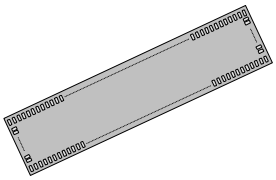
128COMMON x 80RGB LCD DRIVER FOR 4,096-COLOR STN DISPLAY

■ GENERAL DESCRIPTION

The NJU6815 is a 128COMMON x 80RGB LCD driver for 4,096-color STN display. It contains common drivers, RGB drivers, a serial and a parallel MPU interface circuit, an internal LCD power supply, grayscale palettes and 122,880-bit display data RAM. The segment drivers for RGB (Red, Green, Blue) independently produce optimum 16 grayscales from a built-in 32-grayscale palette, and the LSI achieves 4,096 colors (16x16x16). And the LSI features the display-rotation function which rotates an on-screen image in the unit of 90 degrees.

In addition, the NJU6815 operates with a low voltage of 1.7V and a low operating current, therefore it is ideally suited for battery-powered handheld applications.

■ PACKAGE



BUMP CHIP

■ FEATURES

- 4,096-color STN LCD driver
- Built-in LCD Drivers : 128-common Drivers x 80RGB Drivers (240-segment Drivers in B&W)
- Built-in Display Data RAM (DDRAM) : 122,880 bits for Graphic Display
- Programmable Display Mode
  - Variable 16-grayscale Mode : 4,096 Colors
  - Variable 8-grayscale Mode : 256 Colors
  - Fixed 8-grayscale Mode : 256 Colors
  - B&W Mode : Black & White
- 8-/16-bit Parallel Interface Selectable
- 8-/16-bit Bus Length for Display Data Selectable
- 3-/4-line Serial Interface Selectable
- Programmable Duty Ratio and Bias Ratio
- Programmable Internal Voltage Booster : Maximum 6 times
- Programmable Contrast Control : 128-step Electrical Variable Resistor (EVR)
- Various Useful Instructions
- Display-rotation Function / Mirror-inversion Function
- Low Operating Current : 450uA Typical at V_{DD}=3V, 4-time Boost, Checker Flag Display
- Low Logic Voltage : 1.7V to 3.3V
- Wide LCD Voltage Range : 5.0V to 18.0V
- C-MOS Technology
- Slim Chip for COG
- Package : Bump Chip / TCP

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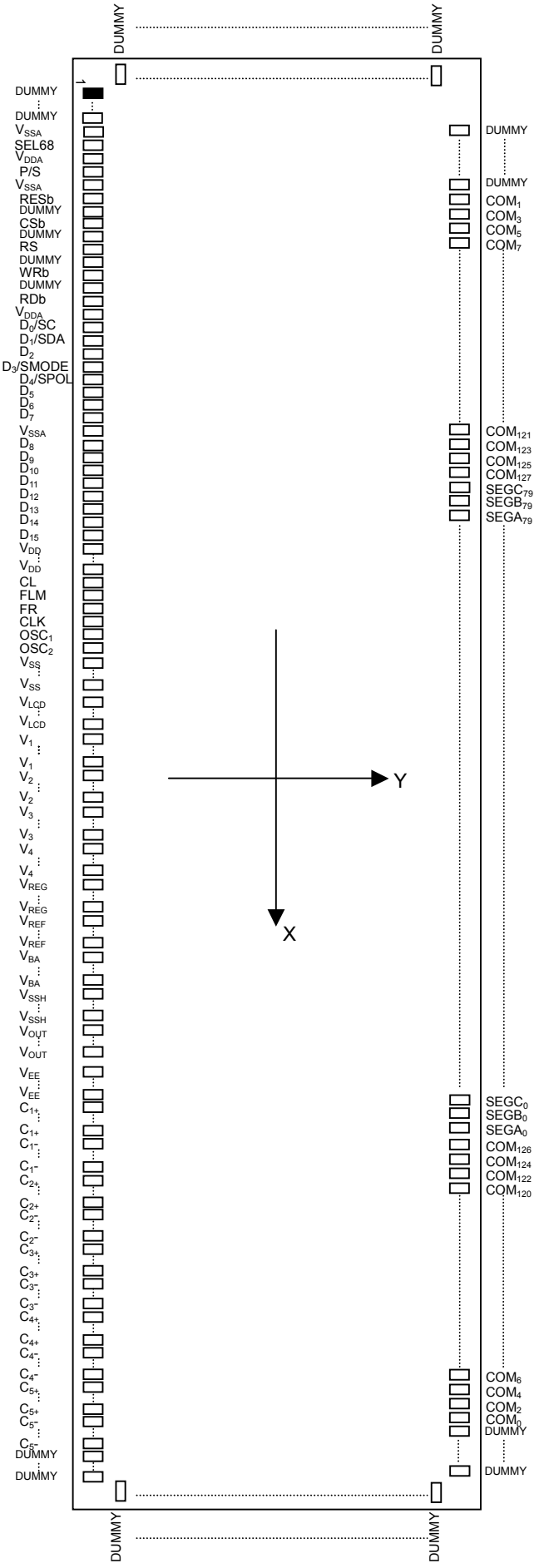
■ PAD LOCATION



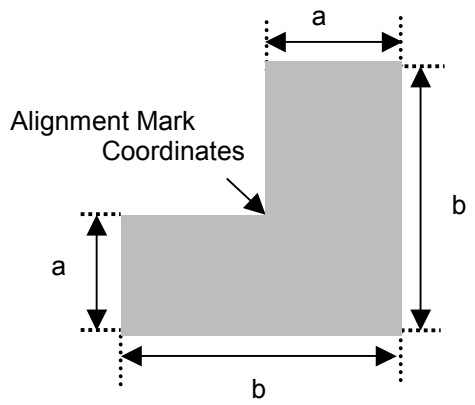
Chip Center	:X=0um, Y=0um
Chip Size	:X=16.70mm, Y= 2.64mm
Chip Thickness	:625um ± 25um
Bump Pitch	:42um(Min)
Bump Space	:15um
Bump Size	:24±3um x 140±5um
Bump Height	:17.5um(Typical)
Bump Material	:Au

NOTE1) Multiple PADs with successive numbers are internally connected.

NOTE2) Dummy PADs, symbolized with DUMMY, are electrically open.

NOTE3) The purpose of this drawing is to show the order of PADs. Use "PAD CORDINATE TABLE 1 to 4" for design.

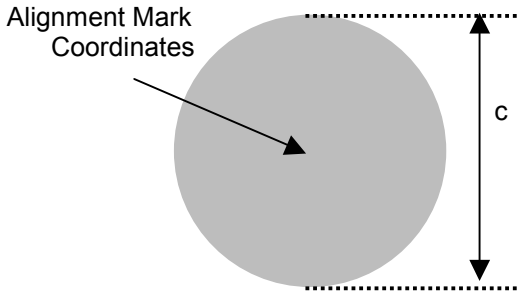
Alignment Mark 1



a : 25μm
b : 50μm

Alignment Mark Coordinates
(-8168, 1138)
(8168, -1138)

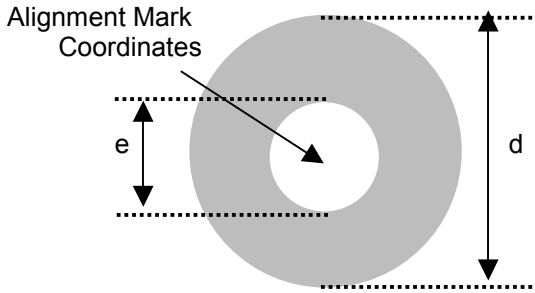
Alignment Mark 2



c : 50μm

Alignment Mark Coordinates
(7982, -1115)

Alignment Mark 3



d : 50μm
e : 20μm

Alignment Mark Coordinates
(-7982, -1115)

■ PAD COORDINATES 1

Chip Size 16,700μm x 2,640μm (Chip Center 0μm x 0μm)

No.	PAD NAME	X (um)	Y (um)
1	DMY_0	-7875.00	-1115.00
2	DMY_1	-7833.00	-1115.00
3	DMY_2	-7791.00	-1115.00
4	V_{SSA}	-7749.00	-1115.00
5	V_{SSA}	-7707.00	-1115.00
6	DMY_3	-7665.00	-1115.00
7	SEL68	-7623.00	-1115.00
8	SEL68	-7581.00	-1115.00
9	DMY_4	-7539.00	-1115.00
10	V_{DDA}	-7497.00	-1115.00
11	V_{DDA}	-7455.00	-1115.00
12	DMY_5	-7413.00	-1115.00
13	P/S	-7371.00	-1115.00
14	P/S	-7329.00	-1115.00
15	DMY_6	-7287.00	-1115.00
16	V_{SSA}	-7245.00	-1115.00
17	V_{SSA}	-7203.00	-1115.00
18	DMY_7	-7161.00	-1115.00
19	RESB	-7119.00	-1115.00
20	RESB	-7077.00	-1115.00
21	DMY_8	-7035.00	-1115.00
22	CSB	-6993.00	-1115.00
23	CSB	-6951.00	-1115.00
24	DMY_9	-6909.00	-1115.00
25	RS	-6867.00	-1115.00
26	RS	-6825.00	-1115.00
27	DMY_{10}	-6783.00	-1115.00
28	WRB	-6741.00	-1115.00
29	WRB	-6699.00	-1115.00
30	DMY_{11}	-6657.00	-1115.00
31	RDB	-6615.00	-1115.00
32	RDB	-6573.00	-1115.00
33	DMY_{12}	-6531.00	-1115.00
34	V_{DDA}	-6489.00	-1115.00
35	V_{DDA}	-6447.00	-1115.00
36	D_0	-6321.00	-1115.00
37	D_0	-6279.00	-1115.00
38	D_1	-6153.00	-1115.00
39	D_1	-6111.00	-1115.00
40	D_2	-5985.00	-1115.00
41	D_2	-5943.00	-1115.00
42	D_3	-5817.00	-1115.00
43	D_3	-5775.00	-1115.00
44	D_4	-5649.00	-1115.00
45	D_4	-5607.00	-1115.00
46	D_5	-5481.00	-1115.00
47	D_5	-5439.00	-1115.00
48	D_6	-5313.00	-1115.00
49	D_6	-5271.00	-1115.00
50	D_7	-5145.00	-1115.00
51	D_7	-5103.00	-1115.00
52	V_{SSA}	-4977.00	-1115.00
53	V_{SSA}	-4935.00	-1115.00
54	D_8	-4809.00	-1115.00
55	D_8	-4767.00	-1115.00
56	D_9	-4641.00	-1115.00
57	D_9	-4599.00	-1115.00
58	D_{10}	-4473.00	-1115.00
59	D_{10}	-4431.00	-1115.00
60	D_{11}	-4305.00	-1115.00
61	D_{11}	-4263.00	-1115.00
62	D_{12}	-4137.00	-1115.00
63	D_{12}	-4095.00	-1115.00
64	D_{13}	-3969.00	-1115.00
65	D_{13}	-3927.00	-1115.00
66	D_{14}	-3801.00	-1115.00
67	D_{14}	-3759.00	-1115.00
68	D_{15}	-3633.00	-1115.00
69	D_{15}	-3591.00	-1115.00
70	V_{DD}	-3465.00	-1115.00
71	V_{DD}	-3423.00	-1115.00
72	V_{DD}	-3381.00	-1115.00
73	V_{DD}	-3339.00	-1115.00
74	V_{DD}	-3297.00	-1115.00
75	V_{DD}	-3255.00	-1115.00
76	V_{DD}	-3213.00	-1115.00
77	V_{DD}	-3171.00	-1115.00
78	V_{DD}	-3129.00	-1115.00
79	CL	-2961.00	-1115.00
80	CL	-2919.00	-1115.00
81	FLM	-2793.00	-1115.00
82	FLM	-2751.00	-1115.00
83	FR	-2625.00	-1115.00
84	FR	-2583.00	-1115.00
85	CLK	-2457.00	-1115.00
86	CLK	-2415.00	-1115.00
87	DMY_{13}	-2289.00	-1115.00
88	OSC1	-2247.00	-1115.00
89	OSC1	-2205.00	-1115.00
90	DMY_{14}	-2163.00	-1115.00
91	OSC2	-2037.00	-1115.00
92	OSC2	-1995.00	-1115.00
93	V_{SS}	-1869.00	-1115.00
94	V_{SS}	-1827.00	-1115.00
95	V_{SS}	-1785.00	-1115.00
96	V_{SS}	-1743.00	-1115.00
97	V_{SS}	-1701.00	-1115.00
98	V_{SS}	-1659.00	-1115.00
99	V_{SS}	-1617.00	-1115.00
100	V_{SS}	-1575.00	-1115.00
101	V_{SS}	-1533.00	-1115.00
102	DMY_{15}	-1407.00	-1115.00
103	V_{LCD}	-1281.00	-1115.00
104	V_{LCD}	-1239.00	-1115.00
105	V_{LCD}	-1197.00	-1115.00
106	V_{LCD}	-1155.00	-1115.00
107	V_{LCD}	-1113.00	-1115.00
108	V_{LCD}	-1071.00	-1115.00
109	V_{LCD}	-1029.00	-1115.00
110	V_{LCD}	-987.00	-1115.00
111	V_{LCD}	-945.00	-1115.00
112	DMY_{16}	-903.00	-1115.00
113	V_1	-861.00	-1115.00
114	V_1	-819.00	-1115.00
115	V_1	-777.00	-1115.00
116	V_1	-735.00	-1115.00
117	V_1	-693.00	-1115.00
118	V_1	-651.00	-1115.00
119	V_1	-609.00	-1115.00
120	V_1	-567.00	-1115.00
121	V_1	-525.00	-1115.00
122	V_2	-399.00	-1115.00
123	V_2	-357.00	-1115.00
124	V_2	-315.00	-1115.00
125	V_2	-273.00	-1115.00
126	V_2	-231.00	-1115.00
127	V_2	-189.00	-1115.00
128	V_2	-147.00	-1115.00
129	V_2	-105.00	-1115.00
130	V_2	-63.00	-1115.00
131	DMY_{17}	-21.00	-1115.00
132	V_3	21.00	-1115.00
133	V_3	63.00	-1115.00
134	V_3	105.00	-1115.00
135	V_3	147.00	-1115.00
136	V_3	189.00	-1115.00
137	V_3	231.00	-1115.00
138	V_3	273.00	-1115.00
139	V_3	315.00	-1115.00
140	V_3	357.00	-1115.00
141	V_4	483.00	-1115.00
142	V_4	525.00	-1115.00
143	V_4	567.00	-1115.00
144	V_4	609.00	-1115.00
145	V_4	651.00	-1115.00
146	V_4	693.00	-1115.00
147	V_4	735.00	-1115.00
148	V_4	777.00	-1115.00
149	V_4	819.00	-1115.00
150	DMY_{18}	861.00	-1115.00
151	V_{REG}	903.00	-1115.00
152	V_{REG}	945.00	-1115.00
153	V_{REG}	987.00	-1115.00
154	V_{REG}	1029.00	-1115.00
155	V_{REG}	1071.00	-1115.00
156	V_{REG}	1113.00	-1115.00
157	V_{REG}	1155.00	-1115.00
158	V_{REG}	1197.00	-1115.00
159	V_{REG}	1239.00	-1115.00
160	DMY_{19}	1281.00	-1115.00
161	V_{REF}	1323.00	-1115.00
162	V_{REF}	1365.00	-1115.00
163	V_{REF}	1407.00	-1115.00
164	V_{REF}	1449.00	-1115.00
165	V_{REF}	1491.00	-1115.00
166	V_{REF}	1533.00	-1115.00
167	V_{REF}	1575.00	-1115.00
168	V_{REF}	1617.00	-1115.00
169	V_{REF}	1659.00	-1115.00
170	DMY_{20}	1701.00	-1115.00
171	V_{BA}	1743.00	-1115.00
172	V_{BA}	1785.00	-1115.00
173	V_{BA}	1827.00	-1115.00
174	V_{BA}	1869.00	-1115.00
175	V_{BA}	1911.00	-1115.00
176	V_{BA}	1953.00	-1115.00
177	V_{BA}	1995.00	-1115.00
178	V_{BA}	2037.00	-1115.00
179	V_{BA}	2079.00	-1115.00
180	DMY_{21}	2121.00	-1115.00

■ PAD COORDINATES 2

Chip Size 16,700μm x 2,640μm (Chip Center 0μm x 0μm)

No.	PAD NAME	X (um)	Y (um)
181	V_{SSH}	2163.00	-1115.00
182	V_{SSH}	2205.00	-1115.00
183	V_{SSH}	2247.00	-1115.00
184	V_{SSH}	2289.00	-1115.00
185	V_{SSH}	2331.00	-1115.00
186	V_{SSH}	2373.00	-1115.00
187	V_{SSH}	2415.00	-1115.00
188	V_{SSH}	2457.00	-1115.00
189	V_{SSH}	2499.00	-1115.00
190	V_{OUT}	2667.00	-1115.00
191	V_{OUT}	2709.00	-1115.00
192	V_{OUT}	2751.00	-1115.00
193	V_{OUT}	2793.00	-1115.00
194	V_{OUT}	2835.00	-1115.00
195	V_{OUT}	2877.00	-1115.00
196	V_{OUT}	2919.00	-1115.00
197	V_{OUT}	2961.00	-1115.00
198	V_{OUT}	3003.00	-1115.00
199	V_{EE}	3171.00	-1115.00
200	V_{EE}	3213.00	-1115.00
201	V_{EE}	3255.00	-1115.00
202	V_{EE}	3297.00	-1115.00
203	V_{EE}	3339.00	-1115.00
204	V_{EE}	3381.00	-1115.00
205	V_{EE}	3423.00	-1115.00
206	V_{EE}	3465.00	-1115.00
207	V_{EE}	3507.00	-1115.00
208	C_{1+}	3633.00	-1115.00
209	C_{1+}	3675.00	-1115.00
210	C_{1+}	3717.00	-1115.00
211	C_{1+}	3759.00	-1115.00
212	C_{1+}	3801.00	-1115.00
213	C_{1+}	3843.00	-1115.00
214	C_{1+}	3885.00	-1115.00
215	C_{1+}	3927.00	-1115.00
216	C_{1+}	3969.00	-1115.00
217	DMY_{22}	4011.00	-1115.00
218	C_{1-}	4053.00	-1115.00
219	C_{1-}	4095.00	-1115.00
220	C_{1-}	4137.00	-1115.00
221	C_{1-}	4179.00	-1115.00
222	C_{1-}	4221.00	-1115.00
223	C_{1-}	4263.00	-1115.00
224	C_{1-}	4305.00	-1115.00
225	C_{1-}	4347.00	-1115.00
226	C_{1-}	4389.00	-1115.00
227	DMY_{23}	4431.00	-1115.00
228	C_{2+}	4473.00	-1115.00
229	C_{2+}	4515.00	-1115.00
230	C_{2+}	4557.00	-1115.00
231	C_{2+}	4599.00	-1115.00
232	C_{2+}	4641.00	-1115.00
233	C_{2+}	4683.00	-1115.00
234	C_{2+}	4725.00	-1115.00
235	C_{2+}	4767.00	-1115.00
236	C_{2+}	4809.00	-1115.00
237	DMY_{24}	4851.00	-1115.00
238	C_{2-}	4893.00	-1115.00
239	C_{2-}	4935.00	-1115.00
240	C_{2-}	4977.00	-1115.00

No.	PAD NAME	X (um)	Y (um)
241	C_{2-}	5019.00	-1115.00
242	C_{2-}	5061.00	-1115.00
243	C_{2-}	5103.00	-1115.00
244	C_{2-}	5145.00	-1115.00
245	C_{2-}	5187.00	-1115.00
246	C_{2-}	5229.00	-1115.00
247	DMY_{25}	5271.00	-1115.00
248	C_{3+}	5313.00	-1115.00
249	C_{3+}	5355.00	-1115.00
250	C_{3+}	5397.00	-1115.00
251	C_{3+}	5439.00	-1115.00
252	C_{3+}	5481.00	-1115.00
253	C_{3+}	5523.00	-1115.00
254	C_{3+}	5565.00	-1115.00
255	C_{3+}	5607.00	-1115.00
256	C_{3+}	5649.00	-1115.00
257	DMY_{26}	5691.00	-1115.00
258	C_{3-}	5733.00	-1115.00
259	C_{3-}	5775.00	-1115.00
260	C_{3-}	5817.00	-1115.00
261	C_{3-}	5859.00	-1115.00
262	C_{3-}	5901.00	-1115.00
263	C_{3-}	5943.00	-1115.00
264	C_{3-}	5985.00	-1115.00
265	C_{3-}	6027.00	-1115.00
266	C_{3-}	6069.00	-1115.00
267	DMY_{27}	6111.00	-1115.00
268	C_{4+}	6153.00	-1115.00
269	C_{4+}	6195.00	-1115.00
270	C_{4+}	6237.00	-1115.00
271	C_{4+}	6279.00	-1115.00
272	C_{4+}	6321.00	-1115.00
273	C_{4+}	6363.00	-1115.00
274	C_{4+}	6405.00	-1115.00
275	C_{4+}	6447.00	-1115.00
276	C_{4+}	6489.00	-1115.00
277	DMY_{28}	6531.00	-1115.00
278	C_{4-}	6573.00	-1115.00
279	C_{4-}	6615.00	-1115.00
280	C_{4-}	6657.00	-1115.00
281	C_{4-}	6699.00	-1115.00
282	C_{4-}	6741.00	-1115.00
283	C_{4-}	6783.00	-1115.00
284	C_{4-}	6825.00	-1115.00
285	C_{4-}	6867.00	-1115.00
286	C_{4-}	6909.00	-1115.00
287	DMY_{29}	6951.00	-1115.00
288	C_{5+}	6993.00	-1115.00
289	C_{5+}	7035.00	-1115.00
290	C_{5+}	7077.00	-1115.00
291	C_{5+}	7119.00	-1115.00
292	C_{5+}	7161.00	-1115.00
293	C_{5+}	7203.00	-1115.00
294	C_{5+}	7245.00	-1115.00
295	C_{5+}	7287.00	-1115.00
296	C_{5+}	7329.00	-1115.00
297	DMY_{30}	7371.00	-1115.00
298	C_{5-}	7413.00	-1115.00
299	C_{5-}	7455.00	-1115.00
300	C_{5-}	7497.00	-1115.00

No.	PAD NAME	X (um)	Y (um)
301	C_{5-}	7539.00	-1115.00
302	C_{5-}	7581.00	-1115.00
303	C_{5-}	7623.00	-1115.00
304	C_{5-}	7665.00	-1115.00
305	C_{5-}	7707.00	-1115.00
306	C_{5-}	7749.00	-1115.00
307	DMY_{31}	7791.00	-1115.00
308	DMY_{32}	7833.00	-1115.00
309	DMY_{33}	7875.00	-1115.00
310	DMY_{34}	8145.00	-1035.00
311	DMY_{35}	8145.00	-993.00
312	DMY_{35}	8145.00	-951.00
313	DMY_{35}	8145.00	-909.00
314	DMY_{36}	8145.00	-867.00
315	DMY_{37}	8001.00	1115.00
316	DMY_{38}	7959.00	1115.00
317	DMY_{39}	7917.00	1115.00
318	DMY_{40}	7875.00	1115.00
319	COM_0	7833.00	1115.00
320	COM_2	7791.00	1115.00
321	COM_4	7749.00	1115.00
322	COM_6	7707.00	1115.00
323	COM_8	7665.00	1115.00
324	COM_{10}	7623.00	1115.00
325	COM_{12}	7581.00	1115.00
326	COM_{14}	7539.00	1115.00
327	COM_{16}	7497.00	1115.00
328	COM_{18}	7455.00	1115.00
329	COM_{20}	7413.00	1115.00
330	COM_{22}	7371.00	1115.00
331	COM_{24}	7329.00	1115.00
332	COM_{26}	7287.00	1115.00
333	COM_{28}	7245.00	1115.00
334	COM_{30}	7203.00	1115.00
335	COM_{32}	7161.00	1115.00
336	COM_{34}	7119.00	1115.00
337	COM_{36}	7077.00	1115.00
338	COM_{38}	7035.00	1115.00
339	COM_{40}	6993.00	1115.00
340	COM_{42}	6951.00	1115.00
341	COM_{44}	6909.00	1115.00
342	COM_{46}	6867.00	1115.00
343	COM_{48}	6825.00	1115.00
344	COM_{50}	6783.00	1115.00
345	COM_{52}	6741.00	1115.00
346	COM_{54}	6699.00	1115.00
347	COM_{56}	6657.00	1115.00
348	COM_{58}	6615.00	1115.00
349	COM_{60}	6573.00	1115.00
350	COM_{62}	6531.00	1115.00
351	COM_{64}	6489.00	1115.00
352	COM_{66}	6447.00	1115.00
353	COM_{68}	6405.00	1115.00
354	COM_{70}	6363.00	1115.00
355	COM_{72}	6321.00	1115.00
356	COM_{74}	6279.00	1115.00
357	COM_{76}	6237.00	1115.00
358	COM_{78}	6195.00	1115.00
359	COM_{80}	6153.00	1115.00
360	COM_{82}	6111.00	1115.00

■ PAD COORDINATES 3

Chip Size 16,700μm x 2,640μm (Chip Center 0μm x 0μm)

No.	PAD NAME	X (um)	Y (um)
361	COM_{84}	6069.00	1115.00
362	COM_{86}	6027.00	1115.00
363	COM_{88}	5985.00	1115.00
364	COM_{90}	5943.00	1115.00
365	COM_{92}	5901.00	1115.00
366	COM_{94}	5859.00	1115.00
367	COM_{96}	5817.00	1115.00
368	COM_{98}	5775.00	1115.00
369	COM_{100}	5733.00	1115.00
370	COM_{102}	5691.00	1115.00
371	COM_{104}	5649.00	1115.00
372	COM_{106}	5607.00	1115.00
373	COM_{108}	5565.00	1115.00
374	COM_{110}	5523.00	1115.00
375	COM_{112}	5481.00	1115.00
376	COM_{114}	5439.00	1115.00
377	COM_{116}	5397.00	1115.00
378	COM_{118}	5355.00	1115.00
379	COM_{120}	5313.00	1115.00
380	COM_{122}	5271.00	1115.00
381	COM_{124}	5229.00	1115.00
382	COM_{126}	5187.00	1115.00
383	DMY_{41}	5145.00	1115.00
384	DMY_{42}	5103.00	1115.00
385	DMY_{43}	5061.00	1115.00
386	$SEGA_{0}$	5019.00	1115.00
387	$SEGB_{0}$	4977.00	1115.00
388	$SEGC_{0}$	4935.00	1115.00
389	$SEGA_{1}$	4893.00	1115.00
390	$SEGB_{1}$	4851.00	1115.00
391	$SEGC_{1}$	4809.00	1115.00
392	$SEGA_{2}$	4767.00	1115.00
393	$SEGB_{2}$	4725.00	1115.00
394	$SEGC_{2}$	4683.00	1115.00
395	$SEGA_{3}$	4641.00	1115.00
396	$SEGB_{3}$	4599.00	1115.00
397	$SEGC_{3}$	4557.00	1115.00
398	$SEGA_{4}$	4515.00	1115.00
399	$SEGB_{4}$	4473.00	1115.00
400	$SEGC_{4}$	4431.00	1115.00
401	$SEGA_{5}$	4389.00	1115.00
402	$SEGB_{5}$	4347.00	1115.00
403	$SEGC_{5}$	4305.00	1115.00
404	$SEGA_{6}$	4263.00	1115.00
405	$SEGB_{6}$	4221.00	1115.00
406	$SEGC_{6}$	4179.00	1115.00
407	$SEGA_{7}$	4137.00	1115.00
408	$SEGB_{7}$	4095.00	1115.00
409	$SEGC_{7}$	4053.00	1115.00
410	$SEGA_{8}$	4011.00	1115.00
411	$SEGB_{8}$	3969.00	1115.00
412	$SEGC_{8}$	3927.00	1115.00
413	$SEGA_{9}$	3885.00	1115.00
414	$SEGB_{9}$	3843.00	1115.00
415	$SEGC_{9}$	3801.00	1115.00
416	$SEGA_{10}$	3759.00	1115.00
417	$SEGB_{10}$	3717.00	1115.00
418	$SEGC_{10}$	3675.00	1115.00
419	$SEGA_{11}$	3633.00	1115.00
420	$SEGB_{11}$	3591.00	1115.00
421	$SEGC_{11}$	3549.00	1115.00
422	$SEGA_{12}$	3507.00	1115.00
423	$SEGB_{12}$	3465.00	1115.00
424	$SEGC_{12}$	3423.00	1115.00
425	$SEGA_{13}$	3381.00	1115.00
426	$SEGB_{13}$	3339.00	1115.00
427	$SEGC_{13}$	3297.00	1115.00
428	$SEGA_{14}$	3255.00	1115.00
429	$SEGB_{14}$	3213.00	1115.00
430	$SEGC_{14}$	3171.00	1115.00
431	$SEGA_{15}$	3129.00	1115.00
432	$SEGB_{15}$	3087.00	1115.00
433	$SEGC_{15}$	3045.00	1115.00
434	$SEGA_{16}$	3003.00	1115.00
435	$SEGB_{16}$	2961.00	1115.00
436	$SEGC_{16}$	2919.00	1115.00
437	$SEGA_{17}$	2877.00	1115.00
438	$SEGB_{17}$	2835.00	1115.00
439	$SEGC_{17}$	2793.00	1115.00
440	$SEGA_{18}$	2751.00	1115.00
441	$SEGB_{18}$	2709.00	1115.00
442	$SEGC_{18}$	2667.00	1115.00
443	$SEGA_{19}$	2625.00	1115.00
444	$SEGB_{19}$	2583.00	1115.00
445	$SEGC_{19}$	2541.00	1115.00
446	$SEGA_{20}$	2499.00	1115.00
447	$SEGB_{20}$	2457.00	1115.00
448	$SEGC_{20}$	2415.00	1115.00
449	$SEGA_{21}$	2373.00	1115.00
450	$SEGB_{21}$	2331.00	1115.00
451	$SEGC_{21}$	2289.00	1115.00
452	$SEGA_{22}$	2247.00	1115.00
453	$SEGB_{22}$	2205.00	1115.00
454	$SEGC_{22}$	2163.00	1115.00
455	$SEGA_{23}$	2121.00	1115.00
456	$SEGB_{23}$	2079.00	1115.00
457	$SEGC_{23}$	2037.00	1115.00
458	$SEGA_{24}$	1995.00	1115.00
459	$SEGB_{24}$	1953.00	1115.00
460	$SEGC_{24}$	1911.00	1115.00
461	$SEGA_{25}$	1869.00	1115.00
462	$SEGB_{25}$	1827.00	1115.00
463	$SEGC_{25}$	1785.00	1115.00
464	$SEGA_{26}$	1743.00	1115.00
465	$SEGB_{26}$	1701.00	1115.00
466	$SEGC_{26}$	1659.00	1115.00
467	$SEGA_{27}$	1617.00	1115.00
468	$SEGB_{27}$	1575.00	1115.00
469	$SEGC_{27}$	1533.00	1115.00
470	$SEGA_{28}$	1491.00	1115.00
471	$SEGB_{28}$	1449.00	1115.00
472	$SEGC_{28}$	1407.00	1115.00
473	$SEGA_{29}$	1365.00	1115.00
474	$SEGB_{29}$	1323.00	1115.00
475	$SEGC_{29}$	1281.00	1115.00
476	$SEGA_{30}$	1239.00	1115.00
477	$SEGB_{30}$	1197.00	1115.00
478	$SEGC_{30}$	1155.00	1115.00
479	$SEGA_{31}$	1113.00	1115.00
480	$SEGB_{31}$	1071.00	1115.00
481	$SEGC_{31}$	1029.00	1115.00
482	$SEGA_{32}$	987.00	1115.00
483	$SEGB_{32}$	945.00	1115.00
484	$SEGC_{32}$	903.00	1115.00
485	$SEGA_{33}$	861.00	1115.00
486	$SEGB_{33}$	819.00	1115.00
487	$SEGC_{33}$	777.00	1115.00
488	$SEGA_{34}$	735.00	1115.00
489	$SEGB_{34}$	693.00	1115.00
490	$SEGC_{34}$	651.00	1115.00
491	$SEGA_{35}$	609.00	1115.00
492	$SEGB_{35}$	567.00	1115.00
493	$SEGC_{35}$	525.00	1115.00
494	$SEGA_{36}$	483.00	1115.00
495	$SEGB_{36}$	441.00	1115.00
496	$SEGC_{36}$	399.00	1115.00
497	$SEGA_{37}$	357.00	1115.00
498	$SEGB_{37}$	315.00	1115.00
499	$SEGC_{37}$	273.00	1115.00
500	$SEGA_{38}$	231.00	1115.00
501	$SEGB_{38}$	189.00	1115.00
502	$SEGC_{38}$	147.00	1115.00
503	$SEGA_{39}$	105.00	1115.00
504	$SEGB_{39}$	63.00	1115.00
505	$SEGC_{39}$	21.00	1115.00
506	$SEGA_{40}$	-21.00	1115.00
507	$SEGB_{40}$	-63.00	1115.00
508	$SEGC_{40}$	-105.00	1115.00
509	$SEGA_{41}$	-147.00	1115.00
510	$SEGB_{41}$	-189.00	1115.00
511	$SEGC_{41}$	-231.00	1115.00
512	$SEGA_{42}$	-273.00	1115.00
513	$SEGB_{42}$	-315.00	1115.00
514	$SEGC_{42}$	-357.00	1115.00
515	$SEGA_{43}$	-399.00	1115.00
516	$SEGB_{43}$	-441.00	1115.00
517	$SEGC_{43}$	-483.00	1115.00
518	$SEGA_{44}$	-525.00	1115.00
519	$SEGB_{44}$	-567.00	1115.00
520	$SEGC_{44}$	-609.00	1115.00
521	$SEGA_{45}$	-651.00	1115.00
522	$SEGB_{45}$	-693.00	1115.00
523	$SEGC_{45}$	-735.00	1115.00
524	$SEGA_{46}$	-777.00	1115.00
525	$SEGB_{46}$	-819.00	1115.00
526	$SEGC_{46}$	-861.00	1115.00
527	$SEGA_{47}$	-903.00	1115.00
528	$SEGB_{47}$	-945.00	1115.00
529	$SEGC_{47}$	-987.00	1115.00
530	$SEGA_{48}$	-1029.00	1115.00
531	$SEGB_{48}$	-1071.00	1115.00
532	$SEGC_{48}$	-1113.00	1115.00
533	$SEGA_{49}$	-1155.00	1115.00
534	$SEGB_{49}$	-1197.00	1115.00
535	$SEGC_{49}$	-1239.00	1115.00
536	$SEGA_{50}$	-1281.00	1115.00
537	$SEGB_{50}$	-1323.00	1115.00
538	$SEGC_{50}$	-1365.00	1115.00
539	$SEGA_{51}$	-1407.00	1115.00
540	$SEGB_{51}$	-1449.00	1115.00

