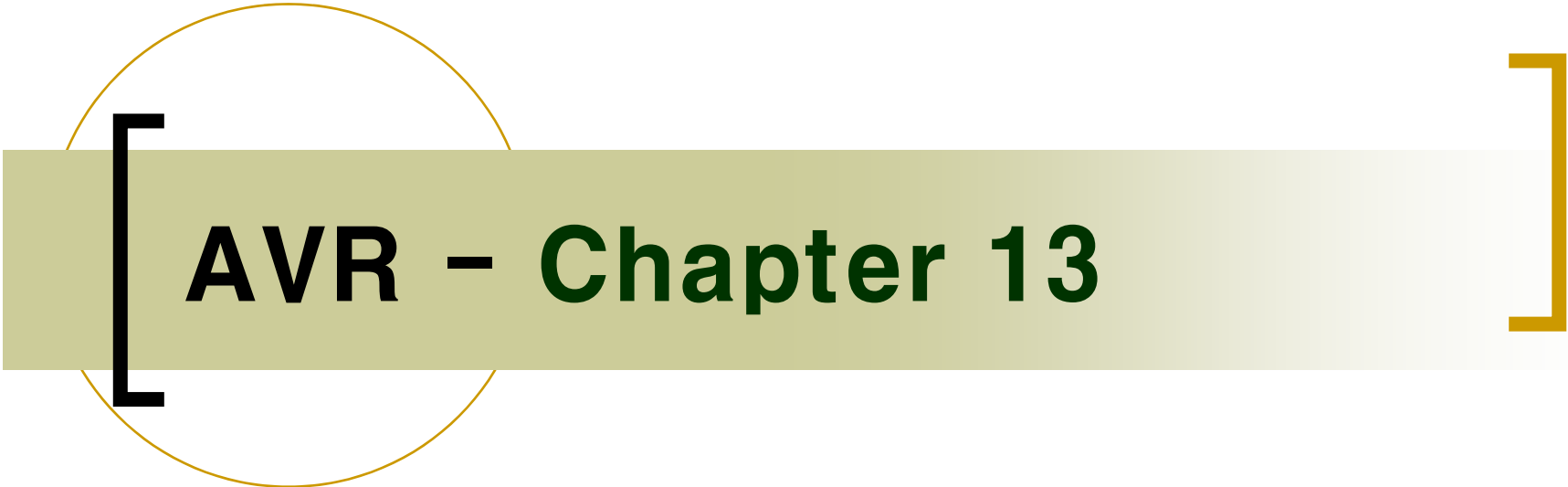




AVR - Chapter 13

류대우

(주)뉴티씨(NEWTC) 대표이사

davidryu@newtc.co.kr

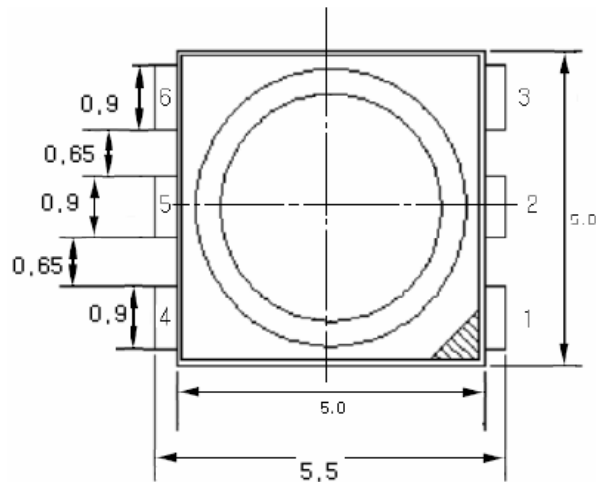
[SPI란?



