

3 - ch. LED driver for illumination

FEATURES

- I²C Interface (Slave address is switchable.)
- Build-in 3-ch. LED Driver Circuit
(Max Current Selectable [63.75 mA / 31.875 mA / 25.50 mA / 12.75 mA])
- 2.4 MHz OSC
- 12 pin Wafer level chip size package (WLCSP)

DESCRIPTION

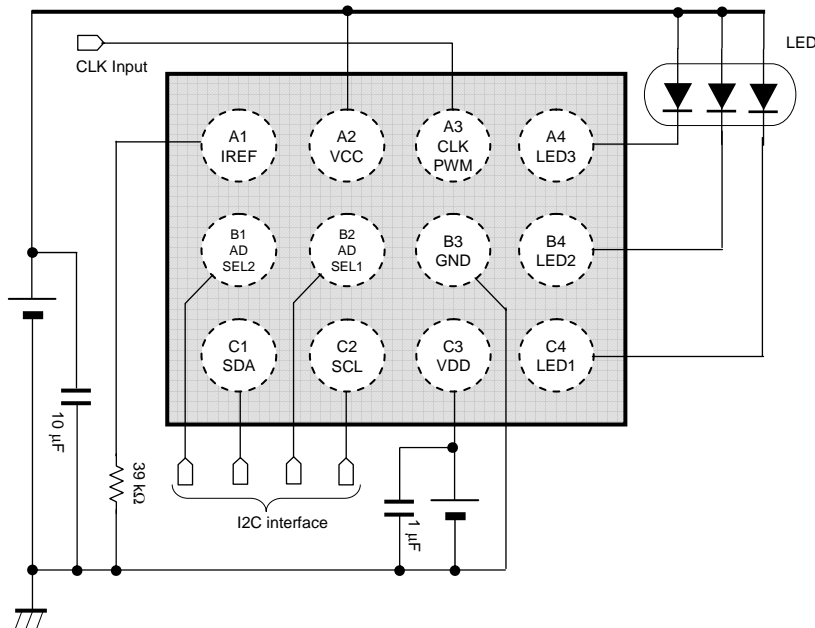
AN30259A has 3-ch. LED Driver. It is a suitable product to use for RGB Illumination. By synchronous clock function, combined operation is possible.

APPLICATIONS

- Mobile Phone
- Smart Phone
- PCs
- Game consoles
- Home Appliances etc.

SIMPLIFIED APPLICATION

TOP VIEW



Notes)

This application circuit is an example. The operation of mass production set is not guaranteed. You should perform enough evaluation and verification on the design of mass production set. You are fully responsible for the incorporation of the above application circuit and information in the design of your equipment.

ABSOLUTE MAXIMUM RATINGS

Parameter	Symbol	Rating	Unit	Note
Supply voltage	$V_{CC_{MAX}}$	7.0	V	*1
	$V_{DD_{MAX}}$	4.6	V	
Output Current	I_{OUT}	—	mA	*1
Operating ambience temperature	T_{opr}	-30 to + 85	°C	*2
Operating junction temperature	T_j	- 30 to + 125	°C	*2
Storage temperature	T_{stg}	- 55 to + 125	°C	*2
Input Voltage Range	ADSEL1, ADSEL2, SCL, SDA, CLKPWM	- 0.3 to 4.3	V	—
Output Voltage Range	LED1, LED2, LED3	- 0.3 to 6.5	V	—
ESD	HBM (Human Body Model)	1.5 to 2.0	kV	—

Notes) *1 $V_{CC_{MAX}} = V_{CC}$, $V_{DD_{MAX}} = V_{DD}$, the values under the condition not exceeding the above absolute maximum ratings and the power dissipation.

*2 Except for the power dissipation, operating ambient temperature, and storage temperature, all ratings are for $T_a = 25^{\circ}\text{C}$.

POWER DISSIPATION RATING

PACKAGE	θ_{JA}	PD ($T_a=25^{\circ}\text{C}$)	PD ($T_a=85^{\circ}\text{C}$)
49 pin Wafer Level Chip Size Package (WLCSP)	537.1 °C /W	0.186 W	0.074 W

Note). For the actual usage, please refer to the PD-Ta characteristics diagram in the package specification, supply voltage, load and ambient temperature conditions to ensure that there is enough margin follow the power and the thermal design does not exceed the allowable value.



CAUTION

Although this has limited built-in ESD protection circuit, but permanent damage may occur on it. Therefore, proper ESD precautions are recommended to avoid electrostatic damage to the MOS gates

RECOMMENDED OPERATING CONDITIONS

Parameter	Symbol	Min.	Typ.	Max.	Unit	Note
Supply voltage range	VCC	3.1	3.7	6.0	V	*1
	VDD	1.7	1.85	3.2	V	*1
Input Voltage Range	ADSEL1, ADSEL2, SCL, SDA, CLKPWM	- 0.3	—	VDD + 0.3	V	—
Output Voltage Range	LED1, LED2, LED3	- 0.3	—	VCC + 0.3	V	—

Note) *1 : The values under the condition not exceeding the above absolute maximum ratings and the power dissipation.

Do not apply external currents and voltages to any pin not specifically mentioned.

Voltage values, unless otherwise specified, are with respect to GND. GND is voltage for GND.

VDD is voltage for VDD. VCC is voltage for VCC.

*2 : (VDD + 0.3) V must not be exceeded 4.6 V. (VCC + 0.3) V must not be exceeded 7 V.

ELECTRICAL CHARACTERISTICS

$V_{CC} = 3.6\text{ V}$, $V_{DD} = 1.8\text{ V}$

Note) $T_a = 25^\circ\text{C} \pm 2^\circ\text{C}$ unless otherwise specified.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
Current consumption							
Current consumption 1 OFF mode	I_{CC1}	$V_{DD} = 0\text{ V}$	—	0	2	μA	—
Current consumption 2 OFF mode	I_{CC2}	$V_{DD} = 1.8\text{ V}$	—	1	5	μA	—
Current consumption 3 LED lighting mode	I_{CC3}	$I_{LED1\text{ to }3} = 25.50\text{ mA}$ setting All LED = ON	—	0.6	1.0	mA	—
LED Driver							
Off time leak current	I_{LEAK}	Off setting $V_{LED1\text{ to }3} = 6.0\text{ V}$	—	—	1.0	μA	—
Minimum setting current value 1	I_{MIN1}	$I_{MAX}[1:0] = 01$, $V_{LED1\text{ to }3} = 1.0\text{ V}$	0.05	0.10	0.15	mA	—
Minimum setting current value 2	I_{MIN2}	$I_{MAX}[1:0] = 01$, $V_{LED1\text{ to }3} = 1.0\text{ V}$	0.736	0.80	0.864	mA	—
Maximum setting current value	I_{MAX}	$I_{MAX}[1:0] = 01$, $V_{LED1\text{ to }3} = 1.0\text{ V}$	23.46	25.50	27.54	mA	—
Current step	I_{STEP}	$I_{MAX}[1:0] = 01$, $V_{LED1\text{ to }3} = 1.0\text{ V}$	0.00	0.10	0.18	mA	—
Minimum voltage for retainable constant current value	V_{SAT}	$I_{MAX}[1:0] = 01$, Terminal minimum voltage of LED1 to 3 becoming 85% of the LED current value in 1 V.	—	0.2	0.4	V	—
Error between channels	I_{MATCH}	12.80 mA setting, $V_{LED1\text{ to }3} = 1.0\text{ V}$	-5	—	5	%	—
Internal oscillator							
Oscillation frequency	f_{OSC}	—	1.92	2.40	2.88	MHz	—

ELECTRICAL CHARACTERISTICS (continued)

$V_{CC} = 3.6\text{ V}$, $V_{DD} = 1.8\text{ V}$

Note) $T_a = 25^\circ\text{C} \pm 2^\circ\text{C}$ unless otherwise specified.

Parameter	Symbol	Condition	Limits			Unit	Note
			Min	Typ	Max		
SCL, SDA							
High-level input voltage range	V_{IH1}	Voltage which recognized that SDA and SCL are High-level	$V_{DD} \times 0.7$	—	$V_{DDmax} + 0.5$	V	*1
Low-level input voltage range	V_{IL1}	Voltage which recognized that SDA and SCL are Low-level	-0.5	—	$V_{DD} \times 0.3$	V	*1
High-level input current	I_{IH1}	$V_{SDA}, V_{SCL} = 1.8\text{ V}$	—	0	1	μA	—
Low-level input current	I_{IL1}	$V_{SDA}, V_{SCL} = 0\text{ V}$	—	0	1	μA	—
Low-level output voltage (SDA)	V_{OL1H}	$I_{SDA} = 3\text{ mA}$, $V_{DD} > 2\text{ V}$	0	—	0.4	V	—
Low-level output voltage (SDA)	V_{OL1L}	$I_{SDA} = 3\text{ mA}$, $V_{DD} < 2\text{ V}$	0	—	$0.2 \times V_{DD}$	V	—
SCL clock frequency	f_{SCL}	—	0	—	400	kHz	—
CLKPWM							
High-level input voltage range	V_{IH2}	—	$V_{DD} \times 0.7$	—	$V_{DD} + 0.2$	V	—
Low-level input voltage range	V_{IL2}	—	-0.2	—	$V_{DD} \times 0.3$	V	—
Pin pull down resistance value	R_{PD2}	—	0.5	1.0	2.0	$\text{M}\Omega$	—
High-level output voltage	V_{OH2}	$I_{CLKPWM} = -2\text{ mA}$	$V_{DD} \times 0.8$	—	$V_{DD} + 0.2$	V	—
Low-level output voltage	V_{OL2}	$I_{CLKPWM} = 2\text{ mA}$	-0.2	—	$V_{DD} \times 0.2$	V	—
ADSEL1, ADSEL2							
High-level input voltage range	V_{IH3}	—	$V_{DD} \times 0.7$	—	$V_{DD} + 0.2$	V	—
Low-level input voltage range	V_{IL3}	—	-0.2	—	$V_{DD} \times 0.3$	V	—
High-level input current	I_{IH3}	$V_{ADSEL1, 2} = 1.8\text{ V}$	—	0	1	μA	—
Low-level input current	I_{IL3}	$V_{ADSEL1, 2} = 0\text{ V}$	—	0	1	μA	—

Note)*1: The input threshold voltage of I²C bus (V_{th}) is linked to V_{DD} (I²C bus I/O stage supply voltage).

