



**THE DATASHEET OF  
BU16501KS2-E2**



# LED Driver with I<sup>2</sup>C Compatible and 3-wire Serial Interface for 8×16 LEDs in Dot Matrix

## BU16501KS2

### General Description

BU16501KS2 is "Matrix LED Driver" that is the most suitable for Home Appliance. It can control 8x16 (128 dot) LED Matrix by internal 8-channel PMOS SWs and 16-channel LED drivers. It can control the brightness in each dot by the setting of the internal register. It supports SPI and I<sup>2</sup>C interface.

### Key Specifications

- Operating power supply voltage range: 2.7V to 5.5V
- Oscillator frequency: 1.2MHz (Typ.)
- Operating temperature range: -40°C to +85°C

### Package(s)

SQFP-T52M  
SQFP-T52

### W(Typ) x D(Typ) x H(Max)

12.00mm x 12.00mm x 1.60mm  
12.00mm x 12.00mm x 1.50mm

### Features

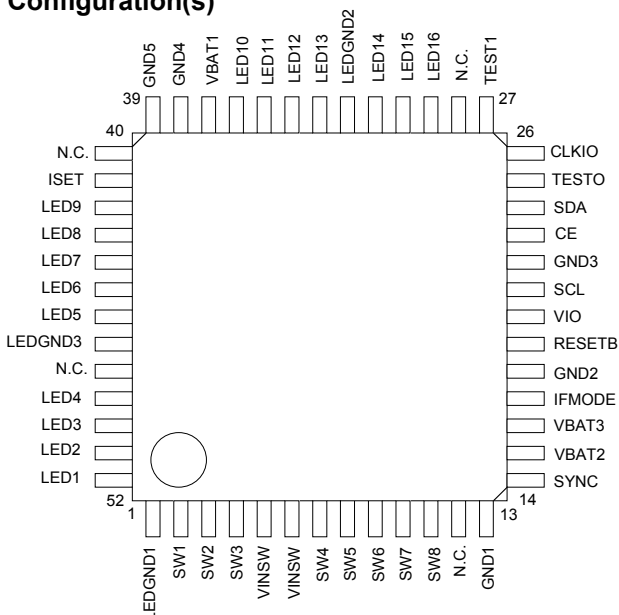
- LED Matrix driver (8x16)
  - It has 8-channel PMOS SWs and 16-channel current drivers with 1/8 TDM timing driven sequentially.
  - Put ON/OFF (for every dot)
  - The current drivers can drive from 0 to 20.00mA current with "16" steps(for every dot)
  - The current drivers can drive maximum 42.5mA/Line (ISET=47kΩ)
  - 64 steps of the luminance control by PWM (common setting for all dots)
- Interface
  - SPI and I<sup>2</sup>C BUS FS mode (max 400 kHz) Compability.
  - For I<sup>2</sup>C mode, I<sup>2</sup>C Device address is selectable (74h or 75h).
- Thermal Shutdown



### Applications

Mobile phone, portable device, home electrical appliance, and general consumer equipment. Device provided with LED display application. LED display. Amusement, Traffic Signboards, hobby, etc.

### Pin Configuration(s)

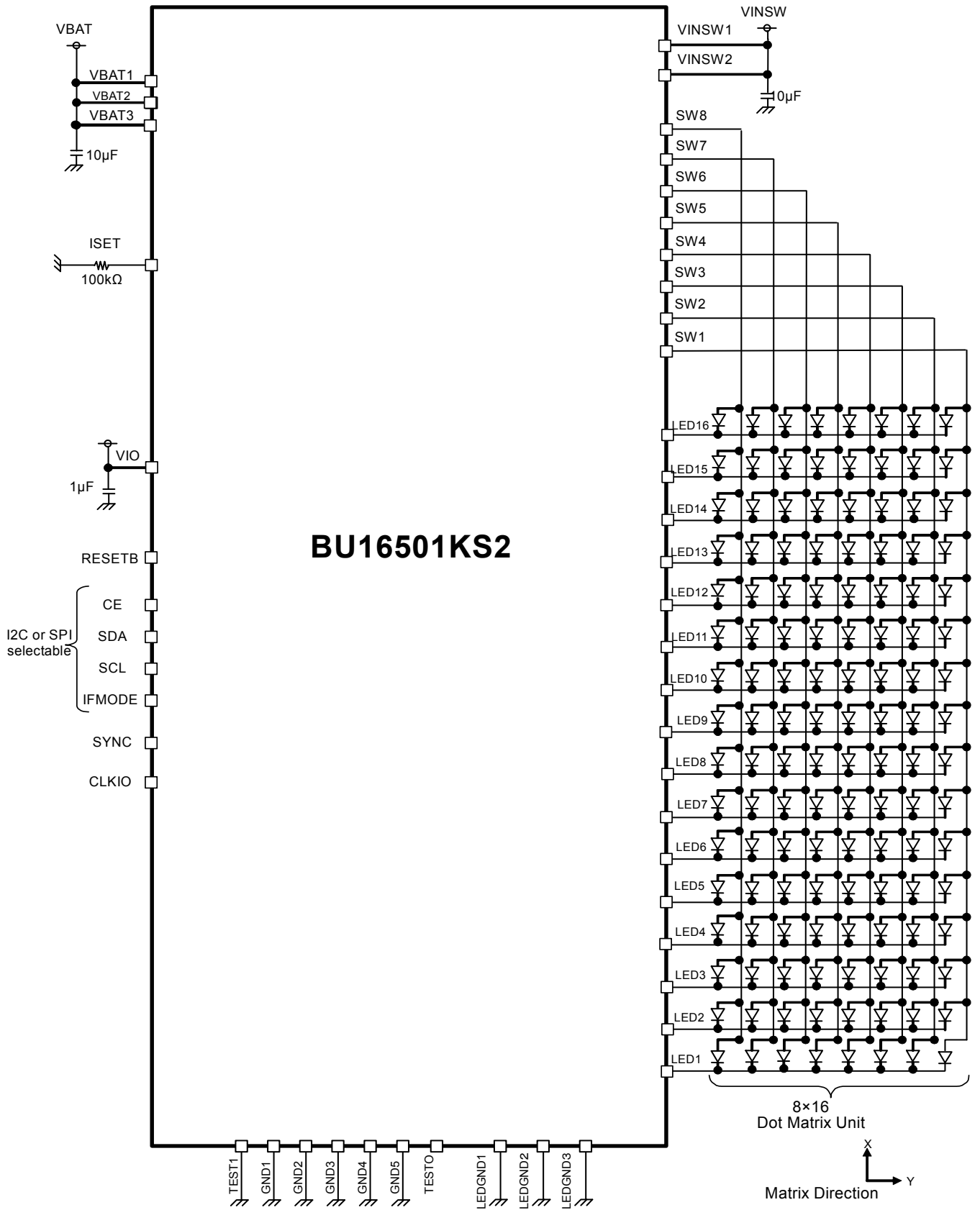


○Product structure : Silicon monolithic integrated circuit ○This product is not designed protection against radioactive rays

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Typical Application Circuit(s)



## Pin Description(s)

| No | Pin Name | I/O | Pull down | Unused processing setting | ESD Diode |            | Functions  | Equivalent Circuit |
|----|----------|-----|-----------|---------------------------|-----------|------------|--|--------------------|
|    |          |     |           |                           | For Power | For Ground |  |                    |
| 1  | LEDGND1  | -   | -         | -                         | VBAT      | -          | Ground   | B                  |
| 2  | SW1      | O   | -         | VINSW                     | VINSW     | GND        | P-MOS SW1 output   | C                  |
| 3  | SW2      | O   | -         | VINSW                     | VINSW     | GND        | P-MOS SW2 output   | C                  |
| 4  | SW3      | O   | -         | VINSW                     | VINSW     | GND        | P-MOS SW3 output   | C                  |
| 5  | VINSW1   | -   | -         | -                         | -         | GND        | Power supply for SW1-8   | A                  |
| 6  | VINSW2   | -   | -         | -                         | -         | GND        | Power supply for SW1-8   | A                  |
| 7  | SW4      | O   | -         | VINSW                     | VINSW     | GND        | P-MOS SW4 output   | C                  |
| 8  | SW5      | O   | -         | VINSW                     | VINSW     | GND        | P-MOS SW5 output   | C                  |
| 9  | SW6      | O   | -         | VINSW                     | VINSW     | GND        | P-MOS SW6 output   | C                  |
| 10 | SW7      | O   | -         | VINSW                     | VINSW     | GND        | P-MOS SW7 output   | C                  |
| 11 | SW8      | O   | -         | VINSW                     | VINSW     | GND        | P-MOS SW8 output   | C                  |
| 12 | NC       | -   | -         | -                         | -         | -          | -  | -                  |
| 13 | GND1     | -   | -         | -                         | VBAT      | -          | Ground   | B                  |
| 14 | SYNC     | I   | -         | GND                       | VBAT      | GND        | External synchronous input pin   | D                  |
| 15 | VBAT2    | -   | -         | -                         | -         | GND        | Battery is connected   | A                  |
| 16 | VBAT3    | -   | -         | -                         | -         | GND        | Battery is connected   | A                  |
| 17 | IFMODE   | I   | -         | GND                       | VBAT      | GND        | I <sup>2</sup> C/SPI select pin (L: I <sup>2</sup> C, H: SPI)                          | D                  |
| 18 | GND2     | -   | -         | -                         | VBAT      | -          | Ground   | B                  |
| 19 | RESETB   | I   | -         | GND                       | VBAT      | GND        | Reset input pin (L: reset, H: reset cancel)  | D                  |
| 20 | VIO      | -   | -         | -                         | VBAT      | GND        | I/O Power supply is connected  | I                  |
| 21 | SCL      | I   | -         | -                         | VBAT      | GND        | SPI, I <sup>2</sup> C CLK input pin  | D                  |
| 22 | GND3     | -   | -         | -                         | VBAT      | -          | Ground   | B                  |
| 23 | CE       | I   | -         | GND                       | VBAT      | GND        | SPI enable pin(H;Enable), or I <sup>2</sup> C slave address selection (L: 74h, H: 75h) | D                  |
| 24 | SDA      | I/O | -         | -                         | VBAT      | GND        | SPI DATA input / I <sup>2</sup> C DATA input-output pin                                | F                  |
| 25 | TESTO    | O   | -         | OPEN                      | VBAT      | GND        | Test output pin1   | G                  |
| 26 | CLKIO    | I/O | 500Ω      | OPEN                      | VBAT      | GND        | Reference CLK input / output pin   | M                  |
| 27 | TEST1    | I   | 94kΩ      | GND                       | VBAT      | GND        | Test input pin 1   | E                  |
| 28 | NC       | -   | -         | -                         | -         | -          | -  | -                  |
| 29 | LED16    | O   | -         | GND                       | -         | GND        | LED16 driver output  | K                  |
| 30 | LED15    | O   | -         | GND                       | -         | GND        | LED15 driver output  | K                  |
| 31 | LED14    | O   | -         | GND                       | -         | GND        | LED14 driver output  | K                  |
| 32 | LEDGND2  | -   | -         | -                         | VBAT      | -          | Ground   | B                  |
| 33 | LED13    | O   | -         | GND                       | -         | GND        | LED13 driver output  | K                  |
| 34 | LED12    | O   | -         | GND                       | -         | GND        | LED12 driver output  | K                  |
| 35 | LED11    | O   | -         | GND                       | -         | GND        | LED11 driver output  | K                  |
| 36 | LED10    | O   | -         | GND                       | -         | GND        | LED10 driver output  | K                  |
| 37 | VBAT1    | -   | -         | -                         | -         | GND        | Battery is connected   | A                  |
| 38 | GND4     | -   | -         | -                         | VBAT      | -          | Ground   | B                  |
| 39 | GND5     | -   | -         | -                         | VBAT      | -          | Ground   | B                  |
| 40 | NC       | -   | -         | -                         | -         | -          | -  | -                  |
| 41 | ISET     | I   | -         | -                         | VBAT      | GND        | LED Constant Current Driver Current setting pin  | J                  |
| 42 | LED9     | O   | -         | GND                       | -         | GND        | LED9 driver output   | K                  |
| 43 | LED8     | O   | -         | GND                       | -         | GND        | LED8 driver output   | K                  |
| 44 | LED7     | O   | -         | GND                       | -         | GND        | LED7 driver output   | K                  |
| 45 | LED6     | O   | -         | GND                       | -         | GND        | LED6 driver output   | K                  |
| 46 | LED5     | O   | -         | GND                       | -         | GND        | LED5 driver output   | K                  |
| 47 | LEDGND3  | -   | -         | -                         | VBAT      | -          | Ground   | B                  |
| 48 | NC       | -   | -         | -                         | -         | -          | -  | -                  |
| 49 | LED4     | O   | -         | GND                       | -         | GND        | LED4 driver output   | K                  |
| 50 | LED3     | O   | -         | GND                       | -         | GND        | LED3 driver output   | K                  |
| 51 | LED2     | O   | -         | GND                       | -         | GND        | LED2 driver output   | K                  |
| 52 | LED1     | O   | -         | GND                       | -         | GND        | LED1 driver output   | K                  |

