

# 4-wire Resistive Touch Screen Controller

## BU21025GUL



### General Description

BU21025GUL is a low power 4-wire resistive touch screen controller. BU21025GUL measures coordinates and touch pressures with a 12bit A/D converter. BU21025GUL has a digital filter for noise reduction.

### Features

- 4-wire resistive touch screen controller
- Single 1.65V to 3.60V supply.
- Low standby current ( 0.8uA max)
- 12bit SAR A/D converter
- 2-wire serial interface
- Command base interface
- Digital filter
- Touch pressure measurement
- Auto power down control
- Built-in clock oscillation circuit

### Key Specifications

|                         |                |
|-------------------------|----------------|
| ■ Power supply voltage  | 1.65V to 3.60V |
| ■ Temperature range     | -30°C to 85°C  |
| ■ Standby current       | 0.8uA (Max.)   |
| ■ Operating current     | 120uA (Typ.)   |
| ■ Coordinate resolution | 12Bits         |

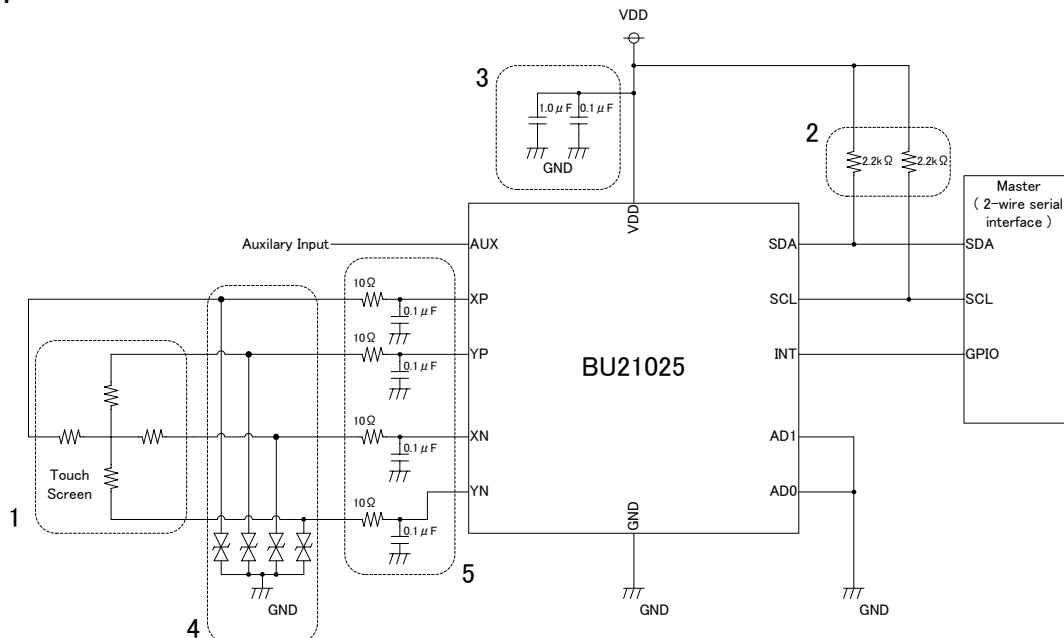
### Package

VCSP50L2 W (Typ.) x D (Typ.) x H (Max.)  
2.00 mm x 1.50 mm x 0.55mm

### Applications

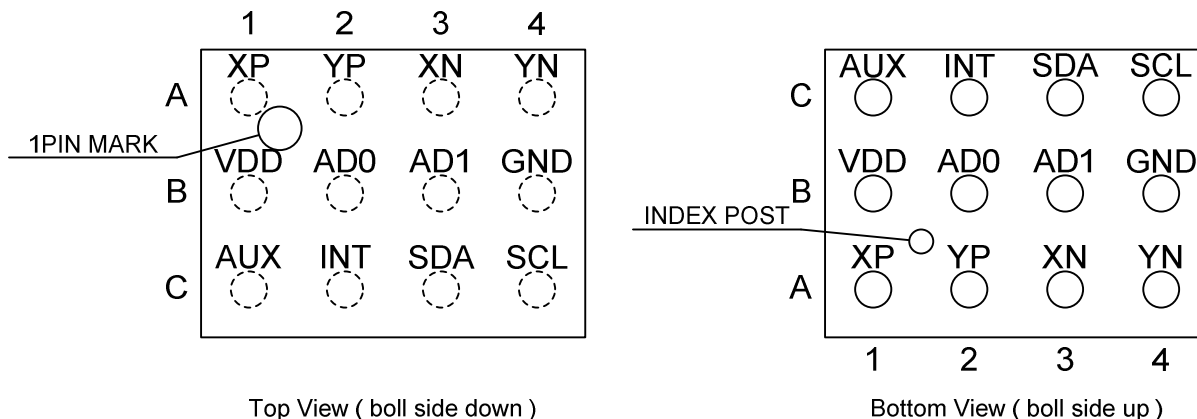
- Equipment with a built in user interface of 4-wire resistive touch screen
- Portable device such as smart phone, tablet, PDA.
- Digital still camera, digital video camera, portable TV.
- PC / PC peripheral equipment such as laptop PC, touch screen monitor, printer.

### Typical Application Circuit



1. 4-wire resistive touch screen
2. Pull-up resistor for 2-wire serial interface
3. Bypass capacitors
4. Diodes for EDS protection
5. Low pass filter for noise reduction

●Pin Configurations



●Pin Descriptions

| PIN NO. | NAME | I/O | DESCRIPTION                                   |
|---------|------|-----|---|
| A1      | XP   | I/O | Screen interface                              |
| A2      | YP   | I/O | Screen interface                              |
| A3      | XN   | I/O | Screen interface                              |
| A4      | YN   | I/O | Screen interface                              |
| B1      | VDD  | -   | Power supply                                  |
| B2      | AD0  | I   | Slave address bit0 input                      |
| B3      | AD1  | I   | Slave address bit1 input                      |
| B4      | GND  | -   | Ground  |
| C1      | AUX  | I   | Auxiliary input                               |
| C2      | INT  | O   | Interrupt output. Pin polarity is active low. |
| C3      | SDA  | I/O | Serial data                                   |
| C4      | SCL  | I/O | Serial clock                                  |

●Absolute Maximum Ratings

| PARAMETER                 | SYMBOL | RATING          | UNIT | CONDITION |
|---------------------------|--------|-----------------|------|-----------|
| Power supply voltage      | VDD    | -0.3 to 4.5     | V    |           |
| Input voltage             | VIN    | -0.3 to VDD+0.3 | V    |           |
| Power dissipation         | Pd     | 600             | mW   | (*1)      |
| Storage temperature range | Tstg   | -50 to 125      | °C   |           |

(\*1) Ambient temperature reduces a permission loss by 6.00mW per case more than 25 degree Celsius, 1degree Celsius.