■ PAD COORDINATES 4

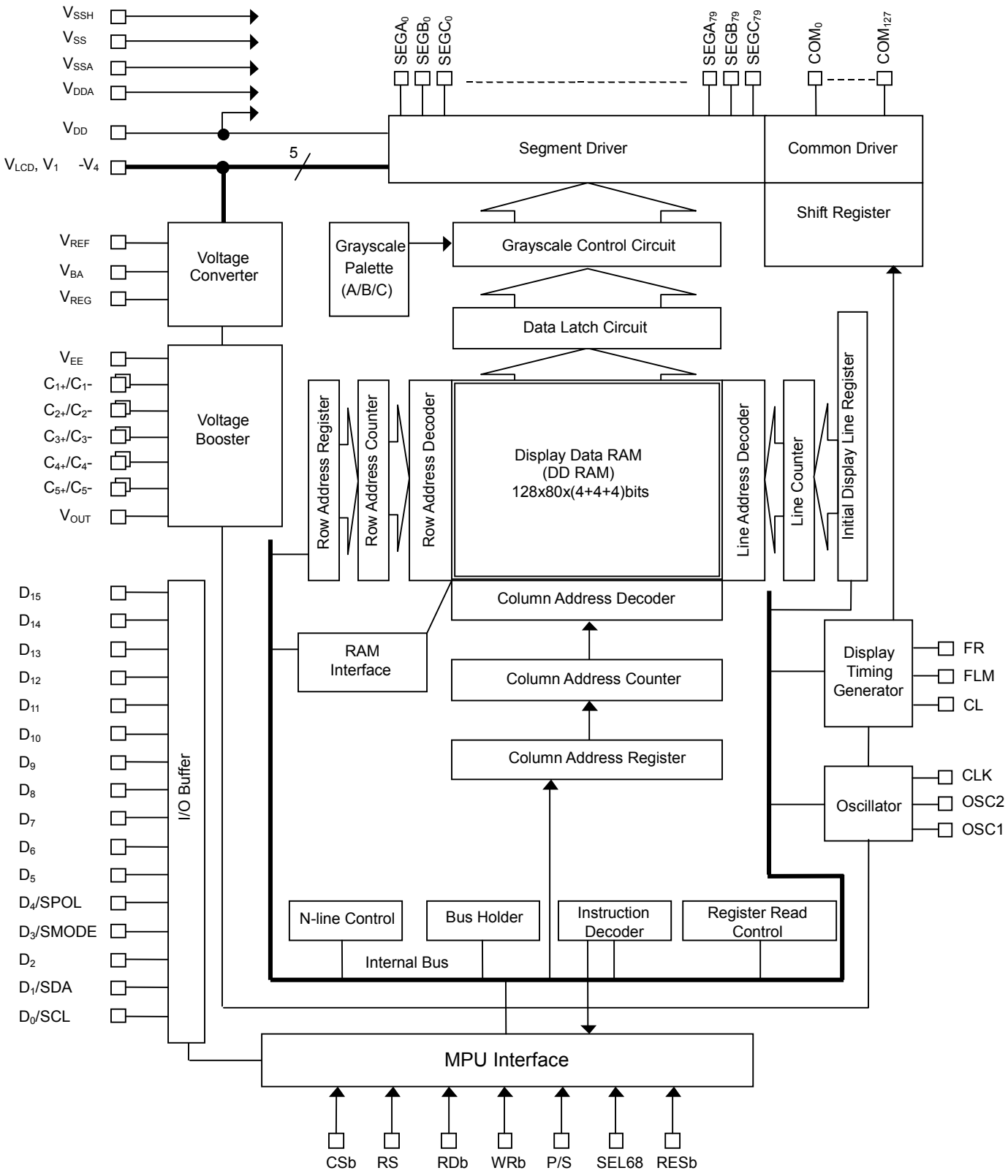
Chip Size 16,700μm x 2,640μm (Chip Center 0μm x 0μm)

No.	PAD NAME	X (um)	Y (um)
541	$SEGC_{51}$	-1491.00	1115.00
542	$SEGA_{52}$	-1533.00	1115.00
543	$SEGB_{52}$	-1575.00	1115.00
544	$SEGC_{52}$	-1617.00	1115.00
545	$SEGA_{53}$	-1659.00	1115.00
546	$SEGB_{53}$	-1701.00	1115.00
547	$SEGC_{53}$	-1743.00	1115.00
548	$SEGA_{54}$	-1785.00	1115.00
549	$SEGB_{54}$	-1827.00	1115.00
550	$SEGC_{54}$	-1869.00	1115.00
551	$SEGA_{55}$	-1911.00	1115.00
552	$SEGB_{55}$	-1953.00	1115.00
553	$SEGC_{55}$	-1995.00	1115.00
554	$SEGA_{56}$	-2037.00	1115.00
555	$SEGB_{56}$	-2079.00	1115.00
556	$SEGC_{56}$	-2121.00	1115.00
557	$SEGA_{57}$	-2163.00	1115.00
558	$SEGB_{57}$	-2205.00	1115.00
559	$SEGC_{57}$	-2247.00	1115.00
560	$SEGA_{58}$	-2289.00	1115.00
561	$SEGB_{58}$	-2331.00	1115.00
562	$SEGC_{58}$	-2373.00	1115.00
563	$SEGA_{59}$	-2415.00	1115.00
564	$SEGB_{59}$	-2457.00	1115.00
565	$SEGC_{59}$	-2499.00	1115.00
566	$SEGA_{60}$	-2541.00	1115.00
567	$SEGB_{60}$	-2583.00	1115.00
568	$SEGC_{60}$	-2625.00	1115.00
569	$SEGA_{61}$	-2667.00	1115.00
570	$SEGB_{61}$	-2709.00	1115.00
571	$SEGC_{61}$	-2751.00	1115.00
572	$SEGA_{62}$	-2793.00	1115.00
573	$SEGB_{62}$	-2835.00	1115.00
574	$SEGC_{62}$	-2877.00	1115.00
575	$SEGA_{63}$	-2919.00	1115.00
576	$SEGB_{63}$	-2961.00	1115.00
577	$SEGC_{63}$	-3003.00	1115.00
578	$SEGA_{64}$	-3045.00	1115.00
579	$SEGB_{64}$	-3087.00	1115.00
580	$SEGC_{64}$	-3129.00	1115.00
581	$SEGA_{65}$	-3171.00	1115.00
582	$SEGB_{65}$	-3213.00	1115.00
583	$SEGC_{65}$	-3255.00	1115.00
584	$SEGA_{66}$	-3297.00	1115.00
585	$SEGB_{66}$	-3339.00	1115.00
586	$SEGC_{66}$	-3381.00	1115.00
587	$SEGA_{67}$	-3423.00	1115.00
588	$SEGB_{67}$	-3465.00	1115.00
589	$SEGC_{67}$	-3507.00	1115.00
590	$SEGA_{68}$	-3549.00	1115.00
591	$SEGB_{68}$	-3591.00	1115.00
592	$SEGC_{68}$	-3633.00	1115.00
593	$SEGA_{69}$	-3675.00	1115.00
594	$SEGB_{69}$	-3717.00	1115.00
595	$SEGC_{69}$	-3759.00	1115.00
596	$SEGA_{70}$	-3801.00	1115.00
597	$SEGB_{70}$	-3843.00	1115.00
598	$SEGC_{70}$	-3885.00	1115.00
599	$SEGA_{71}$	-3927.00	1115.00
600	$SEGB_{71}$	-3969.00	1115.00

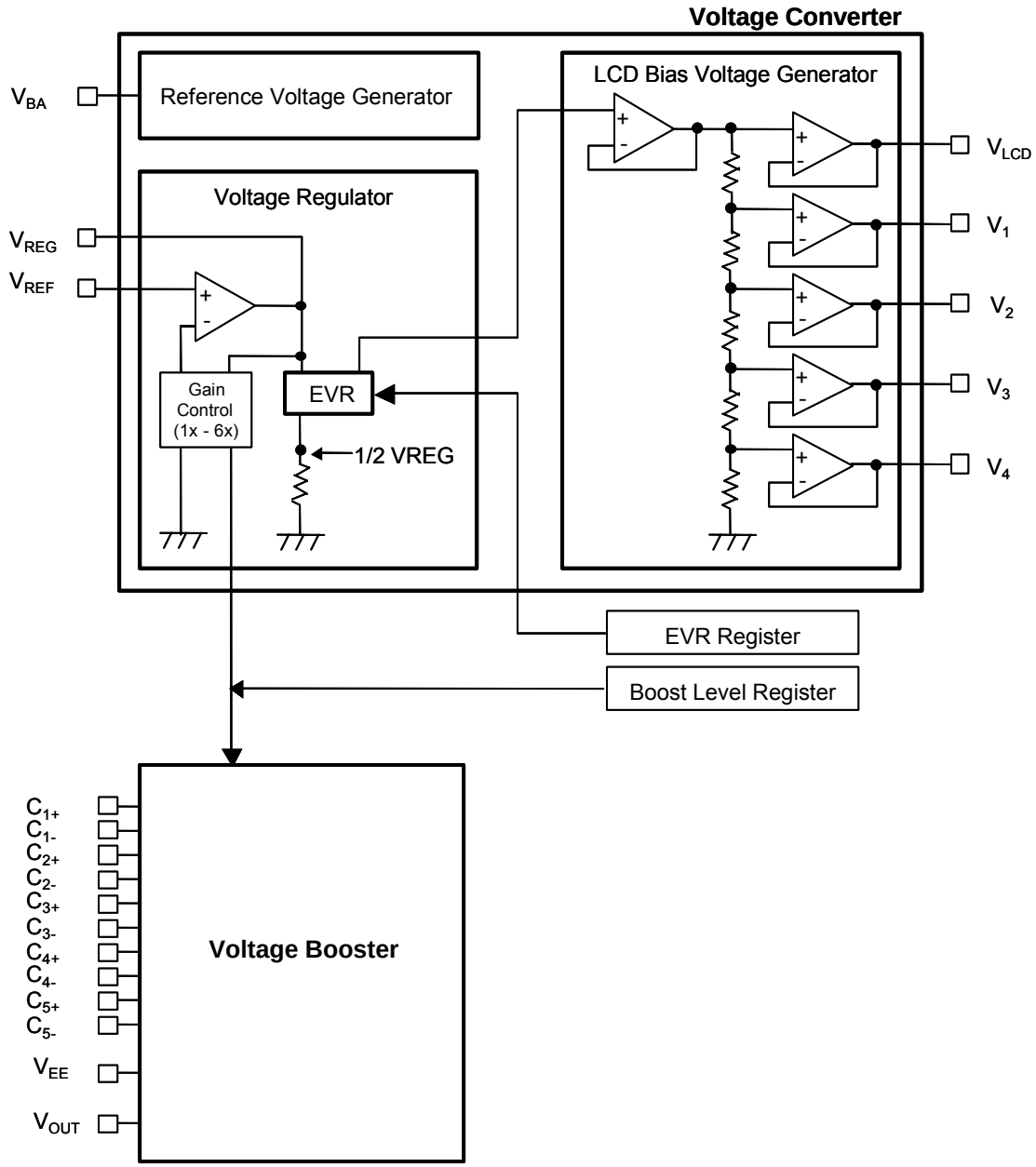
No.	PAD NAME	X (um)	Y (um)
601	$SEGC_{71}$	-4011.00	1115.00
602	$SEGA_{72}$	-4053.00	1115.00
603	$SEGB_{72}$	-4095.00	1115.00
604	$SEGC_{72}$	-4137.00	1115.00
605	$SEGA_{73}$	-4179.00	1115.00
606	$SEGB_{73}$	-4221.00	1115.00
607	$SEGC_{73}$	-4263.00	1115.00
608	$SEGA_{74}$	-4305.00	1115.00
609	$SEGB_{74}$	-4347.00	1115.00
610	$SEGC_{74}$	-4389.00	1115.00
611	$SEGA_{75}$	-4431.00	1115.00
612	$SEGB_{75}$	-4473.00	1115.00
613	$SEGC_{75}$	-4515.00	1115.00
614	$SEGA_{76}$	-4557.00	1115.00
615	$SEGB_{76}$	-4599.00	1115.00
616	$SEGC_{76}$	-4641.00	1115.00
617	$SEGA_{77}$	-4683.00	1115.00
618	$SEGB_{77}$	-4725.00	1115.00
619	$SEGC_{77}$	-4767.00	1115.00
620	$SEGA_{78}$	-4809.00	1115.00
621	$SEGB_{78}$	-4851.00	1115.00
622	$SEGC_{78}$	-4893.00	1115.00
623	$SEGA_{79}$	-4935.00	1115.00
624	$SEGB_{79}$	-4977.00	1115.00
625	$SEGC_{79}$	-5019.00	1115.00
626	DMY_{44}	-5061.00	1115.00
627	DMY_{45}	-5103.00	1115.00
628	DMY_{46}	-5145.00	1115.00
629	COM_{127}	-5187.00	1115.00
630	COM_{125}	-5229.00	1115.00
631	COM_{123}	-5271.00	1115.00
632	COM_{121}	-5313.00	1115.00
633	COM_{119}	-5355.00	1115.00
634	COM_{117}	-5397.00	1115.00
635	COM_{115}	-5439.00	1115.00
636	COM_{113}	-5481.00	1115.00
637	COM_{111}	-5523.00	1115.00
638	COM_{109}	-5565.00	1115.00
639	COM_{107}	-5607.00	1115.00
640	COM_{105}	-5649.00	1115.00
641	COM_{103}	-5691.00	1115.00
642	COM_{101}	-5733.00	1115.00
643	COM_{99}	-5775.00	1115.00
644	COM_{97}	-5817.00	1115.00
645	COM_{95}	-5859.00	1115.00
646	COM_{93}	-5901.00	1115.00
647	COM_{91}	-5943.00	1115.00
648	COM_{89}	-5985.00	1115.00
649	COM_{87}	-6027.00	1115.00
650	COM_{85}	-6069.00	1115.00
651	COM_{83}	-6111.00	1115.00
652	COM_{81}	-6153.00	1115.00
653	COM_{79}	-6195.00	1115.00
654	COM_{77}	-6237.00	1115.00
655	COM_{75}	-6279.00	1115.00
656	COM_{73}	-6321.00	1115.00
657	COM_{71}	-6363.00	1115.00
658	COM_{69}	-6405.00	1115.00
659	COM_{67}	-6447.00	1115.00
660	COM_{65}	-6489.00	1115.00

No.	PAD NAME	X (um)	Y (um)
661	COM_{63}	-6531.00	1115.00
662	COM_{61}	-6573.00	1115.00
663	COM_{59}	-6615.00	1115.00
664	COM_{57}	-6657.00	1115.00
665	COM_{55}	-6699.00	1115.00
666	COM_{53}	-6741.00	1115.00
667	COM_{51}	-6783.00	1115.00
668	COM_{49}	-6825.00	1115.00
669	COM_{47}	-6867.00	1115.00
670	COM_{45}	-6909.00	1115.00
671	COM_{43}	-6951.00	1115.00
672	COM_{41}	-6993.00	1115.00
673	COM_{39}	-7035.00	1115.00
674	COM_{37}	-7077.00	1115.00
675	COM_{35}	-7119.00	1115.00
676	COM_{33}	-7161.00	1115.00
677	COM_{31}	-7203.00	1115.00
678	COM_{29}	-7245.00	1115.00
679	COM_{27}	-7287.00	1115.00
680	COM_{25}	-7329.00	1115.00
681	COM_{23}	-7371.00	1115.00
682	COM_{21}	-7413.00	1115.00
683	COM_{19}	-7455.00	1115.00
684	COM_{17}	-7497.00	1115.00
685	COM_{15}	-7539.00	1115.00
686	COM_{13}	-7581.00	1115.00
687	COM_{11}	-7623.00	1115.00
688	COM_{9}	-7665.00	1115.00
689	COM_{7}	-7707.00	1115.00
690	COM_{5}	-7749.00	1115.00
691	COM_{3}	-7791.00	1115.00
692	COM_{1}	-7833.00	1115.00
693	DMY_{47}	-7875.00	1115.00
694	DMY_{48}	-7917.00	1115.00
695	DMY_{49}	-7959.00	1115.00
696	DMY_{50}	-8001.00	1115.00
697	DMY_{51}	-8145.00	-867.00
698	DMY_{52}	-8145.00	-909.00
699	DMY_{52}	-8145.00	-951.00
700	DMY_{52}	-8145.00	-993.00
701	DMY_{53}	-8145.00	-1035.00

■ BLOCK DIAGRAM



■ LCD POWER SUPPLY BLOCK DIAGRAM



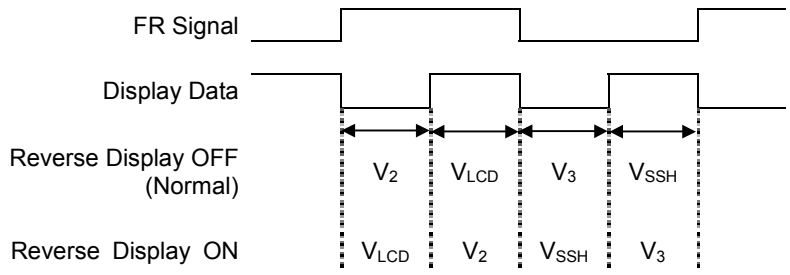
■ TERMINAL DESCRIPTION 1

No.	Terminal	I/O	Function
70~78	V_{DD}	Power	Power Supply for Logic Circuits
93~101	V_{SS}	Power	GND for Logic Circuits
181~189	V_{SSH}	Power	GND for High Voltage Circuits
10,11 34,35 52,53	V_{DDA}	Power	V_{DDA} is internally connected to V_{DD} to fix SEL68 or P/S to "H" if necessary, and cannot be used as main power supply. • V_{DDA} should be open if not used.
4,5 16,17	V_{SSA}	Power	V_{SSA} is internally connected to V_{SS} to fix SEL68 or P/S to "L" if necessary, and cannot be used as main GND. • V_{SSA} should be open if not used.
103~111 113~121 122~130 132~140 141~149	V_{LCD} V_1 V_2 V_3 V_4	Power	LCD Bias Voltages • When the internal LCD power supply is used, internal LCD bias voltages (V_{LCD} and V_1-V_4) are activated by the "Power Control" instruction. Stabilizing capacitors are required between each bias voltage and V_{SS}. • When the external LCD power supply is used, LCD bias voltages are externally supplied on V_{LCD}, V_1, V_2, V_3 and V_4 individually, with the following relation maintained: $V_{SSH}<V_4<V_3<V_2<V_1<V_{LCD}$
208~216 218~226	C_{1+} C_{1-}	Power	Capacitor Connection for Voltage Booster
228~236 238~246	C_{2+} C_{2-}	Power	Capacitor Connection for Voltage Booster
248~256 258~266	C_{3+} C_{3-}	Power	Capacitor Connection for Voltage Booster
268~276 278~286	C_{4+} C_{4-}	Power	Capacitor Connection for Voltage Booster
288~296 298~306	C_{5+} C_{5-}	Power	Capacitor Connection for Voltage Booster
171~179	V_{BA}	Power	Reference-Voltage Generator Output
161~169	V_{REF}	Power	Voltage Regulator Input
199~207	V_{EE}	Power	Voltage Booster Input • V_{EE} is normally connected to V_{DD}.
190~198	V_{OUT}	Power	Voltage Booster Output • Input if an external LCD power supply is used.
151~159	V_{REG}	Power	Voltage Regulator Output
19,20	RESb	I	Reset • Active "L"
7,8	SEL68	I	MPU Mode Select SEL86 | H | L MPU | 68-series | 80-series

■ TERMINAL DESCRIPTION 2

No.	Terminal	I/O	Function
36,37	D_0 /SCL	I/O	Parallel Interface D_7 to D_0 : 8-bit Bi-directional Bus • In the parallel interface mode (P/S="H"), D_7-D_0 are connected to 8-bit bi-directional MPU bus. Serial Interface SDA : Serial Data SCL : Serial Clock SMODE : 3-/4-line Serial Mode Select SPOL : RS Polarity Select (3-line Serial Interface Mode) • In the 3 or 4-line serial interface mode (P/S="L"), D_0 is assigned to SCL, and D_1 to SDA. • In the 3-line serial interface mode, D_4 is assigned to SPOL. • Serial data on SDA is latched at the rising edge of SCL signal in order of D_7, D_6,… and D_0, and then converted into 8-bit parallel data at the timing of the internal signal produced from the 8th SCL. • SCL should be set to "L" right after data transmission or during non-access.
38,39	D_1 /SDA	I/O	
42,43	D_3 /SMODE	I/O	
44,45	D_4 /SPOL	I/O	
40.41 46,47 48,49 50,51	D_2 D_5 D_6 D_7	I/O	
54,55 56,57 58,59 60,61 62,63 64,65 66,67 68,69	D_8 D_9 D_{10} D_{11} D_{12} D_{13} D_{14} D_{15}	I/O	8-bit Bi-directional Bus • In the 16-bit bus length mode, D_{15}-D_8 are assigned to upper 8-bit data bus. • In the serial interface mode or the 8-bit parallel interface mode, D_{15}-D_8 should be fixed to "H" or "L".
22,23	CSb	I	Chip Select • Active "L"
25,26	RS	I	Register Select • This signal interprets transferred data as display data or instruction. RS: H = Instruction, L = Display Data
31,32	RDb (E)	I	80-series MPU Interface (P/S="H", SEL68="L") Data Read (RDb) Signal • Active "L" 68-series MPU Interface (P/S="H", SEL68="H") Enable Signal • Active "H"
28,29	WRb (R/W)	I	80-series MPU Interface (P/S="H", SEL68="L") Data Write (WRb) Signal • Active "L" 68-series MPU Interface (P/S="H", SEL68="H") Data Read or Write (R/W) Signal R/W: H = Read, L = Write

■ TERMINAL DESCRIPTION 3

<table>
<tr><th>No.</th><th>Terminal</th><th>I/O</th><th>Function</th></tr>
<tr><td>13,14</td><td>P/S</td><td>I</td><td>Parallel/Serial Interface Mode Select
<table>
<tr><th>P/S</th><th>Chip Select</th><th>Display / Instruction</th><th>Data</th><th>Read /Write</th><th>Serial Clock</th></tr>
<tr><td>H</td><td>CSb</td><td>RS</td><td>D_0 ~ D_7</td><td>RDb, WRb</td><td>-</td></tr>
<tr><td>L</td><td>CSb</td><td>RS</td><td>SDA (D_1)</td><td>Write Only</td><td>SCL (D_0)</td></tr>
</table>
• In the serial interface mode (P/S=“L”), RDb, WRb, D_2 and D_5-D_{15} should be fixed to “H” or “L”,.</td></tr>
<tr><td>79,80</td><td>CL</td><td>O</td><td>Line Clock
• CL is normally open.</td></tr>
<tr><td>81,82</td><td>FLM</td><td>O</td><td>First Line Maker
• FLM is normally open.</td></tr>
<tr><td>83,84</td><td>FR</td><td>O</td><td>Frame Rate
• FR is normally open.</td></tr>
<tr><td>85,86</td><td>CLK</td><td>O</td><td>Clock Output
• CLK is normally open.</td></tr>
<tr><td>88,89
91,92</td><td>OSC1
OSC2</td><td>I
O</td><td>OSC
• When the internal oscillator is used, fix OSC1 to “H” or “L” and leave OSC2 open. To attain more accurate frequency, connect OSC1 and OSC2 with an external resistor.
• When the internal oscillator is not used, input external clock to OSC1 and leave OSC2 open.</td></tr>
<tr><td>386~625</td><td>$SEGA_0$ ~$SEGA_{79}$
$SEGB_0$ ~$SEGB_{79}$
$SEGC_0$ ~$SEGC_{79}$</td><td>O</td><td>Segment Drivers
<table>
<tr><th>REV Register</th><th>OFF</th><th>ON</th></tr>
<tr><td>Normal</td><td>0</td><td>1</td></tr>
<tr><td>Reverse</td><td>1</td><td>0</td></tr>
</table>
• Segment drivers output the following voltage levels.
B/W Mode (Example)
 
</td></tr>
<tr><td>319~382
629~692</td><td>COM_0 ~ COM_{127}</td><td>O</td><td>Common Drivers
• Common drivers output the following voltage levels.
<table>
<tr><th>Data</th><th>FR</th><th>Output Levels</th></tr>
<tr><td>H</td><td>H</td><td>V_{SSH}</td></tr>
<tr><td>L</td><td>H</td><td>V_1</td></tr>
<tr><td>H</td><td>L</td><td>V_{LCD}</td></tr>
<tr><td>L</td><td>L</td><td>V_4</td></tr>
</table></td></tr>
</table>

NOTE) DUMMY PADs: No. 1~3, 6, 9, 12, 15, 18, 21, 24, 27, 30, 33, 87, 90, 102, 112, 131, 150, 160, 170, 180, 217, 227, 237, 247, 257, 267, 277, 287, 297, 307~318, 383~385, 626~628, 693~701

■ FUNCTIONAL DESCRIPTION

(1) MPU INTERFACE

(1-1) Selection of Parallel/Serial Interface Mode

The P/S selects a parallel or a serial interface mode, as shown in Table 1. In the serial interface mode, neither display data in the DDRAM nor instruction data in the registers can be read out.

Table 1 Selection of Parallel/Serial Interface Mode

P/S	I/F Mode	CSb	RS	RDb	WRb	SEL68	SDA	SCL	Data
H	Parallel I/F	CSb	RS	RDb	WRb	SEL68			D_7-D_0 (D_{15}-D_0)
L	Serial I/F	CSb	RS	-	-	-	SDA	SCL	-

NOTE) " -" : Fix to "H" or "L".

(1-2) Selection of MPU Mode

In the parallel interface mode, the SEL68 selects 68 or 80-series MPU mode, as shown in Table 2.

Table 2 Selection of MPU Mode

SEL68	MPU Mode	CSb	RS	RDb	WRb	Data
H	68-series MPU	CSb	RS	E	R/W	D_7-D_0 (D_{15}-D_0)
L	80-series MPU	CSb	RS	RDb	WRb	D_7-D_0 (D_{15}-D_0)

(1-3) Data Recognition

In the parallel interface mode, the data from MPU is interpreted as display data or instruction according to the combination of the RS, RDb and WRb (R/W) signals, as shown in Table 3.

Table 3 Data Recognition (Parallel Interface Mode)

RS	68-series	80-series		Function
	R/W	RDb	WRb	
H	H	L	H	Read Instruction
H	L	H	L	Write Instruction
L	H	L	H	Read Display Data
L	L	H	L	Write Display Data

(1-4) Selection of 3-/4-line Serial Interface Mode

In the serial interface mode, the SMODE selects 3- or 4-line serial interface mode, as shown in Table 4.

Table 4 Selection of 3-/4-line Serial Interface Mode

SMODE	Serial Interface Mode
H	3-line
L	4-line

(1-5) 4-line Serial Interface Mode

While the chip select is active (CSb="L"), the SDA and SCL are enabled. While the chip select is inactive (CSb="H"), the SDA and SCL are disabled, and the internal shift register and the internal counter are being initialized. 8-bit serial data on the SDA is latched at the rising edge of the SCL signal in order of D_7, D_6,…, and D_0, and converted into 8-bit parallel data at the timing of the internal signal produced from the 8th SCL signal. The data on the SDA is interpreted as display data or instruction according to the RS.