In case the pull-up voltage is not V_{DD}, the threshold voltage (V_{th}) is fixed to $(V_{DD} / 2) \pm (\text{Schmitt width} / 2)$ and High-level, Low-level of input voltage are not specified.

In this case, pay attention to Low-level (max.) value (V_{ILmax}).

It is recommended that the pull-up voltage of I²C bus is set to the I²C bus I/O stage supply voltage (V_{DD}).

APPLICATION INFORMATION

REFERENCE VALUES FOR DESIGN

Notes) $V_{CC} = 3.6\text{ V}$, $V_{DD} = 1.8\text{ V}$

$T_a = 25\text{ °C} \pm 2\text{ °C}$ unless otherwise specified.

The characteristics listed below are reference values derived from the design of the LSI and are not guaranteed by inspection.

Parameter	Symbol	Condition	Reference values			Unit	Note
			Min	Typ	Max		
CLKPWM							
External PWM operation mode Data-enabled high pulse width	W_{PWM}	—	2	—	—	μs	—

APPLICATION INFORMATION (continued)

REFERENCE VALUES FOR DESIGN (continued)

Notes) $V_{CC} = 3.6\text{ V}$, $V_{DD} = 1.8\text{ V}$

$T_a = 25\text{ }^\circ\text{C} \pm 2\text{ }^\circ\text{C}$ unless otherwise specified.

The characteristics listed below are reference values derived from the design of the LSI and are not guaranteed by inspection.

Parameter	Symbol	Condition	Reference values			Unit	Note
			Min	Typ	Max		
I²C bus (Internal I/O stage characteristics)							
Input voltage hysteresis (1)	V_{hys1}	SCL, SDA hysteresis voltage $V_{DD} > 2\text{ V}$	$0.05 \times V_{DD}$	—	—	V	—
Input voltage hysteresis (2)	V_{hys2}	SCL, SDA hysteresis voltage $V_{DD} < 2\text{ V}$	$0.1 \times V_{DD}$	—	—	V	—
Output fall time from V_{IHmin} to V_{ILmax}	t_{of}	Bus capacitance : 10 pF to 400pF $I_P \leq 6\text{ mA}$ ($V_{OLmax} = 0.6\text{ V}$) I_P : Max. sink current	$20 + 0.1 \times C_b$	—	250	ns	—
Spike pulse width kept down by input filter	t_{sp}	—	0	—	50	ns	—
I/O pin capacitance	C_i	—	—	—	10	pF	—

APPLICATION INFORMATION (continued)

REFERENCE VALUES FOR DESIGN (continued)

Notes) $V_{CC} = 3.6\text{ V}$, $V_{DD} = 1.8\text{ V}$

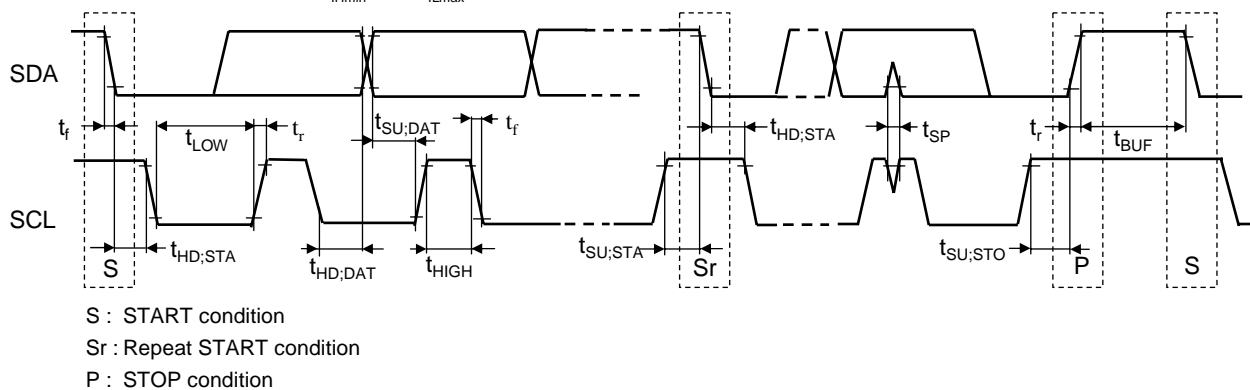
$T_a = 25^\circ\text{C} \pm 2^\circ\text{C}$ unless otherwise specified.

The characteristics listed below are reference values derived from the design of the LSI and are not guaranteed by inspection.

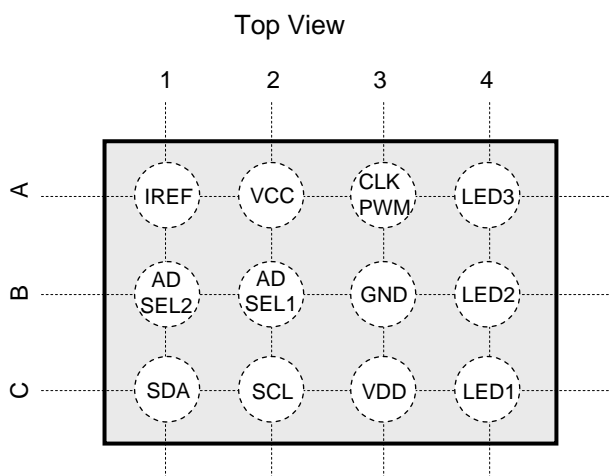
Parameter	Symbol	Condition	Reference values			Unit	Note
			Min	Typ	Max		
I²C bus (Bus line specifications)							
Hold duration (recursive)	$t_{HD:STA}$	After $t_{HD:STA}$, the first clock pulse is generated.	0.6	—	—	μs	*2
SCL clock "L" duration	t_{LOW}	—	1.3	—	—	μs	*2
SCL clock "H" duration	t_{HIGH}	—	0.6	—	—	μs	*2
Recursive "START" condition setting time	$t_{SU:STA}$	—	0.6	—	—	μs	*2
Data hold time	$t_{HD:DAT}$	—	0	—	0.9	μs	*2
Data setup time	$t_{SU:DAT}$	—	100	—	—	ns	*2
SDA, SCL signal rise up time	t_r	—	$20 + 0.1 \times C_b$	—	300	ns	*2
SDA, SCL signal fall time	t_f	—	$20 + 0.1 \times C_b$	—	300	ns	*2
Setup time under "STOP" condition	$t_{SU:STO}$	—	0.6	—	—	μs	*2
Bus free time between under "STOP" condition and "START" condition	t_{BUF}	—	1.3	—	—	μs	*2
Capacitive load for each bus line	C_b	—	—	—	400	pF	*2
Noise margin of each connection device at Low-level	V_{nL}	—	$0.1 \times V_{DD}$	—	—	V	*2
Noise margin of each connection device at High-level	V_{nH}	—	$0.2 \times V_{DD}$	—	—	V	*2

Note) *2: The timing of Fast-mode devices in I²C-bus is specified as follows.

All values referred to V_{IHmin} and V_{ILmax} level.



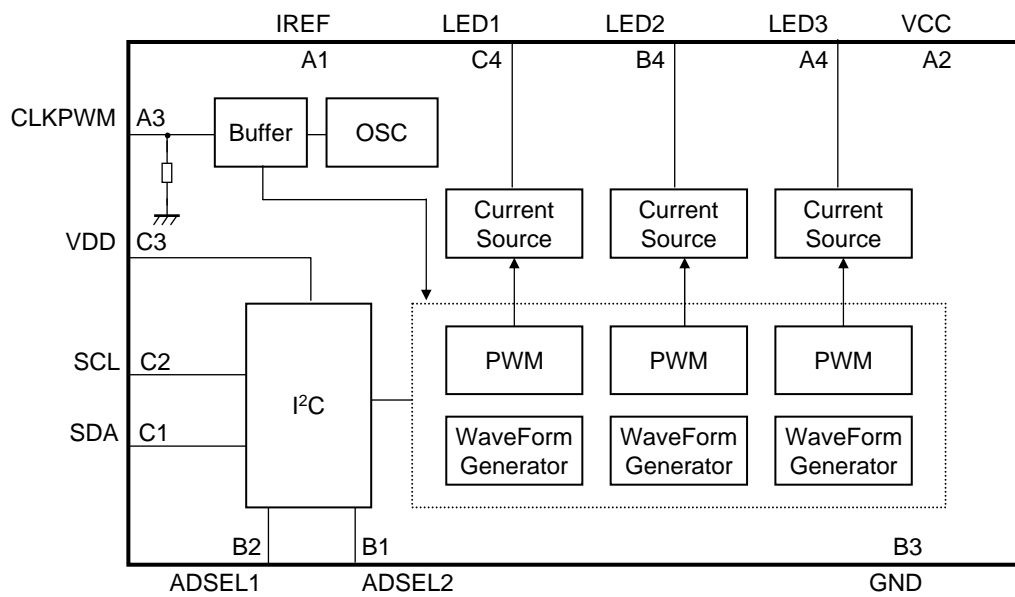
PIN CONFIGURATION



PIN FUNCTIONS

Pin No.	Pin name	Type	Description
A1	IREF	Output	Resistor connection pin for setting constant current value
A2	VCC	Power Supply	Power supply pin for LED Circuit
A3	CLKPWM	Input/Output	Reference clock I/O / PWM input pin
A4	LED3	Output	LED3 output pin
B1	ADSEL2	Input	I ² C Interface slave address switch pin 2
B2	ADSEL1	Input	I ² C Interface slave address switch pin 1
B3	GND	Ground	Ground pin
B4	LED2	Output	LED2 output pin
C1	SDA	Input/Output	I ² C interface data I/O pin
C2	SCL	Input	I ² C interface clock input pin
C3	VDD	Power Supply	Power supply pin for interface
C4	LED1	Output	LED1 output pin

FUNCTIONAL BLOCK DIAGRAM



Note) This block diagram is for explaining functions. The part of the block diagram may be omitted, or it may be simplified.

