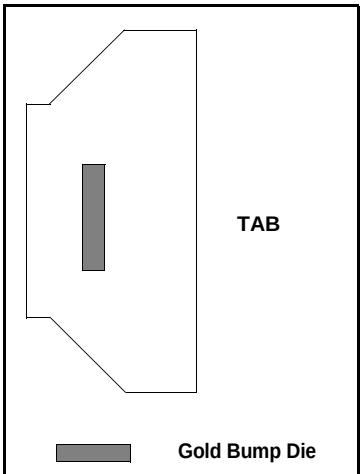
SSD1815

Advanced Information

LCD Segment / Common Driver with Controller

CMOS



ORDERING INFORMATION

SSD1815Z	Gold Bump Die
SSD1815TR	TAB
SSD1815T1R	TAB
SSD1815T2R	TAB
SSD1815T3R	TAB

SSD1815 is a single-chip CMOS LCD driver with controller for liquid crystal dot-matrix graphic display system. It consists of 197 high voltage driving output pins for driving 132 Segments, 64 Commons and 1 icon driving-Common.

SSD1815 displays data directly from its internal 132 X 65 bits Graphic Display Data RAM (GDDRAM). Data/Commands are sent from general MCU through a software selectable 6800-/8080-series compatible Parallel Interface or Serial Peripheral Interface.

SSD1815 embeds a DC-DC Converter, an On-Chip Bias Divider and an On-Chip Oscillator which reduce the number of external components. With the special design on minimizing power consumption and die/package layout, SSD1815 is suitable for any portable battery-driven applications requiring a long operation period and a compact size.

- Single Supply Operation, 1.8 V - 3.5V
- Minimum -12.0V LCD Driving Output Voltage
- Low Current Sleep Mode
- On-Chip Voltage Generator / External Power Supply
- 2X / 3X / 4X On-Chip DC-DC Converter
- On-Chip Oscillator
- Programmable Multiplex ratio (2Mux ~ 65Mux)
- On-Chip Bias Divider
- Programmable bias ratio
- 8-bit 6800-series Parallel Interface, 8-bit 8080-series Parallel Interface and Serial Peripheral Interface
- On-Chip 132 X 65 Graphic Display Data RAM
- Re-mapping of Row and Column Drivers
- Vertical Scrolling
- Display Offset Control
- 64 Level Internal Contrast Control
- External Contrast Control
- Programmable LCD Driving Voltage Temperature Coefficients
- Available in Gold Bump Die and TAB (Tape Automated Bonding) Package

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

Block Diagram

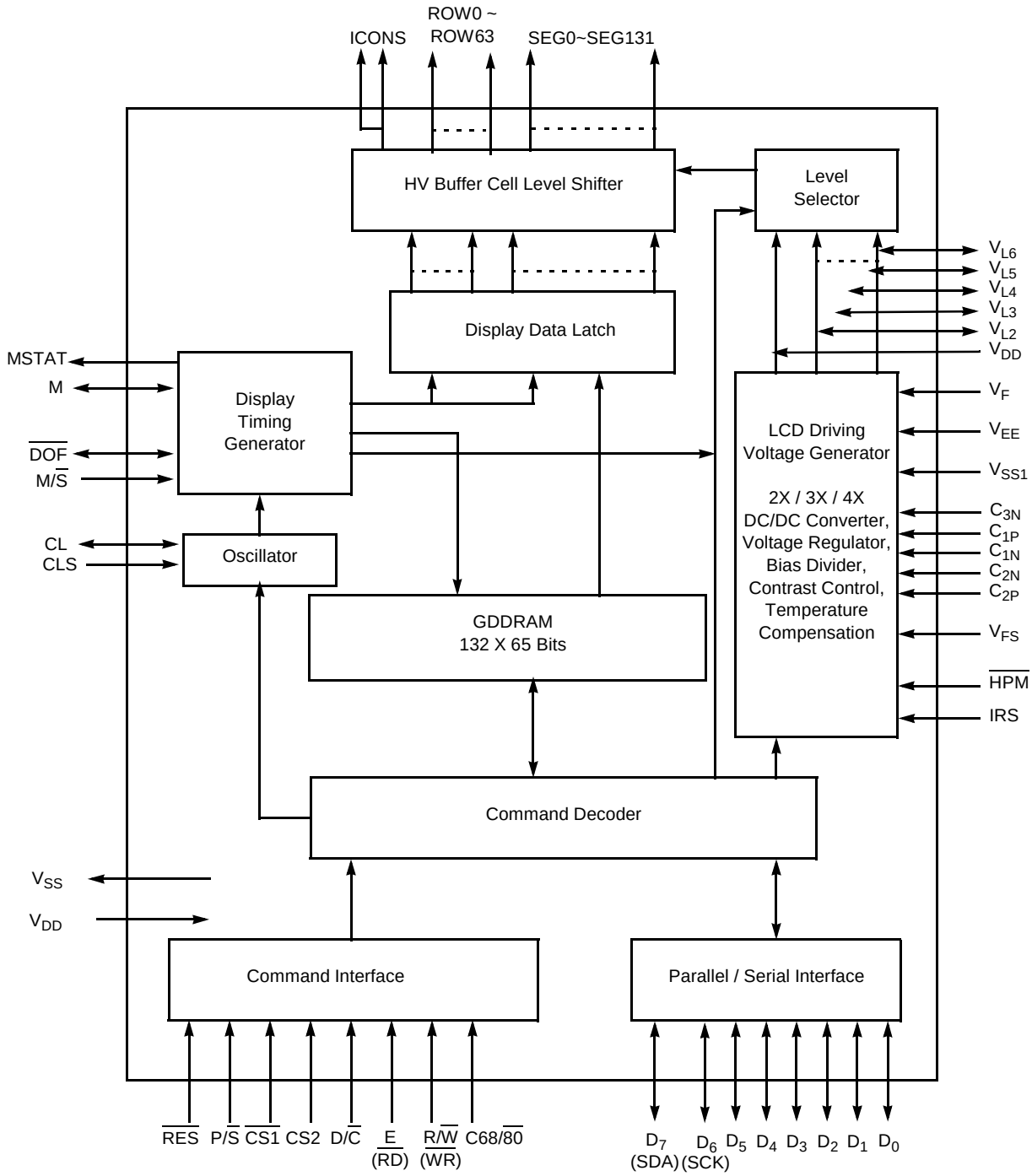
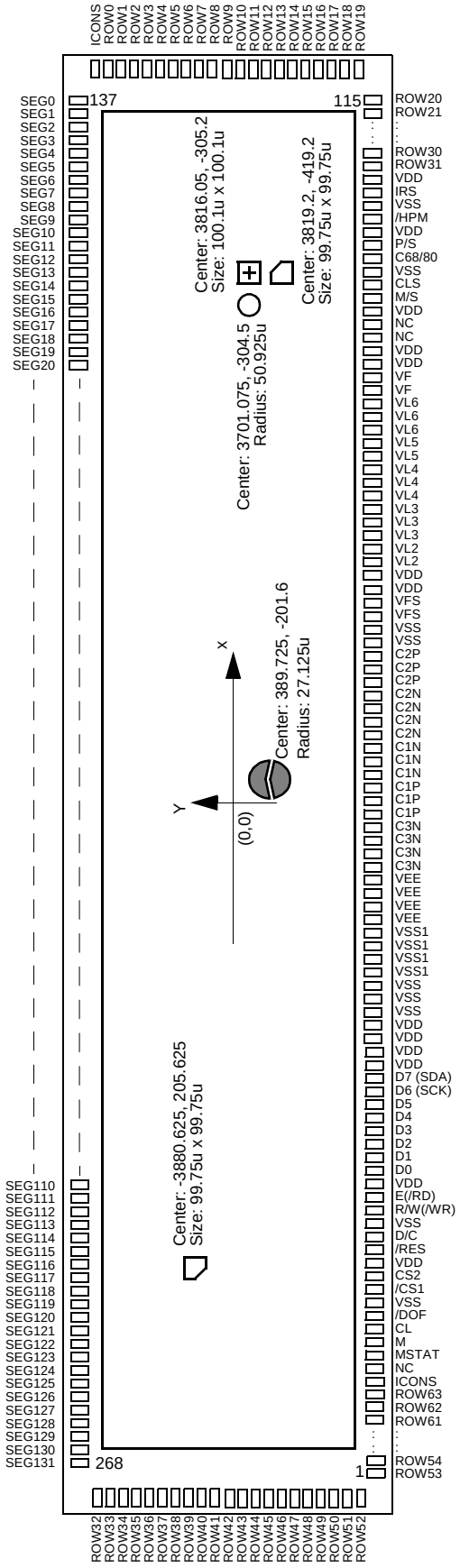


Figure 1 - Block Diagram of SSD1815



Gold Bump Alignment Mark
This alignment mark contains gold nump for IC bumping process alignment and IC identifications. No conductive tracks should be laid underneath this mark to avoid short circuit.

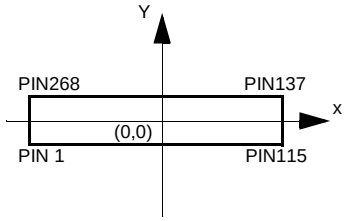
Note:
1. This diagram showing Die Face Up view.
2. Coordinates and Size of all alignment marks are in unit um and w.r.t. center of the chip.

Die Size:	10.977mm X 1.912mm
Die Thickness:	533 +/-25um
Bump Pitch:	76.2 um [Min]
Bump Height:	Nominal 18um
	Tolerance <4um within die
	<8um within lot

Figure 2 - SSD1815Z Die Pin Assignment

Table 1 - SSD1815Z Die Pad Coordinates

PAD #	NAME	X	Y	PAD #	NAME	X	Y	PAD #	NAME	X	Y
1	ROW53	-4958.45	-751.98	61	C2N	266.70	-771.93	116	ROW19	5285.18	-768.78
2	ROW54	-4882.15	-751.98	62	C2N	355.60	-771.93	117	ROW18	5285.18	-692.48
3	ROW55	-4805.85	-751.98	63	C2N	444.50	-771.93	118	ROW17	5285.18	-616.18
4	ROW56	-4729.55	-751.98	64	C2N	533.40	-771.93	119	ROW16	5285.18	-539.88
5	ROW57	-4653.25	-751.98	65	C2P	622.30	-771.93	120	ROW15	5285.18	-463.58
6	ROW58	-4576.95	-751.98	66	C2P	711.20	-771.93	121	ROW14	5285.18	-387.28
7	ROW59	-4500.65	-751.98	67	C2P	800.10	-771.93	122	ROW13	5285.18	-310.98
8	ROW60	-4424.35	-751.98	68	VSS	889.00	-771.93	123	ROW12	5285.18	-234.68
9	ROW61	-4348.05	-751.98	69	VSS	977.90	-771.93	124	ROW11	5285.18	-158.38
10	ROW62	-4271.75	-751.98	70	VFS	1066.80	-771.93	125	ROW10	5285.18	-82.08
11	ROW63	-4195.45	-751.98	71	VFS	1155.70	-771.93	126	ROW9	5285.18	-5.78
12	ICONS	-4119.15	-751.98	72	VDD	1244.60	-771.93	127	ROW8	5285.18	70.53
13	NC	-4000.50	-771.93	73	VDD	1333.50	-771.93	128	ROW7	5285.18	146.83
14	MSTAT	-3911.60	-771.93	74	VL2	1422.40	-771.93	129	ROW6	5285.18	223.13
15	M	-3822.70	-771.93	75	VL2	1511.30	-771.93	130	ROW5	5285.18	299.43
16	CL	-3733.80	-771.93	76	VL3	1600.20	-771.93	131	ROW4	5285.18	375.73
17	/DOF	-3644.90	-771.93	77	VL3	1689.10	-771.93	132	ROW3	5285.18	452.03
18	VSS	-3556.00	-771.93	78	VL3	1778.00	-771.93	133	ROW2	5285.18	528.33
19	/CS1	-3467.10	-771.93	79	VL4	1866.90	-771.93	134	ROW1	5285.18	604.63
20	CS2	-3378.20	-771.93	80	VL4	1955.80	-771.93	135	ROW0	5285.18	680.93
21	VDD	-3289.30	-771.93	81	VL4	2044.70	-771.93	136	ICONS	5285.18	757.23
22	/RES	-3200.40	-771.93	82	VL5	2133.60	-771.93				
23	D/C	-3111.50	-771.93	83	VL5	2222.50	-771.93				
24	VSS	-3022.60	-771.93	84	VL6	2311.40	-771.93				
25	R/W	-2933.70	-771.93	85	VL6	2400.30	-771.93				
26	E/RD	-2844.80	-771.93	86	VL6	2489.20	-771.93				
27	VDD	-2755.90	-771.93	87	VF	2578.10	-771.93				
28	D 0	-2667.00	-771.93	88	VF	2667.00	-771.93				
29	D 1	-2578.10	-771.93	89	VDD	2755.90	-771.93				
30	D 2	-2489.20	-771.93	90	VDD	2844.80	-771.93				
31	D 3	-2400.30	-771.93	91	NC	2933.70	-771.93				
32	D 4	-2311.40	-771.93	92	NC	3022.60	-771.93				
33	D 5	-2222.50	-771.93	93	VDD	3111.50	-771.93				
34	D 6	-2133.60	-771.93	94	M/S	3200.40	-771.93				
35	D 7	-2044.70	-771.93	95	CLS	3289.30	-771.93				
36	VDD	-1955.80	-771.93	96	VSS	3378.20	-771.93				
37	VDD	-1866.90	-771.93	97	C68/80	3467.10	-771.93				
38	VDD	-1778.00	-771.93	98	P/S	3556.00	-771.93				
39	VDD	-1689.10	-771.93	99	VDD	3644.90	-771.93				
40	VSS	-1600.20	-771.93	100	/HPM	3733.80	-771.93				
41	VSS	-1511.30	-771.93	101	VSS	3822.70	-771.93				
42	VSS	-1422.40	-771.93	102	IRS	3911.60	-771.93				
43	VSS1	-1333.50	-771.93	103	VDD	4000.50	-771.93				
44	VSS1	-1244.60	-771.93	104	ROW31	4119.15	-751.98				
45	VSS1	-1155.70	-771.93	105	ROW30	4195.45	-751.98				
46	VSS1	-1066.80	-771.93	106	ROW29	4271.75	-751.98				
47	VEE	-977.90	-771.93	107	ROW28	4348.05	-751.98				
48	VEE	-889.00	-771.93	108	ROW27	4424.35	-751.98				
49	VEE	-800.10	-771.93	109	ROW26	4500.65	-751.98				
50	VEE	-711.20	-771.93	110	ROW25	4576.95	-751.98				
51	C3N	-622.30	-771.93	111	ROW24	4653.25	-751.98				
52	C3N	-533.40	-771.93	112	ROW23	4729.55	-751.98				
53	C3N	-444.50	-771.93	113	ROW22	4805.85	-751.98				
54	C3N	-355.60	-771.93	114	ROW21	4882.15	-751.98				
55	C1P	-266.70	-771.93	115	ROW20	4958.45	-751.98				
56	C1P	-177.80	-771.93								
57	C1P	-88.90	-771.93								
58	C1N	0.00	-771.93								
59	C1N	88.90	-771.93								
60	C1N	177.80	-771.93								



Die Size: 10.977mm X 1.912mm
Bump Height:
- nominal: 18um
- tolerance:<4um (within die)
<6um (within wafer)
<8um (within lot)

Unit in um unless otherwise specified.