Pin ESD Type

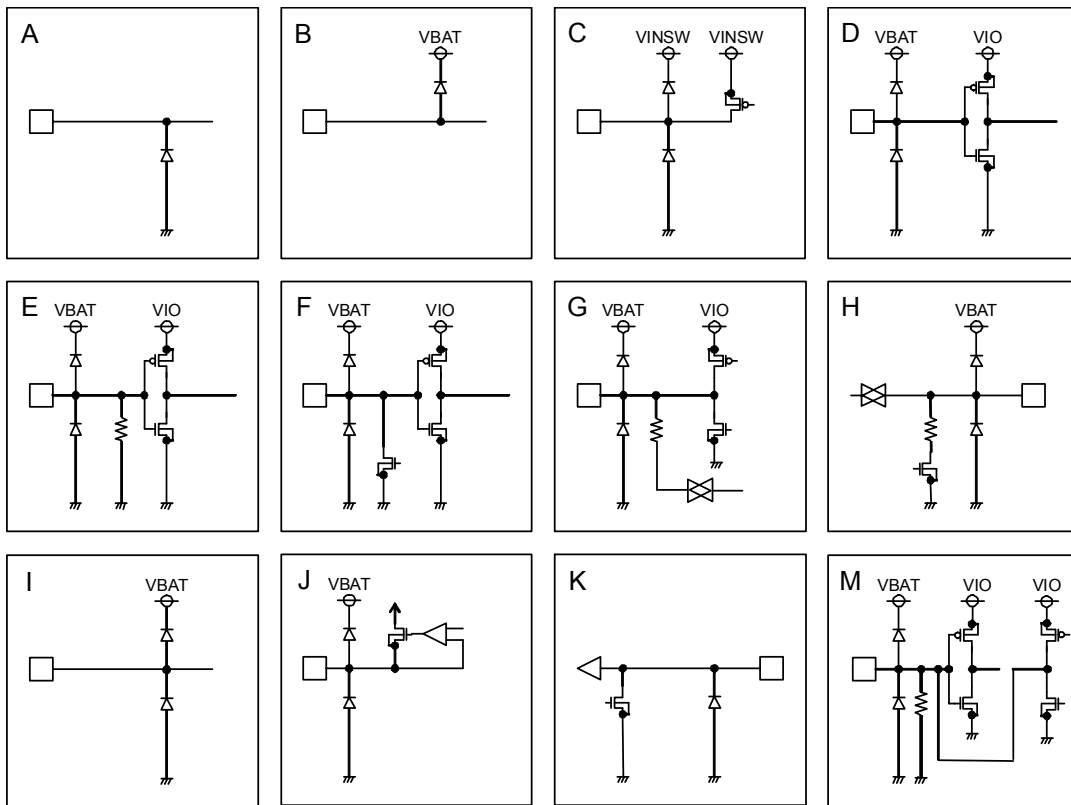


Figure 1. Pin ESD Type

**Absolute Maximum Ratings (Ta=25°C)**

| Parameter                            | Symbol | Limits      | Unit |
|--------------------------------------|--------|-------------|------|
| Terminal voltage                     | VMAX   | -0.3 to +7  | V    |
| Power Dissipation <sup>(note1)</sup> | Pd     | 1.30        | W    |
| Operating Temperature Range          | Topr   | -40 to +85  | °C   |
| Storage Temperature Range            | Tstg   | -55 to +125 | °C   |

(Note1) Power dissipation deleting is 13mW/°C, when it's used in over 25°C  
(ROHM's standard one layer board has been mounted.)  
The power dissipation of the IC has to be less than the one of the package.

**Caution:** Operating the IC over the absolute maximum ratings may damage the IC. The damage can either be a short circuit between pins or an open circuit between pins and the internal circuitry. Therefore, it is important to consider circuit protection measures, such as adding a fuse, in case the IC is operated over the absolute maximum ratings.

**Recommended Operating Ratings (Ta=-40 to 85°C)**

| Parameter           | Symbol | Limits      | Unit |
|---------------------|--------|-------------|------|
| VBAT input voltage  | VBAT   | 2.7 to 5.5  | V    |
| VINSW input voltage | VINSW  | 2.7 to 5.5  | V    |
| VIO pin voltage     | VIO    | 1.65 to 5.5 | V    |

**Electrical Characteristics**

(Unless otherwise specified, Ta=25°C, VBAT=5.0V, VINSW=5.0V, VIO=5.0V)

| Parameter                | Symbol   | Limit         |       |               | Unit | Condition  |
|--------------------------|----------|---------------|-------|---------------|------|--|
|                          |          | Min           | Typ   | Max           |      |  |
| [ Circuit Current ]      |          |               |       |               |      |  |
| VBAT Circuit current 1   | IBAT1    | -             | 0     | 3.0           | μA   | RESETB=0V, VIO=0V  |
| VBAT Circuit current 2   | IBAT2    | -             | 0.7   | 5.0           | μA   | RESETB=0V, VIO=5.0V  |
| VBAT Circuit current 3   | IBAT3    | -             | 2.1   | 3.5           | mA   | When LED1-16 are active with 10.67mA settings.   |
| [ UVLO ]                 |          |               |       |               |      |  |
| UVLO Threshold           | VUVLO    | -             | 2.1   | 2.5           | V    | VBAT falling   |
| UVLO Hysteresis          | VHYUVLO  | 50            | -     | -             | mV   |  |
| [ LED Driver ] (LED1-16) |          |               |       |               |      |  |
| Maximum output current   | ILEDMax1 | -             | 20.00 | -             | mA   | LED1-16 , ISET=100kΩ   |
|                          | ILEDMax2 | -             | 42.50 | -             | mA   | LED1-16 , ISET=47kΩ  |
| Output current           | ILED     | -7.0          | -     | +7.0          | %    | I=10.67mA setting, VLED=1V<br>ISET=100kΩ   |
| LED current Matching     | ILEDMT   | -             | -     | 5             | %    | ILEDMT=<br>(ILEDMax-ILEDMin)/(ILEDMax+ILEDMin)<br>I=10.67mA setting, VLED=1V, ISET=100kΩ |
| Driver pin voltage range | VLED1    | 0.2           | -     | VBAT<br>- 1.4 | V    | LED1-16 , ISET=100kΩ   |
| LED OFF Leak current     | ILKLED   | -             | -     | 1.0           | μA   |  |
| [ PMOS switch ]          |          |               |       |               |      |  |
| Leak current at OFF      | ILEAKP   | -             | -     | 1.0           | μA   |  |
| Resistor at ON           | RonP     | -             | 1.0   | -             | Ω    | Isw=160mA, VINSW=5.0V  |
| [ OSC ]                  |          |               |       |               |      |  |
| OSC frequency            | fosc     | 0.96          | 1.2   | 1.44          | MHz  |  |
| [ CE, SYNC, IFMODE ]     |          |               |       |               |      |  |
| L level input voltage    | VIL1     | -0.3          | -     | 0.25 x<br>VIO | V    |  |
| H level input voltage    | VIH1     | 0.75 x<br>VIO | -     | VIO<br>+0.3   | V    |  |
| input current            | Iin1     | -             | 0     | 1             | μA   | Input voltage = from (0.1 x VIO) to (0.9 x VIO)  |

## Electrical Characteristics - continued

| Parameter                               | Symbol | Limit    |     |          | Unit | Condition  |
|---|--------|----------|-----|----------|------|--|
|   |        | Min      | Typ | Max      |      |  |
| [ SDA, SCL ]                            |        |          |     |          |      |  |
| L level input voltage                   | VIL2   | -0.3     | -   | 0.25×VIO | V    |  |
| H level input voltage                   | VIH2   | 0.75×VIO | -   | VIO+0.3  | V    |  |
| Input hysteresis                        | Vhys   | 0.05×VIO | -   | -        | V    |  |
| L level output voltage<br>(for SDA pin) | VOL2   | -        | -   | 0.3      | V    | IOL=3mA  |
| Input current                           | Iin2   | -3       | -   | 3        | μA   | Input voltage<br>= from (0.1 x VIO) to (0.9 x VIO) |
| [ RESETB ]                              |        |          |     |          |      |  |
| L level input voltage                   | VIL3   | -0.3     | -   | 0.25×VIO | V    |  |
| H level input voltage                   | VIH3   | 0.75×VIO | -   | VIO+0.3  | V    |  |
| Input current                           | Iin3   | -        | 0   | 1        | μA   | Input voltage<br>= from (0.1 x VIO) to (0.9 x VIO) |
| 【CLKIO(output)】                         |        |          |     |          |      |  |
| L level output voltage                  | VOL1   | -        | -   | 0.4      | V    | IOL=2mA  |
| H level output voltage                  | VOH1   | VIO-0.4  | -   | -        | V    | IOH=-2mA   |
| 【CLKIO(input)】                          |        |          |     |          |      |  |
| L level input voltage                   | VIL4   | -0.3     | -   | 0.25×VIO | V    |  |
| H level input voltage                   | VIH4   | 0.75×VIO | -   | VIO+0.3  | V    |  |
| Input current                           | Iin4   | -        | 10  | 20       | μA   | Input voltage =5.0V                                |

(Unless otherwise specified, Ta=25°C, VBAT=5.0V, VINSW=5.0V, VIO=5.0V)

| Parameter                            | Symbol | Limit    |     |     | Unit | Condition |
|--------------------------------------|--------|----------|-----|-----|------|-----------|
|                                      |        | Min      | Typ | Max |      |           |
| SCL cycle time                       | tscyc  | 76       | -   | -   | ns   |           |
| H period of SCL cycle                | Twhc   | 35       | -   | -   | ns   |           |
| L period of SCL cycle                | Twlc   | 35       | -   | -   | ns   |           |
| SDA setup time                       | Tss    | 38       | -   | -   | ns   |           |
| SDA hold time                        | Tsh    | 38       | -   | -   | ns   |           |
| Write interval                       | Tcsw   | 38       | -   | -   | ns   |           |
| Write interval<br>(after RAM access) |        | 2.1      | -   | -   | μs   | (Note 1)  |
|                                      |        | ECLK x 2 | -   | -   | s    | (Note 2)  |
| CE setup time                        | Tcss   | 55       | -   | -   | ns   |           |
| CE hold time                         | Tcgh   | 48       | -   | -   | ns   |           |

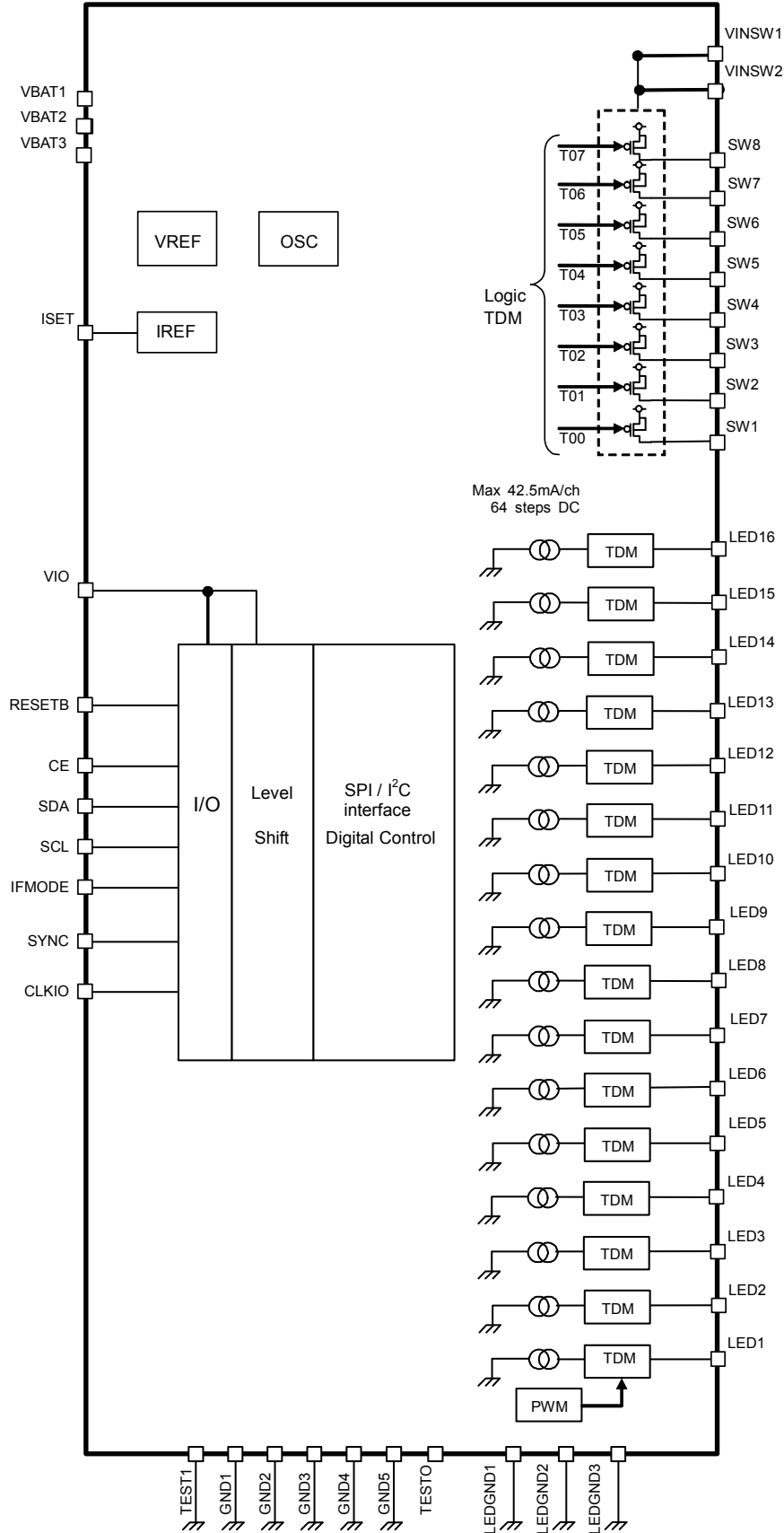
(Note 1) When it used internal clock.

(Note 2) When it used external clock. (ECLK means the cycle of external clock)

(Unless otherwise specified, Ta=25°C, VBAT=5.0V, VINSW=5.0V, VIO=5.0V)

| Parameter   | Symbol  | Standard-mode |     |      | Fast-mode |     |     | Unit |
|---|---------|---------------|-----|------|-----------|-----|-----|------|
|   |         | Min           | Typ | Max  | Min       | Typ | Max |      |
| 【I <sup>2</sup> C BUS format】   |         |               |     |      |           |     |     |      |
| SCL clock frequency   | fSCL    | 0             | -   | 100  | 0         | -   | 400 | kHz  |
| LOW period of the SCL clock   | tLOW    | 4.7           | -   | -    | 1.3       | -   | -   | μs   |
| HIGH period of the SCL clock  | tHIGH   | 4.0           | -   | -    | 0.6       | -   | -   | μs   |
| Hold time (repeated) START condition<br>After this period, the first clock is generated | tHD;STA | 4.0           | -   | -    | 0.6       | -   | -   | μs   |
| Set-up time for a repeated START<br>condition   | tsu;STA | 4.7           | -   | -    | 0.6       | -   | -   | μs   |
| Data hold time  | tHD;DAT | 0             | -   | 3.45 | 0         | -   | 0.9 | μs   |
| Data set-up time  | tsu;DAT | 250           | -   | -    | 100       | -   | -   | ns   |
| Set-up time for STOP condition  | tsu;STO | 4.0           | -   | -    | 0.6       | -   | -   | μs   |
| Bus free time between a STOP<br>and START condition                                     | tBUF    | 4.7           | -   | -    | 1.3       | -   | -   | μs   |

Block Diagram



**Serial Interface**

1. SPI format

- When IFMODE is set to “H”, it can interface with SPI format.
- The serial interface is four terminals (serial clock terminal (SCL), serial data input terminal (SDA), and chip selection input terminal (CE)).