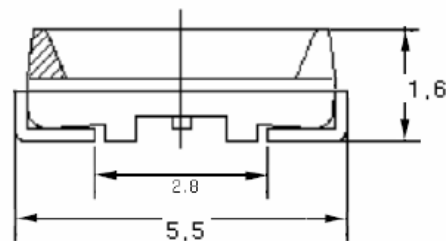
- 한 개의 마스터와 한 개 이상의 슬레이브로 구성됨
- 마스터와 슬레이브의 정의
 - 마스터는 SPI 클럭을 공급하는 마이크로 컴퓨터임
 - 슬레이브는 마스터로부터 SPI 클럭을 받는 IC임
- Master가 /ss 핀에 LOW를 받으면 slave가 된다.
- 만약, 항상 마스터라면, /SS를 VCC에 pull up한다.

[사용한 LED에 관하여]

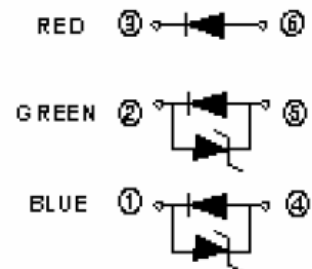
■ IWS-506-RGB-K3



Unit : mm
Tolerance : ± 0.1 mm



Circuit diagram



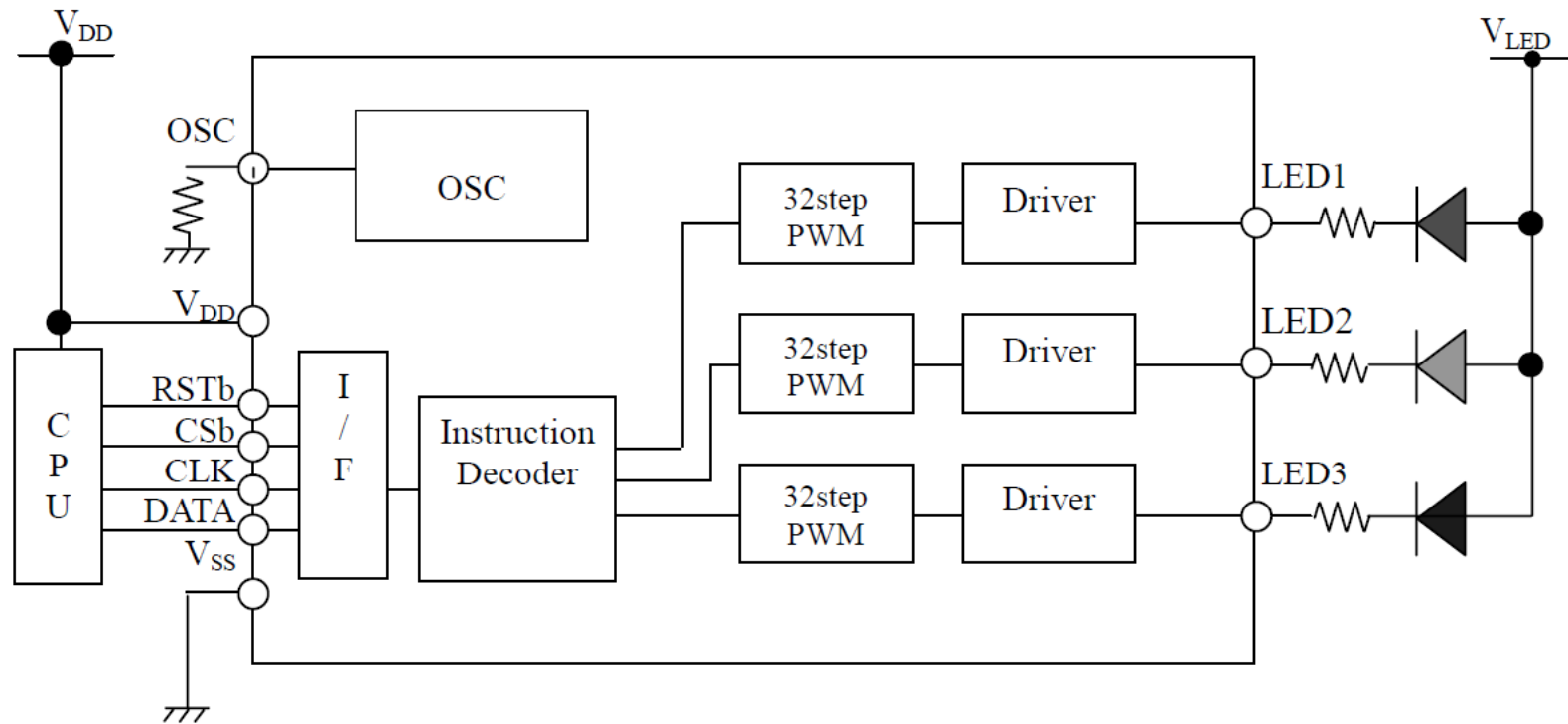
칩에 관하여(1/5)

