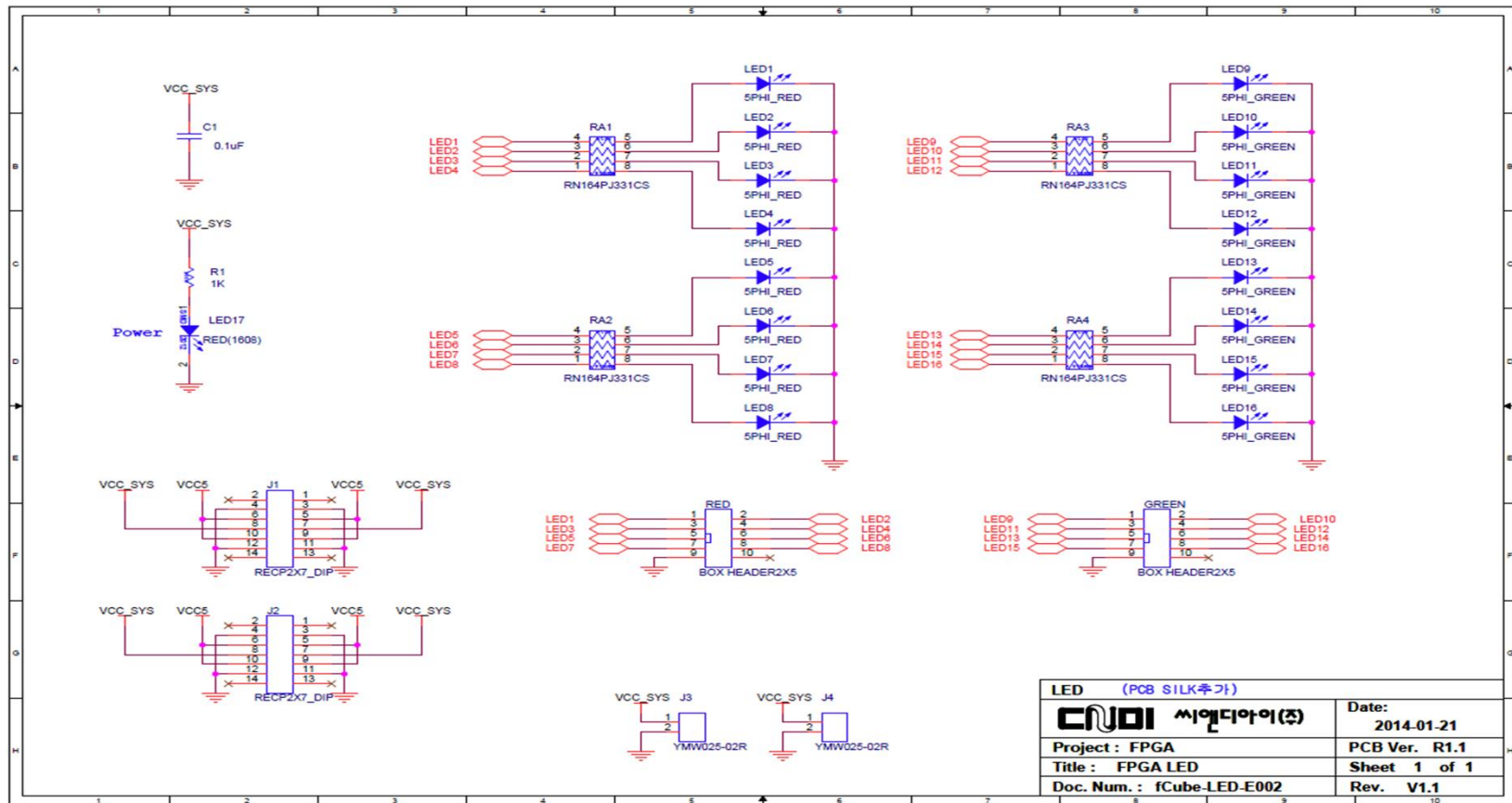


Byte 출력

- Byte 출력
 - `PORTB=0x55;` `// '01010101'`
 - `PORTB=~0x55;` `// '10101010'`
 - `PORTB=0b01010101;`
- 논리곱 &
 - `PORTB &=0xfe;` `//Bit_0만 Clear`
 - `PORTB &=0xf0;` `//하위 4비트 Clear`
- 논리합 |
 - `PORTB |=0x01;` `//Bit_0만 Set`
 - `PORTB |=0xf0;` `//상위 4비트 Set`
- Shift <<
 - `PORTB = 1<<3;` `//Bit_3만 Set`
 - `PORTB = 0<<3;` `//Bit_3만 Clear`



LED Module



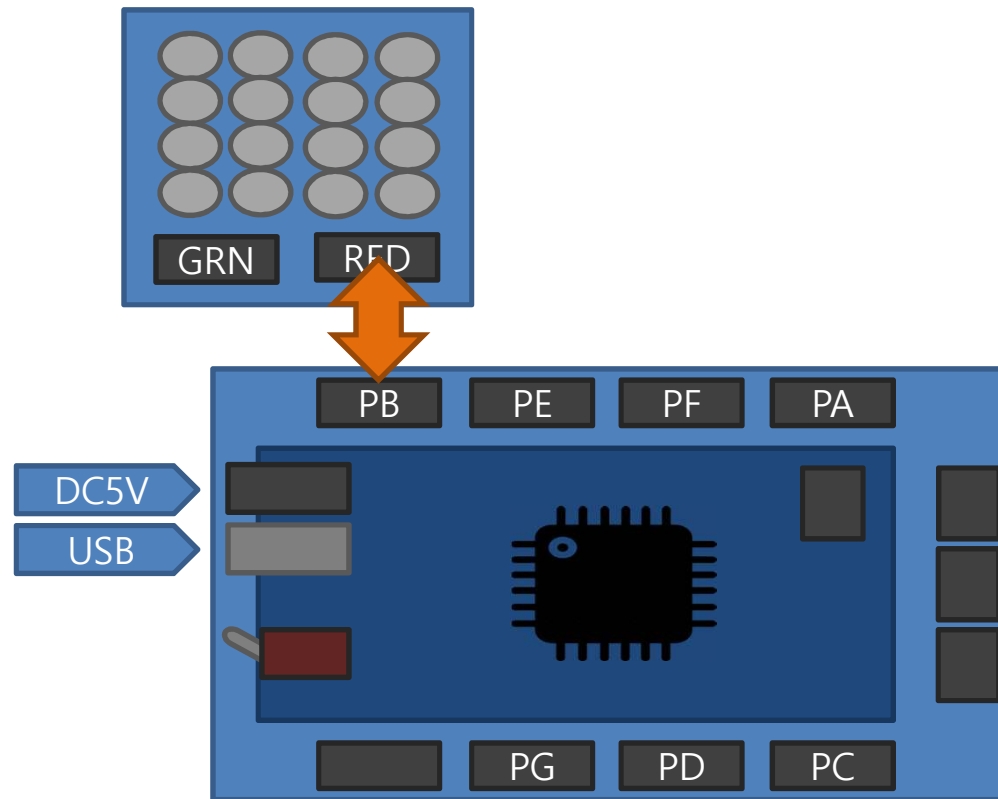
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LED Module Layout



