

**a-Si TFT LCD Single Chip Driver
240RGBx320 Resolution and 262K color
Datasheet**

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1. Introduction

ILI9328 is a 262,144-color one-chip SoC driver for a-TFT liquid crystal display with resolution of 240RGBx320 dots, comprising a 720-channel source driver, a 320-channel gate driver, 172,800 bytes RAM for graphic data of 240RGBx320 dots, and power supply circuit.

ILI9328 has four kinds of system interfaces which are i80-system MPU interface (8-/9-/16-/18-bit bus width), VSYNC interface (system interface + VSYNC, internal clock, DB[17:0]), serial data transfer interface (SPI) and RGB 6-/16-/18-bit interface (DOTCLK, VSYNC, HSYNC, ENABLE, DB[17:0]).

In RGB interface and VSYNC interface mode, the combined use of high-speed RAM write function and widow address function enables to display a moving picture at a position specified by a user and still pictures in other areas on the screen simultaneously, which makes it possible to transfer display the refresh data only to minimize data transfers and power consumption.

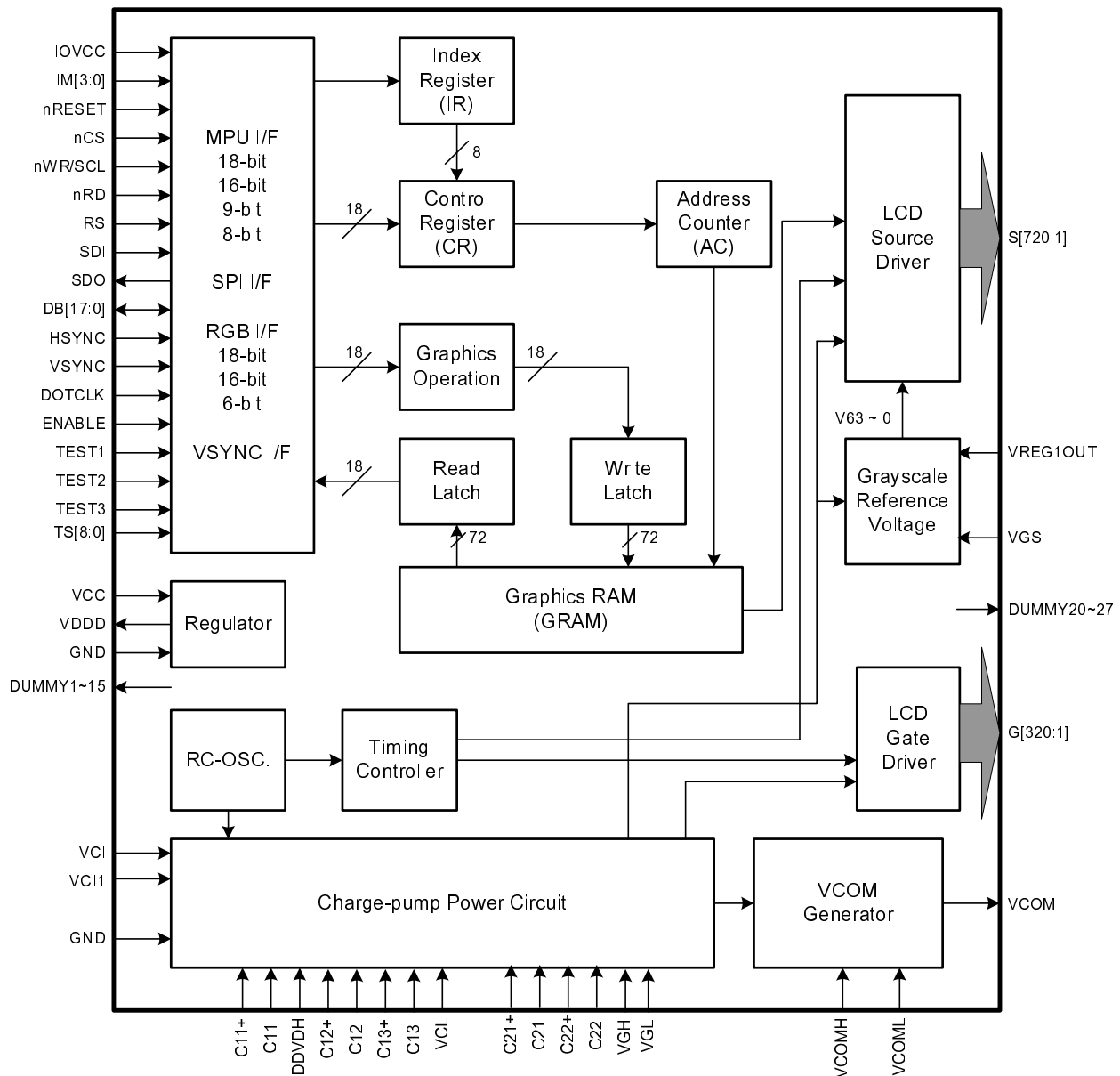
ILI9328 can operate with 1.65V I/O interface voltage, and an incorporated voltage follower circuit to generate voltage levels for driving an LCD. The ILI9328 also supports a function to display in 8 colors and a sleep mode, allowing for precise power control by software and these features make the ILI9328 an ideal LCD driver for medium or small size portable products such as digital cellular phones, smart phone, PDA and PMP where long battery life is a major concern.

2. Features

- ◆ Single chip solution for a liquid crystal QVGA TFT LCD display
- ◆ 240RGBx320-dot resolution capable with real 262,144 display color
- ◆ Support MVA (Multi-domain Vertical Alignment) wide view display
- ◆ Incorporate 720-channel source driver and 320-channel gate driver
- ◆ Internal 172,800 bytes graphic RAM
- ◆ High-speed RAM burst write function
- ◆ System interfaces
 - i80 system interface with 8-/ 9-/16-/18-bit bus width
 - Serial Peripheral Interface (SPI)
 - RGB interface with 6-/16-/18-bit bus width (VSYNC, HSYNC, DOTCLK, ENABLE, DB[17:0])
 - VSYNC interface (System interface + VSYNC)
- ◆ Internal oscillator and hardware reset
- ◆ Resizing function ($\times 1/2$, $\times 1/4$)
- ◆ Reversible source/gate driver shift direction
- ◆ Window address function to specify a rectangular area for internal GRAM access
- ◆ Abundant functions for color display control
 - γ -correction function enabling display in 262,144 colors
 - Line-unit vertical scrolling function

- ◆ Partial drive function, enabling partially driving an LCD panel at positions specified by user
- ◆ Incorporate step-up circuits for stepping up a liquid crystal drive voltage level up to 6 times (x6)
- ◆ Power saving functions
 - 8-color mode
 - standby mode
 - sleep mode
- ◆ Low -power consumption architecture
 - Low operating power supplies:
 - IOVcc = 1.65V ~ 3.3 V (interface I/O)
 - Vci = 2.5V ~ 3.3 V (analog)
- ◆ LCD Voltage drive:
 - Source/VCOM power supply voltage
 - DDVDH - GND = 4.5V ~ 6.0
 - VCL – GND = -2.0V ~ -3.0V
 - VCI – VCL \leq 6.0V
 - Gate driver output voltage
 - VGH - GND = 10V ~ 20V
 - VGL – GND = -5V ~ -15V
 - VGH – VGL \leq 32V
 - VCOM driver output voltage
 - VCOMH = 3.0V ~ (DDVDH-0.2)V
 - VCOML = (VCL+0.5)V ~ 0V
 - VCOMH-VCOML \leq 6.0V
- ◆ a-TFT LCD storage capacitor: Cst only

3. Block Diagram



4. Pin Descriptions

| Pin Name | I/O | Type | Descriptions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|-----|--------------|---|-----|-----|-----|-----------------------------------|--------------------|---------------|---|---|---|---|-----------------|--|---|---|---|---|-----------------|--|---|---|---|---|-----------------------------|--------------------|---|---|---|---|----------------------------|-----------|---|---|---|----|-----------------------------------|----------|---|---|---|---|-----------------|--|---|---|---|---|-----------------|--|---|---|---|---|-----------------|--|---|---|---|---|-----------------------------|----------|---|---|---|---|----------------------------|----------|---|---|---|---|-----------------|--|
| Input Interface | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| IM3, IM2, IM1, IM0/ID | I | IOVcc | Select the MPU system interface mode | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | <table><tr><th>IM3</th><th>IM2</th><th>IM1</th><th>IM0</th><th>MPU-Interface Mode</th><th>DB Pin in use</th></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>Setting invalid</td><td></td></tr><tr><td>0</td><td>0</td><td>0</td><td>1</td><td>Setting invalid</td><td></td></tr><tr><td>0</td><td>0</td><td>1</td><td>0</td><td>i80-system 16-bit interface</td><td>DB[17:10], DB[8:1]</td></tr><tr><td>0</td><td>0</td><td>1</td><td>1</td><td>i80-system 8-bit interface</td><td>DB[17:10]</td></tr><tr><td>0</td><td>1</td><td>0</td><td>ID</td><td>Serial Peripheral Interface (SPI)</td><td>SDI, SDO</td></tr><tr><td>0</td><td>1</td><td>1</td><td>*</td><td>Setting invalid</td><td></td></tr><tr><td>1</td><td>0</td><td>0</td><td>0</td><td>Setting invalid</td><td></td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>Setting invalid</td><td></td></tr><tr><td>1</td><td>0</td><td>1</td><td>0</td><td>i80-system 18-bit interface</td><td>DB[17:0]</td></tr><tr><td>1</td><td>0</td><td>1</td><td>1</td><td>i80-system 9-bit interface</td><td>DB[17:9]</td></tr><tr><td>1</td><td>1</td><td>*</td><td>*</td><td>Setting invalid</td><td></td></tr></table> | IM3 | IM2 | IM1 | IM0 | MPU-Interface Mode | DB Pin in use | 0 | 0 | 0 | 0 | Setting invalid | | 0 | 0 | 0 | 1 | Setting invalid | | 0 | 0 | 1 | 0 | i80-system 16-bit interface | DB[17:10], DB[8:1] | 0 | 0 | 1 | 1 | i80-system 8-bit interface | DB[17:10] | 0 | 1 | 0 | ID | Serial Peripheral Interface (SPI) | SDI, SDO | 0 | 1 | 1 | * | Setting invalid | | 1 | 0 | 0 | 0 | Setting invalid | | 1 | 0 | 0 | 1 | Setting invalid | | 1 | 0 | 1 | 0 | i80-system 18-bit interface | DB[17:0] | 1 | 0 | 1 | 1 | i80-system 9-bit interface | DB[17:9] | 1 | 1 | * | * | Setting invalid | |
| | | | IM3 | IM2 | IM1 | IM0 | MPU-Interface Mode | DB Pin in use | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | 0 | 0 | 0 | 0 | Setting invalid | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | 0 | 0 | 0 | 1 | Setting invalid | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | 0 | 0 | 1 | 0 | i80-system 16-bit interface | DB[17:10], DB[8:1] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | 0 | 0 | 1 | 1 | i80-system 8-bit interface | DB[17:10] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | 0 | 1 | 0 | ID | Serial Peripheral Interface (SPI) | SDI, SDO | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | 0 | 1 | 1 | * | Setting invalid | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | 1 | 0 | 0 | 0 | Setting invalid | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | 1 | 0 | 0 | 1 | Setting invalid | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | 1 | 0 | 1 | 0 | i80-system 18-bit interface | DB[17:0] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | 1 | 0 | 1 | 1 | i80-system 9-bit interface | DB[17:9] | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | | | 1 | 1 | * | * | Setting invalid | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| When the serial peripheral interface is selected, IM0 pin is used for the device code ID setting. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| nCS | I | MPU IOVcc | A chip select signal. Low: the ILI9328 is selected and accessible High: the ILI9328 is not selected and not accessible Fix to the GND level when not in use. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| RS | I | MPU IOVcc | A register select signal. Low: select an index or status register High: select a control register Fix to either IOVcc or GND level when not in use. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| nWR/SCL | I | MPU IOVcc | A write strobe signal and enables an operation to write data when the signal is low. Fix to either IOVcc or GND level when not in use. SPI Mode: Synchronizing clock signal in SPI mode. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| nRD | I | MPU IOVcc | A read strobe signal and enables an operation to read out data when the signal is low. Fix to either IOVcc or GND level when not in use. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| nRESET | I | MPU IOVcc | A reset pin. Initializes the ILI9328 with a low input. Be sure to execute a power-on reset after supplying power. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SDI | I | MPU IOVcc | SPI interface input pin. The data is latched on the rising edge of the SCL signal. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| SDO | O | MPU IOVcc | SPI interface output pin. The data is outputted on the falling edge of the SCL signal. Let SDO as floating when not used. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| DB[17:0] | I/O | MPU IOVcc | An 18-bit parallel bi-directional data bus for MPU system interface mode 8-bit I/F: DB[17:10] is used. 9-bit I/F: DB[17:9] is used. 16-bit I/F: DB[17:10] and DB[8:1] is used. 18-bit I/F: DB[17:0] is used. 18-bit parallel bi-directional data bus for RGB interface operation 6-bit RGB I/F: DB[17:12] are used. | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Pin Name | I/O | Type | Descriptions |
|--|-----|--------------------------------|--|
| | | | 16-bit RGB I/F: DB[17:13] and DB[11:1] are used. 18-bit RGB I/F: DB[17:0] are used. Unused pins must be fixed to GND level. |
| ENABLE | I | MPU IOVcc | Data ENEABLE signal for RGB interface operation. Low: Select (access enabled) High: Not select (access inhibited) The EPL bit inverts the polarity of the ENABLE signal. Fix to either IOVcc or GND level when not in use. |
| DOTCLK | I | MPU IOVcc | Dot clock signal for RGB interface operation. DPL = "0": Input data on the rising edge of DOTCLK DPL = "1": Input data on the falling edge of DOTCLK Fix to the GND level when not in use |
| VSYSNC | I | MPU IOVcc | Frame synchronizing signal for RGB interface operation. VSPL = "0": Active low. VSPL = "1": Active high. Fix to the GND level when not in use. |
| HSYNC | I | MPU IOVcc | Line synchronizing signal for RGB interface operation. HSPL = "0": Active low. HSPL = "1": Active high. Fix to the GND level when not in use |
| FMARK | O | MPU IOVcc | Output a frame head pulse signal. The FMARK signal is used when writing RAM data in synchronization with frame. Leave the pin open when not in use. |
| LCD Driving signals | | | |
| S720~S1 | O | LCD | Source output voltage signals applied to liquid crystal. To change the shift direction of signal outputs, use the SS bit. SS = "0", the data in the RAM address "h00000" is output from S1. SS = "1", the data in the RAM address "h00000" is output from S720. S1, S4, S7, ... display red (R), S2, S5, S8, ... display green (G), and S3, S6, S9, ... display blue (B) (SS = 0). |
| G320~G1 | O | LCD | Gate line output signals. VGH: the level selecting gate lines VGL: the level not selecting gate lines |
| VCOM | O | TFT common electrode | A supply voltage to the common electrode of TFT panel. VCOM is AC voltage alternating signal between the VCOMH and VCOML levels. |
| VCOMH | O | Stabilizing capacitor | The high level of VCOM AC voltage. Connect to a stabilizing capacitor. |
| VCOML | O | Stabilizing capacitor | The low level of VCOM AC voltage. Adjust the VCOML level with the VDV bits. Connect to a stabilizing capacitor. |
| VGS | I | GND or external resistor | Reference level for the grayscale voltage generating circuit. The VGS level can be changed by connecting to an external resistor. |
| Charge-pump and Regulator Circuit | | | |
| Vci | I | Power supply | A supply voltage to the analog circuit. Connect to an external power supply of 2.5 ~ 3.3V. |
| GND | I | Power supply | GND for the analog side: GND = 0V. In case of COG, connect to GND on the FPC to prevent noise. |
| Vci1 | O | Stabilizing capacitor | An internal reference voltage for the step-up circuit1. The amplitude between Vci and GND is determined by the VC[2:0] bits. Make sure to set the Vci1 voltage so that the DDVDH, VGH and VGL voltages are set within the respective specification. |
| DDVDH | O | Stabilizing | Power supply for the source driver and Vcom drive. |

| Pin Name | I/O | Type | Descriptions |
|--|-----|-----------------------|---|
| | | capacitor | |
| VGH | O | Stabilizing capacitor | Power supply for the gate driver. |
| VGL | O | Stabilizing capacitor | Power supply for the gate driver. |
| VCL | O | Stabilizing capacitor | VcomL driver power supply. VCL = 0.5 ~ -VCI . Place a stabilizing capacitor between GND |
| C11+, C11- C12+, C12- | I/O | Step-up capacitor | Capacitor connection pins for the step-up circuit 1. |
| C13+, C13- C21+, C21- C22+, C22- | I/O | Step-up capacitor | Capacitor connection pins for the step-up circuit 2. |
| VREG1OUT | I/O | Stabilizing capacitor | Output voltage generated from the reference voltage. The voltage level is set with the VRH bits. VREG1OUT is (1) a source driver grayscale reference voltage, (2) VcomH level reference voltage, and (3) Vcom amplitude reference voltage. Connect to a stabilizing capacitor. VREG1OUT = 3.0 ~ (DDVDH - 0.2)V. |
| Power Pads | | | |
| IOVcc | I | Power supply | A supply voltage to the interface pins: IM[3:0], nRESET, nCS, nWR, nRD, RS, DB[17:0], VSYNC, HSYNC, DOTCLK, ENABLE, SCL, SDI, SDO. IOVcc = 1.65 ~ 3.3V and Vcc ≥ IOVcc. In case of COG, connect to Vcc on the FPC if IOVcc=Vcc, to prevent noise. |
| VDDD | O | Power | Digital circuit power pad. Connect these pins with the 1uF capacitor. |
| GND | I | Power supply | GND = 0V. |
| Test Pads | | | |
| DUMMY1~ 15 DUMMY20 ~ 27 | - | - | Dummy pad. Leave these pins as open. |
| IOGNDDUM | O | GND | GND pin. |
| TESTO1~16 | O | Open | Test pins. Leave them open. |
| TEST1, 2, 3 | I | IOGND | Test pins (internal pull low). Connect to GND or leave these pins as open. |
| TS0~8 | I | OPEN | Test pins (internal pull low). Leave them open. |

Liquid crystal power supply specifications Table 1

| No. | Item | Description |
|-----|-----------------------------------|----------------------------------|
| 1 | TFT Source Driver | 720 pins (240 x RGB) |
| 2 | TFT Gate Driver | 320 pins |
| 3 | TFT Display's Capacitor Structure | Cst structure only (Common VCOM) |
| 4 | Liquid Crystal Drive Output | S1 ~ S720 |
| | | G1 ~ G320 |
| | | VCOM |
| 5 | Input Voltage | IOVcc |
| | | Vci |

| | | | |
|---|-------------------------------|-----------|--------------------|
| 6 | Liquid Crystal Drive Voltages | DDVDH | 4.5V ~ 6.0V |
| | | VGH | 10V ~ 20V |
| | | VGL | -5V ~ -15V |
| | | VCL | -2.0V ~ -3.0V |
| | | VGH - VGL | Max. 32V |
| | | Vci - VCL | Max. 6.0V |
| 7 | Internal Step-up Circuits | DDVDH | Vci1 x2 |
| | | VGH | Vci1 x4, x5, x6 |
| | | VGL | Vci1 x-3, x-4, x-5 |
| | | VCL | Vci1 x-1 |

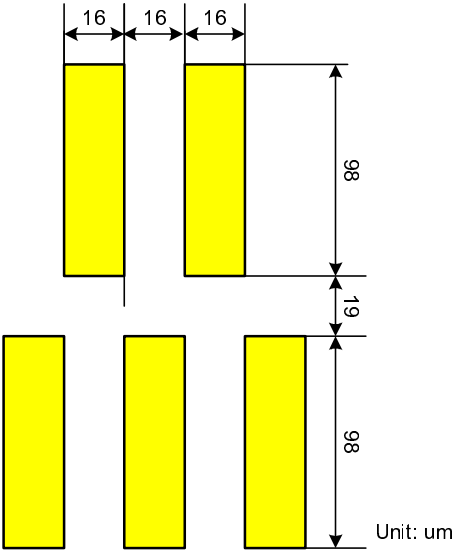
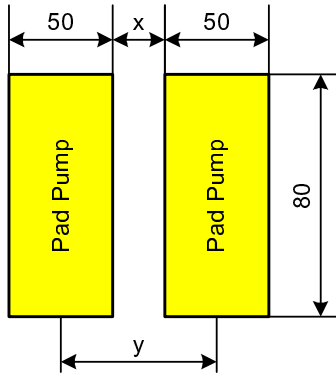
| No. | Name | X | Y | No. | Name | X | Y | No. | Name | X | Y | No. | Name | X | Y | No. | Name | X | Y |
|-----|---------|-------|--------|-----|--------|-------|--------|-----|----------|------|--------|-----|---------|------|--------|-----|---------|------|--------|
| 1 | DUMMY1 | -8610 | -307.5 | 61 | TS4 | -4130 | -307.5 | 121 | VCOML | 70 | -307.5 | 181 | C11+ | 4270 | -307.5 | 241 | C22+ | 8470 | -307.5 |
| 2 | TEST1 | -8540 | -307.5 | 62 | TS3 | -4060 | -307.5 | 122 | VCOML | 140 | -307.5 | 182 | C11+ | 4340 | -307.5 | 242 | DUMMY14 | 8540 | -307.5 |
| 3 | IOGNDUM | -8470 | -307.5 | 63 | TS2 | -3990 | -307.5 | 123 | VCOML | 210 | -307.5 | 183 | C11+ | 4410 | -307.5 | 243 | DUMMY15 | 8610 | -307.5 |
| 4 | TESTO1 | -8400 | -307.5 | 64 | TS1 | -3920 | -307.5 | 124 | VCOML | 280 | -307.5 | 184 | C11+ | 4480 | -307.5 | 244 | DUMMY20 | 8659 | 202.5 |
| 5 | TESTO2 | -8330 | -307.5 | 65 | TS0 | -3850 | -307.5 | 125 | VREG1OUT | 350 | -307.5 | 185 | VGL | 4550 | -307.5 | 245 | G320 | 8643 | 319.5 |
| 6 | TESTO3 | -8260 | -307.5 | 66 | DUMMY2 | -3780 | -307.5 | 126 | VREG1OUT | 420 | -307.5 | 186 | VGL | 4620 | -307.5 | 246 | G318 | 8627 | 202.5 |
| 7 | IM0/ID | -8190 | -307.5 | 67 | IOVCC | -3710 | -307.5 | 127 | VREG1OUT | 490 | -307.5 | 187 | VGL | 4690 | -307.5 | 247 | G316 | 8611 | 319.5 |
| 8 | IM1 | -8120 | -307.5 | 68 | IOVCC | -3640 | -307.5 | 128 | DUMMY7 | 560 | -307.5 | 188 | VGL | 4760 | -307.5 | 248 | G314 | 8595 | 202.5 |
| 9 | IM2 | -8050 | -307.5 | 69 | IOVCC | -3570 | -307.5 | 129 | DUMMY8 | 630 | -307.5 | 189 | VGL | 4830 | -307.5 | 249 | G312 | 8579 | 319.5 |
| 10 | IM3 | -7980 | -307.5 | 70 | IOVCC | -3500 | -307.5 | 130 | DUMMY9 | 700 | -307.5 | 190 | VGL | 4900 | -307.5 | 250 | G310 | 8563 | 202.5 |
| 11 | TEST2 | -7910 | -307.5 | 71 | IOVCC | -3430 | -307.5 | 131 | VCL | 770 | -307.5 | 191 | VGL | 4970 | -307.5 | 251 | G308 | 8547 | 319.5 |
| 12 | TESTO4 | -7840 | -307.5 | 72 | IOVCC | -3360 | -307.5 | 132 | VCL | 840 | -307.5 | 192 | VGL | 5040 | -307.5 | 252 | G306 | 8531 | 202.5 |
| 13 | TESTO5 | -7770 | -307.5 | 73 | VDDD | -3290 | -307.5 | 133 | VCL | 910 | -307.5 | 193 | VGL | 5110 | -307.5 | 253 | G304 | 8515 | 319.5 |
| 14 | TESTO6 | -7700 | -307.5 | 74 | VDDD | -3220 | -307.5 | 134 | VCL | 980 | -307.5 | 194 | VGL | 5180 | -307.5 | 254 | G302 | 8499 | 202.5 |
| 15 | TESTO7 | -7630 | -307.5 | 75 | VDDD | -3150 | -307.5 | 135 | VCL | 1050 | -307.5 | 195 | GND | 5250 | -307.5 | 255 | G300 | 8483 | 319.5 |
| 16 | TESTO8 | -7560 | -307.5 | 76 | VDDD | -3080 | -307.5 | 136 | DDVDH | 1120 | -307.5 | 196 | GND | 5320 | -307.5 | 256 | G298 | 8467 | 202.5 |
| 17 | TESTO9 | -7490 | -307.5 | 77 | VDDD | -3010 | -307.5 | 137 | DDVDH | 1190 | -307.5 | 197 | GND | 5390 | -307.5 | 257 | G296 | 8451 | 319.5 |
| 18 | TESTO10 | -7420 | -307.5 | 78 | VDDD | -2940 | -307.5 | 138 | DDVDH | 1260 | -307.5 | 198 | VGH | 5460 | -307.5 | 258 | G294 | 8435 | 202.5 |
| 19 | nRESET | -7350 | -307.5 | 79 | VDDD | -2870 | -307.5 | 139 | DDVDH | 1330 | -307.5 | 199 | VGH | 5530 | -307.5 | 259 | G292 | 8419 | 319.5 |
| 20 | nRESET | -7280 | -307.5 | 80 | VDDD | -2800 | -307.5 | 140 | DDVDH | 1400 | -307.5 | 200 | VGH | 5600 | -307.5 | 260 | G290 | 8403 | 202.5 |
| 21 | VSYN | -7210 | -307.5 | 81 | VDDD | -2730 | -307.5 | 141 | DDVDH | 1470 | -307.5 | 201 | VGH | 5670 | -307.5 | 261 | G288 | 8387 | 319.5 |
| 22 | HSYN | -7140 | -307.5 | 82 | VDDD | -2660 | -307.5 | 142 | VCI1 | 1540 | -307.5 | 202 | VGH | 5740 | -307.5 | 262 | G286 | 8371 | 202.5 |
| 23 | DOTCLK | -7070 | -307.5 | 83 | VDDD | -2590 | -307.5 | 143 | VCI1 | 1610 | -307.5 | 203 | VGH | 5810 | -307.5 | 263 | G284 | 8355 | 319.5 |
| 24 | ENABLE | -7000 | -307.5 | 84 | DUMMY3 | -2520 | -307.5 | 144 | VCI1 | 1680 | -307.5 | 204 | DUMMY12 | 5880 | -307.5 | 264 | G282 | 8339 | 202.5 |
| 25 | DB17 | -6905 | -307.5 | 85 | GND | -2450 | -307.5 | 145 | VCI | 1750 | -307.5 | 205 | DUMMY13 | 5950 | -307.5 | 265 | G280 | 8323 | 319.5 |
| 26 | DB16 | -6825 | -307.5 | 86 | GND | -2380 | -307.5 | 146 | VCI | 1820 | -307.5 | 206 | C13- | 6020 | -307.5 | 266 | G278 | 8307 | 202.5 |
| 27 | DB15 | -6745 | -307.5 | 87 | GND | -2310 | -307.5 | 147 | VCI | 1890 | -307.5 | 207 | C13- | 6090 | -307.5 | 267 | G276 | 8291 | 319.5 |
| 28 | DB14 | -6665 | -307.5 | 88 | GND | -2240 | -307.5 | 148 | VCI | 1960 | -307.5 | 208 | C13- | 6160 | -307.5 | 268 | G274 | 8275 | 202.5 |
| 29 | DB13 | -6585 | -307.5 | 89 | GND | -2170 | -307.5 | 149 | VCI | 2030 | -307.5 | 209 | C13- | 6230 | -307.5 | 269 | G272 | 8259 | 319.5 |
| 30 | TESTO11 | -6495 | -307.5 | 90 | GND | -2100 | -307.5 | 150 | VCI | 2100 | -307.5 | 210 | C13+ | 6300 | -307.5 | 270 | G270 | 8243 | 202.5 |
| 31 | DB12 | -6405 | -307.5 | 91 | GND | -2030 | -307.5 | 151 | VCI | 2170 | -307.5 | 211 | C13+ | 6370 | -307.5 | 271 | G268 | 8227 | 319.5 |
| 32 | DB11 | -6325 | -307.5 | 92 | GND | -1960 | -307.5 | 152 | VCI | 2240 | -307.5 | 212 | C13+ | 6440 | -307.5 | 272 | G266 | 8211 | 202.5 |
| 33 | DB10 | -6245 | -307.5 | 93 | VGS | -1890 | -307.5 | 153 | VCI | 2310 | -307.5 | 213 | C13+ | 6510 | -307.5 | 273 | G264 | 8195 | 319.5 |
| 34 | DB9 | -6165 | -307.5 | 94 | VGS | -1820 | -307.5 | 154 | VCI | 2380 | -307.5 | 214 | C21- | 6580 | -307.5 | 274 | G262 | 8179 | 202.5 |
| 35 | DB8 | -6085 | -307.5 | 95 | GND | -1750 | -307.5 | 155 | VCI | 2450 | -307.5 | 215 | C21- | 6650 | -307.5 | 275 | G260 | 8163 | 319.5 |
| 36 | TEST3 | -5990 | -307.5 | 96 | GND | -1680 | -307.5 | 156 | VCI | 2520 | -307.5 | 216 | C21- | 6720 | -307.5 | 276 | G258 | 8147 | 202.5 |
| 37 | TESTO12 | -5920 | -307.5 | 97 | GND | -1610 | -307.5 | 157 | VCI | 2590 | -307.5 | 217 | C21- | 6790 | -307.5 | 277 | G256 | 8131 | 319.5 |
| 38 | DB7 | -5825 | -307.5 | 98 | GND | -1540 | -307.5 | 158 | VCI | 2660 | -307.5 | 218 | C21- | 6860 | -307.5 | 278 | G254 | 8115 | 202.5 |
| 39 | DB6 | -5745 | -307.5 | 99 | GND | -1470 | -307.5 | 159 | VCI | 2730 | -307.5 | 219 | C21- | 6930 | -307.5 | 279 | G252 | 8099 | 319.5 |
| 40 | DB5 | -5665 | -307.5 | 100 | GND | -1400 | -307.5 | 160 | VCI | 2800 | -307.5 | 220 | C21- | 7000 | -307.5 | 280 | G250 | 8083 | 202.5 |
| 41 | DB4 | -5585 | -307.5 | 101 | GND | -1330 | -307.5 | 161 | VCI | 2870 | -307.5 | 221 | C21+ | 7070 | -307.5 | 281 | G248 | 8067 | 319.5 |
| 42 | DB3 | -5505 | -307.5 | 102 | GND | -1260 | -307.5 | 162 | VCI | 2940 | -307.5 | 222 | C21+ | 7140 | -307.5 | 282 | G246 | 8051 | 202.5 |
| 43 | DB2 | -5425 | -307.5 | 103 | GND | -1190 | -307.5 | 163 | DUMMY10 | 3010 | -307.5 | 223 | C21+ | 7210 | -307.5 | 283 | G244 | 8035 | 319.5 |
| 44 | DB1 | -5345 | -307.5 | 104 | GND | -1120 | -307.5 | 164 | DUMMY11 | 3080 | -307.5 | 224 | C21+ | 7280 | -307.5 | 284 | G242 | 8019 | 202.5 |
| 45 | DB0 | -5265 | -307.5 | 105 | DUMMY4 | -1050 | -307.5 | 165 | C12- | 3150 | -307.5 | 225 | C21+ | 7350 | -307.5 | 285 | G240 | 8003 | 319.5 |
| 46 | TESTO13 | -5180 | -307.5 | 106 | DUMMY5 | -980 | -307.5 | 166 | C12- | 3220 | -307.5 | 226 | C21+ | 7420 | -307.5 | 286 | G238 | 7987 | 202.5 |
| 47 | SDO | -5110 | -307.5 | 107 | DUMMY6 | -910 | -307.5 | 167 | C12- | 3290 | -307.5 | 227 | C21+ | 7490 | -307.5 | 287 | G236 | 7971 | 319.5 |
| 48 | SDI | -5040 | -307.5 | 108 | VCOM | -840 | -307.5 | 168 | C12- | 3360 | -307.5 | 228 | C22- | 7560 | -307.5 | 288 | G234 | 7955 | 202.5 |
| 49 | nRD | -4970 | -307.5 | 109 | VCOM | -770 | -307.5 | 169 | C12- | 3430 | -307.5 | 229 | C22- | 7630 | -307.5 | 289 | G232 | 7939 | 319.5 |
| 50 | nWR/SCL | -4900 | -307.5 | 110 | VCOM | -700 | -307.5 | 170 | C12+ | 3500 | -307.5 | 230 | C22- | 7700 | -307.5 | 290 | G230 | 7923 | 202.5 |
| 51 | RS | -4830 | -307.5 | 111 | VCOM | -630 | -307.5 | 171 | C12+ | 3570 | -307.5 | 231 | C22- | 7770 | -307.5 | 291 | G228 | 7907 | 319.5 |
| 52 | nCS | -4760 | -307.5 | 112 | VCOM | -560 | -307.5 | 172 | C12+ | 3640 | -307.5 | 232 | C22- | 7840 | -307.5 | 292 | G226 | 7891 | 202.5 |
| 53 | TESTO14 | -4690 | -307.5 | 113 | VCOM | -490 | -307.5 | 173 | C12+ | 3710 | -307.5 | 233 | C22- | 7910 | -307.5 | 293 | G224 | 7875 | 319.5 |
| 54 | TESTO15 | -4620 | -307.5 | 114 | VCOM | -420 | -307.5 | 174 | C12+ | 3780 | -307.5 | 234 | C22- | 7980 | -307.5 | 294 | G222 | 7859 | 202.5 |
| 55 | FMARK | -4550 | -307.5 | 115 | VCOMH | -350 | -307.5 | 175 | C11- | 3850 | -307.5 | 235 | C22+ | 8050 | -307.5 | 295 | G220 | 7843 | 319.5 |
| 56 | TESTO16 | -4480 | -307.5 | 116 | VCOMH | -280 | -307.5 | 176 | C11- | 3920 | -307.5 | 236 | C22+ | 8120 | -307.5 | 296 | G218 | 7827 | 202.5 |
| 57 | TS8 | -4410 | -307.5 | 117 | VCOMH | -210 | -307.5 | 177 | C11- | 3990 | -307.5 | 237 | C22+ | 8190 | -307.5 | 297 | G216 | 7811 | 319.5 |
| 58 | TS7 | -4340 | -307.5 | 118 | VCOMH | -140 | -307.5 | 178 | C11- | 4060 | -307.5 | 238 | C22+ | 8260 | -307.5 | 298 | G214 | 7795 | 202.5 |
| 59 | TS6 | -4270 | -307.5 | 119 | VCOMH | -70 | -307.5 | 179 | C11- | 4130 | -307.5 | 239 | C22+ | 8330 | -307.5 | 299 | G212 | 7779 | 319.5 |
| 60 | TS5 | -4200 | -307.5 | 120 | VCOMH | 0 | -307.5 | 180 | C11+ | 4200 | -307.5 | 240 | C22+ | 8400 | -307.5 | 300 | G210 | 7763 | 202.5 |

| No. | Name | X | Y | No. | Name | X | Y | No. | Name | X | Y | No. | Name | X | Y | No. | Name | X | Y |
|-----|------|------|-------|-----|---------|------|-------|-----|------|------|-------|-----|------|------|-------|-----|------|------|-------|
| 301 | G208 | 7747 | 319.5 | 361 | G88 | 6787 | 319.5 | 421 | S706 | 5807 | 202.5 | 481 | S646 | 4847 | 202.5 | 541 | S586 | 3887 | 202.5 |
| 302 | G206 | 7731 | 202.5 | 362 | G86 | 6771 | 202.5 | 422 | S705 | 5791 | 319.5 | 482 | S645 | 4831 | 319.5 | 542 | S585 | 3871 | 319.5 |
| 303 | G204 | 7715 | 319.5 | 363 | G84 | 6755 | 319.5 | 423 | S704 | 5775 | 202.5 | 483 | S644 | 4815 | 202.5 | 543 | S584 | 3855 | 202.5 |
| 304 | G202 | 7699 | 202.5 | 364 | G82 | 6739 | 202.5 | 424 | S703 | 5759 | 319.5 | 484 | S643 | 4799 | 319.5 | 544 | S583 | 3839 | 319.5 |
| 305 | G200 | 7683 | 319.5 | 365 | G80 | 6723 | 319.5 | 425 | S702 | 5743 | 202.5 | 485 | S642 | 4783 | 202.5 | 545 | S582 | 3823 | 202.5 |
| 306 | G198 | 7667 | 202.5 | 366 | G78 | 6707 | 202.5 | 426 | S701 | 5727 | 319.5 | 486 | S641 | 4767 | 319.5 | 546 | S581 | 3807 | 319.5 |
| 307 | G196 | 7651 | 319.5 | 367 | G76 | 6691 | 319.5 | 427 | S700 | 5711 | 202.5 | 487 | S640 | 4751 | 202.5 | 547 | S580 | 3791 | 202.5 |
| 308 | G194 | 7635 | 202.5 | 368 | G74 | 6675 | 202.5 | 428 | S699 | 5695 | 319.5 | 488 | S639 | 4735 | 319.5 | 548 | S579 | 3775 | 319.5 |
| 309 | G192 | 7619 | 319.5 | 369 | G72 | 6659 | 319.5 | 429 | S698 | 5679 | 202.5 | 489 | S638 | 4719 | 202.5 | 549 | S578 | 3759 | 202.5 |
| 310 | G190 | 7603 | 202.5 | 370 | G70 | 6643 | 202.5 | 430 | S697 | 5663 | 319.5 | 490 | S637 | 4703 | 319.5 | 550 | S577 | 3743 | 319.5 |
| 311 | G188 | 7587 | 319.5 | 371 | G68 | 6627 | 319.5 | 431 | S696 | 5647 | 202.5 | 491 | S636 | 4687 | 202.5 | 551 | S576 | 3727 | 202.5 |
| 312 | G186 | 7571 | 202.5 | 372 | G66 | 6611 | 202.5 | 432 | S695 | 5631 | 319.5 | 492 | S635 | 4671 | 319.5 | 552 | S575 | 3711 | 319.5 |
| 313 | G184 | 7555 | 319.5 | 373 | G64 | 6595 | 319.5 | 433 | S694 | 5615 | 202.5 | 493 | S634 | 4655 | 202.5 | 553 | S574 | 3695 | 202.5 |
| 314 | G182 | 7539 | 202.5 | 374 | G62 | 6579 | 202.5 | 434 | S693 | 5599 | 319.5 | 494 | S633 | 4639 | 319.5 | 554 | S573 | 3679 | 319.5 |
| 315 | G180 | 7523 | 319.5 | 375 | G60 | 6563 | 319.5 | 435 | S692 | 5583 | 202.5 | 495 | S632 | 4623 | 202.5 | 555 | S572 | 3663 | 202.5 |
| 316 | G178 | 7507 | 202.5 | 376 | G58 | 6547 | 202.5 | 436 | S691 | 5567 | 319.5 | 496 | S631 | 4607 | 319.5 | 556 | S571 | 3647 | 319.5 |
| 317 | G176 | 7491 | 319.5 | 377 | G56 | 6531 | 319.5 | 437 | S690 | 5551 | 202.5 | 497 | S630 | 4591 | 202.5 | 557 | S570 | 3631 | 202.5 |
| 318 | G174 | 7475 | 202.5 | 378 | G54 | 6515 | 202.5 | 438 | S689 | 5535 | 319.5 | 498 | S629 | 4575 | 319.5 | 558 | S569 | 3615 | 319.5 |
| 319 | G172 | 7459 | 319.5 | 379 | G52 | 6499 | 319.5 | 439 | S688 | 5519 | 202.5 | 499 | S628 | 4559 | 202.5 | 559 | S568 | 3599 | 202.5 |
| 320 | G170 | 7443 | 202.5 | 380 | G50 | 6483 | 202.5 | 440 | S687 | 5503 | 319.5 | 500 | S627 | 4543 | 319.5 | 560 | S567 | 3583 | 319.5 |
| 321 | G168 | 7427 | 319.5 | 381 | G48 | 6467 | 319.5 | 441 | S686 | 5487 | 202.5 | 501 | S626 | 4527 | 202.5 | 561 | S566 | 3567 | 202.5 |
| 322 | G166 | 7411 | 202.5 | 382 | G46 | 6451 | 202.5 | 442 | S685 | 5471 | 319.5 | 502 | S625 | 4511 | 319.5 | 562 | S565 | 3551 | 319.5 |
| 323 | G164 | 7395 | 319.5 | 383 | G44 | 6435 | 319.5 | 443 | S684 | 5455 | 202.5 | 503 | S624 | 4495 | 202.5 | 563 | S564 | 3535 | 202.5 |
| 324 | G162 | 7379 | 202.5 | 384 | G42 | 6419 | 202.5 | 444 | S683 | 5439 | 319.5 | 504 | S623 | 4479 | 319.5 | 564 | S563 | 3519 | 319.5 |
| 325 | G160 | 7363 | 319.5 | 385 | G40 | 6403 | 319.5 | 445 | S682 | 5423 | 202.5 | 505 | S622 | 4463 | 202.5 | 565 | S562 | 3503 | 202.5 |
| 326 | G158 | 7347 | 202.5 | 386 | G38 | 6387 | 202.5 | 446 | S681 | 5407 | 319.5 | 506 | S621 | 4447 | 319.5 | 566 | S561 | 3487 | 319.5 |
| 327 | G156 | 7331 | 319.5 | 387 | G36 | 6371 | 319.5 | 447 | S680 | 5391 | 202.5 | 507 | S620 | 4431 | 202.5 | 567 | S560 | 3471 | 202.5 |
| 328 | G154 | 7315 | 202.5 | 388 | G34 | 6355 | 202.5 | 448 | S679 | 5375 | 319.5 | 508 | S619 | 4415 | 319.5 | 568 | S559 | 3455 | 319.5 |
| 329 | G152 | 7299 | 319.5 | 389 | G32 | 6339 | 319.5 | 449 | S678 | 5359 | 202.5 | 509 | S618 | 4399 | 202.5 | 569 | S558 | 3439 | 202.5 |
| 330 | G150 | 7283 | 202.5 | 390 | G30 | 6323 | 202.5 | 450 | S677 | 5343 | 319.5 | 510 | S617 | 4383 | 319.5 | 570 | S557 | 3423 | 319.5 |
| 331 | G148 | 7267 | 319.5 | 391 | G28 | 6307 | 319.5 | 451 | S676 | 5327 | 202.5 | 511 | S616 | 4367 | 202.5 | 571 | S556 | 3407 | 202.5 |
| 332 | G146 | 7251 | 202.5 | 392 | G26 | 6291 | 202.5 | 452 | S675 | 5311 | 319.5 | 512 | S615 | 4351 | 319.5 | 572 | S555 | 3391 | 319.5 |
| 333 | G144 | 7235 | 319.5 | 393 | G24 | 6275 | 319.5 | 453 | S674 | 5295 | 202.5 | 513 | S614 | 4335 | 202.5 | 573 | S554 | 3375 | 202.5 |
| 334 | G142 | 7219 | 202.5 | 394 | G22 | 6259 | 202.5 | 454 | S673 | 5279 | 319.5 | 514 | S613 | 4319 | 319.5 | 574 | S553 | 3359 | 319.5 |
| 335 | G140 | 7203 | 319.5 | 395 | G20 | 6243 | 319.5 | 455 | S672 | 5263 | 202.5 | 515 | S612 | 4303 | 202.5 | 575 | S552 | 3343 | 202.5 |
| 336 | G138 | 7187 | 202.5 | 396 | G18 | 6227 | 202.5 | 456 | S671 | 5247 | 319.5 | 516 | S611 | 4287 | 319.5 | 576 | S551 | 3327 | 319.5 |
| 337 | G136 | 7171 | 319.5 | 397 | G16 | 6211 | 319.5 | 457 | S670 | 5231 | 202.5 | 517 | S610 | 4271 | 202.5 | 577 | S550 | 3311 | 202.5 |
| 338 | G134 | 7155 | 202.5 | 398 | G14 | 6195 | 202.5 | 458 | S669 | 5215 | 319.5 | 518 | S609 | 4255 | 319.5 | 578 | S549 | 3295 | 319.5 |
| 339 | G132 | 7139 | 319.5 | 399 | G12 | 6179 | 319.5 | 459 | S668 | 5199 | 202.5 | 519 | S608 | 4239 | 202.5 | 579 | S548 | 3279 | 202.5 |
| 340 | G130 | 7123 | 202.5 | 400 | G10 | 6163 | 202.5 | 460 | S667 | 5183 | 319.5 | 520 | S607 | 4223 | 319.5 | 580 | S547 | 3263 | 319.5 |
| 341 | G128 | 7107 | 319.5 | 401 | G8 | 6147 | 319.5 | 461 | S666 | 5167 | 202.5 | 521 | S606 | 4207 | 202.5 | 581 | S546 | 3247 | 202.5 |
| 342 | G126 | 7091 | 202.5 | 402 | G6 | 6131 | 202.5 | 462 | S665 | 5151 | 319.5 | 522 | S605 | 4191 | 319.5 | 582 | S545 | 3231 | 319.5 |
| 343 | G124 | 7075 | 319.5 | 403 | G4 | 6115 | 319.5 | 463 | S664 | 5135 | 202.5 | 523 | S604 | 4175 | 202.5 | 583 | S544 | 3215 | 202.5 |
| 344 | G122 | 7059 | 202.5 | 404 | G2 | 6099 | 202.5 | 464 | S663 | 5119 | 319.5 | 524 | S603 | 4159 | 319.5 | 584 | S543 | 3199 | 319.5 |
| 345 | G120 | 7043 | 319.5 | 405 | DUMMY21 | 6083 | 319.5 | 465 | S662 | 5103 | 202.5 | 525 | S602 | 4143 | 202.5 | 585 | S542 | 3183 | 202.5 |
| 346 | G118 | 7027 | 202.5 | 406 | DUMMY22 | 6067 | 319.5 | 466 | S661 | 5087 | 319.5 | 526 | S601 | 4127 | 319.5 | 586 | S541 | 3167 | 319.5 |
| 347 | G116 | 7011 | 319.5 | 407 | S720 | 6031 | 202.5 | 467 | S660 | 5071 | 202.5 | 527 | S600 | 4111 | 202.5 | 587 | S540 | 3151 | 202.5 |
| 348 | G114 | 6995 | 202.5 | 408 | S719 | 6015 | 319.5 | 468 | S659 | 5055 | 319.5 | 528 | S599 | 4095 | 319.5 | 588 | S539 | 3135 | 319.5 |
| 349 | G112 | 6979 | 319.5 | 409 | S718 | 5999 | 202.5 | 469 | S658 | 5039 | 202.5 | 529 | S598 | 4079 | 202.5 | 589 | S538 | 3119 | 202.5 |
| 350 | G110 | 6963 | 202.5 | 410 | S717 | 5983 | 319.5 | 470 | S657 | 5023 | 319.5 | 530 | S597 | 4063 | 319.5 | 590 | S537 | 3103 | 319.5 |
| 351 | G108 | 6947 | 319.5 | 411 | S716 | 5967 | 202.5 | 471 | S656 | 5007 | 202.5 | 531 | S596 | 4047 | 202.5 | 591 | S536 | 3087 | 202.5 |
| 352 | G106 | 6931 | 202.5 | 412 | S715 | 5951 | 319.5 | 472 | S655 | 4991 | 319.5 | 532 | S595 | 4031 | 319.5 | 592 | S535 | 3071 | 319.5 |
| 353 | G104 | 6915 | 319.5 | 413 | S714 | 5935 | 202.5 | 473 | S654 | 4975 | 202.5 | 533 | S594 | 4015 | 202.5 | 593 | S534 | 3055 | 202.5 |
| 354 | G102 | 6899 | 202.5 | 414 | S713 | 5919 | 319.5 | 474 | S653 | 4959 | 319.5 | 534 | S593 | 3999 | 319.5 | 594 | S533 | 3039 | 319.5 |
| 355 | G100 | 6883 | 319.5 | 415 | S712 | 5903 | 202.5 | 475 | S652 | 4943 | 202.5 | 535 | S592 | 3983 | 202.5 | 595 | S532 | 3023 | 202.5 |
| 356 | G98 | 6867 | 202.5 | 416 | S711 | 5887 | 319.5 | 476 | S651 | 4927 | 319.5 | 536 | S591 | 3967 | 319.5 | 596 | S531 | 3007 | 319.5 |
| 357 | G96 | 6851 | 319.5 | 417 | S710 | 5871 | 202.5 | 477 | S650 | 4911 | 202.5 | 537 | S590 | 3951 | 202.5 | 597 | S530 | 2991 | 202.5 |
| 358 | G94 | 6835 | 202.5 | 418 | S709 | 5855 | 319.5 | 478 | S649 | 4895 | 319.5 | 538 | S589 | 3935 | 319.5 | 598 | S529 | 2975 | 319.5 |
| 359 | G92 | 6819 | 319.5 | 419 | S708 | 5839 | 202.5 | 479 | S648 | 4879 | 202.5 | 539 | S588 | 3919 | 202.5 | 599 | S528 | 2959 | 202.5 |
| 360 | G90 | 6803 | 202.5 | 420 | S707 | 5823 | 319.5 | 480 | S647 | 4863 | 319.5 | 540 | S587 | 3903 | 319.5 | 600 | S527 | 2943 | 319.5 |

