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SSD1801

Advance Information

LCD Segment / Common Driver with Controller for Character Display System CMOS

GENERAL DESCRIPTION

SSD1801 is a single-chip CMOS LCD driver with controller for liquid crystal dot-matrix character display system. It consists of 105 high voltage driving output pins for driving 80 Segments, 24 Commons and 1 icon driving-Common. It can display 2 or 3 lines of 16 characters with 5x8 dots format. The double height character mode and line vertical scroll functions are supported.

SSD1801 displays character directly from its internal 10,240 bits (256 characters x 5 x 8 dots) Character Generator ROM (CGROM). All the character codes are stored in the 512 bits (16 character x 4 lines) Data Display RAM (DDRAM). User defined character can be loaded via 320 bits (8 characters x 5 x 8 dots) Character Generator RAM (CGRAM). In addition, there is a 80 bits Icon RAM for Icon display. Data/ Commands are sent from general MCU through a software selectable 6800-/8080-series compatible 4/ 8-bit Parallel Interface or Serial Peripheral Interface.

SSD1801 embeds a DC-DC Converter, Voltage Regulator, Voltage divider and RC oscillator which reduce the number of external components. With the special design on minimizing power consumption and die size, SSD1801 is suitable for portable battery-driven applications requiring a long operation period and a compact size.

FEATURES

- Single Supply Operation, 2.4V - 3.6V
- Maximum 5.8V LCD Driving Output Voltage
- Low Current Sleep Mode
- On-Chip 2x/3x DC-DC Converter/ External Power Supply
- On-Chip RC Oscillator/ External Clock
- On-Chip Voltage Regulator
- On-Chip Voltage Divider with programmable bias ratio (1/4, 1/5)
- 32 Level Internal Contrast Control/ External Contrast Control
- 2 or 3 lines x 16 characters with 5x8 dots format display and 80 icons
- Double Height Character Mode, Blink Mode, Cursor Display and Line Vertical Scroll Functions
- Row remapping and column remapping (4-type LCD application available)
- 8/4-bit 6800-series Parallel Interface, 8/4-bit 8080-series Parallel Interface and Serial Peripheral Interface
- 256 Build in characters and 8 user defined characters
- On-Chip Memories
 - Character Generator ROM (CGROM): 10240 bits (256 characters x 5 x 8 dots)
 - Character Generator RAM (CGRAM): 320 bits (8 characters x 5 x 8 dots)
 - Display Data RAM (DDRAM): 512 bits (16 characters x 4 lines)
 - Segment Icon RAM (ICONRAM): 80 bits (80 icons)
- Available in Gold Bump Die and Bare Die

This document contains information on a new product. Specification and information herein are subject to change without notice.



ORDERING INFORMATION

Table 1 - Ordering Information

| Ordering Part Number | Package Form |
|----------------------|---------------|
| SSD1801Z | Gold Bump Die |
| SSD1801AV | Bare Die |

BLOCK DIAGRAM

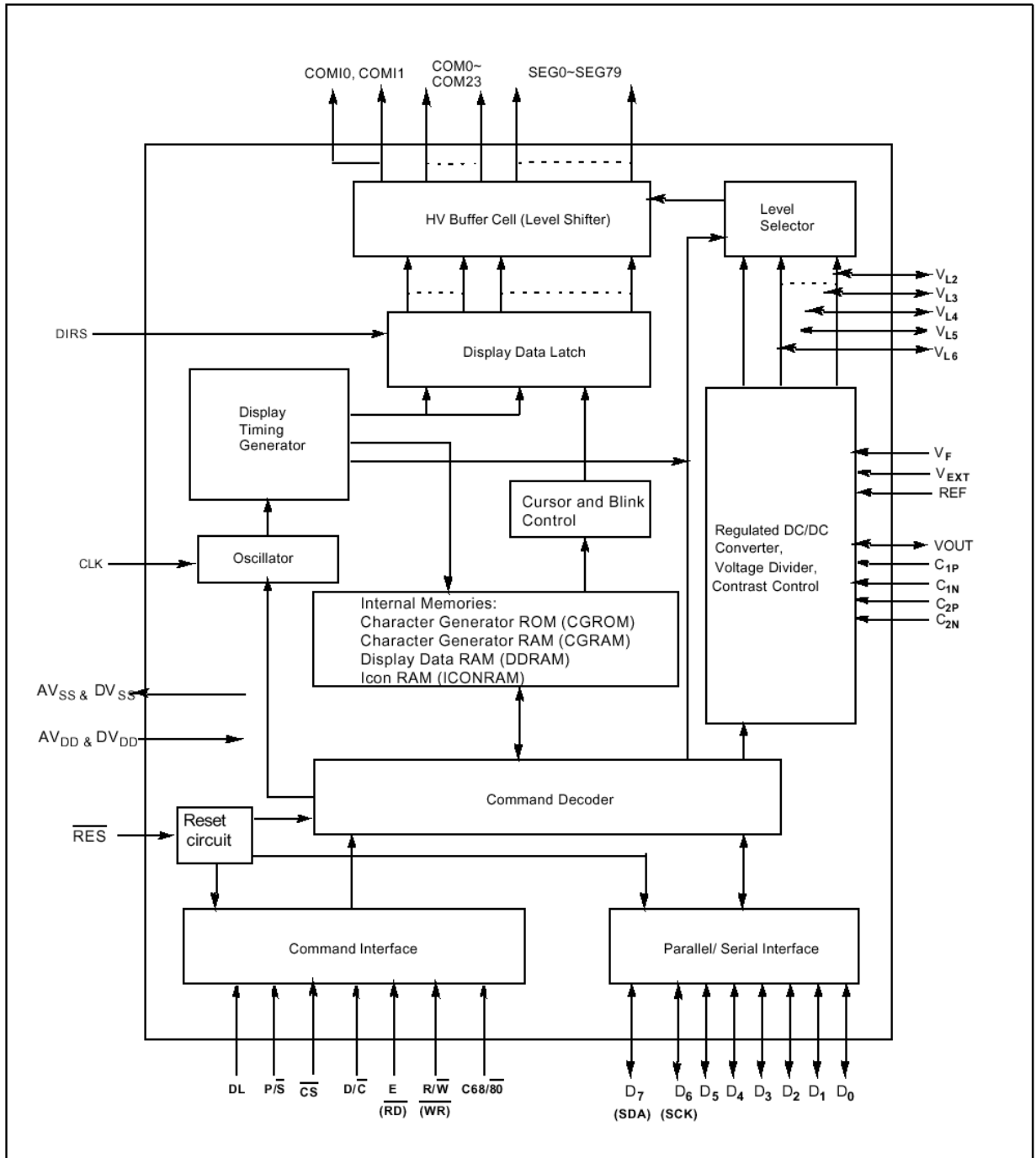


Figure 1 – Block Diagram of SSD1801

PIN ARRANGEMENT OF SSD1801Z GOLD BUMP DIE

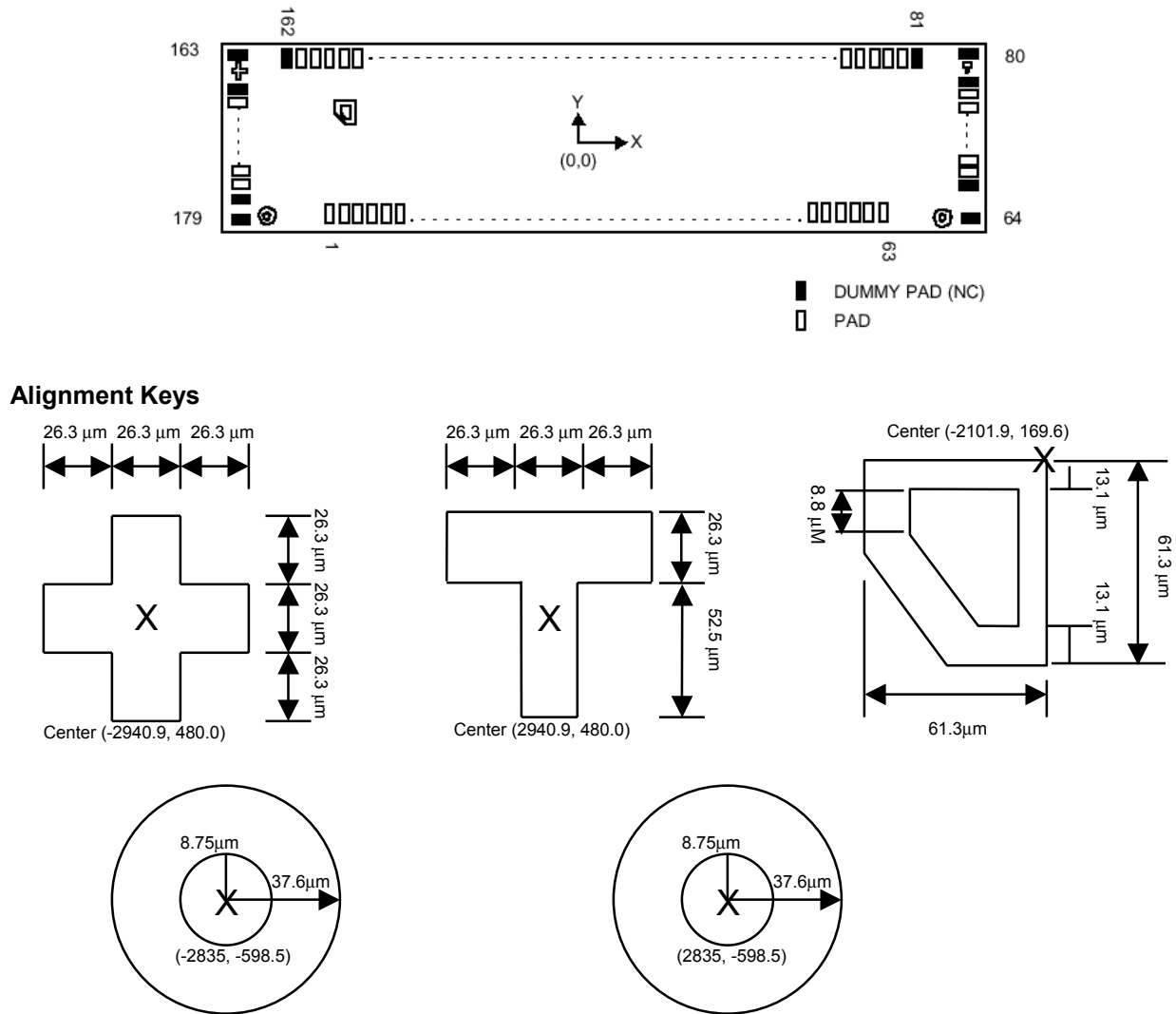


Figure 2 – SSD1801Z Pin Arrangement

Die Size: 6170µm x 1480µm (include scribe line)
6070µm x 1380µm (exclude scribe line)
Die Thickness: 670 +/-25µm

| | Bump Size | Minimum Pitch |
|--------------------|----------------------|---------------|
| PAD: 1-63 | 52.15 x 60.2 µm | 76.3µm |
| PAD: 65-79, | 164-178 74.9 x 42 µm | 63.7µm |
| PAD: 81-162 | 42 x 74.9 µm | 63.7µm |
| PAD: 64,80,163,179 | 52.15 X 52.15 µm | |

Bump Height: Nominal 18µm

Note:

1. The die faces up in the diagram.
2. Coordinates are reference to the center of the chip.
3. Unit of coordinates and size of all alignment keys are in µm.
4. All alignment keys do not contain gold bump.

Table 2 – SSD1801Z Gold Bump Die Pad Coordinates

| PAD# | NAME | X | Y | PAD# | NAME | X | Y |
|------|---------------------------------------|----------|---------|------|-------------------------|---------|---------|
| 1 | D/ \overline{C} | -2401.53 | -600.78 | 41 | C1N | 684.78 | -600.78 |
| 2 | DVSS | -2325.23 | -600.78 | 42 | C1N | 761.08 | -600.78 |
| 3 | R/ \overline{W} (\overline{WR}) | -2248.93 | -600.78 | 43 | C1P | 837.38 | -600.78 |
| 4 | DVDD | -2172.63 | -600.78 | 44 | C1P | 913.68 | -600.78 |
| 5 | E(\overline{RD}) | -2096.33 | -600.78 | 45 | VEXT | 989.98 | -600.78 |
| 6 | \overline{CS} | -2020.03 | -600.78 | 46 | DVSS | 1080.63 | -600.78 |
| 7 | D7 | -1943.73 | -600.78 | 47 | AVSS | 1156.93 | -600.78 |
| 8 | D6 | -1867.43 | -600.78 | 48 | DVSS | 1233.23 | -600.78 |
| 9 | D5 | -1791.13 | -600.78 | 49 | REF | 1309.53 | -600.78 |
| 10 | D4 | -1714.83 | -600.78 | 50 | DIRS | 1385.83 | -600.78 |
| 11 | D3 | -1638.53 | -600.78 | 51 | DVDD | 1462.13 | -600.78 |
| 12 | D2 | -1562.23 | -600.78 | 52 | AVDD | 1538.43 | -600.78 |
| 13 | D1 | -1485.93 | -600.78 | 53 | DVDD | 1614.73 | -600.78 |
| 14 | D0 | -1409.63 | -600.78 | 54 | CLK | 1691.03 | -600.78 |
| 15 | DVDD | -1333.33 | -600.6 | 55 | VSS | 1767.33 | -600.78 |
| 16 | AVDD | -1257.03 | -600.6 | 56 | P / \overline{S} | 1843.63 | -600.78 |
| 17 | DVDD | -1180.73 | -600.6 | 57 | DVDD | 1919.93 | -600.78 |
| 18 | DVSS | -1104.43 | -600.78 | 58 | DL | 1996.23 | -600.78 |
| 19 | AVSS | -1028.13 | -600.6 | 59 | DVSS | 2072.53 | -600.78 |
| 20 | DVSS | -951.83 | -600.6 | 60 | C68/($\overline{80}$) | 2148.83 | -600.78 |
| 21 | VL2 | -861.18 | -600.6 | 61 | DVDD | 2225.13 | -600.78 |
| 22 | VL2 | -784.88 | -600.6 | 62 | \overline{RES} | 2301.43 | -600.78 |
| 23 | VL3 | -708.58 | -600.6 | 63 | TEST | 2377.73 | -600.78 |
| 24 | VL3 | -632.28 | -600.78 | 64 | NC | 2939.3 | -600.78 |
| 25 | VL4 | -555.98 | -600.78 | 65 | NC | 2939.3 | -520.1 |
| 26 | VL4 | -479.68 | -600.78 | 66 | COM10 | 2939.3 | -456.4 |
| 27 | VL5 | -403.38 | -600.78 | 67 | COM 0 | 2939.3 | -392.7 |
| 28 | VL5 | -327.08 | -600.78 | 68 | COM 1 | 2939.3 | -329 |
| 29 | VL6 | -246.05 | -600.78 | 69 | COM 2 | 2939.3 | -265.3 |
| 30 | VL6 | -169.75 | -600.78 | 70 | COM 3 | 2939.3 | -201.6 |
| 31 | VL6 | -93.45 | -600.78 | 71 | COM 4 | 2939.3 | -137.9 |
| 32 | VL6 | -17.15 | -600.78 | 72 | COM 5 | 2939.3 | -74.2 |
| 33 | VF | 64.75 | -600.78 | 73 | COM 6 | 2939.3 | -10.5 |
| 34 | VF | 141.05 | -600.78 | 74 | COM 7 | 2939.3 | 53.2 |
| 35 | VOUT | 222.25 | -600.78 | 75 | COM16 | 2939.3 | 116.90 |
| 36 | VOUT | 298.55 | -600.78 | 76 | COM17 | 2939.3 | 180.6 |
| 37 | C2N | 379.58 | -600.78 | 77 | COM18 | 2939.3 | 244.3 |
| 38 | C2N | 455.88 | -600.78 | 78 | COM19 | 2939.3 | 308.0 |
| 39 | C2P | 532.18 | -600.78 | 79 | NC | 2939.3 | 371.7 |
| 40 | C2P | 608.48 | -600.78 | 80 | NC | 2939.3 | 593.43 |