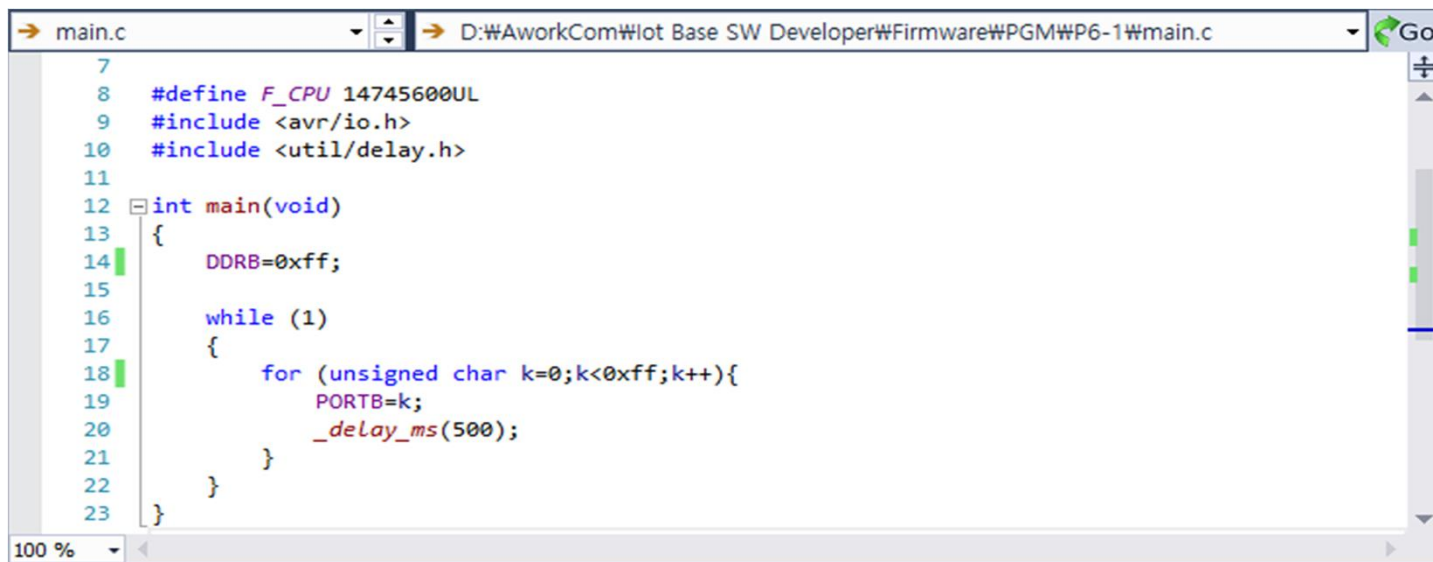
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Wiring



Ex : Binary Number Display

- 0~255 (0x00~0xFF)의 숫자를 LED로 켜보자



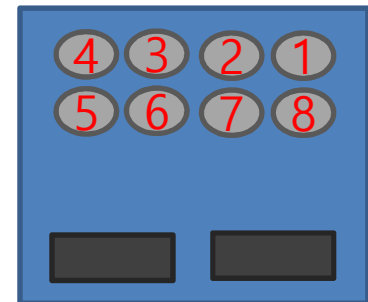
```
main.c D:\AworkCom\Iot Base SW Developer\Firmware\PGM\#P6-1\main.c Go
7
8 #define F_CPU 14745600UL
9 #include <avr/io.h>
10 #include <util/delay.h>
11
12 int main(void)
13 {
14     DDRB=0xff;
15
16     while (1)
17     {
18         for (unsigned char k=0;k<0xff;k++){
19             PORTB=k;
20             _delay_ms(500);
21         }
22     }
23 }
```



