# AN30259A

# 3 - ch. LED driver for illumination

## FEATURES

- I$^2$C 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

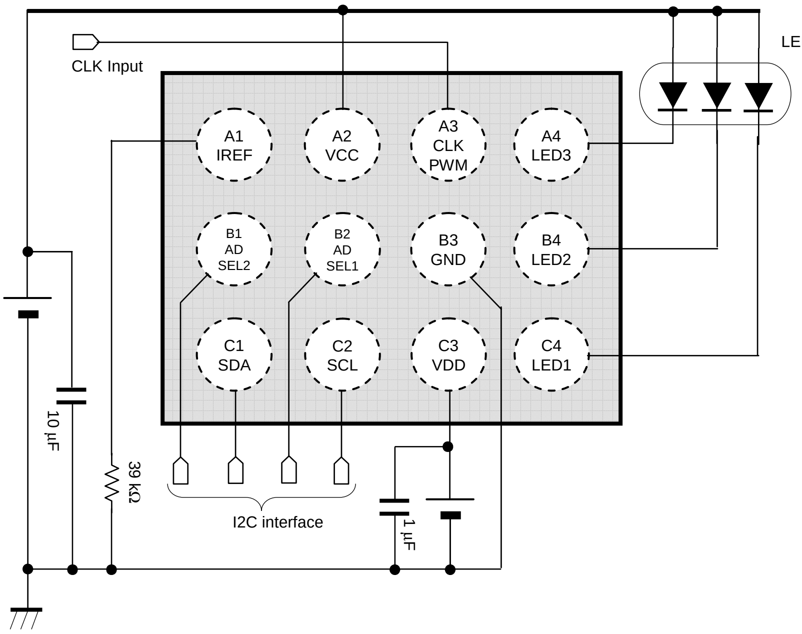
AN30259A has 3-ch. LED Driver. It is a suitable product to use for RGB Illumination. By synchronous clock function, combined operation is possible.

## APPLICATIONS

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

## SIMPLIFIED APPLICATION

TOP VIEW


LED
CLK Input
A1
IREF
A2
VCC
A3
CLK
PWM
A4
LED3
B1
AD
SEL2
B2
AD
SEL1
B3
GND
B4
LED2
C1
SDA
C2
SCL
C3
VDD
C4
LED1
10 µF
39 kΩ
I2C interface
1 µF

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 | $VCC_{MAX}$ | 7.0 | V | *1 |
| | $VDD_{MAX}$ | 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,<br>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 $VCC_{MAX}$ = VCC, $VDD_{MAX}$ = VDD, 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°C.

## POWER DISSIPATION RATING

| PACKAGE | $\theta_{JA}$ | PD (Ta=25 °C) | PD (Ta=85 °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.

## ELECRTRICAL CHARACTERISTICS

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

Note) $T_a$ = 25°C±2°C unless otherwise specified.

| Parameter | Symbol | Condition | Limits | | | Unit | Note |
|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | | |
| **Current consumption** | | | | | | | |
| Current consumption 1<br>OFF mode | $I_{CC1}$ | $V_{DD}$ = 0 V | — | 0 | 2 | µA | — |
| Current consumption 2<br>OFF mode | $I_{CC2}$ | $V_{DD}$ = 1.8 V | — | 1 | 5 | µA | — |
| Current consumption 3<br>LED lighting mode | $I_{CC3}$ | $I_{\mathrm{LED1\ to\ 3}}$ = 25.50 mA setting<br>All LED = ON | — | 0.6 | 1.0 | mA | — |
| **LED Driver** | | | | | | | |
| Off time leak current | $I_{LEAK}$ | Off setting<br>$V_{\mathrm{LED1\ to\ 3}}$ = 6.0 V | — | — | 1.0 | µA | — |
| Minimum setting current value 1 | $I_{MIN1}$ | IMAX[1:0] = 01,<br>$V_{\mathrm{LED1\ to\ 3}}$ = 1.0 V | 0.05 | 0.10 | 0.15 | mA | — |
| Minimum setting current value 2 | $I_{MIN2}$ | IMAX[1:0] = 01,<br>$V_{\mathrm{LED1\ to\ 3}}$ = 1.0 V | 0.736 | 0.80 | 0.864 | mA | — |
| Maximum setting current value | $I_{MAX}$ | IMAX[1:0] = 01,<br>$V_{\mathrm{LED1\ to\ 3}}$ = 1.0 V | 23.46 | 25.50 | 27.54 | mA | — |
| Current step | $I_{STEP}$ | IMAX[1:0] = 01,<br>$V_{\mathrm{LED1\ to\ 3}}$ = 1.0 V | 0.00 | 0.10 | 0.18 | mA | — |
| Minimum voltage for retainable constant current value | $V_{SAT}$ | IMAX[1:0] = 01,<br>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,<br>$V_{\mathrm{LED1\ to\ 3}}$ = 1.0 V | –5 | — | 5 | % | — |
| **Internal oscillator** | | | | | | | |
| Oscillation frequency | $f_{OSC}$ | — | 1.92 | 2.40 | 2.88 | MHz | — |

