

# Multi-function LCD Segment Drivers

## BU97981xxx Series MAX 196 Segments (SEG49xCOM4)

### Features

- Integrated RAM for Display Data (DDRAM):  
49 x4 Bit (Max 196 Segment)
- LCD Drive Output:  
4 Common Output, Max 49 Segment Output
- Integrated 3ch LED Driver Circuit
- Segment/ LED (Max 3port) Output Mode Selectable
- Segment/ GPO (Max 31port) Output Mode Selectable
- Support PWM Generation from Ext. or Internal Clock  
(Resolution: 8bit Mode/12bit Mode Selectable)
- Support Standby Mode
- Integrated Power-on-Reset Circuit (POR)
- Integrated Oscillator Circuit
- No External Component
- Low Power Consumption Design
- Independent Power Supply for LCD Driving
- Support Blink Function  
(Blink Frequency 1.6, 2.0, 2.6, 4.0Hz selectable)

### Key Specifications

- Supply Voltage Range: +1.8V to +3.6V
- LCD Drive Power Supply Range: +3.3V to +5.5V
- Operating Temperature Range: -30°C to +75°C
- Max Segments:
 

|            |              |
|------------|--------------|
| BU97981KV  | 196 Segments |
| BU97981MUV | 168 Segments |
| BU97981GU  | 196 Segments |
- Max GPO Outputs:
 

|            |        |
|------------|--------|
| BU97981KV  | 31port |
| BU97981MUV | 27port |
| BU97981GU  | 31port |
- Max LED Drive Outputs:
 

|            |       |
|------------|-------|
| BU97981KV  | 3port |
| BU97981MUV | 3port |
| BU97981GU  | 3port |
- Display Duty: Static. 1/3, 1/4 Selectable
- Bias: Static, 1/3
- Integrated Regulator for LCD Drive:  
3.2, 3.3, 3.4, 4.4, 4.5, 4.6, 5.0V Selectable
- Interface: 3wire Serial Interface

### Applications

- Telephone
  - FAX
  - Portable Equipment (POS, ECR, PDA etc.)
  - DSC
  - DVC
  - Car audio
  - Home Electrical Appliance
  - Meter Equipment
- etc.

### Typical Application Circuit

BU97981KV LED/GPO using case  
LED : 3port  
GPO : 5port  
LCD :164seg

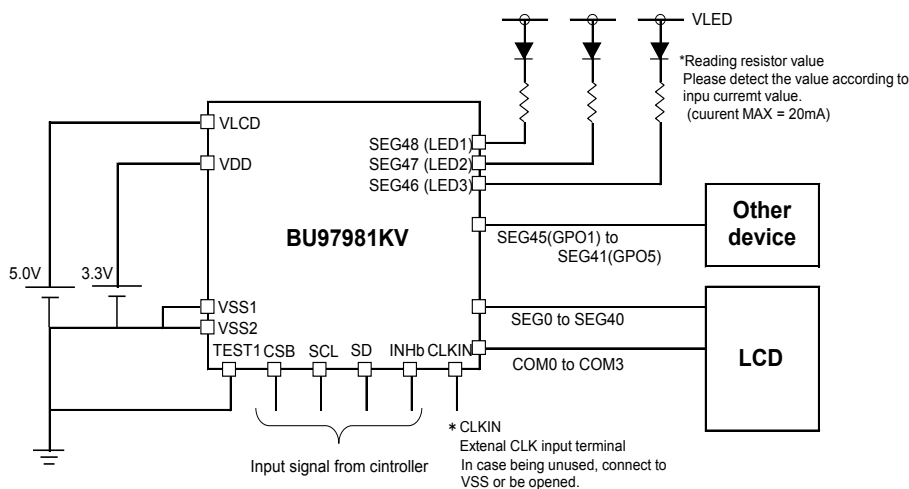


Figure 1. Typical Application Circuit

Block Diagram / Pin Arrangement / Pin Description

BU97981KV

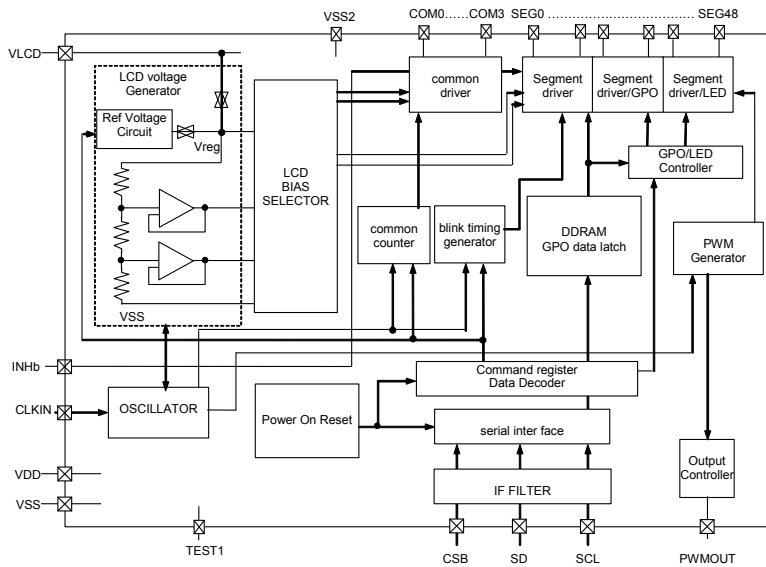


Figure 2. Block Diagram

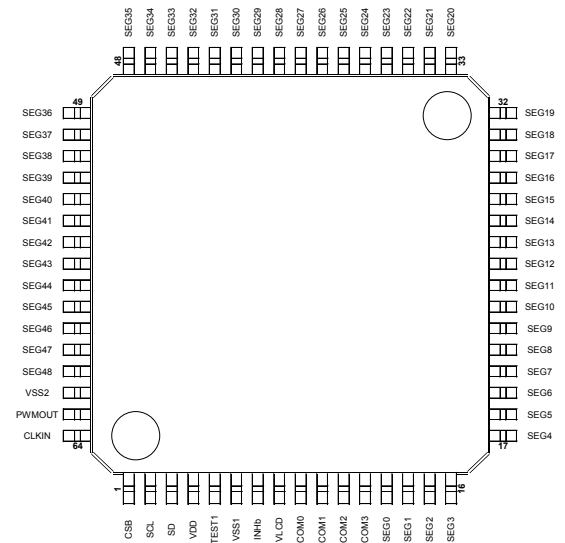


Figure 3. Pin Configuration (TOP VIEW)

Table 1. Pin Description

| Terminal    | Terminal number | I/O | Unused case | Function  |
|-------------|-----------------|-----|-------------|---|
| CSB         | 1               | I   | -           | Chip select: "L" active   |
| SCL         | 2               | I   | -           | Serial data transfer clock  |
| SD          | 3               | I   | -           | Input serial data   |
| VDD         | 4               | -   | -           | Power supply for LOGIC  |
| CLKIN       | 64              | I   | OPEN / VSS  | External clock input terminal (for display/PWM using selectable)<br>Support Hi-Z input mode at internal clock mode  |
| TEST1       | 5               | I   | -           | TEST terminal (Please connect VSS terminal)   |
| VSS1        | 6               | -   | -           | GND   |
| VLCD        | 8               | -   | -           | Power supply for LCD  |
| INHb        | 7               | I   | VDD         | Display turning on/off select terminal<br>H: turning on display, L: turning off display<br><br>INHb = "L": All SEG/COM terminal : output VSS level<br>GPO terminal : output VSS level<br>LED drive terminal : output Hi-Z |
| PWMOUT      | 63              | O   | OPEN        | PWM output for LED2 group   |
| COM0 to 3   | 9 to 12         | O   | OPEN        | COMMON output for LCD   |
| SEG0 to 14  | 13 to 27        | O   | OPEN        | SEGMENT output for LCD  |
| SEG15 to 45 | 28 to 58        | O   | OPEN        | SEGMENT output for LCD/GPO  |
| SEG46 to 48 | 59 to 61        | O   | OPEN        | SEGMENT output for LCD/LED driver   |
| VSS2        | 62              | -   | GND         | GND (for SEG46-48 / LED driver)   |

Block Diagram / Pin Arrangement / Pin Description

BU97981MUV

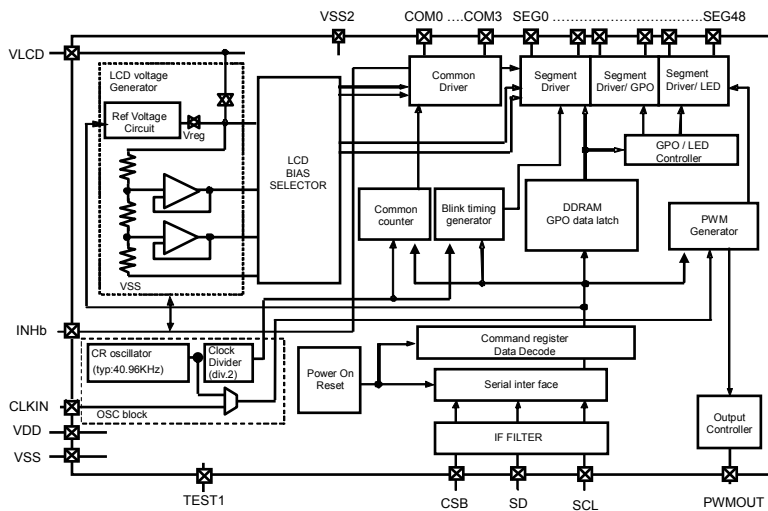


Figure 4. Block Diagram

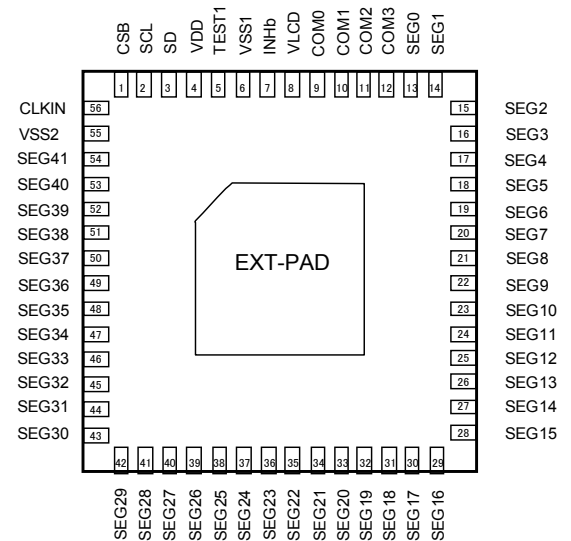


Figure 5. Pin Configuration (BOTTOM VIEW)

Table 2. Pin Description

| Terminal | Terminal number | I/O | Unused case | Function  |
|----------|-----------------|-----|-------------|---|
| CSB      | 1               | I   | -           | Chip select: "L" active   |
| SCL      | 2               | I   | -           | Serial data transfer clock  |
| SD       | 3               | I   | -           | Input serial data   |
| VDD      | 4               | -   | -           | Power supply for LOGIC  |
| CLKIN    | 56              | I   | OPEN / VSS  | External clock input terminal (for display/PWM using selectable)<br>Support Hi-Z input mode at internal clock mode  |
| TEST1    | 5               | I   | -           | TEST terminal (Please connect VSS terminal)   |
| VSS1     | 6               | -   | -           | GND   |
| VLCD     | 8               | -   | -           | Power supply for LCD  |
| INHb     | 7               | I   | VDD         | Display turning on/off select terminal<br>H: turning on display, L: turning off display<br><br>INHb = "L": All SEG/COM terminal : output VSS level<br>GPO terminal : output VSS level<br>LED drive terminal : output Hi-Z |
| COM0~3   | 9-12            | O   | OPEN        | COMMON output for LCD   |
| SEG0~11  | 13-24           | O   | OPEN        | SEGMENT output for LCD  |
| SEG12~38 | 25-51           | O   | OPEN        | SEGMENT output for LCD/GPO  |
| SEG39~41 | 52-54           | O   | OPEN        | SEGMENT output for LCD/LED driver   |
| VSS2     | 55              | -   | GND         | GND (for SEG39-41 / LED driver)   |
| EXT-PAD  | _(Note1)        | -   | VSS         | substrate   |

(Note1) To radiate heat, please contact a board with the EXT-PAD which is located at the bottom side of VQFN56AV8080 package.  
Please supply VSS level or Open state as the input condition for this PAD.

Block Diagram / Pin Arrangement / Pin Description

BU97981GU

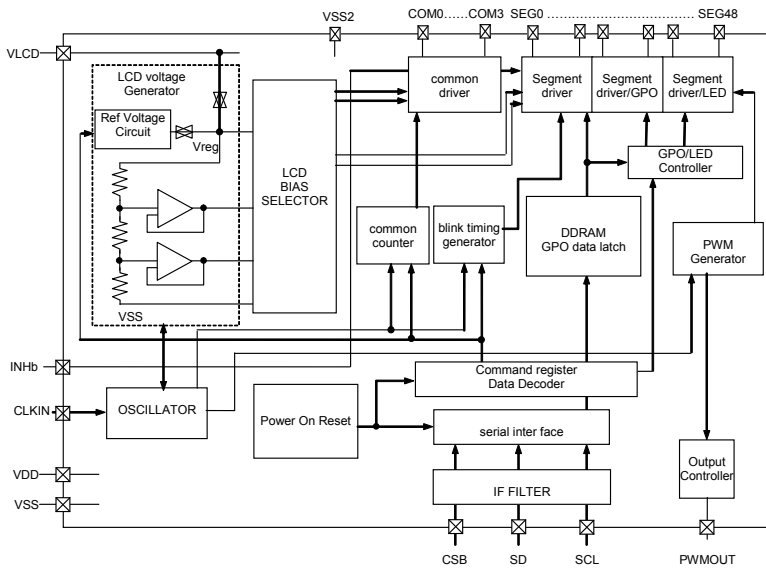


Figure 6. Block Diagram

|   |      |         |       |       |       |       |       |       |
|---|------|---------|-------|-------|-------|-------|-------|-------|
|   | 1    | 2       | 3     | 4     | 5     | 6     | 7     | 8     |
| H | SEG4 | SEG5    | SEG9  | SEG11 | SEG14 | SEG16 | SEG18 | SEG20 |
| G | SEG2 | SEG3    | SEG7  | SEG8  | SEG12 | SEG17 | SEG19 | SEG21 |
| F | SEG0 | SEG1    | SEG6  | SEG10 | SEG13 | SEG22 | SEG23 | SEG25 |
| E | COM2 | COM0    | COM1  | COM3  | SEG15 | SEG26 | SEG24 | SEG27 |
| D | VLCD | VDD     | INHb  | SEG47 | SEG31 | SEG29 | SEG28 | SEG30 |
| C | VSS1 | SDA     | SCL   | SEG45 | SEG42 | SEG38 | SEG33 | SEG32 |
| B | (NC) | CLKIN   | VSS2  | SEG44 | SEG40 | SEG39 | SEG35 | SEG34 |
| A | CSB  | PWM OUT | SEG48 | SEG46 | SEG43 | SEG41 | SEG37 | SEG36 |

Figure 7. Pin Configuration (TOP VIEW)

Table 3. Pin Description

| Terminal    | I/O | Unused case | Function  |
|-------------|-----|-------------|---|
| CSB         | I   | -           | Chip select: "L" active   |
| SCL         | I   | -           | Serial data transfer clock  |
| SD          | I   | -           | Input serial data   |
| VDD         | -   | -           | Power supply for LOGIC  |
| CLKIN       | I   | OPEN / VSS  | External clock input terminal (for display/PWM using selectable)<br>Support Hi-Z input mode at internal clock mode  |
| VSS1        | -   | -           | GND   |
| VLCD        | -   | -           | Power supply for LCD  |
| INHb        | I   | VDD         | Display turning on/off select terminal<br>H: turning on display, L: turning off display<br>INHb = "L": All SEG/COM terminal : output VSS level<br>GPO terminal : output VSS level<br>LED drive terminal : output Hi-Z |
| PWMOUT      | O   | OPEN        | PWM output for LED2 group   |
| COM0 to 3   | O   | OPEN        | COMMON output for LCD   |
| SEG0 to 14  | O   | OPEN        | SEGMENT output for LCD  |
| SEG15 to 45 | O   | OPEN        | SEGMENT output for LCD/GPO  |
| SEG46 to 48 | O   | OPEN        | SEGMENT output for LCD/LED driver   |
| VSS2        | -   | GND         | GND (for SEG46-48 / LED driver)   |

**Absolute Maximum Ratings** (VSS=0V)

| Parameter                     | Symbol | Ratings                | Unit | Remarks              |
|-------------------------------|--------|------------------------|------|----------------------|
| Power Supply Voltage 1        | VDD    | -0.3 to +4.5           | V    | Power supply         |
| Power Supply Voltage 2        | VLCD   | -0.5 to +7.0           | V    | Power supply for LCD |
| Power Dissipation             | Pd     | 1.0 <sup>(Note1)</sup> | W    | BU97981KV            |
|                               |        | 3.6 <sup>(Note2)</sup> |      | BU97981MUV           |
|                               |        | 0.8 <sup>(Note3)</sup> |      | BU97981GU            |
| Input Voltage Range           | VIN    | -0.5 to VDD+0.5        | V    |                      |
| Operational Temperature Range | Topr   | -30 to +75             | °C   |                      |
| Storage Temperature Range     | Tstg   | -55 to +125            | °C   |                      |
| Output Current                | lout1  | 5                      | mA   | SEG output           |
|                               | lout2  | 5                      | mA   | COM output           |
|                               | lout3  | 10                     | mA   | GPO output           |
|                               | lout4  | 50                     | mA   | LED output           |

(Note1) When use more than Ta=25°C, subtract 10mW per degree. (using ROHM standard board)  
(board size : 70mm×70mm×1.6mm material: FR4 board copper foil: land pattern only).