| No. | Name | X | Y | No. | Name | X | Y | No. | Name | X | Y | No. | Name | X | Y | No. | Name | X | Y |
|-----|------|------|-------|-----|------|------|-------|-----|---------|------|-------|-----|------|-------|-------|-----|------|-------|-------|
| 601 | S526 | 2927 | 202.5 | 661 | S466 | 1967 | 202.5 | 721 | S406 | 1007 | 202.5 | 781 | S348 | -479 | 319.5 | 841 | S288 | -1439 | 319.5 |
| 602 | S525 | 2911 | 319.5 | 662 | S465 | 1951 | 319.5 | 722 | S405 | 991 | 319.5 | 782 | S347 | -495 | 202.5 | 842 | S287 | -1455 | 202.5 |
| 603 | S524 | 2895 | 202.5 | 663 | S464 | 1935 | 202.5 | 723 | S404 | 975 | 202.5 | 783 | S346 | -511 | 319.5 | 843 | S286 | -1471 | 319.5 |
| 604 | S523 | 2879 | 319.5 | 664 | S463 | 1919 | 319.5 | 724 | S403 | 959 | 319.5 | 784 | S345 | -527 | 202.5 | 844 | S285 | -1487 | 202.5 |
| 605 | S522 | 2863 | 202.5 | 665 | S462 | 1903 | 202.5 | 725 | S402 | 943 | 202.5 | 785 | S344 | -543 | 319.5 | 845 | S284 | -1503 | 319.5 |
| 606 | S521 | 2847 | 319.5 | 666 | S461 | 1887 | 319.5 | 726 | S401 | 927 | 319.5 | 786 | S343 | -559 | 202.5 | 846 | S283 | -1519 | 202.5 |
| 607 | S520 | 2831 | 202.5 | 667 | S460 | 1871 | 202.5 | 727 | S400 | 911 | 202.5 | 787 | S342 | -575 | 319.5 | 847 | S282 | -1535 | 319.5 |
| 608 | S519 | 2815 | 319.5 | 668 | S459 | 1855 | 319.5 | 728 | S399 | 895 | 319.5 | 788 | S341 | -591 | 202.5 | 848 | S281 | -1551 | 202.5 |
| 609 | S518 | 2799 | 202.5 | 669 | S458 | 1839 | 202.5 | 729 | S398 | 879 | 202.5 | 789 | S340 | -607 | 319.5 | 849 | S280 | -1567 | 319.5 |
| 610 | S517 | 2783 | 319.5 | 670 | S457 | 1823 | 319.5 | 730 | S397 | 863 | 319.5 | 790 | S339 | -623 | 202.5 | 850 | S279 | -1583 | 202.5 |
| 611 | S516 | 2767 | 202.5 | 671 | S456 | 1807 | 202.5 | 731 | S396 | 847 | 202.5 | 791 | S338 | -639 | 319.5 | 851 | S278 | -1599 | 319.5 |
| 612 | S515 | 2751 | 319.5 | 672 | S455 | 1791 | 319.5 | 732 | S395 | 831 | 319.5 | 792 | S337 | -655 | 202.5 | 852 | S277 | -1615 | 202.5 |
| 613 | S514 | 2735 | 202.5 | 673 | S454 | 1775 | 202.5 | 733 | S394 | 815 | 202.5 | 793 | S336 | -671 | 319.5 | 853 | S276 | -1631 | 319.5 |
| 614 | S513 | 2719 | 319.5 | 674 | S453 | 1759 | 319.5 | 734 | S393 | 799 | 319.5 | 794 | S335 | -687 | 202.5 | 854 | S275 | -1647 | 202.5 |
| 615 | S512 | 2703 | 202.5 | 675 | S452 | 1743 | 202.5 | 735 | S392 | 783 | 202.5 | 795 | S334 | -703 | 319.5 | 855 | S274 | -1663 | 319.5 |
| 616 | S511 | 2687 | 319.5 | 676 | S451 | 1727 | 319.5 | 736 | S391 | 767 | 319.5 | 796 | S333 | -719 | 202.5 | 856 | S273 | -1679 | 202.5 |
| 617 | S510 | 2671 | 202.5 | 677 | S450 | 1711 | 202.5 | 737 | S390 | 751 | 202.5 | 797 | S332 | -735 | 319.5 | 857 | S272 | -1695 | 319.5 |
| 618 | S509 | 2655 | 319.5 | 678 | S449 | 1695 | 319.5 | 738 | S389 | 735 | 319.5 | 798 | S331 | -751 | 202.5 | 858 | S271 | -1711 | 202.5 |
| 619 | S508 | 2639 | 202.5 | 679 | S448 | 1679 | 202.5 | 739 | S388 | 719 | 202.5 | 799 | S330 | -767 | 319.5 | 859 | S270 | -1727 | 319.5 |
| 620 | S507 | 2623 | 319.5 | 680 | S447 | 1663 | 319.5 | 740 | S387 | 703 | 319.5 | 800 | S329 | -783 | 202.5 | 860 | S269 | -1743 | 202.5 |
| 621 | S506 | 2607 | 202.5 | 681 | S446 | 1647 | 202.5 | 741 | S386 | 687 | 202.5 | 801 | S328 | -799 | 319.5 | 861 | S268 | -1759 | 319.5 |
| 622 | S505 | 2591 | 319.5 | 682 | S445 | 1631 | 319.5 | 742 | S385 | 671 | 319.5 | 802 | S327 | -815 | 202.5 | 862 | S267 | -1775 | 202.5 |
| 623 | S504 | 2575 | 202.5 | 683 | S444 | 1615 | 202.5 | 743 | S384 | 655 | 202.5 | 803 | S326 | -831 | 319.5 | 863 | S266 | -1791 | 319.5 |
| 624 | S503 | 2559 | 319.5 | 684 | S443 | 1599 | 319.5 | 744 | S383 | 639 | 319.5 | 804 | S325 | -847 | 202.5 | 864 | S265 | -1807 | 202.5 |
| 625 | S502 | 2543 | 202.5 | 685 | S442 | 1583 | 202.5 | 745 | S382 | 623 | 202.5 | 805 | S324 | -863 | 319.5 | 865 | S264 | -1823 | 319.5 |
| 626 | S501 | 2527 | 319.5 | 686 | S441 | 1567 | 319.5 | 746 | S381 | 607 | 319.5 | 806 | S323 | -879 | 202.5 | 866 | S263 | -1839 | 202.5 |
| 627 | S500 | 2511 | 202.5 | 687 | S440 | 1551 | 202.5 | 747 | S380 | 591 | 202.5 | 807 | S322 | -895 | 319.5 | 867 | S262 | -1855 | 319.5 |
| 628 | S499 | 2495 | 319.5 | 688 | S439 | 1535 | 319.5 | 748 | S379 | 575 | 319.5 | 808 | S321 | -911 | 202.5 | 868 | S261 | -1871 | 202.5 |
| 629 | S498 | 2479 | 202.5 | 689 | S438 | 1519 | 202.5 | 749 | S378 | 559 | 202.5 | 809 | S320 | -927 | 319.5 | 869 | S260 | -1887 | 319.5 |
| 630 | S497 | 2463 | 319.5 | 690 | S437 | 1503 | 319.5 | 750 | S377 | 543 | 319.5 | 810 | S319 | -943 | 202.5 | 870 | S259 | -1903 | 202.5 |
| 631 | S496 | 2447 | 202.5 | 691 | S436 | 1487 | 202.5 | 751 | S376 | 527 | 202.5 | 811 | S318 | -959 | 319.5 | 871 | S258 | -1919 | 319.5 |
| 632 | S495 | 2431 | 319.5 | 692 | S435 | 1471 | 319.5 | 752 | S375 | 511 | 319.5 | 812 | S317 | -975 | 202.5 | 872 | S257 | -1935 | 202.5 |
| 633 | S494 | 2415 | 202.5 | 693 | S434 | 1455 | 202.5 | 753 | S374 | 495 | 202.5 | 813 | S316 | -991 | 319.5 | 873 | S256 | -1951 | 319.5 |
| 634 | S493 | 2399 | 319.5 | 694 | S433 | 1439 | 319.5 | 754 | S373 | 479 | 319.5 | 814 | S315 | -1007 | 202.5 | 874 | S255 | -1967 | 202.5 |
| 635 | S492 | 2383 | 202.5 | 695 | S432 | 1423 | 202.5 | 755 | S372 | 463 | 202.5 | 815 | S314 | -1023 | 319.5 | 875 | S254 | -1983 | 319.5 |
| 636 | S491 | 2367 | 319.5 | 696 | S431 | 1407 | 319.5 | 756 | S371 | 447 | 319.5 | 816 | S313 | -1039 | 202.5 | 876 | S253 | -1999 | 202.5 |
| 637 | S490 | 2351 | 202.5 | 697 | S430 | 1391 | 202.5 | 757 | S370 | 431 | 202.5 | 817 | S312 | -1055 | 319.5 | 877 | S252 | -2015 | 319.5 |
| 638 | S489 | 2335 | 319.5 | 698 | S429 | 1375 | 319.5 | 758 | S369 | 415 | 319.5 | 818 | S311 | -1071 | 202.5 | 878 | S251 | -2031 | 202.5 |
| 639 | S488 | 2319 | 202.5 | 699 | S428 | 1359 | 202.5 | 759 | S368 | 399 | 202.5 | 819 | S310 | -1087 | 319.5 | 879 | S250 | -2047 | 319.5 |
| 640 | S487 | 2303 | 319.5 | 700 | S427 | 1343 | 319.5 | 760 | S367 | 383 | 319.5 | 820 | S309 | -1103 | 202.5 | 880 | S249 | -2063 | 202.5 |
| 641 | S486 | 2287 | 202.5 | 701 | S426 | 1327 | 202.5 | 761 | S366 | 367 | 202.5 | 821 | S308 | -1119 | 319.5 | 881 | S248 | -2079 | 319.5 |
| 642 | S485 | 2271 | 319.5 | 702 | S425 | 1311 | 319.5 | 762 | S365 | 351 | 319.5 | 822 | S307 | -1135 | 202.5 | 882 | S247 | -2095 | 202.5 |
| 643 | S484 | 2255 | 202.5 | 703 | S424 | 1295 | 202.5 | 763 | S364 | 335 | 202.5 | 823 | S306 | -1151 | 319.5 | 883 | S246 | -2111 | 319.5 |
| 644 | S483 | 2239 | 319.5 | 704 | S423 | 1279 | 319.5 | 764 | S363 | 319 | 319.5 | 824 | S305 | -1167 | 202.5 | 884 | S245 | -2127 | 202.5 |
| 645 | S482 | 2223 | 202.5 | 705 | S422 | 1263 | 202.5 | 765 | S362 | 303 | 202.5 | 825 | S304 | -1183 | 319.5 | 885 | S244 | -2143 | 319.5 |
| 646 | S481 | 2207 | 319.5 | 706 | S421 | 1247 | 319.5 | 766 | S361 | 287 | 319.5 | 826 | S303 | -1199 | 202.5 | 886 | S243 | -2159 | 202.5 |
| 647 | S480 | 2191 | 202.5 | 707 | S420 | 1231 | 202.5 | 767 | DUMMY23 | 271 | 202.5 | 827 | S302 | -1215 | 319.5 | 887 | S242 | -2175 | 319.5 |
| 648 | S479 | 2175 | 319.5 | 708 | S419 | 1215 | 319.5 | 768 | DUMMY24 | -271 | 202.5 | 828 | S301 | -1231 | 202.5 | 888 | S241 | -2191 | 202.5 |
| 649 | S478 | 2159 | 202.5 | 709 | S418 | 1199 | 202.5 | 769 | S360 | -287 | 319.5 | 829 | S300 | -1247 | 319.5 | 889 | S240 | -2207 | 319.5 |
| 650 | S477 | 2143 | 319.5 | 710 | S417 | 1183 | 319.5 | 770 | S359 | -303 | 202.5 | 830 | S299 | -1263 | 202.5 | 890 | S239 | -2223 | 202.5 |
| 651 | S476 | 2127 | 202.5 | 711 | S416 | 1167 | 202.5 | 771 | S358 | -319 | 319.5 | 831 | S298 | -1279 | 319.5 | 891 | S238 | -2239 | 319.5 |
| 652 | S475 | 2111 | 319.5 | 712 | S415 | 1151 | 319.5 | 772 | S357 | -335 | 202.5 | 832 | S297 | -1295 | 202.5 | 892 | S237 | -2255 | 202.5 |
| 653 | S474 | 2095 | 202.5 | 713 | S414 | 1135 | 202.5 | 773 | S356 | -351 | 319.5 | 833 | S296 | -1311 | 319.5 | 893 | S236 | -2271 | 319.5 |
| 654 | S473 | 2079 | 319.5 | 714 | S413 | 1119 | 319.5 | 774 | S355 | -367 | 202.5 | 834 | S295 | -1327 | 202.5 | 894 | S235 | -2287 | 202.5 |
| 655 | S472 | 2063 | 202.5 | 715 | S412 | 1103 | 202.5 | 775 | S354 | -383 | 319.5 | 835 | S294 | -1343 | 319.5 | 895 | S234 | -2303 | 319.5 |
| 656 | S471 | 2047 | 319.5 | 716 | S411 | 1087 | 319.5 | 776 | S353 | -399 | 202.5 | 836 | S293 | -1359 | 202.5 | 896 | S233 | -2319 | 202.5 |
| 657 | S470 | 2031 | 202.5 | 717 | S410 | 1071 | 202.5 | 777 | S352 | -415 | 319.5 | 837 | S292 | -1375 | 319.5 | 897 | S232 | -2335 | 319.5 |
| 658 | S469 | 2015 | 319.5 | 718 | S409 | 1055 | 319.5 | 778 | S351 | -431 | 202.5 | 838 | S291 | -1391 | 202.5 | 898 | S231 | -2351 | 202.5 |
| 659 | S468 | 1999 | 202.5 | 719 | S408 | 1039 | 202.5 | 779 | S350 | -447 | 319.5 | 839 | S290 | -1407 | 319.5 | 899 | S230 | -2367 | 319.5 |
| 660 | S467 | 1983 | 319.5 | 720 | S407 | 1023 | 319.5 | 780 | S349 | -463 | 202.5 | 840 | S289 | -1423 | 202.5 | 900 | S229 | -2383 | 202.5 |

| No. | Name | X | Y | No. | Name | X | Y | No. | Name | X | Y | No. | Name | X | Y | No. | Name | X | Y |
|-----|------|-------|-------|------|------|-------|-------|------|------|-------|-------|------|---------|-------|-------|------|------|-------|-------|
| 901 | S228 | -2399 | 319.5 | 961 | S168 | -3359 | 319.5 | 1021 | S108 | -4319 | 319.5 | 1081 | S48 | -5279 | 319.5 | 1141 | G21 | -6259 | 202.5 |
| 902 | S227 | -2415 | 202.5 | 962 | S167 | -3375 | 202.5 | 1022 | S107 | -4335 | 202.5 | 1082 | S47 | -5295 | 202.5 | 1142 | G23 | -6275 | 319.5 |
| 903 | S226 | -2431 | 319.5 | 963 | S166 | -3391 | 319.5 | 1023 | S106 | -4351 | 319.5 | 1083 | S46 | -5311 | 319.5 | 1143 | G25 | -6291 | 202.5 |
| 904 | S225 | -2447 | 202.5 | 964 | S165 | -3407 | 202.5 | 1024 | S105 | -4367 | 202.5 | 1084 | S45 | -5327 | 202.5 | 1144 | G27 | -6307 | 319.5 |
| 905 | S224 | -2463 | 319.5 | 965 | S164 | -3423 | 319.5 | 1025 | S104 | -4383 | 319.5 | 1085 | S44 | -5343 | 319.5 | 1145 | G29 | -6323 | 202.5 |
| 906 | S223 | -2479 | 202.5 | 966 | S163 | -3439 | 202.5 | 1026 | S103 | -4399 | 202.5 | 1086 | S43 | -5359 | 202.5 | 1146 | G31 | -6339 | 319.5 |
| 907 | S222 | -2495 | 319.5 | 967 | S162 | -3455 | 319.5 | 1027 | S102 | -4415 | 319.5 | 1087 | S42 | -5375 | 319.5 | 1147 | G33 | -6355 | 202.5 |
| 908 | S221 | -2511 | 202.5 | 968 | S161 | -3471 | 202.5 | 1028 | S101 | -4431 | 202.5 | 1088 | S41 | -5391 | 202.5 | 1148 | G35 | -6371 | 319.5 |
| 909 | S220 | -2527 | 319.5 | 969 | S160 | -3487 | 319.5 | 1029 | S100 | -4447 | 319.5 | 1089 | S40 | -5407 | 319.5 | 1149 | G37 | -6387 | 202.5 |
| 910 | S219 | -2543 | 202.5 | 970 | S159 | -3503 | 202.5 | 1030 | S99 | -4463 | 202.5 | 1090 | S39 | -5423 | 202.5 | 1150 | G39 | -6403 | 319.5 |
| 911 | S218 | -2559 | 319.5 | 971 | S158 | -3519 | 319.5 | 1031 | S98 | -4479 | 319.5 | 1091 | S38 | -5439 | 319.5 | 1151 | G41 | -6419 | 202.5 |
| 912 | S217 | -2575 | 202.5 | 972 | S157 | -3535 | 202.5 | 1032 | S97 | -4495 | 202.5 | 1092 | S37 | -5455 | 202.5 | 1152 | G43 | -6435 | 319.5 |
| 913 | S216 | -2591 | 319.5 | 973 | S156 | -3551 | 319.5 | 1033 | S96 | -4511 | 319.5 | 1093 | S36 | -5471 | 319.5 | 1153 | G45 | -6451 | 202.5 |
| 914 | S215 | -2607 | 202.5 | 974 | S155 | -3567 | 202.5 | 1034 | S95 | -4527 | 202.5 | 1094 | S35 | -5487 | 202.5 | 1154 | G47 | -6467 | 319.5 |
| 915 | S214 | -2623 | 319.5 | 975 | S154 | -3583 | 319.5 | 1035 | S94 | -4543 | 319.5 | 1095 | S34 | -5503 | 319.5 | 1155 | G49 | -6483 | 202.5 |
| 916 | S213 | -2639 | 202.5 | 976 | S153 | -3599 | 202.5 | 1036 | S93 | -4559 | 202.5 | 1096 | S33 | -5519 | 202.5 | 1156 | G51 | -6499 | 319.5 |
| 917 | S212 | -2655 | 319.5 | 977 | S152 | -3615 | 319.5 | 1037 | S92 | -4575 | 319.5 | 1097 | S32 | -5535 | 319.5 | 1157 | G53 | -6515 | 202.5 |
| 918 | S211 | -2671 | 202.5 | 978 | S151 | -3631 | 202.5 | 1038 | S91 | -4591 | 202.5 | 1098 | S31 | -5551 | 202.5 | 1158 | G55 | -6531 | 319.5 |
| 919 | S210 | -2687 | 319.5 | 979 | S150 | -3647 | 319.5 | 1039 | S90 | -4607 | 319.5 | 1099 | S30 | -5567 | 319.5 | 1159 | G57 | -6547 | 202.5 |
| 920 | S209 | -2703 | 202.5 | 980 | S149 | -3663 | 202.5 | 1040 | S89 | -4623 | 202.5 | 1100 | S29 | -5583 | 202.5 | 1160 | G59 | -6563 | 319.5 |
| 921 | S208 | -2719 | 319.5 | 981 | S148 | -3679 | 319.5 | 1041 | S88 | -4639 | 319.5 | 1101 | S28 | -5599 | 319.5 | 1161 | G61 | -6579 | 202.5 |
| 922 | S207 | -2735 | 202.5 | 982 | S147 | -3695 | 202.5 | 1042 | S87 | -4655 | 202.5 | 1102 | S27 | -5615 | 202.5 | 1162 | G63 | -6595 | 319.5 |
| 923 | S206 | -2751 | 319.5 | 983 | S146 | -3711 | 319.5 | 1043 | S86 | -4671 | 319.5 | 1103 | S26 | -5631 | 319.5 | 1163 | G65 | -6611 | 202.5 |
| 924 | S205 | -2767 | 202.5 | 984 | S145 | -3727 | 202.5 | 1044 | S85 | -4687 | 202.5 | 1104 | S25 | -5647 | 202.5 | 1164 | G67 | -6627 | 319.5 |
| 925 | S204 | -2783 | 319.5 | 985 | S144 | -3743 | 319.5 | 1045 | S84 | -4703 | 319.5 | 1105 | S24 | -5663 | 319.5 | 1165 | G69 | -6643 | 202.5 |
| 926 | S203 | -2799 | 202.5 | 986 | S143 | -3759 | 202.5 | 1046 | S83 | -4719 | 202.5 | 1106 | S23 | -5679 | 202.5 | 1166 | G71 | -6659 | 319.5 |
| 927 | S202 | -2815 | 319.5 | 987 | S142 | -3775 | 319.5 | 1047 | S82 | -4735 | 319.5 | 1107 | S22 | -5695 | 319.5 | 1167 | G73 | -6675 | 202.5 |
| 928 | S201 | -2831 | 202.5 | 988 | S141 | -3791 | 202.5 | 1048 | S81 | -4751 | 202.5 | 1108 | S21 | -5711 | 202.5 | 1168 | G75 | -6691 | 319.5 |
| 929 | S200 | -2847 | 319.5 | 989 | S140 | -3807 | 319.5 | 1049 | S80 | -4767 | 319.5 | 1109 | S20 | -5727 | 319.5 | 1169 | G77 | -6707 | 202.5 |
| 930 | S199 | -2863 | 202.5 | 990 | S139 | -3823 | 202.5 | 1050 | S79 | -4783 | 202.5 | 1110 | S19 | -5743 | 202.5 | 1170 | G79 | -6723 | 319.5 |
| 931 | S198 | -2879 | 319.5 | 991 | S138 | -3839 | 319.5 | 1051 | S78 | -4799 | 319.5 | 1111 | S18 | -5759 | 319.5 | 1171 | G81 | -6739 | 202.5 |
| 932 | S197 | -2895 | 202.5 | 992 | S137 | -3855 | 202.5 | 1052 | S77 | -4815 | 202.5 | 1112 | S17 | -5775 | 202.5 | 1172 | G83 | -6755 | 319.5 |
| 933 | S196 | -2911 | 319.5 | 993 | S136 | -3871 | 319.5 | 1053 | S76 | -4831 | 319.5 | 1113 | S16 | -5791 | 319.5 | 1173 | G85 | -6771 | 202.5 |
| 934 | S195 | -2927 | 202.5 | 994 | S135 | -3887 | 202.5 | 1054 | S75 | -4847 | 202.5 | 1114 | S15 | -5807 | 202.5 | 1174 | G87 | -6787 | 319.5 |
| 935 | S194 | -2943 | 319.5 | 995 | S134 | -3903 | 319.5 | 1055 | S74 | -4863 | 319.5 | 1115 | S14 | -5823 | 319.5 | 1175 | G89 | -6803 | 202.5 |
| 936 | S193 | -2959 | 202.5 | 996 | S133 | -3919 | 202.5 | 1056 | S73 | -4879 | 202.5 | 1116 | S13 | -5839 | 202.5 | 1176 | G91 | -6819 | 319.5 |
| 937 | S192 | -2975 | 319.5 | 997 | S132 | -3935 | 319.5 | 1057 | S72 | -4895 | 319.5 | 1117 | S12 | -5855 | 319.5 | 1177 | G93 | -6835 | 202.5 |
| 938 | S191 | -2991 | 202.5 | 998 | S131 | -3951 | 202.5 | 1058 | S71 | -4911 | 202.5 | 1118 | S11 | -5871 | 202.5 | 1178 | G95 | -6851 | 319.5 |
| 939 | S190 | -3007 | 319.5 | 999 | S130 | -3967 | 319.5 | 1059 | S70 | -4927 | 319.5 | 1119 | S10 | -5887 | 319.5 | 1179 | G97 | -6867 | 202.5 |
| 940 | S189 | -3023 | 202.5 | 1000 | S129 | -3983 | 202.5 | 1060 | S69 | -4943 | 202.5 | 1120 | S9 | -5903 | 202.5 | 1180 | G99 | -6883 | 319.5 |
| 941 | S188 | -3039 | 319.5 | 1001 | S128 | -3999 | 319.5 | 1061 | S68 | -4959 | 319.5 | 1121 | S8 | -5919 | 319.5 | 1181 | G101 | -6899 | 202.5 |
| 942 | S187 | -3055 | 202.5 | 1002 | S127 | -4015 | 202.5 | 1062 | S67 | -4975 | 202.5 | 1122 | S7 | -5935 | 202.5 | 1182 | G103 | -6915 | 319.5 |
| 943 | S186 | -3071 | 319.5 | 1003 | S126 | -4031 | 319.5 | 1063 | S66 | -4991 | 319.5 | 1123 | S6 | -5951 | 319.5 | 1183 | G105 | -6931 | 202.5 |
| 944 | S185 | -3087 | 202.5 | 1004 | S125 | -4047 | 202.5 | 1064 | S65 | -5007 | 202.5 | 1124 | S5 | -5967 | 202.5 | 1184 | G107 | -6947 | 319.5 |
| 945 | S184 | -3103 | 319.5 | 1005 | S124 | -4063 | 319.5 | 1065 | S64 | -5023 | 319.5 | 1125 | S4 | -5983 | 319.5 | 1185 | G109 | -6963 | 202.5 |
| 946 | S183 | -3119 | 202.5 | 1006 | S123 | -4079 | 202.5 | 1066 | S63 | -5039 | 202.5 | 1126 | S3 | -5999 | 202.5 | 1186 | G111 | -6979 | 319.5 |
| 947 | S182 | -3135 | 319.5 | 1007 | S122 | -4095 | 319.5 | 1067 | S62 | -5055 | 319.5 | 1127 | S2 | -6015 | 319.5 | 1187 | G113 | -6995 | 202.5 |
| 948 | S181 | -3151 | 202.5 | 1008 | S121 | -4111 | 202.5 | 1068 | S61 | -5071 | 202.5 | 1128 | S1 | -6031 | 202.5 | 1188 | G115 | -7011 | 319.5 |
| 949 | S180 | -3167 | 319.5 | 1009 | S120 | -4127 | 319.5 | 1069 | S60 | -5087 | 319.5 | 1129 | DUMMY25 | -6047 | 319.5 | 1189 | G117 | -7027 | 202.5 |
| 950 | S179 | -3183 | 202.5 | 1010 | S119 | -4143 | 202.5 | 1070 | S59 | -5103 | 202.5 | 1130 | DUMMY26 | -6063 | 319.5 | 1190 | G119 | -7043 | 319.5 |
| 951 | S178 | -3199 | 319.5 | 1011 | S118 | -4159 | 319.5 | 1071 | S58 | -5119 | 319.5 | 1131 | G1 | -6099 | 202.5 | 1191 | G121 | -7059 | 202.5 |
| 952 | S177 | -3215 | 202.5 | 1012 | S117 | -4175 | 202.5 | 1072 | S57 | -5135 | 202.5 | 1132 | G3 | -6115 | 319.5 | 1192 | G123 | -7075 | 319.5 |
| 953 | S176 | -3231 | 319.5 | 1013 | S116 | -4191 | 319.5 | 1073 | S56 | -5151 | 319.5 | 1133 | G5 | -6131 | 202.5 | 1193 | G125 | -7091 | 202.5 |
| 954 | S175 | -3247 | 202.5 | 1014 | S115 | -4207 | 202.5 | 1074 | S55 | -5167 | 202.5 | 1134 | G7 | -6147 | 319.5 | 1194 | G127 | -7107 | 319.5 |
| 955 | S174 | -3263 | 319.5 | 1015 | S114 | -4223 | 319.5 | 1075 | S54 | -5183 | 319.5 | 1135 | G9 | -6163 | 202.5 | 1195 | G129 | -7123 | 202.5 |
| 956 | S173 | -3279 | 202.5 | 1016 | S113 | -4239 | 202.5 | 1076 | S53 | -5199 | 202.5 | 1136 | G11 | -6179 | 319.5 | 1196 | G131 | -7139 | 319.5 |
| 957 | S172 | -3295 | 319.5 | 1017 | S112 | -4255 | 319.5 | 1077 | S52 | -5215 | 319.5 | 1137 | G13 | -6195 | 202.5 | 1197 | G133 | -7155 | 202.5 |
| 958 | S171 | -3311 | 202.5 | 1018 | S111 | -4271 | 202.5 | 1078 | S51 | -5231 | 202.5 | 1138 | G15 | -6211 | 319.5 | 1198 | G135 | -7171 | 319.5 |
| 959 | S170 | -3327 | 319.5 | 1019 | S110 | -4287 | 319.5 | 1079 | S50 | -5247 | 319.5 | 1139 | G17 | -6227 | 202.5 | 1199 | G137 | -7187 | 202.5 |
| 960 | S169 | -3343 | 202.5 | 1020 | S109 | -4303 | 202.5 | 1080 | S49 | -5263 | 202.5 | 1140 | G19 | -6243 | 319.5 | 1200 | G139 | -7203 | 319.5 |

| No. | Name | X | Y | No. | Name | X | Y |
|------|------|-------|-------|----------------|---------|-------|-------|
| 1201 | G141 | -7219 | 202.5 | 1261 | G261 | -8179 | 202.5 |
| 1202 | G143 | -7235 | 319.5 | 1262 | G263 | -8195 | 319.5 |
| 1203 | G145 | -7251 | 202.5 | 1263 | G265 | -8211 | 202.5 |
| 1204 | G147 | -7267 | 319.5 | 1264 | G267 | -8227 | 319.5 |
| 1205 | G149 | -7283 | 202.5 | 1265 | G269 | -8243 | 202.5 |
| 1206 | G151 | -7299 | 319.5 | 1266 | G271 | -8259 | 319.5 |
| 1207 | G153 | -7315 | 202.5 | 1267 | G273 | -8275 | 202.5 |
| 1208 | G155 | -7331 | 319.5 | 1268 | G275 | -8291 | 319.5 |
| 1209 | G157 | -7347 | 202.5 | 1269 | G277 | -8307 | 202.5 |
| 1210 | G159 | -7363 | 319.5 | 1270 | G279 | -8323 | 319.5 |
| 1211 | G161 | -7379 | 202.5 | 1271 | G281 | -8339 | 202.5 |
| 1212 | G163 | -7395 | 319.5 | 1272 | G283 | -8355 | 319.5 |
| 1213 | G165 | -7411 | 202.5 | 1273 | G285 | -8371 | 202.5 |
| 1214 | G167 | -7427 | 319.5 | 1274 | G287 | -8387 | 319.5 |
| 1215 | G169 | -7443 | 202.5 | 1275 | G289 | -8403 | 202.5 |
| 1216 | G171 | -7459 | 319.5 | 1276 | G291 | -8419 | 319.5 |
| 1217 | G173 | -7475 | 202.5 | 1277 | G293 | -8435 | 202.5 |
| 1218 | G175 | -7491 | 319.5 | 1278 | G295 | -8451 | 319.5 |
| 1219 | G177 | -7507 | 202.5 | 1279 | G297 | -8467 | 202.5 |
| 1220 | G179 | -7523 | 319.5 | 1280 | G299 | -8483 | 319.5 |
| 1221 | G181 | -7539 | 202.5 | 1281 | G301 | -8499 | 202.5 |
| 1222 | G183 | -7555 | 319.5 | 1282 | G303 | -8515 | 319.5 |
| 1223 | G185 | -7571 | 202.5 | 1283 | G305 | -8531 | 202.5 |
| 1224 | G187 | -7587 | 319.5 | 1284 | G307 | -8547 | 319.5 |
| 1225 | G189 | -7603 | 202.5 | 1285 | G309 | -8563 | 202.5 |
| 1226 | G191 | -7619 | 319.5 | 1286 | G311 | -8579 | 319.5 |
| 1227 | G193 | -7635 | 202.5 | 1287 | G313 | -8595 | 202.5 |
| 1228 | G195 | -7651 | 319.5 | 1288 | G315 | -8611 | 319.5 |
| 1229 | G197 | -7667 | 202.5 | 1289 | G317 | -8627 | 202.5 |
| 1230 | G199 | -7683 | 319.5 | 1290 | G319 | -8643 | 319.5 |
| 1231 | G201 | -7699 | 202.5 | 1291 | DUMMY27 | -8659 | 202.5 |
| 1232 | G203 | -7715 | 319.5 | Alignment mark | | X | Y |
| 1233 | G205 | -7731 | 202.5 | | 1-a | -8751 | 269 |
| 1234 | G207 | -7747 | 319.5 | | 1-b | 8751 | 269 |
| 1235 | G209 | -7763 | 202.5 | | | | |
| 1236 | G211 | -7779 | 319.5 | | | | |
| 1237 | G213 | -7795 | 202.5 | | | | |
| 1238 | G215 | -7811 | 319.5 | | | | |
| 1239 | G217 | -7827 | 202.5 | | | | |
| 1240 | G219 | -7843 | 319.5 | | | | |
| 1241 | G221 | -7859 | 202.5 | | | | |
| 1242 | G223 | -7875 | 319.5 | | | | |
| 1243 | G225 | -7891 | 202.5 | | | | |
| 1244 | G227 | -7907 | 319.5 | | | | |
| 1245 | G229 | -7923 | 202.5 | | | | |
| 1246 | G231 | -7939 | 319.5 | | | | |
| 1247 | G233 | -7955 | 202.5 | | | | |
| 1248 | G235 | -7971 | 319.5 | | | | |
| 1249 | G237 | -7987 | 202.5 | | | | |
| 1250 | G239 | -8003 | 319.5 | | | | |
| 1251 | G241 | -8019 | 202.5 | | | | |
| 1252 | G243 | -8035 | 319.5 | | | | |
| 1253 | G245 | -8051 | 202.5 | | | | |
| 1254 | G247 | -8067 | 319.5 | | | | |
| 1255 | G249 | -8083 | 202.5 | | | | |
| 1256 | G251 | -8099 | 319.5 | | | | |
| 1257 | G253 | -8115 | 202.5 | | | | |
| 1258 | G255 | -8131 | 319.5 | | | | |
| 1259 | G257 | -8147 | 202.5 | | | | |
| 1260 | G259 | -8163 | 319.5 | | | | |

| | |
|--|--|
| <p>S1 ~ S720 G1 ~ G320 DUMMY20~27 (No. 244 ~ 1291)</p> |  <p>Unit: um</p> |
| <p>I/O Pads (No. 1 ~ 243)</p> |  <p>Unit: um</p> <p>X=20, 30, 35 Y=70, 80, 85</p> |

5. Block Description

MPU System Interface

ILI9328 supports three system high-speed interfaces: i80-system high-speed interfaces to 8-, 9-, 16-, 18-bit parallel ports and serial peripheral interface (SPI). The interface mode is selected by setting the IM[3:0] pins.

ILI9328 has a 16-bit index register (IR), an 18-bit write-data register (WDR), and an 18-bit read-data register (RDR). The IR is the register to store index information from control registers and the internal GRAM. The WDR is the register to temporarily store data to be written to control registers and the internal GRAM. The RDR is the register to temporarily store data read from the GRAM. Data from the MPU to be written to the internal GRAM are first written to the WDR and then automatically written to the internal GRAM in internal operation. Data are read via the RDR from the internal GRAM. Therefore, invalid data are read out to the data bus when the ILI9328 read the first data from the internal GRAM. Valid data are read out after the ILI9328 performs the second read operation.

Registers are written consecutively as the register execution time.

| Registers selection by system interface (8-/9-/16-/18-bit bus width) | | | I80 |
|--|----|-----|-----|
| Function | RS | nWR | nRD |
| Write an index to IR register | 0 | 0 | 1 |
| Read an internal status | 0 | 1 | 0 |
| Write to control registers or the internal GRAM by WDR register. | 1 | 0 | 1 |
| Read from the internal GRAM by RDR register. | 1 | 1 | 0 |

| Registers selection by the SPI system interface | | |
|--|-----|----|
| Function | R/W | RS |
| Write an index to IR register | 0 | 0 |
| Read an internal status | 1 | 0 |
| Write to control registers or the internal GRAM by WDR register. | 0 | 1 |
| Read from the internal GRAM by RDR register. | 1 | 1 |

Parallel RGB Interface

ILI9328 supports the RGB interface and the VSYNC interface as the external interface for displaying a moving picture. When the RGB interface is selected, display operations are synchronized with externally supplied signals, VSYNC, HSYNC, and DOTCLK. In RGB interface mode, data (DB17-0) are written in synchronization with these signals according to the polarity of enable signal (ENABLE) to prevent flicker on display while updating display data.

In VSYNC interface mode, the display operation is synchronized with the internal clock except frame synchronization, where the operation is synchronized with the VSYNC signal. Display data are written to the internal GRAM via the system interface. In this case, there are constraints in speed and method in writing data to the internal RAM. For details, see the "External Display Interface" section. The ILI9328 allows for switching between the external display interface and the system interface by instruction so that the optimum interface is selected for the kind of picture to be displayed on the screen (still and/or moving picture(s)). The RGB

interface, by writing all display data to the internal RAM, allows for transferring data only when updating the frames of a moving picture, contributing to low power requirement for moving picture display.

Address Counter (AC)

The address counter (AC) gives an address to the internal GRAM. When the index of the register for setting a RAM address in the AC is written to the IR, the address information is sent from the IR to the AC. As writing data to the internal GRAM, the address in the AC is automatically updated plus or minus 1. The window address function enables writing data only in the rectangular area arbitrarily set by users on the GRAM.

Graphics RAM (GRAM)

GRAM is graphics RAM storing bit-pattern data of 172,820 (240 x 320x 18/8) bytes with 18 bits per pixel.

Grayscale Voltage Generating Circuit

The grayscale voltage generating circuit generates a liquid crystal drive voltage according to grayscale data set in the γ -correction register to display in 262,144 colors. For details, see the “ γ -Correction Register” section.

Timing Controller

The timing generator generates a timing signal for operation of internal circuits such as the internal GRAM. The timing for the display operation such as RAM read operation and the timing for the internal operation such as access from the MPU are generated in the way not to interfere each other.

Oscillator (OSC)

ILI9328 generates RC oscillation with an internal oscillation resistor. The frame rate is adjusted by the register setting.

LCD Driver Circuit

The LCD driver circuit of ILI9328 consists of a 720-output source driver (S1 ~ S720) and a 320-output gate driver (G1~G320). Display pattern data are latched when the 720th bit data are input. The latched data control the source driver and generate a drive waveform. The gate driver for scanning gate lines outputs either VGH or VGL level. The shift direction of 720 source outputs from the source driver is set with the SS bit and the shift direction of gate outputs from the gate driver is set with the GS bit. The scan mode by the gate driver is set with the SM bit. These bits allow setting an appropriate scan method for an LCD module.

LCD Driver Power Supply Circuit

The LCD drive power supply circuit generates the voltage levels VREG1OUT, VGH, VGL and Vcom for driving an LCD.

6. System Interface

6.1. Interface Specifications

ILI9328 has the system interface to read/write the control registers and display graphics memory (GRAM), and the RGB Input Interface for displaying a moving picture. User can select an optimum interface to display the moving or still picture with efficient data transfer. All display data are stored in the GRAM to reduce the data transfer efforts and only the updating data is necessary to be transferred. User can only update a sub-range of GRAM by using the window address function.

ILI9328 also has the RGB interface and VSYNC interface to transfer the display data without flicker the moving picture on the screen. In RGB interface mode, the display data is written into the GRAM through the control signals of ENABLE, VSYNC, HSYNC, DOTCLK and data bus DB[17:0].

In VSYNC interface mode, the internal display timing is synchronized with the frame synchronization signal (VSYNC). The VSYNC interface mode enables to display the moving picture display through the system interface. In this case, there are some constraints of speed and method to write data to the internal RAM.

ILI9328 operates in one of the following 4 modes. The display mode can be switched by the control register. When switching from one mode to another, refer to the sequences mentioned in the sections of RGB and VSYNC interfaces.

| Operation Mode | RAM Access Setting (RM) | Display Operation Mode (DM[1:0]) |
|---|------------------------------|--|
| Internal operating clock only (Displaying still pictures) | System interface (RM = 0) | Internal operating clock (DM[1:0] = 00) |
| RGB interface (1) (Displaying moving pictures) | RGB interface (RM = 1) | RGB interface (DM[1:0] = 01) |
| RGB interface (2) (Rewriting still pictures while displaying moving pictures) | System interface (RM = 0) | RGB interface (DM[1:0] = 01) |
| VSYNC interface (Displaying moving pictures) | System interface (RM = 0) | VSYNC interface (DM[1:0] = 01) |

Note 1) Registers are set only via the system interface.

Note 2) The RGB-I/F and the VSYNC-I/F are not available simultaneously.