●Recommended Operating Ratings

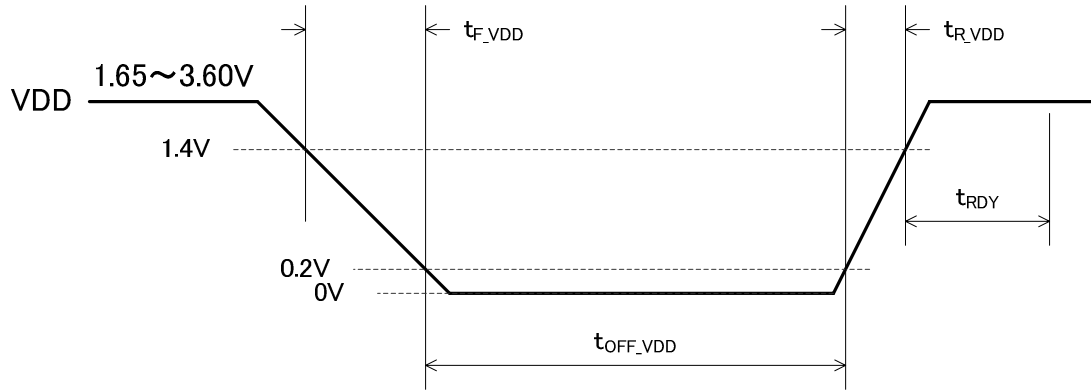
| PARAMETER                   | SYMBOL | RATING |      |      | UNIT | CONDITION |
|-----------------------------|--------|--------|------|------|------|-----------|
|                             |        | MIN.   | TYP. | MAX. |      |           |
| Power supply voltage        | VDD    | 1.65   | 3.00 | 3.60 | V    |           |
| Operating temperature range | Topr   | -30    | 25   | 85   | °C   |           |

●Electrical Characteristics

All specifications typical at 25°C, VDD = 3.00V, GND=0.00V unless otherwise noted.

| PARAMETER                        | SYMBOL | RATING  |      |         | UNIT | CONDITION              |
|----------------------------------|--------|---------|------|---------|------|------------------------|
|                                  |        | MIN.    | TYP. | MAX.    |      |                        |
| Low-level input voltage          | VIL    | -0.3    | -    | 0.3xVDD | V    |                        |
| High-level input voltage         | VIH    | 0.7xVDD | -    | VDD+0.3 | V    |                        |
| Low-level output voltage         | VOL    | 0       | -    | 0.2     | V    | IL = 3.6mA             |
| High-level output voltage        | VOH    | VDD-0.2 | -    | VDD     | V    | IL = -3.6mA            |
| A/D converter resolution         | AD     | -       | -    | 12      | Bits | Programmable 8/12 bits |
| Differential non-linearity error | DNL    | -3.5    | -    | 3.5     | LSB  |                        |
| Integral non-linearity error     | INL    | -5      | -    | 5       | LSB  |                        |
| Internal clock frequency         | Freq   | 2.6     | 4.0  | 5.1     | MHz  |                        |
| Active current                   | Idd    | -       | 120  | 450     | uA   | 8.2kSPS (operation )   |
| Standby current                  | Ist    | -       | -    | 0.8     | uA   | After reset releasing  |

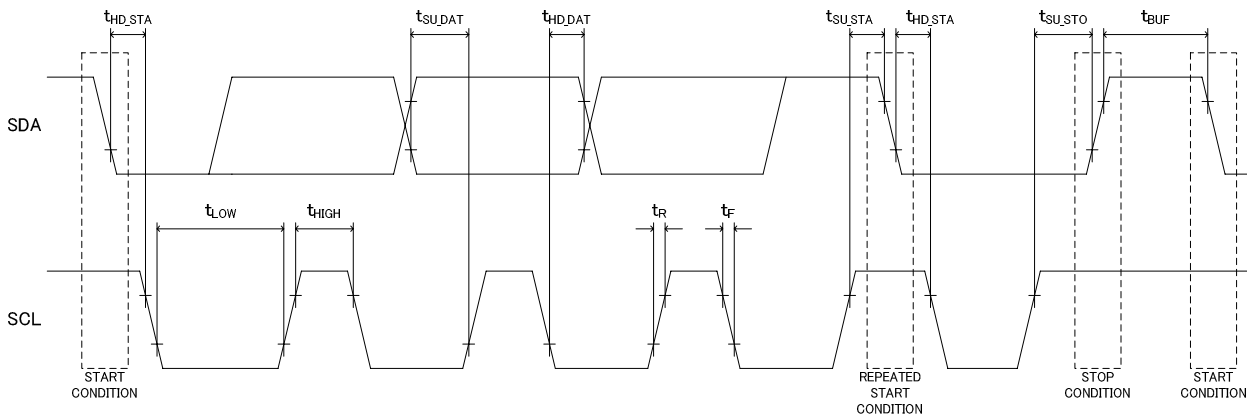
●Power On Reset Timing Chart



All specifications at 25°C, GND=0.00V unless otherwise noted.

| PARAMETER             | SYMBOL         | RATING |      |      | UNIT | CONDITION |
|-----------------------|----------------|--------|------|------|------|-----------|
|                       |                | MIN.   | TYP. | MAX. |      |           |
| Off period of VDD     | $t_{OFF\_VDD}$ | 0.3    | -    | -    | s    |           |
| Rise time for VDD     | $t_{R\_VDD}$   | -      | -    | 100  | us   |           |
| Fall time for VDD     | $t_{F\_VDD}$   | 0.5    | -    | -    | ms   |           |
| Ready time for device | $t_{RDY}$      | -      | -    | 2    | ms   |           |

●2-wire Serial Interface Timing Chart



All specifications at 25°C, VDD = 3.00V, GND=0.00V unless otherwise noted.

| PARAMETER  | SYMBOL        | RATING |      |      | UNIT | CONDITION |
|--|---------------|--------|------|------|------|-----------|
|  |               | MIN.   | TYP. | MAX. |      |           |
| SCL clock frequency                              | $f_{SCL}$     | 0      | -    | 400  | KHz  |           |
| Hold time for (repeated) START condition         | $t_{HD\_STA}$ | 0.6    | -    | -    | us   |           |
| Low period of SCL                                | $t_{LOW}$     | 1.3    | -    | -    | us   |           |
| High period of SCL                               | $t_{HIGH}$    | 0.6    | -    | -    | us   |           |
| Setup time for repeated START condition          | $t_{SU\_STA}$ | 0.6    | -    | -    | us   |           |
| Data hold time                                   | $t_{HD\_DAT}$ | 0      | -    | 0.9  | us   |           |
| Data setup time                                  | $t_{SU\_DAT}$ | 100    | -    | -    | ns   |           |
| Rise time for both SCL and SDA                   | $t_R$         | 20     | -    | 300  | ns   |           |
| Fall time for both SCL and SDA                   | $t_F$         | 20     | -    | 300  | ns   |           |
| Setup time for STOP condition                    | $t_{SU\_STO}$ | 0.6    | -    | -    | us   |           |
| Bus free time between a STOP and START condition | $t_{BUF}$     | 1.3    | -    | -    | us   |           |

## ●2-wire Serial Interface

BU21025GUL supports a 2-wire serial interface. A device that controls transfer is called a master. A device that controlled by the master is called a slave. BU21025GUL is a slave device.