Die Size: 10.977mm X 1.912mm
Bump Size:

Pad #	X [um]	Y [um]	Pad #	X [um]	Y [um]	Pad #	X [um]	Y [um]	Pad #	X [um]	Y [um]
1 - 12	43.5	101.6	116 - 136	101.6	43.5	137 - 268	43.5	101.6	269 - 289	101.6	43.5
13 - 103	61.7	61.7	Gold bump size tolerance: +/-1.5um.								
104 - 115	43.5	101.6									

PAD #	NAME	X	Y	PAD #	NAME	X	Y	PAD #	NAME	X	Y
137	SEG0	4997.65	751.98	203	SEG66	-38.15	751.98	269	ROW32	-5285.18	757.23
138	SEG1	4921.35	751.98	204	SEG67	-114.45	751.98	270	ROW33	-5285.18	680.93
139	SEG2	4845.05	751.98	205	SEG68	-190.75	751.98	271	ROW34	-5285.18	604.63
140	SEG3	4768.75	751.98	206	SEG69	-267.05	751.98	272	ROW35	-5285.18	528.33
141	SEG4	4692.45	751.98	207	SEG70	-343.35	751.98	273	ROW36	-5285.18	452.03
142	SEG5	4616.15	751.98	208	SEG71	-419.65	751.98	274	ROW37	-5285.18	375.73
143	SEG6	4539.85	751.98	209	SEG72	-495.95	751.98	275	ROW38	-5285.18	299.43
144	SEG7	4463.55	751.98	210	SEG73	-572.25	751.98	276	ROW39	-5285.18	223.13
145	SEG8	4387.25	751.98	211	SEG74	-648.55	751.98	277	ROW40	-5285.18	146.83
146	SEG9	4310.95	751.98	212	SEG75	-724.85	751.98	278	ROW41	-5285.18	70.53
147	SEG10	4234.65	751.98	213	SEG76	-801.15	751.98	279	ROW42	-5285.18	-5.78
148	SEG11	4158.35	751.98	214	SEG77	-877.45	751.98	280	ROW43	-5285.18	-82.08
149	SEG12	4082.05	751.98	215	SEG78	-953.75	751.98	281	ROW44	-5285.18	-158.38
150	SEG13	4005.75	751.98	216	SEG79	-1030.05	751.98	282	ROW45	-5285.18	-234.68
151	SEG14	3929.45	751.98	217	SEG80	-1106.35	751.98	283	ROW46	-5285.18	-310.98
152	SEG15	3853.15	751.98	218	SEG81	-1182.65	751.98	284	ROW47	-5285.18	-387.28
153	SEG16	3776.85	751.98	219	SEG82	-1258.95	751.98	285	ROW48	-5285.18	-463.58
154	SEG17	3700.55	751.98	220	SEG83	-1335.25	751.98	286	ROW49	-5285.18	-539.88
155	SEG18	3624.25	751.98	221	SEG84	-1411.55	751.98	287	ROW50	-5285.18	-616.18
156	SEG19	3547.95	751.98	222	SEG85	-1487.85	751.98	288	ROW51	-5285.18	-692.48
157	SEG20	3471.65	751.98	223	SEG86	-1564.15	751.98	289	ROW52	-5285.18	-768.78
158	SEG21	3395.35	751.98	224	SEG87	-1640.45	751.98				
159	SEG22	3319.05	751.98	225	SEG88	-1716.75	751.98				
160	SEG23	3242.75	751.98	226	SEG89	-1793.05	751.98				
161	SEG24	3166.45	751.98	227	SEG90	-1869.35	751.98				
162	SEG25	3090.15	751.98	228	SEG91	-1945.65	751.98				
163	SEG26	3013.85	751.98	229	SEG92	-2021.95	751.98				
164	SEG27	2937.55	751.98	230	SEG93	-2098.25	751.98				
165	SEG28	2861.25	751.98	231	SEG94	-2174.55	751.98				
166	SEG29	2784.95	751.98	232	SEG95	-2250.85	751.98				
167	SEG30	2708.65	751.98	233	SEG96	-2327.15	751.98				
168	SEG31	2632.35	751.98	234	SEG97	-2403.45	751.98				
169	SEG32	2556.05	751.98	235	SEG98	-2479.75	751.98				
170	SEG33	2479.75	751.98	236	SEG99	-2556.05	751.98				
171	SEG34	2403.45	751.98	237	SEG100	-2632.35	751.98				
172	SEG35	2327.15	751.98	238	SEG101	-2708.65	751.98				
173	SEG36	2250.85	751.98	239	SEG102	-2784.95	751.98				
174	SEG37	2174.55	751.98	240	SEG103	-2861.25	751.98				
175	SEG38	2098.25	751.98	241	SEG104	-2937.55	751.98				
176	SEG39	2021.95	751.98	242	SEG105	-3013.85	751.98				
177	SEG40	1945.65	751.98	243	SEG106	-3090.15	751.98				
178	SEG41	1869.35	751.98	244	SEG107	-3166.45	751.98				
179	SEG42	1793.05	751.98	245	SEG108	-3242.75	751.98				
180	SEG43	1716.75	751.98	246	SEG109	-3319.05	751.98				
181	SEG44	1640.45	751.98	247	SEG110	-3395.35	751.98				
182	SEG45	1564.15	751.98	248	SEG111	-3471.65	751.98				
183	SEG46	1487.85	751.98	249	SEG112	-3547.95	751.98				
184	SEG47	1411.55	751.98	250	SEG113	-3624.25	751.98				
185	SEG48	1335.25	751.98	251	SEG114	-3700.55	751.98				
186	SEG49	1258.95	751.98	252	SEG115	-3776.85	751.98				
187	SEG50	1182.65	751.98	253	SEG116	-3853.15	751.98				
188	SEG51	1106.35	751.98	254	SEG117	-3929.45	751.98				
189	SEG52	1030.05	751.98	255	SEG118	-4005.75	751.98				
190	SEG53	953.75	751.98	256	SEG119	-4082.05	751.98				
191	SEG54	877.45	751.98	257	SEG120	-4158.35	751.98				
192	SEG55	801.15	751.98	258	SEG121	-4234.65	751.98				
193	SEG56	724.85	751.98	259	SEG122	-4310.95	751.98				
194	SEG57	648.55	751.98	260	SEG123	-4387.25	751.98				
195	SEG58	572.25	751.98	261	SEG124	-4463.55	751.98				
196	SEG59	495.95	751.98	262	SEG125	-4539.85	751.98				
197	SEG60	419.65	751.98	263	SEG126	-4616.15	751.98				
198	SEG61	343.35	751.98	264	SEG127	-4692.45	751.98				
199	SEG62	267.05	751.98	265	SEG128	-4768.75	751.98				
200	SEG63	190.75	751.98	266	SEG129	-4845.05	751.98				
201	SEG64	114.45	751.98	267	SEG130	-4921.35	751.98				
202	SEG65	38.15	751.98	268	SEG131	-4997.65	751.98				

PIN DESCRIPTIONS

MSTAT

This pin is the static indicator driving output. It is only active in master operation. The frame signal output pin, M, should be used as the back plane signal for the static indicator.

The duration of overlapping could be programmable. See Extended Command Table for details.

This pin becomes high impedance if the chip is operating in slave mode.

M

This pin is the frame signal input/output. In master mode, the pin supplies frame signal to slave devices while in slave mode, the pin receives frame signal from the master device.

CL

This pin is the display clock input/output. In master mode, the pin supplies display clock signal to slave devices while in slave mode, the pin receives display clock signal from the master device.

$\overline{\text{DOF}}$

This pin is diaplay blanking control between master and slave devices. In master mode, this pin supplies on/off signal to slave devices. In slave mode, this pin receives on/off signal from the master device.

$\overline{\text{CS1}}$, CS2

These pins are the chip select inputs. The chip is enabled for MCP communication only when both $\overline{\text{CS1}}$ is pulled low and CS2 is pulled high.

$\overline{\text{RES}}$

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 1us.

D/$\overline{\text{C}}$

This pin is Data/Command control pin. When the pin is pulled high, the data at D_7-D_0 is treated as display data. When the pin is pulled low, the data at D_7-D_0 will be tranferred to the command register.

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

This pin is microprocessor interface input. When interfacing to an 6800-series microprocessor, this pin will be used as R/$\overline{\text{W}}$ singal input. Read mode will be carried out when this pin is pulled high and write mode when low.

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

E($\overline{\text{RD}}$)

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

When interfacing to an 8080-microprocessor, this pin receives the RD signal. Data read operation is initiated when this pin is pulled low when the chip is selected.

D_7-D_0

These pins are the 8-bit bi-directional data bus to be connected to the microprocessor in parallel interface mode. D_7 is the MSB while D_0 is the LSB.

When serial mode is selected, D_7 is the serial data input (SDA) and D_6 is the serial clock input (SCK).

V_{DD}

Power supply pin.

V_{SS}

Ground.

V_{SS1}

Reference voltage input for internal DC-DC converter. The voltage of generated, V_{EE}, equals to the multiple factor times the potential different between this pin, V_{SS1}, and V_{DD}. The multiple factor, 2X, 3X or 4X, is selected by different external capacitor connections. All voltage levels are referenced to V_{DD}.

Note: the potential at this input pin must lower than or equal to V_{SS}.

V_{EE}

This is the most negative voltage supply pin of the chip. It can be supplied externally or generated by the internal DC-DC converter.

When using internal DC-DC converter as generator, voltage at this pin is for internal reference only. It CANNOT be used for driving external circuitries.

C_{3N}, C_{1P}, C_{1N}, C_{2N} and C_{2P}

When internal DC-DC voltage converter is used, external capacitor(s) is/are connected between these pins. Different connection will result in different DC-DC converter multiple factor, 2X, 3X or 4X. Details please refer to voltage converter section in the block diagram description.

V_{FS}

This is an input pin to provide an external voltage reference for the internal voltage regulator. The function of this pin is only enabled for the External Input chip models which are required special ordering. For normal chip model, please leave this pin NC.

V_{L2}, V_{L3}, V_{L4} and V_{L5} (Voltages referenced to V_{DD})

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

$$V_{DD} > V_{L2} > V_{L3} > V_{L4} > V_{L5} > V_{L6}$$

	1:7 bias	1:9 bias (default)
V_{L2}	1/7*V_{L6}	1/9*V_{L6}
V_{L3}	2/7*V_{L6}	2/9*V_{L6}
V_{L4}	5/7*V_{L6}	7/9*V_{L6}
V_{L5}	6/7*V_{L6}	8/9*V_{L6}

V_{L6}

This pin is the most negative LCD driving voltage. It can be supplied externally or generated by the internal regulator.

V_F

This pin is the input of the built-in voltage regulator. When external resistor network is selected to generate the LCD driving level, V_{L6}, two external resistors, R_1 and R_2, are connected between V_{DD} and V_F, and V_F and V_{L6}, respectively (see application circuit).

M/$\overline{S}$

This pin is the master/slave mode selection input. When this pin is pulled high, master mode is selected, which CL, M, MSTAT and DOF signals will be output for slave devices. When this pin is pulled low, slave mode is selected, which CL, M, $\overline{DOF}$ are required to be input from master device and MSTAT is high impedance.

CLS

This pin is the internal clock enable pin. When this pin is pulled high, internal clock is enabled. The internal clock will be disabled when it is pulled low, an external clock source should be input to CL pin.

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.

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.

$\overline{HPM}$

This pin is the control input of High Power Current Mode. The function of this pin is only enabled for High Power model which required special ordering.

For normal models, High Power Mode is disabled and the LCD driving characteristics are the same no matter this pin is pulled High or Low.

Note: This pin must be pulled to either High or Low. Leaving this pin floating is prohibited.

IRS

This is the input pin to enable the internal resistors network for the voltage regulator. When this pin is pulled high the internal resistors will be enalbed, and when it is low, the external resistors, R_1 and R_2, should be connected to V_{DD} and V_F, and V_F and V_{L6}, respectively (see application circuits).

ROW0 - ROW63

These pins provide the row driving signal COM0 - COM63 to the LCD panel. See Table.1 about the COM signal mapping in different multiplex ratio N.

SEG0 - SEG131

These pins provide the LCD column driving signals. Their output voltage level is V_{DD} during sleep mode and standby mode.

ICONS

There are two ICONS pins (pin12 and 136) on the chip. Both pins output exactly the same signal. The reason for duplicating the pin is to enhance the flexibility of the LCD layout.

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.

Table 2 - ROW pins assignment for COM signals in different Programmable Multiplex Ratio
[After power-on-reset, SSD1815 is set to 64 Multiplex]

Die Pad Name	64 Mux Com Signal Output	54 Mux Com Signal Output	53 Mux Com Signal Output	52 Mux Com Signal Output	49 Mux Com Signal Output	48 Mux Com Signal Output	34 Mux Com Signal Output	33 Mux Com Signal Output	32 Mux Com Signal Output
ROW0	COM0	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW1	COM1	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW2	COM2	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW3	COM3	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW4	COM4	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW5	COM5	COM0	COM0	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW6	COM6	COM1	COM1	COM0	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW7	COM7	COM2	COM2	COM1	COM0	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW8	COM8	COM3	COM3	COM2	COM1	COM0	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW9	COM9	COM4	COM4	COM3	COM2	COM1	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW10	COM10	COM5	COM5	COM4	COM3	COM2	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW11	COM11	COM6	COM6	COM5	COM4	COM3	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW12	COM12	COM7	COM7	COM6	COM5	COM4	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW13	COM13	COM8	COM8	COM7	COM6	COM5	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW14	COM14	COM9	COM9	COM8	COM7	COM6	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW15	COM15	COM10	COM10	COM9	COM8	COM7	COM0	COM0	NON-SELECT*
ROW16	COM16	COM11	COM11	COM10	COM9	COM8	COM1	COM1	COM0
ROW17	COM17	COM12	COM12	COM11	COM10	COM9	COM2	COM2	COM1
ROW18	COM18	COM13	COM13	COM12	COM11	COM10	COM3	COM3	COM2
ROW19	COM19	COM14	COM14	COM13	COM12	COM11	COM4	COM4	COM3
ROW20	COM20	COM15	COM15	COM14	COM13	COM12	COM5	COM5	COM4
ROW21	COM21	COM16	COM16	COM15	COM14	COM13	COM6	COM6	COM5
ROW22	COM22	COM17	COM17	COM16	COM15	COM14	COM7	COM7	COM6
ROW23	COM23	COM18	COM18	COM17	COM16	COM15	COM8	COM8	COM7
ROW24	COM24	COM19	COM19	COM18	COM17	COM16	COM9	COM9	COM8
ROW25	COM25	COM20	COM20	COM19	COM18	COM17	COM10	COM10	COM9
ROW26	COM26	COM21	COM21	COM20	COM19	COM18	COM11	COM11	COM10
ROW27	COM27	COM22	COM22	COM21	COM20	COM19	COM12	COM12	COM11
ROW28	COM28	COM23	COM23	COM22	COM21	COM20	COM13	COM13	COM12
ROW29	COM29	COM24	COM24	COM23	COM22	COM21	COM14	COM14	COM13
ROW30	COM30	COM25	COM25	COM24	COM23	COM22	COM15	COM15	COM14
ROW31	COM31	COM26	COM26	COM25	COM24	COM23	COM16	COM16	COM15
ROW32	COM32	COM27	COM27	COM26	COM25	COM24	COM17	COM17	COM16
ROW33	COM33	COM28	COM28	COM27	COM26	COM25	COM18	COM18	COM17
ROW34	COM34	COM29	COM29	COM28	COM27	COM26	COM19	COM19	COM18
ROW35	COM35	COM30	COM30	COM29	COM28	COM27	COM20	COM20	COM19
ROW36	COM36	COM31	COM31	COM30	COM29	COM28	COM21	COM21	COM20
ROW37	COM37	COM32	COM32	COM31	COM30	COM29	COM22	COM22	COM21
ROW38	COM38	COM33	COM33	COM32	COM31	COM30	COM23	COM23	COM22
ROW39	COM39	COM34	COM34	COM33	COM32	COM31	COM24	COM24	COM23
ROW40	COM40	COM35	COM35	COM34	COM33	COM32	COM25	COM25	COM24
ROW41	COM41	COM36	COM36	COM35	COM34	COM33	COM26	COM26	COM25
ROW42	COM42	COM37	COM37	COM36	COM35	COM34	COM27	COM27	COM26
ROW43	COM43	COM38	COM38	COM37	COM36	COM35	COM28	COM28	COM27
ROW44	COM44	COM39	COM39	COM38	COM37	COM36	COM29	COM29	COM28
ROW45	COM45	COM40	COM40	COM39	COM38	COM37	COM30	COM30	COM29
ROW46	COM46	COM41	COM41	COM40	COM39	COM38	COM31	COM31	COM30
ROW47	COM47	COM42	COM42	COM41	COM40	COM39	COM32	COM32	COM31
ROW48	COM48	COM43	COM43	COM42	COM41	COM40	COM33	NON-SELECT*	NON-SELECT*
ROW49	COM49	COM44	COM44	COM43	COM42	COM41	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW50	COM50	COM45	COM45	COM44	COM43	COM42	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW51	COM51	COM46	COM46	COM45	COM44	COM43	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW52	COM52	COM47	COM47	COM46	COM45	COM44	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW53	COM53	COM48	COM48	COM47	COM46	COM45	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW54	COM54	COM49	COM49	COM48	COM47	COM46	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW55	COM55	COM50	COM50	COM49	COM48	COM47	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW56	COM56	COM51	COM51	COM50	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW57	COM57	COM52	COM52	COM51	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW58	COM58	COM53	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW59	COM59	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW60	COM60	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW61	COM61	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW62	COM62	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*
ROW63	COM63	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*	NON-SELECT*

Remark:
* The ROW will output a Non-Select COM signal.

OPERATION OF LIQUID CRYSTAL DISPLAY DRIVER

Description of Block Diagram Module

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 Graphic Display Data RAM (GDDRAM). If D/$\overline{C}$ is low, the input at D_7-D_0 is interpreted as a Command and it will be decoded and be written to the corresponding command register.

MPU Parallel 6800-series Interface

The parallel interface consists of 8 bi-directional data pins (D_7-D_0), R/$\overline{W}$($\overline{WR}$), D/$\overline{C}$, E($\overline{RD}$), $\overline{CS1}$ and CS2. R/$\overline{W}$($\overline{WR}$) input High indicates a read operation from the Graphic Display Data RAM (GDDRAM) or the status register. R/$\overline{W}$($\overline{WR}$) input Low indicates a write operation to Display Data RAM 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 $\overline{CS1}$ and CS2 are low and high respectively. Refer to Figure 9 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 processing is internally performed which requires the insertion of a dummy read before the first actual display data read. This is shown in Figure 3 below.

MPU Parallel 8080-series interface

The parallel interface consists of 8 bi-directional data pins (D_7-D_0), E($\overline{RD}$), R/$\overline{W}$($\overline{WR}$), D/$\overline{C}$, $\overline{CS1}$ and CS2. E($\overline{RD}$) input serves as data read latch signal (clock) when low provided that $\overline{CS1}$ and CS2 are low and high respectively. Whether it is display data or status register read is controlled by D/$\overline{C}$. R/$\overline{W}$($\overline{WR}$) input serves as data write latch signal(clock) when high provided that $\overline{CS1}$ and CS2 are low and high respectively. Whether it is display data or command register write is controlled by D/$\overline{C}$. Refer to Figure 10 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.

MPU Serial interface

The serial interface consists of serial clock SCK (D_6), serial data SDA (D_7), D/$\overline{C}$, $\overline{CS1}$ and CS2. SDA is shifted into a 8-bit shift register on every rising edge of SCL 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 Display Data RAM or command register at the same clock.

