

## Image Correction ICs

# Image Correction IC for Panel



BU1523KV

No.11060EAT05

**●Description**

BU1523KV is an image quality adjustment IC for in-vehicle displays. It can control brightness, contrast, hue, intensity, sharpness, etc. It is equipped with both RGB and YCbCr as input/output interfaces. It also incorporates LVDS output capability with an embedded LVDS transmitter.

**●Features**

- 1) RGB input data format  
Width of data bus 24bit  
Vertical/horizontal synchronizing and data enable signal
- 2) RGB output data format  
It is the same as the entry format
- 3) YCbCr input data format  
ITU-R BT.656-4 or synchronization signal YCbCr  
Width of data bus 8bit  
Vertical/horizontal synchronizing and data field signal  
Date range conform ITU-R BT.601 or full range
- 4) YCbCr output data format  
The same as the entry format  
Capable of processing BT.656 input to generate and output  
synchronization signal from SAV/EAV
- 5) RGB IF Image quality adjustment  
Contrast, Brightness, Hue, Chroma and Sharpness  
Independent RGB gamma correction
- 6) YCbCr Image quality adjustment  
Contrast, Brightness, Hue, Chroma and Sharpness
- 7) LVDS Transmitter  
Built-in LVDS transmitter  
Converts RGB24 bit, vertical/horizontal synchronization signal  
and data enable inputs into 4ch LVDS data streams
- 8) 2-line serial interface slave function  
The register in BU1523KV can be set
- 9) Package  
VQFP100

**●Applications**

In-vehicle display etc.

### ●Absolute maximum ratings

[Table 1]

| Parameter                 | Symbol | Ratings                                 | Unit |
|---------------------------|--------|---|------|
| Supply voltage 1          | VDDIO  | -0.3~+4.0                               | V    |
| Supply voltage 2          | VDDI2C | -0.3~+4.0                               | V    |
| Supply voltage 3          | PVDD   | -0.3~+4.0                               | V    |
| Supply voltage 4          | LVDD   | -0.3~+4.0                               | V    |
| Supply voltage 5          | VDD    | -0.3~+2.1                               | V    |
| Input voltage range       | VIN    | -0.3~IO_LVL+0.3 <sup>*1</sup>           | V    |
| Storage temperature range | Tstg   | -40~+125                                | °C   |
| Power dissipation         | PD     | 1000 <sup>*2</sup> , 1499 <sup>*3</sup> | mW   |

\*1 IO\_LVL is a generic name of VDDIO, VDDI2C

\*2 IC only. In the case exceeding 25°C, 10mW should be reduced at the rating 1°C.

\*3 When packaging a glass epoxy board of 70x70x1.6mm. If exceeding 25°C, 14.99mW should be reduced at the rating 1°C

\* Has not been designed to withstand radiation.

\* Operation is not guaranteed at absolute maximum ratings.

### ●Operating conditions

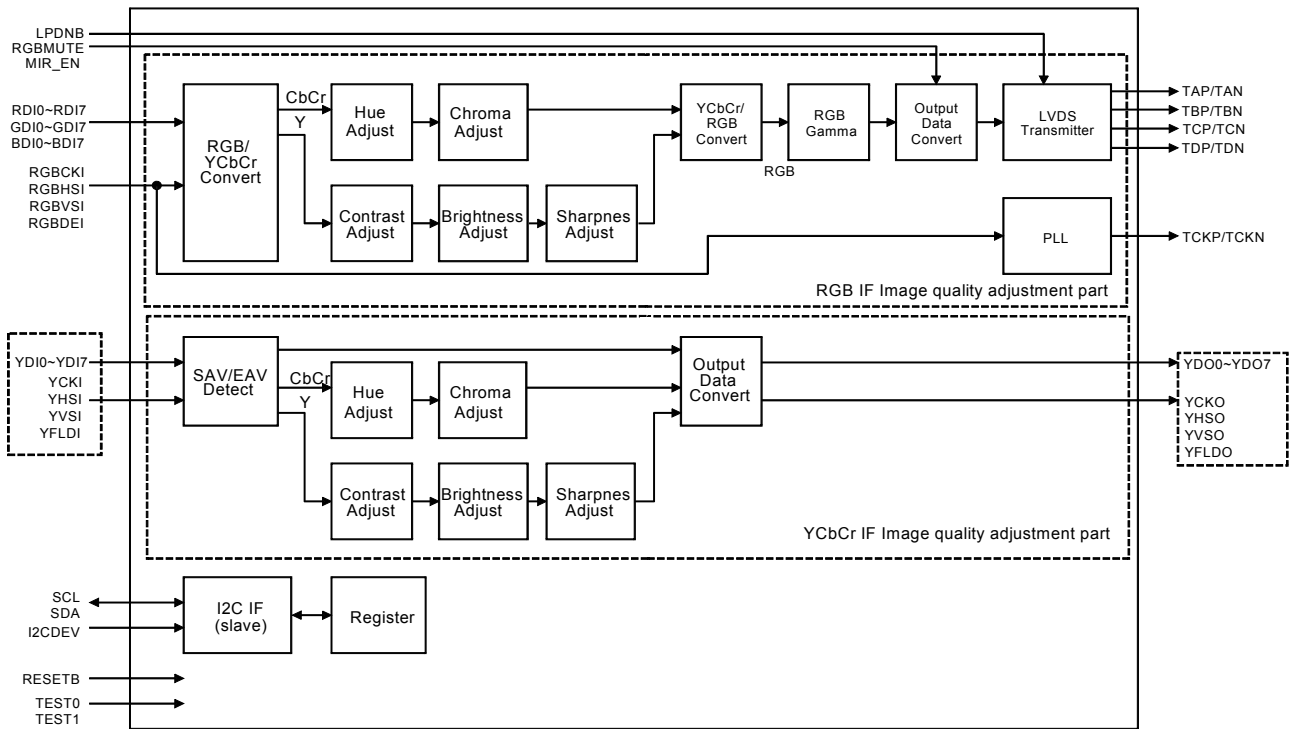
[Table 2]

| Parameter                   | Symbol | Ratings |      |                      | Unit |
|-----------------------------|--------|---------|------|----------------------|------|
|                             |        | Min.    | Typ. | Max.                 |      |
| Supply voltage1(IO)         | VDDIO  | 3.0     | 3.3  | 3.6                  | V    |
| Supply voltage2(IO)         | VDDI2C | 3.0     | 3.3  | 3.6                  | V    |
| Supply voltage3(PLL)        | PVDD   | 3.0     | 3.3  | 3.6                  | V    |
| Supply voltage4(LVDS)       | LVDD   | 3.0     | 3.3  | 3.6                  | V    |
| Supply voltage5(CORE)       | VDD    | 1.65    | 1.8  | 1.95                 | V    |
| Input voltage range         | VIN    | 0.0     | -    | IO_LVL <sup>*1</sup> | V    |
| Operating temperature range | Topr   | -40     | -    | +85                  | °C   |

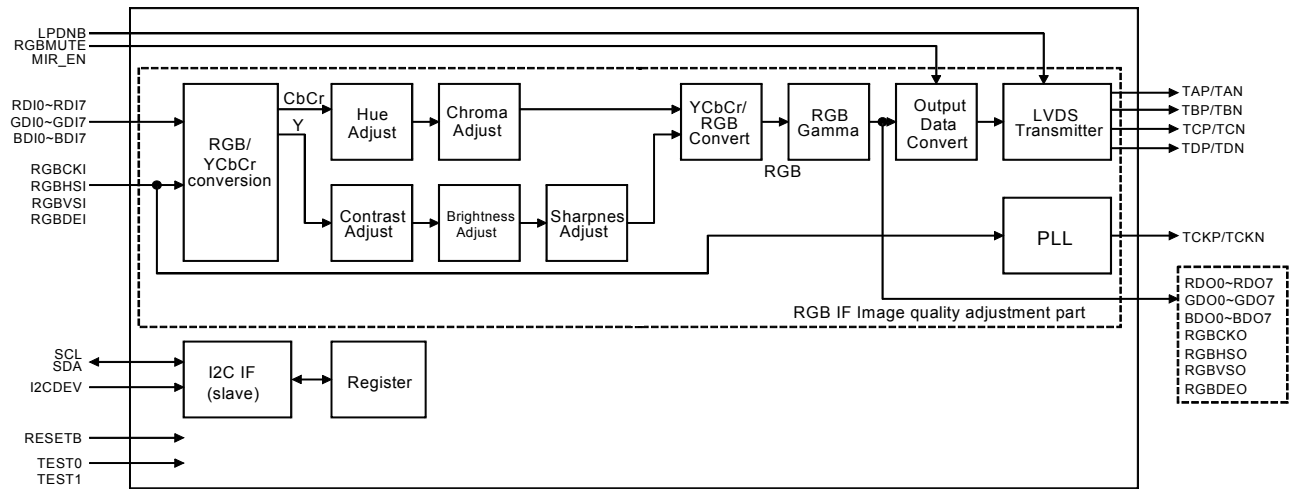
\*1 IO\_LVL is a generic name of VDDIO, VDDI2C.

\* Please supply power source in order of VDD→ (VDDIO, VDDI2C, PVDD, LVDD).

●Block Diagram



The LVDS data output mode



The RGB data output mode (YCbCr interface cannot be used.)

Terminal selection from register

\*Change their modes with register setting.