| PAD# | NAME | X | Y | PAD# | NAME | X | Y |
|------|-------|---------|--------|------|-------|----------|---------|
| 81 | NC | 2579.85 | 593.43 | 131 | SEG49 | -605.15 | 593.43 |
| 82 | SEG0 | 2516.15 | 593.43 | 132 | SEG50 | -668.85 | 593.43 |
| 83 | SEG1 | 2452.45 | 593.43 | 133 | SEG51 | -732.55 | 593.43 |
| 84 | SEG2 | 2388.75 | 593.43 | 134 | SEG52 | -796.25 | 593.43 |
| 85 | SEG3 | 2325.05 | 593.43 | 135 | SEG53 | -859.95 | 593.43 |
| 86 | SEG4 | 2261.35 | 593.43 | 136 | SEG54 | -923.65 | 593.43 |
| 87 | SEG5 | 2197.65 | 593.43 | 137 | SEG55 | -987.35 | 593.43 |
| 88 | SEG6 | 2133.95 | 593.43 | 138 | SEG56 | -1051.05 | 593.43 |
| 89 | SEG7 | 2070.25 | 593.43 | 139 | SEG57 | -1114.75 | 593.43 |
| 90 | SEG8 | 2006.55 | 593.43 | 140 | SEG58 | -1178.45 | 593.43 |
| 91 | SEG9 | 1942.85 | 593.43 | 141 | SEG59 | -1242.15 | 593.43 |
| 92 | SEG10 | 1879.15 | 593.43 | 142 | SEG60 | -1305.85 | 593.43 |
| 93 | SEG11 | 1815.45 | 593.43 | 143 | SEG61 | -1369.55 | 593.43 |
| 94 | SEG12 | 1751.75 | 593.43 | 144 | SEG62 | -1433.25 | 593.43 |
| 95 | SEG13 | 1688.05 | 593.43 | 145 | SEG63 | -1496.95 | 593.43 |
| 96 | SEG14 | 1624.35 | 593.43 | 146 | SEG64 | -1560.65 | 593.43 |
| 97 | SEG15 | 1560.65 | 593.43 | 147 | SEG65 | -1624.35 | 593.43 |
| 98 | SEG16 | 1496.95 | 593.43 | 148 | SEG66 | -1688.05 | 593.43 |
| 99 | SEG17 | 1433.25 | 593.43 | 149 | SEG67 | -1751.75 | 593.43 |
| 100 | SEG18 | 1369.55 | 593.43 | 150 | SEG68 | -1815.45 | 593.43 |
| 101 | SEG19 | 1305.85 | 593.43 | 151 | SEG69 | -1879.15 | 593.43 |
| 102 | SEG20 | 1242.15 | 593.43 | 152 | SEG70 | -1942.85 | 593.43 |
| 103 | SEG21 | 1178.45 | 593.43 | 153 | SEG71 | -2006.55 | 593.43 |
| 104 | SEG22 | 1114.75 | 593.43 | 154 | SEG72 | -2070.25 | 593.43 |
| 105 | SEG23 | 1051.05 | 593.43 | 155 | SEG73 | -2133.95 | 593.43 |
| 106 | SEG24 | 987.35 | 593.43 | 156 | SEG74 | -2197.65 | 593.43 |
| 107 | SEG25 | 923.65 | 593.43 | 157 | SEG75 | -2261.35 | 593.43 |
| 108 | SEG26 | 859.95 | 593.43 | 158 | SEG76 | -2325.05 | 593.43 |
| 109 | SEG27 | 796.25 | 593.43 | 159 | SEG77 | -2388.75 | 593.43 |
| 110 | SEG28 | 732.55 | 593.43 | 160 | SEG78 | -2452.45 | 593.43 |
| 111 | SEG29 | 668.85 | 593.43 | 161 | SEG79 | -2516.15 | 593.43 |
| 112 | SEG30 | 605.15 | 593.43 | 162 | NC | -2579.85 | 593.43 |
| 113 | SEG31 | 541.45 | 593.43 | 163 | NC | -2939.3 | 593.43 |
| 114 | SEG32 | 477.75 | 593.43 | 164 | NC | -2939.3 | 371.7 |
| 115 | SEG33 | 414.05 | 593.43 | 165 | COM11 | -2939.3 | 308 |
| 116 | SEG34 | 350.35 | 593.43 | 166 | COM23 | -2939.3 | 244.3 |
| 117 | SEG35 | 286.65 | 593.43 | 167 | COM22 | -2939.3 | 180.6 |
| 118 | SEG36 | 222.95 | 593.43 | 168 | COM21 | -2939.3 | 116.9 |
| 119 | SEG37 | 159.25 | 593.43 | 169 | COM20 | -2939.3 | 53.2 |
| 120 | SEG38 | 95.55 | 593.43 | 170 | COM15 | -2939.3 | -10.5 |
| 121 | SEG39 | 31.85 | 593.43 | 171 | COM14 | -2939.3 | -74.2 |
| 122 | SEG40 | -31.85 | 593.43 | 172 | COM13 | -2939.3 | -137.9 |
| 123 | SEG41 | -95.55 | 593.43 | 173 | COM12 | -2939.3 | -201.6 |
| 124 | SEG42 | -159.25 | 593.43 | 174 | COM11 | -2939.3 | -265.3 |
| 125 | SEG43 | -222.95 | 593.43 | 175 | COM10 | -2939.3 | -329 |
| 126 | SEG44 | -286.65 | 593.43 | 176 | COM9 | -2939.3 | -392.7 |
| 127 | SEG45 | -350.35 | 593.43 | 177 | COM8 | -2939.3 | -456.4 |
| 128 | SEG46 | -414.05 | 593.43 | 178 | NC | -2939.3 | -520.1 |
| 129 | SEG47 | -477.75 | 593.43 | 179 | NC | -2939.3 | -600.78 |
| 130 | SEG48 | -541.45 | 593.43 | | | | |

PIN ARRANGEMENT OF SSD1801AV BARE DIE

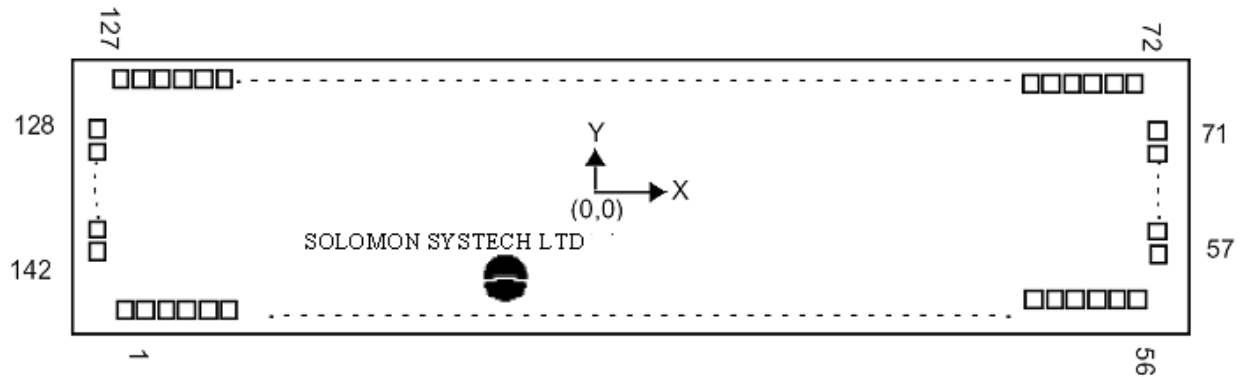


Figure 3 – SSD1801AV Pin Arrangement

Die Size: 6296um x 1845um +/- 36um (include scribe line)
 Die Thickness: 670 +/-25um
 Pad Metal Size: 88 x 88um
 Pad Opening Size: 80 x 80um

| Pad number | Pad metal size |
|--|-----------------------|
| PADS: 1-9, 48-56, 72-80, 119-127 | 103um x111um |
| PADS: 57, 58, 70, 71, 128, 129, 141, 142 | 111um x103um |
| PADS: 10-47, 81-118 | 90um x111um |
| PADS: 59-69, 130-140 | 111um x90um |

Note:

1. The die faces up in the diagram.
2. Coordinates are reference to the center of the chip.

Table 3 - SSD1801AV Bare Die Pad Coordinates

| PAD # | NAME | X | Y | PAD # | NAME | X | Y | PAD # | NAME | X | Y |
|-------|----------|----------|---------|-------|-------|---------|---------|-------|--------|----------|---------|
| 1 | COM21 | -2748.20 | -772.71 | 51 | COM3 | 2198.53 | -772.71 | 101 | SEG41 | -145.08 | 772.98 |
| 2 | COM20 | -2638.13 | -772.71 | 52 | COM4 | 2308.60 | -772.71 | 102 | SEG42 | -239.93 | 772.98 |
| 3 | COM15 | -2528.05 | -772.71 | 53 | COM5 | 2418.68 | -772.71 | 103 | SEG43 | -334.78 | 772.98 |
| 4 | COM14 | -2417.98 | -772.71 | 54 | COM6 | 2528.75 | -772.71 | 104 | SEG44 | -429.63 | 772.98 |
| 5 | COM13 | -2307.90 | -772.71 | 55 | COM7 | 2638.83 | -772.71 | 105 | SEG45 | -524.48 | 772.98 |
| 6 | COM12 | -2197.83 | -772.71 | 56 | COM16 | 2748.90 | -772.71 | 106 | SEG46 | -619.33 | 772.98 |
| 7 | COM11 | -2087.75 | -772.71 | 57 | COM17 | 2998.10 | -687.75 | 107 | SEG47 | -714.18 | 772.98 |
| 8 | COM10 | -1977.68 | -772.71 | 58 | COM18 | 2998.10 | -577.68 | 108 | SEG48 | -809.03 | 772.98 |
| 9 | COM9 | -1867.60 | -772.71 | 59 | COM19 | 2998.10 | -467.60 | 109 | SEG49 | -903.88 | 772.98 |
| 10 | COM8 | -1757.53 | -772.71 | 60 | SEG0 | 2998.10 | -372.75 | 110 | SEG50 | -998.73 | 772.98 |
| 11 | D/C | -1662.68 | -772.71 | 61 | SEG1 | 2998.10 | -277.90 | 111 | SEG51 | -1093.58 | 772.98 |
| 12 | R/W (WR) | -1567.83 | -772.71 | 62 | SEG2 | 2998.10 | -183.05 | 112 | SEG52 | -1188.43 | 772.98 |
| 13 | E(RD) | -1472.98 | -772.71 | 63 | SEG3 | 2998.10 | -88.20 | 113 | SEG53 | -1283.28 | 772.98 |
| 14 | CS | -1378.13 | -772.71 | 64 | SEG4 | 2998.10 | 6.65 | 114 | SEG54 | -1378.13 | 772.98 |
| 15 | D7 | -1283.28 | -772.71 | 65 | SEG5 | 2998.10 | 101.50 | 115 | SEG55 | -1472.98 | 772.98 |
| 16 | D6 | -1187.73 | -772.71 | 66 | SEG6 | 2998.10 | 196.35 | 116 | SEG56 | -1567.83 | 772.98 |
| 17 | D5 | -1092.18 | -772.71 | 67 | SEG7 | 2998.10 | 291.20 | 117 | SEG57 | -1662.68 | 772.98 |
| 18 | D4 | -996.63 | -772.71 | 68 | SEG8 | 2998.10 | 386.05 | 118 | SEG58 | -1757.53 | 772.98 |
| 19 | D3 | -901.08 | -772.71 | 69 | SEG9 | 2998.10 | 480.90 | 119 | SEG59 | -1867.60 | 772.98 |
| 20 | D2 | -805.53 | -772.71 | 70 | SEG10 | 2998.10 | 590.98 | 120 | SEG60 | -1977.68 | 772.98 |
| 21 | D1 | -709.98 | -772.71 | 71 | SEG11 | 2998.10 | 701.05 | 121 | SEG61 | -2087.75 | 772.98 |
| 22 | D0 | -614.43 | -772.71 | 72 | SEG12 | 2742.43 | 772.98 | 122 | SEG62 | -2197.83 | 772.98 |
| 23 | VL2 | -519.58 | -772.71 | 73 | SEG13 | 2632.35 | 772.98 | 123 | SEG63 | -2307.90 | 772.98 |
| 24 | VL3 | -424.73 | -772.71 | 74 | SEG14 | 2522.28 | 772.98 | 124 | SEG64 | -2417.98 | 772.98 |
| 25 | VL4 | -329.88 | -772.71 | 75 | SEG15 | 2412.20 | 772.98 | 125 | SEG65 | -2528.05 | 772.98 |
| 26 | VL5 | -235.03 | -772.71 | 76 | SEG16 | 2302.13 | 772.98 | 126 | SEG66 | -2638.13 | 772.98 |
| 27 | VL6 | -140.18 | -772.71 | 77 | SEG17 | 2192.05 | 772.98 | 127 | SEG67 | -2748.20 | 772.98 |
| 28 | VF | -45.33 | -772.71 | 78 | SEG18 | 2081.98 | 772.98 | 128 | SEG68 | -2998.10 | -687.75 |
| 29 | VOUT | 49.53 | -772.71 | 79 | SEG19 | 1971.90 | 772.98 | 129 | SEG69 | -2998.10 | -577.68 |
| 30 | C2N | 144.38 | -772.71 | 80 | SEG20 | 1861.83 | 772.98 | 130 | SEG70 | -2998.10 | -467.60 |
| 31 | C2P | 239.23 | -772.71 | 81 | SEG21 | 1751.75 | 772.98 | 131 | SEG71 | -2998.10 | -372.75 |
| 32 | C1N | 334.08 | -772.71 | 82 | SEG22 | 1657.08 | 772.98 | 132 | SEG72 | -2998.10 | -277.90 |
| 33 | C1P | 428.93 | -772.71 | 83 | SEG23 | 1562.23 | 772.98 | 133 | SEG73 | -2998.10 | -183.05 |
| 34 | VEXT | 523.78 | -772.71 | 84 | SEG24 | 1467.38 | 772.98 | 134 | SEG74 | -2998.10 | -88.20 |
| 35 | AVSS | 618.63 | -772.71 | 85 | SEG25 | 1372.53 | 772.98 | 135 | SEG75 | -2998.10 | 6.65 |
| 36 | DVSS | 713.48 | -772.71 | 86 | SEG26 | 1277.68 | 772.98 | 136 | SEG76 | -2998.10 | 101.50 |
| 37 | REF | 808.33 | -772.71 | 87 | SEG27 | 1182.83 | 772.98 | 137 | SEG77 | -2998.10 | 196.35 |
| 38 | DIRS | 903.18 | -772.71 | 88 | SEG28 | 1087.98 | 772.98 | 138 | SEG78 | -2998.10 | 291.20 |
| 39 | AVDD | 998.03 | -772.71 | 89 | SEG29 | 993.13 | 772.98 | 139 | SEG79 | -2998.10 | 386.05 |
| 40 | DVDD | 1092.88 | -772.71 | 90 | SEG30 | 898.28 | 772.98 | 140 | ICONS2 | -2998.10 | 480.90 |
| 41 | CLK | 1187.73 | -772.71 | 91 | SEG31 | 803.43 | 772.98 | 141 | COM23 | -2998.10 | 590.98 |
| 42 | P/S | 1282.58 | -772.71 | 92 | SEG32 | 708.58 | 772.98 | 142 | COM22 | -2998.10 | 701.05 |
| 43 | DL | 1377.43 | -772.71 | 93 | SEG33 | 613.73 | 772.98 | | | | |
| 44 | C68/(80) | 1472.28 | -772.71 | 94 | SEG34 | 518.88 | 772.98 | | | | |
| 45 | RES | 1567.13 | -772.71 | 95 | SEG35 | 424.03 | 772.98 | | | | |
| 46 | TEST | 1661.98 | -772.71 | 96 | SEG36 | 329.18 | 772.98 | | | | |
| 47 | ICONS1 | 1758.23 | -772.71 | 97 | SEG37 | 234.33 | 772.98 | | | | |
| 48 | COM0 | 1868.30 | -772.71 | 98 | SEG38 | 139.48 | 772.98 | | | | |
| 49 | COM1 | 1978.38 | -772.71 | 99 | SEG39 | 44.63 | 772.98 | | | | |
| 50 | COM2 | 2088.45 | -772.71 | 100 | SEG40 | -50.23 | 772.98 | | | | |

PIN DESCRIPTIONS

$\overline{D/C}$

This pin is Data/ Command control pin. When the pin is pulled high, the data at D7-D0 is treated as display data. When the pin is pulled low, the data at D7-D0 will be transferred to the command register.

$\overline{R/W}$ (\overline{WR})

This pin is microprocessor interface input. When interfacing to a 6800-series microprocessor, this pin will be used as R/W signal input. Read mode will be carried out when this pin is pulled high and write mode when low.

When interfacing to a 8080-microprocessor, this pin will be the \overline{WR} input. Data write operation is initiated when this pin is pulled low and the chip is selected.