Ex : Ring display-1

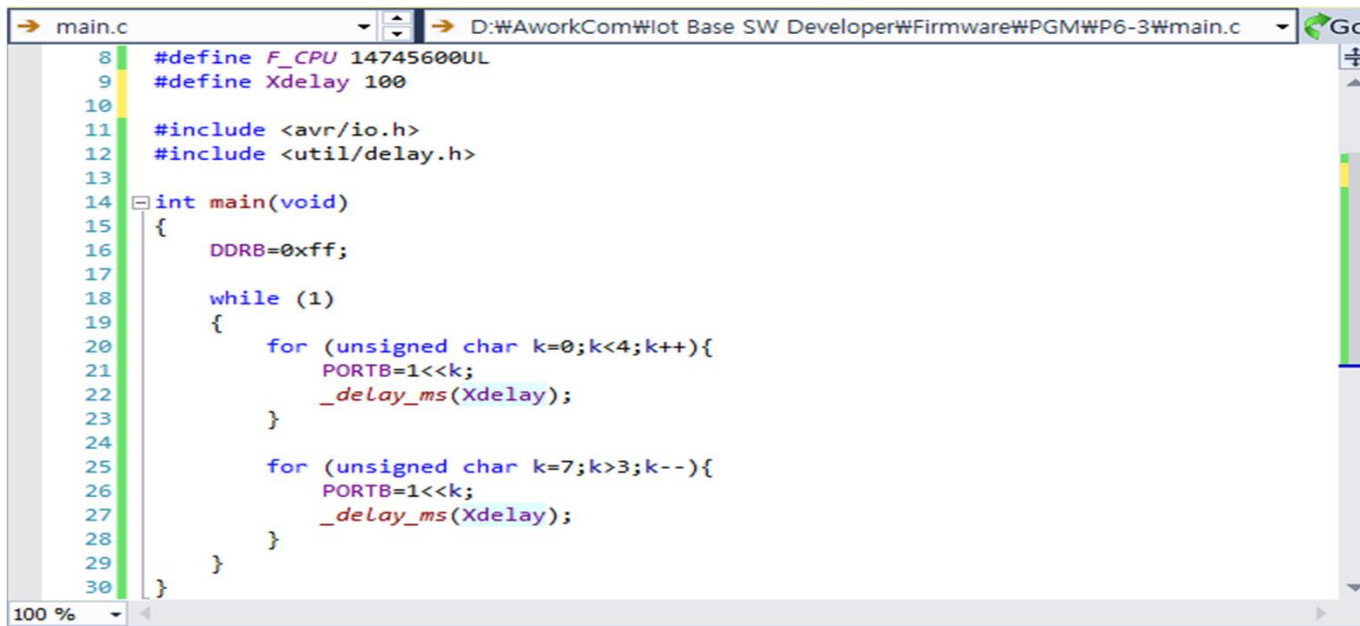
- 그림과 같이 Ring으로 회전하는 LED Display를 구현해 보자

```
main.c D:\AworkCom\Iot Base SW Developer\Firmware\PGM\#P6-2\main.c Go
8  #define F_CPU 14745600UL
9  #include <avr/io.h>
10 #include <util/delay.h>
11
12 int main(void)
13 {
14     DDRB=0xff;
15
16     while (1)
17     {
18         for (unsigned char k=0;k<4;k++){
19             PORTB=1<<k;
20             _delay_ms(500);
21         }
22
23         for (unsigned char k=7;k>3;k--){
24             PORTB=1<<k;
25             _delay_ms(500);
26         }
27     }
28 }
```



Ex : Ring Display-2

- 시간을 조절 하여 박진감 있는 Display를 구현해 보자

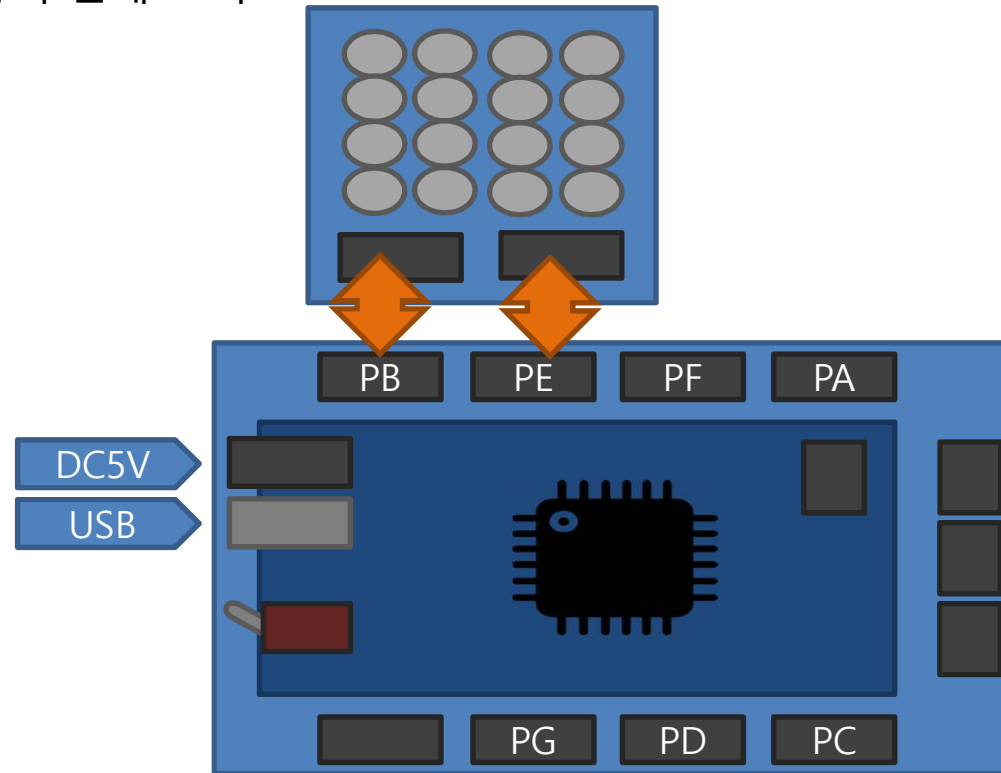


```
main.c D:\WorkCom\Iot Base SW Developer\Firmware\PGM\WP6-3\main.c Go
8  #define F_CPU 14745600UL
9  #define Xdelay 100
10
11 #include <avr/io.h>
12 #include <util/delay.h>
13
14 int main(void)
15 {
16     DDRB=0xff;
17
18     while (1)
19     {
20         for (unsigned char k=0;k<4;k++){
21             PORTB=1<<k;
22             _delay_ms(Xdelay);
23         }
24
25         for (unsigned char k=7;k>3;k--){
26             PORTB=1<<k;
27             _delay_ms(Xdelay);
28         }
29     }
30 }
```



Ex : 경찰차 경광등

- 경찰차의 경광등을 구현해 보자



Ex : Program

```
8  #define F_CPU 14745600UL
9  #define Xdelay 250
10
11 #include <avr/io.h>
12 #include <util/delay.h>
13
14 int main(void)
15 {
16     DDRB=0xff;
17     DDRE=0xff;
18
19     while (1)
20     {
21         PORTB=0xff;
22         PORTE=0x00;
23         _delay_ms(Xdelay);
24
25         PORTB=0x00;
26         PORTE=0xFF;
27         _delay_ms(Xdelay);
28     }
29 }
```



