Full Color LED Controller Driver with PWM Control

■ GENERAL DESCRIPTION

The **NJU6060** is Full Color LEDs Controller Driver. It drives specifically RGB(Red, Green and Blue) color LEDs by 1 package and control the each color LED separately.

The **NJU6060** contains PWM (Pulse Width Modulation) luminance control, a LED driver, MPU interface circuit and so on.

The PWM luminance control's output level are 32 steps to 1 LED. Therefore totally it control 32,768 kinds of color.

**NJU6060** is suitable for Cellular Phone, Car Audio and so on.

■ PACKAGE OUTLINE
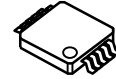
NJU6060V

■ FEATURES

● Controls the 3-color LED Separately (ILED=10mA x 3 outputs)
● Built-in PWM Luminance Control (32 steps x 3)
● Built-in 8bit serial Interface Circuit
● Built-in Oscillation Circuit
● Operating Voltage for Step-up Circuits   : 2.4V to 5.5V
● Package   : SSOP-10
● CMOS Technology

NJU6060

■ PIN CONNECTIONS (TOP VIEW)
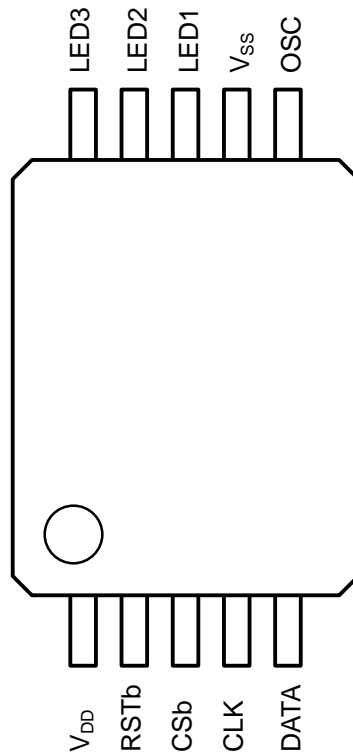
■ PIN DESCRIPTIONS

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)
9	LED2	Output	Output level are 32 steps PWM by instruction control.
10	LED3	Output	Connecting cathode of LED.

■ BLOCK DIAGRAM
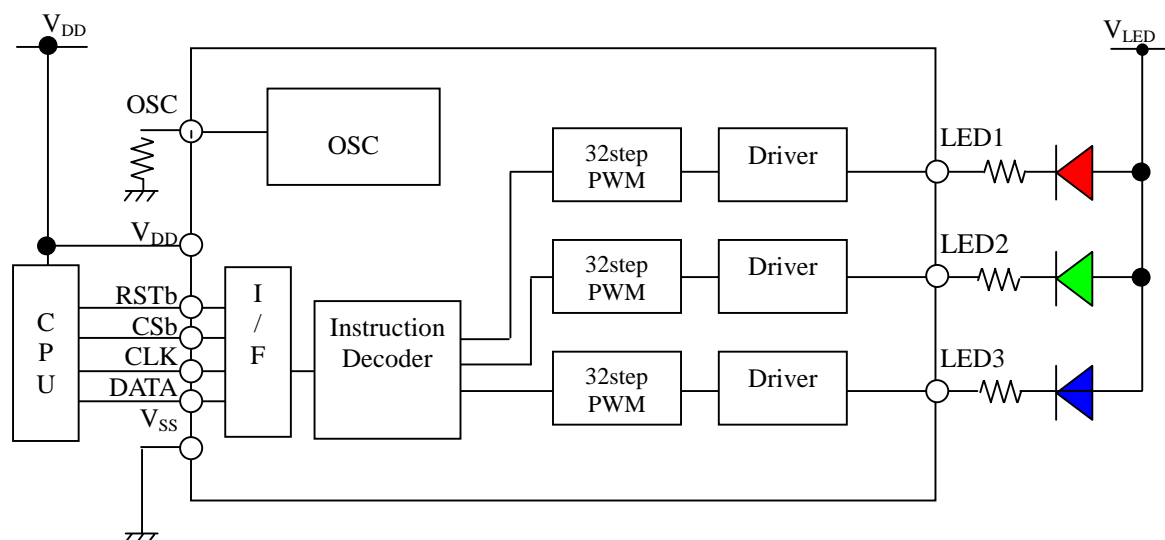
■ FUNCTIONAL DESCRIPTIONS

(1) Description for each blocks

   (1-1) PWM Luminance Control

   The **NJU6060** incorporates three channel of 32 steps PWM Luminance Control circuits. 32 steps of Luminance Control by setting up DUTY. The relation between a register and DUTY is shown below:

REGISTER	DUTY	REGISTER	DUTY	REGISTER	DUTY	REGISTER	DUTY
0,0,0,0,0	1/32	0,1,0,0,0	9/32	1,0,0,0,0	17/32	1,1,0,0,0	25/32
0,0,0,0,1	2/32	0,1,0,0,1	10/32	1,0,0,0,1	18/32	1,1,0,0,1	26/32
0,0,0,1,0	3/32	0,1,0,1,0	11/32	1,0,0,1,0	19/32	1,1,0,1,0	27/32
0,0,0,1,1	4/32	0,1,0,1,1	12/32	1,0,0,1,1	20/32	1,1,0,1,1	28/32
0,0,1,0,0	5/32	0,1,1,0,0	13/32	1,0,1,0,0	21/32	1,1,1,0,0	29/32
0,0,1,0,1	6/32	0,1,1,0,1	14/32	1,0,1,0,1	22/32	1,1,1,0,1	30/32
0,0,1,1,0	7/32	0,1,1,1,0	15/32	1,0,1,1,0	23/32	1,1,1,1,0	31/32
0,0,1,1,1	8/32	0,1,1,1,1	16/32	1,0,1,1,1	24/32	1,1,1,1,1	32/32

   (1-2) Oscillator

   The **NJU6060** Oscillation circuit is generated clock which generates PWM by connecting external resistor.

   The oscillation circuit with the external register generate the clock for PWM. The PWM frequency (f_{PWM}) is finely adjusted by value of the external register. In addition, the ON/OFF of oscillation circuit is controlled by the instruction, and the current consumption is decreased when it was OFF of the oscillation circuit.
   If PWM was high when the oscillation circuit became OFF, the situation of PWM was kept. Input OFF command of the output port.

NJU6060

(2) Instructions

3 line type serial interface using a setup of PWM data, ON/OFF of Light Emitting Diode, etc. are made.

The input data and latched at rising edge of chip shift clock (CLK) and the 8-bit data are fetched into the **NJU6060** at the rising edge of chip select (CS). The data to input is MSB first.

Table.1 shows the instruction codes of the **NJU6060**.

Table 1. Instruction Code

Instruction	Code								Discription
	D7	D6	D5	D4	D3	D2	D1	D0	
LED1 PWM Data Set	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.

PWM Frequency set / 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 PWM Phase set	1	0	0	*	*	*	Phase value		0,0: Same phase
LED2 PWM Phase set	1	0	1	*	*	*	Phase value		0,1: 4-step shift 1,0: 8-step shift
LED3 PWM Phase set	1	1	0	*	*	*	Phase value		1,1: 16-step shift
Test	1	1	1	Test Data					Inhibited command

* : Don't Care

Note) The "PWM data set", the "PWM Frequency set" and the "PWM phase set" commands are executed, asynchronously to the PWM counter, thus the user's command setting is executed after execution time, which is about 128/fosc if {"f_{PWM}=(fosc/2)/2"} is set up. During that execution time, the IC may execute an unexpected setting. For this reason, it is recommended to make sure actual performance is the user's practical application.

(2-1) Explanation of instruction code
 (a) LED1 to 3 PWM Data Set
    This instruction set the PWM luminance control Duty data. It sets up for every LED port.

LED1 PWM Data Set

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	0	D	D	D	D	D

LED2 PWM Data Set

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	1	D	D	D	D	D

LED3 PWM Data Set

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	0	D	D	D	D	D

D   :DUTY
    0,0,0,0,0 to 1,1,1,1,1

(b) PWM Frequency set / OSC ON/OFF / Output port ON/OFF
This instruction set the PWM Frequency, Oscillator ON/OFF and Output port ON/OFF.