This pin must be fixed to high or low in serial mode.

DVDD & AVDD

Digital and Analog Power supply pin.

DVSS & AVSS

Ground.

$\overline{E(RD)}$

This pin is microprocessor interface input. When interfacing to a 6800-series microprocessor, this pin will be used as the enable signal, E. Read/ Write operation is initiated when this pin is pulled high and the chip is selected.

When interfacing to a 8080-microprocessor, this pin receives the \overline{RD} signal. Data read operation is initiated when this pin is pulled low and the chip is selected.

This pin must be fixed to high or low in serial mode.

\overline{CS}

This pin is the chip select input.

D7-D0

These pins are the 8-bit bi-directional data bus to be connected to the microprocessor in parallel interface mode. In 8-bit bus mode, D7 is the MSB while D0 is the LSB. In 4-bit bus mode, it is needed to transfer 4-bit data (through D7-D4) by two times. The high order bits (for 8-bit mode D7-D4) are written before the low order bits (for 8-bit mode D3-D0) in write transaction and low order bits (8-bit mode D3-D0) are read before the high order bits (8-bit mode D7-D4) in read transaction. The D3-D0 pins must be fixed to high or low in 4-bit bus mode. After resets, SSD1801 considers first 4-bit data from MPU as the high order bits.

When serial mode is selected, D7 is the serial data input (SDA) and D6 is the serial clock input (SCK). D5-D0 must be fixed to high or low in serial mode

VL6, VL5, VL4, VL3, VL2

LCD driving voltages. They can be supplied externally or generated by the internal bias divider. They have the following relationship:

$$VL6 > VL5 > VL4 > VL3 > VL2 > V_{ss}$$

| | 1:4 bias | 1:5 bias (default) |
|-----|-------------|--------------------|
| VL5 | $3/4 * VL6$ | $4/5 * VL6$ |
| VL4 | $2/4 * VL6$ | $3/5 * VL6$ |
| VL3 | $2/4 * VL6$ | $2/5 * VL6$ |
| VL2 | $1/4 * VL6$ | $1/5 * VL6$ |

VL6 is the most positive LCD driving voltage. It can be supplied externally or generated by the internal regulator. It is recommended to add a capacitor between VL6 and Vss for external regulator.

VF

This pin is the input of the built-in voltage regulator. When external resistor network is selected to generate the LCD driving level, VL6, two external resistors, R1 and R2, are connected between AVSS and VF, and VF and VL6, respectively (see application circuit)

VOUT

Regulated DC/DC voltage converter output. External capacitor is connected to AVDD for internal regulated DC-DC converter and divider mode only.

VEXT

This is an input pin to provide an external voltage reference for the internal voltage regulator. It is selected by REF signal pin. Leave this pin open (NC) if internal voltage regulator is used.

REF

This pin is to select the input voltage of internal voltage regulator. When this pin is pulled low, the internal voltage reference VREF is used. When this pin is pulled high, external voltage reference (VEXT) is selected.

DIRS

This pin controls the direction of Segment.

When DIRS = Low

SEG0 -> SEG2 -> -> SEG78 -> SEG79

When DIRS = High

SEG79 -> SEG78 -> -> SEG1 -> SEG0

CLK

External clock input. It must be fixed to high or low when the internal oscillation circuit is used. In case of the external clock mode, CLK is used as the clock and OSC bit should be OFF.

P/ \overline{S}

This pin is serial/ parallel interface selection input. When this pin is pulled high, parallel mode is selected. When it is pulled low, serial interface will be selected. Read back operation is only available in parallel mode.

DL

This pin is to select the data length for parallel data input.

When P/ \overline{S} = Low

DL = Low or High: serial interface mode

When P/ \overline{S} = High

DL = Low: 4-bit bus mode

DL = High: 8-bit bus mode

This pin must be fixed to high or low in serial mode.

C68/ $\overline{80}$

This pin is microprocessor interface selection input. When the pin is pulled high, 6800 series interface is selected and when the pin is pulled low, 8080 series MCU interface is selected. This pin must be fixed to high or low in serial mode.

 \overline{RES}

This pin is reset signal input. Initialization of the chip is started once this pin is pulled low. Minimum pulse width for completing the reset is 10ms.

TEST

Test pin. This pin is not used for normal operation. Leave this pin open (NC).

C1P, C1N, C2P and C2N

When internal DC-DC voltage converter is used, external capacitors are connected between these pins. Different connection will result in different DC-DC converter multiple factor, 2x/3x. Details connections please refer to Figure 12.

COMI0, COMI1

There are two icons pins (pin 66 and 165) on SSD1801Z and (pin47 and 140) on SSD1801AV. Both pins output exactly the same signal. The reason for duplicating the pin is to enhance the flexibility of the LCD layout.

COM0 - COM23

These pins provide the common driving signal COM0 - COM23 to the LCD panel. In case of 2-line display mode, COM0 - COM15 will be used, and in 3-line mode, all common signals will be used to drive LCD panel. Their output voltage levels are AV_{ss} during sleep mode and standby mode.

SEG0 - SEG79

These pins provide the LCD segment driving signals. Their output voltage levels are AV_{ss} during sleep mode and standby mode.

NC

These are the No Connection pins. Nothing should be connected to these pins, nor they are connected together. These pins should be left open individually.

FUNCTIONAL BLOCK DESCRIPTIONS

Command Decoder and Command Interface

This module determines whether the input data is interpreted as data or command. Data is directed to this module based upon the input of the D/\overline{C} pin. If D/\overline{C} is high, data is written to internal memories (DDRAM, CGRAM, ICONRAM). If D/\overline{C} is low, the input at D7-D0 is interpreted as a Command and it will be decoded and be written to the corresponding command register.

MPU Parallel 6800-series Interface in 8 bits bus mode

The parallel interface consists of 8 bi-directional data pins (D_7 - D_0), R/\overline{W} (\overline{WR}), D/\overline{C} , $E(\overline{RD})$, \overline{CS} . R/\overline{W} (\overline{WR}) input high indicates a read operation from the internal RAM (DDRAM, CGRAM and ICONRAM). R/\overline{W} (\overline{WR}) input low indicates a write operation to internal RAM (DDRAM, CGRAM and ICONRAM) or Internal Command Registers depending on the status of D/\overline{C} input. The $E(\overline{RD})$ input serves as data latch signal (clock) when high provided that \overline{CS} are low. Refer to Figure 20 for Parallel Interface Timing Diagram of 6800-series microprocessors.

In order to match the operating frequency of display RAM with that of the microprocessor, some pipeline processings are internally performed which require the insertion of a dummy read before the first actual display data read. This is shown in Figure 4 below. The dummy read make the address counter (AC) increased by 1. So it is recommended to set address again before writing. The consecutive read after the dummy read are also the valid data. The instruction read cycle is not supported and it is regarded as a no operation cycle.

MPU Parallel 8080-series Interface in 8 bits bus mode

The parallel interface consists of 8 bi-directional data pins (D_7 - D_0), R/\overline{W} (\overline{WR}), D/\overline{C} , $E(\overline{RD})$, \overline{CS} . $E(\overline{RD})$ input serves as data read latch signal (clock) when low provided that \overline{CS} is low whether it is Command write or internal RAM read/ write is controlled by D/\overline{C} . R/\overline{W} (\overline{WR}) input serves as data write latch signal (clock) when low provided that \overline{CS} is low. Refer to Figure 21 for Parallel Interface Timing Diagram of 8080-series microprocessor.

Similar to 6800-series interface, a dummy read is also required before the first actual display data read.

4-bit MPU Parallel 6800/8080-Series Interface

The control of 4-bit bus mode is exactly the same as 8-bit bus mode except 2 consecutive access (read/ write) is needed to read/ write 8 bits data. For write operation, upper order bits are written before the low order bits, and low order bits are always read before the upper order bit in read transaction.

MPU Serial Interface

The serial interface consists of serial clock SCK (D_6), serial data SDA (D_7), D/\overline{C} , \overline{CS} . SDA is shifted into a 8-bit shift register on every rising edge of SCK in the order of D_7 , D_6 , ... D_0 . D/\overline{C} is sampled on every eighth clock to determine whether the data byte in the shift register is written to the internal RAM (DDRAM, CGRAM, ICONRAM) or command register at the same clock.

Oscillator Circuit

This module is an On-Chip low power RC oscillator circuitry. The oscillator generates the clock for the DC-DC voltage converter. This clock is also used in the Display Timing Generator.

ADDRESS COUNTER (AC)

Address Counter (AC) in SSD1801 stores DDRAM/ CGRAM/ ICONRAM address. After writing into or reading from DDRAM/ CGRAM/ ICONRAM. AC is automatically increased by 1. There is only one address counter and stores the address among DDRAM / CGRAM / ICONRAM.

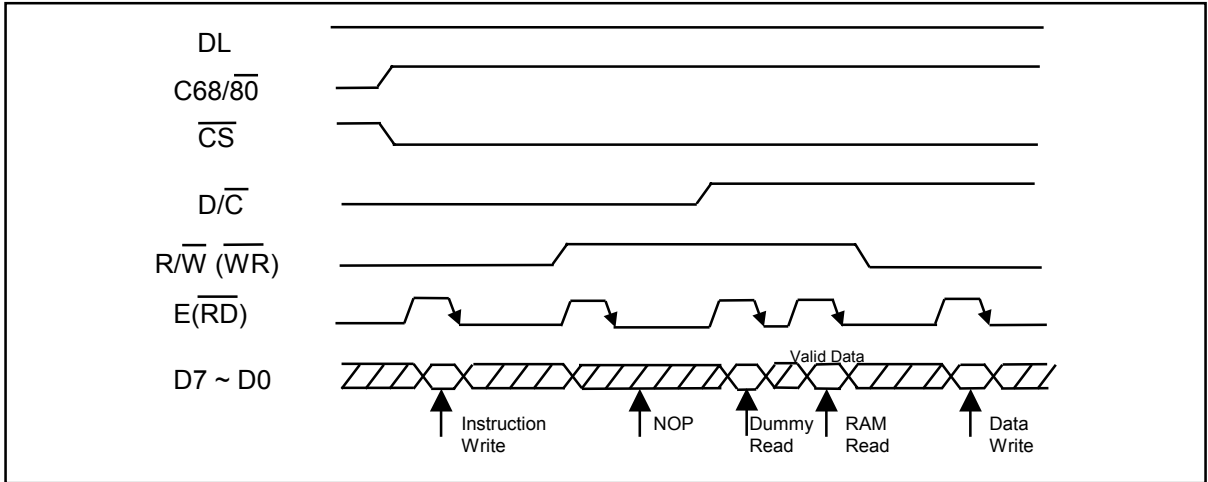


Figure 4 - Timing Diagram of 8-bit Parallel Bus Mode Data Transfer (6800 MPU Mode)

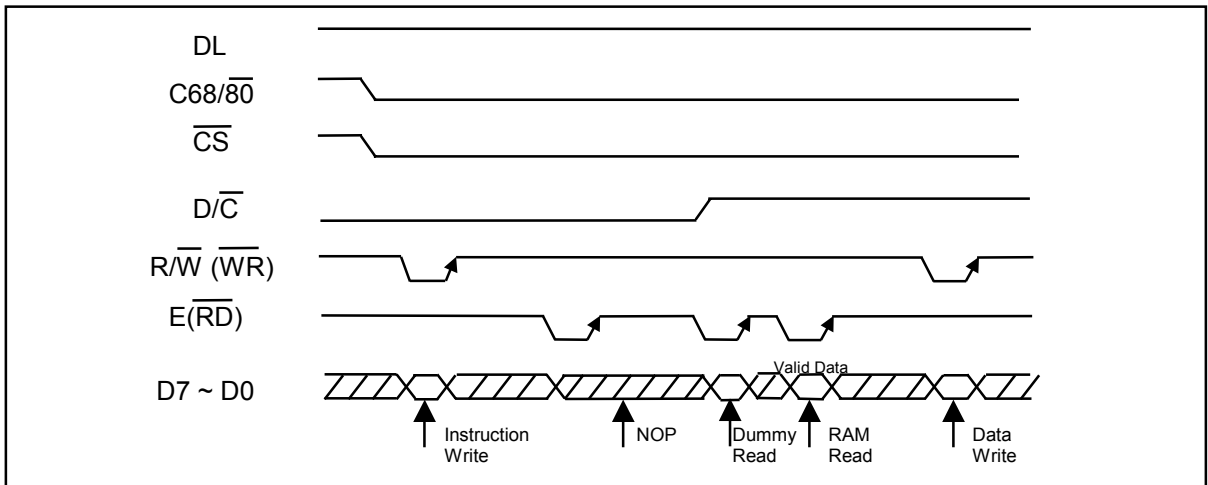


Figure 5 - Timing Diagram of 8-bit Parallel Bus Mode Data Transfer (8080 MPU Mode)

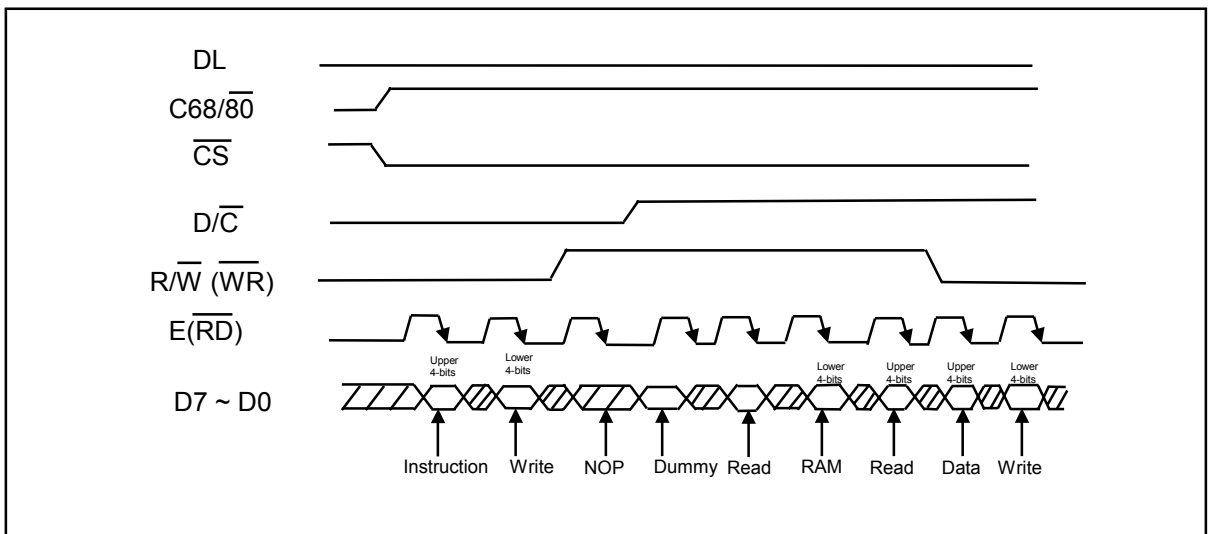


Figure 6 - Timing Diagram of 4-bit Parallel Bus Mode Data Transfer (6800 MPU Mode)

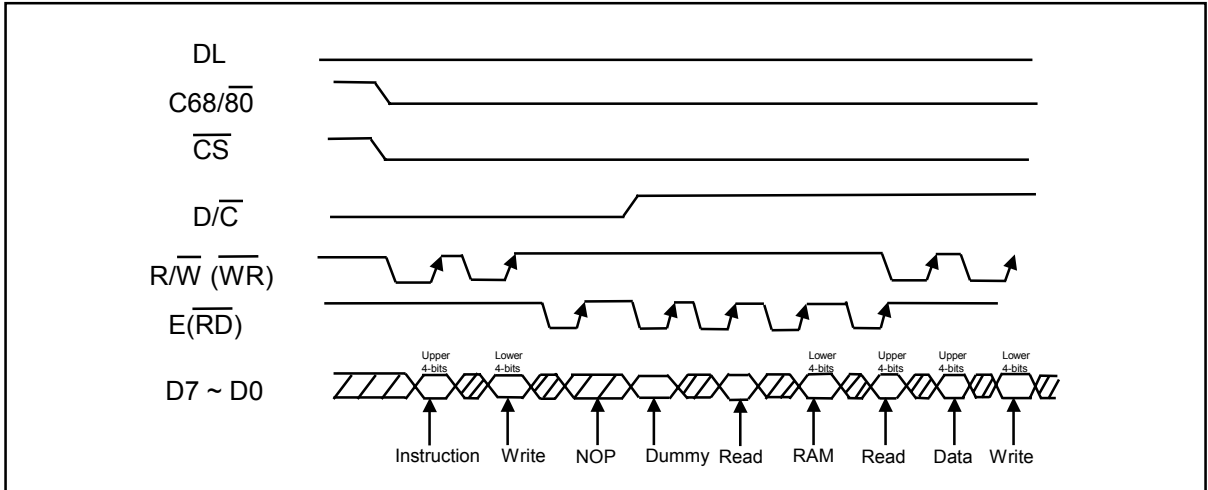


Figure 7 - Timing Diagram of 4-bit Parallel Bus Mode Data Transfer (8080 MPU Mode)