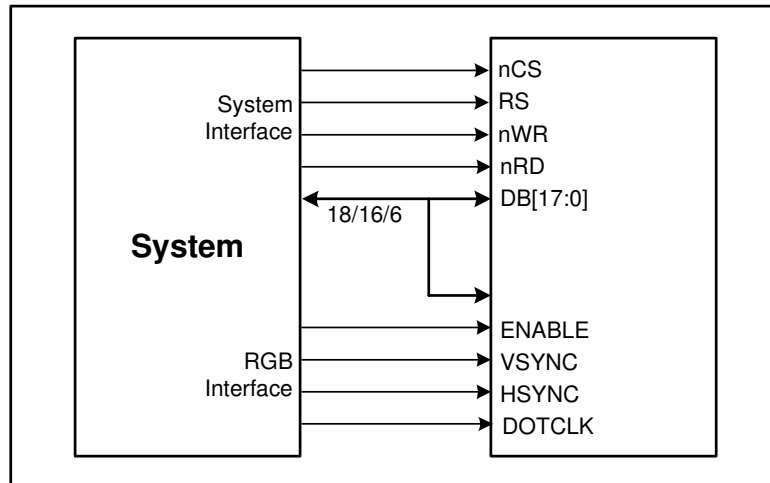


Figure1 System Interface and RGB Interface connection

6.2. Input Interfaces

The following are the system interfaces available with the ILI9328. The interface is selected by setting the IM[3:0] pins. The system interface is used for setting registers and GRAM access.

| IM3 | IM2 | IM1 | IM0/ID | Interface Mode | DB Pin |
|-----|-----|-----|--------|-----------------------------------|--------------------|
| 0 | 0 | 0 | 0 | Setting invalid | |
| 0 | 0 | 0 | 1 | Setting invalid | |
| 0 | 0 | 1 | 0 | i80-system 16-bit interface | DB[17:10], DB[8:1] |
| 0 | 0 | 1 | 1 | i80-system 8-bit interface | DB[17:10] |
| 0 | 1 | 0 | ID | Serial Peripheral Interface (SPI) | SDI, SDO |
| 0 | 1 | 1 | * | Setting invalid | |
| 1 | 0 | 0 | 0 | Setting invalid | |
| 1 | 0 | 0 | 1 | Setting invalid | |
| 1 | 0 | 1 | 0 | i80-system 18-bit interface | DB[17:0] |
| 1 | 0 | 1 | 1 | i80-system 9-bit interface | DB[17:9] |
| 1 | 1 | * | * | Setting invalid | |

6.2.1. i80/18-bit System Interface

The i80/18-bit system interface is selected by setting the IM[3:0] as "1010" levels.

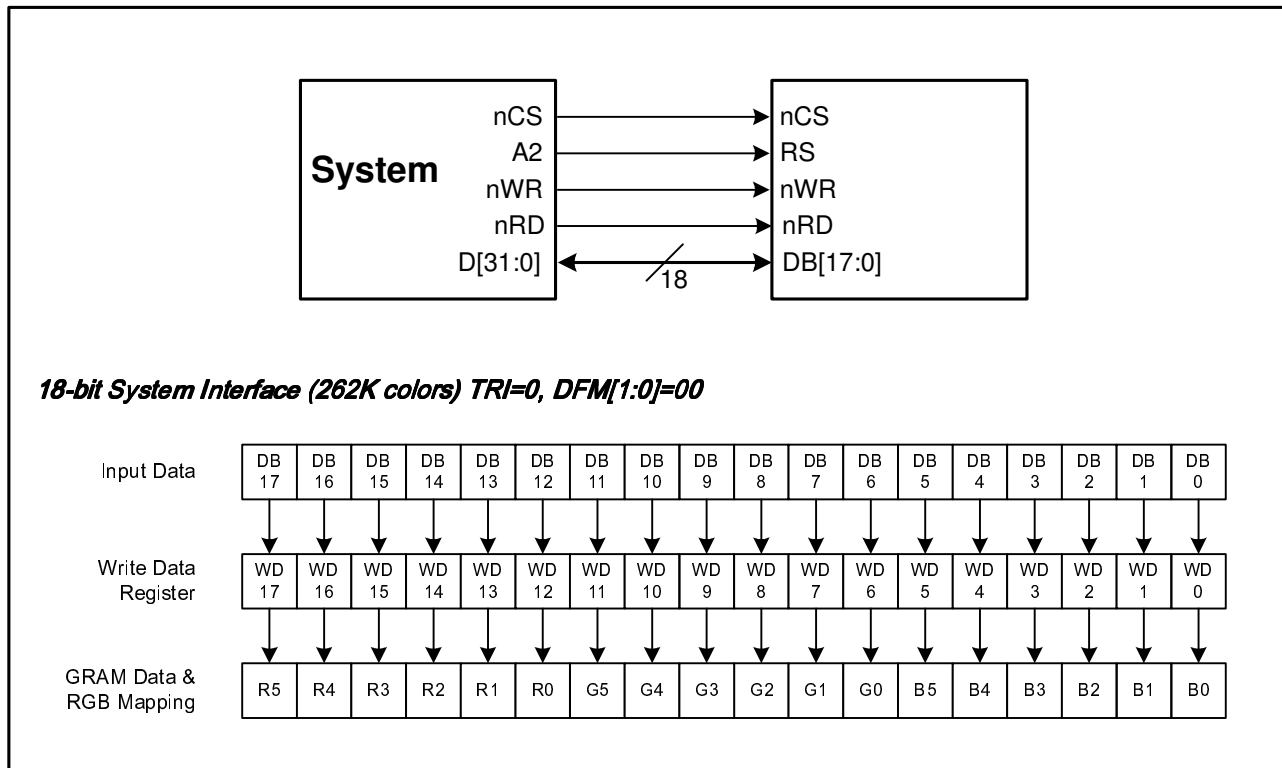


Figure2 18-bit System Interface Data Format

6.2.2. i80/16-bit System Interface

The i80/16-bit system interface is selected by setting the IM[3:0] as "0010" levels. The 262K or 65K color can be display through the 16-bit MPU interface. When the 262K color is displayed, two transfers (1st transfer: 2 bits, 2nd transfer: 16 bits or 1st transfer: 16 bits, 2nd transfer: 2 bits) are necessary for the 16-bit CPU interface.

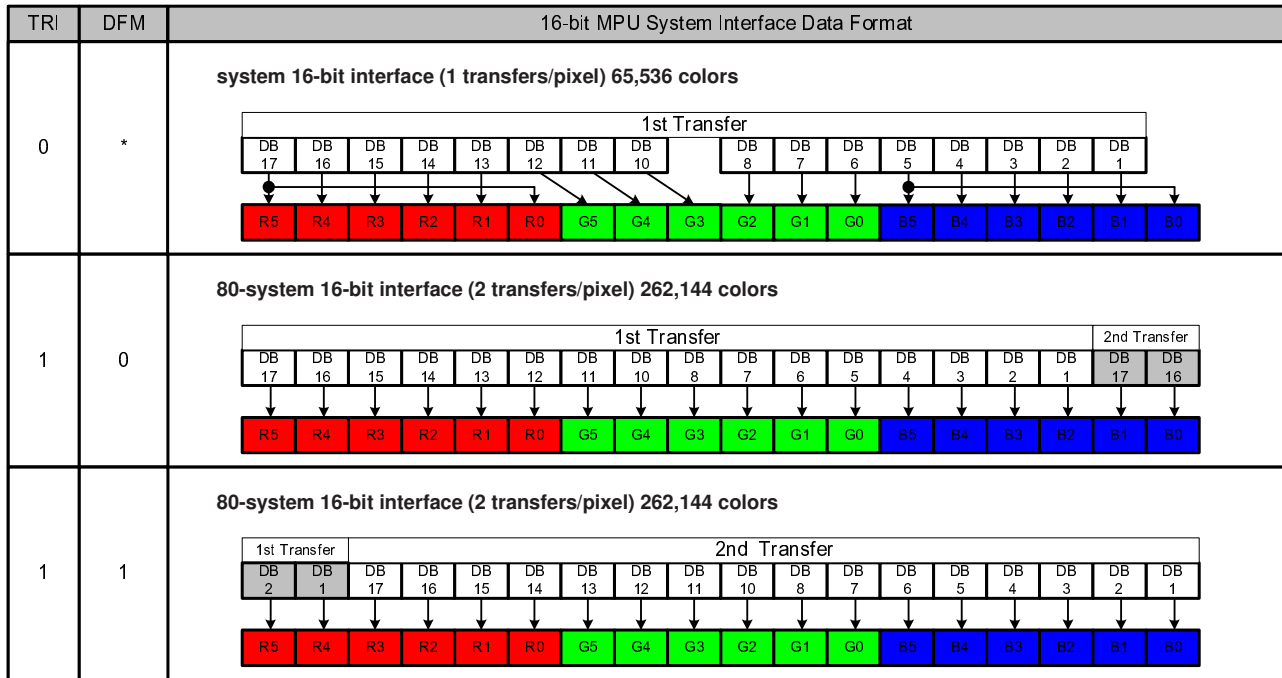


Figure3 16-bit System Interface Data Format

6.2.3. i80/9-bit System Interface

The i80/9-bit system interface is selected by setting the IM[3:0] as “1011” and the DB17~DB9 pins are used to transfer the data. When writing the 16-bit register, the data is divided into upper byte (8 bits and LSB is not used) lower byte and the upper byte is transferred first. The display data is also divided in upper byte (9 bits) and lower byte, and the upper byte is transferred first. The unused DB[8:0] pins must be tied to GND.

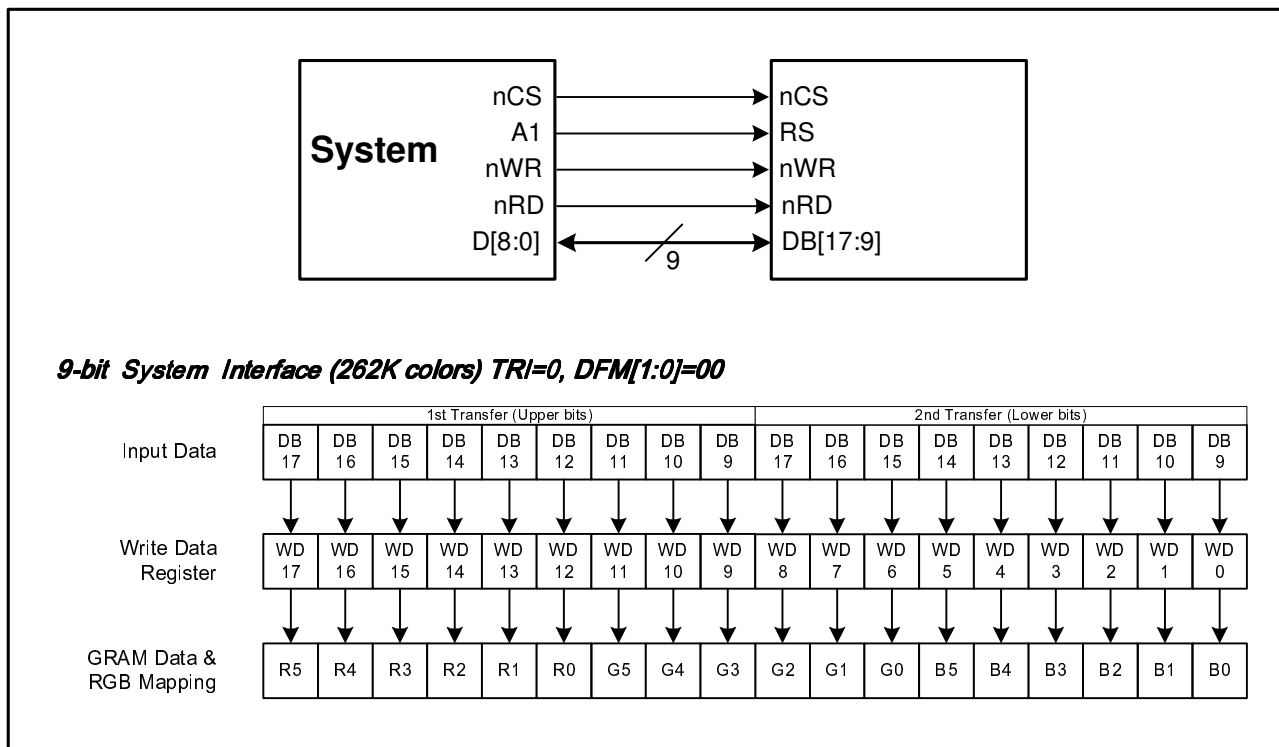


Figure4 9-bit System Interface Data Format

6.2.4. i80/8-bit System Interface

The i80/8-bit system interface is selected by setting the IM[3:0] as “0011” and the DB17~DB10 pins are used to transfer the data. When writing the 16-bit register, the data is divided into upper byte (8 bits and LSB is not used) lower byte and the upper byte is transferred first. The display data is also divided in upper byte (8 bits) and lower byte, and the upper byte is transferred first. The written data is expanded into 18 bits internally (see the figure below) and then written into GRAM. The unused DB[9:0] pins must be tied to GND.

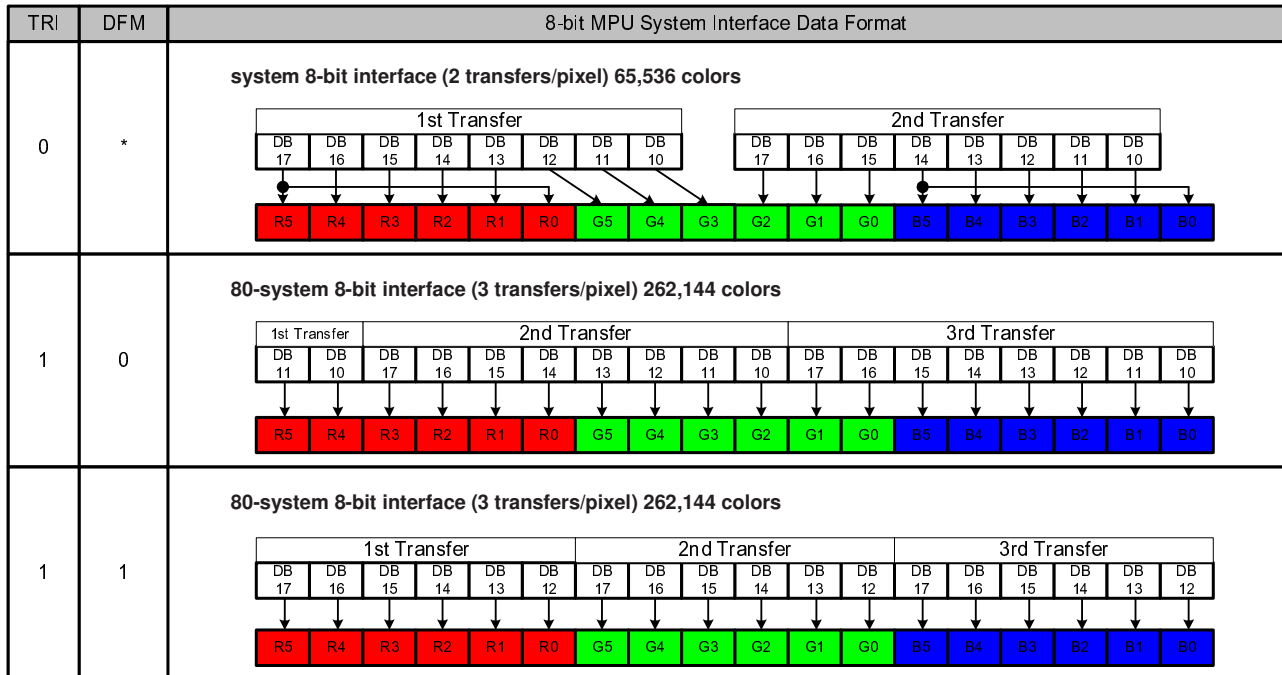


Figure5 8-bit System Interface Data Format

Data transfer synchronization in 8/9-bit bus interface mode

ILI9328 supports a data transfer synchronization function to reset upper and lower counters which count the transfers numbers of upper and lower byte in 8/9-bit interface mode. If a mismatch arises in the numbers of transfers between the upper and lower byte counters due to noise and so on, the "00"h register is written 4 times consecutively to reset the upper and lower counters so that data transfer will restart with a transfer of upper byte. This synchronization function can effectively prevent display error if the upper/lower counters are periodically reset.

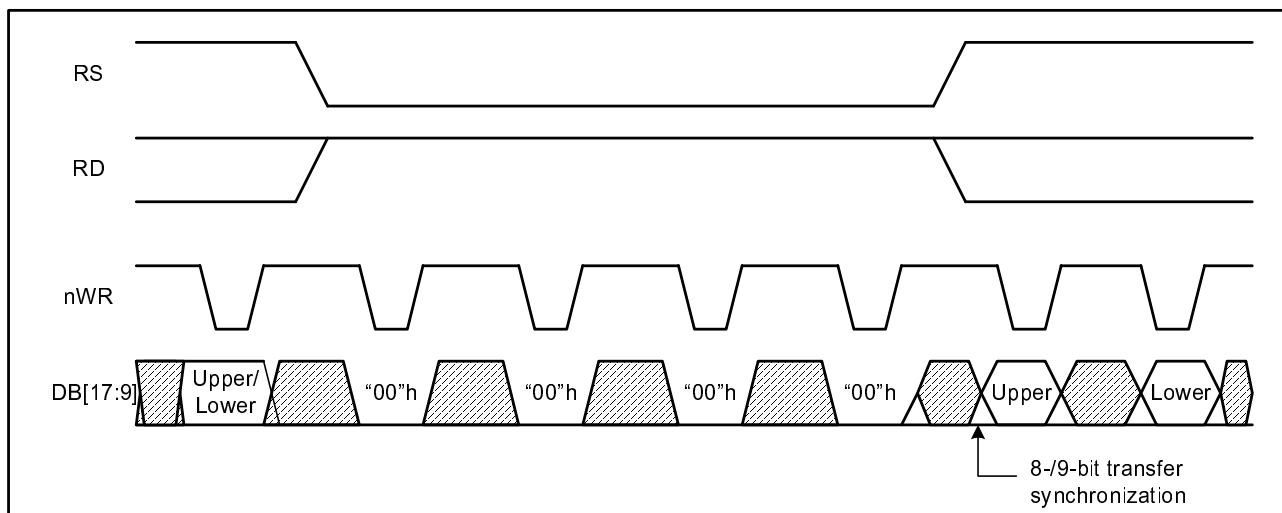


Figure6 Data Transfer Synchronization in 8/9-bit System Interface

6.3. Serial Peripheral Interface (SPI)

The Serial Peripheral Interface (SPI) is selected by setting the IM[3:0] pins as "010x" level. The chip select pin

(nCS), the serial transfer clock pin (SCL), the serial data input pin (SDI) and the serial data output pin (SDO) are used in SPI mode. The ID pin sets the least significant bit of the identification code. The DB[17:0] pins, which are not used, must be tied to GND.

The SPI interface operation enables from the falling edge of nCS and ends of data transfer on the rising edge of nCS. The start byte is transferred to start the SPI interface and the read/write operation and RS information are also included in the start byte. When the start byte is matched, the subsequent data is received by ILI9328.

The seventh bit of start byte is RS bit. When RS = "0", either index write operation or status read operation is executed. When RS = "1", either register write operation or RAM read/write operation is executed. The eighth bit of the start byte is used to select either read or write operation (R/W bit). Data is written when the R/W bit is "0" and read back when the R/W bit is "1".

After receiving the start byte, ILI9328 starts to transfer or receive the data in unit of byte and the data transfer starts from the MSB bit. All the registers of the ILI9328 are 16-bit format and receive the first and the second byte data as the upper and the lower eight bits of the 16-bit register respectively. In SPI mode, 5 bytes dummy read is necessary and the valid data starts from 6th byte of read back data.

Start Byte Format

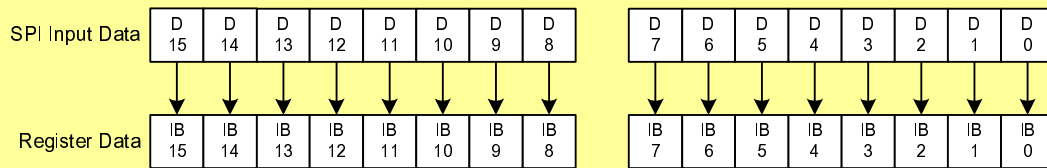
| Transferred bits | S | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|-------------------|----------------|----------------|---|---|---|---|----|-----|-----|
| Start byte format | Transfer start | Device ID code | | | | | ID | RS | R/W |
| | | 0 | 1 | 1 | 1 | 0 | | 1/0 | 1/0 |

Note: ID bit is selected by setting the IM0/ID pin.

RS and R/W Bit Function

| RS | R/W | Function |
|----|-----|-------------------------------|
| 0 | 0 | Set an index register |
| 0 | 1 | Read a status |
| 1 | 0 | Write a register or GRAM data |
| 1 | 1 | Read a register or GRAM data |

Serial Peripheral Interface for register access



Serial Peripheral Interface 65K colors

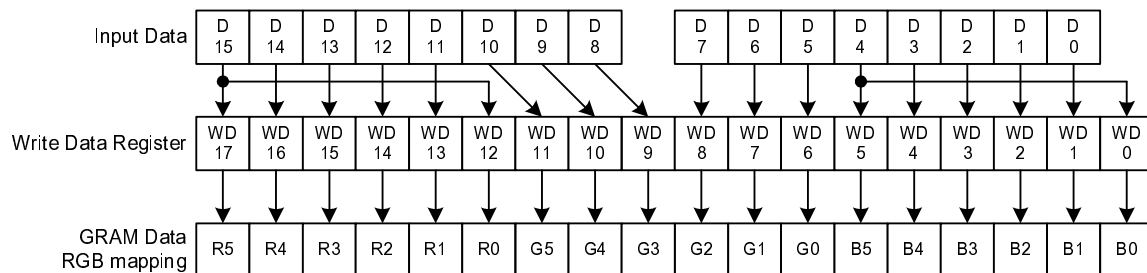
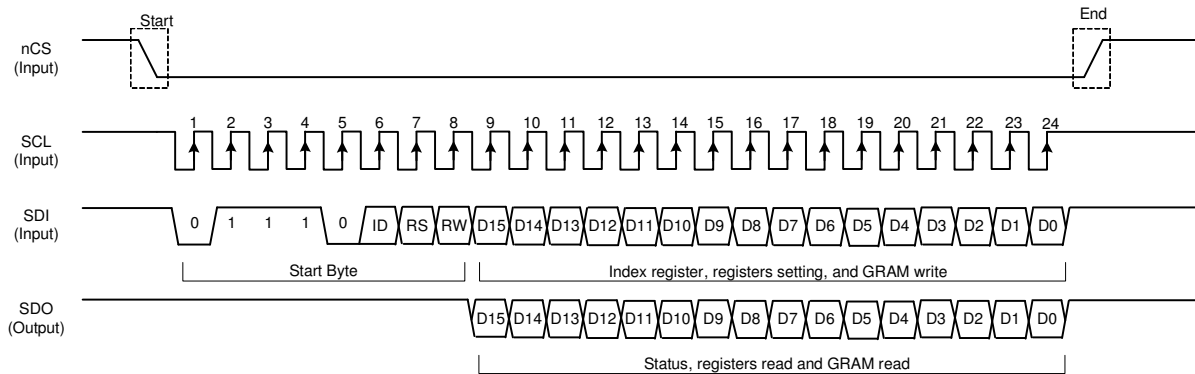
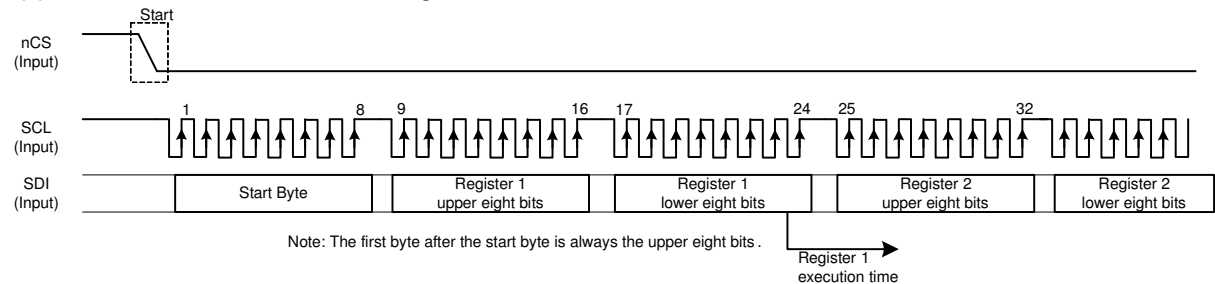


Figure 7 Data Format of SPI Interface

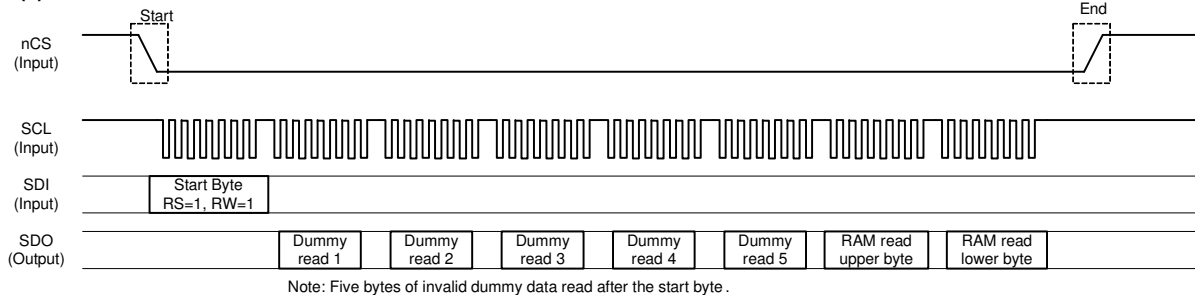
(a) Basic data transmission through SPI



(b) Consecutive data transmission through SPI



(c) GRAM data read transmission



(d) Status/registers read transmission

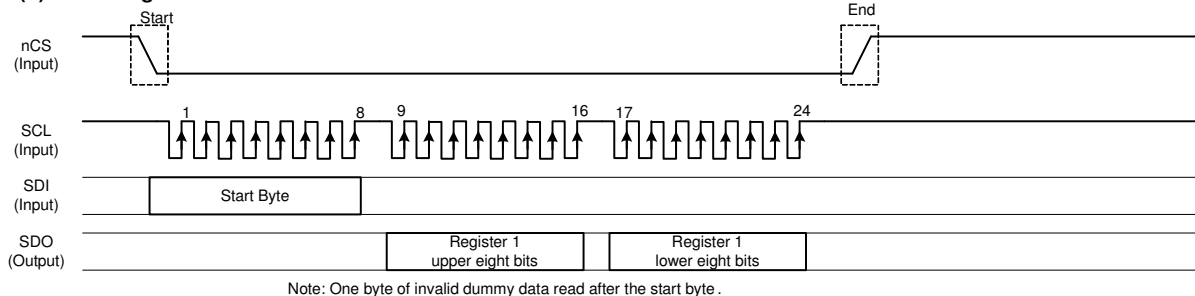
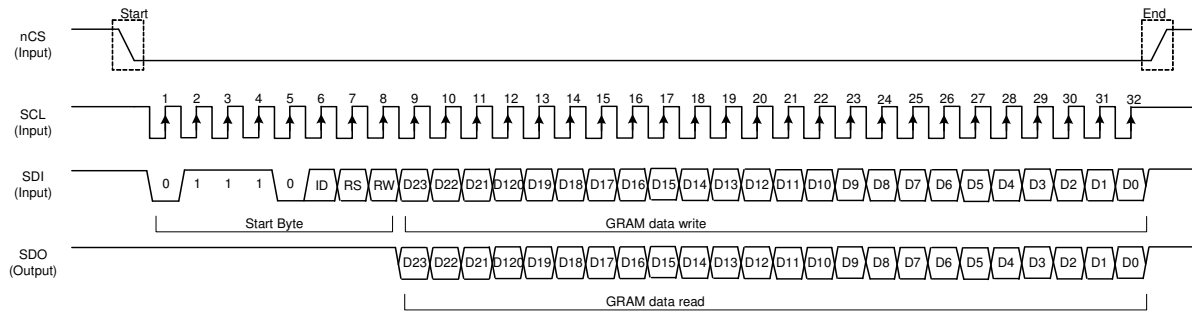
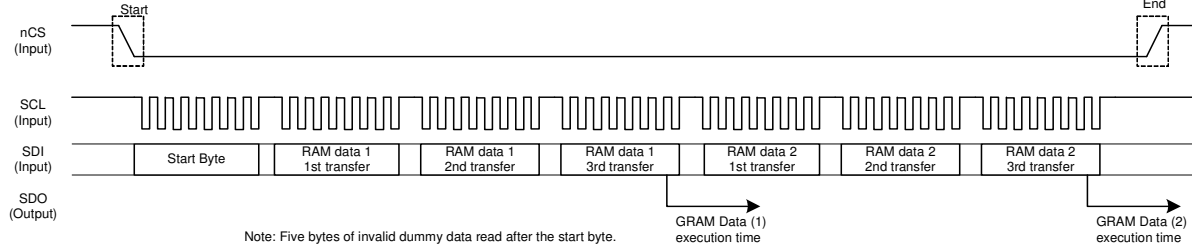


Figure8 Data transmission through serial peripheral interface (SPI)

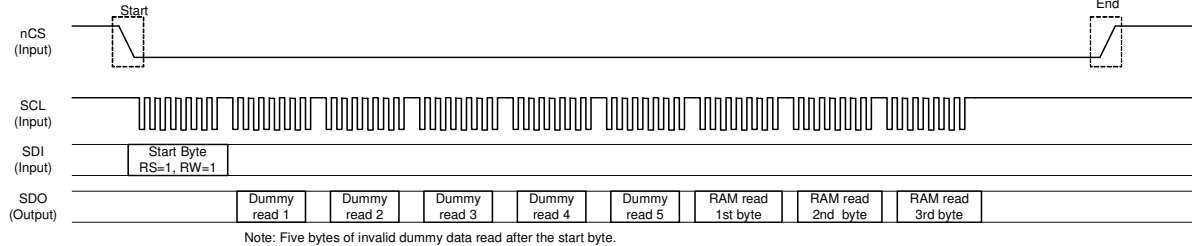
(e) Basic data transmission through SPI



(f) GRAM data write transmission



(g) GRAM data read transmission



RAM data transfer in SPI mode when TRI=1 and DFM[1:0]=10.

Figure9 Data transmission through serial peripheral interface (SPI), TRI="1" and DFM="10"

6.4. VSYNC Interface

ILI9328 supports the VSYNC interface in synchronization with the frame-synchronizing signal VSYNC to display the moving picture with the i80 system interface. When the VSYNC interface is selected to display a moving picture, the minimum GRAM update speed is limited and the VSYNC interface is enabled by setting DM[1:0] = "10" and RM = "0".

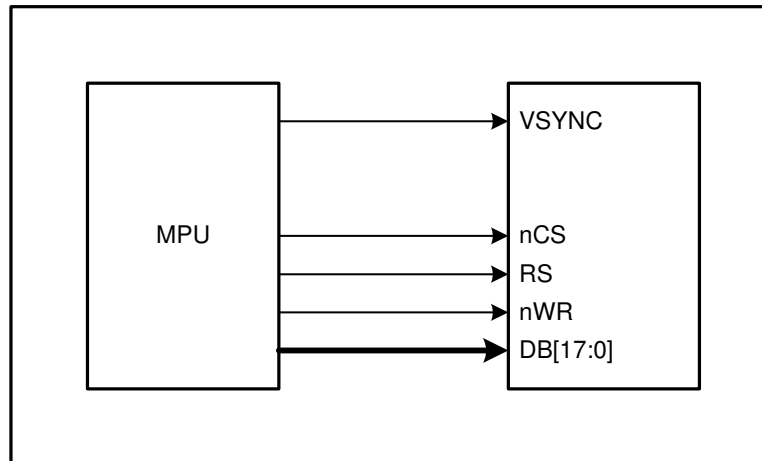


Figure10 Data transmission through VSYNC interface)

In the VSYNC mode, the display operation is synchronized with the internal clock and VSYNC input and the frame rate is determined by the pulse rate of VSYNC signal. All display data are stored in GRAM to minimize total data transfer required for moving picture display.

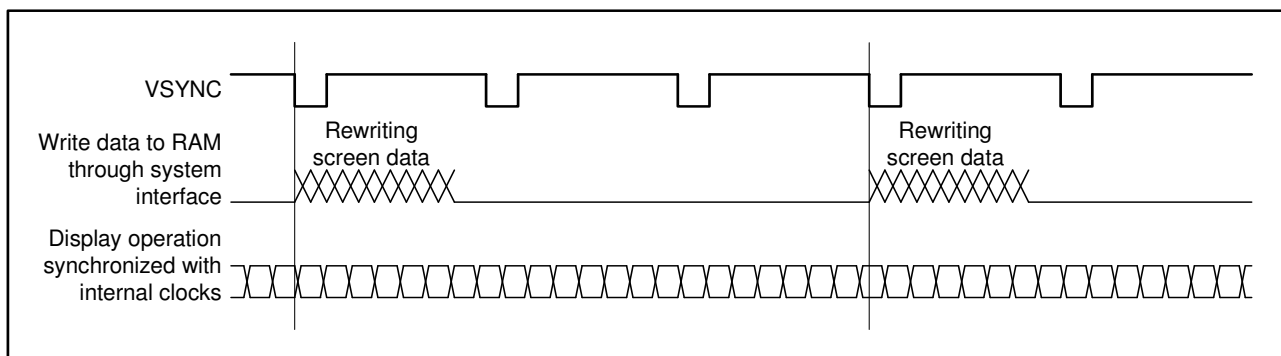


Figure11 Moving picture data transmission through VSYNC interface

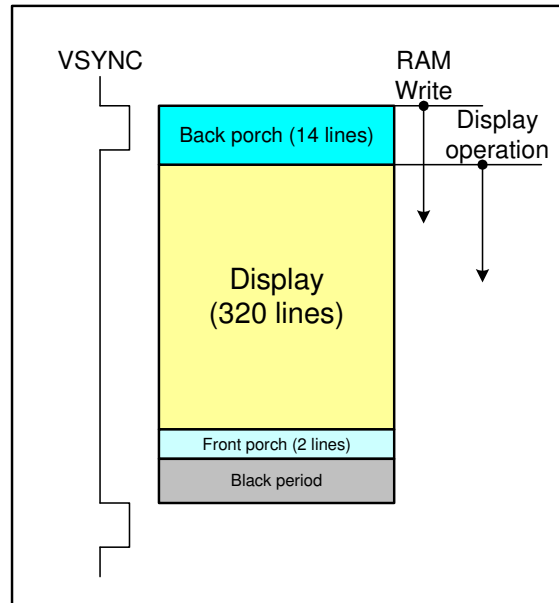


Figure12 Operation through VSYNC Interface

The VSYNC interface has the minimum speed limitation of writing data to the internal GRAM via the system interface, which are calculated from the following formula.

Internal clock frequency (fosc.) [Hz] = FrameFrequency x (DisplayLine (NL) + FrontPorch (FP) + BackPorch (BP)) x ClockCyclePerLines (RTN) x FrequencyFluctuation.

$$\text{Minimum RAM write speed(HZ)} > \frac{240 \times \text{DisplayLines (NL)}}{[(\text{BackPorch(BP)} + \text{DisplayLines(NL)} - \text{margins}) \times 16 (\text{clocks}) \times 1/\text{fosc}]}$$

Note: When the RAM write operation does not start from the falling edge of VSYNC, the time from the falling edge of VSYNC until the start of RAM write operation must also be taken into account.

An example of minimum GRAM writing speed and internal clock frequency in VSYNC interface mode is as below.

[Example]

Display size: 240 RGB x 320 lines

Lines: 320 lines (NL = 100111)

Back porch: 14 lines (BP = 1110)

Front porch: 2 lines (FP = 0010)

Frame frequency: 60 Hz

Frequency fluctuation: 10%

$$\text{Internal oscillator clock (fosc.) [Hz]} = 60 \times [320 + 2 + 14] \times 16 \text{ clocks} \times (1.1/0.9) \div 394\text{KHz}$$

When calculate the internal clock frequency, the oscillator variation is needed to be taken into consideration. In the above example, the calculated internal clock frequency with $\pm 10\%$ margin variation is considered and ensures to complete the display operation within one VSYNC cycle. The causes of frequency variation come from fabrication process of LSI, room temperature, external resistors and VCI voltage variation.

$$\text{Minimum speed for RAM writing [Hz]} > 240 \times 320 \times 394\text{K} / [(14 + 320 - 2)\text{lines} \times 16\text{clocks}] \div 5.7 \text{ MHz}$$

The above theoretical value is calculated based on the premise that the ILI9328 starts to write data into the internal GRAM on the falling edge of VSYNC. There must at least be a margin of 2 lines between the physical display line and the GRAM line address where data writing operation is performed. The GRAM write speed of 5.7MHz or more will guarantee the completion of GRAM write operation before the ILI9328 starts to display the GRAM data on the screen and enable to rewrite the entire screen without flicker.

Notes in using the VSYNC interface

1. The minimum GRAM write speed must be satisfied and the frequency variation must be taken into consideration.
2. The display frame rate is determined by the VSYNC signal and the period of VSYNC must be longer than the scan period of an entire display.
3. When switching from the internal clock operation mode (DM[1:0] = "00") to the VSYNC interface mode or inversely, the switching starts from the next VSYNC cycle, i.e. after completing the display of the frame.
4. The partial display, vertical scroll, and interlaced scan functions are not available in VSYNC interface mode and set the AM bit to "0" to transfer display data.

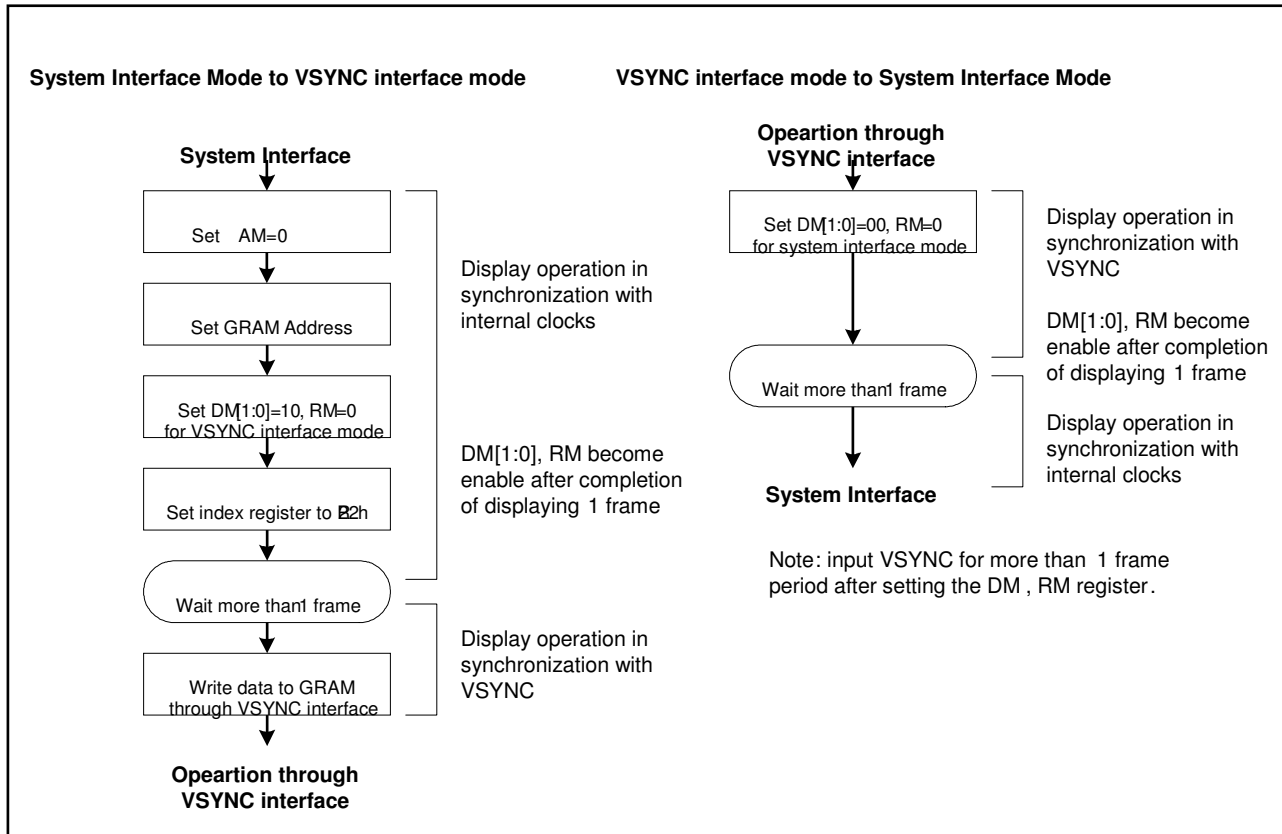


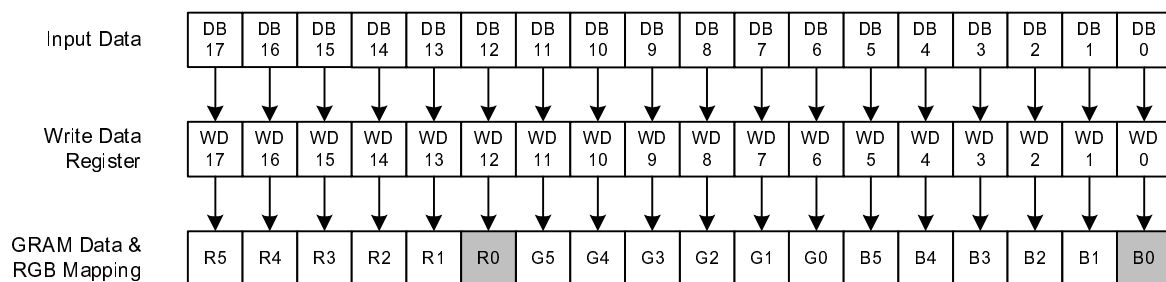
Figure13 Transition flow between VSYNC and internal clock operation modes

6.5. RGB Input Interface

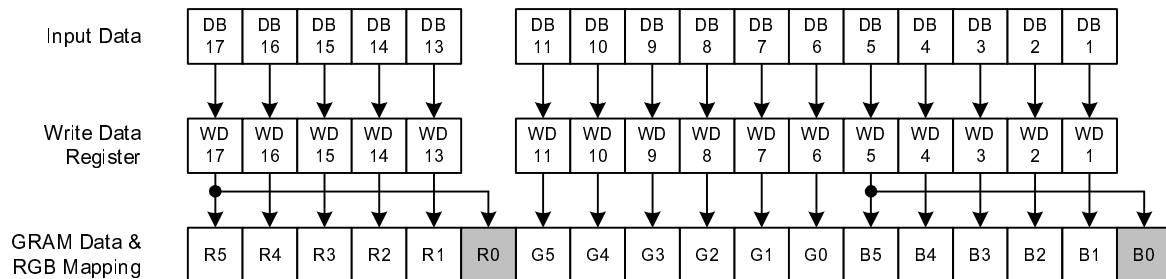
The RGB Interface mode is available for ILI9328 and the interface is selected by setting the RIM[1:0] bits as following table.

| RIM1 | RIM0 | RGB Interface | DB pins |
|------|------|----------------------|---------------------|
| 0 | 0 | 18-bit RGB Interface | DB[17:0] |
| 0 | 1 | 16-bit RGB Interface | DB[17:13], DB[11:1] |
| 1 | 0 | 6-bit RGB Interface | DB[17:12] |
| 1 | 1 | Setting prohibited | |

18-bit RGB Interface (262K colors)



16-bit RGB Interface (65K colors)



6-bit RGB Interface (262K colors)

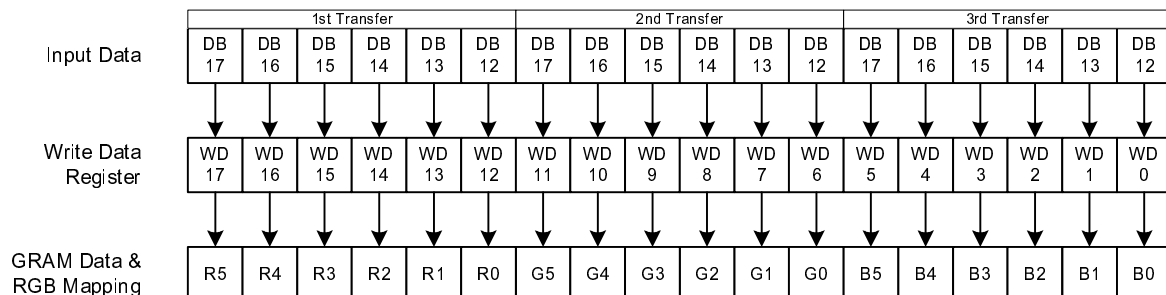


Figure14 RGB Interface Data Format

6.5.1. RGB Interface

The display operation via the RGB interface is synchronized with the VSYNC, HSYNC, and DOTCLK signals. The RGB interface transfers the updated data to GRAM with the high-speed write function and the update area is defined by the window address function. The back porch and front porch are used to set the RGB interface timing.

