RGB LED Controller Driver with PWM Control

■ GENERAL DESCRIPTION

The NJU6063 is RGB LED controller driver with PWM control.

It contains PWM controller, LED drivers, I^2C interface and constant current driver etc. and can control RGB LED individually.

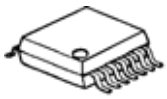
NJU6063 can reduce board density because the external parts are unnecessary for it includes constant current driver.

Making LED a polychromatic light is possible by the control of the PWM dimming Circuit.

Also, multiple NJU6063 can be controlled by the multi device control.

The NJU6063 is suited for a large number of applications such as cellular phones, car stereo sets, household appliances, illumination equipment and gaming equipments, etc.

■ PACKAGE OUTLINE

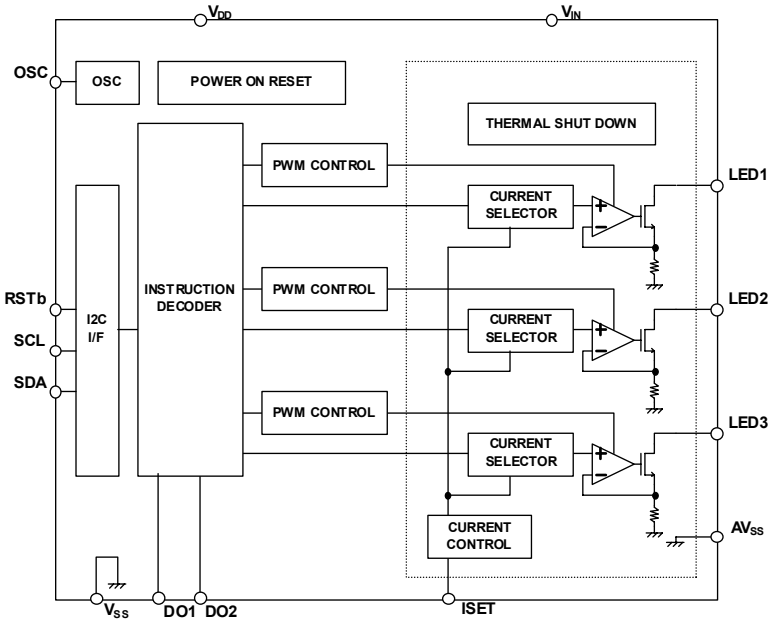


NJU6063V

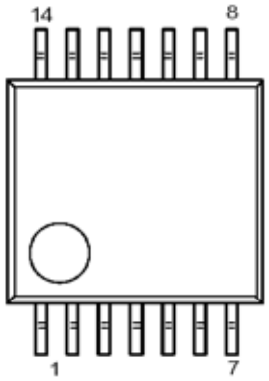
■ FEATURES

- Controlling a 3-in-1 packaged RGB LED : I_{LED} = 30mA * 3 output
- Built in PWM luminance control : 128 Step * 3
- Built in gradual dimming function
- Multi device control
- Adjustable of constant current function
- Built in I^2C interface circuit
- Built in CR oscillation circuit
- Operating voltage : 2.7 V to 5.5V
- Package : SSOP-14
- CMOS Technology

■ BLOCK DIAGRAM



■ TERMINAL CONECTION (TOP VIEW)



1 AV_{SS}
2 ISET
3 V_{SS}
4 DO1
5 DO2
6 OSC
7 SDA
8 SCL
9 RSTb
10 V_{DD}
11 V_{IN}
12 LED3
13 LED2
14 LED1

SSOP-14

■ TERMINAL DISCRIPTION

TERMINAL NAME	DESCRIPTION
AV_{SS}	Analog Ground
DO1	Data Output terminal 1 The following two kinds of use can be selected by the instruction. 1) Multi device control Please connect it with terminal RSTb of NJU6063 in the next device. 2) Enable control of external LED driver It can be use as enable control output terminal using an external LED driver. It outputs “H” level or “L” level by instruction code.
DO2	Data Output terminal 2 It outputs the PWM signal same as LED3 Terminal. It is used to PWM dimming using an external LED driver.
LED1	LED Output terminal (Open drain output) Output level can be divided into 128 steps by PWM signal. Connecting with the cathode of LED. Connecting with the cathode of LED.
LED2	
LED3	
N.C.	Not connect. These terminals are electrically open.
OSC	External clock input terminal It is used by external clock. Normally open.
ISET	Set of Maximum LED drive current. It should connect a resistance between ISET Terminal and AV_{SS} Terminal to set a maximum LED current.
RSTb	Reset terminal - Active “L”. "L" status: Reset state "H" status: Operating state
SCL	Serial clock input terminal
SDA	Serial data input terminal
V_{DD}	Digital power supply
V_{IN}	Analog power supply
V_{SS}	Digital Ground

■ ABSOLUTE MAXIMUMN RATINGS

(Ta=25˚C)

PARAMETER	SYMBOL	RATING	UNIT
Power supply 1	V_{DD}	- 0.3 ~ + 7.0	V
Power supply 2	V_{IN}	- 0.3 ~ + 7.0	V
Input voltage 1	V_{I1}	- 0.3 ~ + 7.0 (*1)	V
Input voltage 2	V_{I2}	- 0.3 ~ + 7.0 (*2)	V
Input voltage 3	V_{I3}	- 0.3 ~ + 7.0 (*3)	V
Input voltage 4	V_{I4}	- 0.3 ~ + 7.0 (*4)	V
Output current 1	I_{LED}	0 ~ 60 (*1)	mA
Output current 2	I_{DO}	5 (*5)	mA
Power dissipation	P_D	450 (*6) 570 (*7)	mW
Operating temperature	T_{opr}	- 40 ~ + 85	°C
Storage temperature	T_{stg}	- 55 ~ + 125	°C

Note) V_{SS} = AV_{SS} = 0 V to all condition

*1) It applies to the terminal LED1, LED2 and LED3.

*2) It applies to the terminal ISET.
When the power supply voltage less than 7V, it becomes equal with power supply voltage 2.

*3) It applies to the terminal RSTb and OSC.

*4) It applies to the terminal SCL and SDA.

*5) It applies to the terminal DO1and DO2.

*6) Mounted on glass epoxy board. (76.2×114.3×1.6mm:EIA/JDEC standard size, 2Layers)

*7) Mounted on glass epoxy board. (76.2×114.3×1.6mm:EIA/JDEC standard size, 4Layers)

■ RECOMMENDED OPERATING CONDITION

(Ta=25˚C)

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX	UNIT
Logic power supply voltage	V_{DD}		1.8	3.0	5.5	V
Analog power supply voltage	V_{IN}		2.7	3.0	5.5	V
Input voltage	V_{LED}		-	-	5.5	V

■ ELECTRICAL CHARACTERISTICS

(V_{DD} = 3.0V, V_{IN} = 3.0V, RSTb = V_{DD}, RISET = 3.3kΩ, Ta=25°C)

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNIT
< INPUT BLOCK >						
Input "H" level voltage 1	V_{IH1}	SCL, SDA	0.7V_{DD}	-	V_{DD}	V
Input "H" level voltage 2	V_{IH2}	RSTb, OSC	0.8V_{DD}	-	V_{DD}	V
Input "L" level voltage 1	V_{IL1}	SCL, SDA	0	-	0.3V_{DD}	V
Input "L" level voltage 2	V_{IL2}	RSTb, OSC	0	-	0.2V_{DD}	V
Input "H" level current	I_{IH}	RSTb, OSC, SCL, SDA, V_I = V_{DD} When the OSC terminal is measured, initialization is 02H.	-	-	0.3	μA
Input "L" level current	I_{IL}	RSTb, OSC, SCL, SDA, V_I = 0V When the OSC terminal is measured, initialization is 02H.	- 0.3	-	-	μA
Pull up resistance current	I_{RUP}	OSC, Initialization = 00h, V_I = 0V	-	8	12	μA
< OSCILLATION BLOCK >						
Oscillation frequency	$f_{OSC(1)}$	FC_1 = 0, FC_0 = 0	0.7	1	1.3	MHz
	$f_{OSC(2)}$	FC_1 = 0, FC_0 = 1	0.91	1.3	1.69	
	$f_{OSC(3)}$	FC_1 = 1, FC_0 = 0	1.54	2.2	2.86	
	$f_{OSC(4)}$	FC_1 = 1, FC_0 = 1	0.56	0.8	1.04	
External clock maximum frequency	f_{EX}	OSC	-	-	5	MHz
Clock pulse width " L "	t_{EXL}	OSC	100	-	-	ns
Clock pulse width " H "	t_{EXH}	OSC	100	-	-	ns
Rise time 3	t_{r3}	OSC	-	-	300	ns
Fall time 3	t_{f3}	OSC	-	-	300	ns
Maximum frame frequency	f_{FRAME}	LED1, LED2, LED3, Setting of current magnification = 100% PWM setting = 01h, FD_1 = 0, FD_0 = 0	-	-	5.23	kHz
< GENERAL CHARACTERISTICS >						
Operating current 1	I_{OP1}	V_{DD}, Initialization = 01h, LED1 ~ LED3 PWM Setting = 00h, V_{I1} = 2V	-	160	240	μA
Operating current 2	I_{OP2}	V_{IN}, Initialization = 01h, Setting of current magnification = 100% LED1 ~ LED3 PWM Setting = 00h, Static ON = 00h, V_{I1} = 2V	-	660	760	μA
Operating current at OFF state 1	I_{NOP1}	V_{DD}, Initialization = 00h, V_{I1} = 2V	-	2.3	3.9	μA
Operating current at OFF state 2	I_{NOP2}	V_{IN}, Initialization = 00h, V_{I1} = 2V	-	-	1	μA

■ ELECTRICAL CHARACTERISTICS

(V_{DD} = 3.0V, V_{IN} = 3.0V, RSTb = V_{DD}, RISET = 3.3kΩ, Ta=25°C)