OPERATION

1. I²C-bus Interface

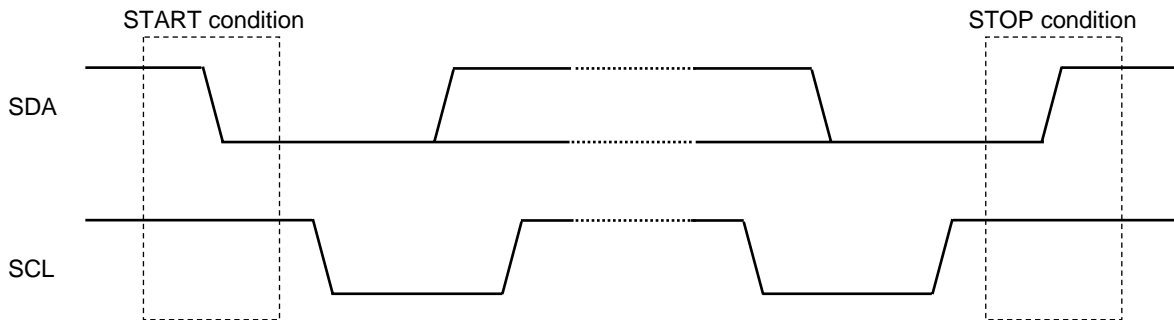
1) Basic Rules

- This LSI, I²C-bus, is designed to correspond to the Standard-mode (100 kbps) and Fast-mode(400 kbps) devices in the version 2.1 of Philips Co.'s specification. However, it does not correspond to the H_S-mode (to 3.4 Mbps).
- This LSI will be operated as a slave device in the I²C-bus system.
- The program operation check of this LSI has not been conducted on the multi-master bus system and the mix-speed bus system, yet. The connected confirmation of this LSI to the CBUS receiver also has not been checked. Please confirm our company if it will be used in these mode systems.
- Purchase of Panasonic I²C Components conveys a license under the Philips I²C patent right to use these components in an I²C systems, provided that the system conforms to the I²C standard specifications as defined by Philips.

2) START and STOP conditions

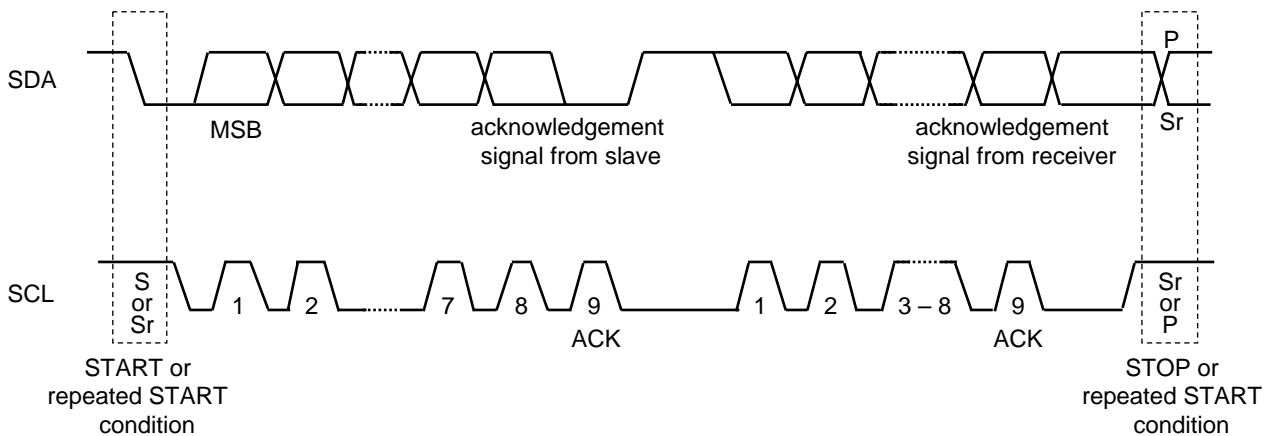
A High to Low transition on the SDA line while SCL is High is one such unique case. This situation indicates START condition. A Low to High transition on the SDA line while SCL is High defines STOP condition. START and STOP conditions are always generated by the master. After START condition occur, the bus will be busy.

The bus is considered to be free again a certain time after the STOP condition.



3) Transferring Data

Every byte put on the SDA line must be 8-bits long. The number of bytes that can be transmitted per transfer is unrestricted. Each byte has to be followed by an acknowledge bit. Data is transferred with the most significant bit (MSB) first.



OPERATION (continued)

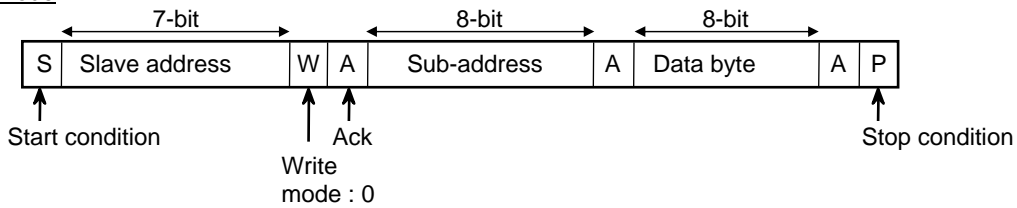
1. I²C-bus Interface (continued)

4) Data format

Slave address can be switched by switching the ADSEL1, ADSEL2 pin connections.
The chart on the right shows the slave address of this product.

ADSEL2	ADSEL1	Slave address
Low (Ground)	Low (Ground)	30 h (0110000)
Low (Ground)	High (VDD)	31 h (0110001)
High (VDD)	Low (Ground)	32 h (0110010)
High (VDD)	High (VDD)	33 h (0110011)

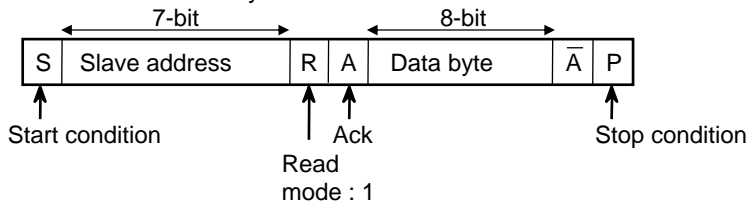
Write mode



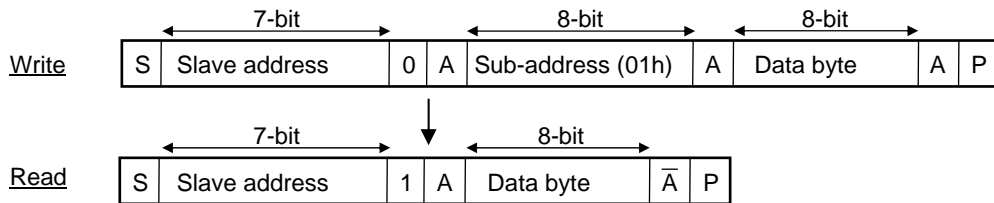
Read mode

A) When sub-address is not assigned.

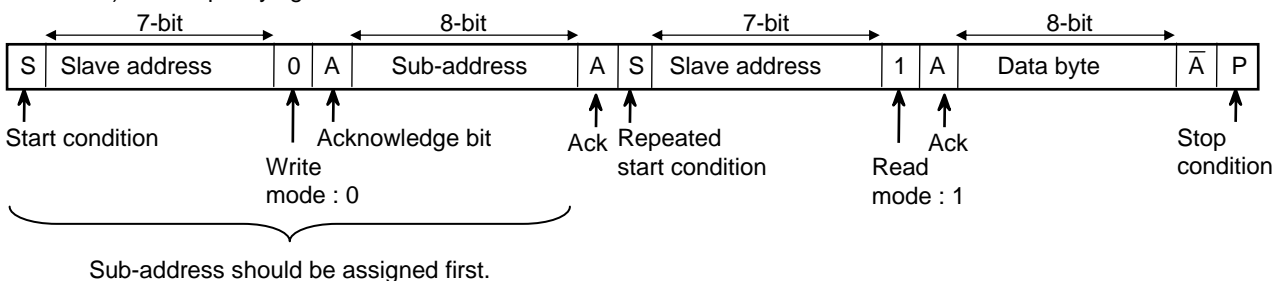
When data is read without assigning sub-address, it is possible to read the value of sub-address specified in Write mode immediately before.



Ex) When writing data into address and reading data from "01 h"



B) When specifying sub-address



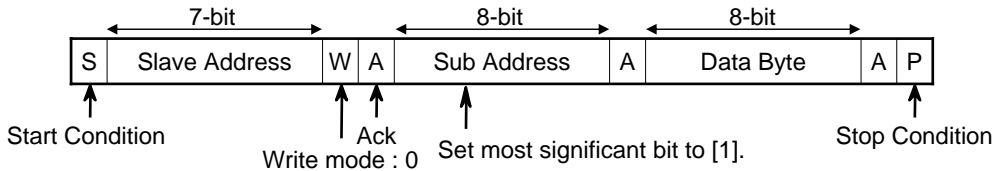
OPERATION (continued)

1. I²C-bus Interface (continued)

4) DATA format (continued)

• Continuous Write mode

When using the continuous Write mode, the most significant bit of Sub address should be set to [1].

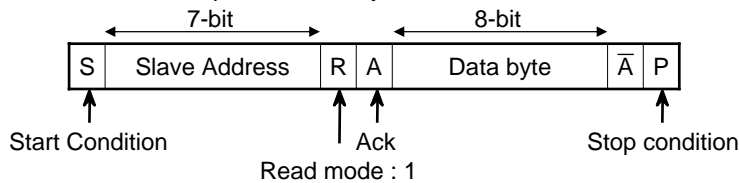


Ex) 05h → 85h, 11h → 91h

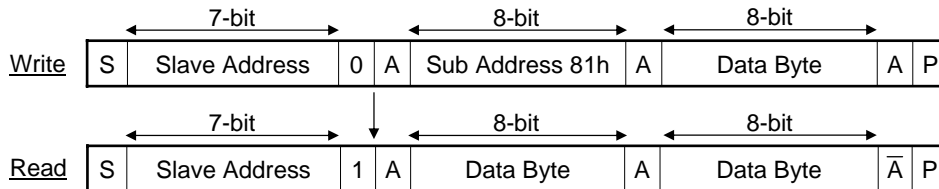
• Continuous Read mode

A) When Sub address is not specified

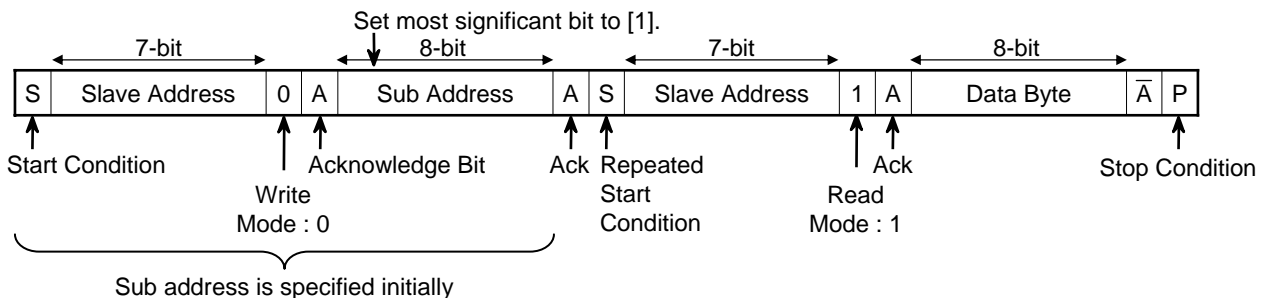
When the most significant bit specified in the last Write mode is [1], it is possible to perform the continuous Read mode operation directly after it.



