2023년 IoT기반 스마트 솔루션 개발자 양성과정

Embedded Application

5-LED/FND Output

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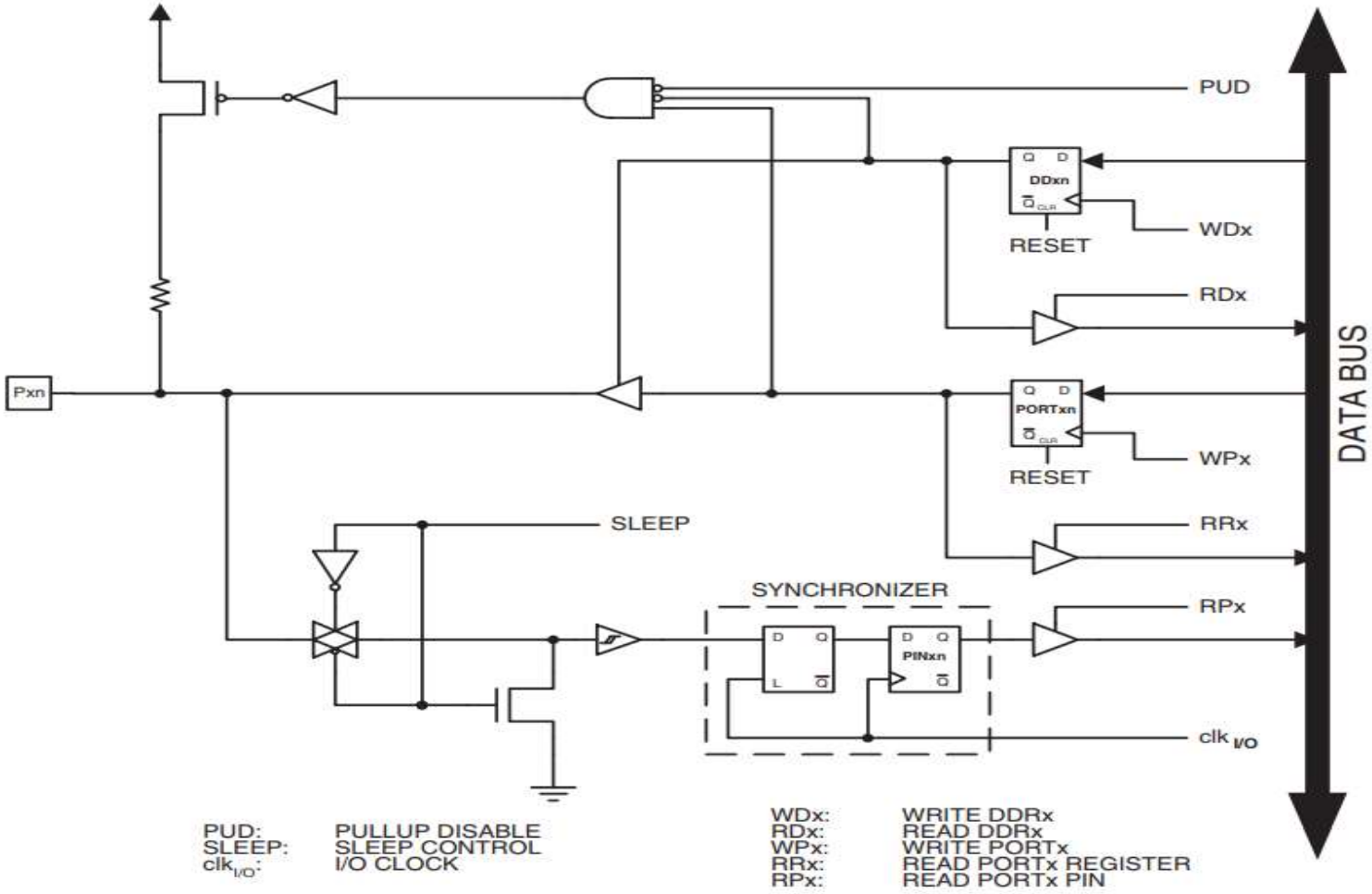
I/O 관련 레지스터

- DDRxn : PORT 입출력 방향 설정
  X :PORTA-PORTG
  1 (출력), 0 (입력)