Table 5 Data Recognition (4-line Serial Interface)

RS	Data Recognition
H	Instruction
L	Display Data

Note that the SCL should be set to "L" right after data transmission or during non-access because the serial interface is susceptible to external noises which may cause malfunctions. For added safety, inactivate the chip-select (CSb="H") temporary whenever 8-bit data transmission is completed. Fig 1 illustrates the interface timing of the 4-line serial interface mode.

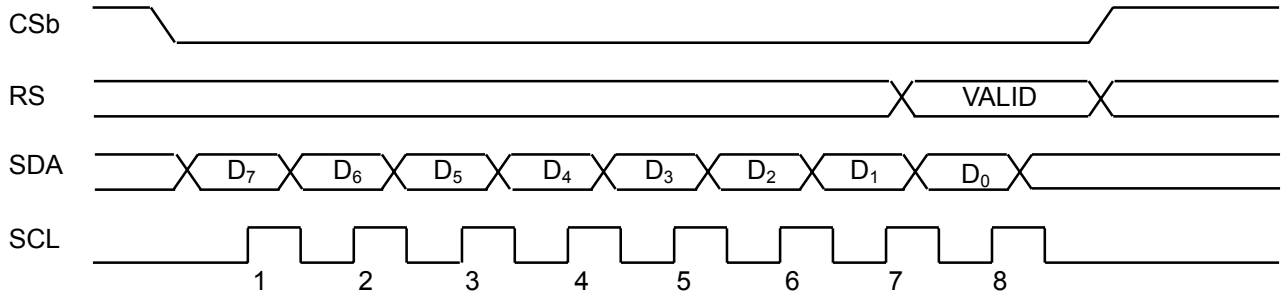


Fig 1 4-line Serial Interface Timing

(1-6) 3-line Serial Interface Mode

While the chip select is active (CSb="L"), the SDA and SCL are enabled. While the chip select is not active (CSb="H"), the SDA and SCL are disabled, and the internal shift register and the internal counter are being initialized. 9-bit serial data on the SDA is latched at the rising edge of the SCL signal in order of RS, D_7, D_6,…, and D_0, and then converted into 9-bit parallel data at the timing of the internal signal produced from the 9^{th} SCL signal. The data on the SDA is interpreted as display data or instruction according to the combination of the RS bit and the SPOL status, as follows.

Table 6 Data Recognition (3-line Serial Interface)

SPOL=L		SPOL=H	
RS	Data Recognition	RS	Data Recognition
0	Display Data	0	Instruction
1	Instruction	1	Display Data

Note that the SCL should be set to "L" right after data transmission or during non-access because the serial interface is susceptible to external noises which may cause malfunctions. For added safety, inactivate the chip-select (CSb="H") temporary whenever 9-bit data transmission is completed. Fig 2 illustrates the interface timing of the 3-line serial interface mode.

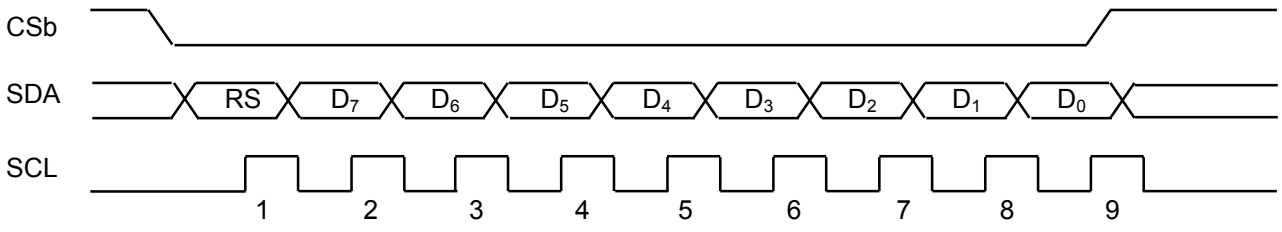


Fig 2 3-line Serial Interface Timing

(1-7) Accessing DDRAM

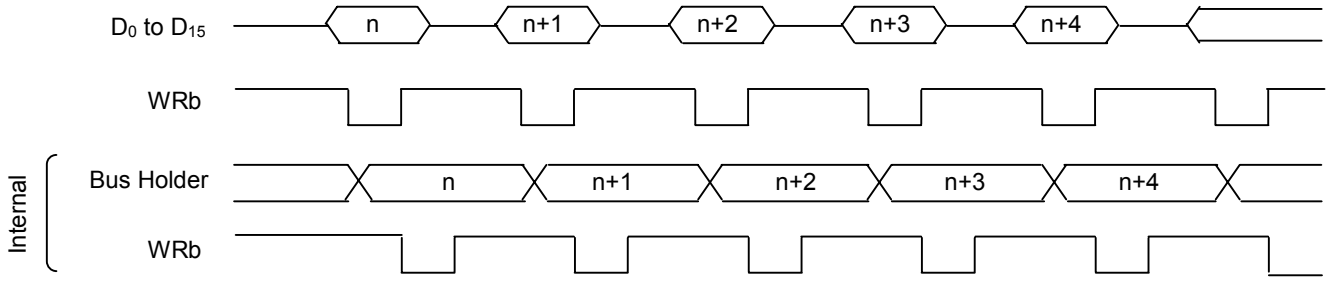
While the chip select is active (CSb="L"), the data from MPU can be written into the DDRAM or the instruction register. When the RS is "L", the data is interpreted as display data which is stored in the DDRAM. The display data is latched at the rising edge of the WRb signal in the 80-series MPU mode, or at the falling edge of the E signal in the 68-series MPU mode.

Table 7 Data Recognition

RS	Data Recognition
L	Display Data
H	Instruction

In the DDRAM read sequence, be sure to execute a dummy read right after setting an address or right after writing display data or instruction. The data from MPU is temporarily held in the internal bus-holder, then released on the internal data-bus, therefore a dummy data is read out by the 1st "Display Data Read" instruction. After that, the display data is read out from a specified address by the 2nd instruction. Note that the "Display Data Read" instruction cannot be used in the serial interface mode.

Display Data Write Operation



Display Data Read Operation

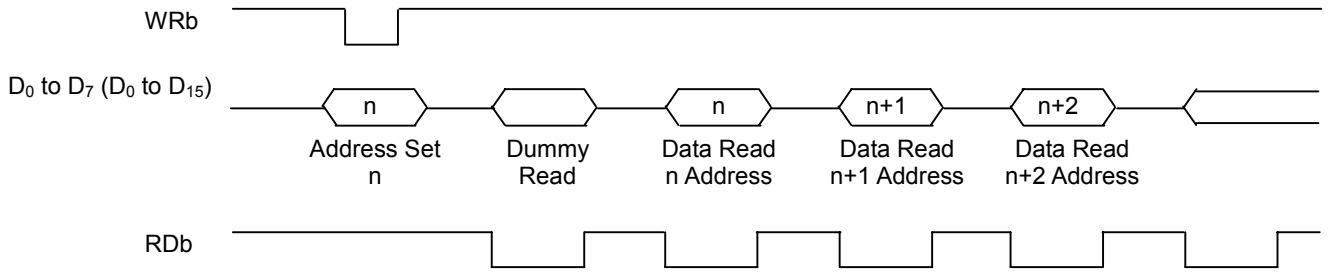


Fig 3 Internal-signal Timing of Display Data Read/Write Operations

NOTE) In 16-bit bus length mode, instruction is transmitted to/from instruction register in 16 bits, as well as display data.

(1-8) Accessing Instruction Register

Each instruction register has a specific address in between (0H) and (FH), and instruction data is read out from the register by the “Register Address” and ”Register Read” instructions. For more information, refer to “(14-23) Register Address” and “(14-24) Register Read”.

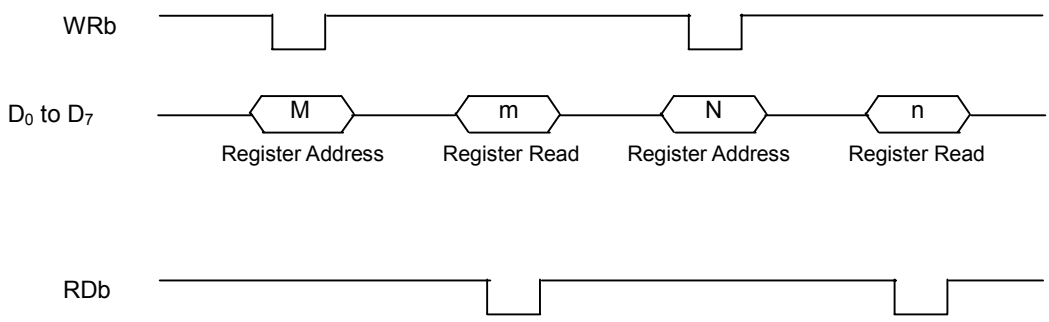


Fig 4 Access Timing of Instruction Register

(1-9) Selection of 8-/16-bit Bus Length (Parallel Interface Mode)

Either 8- or 16-bit bus length is selected by the D_0 (WLS) bit of the “Bus Length” instruction. In the 16-bit bus length mode, instruction as well as display data is transmitted to/from the instruction registers in 16 bits (D_{15} to D_0). However, only lower 8 bits (D_7 to D_0) are valid for instruction register access. And only 12 bits are actually stored in the DDRAM, even though entire 16 bits (D_{15} to D_0) are transmitted for DDRAM access. For more information, refer to “(4-4) Bit Assignment of Display Data”.

Table 8 Selection of 8-/16-bit Bus Length Mode

WLS	Bus Length Mode
L	8-bit Bus Length
H	16-bit Bus Length

(2) INITIAL DISPLAY LINE REGISTER

The address data in the initial display line register specifies the row address, which corresponds to an initial COM and is normally positioned on top of a screen in full display. The initial COM is the start position of common scanning, which is specified by the “Initial COM” instruction.

The row address, which is established in the initial display line register, is preset into the line counter whenever the FLM becomes “H”. At the rising edge of the CL signal, the line counter is counted-up, then 240-bit display data is latched into the data latch circuit. At the falling edge of the CL signal, the latch data is released to the grayscale control circuit to decide a grayscale level, then the segment drivers Ai, Bi and Ci (i=0 to 79) generate LCD waveforms.

(3) COLUMN AND ROW ADDRESS COUNTERS

The column and row address counters designate a column address and a row address respectively for DDRAM access, but they are completely independent from the line counter. The line counter provides a line address which is synchronized with display control timings such as the FLM and the CL.

(4) DDRAM

(4-1) DDRAM Address Range

The DDRAM is capable of 128 bits for row address and 960 bits (12-bit x 80-segment) for column address. The range of the column address is from (00H) to (4FH), and the row address is from (00H) to (7FH). Setting outside these ranges is not allowed, otherwise it may cause malfunctions. For DDRAM access, two data transmissions are needed for 1 RGB-pixel in the 8-bit bus length mode, and one transmission in the 16-bit bus length mode.

8-bit Bus Length

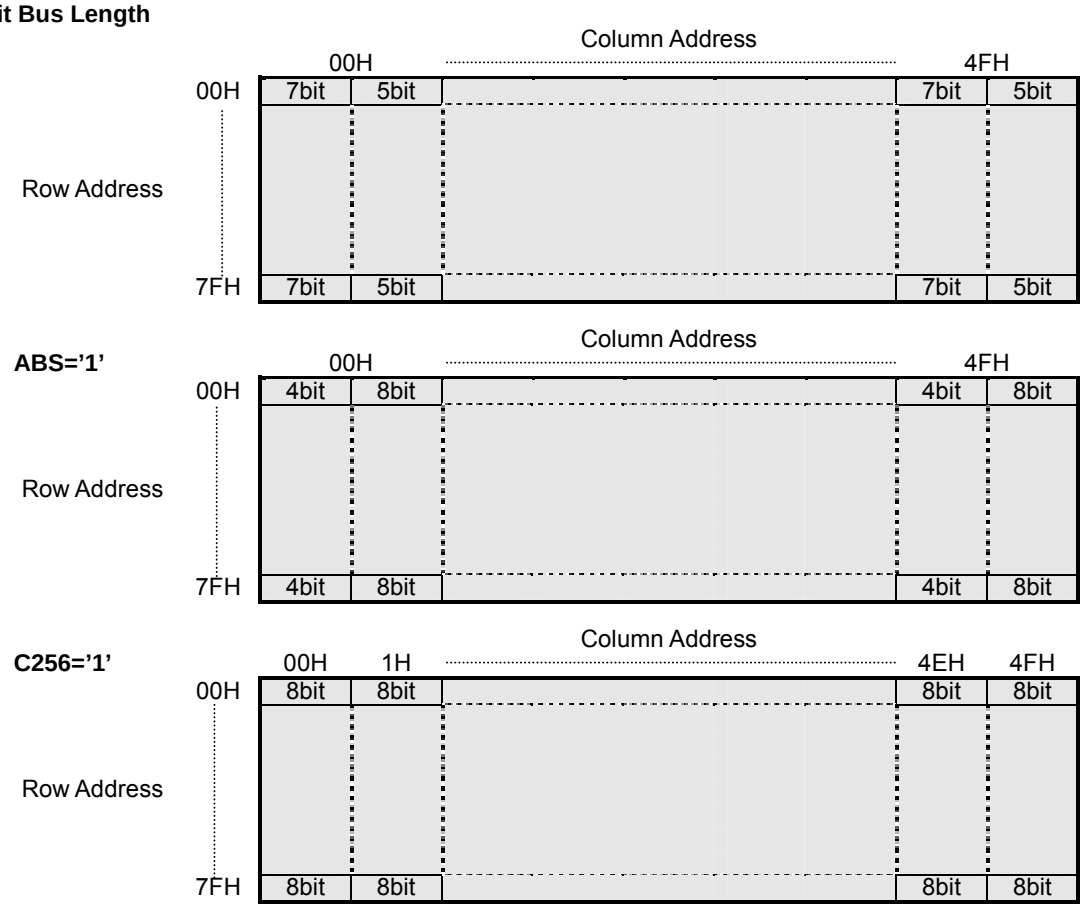


Fig 5 Range of Column Address in 8-bit Bus Length

16-bit Bus Length

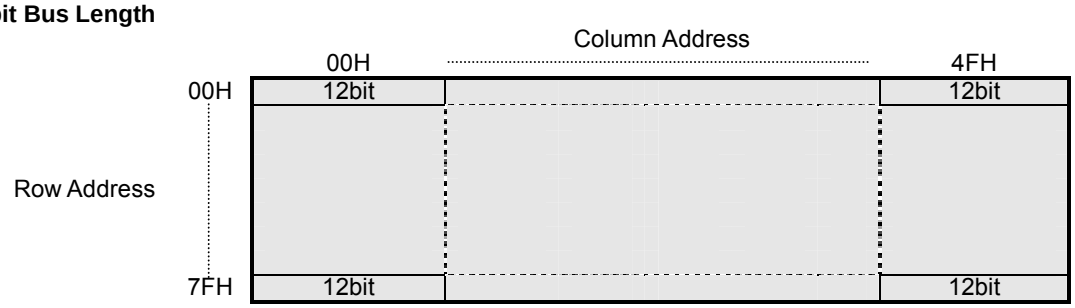


Fig 6 Range of Column Address in 16-bit Bus Length

(4-2) Window Area for DDRAM Access

Be sure to set up window area prior to DDRAM access. This area is set by the "Increment/Decrement Control" instruction and the designation of the start point and the end point.

By the "Increment/Decrement Control", either auto-increment or -decrement is set for column address and row address individually. Once this mode is set up, the column address, row address or both are automatically counted up or down, whenever the DDRAM is accessed. And, the start point is specified by the "Window Start Column Address" and "Window Start Row Address" instructions, and the end point by the "Window End Column Address" and "Window End Row Address" instructions. For more information, refer to "(14-9) Increment/Decrement Control", "(14-25) Window End Column Address" and "(14-26)Window End Row Address". The typical sequence of the window area setting is listed below.

1. Set D_2 (HV), D_1 (XD) and D_0 (YD) of "Increment/Decrement Control" instruction.
2. Set start point by "Window Start Column Address" and "Window Start Row Address" instructions.
3. Set end point by "Window End Column Address" and "Window End Row Address" instructions.
4. Window area is set up, and DDRAM can be accessed.

NOTE) The order of address setting is column address first, then row address.

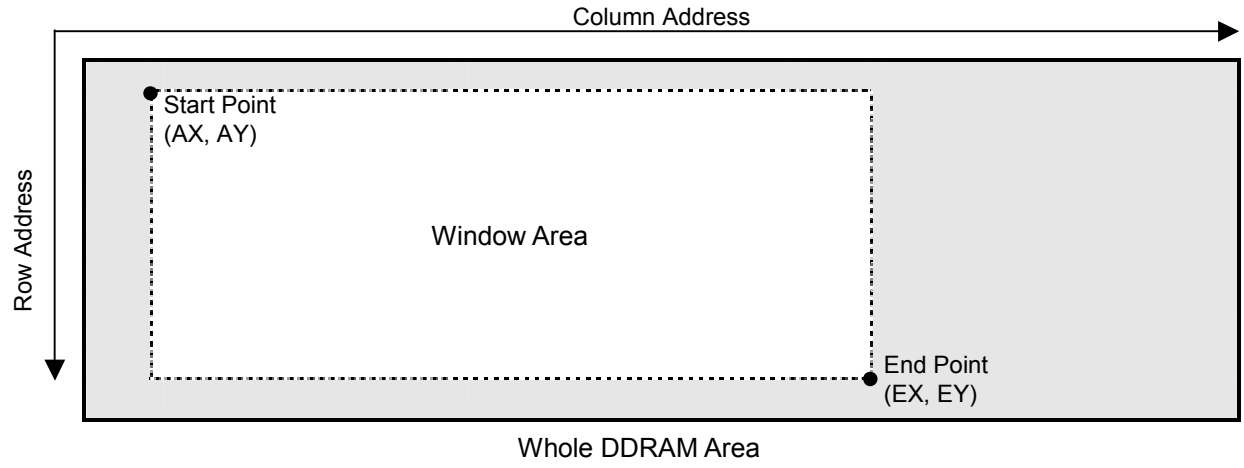


Fig 7 Window Area

NOTE1) The following relation should be maintained to avoid malfunctions.
- AX (Window Start Column Address) < EX (Window End Column Address) < Maximum Column Address
- AY (Window Start Row Address) < EY (Window End Row Address) < Maximum Row Address

NOTE2) The display-rotation function or the mirror-inversion function is enabled by this setting. Refer to "(4-3) DDRAM Access Direction".

NOTE3)A read-modify-write operation is enabled by setting "1" at the D_3 (AIM) of the "Increment/Decrement Control" instruction. Refer to the description about "AIM" bit in "(14-9) Increment/Decrement Control".

(4-3) DDRAM Access Direction (Display-rotation and Mirror-inversion Functions)

The access direction of the DDRAM is selected out of eight options by setting the D_2 (HV), D_1 (XD) and D_0 (YD) bits of the "Increment/Decrement Control" instruction. This function allows the display data to be rotated 90, 180 or 270 degrees or mirror-inversed while being written onto the DDRAM. The following table shows the correspondences between instruction setting and on-screen image.

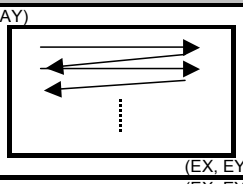
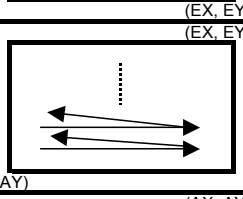
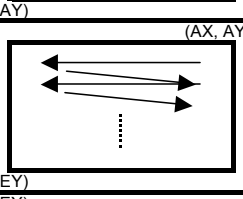
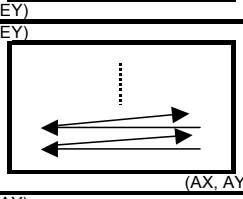
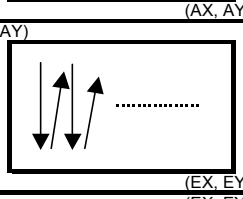
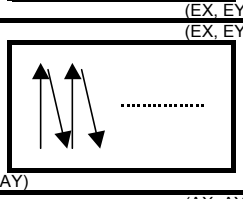
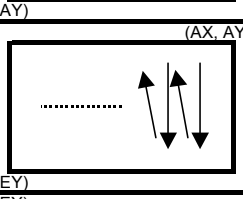
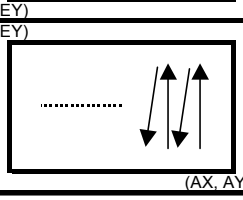
No.	HV	XD	YD	DDRAM Access Direction	On-screen Image	Valid Address
0	0	0	0			AX < EX AY < EY
1	0	0	1			AX < EX AY > EY
2	0	1	0			AX > EX AY < EY
3	0	1	1			AX > EX AY > EY
4	1	0	0			AX < EX AY < EY
5	1	0	1			AX < EX AY > EY
6	1	1	0			AX > EX AY < EY
7	1	1	1			AX >EX AY > EY

Fig 8 Display-rotation Function and Mirror-inverse Function

NOTE1) The same display data is used for each option's on-screen image. Only difference is "HV", "XD" and "YD" bits setting.
NOTE2) The following relation must be maintained to avoid malfunctions.
AX (Window Start Column Address) < EX (Window End Column Address) < Maximum Column Address
AY (Window Start Row Address) < EY (Window End Row Address) < Maximum Row Address

(4-4) Bit Assignment of Display Data

(4-4-1) Bit Assignment Overview

These maps is used for grasping general outlines of the variations in the bit assignment of display data.

Table 9-1 RAM MAP 1 (Variable 16-grayscale Mode, Fixed 8-grayscale Mode or B&W Mode)

Mode	WLS	ABS	C256	SEG0 Palette A	SEG0 Palette B	SEG0 Palette C	SEG1 Palette A	SEG1 Palette B	SEG1 Palette C	SEG78 Palette A	SEG78 Palette B	SEG78 Palette C	SEG79 Palette A	SEG79 Palette B	SEG79 Palette C
16bit	1	0	0	X=00H			X=01H			X=4EH			X=4FH		
				A_3 A_2	A_1 A_0 B_3 B_2	B_1 B_0 C_3 C_2 C_1 C_0	D_{15} D_{14}	D_{13} D_{12} D_{10} D_9	D_8 D_7 D_6 D_5 D_4 D_3 D_2 D_1	D_{15} D_{14}	D_{13} D_{12} D_{10} D_9	D_8 D_7 D_6 D_5 D_4 D_3 D_2 D_1	D_{11} D_{10}	D_9 D_8 D_7 D_6 D_5 D_4 D_3 D_2	D_1 D_0
	1	1	0	X=00H			X=01H			X=4EH			X=4FH		
				A_3 A_2	A_1 A_0 B_3 B_2	B_1 B_0 C_3 C_2 C_1 C_0	D_{15} D_{14}	D_{13} D_{12} D_{10} D_9	D_8 D_7 D_6 D_5 D_4 D_3 D_2 D_1	D_{15} D_{14}	D_{13} D_{12} D_{10} D_9	D_8 D_7 D_6 D_5 D_4 D_3 D_2 D_1	D_{11} D_{10}	D_9 D_8 D_7 D_6 D_5 D_4 D_3 D_2	D_1 D_0
8bit	0	0	0	X=00H (Upper)	X=00H (Lower)		X=01H (Upper)	X=01H (Lower)		X=4EH (Upper)	X=4EH (Lower)		X=4FH (Upper)	X=4FH (Lower)	
				A_3 A_2	A_1 A_0 B_3 B_2	B_1 B_0 C_3 C_2 C_1 C_0	D_7 D_6	D_5 D_4 D_3 D_2 D_1 D_0	D_7 D_6 D_5 D_4 D_3 D_2 D_1 D_0	D_7 D_6	D_5 D_4 D_3 D_2 D_1 D_0	D_7 D_6 D_5 D_4 D_3 D_2 D_1 D_0	D_7 D_6	D_5 D_4 D_3 D_2 D_1 D_0	D_7 D_6 D_5 D_4 D_3 D_2 D_1 D_0
	0	1	0	X=00H (Upper)	X=00H (Lower)		X=01H (Upper)	X=01H (Lower)		X=4EH (Upper)	X=4EH (Lower)		X=4FH (Upper)	X=4FH (Lower)	
				A_3 A_2	A_1 A_0 B_3 B_2	B_1 B_0 C_3 C_2 C_1 C_0	D_7 D_6	D_5 D_4 D_3 D_2 D_1 D_0	D_7 D_6 D_5 D_4 D_3 D_2 D_1 D_0	D_7 D_6	D_5 D_4 D_3 D_2 D_1 D_0	D_7 D_6 D_5 D_4 D_3 D_2 D_1 D_0	D_7 D_6	D_5 D_4 D_3 D_2 D_1 D_0	D_7 D_6 D_5 D_4 D_3 D_2 D_1 D_0

Table 9-2 RAM MAP 2 (Variable 8-grayscale Mode, Fixed 8-grayscale Mode or B&W Mode)

Mode	WLS	ABS	C256	SEG0 Palette A	SEG0 Palette B	SEG0 Palette C	SEG1 Palette A	SEG1 Palette B	SEG1 Palette C	SEG78 Palette A	SEG78 Palette B	SEG78 Palette C	SEG79 Palette A	SEG79 Palette B	SEG79 Palette C
8bit	0	X	1	X=00H			X=01H			X=4EH			X=4FH		
				A_3 A_2	A_1 A_0 B_3 B_2	B_1 B_0 C_3 C_2 C_1 C_0	- -	- - D_7 D_6	D_5 D_4 D_3 D_2 D_1 D_0	- -	- - D_7 D_6	D_5 D_4 D_3 D_2 D_1 D_0	- -	- - D_7 D_6	D_5 D_4 D_3 D_2 D_1 D_0

Table 10 SWAP

SWAP	Palette A				Palette B				Palette C			
	A_3	A_2	A_1	A_0	B_3	B_2	B_1	B_0	C_3	C_2	C_1	C_0
0	SEGAx				SEGBx				SEGCx			
1	SEGCx				SEGBx				SEGAx			

NOTE1) On the RAM MAP 2, A_0, B_0, C_1 and C_0 bits are fixed to "1".
NOTE2) The functions of the variable 8-grayscale mode are different from those of the fixed 8-grayscale mode.
NOTE3) The contents of the DDRAM at "C256=0" are not compatible with the contents at "C256=1".
NOTE4) "C256=1" can be used in the 8-bit bus length mode, but not in the 16-bit bus length mode.
NOTE5) In the 8-bit bus length mode at "C256=0", odd accesses are prohibited because display data for 1 pixel is completed in successive two accesses.
NOTE6) In the 8-bit bus length mode at "C256=0", write upper bits first, then lower bits. This order is always adopted regardless of the "HV", "XD" and "YD" bits.

(4-4-2) Bit Assignment in Variable 16-grayscale Mode

16-bit Bus Length (MON=0, PWM=0, C256=0, WLS=1)

ABS	SWAP	Column Address / Display Data / Segment Driver																							
0	0	X=00H											←→	X=4FH											
Display Data in DDRAM		D_{15}	D_{14}	D_{13}	D_{12}	D_{10}	D_9	D_8	D_7	D_4	D_3	D_2	D_1	←→	D_{15}	D_{14}	D_{13}	D_{12}	D_{10}	D_9	D_8	D_7	D_4	D_3	D_2	D_1
Grayscale Palette		Palette A				Palette B				Palette C				←→	Palette A				Palette B				Palette C			
Segment Driver		$SEGA_0$				$SEGB_0$				$SEGC_0$				←→	$SEGA_{79}$				$SEGB_{79}$				$SEGC_{79}$			

ABS	SWAP	Column Address / Display Data / Segment Driver																							
0	1	X=00H											←→	X=4FH											
Display Data in DDRAM		D_{15}	D_{14}	D_{13}	D_{12}	D_{10}	D_9	D_8	D_7	D_4	D_3	D_2	D_1	←→	D_{15}	D_{14}	D_{13}	D_{12}	D_{10}	D_9	D_8	D_7	D_4	D_3	D_2	D_1
Grayscale Palette		Palette A				Palette B				Palette C				←→	Palette A				Palette B				Palette C			
Segment Driver		$SEGC_0$				$SEGB_0$				$SEGA_0$				←→	$SEGC_{79}$				$SEGB_{79}$				$SEGA_{79}$			

ABS	SWAP	Column Address / Display Data / Segment Driver																							
1	0	X=00H											←→	X=4FH											
Display Data in DDRAM		D_{11}	D_{10}	D_9	D_8	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	←→	D_{11}	D_{10}	D_9	D_8	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
Grayscale Palette		Palette A				Palette B				Palette C				←→	Palette A				Palette B				Palette C			
Segment Driver		$SEGA_0$				$SEGB_0$				$SEGC_0$				←→	$SEGA_{79}$				$SEGB_{79}$				$SEGC_{79}$			

ABS	SWAP	Column Address / Display Data / Segment Driver																							
1	1	X=00H											←→	X=4FH											
Display Data in DDRAM		D_{11}	D_{10}	D_9	D_8	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	←→	D_{11}	D_{10}	D_9	D_8	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
Grayscale Palette		Palette A				Palette B				Palette C				←→	Palette A				Palette B				Palette C			
Segment Driver		$SEGC_0$				$SEGB_0$				$SEGA_0$				←→	$SEGC_{79}$				$SEGB_{79}$				$SEGA_{79}$			

8-bit Bus Length (MON=0, PWM=0, C256=0, WLS=0)

ABS	SWAP	Column Address / Display Data / Segment Driver																							
0	0	X=00H(Upper)							X=00H(Lower)					←→	X=4FH(Upper)							X=4FH(Lower)				
Display Data in DDRAM		D_7	D_6	D_5	D_4	D_2	D_1	D_0	D_7	D_4	D_3	D_2	D_1	←→	D_7	D_6	D_5	D_4	D_2	D_1	D_0	D_7	D_4	D_3	D_2	D_1
Grayscale Palette		Palette A				Palette B			Palette C					←→	Palette A				Palette B			Palette C				
Segment Driver		$SEGA_0$				$SEGB_0$			$SEGC_0$					←→	$SEGA_{79}$				$SEGB_{79}$			$SEGC_{79}$				

ABS	SWAP	Column Address / Display Data / Segment Driver																							
0	1	X=00H(Upper)							X=00H(Lower)					←→	X=4FH(Upper)							X=4FH(Lower)				
Display Data in DDRAM		D_7	D_6	D_5	D_4	D_2	D_1	D_0	D_7	D_4	D_3	D_2	D_1	←→	D_7	D_6	D_5	D_4	D_2	D_1	D_0	D_7	D_4	D_3	D_2	D_1
Grayscale Palette		Palette A				Palette B			Palette C					←→	Palette A				Palette B			Palette C				
Segment Driver		$SEGC_0$				$SEGB_0$			$SEGA_0$					←→	$SEGC_{79}$				$SEGB_{79}$			$SEGA_{79}$				

ABS	SWAP	Column Address / Display Data / Segment Driver																							
1	0	X=00H (Upper)							X=00H(Lower)					←→	X=4FH (Upper)							X=4FH(Lower)				
Display Data in DDRAM		D_3	D_2	D_1	D_0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	←→	D_3	D_2	D_1	D_0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
Grayscale Palette		Palette A				Palette B			Palette C					←→	Palette A				Palette B			Palette C				
Segment Driver		$SEGA_0$				$SEGB_0$			$SEGC_0$					←→	$SEGA_{79}$				$SEGB_{79}$			$SEGC_{79}$				

ABS	SWAP	Column Address / Display Data / Segment Driver																							
1	1	X=00H (Upper)							X=00H(Lower)					←→	X=4FH (Upper)							X=4FH(Lower)				
Display Data in DDRAM		D_3	D_2	D_1	D_0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	←→	D_3	D_2	D_1	D_0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
Grayscale Palette		Palette A				Palette B			Palette C					←→	Palette A				Palette B			Palette C				
Segment Driver		$SEGC_0$				$SEGB_0$			$SEGA_0$					←→	$SEGC_{79}$				$SEGB_{79}$			$SEGA_{79}$				

(4-4-3) Bit Assignment in variable 8-grayscale Mode

8-bit Bus Length (MON=0, PWM=0, C256=1, WLS=0)

ABS	SWAP	Column Address / Display Data / Segment Driver															
*	0	X=00H							←→	X=4FH							
Display Data in DDRAM		D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	←→	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
Grayscale Palette		Palette A			Palette B			Palette C		←→	Palette A			Palette B			Palette C	
Segment Driver		$SEGA_0$			$SEGB_0$			$SEGC_0$		←→	$SEGA_{79}$			$SEGB_{79}$			$SEGC_{79}$	

ABS	SWAP	Column Address / Display Data / Segment Driver															
*	1	X=00H							←→	X=4FH							
Display Data in DDRAM		D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	←→	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
Grayscale Palette		Palette A			Palette B			Palette C		←→	Palette A			Palette B			Palette C	
Segment Driver		$SEGC_0$			$SEGB_0$			$SEGA_0$		←→	$SEGC_{79}$			$SEGB_{79}$			$SEGA_{79}$	

(4-4-4) Bit Assignment in Fixed 8-grayscale Mode

16-bit Bus Length (MON=0, PWM=1, C256=0, WLS=1)

ABS	SWAP	Column Address / Display Data / Segment Driver																							
0	0	X=00H											←→	X=4FH											
Display Data in DDRAM		D_{15}	D_{14}	D_{13}	D_{12}	D_{10}	D_9	D_8	D_7	D_4	D_3	D_2	D_1	←→	D_{15}	D_{14}	D_{13}	D_{12}	D_{10}	D_9	D_8	D_7	D_4	D_3	D_2	D_1
Grayscale Palette		Palette A				Palette B				Palette C				←→	Palette A				Palette B				Palette C			
Segment Driver		$SEGA_0$				$SEGB_0$				$SEGC_0$				←→	$SEGA_{79}$				$SEGB_{79}$				$SEGC_{79}$			

ABS	SWAP	Column Address / Display Data / Segment Driver																							
0	1	X=00H											←→	X=4FH											
Display Data in DDRAM		D_{15}	D_{14}	D_{13}	D_{12}	D_{10}	D_9	D_8	D_7	D_4	D_3	D_2	D_1	←→	D_{15}	D_{14}	D_{13}	D_{12}	D_{10}	D_9	D_8	D_7	D_4	D_3	D_2	D_1
Grayscale Palette		Palette A				Palette B				Palette C				←→	Palette A				Palette B				Palette C			
Segment Driver		$SEGC_0$				$SEGB_0$				$SEGA_0$				←→	$SEGC_{79}$				$SEGB_{79}$				$SEGA_{79}$			

NOTE) The data indicated with a slash mark (/) are invalid.