## ELECRTRICAL CHARACTERISTICS (continued)

**$V_{CC}$ = 3.6 V, $V_{DD}$ = 1.8 V**

Note) $T_a$ = 25°C±2°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 | $V_{DD}$ × 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 | — | $V_{DD}$ × 0.3 | V | *1 |
| High-level input current | $I_{IH1}$ | $V_{SDA}$ ,$V_{SCL}$ = 1.8 V | — | 0 | 1 | µA | — |
| Low-level input current | $I_{IL1}$ | $V_{SDA}$ ,$V_{SCL}$ = 0 V | — | 0 | 1 | µA | — |
| Low-level output voltage (SDA) | $V_{OL1H}$ | $I_{SDA}$ = 3 mA, $V_{DD}$ > 2 V | 0 | — | 0.4 | V | — |
| Low-level output voltage (SDA) | $V_{OL1L}$ | $I_{SDA}$ = 3 mA, $V_{DD}$ < 2 V | 0 | — | 0.2 × $V_{DD}$ | V | — |
| SCL clock frequency | $f_{SCL}$ | — | 0 | — | 400 | kHz | — |
| **CLKPWM** | | | | | | | |
| High-level input voltage range | $V_{IH2}$ | — | $V_{DD}$ × 0.7 | — | $V_{DD}$ + 0.2 | V | — |
| Low-level input voltage range | $V_{IL2}$ | — | –0.2 | — | $V_{DD}$ × 0.3 | V | — |
| Pin pull down resistance value | $R_{PD2}$ | — | 0.5 | 1.0 | 2.0 | MΩ | — |
| High-level output voltage | $V_{OH2}$ | $I_{CLKPWM}$ = –2 mA | $V_{DD}$ × 0.8 | — | $V_{DD}$ + 0.2 | V | — |
| Low-level output voltage | $V_{OL2}$ | $I_{CLKPWM}$ = 2 mA | –0.2 | — | $V_{DD}$ × 0.2 | V | — |
| **ADSEL1, ADSEL2** | | | | | | | |
| High-level input voltage range | $V_{IH3}$ | — | $V_{DD}$ × 0.7 | — | $V_{DD}$ + 0.2 | V | — |
| Low-level input voltage range | $V_{IL3}$ | — | –0.2 | — | $V_{DD}$ × 0.3 | V | — |
| High-level input current | $I_{IH3}$ | $V_{ADSEL1,\,2}$ = 1.8 V | — | 0 | 1 | µA | — |
| Low-level input current | $I_{IL3}$ | $V_{ADSEL1,\,2}$ = 0 V | — | 0 | 1 | µA | — |

Note)*1 : The input threshold voltage of I²C bus (Vth) 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 (Vth) is fixed to (($V_{DD}$ / 2) ± (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 V, $V_{DD}$ = 1.8 V

$T_a$ = 25 °C ± 2 °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<br>Data-enabled high pulse width | $W_{PWM}$ | — | 2 | — | — | µs | — |

## APPLICATION INFORMATION (continued)

### REFERENCE VALUES FOR DESIGN (continued)

Notes) $V_{CC}$ = 3.6 V, $V_{DD}$ = 1.8 V
$T_a$ = 25 °C ± 2 °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 | | |
| **$I^2C$ bus (Internal I/O stage characteristics)** | | | | | | | |
| Input voltage hysteresis (1) | $V_{hys1}$ | SCL, SDA hysteresis voltage<br>VDD > 2 V | $0.05 \times V_{DD}$ | — | — | V | — |
| Input voltage hysteresis (2) | $V_{hys2}$ | SCL, SDA hysteresis voltage<br>VDD < 2 V | $0.1 \times V_{DD}$ | — | — | V | — |
| Output fall time from $V_{IHmin}$ to $V_{ILmax}$ | $t_{of}$ | Bus capacitance : 10 pF to 400pF<br>$I_P \leq 6$ mA ($V_{OLmax}$ = 0.6 V)<br>$I_P$ : 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 | — |

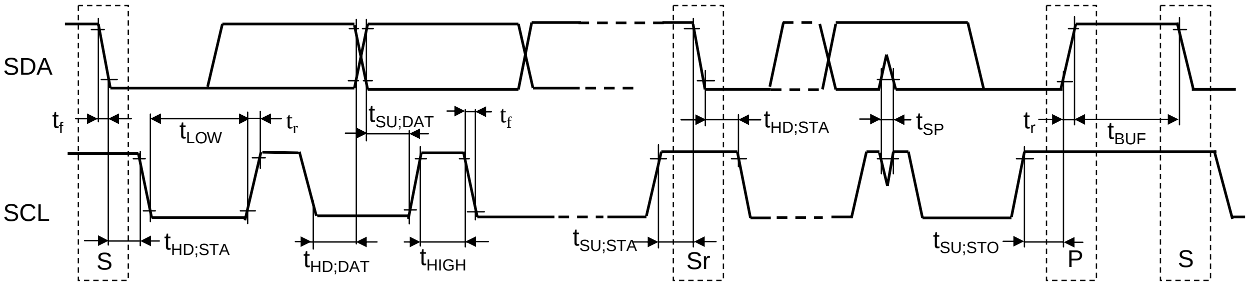
## APPLICATION INFORMATION (continued)

### REFERENCE VALUES FOR DESIGN (continued)

Notes) $V_{CC}$ = 3.6 V, $V_{DD}$ = 1.8 V
$T_a$ = 25°C±2°C unless otherwise specified.
The characteristics listed below are reference values derived from the design of the LSI and are not guaranteed by inspection.

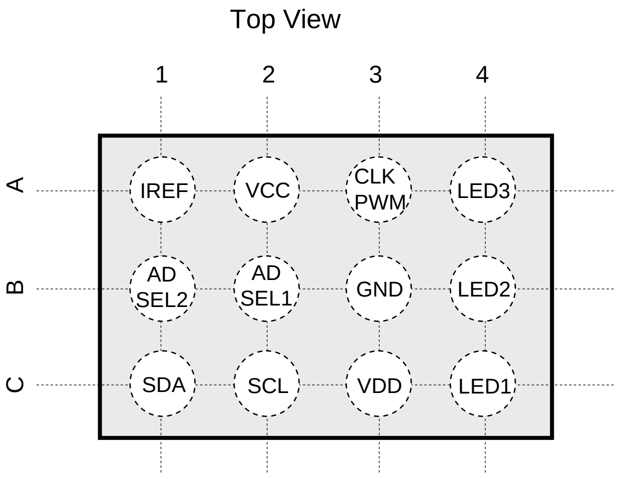
| Parameter | Symbol | Condition | Reference values | | | Unit | Note |
|---|---|---|---|---|---|---|---|
| | | | Min | Typ | Max | | |
| **$I^2C$ bus (Bus line specifications)** | | | | | | | |
| Hold duration (recursive) | $t_{HD:STA}$ | After $t_{HD:STA,.}$ the first clock pulse is generated. | 0.6 | — | — | 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 $I^2C$-bus is specified as follows.
All values referred to $V_{IHmin}$ and $V_{ILmax}$ level.