(Note2) When use more than Ta=25°C, subtract 36mW per degree. (using ROHM standard board)  
(board size : 74.2mm×74.2mm×1.6mm SEMI standard 4 layer board)

(Note3) When operated higher than Ta=25°C, subtract 8.0mW per degree. (using ROHM standard board)  
(board size : 114.3mm×76.2mm×1.6mm)

**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 Conditions** (Ta=-30°C to +75°C, VSS=0V)

| Parameter              | Symbol | Ratings |     |      | Unit | Remarks                |
|------------------------|--------|---------|-----|------|------|------------------------|
|                        |        | Min     | Typ | Max  |      |                        |
| Power Supply Voltage 1 | VDD    | 1.8     | -   | 3.6  | V    | Power supply           |
| Power Supply Voltage 2 | VLCD   | 3.3     | -   | 5.5  | V    | Power supply for LCD   |
| LED Supply Voltage     | VLED   | 1.0     | -   | VLCD | V    | Power supply for LED   |
| Output Current         | lout4  | -       | -   | 20   | mA   | Per LED port 1ch       |
|                        | lout4  | -       | -   | 60   | mA   | Total LED port current |

## Electrical Characteristics

DC characteristics (Ta=-30°C to +75°C, VDD=1.8V to 3.6V, VLCD=3.3V to 5.5V, VSS=0)  
(BU97981KV, BU97981GU)

| Parameter                             | Symbol              | Limits       |      |        | Unit | Conditions  |
|---------------------------------------|---------------------|--------------|------|--------|------|---|
|                                       |                     | Min          | Typ  | Max    |      |   |
| "H" level Input Voltage               | VIH                 | 0.8VDD       | -    | VDD    | V    | SD, SCL, CSB, TEST1 <sup>(Note4)</sup> , CLKIN, INHb  |
| "L" level Input Voltage               | VIL                 | VSS          | -    | 0.2VDD | V    | SD, SCL, CSB, TEST1 <sup>(Note4)</sup> , CLKIN, INHb  |
| Hysteresis Width                      | VH                  | -            | 0.2  | -      | V    | SCL, INHb, VDD=3.3V, Ta=25°C  |
| "H" Level Input Current               | I <sub>IH1</sub>    | -            | -    | 5      | μA   | SD, SCL, CSB, CLKIN, INHb, VI=3.6V  |
| "L" Level Input Current               | I <sub>IL1</sub>    | -5           | -    | -      | μA   | SD, SCL, CSB, CLKIN, INHb, TEST1 <sup>(Note4)</sup> , VI=0V   |
| "H" Level Output Voltage<br>(Note1&3) | VOH1                | VLCD<br>-0.4 | -    | -      | V    | Iload=-50μA, VLCD=5.0V<br>SEG0 to SEG48,<br>Unused integrated regulator   |
|                                       | VOH2                | VLCD<br>-0.4 | -    | -      | V    | Iload=-50μA, VLCD=5.0V,<br>COM0 to COM3,<br>Unused integrated regulator   |
|                                       | VOH3                | VLCD<br>-0.6 | -    | -      | V    | Iload=-1mA, VLCD=5.0V,<br>SEG15 to SEG45 (GPO mode)<br>Unused integrated regulator  |
|                                       | VOH4                | VDD<br>-0.6  | -    | -      | V    | Iload=-1mA, VDD=3.0V, PWMOUT  |
| "L" Level Output Voltage (Note3)      | VOL1                | -            | -    | 0.4    | V    | Iload= 50μA, VLCD=5.0V, SEG0 to SEG48   |
|                                       | VOL2                | -            | -    | 0.4    | V    | Iload= 50μA, VLCD=5.0V, COM0 to COM3  |
|                                       | VOL3                | -            | -    | 0.5    | V    | Iload=1mA, VLCD=5.0V,<br>SEG15 to SEG45 (GPO mode), PWMOUT  |
|                                       | VOL4                | -            | 0.11 | 0.5    | V    | Iload=20mA, VLCD=5.0V,<br>SEG46 to 48 (LED drive mode)  |
| Current Consumption (Note2)           | I <sub>stVDD</sub>  | -            | 3    | 10     | μA   | Input terminal ALL'L',<br>Display off, Oscillation off  |
|                                       | I <sub>stVLCD</sub> | -            | 0.5  | 5      | μA   | Input terminal ALL'L',<br>Display off, Oscillation off  |
|                                       | I <sub>VDD1</sub>   | -            | 8    | 15     | μA   | VDD=3.3V, Ta=25 C, 1/3bias, fFR=64Hz,<br>PWM generate off,<br>All output pin open   |
|                                       | I <sub>VDD2</sub>   | -            | 90   | 130    | μA   | VDD=3.3V, Ta=25 C, 1/3bias, fFR=64Hz,<br>PWM Frequency=500Hz setting,<br>All output pin open                                |
|                                       | I <sub>VLCD1</sub>  | -            | 10   | 15     | μA   | VLCD=5.0V, Ta=25 C, 1/3bias, fFR=64Hz,<br>Unused Integrated regulator,<br>LED generate off,<br>All output pin open          |
|                                       | I <sub>VLCD2</sub>  | -            | 25   | 40     | μA   | VLCD=5.0V, Ta=25 C, 1/3bias, fFR=64Hz,<br>Used Integrated regulator,<br>LED generate off,<br>All output pin open            |
|                                       | I <sub>VLCD3</sub>  | -            | 30   | 48     | μA   | VLCD=5.0V, Ta=25 C, 1/3bias, fFR=64Hz,<br>Used Integrated regulator,<br>PWM Frequency=500Hz setting,<br>All output pin open |

(Note1) Integrated regulator using case, please add load regulation value to output voltage listed above.

(Note2) Power save mode 1 and frame inversion setting

(Note3) Iload: In case, load current from only one port

(Note4) There is not TEST1 port in BU97981GU

## Electrical Characteristics – Continued

DC characteristics (Ta=-30°C to +75°C, VDD=1.8V to 3.6V, VLCD=3.3V to 5.5V, VSS=0)  
(BU97981MUV)

| Parameter                             | Symbol           | Limits       |      |        | Unit | Conditions  |
|---------------------------------------|------------------|--------------|------|--------|------|---|
|                                       |                  | Min          | Typ  | Max    |      |   |
| "H" level Input Voltage               | VIH              | 0.8VDD       | -    | VDD    | V    | SD, SCL, CSB, TEST1,CLKIN, INHb   |
| "L" level Input Voltage               | VIL              | VSS          | -    | 0.2VDD | V    | SD, SCL, CSB, TEST1,CLKIN, INHb   |
| Hysteresis Width                      | VH               | -            | 0.2  | -      | V    | SCL, INHb, VDD=3.3V, Ta=25°C  |
| "H" level Input Current               | I <sub>IH1</sub> | -            | -    | 5      | μA   | SD, SCL, CSB, CLKIN, INHb, VI=3.6V  |
| "L" level Input Current               | I <sub>IL1</sub> | -5           | -    | -      | μA   | SD, SCL, CSB, CLKIN, INHb, TEST1, VI=0V   |
| "H" Level Output Voltage<br>(Note1&3) | VOH1             | VLCD<br>-0.4 | -    | -      | V    | Iload=-50μA, VLCD=5.0V<br>SEG0 to SEG41,<br>Unused integrated regulator   |
|                                       | VOH2             | VLCD<br>-0.4 | -    | -      | V    | Iload=-50μA, VLCD=5.0V,<br>COM0 to COM3,<br>Unused integrated regulator   |
|                                       | VOH3             | VLCD<br>-0.6 | -    | -      | V    | Iload=-1mA,VLCD=5.0V,<br>SEG12 to SEG38 (GPO mode)<br>Unused integrated regulator   |
| "L" Level Output Voltage (Note3)      | VOL1             | -            | -    | 0.4    | V    | Iload= 50μA, VLCD=5.0V, SEG0 to SEG41   |
|                                       | VOL2             | -            | -    | 0.4    | V    | Iload= 50μA, VLCD=5.0V, COM0 to COM3  |
|                                       | VOL3             | -            | -    | 0.5    | V    | Iload=1mA, VLCD=5.0V,<br>SEG12 to SEG38 (GPO mode), PWMOUT  |
|                                       | VOL4             | -            | 0.11 | 0.5    | V    | Iload=20mA, VLCD=5.0V,<br>SEG39 to SEG41 (LED drive mode)   |
| Current Consumption (Note2)           | IstVDD           | -            | 3    | 10     | μA   | Input terminal ALL'L',<br>Display off, Oscillation off  |
|                                       | IstVLCD          | -            | 0.5  | 5      | μA   | Input terminal ALL'L',<br>Display off, Oscillation off  |
|                                       | IVDD1            | -            | 8    | 15     | μA   | VDD=3.3V, Ta=25 C, 1/3bias, fFR=64Hz,<br>PWM generate off,<br>All output pin open   |
|                                       | IVDD2            | -            | 90   | 130    | μA   | VDD=3.3V, Ta=25 C, 1/3bias, fFR=64Hz,<br>PWM Frequency=500Hz setting,<br>All output pin open                                |
|                                       | IVLCD1           | -            | 10   | 15     | μA   | VLCD=5.0V, Ta=25 C, 1/3bias, fFR=64Hz,<br>Unused Integrated regulator,<br>LED generate off,<br>All output pin open          |
|                                       | IVLCD2           | -            | 25   | 40     | μA   | VLCD=5.0V, Ta=25 C, 1/3bias, fFR=64Hz,<br>Used Integrated regulator,<br>LED generate off,<br>All output pin open            |
|                                       | IVLCD3           | -            | 30   | 48     | μA   | VLCD=5.0V, Ta=25 C, 1/3bias, fFR=64Hz,<br>Used Integrated regulator,<br>PWM Frequency=500Hz setting,<br>All output pin open |

(Note1) Integrated regulator using case, please add load regulation value to output voltage listed above.

(Note2) Power save mode 1 and frame inversion setting

(Note3) Iload: In case, load current from only one port

## Electrical Characteristics – continued

Integrated Regulator Characteristics (Ta=-30°C to +75°C, VDD=1.8V to 3.6V, VLCD=3.3V to 5.5V, VSS=0)  
(BU97981KV)

| Parameter                          | Symbol        | Limits |     |      | Unit | Conditions  |
|------------------------------------|---------------|--------|-----|------|------|---|
|                                    |               | Min    | Typ | Max  |      |   |
| Output Voltage 1                   | Vreg1         | 4.35   | 4.5 | 4.65 | V    | 4.5V setting (VLCD=5.5V, Ta=-30°C to 75°C)<br>(Note1) |
| Output Voltage 2                   | Vreg2         | 4.42   | 4.5 | 4.58 | V    | 4.5V setting (VLCD=5.5V, Ta=25°C) <sup>(Note1)</sup>  |
| Load Regulation <sup>(Note2)</sup> | delta<br>Vreg | -      | -   | 0.3  | V    | Iout = -300μA   |

(Note1) In case integrated regulator using, please satisfy condition that Vreg output lower than VLCD - 0.5V.

(Note2) Load regulation: Vreg block load regulation only. Do not include other block ability.

(BU97981MUV)

| Parameter                          | Symbol        | Limits |     |      | Unit | Conditions  |
|------------------------------------|---------------|--------|-----|------|------|---|
|                                    |               | Min    | Typ | Max  |      |   |
| Output Voltage 1                   | Vreg1         | 4.30   | 4.5 | 4.70 | V    | 4.5V setting (VLCD=5.5V, Ta=-30°C to 75°C)<br>(Note1) |
| Output Voltage 2                   | Vreg2         | 4.38   | 4.5 | 4.62 | V    | 4.5V setting (VLCD=5.5V, Ta=25°C) <sup>(Note1)</sup>  |
| Load Regulation <sup>(Note2)</sup> | delta<br>Vreg | -      | -   | 0.3  | V    | Iout = -300μA   |

(Note1) In case integrated regulator using, please satisfy condition that Vreg output lower than VLCD - 0.5V.

(Note2) Load regulation: Vreg block load regulation only. Do not include other block ability.

(BU97981GU)

| Parameter                          | Symbol        | Limits |     |      | Unit | Conditions  |
|------------------------------------|---------------|--------|-----|------|------|---|
|                                    |               | Min    | Typ | Max  |      |   |
| Output Voltage 1                   | Vreg1         | 4.25   | 4.5 | 4.70 | V    | 4.5V setting (VLCD=5.5V, Ta=-30°C to 75°C)<br>(Note1) |
| Output Voltage 2                   | Vreg2         | 4.40   | 4.5 | 4.60 | V    | 4.5V setting (VLCD=5.5V, Ta=25°C) <sup>(Note1)</sup>  |
| Load Regulation <sup>(Note2)</sup> | delta<br>Vreg | -      | -   | 0.3  | V    | Iout = -300μA   |

(Note1) In case integrated regulator using, please satisfy condition that Vreg output lower than VLCD - 0.5V.

(Note2) Load regulation: Vreg block load regulation only. Do not include other block ability.

Oscillation Frequency Characteristics (Ta=-30°C to +75°C, VDD=1.8V to 3.6V, VLCD=3.3V to 5.5V, VSS=0)

| Parameter             | Symbol | Limits |     |      | Unit | Conditions                          |
|-----------------------|--------|--------|-----|------|------|-------------------------------------|
|                       |        | Min    | Typ | Max  |      |                                     |
| Frame Frequency 1     | fFR1   | 57.6   | 64  | 70.4 | Hz   | VDD=3.3V, Ta=25°C, fFR=64Hz setting |
| Frame Frequency 2     | fFR2   | 51.2   | 64  | 73.0 | Hz   | VDD=2.5V to 3.6V fFR=64Hz setting   |
| Frame Frequency 3     | fFR3   | 45.0   | -   | 64   | Hz   | VDD=1.8V to 2.5V fFR=64Hz setting   |
| CLKIN Input Frequency | fCLK   | -      | 2   | 4    | MHz  |                                     |

About detail function, please refer to the frame frequency setting of DISCTL command.



MPU Interface Characteristics (Ta=-30°C to +75 °C, VDD=1.8V to 3.6V, VLCD=3.3V to 5.5V, VSS=0)

| Parameter           | Symbol     | Limits |     |     | Unit | Conditions |
|---------------------|------------|--------|-----|-----|------|------------|
|                     |            | Min    | Typ | Max |      |            |
| Input Rise Time     | $t_r$      | -      | -   | 50  | ns   |            |
| Input Fall Time     | $t_f$      | -      | -   | 50  | ns   |            |
| SCL Cycle Time      | $t_{SCYC}$ | 250    | -   | -   | ns   |            |
| "H" SCL Pulse Width | $t_{SHW}$  | 50     | -   | -   | ns   |            |
| "L" SCL Pulse Width | $t_{SLW}$  | 50     | -   | -   | ns   |            |
| SD Setup Time       | $t_{SDS}$  | 50     | -   | -   | ns   |            |
| SD Hold Time        | $t_{SDH}$  | 50     | -   | -   | ns   |            |
| CSB Setup Time      | $t_{CSS}$  | 50     | -   | -   | ns   |            |
| CSB Hold Time       | $t_{CSH}$  | 50     | -   | -   | ns   |            |
| "H" CSB Pulse Width | $t_{CHW}$  | 50     | -   | -   | ns   |            |

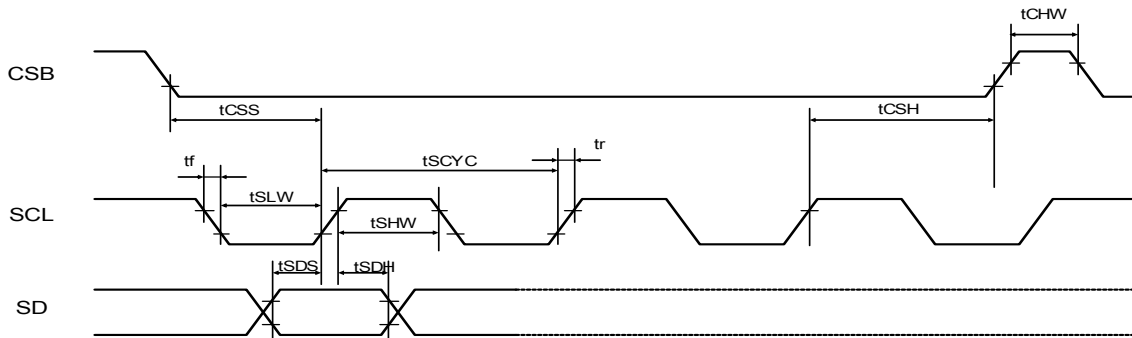


Figure 8. Serial Interface Timing

**I/O Equivalence Circuit**  
(BU97981KV)

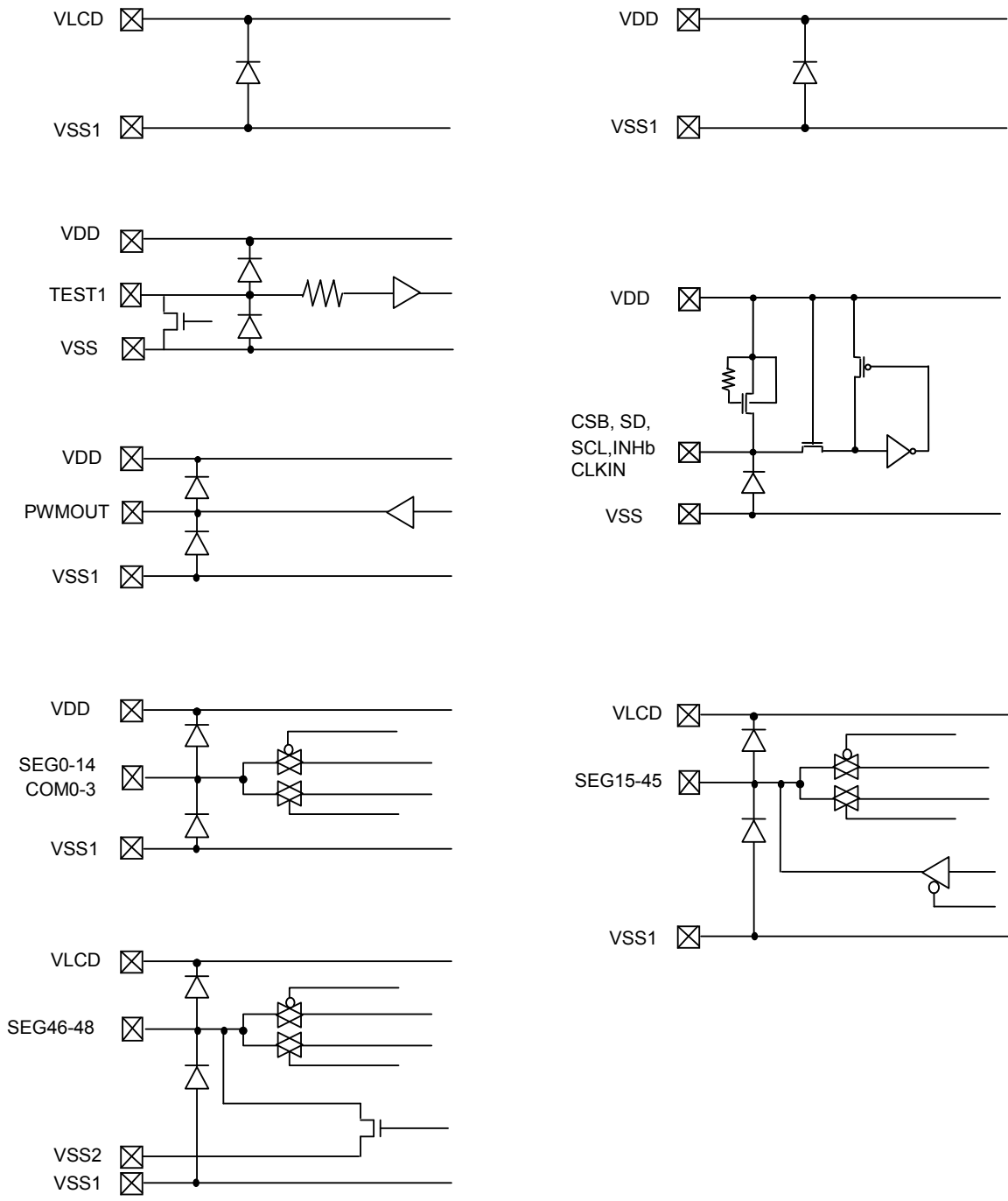


Figure 9. I/O Equivalence Circuit

I/O Equivalence Circuit - Continued  
(BU97981MUV)

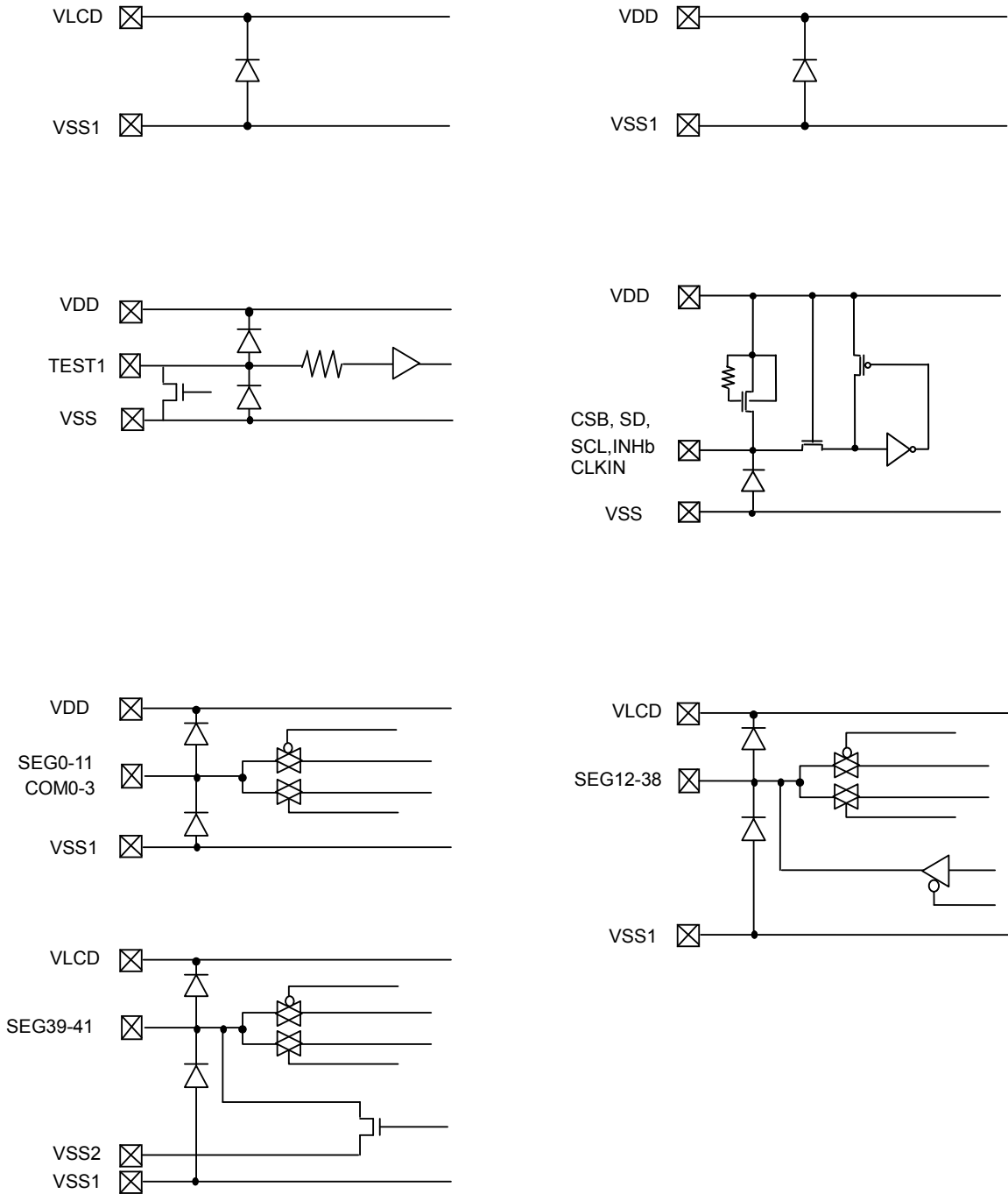


Figure 10. I/O Equivalence Circuit

I/O Equivalence Circuit - Continued  
(BU97981GU)