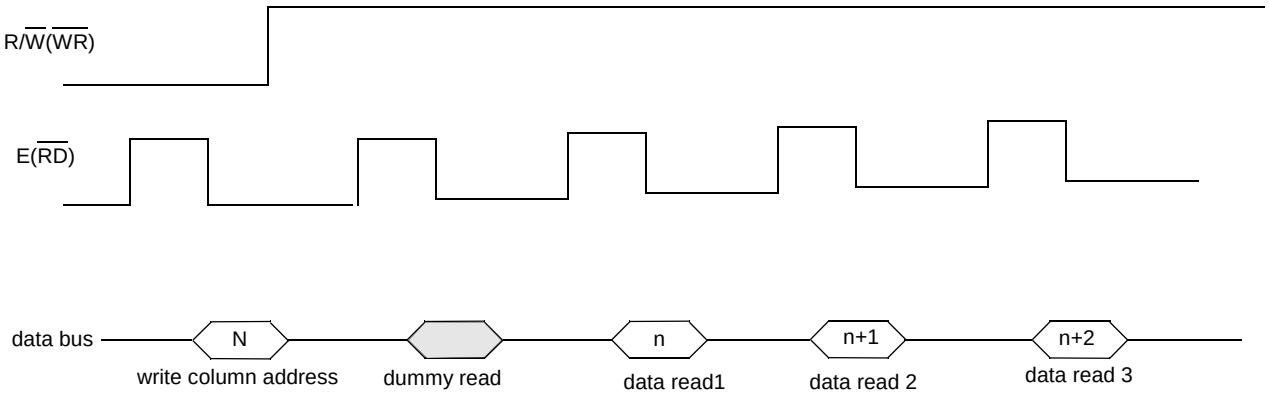


Figure 3 - Display data read with the insertion of dummy read

Oscillator Circuit

This module is an On-Chip low power RC oscillator circuitry (Figure 4). The oscillator generates the clock for the DC-DC voltage converter. This clock is also used in the Display Timing Generator.

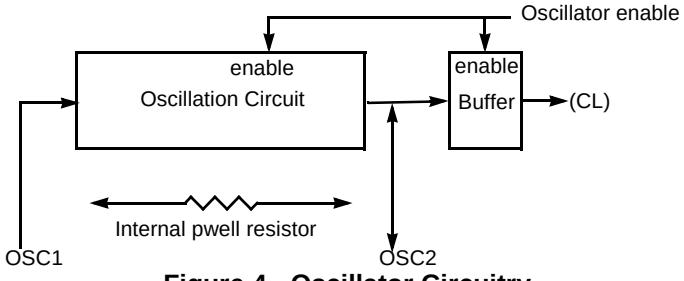
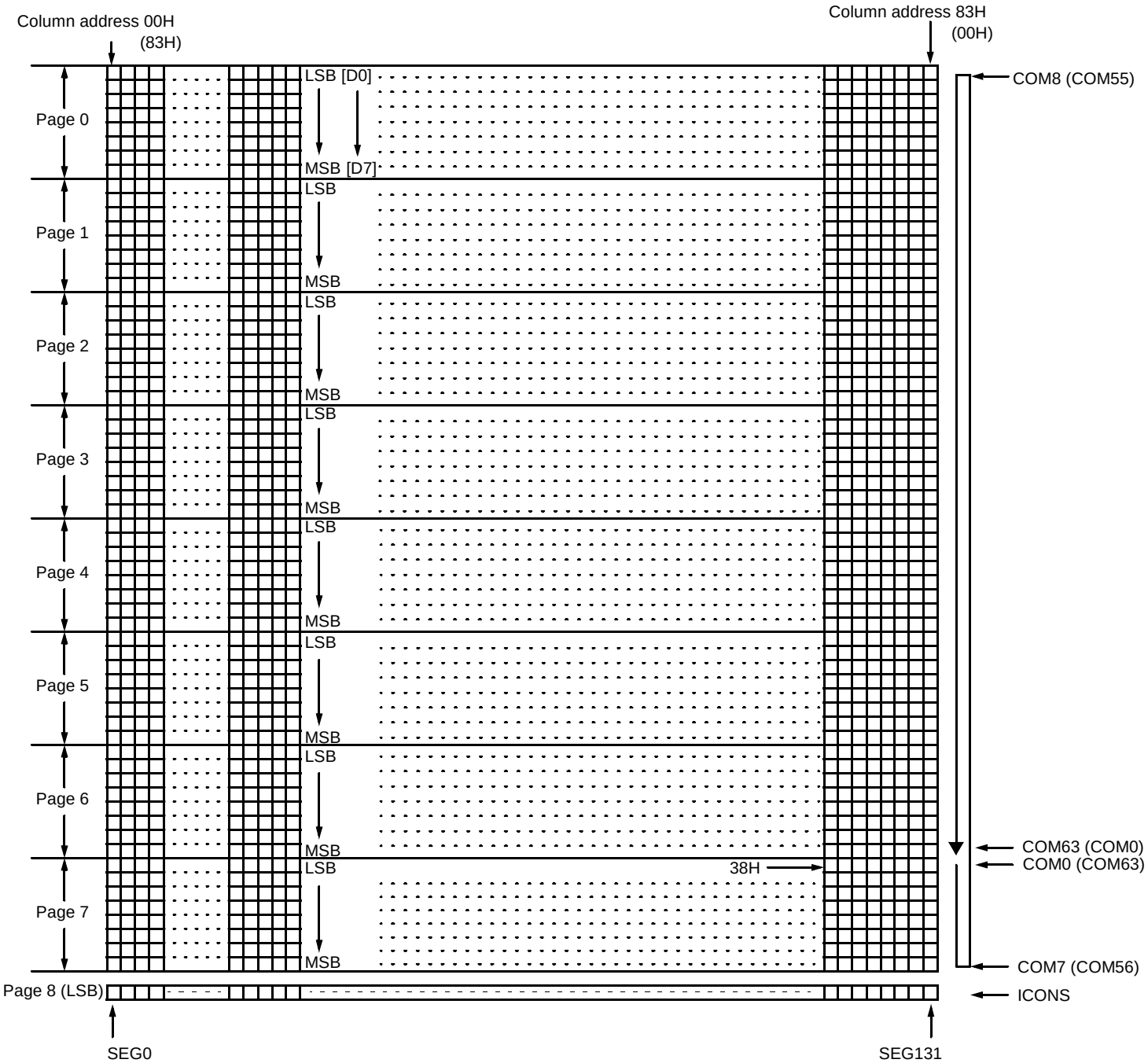


Figure 4 - Oscillator Circuitry

Graphic Display Data RAM (GDDRAM)

The GDDRAM is a bit mapped static RAM holding the bit pattern to be displayed. The size of the RAM is 132 X 65= 8580 bits. Figure 5 is a description of the GDDRAM address map. For mechanical flexibility, re-mapping on both Segment and Common outputs can be selected by software. For vertical scrolling of display, an internal register storing the display start line can be set to control the portion of the RAM data to be mapped to the display. Figure 5 shows the case in which the display start line register is set to 38h.



Note: The configuration in parentheses represent the remapped values of Rows and Columns

Figure 5. Graphic Display Data RAM (GDDRAM) Address Map (with display start line at 38H) For 132 X 64 Graphic Display Mode with separated Icon Line

LCD Driving Voltage Generator and Regulator

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

1. 2X, 3X and 4X DC-DC voltage converter
   The built-in DC-DC voltage converter is use to generate large negative LCD driving voltage with reference to V_{DD} from the voltage input (V_{SS1}). For SSD1815, it is possible to produce 2X, 3X or 4X boosting from the protential different between V_{SS1} - V_{DD}.
   Detail configurations of the DC-DC converter for different boosting multiples are given in Figure 6 at the right.

2. Voltage Regulator (Voltages referenced to V_{DD})
   The feedback gain control for LCD driving contrast curves can be selected by IRS pin to either internal (IRS pin = H) or external (IRS pin = L).
   For internal resistor network is enabled, there are eight setting can be set by software.
   If external control is selected, external resistors are required to be connected between V_{DD} and V_F (R1), and between V_F and V_{L6} (R2).

3. Contrast Control (Voltages referenced to V_{DD})
   Software control of the 64 contrast voltage levels at each voltage regulator feedback gain. The equation of calculating the LCD driving voltage is given as:

$$V_{L6} - V_{DD} = Gain * (1 + \frac{Contrast}{b}) * V_{ref}$$

$$V_{ref} = (\frac{V_{BE} + R * (V_{DD} - V_{SS})}{1 + R})$$

where

Int. Reg. Resistor Ratio Setting	0	1	2	3	4	5	6	7	Ext. Resistor
Gain	-3.29	-3.76	-4.29	-4.82	-5.39	-5.76	-6.40	-6.95	-(1+R2/R1)
β	92.59	91.86	91.12	90.40	89.67	89.18	88.29	87.49	96.68

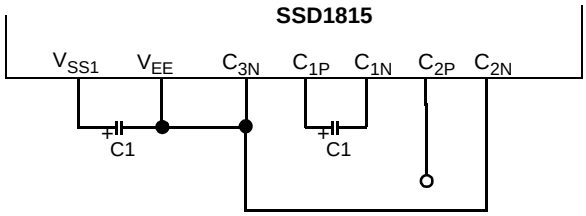
and

TC	0 (-0.01%/°C)	2 (-0.10%/°C)	4 (-0.18%/°C)	7 (-0.25%/°C)
V_{BE}	0.025	0.523	0.520	0.517
R	0.72	0.423	0.272	0.121

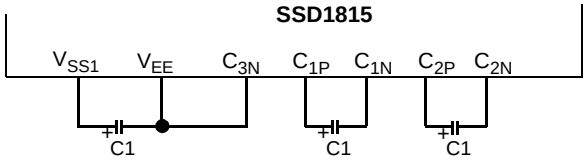
4. Bias Divider
   Divide the regulator output to give the LCD driving voltages (V_{L2} - V_{L5}). A low power consumption circuit design in this bias divider saves most of the display current comparing to traditional design.

5. Bias Ratio Selection circuitry
   Software control of 1/7 and 1/9 bias ratio to match the characteristic of LCD panel. In addition, 1/4, 1/5, 1/6 and 1/8 bias ratios are also software selectable using the extended command for any mux application.

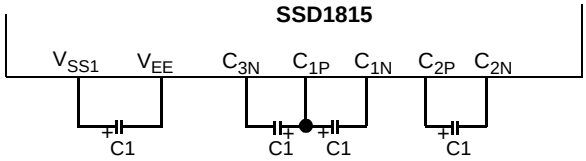
6. Self adjust temperature compensation circuitry
   This block provides 4 different compensation settings to satisfy various liquid crystal temperature gradings by software control. Default temperature coefficient (TC) setting is TC0.



2X Boosting Configuration



3X Boosting Configuration



4X Boosting Configuration

Remarks:
1. C1 = 0.47 - 1.0uF
2. Boosting input from V_{SS1}.
3. V_{SS1} should be lower potential than or equal to V_{SS}
4. All voltages are referenced to V_{DD}

Figure 6 - Configurations for DC-DC Converter

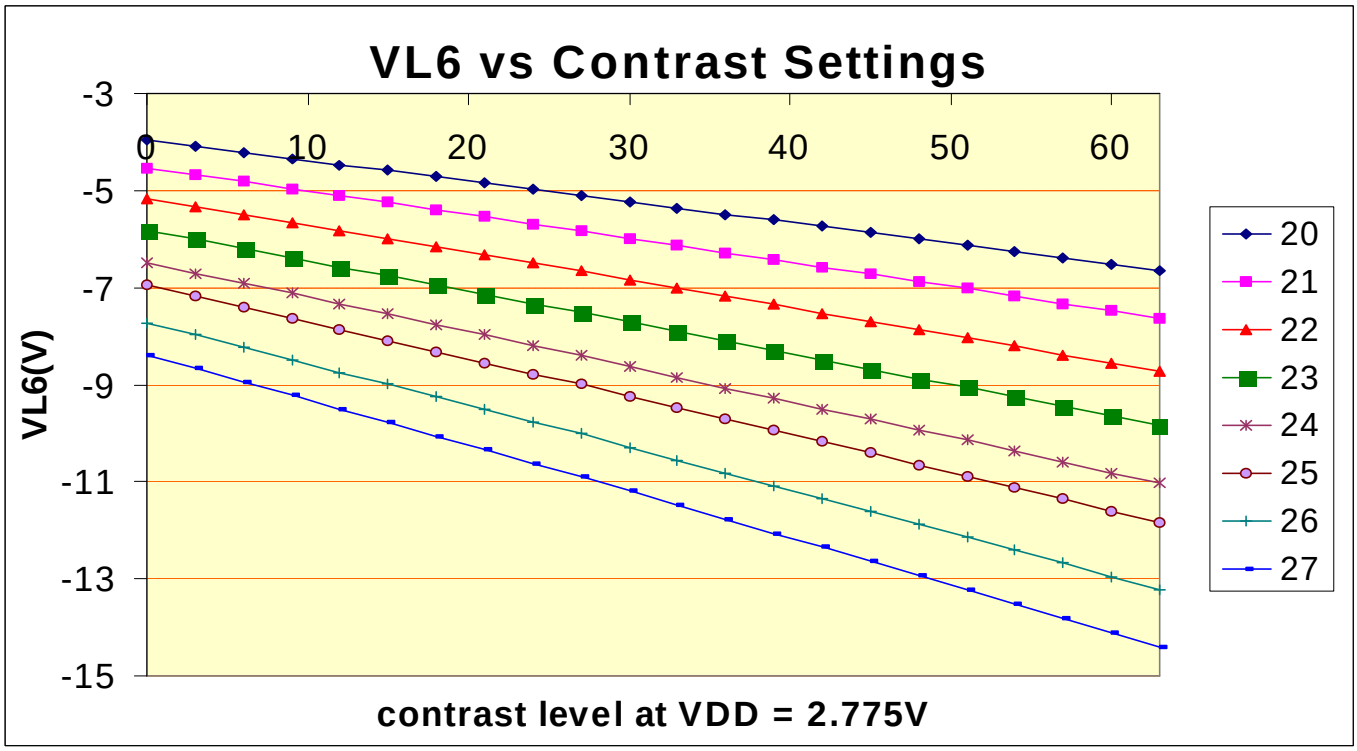


Figure 7 - Contrast Curves at Different Interneal Feedback Resistor Ratio Settings

Reset Circuit

This block includes Power On Reset circuitry and the Reset pin, RES. Both of these having the same reset function. Once RES receives a negative reset pulse, all internal circuitry will start to initialize. Minimum pulse width for completing the reset sequence is 1us. The status of the chip after reset is given by:

1. Display is turned OFF
2. 132X64 Display Display Mode with seperated Icon Line
3. Normal segment and display data column address mapping (SEG0 mapped to address 00h)
4. Read-modify-write mode is OFF
5. Power control register is set to 000b
6. Shift register data clear in serial interface
7. Bias ratio is set to 1/9
8. Static indicator is turned OFF
9. Display start line is set to display RAM column address 0
10. Column address counter is set to 0
11. Page address is set to 0
12. Normal scan direction of the COM outputs
13. Contrast control register is set to 20h
14. Test mode is turned OFF

Display Data Latch

A series of registers carrying the display signal information. For SSD1815, there are 197 latches (132 + 65) for holding the data, which will be fed to the HV Buffer Cell and Level Selector to output the required voltage level.

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)

HV 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.

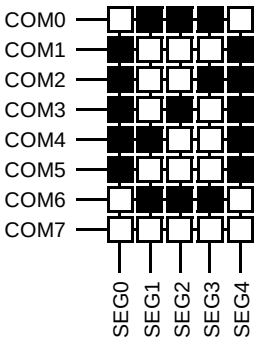
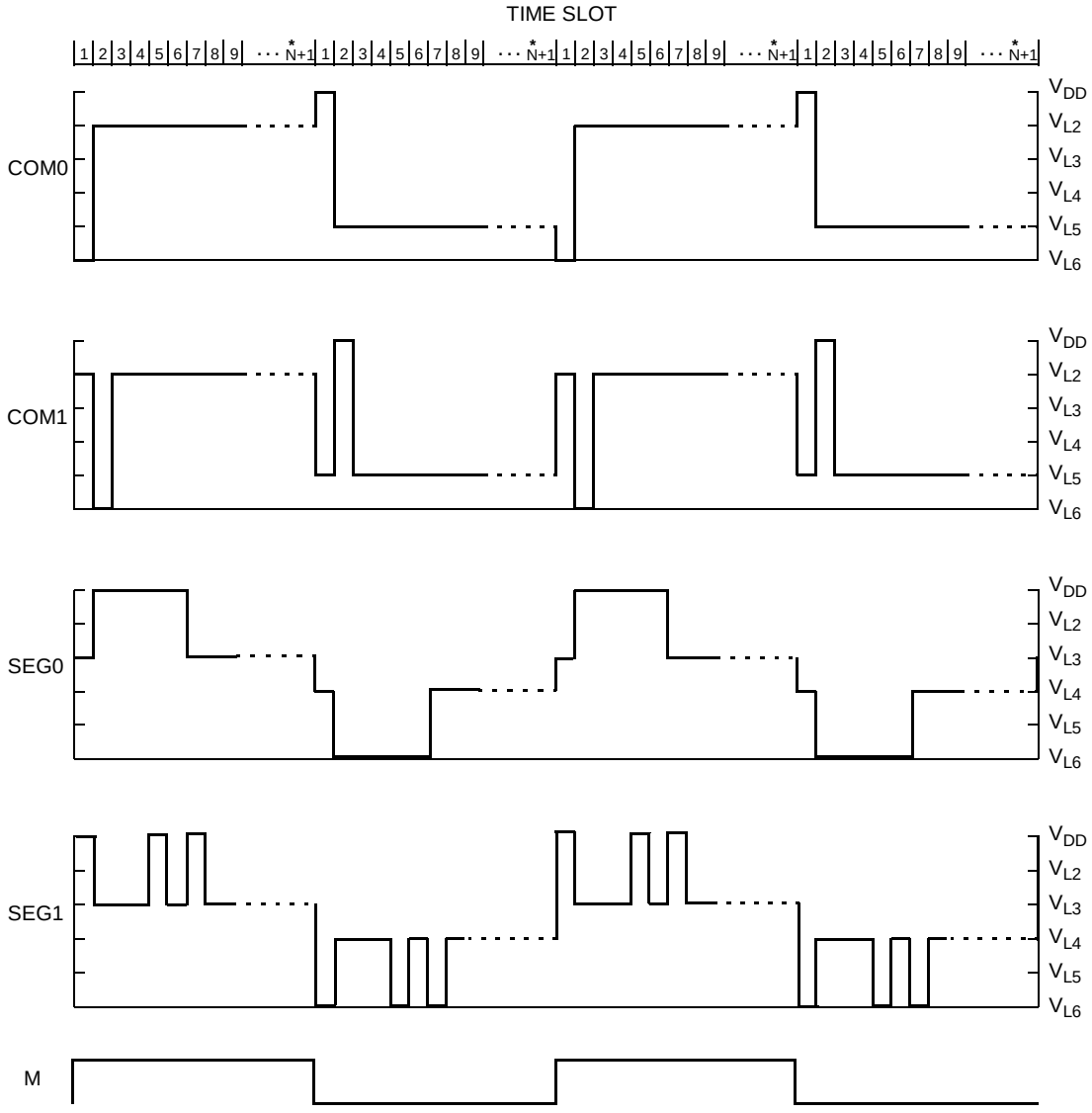


Figure 8a. LCD Display Example "0"



* Note : N is the number of multiplex ratio not included Icon, N is equal to 64 on POR.