PWM Frequency set / OSC ON/OFF / Output port ON/OFF

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	f_{PWM}	OSC	LED 1	LED 2	LED 3

PWM Frequency set
f_{PWM} 0 : fsys / 32 frequency(Default)
             1 : fsys / 64 frequency
                (fsys : System clock = fosc / 2)

OSC ON/OFF
OSC   0 : Oscillator OFF(Default)
             1 : Oscillator ON

Output port ON/OFF
LED1 to 3   0 : Output port OFF(Default)
             1 : Output port ON
                It sets up for every LED port.

(c) LED1 to 3 PWM Phase set
This instruction set the PWM waveform Phase of output LED ports.

LED1 PWM Phase set

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	0	*	*	*	Phase	

*: Don't Care

LED2 PWM Phase set

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	1	*	*	*	Phase	

*: Don't Care

LED3 PWM Phase set

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	1	0	*	*	*	Phase	

*: Don't Care

D_1	D_0	Shift Phase Value
0	0	Same Phase
0	1	4-step shift
1	0	8-step shift
1	1	16-step shift

NJU6060

Example) Set Output PWM waveform of LED1 to LED3 terminal, shown below:
- LED1 PWM Phase set $D_1=0$, $D_0=0$
- LED2 PWM Phase set $D_1=1$, $D_0=0$
- LED3 PWM Phase set $D_1=1$, $D_0=1$
- PWM Frequency set / OSC ON/OFF / Output port ON/OFF $D_4=0$, $D_3=1$, $D_2=1$, $D_1=1$, $D_0=1$
- LED1 to 3 PWM Data Set
    $(PWM_4, PWM_3, PWM_2, PWM_1, PWM_0) = (1,0,0,0,0)$
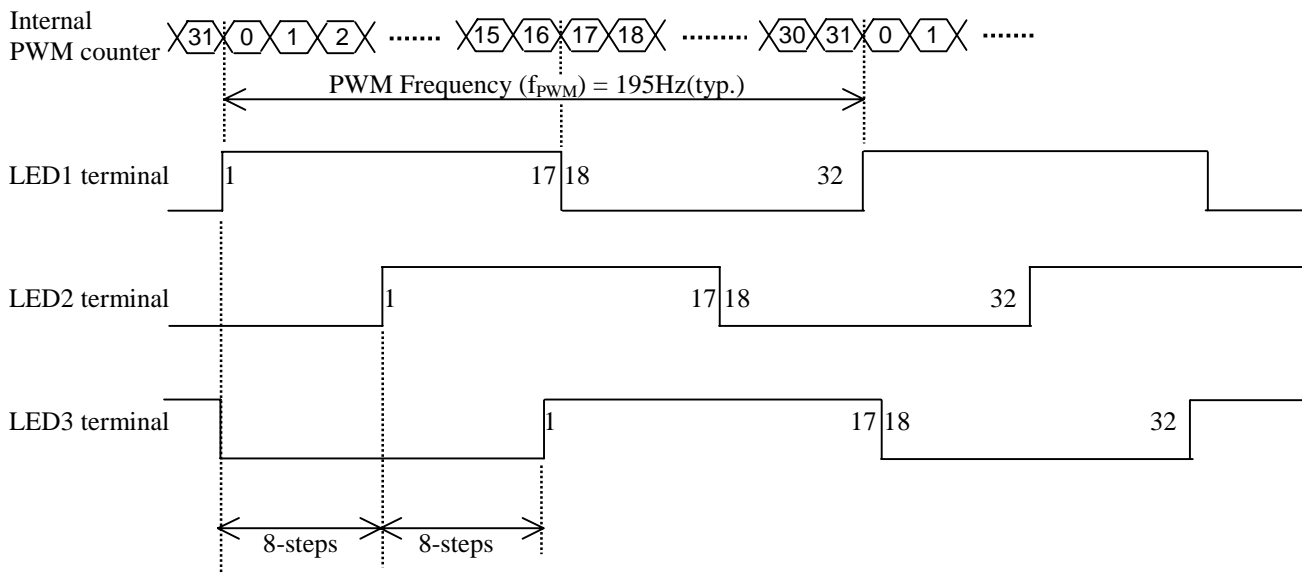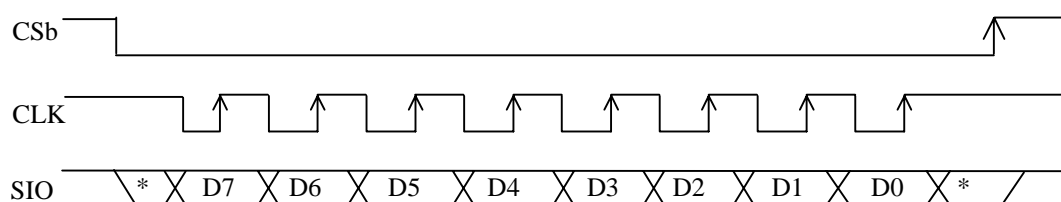