Ex) Case where data is read from Address 01h after data is written to Address 01h



B) When Sub address is specified



OPERATION (continued)

2. Register map

Sub Address	R/W	Register Name	Data							
			D7	D6	D5	D4	D3	D2	D1	D0
00h	W	SRESET	—	—	—	—	—	—	—	SRESET
01h	R/W	LEDON	—	LED3MD	LED2MD	LED1MD	—	LED3ON	LED2ON	LED1ON
02h	R/W	SEL	IMAX [1:0]		IOEN	CLKDIR	EXTPWM	DLYSEL3	DLYSEL2	DLYSEL1
03h	R/W	LED1CC	LED1CC [7:0]							
04h	R/W	LED2CC	LED2CC [7:0]							
05h	R/W	LED3CC	LED3CC [7:0]							
06h	R/W	LED1SLP	SLP1TT2 [3:0]				SLP1TT1 [3:0]			
07h	R/W	LED2SLP	SLP2TT2 [3:0]				SLP2TT1 [3:0]			
08h	R/W	LED3SLP	SLP3TT2 [3:0]				SLP3TT1 [3:0]			
09h	R/W	LED1CNT1	DUTYMAX1 [3:0]				DUTYMID1 [3:0]			
0Ah	R/W	LED1CNT2	DELAY1 [3:0]				DUTYMIN1 [3:0]			
0Bh	R/W	LED1CNT3	SLP1DT2 [3:0]				SLP1DT1 [3:0]			
0Ch	R/W	LED1CNT4	SLP1DT4 [3:0]				SLP1DT3 [3:0]			
0Dh	R/W	LED2CNT1	DUTYMAX2 [3:0]				DUTYMID2 [3:0]			
0Eh	R/W	LED2CNT2	DELAY2 [3:0]				DUTYMIN2 [3:0]			
0Fh	R/W	LED2CNT3	SLP2DT2 [3:0]				SLP2DT1 [3:0]			
10h	R/W	LED2CNT4	SLP2DT4 [3:0]				SLP2DT3 [3:0]			
11h	R/W	LED3CNT1	DUTYMAX3 [3:0]				DUTYMID3 [3:0]			
12h	R/W	LED3CNT2	DELAY3 [3:0]				DUTYMIN3 [3:0]			
13h	R/W	LED3CNT3	SLP3DT2 [3:0]				SLP3DT1 [3:0]			
14h	R/W	LED3CNT4	SLP3DT4 [3:0]				SLP3DT3 [3:0]			

Note) Read value in "—" is [0].

OPERATION (continued)

3. Register map details

Register Name		SRESET							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
00 h	W	—	—	—	—	—	—	—	SRESET
Default	00 h	0	0	0	0	0	0	0	0

D0 : Software reset pin

[0] : Normal condition (default)

[1] : Reset (Reset all the other register and return to Low automatically)

OPERATION (continued)

3. Register map details (continued)

Register Name		LEDON							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
01 h	R/W	—	LED3MD	LED2MD	LED1MD	—	LED3ON	LED2ON	LED1ON
Default	00 h	0	0	0	0	0	0	0	0

D6 : LED3MD LED3 lighting mode setting
 [0] : LED3 constant current mode (default)
 [1] : LED3 slope mode

D5 : LED2MD LED2 lighting mode setting
 [0] : LED2 constant current mode (default)
 [1] : LED2 slope mode

D4 : LED1MD LED1 lighting mode setting
 [0] : LED1 constant current mode (default)
 [1] : LED1 slope mode

D2 : LED3ON LED3 enable control
 [0] : LED3 OFF (default)
 [1] : LED3 ON

D1 : LED2ON LED2 enable control
 [0] : LED2 OFF (default)
 [1] : LED2 ON

D0 : LED1ON LED1 enable control
 [0] : LED1 OFF (default)
 [1] : LED1 ON

LED1 operation mode

D4	D0	LED1 operation mode
LED1MD	LED1ON	
0	0	OFF
1	0	OFF
0	1	ON (constant current mode)
1	1	ON (slope mode)

This mode applies to LED2, LED3 operation modes.

OPERATION (continued)

3. Register map details (continued)

Register Name		SEL							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
02 h	R/W	IMAX [1:0]		IOEN	CLKDIR	EXTPWM	DLYSEL3	DLYSEL2	DLYSEL1
Default	40 h	0	1	0	0	0	0	0	0

D7-6 : IMAX [1:0] Max value, Step value setting for current setting
 [00] : Max value 12.75 mA, Step value 0.05 mA
 [01] : Max value 25.50 mA, Step value 0.10 mA (default)
 [10] : Max value 31.875 mA, Step value 0.125 mA
 [11] : Max value 63.75 mA, Step value 0.25 mA

D5 : IOEN CLKPWM pin enable control
 [0] : CLKPWM pin invalid (default)
 [1] : CLKPWM pin valid

D5	D4	D3	CLKPWM operation mode (Clock mode/PWM mode)
IOEN	CLKDIR	EXTPWM	
0	0 or 1	0 or 1	OFF
1	0 or 1	1	External PWM operation mode
1	0	0	External clock input mode
1	1	0	Internal clock output mode

D4 : CLKDIR CLKPWM pin I/O mode setting
 [0] : CLKPWM pin input mode (default)
 [1] : CLKPWM pin output mode

D3 : EXTPWM CLKPWM pin PWM mode setting
 [0] : CLKPWM pin PWM mode invalid (default)
 [1] : CLKPWM pin PWM mode valid

D2 : DLYSEL3 Lighting delay time mode setting at LED3 Slope mode
 [0] : LED3 delay time Max 7.50 s mode (default)
 [1] : LED3 delay time Max 1.86 s mode

D1 : DLYSEL2 Lighting delay time mode setting at LED2 Slope mode
 [0] : LED2 Delay time Max 7.50 s mode (default)
 [1] : LED2 Delay time Max 1.86 s mode

D0 : DLYSEL1 Lighting delay time mode setting at LED1 Slope mode
 [0] : LED1 Delay time Max 7.50 s mode (default)
 [1] : LED1 Delay time Max 1.86 s mode

Please refer to a detail explanation of following register DELAY1 for DLYSEL* details.

<External PWM operation mode>

LED lighting turns ON/OFF by High/Low setting of CLKPWM pin at the time of LED lighting setting
 This mode enables LED lighting synchronization with music signal and brightness control by High/Low Duty ratio.

<External clock input mode>

The reference clock for Slope control is CLKPWM pin. Synchronization with external signals is possible.

<Internal clock output mode>

Internal reference clock for Slope control is generated via CLKPWM pin.
 (The output clock will not be available when LED1ON=LED2ON=LED3ON=0.)
 Synchronized operation is possible between products, for example, when using more than one this product connected.

OPERATION (continued)

3. Register map details (continued)

Register Name		LED1CC							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
03 h	R/W	LED1CC [7: 0]							
Default	00 h	0	0	0	0	0	0	0	0

D7-0 : LED1CC [7: 0] Current setting for LED1 constant current output

Register Name		LED2CC							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
04 h	R/W	LED2CC [7: 0]							
Default	00 h	0	0	0	0	0	0	0	0

D7-0 : LED2CC [7: 0] Current setting for LED2 constant current output

Register Name		LED3CC							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
05 h	R/W	LED3CC [7: 0]							
Default	00 h	0	0	0	0	0	0	0	0

D7-0 : LED3CC [7: 0] Current setting for LED3 constant current output

Output current value can be changed by IMAX setting as below.

LED*CC [7: 0]								IMAX [1: 0]			
D7	D6	D5	D4	D3	D2	D1	D0	00h	01h	10h	11h
0	0	0	0	0	0	0	0	0.000 mA	0.000 mA	0.000 mA	0.000 mA
0	0	0	0	0	0	0	1	0.050 mA	0.100 mA	0.125 mA	0.250 mA
0	0	0	0	0	0	1	0	0.100 mA	0.200 mA	0.250 mA	0.500 mA
:	:	:	:	:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:	0.050 mA	0.100 mA	0.125 mA	0.250 mA
:	:	:	:	:	:	:	:	Step	Step	Step	Step
:	:	:	:	:	:	:	:	:	:	:	:
1	1	1	1	1	1	1	0	12.700 mA	25.400 mA	31.750 mA	63.500 mA
1	1	1	1	1	1	1	1	12.750 mA	25.500 mA	31.875 mA	63.750 mA

OPERATION (continued)

3. Register map details (continued)

Register Name		LED1SLP							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
06 h	R/W	SLP1TT2 [3: 0]				SLP1TT1 [3: 0]			
Default	88 h	1	0	0	0	1	0	0	0

Total time of SLOPE operation for LED1 will be set.

Please refer to following "4. LED control Slope lighting mode" for the details of slope operation.

SLP1TT1 [3: 0] is set as the chart below shows.

SLP1TT1 [3:0]				Total time of SLOPE operation 1, 2
0	0	0	0	(PWM cycle = 53.3 μ s) × 75 × 125 × 0 = 0.0 s
0	0	0	1	(PWM cycle = 53.3 μ s) × 75 × 125 × 1 = 0.5 s
0	0	1	0	(PWM cycle = 53.3 μ s) × 75 × 125 × 2 = 1.0 s
:	:	:	:	:
:	:	:	:	0.5 s Step
:	:	:	:	:
1	1	0	0	(PWM cycle = 53.3 μ s) × 75 × 125 × 12 = 6.0 s
1	1	0	1	(PWM cycle = 53.3 μ s) × 75 × 125 × 13 = 6.5 s
1	1	1	0	(PWM cycle = 53.3 μ s) × 75 × 125 × 14 = 7.0 s
1	1	1	1	(PWM cycle = 53.3 μ s) × 75 × 125 × 15 = 7.5 s

SLP1TT2 [3: 0] is set as the chart below shows.