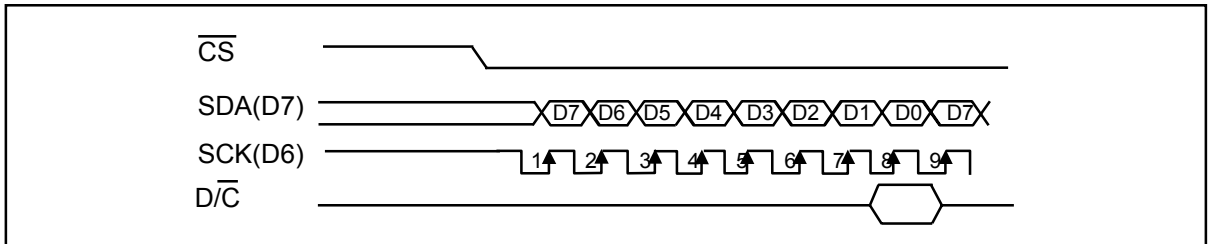
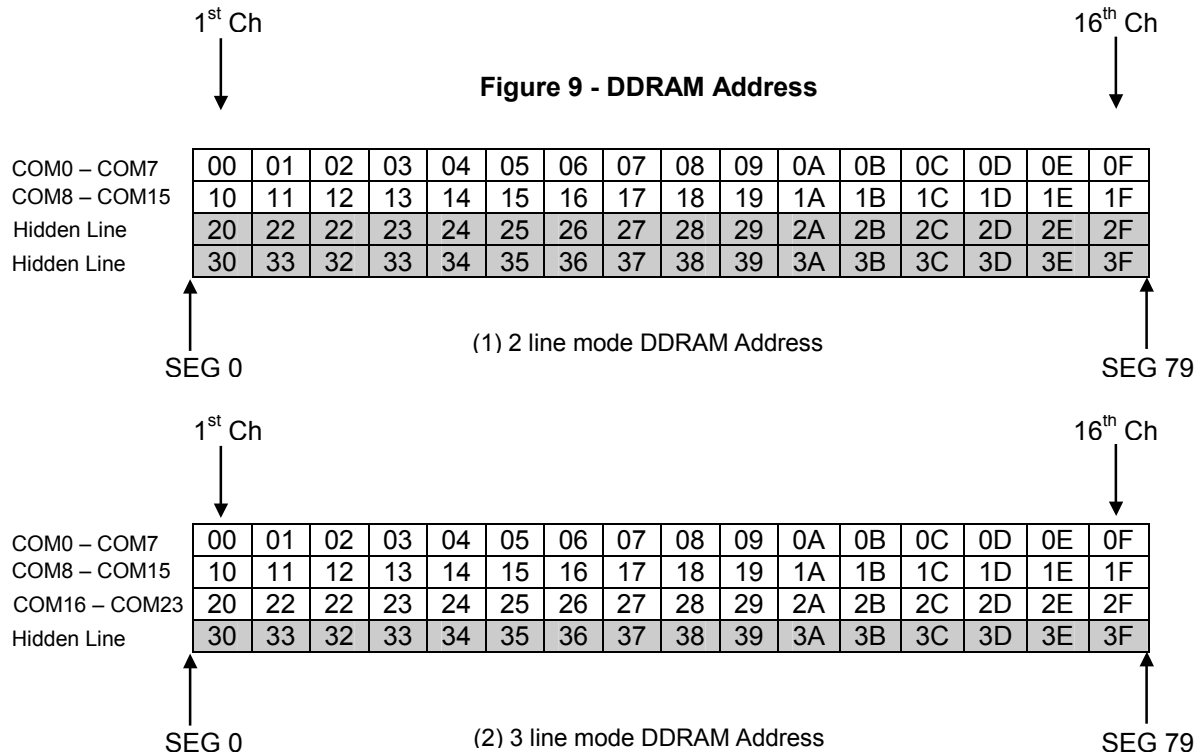


Figure 8 - Timing Diagram of Serial Data Transfer

Display Data RAM (DDRAM)

DDRAM stores display data of maximum 64 x 8 bits (Max 64 characters). DDRAM address is set in the address counter as a hexadecimal number.



SEGMENT ICON RAM (ICONRAM)

ICONRAM has segment control data and segment pattern data. There are 2 ICONS pins (COMI0 & COMI1), which has the same signal. So the icons on the same SEG are displayed at the same time. The number of icons is 80.

Table 4 - Relationship between ICONRAM Address and Display Pattern

| ICONRAM address | ICONRAM bits | | | | | | | |
|-----------------|--------------|-----|-----|-----|-----|-----|-----|-----|
| | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| 00h | - | - | - | S0 | S1 | S2 | S3 | S4 |
| 01h | - | - | - | S5 | S6 | S7 | S8 | S9 |
| 02h | - | - | - | S10 | S11 | S12 | S13 | S14 |
| ... | ... | ... | ... | ... | ... | ... | ... | ... |
| 0Dh | - | - | - | S65 | S66 | S67 | S68 | S69 |
| 0Eh | - | - | - | S70 | S71 | S72 | S73 | S74 |
| 0Fh | - | - | - | S75 | S76 | S77 | S78 | S79 |

Note: "-": Don't care.

Character Generator ROM (CGROM)

CGROM has 5 x 8 dot 256 characters. The Function Set instruction selects the 8 characters (00h - 07h) of CGROM or CGRAM.

Table 5 - CGROM Character Code

| | | Lower 4 bits | | | | | | | | | | | | | | | |
|--------------|------|--------------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| | | 0000 | 0001 | 0010 | 0011 | 0100 | 0101 | 0110 | 0111 | 1000 | 1001 | 1010 | 1011 | 1100 | 1101 | 1110 | 1111 |
| Upper 4 bits | 0000 | | | | | | | | | | | | | | | | |
| | 0001 | ⌘ | ⌘ | ⌘ | ⌘ | ⌘ | ⌘ | ⌘ | ⌘ | ⌘ | ⌘ | ⌘ | ⌘ | ⌘ | ⌘ | ⌘ | ⌘ |
| | 0010 | ! | " | # | \$ | % | & | ' | (|) | * | + | , | - | . | / | |
| | 0011 | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | : | < | = | > | | |
| | 0100 | @ | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O |
| | 0101 | P | Q | R | S | T | U | V | W | X | Y | Z | [| \ |] | ^ | _ |
| | 0110 | ` | a | b | c | d | e | f | g | h | i | j | k | l | m | n | o |
| | 0111 | p | q | r | s | t | u | v | w | x | y | z | { | | } | ~ | |
| | 1000 | Ⓔ | Ⓕ | Ⓖ | Ⓗ | Ⓘ | Ⓚ | Ⓛ | Ⓜ | Ⓝ | Ⓟ | Ⓠ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ |
| | 1001 | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ |
| | 1010 | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ |
| | 1011 | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ |
| | 1100 | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ |
| | 1101 | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ |
| | 1110 | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ |
| | 1111 | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ | Ⓢ | Ⓣ | Ⓤ | Ⓡ |

Note: The CGROM 0000xxxx are empty.

Character Generator RAM (CGRAM)

CGRAM has up to 5 x 8 dots 8 characters. By writing font data to CGRAM, user defined character can be used. CGRAM can be written regardless of Function Set instruction.

Table 6 - Relationship between Character Code (DDRAM) and Character Pattern (CGRAM)

| Character Code (DDRAM data) | CGRAM address | ICONRAM bits | | | | | | | |
|--------------------------------|---------------|--------------|----|----|----|----|----|----|----|
| | | D7 | D6 | D5 | D4 | D3 | D2 | D1 | D0 |
| 00h (Pattern 0) | 40h | - | - | - | X | X | X | X | X |
| | 41h | - | - | - | X | X | X | X | X |
| | 42h | - | - | - | X | X | X | X | X |
| | 43h | - | - | - | X | X | X | X | X |
| | 44h | - | - | - | X | X | X | X | X |
| | 45h | - | - | - | X | X | X | X | X |
| | 46h | - | - | - | X | X | X | X | X |
| | 47h | - | - | - | X | X | X | X | X |
| 01h (Pattern 1) | 48h | - | - | - | X | X | X | X | X |
| | 49h | - | - | - | X | X | X | X | X |
| | 4Ah | - | - | - | X | X | X | X | X |
| | 4Bh | - | - | - | X | X | X | X | X |
| | 4Ch | - | - | - | X | X | X | X | X |
| | 4Dh | - | - | - | X | X | X | X | X |
| | 4Eh | - | - | - | X | X | X | X | X |
| | 4Fh | - | - | - | X | X | X | X | X |
| 02h (Pattern 2) | 50h | - | - | - | X | X | X | X | X |
| | 51h | - | - | - | X | X | X | X | X |
| | 52h | - | - | - | X | X | X | X | X |
| | 53h | - | - | - | X | X | X | X | X |
| | 54h | - | - | - | X | X | X | X | X |
| | 55h | - | - | - | X | X | X | X | X |
| | 56h | - | - | - | X | X | X | X | X |
| | 57h | - | - | - | X | X | X | X | X |
| 03h (Pattern 3) | 58h | - | - | - | X | X | X | X | X |
| | 59h | - | - | - | X | X | X | X | X |
| | 5Ah | - | - | - | X | X | X | X | X |
| | 5Bh | - | - | - | X | X | X | X | X |
| | 5Ch | - | - | - | X | X | X | X | X |
| | 5Dh | - | - | - | X | X | X | X | X |
| | 5Eh | - | - | - | X | X | X | X | X |
| | 5Fh | - | - | - | X | X | X | X | X |
| 04h (Pattern 4) | 60h | - | - | - | X | X | X | X | X |
| | 61h | - | - | - | X | X | X | X | X |
| | 62h | - | - | - | X | X | X | X | X |
| | 63h | - | - | - | X | X | X | X | X |
| | 64h | - | - | - | X | X | X | X | X |
| | 65h | - | - | - | X | X | X | X | X |
| | 66h | - | - | - | X | X | X | X | X |
| | 67h | - | - | - | X | X | X | X | X |
| 05h (Pattern 5) | 68h | - | - | - | X | X | X | X | X |
| | 69h | - | - | - | X | X | X | X | X |
| | 6Ah | - | - | - | X | X | X | X | X |
| | 6Bh | - | - | - | X | X | X | X | X |
| | 6Ch | - | - | - | X | X | X | X | X |
| | 6Dh | - | - | - | X | X | X | X | X |
| | 6Eh | - | - | - | X | X | X | X | X |
| | 6Fh | - | - | - | X | X | X | X | X |

| | | | | | | | | | |
|-----------------|-----|---|---|---|---|---|---|---|---|
| 06h (Pattern 6) | 70h | - | - | - | X | X | X | X | X |
| | 71h | - | - | - | X | X | X | X | X |
| | 72h | - | - | - | X | X | X | X | X |
| | 73h | - | - | - | X | X | X | X | X |
| | 74h | - | - | - | X | X | X | X | X |
| | 75h | - | - | - | X | X | X | X | X |
| | 76h | - | - | - | X | X | X | X | X |
| | 77h | - | - | - | X | X | X | X | X |
| 07h (Pattern 7) | 78h | - | - | - | X | X | X | X | X |
| | 79h | - | - | - | X | X | X | X | X |
| | 7Ah | - | - | - | X | X | X | X | X |
| | 7Bh | - | - | - | X | X | X | X | X |
| | 7Ch | - | - | - | X | X | X | X | X |
| | 7Dh | - | - | - | X | X | X | X | X |
| | 7Eh | - | - | - | X | X | X | X | X |
| | 7Fh | - | - | - | X | X | X | X | X |

NOTE: “-” Don’t use
“X” Pattern 0 or 1

LCD Driving Voltage Generator and Regulator

This module generates the LCD voltage required for display driving output. It takes a single supply input and generates necessary voltage levels. This block consists of:

1. 2x/3x DC-DC voltage converter

The built-in Regulated DC-DC voltage converter is used to generate positive LCD driving voltage with reference to AVss. For SSD1801, it is possible to produce boosting from the internal reference voltage VREF. Detail configurations of the DC-DC converter for boosting are given in Figure 10.

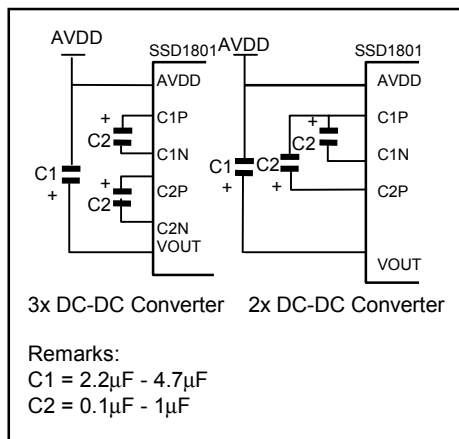


Figure 10 – Configurations for DC-DC Converter

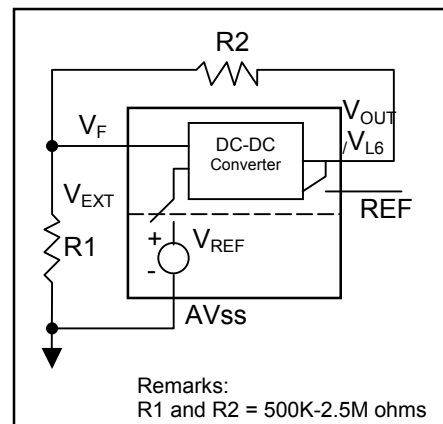


Figure 11 - Configurations for Voltage Regulator

2. Voltage Regulator

The feedback gain control for LCD driving contrast can be adjusted by using reference voltage and external resistor network. The reference voltage is selected by REF pin. When it is pulled low, internal voltage reference V_{REF} is used. When it is pulled high, external voltage reference V_{EXT} will be in use. The external resistors are required to be connected between AV_{SS} and V_F (R1), and between V_F and V_{L6} (R2). The following equations are used to calculate the regulator output voltages.

When REF is low:

$$V_{out} = V_{L6} = \left(1 + \frac{R2}{R1}\right) \times V_{REF}$$

AND

$$V_{REF} = 2V \pm 0.06$$

When REF is high:

$$V_{out} = V_{L6} = \left(1 + \frac{R2}{R1}\right) \times V_{EXT}$$

3. Contrast Control

Software control of the 32 contrast voltage levels at each voltage regulator feedback gain. The equation of calculating the LCD driving voltage is given as:

When REF is low:

$$V_{out} = V_{L6} = \left(1 + \frac{R2}{R1}\right) \times V_{REF} \times \left(1 - \frac{n}{150}\right)$$

When REF is high:

$$V_{out} = V_{L6} = \left(1 + \frac{R2}{R1}\right) \times V_{EXT} \times \left(1 - \frac{n}{150}\right)$$

where n is set in contrast control register.

Table 7- Contrast Control Register

| No. | X7 | X6 | X5 | X4 | X3 | X2 | X1 | X0 | n | Vout | Contrast |
|-----|----|----|----|----|----|----|----|----|-------------|---------|----------|
| 1 | - | - | - | 0 | 0 | 0 | 0 | 0 | 0 (default) | Maximum | High |
| 2 | - | - | - | 0 | 0 | 0 | 0 | 1 | 1 | | |
| 3 | - | - | - | 0 | 0 | 0 | 1 | 0 | 2 | | |
| 4 | - | - | - | 0 | 0 | 0 | 1 | 1 | 3 | | |
| . | - | - | - | . | . | . | . | . | . | . | . |
| . | - | - | - | . | . | . | . | . | . | . | . |
| . | - | - | - | . | . | . | . | . | . | . | . |
| 31 | - | - | - | 1 | 1 | 1 | 1 | 0 | 30 | . | . |
| 32 | | | | 1 | 1 | 1 | 1 | 1 | 31 | Minimum | Low |

(" - ": Don't care)

4. Bias Divider

Divide the regulator output to give the LCD driving voltages (V_{L5}-V_{L2}). A low power consumption circuit design in this bias divider saves most of the display current comparing to traditional design.