ABS	SWAP	Column Address / Display Data / Segment Driver																							
1	0	X=00H											←→	X=4FH											
Display Data in DDRAM		D_{11}	D_{10}	D_9	D_8	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	←→	D_{11}	D_{10}	D_9	D_8	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
Grayscale Palette		Palette A				Palette B				Palette C				←→	Palette A				Palette B				Palette C			
Segment Driver		$SEGA_0$				$SEGB_0$				$SEGC_0$				←→	$SEGA_{79}$				$SEGB_{79}$				$SEGC_{79}$			

ABS	SWAP	Column Address / Display Data / Segment Driver																							
1	1	X=00H											←→	X=4FH											
Display Data in DDRAM		D_{11}	D_{10}	D_9	D_8	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	←→	D_{11}	D_{10}	D_9	D_8	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
Grayscale Palette		Palette A				Palette B				Palette C				←→	Palette A				Palette B				Palette C			
Segment Driver		$SEGC_0$				$SEGB_0$				$SEGA_0$				←→	$SEGC_{79}$				$SEGB_{79}$				$SEGA_{79}$			

NOTE) The data indicated with a slash mark (/) is invalid.

8-bit Bus Length (MON=0, PWM=1, C256=0, WLS=0)

ABS	SWAP	Column Address / Display Data / Segment Driver																							
0	0	X=00H(Upper)							X=00H(Lower)				⟷	X=4FH Upper)							X=4FH(Lower)			
Display Data in DDRAM		D_7	D_6	D_5	D_4	D_2	D_1	D_0	D_7	D_4	D_3	D_2	D_1	⟷	D_7	D_6	D_5	D_4	D_2	D_1	D_0	D_7	D_4	D_3	D_2	D_1
Grayscale Palette		Palette A				Palette B			Palette C				⟷	Palette A				Palette B			Palette C				
Segment Driver		$SEGA_0$				$SEGB_0$			$SEGC_0$				⟷	$SEGA_{79}$				$SEGB_{79}$			$SEGC_{79}$				

ABS	SWAP	Column Address / Display Data / Segment Driver																							
0	1	X=00H(Upper)							X=00H(Lower)				⟷	X=4FH(Upper)							X=4FH(Lower)			
Display Data in DDRAM		D_7	D_6	D_5	D_4	D_2	D_1	D_0	D_7	D_4	D_3	D_2	D_1	⟷	D_7	D_6	D_5	D_4	D_2	D_1	D_0	D_7	D_4	D_3	D_2	D_1
Grayscale Palette		Palette A				Palette B			Palette C				⟷	Palette A				Palette B			Palette C				
Segment Driver		$SEGC_0$				$SEGB_0$			$SEGA_0$				⟷	$SEGC_{79}$				$SEGB_{79}$			$SEGA_{79}$				

NOTE) The data indicated with a slash mark (/) is invalid.

ABS	SWAP	Column Address / Display Data / Segment Driver																							
1	0	X=00H (Upper)				X=00H(Lower)								⟷	X=4FH (Upper)				X=4FH(Lower)							
Display Data in DDRAM		D_3	D_2	D_1	D_0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	⟷	D_3	D_2	D_1	D_0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
Grayscale Palette		Palette A				Palette B			Palette C					⟷	Palette A				Palette B			Palette C				
Segment Driver		$SEGA_0$				$SEGB_0$			$SEGC_0$					⟷	$SEGA_{79}$				$SEGB_{79}$			$SEGC_{79}$				

ABS	SWAP	Column Address / Display Data / Segment Driver																							
1	1	X=00H (Upper)				X=00H(Lower)								⟷	X=4FH (Upper)				X=4FH(Lower)							
Display Data in DDRAM		D_3	D_2	D_1	D_0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	⟷	D_3	D_2	D_1	D_0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
Grayscale Palette		Palette A				Palette B			Palette C					⟷	Palette A				Palette B			Palette C				
Segment Driver		$SEGC_0$				$SEGB_0$			$SEGA_0$					⟷	$SEGC_{79}$				$SEGB_{79}$			$SEGA_{79}$				

NOTE) The data indicated with a slash mark (/) is invalid.

8-bit Bus Length (MON=0, PWM=1, C256=1, WLS=0)

ABS	SWAP	Column Address / Display Data / Segment Driver																							
*	0	X=00H												⟷	X=4FH										
Display Data in DDRAM		D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0					⟷	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0			
Grayscale Palette		Palette A				Palette B			Palette C					⟷	Palette A				Palette B			Palette C				
Segment Driver		$SEGA_0$				$SEGB_0$			$SEGC_0$					⟷	$SEGA_{79}$				$SEGB_{79}$			$SEGC_{79}$				

ABS	SWAP	Column Address / Display Data / Segment Driver																							
*	1	X=00H												⟷	X=4FH										
Display Data in DDRAM		D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0					⟷	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0			
Grayscale Palette		Palette A				Palette B			Palette C					⟷	Palette A				Palette B			Palette C				
Segment Driver		$SEGC_0$				$SEGB_0$			$SEGA_0$					⟷	$SEGC_{79}$				$SEGB_{79}$			$SEGA_{79}$				

(4-4-5) Bit Assignment in B&W Mode

16-bit Bus Length (MON=1, PWM=*, C256=0, WLS=1)

ABS	SWAP	Column Address / Display Data / Segment Driver																					
0	0	X=00H										←→	X=4FH										
Display Data in DDRAM		D_{15}	D_{14}	D_{13}	D_{12}	D_{10}	D_9	D_8	D_7	D_4	D_3	D_2	D_1	←→	D_{15}	D_{14}	D_{13}	D_{12}	D_{10}	D_9	D_8	D_7	D_4	D_3	D_2	D_1
Grayscale Palette		Palette A				Palette B				Palette C				←→	Palette A				Palette B				Palette C			
Segment Driver		$SEGA_0$				$SEGB_0$				$SEGC_0$				←→	$SEGA_{79}$				$SEGB_{79}$				$SEGC_{79}$			

ABS	SWAP	Column Address / Display Data / Segment Driver																					
0	1	X=00H										←→	X=4FH										
Display Data in DDRAM		D_{15}	D_{14}	D_{13}	D_{12}	D_{10}	D_9	D_8	D_7	D_4	D_3	D_2	D_1	←→	D_{15}	D_{14}	D_{13}	D_{12}	D_{10}	D_9	D_8	D_7	D_4	D_3	D_2	D_1
Grayscale Palette		Palette A				Palette B				Palette C				←→	Palette A				Palette B				Palette C			
Segment Driver		$SEGC_0$				$SEGB_0$				$SEGA_0$				←→	$SEGC_{79}$				$SEGB_{79}$				$SEGA_{79}$			

ABS	SWAP	Column Address / Display Data / Segment Driver																					
1	0	X=00H										←→	X=4FH										
Display Data in DDRAM		D_{11}	D_{10}	D_9	D_8	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	←→	D_{11}	D_{10}	D_9	D_8	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
Grayscale Palette		Palette A				Palette B				Palette C				←→	Palette A				Palette B				Palette C			
Segment Driver		$SEGA_0$				$SEGB_0$				$SEGC_0$				←→	$SEGA_{79}$				$SEGB_{79}$				$SEGC_{79}$			

ABS	SWAP	Column Address / Display Data / Segment Driver																					
1	1	X=00H										←→	X=4FH										
Display Data in DDRAM		D_{11}	D_{10}	D_9	D_8	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	←→	D_{11}	D_{10}	D_9	D_8	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
Grayscale Palette		Palette A				Palette B				Palette C				←→	Palette A				Palette B				Palette C			
Segment Driver		$SEGC_0$				$SEGB_0$				$SEGA_0$				←→	$SEGC_{79}$				$SEGB_{79}$				$SEGA_{79}$			

NOTE) The data indicated with a slash mark (/) is invalid, and only MSB bits are effective.

8-bit Bus Length (MON=1, PWM=*, C256=0, WLS=0)

ABS	SWAP	Column Address / Display Data / Segment Driver																							
0	0	X=00H(Upper)							X=00H(Lower)				⟷	X=4FH(Upper)							X=4FH(Lower)			
Display Data in DDRAM		D_7	D_6	D_5	D_4	D_2	D_1	D_0	D_7	D_4	D_3	D_2	D_1	⟷	D_7	D_6	D_5	D_4	D_2	D_1	D_0	D_7	D_4	D_3	D_2	D_1
Grayscale Palette		Palette A				Palette B			Palette C				⟷	Palette A				Palette B			Palette C				
Segment Driver		$SEGA_0$				$SEGB_0$			$SEGC_0$				⟷	$SEGA_{79}$				$SEGB_{79}$			$SEGC_{79}$				

ABS	SWAP	Column Address / Display Data / Segment Driver																							
0	1	X=00H(Upper)							X=00H(Lower)				⟷	X=4FH(Upper)							X=4FH(Lower)			
Display Data in DDRAM		D_7	D_6	D_5	D_4	D_2	D_1	D_0	D_7	D_4	D_3	D_2	D_1	⟷	D_7	D_6	D_5	D_4	D_2	D_1	D_0	D_7	D_4	D_3	D_2	D_1
Grayscale Palette		Palette A				Palette B			Palette C				⟷	Palette A				Palette B			Palette C				
Segment Driver		$SEGC_0$				$SEGB_0$			$SEGA_0$				⟷	$SEGC_{79}$				$SEGB_{79}$			$SEGA_{79}$				

ABS	SWAP	Column Address / Display Data / Segment Driver																							
1	0	X=00H (Upper)							X=00H(Lower)				⟷	X=4FH (Upper)							X=4FH(Lower)			
Display Data in DDRAM		D_3	D_2	D_1	D_0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	⟷	D_3	D_2	D_1	D_0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
Grayscale Palette		Palette A				Palette B			Palette C				⟷	Palette A				Palette B			Palette C				
Segment Driver		$SEGA_0$				$SEGB_0$			$SEGC_0$				⟷	$SEGA_{79}$				$SEGB_{79}$			$SEGC_{79}$				

ABS	SWAP	Column Address / Display Data / Segment Driver																							
1	1	X=00H (Upper)							X=00H(Lower)				⟷	X=4FH (Upper)							X=4FH(Lower)			
Display Data in DDRAM		D_3	D_2	D_1	D_0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	⟷	D_3	D_2	D_1	D_0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
Grayscale Palette		Palette A				Palette B			Palette C				⟷	Palette A				Palette B			Palette C				
Segment Driver		$SEGC_0$				$SEGB_0$			$SEGA_0$				⟷	$SEGC_{79}$				$SEGB_{79}$			$SEGA_{79}$				

NOTE) The data indicated with a slash mark (/) is invalid, and only MSB bits are effective.

8-bit Bus Length (MON=1, PWM=*, C256=1, WLS=0)

ABS	SWAP	Column Address / Display Data / Segment Driver																							
*	0	X=00H												⟷	X=4FH										
Display Data in DDRAM		D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0					⟷	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0			
Grayscale Palette		Palette A				Palette B			Palette C					⟷	Palette A				Palette B			Palette C			
Segment Driver		$SEGA_0$				$SEGB_0$			$SEGC_0$					⟷	$SEGA_{79}$				$SEGB_{79}$			$SEGC_{79}$			

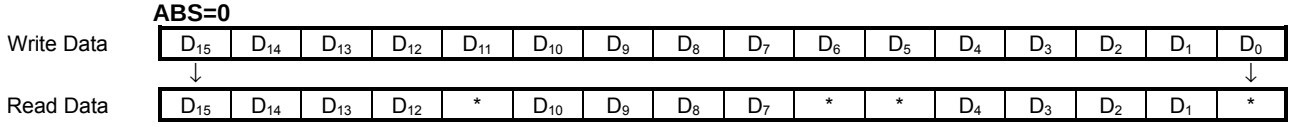
ABS	SWAP	Column Address / Display Data / Segment Driver																							
*	1	X=00H												⟷	X=4FH										
Display Data in DDRAM		D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0					⟷	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0			
Grayscale Palette		Palette A				Palette B			Palette C					⟷	Palette A				Palette B			Palette C			
Segment Driver		$SEGC_0$				$SEGB_0$			$SEGA_0$					⟷	$SEGC_{79}$				$SEGB_{79}$			$SEGA_{79}$			

NOTE) The data indicated with a slash mark (/) is invalid, and only MSB bits are effective.

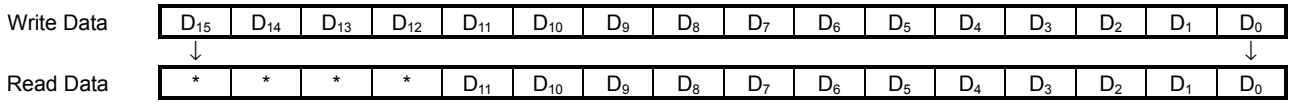
(4-5) Write Data and Read Data

16-bit Bus Length

ABS=0

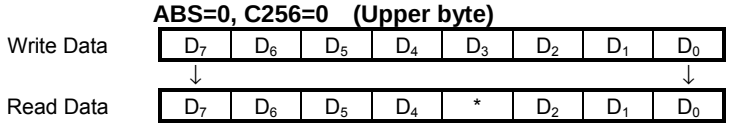


ABS=1

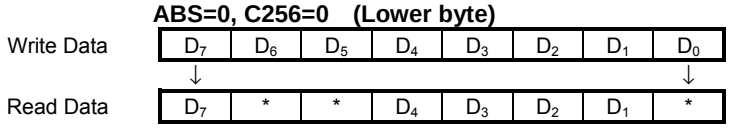


8-bit Bus Length

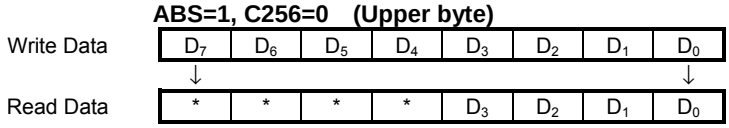
ABS=0, C256=0 (Upper byte)



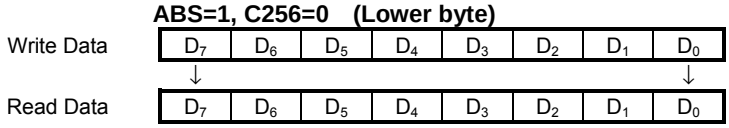
ABS=0, C256=0 (Lower byte)



ABS=1, C256=0 (Upper byte)



ABS=1, C256=0 (Lower byte)



ABS=0, C256=1

NOTE) * : Invalid Data

(5) GRAYSCALE CONTROL CIRCUIT

(5-1) Display Mode Selection

A display mode is selected by the combination of the D_2 (MON) bit of the "Display Control (1)" instruction and the D_3 (PWM) and D_2 (C256) bits of the "Display Mode Control" instruction, as shown below.

Table 11 Display Mode Selection

MON	PWM	C256 (NOTE1)	Display Mode		Bus Length		Oscillation (NOTE2)
0	0	0	Variable 16-grayscale Mode	4096 Colors	8-/16-bit	(WLS=0/1)	f_{OSC1}
		1	Variable 8-grayscale Mode	256 Colors	8-bit	(WLS=0)	
	1	0	Fixed 8-grayscale Mode	256 Colors	8-/16-bit	(WLS=0/1)	f_{OSC2}
		1			8-bit	(WLS=0)	
1	*	0	B&W Mode	Black & White	8-/16-bit	(WLS=0/1)	f_{OSC3}
		1			8-bit	(WLS=0)	

NOTE1) In the variable grayscale mode, "C256" bit selects either 16-grayscale (4K colors) or 8-grayscale (256 colors). When C256="0" (16-grayscale), all 12 bits are assigned to 1 RGB-pixel. When C256="1" (8-grayscale), only 8 bits are assigned and the 8-bit bus length should be used. In the fixed 8-grayscale mode or the B&W mode, the "C256" bit is usually "1". For more information how the display data is assigned, refer to "(4-4) Bit Assignment of Display Data".

NOTE2) Oscillation frequency is decided according to the display mode, and is fine-tuned by the "Frequency Control" Instruction. Refer to "(10) OSCILLATOR" and "OSCILLATION FREQUENCY AND FRAME FREQUENCY".

(5-1-1) Variable 16-grayscale Mode

In this mode, each of the palettes Aj, Bj and Cj (j=0-15) is capable of selecting 16 from 32 grayscales (0/31-31/31) by setting palette data in the grayscale palette. Then, each of the segment drivers SEGAi, SEGBi and SEGCi (i=0 to 79) generates 16 grayscales to achieve 4,096 colors. Refer to Table 12-1 and Table 12-2.

(5-1-2) Variable 8-grayscale Mode

Each of the palettes Aj, Bj and Cj (j=0-15) is capable of selecting 8 from 32 grayscales (0/31-31/31). 2 segment drivers of 1 RGB-group (SEGAi, SEGBi and SEGCi (i=0 to 79)) generate 8 grayscales, and the other driver does 4 grayscales to achieve 256 colors. Refer to Table 13-1 through Table 13-4. The 8-bit bus length is usually used in this mode.

(5-1-3) Fixed 8-grayscale Mode

The palette setting is not necessary, because the palettes Aj, Bj and Cj (j=0-15) are always fixed at 4 or 8 grayscales between 0/7 and 7/7. 2 segment drivers of 1 RGB-group (SEGAi, SEGBi and SEGCi (i=0 to 79)) are fixed at 8 grayscales, and the other driver is 4 grayscales, then results in 256 colors. Refer to Table 14-1 and Table 14-2.

(5-1-4) B&W Mode

The palette setting is not necessary, where the only MSB bits of display data are valid. Refer to Table 15.

(6) GRAYSCALE PALETTE

(6-1) Grayscale Selection in Variable 16-grayscale Mode

Table 12-1 Grayscale selection

(Palette Aj, Bj, and Cj)

Display Data MSB----LSB	Palette Name
0 0 0 0	Palette A0/B0/C0
0 0 0 1	Palette A1/B1/C1
0 0 1 0	Palette A2/B2/C2
0 0 1 1	Palette A3/B3/C3
0 1 0 0	Palette A4/B4/C4
0 1 0 1	Palette A5/B5/C5
0 1 1 0	Palette A6/B6/C6
0 1 1 1	Palette A7/B7/C7
1 0 0 0	Palette A8/B8/C8
1 0 0 1	Palette A9/B9/C9
1 0 1 0	Palette A10/B10/C10
1 0 1 1	Palette A11/B11/C11
1 1 0 0	Palette A12/B12/C12
1 1 0 1	Palette A13/B13/C13
1 1 1 0	Palette A14/B14/C14
1 1 1 1	Palette A15/B15/C15

Table 12-2 Grayscale Palette

(Palette Aj, Bj, and Cj)

Palette Data MSB---LSB	Grayscale	Default Setting	Palette Data MSB---LSB	Grayscale	Default Setting
0 0 0 0 0	0	Palette A0/B0/C0	1 0 0 0 0	16/31	
0 0 0 0 1	1/31		1 0 0 0 1	17/31	Palette A8/B8/C8
0 0 0 1 0	2/31		1 0 0 1 0	18/31	
0 0 0 1 1	3/31	Palette A1/B1/C1	1 0 0 1 1	19/31	Palette A9/B9/C9
0 0 1 0 0	4/31		1 0 1 0 0	20/31	
0 0 1 0 1	5/31	Palette A2/B2/C2	1 0 1 0 1	21/31	Palette A10/B10/C10
0 0 1 1 0	6/31		1 0 1 1 0	22/31	
0 0 1 1 1	7/31	Palette A3/B3/C3	1 0 1 1 1	23/31	Palette A11/B11/C11
0 1 0 0 0	8/31		1 1 0 0 0	24/31	
0 1 0 0 1	9/31	Palette A4/B4/C4	1 1 0 0 1	25/31	Palette A12/B12/C12
0 1 0 1 0	10/31		1 1 0 1 0	26/31	
0 1 0 1 1	11/31	Palette A5/B5/C5	1 1 0 1 1	27/31	Palette A13/B13/C13
0 1 1 0 0	12/31		1 1 1 0 0	28/31	
0 1 1 0 1	13/31	Palette A6/B6/C6	1 1 1 0 1	29/31	Palette A14/B14/C14
0 1 1 1 0	14/31		1 1 1 1 0	30/31	
0 1 1 1 1	15/31	Palette A7/B7/C7	1 1 1 1 1	31/31	Palette A15/B15/C15

NOTE1) “MON=0”, “PWM=0”, “C256=0”
NOTE2) Applied to palette Aj, Bj and Cj (j=0 to 15)

(6-2) Grayscale Selection in Variable 8-grayscale Mode

Table 13-1 Grayscale selection

(Palette Aj and Bj)

Display Data MSB----LSB	Palette Name
0 0 0 *	Palette A1/B1/C1
0 0 1 *	Palette A3/B3/C3
0 1 0 *	Palette A5/B5/C5
0 1 1 *	Palette A7/B7/C7
1 0 0 *	Palette A9/B9/C9
1 0 1 *	Palette A11/B11/C11
1 1 0 *	Palette A13/B13/C13
1 1 1 *	Palette A15/B15/C15

Table 13-2 Grayscale Palette

(Palette Aj and Bj)

Palette Data MSB---LSB	Grayscale	Default Setting	Palette Data MSB---LSB	Grayscale	Default Setting
0 0 0 0 0	0		1 0 0 0 0	16/31	
0 0 0 0 1	1/31		1 0 0 0 1	17/31	
0 0 0 1 0	2/31		1 0 0 1 0	18/31	
0 0 0 1 1	3/31	Palette A1/B1/C1	1 0 0 1 1	19/31	Palette A9/B9/C9
0 0 1 0 0	4/31		1 0 1 0 0	20/31	
0 0 1 0 1	5/31		1 0 1 0 1	21/31	
0 0 1 1 0	6/31		1 0 1 1 0	22/31	
0 0 1 1 1	7/31	Palette A3/B3/C3	1 0 1 1 1	23/31	Palette A11/B11/C11
0 1 0 0 0	8/31		1 1 0 0 0	24/31	
0 1 0 0 1	9/31		1 1 0 0 1	25/31	
0 1 0 1 0	10/31		1 1 0 1 0	26/31	
0 1 0 1 1	11/31	Palette A5/B5/C5	1 1 0 1 1	27/31	Palette A13/B13/C13
0 1 1 0 0	12/31		1 1 1 0 0	28/31	
0 1 1 0 1	13/31		1 1 1 0 1	29/31	
0 1 1 1 0	14/31		1 1 1 1 0	30/31	
0 1 1 1 1	15/31	Palette A7/B7/C7	1 1 1 1 1	31/31	Palette A15/B15/C15

NOTE1) “MON=0”, “PWM=0”, “C256=1”.
NOTE2) Applied to palette Aj and Bj (j=0 to 15)
NOTE3) Palette 0, 2, 4, 6, 8, 10, 12 and 14 are disabled.

Table 13-3 Grayscale selection

(Palette Cj)

Display Data MSB----LSB	Palette Name
0 0 * *	Palette A3/B3/C3
0 1 * *	Palette A7/B7/C7
1 0 * *	Palette A11/B11/C11
1 1 * *	Palette A15/B15/C15

Table 13-4 Grayscale Palette

(Palette Cj)

Palette Data MSB---LSB	Grayscale	Default Setting	Palette Data MSB---LSB	Grayscale	Default Setting
0 0 0 0 0	0		1 0 0 0 0	16/31	
0 0 0 0 1	1/31		1 0 0 0 1	17/31	
0 0 0 1 0	2/31		1 0 0 1 0	18/31	
0 0 0 1 1	3/31		1 0 0 1 1	19/31	
0 0 1 0 0	4/31		1 0 1 0 0	20/31	
0 0 1 0 1	5/31		1 0 1 0 1	21/31	
0 0 1 1 0	6/31		1 0 1 1 0	22/31	
0 0 1 1 1	7/31	Palette A3/B3/C3	1 0 1 1 1	23/31	Palette A11/B11/C11
0 1 0 0 0	8/31		1 1 0 0 0	24/31	
0 1 0 0 1	9/31		1 1 0 0 1	25/31	
0 1 0 1 0	10/31		1 1 0 1 0	26/31	
0 1 0 1 1	11/31		1 1 0 1 1	27/31	
0 1 1 0 0	12/31		1 1 1 0 0	28/31	
0 1 1 0 1	13/31		1 1 1 0 1	29/31	
0 1 1 1 0	14/31		1 1 1 1 0	30/31	
0 1 1 1 1	15/31	Palette A7/B7/C7	1 1 1 1 1	31/31	Palette A15/B15/C15

NOTE1) “MON=0”, “PWM=0”, “C256=1”
NOTE2) Applied to palette Cj (j=0 to 15)
NOTE3) Palette 0, 1, 2, 4, 5, 6, 8, 9, 10, 12, 13 and 14 are disabled.

(6-3) Grayscale Selection in Fixed 8-grayscale Mode

Table 14-1 Grayscale Selection

(Palette Aj and Bj)

Display Data MSB- - - -LSB	Grayscale
0 0 0 *	0/7
0 0 1 *	1/7
0 1 0 *	2/7
0 1 1 *	3/7
1 0 0 *	4/7
1 0 1 *	5/7
1 1 0 *	6/7
1 1 1 *	7/7

Table 14-2 Grayscale Palette

(Palette Cj)

Display Data MSB- - - -LSB	Grayscale
0 0 * *	0/7
0 1 * *	3/7
1 0 * *	5/7
1 1 * *	7/7

NOTE1) “MON=0”, “PWM=1”, “C256=0 or 1”

(6-4) Grayscale Selection in B&W Mode

Table 15 Grayscale Selection

Display Data MSB- - - -LSB	Grayscale
0 * * *	0
1 * * *	1

NOTE1) “MON=1”, “PWM=0 or 1” and “C256=0 or 1”

(7) DISPLAY TIMING GENERATOR

The display timing generator generates timing clocks such as the CL (Line Clock), FR (Frame Rate) and FLM (First Line Maker) by dividing an oscillation frequency. These clocks are used inside the LSI, and are activated by setting "1" at the D_0 (SON) bit of the "Duty-1 /Display Clock ON/OFF" instruction.

The CL is used for the line counter and the data latch circuit. At the rising edge of the CL signal, the line counter is counted up, then 240-bit display data is latched into the data latch circuit. At the falling edge of the CL signal, the latch data is released to the grayscale control circuit, then segment drivers Ai, Bi and Ci (i=0 to 79) produce LCD driving waveforms. The internal data-transmission timing between the DDRAM and segment drivers is completely independent of external data-transmission timing, so that MPU makes access to the LSI without concern for the LSI's internal operation.

The FR and FLM are generated by the CL. The FR toggles once every frame in the default status, and is programmed to toggle once every N lines. And the FLM is used to specify an initial display line, which is preset whenever the FLM becomes "H".

(8) DATA LATCH CIRCUIT

The data latch circuit is used to temporarily store display data which is released to the grayscale control circuit. The display data in this circuit is updated in synchronization with the CL. The "All Pixels ON/OFF", "Display ON/OFF" and "Reverse Display ON/OFF" instructions control the data in this circuit, but does not change the data in the DDRAM.

(9) COMMON DRIVERS AND SEGMENT DRIVERS

The LSI includes 128-common drivers and 240-segment drivers. The common drivers generate LCD driving waveforms formed on the V_{LCD}, V_1, V_4 and V_{SSH} levels. The segment drivers generate waveforms formed on the V_{LCD}, V_2, V_3 and V_{SSH} levels.