BU21025GUL has a write protocol and a read protocol. The write protocol consists of a start condition, an address byte, a command byte, and a stop condition. The read protocol consists of a start condition, an address byte, one or two data bytes, and a stop condition.

### Start Condition

BU21025GUL recognizes as a start condition that falling edge of SDA while SCL is set "H". If the start condition is received, BU21025GUL will be in the state that can be transfer and received data. When the start condition is fulfilled, BU21025GUL recognize the (repeated) start condition also in data transfer.

### Stop Condition

BU21025GUL recognizes as a stop condition that rising edge of SDA while SCL is set "H". If the stop condition is received, BU21025GUL will be in the state that can not be transfer and received data.

### Data Transfer

Data is transferred with the most significant bit (MSB) first and 8-bits long. Each byte has to be followed by an acknowledge bit. A Timing of SDA data receiving is rising edge of SCL. A state of SDA can only change when SCL set to "L". If SDA is changed while SCL is set "H", a start or stop condition will be recognized by BU21025GUL.

### Acknowledge Bit (sending)

After the master sends a byte to BU21025GUL, an acknowledge bit is used in order that BU21025GUL may return a response to the master. At this time, the master needs to set SDA into a high impedance state. When BU21025GUL receives effectively data, it sets SDA to "L" (ACK). Otherwise SDA is set to "H" (NACK).

### Acknowledge Bit (receiving)

After the master receives a byte from BU21025GUL, an acknowledge bit is used for judgment of whether BU21025GUL continues data transfer. In this case, the master needs to set SDA. When SDA is set to "L" (ACK), BU21025GUL continues data transfer. When SDA is set to "H" (NACK), BU21025GUL ends data transfer.

### Address Byte

BU21025GUL recognizes one byte data as an address byte after a start condition. The address byte is consisted a 7-bit slave address and a read-write bit. If a received slave address is matched with its one, BU21025GUL issues an acknowledge to the master. Otherwise BU21025GUL doesn't issue an acknowledge to the master and stops data transfer. Upper 5 bits of the 7-bit slave address are "10010". And lower 2 bits of the 7-bit slave address are programmable by AD1 and AD0. The read-write bit (R/WB) determines direction. When it is '1', the master reads from BU21025GUL. When it is '0', the master writes to BU21025GUL.

Table 1. Address Byte

| BIT   | MSB<br>7 | 6  | 5  | 4  | 3  | 2   | 1   | LSB<br>0 |
|-------|----------|----|----|----|----|-----|-----|----------|
| NAME  | S6       | S5 | S4 | S3 | S2 | S1  | S0  | R/WB     |
| SLAVE | 1        | 0  | 0  | 1  | 0  | AD1 | AD0 | -        |

BIT 7-1 : S6-0

Slave address

BIT 0 : R/WB

0: The master writes to BU21025GUL

1: The master reads from BU21025GUL.

**Command Byte**

BU21025GUL has a command byte after the address byte. Upper 4 bits of the command byte select an operation code. And lower 4 bits of the command byte select an operand. Effects of the operands are changed by the operation code.

Table 2. Command Byte

| BIT  | MSB<br>7 | 6  | 5  | 4  | 3  | 2  | 1  | LSB<br>0 |
|------|----------|----|----|----|----|----|----|----------|
| NAME | C3       | C2 | C1 | C0 | O3 | O2 | O1 | O0       |

BIT 7-4 : C3-0

Operation code: It is select an operation of the command. Detail is shown in Table 3.

BIT 3-0 : O3-0

Operand: It has 3 types. The operand type is selected by the operation code. When the operation code is not "0101" or "1011", the option type is 0. When it is "1011", the option type is 1. When it is "0101" option type is 2. Detail is shown in Table 3 and 4.

Table 3. Operation Code Function

| C3 | C2 | C1 | C0 | FUNCTION       | AD-INPUT | X-DRIVER | Y-DRIVER | INT<br>POLARITY | OPERAND<br>TYPE |
|----|----|----|----|----------------|----------|----------|----------|-----------------|-----------------|
| 0  | 0  | 0  | 0  | Set Power      | OFF      | OFF      | OFF      | H               | 0               |
| 0  | 0  | 0  | 1  | Reserved       | -        | -        | -        | -               | -               |
| 0  | 0  | 1  | 0  | Measure AUX    | AUX      | OFF      | OFF      | H               | 0               |
| 0  | 0  | 1  | 1  | Reserved       | -        | -        | -        | -               | -               |
| 0  | 1  | 0  | 0  | Set Power      | OFF      | OFF      | OFF      | H               | 0               |
| 0  | 1  | 0  | 1  | Software Reset | OFF      | OFF      | OFF      | H               | 2               |
| 0  | 1  | 1  | 0  | Reserved       | -        | -        | -        | -               | -               |
| 0  | 1  | 1  | 1  | Reserved       | -        | -        | -        | -               | -               |
| 1  | 0  | 0  | 0  | Drive X        | OFF      | ON       | OFF      | L               | 0               |
| 1  | 0  | 0  | 1  | Drive Y        | OFF      | OFF      | ON       | L               | 0               |
| 1  | 0  | 1  | 0  | Drive Z        | OFF      | XN-ON    | YP-ON    | L               | 0               |
| 1  | 0  | 1  | 1  | Setup          | Keep     | Keep     | Keep     | Keep            | 1               |
| 1  | 1  | 0  | 0  | Measure X      | YP       | ON       | OFF      | L               | 0               |
| 1  | 1  | 0  | 1  | Measure Y      | XP       | OFF      | ON       | L               | 0               |
| 1  | 1  | 1  | 0  | Measure Z1     | YN       | XN-ON    | YP-ON    | L               | 0               |
| 1  | 1  | 1  | 1  | Measure Z2     | XP       | XN-ON    | YP-ON    | L               | 0               |

Set Power (0000, 0100)

This code is used for returning to a state for touch detection without A/D conversion after sending screen drive command. After this command, A/D converted data is set to 0.

