
HD66787

528-channel, One-chip Driver
with 262,144-color Display RAM and Power Supply Circuit
for Low-temperature Poli-Si TFT (LTPS-TFT) Panels
with Incorporated Gate Drivers

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Description

The HD66787 handles 262,144 TFT colors and can drive a TFT color liquid crystal display of 176RGB x 240 dots with an incorporated RAM compliant to a graphics display of 176 RGB x 240 dots at maximum, a 528-channel source driver, and a power supply circuit. The HD66787 generates signals to control panel-integrated gate circuit to drive a TFT panel with incorporated gate driver with a single chip.

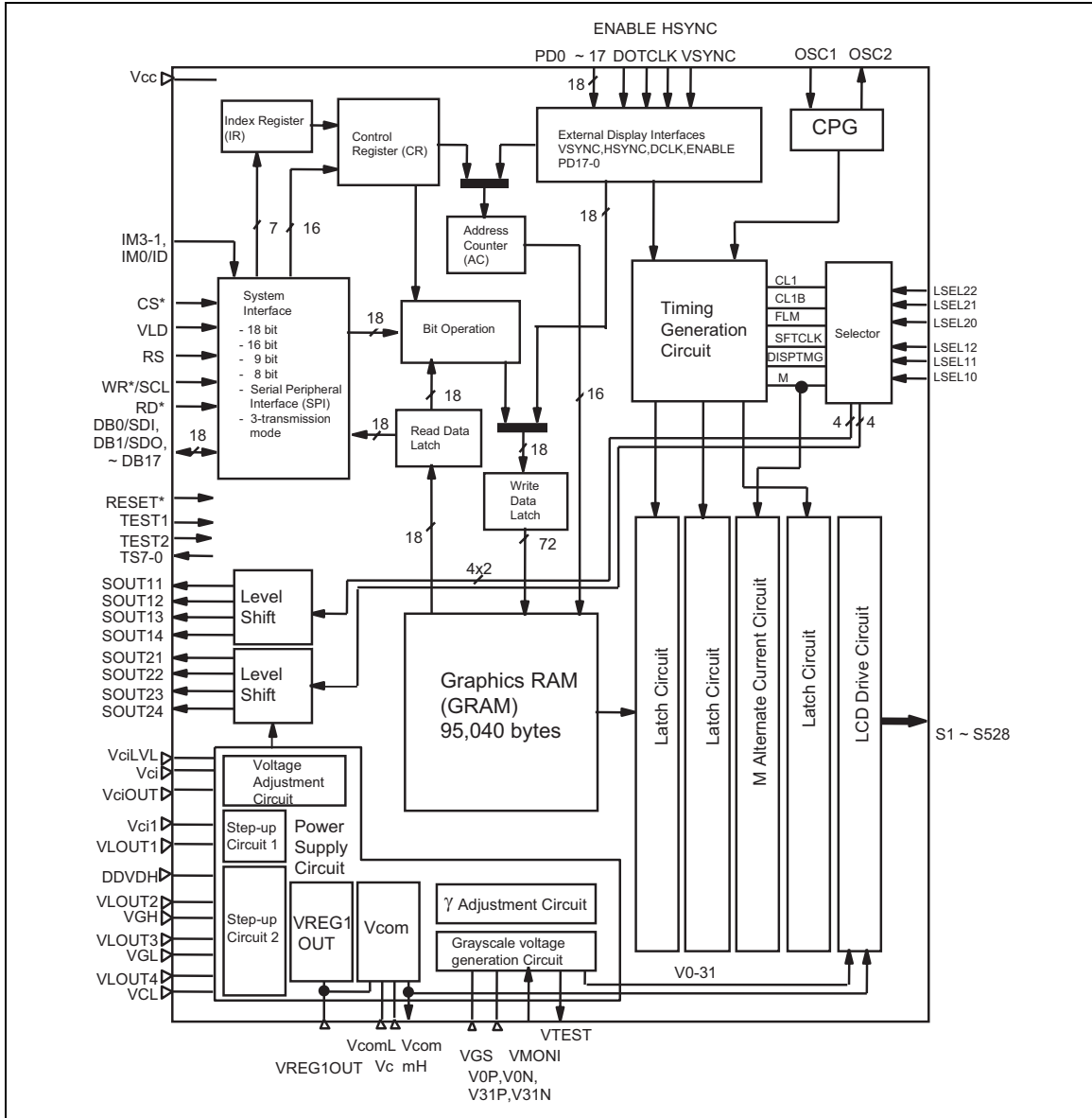
The HD66787's bit-operation functions, 8/9/16/18-bit high-speed bus interface, and high-speed RAM-write functions enable efficient transfer of data and high-speed data update on a graphics RAM. The HD66787 incorporates 6/16/18-bit RGB interface (VSYNC, HSYNC, DOTCLK, ENABLE, and PD 17 to 0) and VSYNC interface (system interface + VSYNC) as an interface for moving picture display. With a window address function that facilitates the moving picture display in an arbitrary area and simultaneous display of moving pictures and the contents of the internal RAM, the HD66787 enables moving picture display not constrained by the still picture area. Accordingly, the data transmission is reduced to minimum, thereby saving power consumed by a system as a whole when displaying moving pictures.

The HD66787 supports power-saving operation up to the power supply voltage of 2.4V with a voltage follower circuit that generate voltage to drive liquid crystal. The HD66787 also incorporates 8-color display and standby functions that allow precise power control by software. These features make this LSI the ideal solution for any medium or small sized portable battery-driven products such as digital cellular phones supporting WWW browsers or small PDA, where long battery life and board size are major concern.

Features

- Liquid crystal controller/driver for 262,144 TFT-color 176RGB x 240-dot graphics display
- Control signal for a low-temperature poly-Si TFT (LTPS-TFT) panel with incorporated gate circuit
- Single chip solution for gate-less display panels
- System interface
 - 8-/9-/16-/18-bit high-speed bus interface
 - Serial Peripheral Interface (SPI)
 - 8-bit transmission x 3 times (262k/65k color modes)
- Interface for moving picture display
 - 6-/16-/18-bit RGB interface (VSYNC, HSYNC, DOTCLK, ENABLE, PD17-0)
 - VSYNC interface (System interface + VSYNC)
- High-speed burst RAM write function
- Window address function to write data to the rectangular area of RAM specified by the window address
 - Interface to facilitate moving picture display in an arbitrary area
 - Reduce data transmission by transmitting only the data for the moving picture display area
 - Simultaneous display of moving pictures and the contents of the internal RAM
- Bit unit operations for processing graphics
 - Write data mask function by bit
 - Logical operation and conditional rewrite by pixel
- Functions for controlling abundant color displays
 - Simultaneous availability of 262,144 colors with γ -correction function
 - Line-unit vertical scrolling
- Low-power architecture: features for low-power operation
 - $V_{cc} = 2.4 \sim 3.3$ V (internal logic power supply)
 - $IOV_{cc} = 1.8 \sim 3.3$ V (interface I/O power supply)
 - $V_{ci} = 2.5 \sim 3.3$ V (analogue power supply)
 - $DDVDH = 4.5 \sim 5.5$ V (liquid-crystal drive voltage)
 - Power-saving drive function (standby mode etc.)
 - Partial liquid crystal drive to display two screens at arbitrary positions
 - Voltage followers for liquid crystal drive power circuit to fend off the direct current from bleeder-resistors
- Step-up circuit generating liquid crystal drive voltage boosted up to 6-time scale
- 95,040-byte internal RAM
- Incorporated liquid crystal display driver with 582 source outputs
- n-raster-row liquid crystal AC drive, enabling polarity inversion by every arbitrary number of raster-rows
- Internal oscillation, and hardware reset
- Reversible direction of signals between RAM and source driver
- Exclusive for Cst structure

Block Diagram



Pin Functions

| Signals | Number of Pins | I/O | Connected to | Functions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---------------|----------------|-----------|--------------|---|----------------|-----|-----------|-------------|--------------------|--------|-------|---------|-----|-----|------------------|---------|-----|-----|---------|-------|------------------|---|-----|-----|-------|-----|----------------------------|----------------|-----|-----|-------|-------|---------------------------|----------|-----|-------|-----|----|-----------------------------------|--------|-----|-------|-------|---|------------------|--|-------|-----|-----|-----|------------------|--|-------|-----|-----|-------|------------------|--|-------|-----|-------|-----|----------------------------|--------|-------|-----|-------|-------|---------------------------|--------|-------|-------|---|---|------------------|--|
| IM3~1, IM0/ID | 4 | I | GND or IOVcc | <p>Pins to select MPU-interface mode.</p> <table border="1"> <thead> <tr> <th>IM3</th> <th>IM2</th> <th>IM1</th> <th>IM0/ID</th> <th>MPU-Interface Mode</th> <th>DB Pin</th> </tr> </thead> <tbody> <tr> <td>GND</td> <td>GND</td> <td>GND</td> <td>GND</td> <td>Setting disabled</td> <td>—</td> </tr> <tr> <td>GND</td> <td>GND</td> <td>GND</td> <td>IOVcc</td> <td>Setting disabled</td> <td>—</td> </tr> <tr> <td>GND</td> <td>GND</td> <td>IOVcc</td> <td>GND</td> <td>80-system 16-bit interface</td> <td>DB17~10, DB8~1</td> </tr> <tr> <td>GND</td> <td>GND</td> <td>IOVcc</td> <td>IOVcc</td> <td>80-system 8-bit interface</td> <td>DB17 ~10</td> </tr> <tr> <td>GND</td> <td>IOVcc</td> <td>GND</td> <td>ID</td> <td>Serial Peripheral Interface (SPI)</td> <td>DB1~ 0</td> </tr> <tr> <td>GND</td> <td>IOVcc</td> <td>IOVcc</td> <td>*</td> <td>Setting disabled</td> <td></td> </tr> <tr> <td>IOVcc</td> <td>GND</td> <td>GND</td> <td>GND</td> <td>Setting disabled</td> <td></td> </tr> <tr> <td>IOVcc</td> <td>GND</td> <td>GND</td> <td>IOVcc</td> <td>Setting disabled</td> <td></td> </tr> <tr> <td>IOVcc</td> <td>GND</td> <td>IOVcc</td> <td>GND</td> <td>80-system 18-bit interface</td> <td>DB17~0</td> </tr> <tr> <td>IOVcc</td> <td>GND</td> <td>IOVcc</td> <td>IOVcc</td> <td>80-system 9-bit interface</td> <td>DB17~9</td> </tr> <tr> <td>IOVcc</td> <td>IOVcc</td> <td>*</td> <td>*</td> <td>Setting disabled</td> <td></td> </tr> </tbody> </table> <p>When Serial Peripheral Interface is selected, IM0 pin is used for the device code ID setting.</p> | IM3 | IM2 | IM1 | IM0/ID | MPU-Interface Mode | DB Pin | GND | GND | GND | GND | Setting disabled | — | GND | GND | GND | IOVcc | Setting disabled | — | GND | GND | IOVcc | GND | 80-system 16-bit interface | DB17~10, DB8~1 | GND | GND | IOVcc | IOVcc | 80-system 8-bit interface | DB17 ~10 | GND | IOVcc | GND | ID | Serial Peripheral Interface (SPI) | DB1~ 0 | GND | IOVcc | IOVcc | * | Setting disabled | | IOVcc | GND | GND | GND | Setting disabled | | IOVcc | GND | GND | IOVcc | Setting disabled | | IOVcc | GND | IOVcc | GND | 80-system 18-bit interface | DB17~0 | IOVcc | GND | IOVcc | IOVcc | 80-system 9-bit interface | DB17~9 | IOVcc | IOVcc | * | * | Setting disabled | |
| IM3 | IM2 | IM1 | IM0/ID | MPU-Interface Mode | DB Pin | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| GND | GND | GND | GND | Setting disabled | — | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| GND | GND | GND | IOVcc | Setting disabled | — | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| GND | GND | IOVcc | GND | 80-system 16-bit interface | DB17~10, DB8~1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| GND | GND | IOVcc | IOVcc | 80-system 8-bit interface | DB17 ~10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| GND | IOVcc | GND | ID | Serial Peripheral Interface (SPI) | DB1~ 0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| GND | IOVcc | IOVcc | * | Setting disabled | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| IOVcc | GND | GND | GND | Setting disabled | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| IOVcc | GND | GND | IOVcc | Setting disabled | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| IOVcc | GND | IOVcc | GND | 80-system 18-bit interface | DB17~0 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| IOVcc | GND | IOVcc | IOVcc | 80-system 9-bit interface | DB17~9 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| IOVcc | IOVcc | * | * | Setting disabled | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CS* | 1 | I | MPU | <p>Select the HD66787.</p> <p>Low: the HD66787 is selected and accessible High: the HD66787 is not selected and not accessible Must be fixed to the GND level while not used.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| VLD | 1 | I | MPU | <p>Indicate whether data is valid or not during RAM write.</p> <p>Low: Valid (Write data to RAM). High: Invalid (Not write data to RAM). RAM address is updated irrespective of VLD. Must be fixed to the GND level while not used. This signal is available when external display interface is used.</p> <table border="1"> <thead> <tr> <th>CS</th> <th>VLD</th> <th>RAM Write</th> <th>RAM Address</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>0</td> <td>Valid</td> <td>Updated</td> </tr> <tr> <td>0</td> <td>1</td> <td>Invalid</td> <td>Updated</td> </tr> <tr> <td>1</td> <td>*</td> <td>Invalid</td> <td>Hold</td> </tr> </tbody> </table> | CS | VLD | RAM Write | RAM Address | 0 | 0 | Valid | Updated | 0 | 1 | Invalid | Updated | 1 | * | Invalid | Hold | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| CS | VLD | RAM Write | RAM Address | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | Valid | Updated | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 1 | Invalid | Updated | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | * | Invalid | Hold | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Signals | Number of Pins | I/O | Connected to | Functions |
|----------|----------------|-----|--------------|--|
| RS | 1 | I | MPU | Select register. Low: Index/status, High: Control Fix to the "IOVcc" or "GND" level while using SPI. |
| WR*/SCL | 1 | I | MPU | In 80-system bus interface mode, serves as a write strobe signal. Data are written at "Low" level. In Serial Peripheral Interface mode, serves as synchronizing clock signal. |
| RD* | 1 | I | MPU | In 80-system bus interface mode, serves as read-strobe signal. Data are read at the low level of the signal. Fix to the "IOVcc" or "GND" level while using SPI. |
| DB0/SDI | 1 | I/O | MPU | 18-bit parallel bi-directional data bus. 8-bit bus: DB17-DB10 9-bit bus: DB17-DB9 16-bit bus: DB17-DB10 and DB8-DB1 18-bit bus: DB17-DB0 Unused pins must be fixed to the IOVcc or GND level. Serves as serial data input pin (SDI) in Serial Peripheral Interface mode, where data are input on the rising edge of SCL signal. |
| DB1/SDO | 1 | I/O | MPU | 18-bit parallel bi-directional data bus. 8-bit bus: DB17-DB10 9-bit bus: DB17-DB9 16-bit bus: DB17-DB10 and DB8-DB1 18-bit bus: DB17-DB0 Unused pins must be fixed to the IOVcc or GND level. Serves as serial data output pin (SDO) in Serial Peripheral Interface mode, where data are output on the falling edge of the SCL signal. |
| DB2~DB17 | 16 | I/O | MPU | 18-bit parallel bi-directional data bus. 8-bit bus: DB17-DB10 9-bit bus: DB17-DB9 16-bit bus: DB17-DB10 and DB8-DB1 18-bit bus: DB17-DB0 Unused pins must be fixed to the IOVcc or GND level. |
| ENABLE | 1 | I | MPU | Indicate whether RAM data are valid or not when RGB interface is used. Low: Selected (access enabled) High: Not selected (access disabled) Must be fixed to the IOVcc or GND level while not used. ENABLE signal invert the polarity according to the setting of EPL resister. |

| Signals | Number of Pins | I/O | Connected to | Functions | | | | |
|--------------|----------------|-----|----------------------|---|--------|-----|-----------|-------------|
| | | | | EPL | ENABLE | VLD | RAM Write | RAM Address |
| ENABLE | 1 | I | MPU | 0 | 0 | 0 | Valid | Updated |
| | | | | 0 | 0 | 1 | Invalid | Updated |
| | | | | 0 | 1 | * | Invalid | Held |
| | | | | 1 | 0 | * | Invalid | Held |
| | | | | 1 | 1 | 0 | Valid | Updated |
| | | | | 1 | 1 | 1 | Invalid | Updated |
| VSYNC | 1 | I | MPU | Frame synchronizing signal. This signal is active low. Must be fixed at the IOVcc level while not used. | | | | |
| HSYNC | 1 | I | MPU | Line synchronizing signal. This signal is active low. Must be fixed at the IOVcc level while not used. | | | | |
| DOTCLK | 1 | I | MPU | Dot-clock signal This signal is active low The timing of data input is determined at the falling edge of the signal. Must be fixed at the IOVcc level while not used | | | | |
| PD0~PD17 | 18 | I | MPU | 18-bit bus for RGB data. 6-bit bus: PD17-PD12 16-bit bus: PD17-PD13 and PD11-PD1 18-bit bus: PD17-PD0 Unused pins must be fixed to the IOVcc or GND level. | | | | |
| RESET* | 1 | I | MPU or reset circuit | Reset pin. Initializes the LSI at the "Low" level. Power-on reset required after turning on the power. | | | | |
| S1~S528 | 528 | O | LCD | Output voltage applied to liquid crystal. The shift direction of segment signals is changeable with SS bit. For example, if SS = 0, RAM address "0000" is output from S1. If SS = 1, it is output from S528. S1, S4, S7, ... display red (R), S2, S5, S8, ... display green (G), and S3, S6, S9, ... display blue (B) (SS = 0). | | | | |
| LSEL22,21,20 | 3 | I | GND or IOVcc | Output level shift output signals, SOUT24, 23, 22,21. | | | | |
| LSEL12,11,10 | 3 | I | GND or IOVcc | Output level shift output signals, SOUT14, 13, 12,11. | | | | |

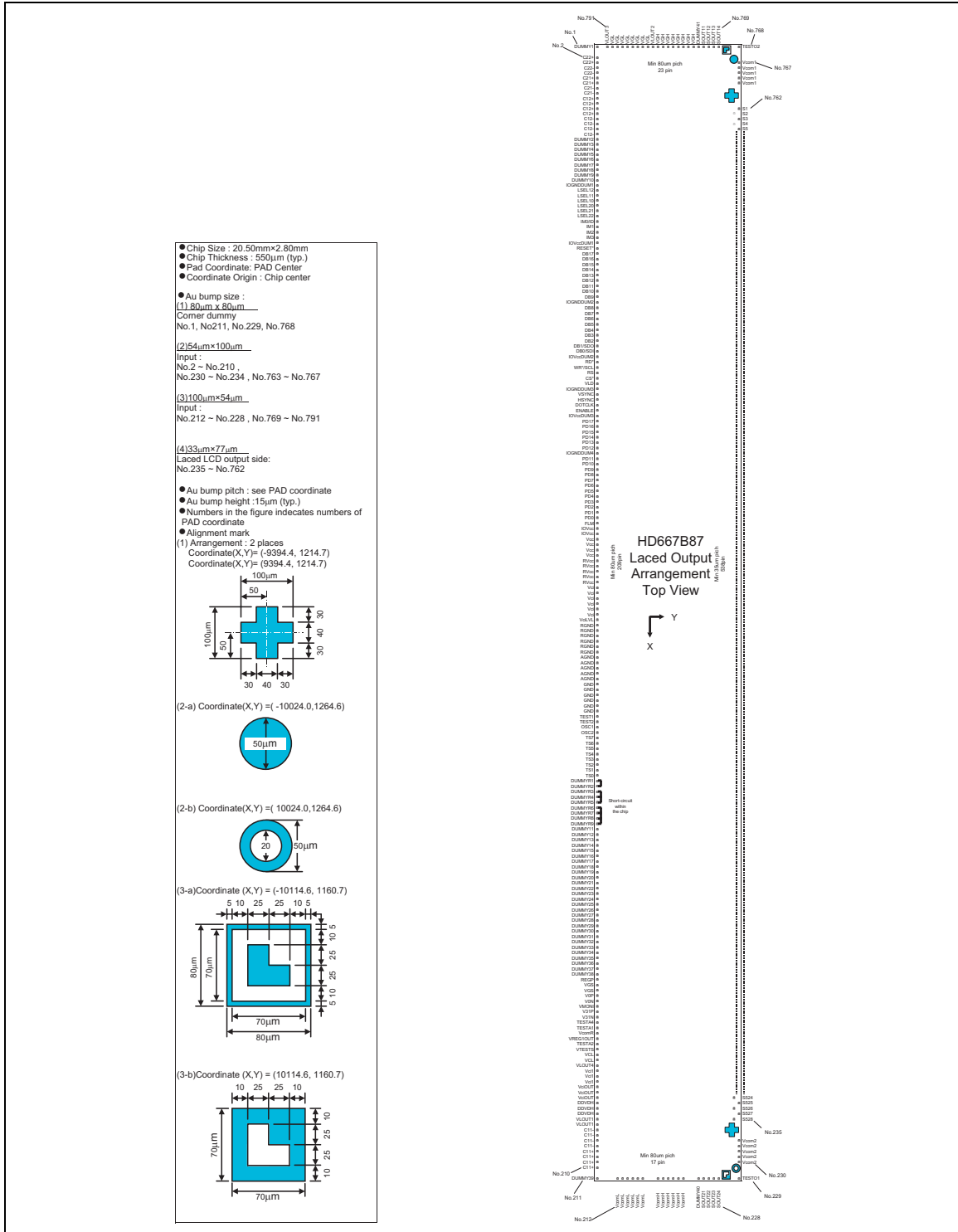
| Signals | Number of Pins | I/O | Connected to | Functions | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|------------------------------------|----------------|---------|-------------------------------|--|--------------|------------|--|--------------------|--|--|--|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|-----|-----|-----|-----|--------|-----|------|-----|-----|-------|-----|--------|-----|---------|-----|-------|-----|-----|--------|---|------|-----|-------|-------|-----|--------|---|---------|-------|-----|-----|-----|---------|-----|------|-------|-----|-------|------------------|--|--|--|-------|-------|-----|------------------|--|--|--|-------|-------|-------|------------|------------|------------|------------|
| SOUT14,13,12,11 SOUT24,23,22,21 | 8 | O | LCD | <p>Level-shift and then output display clocks.</p> <p>Output pins for SOUT14-11 are arranged on either left or right side of the chip and pins for SOUT24-21 are arranged on the other side of the chip. The kinds of output signals can be selected as shown in the following table with LSEL22-20 and LSEL12-10 bits and output from both or either one side of SOUT14-11 and SOUT 24-21 pins. If signals are output from either one side, halt the operation of unused circuits.</p> <p>When signals are output from SOUT14-11, SOUT 24-21 pins, 6 different kind of 8 level-shift signals are output at maximum. The amplitude of level-shift signal is between VGH and VGL.</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th colspan="3">Pin settings</th> <th colspan="4">Level shift signal</th> </tr> <tr> <th>LSEL 12</th> <th>LSEL 11</th> <th>LSEL 10</th> <th>SOUT 11</th> <th>SOUT 12</th> <th>SOUT 13</th> <th>SOUT 14</th> </tr> <tr> <th>LSEL 22</th> <th>LSEL 21</th> <th>LSEL 20</th> <th>SOUT 21</th> <th>SOUT 22</th> <th>SOUT 23</th> <th>SOUT 24</th> </tr> </thead> <tbody> <tr> <td>GND</td> <td>GND</td> <td>GND</td> <td>FLM</td> <td>SFTCLK</td> <td>CL1</td> <td>CL1B</td> </tr> <tr> <td>GND</td> <td>GND</td> <td>IOVcc</td> <td>FLM</td> <td>SFTCLK</td> <td>CL1</td> <td>DISPTMG</td> </tr> <tr> <td>GND</td> <td>IOVcc</td> <td>GND</td> <td>FLM</td> <td>SFTCLK</td> <td>M</td> <td>CL1B</td> </tr> <tr> <td>GND</td> <td>IOVcc</td> <td>IOVcc</td> <td>FLM</td> <td>SFTCLK</td> <td>M</td> <td>DISPTMG</td> </tr> <tr> <td>IOVcc</td> <td>GND</td> <td>GND</td> <td>FLM</td> <td>DISPTMG</td> <td>CL1</td> <td>CL1B</td> </tr> <tr> <td>IOVcc</td> <td>GND</td> <td>IOVcc</td> <td colspan="4" style="text-align: center;">Setting disabled</td> </tr> <tr> <td>IOVcc</td> <td>IOVcc</td> <td>GND</td> <td colspan="4" style="text-align: center;">Setting disabled</td> </tr> <tr> <td>IOVcc</td> <td>IOVcc</td> <td>IOVcc</td> <td>Halt (VGL)</td> <td>Halt (VGL)</td> <td>Halt (VGL)</td> <td>Halt (VGL)</td> </tr> </tbody> </table> | Pin settings | | | Level shift signal | | | | LSEL 12 | LSEL 11 | LSEL 10 | SOUT 11 | SOUT 12 | SOUT 13 | SOUT 14 | LSEL 22 | LSEL 21 | LSEL 20 | SOUT 21 | SOUT 22 | SOUT 23 | SOUT 24 | GND | GND | GND | FLM | SFTCLK | CL1 | CL1B | GND | GND | IOVcc | FLM | SFTCLK | CL1 | DISPTMG | GND | IOVcc | GND | FLM | SFTCLK | M | CL1B | GND | IOVcc | IOVcc | FLM | SFTCLK | M | DISPTMG | IOVcc | GND | GND | FLM | DISPTMG | CL1 | CL1B | IOVcc | GND | IOVcc | Setting disabled | | | | IOVcc | IOVcc | GND | Setting disabled | | | | IOVcc | IOVcc | IOVcc | Halt (VGL) | Halt (VGL) | Halt (VGL) | Halt (VGL) |
| Pin settings | | | Level shift signal | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| LSEL 12 | LSEL 11 | LSEL 10 | SOUT 11 | SOUT 12 | SOUT 13 | SOUT 14 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| LSEL 22 | LSEL 21 | LSEL 20 | SOUT 21 | SOUT 22 | SOUT 23 | SOUT 24 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| GND | GND | GND | FLM | SFTCLK | CL1 | CL1B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| GND | GND | IOVcc | FLM | SFTCLK | CL1 | DISPTMG | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| GND | IOVcc | GND | FLM | SFTCLK | M | CL1B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| GND | IOVcc | IOVcc | FLM | SFTCLK | M | DISPTMG | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| IOVcc | GND | GND | FLM | DISPTMG | CL1 | CL1B | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| IOVcc | GND | IOVcc | Setting disabled | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| IOVcc | IOVcc | GND | Setting disabled | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| IOVcc | IOVcc | IOVcc | Halt (VGL) | Halt (VGL) | Halt (VGL) | Halt (VGL) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Vcom1, Vcom2 | 2 | O | TFT common electrode | <p>Power supply for TFT common electrode.</p> <p>When Vcom AC drive is not selected, output the same level of voltage as VcomL level. When Vcom AC drive is selected, output the voltage with the amplitude between VcomH and VcomL. The AC cycle can be set with M signal.</p> <p>Connect to the TFT common electrode.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| VcomR | 1 | I | Variable resistor or open | <p>Reference voltage for VcomH.</p> <p>When adjusting VcomH externally, VcomH internal adjusting circuit must be halted by register setting and place a variable resistor between VREG1OUT and GND to make an adjustment. Otherwise, leave open and adjust VcomH by internal-register setting.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| VcomH | 1 | O | Stabilizing capacitor | <p>High level of Vcom during Vcom AC drive. Connect to a stabilizing capacitor.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| VcomL | 1 | O | Stabilizing capacitor or open | <p>Vcom voltage when Vcom AC drive is not selected.</p> <p>Low level of Vcom during Vcom AC drive. Voltage can be adjusted with internal registers. Connect to a stabilizing capacitor. When VCOMG bit is set to LOW, a stabilizing capacitor is not necessary because VcomL output is halted.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| C11+, C11- | 2 | - | Step-up capacitor | <p>Step-up capacitor connection pins for step-up circuit 1. When the internal step-up circuit is not used, leave open.</p> | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Signals | Number of Pins | I/O | Connected to | Functions |
|--|----------------|--------|------------------------------|--|
| C12+, C12- C21+, C21- C22+, C22- | 6 | - | Step-up capacitor | Step-up capacitor connection pins for step-up circuit 2. Capacitor connection will be necessary depending on the step-up scale. When the internal step-up circuit is not used, leave open. |
| OSC1, OSC2 | 2 | I or O | Resistor for the oscillator | Connect to an external resistor for R-C oscillation. When supplying clock signals externally, it must be supplied through OSC1 and leave OSC2 open. |
| FLM | 1 | O | MPU or open | Frame head pulse with amplitude between GND and Vcc. Use when writing data to RAM in synchronization with FLM. When FLM is not used, leave open. |
| Vci | 1 | I | Power supply | Power supply for analogue circuits. In this case, power supply for the VciOUT amplifier. Connect to an external power supply of 2.5~3.3V. |
| VciLVL | 1 | I | Power supply | Generates a reference voltage (VciOUT, REGP) in accordance to the ratio set with VC2~0 registers. Connect to the same power supply as the Vci, which has separate wiring from the VciLVL on the FPC. |
| REGP | 1 | I/O | Test pin | Test pin for VREG1OUT. Leave open. |
| VciOUT | 1 | I | Stabilizing capacitor, Vci1 | Internal reference voltage with amplitude between Vci and GND. Set with VC bit. |
| Vci1 | 1 | I | VciOUT | A reference voltage for the step-up circuit 1. Connect to an external power supply of 2.75V or less when the internal reference voltage is not used. |
| VLOUT1 | 1 | O | Stabilizing capacitor, DDVDH | Output twice stepped-up Vci1 voltage from the step-up circuit 1. Connect to a stabilizing capacitor. VLOUT1 = 4.0~5.5V |
| DDVDH | 1 | I | VLOUT1 | Power supply for source driver liquid crystal output portion. A reference voltage for the step-up circuit 2. |
| VLOUT2 | 1 | O | Stabilizing capacitor, VGH | Output stepped-up DDVDH voltage, which is stepped up to the level Vci1 x 4~6 from the step-up circuit 2. The step-up scale is determined with BT bits. Connect to a stabilizing capacitor. VLOUT2 = max 16.5V |
| VGH | 1 | I | VLOUT2 | Power supply for TFT gate drive. Connect to VLOUT2. |
| VLOUT3 | 1 | O | Stabilizing capacitor, VGL | Output stepped-up DDVDH voltage, which is stepped up to the level Vci1 x (-3) ~ (-5) from the step-up circuit 2. The step-up scale is determined with BT bits. Connect to a stabilizing capacitor. VLOUT2 = min -16.5V |
| VGL | 1 | I | VLOUT3 | A power supply for TFT gate drive. Connect to VLOUT3. |
| VLOUT4 | 1 | O | Stabilizing capacitor, VCL | Output the Vci1 x (-1) voltage from the step-up circuit 2. Connect to a stabilizing capacitor. VLOUT4 = 0 ~ -3.3V |
| VCL | 1 | I | VLOUT4 | Power supply for VcomL drive. Connect to VLOUT4. |

| Signals | Number of Pins | I/O | Connected to | Functions |
|-------------|----------------|--------|---------------------------------------|---|
| VREG1OUT | 1 | I/O | Stabilizing capacitor or power supply | Reference voltage with amplitude between DDVDH and GND, which is generated from the reference voltage internally generated with amplitude between Vci and GND. The scale of output voltage can be set with VRH bits. VREG1OUT becomes (1) a source driver grayscale reference voltage VDH, (2) a VcomH level reference voltage, or (3) a Vcom amplitude reference voltage. Connect to a stabilizing capacitor. $VREG1OUT = 3.0 \sim (DDVDH - 0.5)V$ |
| Vcc | 1 | - | Power supply | Power supply for a logic circuit. $Vcc = 2.4 \sim 3.3V$ |
| IOVcc | 1 | - | Power supply | Power supply for interface pins. $IOVcc = 1.8 \sim 3.3V$. IOVcc must be turned on with the same voltage as the internal logic voltage Vcc. When it is assembled on COG, connect to Vcc on the FPC to avoid effects from the noise when IOVcc is used. |
| RVcc | 1 | - | Power supply | Vcc power supply for RAM. Supply with the same potential as the Vcc. |
| GND | 1 | - | Power supply | Ground for the logic side. $GND = 0V$ |
| AGND | 1 | - | Power supply | Ground for the analog side. $AGND = 0V$. When assembled on COG, connect to GND on the FPC to avoid effects from the noise. |
| RGND | 1 | - | Power supply | Ground for internal RAM. $RGND = 0V$. When assembled on COG, connect to GND on the FPC to avoid effects from the noise. |
| TEST1 | 1 | I | GND | Test pin. Fix it to the GND level. |
| TEST2 | 1 | I | GND | Test pin. Fix it to the GND level. |
| V0P, V31P | 2 | I or O | Stabilizing capacitor | Output from internal positive polarity operational amplifier when the operational amplifier is ON (SAP2-0 = "001", "010", "011", "100", and "101"). Stabilize by connecting to a capacitor. |
| V0N, V31N | 2 | I or O | Stabilizing capacitor | Output from internal negative polarity operational amplifier when the operational amplifier is ON (SAP2-0 = "001", "010", "011", "100", and "101"). Stabilize by connecting to a capacitor. |
| VGS | 1 | I | GND or external resistor | Reference level for grayscale voltage generation circuit. Connect to an external resistor when source driver is used to adjust grayscale levels for each panel. |
| VTESTS | 1 | I/O | open | Test pin. Leave open. |
| TS0~TS7 | 8 | O | open | Test pin. Leave open. |
| TESTA1 | 1 | I/O | open | Test pin for VcomH. Leave open. |
| TESTA2 | 1 | I/O | open | Test pin for VcomL. Leave open. |
| TESTA4 | 1 | I/O | open | Test pin for VcomL. Leave open or connect to a stabilizing capacitor depending on the display quality. |
| VMONI | 1 | O | open | Test pin. Leave open. |
| IOVccDUM1~4 | 4 | O | Input pin | Internal IOVcc level. When neighboring input pins are fixed to the IOVcc side, short-circuit them. |

| Signals | Number of Pins | I/O | Connected to | Functions |
|--------------|----------------|-----|--------------|--|
| I0GND DUM1~7 | 7 | O | Input pin | Internal GND level. When neighboring input pins are fixed to the IOVcc side, short-circuit them. |
| TESTO1~2 | 2 | - | - | Dummy pads. Leave open. |
| DUMMY | | - | - | Dummy pad. Leave open. |
| DUMMYR | | - | - | Dummy pad. Leave open. |

PAD Arrangement



PAD Coordinate

| pad No | pad name | X | Y | pad No | pad name | X | Y | pad No | pad name | X | Y | pad No | pad name | X | Y |
|--------|-----------|---------|---------|--------|----------|--------|---------|--------|----------|--------|---------|--------|----------|-------|--------|
| 1 | DUMMY1 | -1011.0 | -1254.0 | 101 | Rvcc | -752.0 | -1254.0 | 201 | VLOUT1 | 910.0 | -1254.0 | 301 | S462 | 693.0 | 1148.5 |
| 2 | C22* | -9885.5 | -1254.0 | 102 | Vcc | -698.1 | -1254.0 | 202 | VLOUT1 | 910.0 | -1254.0 | 302 | S461 | 699.0 | 1265.5 |
| 3 | C22* | -9805.3 | -1254.0 | 103 | Vcc | -528.0 | -1254.0 | 203 | C11- | 932.4 | -1254.0 | 303 | S460 | 686.0 | 1148.5 |
| 4 | C22* | -9725.2 | -1254.0 | 104 | Vcc | -447.8 | -1254.0 | 204 | C11- | 940.4 | -1254.0 | 304 | S459 | 682.0 | 1265.5 |
| 5 | C22* | -9645.0 | -1254.0 | 105 | Vcc | -387.7 | -1254.0 | 205 | C11- | 948.4 | -1254.0 | 305 | S458 | 678.0 | 1148.5 |
| 6 | C21+ | -9564.9 | -1254.0 | 106 | Vcc | -287.5 | -1254.0 | 206 | C11- | 956.4 | -1254.0 | 306 | S457 | 675.0 | 1265.5 |
| 7 | C21+ | -9484.7 | -1254.0 | 107 | Vcc | -207.4 | -1254.0 | 207 | C11+ | 9645.0 | -1254.0 | 307 | S456 | 672.0 | 1148.5 |
| 8 | C21- | -9404.6 | -1254.0 | 108 | voLVL | -57.7 | -1254.0 | 208 | C11+ | 9725.2 | -1254.0 | 308 | S455 | 668.0 | 1265.5 |
| 9 | C21- | -9324.4 | -1254.0 | 109 | RGND | 56.6 | -1254.0 | 209 | C11+ | 9805.3 | -1254.0 | 309 | S454 | 665.0 | 1148.5 |
| 10 | C12* | -9186.0 | -1254.0 | 110 | RGND | 166.8 | -1254.0 | 210 | C11+ | 9885.5 | -1254.0 | 310 | S453 | 661.0 | 1265.5 |
| 11 | C12* | -9105.9 | -1254.0 | 111 | RGND | 246.9 | -1254.0 | 211 | DUMMY39 | 1011.0 | -1254.0 | 311 | S452 | 658.0 | 1148.5 |
| 12 | C12* | -9025.7 | -1254.0 | 112 | RGND | 327.1 | -1254.0 | 212 | VcomL | 1010.0 | -1035.5 | 312 | S451 | 654.0 | 1265.5 |
| 13 | C12* | -8945.6 | -1254.0 | 113 | RGND | 407.2 | -1254.0 | 213 | VcomL | 1010.0 | -897.1 | 313 | S450 | 651.0 | 1148.5 |
| 14 | C12* | -8867.1 | -1254.0 | 114 | RGND | 487.4 | -1254.0 | 214 | VcomL | 1010.0 | -758.6 | 314 | S449 | 647.0 | 1265.5 |
| 15 | C12* | -8787.0 | -1254.0 | 115 | AGND | 630.4 | -1254.0 | 215 | VcomL | 1010.0 | -620.2 | 315 | S448 | 644.0 | 1148.5 |
| 16 | C12* | -8646.8 | -1254.0 | 116 | AGND | 700.5 | -1254.0 | 216 | VcomL | 1010.0 | -481.8 | 316 | S447 | 640.0 | 1265.5 |
| 17 | C12* | -8566.7 | -1254.0 | 117 | AGND | 780.7 | -1254.0 | 217 | VcomL | 1010.0 | -343.4 | 317 | S446 | 637.0 | 1148.5 |
| 18 | DUMMY2 | -8433.7 | -1254.0 | 118 | AGND | 860.9 | -1254.0 | 218 | VcomH | 1010.0 | -204.9 | 318 | S445 | 633.0 | 1265.5 |
| 19 | DUMMY3 | -8353.5 | -1254.0 | 119 | AGND | 941.0 | -1254.0 | 219 | VcomH | 1010.0 | -85.5 | 319 | S444 | 630.0 | 1148.5 |
| 20 | DUMMY4 | -8273.4 | -1254.0 | 120 | GND | 1074.0 | -1254.0 | 220 | VcomH | 1010.0 | 71.9 | 320 | S443 | 626.0 | 1265.5 |
| 21 | DUMMY5 | -8193.2 | -1254.0 | 121 | GND | 1154.1 | -1254.0 | 221 | VcomH | 1010.0 | 216.0 | 321 | S442 | 623.0 | 1148.5 |
| 22 | DUMMY6 | -8113.1 | -1254.0 | 122 | GND | 1237.1 | -1254.0 | 222 | VcomH | 1010.0 | 348.9 | 322 | S441 | 619.0 | 1265.5 |
| 23 | DUMMY7 | -8032.9 | -1254.0 | 123 | GND | 1367.3 | -1254.0 | 223 | VcomH | 1010.0 | 487.2 | 323 | S440 | 616.0 | 1148.5 |
| 24 | DUMMY8 | -7952.8 | -1254.0 | 124 | GND | 1447.4 | -1254.0 | 224 | DUMMY40 | 1010.0 | 655.3 | 324 | S439 | 612.0 | 1265.5 |
| 25 | DUMMY9 | -7872.6 | -1254.0 | 125 | GND | 1542.6 | -1254.0 | 225 | SQUT1 | 1010.0 | 785.9 | 325 | S438 | 608.0 | 1148.5 |
| 26 | DUMMY10 | -7792.5 | -1254.0 | 126 | TEST1 | 1679.2 | -1254.0 | 226 | SQUT2 | 1010.0 | 868.4 | 326 | S437 | 605.0 | 1265.5 |
| 27 | ICGNDUM1 | -7618.5 | -1254.0 | 127 | TEST2 | 1759.4 | -1254.0 | 227 | SQUT3 | 1010.0 | 948.6 | 327 | S436 | 602.0 | 1148.5 |
| 28 | SEL12 | -7501.1 | -1254.0 | 128 | OSC1 | 1839.0 | -1254.0 | 228 | SQUT4 | 1010.0 | 1028.1 | 328 | S435 | 598.0 | 1265.5 |
| 29 | SEL11 | -7421.0 | -1254.0 | 129 | OSC2 | 1979.2 | -1254.0 | 229 | TEST01 | 1011.0 | 1264.0 | 329 | S434 | 595.0 | 1148.5 |
| 30 | SEL10 | -7340.8 | -1254.0 | 130 | TS7 | 2158.8 | -1254.0 | 230 | Vcom2 | 999.2 | 1254.0 | 330 | S433 | 591.0 | 1265.5 |
| 31 | SEL20 | -7260.7 | -1254.0 | 131 | TS8 | 2198.0 | -1254.0 | 231 | Vcom2 | 991.1 | 1250.0 | 331 | S432 | 588.0 | 1148.5 |
| 32 | SEL21 | -7180.5 | -1254.0 | 132 | TS5 | 2279.1 | -1254.0 | 232 | Vcom2 | 973.8 | 1254.0 | 332 | S431 | 584.0 | 1265.5 |
| 33 | SEL22 | -7100.4 | -1254.0 | 133 | TS4 | 2359.3 | -1254.0 | 233 | Vcom2 | 965.8 | 1254.0 | 333 | S430 | 581.0 | 1148.5 |
| 34 | IMID | -7020.2 | -1254.0 | 134 | TS3 | 2439.4 | -1254.0 | 234 | Vcom2 | 957.8 | 1250.0 | 334 | S429 | 577.0 | 1265.5 |
| 35 | IM2 | -6940.1 | -1254.0 | 135 | TS2 | 2519.6 | -1254.0 | 235 | S528 | 924.0 | 1148.5 | 335 | S428 | 574.0 | 1148.5 |
| 36 | IM2 | -6869.9 | -1254.0 | 136 | TS1 | 2599.7 | -1254.0 | 236 | S527 | 920.0 | 1265.5 | 336 | S427 | 570.0 | 1265.5 |
| 37 | IM2 | -6789.8 | -1254.0 | 137 | TS0 | 2679.9 | -1254.0 | 237 | S526 | 917.0 | 1148.5 | 337 | S426 | 567.0 | 1148.5 |
| 38 | IOVccDUM1 | -6665.3 | -1254.0 | 138 | DUMMYR1 | 2829.3 | -1254.0 | 238 | S525 | 913.0 | 1265.5 | 338 | S425 | 563.0 | 1265.5 |
| 39 | RESET* | -6512.5 | -1254.0 | 139 | DUMMYR2 | 2904.5 | -1254.0 | 239 | S524 | 910.0 | 1148.5 | 339 | S424 | 560.0 | 1148.5 |
| 40 | DB17 | -6372.9 | -1254.0 | 140 | DUMMYR3 | 2984.6 | -1254.0 | 240 | S523 | 906.0 | 1265.5 | 340 | S423 | 556.0 | 1265.5 |
| 41 | DB16 | -6292.7 | -1254.0 | 141 | DUMMYR4 | 3064.8 | -1254.0 | 241 | S522 | 903.0 | 1148.5 | 341 | S422 | 553.0 | 1148.5 |
| 42 | DB15 | -6212.6 | -1254.0 | 142 | DUMMYR5 | 3144.9 | -1254.0 | 242 | S521 | 899.0 | 1265.5 | 342 | S421 | 549.0 | 1265.5 |
| 43 | DB14 | -6132.4 | -1254.0 | 143 | DUMMYR6 | 3225.1 | -1254.0 | 243 | S520 | 896.0 | 1148.5 | 343 | S420 | 546.0 | 1148.5 |
| 44 | DB13 | -6052.3 | -1254.0 | 144 | DUMMYR7 | 3305.2 | -1254.0 | 244 | S519 | 892.0 | 1265.5 | 344 | S419 | 542.0 | 1265.5 |
| 45 | DB12 | -5972.1 | -1254.0 | 145 | DUMMYR8 | 3385.4 | -1254.0 | 245 | S518 | 889.0 | 1148.5 | 345 | S418 | 539.0 | 1148.5 |
| 46 | DB11 | -5892.0 | -1254.0 | 146 | DUMMYR9 | 3465.5 | -1254.0 | 246 | S517 | 885.0 | 1265.5 | 346 | S417 | 535.0 | 1265.5 |
| 47 | DB10 | -5811.8 | -1254.0 | 147 | DUMMYR10 | 3545.7 | -1254.0 | 247 | S516 | 881.0 | 1148.5 | 347 | S416 | 531.0 | 1148.5 |
| 48 | DB9 | -5731.7 | -1254.0 | 148 | DUMMYR12 | 3678.7 | -1254.0 | 248 | S515 | 878.0 | 1265.5 | 348 | S415 | 528.0 | 1265.5 |
| 49 | ICGNDUM2 | -5587.2 | -1254.0 | 149 | DUMMYR13 | 3758.8 | -1254.0 | 249 | S514 | 875.0 | 1148.5 | 349 | S414 | 525.0 | 1148.5 |
| 50 | DB8 | -5469.9 | -1254.0 | 150 | DUMMYR14 | 3838.9 | -1254.0 | 250 | S513 | 871.0 | 1265.5 | 350 | S413 | 521.0 | 1265.5 |
| 51 | DB7 | -5389.7 | -1254.0 | 151 | DUMMYR15 | 3919.1 | -1254.0 | 251 | S512 | 868.0 | 1148.5 | 351 | S412 | 518.0 | 1148.5 |
| 52 | DB6 | -5309.6 | -1254.0 | 152 | DUMMYR16 | 3999.3 | -1254.0 | 252 | S511 | 864.0 | 1265.5 | 352 | S411 | 514.0 | 1265.5 |
| 53 | DB5 | -5229.4 | -1254.0 | 153 | DUMMYR17 | 4079.4 | -1254.0 | 253 | S510 | 861.0 | 1148.5 | 353 | S410 | 511.0 | 1148.5 |
| 54 | DB4 | -5149.3 | -1254.0 | 154 | DUMMYR18 | 4159.6 | -1254.0 | 254 | S509 | 857.0 | 1265.5 | 354 | S409 | 507.0 | 1265.5 |
| 55 | DB3 | -5069.1 | -1254.0 | 155 | DUMMYR19 | 4239.7 | -1254.0 | 255 | S508 | 854.0 | 1148.5 | 355 | S408 | 504.0 | 1148.5 |
| 56 | DB2 | -4989.0 | -1254.0 | 156 | DUMMYR20 | 4319.9 | -1254.0 | 256 | S507 | 850.0 | 1265.5 | 356 | S407 | 500.0 | 1265.5 |
| 57 | DB15SD0 | -4908.8 | -1254.0 | 157 | DUMMYR21 | 4400.0 | -1254.0 | 257 | S506 | 847.0 | 1148.5 | 357 | S406 | 497.0 | 1148.5 |
| 58 | DB05SD1 | -4828.7 | -1254.0 | 158 | DUMMYR22 | 4480.2 | -1254.0 | 258 | S505 | 843.0 | 1265.5 | 358 | S405 | 493.0 | 1265.5 |
| 59 | IOVccDUM2 | -4684.2 | -1254.0 | 159 | DUMMYR23 | 4560.3 | -1254.0 | 259 | S504 | 840.0 | 1148.5 | 359 | S404 | 490.0 | 1148.5 |
| 60 | RD0 | -4569.9 | -1254.0 | 160 | DUMMYR24 | 4640.5 | -1254.0 | 260 | S503 | 836.0 | 1265.5 | 360 | S403 | 486.0 | 1265.5 |
| 61 | WRFSQCL | -4486.7 | -1254.0 | 161 | DUMMYR25 | 4720.6 | -1254.0 | 261 | S502 | 833.0 | 1148.5 | 361 | S402 | 483.0 | 1148.5 |
| 62 | RS | -4406.6 | -1254.0 | 162 | DUMMYR26 | 4800.8 | -1254.0 | 262 | S501 | 829.0 | 1265.5 | 362 | S401 | 479.0 | 1265.5 |
| 63 | CS | -4326.4 | -1254.0 | 163 | DUMMYR27 | 4880.9 | -1254.0 | 263 | S500 | 826.0 | 1148.5 | 363 | S400 | 476.0 | 1148.5 |
| 64 | VLD | -4246.3 | -1254.0 | 164 | DUMMYR28 | 4961.1 | -1254.0 | 264 | S499 | 822.0 | 1265.5 | 364 | S399 | 472.0 | 1265.5 |
| 65 | ICGNDUM3 | -4101.8 | -1254.0 | 165 | DUMMYR29 | 5041.2 | -1254.0 | 265 | S498 | 819.0 | 1148.5 | 365 | S398 | 469.0 | 1148.5 |
| 66 | HSYNC | -3984.5 | -1254.0 | 166 | DUMMYR30 | 5121.4 | -1254.0 | 266 | S497 | 815.0 | 1265.5 | 366 | S397 | 465.0 | 1265.5 |
| 67 | HSYNC | -3894.3 | -1254.0 | 167 | DUMMYR31 | 5201.5 | -1254.0 | 267 | S496 | 812.0 | 1148.5 | 367 | S396 | 462.0 | 1148.5 |
| 68 | DOTCLK | -3824.2 | -1254.0 | 168 | DUMMYR32 | 5281.7 | -1254.0 | 268 | S495 | 808.0 | 1265.5 | 368 | S395 | 458.0 | 1265.5 |
| 69 | ENABLE | -3744.0 | -1254.0 | 169 | DUMMYR33 | 5361.8 | -1254.0 | 269 | S494 | 805.0 | 1148.5 | 369 | S394 | 455.0 | 1148.5 |
| 70 | IOVccDUM3 | -3699.6 | -1254.0 | 170 | DUMMYR34 | 5442.0 | -1254.0 | 270 | S493 | 801.0 | 1265.5 | 370 | S393 | 451.0 | 1265.5 |
| 71 | PD17 | -3482.2 | -1254.0 | 171 | DUMMYR35 | 5522.1 | -1254.0 | 271 | S492 | 798.0 | 1148.5 | 371 | S392 | 4 | |

