OLED
Character type

Version 3.0
Date: 2013/11/07
1 RECORD OF REVISION ................................................................. 4

2 DESCRIPTION & FEATURES .......................................................... 5

3 APPLICATION CIRCUIT ............................................................... 6
   3.1 Parallel 8-bit 68/80 mode .......................................................... 6
   3.2 Parallel 4-bit 68/80 mode .......................................................... 7
   3.3 3-Line series SPI ................................................................. 8

4 INSTRUCTIONS ................................................................. 9
   4.1 INSTRUCTIONS TABLE ......................................................... 9
   4.2 INSTRUCTION DESCRIPTION .............................................. 12
      4.2.1 CLEAR DISPLAY INSTRUCTION
      4.2.2 RETURN HOME INSTRUCTION
      4.2.3 ENTRY MODE SET INSTRUCTION
      4.2.4 DISPLAY ON/OFF CONTROL INSTRUCTION
      4.2.5 CURSOR/DISPLAY SHIFT INSTRUCTION
      4.2.6 FUNCTION SET INSTRUCTION
      4.2.7 SET CGRAM ADDRESS INSTRUCTION
      4.2.8 SET DDRAM ADDRESS INSTRUCTION
      4.2.9 READ BUSY FLAG AND ADDRESS INSTRUCTION
      4.2.10 WRITE DATA TO CGRAM / DDRAM INSTRUCTION
      4.2.11 READ DATA FROM THE CGRAM OR DDRAM

5 CGRAM .................................................................................... 22

6 Initialization by Instruction .......................................................... 25
   6.1 8-bit mode ................................................................. 25
   6.2 4-bit mode ................................................................. 26

7 MCU Interface ........................................................................... 27
   7.1 6800-series ............................................................. 27
   7.2 8080-series ............................................................. 28
   7.3 SPI-4 ................................................................. 29

8 MCU Interface Timing ............................................................ 31
   8.1 Read / Write Characteristics (6800-series Microprocessor) .................. 31
   8.2 Read / Write Characteristics (8080-series Microprocessor) .................. 32
   8.3 Serial Interface Characteristics ............................................ 33

9 REFERENCE INITIAL CODE ...................................................... 34
   9.1 8BIT-68 interface mode .................................................. 34
   9.2 4BIT-68 interface mode .................................................. 36
OLED Application Note

9.3 8BIT-80 interface mode.................................................................38
9.4 4BIT-80 interface mode.................................................................39
9.5 3-Line series SPI mode.................................................................41
9.6 Graphic mode..............................................................................43

Appendix  Font table ........................................................................... 45


# OLED Application Note

## 1 RECORD OF REVISION

<table>
<thead>
<tr>
<th>Revision Date</th>
<th>Page</th>
<th>Contents</th>
<th>Editor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010/1/20</td>
<td>-</td>
<td>New Release</td>
<td></td>
</tr>
<tr>
<td>2010/11/17</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2010/12/10</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011/3/23</td>
<td>9</td>
<td>Add description for Entry Mode Set command</td>
<td></td>
</tr>
<tr>
<td>2011/4/7</td>
<td>9</td>
<td>Modified the description for Clear Display command</td>
<td></td>
</tr>
<tr>
<td>2011/7/20</td>
<td>7</td>
<td>Modified the SPI circuit</td>
<td></td>
</tr>
<tr>
<td>2011/10/04</td>
<td>10</td>
<td>Modified 4-bit test code</td>
<td></td>
</tr>
<tr>
<td>2012/10/19</td>
<td>10</td>
<td>Modified Instruction Table</td>
<td></td>
</tr>
<tr>
<td>2012/12/05</td>
<td>31~33</td>
<td>Update MPU Interface Timing</td>
<td>Austin</td>
</tr>
<tr>
<td>2013/05/02</td>
<td>10, 17</td>
<td>Modified description for Function Set command.</td>
<td>Austin</td>
</tr>
<tr>
<td>2013/11/07</td>
<td>45~48</td>
<td>Add Appendix Font table</td>
<td>Austin</td>
</tr>
</tbody>
</table>
2. DESCRIPTION
The OLED character displays utilizing CMOS Technology specially designed to display alphanumeric and Japanese kana characters as well as symbols and graphics. It can interface with either 4-bit, 8-bit (8080, 6800) or 3-lin SPI Microprocessor and display two 8-character lines. Display RAM, 4 Character Generator, OLED Driver as well as a wide range of instruction functions such as Display Clear, Cursor Home, Display ON/OFF, Cursor ON/OFF, Display Character Blink, Cursor Shift, Display Shift are all incorporated into the module having the highest performance and reliability. Pin assignments and application circuit are optimized for easy PCB layout and cost saving advantages.

2.1 FEATURES
- IC CMOS technology
- Low power consumption
- Microprocessor Interface
  -- High-speed 8-bit parallel bi-directional interface with 6800-series or 8080-series
  -- Serial interface available
- 4-bit or 8-Bit MPU interface
- High speed MPU interface: 2MHz (VDD=5V)
- 128 x 8-bit display RAM (128 characters max.)
- Auto reset function
- 5 x 8 and 5 x 10 dot matrix
- Built-in oscillator with external resistors
- Programmable duty cycle:
  - 1/8 duty: (1 display line, 5 x 8 dots with cursor)
  - 1/11 duty: (1 display line, 5 x 10 dots with cursor)
  - 1/16 duty: (2 display lines, 5 x 8 dots with cursor)
- Build-in selectable three set of character generator ROM (CGROM)
  - English Japanese Character
  - Western European Character-I
  - English Russian Character
  - Western European Character-II
- 64 x 8-bits character generator RAM (CGRAM)
  - Either 8 character fonts (5 x 8 dot matrix)
  - or 4 character fonts (5 x 10 dot matrix)
- 16 common x 100 segment OLED drivers
- Support graphic mode
- Embedded DC-DC voltage converter
- Package : bare die
3 Application Circuit

3.1 Parallel 8-bit 68/80 mode

| 1  | VSS          | 2  |  | 1  | VSS          |
| 2  | VDD          | 2  |  | 2  | VDD          |
| 3  | 3            | 3  |  | 3  | 3            |
| 4  | P3.0         | 4  |  | 4  | P3.0         |
| 5  | P3.7         | 5  |  | 5  | P3.7         |
| 6  | P3.4         | 6  |  | 6  | P3.4         |
| 7  | P1.0         | 7  |  | 7  | P1.0         |
| 8  | P1.1         | 8  |  | 8  | P1.1         |
| 9  | P1.2         | 9  |  | 9  | P1.2         |
| 10 | P1.3         | 10 |  | 10 | P1.3         |
| 11 | P1.4         | 11 |  | 11 | P1.4         |
| 12 | P1.5         | 12 |  | 12 | P1.5         |
| 13 | P1.6         | 13 |  | 13 | P1.6         |
| 14 | P1.7         | 14 |  | 14 | P1.7         |
| 15 |              | 15 |  | 15 |              |
| 16 |              | 16 |  | 16 |              |
| 17 |              | 17 |  | 17 |              |
| 18 |              | 18 |  | 18 |              |
| 19 |              | 19 |  | 19 |              |
| 20 |              | 20 |  | 20 |              |