(1) Write operation

- Data is taken into an internal shift register with rising edge of SCL. (Max of the frequency is 13MHz.)
- The receive data becomes enable in the “H” section of CE. (Active “H”.)
- The transmit data is forwarded (with MSB-First) in the order of write command “0”(1bit), the control register address (7bit) and data (8bit).

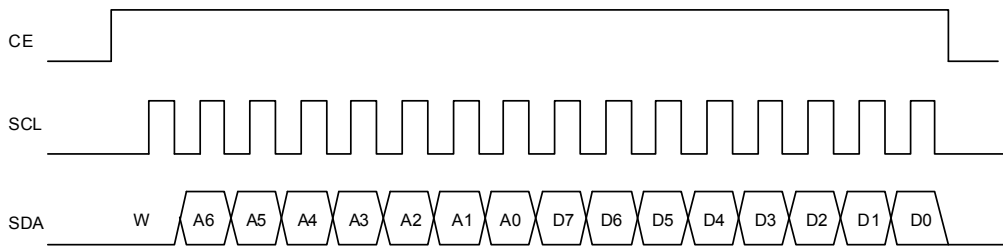


Figure 2. Writing format

(2) Timing diagram

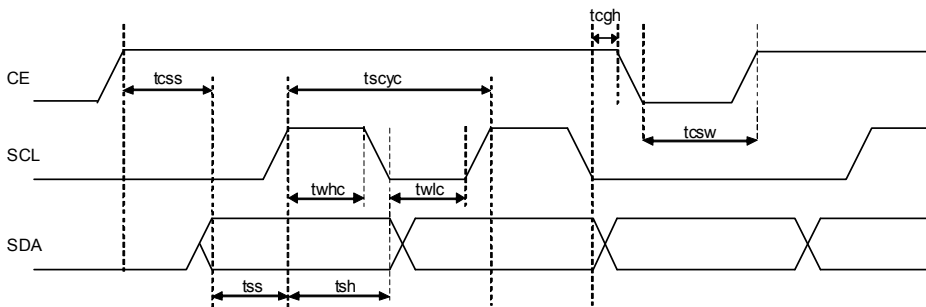


Figure 3. Timing diagram (SPI format)

2. I<sup>2</sup>C BUS format

When IFMODE is set to “L”, it can interface with I<sup>2</sup>C BUS format.

(1) Slave address

|    |    |    |    |    |    |    |    |     |
|----|----|----|----|----|----|----|----|-----|
| CE | A7 | A6 | A5 | A4 | A3 | A2 | A1 | R/W |
| L  | 1  | 1  | 1  | 0  | 1  | 0  | 0  | 0   |
| H  | 1  | 1  | 1  | 0  | 1  | 0  | 1  |     |

(2) Bit Transfer

SCL transfers 1-bit data during H. During H of SCL, SDA cannot be changed at the time of bit transfer. If SDA changes while SCL is H, START conditions or STOP conditions will occur and it will be interpreted as a control signal.

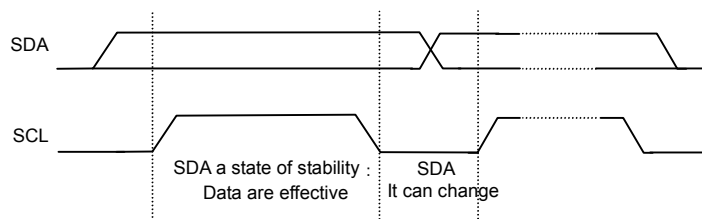


Figure 4. Bit transfer (I<sup>2</sup>C format)

**Serial Interface - continued**

(3) START and STOP condition

When SDA and SCL are H, data is not transferred on the I<sup>2</sup>C- bus. This condition indicates, if SDA changes from H to L while SCL has been H, it will become START (S) conditions, and an access start, if SDA changes from L to H while SCL has been H, it will become STOP (P) conditions and an access end.

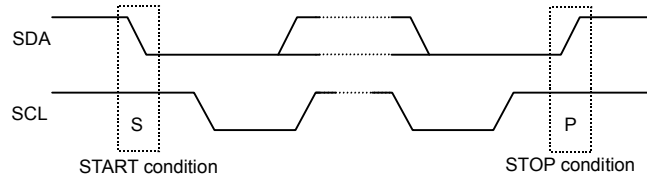


Figure 5. START/STOP condition (I<sup>2</sup>C format)

(4) Acknowledge

It transfers data 8 bits each after the occurrence of START condition. A transmitter opens SDA after transfer 8bits data, and a receiver returns the acknowledge signal by setting SDA to L.

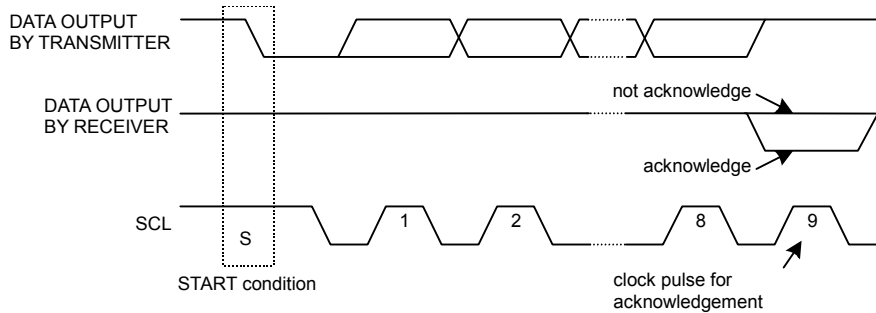
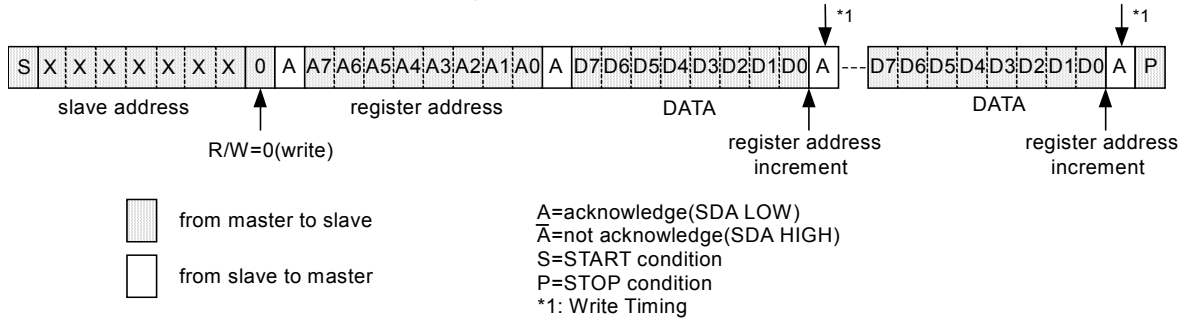


Figure 6. Acknowledge (I<sup>2</sup>C format)

(5) Writing protocol

A register address is transferred by the next 1 byte that transferred the slave address and the write-in command. The 3rd byte writes data in the internal register written in by the 2nd byte, and after 4th byte or, the increment of register address is carried out automatically. However, when a register address turns into the last address (40h), it is set to 00h by the next transmission. After the transmission end, the increment of the address is carried out.



(6) Timing diagram

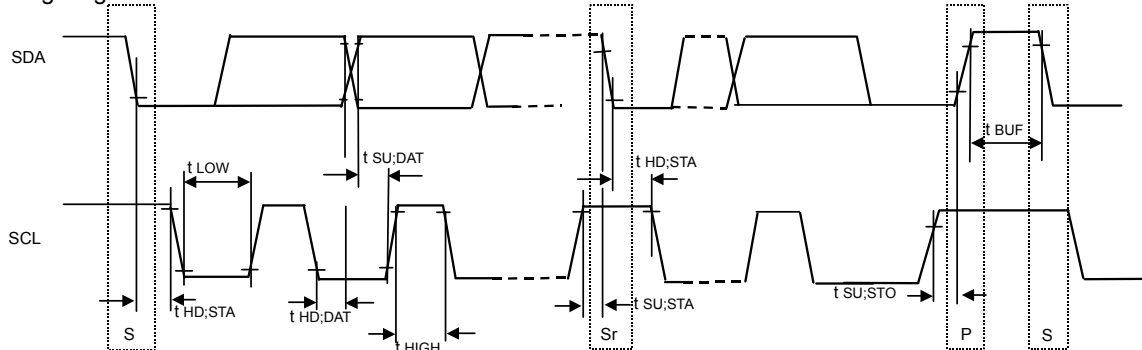


Figure 7. Timing diagram (I<sup>2</sup>C C format)

## Register List

(Note) Please be sure to write "0" in the register which is not assigned.  
It is prohibition to write data to the address which is not assigned.

## Control register

| Address | default | D7          | D6      | D5          | D4      | D3      | D2      | D1      | D0     | Block      | Remark                                   |                     |
|---------|---------|-------------|---------|-------------|---------|---------|---------|---------|--------|------------|--|---------------------|
| 00h     | 00h     | -           | -       | -           | -       | -       | -       | -       | SFTRST | RESET      | Software Reset                           |                     |
| 01h     | 00h     | -           | -       | -           | -       | OSCEN   | -       | -       | -      | OSC        | OSC ON/OFF control                       |                     |
| 11h     | 00h     | LED8ON      | LED7ON  | LED6ON      | LED5ON  | LED4ON  | LED3ON  | LED2ON  | LED1ON | LED driver | LED1-8 Enable                            |                     |
| 12h     | 00h     | LED16ON     | LED15ON | LED14ON     | LED13ON | LED12ON | LED11ON | LED10ON | LED9ON |            | LED9-16 Enable                           |                     |
| 20h     | 00h     | -           | -       | PWMSET[5:0] |         |         |         |         |        | -          | PWM                                      | LED1-16 PWM setting |
| 21h     | 00h     | CLKSEL[1:0] |         | -           | -       | SYNCACT | SYNCON  | CLKOUT  | CLKIN  | CLK        | CLK selection,<br>SYNC operation control |                     |
| 2Dh     | 00h     | -           | -       | -           | -       | -       | PWMEN   | -       | -      | MATRIX     | PWM ON/OFF setting                       |                     |
| 30h     | 00h     | -           | -       | -           | -       | -       | -       | -       | START  |            | LED matrix control                       |                     |
| 31h     | 00h     | -           | -       | -           | -       | -       | -       | -       | CLRA   |            | Matrix data clear                        |                     |
| 7Fh     | 00h     | -           | -       | -           | -       | -       | -       | -       | RMCG   | RMAP       | Resistor map change                      |                     |