Fig. 1 Block diagram

● Terminal Functions - Equivalent circuit diagram

Table 3 Terminal Functions (1/4)

| PIN No. | PIN Name    | In/Out (*1) | Init (*2) | Function Description                             | PowerSupply System (*4) | I/O Type |
|---------|-------------|-------------|-----------|--|-------------------------|----------|
| 1       | BDI4        | I           | -         | RGB B Data [4] input                             | a                       | A        |
| 2       | BDI5        | I           | -         | RGB B Data [5] input                             | a                       | A        |
| 3       | BDI6        | I           | -         | RGB B Data [6] input                             | a                       | A        |
| 4       | BDI7        | I           | -         | RGB B Data [7] input                             | a                       | A        |
| 5       | RGBHSI      | I           | -         | RGB H Sync input                                 | a                       | A        |
| 6       | RGBVSI      | I           | -         | RGB V Sync input                                 | a                       | A        |
| 7       | RGBDEI      | I           | -         | RGB Data Enable input                            | a                       | A        |
| 8       | GND         | G           | -         | Ground   | a,b                     | -        |
| 9       | RGBCKI      | I           | -         | RGB Clock input                                  | a                       | B        |
| 10      | VDDIO       | P           | -         | IO power source                                  | a                       | -        |
| 11      | I2CVDD      | P           | -         | 2-line serial interface IO power source          | b                       | -        |
| 12      | SDA         | I/O         | In        | 2-line serial interface data input / output (*6) | b                       | G        |
| 13      | SCL         | I           | -         | 2-line serial interface clock input              | b                       | H        |
| 14      | GND         | G           | -         | Ground   | a,b                     | -        |
| 15      | VDDIO       | P           | -         | IO power source                                  | a                       | -        |
| 16      | VDD         | P           | -         | CORE power source                                | -                       | -        |
| 17      | YDO7/RGBDEO | O           | Low       | BT601 YcbCr data [7] / RGB data output           | a                       | D        |
| 18      | YDO6/RGBVSO | O           | Low       | BT601 YcbCr data [6] / RGB V Sync output         | a                       | D        |
| 19      | YDO5/RGBHSO | O           | Low       | BT601 YcbCr data [5] / RGB H Sync output         | a                       | D        |
| 20      | YDO4/BDO7   | O           | Low       | BT601 YcbCr data [4] / RGB B data [7] output     | a                       | D        |
| 21      | YDO3/BDO6   | O           | Low       | BT601 YcbCr data [3] / RGB B data [6] output     | a                       | D        |
| 22      | YDO2/BDO5   | O           | Low       | BT601 YcbCr data [2] / RGB B data [5] output     | a                       | D        |
| 23      | YDO1/BDO4   | O           | Low       | BT601 YcbCr data [1] / RGB B data [4] output     | a                       | D        |
| 24      | YDO0/BDO3   | O           | Low       | BT601 YcbCr data [0] / RGB B data [3] output     | a                       | D        |
| 25      | YFLDO/BDO2  | O           | Low       | BT601 Field output / RGB B data [2] output       | a                       | D        |

\* Fix an unused input pin to GND or VDDIO (Fix SDA and SCL to I2CVDD. TEST0 and TEST1 are excluded.)

\*1) "I" shows the input, "O" shows the output, "I/O" shows the bidirection, "P" shows the power supply, and "G" shows GND.

\*2) "PD" shows the pull-down, "In" shows the input mode, and "Low" shows the Low level output.

\*4) "a" in the column in the power supply system shows VDDIO, "b" shows I2CVDD, "c" shows LVDD, and "d" shows PVDD.

\*6) "SDA" is output at "L" level when usually using it or is in the state of high impedance, and "H" level is not output.

[Table 3 Terminal Functions (2/4)]

| PIN No. | PIN Name   | In/Out (*1) | Init (*2) | Function Description                                | Power Supply System (*4) | I/O Type |
|---------|------------|-------------|-----------|---|--------------------------|----------|
| 26      | YVSO/BDO1  | O           | Low       | BT601 YcbCr data [1] / RGB V Sync output            | a                        | D        |
| 27      | YHSO/BDO0  | O           | Low       | BT601 YcbCr data [0] / RGB H Sync output            | a                        | D        |
| 28      | GND        | G           | -         | Ground  | a,b                      | -        |
| 29      | YCKO/RGBCO | O           | Low       | BT601 Clock output / RGB Clock output               | a                        | D        |
| 30      | VDDIO      | P           | -         | IO power source                                     | a                        | -        |
| 31      | GDO7       | O           | Low       | RGB G data [7] output                               | a                        | D        |
| 32      | GDO6       | O           | Low       | RGB G data [6] output                               | a                        | D        |
| 33      | GDO5       | O           | Low       | RGB G data [5] output                               | a                        | D        |
| 34      | GDO4       | O           | Low       | RGB G data [4] output                               | a                        | D        |
| 35      | VDDIO      | P           | -         | IO power source                                     | a                        | -        |
| 36      | YCKI/GDO3  | I/O         | In        | BT656 Clock input / RGB G data [3] output (*5)      | a                        | F        |
| 37      | GND        | G           | -         | Ground  | a,b                      | -        |
| 38      | YHSI/GDO2  | I/O         | In        | BT656 H Sync input / RGB G data [2] output (*5)     | a                        | E        |
| 39      | YVSI/GDO1  | I/O         | In        | BT656 V Sync input / RGB G data [1] output (*5)     | a                        | E        |
| 40      | YFLDI/GDO0 | I/O         | In        | BT601 Field input / RGB G data [0] output           | a                        | E        |
| 41      | VDD        | P           | -         | CORE power source                                   | -                        | -        |
| 42      | YDI0/RDO7  | I/O         | In        | BT656 Y data [0] input / RGB R data [7] output (*5) | a                        | E        |
| 43      | YDI1/RDO6  | I/O         | In        | BT656 Y data [1] input / RGB R data [6] output (*5) | a                        | E        |
| 44      | YDI2/RDO5  | I/O         | In        | BT656 Y data [2] input / RGB R data [5] output (*5) | a                        | E        |
| 45      | VDDIO      | P           | -         | IO power source                                     | a                        | -        |
| 46      | YDI3/RDO4  | I/O         | In        | BT656 Y data [3] input / RGB R data [4] output (*5) | a                        | E        |
| 47      | YDI4/RDO3  | I/O         | In        | BT656 Y data [4] input / RGB R data [3] output (*5) | a                        | E        |
| 48      | YDI5/RDO2  | I/O         | In        | BT656 Y data [5] input / RGB R data [2] output (*5) | a                        | E        |
| 49      | YDI6/RDO1  | I/O         | In        | BT656 Y data [6] input / RGB R data [7] output (*5) | a                        | E        |
| 50      | YDI7/RDO0  | I/O         | In        | BT656 Y data [7] input / RGB R data [0] output (*5) | a                        | E        |

\* Fix an unused input pin to GND or VDDIO (Fix SDA and SCL to I2CVDD. TEST0 and TEST1 are excluded.)

\*1) "I" shows the input, "O" shows the output, "I/O" shows the bidirection, "P" shows the power supply, and "G" shows GND.

\*2) "PD" shows the pull-down, "In" shows the input mode, and "Low" shows the Low level output.

\*4) "a" in the column in the power supply system shows VDDIO, "b" shows I2CVDD, "c" shows LVDD, and "d" shows PVDD.

\*5) 36-50 pins direction depends on the modes.

the RGB data output mode: output

the LVDS data output mode: input

[Table 3 Terminal Functions (3/4)]

| PIN No. | PIN Name | In/Out (*1) | Init (*2) | Function Description                    | Power Supply System (*4) | I/O Type |
|---------|----------|-------------|-----------|---|--------------------------|----------|
| 51      | GND      | G           | -         | Ground                                  | a,b                      | -        |
| 52      | I2CDEV   | I           | -         | I <sup>2</sup> C device address setting | a                        | A        |
| 53      | RGBMUTE  | I           | -         | MUTE signal : High active               | a                        | B        |
| 54      | MIR_EN   | I           | -         | LVDS data mirror enable : High active   | a                        | A        |
| 55      | TEST0    | I           | PD        | Test pin 0 (*3) (Connect to GND)        | a                        | C        |
| 56      | TEST1    | I           | PD        | Test pin 1 (*3) (Connect to GND)        | a                        | C        |
| 57      | RESETB   | I           | -         | Logic reset signal: Low active          | a                        | B        |
| 58      | LPDNB    | I           | -         | LVDS reset signal: Low active           | a                        | B        |
| 59      | VDDIO    | P           | -         | IO power source                         | a                        | -        |
| 60      | PGND     | G           | -         | PLL ground                              | d                        | -        |
| 61      | PVDD     | P           | -         | PLL ground                              | d                        | -        |
| 62      | LGND     | G           | -         | LVDS ground                             | c                        | -        |
| 63      | TDP      | O           | -         | LVDS data output D ch P                 | c                        | I        |
| 64      | TDN      | O           | -         | LVDS data output D ch N                 | c                        | I        |
| 65      | TCKP     | O           | -         | LVDS clock output P                     | c                        | I        |
| 66      | TCKN     | O           | -         | LVDS clock output N                     | c                        | I        |
| 67      | TCP      | O           | -         | LVDS data output C ch P                 | c                        | I        |
| 68      | TCN      | O           | -         | LVDS data output C ch N                 | c                        | I        |
| 69      | LGND     | G           | -         | LVDS ground                             | c                        | -        |
| 70      | LVDD     | P           | -         | LVDS power source                       | c                        | -        |
| 71      | TBP      | O           | -         | LVDS data output B ch P                 | c                        | I        |
| 72      | TBN      | O           | -         | LVDS data output B ch N                 | c                        | I        |
| 73      | TAP      | O           | -         | LVDS data output A ch P                 | c                        | I        |
| 74      | TAN      | O           | -         | LVDS data output A ch N                 | c                        | I        |
| 75      | LGND     | G           | -         | LVDS ground                             | c                        | -        |

\* Fix an unused input pin to GND or VDDIO (Fix SDA and SCL to I2CVDD. TEST0 and TEST1 are excluded.).

\*1) "I" shows the input, "O" shows the output, "I/O" shows the bidirection, "P" shows the power supply, and "G" shows GND.

\*2) "PD" shows the pull-down, "In" shows the input mode, and "Low" shows the Low level output.