20PIN

MPU

8051 Interface face

VSS
VDD
NC
RS
R/W
E
DB0
DB1
DB2
DB3
DB4
DB5
DB6
DB7
NC
NC
OLED
3.2 Parallel 4-bit 68/80 mode

| 1 | VSS          | 1 | VSS          |
| 2 | VDD          | 2 | VDD          |
| 3 |              | 3 |              |
| 4 | P3.0         | 4 | NC           |
| 5 | P3.7         | 5 | RS           |
| 6 | P3.4         | 6 | R/W          |
| 7 |              | 7 | E            |
| 8 |              | 8 | DB0          |
| 9 |              | 9 | DB1          |
|10 |              |10 | DB2          |
|11 | P1.4         |11 | DB3          |
|12 | P1.5         |12 | DB4          |
|13 | P1.6         |13 | DB5          |
|14 | P1.7         |14 | DB6          |
|15 |              |15 | DB7          |
|16 |              |16 | NC           |
|17 |              |    | NC           |
|18 |              |    |              |
|19 |              |    |              |
|20 |              |    | OLED         |

20PIN

**MPU**

8051 Interface face
3.3 4-Line series SPI

| 1  | VSS          | 1  | VSS          |
| 2  | VDD          | 2  | VDD          |
| 3  |              | 3  | NC           |
| 4  |              | 4  | RS           |
| 5  |              | 5  | R/W          |
| 6  |              | 6  | E            |
| 7  |              | 7  | DB 0         |
| 8  |              | 8  | DB 1         |
| 9  |              | 9  | DB 2         |
| 10 |              | 10 | DB 3         |
| 11 |              | 11 | DB 4         |
| 12 | P1.5 (SCL)  | 12 | DB 5         |
| 13 | P1.6 (SDO)  | 13 | DB 6         |
| 14 | P1.7 (SDI)  | 14 | DB 7         |
| 15 |              | 15 | NC           |
| 16 | CS           | 16 | NC           |
| 17 |              |   |              |
| 18 |              |   |              |
| 19 |              |   |              |
| 20 |              |   |              |

20PIN

MPU

8051 Interface face
4. INSTRUCTIONS

Instruction Register (IR) and Data Register (DR) are the only registers that can be controlled by the MPU. Prior to the commencement of its internal operation, IST0010 temporarily stores the control information to its Instruction Register (IR) and Data Register (DR) in order to easily facilitate interface with various types of MPU. The internal operations of the IST0010 are determined by the signals (RS, R/WB, DB0 to DB7) that are sent from the MPU. These signals are categorized into 4 instruction types, namely:

1. Function Setting Instructions (i.e. Display, Format, Data Length etc.)
2. Internal RAM Address Setting Instructions
3. Data Transfer with Internal RAM Instructions
4. Miscellaneous Function Instructions

The generally used instructions are those that execute data transfers with the internal RAM. However, when the internal RAM addresses are auto incremented/decremented by 1 after each Data Write, the program load of the MPU is lightened. The Display Shift Instruction can be executed at the same time as the Display Data Write, thereby minimizing system development time with maximum programming efficiency.

When an instruction is being executed for an internal operation, only the Busy Flag/Address Read Instruction can be performed. The other instructions are not valid. It should be noted that during the execution of an instruction, the Busy Flag is set to "1". The Busy Flag is set to "0" when the instructions are can be accepted and executed. Therefore, the Busy Flag should be checked to make certain that BF = "0" before sending another instruction from the MPU. If not, the time between the first instruction and the next instruction is longer than the time it takes to execute the instruction itself.
### 4.1 INSTRUCTIONS TABLE

<table>
<thead>
<tr>
<th>Instruction</th>
<th>Code</th>
<th>Description</th>
<th>Max. Execution Time when fsp or fosc = 250KHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear Display</td>
<td>0 0 0 0 0 0 0 0 1</td>
<td>Clears entire display.</td>
<td>6.2ms</td>
</tr>
<tr>
<td>Return Home</td>
<td>0 0 0 0 0 0 0 1 0</td>
<td>Sets DDRAM Address 0 into the Address Counter. Returns shifted display to original position. DDRAM contents remain unchanged. (DB0 is test pin. User should set DB0=0 all the time)</td>
<td>TBD</td>
</tr>
<tr>
<td>Entry Mode Set</td>
<td>0 0 0 0 0 0 0 1 I/D S</td>
<td>Sets cursor move direction and specifies display shift. (These operations are performed during data write and read.) DDRAM address is incremented/decremented by 1. Default value is 0x40</td>
<td>TBD</td>
</tr>
<tr>
<td>Display ON/OFF Control</td>
<td>0 0 0 0 0 0 1 D C B</td>
<td>Sets entire Display (D) ON/OFF. Sets Cursor (C) ON/OFF. Sets Blinking (B) of Cursor Position Character.</td>
<td>TBD</td>
</tr>
<tr>
<td>Cursor/Display Shift/Mode/ Pwr</td>
<td>0 0 0 0 0 1 S/C R/L 0 0</td>
<td>Moves cursor &amp; shifts display without changing DDRAM contents.</td>
<td>TBD</td>
</tr>
<tr>
<td></td>
<td>G/C PWR 1 1</td>
<td>Sets Graphic/Character Mode Sets internal power on/off</td>
<td>TBD</td>
</tr>
<tr>
<td>Function Set</td>
<td>0 0 0 0 1 DL N F FT1 FT0</td>
<td>Sets interface data length (DL), Sets number of display lines (N), Sets Character Font (F), Sets Font Table (FT)</td>
<td>TBD</td>
</tr>
<tr>
<td>Set CGRAM Address</td>
<td>0 0 0 1 ACG ACG ACG ACG ACG</td>
<td>Sets CGRAM Address. CGRAM data is sent and received after this setting.</td>
<td>TBD</td>
</tr>
<tr>
<td>Set DDRAM Address</td>
<td>0 0 1 ADD ADD ADD ADD ADD ADD</td>
<td>Sets DDRAM Address. The DDRAM data is sent and received after this setting.</td>
<td>TBD</td>
</tr>
<tr>
<td>Read Busy Flag &amp; Address</td>
<td>0 1 BF AC AC AC AC AC</td>
<td>Reads Busy Flag (BF) indicating that internal operation is being performed. Reads Address Counter contents.</td>
<td>TBD</td>
</tr>
<tr>
<td>Write data into the CGRAM or DDRAM</td>
<td>1 0</td>
<td>Write Data Writes data into the CGRAM or DDRAM</td>
<td>TBD tADD=TBD</td>
</tr>
<tr>
<td>Read Data from the CGRAM or DDRAM</td>
<td>1 1</td>
<td>Read Data Read data from the CGRAM or DDRAM</td>
<td>TBD tADD=TBD</td>
</tr>
</tbody>
</table>
OLED Application Note

Notes:
1. After the CGRAM/DDRAM Read or Write Instruction has been executed, the RAM Address Counter is incremented or decremented by 1. After the Busy Flag is turned OFF, the RAM Address is updated.
2. I/D=Increment/Decrement Bit
   - I/D="1": Increment
   - I/D="0": Decrement
3. S=Shift Entire Display Control Bit. When S="0", shift function disable.
4. BF=Busy Flag
   - BF="1": Internal Operating in Progress
   - BF="0": No Internal Operation is being executed, next instruction can be accepted.
5. R/L=Shift Right/Left
   - R/L="1": Shift to the Right
   - R/L="0": Shift to the Left
   - S/C="1": Display Shift
   - S/C="0": Cursor Move
7. G/C=Graphic/Character mode selection. G/C="0", Character mode is selected. G/C="1", Graphic mode is selected.
8. PWR=Internal DCDC on/of control. PWR="1", DCDC on. PWR="0", DCDC off.
9. DDRAM=Display Data RAM
10. CGRAM=Character Generator RAM
11. ACG=CGRAM Address
12. ADD=Address Counter Address (corresponds to cursor address)
13. AC=Address Counter (used for DDRAM and CGRAM Addresses)
14. F=Character Pattern Mode
   - F="1": 5 x 10 dots
   - F="0": 5 x 8 dots
15. N=Number of Lines Displayed
   - N="1": 2-Line Display
   - N="0": 1-Line Display
16. tADD is the time period starting when the Busy Flag is turned OFF up to the time the Address Counter is updated. Please refer to the diagram below.