| pad No | pad name | X | Y | pad No | pad name | X | Y | pad No | pad name | X | Y | pad No | pad name | X | Y |
|--------|----------|--------|--------|--------|----------|---------|--------|--------|----------|---------|--------|--------|----------|----------|--------|
| 401 | S362 | 3430.0 | 1148.5 | 501 | S262 | -105.0 | 1148.5 | 601 | S162 | -3605.0 | 1148.5 | 701 | S62 | -7105.0 | 1148.5 |
| 402 | S361 | 3395.0 | 1265.5 | 502 | S261 | -140.0 | 1265.5 | 602 | S161 | -3640.0 | 1265.5 | 702 | S61 | -7140.0 | 1265.5 |
| 403 | S360 | 3360.0 | 1148.5 | 503 | S260 | -175.0 | 1148.5 | 603 | S160 | -3675.0 | 1148.5 | 703 | S60 | -7175.0 | 1148.5 |
| 404 | S359 | 3325.0 | 1265.5 | 504 | S259 | -210.0 | 1265.5 | 604 | S159 | -3710.0 | 1265.5 | 704 | S59 | -7210.0 | 1265.5 |
| 405 | S358 | 3290.0 | 1148.5 | 505 | S258 | -245.0 | 1148.5 | 605 | S158 | -3745.0 | 1148.5 | 705 | S58 | -7245.0 | 1148.5 |
| 406 | S357 | 3255.0 | 1265.5 | 506 | S257 | -280.0 | 1265.5 | 606 | S157 | -3780.0 | 1265.5 | 706 | S57 | -7280.0 | 1265.5 |
| 407 | S356 | 3220.0 | 1148.5 | 507 | S256 | -315.0 | 1148.5 | 607 | S156 | -3815.0 | 1148.5 | 707 | S56 | -7315.0 | 1148.5 |
| 408 | S355 | 3185.0 | 1265.5 | 508 | S255 | -350.0 | 1265.5 | 608 | S155 | -3850.0 | 1265.5 | 708 | S55 | -7350.0 | 1265.5 |
| 409 | S354 | 3150.0 | 1148.5 | 509 | S254 | -385.0 | 1148.5 | 609 | S154 | -3885.0 | 1148.5 | 709 | S54 | -7385.0 | 1148.5 |
| 410 | S353 | 3115.0 | 1265.5 | 510 | S253 | -420.0 | 1265.5 | 610 | S153 | -3920.0 | 1265.5 | 710 | S53 | -7420.0 | 1265.5 |
| 411 | S352 | 3080.0 | 1148.5 | 511 | S252 | -455.0 | 1148.5 | 611 | S152 | -3955.0 | 1148.5 | 711 | S52 | -7455.0 | 1148.5 |
| 412 | S351 | 3045.0 | 1265.5 | 512 | S251 | -490.0 | 1265.5 | 612 | S151 | -3990.0 | 1265.5 | 712 | S51 | -7490.0 | 1265.5 |
| 413 | S350 | 3010.0 | 1148.5 | 513 | S250 | -525.0 | 1148.5 | 613 | S150 | -4025.0 | 1148.5 | 713 | S50 | -7525.0 | 1148.5 |
| 414 | S349 | 2975.0 | 1265.5 | 514 | S249 | -560.0 | 1265.5 | 614 | S149 | -4060.0 | 1265.5 | 714 | S49 | -7560.0 | 1265.5 |
| 415 | S348 | 2940.0 | 1148.5 | 515 | S248 | -595.0 | 1148.5 | 615 | S148 | -4095.0 | 1148.5 | 715 | S48 | -7595.0 | 1148.5 |
| 416 | S347 | 2905.0 | 1265.5 | 516 | S247 | -630.0 | 1265.5 | 616 | S147 | -4130.0 | 1265.5 | 716 | S47 | -7630.0 | 1265.5 |
| 417 | S346 | 2870.0 | 1148.5 | 517 | S246 | -665.0 | 1148.5 | 617 | S146 | -4165.0 | 1148.5 | 717 | S46 | -7665.0 | 1148.5 |
| 418 | S345 | 2835.0 | 1265.5 | 518 | S245 | -700.0 | 1265.5 | 618 | S145 | -4200.0 | 1265.5 | 718 | S45 | -7700.0 | 1265.5 |
| 419 | S344 | 2800.0 | 1148.5 | 519 | S244 | -735.0 | 1148.5 | 619 | S144 | -4235.0 | 1148.5 | 719 | S44 | -7735.0 | 1148.5 |
| 420 | S343 | 2765.0 | 1265.5 | 520 | S243 | -770.0 | 1265.5 | 620 | S143 | -4270.0 | 1265.5 | 720 | S43 | -7770.0 | 1265.5 |
| 421 | S342 | 2730.0 | 1148.5 | 521 | S242 | -805.0 | 1148.5 | 621 | S142 | -4305.0 | 1148.5 | 721 | S42 | -7805.0 | 1148.5 |
| 422 | S341 | 2695.0 | 1265.5 | 522 | S241 | -840.0 | 1265.5 | 622 | S141 | -4340.0 | 1265.5 | 722 | S41 | -7840.0 | 1265.5 |
| 423 | S340 | 2660.0 | 1148.5 | 523 | S240 | -875.0 | 1148.5 | 623 | S140 | -4375.0 | 1148.5 | 723 | S40 | -7875.0 | 1148.5 |
| 424 | S339 | 2625.0 | 1265.5 | 524 | S239 | -910.0 | 1265.5 | 624 | S139 | -4410.0 | 1265.5 | 724 | S39 | -7910.0 | 1265.5 |
| 425 | S338 | 2590.0 | 1148.5 | 525 | S238 | -945.0 | 1148.5 | 625 | S138 | -4445.0 | 1148.5 | 725 | S38 | -7945.0 | 1148.5 |
| 426 | S337 | 2555.0 | 1265.5 | 526 | S237 | -980.0 | 1265.5 | 626 | S137 | -4480.0 | 1265.5 | 726 | S37 | -7980.0 | 1265.5 |
| 427 | S336 | 2520.0 | 1148.5 | 527 | S236 | -1015.0 | 1148.5 | 627 | S136 | -4515.0 | 1148.5 | 727 | S36 | -8015.0 | 1148.5 |
| 428 | S335 | 2485.0 | 1265.5 | 528 | S235 | -1050.0 | 1265.5 | 628 | S135 | -4550.0 | 1265.5 | 728 | S35 | -8050.0 | 1265.5 |
| 429 | S334 | 2450.0 | 1148.5 | 529 | S234 | -1085.0 | 1148.5 | 629 | S134 | -4585.0 | 1148.5 | 729 | S34 | -8085.0 | 1148.5 |
| 430 | S333 | 2415.0 | 1265.5 | 530 | S233 | -1120.0 | 1265.5 | 630 | S133 | -4620.0 | 1265.5 | 730 | S33 | -8120.0 | 1265.5 |
| 431 | S332 | 2380.0 | 1148.5 | 531 | S232 | -1155.0 | 1148.5 | 631 | S132 | -4655.0 | 1148.5 | 731 | S32 | -8155.0 | 1148.5 |
| 432 | S331 | 2345.0 | 1265.5 | 532 | S231 | -1190.0 | 1265.5 | 632 | S131 | -4690.0 | 1148.5 | 732 | S31 | -8190.0 | 1265.5 |
| 433 | S330 | 2310.0 | 1148.5 | 533 | S230 | -1225.0 | 1148.5 | 633 | S130 | -4725.0 | 1148.5 | 733 | S30 | -8225.0 | 1148.5 |
| 434 | S329 | 2275.0 | 1265.5 | 534 | S229 | -1260.0 | 1265.5 | 634 | S129 | -4760.0 | 1265.5 | 734 | S29 | -8260.0 | 1265.5 |
| 435 | S328 | 2240.0 | 1148.5 | 535 | S228 | -1295.0 | 1148.5 | 635 | S128 | -4795.0 | 1148.5 | 735 | S28 | -8295.0 | 1148.5 |
| 436 | S327 | 2205.0 | 1265.5 | 536 | S227 | -1330.0 | 1265.5 | 636 | S127 | -4830.0 | 1265.5 | 736 | S27 | -8330.0 | 1265.5 |
| 437 | S326 | 2170.0 | 1148.5 | 537 | S226 | -1365.0 | 1148.5 | 637 | S126 | -4865.0 | 1148.5 | 737 | S26 | -8365.0 | 1148.5 |
| 438 | S325 | 2135.0 | 1265.5 | 538 | S225 | -1400.0 | 1265.5 | 638 | S125 | -4900.0 | 1265.5 | 738 | S25 | -8400.0 | 1265.5 |
| 439 | S324 | 2100.0 | 1148.5 | 539 | S224 | -1435.0 | 1148.5 | 639 | S124 | -4935.0 | 1148.5 | 739 | S24 | -8435.0 | 1148.5 |
| 440 | S323 | 2065.0 | 1265.5 | 540 | S223 | -1470.0 | 1265.5 | 640 | S123 | -4970.0 | 1265.5 | 740 | S23 | -8470.0 | 1265.5 |
| 441 | S322 | 2030.0 | 1148.5 | 541 | S222 | -1505.0 | 1148.5 | 641 | S122 | -5005.0 | 1148.5 | 741 | S22 | -8505.0 | 1148.5 |
| 442 | S321 | 1995.0 | 1265.5 | 542 | S221 | -1540.0 | 1265.5 | 642 | S121 | -5040.0 | 1265.5 | 742 | S21 | -8540.0 | 1265.5 |
| 443 | S320 | 1960.0 | 1148.5 | 543 | S220 | -1575.0 | 1148.5 | 643 | S120 | -5075.0 | 1148.5 | 743 | S20 | -8575.0 | 1148.5 |
| 444 | S319 | 1925.0 | 1265.5 | 544 | S219 | -1610.0 | 1148.5 | 644 | S119 | -5110.0 | 1148.5 | 744 | S19 | -8610.0 | 1265.5 |
| 445 | S318 | 1890.0 | 1148.5 | 545 | S218 | -1645.0 | 1148.5 | 645 | S118 | -5145.0 | 1148.5 | 745 | S18 | -8645.0 | 1148.5 |
| 446 | S317 | 1855.0 | 1265.5 | 546 | S217 | -1680.0 | 1265.5 | 646 | S117 | -5180.0 | 1265.5 | 746 | S17 | -8680.0 | 1265.5 |
| 447 | S316 | 1820.0 | 1148.5 | 547 | S216 | -1715.0 | 1148.5 | 647 | S116 | -5215.0 | 1148.5 | 747 | S16 | -8715.0 | 1148.5 |
| 448 | S315 | 1785.0 | 1265.5 | 548 | S215 | -1750.0 | 1265.5 | 648 | S115 | -5250.0 | 1265.5 | 748 | S15 | -8750.0 | 1265.5 |
| 449 | S314 | 1750.0 | 1148.5 | 549 | S214 | -1785.0 | 1148.5 | 649 | S114 | -5285.0 | 1148.5 | 749 | S14 | -8785.0 | 1148.5 |
| 450 | S313 | 1715.0 | 1265.5 | 550 | S213 | -1820.0 | 1265.5 | 650 | S113 | -5320.0 | 1265.5 | 750 | S13 | -8820.0 | 1265.5 |
| 451 | S312 | 1680.0 | 1148.5 | 551 | S212 | -1855.0 | 1148.5 | 651 | S112 | -5355.0 | 1148.5 | 751 | S12 | -8855.0 | 1148.5 |
| 452 | S311 | 1645.0 | 1265.5 | 552 | S211 | -1890.0 | 1265.5 | 652 | S111 | -5390.0 | 1265.5 | 752 | S11 | -8890.0 | 1265.5 |
| 453 | S310 | 1610.0 | 1148.5 | 553 | S210 | -1925.0 | 1148.5 | 653 | S110 | -5425.0 | 1148.5 | 753 | S10 | -8925.0 | 1148.5 |
| 454 | S309 | 1575.0 | 1265.5 | 554 | S209 | -1960.0 | 1265.5 | 654 | S109 | -5460.0 | 1265.5 | 754 | S9 | -8960.0 | 1265.5 |
| 455 | S308 | 1540.0 | 1148.5 | 555 | S208 | -1995.0 | 1148.5 | 655 | S108 | -5495.0 | 1148.5 | 755 | S8 | -8995.0 | 1148.5 |
| 456 | S307 | 1505.0 | 1265.5 | 556 | S207 | -2030.0 | 1265.5 | 656 | S107 | -5530.0 | 1265.5 | 756 | S7 | -9030.0 | 1265.5 |
| 457 | S306 | 1470.0 | 1148.5 | 557 | S206 | -2065.0 | 1148.5 | 657 | S106 | -5565.0 | 1148.5 | 757 | S6 | -9065.0 | 1148.5 |
| 458 | S305 | 1435.0 | 1265.5 | 558 | S205 | -2100.0 | 1265.5 | 658 | S105 | -5600.0 | 1265.5 | 758 | S5 | -9100.0 | 1265.5 |
| 459 | S304 | 1400.0 | 1148.5 | 559 | S204 | -2135.0 | 1148.5 | 659 | S104 | -5635.0 | 1148.5 | 759 | S4 | -9135.0 | 1148.5 |
| 460 | S303 | 1365.0 | 1265.5 | 560 | S203 | -2170.0 | 1265.5 | 660 | S103 | -5670.0 | 1265.5 | 760 | S3 | -9170.0 | 1265.5 |
| 461 | S302 | 1330.0 | 1148.5 | 561 | S202 | -2205.0 | 1148.5 | 661 | S102 | -5705.0 | 1148.5 | 761 | S2 | -9205.0 | 1148.5 |
| 462 | S301 | 1295.0 | 1265.5 | 562 | S201 | -2240.0 | 1265.5 | 662 | S101 | -5740.0 | 1265.5 | 762 | S1 | -9240.0 | 1265.5 |
| 463 | S300 | 1260.0 | 1148.5 | 563 | S200 | -2275.0 | 1148.5 | 663 | S100 | -5775.0 | 1148.5 | 763 | Vcom1 | -9275.0 | 1254.0 |
| 464 | S299 | 1225.0 | 1265.5 | 564 | S199 | -2310.0 | 1265.5 | 664 | S99 | -5810.0 | 1265.5 | 764 | Vcom1 | -9251.6 | 1254.0 |
| 465 | S298 | 1190.0 | 1148.5 | 565 | S198 | -2345.0 | 1148.5 | 665 | S98 | -5845.0 | 1148.5 | 765 | Vcom1 | -9211.3 | 1254.0 |
| 466 | S297 | 1155.0 | 1265.5 | 566 | S197 | -2380.0 | 1265.5 | 666 | S97 | -5880.0 | 1265.5 | 766 | Vcom1 | -9171.9 | 1254.0 |
| 467 | S296 | 1120.0 | 1148.5 | 567 | S196 | -2415.0 | 1148.5 | 667 | S96 | -5915.0 | 1148.5 | 767 | Vcom1 | -9132.5 | 1254.0 |
| 468 | S295 | 1085.0 | 1265.5 | 568 | S195 | -2450.0 | 1265.5 | 668 | S95 | -5950.0 | 1265.5 | 768 | TEST02 | -10114.0 | 1264.0 |
| 469 | S294 | 1050.0 | 1148.5 | 569 | S194 | -2485.0 | 1148.5 | 669 | S94 | -5985.0 | 1148.5 | 769 | SOUT14 | -10104.0 | 1028.7 |
| 470 | S293 | 1015.0 | 1265.5 | 570 | S193 | -2520.0 | 1265.5 | 670 | S93 | -6020.0 | 1265.5 | 770 | SOUT13 | -10104.0 | 948.6 |
| 471 | S292 | 980.0 | 1148.5 | 571 | S192 | -2555.0 | 1148.5 | 671 | S92 | -6055.0 | 1148.5 | 771 | SOUT12 | -10104.0 | 868.4 |
| 472 | S291 | 945.0 | 1265.5 | 572 | S191 | -2590.0 | 1265.5 | 672 | S91 | -6090.0 | 1265.5 | 772 | SOUT11 | -10104.0 | 788.3 |
| 473 | S290 | 910.0 | 1148.5 | 573 | S190 | -2625.0 | 1148.5 | 673 | S90 | -6125.0 | 1148.5 | 773 | DUMMY41 | -10104.0 | 655.3 |
| 474 | S289 | 875.0 | 1265.5 | 574 | S189 | -2660.0 | 1265.5 | 674 | S89 | -6160.0 | 1265.5 | 774 | VGH | -10104.0 | 512.8 |
| 475 | S288 | 840.0 | 1148.5 | 575 | S188 | -2695.0 | 1148.5 | 675 | S88 | -6195.0 | 1148.5 | 775 | VGH | -10104.0 | 432.6 |
| 476 | S287 | 805.0 | 1265.5 | 576 | S187 | -2730.0 | 1265.5 | 676 | S87 | -6230.0 | 1265.5 | 776 | VGH | -10104.0 | 352.5 |
| 477 | S286 | 770.0 | 1148.5 | 577 | S186 | -2765.0 | 1148.5 | 677 | S86 | -6265.0 | 1148.5 | 777 | VGH | -10104.0 | 272.3 |
| 478 | S285 | 735.0 | 1265.5 | 578 | S185 | -2800.0 | 1265.5 | 678 | S85 | -6300.0 | 1265.5 | 778 | VGH | -10104.0 | 192.2 |
| 479 | | | | | | | | | | | | | | | |

BUMP Arrangements (T.B.D.)



Block Function

1. System Interface

The HD66787 has five high-speed system interfaces: 80-system 18-/16-/9-/8-bit bus and Serial Peripheral Interface (SPI) port. The interface mode is selected with IM3-0 pins.

The HD66787 has three registers: 16-bit index register (IR), 18-bit write-data register (WDR), and 18-bit read-data register (RDR). The IR stores index information from control registers and GRAM. The WDR temporarily stores data to write into the control registers and GRAM, and the RDR temporarily stores data read from GRAM. Data written into GRAM from the MPU is first written into the WDR and then automatically written into GRAM by internal operation. Since data are read through the RDR from GRAM, the data read out first are invalid data and the ensuing data are read out normally.

The execution time for instructions other than oscillation start is 0-clock cycle, which enables writing instructions consecutively.

Register Selection (8/9/16/18 Parallel Interfaces)

80-system Bus

| WR* | RD* | RS | Operation |
|-----|-----|----|--|
| 0 | 1 | 0 | Write index to IR |
| 1 | 0 | 0 | Read internal status |
| 0 | 1 | 1 | Write to the control registers or GRAM through WDR |
| 1 | 0 | 1 | Read from GRAM through RDR |

Values of CS and VLD during RAM Write

| CS* | VLD | Operations |
|-----|-----|---|
| 0 | 0 | Write data to GRAM. RAM address is updated. |
| 1 | 0 | Not write data to GRAM. RAM address is not updated. |
| 0 | 1 | Not write data to GRAM. RAM address is updated. |
| 1 | 1 | Not write data to GRAM. RAM address is not updated. |

Note 1) The VLD setting is only effective with RAM write instructions.

Register Selection (Serial Peripheral Interface)

Start bytes

| R/W | RS | Operations |
|-----|----|--|
| 0 | 0 | Write index to IR |
| 1 | 0 | Read internal status |
| 0 | 1 | Write into the control register and GRAM through WDR |
| 1 | 1 | Read from GRAM through RDR |

2. External Display Interface

The HD66787 incorporates RGB and VSYNC interfaces as an external interface for displaying moving pictures. When RGB-I/F is selected, the display operation is executed in synchronization with the externally supplied signals, VSYNC, HSYNC, and DOTCLK. The display data (PD17-0) are written according to the values of data enable signal (ENABLE) and data valid signal (VLD) in synchronization with VSYNC, HSYNC, and DOTCLK signals. This data write method allows flicker-free screen update. When VSYNC-I/F is selected, operations other than the frame synchronization by VSYNC signal are synchronized with internal clocks. The display data are written to GRAM through a system interface. In this case, there are constraints on the timing and methods of RAM update. See the “External Display Interface” section for more details.

Switching between conventional system interfaces and external display interfaces is made through instructions. An optimum interface is selected whether the screen is displaying moving or still pictures. All data written through RGB-I/F are written to GRAM. Therefore, data is transmitted only when the screen is being updated, which reduces the amount of data transmission, thereby saving power when moving pictures are being displayed.

3. Bit Operations

The HD66787 supports a write data mask function that selects and writes data into GRAM by bit, and performs logical operation or conditional rewrite on the contents of compare registers and the data to write to GRAM. For details, see the “Graphics Operation Functions” section.

4. Address Counter (AC)

Address counter (AC) assigns address to GRAM. When an address set instruction is written into the IR, the address information is sent from the IR to the AC.

After writing data to GRAM, the AC is automatically updated plus or minus 1. The AC is not updated when the data are read from GRAM. Window address function enables data write only in the rectangular area of GRAM specified by the window address.

5. Graphics RAM (GRAM)

GRAM is a graphics RAM that stores bit-pattern data of 176 x 240 bytes with 18 bits per pixel.

6. Grayscale Power Supply Voltage Generating Circuit

Grayscale voltage generation circuit generates liquid crystal drive voltage according to the grayscale data set in the γ -correction register, enabling 262,144-color display. For details, see the “ γ -Correction Register” section.

7. Timing Generator

Timing generator generates timing signals for the operation of internal circuits such as GRAM. The timing for display operation such as RAM read and the internal operation timing such as access from MPU are generated in a way to avoid mutual interfere. The interface signals (M, FLM, CL1, EQ, DCCLK,

DISPTMG, and SFTCLK) are generated internally, and a part of the signals is output through a level transforming circuit.

8. Oscillation Circuit (OSC)

The HD66787 can provide R-C oscillation simply by placing an external oscillation-resistor between OSC1 and OSC2 pins. An appropriate oscillation frequency for operating voltage, display size, and frame frequency can be obtained by adjusting the external-resistor value. Clock pulses can be supplied externally. Since R-C oscillation is halted during the standby mode, current consumption will be reduced. For details, see the "Oscillation Circuit" section.

9. LCD Driver Circuit

The LCD driver circuit of HD66787 consists of a 528-output source driver (S1 ~ S528). Display pattern data are latched when 528-bit data arrive. The latched data controls the source driver and generates drive waveforms. The shift direction of outputting 528 bits from source driver is changeable with the SS bit. Select an appropriate shift direction for an assembly.

10. LCD Drive Power Supply Circuit

The LCD drive power supply circuit of HD66787 generates voltages V0, V31P, V31N, VGH, and Vcom required for driving LCD.

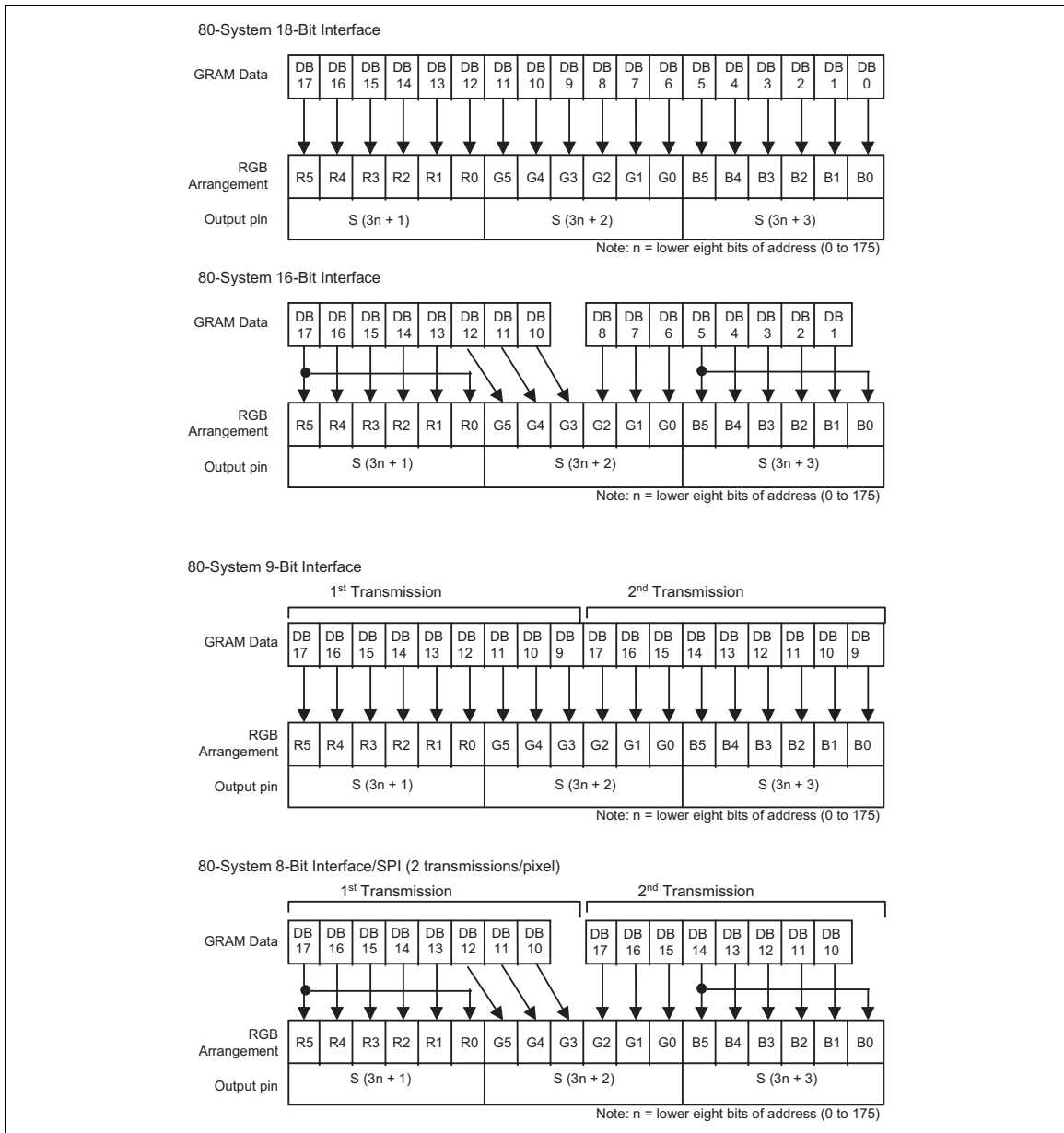
11. LTPS Panel Interface Circuit

LTPS Panel Interface Circuit level-shifts and outputs display clock signal to control LTPS (gate-less) panel. Output pins arranged on both sides of the LSI allow flexible panel design. The LSEL22-20 pins allows a combination of display clocks from SOUT24-21 and the LSEL12-10 pins allows a combination of display clocks from SOUT14-11.

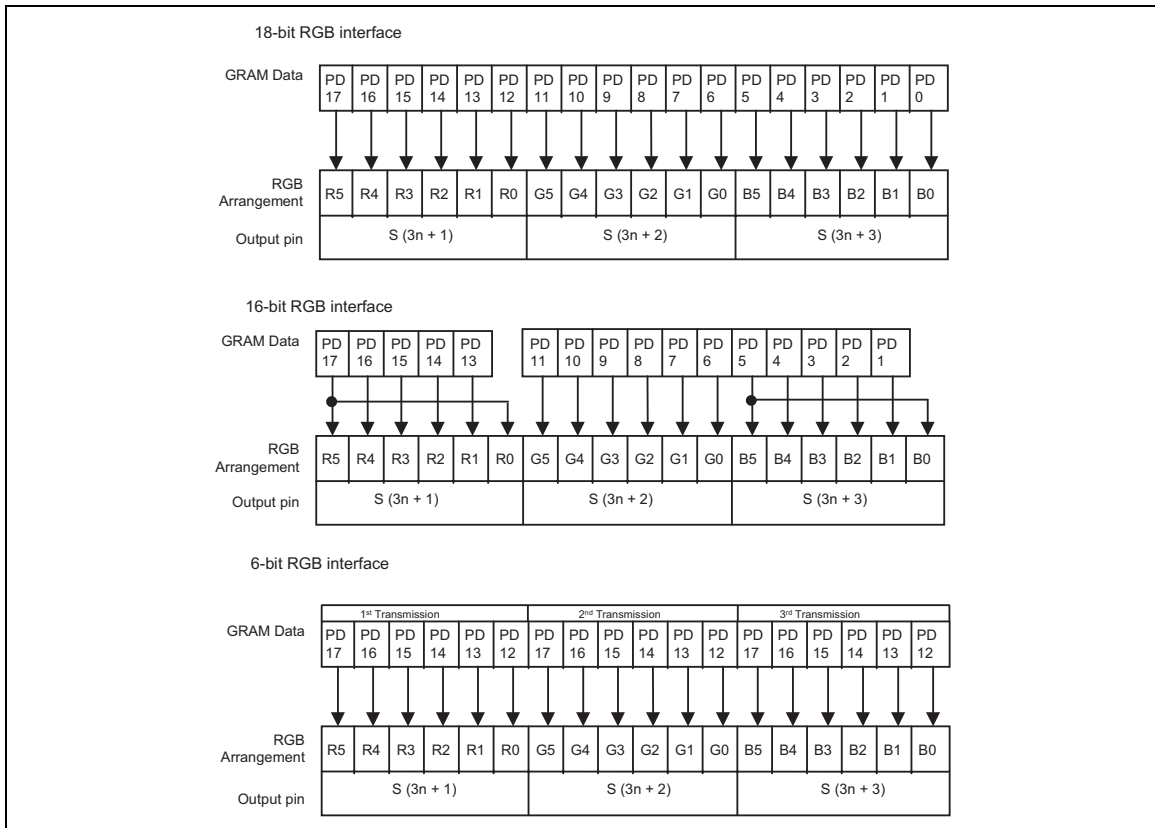
GRAM Address MAP

| SG pin | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 | S12 | ..... | S517 | S518 | S519 | S520 | S521 | S522 | S523 | S524 | S525 | S526 | S527 | S528 |
|--------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | ..... | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 |
| G1 | "0000"H | "0001"H | "0002"H | "0003"H | ..... | "00AC"H | "00AD"H | "00AE"H | "00AF"H | | | | | | | | | | | | | | | | |
| G2 | "0100"H | "0101"H | "0102"H | "0103"H | ..... | "01AC"H | "01AD"H | "01AE"H | "01AF"H | | | | | | | | | | | | | | | | |
| G3 | "0200"H | "0201"H | "0202"H | "0203"H | ..... | "02AC"H | "02AD"H | "02AE"H | "02AF"H | | | | | | | | | | | | | | | | |
| G4 | "0300"H | "0301"H | "0302"H | "0303"H | ..... | "03AC"H | "03AD"H | "03AE"H | "03AF"H | | | | | | | | | | | | | | | | |
| G5 | "0400"H | "0401"H | "0402"H | "0403"H | ..... | "04AC"H | "04AD"H | "04AE"H | "04AF"H | | | | | | | | | | | | | | | | |
| G6 | "0500"H | "0501"H | "0502"H | "0503"H | ..... | "05AC"H | "05AD"H | "05AE"H | "05AF"H | | | | | | | | | | | | | | | | |
| G7 | "0600"H | "0601"H | "0602"H | "0603"H | ..... | "06AC"H | "06AD"H | "06AE"H | "06AF"H | | | | | | | | | | | | | | | | |
| G8 | "0700"H | "0701"H | "0702"H | "0703"H | ..... | "07AC"H | "07AD"H | "07AE"H | "07AF"H | | | | | | | | | | | | | | | | |
| G9 | "0800"H | "0801"H | "0802"H | "0803"H | ..... | "08AC"H | "08AD"H | "08AE"H | "08AF"H | | | | | | | | | | | | | | | | |
| G10 | "0900"H | "0901"H | "0902"H | "0903"H | ..... | "09AC"H | "09AD"H | "09AE"H | "09AF"H | | | | | | | | | | | | | | | | |
| G11 | "0A00"H | "0A01"H | "0A02"H | "0A03"H | ..... | "0AAC"H | "0AAD"H | "0AAE"H | "0AAF"H | | | | | | | | | | | | | | | | |
| G12 | "0B00"H | "0B01"H | "0B02"H | "0B03"H | ..... | "0BAC"H | "0BAD"H | "0BAE"H | "0BAF"H | | | | | | | | | | | | | | | | |
| G13 | "0C00"H | "0C01"H | "0C02"H | "0C03"H | ..... | "0CAC"H | "0CAD"H | "0CAE"H | "0CAF"H | | | | | | | | | | | | | | | | |
| G14 | "0D00"H | "0D01"H | "0D02"H | "0D03"H | ..... | "0DAC"H | "0DAD"H | "0DAE"H | "0DAF"H | | | | | | | | | | | | | | | | |
| G15 | "0E00"H | "0E01"H | "0E02"H | "0E03"H | ..... | "0EAC"H | "0EAD"H | "0EAE"H | "0EAF"H | | | | | | | | | | | | | | | | |
| G16 | "0F00"H | "0F01"H | "0F02"H | "0F03"H | ..... | "0FAC"H | "0FAD"H | "0FAE"H | "0FAF"H | | | | | | | | | | | | | | | | |
| G17 | "1000"H | "1001"H | "1002"H | "1003"H | ..... | "10AC"H | "10AD"H | "10AE"H | "10AF"H | | | | | | | | | | | | | | | | |
| G18 | "1100"H | "1101"H | "1102"H | "1103"H | ..... | "11AC"H | "11AD"H | "11AE"H | "11AF"H | | | | | | | | | | | | | | | | |
| G19 | "1200"H | "1201"H | "1202"H | "1203"H | ..... | "12AC"H | "12AD"H | "12AE"H | "12AF"H | | | | | | | | | | | | | | | | |
| G20 | "1300"H | "1301"H | "1302"H | "1303"H | ..... | "13AC"H | "13AD"H | "13AE"H | "13AF"H | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| G233 | "0800"H | "0801"H | "0802"H | "0803"H | ..... | "E8AC"H | "E8AD"H | "E8AE"H | "E8AF"H | | | | | | | | | | | | | | | | |
| G234 | "0900"H | "0901"H | "0902"H | "0903"H | ..... | "E9AC"H | "E9AD"H | "E9AE"H | "E9AF"H | | | | | | | | | | | | | | | | |
| G235 | "EA00"H | "EA01"H | "EA02"H | "EA03"H | ..... | "EAAC"H | "EAAD"H | "EAAE"H | "EAAF"H | | | | | | | | | | | | | | | | |
| G236 | "EB00"H | "EB01"H | "EB02"H | "EB03"H | ..... | "EBAC"H | "EBAD"H | "EBAE"H | "EBAF"H | | | | | | | | | | | | | | | | |
| G237 | "EC00"H | "EC01"H | "EC02"H | "EC03"H | ..... | "ECAC"H | "ECAD"H | "ECAE"H | "ECAF"H | | | | | | | | | | | | | | | | |
| G238 | "ED00"H | "ED01"H | "ED02"H | "ED03"H | ..... | "EDAC"H | "EDAD"H | "EDAE"H | "EDAF"H | | | | | | | | | | | | | | | | |
| G239 | "EE00"H | "EE01"H | "EE02"H | "EE03"H | ..... | "EEAC"H | "EEAD"H | "EEAE"H | "EEAF"H | | | | | | | | | | | | | | | | |
| G240 | "EF00"H | "EF01"H | "EF02"H | "EF03"H | ..... | "EFAC"H | "EFAD"H | "EFAE"H | "EFAF"H | | | | | | | | | | | | | | | | |

GRAM address and display panel position (SS = "0")



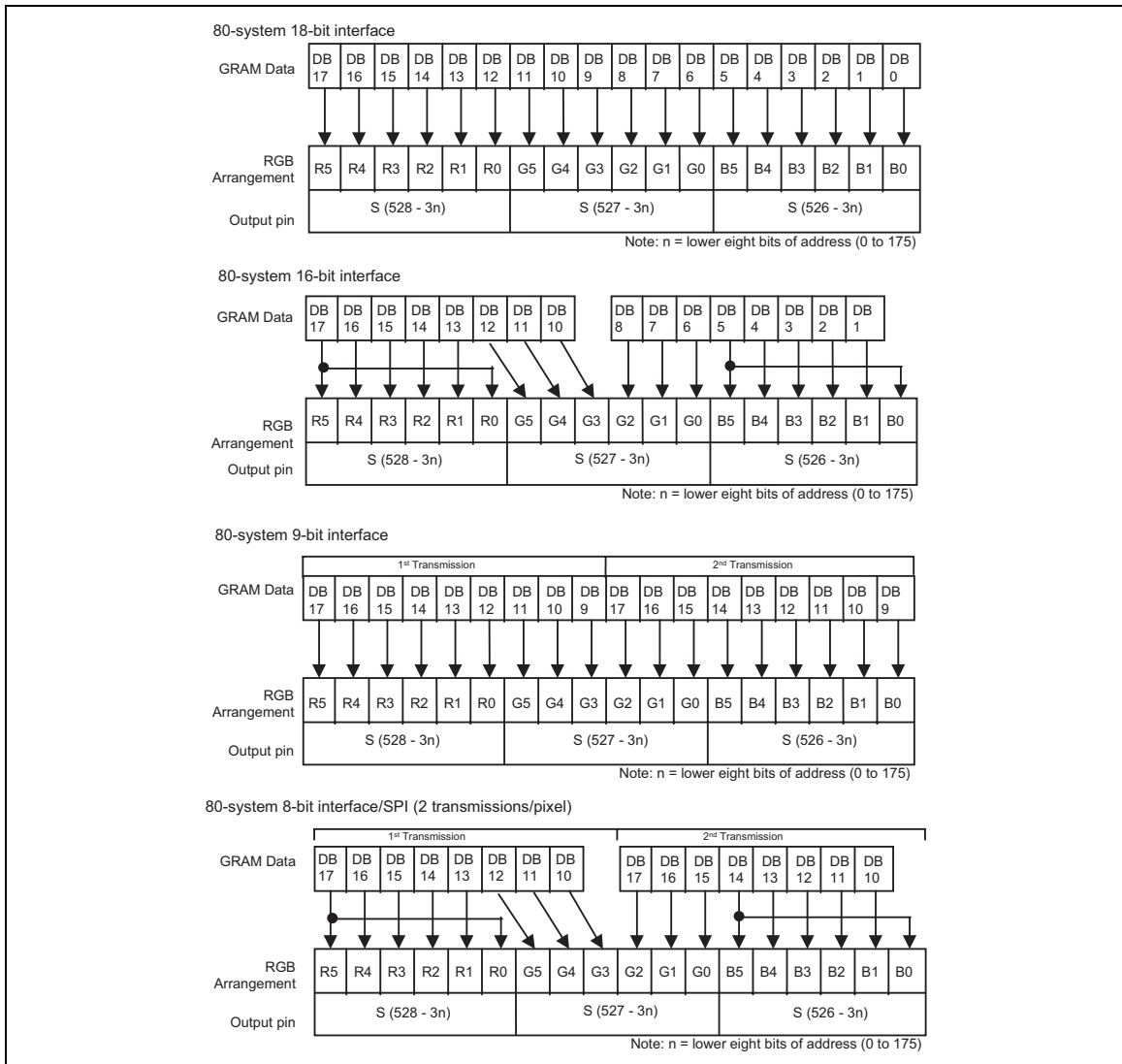
GRAM data and RGB assignment (SS = "0", BGR = "0")



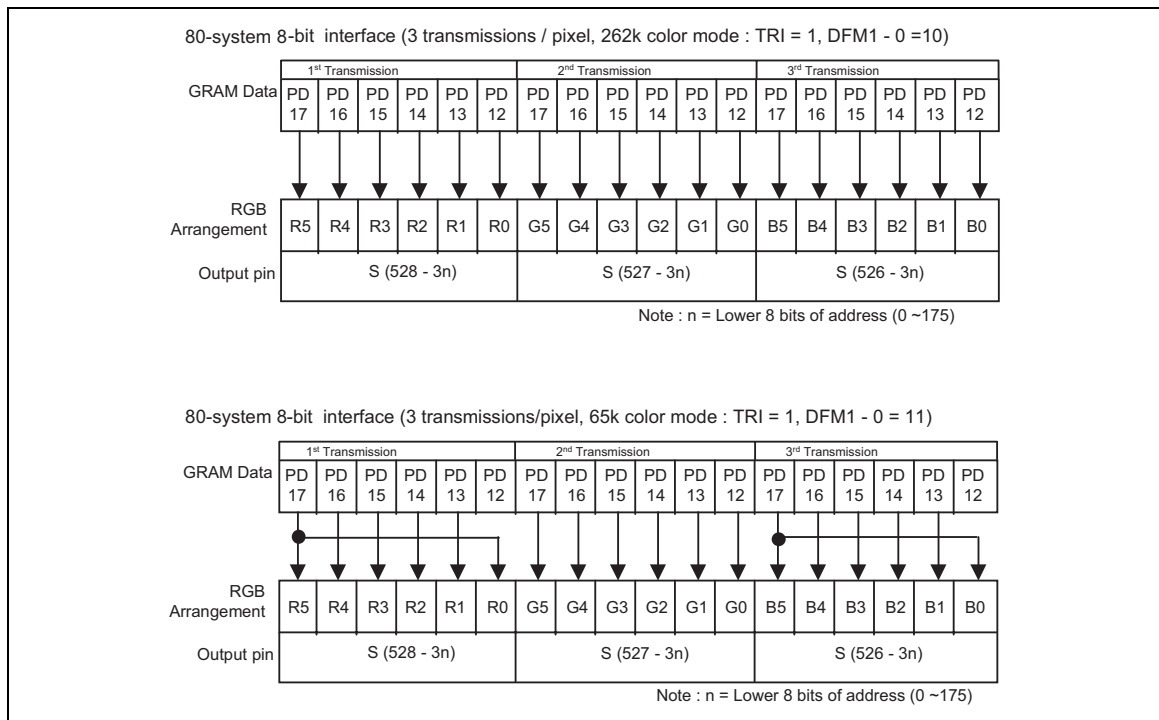
GRAM data and RGB assignment (SS = "0", BGR = "0")

| SG pin | S1 | S2 | S3 | S4 | S5 | S6 | S7 | S8 | S9 | S10 | S11 | S12 | ..... | S517 | S518 | S519 | S520 | S521 | S522 | S523 | S524 | S525 | S526 | S527 | S528 |
|--------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|-------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | ..... | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 | PD 17 ... 0 |
| G1 | "00AF"H | "00AE"H | "00AD"H | "00AC"H | ..... | "0003"H | "0002"H | "0001"H | "0000"H | | | | | | | | | | | | | | | | |
| G2 | "01AF"H | "01AE"H | "01AD"H | "01AC"H | ..... | "0103"H | "0102"H | "0101"H | "0100"H | | | | | | | | | | | | | | | | |
| G3 | "02AF"H | "02AE"H | "02AD"H | "02AC"H | ..... | "0203"H | "0202"H | "0201"H | "0200"H | | | | | | | | | | | | | | | | |
| G4 | "03AF"H | "03AE"H | "03AD"H | "03AC"H | ..... | "0303"H | "0302"H | "0301"H | "0300"H | | | | | | | | | | | | | | | | |
| G5 | "04AF"H | "04AE"H | "04AD"H | "04AC"H | ..... | "0403"H | "0402"H | "0401"H | "0400"H | | | | | | | | | | | | | | | | |
| G6 | "05AF"H | "05AE"H | "05AD"H | "05AC"H | ..... | "0503"H | "0502"H | "0501"H | "0500"H | | | | | | | | | | | | | | | | |
| G7 | "06AF"H | "06AE"H | "06AD"H | "06AC"H | ..... | "0603"H | "0602"H | "0601"H | "0600"H | | | | | | | | | | | | | | | | |
| G8 | "07AF"H | "07AE"H | "07AD"H | "07AC"H | ..... | "0703"H | "0702"H | "0701"H | "0700"H | | | | | | | | | | | | | | | | |
| G9 | "08AF"H | "08AE"H | "08AD"H | "08AC"H | ..... | "0803"H | "0802"H | "0801"H | "0800"H | | | | | | | | | | | | | | | | |
| G10 | "09AF"H | "09AE"H | "09AD"H | "09AC"H | ..... | "0903"H | "0902"H | "0901"H | "0900"H | | | | | | | | | | | | | | | | |
| G11 | "0AAF"H | "0AAE"H | "0AAD"H | "0AAC"H | ..... | "0A03"H | "0A02"H | "0A01"H | "0A00"H | | | | | | | | | | | | | | | | |
| G12 | "0BAF"H | "0BAE"H | "0BAD"H | "0BAC"H | ..... | "0B03"H | "0B02"H | "0B01"H | "0B00"H | | | | | | | | | | | | | | | | |
| G13 | "0CAF"H | "0CAE"H | "0CAD"H | "0CAC"H | ..... | "0C03"H | "0C02"H | "0C01"H | "0C00"H | | | | | | | | | | | | | | | | |
| G14 | "0DAF"H | "0DAE"H | "0DAD"H | "0DAC"H | ..... | "0D03"H | "0D02"H | "0D01"H | "0D00"H | | | | | | | | | | | | | | | | |
| G15 | "0EAF"H | "0EAE"H | "0EAD"H | "0EAC"H | ..... | "0E03"H | "0E02"H | "0E01"H | "0E00"H | | | | | | | | | | | | | | | | |
| G16 | "0FAF"H | "0FAE"H | "0FAD"H | "0FAC"H | ..... | "0F03"H | "0F02"H | "0F01"H | "0F00"H | | | | | | | | | | | | | | | | |
| G17 | "10AF"H | "10AE"H | "10AD"H | "10AC"H | ..... | "1003"H | "1002"H | "1001"H | "1000"H | | | | | | | | | | | | | | | | |
| G18 | "11AF"H | "11AE"H | "11AD"H | "11AC"H | ..... | "1103"H | "1102"H | "1101"H | "1100"H | | | | | | | | | | | | | | | | |
| G19 | "12AF"H | "12AE"H | "12AD"H | "12AC"H | ..... | "1203"H | "1202"H | "1201"H | "1200"H | | | | | | | | | | | | | | | | |
| G20 | "13AF"H | "13AE"H | "13AD"H | "13AC"H | ..... | "1303"H | "1302"H | "1301"H | "1300"H | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | |
| G233 | "E8AF"H | "E8AE"H | "E8AD"H | "E8AC"H | ..... | "0803"H | "0802"H | "0801"H | "0800"H | | | | | | | | | | | | | | | | |
| G234 | "E9AF"H | "E9AE"H | "E9AD"H | "E9AC"H | ..... | "0903"H | "0902"H | "0901"H | "0900"H | | | | | | | | | | | | | | | | |
| G235 | "EAAF"H | "EAAE"H | "EAAD"H | "EAAC"H | ..... | "EA03"H | "EA02"H | "EA01"H | "EA00"H | | | | | | | | | | | | | | | | |
| G236 | "EBAF"H | "EBAE"H | "EBAD"H | "EBAC"H | ..... | "EB03"H | "EB02"H | "EB01"H | "EB00"H | | | | | | | | | | | | | | | | |
| G237 | "ECAF"H | "ECAE"H | "ECAD"H | "ECAC"H | ..... | "EC03"H | "EC02"H | "EC01"H | "EC00"H | | | | | | | | | | | | | | | | |
| G238 | "EDAF"H | "EDAE"H | "EDAD"H | "EDAC"H | ..... | "ED03"H | "ED02"H | "ED01"H | "ED00"H | | | | | | | | | | | | | | | | |
| G239 | "EEAF"H | "EEAE"H | "EEAD"H | "EEAC"H | ..... | "EE03"H | "EE02"H | "EE01"H | "EE00"H | | | | | | | | | | | | | | | | |
| G240 | "EFAF"H | "EFAE"H | "EFAD"H | "EFAC"H | ..... | "EF03"H | "EF02"H | "EF01"H | "EF00"H | | | | | | | | | | | | | | | | |

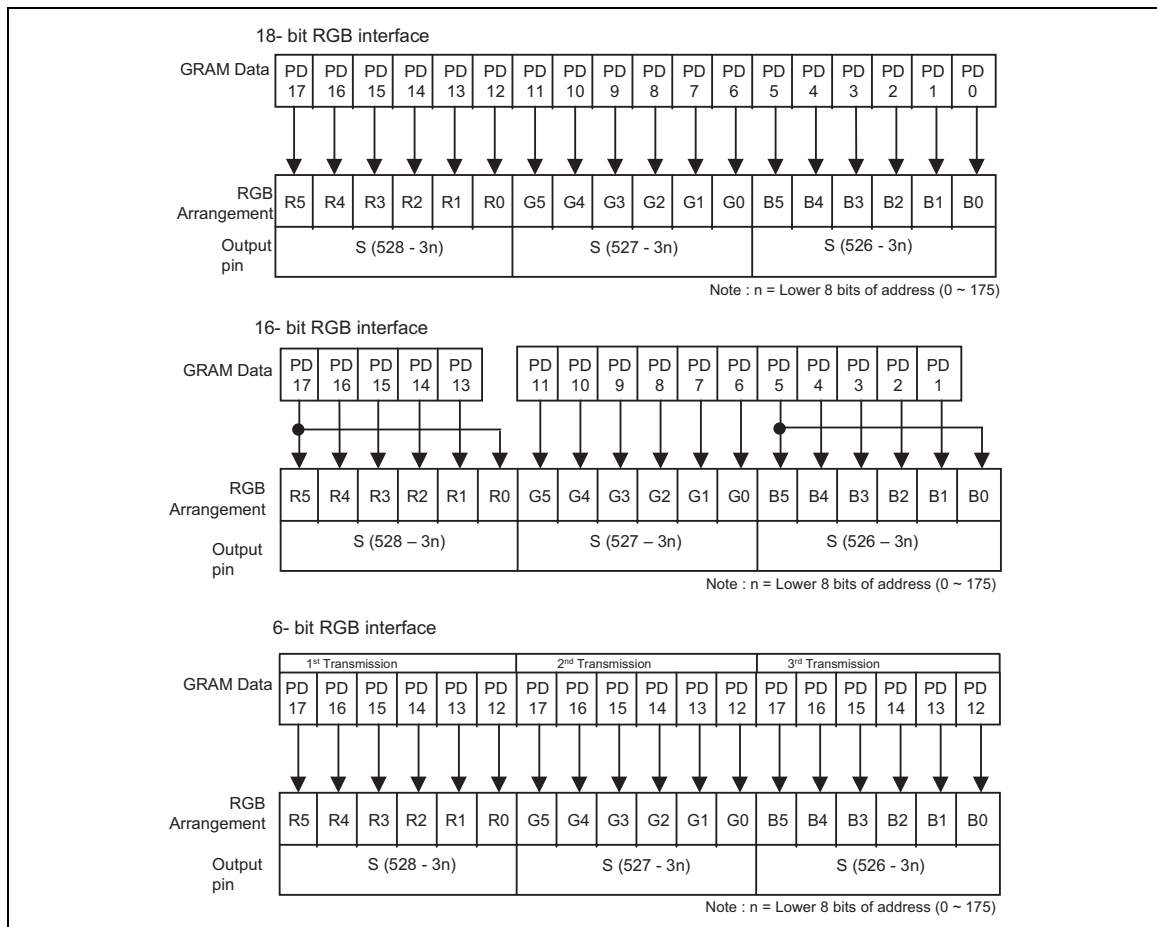
GRAM address and display panel position (SS ="1", BGR "1")



GRAM data and RGB assignment (SS = "1", BGR = "1")



GRAM data and RGB assignment (SS = "1", BGR = "1")



GRAM data and RGB assignment (SS = "1", BGR = "1")

Instructions

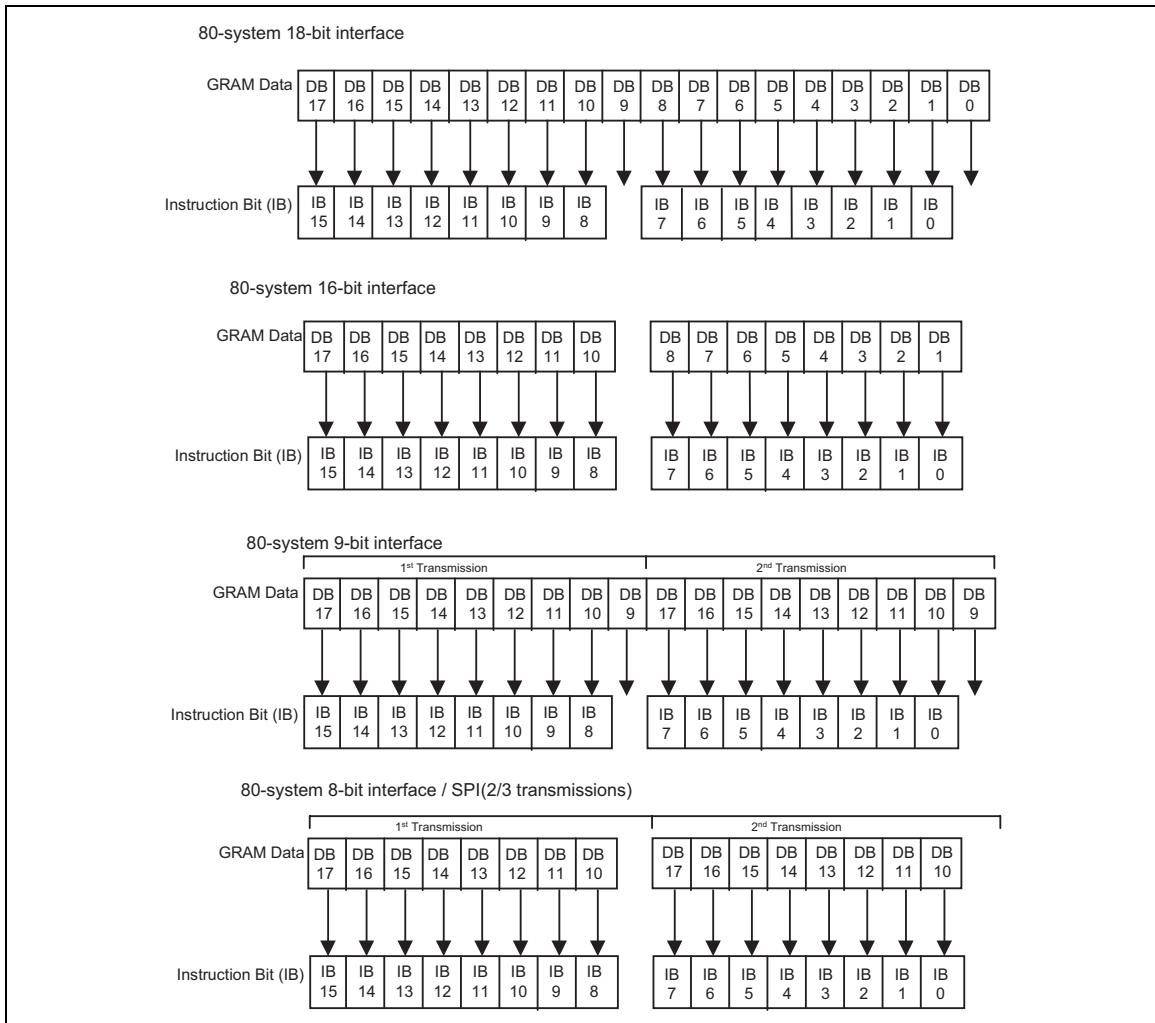
Outline

The HD66787 adapts 18-bit bus architecture that enables high-speed interfacing with a high-performance microcomputer. Data sent from external (18/16/9/8 bits) are stored temporarily in the instruction register (IR) and the data register (DR) to store control information before internal operation starts. Since internal operation is decided according to the signal sent from the microcomputer, register selection signal (RS), read/write signal (R/W), and internal 16-bit data bus signal (DB15 to DB0) are called instruction. GRAM is accessed through internal 18-bit data bus. There are eight categories of instructions:

1. Specify index
2. Read status
3. Control display
4. Control power management
5. Process graphics data
6. Set internal GRAM address
7. Transfer data to and from internal GRAM
8. Set grayscale level for internal grayscale γ -adjustment

Normally, the 7th instruction to write display data is executed the most frequently. The address of internal GRAM is updated automatically after data are written to the internal GRAM. With the window address function, this reduces the amount of data transmission to minimum and thereby lightens the load on the program in the microcomputer. Since instructions are executed in 0 cycle, it is possible to write instructions consecutively.

As the following figure shows, the assignment to the 16 instruction bits (IB15-0) varies according to the interface in use. An instruction must adopt the data format for each interface.



Instruction bits

Instruction Descriptions

The following are detail explanations of instructions with illustrations of instruction bits (IB15-0) assigned to each interface.

Index

The index instruction specifies the index (R00h to R4Fh) of control register and RAM control. It sets the register number from 0000000 to 1111111 in binary form. Do not try to access to the register to which the index is not assigned.

| | | | | | | | | | | | | | | | | | |
|-----|----|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| R/W | RS | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 |
| W | 0 | * | * | * | * | * | * | * | * | * | ID6 | ID5 | ID4 | ID3 | ID2 | ID1 | ID0 |

The following table shows the relationship between EPL, ENABLE, VLD and RAM access.

| EPL | ENABLE | VLD | RAM write | RAM address |
|-----|--------|-----|-----------|-------------|
| 0 | 0 | 0 | Valid | Updated |
| 0 | 0 | 1 | Invalid | Updated |
| 0 | 1 | * | Invalid | Hold |
| 1 | 0 | * | Invalid | Hold |
| 1 | 1 | 0 | Valid | Updated |
| 1 | 1 | 1 | Invalid | Updated |

VSPL: Invert the polarity of signal for VSYNC pin.

VSPL = "0" : Low active.

VSPL = "1" : High active.

HSPL: Invert the polarity of signal for HSYNC pin.

HSPL = "0" : Low active.

HSPL = "1" : High active.

DPL: Invert the polarity of signal for DOTCLK pin.

DPL = "0" : Data are read in synchronization with the rising edge of the DOTCLK.

DPL = "1" : Data are read in synchronization with the falling edge of the DOTCLK.

NL4-0: Specify the number of LCD drive raster-rows. The number of drive raster-rows is changeable by 8 multiples. The GRAM address mapping is independent of this setting. Select a number of raster-rows that the display size covers the size of a panel.

NL bits

| NL4 | NL3 | NL2 | NL1 | NL0 | Display Size | Liquid crystal drive raster-rows | Gate Driver Lines Used |
|-----|-----|-----|-----|-----|------------------|----------------------------------|------------------------|
| 0 | 0 | 0 | 0 | 0 | Setting disabled | Setting disabled | Setting disabled |
| 0 | 0 | 0 | 0 | 1 | 528 x 16 dots | 16 | G1-G16 |
| 0 | 0 | 0 | 1 | 0 | 528 x 24 dots | 24 | G1-G24 |
| 0 | 0 | 0 | 1 | 1 | 528 x 32 dots | 32 | G1-G32 |
| 0 | 0 | 1 | 0 | 0 | 528 x 40 dots | 40 | G1-G40 |
| 0 | 0 | 1 | 0 | 1 | 528 x 48 dots | 48 | G1-G48 |
| 0 | 0 | 1 | 1 | 0 | 528 x 56 dots | 56 | G1-G56 |
| 0 | 0 | 1 | 1 | 1 | 528 x 64 dots | 64 | G1-G64 |
| 0 | 1 | 0 | 0 | 0 | 528 x 72 dots | 72 | G1-G72 |
| | | . | | | . | . | . |
| | | . | | | . | . | . |
| | | . | | | . | . | . |
| | | . | | | . | . | . |
| | | . | | | . | . | . |
| 1 | 1 | 0 | 0 | 0 | 528 x 200 dots | 200 | G1-G200 |
| 1 | 1 | 0 | 0 | 1 | 528 x 208 dots | 208 | G1-G208 |
| 1 | 1 | 0 | 1 | 0 | 528 x 216 dots | 216 | G1-G216 |
| 1 | 1 | 0 | 1 | 1 | 528 x 224 dots | 224 | G1-G224 |
| 1 | 1 | 1 | 0 | 0 | 528 x 232 dots | 232 | G1-G232 |
| 1 | 1 | 1 | 0 | 1 | 528 x 240 dots | 240 | G1-G240 |

Note 1) A front porch period (set in the FP register) and a back porch period (set in the BP register) will be inserted as a blank period before and after driving all gate lines.

LCD Driving Waveform Control (R02h)

| | | | | | | | | | | | | | | | | | |
|-----|----|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| R/W | RS | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 |
| W | 1 | 0 | 0 | 0 | 0 | 0 | 1 | B/C | EOR | 0 | 0 | NW5 | NW4 | NW3 | NW2 | NW1 | NW0 |

NW5-0: Specify n, the number of raster-rows from 1 to 64 to alternate every n+1 raster-rows when C-pattern waveform is generated (B/C = 1).

EOR: When EOR = 1 and a C-pattern waveform is generated (B/C = 1), an odd/even frame select signal and an n-raster-row inversion signal are AC-driven. This instruction is available when liquid crystal AC drive is not made depending on the combination of numbers of LCD drive raster-rows and the value of “n” of n-raster-row inversion AC drive. For details, see “n-raster-row inversion AC drive”.

B/C: When B/C =0, a field AC waveform is generated. Alternation occurs every frame when driving liquid crystal. When B/C=1, alternation occurs every n raster-row. For details, see the “n-raster-row Inversion AC Drive” section.

Entry Mode (R03h)

Compare Register 1 (R04h)

Compare Register 2 (R05h)

| R/W | RS | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 |
|-----|----|------|------|------|------|------|------|-----|-----|-----|-----|------|------|------|------|------|------|
| W | 1 | TRI | DFM1 | DFM0 | BGR | 0 | 0 | HWM | 0 | 0 | 0 | I/D1 | I/D0 | AM | LG2 | LG1 | LG0 |
| W | 1 | 0 | 0 | CP11 | CP10 | CP9 | CP8 | CP7 | CP6 | 0 | 0 | CP5 | CP4 | CP3 | CP2 | CP1 | CP0 |
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | CP17 | CP16 | CP15 | CP14 | CP13 | CP12 |

The HD66787 modifies write data sent from the microcomputer before writing to GRAM. This enables high-speed GRAM data update, and reduces the load on the microcomputer software. For details, see the “Graphics Operation Function” section.

TRI: RAM write data are transmitted in 3 times through 8-bit interface when TRI = 1. When 8-bit interface mode is not selected, set TRI to 0.

DFM1-0: Specify the data format for RAM write data transmission when TRI = 1 (8-bit interface mode only).