Software Reset (0101)

BU21025GUL resets an A/D converted data, setup settings, and state of analog blocks to the initial state. If BU21025GUL receives this code during an A/D conversion, the A/D conversion is stopped.

Drive X (1000), Drive Y (1001), Drive Z (1010)

BU21025GUL starts driving screen voltage by each code. PD is not effective. So, Driving is continuous until reserving another command that changes state of driving screen voltage.

Measure AUX (0010), Measure X (1100), Measure Y (1101), Measure Z1 (1110), Measure Z2 (1111)

BU21025GUL starts driving screen voltage and A/D conversion. A PD of operand set, state of BU21025GUL after A/D conversion is finished.

Setup (1011)

The setup command has a special operand (type is 1). The operand has MAF and pull-up resistor settings. Detail is shown in Table 4.

Table 4. Operands of Each Type

| OPERAND TYPE | O3 | O2 | C1  | C0   |
|--------------|----|----|-----|------|
| 0            | X  | PD | M   | X    |
| 1            | L1 | L0 | MAF | PU90 |
| 2            | X  | X  | X   | X    |

## Operand Type 0

O3 : X

Don't care

O2 : PD

Power down setting.

0 : The analog blocks off and touch detection is enable automatically after A/D conversion is finished.

1 : The analog blocks keep measuring state after A/D conversion is finished.

O1 : M

A/D conversion mode setting.

0 : The resolution of A/D conversion is 12-bit. The Conversion clock frequency is 1MHz.

1 : The resolution of A/D conversion is 8-bit. The conversion clock frequency is 2MHz

O0 : X

Don't care

## Operand Type 1

O3 -2: L1-0

Fixed. Must write "00".

O1 : MAF

Median Average Filter (MAF) Setting

0 : MAF is enabled (default).

1 : MAF is disabled.

O0 : PU90

pull-up resistor Setting.

0 : 50 kohm (default).

1 : 90 kohm

## Operand Type 2

O3 -0: X

Don't care

**Write Protocol**

An command write is started in BU21025GUL when the master sends the start condition, the slave address of BU21025GUL, and zero in bit 0( 8<sup>th</sup> bit) for writing, as shown in Table 1. If the slave address is matched with its own, BU21025GUL issues an acknowledge to the master. When the master receives the acknowledge from BU21025GUL, the master send the command byte. When BU21025GUL received next 8 bits, it issues another acknowledge to the master. After the acknowledge is received by the master, the master sends the stop or repeated start condition for ending write.

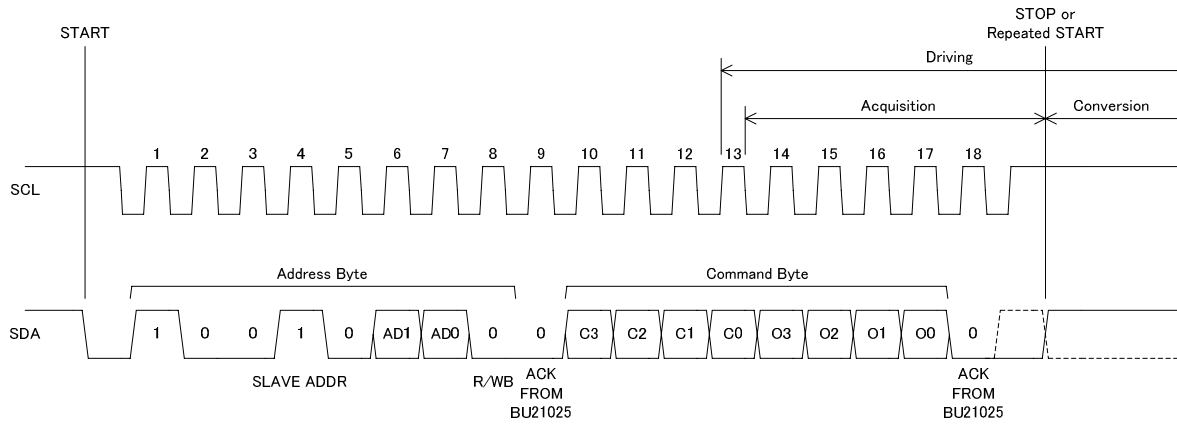


Figure 1. Write Protocol

If a receiving command in BU21025GUL is not the software reset or setup, BU21025GUL starts driving screen voltage when C0 is latched by rising edge of SCL. Next, if the received type of operation code is measurement, BU21025GUL starts acquisition in A/D converter when next falling edge of SCL. BU21025GUL stops acquisition and starts A/D conversion when BU21025GUL receive the stop or repeated start condition.

When BU21025GUL receives a command other than software reset during the A/D conversion, the command is ignored. And if the command is ignored, BU21025GUL doesn't return an acknowledge at the ACK timing behind the command byte. (18<sup>th</sup> timing in Figure. 1)

**Read Protocol**

A data read is started in BU21025GUL when the master sends the start condition, the slave address of BU21025GUL, and one in bit 0 (8<sup>th</sup> bit) for reading, as shown in Table 1. If the slave address is matched with its own, BU21025GUL issues an acknowledge to the master. Next, BU21025GUL send upper 8-bit (D11-4) of an A/D converted 12-bit data as data byte 1 and wait an acknowledge from the master. After receiving the acknowledge, the data byte 2 is sent. Upper 4 bits of it are lower 4 bits (D3-0) of the A/D converted 12-bit data, and lower 4 bits of it are all zero. In next acknowledge timing, the master send a not-acknowledge and the stop or repeated start condition for ending read. In the last acknowledge timing, BU21025GUL doesn't check the acknowledge and stop sending data. So if the master send an acknowledge and continue reading a byte, the read data become 0xFF. In the 8-bit mode, all of an A/D converted 8-bit data is in the data byte 1. So, the master doesn't need to read the data byte 2.

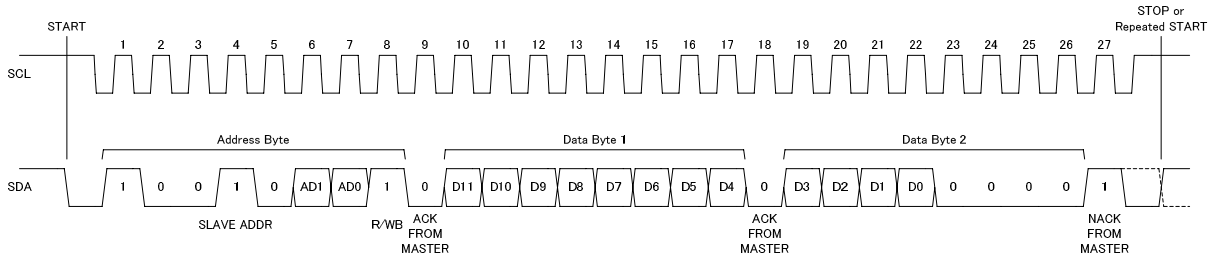


Figure 2. Read Protocol

If an A/D conversion is not finished until falling edge SCL after first acknowledge timing with read mode, SCL pin is stretched by BU21025GUL. In this state, SCL pin is forced to low by BU21025GUL and SDA value is invalid data. This state is ended when the A/D conversion is finished. After this state end, the master can control the SCL line and read converted data.