where:

where:
tADD depends on the operation frequency and may be calculated using the following equation

\[ tADD = T.B.D. \text{ seconds} \]
4.2 INSTRUCTION DESCRIPTION

4.2.1 CLEAR DISPLAY INSTRUCTION

<table>
<thead>
<tr>
<th>RS</th>
<th>R/WB</th>
<th>DB7</th>
<th>DB6</th>
<th>DB5</th>
<th>DB4</th>
<th>DB3</th>
<th>DB2</th>
<th>DB1</th>
<th>DB0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

This instruction is used to clear the Display Write Space 20H in all DDRAM Addresses. That is, the character pattern for the Character Code 20H must be a BLANK pattern. It then sets the DDRAM Address 0 into the Address Counter and reverts the display to its original state (if the display has been shifted). The display will be cleared and the cursor or blinking will go to the left edge of the display. If there are 2 lines displayed, the cursor or blinking will go to the first line’s left edge of the display. Under the Entry Mode, this instruction also sets the I/D to 1 (Increment Mode). The S Bit of the Entry Mode does not change.

4.2.2 RETURN HOME INSTRUCTION

<table>
<thead>
<tr>
<th>RS</th>
<th>R/WB</th>
<th>DB7</th>
<th>DB6</th>
<th>DB5</th>
<th>DB4</th>
<th>DB3</th>
<th>DB2</th>
<th>DB1</th>
<th>DB0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: * = Not Relevant

This instruction is used to set the DDRAM Address 0 into the Address Counter and revert the display to its original status (if the display has been shifted). The DDRAM contents do not change. The cursor or blinking will go to the left edge of the display. If there are 2 lines displayed, the cursor or blinking will go to the first line’s left edge of the display.
4.2.3 ENTRY MODE SET INSTRUCTION

The Entry Mode Set Instruction has two controlling bits: I/D and S. Please refer to the table below.

<table>
<thead>
<tr>
<th>RS</th>
<th>R/WB</th>
<th>DB7</th>
<th>DB6</th>
<th>DB5</th>
<th>DB4</th>
<th>DB3</th>
<th>DB2</th>
<th>DB1</th>
<th>DB0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>I/D</td>
<td>S</td>
</tr>
</tbody>
</table>

**I/D IS THE INCREMENT/DECREMENT BIT.**

When I/D is set to "1", the DDRAM Address is incremented by "1" when a character code is written into or read from the DDRAM. An increment of 1 will move the cursor or blinking one step to the right.

When I/D is set to "0", the DDRAM is decremented by 1 when a character code is written into or read from the DDRAM. A decrement of 1 will move the cursor or blinking one step to the left.

**S: SHIFT ENTIRE DISPLAY CONTROL BIT**

This bit is used to shift the entire display. When S is set to "1", the entire display is shifted to the right (when I/D ="0") or left (when I/D ="1"). When S is set to "0", the display is not shifted.

**Ex1 : I/D=1, S=1**

Initial display

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>A</th>
</tr>
</thead>
</table>
Input new character "A"

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>A</th>
<th>B</th>
</tr>
</thead>
</table>
Input new character "B"

<table>
<thead>
<tr>
<th>2</th>
<th>3</th>
<th>4</th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
</table>
Input new character "C"

<table>
<thead>
<tr>
<th>3</th>
<th>4</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
</tr>
</thead>
</table>
Input new character "D"

**Ex2 : I/D=0, S=1**

Initial display

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th></th>
</tr>
</thead>
</table>
Input new character "A"

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>A</th>
</tr>
</thead>
</table>
Input new character "B"

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>B</th>
<th>A</th>
</tr>
</thead>
</table>
Input new character "C"

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>C</th>
<th>B</th>
</tr>
</thead>
</table>
Input new character "D"

***Note : Default setting is 0 for I/D which means the cursor will move from right to left.***
4.2.4 DISPLAY ON/OFF CONTROL INSTRUCTION

The Display On / OFF Instruction is used to turn the display ON or OFF. The controlling bits are D, C and B.

<table>
<thead>
<tr>
<th>RS</th>
<th>R/WB</th>
<th>DB7</th>
<th>DB6</th>
<th>DB5</th>
<th>DB4</th>
<th>DB3</th>
<th>DB2</th>
<th>DB1</th>
<th>DB0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>D</td>
<td>C</td>
<td>B</td>
</tr>
</tbody>
</table>

**D: DISPLAY ON/OFF BIT**

When D is set to "1", the display is turned ON. When D is set to "0", the display is turned OFF and the display data is stored in the DDRAM. The display data can be instantly displayed by setting D to "1".

**C: CURSOR DISPLAY CONTROL BIT**

When C is set to "1", the cursor is displayed. In a 5 x 8 dot character font, the cursor is displayed via the 5 dots in the 8th line. In a 5 x 10 dot character font, it is displayed via 5 dots in the 11th line.

When C is set to "0", the cursor display is disabled.

During a Display Data Write, the function of the I/D and others will not be altered even if the cursor is not present. Please refer to the figure below.
**B: BLINKING CONTROL BIT**

When B is set to ‘1’, the character specified by the cursor blinks. The blinking feature is displayed by switching between the blank dots and the displayed character at a speed of 409.6ms intervals when the fcp or fosc is 250kHz. Please refer to the figure below.

![Figure 1](image1.png)  ![Figure 2](image2.png)

Note: Figures 1 and 2 are alternately displayed

The cursor and the blinking can be set to display at the same time. The blinking frequency depends on the fosc or the reciprocal of fcp.

To illustrate, when fosc=TBD Hz, then, the blinking frequency=409.6 x 250/270=379.2ms
4.2.5 CURSOR/DISPLAY SHIFT INSTRUCTION

This instruction is used to shift the cursor or display position to the left or right without writing or reading the Display Data. This function is used to correct or search the display. Please refer to the table below.

<table>
<thead>
<tr>
<th>RS</th>
<th>R/WB</th>
<th>DB7</th>
<th>DB6</th>
<th>DB5</th>
<th>DB4</th>
<th>DB3</th>
<th>DB2</th>
<th>DB1</th>
<th>DB0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>S/C</td>
<td>R/L</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>G/C</td>
<td>PWR</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>S/C</th>
<th>R/L</th>
<th>Shift Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>Shifts the cursor position to the left. (AC is decremented by 1).</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>Shifts cursor position to the right. (AC incremented by 1).</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>Shifts entire display to the left. The cursor follows the display shift.</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>Shifts the entire display to the right. The cursor follows the display shift.</td>
</tr>
</tbody>
</table>

In a 2-line Display, the cursor moves to the second line when it passes the 40th digit of the first line. The first and second line displays will shift at the same time.

When the displayed data is shifted repeatedly, each line moves only horizontally. The second line display does not shift into the first line position.

The Address Counter (AC) contents will not change if the only action performed is a Display Shift.

G/C: GRAPHIC MODE / CHARACTER MODE SELECTION

This bit is used to select the display mode for further process.
When G/C = 1, the GRAPHIC MODE will be selected.
When G/C = 0, the CHARACTER MODE will be selected.

PWR: ENABLE/DISABLE INTERNAL POWER

This bit is used to turn ON or turn OFF the internal power.
When PWR = 1, the internal power is turned ON.
When PWR = 0, the internal power is turned OFF.
4.2.6 FUNCTION SET INSTRUCTION
The Function Set Instruction has three controlling 3 bits, namely: DL, N and F. Please refer to the table below.