5. Bias Ratio Selection circuitry

Software control of 1/4 and 1/5 bias ratio to match the characteristic of LCD panel.

Reset Circuit

This block includes Power On Reset circuitry and the Reset pin $\overline{\text{RES}}$. Both of these having the same reset function. Once $\overline{\text{RES}}$ receives a negative reset pulse, all internal circuitry will start to initialize. Minimum pulse width for completing the reset sequence is 10ms.

The status of the chip after reset is given by:

1. Display/ cursor/ blink is turned OFF
2. 2-line display mode
3. Power control register is set to 000b
4. Oscillator is OFF
5. Power save is OFF
6. CGRAM is not used
7. Shift register data clear in serial interface
8. Bias ratio is set to 1/5
9. Address counter is set to 00h
10. Normal scan direction of the COM outputs
11. Contrast control register is set to 00h
12. Test mode is turned OFF
13. In case of 4-bit interface mode selection, SSD1801 considers the 1st 4-bit data from MPU as the high order bits.
14. The 1st line of display is the address 00h-0Fh.

Display Data Latch

A series of registers carrying the display signal information. For SSD1801, there are 105 latches (80 + 25) for holding the data, which will be fed to the HV Buffer Cell and Level Selector to output the required voltage levels.

Level Selector

Level Selector is a control of the display synchronization. Display voltage can be separated into two sets and used with different cycles. Synchronization is important since it selects the required LCD voltage level to the HV Buffer Cell, which in turn outputs the COM or SEG LCD waveform.

HV Buffer Cell (Level Shifter)

Buffer Cell work as a level shifter which translates the low voltage output signal to the required driving voltage. The output is shifted out with an internal FRM clock which comes from the Display Timing Generator. The voltage levels are given by the level selector which is synchronized with the internal M signal.

VOLTAGE GENERATOR CIRCUIT

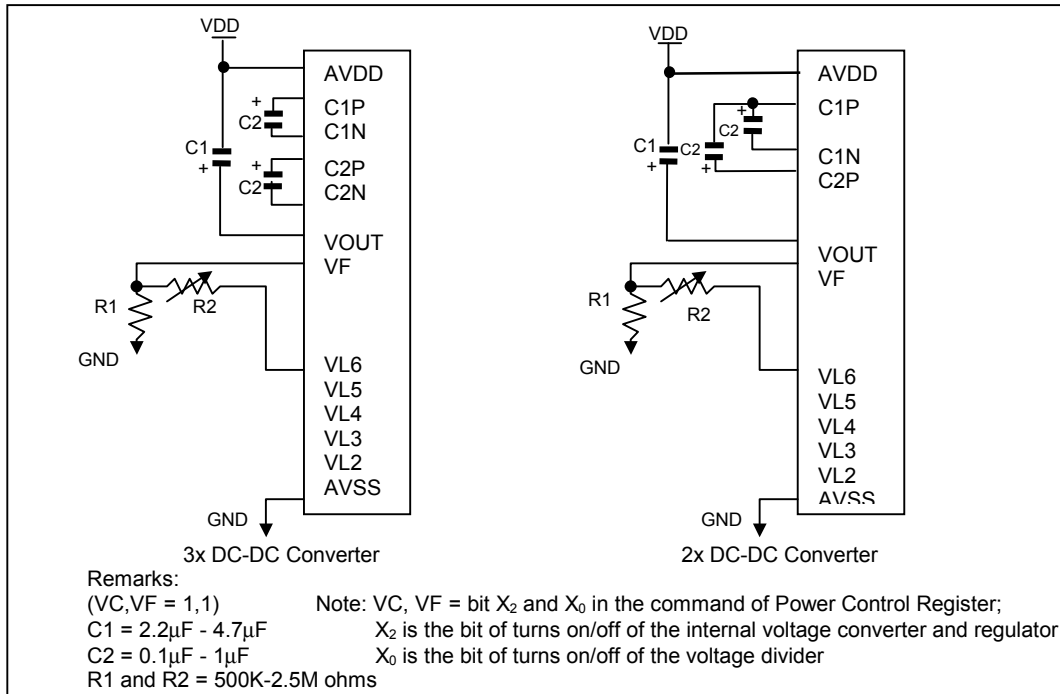


Figure 12 – When Built – in Power Supply is used

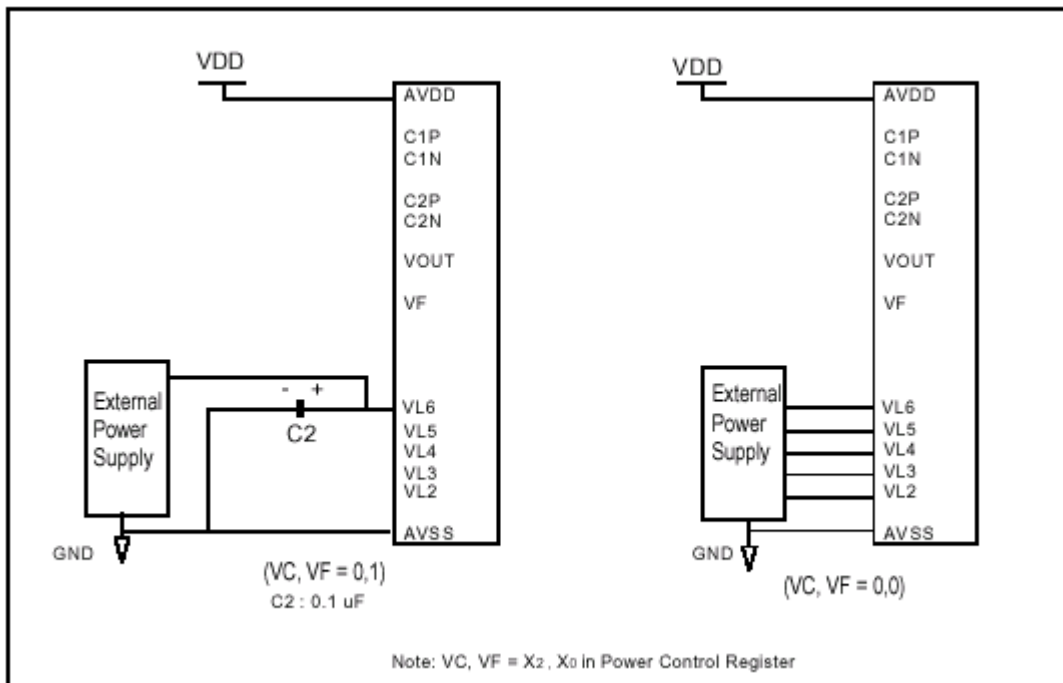
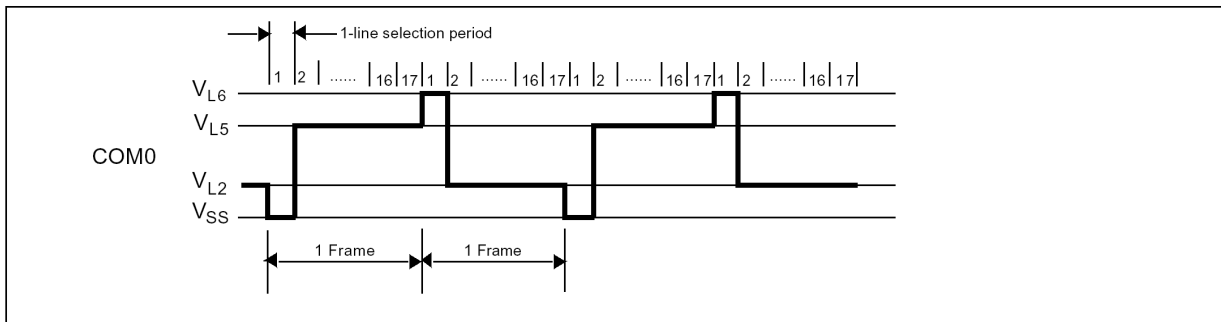


Figure 13 – When External Power Supply is used

FRAME FREQUENCY

2-line mode (1/17 Duty)

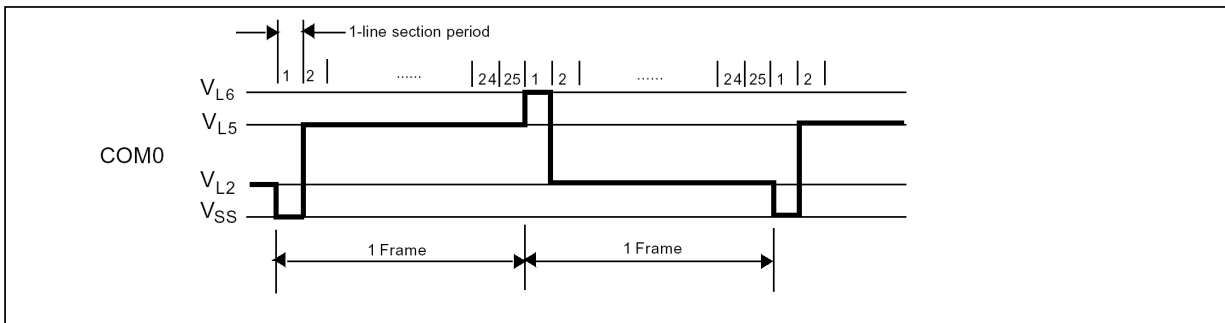


1-line selection period = 16 clocks

One frame = $16 \times 17 \times 49.02\mu\text{s} = 13.33\text{ms}$ (1 clock = $49.02\mu\text{s}$ at $f_{\text{osc}} = 20.4\text{kHz}$)

Frame frequency = $1 / 13.33\text{ms} = 75\text{Hz}$

3-line mode (1/25 Duty)



1-line selection period = 16 clocks

One frame = $16 \times 25 \times 33.33\mu\text{s} = 13.33\text{ms}$ (1 clock = $33.33\mu\text{s}$ at $f_{\text{osc}} = 30\text{kHz}$)

Frame frequency = $1 / 13.33\text{ms} = 75\text{Hz}$

COMMAND TABLE

Table 8 - Command Table

| Bit Pattern | Instruction | Description |
|---|--|--|
| 0000001X ₀ | Return Home | DDRAM address is set to 00h from address counter and the cursor returns to 00h position The contents of DDRAM are not changed. |
| 000010X ₁ X ₀ | Set Double Height Mode | X ₁ X ₀ = 00: normal display (POR) X ₁ X ₀ = 01: COM0 - COM15 is double height COM16 - COM23 is normal X ₁ X ₀ = 10: 1) 2-line mode: normal display 2) 3-line mode: COM0 -COM7 is normal COM8 - COM23 is double height X ₁ X ₀ = 11: normal display |
| 000011X ₁ X ₀ | Set Power Save Mode / Oscillator Control | X ₀ = 0: power save OFF (POR) X ₀ = 1: power save ON X ₁ = 0: oscillator OFF (POR) X ₁ = 1: oscillator ON |
| 00010X ₂ X ₁ X ₀ | Function Set | X ₀ = 0: CGROM is selected (POR) X ₀ = 1: CGRAM is selected X ₁ = 0: 1) 2-line mode: COM0 -> COM15 (POR) 2) 3-line mode: COM0 -> COM23 (POR) X ₁ = 1: 1) 2-line mode: COM15 -> COM0 2) 3-line mode: COM23 -> COM0 X ₂ = 0: 2-line display mode (POR) X ₂ = 1: 3-line display mode |
| 000110X ₁ X ₀ | Set Display Start Line | X ₁ X ₀ = 00: DDRAM line 1 shows at the first line of LCD (POR). X ₁ X ₀ = 01: DDRAM line 2 shows at the first line of LCD. X ₁ X ₀ = 10: DDRAM line 3 shows at the first line of LCD. X ₁ X ₀ = 11: DDRAM line 4 shows at the first line of LCD. |
| 000111*X ₀ | Set Bias Control | X ₀ = 0: 1/5 bias (POR) X ₀ = 1: 1/4 bias |
| 00100X ₂ X ₁ X ₀ | Set Power Control Register | X ₀ = 0: turns off the voltage divider (POR) X ₀ = 1: turns on the voltage divider X ₁ : Don't care X ₂ = 0: turns off the internal voltage converter and regulator (POR) X ₂ = 1: turns on the internal voltage converter and regulator |
| 00101X ₂ X ₁ X ₀ | Set Display Control | X ₀ = 0: turns off the display (POR) X ₀ = 1: turns on the display X ₁ = 0: blink off (POR) X ₁ = 1: blink on X ₂ = 0: cursor off (POR) X ₂ = 1: cursor on |
| 1X ₆ X ₅ X ₄ X ₃ X ₂ X ₁ X ₀ | Set DD/CGRAM address | DDRAM/ CGRAM address range: DDRAM: 00h - 3Fh CGRAM: 40h - 7Fh |
| 010X ₄ X ₃ X ₂ X ₁ X ₀ | Set ICONRAM address / Contrast Control | ICONRAM address range / Contrast Control Register: ICONRAM: 00h - 0Fh Contrast Control Register: 10h TE: 11h (test byte) |
| 00000000 | NOP | Command for No Operation |
| 0011**** | Set Test Mode | Reserved for IC testing. Do Not use. |

Note:

1. Patterns other than that given in Command Table are prohibited to enter to the chip as a command. Otherwise, unexpected result will occur.
2. “*”: Don't care.

Data Read/ Write

To read data from the internal memories (DDRAM/ CGRAM/ ICONRAM), input high to $\overline{R/W}$ (\overline{WR}) pin and $\overline{D/C}$ pin for 6800-series parallel mode, low to $\overline{E(RD)}$ pin and high to $\overline{D/C}$ pin for 8080-series parallel mode. No data read is provided for serial mode. In normal mode, address counter will be increased by one automatically after each data read. A dummy read is required before the first data read. See Figure 4 in Functional Description.

To write data to the internal memories (DDRAM/ CGRAM/ ICONRAM), input low to $\overline{R/W}$ (\overline{WR}) pin and high to $\overline{D/C}$ pin for 6800-series and 8080-series parallel mode. For serial interface, it will always be in write mode. Address counter will be increased by one automatically after each data write.

COMMAND DESCRIPTIONS

Return Home

Return Home instruction field makes cursor return home. DDRAM address is set to 00h from address counter and the cursor returns to 00h position. The contents of DDRAM are not changed.

Set Double Height Mode

This command increases the height of one character line from 8 to 16 dots. If the number of COM signal needed exceeds the existing COM signal (COM0-COM15 for 2-line mode, COM0-COM23 for 3-line mode), the last character line will not be displayed. It will happen at following cases:

1. 3-line mode, $X_1X_0 = 01$ where COM0-COM15 is double height, COM16-COM23 is normal. The 3rd line will not be displayed.
2. 3-line mode, $X_1X_0 = 10$ where COM0-COM7 is normal, COM8-COM23 is double height. The 3rd line will be displayed.
3. 2-line mode, $X_1X_0 = 01$ where COM0-COM15 is double height. The 2nd line will not be displayed.