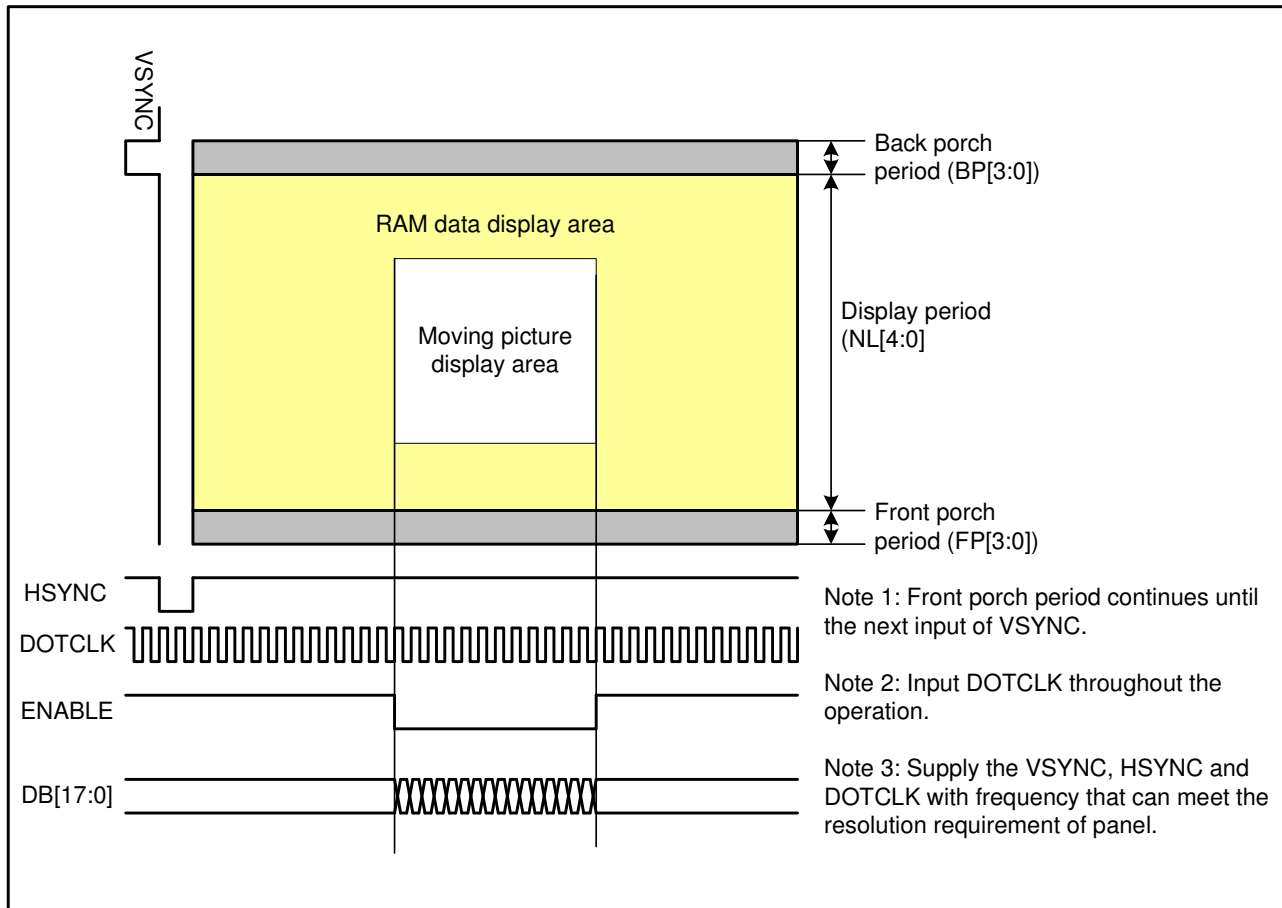


Figure15 GRAM Access Area by RGB Interface

6.5.2. RGB Interface Timing

The timing chart of 18-/16-bit RGB interface mode is shown as follows.

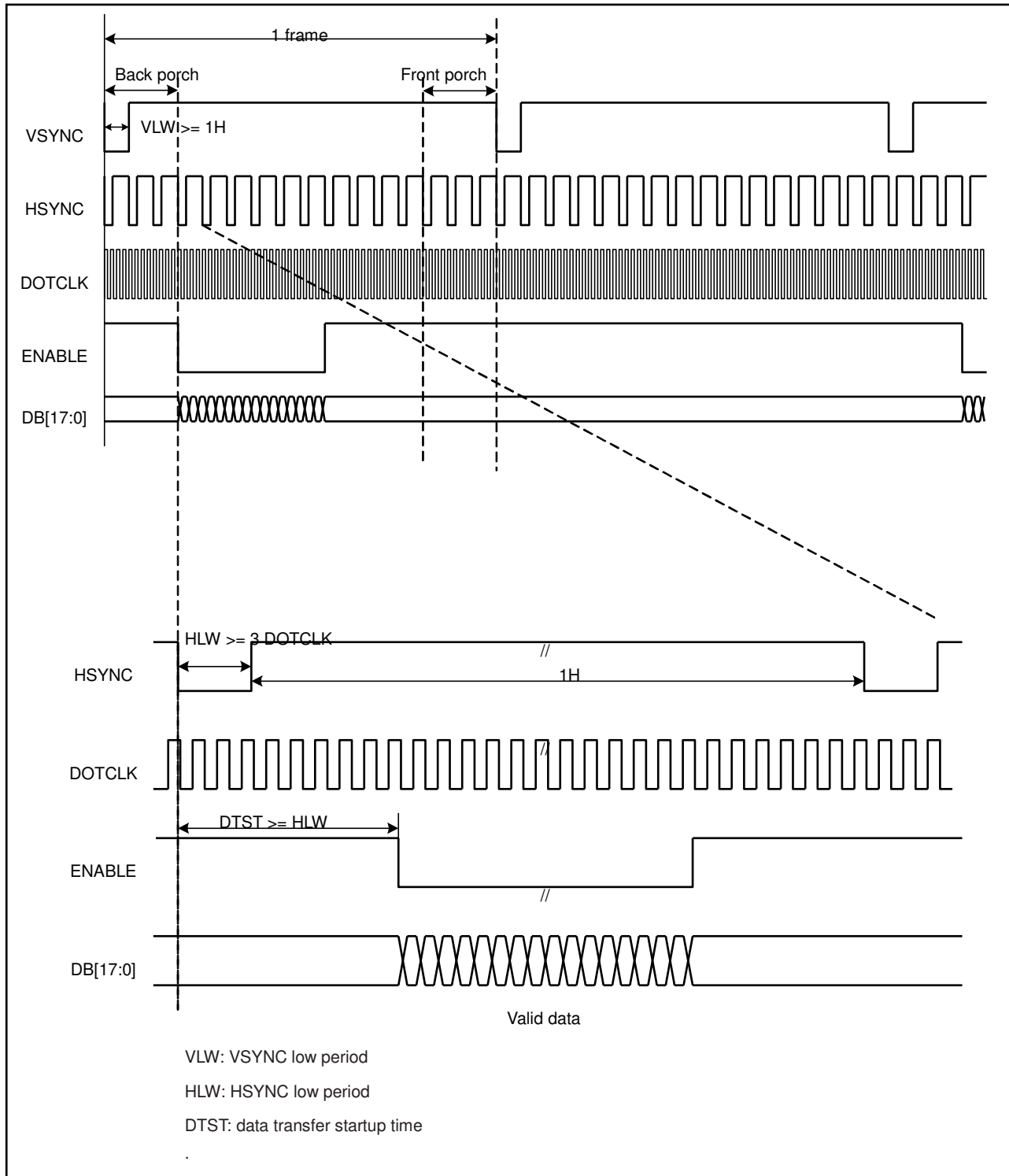


Figure16 Timing Chart of Signals in 18-/16-bit RGB Interface Mode

The timing chart of 6-bit RGB interface mode is shown as follows.

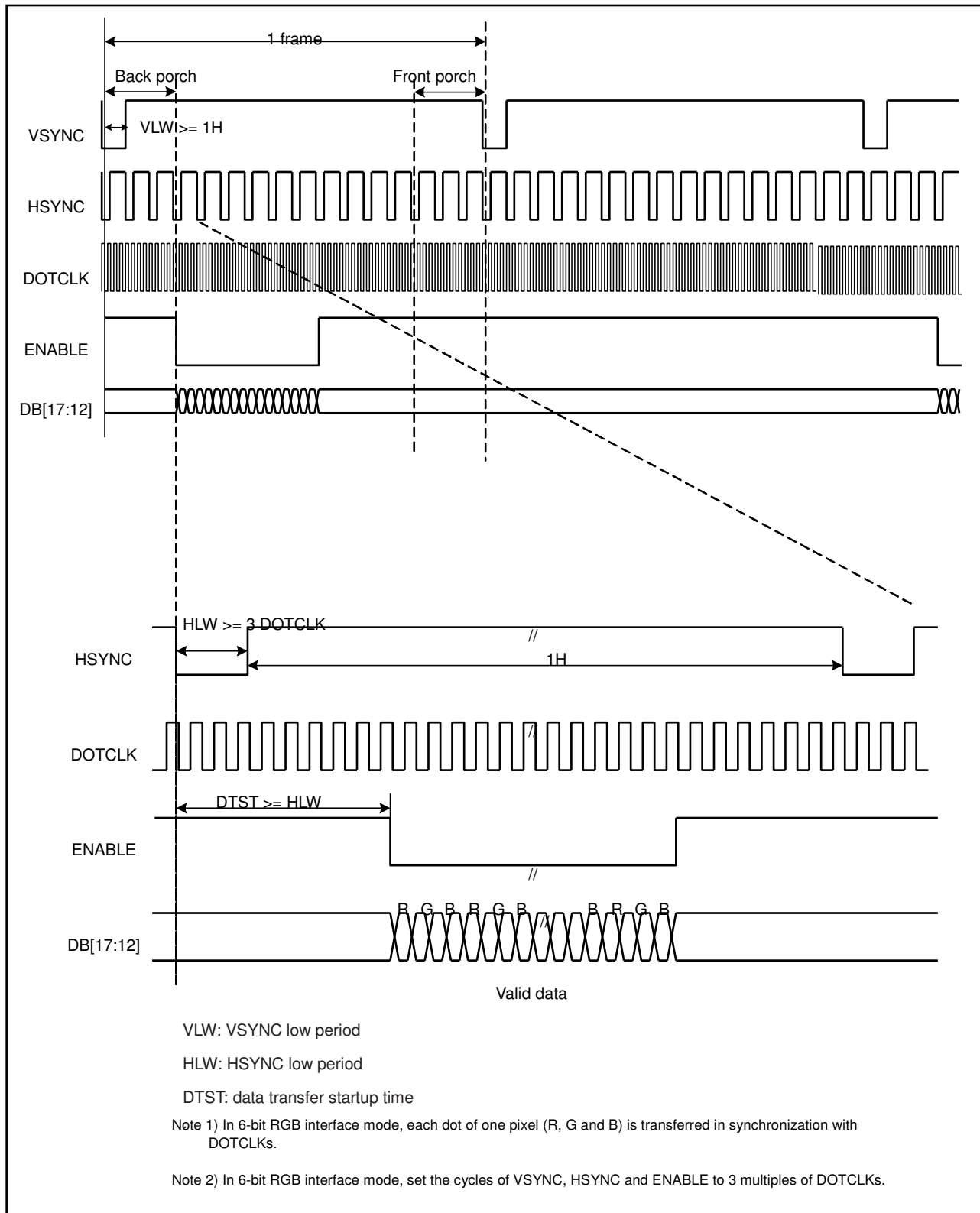


Figure17 Timing chart of signals in 6-bit RGB interface mode

6.5.3. Moving Picture Mode

ILI9328 has the RGB interface to display moving picture and incorporates GRAM to store display data, which has following merits in displaying a moving picture.

- The window address function defined the update area of GRAM.
- Only the moving picture area of GRAM is updated.
- When display the moving picture in RGB interface mode, the DB[17:0] can be switched as system interface to update still picture area and registers, such as icons.

RAM access via a system interface in RGB-I/F mode

ILI9328 allows GRAM access via the system interface in RGB interface mode. In RGB interface mode, data are written to the internal GRAM in synchronization with DOTCLK and ENABLE signals. When write data to the internal GRAM by the system interface, set ENABLE to terminate the RGB interface and switch to the system interface to update the registers (RM = "0") and the still picture of GRAM. When restart RAM access in RGB interface mode, wait one read/write cycle and then set RM = "1" and the index register to R22h to start accessing RAM via the RGB interface. If RAM accesses via two interfaces conflicts, there is no guarantee that data are written to the internal GRAM.

The following figure illustrates the operation of the ILI9328 when displaying a moving picture via the RGB interface and rewriting the still picture RAM area via the system interface.

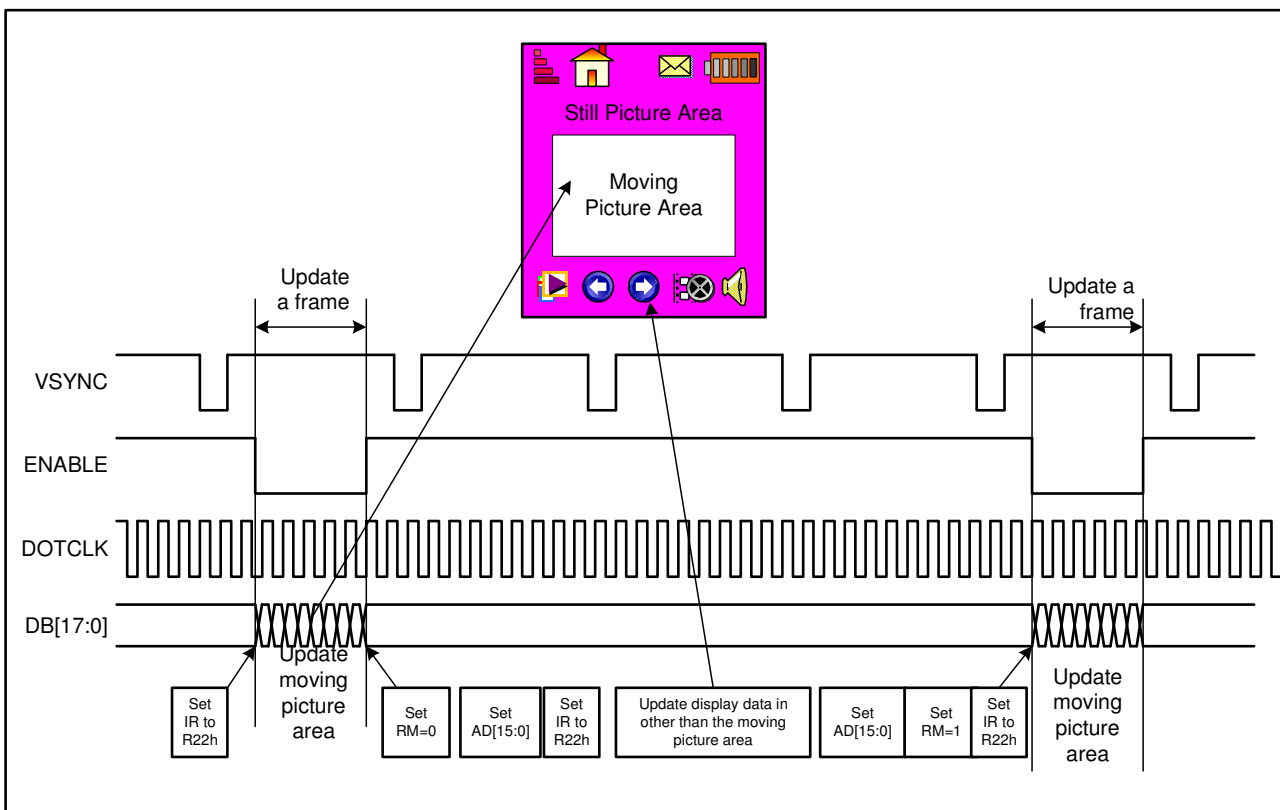
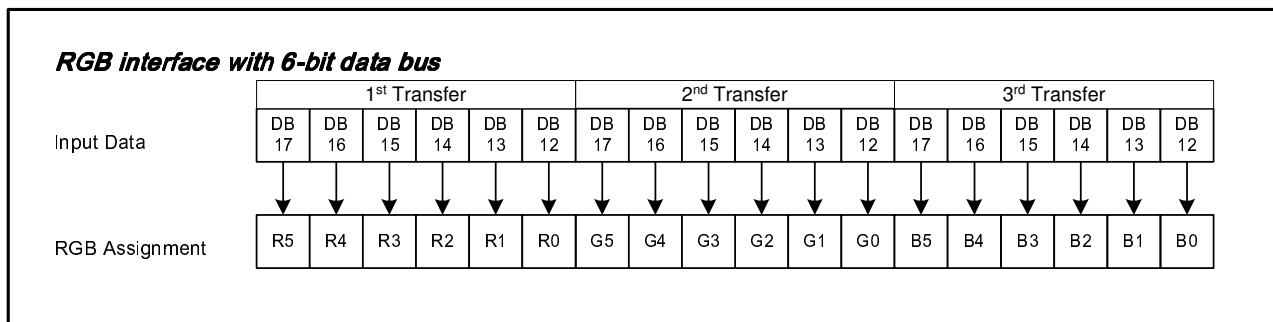


Figure18 Example of update the still and moving picture

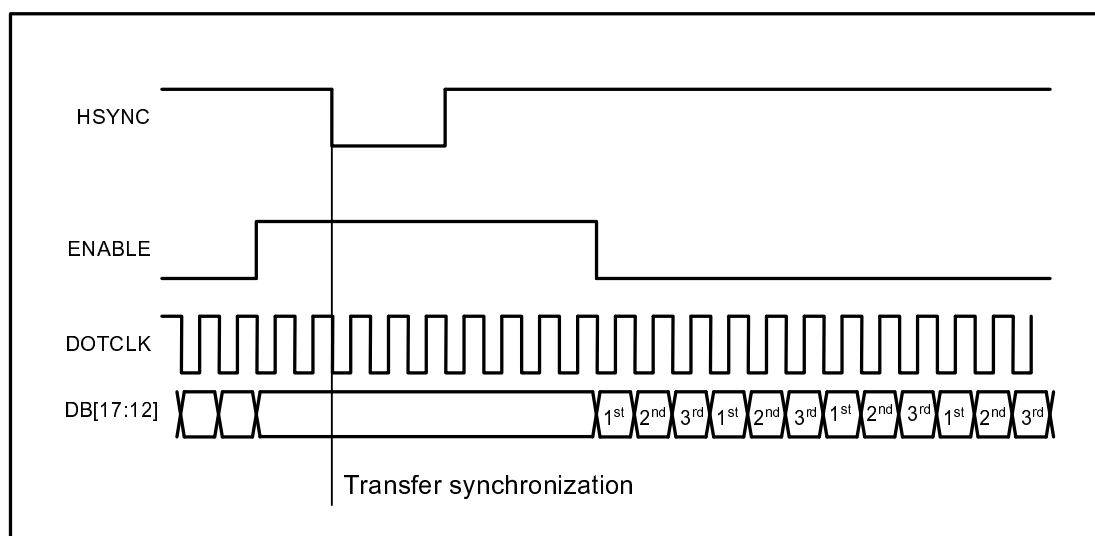
6.5.4. 6-bit RGB Interface

The 6-bit RGB interface is selected by setting the RIM[1:0] bits to “10”. The display operation is synchronized with VSYNC, HSYNC, and DOTCLK signals. Display data are transferred to the internal GRAM in synchronization with the display operation via 6-bit RGB data bus (DB[17:12]) according to the data enable signal (ENABLE). Unused pins (DB[11:0]) must be fixed at GND level. Registers can be set by the system interface (i80/SPI).



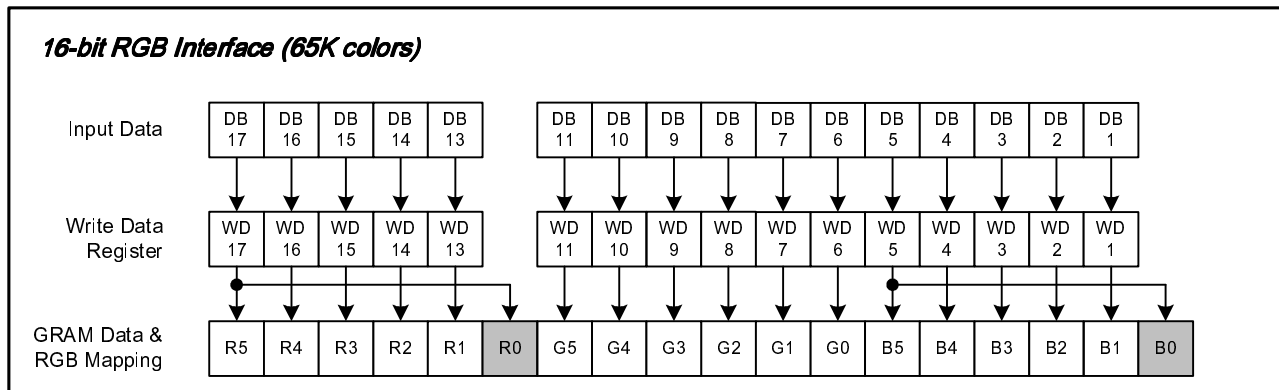
Data transfer synchronization in 6-bit RGB interface mode

ILI9328 has data transfer counters to count the first, second, third data transfers in 6-bit RGB interface mode. The transfer counter is always reset to the state of first data transfer on the falling edge of VSYNC. If a mismatch arises in the number of each data transfer, the counter is reset to the state of first data transfer at the start of the frame (i.e. on the falling edge of VSYNC) to restart data transfer in the correct order from the next frame. This function is expedient for moving picture display, which requires consecutive data transfer in light of minimizing effects from failed data transfer and enabling the system to return to a normal state. Note that internal display operation is performed in units of pixels (RGB: taking 3 inputs of DOTCLK). Accordingly, the number of DOTCLK inputs in one frame period must be a multiple of 3 to complete data transfer correctly. Otherwise it will affect the display of that frame as well as the next frame.



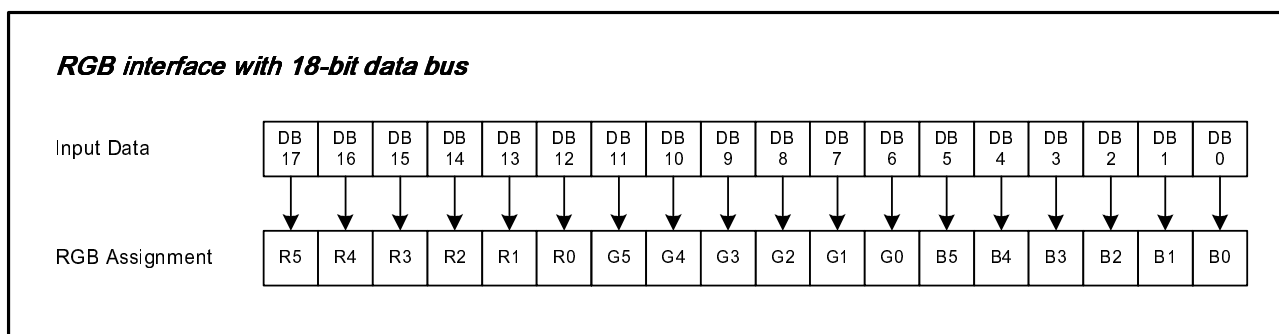
6.5.5. 16-bit RGB Interface

The 16-bit RGB interface is selected by setting the RIM[1:0] bits to "01". The display operation is synchronized with VSYNC, HSYNC, and DOTCLK signals. Display data are transferred to the internal RAM in synchronization with the display operation via 16-bit RGB data bus (DB17-13, DB11-1) according to the data enable signal (ENABLE). Registers are set only via the system interface.



6.5.6. 18-bit RGB Interface

The 18-bit RGB interface is selected by setting the RIM[1:0] bits to "00". The display operation is synchronized with VSYNC, HSYNC, and DOTCLK signals. Display data are transferred to the internal RAM in synchronization with the display operation via 18-bit RGB data bus (DB[17:0]) according to the data enable signal (ENABLE). Registers are set only via the system interface.



Notes in using the RGB Input Interface

1. The following are the functions not available in RGB Input Interface mode.

| Function | RGB interface | I80 system interface |
|-----------------|---------------|----------------------|
| Partial display | Not available | Available |
| Scroll function | Not available | Available |
| Interlaced scan | Not available | Available |

2. VSYNC, HSYNC, and DOTCLK signals must be supplied throughout a display operation period.
3. The periods set with the NO[1:0] bits (gate output non-overlap period), STD[1:0] bits (source output delay period) and EQ[1:0] bits (equalization period) are not based on the internal clock but based on DOTCLK in

RGB interface mode.

4. In 6-bit RGB interface mode, each of RGB dots is transferred in synchronization with a DOTCLK input. In other words, it takes 3 DOTCLK inputs to transfer one pixel. Be sure to complete data transfer in units of 3 DOTCLK inputs in 6-bit RGB interface mode.
5. In 6-bit RGB interface mode, data of one pixel, which consists of RGB dots, are transferred in units of 3 DOTCLK. Accordingly, set the cycle of each signal in 6-bit interface mode (VSYNC, HSYNC, ENABLE, DB[17:0]) to contain DOTCLK inputs of a multiple of 3 to complete data transfer in units of pixels.
6. When switching from the internal operation mode to the RGB Input Interface mode, or the other way around, follow the sequence below.
7. In RGB interface mode, the front porch period continues until the next VSYNC input is detected after drawing one frame.
8. In RGB interface mode, a RAM address (AD[15:0]) is set in the address counter every frame on the falling edge of VSYNC.

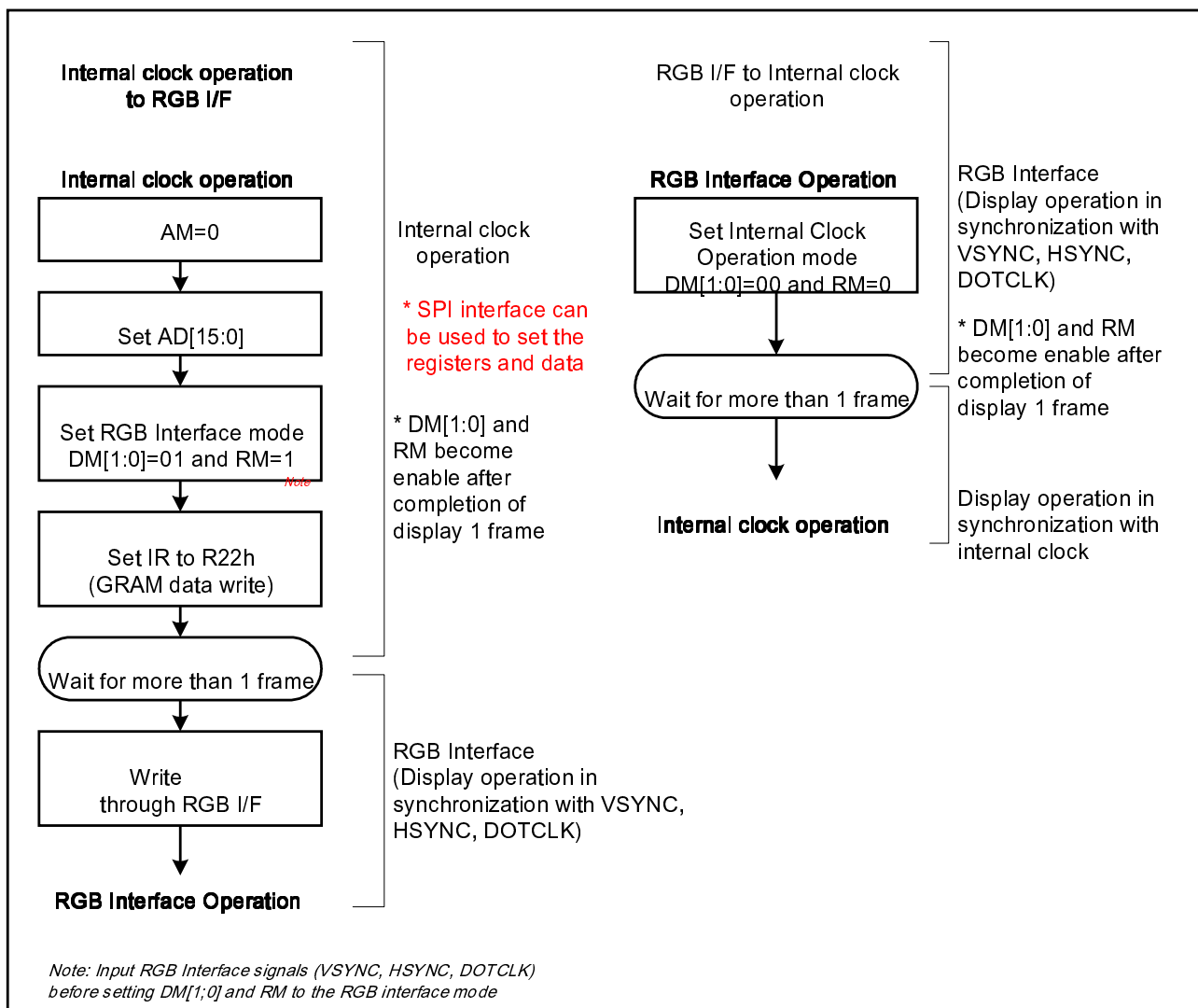


Figure19 Internal clock operation/RGB interface mode switching

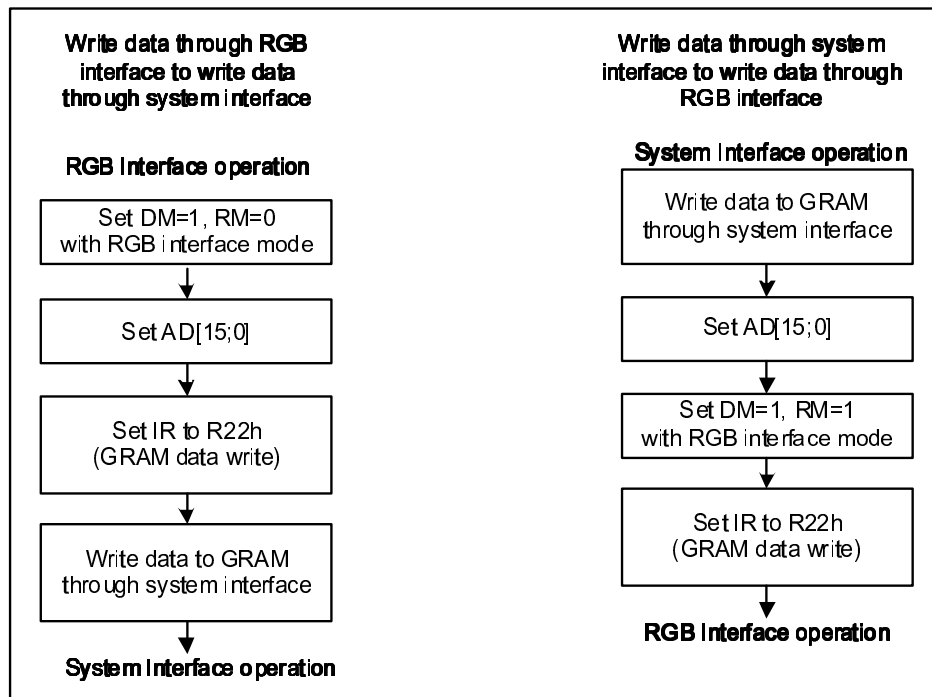


Figure20 GRAM access between system interface and RGB interface

6.6. Interface Timing

The following are diagrams of interfacing timing with LCD panel control signals in internal operation and RGB interface modes.

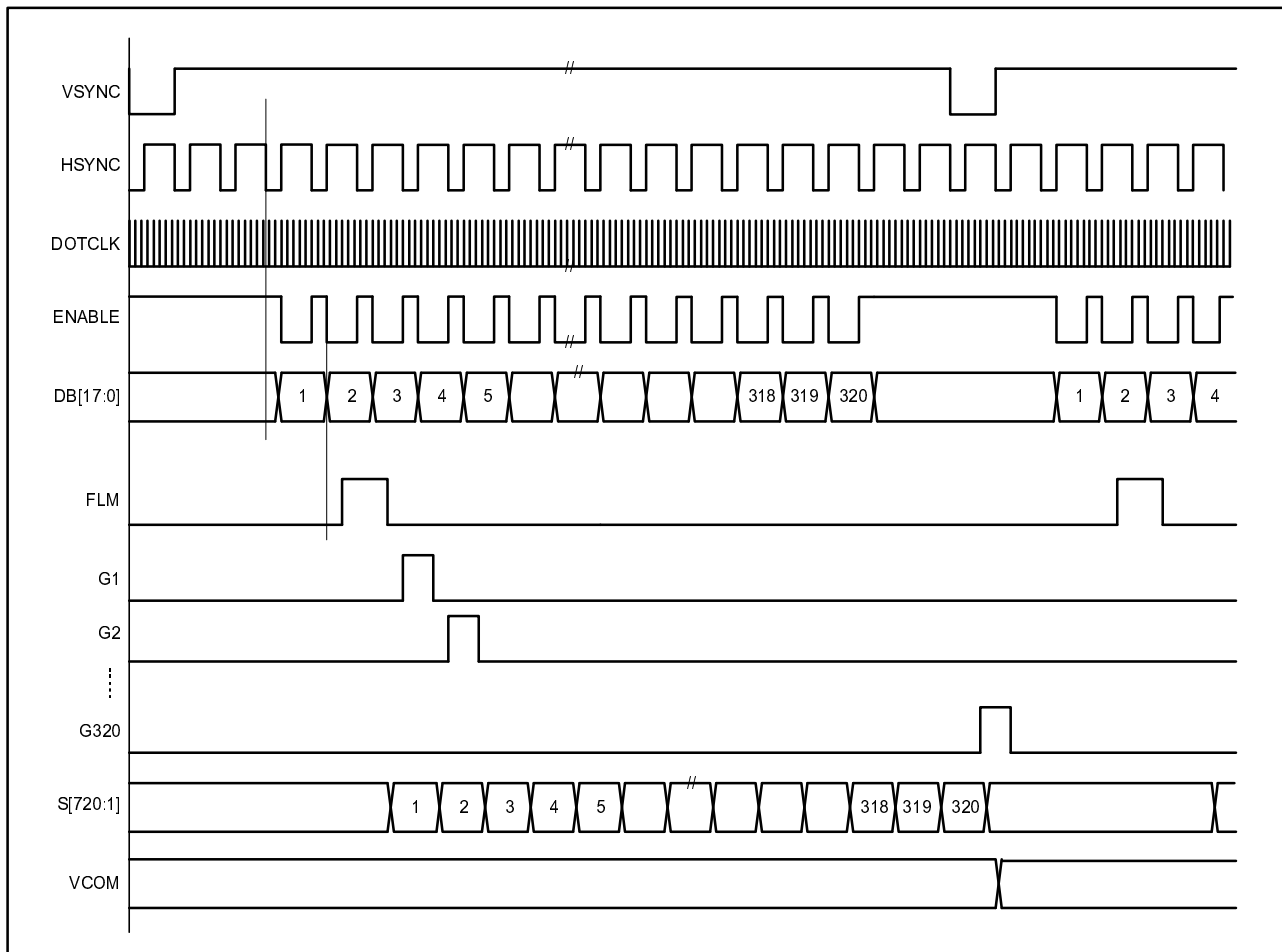


Figure21 Relationship between RGB I/F signals and LCD Driving Signals for Panel

7. Register Descriptions

7.1. Registers Access

ILI9328 adopts 18-bit bus interface architecture for high-performance microprocessor. All the functional blocks of ILI9328 starts to work after receiving the correct instruction from the external microprocessor by the 18-, 16-, 9-, 8-bit interface. The index register (IR) stores the register address to which the instructions and display data will be written. The register selection signal (RS), the read/write signals (nRD/nWR) and data bus D17-0 are used to read/write the instructions and data of ILI9328. The registers of the ILI9328 are categorized into the following groups.

1. Specify the index of register (IR)
2. Read a status
3. Display control
4. Power management Control
5. Graphics data processing
6. Set internal GRAM address (AC)
7. Transfer data to/from the internal GRAM (R22)
8. Internal grayscale γ -correction (R30 ~ R39)

Normally, the display data (GRAM) is most often updated, and in order since the ILI9328 can update internal GRAM address automatically as it writes data to the internal GRAM and minimize data transfer by using the window address function, there are fewer loads on the program in the microprocessor. As the following figure shows, the way of assigning data to the 16 register bits (D[15:0]) varies for each interface. Send registers in accordance with the following data transfer format.

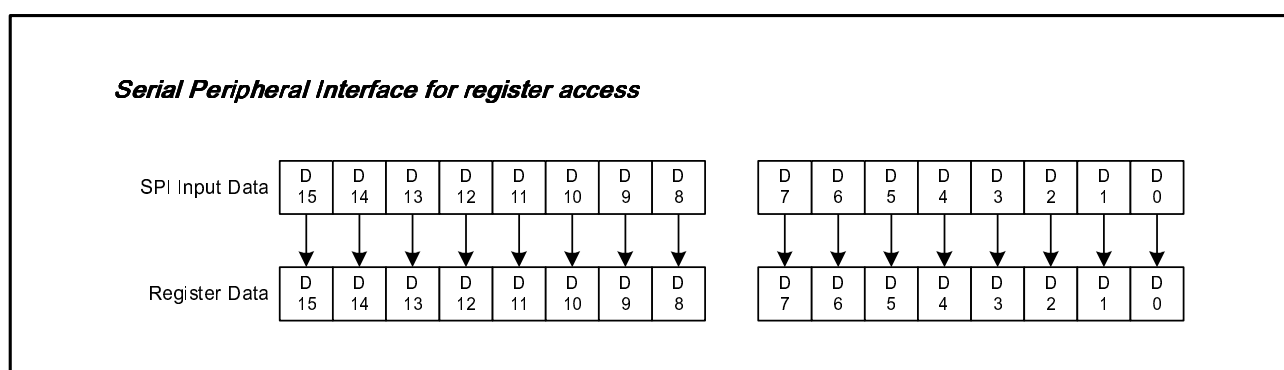
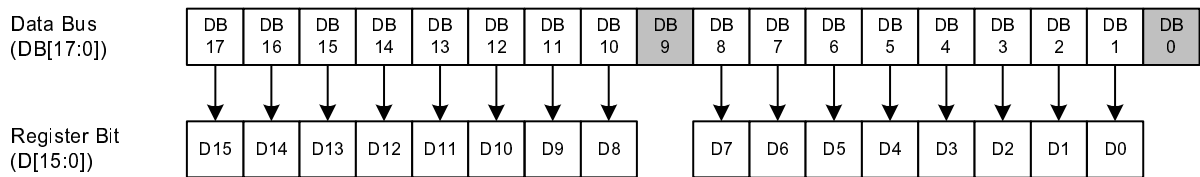
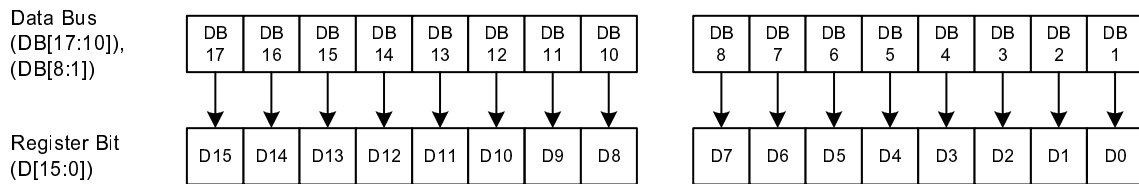


Figure22 Register Setting with Serial Peripheral Interface (SPI)

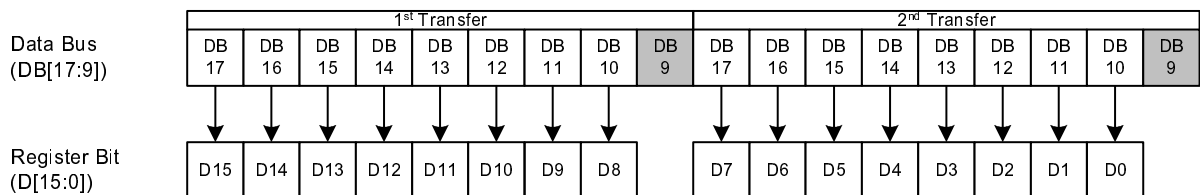
i80/M68 system 18-bit data bus interface



i80/M68 system 16-bit data bus interface



i80/M68 system 9-bit data bus interface



i80/M68 system 8-bit data bus interface/Serial peripheral interface (2/3 transmission)

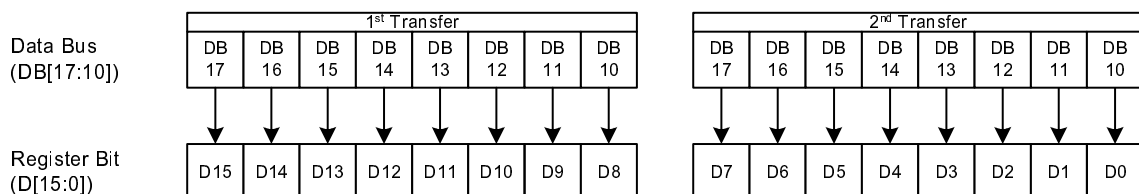


Figure23 Register setting with i80 System Interface

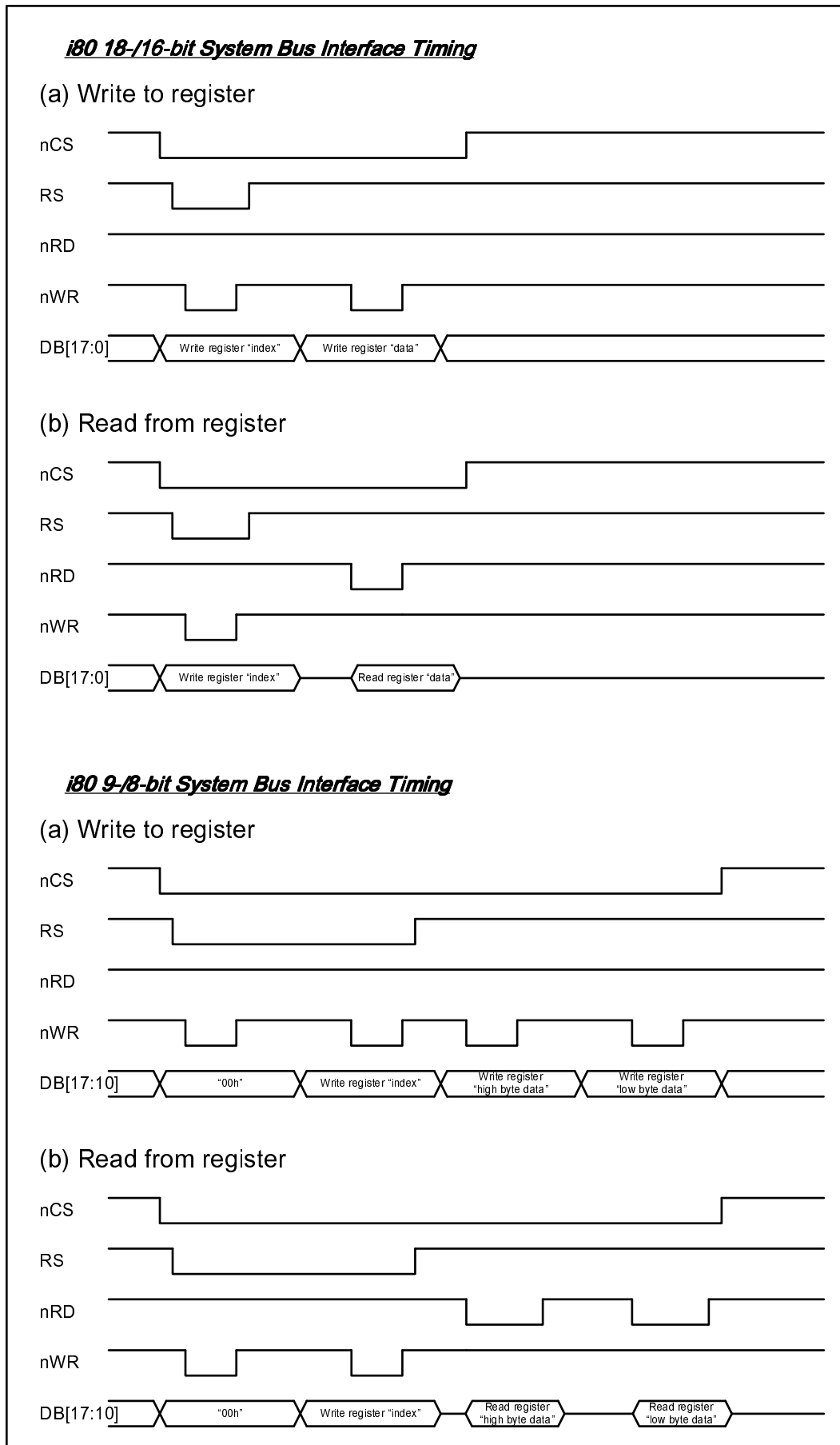


Figure 24 Register Read/Write Timing of i80 System Interface

7.2. Instruction Descriptions

| No. | Registers Name | R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|---------------------------------|-----|----|--|------|-------|---------|---------|---------|---------|---------|-------|------|------|------|---------|---------|---------|---------|
| IR | Index Register | W | 0 | - | - | - | - | - | - | - | - | ID7 | ID6 | ID5 | ID4 | ID3 | ID2 | ID1 | ID0 |
| 00h | Driver Code Read | RO | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 01h | Driver Output Control 1 | W | 1 | 0 | 0 | 0 | 0 | 0 | SM | 0 | SS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 02h | LCD Driving Control | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | BC0 | EOR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 03h | Entry Mode | W | 1 | TRI | DFM | 0 | BGR | 0 | 0 | 0 | 0 | ORG | 0 | I/D1 | I/D0 | AM | 0 | 0 | 0 |
| 04h | Resize Control | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | RCV1 | RCV0 | 0 | 0 | RCH1 | RCH0 | 0 | 0 | RSZ1 | RSZ0 |
| 07h | Display Control 1 | W | 1 | 0 | 0 | PTDE1 | PTDE0 | 0 | 0 | 0 | BASEE | 0 | 0 | GON | DTE | CL | 0 | D1 | D0 |
| 08h | Display Control 2 | W | 1 | 0 | 0 | 0 | 0 | FP3 | FP2 | FP1 | FP0 | 0 | 0 | 0 | 0 | BP3 | BP2 | BP1 | BP0 |
| 09h | Display Control 3 | W | 1 | 0 | 0 | 0 | 0 | 0 | PTS2 | PTS1 | PTS0 | 0 | 0 | PTG1 | PTG0 | ISC3 | ISC2 | ISC1 | ISC0 |
| 0Ah | Display Control 4 | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | FMARKOE | FMI2 | FMI1 | FMI0 |
| 0Ch | RGB Display Interface Control 1 | W | 1 | 0 | ENC2 | ENC1 | ENC0 | 0 | 0 | 0 | RM | 0 | 0 | DM1 | DM0 | 0 | 0 | RIM1 | RIM0 |
| 0Dh | Frame Maker Position | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | FMP8 | FMP7 | FMP6 | FMP5 | FMP4 | FMP3 | FMP2 | FMP1 | FMP0 |
| 0Fh | RGB Display Interface Control 2 | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VSPL | HSPL | 0 | DPL | EPL |
| 10h | Power Control 1 | W | 1 | 0 | 0 | 0 | SAP | 0 | BT2 | BT1 | BT0 | APE | AP2 | AP1 | AP0 | 0 | 0 | SLP | STB |
| 11h | Power Control 2 | W | 1 | 0 | 0 | 0 | 0 | 0 | DC12 | DC11 | DC10 | 0 | DC02 | DC01 | DC00 | 0 | VC2 | VC1 | VC0 |
| 12h | Power Control 3 | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VCIRE | 0 | 0 | PON | VRH3 | VRH2 | VRH1 | VRH0 |
| 13h | Power Control 4 | W | 1 | 0 | 0 | 0 | VDV4 | VDV3 | VDV2 | VDV1 | VDV0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 20h | Horizontal GRAM Address Set | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | AD7 | AD6 | AD5 | AD4 | AD3 | AD2 | AD1 | AD0 |
| 21h | Vertical GRAM Address Set | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | AD16 | AD15 | AD14 | AD13 | AD12 | AD11 | AD10 | AD9 | AD8 |
| 22h | Write Data to GRAM | W | 1 | RAM write data (WD17-0) / read data (RD17-0) bits are transferred via different data bus lines according to the selected interfaces. | | | | | | | | | | | | | | | |
| 29h | Power Control 7 | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VCM5 | VCM4 | VCM3 | VCM2 | VCM1 | VCM0 |
| 2Bh | Frame Rate and Color Control | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | FRS[3] | FRS[2] | FRS[1] | FRS[0] |
| 30h | Gamma Control 1 | W | 1 | 0 | 0 | 0 | 0 | 0 | KP1[2] | KP1[1] | KP1[0] | 0 | 0 | 0 | 0 | 0 | KP0[2] | KP0[1] | KP0[0] |
| 31h | Gamma Control 2 | W | 1 | 0 | 0 | 0 | 0 | 0 | KP3[2] | KP3[1] | KP3[0] | 0 | 0 | 0 | 0 | 0 | KP2[2] | KP2[1] | KP2[0] |
| 32h | Gamma Control 3 | W | 1 | 0 | 0 | 0 | 0 | 0 | KP5[2] | KP5[1] | KP5[0] | 0 | 0 | 0 | 0 | 0 | KP4[2] | KP4[1] | KP4[0] |
| 35h | Gamma Control 4 | W | 1 | 0 | 0 | 0 | 0 | 0 | RP1[2] | RP1[1] | RP1[0] | 0 | 0 | 0 | 0 | 0 | RP0[2] | RP0[1] | RP0[0] |
| 36h | Gamma Control 5 | W | 1 | 0 | 0 | 0 | VRP1[4] | VRP1[3] | VRP1[2] | VRP1[1] | VRP1[0] | 0 | 0 | 0 | 0 | VRP0[3] | VRP0[2] | VRP0[1] | VRP0[0] |
| 37h | Gamma Control 6 | W | 1 | 0 | 0 | 0 | 0 | 0 | KN1[2] | KN1[1] | KN1[0] | 0 | 0 | 0 | 0 | 0 | KN0[2] | KN0[1] | KN0[0] |
| 38h | Gamma Control 7 | W | 1 | 0 | 0 | 0 | 0 | 0 | KN3[2] | KN3[1] | KN3[0] | 0 | 0 | 0 | 0 | 0 | KN2[2] | KN2[1] | KN2[0] |
| 39h | Gamma Control 8 | W | 1 | 0 | 0 | 0 | 0 | 0 | KN5[2] | KN5[1] | KN5[0] | 0 | 0 | 0 | 0 | 0 | KN4[2] | KN4[1] | KN4[0] |
| 3Ch | Gamma Control 9 | W | 1 | 0 | 0 | 0 | 0 | 0 | RN1[2] | RN1[1] | RN1[0] | 0 | 0 | 0 | 0 | 0 | RN0[2] | RN0[1] | RN0[0] |
| 3Dh | Gamma Control 10 | W | 1 | 0 | 0 | 0 | VRN1[4] | VRN1[3] | VRN1[2] | VRN1[1] | VRN1[0] | 0 | 0 | 0 | 0 | VRN0[3] | VRN0[2] | VRN0[1] | VRN0[0] |
| 50h | Horizontal Address Start | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | HSA7 | HSA6 | HSA5 | HSA4 | HSA3 | HSA2 | HSA1 | HSA0 |