[NJU6060 란?

- PWM 컨트롤을 내장한 RGB LED Driver
- 8 비트 시리얼 인터페이스(SPI)를 가지고, R, G, B 각각은 32단계 개별적으로 출력하며, 즉, 표현 가능 칼라는 $32 \times 32 \times 32 = 32,768$ 칼라임.
- 2.4V ~ 5.5V의 넓은 동작 전압
- CMOS Technology로 저전력 동작
- 내장 SPI 인터페이스
- 삼색 칼라의 독립적인 제어

칩에 관하여(2/5)

[블럭도]



칩에 관하여(3/5)

[f_{pwm} 에 관하여]

- f_{pwm} 은 외부 저항에 의하여 정밀 조정됩니다.
- 오실레이션의 ON/OFF가 instruction에 의해 조정

칩에 관하여(4/5)

[Absolute Maximum Ratings]

Ta=25°C

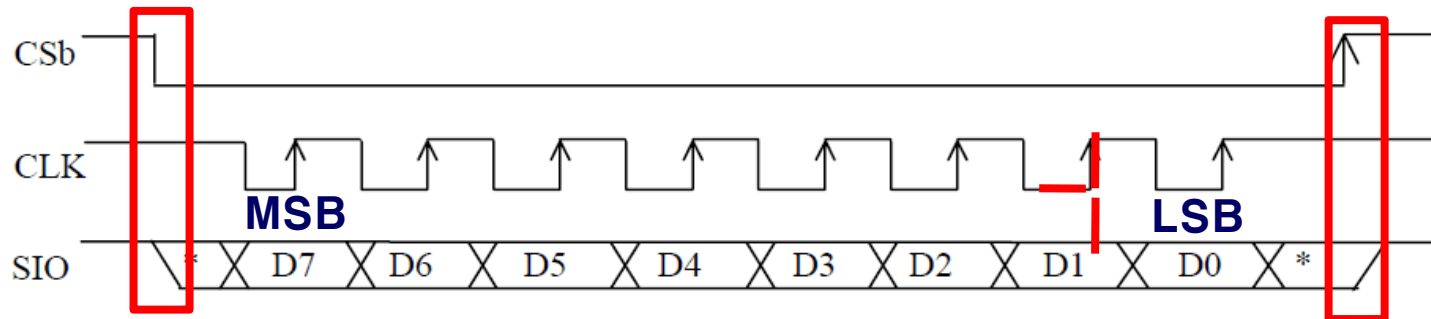
PARAMETERS	SYMBOL	CONDITIONS	RATINGS	UNIT
VDD Power Supply	V _{DD}	VDD terminal	-0.3 to +6.0	V
Driver Off Break Down Voltage	V _{offmax}	LED1, LED2, LED3 terminals	7.0	V
Driver On Break Down Voltage	V _{onmax}	LED1, LED2, LED3 terminals	5.5	V
Input Voltage	V _{IN1}	CSb, DATA, CLK, RSTb, OSC Terminals	-0.3 to V _{DD} +0.3	V
Power Dissipation	Pd _{max}	Ta=25°C	250	mW
Operating Temperature	T _{opr}		-40 to +85	°C
Storage Temperature	T _{stg}		-55 to +125	°C

칩에 관하여(5/5)

[DC 전기적 특성]