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNIT
< OUTPUT BLOCK >						
Output "H" level voltage 1	V_{OH1}	DO1, I_O = - 0.1mA	$0.8V_{DD}$	-	-	V
Output "L" level voltage 1	V_{OL1}	DO1, I_O = 0.1mA	-	-	$0.2V_{DD}$	V
Output "H" level voltage 2	V_{OH2}	DO2, I_O = - 0.1mA	$0.8V_{DD}$	-	-	V
Output "L" level voltage 2	V_{OL2}	DO2, I_O = 0.1mA	-	-	$0.2V_{DD}$	V
Output "L" level voltage 3	V_{OL3}	SDA, I_O = 3mA	-	-	0.4	V
< LED DRIVE BLOCK >						
OFF leakage current 1	I_{LED_OFFH1}	LED1, V_{I1} = 5.5V	-	-	0.3	μA
OFF leakage current 2	I_{LED_OFFH2}	LED2, V_{I1} = 5.5V				
OFF leakage current 3	I_{LED_OFFH3}	LED3, V_{I1} = 5.5V				
Drive current 1	I_{LED1}	LED1, setting of current magnification = 100%	29.1	30.3	31.5	mA
Drive current 2	I_{LED2}	LED2, setting of current magnification = 100%				
Drive current 3	I_{LED3}	LED3, setting of current magnification = 100%				
Drive current matching 1	I_{MLED1}	(I_{LED1} – I_{LED_AVG}) / I_{LED_AVG} * 100 I_{LED_AVG} = (I_{LED1} + I_{LED2} + I_{LED3}) / 3 setting of current magnification = 100%	- 1.7	-	1.7	%
Drive current matching 2	I_{MLED2}	(I_{LED2} – I_{LED_AVG}) / I_{LED_AVG} * 100 I_{LED_AVG} = (I_{LED1} + I_{LED2} + I_{LED3}) / 3 setting of current magnification = 100%				
Drive current matching 3	I_{MLED3}	(I_{LED3} – I_{LED_AVG}) / I_{LED_AVG} * 100 I_{LED_AVG} = (I_{LED1} + I_{LED2} + I_{LED3}) / 3 setting of current magnification = 100%				
LED terminal saturation voltage 1	V_{LED_SAT1}	LED1, I_{LED1}=28mA, setting of current magnification = 100%	-	-	0.65	V
LED terminal saturation voltage 2	V_{LED_SAT2}	LED2, I_{LED2}=28mA, setting of current magnification = 100%				
LED terminal saturation voltage 3	V_{LED_SAT3}	LED3, I_{LED3}=28mA, setting of current magnification = 100%				
< OUTPUT TIMING >						
Output delay time	t_{DC}	DO1, CL = 10pF	-	-	300	ns
< RESET TIMING >						
RESET "L" pulse width	t_{RW}	RSTb	400	-	-	ns
RESET time	t_R	RSTb	1	-	-	μs
Rise time 2	t_{r2}	RSTb	-	-	300	ns
Fall time 2	t_{f2}	RSTb	-	-	300	ns

■ ELECTRICAL CHARACTERISTICS

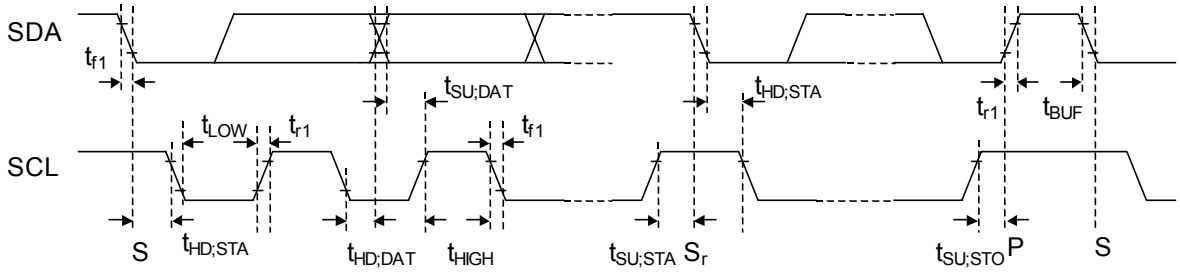
(V_{DD} = 3.0V, V_{IN} = 3.0V, RSTb = V_{DD}, RISET = 3.3kΩ, Ta=25°C)

PARAMETER	SYMBOL	CONDITIONS	MIN.	TYP.	MAX.	UNIT
< MULTI DEVICE ACCESS TIMING >						
Access time of multi device control	t_{MA}	SDA, DO1	4.5	-	-	µs

< I^2C BUS TIMING (V_{DD} = 3.0V, High Speed Mode) >						
SCL clock frequency	f_{SCL}	SCL	-	-	400	kHz
Hold time for repeated START condition	$t_{HD;STA}$	SCL, SDA	0.6	-	-	µs
SCL clock " L "	t_{LOW}	SCL	1.3	-	-	µs
SCL clock " H "	t_{HIGH}	SCL	0.6	-	-	µs
Setup time for repeated START condition	$t_{SU;STA}$	SCL, SDA	0.6	-	-	µs
Data hold time	$t_{HD;DAT}$	SCL, SDA	0	-	0.9	µs
Data setup time	$t_{SU;DAT}$	SCL, SDA	100	-	-	ns
Rise time	t_{r1}	SCL, SDA	-	-	300	ns
Fall time	t_{f1}	SCL, SDA	-	-	300	ns
Setup time for STOP condition	$t_{SU;STO}$	SCL, SDA	0.6	-	-	µs
Bus free time between STOP and START condition	t_{BUF}	SDA	1.3	-	-	µs

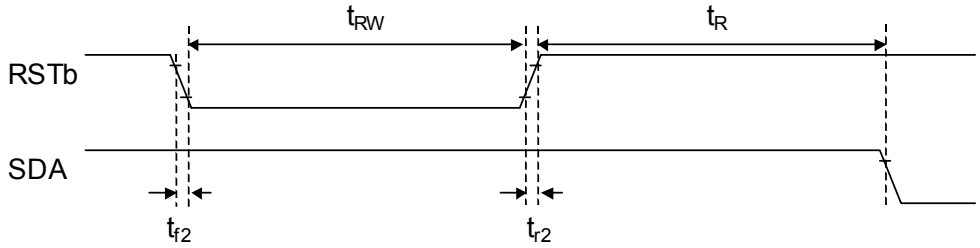
< I^2C BUS TIMING (V_{DD} = 1.8V, NORMAL Mode) >						
SCL clock frequency	f_{SCL}	SCL	-	-	100	kHz
Hold time for repeated START condition	$t_{HD;STA}$	SCL, SDA	4.0	-	-	µs
SCL clock " L "	t_{LOW}	SCL	4.7	-	-	µs
SCL clock " H "	t_{HIGH}	SCL	4.0	-	-	µs
Setup time for repeated START condition	$t_{SU;STA}$	SCL, SDA	4.7	-	-	µs
Data hold time	$t_{HD;DAT}$	SCL, SDA	0	-	3.45	µs
Data setup time	$t_{SU;DAT}$	SCL, SDA	250	-	-	ns
Rise time	t_{r1}	SCL, SDA	-	-	1000	ns
Fall time	t_{f1}	SCL, SDA	-	-	300	ns
Setup time for STOP condition	$t_{SU;STO}$	SCL, SDA	4.0	-	-	µs
Bus free time between STOP and START condition	t_{BUF}	SDA	4.7	-	-	µs

(1) I^2C Bus Timing



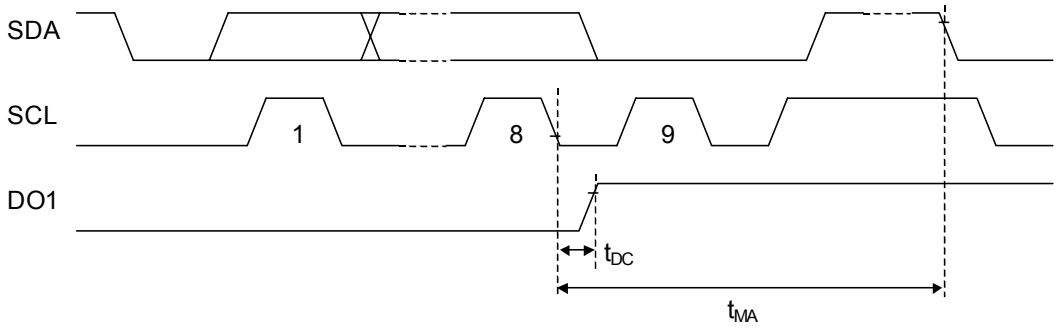
S : START Condition
Sr : Repetition START Condition
P : STOP Condition

(2) RESET Timing

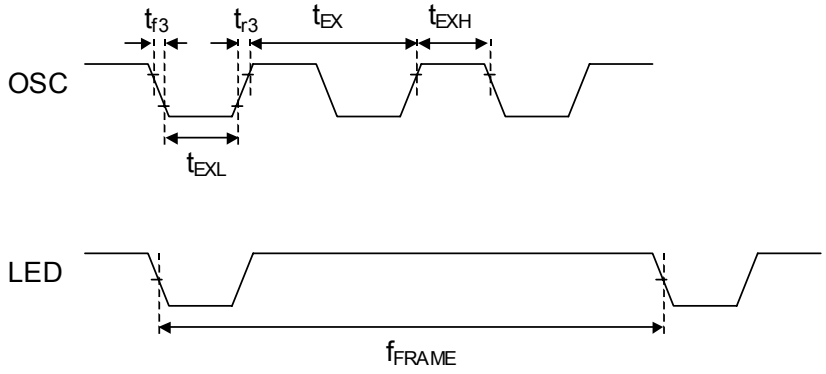


(3) Multi Device Access Timing

- Setting of Upper Address



(4) External Clock

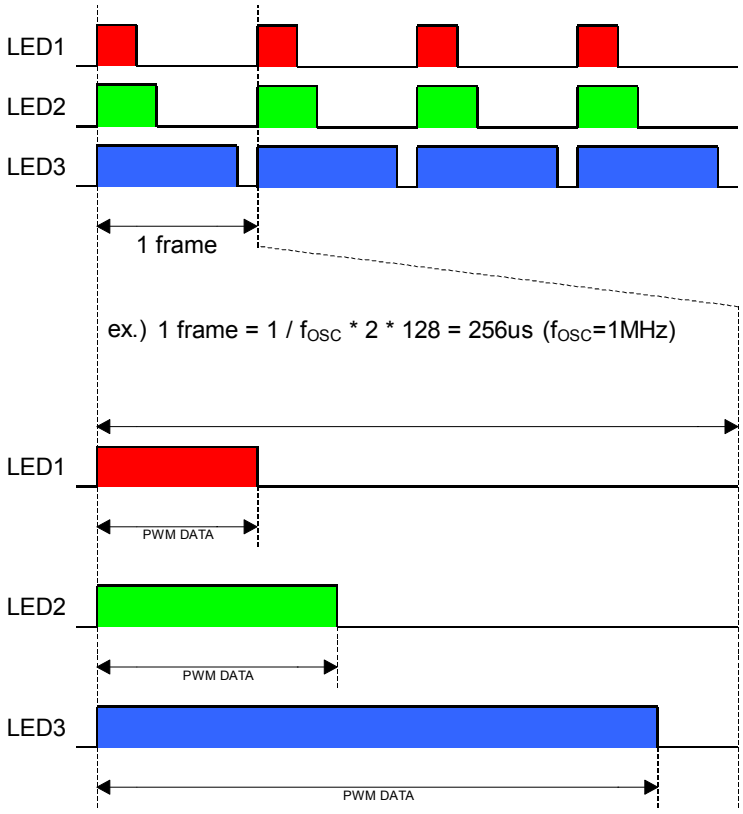


■ FUNCTIONAL DESCRIPTIONS

(1) Description for Each Block

(1-1) PWM Luminance Control Circuit

The NJU6063 incorporates three 128 steps PWM Luminance Control circuits.
At the user's option, PWM data can be set.
The frame frequency can be changed by the instruction.
Reference: (3) Instruction code (3-1) Function set, OSC Frequency select, Divide ratio select



(1-2) Oscillator Circuit

The oscillation circuit with the internal register and capacitor generates the clock signal for PWM.
The oscillation circuit can be turned on/off by the instruction to minimize the current consumption.