Ex : 소방차 경광등

- 소방차의 경광등을 구현해 보자

```
main.c D:\AworkCom\Iot Base SW Developer\Firmware\PGM\#P6-5\main.c Go
8  #define F_CPU 14745600UL
9  #define Xdelay 100
10
11  #include <avr/io.h>
12  #include <util/delay.h>
13
14  int main(void)
15  {
16      DDRB=0xff;
17      DDRE=0xff;
18
19      while (1)
20      {
21          PORTB=0xff;    PORTE=0x00;    _delay_ms(Xdelay);
22          PORTB=0x00;    PORTE=0x00;    _delay_ms(Xdelay);
23          PORTB=0xff;    PORTE=0x00;    _delay_ms(Xdelay);
24          PORTB=0x00;    PORTE=0x00;    _delay_ms(Xdelay);
25
26          PORTB=0x00;    PORTE=0xFF;    _delay_ms(Xdelay);
27          PORTB=0x00;    PORTE=0x00;    _delay_ms(Xdelay);
28          PORTB=0x00;    PORTE=0xFF;    _delay_ms(Xdelay);
29          PORTB=0x00;    PORTE=0x00;    _delay_ms(Xdelay);
30      }
31  }
```



Ex : Optimization

- 소방차 경광등을 최적화 해보자

선언, Setup

```
8  #define F_CPU 14745600UL
9  #define Xdelay 100
10
11 #include <avr/io.h>
12 #include <util/delay.h>
13
14 void CPU_Setup()
15 {
16     DDRB=0xff;
17     DDRE=0xff;
18 }
```

Sub 함수

```
20 void RED_LED(char M)
21 {
22     if (M==0){
23         PORTB=0x00;
24         _delay_ms(Xdelay);
25     } else{
26         PORTB=0xff;
27         _delay_ms(Xdelay);
28     }
29 }
30
31 void GRN_LED(char M)
32 {
33     if (M==0){
34         PORTE=0x00;
35         _delay_ms(Xdelay);
36     } else{
37         PORTE=0xff;
38         _delay_ms(Xdelay);
39     }
40 }
```

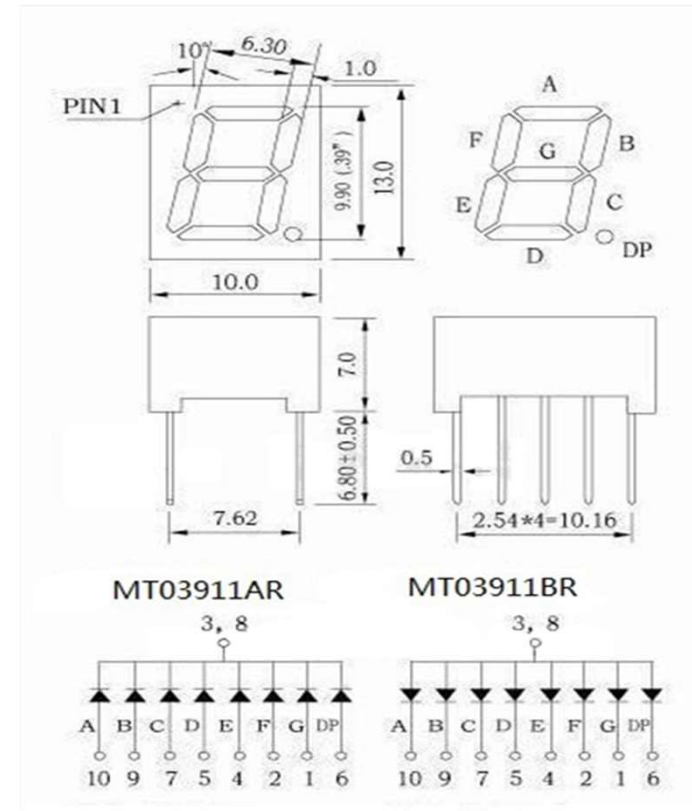
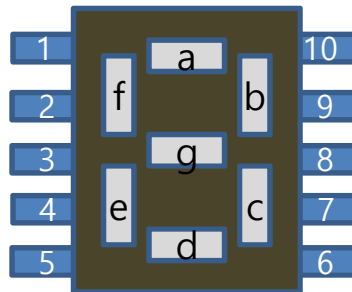
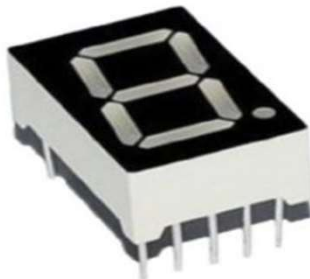
Main 함수

```
42 int main(void)
43 {
44     CPU_Setup();
45
46     while (1)
47     {
48         RED_LED(1);    RED_LED(0);
49         RED_LED(1);    RED_LED(0);
50
51         GRN_LED(1);    GRN_LED(0);
52         GRN_LED(1);    GRN_LED(0);
53     }
54 }
```