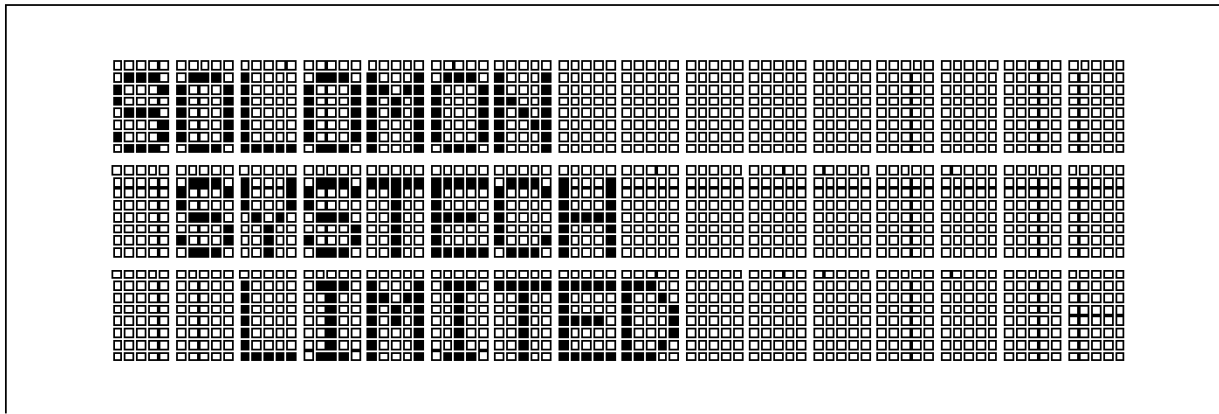


Figure 14 – 3-line Normal Mode Display in 3-line mode ($X_1X_0 = 00$)

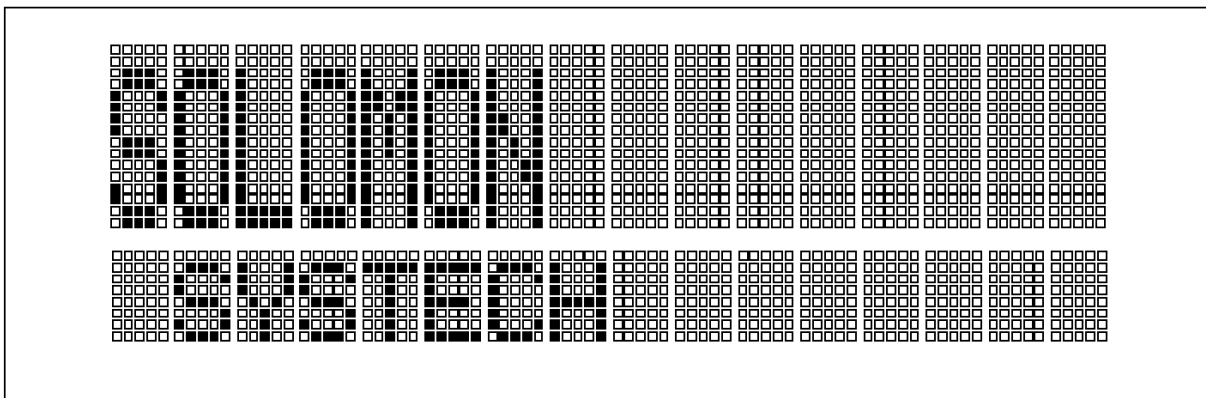


Figure 15 – COM0 ~ COM15 is a Double Height Line, COM16 ~COM23 is Normal in 3-line mode ($X_1X_0 = 01$)

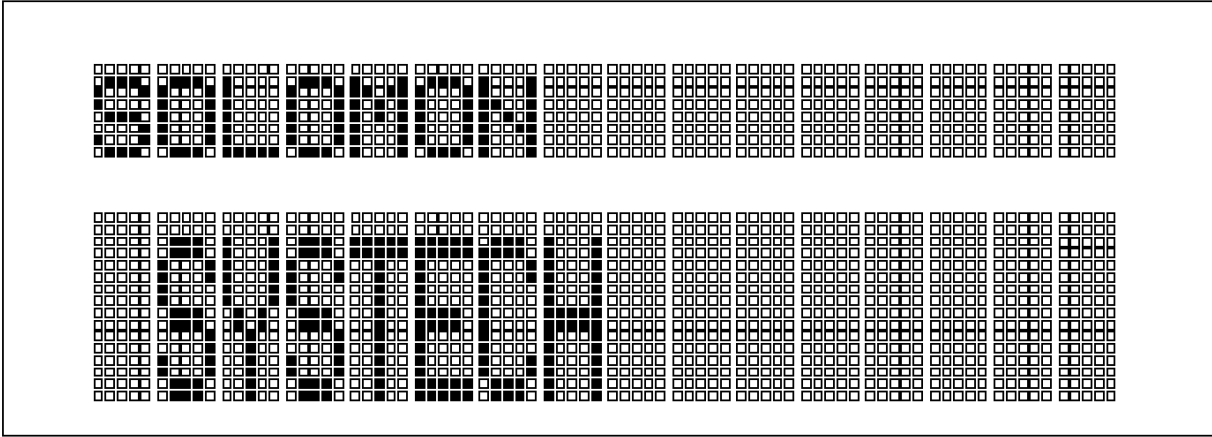


Figure 16 – COM0 ~ COM7 is Normal, COM8 ~ COM23 is a Double Height Line in 3-line mode ($X_1X_0 = 10$)

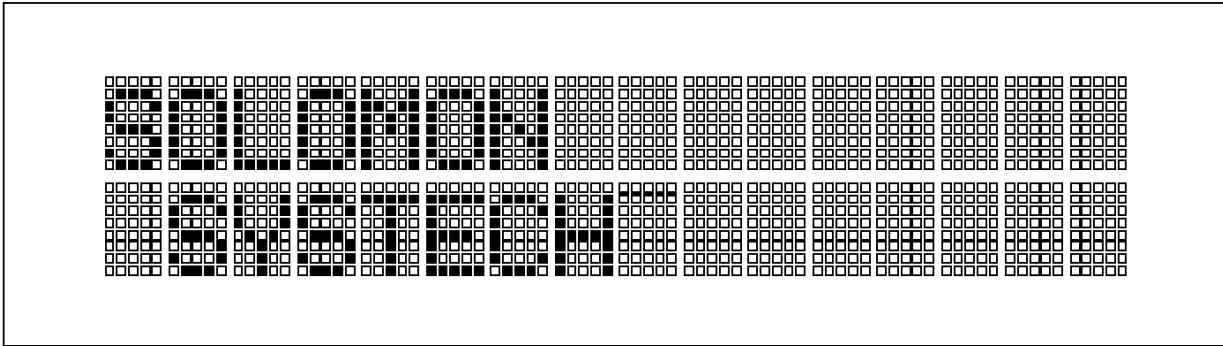


Figure 17 – 2-line Normal Mode Display in 2-line mode ($X_1X_0 = 00$)

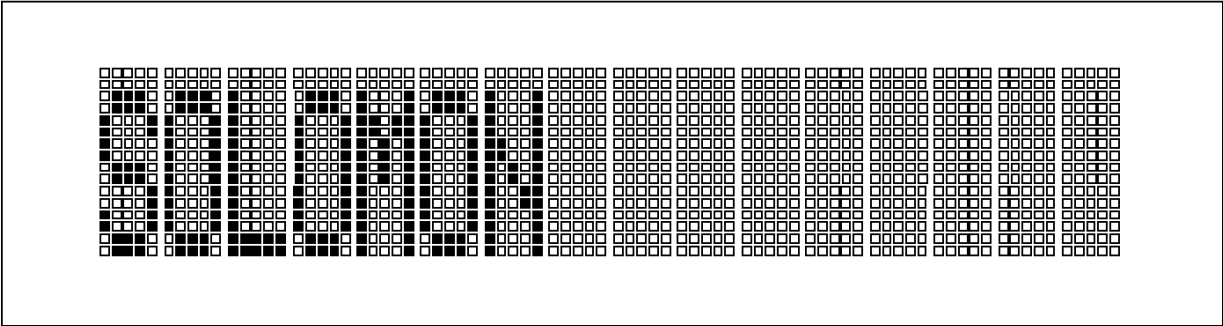


Figure 18 – COM0 ~ COM15 is a Double Height Line in 2-line mode ($X_1X_0 = 01$)

Set Power Save Mode / Oscillator Control

To enter Standby or Sleep Mode, it should be done by turning off the internal oscillator and turning on the power save control bit. The corresponding control bits are $X_1X_0 = 01$. In order to put the system into low power consumption mode, internal voltage converter, voltage regulator and voltage divider should also be turned off by using Power Control Register. After putting the system into power save mode, the following status will be entered:

1. Internal oscillator and LCD power supply circuits are stopped.
2. Segment and Common drivers output AVss level.
3. The display data and operation mode before sleep are held. All the internal circuit are stopped.

Function Set

This command sets 3 functions on the system. They are the number of display line (2 or 3), COM shift direction (left or right) and CGROM/ CGRAM character area select.

Set Display Start Line

This command is to set Display Start Line register to determine starting address of display data RAM to be displayed by selecting a value from 0 to 3. With the value equals to 0, the display will start from address (00h-0Fh). With the value equals to 1, the display will start from address (10h-1Fh). With the value equals to 2, the display will start from address (20h-2Fh). With the value equals to 3, the display will start from address (30-3Fh).

Set Bias Control

Bias ratio 1/4 or 1/5 could be set using this command. When changing the number of line display, the bias ratio also needs to be adjusted to make display contrast consistent.

Set Power Control Register

This command turns on / off the various power circuits associated with the chip which including regulated DC-DC converter and voltage divider.

Set Display Control

This command provides 3 display functions. It turns on/off both the cursor, blink and display. When both cursor and blink control bit set high, the driver make LCD alternate between inverting display character and normal display character at the cursor position with about a half second. On the contrary, if cursor control bit is low, only a normal character is displayed regardless of blink control bit.

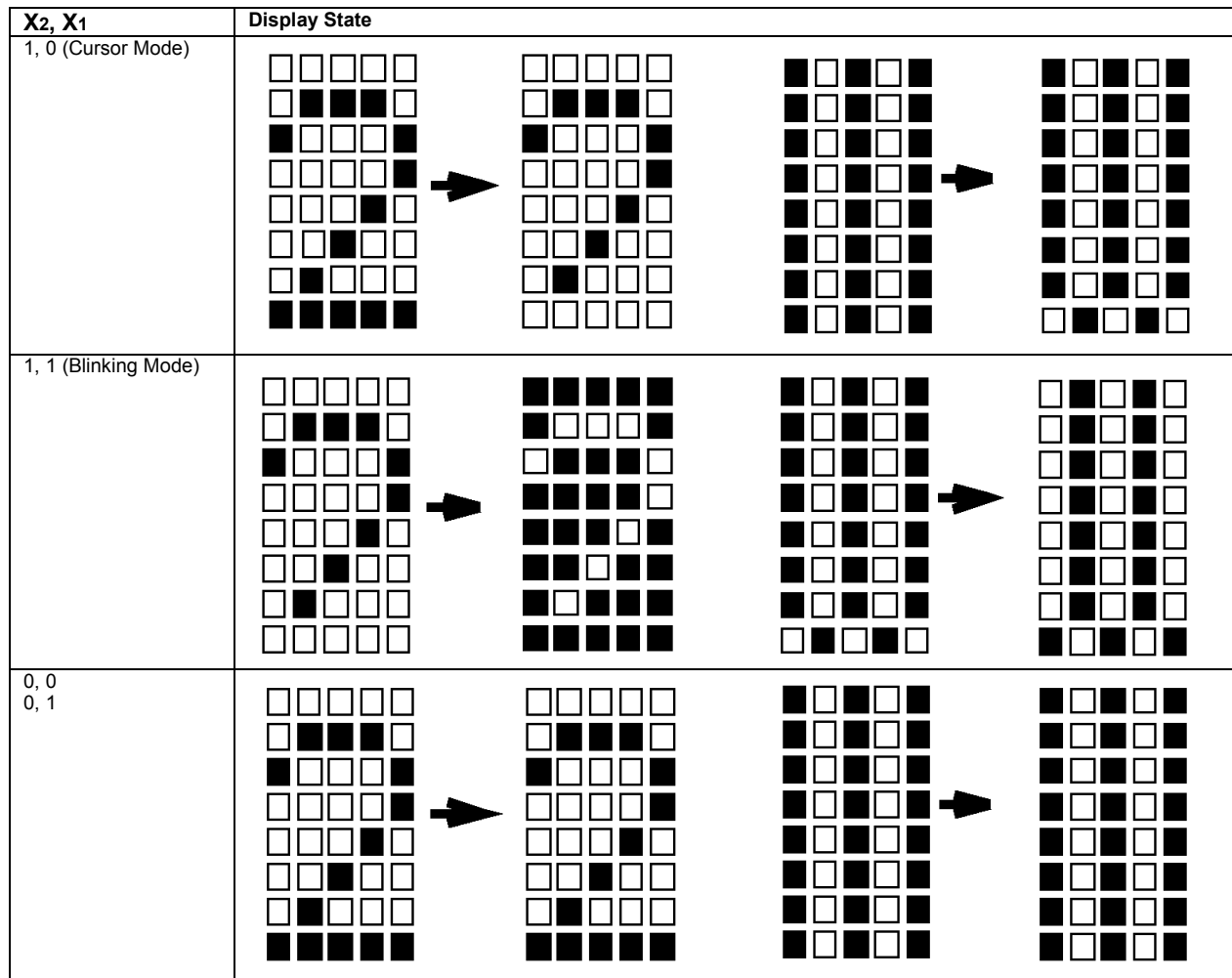


Figure 19 - Display Attributes

Set DD/ CGRAM Address

Before writing/ reading data into/ from the RAM, set the address by RAM address set instruction. Next, when data are written/ read in succession, the address is automatically increased by 1. After accessing 7Fh, the address is 00h.

Table 9 - DD/ CGRAM Address Mapping

| ADDRESS | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|---------|--------------------------|---|---|---|---|---|---|---|-------------------|---|---|---|---|---|---|---|
| 00H | DDRAM LINE 1 (00H - 0FH) | | | | | | | | | | | | | | | |
| 10H | DDRAM LINE 2 (10H - 1FH) | | | | | | | | | | | | | | | |
| 20H | DDRAM LINE 3 (20H - 2FH) | | | | | | | | | | | | | | | |
| 30H | DDRAM LINE 4 (30H - 3FH) | | | | | | | | | | | | | | | |
| 40H | CGRAM (PATTERN 0) | | | | | | | | CGRAM (PATTERN 1) | | | | | | | |
| 50H | CGRAM (PATTERN 2) | | | | | | | | CGRAM (PATTERN 3) | | | | | | | |
| 60H | CGRAM (PATTERN 4) | | | | | | | | CGRAM (PATTERN 5) | | | | | | | |
| 70H | CGRAM (PATTERN 6) | | | | | | | | CGRAM (PATTERN 7) | | | | | | | |

Set ICONRAM Address Set

Before writing/ reading data into/ from the ICONRAM, set the address by ICONRAM Address Set instruction. Next, when data are written/ read in succession, the address is automatically increased by 1. The 5 icons at a time can blink if blinking is enabled. The blink attributes of ICON are the same as the cursor blink. For accessing DD/ CGRAM, the DD/ CGRAM Address Set instruction should be set before. After accessing 0Fh, the address of ICONRAM address is 00h. The ICONRAM address ranges are 00h-0Fh.

Table 10 - ICONRAM Address Mapping

| ADDRESS | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | A | B | C | D | E | F |
|---------|---------------------|---|----------|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 00H | ICONRAM (00h - 0Fh) | | | | | | | | | | | | | | | |
| 10H | C | T | Reserved | | | | | | | | | | | | | |
| | C | E | | | | | | | | | | | | | | |
| | R | | | | | | | | | | | | | | | |

Set Contrast Control Register

Set the Contrast Control Register (CCR) by ICONRAM Address Set Instruction. Next, data are written to the CCR. The default value of CCR is (00000).

TE: Test Mode Register (Do not Use) (11H)

When the CCR and TE registers are written, the address counter is not increased.

NOP

A command causing No Operation.

Set Test Mode

This command force the driver chip into its test mode for internal testing of the chip. Under normal operation, user should NOT use this command.

MAXIMUM RATINGS

Table 11 - Maximum Ratings (Voltage Reference to VSS)

| Symbol | Parameter | Value | Unit |
|------------------|---------------------------|--|------|
| AVDD, DVDD | Supply Voltage | -0.3 to +4.0V | V |
| VL6 | VLCD Voltage | -0.3 to +6.5V | V |
| V _{IN} | Input Voltage | V _{SS} -0.3 to V _{DD} +0.3 | V |
| T _A | Operating Temperature | -30 to +85 | °C |
| T _{stg} | Storage Temperature Range | -65 to +150 | °C |

* Maximum Ratings are those values beyond which damage to the device may occur. Functional operation should be restricted to the limits in the Electrical Characteristics tables or Pin Description section

This device contains circuitry to protect the inputs against damage due to high static voltages or electric fields; however, it is advised that normal precautions to be taken to avoid application of any voltage higher than maximum rated voltages to this high impedance circuit. For proper operation it is recommended that V_{in} and V_{out} be constrained to the range V_{SS} < or = (V_{in} or V_{out}) < or = V_{DD}.

Reliability of operation is enhanced if unused inputs are connected to an appropriate logic voltage level (e.g., either V_{SS} or V_{DD}). Unused outputs must be left open. This device may be light sensitive. Caution should be taken to avoid exposure of this device to any light source during normal operation. This device is not radiation protected.