Figure 8b - LCD Driving Waveform

COMMAND TABLE

Bit Pattern	Write Command (D/C=0, R/W(WR)=0, E(RD)=1)	Comment
$0000X_3X_2X_1X_0$	Set Lower Column Address	Set the lower nibble of the colume address register using $X_3X_2X_1X_0$ as data bits. The initial display line register is reset to 0000b during POR.
$0001X_3X_2X_1X_0$	Set Higher Column Address	Set the higher nibble of the colume address register using $X_3X_2X_1X_0$ as data bits. The initial display line register is reset to 0000b during POR.
$00100X_2X_1X_0$	Set Internal Regulator Resistor Ratio	Internal regulator gain increases as $X_2X_1X_0$ increased from 000b to 111b. At POR, $X_2X_1X_0$ = 100b.
$00101X_2X_1X_0$	Set Power Control Register	X_0=0: turns off the output op-amp buffer (POR) X_0=1: turns on the output op-amp buffer X_1=0: turns off the internal regulator (POR) X_1=1: turns on the internal regulator X_2=0: turns off the internal voltage booster (POR) X_2=1: turns on the internal voltage booster
$01X_5X_4X_3X_2X_1X_0$	Set Display Start Line	Set display RAM display start line register from 0-63 using $X_5X_4X_3X_2X_1X_0$. Display start line register is reset to 000000 during POR.
10000001 * * $X_5X_4X_3X_2X_1X_0$	Set Contrast Control Register	Set Contrast level from 64 contrast steps. Contrast increases (V_{L6} decreases) as $X_5X_4X_3X_2X_1X_0$ is increased. $X_5X_4X_3X_2X_1X_0$ = 100000b (POR)
$1010000X_0$	Set Segment Re-map	X_0=0: column address 00h is mapped to SEG0 (POR) X_0=1: column address 83h is mapped to SEG0 Refer to Figure 5 for example.
$1010001X_0$	Set LCD Bias	X_0=0: 1/9 bias (POR) X_0=1: 1/7 bias For setting bias ratio to 1/4, 1/5, 1/6 or 1/8, see Extended Command Table.
$1010010X_0$	Set Entire Display On/Off	X_0=0: normal display (POR) X_0=1: entire display on
$1010011X_0$	Set Normal/Reverse Display	X_0=0: normal display (POR) X_0=1: reverse display
$1010111X_0$	Set Display On/Off	X_0=0: turns off LCD panel (POR) X_0=1: turns on LCD panel
$1011X_3X_2X_1X_0$	Set Page Address	Set GDDRAM Page Address (0-8) using $X_3X_2X_1X_0$
$1100X_3$ * * *	Set COM Output Scan Direction	X_3=0: normal mode (POR) X_3=1: remapped mode, COM0 to COM[N-1] becomes COM[N-1] to COM0 when Multiplex ratio is equal to N. See Figure 5 as an example for N equal to 64.
11100000	Set Read-Modify-Write Mode	Read-modify-write mode will be entered in which the column address will not be incremented during display data read. At POR, Read-modify-write mode is turned OFF.
11100010	Software Reset	Initialize the internal status register.
11101110	Set End of Read-Modify-Write Mode	Exit Read-modify-write mode. Column address before entering the mode will be restored. At POR, Read-modify-write mode is OFF.
$1010110X_0$ * * * * * * X_1X_0	Set Indicator On/Off Indicator Display Mode, This second byte command is required ONLY when “Set Indicator On” command is sent.	X_0 = 0: indicator off (POR, no need of second command byte) X_0 = 1: indicator on (second command byte required) X_1X_0 = 00: indicator off X_1X_0 = 01: indicator on and blinking at ~1 second interval X_1X_0 = 10: indicator on and blinking at ~1/2 second interval X_1X_0 = 11: indicator on constantly
11100011	NOP	Command for No Operation
11110000	Test Mode Reset	Reserved for IC testing. Do NOT use.
1111 * * * *	Set Test Mode	Reserved for IC testing. Do NOT use.
* * * * * * * *	Set Power Save Mode	Standby or sleep mode will be entered with compound commands

Bit Pattern	Read Command (D/C=0, R/W(WR)=1, E(RD)=0)	Comment
$D_7D_6D_5D_4D_3D_2D_1D_0$ (Data Read Back from the driver)	Status Register Read	D_7=0: indicates an internal operation is completed. D_7=1: indicates an internal operation is in progress. D_6=0: indicates reverse segment mapping with column address D_6=1: indicates normal segment mapping with column address D_5=0: indicates the display is ON D_5=1: indicates the display is OFF D_4=0: initialization is not in progress D_4=1: initialization is in progress after $\overline{RES}$ or software reset $D_3D_2D_1D_0$ = 1010, these 4-bit is fixed to 1010 which could be used to identify as Solomon Systech Device.

EXTENDED COMMAND TABLE

Bit Pattern	Command	Comment
10101000 $00X_5X_4X_3X_2X_1X_0$	$X_5X_4X_3X_2X_1X_0$: Set Multiplex Ratio	To select multiplex ratio N from 2 to 65 [Included Icon Line]. N = $X_5X_4X_3X_2X_1X_0$ + 2, eg. N = 111111b + 2 = 65 (POR)
10101001 $X_7X_6X_5X_4X_3X_2X_1X_0$	X_1X_0: Set Bias Ratio	X_1X_0 = 00: 1/8, 1/6 X_1X_0 = 01: 1/6, 1/5 X_1X_0 = 10: 1/9, 1/7 (POR) X_1X_0 = 11: Prohibited
	$X_4X_3X_2$: Set TC Value	$X_4X_3X_2$ = 000: -0.01%/C (TC0, POR) $X_4X_3X_2$ = 010: -0.10%/C (TC2) $X_4X_3X_2$ = 100: -0.18%/C (TC4) $X_4X_3X_2$ = 111: -0.25%/C (TC7) $X_4X_3X_2$ = 001, 011, 101, 110: Reserved
	$X_7X_6X_5$: Modify Osc. Freq.	Increase the value of $X_7X_6X_5$ will increase the oscillator frequency and vice versa. This command is not recommended to be used. $X_7X_6X_5$ = 011(POR)
$1010101X_0$	X_0: Set 1/4 Bias Ratio	X_0 = 0: use Normal Setting (POR) X_0 = 1: fixed at 1/4 Bias
11010010 $0X_6X_500010$	X_6X_5: Set Total Frame Phases	The On/Off of the Static Icon is given by 3 phases/1 phase overlapping of the M and MSTAT signals. This command set how many phases of dividing the M/MSTAT signals for each frame. The more the phases, the less the overlapping and thus the lower the effective driving voltage. X_6X_5 = 00: 3 phases X_6X_5 = 01: 5 phases X_6X_5 = 10: 7 phases (POR) X_6X_5 = 11: 16 phases
11010011 $00X_5X_4X_3X_2X_1X_0$	$X_5X_4X_3X_2X_1X_0$: Set Display Offset (for mux ratio has been set less than 64 only)	After POR, $X_5X_4X_3X_2X_1X_0$ = 0 After setting mux ratio less than 64, data will be displayed at Center of matrix. See Table 1. To move display towards Row 0 by L, $X_5X_4X_3X_2X_1X_0$ = L To move display away from Row 0 by L, $X_5X_4X_3X_2X_1X_0$ = 64-L Note: max. value of L = (64 - display mux)/2

Note: Patterns other than that given in Command Table and Extended Command Table are prohibited to enter to the chip as a command. Otherwise, unexpected result will occurs.

Data Read / Write

To read data from the GDDRAM, input High to R/W(WR) pin and D/C pin for 6800-series parallel mode, Low to E(RD) pin and High to D/C pin for 8080-series parallel mode. No data read is provided for serial mode. In normal mode, GDDRAM column address pointer will be increased by one automatically after each data read. However, no automatic increase will be performed in read-modify-write mode. Also, a dummy read is required before the first data read. See Figure 3 in Functional Description.

To write data to the GDDRAM, input Low to R/W(WR) pin and High to D/C pin for 6800-series parallel mode. For serial interface, it will always be in write mode. GDDRAM column address pointer will be increased by one automatically after each data write.

Address Increment Table (Automatic)

D/C	R/W(WR)	Comment	Address Increment	Remarks
0	0	Write Command	No	
0	1	Read Status	No	
1	0	Write Data	Yes	
1	1	Read Data	Yes	*1

Address Increment is done automatically after data read write. The column address pointer of GDDRAM*2 is affected.

Remarks: 1. If read data is issued in read-modify-write mode, address will NOT be increased.
2. Column Address will NOT wrap round to zero when overflow.

Commands Required for R/W(WR) Actions on RAM

R/W(WR) Actions on RAMs	Commands Required	
Read/Write Data from/to GDDRAM.	Set GDDRAM Page Address Set GDDRAM Column Address Read/Write Data	$(1011X_3X_2X_1X_0)$* $(0001X_3X_2X_1X_0)$* $(0000X_3X_2X_1X_0)$ $(X_7X_6X_5X_4X_3X_2X_1X_0)$
Save/Restore GDDRAM Column Address.	Save GDDRAM Column Address by read-modify-write mode Restore GDDRAM Column Address by end of read-modify-write mode	(11100000) (11101110)

Note: 1. No need to resend the command again if it is set previously.
2. The read / write action to the Display Data RAM does not depend on the display mode. This means the user can change the RAM content whether the target RAM content is being displayed or not.

Command Description

Set Lower Column Address

This command specifies the lower nibble of the 8-bit column address of the display data RAM. The column address will be incremented by each data access after it is pre-set by the MCU.

Set Higher Column Address

This command specifies the higher nibble of the 8-bit column address of the display data RAM. The column address will be incremented by each data access after it is pre-set by the MCU.

Set Internal Regulator Resistors Ratio

This command is to enable any one of the eight internal resistor sets for different regulator gain when using internal regulator resistor network (IRS pin pulled high). Please refer to Block Diagram Description section for detail calculation of the LCD driving voltage.

Set Power Control Register

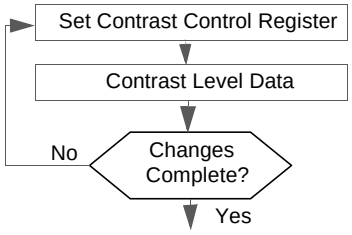
This command turns on/off the various power circuits associated with the chip.

Set Display Start Line

This command is to set Display Start Line register to determine starting address of display RAM to be displayed by selecting a value from 0 to 63. With value equals to 0, D0 of Page 0 is mapped to COM0. With value equals to 1, D1 of Page0 is mapped to COM0. The display start line values of 0 to 63 are assigned to Page 0 to 7.

Set Contrast Control Register

This commands adjusts the contrast of the LCD panel by changing V_{L6} of the LCD drive voltage provided by the On-Chip power circuits. V_{L6} is set with 64 steps (6-bit) contrast control register. It is a compound commands:



Set Segment Re-map

This commands changes the mapping between the display data column address and segment driver. It allows flexibility in layout during LCD module assembly. Refer to Figure 5 for example.

Set LCD Bias

This command selects a suitable bias ratio (1/7 or 1/9) required for driving the particular LCD panel in use. The POR default for SSD1815 is set to 1/9 bias. For setting 1/4, 1/5, 1/6 and 1/8 bias, an extended compound command should be used.

Set Entire Display On/Off

This command forces the entire display, including the icon row, to be “ON” regardless of the contents of the display data RAM. This command has priority over normal/reverse display. This command will be used with “Set Display Display ON/OFF” command to form a compound command for entering power save mode. See “Set Power Save Mode”.

Set Normal/Reverse Display

This command sets the display to be either normal/ reverse. In normal display, a RAM data of 1 indicates an “ON” pixel while in reverse display, a RAM data of 0 indicates an “ON” pixel. In icon mode, the icon line is not reversed by this command.

Set Display On/Off

This command alternatively turns the display on and off. When display off is issued with entire display on, power save mode will be entered. See “Set Power Save Mode” for details.

Set Page Address

This command positions the page address from 0 to 8 possible positions in GDDRAM. Refer to Figure 5 for mapping.

Set COM Output Scan Direction

This command sets the scan direction of the COM output allowing layout flexibility in LCD module assembly.

Set Read-Modify-Write Mode

This command puts the chip in read-modify-write mode in which:

1. the column address is saved before entering the mode
2. the column address is incremented by display data write but not by display data read

Software Reset

This command causes some of the internal status registers of the chip to be initialized:

1. Static indicator is turned OFF
2. Display start line register is set to 0
3. Column address counter is set to 0
4. Page address is set to 0
5. Normal scan direction of the COM outputs
6. Contrast control register is set to 0
7. Test mode is turned OFF

Set End of Read-Modify-Write Mode

This command relieves the chip from read-modify-write mode. The column address that is saved before entering read-modify-write mode will be restored.

Set Indicator On/Off

This command turns on and off the static drive indicators. It also controls whether standby mode or sleep mode will be

entered after the power save compound command. See “Set Power Save Mode”.

When the “Set Indicator On” command is sent, the “Indicator Display Mode” must be followed in the next command. The “Set Indicator Off” command is a single byte command and no following command is required.

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.

Set Power Save Mode

To enter Standby or Sleep Mode, it should be done by using a compound command composed of “Set Display ON/OFF” and “Set Entire Display ON/OFF” commands. When “Set Entire Display ON” is issued when display is OFF, either Standby Mode or Sleep Mode will be entered.

The status of the Static Indicator will determine which power save mode is entered. If static indicator is off, the Sleep Mode will be entered:

1. Internal oscillator and LCD power supply circuits are stopped
2. Segment and Common drivers output V_{DD} level
3. The display data and operation mode before sleep are held
4. Internal display RAM can still be accessed

If the static indicator is on, the chip enters Standby Mode which is similar to sleep mode except:

1. Internal oscillator is on
2. Static drive system is on

Note also that if the software reset command is issued during Standby Mode, Sleep Mode will be entered. Both power save modes can be exited by the issue of a new software command or by pulling Low at hardware pin $\overline{RES}$.

Status register Read

This command is issued by pulling D/$\overline{C}$ Low during a data read (refer to Figure 9 and 10 for parallel interface waveforms). It allows the MCU to monitor the internal status of the chip. No status read is provided for serial mode.

EXTENDED COMMANDS

These commands are used, in addition to basic commands, to trigger the enhanced features, on top of general ones, designed for the chip.

Set Multiplex Ratio

This command switches default 64 multiplex mode to any multiplex mode from 2 to 64. The chip pads ROW0-ROW63 will be switched to corresponding COM signal output, see Table 1 for examples of different multiplex settings.

Set Bias Ratio

Except the 1/4 bias, all the available bias ratios (1/5, 1/6, 1/7, 1/8 and 1/9) could be set using this command plus the Set LCD Bias. When changing the display multiplex ratio, the bias ratio also need to be adjusted to make display contrast consistent.

Set Temperature Coefficient (TC) Value

4 different temperature coefficient settings is selected by this command in order to match various liquid crystal temperature grades.

Modify Oscillator Frequency

The oscillator frequncy can be fine tuned by applying this command. Since the oscillator frequency will be affected by some other factors, this command is not recommended for general usage. Please contact our application engineer for more detail explaination on this command.

Set 1/4 Bias Ratio

This command sets the bias ratio directly to 1/4 bias. This ratio is especially for use in under 12mux display.

In order to restore to other bias ratio, this command must be executed, with LSB=0, before the “Set Multiplex ratio” or “Set LCD Bias” command is sent.

Set Total Frame Phases

The total number of phases for one display frame is set by this command.

The Static Icon is generated by the overlapping of the M and MSTAT signals. To turn on the Static Icon, 3 phases overlapping will be applied to these signals, while 1 phase overlapping will be given to the Off status.

The more the total number of phasesin one frame, the less the overlapping time and thus the lower the effective driving voltage at the Static Icon on the LCD panel.

Set Display Offset

This command should be sent ONLY when the multiplex ratio is set less than 64.

When the mulitplex ratio less than 64 is set, the display will be mapped in the middle (y-direction) of the LCD, see Table 1. Use this command could move the display vertically within the 64 commons.