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| No. | Registers Name | R/W | RS | | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|-----------------------------------|-----|----|--|----------|----------|--------|--------|------------|--------|--------|--------|--------|--------|----------|----------|----------|----------|----------|----------|
| | Position | | | | | | | | | | | | | | | | | | | |
| 51h | Horizontal Address End Position | W | 1 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | HEA7 | HEA6 | HEA5 | HEA4 | HEA3 | HEA2 | HEA1 | HEA0 |
| 52h | Vertical Address Start Position | W | 1 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VSA8 | VSA7 | VSA6 | VSA5 | VSA4 | VSA3 | VSA2 | VSA1 | VSA0 |
| 53h | Vertical Address End Position | W | 1 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VEA8 | VEA7 | VEA6 | VEA5 | VEA4 | VEA3 | VEA2 | VEA1 | VEA0 |
| 60h | Driver Output Control 2 | W | 1 | | GS | 0 | NL5 | NL4 | NL3 | NL2 | NL1 | NL0 | 0 | 0 | SCN5 | SCN4 | SCN3 | SCN2 | SCN1 | SCN0 |
| 61h | Base Image Display Control | W | 1 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | NDL | VLE | REV |
| 6Ah | Vertical Scroll Control | W | 1 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VL8 | VL7 | VL6 | VL5 | VL4 | VL3 | VL2 | VL1 | VL0 |
| 80h | Partial Image 1 Display Position | W | 1 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | PTDP08 | PTDP07 | PTDP06 | PTDP05 | PTDP04 | PTDP03 | PTDP02 | PTDP01 | PTDP00 |
| 81h | Partial Image 1 Area (Start Line) | W | 1 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | PTSA08 | PTSA07 | PTSA06 | PTSA05 | PTSA04 | PTSA03 | PTSA02 | PTSA01 | PTSA00 |
| 82h | Partial Image 1 Area (End Line) | W | 1 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | PTEA08 | PTEA07 | PTEA06 | PTEA05 | PTEA04 | PTEA03 | PTEA02 | PTEA01 | PTEA00 |
| 83h | Partial Image 2 Display Position | W | 1 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | PTDP18 | PTDP17 | PTDP16 | PTDP15 | PTDP14 | PTDP13 | PTDP12 | PTDP11 | PTDP10 |
| 84h | Partial Image 2 Area (Start Line) | W | 1 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | PTSA18 | PTSA17 | PTSA16 | PTSA15 | PTSA14 | PTSA13 | PTSA12 | PTSA11 | PTSA10 |
| 85h | Partial Image 2 Area (End Line) | W | 1 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | PTEA18 | PTEA17 | PTEA16 | PTEA15 | PTEA14 | PTEA13 | PTEA12 | PTEA11 | PTEA10 |
| 90h | Panel Interface Control 1 | W | 1 | | 0 | 0 | 0 | 0 | 0 | 0 | DIV11 | DIV10 | 0 | 0 | 0 | 0 | RTNI3 | RTNI2 | RTNI1 | RTNI0 |
| 92h | Panel Interface Control 2 | W | 1 | | 0 | 0 | 0 | 0 | 0 | NOWI2 | NOWI1 | NOWI0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 95h | Panel Interface Control 4 | W | 1 | | 0 | 0 | 0 | 0 | 0 | 0 | DIVE1 | DIVE0 | 0 | 0 | RTNE5 | RTNE4 | RTNE3 | RTNE2 | RTNE1 | RTNE0 |
| A1h | OTP VCM Programming Control | W | 1 | | 0 | 0 | 0 | 0 | OTP_PGM_EN | 0 | 0 | 0 | 0 | 0 | VCM_OTP5 | VCM_OTP4 | VCM_OTP3 | VCM_OTP2 | VCM_OTP1 | VCM_OTP0 |
| A2h | OTP VCM Status and Enable | W | 1 | | PGM_CNT1 | PGM_CNT0 | VCM_D5 | VCM_D4 | VCM_D3 | VCM_D2 | VCM_D1 | VCM_D0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VCM_EN |
| A5h | OTP Programming ID Key | W | 1 | | KEY 15 | KEY 14 | KEY 13 | KEY 12 | KEY 11 | KEY 10 | KEY 9 | KEY 8 | KEY 7 | KEY 6 | KEY 5 | KEY 4 | KEY 3 | KEY 2 | KEY 1 | KEY 0 |

7.2.1. Index (IR)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|
| W | 0 | - | - | - | - | - | - | - | - | ID7 | ID6 | ID5 | ID4 | ID3 | ID2 | ID1 | ID0 |

The index register specifies the address of register (R00h ~ RFFh) or RAM which will be accessed.

7.2.2. ID code (R00h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|----|----|
| RO | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |

The device code "9328" is read out when read this register.

7.2.3. Driver Output Control (R01h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|----|----|
| W | 1 | 0 | 0 | 0 | 0 | 0 | SM | 0 | SS | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

SS: Select the shift direction of outputs from the source driver.

When SS = 0, the shift direction of outputs is from S1 to S720

When SS = 1, the shift direction of outputs is from S720 to S1.

In addition to the shift direction, the settings for both SS and BGR bits are required to change the assignment of R, G, B dots to the source driver pins.

To assign R, G, B dots to the source driver pins from S1 to S720, set SS = 0.

To assign R, G, B dots to the source driver pins from S720 to S1, set SS = 1.

When changing SS or BGR bits, RAM data must be rewritten.

SM: Sets the gate driver pin arrangement in combination with the GS bit (R60h) to select the optimal scan mode for the module.

| SM | GS | Scan Direction | Gate Output Sequence |
|----|----|----------------|--|
| 0 | 0 | | G1, G2, G3, G4, ..., G316 G317, G318, G319, G320 |
| 0 | 1 | | G320, G319, G318, ..., G6, G5, G4, G3, G2, G1 |
| 1 | 0 | | G1, G3, G5, G7, ..., G311 G313, G315, G317, G319 G2, G4, G6, G8, ..., G312 G314, G316, G318, G320 |
| 1 | 1 | | G320, G318, G316, ..., G10, G8, G6, G4, G2 G319, G317, G315, ..., G9, G78, G5, G3, G1 |

7.2.4. LCD Driving Wave Control (R02h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|
| W | 1 | 0 | 0 | 0 | 0 | 0 | 1 | B/C | EOR | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

.B/C 0 : Frame/Field inversion

1 : Line inversion

EOR: EOR = 1 and B/C=1 to set the line inversion.

7.2.5. Entry Mode (R03h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|----|----|-----|----|------|------|----|----|----|----|
| W | 1 | TRI | DFM | 0 | BGR | 0 | 0 | 0 | 0 | ORG | 0 | I/D1 | I/D0 | AM | 0 | 0 | 0 |

AM Control the GRAM update direction.

When AM = "0", the address is updated in horizontal writing direction.

When AM = "1", the address is updated in vertical writing direction.

When a window area is set by registers R50h ~R53h, only the addressed GRAM area is updated based on I/D[1:0] and AM bits setting.

I/D[1:0] Control the address counter (AC) to automatically increase or decrease by 1 when update one pixel display data. Refer to the following figure for the details.

| | I/D[1:0] = 00 Horizontal : decrement Vertical : decrement | I/D[1:0] = 01 Horizontal : increment Vertical : decrement | I/D[1:0] = 10 Horizontal : decrement Vertical : increment | I/D[1:0] = 11 Horizontal : increment Vertical : increment |
|----------------------|---|---|---|---|
| AM = 0 Horizontal | | | | |
| AM = 1 Vertical | | | | |

Figure25 GRAM Access Direction Setting

ORG Moves the origin address according to the ID setting when a window address area is made. This function is enabled when writing data with the window address area using high-speed RAM write.

ORG = "0": The origin address is not moved. In this case, specify the address to start write operation according to the GRAM address map within the window address area.

ORG = "1": The original address "00000h" moves according to the I/D[1:0] setting.

Notes: 1. When ORG=1, only the origin address address"00000h" can be set in the RAM address set registers R20h, and R21h.

2. In RAM read operation, make sure to set ORG=0.

BGR Swap the R and B order of written data.

BGR="0": Follow the RGB order to write the pixel data.

BGR="1": Swap the RGB data to BGR in writing into GRAM.

TRI When TRI = "1", data are transferred to the internal RAM in 8-bit x 3 transfers mode via the 8-bit interface. It is also possible to send data via the 16-bit interface or SPI in the transfer mode that realizes display in 262k colors in combination with DFM bits. When not using these interface modes, be sure to set TRI = "0".

DFM Set the mode of transferring data to the internal RAM when TRI = "1". See the following figures for details.

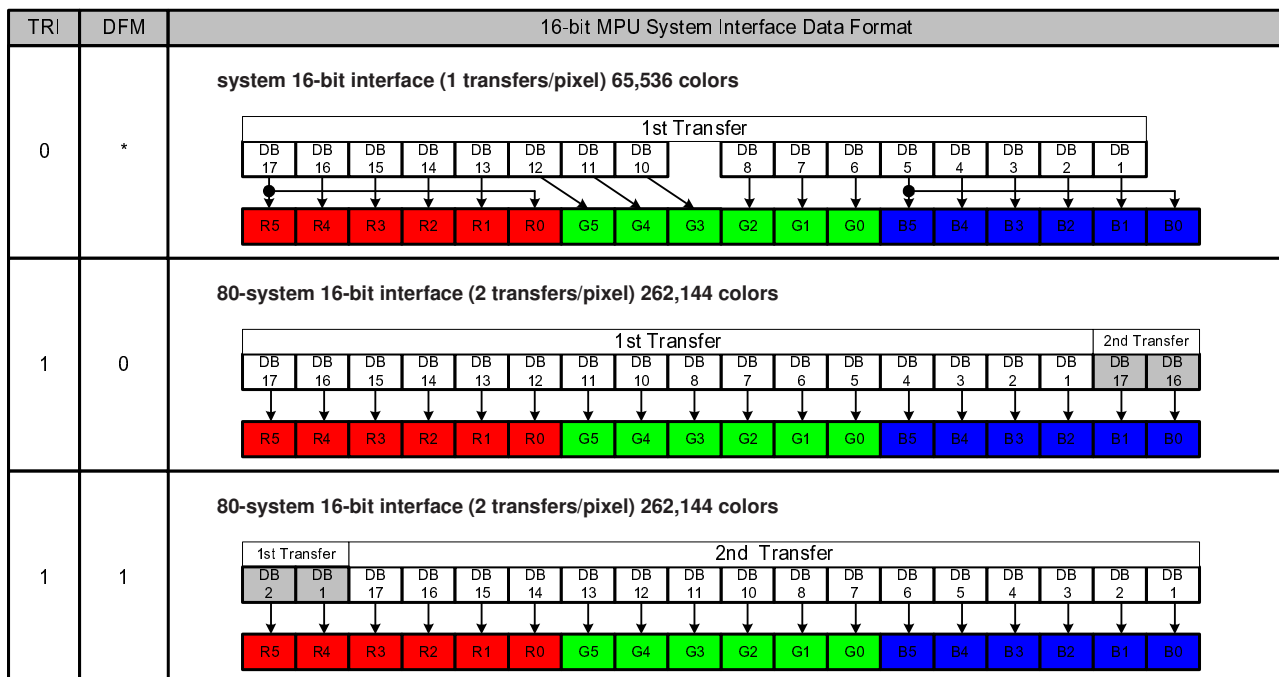


Figure26 16-bit MPU System Interface Data Format

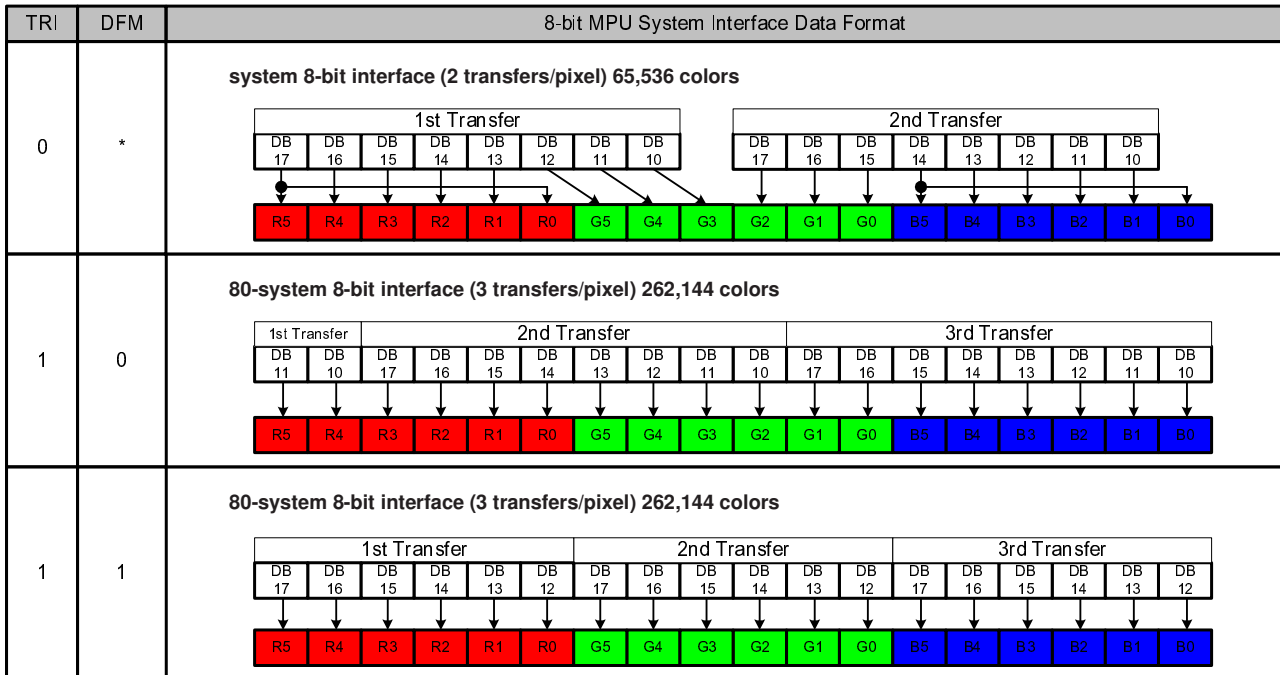


Figure27 8-bit MPU System Interface Data Format

7.2.6. Resizing Control Register (R04h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|------|------|----|----|------|------|----|----|------|------|
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | RCV1 | RCV0 | 0 | 0 | RCH1 | RCH0 | 0 | 0 | RSZ1 | RSZ0 |

RSZ[1:0] Sets the resizing factor.

When the RSZ bits are set for resizing, the ILI9328 writes the data according to the resizing factor so that the original image is displayed in horizontal and vertical dimensions, which are contracted according to the factor respectively. See “Resizing function”.

RCH[1:0] Sets the number of remainder pixels in horizontal direction when resizing a picture.

By specifying the number of remainder pixels by RCH bits, the data can be transferred without taking the reminder pixels into consideration. Make sure that RCH = 2'h0 when not using the resizing function (RSZ = 2'h0) or there are no remainder pixels.

RCV[1:0] Sets the number of remainder pixels in vertical direction when resizing a picture.

By specifying the number of remainder pixels by RCV bits, the data can be transferred without taking the reminder pixels into consideration. Make sure that RCV = 2'h0 when not using the resizing function (RSZ = 2'h0) or there are no remainder pixels.

| RSZ[1:0] | Resizing factor |
|----------|--------------------|
| 00 | No resizing (x1) |
| 01 | x 1/2 |
| 10 | Setting prohibited |
| 11 | x 1/4 |

| RCH[1:0] | Number of remainder Pixels in Horizontal Direction |
|----------|--|
| 00 | 0 pixel* |

| | |
|----|---------|
| 01 | 1 pixel |
| 10 | 2 pixel |
| 11 | 3 pixel |

| RCV[1:0] | Number of remainder Pixels in Vertical Direction |
|----------|--|
| 00 | 0 pixel* |
| 01 | 1 pixel |
| 10 | 2 pixel |
| 11 | 3 pixel |

*1 pixel = 1RGB

7.2.7. Display Control 1 (R07h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-------|-------|-----|-----|----|-------|----|----|-----|-----|----|----|----|----|
| W | 1 | 0 | 0 | PTDE1 | PTDE0 | 0 | 0 | 0 | BASEE | 0 | 0 | GON | DTE | CL | 0 | D1 | D0 |

D[1:0] Set D[1:0]="11" to turn on the display panel, and D[1:0]="00" to turn off the display panel.

A graphics display is turned on the panel when writing D1 = "1", and is turned off when writing D1 = "0".

When writing D1 = "0", the graphics display data is retained in the internal GRAM and the ILI9328 displays the data when writing D1 = "1". When D1 = "0", i.e. while no display is shown on the panel, all source outputs becomes the GND level to reduce charging/discharging current, which is generated within the LCD while driving liquid crystal with AC voltage.

When the display is turned off by setting D[1:0] = "01", the ILI9328 continues internal display operation. When the display is turned off by setting D[1:0] = "00", the ILI9328 internal display operation is halted completely. In combination with the GON, DTE setting, the D[1:0] setting controls display ON/OFF.

| D1 | D0 | BASEE | Source, VCOM Output | ILI9328 internal operation |
|----|----|-------|---------------------|----------------------------|
| 0 | 0 | 0 | GND | Halt |
| 0 | 1 | 1 | GND | Operate |
| 1 | 0 | 0 | Non-lit display | Operate |
| 1 | 1 | 0 | Non-lit display | Operate |
| 1 | 1 | 1 | Base image display | Operate |

Note: 1. data write operation from the microcontroller is performed irrespective of the setting of D[1:0] bits.

2. The D[1:0] setting is valid on both 1st and 2nd displays.

3. The non-lit display level from the source output pins is determined by instruction (PTS).

CL When CL = "1", the 8-color display mode is selected.

| CL | Colors |
|----|---------|
| 0 | 262,144 |
| 1 | 8 |

GON and DTE Set the output level of gate driver G1 ~ G320 as follows

| GON | DTE | G1 ~G320 Gate Output |
|-----|-----|----------------------|
| 0 | 0 | VGH |
| 0 | 1 | VGH |

| | | |
|---|---|----------------|
| 1 | 0 | VGL |
| 1 | 1 | Normal Display |

BASEE

Base image display enable bit. When BASEE = "0", no base image is displayed. The ILI9328 drives liquid crystal at non-lit display level or displays only partial images. When BASEE = "1", the base image is displayed. The D[1:0] setting has higher priority over the BASEE setting.

PTDE[1:0]

Partial image 2 and Partial image 1 enable bits

PTDE1/0 = 0: turns off partial image. Only base image is displayed.

PTDE1/0 = 1: turns on partial image. Set the base image display enable bit to 0 (BASEE = 0).

7.2.8. Display Control 2 (R08h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|-----|-----|-----|-----|
| W | 1 | 0 | 0 | 0 | 0 | FP3 | FP2 | FP1 | FP0 | 0 | 0 | 0 | 0 | BP3 | BP2 | BP1 | BP0 |

FP[3:0]/BP[3:0]

The FP[3:0] and BP[3:0] bits specify the line number of front and back porch periods respectively.

When setting the FP[3:0] and BP[3:0] value, the following conditions shall be met:

$BP + FP \leq 16$ lines

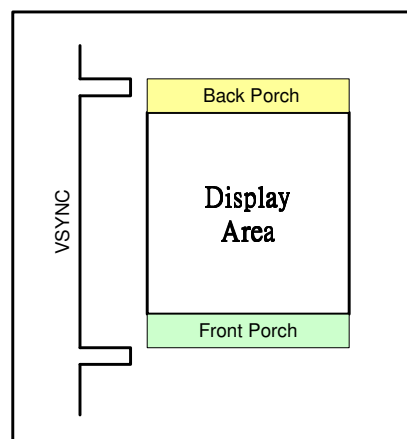
$FP \geq 2$ lines

$BP \geq 2$ lines

Set the BP[3:0] and FP[3:0] bits as below for each operation modes

| Operation Mode | BP | FP | BP+FP |
|-------------------------------------|-------------------|-------------------|-------------------------|
| 180 System Interface Operation Mode | $BP \geq 2$ lines | $FP \geq 2$ lines | $FP + BP \leq 16$ lines |
| RGB interface Operation | $BP \geq 2$ lines | $FP \geq 2$ lines | $FP + BP \leq 16$ lines |
| VSYNC interface Operation | $BP \geq 2$ lines | $FP \geq 2$ lines | $FP + BP = 16$ lines |

| FP[3:0] | Number of lines for Front Porch |
|---------|---------------------------------|
| BP[3:0] | Number of lines for Back Porch |
| 0000 | Setting Prohibited |
| 0001 | Setting Prohibited |
| 0010 | 2 lines |
| 0011 | 3 lines |
| 0100 | 4 lines |
| 0101 | 5 lines |
| 0110 | 6 lines |
| 0111 | 7 lines |
| 1000 | 8 lines |
| 1001 | 9 lines |
| 1010 | 10 lines |
| 1011 | 11 lines |
| 1100 | 12 lines |
| 1101 | 13 lines |



Note: The output timing to the LCD is delayed by 2 lines period from the input of synchronizing signal

| | |
|------|--------------------|
| 1110 | 14 lines |
| 1111 | Setting Prohibited |

7.2.9. Display Control 3 (R09h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|------|------|------|----|----|------|------|------|------|------|------|
| W | 1 | 0 | 0 | 0 | 0 | 0 | PTS2 | PTS1 | PTS0 | 0 | 0 | PTG1 | PTG0 | ISC3 | ISC2 | ISC1 | ISC0 |

ISC[3:0]: Specify the scan cycle interval of gate driver in non-display area when PTG[1:0]="10" to select interval scan. Then scan cycle is set as odd number from 0~29 frame periods. The polarity is inverted every scan cycle.

| ISC3 | ISC2 | ISC1 | ISC0 | Scan Cycle | f _{FLM} =60 Hz |
|------|------|------|------|------------|-------------------------|
| 0 | 0 | 0 | 0 | 0 frame | - |
| 0 | 0 | 0 | 1 | 1 frame | 17ms |
| 0 | 0 | 1 | 0 | 3 frame | 50ms |
| 0 | 0 | 1 | 1 | 5 frame | 84ms |
| 0 | 1 | 0 | 0 | 7 frame | 117ms |
| 0 | 1 | 0 | 1 | 9 frame | 150ms |
| 0 | 1 | 1 | 0 | 11 frame | 184ms |
| 0 | 1 | 1 | 1 | 13 frame | 217ms |
| 1 | 0 | 0 | 0 | 15 frame | 251ms |
| 1 | 0 | 0 | 1 | 17 frame | 284ms |
| 1 | 0 | 1 | 0 | 19 frame | 317ms |
| 1 | 0 | 1 | 1 | 21 frame | 351ms |
| 1 | 1 | 0 | 0 | 23 frame | 384ms |
| 1 | 1 | 0 | 1 | 25 frame | 418ms |
| 1 | 1 | 1 | 0 | 27 frame | 451ms |
| 1 | 1 | 1 | 1 | 29 frame | 484ms |

PTG[1:0] Set the scan mode in non-display area.

| PTG1 | PTG0 | Gate outputs in non-display area | Source outputs in non-display area | Vcom output |
|------|------|----------------------------------|------------------------------------|-------------|
| 0 | 0 | Normal scan | Set with the PTS[2:0] bits | VcomH/VcomL |
| 0 | 1 | Setting Prohibited | - | - |
| 1 | 0 | Interval scan | Set with the PTS[2:0] bits | VcomH/VcomL |
| 1 | 1 | Setting Prohibited | - | - |

PTS[2:0]

Set the source output level in non-display area drive period (front/back porch period and blank area between partial displays).

When PTS[2] = 1, the operation of amplifiers which generates the grayscales other than V0 and V63 are halted and the step-up clock frequency becomes half the normal frequency in non-display drive period in order to reduce power consumption.

| PTS[2:0] | Source output level | | Grayscale amplifier in operation | Step-up clock frequency |
|----------|---------------------|--------------------|----------------------------------|-----------------------------|
| | Positive polarity | Negative polarity | | |
| 000 | V63 | V0 | V63 to V0 | Register Setting (DC1, DC0) |
| 001 | Setting Prohibited | Setting Prohibited | - | - |

| | | | | |
|-----|--------------------|--------------------|------------|-------------------------------|
| 010 | GND | GND | V63 to V0 | Register Setting (DC1, DC0) |
| 011 | Hi-Z | Hi-Z | V63 to V0 | Register Setting (DC1, DC0) |
| 100 | V63 | V0 | V63 and V0 | frequency setting by DC1, DC0 |
| 101 | Setting Prohibited | Setting Prohibited | - | - |
| 110 | GND | GND | V63 and V0 | frequency setting by DC1, DC0 |
| 111 | Hi-Z | Hi-Z | V63 and V0 | frequency setting by DC1, DC0 |

- Notes: 1. The power efficiency can be improved by halting grayscale amplifiers and slowing down the step-up clock frequency only in non-display drive period.
2. The gate output level in non-lit display area drive period is determined by PTG[1:0].

7.2.10. Display Control 4 (R0Ah)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|---------|------|------|------|
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | FMARKOE | FMI2 | FMI1 | FMI0 |

FMI[2:0] Set the output interval of FMARK signal according to the display data rewrite cycle and data transfer rate.

FMARKOE When FMARKOE=1, ILI9328 starts to output FMARK signal in the output interval set by FMI[2:0] bits.

| FMI[2:0] | Output Interval |
|----------|------------------|
| 000 | 1 frame |
| 001 | 2 frame |
| 011 | 4 frame |
| 101 | 6 frame |
| Others | Setting disabled |

7.2.11. RGB Display Interface Control 1 (R0Ch)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|------|------|------|-----|-----|----|----|----|----|-----|-----|----|----|------|------|
| W | 1 | 0 | ENC2 | ENC1 | ENC0 | 0 | 0 | 0 | RM | 0 | 0 | DM1 | DM0 | 0 | 0 | RIM1 | RIM0 |

RIM[1:0] Select the RGB interface data width.

| RIM1 | RIM0 | RGB Interface Mode |
|------|------|---|
| 0 | 0 | 18-bit RGB interface (1 transfer/pixel), DB[17:0] |
| 0 | 1 | 16-bit RGB interface (1 transfer/pixel), DB[17:13] and DB[11:1] |
| 1 | 0 | 6-bit RGB interface (3 transfers/pixel), DB[17:12] |
| 1 | 1 | Setting disabled |

Note1: Registers are set only by the system interface.

Note2: Be sure that one pixel (3 dots) data transfer finished when interface switch.

DM[1:0] Select the display operation mode.

| DM1 | DM0 | Display Interface |
|-----|-----|-----------------------|
| 0 | 0 | Internal system clock |
| 0 | 1 | RGB interface |
| 1 | 0 | VSYSN interface |
| 1 | 1 | Setting disabled |

The DM[1:0] setting allows switching between internal clock operation mode and external display interface operation mode. However, switching between the RGB interface operation mode and the

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VSYNC interface operation mode is prohibited.

RM Select the interface to access the GRAM.

Set RM to “1” when writing display data by the RGB interface.

| RM | Interface for RAM Access |
|-----------|----------------------------------|
| 0 | System interface/VSYNC interface |
| 1 | RGB interface |

| Display State | Operation Mode | RAM Access (RM) | Display Operation Mode (DM[1:0]) |
|---|--------------------------|------------------------------|--|
| Still pictures | Internal clock operation | System interface (RM = 0) | Internal clock operation (DM[1:0] = 00) |
| Moving pictures | RGB interface (1) | RGB interface (RM = 1) | RGB interface (DM[1:0] = 01) |
| Rewrite still picture area while Displaying moving pictures. | RGB interface | System interface (RM = 0) | RGB interface (DM[1:0] = 01) |
| Moving pictures | VSYNC interface | System interface (RM = 0) | VSYNC interface (DM[1:0] = 10) |

Note 1: Registers are set only via the system interface or SPI interface.

Note 2: Refer to the flowcharts of “RGB Input Interface” section for the mode switch.

ENC[2:0] Set the GRAM write cycle through the RGB interface

| ENC[2:0] | GRAM Write Cycle (Frame periods) |
|-----------------|---|
| 000 | 1 Frame |
| 001 | 2 Frames |
| 010 | 3 Frames |
| 011 | 4 Frames |
| 100 | 5 Frames |
| 101 | 6 Frames |
| 110 | 7 Frames |
| 111 | 8 Frames |

7.2.12. Frame Marker Position (R0Dh)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|----|------|------|------|------|------|------|------|------|------|
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | FMP8 | FMP7 | FMP6 | FMP5 | FMP4 | FMP3 | FMP2 | FMP1 | FMP0 |

FMP[8:0] Sets the output position of frame cycle (frame marker).

When FMP[8:0]=0, a high-active pulse FMARK is output at the start of back porch period for one display line period (1H).

Make sure the $9'h000 \leq FMP \leq BP+NL+FP$

| FMP[8:0] | FMARK Output Position |
|-----------------|------------------------------|
| 9'h000 | 0 th line |
| 9'h001 | 1 st line |
| 9'h002 | 2 nd line |
| 9'h003 | 3 rd line |
| ⋮ | ⋮ |
| 9'h175 | 373 rd line |

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| | |
|--------|------------------------|
| 9'h176 | 374 th line |
| 9'h177 | 375 th line |

7.2.13. RGB Display Interface Control 2 (R0Fh)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|----|----|----|----|----|------|------|----|-----|-----|
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VSPL | HSPL | 0 | EPL | DPL |

DPL: Sets the signal polarity of the DOTCLK pin.

DPL = "0" The data is input on the rising edge of DOTCLK

DPL = "1" The data is input on the falling edge of DOTCLK

EPL: Sets the signal polarity of the ENABLE pin.

EPL = "0" The data DB17-0 is written when ENABLE = "0". Disable data write operation when ENABLE = "1".

EPL = "1" The data DB17-0 is written when ENABLE = "1". Disable data write operation when ENABLE = "0".

HSPL: Sets the signal polarity of the HSYNC pin.

HSPL = "0" Low active

HSPL = "1" High active

VSPL: Sets the signal polarity of the VSYNC pin.

VSPL = "0" Low active

VSPL = "1" High active

7.2.14. Power Control 1 (R10h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|----|----|-----|-----|
| W | 1 | 0 | 0 | 0 | SAP | 0 | BT2 | BT1 | BT0 | APE | AP2 | AP1 | AP0 | 0 | 0 | SLP | STB |

SLP: When SLP = 1, ILI9328 enters the sleep mode and the display operation stops except the RC oscillator to reduce the power consumption. In the sleep mode, the GRAM data and instructions cannot be updated except the following two instructions.

- Exit sleep mode (SLP = "0")
- Start oscillation

STB: When STB = 1, ILI9328 enters the standby mode and the display operation stops except the GRAM power supply to reduce the power consumption. In the STB mode, the GRAM data and instructions cannot be updated except the following two instructions.

- Exit standby mode (STB = "0")
- Start oscillation

AP[2:0]: Adjusts the constant current in the operational amplifier circuit in the LCD power supply circuit. The larger constant current enhances the drivability of the LCD, but it also increases the current consumption. Adjust the constant current taking the trade-off into account between the display quality

and the current consumption. In no-display period, set AP[2:0] = "000" to halt the operational amplifier circuits and the step-up circuits to reduce current consumption.

| AP[2:0] | Gamma driver amplifiers | Source driver amplifiers |
|---------|-------------------------|--------------------------|
| 000 | Halt | Halt |
| 001 | 1.00 | 1.00 |
| 010 | 1.00 | 0.75 |
| 011 | 1.00 | 0.50 |
| 100 | 0.75 | 1.00 |
| 101 | 0.75 | 0.75 |
| 110 | 0.75 | 0.50 |
| 111 | 0.50 | 0.50 |

SAP: Source Driver output control

SAP=0, Source driver is disabled.

SAP=1, Source driver is enabled.

When starting the charge-pump of LCD in the Power ON stage, make sure that SAP=0, and set the SAP=1, after starting up the LCD power supply circuit.

APE: Power supply enable bit.

Set APE = "1" to start the generation of power supply according to the power supply startup sequence.

BT[3:0]: Sets the factor used in the step-up circuits.

Select the optimal step-up factor for the operating voltage. To reduce power consumption, set a smaller factor.

| BT[2:0] | DDVDH | VCL | VGH | VGL |
|---------|----------|--------|----------|------------|
| 3'h0 | Vci1 x 2 | - Vci1 | Vci1 x 6 | - Vci1 x 5 |
| 3'h1 | | - Vci1 | | - Vci1 x 4 |
| 3'h2 | | - Vci1 | | - Vci1 x 3 |
| 3'h3 | Vci1 x 2 | - Vci1 | Vci1 x 5 | - Vci1 x 5 |
| 3'h4 | | | | - Vci1 x 4 |
| 3'h5 | | | | - Vci1 x 3 |
| 3'h6 | Vci1 x 2 | - Vci1 | Vci1 x 4 | - Vci1 x 4 |
| 3'h7 | | | | - Vci1 x 3 |

Notes: 1. Connect capacitors to the capacitor connection pins when generating DDVDH, VGH, VGL and VCL levels.

2. Make sure DDVDH = 6.0V (max.), VGH = 15.0V (max.), VGL = - 12.5V (max) and VCL = -3.0V (max.)

7.2.15. Power Control 2 (R11h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|------|------|------|----|------|------|------|----|-----|-----|-----|
| W | 1 | 0 | 0 | 0 | 0 | 0 | DC12 | DC11 | DC10 | 0 | DC02 | DC01 | DC00 | 0 | VC2 | VC1 | VC0 |

VC[2:0] Sets the ratio factor of Vci to generate the reference voltages Vci1.

| VC2 | VC1 | VC0 | Vci1 voltage |
|-----|-----|-----|--------------|
| 0 | 0 | 0 | 0.95 x Vci |
| 0 | 0 | 1 | 0.90 x Vci |

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| | | | |
|---|---|---|------------|
| 0 | 1 | 0 | 0.85 x Vci |
| 0 | 1 | 1 | 0.80 x Vci |
| 1 | 0 | 0 | 0.75 x Vci |
| 1 | 0 | 1 | 0.70 x Vci |
| 1 | 1 | 0 | Disabled |
| 1 | 1 | 1 | 1.0 x Vci |

DC0[2:0]: Selects the operating frequency of the step-up circuit 1. The higher step-up operating frequency enhances the drivability of the step-up circuit and the quality of display but increases the current consumption. Adjust the frequency taking the trade-off between the display quality and the current consumption into account.

DC1[2:0]: Selects the operating frequency of the step-up circuit 2. The higher step-up operating frequency enhances the drivability of the step-up circuit and the quality of display but increases the current consumption. Adjust the frequency taking the trade-off between the display quality and the current consumption into account.

| DC02 | DC01 | DC00 | Step-up circuit1 step-up frequency (f_{DCDC1}) | DC12 | DC11 | DC10 | Step-up circuit2 step-up frequency (f_{DCDC2}) |
|------|------|------|---|------|------|------|---|
| 0 | 0 | 0 | Fosc | 0 | 0 | 0 | Fosc / 4 |
| 0 | 0 | 1 | Fosc / 2 | 0 | 0 | 1 | Fosc / 8 |
| 0 | 1 | 0 | Fosc / 4 | 0 | 1 | 0 | Fosc / 16 |
| 0 | 1 | 1 | Fosc / 8 | 0 | 1 | 1 | Fosc / 32 |
| 1 | 0 | 0 | Fosc / 16 | 1 | 0 | 0 | Fosc / 64 |
| 1 | 0 | 1 | Fosc / 32 | 1 | 0 | 1 | Fosc / 128 |
| 1 | 1 | 0 | Fosc / 64 | 1 | 1 | 0 | Fosc / 256 |
| 1 | 1 | 1 | Halt step-up circuit 1 | 1 | 1 | 1 | Halt step-up circuit 2 |

Note: Be sure $f_{DCDC1} \geq f_{DCDC2}$ when setting DC0[2:0] and DC1[2:0].

7.2.16. Power Control 3 (R12h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|----|----|-------|----|----|-----|------|------|------|------|
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VCIRE | 0 | 0 | PON | VRH3 | VRH2 | VRH1 | VRH0 |

VRH[3:0] Set the amplifying rate (1.6 ~ 1.9) of Vci applied to output the VREG1OUT level, which is a reference level for the VCOM level and the grayscale voltage level.

VCIRE: Select the external reference voltage Vci or internal reference voltage VCIR.

| | |
|---------|---|
| VCIRE=0 | External reference voltage Vci (default) |
| VCIRE=1 | Internal reference voltage 2.5V |

| VCIRE =0 | | | | | VCIRE =1 | | | | |
|----------|------|------|------|------------|----------|------|------|------|----------------------|
| VRH3 | VRH2 | VRH1 | VRH0 | VREG1OUT | VRH3 | VRH2 | VRH1 | VRH0 | VREG1OUT |
| 0 | 0 | 0 | 0 | Halt | 0 | 0 | 0 | 0 | Halt |
| 0 | 0 | 0 | 1 | Vci x 2.00 | 0 | 0 | 0 | 1 | 2.5V x 2.00 = 5.000V |
| 0 | 0 | 1 | 0 | Vci x 2.05 | 0 | 0 | 1 | 0 | 2.5V x 2.05 = 5.125V |
| 0 | 0 | 1 | 1 | Vci x 2.10 | 0 | 0 | 1 | 1 | 2.5V x 2.10 = 5.250V |
| 0 | 1 | 0 | 0 | Vci x 2.20 | 0 | 1 | 0 | 0 | 2.5V x 2.20 = 5.500V |
| 0 | 1 | 0 | 1 | Vci x 2.30 | 0 | 1 | 0 | 1 | 2.5V x 2.30 = 5.750V |
| 0 | 1 | 1 | 0 | Vci x 2.40 | 0 | 1 | 1 | 0 | 2.5V x 2.40 = 6.000V |

| | | | | | | | | | |
|---|---|---|---|------------|---|---|---|---|----------------------|
| 0 | 1 | 1 | 1 | Vci x 2.40 | 0 | 1 | 1 | 1 | 2.5V x 2.40 = 6.000V |
| 1 | 0 | 0 | 0 | Vci x 1.60 | 1 | 0 | 0 | 0 | 2.5V x 1.60 = 4.000V |
| 1 | 0 | 0 | 1 | Vci x 1.65 | 1 | 0 | 0 | 1 | 2.5V x 1.65 = 4.125V |
| 1 | 0 | 1 | 0 | Vci x 1.70 | 1 | 0 | 1 | 0 | 2.5V x 1.70 = 4.250V |
| 1 | 0 | 1 | 1 | Vci x 1.75 | 1 | 0 | 1 | 1 | 2.5V x 1.75 = 4.375V |
| 1 | 1 | 0 | 0 | Vci x 1.80 | 1 | 1 | 0 | 0 | 2.5V x 1.80 = 4.500V |
| 1 | 1 | 0 | 1 | Vci x 1.85 | 1 | 1 | 0 | 1 | 2.5V x 1.85 = 4.625V |
| 1 | 1 | 1 | 0 | Vci x 1.90 | 1 | 1 | 1 | 0 | 2.5V x 1.90 = 4.750V |
| 1 | 1 | 1 | 1 | Vci x 1.95 | 1 | 1 | 1 | 1 | 2.5V x 1.95 = 4.875V |

When $VCI < 2.5V$, Internal reference voltage will be same as VCI .

Make sure that VC and VRH setting restriction: $VREG1OUT \leq (DDVDH - 0.2)V$.