- The PWM frequency can be selected by the instruction.
- Additionally, it can operate the external clock without using the internal oscillation circuit.

(Note) NJU6063 becomes lights-out state immediately with turning off internal oscillator during LED lights-on. The lighting status will return just moments before status when the internal oscillator restarted. Therefore, the LED luminance may be changed a moment when the internal oscillator was turned on. To avoid this, you should set PWM to "00h" so that lights-off LED, and then turn off the internal oscillator.

(1-3) LED Luminance Control Setting

There are the following three methods of LED Luminance setting.

(a) Setting of maximum LED current with ISET Terminal (LED1~3 common setting)

(b) LED Current Magnification Setting (LED1~3 Separate setting)

(c) PWM Signal Setting (LED 1~3 Separate setting)

(a) Setting of maximum LED current with ISET Terminal (LED1~3 common setting)

The setting of maximum LED current connects resistance between the terminal ISET and the terminal AV_{SS}.

The Maximum LED current range can be set in the 5mA to 10mA range.

$$I_{LED} = \frac{200[times] \times 0.5[V]}{R_{ISET}} = \frac{100}{R_{ISET}}$$ (Ex. I_{LED}(MAX)=30.3mA setting, R_{ISET}=3.3kΩ)

The LED drive transistor is turned off and the LED driving current is intercepted when ISET Terminal and AV_{SS} Terminal are short-circuited.

(b) LED Current Magnification Setting (LED1~3 Separate setting)

The LED current of each LED Terminal can be set the following three magnification: one time, one harf and one-quarter against I_{LED}(MAX) that set by RISET.

The I^2C instruction can set this setting.

Refer to (3) Instruction code: (3-2) LED current setting in detail.

(c) PWM Signal Setting (LED 1~3 Separate setting)

The PWM signal of each LED terminal is set according to the instruction.

PWM Duty can divide between 0% to 100% into 128.

Refer to (3) Instruction code: (3-3) PWM setting in details.

(1-4) Multi Device Function

NJU6063 can control multi device (a number of NJU6063) on I^2C bus line.

Refer to (7) Multi Device Control in details.

(1-5) PWM Data Output Function

The PWM data is output as CMOS output that set to LED3 from DO2 Terminal.

The PWM data is waveform inverted of LED3 Terminal output and this output control is same as LED3 setting.

Moreover, the large current drive LED port can be added by connecting the DO2 Terminal to NJU6080 PWM terminal.

(2) Instructions

The NJU6063 can set the PWM data by I2C interface. The NJU6063 has auto increment function.

So the Lower Address causes the next loop iteration by auto increment.

Apstream: from 00h to 07h, Subsequently: from 02h to 07h

Therefore, it can be write the instruction code from the LED1 PWM setting to START/STOP setting continuously until becoming I2C stop condition.

Moreover, the lower address that the instruction: 08h to 0Fh is been auto increment to the lower address 02h after running.

Instruction Table (* : Don't Care)

Instruction		Address				Function								Description
		Global		Local (*)		D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	
		Upper	Lower	Upper	Lower									
(1)	Function set	FFh	00h	MMh	00h	DM	DO	FC_1	FC_0	FD_1	FD_0	EXT	EN	Set of DO1 Output Mode (DM) Set of DO1 Output Data (DO) Select Oscillation Frequency (FC_1〜FC_0) Select of Dividing Ratio (FD_1〜FD_0) Internal Oscillation / Out width Clock Select (EXT) Oscillation / Constant Current Driver Operation or STOP (EN)
(2)	LEDCurrent set	FFh	01h	MMh	01h	*	*	$ILED_5$	$ILED_4$	$ILED_3$	$ILED_2$	$ILED_1$	$ILED_0$	LED Current Setting ($ILED_5$ to $ILED_1$)
(3)	LED1 PWM set	FFh	02h	MMh	02h	*	PWM DATA							PWM Data set
	LED2 PWM set	FFh	03h	MMh	03h									
	LED3 PWM set	FFh	04h	MMh	04h									
(4)	Gladual dimming set	FFh	05h	MMh	05h	*	STP_3	STP_2	STP_1	$LOOP_4$	$LOOP_3$	$LOOP_2$	$LOOP_1$	Step Count Setting (STP_3 to STP_1) LOOP Count Setting($LOOP_4$〜$LOOP_1$)
(5)	Static ON	FFh	06h	MMh	06h	*	*	*	*	*	SON_3	SON_2	SON_1	All Time ON (SON_3〜SON_1)
(6)	START/STOP	FFh	07h	MMh	07h	*	*	*	*	*	*	STOP	START	Gradual Dimming STOP (STOP) Gradual Dimming Operation (START)
	NOP	FFh	08h	MMh	08h	*	*	*	*	*	*	*	*	Non Operation code (Not Applicable)
(7)	Output reversing	FFh	09h	MMh	09h	*	*	*	*	*	INV_3	INV_2	INV_1	PWM Data Reverce (INV_3 to INV_1)
	NOP	FFh	0Ah	MMh	0Ah	*	*	*	*	*	*	*	*	Non Operation code (Not Applicable)
(8)	Gladual dimming check	FFh	0Bh	MMh	0Bh	*	*	*	*	*	*	*	*	Gradual Dimming Addles Check Operating = Output of ACK Signal Not Operating = No Output ACK Signal
	NOP	FFh	0Ch	MMh	0Ch	*	*	*	*	*	*	*	*	Non Operation code (Not Applicable)
(9)	Multi device addless set	FFh	0Dh	MMh	0Dh	MA_7	MA_6	MA_5	MA_4	MA_3	MA_2	MA_1	MA_0	Multi Device mode address set
	NOP	FFh	0Eh	MMh	0Eh	*	*	*	*	*	*	*	*	Non Operation code (Not Applicable)
(10)	Test mode	FFh	0Fh	MMh	0Fh	T_7	T_6	T_5	T_4	T_3	T_2	T_1	T_0	Inhibited command / Multi Device Control Address = 00h
	Inhibited command	FFh	10h ~ FFh	MMh	10h ~ FFh	*	*	*	*	*	*	*	*	Inhibited command

Note) MMh is changed by Multi Device Address Set.

<Instruction Code Example>

INSTRUCTION	DATA	REMARKS
START CONDITION		I2C START Condition
SLAVE ADDRESS	40h	Slave Address od Device
UPPER ADDRESS	00h	Multi Device Address
LOWER ADDRESS	00h	Address of Internal Resistor
INITIAL SETTING	01h	Initialization of oscillation etc.
LED CURRENT SETTING	3Fh	Magnification setting of LED current
LED1 PWM SETTING	10h	PWM DATA Setting
LED2 PWM SETTING	10h	
LED3 PWM SETTING	10h	
GRADUAL DIMMING SETTING	31h	Setting of STEP(8) and LOOP(8)
STATIC ON	00h	Setting of All Time ON
START/STOP	01h	START of Gradual Dimming
wait (19ms)		
LED1 PWM SETTING	20h	PWM DATA Re Setting
LED2 PWM SETTING	20h	
LED3 PWM SETTING	20h	
GRADUAL DIMMING SETTING	43h	Setting of STEP(16) and LOOP(16)
STATIC ON	00h	Setting of All Time ON
START/STOP	01h	START of Gradual Dimming
wait (70ms)		
LED1 PWM SETTING	40h	PWM DATA Setting
LED2 PWM SETTING	40h	
LED3 PWM SETTING	40h	
GRADUAL DIMMING SETTING	43h	Setting of STEP(8) and LOOP(4)
STATIC ON	00h	Setting of All Time ON
START/STOP	01h	START of Gradual Dimming
STOP CONDITION		I2C STOP Condition

(3) Instruction Code

(3-1) Initial Setting

The initial setting instruction can set about oscillation frequency and oscillation frequency divide ratio.

Address	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
MM00h	DM	DO	FC_1	FC_0	FD_1	FD_0	EXT	EN

DO1 Output Mode Setting

DO1 : Select DO1 Terminal Output Mode

It selects DO1 terminal output signal to Multi Device connection signal or general port output.

D_7 0: Data Output for Multi Device Connecting

1: General Port Output

DO1 Output Data Setting

DO : DO1 Terminal output data

At the general port output selecting, it outputs the data that is set to D_6.

Oscillation Frequency Selecting, Oscillation Frequency Dividing Ratio Selecting

FC_1~FC_0 : Oscillation Frequency Selecting

FD_1~FD_0 : Oscillation Frequency Dividing Ratio Selecting

You can set 13 different frame frequencies to combine Oscillation Frequency and oscillation frequency dividing ratio.

At the time of an external clock input, you can select the following four frequencies pattern.

Oscillation Frequency Setting

FC_1	FC_0	Oscillation Frequency(f_{osc})
0	0	1MHz
0	1	1.3MHz
1	0	2.2MHz
1	1	0.8MHz

Built-in Oscillator / External Clock Selectable Function

EXT : Built-in Oscillator / External Clock Select

The NJU6063 can operate by external clock input. When using external clock, you should input external clock from OSC Terminal and set D_1=1.

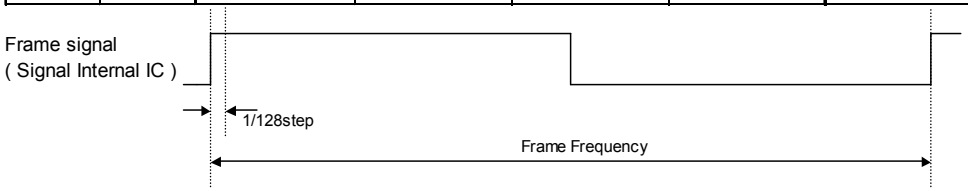
D_1 0: Built-in Oscillator

1: External Clock Input (Built-in Oscillator OFF)

In case of an external clock input, you should set the Oscillation Frequency Dividing Ratio to exceed the maximum Frame Frequency.