S : START condition
Sr : Repeat START condition
P : STOP condition

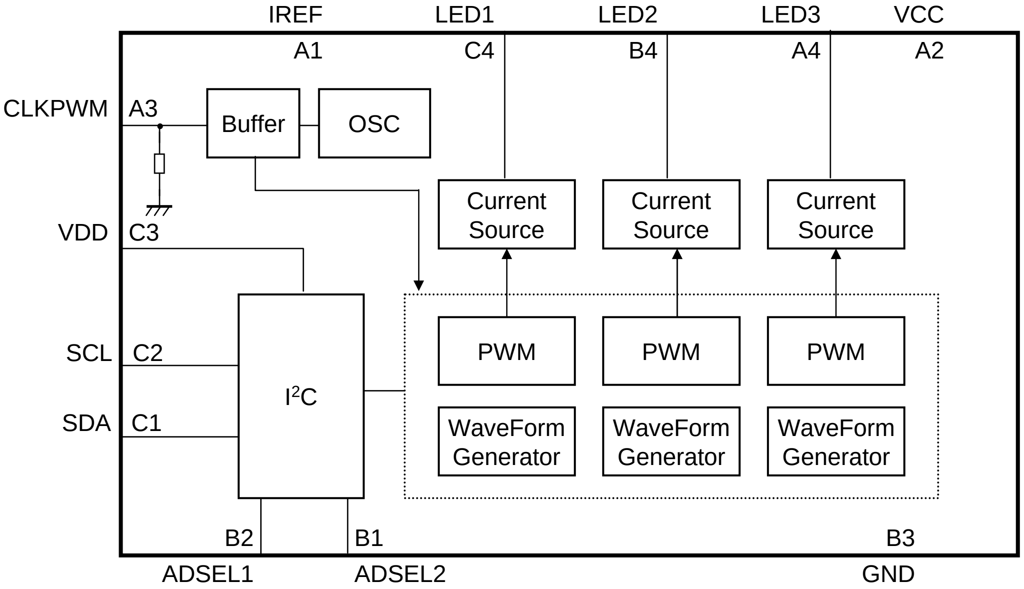
## PIN CONFIGURATION


Top View
1
2
3
4
A
B
C
IREF
VCC
CLK PWM
LED3
AD SEL2
AD SEL1
GND
LED2
SDA
SCL
VDD
LED1

## 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


IREF
LED1
LED2
LED3
VCC
A1
C4
B4
A4
A2
CLKPWM
A3
Buffer
OSC
VDD
C3
Current Source
Current Source
Current Source
PWM
PWM
PWM
SCL
C2
SDA
C1
I²C
WaveForm Generator
WaveForm Generator
WaveForm Generator
B2
B1
B3
ADSEL1
ADSEL2
GND

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

## OPERATION

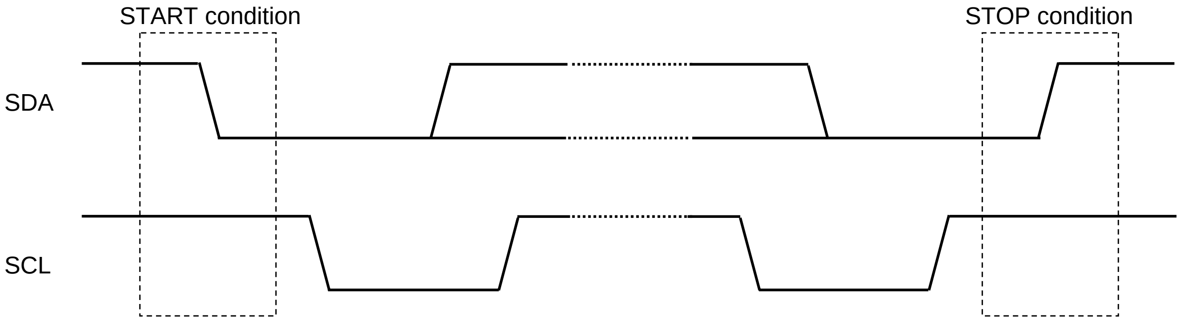
### 1. I²C-bus Interface

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.

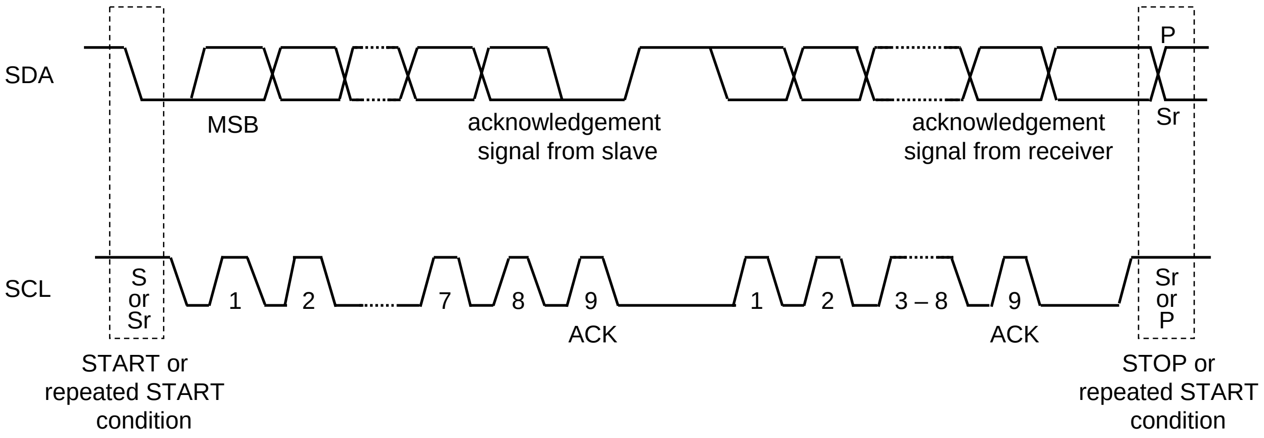
2) START and STOP conditions

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.