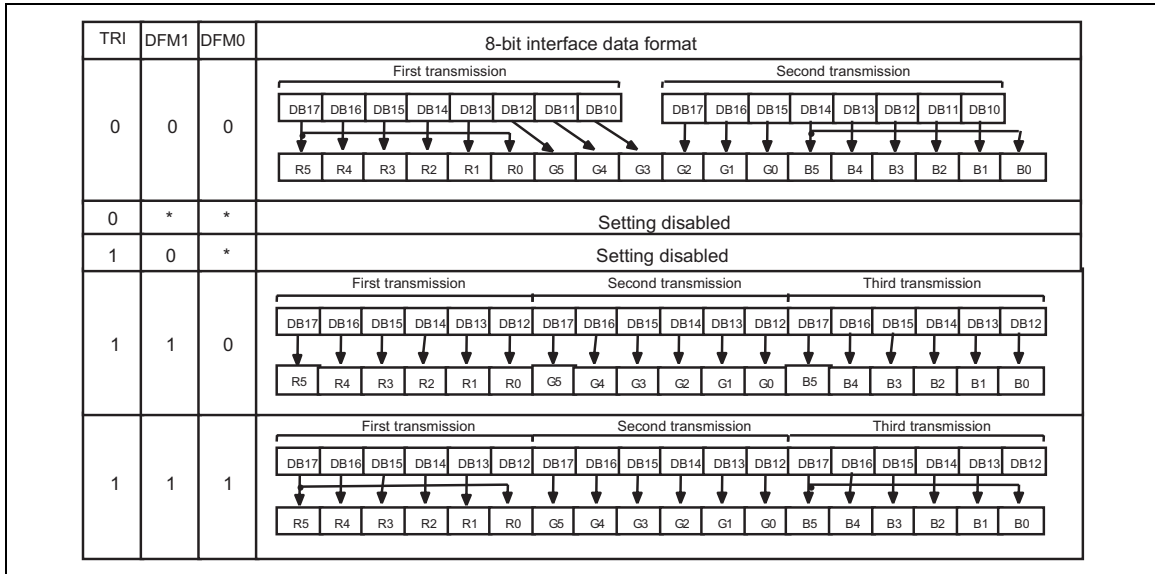
DFM1-0 = “10”: 262k mode (6bit x 3 transmissions)

DFM1-0 = “11”: 65k mode (5,6,5 bits transmissions)

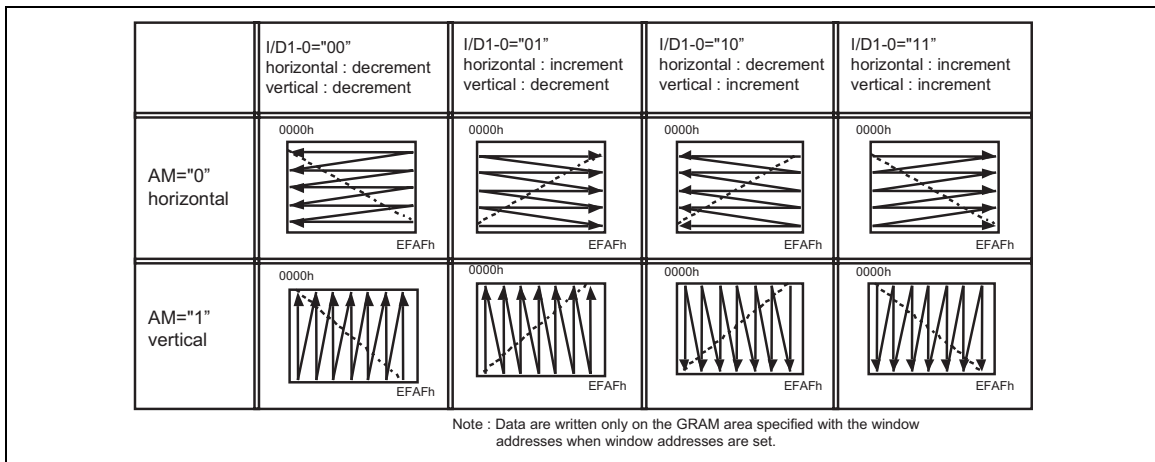
HWM: When HWM=1, data are written to GRAM in high speed. In high-speed write mode, 4 words are written to GRAM in a single operation after executing 4 RAM write operations. If RAM write is terminated before it is executed 4 times, the last data will not be written. Make sure that RAM write is executed 4 times. For this reason, the lower 2 bits must be set to “0” when setting the RAM address. For details, see “High-Speed RAM Write Mode” section.

I/D1-0: The address counter is automatically incremented by 1, after data are written to GRAM when I/D1-0 = “1”. The address counter is automatically decremented by 1, after data are written to GRAM when I/D1-0 = “0”. An independent setting for the increment or decrement of the address counter can be made to the upper (AD15-8) and the lower (AD7-0) bits of the address. The address transition direction when data are written to GRAM is set with AM bits.

AM: Set the direction of updating address counter automatically after data are written to GRAM. When AM = “0”, the address counter is updated in the horizontal direction. When AM = “1”, the address counter is updated in the vertical direction. When the window address is specified, data are written to the GRAM area specified by the window address in the manner specified with I/D1-0, AM bits.



8-bit interface data format

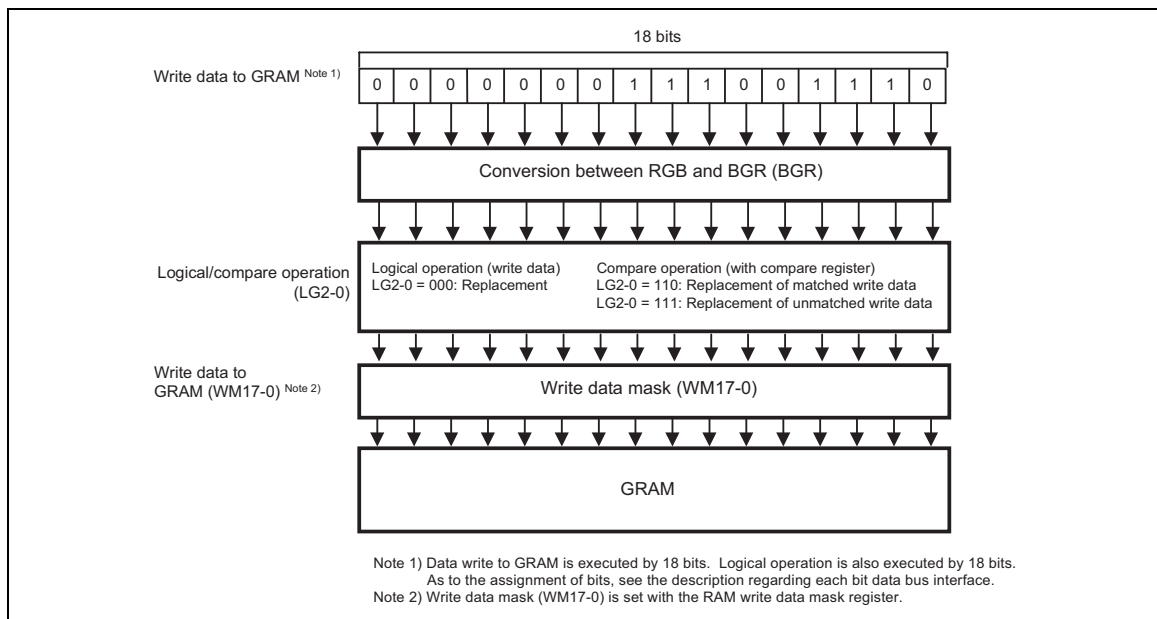


Address transition direction

LG2-0: Rewrite data to GRAM after comparing the data that are written by the microcomputer to GRAM with the values in the compare registers (CP17-0) and performing logical operation. For details, see the “Graphics Operation Function”

CP17-0: Set the value for the compare register, with which the data read out from GRAM or data written to GRAM by the microcomputer are compared. This function is not available with the external display interface mode. In the external display interface mode, make sure LG2-0 = “000”.

BGR: Reverse the order from R, G, B to B, G, R to the 18-bit data to write to GRAM. When setting BGR = 1, CP17-0 and WM17-0 bits will be automatically changed to the same effect.



Logic/Compare Operation

Display Control 1 (R07h)

| | | | | | | | | | | | | | | | | | |
|-----|----|------|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| R/W | RS | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 |
| W | 1 | 0 | 0 | 0 | PT1 | PT0 | VLE2 | VLE1 | SPT | 0 | 0 | 0 | DTE | CL | REV | D1 | D0 |

PT1-0: Determine the kind of source output in a non-display area in the partial display mode. For details, see the “Screen-split Drive function” section.

PT1-0 bits

| | | Source Output for Non-display Area | |
|-----|-----|------------------------------------|-------------------|
| PT1 | PT0 | Positive Polarity | Negative Polarity |
| 0 | 0 | V31 | V0 |
| 0 | 1 | V31 | V0 |
| 1 | 0 | GND | GND |
| 1 | 1 | High impedance | High impedance |

VLE2-1: When VLE1 = 1, the first screen is scrolled in the vertical direction. When VLE2 = 1, the second screen is scrolled in the vertical direction. The first and second screens cannot be scrolled simultaneously. This function is not available with the external display interface mode. In this case, make sure VLE2-1 = 0.

VLE Bits

| VLE2 | VLE1 | Image on 2nd Screen | Image on 1st Screen |
|------|------|---------------------|---------------------|
| 0 | 0 | Stationary | Stationary |
| 0 | 1 | Stationary | Scrolled |
| 1 | 0 | Scrolled | Stationary |
| 1 | 1 | Setting disabled | Setting disabled |

CL: When CL = 1, 8-color display mode is selected. For details, see the “8-Color Display Mode” section.

CL Bit

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

SPT: When SPT = 1, liquid crystal is driven with 2 split screens. For details, see the “Screen Split Drive Function” section. This function is not available in the external display interface mode. In this case, make sure SPT = 0.

REV: When REV = 1, a reverse display is shown. Inverting the grayscale levels allows the display of same data on both normally white and normally black panels. The source output during front, back porch periods and blank periods during the 2-split-screen display is made in accordance with settings with PT1-0 bits.

Source Output in the Display Area

| REV | GRAM Data | Source Output in the Display Area* | |
|-----|-----------|------------------------------------|-------------------|
| | | Positive Polarity | Negative Polarity |
| 0 | 18'h00000 | V31 | V0 |
| | 18'h3FFFF | V0 | V31 |
| 1 | 18'h00000 | V0 | V31 |
| | 18'h3FFFF | V31 | V0 |

Note: The output on the source lines during the front and back porch periods and blanking of the partial display is determined with PT1-0 bits.

DTE: When DTE = 0, the DISPTMG output is fixed to GND.

DTE Bit

| DTE | DISPTMG Output |
|-----|---------------------|
| 0 | Halt (GND) |
| 1 | Operation (Vcc/GND) |

D1-0: The graphics display is on when D1 = 1, and off when D1 = 0. When setting D1 = 0, the data are retained in GRAM. This means the graphics is instantly redisplayed when setting D1 to 1. When D1 is 0 (i.e., the display is off) all the source outputs are set to the GND level. This reduces the charged/discharged current on LCD, accompanied by the liquid crystal AC drive.

When D1-0 = 01, the HD66787 continues the internal display operation, even while the external display is off. When D1-0 = 00, both the internal display operations and the external display operation are halted.

In combination with GON and DTE bits, D1-0 bits control ON/OFF of display. For details, see the "Instruction Setting Flow" section.

D1-0

| D1 | D0 | Source Output | HD67789 Internal Operations | Gate-Driver Control Signals (CL1, FLM, and M) |
|----|----|---------------|--------------------------------|--|
| 0 | 0 | GND | Halt | Halt |
| 0 | 1 | GND | Operate | Operate |
| 1 | 0 | Unlit display | Operate | Operate |
| 1 | 1 | Display | Operate | Operate |

Note 1) Data are written to GRAM from the microcomputer irrespective of the setting of D1-0 bits.

Note 2) In the standby mode, D1-0 = "00". However, the D1-0 register setting before entering standby modes is retained.

Display Control 2 (R08h)

| | | | | | | | | | | | | | | | | | |
|-----|----|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| R/W | RS | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 |
| W | 1 | 0 | 0 | 0 | 0 | FP3 | FP2 | FP1 | FP0 | 0 | 0 | 0 | 0 | BP3 | BP2 | BP1 | BP0 |

FP3-0/BP3-0: Make settings for blank periods (the front and back porches), which are placed at the beginning and end of the display. FP3-0 and BP3-0 bits specify the number of raster-rows for the front and back porch respectively. When making this setting, make sure:

$$BP + FP = <16 \text{ raster-rows}$$

$$FP \geq 2 \text{ raster-rows}$$

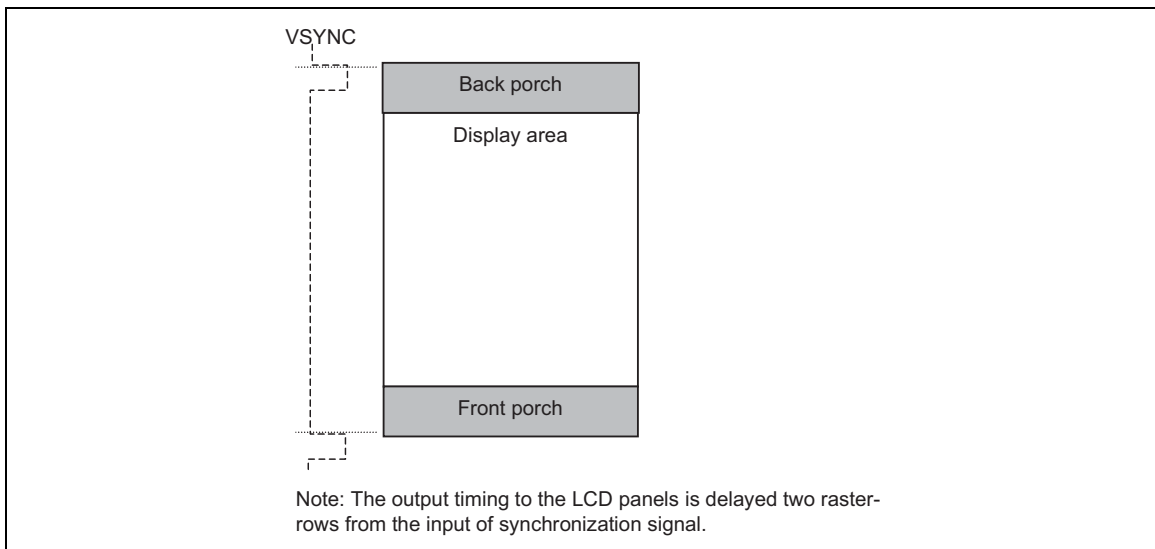
$$BP \geq 2 \text{ raster-rows}$$

In the external display interface mode, the back porch (BP) starts on the falling edge of VSYNC signal,

followed by display operation. After displaying the number of raster-rows set with NL bits, the front porch starts. After the front porch, a blank period ensues until an input of next VSYNC signal.

FP and BP

| FP3 | FP2 | FP1 | FP0 | Number of lines for the Front Porch |
|-----|-----|-----|-----|-------------------------------------|
| BP3 | BP2 | BP1 | BP0 | Number of lines for the Back Porch |
| 0 | 0 | 0 | 0 | Setting disabled |
| 0 | 0 | 0 | 1 | Setting disabled |
| 0 | 0 | 1 | 0 | 2 |
| 0 | 0 | 1 | 1 | 3 |
| 0 | 1 | 0 | 0 | 4 |
| ⋮ | | | | ⋮ |
| 1 | 1 | 0 | 0 | 12 |
| 1 | 1 | 0 | 1 | 13 |
| 1 | 1 | 1 | 0 | 14 |
| 1 | 1 | 1 | 1 | Setting disabled |



External display interface

BP3-0, FP3-0 Setting

Set BP3-0, FP3-0 bits as follows each in the following operation modes.

| | | | | |
|------------------------------------|--------------------|---------------|---------------|--------------------|
| Operation of internal clock | FLD1-0 = 01 | BP >= 2 lines | FP >= 2 lines | FP +BP <= 16 lines |
| | FLD1-0 = 11 | BP = 3 lines | FP = 5 lines | |
| RGB interface | | BP >= 2 lines | FP >= 2 lines | FP +BP <= 16 lines |
| VSYNC interface | | BP >= 2 lines | FP >= 2 lines | FP +BP = 16 lines |

Frame Cycle Control (R0Bh)

| | | | | | | | | | | | | | | | | | |
|-----|----|------|------|------|------|------|------|------|------|-----|-----|-----|-----|------|------|------|------|
| R/W | RS | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 |
| W | 1 | NO1 | NO0 | SDT1 | SDT0 | EQ1 | EQ0 | DIV1 | DIV0 | 0 | 0 | 0 | 0 | RTN3 | RTN2 | RTN1 | RTN0 |

RTN3-0: Set the 1H (1 raster-row) period.

RTN Bits and Clock Cycles

| RTN3 | RTN2 | RTN1 | RTN0 | Clock Cycles per Raster-row |
|------|------|------|------|-----------------------------|
| 0 | 0 | 0 | 0 | 16 |
| 0 | 0 | 0 | 1 | 17 |
| 0 | 0 | 1 | 0 | 18 |
| | | : | : | |
| 1 | 1 | 1 | 0 | 30 |
| 1 | 1 | 1 | 1 | 31 |

DIV1-0: Set the division ratio of clocks for internal operations (DIV1-0). Internal operations are in synchronization with the clock, the frequency of which is divided according to the DIV1-0 setting. When changing the number of drive raster-rows, adjust the frame frequency too. For details, see “Frame Frequency Adjustment Function”.

DIV Bits and Division Ratio

| DIV1 | DIV0 | Division Ratio | Internal Operating Clock Frequency |
|------|------|----------------|------------------------------------|
| 0 | 0 | 1 | fosc / 1 |
| 0 | 1 | 2 | fosc / 2 |
| 1 | 0 | 4 | fosc / 4 |
| 1 | 1 | 8 | fosc / 8 |

fosc = R-C oscillation frequency

Formula for the frame frequency

$$\text{Frame frequency} = \frac{\text{fosc}}{\text{Clock cycles per raster-row} \times \text{division ratio} \times (\text{Line} + \text{BP} + \text{FP})} \quad [\text{Hz}]$$

fosc: R-C oscillation frequency

Line: number of drive raster-rows (NL bit)

Division ratio: DIV bit

Clock cycles per raster-row: RTN bit

FP : the number of raster-rows in the front porch

BP : the number of raster-rows in the back porch

EQ1-0: Equalizing period is prolonged as the number of clocks specified with EQ1-0 bits. The equalization signal is output only with the alternating current.

EQ Bits

| EQ1 | EQ0 | Equalizing period | |
|-----|-----|--|---|
| | | Internal Operation (synchronized with the internal operating clock) | RGB I/F Operation (synchronized with DOTCLK) |
| 0 | 0 | Not equalized | Not equalized |
| 0 | 1 | 1 clock | 8 clocks |
| 1 | 0 | 2 clocks | 16 clocks |
| 1 | 1 | 3 clocks | 24 clocks |

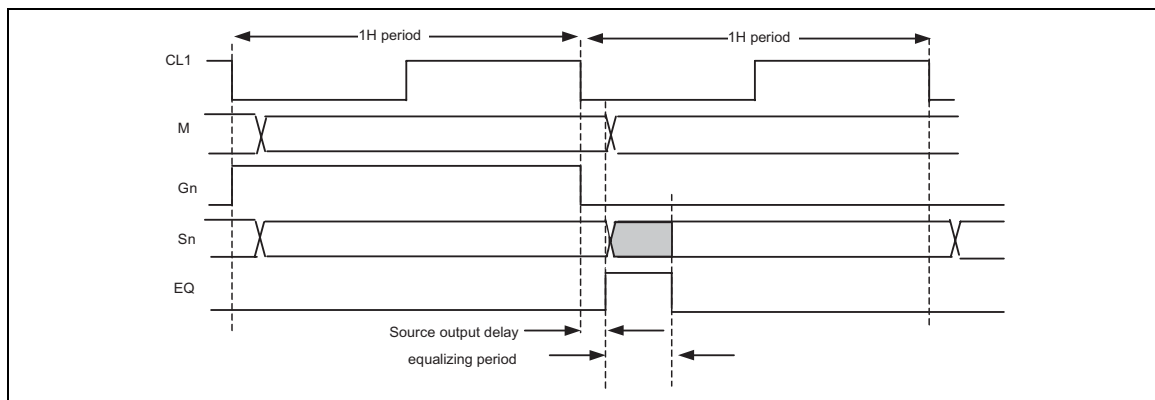
SDT1-0: Determine the amount of delay for the source output from the falling edge of the gate output.

SDT Bits

Delay Time for Source Signal

| SDT1 | SDT0 | Internal Operation (synchronized with the internal operating clock) | RGB I/F Operation (synchronized with DOTCLK) |
|------|------|--|---|
| 0 | 0 | 1 clock | 8 clocks |
| 0 | 1 | 2 clocks | 16 clocks |
| 1 | 0 | 3 clocks | 24 clocks |
| 1 | 1 | 4 clocks | 32 clocks |

Note 1) The amount of delay for the source output is measured from the falling edge of the CL1.



Source output delay and equalize period

Note 1) In internal operation and VSYNC interface modes, the reference clock is the internal operating clock. In RGB interface modes, the reference clock is DOTCLK.

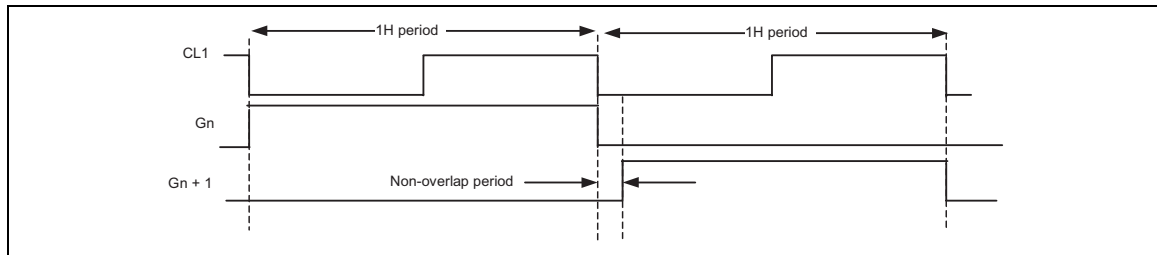
NO1-0: Specify the amount of non-overlap time for the gate output.

NO Bits

Non-overlap time

| NO1 | NO0 | Internal Operation (synchronized with the internal operating clock) | RGB I/F Operation (synchronized with DOTCLK) |
|-----|-----|--|---|
| 0 | 0 | 0 clock | 0 clock |
| 0 | 1 | 4 clocks | 32 clocks |
| 1 | 0 | 6 clocks | 48 clocks |
| 1 | 1 | 8 clocks | 64 clocks |

Note 1) The amount of non-overlap time is defined from the falling edge of the CL1.



Non-overlap period

External Display Interface Control (R0Ch)

| | | | | | | | | | | | | | | | | | |
|-----|----|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|-----|-----|------|------|
| R/W | RS | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 |
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | RM | 0 | 0 | DM1 | DM0 | 0 | 0 | RIM1 | RIM0 |

RIM1-0: Specify the RGB I/F mode when RGB interface is selected. Specifically, this setting specifies the RGB interface mode when it is selected by the setting DM and RM bits. The setting must be made before the display operation through external display interface. Do not make a setting during display.

RIM Bits

| RIM1 | RIM0 | RGB Interface Mode |
|------|------|--|
| 0 | 0 | 18-bit RGB interface (one-time transfer/pixel) |
| 0 | 1 | 16-bit RGB interface (one-time transfer/pixel) |
| 1 | 0 | 6-bit RGB interface (three-time transfers/pixel) |
| 1 | 1 | Setting disabled |

Note 1) The instruction register setting is possible only through a system interface.

Note 2) Data transmission and input of DOTCLK in the 6-bit RGB interface mode should be executed by RGB.

DM1-0: Specify the display operation mode. The interface through which display operation is executed is selected with DM1-0 bits. This setting enables switching between internal clock operation and external display interface. Switching within the external display interface modes (between RGB-I/F and VSYNC-I/F) cannot be made.

DM Bits

| DM1 | DM0 | Display Interface |
|------------|------------|--------------------------|
| 0 | 0 | Internal clock operation |
| 0 | 1 | RGB interface |
| 1 | 0 | VSYNC interface |
| 1 | 1 | Setting disabled |

RM: Specify the interface for RAM accesses. RAM is accessible only through the interface specified with RM bit. When the display data is written through RGB-I/F, set RM = 1. The RM-bit setting can be made irrespective of the display operation mode. This means the display data can be updated through a system interface even during the display period through RGB interface by setting RM = 0.

RM Bit

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

Setting for external display interface control allows selecting an optimum interface for the kind of display as follows. When displaying a moving picture (RGB-I/F/VSYNC-I/F), the display data must be written in the high-speed mode (HWM = 1) which enables high-speed RAM access with low power consumption.

Display state and interfaces

| Display State | Operation Mode | RAM Access (RM) | Display Operation Mode (DM1-0) |
|--|--------------------------|---------------------------|---------------------------------------|
| Still pictures | Internal clock operation | System interface (RM = 0) | Internal clock operation (DM1-0 = 00) |
| Moving pictures | RGB interface (1) | RGB interface (RM = 1) | RGB interface (DM1-0 = 01) |
| Rewrite still picture area while displaying moving pictures. | RGB interface (2) | System interface (RM = 0) | RGB interface (DM1-0 = 01) |
| Moving pictures | VSYNC interface | System interface (RM = 0) | VSYNC interface (DM1-0 = 10) |

Note 1) The instruction register setting is made only through system interface.

Note 2) Switching between RGB-I/F and VSYNC-I/F cannot be made.

Note 3) The RGB-I/F mode settings is not changeable during RGB I/F operation.

Note 4) For details on the transition flow between operation modes, see the "External Display Interface" section.

Note 5) Use the high-speed write mode (HWM = 1) during the write operation in RGB-I/F and VSYNC-I/F modes.

Internal clock operation mode

All display operations are controlled by signals generated by the internal clock in internal clock operation mode. All inputs through the external display interface are invalid. The internal RAM is accessible only through a system interface.

RGB interface mode (1)

Display operation is controlled by the frame synchronization clock (VSYNC), line synchronizing signal (VSYNC), and dot clock (DOTCLK) in the RGB interface mode. These signals must be supplied throughout the display operation in this mode.

All display data are stored in the internal RAM, transmitted with PD17-0 bits by pixel. The combination with the high-speed write mode and window address function enables simultaneous display of both moving picture areas and the internal RAM area. The data are transmitted only when the screen is being updated, thereby reducing the overall data transmission to minimum.

The periods of the front (FP) and back (BP) porches and the display period (NL) are automatically generated in the HD66782 by counting the clock of line synchronizing signal (HSYNC) in accordance to the frame synchronizing signal (VSYNC). Transmit pixel data with PD 17-0 bits in accordance with the setting specified above.

RGB interface mode (2)

When RGB-I/F is selected, RAM data are changeable through the system interface. This write operation must be performed while display data are not being transmitted through the RGB-I/F (ENABLE = High). When reverting from the system interface mode to the data transmission through the RGB interface, make a new setting for the address set and index (R22h) after changing the aforementioned settings.

VSYNC interface mode

The internal display operation is synchronized with the frame-synchronizing signal (VSYNC) in the VSYNC interface mode. By writing data to RAM at a fixed speed on the falling edge of VSYNC, it enables moving pictures display with a system interface. In this case, there are some constraints in the RAM write speed and methods. For details, see the “External Display Interface” section.

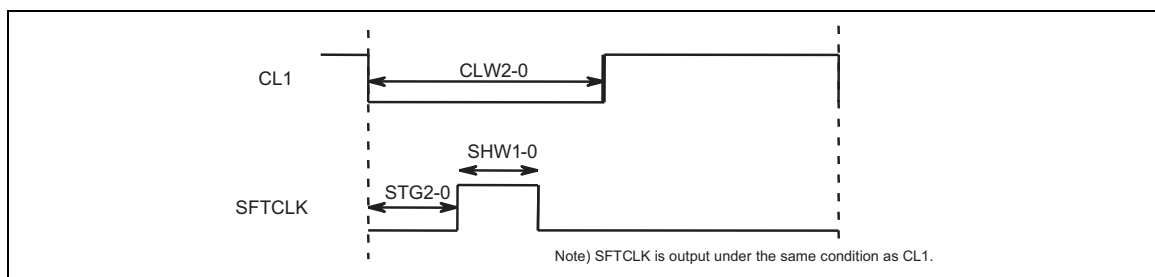
In the VSYNC-I/F mode, only VSYNC input is valid. Other input signals for the external display interface are invalid.

The front porch (FP), back porch (BP) periods and display period (NL) are automatically generated in accordance to the frame synchronizing signal (VSYNC) according to the register setting of HD66787.

LTPS Interface Control (R0Dh)

| | | | | | | | | | | | | | | | | | |
|-----|----|------|------|------|------|------|----------|----------|----------|-----|-----|----------|----------|-----|----------|----------|----------|
| R/W | RS | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 |
| W | 1 | 0 | 0 | 0 | TG0 | 0 | CLW 2 | CLW 1 | CLW 0 | 0 | 0 | SHW 1 | SHW 0 | 0 | STG 2 | STG 1 | STG 0 |

The HD66787 enables connection to LTPS-TFT panels by outputting timing signals (CL1, SFTCLK) for controlling low-temperature poli-Si TFT (LTPS-TFT) panels with incorporated gates. For details, see the “Low-temperature Poli-Si TFT Control” section.



Timing signals for LTPS-TFT panels

STG2-0: Set the output position of the pulse of SFTCLK signal.

STG2-0

| STG 2 | STG 1 | STG 0 | SFTCLK signal : pulse output position | |
|----------|----------|----------|--|---|
| | | | internal operation (synchronized with the internal operating clock) | RGB interface operation (synchronized with DOTCLK) |
| 0 | 0 | 0 | 0 clock | 0 clock |
| 0 | 0 | 1 | 1 clock | 8 clocks |
| 0 | 1 | 0 | 2 clocks | 16 clocks |
| 0 | 1 | 1 | 3 clocks | 24 clocks |
| 1 | 0 | 0 | 4 clocks | 32 clocks |
| 1 | 0 | 1 | 5 clocks | 40 clocks |
| 1 | 1 | 0 | 6 clocks | 48 clocks |
| 1 | 1 | 1 | 7 clocks | 56 clocks |

Note 1) The number of clocks is counted from the falling edge of the CL1 signal.

SHW1-0: Set the width of the pulse of SFTCLK signal during “High”.

SHW1-0

| SHW 1 | SHW 0 | SFTCLK signal : pulse width during “High” | |
|----------|----------|--|---|
| | | internal operation (synchronized with the internal operating clock) | RGB interface operation (synchronized with DOTCLK) |
| 0 | 0 | 1 clock | 8 clocks |
| 0 | 1 | 2 clocks | 16 clocks |
| 1 | 0 | 3 clocks | 24 clocks |
| 1 | 1 | 4 clocks | 32 clocks |

In making settings for SFTCLK signal, the following condition must be observed.

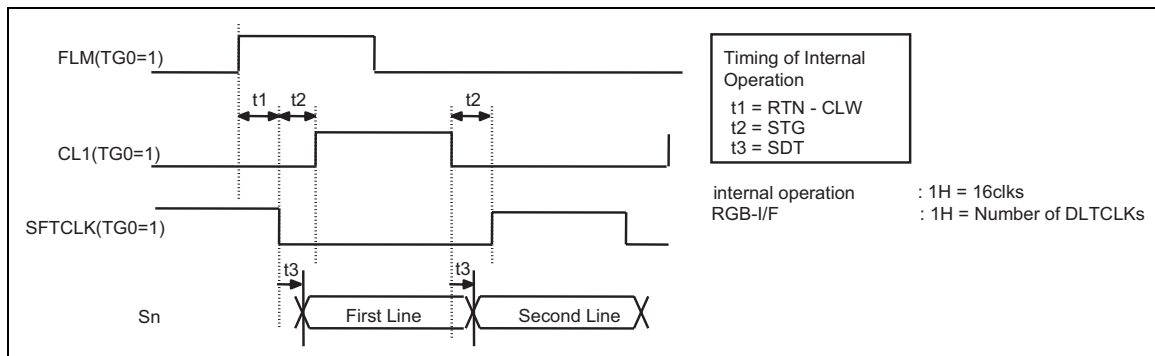
$$\begin{aligned} \text{STG2-0} + \text{SHW1-0} &\leq 8 \text{ clocks (Internal operation)} \\ &\leq 64 \text{ clocks (RGB interface operation)} \end{aligned}$$

CLW2-0: Set the width of the pulse of CL1 signal during “Low”.

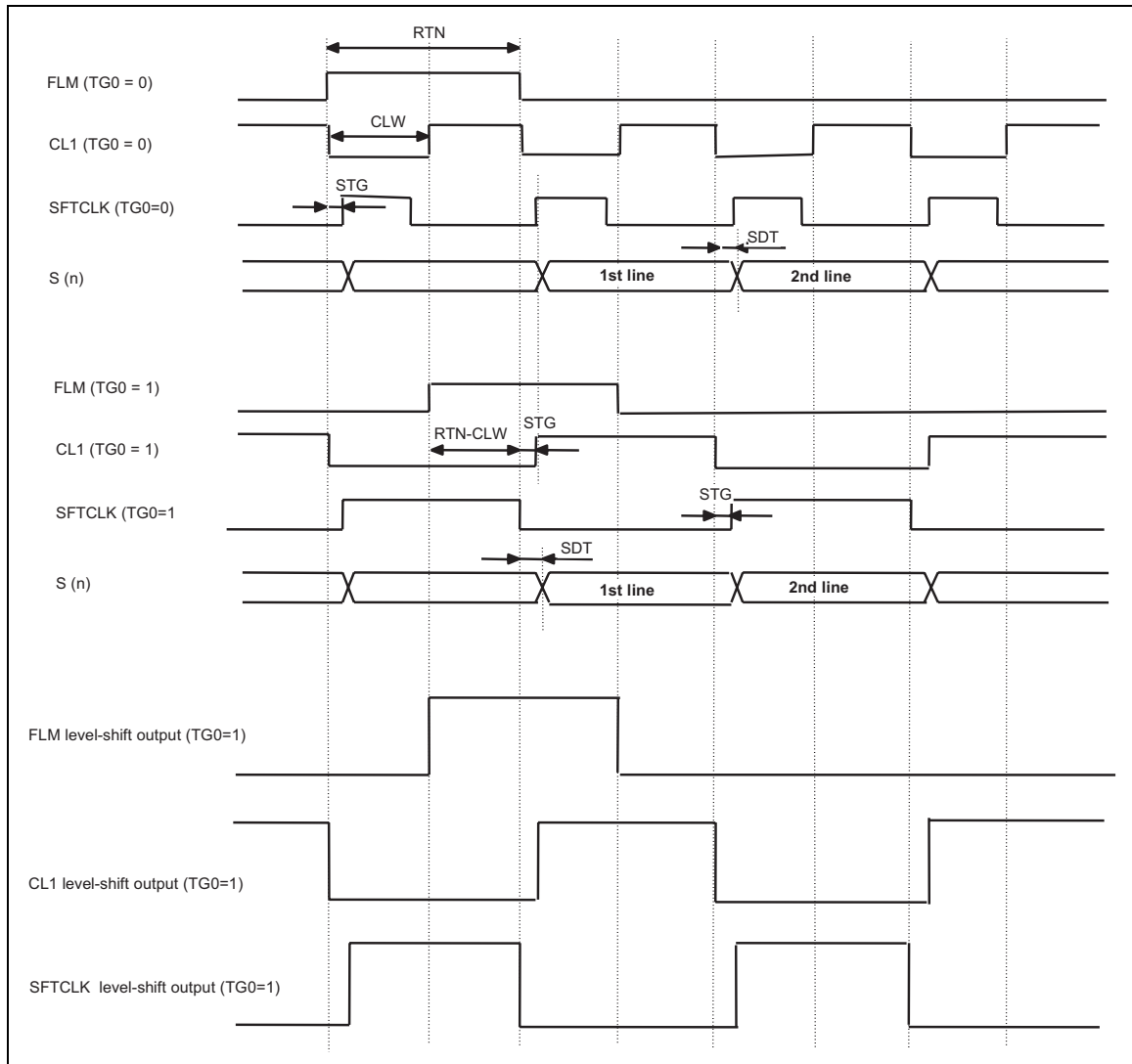
| CLW 2 | CLW 1 | CLW 0 | CL1 signal : pulse width during “Low” | |
|----------|----------|----------|--|---|
| | | | internal operation (synchronized with the internal operating clock) | RGB interface operation (synchronized with DOTCLK) |
| 0 | 0 | 0 | 1 clock | 8 clocks |
| 0 | 0 | 1 | 2 clocks | 16 clocks |
| 0 | 1 | 0 | 3 clocks | 24 clocks |
| 0 | 1 | 1 | 4 clocks | 32 clocks |
| 1 | 0 | 0 | 5 clocks | 40 clocks |
| 1 | 0 | 1 | 6 clocks | 48 clocks |
| 1 | 1 | 0 | 7 clocks | 56 clocks |
| 1 | 1 | 1 | 8 clocks | 64 clocks |

Note 1) The number of clocks is counted from the falling edge of the CL1 signal.

TG0: Change the output timing of CL1 and SFTCLK signals. If TG0=1, the setting in SHW is nullified and the frequencies of CL1 and SFTCLK become the frequency of normal mode divided by 2. The output timing of each signal is illustrated as follows.



CL1 and SFTCLK (TG0 = 1)



CL1 and SFTCLK timing chart

Power Control 1 (R10h)**Power Control 2 (R11h)**

| | | | | | | | | | | | | | | | | | |
|-----|----|------|------|------|------|------|------|------|------|-----|------|------|------|-----|-----|-----|-----|
| R/W | RS | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 |
| W | 1 | 0 | SAP2 | SAP1 | SAP0 | 0 | BT2 | BT1 | BT0 | 0 | AP2 | AP1 | AP0 | 0 | DK | SLP | STB |
| W | 1 | 0 | 0 | 0 | 0 | 0 | DC12 | DC11 | DC10 | 0 | DC02 | DC01 | DC00 | 0 | VC2 | VC1 | VC0 |

SAP2-0: Adjust the amount of fixed current from the fixed current source of operational amplifier for the source driver. When the amount of fixed current is set large, the operational amplifier will stabilize, while the current consumption will increase. Select an optimum amount of current taking both the display quality and the current consumption into account. During non-display operation, set SAP2-0 = “000” to halt the operation of operational amplifier, to reduce the current consumption.

SAP Bits and the amount of current for the Op-amp

| SAP2 | SAP1 | SAP0 | Op-amp Current | SAP2 | SAP1 | SAP0 | Op-amp Current |
|------|------|------|------------------|------|------|------|------------------|
| 0 | 0 | 0 | Halt | 1 | 0 | 0 | 1 (fixed) |
| 0 | 0 | 1 | Setting disabled | 1 | 0 | 1 | 1.25 (fixed) |
| 0 | 1 | 0 | 0.62 (fixed) | 1 | 1 | 0 | 1.43 (fixed) |
| 0 | 1 | 1 | 0.71 (fixed) | 1 | 1 | 1 | Setting disabled |

BT2-0: Change the step-up scale of the step-up circuit. Adjust the scale according to the voltage. Smaller scale consumes lesser current.

DC02-00: Select the operating frequency for the step-up circuit 1. The higher frequency enhances the drive capacity of step-up circuit as well as the display quality, while the current consumption will increase. Adjust the frequency taking both the display quality and the current consumption into consideration.

DC12-10: Select the operating frequency for the step-up circuit 2. The higher frequency enhances the drive capacity of step-up circuit as well as the display quality, while the current consumption will increase. Adjust the frequency taking both the display quality and the current consumption into consideration.

AP2-0: Adjust the amount of fixed current from the fixed current source of operational amplifier for the liquid crystal drive power supply. When the amount of fixed current is set large, the liquid crystal drive capacity will be enhanced and the display quality will improve, while the current consumption will increase. Select an optimum amount of current taking both the display quality and the current consumption into account. During non-display operation, set AP2-0 = “000” to halt the operation of operational amplifier to reduce current consumption.

DK: Control the operation of the step-up circuit 1. When turning on the power supply, stop the start up of VLOUT1 for a moment, and wait for an enough time until VLOUT2 is stabilized before starting up VLOUT1. For details, see the “Power Supply Setting Flow” section.

SLP: When SLP = 1, the HD66789 enters into the sleep mode. In the sleep mode, internal display operation is halted except the R-C oscillator to reduce current consumption. Only power control instructions (BT2-0, DC2-0, AP2-0, SLP, STB, VC2-0, VRH4-0, VCOMG, VDV4-0, and VCM4-0 bits) are executed during the sleep mode. No change is made to the GRAM data or instructions during the sleep mode, although it is retained.

STB: When STB = 1, the HD66789 enters into the standby mode. In the standby mode, display operation is completely halted, and all internal operation including the internal R-C oscillator and reception of external clock pulse, is halted. For details, see the "Standby Mode" section. Only instructions to release the standby mode (STB = 0) and to start oscillation are accepted during the standby mode. Changes in the GRAM data or instructions during the standby mode are susceptible to destruction. These changes should be made after releasing the standby mode.

VC2-0: Adjust the reference voltage for VREG1OUT, VciOUT voltages to the optimum ratio of Vci.

| AP2 | AP1 | AP0 | Amount of current in operational amplifier |
|-----|-----|-----|--|
| 0 | 0 | 0 | halt |
| 0 | 0 | 1 | setting disabled |
| 0 | 1 | 0 | 0.5 (fixed) |
| 0 | 1 | 1 | 0.75 (fixed) |
| 1 | 0 | 0 | 1 (fixed) |
| 1 | 0 | 1 | 1.25 (fixed) |
| 1 | 1 | 0 | 1.5 (fixed) |
| 1 | 1 | 1 | setting disabled |

| DC02 | DC01 | DC00 | Step-up circuit 1 step-up frequency | DC12 | DC11 | DC10 | Step-up circuit 2 step-up frequency |
|------|------|------|--|------|------|------|--|
| 0 | 0 | 0 | oscillation clock / 8 | 0 | 0 | 0 | oscillation clock / 16 |
| 0 | 0 | 1 | oscillation clock / 16 | 0 | 0 | 1 | oscillation clock / 32 |
| 0 | 1 | 0 | oscillation clock / 32 | 0 | 1 | 0 | oscillation clock / 64 |
| 0 | 1 | 1 | oscillation clock / 64 | 0 | 1 | 1 | oscillation clock / 128 |
| 1 | 0 | 0 | oscillation clock / 128 | 1 | 0 | 0 | oscillation clock / 256 |
| 1 | 0 | 1 | setting disabled | 1 | 0 | 1 | setting disabled |
| 1 | 1 | 0 | setting disabled | 1 | 1 | 0 | setting disabled |
| 1 | 1 | 1 | setting disabled | 1 | 1 | 1 | setting disabled |

| BT2 | BT1 | BT0 | VLOUT1 output (DDVDH) | VLOUT4 output (VCL) | VLOUT2 output (VGH) | VLOUT3 output (VGL) | Capacitor connection pins |
|-----|-----|-----|----------------------------|------------------------------|-------------------------------------|---|--|
| 0 | 0 | 0 | $V_{ci1} \times 2$ [x2] | $V_{ci1} \times -1$ [x-1] | DDVDH x 3 [x 6] | $-(V_{ci1} + DDVDH) \times 2$ [x -5] | DDVDH, VGH, VGL, VCL, C11±, C12±, C21±, C22±, |
| 0 | 0 | 1 | | | DDVDH x 3 [x 6] | $-(DDVDH) \times 2$ [x -4] | DDVDH, VGH, VGL, VCL, C11±, C12±, C21±, C22±, |
| 0 | 1 | 0 | | | DDVDH x 3 [x 6] | $-(V_{ci1} + DDVDH)$ [x -3] | DDVDH, VGH, VGL, VCL, C11±, C12±, C21±, C22±, |
| 0 | 1 | 1 | | | $V_{ci1} + DDVDH \times 2$ [x 5] | $-(V_{ci1} + DDVDH) \times 2$ [x -5] | DDVDH, VGH, VGL, VCL, C11±, C12±, C21±, C22±, |
| 1 | 0 | 0 | | | $V_{ci1} + DDVDH \times 2$ [x 5] | $-(DDVDH) \times 2$ [x -4] | DDVDH, VGH, VGL, VCL, C11±, C12±, C21±, C22±, |
| 1 | 0 | 1 | | | $V_{ci1} + DDVDH \times 2$ [x 5] | $-(V_{ci1} + DDVDH)$ [x -3] | DDVDH, VGH, VGL, VCL, C11±, C12±, C21±, C22±, |
| 1 | 1 | 0 | | | DDVDH x 2 [x 4] | $-(DDVDH) \times 2$ [x -4] | DDVDH, VGH, VGL, VCL, C11±, C12±, C21±, C22±, |
| 1 | 1 | 1 | | | DDVDH x 2 [x 4] | $-(V_{ci1} + DDVDH)$ [x -3] | DDVDH, VGH, VGL, VCL, C11±, C12±, C21± |

Note 1) The numerals in the bracket [] show the step-up scale from V_{ci1} .

Note 2) The capacitor connection pins are step-up capacitors which are necessary for DDVDH, VCL, VGH, VGL voltages.

Note 3) Set the voltage within the following range: DDVDH = 5.5 V (Max.), VCL = -3.3 V (Min.), VGH = 16.5 V (Max.), VGL = -16.5 V (Min.)

| VC2 | VC1 | VC0 | $V_{ci}OUT$ output voltage (REGP) | DK | Operation of step-up circuit 1 |
|-----|-----|-----|-----------------------------------|----|--------------------------------|
| 0 | 0 | 0 | V_{ci} | 0 | Operation |
| 0 | 0 | 1 | $0.92 \times V_{ci}$ | 1 | Halt |
| 0 | 1 | 0 | $0.87 \times V_{ci}$ | | |
| 0 | 1 | 1 | $0.83 \times V_{ci}$ | | |
| 1 | 0 | 0 | $0.76 \times V_{ci}$ | | |
| 1 | 0 | 1 | $0.73 \times V_{ci}$ | | |
| 1 | 1 | 0 | setting disabled | | |
| 1 | 1 | 1 | setting disabled | | |

Power Control 3 (R12h)**Power Control 4 (R13h)**

| R/W | RS | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 |
|-----|----|------|------|-------|------|------|------|------|------|-----|-----|-----|------|------|------|------|------|
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | PON | VRH3 | VRH2 | VRH1 | VRH0 |
| W | 1 | 0 | 0 | VCOMG | VDV4 | VDV3 | VDV2 | VDV1 | VDV0 | 0 | 0 | 0 | VCM4 | VCM3 | VCM2 | VCM1 | VCM0 |

PON: Start operation of VLOUT3. To stop operation, set PON = 0. To start operation, set PON = 1.

VRH3-0: Set the scale for amplifying VLOUT1 voltage (the reference voltage for VCOM and grayscale voltage). REGP voltage is amplified by 1.33 ~ 2.775 times.

VCOMG: When VCOMG = 1, VcomL outputs a negative voltage (1.0V ~ -Vci+0.5V Max.). When VCOMG = 0, the amplifiers for the negative voltage is halted, thereby saving power consumption. When VCOMG = 0, settings with VDV4-0 bits are invalid. In this case, to adjust AC amplitude of Vcom, make settings with VCM4-0 bits (VcomH setting). VCOMG = 1 is valid when PON = 1.

VDV4-0: Set the AC amplitude of Vcom during Vcom AC drive. The amplitude can be specified within the range of 0.6 ~ 1.23 times of VREG1OUT. When VCOMG = 0, this setting is invalid.

VCM4-0: Set the VcomH voltage (The higher voltage during Vcom AC drive). The voltage can be specified within the range of 0.4 ~ 0.98 times of VREG1OUT. When VCM4-0 = "11111", the internal volume adjustment operation is halted, and the VcomH voltage can be adjust by placing an external resistor from VcomR.

| VRH3 | VRH2 | VRH1 | VRH0 | VREG1OUT voltage |
|------|------|------|------|------------------|
| 0 | 0 | 0 | 0 | REGP x 1.33 |
| 0 | 0 | 0 | 1 | REGP x 1.45 |
| 0 | 0 | 1 | 0 | REGP x 1.55 |
| 0 | 0 | 1 | 1 | REGP x 1.65 |
| 0 | 1 | 0 | 0 | REGP x 1.75 |
| 0 | 1 | 0 | 1 | REGP x 1.80 |
| 0 | 1 | 1 | 0 | REGP x 1.85 |
| 0 | 1 | 1 | 1 | halt |
| 1 | 0 | 0 | 0 | REGP x 1.90 |
| 1 | 0 | 0 | 1 | REGP x 2.175 |
| 1 | 0 | 1 | 0 | REGP x 2.325 |
| 1 | 0 | 1 | 1 | REGP x 2.475 |
| 1 | 1 | 0 | 0 | REGP x 2.625 |
| 1 | 1 | 0 | 1 | REGP x 2.700 |
| 1 | 1 | 1 | 0 | REGP x 2.775 |
| 1 | 1 | 1 | 1 | halt |

| VCM4 | VCM3 | VCM2 | VCM1 | VCM0 | VcomH | VDV4 | VDV3 | VDV2 | VDV1 | VDV0 | Vcom amplitude |
|------|------|------|------|------|---|------|------|------|------|------|------------------|
| 0 | 0 | 0 | 0 | 0 | VREG1OUT x 0.40 | 0 | 0 | 0 | 0 | 0 | VREG1OUT x 0.60 |
| 0 | 0 | 0 | 0 | 1 | VREG1OUT x 0.42 | 0 | 0 | 0 | 0 | 1 | VREG1OUT x 0.63 |
| 0 | 0 | 0 | 1 | 0 | VREG1OUT x 0.44 | 0 | 0 | 0 | 1 | 0 | VREG1OUT x 0.66 |
| : | : | : | : | : | : | : | : | : | : | : | : |
| 0 | 1 | 1 | 0 | 0 | VREG1OUT x 0.64 | 0 | 1 | 1 | 0 | 0 | VREG1OUT x 0.96 |
| 0 | 1 | 1 | 0 | 1 | VREG1OUT x 0.66 | 0 | 1 | 1 | 0 | 1 | VREG1OUT x 0.99 |
| 0 | 1 | 1 | 1 | 0 | VREG1OUT x 0.68 | 0 | 1 | 1 | 1 | 0 | VREG1OUT x 1.02 |
| 0 | 1 | 1 | 1 | 1 | Halt internal volume. Adjust with a variable external resistor from VcomR. | 0 | 1 | 1 | 1 | 1 | Setting disabled |
| 1 | 0 | 0 | 0 | 0 | VREG1OUT x 0.70 | 1 | 0 | 0 | 0 | 0 | VREG1OUT x 1.05 |
| 1 | 0 | 0 | 0 | 1 | VREG1OUT x 0.72 | 1 | 0 | 0 | 0 | 1 | VREG1OUT x 1.08 |
| 1 | 0 | 0 | 1 | 0 | VREG1OUT x 0.74 | 1 | 0 | 0 | 1 | 0 | VREG1OUT x 1.11 |
| : | : | : | : | : | : | : | : | : | : | : | : |
| 1 | 1 | 1 | 0 | 0 | VREG1OUT x 0.94 | 1 | 0 | 1 | 0 | 0 | VREG1OUT x 1.17 |
| 1 | 1 | 1 | 0 | 1 | VREG1OUT x 0.96 | 1 | 0 | 1 | 0 | 1 | VREG1OUT x 1.20 |
| 1 | 1 | 1 | 1 | 0 | VREG1OUT x 0.98 | 1 | 0 | 1 | 1 | 0 | VREG1OUT x 1.23 |
| 1 | 1 | 1 | 1 | 1 | Halt internal volume. Adjust with a variable external resistor from VcomR. | 1 | 0 | 1 | 1 | 1 | Setting disabled |
| 1 | 1 | 1 | 1 | 1 | | 1 | 1 | * | * | * | Setting disabled |

Note 1) Adjust VREG1OUT and VCM0-4 to set VcomH the same level as VDH or less.

Note 2) Adjust VREG1OUT and VDV0-4 to set the amplitude of Vcom 6.0V or less.

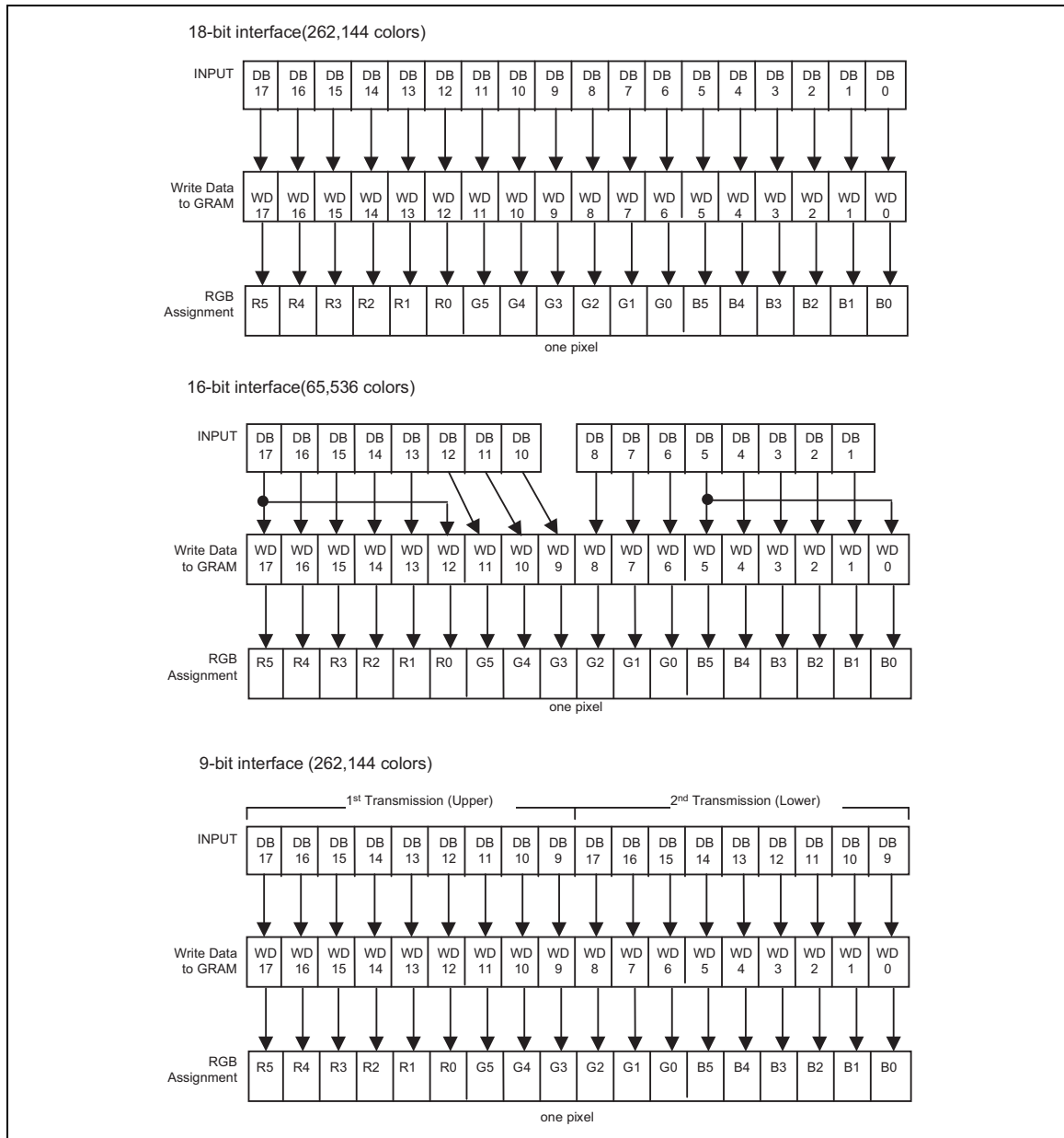
RAM Address Set (R21h)

| | | | | | | | | | | | | | | | | | |
|-----|----|----------|----------|----------|----------|----------|----------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| R/W | RS | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 |
| W | 1 | AD 15 | AD 14 | AD 13 | AD 12 | AD 11 | AD 10 | AD 9 | AD 8 | AD 7 | AD 6 | AD 5 | AD 4 | AD 3 | AD 2 | AD 1 | AD 0 |

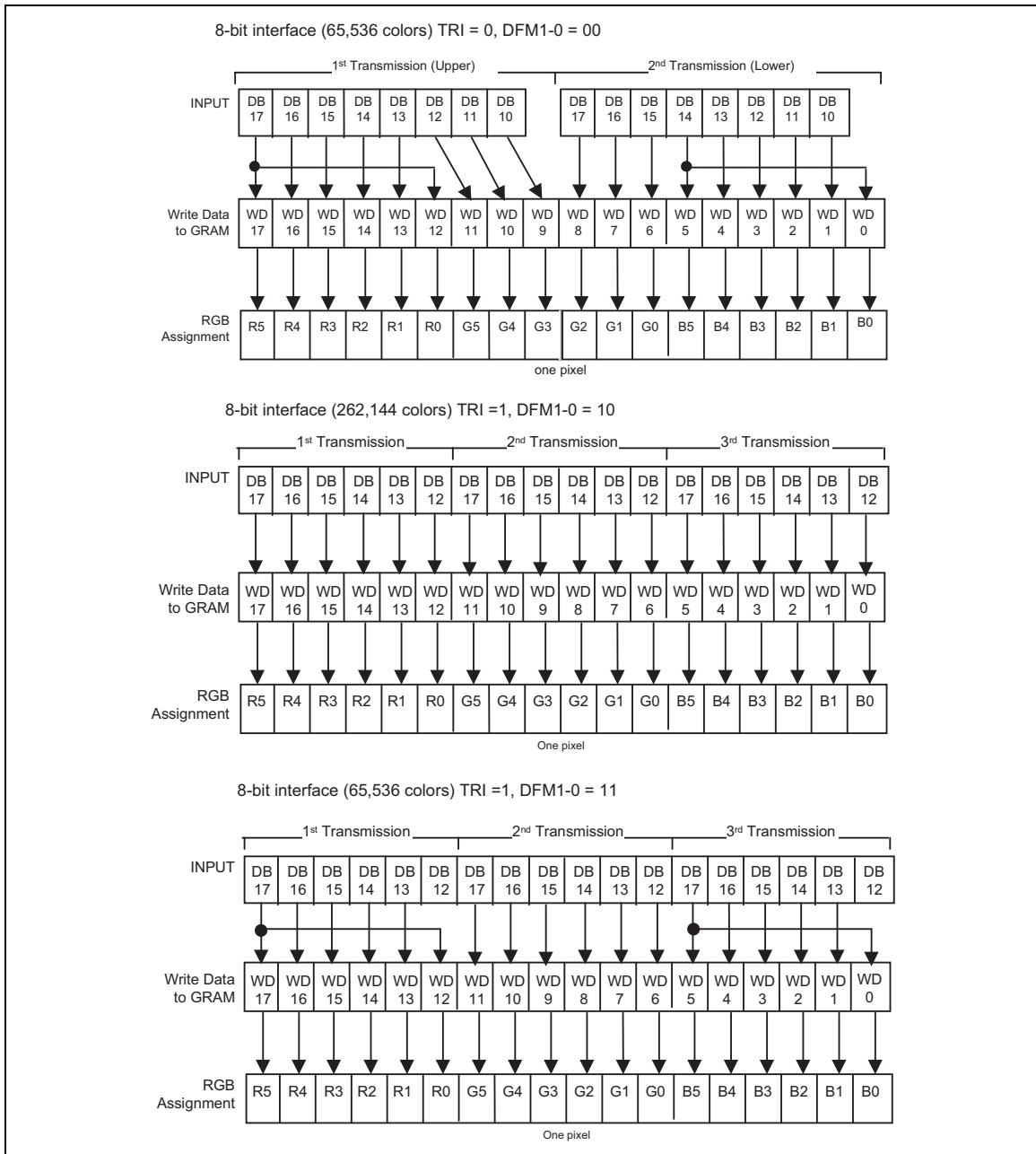
AD15-0: Make the initial setting for the GRAM address in the address counter (AC). After GRAM data are written, the address counter is automatically updated according to the settings with AM, I/D bits and the setting for a new GRAM address is not required in the address counter. Therefore, data are written consecutively without resetting the address. The address counter is not automatically updated when data are read out from GRAM.