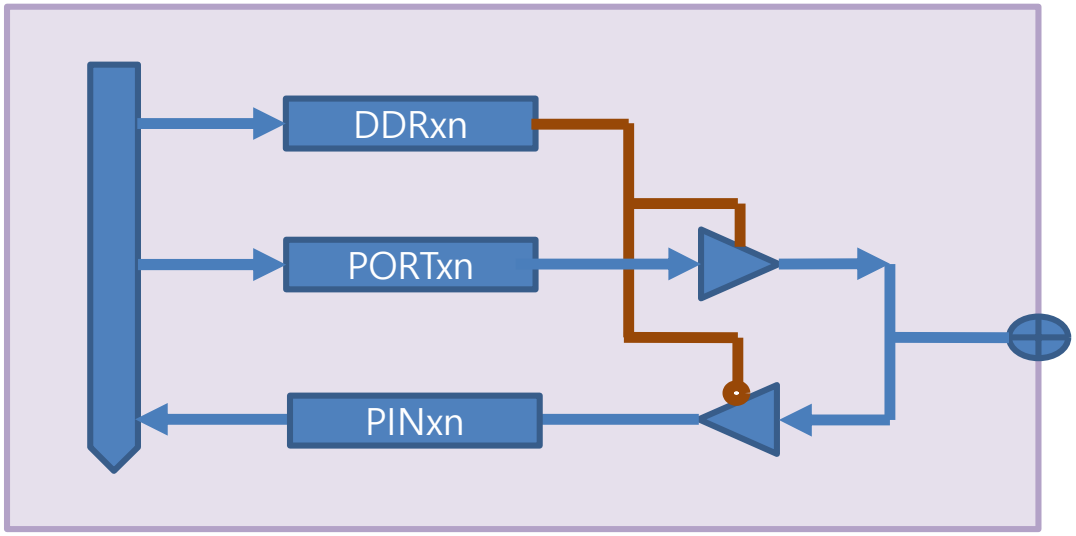
- PORTxn : PORT 출력 버퍼 레지스터
  데이터 출력

- PINxn : PORT 입력 버퍼 레지스터
  포트 입력

General Digital I/O pin



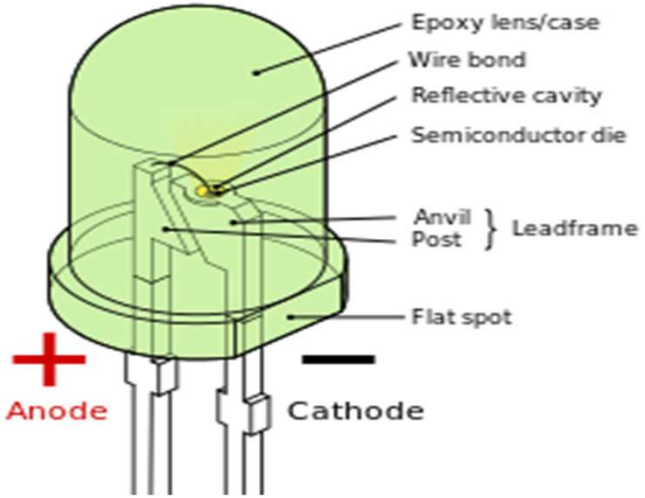
DDR,PORT,PIN



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

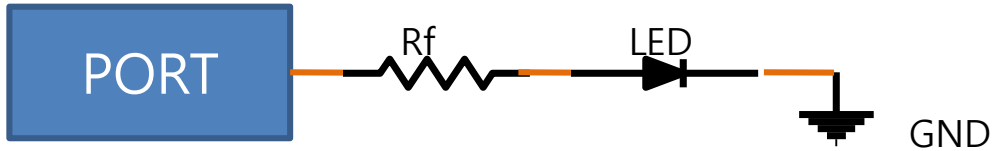
LED

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

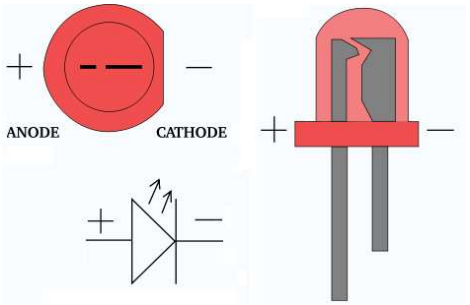


LED의 사용

- 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

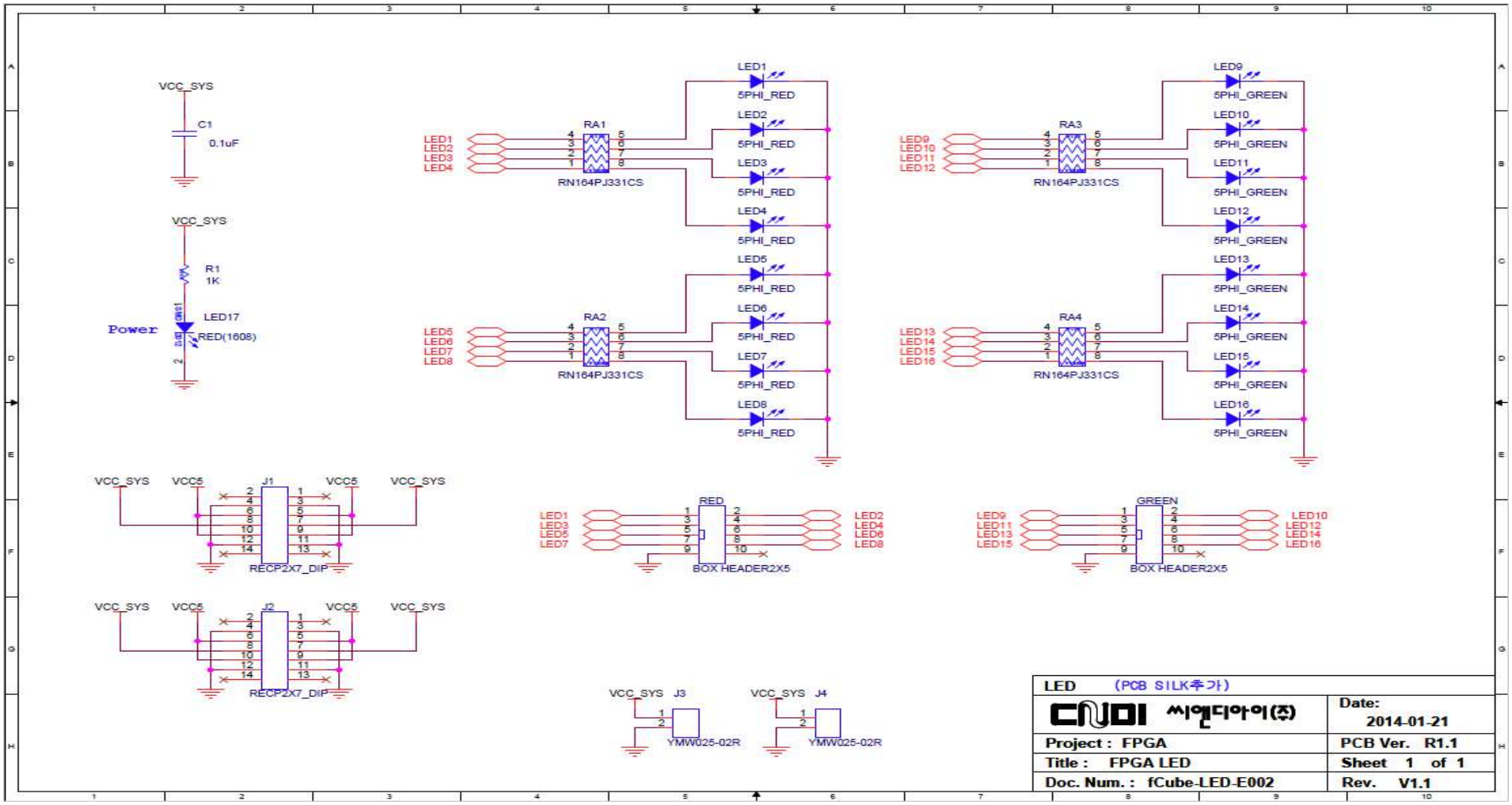
- 옴의 공식 : R = V / I
- LED에 흐르는 정격 전류 : 10mA=0.01A
- LED의 순방향전압 : Forward Voltage = 1.4V
- LED의 공급전압 : 5V

- Rf = (5V - 1.4V) / 0.01A
  = 360 Ω => 390 Ω (< 1K Ω)