START condition
STOP condition
SDA
SCL

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.


SDA
SCL
MSB
acknowledgement signal from slave
acknowledgement signal from receiver
P
Sr
S or Sr
1
2
7
8
9
ACK
1
2
3 – 8
9
ACK
Sr or P
START or repeated START condition
STOP or repeated START condition

## OPERATION (continued)

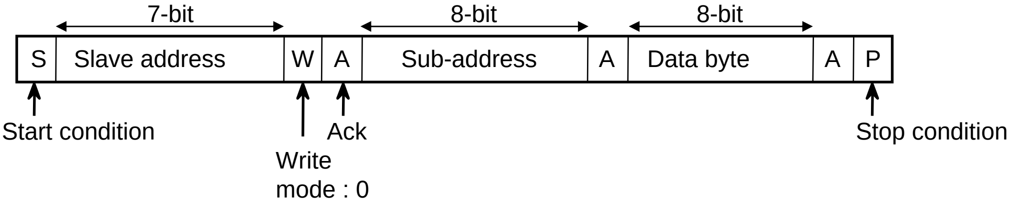
### 1. I²C-bus Interface (continued)

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) |

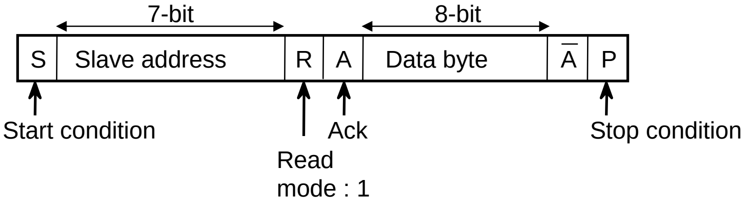
Write mode


7-bit
8-bit
8-bit
S
Slave address
W
A
Sub-address
A
Data byte
A
P
Start condition
Ack
Write mode : 0
Stop condition

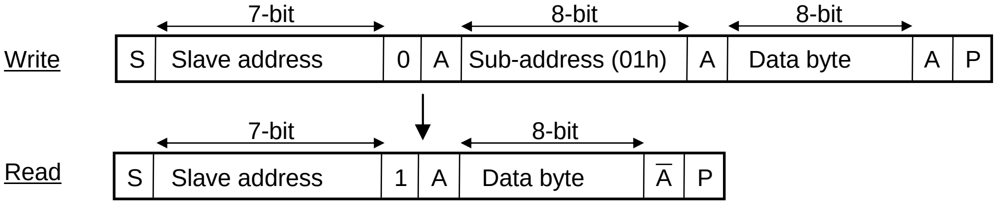
Read mode

A) When sub-address is not assigned.

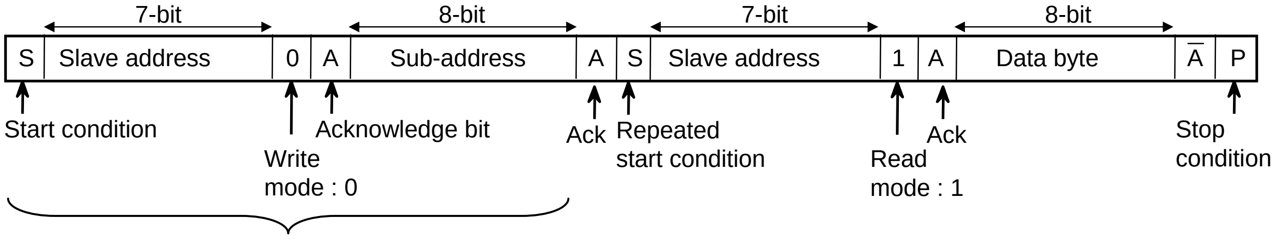
When data is read without assigning sub-address, it is possible to read the value of sub-address specified in Write mode immediately before.


7-bit
8-bit
S
Slave address
R
A
Data byte
$\overline{A}$
P
Start condition
Ack
Read mode : 1
Stop condition

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


Write
7-bit
8-bit
8-bit
S
Slave address
0
A
Sub-address (01h)
A
Data byte
A
P
Read
7-bit
8-bit
S
Slave address
1
A
Data byte
$\overline{A}$
P

B) When specifying sub-address


7-bit
8-bit
7-bit
8-bit
S
Slave address
0
A
Sub-address
A
S
Slave address
1
A
Data byte
$\overline{A}$
P
Start condition
Acknowledge bit
Write mode : 0
Ack
Repeated start condition
Read mode : 1
Ack
Stop condition

Sub-address should be assigned first.

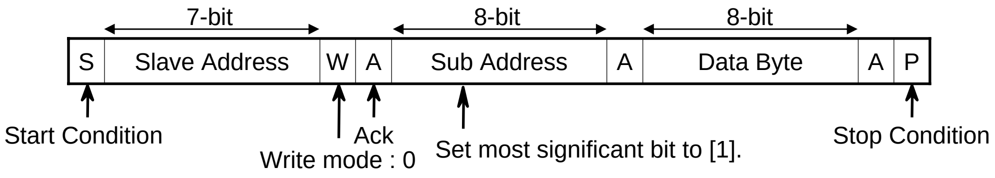
## OPERATION (continued)

### 1. I$^2$C-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].

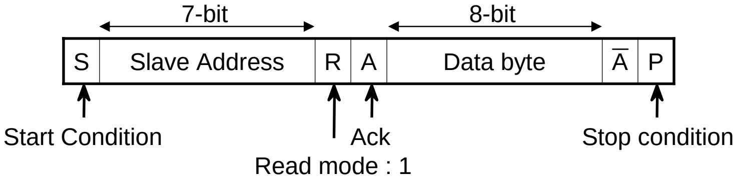

7-bit
8-bit
8-bit
S
Slave Address
W
A
Sub Address
A
Data Byte
A
P
Start Condition
Ack
Write mode : 0
Set most significant bit to [1].
Stop Condition