(d) Maker Testing

This instruction is using for device testing mode (only for maker).

If it's absolute necessary in the user's command sequence, the only one command data (1,1,1,0,0,0,0,0) to release the test mode can be accepted.

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	1	1			Test Data		

(3)   Serial Interface
        The **NJU6060** interface with MPU by Serial Interface, control for LED.

    Note1) Data is not concerned with the signal of CSb but is read into the internal shift register by the rising edge of CLK.
    Note2) The contents of a shift register are read into the internal instruction decoder by the rising edge of CSb.
    note3) An instruction and data should surely input 8 bits. In case of entering over than 8 bits data, valid data is last 8 bits
        data.

(4)   Reset Circuit
        Reset Circuit initializes the LSI to the following status by using of the more 1μs reset signal into the RES terminal

        Reset status using the RES terminal
            1, f_{PWM} 0: (fosc/2)/32
            2, OSC   0: Oscillation OFF
            3, LED1 to 3   0: OFF
            4, Phase   0,0: Same Phase
            5, PWM data   0,0,0,0,0: 1/32

NJU6060

■ ABSOLUTE MAXIMUMN 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

Note1) V_{SS} = 0V to all conditions

Note2) If the LSI was used out of the absolute maximum ratings, LSI is damaged completely and the riliability become poor. The LSI is used on the electrical characteristics is recommended strongly for normal operation.

NJU6060

■ DC ELECTRICAL CHARACTERISTICS

V_{DD}=2.4 to 5.5V, Ta=-40 to 85°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}=910kΩ, T_a=25°C	10.23	12.48	14.72	kHz
Reset "L" Level Pulse Width	t_{RW}	RSTb	1.0			μs
Operating Current	I_{DD}	VDD=3V, PWM DUTY: 17/32, Output terminal open, R_{OSC}=910kΩ, T_a=25°C		6.0	12.0	μA