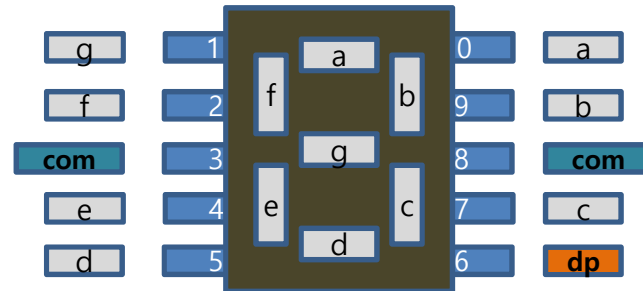
FND 숫자표시기

- FND : Fixed Numeric Display
- 7-Segment



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Numeric Display

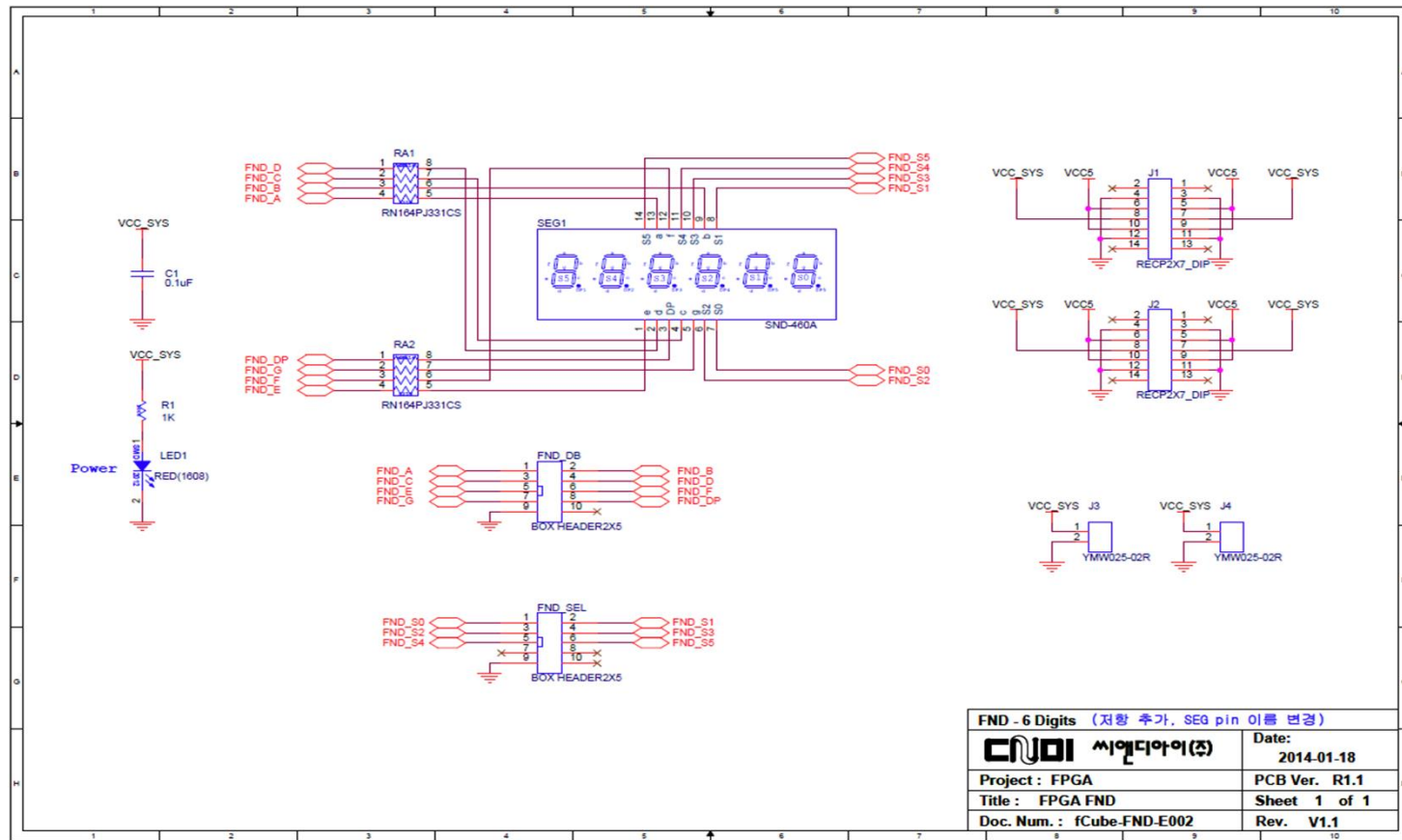


0	1	2	3	4	5	6	7	8	9
ABCDEFG. 00000011	ABCDEFG. 10011111	ABCDEFG. 00100101	ABCDEFG. 00001101	ABCDEFG. 10011001	ABCDEFG. 01001001	ABCDEFG. 01000000	ABCDEFG. 00011111	ABCDEFG. 00000001	ABCDEFG. 00001001



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Schematic



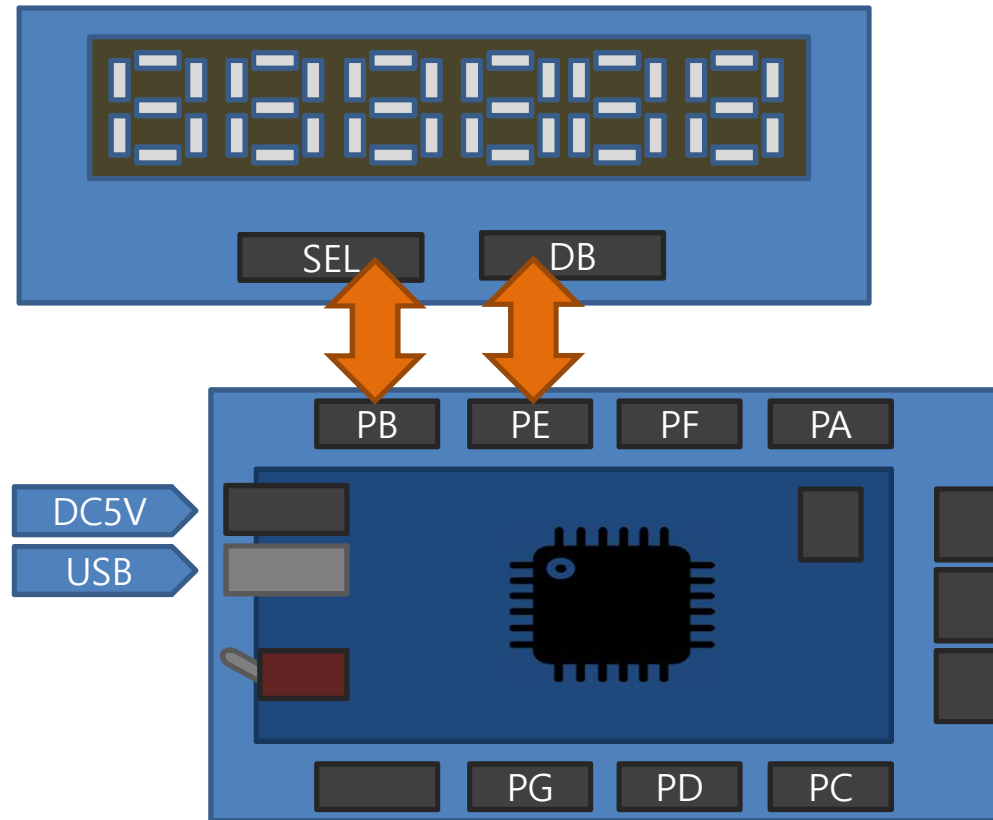
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FND Module