<table>
<thead>
<tr>
<th>RS</th>
<th>R/WB</th>
<th>DB7</th>
<th>DB6</th>
<th>DB5</th>
<th>DB4</th>
<th>DB3</th>
<th>DB2</th>
<th>DB1</th>
<th>DB0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>DL</td>
<td>N</td>
<td>F</td>
<td>FT1</td>
<td>FT0</td>
</tr>
</tbody>
</table>

DL: INTERFACE DATA LENGTH CONTROL BIT
This is used to set the interface data length. When DL is set to "1", the data is sent or received in 8-bit length via the DB0 to DB7 (for an 8-Bit Data Transfer). When DL is set to "0", the data is sent or received in 4-bit length via DB4 to DB7 (for a 4-Bit Data Transfer). When the 4-bit data length is selected, the data must be sent or received twice.

N: NUMBER OF DISPLAY LINE
This is used to set the number of display lines. When N="1", the 2-line display is selected. When N is set to "0", the 1-line display is selected.

F: CHARACTER FONT SET
This is used to set the character font set. When F is set to "0", the 5 x 8 dot character font is selected. When F is set to "1", the 5 x 10 dot character font is selected.

It must be noted that the character font setting must be performed at the head of the program before executing any instructions other than the Busy Flag and Address Instruction. Otherwise, the Function Set Instruction cannot be executed unless the interface data length is changed.

FT1, FT0: FONT TABLE SELECTION
These two bits are used to select one font table out of the three for further process.
When (FT1, FT0) = (0, 0), the ENGLISH_JAPANESE CHARACTER FONT TABLE will be selected.  
(FT1, FT0) = (0, 1), the WESTERN EUROPEAN CHARACTER FONT TABLE-I will be selected.  
(FT1, FT0) = (1, 0), the ENGLISH_RUSSIAN CHARACTER FONT TABLE will be selected.  
(FT1, FT0) = (1, 1), the WESTERN EUROPEAN CHARACTER FONT TABLE-II will be selected.

4.2.7 SET CGRAM ADDRESS INSTRUCTION
This instruction is used to set the CGRAM Address binary AAAAAA into the Address Counter. Data is then written to or read from the MPU for CGRAM.

<table>
<thead>
<tr>
<th>RS</th>
<th>R/WB</th>
<th>DB7</th>
<th>DB6</th>
<th>DB5</th>
<th>DB4</th>
<th>DB3</th>
<th>DB2</th>
<th>DB1</th>
<th>DB0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>ACG</td>
<td>ACG</td>
<td>ACG</td>
<td>ACG</td>
<td>ACG</td>
<td>ACG</td>
</tr>
</tbody>
</table>

Note: ACG is the CGRAM Address
OLED Application Note

4.2.8 SET DDRAM ADDRESS INSTRUCTION
This instruction is used to set the DDRAM Address binary AAAAAAA into the Address Counter. The data is written to or read from the MPU for the DDRAM. If 1-line display is selected (N="0"), then AAAAAAA can be 00H to 4FH. When the 2-line display is selected, then AAAAAAA can be 00H to 27H for the first line and 40H to 67H for the second line.

<table>
<thead>
<tr>
<th>RS</th>
<th>R/WB</th>
<th>DB7</th>
<th>DB6</th>
<th>DB5</th>
<th>DB4</th>
<th>DB3</th>
<th>DB2</th>
<th>DB1</th>
<th>DB0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>ADD</td>
<td>ADD</td>
<td>ADD</td>
<td>ADD</td>
<td>ADD</td>
<td>ADD</td>
<td>ADD</td>
</tr>
</tbody>
</table>

Note: ADD = DDRAM Address

CHARACTER MODE ADDRESSING
WIN0010 provides two kind of character mode. User can fill in 128 characters data (N=0, one line) or 64 characters data per line (N=1, two line) in embedded RAM to display graphic. Character mode address can be controlled by DDRAM address instruction.

<table>
<thead>
<tr>
<th>Address Format</th>
<th>DB7</th>
<th>DB6</th>
<th>DB5</th>
<th>DB4</th>
<th>DB3</th>
<th>DB2</th>
<th>DB1</th>
<th>DB0</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA (Character Address)</td>
<td>1</td>
<td>ADD6</td>
<td>ADD5</td>
<td>ADD4</td>
<td>ADD3</td>
<td>ADD2</td>
<td>ADD1</td>
<td>ADD0</td>
</tr>
</tbody>
</table>

(1) 1-Line condition (N=0)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>......</th>
<th>......</th>
<th>125</th>
<th>126</th>
<th>127</th>
<th>128</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA</td>
<td>=10000000</td>
<td>CA</td>
<td>=10000001</td>
<td>CA</td>
<td>=10000010</td>
<td>CA</td>
<td>=10000011</td>
<td>CA</td>
<td>=11111100</td>
<td>CA</td>
</tr>
</tbody>
</table>
(2) 2-Line condition (N=1)

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>......</th>
<th>......</th>
<th>61</th>
<th>62</th>
<th>63</th>
<th>64</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA=10000000</td>
<td>CA=10000001</td>
<td>CA=10000010</td>
<td>CA=10000011</td>
<td>CA=10111100</td>
<td>CA=10111101</td>
<td>CA=10111110</td>
<td>CA=10111111</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CA=11000000</td>
<td>CA=11000001</td>
<td>CA=11000010</td>
<td>CA=11000011</td>
<td>CA=11111100</td>
<td>CA=11111101</td>
<td>CA=11111110</td>
<td>CA=11111111</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**GRAPHIC MODE ADDRESSING**

WIN0010 provides not only character mode but also graphic mode. User can fill in 100x16 data in embedded RAM to display graphic. Graphic mode addressing is different from character mode.

Use DDRAM address instruction to set X-axis address of Graphic mode and CGRAM address instruction to set Y-axis of Graphic mode.

<table>
<thead>
<tr>
<th>Address Format</th>
<th>DB7</th>
<th>DB6</th>
<th>DB5</th>
<th>DB4</th>
<th>DB3</th>
<th>DB2</th>
<th>DB1</th>
<th>DB0</th>
</tr>
</thead>
<tbody>
<tr>
<td>GXA (Graphic X-axis Address)</td>
<td>1</td>
<td>ADD6</td>
<td>ADD5</td>
<td>ADD4</td>
<td>ADD3</td>
<td>ADD2</td>
<td>ADD1</td>
<td>ADD0</td>
</tr>
<tr>
<td>GYA (Graphic Y-axis Address)</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>CGA0</td>
</tr>
</tbody>
</table>
4.2.9 READ BUSY FLAG AND ADDRESS INSTRUCTION

This instruction is used to read the Busy Flag (BF) to indicate if IST0010 is internally operating on a previously received instruction. If BF is set to "1", then the internal operation is in progress and the next instruction will not be accepted. If the BF is set to "0", then the previously received instruction has been executed and the next instruction can be accepted and processed. It is important to check the BF status before proceeding to the next write operation. The value of the Address Counter in binary AAAAAAAA is simultaneously read out. This Address Counter is used by both the CGRAM and the DDRAM and its value is determined by the previous instruction. The contents of the address are the same as for the instructions -- Set CGRAM Address and Set DDRAM Address.

<table>
<thead>
<tr>
<th>RS</th>
<th>R/WB</th>
<th>DB7</th>
<th>DB6</th>
<th>DB5</th>
<th>DB4</th>
<th>DB3</th>
<th>DB2</th>
<th>DB1</th>
<th>DB0</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1</td>
<td>BF</td>
<td>AC</td>
<td>AC</td>
<td>AC</td>
<td>AC</td>
<td>AC</td>
<td>AC</td>
<td>AC</td>
</tr>
</tbody>
</table>

Notes:
1. BF=Busy Flag
2. AC=Address Counter
4.2.10 WRITE DATA TO CGRAM / DDRAM INSTRUCTION
This instruction writes 8-bit binary data -- DDDDDDDD to the CGRAM or the DDRAM. The previous CGRAM or DDRAM Address setting determines whether a data is to be written into the CGRAM or the DDRAM. After the write process is completed, the address is automatically incremented or decremented by 1 in accordance with the Entry Mode instruction. It must be noted that the Entry Mode instruction also determines the Display Shift.