With stretch function, the master can access immediately after sending a conversion command. If performance of an A/D conversion is needed, the master send the read command after the A/D conversion is finished. Detail of a A/D conversion time is shown in Table 6.

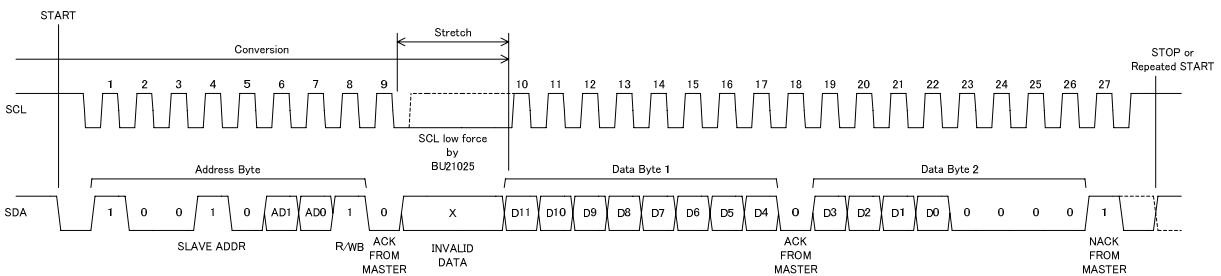
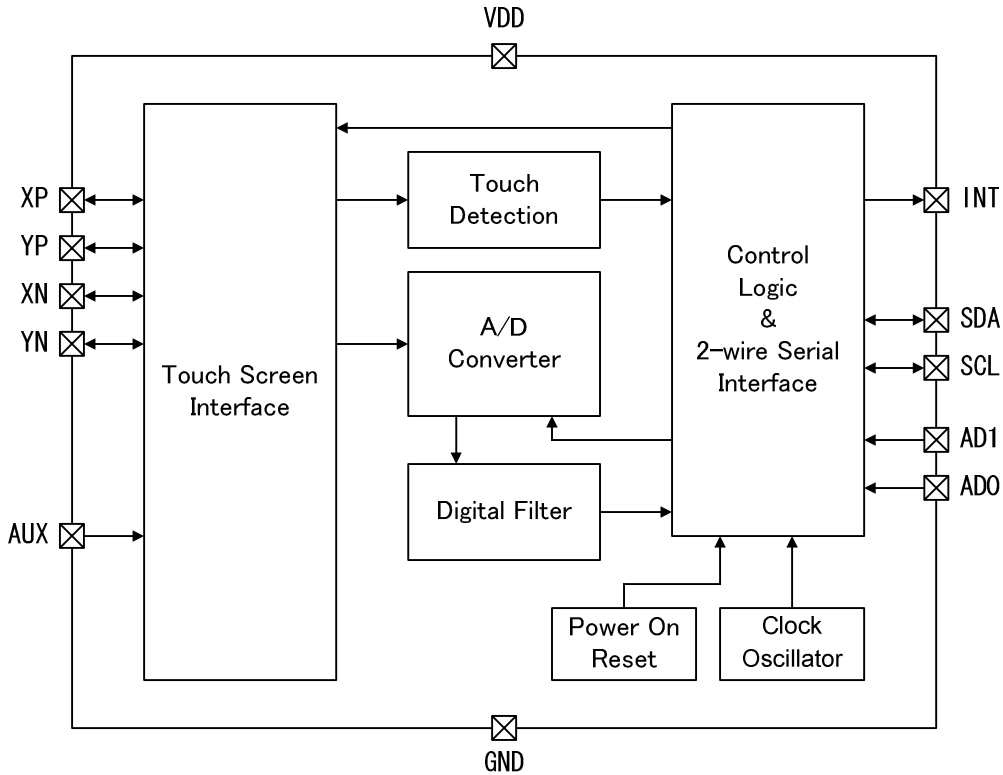


Figure 3. Read with Stretch



●Block Diagram



●Overview

**Power On Reset**

BU21025GUL requests that the Power On Reset Timing should be observed. If the Power On Reset Timing not be observed, BU21025GUL may wakeup with a random state. The touch detection and 2-wire serial interface is enabled after taking the device ready time.

**A/D Converter**

BU21025GUL has a 12-bit Successive Approximation Resistor (SAR) Analog to Digital (A/D) converter. This A/D converter is used for measuring X and Y position and Auxiliary input voltage. Output format is in straight binary as shown in Table 5.

Table 5. A/D Converter Output Format

| INPUT VOLTAGE                     | OUTPUT |
|-----------------------------------|--------|
| (VREF - 1.5LSB) ~ VREF            | FFFh   |
| (VREF - 2.5LSB) ~ (VREF - 1.5LSB) | FFEh   |
| (VREF - 3.5LSB) ~ (VREF - 2.5LSB) | FFDh   |
| :                                 | :      |
| 1.5LSB ~ 2.5LSB                   | 002h   |
| 0.5LSB ~ 1.5LSB                   | 001h   |
| 0 ~ 0.5LSB                        | 000h   |

Note: VREF = VREFP - VREFN, LSB = VREF / 4096

**Touch Screen I/F**

A touch screen interface is consisted many switches. These switches are used for the driving screen voltage and selection an input of the A/D converter. State of these switches is selected by a command that sent from the master.

### Touch Detection

A touch detection function of BU21025GUL is automatically enabled after wakeup. BU21025GUL inform that touch screen is touched or not by INT pin when touch detection is enabled. Output level of INT becomes low during screen is touched. In this state, XP pin is pulled-up high by pull-up resistor ( $R_{PU}$ ) and YN pin is connected to GND. A resistance of  $R_{PU}$  is selectable from either 50 kohm (default) or 90 kohm by the setup command. When the screen isn't touched, XP is connected to VDD trough the pull-up resistor. When the screen is touched, XP is connected to GND trough the screen and BU21025GUL detect touch.

When a received command is not setup (1011), the touch detection is disabled and  $R_{PU}$  is disconnected from XP pin. And output level of INT is fixed high or low by each command (see Table 3 for details about operation code).