Oscillation Frequency Dividing Ratio and Frame Frequency Example

FD_1	FD_0	Frame Oscillation	Example Frame Oscillation			
			f_{osc}=1MHz	f_{osc}=1.3MHz	f_{osc}=2.2MHz	f_{osc}=0.8MHz
0	0	$\frac{f_{OSC}}{2\times1\times128}$	3.9kHz			3.1kHz
0	1	$\frac{f_{OSC}}{2\times2\times128}$	2.0kHz	2.5kHz		1.6kHz
1	0	$\frac{f_{OSC}}{2\times4\times128}$	1.0kHz	1.3kHz	2.1kHz	0.8kHz
1	1	$\frac{f_{OSC}}{2\times8\times128}$	0.5kHz	0.6kHz	1.1kHz	0.4kHz



f_{osc} = 1MHz, FD_1 = 0, FD_0 = 0 Set

Frame Frequency = f_{osc} / 2 * 1 * 128 = 3.9kHz

Frame Cycle = 1/ f_{osc} * 2 * 128 = 256 us

Minimum PWM Width = Frame Cycle / 128 = 2us

Enable Function

EN : Enable / Disable Selecting

The LED13 output stops by common setting. The built-in oscillation circuit stops at disable. The I^2C interface is operating.

D0 0: Disable (Stop LED1~3 output (Turn OFF))

1: Enable

(3-2) LED Current Setting

The LED driving current magnification can be set by LED Current Setting instruction.

Address	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
MM01h	*	*	$ILED_5$	$ILED_4$	$ILED_3$	$ILED_2$	$ILED_1$	$ILED_0$

It selects the LED current from the following three (3) magnifications: 1 time, 0.5 times and 0.25 times

$ILED_0$、$ILED_1$	Output current magnification adjustment of LED1 terminal
$ILED_2$、$ILED_3$	Output current magnification adjustment of LED2 terminal
$ILED_4$、$ILED_5$	Output current magnification adjustment of LED3 terminal

LED1 Terminal Adjustment Example

$ILED_1$	$ILED_0$	LED Magnification of Driving Current	REMARK
0	0	I_{LED} x 0	LED Driver OFF (Turn off)
0	1	I_{LED} x 0.25	
1	0	I_{LED} x 0.5	
1	1	I_{LED} x 1	

Regarding $ILED_2$, $ILED_3$ and $ILED_4$, $ILED_5$ setting, same specifications as above.

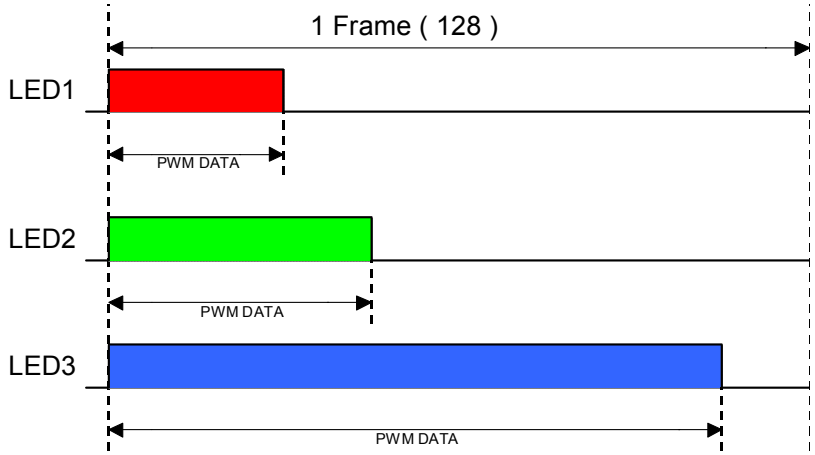
(3-3) PWM Setting

Address	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
MM02h	*	LED1 Terminal PWM data						
MM03h	*	LED2 Terminal PWM data						
MM04h	*	LED3 Terminal PWM data						

It sets the PWM data that is output to the LED1~3 Terminal.
The PWM data can be set the PWM output of 128 step from 0 to 127.

$\frac{128}{128}$ can be set by <Static ON> instruction.

PWM Data Setting Example



PWM DUTY corresponding to PWM Data Example

PWM_7	PWM_6	PWM_5	PWM_4	PWM_3	PWM_2	PWM_1	PWM_0	PWM DUTY
*	0	0	0	0	0	0	0	$\frac{0}{128}$
*	0	0	0	0	0	0	1	$\frac{1}{128}$
*	0	0	0	0	0	1	0	$\frac{2}{128}$
*	0	0	0	0	0	1	1	$\frac{3}{128}$
*	0	0	0	0	1	0	0	$\frac{4}{128}$
*	0	0	0	0	1	0	1	$\frac{5}{128}$
∫	∫							
*	1	1	1	1	1	0	1	$\frac{125}{128}$
*	1	1	1	1	1	1	0	$\frac{126}{128}$
*	1	1	1	1	1	1	1	$\frac{127}{128}$

(3-4) Gradual Dimming Setting

It can be set Gradual Dimming Luminance Timing Setting.

Address	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
MM05h	*	STP_3	STP_2	STP_1	$LOOP_4$	$LOOP_3$	$LOOP_2$	$LOOP_1$

The Gradual Dimming is a function that changes it while interpolating the middle data to the PWM data newly set from the PWM data that has already been set.

The Gradual Dimming Setting instruction sets the following condition:

- The step of number the intermediate data interpolation.
- The loop count of each step.

These setting detail are as follows.

STEP Number Setting

STP_3	STP_2	STP_1	STEP Count	
0	0	0	1	
0	0	1	2	
0	1	0	4	
0	1	1	8	
1	0	0	16	
1	0	1	32	
1	1	0	Prohibit Set	(STEP Count = 1)
1	1	1	Prohibit Set	(STEP Count = 1)

LOOP Number Setting

$LOOP_4$	$LOOP_3$	$LOOP_2$	$LOOP_1$	LOOP Count
0	0	0	0	4
0	0	0	1	8
0	0	1	0	12
0	0	1	1	16
0	1	0	0	20
0	1	0	1	24
0	1	1	0	28
0	1	1	1	32
1	0	0	0	36
1	0	0	1	40
1	0	1	0	44
1	0	1	1	48
1	1	0	0	52
1	1	0	1	56
1	1	1	0	60
1	1	1	1	64

Regarding Gradual Dimming Operating Time

The Gradual Dimming Operating Time depends on each following setting: Frame Frequency, Step Number and Loop Frequency. The formula is as follows.

Operating Time = Frame Frequency×[(Step Number+1)×Loop Number+1(Internal Processing Time)]

i.e. In case of Frame Frequency: 3.9kHz, Step Number: 32, Loop Number: 64

$$\text{Operating Time} = \frac{1}{3.9[kHz]} \times \left[(32+1)\times 64+1\right] = 0.542[\text{sec}]$$

In actual operation, this function to start running in synchronization with the frame signal. Therefore, the frame may be delayed maximum one (1) frame cycle against the calculated time.

Running Instruction under Gradual Dimming Operating

During Gradual Dimming operation, IC inside is BUSY state.

Therefore, does not accept non-specific instruction.

In addition, ACK is not output about not acceptable instructions.

If ACK is not output, it should resend from START condition.

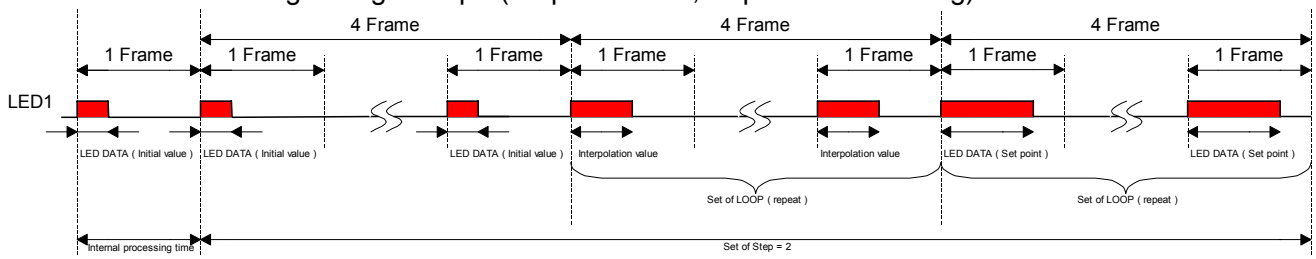
	INSTRUCTION	Condition of Gradual Dimming
(1)	Initial Setting	Not Receive
(2)	LED Current Set up	Not Receive
(3)	LED1 PWM Set up	Not Receive
	LED2 PWM Set up	Not Receive
	LED3 PWM Set up	Not Receive
(4)	Gradual Dimming Set up	Not Receive
(5)	Static ON	Not Receive
(6)	START/STOP	STOP=1 : Forced STOP of Gradual Dimming
(7)	Output Reverse	Not Receive
(8)	Gradual Dimming Check	Operating Check of Gradual Dimming
(9)	Multi Device Address Set up	Not Receive
(10)	TEST MODE	Normal Function

The Gradual Dimming operation does the forced stop by making it to D1=1 by the START/STOP instruction. The PWM output of each LED terminal after forced stop becomes the PWM output of point that does the forced stop.

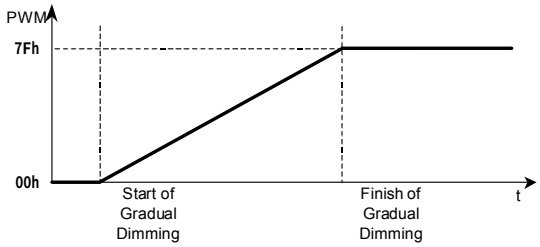
Moreover, Gradual Dimming operates to the PWM data set from the last PWM data setting value again in the Dimming setting immediately after compulsion the stop.

When the forced stop is done, it is not possible to restart. You should set a data again.

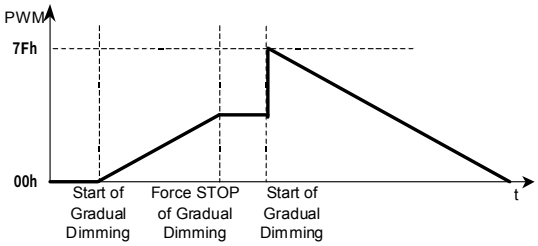
Gradual Dimming Setting Example (Loop Number: 4, Step Number: 2 setting)



After the forced stop during Gradual Dimming operation, it is shown the PWM data variant output from LED Terminal to 00h when Gradual Dimming is re-operated.



At normal function



At forced STOP

(3-5) Static ON

It can be set Static ON (PWM Duty $= \frac{128}{128}$).