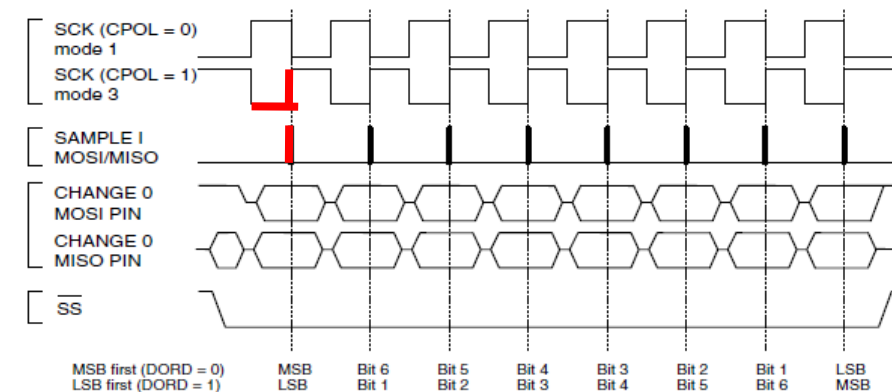
$V_{DD}=2.4$ to $5.5V$, $T_a=-40$ to $85^{\circ}C$

PARAMETERS	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	Unit
V_{DD} Power Supply	V_{DD}		2.4		5.5	V
Input "H" Level Voltage	V_{IH}	RSTb, CSb, CLK, DATA	$0.8V_{DD}$		V_{DD}	V
Input "L" Level Voltage	V_{IL}	RSTb, CSb, CLK, DATA	0		$0.2V_{DD}$	V
Input "H" Level Current	I_{IH}	RSTb, CSb, CLK, DATA, $V_{IN}=V_{DD}$			5.0	μA
Input "L" Level Current	I_{IL}	RSTb, CSb, CLK, DATA, $V_{IN}=0V$	-5.0			μA
Output Off Leak Current	I_{OFFH}	LED1, LED2, LED3: $V_O=5.5V$, Output OFF			6.0	μA
Output "L" Level Voltage	V_{OL}	LED1, LED2, LED3, $I_O=10mA$			0.5	V
Oscillation Frequency	f_{OSC}	$V_{DD}=3V$, $R_{OSC}=910k\Omega$, $T_a=25^{\circ}C$	10.23	12.48	14.72	kHz
Reset "L" Level Pulse Width	t_{RW}	RSTb	1.0			μs
Operating Current	I_{DD}	$V_{DD}=3V$, PWM DUTY: 17/32, Output terminal open, $R_{OSC}=910k\Omega$, $T_a=25^{\circ}C$		6.0	12.0	μA

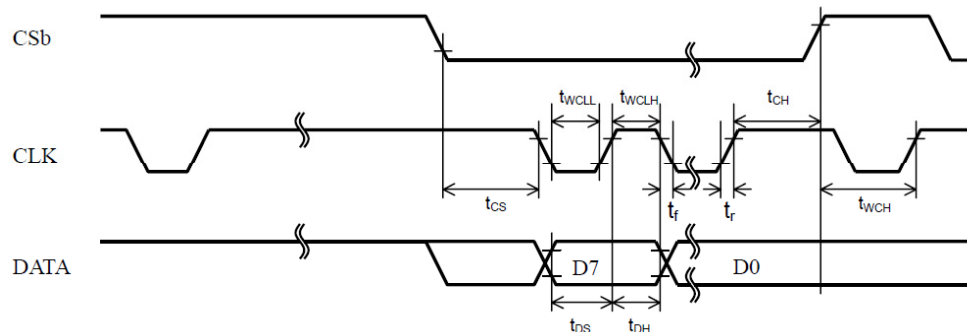


VDD=2.4 to 5.5V, Ta=-40 to 85°C						
PARAMETERS	SYMBOL	Terminal	MIN.	TYP.	MAX.	UNIT
"L" Level CLK Clock Width	t _{WCLL}	CLK	160			ns
"H" Level CLK Clock Width	t _{WCLH}	CLK	160			ns
Data Set-Up Time	t _{DS}	CLK, DATA	150			ns
Data Hold Time	t _{DH}	CLK, DATA	150			ns
CSb Set-Up Time	t _{CS}	CSb, CLK	160			ns
CSb Hold Time	t _{CH}	CSb, CLK	640			ns
CLK Wait Time	t _{WCH}	CSb	640			ns
Rising Time	t _r				15	ns
Falling Time	t _f				15	ns