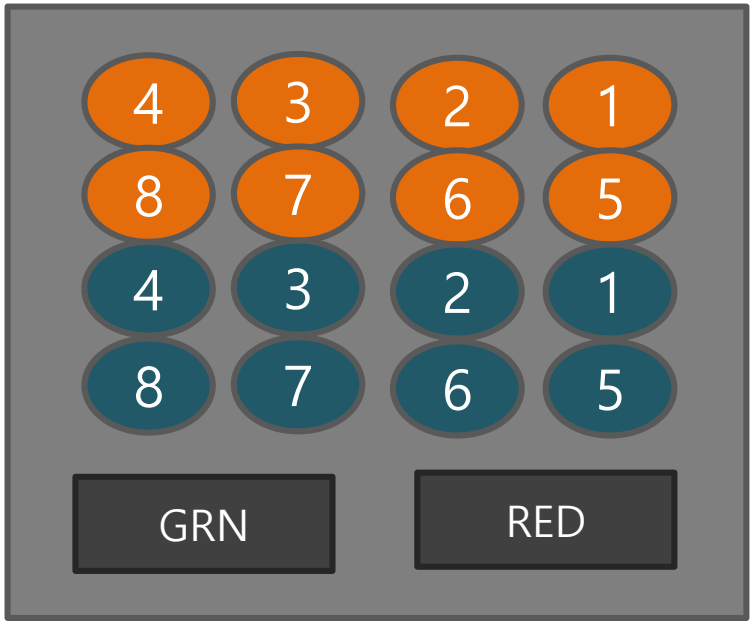
Byte 출력

- 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

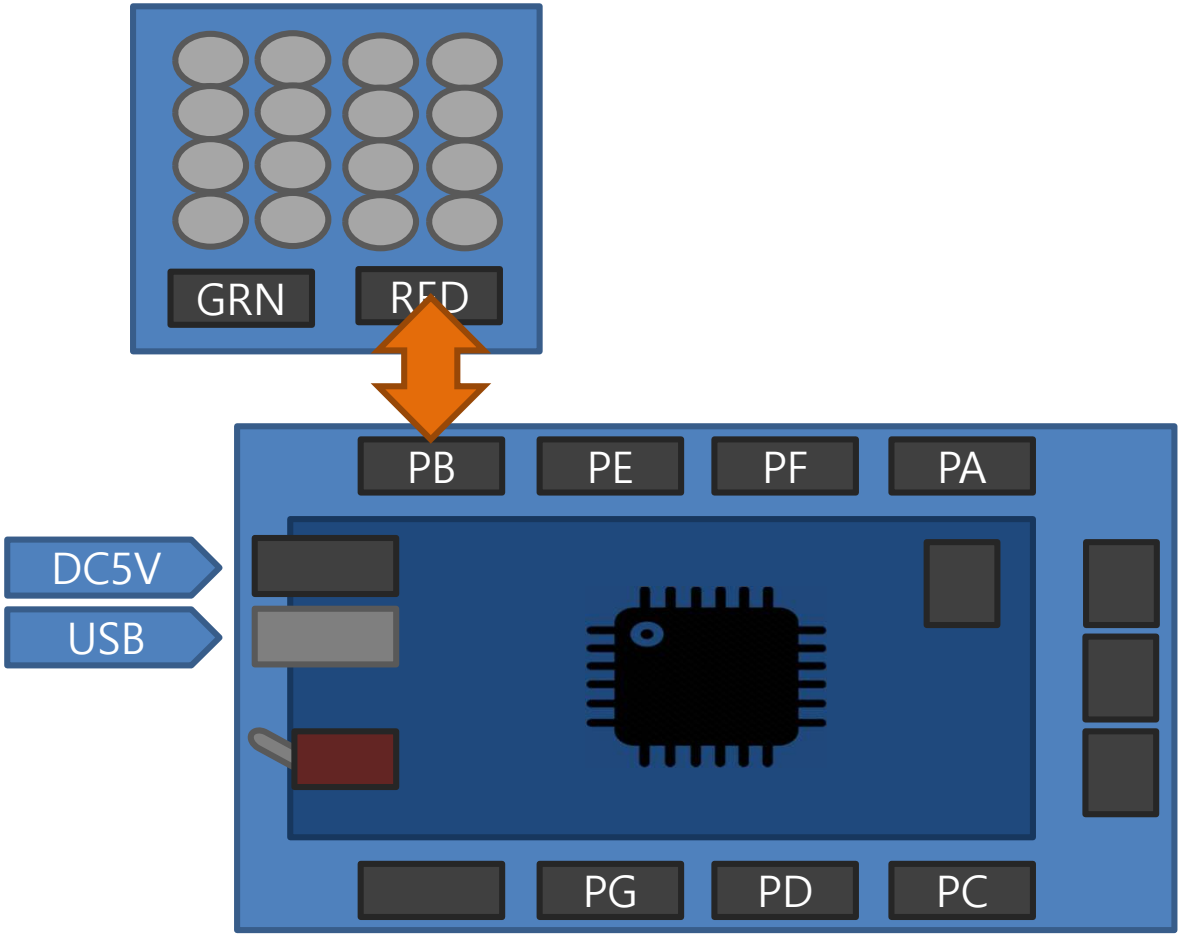
LED Module


VCC_SYS
C1
0.1uF
R1
1K
Power
LED17
RED(1608)
RA1
RA2
RA3
RA4
RN164PJ331CS
LED1
LED2
LED3
LED4
LED5
LED6
LED7
LED8
LED9
LED10
LED11
LED12
LED13
LED14
LED15
LED16
5PHI_RED
5PHI_GREEN
J1
J2
RECP2X7_DIP
RED
GREEN
BOX HEADER2X5
J3
J4
YMW025-02R
LED (PCB SILK추가)
씨엔디아이(주)
Date: 2014-01-21
Project : FPGA
PCB Ver. R1.1
Title : FPGA LED
Sheet 1 of 1
Doc. Num. : fCube-LED-E002
Rev. V1.1

LED Module Layout



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  }
```

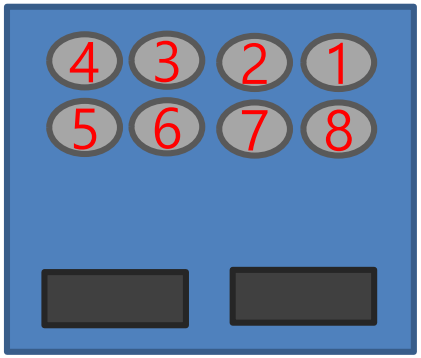
100 %

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