SLP1TT2 [3:0]				Total time of SLOPE operation 3, 4
0	0	0	0	(PWM cycle = 53.3 μ s) × 75 × 125 × 0 = 0.0 s
0	0	0	1	(PWM cycle = 53.3 μ s) × 75 × 125 × 1 = 0.5 s
0	0	1	0	(PWM cycle = 53.3 μ s) × 75 × 125 × 2 = 1.0 s
:	:	:	:	:
:	:	:	:	0.5 s Step
:	:	:	:	:
1	1	0	0	(PWM cycle = 53.3 μ s) × 75 × 125 × 12 = 6.0 s
1	1	0	1	(PWM cycle = 53.3 μ s) × 75 × 125 × 13 = 6.5 s
1	1	1	0	(PWM cycle = 53.3 μ s) × 75 × 125 × 14 = 7.0 s
1	1	1	1	(PWM cycle = 53.3 μ s) × 75 × 125 × 15 = 7.5 s

OPERATION (continued)

3. Register map details (continued)

Register Name		LED2SLP							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
07 h	R/W	SLP2TT2 [3: 0]				SLP2TT1 [3: 0]			
Default	88 h	1	0	0	0	1	0	0	0

Total time of Slope operation for LED2 setting

Register Name		LED3SLP							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
08 h	R/W	SLP3TT2 [3: 0]				SLP3TT1 [3: 0]			
Default	88 h	1	0	0	0	1	0	0	0

Total time of Slope operation for LED3 will be set.

Please refer to following “ 4. LED control Slope lighting mode ” for the details of slope operation.

The Slope setting charts for LED2 and LED3 are same as the one for LED1 in the previous page.

OPERATION (continued)

3. Register map details (continued)

Register Name		LED1CNT1							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
09 h	R/W	DUTYMAX1 [3: 0]				DUTYMID1 [3: 0]			
Default	F8 h	1	1	1	1	1	0	0	0

D7-4 : DUTYMAX1 [3: 0] LED1 at Slope lighting maximum PWM Duty setting

D3-0 : DUTYMID1 [3: 0] LED1 at Slope lighting middle PWM Duty setting

Register Name		LED1CNT2							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
0A h	R/W	DELAY1 [3: 0]				DUTYMIN1 [3: 0]			
Default	00 h	0	0	0	0	0	0	0	0

D7-4 : DELAY1 [3: 0] LED1 starting delay time setting

D3-0 : DUTYMIN1 [3: 0] LED1 at Slope lighting minimum PWM Duty setting

Register Name		LED1CNT3							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
0B h	R/W	SLP1DT2 [3: 0]				SLP1DT1 [3: 0]			
Default	88 h	1	0	0	0	1	0	0	0

D7-4 : SLP1DT2 [3: 0] LED1 slope lighting, SLOPE operation 2 detention time setting

D3-0 : SLP1DT1 [3: 0] LED1 slope lighting, SLOPE operation 1 detention time setting

Register Name		LED1CNT4							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
0C h	R/W	SLP1DT4 [3: 0]				SLP1DT3 [3: 0]			
Default	88 h	1	0	0	0	1	0	0	0

D7-4 : SLP1DT4 [3: 0] LED1 slope lighting , SLOPE operation 4 detention time setting

D3-0 : SLP1DT3 [3: 0] LED1 slope lighting, SLOPE operation 3 detention time setting

Operation parameter of LED1 SLOPE operation will be set.

Please refer to following " 4. LED control Slope lighting mode " for the details of slope operation.

OPERATION (continued)

3. Register map details (continued)

DUTYMAX1 [3: 0] correspond to the following PWM Duty setting as the following chart shows.

DUTYMAX1 [3: 0]				Duty setting for PWM operation [6: 0]						
D3	D2	D1	D0	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	0	0	0	0	1	1	1
0	0	0	1	0	0	0	1	1	1	1
0	0	1	0	0	0	1	0	1	1	1
0	0	1	1	0	0	1	1	1	1	1
~				~						
1	1	1	0	1	1	1	0	1	1	1
1	1	1	1	1	1	1	1	1	1	1

Duty setting for PWM operation [6: 0]

[0000111] : 7 / 128 = 5.47 %

[0001111] : 15 / 128 = 11.72 %

[0010111] : 23 / 128 = 17.97 %

[0011111] : 31 / 128 = 24.22 %

:

[1110111] : 119 / 128 = 92.97 %

[1111111] : 127 / 128 = 99.22 %

DUTYMID1 [3: 0] correspond to the following PWM Duty setting as the following chart shows.

DUTYMID1 [3: 0]				Duty setting for PWM operation[6: 0]						
D3	D2	D1	D0	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1	1	1	1
0	0	1	0	0	0	1	0	1	1	1
0	0	1	1	0	0	1	1	1	1	1
~				~						
1	1	1	0	1	1	1	0	1	1	1
1	1	1	1	1	1	1	1	1	1	1

Duty setting for PWM operation [6: 0]

[0000000] : 0 / 128 = 0 %

[0001111] : 15 / 128 = 11.72 %

[0010111] : 23 / 128 = 17.97 %

[0011111] : 31 / 128 = 24.22 %

:

[1110111] : 119 / 128 = 92.97 %

[1111111] : 127 / 128 = 99.22 %

OPERATION (continued)

3. Register map details (continued)

DUTYMIN1 [3: 0] correspond to the following PWM Duty setting as the following chart shows.

DUTYMIN1 [3: 0]				Duty setting for PWM operation [6: 0]						
D3	D2	D1	D0	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	0	0	0	1	0	0	0
0	0	1	0	0	0	1	0	0	0	0
0	0	1	1	0	0	1	1	0	0	0
~				~						
1	1	1	0	1	1	1	0	0	0	0
1	1	1	1	1	1	1	1	0	0	0

Duty setting for PWM operation [6: 0]

- [0000000] : 0 / 128 = 0 %
- [0001000] : 8 / 128 = 6.25 %
- [0010000] : 16 / 128 = 12.5 %
- [0011000] : 24 / 128 = 18.75 %
- :
- [1110000] : 112 / 128 = 87.5 %
- [1111000] : 120 / 128 = 93.75 %

DELAY1 [3: 0] is set as the following chart shows.

DELAY1 [3: 0]				DLYSEL1 = 0	DLYSEL1 = 1
0	0	0	0	0.00 s	0.000 s
0	0	0	1	0.50 s	0.124 s
0	0	1	0	1.00 s	0.248 s
~				~	~
1	1	1	0	7.00 s	1.736 s
1	1	1	1	7.50 s	1.860 s

OPERATION (continued)

3. Register map details (continued)

SLP1DT1 [3: 0] is set as the following chart shows.

SLP1DT1 [3: 0]				Detention time at each step
0	0	0	0	(PWM cycle = 53.3 μ s) × 1 = 53.3 μ s
0	0	0	1	(PWM cycle = 53.3 μ s) × 75 × 1 = 4.0 ms
0	0	1	0	(PWM cycle = 53.3 μ s) × 75 × 2 = 8.0 ms
~				~
1	1	1	0	(PWM cycle = 53.3 μ s) × 75 × 14 = 56.0 ms
1	1	1	1	(PWM cycle = 53.3 μ s) × 75 × 15 = 60.0 ms

SLP1DT2 [3: 0] is set as the following chart shows.

SLP1DT2 [3: 0]				Detention time at each step
0	0	0	0	(PWM cycle = 53.3 μ s) × 1 = 53.3 μ s
0	0	0	1	(PWM cycle = 53.3 μ s) × 75 × 1 = 4.0 ms
0	0	1	0	(PWM cycle = 53.3 μ s) × 75 × 2 = 8.0 ms
~				~
1	1	1	0	(PWM cycle = 53.3 μ s) × 75 × 14 = 56.0 ms
1	1	1	1	(PWM cycle = 53.3 μ s) × 75 × 15 = 60.0 ms

SLP1DT3 [3: 0] is set as the following chart shows.

SLP1DT3 [3: 0]				Detention time at each step
0	0	0	0	(PWM cycle = 53.3 μ s) × 1 = 53.3 μ s
0	0	0	1	(PWM cycle = 53.3 μ s) × 75 × 1 = 4.0 ms
0	0	1	0	(PWM cycle = 53.3 μ s) × 75 × 2 = 8.0 ms
~				~
1	1	1	0	(PWM cycle = 53.3 μ s) × 75 × 14 = 56.0 ms
1	1	1	1	(PWM cycle = 53.3 μ s) × 75 × 15 = 60.0 ms

SLP1DT4 [3: 0] is set as the following chart shows.

SLP1DT4 [3: 0]				Detention time at each step
0	0	0	0	(PWM cycle = 53.3 μ s) × 1 = 53.3 μ s
0	0	0	1	(PWM cycle = 53.3 μ s) × 75 × 1 = 4.0 ms
0	0	1	0	(PWM cycle = 53.3 μ s) × 75 × 2 = 8.0 ms
~				~
1	1	1	0	(PWM cycle = 53.3 μ s) × 75 × 14 = 56.0 ms
1	1	1	1	(PWM cycle = 53.3 μ s) × 75 × 15 = 60.0 ms

OPERATION (continued)

3. Register map details (continued)

Register Name		LED2CNT1							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
0D h	R/W	DUTYMAX2 [3: 0]				DUTYMID2 [3: 0]			
Default	F8 h	1	1	1	1	1	0	0	0

D7-4 : DUTYMAX2 [3: 0] LED2 at slope lighting, maximum PWM Duty setting

D3-0 : DUTYMID2 [3: 0] LED2 at slope lighting, middle PWM Duty setting

Register Name		LED2CNT2							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
0E h	R/W	DELAY2 [3: 0]				DUTYMIN2 [3: 0]			
Default	00 h	0	0	0	0	0	0	0	0

D7-4 : DELAY2 [3: 0] LED2 starting delay time setting

D3-0 : DUTYMIN2 [3: 0] LED2 at slope lighting, minimum PWM Duty setting

Register Name		LED2CNT3							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
0F h	R/W	SLP2DT2 [3: 0]				SLP2DT1 [3: 0]			
Default	88 h	1	0	0	0	1	0	0	0

D7-4 : SLP2DT2 [3: 0] LED2 slope lighting SLOPE operation 2, detention time setting

D3-0 : SLP2DT1 [3: 0] LED2 slope lighting SLOPE operation 1, detention time setting

Register Name		LED2CNT4							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
10 h	R/W	SLP2DT4 [3: 0]				SLP2DT3 [3: 0]			
Default	88 h	1	0	0	0	1	0	0	0

D7-4 : SLP2DT4 [3: 0] LED2 slope lighting SLOPE operation 4, detention time setting

D3-0 : SLP2DT3 [3: 0] LED2 slope lighting SLOPE operation 3, detention time setting

Operation parameter of LED2 SLOPE operation will be set.