PON: Control ON/OFF of circuit3 (VGL) output.

| | |
|-------|-----------------------|
| PON=0 | VGL output is disable |
| PON=1 | VGL output is enable |

7.2.17. Power Control 4 (R13h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|------|------|------|------|------|----|----|----|----|----|----|----|----|
| W | 1 | 0 | 0 | 0 | VDV4 | VDV3 | VDV2 | VDV1 | VDV0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

VDV[4:0] Select the factor of $VREG1OUT$ to set the amplitude of $Vcom$ alternating voltage from 0.70 to 1.24 x $VREG1OUT$.

| VDV4 | VDV3 | VDV2 | VDV1 | VDV0 | VCOM amplitude |
|------|------|------|------|------|------------------------|
| 0 | 0 | 0 | 0 | 0 | $VREG1OUT \times 0.70$ |
| 0 | 0 | 0 | 0 | 1 | $VREG1OUT \times 0.72$ |
| 0 | 0 | 0 | 1 | 0 | $VREG1OUT \times 0.74$ |
| 0 | 0 | 0 | 1 | 1 | $VREG1OUT \times 0.76$ |
| 0 | 0 | 1 | 0 | 0 | $VREG1OUT \times 0.78$ |
| 0 | 0 | 1 | 0 | 1 | $VREG1OUT \times 0.80$ |
| 0 | 0 | 1 | 1 | 0 | $VREG1OUT \times 0.82$ |
| 0 | 0 | 1 | 1 | 1 | $VREG1OUT \times 0.84$ |
| 0 | 1 | 0 | 0 | 0 | $VREG1OUT \times 0.86$ |
| 0 | 1 | 0 | 0 | 1 | $VREG1OUT \times 0.88$ |
| 0 | 1 | 0 | 1 | 0 | $VREG1OUT \times 0.90$ |
| 0 | 1 | 0 | 1 | 1 | $VREG1OUT \times 0.92$ |
| 0 | 1 | 1 | 0 | 0 | $VREG1OUT \times 0.94$ |
| 0 | 1 | 1 | 0 | 1 | $VREG1OUT \times 0.96$ |
| 0 | 1 | 1 | 1 | 0 | $VREG1OUT \times 0.98$ |
| 0 | 1 | 1 | 1 | 1 | $VREG1OUT \times 1.00$ |

| VDV4 | VDV3 | VDV2 | VDV1 | VDV0 | VCOM amplitude |
|------|------|------|------|------|------------------------|
| 1 | 0 | 0 | 0 | 0 | $VREG1OUT \times 0.94$ |
| 1 | 0 | 0 | 0 | 1 | $VREG1OUT \times 0.96$ |
| 1 | 0 | 0 | 1 | 0 | $VREG1OUT \times 0.98$ |
| 1 | 0 | 0 | 1 | 1 | $VREG1OUT \times 1.00$ |
| 1 | 0 | 1 | 0 | 0 | $VREG1OUT \times 1.02$ |
| 1 | 0 | 1 | 0 | 1 | $VREG1OUT \times 1.04$ |
| 1 | 0 | 1 | 1 | 0 | $VREG1OUT \times 1.06$ |
| 1 | 0 | 1 | 1 | 1 | $VREG1OUT \times 1.08$ |
| 1 | 1 | 0 | 0 | 0 | $VREG1OUT \times 1.10$ |
| 1 | 1 | 0 | 0 | 1 | $VREG1OUT \times 1.12$ |
| 1 | 1 | 0 | 1 | 0 | $VREG1OUT \times 1.14$ |
| 1 | 1 | 0 | 1 | 1 | $VREG1OUT \times 1.16$ |
| 1 | 1 | 1 | 0 | 0 | $VREG1OUT \times 1.18$ |
| 1 | 1 | 1 | 0 | 1 | $VREG1OUT \times 1.20$ |
| 1 | 1 | 1 | 1 | 0 | $VREG1OUT \times 1.22$ |
| 1 | 1 | 1 | 1 | 1 | $VREG1OUT \times 1.24$ |

Set **VDV[4:0]** to let $Vcom$ amplitude less than 6V.

7.2.18. GRAM Horizontal/Vertical Address Set (R20h, R21h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|----|------|------|------|------|------|------|------|-----|-----|
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | AD7 | AD6 | AD5 | AD4 | AD3 | AD2 | AD1 | AD0 |
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | AD16 | AD15 | AD14 | AD13 | AD12 | AD11 | AD10 | AD9 | AD8 |

AD[16:0] Set the initial value of address counter (AC).

The address counter (AC) is automatically updated in accordance to the setting of the AM, I/D bits as data is written to the internal GRAM. The address counter is not automatically updated when read data from the internal GRAM.

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| AD[16:0] | GRAM Data Map |
|-----------------------|----------------------------------|
| 17'h00000 ~ 17'h000EF | 1 st line GRAM Data |
| 17'h00100 ~ 17'h001EF | 2 nd line GRAM Data |
| 17'h00200 ~ 17'h002EF | 3 rd line GRAM Data |
| 17'h00300 ~ 17'h003EF | 4 th line GRAM Data |
| 17'h13D00 ~ 17'h13DEF | 318 th line GRAM Data |
| 17'h13E00 ~ 17'h13EEF | 319 th line GRAM Data |
| 17'h13F00 ~ 17'h13FEF | 320 th line GRAM Data |

Note1: When the RGB interface is selected (RM = "1"), the address AD[16:0] is set to the address counter every frame on the falling edge of VSYNC.

Note2: When the internal clock operation or the VSYNC interface mode is selected (RM = "0"), the address AD[16:0] is set to address counter when update register R21.

7.2.19. Write Data to GRAM (R22h)

| R/W | RS | D17 | D16 | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|---|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|----|----|
| W | 1 | RAM write data (WD[17:0], the DB[17:0] pin assignment differs for each interface. | | | | | | | | | | | | | | | | | |

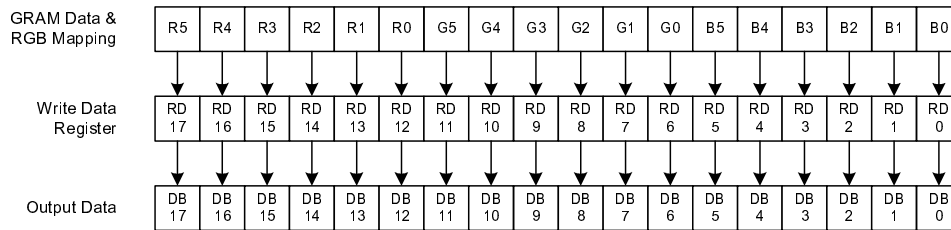
This register is the GRAM access port. When update the display data through this register, the address counter (AC) is increased/decreased automatically.

7.2.20. Read Data from GRAM (R22h)

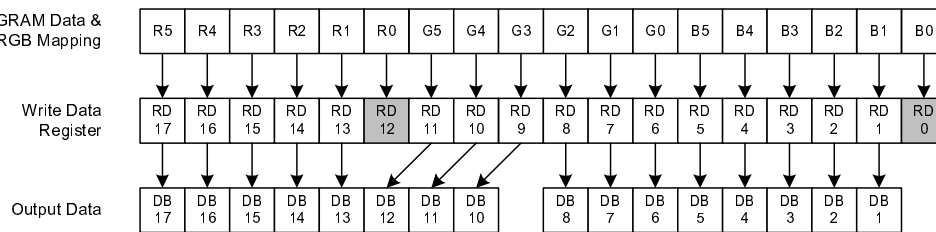
| R/W | RS | D17 | D16 | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|--|-----|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|----|----|----|----|
| R | 1 | RAM Read Data (RD[17:0], the DB[17:0] pin assignment differs for each interface. | | | | | | | | | | | | | | | | | |

RD[17:0] Read 18-bit data from GRAM through the read data register (RDR).

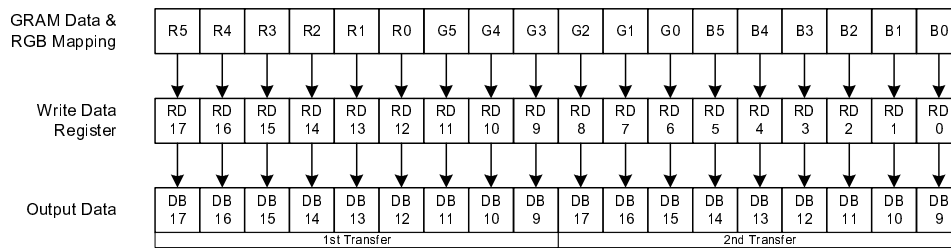
18-bit System Interface



16-bit System Interface



9-bit System Interface



8-bit System Interface / Serial Data Transfer Interface

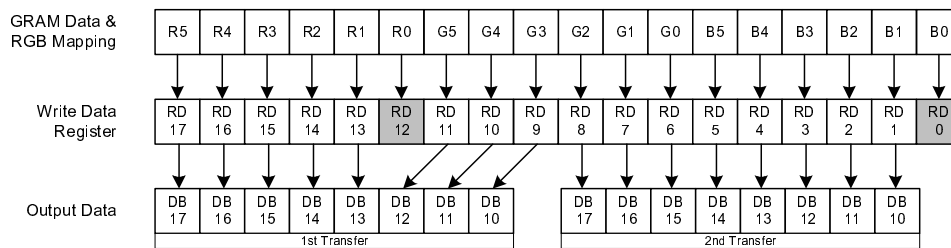


Figure 28 Data Read from GRAM through Read Data Register in 18-/16-/9-/8-bit Interface Mode

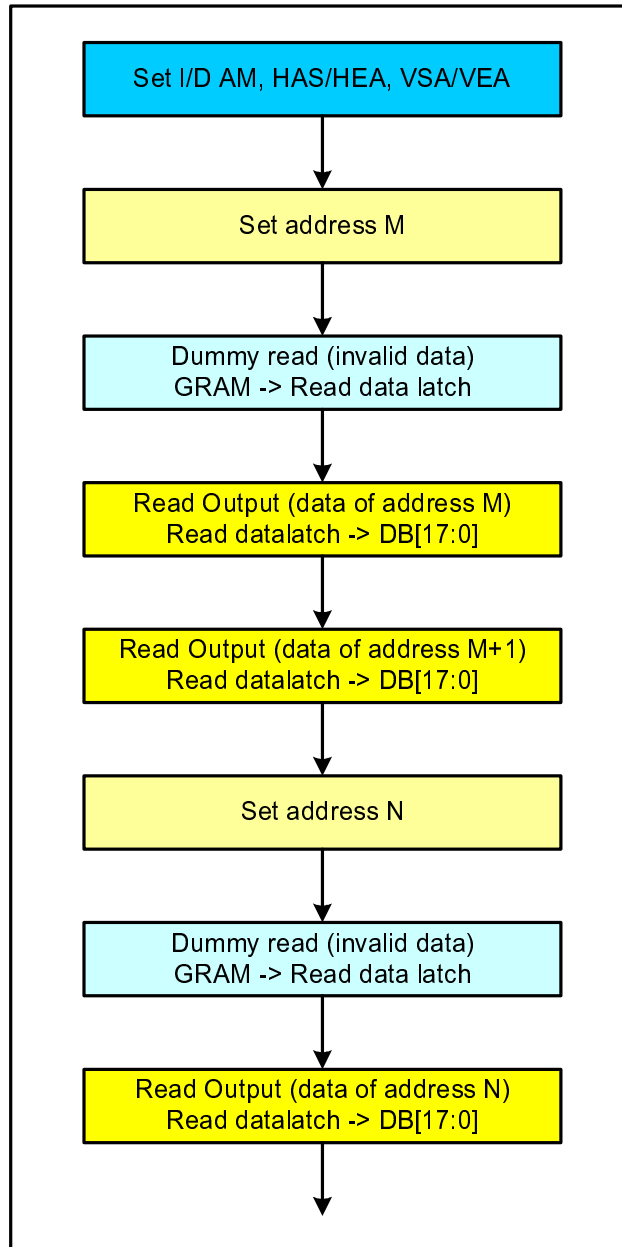


Figure 29 GRAM Data Read Back Flow Chart

7.2.21. Power Control 7 (R29h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|----|----|----|----|------|------|------|------|------|------|
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VCM5 | VCM4 | VCM3 | VCM2 | VCM1 | VCM0 |

VCM[5:0] Set the internal VcomH voltage.

| VCM5 | VCM4 | VCM3 | VCM2 | VCM1 | VCM0 | VCOMH | | VCM5 | VCM4 | VCM3 | VCM2 | VCM1 | VCM0 | VCOMH | |
|------|------|------|------|------|------|-------------------|---|------|------|------|------|------|------|-------------------|---|
| 0 | 0 | 0 | 0 | 0 | 0 | VREG1OUT 0.685 | x | 1 | 0 | 0 | 0 | 0 | 0 | VREG1OUT 0.845 | x |
| 0 | 0 | 0 | 0 | 0 | 1 | VREG1OUT 0.690 | x | 1 | 0 | 0 | 0 | 0 | 1 | VREG1OUT 0.850 | x |
| 0 | 0 | 0 | 0 | 1 | 0 | VREG1OUT 0.695 | x | 1 | 0 | 0 | 0 | 1 | 0 | VREG1OUT 0.855 | x |
| 0 | 0 | 0 | 0 | 1 | 1 | VREG1OUT 0.700 | x | 1 | 0 | 0 | 0 | 1 | 1 | VREG1OUT 0.860 | x |
| 0 | 0 | 0 | 1 | 0 | 0 | VREG1OUT | x | 1 | 0 | 0 | 1 | 0 | 0 | VREG1OUT | x |

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| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|-------------------|---|---|---|---|---|---|-------|-------------------|---|--|--|--|--|
| | | | | | | 0.705 | | | | | | | 0.865 | | | | | | |
| 0 | 0 | 0 | 1 | 0 | 1 | VREG1OUT 0.710 | x | 1 | 0 | 0 | 1 | 0 | 1 | VREG1OUT 0.870 | x | | | | |
| 0 | 0 | 0 | 1 | 1 | 0 | VREG1OUT 0.715 | x | 1 | 0 | 0 | 1 | 1 | 0 | VREG1OUT 0.875 | x | | | | |
| 0 | 0 | 0 | 1 | 1 | 1 | VREG1OUT 0.720 | x | 1 | 0 | 0 | 1 | 1 | 1 | VREG1OUT 0.880 | x | | | | |
| 0 | 0 | 1 | 0 | 0 | 0 | VREG1OUT 0.725 | x | 1 | 0 | 1 | 0 | 0 | 0 | VREG1OUT 0.885 | x | | | | |
| 0 | 0 | 1 | 0 | 0 | 1 | VREG1OUT 0.730 | x | 1 | 0 | 1 | 0 | 0 | 1 | VREG1OUT 0.890 | x | | | | |
| 0 | 0 | 1 | 0 | 1 | 0 | VREG1OUT 0.735 | x | 1 | 0 | 1 | 0 | 1 | 0 | VREG1OUT 0.895 | x | | | | |
| 0 | 0 | 1 | 0 | 1 | 1 | VREG1OUT 0.740 | x | 1 | 0 | 1 | 0 | 1 | 1 | VREG1OUT 0.900 | x | | | | |
| 0 | 0 | 1 | 1 | 0 | 0 | VREG1OUT 0.745 | x | 1 | 0 | 1 | 1 | 0 | 0 | VREG1OUT 0.905 | x | | | | |
| 0 | 0 | 1 | 1 | 0 | 1 | VREG1OUT 0.750 | x | 1 | 0 | 1 | 1 | 0 | 1 | VREG1OUT 0.910 | x | | | | |
| 0 | 0 | 1 | 1 | 1 | 0 | VREG1OUT 0.755 | x | 1 | 0 | 1 | 1 | 1 | 0 | VREG1OUT 0.915 | x | | | | |
| 0 | 0 | 1 | 1 | 1 | 1 | VREG1OUT 0.760 | x | 1 | 0 | 1 | 1 | 1 | 1 | VREG1OUT 0.920 | x | | | | |
| 0 | 1 | 0 | 0 | 0 | 0 | VREG1OUT 0.765 | x | 1 | 1 | 0 | 0 | 0 | 0 | VREG1OUT 0.925 | x | | | | |
| 0 | 1 | 0 | 0 | 0 | 1 | VREG1OUT 0.770 | x | 1 | 1 | 0 | 0 | 0 | 1 | VREG1OUT 0.930 | x | | | | |
| 0 | 1 | 0 | 0 | 1 | 0 | VREG1OUT 0.775 | x | 1 | 1 | 0 | 0 | 1 | 0 | VREG1OUT 0.935 | x | | | | |
| 0 | 1 | 0 | 0 | 1 | 1 | VREG1OUT 0.780 | x | 1 | 1 | 0 | 0 | 1 | 1 | VREG1OUT 0.940 | x | | | | |
| 0 | 1 | 0 | 1 | 0 | 0 | VREG1OUT 0.785 | x | 1 | 1 | 0 | 1 | 0 | 0 | VREG1OUT 0.945 | x | | | | |
| 0 | 1 | 0 | 1 | 0 | 1 | VREG1OUT 0.790 | x | 1 | 1 | 0 | 1 | 0 | 1 | VREG1OUT 0.950 | x | | | | |
| 0 | 1 | 0 | 1 | 1 | 0 | VREG1OUT 0.795 | x | 1 | 1 | 0 | 1 | 1 | 0 | VREG1OUT 0.955 | x | | | | |
| 0 | 1 | 0 | 1 | 1 | 1 | VREG1OUT 0.800 | x | 1 | 1 | 0 | 1 | 1 | 1 | VREG1OUT 0.960 | x | | | | |
| 0 | 1 | 1 | 0 | 0 | 0 | VREG1OUT 0.805 | x | 1 | 1 | 1 | 0 | 0 | 0 | VREG1OUT 0.965 | x | | | | |
| 0 | 1 | 1 | 0 | 0 | 1 | VREG1OUT 0.810 | x | 1 | 1 | 1 | 0 | 0 | 1 | VREG1OUT 0.970 | x | | | | |
| 0 | 1 | 1 | 0 | 1 | 0 | VREG1OUT 0.815 | x | 1 | 1 | 1 | 0 | 1 | 0 | VREG1OUT 0.975 | x | | | | |
| 0 | 1 | 1 | 0 | 1 | 1 | VREG1OUT 0.820 | x | 1 | 1 | 1 | 0 | 1 | 1 | VREG1OUT 0.980 | x | | | | |
| 0 | 1 | 1 | 1 | 0 | 0 | VREG1OUT 0.825 | x | 1 | 1 | 1 | 1 | 0 | 0 | VREG1OUT 0.985 | x | | | | |
| 0 | 1 | 1 | 1 | 0 | 1 | VREG1OUT 0.830 | x | 1 | 1 | 1 | 1 | 0 | 1 | VREG1OUT 0.990 | x | | | | |
| 0 | 1 | 1 | 1 | 1 | 0 | VREG1OUT 0.835 | x | 1 | 1 | 1 | 1 | 1 | 0 | VREG1OUT 0.995 | x | | | | |
| 0 | 1 | 1 | 1 | 1 | 1 | VREG1OUT 0.840 | x | 1 | 1 | 1 | 1 | 1 | 1 | VREG1OUT 1.000 | x | | | | |

7.2.22. Frame Rate and Color Control (R2Bh)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|----|----|----|----|----|----|------|------|------|------|
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | FRS3 | FRS2 | FRS1 | FRS0 |

FRS[4:0] Set the frame rate when the internal resistor is used for oscillator circuit.

| FRS[3:0] | FRS[3:0] | Frame Rate |
|----------|----------|------------|
| 0000 | 4'h0 | 30 |

| | | |
|------|------|--------------------|
| 0001 | 4'h1 | 31 |
| 0010 | 4'h2 | 33 |
| 0011 | 4'h3 | 35 |
| 0100 | 4'h4 | 38 |
| 0101 | 4'h5 | 40 |
| 0110 | 4'h6 | 43 |
| 0111 | 4'h7 | 47 |
| 1000 | 4'h8 | 51 |
| 1001 | 4'h9 | 56 |
| 1010 | 4'hA | 62 |
| 1011 | 4'hB | 70 |
| 1100 | 4'hC | 80 |
| 1101 | 4'hD | 93 |
| 1110 | 4'hE | 112 |
| 1111 | 4'hF | Setting Prohibited |

7.2.23. Gamma Control (R30h ~ R3Dh)

| | R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|------|-----|----|-----|-----|-----|---------|---------|---------|---------|---------|----|----|----|----|---------|---------|---------|---------|
| R30h | W | 1 | 0 | 0 | 0 | 0 | 0 | KP1[2] | KP1[1] | KP1[0] | 0 | 0 | 0 | 0 | 0 | KP0[2] | KP0[1] | KP0[0] |
| R31h | W | 1 | 0 | 0 | 0 | 0 | 0 | KP3[2] | KP3[1] | KP3[0] | 0 | 0 | 0 | 0 | 0 | KP2[2] | KP2[1] | KP2[0] |
| R32h | W | 1 | 0 | 0 | 0 | 0 | 0 | KP5[2] | KP5[1] | KP5[0] | 0 | 0 | 0 | 0 | 0 | KP4[2] | KP4[1] | KP4[0] |
| R35h | W | 1 | 0 | 0 | 0 | 0 | 0 | RP1[2] | RP1[1] | RP1[0] | 0 | 0 | 0 | 0 | 0 | RP0[2] | RP0[1] | RP0[0] |
| R36h | W | 1 | 0 | 0 | 0 | VRP1[4] | VRP1[3] | VRP1[2] | VRP1[1] | VRP1[0] | 0 | 0 | 0 | 0 | VRP0[3] | VRP0[2] | VRP0[1] | VRP0[0] |
| R37h | W | 1 | 0 | 0 | 0 | 0 | 0 | KN1[2] | KN1[1] | KN1[0] | 0 | 0 | 0 | 0 | 0 | KN0[2] | KN0[1] | KN0[0] |
| R38h | W | 1 | 0 | 0 | 0 | 0 | 0 | KN3[2] | KN3[1] | KN3[0] | 0 | 0 | 0 | 0 | 0 | KN2[2] | KN2[1] | KN2[0] |
| R39h | W | 1 | 0 | 0 | 0 | 0 | 0 | KN5[2] | KN5[1] | KN5[0] | 0 | 0 | 0 | 0 | 0 | KN4[2] | KN4[1] | KN4[0] |
| R3Ch | W | 1 | 0 | 0 | 0 | 0 | 0 | RN1[2] | RN1[1] | RN1[0] | 0 | 0 | 0 | 0 | 0 | RN0[2] | RN0[1] | RN0[0] |
| R3Dh | W | 1 | 0 | 0 | 0 | VRN1[4] | VRN1[3] | VRN1[2] | VRN1[1] | VRN1[0] | 0 | 0 | 0 | 0 | VRN0[3] | VRN0[2] | VRN0[1] | VRN0[0] |

KP5-0[2:0] : γ fine adjustment register for positive polarity

RP1-0[2:0] : γ gradient adjustment register for positive polarity

VRP1-0[4:0] : γ amplitude adjustment register for positive polarity

KN5-0[2:0] : γ fine adjustment register for negative polarity

RN1-0[2:0] : γ gradient adjustment register for negative polarity

VRN1-0[4:0] : γ amplitude adjustment register for negative polarity

For details “ γ -Correction Function” section.

7.2.24. Horizontal and Vertical RAM Address Position (R50h, R51h, R52h, R53h)

| | R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|------|-----|----|-----|-----|-----|-----|-----|-----|----|----|------|------|------|------|------|------|------|------|
| R50h | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | HSA7 | HSA6 | HSA5 | HSA4 | HSA3 | HSA2 | HSA1 | HSA0 |
| R51h | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | HEA7 | HEA6 | HEA5 | HEA4 | HEA3 | HEA2 | HEA1 | HEA0 |
| R52h | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VSA8 | VSA7 | VSA6 | VSA5 | VSA4 | VSA3 | VSA2 | VSA1 |
| R53h | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VEA8 | VEA7 | VEA6 | VEA5 | VEA4 | VEA3 | VEA2 | VEA1 |

HSA[7:0]/HEA[7:0] HSA[7:0] and HEA[7:0] represent the respective addresses at the start and end of the window address area in horizontal direction. By setting HSA and HEA bits, it is possible to limit the area on the GRAM horizontally for writing data. The HSA and HEA bits must be set before starting RAM write operation. In setting these bits, be sure $0000h \leq HSA[7:0] < HEA[7:0] \leq EFh$. and $04h \leq HEA-HAS$.

VSA[8:0]/VEA[8:0] VSA[8:0] and VEA[8:0] represent the respective addresses at the start and end of the window address area in vertical direction. By setting VSA and VEA bits, it is possible to limit the area on the GRAM vertically for writing data. The VSA and VEA bits must be set before starting RAM write operation. In setting, be sure $000h \leq VSA[8:0] < VEA[8:0] \leq 13Fh$.

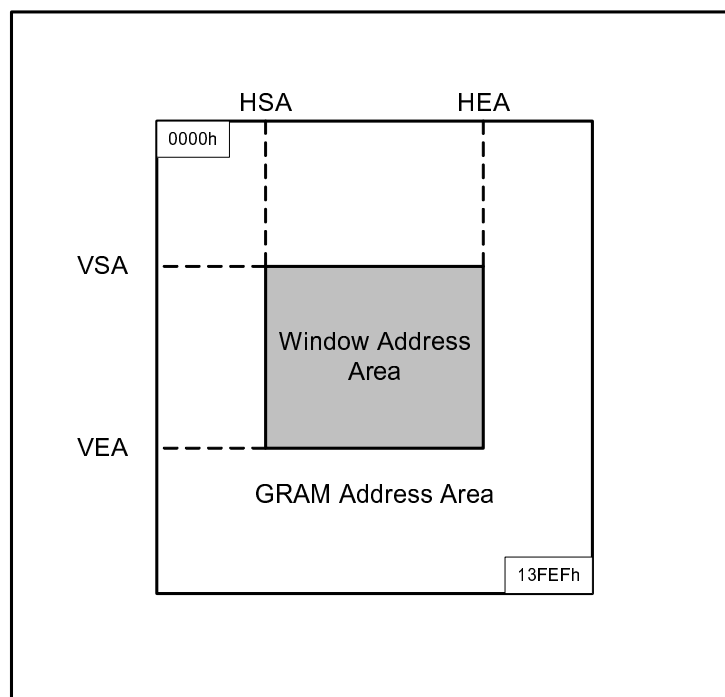


Figure 30 GRAM Access Range Configuration

$$0000h \leq HAS[7:0] \leq HEA[7:0] \leq EFh$$

$$000h \leq VSA[8:0] \leq VEA[8:0] \leq 13Fh$$

Note1. The window address range must be within the GRAM address space.

Note2. Data are written to GRAM in four-words when operating in high speed mode, the dummy write operations should be inserted depending on the window address area. For details, see the High-Speed RAM Write Function section.

7.2.25. Gate Scan Control (R60h, R61h, R6Ah)

| | R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|------|-----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|------|------|------|------|------|------|
| R60h | W | 1 | GS | 0 | NL5 | NL4 | NL3 | NL2 | NL1 | NL0 | 0 | 0 | SCN5 | SCN4 | SCN3 | SCN2 | SCN1 | SCN0 |
| R61h | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | NDL | VLE | REV |
| R6Ah | W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VL8 | VL7 | VL6 | VL5 | VL4 | VL3 | VL2 | VL1 | VL0 |

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SCN[5:0] The ILI9328 allows to specify the gate line from which the gate driver starts to scan by setting the SCN[5:0] bits.

| SCN[5:0] | Scanning Start Position | | | |
|-----------|-------------------------|------------------|------------------|------------------|
| | SM=0 | | SM=1 | |
| | GS=0 | GS=1 | GS=0 | GS=1 |
| 00h | G1 | G320 | G1 | G320 |
| 01h | G9 | G312 | G17 | G304 |
| 02h | G17 | G304 | G33 | G288 |
| 03h | G25 | G296 | G49 | G272 |
| 04h | G33 | G288 | G65 | G256 |
| 05h | G41 | G280 | G81 | G240 |
| 06h | G49 | G272 | G97 | G224 |
| 07h | G57 | G264 | G113 | G208 |
| 08h | G65 | G256 | G129 | G192 |
| 09h | G73 | G248 | G145 | G176 |
| 0Ah | G81 | G240 | G161 | G160 |
| 0Bh | G89 | G232 | G177 | G144 |
| 0Ch | G97 | G224 | G193 | G128 |
| 0Dh | G105 | G216 | G209 | G112 |
| 0Eh | G113 | G208 | G2 | G96 |
| 0Fh | G121 | G200 | G18 | G80 |
| 10h | G129 | G192 | G34 | G64 |
| 11h | G137 | G184 | G50 | G48 |
| 12h | G145 | G176 | G66 | G32 |
| 13h | G153 | G168 | G82 | G16 |
| 14h | G161 | G160 | G98 | G319 |
| 15h | G169 | G152 | G114 | G303 |
| 16h | G177 | G144 | G130 | G287 |
| 17h | G185 | G136 | G146 | G271 |
| 18h | G193 | G128 | G162 | G255 |
| 19h | G201 | G120 | G178 | G239 |
| 1Ah | G209 | G112 | G194 | G223 |
| 1Bh | G217 | G104 | G114 | G207 |
| 1Ch | G225 | G96 | G130 | G191 |
| 1Dh | G233 | G88 | G146 | G175 |
| 1Eh | G241 | G80 | G162 | G159 |
| 1Fh | G249 | G72 | G178 | G143 |
| 20h | G257 | G64 | G194 | G127 |
| 21h | G265 | G56 | G210 | G111 |
| 22h | G273 | G48 | G226 | G95 |
| 23h | G281 | G40 | G242 | G79 |
| 24h | G289 | G32 | G258 | G63 |
| 25h | G297 | G24 | G274 | G47 |
| 26h | G305 | G16 | G290 | G31 |
| 27h | G313 | G8 | G306 | G15 |
| 28h ~ 3Fh | Setting disabled | Setting disabled | Setting disabled | Setting disabled |

NL[5:0]: Sets the number of lines to drive the LCD at an interval of 8 lines. The GRAM address mapping is not affected by the number of lines set by NL[5:0]. The number of lines must be the same or more than the number of lines necessary for the size of the liquid crystal panel.

| NL[5:0] | LCD Drive Line |
|----------------|-----------------------|
| 6'h00 | 8 lines |
| 6'h01 | 16 lines |
| 6'h02 | 24lines |
| ... | ... |
| 6'h1D | 240 lines |
| 6'h1E | 248 lines |
| 6'h1F | 256 lines |
| 6'h20 | 264 lines |
| 6'h21 | 272 lines |
| 6'h22 | 280 lines |
| 6'h23 | 288 lines |
| 6'h24 | 296 lines |
| 6'h25 | 304 lines |
| 6'h26 | 312 line |
| 6'h27 | 320 line |
| Others | Setting inhibited |

NDL: Sets the source driver output level in the non-display area.

| NDL | Non-Display Area | |
|------------|--------------------------|--------------------------|
| | Positive Polarity | Negative Polarity |
| 0 | V63 | V0 |
| 1 | V0 | V63 |

GS: Sets the direction of scan by the gate driver in the range determined by SCN[4:0] and NL[4:0]. The scan direction determined by GS = 0 can be reversed by setting GS = 1.

When GS = 0, the scan direction is from G1 to G320.

When GS = 1, the scan direction is from G320 to G1

REV: Enables the grayscale inversion of the image by setting REV=1.

| REV | GRAM Data | Source Output in Display Area | |
|------------|------------------|--------------------------------------|--------------------------|
| | | Positive polarity | negative polarity |
| 0 | 18'h00000 | V63 | V0 |
| | . | . | . |
| | . | . | . |
| | 18'h3FFFF | V0 | V63 |
| 1 | 18'h00000 | V0 | V63 |
| | . | . | . |
| | . | . | . |
| | 18'h3FFFF | V63 | V0 |

VLE: Vertical scroll display enable bit. When VLE = 1, the ILI9328 starts displaying the base image from the line (of the physical display) determined by VL[8:0] bits. VL[8:0] sets the amount of scrolling, which is the number of lines to shift the start line of the display from the first line of the physical display. Note that the partial image display position is not affected by the base image scrolling.

The vertical scrolling is not available in external display interface operation. In this case, make sure to

set VLE = "0".

| VLE | Base Image Display |
|-----|--------------------|
| 0 | Fixed |
| 1 | Enable Scrolling |

VL[8:0]: Sets the scrolling amount of base image. The base image is scrolled in vertical direction and displayed from the line determined by VL[8:0]. Make sure that VL[8:0] ≤ 320 .

7.2.26. Partial Image 1 Display Position (R80h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | PTD | PTD | PTD | PTD | PTD | PTD | PTD | PTD | PTD |
| | | | | | | | | | P0[8] | P0[7] | P0[6] | P0[5] | P0[4] | P0[3] | P0[2] | P0[1] | P0[0] |

PTDP0[8:0]: Sets the display start position of partial image 1. The display areas of the partial images 1 and 2 must not overlap each another.

7.2.27. Partial Image 1 RAM Start/End Address (R81h, R82h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | PTS | PTS | PTS | PTS | PTS | PTS | PTS | PTS | PTS |
| | | | | | | | | | A0[8] | A0[7] | A0[6] | A0[5] | A0[4] | A0[3] | A0[2] | A0[1] | A0[0] |
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | PTE | PTE | PTE | PTE | PTE | PTE | PTE | PTE | PTE |
| | | | | | | | | | A0[8] | A0[7] | A0[6] | A0[5] | A0[4] | A0[3] | A0[2] | A0[1] | A0[0] |

PTSA0[8:0] PTEA0[8:0]: Sets the start line address and the end line address of the RAM area storing the data of partial image 1. Make sure PTSA0[8:0] \leq PTEA0[8:0].

7.2.28. Partial Image 2 Display Position (R83h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | PTD | PTD | PTD | PTD | PTD | PTD | PTD | PTD | PTD |
| | | | | | | | | | P1[8] | P1[7] | P1[6] | P1[5] | P1[4] | P1[3] | P1[2] | P1[1] | P1[0] |

PTDP1[8:0]: Sets the display start position of partial image 2. The display areas of the partial images 1 and 2 must not overlap each another.

7.2.29. Partial Image 2 RAM Start/End Address (R84h, R85h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|----|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | PTS | PTS | PTS | PTS | PTS | PTS | PTS | PTS | PTS |
| | | | | | | | | | A1[8] | A1[7] | A1[6] | A1[5] | A1[4] | A1[3] | A1[2] | A1[1] | A1[0] |
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | PTE | PTE | PTE | PTE | PTE | PTE | PTE | PTE | PTE |
| | | | | | | | | | A1[8] | A1[7] | A1[6] | A1[5] | A1[4] | A1[3] | A1[2] | A1[1] | A1[0] |

PTSA1[8:0] PTEA1[8:0]: Sets the start line address and the end line address of the RAM area storing the data of partial image 2. Make sure PTSA1[8:0] \leq PTEA1[8:0].

7.2.30. Panel Interface Control 1 (R90h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|-------|-------|----|----|----|-------|-------|-------|-------|-------|
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | DIVI1 | DIVI0 | 0 | 0 | 0 | RTNI4 | RTNI3 | RTNI2 | RTNI1 | RTNI0 |

RTNI[4:0]: Sets 1H (line) clock number of internal clock operating mode. In this mode, ILI9328 display operation is synchronized with internal clock signal.

| RTNI[4:0] | Clocks/Line | RTNI[4:0] | Clocks/Line |
|-------------|------------------|-----------|-------------|
| 00000~01111 | Setting Disabled | 11000 | 24 clocks |
| 10000 | 16 clocks | 11001 | 25 clocks |
| 10001 | 17 clocks | 11010 | 26 clocks |
| 10010 | 18 clocks | 11011 | 27 clocks |
| 10011 | 19 clocks | 11100 | 28 clocks |
| 10100 | 20 clocks | 11101 | 29 clocks |
| 10101 | 21 clocks | 11110 | 30 clocks |
| 10110 | 22 clocks | 11111 | 31 clocks |
| 10111 | 23 clocks | | |

DIVI[1:0]: Sets the division ratio of internal clock frequency.

| DIVI1 | DIVI0 | Division Ratio | Internal Operation Clock Frequency |
|-------|-------|----------------|------------------------------------|
| 0 | 0 | 1 | $f_{osc} / 1$ |
| 0 | 1 | 2 | $f_{osc} / 2$ |
| 1 | 0 | 4 | $f_{osc} / 4$ |
| 1 | 1 | 8 | $f_{osc} / 8$ |

7.2.31. Panel Interface Control 2 (R92h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|---------|---------|---------|----|----|----|----|----|----|----|----|
| W | 1 | 0 | 0 | 0 | 0 | 0 | NOWI[2] | NOWI[1] | NOWI[0] | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

NOWI[2:0]: Sets the gate output non-overlap period when ILI9328 display operation is synchronized with internal clock signal.

| NOWI[2:0] | Gate Non-overlap Period |
|-----------|-------------------------|
| 000 | 0 clocks |
| 001 | 1 clocks |
| 010 | 2 clocks |
| 011 | 3 clocks |
| 100 | 4 clocks |
| 101 | 5 clocks |
| 110 | 6 clocks |
| 111 | 7 clocks |

Note: The gate output non-overlap period is defined by the number of frequency-divided internal clocks, the frequency of which is determined by instruction (DIVI), from the reference point.

7.2.32. Panel Interface Control 4 (R95h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-----|-----|-------|-------|----|----|-------|-------|-------|-------|-------|-------|
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | DIVE1 | DIVE0 | 0 | 0 | RTNE5 | RTNE4 | RTNE3 | RTNE2 | RTNE1 | RTNE0 |

RTNE[5:0]: Sets 1H (line) clock number of RGB interface mode. In this mode, ILI9328 display operation is

synchronized with RGB interface signals.

$$DIVE \text{ (division ratio)} \times RTNE \text{ (DOTCLKs)} \leq \text{DOTCLKs in 1H period.}$$

| RTNE[5:0] | Clocks per line period (1H) | RTNE[5:0] | Clocks per line period (1H) | RTNE[5:0] | Clocks per line period (1H) | RTNE[5:0] | Clocks per line period (1H) |
|-----------|-----------------------------|-----------|-----------------------------|-----------|-----------------------------|-----------|-----------------------------|
| 00h | Setting Prohibited | 10h | 16 clocks | 20h | 32 clocks | 30h | 48 clocks |
| 01h | Setting Prohibited | 11h | 17 clocks | 21h | 33 clocks | 31h | 49 clocks |
| 02h | Setting Prohibited | 12h | 18 clocks | 22h | 34 clocks | 32h | 50 clocks |
| 03h | Setting Prohibited | 13h | 19 clocks | 23h | 35 clocks | 33h | 51 clocks |
| 04h | Setting Prohibited | 14h | 20 clocks | 24h | 36 clocks | 34h | 52 clocks |
| 05h | Setting Prohibited | 15h | 21 clocks | 25h | 37 clocks | 35h | 53 clocks |
| 06h | Setting Prohibited | 16h | 22 clocks | 26h | 38 clocks | 36h | 54 clocks |
| 07h | Setting Prohibited | 17h | 23 clocks | 27h | 39 clocks | 37h | 55 clocks |
| 08h | Setting Prohibited | 18h | 24 clocks | 28h | 40 clocks | 38h | 56 clocks |
| 09h | Setting Prohibited | 19h | 25 clocks | 29h | 41 clocks | 39h | 57 clocks |
| 0ah | Setting Prohibited | 1ah | 26 clocks | 2ah | 42 clocks | 3ah | 58 clocks |
| 0bh | Setting Prohibited | 1bh | 27 clocks | 2bh | 43 clocks | 3bh | 59 clocks |
| 0ch | Setting Prohibited | 1ch | 28 clocks | 2ch | 44 clocks | 3ch | 60 clocks |
| 0dh | Setting Prohibited | 1dh | 29 clocks | 2dh | 45 clocks | 3dh | 61 clocks |
| 0eh | Setting Prohibited | 1eh | 30 clocks | 2eh | 46 clocks | 3eh | 62 clocks |
| 0fh | Setting Prohibited | 1fh | 31 clocks | 2fh | 47 clocks | 3fh | 63 clocks |

DIVE[1:0]: Sets the division ratio of DOTCLK when ILI9328 display operation is synchronized with RGB interface signals.

| DIVE[1:0] | Division Ratio | 18/16-bit RGB Interface | DOTCLK=5MHz | 6-bit x 3 Transfers RGB Interface | DOTCLK=5MHz |
|-----------|--------------------|-------------------------|-------------|-----------------------------------|-------------|
| 00 | Setting Prohibited | Setting Prohibited | - | Setting Prohibited | - |
| 01 | 1/4 | 4 DOTCLKS | 0.8 μs | 12 DOTCLKS | 0.8 μs |
| 10 | 1/8 | 8 DOTCLKS | 1.6 μs | 24 DOTCLKS | 1.6 μs |
| 11 | 1/16 | 16 DOTCLKS | 3.2 μs | 48 DOTCLKS | 3.2 μs |

7.2.33. Panel Interface Control 5 (R97h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|-------|-------|-------|-------|----|----|----|----|----|----|----|----|
| W | 1 | 0 | 0 | 0 | 0 | NOWE3 | NOWE2 | NOWE1 | NOWE0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

NOWE[2:0]: Sets the gate output non-overlap period when the ILI9320 display operation is synchronized with RGB interface signals.

| NOWE[3:0] | Gate Non-overlap Period | NOWE[3:0] | Gate Non-overlap Period |
|-----------|-------------------------|-----------|-------------------------|
| 0000 | 0 clocks | 1000 | 8 clocks |
| 0001 | 1 clocks | 1001 | 9 clocks |
| 0010 | 2 clocks | 1010 | 10 clocks |
| 0011 | 3 clocks | 1011 | 11 clocks |
| 0100 | 4 clocks | 1100 | 12 clocks |
| 0101 | 5 clocks | 1101 | 13 clocks |
| 0110 | 6 clocks | 1110 | 14 clocks |
| 0111 | 7 clocks | 1111 | 15 clocks |

Note: 1 clock = (number of data transfer/pixel) x DIVE (division ratio) [DOTCLK]

7.2.34. OTP VCM Programming Control (RA1h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|-----|-----|-----|-----|------------|-----|----|----|----|----|----------|----------|----------|----------|----------|----------|
| W | 1 | 0 | 0 | 0 | 0 | OTP_PGM_EN | 0 | 0 | 0 | 0 | 0 | VCM_OTP5 | VCM_OTP4 | VCM_OTP3 | VCM_OTP2 | VCM_OTP1 | VCM_OTP0 |

OTP_PGM_EN: OTP programming enable. When program OTP, must set this bit. OTP data can be

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programmed 3 times.

VCM_OTP[5:0]: OTP programming data for VCOMH voltage, the voltage refer to VCM[5:0] value.

7.2.35. OTP VCM Status and Enable (RA2h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|----------|----------|--------|--------|--------|--------|--------|--------|----|----|----|----|----|----|----|--------|
| W | 1 | PGM_CNT1 | PGM_CNT0 | VCM_D5 | VCM_D4 | VCM_D3 | VCM_D2 | VCM_D1 | VCM_D0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VCM_EN |

PGM_CNT[1:0]: OTP programmed record. These bits are read only.

| OTP_PGM_CNT[1:0] | Description |
|------------------|------------------------|
| 00 | OTP clean |
| 01 | OTP programmed 1 time |
| 10 | OTP programmed 2 times |
| 11 | OTP programmed 3 times |

VCM_D[5:0]: OTP VCM data read value. These bits are read only.

VCM_EN: OTP VCM data enable.

'1': Set this bit to enable OTP VCM data to replace R29h VCM value.

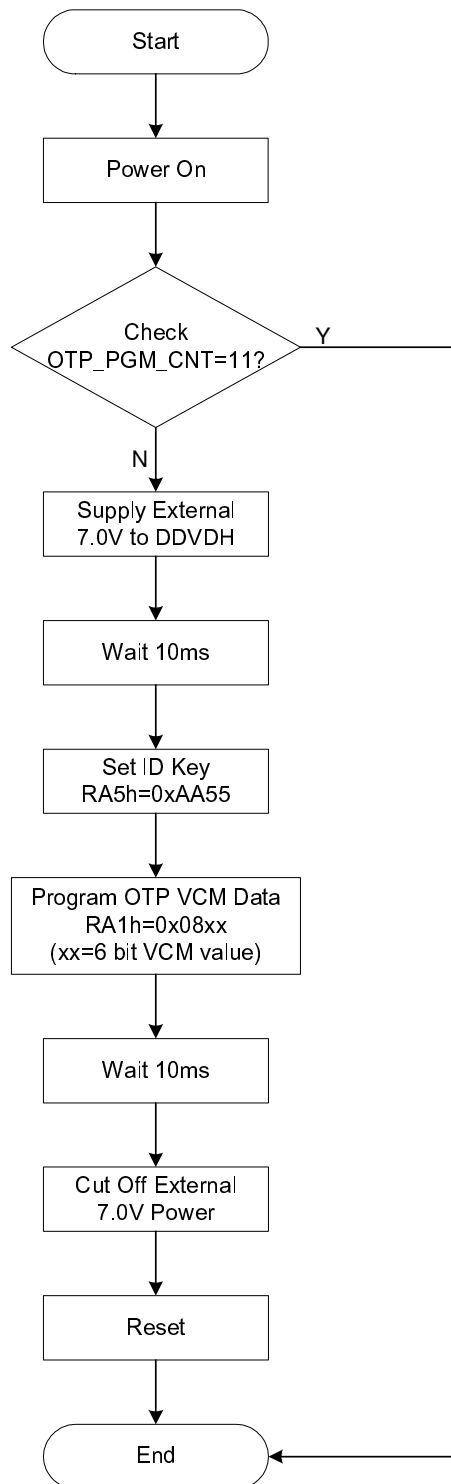
'0': Default value, use R29h VCM value.

7.2.36. OTP Programming ID Key (RA5h)

| R/W | RS | D15 | D14 | D13 | D12 | D11 | D10 | D9 | D8 | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
|-----|----|--------|--------|--------|--------|--------|--------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| W | 1 | KEY 15 | KEY 14 | KEY 13 | KEY 12 | KEY 11 | KEY 10 | KEY 9 | KEY 8 | KEY 7 | KEY 6 | KEY 5 | KEY 4 | KEY 3 | KEY 2 | KEY 1 | KEY 0 |

KEY[15:0]: OTP Programming ID key protection. Before writing OTP programming data RA1h, it must write RA5h with 0xAA55 value first to make OTP programming successfully. If RA5h is not written with 0xAA55, OTP programming will be fail. See OTP Programming flow.

8. OTP Programming Flow



9. GRAM Address Map & Read/Write

ILI9328 has an internal graphics RAM (GRAM) of 87,120 bytes to store the display data and one pixel is constructed of 18 bits. The GRAM can be accessed through the i80 system, SPI and RGB interfaces.