<table>
<thead>
<tr>
<th>RS</th>
<th>R/WB</th>
<th>DB7</th>
<th>DB6</th>
<th>DB5</th>
<th>DB4</th>
<th>DB3</th>
<th>DB2</th>
<th>DB1</th>
<th>DB0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>

4.2.11 READ DATA FROM THE CGRAM OR DDRAM INSTRUCTION
This instruction reads the 8-bit binary data -- DDDDDDDD from the CGRAM or the DDRAM. The Set CGRAM Address or Set DDRAM Address Set Instruction must be executed before this instruction can be performed, otherwise, the first Read Data will not be valid.

<table>
<thead>
<tr>
<th>RS</th>
<th>R/WB</th>
<th>DB7</th>
<th>DB6</th>
<th>DB5</th>
<th>DB4</th>
<th>DB3</th>
<th>DB2</th>
<th>DB1</th>
<th>DB0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
</tbody>
</table>

When the Read Instruction is executed in series, the next address data is normally read from the Second Read. There is no need for the Address Set Instruction to be performed before this Read instruction when using the Cursor Shift Instruction to shift the cursor (Reading the DDRAM). The Cursor Shift Instruction has the same operation as that of the Set the DDRAM Address Instruction.

After a Read instruction has been executed, the Entry Mode is automatically incremented or decremented by 1. It must be noted that regardless of the Entry Mode, the Display Shift is not executed.

After the Write instruction to either the CGRAM or DDRAM has been performed, the Address Counter is automatically increased or decreased by 1. The RAM data selected by the Address Counter cannot be read out at this time even if the Read Instructions are executed. Therefore, in order to correctly read the data, the following procedure has suggested:

1. Execute the Address Set or Cursor Shift (only with DDRAM) Instruction
2. Just before reading the desired data, execute the Read Instruction from the second time the Read Instruction has been sent.
5. CHARACTER GENERATOR RAM (CGRAM)
The Character Generator RAM (CGRAM) is used to generate either 5 x 8 dot or 5 x 10 dot character patterns. It can generate eight 5 x 8 dot character patterns or four 5 x 10 dot character patterns. The character patterns generated by the CGRAM can be rewritten. User-defined character patterns for the CGRAM are supported.
RELATIONSHIP BETWEEN CGRAM ADDRESS, DDRAM CHARACTER CODE AND CGRAM CHARACTER PATTERNS (FOR 5 X 8 DOT CHARACTER PATTERN)

<table>
<thead>
<tr>
<th>Character Codes (DDRAM Data)</th>
<th>CGRAM Address</th>
<th>Character Patterns (CGRAM Data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 6 5 4 3 2 1 0</td>
<td>5 4 3 2 1 0</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>Low</td>
<td></td>
</tr>
<tr>
<td>0 0 0 0 * 0 0 0</td>
<td>0 0 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Character pattern 1</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 0 0 0 * 0 0 1</td>
<td>0 0 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Character pattern 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 0 0 0 * 1 1 1</td>
<td>1 1 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Character pattern 3~7</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0 0 0 0 * 1 1 1</td>
<td>1 1 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cursor Position

Character pattern 1

Character pattern 2

Cursor position

Character pattern 8

Cursor position

Character pattern 1

Character pattern 2

Cursor position

Character pattern 3~7

Character pattern 8

Cursor position
Notes:
1. * = Not Relevant
2. The character pattern row positions correspond to the CGRAM data bits -- 0 to 4, where bit 4 is in the left position.
3. Character Code Bits 0 to 2 correspond to the CGRAM Address Bits 3 to 5 (3 bits: 8 types)
4. If the CGRAM Data is set to "1", then the selection is displayed. If the CGRAM is set to "0", there no selection is made.
5. The CGRAM Address Bits 0 to 2 are used to define the character pattern line position. The 8th line is the cursor position and its display is formed by the logical OR with the cursor. The 8th line CGRAM data bits 0 to 4 must be set to "0". If any of the 8th line CGRAM data bits 0 to 4 is set to "1", the corresponding display location will light up regardless of the cursor position.
6. When the Character Code Bits 4 to 7 are set to "0", then the CGRAM Character Pattern is selected. It must be noted that Character Code Bit 3 is not relevant and will not have any effect on the character display. Because of this, the first Character Pattern shown above (R) can be displayed when the Character Code is 00H or 08H.
6 Initialization by Instruction
6.1 8-bit mode

- Power on
- Wait for power stabilization ??ms
- Function set
  - RS  R/W  DB7  DB6  DB5  DB4  DB3  DB2  DB1  DB0
  - 0    0    0    0    1    1    N    F    X    X
- Check Busy Flag
- Display ON/OFF Control
  - RS  R/W  DB7  DB6  DB5  DB4  DB3  DB2  DB1  DB0
  - 0    0    0    0    0    0    1    D    C    B
- Check Busy Flag
- Display Clear
  - RS  R/W  DB7  DB6  DB5  DB4  DB3  DB2  DB1  DB0
  - 0    0    0    0    0    0    0    0    0    1
- Check Busy Flag
- Entry Mode Set
  - RS  R/W  DB7  DB6  DB5  DB4  DB3  DB2  DB1  DB0
  - 0    0    0    0    0    0    0    1    I/D    SH
- Initialization end
6.2 4-bit mode

Note: Repeated procedures for an 4-bit bus interface
Noise causing transfer mismatch between the four upper and lower bits can be corrected by a reset triggered by consecutively writing a “0000” instruction five times. The next transfer starts from the lower four bits and then first instruction “Function set” can be executed normally.
Please insert the synchronization function in the end of procedures. The repeated procedures are show as follows:

1. **Power ON**
   - Wait for power stabilization 500ms

2. **Function Set**
   - RS | R/W | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0
   - 0  | 0   | 0   | 0   | 1   | 0   | X   | X   | X   | X
   - 0  | 0   | 0   | 0   | 1   | 0   | X   | X   | X   | X
   - 0  | 0   | N   | F   | FT1 | FTO | X   | X   | X   | X

3. **Check Busy Flay**

4. **Initial Command Setting**
   - RS | R/W | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0
   - 0  | 0   | 0   | 0   | 1   | 0   | X   | X   | X   | X
   - 0  | 0   | 0   | 0   | 0   | 0   | X   | X   | X   | X

5. **Check Busy Flay**

6. **Display RAM Write**
   - RS | R/W | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0
   - 1  | 0   | 0   | 0   | 0   | 0   | X   | X   | X   | X
   - 1  | 0   | 0   | 0   | 0   | 0   | X   | X   | X   | X

7. **Synchronization function for an 4-bit bus**
   - RS | R/W | DB7 | DB6 | DB5 | DB4 | DB3 | DB2 | DB1 | DB0
   - 0  | 0   | 0   | 0   | 0   | 0   | X   | X   | X   | X
   - 0  | 0   | 0   | 0   | 0   | 0   | X   | X   | X   | X
   - 0  | 0   | 0   | 0   | 0   | 0   | X   | X   | X   | X
   - 0  | 0   | 0   | 0   | 0   | 0   | X   | X   | X   | X
   - 0  | 0   | 0   | 0   | 0   | 0   | X   | X   | X   | X
7  MCU Interface

7.1 6800 series

(a) 8-bit

(b) 4-bit
7.2 8080 series

(a) 8-bit

(b) 4-bit
OLED Application Note

7.3 SPI-4

(a) Command/RAM Data Write(Single)