To make the Reduced-Mux Com 0 (Com 0 after reducing the multiplex ratio) towards the Row 0 direction for L lines, the 6-bit data in second command should be given by L.

To move in the other direction by L lines, the 6-bit data should be given by 64-L.

Please note that the display is confined within the un-reduced 64 mux. That is maximum value of L is given by the half of 64 minus the reduced-multiplex ratio. For an odd display mux after reduction, moving away from Row 0 direction will has 1 more step.

MAXIMUM RATINGS* (Voltages Referenced to V_{SS})

Symbol	Parameter	Value	Unit
V_{DD}	Supply Voltage	-0.3 to +4.0	V
V_{EE}		0 to -12.0	V
V_{in}	Input Voltage	V_{SS}-0.3 to V_{DD}+0.3	V
I	Current Drain Per Pin Excluding V_{DD} and V_{SS}	25	mA
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 input 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 (Unless otherwise specified, Voltage Referenced to V_{SS}, V_{DD} = 2.4 to 3.5V, T_A = -30 to 85°C.)

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
V_{DD}	Logic Circuit Supply Voltage Range	Recommend Operating Voltage Possible Operating Voltage	2.4 1.8	2.7 -	3.5 3.5	V V
I_{AC}	Access Mode Supply Current Drain (V_{DD} Pins)	V_{DD} = 2.7V, Voltage Generator On, 4X DC-DC Converter Enabled, Write accessing, T_{cyc} =3.3MHz, Osc. Freq.=17kHz, Display On.	-	300	600	µA
I_{DP1}	Display Mode Supply Current Drain (V_{DD} Pins)	V_{DD} = 2.7V, V_{EE} = -8.1V, Voltage Generator Disabled, R/W(WR) Halt, Osc. Freq. = 17kHz, Display On, V_{L6} - V_{DD} = -8.1V.	-	60	100	µA
I_{DP2}	Display Mode Supply Current Drain (V_{DD} Pins)	V_{DD} = 2.7V, V_{EE} = -8.1V, Voltage Generator On, 4x DC-DC Converter Enabled, R/W(WR) Halt, Osc. Freq. = 17kHz, Display On, V_{L6} - V_{DD} = -8.1V.	-	150	200	µA
I_{SB}	Standby Mode Supply Current Drain (V_{DD} Pins)	V_{DD}=2.7V, LCD Driving Waveform Off, Osc. Freq. = 17kHz, R/W(WR) halt.	-	3.5	10	µA
I_{SLEEP}	Sleep Mode Supply Current Drain (V_{DD} Pins)	V_{DD} = 2.7V, LCD Driving Waveform Off, Oscillator Off, R/W(WR) halt.	-	0.2	5	µA
V_{EE}	LCD Driving Voltage Generator Output (V_{EE} Pin)	Display On, Voltage Generator Enabled, DC/DC Converter Enabled, Osc. Freq.=17kHz, Regulator Enabled, Divider Enabled.	-12.0	-	-1.8	V
V_{LCD}	LCD Driving Voltage Input (V_{EE} Pin)	Voltage Generator Disabled.	-12.0	-	-1.8	V
V_{OH1}	Logic High Output Voltage	I_{out}=100µA	0.9*V_{DD}	-	V_{DD}	V
V_{OL1}	Logic Low Output Voltage	I_{out}=100µA	0	-	0.1*V_{DD}	V
V_{L6}	LCD Driving Voltage Source (V_{L6} Pin)	Regulator Enabled (V_{L6} voltage depends on Int/Ext Contrast Control)	V_{EE}-0.5	-	V_{DD}	V
V_{L6}	LCD Driving Voltage Source (V_{L6} Pin)	Regulator Disable	-	Floating	-	V
V_{IH1}	Logic High Input voltage		0.8*V_{DD}	-	V_{DD}	V
V_{IL1}	Logic Low Input voltage		0	-	0.2*V_{DD}	V

V_{L2}	LCD Display Voltage Output	Voltage reference to V_{DD}, Bias Divider Enabled, 1:7	-	$1/7*V_{L6}$	-	V
V_{L3}	(V_{L2}, V_{L3}, V_{L4}, V_{L5}, V_{L6} Pins)	bias ratio	-	$2/7*V_{L6}$	-	V
V_{L4}			-	$5/7*V_{L6}$	-	V
V_{L5}			-	$6/7*V_{L6}$	-	V
V_{L6}			-	V_{L6}	-	V
V_{L2}	LCD Display Voltage Output	Voltage reference to V_{DD}, Bias Divider Enabled, 1:9	-	$1/9*V_{L6}$	-	V
V_{L3}	(V_{L2}, V_{L3}, V_{L4}, V_{L5}, V_{L6} Pins)	bias ratio	-	$2/9*V_{L6}$	-	V
V_{L4}			-	$7/9*V_{L6}$	-	V
V_{L5}			-	$8/9*V_{L6}$	-	V
V_{L6}			-	V_{L6}	-	V
V_{L2}	LCD Display Voltage Input	Voltage reference to V_{DD}, External Voltage Generator, Bias Divider Disabled	V_{L3}	-	V_{DD}	V
V_{L3}	(V_{L2}, V_{L3},V_{L4}, V_{L5}, V_{L6} Pins)		V_{L4}	-	V_{L2}	V
V_{L4}			V_{L5}	-	V_{L3}	V
V_{L5}			V_{L6}	-	V_{L4}	V
V_{L6}			-12V	-	V_{L5}	V
I_{OH}	Logic High Output Current Source	$V_{out} = V_{DD}$-0.4V	50	-	-	µA
I_{OL}	Logic Low Output Current Drain	V_{out} = 0.4V	-	-	-50	µA
I_{OZ}	Logic Output Tri-state Current Drain Source		-1	-	1	µA
I_{IL}/I_{IH}	Logic Input Current		-1	-	1	µA
C_{IN}	Logic Pins Input Capacitance		-	5	7.5	pF
ΔV_{L6}	Variation of V_{L6} Output (V_{DD} is fixed)	Regulator Enabled, Internal Contrast Control Enabled, Set Contrast Control Register = 0	-	± 3	-	%
	Temperature Coefficient Compensation					
PTC0	Flat Temperature Coefficient (POR)	Voltage Regulator Enabled	0	-0.01	-0.075	%/C
PTC2	Temperature Coefficient 2*	Voltage Regulator Enabled	-0.075	-0.10	-0.15	%/C
PTC4	Temperature Coefficient 4*	Voltage Regulator Enabled	-0.15	-0.18	-0.20	%/C
PTC7	Temperature Coefficient 7*	Voltage Regulator Enabled	-0.20	-0.25	-	%/C

* The formula for the temperature coefficient is:

$$TC(\%) = \frac{V_{ref} \text{ at } 50°C - V_{ref} \text{ at } 0°C}{50°C - 0°C} \times \frac{1}{V_{ref} \text{ at } 25°C} \times 100\%$$

AC ELECTRICAL CHARACTERISTICS (Unless otherwise specified, Voltage Referenced to V_{SS}, V_{DD} = 2.4 to 3.5V, T_A = -30 to 85°C.)

Symbol	Parameter	Test Condition	Min	Typ	Max	Unit
F_{OSC}	Oscillation Frequency of Display Timing Generator	Internal Oscillator Enabled, V_{DD} = 2.7V	15	17	19	kHz
F_{FRM}	Frame Frequency	Display ON, Set 132 X 64 Graphic Display Mode	-	$\frac{F_{OSC}}{4*65}$	-	Hz

TABLE 3. 6800-Series MPU Parallel Interface Timing Characteristics (V_{DD} - V_{SS} = 2.4 to 3.5V, T_A = -30 to 85°C)

Symbol	Parameter	Min	Typ	Max	Unit
t_{cycle}	Clock Cycle Time	300	-	-	ns
t_{AS}	Address Setup Time	0	-	-	ns
t_{AH}	Address Hold Time	0	-	-	ns
t_{DSW}	Write Data Setup Time	40	-	-	ns
t_{DHW}	Write Data Hold Time	15	-	-	ns
t_{DHR}	Read Data Hold Time	20	-	-	ns
t_{OH}	Output Disable Time	-	-	70	ns
t_{ACC}	Access Time	-	-	140	ns
PW_{CSL}	Chip Select Low Pulse Width (read) Chip Select Low Pulse Width (write)	120 60	- -	- -	ns ns
PW_{CSH}	Chip Select High Pulse Width (read) Chip Select High Pulse Width (write)	60 60	- -	- -	ns ns
t_R	Rise Time	-	-	15	ns
t_F	Fall Time	-	-	15	ns

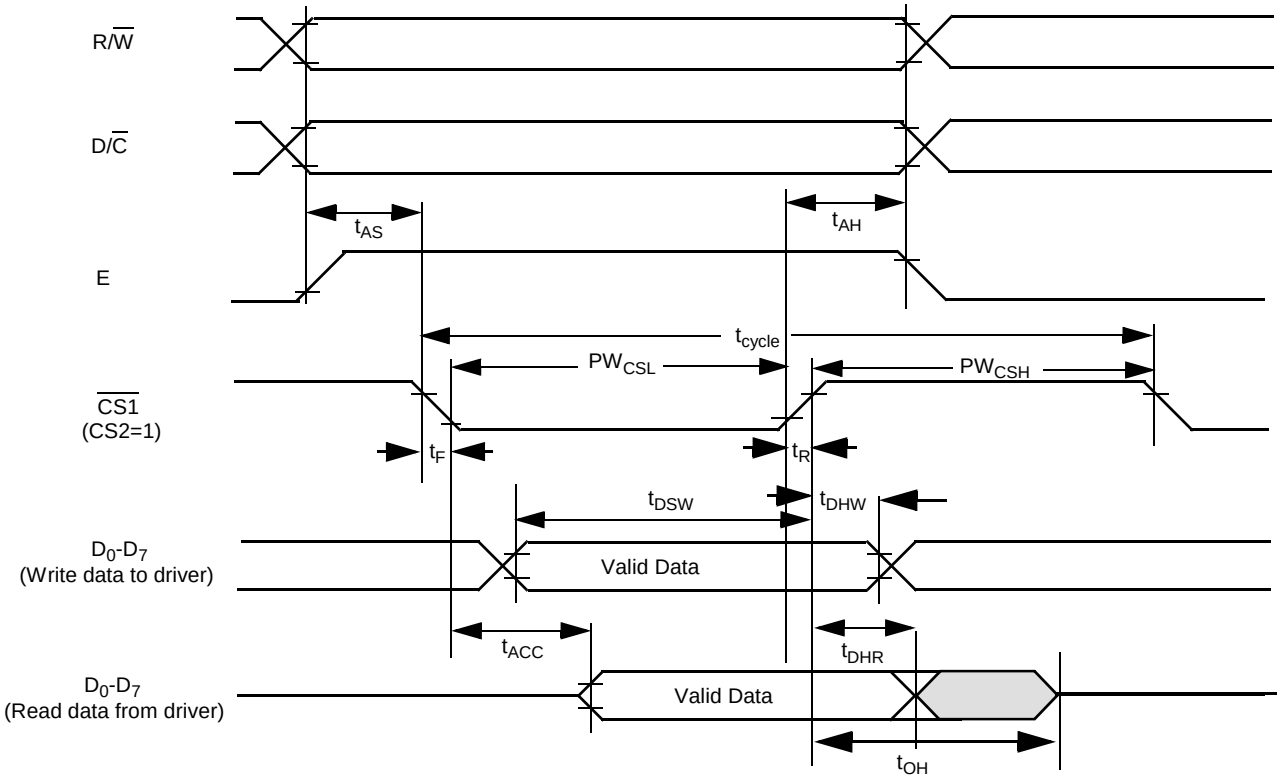


Figure 9 - 6800-series MPU Parallel Interface Characteristics

TABLE 4. 8080-Series MPU Parallel Interface Timing Characteristics (V_{DD} - V_{SS} = 2.4 to 3.5V, T_A = -30 to 85°C)

Symbol	Parameter	Min	Typ	Max	Unit
t_{cycle}	Clock Cycle Time	300	-	-	ns
t_{AS}	Address Setup Time	0	-	-	ns
t_{AH}	Address Hold Time	0	-	-	ns
t_{DSW}	Write Data Setup Time	40	-	-	ns
t_{DHW}	Write Data Hold Time	15	-	-	ns
t_{DHR}	Read Data Hold Time	20	-	-	ns
t_{OH}	Output Disable Time	-	-	70	ns
t_{ACC}	Access Time	-	-	140	ns
PW_{CSL}	Chip Select Low Pulse Width (read) Chip Select Low Pulse Width (write)	120 60	- -	- -	ns ns
PW_{CSH}	Chip Select High Pulse Width (read) Chip Select High Pulse Width (write)	60 60	- -	- -	ns ns
t_R	Rise Time	-	-	15	ns
t_F	Fall Time	-	-	15	ns

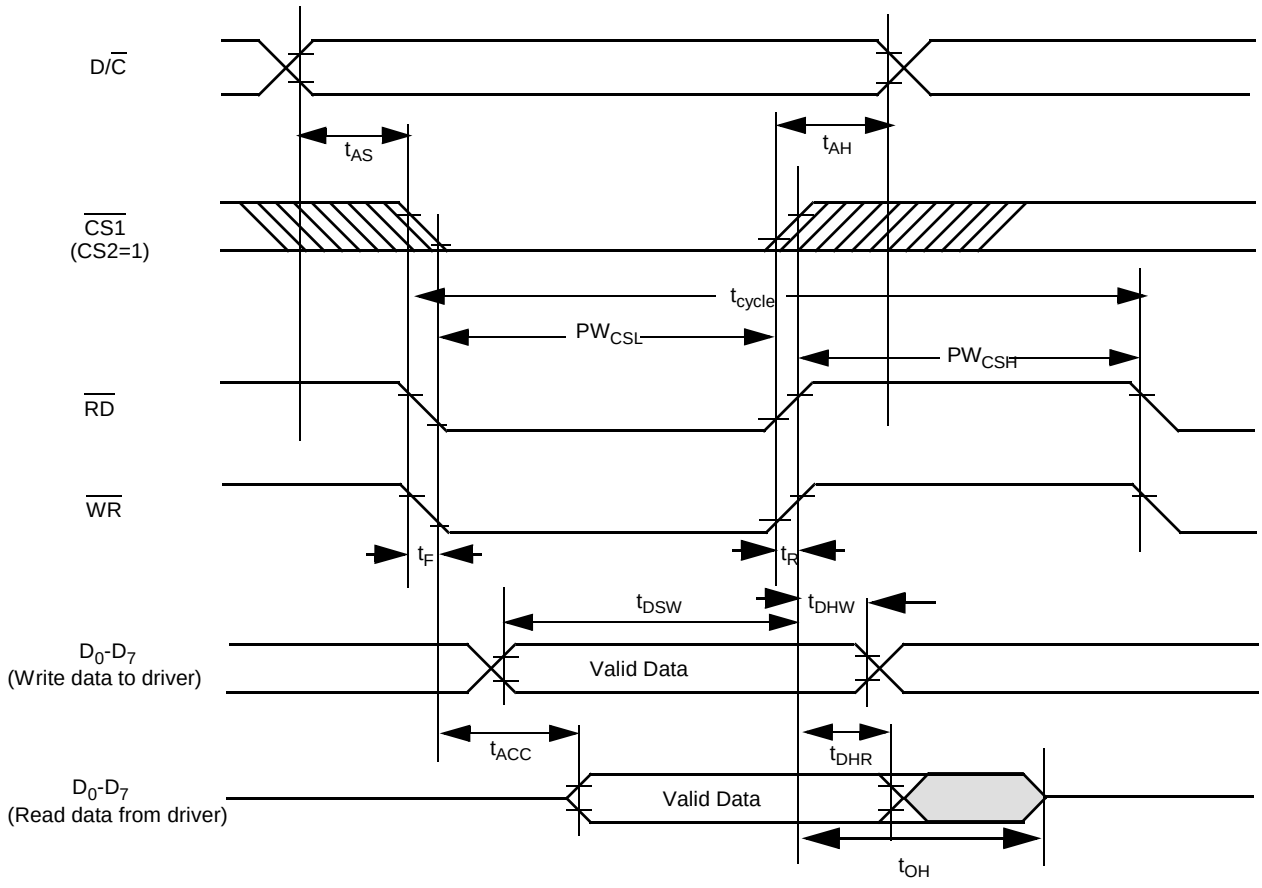
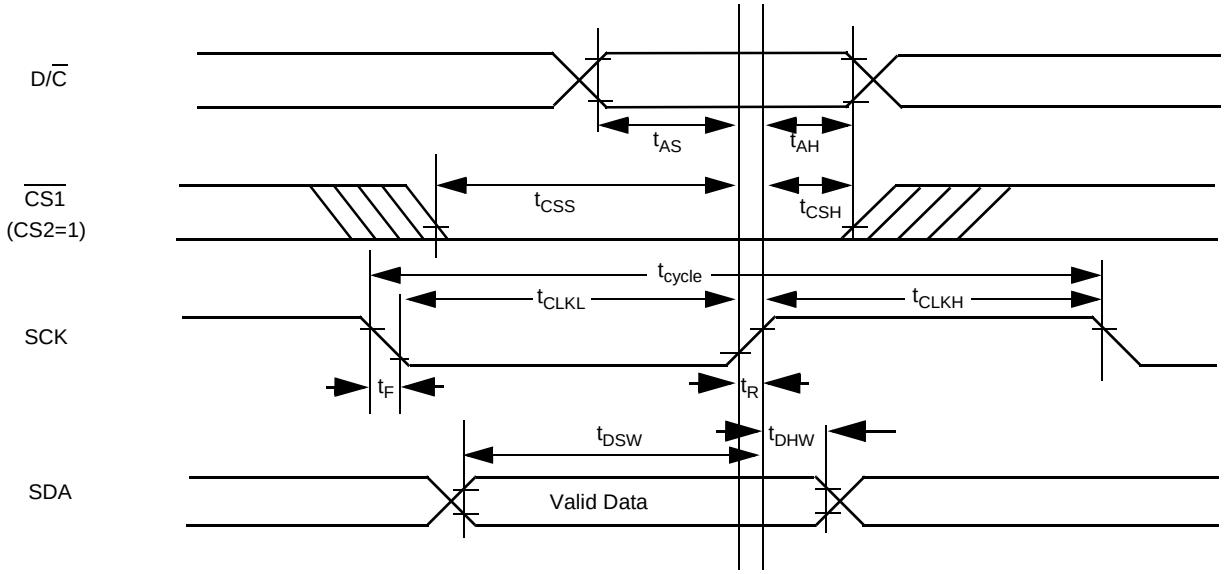