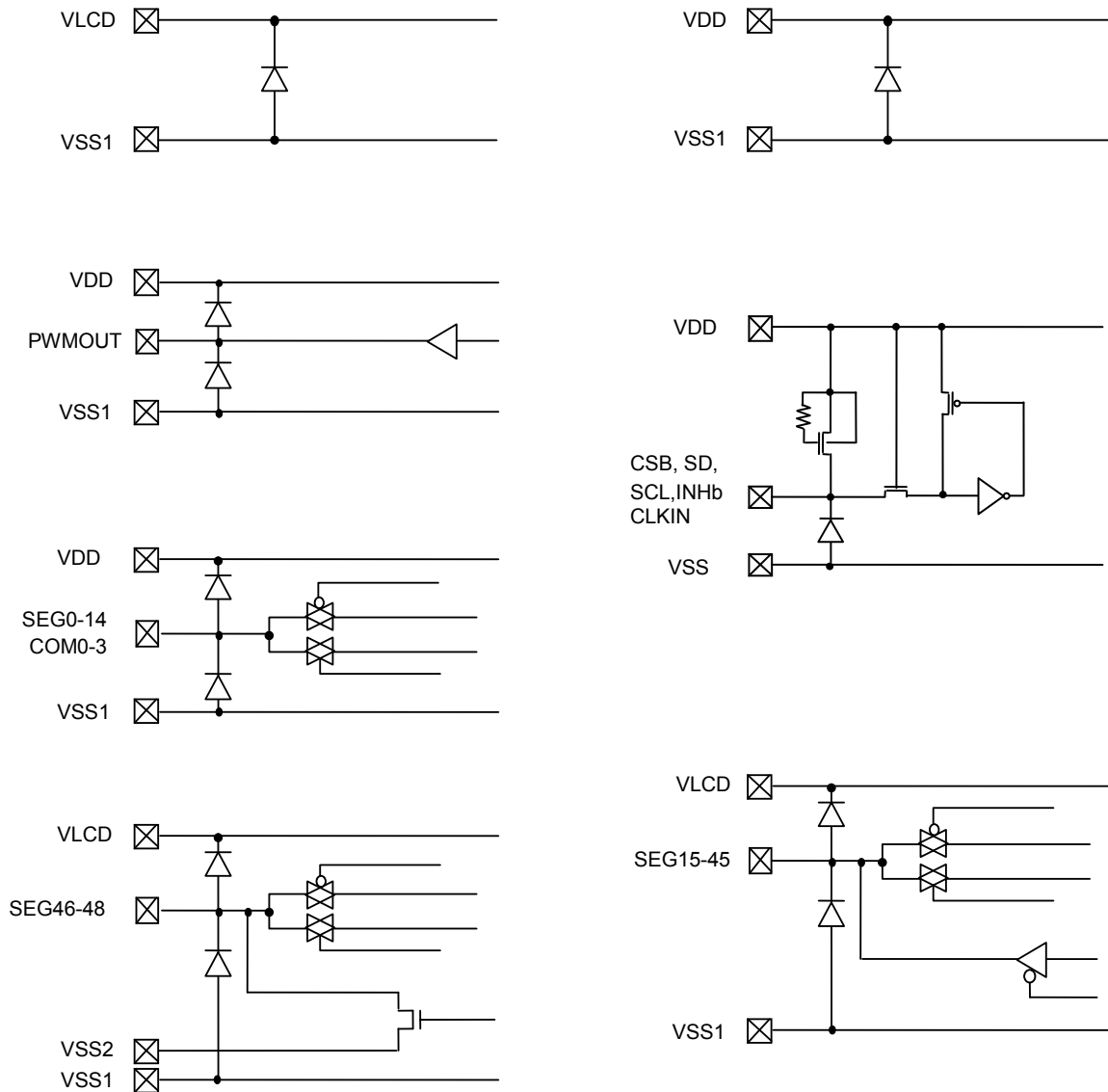


Figure 11. I/O Equivalence Circuit

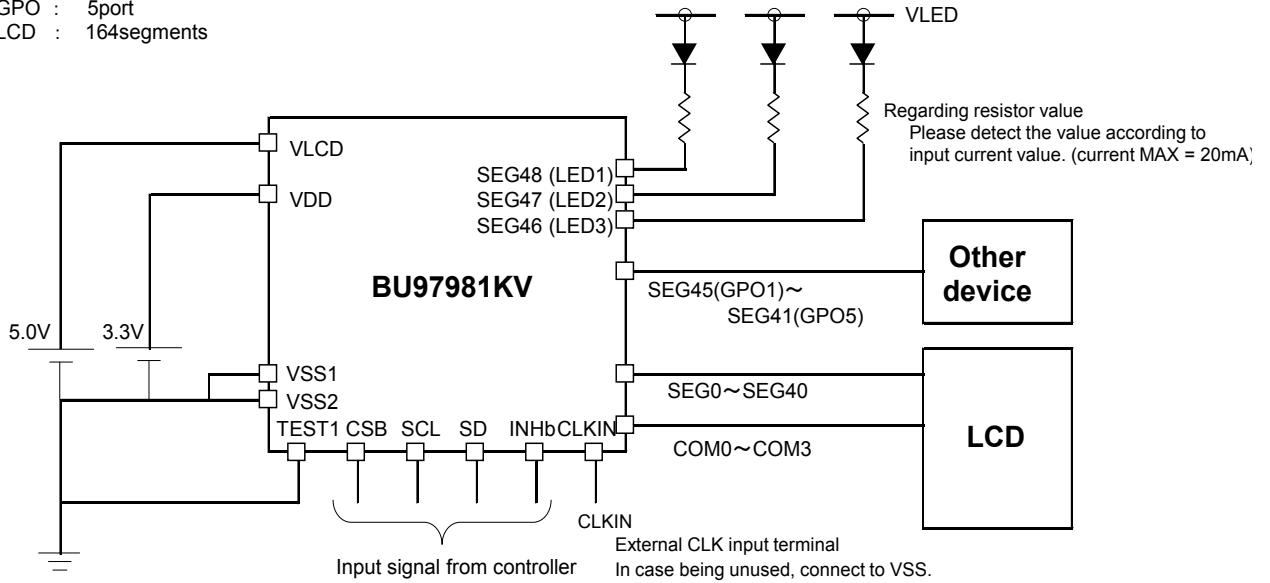
Example of Recommended Circuit

(BU97981KV)

1. LED/GPO Using Case

[LED]&[GPO]

- LED : 3port
- GPO : 5port
- LCD : 164segments



2. SEG Output Only Case

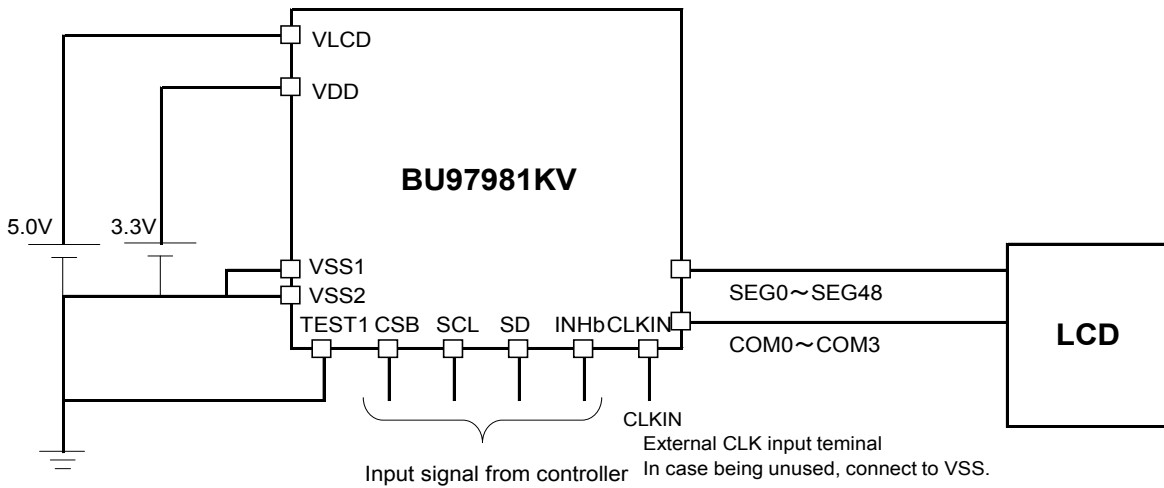


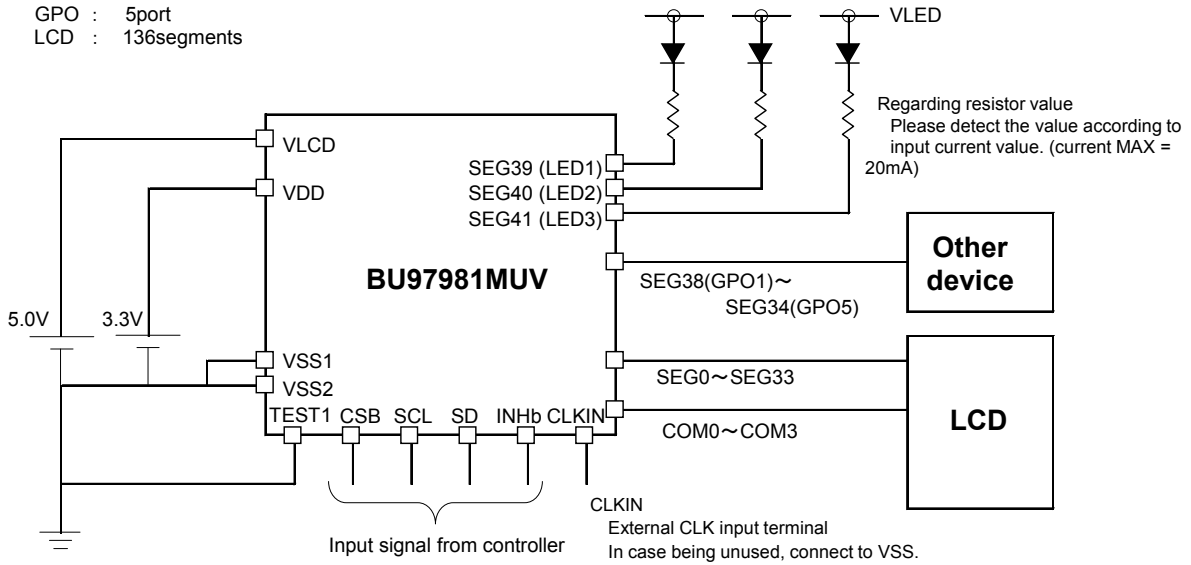
Figure 12. BU97981KV E.g. of Recommended Circuit

Example of Recommended Circuit – Continued

(BU97981MUV)

1. LED/GPO Using Case

LED : 3port  
 GPO : 5port  
 LCD : 136segments



2. SEG Output Only Case

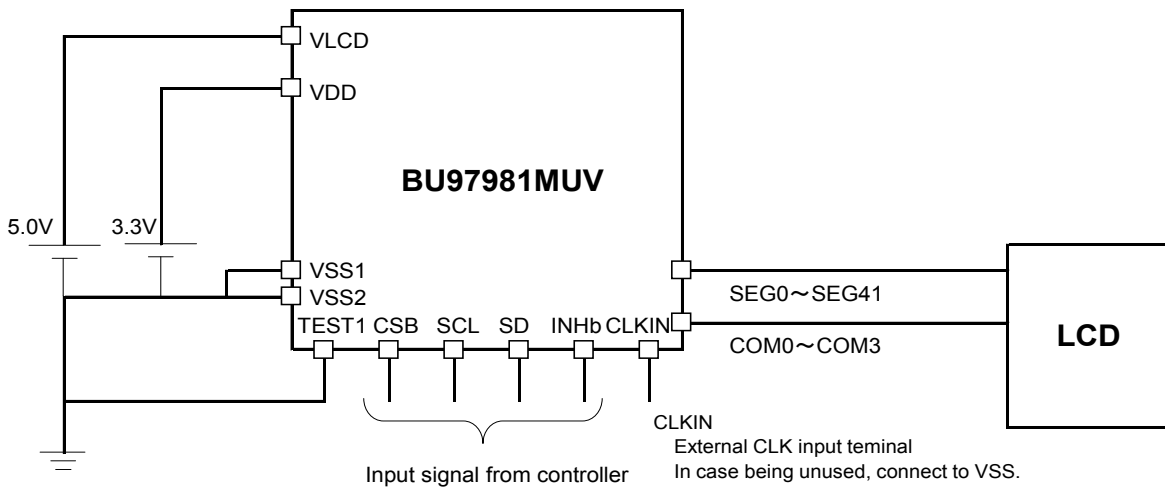


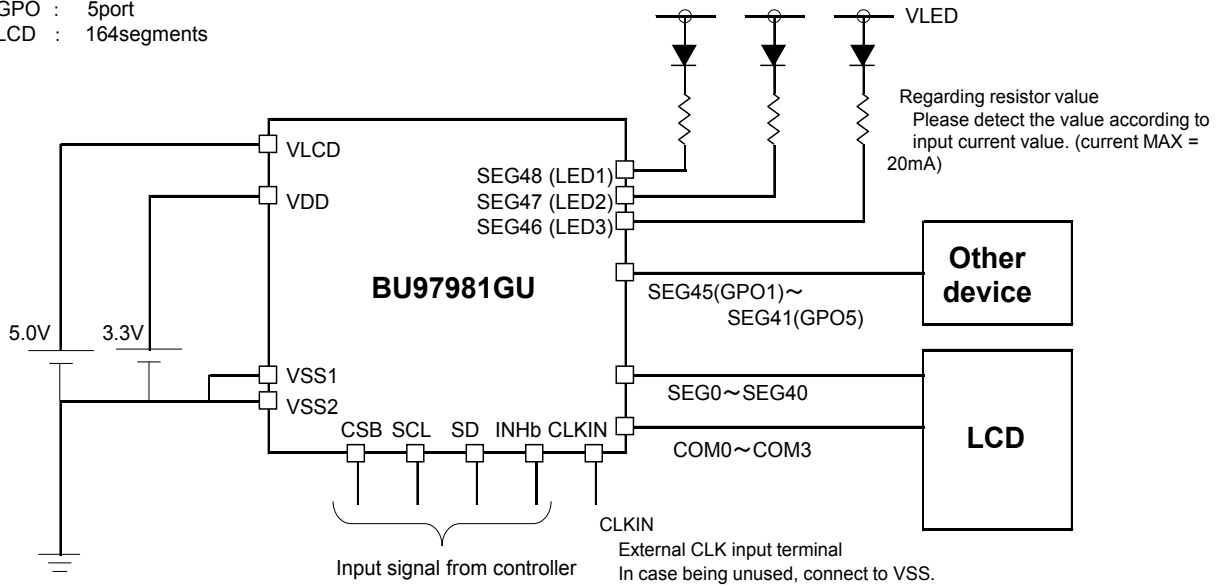
Figure 13. BU97981MUV E.g. of Recommended Circuit

Example of Recommended Circuit – Continued

(BU97981GU)

1. LED/GPO Using Case

- LED : 3port
- GPO : 5port
- LCD : 164segments



2. SEG Output Only Case

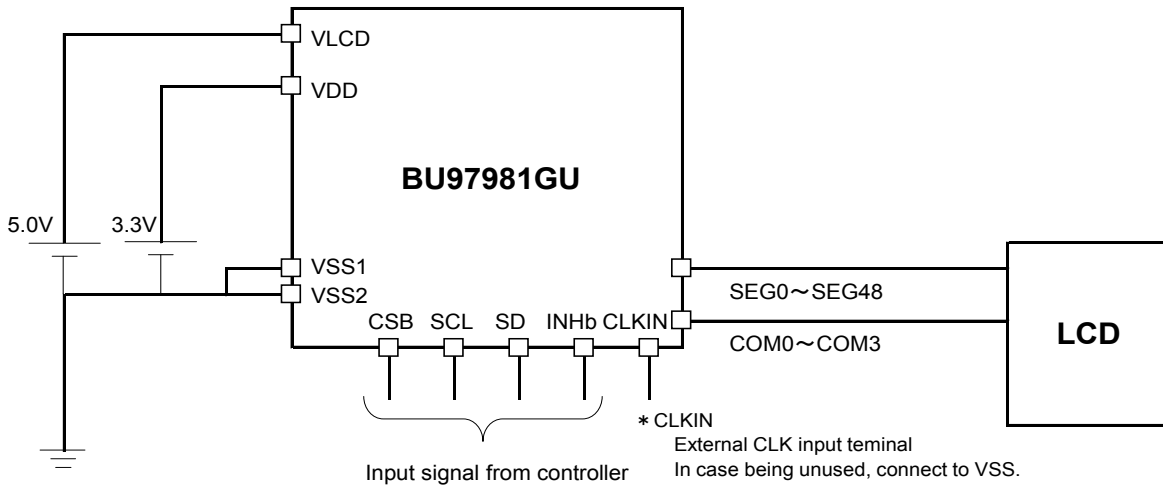


Figure 14. BU97981GU E.g. of Recommended Circuit

**Function Descriptions**

Command and Data Transfer Method

3-SPI (3 wire serial interface)

This device is controlled by 3-wire signal (CSB, SCL, and SD).

First, Interface counter is initialized with CSB="H",

and CSB="L" makes SD and SCL input enable.

The protocol of 3-SPI transfer is as follows.

Each command starts with Command or Data judgment bit (D/C) as MSB data,

and continuously in order of D6 to D0 are followed after CSB = "L".

(Internal data is latched at the rising edge of SCL, it converted to 8bits parallel data at the falling edge of 8<sup>th</sup> CLK.)

When CSB rise from "L" to "H", and at this time sending commands are less than 8bit, command and data transfer are canceled. To start sending command again, please fall CSB="L" and send command continuously.

After sending RAMWR or BLKWR or GPOSET command, BU97981KV/MUV is in the RAM data input mode. Under this mode, device can not accept new commands.

In this case, please rise CSB="H" and fall CSB="L", after this sequence device released from RAM data input mode, and can accept new command.