Ex) 05h → 85h, 11h → 91h

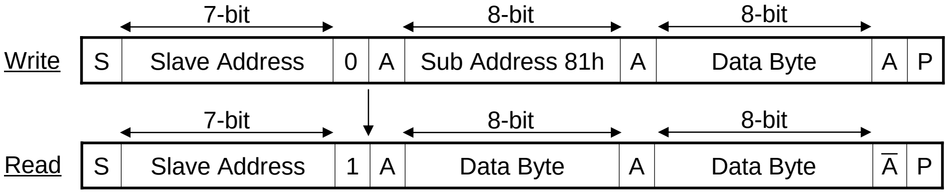
- Continuous Read mode

A) When Sub address is not specified

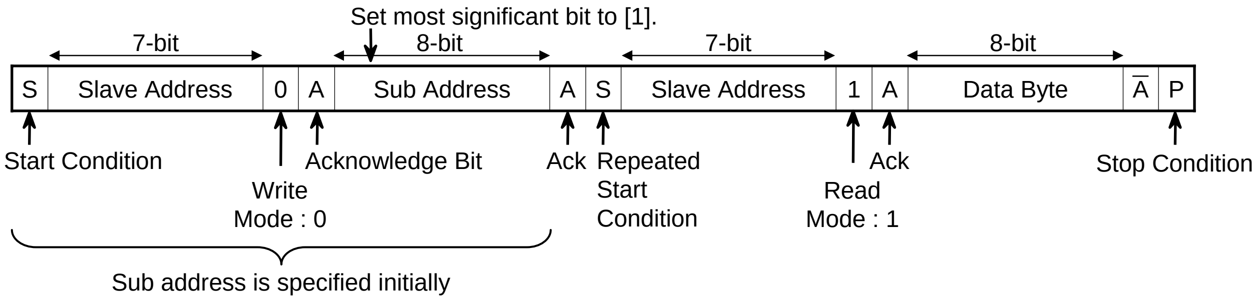
When the most significant bit specified in the last Write mode is [1], it is possible to perform the continuous Read mode operation directly after it.


7-bit
8-bit
S
Slave Address
R
A
Data byte
$\overline{A}$
P
Start Condition
Ack
Read mode : 1
Stop condition

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


Write
7-bit
8-bit
8-bit
S
Slave Address
0
A
Sub Address 81h
A
Data Byte
A
P
Read
7-bit
8-bit
8-bit
S
Slave Address
1
A
Data Byte
A
Data Byte
$\overline{A}$
P

B) When Sub address is specified


Set most significant bit to [1].
7-bit
8-bit
7-bit
8-bit
S
Slave Address
0
A
Sub Address
A
S
Slave Address
1
A
Data Byte
$\overline{A}$
P
Start Condition
Acknowledge Bit
Write Mode : 0
Ack
Repeated Start Condition
Read Mode : 1
Ack
Stop Condition
Sub address is specified initially

## 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

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

| D5 | D4 | D3 | CLKPWM operation mode |
|---|---|---|---|
| **IOEN** | **CLKDIR** | **EXTPWM** | **(Clock mode/PWM mode)** |
| 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 |

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 |
| :<br>:<br>:<br>: | :<br>:<br>:<br>: | :<br>:<br>:<br>: | :<br>:<br>:<br>: | :<br>:<br>:<br>: | :<br>:<br>:<br>: | :<br>:<br>:<br>: | :<br>:<br>:<br>: | :<br>0.050 mA Step<br>: | :<br>0.100 mA Step<br>: | :<br>0.125 mA Step<br>: | :<br>0.250 mA Step<br>: |
| 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 |
| :<br>:<br>: | :<br>:<br>: | :<br>:<br>: | :<br>:<br>: | :<br>0.5 s Step<br>: |
| 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 |
| :<br>:<br>: | :<br>:<br>: | :<br>:<br>: | :<br>:<br>: | :<br>0.5 s Step<br>: |
| 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

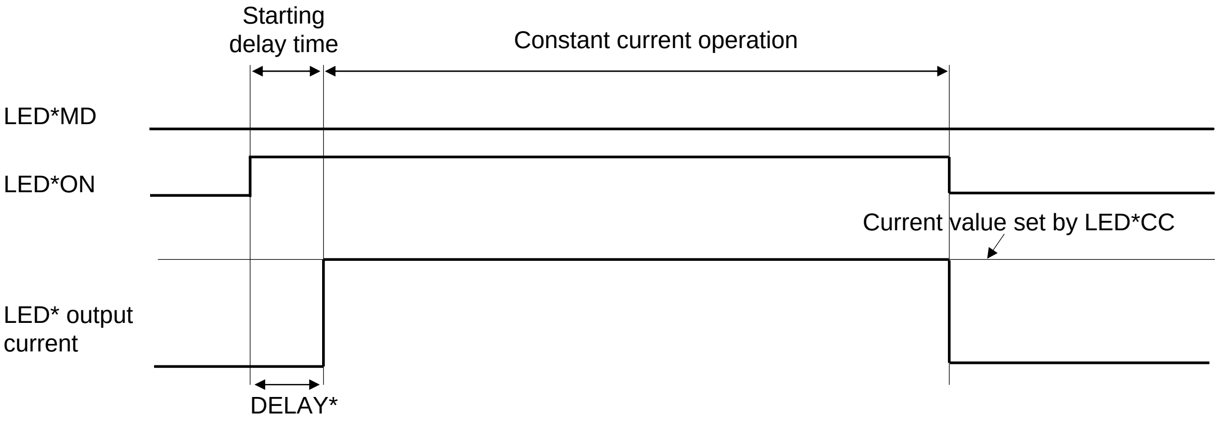
Operation parameter of LED3 SLOPE operation will be set.
Each parameter is the same as LED1 parameter.
Please refer to following “ 4. LED control Slope lighting mode ” for the details of slope operation.