GRAM address setting can not be made during the standby mode. An address set should be made within the area specified with the window address.

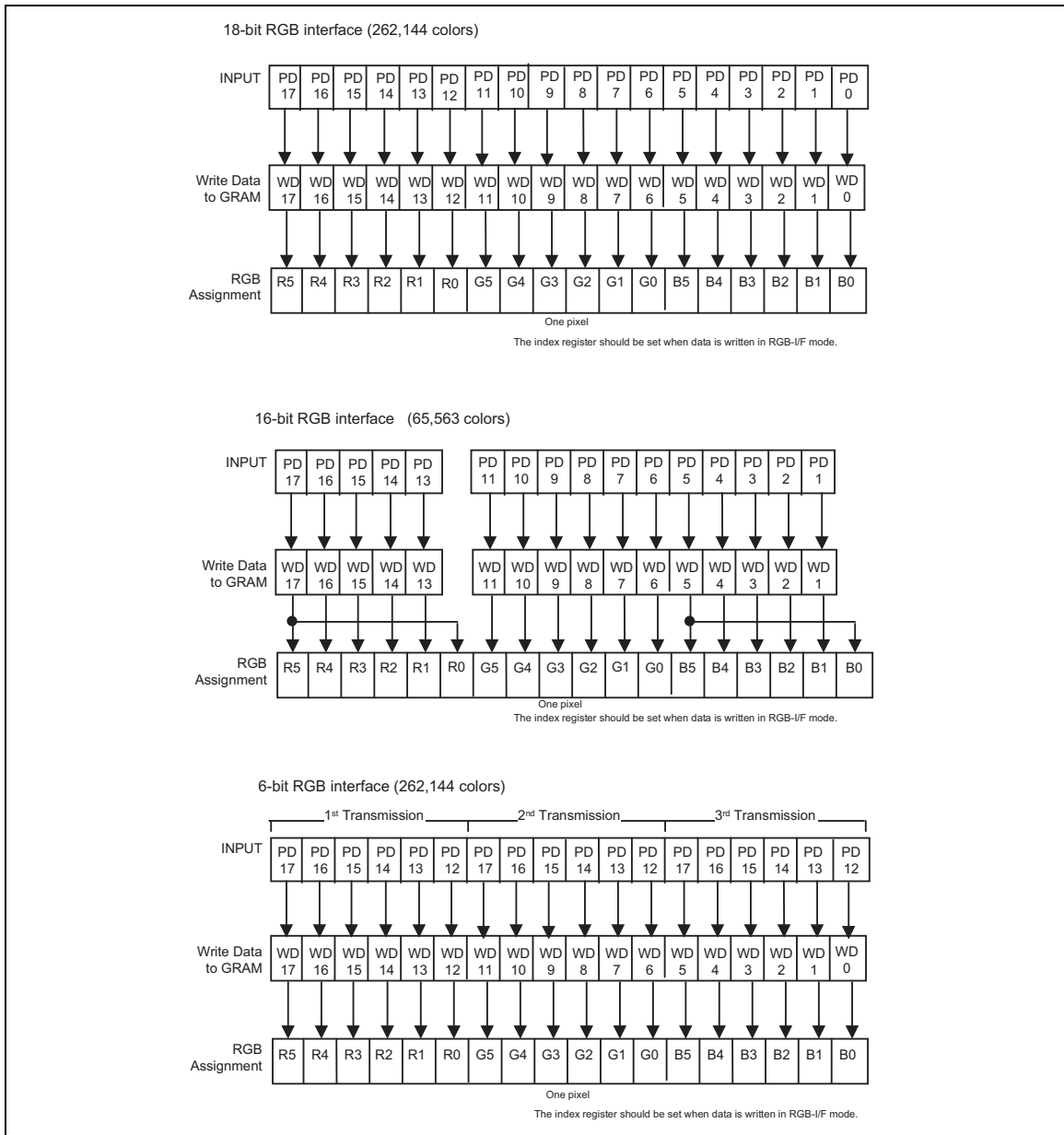
When the RGB interface is selected (RM = 1), the setting of the address for AD15-0 is made every frame at the falling edge of VSYNC. When the internal clock operation or VSYNC interface is selected (RM = 0), the setting of the address is made when the instruction is executed.



Write data to GRAM: Bit assignment



Write data to GRAM: Bit assignment



Write data to GRAM (RGB interface): Bit assignment

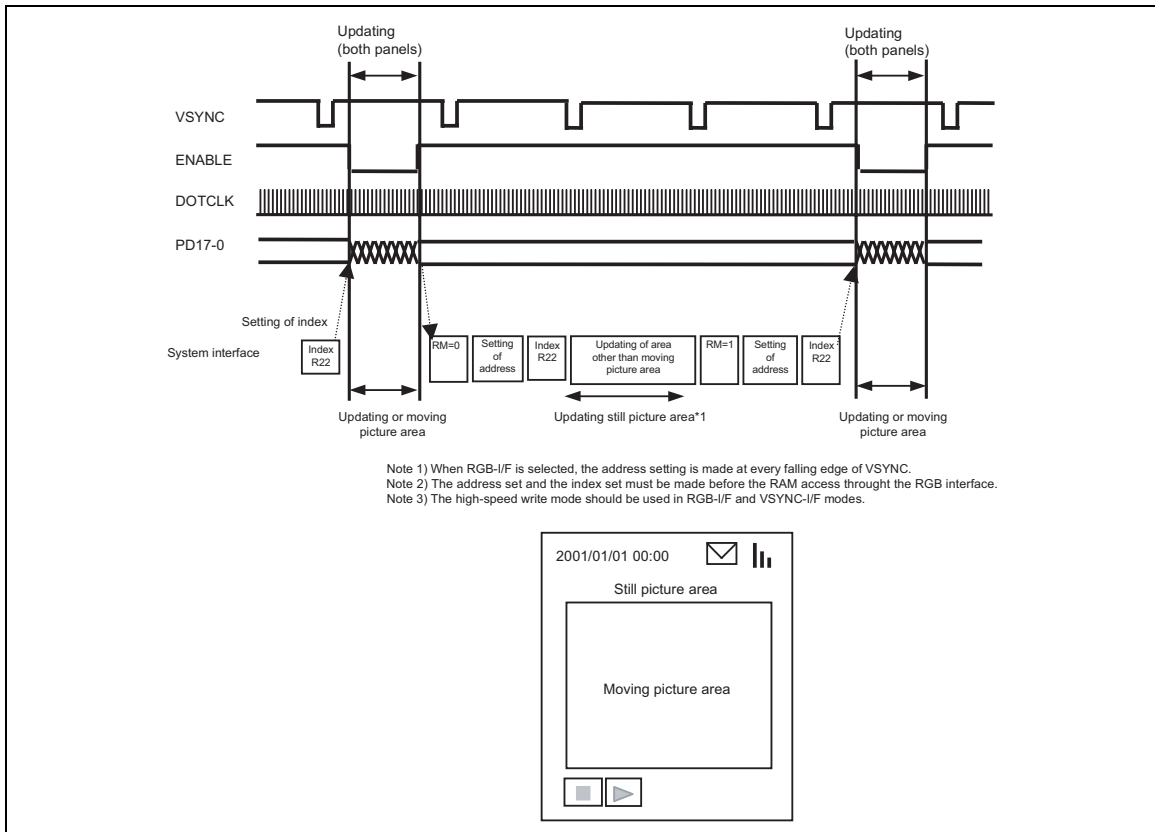
| GRAM data settings RGB | Grayscale | | GRAM data settings RGB | Grayscale | |
|---------------------------|-------------|-------------|---------------------------|-------------|-------------|
| | Negative | Positive | | Negative | Positive |
| 000000 | V0 | V31 | 100000 | V16 | V15 |
| 000001 | (V0-V1)/2 | (V30-V31)/2 | 100001 | (V16-V17)/2 | (V14-V15)/2 |
| 000010 | V1 | V30 | 100010 | V17 | V14 |
| 000011 | (V1-V2)/2 | (V29-V30)/2 | 100011 | (V17-V18)/2 | (V13-V14)/2 |
| 000100 | V2 | V29 | 100100 | V18 | V13 |
| 000101 | (V2-V3)/2 | (V28-V29)/2 | 100101 | (V18-V19)/2 | (V12-V13)/2 |
| 000110 | V3 | V28 | 100110 | V19 | V12 |
| 000111 | (V3-V4)/2 | (V27-V28)/2 | 100111 | (V19-V20)/2 | (V11-V12)/2 |
| 001000 | V4 | V27 | 101000 | V20 | V11 |
| 001001 | (V4-V5)/2 | (V26-V27)/2 | 101001 | (V20-V21)/2 | (V10-V11)/2 |
| 001010 | V5 | V26 | 101010 | V21 | V10 |
| 001011 | (V5-V6)/2 | (V25-V26)/2 | 101011 | (V21-V22)/2 | (V9-V10)/2 |
| 001100 | V6 | V25 | 101100 | V22 | V9 |
| 001101 | (V6-V7)/2 | (V24-V25)/2 | 101101 | (V22-V23)/2 | (V8-V9)/2 |
| 001110 | V7 | V24 | 101110 | V23 | V8 |
| 001111 | (V7-V8)/2 | (V23-V24)/2 | 101111 | (V23-V24)/2 | (V7-V8)/2 |
| 010000 | V8 | V23 | 110000 | V24 | V7 |
| 010001 | (V8-V9)/2 | (V22-V23)/2 | 110001 | (V24-V25)/2 | (V6-V7)/2 |
| 010010 | V9 | V22 | 110010 | V25 | V6 |
| 010011 | (V9-V10)/2 | (V21-V22)/2 | 110011 | (V25-V26)/2 | (V5-V6)/2 |
| 010100 | V10 | V21 | 110100 | V26 | V5 |
| 010101 | (V10-V11)/2 | (V20-V21)/2 | 110101 | (V26-V27)/2 | (V4-V5)/2 |
| 010110 | V11 | V20 | 110110 | V27 | V4 |
| 010111 | (V11-V12)/2 | (V19-V20)/2 | 110111 | (V27-V28)/2 | (V3-V4)/2 |
| 011000 | V12 | V19 | 111000 | V28 | V3 |
| 011001 | (V12-V13)/2 | (V18-V19)/2 | 111001 | (V28-V29)/2 | (V2-V3)/2 |
| 011010 | V13 | V18 | 111010 | V29 | V2 |
| 011011 | (V13-V14)/2 | (V17-V18)/2 | 111011 | (V29-V30)/2 | (V1-V2)/2 |
| 011100 | V14 | V17 | 111100 | V30 | V1 |
| 011101 | (V14-V15)/2 | (V16-V17)/2 | 111101 | (V30-V31)/2 | (V0-V1)/2 |
| 011110 | V15 | V16 | 111110 | (V30-V31)/3 | (V0-V1)/3 |
| 011111 | (V15-V16)/2 | (V15-V16)/2 | 111111 | V31 | V0 |

GRAM data and LCD output level

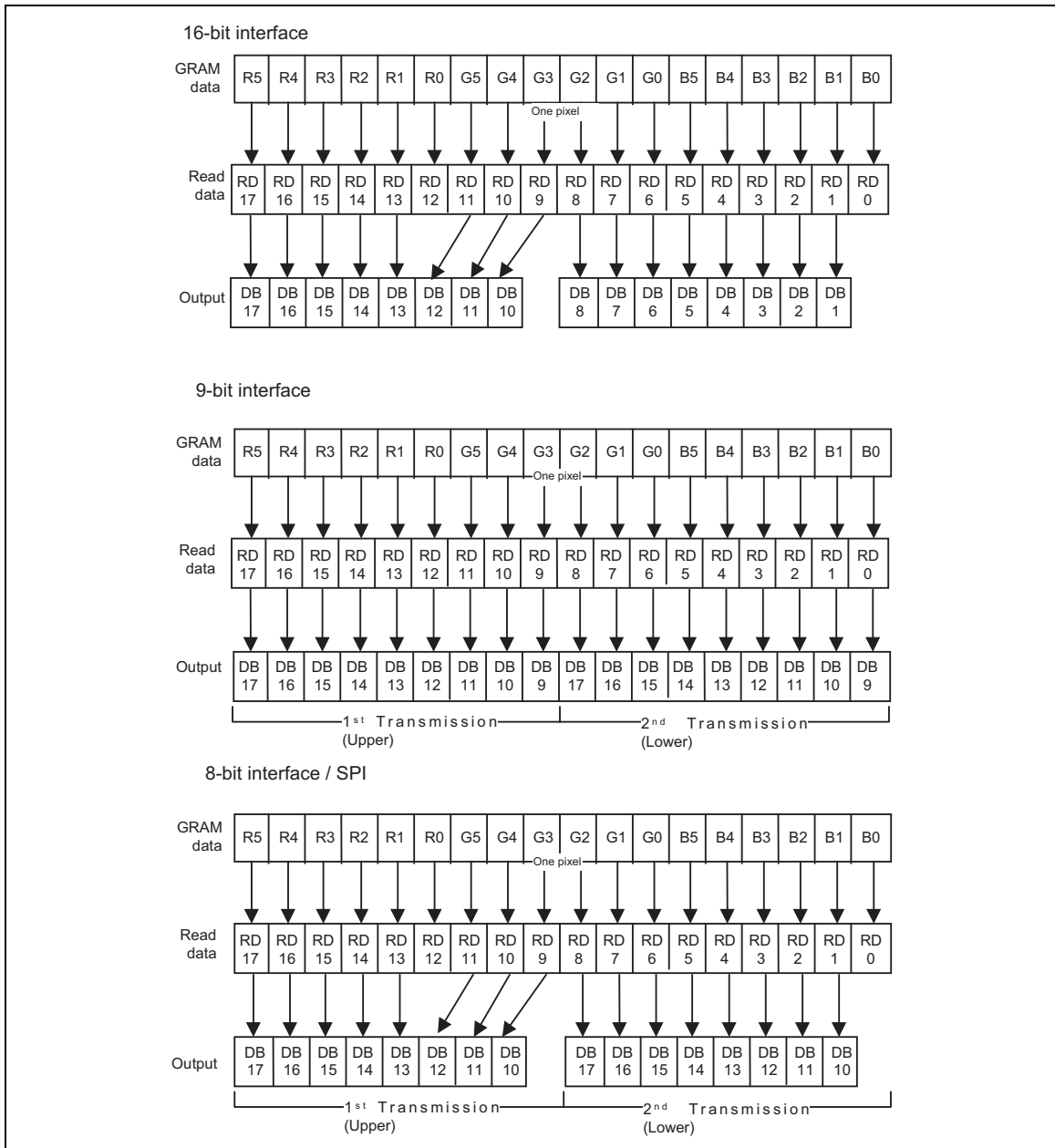
RAM Access through RGB-I/F and System I/F

The HD66787 writes all display data on the panels to the internal RAM. This enables the transfer of only the data for the moving picture area as well as for the frames for updating screens through the RGB interface. By writing data in the high speed write mode (HWM = 1) and with the window address function, the HD66787 enables the high-speed access to RAM with low power consumption while displaying moving pictures. In the frames other than the moving picture screen update, the display data in the area other than the moving picture area can be updated through a system interface.

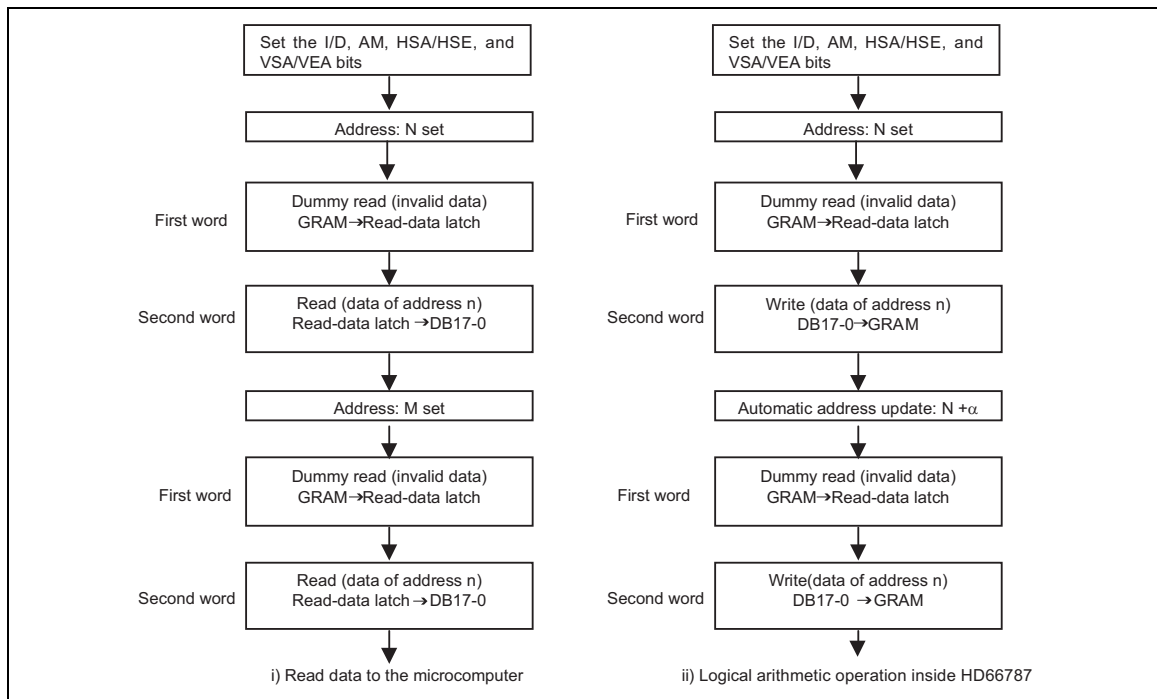
The RAM access is also possible through a system interface even in the RGB-I/F mode. In the RGB interface mode, data are written to RAM in synchronization with the DOTCLK during ENABLE = "Low". When writing data in the RGB-I/F mode through the system interface, it is necessary to set the ENABLE "High" to stop writing through the RGB interface. After accessing to RAM through the system interface, wait an enough time for the write/read bus cycle before starting accessing to RAM through the RGB interface. When RAM accesses through the RGB and system interfaces conflict, there will be no guarantee that data are properly written to RAM.



Updating Still Picture Area during Displaying a Moving Picture



Read data from GRAM: Bit assignment



GRAM read sequence

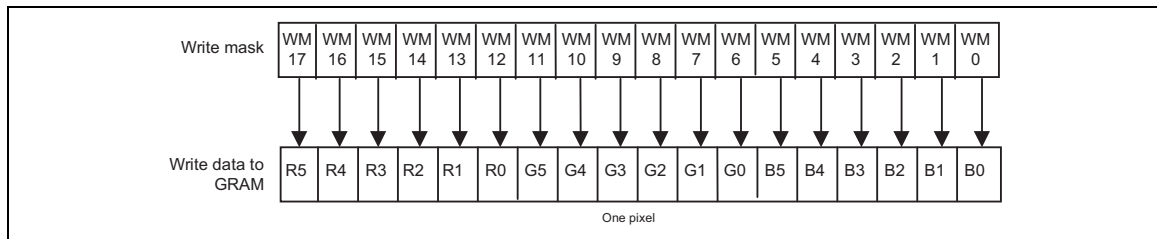
RAM Write Data Mask (R23h)

RAM Write Data Mask (R24h)

| R/W | RS | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 |
|-----|----|------|------|----------|----------|---------|---------|---------|---------|-----|-----|----------|----------|----------|----------|----------|----------|
| W | 1 | 0 | 0 | WM 11 | WM 10 | WM 9 | WM 8 | WM 7 | WM 6 | 0 | 0 | WM 5 | WM 4 | WM 3 | WM 2 | WM 1 | WM 0 |
| W | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | WM 17 | WM 16 | WM 15 | WM 14 | WM 13 | WM 12 |

WM17-0: Write-mask the data when these data are written to GRAM by bit. For example, if WM17 = 1, the WM17 write-mask the MSB of the data to write to GRAM so that the data in the MSB are not written to GRAM. The rest of WM16-0 bits also write-mask the data in the corresponding bits when these bits are set to “1”. For details, see the “Graphics Operation Function” section.

The WM17-0 bits write-mask the data to write to GRAM, which are expanded, if necessary, into 18 bits. This function is not available in the RGB-I/F mode.



RAM write data mask

γ Control (R30h to R39h)

| | R/W | RS | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 |
|-----|-----|----|------|------|------|-----------|-----------|-----------|-----------|-----------|-----|-----|-----|-----|-----------|-----------|-----------|-----------|
| R30 | W | 1 | 0 | 0 | 0 | 0 | 0 | PKP 12 | PKP 11 | PKP 10 | 0 | 0 | 0 | 0 | 0 | PKP 02 | PKP 01 | PKP 00 |
| R31 | W | 1 | 0 | 0 | 0 | 0 | 0 | PKP 32 | PKP 31 | PKP 30 | 0 | 0 | 0 | 0 | 0 | PKP 22 | PKP 21 | PKP 20 |
| R31 | W | 1 | 0 | 0 | 0 | 0 | 0 | PKP 52 | PKP 51 | PKP 50 | 0 | 0 | 0 | 0 | 0 | PKP 42 | PKP 41 | PKP 40 |
| R33 | W | 1 | 0 | 0 | 0 | 0 | 0 | PRP 12 | PRP 11 | PRP 10 | 0 | 0 | 0 | 0 | 0 | PRP 02 | PRP 01 | PRP 00 |
| R34 | W | 1 | 0 | 0 | 0 | 0 | 0 | PKN 12 | PKN 11 | PKN 10 | 0 | 0 | 0 | 0 | 0 | PKN 02 | PKN 01 | PKN 00 |
| R35 | W | 1 | 0 | 0 | 0 | 0 | 0 | PKN 32 | PKN 31 | PKN 30 | 0 | 0 | 0 | 0 | 0 | PKN 22 | PKN 21 | PKN 20 |
| R36 | W | 1 | 0 | 0 | 0 | 0 | 0 | PKN 52 | PKN 51 | PKN 50 | 0 | 0 | 0 | 0 | 0 | PKN 42 | PKN 41 | PKN 40 |
| R37 | W | 1 | 0 | 0 | 0 | 0 | 0 | PRN 12 | PRN 11 | PRN 10 | 0 | 0 | 0 | 0 | 0 | PRN 02 | PRN 01 | PRN 00 |
| R38 | W | 1 | 0 | 0 | 0 | VRP 14 | VRP 13 | VRP 12 | VRP 11 | VRP 10 | 0 | 0 | 0 | 0 | VRP 03 | VRP 02 | VRP 01 | VRP 00 |
| R39 | W | 1 | 0 | 0 | 0 | VRN 14 | VRN 13 | VRN 12 | VRN 11 | VRN 10 | 0 | 0 | 0 | 0 | VRN 03 | VRN 02 | VRN 01 | VRN 00 |

γ Control Instructions

- PKP52-00 : The γ fine adjustment registers for positive polarity.
- PRP12-00 : The γ gradient adjustment registers for positive polarity.
- PKN52-00 : The γ fine adjustment registers for negative polarity.
- PRN12-00 : The γ gradient adjustment registers for negative polarity.
- VRP14-00 : The amplitude adjustment registers for positive polarity.
- VRN14-00 : The amplitude adjustment registers for negative polarity.

For details, see the “ γ adjustment” section.

Vertical Scroll Control (R41h)

| | | | | | | | | | | | | | | | | | |
|-----|----|------|------|------|------|------|------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| R/W | RS | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 |
| W | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VL7 | VL6 | VL5 | VL4 | VL3 | VL2 | VL1 | VL0 |

VL7–0: Specify the number of raster-rows that are scrolled and control smooth scrolling in the vertical direction. The number of raster-rows is specified between 0 to 240. The raster-rows of the specified number are being scrolled during display. When the 240th raster-row is displayed, the scrolling display starts afresh from the 1st raster-row. The number of raster-rows that are scrolled (VL7–0) can be specified when the first panel vertical scroll enable bit VLE1 = 1 or the second panel vertical scroll enable bit VLE2 = 1. The number of raster-rows is fixed (not changeable) when VLE2-1 = 00. This function is not available in the external display interface mode.

VL Bits and Display-start Raster-row

| VL7 | VL6 | VL5 | VL4 | VL3 | VL2 | VL1 | VL0 | Amount of Scrolling (Number of raster-row) |
|-----|-----|-----|-----|-----|-----|-----|-----|--|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 raster-row |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 raster-row |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 2 raster-rows |
| . | . | . | . | . | . | . | . | . |
| 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 238 raster-rows |
| 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 239 raster-rows |

Note: When setting the number of raster-rows for scrolling, it must be 239 or less.

1st-Screen Drive Position (R42h)**2nd-Screen Drive Position (R43h)**

| | | | | | | | | | | | | | | | | | |
|-----|----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| R/W | RS | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 |
| W | 1 | SE17 | SE16 | SE15 | SE14 | SE13 | SE12 | SE11 | SE10 | SS17 | SS16 | SS15 | SS14 | SS13 | SS12 | SS11 | SS10 |
| W | 1 | SE27 | SE26 | SE25 | SE24 | SE23 | SE22 | SE21 | SE20 | SS27 | SS26 | SS25 | SS24 | SS23 | SS22 | SS21 | SS20 |

SS17–10: Specify the start position for driving the first screen by line. The liquid crystal is driven by from the gate driver of “the set value + 1”.

SE17–10: Specify the end position for driving the first screen by line. The liquid crystal is driven by to the gate driver of “the set value + 1”. For instance, when SS17–10 = “07”H and SE17–10 = “10”H, the liquid crystal is driven from G8 to G17, and black display is driven from G1 to G7, and G18 thereafter. Make sure that SS17–10 ≤ SE17–10 ≤ “EF”H. For details, see the “Screen Split Drive Function” section.

SS27-20: Specify the start position for driving the second screen by line. The liquid crystal is driven by from the gate driver of “the set value + 1”. The second screen is driven when SPT = 1.

SE27-20: Specify the end position for driving the second screen by line. The liquid crystal is driven by to the gate driver of “the set value + 1”. For instance, when SPT = 1, and SS27-20 = “20”H, SE27-20 = “4F”H, the liquid crystal is driven from G33 to G80. Make sure that SS17-10 ≤ SE17-10 < SS27-20 ≤ SE27-20 ≤ “EF”H. For details, see the “Screen Split Drive Function” section.

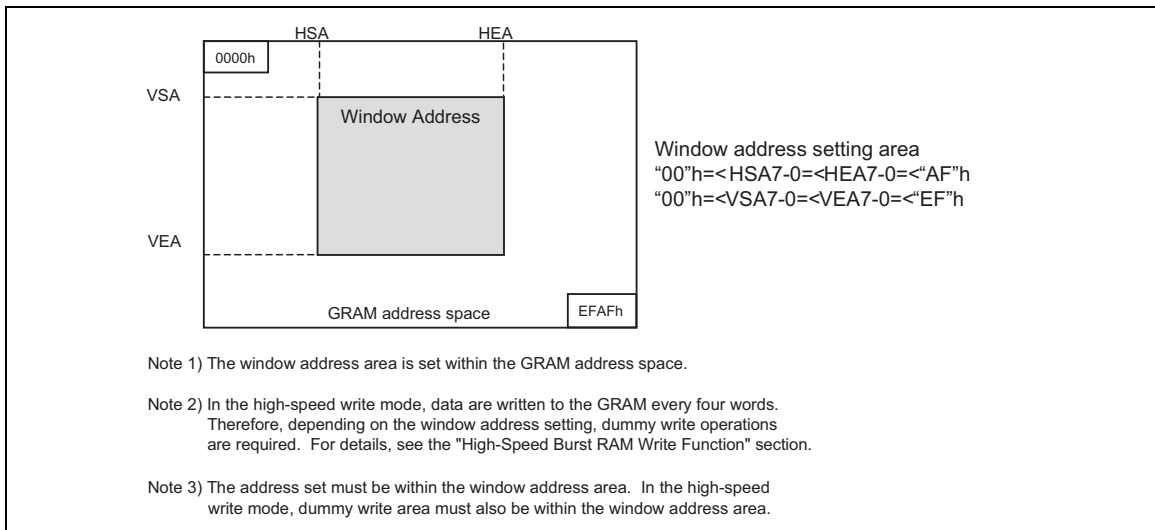
Horizontal RAM Address Position (R44h)

Vertical RAM Address Position (R45h)

| | | | | | | | | | | | | | | | | | |
|-----|----|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| R/W | RS | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 |
| W | 1 | HEA7 | HEA6 | HEA5 | HEA4 | HEA3 | HEA2 | HEA1 | HEA0 | HSA7 | HSA6 | HSA5 | HSA4 | HSA3 | HSA2 | HSA1 | HSA0 |
| W | 1 | VEA7 | VEA6 | VEA5 | VEA4 | VEA3 | VEA2 | VEA1 | VEA0 | VSA7 | VSA6 | VSA5 | VSA4 | VSA3 | VSA2 | VSA1 | VSA0 |

HSA7-0/HEA7-0: Specify the start/end positions of the window-address range in the horizontal direction by address. Data are written to GRAM within the area determined by the addresses specified by HEA7-0 and HSA7-0. These addresses must be set before RAM write. In setting these bits, make sure that “00”h ≤ HSA7-0 ≤ HEA7-0 ≤ “AF”h.

VSA7-0/VEA7-0: Specify the start/end positions of the window-address range in the vertical direction by address. Data are written to GRAM within the area determined by the addresses specified by VEA7-0 and VSA7-0. These addresses must be set before RAM write. In setting these bits, make sure that “00”h ≤ VSA7-0 ≤ VEA7-0 ≤ “EF”h.



GRAM address area and window-address range

Instruction List

| Upper Index | Main Category | Sub Category | Upper Code | | | | | | | | | | | | | | | | Lower Code | | | | | | | | Note |
|-------------|----------------------|------------------------------------|--|-------------------|-------|-------|-------|-------|-------|-------|-------|------|------|------|-------|-------|-------|-------|------------|------|------|-----|-----|-----|------|------|------|
| | | | IB15 | IB14 | IB13 | IB12 | IB11 | IB10 | IB9 | IB8 | IB7 | IB6 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 | | | |
| 0 | Display Control | 00h | Status Read | | | | | | | | | | | | | | | | | | | | | | | | |
| 01h | | Device Code Read | L7 | L6 | L5 | L4 | L3 | L2 | L1 | L0 | IB8 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 | IB5 | IB4 | IB3 | IB2 | IB1 | IB0 | 787 | | | |
| 02h | | Driver Output Control | VSPL | HSPL | DPL | EPL | SS | B/C | EOR | NW5 | NW4 | NW3 | NW2 | NW1 | NW0 | | | | | | | | | | | | |
| 03h | | LCD AC driving Control | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | IB1 | IB0 | AM | LG2 | LG1 | LG0 | | | | | | |
| 04h | | Entry Mode | TRI | DFM1 | DFM0 | BGR | 0 | 0 | HWM | 0 | 0 | 0 | 0 | 0 | 0 | CP5 | CP4 | CP3 | CP2 | CP1 | CP0 | | | | | | |
| 05h | | Compare Register (1) | 0 | 0 | CP11 | CP10 | CP9 | CP8 | CP7 | CP6 | 0 | 0 | CP5 | CP4 | CP3 | CP2 | CP1 | CP0 | | | | | | | | | |
| 06h | | Compare Register (2) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | CP15 | CP14 | CP13 | CP12 | CP11 | CP10 | | | | | | | | | |
| 07h | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 08h | | Display Control (1) | 0 | 0 | 0 | P11 | P10 | VLE2 | VLE1 | SP1 | 0 | 0 | 0 | 0 | 0 | D1E | CL | REV | D1 | D0 | | | | | | | |
| 09h | | Display Control (2) | 0 | 0 | 0 | 0 | FP3 | FP2 | FP1 | FP0 | 0 | 0 | 0 | 0 | 0 | BP3 | BP2 | BP1 | BP0 | | | | | | | | |
| 0Ah | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0Bh | | Frame Cycle Adjustment Control | NO1 | NO0 | SDT1 | SDT0 | EQ1 | EQ0 | DIV1 | DIV0 | 0 | 0 | 0 | 0 | RTN3 | RTN2 | RTN1 | RTN0 | | | | | | | | | |
| 0Ch | | External Display Interface Control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | DM1 | DM0 | 0 | 0 | RM1 | RM0 | | | | | | | | | |
| 0Dh | | LTPS Interface Control | 0 | 0 | 0 | TG0 | 0 | 0 | CLW3 | CLW2 | CLW1 | CLW0 | 0 | 0 | SHW1 | SHW0 | 0 | STG2 | STG1 | STG0 | | | | | | | |
| 0Eh | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 0Fh | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | | Power Control | 10h | Power Control (1) | SAP2 | SAP1 | SAP0 | 0 | B12 | B11 | B10 | B7 | B6 | B5 | B4 | B3 | B2 | B1 | B0 | AP2 | AP1 | AP0 | 0 | DK | SLP | STB | |
| 11h | | | Power Control (2) | 0 | 0 | 0 | 0 | 0 | 0 | DC12 | DC11 | DC10 | 0 | 0 | DC02 | DC01 | DC00 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VRH2 | VRH1 | VRH0 |
| 12h | | | Power Control (3) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | PON | VRH3 | VRH2 | VRH1 | VRH0 | | | | | | |
| 13h | | | Power Control (4) | 0 | 0 | VCOM | VDV4 | VDV3 | VDV2 | VDV1 | VDV0 | 0 | 0 | 0 | 0 | VCM4 | VCM3 | VCM2 | VCM1 | VCM0 | | | | | | | |
| 14h | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 15h | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 16h | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 17h | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18h | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 19h | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1Ah | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1Bh | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1Ch | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1Dh | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1Eh | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1Fh | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | RAM Access | 20h | RAM Address Set | AD15 | AD14 | AD13 | AD12 | AD11 | AD10 | AD9 | AD8 | AD7 | AD6 | AD5 | AD4 | AD3 | AD2 | AD1 | AD0 | | | | | | | | |
| 21h | | RAM data Write/Read | RAM Write Data (WD17-0) /RAM Read Data (RD17-0) *Bit assignment changes depending on the interface to be selected. | | | | | | | | | | | | | | | | | | | | | | | | |
| 22h | | RAM Write Data Mask (1) | 0 | 0 | WM11 | WM10 | WM9 | WM8 | WM7 | WM6 | 0 | 0 | WM5 | WM4 | WM3 | WM2 | WM1 | WM0 | | | | | | | | | |
| 23h | | RAM Write Data Mask (2) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | WM17 | WM16 | WM15 | WM14 | WM13 | WM12 | | | | | | | |
| 24h | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 25h | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 26h | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 27h | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 28h | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 29h | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2Ah | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2Bh | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2Ch | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2Dh | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2Eh | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2Fh | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | γ Control | 30h | γ Control (1) | 0 | 0 | 0 | 0 | 0 | PKP12 | PKP11 | PKP10 | 0 | 0 | 0 | 0 | 0 | PKP02 | PKP01 | PKP00 | | | | | | | | |
| 31h | | γ Control (2) | 0 | 0 | 0 | 0 | 0 | 0 | PKP32 | PKP31 | PKP30 | 0 | 0 | 0 | 0 | 0 | PKP22 | PKP21 | PKP20 | | | | | | | | |
| 32h | | γ Control (3) | 0 | 0 | 0 | 0 | 0 | 0 | PKP52 | PKP51 | PKP50 | 0 | 0 | 0 | 0 | 0 | PKP42 | PKP41 | PKP40 | | | | | | | | |
| 33h | | γ Control (4) | 0 | 0 | 0 | 0 | 0 | 0 | PRP12 | PRP11 | PRP10 | 0 | 0 | 0 | 0 | 0 | PRP02 | PRP01 | PRP00 | | | | | | | | |
| 34h | | γ Control (5) | 0 | 0 | 0 | 0 | 0 | 0 | PKN12 | PKN11 | PKN10 | 0 | 0 | 0 | 0 | 0 | PKN02 | PKN01 | PKN00 | | | | | | | | |
| 35h | | γ Control (6) | 0 | 0 | 0 | 0 | 0 | 0 | PKN32 | PKN31 | PKN30 | 0 | 0 | 0 | 0 | 0 | PKN22 | PKN21 | PKN20 | | | | | | | | |
| 36h | | γ Control (7) | 0 | 0 | 0 | 0 | 0 | 0 | PKN52 | PKN51 | PKN50 | 0 | 0 | 0 | 0 | 0 | PKN42 | PKN41 | PKN40 | | | | | | | | |
| 37h | | γ Control (8) | 0 | 0 | 0 | 0 | 0 | 0 | PRN12 | PRN11 | PRN10 | 0 | 0 | 0 | 0 | 0 | PRN02 | PRN01 | PRN00 | | | | | | | | |
| 38h | | γ Control (9) | | | VRP14 | VRP13 | VRP12 | VRP11 | VRP10 | | | | | | VRP03 | VRP02 | VRP01 | VRP00 | | | | | | | | | |
| 39h | | γ Control (10) | | | VRN14 | VRN13 | VRN12 | VRN11 | VRN10 | | | | | | VRN03 | VRN02 | VRN01 | VRN00 | | | | | | | | | |
| 3Ah | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3Bh | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3Ch | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3Dh | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3Eh | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3Fh | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Coordination Control | 40h | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | |
| 41h | | Vertical Scroll Control | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | VL7 | VL6 | VL5 | VL4 | VL3 | VL2 | VL1 | VL0 | | | | | | | |
| 42h | | First Screen Driving Position | SE17 | SE16 | SE15 | SE14 | SE13 | SE12 | SE11 | SE10 | SS17 | SS16 | SS15 | SS14 | SS13 | SS12 | SS11 | SS10 | | | | | | | | | |
| 43h | | Second Screen Driving Position | SE27 | SE26 | SE25 | SE24 | SE23 | SE22 | SE21 | SE20 | SS27 | SS26 | SS25 | SS24 | SS23 | SS22 | SS21 | SS20 | | | | | | | | | |
| 44h | | Horizontal RAM Address Position | HEA7 | HEA6 | HEA5 | HEA4 | HEA3 | HEA2 | HEA1 | HEA0 | HSA7 | HSA6 | HSA5 | HSA4 | HSA3 | HSA2 | HSA1 | HSA0 | | | | | | | | | |
| 45h | | Vertical RAM Address Position | VEA7 | VEA6 | VEA5 | VEA4 | VEA3 | VEA2 | VEA1 | VEA0 | VSA7 | VSA6 | VSA5 | VSA4 | VSA3 | VSA2 | VSA1 | VSA0 | | | | | | | | | |
| 46h | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 47h | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 48h | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 49h | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4Ah | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4Bh | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4Ch | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4Dh | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4Eh | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4Fh | | Setting Disabled | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | - | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | - | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | - | | | | | | | | | | | | | | | | | | | | | | | | | | |

Note 1) The numerals in parenthesis in the bit cells are initialized value.
 Note 2) Do not access to the "Setting Disabled" indexes.

Reset Function

The HD66787 makes internal initialization with RESET input. During RESET, the HD66787 is in a busy state, and no instruction from the MPU and access to GRAM are accepted. The time required for the RESET input is at least 1ms. In case of power-on reset, wait at least 10ms after the power is turned on until the R-C oscillation frequency becomes stabilized. While waiting, do not make an initial setting for the instruction set or an access to GRAM.

Initial State of Instructions

- a. Start oscillation
- b. Driver output control (NL4-0 = "11101", SS = "0", SM = "0", EPL = "0", DPL = "0", HSPL = "0", VSPL = "0")
- c. Liquid crystal AC drive control (B/C = "0", EOR = "0", NW5-0 = "00000")
- d. Entry mode set (HWM = "0", I/D1-0 = "11": Increment by 1, AM = "0": Horizontal direction, LG2-0 = "000": Replace mode, BGR = "0", TRI = "0", DFM1-0 = "00")
- e. Compare register (CP17-0 = "00 0000 0000 0000 0000")
- f. Display control 1 (PT1-0 = "00", VLE2-1 = "00": No vertical scroll, SPT = "0", DTE = "0", CL = "0": 65,536-color mode, REV = "0", D1-0 = "00": Display OFF)
- g. Display control 2 (BP3-0 = "1000", FP3-0 = "1000")
- h. Frame cycle control (NO1-0 = "00", SDT1-0 = "00", EQ1-0 = "00": No equalization, DIV1-0 = "00": clock/1, RTN3-0 = "0000": 16 clocks in 1H period)
- i. External display interface (RIM1-0 = "00": 18-bit RGB interface, DM1-0 = "00": internal clock operation, RM = "0": System interface)
- j. LTPS interface control (TG0 = "1", STG2-0 = "000", SHW1-0 = "00", CLW2-0 = "000")
- k. Power control 1 (SAP2-0 = "000", BT2-0 = "000", AP2-0 = "000": liquid crystal power off, DK = "1": DCDC1 off, SLP = "0", STB = "0": Standby mode off)
- l. Power control 2 (DC12-0 = "000", DC02-00 = "000", VC2-0 = "000")
- m. Power control 3 (PON = "0", VRH3-0 = "00000")
- n. Power control 4 (VCOMG = "0", VDV4-0 = "00000", VCM4-0 = "00000")
- o. RAM address set (AD15-0 = "0000"H)
- p. RAM write data mask (WM17-0 = "18'h00000": No mask)
- q. γ control
(PKP02-00 = "000", PKP12-10 = "000", PKP22-20 = "000", PKP32-30 = "000",
PKP42-40 = "000", PKP52-50 = "000", PRP02-00 = "000", PRP12-10 = "000")
(PKN02-00 = "000", PKN12-10 = "000", PKN22-20 = "000", PKN32-30 = "000",
PKN42-40 = "000", PKN52-50 = "000", PRN02-00 = "000", PRN12-10 = "000")
(VRP14-10 = "00000", VRP03-00 = "0000", VRN14-10 = "00000", VRN12-10 = "000")
- r. Vertical scroll (VL7-0 = "00000000")
- s. 1st split screen (SE17-10 = "11111111", SS17-10 = "00000000")
- t. 2nd split screen (SE27-20 = "11111111", SS27-20 = "00000000")
- u. Horizontal RAM address position (HEA7-0 = "10000011", HSA7-0 = "00000000")
- v. Vertical RAM address position (VEA7-0 = "10101111", VSA7-0 = "00000000")

GRAM Data Initialization

The data in GRAM are not initialized by the RESET input. Initialize through software during the display OFF (D1-0 = "00").

Initial state of Output Pins

- a. Liquid crystal driver output pins (source outputs): Output GND level
- b. Oscillator output pin (OSC2): Outputs oscillation signal

Interface Specifications

The HD66787 incorporates a system interface to make settings for instructions, and an external display interface to display moving pictures. By selecting an optimum interface for display (moving or still picture, or both), data are transmitted efficiently.

The external display interfaces are RGB-I/F and VSYNC-I/F. Through these interfaces, the data can be updated without flickering the moving picture on the display.

In the RGB-I/F mode, the display operation is performed in synchronization with the signals (VSYNC, HSYNC, and DOTCLK). The display data are written according to the values of the data enable signal (ENABLE), data valid signal (VLD) and PD17-0 bits in synchronization with VSYNC, HSYNC, and DOTCLK signals. The display data are written to GRAM to reduce the data transmission to minimum, i.e. only when the displays are being updated. With the window address function, only the RAM area used for moving picture display is overwritten, and therefore the simultaneous display of moving picture area, which is overwritten, and the RAM data in the area other than the moving picture area, which is not overwritten, is possible. In the RGB and VSYNC interface modes, write data to GRAM in the high speed write mode (HWM = 1) while displaying moving pictures to make an access to GRAM in high speed with low power consumption.

In the VSYNC interface mode, internal display operations are synchronized with the frame-synchronizing signal (VSYNC). By writing data in synchronization with the falling edge of VSYNC at a fixed speed to GRAM through a system interface, it enables moving pictures display with a system interface. In this case, there are some constraints in the RAM writing speed and method.

The HD66787 handles the following 4 operational modes for the type of display. The setting can be made through an external display interface. A transition between the modes must follow the transition flow.

Operation modes and interfaces

| Operation Mode | RAM Access Setting (RM) | Display Operation Mode (DM1-0) |
|--|------------------------------|--|
| Internal operating clock only (Displaying still pictures) | System interface (RM = 0) | Internal operating clock (DM1-0 = 00) |
| RGB interface (1) (Displaying moving pictures) | RGB interface (RM = 1) | RGB interface (DM1-0 = 01) |
| RGB interface (2) (Rewriting still pictures while displaying moving pictures) | System interface (RM = 0) | RGB interface (DM1-0 = 01) |
| VSYNC interface (Displaying moving pictures) | System interface (RM = 0) | VSYNC interface (DM1-0 = 10) |

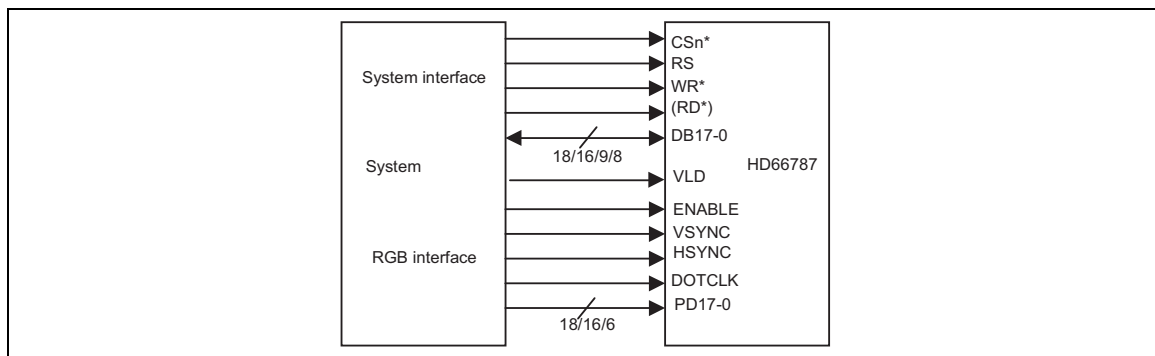
Note 1) the instruction register setting can be made only through a system interface.

Note 2) The RGB-I/F and VSYNC-I/F are not compatible with each other.

Note 3) Do not change the setting for RGB-I/F mode (RIM-0) while RGB I/F is in operation.

Note 4) See the “External Display Interface” section for the transition flow of each operation mode.

Note 5) In the RGB-I/F and VSYNC-I/F modes, write data in the high speed write mode (HWM = 1).



Interfaces and HD66787

System Interface

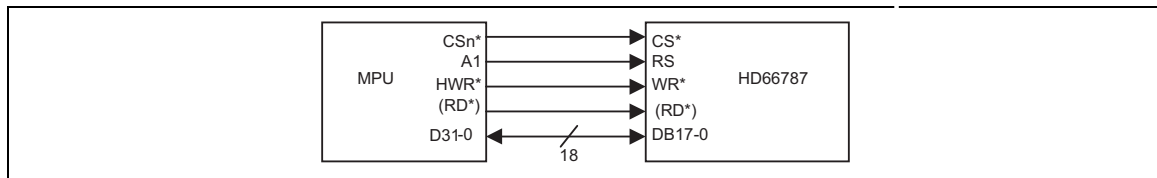
The following shows the kinds of system interfaces and the IM pins setting for selecting an interface. The instruction setting and RAM access are made through a system interface.

IM bits setting and the type of system interface

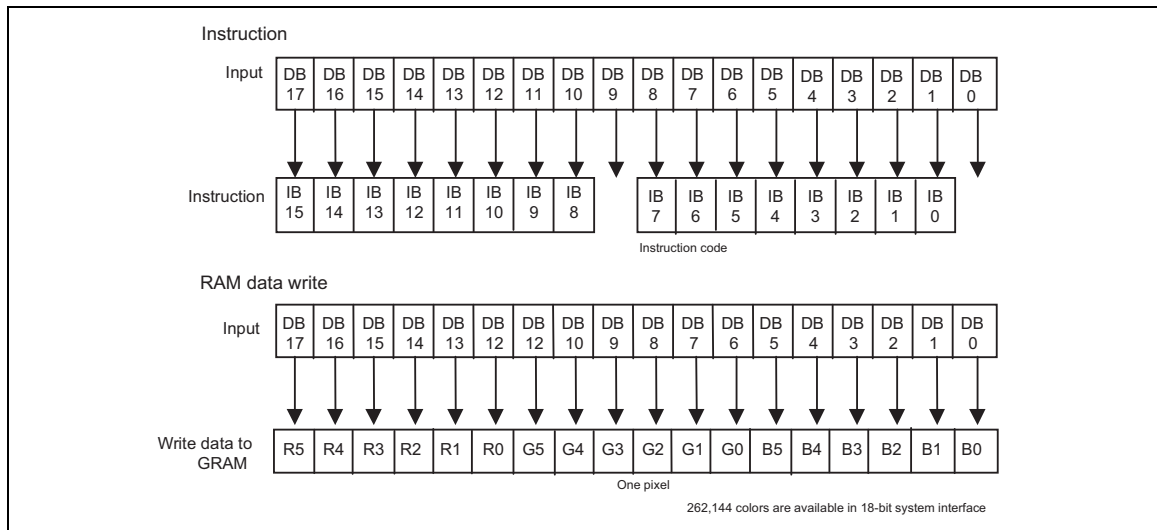
| IM3 | IM2 | IM1 | IM0 | MPU-Interface Mode | DB Pin |
|-----|-----|-----|-----|-----------------------------------|-----------------------|
| 0 | 0 | 0 | 0 | Setting disabled | |
| 0 | 0 | 0 | 1 | Setting disabled | |
| 0 | 0 | 1 | 0 | 80-system 16-bit interface | DB17 to 10 and 8-to-1 |
| 0 | 0 | 1 | 1 | 80-system 8-bit interface | DB17 to 10 |
| 0 | 1 | 0 | * | Serial peripheral interface (SPI) | SDI, SDO |
| 0 | 1 | 1 | * | Setting disabled | |
| 1 | 0 | 0 | 0 | Setting disabled | |
| 1 | 0 | 0 | 1 | Setting disabled | |
| 1 | 0 | 1 | 0 | 80-system 18-bit interface | DB17 to 0 |
| 1 | 0 | 1 | 1 | 80-system 9-bit interface | DB17 to 9 |
| 1 | 1 | * | * | Setting disabled | |

80-system 18-bit interface

80-system 18-bit parallel data transmission becomes operable by setting IM3/2/1/0 pins to IOVcc/GND/IOVcc/GND levels respectively.



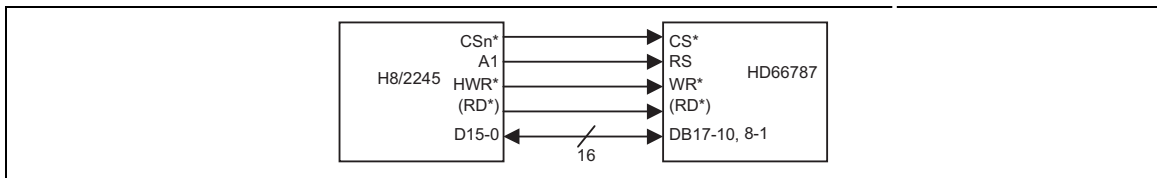
18-bit microcomputer and HD66787



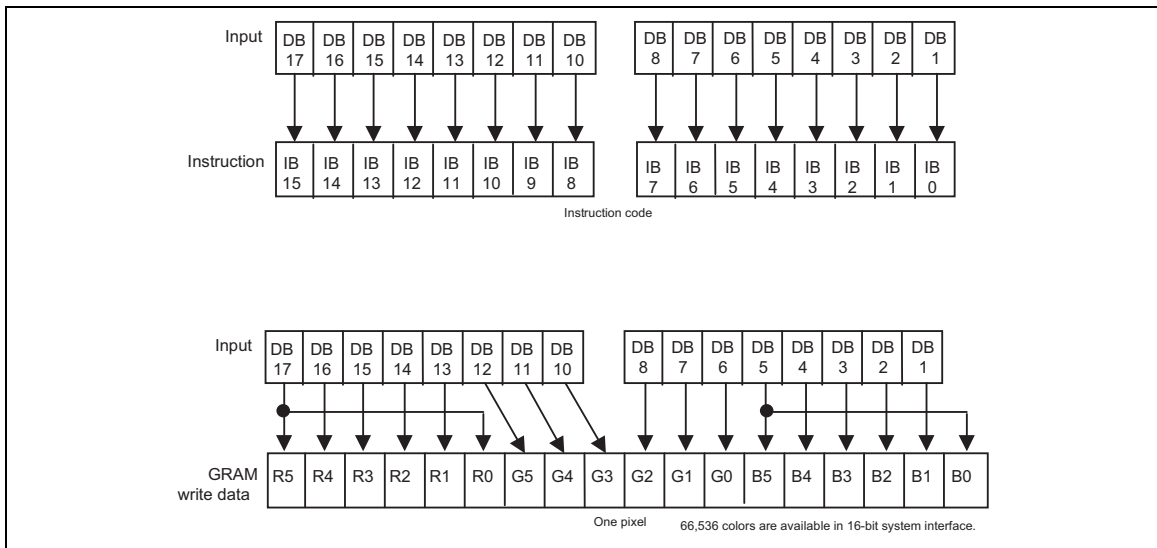
Data format for 18-bit interface

80-system 16-bit interface

The 80-system 16-bit parallel data transmission becomes operable by setting IM3/2/1/0 pins to GND/GND/IOVcc/GND levels respectively.



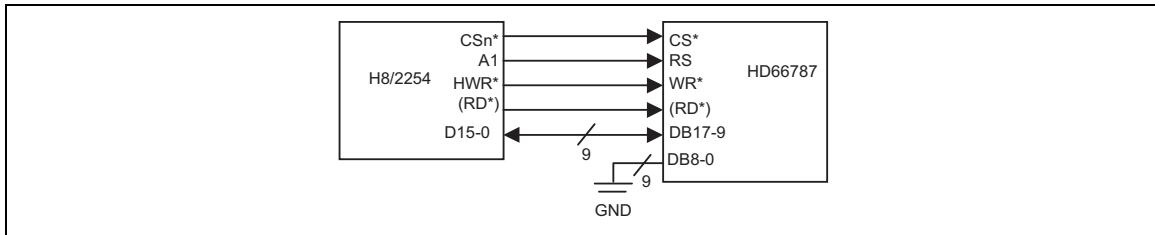
16-bit microcomputer and HD66787



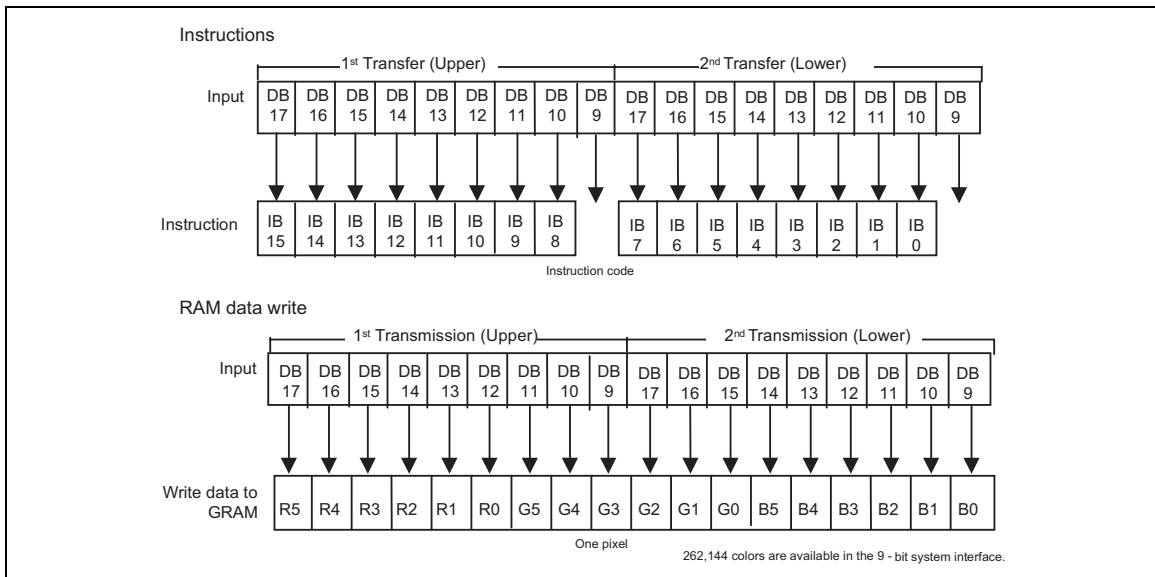
Data format for 16-bit interface

80-system 9-bit interface

The 80-system 9-bit parallel data transmission becomes operable by setting IM3/2/1/0 pins to IOVcc/GND/IOVcc/IOVcc levels respectively. When transmitting a 16-bit instruction, it is divided into upper and lower 8 bits (the LSB is not used) and the upper 8 bits are transmitted first. The RAM data is also divided into the upper and lower 9 bits, and the upper bits are transmitted first. The unused pins DB8-0 pins must be fixed to either IOVcc or GND level. When writing into the index register, the upper byte (8 bits) must be written.