Each parameter is the same as LED1 Parameter.

Please refer to following "4. LED control Slope lighting mode" for the details of slope operation.

OPERATION (continued)

3. Register map details (continued)

Register Name		LED3CNT1							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
11 h	R/W	DUTYMAX3 [3: 0]				DUTYMID3 [3: 0]			
Default	F8 h	1	1	1	1	1	0	0	0

D7-4 : DUTYMAX3 [3: 0] LED3 at slope lighting maximum PWM Duty setting

D3-0 : DUTYMID3 [3: 0] LED3 at slope lighting middle PWM Duty setting

Register Name		LED3CNT2							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
12 h	R/W	DELAY3 [3: 0]				DUTYMIN3 [3: 0]			
Default	00 h	0	0	0	0	0	0	0	0

D7-4 : DELAY3 [3: 0] LED3 starting delay time setting

D3-0 : DUTYMIN3 [3: 0] LED3 at slope lighting minimum PWM Duty setting

Register Name		LED3CNT3							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
13 h	R/W	SLP3DT2 [3: 0]				SLP3DT1 [3: 0]			
Default	88 h	1	0	0	0	1	0	0	0

D7-4 : SLP3DT2 [3: 0] LED3 slope lighting SLOPE operation 2, detention time setting

D3-0 : SLP3DT1 [3: 0] LED3 slope lighting SLOPE operation 1, detention time setting

Register Name		LED3CNT4							
Address	R / W mode	D7	D6	D5	D4	D3	D2	D1	D0
14 h	R/W	SLP3DT4 [3: 0]				SLP3DT3 [3: 0]			
Default	88 h	1	0	0	0	1	0	0	0

D7-4 : SLP3DT4 [3: 0] LED3 slope lighting SLOPE operation 4, detention time setting

D3-0 : SLP3DT3 [3: 0] LED3 slope lighting SLOPE operation 3, detention time setting

Operation parameter of LED3 SLOPE operation will be set.

Each parameter is the same as LED1 parameter.

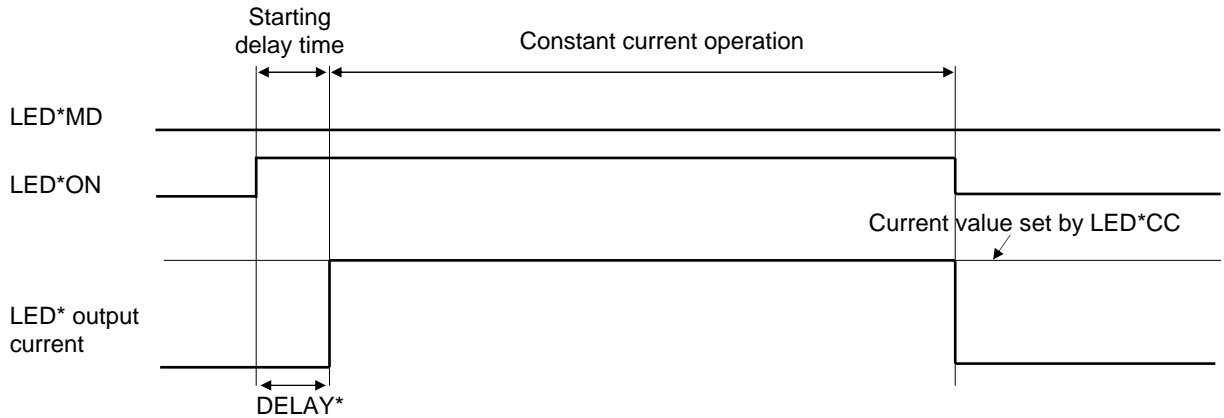
Please refer to following “ 4. LED control Slope lighting mode ” for the details of slope operation.

OPERATION (continued)

4.LED control

Constant current lighting mode

- It is possible to choose "Constant current lighting mode" and "Slope lighting mode" by setting Register LED*MD. To operate at "Constant current mode", please set LED*MD at "0". ("*" can be 1, 2, or 3.)



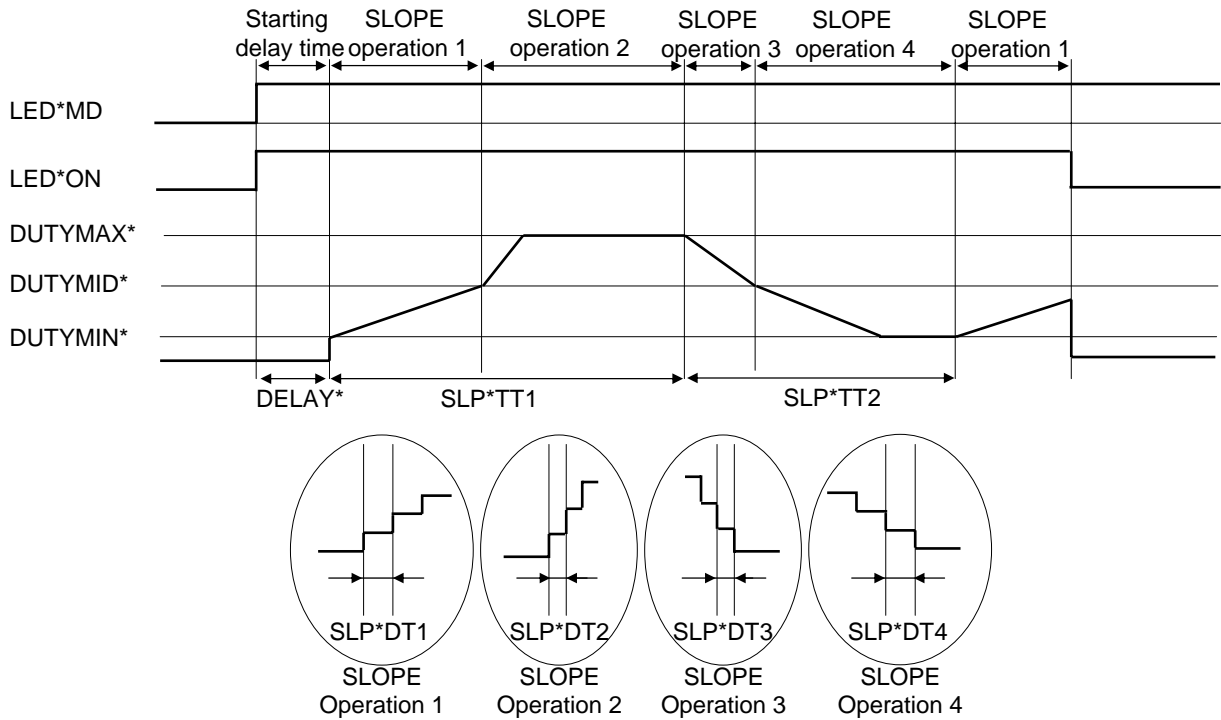
- Upon setting LED*ON to "1", constant current operation will start after the previously set starting delay time, DELAY*.
- As described later, it is possible to turn on and off at High/Low of CLKPWM pin by making the external PWM operating mode for CLKPWM pin setting valid.

OPERATION (continued)

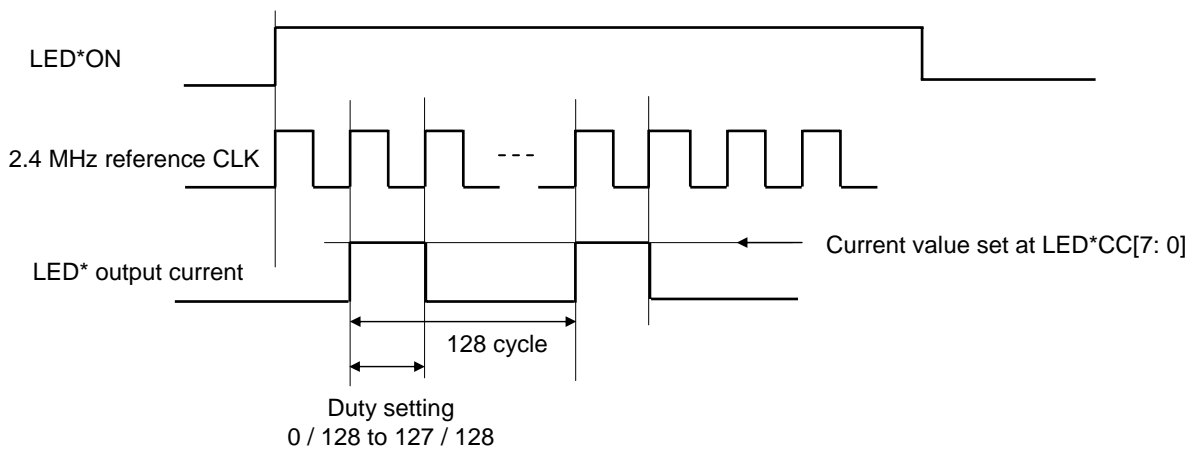
4.LED control (continued)

Slope lighting mode

- To operate at "Slope lighting mode", please set LED*MD at "1". ("*" can be 1, 2, or 3.)



- To repeat Slope operation from 1 to 4 after the previously set starting delay time, DELAY*, please set Register LED*ON at "1".
- The minimum resolution of SLOPE sequence control is 2.40 MHz reference clock cycle as below.



OPERATION (continued)

4.LED control (continued)

1) Total time of Slope operation 1, 2

Total time of Slope operation 1, 2 can be controlled by SLP*TT1[3: 0].

SLP* TT1[3: 0] is set as described before.