DC CHARACTERISTICS

Table 12 - DC Characteristics (Unless otherwise specified, Voltage Referenced to VSS, VDD = 2.4 to 3.6V, TA = -30 to 85°C.)

| Symbol | Parameter | Test Condition | Min | Typ | Max | Unit |
|---------------------------------|--|--|---------------------------------|---|---------------------------------|-----------------------|
| DVDD AVDD | Logic and Analog Circuit Supply Voltage Range | (Absolute value referenced to DVSS and AVSS) | 2.4 | 2.7 | 3.6 | V |
| IDD1 | Display Operation Supply Current Drain | VDD = 3V, TA = 25°C VLCD = 5.8V without load No access from MPU | - | - | 85 | μA |
| IDD2 | Access operation from MPU Supply Current Drain | VDD = 3V, TA = 25°C fcyc = 200kHz | - | - | 500 | μA |
| ISB | Standby Mode Supply Current | Current No load Oscillator OFF Power Save ON | - | - | 5 | μA |
| VLCD V _{OUT} | LCD Driving Voltage Input Voltage Converter Output Voltage | VLCD = VL6 - VSS TA = 25°C, C = 1μF | 4 AVDD | - - | 5.8 5.8 | V V |
| VIH | Logic High Input Voltage | | 0.8*DVDD | - | DVDD | V |
| VIL | Logic Low Input Voltage | | 0 | - | 0.2*DVDD | V |
| VOH | Logic High Output Voltage | IOH = -1mA, VDD = 2.4V | DVDD - 0.4 | - | - | V |
| VOL | Logic Low Output Voltage | IOL = 1mA, VDD = 2.4V | - | - | 0.4 | V |
| VL6 | LCD Driving Voltage Source (VL6) | Regulator Enable (VL6 voltage depends on contrast control/ external resistors network) | AVSS - 0.5 | - | Vout | V |
| VL6 | LCD Driving Voltage Source (VL6) | Regulator Disable | - | Floating | - | V |
| VL6 VL5 VL4 VL3 VL2 | LCD Display Voltage Output (V _{L5} , V _{L4} , V _{L3} , V _{L2}) | Voltage reference to AVSS, Bias Divider Enabled, 1:a bias ratio | - - - - - | VL6 (a-1)/a * VL6 (a-2)/a * VL6 2/a * VL6 1/a * VL6 | - - - - - | V V V V V |
| VL6 VL5 VL4 VL3 VL2 | LCD Display Voltage Output (V _{L5} , V _{L4} , V _{L3} , V _{L2}) | Voltage reference to AVSS, External Voltage Generator, Bias Divider Disable | VL5 VL4 VL3 VL2 VSS | - - - - - | 5.8 VL6 VL5 VL4 VL3 | V V V V V |
| IOH | Logic High Output Current Source | VOUT = VDD - 0.4V | 50 | - | - | μA |
| IOL | Logic Low Output Current Drain | VOUT = 0.4V | - | - | -50 | μA |
| IOZ | Logic Output Tri-state Current Drain Source | | -1 | - | 1 | μA |
| IIL/ IIH | Logic Input Current | | -1 | - | 1 | μA |
| CIN | Logic Pins Input Capacitance | | - | 5 | 7.5 | PF |

| Symbol | Parameter | Test Condition | Min | Typ | Max | Unit |
|---------------|-------------------------------------|-----------------------|------------|------------|------------|-------------|
| Vref | Voltage regulator reference voltage | | 1.94 | 2 | 2.06 | V |
| Vext | External voltage reference | | 1.2 | 2 | VDD | V |

AC CHARACTERISTICS

Table 13 - AC Characteristics (Unless otherwise specified, Voltage Referenced to VSS, VDD = 2.4 to 3.6V, TA = -30 to 85°C.)

| Symbol | Parameter | Test Condition | Min | Typ | Max | Unit |
|------------------|-----------------|--|------|-----|-----|------|
| F _{FRM} | Frame Frequency | Internal Oscillator VDD = 3V, TA = 25°C | 67.5 | 75 | 90 | Hz |

Table 14 - 6800-Series MPU Parallel Interface Timing Characteristics (VDD - VSS = 2.4 to 3.6V, TA = -30 to 85°C)

| Symbol | Parameter | Min | Typ | Max | Unit |
|--------------------|---|-----|-----|-----|------|
| t _{cycle} | Clock Cycle Time | 650 | - | - | ns |
| t _{AS} | Address Setup Time | 60 | - | - | ns |
| t _{AH} | Address Hold Time | 30 | - | - | Ns |
| t _{DSW} | Write Data Setup Time | 100 | - | - | Ns |
| t _{DHW} | Write Data Hold Time | 50 | - | - | Ns |
| t _{DHR} | Read Data Hold Time | 50 | - | - | ns |
| t _{OH} | Output Disable Time | - | - | 70 | ns |
| t _{ACC} | Access Time | - | - | 100 | ns |
| PW _{EL} | E(\overline{RD}) Low Pulse Width (read) | 150 | - | - | ns |
| | E(\overline{RD}) Low Pulse Width (write) | 150 | - | - | ns |
| PW _{EH} | E(\overline{RD}) High Pulse Width (read) | 450 | - | - | ns |
| | E(\overline{RD}) High Pulse Width (write) | 450 | - | - | ns |
| t _R | Rise Time | - | - | 25 | ns |
| t _F | Fall Time | - | - | 25 | ns |

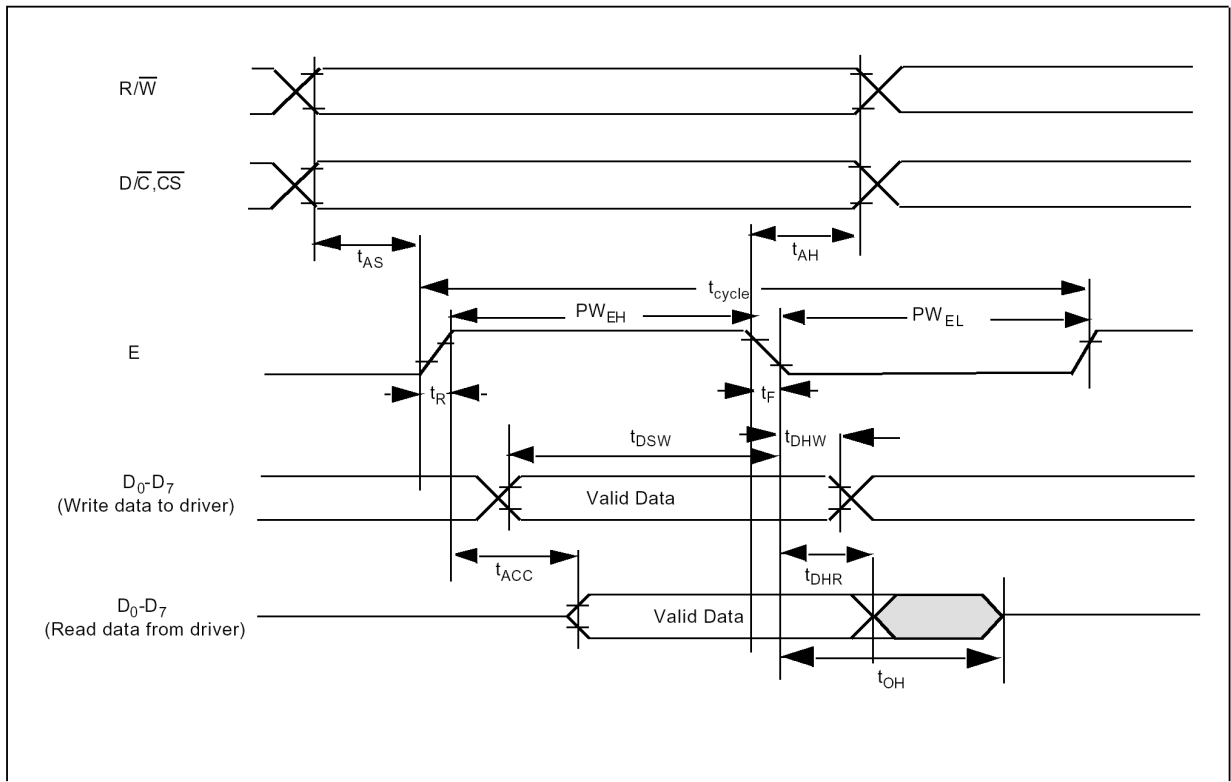


Figure 20 – 6800-series MCU Parallel Interface Waveform

Table 15 - 8080-Series MPU Parallel Interface Timing Characteristics (VDD - VSS = 2.4 to 3.6V, TA = -30 to 85°C)

| Symbol | Parameter | Min | Typ | Max | Unit |
|-------------|--|-----|-----|-----|------|
| t_{cycle} | Clock Cycle Time | 650 | - | - | ns |
| t_{AS} | Address Setup Time | 60 | - | - | ns |
| t_{AH} | Address Hold Time | 30 | - | - | ns |
| t_{DSW} | Write Data Setup Time | 100 | - | - | ns |
| t_{DHW} | Write Data Hold Time | 50 | - | - | ns |
| t_{DHR} | Read Data Hold Time | 50 | - | - | ns |
| t_{OH} | Output Disable Time | - | - | 70 | ns |
| t_{ACC} | Access Time | - | - | 100 | ns |
| PW_{WRL} | \overline{WR} Low Pulse Width (read) | 450 | - | - | ns |
| | \overline{WR} Low Pulse Width (write) | 450 | - | - | ns |
| PW_{WRH} | \overline{WR} High Pulse Width (read) | 150 | - | - | ns |
| | \overline{WR} High Pulse Width (write) | 150 | - | - | ns |
| t_R | Rise Time | - | - | 25 | ns |
| t_F | Fall Time | - | - | 25 | ns |

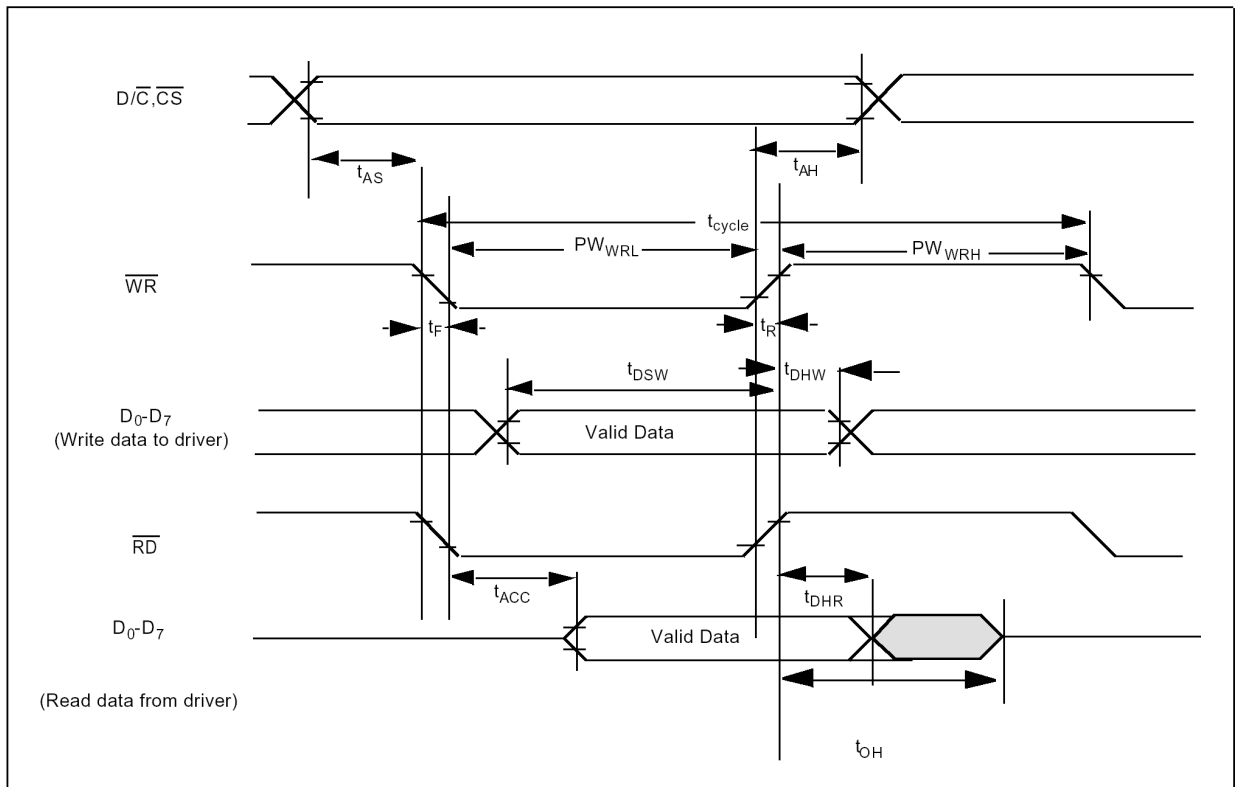


Figure 21 – 8080-series MCU Parallel Interface Waveform

Table 16 - Serial Interface Timing Characteristics (VDD - VSS = 2.4 to 3.6V, TA = -30 to 85°C)

| Symbol | Parameter | Min | Typ | Max | Unit |
|-------------|------------------------|------|-----|-----|------|
| t_{cycle} | Clock Cycle Time | 1000 | - | - | ns |
| t_{AS} | Address Setup Time | 50 | - | - | ns |
| t_{AH} | Address Hold Time | 300 | - | - | ns |
| t_{CSS} | Chip Select Setup Time | 150 | - | - | ns |
| t_{CSH} | Chip Select Hold Time | 700 | - | - | ns |
| t_{DSW} | Write Data Setup Time | 50 | - | - | ns |
| t_{DHW} | Write Data Hold Time | 50 | - | - | ns |
| t_{CLKL} | Clock Low Time | 300 | - | - | ns |
| t_{CLKH} | Clock High Time | 300 | - | - | ns |
| t_R | Rise Time | - | - | 25 | ns |
| t_F | Fall Time | - | - | 25 | ns |