- SEL : FND Digit Selector (부논리로 선택됨)
- DB : FND Data



Wiring



Ex : 숫자 2

- FND Selector

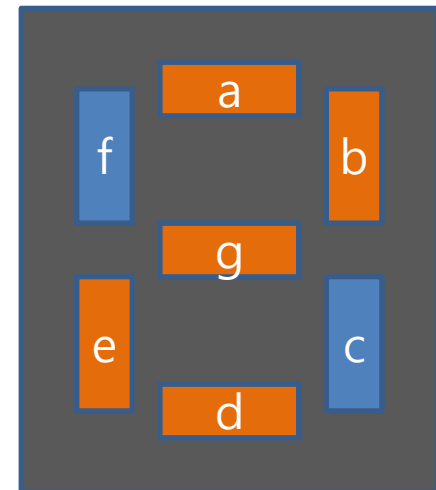
6	5	4	3	2	1
x	x	x	x	x	선택
1	1	1	1	1	0

Ob11111110 = 0xFE = ~0x01

- FND DB

x	g	f	e	d	c	b	a
OFF	On	OFF	On	On	OFF	On	On
0	1	0	1	1	0	1	1

Ob01011011 = 0x5b



Ex : Program

```
#define F_CPU 14745600UL
#define FND_SEL PORTB
#define FND_DB PORTE

#include <avr/io.h>
#include <util/delay.h>

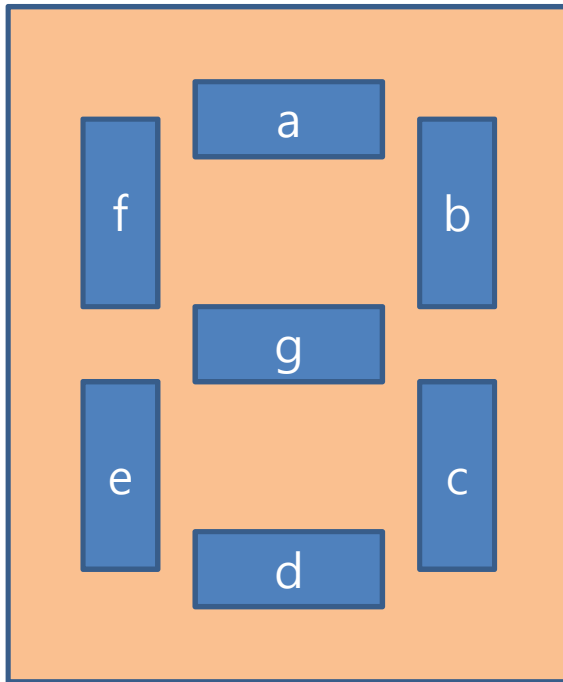
void CPU_Setup()
{
    DDRB=0xff;
    DDRE=0xff;
}

int main(void)
{
    CPU_Setup();

    while (1)
    {
        FND_SEL=~0x01;    //첫번째 FND
        FND_DB=0x5b;      //숫자 '2'
    }
}
```



FND Lookup Table



No	x	g	f	e	d	c	b	a	Hex
0	0	0	1	1	1	1	1	1	3f
1	0	0	0	0	0	1	1	0	06
2	0	1	0	1	1	0	1	1	5b
3	0	1	0	0	1	1	1	1	4f
4	0	1	1	0	0	1	1	0	66
5	0	1	1	0	1	1	0	1	6d
6	0	1	1	1	1	1	0	1	7d
7	0	0	1	0	0	1	1	1	27
8	0	1	1	1	1	1	1	1	7f
9	0	1	1	0	1	1	1	1	6f



Ex : 십진 카운트(Static)

```
#define F_CPU 14745600UL
#define FND_SEL PORTB
#define FND_DB PORTE
```

```
#include <avr/io.h>
#include <util/delay.h>
```

```
unsigned char FND[10]={0x3f, 0x06, 0x5b, 0x4f, 0x66, 0x6d, 0x7d, 0x27, 0x7f, 0x6f};
```

```
void CPU_Setup()
{
    DDRB=0xff;
    DDRE=0xff;
}
```

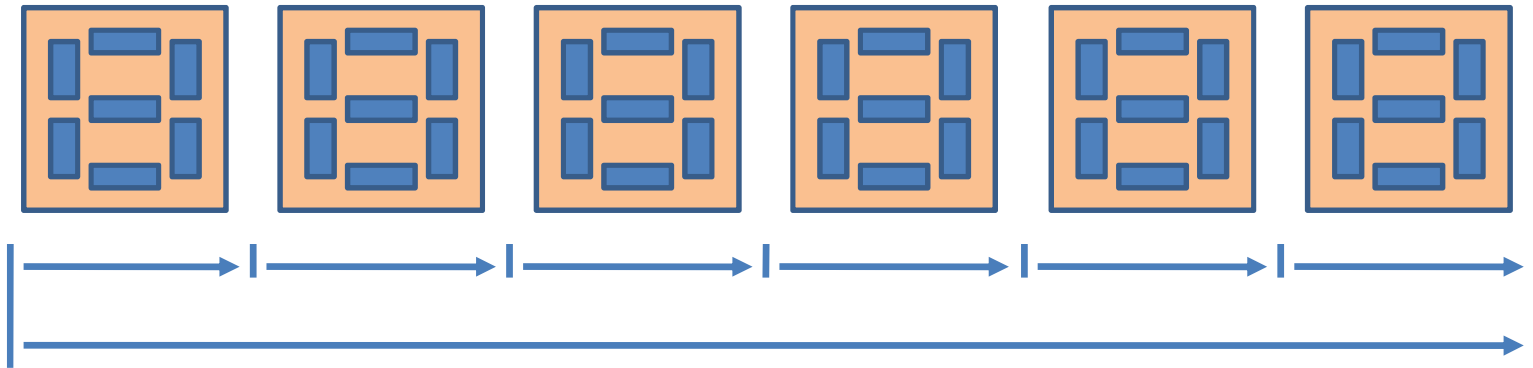
```
int main(void)
{
    CPU_Setup();

    while (1)
    {
        FND_SEL=~0x01;    //첫번째 FND

        for (char k=0; k<10; k++){
            FND_DB=FND[k];
            _delay_ms(300);
        }
    }
}
```