Note1):   Input Terminal Structure
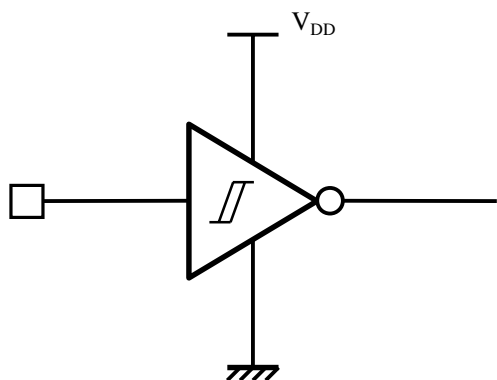
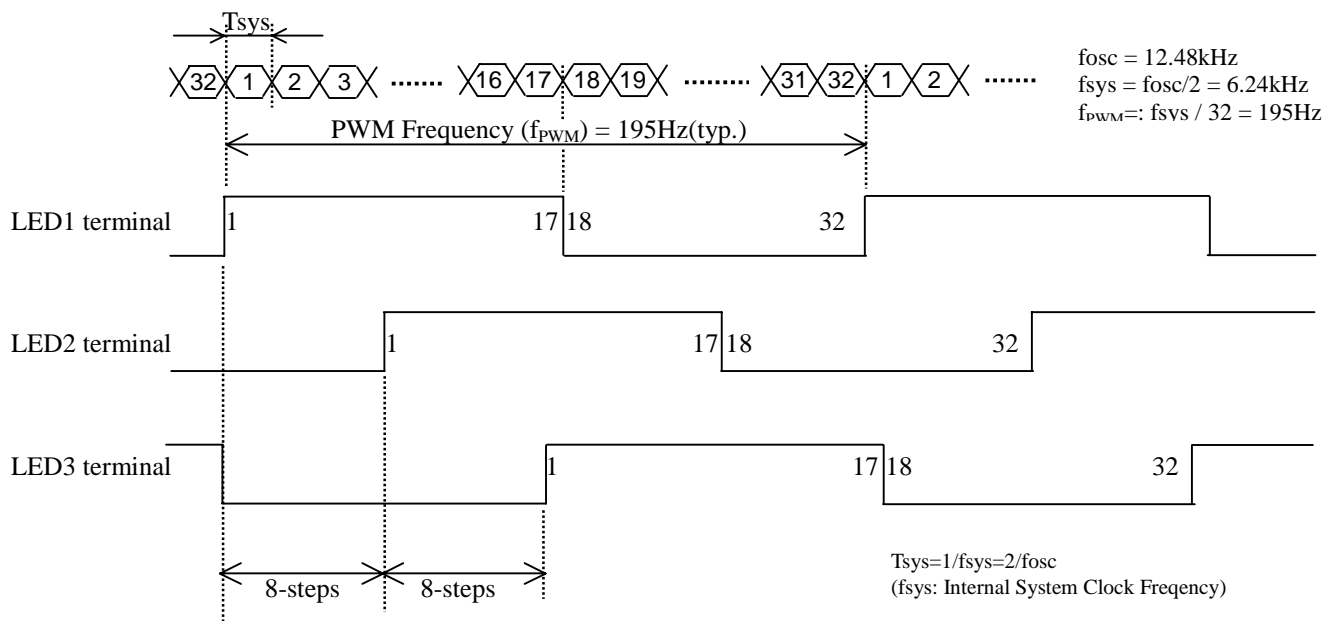