When BU21025GUL receives software reset command (0101), touch detection is enabled after the 2<sup>nd</sup> acknowledge timing. When BU21025GUL receives A/D conversion with PD=0 commandn touch detection is enabled after an A/D conversion is finished.

When BU21025GUL receives a driving screen voltage or an A/D conversion with PD=1 command, touch detection is not enable automatically. A method for re-enable the touch detection is sending new command that return to enable touch detection. The set power command is almost same as an A/D conversion command.

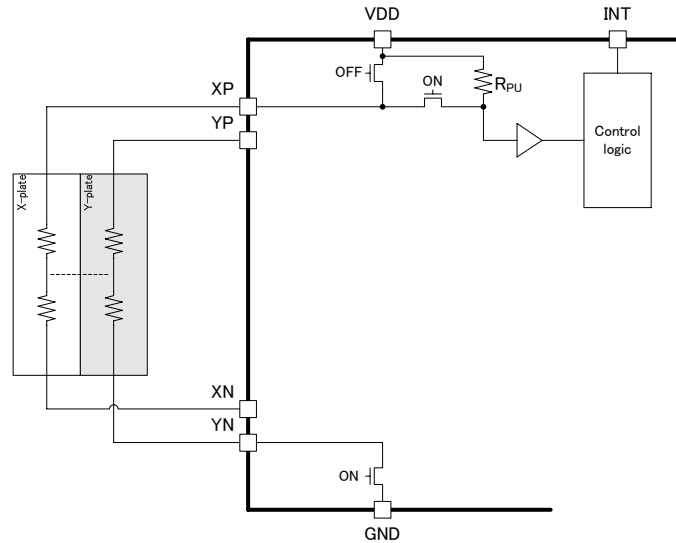


Figure 4. Touch Detection Circuit

### Digital Filter

BU21025GUL has a Median Average Filter (MAF) as a digital filter for noise reduction. When the MAF is enabled, BU21025GUL operates A/D conversion 7 times and stores converted data. Next, these stored data are sorted. An output data of MAF is an average value of middle three values of the sorted data. An abnormal value becomes difficult to affect the results. So noise reduction performance of MAF is higher than one of normal average filter. When the MAF is disabled, BU21025GUL operates A/D conversion one times and output the converted data. The MAF is enabled in defaults and is changed by the setup command.

●Operation

**Position Detection of Touch Screen**

The 4-wire resistive touch screen is mainly constituted in two resistive plates, X and Y. If screen is pressed, these 2 plates are connected.

A position of touch screen is detected by applying voltage to one plate and measuring voltage of another plate. This measurement voltage is divided by touch position. In X-position detection, X-plate is applied voltage. And Voltage of Y-plate is measured. In Y-position detection, Y-plate is applied voltage. And Voltage of Y-plate is measured. The master needs to detection 2 times for detecting X and Y position

When screen is not touched, a measuring plate is high impedance from another plate. So, it can't get voltage. And a value of the A/D conversion became unknown. If unknown values are used for calculating the coordinates, the coordinates will not show touch points. So it is require to filter unknown values when the calculate coordinates.

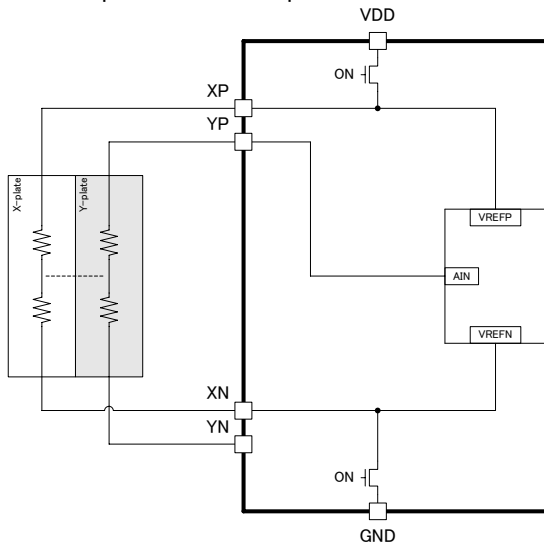


Figure 5. X-Position Detection Mode

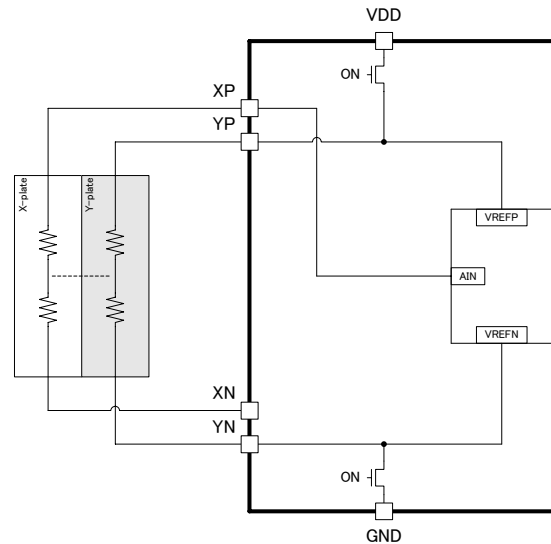


Figure 6. Y-Position Detection Mode

**Touch Resistance Measurement**

These are two methods for measuring touch resistance. The first method requires that a resistance of X-plate ( $R_{X\text{-plate}}$ ) is known. In this method, the calculation of touch resistance ( $R_{TOUCH}$ ) needs X position and 2 additional measurement data ( $Z_1$  and  $Z_2$ ) that shown in Figure 7 and 8. The equation is as follows,

$$R_{TOUCH} = R_{X\text{-plate}} \cdot \frac{X_{\text{position}}}{4096} \left( \frac{Z_2}{Z_1} - 1 \right)$$

The second method requires that both resistance of X-plate and resistance of Y-plate ( $R_{Y\text{-plate}}$ ) are known. In this method, the calculation of  $R_{TOUCH}$  needs X and Y position and  $Z_1$ . The equation is as follows,

$$R_{TOUCH} = \frac{R_{X\text{-plate}} - X_{\text{position}}}{4096} \cdot \left( \frac{4096}{Z_1} - 1 \right) - R_{Y\text{-plate}} \cdot \left( 1 - \frac{Y_{\text{position}}}{4096} \right)$$