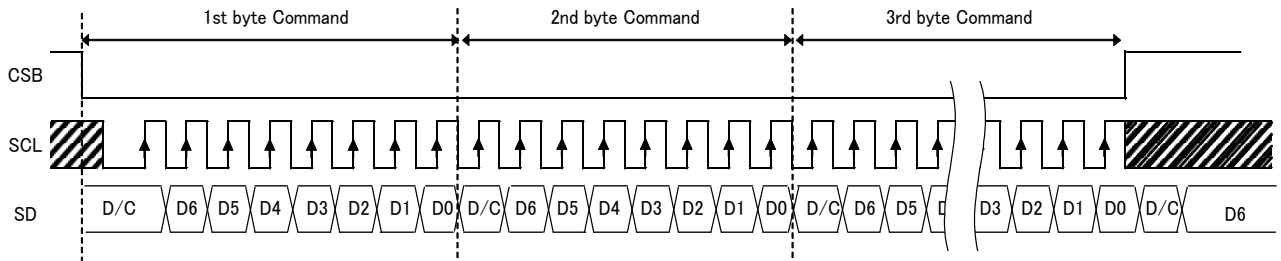


Figure 15. 3-SPI Data Transfer Format

8bit data, sending after RAMWR command, are display RAM data

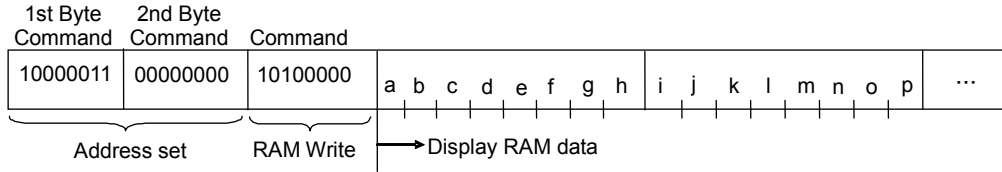
8bit data, sending after BLKWR command, are blink RAM data

SCL and SD can be set to "H" or cleared to "L" during CSB="H"



Write Display Data and Transfer Method

This device has Display Data RAM (DDRAM) of 49x4=196bit.  
 The relationship between data input and display data, DDRAM data and address are as follows.



According to this command, 8bit binary data will write to DDRAM. The address which starts data writing is specified by "ADSET" command, and increment after finish writing display data every 4 bit.

It is able to write to DDRAM by continuously sending data.  
 (In case data is sent continuously after write date at 30h (KV: SEG48), RAM data will be written to 31h (dummy address) and return to address 00h (SEG0) automatically.)

In case, SEG port assigned to GPO or LED port by OUTSET1 command, corresponding SEG address do not change and used as dummy address.

(BU97981KV, BU97981GU)

|     |   | DDRAM address |       |       |       |       |       |       |       |      |        |        |               |      |  |
|-----|---|---------------|-------|-------|-------|-------|-------|-------|-------|------|--------|--------|---------------|------|--|
|     |   | 00            | 01    | 02    | 03    | 04    | 05    | 06    | 07    | ...  | 2Fh    | 30h    | 31h           |      |  |
| BIT | 0 | a             | e     | i     | m     |       |       |       |       |      |        |        | DUMMY ADDRESS | COM0 |  |
|     | 1 | b             | f     | j     | n     |       |       |       |       |      |        |        |               | COM1 |  |
|     | 2 | c             | g     | k     | o     |       |       |       |       |      |        |        |               | COM2 |  |
|     | 3 | d             | h     | l     | p     |       |       |       |       |      |        |        |               | COM3 |  |
|     |   | SEG 0         | SEG 1 | SEG 2 | SEG 3 | SEG 4 | SEG 5 | SEG 6 | SEG 7 | .... | SEG 47 | SEG 48 |               |      |  |

(BU97981MUV)

|     |   | DDRAM address |       |       |       |       |     | Dummy data |               |     |     |     |     |      |  |
|-----|---|---------------|-------|-------|-------|-------|-----|------------|---------------|-----|-----|-----|-----|------|--|
|     |   | 00            | 01    | 02    | 03    | 04    | ... | 29         | 2A            | ... | 2Fh | 30h | 31h |      |  |
| BIT | 0 | a             | e     | i     | m     |       |     |            | DUMMY ADDRESS |     |     |     |     | COM0 |  |
|     | 1 | b             | f     | j     | n     |       |     |            |               |     |     |     |     | COM1 |  |
|     | 2 | c             | g     | k     | o     |       |     |            |               |     |     |     |     | COM2 |  |
|     | 3 | d             | h     | l     | p     |       |     |            |               |     |     |     |     | COM3 |  |
|     |   | SEG 0         | SEG 1 | SEG 2 | SEG 3 | SEG 4 |     | SEG 41     |               |     |     |     |     |      |  |

Display data write to DDRAM every 4bits.  
 In case CSB change from "L" to "H" before 4bits data transfer finish, RAM write is canceled.

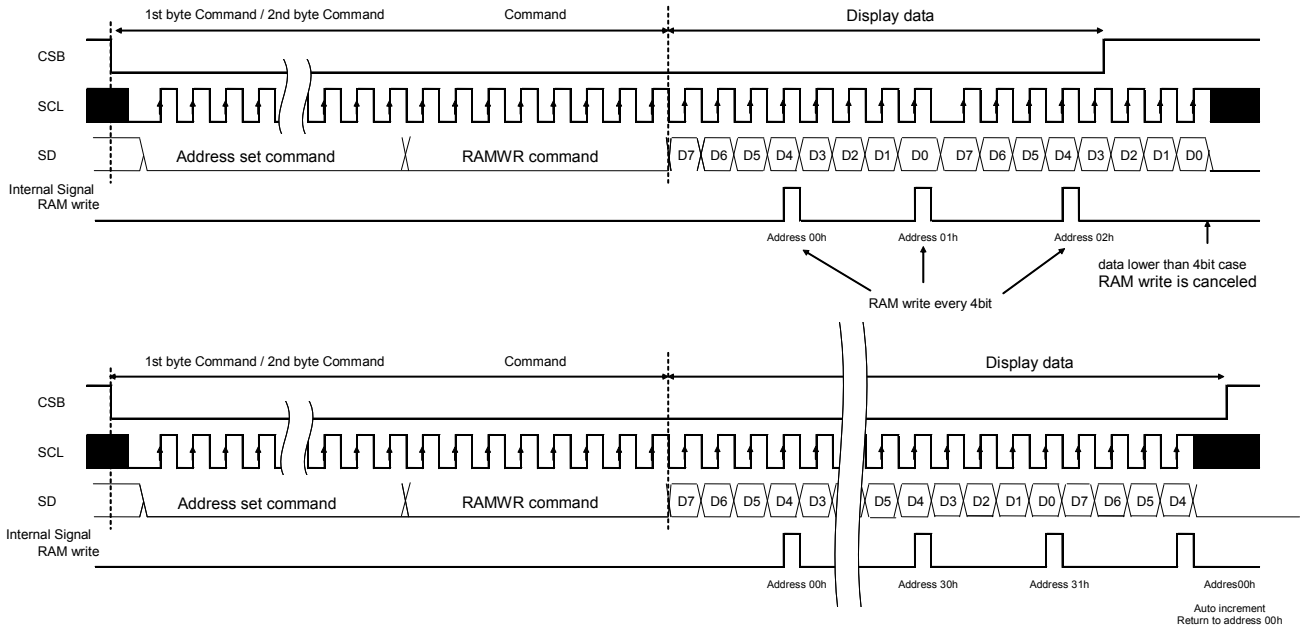


Figure 16. Display Data Transfer Method

**Blink Function**

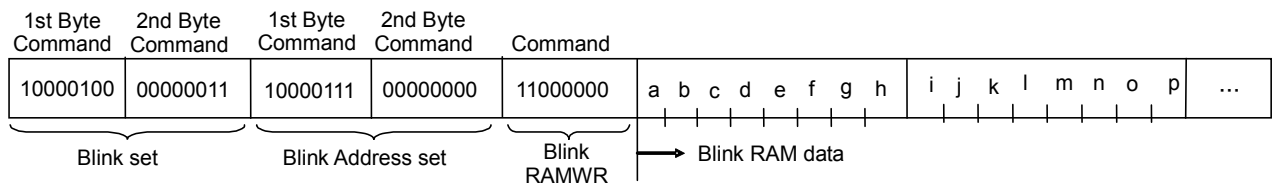
This device has Blink function. Blink function is able to set each segment port individually. Blink ON/OFF and Blink frequency are set by the BLKSET command. Blink frequency varies, according to fCLK characteristics. Blink setup of each segments are controlled by BLKWWR command.

The write start address is specified by “BLKADSET” command. And this address will increment after finish writing blink data every 4 bit. The relation of BLKWWR command, blink ram data, and blinking segment port is below.

In case of data is “1”, segment will blink, on the other hand data is “0”, do not blink. (In case data is written continuously, after write date at 30h (KV: SEG48), ram data will be written to 31h (dummy address) and return to address 00h (SEG0) automatically.)

Please refer to following figure about Blink operation of each segment.

In case, SEG port assigned to GPO or LED port by OUTSET1 command, corresponding SEG address do not change and used as dummy address.



(BU97981KV,BU97981GU)

|     |   | Blink RAM Address |       |       |       |       |       |       |       |     |        |        |               |      |
|-----|---|-------------------|-------|-------|-------|-------|-------|-------|-------|-----|--------|--------|---------------|------|
|     |   | 00                | 01    | 02    | 03    | 04    | 05    | 06    | 07    | ... | 2Fh    | 30h    | 31h           |      |
| BIT | 0 | A                 | e     | i     | m     |       |       |       |       |     |        |        | DUMMY ADDRESS | COM0 |
|     | 1 | B                 | f     | j     | n     |       |       |       |       |     |        |        |               | COM1 |
|     | 2 | C                 | g     | k     | o     |       |       |       |       |     |        |        |               | COM2 |
|     | 3 | D                 | h     | l     | p     |       |       |       |       |     |        |        |               | COM3 |
|     |   | SEG 0             | SEG 1 | SEG 2 | SEG 3 | SEG 4 | SEG 5 | SEG 6 | SEG 7 |     | SEG 47 | SEG 48 |               |      |

(BU97981MUV)

|     |   | Blink RAM Address |       |       |       |       |     |        |               |     |     | Dummy data |     |      |
|-----|---|-------------------|-------|-------|-------|-------|-----|--------|---------------|-----|-----|------------|-----|------|
|     |   | 00                | 01    | 02    | 03    | 04    | ... | 29     | 2A            | ... | 2Fh | 30h        | 31h |      |
| BIT | 0 | a                 | e     | i     | m     |       |     |        | DUMMY ADDRESS |     |     |            |     | COM0 |
|     | 1 | b                 | f     | j     | n     |       |     |        |               |     |     |            |     | COM1 |
|     | 2 | c                 | g     | k     | o     |       |     |        |               |     |     |            |     | COM2 |
|     | 3 | d                 | h     | l     | p     |       |     |        |               |     |     |            |     | COM3 |
|     |   | SEG 0             | SEG 1 | SEG 2 | SEG 3 | SEG 4 |     | SEG 41 |               |     |     |            |     |      |

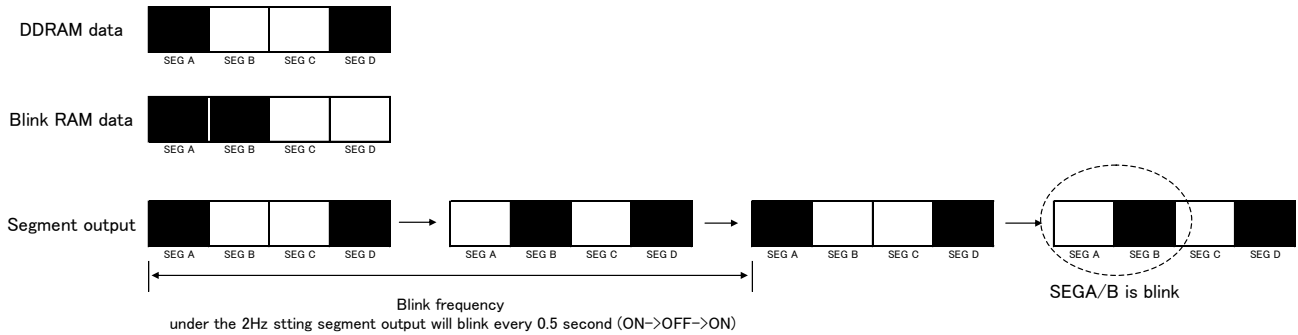


Figure 17. Blink Operation

## LCD Driver Bias/Duty Circuit

This LSI generates LCD driving voltage with on-chip Buffer AMP.

And it can drive LCD at low power consumption

Line and frame inversion can be set in MODESET command.

1/4duty, 1/3duty and static mode can be set DISCTL command.

About each LCD driving waveform, please refer to "LCD driving waveform" descriptions.

## Initial state

Initial state, after Software Reset command input

1. Display off

2. All command register value set Reset state.

3. DDRAM address data and Blink address data are initializing

(DDRAM data and Blink RAM data are not initializing.

Please write DDRAM data and Blink RAM data before Display on.)

## Command / Function list

## Function Description Table

| NO | Command  | Function   |
|----|--|--|
| 1  | Mode Set (MODESET)   | Set LCD drive mode (display on/off, current mode)      |
| 2  | Display control (DISCTL)                                       | Set LCD drive mode (frame freq., line/frame inversion) |
| 3  | Address set (ADSET)  | Set display data RAM address for RAMWR command         |
| 4  | Blink set (BLKSET)   | Set Blink mode on/off                                  |
| 5  | Blink address set (BLKADSET)                                   | Set Blink data RAM address for BLKWR command           |
| 6  | SEG/GPO port change (OUTSET1)                                  | Select segment output/general purpose output (GPO)     |
| 7  | SEG/LED port change (OUTSET2)                                  | Select segment output/LED driving output               |
| 8  | LED1 drive control (PWM1SET)<br>(H piece adjustment of PWM1)   | Set PWM1 signal "H" width for LED1 driving             |
| 9  | LED2-3 drive control (PWM2SET)<br>(H piece adjustment of PWM2) | Set PWM2 signal "H" width for LED2-3 driving           |
| 10 | Display data RAM WRITE (RAMWR)                                 | Write display data to display data RAM                 |
| 11 | Blink RAM WRITE (BLKWR)  | Write Blink data to BLINK data RAM                     |
| 12 | All Pixel ON (APON)  | Set all Pixel display on                               |
| 13 | All Pixel OFF (APOFF)  | Set all Pixel display off                              |
| 14 | All Pixel On/Off mode off (NORON)                              | Set normal display mode (APON/APOFF cancel)            |
| 15 | Software Reset (SWRST)   | Software Reset   |
| 16 | OSC external input (OSCSET)                                    | Set External clock input                               |
| 17 | Integrated Regulator setup (REGSET)                            | Set integrated regulator voltage output                |
| 18 | GPO output set (GPOSET)  | Set GPO output data                                    |

## Command Detail Descriptions

D/C, Data / Command judgment bit (MSB)  
Detail, please refer to 3wire serial I/F

### Mode Set (MODESET)

|                              | MSB |    |    |    |    |    |    | LSB |     |     | Reset |
|------------------------------|-----|----|----|----|----|----|----|-----|-----|-----|-------|
|                              | D/C | D6 | D5 | D4 | D3 | D2 | D1 | D0  | Hex |     |       |
| 1 <sup>st</sup> byte command | 1   | 0  | 0  | 0  | 0  | 0  | 0  | 1   | 81h | -   |       |
| 2 <sup>nd</sup> byte command | 0   | 0  | 0  | 0  | P3 | P2 | P1 | P0  | -   | 00h |       |

#### Display Set

| Condition   | P3 | Reset state |
|-------------|----|-------------|
| Display OFF | 0  | ○           |
| Display ON  | 1  |             |

Display OFF : No LCD driving mode (Output: VSS Level)

Turn off OSC circuit and LCD power supply circuit. (Synchronized with frame freq)

Display ON : LCD driving mode

Turn on OSC circuit and LCD power supply circuit.

Read data from DDRAM and display to LCD.

LED port and GPO port output state are not influenced by a Display on/off state

Output state is decided by command setup (GPOSET, OUTSET1, OUTSET2, PWM1SET, PWM2SET) and INHb terminal state. About detail, please refer to each command description.

#### LCD drive mode set

| Condition       | P2 | Reset state |
|-----------------|----|-------------|
| Frame inversion | 0  | ○           |
| Line inversion  | 1  |             |

#### Current mode set

| Condition        | P1 | P0 | Reset state |
|------------------|----|----|-------------|
| Power save mode1 | 0  | 0  | ○           |
| Power save mode2 | 0  | 1  |             |
| Normal mode      | 1  | 0  |             |
| High power mode  | 1  | 1  |             |

#### (Reference data of consumption current)

| Condition         | Current consumption |
|-------------------|---------------------|
| Power save mode 1 | ×1.0                |
| Power save mode 2 | ×1.7                |
| Normal mode       | ×2.7                |
| High power mode   | ×5.0                |

The value changes according to the panel load.

Display Control (DISCTL)

|                              | MSB |    |    |    |    |    |    | LSB |     | Hex | Reset |
|------------------------------|-----|----|----|----|----|----|----|-----|-----|-----|-------|
|                              | D/C | D6 | D5 | D4 | D3 | D2 | D1 | D0  |     |     |       |
| 1 <sup>st</sup> byte Command | 1   | 0  | 0  | 0  | 0  | 0  | 1  | 0   | 82h | -   |       |
| 2 <sup>nd</sup> byte Command | 0   | 0  | 0  | 0  | P3 | P2 | P1 | P0  | -   | 02h |       |

Duty Set

| Condition         | P3 | P2 | Reset state |
|-------------------|----|----|-------------|
| 1/4duty (1/3bias) | 0  | 0  | ○           |
| 1/3duty (1/3bias) | 0  | 1  |             |
| Static (1/1bias)  | 1  | *  |             |

\*: Don't care

In 1/3duty, Display data and Blink data of COM3 is ineffective. COM1 and COM3 output are same data.

Please be careful of transmission of display data and blink data. The examples of SEG/COM output waveform, under the each Bias/Duty set up, are shown at "LCD Driver Bias/Duty Circuit" description.

Frame Frequency Set

| Condition<br>(1/4, 1/3, 1/1duty) | P1 | P0 | Reset state |
|----------------------------------|----|----|-------------|
| (128Hz, 130Hz, 128Hz)            | 0  | 0  |             |
| (85Hz, 86hz, 64Hz)               | 0  | 1  |             |
| (64Hz, 65Hz, 48Hz)               | 1  | 0  | ○           |
| (51Hz, 52Hz, 32Hz)               | 1  | 1  |             |

Relation table, between Frame frequencies (FR), integrated oscillator circuit (OSC) and Divide number.

| DISCTL<br>(P1,P0) | Divide           |                  |                  | FR [Hz] <sup>(Note1)</sup> |                  |                  |
|-------------------|------------------|------------------|------------------|----------------------------|------------------|------------------|
|                   | Duty set (P3,P2) |                  |                  | Duty set (P3,P2)           |                  |                  |
|                   | (0,0)<br>1/4duty | (0,1)<br>1/3duty | (1,*)<br>1/1duty | (0,0)<br>1/4duty           | (0,1)<br>1/3duty | (1,*)<br>1/1duty |
| (0,0)             | 160              | 156              | 160              | 128                        | 131.3            | 128              |
| (0,1)             | 240              | 237              | 320              | 85.3                       | 86.4             | 64               |
| (1,0)             | 320              | 315              | 428              | 64                         | 65               | 47.9             |
| (1,1)             | 400              | 393              | 640              | 51.2                       | 52.1             | 32               |

(Note1) FR is frame frequency, in case OSC frequency = 20.48KHz (typ).

The Formula, to calculate OSC frequency from Frame frequency is below.

“ OSC frequency = Frame frequency (measurement value) x Divide number ”

Divide number : Please decide by using the value of Frame Frequency Set (P1,P0) and duty setting (P3,P2).

Ex) (P1,P0) = (0,1) , (P3,P2) = (0,1) => Divide number= 237

**Address Set (ADSET)**

|                              | MSB |    |    |    |    |    |    | LSB |     |       |  |
|------------------------------|-----|----|----|----|----|----|----|-----|-----|-------|--|
|                              | D/C | D6 | D5 | D4 | D3 | D2 | D1 | D0  | Hex | Reset |  |
| 1 <sup>st</sup> byte Command | 1   | 0  | 0  | 0  | 0  | 0  | 1  | 1   | 83h | -     |  |
| 2 <sup>nd</sup> byte Command | 0   | 0  | P5 | P4 | P3 | P2 | P1 | P0  | -   | 00h   |  |

Set start address to write DDRAM data.

The address can be set from 00h to 30h. (Address 31h is used at dummy address)

Do not set other address. (Except 00h to 31h address is not acceptable.)

In case, write data to DDRAM, please send RAMWR command certainly.