\*3) Fix TEST0 and TEST1 to GND (The opening is a prohibition of use)

\*4) "a" in the column in the power supply system shows VDDIO, "b" shows I2CVDD, "c" shows LVDD, and "d" shows PVDD.

[Table 3 Terminal Functions (4/4) ]

| PIN No. | PIN Name | In/Out (*1) | Init (*2) | Function Description | Power Supply System (*4) | I/O Type |
|---------|----------|-------------|-----------|----------------------|--------------------------|----------|
| 76      | GND      | G           | -         | Ground               | a,b                      | -        |
| 77      | RDI0     | I           | -         | RGB R data [0] input | a                        | A        |
| 78      | RDI1     | I           | -         | RGB R data [1] input | a                        | A        |
| 79      | RDI2     | I           | -         | RGB R data [2] input | a                        | A        |
| 80      | RDI3     | I           | -         | RGB R data [3] input | a                        | A        |
| 81      | RDI4     | I           | -         | RGB R data [4] input | a                        | A        |
| 82      | RDI5     | I           | -         | RGB R data [5] input | a                        | A        |
| 83      | RDI6     | I           | -         | RGB R data [6] input | a                        | A        |
| 84      | RDI7     | I           | -         | RGB R data [7] input | a                        | A        |
| 85      | VDDIO    | P           | -         | IO power source      | a                        | -        |
| 86      | GDI0     | I           | -         | RGB G data [0] input | a                        | A        |
| 87      | GDI1     | I           | -         | RGB G data [1] input | a                        | A        |
| 88      | GND      | G           | -         | GND                  | a,b                      | -        |
| 89      | GDI2     | I           | -         | RGB G data [2] input | a                        | A        |
| 90      | GDI3     | I           | -         | RGB G data [3] input | a                        | A        |
| 91      | GDI4     | I           | -         | RGB G data [4] input | a                        | A        |
| 92      | GDI5     | I           | -         | RGB G data [5] input | a                        | A        |
| 93      | GDI6     | I           | -         | RGB G data [6] input | a                        | A        |
| 94      | GDI7     | I           | -         | RGB G data [7] input | a                        | A        |
| 95      | VDD      | P           | -         | CORE power source    | -                        | -        |
| 96      | BDI0     | I           | -         | RGB B data [0] input | a                        | A        |
| 97      | BDI1     | I           | -         | RGB B data [1] input | a                        | A        |
| 98      | BDI2     | I           | -         | RGB B data [2] input | a                        | A        |
| 99      | BDI3     | I           | -         | RGB B data [3] input | a                        | A        |
| 100     | VDDIO    | P           | -         | IO power source      | a                        | -        |

\* Fix an unused input pin to GND or VDDIO (Fix SDA and SCL to I2CVDD. TEST0 and TEST1 are excluded.) .

\*1) "I" shows the input, "O" shows the output, "I/O" shows the bidirection, "P" shows the power supply, and "G" shows GND.

\*2) "PD" shows the pull-down, "In" shows the input mode, and "Low" shows the Low level output.

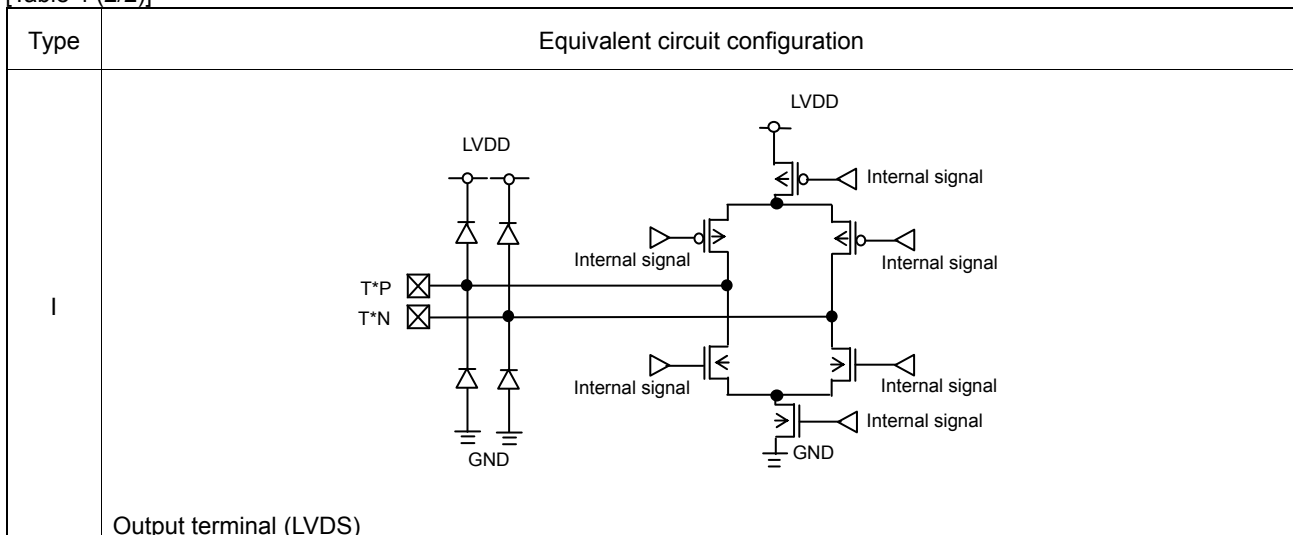
\*4) "a" in the column in the power supply system shows VDDIO, "b" shows I2CVDD, "c" shows LVDD, and "d" shows PVDD.

[Table 4 (1/2)]

| Type | Equivalent circuit configuration                 | Type | Equivalent circuit configuration                       |
|------|--|------|--|
| A    | <p>Input terminal</p>                            | B    | <p>Input terminal with schmitt</p>                     |
| C    | <p>Input terminal with pull down</p>             | D    | <p>Output terminal</p>                                 |
| E    | <p>Input/Output terminal</p>                     | F    | <p>Input/Output terminal with schmitt</p>              |
| G    | <p>Input/Output terminal (2-line serial I/F)</p> | H    | <p>Input terminal with schmitt (2-line serial I/F)</p> |



[Table 4 (2/2)]



●Pin configurations

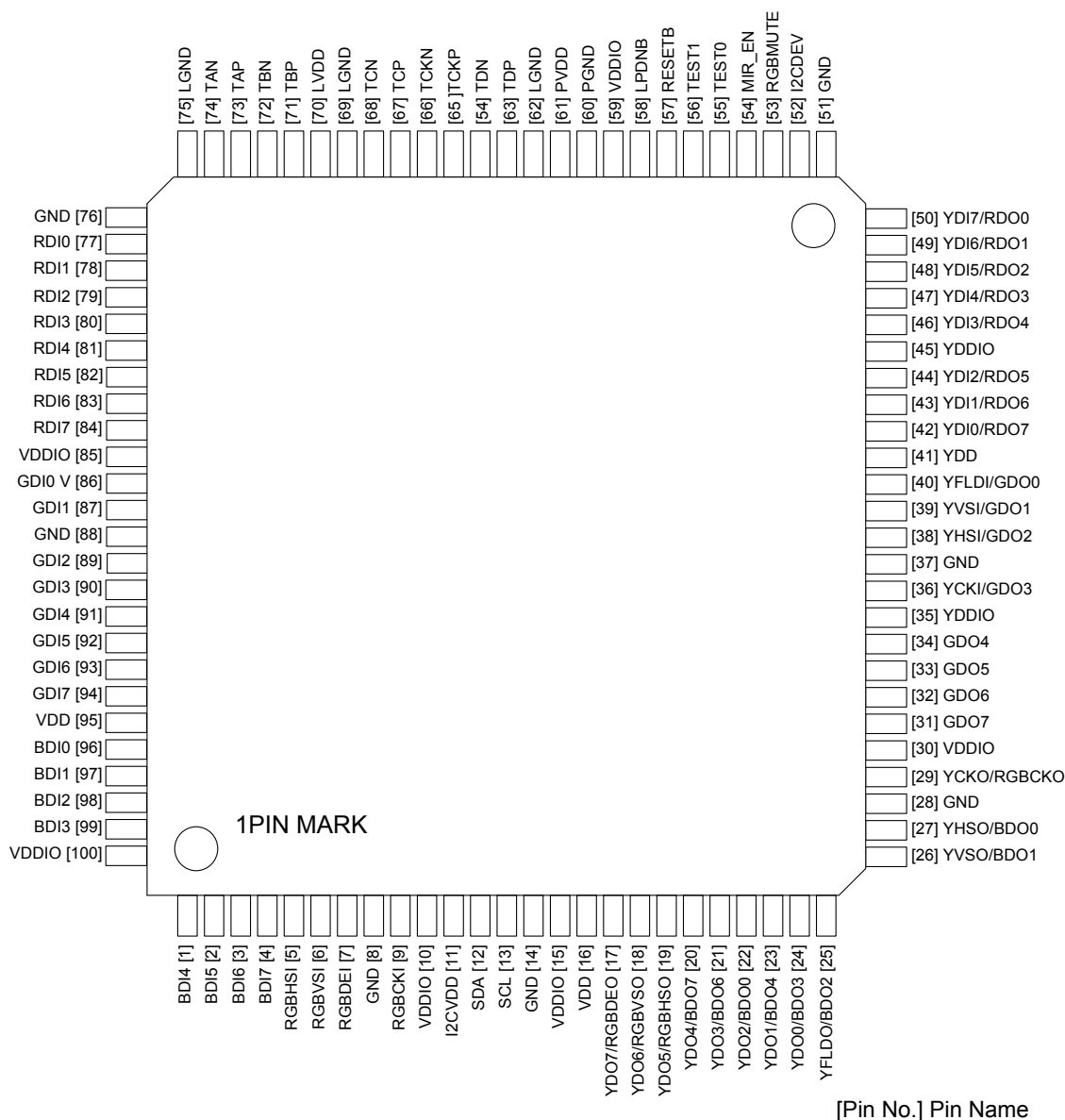


Fig.2 Pin configurations

### ●Electrical characteristics (DC)

[Table 5]