Figure 77. SPI Transfer Format with CPHA = 1



Serial Input Timing



제어방법 (2/2)

[Instruction Code]

Table 1. Instruction Code

Instruction	Code								Discription
	D7	D6	D5	D4	D3	D2	D1	D0	
LED1 <u>PWM Data Set</u>	0	0	0	D	D	D	D	D	5-bit PWM data is set.
LED2 PWM Data Set	0	0	1	D	D	D	D	D	5-bit PWM data is set.
LED3 PWM Data Set	0	1	0	D	D	D	D	D	5-bit PWM data is set.
<u>PWM Frequency set</u> / OSC ON/OFF /Output port ON/OFF	0	1	1	f_{PWM}	OSC	LED1	LED2	LED3	f_{PWM} 0:(fosc/2)/32 1:(fosc/2)/64 OSC 0:OFF 1:ON LED1 to 3 0:OFF 1:ON
LED1 <u>PWM Phase set</u>	1	0	0	*	*	*	Phase value		0,0: Same phase 0,1: 4-step shift 1,0: 8-step shift 1,1: 16-step shift
LED2 PWM Phase set	1	0	1	*	*	*	Phase value		
LED3 PWM Phase set	1	1	0	*	*	*	Phase value		
Test	1	1	1	Test Data					Inhibited command

* : Don't Care

[3가지 인스트럭션

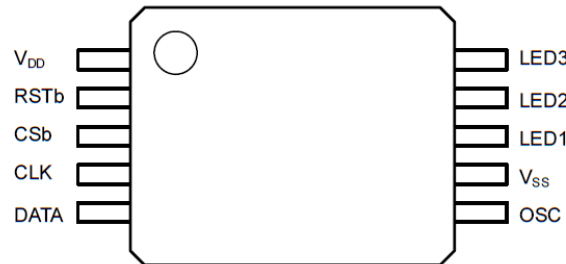
]

- 3가지 인스트럭션을 수행할 함수를 만든다
 - (주의) 칩마다 3개의 LED가 있음에 유의
 - PWM Data Set
 - 각 LED마다 데이터 셋
 - PWM Frequency Set
 - PWM 주파수, OSC onoff, LED onoff 셋
 - PWM Phase Set
 - Phase shift 셋

회로설계(1/3)

[NJU6060 핀배열]

■ 핀 배열



■ 핀 설명

No.	PIN NAME	TYPE	DESCRIPTIONS
1	V _{DD}	Power	V _{DD} Power Supply terminal
2	RSTb	Input	Reset terminal - Active "L".
3	CSb	Input	Chip Select terminal The serial data is fixed on the rising edge of CSb clock.
4	CLK	Input	Shift Clock terminal
5	DATA	Input	Serial Data terminal
6	OSC	Input	Oscillating terminal External resistor connecting
7	V _{SS}	Power	Ground terminal
8	LED1	Output	LED Connect terminals (Open drain output) Output level are 32 steps PWM by instruction control. Connecting cathode of LED.
9	LED2	Output	
10	LED3	Output	