Figure 10 - 8080-series MPU Parallel Interface Characteristics

TABLE 5. Serial Interface Timing Characteristics (V_{DD} - V_{SS} = 2.4 to 3.5V, T_A = -30 to 85°C)

Symbol	Parameter	Min	Typ	Max	Unit
t_{cycle}	Clock Cycle Time	250	-	-	ns
t_{AS}	Address Setup Time	150	-	-	ns
t_{AH}	Address Hold Time	150	-	-	ns
t_{CSS}	Chip Select Setup Time (for D_7 input)	120	-	-	ns
t_{CSH}	Chip Select Hold Time (for D_0 input)	60	-	-	ns
t_{DSW}	Write Data Setup Time	100	-	-	ns
t_{DHW}	Write Data Hold Time	100	-	-	ns
t_{CLKL}	Clock Low Time	100	-	-	ns
t_{CLKH}	Clock High Time	100	-	-	ns
t_R	Rise Time	-	-	15	ns
t_F	Fall Time	-	-	15	ns



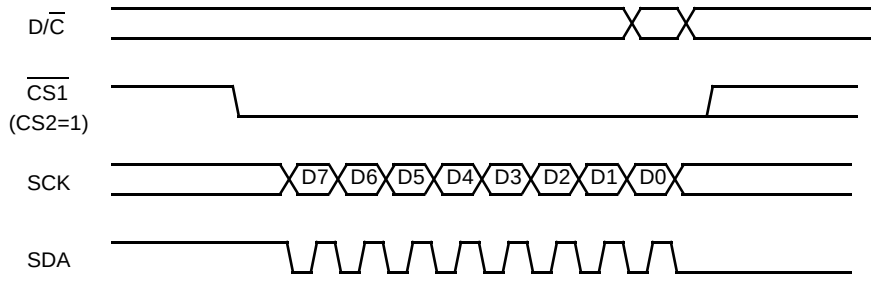
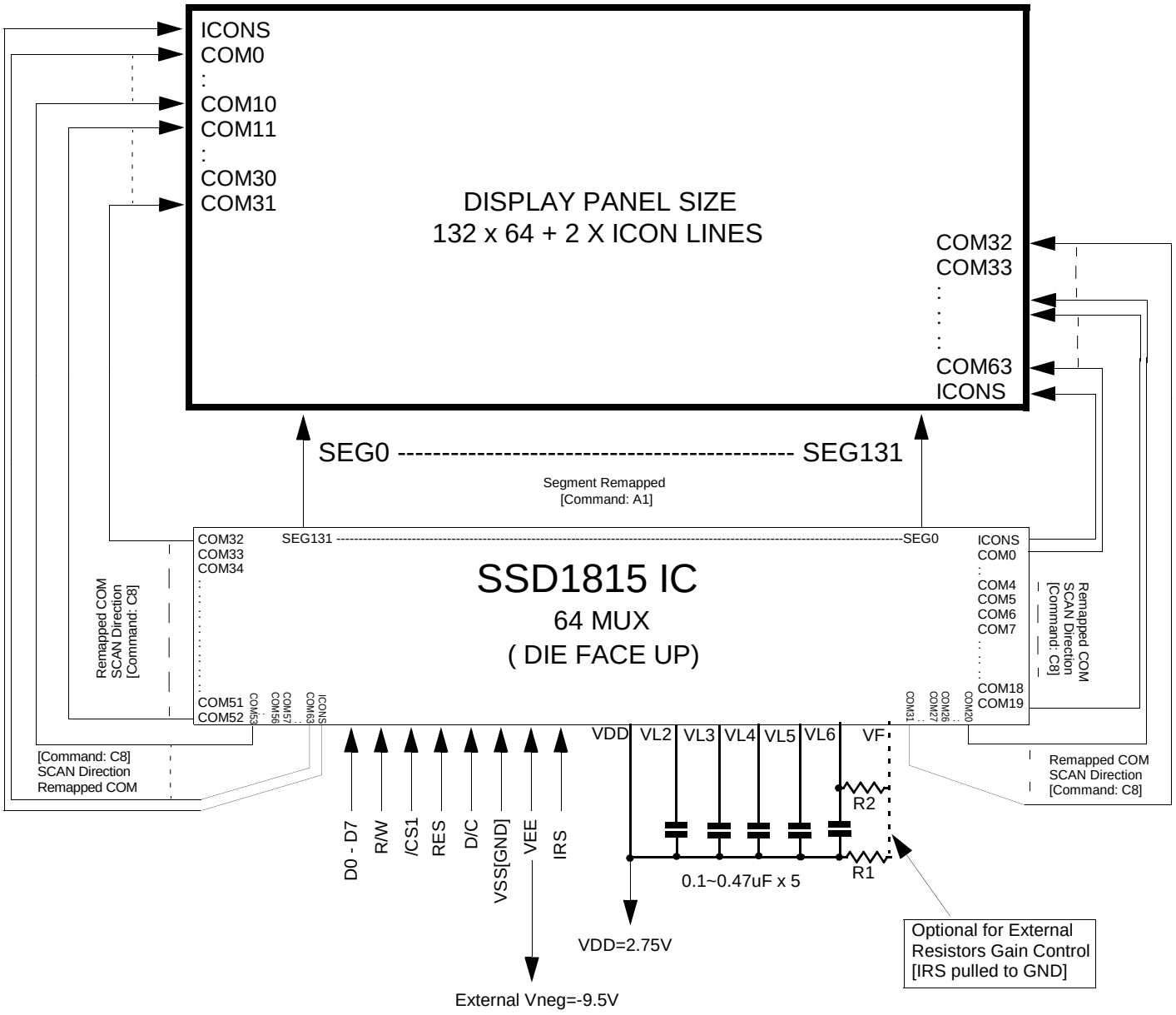


Figure 11 - Serial Interface Characteristics

Figure 12 - Application Circuit: External VEE with internal regulator and divider mode [Command: 2B] in 64 Mux.



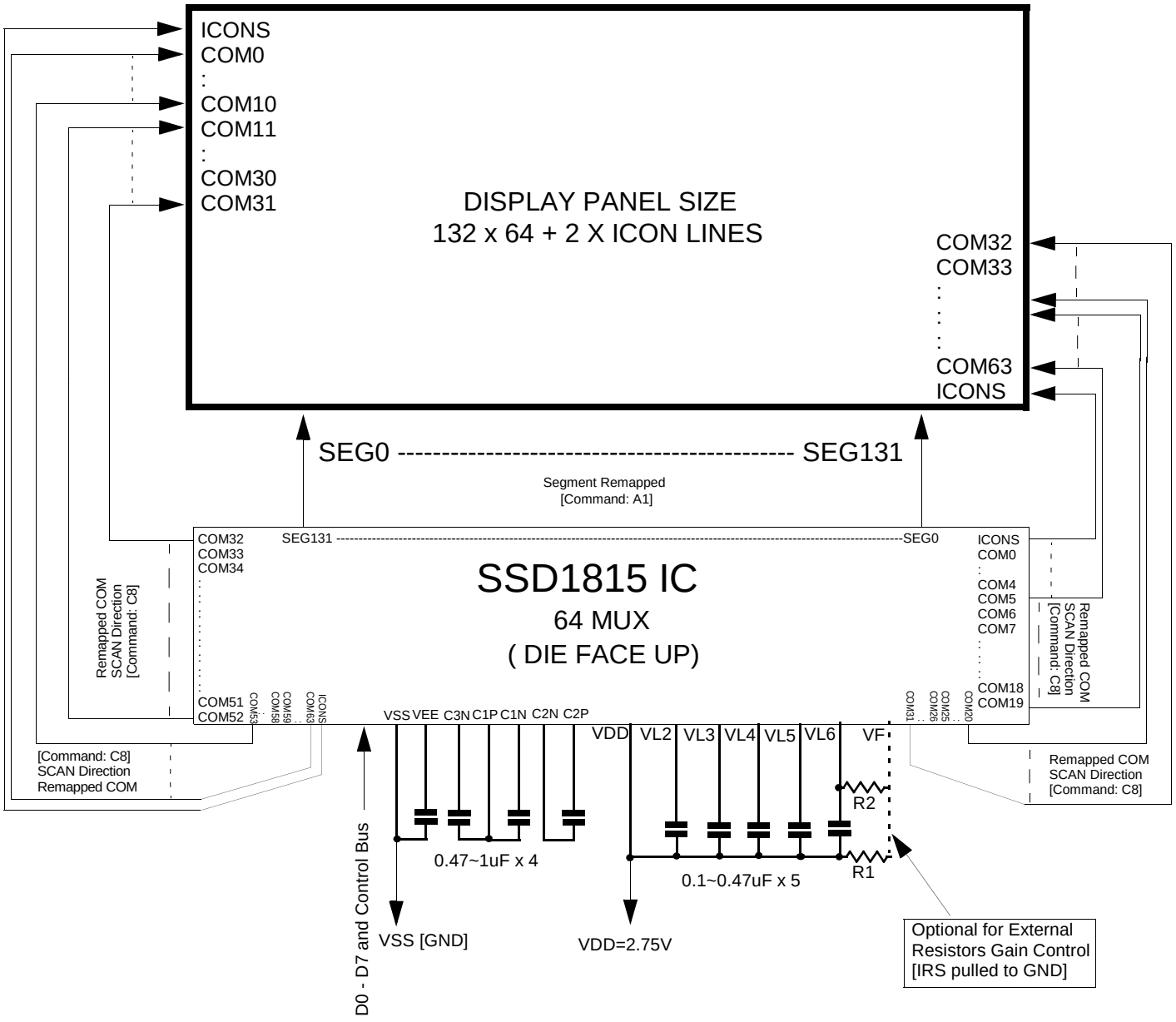
Logic pin connections not specified above:

Pins connected to V_{DD}: CS2, $\overline{RD}$, M/$\overline{S}$, CLS, C68/$\overline{80}$, P/$\overline{S}$, $\overline{HPM}$

Pins connected to V_{SS}: V_{SS1}

Pins floating: $\overline{DOF}$, CL, V_{FS}

Figure 13 - Application Circuit: ALL internal power mode [Command: 2F] in 64 Mux.



Logic pin connections not specified above:

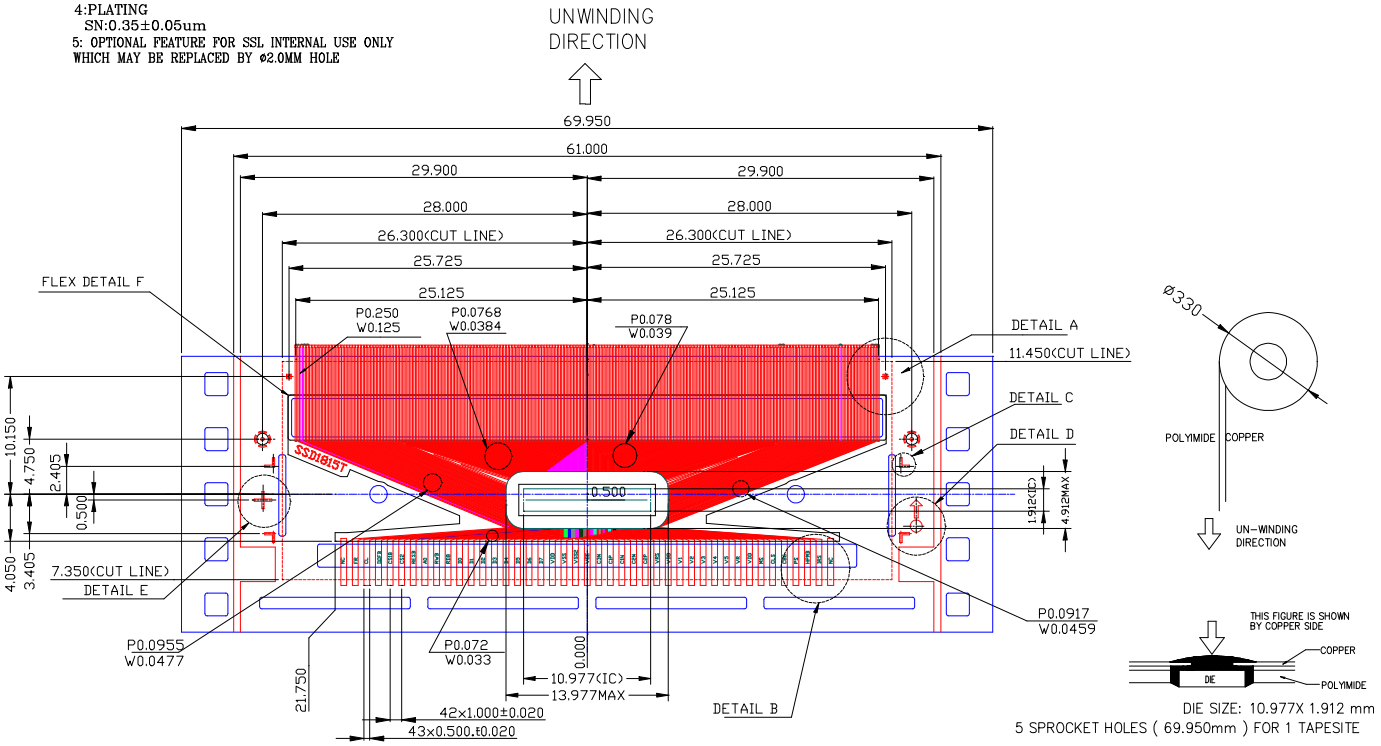
Pins connected to V_{DD}: CS2, $\overline{RD}$, M/$\overline{S}$, CLS, C68/$\overline{80}$, P/$\overline{S}$, $\overline{HPM}$

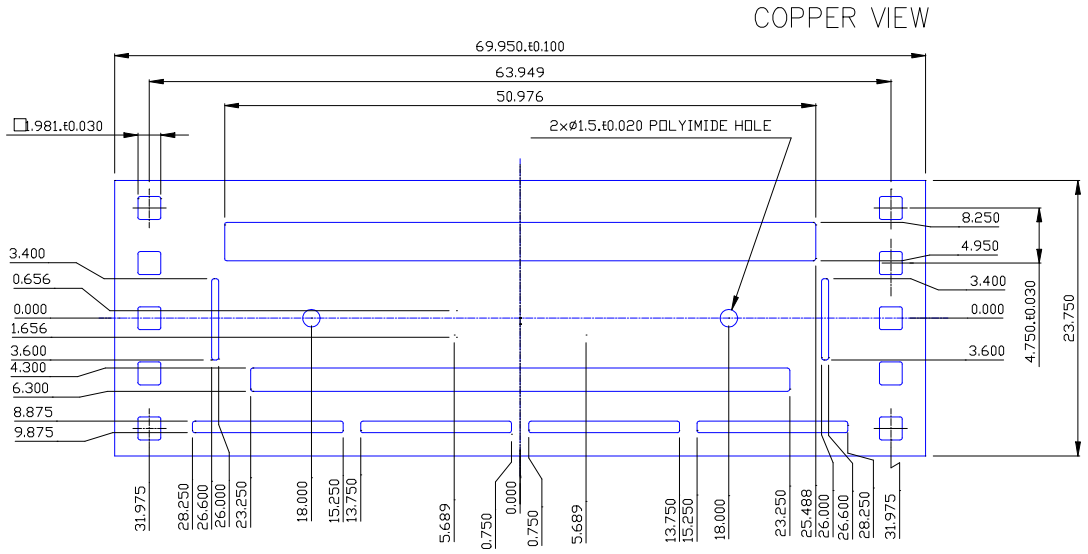
Pins connected to V_{SS}: V_{SS1}

Pins floating: $\overline{DOF}$, CL, V_{FS}

APPENDIX A0-1. SDD1815T TAB Drawing

1:GENERAL TOLERANCE :±0.050MM
2:ALL CHAMFER IS R0.20
3:MATERIAL
PI :UPILEX-S 75um ±6 THICKNESS
CU :ED-SLP 25um
SOLDER RESIST: 26±14um
4:PLATING
SN:0.35±0.05um
5: OPTIONAL FEATURE FOR SSL INTERNAL USE ONLY
WHICH MAY BE REPLACED BY ø2.0MM HOLE