(b) RAM Data Continuous Write
(c) Command Read

(d) RAM Data Read


**OLED Application Note**

8 **MCU Interface Timing**

8.1 Read / Write Characteristics (6800-series Microprocessor)

![Figure 1. Read / Write Characteristics (6800-series MPU)](image)

* Our standard set is 6800 interface

(Vcc = 4.5 to 5.5V, Ta = -40 to +85°C)

<table>
<thead>
<tr>
<th>Item</th>
<th>Signal</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address setup time</td>
<td>RS</td>
<td>$t_{AS68}$</td>
<td>20</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Address hold time</td>
<td></td>
<td>$t_{AH68}$</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>System cycle time</td>
<td></td>
<td>$t_{cy68}$</td>
<td>500</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Pulse width (E)</td>
<td>E_RDB</td>
<td>$t_{PW68(W)}$</td>
<td>250</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Pulse width (E)</td>
<td>E_RDB</td>
<td>$t_{PW68(R)}$</td>
<td>250</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Data setup time</td>
<td>DB7 to DB0</td>
<td>$t_{DS68}$</td>
<td>40</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Data hold time</td>
<td>DB7 to DB0</td>
<td>$t_{DH68}$</td>
<td>20</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Read access time</td>
<td></td>
<td>$t_{ACC68}$</td>
<td>-</td>
<td>-</td>
<td>180</td>
<td>ns</td>
<td>CL = 100pF</td>
</tr>
<tr>
<td>Output disable time</td>
<td></td>
<td>$t_{od68}$</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note:
The name deferent between 8080 and 6800

<table>
<thead>
<tr>
<th>Pin number</th>
<th>8080 series</th>
<th>6800 series</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin 4</td>
<td>RS (A0)</td>
<td>RS (A0)</td>
</tr>
<tr>
<td>Pin 5</td>
<td>Write</td>
<td>RW</td>
</tr>
<tr>
<td>Pin 6</td>
<td>Read</td>
<td>E</td>
</tr>
</tbody>
</table>

Date : 2013/11/07

ELECTRONIC ASSEMBLY
8.2 Read / Write Characteristics (8080-series Microprocessor)

![Figure 2. Read / Write Characteristics (8080-series MPU)](image)

Vcc = 4.5 to 5.5V, Ta = -40 to +85°C

<table>
<thead>
<tr>
<th>Item</th>
<th>Signal</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Address setup time</td>
<td>RS</td>
<td>tAS80</td>
<td>20</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Address hold time</td>
<td></td>
<td>tAH80</td>
<td>0</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>System cycle time</td>
<td></td>
<td>tcY80</td>
<td>500</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Pulse width (WRB)</td>
<td>RW_WRB</td>
<td>tpW80(W)</td>
<td>250</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Pulse width (RDB)</td>
<td>E_RDB</td>
<td>tpW80(R)</td>
<td>250</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Data setup time</td>
<td>DB7 to</td>
<td>tdS80</td>
<td>40</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Data hold time</td>
<td>DB0</td>
<td>tdH80</td>
<td>20</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Read access time</td>
<td></td>
<td>tACC80</td>
<td>-</td>
<td>-</td>
<td>180</td>
<td>ns</td>
<td>CL = 100pF</td>
</tr>
<tr>
<td>Output disable time</td>
<td></td>
<td>tod80</td>
<td>10</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
</tbody>
</table>
8.3 Serial Interface Characteristics

Figure 3. Serial Interface Characteristics

(VCC = 4.5 to 5.5V, Ta = -40 to +85°C)

<table>
<thead>
<tr>
<th>Item</th>
<th>Signal</th>
<th>Symbol</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Unit</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>Serial clock cycle</td>
<td>DB5 (SCL)</td>
<td>tCYS</td>
<td>300</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>SCL high pulse width</td>
<td></td>
<td>tWH</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>ns</td>
</tr>
<tr>
<td>SCL low pulse width</td>
<td></td>
<td>tWLS</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>CS1B setup time</td>
<td>CSB</td>
<td>tCSS</td>
<td>150</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>CS1B hold time</td>
<td></td>
<td>tCHS</td>
<td>150</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Data setup time</td>
<td>DB7 (SDI)</td>
<td>tDSS</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Data hold time</td>
<td></td>
<td>tDHS</td>
<td>100</td>
<td>-</td>
<td>-</td>
<td>ns</td>
<td></td>
</tr>
<tr>
<td>Read access time</td>
<td>DB6 (SDO)</td>
<td>tACCs</td>
<td>-</td>
<td>-</td>
<td>80</td>
<td>ns</td>
<td></td>
</tr>
</tbody>
</table>
9 Reference Initial code :

9.1 8 bit-68 interface mode

#define one 0x80
#define two 0xc0
#define Data_BUS P1
sbit busy = P1^7;
sbit RS = P3^0;
sbit RW = P3^7;
sbit Enable = P3^4;
//sbit CS = P3^3; //only for SPI

unsigned char code CGRAM1[8] ={0x04,0x0E,0x15,0x04,0x04,0x04,0x04,0x04,}; // ↑

main()
{
  unsigned char i,mode,CHAR_ADD,font;
  Initial_IC();
  CGRAM();
  CHAR_ADD=0x41;
  while(1)
  {
    //show char Max
    WriteIns(one); //the first word in top line address is 0x80
    for(i = 0; i<20;i++)
      WriteData(CHAR_ADD+i);
    WriteIns(two); //the first word in second line address is 0xC0
    for(i = 0; i<20;i++)
      WriteData(CHAR_ADD+i);
  }
}

void Initial_IC()
{
  WriteIns(0x38); //function set,8-bit transfer,2-lines display & 5*8 dot characteristic, font 00
delay(1);
  WriteIns(0x38); //function set,8-bit transfer,2-lines display & 5*8 dot characteristic, font 00
delay(1);
  WriteIns(0x38); //function set,8-bit transfer,2-lines display & 5*8 dot characteristic, font 00
delay(1);
  WriteIns(0x38); //function set,8-bit transfer,2-lines display & 5*8 dot characteristic, font 00
delay(1);
  WriteIns(0x0C); //Display ON/OFF control,Display ON,Cursor&Blink OFF
delay(1);
  WriteIns(0x06); //Entry Mode Set, address increment & Shift off
delay(1);
  WriteIns(0x02); //Return Home
delay(1);
  WriteIns(0x01); //Clear Display
delay(1);
}
void WriteIns(char instruction)
{
    CheckBusy();
    RS = 0;
    RW = 0;
    Enable = 1;
    Data_BUS = instruction;
    Enable = 0;  //1us
}

void WriteData(char data1)
{
    CheckBusy();
    RS = 1;
    RW = 0;
    Enable = 1;
    Data_BUS = data1;
    Enable = 0;
}

void CheckBusy()
{
    Data_BUS = 0xff;
    RS = 0;
    RW = 1;
    do
    {
        Enable = 1;
        busy_f = busy;
        Enable = 0;
    }while(busy_f);
}

void CGRAM()
{
    unsigned char i;
    WriteIns(0x40);  //SET CG_RAM ADDRESS 000000
    for(i = 0;i<=24;i++)
    {
        WriteData(CGRAM1[i]);
    }
}
9.2 4 bit-68 interface mode

main()
{
    The same as 8 bit-68 interface mode
}

void Initial_IC()
{
/*need to set five "0x00" cmds. Could put in the start of program or in the end of program*/
WriteIns(0x00);
WriteIns(0x00);
WriteIns(0x00);
WriteIns(0x00);
WriteIns(0x00);
WriteIns(0x020);//function set //do it only once
WriteCmd(0x28);//function set
WriteCmd(0x0c);//display on
WriteCmd(0x06);//entry mode set
WriteCmd(0x02);//Return Home
WriteCmd(0x01);//clear display
}