**Blink Set (BLKSET)**

|                              | MSB |    |    |    |    |    |    | LSB |     |       |  |
|------------------------------|-----|----|----|----|----|----|----|-----|-----|-------|--|
|                              | D/C | D6 | D5 | D4 | D3 | D2 | D1 | D0  | Hex | Reset |  |
| 1 <sup>st</sup> byte Command | 1   | 0  | 0  | 0  | 0  | 1  | 0  | 0   | 84h | -     |  |
| 2 <sup>nd</sup> byte Command | 0   | 0  | 0  | 0  | 0  | P2 | P1 | P0  | -   | 00h   |  |

Set Blink ON/OFF.

About detail, please refer to a "Blink function".

**Blink set**

| Blink mode(Hz) | P2 | P1    | P0    | Reset state |
|----------------|----|-------|-------|-------------|
| OFF            | 0  | 0 / * | 0 / * | ○           |
| 1.6            | 1  | 0     | 0     |             |
| 2.0            | 1  | 0     | 1     |             |
| 2.6            | 1  | 1     | 0     |             |
| 4.0            | 1  | 1     | 1     |             |

\*: Don't care

**Blink Address Set (BLKADSET)**

|                              | MSB |    |    |    |    |    |    | LSB |     |       |  |
|------------------------------|-----|----|----|----|----|----|----|-----|-----|-------|--|
|                              | D/C | D6 | D5 | D4 | D3 | D2 | D1 | D0  | Hex | Reset |  |
| 1 <sup>st</sup> byte Command | 1   | 0  | 0  | 0  | 0  | 1  | 1  | 1   | 87h | -     |  |
| 2 <sup>nd</sup> byte Command | 0   | 0  | P5 | P4 | P3 | P2 | P1 | P0  | -   | 00h   |  |

Set Blink data RAM start address to write.

The address can be set from 00h to 30h. (Address 31h is used at dummy address)

Do not set other address. (Except 00h-31h address is not acceptable.)

In case, write data to Blink RAM, please send BLKWR command certainly.

SEG/GPO Port Change (OUTSET1)

|                              | MSB |    |    |    |    |    |    | LSB |     |       |  |
|------------------------------|-----|----|----|----|----|----|----|-----|-----|-------|--|
|                              | D/C | D6 | D5 | D4 | D3 | D2 | D1 | D0  | Hex | Reset |  |
| 1 <sup>st</sup> byte Command | 1   | 0  | 0  | 0  | 1  | 0  | 0  | 0   | 88h | -     |  |
| 2 <sup>nd</sup> byte Command | 0   | 0  | 0  | P4 | P3 | P2 | P1 | P0  | -   | 00h   |  |

Set output mode, Segment output or GPO output.  
 P4 to P0: Select changing port number. (SEG15 to SEG45 ports are SEG mode/GPO mode selectable)

In case, GPO output is selected, Terminal output data is set by GPOSET command.

Ex) In case SEG45 port assigned to GPO,  
 If GPO1 data is "H", GPO1 (SEG45) port outputs "H" (VLCD Level).  
 If GPO1 data is "L", GPO1 (SEG45) port outputs "L" (VSS level).

Output terminal state under the P2 to P0 set condition is listed below

(BU97981KV ,BU97981GU)

| Condition |    |    |    |    | SEG Terminal state (SEG output/GPO output) |                |                |                |  |                |                |                |                |  |
|-----------|----|----|----|----|--|----------------|----------------|----------------|--|----------------|----------------|----------------|----------------|--|
| P4        | P3 | P2 | P1 | P0 | SEG15 Terminal                             | SEG16 Terminal | SEG17 Terminal | SEG18 Terminal |  | SEG42 Terminal | SEG43 Terminal | SEG44 Terminal | SEG45 Terminal |  |
| 0         | 0  | 0  | 0  | 0  | SEG15                                      | SEG16          | SEG17          | SEG18          |  | SEG42          | SEG43          | SEG44          | SEG45          |  |
| 0         | 0  | 0  | 0  | 1  | SEG15                                      | SEG16          | SEG17          | SEG18          |  | SEG42          | SEG43          | SEG44          | GPO1           |  |
| 0         | 0  | 0  | 1  | 0  | SEG15                                      | SEG16          | SEG17          | SEG18          |  | SEG42          | SEG43          | GPO2           | GPO1           |  |
| 0         | 0  | 0  | 1  | 1  | SEG15                                      | SEG16          | SEG17          | SEG18          |  | SEG42          | GPO3           | GPO2           | GPO1           |  |
| 0         | 0  | 1  | 0  | 0  | SEG15                                      | SEG16          | SEG17          | SEG18          |  | GPO4           | GPO3           | GPO2           | GPO1           |  |
| ⋮         |    |    |    |    | ⋮  |                |                |                |  |                |                |                |                |  |
| 1         | 1  | 0  | 1  | 1  | SEG15                                      | SEG16          | SEG17          | SEG18          |  | GPO4           | GPO3           | GPO2           | GPO1           |  |
| 1         | 1  | 1  | 0  | 0  | SEG15                                      | SEG16          | SEG17          | GPO28          |  | GPO4           | GPO3           | GPO2           | GPO1           |  |
| 1         | 1  | 1  | 0  | 1  | SEG15                                      | SEG16          | GPO29          | GPO28          |  | GPO4           | GPO3           | GPO2           | GPO1           |  |
| 1         | 1  | 1  | 1  | 0  | SEG15                                      | GPO30          | GPO29          | GPO28          |  | GPO4           | GPO3           | GPO2           | GPO1           |  |
| 1         | 1  | 1  | 1  | 1  | GPO31                                      | GPO30          | GPO29          | GPO28          |  | GPO4           | GPO3           | GPO2           | GPO1           |  |

(BU97981MUV)

| Condition     |    |    |    |    | SEG Terminal state (SEG output/GPO output) |                |                |                |  |                |                |                |                |  |
|---------------|----|----|----|----|--|----------------|----------------|----------------|--|----------------|----------------|----------------|----------------|--|
| P4            | P3 | P2 | P1 | P0 | SEG12 Terminal                             | SEG13 Terminal | SEG14 Terminal | SEG15 Terminal |  | SEG35 Terminal | SEG36 Terminal | SEG37 Terminal | SEG38 Terminal |  |
| 0             | 0  | 0  | 0  | 0  | SEG12                                      | SEG13          | SEG14          | SEG15          |  | SEG35          | SEG36          | SEG37          | SEG38          |  |
| 0             | 0  | 0  | 0  | 1  | SEG12                                      | SEG13          | SEG14          | SEG15          |  | SEG35          | SEG36          | SEG37          | GPO1           |  |
| 0             | 0  | 0  | 1  | 0  | SEG12                                      | SEG13          | SEG14          | SEG15          |  | SEG35          | SEG36          | GPO2           | GPO1           |  |
| 0             | 0  | 0  | 1  | 1  | SEG12                                      | SEG13          | SEG14          | SEG15          |  | SEG35          | GPO3           | GPO2           | GPO1           |  |
| 0             | 0  | 1  | 0  | 0  | SEG12                                      | SEG13          | SEG14          | SEG15          |  | GPO4           | GPO3           | GPO2           | GPO1           |  |
| ⋮             |    |    |    |    | ⋮  |                |                |                |  |                |                |                |                |  |
| 1             | 0  | 1  | 1  | 1  | SEG12                                      | SEG13          | SEG14          | SEG15          |  | GPO4           | GPO3           | GPO2           | GPO1           |  |
| 1             | 1  | 0  | 0  | 0  | SEG12                                      | SEG13          | SEG14          | GPO24          |  | GPO4           | GPO3           | GPO2           | GPO1           |  |
| 1             | 1  | 0  | 0  | 1  | SEG12                                      | SEG13          | GPO25          | GPO24          |  | GPO4           | GPO3           | GPO2           | GPO1           |  |
| 1             | 1  | 0  | 1  | 0  | SEG12                                      | GPO26          | GPO25          | GPO24          |  | GPO4           | GPO3           | GPO2           | GPO1           |  |
| 1             | 1  | 0  | 1  | 1  | GPO27                                      | GPO26          | GPO25          | GPO24          |  | GPO4           | GPO3           | GPO2           | GPO1           |  |
| 11100 – 11111 |    |    |    |    | GPO27                                      | GPO26          | GPO25          | GPO24          |  | GPO4           | GPO3           | GPO2           | GPO1           |  |

In case, the SEG port is switched to the GPO port, DDRAM address and Blink RAM address do not change.  
 In this case, DDRAM address and Blink RAM address, selected GPO output mode, is dummy address.



**Change Command of a SEG/LED port (OUTSET2)**

|                              | MSB |    |    |    |    |    |    | LSB |     |     | Reset |
|------------------------------|-----|----|----|----|----|----|----|-----|-----|-----|-------|
|                              | D/C | D6 | D5 | D4 | D3 | D2 | D1 | D0  | Hex |     |       |
| 1 <sup>st</sup> byte Command | 1   | 0  | 0  | 0  | 1  | 0  | 0  | 1   | 89h | -   |       |
| 2 <sup>nd</sup> byte Command | 0   | 0  | 0  | 0  | 0  | P2 | P1 | P0  | -   | 00h |       |

This command affects segment port/LED port selection and PWM resolution set up.

**P2: Resolution setting**

| Setting               | P2 | Reset condition |
|-----------------------|----|-----------------|
| 12bit resolution mode | 0  | ○               |
| 8bit resolution mode  | 1  |                 |

P1 to P0: select SEG driving mode or LED driving mode, this command affect at SEG46 to SEG48 port. The effective address is 00h to 03h. In case LED driving mode is selected, output turns into “NMOS Open Drain” from segment output.

The state of the output terminal in case P1 to P0 are setup is shown below (BU97981KV, BU97981GU)

| Setting |    | SEG Terminal state (SEG output/LED output) |                |                |
|---------|----|--|----------------|----------------|
| P1      | P0 | SEG46 Terminal                             | SEG47 Terminal | SEG48 Terminal |
| 0       | 0  | SEG46                                      | SEG47          | SEG48          |
| 0       | 1  | SEG46                                      | SEG47          | LED1           |
| 1       | 0  | SEG46                                      | LED2           | LED1           |
| 1       | 1  | LED3                                       | LED2           | LED1           |

**(BU97981MUV)**

| Setting |    | SEG Terminal state (SEG output/LED output) |                |                |
|---------|----|--|----------------|----------------|
| P1      | P0 | SEG39 Terminal                             | SEG40 Terminal | SEG41 Terminal |
| 0       | 0  | SEG39                                      | SEG40          | SEG41          |
| 0       | 1  | SEG39                                      | SEG40          | LED1           |
| 1       | 0  | SEG39                                      | LED2           | LED1           |
| 1       | 1  | LED3                                       | LED2           | LED1           |

In this case, DDRAM address and a Blink RAM address of SEG port that set up to LED port, do not change. The address assigned to LED port is used as dummy address respectively.

The output state of GPO, LED, and PWMOUT port under the INHb H/L, display on/off, and RESET state are listed below.

| Control port | INHb                              |         | DISPLAY                           |                                   | RESET state                     |
|--------------|-----------------------------------|---------|-----------------------------------|-----------------------------------|---------------------------------|
|              | H                                 | L       | ON                                | OFF                               |                                 |
| GPO          | According to GPOSET command       | Low Fix | According to GPOSET command       | According to GPOSET command       | GPO unselected (All SEG output) |
| PWMOUT       | According to PWM2SET command      | Low Fix | According to PWM2SET command      | According to PWM2SET command      | Low Fix                         |
| LED          | According to PWM1/PWM2SET command | Hi-Z    | According to PWM1/PWM2SET command | According to PWM1/PWM2SET command | LED unselected (All SEG output) |

**LED1 Drive-Control (PWM1 “H” width control) Command (PWM1SET)**

|                              | MSB |    |     |     |    |    | LSB |    |     |     | Reset |
|------------------------------|-----|----|-----|-----|----|----|-----|----|-----|-----|-------|
|                              | D/C | D6 | D5  | D4  | D3 | D2 | D1  | D0 | Hex |     |       |
| 1 <sup>st</sup> byte Command | 1   | 0  | 0   | 0   | 1  | 0  | 1   | 0  | 8Ah | -   |       |
| 2 <sup>nd</sup> byte Command | 0   | 0  | P11 | P10 | P9 | P8 | P7  | P6 | -   | 00h |       |
| 3 <sup>rd</sup> byte Command | 0   | 0  | P5  | P4  | P3 | P2 | P1  | P0 | -   | 00h |       |

2<sup>nd</sup> and 3<sup>rd</sup> byte command data are able to set from 00h to 3Fh (described as 8bit binary data).  
 In case, other value selected, sending command is ignored, and 2<sup>nd</sup> and 3<sup>rd</sup> byte command data set 3Fh.  
 In reset state, 2<sup>nd</sup> and 3<sup>rd</sup> byte command data set 00h.  
 In case, the command less than 3 byte, sending command are canceled.

According to PWM1SET command, LED1 driving signal is adjustable. PWM “H” width is adjustable by 12bit/8bit resolution.

Explanation about P11 to P6 data of 2<sup>nd</sup> byte command and P5 to P0 data of 3<sup>rd</sup> byte command as follows  
 (The 2<sup>nd</sup> byte data are used as upper 6bit, and 3<sup>rd</sup> byte data are used as lower 6 bits.)

- 12bit mode : P11 data is used as MSB of 12 bits, and P0 data is used as LSB.
- 8bit mode : P11 to P8 are used as invalid bit.  
 P7 data is used as MSB of 8 bits, and P0 data is used LSB.

LED driving period is decided by the “H” width of PWM signal, generated by PWM generator circuit.  
 (resolution: 8bit/12bit selectable)

Ex.1

In case of external PWM clock 2MHz, parameter setting value is 2047 (P11 to P0 data: 7FFh)  
 1bit resolution: 500ns  
 ALL HI setting: PWM signal frequency about 500Hz, H width about 2.00msec  
 ALL Low setting: PWM signal frequency about 500Hz, H width 0us (In case of 12bit)

Ex.2

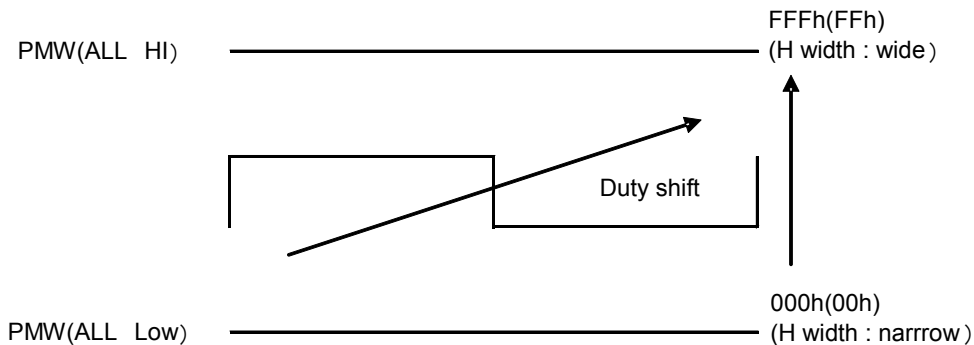
In case of internal PWM clock 40.96KHz(TYP), parameter 127 (P11 to P0 data: 7Fh)  
 1bit resolution: 24.41us  
 ALL HI setting: PWM signal frequency about 160Hz, H width about 6.20msec  
 ALL Low setting: PWM signal frequency about 160Hz, H width 0us (In case of 8bit)

BU97981 series PWM frequency is twice faster than BU9798 series in case of internal OSC clock use.  
 This command is reflected, synchronizing with a next PWM frame head.

And, LED port output is as follows

- INHb=“H” : LED port output LED driving signal.
- INHb=“L” : LED port output Hi-Z.

LED port operation does not affect Display ON/OFF state.



About the PWM frequency and PWM “H” width calculation

PWM cycle and PWM “H” width, decided by PWM clock cycle is described as follows.  
 (PWM clock cycle is a minimum unit of PWM “H” width)

$$\begin{aligned} \text{PWM frequency} &= \text{PWM clock cycle} \times (\text{Number of the steps}(12\text{bit} = 4096, 8\text{bit} = 256) - 1) \\ \text{PWM H width} &= \text{PWM clock cycle} \times \text{Parameter set value}(12\text{bit}: 0 \text{ to } 4095, 8\text{bit}: 0 \text{ to } 255) \\ \text{PWM Duty} &= \text{PWM H width} / \text{PWM cycle} = \text{Parameter set value} / \text{Number of the steps} \end{aligned}$$

In case, PWM is generated from internal clock, the PWM cycle varies, according to OSC frequency.

**LED2 to 3 Drive-Control (PWM2 “H” width control) Command (PWM2SET)**

|                              | MSB |    |     |     |    |    | LSB |    |     |     | Hex | Reset |
|------------------------------|-----|----|-----|-----|----|----|-----|----|-----|-----|-----|-------|
|                              | D/C | D6 | D5  | D4  | D3 | D2 | D1  | D0 |     |     |     |       |
| 1 <sup>st</sup> byte Command | 1   | 0  | 0   | 0   | 1  | 0  | 1   | 1  | 8Bh | -   |     |       |
| 2 <sup>nd</sup> byte Command | 0   | 0  | P11 | P10 | P9 | P8 | P7  | P6 | -   | 00h |     |       |
| 3 <sup>rd</sup> byte Command | 0   | 0  | P5  | P4  | P3 | P2 | P1  | P0 | -   | 00h |     |       |

P7 to P0 data are able to set from 00h to 3Fh (described as 8bit binary data).  
 In case, other value selected, sending command is ignored, and P7 to P0 data set 3Fh.  
 In reset state, P7 to P0 data is 00h.  
 In case, the command less than 3 byte, sending command are canceled.

According to PWM2SET command, LED2 driving signal, LED3 driving signal, and PWMOUT output “H” width are adjustable. PWM “H” width is adjustable by 12bit/8bit resolution.

Explanation about P11 to P6 data of 2<sup>nd</sup> byte command and P5 to P0 data of 3<sup>rd</sup> byte command as follows (The 2<sup>nd</sup> byte data are used as upper 6bit, and 3<sup>rd</sup> byte data are used as lower 6 bits.)

12bit mode : P11 data is used as MSB of 12 bits, and P0 data is used as LSB.  
 8bit mode : P11 to P8 are used as invalid bit.  
 P7 data is used as MSB of 8 bits, and P0 data is used LSB.

LED driving period is decided by the “H” width of PWM signal, generated by PWM generator circuit. (resolution : 8bit/12bit selectable)

**Ex.1**

In case of external PWM clock 2MHz, parameter setting value is 2047 (P11 to P0 data: 7FFh)  
 1bit resolution: 500ns  
 ALL HI setting: PWM signal frequency about 500Hz, H width about 2.00msec  
 ALL Low setting: PWM signal frequency about 500Hz, H width 0us (In case of 12bit)

**Ex.2**

In case of internal PWM clock 40.96KHz(TYP), parameter 127 (P11 to P0 data: 7Fh)  
 1bit resolution: 24.41us  
 ALL HI setting: PWM signal frequency about 160Hz, H width about 6.20msec  
 ALL Low setting: PWM signal frequency about 160Hz, H width 0us (In case of 8bit)

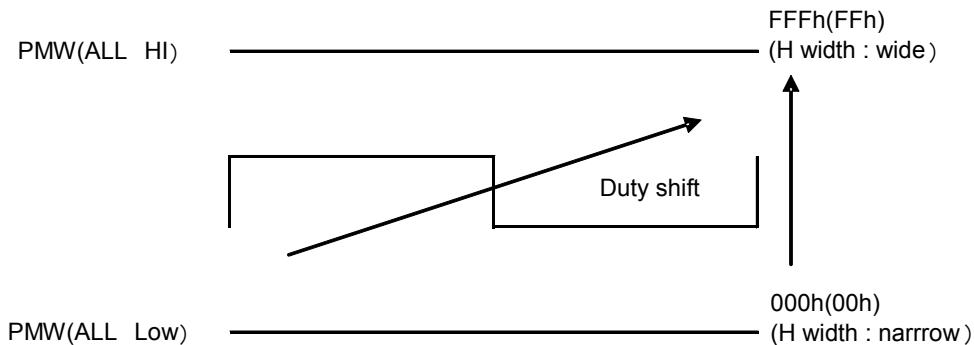
BU97981 PWM frequency is twice faster than BU9798 in case of internal OSC clock use.  
 This command is reflected, synchronizing with a next PWM frame head.