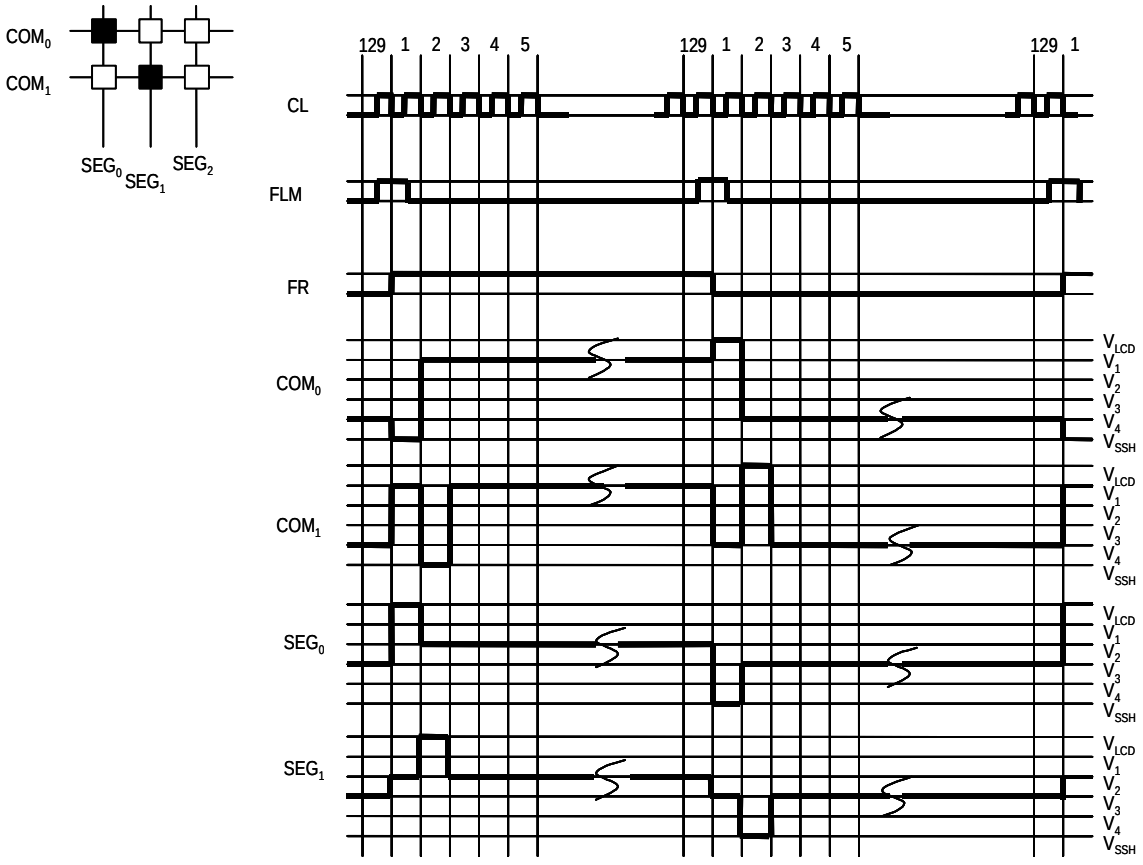


Fig 9 LCD Driving Waveforms (B&W Mode, Color Reverse OFF, 1/129 Duty)

(10) OSCILLATOR

The oscillator is equipped with a resistor and a capacitor, and generates internal clocks used for the display timing generator and the voltage booster. The internal resistor is enabled by setting "0" at the D_1 (CKS) bit of the "Bus Length" instruction. For more accurate frequency, using an external resistor or external clock is recommended.

When using the internal resistor, the resistance is controlled to optimize frame frequency for different LCD panels, by setting the D_2-D_0 (RF2-RF0) bits of the "Frequency Control" instruction. For more safety, make sure what is the best frequency in the particular application.

(10-1) Using Internal Resistor (CKS=0)

In this case, the OSC1 should be fixed at "H" or "L" and the OSC2 is open. The oscillation frequency is varied according to the display mode, as follows.

Table 16 Oscillation Frequency vs. Display Mode

Symbol	MON	PWM	Display Mode
f_{OSC1}	0	0	Variable 8-/16-grayscale Mode
f_{OSC2}	0	1	Fixed 8-grayscale Mode
f_{OSC3}	1	*	B&W Mode

*: Don't care

(10-2) Using External Resistor (CKS=1)

Be sure to connect the OSC1 and OSC2 with an external resistor. The frequency of the oscillator should be adjusted to the same value generated by the internal resistor.

(10-3) Using External Clock (CKS=1)

Input external clock to the OSC1 and leave the OSC2 open. The external clock with 50% duty is recommended. The frequency of the external clock should be the same value generated by the internal resistor.

(11) LCD POWER SUPPLY

The internal LCD power supply is organized into the voltage converter and the voltage booster. The voltage converter consists of the reference voltage generator, the voltage regulator with EVR and the LCD bias voltage generator. The configuration of the LCD power supply is arranged by setting the D_3 (AMPON) and D_1 (DCON) bits of the "Power Control" instruction. For this configuration, the internal LCD power supply can be partially used in combination with an external supply voltage, as shown in Table 17.

Table 17 Configuration of LCD Power Supply

DCON	AMPON	Voltage Booster	Voltage Converter	External Supply Voltage	NOTE
0	0	Inactive	Inactive	V_{OUT}, V_{LCD}, V_1, V_2, V_3, V_4	1, 3, 4
0	1	Inactive	Active	V_{OUT}	2, 3, 4
1	1	Active	Active	–	-

NOTE1) No internal LCD power supply is used. The LCD bias voltages are externally supplied, and the C_{1+}, C_{1-}, C_{2+}, C_{2-}, C_{3+}, C_{3-}, C_{4+}, C_{4-}, C_{5+}, C_{5-}, V_{REF}, V_{REG} and V_{EE} are open.

NOTE2) Only the voltage converter is used. The V_{OUT} is externally supplied, and the C_{1+}, C_{1-}, C_{2+}, C_{2-}, C_{3+}, C_{3-}, C_{4+}, C_{4-}, C_{5+}, C_{5-} and V_{EE} are open. The reference voltage is supplied on the V_{REF}.

NOTE3) The following relation among each LCD bias voltages must be maintained.

$$V_{OUT} \geq V_{LCD} \geq V_1 \geq V_2 \geq V_3 \geq V_4 \geq V_{SSH}$$

NOTE4) If the internal LCD power supply doesn't have enough capability to drive the particular LCD panel, use the external LCD power supply. Otherwise, it may affect display quality.

(11-1) Voltage Booster

The internal voltage booster generates up to $6xV_{EE}$ voltage. The boost level is selected from 2x, 3x, 4x, 5x or 6x by setting the D_2-D_0 (VU2-VU0) bits of the "Boost Level" instruction. The boost voltage V_{OUT} must not exceed 18.0V, otherwise the voltage stress may cause a permanent damage to the LSI.

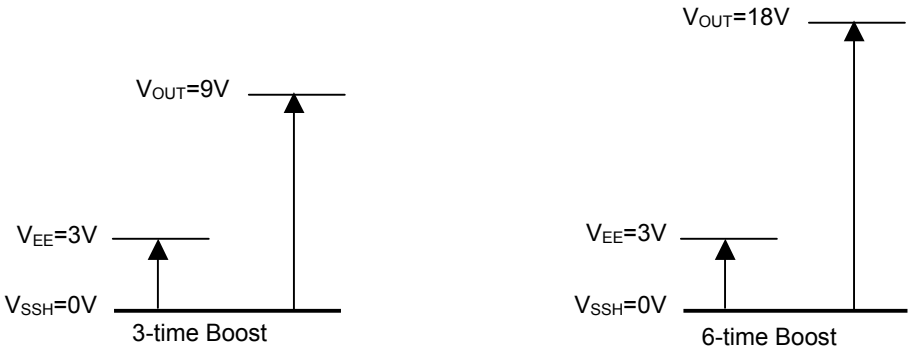


Fig 10 Boost Voltage

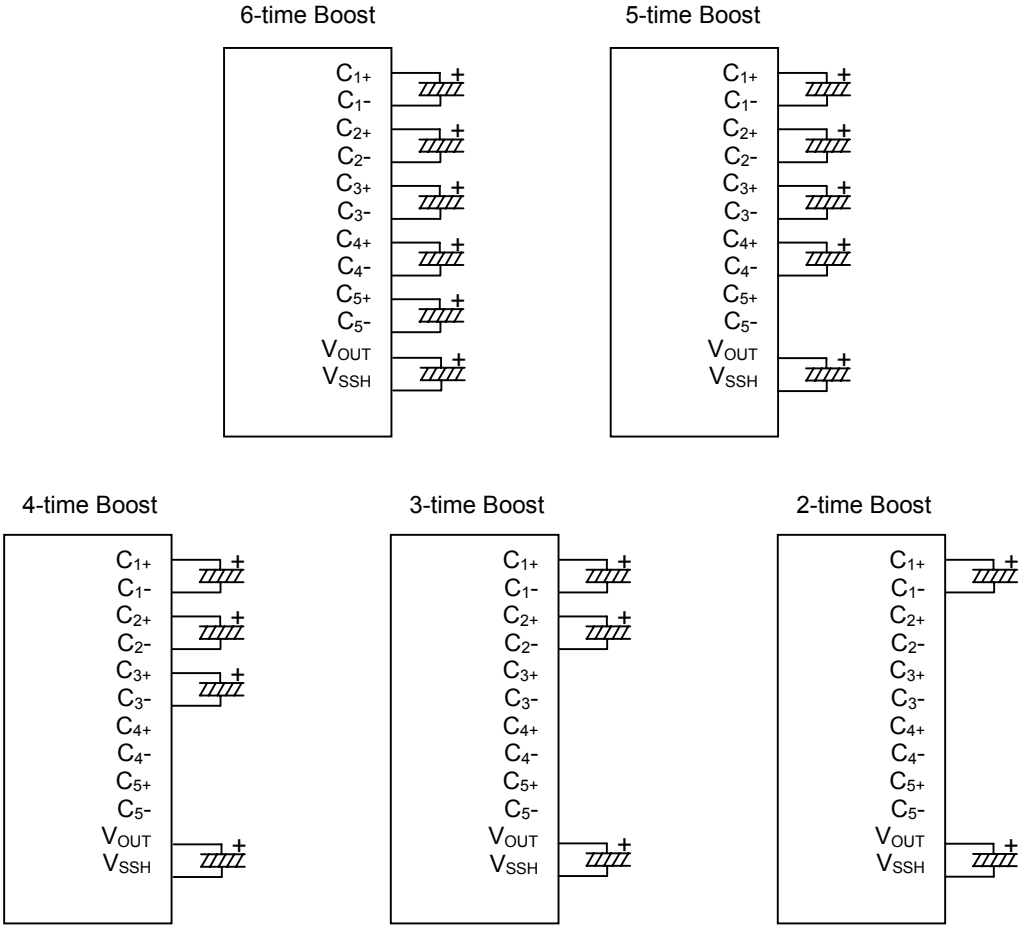


Fig 11 External Capacitor Connection of Voltage Booster

(11-2) Voltage Converter

(11-2-1) Reference Voltage Generator

The reference voltage generator produces the reference voltage (V_{BA}=0.9xV_{EE}). When using the internal LCD power supply, connect the V_{BA} and the V_{REF}, or supply 0.9xV_{EE} or lower voltage on the V_{REF}. When using an external LCD power supply, the V_{BA} should be open. Refer to Fig 12, 14 and 15.

(11-2-2) Voltage Regulator

The voltage regulator consists of an operational amplifier with gain control and EVR. The V_{REF} voltage is multiplied to obtain the V_{REG} voltage, and its multiple (boost level) is set by the D_2-D_0 (VU2-VU0) bits of the "Boost Level" instruction. The formula is shown below.

$$V_{REG} = V_{REF} \times N \qquad \text{(N: Boost Level)}$$

(11-2-3) Electrical Variable Resistor (EVR)

The EVR is used to fine-tune the V_{LCD} voltage to optimize display contrast. The EVR value is controlled in 128 steps by setting the D_3-D_0 (DV_6-DV_0) bits of the "EVR Control" instruction. The formula is shown below.

$$V_{LCD} = 0.5 \times V_{REG} + M (V_{REG} - 0.5 \times V_{REG}) / 127 \qquad \text{(M: EVR Value)}$$

(11-2-4) LCD Bias Voltage Generator

The LCD bias voltage generator consists of buffer amplifiers and bleeder resistors to generate the LCD bias voltages such as the V_{LCD}, V_1, V_2, V_3 and V_4, and its bias ratio is selected from 1/5, 1/6, 1/7, 1/8, 1/9, 1/10, 1/11 and 1/12.

As shown in Fig 12, when using only the internal LCD power supply, the capacitors CA2 are connected to the V_{LCD}, V_1, V_2, V_3 and V_4 respectively.

As shown in Fig 13, when using no internal LCD power supply, the LCD bias voltages are externally supplied on the V_{LCD}, V_1, V_2, V_3 and V_4, and the internal LCD power supply should be turned off by setting "0" at the "DCON" and "AMPON" bits. And the C_{1+}, C_1-, C_{2+}, C_{2-}, C_{3+}, C_3-, C_{4+}, C_4-, C_{5+}, C_5-, V_{EE}, V_{REF} and V_{REG} are open.

Fig 14 and 15 show typical peripheral circuits when partially using the LCD power supply without the reference voltage generator.

Fig 16 shows the circuit when partially using the LCD power supply without the voltage booster.

(11-3) External Components for LCD Power Supply

Using Only Internal LCD Power Supply (6x boost)

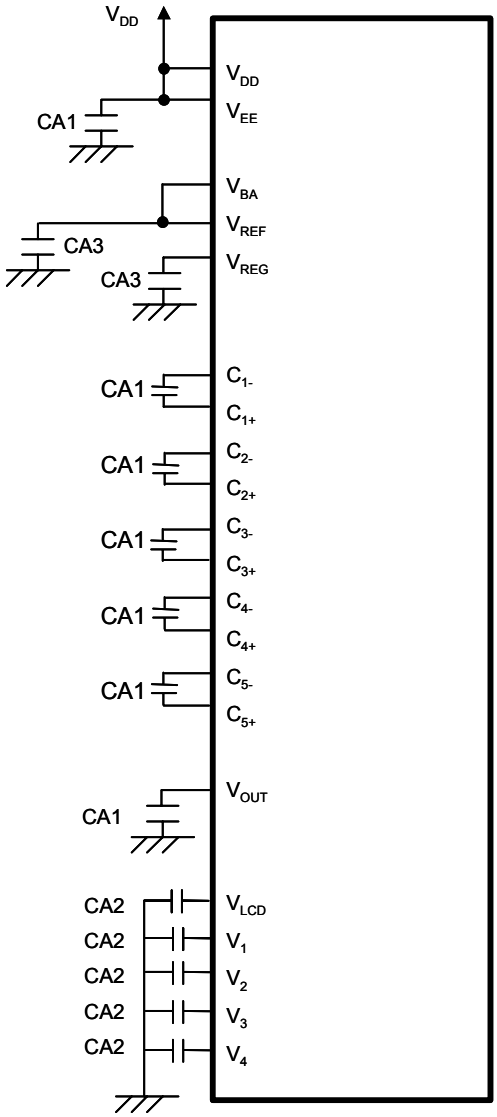


Fig 12

Using Only External LCD Power Supply

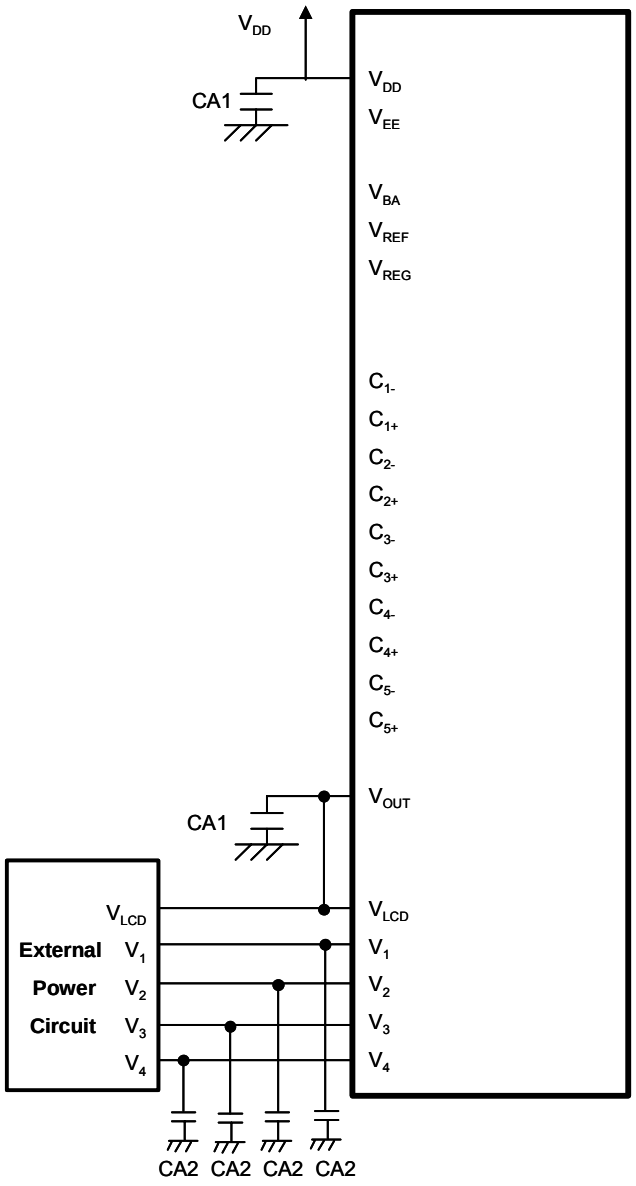


Fig 13

Reference Values

CA1	1.0 to 4.7μF
CA2	1.0 to 2.2μF
CA3	0.1μF

NOTE1) B grade capacitor is recommended for CA1-CA3. Make sure what is the best capacitor value in the particular application.

NOTE2) Parasitic resistance on the power supply lines (V_{DD}, V_{SS}, V_{EE}, V_{SSH}, V_{OUT}, V_{LCD}, V_1, V_2, V_3 and V_4) reduces step-up efficiency of the voltage booster, and may have an impact on the LSI's operation and display quality. To minimize this impact, be sure to lay out the shortest wires and place capacitors as close to the LSI as possible.

Using Internal LCD Power Supply Without Reference Voltage Generator(1) (6x boost)

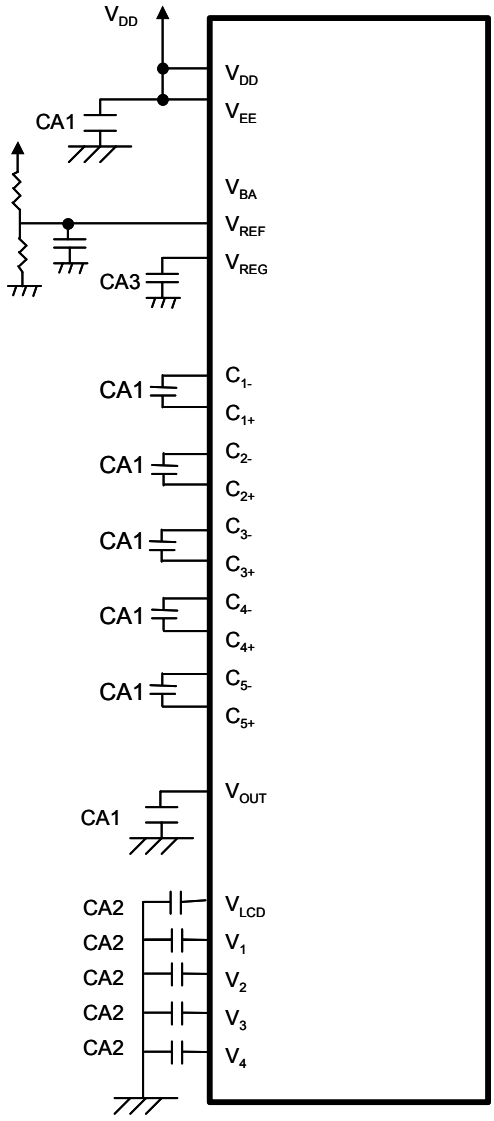


Fig 14

Using Internal LCD Power Supply Without Reference Voltage Generator(1) (6x boost)

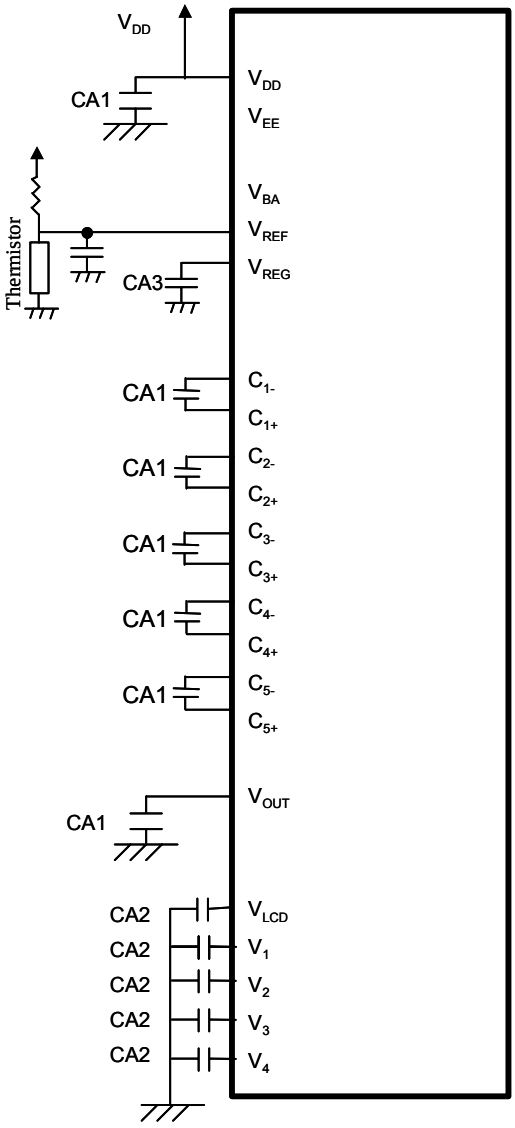


Fig 15

Reference Values

CA1	1.0 to 4.7μF
CA2	1.0 to 2.2μF
CA3	0.1μF

NOTE1) B grade capacitor is recommended for CA1-CA3. Make sure what is the best capacitor value in the particular application.

NOTE2) Parasitic resistance on the power supply lines (V_{DD}, V_{SS}, V_{EE}, V_{SSH}, V_{OUT}, V_{LCD}, V_1, V_2, V_3 and V_4) reduces step-up efficiency of the voltage booster, and may have an impact on the LSI's operation and display quality. To minimize this impact, be sure to lay out the shortest wires and place capacitors as close to the LSI as possible.

Using Internal LCD Power Supply
Without Voltage Booster

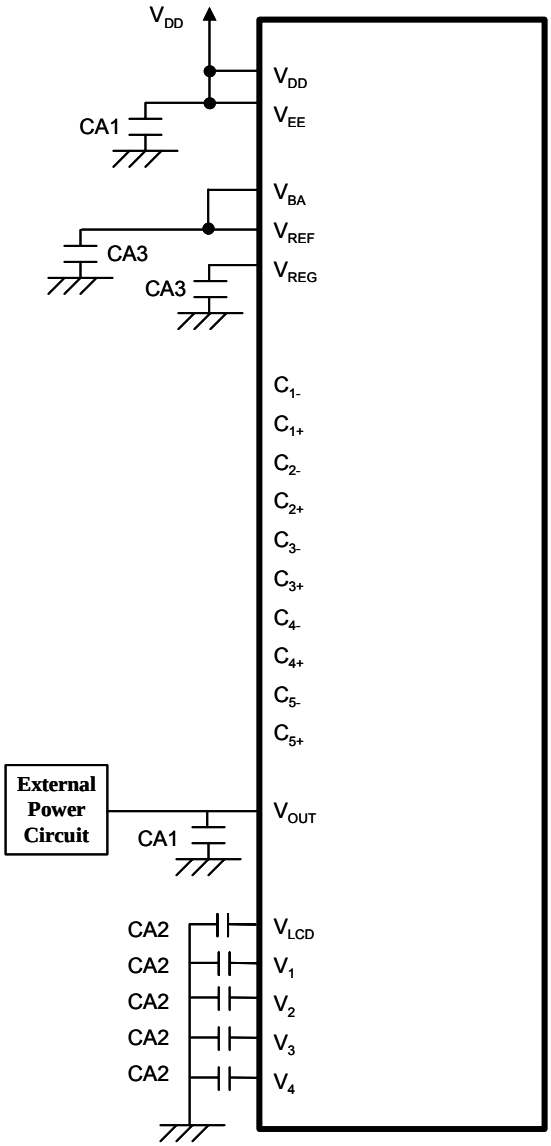


Fig 16

Reference Values

CA1	1.0 to 4.7μF
CA2	1.0 to 2.2μF
CA3	0.1μF

NOTE1) B grade capacitor is recommended for CA1-CA3. Make sure what is the best capacitor value in the particular application.

NOTE2) Parasitic resistance on the power supply lines (V_{DD}, V_{SS}, V_{EE}, V_{SSH}, V_{OUT}, V_{LCD}, V_1, V_2, V_3 and V_4) reduces step-up efficiency of the voltage booster, and may have an impact on the LSI's operation and display quality. To minimize this impact, be sure to lay out the shortest wires and place capacitors as close to the LSI as possible.

(11-4) Discharge Circuit

The LSI incorporates two discharge circuits which are independently controlled for the V_{LCD} and V_1-V_4 and for the V_{OUT}. The V_{LCD} and V_1-V_4 are discharged by setting "1" at the D_0 (DIS) bit of the "Discharge ON/OFF" instruction or the reset by the RESb. And the V_{OUT} (100KΩ internal resistor between V_{OUT} and V_{EE}) is discharged by setting "1" at the D_1 (DIS2) bit of this instruction. Be sure to turned off the internal or external LCD power supply when this instruction is executed, otherwise it may function as a current load and affect an operating current. Refer to "(14-22) Discharge ON/OFF".

(11-5) Power ON/OFF

To protect the LSI from overcurrent, the following sequences must be maintained to turn on and off the power supply. In addition to the following discussions, refer to "(18) TYPICAL INSTRUCTION SEQUENCES".

(11-5-1) Power ON/OFF in Using Internal LCD Power Supply

Power ON

First "V_{DD} and V_{EE} ON", next "Reset by RESb", then "Internal LCD power supply ON". Be sure to execute the "Display ON" instruction later than the completion of this power ON sequence. Otherwise, unexpected pixels may be turned on instantly.

Power OFF

First "Reset by RESb or "HALT" instruction", next "V_{DD} and V_{EE} OFF". If using different power sources for the V_{DD} and the V_{EE} individually, the V_{EE} must be turned off after the reset or the "HALT". After that, the V_{DD} can be turned off, waiting until the LCD bias voltages (V_{LCD}, V_1, V_2, V_3 and V_4) drop below the threshold level of LCD pixels.

(11-5-2) Power ON/OFF in Using External LCD Power Supply

Power ON

First "V_{DD} and V_{EE} ON", next "Reset by RESb", then "External LCD power supply ON". When using only external V_{OUT}, first "V_{DD} ON", next "Reset by RESb", then "External V_{OUT} ON", as well.

Power OFF

First "Reset by RESb or "HALT" instruction" to isolate external LCD bias voltages, next "V_{DD} OFF". For more safety, placing a resistor in series on the V_{LCD} line (or the V_{OUT} line in using only the external V_{OUT}) is recommended. That resistance is usually between 50Ω and 100Ω.

(12) RESET FUNCTION

The reset function initializes the LSI to the following default status by setting the RESb to "L". Connecting the RESb with MPU's reset is recommended so that the LSI and MPU is initialized at a time.

Default Status

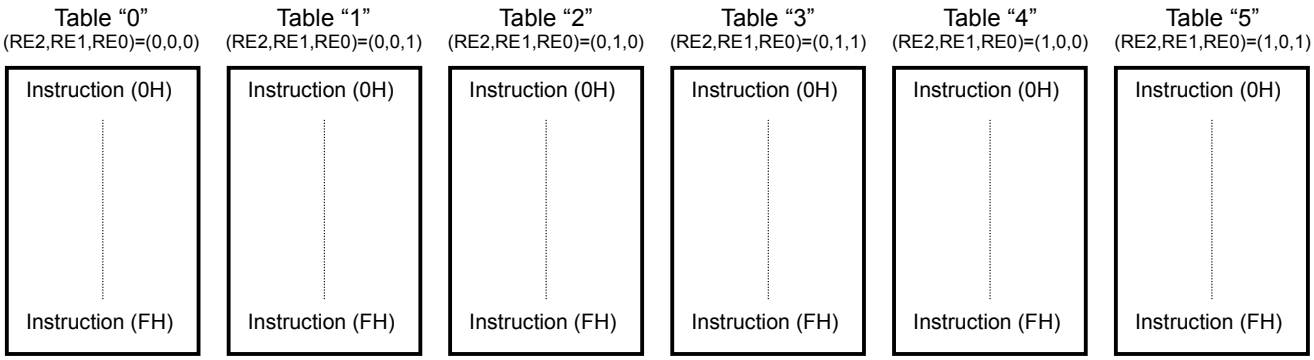
1. Display Data in DDRAM :Undefined
2. Window Start Column Address :(00)H
3. Window Start Row Address :(00)H
4. Initial Display Line :(0)H (1st line)
5. Display ON/OFF :OFF
6. Reverse Display ON/OFF :OFF (Normal)
7. Duty Cycle Ratio :1/129 Duty (DSE=0)
8. N-line Inversion ON/OFF :OFF
9. COM Scan Direction :$COM_0 \rightarrow COM_{127}$
10. Increment/Decrement Control :(HV, XD, YD)=(0, 0, 0)
11. Read-modify-write :OFF (AIM=0)
12. Swap :OFF (Normal)
13. EVR Value :(0, 0, 0, 0, 0, 0, 0)
14. Internal LCD Power Supply :OFF
15. Display Mode :Grayscale Mode
16. LCD Bias Ratio :1/9 Bias
17. Palette 0 :(0, 0, 0, 0, 0)
18. Palette 1 :(0, 0, 0, 1, 1)
19. Palette 2 :(0, 0, 1, 0, 1)
20. Palette 3 :(0, 0, 1, 1, 1)
21. Palette 4 :(0, 1, 0, 0, 1)
22. Palette 5 :(0, 1, 0, 1, 1)
23. Palette 6 :(0, 1, 1, 0, 1)
24. Palette 7 :(0, 1, 1, 1, 1)
25. Palette 8 :(1, 0, 0, 0, 1)
26. Palette 9 :(1, 0, 0, 1, 1)
27. Palette 10 :(1, 0, 1, 0, 1)
28. Palette 11 :(1, 0, 1, 1, 1)
29. Palette 12 :(1, 1, 0, 0, 1)
30. Palette 13 :(1, 1, 0, 1, 1)
31. Palette 14 :(1, 1, 1, 0, 1)
32. Palette 15 :(1, 1, 1, 1, 1)
33. Display Mode Control :Variable 16-grayscale Mode (4,096 Colors)
34. Bus Length :8-bit Bus Length
35. Discharge ON/OFF :OFF (DIS,DIS2)=(0,0)

(13) INSTRUCTION TABLES

(13-1) Instruction Table and Register Address

The LSI incorporates 6 instruction tables as shown in Fig 17, and each instruction table has a specific address in between “0” and “5”. And each instruction register has a specific address in between (0H) and (FH), and instruction is read out from the register by the “Register Address” and “Register Read” instructions.