void CheckBusy()
{
    Data_BUS = 0xff;
    RS = 0;
    RW = 1;
    do
    {
        Enable = 1;
        busy_f = busy;
        Enable = 0;
        Enable = 1; //dummy read
        Enable = 0;
        _nop_();
    }while(busy_f);
}

void WriteIns(unsigned char instruction)
{
    RS = 0;
    Enable = 0;
    RW = 0;
    Data_BUS = instruction&0xf0;
    Enable = 1;       //1us
    _nop_();         //1us
    Enable = 0;      //1us
}

void WriteCmd(unsigned char cmd)
{
    unsigned char hIns=cmd,lIns=cmd;
    RS = 0;
    RW = 0;
    Data_BUS = hIns&0xf0;
Enable = 1;            //1us
    _nop_();            //1us
Enable = 0;  //1us  
Data_BUS = IlIns<<4; 
Enable = 1;            //1us
    _nop_();            //1us
Enable = 0;  //1us  
CheckBusy();
}

void WriteData(unsigned char dat)
{
    unsigned char hDat=dat,lDat=dat;

    RS = 1;
    RW = 0;
    Data_BUS = hDat&0xf0;
    Enable = 1;
        _nop_();
    Enable = 0;
    Data_BUS = lDat<<4;
    Enable = 1;
        _nop_();
    Enable = 0;
    CheckBusy();
}

void WriteString(unsigned char count,unsigned char * MSG)
{
    unsigned char i;
    for(i = 0; i<count;i++)
    {
        WriteData(MSG[i]);
    }
}

void CGRAM()
{
    unsigned char i;
    WriteIns(0x40);         //SET CG_RAM ADDRESS 000000
    for(i = 0;i<=24;i++)
    {
        WriteData(CGRAM1[i]);
    }
}
9.3 8 bit-80 interface mode

main()
{
    The same as 8 bit-68 interface mode
}

void Initial_IC()
{
    The same as 8 bit-68 interface mode
}

void WriteIns(char instruction)
{
    CheckBusy();
    RDB = 1;
    RS = 0;
    WRB = 0;
    Data_BUS = instruction;
    WRB = 1; //1us
}

void WriteData(char data1)
{
    CheckBusy();
    RDB = 1;
    RS = 1;
    WRB = 0;
    Data_BUS = data1;
    WRB = 1;
}

void CheckBusy()
{
    Data_BUS = 0xff;
    RS = 0;
    WRB = 1;
    do
    {
        RDB = 0;
        busy_f = busy;
        RDB = 1;
    }while(busy_f);
}

void CGRAM()
{
    unsigned char i;
    WriteIns(0x40); //SET CG_RAM ADDRESS 000000
    for(i = 0;i<=24;i++)
    {
        WriteData(CGRAM1[i]);
    }
}
9.4 4 bit-80 interface mode

main()
{
    The same as 8 bit-68 interface mode
}

void Initial_IC()
{
    The same as 4 bit-68 interface mode
}

void WriteIns(unsigned char instruction)
{
    RS = 0;
    WRB = 1;
    RDB = 1;
    Data_BUS = instruction&0xf0;
    WRB = 0;         //1us
    _nop_();          //1us
    WRB = 1;         //1us
}

void WriteCmd(unsigned char cmd)
{
    unsigned char hIns=cmd,lIns=cmd;
    RS = 0;
    RDB = 1;
    Data_BUS = hIns&0xf0;
    WRB = 0;         //1us
    _nop_();          //1us
    WRB = 1;         //1us
    Data_BUS = lIns<<4;
    WRB = 0;         //1us
    _nop_();          //1us
    WRB = 1;         //1us
    CheckBusy();
}
void WriteData(unsigned char dat)
{
    unsigned char hDat=dat,lDat=dat;

    RS = 1;
    RDB = 1;
    Data_BUS = hDat&0xf0;
    WRB = 0;
    _nop_();
    WRB = 1;

    Data_BUS = lDat<<4;
    WRB = 0;
    _nop_();
    WRB = 1;
    CheckBusy();
}

void WriteString(unsigned char count,unsigned char * MSG)
{
    unsigned char  i;

    for(i = 0; i<count;i++)
    {
        WriteData(MSG[i]);
    }
}

void CheckBusy()
{
    Data_BUS = 0xff; //訊號由 high 變為 low 比較容易,所以全部設為 high.
    RS = 0;
    WRB = 1;
    do
    {
        RDB = 0;
        busy_f = busy;
        RDB = 1;
        RDB = 0; //dummy read
        RDB = 1;
        _nop_();
    }while(busy_f);
}
9.5  4-Lines serial interface mode

main()
{
   The same as 8 bit-68 interface mode
}

void Initial_IC()
{
   WriteIns(0x38);//function set
   WriteIns(0x06);//entry mode set
   WriteIns(0x02);
   WriteIns(0x01);//clear display
   delay(30);
   WriteIns(0x0c);//display on
}

void WriteIns(unsigned char ins)
{
   unsigned char i;
   CS=0;
   SDI = 0; //RS = 0
   _nop_();
   SCL = 1;
   _nop_();
   SCL = 0;
   _nop_();
   SDI = 0; //RW = 0
   SCL = 1;
   _nop_();
   SCL = 0;
   for (i=0x80;i;i>>=1)
   {
      SDI = ins & i;
      SCL = 1;
      _nop_();
      SCL = 0;
   }
   CS=1;
}

void WriteData(unsigned char dat)
{
   unsigned char i;
   for (i=0x80;i;i>>=1)
   {
      SDI = dat & i;
      SCL = 1;
      _nop_();
      SCL = 0;
   }
}
void WriteOneData(unsigned char dat)
{
    CS=0;
    SDI = 1; //RS = 1
    _nop_();
    SCL = 1;
    _nop_();
    SCL = 0;
    SDI = 0; //RW = 0
    _nop_();
    SCL = 1;
    _nop_();
    SCL = 0;

    WriteData(dat);
    CS=1;
}

void WriteSerialData(unsigned char count,unsigned char * MSG)
{
    unsigned char  i;
    CS=0;
    SDI = 1; //RS = 1
    _nop_();
    SCL = 1;
    _nop_();
    SCL = 0;
    SDI = 0; //RW = 0
    _nop_();
    SCL = 1;
    _nop_();
    SCL = 0;

    for(i = 0; i<count;i++)
    {
        WriteData(MSG[i]);
    }
    CS=1;
}

void CGRAM(void)
{
    WriteIns(0x40);
    WriteSerialData(8,CGRAM1);
}
9.6 Graphic mode

main()
{
    The same as 8 bit-68 interface mode
}

void Initial_IC()
{
    WriteIns(0x38); // function set, 8-bit transfer, 2-lines display & 5*8 dot characteristic, font 00
delay(1);
    WriteIns(0x38); // function set, 8-bit transfer, 2-lines display & 5*8 dot characteristic, font 00
delay(1);
    WriteIns(0x38); // function set, 8-bit transfer, 2-lines display & 5*8 dot characteristic, font 00
delay(1);
    WriteIns(0x38); // function set, 8-bit transfer, 2-lines display & 5*8 dot characteristic, font 00
delay(1);
    WriteCmd(0x0C); // Display ON/OFF control, Display ON, Cursor&Blink OFF
delay(1);
    WriteCmd(0x06); // Entry Mode Set, address increment & Shift off
delay(1);
    WriteCmd(0x1F); // Graphic mode
delay(1);
    WriteCmd(0x02); // Return Home
delay(1);
    WriteCmd(0x01); // Clear Display
delay(1);
}

void WriteIns(unsigned char instruction)
{
    RS = 0;
    RW = 0;
    Data_BUS = instruction;
    Enable = 1;     // 1us
    _nop_();        // 1us
    Enable = 0;     // 1us
}

void WriteCmd(char instruction)
{
    CheckBusy();
    RS = 0;
    RW = 0;
    Enable = 1;
    Data_BUS = instruction;
    Enable = 0;     // 1us
}
void WriteData(char data1)
{
    CheckBusy();
    RS = 1;
    RW = 0;
    Enable = 1;
    Data_BUS = data1;
    Enable = 0;
}

void CheckBusy()
{
    Data_BUS = 0xff;
    RS = 0;
    RW = 1;
    do
    {
        Enable = 1;
        busy_f = busy;
        Enable = 0;
    } while(busy_f);
## OLED Application Note