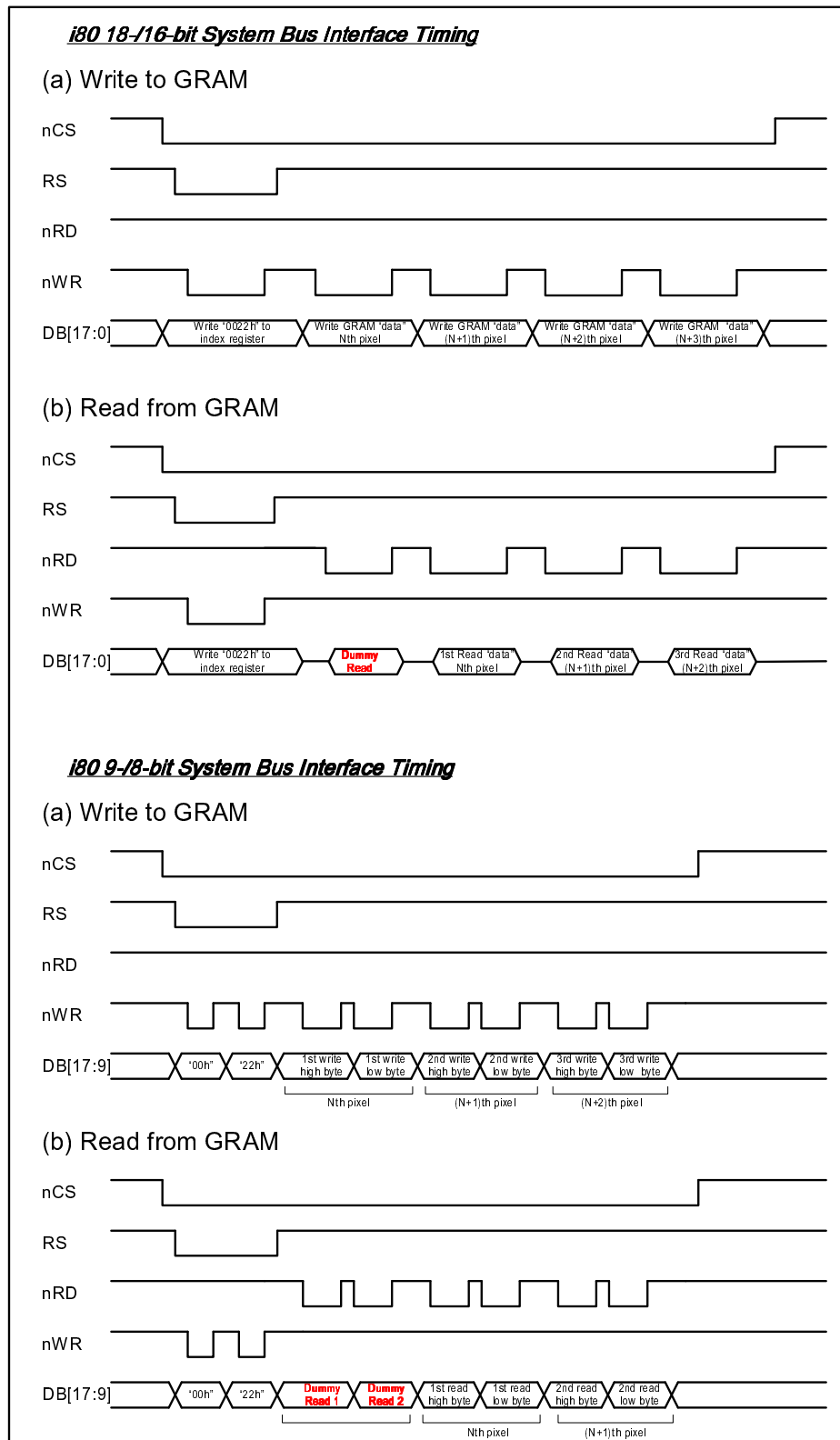
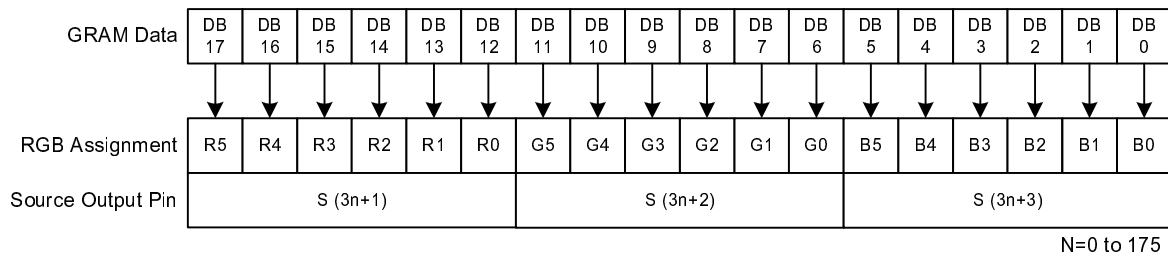


Figure31 GRAM Read/Write Timing of i80-System Interface

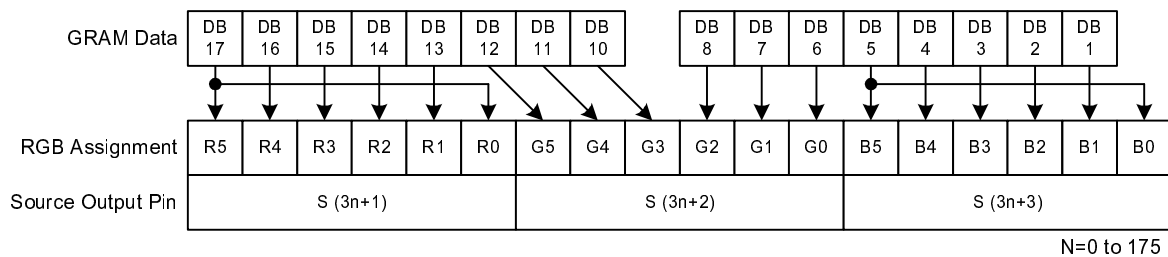
GRAM address map table of SS=0, BGR=0

| SS=0, BGR=0 | S1...S3 | S4...S6 | S7...S9 | S10...S12 | ... | S517...S519 | S520...S522 | S523...S525 | S526...S720 |
|-------------|---------|----------|----------|-----------|----------|-------------|-------------|-------------|-------------|
| GS=0 | GS=1 | DB17...0 | DB17...0 | DB17...0 | DB17...0 | ... | DB17...0 | DB17...0 | DB17...0 |
| G1 | G320 | "00000h" | "00001h" | "00002h" | "00003h" | ... | "000ECh" | "000EDh" | "000EEh" |
| G2 | G319 | "00100h" | "00101h" | "00102h" | "00103h" | ... | "001ECh" | "001EDh" | "001EEh" |
| G3 | G318 | "00200h" | "00201h" | "00202h" | "00203h" | ... | "002ECh" | "002EDh" | "002EEh" |
| G4 | G317 | "00300h" | "00301h" | "00302h" | "00303h" | ... | "003ECh" | "003EDh" | "003EEh" |
| G5 | G316 | "00400h" | "00401h" | "00402h" | "00403h" | ... | "004ECh" | "004EDh" | "004EEh" |
| G6 | G315 | "00500h" | "00501h" | "00502h" | "00503h" | ... | "005ECh" | "005EDh" | "005EEh" |
| G7 | G314 | "00600h" | "00601h" | "00602h" | "00603h" | ... | "006ECh" | "006EDh" | "006EEh" |
| G8 | G313 | "00700h" | "00701h" | "00702h" | "00703h" | ... | "007ECh" | "007EDh" | "007EEh" |
| G9 | G312 | "00800h" | "00801h" | "00802h" | "00803h" | ... | "008ECh" | "008EDh" | "008EEh" |
| G10 | G311 | "00900h" | "00901h" | "00902h" | "00903h" | ... | "009ECh" | "009EDh" | "009EEh" |
| . | . | . | . | . | . | ... | . | . | . |
| . | . | . | . | . | . | ... | . | . | . |
| . | . | . | . | . | . | ... | . | . | . |
| G311 | G10 | "13600h" | "13601h" | "13602h" | "13603h" | ... | "136ECh" | "136EDh" | "136EEh" |
| G312 | G9 | "13700h" | "13701h" | "13702h" | "13703h" | ... | "137ECh" | "137EDh" | "137EEh" |
| G313 | G8 | "13800h" | "13801h" | "13802h" | "13803h" | ... | "138ECh" | "138EDh" | "138EEh" |
| G314 | G7 | "13900h" | "13901h" | "13902h" | "13903h" | ... | "139ECh" | "139EDh" | "139EEh" |
| G315 | G6 | "13A00h" | "13A01h" | "13A02h" | "13A03h" | ... | "13AECh" | "13AEDh" | "13AEEh" |
| G316 | G5 | "13B00h" | "13B01h" | "13B02h" | "13B03h" | ... | "13BECh" | "13BEDh" | "13BEEh" |
| G317 | G4 | "13C00h" | "13C01h" | "13C02h" | "13C03h" | ... | "13CECh" | "13CEDh" | "13CEEh" |
| G318 | G3 | "13D00h" | "13D01h" | "13D02h" | "13D03h" | ... | "13DECh" | "13DEDh" | "13DEEh" |
| G319 | G2 | "13E00h" | "13E01h" | "13E02h" | "13E03h" | ... | "13EECh" | "13EEDh" | "13EEEh" |
| G320 | G1 | "13F00h" | "13F01h" | "13F02h" | "13F03h" | ... | "13FECh" | "13FEDh" | "13FEEh" |

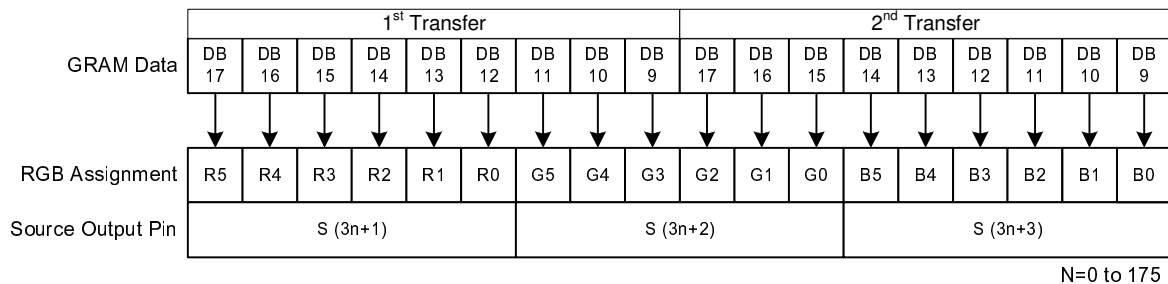
i80/M68 system 18-bit data bus interface



i80/M68 system 16-bit data bus interface



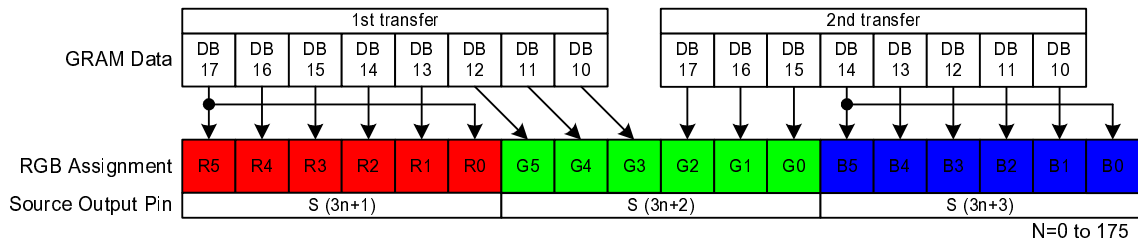
i80/M68 system 9-bit data bus interface



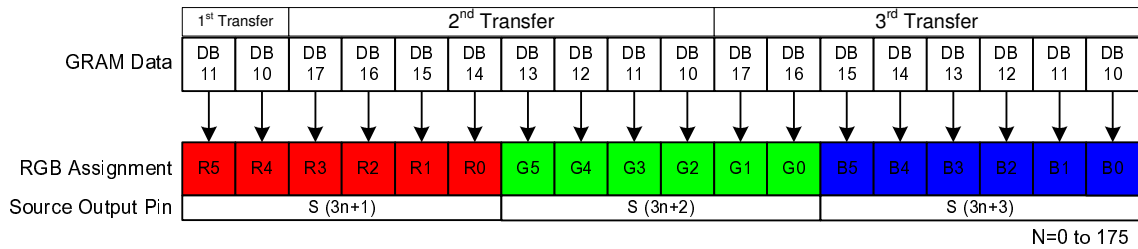
GRAM Data and display data of 18-/16-/9-bit system interface (SS="0", BGR="0")

Figure32 i80-System Interface with 18-/16-/9-bit Data Bus (SS="0", BGR="0")

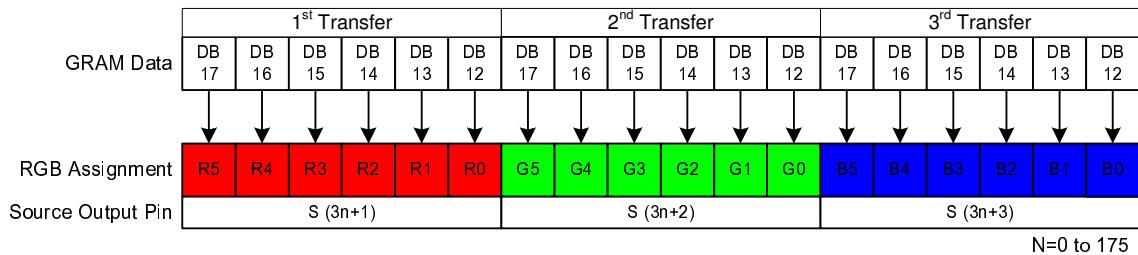
i80/M68 system 8-bit interface / SPI Interface (2 transfers/pixel)



i80/M68 system 8-bit interface (3 transfers/pixel, TRI="1", DFM[1:0]="00")



i80/M68 system 8-bit interface (3 transfers/pixel, TRI="1", DFM[1:0]="10")



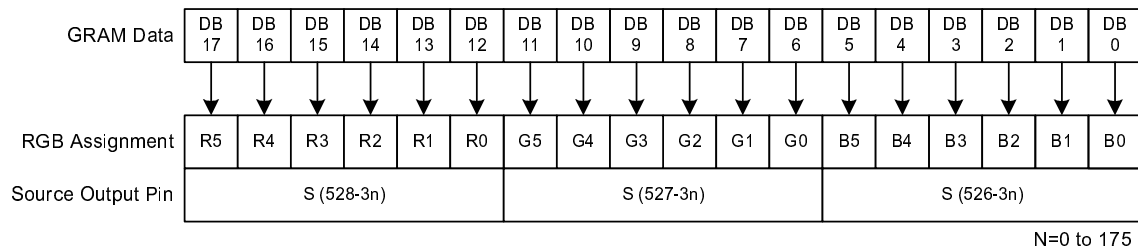
i80/M68 system 8-bit interface (SS="0", BGR="0")

Figure33 i80-System Interface with 8-bit Data Bus (SS="0", BGR="0")

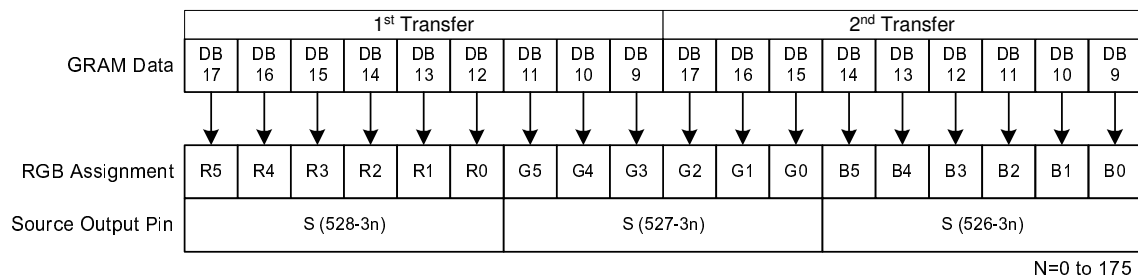
GRAM address map table of SS=1, BGR=1

| SS=1, BGR=1 | | S720...S718 | S717...S715 | S714...S712 | S711...S709 | ... | S12...S10 | S9...S7 | S6...S4 | S3...S1 |
|-------------|------|-------------|-------------|-------------|-------------|-----|-----------|----------|----------|----------|
| GS=0 | GS=1 | DB17...0 | DB17...0 | DB17...0 | DB17...0 | ... | DB17...0 | DB17...0 | DB17...0 | DB17...0 |
| G1 | G320 | "00000h" | "00001h" | "00002h" | "00003h" | ... | "000ECh" | "000EDh" | "000EEh" | "000EFh" |
| G2 | G319 | "00100h" | "00101h" | "00102h" | "00103h" | ... | "001ECh" | "001EDh" | "001EEh" | "001EFh" |
| G3 | G318 | "00200h" | "00201h" | "00202h" | "00203h" | ... | "002ECh" | "002EDh" | "002EEh" | "002EFh" |
| G4 | G317 | "00300h" | "00301h" | "00302h" | "00303h" | ... | "003ECh" | "003EDh" | "003EEh" | "003EFh" |
| G5 | G316 | "00400h" | "00401h" | "00402h" | "00403h" | ... | "004ECh" | "004EDh" | "004EEh" | "004EFh" |
| G6 | G315 | "00500h" | "00501h" | "00502h" | "00503h" | ... | "005ECh" | "005EDh" | "005EEh" | "005EFh" |
| G7 | G314 | "00600h" | "00601h" | "00602h" | "00603h" | ... | "006ECh" | "006EDh" | "006EEh" | "006EFh" |
| G8 | G313 | "00700h" | "00701h" | "00702h" | "00703h" | ... | "007ECh" | "007EDh" | "007EEh" | "007EFh" |
| G9 | G312 | "00800h" | "00801h" | "00802h" | "00803h" | ... | "008ECh" | "008EDh" | "008EEh" | "008EFh" |
| G10 | G311 | "00900h" | "00901h" | "00902h" | "00903h" | ... | "009ECh" | "009EDh" | "009EEh" | "009EFh" |
| . | . | . | . | . | . | ... | . | . | . | . |
| . | . | . | . | . | . | | . | . | . | . |
| . | . | . | . | . | . | | . | . | . | . |
| G311 | G10 | "13600h" | "13601h" | "13602h" | "13603h" | ... | "136ECh" | "136EDh" | "136EEh" | "136EFh" |
| G312 | G9 | "13700h" | "13701h" | "13702h" | "13703h" | ... | "137ECh" | "137EDh" | "137EEh" | "137EFh" |
| G313 | G8 | "13800h" | "13801h" | "13802h" | "13803h" | ... | "138ECh" | "138EDh" | "138EEh" | "138EFh" |
| G314 | G7 | "13900h" | "13901h" | "13902h" | "13903h" | ... | "139ECh" | "139EDh" | "139EEh" | "139EFh" |
| G315 | G6 | "13A00h" | "13A01h" | "13A02h" | "13A03h" | ... | "13AECh" | "13AEDh" | "13AEEh" | "13AEFh" |
| G316 | G5 | "13B00h" | "13B01h" | "13B02h" | "13B03h" | ... | "13BECh" | "13BEDh" | "13BEEh" | "13BEFh" |
| G317 | G4 | "13C00h" | "13C01h" | "13C02h" | "13C03h" | ... | "13CECh" | "13CEDh" | "13CEEh" | "13CEFh" |
| G318 | G3 | "13D00h" | "13D01h" | "13D02h" | "13D03h" | ... | "13DECh" | "13DEDh" | "13DEEh" | "13DEFh" |
| G319 | G2 | "13E00h" | "13E01h" | "13E02h" | "13E03h" | ... | "13EECh" | "13EEDh" | "13EEEh" | "13EEFh" |
| G320 | G1 | "13F00h" | "13F01h" | "13F02h" | "13F03h" | ... | "13FECh" | "13FEDh" | "13FEEh" | "13FEFh" |

i80/M68 system 18-bit data bus interface



i80/M68 system 9-bit data bus interface



GRAM Data and display data of 18-/9-bit system interface (SS="1", BGR="1")

Figure 34 i80-System Interface with 18-/9-bit Data Bus (SS="1", BGR="1")

10. Window Address Function

The window address function enables writing display data consecutively in a rectangular area (a window address area) made on the internal RAM. The window address area is made by setting the horizontal address register (start: HSA[7:0], end: HEA[7:0] bits) and the vertical address register (start: VSA[8:0], end: VEA[8:0] bits). The AM bit sets the transition direction of RAM address (either increment or decrement). These bits enable the ILI9328 to write data including image data consecutively not taking data wrap positions into account.

The window address area must be made within the GRAM address map area. Also, the GRAM address bits (RAM address set register) must be an address within the window address area.

[Window address setting area]

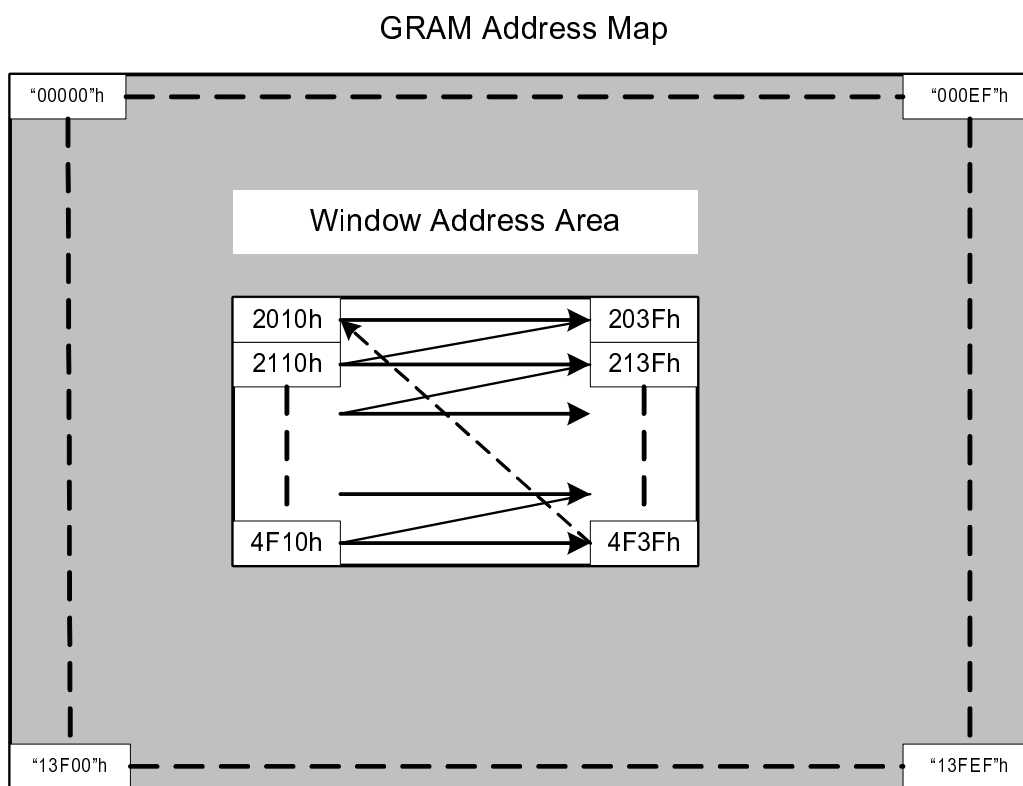
(Horizontal direction) $00H \leq HSA[7:0] \leq HEA[7:0] \leq "EF"H$

(Vertical direction) $00H \leq VSA[8:0] \leq VEA[8:0] \leq "13F"H$

[RAM address, AD (an address within a window address area)]

(RAM address) $HSA[7:0] \leq AD[7:0] \leq HEA[7:0]$

$VSA[8:0] \leq AD[15:8] \leq VEA[8:0]$



Window address setting area

HSA[7:0] = 10h, HSA[7:0] = 3Fh, I/D = 1 (increment)
VSA[8:0] = 20h, VSA[8:0] = 4Fh, AM = 0 (horizontal writing)

Figure 35 GRAM Access Window Map

11. Gamma Correction

ILI9328 incorporates the γ -correction function to display 262,144 colors for the LCD panel. The γ -correction is performed with 3 groups of registers determining eight reference grayscale levels, which are gradient adjustment, amplitude adjustment and fine-adjustment registers for positive and negative polarities, to make ILI9328 available with liquid crystal panels of various characteristics.

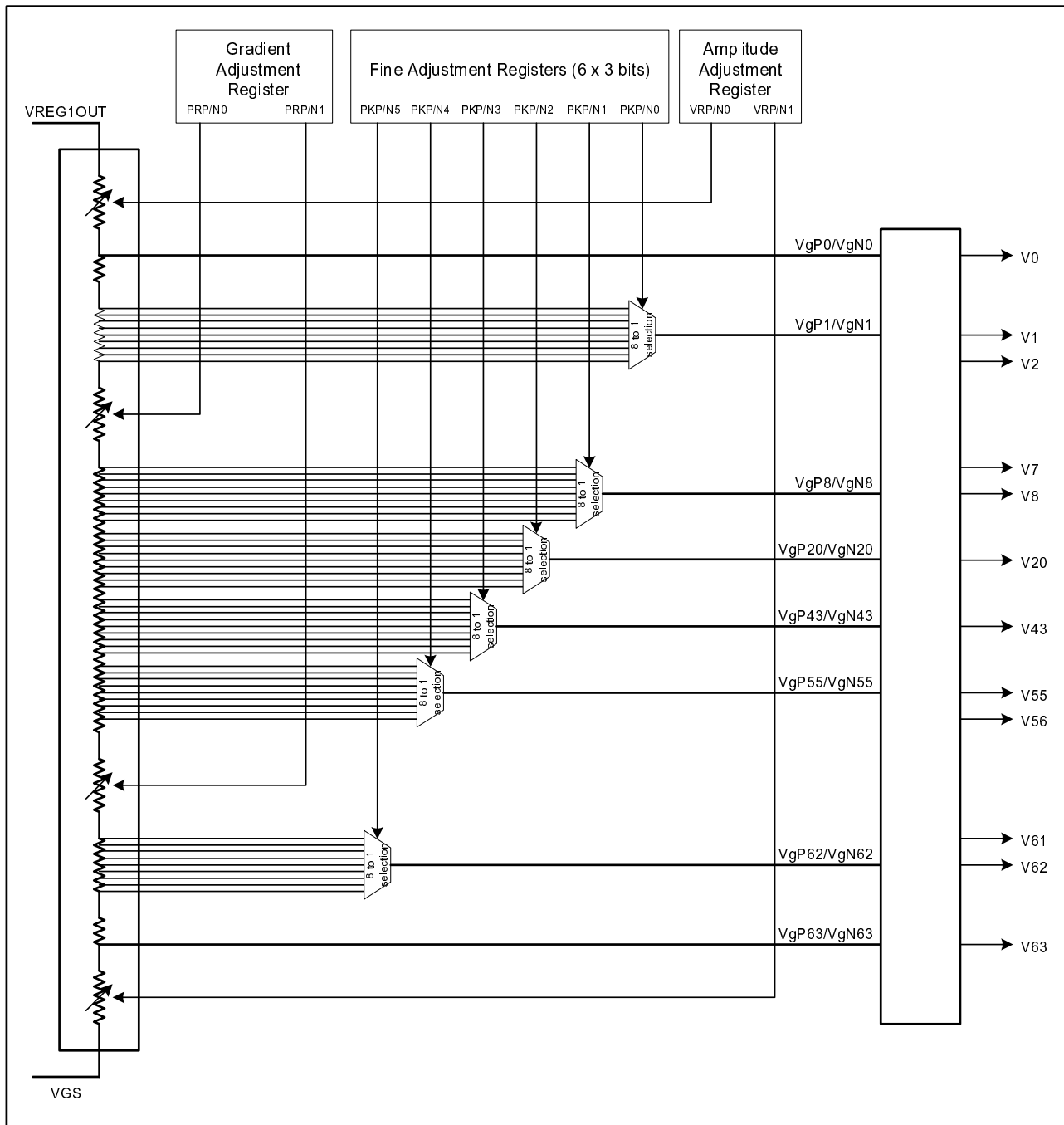


Figure 36 Grayscale Voltage Generation



1. Gradient adjustment registers

The gradient adjustment registers are used to adjust the gradient of the curve representing the relationship between the grayscale and the grayscale reference voltage level. To adjust the gradient, the resistance values of variable resistors in the middle of the ladder resistor are adjusted by registers PRP0[2:0]/PRN0[2:0], PRP1[2:0]/PRN1[2:0]. The registers consist of positive and negative polarity registers, allowing asymmetric drive.

2. Amplitude adjustment registers

The amplitude adjustment registers, VRP0[3:0]/VRN0[3:0], VRP1[4:0]/VRN1[4:0], are used to adjust the amplitude of grayscale voltages. To adjust the amplitude, the resistance values of variable resistors at the top and bottom of the ladder resistor are adjusted. Same as the gradient registers, the amplitude adjustment registers consist of positive and negative polarity registers.

3. Fine adjustment registers

The fine adjustment registers are used to fine-adjust grayscale voltage levels. To fine-adjust grayscale voltage levels, fine adjustment registers adjust the reference voltage levels, 8 levels for each register generated from the ladder resistor, in respective 8-to-1 selectors. Same with other registers, the fine adjustment registers consist of positive and negative polarity registers.

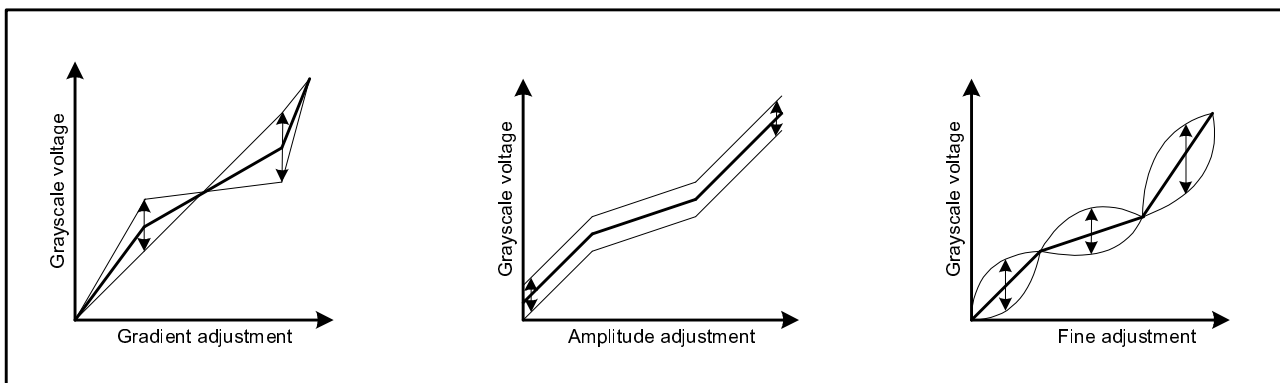


Figure 38 Gamma Curve Adjustment

| Register Groups | Positive Polarity | Negative Polarity | Description |
|----------------------|-------------------|-------------------|---|
| Gradient adjustment | PRP0 [2:0] | PRN0 [2:0] | Variable resistor VRCP0, VRCN0 |
| | PRP1 [2:0] | PRN1 [2:0] | Variable resistor VRCP1, VRCN1 |
| Amplitude adjustment | VRP0 [3:0] | VRN0 [3:0] | Variable resistor VROP0, VRON0 |
| | VRP1 [4:0] | VRN1 [4:0] | Variable resistor VROP1, VRON1 |
| Fine adjustment | KP0 [2:0] | KN0 [2:0] | 8-to-1 selector (voltage level of grayscale 1) |
| | KP1 [2:0] | KN1 [2:0] | 8-to-1 selector (voltage level of grayscale 8) |
| | KP2 [2:0] | KN2 [2:0] | 8-to-1 selector (voltage level of grayscale 20) |
| | KP3 [2:0] | KN3 [2:0] | 8-to-1 selector (voltage level of grayscale 43) |
| | KP4 [2:0] | KN4 [2:0] | 8-to-1 selector (voltage level of grayscale 55) |
| | KP5 [2:0] | KN5 [2:0] | 8-to-1 selector (voltage level of grayscale 62) |

Ladder resistors and 8-to-1 selector Block configuration

The reference voltage generating block consists of two ladder resistor units including variable resistors and 8-to-1 selectors. Each 8-to-1 selector selects one of the 8 voltage levels generated from the ladder resistor unit to output as a grayscale reference voltage. Both variable resistors and 8-to-1 selectors are controlled according to the γ -correction registers. This unit has pins to connect a volume resistor externally to compensate differences in various characteristics of panels.

Variable resistors

ILI9328 uses variable resistors of the following three purposes: gradient adjustment (VRCP(N)0/VRCP(N)1); amplitude adjustment (1) (VROP(N)0); and the amplitude adjustment (2) (VROP(N)1). The resistance values of these variable resistors are set by gradient adjustment registers and amplitude adjustment registers as follows.

| Gradient adjustment | | Amplitude adjustment (1) | | Amplitude adjustment (2) | |
|---------------------|------------|--------------------------|------------|--------------------------|------------|
| PRP(N)0/1[2:0] | VRCP(N)0 | VRP(N)0[3:0] | VROP(N)0 | VRP(N)1[4:0] | VROP(N)1 |
| Register | Resistance | Register | Resistance | Register | Resistance |
| 000 | 0R | 0000 | 0R | 00000 | 0R |
| 001 | 4R | 0001 | 2R | 00001 | 1R |
| 010 | 8R | 0010 | 4R | 00010 | 2R |
| 011 | 12R | : | : | : | : |
| 100 | 16R | : | : | : | : |
| 101 | 20R | 1101 | 26R | 11101 | 29R |
| 110 | 24R | 1111 | 28R | 11110 | 30R |
| 111 | 28R | 1111 | 30R | 11111 | 31R |

8-to-1 selectors

The 8-to-1 selector selects one of eight voltage levels generated from the ladder resistor unit according to the fine adjustment register and output the selected voltage level as a reference grayscale voltage (VgP(N)1~6).

The table below shows the setting in the fine adjustment register and the selected voltage levels for respective reference grayscale voltages.

| Fine adjustment registers and selected voltage | | | | | | |
|--|---------|------------------|----------|----------|----------|----------|
| Register | | Selected Voltage | | | | |
| KP(N)[2:0] | VgP(N)1 | VgP(N)8 | VgP(N)20 | VgP(N)43 | VgP(N)55 | VgP(N)62 |
| 000 | VP(N)1 | VP(N)9 | VP(N)17 | VP(N)25 | VP(N)33 | VP(N)41 |
| 001 | VP(N)2 | VP(N)10 | VP(N)18 | VP(N)26 | VP(N)34 | VP(N)42 |
| 010 | VP(N)3 | VP(N)11 | VP(N)19 | VP(N)27 | VP(N)35 | VP(N)43 |
| 011 | VP(N)4 | VP(N)12 | VP(N)20 | VP(N)28 | VP(N)36 | VP(N)44 |
| 100 | VP(N)5 | VP(N)13 | VP(N)21 | VP(N)29 | VP(N)37 | VP(N)45 |
| 101 | VP(N)6 | VP(N)14 | VP(N)22 | VP(N)30 | VP(N)38 | VP(N)46 |
| 110 | VP(N)7 | VP(N)15 | VP(N)23 | VP(N)31 | VP(N)39 | VP(N)47 |
| 111 | VP(N)8 | VP(N)16 | VP(N)24 | VP(N)32 | VP(N)40 | VP(N)48 |

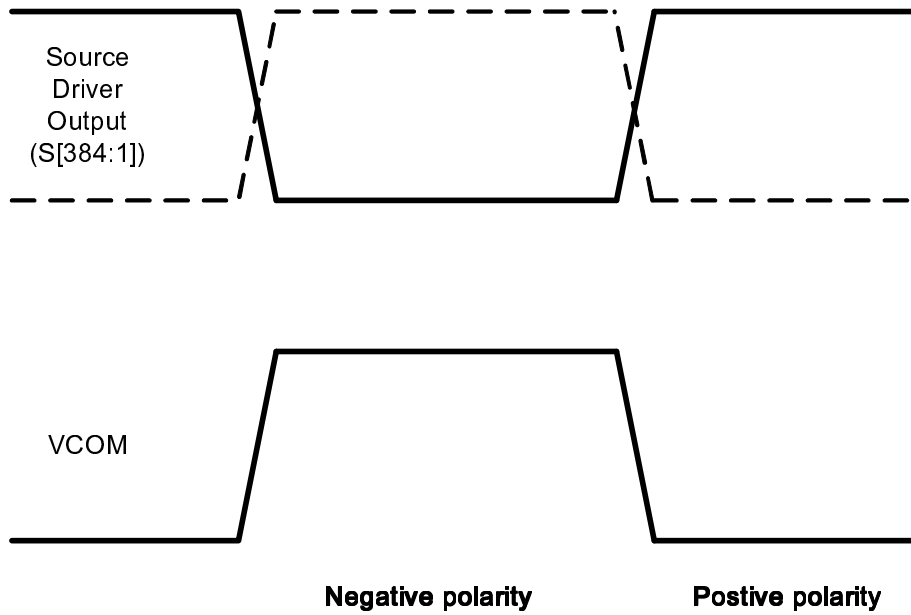


Figure 39 Relationship between Source Output and VCOM

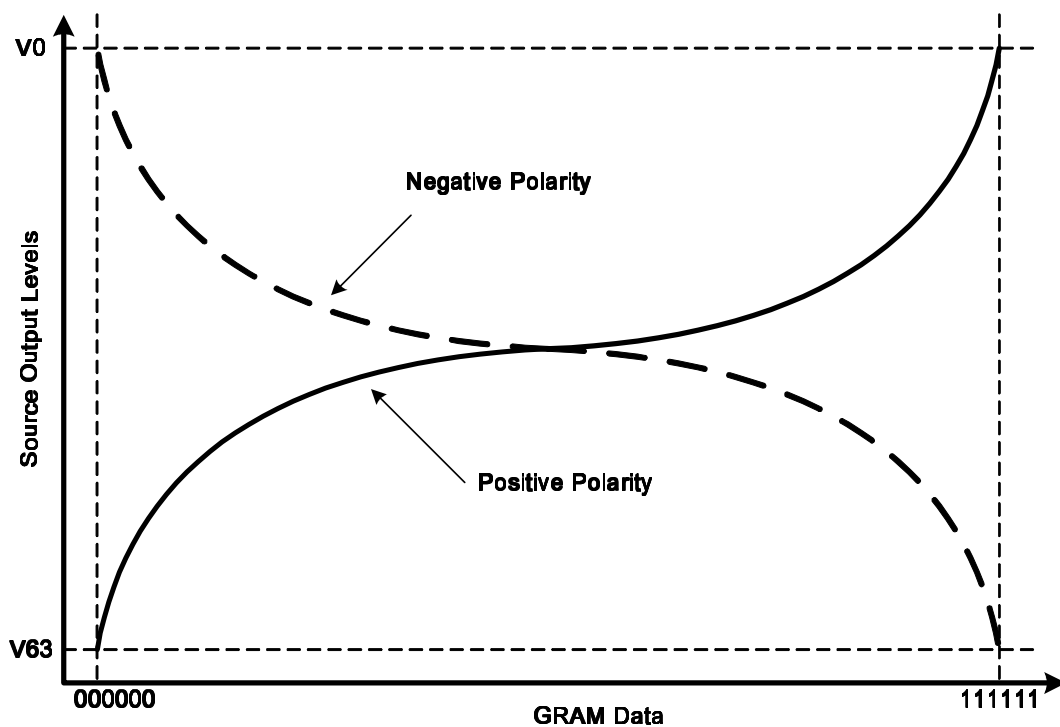


Figure 40 Relationship between GRAM Data and Output Level

12. Application

12.1. Configuration of Power Supply Circuit

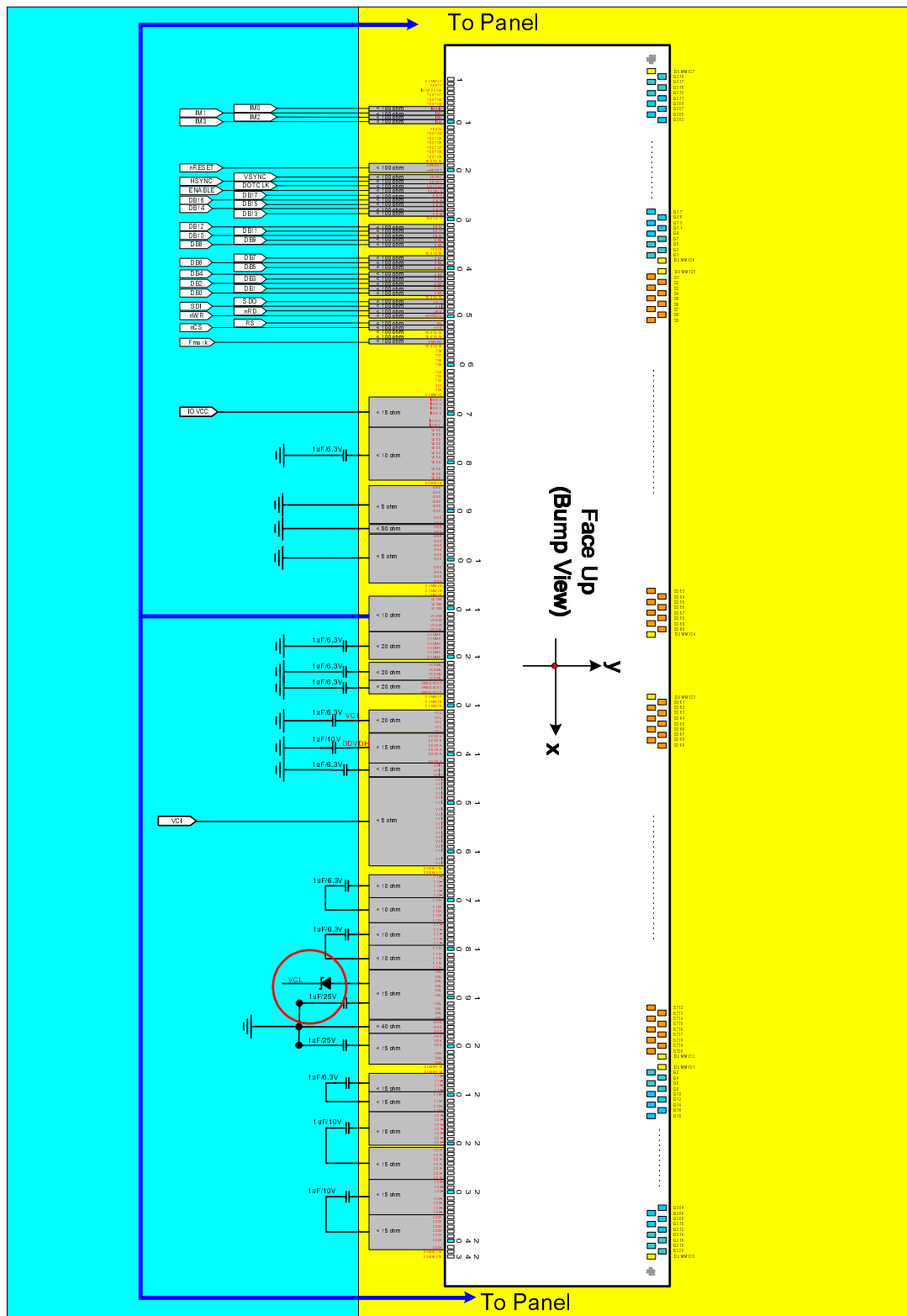


Figure 41 Power Supply Circuit Block

The following table shows specifications of external elements connected to the ILI9328's power supply circuit.

| Items | Recommended Specification | Pin connection |
|--|---|--|
| Capacity 1 μ F (B characteristics) | 6.3V | VREG1OUT, VCI1, VDDD, VCL, VCOMH, VCOML, C11+/-, C12+/-, C13+/-, |
| | 10V | DDVDH, C21+/-, C22+/- |
| | 25V | VGH, VGL |
| Schottky diode | $V_F < 0.4V/20mA$ at $25^\circ C$, $V_R \geq 30V$ (Recommended diode: HSC226) | (VCL – VGL), (DDVDH – VGH), (Vci – DDVDH) |

12.2. Display ON/OFF Sequence

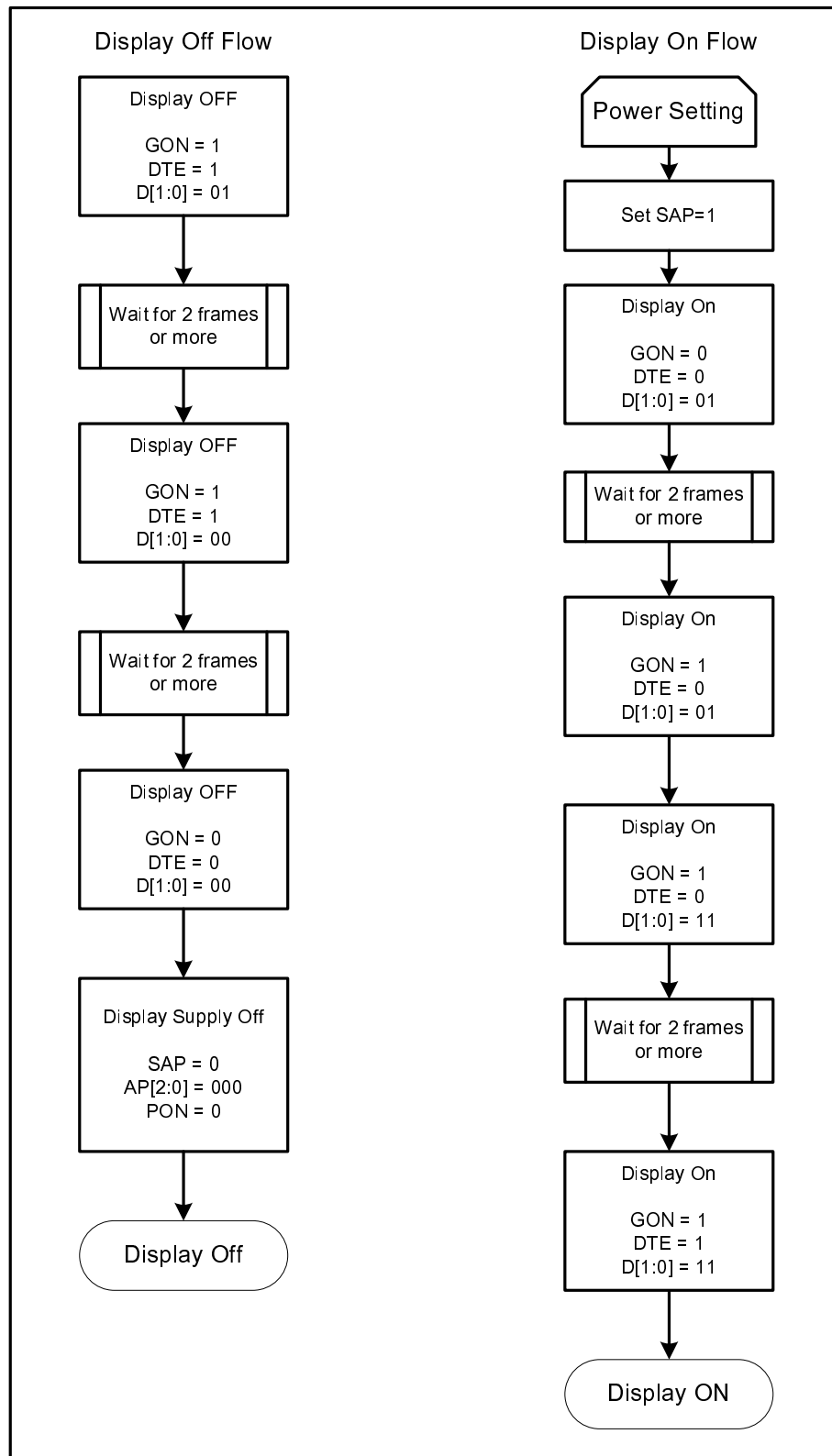


Figure 42 Display On/Off Register Setting Sequence

12.3. Standby and Sleep Mode

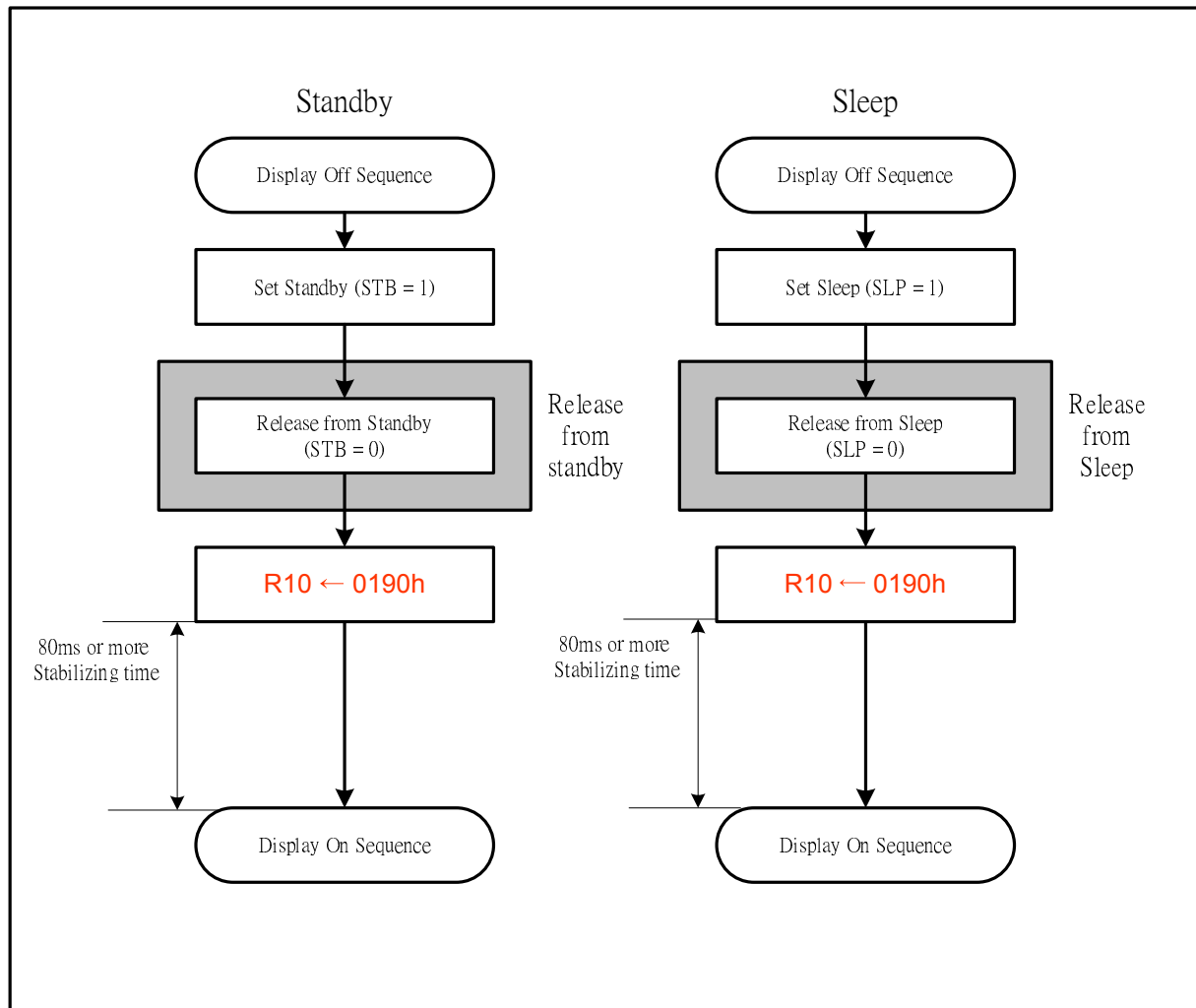


Figure 43 Standby/Sleep Mode Register Setting Sequence

12.4. Power Supply Configuration

When supplying and cutting off power, follow the sequence below. The setting time for step-up circuits and operational amplifiers depends on external resistance and capacitance.