Dynamic Display



전체 주기 = 60hz
전체 시간 = $1/60\text{hz} = 16.67\text{msec}$
개별 시간 = $16.67 / 6 = 2.778\text{msec}$

예제)
개별 시간 = 3msec
전체 주기 = $1 / (0.003 \times 6) = 55.55\text{hz}$



Ex : 123456 표시

```
#define F_CPU 14745600UL
#define FND_SEL PORTB
#define FND_DB PORTE
#define dTime 3
```

```
#include <avr/io.h>
#include <util/delay.h>
```

```
unsigned char FND[10]={0x3f, 0x06, 0x5b, 0x4f, 0x66, 0x6d, 0x7d, 0x27, 0x7f, 0x6f};
```

```
void CPU_Setup()
{
    DDRB=0xff;
    DDRE=0xff;
}
```

```
int main(void)
{
    CPU_Setup();

    while (1)
    {
        FND_SEL=~0x01; FND_DB=FND[6]; _delay_ms(dTime );
        FND_SEL=~0x02; FND_DB=FND[5]; _delay_ms(dTime );
        FND_SEL=~0x04; FND_DB=FND[4]; _delay_ms(dTime );
        FND_SEL=~0x08; FND_DB=FND[3]; _delay_ms(dTime );
        FND_SEL=~0x10; FND_DB=FND[2]; _delay_ms(dTime );
        FND_SEL=~0x20; FND_DB=FND[1]; _delay_ms(dTime );
    }
}
```



고찰

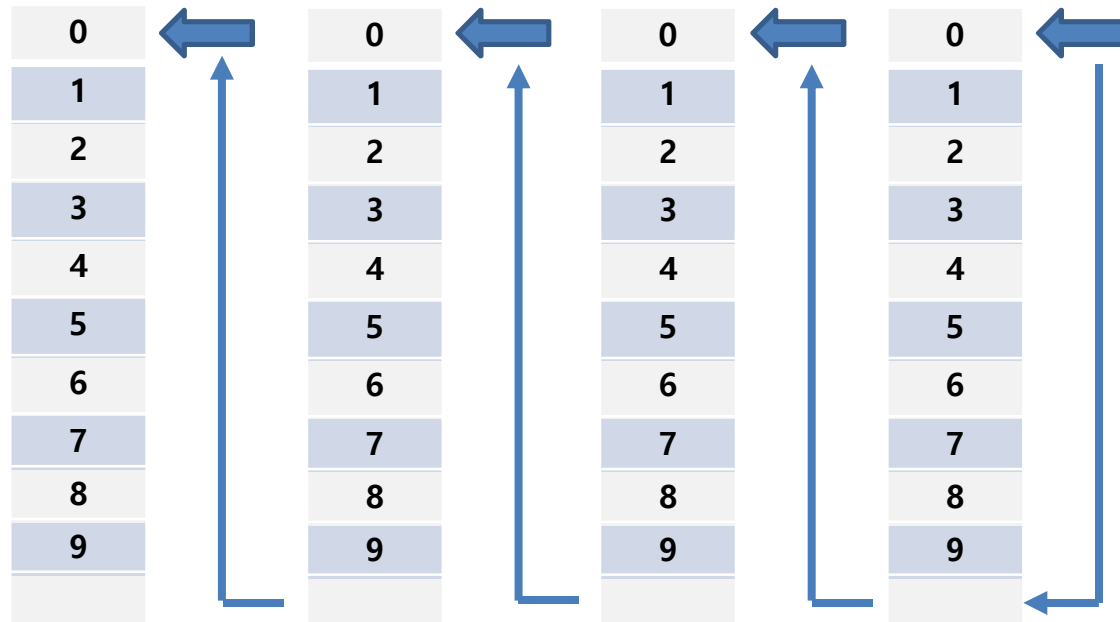
- Dtime을 변경해 보자
 - 50 ~ 1msec 의 범위
 - FND의 밝기
 - 표시의 깜빡임
- 최적의 밝기와 안정된 표시를 찾기 위한 방법은 무엇인가?
- 디스플레이 검사를 위한 방법은 무엇인가?



BCD

- BCD : Binary Coded Decimal

HEX	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
DEC	0	1	2	3	4	5	6	7	8	9	-	-	-	-	-	-



Ex : BCD Up Counter

```
#define F_CPU 14745600UL
#define FND_SEL PORTB
#define FND_DB PORTE
#define dTime 3

#include <avr/io.h>
#include <util/delay.h>

unsigned char FND[10]={0x3f, 0x06, 0x5b, 0x4f, 0x66, 0x6d, 0x7d, 0x27, 0x7f, 0x6f};
unsigned char DGT[6]={0xfe, 0xfd, 0xfb, 0xf7, 0xef, 0xdf};
unsigned char NUM[6]={0x00, 0x00, 0x00, 0x00, 0x00, 0x00};

void CPU_Setup( ) {
    DDRB=0xff;
    DDRE=0xff;
}
```



BCD_UP / main

```
void BCD_UP( ) {  
    if (++NUM[0] > 9) {  
        NUM[0] = 0x00;  
        if (++NUM[1] > 9) {  
            NUM[1] = 0x00;  
            if (++NUM[2] > 9) {  
                NUM[2] = 0x00;  
                if (++NUM[3] > 9) {  
                    NUM[3] = 0x00;  
                    if (++NUM[4] > 9) {  
                        NUM[4] = 0x00;  
                        if (++NUM[5] > 9) {  
                            NUM[5] = 0x00;  
                        }  
                    }  
                }  
            }  
        }  
    }  
}
```

```
int main(void) {  
    CPU_Setup( );  
  
    while (1) {  
        for (char k=0; k<6; k++) {  
            FND_SEL=DGT[k];  
            FND_DB=FND[ NUM[k] ];  
            _delay_ms(dTime );  
        }  
        BCD_UP( );  
    }  
}
```