### Appendix  Font table

### English - Japanese Character Font

| Upper   | Upper   | Upper   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   | Lower   |
|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| LLLL    | CG RAM  | LLLL    | CG RAM  | LLLL    | CG RAM  | LLLL    | CG RAM  | LLLL    | CG RAM  | LLLL    | CG RAM  | LLLL    | CG RAM  | LLLL    | CG RAM  | LLLL    | CG RAM  | LLLL    | CG RAM  | LLLL    | CG RAM  | LLLL    | CG RAM  | LLLL    | CG RAM  |
| LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  |
| LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  |
| LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  | LLLH    | CG RAM  |
| LHHH    | CG RAM  | LHHH    | CG RAM  | LHHH    | CG RAM  | LHHH    | CG RAM  | LHHH    | CG RAM  | LHHH    | CG RAM  | LHHH    | CG RAM  | LHHH    | CG RAM  | LHHH    | CG RAM  | LHHH    | CG RAM  | LHHH    | CG RAM  | LHHH    | CG RAM  |
| HLLL    | CG RAM  | HLLL    | CG RAM  | HLLL    | CG RAM  | HLLL    | CG RAM  | HLLL    | CG RAM  | HLLL    | CG RAM  | HLLL    | CG RAM  | HLLL    | CG RAM  | HLLL    | CG RAM  | HLLL    | CG RAM  | HLLL    | CG RAM  | HLLL    | CG RAM  |
| HLLH    | CG RAM  | HLLH    | CG RAM  | HLLH    | CG RAM  | HLLH    | CG RAM  | HLLH    | CG RAM  | HLLH    | CG RAM  | HLLH    | CG RAM  | HLLH    | CG RAM  | HLLH    | CG RAM  | HLLH    | CG RAM  | HLLH    | CG RAM  |
| HLHL    | CG RAM  | HLHL    | CG RAM  | HLHL    | CG RAM  | HLHL    | CG RAM  | HLHL    | CG RAM  | HLHL    | CG RAM  | HLHL    | CG RAM  | HLHL    | CG RAM  | HLHL    | CG RAM  | HLHL    | CG RAM  |
| HHLH    | CG RAM  | HHLH    | CG RAM  | HHLH    | CG RAM  | HHLH    | CG RAM  | HHLH    | CG RAM  | HHLH    | CG RAM  | HHLH    | CG RAM  | HHLH    | CG RAM  | HHLH    | CG RAM  | HHLH    | CG RAM  |
| HHHL    | CG RAM  | HHHL    | CG RAM  | HHHL    | CG RAM  | HHHL    | CG RAM  | HHHL    | CG RAM  | HHHL    | CG RAM  | HHHL    | CG RAM  | HHHL    | CG RAM  | HHHL    | CG RAM  |
| HHHH    | CG RAM  | HHHH    | CG RAM  | HHHH    | CG RAM  | HHHH    | CG RAM  | HHHH    | CG RAM  | HHHH    | CG RAM  | HHHH    | CG RAM  | HHHH    | CG RAM  | HHHH    | CG RAM  | HHHH    | CG RAM  | HHHH    | CG RAM  |

*Date : 2013/11/07*  
*ELECTRONIC ASSEMBLY*  
45
## Western European Character Font I

<table>
<thead>
<tr>
<th>Upper 4-bit</th>
<th>Lower 4-bit</th>
<th>Character</th>
<th>RAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>LLLL</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>LLLH</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>LLLH</td>
<td>3</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>LLHH</td>
<td>4</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>LHLH</td>
<td>5</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>LHHL</td>
<td>6</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>LHLL</td>
<td>7</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>LHHH</td>
<td>8</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>HLLL</td>
<td>9</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>HLLH</td>
<td>10</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>HLHL</td>
<td>11</td>
<td>A</td>
<td>10</td>
</tr>
<tr>
<td>HLHH</td>
<td>12</td>
<td>B</td>
<td>11</td>
</tr>
<tr>
<td>HHLL</td>
<td>13</td>
<td>C</td>
<td>12</td>
</tr>
<tr>
<td>HHLH</td>
<td>14</td>
<td>D</td>
<td>13</td>
</tr>
<tr>
<td>HHHL</td>
<td>15</td>
<td>E</td>
<td>14</td>
</tr>
<tr>
<td>HHHH</td>
<td>16</td>
<td>F</td>
<td>15</td>
</tr>
</tbody>
</table>

Date: 2013/11/07

ELECTRONIC ASSEMBLY
# OLED Application Note

## English - Russian Character Font

<table>
<thead>
<tr>
<th>Upper row</th>
<th>LLLL</th>
<th>LLHL</th>
<th>LLHL</th>
<th>LLHH</th>
<th>LHHL</th>
<th>LHHL</th>
</tr>
</thead>
<tbody>
<tr>
<td>LLLL</td>
<td>CS</td>
<td>RAM</td>
<td>(1)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LLHL</td>
<td>CS</td>
<td>RAM</td>
<td>(2)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LLHL</td>
<td>CS</td>
<td>RAM</td>
<td>(3)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LLHH</td>
<td>CS</td>
<td>RAM</td>
<td>(4)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LHLL</td>
<td>CS</td>
<td>RAM</td>
<td>(5)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LHLH</td>
<td>CS</td>
<td>RAM</td>
<td>(6)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LHHL</td>
<td>CS</td>
<td>RAM</td>
<td>(7)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LHHH</td>
<td>CS</td>
<td>RAM</td>
<td>(8)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HLLL</td>
<td>CS</td>
<td>RAM</td>
<td>(9)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HLLH</td>
<td>CS</td>
<td>RAM</td>
<td>(10)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HLHL</td>
<td>CS</td>
<td>RAM</td>
<td>(11)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HHHH</td>
<td>CS</td>
<td>RAM</td>
<td>(12)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Date**: 2013/11/07  
**ELECTRONIC ASSEMBLY**  
47
## Western European Character Font II

<table>
<thead>
<tr>
<th>Upper Left</th>
<th>Upper Center</th>
<th>Upper Right</th>
<th>Lower Left</th>
<th>Lower Center</th>
<th>Lower Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>LLLL</td>
<td>CG RAM (1)</td>
<td></td>
<td>LLLL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LHHL</td>
<td></td>
<td>CG RAM (2)</td>
<td>LHHL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LLHL</td>
<td></td>
<td>CG RAM (3)</td>
<td>LLHH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LHLL</td>
<td></td>
<td>CG RAM (4)</td>
<td>LHHL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LHHH</td>
<td></td>
<td>CG RAM (5)</td>
<td>LHHH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HLHH</td>
<td></td>
<td>CG RAM (6)</td>
<td>HLHL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HLLH</td>
<td></td>
<td>CG RAM (7)</td>
<td>HLLH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HHLL</td>
<td></td>
<td>CG RAM (8)</td>
<td>HHHL</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HHHH</td>
<td></td>
<td>CG RAM (9)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

Date: 2013/11/07

48