Address	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
MM06h	*	*	*	*	*	SON_3	SON_2	SON_1

Static ON Function

SON_3~SON_1: LED3~LED1 always-on setting

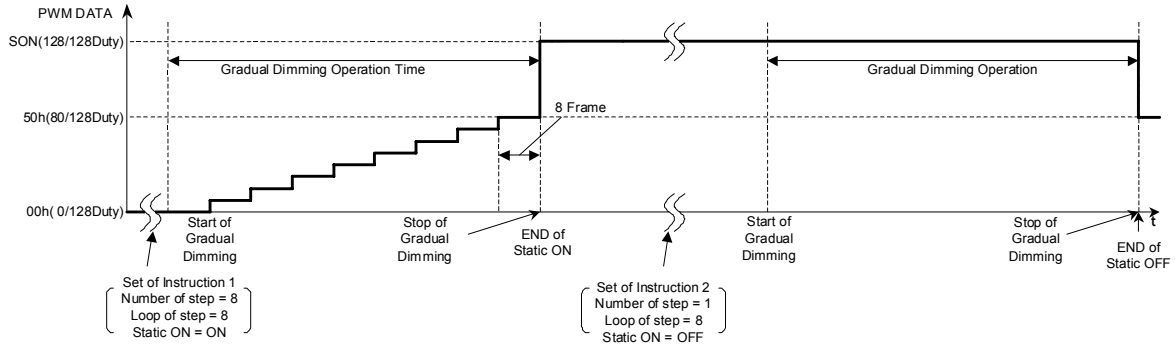
The PWM data becomes invalid by making the SON_1~SON_3 bit "H" for each LED Terminal,

and the output always turns on ($\frac{128}{128}$ PWM Duty).

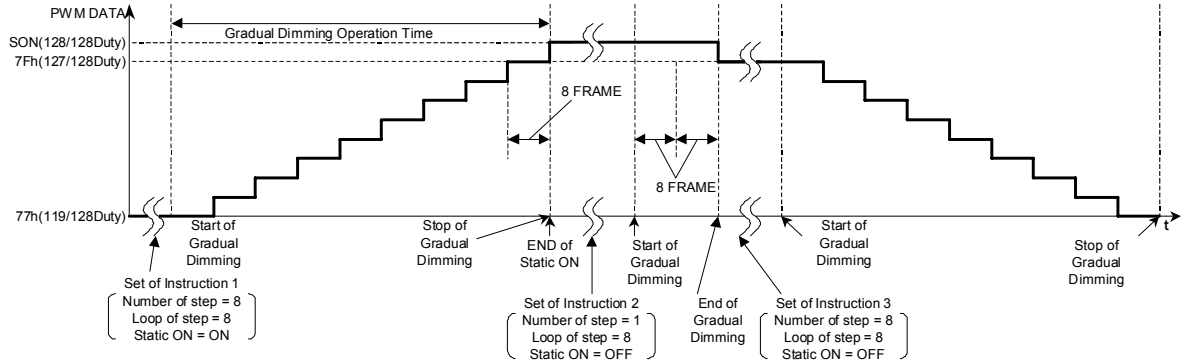
It should make the SON_1~SON_3 bit "L" so that the PWM data effective, and set the PWM

pulse width to 00h when you always turn off ($\frac{0}{128}$ PWM Duty) each LED Terminal.

Moreover, all LED Terminals can be made “H” (Turn OFF) by making EN=0 the initialization instruction.
It corresponds to SON_1=LED_1, SON_2=LED_2, and SON_3=LED_3.
After the Gradual Dimming operation is completed, the Static ON operation is executed.
The Static ON the operation and the instruction setting example are shown on next page.



Static ON Operation Example1



Static ON Operation Example2

Static ON Explanation of Instruction Code (1)

	INSTRUCTION	DATA	REMARKS
INITIAL SETTING	START CONDITION		I2C START Condition
	SLAVE ADDRESS	40h	Slave Address od Device
	UPPER ADDRESS	00h	Multi Device Address
	LOWER ADDRESS	00h	Address of Internal Resistor
	INITIAL SETTING	01h	Initialization of oscillation etc.
	LED CURRENT SETTING	3Fh	Magnification setting of LED current
	LED1 PWM SETTING	00h	PWM DATA Setting
	LED2 PWM SETTING	00h	
	LED3 PWM SETTING	00h	
	GRADUAL DIMMING SETTING	00h	Setting of STEP(1) and LOOP(4)
	STATIC ON	00h	Setting of All Time ON
	START/STOP	01h	START of Gradual Dimming
	wait (3ms)		
INSTRUCTION SETTING 1	LED1 PWM SETTING	50h	PWM DATA Setting
	LED2 PWM SETTING	50h	
	LED3 PWM SETTING	50h	
	GRADUAL DIMMING SETTING	30h	Setting of STEP(8) and LOOP(4)
	STATIC ON	07h	Setting of All Time ON
	START/STOP	01h	START of Gradual Dimming
	wait (10ms)		
	STOP CONDITION		I2C STOP Condition
INSTRUCTION SETTING 2	START CONDITION		I2C START Condition
	SLAVE ADDRESS	40h	Slave Address od Device
	UPPER ADDRESS	00h	Multi Device Address
	LOWER ADDRESS	06h	Address of Internal Resistor
	STATIC ON	00h	Setting of All Time ON
	START/STOP	01h	START of Gradual Dimming

Static ON Explanation of Instruction Code (2)

	INSTRUCTION	DATA	REMARKS
INITIAL SETTING	START CONDITION		I2C START Condition
	SLAVE ADDRESS	40h	Slave Address od Device
	UPPER ADDRESS	00h	Multi Device Address
	LOWER ADDRESS	00h	Address of Internal Resistor
	INITIAL SETTING	01h	Initialization of oscillation etc.
	LED CURRENT SETTING	3Fh	Magnification setting of LED current
	LED1 PWM SETTING	77h	PWM DATA Setting
	LED2 PWM SETTING	77h	
	LED3 PWM SETTING	77h	
	GRADUAL DIMMING SETTING	00h	Setting of STEP(1) and LOOP(4)
	STATIC ON	00h	Setting of All Time ON
	START/STOP	01h	START of Gradual Dimming
	wait (3ms)		
INSTRUCTION SETTING 1	LED1 PWM SETTING	7Fh	PWM DATA Setting
	LED2 PWM SETTING	7Fh	
	LED3 PWM SETTING	7Fh	
	STEP / TIME	30h	Setting of STEP(8) and LOOP(4)
	STATIC ON	07h	Setting of All Time ON
	START/STOP	01h	START of Gradual Dimming
	wait (10ms)		
	STOP CONDITION		I2C STOP Condition
INSTRUCTION SETTING 2	START CONDITION		I2C START Condition
	SLAVE ADDRESS	40h	Slave Address od Device
	UPPER ADDRESS	00h	Multi Device Address
	LOWER ADDRESS	05h	Address of Internal Resistor
	GRADUAL DIMMING SETTING	00h	Setting of STEP(1) and LOOP(4)
	STATIC ON	00h	Setting of All Time ON
	START/STOP	01h	START of Gradual Dimming
	wait (3ms)		
	STOP CONDITION		I2C STOP Condition
INSTRUCTION SETTING 3	START CONDITION		I2C START Condition
	SLAVE ADDRESS	40h	Slave Address od Device
	UPPER ADDRESS	00h	Multi Device Address
	LOWER ADDRESS	02h	Address of Internal Resistor
	LED1 PWM SETTING	77h	PWM DATA Setting
	LED2 PWM SETTING	77h	
	LED3 PWM SETTING	77h	
	GRADUAL DIMMING SETTING	30h	Setting of STEP(8) and LOOP(4)
	STATIC ON	00h	Setting of All Time ON
	START/STOP	01h	START of Gradual Dimming

(3-6) START / STOP

It controls Gradual Dimming Function Start and Force Stop.

Address	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
MM07h	*	*	*	*	*	*	STOP	START

Gradual Dimming Start Function

START : Gradual Dimming Function Start

The Gradual Dimming function starts with D0=1. The actual execution start synchronizes to the frame signal. The PWM output of each LED Terminal is not updated with D0=0.

Moreover, during running the Gradual Dimming function, D0 = 0 is not accepted.

Therefore, running the Gradual Dimming function does not stop.

Force Stop Function

STOP : Force Stop under Gradual Dimming Function

The Gradual Dimming function stops with D0=0. The stop procedure synchronizes to the frame signal. The PWM output of each LED Terminal is not updated with D0=0.

It should set the STOP setting "H" to D1 after specifying the Lower address 07h.

(It doesn't accept except 07h and 0Fh instruction while executing the function.)

Refer to (3-4) Gradual Dimming Setting regarding behavior at Force Stop.

Caution: DO NOT SET STOP and START to "H" at the same time.

(3-7) Output Inverting

It sets the inverting output corresponding to each LED output, the DO2 output, and the each PWM setting data.

Address	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
MM09h	*	*	*	*	*	INV_3	INV_2	INV_1

LED Output Inverting Function

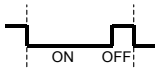
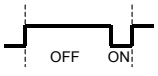
INV_3~INV_1 : LED_3~LED_1 output setting

It can be inverted LED1~LED3 Terminal output to the PWM data.

INV_1~INV_3 is corresponding to LED_1~LED_3, the PWM Duty is inverted to setting INV=1.

The relation among the PWM data, INV_3~INV_1 and LED_3~LED_1 is shown below.

Also, this setting is applicable to DO2 output.

	LED1Terminal	LED2Terminal	LED3Terminal
PWM DATA	50h	50h	50h
LED output Turn over	INV_1=0	INV_2=1	INV_3=0
LED terminal output signal			

(3-8) Gradual dimming check

It can be confirmed whether gradual dimming function is operated by writing arbitrary data to address 0Bh.

Address	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
MM0Bh	*	*	*	*	*	*	*	*

The written data doesn't influence operation. ACK is output while Gradual Dimming is operating.

When Gradual Dimming doesn't operate, ACK is not output. Whether all devices Gradual Dimming operating that connects the Multi Device is completed can be confirmed by using this function.

By using this function, it can check the Gradual Dimming operation completion of all multi-device connected devices.

When data is written at address FF0Bh, ACK is not output if Gradual Dimming operation of all devices is completed. If one or more devices are working, ACK is output.

(3-9) Multi device address set

It sets upper address to use Multi Device connection.

Address	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
MM0Dh	MA_7	MA_6	MA_5	MA_4	MA_3	MA_2	MA_1	MA_0

There is upper address (MA) from 01h to FEh, and it can be set 254 different addresses.

When FF0Xh is set, the register of all connected devices is rewritten at the same time.

(3-10) Test mode

DO NOT USE this mode. This is instruction for IC chip test.

(4) Memory map

MMMM_MMMM : Multi device address.