## 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.)


Starting
delay time
Constant current operation
LED*MD
LED*ON
Current value set by LED*CC
LED* output
current
DELAY*

- Upon setting LED*ON to "1", constant current operation will start after the previously set starting delay time, DELAY*.

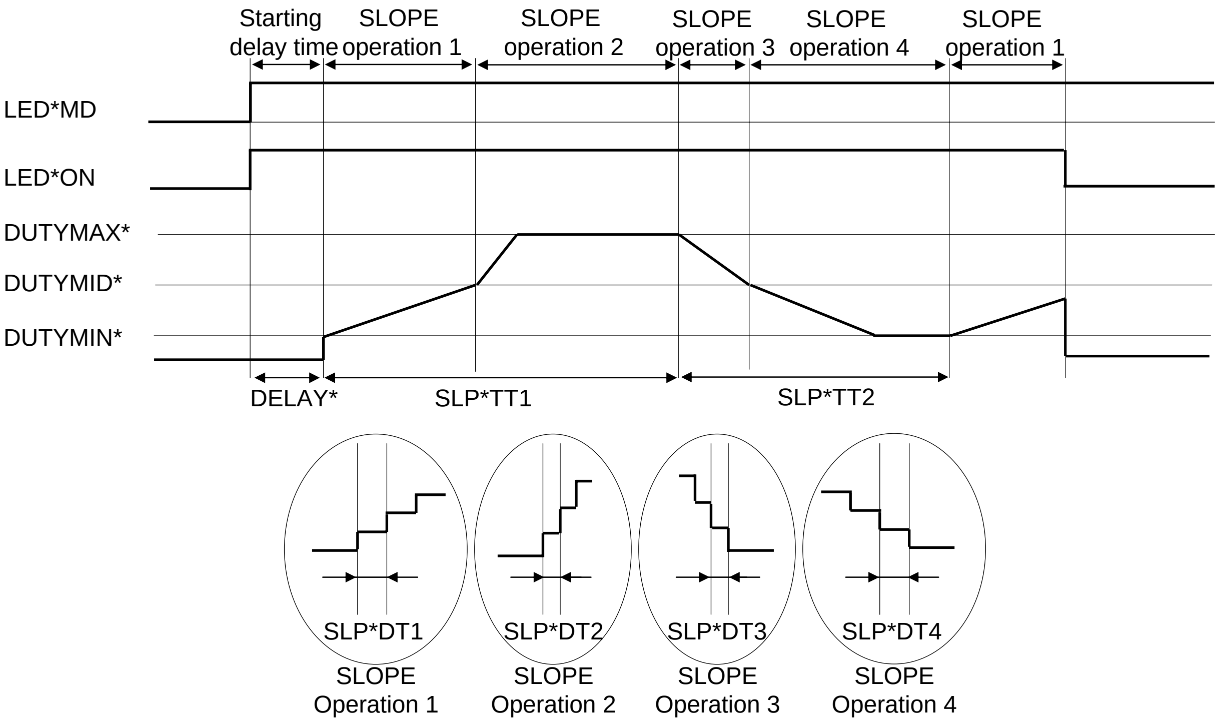
- As described later, it is possible to turn on and off at High/Low of CLKPWM pin by making the external PWM operating mode for CLKPWM pin setting valid.

## OPERATION (continued)

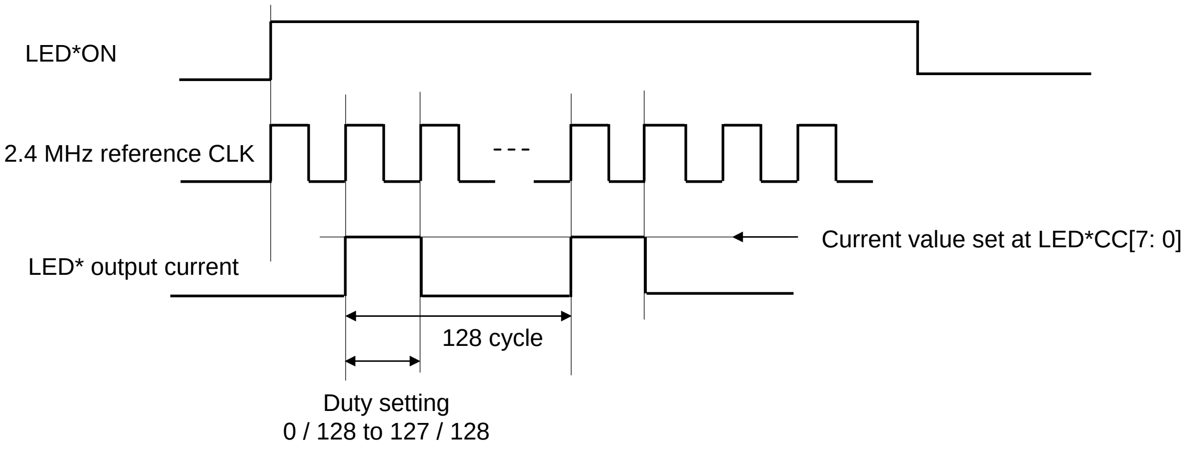
### 4.LED control (continued)

Slope lighting mode

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


Starting delay time
SLOPE operation 1
SLOPE operation 2
SLOPE operation 3
SLOPE operation 4
SLOPE operation 1
LED*MD
LED*ON
DUTYMAX*
DUTYMID*
DUTYMIN*
DELAY*
SLP*TT1
SLP*TT2
SLP*DT1
SLP*DT2
SLP*DT3
SLP*DT4
SLOPE Operation 1
SLOPE Operation 2
SLOPE Operation 3
SLOPE Operation 4

- 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.