And, LED port output is as follows

INHb=“H” : LED port output LED driving signal, PWMOUT port output PWM signal.

INHb=“L” : LED port output Hi-Z, PWMOUT port output “L”

LED port and PWMOUT port operation do not affect Display ON/OFF state.



About the PWM frequency and PWM “H” width calculation  
 PWM cycle and PWM “H” width, decided by PWM clock cycle is described as follows.  
 (PWM clock cycle is a minimum unit of PWM “H” width)

$$\begin{aligned} \text{PWM frequency} &= \text{PWM clock cycle} \times (\text{Number of the steps (12bit} = 4096, 8\text{bit} = 256) - 1) \\ \text{PWM H width} &= \text{PWM clock cycle} \times \text{Parameter set value (12bit: 0 to 4095, 8bit: 0 to 255)} \\ \text{PWM Duty} &= \text{PWM H width} / \text{PWM cycle} = \text{Parameter set value} / \text{Number of the steps} \end{aligned}$$

In case, PWM is generated from internal clock, the PWM cycle varies, according to OSC frequency.

**RAM WRITE (RAMWR)**

|                              | MSB          |    |    |    |    |    |    | LSB |     |        | Reset |
|------------------------------|--------------|----|----|----|----|----|----|-----|-----|--------|-------|
|                              | D/C          | D6 | D5 | D4 | D3 | D2 | D1 | D0  | Hex |        |       |
| 1 <sup>st</sup> byte Command | 1            | 0  | 1  | 0  | 0  | 0  | 0  | 0   | A0h | -      |       |
| 2 <sup>nd</sup> byte Command | Display data |    |    |    |    |    |    |     |     | Random |       |
|                              | ....         |    |    |    |    |    |    |     |     |        |       |
| N byte Command               | Display data |    |    |    |    |    |    |     |     | Random |       |

Input data, sending after 1<sup>st</sup> byte command, are used as Display data. And display data are sent every 4bits. Please set this command after the ADSET command.

**Blink RAM WRITE (BLKWR)**

|                              | MSB        |    |    |    |    |    |    | LSB |     |        | Reset |
|------------------------------|------------|----|----|----|----|----|----|-----|-----|--------|-------|
|                              | D/C        | D6 | D5 | D4 | D3 | D2 | D1 | D0  | Hex |        |       |
| 1 <sup>st</sup> byte Command | 1          | 1  | 0  | 0  | 0  | 0  | 0  | 0   | C0h | -      |       |
| 2 <sup>nd</sup> byte Command | Blink data |    |    |    |    |    |    |     |     | Random |       |
|                              | ....       |    |    |    |    |    |    |     |     |        |       |
| N byte Command               | Blink data |    |    |    |    |    |    |     |     | Random |       |

Input data, sending after 1<sup>st</sup> byte command, are used as Display data. And display data are sent every 4bits. Please set this command after the BLKADSET command.

**All Pixel ON (APON)**

|                              | MSB |    |    |    |    |    |    | LSB |     |   | Reset |
|------------------------------|-----|----|----|----|----|----|----|-----|-----|---|-------|
|                              | D/C | D6 | D5 | D4 | D3 | D2 | D1 | D0  | Hex |   |       |
| 1 <sup>st</sup> byte Command | 1   | 0  | 0  | 1  | 0  | 0  | 0  | 1   | 91h | - |       |

After sending the command, all SEG output set display on state regardless of the DDRAM data.  
(This command affect to the SEG output terminal only (except GPO and LED output) )

**All Pixel OFF (APOFF)**

|                              | MSB |    |    |    |    |    |    | LSB |     |   | Reset |
|------------------------------|-----|----|----|----|----|----|----|-----|-----|---|-------|
|                              | D/C | D6 | D5 | D4 | D3 | D2 | D1 | D0  | Hex |   |       |
| 1 <sup>st</sup> byte Command | 1   | 0  | 0  | 1  | 0  | 0  | 0  | 0   | 90h | - |       |

After sending the command, all SEG output set display off state regardless of the DDRAM data.  
(This command affect to the SEG output terminal only (except GPO and LED output) )

**All Pixel ON/OFF mode off (NORON)**

|                              | MSB |    |    |    |    |    |    | LSB |     |   | Reset |
|------------------------------|-----|----|----|----|----|----|----|-----|-----|---|-------|
|                              | D/C | D6 | D5 | D4 | D3 | D2 | D1 | D0  | Hex |   |       |
| 1 <sup>st</sup> byte Command | 1   | 0  | 0  | 1  | 0  | 0  | 1  | 1   | 93h | - |       |

After sending the command, all SEG output released from APON/APOFF state.  
And SEG port output signal according to DDRAM data.  
(This command affect to the SEG output terminal only (except GPO and LED output) )  
After reset sequence or SWRST, all output set NORON state.

**Software Reset (SWRST)**

|                              | MSB |    |    |    |    |    |    | LSB |     |   | Reset |
|------------------------------|-----|----|----|----|----|----|----|-----|-----|---|-------|
|                              | D/C | D6 | D5 | D4 | D3 | D2 | D1 | D0  | Hex |   |       |
| 1 <sup>st</sup> byte Command | 1   | 0  | 0  | 1  | 0  | 0  | 1  | 0   | 92h | - |       |

After sending the command, device set the reset state.

OSC External Input Command (OSCSET)

|                              | MSB |    |    |    |    |    |    | LSB |     | Hex | Reset |
|------------------------------|-----|----|----|----|----|----|----|-----|-----|-----|-------|
|                              | D/C | D6 | D5 | D4 | D3 | D2 | D1 | D0  |     |     |       |
| 1 <sup>st</sup> byte Command | 1   | 0  | 0  | 1  | 1  | 0  | 0  | 0   | 98h | -   |       |
| 2 <sup>nd</sup> byte Command | 0   | 0  | 0  | 0  | 0  | P2 | P1 | P0  | -   | 00h |       |

According to the command, 4 type of clock mode selectable include external clock input mode.  
Detail of this command function as follows.

| Condition                                       | P2 | P1 | P0 | Reset state |
|---|----|----|----|-------------|
| Internal CLK (PWM generation OFF)               | 0  | 0  | 0  | ○           |
| External CLK input for PWM (PWM generation OFF) | 0  | 0  | 1  |             |
| Internal CLK (PWM generation ON)                | 0  | 1  | 0  |             |
| External CLK input for PWM (PWM generation ON)  | 0  | 1  | 1  |             |
| External CLK input for Display (ROHM use only)  | 1  | *  | *  |             |

\*: Don't care

- (P2,P1,P0)=(0,0,1) : External PWM input mode  
CLKIN: external PWM input available.  
PWMOUT: "L" Output  
\*under the (P2,P1,P0)=(0,0,0) condition PWMOUT into same state
- (P2,P1,P0)=(0,1,0) : PWM is made from integrated oscillation frequency  
PWM width is set up by PWM1SET and PWM2SET command.  
PWM waveform output from PWMOUT is set up by PWM2SET command.
- (P2,P1,P0)=(0,1,1) : PWM is made from External CLK input from CLKIN  
PWM width is set up by PWM1SET and PWM2SET command.  
PWM waveform output from PWMOUT is set up by PWM2SET command.

The relation of OSC function control by each command is as follows

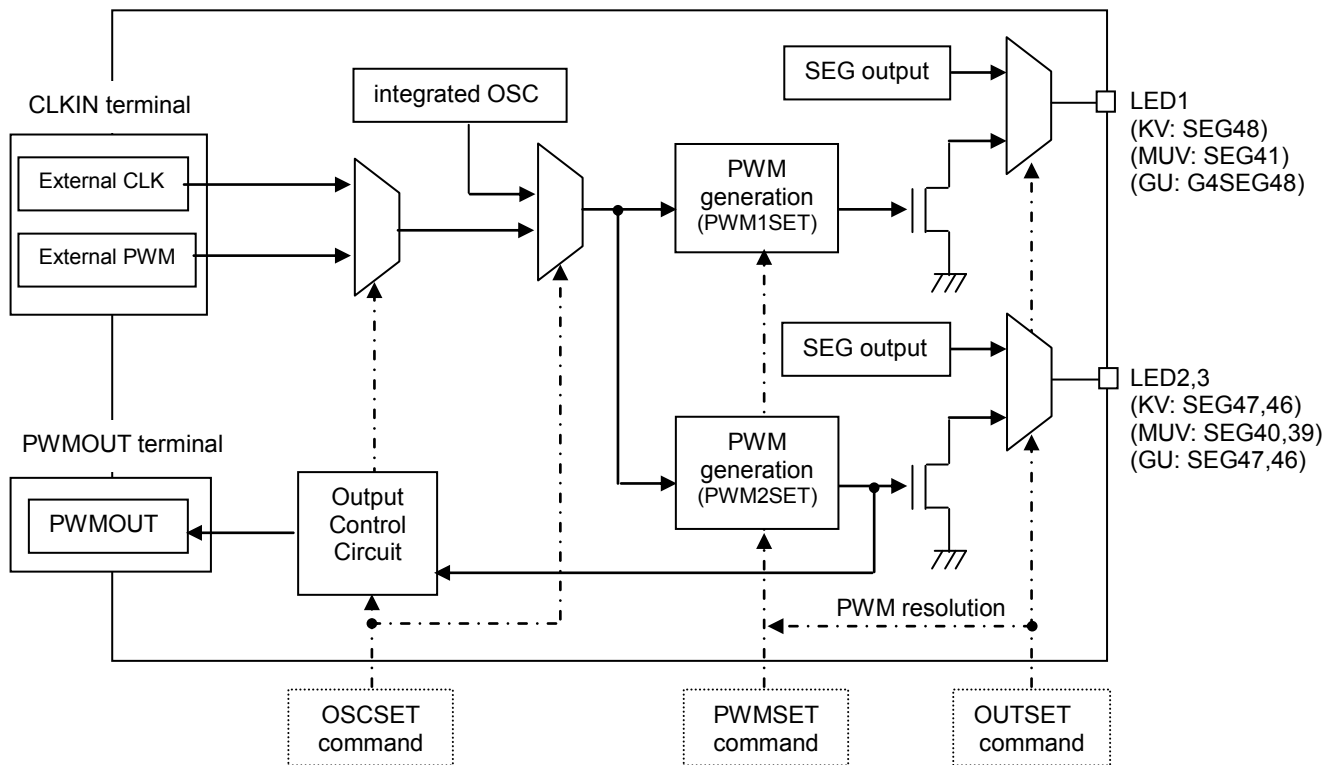


Figure 18. OSC External Input

## Integrated Regulator Setting (REGSET)

|                              | MSB |    |    |    |    |    |    | LSB |     |     | Hex | Reset |
|------------------------------|-----|----|----|----|----|----|----|-----|-----|-----|-----|-------|
|                              | D/C | D6 | D5 | D4 | D3 | D2 | D1 | D0  |     |     |     |       |
| 1 <sup>st</sup> byte Command | 1   | 0  | 0  | 1  | 1  | 0  | 0  | 1   | 99h | -   |     |       |
| 2 <sup>nd</sup> byte Command | 0   | 0  | 0  | 0  | 0  | P2 | P1 | P0  | -   | 00h |     |       |

Set integrated regulator output voltage (Vreg).

Integrated regulator is turned ON/OFF according to DISPON/OFF state that controlled by MODESET command.

| Setting            | P2 | P1 | P0 | Reset state |
|--------------------|----|----|----|-------------|
| OFF (VLCD voltage) | 0  | 0  | 0  | ○           |
| 5.0V               | 0  | 0  | 1  |             |
| 4.6V               | 0  | 1  | 0  |             |
| 4.5V               | 0  | 1  | 1  |             |
| 4.4V               | 1  | 0  | 0  |             |
| 3.4V               | 1  | 0  | 1  |             |
| 3.3V               | 1  | 1  | 0  |             |
| 3.2V               | 1  | 1  | 1  |             |

Please satisfy condition that REG voltage  $\leq$  VLCD-0.5V.

**GPO Output Set Command (GPOSET)**

|                              | MSB                        |                            |    |    |    |    |    | LSB |     | Hex | Reset |
|------------------------------|----------------------------|----------------------------|----|----|----|----|----|-----|-----|-----|-------|
|                              | D/C                        | D6                         | D5 | D4 | D3 | D2 | D1 | D0  |     |     |       |
| 1 <sup>st</sup> byte Command | 1                          | 0                          | 0  | 1  | 1  | 0  | 1  | 0   | 9Ah | -   |       |
| 2 <sup>nd</sup> byte Command | GPO output data: P7 to P0  |                            |    |    |    |    |    |     | -   | 00h |       |
| 3 <sup>rd</sup> byte Command | GPO output data: P15 to P8 |                            |    |    |    |    |    |     | -   | 00h |       |
| 4 <sup>th</sup> byte Command | GPO output data: P23 to 16 |                            |    |    |    |    |    |     | -   | 00h |       |
| 5 <sup>th</sup> byte Command | *                          | GPO output data: P30 to 24 |    |    |    |    |    |     | -   | 00h |       |

\*: Don't care

Set GPO output data.

The relation between SEG port (GPO port) and data is below.

(BU97981KV, BU97981GU)

| GPOSET data | GPO port | SEG port | GPOSET data | GPO port | SEG port | GPOSET data | GPO port | SEG port |
|-------------|----------|----------|-------------|----------|----------|-------------|----------|----------|
| P0          | GPO1     | SEG45    | P10         | GPO11    | SEG35    | P20         | GPO21    | SEG25    |
| P1          | GPO2     | SEG44    | P11         | GPO12    | SEG34    | P21         | GPO22    | SEG24    |
| P2          | GPO3     | SEG43    | P12         | GPO13    | SEG33    | P22         | GPO23    | SEG23    |
| P3          | GPO4     | SEG42    | P13         | GPO14    | SEG32    | P23         | GPO24    | SEG22    |
| P4          | GPO5     | SEG41    | P14         | GPO15    | SEG31    | P24         | GPO25    | SEG21    |
| P5          | GPO6     | SEG40    | P15         | GPO16    | SEG30    | P25         | GPO26    | SEG20    |
| P6          | GPO7     | SEG39    | P16         | GPO17    | SEG29    | P26         | GPO27    | SEG19    |
| P7          | GPO8     | SEG38    | P17         | GPO18    | SEG28    | P27         | GPO28    | SEG18    |
| P8          | GPO9     | SEG37    | P18         | GPO19    | SEG27    | P28         | GPO29    | SEG17    |
| P9          | GPO10    | SEG36    | P19         | GPO20    | SEG26    | P29         | GPO30    | SEG16    |
|             |          |          |             |          |          | P30         | GPO31    | SEG15    |

(BU97981MUV)

| GPOSET data | GPO port | SEG port | GPOSET data | GPO port | SEG port | GPOSET data | GPO port | SEG port |
|-------------|----------|----------|-------------|----------|----------|-------------|----------|----------|
| P0          | GPO1     | SEG38    | P10         | GPO11    | SEG28    | P20         | GPO21    | SEG18    |
| P1          | GPO2     | SEG37    | P11         | GPO12    | SEG27    | P21         | GPO22    | SEG17    |
| P2          | GPO3     | SEG36    | P12         | GPO13    | SEG26    | P22         | GPO23    | SEG16    |
| P3          | GPO4     | SEG35    | P13         | GPO14    | SEG25    | P23         | GPO24    | SEG15    |
| P4          | GPO5     | SEG34    | P14         | GPO15    | SEG24    | P24         | GPO25    | SEG14    |
| P5          | GPO6     | SEG33    | P15         | GPO16    | SEG23    | P25         | GPO26    | SEG13    |
| P6          | GPO7     | SEG32    | P16         | GPO17    | SEG22    | P26         | GPO27    | SEG12    |
| P7          | GPO8     | SEG31    | P17         | GPO18    | SEG21    | P27         | -        | -        |
| P8          | GPO9     | SEG30    | P18         | GPO19    | SEG20    | P28         | -        | -        |
| P9          | GPO10    | SEG29    | P19         | GPO20    | SEG19    | P29         | -        | -        |
|             |          |          |             |          |          | P30         | -        | -        |

GPO data is transmitted for every 1byte, and GPO data output is asynchronous from frame cycle.

In case INHb="H", GPO output signal according to GPOSET data, on the other hand, in case INHb="L" GPO output GND level. GPO output does not influence by Display ON/OFF state.