Unless otherwise specified, VDD=1.80V, VDDIO=3.3V, I2CVDD=3.3V, PVDD=3.3V, LVDD=3.3V, GND=0.0V, Ta=25°C, fIN=36MHz

| Parameter   | Symbol           | Limits                      |      |                              | Unit | Condition  |  |
|---|------------------|-----------------------------|------|------------------------------|------|--|--|
|   |                  | Min.                        | Typ. | Max.                         |      |  |  |
| Input frequency 1                                 | FIN1             | 8.0                         | -    | 36.0                         | MHz  | RGBCKI   |  |
| Input frequency 2                                 | FIN2             | 8.0                         | -    | 55.0                         | MHz  | YCKI   |  |
| Input clock duty                                  | DCKI             | 45                          | 50   | 55                           | %    | RGBCKI, YCKI   |  |
| Operational current                               | IDD1             | -                           | 16   | -                            | mA   | 36MHz (VDD)  |  |
| LVDS supply current                               | ILVDD1           | -                           | 55   | -                            | mA   | 36MHz, LVDS_RS = 1 (LVDD, PVDD)<br>Input toggle pattern (Fig.4)        |  |
| LVDS supply current                               | ILVDD2           | -                           | 38   | -                            | mA   | 36MHz, LVDS_RS = 0 (LVDD, PVDD)<br>Input toggle pattern (Fig.4)        |  |
| Leakage current                                   | IDDst1           | -                           | -    | 50                           | μA   | Release reset , input pin =GND<br>(VDD)                                |  |
| Input "H" current                                 | I <sub>IH</sub>  | -10                         | -    | 10                           | μA   | V <sub>IH</sub> =I <sub>O_LVL</sub>                                    |  |
| Input "L" current                                 | I <sub>IL</sub>  | -10                         | -    | 10                           | μA   | V <sub>IL</sub> =GND   |  |
| Pull-down current                                 | IPD              | 25                          | 50   | 100                          | μA   | V <sub>IH</sub> =I <sub>O_LVL</sub>                                    |  |
| Input "H" voltage 1                               | V <sub>IH1</sub> | I <sub>O_LVL</sub><br>x0.8  | -    | I <sub>O_LVL</sub><br>+0.3   | V    | Normal input<br>(Including input mode of I/O terminal)                 |  |
| Input "L" voltage 1                               | V <sub>IL1</sub> | -0.3                        | -    | I <sub>O_LVL</sub><br>x 0.2  | V    | Normal input<br>(Including input mode of I/O terminal)                 |  |
| Input "H" voltage 2                               | V <sub>IH2</sub> | I <sub>O_LVL</sub><br>x0.85 | -    | I <sub>O_LVL</sub><br>+0.3   | V    | Hysteresis input<br>(RESETB, RGBCKI, YCKI, LPDNB, SCL, RGBMUTE)        |  |
| Input "L" voltage 2                               | V <sub>IL2</sub> | -0.3                        | -    | I <sub>O_LVL</sub><br>x 0.15 | V    | Hysteresis input<br>(RESETB, RGBCKI, YCKI, LPDNB, SCL, RGBMUTE)        |  |
| Output "H" voltage                                | V <sub>OH</sub>  | I <sub>O_LVL</sub><br>-0.4  | -    | I <sub>O_LVL</sub>           | V    | I <sub>OH</sub> =-1.0mA(DC)<br>(including output mode of I/O terminal) |  |
| Output "L" voltage                                | V <sub>OL</sub>  | 0.0                         | -    | 0.4                          | V    | I <sub>OL</sub> =1.0mA(DC)<br>(including output mode of I/O terminal)  |  |
| LVDS Transmitter                                  |                  |                             |      |                              |      |  |  |
| Differential output voltage                       | V <sub>OD</sub>  | 250                         | 350  | 450                          | mV   | RL=100Ω  | Normal Swing<br>LVDS_RS <sup>(*1)</sup> = 1  |
|   |                  | 120                         | 200  | 300                          | mV   |  | Reduced Swing<br>LVDS_RS <sup>(*1)</sup> = 0 |
| Change in VOD between complementary output states | ΔV <sub>OD</sub> | -                           | -    | 35                           | mV   | RL=100Ω  |  |
| Common mode voltage                               | V <sub>OC</sub>  | 1.125                       | 1.25 | 1.375                        | V    |  |  |
| Change in VOC between complementary output states | ΔV <sub>OC</sub> | -                           | -    | 35                           | mV   |  |  |
| Output short circuit current                      | I <sub>OS</sub>  | -                           | -    | -24                          | mA   | V <sub>OUT</sub> <sup>(*2)</sup> =0V, RL=100Ω                          |  |
| Output TRI-STATE current                          | I <sub>OZ</sub>  | -                           | -    | ±10                          | μA   | LPDNB=GND<br>V <sub>OUT</sub> <sup>(*2)</sup> =GND to LVDD             |  |

\* I<sub>O\_LVL</sub> is a generic name of VDDIO, VDDI2C.

(\*1) LVDS\_RS is a register name controlled with 2-line serial interface.

(\*2) V<sub>OUT</sub>=TAN/P, TBN/P, TCN/P, TDN/P, TCKN/P

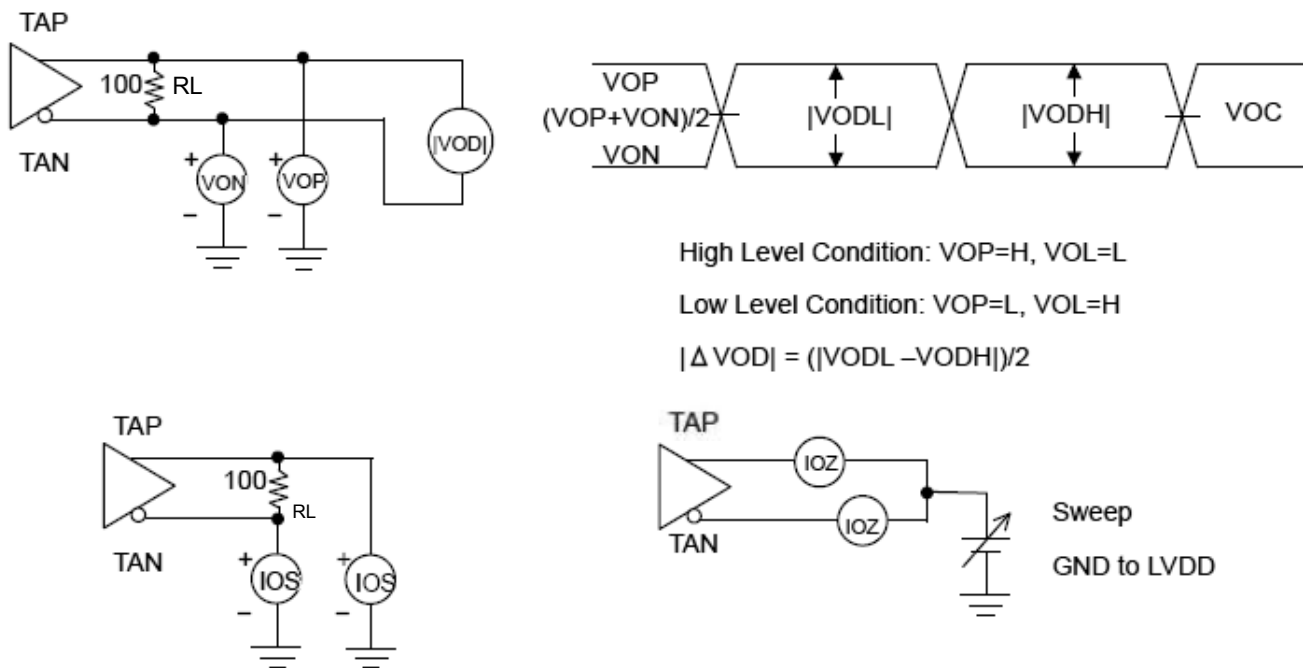
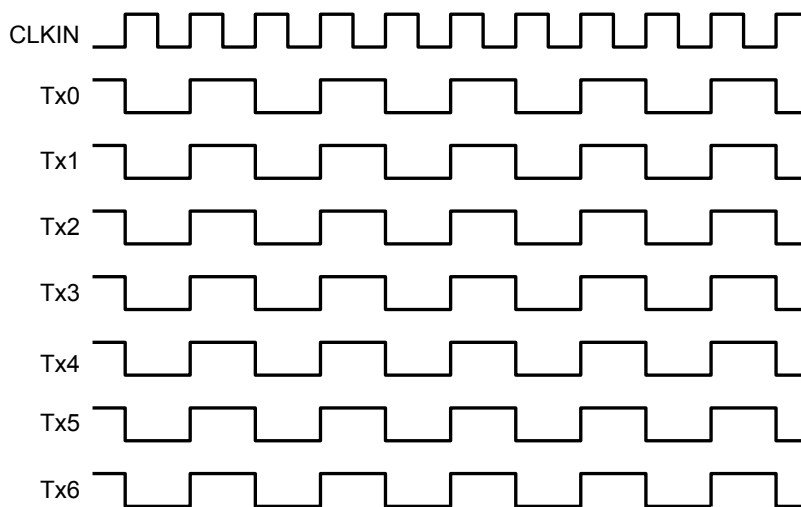


Fig.3 LVDS Transmitter characteristic diagram



X=A,B,C,D

※Input waveform to the LVDS transmitter block

※Tx0-7 are the data before being serialized by the LVDS transmitter.

Refer to Fig.8 for the serialized data sequence.