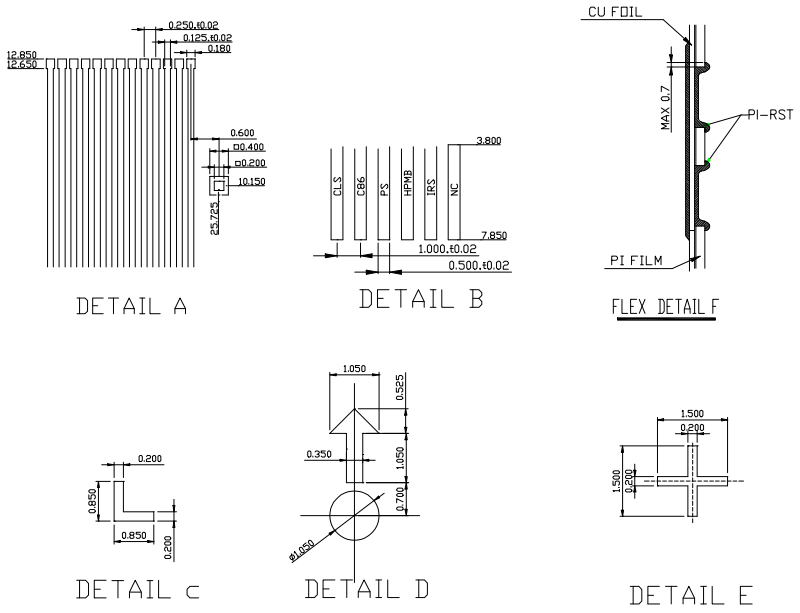


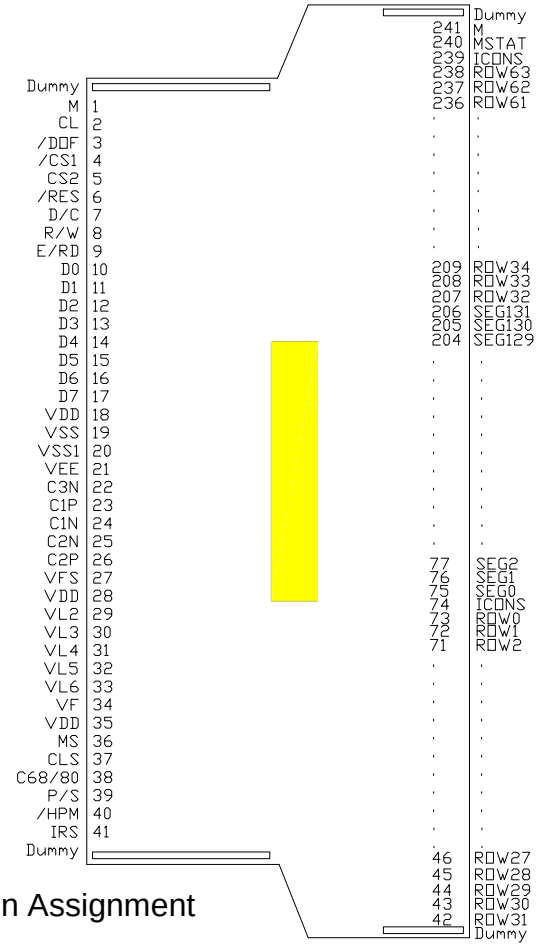
MATERIAL	UPILEX-S	PI FILM	75um±6um
HARD TOOL	YES	Adhesive	12 um±2um
	NO	PROTECT FILM	20 um

HOLE	HOLE DIMENSION	NUMBER
SQUARE	1.981X1.981	10
	11.378X2.312	1
	50.976X3.300	1
	13.000X1.000	4
	7.000X0.600	2
	46.500x2.500	1
CIRCLE	ø1.500	2
ELLIPSE		

ALL OTHER CHAMFER IS R0.200
GENERAL TOLERANCE ±0.05

APPENDIX A0-2. SDD1815T TAB Drawing

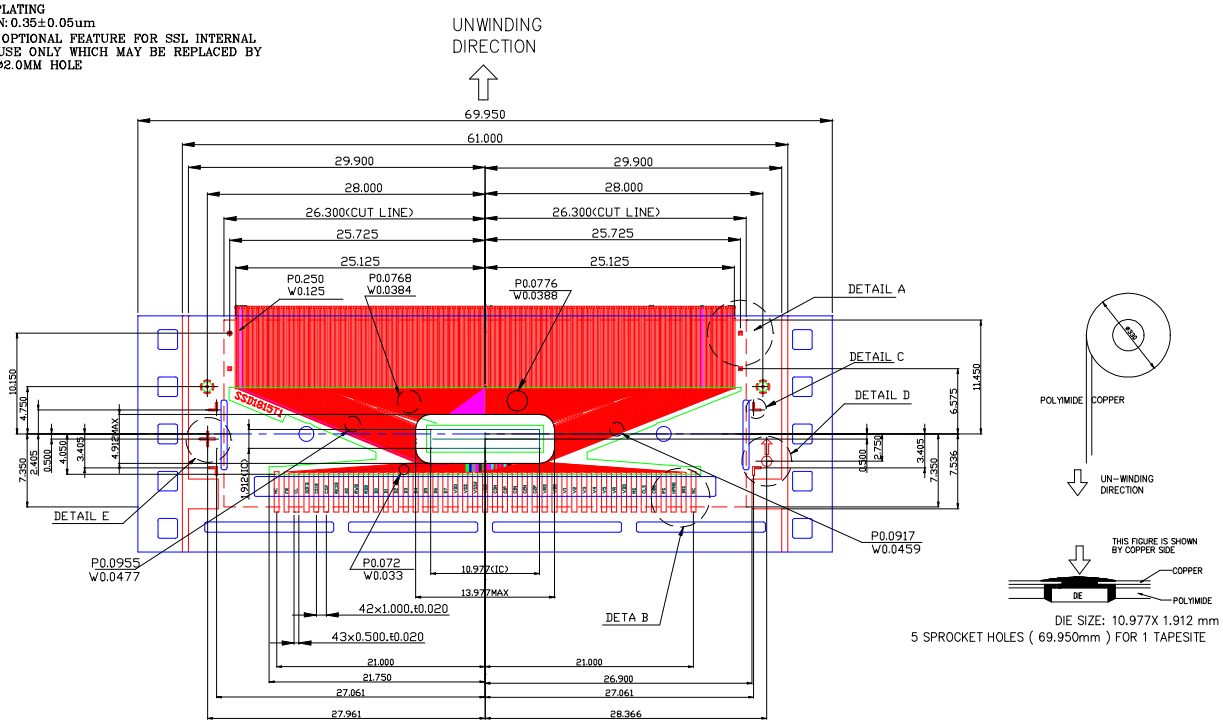


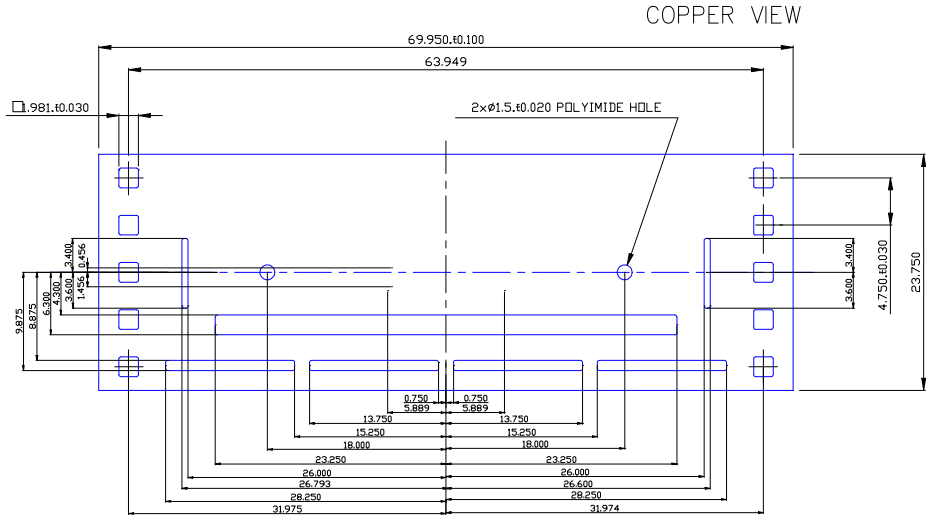


Copper View Pin Assignment

APPENDIX A1-1. SDD1815T1 TAB Drawing

1: GENERAL TOLERANCE : ±0.050MM
2: ALL CHAMFER IS R0.20
3: MATERIAL
PI : UPILEX-S 75um ±6 THICKNESS
CU : ED-SLP 25um
4: PLATING
SN: 0.35±0.05um
5: OPTIONAL FEATURE FOR SSL INTERNAL USE ONLY WHICH MAY BE REPLACED BY ø2.0MM HOLE



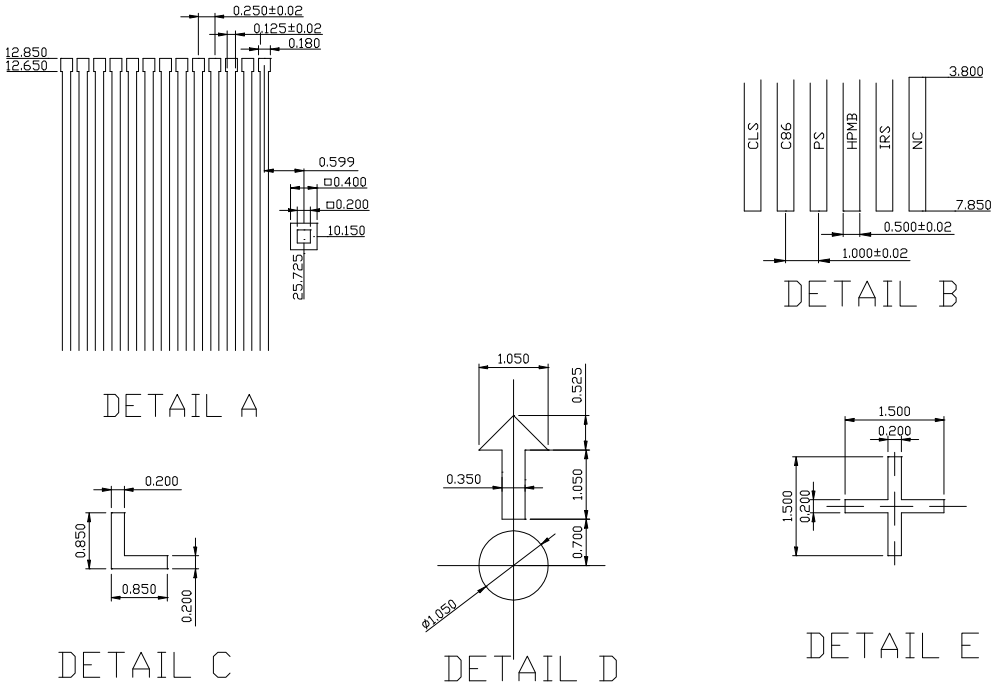


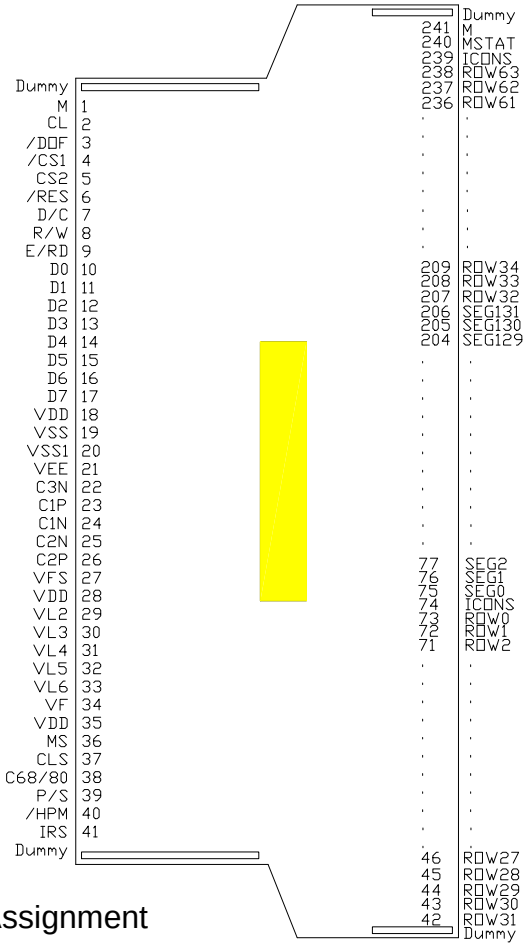
MATERIAL	UPILEX-S	PI FILM	75um±6um
HARD TOOL	YES		
	NO		

HOLE	HOLE DIMENSION	NUMBER
SQUARE	1.981X1.981	10
	11.378X2.312	1
	13.000X1.000	4
	7.000X0.600	2
	46.500X2.500	1
CIRCLE	ø1.500	2
ELLIPSE		

ALL OTHER CHAMFER IS R0.200
GENERAL TOLERANCE ±0.05

APPENDIX A1-2. SDD1815T1 TAB Drawing

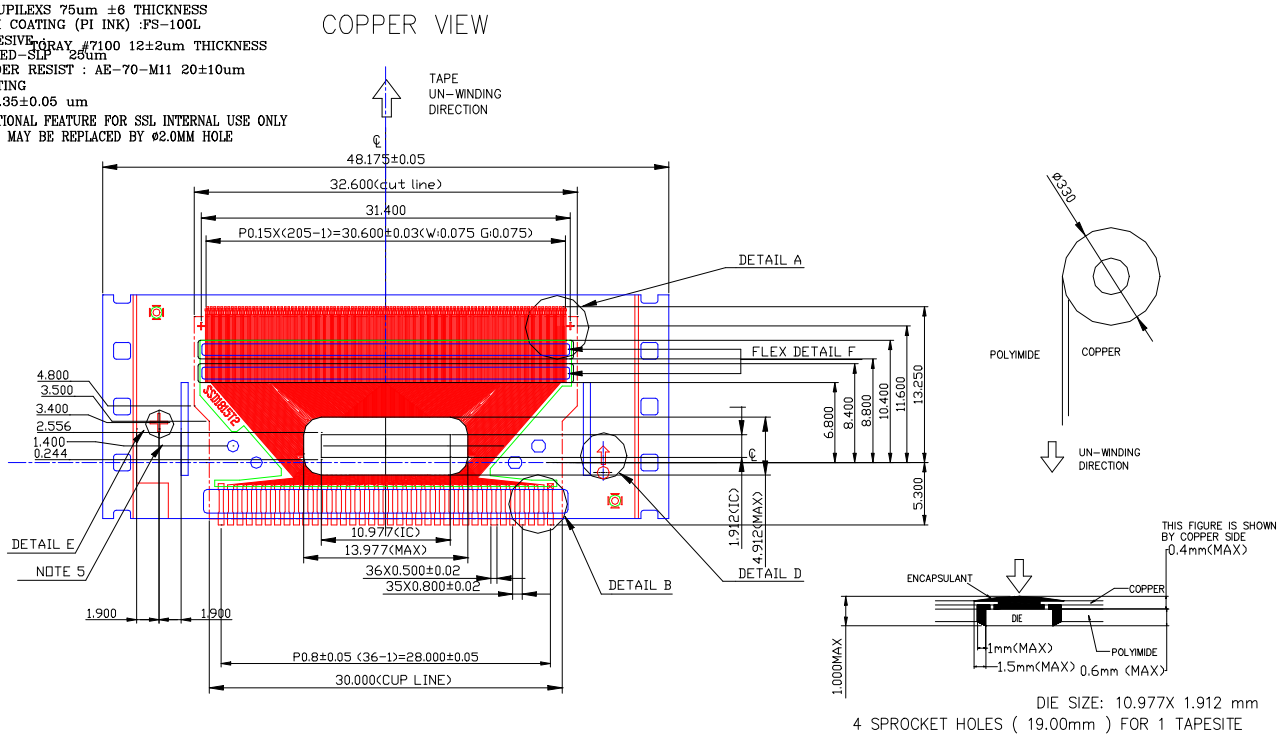




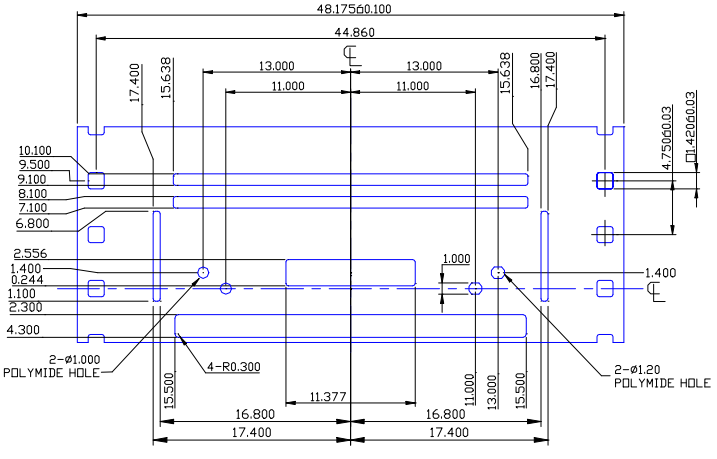
Copper View Pin Assignment

APPENDIX A2-1. SDD1815T2 TAB Drawing

1:GENERAL TOLERANCE :±0.050MM
2:ALL CHAMFER IS R0.20
3:MATERIAL
PI :UPILEXS 75um ±6 THICKNESS
FLEX COATING (PI INK) :FS-100L
ADHESIVE :TORAY #7100 12±2um THICKNESS
CU :ED-SLP 25um
SOLDER RESIST : AE-70-M11 20±10um
4:PLATING
SN:0.35±0.05 um
5: OPTIONAL FEATURE FOR SSL INTERNAL USE ONLY
WHICH MAY BE REPLACED BY ø2.0MM HOLE