LCD Driving Waveform

1/4Duty

Line inversion

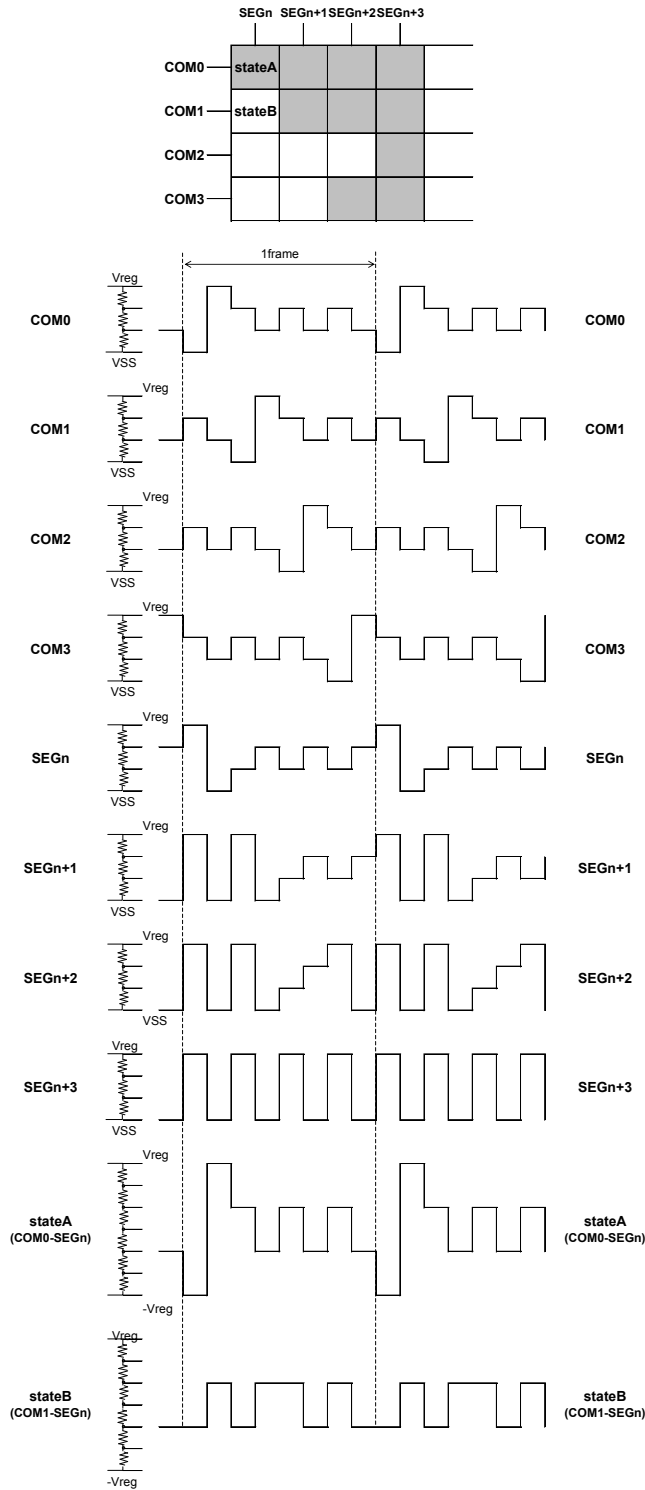


Figure 19. Waveform of Line Inversion

Frame inversion

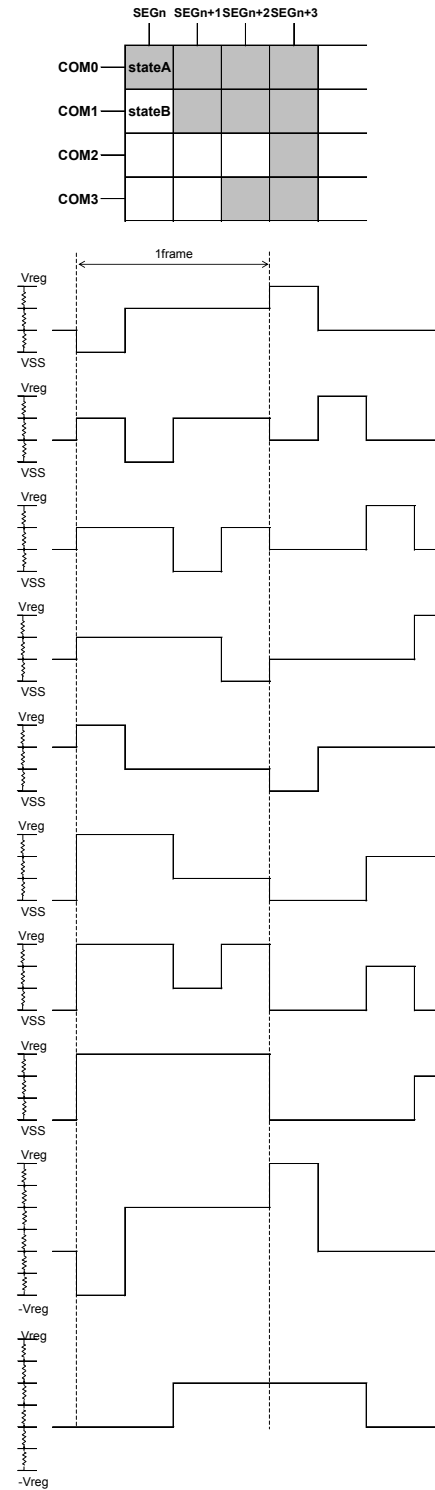


Figure 20. Waveform of Frame Inversion



1/3Duty

Line inversion

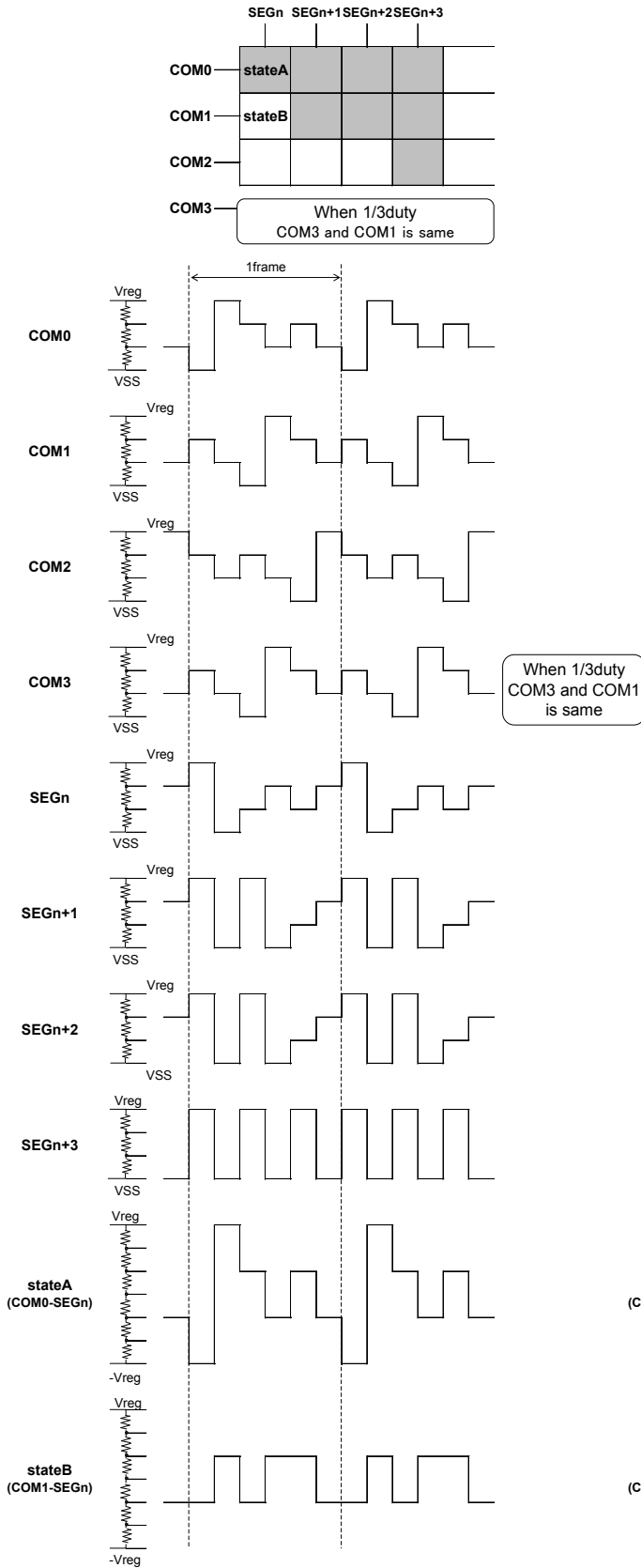


Figure 21. Waveform of Line Inversion

Frame inversion

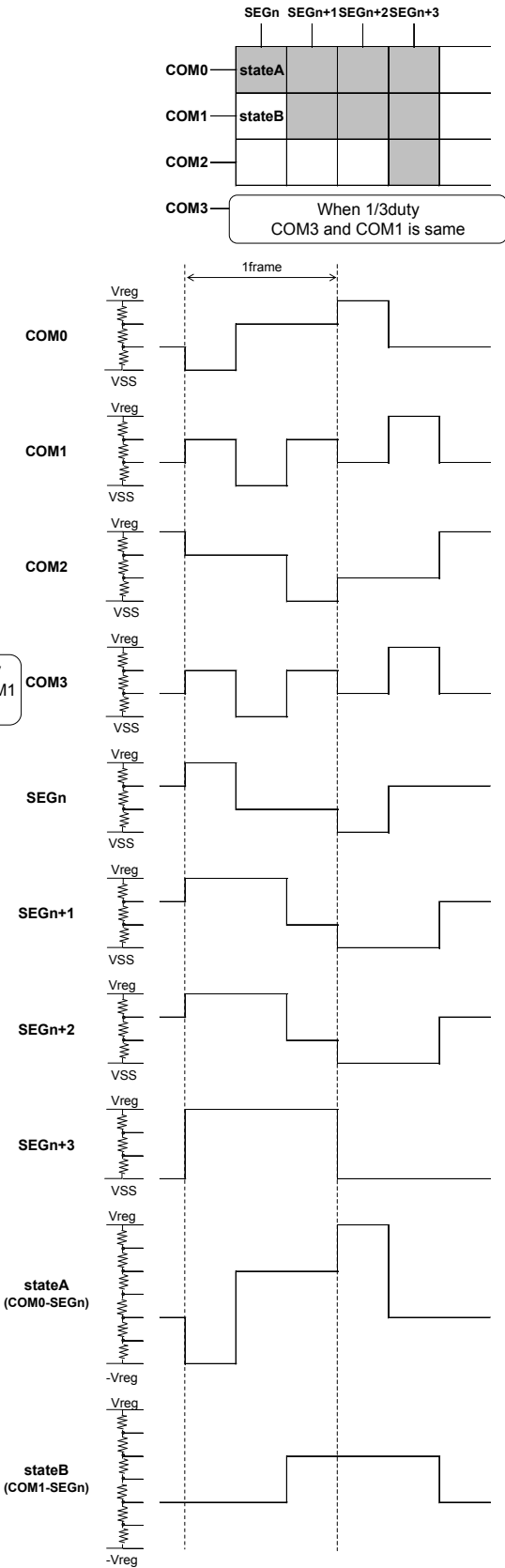


Figure 22. Waveform of Frame Inversion

1/1Duty (Static)

Line inversion

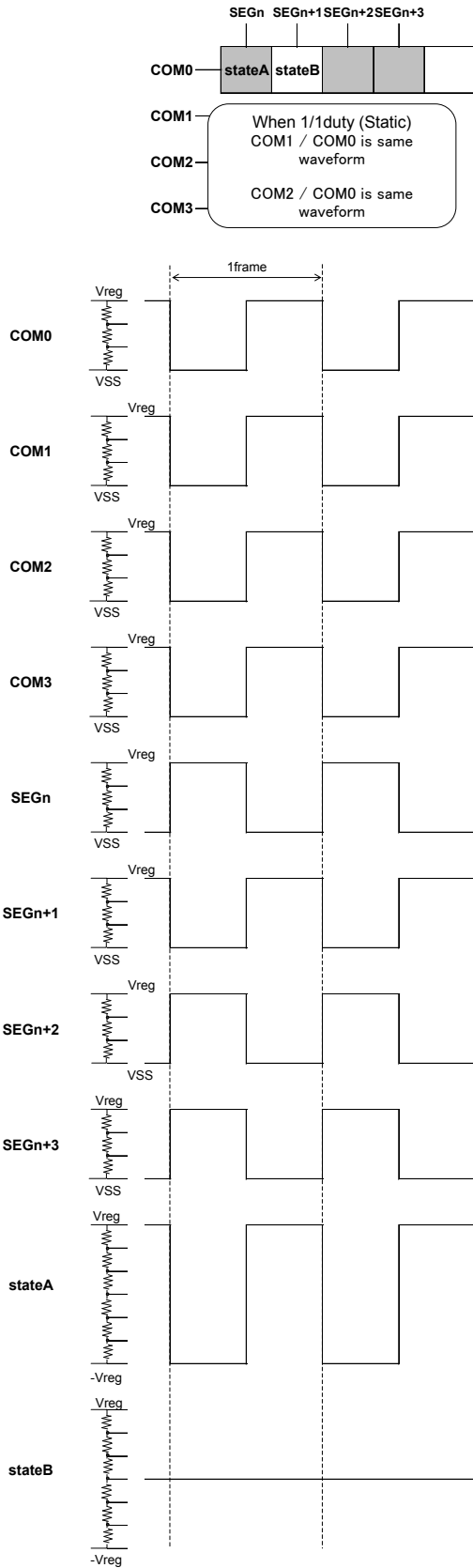


Figure 23. Waveform of Line Inversion

Frame inversion

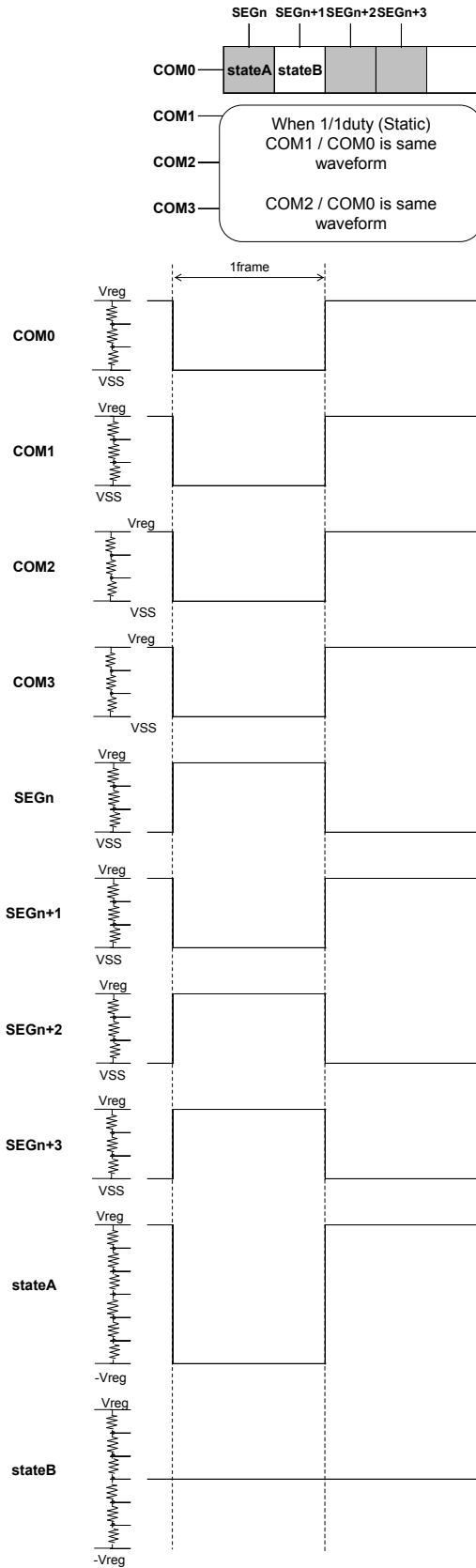
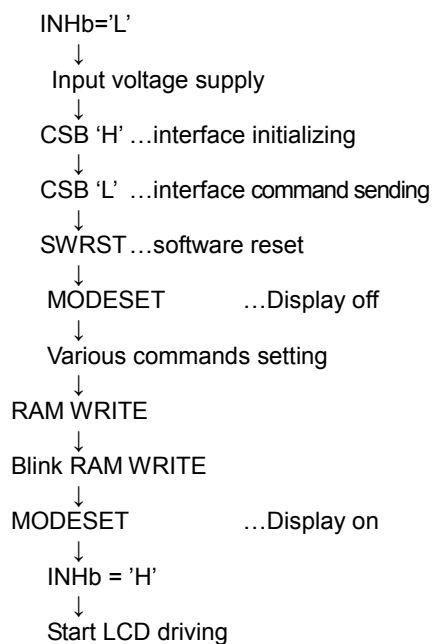


Figure 24. Waveform of Frame Inversion

**Initialize Sequence**

Please input sequence listed below, before start LCD driving.  
(Refer to Power ON/OFF sequence)



Before initialize sequence, DDRAM address, DDRAM data, Blink address and Blink data are random condition.

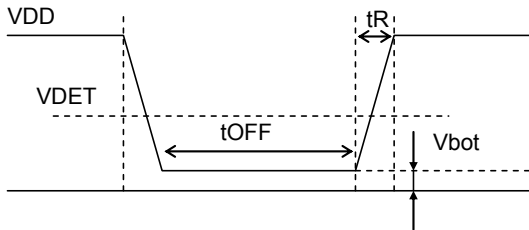
**Cautions of Power-On/ Power-Off condition**

**POR circuit**

This LSI has "P.O.R" (Power-On Reset) circuit and Software Reset function.

Please keep the following recommended Power-On conditions in order to power up properly.

1. Please set power up conditions to meet the recommended  $t_R$ ,  $t_F$ ,  $t_{OFF}$ , and  $V_{bot}$  spec below in order to ensure P.O.R operation.  
(The detection voltage of POR varies because of environment etc. To operate POR surely, Please satisfy  $V_{bot}$  lower than 0.5V condition.)



Recommendation condition of  $t_R$ ,  $t_F$ ,  $t_{OFF}$ ,  $V_{bot}$

| $t_R$          | $t_{OFF}$ | $V_{bot}$      | $V_{DET}$ |
|----------------|-----------|----------------|-----------|
| less than 10ms | Over 1ms  | less than 0.5V | TYP 1.2V  |

\*  $V_{DET}$  : POR detect level

Figure 25. Power ON/OFF Wave

2. If it is difficult to meet above conditions, execute the following sequence after Power-On.
  - (1) CSB="L"→"H" condition
  - (2) After CSB"H"→"L", execute SWRST command.

In addition, in order to the SWRST command certainly, please wait 1ms after a VDD level reaches to 90% and CSB="L"→"H".

Before SWRST command input device will be in unstable state, since SWRST command does not operate perfect substitution of a POR function.

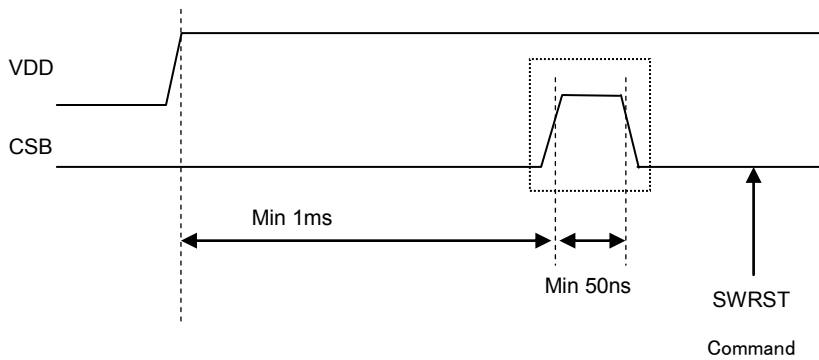


Figure 26. SWRST Command Sequence

Power ON/OFF Sequence

Display ON/OFF control by INHb terminal is not asynchronous frame cycle.  
 To prevent incorrect display, malfunction and abnormal current,  
 VDD must be turned on before VLCD in power up sequence.  
 VDD must be turned off after VLCD in power down sequence.  
 Please set INHb terminal = "L" during Power ON/OFF sequence.  
 Please satisfies VLCD Please satisfies VLCD ≥ VDD, t1 > 0ns, t2 > 0ns

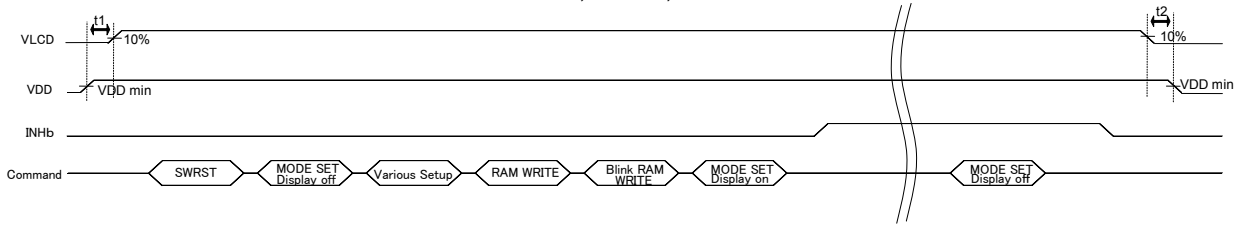


Figure 27. Power On/Off Sequence

Integrated Regulator Start-up Sequence

BU97981KV/MUV do not support integrated regulator start-up, during the normal (Vreg unused) display operation.  
 So, in case, LCD power supply change to Vreg output under the normal operation period, display flickering will occur.  
 In order to prevent this phenomenon please send MODESET command (Disp on) after REGSET command.  
 Please satisfies VLCD Please satisfies VLCD ≥ VDD, t1 > 0ns, t2 > 0ns  
 After SWRST command sending, please send same sequence.

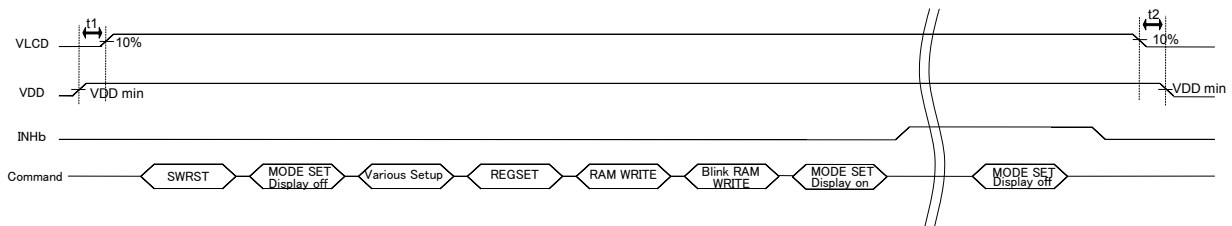


Figure 28. Integrated Regulator Start-up Sequence

LED Power Supply On/Off Sequence

In order to prevent irregular current, please start LED power supply after VLCD input and OUTSET2 command sending.  
 Please satisfies VLCD Please satisfies VLCD ≥ VDD, t1 > 0ns, t2 > 0ns

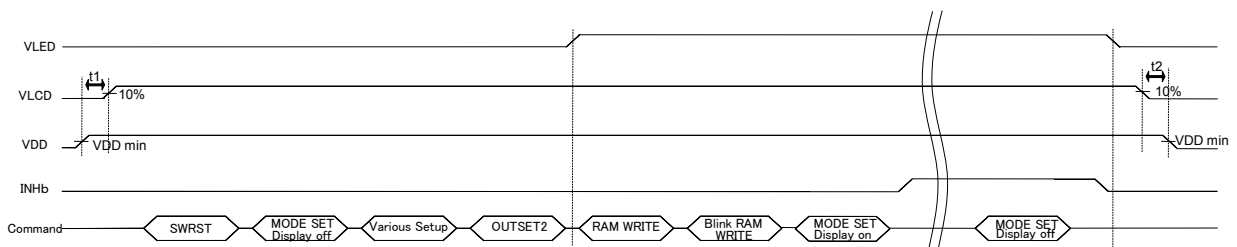


Figure 29. LED Power Supply On/Off Sequence

**Attention About Input Port Pull Down**

Satisfy the following sequence if input terminals are pulled down by external resistors (In case MPU output Hi-Z).