```
 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

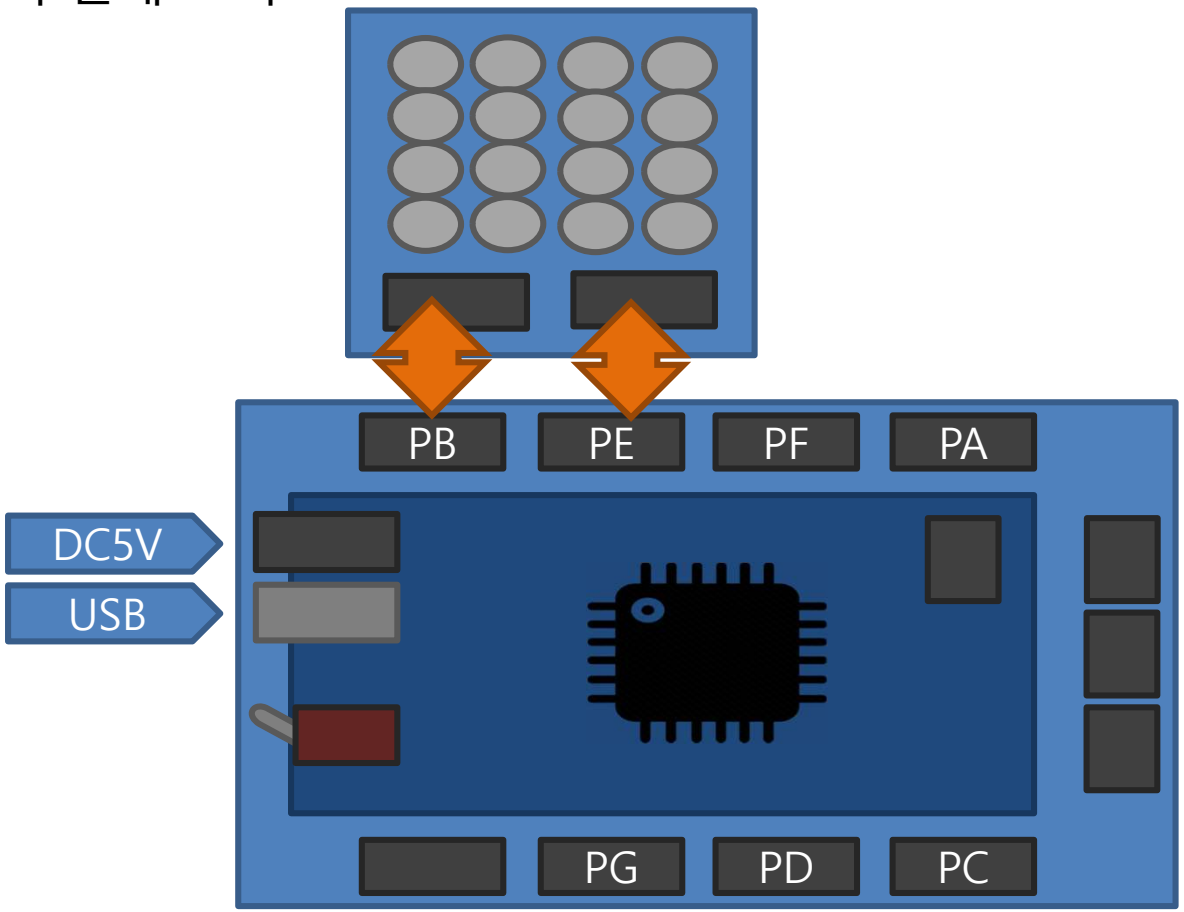
main.c — D:₩AworkCom₩Iot Base SW Developer₩Firmware₩PGM₩P6-3₩main.c

```
 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  }
```

100 %

Ex : 경찰차 경광등

- 경찰차의 경광등을 구현해 보자

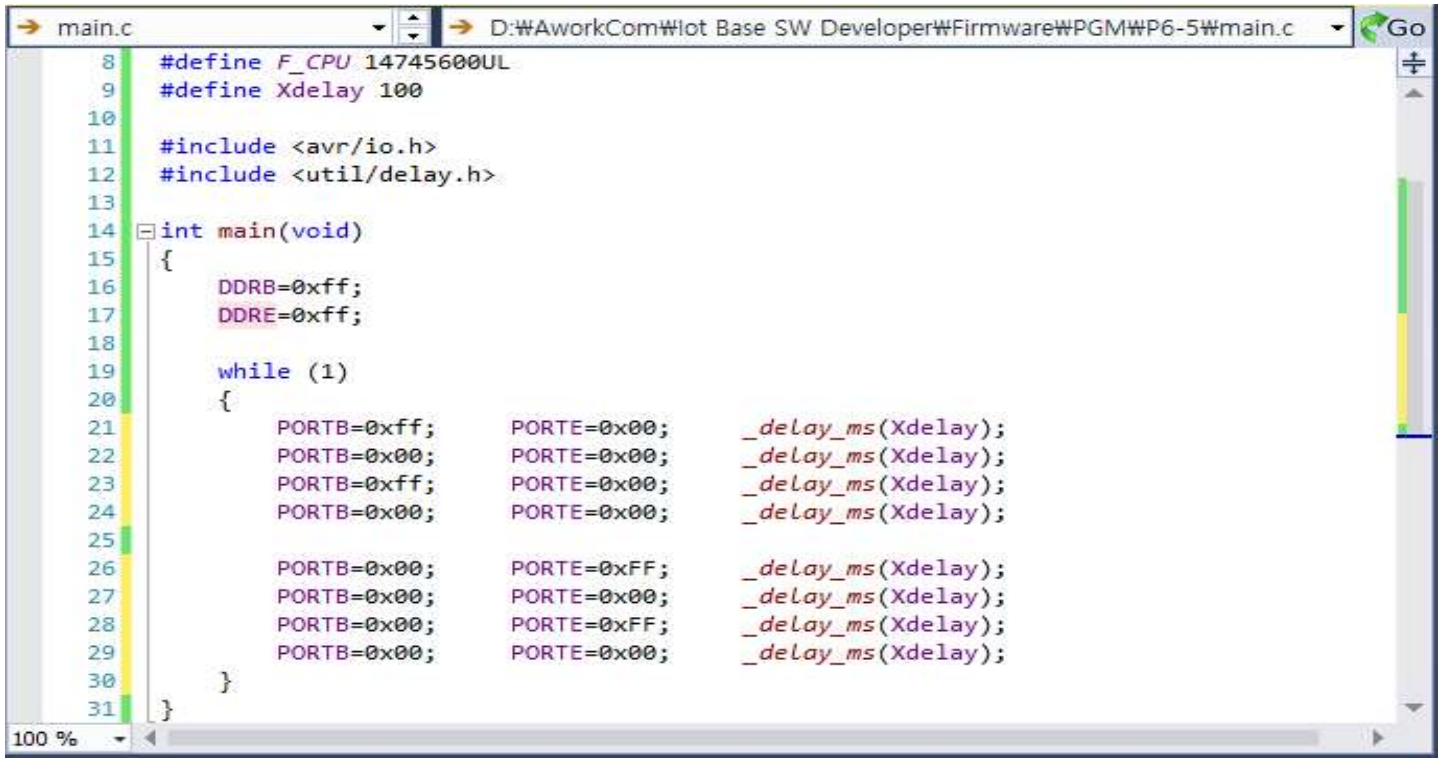


Ex : Program

```
 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




```
#define F_CPU 14745600UL
#define Xdelay 100

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

int main(void)
{
    DDRB=0xff;
    DDRE=0xff;

    while (1)
    {
        PORTB=0xff;     PORTE=0x00;     _delay_ms(Xdelay);
        PORTB=0x00;     PORTE=0x00;     _delay_ms(Xdelay);
        PORTB=0xff;     PORTE=0x00;     _delay_ms(Xdelay);
        PORTB=0x00;     PORTE=0x00;     _delay_ms(Xdelay);

        PORTB=0x00;     PORTE=0xFF;     _delay_ms(Xdelay);
        PORTB=0x00;     PORTE=0x00;     _delay_ms(Xdelay);
        PORTB=0x00;     PORTE=0xFF;     _delay_ms(Xdelay);
        PORTB=0x00;     PORTE=0x00;     _delay_ms(Xdelay);
    }
}
```

Ex : Optimization

- 소방차 경광등을 최적화 해보자

선언, Setup