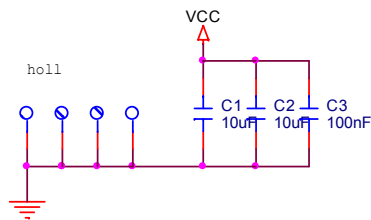
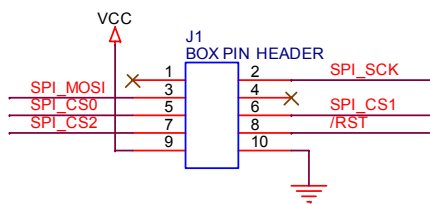
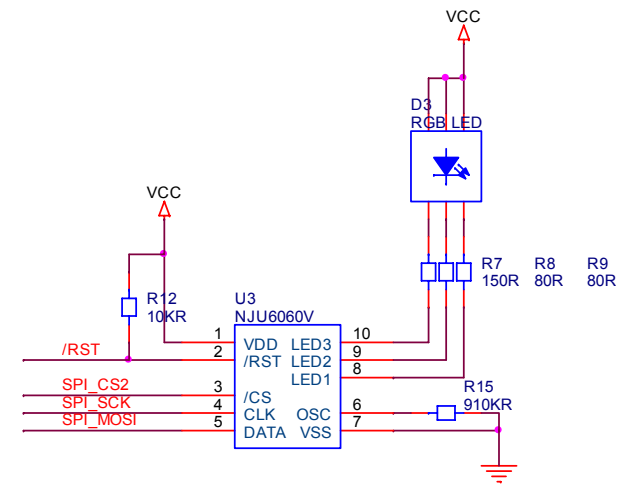
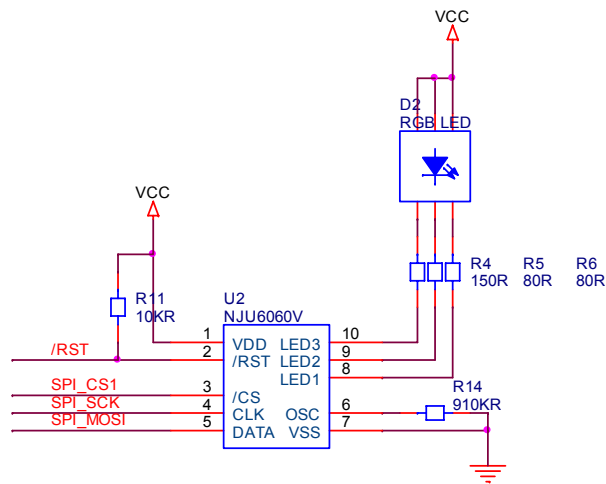
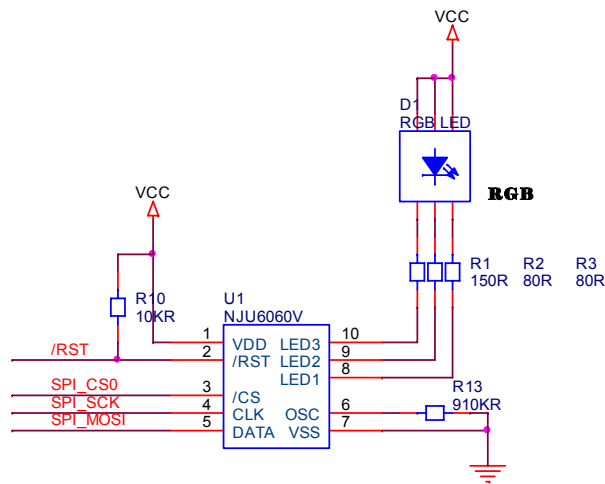
회로설계(2/3)

[리셋회로]