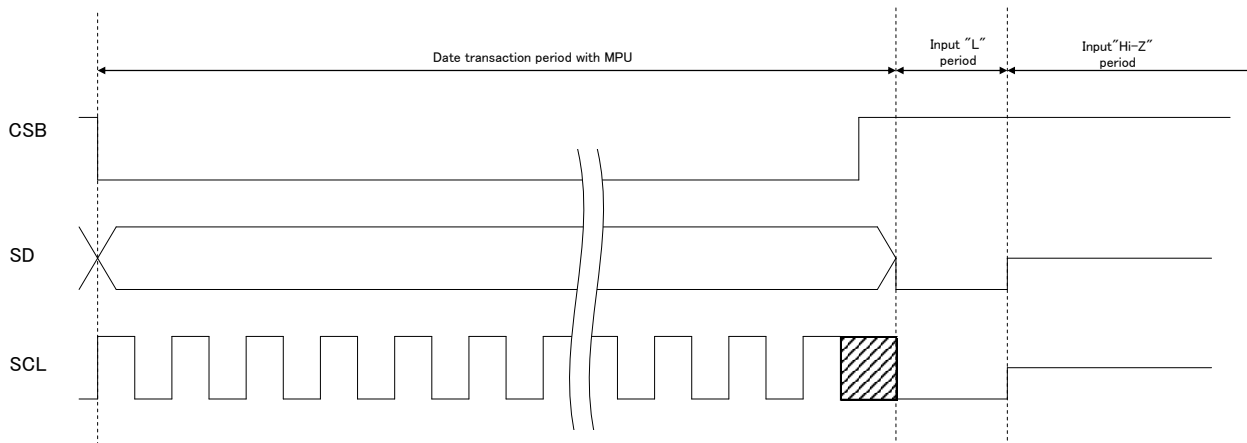


Figure 30. Recommended Sequence When Input Ports are Pulled Down

BU97981KV / BU9798MUV /BU97981GU adopts a 5V tolerant I/O for the digital input. This circuit includes a bus-hold function to keep the level of HIGH. A pull down resistor of below 10K $\omega$  shall be connected to the input terminals to transit from HIGH to LOW because the bus-hold transistor turns on during the input's HIGH level. (Refer to the **Figure 7, Figure 8; I/O Equivalent Circuit**)

A higher resistor than approximate 10K $\omega$  causes input terminals being steady by intermediate potential between HIGH and LOW level so unexpected current is consumed by the system.

The potential depends on the pull down resistance and bus-hold transistor's resistance.

As the bus-hold transistor turns off upon the input level cleared to LOW a higher resistor can be used as a pull down resistor if a MPU set SD and SCL lines to LOW before it releases the lines.

The LOW period preceding MPU's bus release shall be at least 50ns as same as a minimum CLK width ( tSLW ).

## 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**

In the construction of this IC, P-N junctions are inevitably formed creating parasitic diodes or transistors. The operation of these parasitic elements can result in mutual interference among circuits, operational faults, or physical damage. Therefore, conditions which cause these parasitic elements to operate, such as applying a voltage to an input pin lower than the ground voltage should be avoided. Furthermore, do not apply a voltage to the input pins when no power supply voltage is applied to the IC. Even if the power supply voltage is applied, make sure that the input pins have voltages within the values specified in the electrical characteristics of this IC.

**13. Data transmission**

To refrain from data transmission is strongly recommended while power supply is rising up or falling down to prevent from the occurrence of disturbances on transmission and reception.



**Ordering Information**

|                     |                    |                                     |
|---------------------|--------------------|-------------------------------------|
| B U 9 7 9 8 1 x x x | -                  | E 2                                 |
| Part Number         | Package            | Packaging and forming specification |
|                     | KV : VQFP64        | E2: Embossed tape and reel          |
|                     | MUV : VQFN56AV8080 | (VQFP64, VQFN56AV8080)              |
|                     | GU : VBGA64T050A   |                                     |

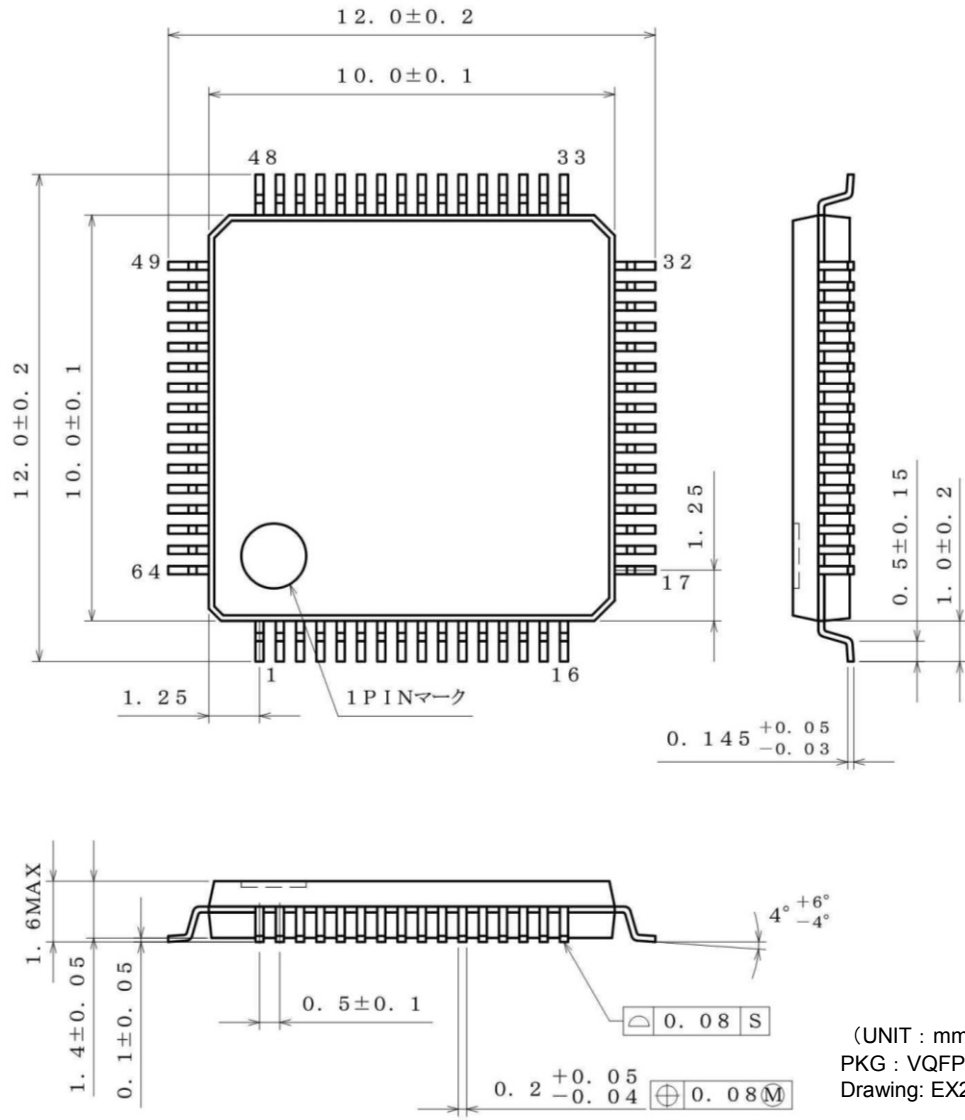
|                   |                  |                                     |
|-------------------|------------------|-------------------------------------|
| B U 9 7 9 8 1 G U | -                | ZE 2                                |
| Part Number       | Package          | Packaging and forming specification |
|                   | GU : VBGA64T050A | E2: Embossed tape and reel          |
|                   |                  | (VBGA64T050A)                       |

**Lineup**

| Package      |              | Orderable Part Number |
|--------------|--------------|-----------------------|
| VQFP64       | Reel of 1000 | BU97981KV-E2          |
| VQFN56AV8080 | Reel of 1000 | BU97981MUV-E2         |
| VBGA64T050A  | Reel of 2500 | BU97981GU-ZE2         |

Physical Dimension, Tape and Reel Information

|              |        |
|--------------|--------|
| Package Name | VQFP64 |
|--------------|--------|



(UNIT : mm)  
 PKG : VQFP64  
 Drawing: EX252-5001-1

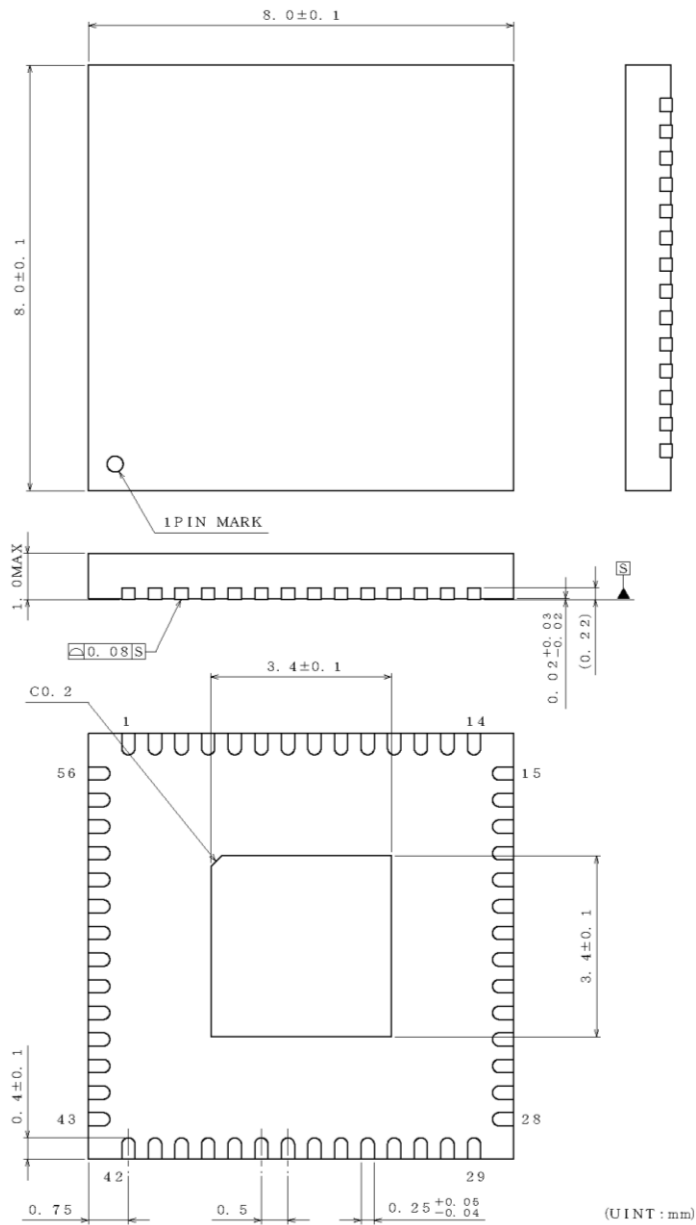
<Tape and Reel information>

|                   |   |
|-------------------|---|
| Tape              | Embossed carrier tape (with dry pack)   |
| 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 ) |

Reel ← 1pin → Direction of feed →

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

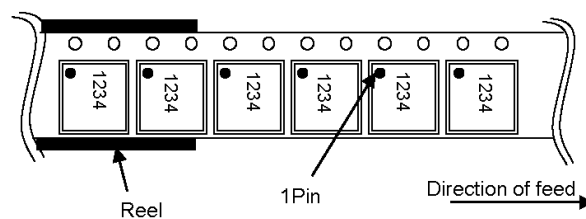
|              |              |
|--------------|--------------|
| Package Name | VQFN56AV8080 |
|--------------|--------------|



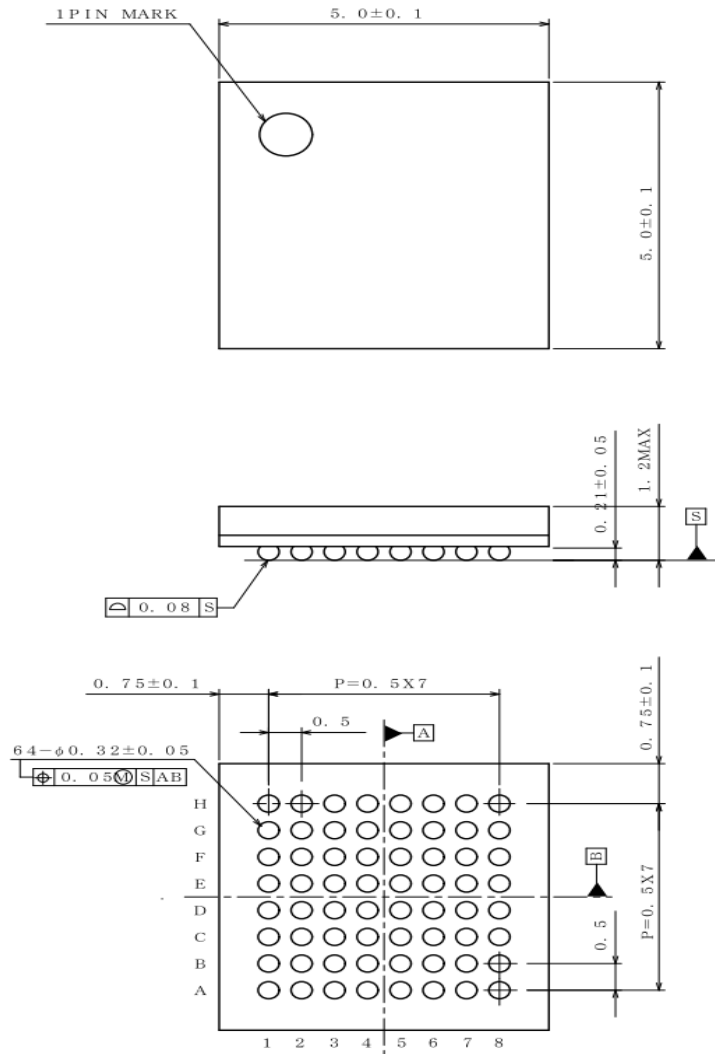
PKG : VQFN56AV8080  
 Drawing No. EX494-5001

< 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 )<br>reel on the left hand and you pull out the tape on the right hand |



|              |              |
|--------------|--------------|
| Package Name | VBGA064T050A |
|--------------|--------------|

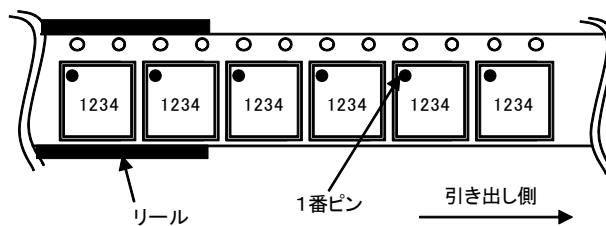


(UNIT : mm)

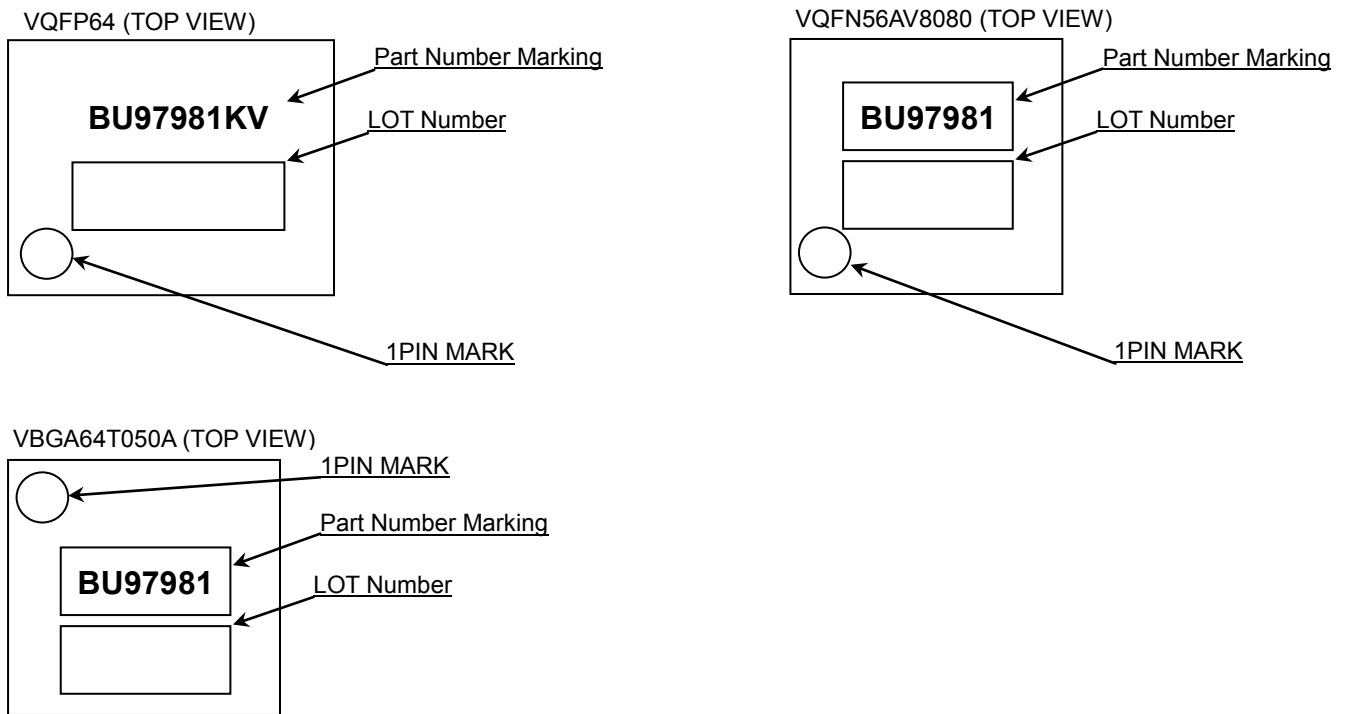
PKG : VBGA64T050A  
Drawing No. EX001-0010

<包装仕様>

|      |  |
|------|--|
| 包装形態 | エンボステーピング(防湿仕様)                                    |
| 包装数量 | 2500pcs  |
| 包装方向 | E2<br>(リールを左手に持ち、右手でテープを引き出したときに、製品の1番ピンが左上にくる方向。) |



Marking Diagrams



| Part Number | Package      | Part Number Marking |
|-------------|--------------|---------------------|
| BU97981KV   | VQFP64       | BU97981KV           |
| BU97981MUV  | VQFN56AV8080 | BU97981             |
| BU97981GU   | VBGA64T050A  | BU97981             |

## Revision History

| Date        | Revision | Changes   |
|-------------|----------|---|
| 31.Aug.2012 | 001      | New Release   |
| 10.Oct.2012 | 002      | P.7<br>(BU97981MUV)<br>Output voltage1<br>MIN: 4.35 -> 4.25,    MAX:4.65 -> 4.70<br>Output voltage2<br>MIN:4.42 -> 4.38,    MAX:4.58 -> 4.62<br><br>P.10, P.11<br>Example of recommended circuit<br>seg -> segments |
| 21.Aug.2013 | 003      | Change to New Style<br><br>P.7<br>(BU97981MUV)<br>Output voltage1<br>MIN: 4.25 -> 4.30  |
| 17.Dec.2014 | 004      | Add GU Package<br>P.1    Delete Package figure<br>P.41 Add "Z" character in Ordering information  |
| 4.Feb.2015  | 005      | P.37 Add the condition when power supply  |
| 10.Apr.2015 | 006      | P.37 Modified and add the Figure of Power ON/OFF Sequence   |

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- 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  |           |

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  - 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 (Pd) depending on Ambient temperature (Ta). When used in sealed area, confirm the actual ambient 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.

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QR code 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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## BU97981MUV - Web Page

[Distribution Inventory](#)

|                             |              |
|-----------------------------|--------------|
| Part Number                 | BU97981MUV   |
| Package                     | VQFN56AV8080 |
| Unit Quantity               | 1000         |
| Minimum Package Quantity    | 1000         |
| Packing Type                | Taping       |
| Constitution Materials List | inquiry      |
| RoHS                        | Yes          |