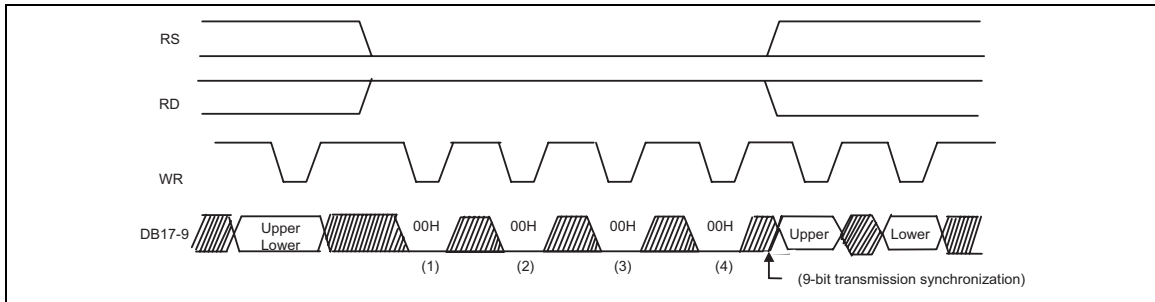
9-bit microcomputer and HD66787



Data format for 9-bit interface

Data transmission synchronizing in 9-bit bus interface mode

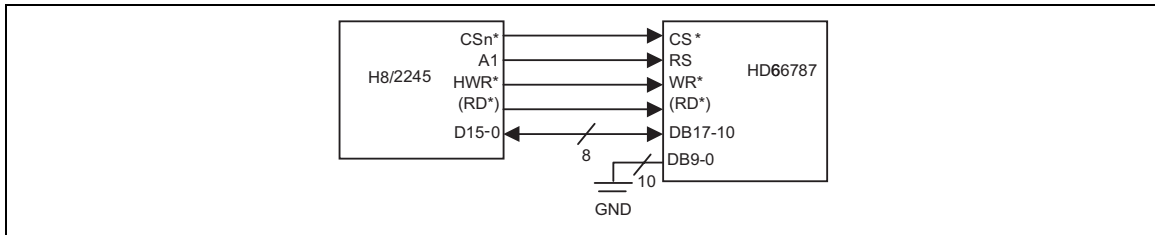
The HD66787 supports a data transmission synchronizing function, which resets the upper/lower counter that counts the number of transmission of upper/lower 9-bit data in the 9-bit bus interface mode. When a discrepancy occurs in the upper/lower 9-bit data transmission due to effects from noise and so on, the “00” H instruction is written 4 times consecutively to forcibly reset the upper/lower counter so that data transmission restarts with an upper 9-bit data transmission. The excursion can be recovered by executing the synchronizing function periodically.



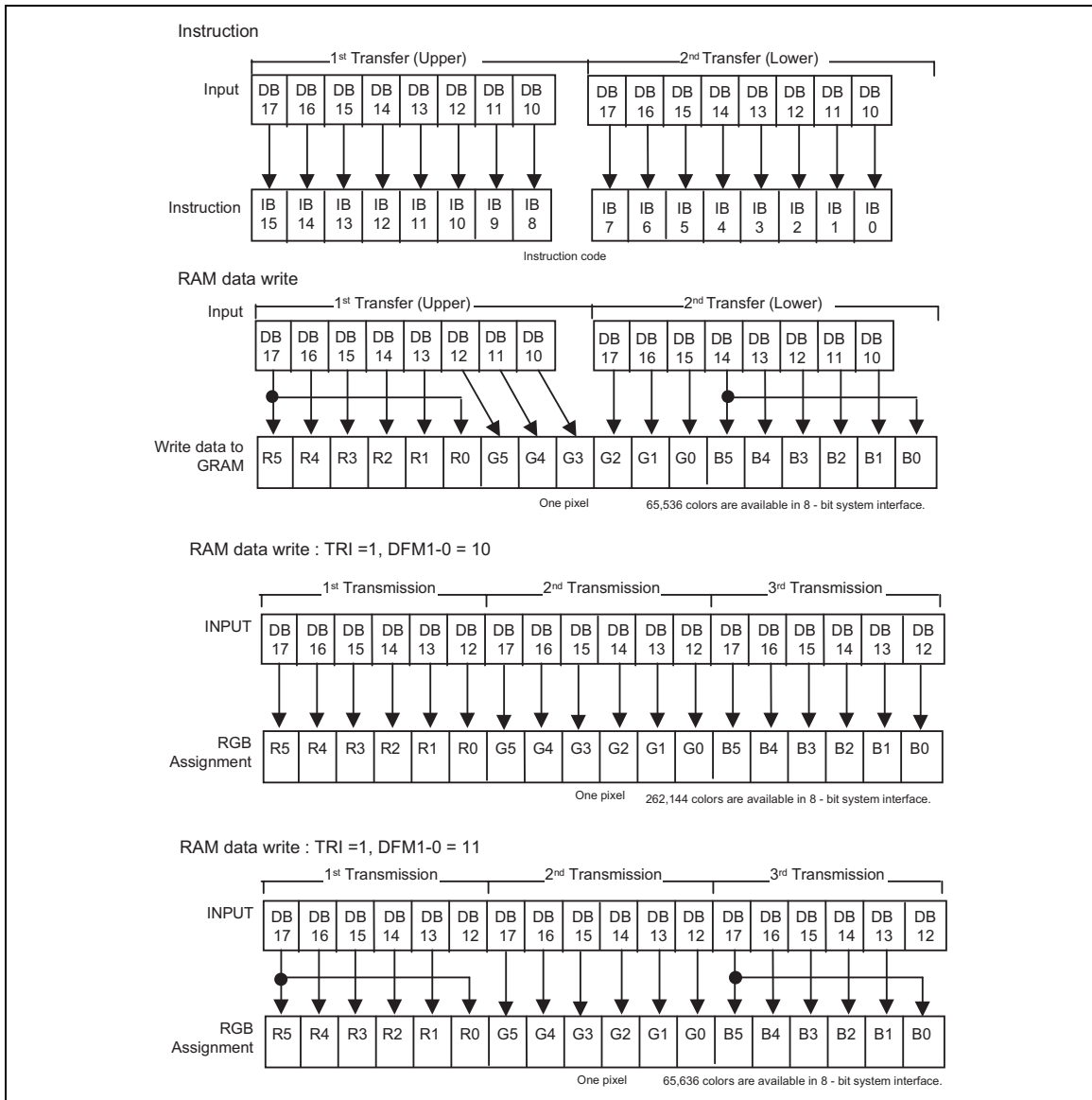
9-bit data transmission synchronization

80-system 8-bit interface

The 80-system 8-bit parallel data transmission becomes operable by setting IM3/2/1/0 pins to GND/GND/IOVcc/IOVcc levels respectively. When transmitting a 16-bit instruction, it is divided into upper and lower 8 bits and the upper 8 bits are transmitted first. The RAM data is also divided into the upper and lower 8 bits, and the upper bits are transmitted first. The data to write to RAM are expanded into 18 bits internally. The unused pins DB9-0 must be fixed to either IOVcc or GND level. When writing into the index register, the upper byte (8 bits) must be written.



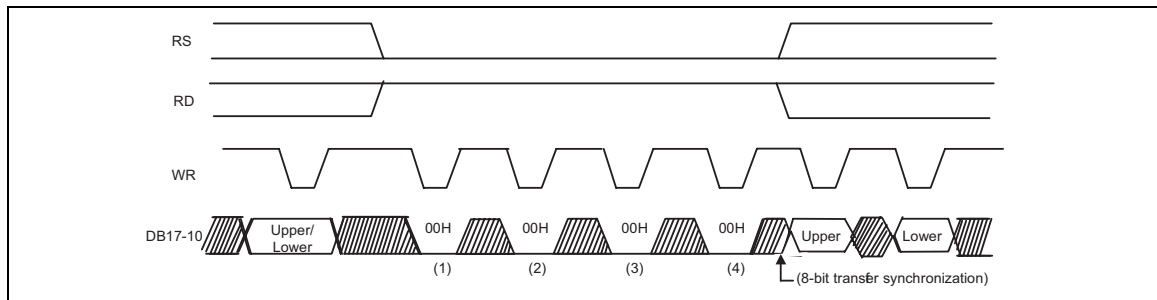
8-bit microcomputer and HD66787



Data format for 8-bit interface

Data transmission synchronization in 8-bit bus interface mode

The HD66787 supports a data transmission synchronizing function, which resets the upper/lower counter that counts the number of transmission of upper/lower 8-bit data in the 8-bit bus interface mode. When a discrepancy occurs in the transmission of upper/lower 8-bit data due to effects from noise and so on, the “00” H instruction is written 4 times consecutively to forcibly reset the upper/lower counter so that data transmission restarts with the upper 8-bit transmission. The excursion can be recovered by executing the synchronizing function periodically.



8-bit data transmission synchronization

Serial Peripheral interface (SPI)

The Serial Peripheral Interface (SPI) becomes operable by setting IM3/2/1 pins to GND/IOVcc/GND levels respectively. The SPI is available through the chip select line (CS*), serial transfer clock line (SCL), serial data input (SDI), and serial data output (SDO). In the SPI mode, the IM0/ID pin functions as ID pin. In the SPI mode, the unused DB15-2 pins must be fixed at either IOVcc or GND level.

The HD66787 recognizes the start of data transfer at the falling edge of CS* input to initiate the transfer of start byte. It recognizes the end of data transfer at the rising edge of CS* input. The HD66787 is selected when the 6-bit chip address in the start byte transferred from the transmission device and the 6-bit device identification code assigned to the HD66787 are compared and the both 6-bit data correspond. When selected, the HD66787 starts taking in the subsequent data string. The setting for the least significant bit of the identification code is made with the ID pin. The five upper bits of the identification code must be 01110. Two different chip addresses must be assigned to the HD66787 because the seventh bit of the start byte is assigned to a register select bit (RS). When RS = 0, index register write or status read is executed. When RS = 1, instruction write or RAM read/write is executed. The eighth bit of the start byte is to specify read or write (R/W bit). The data are received when the R/W bit is 0, and are transmitted when the R/W bit is 1.

In the SPI mode, the data are written to GRAM after two-byte data transmission. The data are expanded into 18 bits by adding one bit (the same data as the MSB of RB) next to the LSB of RB data.

After receiving the start byte, the HD66787 starts to transmit or receive data by byte. The data transmission adopts a format by which the MSB is first transmitted. All HD66787 instructions consist of 16 bits and they are executed internally after two bytes are transmitted with the MSB first (DB15 to 0). The data to write to RAM are expanded into 18-bit data. After the start byte is received, the first byte is always fetched as the upper eight bits of the instruction and the second byte is fetched as the lower eight bits of the instruction. The 4-byte data that are read from RAM right after the start byte are made invalid. The HD66789 reads as valid data from the 5th-byte data.

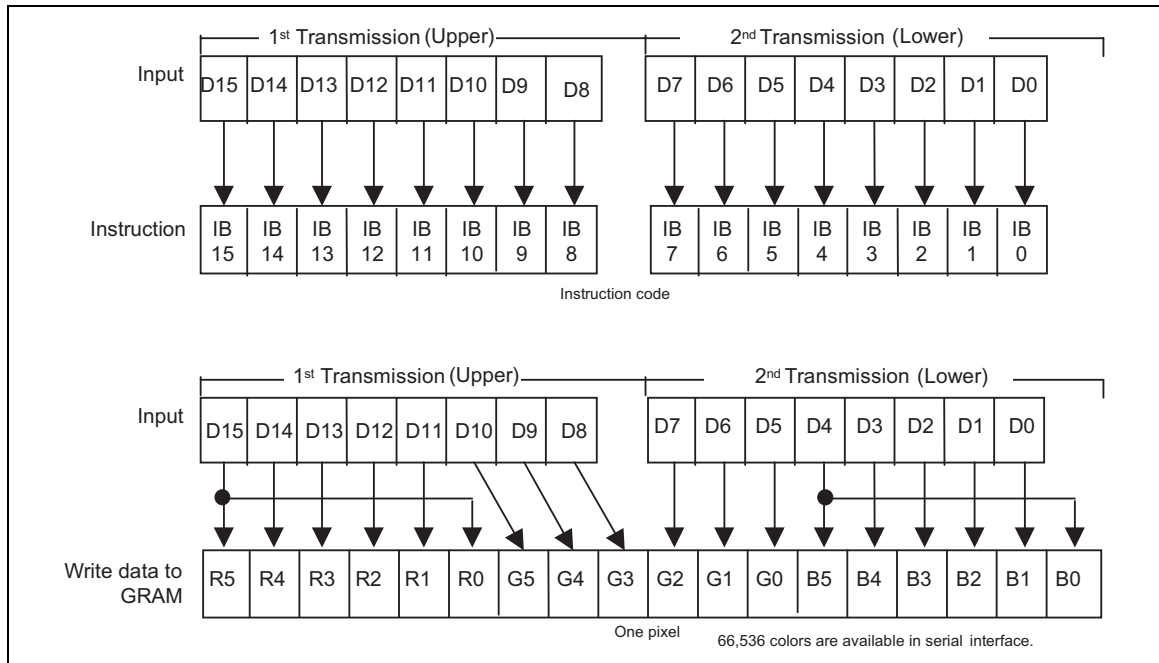
Start Byte Format

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

Note 1) ID bit is selected with the IM0/ID pin.

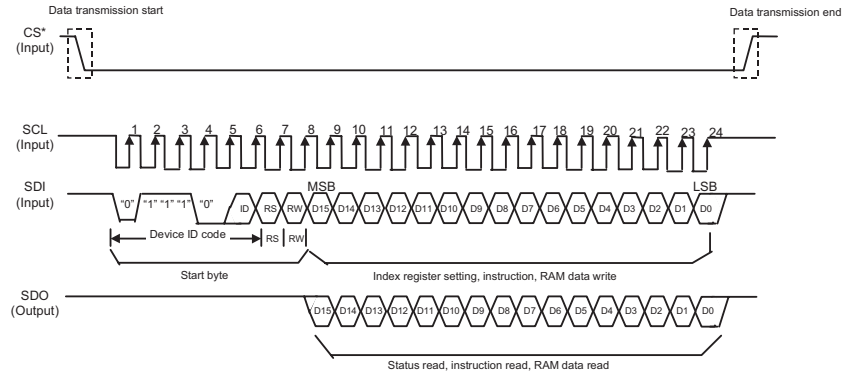
RS and R/W Bit Function

| RS | R/W | Function |
|----|-----|-------------------------------|
| 0 | 0 | Set index register |
| 0 | 1 | Read status |
| 1 | 0 | Write instruction or RAM data |
| 1 | 1 | Read instruction or RAM data |

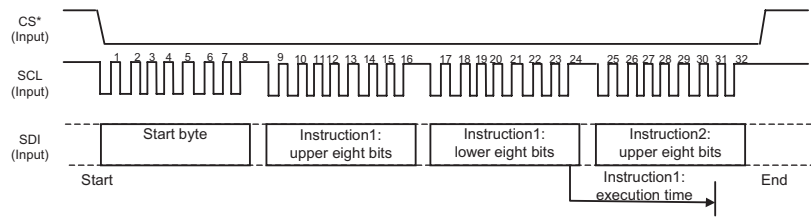


Data format for SPI

A) Basic data transmission through SPI

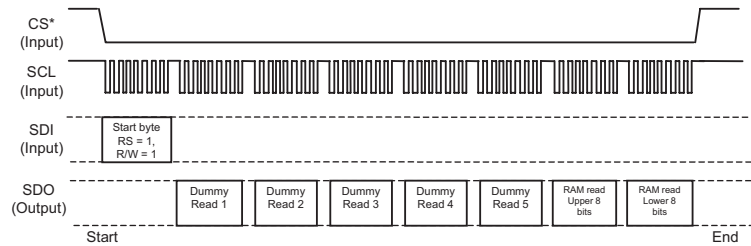


B) Consecutive data transmission through SPI



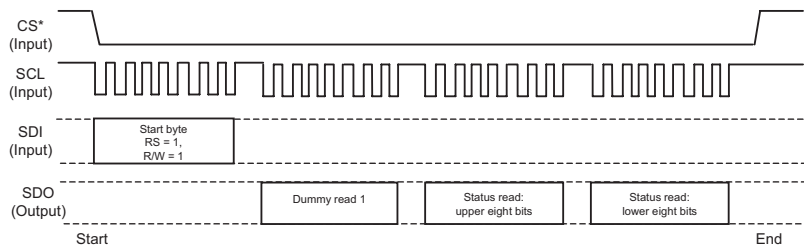
Note: The first byte after the start byte is always the upper eight bits.

C) RAM data read transmission



Note: Five bytes of invalid dummy data are read after the start byte. The valid data are read from the 6th byte.

D) Status read / instruction read

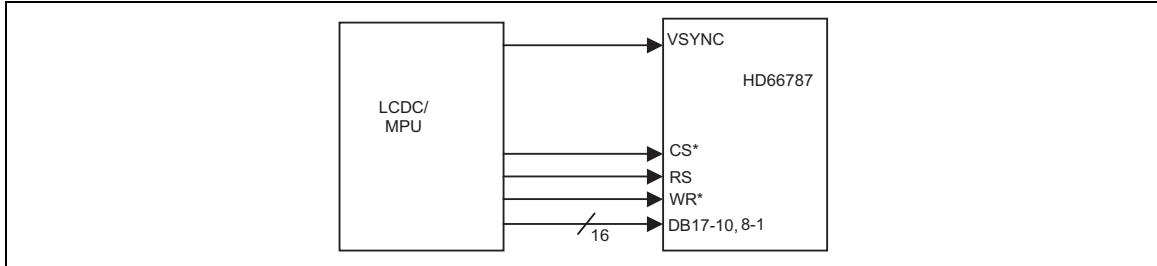


Note: One byte of invalid dummy data are read after the start byte. The valid data are read from the second byte.

Data transmission through SPI

VSYNC Interface

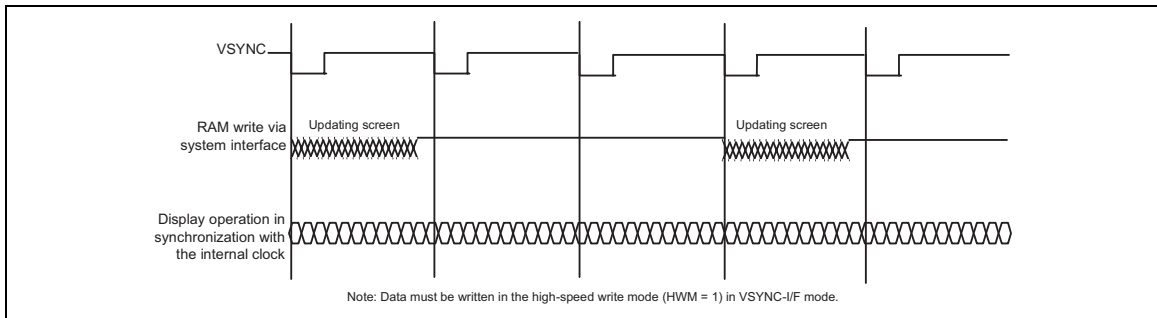
The HD66787 incorporates a VSYNC-I/F, which enables moving picture display with only a system interface and the frame-synchronizing signal (VSYNC). This interface enables moving picture display with minimum modification to a conventional system.



VYSNC interface

The VSYNC-I/F becomes operable by setting DM1-0 = 10 and RM = 0. In the VSYNC I/F mode, the internal display operations are synchronized with VSYNC. By writing data to RAM through a system interface in a speed that is higher for more than a fixed speed than the internal display operation speed, it enables moving picture display through a system interface, while preventing flickers while the screens are being updated.

Display operations are executed by the internal clock generated by the internal oscillator and VSYNC input. All display data are stored in RAM. This enables moving picture display only by transmitting data that are written over, thereby minimizing the number of data transmission while displaying moving picture. The high-speed write mode (HWM = 1) enables RAM access in high speed with low power consumption.



Moving picture data transmission through VSYNC interface

The VSYNC-I/F has limits on the minimum speed and the frequency of the internal clock for the RAM write through system interface. It requires a RAM write speed more than the result that is calculated from the following formula.

- Internal clock frequency (fosc) [Hz] = Frame frequency × (Display line (NL) + Front porch (FP) + Back porch (BP)) × 16 clocks × Fluctuation
- Minimum speed for RAM write (min.) [Hz] > $176 \times \text{Display line (NL)} / \{((\text{Back porch (BP)} + \text{Display raster-row (NL)} - \text{Margin}) \times 16 \text{ clock}) / \text{fosc}\}$

Note 1) When RAM write does not start right after the falling edge of VSYNC, the time between the falling edge of VSYNC and the start of RAM write must also be taken into account.

An example of RAM write speed and the frequency of the internal clock in the VSYNC interface mode is as follows.

[Example]

| | |
|------------------|----------------------------------|
| Display size | 176 RGB × 240 lines |
| Display line | 240 lines (NL = 11110) |
| Back/front porch | 14/2 lines (BP = 1110/FP = 0010) |
| Frame frequency | 60 Hz |

$$\text{Internal clock frequency (fosc) [Hz]} = 60 \text{ Hz} \times (240 + 2 + 14) \times 16 \text{ Clock} \times 1.1 / 0.9 = 300 \text{ kHz}$$

When calculating the internal clock frequency, possible causes of fluctuations must also be taken into consideration. The allowance for this fluctuation is ± 10 % from the center value, and the range of the frequency must be within VSYNC period.

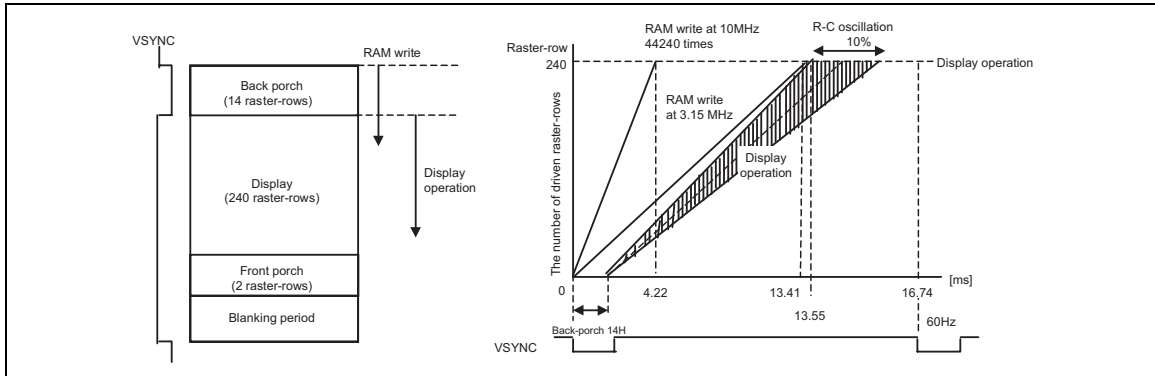
As the causes of fluctuations, the above example takes the variation in the LSI fabrication and the room temperature into account. Other possible causes of fluctuations, such as variation in the external resistors or the voltage change are not considered in the above example. It is necessary to make a setting with enough margins to include the allowances for these factors.

$$\begin{aligned} & \text{Minimum speed for RAM writing [Hz]} \\ & > 176 \times 240 / \{((14 + 240 - 2) \text{ raster-rows} \times 16 \text{ clock}) / 300 \text{ kHz}\} = 3.14 \text{ MHz} \end{aligned}$$

In this case, RAM write is performed in synchronization with the falling edge of VSYNC.

When the data for one frame are written to RAM completely, there must be more than 2 raster-rows of margin before the raster-row starts to drive for the next frame.

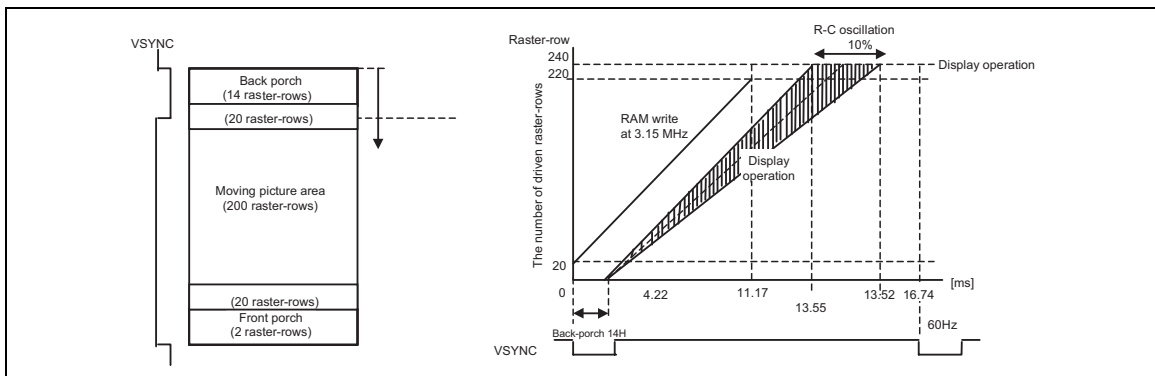
By writing data to RAM on the falling edge of VSYNC at the speed of 3.14 MHz or more, the data for the whole screen on RAM are overwritten before the display operation starts. Accordingly, the flicker due to updating moving picture data can be avoided while displaying a moving picture.



Operation through VSYNC interface

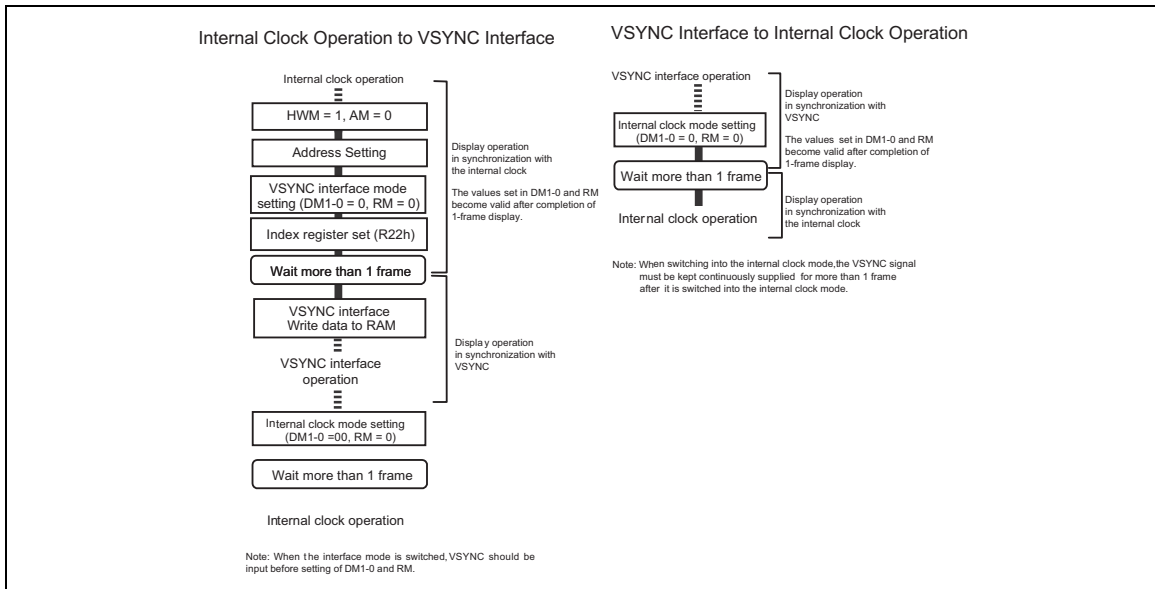
Notes to the VSYNC interface

1. The aforementioned example of calculation is just a result of calculation. In the actual settings, causes for the fluctuations such as internal clocks should be taken into consideration. It is necessary to make a setting for RAM write speed with enough margins.
2. The aforementioned example of calculation is the value in case of writing over the entire screen. Limiting the area for the moving picture display will create more margins for the RAM write speed.



Limiting moving picture display area

3. A front porch period continues after the completion of 1 frame display and until the next input of VSYNC.
4. The transition between the internal clock operation mode (DM1-0 = 00) and the VSYNC interface mode becomes effective after displaying one frame made during instruction setting.
5. In the VSYNC interface mode, the partial display, vertical scroll, and interlaced drive functions are not available.
6. In the VSYNC interface mode, set AM to 0 to transmit display data in the aforementioned method.
7. In the VSYNC interface mode, write display data to RAM in the high speed write mode (HWM = 1)



Transition flow between VSYNC and internal clock operation modes

External Display Interface

The following interfaces are available as the external display interface (RGB interface). The interface is selected by setting RIM1-0 bits. RAM is accessible through the RGB interface.

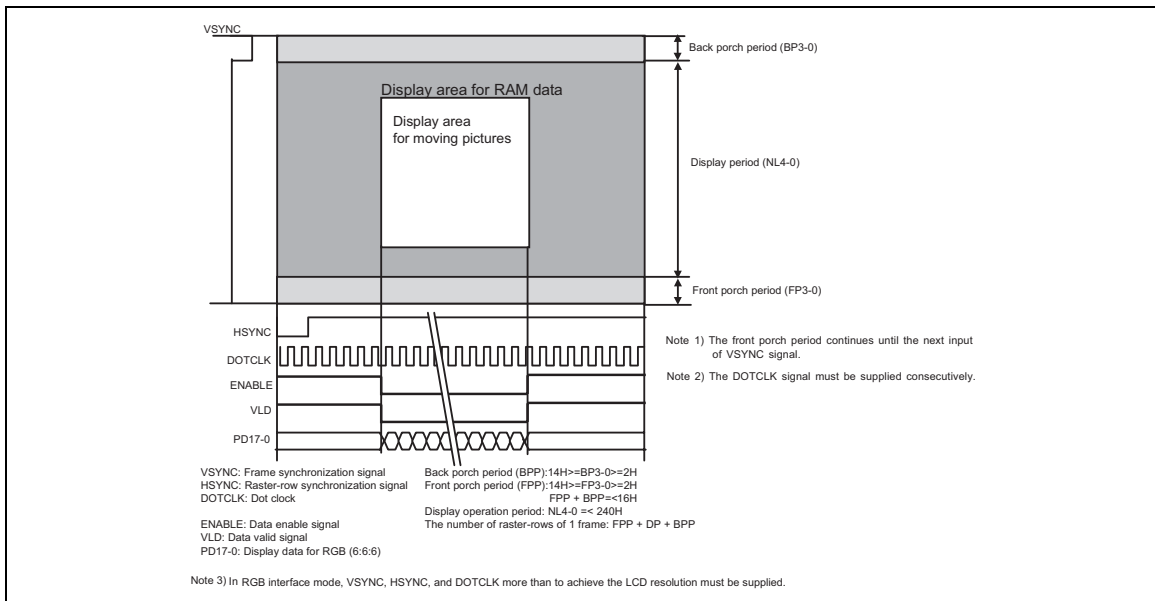
RIM bits setting and RGB interface

| RIM1 | RIM0 | RGB Interface | PD Pin |
|------|------|----------------------|---------------|
| 0 | 0 | 18-bit RGB interface | PD17-0 |
| 0 | 1 | 16-bit RGB interface | PD17-13, 11-1 |
| 1 | 0 | 6-bit RGB interface | PD17-12 |
| 1 | 1 | Setting disabled | |

Note 1) The use of multiple interfaces simultaneously is not possible.

RGB interface

Through the RGB-I/F, the display operation is performed in synchronization with VSYNC, HSYNC, and DOTCLK. The RGB interface enables data transmission with low power consumption by overwriting the area that needs update in high-speed write mode in combination with the window address function. The front and back porches must be set before and after the display period.



RGB interface

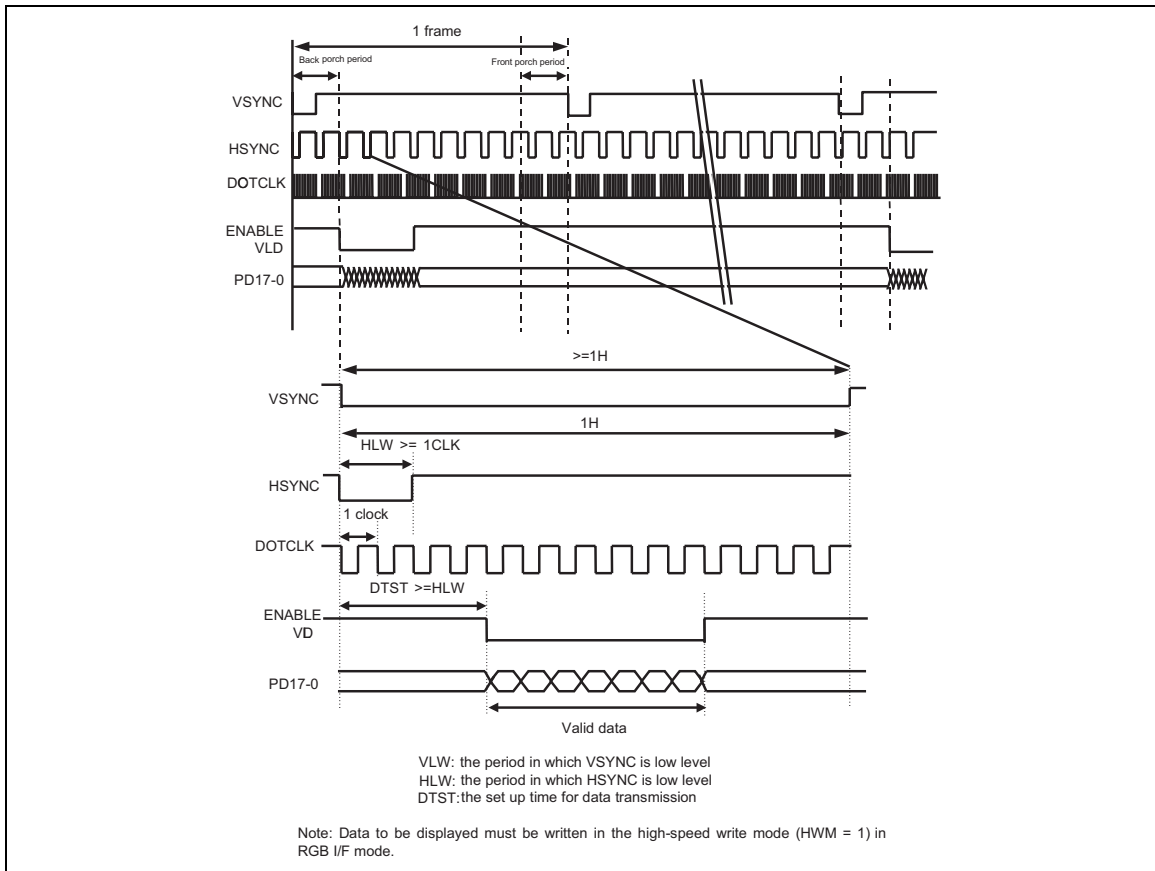
VLD and ENABLE signals

The relationship with the VLD and ENABLE signals is as follows. With the ENABLE signal, the addresses are not updated during data write, while with the VLD signal, the addresses are updated during data write when the ENABLE is “Low”. The polarity of the ENABLE signal is inverted by the setting of EPL bit.

| EPL | ENABLE | VLD | RAM Write | RAM Address |
|-----|--------|-----|-----------|-------------|
| 0 | 0 | 0 | Valid | Updated |
| 0 | 0 | 1 | Invalid | Updated |
| 0 | 1 | * | Invalid | Unchanged |
| 1 | 0 | * | Invalid | Unchanged |
| 1 | 1 | 0 | Valid | Updated |
| 1 | 1 | 1 | Invalid | Updated |

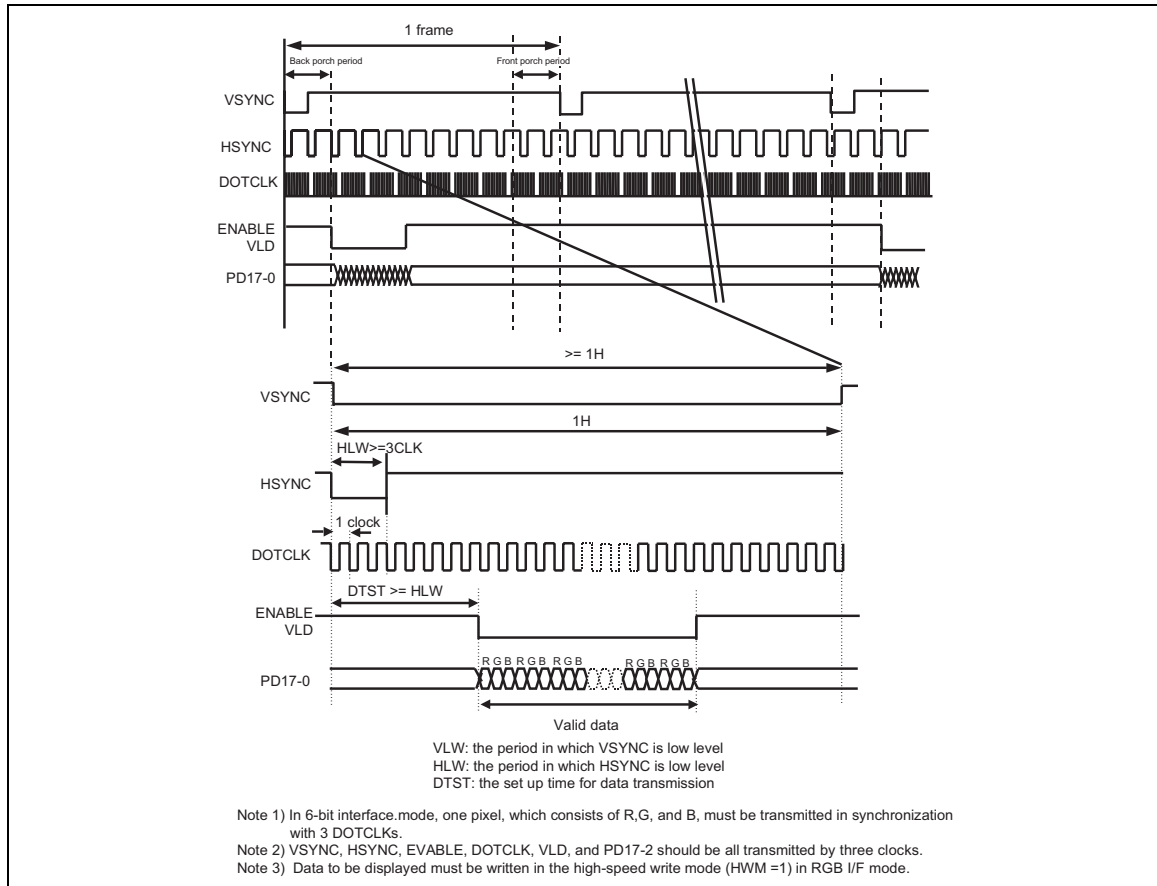
RGB interface timing

The timing chart of 16/18-bit RGB interfaces is as follows.



16-/18-bit RGB Interface Timing

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



6-bit RGB Interface Timing

Moving picture display

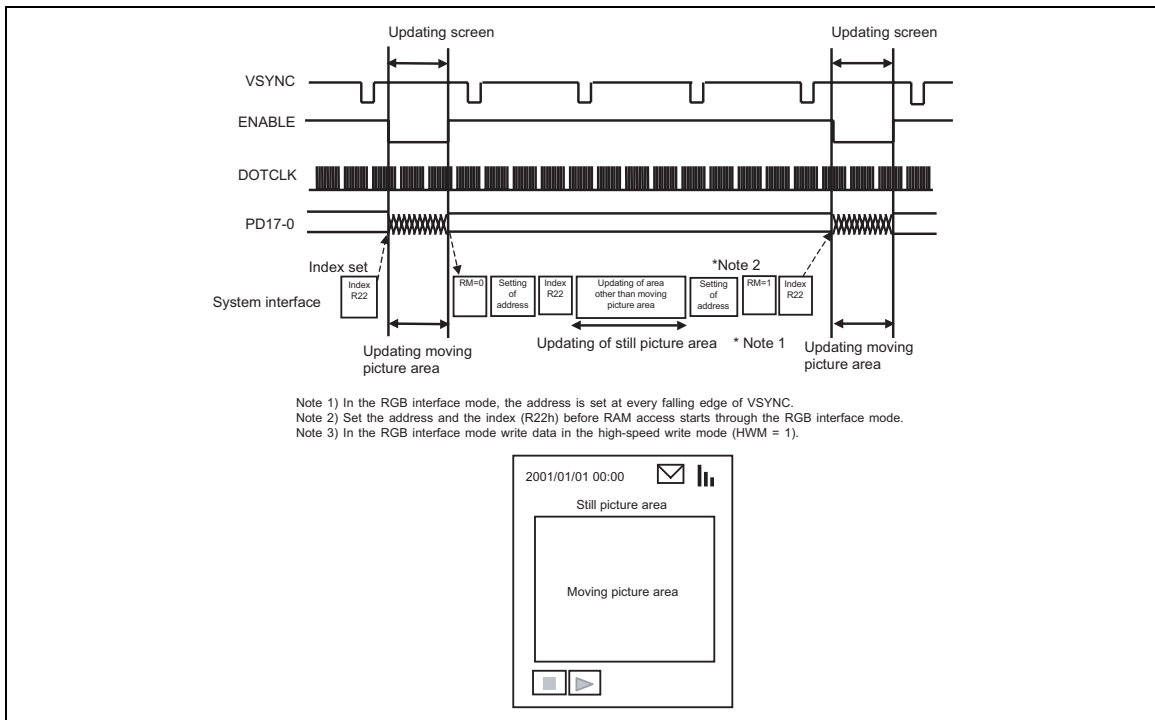
The HD66787 incorporates the RGB interface to display moving pictures and RAM to store display data, which provides the following merits in displaying moving pictures.

- The window address function enables the transfer of only the data for the moving picture area.
- The high-speed write modes enables high-speed access to RAM with low power consumption
- Only transmitting the data that are written over the moving picture area.
- By reducing the amount of data transmission, the power consumption of the whole system is reduced.
- In combination with a system interface the still picture area, such as an icon, can be updated while displaying moving pictures.

RAM access through system interface in RGB-I/F mode

RAM is accessible through a system interface in the RGB-I/F mode. In the RGB interface mode, data are being written to RAM in synchronization with the DOTCLK input while the ENABLE is “Low”. When writing data to RAM through the system interface, it is necessary to set ENABLE to “High” to stop data write through the RGB-I/F. Setting RM = 0 allows RAM access through the system interface. When reverting to the RGB interface mode, wait a write/read bus cycle. Then, set RM = 1 and the index to R22h to start RAM access through the RGB-I/F. When the RAM writes through the RGB and system interface conflicts, it is not guaranteed that the data are properly written to RAM.

The following is an example of moving picture display through the RGB-I/F and updating still picture area through the system interface.

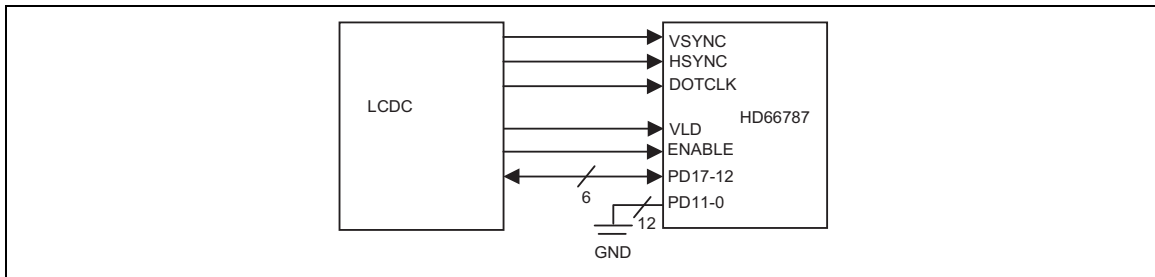


Updating Still Picture Area during Displaying Moving Picture

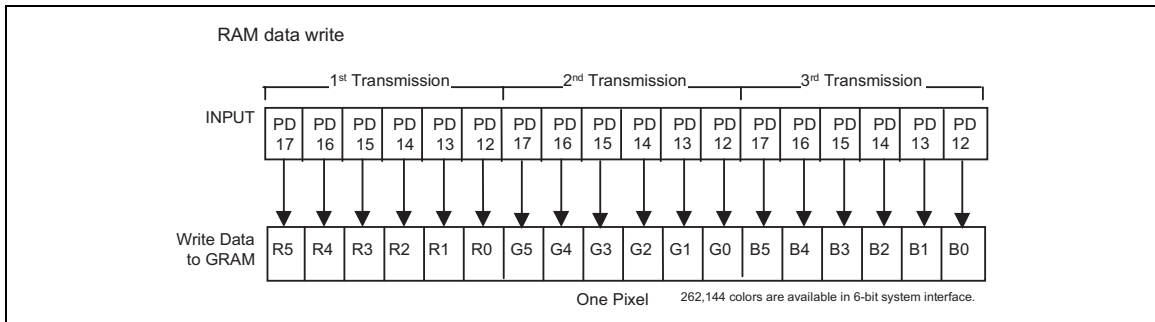
6-bit RGB interface

The 6-bit RGB interface is selected by setting RIM1-0 bits to 10. The display operation is synchronized with VSYNC, HSYNC, and DOTCLK signals. Display data are transmitted to RAM in synchronization with the display operation through 6-bit RGB data bus (PD17-12) according to data valid signal (VLD), and the data enable signal (ENABLE). Unused pins (PD11 to 0) must be fixed to either IOVcc or GND level.

The instructions are set only through a system interface.



6-bit RGB interface

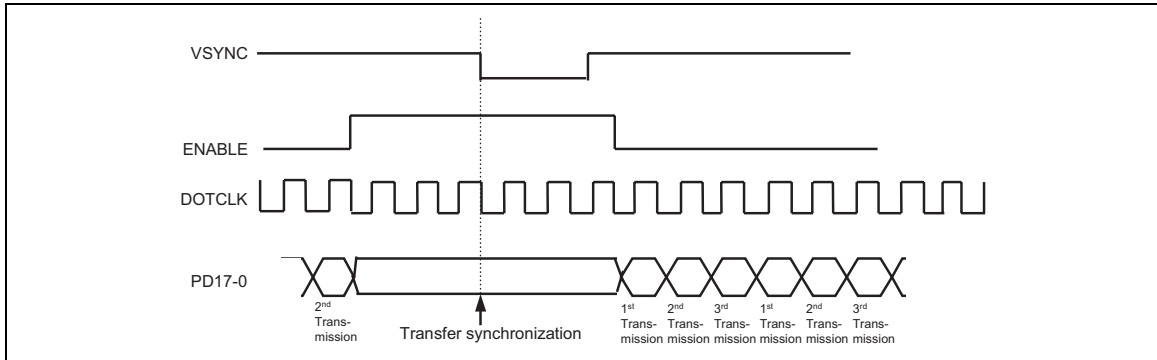


Data format for 6-bit interface

Data transmission synchronization in 6-bit RGB interface mode

The HD66787 incorporates a transmission counter to count the first, second, third data transmissions in the 6-bit RGB interface mode. The transmission counter is reset to the first transmission on the falling edge of VSYNC. When a discrepancy occurs in the transmission of first, second and third data, the counter is reset to the first data transmission at the start of each frame (on the falling edge of VSYNC) and the data transmission restarts in the correct order from the next frame. In case of displaying moving pictures, which requires consecutive data transfer, this function minimizes the effect from the discrepancy in the data transmission and makes it easy to return to the normal display.

The internal display operation is executed by pixel. Note that each DOTCLK input must correspond to a pixel. Otherwise data transmission discrepancies will occur and affect the displays of the current and ensuing frames.

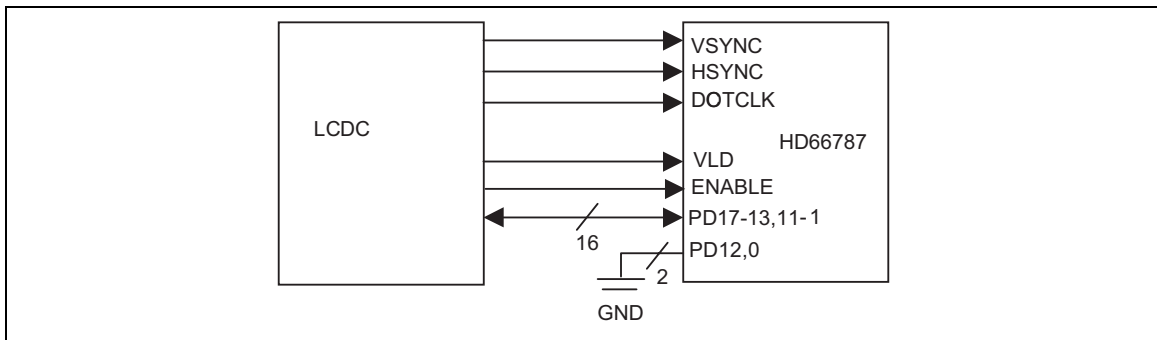


6-bit data transmission synchronization

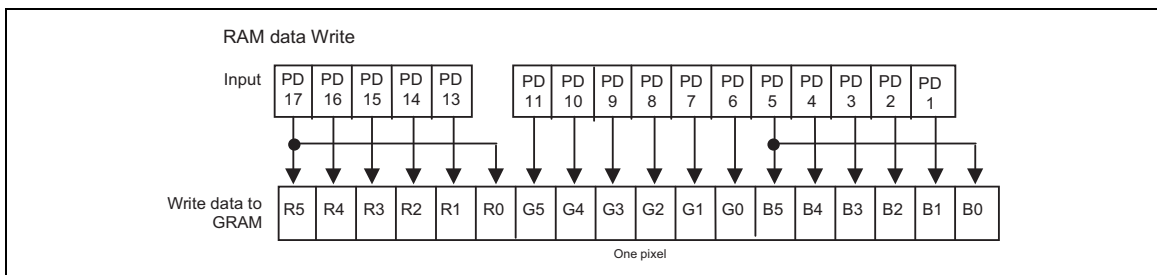
16-bit RGB interface

The 16-bit RGB interface is selected by setting RIM1-0 bits to 01. The display operation is synchronized with VSYNC, HSYNC, and DOTCLK signals. Display data are transmitted to RAM in synchronization with the display operation through 16-bit RGB data bus (PD17-13, 11-1) according to the data valid signal (VLD), and the data enable signal (ENABLE).

The instructions are set only through system interface.



16-bit RGB interface

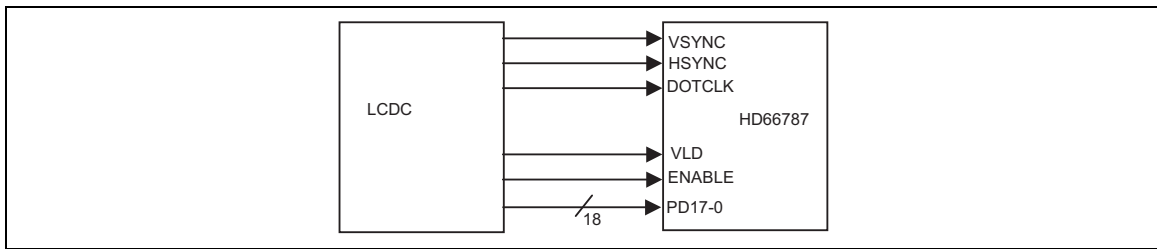


Data format for 16-bit interface

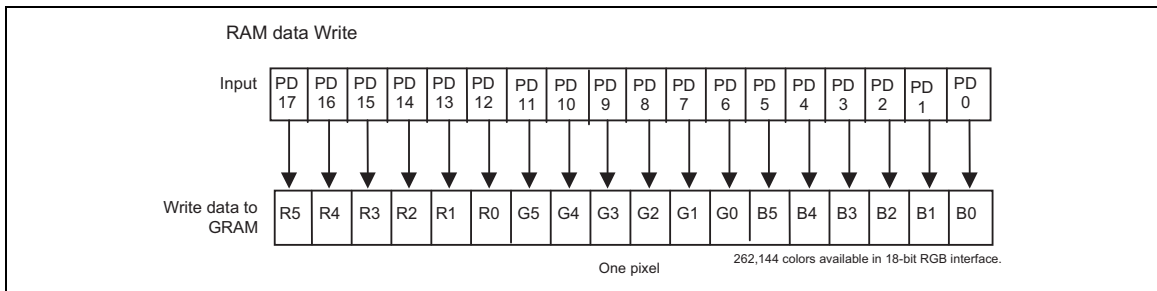
18-bit RGB interface

The 18-bit RGB interface is selected by setting RIM1-0 bits to 00. The display operation is synchronized with VSYNC, HSYNC, and DOTCLK signals. Display data are transmitted to RAM in synchronization with the display operation through 18-bit RGB data bus (PD17-0) according to the data valid signal (VLD), and the data enable signal (ENABLE).

The instructions are set only through a system interface.



18-bit RGB interface



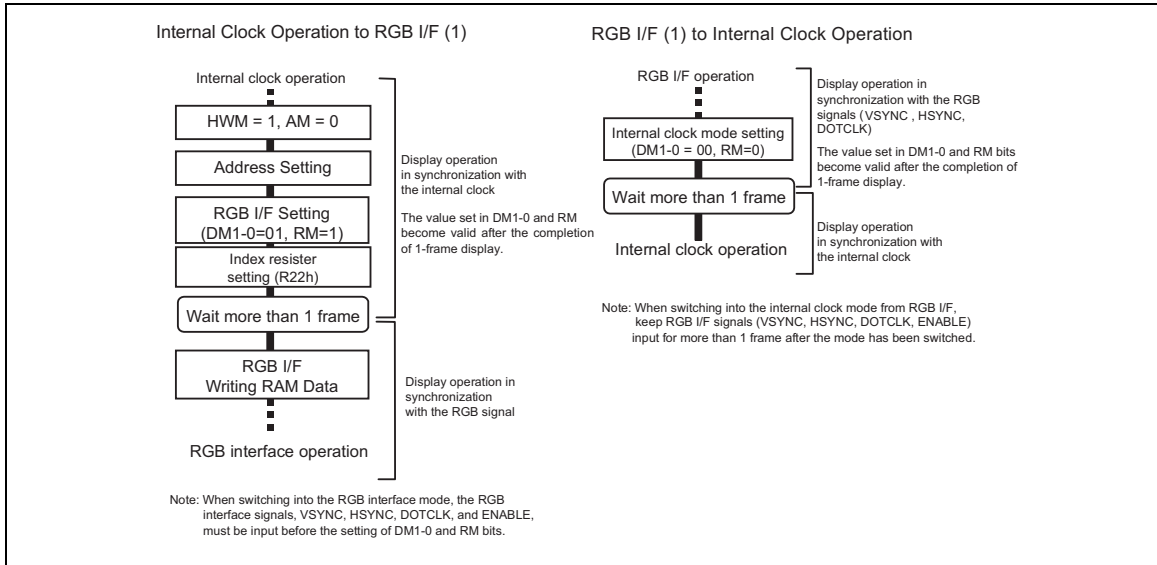
Data format for 18-bit interface

Notes to the external display interface

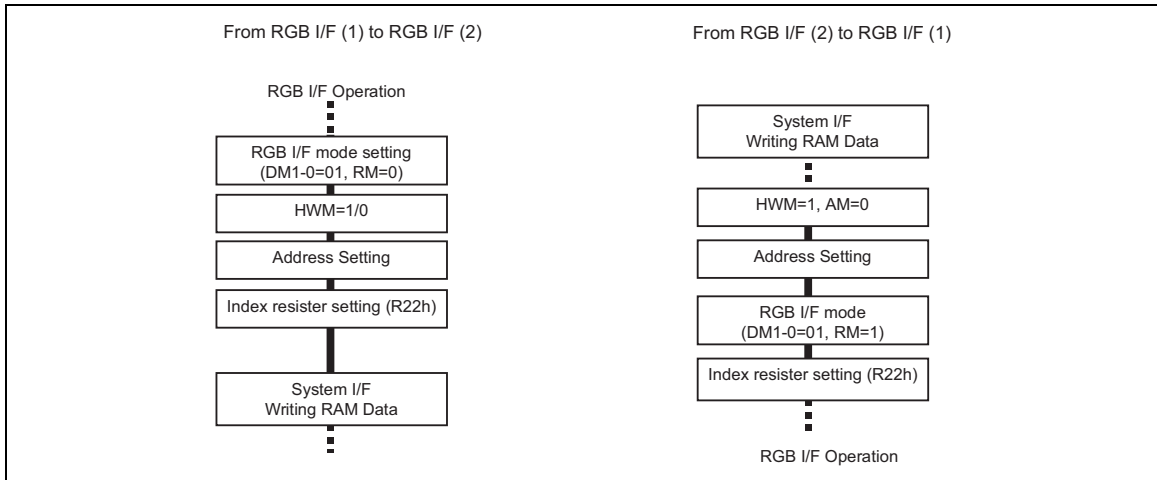
1. While an external display interface is selected, the following functions are not available.

| Function | External Display Interface | Internal Display Operation |
|-----------------------------|-----------------------------------|-----------------------------------|
| Partial display | Not available | Available |
| Scroll function | Not available | Available |
| Graphics operation function | Not available | Available |

2. The VSYNC, HSYNC, and DOTCLK signals must be supplied consecutively during display operation through the RGB-I/F.
3. When setting NO1-0, SDT1-0, and EQ1-0 bits in the RGB-I/F mode, the reference clock is the DOTCLK, not the internal operation clock.
4. In the 6-bit RGB-I/F mode, RGB (pixels) data are transmitted by three clocks. The data transmission, therefore, should be made by RGB.
5. In the 6-bit RGB-I/F mode, the interface signals, VSYNC, HSYNC, DOTCL, ENABLE, VLD, and PD17-0, should be set in RGB (pixels) in convenience for transmitting RGB pixels.
6. The transitions between the internal operation mode and external display interface should be made according to the mode switching sequence below.
7. In the RGB-I/F mode, the front porch period continues after displaying one frame data until the next VSYNC signal input.
8. In the RGB-I/F mode, the data must be written in the high-speed write mode (HWM = 1).
9. In the RGB-I/F mode, the address is set every frame on the falling edge of VSYNC.