LED*ON
2.4 MHz reference CLK
- - -
LED* output current
Current value set at LED*CC[7: 0]
128 cycle
Duty setting
0 / 128 to 127 / 128

## 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)

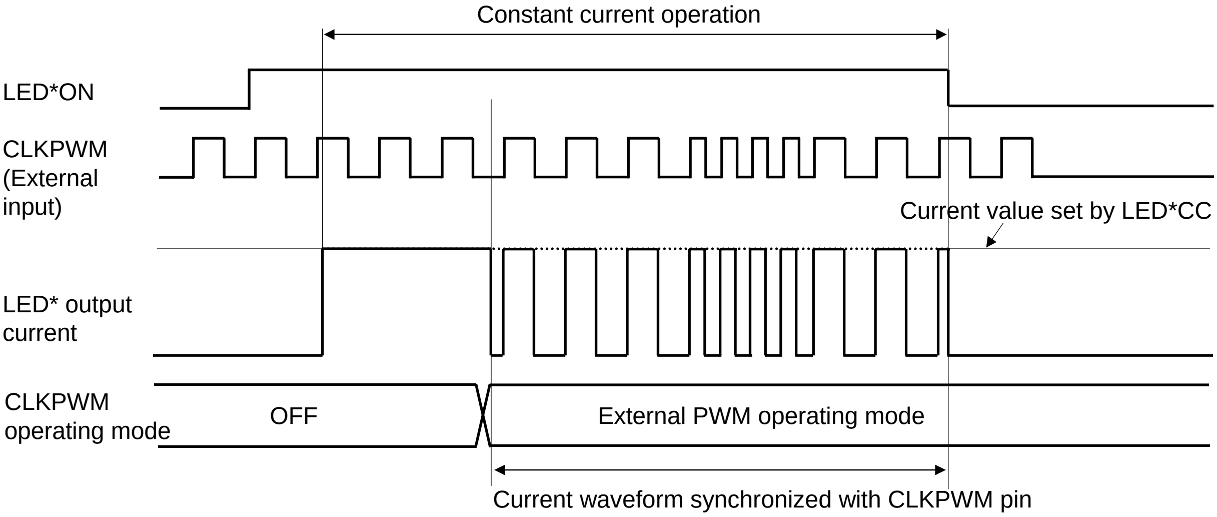
### 4.LED control (continued)

4) External PWM operation mode of CLKPWM pin

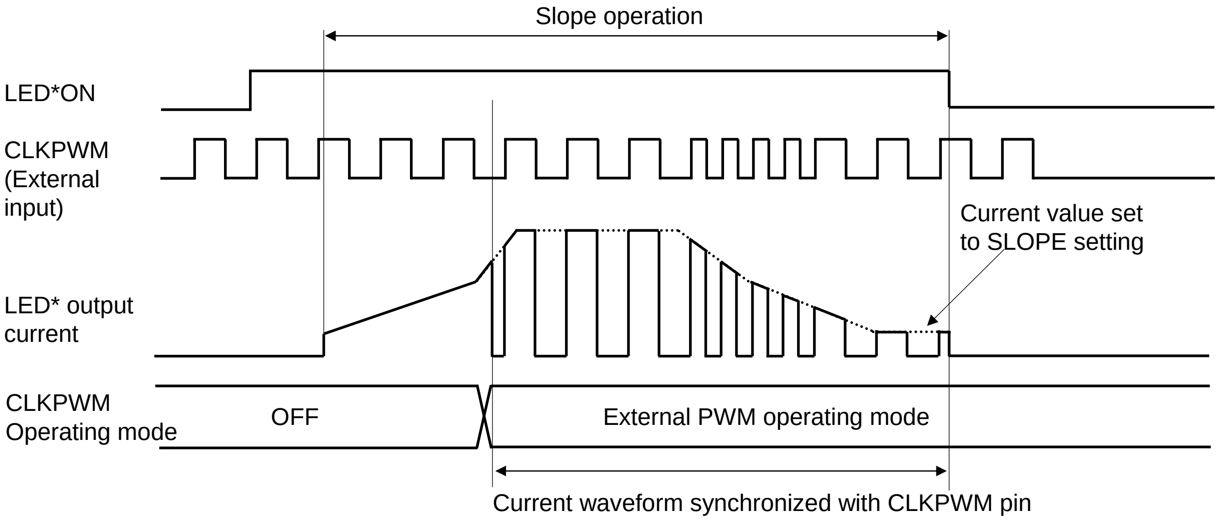
The lighting synchronization with CLKPWM signal can be turned on by setting "External PWM operation mode" in register setting.

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

< At Constant current mode >


Constant current operation
LED*ON
CLKPWM
(External
input)
Current value set by LED*CC
LED* output
current
CLKPWM
operating mode
OFF
External PWM operating mode
Current waveform synchronized with CLKPWM pin

< At Slope lighting mode>


Slope operation
LED*ON
CLKPWM
(External
input)
Current value set
to SLOPE setting
LED* output
current
CLKPWM
Operating mode
OFF
External PWM operating mode
Current waveform synchronized with CLKPWM pin

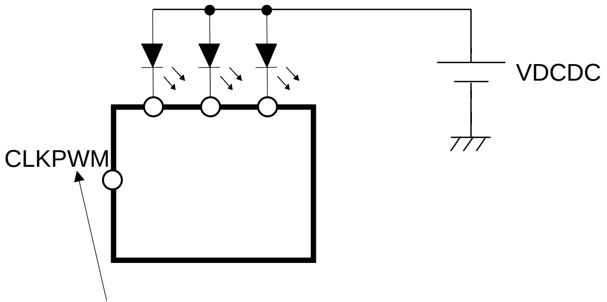
## OPERATION (continued)

### 4.LED control (continued)

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

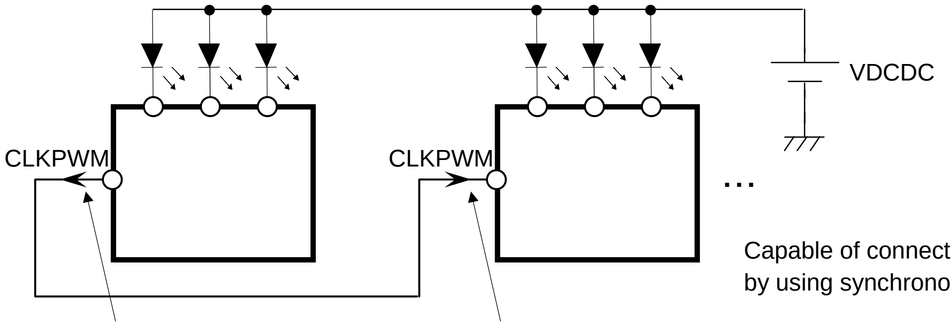
The following configuration can be made up by choosing "External clock input mode", "Internal clock output mode" in register setting.