RSTb, CSb, CLK, DATA terminals   LED1, LED2, LED3 terminals

NJU6060
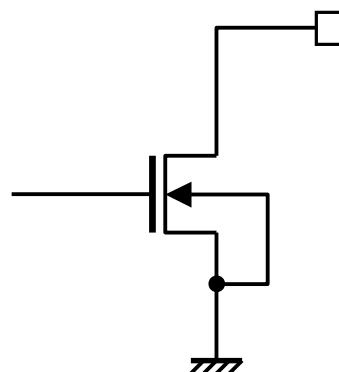
Relation between oscillation frequency and LCD frame frequency
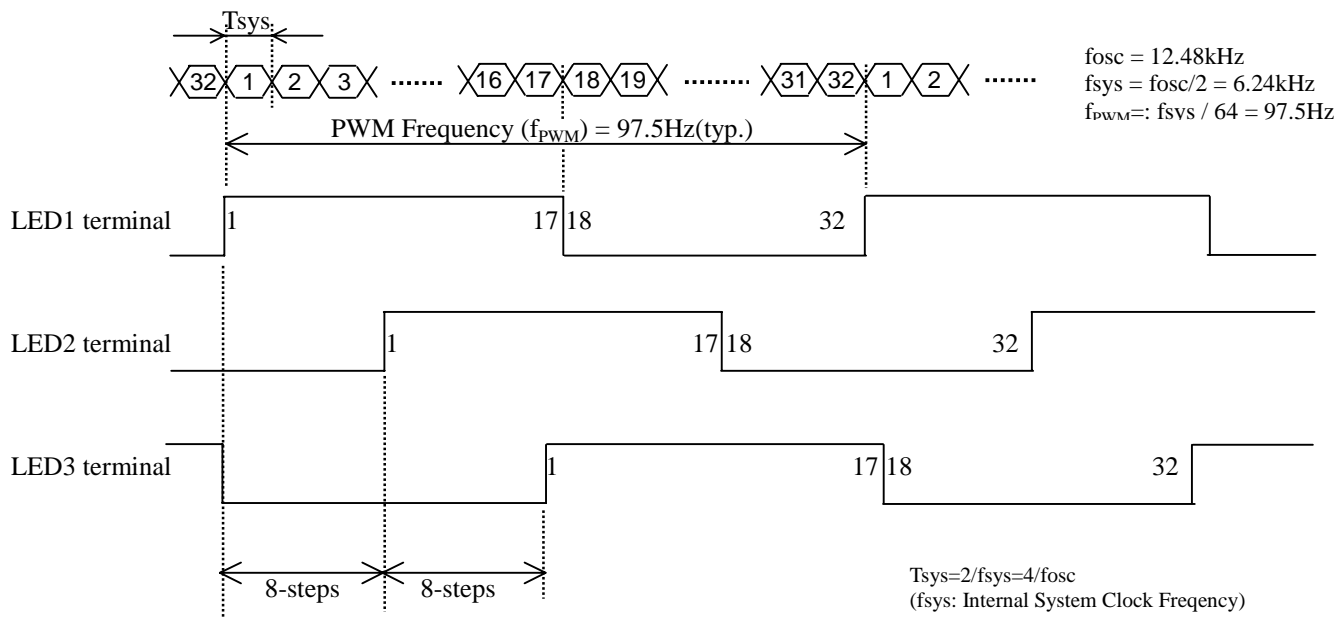
Set Output PWM waveform of LED1 to LED3 terminal, shown below:
  - LED1 PWM Phase set $D_1=0$, $D_0=0$
  - LED2 PWM Phase set $D_1=1$, $D_0=0$
  - LED3 PWM Phase set $D_1=1$, $D_0=1$
  - PWM Frequency set / OSC ON/OFF / Output port ON/OFF $D_4=0$, $D_3=1$, $D_2=1$, $D_1=1$, $D_0=1$
  - LED1 to 3 PWM Data Set $(PWM_4, PWM_3, PWM_2, PWM_1, PWM_0) = (1,0,0,0,0)$

$fosc = 12.48kHz$
$fsys = fosc/2 = 6.24kHz$
$f_{PWM} =: fsvs / 32 = 195Hz$

PWM Frequency $(f_{PWM}) = 195Hz(typ.)$

LED1 terminal
LED2 terminal
LED3 terminal

$Tsys=1/fsys=2/fosc$
(fsys: Internal System Clock Freqency)

8-steps   8-steps

Set Output PWM waveform of LED1 to LED3 terminal, shown below:
  - LED1 PWM Phase set $D_1=0$, $D_0=0$
  - LED2 PWM Phase set $D_1=1$, $D_0=0$
  - LED3 PWM Phase set $D_1=1$, $D_0=1$
  - PWM Frequency set / OSC ON/OFF / Output port ON/OFF $D_4=1$, $D_3=1$, $D_2=1$, $D_1=1$, $D_0=1$
 - LED1 to 3 PWM Data Set $(PWM_4, PWM_3, PWM_2, PWM_1, PWM_0) = (1,0,0,0,0)$

$fosc = 12.48kHz$
$fsys = fosc/2 = 6.24kHz$
$f_{PWM} =: fsvs / 64 = 97.5Hz$

PWM Frequency $(f_{PWM}) = 97.5Hz(typ.)$

LED1 terminal
LED2 terminal
LED3 terminal

$Tsys=2/fsys=4/fosc$
(fsys: Internal System Clock Freqency)