- SLP*TT1[3: 0] setting is preferred (has higher priority) in cases where SLP*TT1[3: 0] < "SLOPE operation 1" + "SLOPE operation 2".
- Under the case where the time set by SLP*TT1[3: 0] is reached before SLOPE operation 2 starts, SLOPE operation 2 is omitted and transferred to SLOPE operation 3 from the position of DUTYMAX.

2) Total time of Slope operation 3, 4

Total time of Slope operation 3, 4 can be controlled by SLP*TT2[3: 0].

SLP* TT2[3: 0] is set as described before.

- SLP*TT2[3: 0] setting is preferred (has higher priority) in cases where SLP*TT2[3: 0] < "SLOPE operation 3" + "SLOPE operation 4".
- Under the case where the time set by SLP*TT2[3: 0] is reached before SLOPE operation 4 starts, SLOPE operation 4 is omitted and transferred to SLOPE operation 1 from the position of DUTYMIN.

3) DUTYMIN, DUTYMID, DUTYMAX setting for SLOPE operation

- SLOPE operation 1

PWM control can be added step by step from the value set at DUTYMIN* [3: 0] to the value set at DUTYMID* [3: 0].

Please set the detention time by SLP*DT1 [3: 0] for each step.

The value should be DUTYMIN* [3: 0] < DUTYMID* [3: 0].

SLOPE operation 1 operates at DUTYMIN = DUTYMID in case DUTYMIN* [3: 0] ³ DUTYMID* [3: 0] .

- SLOPE operation 2

PWM control can be added step by step from the value set at DUTYMID* [3: 0] to the value set at DUTYMAX* [3: 0].

Please set the detention time by SLP*DT2 [3: 0] for each step.

The value should be DUTYMID* [3: 0] < DUTYMAX* [3: 0].

SLOPE operation 2 operates at DUTYMID = DUTYMAX in case DUTYMID* [3: 0] ³ DUTYMAX* [3: 0] .

- Slope operation 3

PWM control can be subtracted step by step from the value set at DUTYMAX* [3: 0] to the value set at DUTYMID* [3: 0].

Please set the detention time by SLP*DT3 [3: 0] for each step.

The value should be DUTYMID* [3: 0] < DUTYMAX* [3: 0].

SLOPE operation 3 operates at DUTYMID = DUTYMAX in case DUTYMID* [3: 0] ³ DUTYMAX* [3: 0] .

- SLOPE operation 4

PWM control can be subtracted step by step from the value set at DUTYMID* [3: 0] to the value set at DUTYMIN* [3: 0].

Please set the detention time by SLP*DT4 [3: 0] for each step.

The value should be DUTYMIN* [3: 0] < DUTYMID* [3: 0].

SLOPE operation 4 operates at DUTYMIN = DUTYMID in case DUTYMIN* [3: 0] ³ DUTYMID* [3: 0] .

OPERATION (continued)

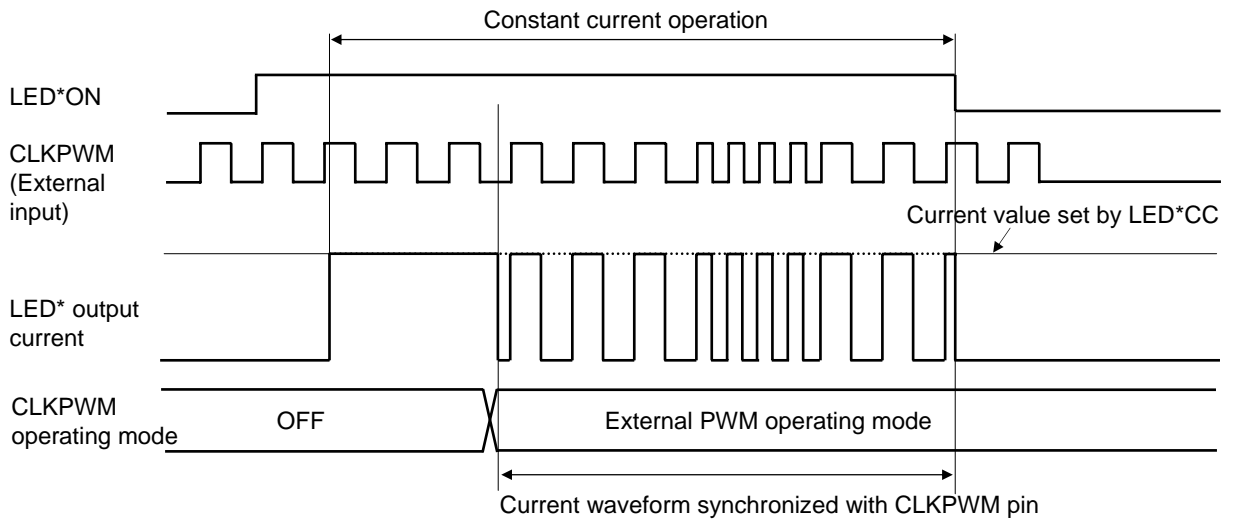
4.LED control (continued)

4) External PWM operation mode of CLKPWM pin

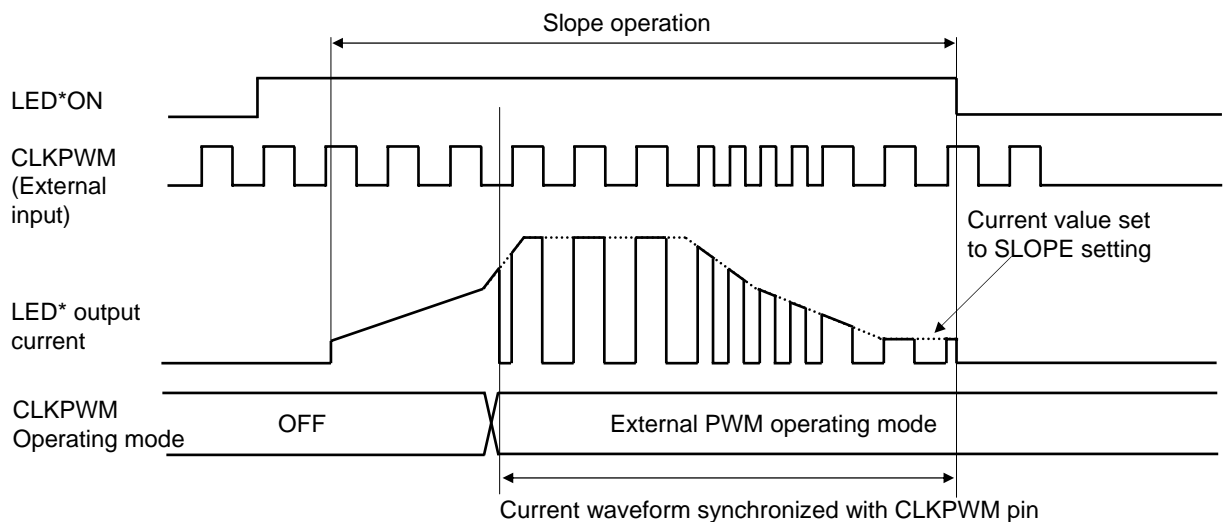
The lighting synchronization with CLKPWM signal can be turned on by setting "External PWM operation mode" in register setting.

The frequency which can be entered to CLKPWM pin is Max 20kHz.

< At Constant current mode >



< At Slope lighting mode >



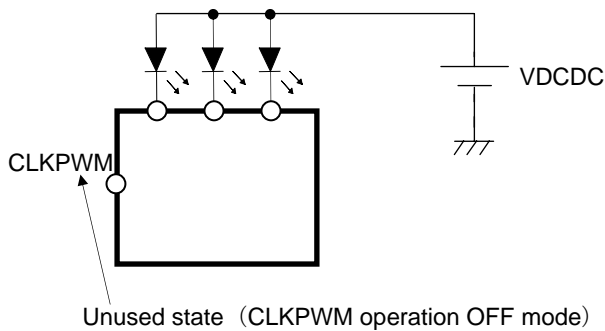
OPERATION (continued)

4.LED control (continued)

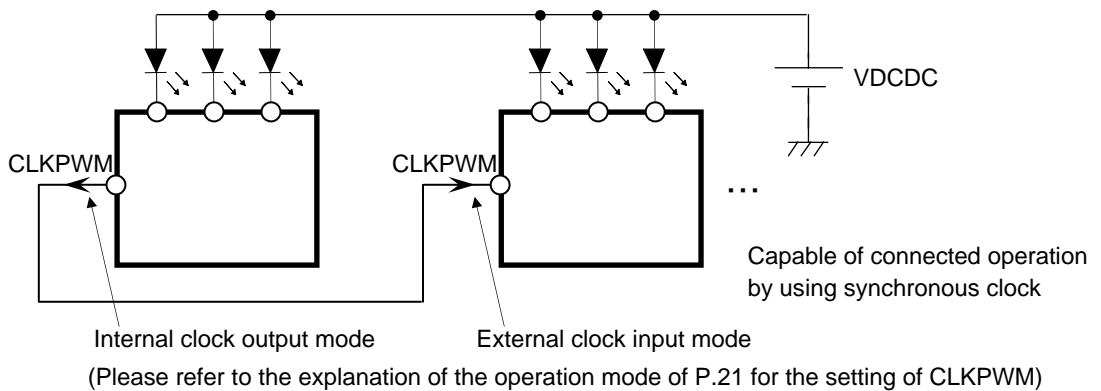
5) External clock input mode and internal clock output mode of CLKPWM pin

The following configuration can be made up by choosing "External clock input mode", "Internal clock output mode" in register setting.