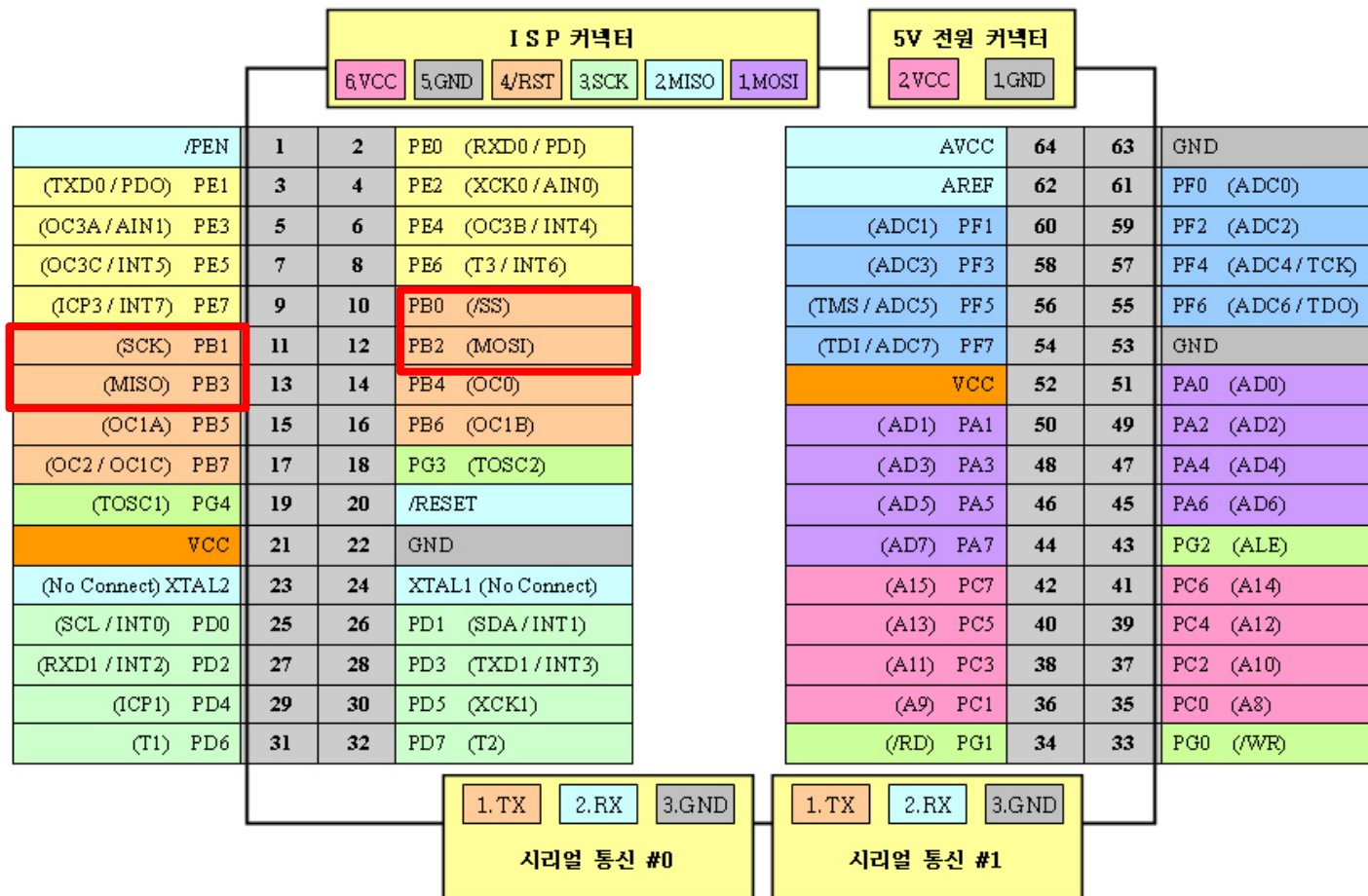
- $1\mu s$ 이상의 리셋 신호를 RES 터미널에 넣어주면, 다음과 같이 초기화 된다.
 - f_{pwm} : 0 : $(f_{osc}/2)32$
 - OSC : 0 : Oscillation OFF
 - LED1 to 3 : 0 : OFF
 - Phase : 0,0 : Same Phase
 - PWM data : 0,0,0,0,0 : 1/32

회로설계(3/3)

[조명용 3색 LED 회로도]



[AM-128PRO의 핀배치도]



AVR에서의 SPI 제어

[소스코드 분석]

■ 10핀 박스 헤더 핀 배치

- **D1 : SCK** : #define NJU_SCK (1<< 1)
- **D2 : DATA** (MOSI(Master Out Slave In))
#define NJU_DATA (1<< 2)
- **D4: /CS0** : #define NJU_CS0 (1<< 4)
- **D5 : /CS1** : #define NJU_CS1 (1<< 5)
- **D6 : /CS2** : #define NJU_CS2 (1<< 6)
- **D7 : /RST** : #define NJU_RST (1<< 7)