## Pattern register

| Address | default | D7              | D6 | D5 | D4 | D3              | D2 | D1 | D0 | Block       | R/W                   | Remark                |
|---------|---------|-----------------|----|----|----|-----------------|----|----|----|-------------|-----------------------|-----------------------|
| 01h     | 00h     | ILED01SET[3:0]  |    |    |    | ILED00SET[3:0]  |    |    |    | MATRIX DATA | W                     | Data for Matrix 01/00 |
| 02h     | 00h     | ILED03SET[3:0]  |    |    |    | ILED02SET[3:0]  |    |    |    |             | W                     | Data for Matrix 03/02 |
| 03h     | 00h     | ILED05SET[3:0]  |    |    |    | ILED04SET[3:0]  |    |    |    |             | W                     | Data for Matrix 05/04 |
| 04h     | 00h     | ILED07SET[3:0]  |    |    |    | ILED06SET[3:0]  |    |    |    |             | W                     | Data for Matrix 07/06 |
| 05h     | 00h     | ILED11SET[3:0]  |    |    |    | ILED10SET[3:0]  |    |    |    |             | W                     | Data for Matrix 11/10 |
| 06h     | 00h     | ILED13SET[3:0]  |    |    |    | ILED12SET[3:0]  |    |    |    |             | W                     | Data for Matrix 13/12 |
| 07h     | 00h     | ILED15SET[3:0]  |    |    |    | ILED14SET[3:0]  |    |    |    |             | W                     | Data for Matrix 15/14 |
| 08h     | 00h     | ILED17SET[3:0]  |    |    |    | ILED16SET[3:0]  |    |    |    |             | W                     | Data for Matrix 17/16 |
| 09h     | 00h     | ILED21SET[3:0]  |    |    |    | ILED20SET[3:0]  |    |    |    |             | W                     | Data for Matrix 21/20 |
| 0Ah     | 00h     | ILED23SET[3:0]  |    |    |    | ILED22SET[3:0]  |    |    |    |             | W                     | Data for Matrix 23/22 |
| 0Bh     | 00h     | ILED25SET[3:0]  |    |    |    | ILED24SET[3:0]  |    |    |    |             | W                     | Data for Matrix 25/24 |
| 0Ch     | 00h     | ILED27SET[3:0]  |    |    |    | ILED26SET[3:0]  |    |    |    |             | W                     | Data for Matrix 27/26 |
| 0Dh     | 00h     | ILED31SET[3:0]  |    |    |    | ILED30SET[3:0]  |    |    |    |             | W                     | Data for Matrix 31/30 |
| 0Eh     | 00h     | ILED33SET[3:0]  |    |    |    | ILED32SET[3:0]  |    |    |    |             | W                     | Data for Matrix 33/32 |
| 0Fh     | 00h     | ILED35SET[3:0]  |    |    |    | ILED34SET[3:0]  |    |    |    |             | W                     | Data for Matrix 35/34 |
| 10h     | 00h     | ILED37SET[3:0]  |    |    |    | ILED36SET[3:0]  |    |    |    |             | W                     | Data for Matrix 37/36 |
| 11h     | 00h     | ILED41SET[3:0]  |    |    |    | ILED40SET[3:0]  |    |    |    |             | W                     | Data for Matrix 41/40 |
| 12h     | 00h     | ILED43SET[3:0]  |    |    |    | ILED42SET[3:0]  |    |    |    |             | W                     | Data for Matrix 43/42 |
| 13h     | 00h     | ILED45SET[3:0]  |    |    |    | ILED44SET[3:0]  |    |    |    |             | W                     | Data for Matrix 45/44 |
| 14h     | 00h     | ILED47SET[3:0]  |    |    |    | ILED46SET[3:0]  |    |    |    |             | W                     | Data for Matrix 47/46 |
| 15h     | 00h     | ILED51SET[3:0]  |    |    |    | ILED50SET[3:0]  |    |    |    |             | W                     | Data for Matrix 51/50 |
| 16h     | 00h     | ILED53SET[3:0]  |    |    |    | ILED52SET[3:0]  |    |    |    |             | W                     | Data for Matrix 53/52 |
| 17h     | 00h     | ILED55SET[3:0]  |    |    |    | ILED54SET[3:0]  |    |    |    |             | W                     | Data for Matrix 55/54 |
| 18h     | 00h     | ILED57SET[3:0]  |    |    |    | ILED56SET[3:0]  |    |    |    |             | W                     | Data for Matrix 57/56 |
| 19h     | 00h     | ILED61SET[3:0]  |    |    |    | ILED60SET[3:0]  |    |    |    |             | W                     | Data for Matrix 61/60 |
| 1Ah     | 00h     | ILED63SET[3:0]  |    |    |    | ILED62SET[3:0]  |    |    |    |             | W                     | Data for Matrix 63/62 |
| 1Bh     | 00h     | ILED65SET[3:0]  |    |    |    | ILED64SET[3:0]  |    |    |    |             | W                     | Data for Matrix 65/64 |
| 1Ch     | 00h     | ILED67SET[3:0]  |    |    |    | ILED66SET[3:0]  |    |    |    |             | W                     | Data for Matrix 67/66 |
| 1Dh     | 00h     | ILED71SET[3:0]  |    |    |    | ILED70SET[3:0]  |    |    |    |             | W                     | Data for Matrix 71/70 |
| 1Eh     | 00h     | ILED73SET[3:0]  |    |    |    | ILED72SET[3:0]  |    |    |    |             | W                     | Data for Matrix 73/72 |
| 1Fh     | 00h     | ILED75SET[3:0]  |    |    |    | ILED74SET[3:0]  |    |    |    |             | W                     | Data for Matrix 75/74 |
| 20h     | 00h     | ILED77SET[3:0]  |    |    |    | ILED76SET[3:0]  |    |    |    |             | W                     | Data for Matrix 77/76 |
| 21h     | 00h     | ILED81SET[3:0]  |    |    |    | ILED80SET[3:0]  |    |    |    | W           | Data for Matrix 81/80 |                       |
| 22h     | 00h     | ILED83SET[3:0]  |    |    |    | ILED82SET[3:0]  |    |    |    | W           | Data for Matrix 83/82 |                       |
| 23h     | 00h     | ILED85SET[3:0]  |    |    |    | ILED84SET[3:0]  |    |    |    | W           | Data for Matrix 85/84 |                       |
| 24h     | 00h     | ILED87SET[3:0]  |    |    |    | ILED86SET[3:0]  |    |    |    | W           | Data for Matrix 87/86 |                       |
| 25h     | 00h     | ILED91SET[3:0]  |    |    |    | ILED90SET[3:0]  |    |    |    | W           | Data for Matrix 91/90 |                       |
| 26h     | 00h     | ILED93SET[3:0]  |    |    |    | ILED92SET[3:0]  |    |    |    | W           | Data for Matrix 93/92 |                       |
| 27h     | 00h     | ILED95SET[3:0]  |    |    |    | ILED94SET[3:0]  |    |    |    | W           | Data for Matrix 95/94 |                       |
| 28h     | 00h     | ILED97SET[3:0]  |    |    |    | ILED96SET[3:0]  |    |    |    | W           | Data for Matrix 97/96 |                       |
| 29h     | 00h     | ILED A1SET[3:0] |    |    |    | ILED A0SET[3:0] |    |    |    | W           | Data for Matrix A1/A0 |                       |
| 2Ah     | 00h     | ILED A3SET[3:0] |    |    |    | ILED A2SET[3:0] |    |    |    | W           | Data for Matrix A3/A2 |                       |
| 2Bh     | 00h     | ILED A5SET[3:0] |    |    |    | ILED A4SET[3:0] |    |    |    | W           | Data for Matrix A5/A4 |                       |
| 2Ch     | 00h     | ILED A7SET[3:0] |    |    |    | ILED A6SET[3:0] |    |    |    | W           | Data for Matrix A7/A6 |                       |
| 2Dh     | 00h     | ILED B1SET[3:0] |    |    |    | ILED B0SET[3:0] |    |    |    | W           | Data for Matrix B1/B0 |                       |
| 2Eh     | 00h     | ILED B3SET[3:0] |    |    |    | ILED B2SET[3:0] |    |    |    | W           | Data for Matrix B3/B2 |                       |
| 2Fh     | 00h     | ILED B5SET[3:0] |    |    |    | ILED B4SET[3:0] |    |    |    | W           | Data for Matrix B5/B4 |                       |

## Pattern register - continued

| Address | default | D7              | D6 | D5 | D4              | D3 | D2 | D1          | D0 | Block | R/W | Remark                |
|---------|---------|-----------------|----|----|-----------------|----|----|-------------|----|-------|-----|-----------------------|
| 30h     | 00h     | ILED B7SET[3:0] |    |    | ILED B6SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix B7/B6 |
| 31h     | 00h     | ILED C1SET[3:0] |    |    | ILED C0SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix C1/C0 |
| 32h     | 00h     | ILED C3SET[3:0] |    |    | ILED C2SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix C3/C2 |
| 33h     | 00h     | ILED C5SET[3:0] |    |    | ILED C4SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix C5/C4 |
| 34h     | 00h     | ILED C7SET[3:0] |    |    | ILED C6SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix C7/C6 |
| 35h     | 00h     | ILED D1SET[3:0] |    |    | ILED D0SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix D1/D0 |
| 36h     | 00h     | ILED D3SET[3:0] |    |    | ILED D2SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix D3/D2 |
| 37h     | 00h     | ILED D5SET[3:0] |    |    | ILED D4SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix D5/D4 |
| 38h     | 00h     | ILED D7SET[3:0] |    |    | ILED D6SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix D7/D6 |
| 39h     | 00h     | ILED E1SET[3:0] |    |    | ILED E0SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix E1/E0 |
| 3Ah     | 00h     | ILED E3SET[3:0] |    |    | ILED E2SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix E3/E2 |
| 3Bh     | 00h     | ILED E5SET[3:0] |    |    | ILED E4SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix E5/E4 |
| 3Ch     | 00h     | ILED E7SET[3:0] |    |    | ILED E6SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix E7/E6 |
| 3Dh     | 00h     | ILED F1SET[3:0] |    |    | ILED F0SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix F1/F0 |
| 3Eh     | 00h     | ILED F3SET[3:0] |    |    | ILED F2SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix F3/F2 |
| 3Fh     | 00h     | ILED F5SET[3:0] |    |    | ILED F4SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix F5/F4 |
| 40h     | 00h     | ILED F7SET[3:0] |    |    | ILED F6SET[3:0] |    |    | MATRIX DATA |    |       | W   | Data for Matrix F7/F6 |

## Register Map

Address 00h &lt; Software Reset &gt;

| Address (Index) | R/W | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0   |
|-----------------|-----|------|------|------|------|------|------|------|--------|
| 00h             | W   | -    | -    | -    | -    | -    | -    | -    | SFTRST |
| Initial value   | 00h | -    | -    | -    | -    | -    | -    | -    | 0      |

Bit 0 : SFTRST Software Reset  
 "0" : Reset cancel  
 "1" : Reset (All register initializing)  
 SFTRST register return to 0 automatically.

Address 01h &lt; OSC control &gt;

| Address (Index) | R/W | Bit7 | Bit6 | Bit5 | Bit4 | Bit3  | Bit2 | Bit1 | Bit0 |
|-----------------|-----|------|------|------|------|-------|------|------|------|
| 01h             | W   | -    | -    | -    | -    | OSCEN | -    | -    | -    |
| Initial value   | 00h | -    | -    | -    | -    | 0     | -    | -    | -    |

Bit 3 : OSCEN OSC block ON/OFF control  
 "0" : OFF (Initial)  
 "1" : ON

This register should not change into "1" → "0" at the time of START (30h, D0) register = "1" setup (under lighting operation).

This register must be set to "0" after LED putting out lights ("START register = 0"), and please surely stop an internal oscillation circuit.

**Register Map - continued**

Address 11h &lt; LED1-8 Enable &gt;

| Address (Index) | R/W | Bit7   | Bit6   | Bit5   | Bit4   | Bit3   | Bit2   | Bit1   | Bit0   |
|-----------------|-----|--------|--------|--------|--------|--------|--------|--------|--------|
| 11h             | W   | LED8ON | LED7ON | LED6ON | LED5ON | LED4ON | LED3ON | LED2ON | LED1ON |
| Initial value   | 00h | 0      | 0      | 0      | 0      | 0      | 0      | 0      | 0      |

Bit 0 : LED1ON LED1 ON/OFF setting

“0” : LED1 OFF (initial)

“1” : LED1 ON

Bit 1 : LED2ON LED2 ON/OFF setting

“0” : LED2 OFF (initial)

“1” : LED2 ON

Bit 2 : LED3ON LED3 ON/OFF setting

“0” : LED3 OFF (initial)

“1” : LED3 ON

Bit 3 : LED4ON LED4 ON/OFF setting

“0” : LED4 OFF (initial)

“1” : LED4 ON

Bit 4 : LED5ON LED5 ON/OFF setting

“0” : LED5 OFF (initial)

“1” : LED5 ON

Bit 5 : LED6ON LED6 ON/OFF setting

“0” : LED6 OFF (initial)

“1” : LED6 ON

Bit 6 : LED7ON LED7 ON/OFF setting

“0” : LED7 OFF (initial)

“1” : LED7 ON

Bit 7 : LED8ON LED8 ON/OFF setting

“0” : LED8 OFF (initial)

“1” : LED8 ON

(Note) Current setting follows ILEDXXSET[3:0] register.

**Register Map - continued**

Address 12h &lt; LED9-16 Enable &gt;

| Address (Index) | R/W | Bit7     | Bit6     | Bit5     | Bit4     | Bit3     | Bit2     | Bit1     | Bit0    |
|-----------------|-----|----------|----------|----------|----------|----------|----------|----------|---------|
| 12h             | W   | LED16 ON | LED15 ON | LED14 ON | LED13 ON | LED12 ON | LED11 ON | LED10 ON | LED9 ON |
| Initial value   | 00h | 0        | 0        | 0        | 0        | 0        | 0        | 0        | 0       |

Bit 0 : LED9ON LED9 ON/OFF setting

“0” : LED9 OFF (initial)

“1” : LED9 ON

Bit 1 : LED10ON LED10 ON/OFF setting

“0” : LED10 OFF (initial)

“1” : LED10 ON

Bit 2 : LED11ON LED11 ON/OFF setting

“0” : LED11 OFF (initial)

“1” : LED11 ON

Bit 3 : LED12ON LED12 ON/OFF setting

“0” : LED12 OFF (initial)

“1” : LED12 ON

Bit 4 : LED13ON LED13 ON/OFF setting

“0” : LED13 OFF (initial)

“1” : LED13 ON

Bit 5 : LED14ON LED14 ON/OFF setting

“0” : LED14 OFF (initial)

“1” : LED14 ON

Bit 6 : LED15ON LED15 ON/OFF setting

“0” : LED15 OFF (initial)

“1” : LED15 ON

Bit 7 : LED16ON LED16 ON/OFF setting

“0” : LED16 OFF (initial)

“1” : LED16 ON

(Note) Current setting follows ILEDXXSET[3:0] register.

**Register Map - continued**

Address 20h &lt; LED1-16 PWM setting &gt;

| Address (Index) | R/W | Bit7 | Bit6 | Bit5         | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|-----------------|-----|------|------|--------------|------|------|------|------|------|
| 20h             | W   | -    | -    | PWMSET [5:0] |      |      |      |      |      |
| Initial value   | 00h | -    | -    | 0            | 0    | 0    | 0    | 0    | 0    |

Bit 5-0 : PWMSET[5:0] LED1-16 PWM DUTY setting

"000000" : 0/63=0%(initial)

"000001" : 1/63=1.59%

:

:

"100000" : 32/63=50.8%

:

:

"111110" : 62/63=98.4%

"111111" : 63/63=100%

(Note)Please refer to Description of operation, chapter 2

Address 21h &lt;Clock control / SYNC operation control&gt;

| Address (Index) | R/W | Bit7        | Bit6 | Bit5 | Bit4 | Bit3    | Bit2   | Bit1   | Bit0  |
|-----------------|-----|-------------|------|------|------|---------|--------|--------|-------|
| 21h             | W   | CLKSEL[1:0] |      | -    | -    | SYNCACT | SYNCON | CLKOUT | CLKIN |
| Initial value   | 00h | 0           | 0    | -    | -    | 0       | 0      | 0      | 0     |

Bit 0 : CLKIN Selection CLK for PWM control

"0" : Internal OSC (initial)

"1" : External CLK input (to CLKIO pin)

Bit 1 : CLKOUT Output CLK enable

"0" : CLK is not output (initial)

"1" : Output selected CLK from CLKIO pin

As for CLKIN &amp; CLKOUT, setting change is forbidden under OSCEN (01h, D3) register ="1" and also under clock input to CLKIO terminal.