8 bit 0000_0001(1) to 1111_1110(254) control resistor

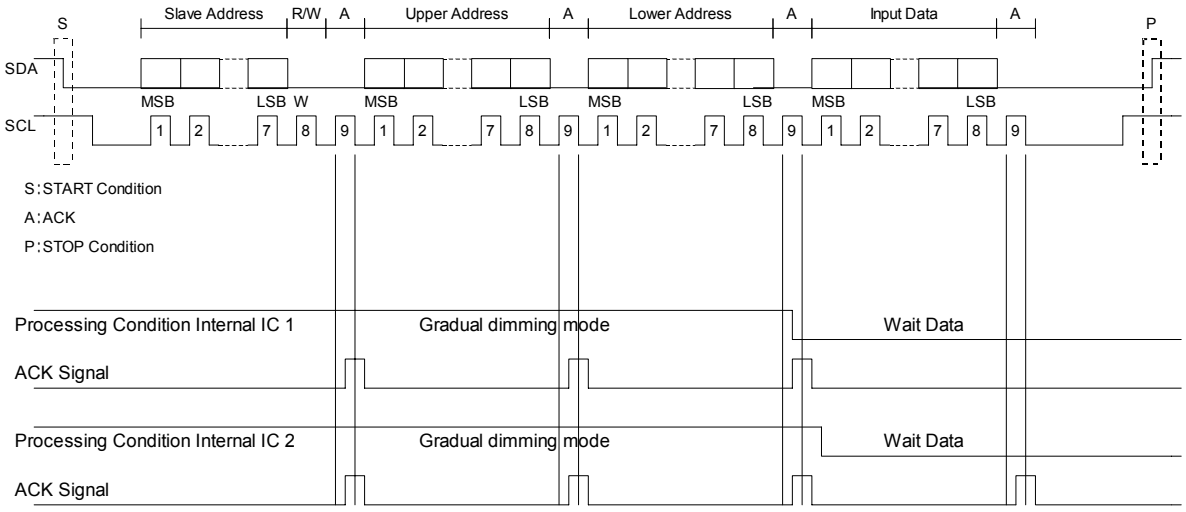
Address		Register
Upper Address	Lower Address	
M M M M _ M M M M	0 0 0 0 _ 0 0 0 0	Initial Setting
M M M M _ M M M M	0 0 0 0 _ 0 0 0 1	Setting of LED current
M M M M _ M M M M	0 0 0 0 _ 0 0 1 0	LED 1 terminal PWM data
M M M M _ M M M M	0 0 0 0 _ 0 0 1 1	LED 2 terminal PWM data
M M M M _ M M M M	0 0 0 0 _ 0 1 0 0	LED 3 terminal PWM data
M M M M _ M M M M	0 0 0 0 _ 0 1 0 1	Setting of gradual dimming
M M M M _ M M M M	0 0 0 0 _ 0 1 1 0	Static ON
M M M M _ M M M M	0 0 0 0 _ 0 1 1 1	START / STOP
M M M M _ M M M M	0 0 0 0 _ 1 0 0 0	NOP
M M M M _ M M M M	0 0 0 0 _ 1 0 0 1	Output turn over
M M M M _ M M M M	0 0 0 0 _ 1 0 1 0	NOP
M M M M _ M M M M	0 0 0 0 _ 1 0 1 1	Gradual dimming check
M M M M _ M M M M	0 0 0 0 _ 1 1 0 0	NOP
M M M M _ M M M M	0 0 0 0 _ 1 1 0 1	Multi device address
M M M M _ M M M M	0 0 0 0 _ 1 1 1 0	NOP
M M M M _ M M M M	0 0 0 0 _ 1 1 1 1	TEST
1 1 1 1 _ 1 1 1 1	* * * * _ * * * *	Global address

(5) Data input timing

The Data format is shown below.

There are the Upper Address and the Lower Address with the Slave Address. When multi Device control is used, the Upper address is used for the device select. The Lower address identifies each instruction. You should set 00h when you do not use the Multi Device Control (For 1 piece use).

The data of SDA is retrieved by rising edge about SCL. The Lower Address does the increment based on the Lower Address increment set (AI) instruction. It is possible to write it continuously until the stop condition is approved.



1. Start Condition

When SCL Terminal is High level, the data read-in is started by falling edge inputting to SDA Terminal.

2. Slave address

You should input the Slave Address and R/W condition to 1st byte data. The NJU6063 Slave Address is (0100_000). When the Slave Address is corresponding to written Data, ACK is output to 9th bit.

It does not correspond to general code address.

3. Register Upper Address

It should input Register Upper Address to 2nd byte data. Even if the Upper Address is not corresponding, ACK is output to the ninth bit if the Slave Address is corresponding.

4. Register Lower Address

It should input Register Lower Address to 3rd byte data. When the Slave Address is corresponding to written Data, ACK is output to 9th bit. When the Slave Address is not corresponding to written Data, ACK is not output to 9th bit.

5. Data

It should input a Data to 4th byte data or later.

Only when it doesn't complete internal processing by gradual dimming within IC, ACK is not output against input data (Processing Condition Internal IC-2).

If ACK is not output, it should re-enter data from the (1) Start Condition.

Refer to (3-4) Gradual Dimming Setting regarding detailed Gradual Dimming Operating Time.

6. Stop condition

When SCL Terminal is High level, the data read-in is stopped by rising edge inputting to SDA Terminal.

7. Repeat start condition

When SCL Terminal is High level after Start Condition setting, the data read-in is started by falling edge inputting to SDA Terminal.

(Note): When VDD=1.8V, you should use I^2C standard mode.

(6) RESET

(6-1) Hardware RESET

The device is initialized by inputting a “L” into the RSTb terminal.

Reset status using the RSTb terminal

(A) Oscillation / constant current driver “OFF”

(B) Internal Oscillator use

(C) Stop of gradual dimming

(D) Set of PWM data (LED1 to 3) : 00h

(E) Set of frame oscillation : fosc / 2 * 1 * 128

(F) Set of DO1 output mode DM : 00h (output of multi device control signal)

(G) Set of DO1 output data DO : 00h

(H) Set of current power ($ILED_0$ to $ILED_5$) : 00h (output is disable)

(I) Set of gradual dimming step (STP_3, STP_2, STP_1) : 00h

(J) Set of gradual dimming loop ($LOOP_4$ to $LOOP_1$) : 00h

(K) Set of static ON (SON_3, SON_2, SON_2) : 00h

(L) Set of turn over PWM data (INV_3, INV_2, INV_1) : 00h

(M) Set of multi device address : 00h

(N) I^2C interface reset

(6-2) Power ON RESET

NJU6063 is including power ON RESET circuit.

The device is initialized by power ON.

Operation follows hardware reset.

(7) Multi device control

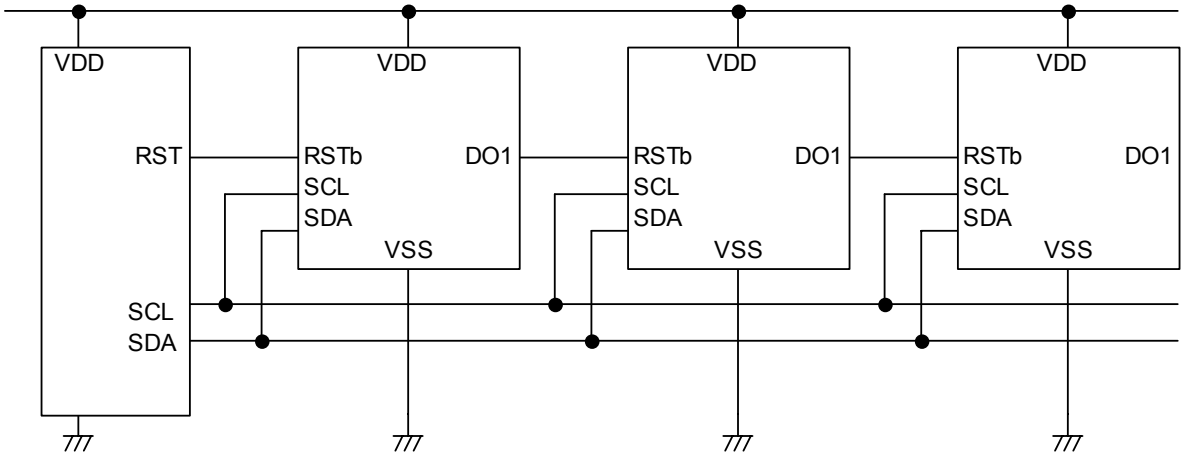
It is possible to control multiple NJU6063 by a I2C address.

Connect the DO1 and RSTb terminal, and multi device control is enabled by assigning a unique address to each device in default configuration.

Output "L" from DO1 terminal when the upper address is "00h".

Output "H" from DO1 terminal when the upper address is "01h~FFh".

After reset, upper address is set to "00h".