AVR에서의 SPI제어

[spi_init()]

■ SPCR = 0x5c; //setup SPI Control Register

Bit	7	6	5	4	3	2	1	0	
	SPIE	SPE	DORD	MSTR	CPOL	CPHA	SPR1	SPR0	SPCR
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

- SPIE: 0 SPE: 1(SPI Enable) DORD:0(MSB First) MSTR:1(Master mode)
- CPOL:1 CPHA:1 :SPImode(3) SCK Freq (0,0,0):fosc/4 : 4MHz (0,0,0)

■ SPSR = 0x00; //setup SPI status Register

Bit	7	6	5	4	3	2	1	0	
	SPIF	WCOL	-	-	-	-	-	SPI2X	SPSR
Read/Write	R	R	R	R	R	R	R	R/W	
Initial Value	0	0	0	0	0	0	0	0	

- SPIF : SPI Interrupt Flag 전송이 끝나면 SET 됨.
- WCOL : Write Collision flag 전송중 SDPR에 데이터가 써질 때 SET 됨.
- SPI2X : 10이 되면 더블 스피드임.

AVR에서의 SPI제어

[SPI_Master_Transmit_Receive()]

■ SPDR (SPI Data Register)

Bit	7	6	5	4	3	2	1	0	
	MSB							LSB	SPDR
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	X	X	X	X	X	X	X	X	Undefined

- 데이터를 쓰면 데이터 전송을 초기화 한다.
- 데이터를 읽으면 Shift Register Receive buffer를 읽는다.

- `SPDR = cData;` // Start transmission
- `while( !( SPSR & ( 1 << SPIF ) ));` // Wait for transmission complete
- `#define SPIF 7` ← iom128v.h에 있습니다.
- `return SPDR;` // Return data register Datasheet P.297.참조

[NJU6060_Init()



- 1us 이상의 리셋 신호를 /RST에 넣는다.

- CSn=LOW ← PORTB &= ~NJU_CSn;
- CSn=LOW ← PORTB |= NJU_RST;

- PWM Frequency Set

- SPI_Master_Transmit_Receive(0x6f);
 - fpwm : (fosc/2) /32
 - LED1~3 ON, OSC ON

- PWM Phase Set

- SPI_Master_Transmit_Receive(0x81);
 - LED1 PWM Phase set : 0,1 : 4-step shift
- SPI_Master_Transmit_Receive(0xa2);
 - LED2 PWM Phase set : 1,0 : 8-step shift
- SPI_Master_Transmit_Receive(0xc3);
 - LED3 PWM Phase set : 1,1 : 16-step shift

[NJU6060_RGB_Write()

- PWM Data set 인스트럭션 수행

- 파라메타

- **ch** : 채널
- **red** : 0~31
- **green** : 0~31
- **blue** : 0~31

- `PORTB &= ~NJU_CS0;`
- `SPI_Master_Transmit_Receive(0x00|red);`
- `PORTB |= NJU_CS0;`
- `PORTB &= ~NJU_CS0;`
- `SPI_Master_Transmit_Receive(0x20|green);`
- `PORTB |= NJU_CS0;`
- `PORTB &= ~NJU_CS0;`
- `SPI_Master_Transmit_Receive(0x40|blue);`
- `PORTB |= NJU_CS0;`

[과제



- LED를 가장 최고의 밝기로 켜 보라.
- LED를 가장 최저의 밝기로 켜 보라.
- 시리얼로 LED의 밝기를 조절할 수 있도록 만든다.
 - ‘a’ : 밝아짐
 - ‘z’ : 어두워짐
 - ‘0’ ~ ‘9’ : 숫자에 따라 밝은 밝기
- 시리얼 프로토콜로 삼색 LED 1, 2, 3을 제어한다.
 - 예 : L1,1,B32 : L1의 1번 LED(R)를 최고의 밝기로
 - 예 : L2,2,B00 : L2의 2번 LED(G)를 최저의 밝기로(끄는 수준)
 - 예 : L3,3,F1 : fpwm 주파수를 1 모드로($f_{osc}/2$)/64