Bit 2 : SYNCON SYNC operation enable

"0" : Disable SYNC operation (initial)

"1" : SYNC pin control LED driver ON/OFF

Bit 3 : SYNCACT SYNC operation setting

"0" : When SYNC pin is "L", LED drivers are ON (initial)

"1" : When SYNC pin is "H", LED drivers are ON

Bit 7-6 : CLKSEL[1:0] Select Clock Frequency

"00" : 1.2MHz (initial)

"01" : 300kHz

"10" : 150kHz

"11" : 37.5kHz

**Register Map - continued**

Address 2Dh &lt; PWM ON/OFF setting &gt;

| Address (Index) | R/W | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2  | Bit1 | Bit0 |
|-----------------|-----|------|------|------|------|------|-------|------|------|
| 2Dh             | W   | -    | -    | -    | -    | -    | PWMEN | -    | -    |
| Initial value   | 00h | -    | -    | -    | -    | -    | 0     | -    | -    |

Bit 2 : PWMEN PWM control at LED1-16 ON/OFF setting

"0" : PWM operation is invalid (initial value)

"1" : PWM operation is valid

(Note)Please refer to Description of operation, chapter 2

Address 30h &lt; LED Matrix control &gt;

| Address (Index) | R/W | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0  |
|-----------------|-----|------|------|------|------|------|------|------|-------|
| 30h             | W   | -    | -    | -    | -    | -    | -    | -    | START |
| Initial value   | 00h | -    | -    | -    | -    | -    | -    | -    | 0     |

Bit 0 : START Lighting/turning off bit of MATRIX LED(LED1-16)

"0" : MATRIX LED (LED1-16) Lights out (initial)

"1" : MATRIX LED (LED1-16) Lighting start

Address 31h &lt; Matrix data clear &gt;

| Address (Index) | R/W | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|-----------------|-----|------|------|------|------|------|------|------|------|
| 31h             | W   | -    | -    | -    | -    | -    | -    | -    | CLRA |
| Initial value   | 00h | -    | -    | -    | -    | -    | -    | -    | 0    |

Bit 0 : CLRA Reset Pattern register

"0" : Pattern register is not reset and writable (initial value)

"1" : Pattern register is reset

(Note)CLRA register return to 0 automatically.

Address 7Fh &lt; Register map change &gt;

| Address (Index) | R/W | Bit7 | Bit6 | Bit5 | Bit4 | Bit3 | Bit2 | Bit1 | Bit0 |
|-----------------|-----|------|------|------|------|------|------|------|------|
| 7Fh             | W   | -    | -    | -    | -    | -    | -    | -    | RMCG |
| Initial value   | 00h | -    | -    | -    | -    | -    | -    | -    | 0    |

Bit 0 : RMCG Change register map

"0" : Control register is selected (initial value)

"1" : Pattern register is selected

## Register Map - continued

Address 01h-40h &lt; Pattern register data &gt;

| Address (Index) | R/W | Bit7            | Bit6 | Bit5 | Bit4 | Bit3            | Bit2 | Bit1 | Bit0 |
|-----------------|-----|-----------------|------|------|------|-----------------|------|------|------|
| 01-40h          | W   | ILEDXXSET [3:0] |      |      |      | ILEDXXSET [3:0] |      |      |      |
| Initial value   | 00h | 0               | 0    | 0    | 0    | 0               | 0    | 0    | 0    |

Bit7-4/Bit 3-0 : ILEDXXSET[3:0] LED output current setting for Pattern matrix data

| ILEDxxSET[3:0] |   |   |   | 電流値                         |
|----------------|---|---|---|-----------------------------|
| 0              | 0 | 0 | 0 | 0 [mA]                      |
| 0              | 0 | 0 | 1 | 1/15 x ILEDmax [mA]         |
| 0              | 0 | 1 | 0 | 2/15 x ILEDmax [mA]         |
| .              | . | . | . | 1/15 x ILEDmax [mA]<br>Step |
| .              | . | . | . |                             |
| .              | . | . | . |                             |
| .              | . | . | . |                             |
| 1              | 1 | 0 | 1 | 13/15 x ILEDmax [mA]        |
| 1              | 1 | 1 | 0 | 14/15 x ILEDmax [mA]        |
| 1              | 1 | 1 | 1 | 15/15 x ILEDmax [mA]        |

example : ILEDmax=20mA (ISET=100 kΩ) , LED current setting as below.

"0000" : 0.00mA  
 "0001" : 1.33mA  
 "0010" : 2.67mA  
 "0011" : 4.00mA  
 "0100" : 5.33mA  
 "0101" : 6.67mA  
 "0110" : 8.00mA  
 "0111" : 9.33mA  
 "1000" : 10.67mA (initial value)  
 "1001" : 12.00mA  
 "1010" : 13.33mA  
 "1011" : 14.67mA  
 "1100" : 16.00mA  
 "1101" : 17.33mA  
 "1110" : 18.67mA  
 "1111" : 20.00mA

(Note) In a SPI interface, the interval to the following access has regulation after this address access.

For details, please refer to the clause of the chapter of serial interface, and the electrical property of a SPI format.

(Note) The change of this register needs OSC frequency or CLKIO external input frequency.

Please set "Address 01H" or "Address 21H" before the change of this register.

**Description of operation**

1. LED Matrix

1-1. Lighting method of dot Matrix

It can control 8 x 16 Matrix.

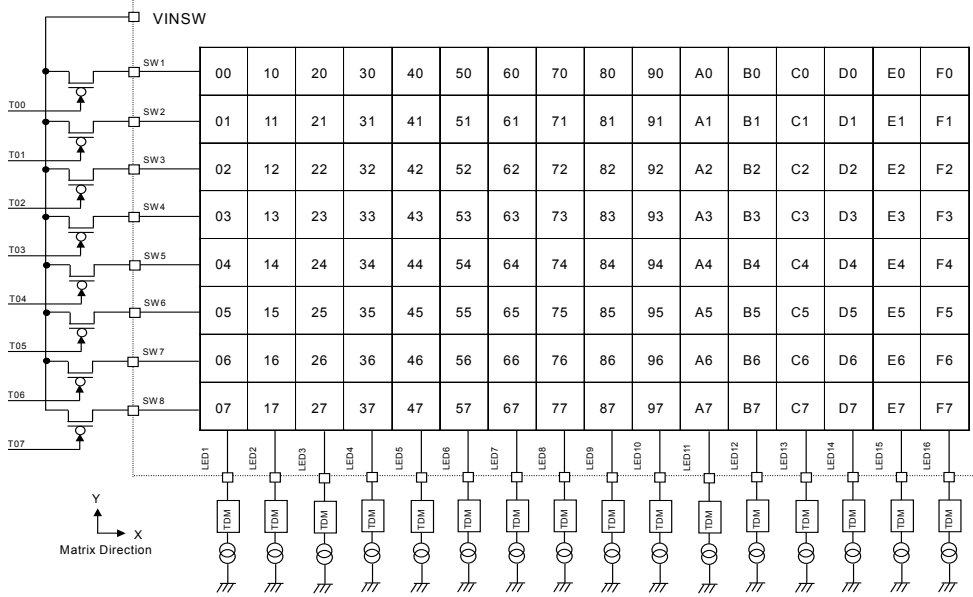


Figure 8. 8 x 16 LED Matrix coordinate

The SW1 – SW8 is turned on by serial. LED is driven one by one within the ON period.

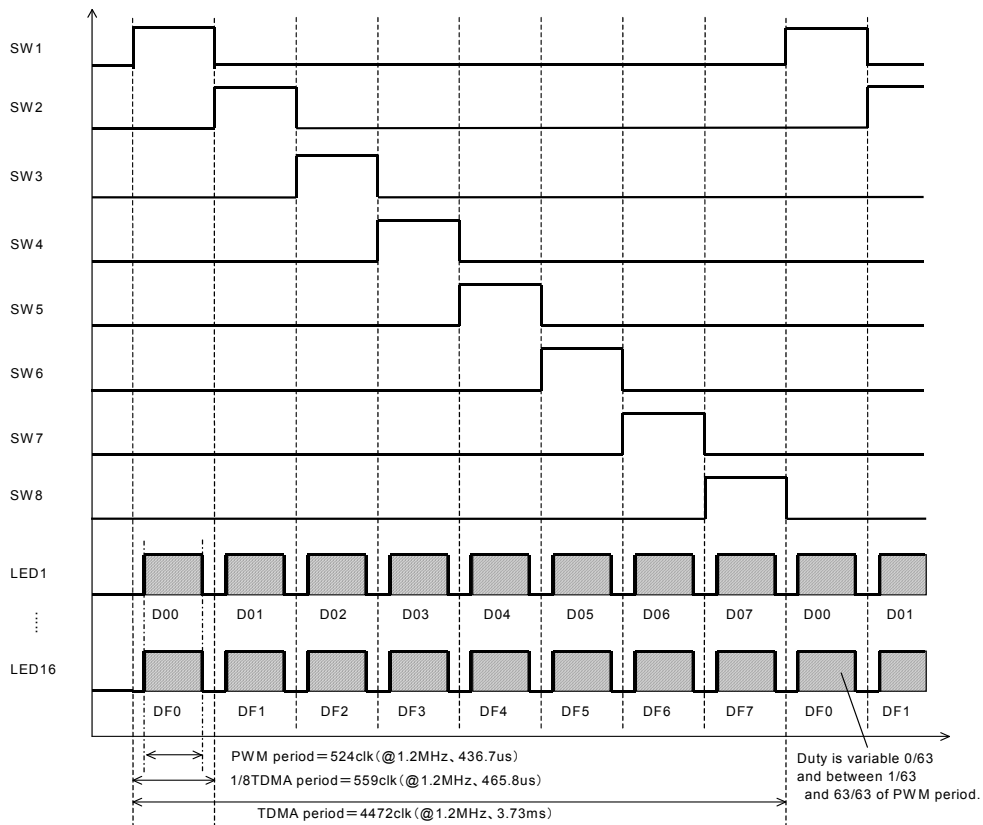


Figure 9. SW timing

**Description of operation - continued**

1-2. LED lighting example

The following command set is the example of LED matrix lighting.

- 1) 7Fh 00000000 Select control register
- 2) 21h 00000000 Select internal OSC for CLK
- 3) 01h 00001000 Start OSC
- 4) 11h 11111111 Set LED1-8 enable
- 5) 12h 11111111 Set LED9-16 enable
- 6) 20h 00111111 Set Max Duty at Slop Set Max Duty
- 7) 7Fh 00000001 Select Pattern register to write matrix data
- 8) 01-40h xxxxxxxx Write pattern data
- 9) 7Fh 00000000 Select control register, Pattern register to output for matrix
- 10) 30h 00000001 Start lighting
- 11) 30h 00000000 Light off

2. LED Driver Current Control

It can be controlled PWM Duty and DC current for LED driver current.

|                        | Item       | Control object  | Control detail          | Setting Registers       |      |
|------------------------|------------|-----------------|-------------------------|-------------------------|------|
|                        |            |                 |                         | Name <sup>(Note1)</sup> | Bits |
| (A) <sup>(Note2)</sup> | PWM Duty   | Whole matrix    | 0/63 to 63/63 (64 step) | PWMSET                  | 6    |
| (B) <sup>(Note3)</sup> | DC current | Each matrix dot | 0 to 20.00mA (16 step)  | ILEDXXSET               | 4    |

(Note1) The "XX" shows the matrix number from "00" to "F7". Please refer 8x16 LED Matrix coordinate.

(Note2) For setting(A), please refer to P14 :register map of address 20H.

(Note3) For setting(B), please refer to P16 :register map of address 01H-40H.

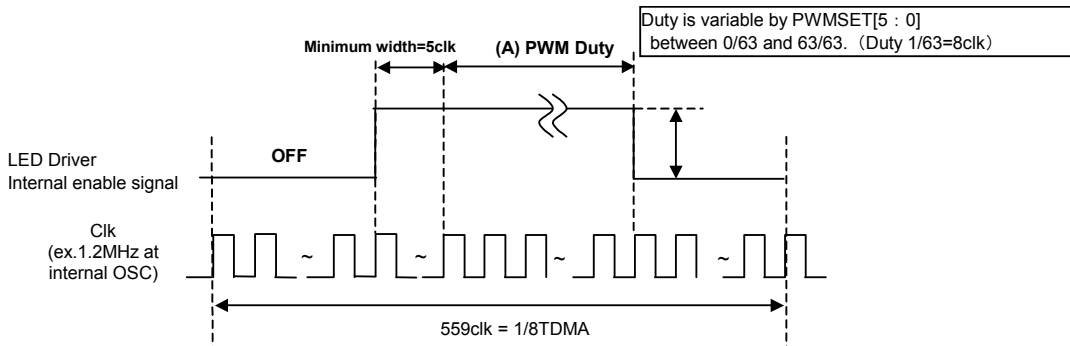


Figure 10. LED output current timing and PWM cycle

524clk of PWM period is set in the 1/8 TDM period (559clk).

PWM is operated 63 steps of 8clk. TDM period is 3.73ms (@1.2MHz).

Moreover, it has the starting waiting time of a constant current driver by 20clk.

PWM"H" time turns into ON time after waiting 20clk.

(However, LED driver is set "OFF" compulsorily at PWM=0% setting.)

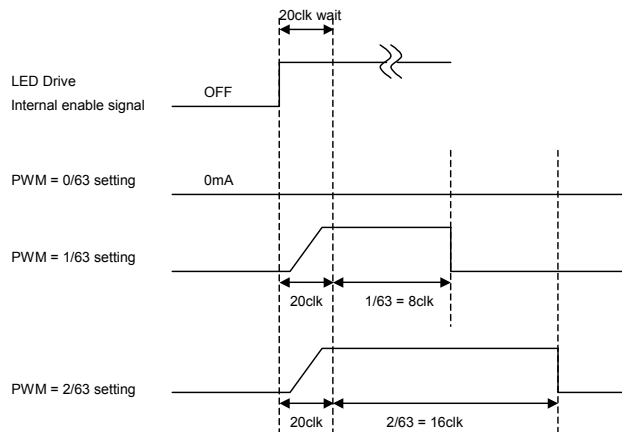


Figure 11. LED output current timing and a PWM cycle

**Description of operation - continued**

## 3. About LEDMax current setting

LED Current is variable by RISET resistor connecting ISET terminal. Maximum LED current can be leads by next formula.

$$I_{LEDmax} [A] = 2.0 / R_{ISET} [k\Omega] \quad (\text{Typ})$$

Caution that Maximum LED current value is up to 42.5mA.