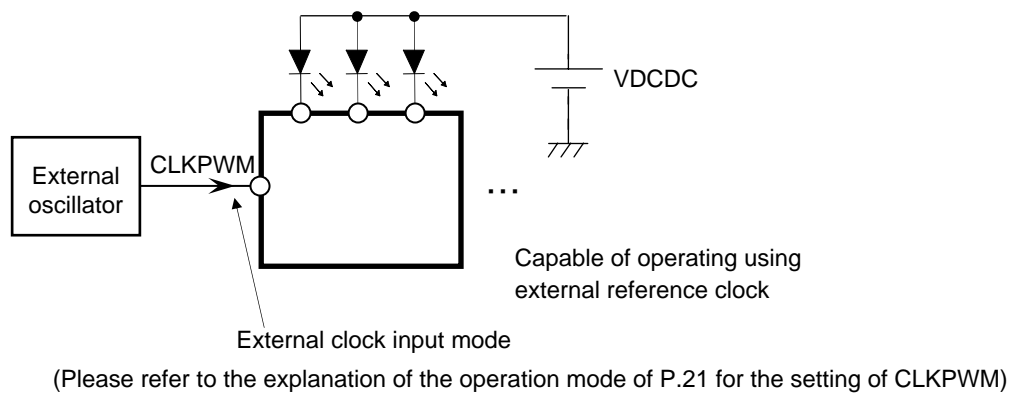
< Single application >



< Connected application >



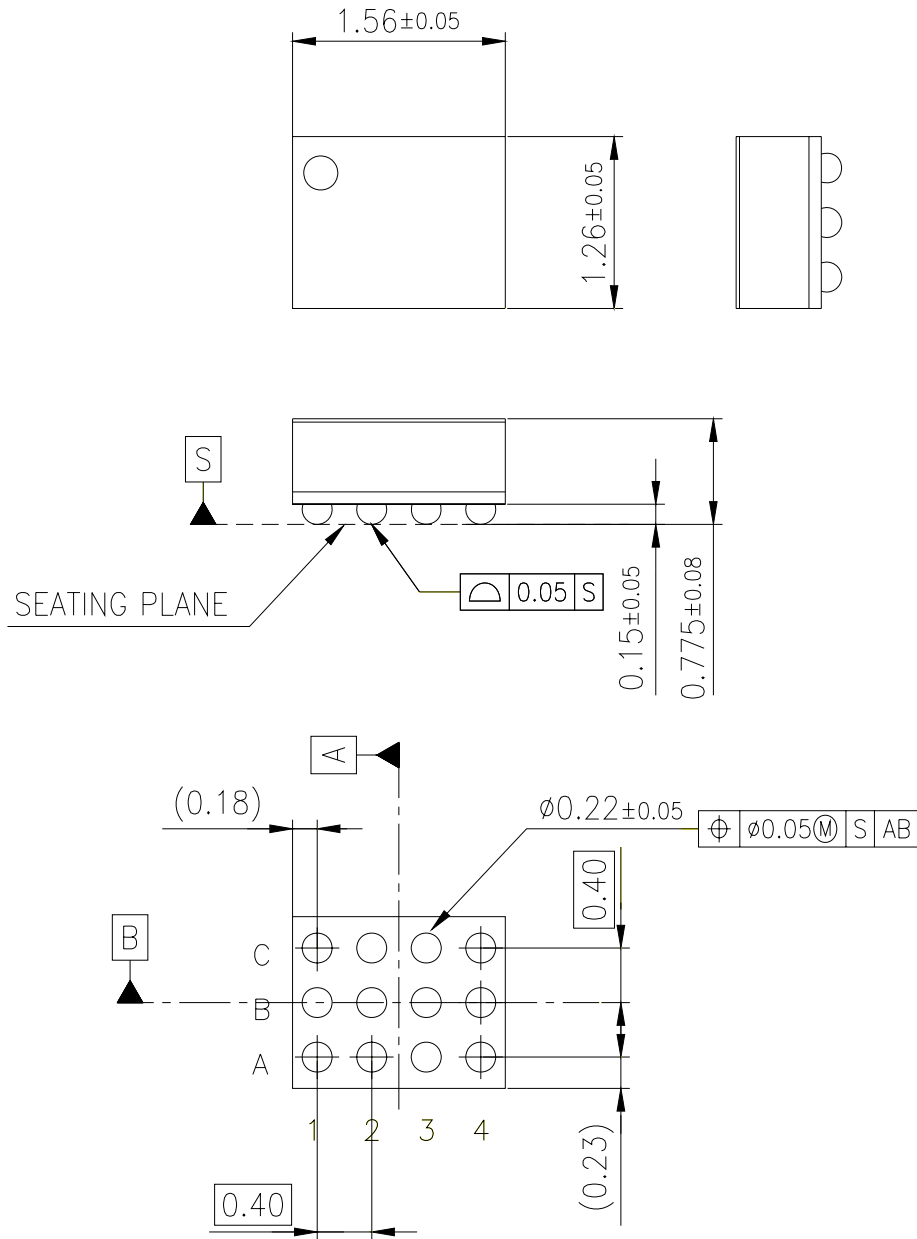
< External reference clock application >



PACKAGE INFORMATION (Reference Data)

Package Code:XBGA012-W-1316AEL

unit:mm



Body Material	:	Br/Sb Free Epoxy Resin
Lead Material	:	Cu
Bump	:	SnAgCu

IMPORTANT NOTICE

1. The products and product specifications described in this book are subject to change without notice for modification and/or improvement. At the final stage of your design, purchasing, or use of the products, therefore, ask for the most up-to-date Product Standards in advance to make sure that the latest specifications satisfy your requirements.
2. When using the LSI for new models, verify the safety including the long-term reliability for each product.
3. When the application system is designed by using this LSI, be sure to confirm notes in this book.
Be sure to read the notes to descriptions and the usage notes in the book.
4. The technical information described in this book is intended only to show the main characteristics and application circuit examples of the products. No license is granted in and to any intellectual property right or other right owned by Panasonic Corporation or any other company. Therefore, no responsibility is assumed by our company as to the infringement upon any such right owned by any other company which may arise as a result of the use of technical information de-scribed in this book.
5. This book may be not reprinted or reproduced whether wholly or partially, without the prior written permission of our company.
6. This LSI is intended to be used for general electronic equipment [LED Driver for portable applications].
Consult our sales staff in advance for information on the following applications: Special applications in which exceptional quality and reliability are required, or if the failure or malfunction of this LSI may directly jeopardize life or harm the human body.
Any applications other than the standard applications intended.
 - (1) Space appliance (such as artificial satellite, and rocket)
 - (2) Traffic control equipment (such as for automobile, airplane, train, and ship)
 - (3) Medical equipment for life support
 - (4) Submarine transponder
 - (5) Control equipment for power plant
 - (6) Disaster prevention and security device
 - (7) Weapon
 - (8) Others : Applications of which reliability equivalent to (1) to (7) is requiredIt is to be understood that our company shall not be held responsible for any damage incurred as a result of or in connection with your using the LSI described in this book for any special application, unless our company agrees to your using the LSI in this book for any special application.
7. This LSI is neither designed nor intended for use in automotive applications or environments unless the specific product is designated by our company as compliant with the ISO/TS 16949 requirements.
Our company shall not be held responsible for any damage incurred by you or any third party as a result of or in connection with your using the LSI in automotive application, unless our company agrees to your using the LSI in this book for such application.
8. If any of the products or technical information described in this book is to be exported or provided to non-residents, the laws and regulations of the exporting country, especially, those with regard to security export control, must be observed.
9. Please use this product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Our company shall not be held responsible for any damage incurred as a result of your using the LSI not complying with the applicable laws and regulations.

USAGE NOTES

1. When designing your equipment, comply with the range of absolute maximum rating and the guaranteed operating conditions (operating power supply voltage and operating environment etc.). Especially, please be careful not to exceed the range of absolute maximum rating on the transient state, such as power-on, power-off and mode-switching. Otherwise, we will not be liable for any defect which may arise later in your equipment.

Even when the products are used within the guaranteed values, take into the consideration of incidence of break down and failure mode, possible to occur to semiconductor products. Measures on the systems such as redundant design, arresting the spread of fire or preventing glitch are recommended in order to prevent physical injury, fire, social damages, for example, by using the products.

2. Comply with the instructions for use in order to prevent breakdown and characteristics change due to external factors (ESD, EOS, thermal stress and mechanical stress) at the time of handling, mounting or at customer's process. When using products for which damp-proof packing is required, satisfy the conditions, such as shelf life and the elapsed time since first opening the packages.
3. Pay attention to the direction of LSI. When mounting it in the wrong direction onto the PCB (printed-circuit-board), it might smoke or ignite.
4. Pay attention in the PCB (printed-circuit-board) pattern layout in order to prevent damage due to short circuit between pins. In addition, refer to the Pin Description for the pin configuration.
5. Perform a visual inspection on the PCB before applying power, otherwise damage might happen due to problems such as a solder-bridge between the pins of the semiconductor device. Also, perform a full technical verification on the assembly quality, because the same damage possibly can happen due to conductive substances, such as solder ball, that adhere to the LSI during transportation.
6. Take notice in the use of this product that it might break or occasionally smoke when an abnormal state occurs such as output pin-VCC short (Power supply fault), output pin-GND short (Ground fault), or output-to-output-pin short (load short) .

And, safety measures such as an installation of fuses are recommended because the extent of the above-mentioned damage and smoke emission will depend on the current capability of the power supply.

7. The protection circuit is for maintaining safety against abnormal operation. Therefore, the protection circuit should not work during normal operation.

Especially for the thermal protection circuit, if the area of safe operation or the absolute maximum rating is momentarily exceeded due to output pin to VCC short (Power supply fault), or output pin to GND short (Ground fault), the LSI might be damaged before the thermal protection circuit could operate.
8. Unless specified in the product specifications, make sure that negative voltage or excessive voltage are not applied to the pins because the device might be damaged, which could happen due to negative voltage or excessive voltage generated during the ON and OFF timing when the inductive load of a motor coil or actuator coils of optical pick-up is being driven.
9. The product which has specified ASO (Area of Safe Operation) should be operated in ASO
10. Verify the risks which might be caused by the malfunctions of external components.
11. Due to unshielded structure of this LSI, under exposure of light, function and characteristic of the product cannot be guaranteed. During normal operation or even under testing condition, please ensure that LSI is not exposed to light.
12. Basically, chip surface is ground potential. Please design to ensure no contact between chip surface and metal shielding.

Request for your special attention and precautions in using the technical information and semiconductors described in this book

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- (3) The products described in this book are intended to be used for general applications (such as office equipment, communications equipment, measuring instruments and household appliances), or for specific applications as expressly stated in this book.
Consult our sales staff in advance for information on the following applications:
 - Special applications (such as for airplanes, aerospace, automotive equipment, traffic signaling equipment, combustion equipment, life support systems and safety devices) in which exceptional quality and reliability are required, or if the failure or malfunction of the products may directly jeopardize life or harm the human body.It is to be understood that our company shall not be held responsible for any damage incurred as a result of or in connection with your using the products described in this book for any special application, unless our company agrees to your using the products in this book for any special application.
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