Fig 18 shows part of the instruction sequence, where the instruction table should be specified prior to other instructions. However, when some instructions of the same table are sequentially executed, the table selection may be omitted. In addition, the “Display Data Write”, “Display Data Read” and “Register Read” instructions can be performed in any table.



NOTE) Address (FH) is assigned to “Instruction Table Select” in any table.

Fig 17 Instruction Table Overview

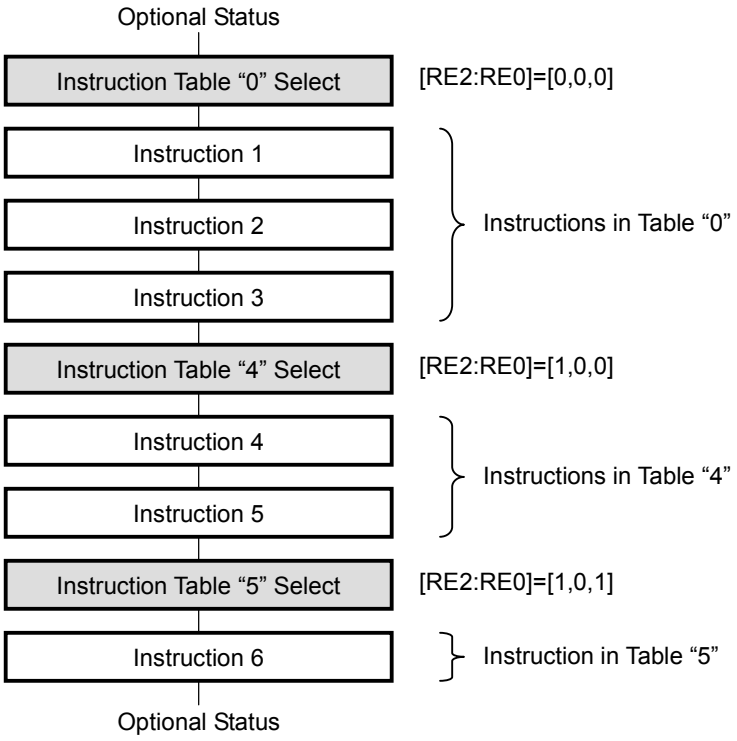


Fig 18 Outline of Instruction Sequence

(13-2) Instruction Table 0 (RE2, RE1, RE0)=(0, 0, 0)

	Instructions/ Register Address [NH]	Code (80 Series MPU I/F)							Code								Functions
		CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	
1	Display Data Write	0	0	1	0	0/1	0/1	0/1	Write Data								Writing Display Data
2	Display Data Read	0	0	0	1	0/1	0/1	0/1	Read Data								Reading Display Data
3	Window Start Column Address (Lower) [0H]	0	1	1	0	0	0	0	0	0	0	0	AX3	AX2	AX1	AX0	Setting Column Address for start point
	Window Start Column Address (Upper) [1H]	0	1	1	0	0	0	0	0	0	0	1	AX7	AX6	AX5	AX4	Setting Column Address for start point
4	Window Start Row Address (Lower) [2H]	0	1	1	0	0	0	0	0	0	1	0	AY3	AY2	AY1	AY0	Setting Row Address for start point
	Window Start Row Address (Upper) [3H]	0	1	1	0	0	0	0	0	0	1	1	*	AY6	AY5	AY4	Setting Row Address for start point
5	Initial Display Line (Lower) [4H]	0	1	1	0	0	0	0	0	1	0	0	LA3	LA2	LA1	LA0	Setting Row Address for Initial COM
	Initial Display Line (Upper) [5H]	0	1	1	0	0	0	0	0	1	0	1	*	LA6	LA5	LA4	Setting Row Address for Initial COM
6	N-line Inversion (Lower) [6H]	0	1	1	0	0	0	0	0	1	1	0	N3	N2	N1	N0	Setting the Number of N-line Inversion
	N-line Inversion (Upper) [7H]	0	1	1	0	0	0	0	0	1	1	1	*	N6	N5	N4	Setting the Number of N-line Inversion
7	Display Control (1) [8H]	0	1	1	0	0	0	0	1	0	0	0	SHIFT	MON	ALL ON	ON/ OFF	SHIFT : Common Scan Direction MON : Grayscale/B/W Mode ALLON : All Pixels ON/OFF ON/OFF : Display ON/OFF
8	Display Control (2) [9H]	0	1	1	0	0	0	0	1	0	0	1	REV	NLIN	SWAP	*	REV : Reverse Display ON/OFF NLIN : N-line Inversion ON/OFF SWAP : SWAP ON/OFF
9	Increment/Decrement Control [AH]	0	1	1	0	0	0	0	1	0	1	0	AIM	HV	XD	YD	AIM : Read-Modify-Write ON/OFF HV :Horizontal/ Vertical Direction XD : X Increment / Decrement YD : Y Increment / Decrement
10	Power Control [BH]	0	1	1	0	0	0	0	1	0	1	1	AMP ON	HALT	DC ON	ACL	AMPON : Voltage Converter ON/OFF HALT : Power Save ON/OFF DCON : Voltage Booster ON/OFF ACL : Reset
11	Duty Cycle Ratio [CH]	0	1	1	0	0	0	0	1	1	0	0	DS3	DS2	DS1	DS0	Setting LCD Duty Cycle Ratio
12	Boost Level [DH]	0	1	1	0	0	0	0	1	1	0	1	*	VU2	VU1	VU0	Setting Boost Level
13	LCD Bias Ratio [EH]	0	1	1	0	0	0	0	1	1	1	0	*	B2	B1	B0	Setting LCD Bias Ratio
14	Instruction Table Select [FH]	0	1	1	0	0/1	0/1	0/1	1	1	1	1	TST0	RE2	RE1	RE0	Setting Instruction Table

NOTE1) * : Don't care.
NOTE2) [NH] (N=0-F) : Register Address
NOTE3) Any nonexistent instruction code is prohibited.
NOTE4) Dual instructions except for "EVR Control" are already effective when either upper byte or lower byte is set.
NOTE5) "EVR Control" instruction is finally effective when both upper and lower bytes are set. Send upper byte first, next lower byte.

(13-3) Instruction Table 1 (RE2, RE1, RE0)=(0, 0, 1)

	Instructions/ Register Address [NH]	Code (80 series MPU I/F)							Code								Functions
		CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	
15	Palette A0/A8 (Lower) [0H]	0	1	1	0	0	0	1	0	0	0	0	PA03/ PA83	PA02/ PA82	PA01/ PA81	PA00/ PA80	Setting Palette Data : A0(PS=0) /A8(PS=1)
	Palette A0/A8 (Upper) [1H]	0	1	1	0	0	0	1	0	0	0	1	*	*	*	PA04/ PA84	Setting Palette Data : A0(PS=0) /A8(PS=1)
	Palette A1/A9 (Lower) [2H]	0	1	1	0	0	0	1	0	0	1	0	PA13/ PA93	PA12/ PA92	PA11/ PA91	PA10/ PA90	Setting Palette Data : A1(PS=0) /A9(PS=1)
	Palette A1/A9 (Upper) [3H]	0	1	1	0	0	0	1	0	0	1	1	*	*	*	PA14/ PA94	Setting Palette Data : A1(PS=0) /A9(PS=1)
	Palette A2/A10 (Lower) [4H]	0	1	1	0	0	0	1	0	1	0	0	PA23/ PA103	PA22/ PA102	PA21/ PA101	PA20/ PA100	Setting Palette Data : A2(PS=0) /A10(PS=1)
	Palette A2/A10 (Upper) [5H]	0	1	1	0	0	0	1	0	1	0	1	*	*	*	PA24/ PA104	Setting Palette Data : A2(PS=0) /A10(PS=1)
	Palette A3/A11 (Lower) [6H]	0	1	1	0	0	0	1	0	1	1	0	PA33/ PA113	PA32/P A112	PA31/ PA111	PA30/ PA110	Setting Palette Data : A3(PS=0) /A11(PS=1)
	Palette A3/A11 (Upper) [7H]	0	1	1	0	0	0	1	0	1	1	1	*	*	*	PA34/ PA114	Setting Palette Data : A3(PS=0) /A11(PS=1)
	Palette A4/A12 (Lower) [8H]	0	1	1	0	0	0	1	1	0	0	0	PA43/ PA123	PA42/P A122	PA41/ PA121	PA40/ PA120	Setting Palette Data : A4(PS=0) /A12(PS=1)
	Palette A4/A12 (Upper) [9H]	0	1	1	0	0	0	1	1	0	0	1	*	*	*	PA44/ PA124	Setting Palette Data : A4(PS=0) /A12(PS=1)
	Palette A5/A13 (Lower) [AH]	0	1	1	0	0	0	1	1	0	1	0	PA53/ PA133	PA52/P A132	PA51/ PA131	PA50/ PA130	Setting Palette Data : A5(PS=0) /A13(PS=1)
	Palette A5/A13 (Upper) [BH]	0	1	1	0	0	0	1	1	0	1	1	*	*	*	PA54/ PA134	Setting Palette Data : A5(PS=0) /A13(PS=1)
	Palette A6/A14 (Lower) [CH]	0	1	1	0	0	0	1	1	1	0	0	PA63/ PA143	PA62/P A142	PA61/ PA141	PA60/ PA140	Setting Palette Data : A6(PS=0) /A14(PS=1)
	Palette A6/A14 (Upper) [DH]	0	1	1	0	0	0	1	1	1	0	1	*	*	*	PA64/ PA144	Setting Palette Data : A6(PS=0) /A14(PS=1)
14	Instruction Table Select [FH]	0	1	1	0	0/1	0/1	0/1	1	1	1	1	TST0	RE2	RE1	RE0	Setting Instruction Table

NOTE1) * : Don't care.
NOTE2) [NH] (N=0-F) : Register Address
NOTE3) Any nonexistent instruction code is prohibited.
NOTE4) Dual instructions except for "EVR Control" are already effective when either upper byte or lower byte is set.
NOTE5) "EVR Control" instruction is finally effective when both upper and lower bytes are set. Send upper byte first, next lower byte.

(13-4) Instruction Table 2 (RE2, RE1, RE0)=(0, 1, 0)

Instructions/ Register Address [NH]		Code (80 series MPU I/F)							Code								Functions
		CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	
15	Palette A7/A15 (Lower) [0H]	0	1	1	0	0	1	0	0	0	0	0	PA73/ PA153	PA72/P A152	PA71/ PA151	PA70/ PA150	Setting Palette Data : A7(PS=0) /A15(PS=1)
	Palette A7/A15 (Upper) [1H]	0	1	1	0	0	1	0	0	0	0	1	*	*	*	PA74/ PA154	Setting Palette Data : A7(PS=0) /A15(PS=1)
	Palette B0/B8 (Lower) [2H]	0	1	1	0	0	1	0	0	0	1	0	PB03/ PB83	PB02/ PB82	PB01/ PB81	PB00/ PB80	Setting Palette Data : B0(PS=0) /B8(PS=1)
	Palette B0/B8 (Upper) [3H]	0	1	1	0	0	1	0	0	0	1	1	*	*	*	PB04/ PG84	Setting Palette Data : B0(PS=0) /B8(PS=1)
	Palette B1/B9 (Lower) [4H]	0	1	1	0	0	1	0	0	1	0	0	PB13/ PB93	PB12/ PB92	PB11/ PB91	PB10/ PB90	Setting Palette Data : B1(PS=0) /B9(PS=1)
	Palette B1/B9 (Upper) [5H]	0	1	1	0	0	1	0	0	1	0	1	*	*	*	PB14/ PB94	Setting Palette Data : B1(PS=0) /B9(PS=1)
	Palette B2/B10 (Lower) [6H]	0	1	1	0	0	1	0	0	1	1	0	PB23/ PB103	PB22/ PB102	PB21/ PB101	PB20/ PB100	Setting Palette Data : B2(PS=0) /B10(PS=1)
	Palette B2/B10 (Upper) [7H]	0	1	1	0	0	1	0	0	1	1	1	*	*	*	PB24/ PB104	Setting Palette Data : B2(PS=0) /B10(PS=1)
	Palette B3/B11 (Lower) [8H]	0	1	1	0	0	1	0	1	0	0	0	PB33/ PB113	PB32/ PB112	PB31/ PB111	PB30/ PB110	Setting Palette Data : B3(PS=0) /B11(PS=1)
	Palette B3/B11 (Upper) [9H]	0	1	1	0	0	1	0	1	0	0	1	*	*	*	PB34/ PB114	Setting Palette Data : B3(PS=0) /B11(PS=1)
	Palette B4/B12 (Lower) [AH]	0	1	1	0	0	1	0	1	0	1	0	PB43/ PB123	PB42/ PB122	PB41/ PB121	PB40/ PB120	Setting Palette Data : B4(PS=0) /B12(PS=1)
	Palette B4/B12 (Upper) [BH]	0	1	1	0	0	1	0	1	0	1	1	*	*	*	PB44/ PB124	Setting Palette Data : B4(PS=0) /B12(PS=1)
	Palette B5/B13 (Lower) [CH]	0	1	1	0	0	1	0	1	1	0	0	PB53/ PB133	PB52/ PB132	PB51/ PB131	PB50/ PB130	Setting Palette Data : B5(PS=0) /B13(PS=1)
	Palette B5/B13 (Upper) [DH]	0	1	1	0	0	1	0	1	1	0	1	*	*	*	PB54/ PB134	Setting Palette Data : B5(PS=0) /B13(PS=1)
14	Instruction Table Select [FH]	0	1	1	0	0/1	0/1	0/1	1	1	1	1	TST0	RE2	RE1	RE0	Setting Instruction Tablet

NOTE1) * : Don't care.
NOTE2) [NH] (N=0-F) : Register Address
NOTE3) Any nonexistent instruction code is prohibited.
NOTE4) Dual instructions except for "EVR Control" are already effective when either upper byte or lower byte is set.
NOTE5) "EVR Control" instruction is finally effective when both upper and lower bytes are set. Send upper byte first, next lower byte.

(13-5) Instruction Table 3 (RE2, RE1, RE0)=(0, 1, 1)

Instructions/ Register Address [NH]		Code (80 series MPU I/F)							Code								Functions
		CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	
15	Palette B6/B14 (Lower) [0H]	0	1	1	0	0	1	1	0	0	0	0	PB63/ PB143	PB62/ PB142	PB61/ PB141	PB60/ PB140	Setting Palette Data : B6(PS=0) /B14(PS=1)
	Palette B6/B14 (Upper) [1H]	0	1	1	0	0	1	1	0	0	0	1	*	*	*	PB64/ PB144	Setting Palette Data : B6(PS=0) /B14(PS=1)
	Palette B7/B15 (Lower) [2H]	0	1	1	0	0	1	1	0	0	1	0	PB73/ PB153	PB72/ PB152	PB71/ PB151	PB70/ PB150	Setting Palette Data : B7(PS=0) /B15(PS=1)
	Palette B7/B15 (Upper) [3H]	0	1	1	0	0	1	1	0	0	1	1	*	*	*	PB74/ PB154	Setting Palette Data : B7(PS=0) /B15(PS=1)
	Palette C0/C8 (Lower) [4H]	0	1	1	0	0	1	1	0	1	0	0	PC03/ PC83	PC02/ PC82	PC01/ PC81	PC00/ PC80	Setting Palette Data : C0(PS=0) /C8(PS=1)
	Palette C0/C8 (Upper) [5H]	0	1	1	0	0	1	1	0	1	0	1	*	*	*	PC04/ PC84	Setting Palette Data : C0(PS=0) /C8(PS=1)
	Palette C1/C9 (Lower) [6H]	0	1	1	0	0	1	1	0	1	1	0	PC13/ PC93	PC12/ PC92	PC11/ PC91	PC10/ PC90	Setting Palette Data : C1(PS=0) /C9(PS=1)
	Palette C1/C9 (Upper) [7H]	0	1	1	0	0	1	1	0	1	1	1	*	*	*	PC14/ PC94	Setting Palette Data : C1(PS=0) /C9(PS=1)
	Palette C2/C10 (Lower) [8H]	0	1	1	0	0	1	1	1	0	0	0	PC23/ PC103	PC22/ PC102	PC21/ PC101	PC20/ PC100	Setting Palette Data : C2(PS=0) /C10(PS=1)
	Palette C2/C10 (Upper) [9H]	0	1	1	0	0	1	1	1	0	0	1	*	*	*	PC24/ PC104	Setting Palette Data : C2(PS=0) /C10(PS=1)
	Palette C3/C11 (Lower) [AH]	0	1	1	0	0	1	1	1	0	1	0	PC33P C113	PC32/ PC112	PC31/ PC111	PC30/ PC110	Setting Palette Data : C3(PS=0) /C11(PS=1)
	Palette C3/C11 (Upper) [BH]	0	1	1	0	0	1	1	1	0	1	1	*	*	*	PC34/ PC114	Setting Palette Data : C3(PS=0) /C11(PS=1)
	Palette C4/C12 (Lower) [CH]	0	1	1	0	0	1	1	1	1	0	0	PC43/ PC123	PC42/ PC122	PC41/ PC121	PC40/ PC120	Setting Palette Data : C4(PS=0) /C12(PS=1)
	Palette C4/C12 (Upper) [DH]	0	1	1	0	0	1	1	1	1	0	1	*	*	*	PC44/ PC124	Setting Palette Data : C4(PS=0) /C12(PS=1)
14	Instruction Table Select [FH]	0	1	1	0	0/1	0/1	0/1	1	1	1	1	TST0	RE2	RE1	RE0	Setting Instruction Table

NOTE1) * : Don't care.
NOTE2) [NH] (N=0-F) : Register Address
NOTE3) Any nonexistent instruction code is prohibited.
NOTE4) Dual instructions except for "EVR Control" are already effective when either upper byte or lower byte is set.
NOTE5) "EVR Control" instruction is finally effective when both upper and lower bytes are set. Send upper byte first, next lower byte.

(13-6) Instruction Table 4 (RE2, RE1, RE0)=(1, 0, 0)

Instructions/ Register Address [NH]		Code (80 series MPU I/F)							Code								Functions
		CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	
15	Palette C5/C13 (Lower) [0H]	0	1	1	0	1	0	0	0	0	0	0	PC53/ PC133	PC52/ PC132	PC51/ PC131	PC50/ PC130	Setting Palette Data : C5(PS=0) /C13(PS=1)
	Palette C5/C13 (Upper) [1H]	0	1	1	0	1	0	0	0	0	0	1	*	*	*	PC54/ PC134	Setting Palette Data : C5(PS=0) /C13(PS=1)
	Palette C6/C14 (Lower) [2H]	0	1	1	0	1	0	0	0	0	1	0	PC63/P C143	PC62/ PC142	PC61/ PC141	PC60/ PC140	Setting Palette Data : C6(PS=0) /C14(PS=1)
	Palette C6/C14 (Upper) [3H]	0	1	1	0	1	0	0	0	0	1	1	*	*	*	PC64/ PC144	Setting Palette Data : C6(PS=0) /C14(PS=1)
	Palette C7/C15 (Lower) [4H]	0	1	1	0	1	0	0	0	1	0	0	PC73/ PC153	PC72/ PC152	PC71/ PC151	PC70/ PC150	Setting Palette Data : C7(PS=0) /C15(PS=1)
	Palette C7/C15 (Upper) [5H]	0	1	1	0	1	0	0	0	1	0	1	*	*	*	PC74/ PC154	Setting Palette Data : C7(PS=0) /C15(PS=1)
16	Initial COM [6H]	0	1	1	0	1	0	0	0	1	1	0	SC3	SC2	SC1	SC0	Setting start COM for scanning
17	Duty-1 /Display Clock ON/OFF [7H]	0	1	1	0	1	0	0	0	1	1	1	*	*	DSE	SON	SON : Display Clock ON/OFF DSE : Duty-1 ON/OFF
18	Display Mode Control [8H]	0	1	1	0	1	0	0	1	0	0	0	PWM	C256	*	*	PWM : Variable/Fixed Grayscale Mode C256 : 256-color Mode ON/OFF
19	Bus Length [9H]	0	1	1	0	1	0	0	1	0	0	1	*	ABS	CKS	WLS	ABS : Bit Assignment CKS : Oscillator Set WLS : 8-/16-bit Bus Length
20	EVR Control (Lower) [AH]	0	1	1	0	1	0	0	1	0	1	0	DV3	DV2	DV1	DV0	Setting EVR Value (Lower Bit)
	EVR Control (Upper) [BH]	0	1	1	0	1	0	0	1	0	1	1	*	DV6	DV5	DV4	Setting EVR Value (Upper Bit)
21	Frequency Control [DH]	0	1	1	0	1	0	0	1	1	0	1	*	RF2	RF1	RF0	Adjusting Oscillation Frequency
22	Discharge ON/OFF [EH]	0	1	1	0	1	0	0	1	1	1	0	*	*	DIS2	DIS	Discharge ON/OFF
23	Register Address [CH]	0	1	1	0	1	0	0	1	1	0	0	Register Address				Setting Register Address
24	Register Read	0	1	0	1	0/1	0/1	0/1	*	*	*	*	Read Data				Reading Instruction
14	Instruction Table Select [FH]	0	1	1	0	0/1	0/1	0/1	1	1	1	1	TST0	RE2	RE1	RE0	Setting Instruction Table Select

NOTE1) * : Don't care.
NOTE2) [NH] (N=0-F) : Register Address
NOTE3) Any nonexistent instruction code is prohibited.
NOTE4) Dual instructions except for "EVR Control" are already effective when either upper byte or lower byte is set.
NOTE5) "EVR Control" instruction is finally effective when both upper and lower bytes are set. Send upper byte first, next lower byte.

(13-7) Instruction Table 5 (RE2, RE1, RE0)=(1, 0, 1)

Instructions/ Register Address [NH]		Code (80 series MPU I/F)							Code								Functions
		CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	
25	Window End Column Address (Lower) [0H]	0	1	1	0	1	0	1	0	0	0	0	EX3	EX2	EX1	EX0	Setting Column Address for end point
	Window End Column Address (Upper) [1H]	0	1	1	0	1	0	1	0	0	0	1	EX7	EX6	EX5	EX4	Setting Column Address for end point
26	Window End Row Address (Lower) [2H]	0	1	1	0	1	0	1	0	0	1	0	EY3	EY2	EY1	EY0	Setting Row Address for end point
	Window End Row Address (Upper) [3H]	0	1	1	0	1	0	1	0	0	1	1	*	EY6	EY5	EY4	Setting Row Address for end point
27	Initial Line-reverse Address (Lower) [4H]	0	1	1	0	1	0	1	0	1	0	0	LS3	LS2	LS1	LS0	Setting Start Line for Line-reverse Display
	Initial Line-reverse Address (Upper) [5H]	0	1	1	0	1	0	1	0	1	0	1	*	LS6	LS5	LS4	Setting Start Line for Line-reverse Display
28	Last Line-reverse Address (Lower) [6H]	0	1	1	0	1	0	1	0	1	1	0	LE3	LE2	LE1	LE0	Setting End Line for Line-reverse Display
	Last Line-reverse Address (Upper) [7H]	0	1	1	0	1	0	1	0	1	1	1	*	LE6	LE5	LE4	Setting End Line for Line-reverse Display
29	Line Reverse ON/OFF [8H]	0	1	1	0	1	0	1	1	0	0	0	*	*	BT	LREV	BT : Blink Set LREV : Line-reverse ON/OFF
30	Upper/Lower Palette Select [9H]	0	1	1	0	1	0	1	1	0	0	1	*	*	*	PS	PS : Upper/Lower Palette Register
31	PWM Control [AH]	0	1	1	0	1	0	1	1	0	1	0	PWM S	PWM A	PWM B	PWM C	Setting PWM Mode
14	Instruction Table Select [FH]	0	1	1	0	0/1	0/1	0/1	1	1	1	1	TST0	RE2	RE1	RE0	Setting Instruction Table

NOTE1) * : Don't care.
NOTE2) [NH] (N=0-F) : Register Address
NOTE3) Any nonexistent instruction code is prohibited.
NOTE4) Dual instructions except for "EVR Control" are already effective when either upper byte or lower byte is set.
NOTE5) "EVR Control" instruction is finally effective when both upper and lower bytes are set. Send upper byte first, next lower byte.

(14) INSTRUCTION DESCRIPTIONS

This chapter provides detailed descriptions about each instruction. These descriptions are written with the assumption that 80-series MPU is used. When using 68-series MPU, the polarities of the E and R/W signals differ from those of the RDb and WRb signals.

(14-1) Display Data Write

The "Display Data Write" instruction writes display data on a specified DDRAM address.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	0	1	0	0/1	0/1	0/1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
Display Data							

(14-2) Display Data Read

The "Display Data Read" instruction reads out display data from a specified DDRAM address. One dummy read is necessary right after DDRAM address setting.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	0	0	1	0/1	0/1	0/1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
Display Data							

(14-3) Window Start Column Address

The "Window Start Column Address" instruction specifies the column address of the start point. The setting order is lower byte first, then upper byte.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	0	0	AX3	AX2	AX1	AX0

(Default: AX3-AX0=0H / Register Address: 0H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	0	1	AX7	AX6	AX5	AX4

(Default: AX7-AX4=0H / Register Address: 1H)

(14-4) Window Start Row Address

The "Window Start Row Address" instruction specifies the row address of the start point. Available setting range is from (00H) to (7FH), and outside this range is not allowed. The setting order is lower byte first, then upper byte.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	1	0	AY3	AY2	AY1	AY0

(Default: AY3-AY0=0H / Register Address: 2H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	1	1	*	AY6	AY5	AY4

(Default: AY6-AY4=0H / Register Address: 3H)

(14-5) Initial Display Line

This instruction sets the row address, which corresponds to an initial COM and is normally positioned on top of a screen in full display. For more information, refer to "(14-16) Initial COM". The setting order is lower byte first, then upper byte.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	0	0	LA3	LA2	LA1	LA0

(Default: LA3-LA0=0H / Register Address: 4H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	0	1	*	LA6	LA5	LA4

(Default: LA6-LA4=0H / Register Address: 5H)

Table 18 Initial Display Line Address

LA6	LA5	LA4	LA3	LA2	LA1	LA0	Row Address
0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	1
			:				:
1	1	1	1	1	1	1	127

(14-6) N-line Inversion

The number of N line is selected in between “2” and “128”. When the N-line inversion is enabled by setting “1” at the D_2 (NLIN) bit of the “Display Control (2)” instruction, the FR toggles once every N lines. When the N-line inversion is disabled by setting “0” at this bit, the FR toggles by the frame.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	N3	N2	N1	N0

(Default: N3-N0=0H / Register Address: 6H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	1	*	N6	N5	N4

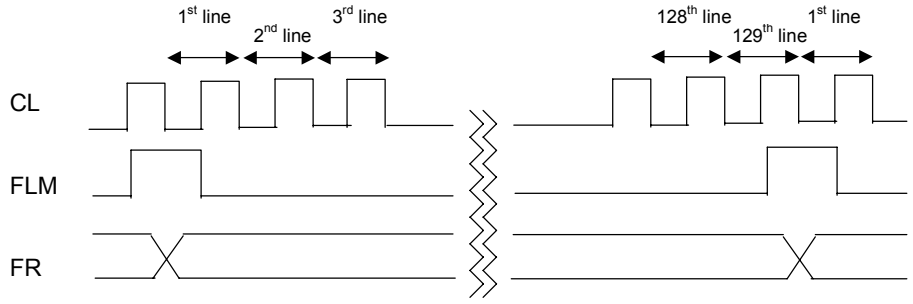
(Default: N6-N4=0H / Register Address: 7H)

Table 19 N-line Inversion

N6	N5	N4	N3	N2	N1	N0	N Line
0	0	0	0	0	0	0	Inhibited
0	0	0	0	0	0	1	2
			:				:
1	1	1	1	1	1	1	128

NOTE1) N Line=(N Value)+1

N-line inversion OFF



N-line inversion ON

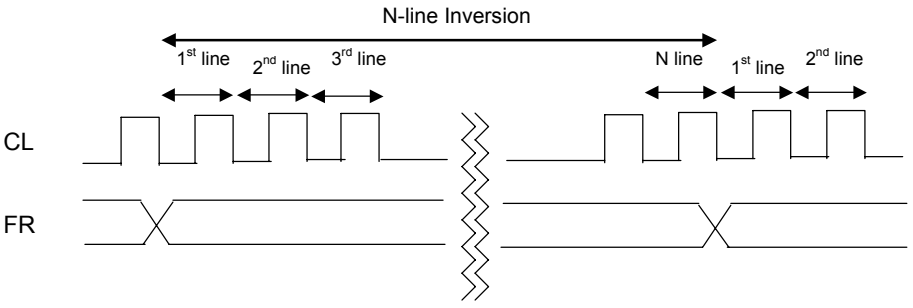


Fig 19 N-line Inversion Timing (1/129 Duty)

(14-7) Display Control (1)

The "Display Control (1)" instruction controls display conditions.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	0	0	SHIFT	MON	ALL ON	ON /OFF

(Default: [SHIFT,MON,ALLON,ON/OFF]=0H / Register Address: 8H)

D_0 (ON/OFF)

ON/OFF=0 : Display OFF (All COM/SEG fixed at V_{SSH} level)
ON/OFF=1 : Display ON

D_1 (ALLON)

This bit forcibly turns on all pixels regardless of display data. This bit has a priority over the "REV" bit of the "Display Control (2)" instruction.

ALLON=0 : Normal
ALLON=1 : All pixels ON

D_2 (MON)

MON=0 : Grayscale Mode (Variable 16-grayscale, Variable 8-grayscale or Fixed 8-grayscale Mode)
MON=1 : B&W Mode

D_3 (SHIFT)

SHIFT=0 : $COM_0 \rightarrow COM_{127}$
SHIFT=1 : $COM_0 \leftarrow COM_{127}$

(14-8) Display Control (2)

The "Display Control (2)" instruction controls display conditions.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	0	1	REV	NLIN	SWAP	*

(Default: [REV,NLIN,SWAP]=0H / Register Address: 9H)

D_1 (SWAP)

This bit swaps palettes Aj and palettes Cj (j=0-15). This function reduces the restrictions on the IC position of an LCD module. For more information, refer to "(16) SWAP FUNCTION".