<ISET terminal resister value vs LED Current (calculation)>

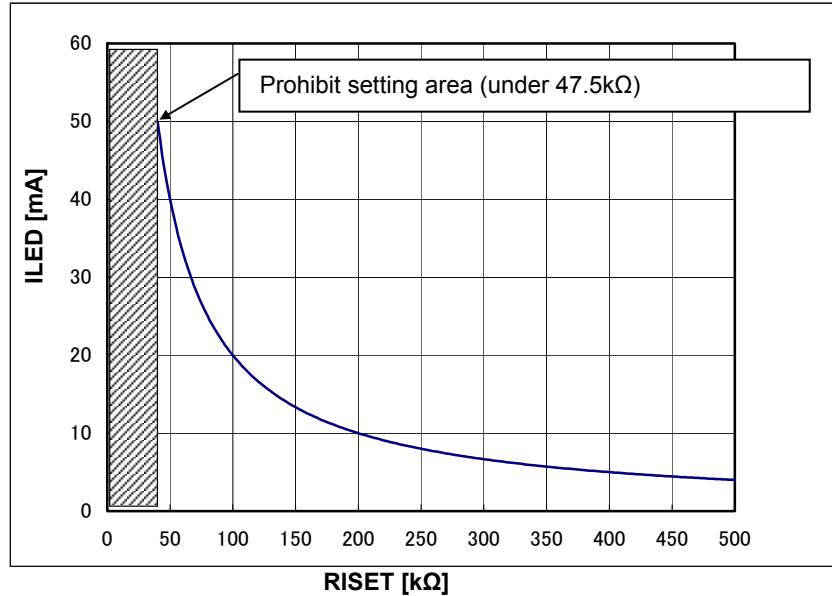


Figure 12. ILED vs RISET

In case of RISET = 100[kΩ], Maximum LED current is 20.0mA.

There are Maximum LED current and Delta LED current value in next table. If you change the RISET value, you can calculate LED current on each step by next table.

Recommended RISET value is 100[kΩ].

In case of RISET under 47.5 [kΩ], ISET short function may be effective.

An example for setting DC current=16mA , PWMDuty=50.8%

1. ILEDMax current setting (set by external resistor):  
RISET=100kΩ -> ILEDmax[A]= 2.0 / RISET [kΩ]=20mA.
2. DC current setting (set by register/Each matrix dot can be set):  
ILEDxxSET[3:0]="1100" -> ILEDxx[A]=12/15 \* ILEDmax=16mA.  
Please refer to P16 to set register of address01H-40H.
3. PWM duty setting (set by register /whole matrix):  
PWMSET[5:0]="100000" (50.8%) -> ILEDxx[A]=16mA \* 50.8%=8.128mA.  
Please refer to P14 to set register of address20H.
4. 1/8TDM active -> ILEDxx[A]=8.128mA \* 1/8=1.016mA.

For this case, average 1.016mA LED current is loaded to one LED.

## Description of operation - continued

## 4. Power up sequence

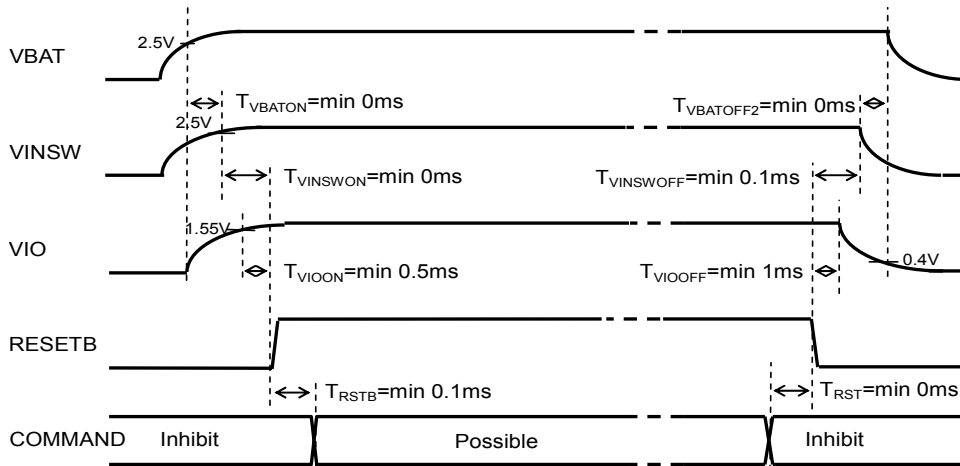


Figure 13. Power up sequence

Please take sufficient wait time for each Power/Control signal.

However, if  $VBAT < 2.1V(\text{Typ})$  or  $T_a > T_{TSD}(\text{Typ}: 175^\circ\text{C})$ , the command input is not effective because of the protection operation

## 5. Reset

There are two kinds of reset, software reset and hardware reset

## (1) Software reset

- All the registers are initialized by  $SFTRST = "1"$ .
- $SFTRST$  is an automatically returned to "0". (Auto Return 0).

## (2) Hardware reset

- It shifts to hardware reset by changing RESETB pin "H" → "L".
- The condition of all the registers under hardware reset pin is returned to the Initial Value, and it stops accepting all address.  
All LED driver turn off.
- It's possible to release from a state of hardware reset by changing RESETB pin "L" → "H".  
RESETB pin has delay circuit. It doesn't recognize as hardware reset in "L" period under  $5\mu\text{s}$ .

## 6. Thermal shutdown

A thermal shutdown function is effective at all blocks of those other than VREF.  
Return to the state before detection automatically at the time of release.

## 7. UVLO Function (VBAT Voltage Low-Voltage Detection)

UVLO function is effective at all blocks of those other than VREF, and when detected, those blocks function is stopped.  
Return to the state before detection automatically at the time of release.

**Description of operation - continued**

8. I/O

When the RESETB pin is Low, the input buffers (SDA and SCL) are disabling for the Low consumption power.

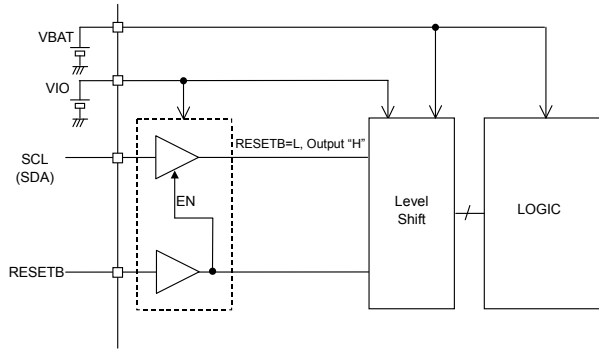


Figure 14. Input disabling by RESETB

9. Standard Clock Input and Output

It is possible to carry out synchronous operation of two or more ICs using the input-and-output function of a standard clock.

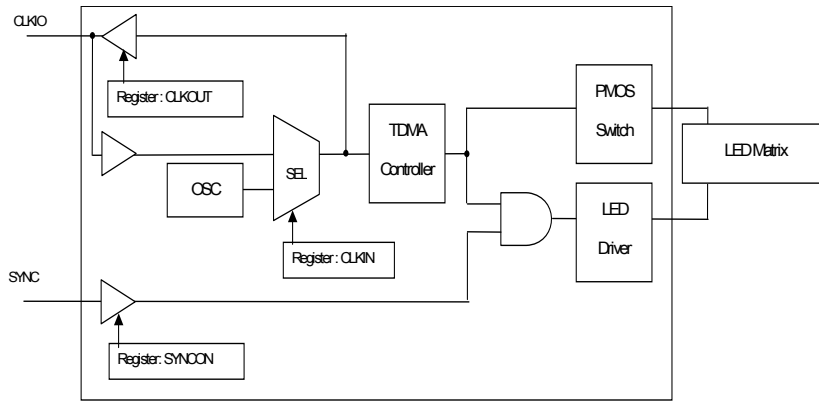


Figure 15. I/O part equivalent circuit diagram

- When a clock is supplied from the exterior  
Inputting an external standard clock from CLKIN and setting register CLKIN=1, IC operates with the clock inputted from CLKIN as a standard clock.
- When the built-in oscillation circuit of one IC is used  
When a clock cannot be supplied from the exterior, it is possible to synchronize between ICs by the connection as the following figure.

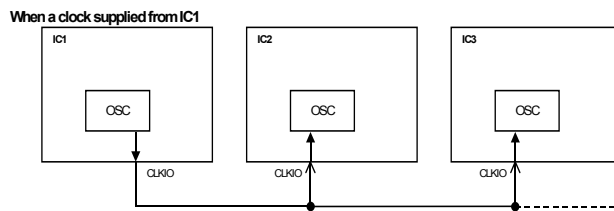


Figure 16. It is an example of application for the usage of two or more.

**Description of operation - continued**

10. External ON/OFF Synchronization (SYNC Terminal)

Lighting of LED that synchronized with the external signal is possible.  
 By setting H/L of SYNC terminal, LED drivers output is set ON/OFF.  
 It's asynchronous operation with the internal TDMA control.

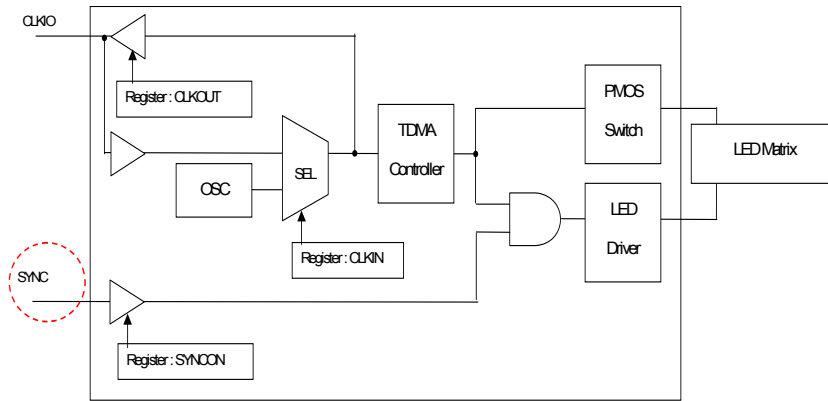


Figure 17. I/O part equivalent circuit diagram

11. About terminal processing of the function which is not used

Please set up a test terminal and the unused terminal as the following table.

Especially, if an input terminal is not fixed, it may occur the unstable state of a device and the unexpected internal current.

| Terminal name | Processing  | Reason   |
|---------------|-------------|--|
| SYNC          | GND Short   | In order to avoid an unfixed state.  |
| CLKIO         | Open        | Pin is fixed to L because pin is connected with a Pull down register of 500Kohm  |
| TEST1         | GND Short   | The input terminal for a test (94k Ω Pull down)  |
| TEST0         | Open        | The output terminal for a test   |
| LED Terminal  | GND Short   | In order to avoid an unfixed state.<br>(Register setup in connection with LED terminal that is not used is forbidden.) |
| SW Terminal   | VINSW Short | In order to avoid an unfixed state.<br>(Register setup in connection with SW terminal that is not used is forbidden.)  |

**Description of operation - continued**

12. Setting about VINSW

VINSW is Power Supply about LED Current. It needs proper Voltage range of LED terminal to get proper LED Current (refer to Page5). If it needs the voltage range, it needs to set up proper Voltage range of VINSW which is Power Supply about LED.

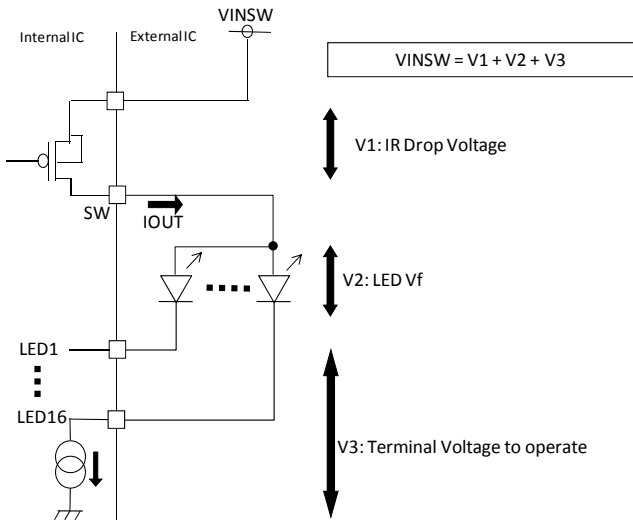


Figure 18. Set up VINSW

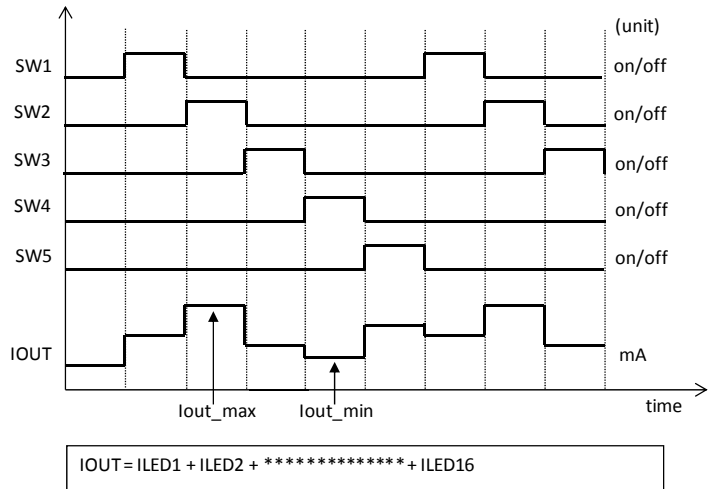


Figure 19. SW timing and IOUT

VINSW's Voltage range is made by V1, V2, V3. (refer to Figure 18)

$$VINSW\_max = V1\_min + V2\_min + V3\_max$$

$$VINSW\_min = V1\_max + V2\_max + V3\_min$$

**V1:IR Drop Voltage**

V1 is IR Voltage drop by SW's Resistor at ON and IOUT which is the sum of every LED Current. It is V1's maximum and minimum that it multiplies by SW's Resistor at ON and IOUT maximum and minimum in each SW timing. Please estimate IOUT by setting application. (refer to figure 19). Please refer to page 5 about SW's Resistor at ON. (And it needs to estimate parasitic resistor on PCB's current route).

$$V1\_max = Ron * Iout\_max$$

$$V1\_min = Ron * Iout\_min$$

**V2: LED Vf**

V2 is the Voltage drop by LED's Vf. Please confirm about all LED's Vf.