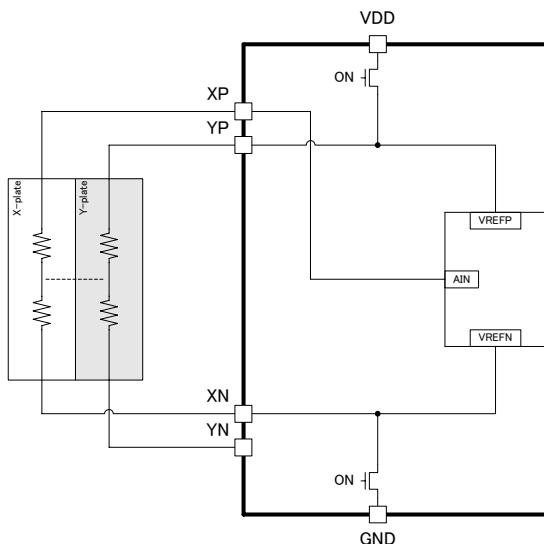


Figure 7. Z1-Position Detection Mode

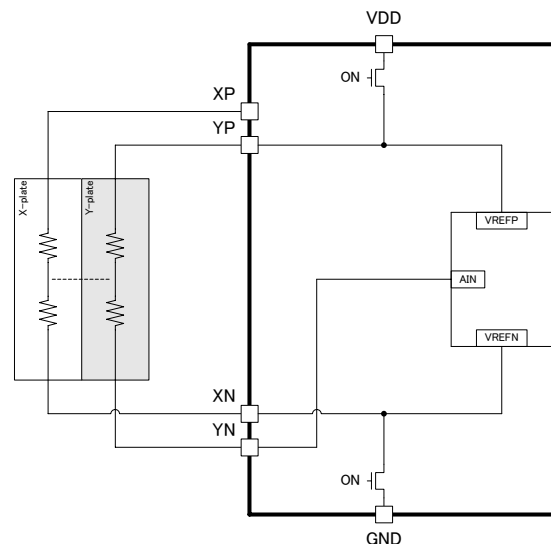


Figure 8. Z2-Position Detection Mode

**A/D Conversion Time**

When MAF is disabled, an A/D conversion takes 66 internal core clocks (CCLK) with 12-bit mode and 38 CCLK with 8-bit mode. When MAF is enabled, it takes 476 CCLK with 12-bit mode and 244 CCLK with 8-bit mode. In MAF mode, the number of sampling becomes 7. So the A/D conversion cycles become large.

The A/D conversion clocks and time are shown in Table 6. The number of CCLK and time are counted from a stop or repeated start condition after sending a conversion command. In this table, the time is calculated by CCLK is 4MHz in typically.

Table 6. A/D Conversion Time (CCLK = 4MHz)

| MAF     | MODE   | NUMBER OF CCLK | TIME [us] |
|---------|--------|----------------|-----------|
| Enable  | 12-bit | 476            | 119.0     |
|         | 8-bit  | 244            | 61.0      |
| Disable | 12-bit | 66             | 16.5      |
|         | 8-bit  | 38             | 9.5       |

**A/D Sampling Time with 2-wire Serial Interface**

The master need to send a conversion command and a read command for getting an A/D converted data. So, a throughput rate is affected by 2-wire serial interface frequency. Each write cycle takes 20 SCL and each read cycle takes 29 SCL (12-bit mode) or 20 SCL (8-bit mode). Note that each a start and a stop condition take 1 SCL in this count.

When the 2-wire serial interface frequency is 400 KHz, one period become 2.5us. Each A/D sampling time takes 241.5us (49 x 2.5 us + 119.0 us) with 12-bit mode and MAF. So, a control throughput rate becomes 4.14 kSPS. In MAF mode, BU21025GUL operates A/D conversion 7 times. It means that an operation throughput rate is increased 7 times. It becomes 28.99 kSPS.

Table 7. Control and Operation Throughput

| 2-WIRE SERIAL INTERFACE FREQUENCY | MAF     | MODE   | NUMBER OF SCL | A/D CONVERSION TIME [us] | CYCLE TIME [us] | CONTROL THROUGHPUT [kSPS] | OPERATION THROUGHPUT [kSPS] |
|-----------------------------------|---------|--------|---------------|--------------------------|-----------------|---------------------------|-----------------------------|
| 100 kHz<br>(10us period)          | Enable  | 12-bit | 49            | 119.0                    | 609.0           | 1.64                      | 11.49                       |
|                                   |         | 8-bit  | 40            | 61.0                     | 461.0           | 2.17                      | 15.18                       |
|                                   | Disable | 12-bit | 49            | 16.5                     | 506.5           | 1.97                      | -                           |
|                                   |         | 8-bit  | 40            | 9.5                      | 409.5           | 2.44                      | -                           |
| 400 kHz<br>(2.5us period)         | Enable  | 12-bit | 49            | 119.0                    | 241.5           | 4.14                      | 28.99                       |
|                                   |         | 8-bit  | 40            | 61.0                     | 161.0           | 6.21                      | 43.48                       |
|                                   | Disable | 12-bit | 49            | 16.5                     | 139.0           | 7.19                      | -                           |
|                                   |         | 8-bit  | 40            | 9.5                      | 109.5           | 9.13                      | -                           |

**•Operational Notes**

## (1) Absolute Maximum Ratings

An excess in the absolute maximum ratings, such as supply voltage, temperature range of operating conditions, etc., can break down devices, thus making impossible to identify breaking mode such as a short circuit or an open circuit. If any special mode exceeding the absolute maximum ratings is assumed, consideration should be given to take physical safety measures including the use of fuses, etc.

## (2) Operating conditions

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

## (3) Reverse connection of power supply connector

The reverse connection of power supply connector can break down ICs. Take protective measures against the breakdown due to the reverse connection, such as mounting an external diode between the power supply and the IC's power supply terminal.

## (4) Power supply line

Design PCB pattern to provide low impedance for the wiring between the power supply and the GND lines. In this regard, for the digital block power supply and the analog block power supply, even though these power supplies has the same level of potential, separate the power supply pattern for the digital block from that for the analog block, thus suppressing the diffraction of digital noises to the analog block power supply resulting from impedance common to the wiring patterns. For the GND line, give consideration to design the patterns in a similar manner. Furthermore, for all power supply terminals to ICs, mount a capacitor between the power supply and the GND terminal. At the same time, in order to use an electrolytic capacitor, thoroughly check to be sure the characteristics of the capacitor to be used present no problem including the occurrence of capacity dropout at a low temperature, thus determining the constant.

## (5) GND voltage

Make setting of the potential of the GND terminal so that it will be maintained at the minimum in any operating state. Furthermore, check to be sure no terminals are at a potential lower than the GND voltage including an actual electric transient.

## (6) Short circuit between terminals and erroneous mounting

In order to mount ICs on a set PCB, pay thorough attention to the direction and offset of the ICs. Erroneous mounting can break down the ICs. Furthermore, if a short circuit occurs due to foreign matters entering between terminals or between the terminal and the power supply or the GND terminal, the ICs can break down.