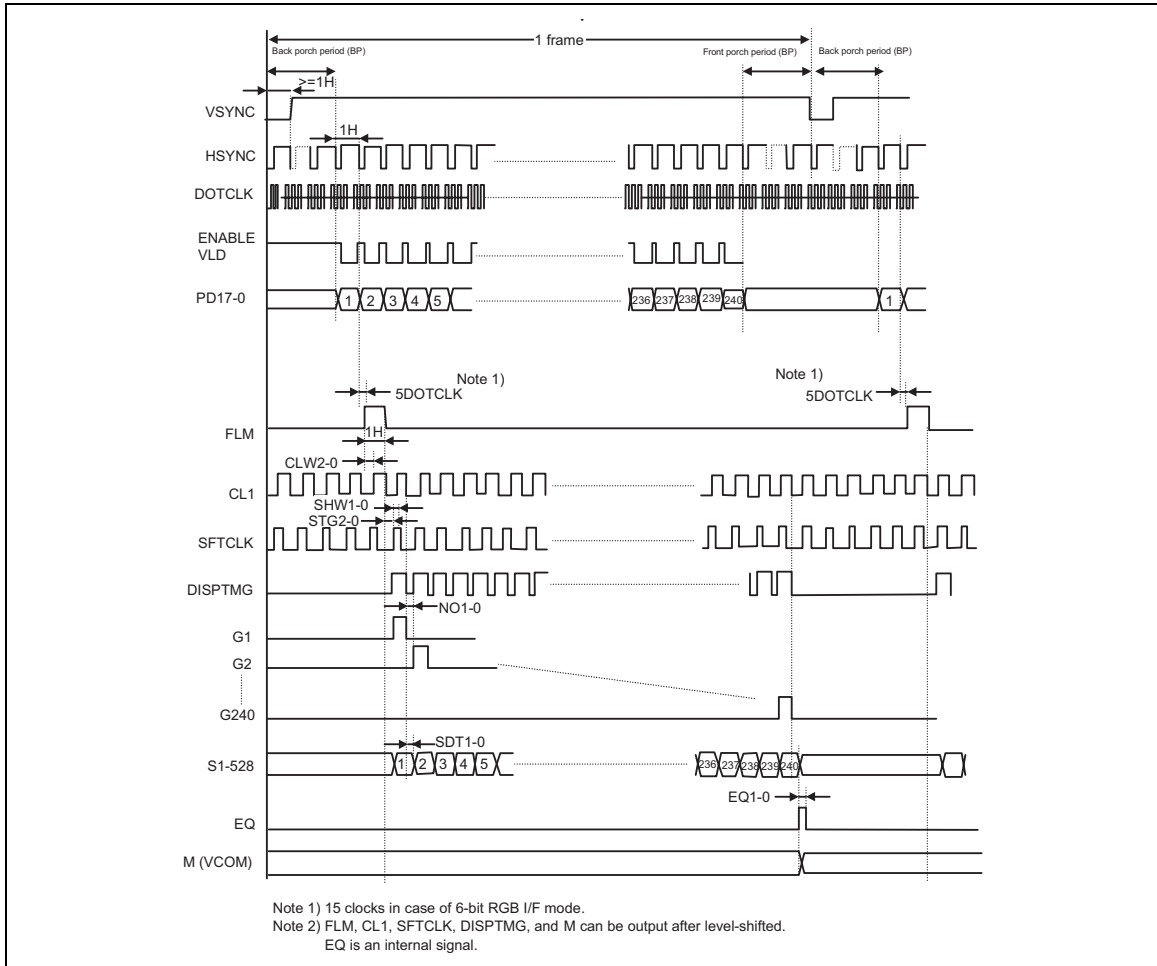
Transition between the Internal Clock Operation Mode and RGB Interface Mode



RAM data write sequence through system interface in RGB-I/F mode

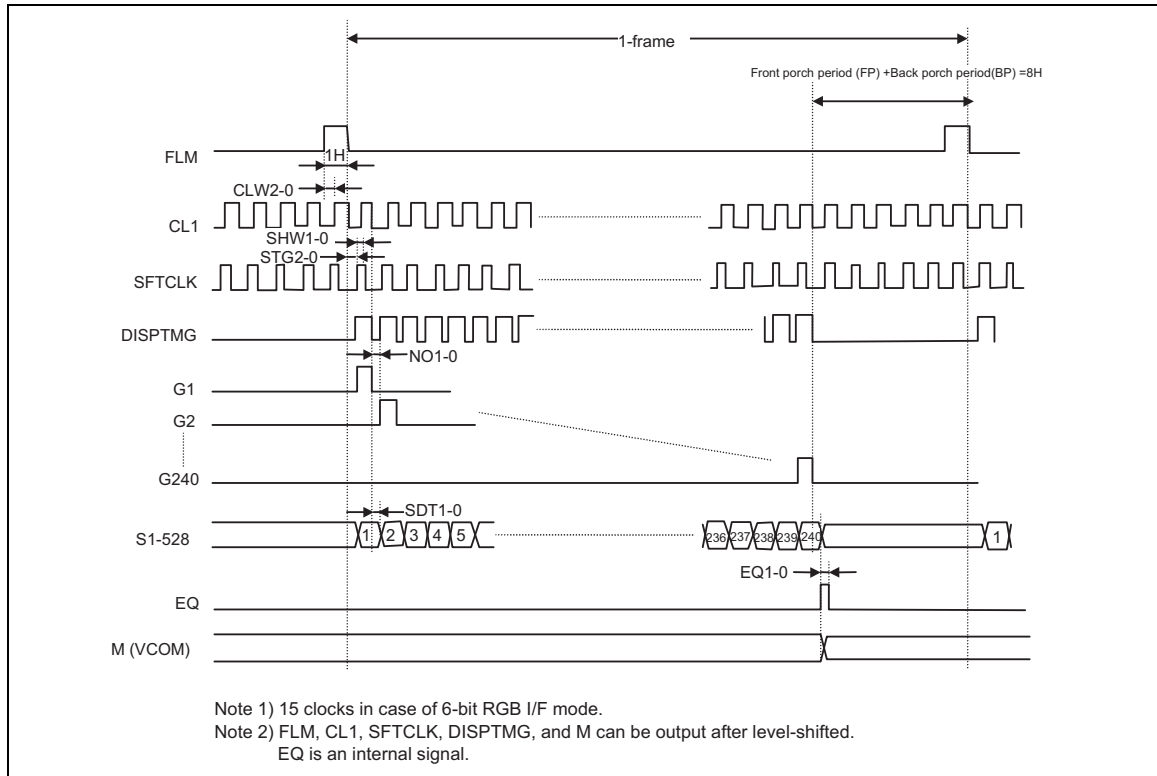
Timing Interfacing with Liquid Crystal Panel Signals

The relationship between RGB I/F signals and the liquid crystal panel signals in the RGB I/F mode is as follows (TG0 = "0").



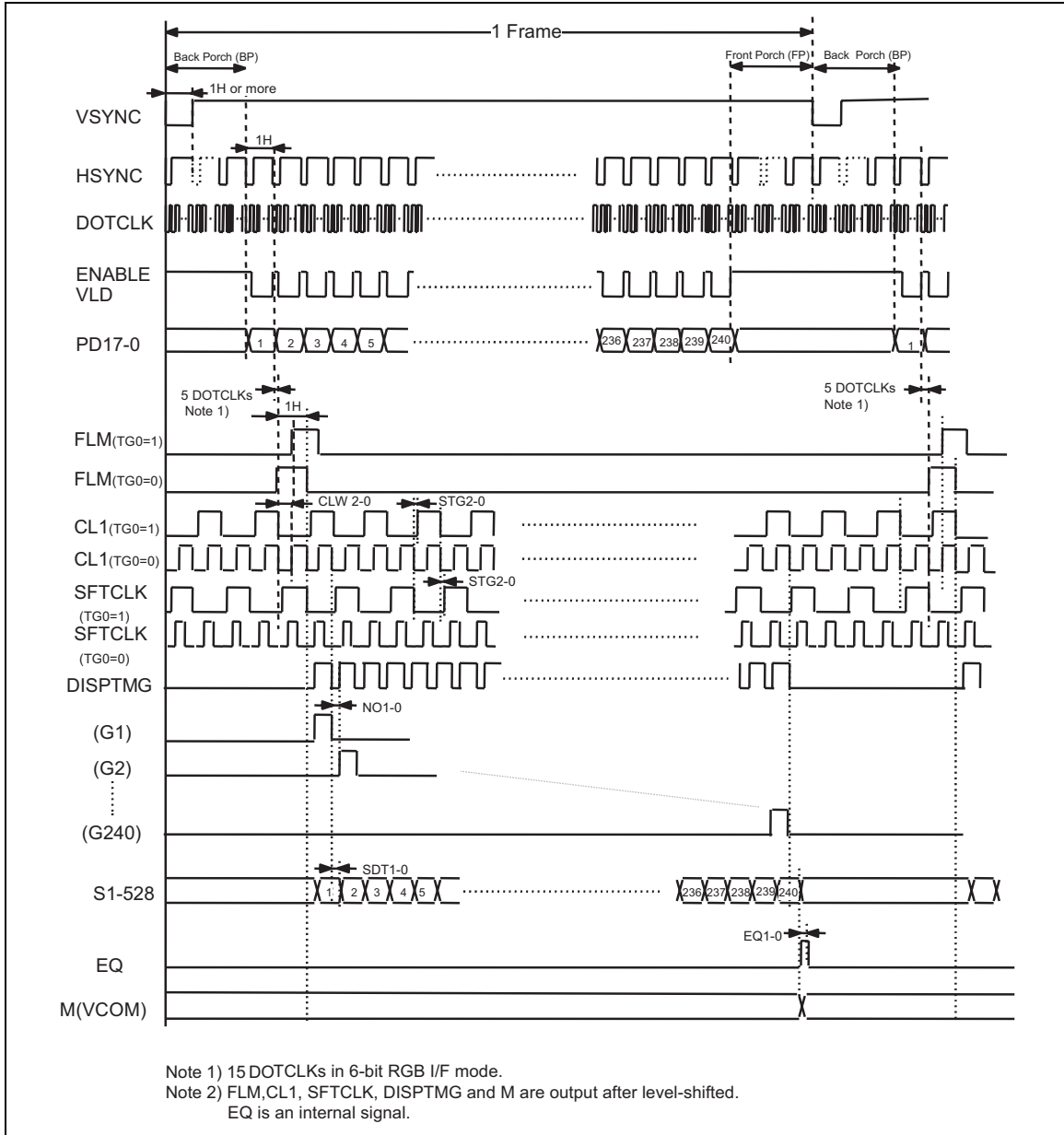
Relationship between RGB I/F signal and the liquid crystal panel signal (TG0 = "0")

The timing interfacing with the liquid crystal panel signals in the internal clock operation mode is as follows (TG0 = "0").



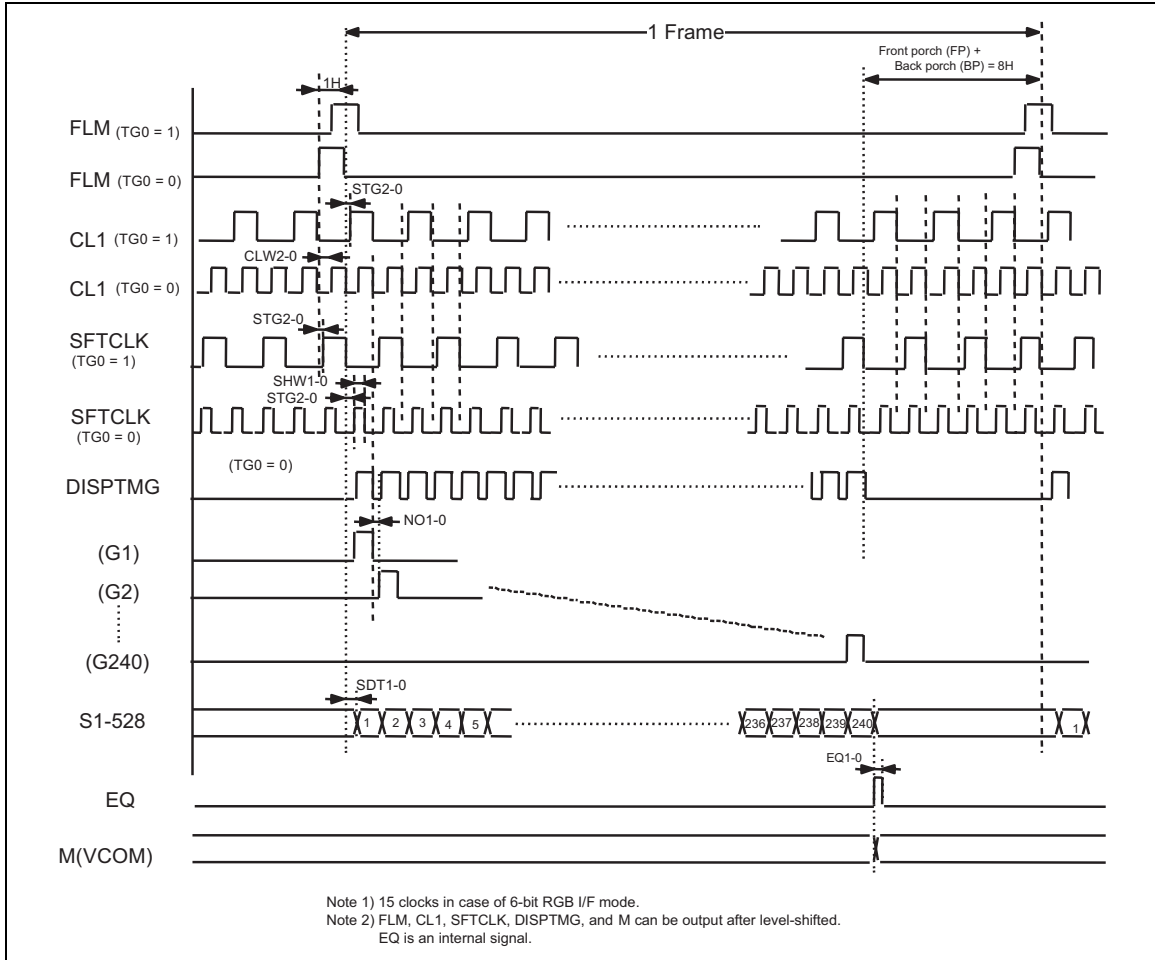
Interfacing with the liquid crystal panel signals in the internal clock operation mode (TG0 = "0")

The timing interfacing with the liquid crystal panel signals in RGB interface mode is as follows (TG0 = "1").



Interfacing with the liquid crystal panel signals in RGB interface mode (TG0 = "1")

The timing interfacing with the liquid crystal panel signals in the internal clock operation mode is as follows (TG0 = "1").



Interfacing with the liquid crystal panel signals in the internal clock operation mode (TG0 = "1")

Register settings**CL1 signal: "Low" width**

| CLW 2 | CLW 1 | CLW 0 | CL1 signal : pulse width during "Low" | |
|----------|----------|----------|--|---|
| | | | internal operation (synchronized with the internal operating clock) | RGB interface operation (synchronized with DOTCLK) |
| 0 | 0 | 0 | 1 clock | 8 clocks |
| 0 | 0 | 1 | 2 clocks | 16 clocks |
| 0 | 1 | 0 | 3 clocks | 24 clocks |
| 0 | 1 | 1 | 4 clocks | 32 clocks |
| 1 | 0 | 0 | 5 clocks | 40 clocks |
| 1 | 0 | 1 | 6 clocks | 48 clocks |
| 1 | 1 | 0 | 7 clocks | 56 clocks |
| 1 | 1 | 1 | 8 clocks | 64 clocks |

Note 1) The number of clocks is counted from the falling edge of CL1 signal.

EQ signal: "High" width

| EQ 1 | EQ 0 | EQ signal : pulse width during "High" | |
|---------|---------|--|---|
| | | internal operation (synchronized with the internal operating clock) | RGB interface operation (synchronized with DOTCLK) |
| 0 | 0 | No equalize | No equalize |
| 0 | 1 | 1 clock | 8 clocks |
| 1 | 0 | 2 clocks | 16 clocks |
| 1 | 1 | 3 clocks | 24 clocks |

Source output delay

| STD 1 | STD 0 | Source output delay | |
|----------|----------|--|---|
| | | internal operation (synchronized with the internal operating clock) | RGB interface operation (synchronized with DOTCLK) |
| 0 | 0 | 1 clock | 8 clocks |
| 0 | 1 | 2 clocks | 16 clocks |
| 1 | 0 | 3 clocks | 24 clocks |
| 1 | 1 | 4 clocks | 32 clocks |

Note 1) The amount of source output delay is measured from the falling edge of CL1 signal.

Gate output non-overlap

| STD 1 | STD 0 | Gate output non-overlap | |
|----------|----------|--|---|
| | | internal operation (synchronized with the internal operating clock) | RGB interface operation (synchronized with DOTCLK) |
| 0 | 0 | 0 clock | 0 clocks |
| 0 | 1 | 4 clocks | 32 clocks |
| 1 | 0 | 6 clocks | 48 clocks |
| 1 | 1 | 8 clocks | 64 clocks |

Note 1) The amount of gate output non-overlap is measured from the falling edge of CL1 signal.

SFTCLK signal: pulse output position

| STG 2 | STG 1 | STG 0 | SFTCLK signal : pulse output position | |
|----------|----------|----------|--|---|
| | | | internal operation (synchronized with the internal operating clock) | RGB interface operation (synchronized with DOTCLK) |
| 0 | 0 | 0 | 0 clock | 0 clock |
| 0 | 0 | 1 | 1 clock | 8 clocks |
| 0 | 1 | 0 | 2 clocks | 16 clocks |
| 0 | 1 | 1 | 3 clocks | 24 clocks |
| 1 | 0 | 0 | 4 clocks | 32 clocks |
| 1 | 0 | 1 | 5 clocks | 40 clocks |
| 1 | 1 | 0 | 6 clocks | 48 clocks |
| 1 | 1 | 1 | 7 clocks | 56 clocks |

Note 1) The number of clocks is counted from the falling edge of the CLT signal.

SFTCLK signal: pulse width during "High"

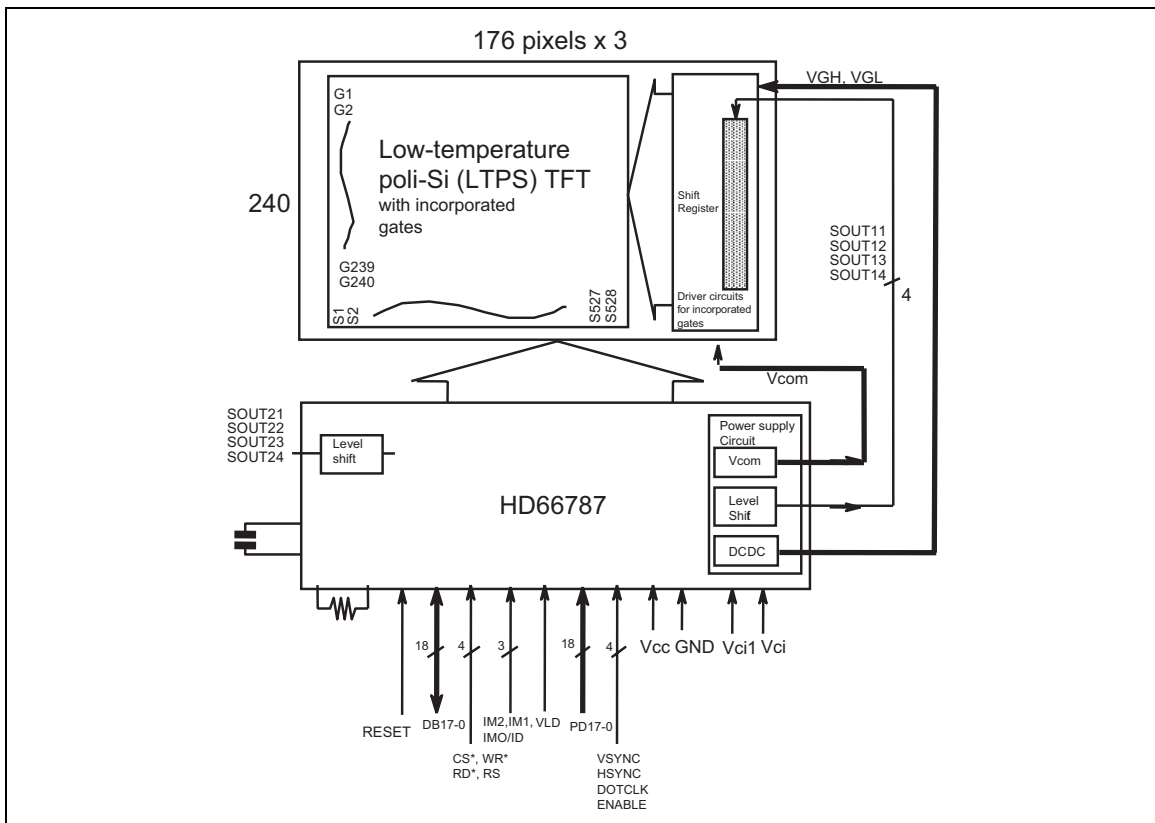
| SHW 1 | SHW 0 | SFTCLK signal : pulse width during "High" | |
|----------|----------|--|---|
| | | internal operation (synchronized with the internal operating clock) | RGB interface operation (synchronized with DOTCLK) |
| 0 | 0 | 1 clock | 8 clocks |
| 0 | 1 | 2 clocks | 16 clocks |
| 1 | 0 | 3 clocks | 24 clocks |
| 1 | 1 | 4 clocks | 32 clocks |

Low-temperature poli-Si TFT Panel Control

HD66787 outputs timing signals (FLM, CL1, SFTCLK) for controlling low-temperature poli-Si TFT (LTPS-TFT) panels with incorporated gates. By level-shifting the voltage of FLM, CL1, SFTCLK, and DISPTMG, the LTPS-TFT panel with incorporated gates becomes easily controllable.

■ Source drivers (HD66787)

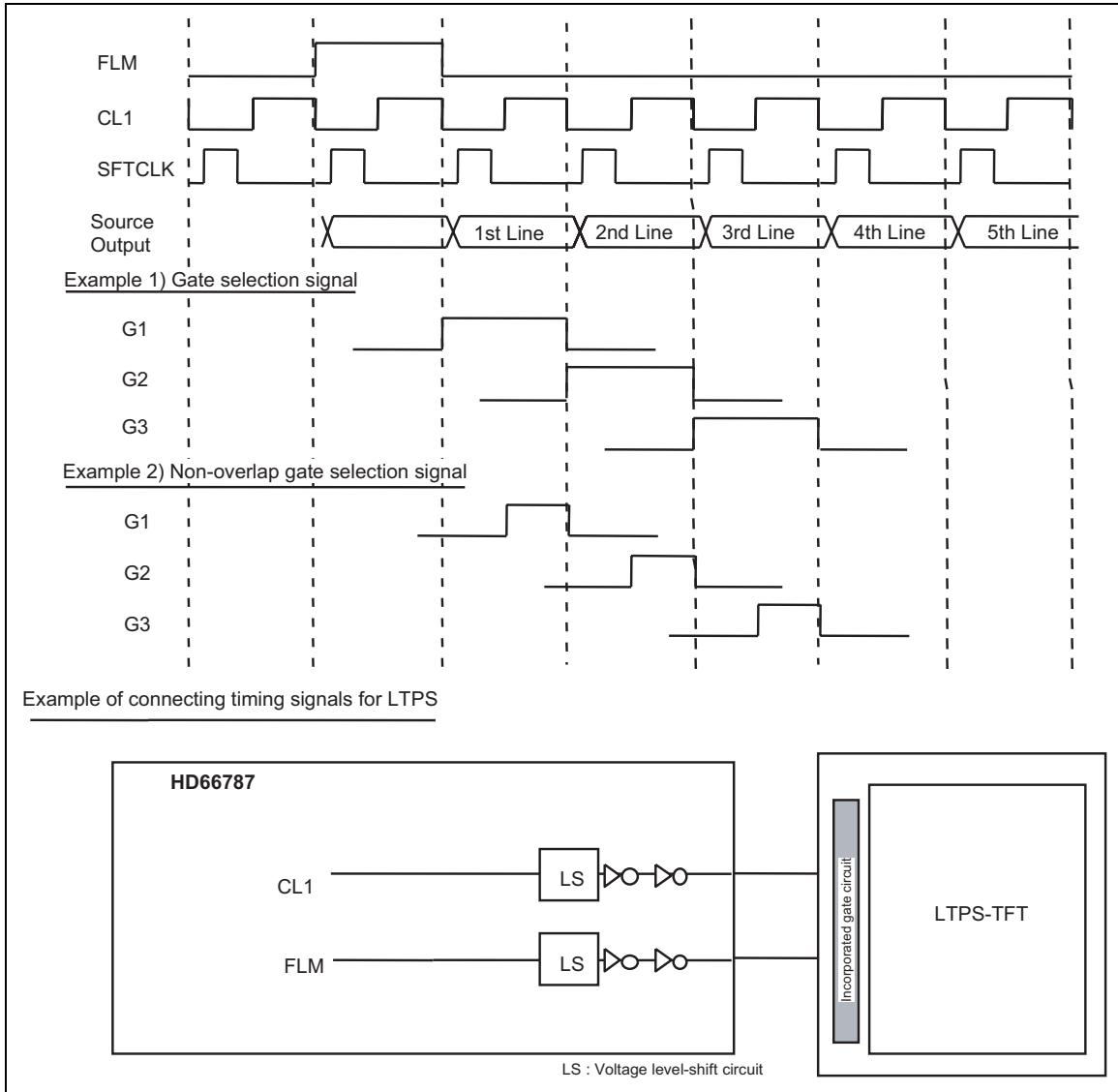
- Output control timing signals (internal signal)
 - FLM (Frame heading pulse)
 - CL1 (Line cycle signal): “Low” width variable with CLW2-0 bits
 - SFTCLK (Line cycle signal): output timing variable with STG2-0, SHW1-0 bits
- Level-shift output
 - VGH ~ VGL amplitude
- ports for LTPS
 - SOUT 11, SOUT 12, SOUT 13, SOUT 14, SOUT 21, SOUT 22, SOUT 23, SOUT 24



System configuration

■ Output timing (HD66787)

HD66787 outputs timing signals (FLM, CL1, SFTCLK) for controlling low-temperature poli-Si TFT (LTPS-TFT) panels with incorporated gates. The output timing of CL1 can be adjusted by instructions for controlling LTPS-TFT interface. Set an optimum timing for the configuration of gate circuits incorporated in the LTPS-TFT panel in use.



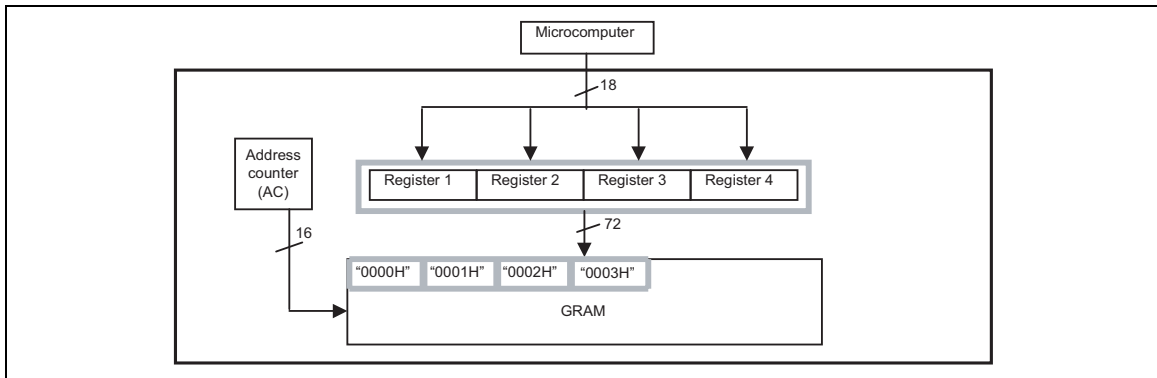
LTPS-TFT control

Note 1) Some gate circuit configuration incorporated in the LTPS-TFT may not allow the use of certain functions with HD66787.

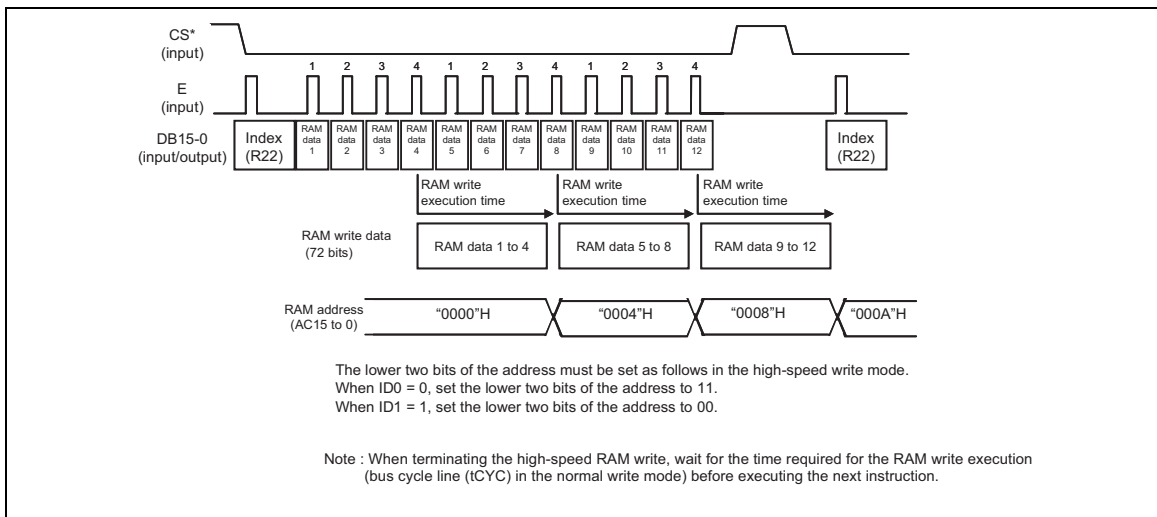
High-Speed Burst RAM Write Function

The HD66787 incorporates high-speed burst RAM-write function, which writes data to RAM in one-fourth the access time required for a standard RAM-write operation. This function is especially useful for applications which require the high-speed rewrite of the display data such as display of colored moving picture and so on.

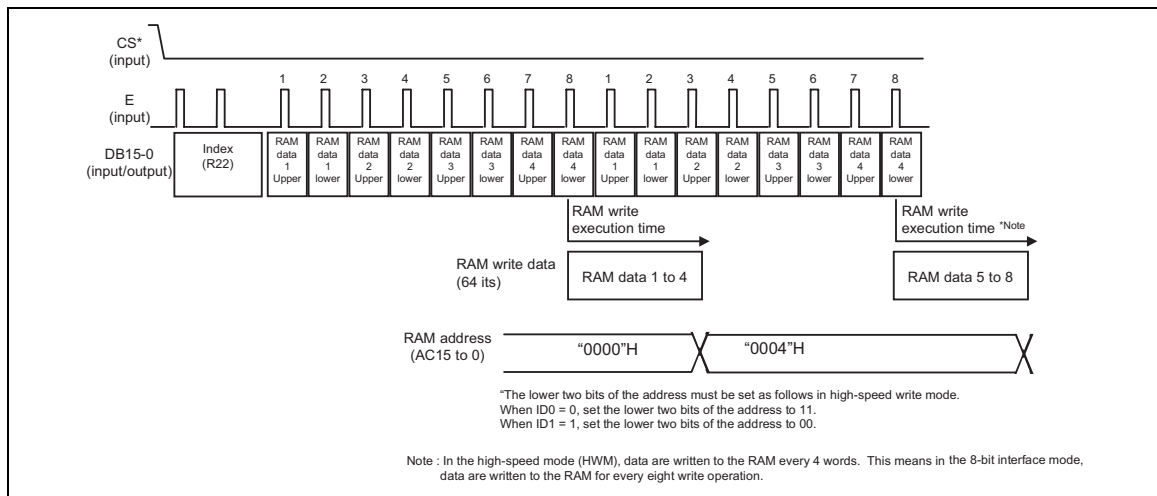
In the high-speed RAM write mode (HWM), data to write to RAM is temporarily stored to the internal register of HD66787. The data storage in the register is executed by word. When the data storage operation is executed 4 times, all data stored in the register are written to RAM at once. While the data is being written from the register to RAM, another set of data is being written to the register. This function enables high-speed and consecutive RAM write, which are required in displaying moving pictures and so on.



Operational flow of High-Speed Burst RAM Write



High-Speed Consecutive Write to RAM



Operation of High-Speed Consecutive Writing to RAM (8-Bit Interface)

Notes to the high-speed RAM write mode

- The logical/compare operations are not available.
- The RAM write operation is executed every four words. Set the lower 2 bits of the addresses as follows when setting addresses.
 - *When ID0=0, the lower two bits in the address must be set to 11 before RAM write.
 - *When ID0=1, the lower two bits in the address must be set to 00 before RAM write.
- The RAM write operation is executed every four words. If RAM write operation is terminated before all four-word data is written to RAM, the last data will not be written to RAM.
- When the index register is set to R22H (RAM data write), the first RAM write operation is always executed. In this case, RAM data read is not operable simultaneously. During RAM read, set the HWM to 0.
- The high-speed RAM write mode is not compatible with the normal RAM write mode. When the mode must be switched to the other, make a new address set before starting RAM write.
- When writing data in high speed RAM write mode within the range specified with the window address, some window-address range may require dummy write operation. See "High-Speed RAM Write with Window Address Function".

Comparison of Normal and High-Speed RAM Write Operations

| | Normal RAM Write (HWM=0) | High-Speed RAM Write (HWM=1) |
|----------------------------|-----------------------------|---|
| Logical operation function | Available | Not available |
| Compare operation function | Available | Not available |
| BGR function | Available | Available |
| Write mask function | Available | Available |
| RAM address set | Specified by one word | ID0 bit=0: Set the lower two bits to 11 ID0 bit=1: Set the lower two bits to 00 |
| RAM read | Read by one word | Not available |
| RAM write | Write by one word | Dummy write operations may be required depending on the specified window-address range |
| Window address | Set by one word | Horizontal range(HSA/HSE): more than four words Number of horizontal writing : 4N (N>=2) |
| External display interface | Available | Available |
| AM Setting | AM = 1/0 | AM = 0 |

High-Speed RAM Write with Window Address Function

To rewrite the data in an arbitrary rectangular area of RAM consecutively in high speed, the number of RAM access should be made 4 multiple times. Accordingly some window-address range may require dummy write operation to make the RAM access 4 multiple times. The number of dummy write is set when setting the window address as follows.

The horizontal window-address range specifying bits (HSA1-0, HEA1-0) specify the number of dummy write operations executed at the start and end of the data to write to RAM. The total RAM access must be 4 multiple times per line.

Number of Dummy Write Operations in High-Speed RAM Write (HSA Bits)

| HSA1 | HSA0 | Number of Dummy Write Operations inserted |
|------|------|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 2 |
| 1 | 1 | 3 |

Number of Dummy Write Operations in High-Speed RAM Write (HEA Bits)

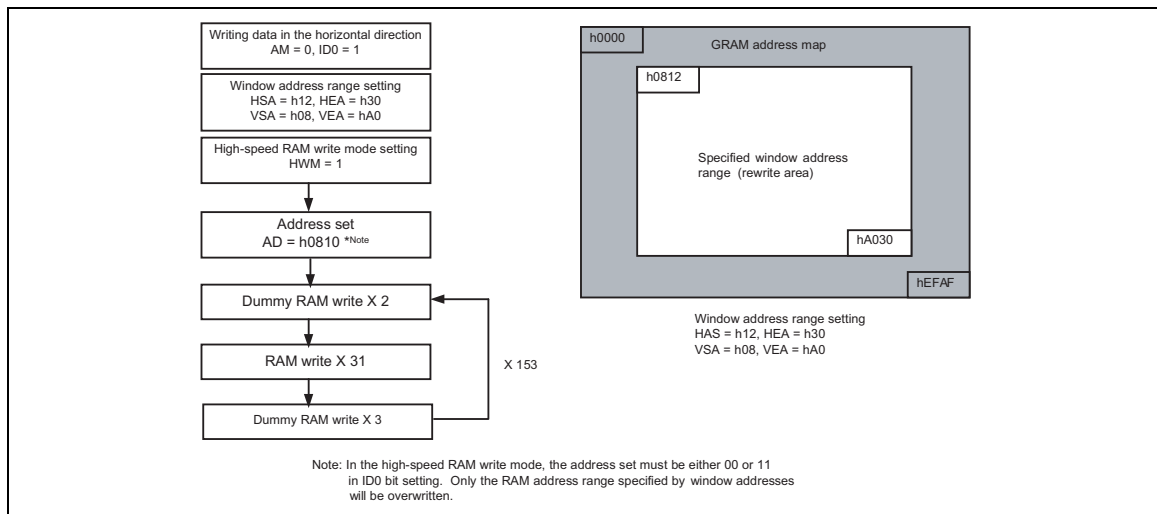
| HEA1 | HEA0 | Number of Dummy Write Operations Inserted |
|------|------|---|
| 0 | 0 | 3 |
| 0 | 1 | 2 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

The number of RAM access when writing data in the horizontal direction must be made $4 \times N$ times by including the dummy writes.

$$\text{Horizontal RAM write} = \text{start dummy write} + \text{write data} + \text{end dummy write} = 4 \times N \text{ (times)}$$

An example of RAM write in high speed RAM write mode with the window address is as follows.

The RAM data in the specified window-address range is written over consecutively in high speed by inserting two dummy writes at the start of the line and three dummy writes at the end of the line. The number of dummy writes is specified with the window-address range specifying bits. In this case, set HSA1-0 to 10, HEA1-0 to 00.



High-Speed RAM Write with Window Address Function

Window Address Function

The window address function enables consecutive data write within the rectangular window-address area on the on-chip GRAM, which is specified with horizontal address registers (start: HSA7-0, end: HEA 7-0) and vertical address registers (start: VSA7-0, end: VEA7-0).

The address transition direction is determined with AM bits (either increment or decrement). Accordingly, the data, including picture data, are written consecutively without taking the data wrap position into consideration.

The window-address range must be specified within the GRAM address area. An address set must be set within the window-address range.

[Condition on setting window-address range]

(Horizontal direction) $00H \leq HSA7-0 \leq HSA7-0 \leq AFH$

(Vertical direction) $00H \leq VSA7-0 \leq VEA7-0 \leq EFH$

[Condition on making an address set within the window-address range]

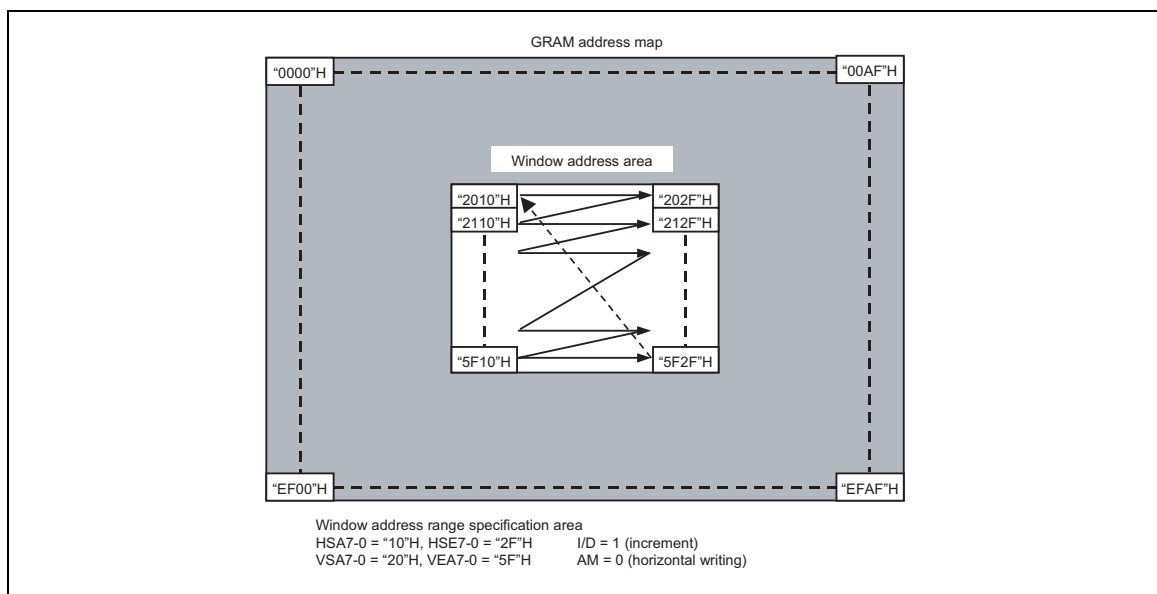
(RAM address) $HSA7-0 \leq AD7-0 \leq HEA7-0$

$VSA7-0 \leq AD15-8 \leq VEA7-0$

Note: In high-speed RAM write mode, the lower two bits of the address must be set as follows.

ID0=0: The lower two bits of the address must be set to 11.

ID0=1: The lower two bits of the address must be set to 00.



Address transition direction in specified window-address range

Graphics Operation Function

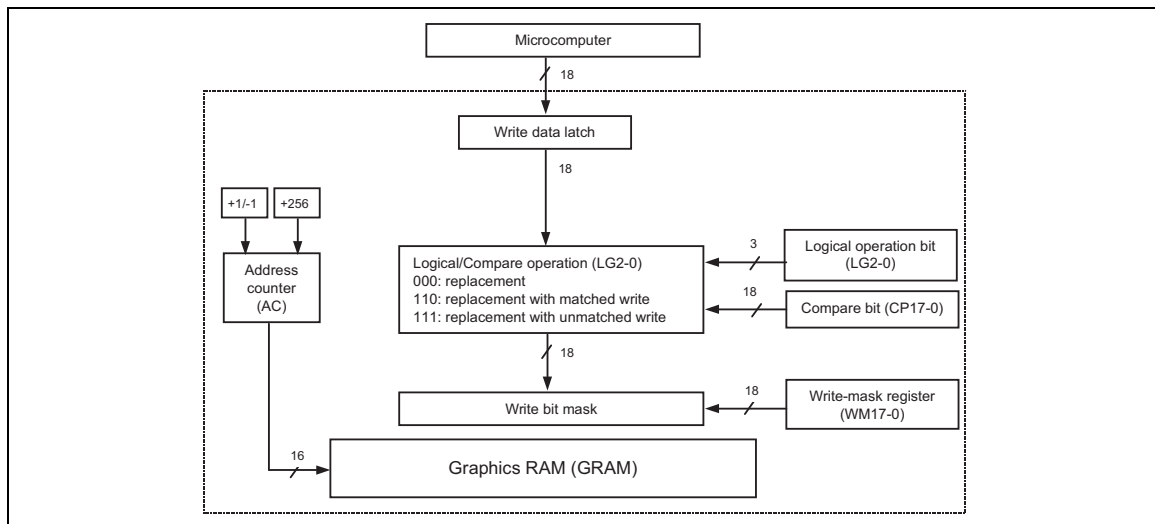
The HD66787 greatly reduces the load on the graphics-processing software in the microcomputer with the 18-bit bus architecture and the graphics bit operation. The graphics bit operation includes:

1. The write data mask function that selectively rewrites some bits of 18-bit write data.
2. The conditional rewrite function that compares the write data and the compare bit data and writes the data sent from the microcomputer only when the conditions are satisfied.

The graphics bit operation is controlled by setting bits in the entry mode register and RAM-write-data mask register, and the write operation from the microcomputer.

Graphics Operation

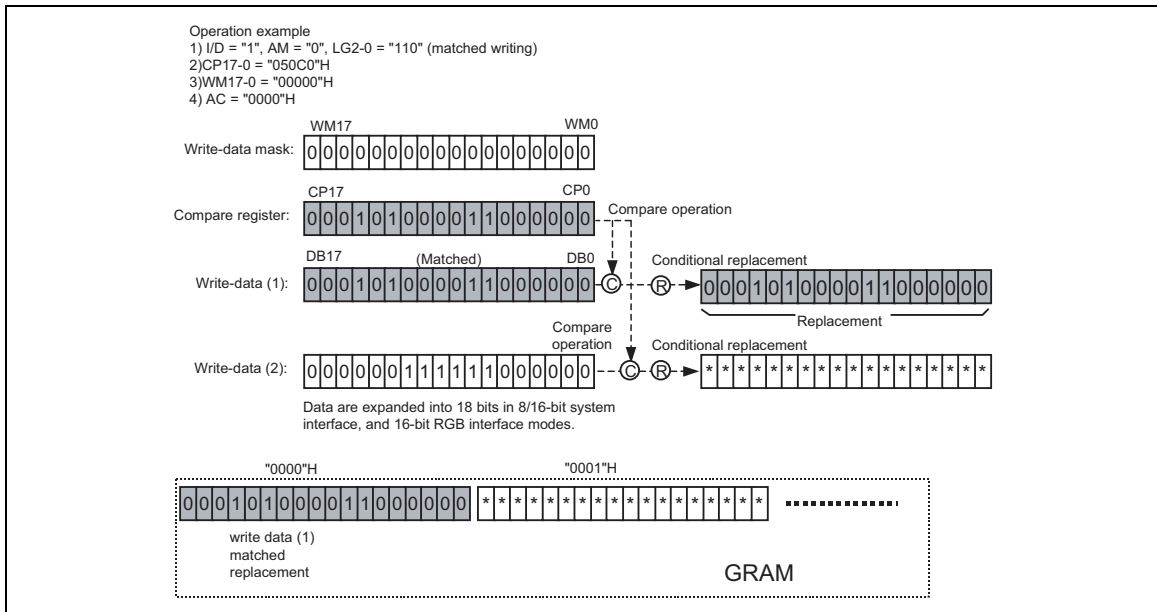
| Operation Mode | Bit Setting | | | Operation and Usage |
|----------------|-------------|----|---------|---|
| | I/D | AM | LG2-0 | |
| Write mode 1 | 0/1 | 0 | 000 | Horizontal data replacement |
| Write mode 2 | 0/1 | 1 | 000 | Vertical data replacement |
| Write mode 3 | 0/1 | 0 | 110 111 | Conditional horizontal data replacement |
| Write mode 4 | 0/1 | 1 | 110 111 | Conditional vertical data replacement |



Graphics operation flow

3. Write mode 3: AM = 0, LG2-0 = 110/111

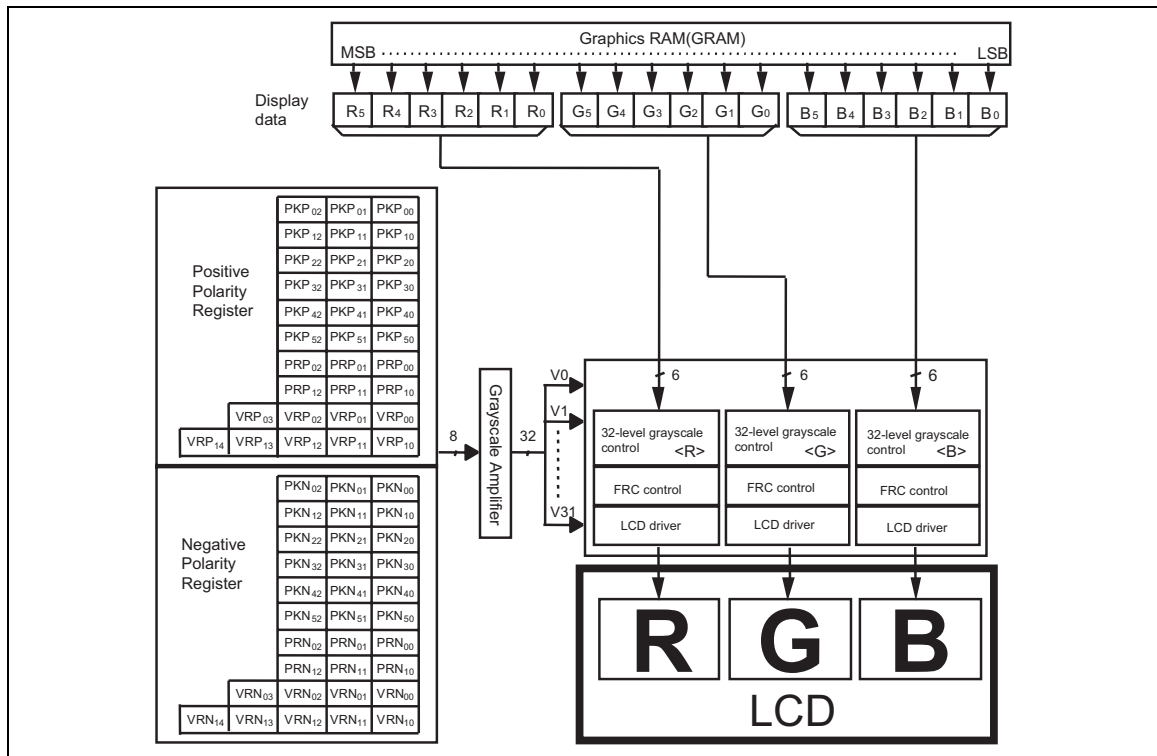
This mode is used when data are horizontally written with comparing the write data and the value set in the compare register (CP17-0) by R, G, B pixel. When the result of the comparison satisfies a condition, the write data sent from the microcomputer are written to GRAM. In this operation, the write-data mask function (WM17-0) is available. After writing, the address counter (AC) automatically increments by 1 (I/D = 1) or decrements by 1 (I/D = 0), and jumps to the counter at the opposing edge of the next one-raster-row below after when the counter reaches either left or right edge of GRAM.



Write Mode 3

γ -Correction Function

The HD66787 incorporates γ -correction function to simultaneously display 262,144 colors, by which 8-level grayscale is determined by the gradient-adjustment and fine-adjustment registers. Select either positive or negative polarity of the registers according to the characteristics of a liquid crystal panel.



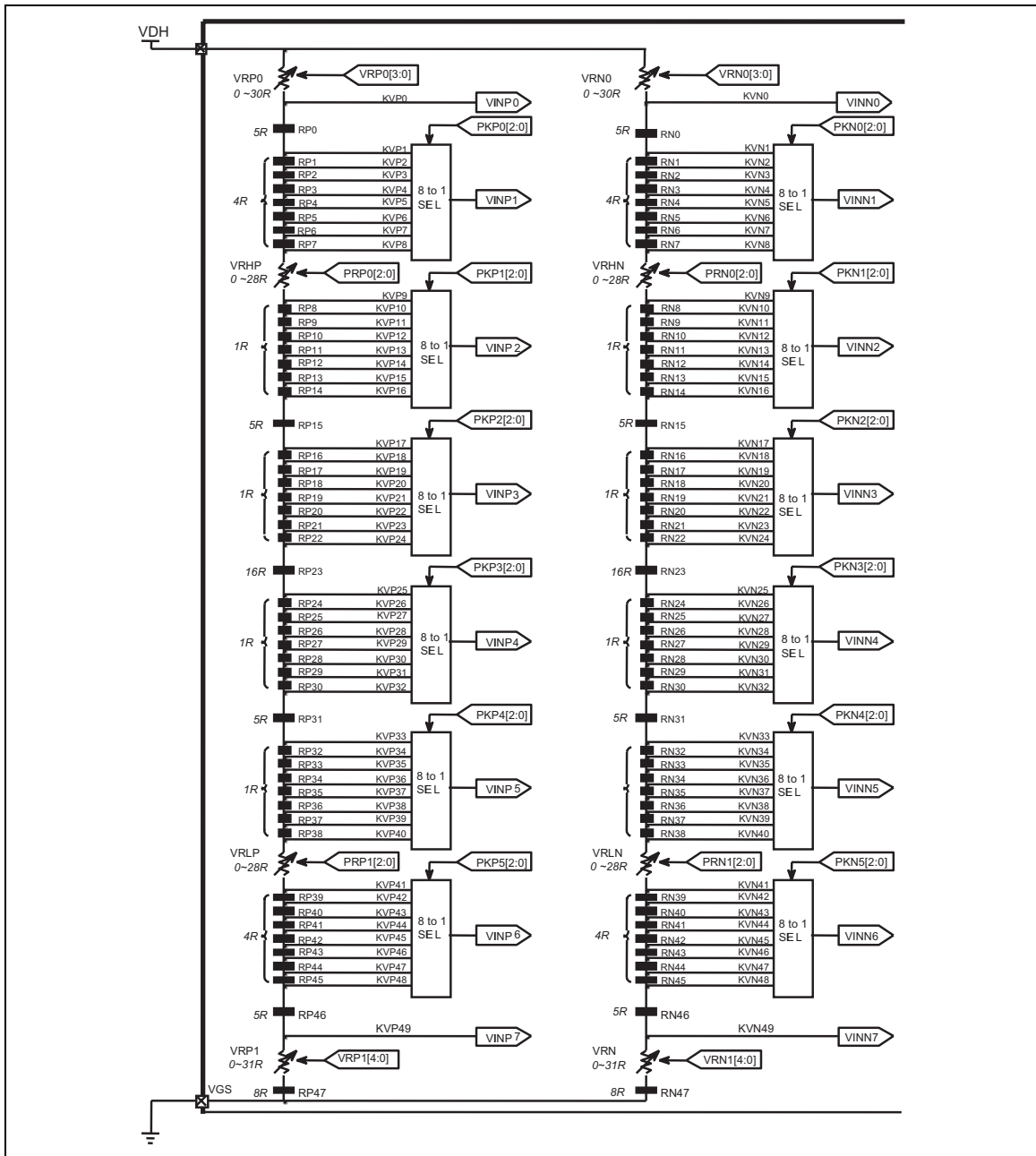
Grayscale control

Configuration of Grayscale Amplifier

The eight levels (VIN0-7) of grayscale are determined by the gradient adjustment and fine adjustment registers. The 8 levels are then divided into 32 levels (V0-31) by the ladder resistors placed between each level.



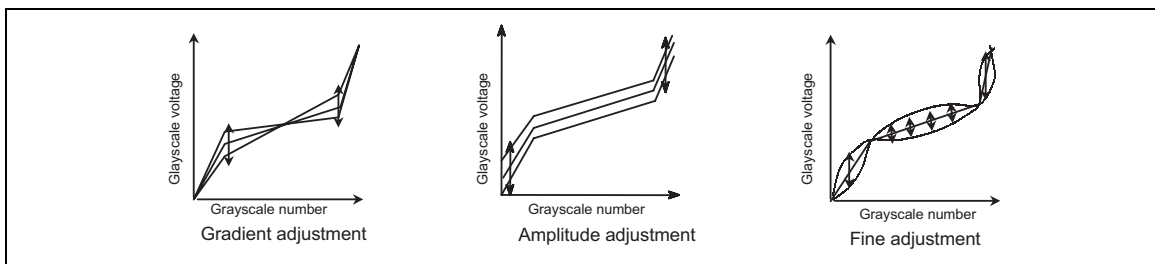
Grayscale amplifier



Ladder Resistors and 8-to-1 Selectors

γ -Correction Register

The γ -adjustment register is a group of registers to set an appropriate grayscale voltage for the γ -characteristics of a liquid crystal panel. The register group is categorized into the ones adjusting gradient, amplitude, and fine-tuning in relation to grayscale number and grayscale voltage characteristics. Each register can make an independent setting for the positive/negative polarity. The reference value and RGB are common to both polarities.



Gradient, Amplitude, Fine Adjustments

1. Gradient adjustment registers

The gradient adjustment registers are used to adjust the gradient around the middle of the grayscale number and voltage characteristics without changing a dynamic range. To adjust a gradient, the values of the variable resistors (VRHP (N)/VRLP (N)) in the ladder resistor block for grayscale voltage generation are controlled. The registers incorporate separate registers for positive and negative polarities to be compatible with asymmetric drive.