Fig.4 Input toggle pattern

●Electric Characteristics (AC)

1. Image quality adjustment data input interface timing

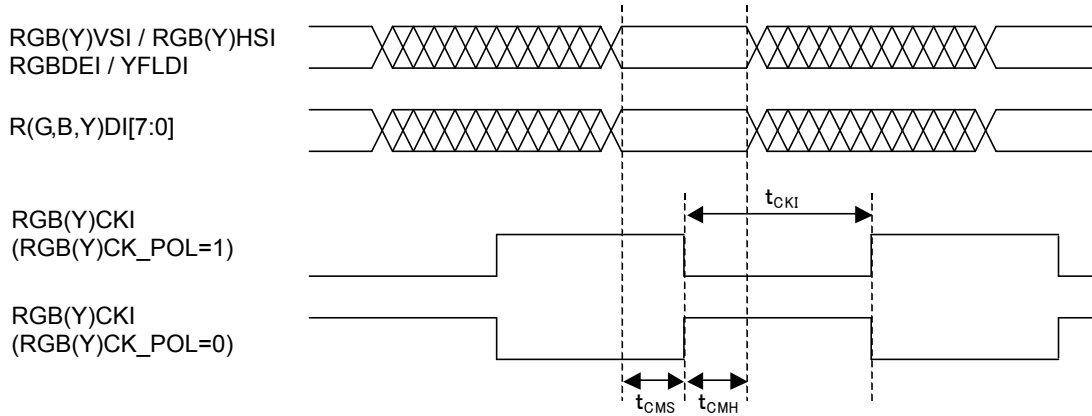


Fig.5 Data input interface timing

[Table 6]

Unless otherwise specified, VDD=1.80V, VDDIO=3.3V, I2CVDD=3.3V, PVDD=3.3V, LVDD=3.3V, GND=0.0V, Ta=25°C

| Symbol     | Description                       | Min. | Typ. | Max. | Unit |
|------------|-----------------------------------|------|------|------|------|
| $t_{CKI1}$ | RGBCKI Clock Cycle                | 27.7 | -    | 125  | ns   |
| $t_{CKI2}$ | YCKI Clock Cycle                  | 18.1 | -    | 125  | ns   |
| $d_{CKI}$  | RGB(Y)CKI Clock Duty              | 45   | 50   | 55   | %    |
| $t_{CMS}$  | RGB(Y)CKI Rise / Fall set-up Time | 6    | -    | -    | ns   |
| $t_{CMH}$  | RGB(Y)CKI Rise / Fall Hold Time   | 5    | -    | -    | ns   |

\* RGB(Y)CK\_POL is an internal register of BU1523KV to determine the polarity of RGB(Y)CKI.

\* Ensure to make the total number of 1 line input pixels to YCbCr interface to be even (multiple of 4, in case of cycles).

2. Image quality adjustment data output interface timing

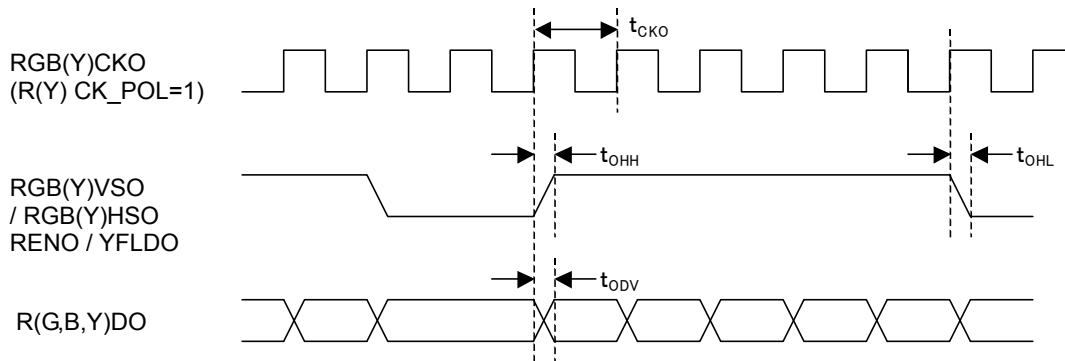


Fig.6 Data output interface timing

[Table 7]

Unless otherwise specified, VDD=1.80V, VDDIO=I2CVDD=PVDD=LVDD=3.3V, GND=0.0V, Ta=25°C

| Symbol             | Description                                   | Min. | Typ. | Max. | Unit |
|--------------------|---|------|------|------|------|
| $t_{CKO1}$         | RGBCKO Clock Cycle                            | 27.7 | -    | 125  | ns   |
| $t_{CKO2}$         | YCKO Clock Cycle                              | 18.1 | -    | 125  | ns   |
| $d_{CKO1}$         | RGBCKO Clock Duty                             | 40   | 50   | 60   | %    |
| $d_{CKO2}$         | YCKO Clock Duty                               | 35   | 50   | 65   | %    |
| $t_{ODV}$          | Output delay R(G, B, Y)DO                     | -    | -    | 5    | ns   |
| $t_{OHL}, t_{OHH}$ | Output delay RGB(Y)VSO, RGB(Y)HSO, RENO/YFLDO | -    | -    | 5    | ns   |

\* The above figure shows the waveform when RGB(Y)CK\_POL= "1" is set. When RGB(Y)CK\_POL= "0" is set, RGB(Y)VSO, RGB(Y)HSO and RGB(Y)DO are output at the falling edge of RGB(Y)CKO.

3. LVDS transmitter switching characteristic

[Table 8]

Unless otherwise specified, VDD=1.80V, VDDIO=I2CVDD=PVDD=LVDD=3.3V, GND=0.0V, Ta=25°C, fIN=36MHz

| Symbol | Description                | MIN                         | TYP                   | MAX                         | Unit |
|--------|----------------------------|-----------------------------|-----------------------|-----------------------------|------|
| tLVT   | LDVS Transition Time       | -                           | 0.6                   | 1.5                         | ns   |
| tTOP1  | Output Data Position 0     | -1.2                        | 0.0                   | +1.2                        | ns   |
| tTOP0  | Output Data Position 1     | $\frac{t_{CKI}}{7} - 1.2$   | $\frac{t_{CKI}}{7}$   | $\frac{t_{CKI}}{7} + 1.2$   | ns   |
| tTOP6  | Output Data Position 2     | $2 \frac{t_{CKI}}{7} - 1.2$ | $2 \frac{t_{CKI}}{7}$ | $2 \frac{t_{CKI}}{7} + 1.2$ | ns   |
| tTOP5  | Output Data Position 3     | $3 \frac{t_{CKI}}{7} - 1.2$ | $3 \frac{t_{CKI}}{7}$ | $3 \frac{t_{CKI}}{7} + 1.2$ | ns   |
| tTOP4  | Output Data Position 4     | $4 \frac{t_{CKI}}{7} - 1.2$ | $4 \frac{t_{CKI}}{7}$ | $4 \frac{t_{CKI}}{7} + 1.2$ | ns   |
| tTOP3  | Output Data Position 5     | $5 \frac{t_{CKI}}{7} - 1.2$ | $5 \frac{t_{CKI}}{7}$ | $5 \frac{t_{CKI}}{7} + 1.2$ | ns   |
| tTOP2  | Output Data Position 6     | $6 \frac{t_{CKI}}{7} - 1.2$ | $6 \frac{t_{CKI}}{7}$ | $6 \frac{t_{CKI}}{7} + 1.2$ | ns   |
| tPLL   | Phase Locked Loop Set Time | -                           | -                     | 10.0                        | ms   |

LVDS Output

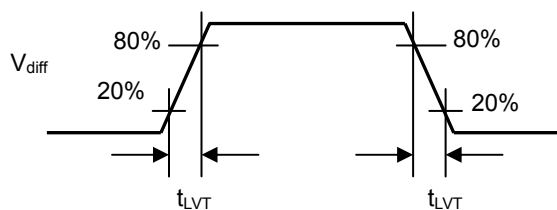
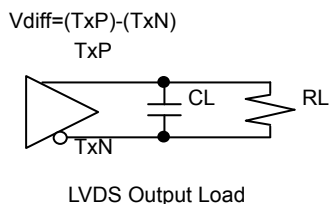