```
#define F_CPU 14745600UL
#define Xdelay 100

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

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

Sub 함수

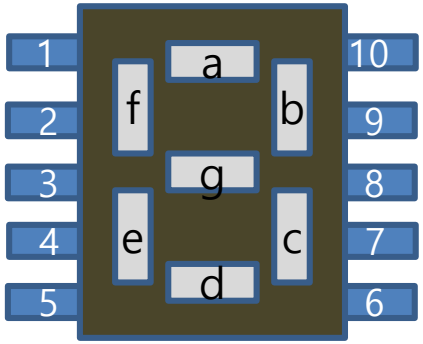
```
void RED_LED(char M)
{
    if (M==0){
        PORTB=0x00;
        _delay_ms(Xdelay);
    } else{
        PORTB=0xff;
        _delay_ms(Xdelay);
    }
}

void GRN_LED(char M)
{
    if (M==0){
        PORTE=0x00;
        _delay_ms(Xdelay);
        } else{
        PORTE=0xff;
        _delay_ms(Xdelay);
    }
}
```

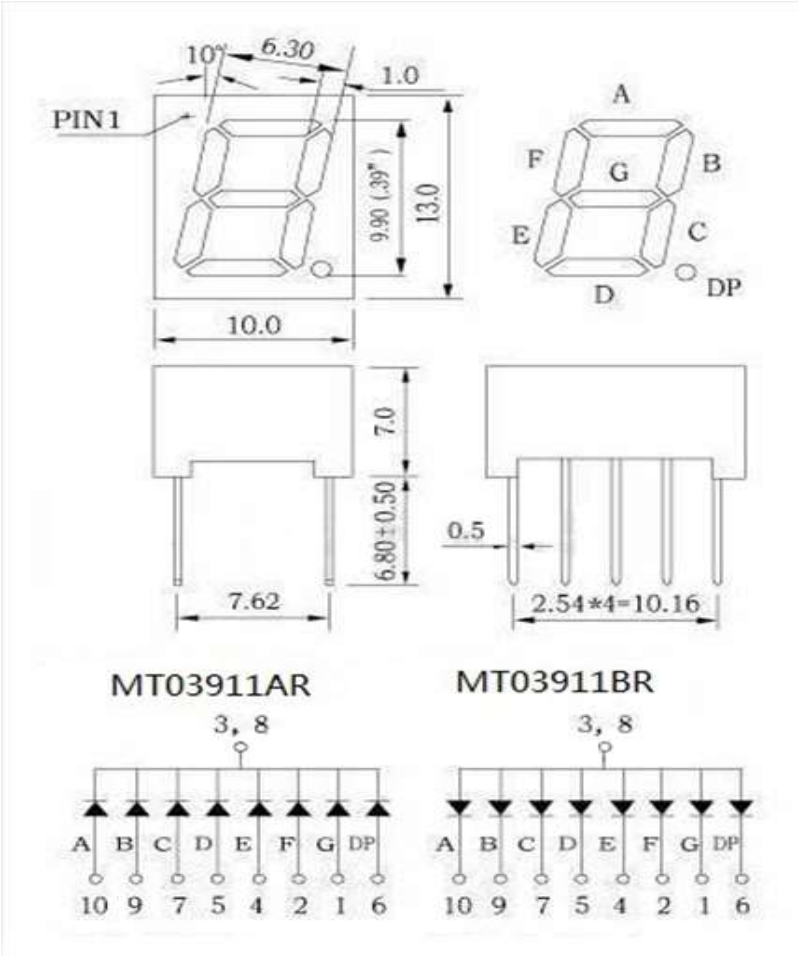
Main 함수

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

    while (1)
    {
        RED_LED(1);     RED_LED(0);
        RED_LED(1);     RED_LED(0);