2. Amplitude adjustment registers

The amplitude adjustment registers are used to adjust the amplitude of the grayscale voltage. To adjust the amplitude, the values of the variable resistors (VRP(N)/0) in the bottom of the ladder resistor block for grayscale voltage generation are adjusted. Same with the gradient registers, the amplitude adjustment registers also incorporate separate registers for positive and negative polarities.

3. Fine adjustment registers

The fine adjustment register is to fine-adjust the grayscale voltage level. To fine-adjust the grayscale voltage level, each level of 8-level reference voltages generated from the ladder registers is controlled by 8-to-1 selector. Same with the other registers, the fine adjustment registers also incorporate separate registers for positive and negative polarities.

γ -Correction Registers

| Register Groups | Positive Polarity | Negative Polarity | Description |
|----------------------|-------------------|-------------------|---|
| Gradient adjustment | PRP0 2 to 0 | PRN0 2 to 0 | Variable resistor VRHP (N) |
| | PRP1 2 to 0 | PRN1 2 to 0 | Variable resistor VRLP (N) |
| Amplitude adjustment | VRP0 3 to 0 | VRN0 3 to 0 | Variable resistor VRP (N)0 |
| | VRP1 4 to 0 | VRN1 4 to 0 | Variable resistor VRP (N)1 |
| Fine adjustment | PKP0 2 to 0 | PKN0 2 to 0 | 8-to-1 selector (voltage level of grayscale 1) |
| | PKP1 2 to 0 | PKN1 2 to 0 | 8-to-1 selector (voltage level of grayscale 8) |
| | PKP2 2 to 0 | PKN2 2 to 0 | 8-to-1 selector (voltage level of grayscale 20) |
| | PKP3 2 to 0 | PKN3 2 to 0 | 8-to-1 selector (voltage level of grayscale 43) |
| | PKP4 2 to 0 | PKN4 2 to 0 | 8-to-1 selector (voltage level of grayscale 55) |
| | PKP5 2 to 0 | PKN5 2 to 0 | 8-to-1 selector (voltage level of grayscale 62) |

Ladder resistors and 8-to-1 selector**Block configuration**

The block diagram of page 117 consists of two ladder resistors including variable resistors, and 8-to-1 selectors which select the voltage generated by the ladder resistors to output a reference voltage for the grayscale voltage. The variable resistors and the 8-to-1 selectors are controlled by the γ correction registers. Pins that are connected to a variable resistor are also provided to compensate the variation among the panels.

Variable resistor

There are three kinds of variable resistors for the gradient adjustment (VRHP(N)/VRLP(N)), the amplitude adjustment (1) (VRP(N)0), and the amplitude adjustment (2) (VRP(N)1). The resistance is determined by the gradient adjustment and amplitude adjustment registers as is shown below.

| Gradient adjustment | | Amplitude adjustment (1) | | Amplitude adjustment (2) | |
|--------------------------------------|-------------------------------|-----------------------------------|--------------------|-----------------------------------|--------------------|
| Contents of Register PRP(N) 0/1[2:0] | Resistance VRHP(N) VRLP(N) | Contents of Register VRP(N)0[3:0] | Resistance VRP(N)0 | Contents of Register VRP(N)1[4:0] | Resistance VRP(N)1 |
| 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 selector

The 8-to-1 selectors select a voltage level generated by the ladder resistors according to fine adjustment registers, and output six kinds of reference voltage, VIN1 to VIN 6. The relationship between the fine adjustment register and the selected voltage is as follows.

Fine adjustment registers and selected voltage

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

The grayscale levels (V0-V31) are calculated according to the following formulas.

Formulas for calculating voltage (Positive polarity) (1)

| Pin | Formula | Fine adjustment register value | Reference Voltage |
|-------|--|--------------------------------|-------------------|
| KVP0 | $VREG1OUT - \Delta V \cdot V_{RP0} / SUMRP$ | - | VINP0 |
| KVP1 | $VREG1OUT - \Delta V \cdot V_{RP0+5R} / SUMRP$ | PKP02-00 = "000" | VINP1 |
| KVP2 | $VREG1OUT - \Delta V \cdot V_{RP0+9R} / SUMRP$ | PKP02-00 = "001" | |
| KVP3 | $VREG1OUT - \Delta V \cdot V_{RP0+13R} / SUMRP$ | PKP02-00 = "010" | |
| KVP4 | $VREG1OUT - \Delta V \cdot V_{RP0+17R} / SUMRP$ | PKP02-00 = "011" | |
| KVP5 | $VREG1OUT - \Delta V \cdot V_{RP0+21R} / SUMRP$ | PKP02-00 = "100" | |
| KVP6 | $VREG1OUT - \Delta V \cdot V_{RP0+25R} / SUMRP$ | PKP02-00 = "101" | |
| KVP7 | $VREG1OUT - \Delta V \cdot V_{RP0+29R} / SUMRP$ | PKP02-00 = "110" | |
| KVP8 | $VREG1OUT - \Delta V \cdot V_{RP0+33R} / SUMRP$ | PKP02-00 = "111" | |
| KVP9 | $VREG1OUT - \Delta V \cdot (V_{RP0+33R} + V_{RH0}) / SUMRP$ | PKP12-10 = "000" | VINP2 |
| KVP10 | $VREG1OUT - \Delta V \cdot (V_{RP0+34R} + V_{RH0}) / SUMRP$ | PKP12-10 = "001" | |
| KVP11 | $VREG1OUT - \Delta V \cdot (V_{RP0+35R} + V_{RH0}) / SUMRP$ | PKP12-10 = "010" | |
| KVP12 | $VREG1OUT - \Delta V \cdot (V_{RP0+36R} + V_{RH0}) / SUMRP$ | PKP12-10 = "011" | |
| KVP13 | $VREG1OUT - \Delta V \cdot (V_{RP0+37R} + V_{RH0}) / SUMRP$ | PKP12-10 = "100" | |
| KVP14 | $VREG1OUT - \Delta V \cdot (V_{RP0+38R} + V_{RH0}) / SUMRP$ | PKP12-10 = "101" | |
| KVP15 | $VREG1OUT - \Delta V \cdot (V_{RP0+39R} + V_{RH0}) / SUMRP$ | PKP12-10 = "110" | |
| KVP16 | $VREG1OUT - \Delta V \cdot (V_{RP0+40R} + V_{RH0}) / SUMRP$ | PKP12-10 = "111" | |
| KVP17 | $VREG1OUT - \Delta V \cdot (V_{RP0+45R} + V_{RH0}) / SUMRP$ | PKP22-20 = "000" | VINP3 |
| KVP18 | $VREG1OUT - \Delta V \cdot (V_{RP0+46R} + V_{RH0}) / SUMRP$ | PKP22-20 = "001" | |
| KVP19 | $VREG1OUT - \Delta V \cdot (V_{RP0+47R} + V_{RH0}) / SUMRP$ | PKP22-20 = "010" | |
| KVP20 | $VREG1OUT - \Delta V \cdot (V_{RP0+48R} + V_{RH0}) / SUMRP$ | PKP22-20 = "011" | |
| KVP21 | $VREG1OUT - \Delta V \cdot (V_{RP0+49R} + V_{RH0}) / SUMRP$ | PKP22-20 = "100" | |
| KVP22 | $VREG1OUT - \Delta V \cdot (V_{RP0+50R} + V_{RH0}) / SUMRP$ | PKP22-20 = "101" | |
| KVP23 | $VREG1OUT - \Delta V \cdot (V_{RP0+51R} + V_{RH0}) / SUMRP$ | PKP22-20 = "110" | |
| KVP24 | $VREG1OUT - \Delta V \cdot (V_{RP0+52R} + V_{RH0}) / SUMRP$ | PKP22-20 = "111" | |
| KVP25 | $VREG1OUT - \Delta V \cdot (V_{RP0+68R} + V_{RH0}) / SUMRP$ | PKP32-30 = "000" | VINP4 |
| KVP26 | $VREG1OUT - \Delta V \cdot (V_{RP0+69R} + V_{RH0}) / SUMRP$ | PKP32-30 = "001" | |
| KVP27 | $VREG1OUT - \Delta V \cdot (V_{RP0+70R} + V_{RH0}) / SUMRP$ | PKP32-30 = "010" | |
| KVP28 | $VREG1OUT - \Delta V \cdot (V_{RP0+71R} + V_{RH0}) / SUMRP$ | PKP32-30 = "011" | |
| KVP29 | $VREG1OUT - \Delta V \cdot (V_{RP0+72R} + V_{RH0}) / SUMRP$ | PKP32-30 = "100" | |
| KVP30 | $VREG1OUT - \Delta V \cdot (V_{RP0+73R} + V_{RH0}) / SUMRP$ | PKP32-30 = "101" | |
| KVP31 | $VREG1OUT - \Delta V \cdot (V_{RP0+74R} + V_{RH0}) / SUMRP$ | PKP32-30 = "110" | |
| KVP32 | $VREG1OUT - \Delta V \cdot (V_{RP0+75R} + V_{RH0}) / SUMRP$ | PKP32-30 = "111" | |
| KVP33 | $VREG1OUT - \Delta V \cdot (V_{RP0+80R} + V_{RH0}) / SUMRP$ | PKP42-40 = "000" | VINP5 |
| KVP34 | $VREG1OUT - \Delta V \cdot (V_{RP0+81R} + V_{RH0}) / SUMRP$ | PKP42-40 = "001" | |
| KVP35 | $VREG1OUT - \Delta V \cdot (V_{RP0+82R} + V_{RH0}) / SUMRP$ | PKP42-40 = "010" | |
| KVP36 | $VREG1OUT - \Delta V \cdot (V_{RP0+83R} + V_{RH0}) / SUMRP$ | PKP42-40 = "011" | |
| KVP37 | $VREG1OUT - \Delta V \cdot (V_{RP0+84R} + V_{RH0}) / SUMRP$ | PKP42-40 = "100" | |
| KVP38 | $VREG1OUT - \Delta V \cdot (V_{RP0+85R} + V_{RH0}) / SUMRP$ | PKP42-40 = "101" | |
| KVP39 | $VREG1OUT - \Delta V \cdot (V_{RP0+86R} + V_{RH0}) / SUMRP$ | PKP42-40 = "110" | |
| KVP40 | $VREG1OUT - \Delta V \cdot (V_{RP0+87R} + V_{RH0}) / SUMRP$ | PKP42-40 = "111" | |
| KVP41 | $VREG1OUT - \Delta V \cdot (V_{RP0+87R} + V_{RH0} + V_{RL0}) / SUMRP$ | PKP52-50 = "000" | VINP6 |
| KVP42 | $VREG1OUT - \Delta V \cdot (V_{RP0+91R} + V_{RH0} + V_{RL0}) / SUMRP$ | PKP52-50 = "001" | |
| KVP43 | $VREG1OUT - \Delta V \cdot (V_{RP0+95R} + V_{RH0} + V_{RL0}) / SUMRP$ | PKP52-50 = "010" | |
| KVP44 | $VREG1OUT - \Delta V \cdot (V_{RP0+99R} + V_{RH0} + V_{RL0}) / SUMRP$ | PKP52-50 = "011" | |
| KVP45 | $VREG1OUT - \Delta V \cdot (V_{RP0+103R} + V_{RH0} + V_{RL0}) / SUMRP$ | PKP52-50 = "100" | |
| KVP46 | $VREG1OUT - \Delta V \cdot (V_{RP0+107R} + V_{RH0} + V_{RL0}) / SUMRP$ | PKP52-50 = "101" | |
| KVP47 | $VREG1OUT - \Delta V \cdot (V_{RP0+111R} + V_{RH0} + V_{RL0}) / SUMRP$ | PKP52-50 = "110" | |
| KVP48 | $VREG1OUT - \Delta V \cdot (V_{RP0+115R} + V_{RH0} + V_{RL0}) / SUMRP$ | PKP52-50 = "111" | |
| KVP49 | $VREG1OUT - \Delta V \cdot (V_{RP0+120R} + V_{RH0} + V_{RL0}) / SUMRP$ | - | VINP7 |

SUMRP : Sum of positive ladder resistors = 128R+VRHP+VRLP+VRP0+VRP1
SUMRN : Sum of negative ladder resistors = 128R+VRHN+VRLN+VRN0+VRN1
ΔV : Voltage difference between VREG1OUT and VGS

Formulas for calculating voltage (Positive polarity) (2)

| Grayscale Voltage | Formula |
|-------------------|-----------------------------|
| V0 | VINP0 |
| V1 | $V4+(VINP1-V4)*(15/24)$ |
| V2 | $V4+(VINP1-V4)*(8/24)$ |
| V3 | $V4+(VINP1-V4)*(4/24)$ |
| V4 | VINP2 |
| V5 | $V10+(V4-V10)*(20/24)$ |
| V6 | $V10+(V4-V10)*(16/24)$ |
| V7 | $V10+(V4-V10)*(12/24)$ |
| V8 | $V10+(V4-V10)*(8/24)$ |
| V9 | $V20+(V8-V20)*(4/24)$ |
| V10 | VINP3 |
| V11 | $V21+(V10-V21)*(21/24)$ |
| V12 | $V21+(V10-V21)*(19/24)$ |
| V13 | $V21+(V10-V21)*(17/24)$ |
| V14 | $V21+(V10-V21)*(15/24)$ |
| V15 | $V21+(V10-V21)*(13/24)$ |
| V16 | $V21+(V10-V21)*(11/24)$ |
| V17 | $V21+(V10-V21)*(9/24)$ |
| V18 | $V21+(V10-V21)*(7/24)$ |
| V19 | $V21+(V10-V21)*(5/24)$ |
| V20 | $V21+(V10-V21)*(3/24)$ |
| V21 | VINP4 |
| V22 | $V27+(V21-V27)*(20/24)$ |
| V23 | $V27+(V21-V27)*(16/24)$ |
| V24 | $V27+(V21-V27)*(12/24)$ |
| V25 | $V27+(V21-V27)*(8/24)$ |
| V26 | $V27+(V21-V27)*(4/24)$ |
| V27 | VINP5 |
| V28 | $VINP6+(V27-VINP6)*(20/24)$ |
| V29 | $VINP6+(V27-VINP6)*(16/24)$ |
| V30 | $VINP6+(V27-VINP6)*(9/24)$ |
| V31 | VINP7 |

Note : Make sure DDVDH - V0 > 0.5V
DDVDH - V4 > 1.1V

Formulas for calculating voltage (Negative polarity) (1)

| Pin | Formula | Fine adjustment register value | Reference Voltage |
|-------|---|--------------------------------|-------------------|
| KVP0 | $VREG1OUT - \Delta V \cdot VRN0 / SUMRN$ | - | VINN0 |
| KVN1 | $VREG1OUT - \Delta V \cdot VRN0 + 5R / SUMRN$ | PKN 02-00 = "000" | VINN1 |
| KVN2 | $VREG1OUT - \Delta V \cdot VRN0 + 9R / SUMRN$ | PKN 02-00 = "001" | |
| KVN3 | $VREG1OUT - \Delta V \cdot VRN0 + 13R / SUMRN$ | PKN 02-00 = "010" | |
| KVN4 | $VREG1OUT - \Delta V \cdot VRN0 + 17R / SUMRN$ | PKN 02-00 = "011" | |
| KVN5 | $VREG1OUT - \Delta V \cdot VRN0 + 21R / SUMRN$ | PKN 02-00 = "100" | |
| KVN6 | $VREG1OUT - \Delta V \cdot VRN0 + 25R / SUMRN$ | PKN 02-00 = "101" | |
| KVN7 | $VREG1OUT - \Delta V \cdot VRN0 + 29R / SUMRN$ | PKN 02-00 = "110" | |
| KVN8 | $VREG1OUT - \Delta V \cdot VRN0 + 33R / SUMRN$ | PKN 02-00 = "111" | |
| KVN9 | $VREG1OUT - \Delta V \cdot (VRN0 + 33R + VRHN) / SUMRN$ | PKN 12-10 = "000" | VINN2 |
| KVN10 | $VREG1OUT - \Delta V \cdot (VRN0 + 34R + VRHN) / SUMRN$ | PKN 12-10 = "001" | |
| KVN11 | $VREG1OUT - \Delta V \cdot (VRN0 + 35R + VRHN) / SUMRN$ | PKN 12-10 = "010" | |
| KVN12 | $VREG1OUT - \Delta V \cdot (VRN0 + 36R + VRHN) / SUMRN$ | PKN 12-10 = "011" | |
| KVN13 | $VREG1OUT - \Delta V \cdot (VRN0 + 37R + VRHN) / SUMRN$ | PKN 12-10 = "100" | |
| KVN14 | $VREG1OUT - \Delta V \cdot (VRN0 + 38R + VRHN) / SUMRN$ | PKN 12-10 = "101" | |
| KVN15 | $VREG1OUT - \Delta V \cdot (VRN0 + 39R + VRHN) / SUMRN$ | PKN 12-10 = "110" | |
| KVN16 | $VREG1OUT - \Delta V \cdot (VRN0 + 40R + VRHN) / SUMRN$ | PKN 12-10 = "111" | |
| KVN17 | $VREG1OUT - \Delta V \cdot (VRN0 + 45R + VRHN) / SUMRN$ | PKN 22-20 = "000" | VINN3 |
| KVN18 | $VREG1OUT - \Delta V \cdot (VRN0 + 46R + VRHN) / SUMRN$ | PKN 22-20 = "001" | |
| KVN19 | $VREG1OUT - \Delta V \cdot (VRN0 + 47R + VRHN) / SUMRN$ | PKN 22-20 = "010" | |
| KVN20 | $VREG1OUT - \Delta V \cdot (VRN0 + 48R + VRHN) / SUMRN$ | PKN 22-20 = "011" | |
| KVN21 | $VREG1OUT - \Delta V \cdot (VRN0 + 49R + VRHN) / SUMRN$ | PKN 22-20 = "100" | |
| KVN22 | $VREG1OUT - \Delta V \cdot (VRN0 + 50R + VRHN) / SUMRN$ | PKN 22-20 = "101" | |
| KVN23 | $VREG1OUT - \Delta V \cdot (VRN0 + 51R + VRHN) / SUMRN$ | PKN 22-20 = "110" | |
| KVN24 | $VREG1OUT - \Delta V \cdot (VRN0 + 52R + VRHN) / SUMRN$ | PKN 22-20 = "111" | |
| KVN25 | $VREG1OUT - \Delta V \cdot (VRN0 + 68R + VRHN) / SUMRN$ | PKN 32-30 = "000" | VINN4 |
| KVN26 | $VREG1OUT - \Delta V \cdot (VRN0 + 69R + VRHN) / SUMRN$ | PKN 32-30 = "001" | |
| KVN27 | $VREG1OUT - \Delta V \cdot (VRN0 + 70R + VRHN) / SUMRN$ | PKN 32-30 = "010" | |
| KVN28 | $VREG1OUT - \Delta V \cdot (VRN0 + 71R + VRHN) / SUMRN$ | PKN 32-30 = "011" | |
| KVN29 | $VREG1OUT - \Delta V \cdot (VRN0 + 72R + VRHN) / SUMRN$ | PKN 32-30 = "100" | |
| KVN30 | $VREG1OUT - \Delta V \cdot (VRN0 + 73R + VRHN) / SUMRN$ | PKN 32-30 = "101" | |
| KVN31 | $VREG1OUT - \Delta V \cdot (VRN0 + 74R + VRHN) / SUMRN$ | PKN 32-30 = "110" | |
| KVN32 | $VREG1OUT - \Delta V \cdot (VRN0 + 75R + VRHN) / SUMRN$ | PKN 32-30 = "111" | |
| KVN33 | $VREG1OUT - \Delta V \cdot (VRN0 + 80R + VRHN) / SUMRN$ | PKN 42-40 = "000" | VINN5 |
| KVN34 | $VREG1OUT - \Delta V \cdot (VRN0 + 81R + VRHN) / SUMRN$ | PKN 42-40 = "001" | |
| KVN35 | $VREG1OUT - \Delta V \cdot (VRN0 + 82R + VRHN) / SUMRN$ | PKN 42-40 = "010" | |
| KVN36 | $VREG1OUT - \Delta V \cdot (VRN0 + 83R + VRHN) / SUMRN$ | PKN 42-40 = "011" | |
| KVN37 | $VREG1OUT - \Delta V \cdot (VRN0 + 84R + VRHN) / SUMRN$ | PKN 42-40 = "100" | |
| KVN38 | $VREG1OUT - \Delta V \cdot (VRN0 + 85R + VRHN) / SUMRN$ | PKN 42-40 = "101" | |
| KVN39 | $VREG1OUT - \Delta V \cdot (VRN0 + 86R + VRHN) / SUMRN$ | PKN 42-40 = "110" | |
| KVN40 | $VREG1OUT - \Delta V \cdot (VRN0 + 87R + VRHN) / SUMRN$ | PKN 42-40 = "111" | |
| KVN41 | $VREG1OUT - \Delta V \cdot (VRN0 + 87R + VRHN + VRLP) / SUMRN$ | PKN 52-50 = "000" | VINN6 |
| KVN42 | $VREG1OUT - \Delta V \cdot (VRN0 + 91R + VRHN + VRLP) / SUMRN$ | PKN 52-50 = "001" | |
| KVN43 | $VREG1OUT - \Delta V \cdot (VRN0 + 95R + VRHN + VRLP) / SUMRN$ | PKN 52-50 = "010" | |
| KVN44 | $VREG1OUT - \Delta V \cdot (VRN0 + 99R + VRHN + VRLP) / SUMRN$ | PKN 52-50 = "011" | |
| KVN45 | $VREG1OUT - \Delta V \cdot (VRN0 + 103R + VRHN + VRLP) / SUMRN$ | PKN 52-50 = "100" | |
| KVN46 | $VREG1OUT - \Delta V \cdot (VRN0 + 107R + VRHN + VRLP) / SUMRN$ | PKN 52-50 = "101" | |
| KVN47 | $VREG1OUT - \Delta V \cdot (VRN0 + 111R + VRHN + VRLP) / SUMRN$ | PKN 52-50 = "110" | |
| KVN48 | $VREG1OUT - \Delta V \cdot (VRN0 + 115R + VRHN + VRLP) / SUMRN$ | PKN 52-50 = "111" | |
| KVN49 | $VREG1OUT - \Delta V \cdot (VRN0 + 120R + VRHN + VRLP) / SUMRN$ | - | VINN7 |

SUMRP : Sum of positive ladder resistors = 128R+VRHP+VRLP+VRP0+VRP1
SUMRN : Sum of negative ladder resistors = 128R+VRHN+VRLN+VRN0+VRN1
ΔV: Voltage difference between VREG1OUT and VGS

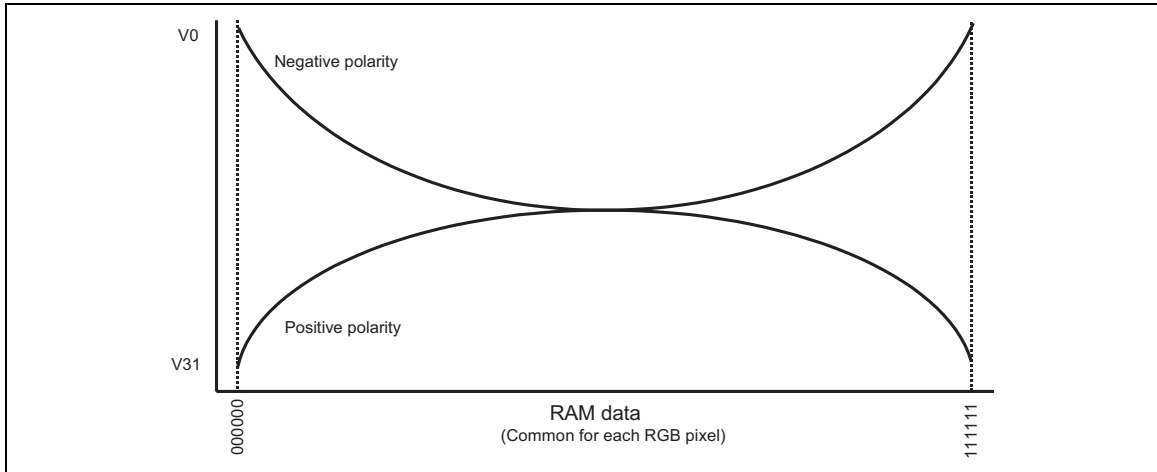
Formulas for calculating voltage (Negative polarity) (2)

| Grayscale Voltage | Formula |
|-------------------|-----------------------------------|
| V0 | VINN0 |
| V1 | $V4 + (VINN1 - V4) * (15/24)$ |
| V2 | $V4 + (VINN1 - V4) * (8/24)$ |
| V3 | $V4 + (VINN1 - V4) * (4/24)$ |
| V4 | VINN2 |
| V5 | $V10 + (V4 - V10) * (20/24)$ |
| V6 | $V10 + (V4 - V10) * (16/24)$ |
| V7 | $V10 + (V4 - V10) * (12/24)$ |
| V8 | $V10 + (V4 - V10) * (8/24)$ |
| V9 | $V20 + (V8 - V20) * (4/24)$ |
| V10 | VINN3 |
| V11 | $V21 + (V10 - V21) * (21/24)$ |
| V12 | $V21 + (V10 - V21) * (19/24)$ |
| V13 | $V21 + (V10 - V21) * (17/24)$ |
| V14 | $V21 + (V10 - V21) * (15/24)$ |
| V15 | $V21 + (V10 - V21) * (13/24)$ |
| V16 | $V21 + (V10 - V21) * (11/24)$ |
| V17 | $V21 + (V10 - V21) * (9/24)$ |
| V18 | $V21 + (V10 - V21) * (7/24)$ |
| V19 | $V21 + (V10 - V21) * (5/24)$ |
| V20 | $V21 + (V10 - V21) * (3/24)$ |
| V21 | VINN4 |
| V22 | $V27 + (V21 - V27) * (20/24)$ |
| V23 | $V27 + (V21 - V27) * (16/24)$ |
| V24 | $V27 + (V21 - V27) * (12/24)$ |
| V25 | $V27 + (V21 - V27) * (8/24)$ |
| V26 | $V27 + (V21 - V27) * (4/24)$ |
| V27 | VINN5 |
| V28 | $VINN6 + (V27 - VINN6) * (20/24)$ |
| V29 | $VINN6 + (V27 - VINN6) * (16/24)$ |
| V30 | $VINN6 + (V27 - VINN6) * (9/24)$ |
| V31 | VINN7 |

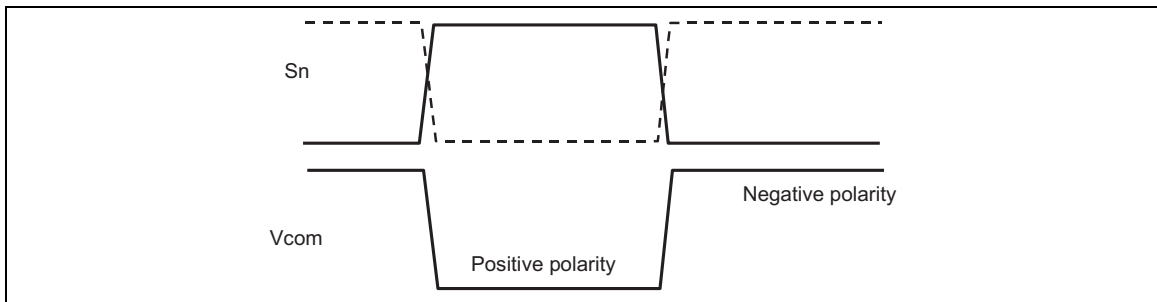
Note : Make sure DDVDH - V0 > 0.5V
DDVDH - V4 > 1.1V

Relationship between RAM data and output level

The relationship between the RAM data and the source output level is as follows.



RAM data and the output voltage

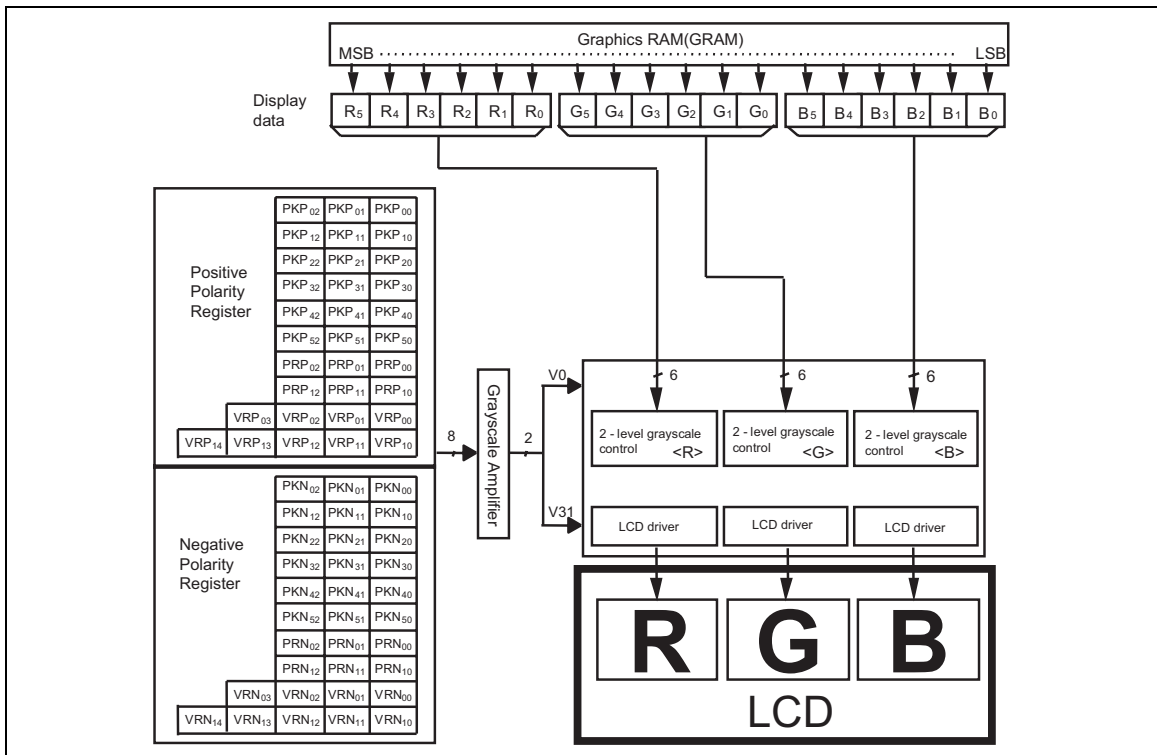


Source output and V_{com}

8-color Display Mode

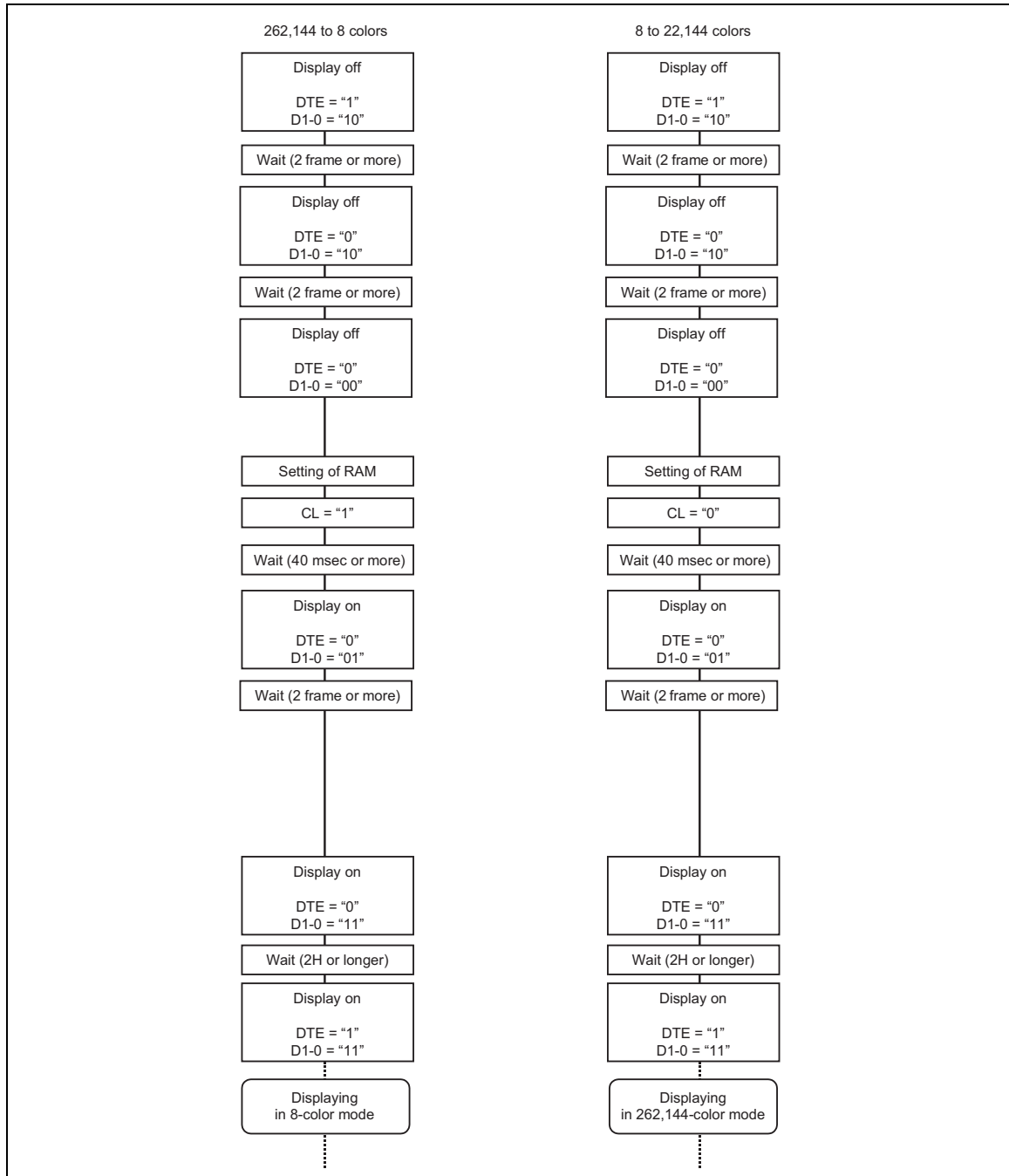
The HD66787 incorporates the 8-color display mode. The available grayscale levels are V0 and V31, and the voltages for the other levels (V1-V30) are halted to reduce power consumption.

The γ -fine-adjustment registers, PKP0-PKP5 and PKN0-PKN5 are not available in the 8-color display mode. Since the power supply for the levels V1-V30 are halted, RGB data in GRAM should be set to either “000000” or “111111” before setting this mode so that V0 or V31 is selected.



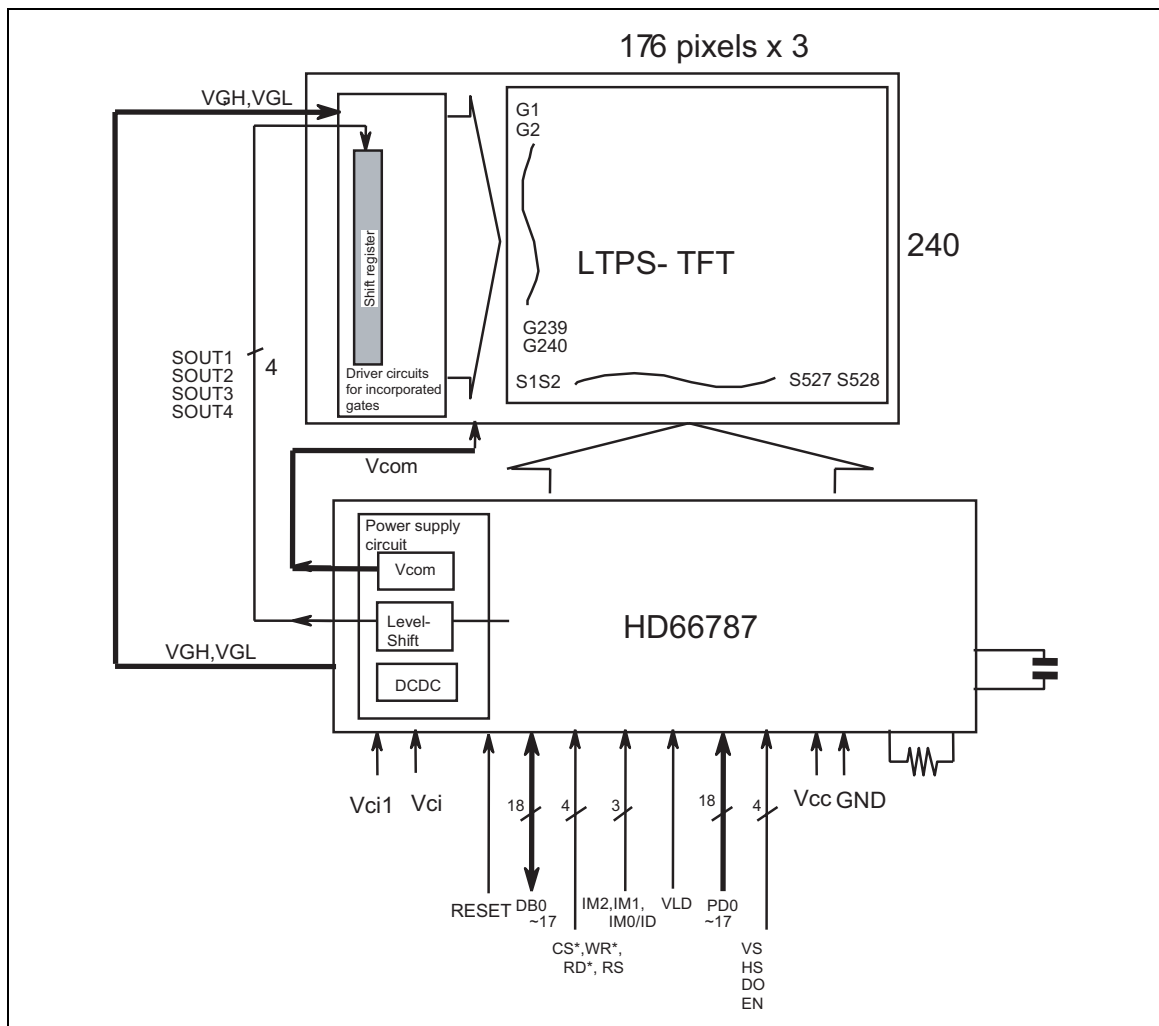
Grayscale control

To switch between the 262, 144-color mode and the 8-color mode, make settings according to the following sequences.



System Configuration

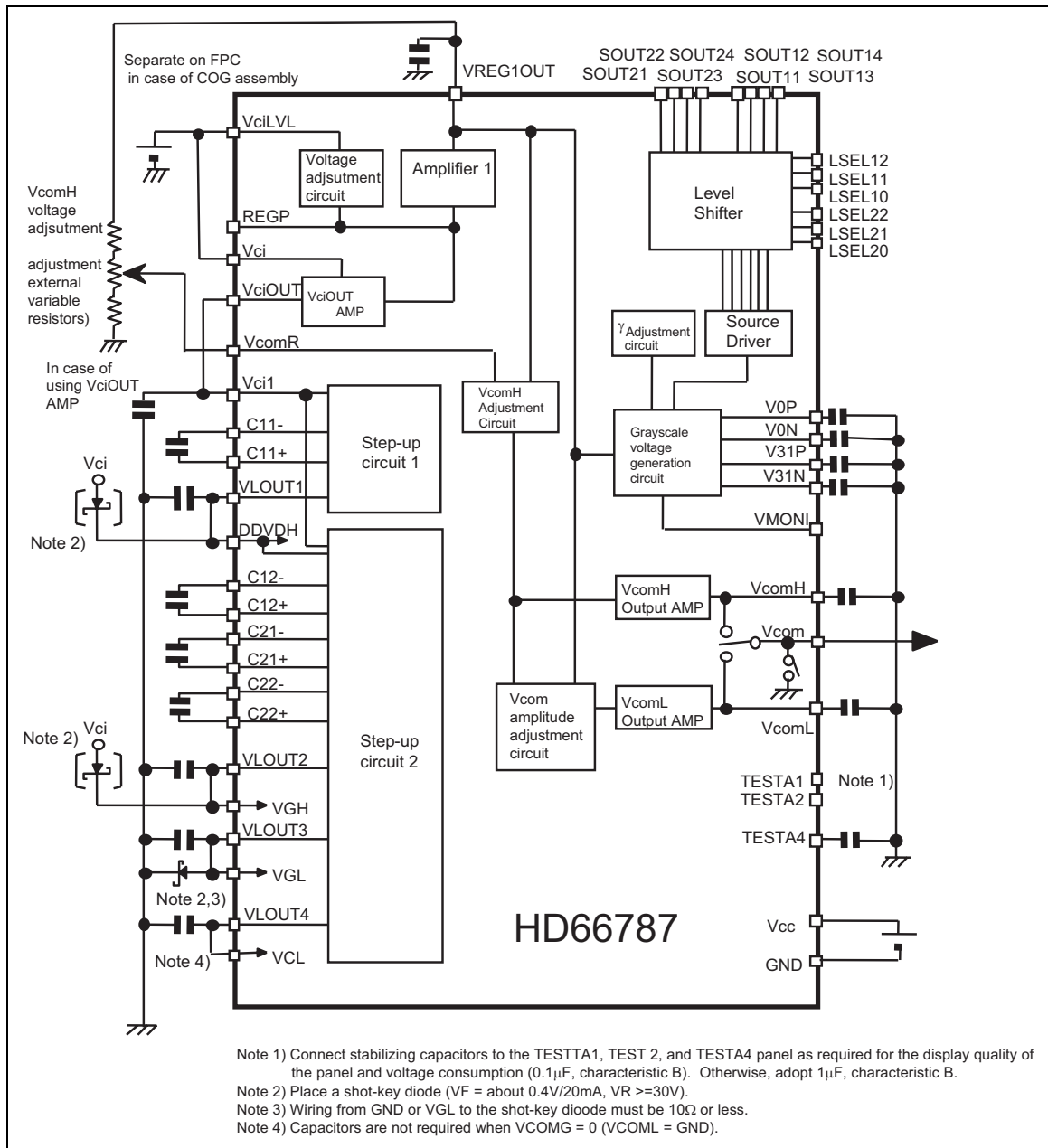
The following figure illustrates an example of configuring a TFT-LCD panel of 176x 240 dots with HD66787.



System configuration with HD66787

Configuration of Power Generation Circuit

The internal configuration of power generation circuit for driving liquid crystal with the HD66787 is as follows.



Power generation circuit

Specification of External Elements Connected to HD66787 Power Supply

The following table shows specifications of external elements connected to HD66787 power supply.

Capacitor

| Capacity | Recommended voltage | Connect pins |
|--------------------------------|---------------------|---|
| 1 μ F (B characteristic) | 6V | VREG1OUT, VciOUT, VOUT4, VcomH, VcomL, C11+/-, C21+/- |
| | 10V | VLOUT1, C21+/-, C22+/- |
| | 25V | VLOUT2, VLOUT3 |
| 0.1 μ F (B characteristic) | 6V | V0P, V0N, V31P, V31N, TESTA4 |

Shot-key diode

| Feature | Connect pin |
|--|---|
| VF < 0.4V / 20mA at 25 centigrade, VR \geq 30V (recommended diode : HSC226) | GND – VGL (Vci – VGH) (Vci – DDVDH) |

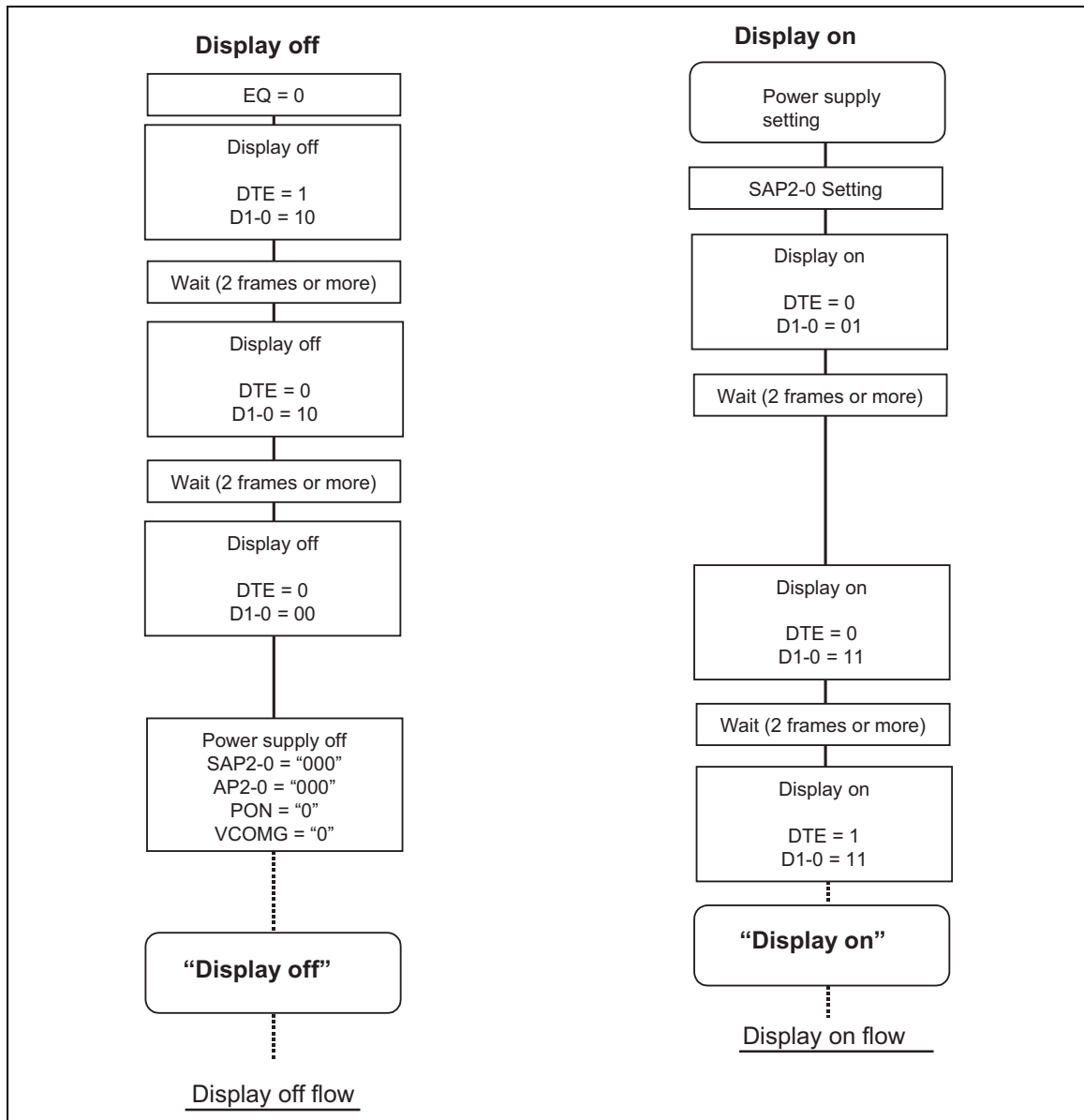
Variable resistor

| Feature | Connect pin |
|------------------|-------------|
| > 200 k Ω | VcomR |

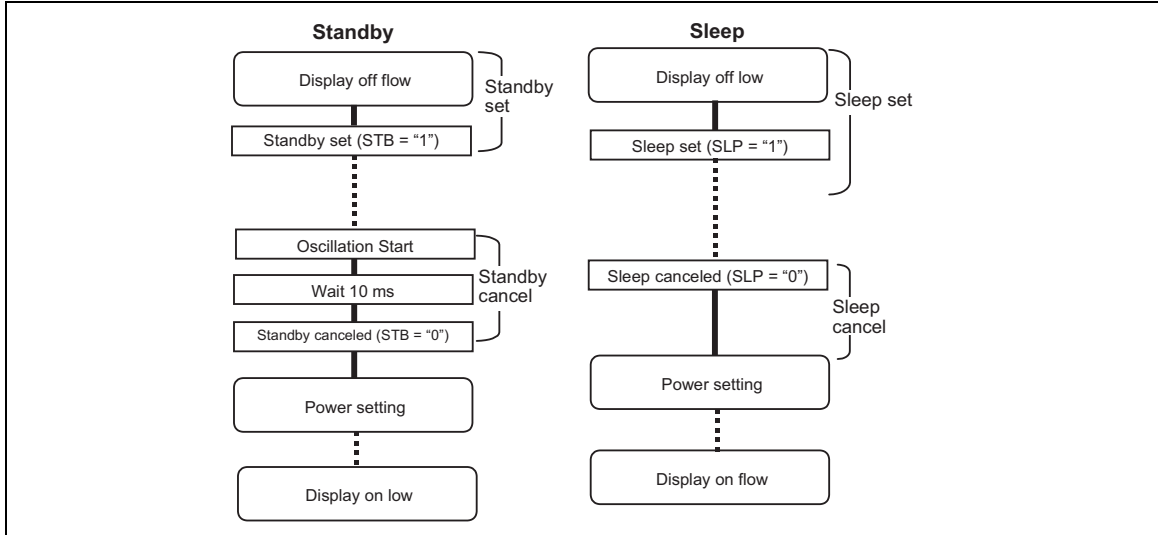
Instruction Setting Flow

Make a setting for each instruction according to the following sequence.

Display ON/OFF



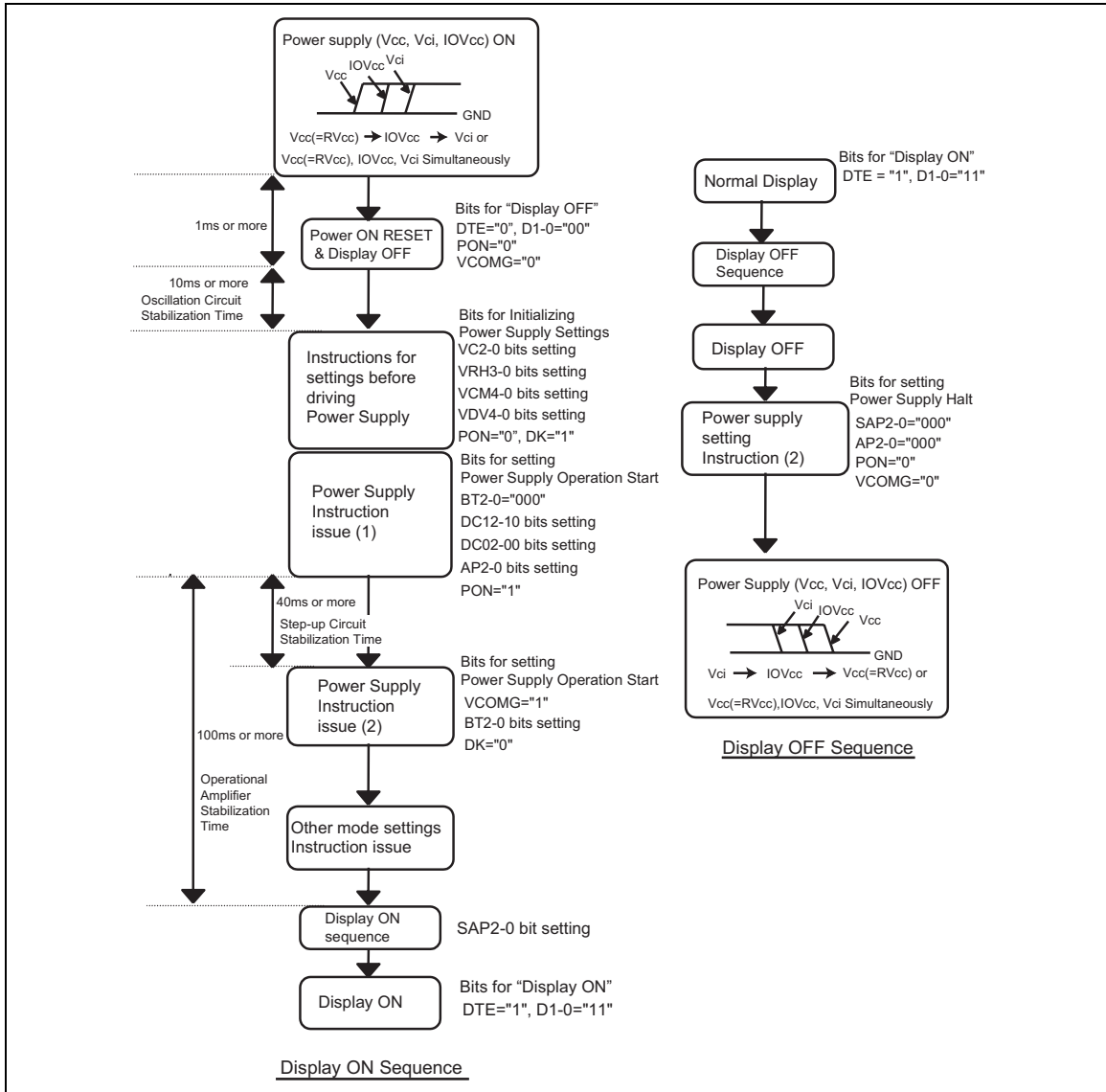
Standby and Sleep



Power Supply Setting Flow

Whenever turning on the power supply, it must be done in accordance to the following procedure.

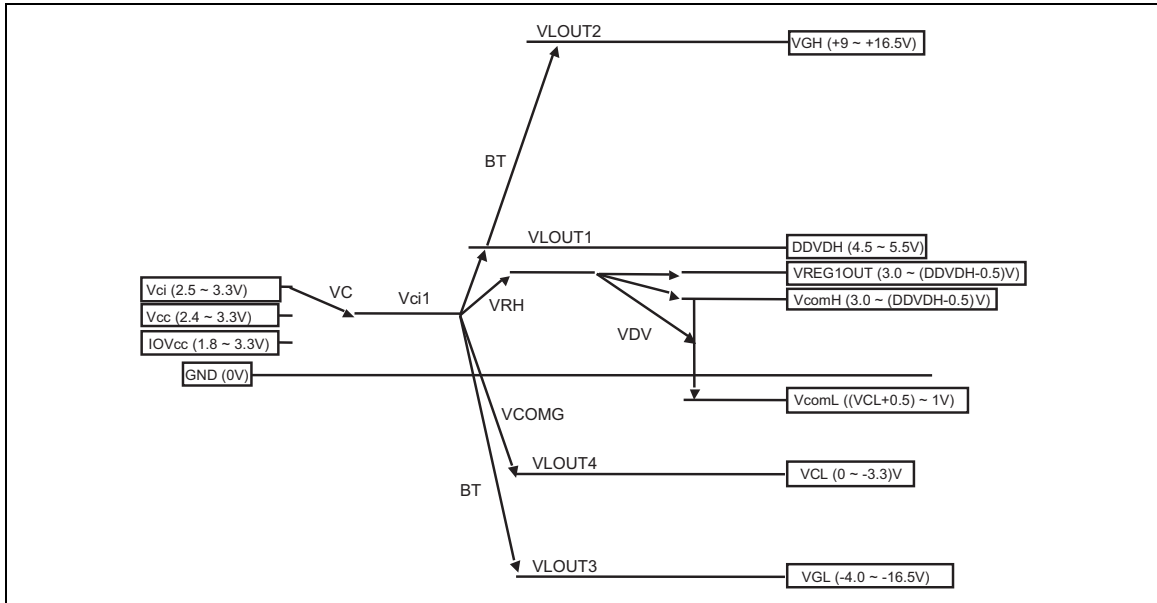
The stabilization time for the oscillation circuits, step-up circuits, and operational amplifiers depends on the external resistors and capacitors.



Power supply setting flow

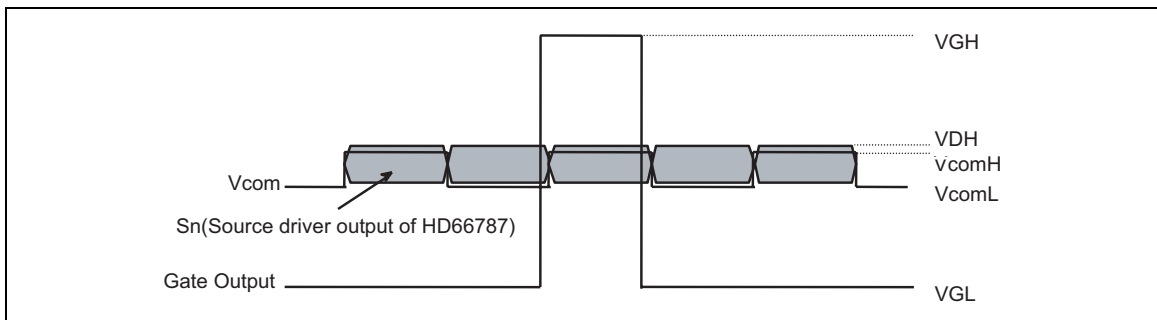
Pattern Diagram for Voltage Setting

The following figures are the pattern diagram of voltage setting for the HD66787 and the voltage waveforms.