Fig.7 LVDS Output AC Timing diagram 1

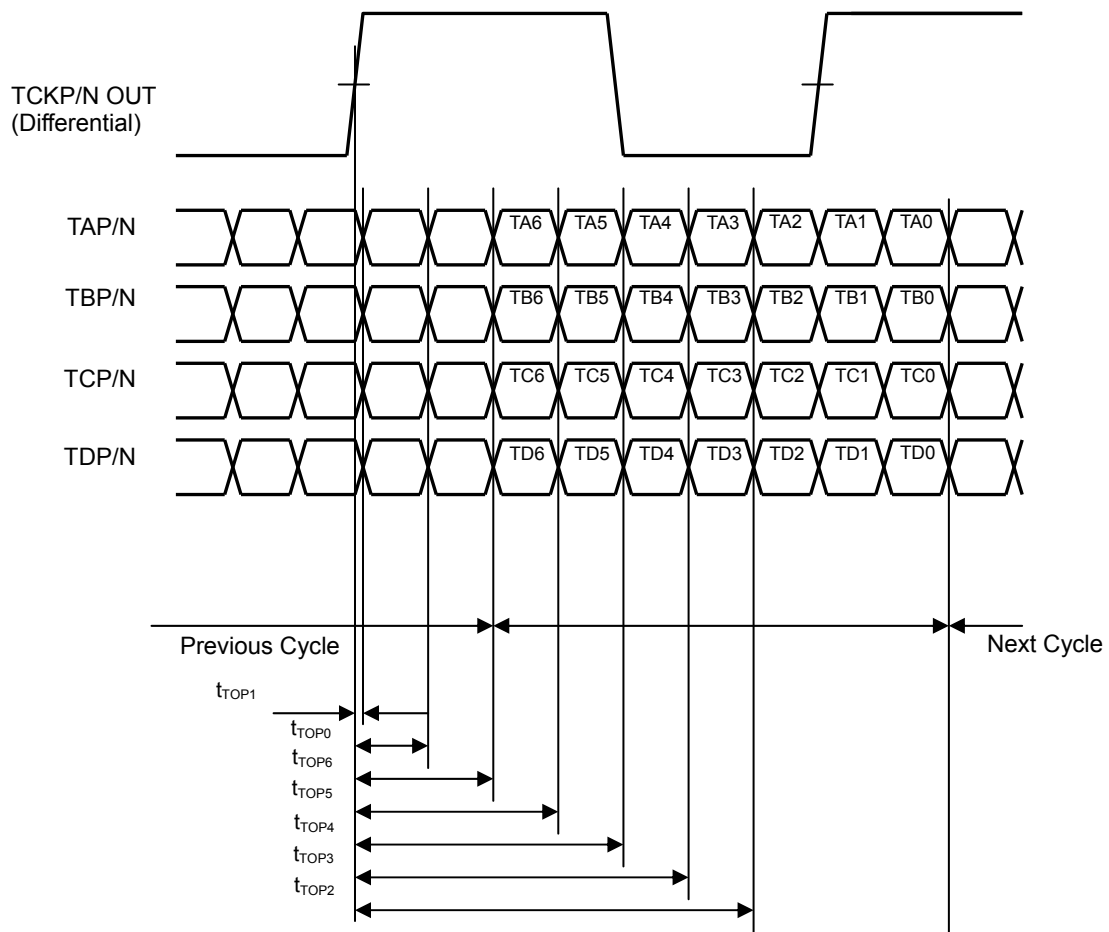
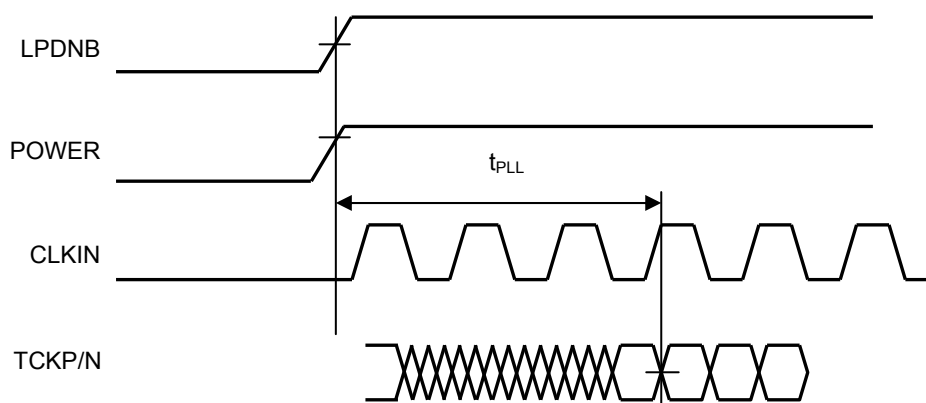


Fig.8 LVDS Output AC Timing diagram 2



\* POWER shows VDDIO, I2CVDD, VDD, LVDD, PVDD  
 \* CLKIN is a clock input to the LVDS transmitter.

Fig.9 LVDS Phase Locked Loop Set Time

## 4. 2-line serial interface timing

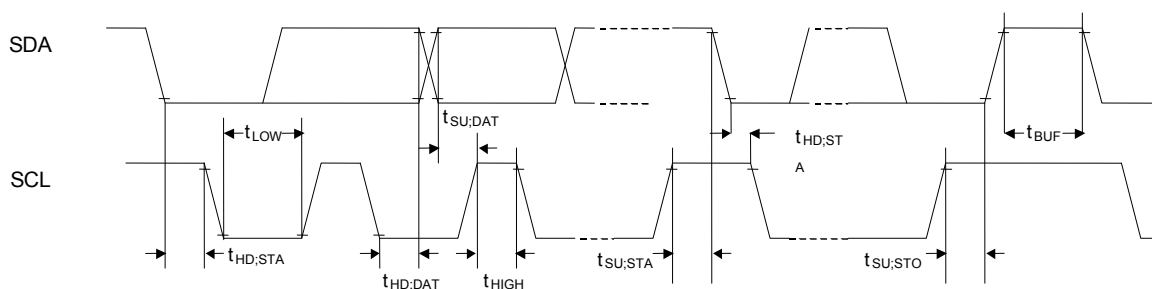


Fig.10 2-line serial interface timing

[Table 9]

Unless otherwise specified, VDD=1.80V, VDDIO=3.3V, I2CVDD=3.3V, PVDD=3.3V, LVDD=3.3V, GND=0.0V, Ta=25°C

| Symbol       | Description  | MIN | TYP | MAX | Unit    |
|--------------|--|-----|-----|-----|---------|
| $f_{SCL}$    | SDL clock frequency  | 0   | -   | 400 | kHz     |
| $t_{HD,STA}$ | Holding time(Repetition) "START" Condition<br>After this period, the first clock pulse is generated. | 0.6 | -   | -   | $\mu$ s |
| $t_{LOW}$    | Low period of SDL clock  | 1.3 | -   | -   | $\mu$ s |
| $t_{HIGH}$   | High period of SDL clock   | 0.6 | -   | -   | $\mu$ s |
| $t_{SU,STA}$ | Setup time of repetition "START" condition   | 0.6 | -   | -   | $\mu$ s |
| $t_{HD,DAT}$ | Data hold time   | 0   |     |     | $\mu$ s |
| $t_{SU,DAT}$ | Data setup time  | 100 | -   | -   | ns      |
| $t_{SU,STO}$ | Setup time of 'STOP' condition   | 0.6 | -   | -   | $\mu$ s |
| $t_{BUF}$    | 'Bus free time between STOP' condition and 'START' condition   | 1.3 | -   | -   | $\mu$ s |

●Operation explanation of each block

1. Image quality adjustment of RGB interface

It adjusts image quality input through 24-bit RGB interface.

The supported I/O interface consists of 24-bit data, vertical synchronization signal, horizontal synchronization signal and data enable signal. It converts 24-bit RGB into YCbCr444 and makes adjustment on the contrast, brightness, sharpness, hue and intensity in the YCbCr space. The contrast, brightness and sharpness are adjusted against the luminance (Y) component and the hue and intensity are adjusted against the color difference (CbCr) component. In addition to the image quality adjustment in the YCbCr space, it is also equipped with the RGB independent gamma correction capability in the RGB space. Converting YCbCr444 to 24-bit RGB, gamma correction is made to each of the RGB components. 16 gamma curve points can be set and the intervals between those set points are linearly interpolated. When the RGBMUTE terminal is set to "High" level, the RGB output data will be all "0" from the next frame.

2. Image quality adjustment of YUV

It adjusts image quality input through YCbCr422 interface.

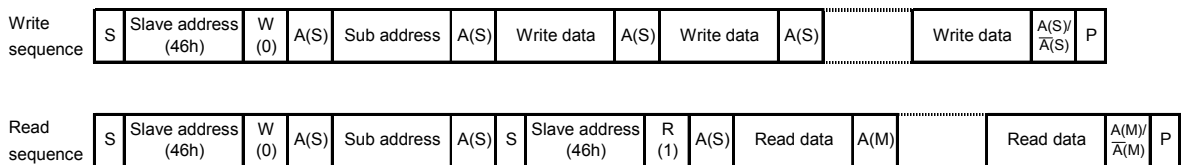
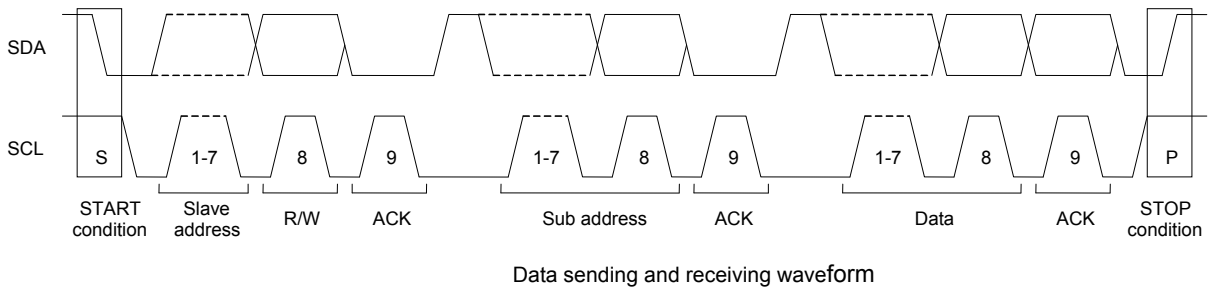
The supported I/O interfaces are ITU-R BT.656-4 and YCbCr with synchronization signal (complied with ITU-R BT.601). When the input is ITU-R BT.656-4, the output can be selected from ITU-R BT.656-4 and YCbCr with synchronization signal. However, when the input is YCbCr with synchronization signal, the output can only be YCbCr with synchronization signal. It makes adjustment on the contrast, brightness, sharpness, hue and intensity in the YCbCr space. The contrast, brightness and sharpness are adjusted against the luminance (Y) component and the hue and intensity are adjusted against the color difference (CbCr) component.

3. LVDS transmitter

It outputs high-speed serial data for image quality adjustment of RGB interface in LVDS format. The data mapping to be output in the LVDS format can be changed by the register setting. When the LPDNB terminal is set to "Low" level, the LVDS transmitter part will go into power down mode. The LVDS output will become Hi-Z status.

4. 2-line serial interface

2-line serial interface slave function is embedded. The registers are accessed through this interface. The slave address is 46h (in 7-bit notation) when I2CDEV=0 and 47h (in 7-bit notation) when I2CDEV=1. The sub address is automatically incremented when consecutively accessed twice or more in read or write operation. \* Slave address of 46h and 47h are in hexadecimal. \* Fig.11 depicts the status when I2CDEV=0.