$$V2\_max = Vf\_max$$

$$V2\_min = Vf\_min$$

**V3: Terminal Voltage to operate**

V3 is the terminal Voltage to operate LED Current. (refer to page 5). The minimum is made by IC's ability. The maximum is made by VBAT's minimum in Voltage range.

$$V3\_max = VBAT\_min - 1.4V$$

$$V3\_min = 0.2V$$

**--Example of Setting VINSW--**

Condition: VBAT=3.2 – 4.0 V, Iout\_max = 100mA, Iout\_min = 20mA, Vf\_max = 3.0V, Vf\_min = 2.5V

$$V1\_max = 1 \text{ ohm} * 100\text{mA} = 0.1V$$

$$V1\_min = 1 \text{ ohm} * 20\text{mA} = 0.02V$$

$$V2\_max = 3.0V$$

$$V2\_min = 2.5V$$

$$V3\_max = 3.2V - 1.4V = 1.8V$$

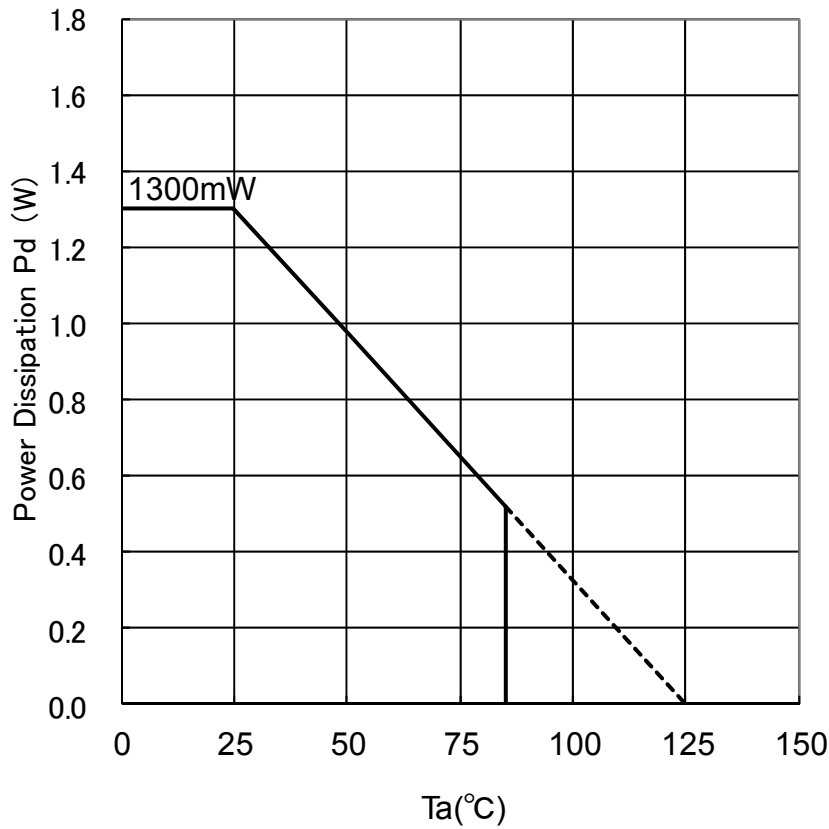
$$V3\_min = 0.2V$$

$$VINSW\_max = 0.02V + 2.5V + 1.8V = 4.32V$$

$$VINSW\_min = 0.1V + 3.0V + 0.2V = 3.3V$$

This is proper Voltage range about VINSW.

Power dissipation (On the ROHM's standard one layer board)



<Calculator>

$$P_d = (V_{INSW} - V_f) \times I_{LED} \times N(\text{Channel})$$

ex)

$$V_{INSW} = 5V, V_f = 3.2V, I_{LED} = 20mA, N = 16\text{channel}, P_d = (5 - 3.2) \times 20 \times 16 = 576mW$$

Please adjust V<sub>INSW</sub> and I<sub>LED</sub> in order to prevent P<sub>d</sub> from exceeding 1300mW of power dissipation.

\*V<sub>INSW</sub>: V<sub>INSW</sub> input voltage

\*V<sub>f</sub>: Diode V<sub>f</sub>

\*I<sub>LED</sub>: LED Current

\*N(Channel): LED Channel

## Operational Notes

### 1. Reverse Connection of Power Supply

Connecting the power supply in reverse polarity can damage the IC. Take precautions against reverse polarity when connecting the power supply, such as mounting an external diode between the power supply and the IC's power supply pins.

### 2. Power Supply Lines

Design the PCB layout pattern to provide low impedance supply lines. Separate the ground and supply lines of the digital and analog blocks to prevent noise in the ground and supply lines of the digital block from affecting the analog block. Furthermore, connect a capacitor to ground at all power supply pins. Consider the effect of temperature and aging on the capacitance value when using electrolytic capacitors.

### 3. Ground Voltage

Ensure that no pins are at a voltage below that of the ground pin at any time, even during transient condition.

### 4. Ground Wiring Pattern

When using both small-signal and large-current ground traces, the two ground traces should be routed separately but connected to a single ground at the reference point of the application board to avoid fluctuations in the small-signal ground caused by large currents. Also ensure that the ground traces of external components do not cause variations on the ground voltage. The ground lines must be as short and thick as possible to reduce line impedance.

### 5. Thermal Consideration

Should by any chance the power dissipation rating be exceeded the rise in temperature of the chip may result in deterioration of the properties of the chip. The absolute maximum rating of the Pd stated in this specification is when the IC is mounted on a 70mm x 70mm x 1.6mm glass epoxy board. In case of exceeding this absolute maximum rating, increase the board size and copper area to prevent exceeding the Pd rating.

### 6. Recommended Operating Conditions

These conditions represent a range within which the expected characteristics of the IC can be approximately obtained. The electrical characteristics are guaranteed under the conditions of each parameter.

### 7. Inrush Current

When power is first supplied to the IC, it is possible that the internal logic may be unstable and inrush current may flow instantaneously due to the internal powering sequence and delays, especially if the IC has more than one power supply. Therefore, give special consideration to power coupling capacitance, power wiring, width of ground wiring, and routing of connections.

### 8. Operation Under Strong Electromagnetic Field

Operating the IC in the presence of a strong electromagnetic field may cause the IC to malfunction.

### 9. Testing on Application Boards

When testing the IC on an application board, connecting a capacitor directly to a low-impedance output pin may subject the IC to stress. Always discharge capacitors completely after each process or step. The IC's power supply should always be turned off completely before connecting or removing it from the test setup during the inspection process. To prevent damage from static discharge, ground the IC during assembly and use similar precautions during transport and storage.

### 10. Inter-pin Short and Mounting Errors

Ensure that the direction and position are correct when mounting the IC on the PCB. Incorrect mounting may result in damaging the IC. Avoid nearby pins being shorted to each other especially to ground, power supply and output pin. Inter-pin shorts could be due to many reasons such as metal particles, water droplets (in very humid environment) and unintentional solder bridge deposited in between pins during assembly to name a few.

## Operational Notes – continued

### 11. Unused Input Pins

Input pins of an IC are often connected to the gate of a MOS transistor. The gate has extremely high impedance and extremely low capacitance. If left unconnected, the electric field from the outside can easily charge it. The small charge acquired in this way is enough to produce a significant effect on the conduction through the transistor and cause unexpected operation of the IC. So unless otherwise specified, unused input pins should be connected to the power supply or ground line.

### 12. Regarding the Input Pin of the IC

This monolithic IC contains P+ isolation and P substrate layers between adjacent elements in order to keep them isolated. P-N junctions are formed at the intersection of the P layers with the N layers of other elements, creating a parasitic diode or transistor. For example (refer to figure below):

When  $GND > Pin A$  and  $GND > Pin B$ , the P-N junction operates as a parasitic diode.

When  $GND > Pin B$ , the P-N junction operates as a parasitic transistor.

Parasitic diodes inevitably occur in the structure of the IC. The operation of parasitic diodes can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions that cause these diodes to operate, such as applying a voltage lower than the GND voltage to an input pin (and thus to the P substrate) should be avoided.

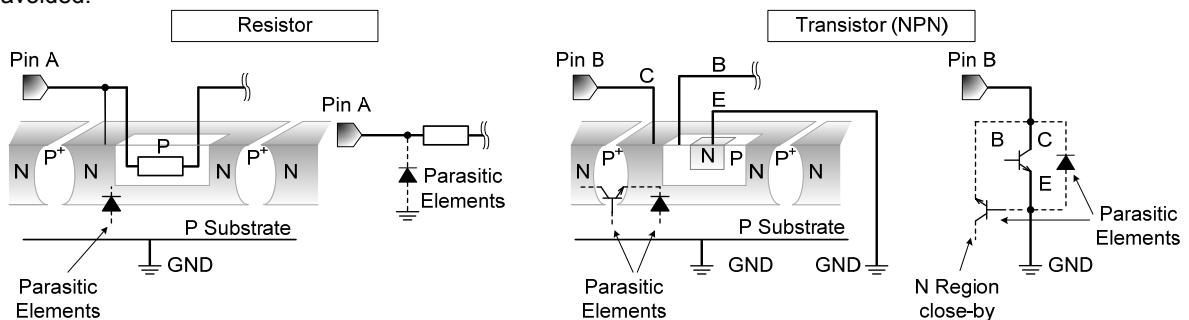


Figure 20. Example of monolithic IC structure

### 13. Ceramic Capacitor

When using a ceramic capacitor, determine the dielectric constant considering the change of capacitance with temperature and the decrease in nominal capacitance due to DC bias and others.

### 14. Area of Safe Operation (ASO)

Operate the IC such that the output voltage, output current, and power dissipation are all within the Area of Safe Operation (ASO).

### 15. Thermal Shutdown Circuit(TSD)

This IC has a built-in thermal shutdown circuit that prevents heat damage to the IC. Normal operation should always be within the IC's power dissipation rating. If however the rating is exceeded for a continued period, the junction temperature ( $T_j$ ) will rise which will activate the TSD circuit that will turn OFF all output pins. When the  $T_j$  falls below the TSD threshold, the circuits are automatically restored to normal operation.

Note that the TSD circuit operates in a situation that exceeds the absolute maximum ratings and therefore, under no circumstances, should the TSD circuit be used in a set design or for any purpose other than protecting the IC from heat damage.

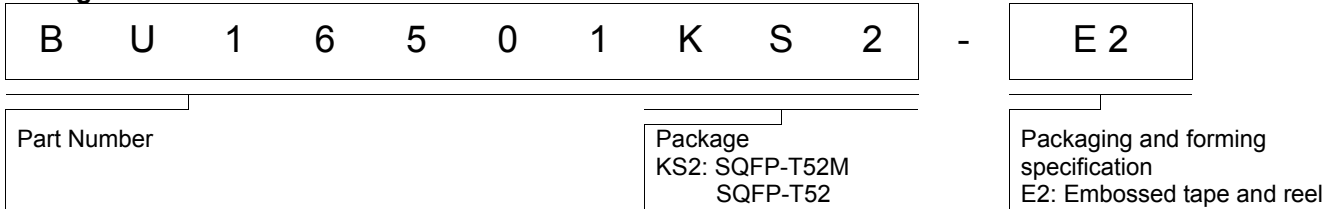
### 16. Over Current Protection Circuit (OCP)

This IC incorporates an integrated overcurrent protection circuit that is activated when the load is shorted. This protection circuit is effective in preventing damage due to sudden and unexpected incidents. However, the IC should not be used in applications characterized by continuous operation or transitioning of the protection circuit.

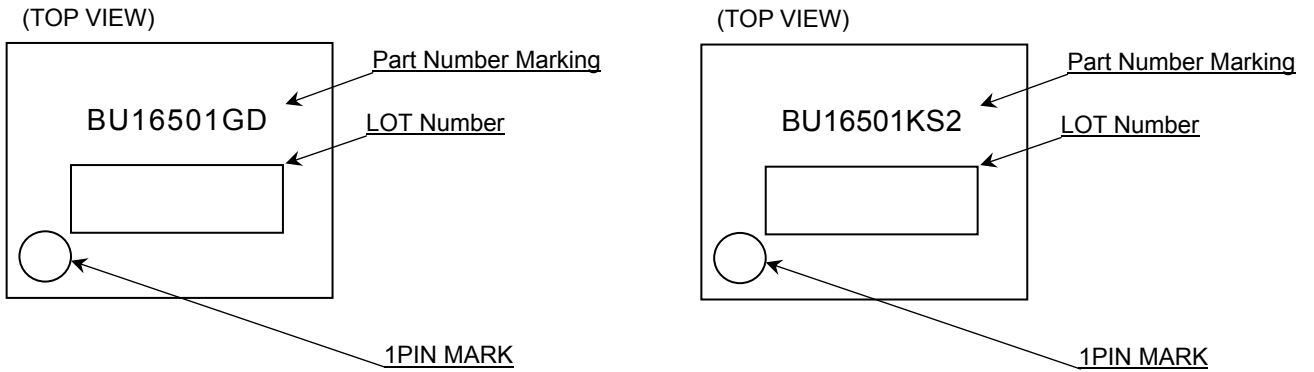
### 17. Disturbance light

In a device where a portion of silicon is exposed to light such as in a WL-CSP, IC characteristics may be affected due to photoelectric effect. For this reason, it is recommended to come up with countermeasures that will prevent the chip from being exposed to light.