        GRN_LED(1);     GRN_LED(0);
        GRN_LED(1);     GRN_LED(0);
    }
}
```

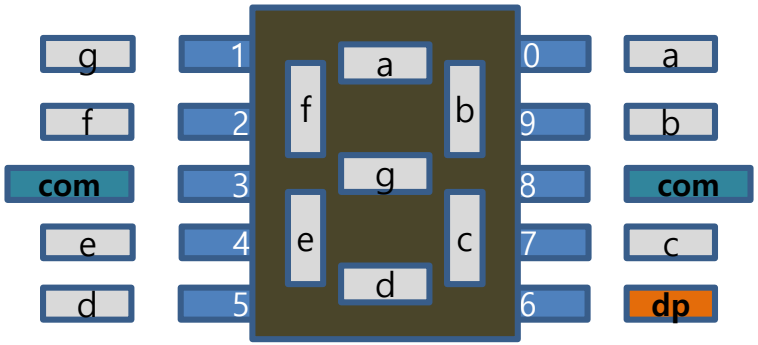
FND 숫자표시기

- FND : Fixed Numeric Display
- 7-Segment



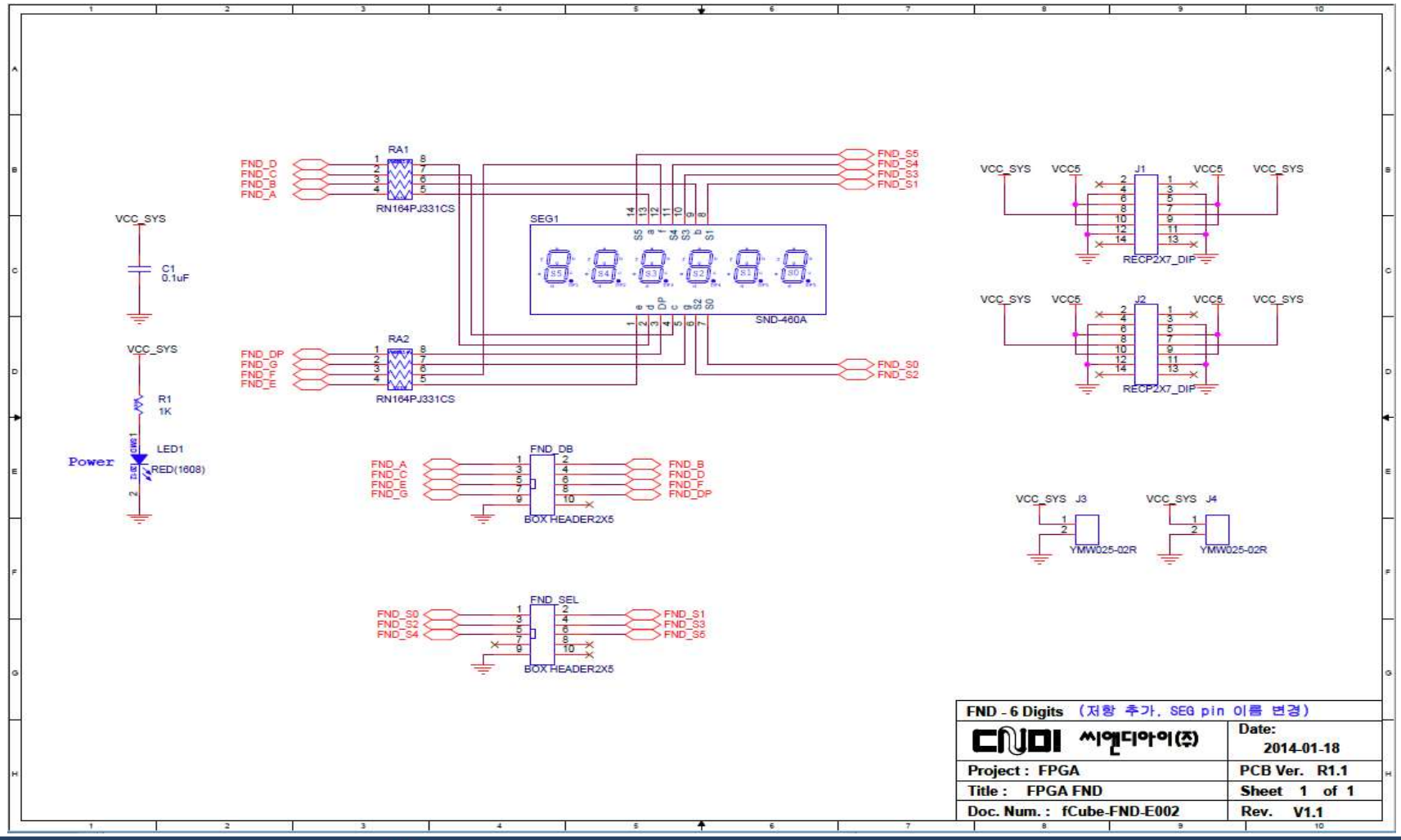


Numeric Display



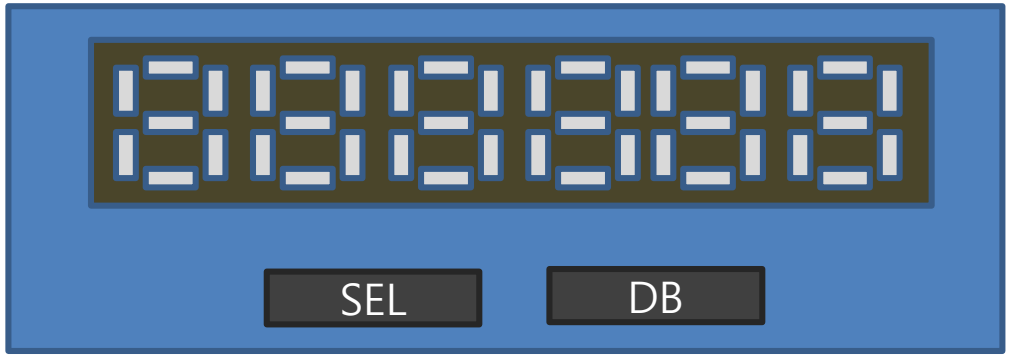
0	1	2	3	4	5	6	7	8	9
ABCDEFG. 00000011	ABCDEFG. 10011111	ABCDEFG. 00100101	ABCDEFG. 00001101	ABCDEFG. 10011001	ABCDEFG. 01001001	ABCDEFG. 01000000	ABCDEFG. 00011111	ABCDEFG. 00000001	ABCDEFG. 00001001

Schematic

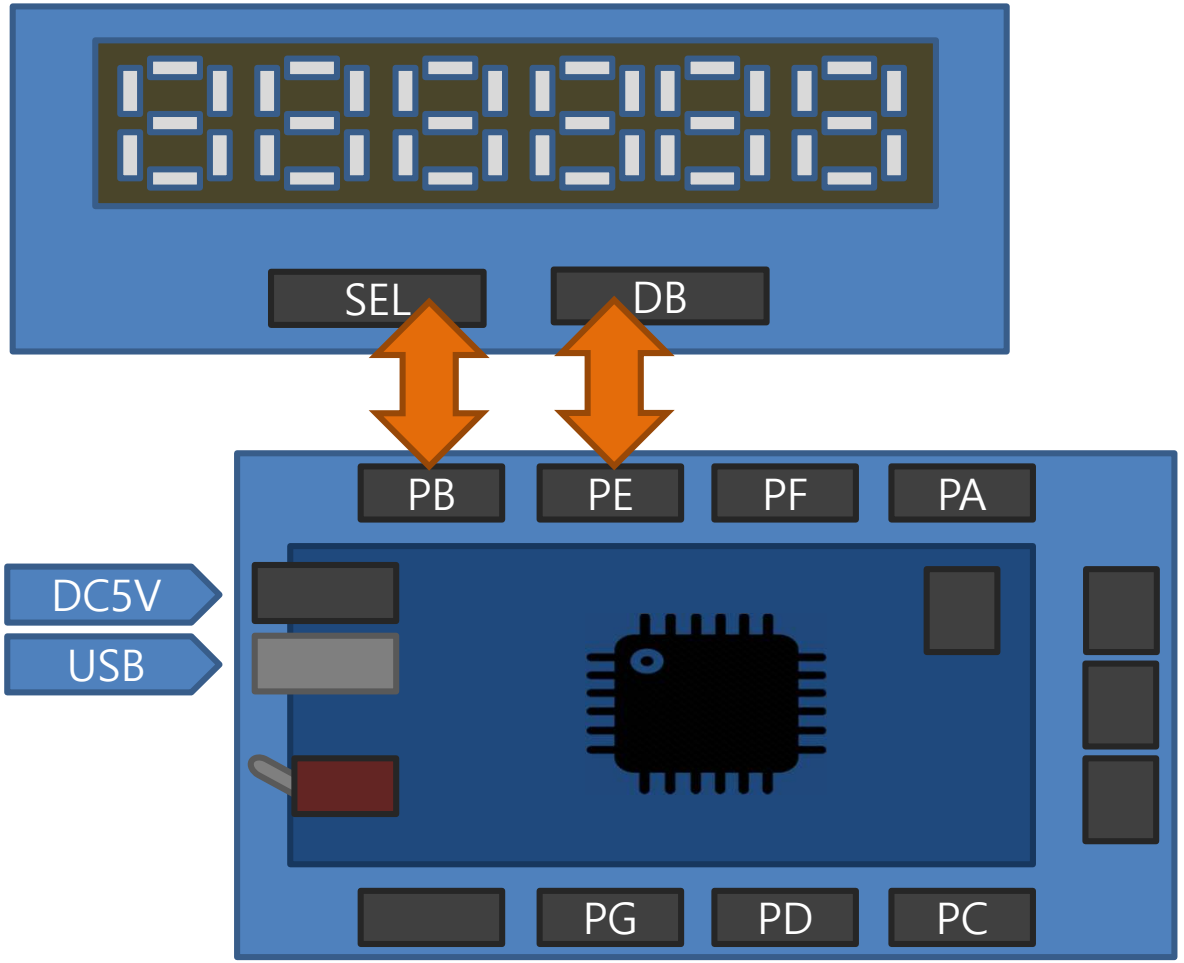

RA1
RN164PJ331CS
RA2
RN164PJ331CS
SEG1
SND-460A
FND_D
FND_C
FND_B
FND_A
FND_DP
FND_G
FND_F
FND_E
FND_S5
FND_S4
FND_S3
FND_S1
FND_S0
FND_S2
VCC_SYS
C1
0.1uF
R1
1K
LED1
RED(1608)
Power
FND_DB
BOXHEADER2X5
FND_SEL
BOXHEADER2X5
VCC5
J1
RECP2X7_DIP
J2
RECP2X7_DIP
J3
YMW025-02R
J4
YMW025-02R
FND - 6 Digits (저항 추가, SEG pin 이름 변경)
씨엔디아이(주)
Date: 2014-01-18
Project : FPGA
PCB Ver. R1.1
Title : FPGA FND
Sheet 1 of 1
Doc. Num. : fCube-FND-E002
Rev. V1.1