Ex : Dec Up Counter

```
#define F_CPU 14745600UL
#define FND_SEL PORTB
#define FND_DB PORTE
#define dTime 3

#include <avr/io.h>
#include <util/delay.h>

unsigned char FND[10]={0x3f, 0x06, 0x5b, 0x4f, 0x66, 0x6d, 0x7d, 0x27, 0x7f, 0x6f};
unsigned char DGT[6]={0xfe, 0xfd, 0xfb, 0xf7, 0xef, 0xdf};
unsigned char NUM[6]={0x00, 0x00, 0x00, 0x00, 0x00, 0x00};

unsigned long Count=0;

void CPU_Setup( ) {
    DDRB=0xff;
    DDRE=0xff;
}
```

← 999,999 = 0x0f423f



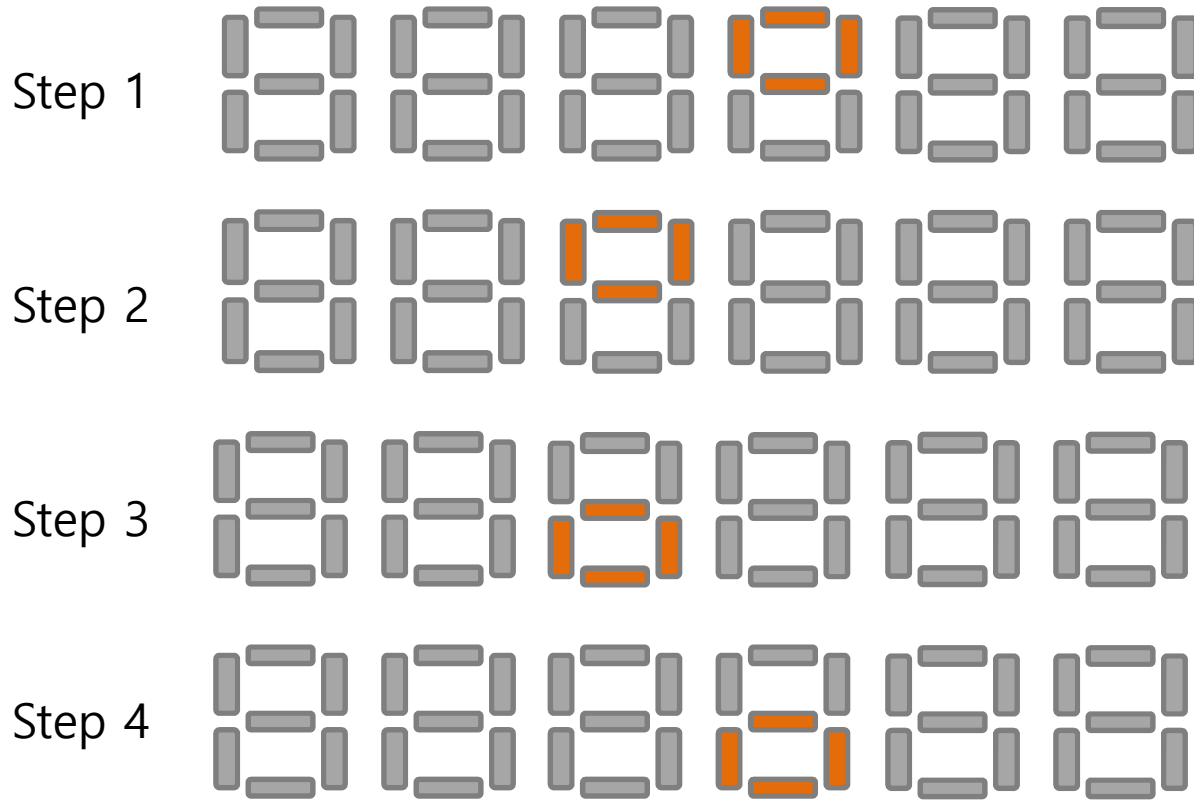
Hex2Dec / main

```
void Hex2Dec(void) {  
    unsigned long temp=Count;  
  
    NUM[5]=temp/100000;  
    temp= temp%100000;  
    NUM[4]=temp/10000;  
    temp= temp%10000;  
    NUM[3]=temp/1000;  
    temp= temp%1000;  
    NUM [2]=temp/100;  
    temp= temp%100;  
    NUM [1]=temp/10;  
    NUM [0]=temp%10;  
}
```

```
int main(void) {  
    CPU_Setup( );  
  
    while (1) {  
        Hex2Dec( );  
        for (char k=0; k<6; k++) {  
            FND_SEL=DGT[k];  
            FND_DB=FND[ NUM[k] ];  
            _delay_ms(dTime );  
        }  
        if (++Count>999999) Count=0;  
    }  
}
```



F6-6 : 눈동자 굴리기



FND Lookup

0		0x00 0000 0000
1		0x63 0110 0011
2		0x5C 0101 1100



program

```
#define F_CPU 14745600UL
#define FND_SEL PORTB
#define FND_DB PORTE
#define dTime 10

#include <avr/io.h>
#include <util/delay.h>

unsigned char FND[4][2]={ {0x63, 0x00}, {0x00, 0x63}, {0x00, 0x5c}, {0x5c, 0x00} };
unsigned char DGT[2]={0xfb, 0xf7};

void CPU_Setup( ) {
    DDRB=0xff;
    DDRE=0xff;
}

int main(void) {
    CPU_Setup( );

    while (1) {
        for (char k=0; k<4; k++) {
            for (char h=0; h<10; h++) {
                for (char m=0; m<2; m++) {
                    FND_SEL=DGT[m];
                    FND_DB=FND[k][m];
                    _delay_ms(dTime );
                }
            }
        }
    }
}
```



Ex : 전기밥솥 흉내내기