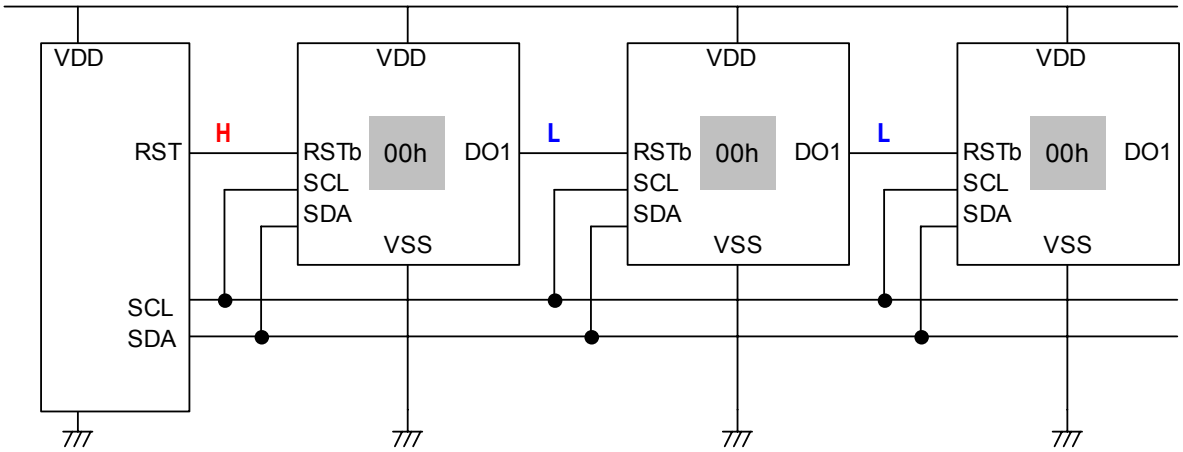


(7-1) Procedure of Address setting

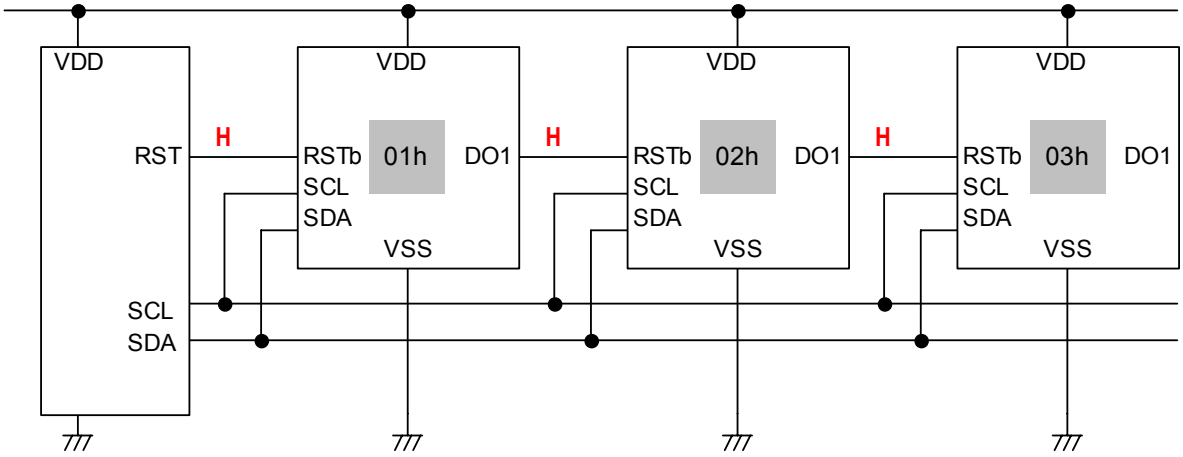
Ex.) In case of using three NJU6063

SLAVE ADDRESS +R/W	REGISTER ADDRESS	INPUT DATA			
40h	000Dh	01h	-	-	Set the upper address of device1 to 01h. RSTb="L" Therefore, device2 and 3 are not responding.
40h	000Dh	02h	-	-	Set the upper address of device2 to 02h. Device 1 has been set to "01h". RSTb="L" Therefore, device3 is not responding
40h	000Dh	03h	-	-	Set the upper address of device3 to 03h. Device1 has been set to "01h". Device2 has been set to "02h".
40h	FF00h	01h	-	-	Send commands (default) to all devices.
40h	FF01h	3Fh	-	-	Set the LED current to all device.
40h	0102h	11h	12h	• • • •	Set the PWM data, gradual dimming, static ON to device1.
40h	0202h	21h	22h	• • • •	Set the PWM data, gradual dimming, static ON to device2.
40h	0302h	31h	32h	• • • •	Set the PWM data, gradual dimming, static ON to device3.
40h	FF07h	01h	-	-	Start the gradual dimming

- After reset upper address Initial value : 00h



- After address set Initialization



(8) Control of NJU6080

NJU6080 can be controlled by using the terminal DO1 and the terminal DO2 of NJU6063.
(Refer to APPRICATION CIRCUIT Example 2)
The LED current can be increased by connecting NJU6080 more than NJU6063. The PWM data of LED3 becomes the PWM data of NJU6080.

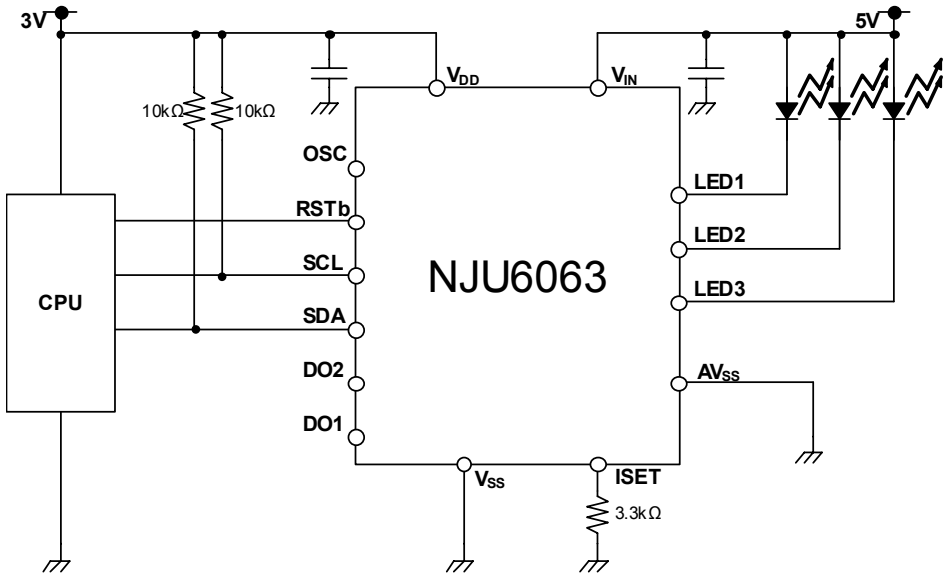
(8-1) Procedure of NJU6080 control

Ex.) In case of lighting with 70/128duty

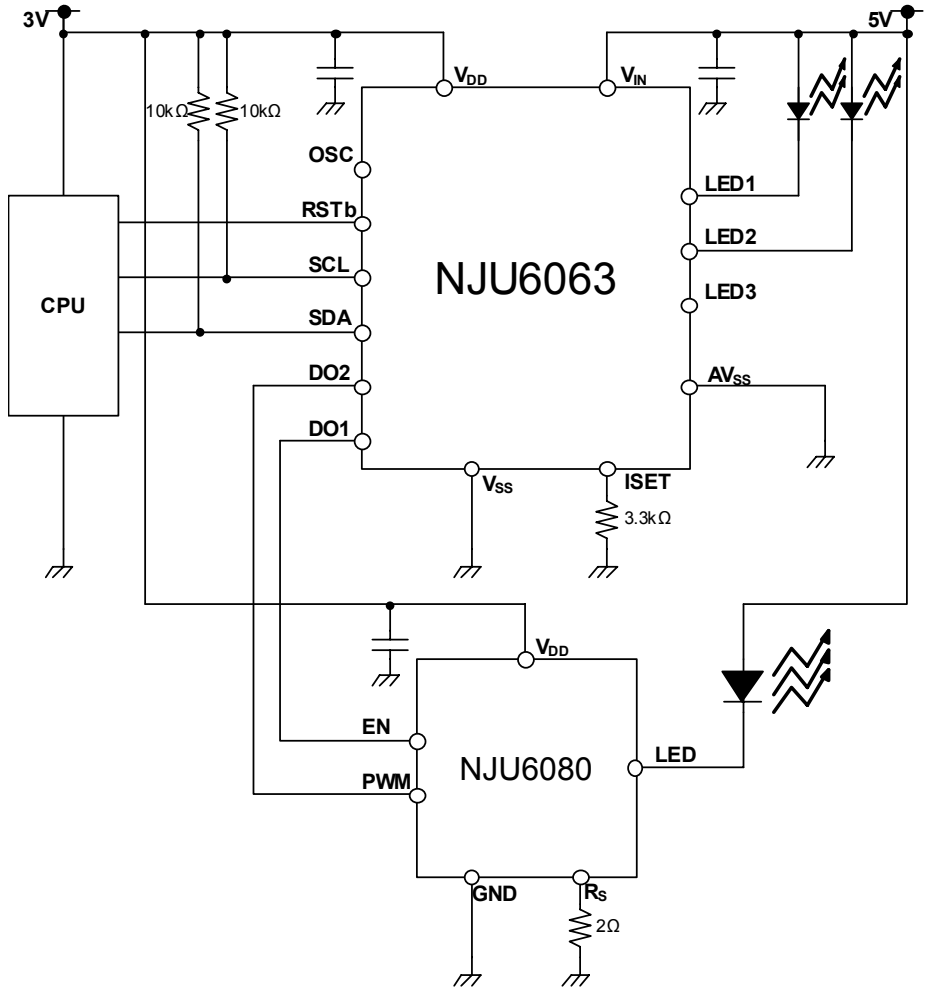
SLAVE ADDRESS +R/W	REGISTER ADDRESS	INPUT DATA			
40h	0000h	C1h	-	-	Send of Function set. "H" is output from the terminal DO1 by setting DM=1 and DO=1. NJU6080 is enable.
40h	0001h	0Fh	-	-	Set of LED3 current to 0 LED3. OFF state of LED3
40h	0004h	46h	48h	• • • •	Set the PWM data, gradual dimming, static ON to LED3.
40h	0007h	01h	-	-	The gradual dimming operation begins by START/STOP. (NJU6080 lights with 70/128Duty)