Pattern diagram for voltage setting

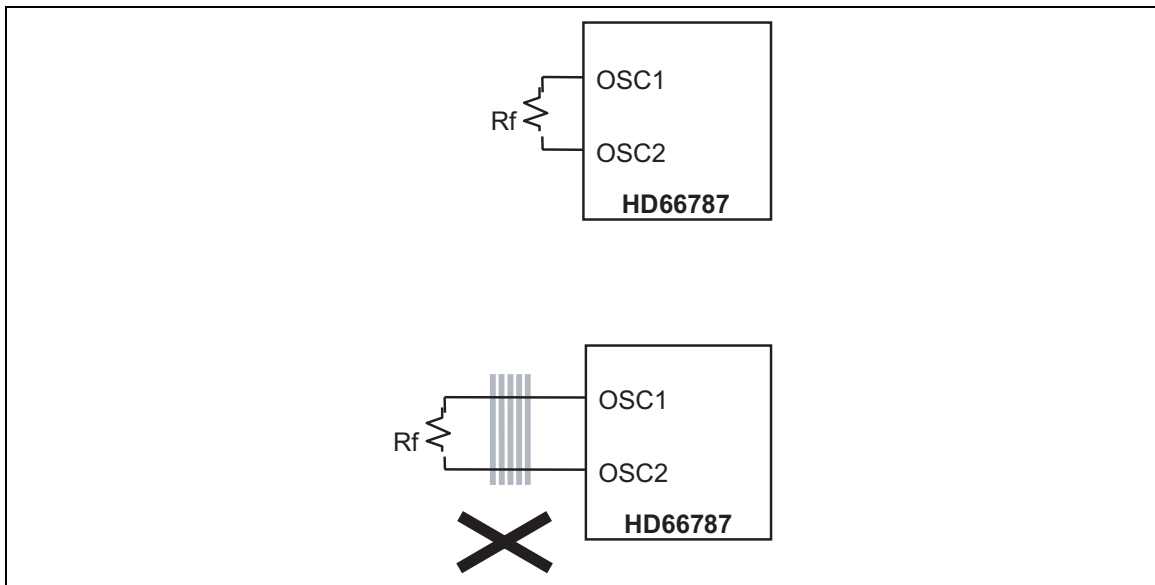
Note 1) Voltage drop occurs in relation to set voltage for each DDVDH, VGH, VGL, VCL output depending on current consumption required for each output. $(DDVDH + VREG1OUT) > 0.5V$ and $(VcomL - VCL) > 0.5V$ show the relationship in relation to the actual voltage. When AC frequency of Vcom1 and Vcom2 is high (e.g. alternation occurs by line), current consumption is also large. In this case, check voltage before use.



Applied voltage to the TFT display

Oscillation Circuit

The HD66787 generates oscillation by internal R-C oscillator with an external oscillation resistor placed between the OSC1 and OSC2 pins. The oscillation frequency varies depending on the value of external resistor, the distance of wiring, and the power supply voltage for the oscillation. For example, the oscillation frequency becomes low when increasing the value of Rf resistor, or lowering the power supply voltage. See the “Electric Characteristics Notes” section for the relationship between the Rf resistor value and the oscillation frequency.



External Resistor Oscillation Mode

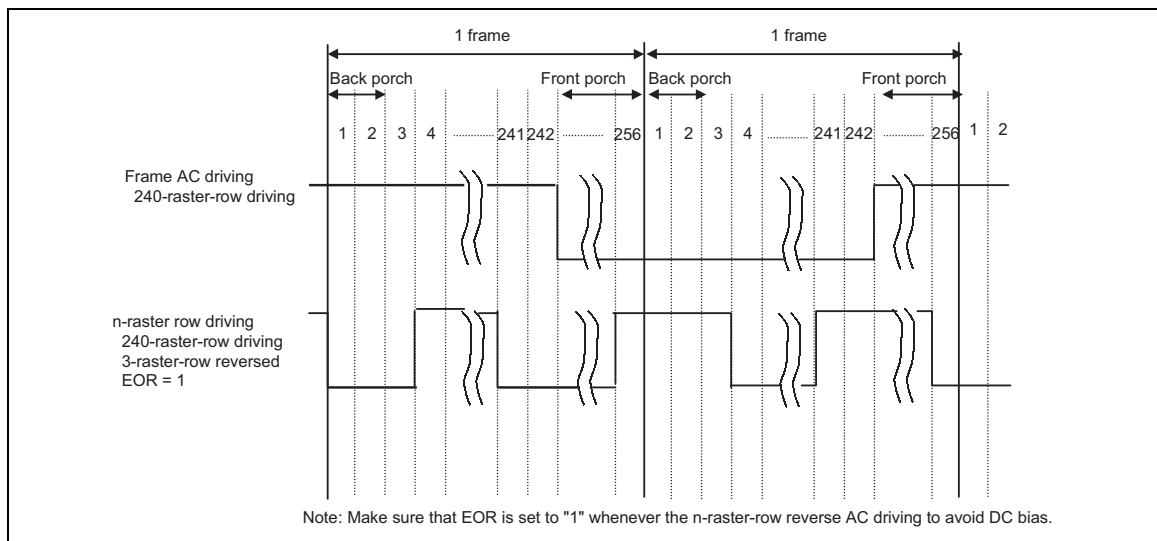
Note 1) Place the Rf resistor close to the OSC1, OSC2 pins.

Note 2) Make sure not to arrange other wiring beneath or close to OSC1-OSC2 wiring to avoid effects from coupling.

n-raster-row inversion AC drive

The HD66787, in addition to LCD inversion AC drive by frame, supports n-raster-row inversion AC drive where alternation occurs by n raster-rows, where n takes a number between 1 to 64. The n-raster-row inversion AC drive enables to overcome the problems related to display quality.

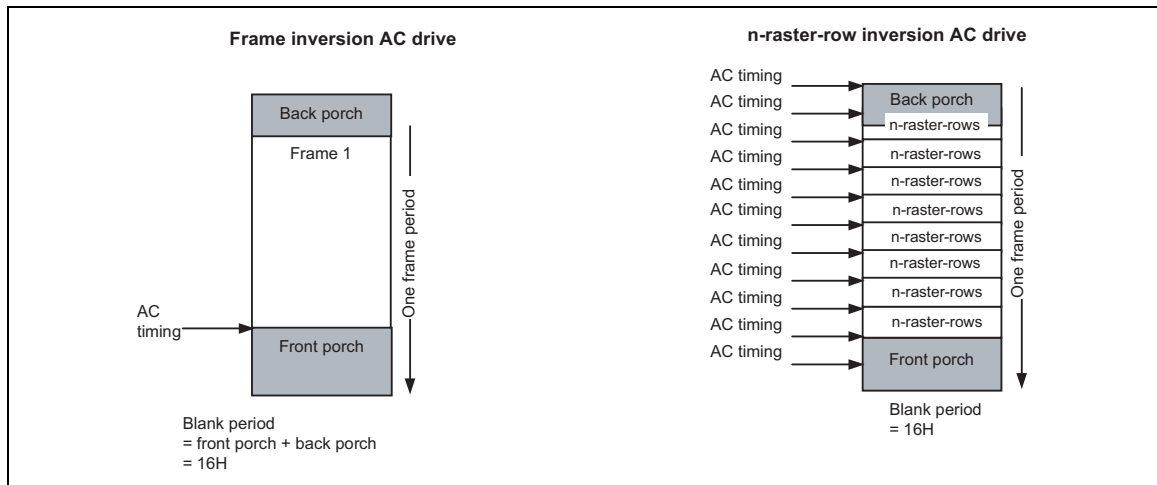
In determining n (the value set in the NW bit +1), the number of raster-rows by which alternation occurs, check the display quality on the actual liquid crystal panel. Setting a small number of raster-rows will raise the AC frequency of the liquid crystal and increase the charge/discharge current on the liquid crystal cells.



n-raster-rows inversion AC drive

AC Timing

The AC timings of frame inversion AC drive and n-raster-row inversion drive are illustrated as follows. In case of frame inversion AC drive, alternation occurs at the completion of drawing one frame, followed by a blank, which lasts for 16H periods. In case of n-raster-row, a blank lasting 16H period is inserted after drawing a full screen.



AC drive timing

Frame-Frequency Adjustment Function

The HD66787 incorporates frame frequency adjustment function. The frame frequency during the liquid crystal drive is adjusted by the instruction setting (DIV, RTN) while keeping the oscillation frequency fixed.

Setting the oscillation frequency high in advance allows switching the frame frequency in accordance to the kind of displayed picture (i.e. moving/still picture). When displaying a still picture, set the frame frequency low to save power consumption, while setting the frame frequency high when displaying a moving picture which requires high-speed switching of screens.

Relationship between Liquid Crystal Drive Duty and Frame Frequency

The relationship between the liquid crystal drive duty and the frame frequency is calculated by the following formula. The frame frequency is adjusted through the instruction setting with the 1-H period adjustment bit (RTN bit) and the operation clock division bit (DIV bit).

(Formula for the frame frequency)

$$\text{Frame frequency} = \frac{\text{fosc}}{\text{Clock cycles per raster-row} \times \text{division ratio} \times (\text{Line} + \text{BP} + \text{FP})} \quad [\text{Hz}]$$

fosc: R-C oscillation frequency

Line: number of drive raster-rows (NL bit)

Clock cycles per raster-row: RTN bit

Division ratio: DIV bit

The number of raster-rows for the front porch: FP

The number of raster-rows for the back porch: BP

Calculation Example The maximum frame frequency = 60 Hz

Number of driven raster-rows: 240

1-H period: 16 clock cycles (RTN3-0 = 0000)

Operation clock division ratio: 1 division

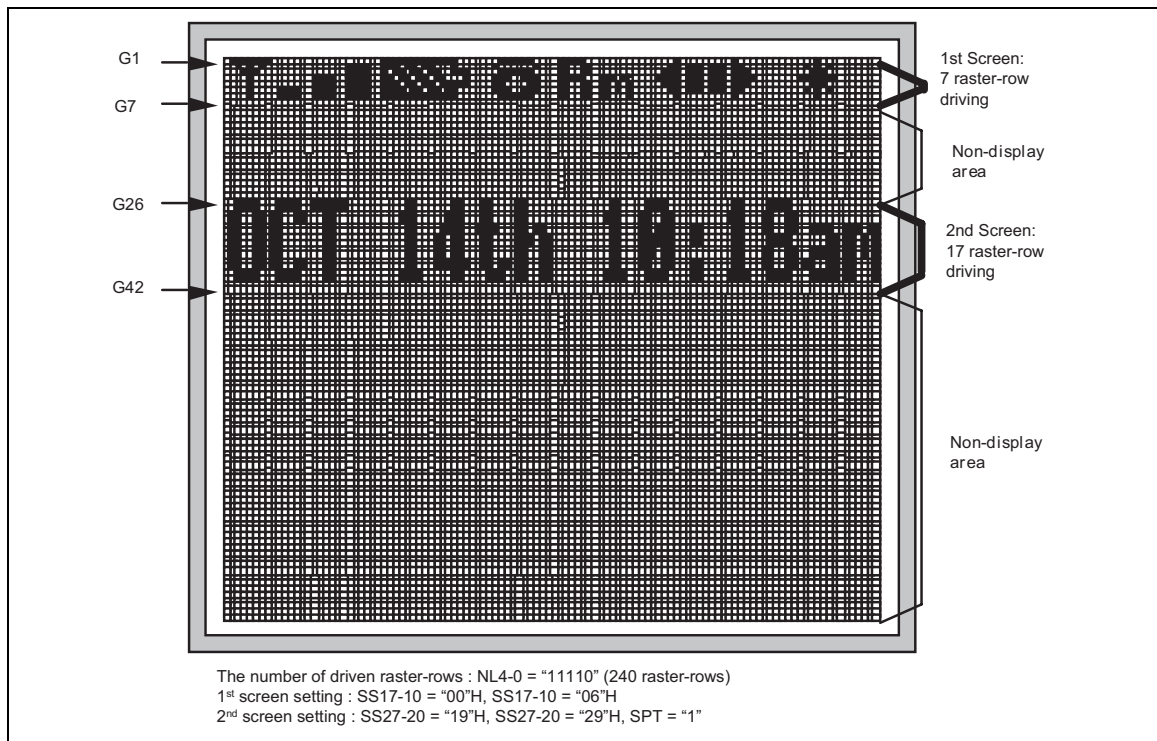
$$\text{fosc} = 60 \text{ Hz} \times (0 + 16) \text{ clock} \times 1 \text{ division} \times (240 + 16) \text{ lines} = 246 \text{ (kHz)}$$

In this case, the R-C oscillation frequency becomes 246 kHz. Adjust the external resistor to the R-C oscillator to 246 kHz.

Screen-split Display Function

The HD66787 allows selectively driving two screens at arbitrary positions with the screen-drive position registers (R42 and R43). Only the raster-rows required to display two screens at arbitrary positions are selectively driven to reduce power consumption.

The first screen drive position register (R42) specifies the start line (SS17-10) and the end line (SE17-10) for displaying the first screen. The second screen drive position register (R43) specifies the start line (SS27-20) and the end line (SE27-20) for displaying the second screen. The second screen control is effective when the SPT bit is set to 1. The total number of raster-rows driven for displaying the first and second screens must be less than the number of liquid crystal drive raster-rows.



Screen-split drive

Notes to the setting of 1st/2nd screen drive position registers

When making settings for the start line (SS17-10) and end line (SE17-10) of the first screen drive position register (R42), and the start line (SS27-20) and end line (SE27-20) of the second screen drive position register (R43) with the HD66787, it is necessary to satisfy the following conditions to display screens correctly.

One Screen Drive (SPT = 0)

| Register Settings | Display Operation |
|------------------------------|--|
| $(SE17-10) - (SS17-10) = NL$ | Full screen display The area of $(SE17-10) - (SS17-10)$ is normally displayed. |
| $(SE17-10) - (SS17-10) < NL$ | Partial screen display The area of $(SE17-10) - (SS17-10)$ is normally displayed. The rest of the area is white display irrespective of data in RAM. |
| $(SE17-10) - (SS17-10) > NL$ | Setting disabled |

Note 1) $SS17-10 \leq SE17-0 \leq "EF"H$
 Note 2) Setting disabled for SS27-20 and SE27-20.

Two Screen Drive (SPT = 1)

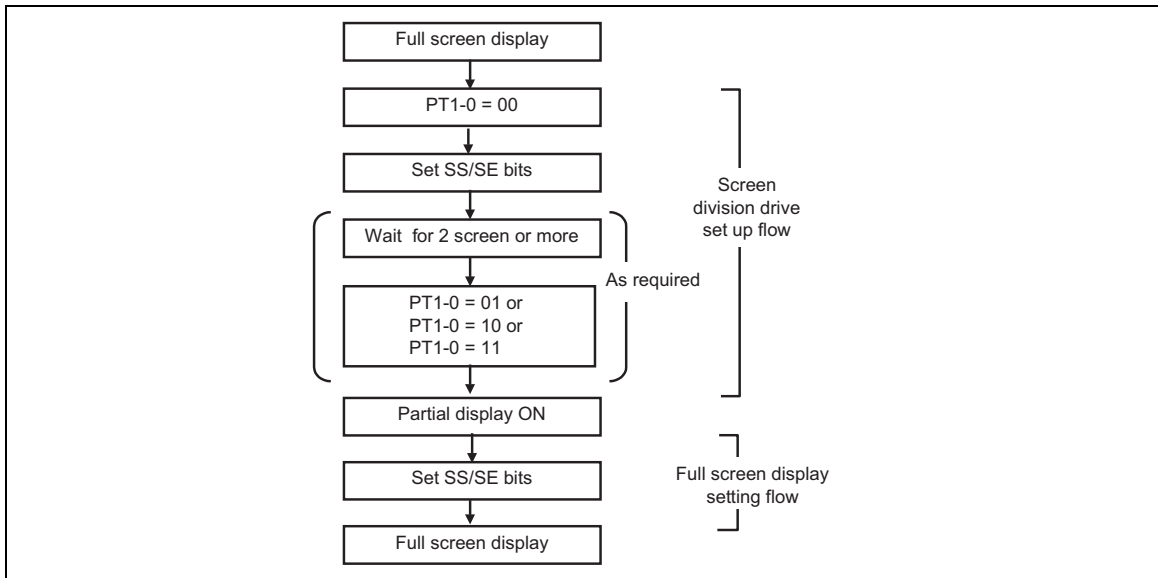
| Register Settings | Display Operation |
|--|--|
| $((SE17-10) - (SS17-10)) + ((SE27-20) - (SS27-20)) = NL$ | Full screen display The area of $(SE27-20) - (SS17-10)$ is normally displayed. |
| $((SE17-10) - (SS17-10)) + ((SE27-20) - (S27-20)) < NL$ | Partial screen display The area of $(SE27-10) - (SS17-10)$ is normally displayed. The rest of the area is white display irrespective of data in RAM. |
| $((SE17-10) - (SS17-10)) + ((SE27-20) - (SS27-20)) > NL$ | Setting disabled |

Note 1) Make sure that $SS17-10 \leq SE17-10 < SS27-20 \leq SE27-20 \leq EFH$.
 Note 2) Make sure that $((SE27-20) - (SS17-10)) \leq NL$.

The setting for the driver output in the non-display area during the partial display is changeable according to the characteristics of the display panel.

Source outputs in non-display area

| PT1 | PT0 | Source Output for Non-display Area | |
|-----|-----|------------------------------------|-------------------|
| | | Positive Polarity | Negative Polarity |
| 0 | 0 | V31 | V0 |
| 0 | 1 | V31 | V0 |
| 1 | 0 | GND | GND |
| 1 | 1 | High-Z | High-Z |



Partial display setting flow

Absolute Maximum Values

| Item | Symbol | Unit | Value | Notes |
|--------------------------|-------------|------|------------------|-------|
| Power supply voltage (1) | Vcc | V | -0.3 ~ + 4.6 | 1, 2 |
| Power supply voltage (2) | Vci - GND | V | -0.3 ~ + 4.6 | 1, 2 |
| Power supply voltage (3) | DDVDH - GND | V | -0.3 ~ + 6.0 | 1, 2 |
| Power supply voltage (4) | GND -VCL | V | -0.3 ~ + 4.6 | 1, 2 |
| Power supply voltage (5) | DDVDH - VCL | V | -0.3 ~ + 9.0 | 1 |
| Power supply voltage (6) | VGH - GND | V | -0.3 ~ + 18.5 | 1, 2 |
| Power supply voltage (7) | GND - VGL | V | -0.3 ~ + 18.5 | 1, 2 |
| Input voltage | Vt | V | -0.3 ~ Vcc + 0.3 | 1 |
| Operating temperature | Topr | °C | -40 ~ + 85 | 1, 3 |
| Storage temperature | Tstg | °C | -55 ~ + 110 | 1 |

Note 1) The LSI may be permanently damaged if it is used under the condition exceeding the above absolute maximum values. It is also recommended to use the LSI within the limit of its electric characteristics during normal operation. Exceeding the conditions may lead to malfunction of LSI and affect its credibility.

Note 2) The voltage from GND.

Note 3) The DC and AC characteristics of chip and wafer products are guaranteed at 85 °C.

Electric Characteristics (T.B.D.)

DC Characteristics

($V_{CC} = 1.8$ to 3.7 V, $T_a = -40$ to $+85^\circ\text{C}$ ^{Note 1})

| Item | Symbol | Unit | Test Condition | Min | Typ | Max | Notes |
|---|--------------|---------------|---|--------------|-----|--------------|-------|
| Input high voltage | V_{IH} | V | $V_{CC} = 1.8$ to 3.7 V | $0.7 V_{CC}$ | — | V_{CC} | 2, 3 |
| Input low voltage (1) (OSC1 pin) | V_{IL1} | V | $V_{CC} = 1.8$ to 3.7 V | -0.3 | — | $0.15V_{CC}$ | 2, 3 |
| Input low voltage (2) (Except OSC1 pin) | V_{IL2} | V | $V_{CC}=1.8\text{V}$ to 2.4V | -0.3 | — | $0.15V_{CC}$ | 2,3 |
| | | | $V_{CC}=2.4\text{V}$ to 3.7V | -0.3 | — | $0.2V_{CC}$ | 2,3 |
| Output high voltage (1) (DB0-17 pins) | V_{OH1} | V | $I_{OH} = -0.1$ mA | $0.75V_{CC}$ | — | — | 2 |
| Output low voltage (1) (DB0-17 pins) | V_{OL1} | V | $V_{CC} = 1.8$ to 2.4 V, $I_{OL} = 0.1$ mA | — | — | $0.2 V_{CC}$ | 2 |
| | | | $V_{CC} = 2.4$ to 3.7 V, $I_{OL} = 0.1$ mA | — | — | $0.15V_{CC}$ | 2 |
| I/O leakage current | I_{Li} | μA | $V_{in} = 0$ to V_{CC} | -1 | — | 1 | 4 |
| Current consumption during normal operation ($V_{CC} - \text{GND}$) | I_{OP} | μA | R-C oscillation; $f_{osc} =$ 250kHz (240line) $V_{CC} = 3.0$ V, $T_a = 25^\circ\text{C}$, RAM data 0000h | — | 190 | 300 | 5,6 |
| Current consumption during standby mode ($V_{CC} - \text{GND}$) | I_{ST} | μA | $V_{CC} = 2\text{V}$, $T_a \leq -50^\circ\text{C}$ | — | 0.1 | 5 | |
| | | | $V_{CC} = 3\text{V}$, $T_a > 50^\circ\text{C}$ | — | — | 20 | 5 |
| Liquid Crystal Power Current (DDVDH-GND) | I_{LCD} | μA | $V_{CC}=3\text{V}$, $V_{LCD}=5.5\text{V}$, $V_{DH}=5.0\text{V}$, CR Oscillation; $f_{osc}=250\text{kHz}(240\text{line})$, $T_a=25^\circ\text{C}$, RAMdata:0000h, REV="0", SAP="001", VRN4-0="0", PKP52- 00="0", PRP12-00="0", VRN4-0=VRP4-0="0" PKP52-00="0", PRP12- 00="0" | — | 500 | 650 | 5,6 |
| Liquid Crystal Drive Voltage(DDVDH-GND) | V_{LCD} | V | — | 4.5 | — | 5.5 | — |
| Output Voltage deviation | ΔV_o | mV | — | — | 5 | — | 7 |
| Variation of average output voltage | | mV | — | — | — | 35 | 8 |

AC Characteristics

(V_{CC} = 1.7 to 3.7 V, Ta = -40 to +85°C ^{Note 1})Clock Characteristics (V_{CC} = 1.8 to 3.7 V)

| Item | Symbol | Unit | Test Condition | Min | Typ | Max | Notes |
|---------------------------|--------|------|--------------------------------|-----|-----|-----|-------|
| External clock frequency | fcp | kHz | V _{CC} = 1.8 to 3.3 V | 100 | 270 | 600 | 9 |
| External clock duty ratio | Du | % | V _{CC} = 1.8 to 3.3 V | 45 | 50 | 55 | 9 |
| External clock rise time | trcp | μs | V _{CC} = 1.8 to 3.3 V | — | — | 0.2 | 9 |
| External clock fall time | tfcp | μs | V _{CC} = 1.8 to 3.3 V | — | — | 0.2 | 9 |
| R-C oscillation clock | fOSC | kHz | Rf = TBD V _{CC} = 3 V | 244 | 305 | 366 | 10 |

80-system Bus Interface Timing Characteristics

Normal Write Mode (HWM=0) (V_{CC} = 1.8 to 2.4 V)

| Item | Symbol | Unit | Test Condition | Min | Typ | Max | |
|------------------------------|-----------------------------------|-------------------|----------------|----------|-----|-----|---|
| Bus cycle time | Write | t _{CYCW} | ns | Figure 2 | 600 | — | — |
| | Read | t _{CYCR} | ns | Figure 2 | 800 | — | — |
| Write low-level pulse width | PW _{LW} | ns | Figure 2 | 90 | — | — | |
| Read low-level pulse width | PW _{LR} | ns | Figure 2 | 350 | — | — | |
| Write high-level pulse width | PW _{HW} | ns | Figure 2 | 300 | — | — | |
| Read high-level pulse width | PW _{HR} | ns | Figure 2 | 400 | — | — | |
| Write/Read rise/fall time | t _{WRr, WRf} | ns | Figure 2 | — | — | 25 | |
| Setup time | Write (RS to CS* ¹) | t _A | ns | Figure 2 | 0 | — | — |
| | Read (RS to CS* ¹ RD*) | t _A | ns | Figure 2 | 10 | — | — |
| Address hold time | t _A | ns | Figure 2 | 5 | — | — | |
| VLD setup time | t _{VS} | ns | Figure 2 | 60 | — | — | |
| VLD hold time | t _{VH} | ns | Figure 2 | 15 | — | — | |
| Write data set up time | t _{DSW} | ns | Figure 2 | 60 | — | — | |
| Write data hold time | t _H | ns | Figure 2 | 15 | — | — | |
| Read data delay time | t _{DDR} | ns | Figure 2 | — | — | 200 | |
| Read data hold time | t _{DHR} | ns | Figure 2 | 5 | — | — | |

High-Speed Write Mode (HWM=1) (Vcc = 1.8 to 2.4 V)

| Item | Symbol | Unit | Test Condition | Min | Typ | Max | |
|------------------------------|------------------------|-------------------|----------------|----------|-----|-----|---|
| Bus cycle time | Write | t _{CYCW} | ns | Figure 2 | 200 | — | — |
| | Read | t _{CYCR} | ns | Figure 2 | 800 | — | — |
| Write low-level pulse width | PW _{LW} | ns | Figure 2 | 90 | — | — | |
| Read low-level pulse width | PW _{LR} | ns | Figure 2 | 350 | — | — | |
| Write high-level pulse width | PW _{HW} | ns | Figure 2 | 90 | — | — | |
| Read high-level pulse width | PW _{HR} | ns | Figure 2 | 400 | — | — | |
| Write/Read rise/fall time | t _{WRr, WRf} | ns | Figure 2 | — | — | 25 | |
| Set up time | Write (RS to CS*, WR*) | | ns | Figure 2 | 0 | — | — |
| | Read (RS to CS*, RD*) | | ns | Figure 2 | 10 | — | — |
| Address hold time | t _{AH} | ns | Figure 2 | 5 | — | — | |
| VLD setup time | t _{VS} | ns | Figure 2 | 60 | — | — | |
| VLD hold time | t _{VH} | ns | Figure 2 | 15 | — | — | |
| Write data set up time | t _{DSW} | ns | Figure 2 | 60 | — | — | |
| Write data hold time | t _H | ns | Figure 2 | 15 | — | — | |
| Read data delay time | t _{DDR} | ns | Figure 2 | — | — | 200 | |
| Read data hold time | t _{DHR} | ns | Figure 2 | 5 | — | — | |

Normal Write Mode (HWM=0) : Vcc = 2.4 to 3.7 V

| Item | Symbol | Unit | Test Condition | Min | Typ | Max | |
|------------------------------|------------------------|-------------------|----------------|----------|-----|-----|---|
| Bus cycle time | Write | t _{CYCW} | ns | Figure 2 | 250 | — | — |
| | Read | t _{CYCR} | ns | Figure 2 | 500 | — | — |
| Write low-level pulse width | PW _{LW} | ns | Figure 2 | 40 | — | — | |
| Read low-level pulse width | PW _{LR} | ns | Figure 2 | 250 | — | — | |
| Write high-level pulse width | PW _{HW} | ns | Figure 2 | 70 | — | — | |
| Read high-level pulse width | PW _{HR} | ns | Figure 2 | 200 | — | — | |
| Write/Read rise/fall time | t _{WRr, WRf} | ns | Figure 2 | — | — | 25 | |
| Set up time | Write (RS to CS*, WR*) | | ns | Figure 2 | 0 | — | — |
| | Read (RS to CS*, WR*) | | ns | Figure 2 | 10 | — | — |
| Address hold time | t _{AH} | ns | Figure 2 | 2 | — | — | |
| VLD set up time | t _{VS} | ns | Figure 2 | 25 | — | — | |
| VLD hold time | t _{VH} | ns | Figure 2 | 2 | — | — | |
| Write data setup time | t _{DSW} | ns | Figure 2 | 25 | — | — | |
| Write data hold time | t _H | ns | Figure 2 | 2 | — | — | |
| Read data delay time | t _{DDR} | ns | Figure 2 | — | — | 200 | |
| Read data hold time | t _{DHR} | ns | Figure 2 | 5 | — | — | |

High-Speed Write Mode (HWM=1) : Vcc = 2.4 to 3.7 V

| Item | Symbol | Unit | Test Condition | Min | Typ | Max |
|-------------------------------|------------------------|---------------|----------------|-----|-----|-----|
| Bus cycle time | Write | t_{CYCW} | Figure 2 | 100 | — | — |
| | Read | t_{CYCR} | | 500 | — | — |
| Write low-level pulse width | PW_{LW} | ns | Figure 2 | 40 | — | — |
| Read low-level pulse width | PW_{LR} | ns | Figure 2 | 250 | — | — |
| Write high -level pulse width | PW_{HW} | ns | Figure 2 | 40 | — | — |
| Read high -level pulse width | PW_{HR} | ns | Figure 2 | 200 | — | — |
| Write/Read rise/fall time | $t_{WRr, WRf}$ | ns | Figure 2 | — | — | — |
| Set up time | Write (RS to CS*, WR*) | $t_{WR, WRf}$ | Figure 2 | 0 | — | 25 |
| | Read (RS to CS*, RD*) | | | 10 | — | — |
| Address hold time | t_{AH} | ns | Figure 2 | 2 | — | — |
| VLD set-up time | t_{VS} | ns | Figure 2 | 25 | — | — |
| VLD hold time | t_{VH} | ns | Figure 2 | 2 | — | — |
| Write data set up time | t_{DSW} | ns | Figure 2 | 25 | — | — |
| Write data hold time | t_H | ns | Figure 2 | 2 | — | — |
| Read data delay time | t_{DDR} | ns | Figure 2 | — | — | 200 |
| Read data hold time | t_{DHR} | ns | Figure 2 | 5 | — | — |

Serial Peripheral Interface Timing Characteristics

V_{CC} = 1.8 to 2.4 V

| Item | Symbol | Unit | Test Condition | Min | Typ | Max | |
|-------------------------------------|------------------------|-------------------|----------------|----------|-----|-----|----|
| Serial clock cycle time | Write (received) | t _{SCYC} | us | Figure 3 | 0.1 | — | 20 |
| | Read (transmitted) | t _{SCYC} | us | Figure 3 | 0.5 | — | 20 |
| Serial clock high-level pulse width | Write (received) | t _{SCH} | ns | Figure 3 | 40 | — | — |
| | Read (transmitted) | t _{SCH} | ns | Figure 3 | 230 | — | — |
| Serial clock low-level pulse width | Write (received) | t _{SCL} | ns | Figure 3 | 40 | — | — |
| | Read (transmitted) | t _{SCL} | ns | Figure 3 | 230 | — | — |
| Serial clock rise/fall time | t _{scr, tscf} | ns | Figure 3 | — | — | 20 | |
| Chip select set up time | t _{CSU} | ns | Figure 3 | 20 | — | — | |
| Chip select hold time | t _{CH} | ns | Figure 3 | 60 | — | — | |
| Serial input data set up time | t _{SISU} | ns | Figure 3 | 30 | — | — | |
| Serial input data hold time | t _{SIH} | ns | Figure 3 | 30 | — | — | |
| Serial input data delay time | t _{SOD} | ns | Figure 3 | — | — | 200 | |
| Serial input data hold time | t _{SOH} | ns | Figure 3 | 5 | — | — | |

V_{CC} = 2.4 to 3.3 V

| Item | Symbol | Unit | Test Condition | Min | Typ | Max | |
|-------------------------------------|-----------------------|-------------------|----------------|----------|------|-----|----|
| Serial clock cycle time | Write (receive) | t _{SCYC} | us | Figure 3 | 0.1 | — | 20 |
| | Read (send) | t _{SCYC} | us | Figure 3 | 0.35 | — | 20 |
| Serial clock high-level pulse width | Write (receive) | t _{SCH} | ns | Figure 3 | 40 | — | — |
| | Read (send) | t _{SCH} | ns | Figure 3 | 150 | — | — |
| Serial clock low-level pulse width | Write (receive) | t _{SCL} | ns | Figure 3 | 40 | — | — |
| | Read (send) | t _{SCL} | ns | Figure 3 | 150 | — | — |
| Serial clock rise/fall time | t _{scr, scf} | ns | Figure 3 | — | — | 20 | |
| Chip select set up time | t _{CSU} | ns | Figure 3 | 20 | — | — | |
| Chip select hold time | t _{CH} | ns | Figure 3 | 60 | — | — | |
| Serial input data set up time | t _{SISU} | ns | Figure 3 | 30 | — | — | |
| Serial input data hold time | t _{SIH} | ns | Figure 3 | 30 | — | — | |
| Serial output data delay time | t _{SOD} | ns | Figure 3 | — | — | 130 | |
| Serial output data hold time | t _{SOH} | ns | Figure 3 | 5 | — | — | |

Reset Timing Characteristics ($V_{CC} = 1.8$ to 3.7 V)

| Item | Symbol | Unit | Test Condition | Min | Typ | Max |
|-----------------------|-----------|------|----------------|-----|-----|-----|
| Reset low-level width | t_{RES} | ms | Figure 4 | 1 | — | — |
| Reset rise time | t_{RES} | μs | Figure 4 | — | — | 10 |

T.B.D.

RGB interface timing characteristics

18/16 bit RGB interface (HWM =1), Vcc = 1.8V to 2.4V

| Item | Symbol | Unit | Test Condition | min. | typ. | max. |
|--|--------------|-------|----------------|------|------|------|
| VSYNC/HSYNC Set up time | tSYNCS | clock | Figure 5 | 0 | — | 1 |
| ENABLE Set up time | tENS | ns | Figure 5 | 20 | — | — |
| ENABLE Hold time | tENH | ns | Figure 5 | 80 | — | — |
| VLD Set up time | tVLS | ns | Figure 5 | 20 | — | — |
| VLD Hold time | tVLH | ns | Figure 5 | 80 | — | — |
| DOTCLK "Low" Level pulse width | PWDL | ns | Figure 5 | 90 | — | — |
| DOTCLK "High" Level pulse width | PWDH | ns | Figure 5 | 90 | — | — |
| DOTCLK cycle time | tCYCD | ns | Figure 5 | 200 | — | — |
| Data Set up time | tPDS | ns | Figure 5 | 20 | — | — |
| Data Hole time | tPDH | ns | Figure 5 | 80 | — | — |
| DOTCLK, VSYNC, HSYNC rising and falling time | trgbr, trgbf | ns | Figure 5 | — | — | 25 |

18/16 bit RGB interface (HWM = 1), Vcc = 2.4V to 3.7 V

| Item | Symbol | Unit | Test Condition | min. | typ. | max. |
|--|--------------|-------|----------------|------|------|------|
| VSYNC/HSYNC Set up time | tSYNCS | clock | Figure 5 | 0 | — | 1 |
| ENABLE Set up time | tENS | ns | Figure 5 | 10 | — | — |
| ENABLE Hold time | tENH | ns | Figure 5 | 20 | — | — |
| VLD Set up time | tVLS | ns | Figure 5 | 10 | — | — |
| VLD Hold time | tVLH | ns | Figure 5 | 40 | — | — |
| DOTCLK "Low" Level pulse width | PWDL | ns | Figure 5 | 40 | — | — |
| DOTCLK "High" Level pulse width | PWDH | ns | Figure 5 | 40 | — | — |
| DOTCLK cycle time | tCYCD | ns | Figure 5 | 100 | — | — |
| Data Set up time | tPDS | ns | Figure 5 | 10 | — | — |
| Data Hole time | tPDH | ns | Figure 5 | 40 | — | — |
| DOTCLK, VSYNC, HSYNC rising and falling time | trgbr, trgbf | ns | Figure 5 | — | — | 25 |

6 bit RGB interface (HWM = 1), Vcc = 1.8V to 2.4 V

| Item | Symbol | Unit | Test Condition | min. | typ. | max. |
|--|--------------|-------|----------------|------|------|------|
| VSYNC/HSYNC Set up time | tSYNCS | clock | Figure 5 | 0 | — | 1 |
| ENABLE Set up time | tENS | ns | Figure 5 | 20 | — | — |
| ENABLE Hold time | tENH | ns | Figure 5 | 50 | — | — |
| VLD Set up time | tVLS | ns | Figure 5 | 20 | — | — |
| VLD Hold time | tVLH | ns | Figure 5 | 65 | — | — |
| DOTCLK "Low" Level pulse width | PWDL | ns | Figure 5 | 50 | — | — |
| DOTCLK "High" Level pulse width | PWDH | ns | Figure 5 | 50 | — | — |
| DOTCLK cycle time | tCYCD | ns | Figure 5 | 120 | — | — |
| Data Set up time | tPDS | ns | Figure 5 | 20 | — | — |
| Data Hold time | tPDH | ns | Figure 5 | 65 | — | — |
| DOTCLK, VSYNC, HSYNC rising and falling time | trgbr, trgbf | ns | Figure 5 | — | — | 25 |

6 bit RGB interface (HWM = 1), Vcc = 2.4V to 3.3 V

| Item | Symbol | Unit | Test Condition | min. | typ. | max. |
|--|-------------------------|-------|----------------|------|------|------|
| VSYNC/HSYNC Set up time | tSYNCS | clock | Figure 5 | 0 | — | 1 |
| ENABLE Set up time | tENS | ns | Figure 5 | 10 | — | — |
| ENABLE Hold time | tENH | ns | Figure 5 | 20 | — | — |
| VLD Set up time | tVLS | ns | Figure 5 | 10 | — | — |
| VLD Hold time | Vcc=2,4 to2,7V tVLH | ns | Figure 5 | 40 | — | — |
| | Vcc=2,7 to 3,7V tVLH | ns | Figure 5 | 30 | — | — |
| DOTCLK "Low" Level pulse width | PWDL | ns | Figure 5 | 30 | — | — |
| DOTCLK "High" Level pulse width | PWDH | ns | Figure 5 | 30 | — | — |
| DOTCLK cycle time | tCYCD | ns | Figure 5 | 70 | — | — |
| Data Set up time | tPDS | ns | Figure 5 | 10 | — | — |
| Data Hole time | Vcc=2,4 to 2,7V tPDH | ns | Figure 5 | 40 | — | — |
| | Vcc=2,7 to 3,7V tPDH | ns | Figure 5 | 30 | — | — |
| DOTCLK, VSYNC, HSYNC rising and falling time | trgbr, trgbf | ns | Figure 5 | — | — | 25 |

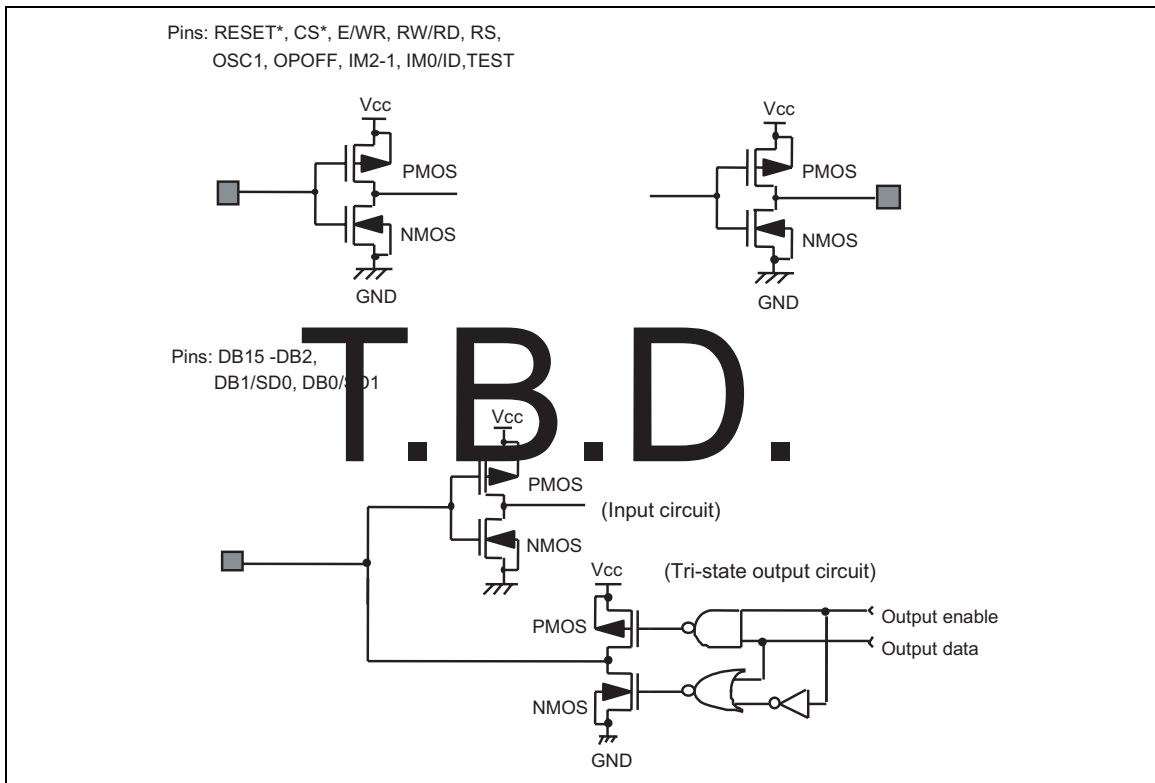
Liquid crystal driver output characteristics

| Item | Symbol | Unit | Test conditions | min. | typ. | max. | Note |
|--------------------------|--------|------|---|------|------|------|------|
| Driver output delay time | tdd | μs | Vcc=3V, VLCD=5.5V, VDH=5.0V, CR oscillation ;fosc=270kHz(240 lines), Ta=25 , REV="0", SAP="001", VRN4-0="0",VRP4-0="0" PKP52-00="0",PRP12-00="0" PKP52-00="0",PRP12-00="0" All pins changes at the same time from same grayscale. The time till output level reaches 35mV when VCOM polarity changes. Load resistance R=10k , Load capacity =20pF | — | 40 | — | (11) |

T.B.D.

Electrical Characteristics Notes

- For bare die and wafer products, specified up to 85°C.
- The following three circuits are I pin, I/O pin, O pin configurations.

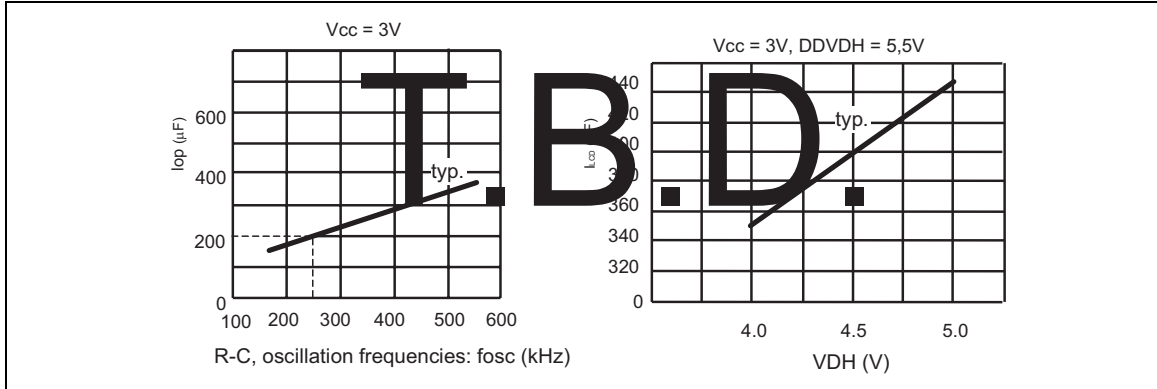


T.B.D.

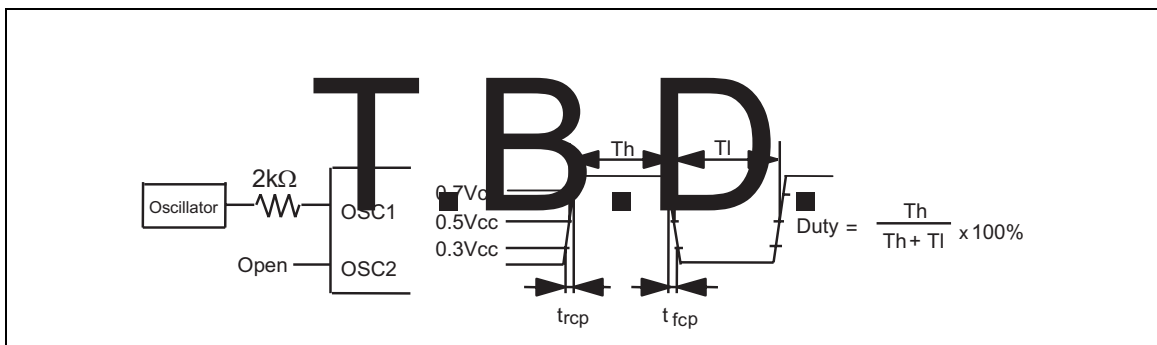
- The TEST pin must be grounded and the IM2/1 and IM0/ID pins must be grounded or connected to Vcc.
- Applies to the resistor value (RSEG) between VSH, GND pins and segment signal pins.

T.B.D.

5. This excludes the current flowing through output drive MOSs. This excludes the current flowing through the input/output units. The input level must be fixed high or low because through current increases if the CMOS input is left floating. Even if the CS pin is low or high when an access with the interface pin is not performed, current consumption does not change.
6. The following figure shows the relationship between the operation frequency and current consumption.



7. This is a voltage difference for the neighboring outputs under the same display condition. The output voltage deviation is a reference value.
8. The fluctuation of average output voltage indicates the difference of average output voltage between chips. The average output voltage is an average voltage within a chip under the same display condition.
9. Applies to the case when clocks are supplied internally (figure).



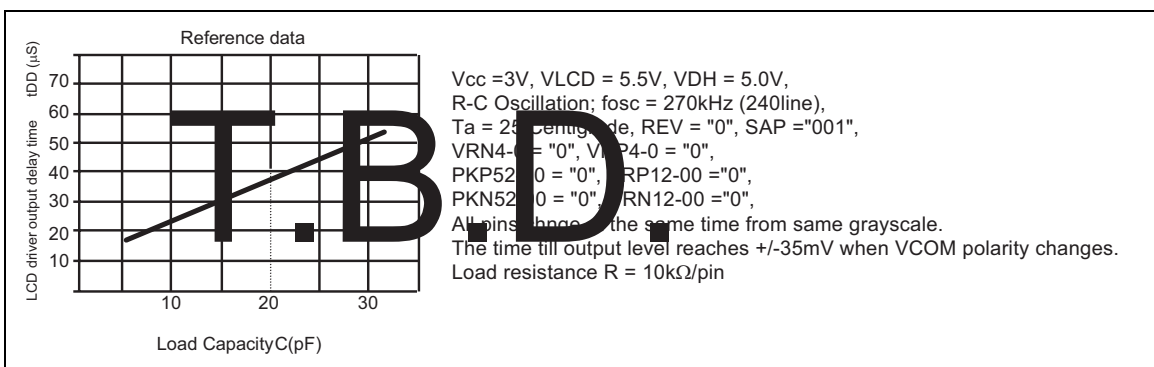
10. Applies to the internal oscillator operations using external oscillation resistor R_f (figure and table).



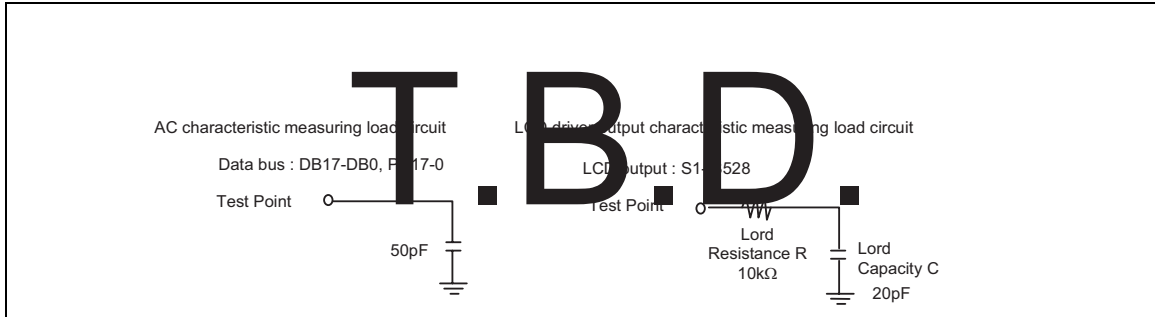
External Resistance Value and R-C Oscillation Frequency (Referential Data)

| External Resistance (Rf) | R-C Oscillation Frequency: fosc | | | | |
|--------------------------|---------------------------------|-----------|-------------|-----------|-------------|
| | Vcc = 1.8 V | Vcc = 2 V | Vcc = 2.4 V | Vcc = 3 V | Vcc = 3.3 V |
| 110 kΩ | 299 | 333 | 372 | 401 | 411 |
| 150 kΩ | 234 | 258 | 284 | 305 | 311 |
| 180 kΩ | 202 | 222 | 243 | 258 | 263 |
| 200 kΩ | 186 | 206 | 222 | 235 | 240 |
| 240 kΩ | 160 | 177 | 188 | 198 | 202 |
| 270 kΩ | 145 | 157 | 169 | 177 | 181 |
| 300 kΩ | 132 | 143 | 153 | 161 | 163 |
| 390 kΩ | 106 | 113 | 121 | 126 | 128 |
| 430 kΩ | 97 | 104 | 110 | 115 | 116 |

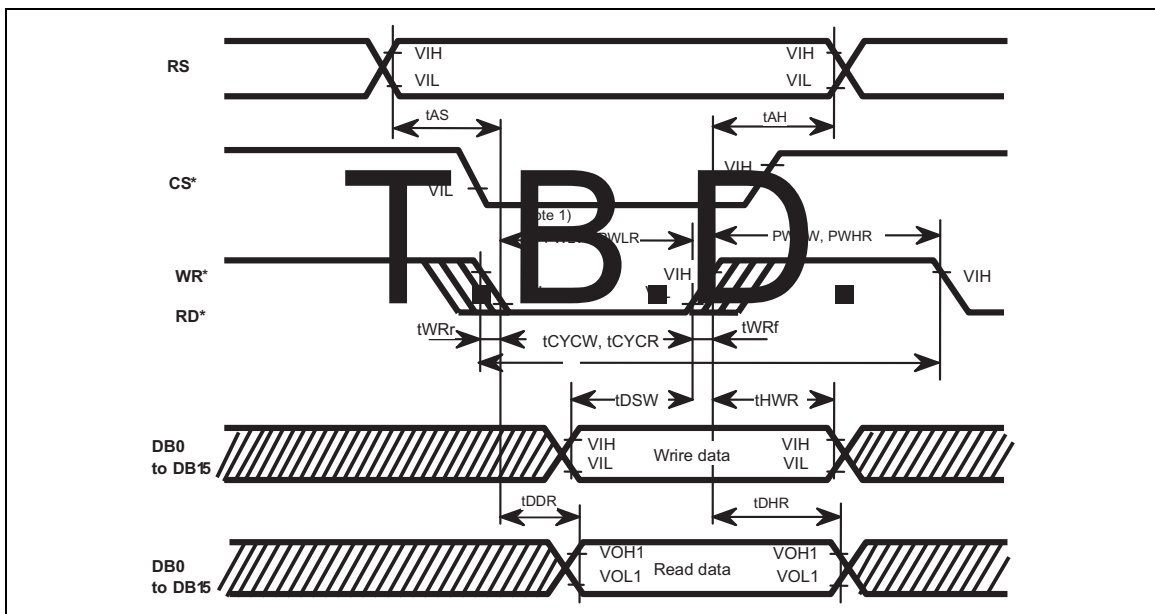
11. Applies to the internal oscillator operations using external oscillation resistor Rf (figure and table).



Load circuits for measuring AC characteristics



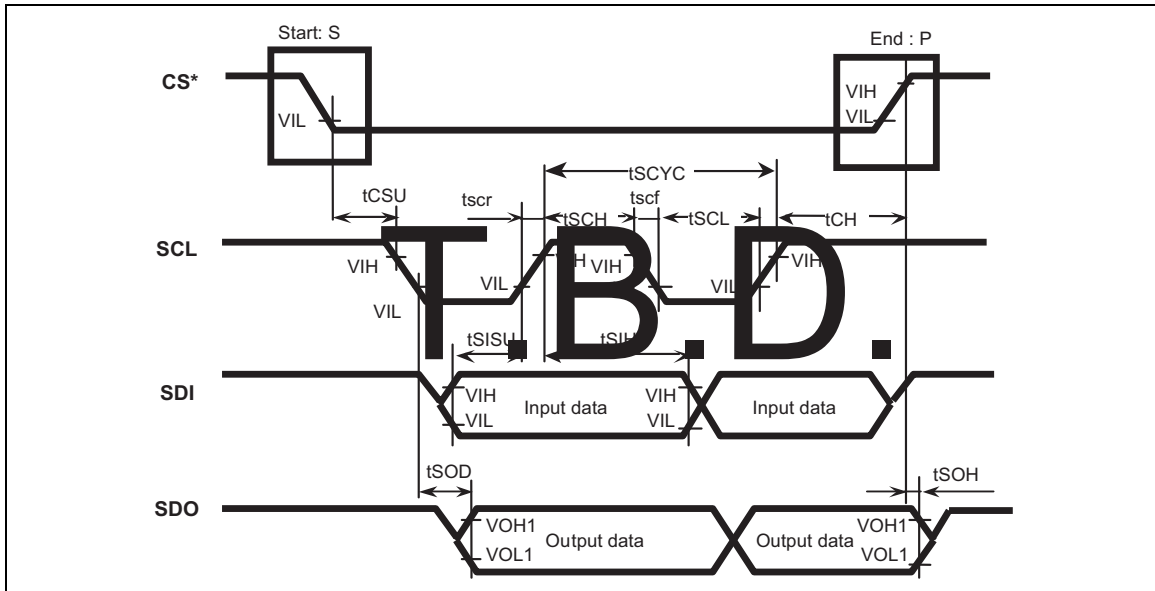
80-system Bus Operation



Note 1) PWLW and PWLR is specified in the overlapped period when CS* is low and WR* or RD* is low.

Note 2) Parallel data transfer is enabled on the DB15-8 pins when the 8-bit bus interface is used. Fix the DB7-0 pins to Vcc or GND.

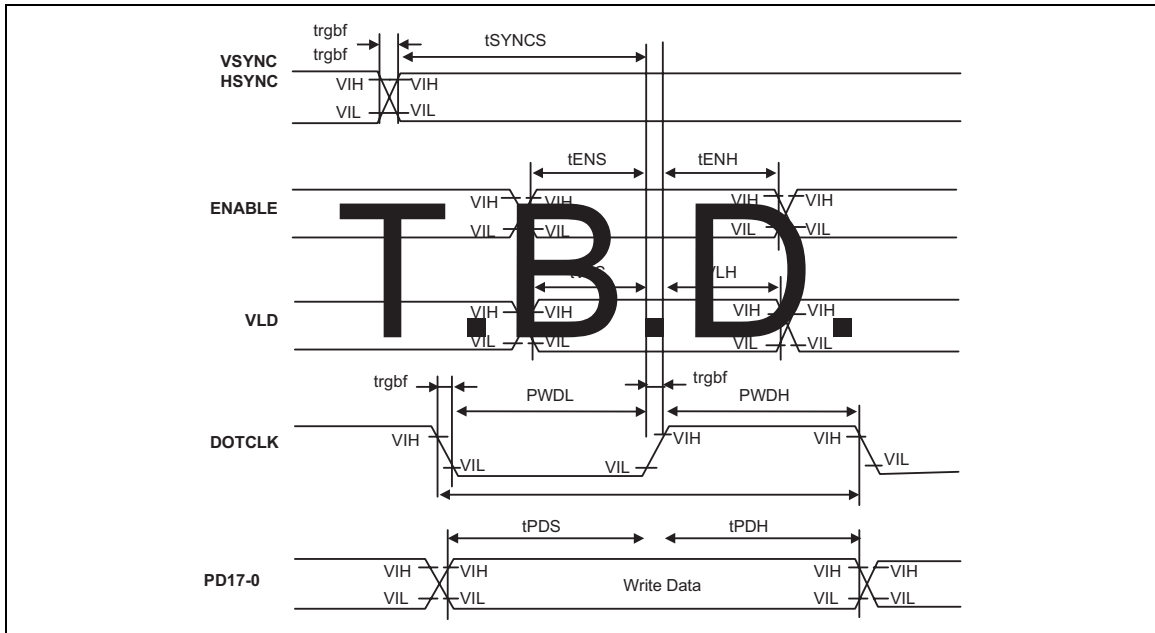
Clock Synchronized Serial Interface Operation



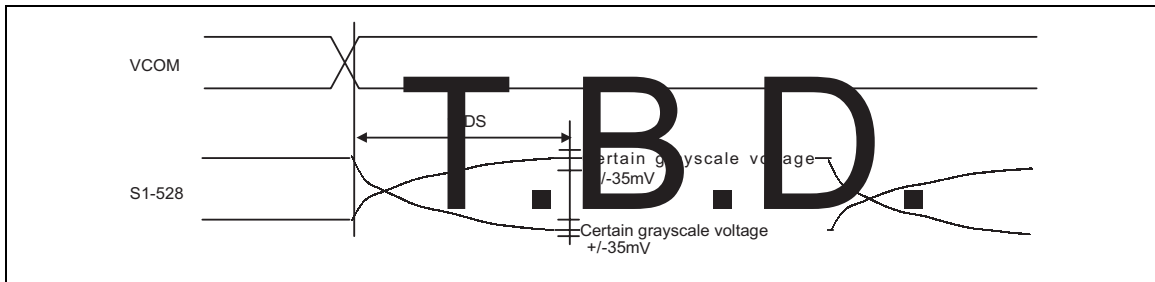
RESET Operation



RGB I/F Operation



Liquid Crystal Driver Output



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