FND Module

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



Wiring

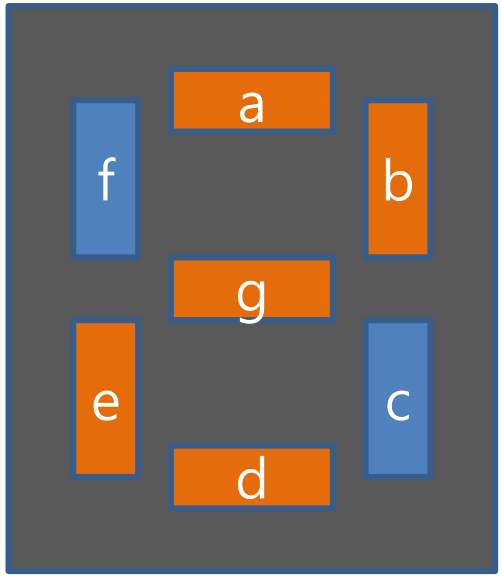


Ex : 숫자 2

- 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

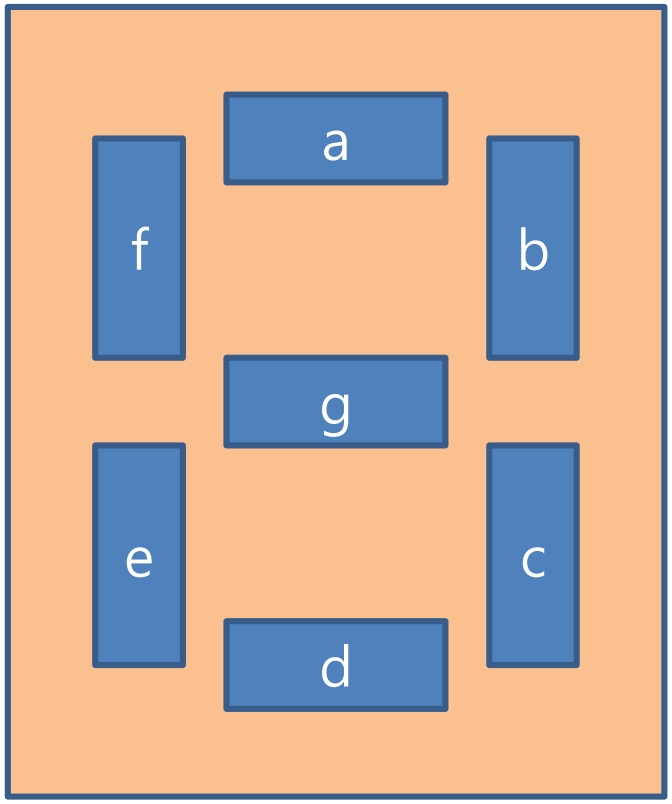
x	g	f	e	d	c	b	a
OFF	On	OFF	On	On	OFF	On	On
0	1	0	1	1	0	1	1

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



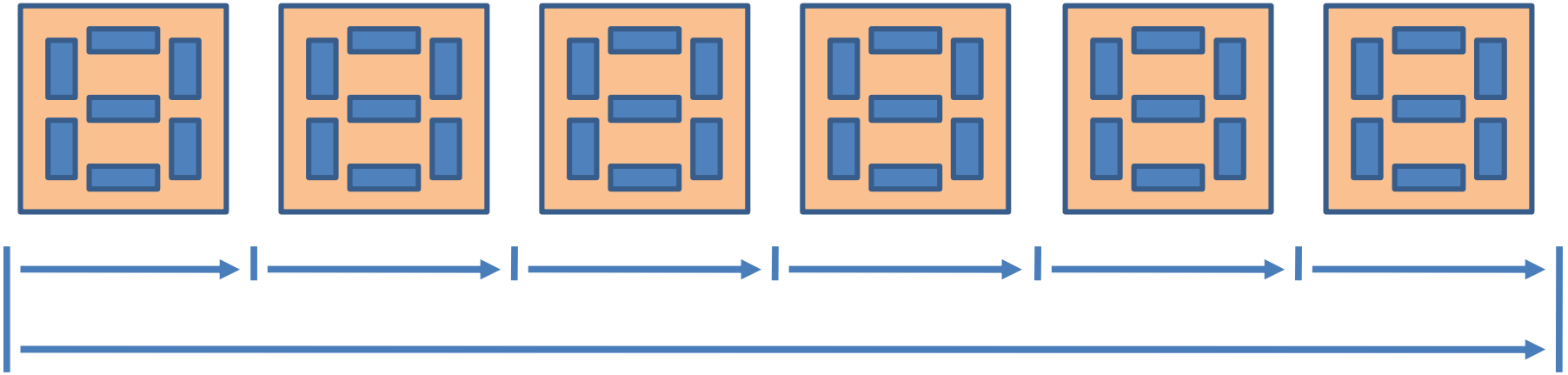
No	x	g	f	e	d	c	b	a	Hex
0	0	0	1	1	1	1	1	1	3f
1	0	0	0	0	0	1	1	0	06
2	0	1	0	1	1	0	1	1	5b
3	0	1	0	0	1	1	1	1	4f
4	0	1	1	0	0	1	1	0	66
5	0	1	1	0	1	1	0	1	6d
6	0	1	1	1	1	1	0	1	7d
7	0	0	1	0	0	1	1	1	27
8	0	1	1	1	1	1	1	1	7f
9	0	1	1	0	1	1	1	1	6f

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 = 1/60hz=16.67msec
개별 시간 = 16.67 / 6 = 2.778msec

예제)
개별 시간 = 3msec
전체 주기 = 1 / (0.003 x 6) = 55.55hz

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

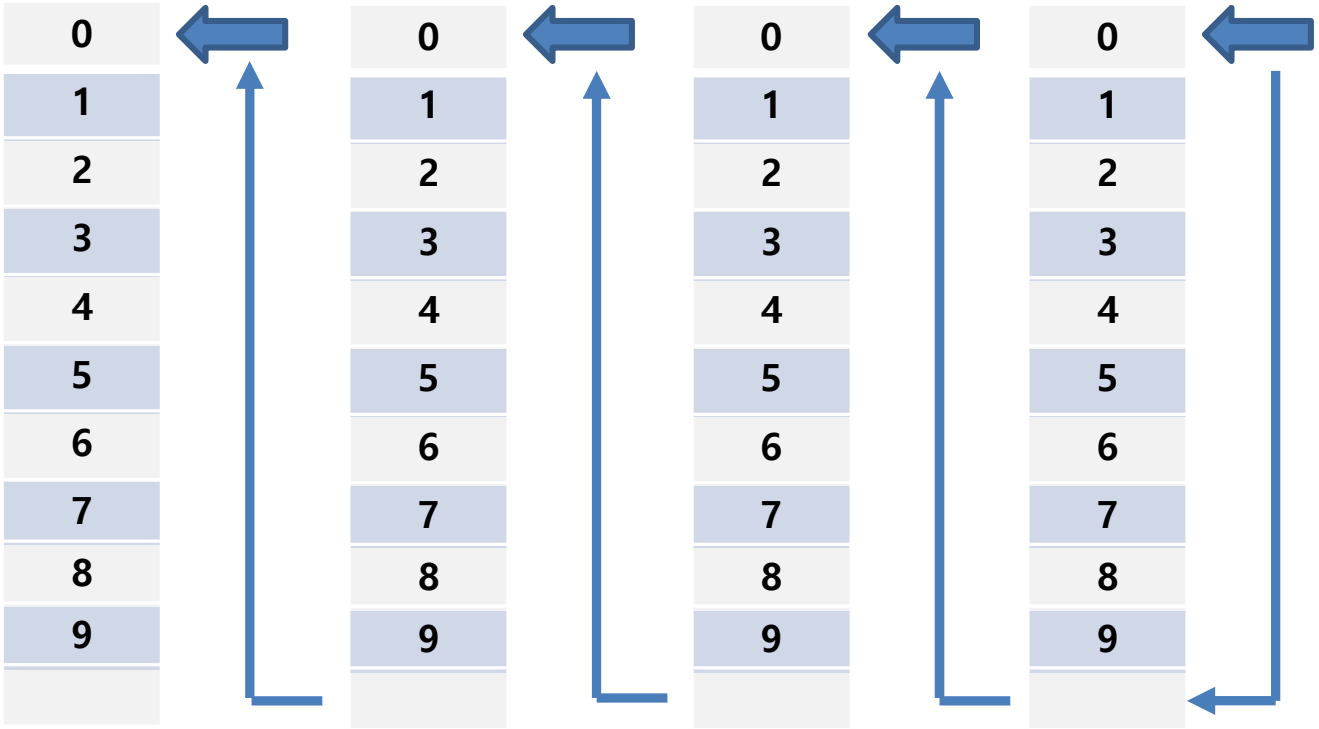
- Dtime을 변경해 보자
  - 50 ~ 1msec 의 범위
  - FND의 밝기
  - 표시의 깜빡임

- 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;
}
```