SWAP=0 : SWAP OFF
SWAP=1 : SWAP ON

D_2 (NLIN)

This bit enables the N-line inversion.

NLIN=0 : N-line Inversion OFF (FR toggles by the frame.)
NLIN=1 : N-line Inversion ON (FR toggles once every N lines.)

D_3 (REV)

This bit enables the reverse display function that reverses the polarities of all display data without changing the DDRAM.

REV=0 : Reverse Display OFF (Normal)
REV=1 : Reverse Display ON

Table 20 Reverse Display ON/OFF

REV	Display	DDRAM Data → Display Data	
0	Normal	0	0
		1	1
1	Reverse	0	1
		1	0

(14-9) Increment/Decrement Control

The “HV”, “XD” and “YD” bits set either auto-increment or auto-decrement mode to the column address and row address individually. Once this mode is set up, the column address, row address or both are automatically counted up or down, whenever the DDRAM is accessed. This instruction is used for the window area setting as well as the “Window Start Column/Row Address” and “Window End Column/Row Address” instructions. The display-rotation function or the mirror-inversion function is also enabled by this setting. For more information, refer to “(4-3) DDRAM Access Direction”.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	1	0	AIM	HV	XD	YD

(Default: [AIM,HV,XD,YD]=0H / Register Address: AH)

D_0 (YD), D_1 (XD), D_2 (HV)

Table 21 Horizontal/Vertical & Increment/Decrement

HV	XD	YD	X	Y	Direction
0	0	0	Increment	Increment	Horizontal
0	0	1	Increment	Decrement	
0	1	0	Decrement	Increment	
0	1	1	Decrement	Decrement	
1	0	0	Increment	Increment	Vertical
1	0	1	Increment	Decrement	
1	1	0	Decrement	Increment	
1	1	1	Decrement	Decrement	

D_3 (AIM)

Table 22 Read-modify-write ON/OFF

AIM	Increment Mode	NOTE
0	Read-modify-write OFF	1
1	Read-modify-write ON	2

NOTE1) Increment or decrement in writing and reading display data
NOTE2) Increment or decrement in writing display data only

(14-10) Power Control

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	1	1	AMPON	HALT	DCON	ACL

(Default: [AMPON,HALT,DCON,ACL]=0H / Register Address: BH)

D_0 (ACL)

This bit initializes the internal LCD power supply.

ACL=0 : Initialization OFF (Normal)
ACL=1 : Initialization ON

NOTE) During the initialization, "1" is read out as the status of the "ACL" bit by the "Register Read" instruction. After the initialization, it is "0". As the CLK triggers the initialization, the "wait time" at least equivalent to 2 cycles of the CLK is required for the next instruction.

D_1 (DCON)

The "DCON" bit activates the voltage booster.

DCON=0 : Voltage Booster OFF
DCON=1 : Voltage Booster ON

D_2 (HALT)

The "HALT" bit enables the power save mode. During the power save, operating current is down to the stand-by level. The internal state of the LSI in the power save mode is listed below.

HALT=0 : Power Save OFF (Normal)
HALT=1 : Power Save ON

Internal State in Power Save Mode (HALT="1")

- Internal oscillator and internal LCD power supply are halted.
- All segment and common drivers are fixed at V_{SSH} level.
- External clock to the OSC1 cannot be accepted.
- Display data in the DDRAM is being maintained.
- Data in the instruction registers are being maintained.
- V_{LCD}, V_1, V_2, V_3 and V_4 are in high impedance.

NOTE) In the power save ON sequence, execute the "Display OFF" prior to the "Power Save ON". In the power save OFF sequence, execute the "Power save OFF" prior to the "Display ON". If the "Power Save ON/OFF" instruction is executed during the "Display ON", unexpected pixels may be turned on instantly.

D_3 (AMPON)

The "AMPON" bit activates the voltage converter which includes the reference voltage generator, the voltage regulator and the LCD bias generator.

AMPON=0 : Voltage Converter OFF
AMPON=1 : Voltage Converter ON

(14-11) Duty Cycle Ratio

The "Duty Cycle Ratio" instruction selects LCD duty cycle ratio, and is used to carry out the partial display in combination with other instructions such as the "Boost Level", the "LCD Bias Ratio" and the "EVR Control".

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	1	0	0	DS3	DS2	DS1	DS0

(Default: DS3-DS0=0H / Register Address: CH)

Table 23 Duty Cycle Ratio

DS3	DS2	DS1	DS0	Duty Cycle Ratio		# of Commons
				DSE=0	DES=1	
0	0	0	0	1/129	1/128	128 commons
0	0	0	1	1/121	1/120	120 commons
0	0	1	0	1/113	1/112	112 commons
0	0	1	1	1/105	1/104	104 commons
0	1	0	0	1/97	1/96	96 commons
0	1	0	1	1/89	1/88	88 commons
0	1	1	0	1/81	1/80	80 commons
0	1	1	1	1/73	1/72	72 commons
1	0	0	0	1/65	1/64	64 commons
1	0	0	1	1/57	1/56	56 commons
1	0	1	0	1/49	1/48	48 commons
1	0	1	1	1/41	1/40	40 commons
1	1	0	0	1/33	1/32	32 commons
1	1	0	1	1/25	1/24	24 commons
1	1	1	0	1/17	1/16	16 commons
1	1	1	1	Inhibited		

NOTE) Duty cycle ratio is subtracted by 1 (Duty-1) from the original duty cycle ratio by setting "1" at the D_1 (DSE) bit of the "Duty-1 ON/OFF" instruction. Refer to "(14-17) Duty-1 /Display Clock ON/OFF".

(14-12) Boost Level

The "Boost level" selects the multiple of the voltage booster.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	1	0	1	*	VU2	VU1	VU0

(Default: VU2-VU0=0H / Register Address: DH)

Table 24 Boost Level

VU2	VU1	VU0	Boost Level
0	0	0	1 time (No boost)
0	0	1	2 times
0	1	0	3 times
0	1	1	4 times
1	0	0	5 times
1	0	1	6 times
1	1	0	Inhibited
1	1	1	Inhibited

(14-13) LCD Bias Ratio

The “LCD bias ratio” selects LCD bias ratio.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	1	1	0	*	B2	B1	B0

(Default: B2-B0=0H / Register Address: EH)

Table 25 LCD Bias Ratio

B2	B1	B0	LCD Bias Ratio
0	0	0	1/9
0	0	1	1/8
0	1	0	1/7
0	1	1	1/6
1	0	0	1/5
1	0	1	1/10
1	1	0	1/11
1	1	1	1/12

(14-14) Instruction Table Select

This instruction specifies an instruction table, and should be executed prior to other instructions.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0/1	0/1	0/1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	1	1	1	TST0	RE2	RE1	RE0

(Default: TST0, RE2-RE0=0H / Register Address: FH)

Table 26 Instruction Table Select

RE2	RE1	RE0	Instructions
0	0	0	Instruction Table (0)
0	0	1	Instruction Table (1)
0	1	0	Instruction Table (2)
0	1	1	Instruction Table (3)
1	0	0	Instruction Table (4)
1	0	1	Instruction Table (5)

NOTE) “TST0” bit must be “0”. This is used for maker tests only.

(14-15) Palette A / B / C

Palette A0 (PS=0) / Palette A8 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	0	1	0	0	0	0	PA03/ PA83	PA02/ PA82	PA01/ PA81	PA00/ PA80

(Register Address: 0H)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	0	1	0	0	0	1	*	*	*	PA04/ PA84

(Register Address: 1H)

Palette A1 (PS=0) / Palette A9 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	0	1	0	0	1	0	PA13/ PA93	PA12/ PA92	PA11/ PA91	PA10/ PA90

(Register Address: 2H)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	0	1	0	0	1	1	*	*	*	PA14/ PA94

(Register Address: 3H)

Palette A2 (PS=0) / Palette A10 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	0	1	0	1	0	0	PA23/ PA103	PA22/ PA102	PA21/ PA101	PA20/ PA100

(Register Address: 4H)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	0	1	0	1	0	1	*	*	*	PA24/ PA104

(Register Address: 5H)

Palette A3 (PS=0) / Palette A11 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	0	1	0	1	1	0	PA33/ PA113	PA32/ PA112	PA31/ PA111	PA30/ PA110

(Register Address: 6H)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	0	1	0	1	1	1	*	*	*	PA34/ PA114

(Register Address: 7H)

Palette A4 (PS=0) / Palette A12 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	0	1	1	0	0	0	PA43/ PA123	PA42/ PA122	PA41/ PA121	PA40/ PA120

(Register Address: 8H)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	0	1	1	0	0	1	*	*	*	PA44/ PA124

(Register Address: 9H)

NOTE) Refer to the tables in “(6) GRAYSCALE PALETTE” for default setting.

Palette A5 (PS=0) / Palette A13 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	1	0	PA53/ PA133	PA52/ PA132	PA51/ PA131	PA50/ PA130

(Register Address: AH)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	1	1	*	*	*	PA54/ PA134

(Register Address: BH)

Palette A6 (PS=0) / Palette A14 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	1	0	0	PA63/ PA143	PA62/ PA142	PA61/ PA141	PA60/ PA140

(Register Address: CH)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	0	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	1	0	1	*	*	*	PA64/ PA144

(Register Address: DH)

Palette A7 (PS=0) / Palette A15 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	0	0	PA73/ PA153	PA72/ PA152	PA71/ PA151	PA70/ PA150

(Register Address: 0H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	0	1	*	*	*	PA74/ PA154

(Register Address: 1H)

NOTE) Refer to the tables in “(6) GRAYSCALE PALETTE” for default setting.

Palette B0 (PS=0) / Palette B8 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	1	0	0	0	1	0	PB03/ PB83	PB02/ PB82	PB01/ PB81	PB00/ PB80

(Register Address: 2H)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	1	0	0	0	1	1	*	*	*	PB04/ PB84

(Register Address: 3H)

Palette B1 (PS=0) / Palette B9 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	1	0	0	1	0	0	PB13/ PB93	PB12/ PB92	PB11/ PB91	PB10/ PB90

(Register Address: 4H)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	1	0	0	1	0	1	*	*	*	PB14/ PB94

(Register Address: 5H)

Palette B2 (PS=0) / Palette B10 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	1	0	0	1	1	0	PB23/ PB103	PB22/ PB102	PB21/ PB101	PB20/ PB100

(Register Address: 6H)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	1	0	0	1	1	1	*	*	*	PB24/ PB104

(Register Address: 7H)

Palette B3 (PS=0) / Palette B11 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	1	0	1	0	0	0	PB33/ PB113	PB32/ PB112	PB31/ PB111	PB30/ PB110

(Register Address: 8H)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	1	0	1	0	0	1	*	*	*	PB34/ PB114

(Register Address: 9H)

Palette B4 (PS=0) / Palette B12 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	1	0	1	0	1	0	PB43/ PB123	PB42/ PB122	PB41/ PB121	PB40/ PB120

(Register Address: AH)

CSb	RS	RDb	WRb	RE2	RE1	RE0	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	0	1	0	1	0	1	1	*	*	*	PB44/ PB124

(Register Address: BH)

NOTE) Refer to the tables in “(6) GRAYSCALE PALETTE” for default setting.

Palette B5 (PS=0) / Palette B13 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	1	0	0	PB53/ PB133	PB52/ PB132	PB51/ PB131	PB50/ PB130

(Register Address: CH)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	1	0	1	*	*	*	PB54/ PB134

(Register Address: DH)

Palette B6 (PS=0) / Palette B14 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	0	0	PB63/ PB143	PB62/ PB142	PB61/ PB141	PB60/ PB140

(Register Address: 0H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	0	1	*	*	*	PB64/ PB144

(Register Address: 1H)

Palette B7 (PS=0) / Palette B15 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	1	0	PB73/ PB153	PB72/ PB152	PB71/ PB151	PB70/ PB150

(Register Address: 2H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	1	1	*	*	*	PB74/ PB154

(Register Address: 3H)

NOTE) Refer to the tables in “(6) GRAYSCALE PALETTE” for default setting.

Palette C0 (PS=0) / Palette C8 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	0	0	PC03/ PC83	PC02/ PC82	PC01/ PC81	PC00/ PC80

(Register Address: 4H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	0	1	*	*	*	PC04/ PC84

(Register Address: 5H)

Palette C1 (PS=0) / Palette C9 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	PC13/ PC93	PC12/ PC92	PC11/ PC91	PC10/ PC90

(Register Address: 6H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	1	*	*	*	PC14/ PC94

(Register Address: 7H)

Palette C2 (PS=0) / Palette C10 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	0	0	PC23/ PC103	PC22/ PC102	PC21/ PC101	PC20/ PC100

(Register Address: 8H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	0	1	*	*	*	PC24/ PC104

(Register Address: 9H)

Palette C3 (PS=0) / Palette C11 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	1	0	PC33/ PC113	PC32/ PC112	PC31/ PC111	PC30/ PC110

(Register Address: AH)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	1	1	*	*	*	PC34/ PC114

(Register Address: BH)

Palette C4 (PS=0) / Palette C12 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	1	0	0	PC43/ PC123	PC42/ PC122	PC41/ PC121	PC40/ PC120

(Register Address: CH)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	0	1	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	1	0	1	*	*	*	PC44/ PC124

(Register Address: DH)

NOTE) Refer to the tables in “(6) GRAYSCALE PALETTE” for default setting.

Palette C5 (PS=0) / Palette C13 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	0	0	PC53/ PC133	PC52/ PC132	PC51/ PC131	PC50/ PC130

(Register Address: 0H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	0	1	*	*	*	PC54/ PC134

(Register Address: 1H)

Palette C6 (PS=0) / Palette C14 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	1	0	PC63/ PC143	PC62/ PC142	PC61/ PB141	PC60/ PB140

(Register Address: 2H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	1	1	*	*	*	PC64/ PC144

(Register Address: 3H)

Palette C7 (PS=0) / Palette C15 (PS=1)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	0	0	PC73/ PC153	PC72/ PC152	PC71/ PC151	PC70/ PC150

(Register Address: 4H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	0	1	*	*	*	PC74/ PC154

(Register Address: 5H)

NOTE) Refer to the tables in “(6) GRAYSCALE PALETTE” for default setting.

(14-16) Initial COM

The "Initial COM" instruction specifies the common driver for a scan start common.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	SC3	SC2	SC1	SC0

(Default: SC3-SC0=0H / Register Address: 6H)

Table 27 Initial COM

SC3	SC2	SC1	SC0	Initial COM (SHIFT=0)	Initial COM (SHIFT=1)
0	0	0	0	COM_0	COM_{127}
0	0	0	1	COM_4	COM_{123}
0	0	1	0	COM_8	COM_{119}
0	0	1	1	COM_{16}	COM_{111}
0	1	0	0	COM_{24}	COM_{103}
0	1	0	1	COM_{32}	COM_{95}
0	1	1	0	COM_{40}	COM_{87}
0	1	1	1	COM_{48}	COM_{79}
1	0	0	0	COM_{56}	COM_{71}
1	0	0	1	COM_{64}	COM_{63}
1	0	1	0	COM_{72}	COM_{55}
1	0	1	1	COM_{80}	COM_{47}
1	1	0	0	COM_{88}	COM_{39}
1	1	0	1	COM_{96}	COM_{31}
1	1	1	0	COM_{104}	COM_{23}
1	1	1	1	COM_{112}	COM_{15}

(14-17) Duty-1 /Display Clock ON/OFF

This instruction controls ON (Duty-1) /OFF (Duty-0) and Display Clock ON/OFF.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	1	*	*	DSE	SON

(Default: SON,DSE=0H / Register Address: 7H)

D_0 (SON)

SON=0 : CL, FLM, FR, and CLK are fixed at "L" level.
SON=1 : CL, FLM, FR, and CLK are enabled.

D_1 (DSE)

The duty cycle ratio is subtracted by 1 (Duty-1) from the original duty cycle ratio by setting "1" at the "DSE" bit.

DSE=0 : OFF (Duty-0)
DSE=1 : ON (Duty-1)

NOTE) For the last common timing at "DSE=0", all common drivers generate non-selective waveforms, and segment drivers generate the same waveforms as for the previous common timing. For instance, in 1/129 duty cycle, the segment waveforms for 129^{th} common timing are the same as for 128^{th} common timing (last line).

(14-18) Display Mode Control

The "Display Mode Control" instruction sets up display modes such as the variable or fixed grayscale mode and the variable 8- or 16-grayscale mode. The D_2 (MON) bit of the "Display Control (1)" is used in combination. Refer to "(5) GRAY SCALE CONTROL CIRCUIT" and "(14-7) Display Control (1)."

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	0	0	PWM	C256	*	*

(Default: PWM,C256=0H / Register Address: 8H)

D_3 (PWM)

PWM=0 : Variable grayscale Mode (Variable 8-/16-grayscale Mode)
PWM=1 : Fixed 8-grayscale Mode

D_2 (C256)

C256=0 : Variable 16-grayscale Mode at "PWM=0" (4096 colors)
C256=1 : Variable 8-grayscale Mode at "PWM=0" (256 colors)

(14-19) Bus Length

This instruction selects 8- or 16-bit bus length, and sets oscillator configuration as well.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	0	1	*	ABS	CKS	WLS

(Default: ABS,CKS,WLS=0H / Register Address: 9H)

D_0 (WLS)

WLS=0: 8-bit Bus Length
WLS=1: 16-bit Bus Length

D_1 (CKS)

CKS =0: Internal Oscillator using an internal resistor
CKS =1: External Clock, or Internal Oscillator using an external resistor

NOTE) Refer to "(10) OSCILLATOR".

D_2 (ABS)

ABS=0: ABS Mode OFF (Normal)
ABS=1: ABS Mode ON

(14-20) EVR Control

The "EVR Control" instruction adjusts V_{LCD} to optimize display contrast. This instruction is finally effective when both upper and lower bytes are transmitted in order to prevent high V_{LCD}. The setting order is upper byte first, then lower byte. Refer to "(11-2-3) Electrical Variable Resistor (EVR)".

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	1	0	DV_3	DV_2	DV_1	DV0

(Default: DV_3-DV0=0H / Register Address: AH)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	1	1	*	DV6	DV_5	DV_4

(Default: DV6-DV_4=0H / Register Address: BH)

Table 28 EVR Control

DV6	DV_5	DV_4	DV_3	DV_2	DV_1	DV0	V_{LCD}
0	0	0	0	0	0	0	Low
0	0	0	0	0	0	1	:
			:				:
			:				:
1	1	1	1	1	1	1	High

Formula of V_{LCD}

V_{LCD} [V] = 0.5x V_{REG} + M (V_{REG} – 0.5x V_{REG}) / 127

$V_{BA} = V_{EE}$ x 0.9
$V_{REG} = V_{REF}$ x N

V_{BA} : Output of the reference voltage generator
V_{REF} : Input of the voltage regulator
V_{REG} : Output of the voltage regulator
N : Boost level
M : EVR Value

(14-21) Frequency Control

The "Frequency Control" instruction adjusts the frame frequency.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	1	0	1	*	Rf2	Rf1	Rf0

(Default: DV_3-DV0=0H / Register Address: DH)

Table 29 Frequency Control

Rf 2	Rf 1	Rf 0	Feedback Resistor Value
0	0	0	Reference Value
0	0	1	0.8 x Reference Value
0	1	0	0.9 x Reference Value
0	1	1	1.1 x Reference Value
1	0	0	1.2 x Reference Value
1	0	1	0.7 x Reference Value
1	1	0	1.3 x Reference Value
1	1	1	Inhibited

(14-22) Discharge ON/OFF

Discharge circuit is used to discharge out of the stabilizing capacitors placed on the V_{LCD}, V_1, V_2, V_3,V_4 and V_{OUT}. Refer to "(11-4) Discharge Circuit".

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	1	1	0	*	*	DIS2	DIS

(Default: DIS2,DIS1=0H / Register Address: EH)

D_0 (DIS)

DIS=0 : Discharge OFF
DIS=1 : Discharge ON (Discharge from V_{LCD}, V_1, V_2, V_3 and V_4)

D_1 (DIS2)

DIS2=0 : Discharge OFF
DIS2=1 : Discharge ON (Discharge from V_{OUT} through the internal resistor between V_{OUT} and V_{EE})

NOTE) Resistance is 100KΩ typical.

(14-23) Register Address

The "Register Address" instruction specifies a register address.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	0

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	1	0	0	RA3	RA2	RA1	RA0

(Default: RA3-RA0=BH / Register Address: CH)

(14-24) Register Read

The "Register Read" instruction reads out instruction data from the register which address is specified by the "Register Address" instruction.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	0	1	0/1	0/1	0/1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
*	*	*	*	Internal register data read			

(14-25) Window End Column Address

The "Window End Column Address" instruction specifies the column address of the end point. Refer to "(4-2) Window Area for DDRAM Access". The setting order is lower byte first, then upper byte.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	0	0	EX3	EX2	EX1	EX0

(Default: EX3-EX0=0H / Register Address: 0H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	0	1	EX7	EX6	EX5	EX4

(Default: EX7-EX4=0H / Register Address: 1H)

(14-26) Window End Row Address

The "Window End Row Address" instruction specifies the row address of the end point. Refer to "(4-2) Window Area for DDRAM Access". The setting order is lower byte first, then upper byte.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	1	0	EY3	EY2	EY1	EY0

(Default: EY3-EY0=0H / Register Address: 2H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	0	1	1	*	EY6	EY5	EY4

(Default: EY6-EY4=0H / Register Address: 3H)

(14-27) Initial Line-reverse Address

The "Initial Line-reverse Address" instruction specifies the start line of the line-reverse display area. The setting order is lower byte first, then upper byte.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	0	0	LS3	LS2	LS1	LS0

(Default: LS3-LS0=0H / Register Address: 4H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	0	1	*	LS6	LS5	LS4

(Default: LS6-LS4=0H / Register Address: 5H)

(14-28) Last Line-reverse Address

The "Last Line-reverse Address" instruction specifies the end line of the line-reverse display area. The setting order is lower byte first, then upper byte.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	0	LE3	LE2	LE1	LE0

(Default: LE3-LE0=0H / Register Address: 6H)

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
0	1	1	1	*	LE6	LE5	LE4

(Default: LE6-LE4=0H / Register Address: 7H)

(14-29) Line Reverse ON/OFF

The "Line Reverse ON/OFF" instruction enables the line-reverse display, and blink function as well. Note that the line reverse display cannot be used for entire display area. In this case, use the reverse display function by the D_3 (REV) bit of the "Display Control (2)" instruction.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	0	0	*	*	BT	LREV

(Default: BT,LREV=0H / Register Address: 8H)

D_0 (LREV)

LREV =0 : Line Reverse OFF (Normal)
LREV =1 : Line Reverse ON

D_1 (BT)

BT =0 : No Blink
BT =1 : Blink once every 32 frames

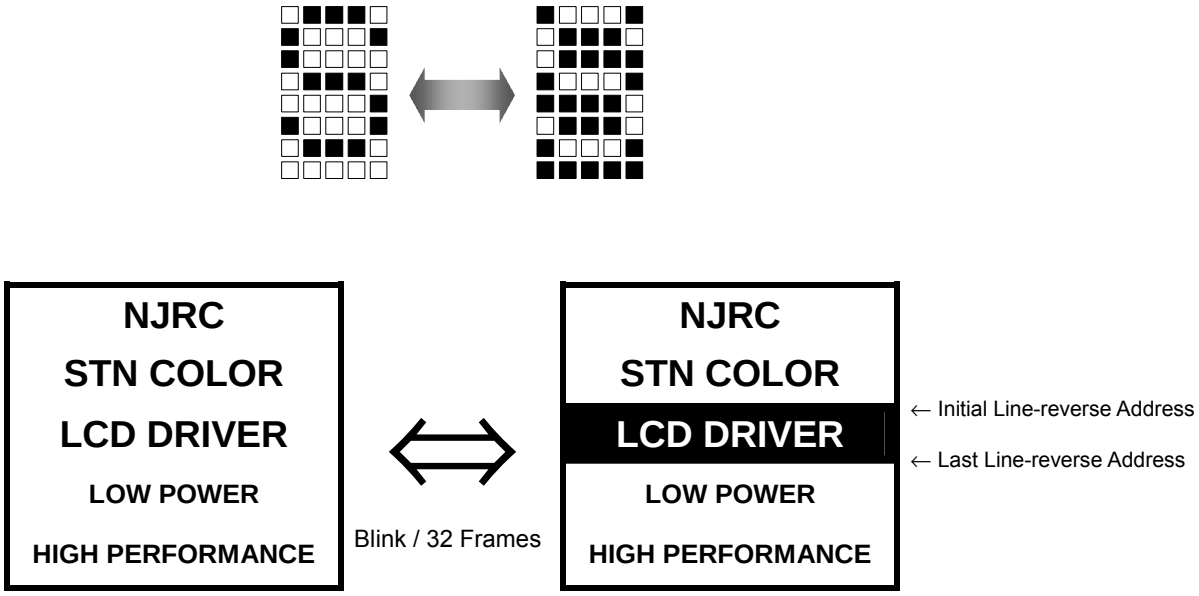


Fig 20 On-screen Image in Using Line-reverse Display and Blink Function

(14-30) Upper/Lower Palette Select

The "Upper/Lower Palette Select" instruction selects either upper or lower palette register.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	0	1	*	*	*	PS

(Default: PS=0 / Register Address: 9H)

D_0 (PS)

PS=0 : Lower Palettes (PA00, PA01, PA02, PA03, …, PC74)
PS=1 : Upper Palettes (PA80, PA81, PA82, PA83, …, PC154)

(14-31) PWM Control

The "PWM control" instruction selects PWM type, as shown in Fig 21.

CSb	RS	RDb	WRb	RE2	RE1	RE0
0	1	1	0	1	0	1

D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0
1	0	1	0	PWMS	PWMA	PWMB	PWMC

(Default: PWMS,PWMA,PWMB,PWMC=0H / Register Address: AH)

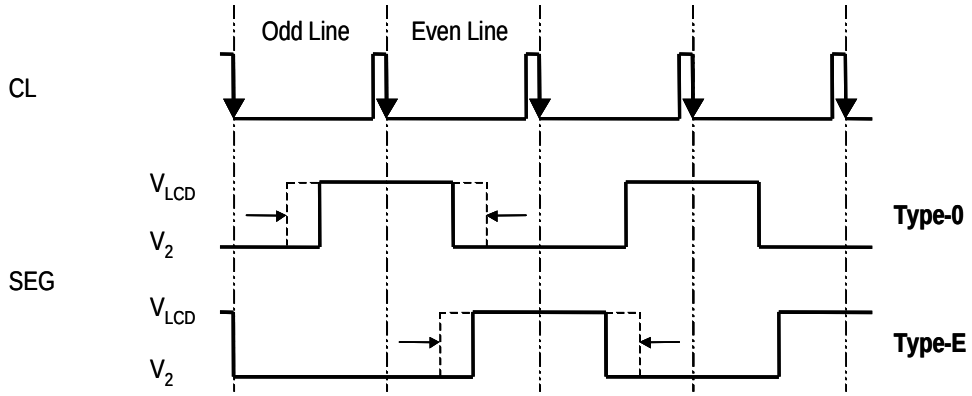
D_3 (PWMS)

PWMS=0 : Type 1
PWMS=1 : Type 2

D_2 (PWMA), D_1 (PWMB), D_0 (PWMC)

PWMZ=0 (Z=A, B and C): Type 1-O
PWMZ=1 (Z=A, B and C): Type 1-E

PWM Type 1 (PWMS=0)



PWM Type 2 (PWMS=1)

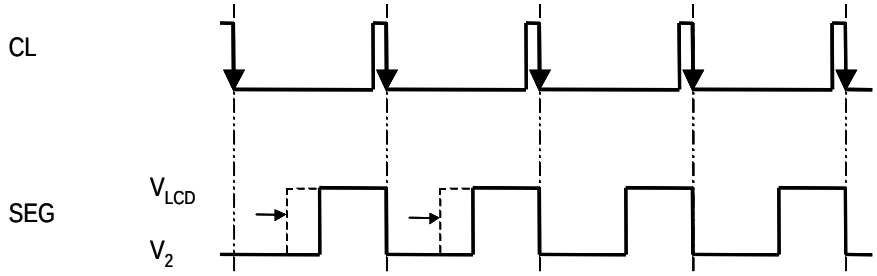


Fig 21 PWM Control

(15) PARTIAL DISPLAY FUNCTION

The partial display function activates specified area on an LCD screen, or equivalently, common drivers are simply scanning this specified area. This function allows LCD modules to work in a minimum duty cycle ratio to minimize power consumption. The partial display function is carried out by the combination of the "Duty Cycle Ratio", "LCD Bias Ratio", "Boost Level" and "EVR Control" instructions. For more information, refer to "(14-11) Duty Cycle Ratio", "(14-12) Boost Level", "(14-13) LCD Bias Ratio" and "(14-20) EVR Control". Typical setting sequence is shown in "(18-4) Partial Display Sequence".

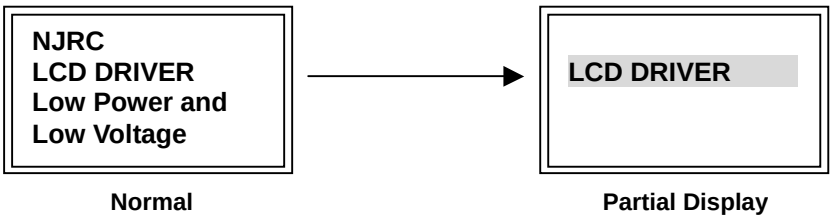


Fig 22 On-screen Image in Using Partial Display Function

(16) SWAP FUNCTION

The swap function switches the palettes Aj and the palettes Cj (j=0-15), and is controlled by the D_1 (SWAP) bit of the "Display Control (2)" instruction. This function reduces the restrictions on the IC position of an LCD module. Fig 23 "Overview of Swap Function" illustrates general outlines of internal operations, and (16-1-1) through (16-1-4) show each configuration on a mode-by-mode basis.