## (7) Operation in strong electromagnetic field

Be noted that using ICs in the strong electromagnetic field can malfunction them.

## (8) Inspection with set PCB

On the inspection with the set PCB, if a capacitor is connected to a low-impedance IC terminal, the IC can suffer stress. Therefore, be sure to discharge from the set PCB by each process. Furthermore, in order to mount or dismount the set PCB to/from the jig for the inspection process, be sure to turn OFF the power supply and then mount the set PCB to the jig. After the completion of the inspection, be sure to turn OFF the power supply and then dismount it from the jig. In addition, for protection against static electricity, establish a ground for the assembly process and pay thorough attention to the transportation and the storage of the set PCB.

## (9) Input terminals

In terms of the construction of IC, parasitic elements are inevitably formed in relation to potential. The operation of the parasitic element can cause interference with circuit operation, thus resulting in a malfunction and then breakdown of the input terminal. Therefore, pay thorough attention not to handle the input terminals, such as to apply to the input terminals a voltage lower than the GND respectively, so that any parasitic element will operate. Furthermore, do not apply a voltage to the input terminals when no power supply voltage is applied to the IC. In addition, even if the power supply voltage is applied, apply to the input terminals a voltage lower than the power supply voltage or within the guaranteed value of electrical characteristics.

## (10) Ground wiring pattern

If small-signal GND and large-current GND are provided, It will be recommended to separate the large-current GND pattern from the small-signal GND pattern and establish a single ground at the reference point of the set PCB so that resistance to the wiring pattern and voltage fluctuations due to a large current will cause no fluctuations in voltages of the small-signal GND. Pay attention not to cause fluctuations in the GND wiring pattern of external parts as well.

## (11) External capacitor

In order to use a ceramic capacitor as the external capacitor, determine the constant with consideration given to a degradation in the nominal capacitance due to DC bias and changes in the capacitance due to temperature, etc.

## (12) Rush current

The IC with some power supplies has a capable of rush current due to procedure and delay at power-on. Pay attention to the capacitance of the coupling condensers and the wiring pattern width and routing of the power supply and the GND lines.

## (13) Others

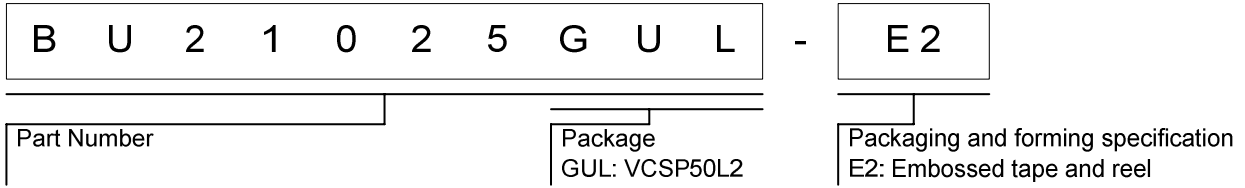
In case of use this LSI, please peruse some other detail documents, we called, Technical note, Functional description, Application note.

## Status of this document

The Japanese version of this document is formal specification. A customer may use this translation version only for a reference to help reading the formal version.

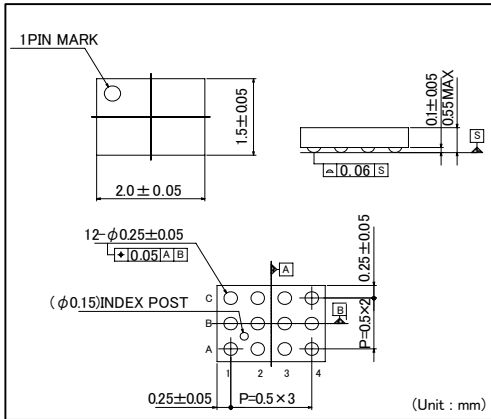
If there are any differences in translation version of this document formal version takes priority

●Ordering Information



●Physical Dimension Tape and Reel Information

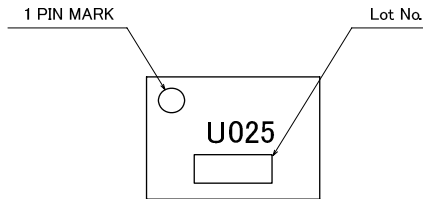
VCSP50L2(BU21025GUL)



| < Tape and Reel information > |  |
|-------------------------------|--|
| Tape                          | Embossed carrier tape  |
| Quantity                      | 3000pcs  |
| Direction of feed             | E2<br>( The direction is the 1 pin of product is at the upper left when you hold reel on the left hand and you pull out the tape on the right hand ) |

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

●Marking Diagram (TOP VIEW)



**•Revision History**

| DATE       | REVISION | CHANGES     |
|------------|----------|-------------|
| 2012/06/28 | 002      | new release |

# Notice

## Precaution on using ROHM Products

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

(Note1) Medical Equipment Classification of the Specific Applications

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

- ROHM designs and manufactures its Products subject to strict quality control system. However, semiconductor products can fail or malfunction at a certain rate. Please be sure to implement, at your own responsibilities, adequate safety measures including but not limited to fail-safe design against the physical injury, damage to any property, which a failure or malfunction of our Products may cause. The following are examples of safety measures:
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  - Installation of redundant circuits to reduce the impact of single or multiple circuit failure
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  - Use of our Products outdoors or in places where the Products are exposed to direct sunlight or dust
  - Use of our Products in places where the Products are exposed to sea wind or corrosive gases, including Cl<sub>2</sub>, H<sub>2</sub>S, NH<sub>3</sub>, SO<sub>2</sub>, and NO<sub>2</sub>
  - Use of our Products in places where the Products are exposed to static electricity or electromagnetic waves
  - Use of our Products in proximity to heat-producing components, plastic cords, or other flammable items
  - Sealing or coating our Products with resin or other coating materials
  - Use of our Products without cleaning residue of flux (even if you use no-clean type fluxes, cleaning residue of flux is recommended); or Washing our Products by using water or water-soluble cleaning agents for cleaning residue after soldering
  - Use of the Products in places subject to dew condensation
- The Products are not subject to radiation-proof design.
- Please verify and confirm characteristics of the final or mounted products in using the Products.
- In particular, if a transient load (a large amount of load applied in a short period of time, such as pulse. is applied, confirmation of performance characteristics after on-board mounting is strongly recommended. Avoid applying power exceeding normal rated power; exceeding the power rating under steady-state loading condition may negatively affect product performance and reliability.
- De-rate Power Dissipation (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; if flow soldering method is preferred, 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.

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Since our Products might fall under controlled goods prescribed by the applicable foreign exchange and foreign trade act, please consult with ROHM representative in case of export.

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