8-steps   8-steps

■ AC ELECTRICAL CHARACTERISTICS

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

Serial Input Timing
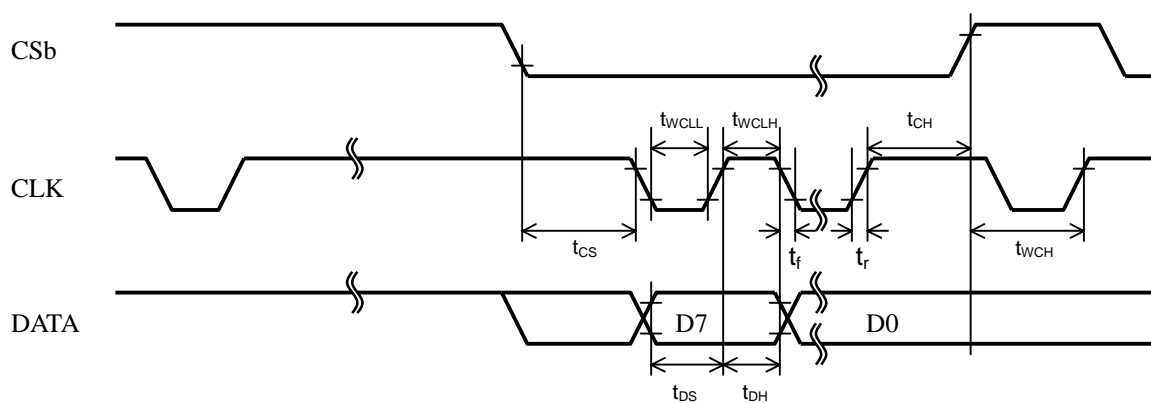
Note) All timing based on 20% and 80% of V_{DD} voltage level.

NJU6060

■ **APPLICATION CIRCUIT**
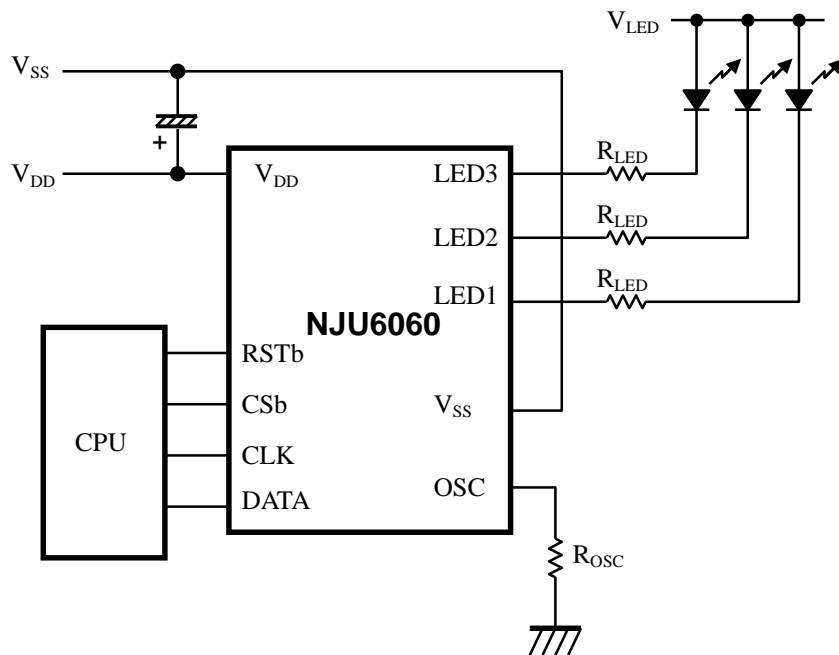
Resistor Selection

$$R_{LED} = \frac{V_{LED} - V_F - V_{OL}}{I_{LED}}$$

R_{LED}:	LED Current Control Resistor
V_{LED}:	LED Voltage
V_F:	LED Forward Voltage (@I_{LED})
V_{OL}:	Output "L" Level Voltage (@I_{LED})
I_{LED}:	LED Forward Current

Example) $I_{LED} = 10mA$, $V_{LED} = 5.0V$, $V_F = 2.0V$(@$I_{LED} = 10mA$), $V_{OL}=0.5V$

$$R_{LED} = \frac{5.0V - 2.0V - 0.5V}{10mA} = 250\Omega$$

Note)
VF and VOL are depended on the situation. And decide the optimum values by the actual test when RLED is selected.