< Single application >



Unused state（CLKPWM operation OFF mode）

< Connected application >



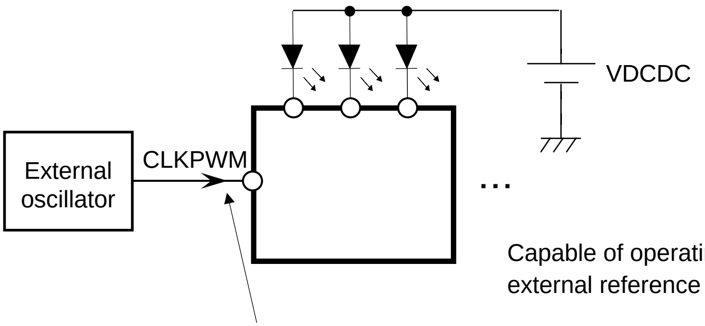
Capable of connected operation
by using synchronous clock

Internal clock output mode

External clock input mode

(Please refer to the explanation of the operation mode of P.21 for the setting of CLKPWM)

< External reference clock application >



Capable of operating using
external reference clock

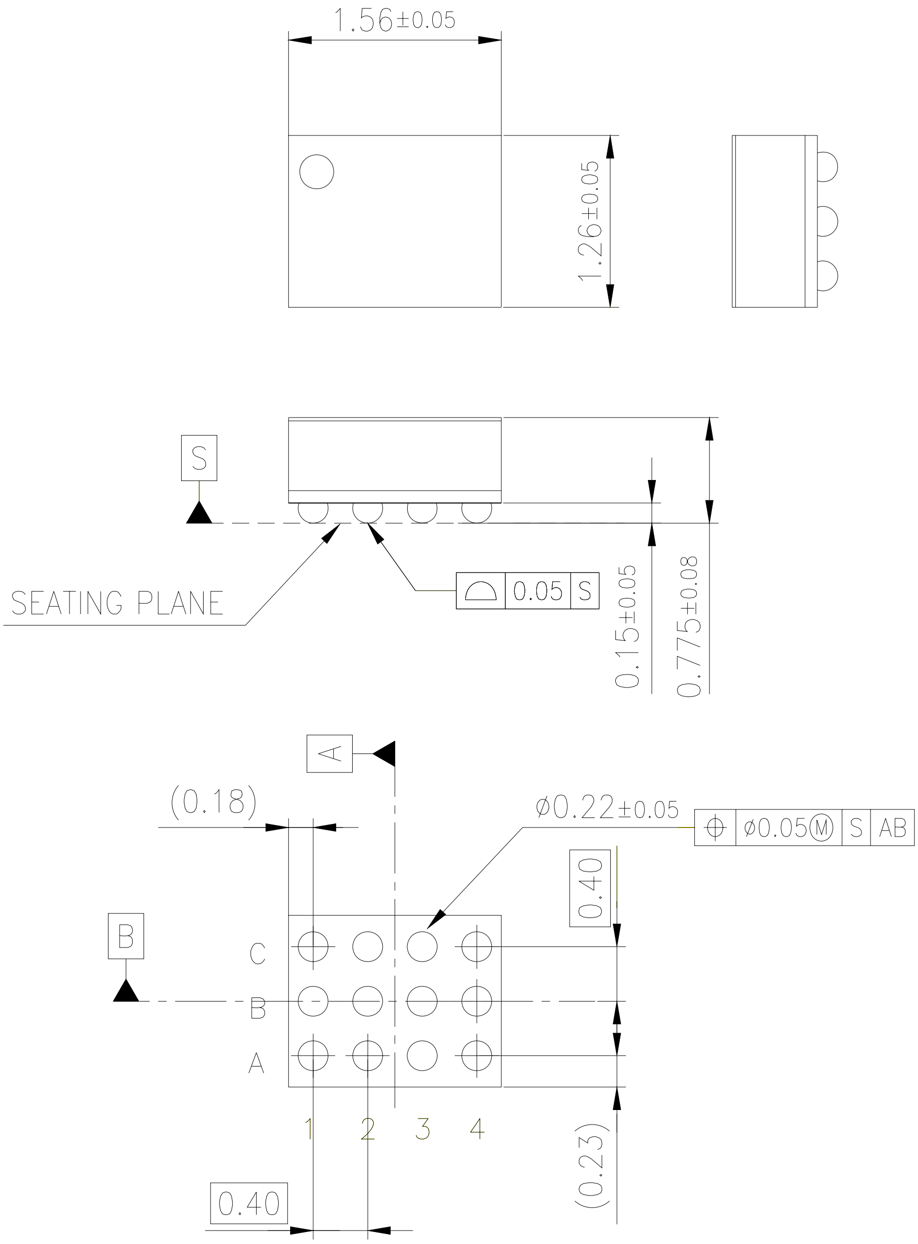
External clock input mode

(Please refer to the explanation of the operation mode of P.21 for the setting of CLKPWM)

## PACKAGE INFORMATION ( Reference Data )

**Package Code:XBGA012-W-1316AEL**

unit:mm


1.56±0.05
1.26±0.05
S
SEATING PLANE
0.05 S
0.15±0.05
0.775±0.08
A
(0.18)
ø0.22±0.05
ø0.05Ⓜ S AB
0.40
B
C
B
A
1
2
3
4
0.40
(0.23)

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

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Be sure to read the notes to descriptions and the usage notes in the book.

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(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 required

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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.

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