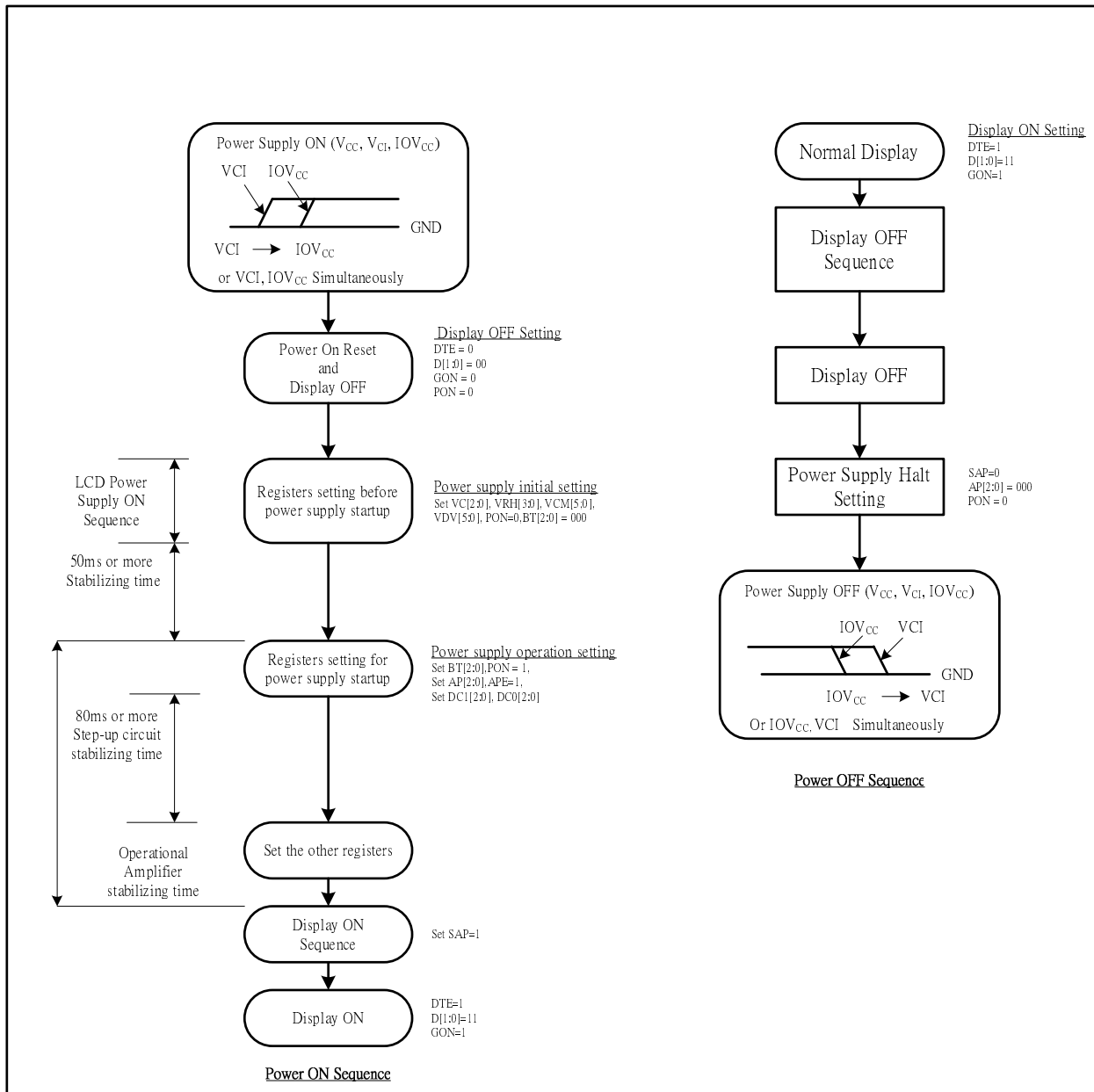


Figure 44 Power Supply ON/OFF Sequence

12.5. Voltage Generation

The pattern diagram for setting the voltages and the waveforms of the voltages of the ILI9328 are as follows.

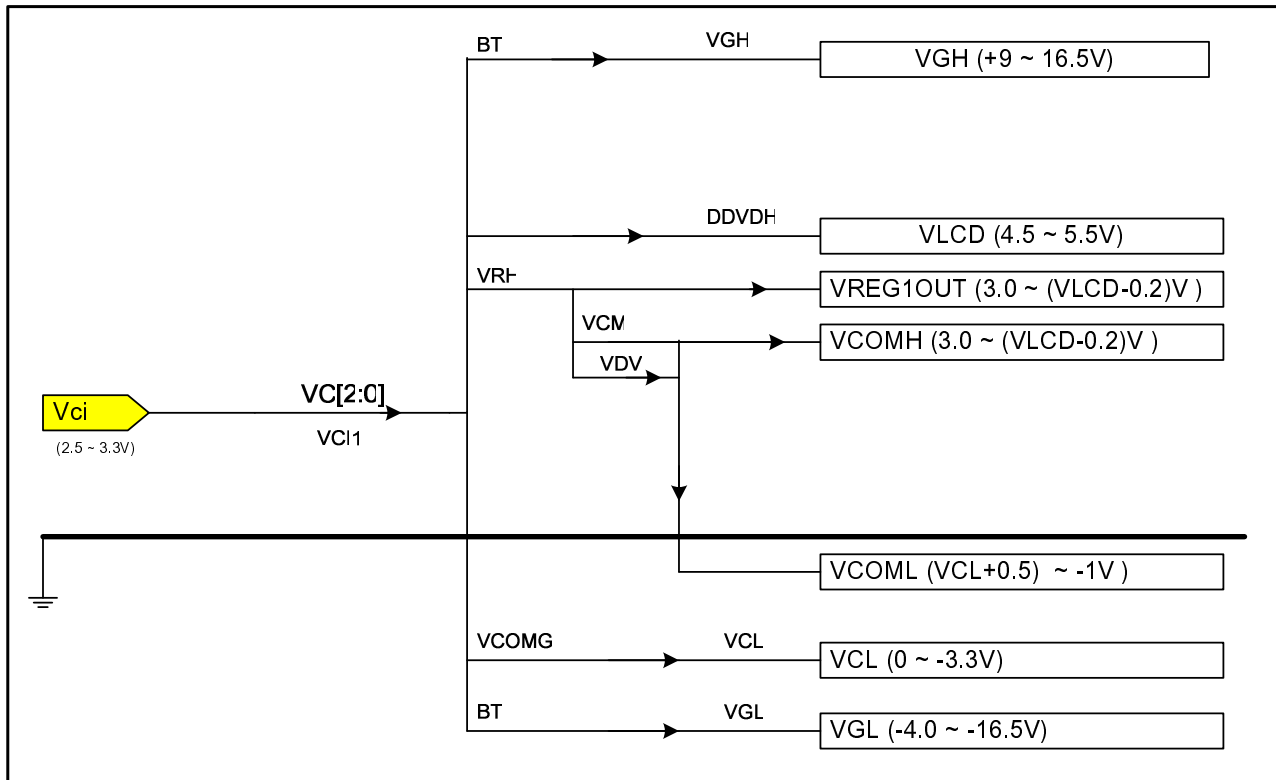


Figure 45 Voltage Configuration Diagram

Note: The DDVDH, VGH, VGL, and VCL output voltage levels are lower than their theoretical levels (ideal voltage levels) due to current consumption at respective outputs. The voltage levels in the following relationships $(DDVDH - VREG1OUT) > 0.2V$ and $(VCOML - VCL) > 0.5V$ are the actual voltage levels. When the alternating cycles of VCOM are set high (e.g. the polarity inverts every line cycle), current consumption is large. In this case, check the voltage before use.

12.6. Applied Voltage to the TFT panel

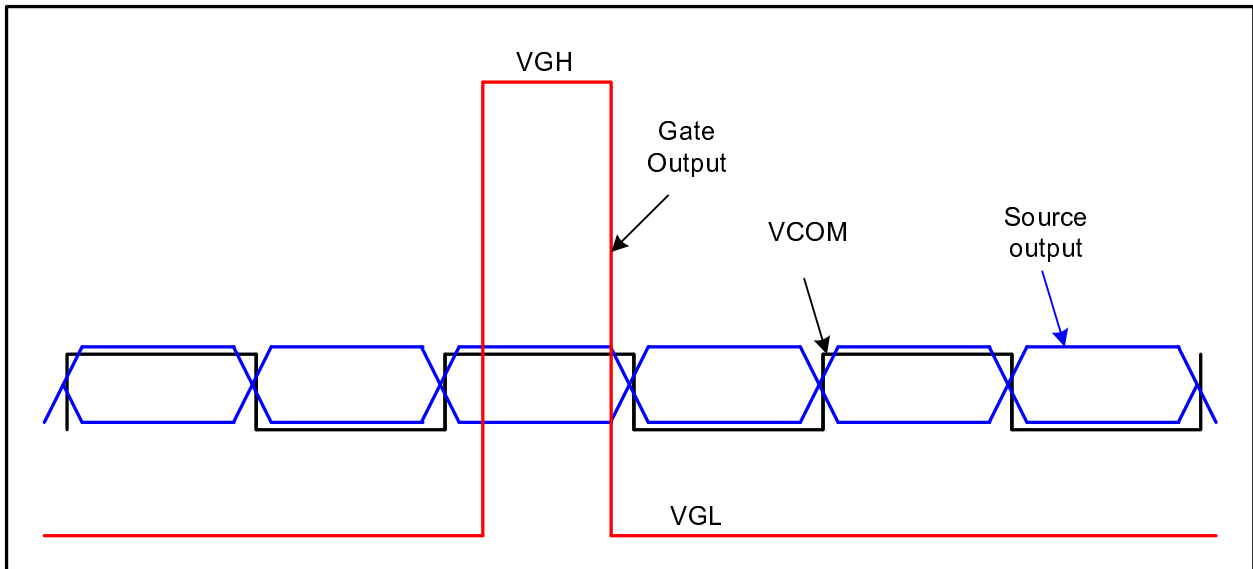


Figure 46 Voltage Output to TFT LCD Panel

12.7. Partial Display Function

The ILI9328 allows selectively driving two partial images on the screen at arbitrary positions set in the screen drive position registers.

The following example shows the setting for partial display function:

| Base Image Display Setting | |
|---------------------------------|--------|
| BASEE | 0 |
| NL[5:0] | 6'h27 |
| Partial Image 1 Display Setting | |
| PTDE0 | 1 |
| PTSA0[8:0] | 9'h000 |
| PTEA0[8:0] | 9'h00F |
| PTDP0[8:0] | 9'h080 |
| Partial Image 2 Display Setting | |
| PTDE1 | 1 |
| PTSA1[8:0] | 9'h020 |
| PTEA1[8:0] | 9'h02F |
| PTDP1[8:0] | 9'h0C0 |

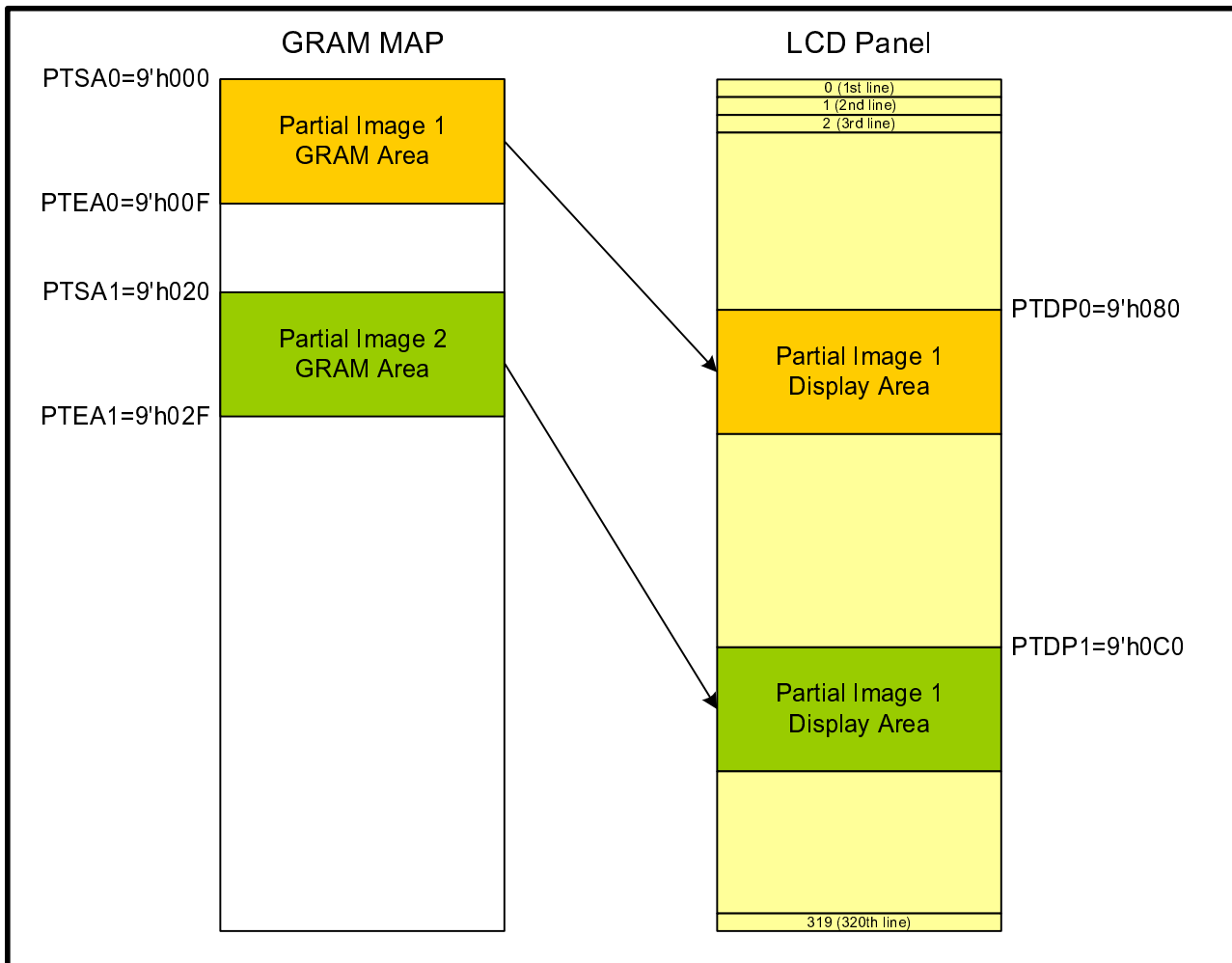


Figure 47 Partial Display Example

12.8. Resizing Function

ILI9328 supports resizing function (x1/2, x1/4), which is performed when writing image data to GRAM. The resizing function is enabled by setting a window address area and the RSZ bit which represents the resizing factor (x1/2, x1/4) of image. The resizing function allows the system to transfer the original-size image data into the GRAM with resized image data.



Figure 48 Data transfer in resizing

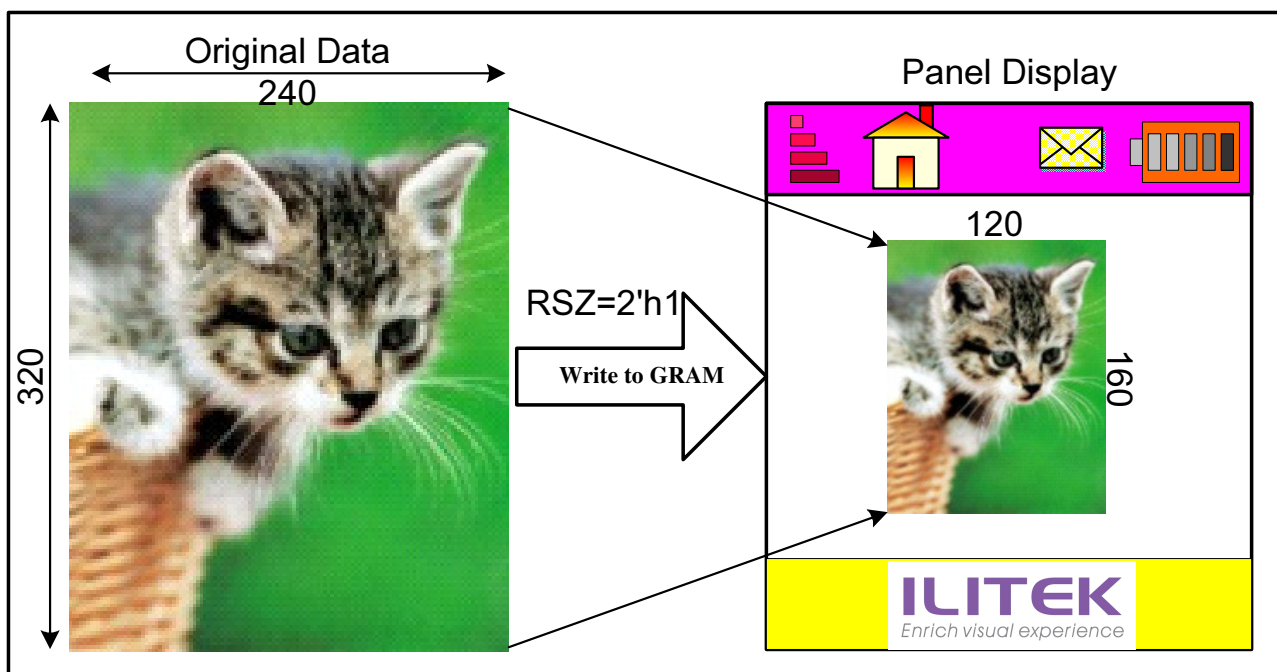
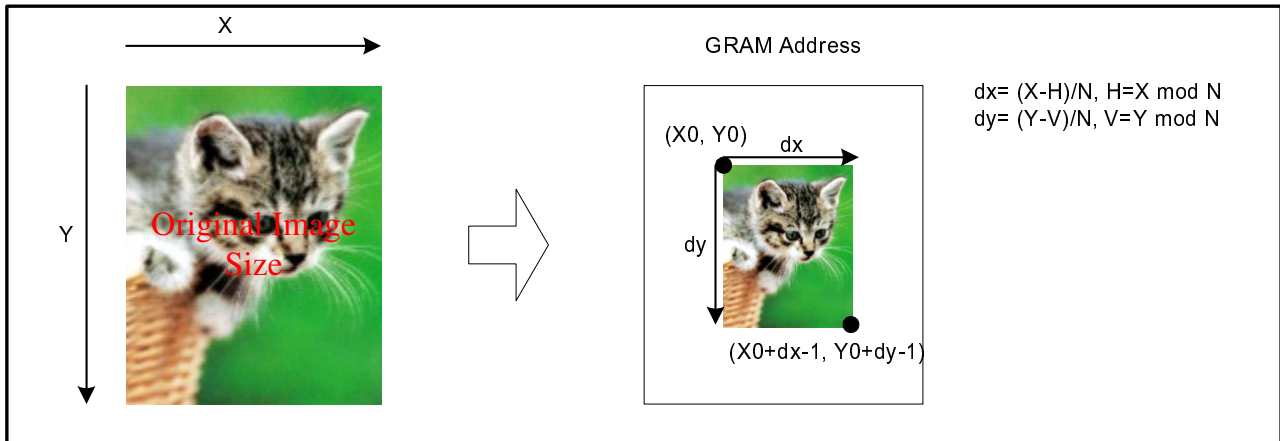


Figure 49 Resizing Example

| Original Image Size (X × Y) | Resized Image Resolution | |
|-----------------------------|--------------------------|----------------|
| | 1/2 (RSZ=2'h1) | 1/4 (RSZ=2'h3) |
| 640 × 480 | 320 × 240 | 160 × 120 |
| 352 × 288 | 176 × 144 | 88 × 72 |
| 320 × 240 | 160 × 120 | 80 × 60 |
| 176 × 144 | 88 × 72 | 44 × 36 |
| 120 × 160 | 60 × 80 | 30 × 40 |
| 132 × 132 | 66 × 66 | 33 × 33 |

The RSZ bit sets the resizing factor of an image. When setting a window address area in the internal GRAM, the GRAM window address area must fit the size of resized image. The following example show the resizing setting.



| | | |
|--|-----|----------|
| Original image data number in horizontal direction | | X |
| Original image data number in Vertical direction | | Y |
| Resizing Ration | | 1/N |
| Resizing Setting | RSZ | N-1 |
| Remainder pixels in horizontal direction | RCH | H |
| Remainder pixels in vertical direction | RCV | V |
| GRAM writing start address | AD | (x0, y0) |
| GRAM window setting | HSA | x0 |
| | HEA | x0+dx-1 |
| | VSA | y0 |
| | VEA | y0+dy-1 |

13. Electrical Characteristics

13.1. Absolute Maximum Ratings

The absolute maximum rating is listed on following table. When ILI9328 is used out of the absolute maximum ratings, the ILI9328 may be permanently damaged. To use the ILI9328 within the following electrical characteristics limit is strongly recommended for normal operation. If these electrical characteristic conditions are exceeded during normal operation, the ILI9328 will malfunction and cause poor reliability.

| Item | Symbol | Unit | Value | Note |
|--------------------------|-------------|------|-----------------|------|
| Power supply voltage (1) | IOVCC | V | -0.3 ~ + 4.6 | 1, 2 |
| Power supply voltage (1) | VCI - GND | V | -0.3 ~ + 4.6 | 1, 4 |
| Power supply voltage (1) | DDVDH - GND | V | -0.3 ~ + 6.0 | 1, 4 |
| Power supply voltage (1) | GND - VCL | V | -0.3 ~ + 4.6 | 1 |
| Power supply voltage (1) | DDVDH - VCL | V | -0.3 ~ + 9.0 | 1, 5 |
| Power supply voltage (1) | VGH - GND | V | -0.3 ~ + 18.5 | 1, 5 |
| Power supply voltage (1) | GND - VGL | V | -0.3 ~ + 18.5 | 1, 6 |
| Input voltage | Vt | V | -0.3 ~ VCC+ 0.3 | 1 |
| Operating temperature | Topr | °C | -40 ~ + 85 | 8, 9 |
| Storage temperature | Tstg | °C | -55 ~ + 110 | 8, 9 |

Notes:

1. GND must be maintained
2. (High) (VCC = VCC) ≥ GND (Low), (High) IOVCC ≥ GND (Low).
3. Make sure (High) VCI ≥ GND (Low).
4. Make sure (High) DDVDH ≥ GND (Low).
5. Make sure (High) DDVDH ≥ VCL (Low).
6. Make sure (High) VGH ≥ GND (Low).
7. Make sure (High) GND ≥ VGL (Low).
8. For die and wafer products, specified up to 85°C.
9. This temperature specifications apply to the TCP package

13.2. DC Characteristics

(VCC = VCI=2.40 ~ 3.0V, IOVCC = 1.65 ~ 3.30V, Ta= -40 ~ 85 °C)

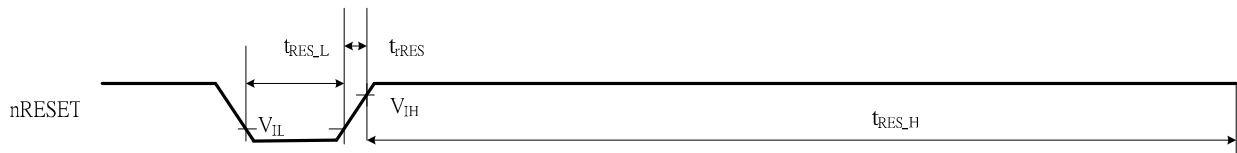
| Item | Symbol | Unit | Test Condition | Min. | Typ. | Max. | Note |
|---|---------------------|------|---|-----------|--------------|-----------|------|
| Input high voltage | V _{IH} | V | IOVCC= 1.8 ~ 3.3V | 0.8*IOVCC | - | IOVCC | - |
| Input low voltage | V _{IL} | V | IOVCC= 1.8 ~ 3.3V | -0.3 | - | 0.2*IOVCC | - |
| Output high voltage(1) (DB0-17 Pins) | V _{OH1} | V | IOH = -0.1 mA | 0.8*IOVCC | - | - | - |
| Output low voltage (DB0-17 Pins) | V _{OL1} | V | IOVCC=1.65~3.3V | - | - | 0.2*IOVCC | - |
| I/O leakage current | I _{LI} | μA | Vin = 0 ~ VCC | -0.1 | - | 0.1 | - |
| Current consumption during normal operation (VCC – GND) | I _{OP} | μA | VCC=2.8V , Ta=25 °C , fOSC = 512KHz (Line) GRAM data = 0000h | - | 100 (VCC) | - | - |
| Current consumption during standby mode (VCC – GND) | I _{ST} | μA | VCI=2.8V , Ta=25 °C | - | 30 | 50 | - |
| LCD Drive Power Supply Current (DDVDH-GND) | ILCD | mA | VCI=2.8V , VREG1OUT =4.8V DDVDH=5.2V , Frame Rate: 70Hz, line-inversion, Ta=25 °C, GRAM data = 0000h, | - | 5.5 | - | - |
| LCD Driving Voltage (DDVDH-GND) | DDVDH | V | - | 4.5 | - | 6 | - |
| Output deviation voltage | V _{DEV} | mV | - | - | - | 20 | - |
| Output offset voltage | V _{OFFSET} | mV | Note1 | - | - | 35 | - |

Note1: The Max. value is between with measure point and Gamma setting value.

13.3. Reset Timing Characteristics

Reset Timing Characteristics (IOVCC = 1.65 ~ 3.3 V)

| Item | Symbol | Unit | Min. | Typ. | Max. |
|------------------------|--------------------|------|------|------|------|
| Reset low-level width | t _{RES_L} | ms | 1 | - | - |
| Reset rise time | t _{RES} | μs | - | - | 10 |
| Reset high-level width | t _{RES_H} | ms | 50 | - | - |



13.4. AC Characteristics

13.4.1. i80-System Interface Timing Characteristics

Normal Write Mode (IOVCC = 1.65~3.3V)

| Item | Symbol | Unit | Min. | Typ. | Max. | Test Condition |
|----------------|--------|------------------|------|------|------|----------------|
| Bus cycle time | Write | t _{cyw} | ns | 100 | - | - |

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| | | | | | | | |
|-------------------------------|----------------------------|------------|-----|-----|-----|---|---|
| | Read | t_{CYCR} | ns | 300 | - | - | - |
| Write low-level pulse width | PW_{LW} | ns | 50 | - | - | - | - |
| Write high-level pulse width | PW_{HW} | ns | 50 | - | - | - | - |
| Read low-level pulse width | PW_{LR} | ns | 150 | - | - | - | - |
| Read high-level pulse width | PW_{HR} | ns | 150 | - | - | - | - |
| Write / Read rise / fall time | t_{WRr}/t_{WRf} | ns | - | - | 25 | - | - |
| Setup time | Write (RS to nCS, E/nWR) | t_{AS} | ns | 10 | - | - | - |
| | Read (RS to nCS, RW/nRD) | | | 5 | - | - | - |
| Address hold time | t_{AH} | ns | 5 | - | - | - | - |
| Write data set up time | t_{DSW} | ns | 10 | - | - | - | - |
| Write data hold time | t_H | ns | 15 | - | - | - | - |
| Read data delay time | t_{DDR} | ns | - | - | 100 | - | - |
| Read data hold time | t_{DHR} | ns | 5 | - | - | - | - |

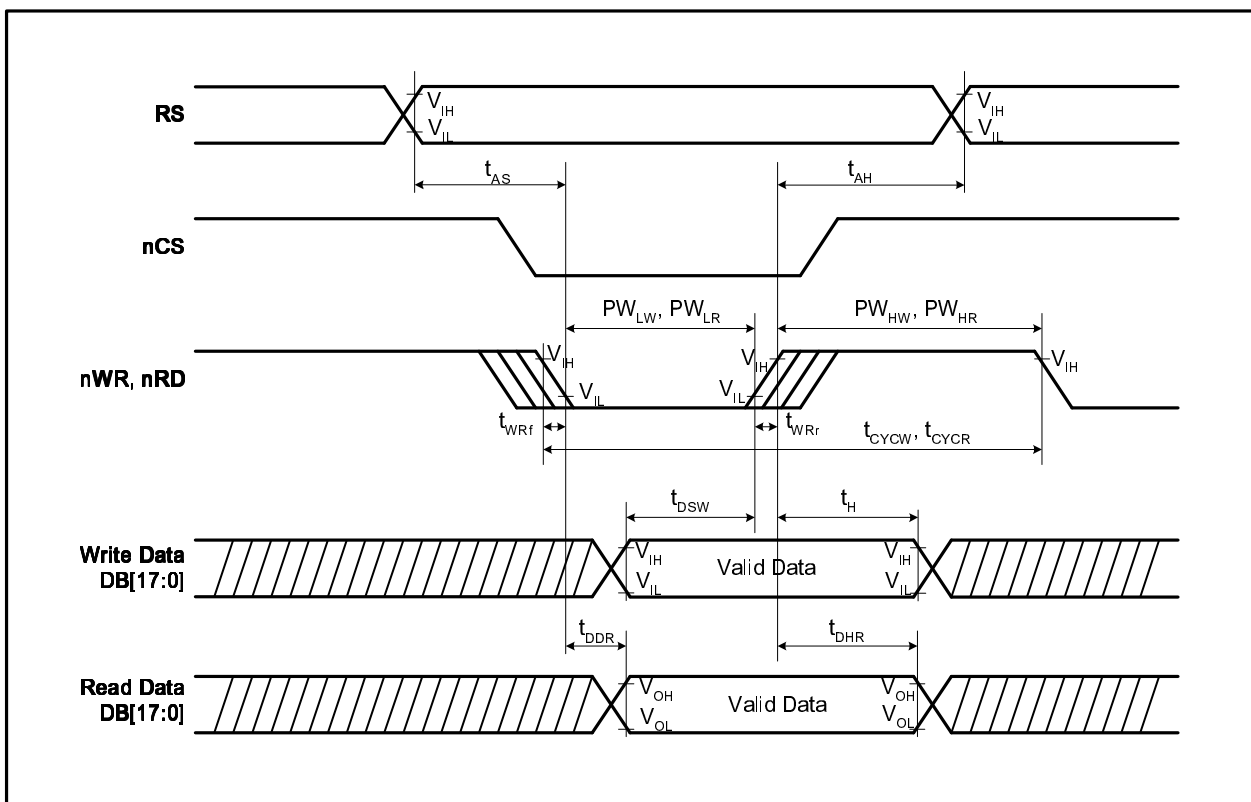


Figure 50 i80-System Bus Timing

13.4.2. Serial Data Transfer Interface Timing Characteristics

(IOVCC= 1.65 ~ 3.3V)

| Item | Symbol | Unit | Min. | Typ. | Max. | Test Condition |
|---------------------------------------|----------------------|------------|------|------|------|----------------|
| Serial clock cycle time | Write (received) | t_{SCYC} | ns | 100 | - | - |
| | Read (transmitted) | t_{SCYC} | ns | 200 | - | - |
| Serial clock high – level pulse width | Write (received) | t_{SCH} | ns | 40 | - | - |
| | Read (transmitted) | t_{SCH} | ns | 100 | - | - |
| Serial clock low – level pulse width | Write (received) | t_{SCL} | ns | 40 | - | - |
| | Read (transmitted) | t_{SCL} | ns | 100 | - | - |
| Serial clock rise / fall time | t_{SCr}, t_{SCf} | ns | - | - | 5 | - |

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| Item | Symbol | Unit | Min. | Typ. | Max. | Test Condition |
|--------------------------------|------------|------|------|------|------|----------------|
| Chip select set up time | t_{CSU} | ns | 10 | - | - | |
| Chip select hold time | t_{CH} | ns | 50 | - | - | |
| Serial input data set up time | t_{SISU} | ns | 20 | - | - | |
| Serial input data hold time | t_{SIH} | ns | 20 | - | - | |
| Serial output data set up time | t_{SOD} | ns | - | - | 100 | |
| Serial output data hold time | t_{SOH} | ns | 5 | - | - | |

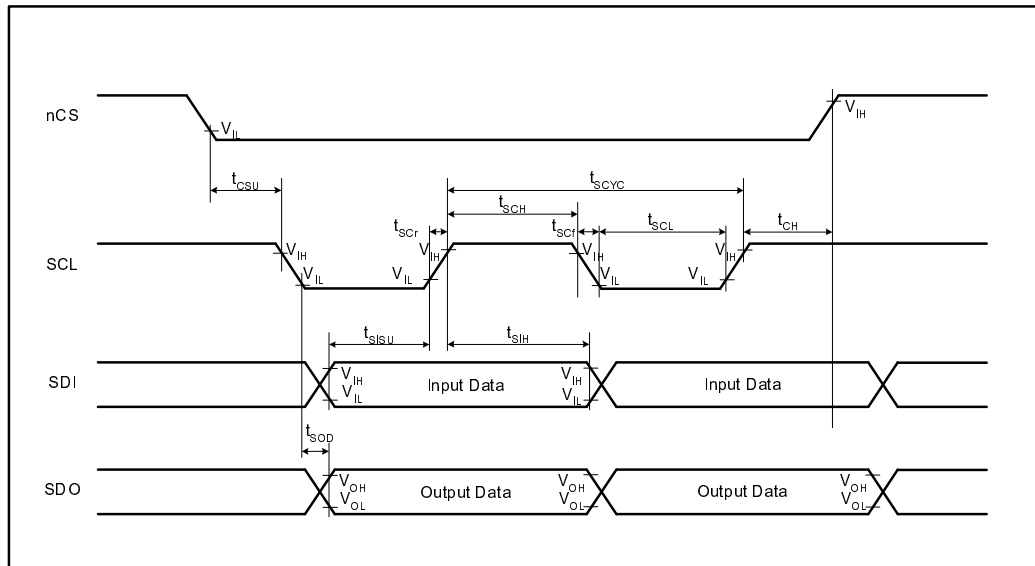


Figure 51 SPI System Bus Timing

13.4.3. RGB Interface Timing Characteristics

18/16-bit Bus RGB Interface Mode (IOVCC = 1.65 ~ 3.3V)

| Item | Symbol | Unit | Min. | Typ. | Max. | Test Condition |
|--------------------------------------|----------------------|------|------|------|------|----------------|
| VSYNC/HSYNC setup time | t_{SYNCS} | ns | 0 | - | - | - |
| ENABLE setup time | t_{ENS} | ns | 10 | - | - | - |
| ENABLE hold time | t_{ENH} | ns | 10 | - | - | - |
| PD Data setup time | t_{PDS} | ns | 10 | - | - | - |
| PD Data hold time | t_{PDH} | ns | 40 | - | - | - |
| DOTCLK high-level pulse width | PWDH | ns | 40 | - | - | - |
| DOTCLK low-level pulse width | PWDL | ns | 40 | - | - | - |
| DOTCLK cycle time | t_{CYCD} | ns | 100 | - | - | - |
| DOTCLK, VSYNC, HSYNC, rise/fall time | t_{rghr}, t_{rghf} | ns | - | - | 25 | - |

6-bit Bus RGB Interface Mode (IOVCC = 1.65 ~ 3.3V)

| Item | Symbol | Unit | Min. | Typ. | Max. | Test Condition |
|-------------------------------|-------------|------|------|------|------|----------------|
| VSYNC/HSYNC setup time | t_{SYNCS} | ns | 0 | - | - | - |
| ENABLE setup time | t_{ENS} | ns | 10 | - | - | - |
| ENABLE hold time | t_{ENH} | ns | 10 | - | - | - |
| PD Data setup time | t_{PDS} | ns | 10 | - | - | - |
| PD Data hold time | t_{PDH} | ns | 30 | - | - | - |
| DOTCLK high-level pulse width | PWDH | ns | 30 | - | - | - |
| DOTCLK low-level pulse width | PWDL | ns | 30 | - | - | - |
| DOTCLK cycle time | t_{CYCD} | ns | 80 | - | - | - |

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| | | | | | | |
|--------------------------------------|----------------------|----|---|---|----|---|
| DOTCLK, VSYNC, HSYNC, rise/fall time | t_{rghr}, t_{rghf} | ns | - | - | 25 | - |
|--------------------------------------|----------------------|----|---|---|----|---|

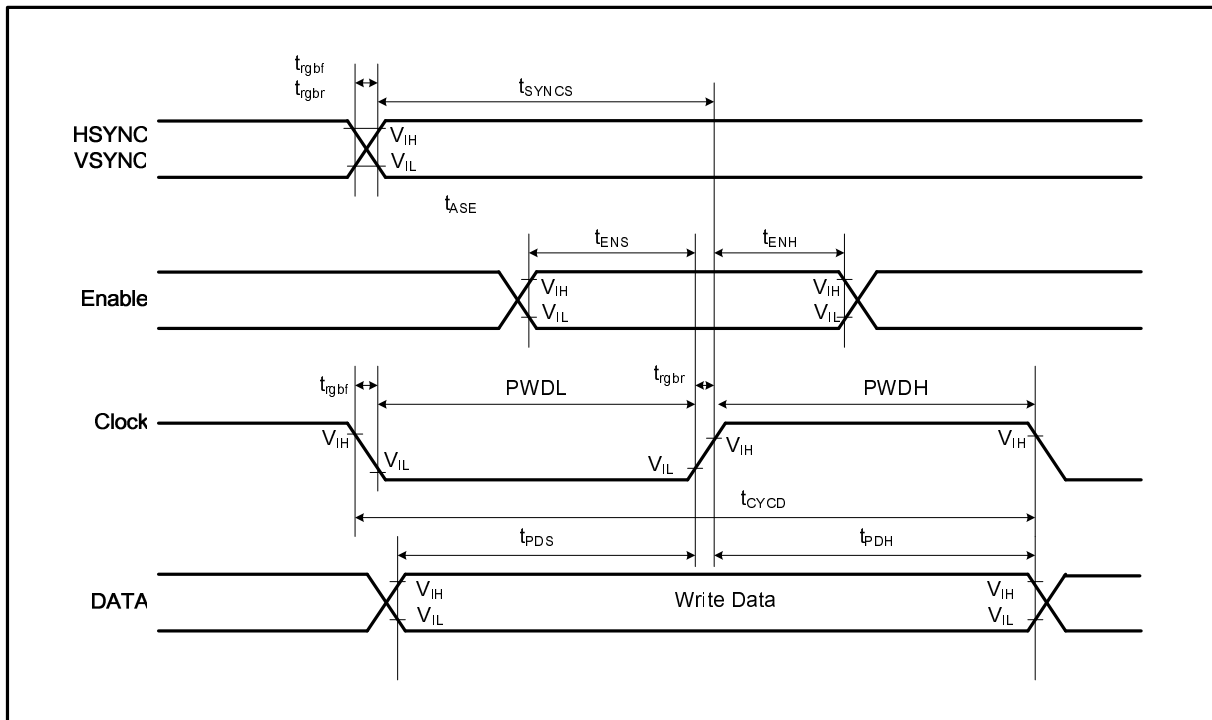


Figure52 RGB Interface Timing

14. Revision History

| Version No. | Date | Page | Description |
|-------------|------------|------|--|
| V0.1 | 2008/10/28 | | New created. |
| V0.11 | 2008/12/04 | | Modify ID code type error. Change 9325 to 9328 |
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