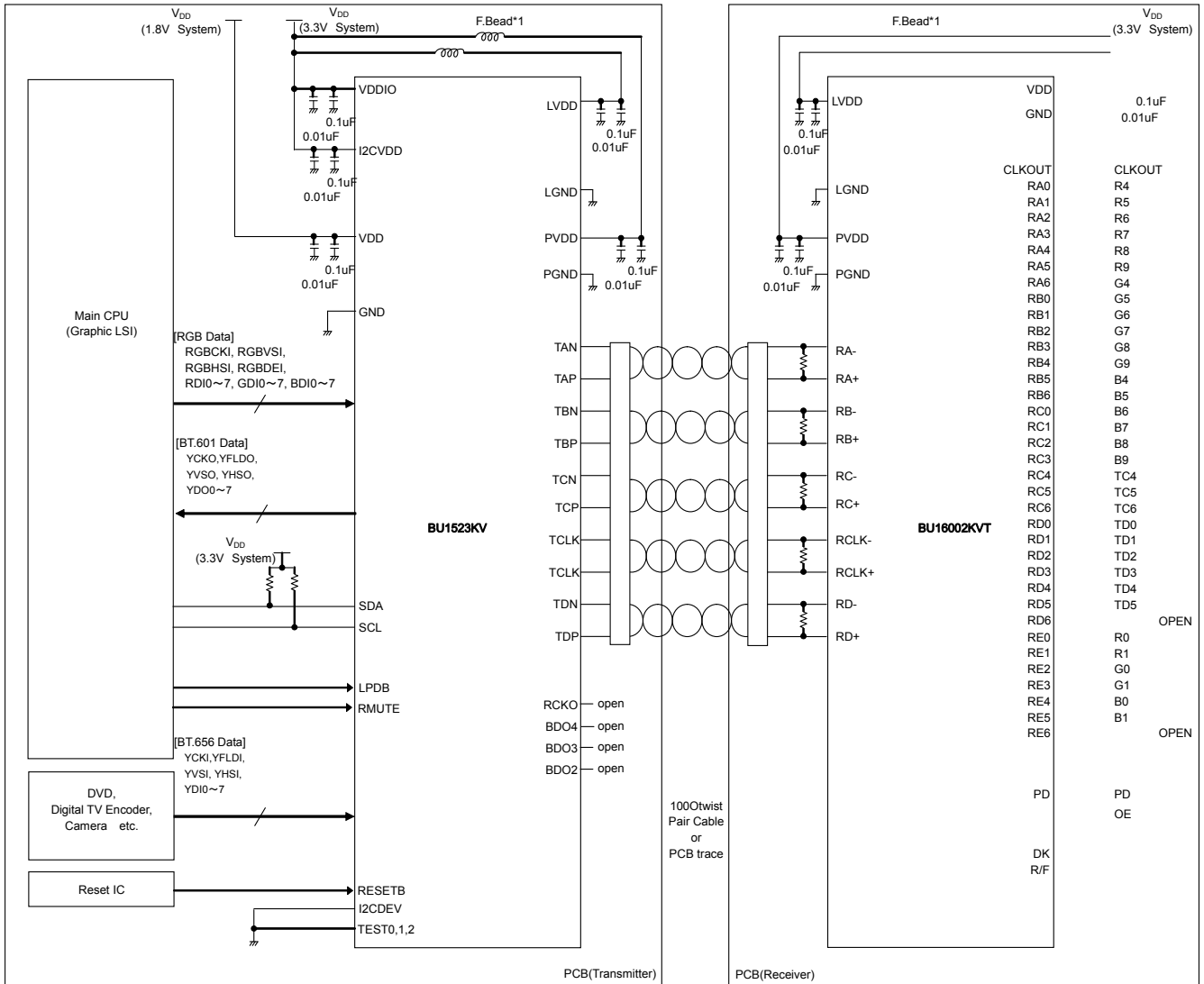


S = START condition      A(S) = acknowledge by slave       $\bar{A}(S)$  = not acknowledge by slave  
 P = STOP condition      A(M) = acknowledge by master       $\bar{A}(M)$  = not acknowledge by master

Fig.11 2-line serial interface format



● Example of application circuit



\*1: Recommended Parts: F.Bead: BLM18A-Series (Murata Manufacturing)  
 \*2: If LVDS\_RS is tied to "1", LVDS swing is 350m V. If LVDS\_RS is tied to "0", LVDS swing is 200m V.

Fig.12 BU1523KV System connection Diagram

The above figure is an example of system connection for reference only and not intended to guarantee operation.

●Procedure for turning on power supply

Follow the power-on sequence of VDD→(VDDIO, I2CVDD, PVDD, LVDD) as depicted in Fig.13. The timing for power-on sequence is shown in Table 10 however, it is recommended to make the intervals of  $t_{PWUV2}$ ,  $t_{PWUV}$  and  $t_{PWUVL}$  as short as possible. Until after voltage is applied to all the power sources, the levels of all the input pins are fixed and the low level is input onto RESETB, the internal status and pins remain unstable. Remove the reset after inputting the clock (RGBCKI, YCKI). When the clock (RGBCKI, YCKI) is to be temporarily halted during the operation, apply the reset after the clock (RGBCKI, YCKI) stopped to fix the operation, then follow the power-on sequence and remove the reset after inputting the clock (RGBCKI, YCKI). 2-line serial interface is enabled for communication after the reset (RESETB) is removed. However, racing may be caused if the rising edge of the reset (RESETB) signal and the signal change of 2-line serial interface occur at the same time. Ensure not to allow the rising edge of the reset (RESETB) signal and the signal change of 2-line serial interface to occur at the same time. Design the system to avoid racing and system malfunction when the internal status and pins are unstable.

\* The reset is also possible by the software reset (SRST\_R\_IP, SRST\_Y\_IP, SRST\_LVDS).

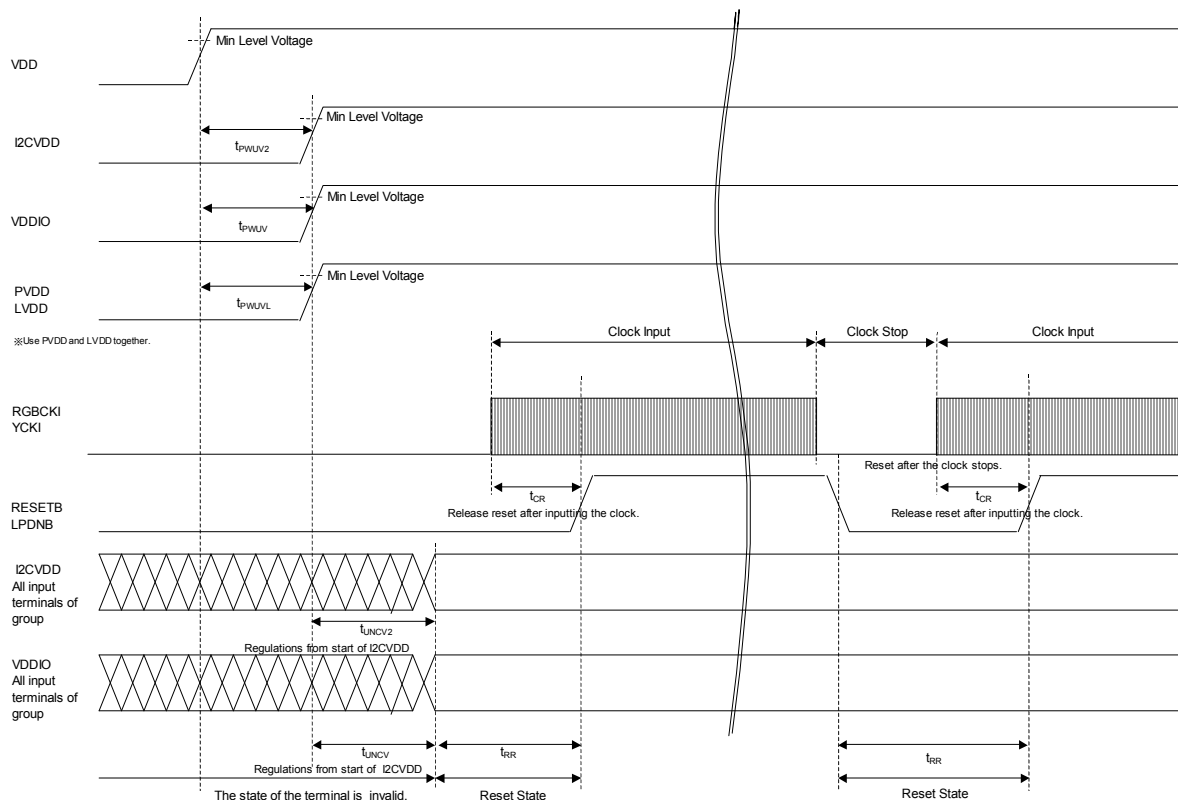


Fig.13 Power supply input procedure (Min level is power-supply voltage lower bound of recommended range.)

[Table 10 Recommended value at time to turn on power supply]

| Item        | Min. | Max. | Unit |
|-------------|------|------|------|
| $t_{PWUV2}$ | 0    | 50   | ms   |
| $t_{PWUV}$  | 0    | 50   | ms   |
| $t_{PWUVL}$ | 0    | 50   | ms   |
| $t_{UNCV2}$ | 0    | 1    | ms   |
| $t_{UNCV}$  | 0    | 1    | ms   |
| $t_{RR}$    | 1    | -    | ms   |
| $t_{CR}$    | 0.1  | -    | ms   |

The power-off sequence is reverse of the power-on sequence, in the order of (VDDIO, I2CVDD, PVDD, LVDD)→VDD as depicted in Fig.14. The timing for power-off sequence is shown in Table 11, however, it is recommended to make the intervals of  $t_{PVDV2}$ ,  $t_{PVDV}$  and  $t_{PVDVL}$  as short as possible.

Note that turning off from the VDD (Power to the internal CORE) makes the internal status and pin status unstable.