DIE SIZE: 10.977X 1.912 mm
4 SPROCKET HOLES (19.00mm) FOR 1 TAPESITE

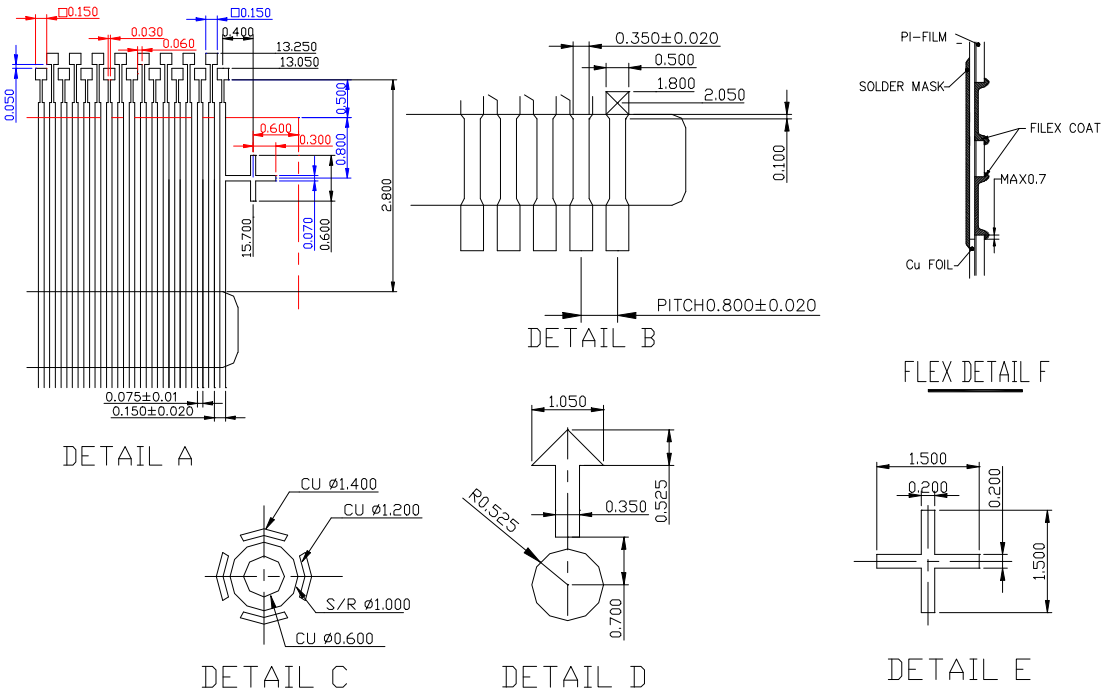


COPPER VIEW

MATERIAL	UPILEX-S	PI FILM	75um±6um
HARD TOOL	YES	Adhesive	12um±2um (TORAY #7100)
	NO	PROTECT FILM	20 um
HOLE	HOLE DIMENSION		NUMBER
SQUARE	31.275X1.000		2
	1.420X1.420		8
	31.000X2.000		1
	7.900x0.600		2
	11.377x2.3120		1
CIRCLE	ø1.000		2
	ø1.200X1.000		2
ELLIPSE			

ALL OTHER CHAMFER IS R0.200
GENERAL TOLERANCE ±0.05

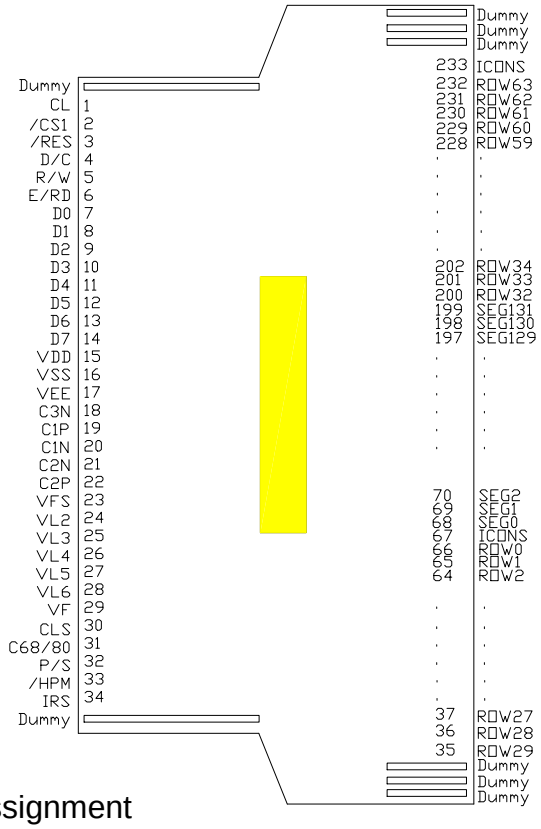
APPENDIX A2-2. SDD1815T2 TAB Drawing



Internal Connections:

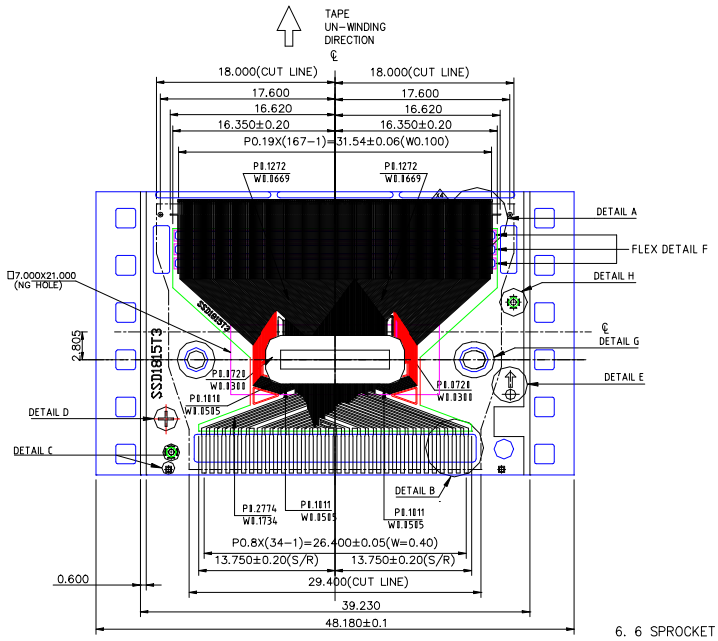
V_{DD}: CS2, M/$\overline{S}$

V_{SS}: V_{SS1}



Copper View Pin Assignment

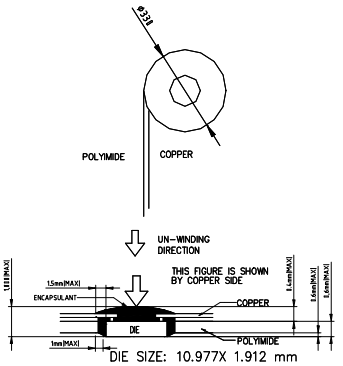
APPENDIX A3-1. SDD1815T3 TAB Drawing



COPPER VIEW

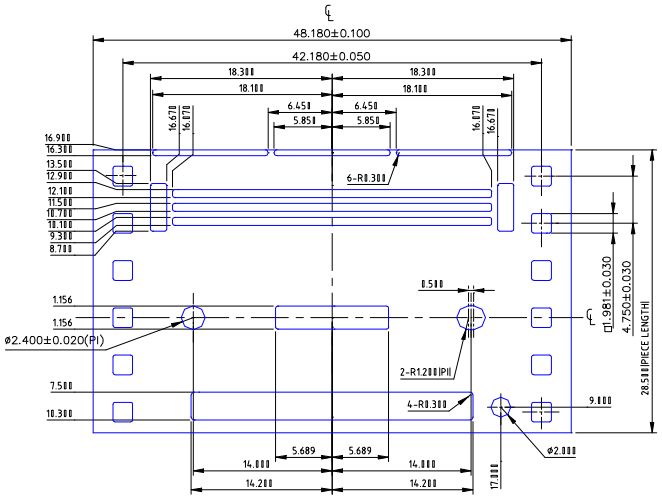
NOTE:

1:GENERAL TOLERANCE :±0.050MM
2:ALL CHAMFER IS R0.20
3:MATERIAL
PI :UPILEX-S 75um ±6 THICKNESS
FLEX COATING (PI INK) :FS-100L
ADHESIVE :TORAY #7100 12±2um THICKNESS
CU :ED-SLP 25um
SOLDER RESIST : AE-70-M11 20±10um
4:PLATING
SN:0.35±0.05 um
5: OPTIONAL FEATURE FOR SSL INTERNAL USE ONLY
WHICH MAY BE REPLACED BY Ø2.0MM HOLE



DIE SIZE: 10.977X 1.912 mm

6. 6 SPROCKET HOLES (28.5mm) FOR 1 TAPESITE,48mm wide,72um pitch

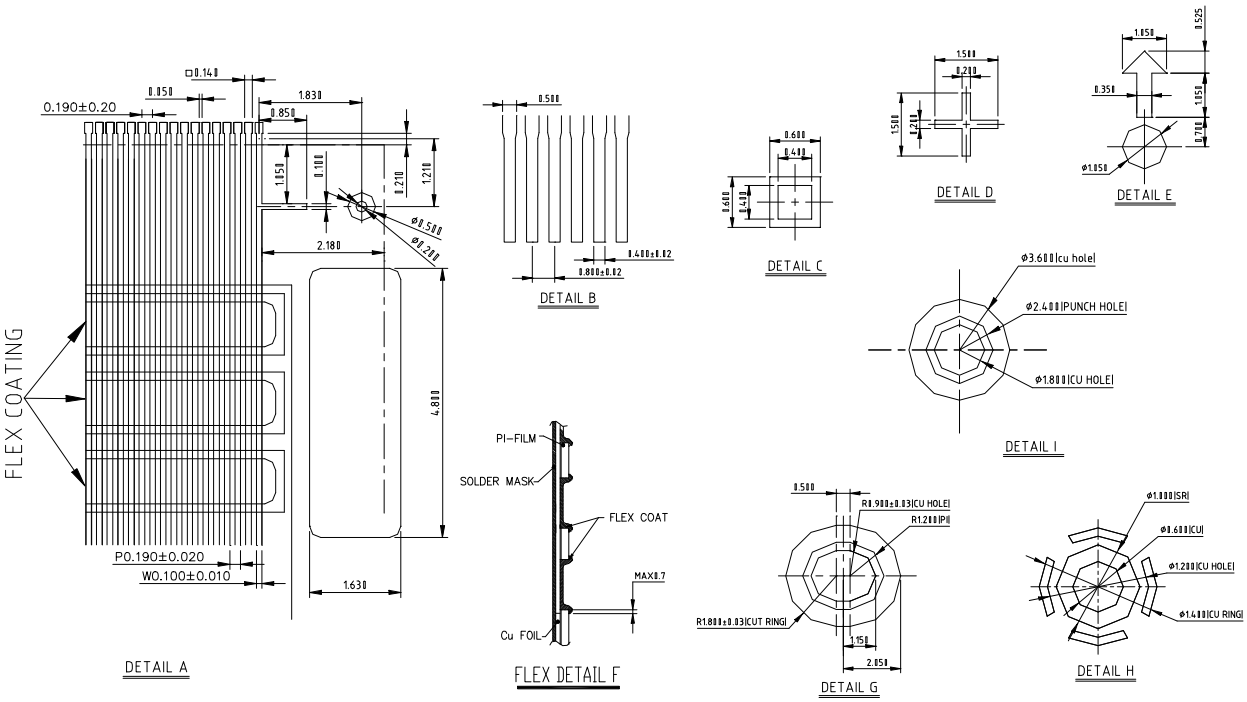


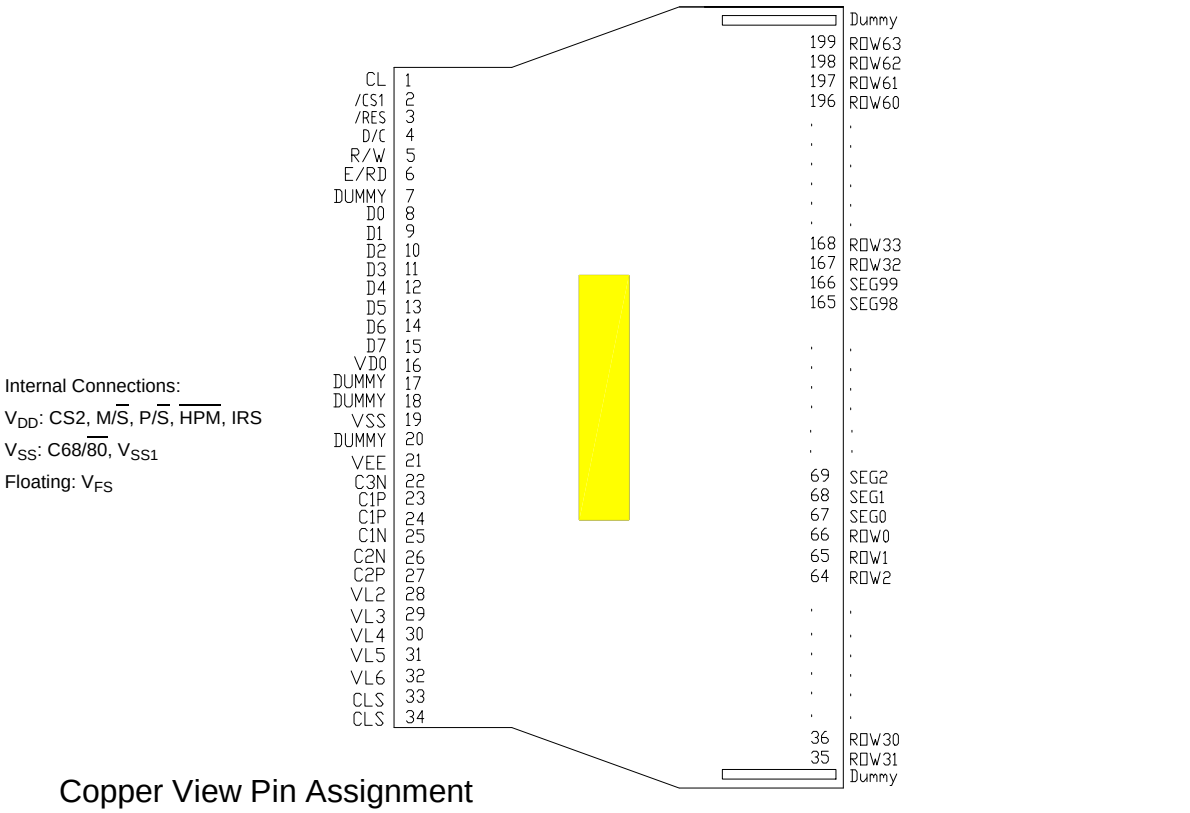
COPPER VIEW

MATERIAL	UPILEX-S	PI FILM	75um±6um
ADHESIVE	YES ✓	Adhesive	12um±2um (TORAY #7100)
	NO	PAINTING	20 um
HOLE	HOLE DIMENSION		NUMBER
SQUARE	1.981X1.981		12
	32.141X1.800		3
	1.630X4.800		2
	11.650X1.600		2
	11.780X1.600		1
	28.400X2.800		1
	11.378X2.312		1
CIRCLE	Ø2.400		1
	Ø2.000		1
ELLIPSE			1

ALL OTHER CHAMFER IS R0.200
GENERAL TOLERANCE ±0.05

APPENDIX A3-2. SDD1815T3 TAB Drawing





Internal Connections:

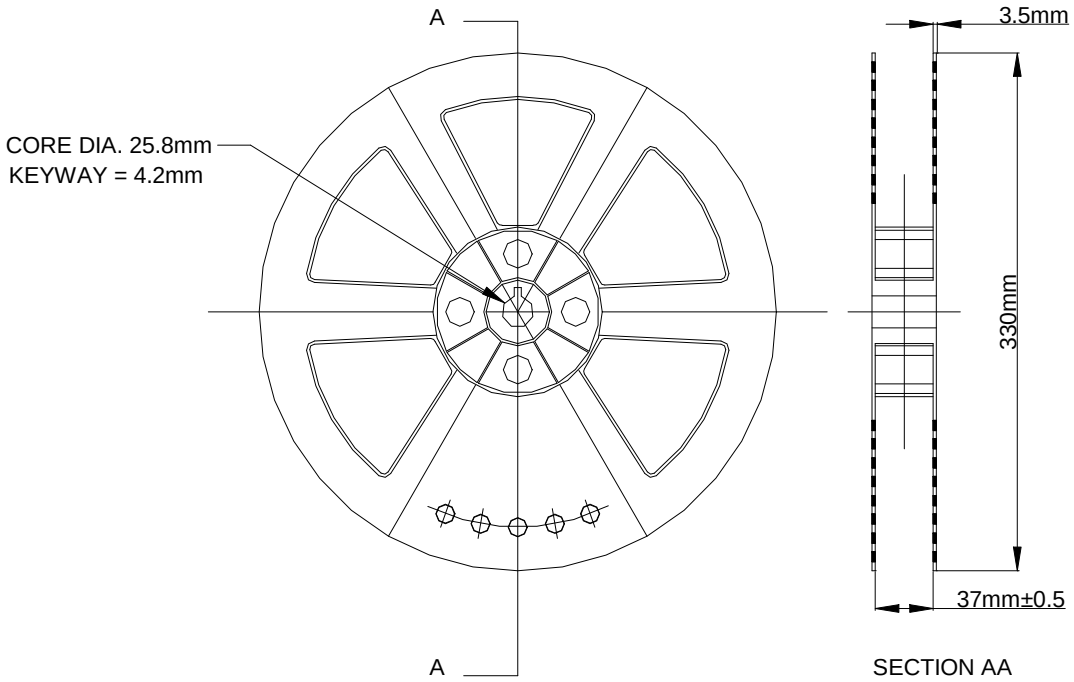
V_{DD}: CS2, M/$\overline{S}$, P/$\overline{S}$, $\overline{HPM}$, IRS

V_{SS}: C68/$\overline{80}$, V_{SS1}

Floating: V_{FS}

Copper View Pin Assignment

APPENDIX B0. R330 TAB Wheel Mechnical Drawing



MATERIAL: HIGH IMPACT POLYSTYRENE (HIPS)
SURFACE RESISTIVITY: 1 X 10^5 OHM MIN
1 X 10^9 OHM MAX
TAPE LENGTH = 20m

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