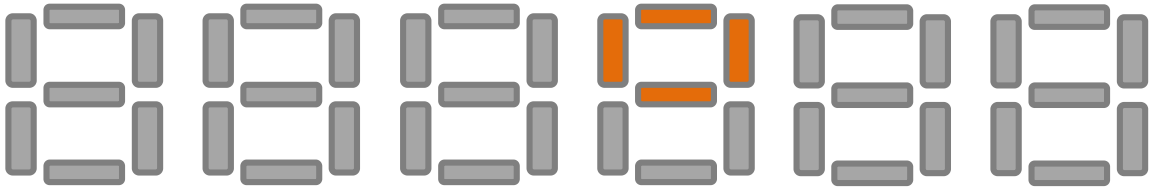
Hex2Dec / main

```
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;
}
```

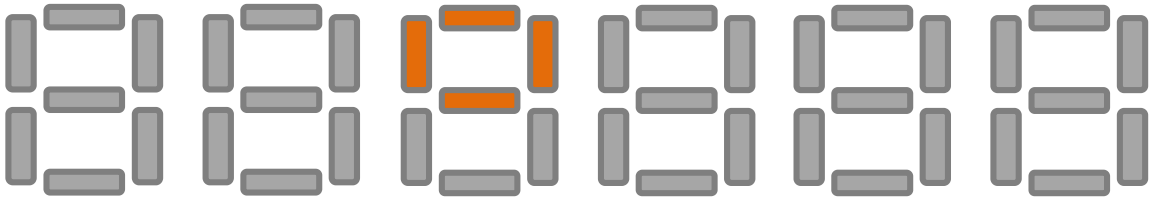
```
int main(void) {
    CPU_Setup( );

    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

Step 1

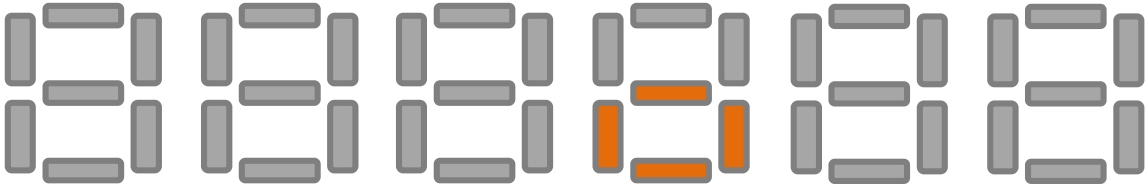


Step 2



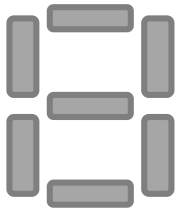
Step 3

Step 4



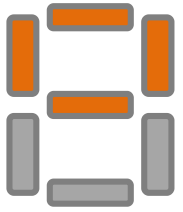
FND Lookup

0



0x00
0000 0000

1



0x63
0110 0011

2

0x5C
0101 1100

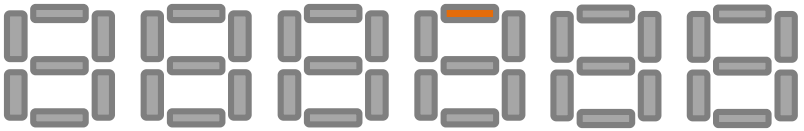
program

```
#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;
}
```

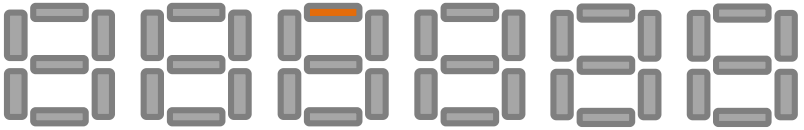
```
int main(void) {
    CPU_Setup( );

    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

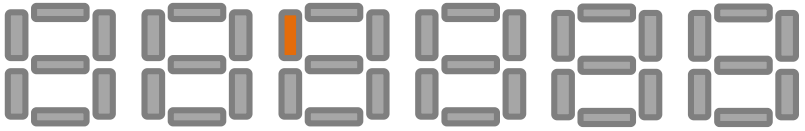
Step 1



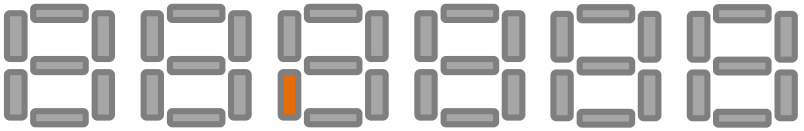
Step 2



Step 3



Step 4



Step 5

Step 6

Step 7