Ordering Information



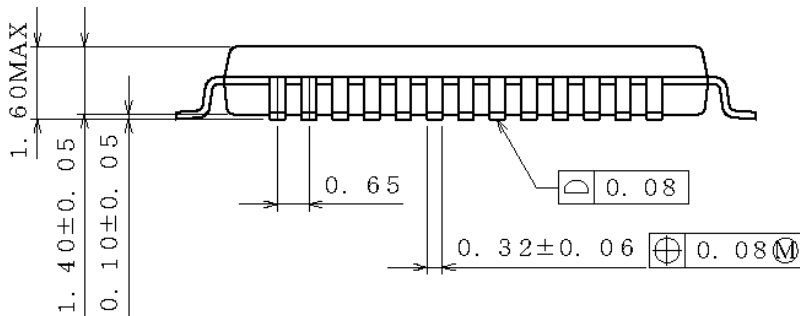
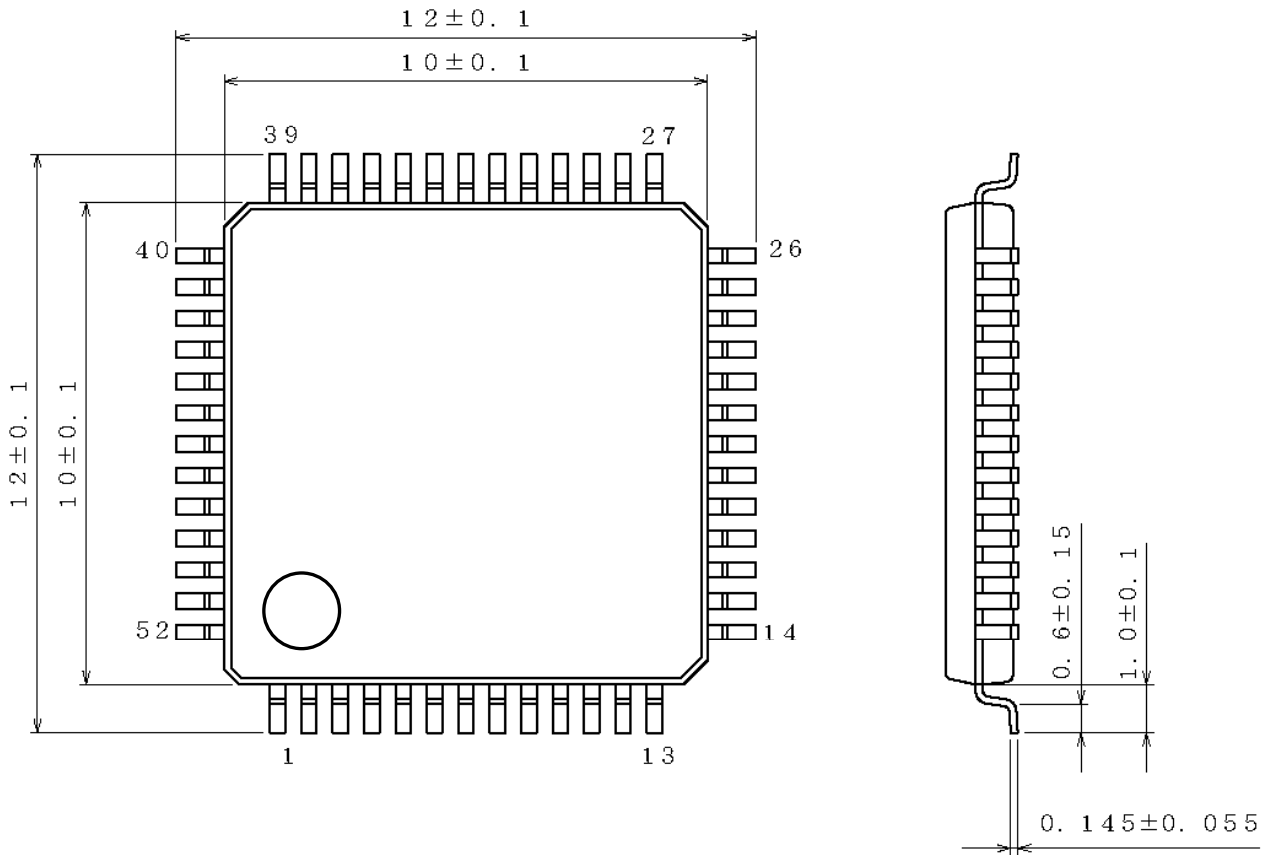
Marking Diagram



| Marking    | Package               | Wire |
|------------|-----------------------|------|
| BU16501GD  | SQFP-T52M<br>SQFP-T52 | Au   |
| BU16501KS2 | SQFP-T52              | Cu   |

Physical Dimensions Tape and Reel Information

|              |           |
|--------------|-----------|
| Package Name | SQFP-T52M |
|--------------|-----------|



(UNIT : mm)

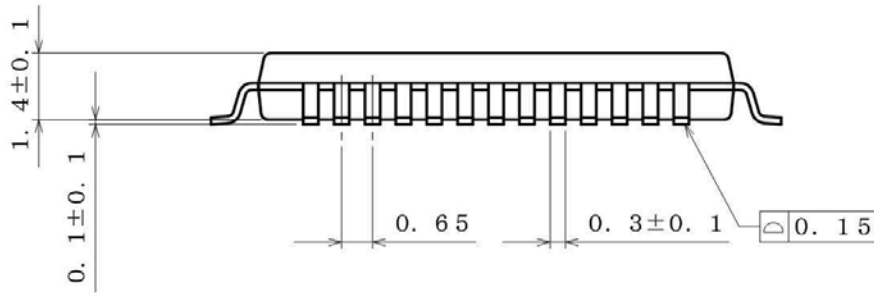
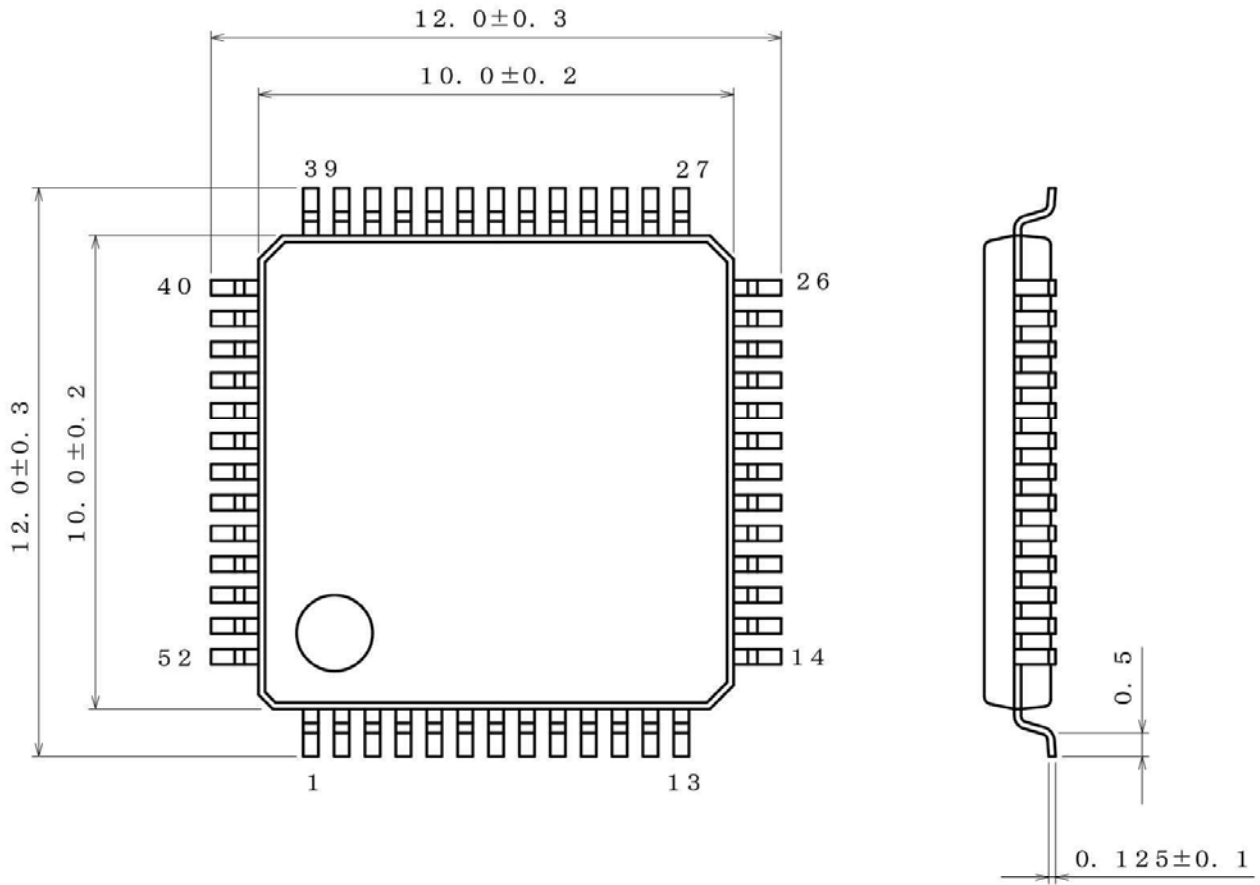
<Tape and Reel information>

|                   |   |
|-------------------|---|
| Tape              | Embossed carrier tape   |
| Quantity          | 1000pcs   |
| Direction of feed | E2<br>( The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand ) |

\* Order quantity needs to be multiple of the minimum quantity.

Physical Dimension, Tape and Reel Information

|              |          |
|--------------|----------|
| Package Name | SQFP-T52 |
|--------------|----------|



(UNIT : mm)  
 PKG : SQFP-T52  
 Drawing No. B0033

<Tape and Reel information>

|                   |   |
|-------------------|---|
| Tape              | Embossed carrier tape   |
| Quantity          | 1000pcs   |
| Direction of feed | E2<br>( The direction is the 1pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand ) |

\* Order quantity needs to be multiple of the minimum quantity.

## Revision History

| Date        | Revision | Changes                                       |
|-------------|----------|---|
| 01.Oct.2013 | 001      | New Release                                   |
| 04.Sep.2014 | 002      | Additional SQFP-T52 package and marking image |
| 14.Mar.2016 | 003      | Modified the marking                          |

# Notice

## Precaution on using ROHM Products

- Our Products are designed and manufactured for application in ordinary electronic equipments (such as AV equipment, OA equipment, telecommunication equipment, home electronic appliances, amusement equipment, etc.). If you intend to use our Products in devices requiring extremely high reliability (such as medical equipment <sup>(Note 1)</sup>, transport equipment, traffic equipment, aircraft/spacecraft, nuclear power controllers, fuel controllers, car equipment including car accessories, safety devices, etc.) and whose malfunction or failure may cause loss of human life, bodily injury or serious damage to property ("Specific Applications"), please consult with the ROHM sales representative in advance. Unless otherwise agreed in writing by ROHM in advance, ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of any ROHM's Products for Specific Applications.

(Note1) Medical Equipment Classification of the Specific Applications

| JAPAN     | USA       | EU         | CHINA     |
|-----------|-----------|------------|-----------|
| CLASS III | CLASS III | CLASS II b | CLASS III |
| CLASS IV  |           | CLASS III  |           |

- ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
  - Installation of protection circuits or other protective devices to improve system safety
  - Installation of redundant circuits to reduce the impact of single or multiple circuit failure
- Our Products are designed and manufactured for use under standard conditions and not under any special or extraordinary environments or conditions, as exemplified below. Accordingly, ROHM shall not be in any way responsible or liable for any damages, expenses or losses arising from the use of any ROHM's Products under any special or extraordinary environments or conditions. If you intend to use our Products under any special or extraordinary environments or conditions (as exemplified below), your independent verification and confirmation of product performance, reliability, etc. prior to use, must be necessary:
  - Use of our Products in any types of liquid, including water, oils, chemicals, and organic solvents
  - Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
  - Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
  - Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
  - Sealing or coating our Products with resin or other coating materials
  - Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
  - Use of the Products in places subject to dew condensation
- The Products are not subject to radiation-proof design.
- Please verify and confirm characteristics of the final or mounted products in using the Products.
- In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse. is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.
- De-rate Power Dissipation depending on ambient temperature. When used in sealed area, confirm that it is the use in the range that does not exceed the maximum junction temperature.
- Confirm that operation temperature is within the specified range described in the product specification.
- ROHM shall not be in any way responsible or liable for failure induced under deviant condition from what is defined in this document.

## Precaution for Mounting / Circuit board design

- When a highly active halogenous (chlorine, bromine, etc.) flux is used, the residue of flux may negatively affect product performance and reliability.
- In principle, the reflow soldering method must be used on a surface-mount products, the flow soldering method must be used on a through hole mount products. If the flow soldering method is preferred on a surface-mount products, please consult with the ROHM representative in advance.

For details, please refer to ROHM Mounting specification

### Precautions Regarding Application Examples and External Circuits

1. If change is made to the constant of an external circuit, please allow a sufficient margin considering variations of the characteristics of the Products and external components, including transient characteristics, as well as static characteristics.
2. You agree that application notes, reference designs, and associated data and information contained in this document are presented only as guidance for Products use. Therefore, in case you use such information, you are solely responsible for it and you must exercise your own independent verification and judgment in the use of such information contained in this document. ROHM shall not be in any way responsible or liable for any damages, expenses or losses incurred by you or third parties arising from the use of such information.

### Precaution for Electrostatic

This Product is electrostatic sensitive product, which may be damaged due to electrostatic discharge. Please take proper caution in your manufacturing process and storage so that voltage exceeding the Products maximum rating will not be applied to Products. Please take special care under dry condition (e.g. Grounding of human body / equipment / solder iron, isolation from charged objects, setting of Ionizer, friction prevention and temperature / humidity control).

### Precaution for Storage / Transportation

1. Product performance and soldered connections may deteriorate if the Products are stored in the places where:
  - [a] the Products are exposed to sea winds or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - [b] the temperature or humidity exceeds those recommended by ROHM
  - [c] the Products are exposed to direct sunshine or condensation
  - [d] the Products are exposed to high Electrostatic
2. Even under ROHM recommended storage condition, solderability of products out of recommended storage time period may be degraded. It is strongly recommended to confirm solderability before using Products of which storage time is exceeding the recommended storage time period.
3. Store / transport cartons in the correct direction, which is indicated on a carton with a symbol. Otherwise bent leads may occur due to excessive stress applied when dropping of a carton.
4. Use Products within the specified time after opening a humidity barrier bag. Baking is required before using Products of which storage time is exceeding the recommended storage time period.

### Precaution for Product Label

A two-dimensional barcode printed on ROHM Products label is for ROHM's internal use only.

### Precaution for Disposition

When disposing Products please dispose them properly using an authorized industry waste company.

### Precaution for Foreign Exchange and Foreign Trade act

Since concerned goods might be fallen under listed items of export control prescribed by Foreign exchange and Foreign trade act, please consult with ROHM in case of export.

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