■ APPLICATION CIRCUIT

< Example 1 >

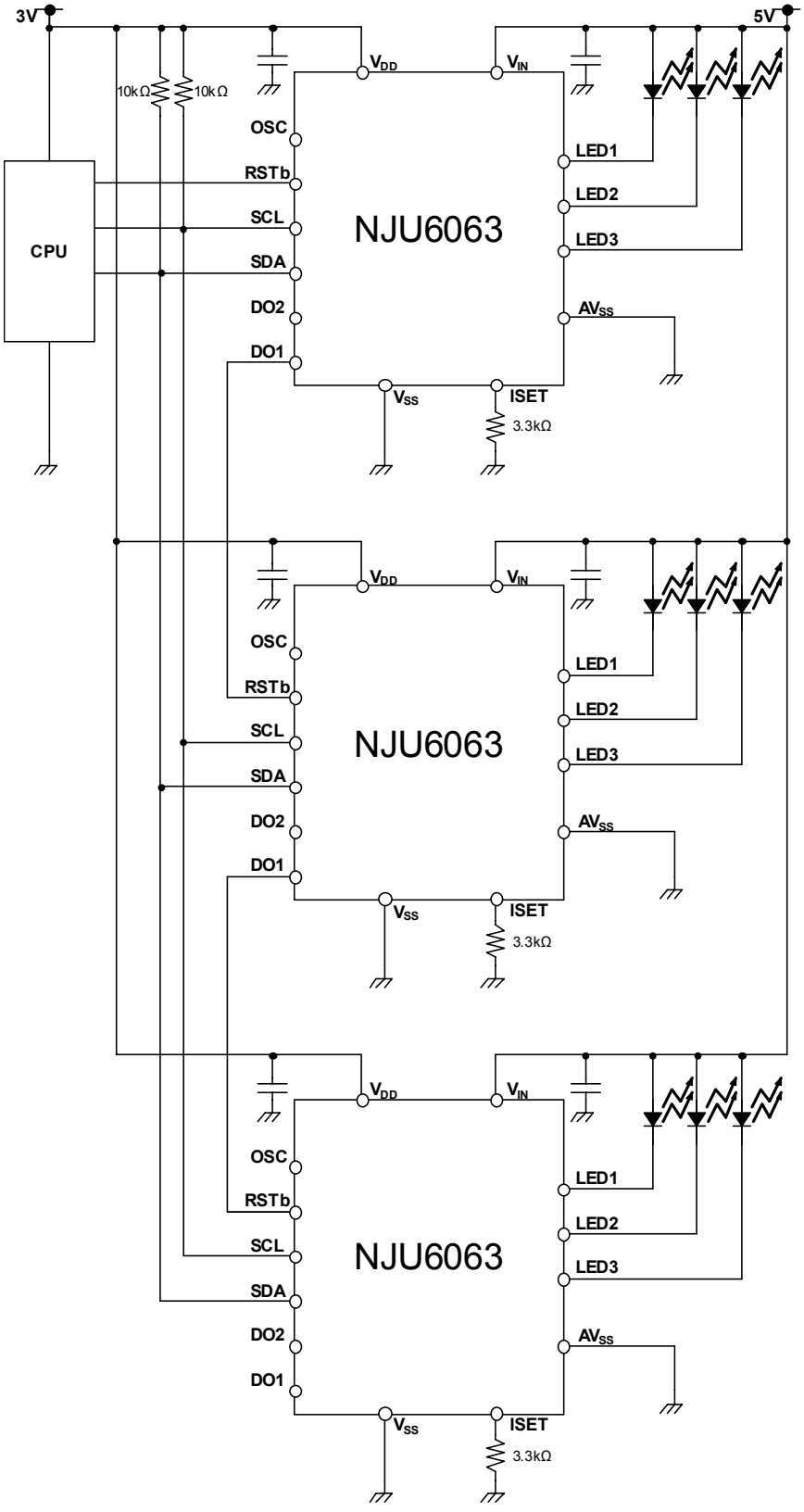


< Example 2 (Connect NJU6080) >

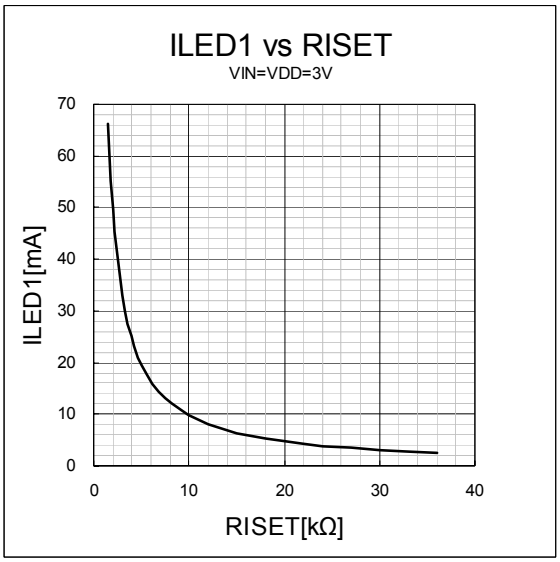


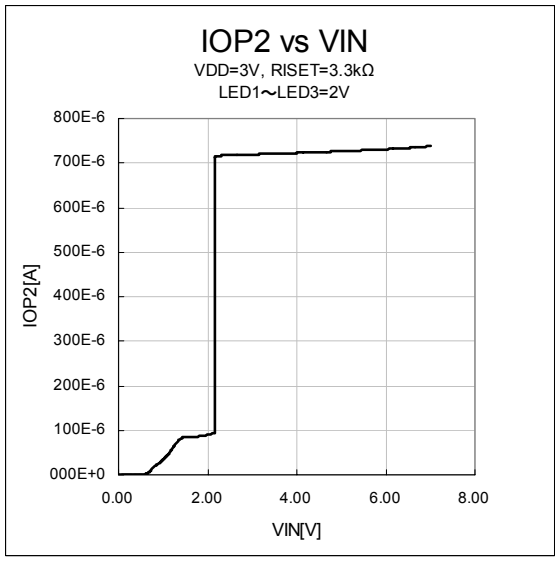
■ APPLICATION CIRCUIT

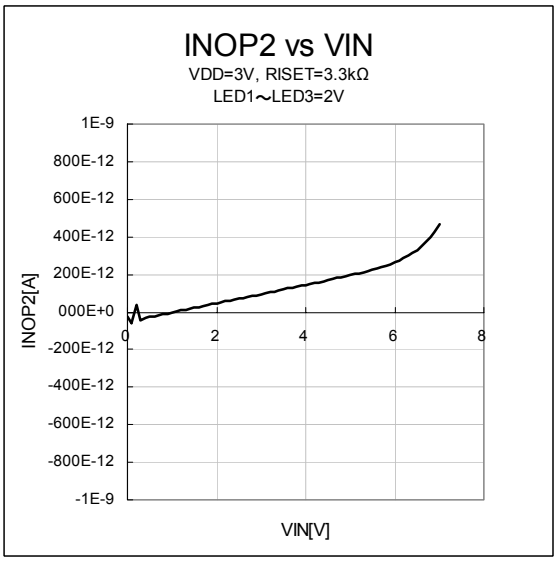
< Example 3 (Multi device control: connect three NJU6063) >

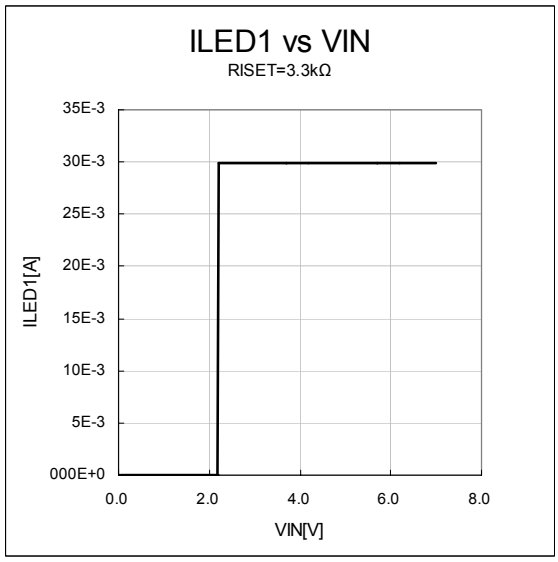


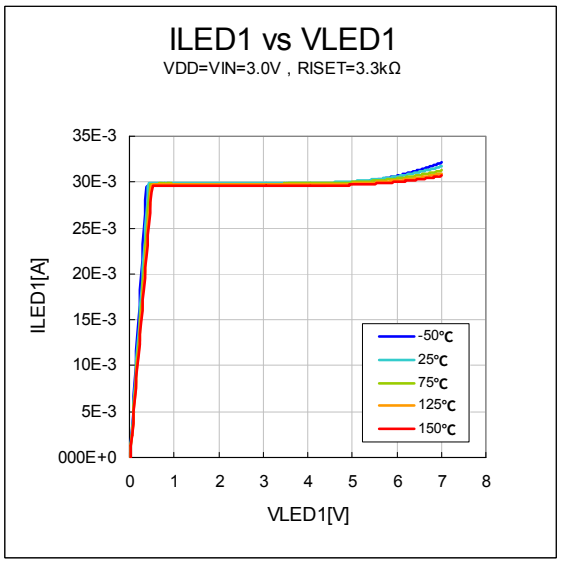
■ ELECTRICAL CHARACTERISTICS

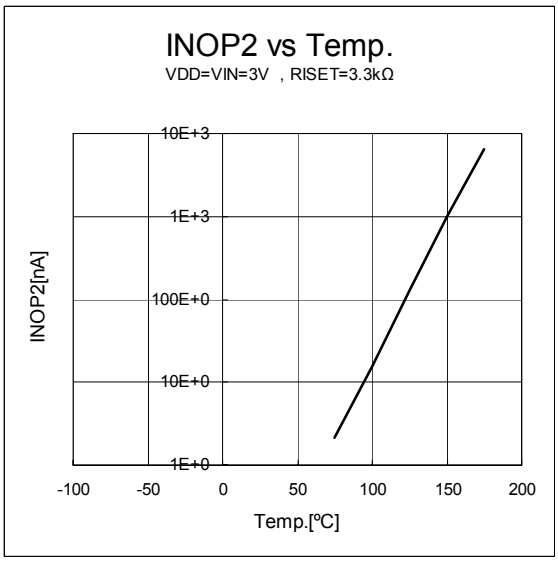




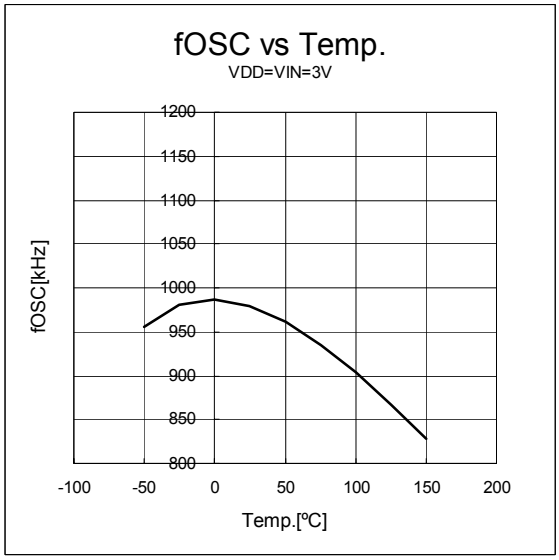


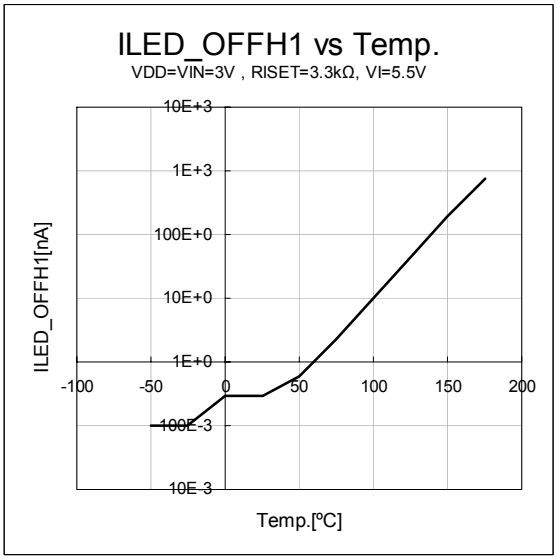






■ ELECTRICAL CHARACTERISTICS





[CAUTION]
The specifications on this data book are only given for information , without any guarantee as regards either mistakes or omissions. The application circuits in this data book are described only to show representative usages of the product and not intended for the guarantee or permission of any right including the industrial rights.