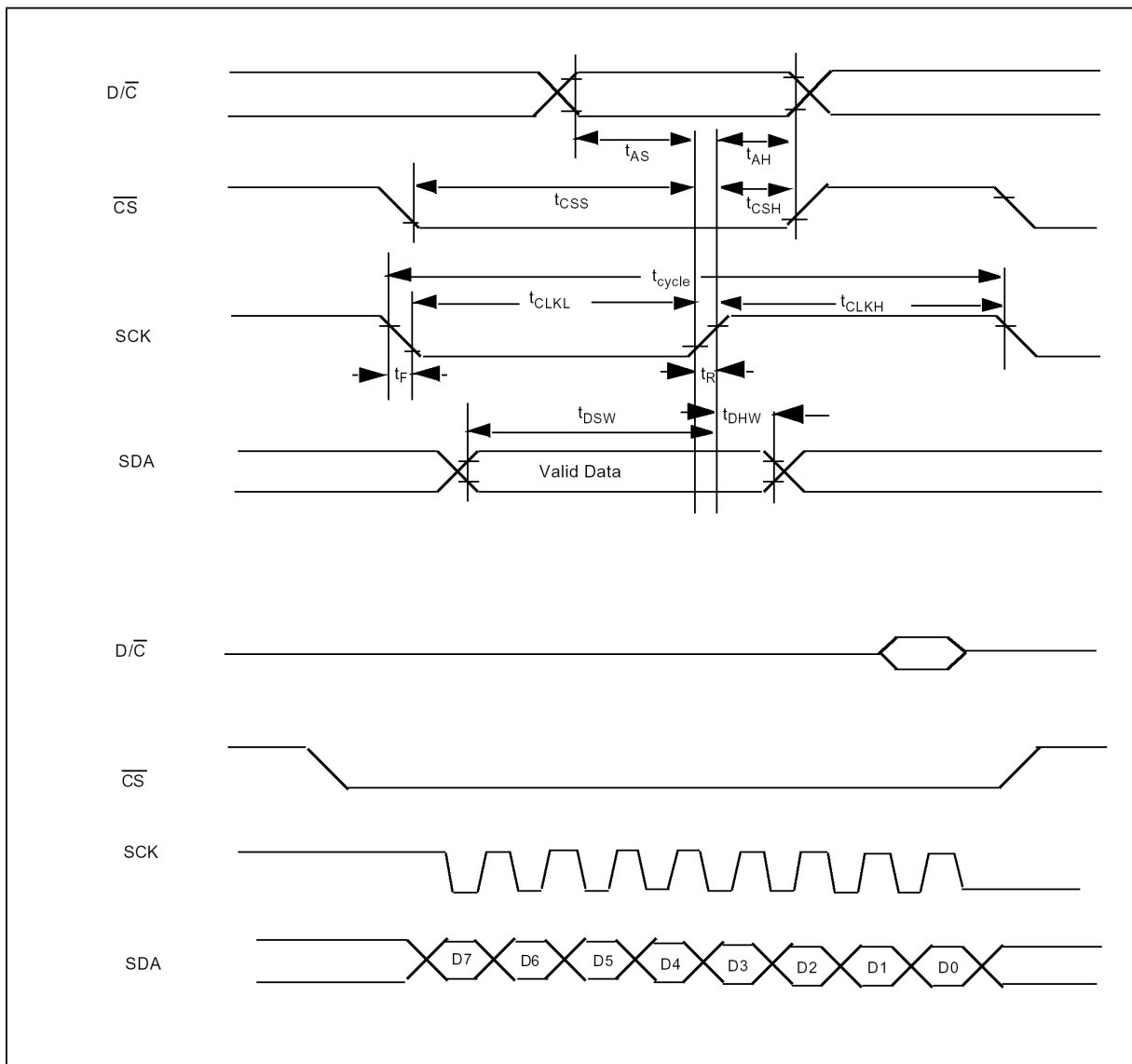


Figure 22 – Serial Interface Characteristics

APPLICATION EXAMPLES

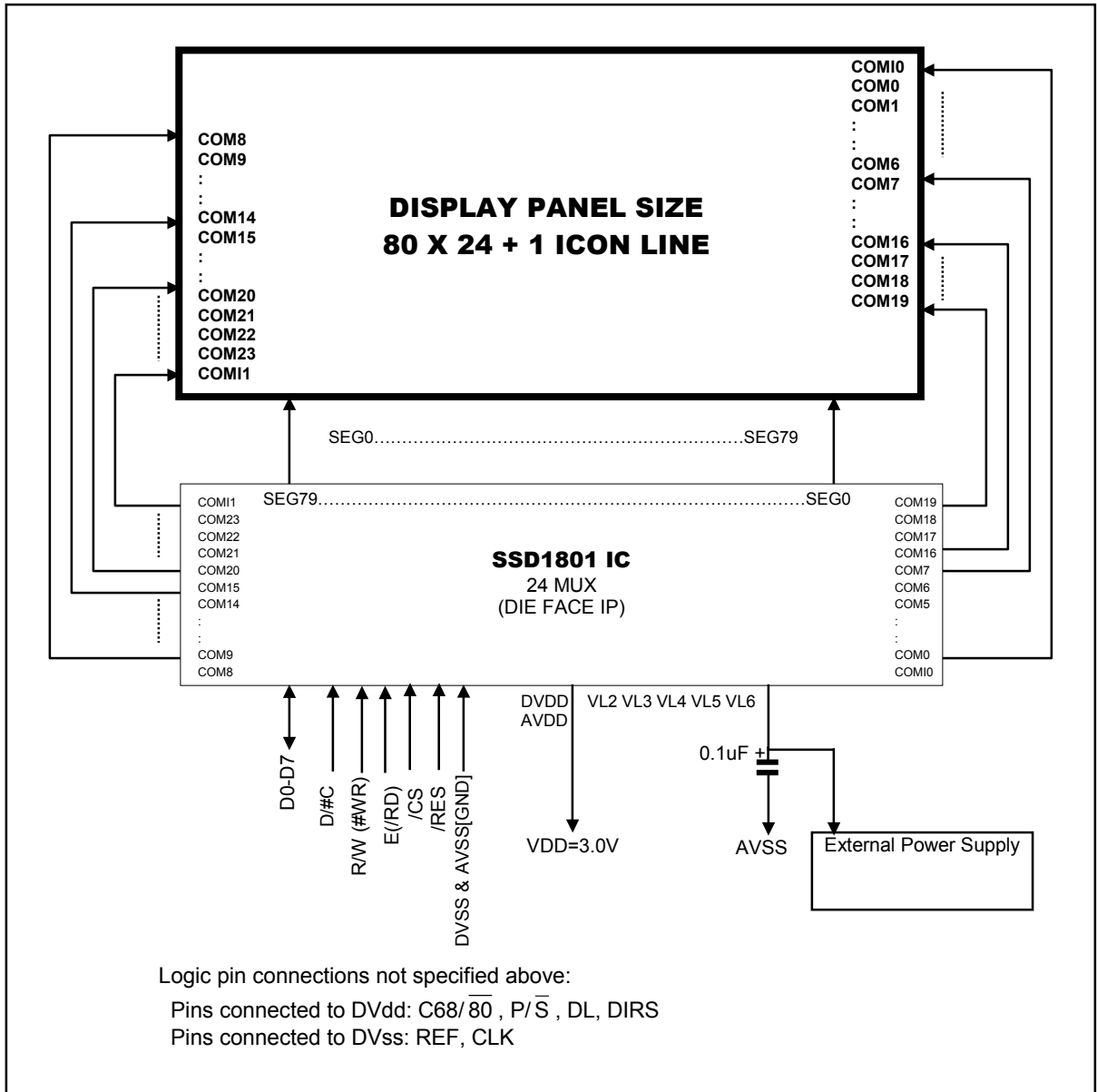


Figure 23 - Application Circuit: External Regulator with internal divider mode (8-bit 6800 mode)

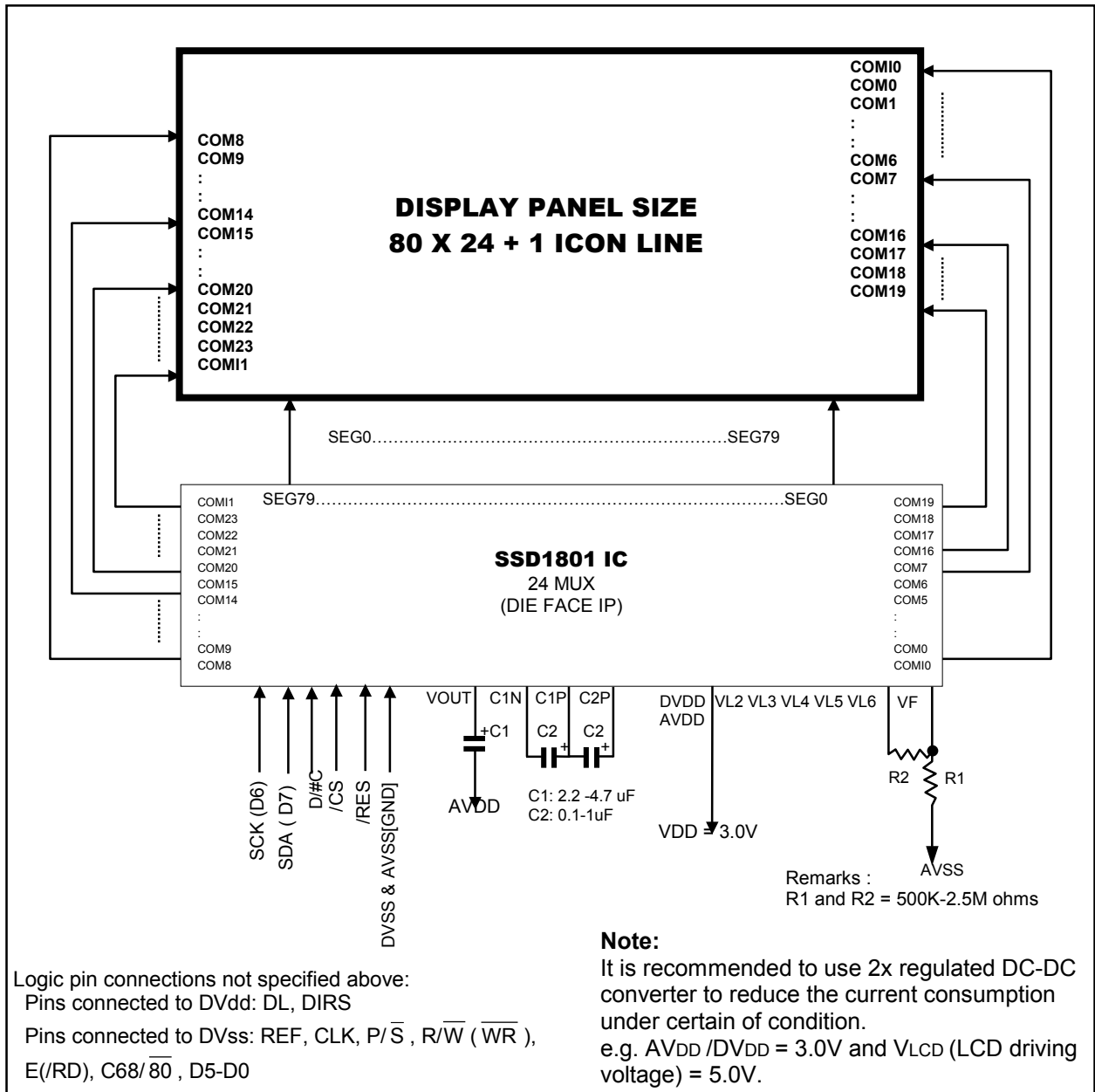


Figure 24 - Application Circuit: ALL internal power mode with 2x regulated DC-DC converter (serial mode)

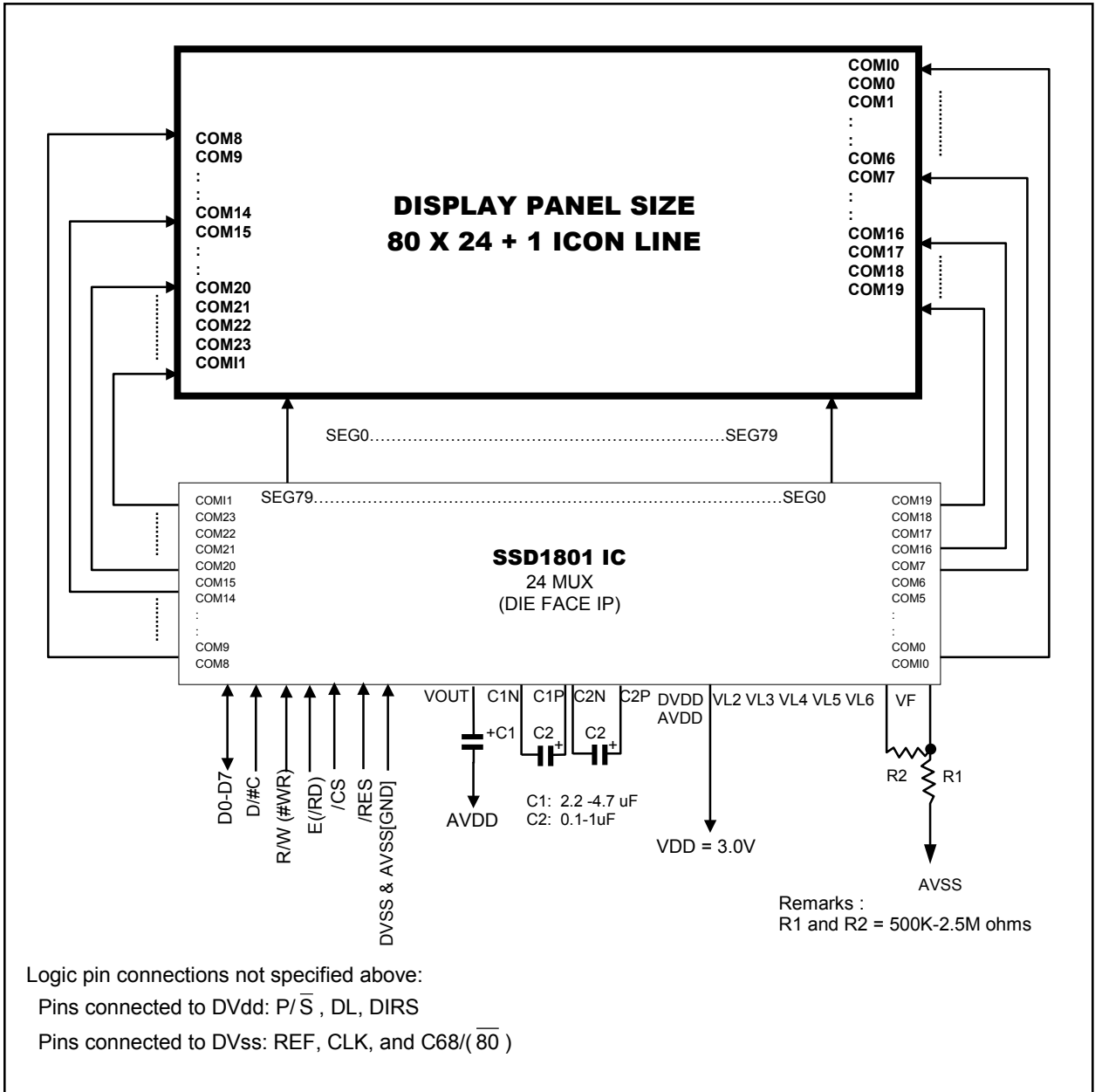


Figure 25 - Application Circuit: ALL internal power mode with 3x regulated DC-DC converter (8-bit 8080 mode)

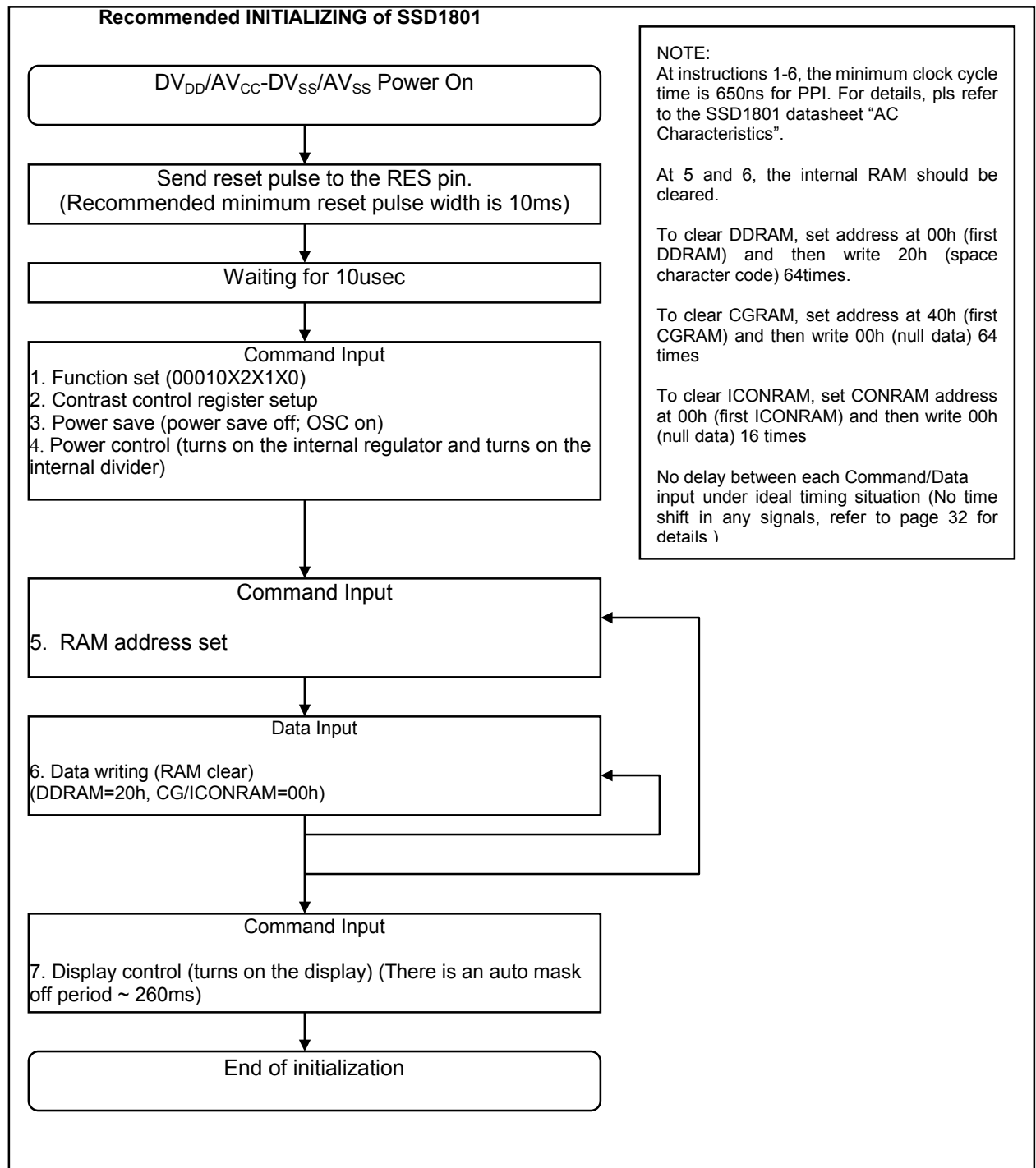


Figure 26 - Recommended INITIALIZING of SSD1801

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