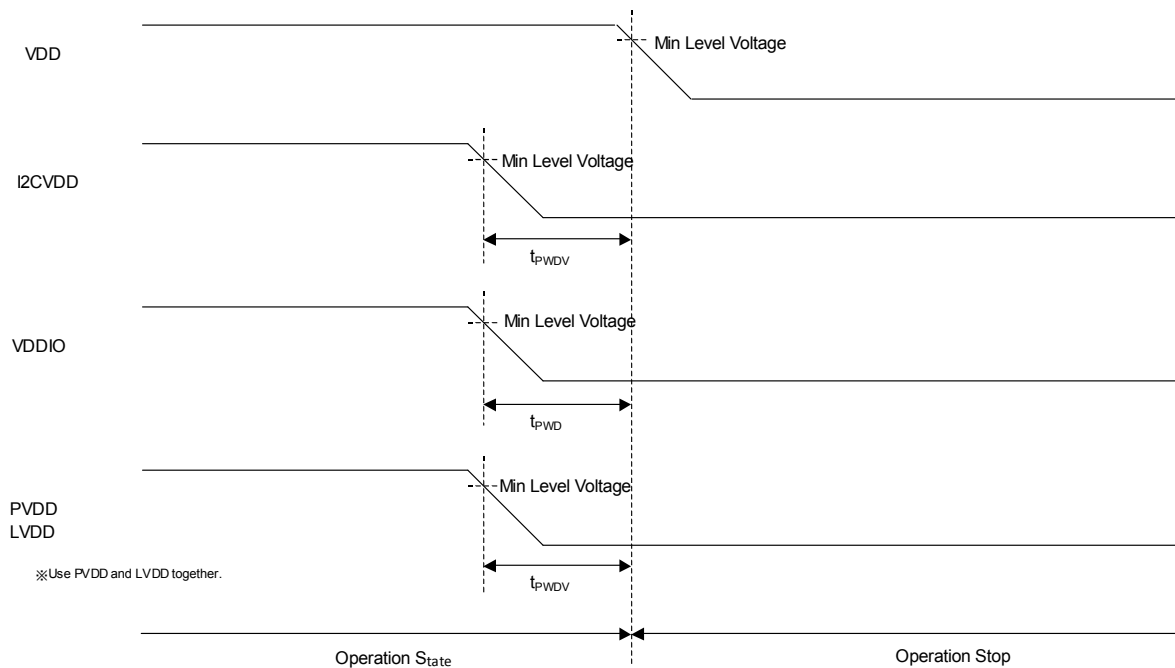


Fig.14 Power-off procedure (Min level is power-supply voltage lower bound of recommended range of motion.)

[Table 11 Power-off time recommended value]

| Item        | Min. | Max. | Unit |
|-------------|------|------|------|
| $t_{PVDV2}$ | 0    | 50   | ms   |
| $t_{PVDV}$  | 0    | 50   | ms   |
| $t_{PVDVL}$ | 0    | 50   | ms   |

●PCB Design Guideline for LVDS

- Interconnecting media between Transmitter and Receiver ( i.e.PCB trace, connector, and cable) should be well balanced. (Keep all these differential impedance and the length of media as same as possible.).
- Locate by –pass capacitors adjacent to the device pins as close as possible.
- Minimize the distance between traces of a pair. (S1) to maximize common mode rejection.
- See following figure.
- Place adjacent LVDS trace pair at least twice (>2 x S1) as far away.
- Avoid 90 degree bends.
- Minimize the number of VIA on LVDS traces.
- Match impedance of PCB trace, connector, media (cable) and termination to minimize reflections (emissions) for cabled applications (typically 100Ω Differential mode characteristic impedance).

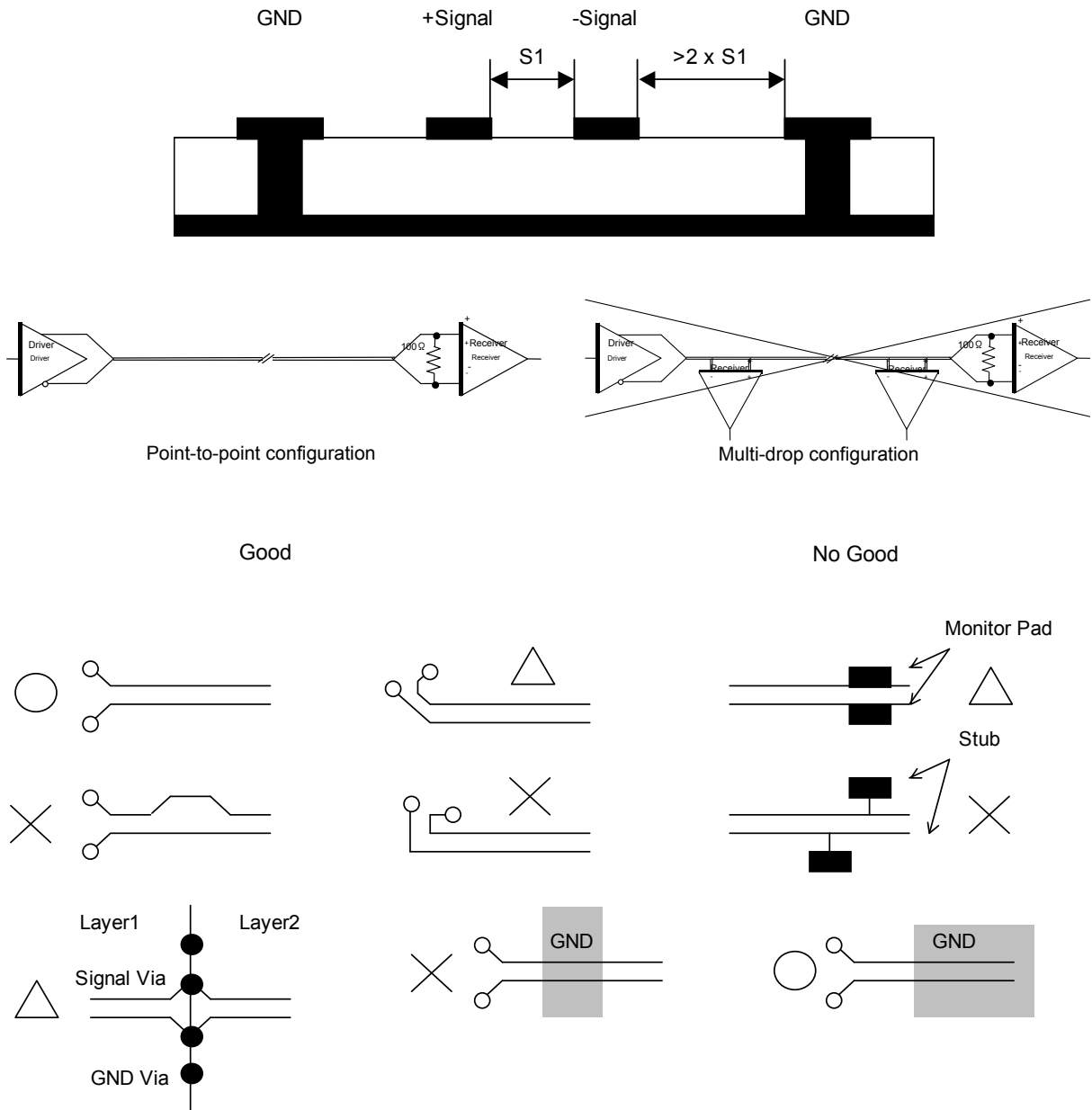
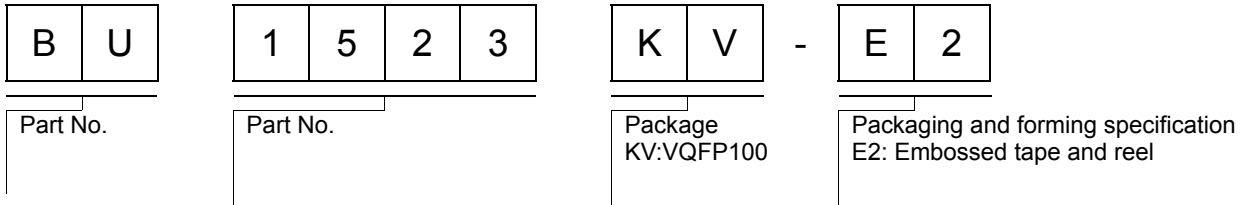


Fig.15 PCB Design Guideline for LVDS

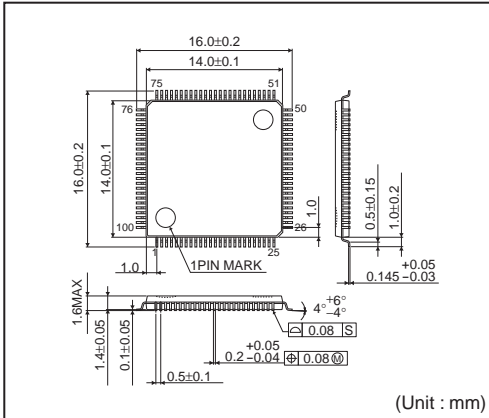
**●Notes for use**

- (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) Recommended 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  
For ICs with more than one power supply, it is possible that rush current may flow instantaneously due to the internal powering sequence and delays. Therefore, give special consideration to power coupling capacitance, power wiring, width of GND wiring, and routing of wiring.

●Ordering part number

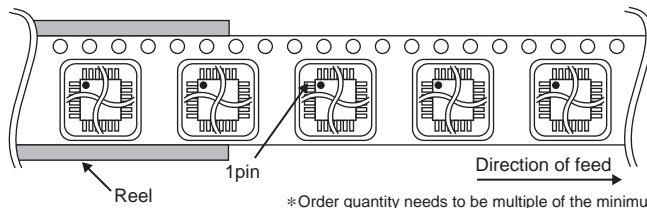


VQFP100



<Tape and Reel information>

|                   |  |
|-------------------|--|
| Tape              | Embossed carrier tape (with dry pack)  |
| Quantity          | 500pcs   |
| 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 ) |



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