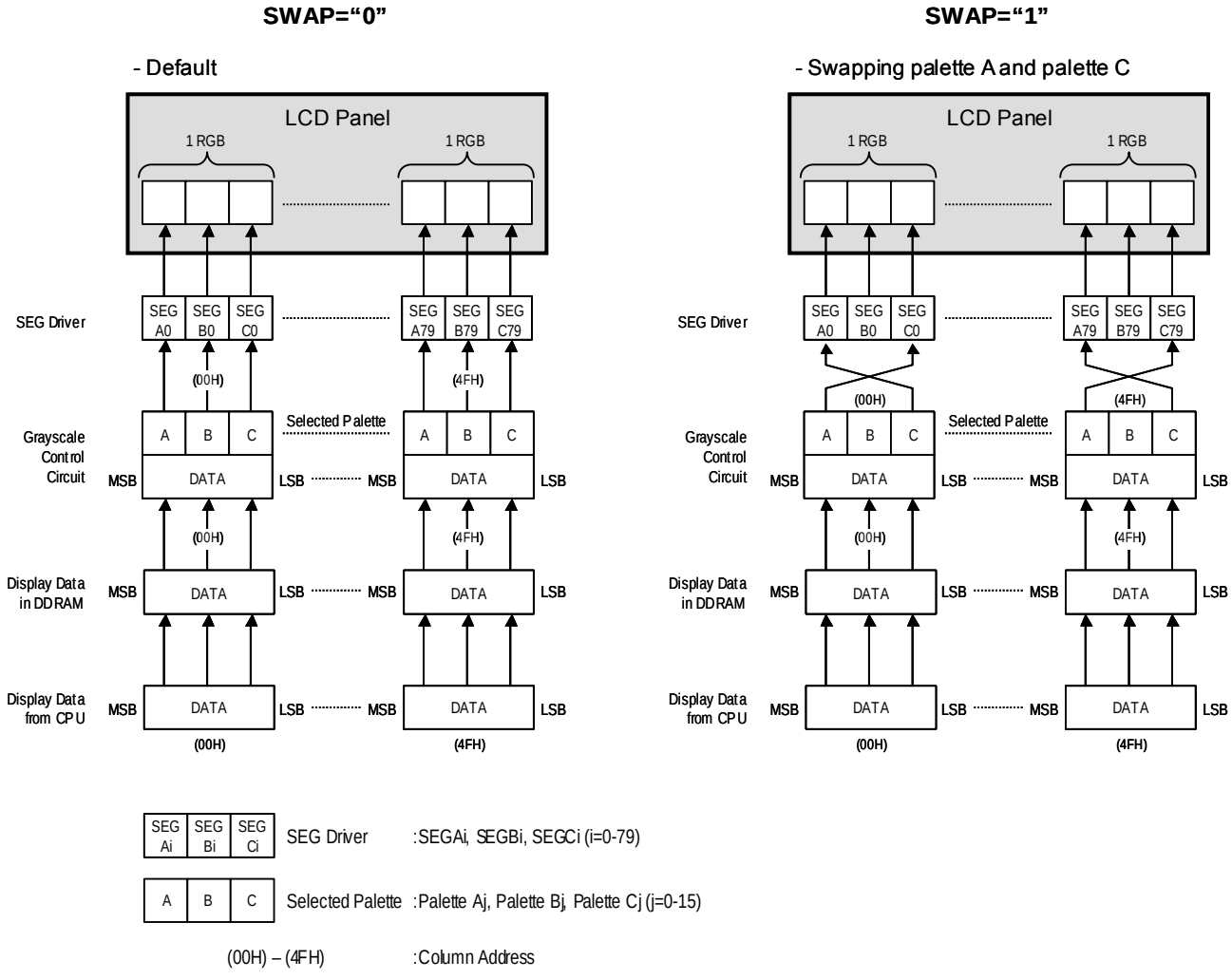
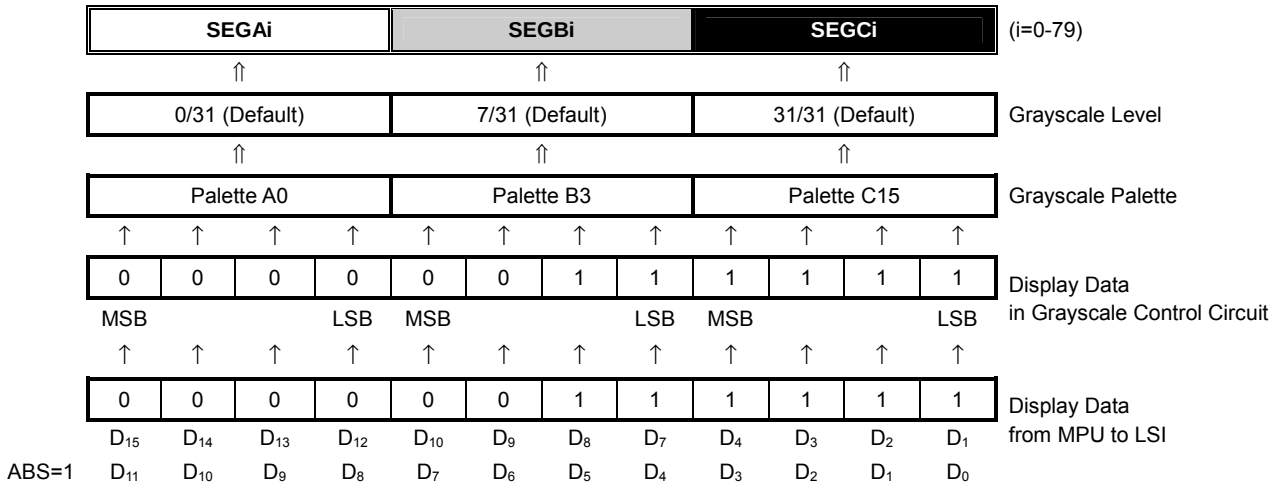


Fig 23 Overview of SWAP Function

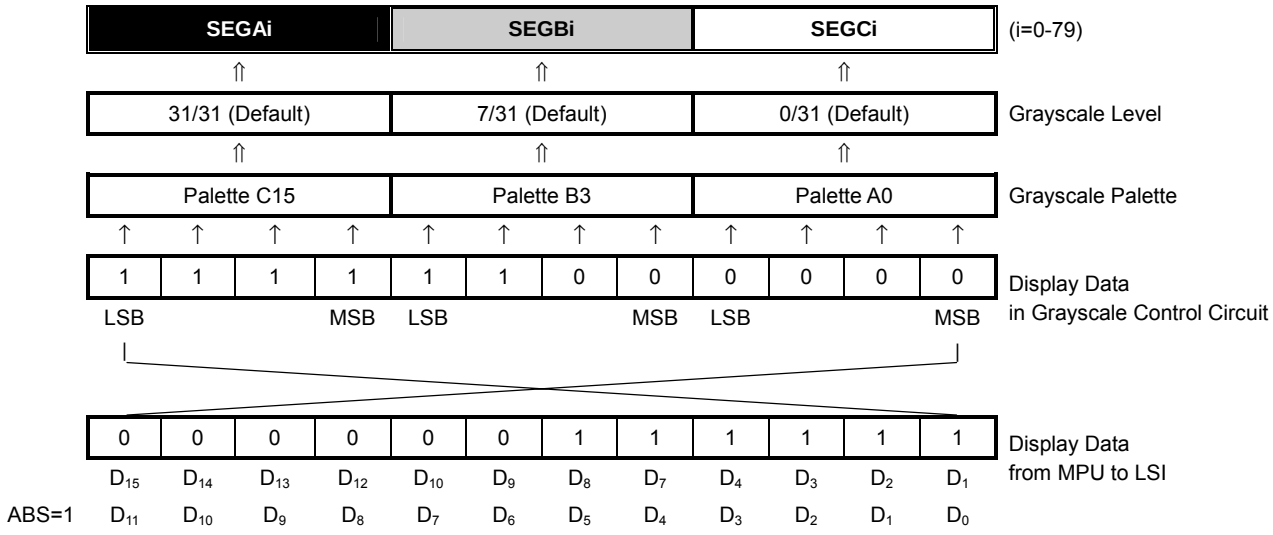
(16-1) Swap Function in Variable 16-grayscale Mode

16-bit Bus Length

SWAP=0



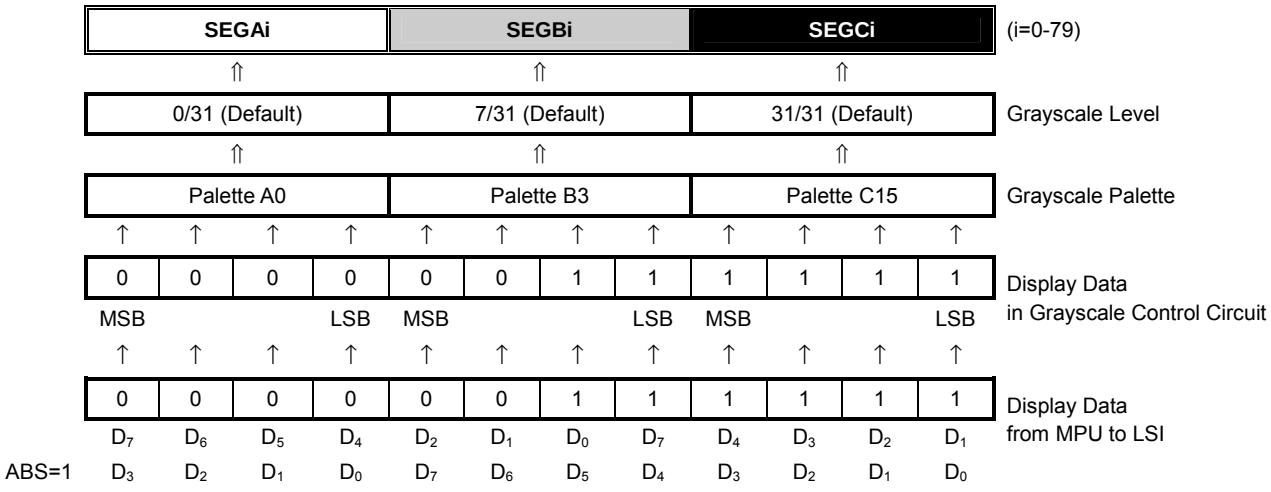
SWAP=1



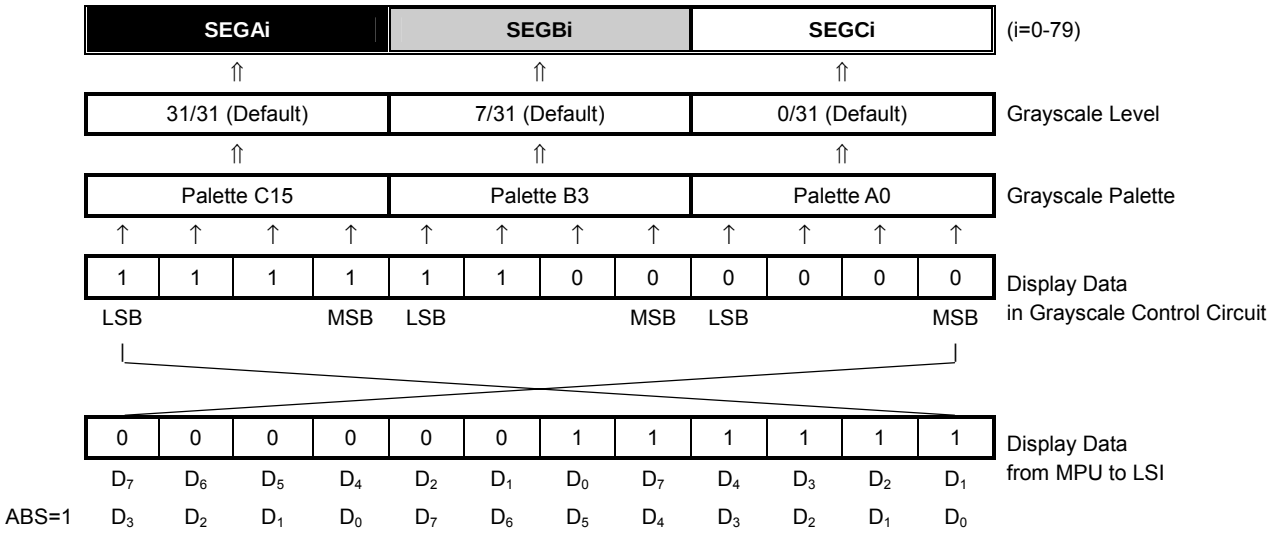
NOTE1) Without a special note on the left, the ABS and C256 bits are regarded as “0”.

8-bit Bus Length

SWAP=0



SWAP=1

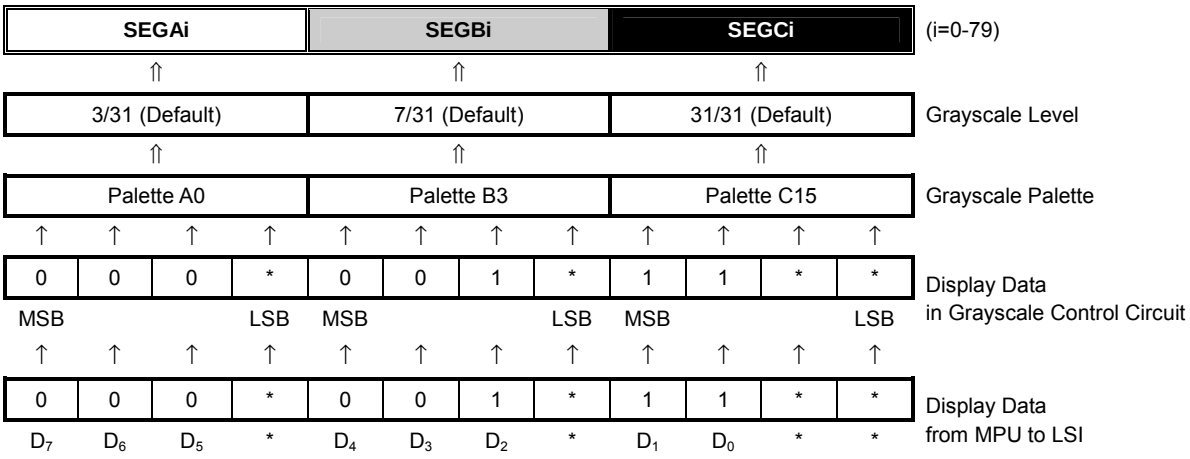


NOTE1) Without a special note on the left, the ABS and C256 bits are regarded as “0”.

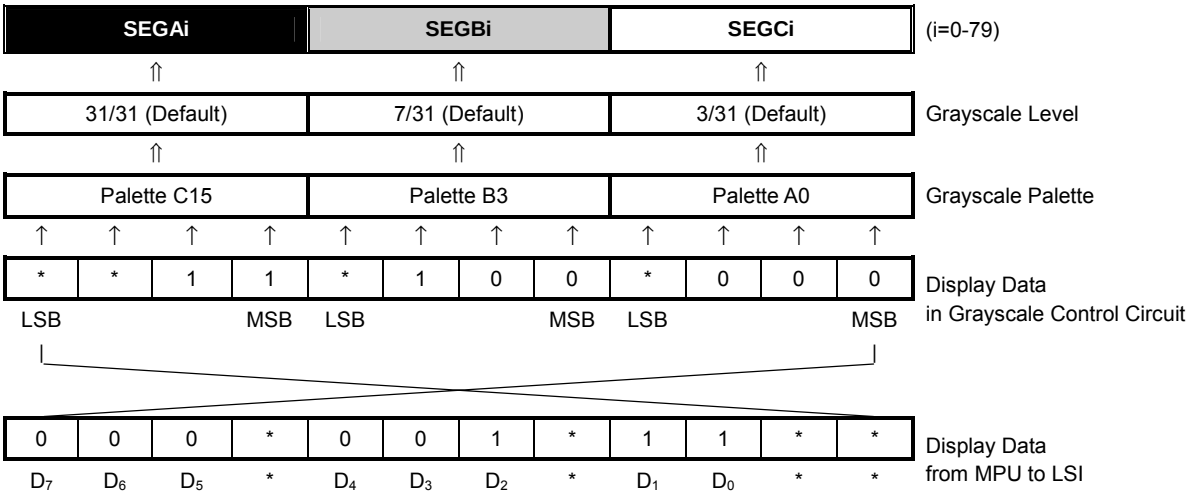
(16-2) Swap Function in Variable 8-Grayscale Mode

8-bit Bus Length

SWAP=0



SWAP=1

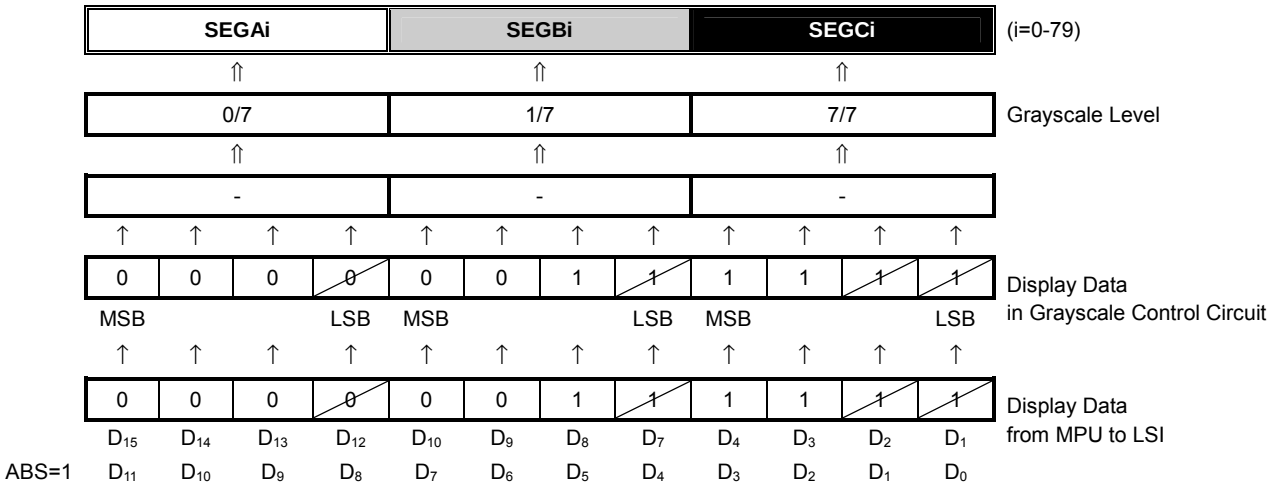


NOTE1) Without a special note on the left, the ABS and C256 bits are regarded as “0”.

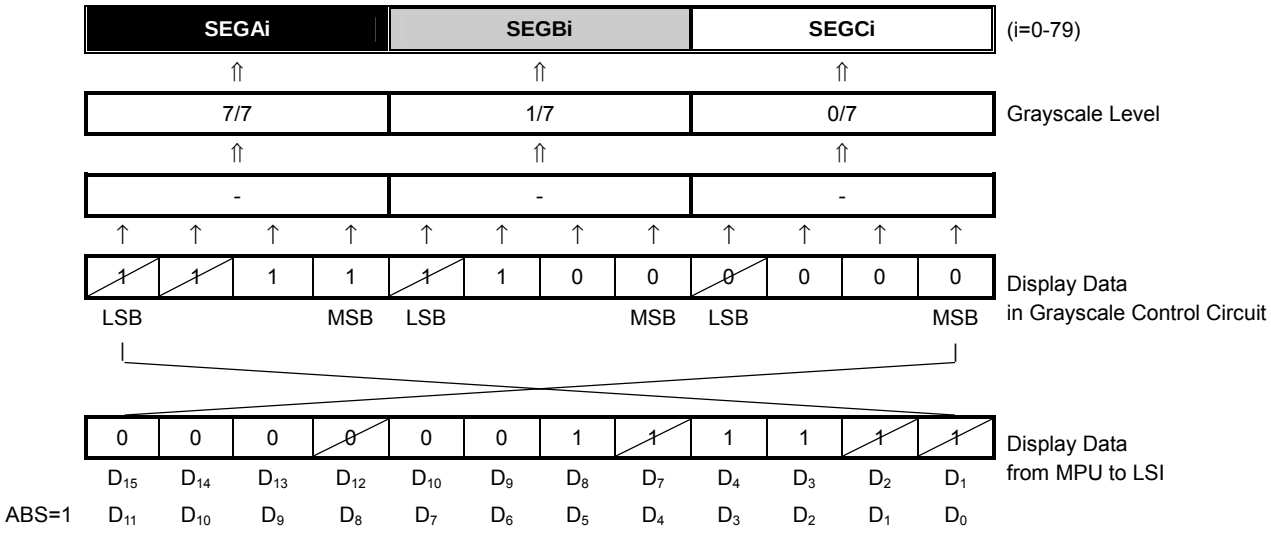
(16-3) Swap Function in Fixed 8-grayscale Mode

16-bit Bus Length

SWAP=0



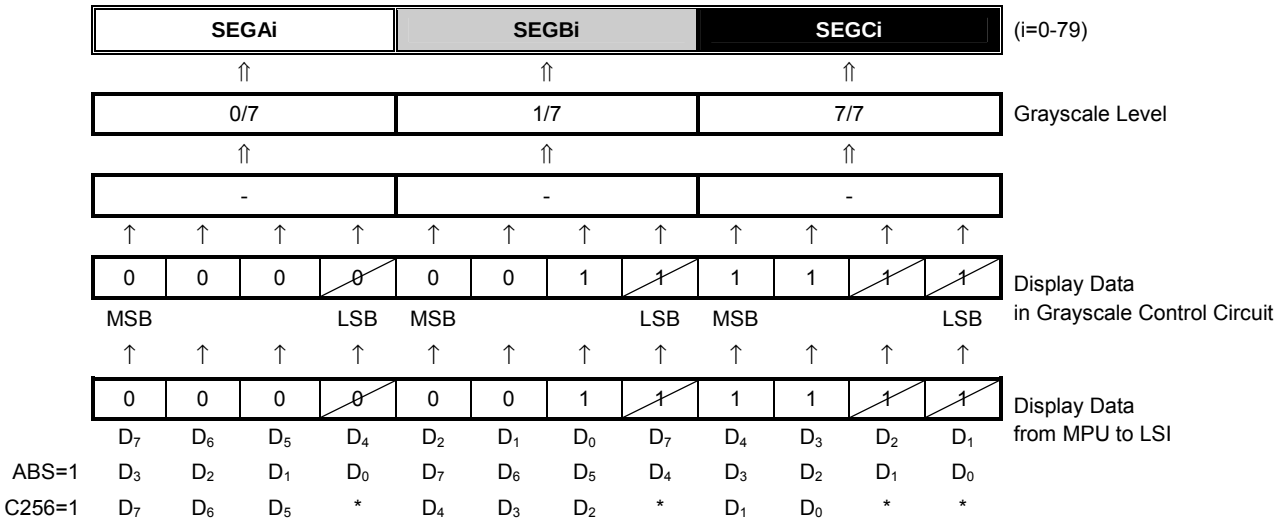
SWAP=1



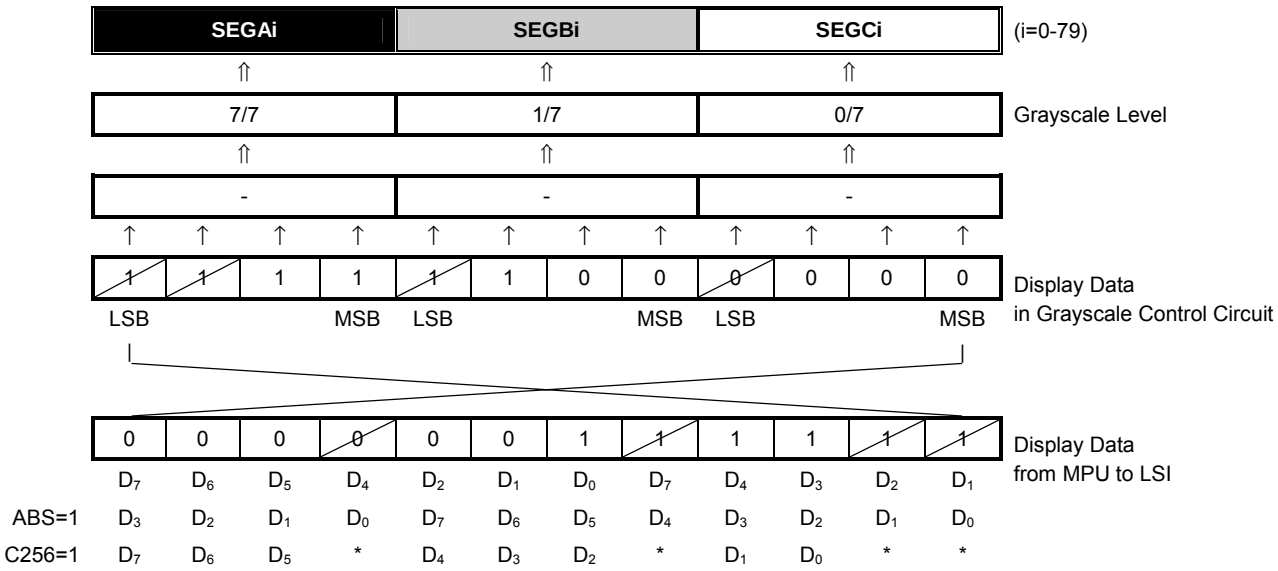
NOTE1) Without a special note on the left, the ABS and C256 bits are regarded as “0”.
NOTE2) The data indicated with a slash mark (/) is invalid.

8-bit Bus Length

SWAP=0



SWAP=1

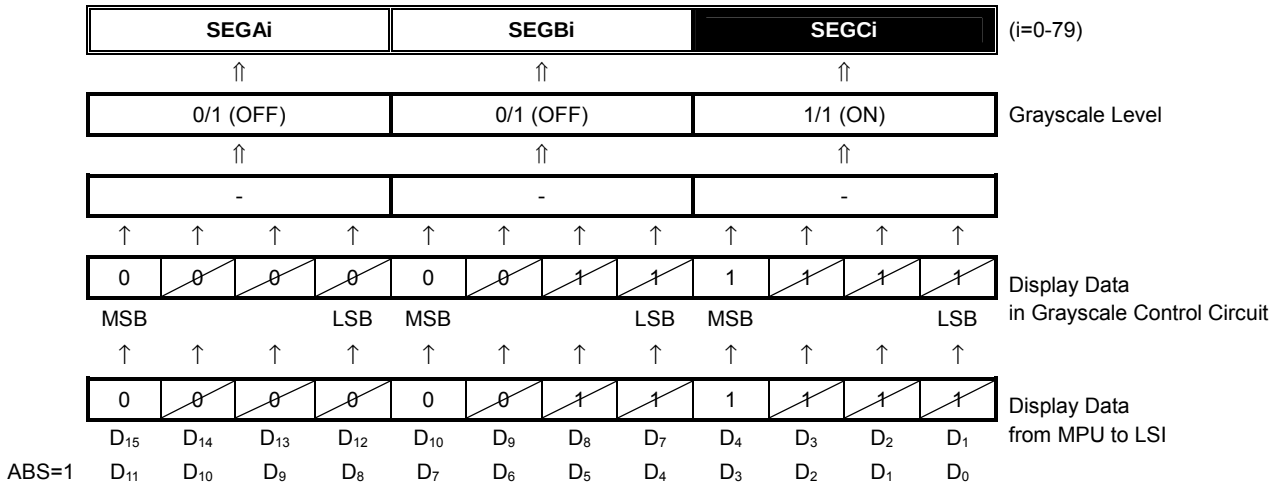


NOTE1) Without a special note on the left, the ABS and C256 bits are regarded as “0”.
NOTE2) The data indicated with a slash mark (/) is invalid.

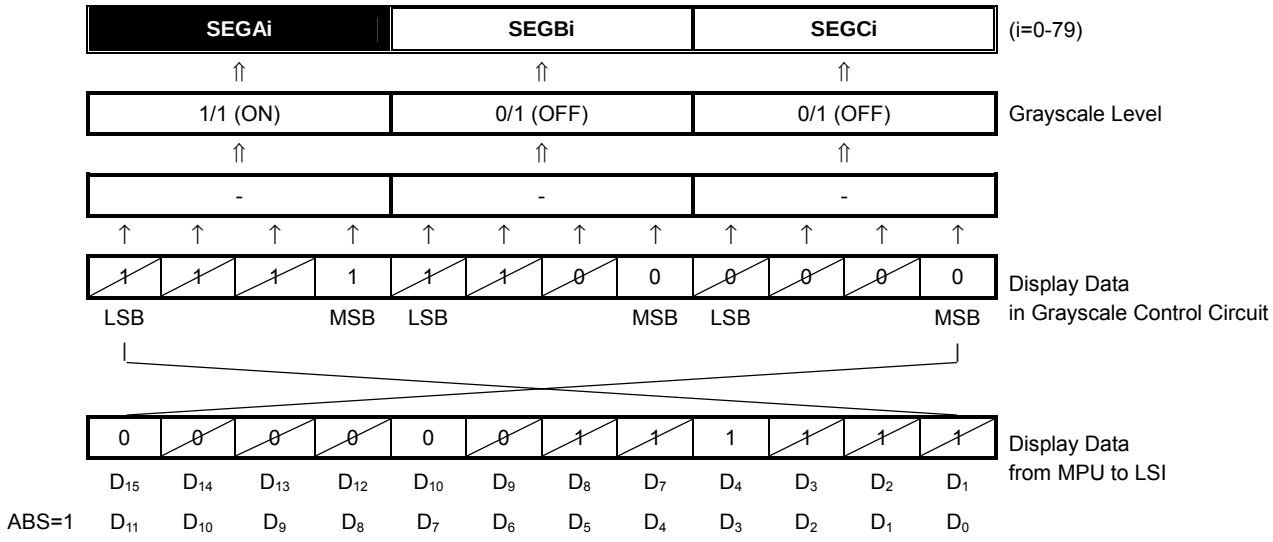
(16-4) Swap Function in B&W Mode

16-bit Bus Length

SWAP=0



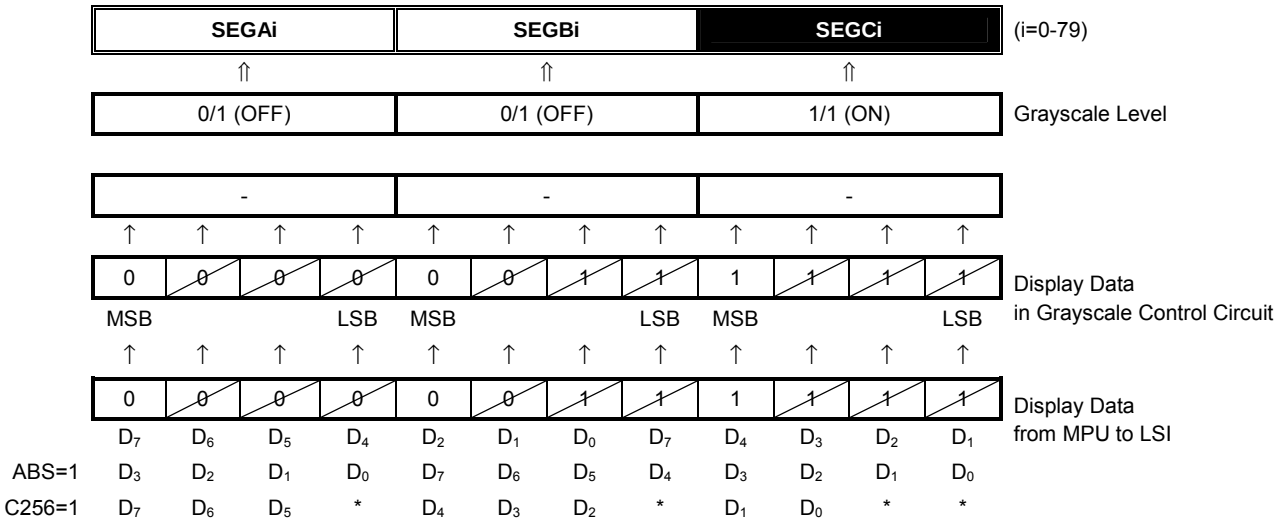
SWAP=1



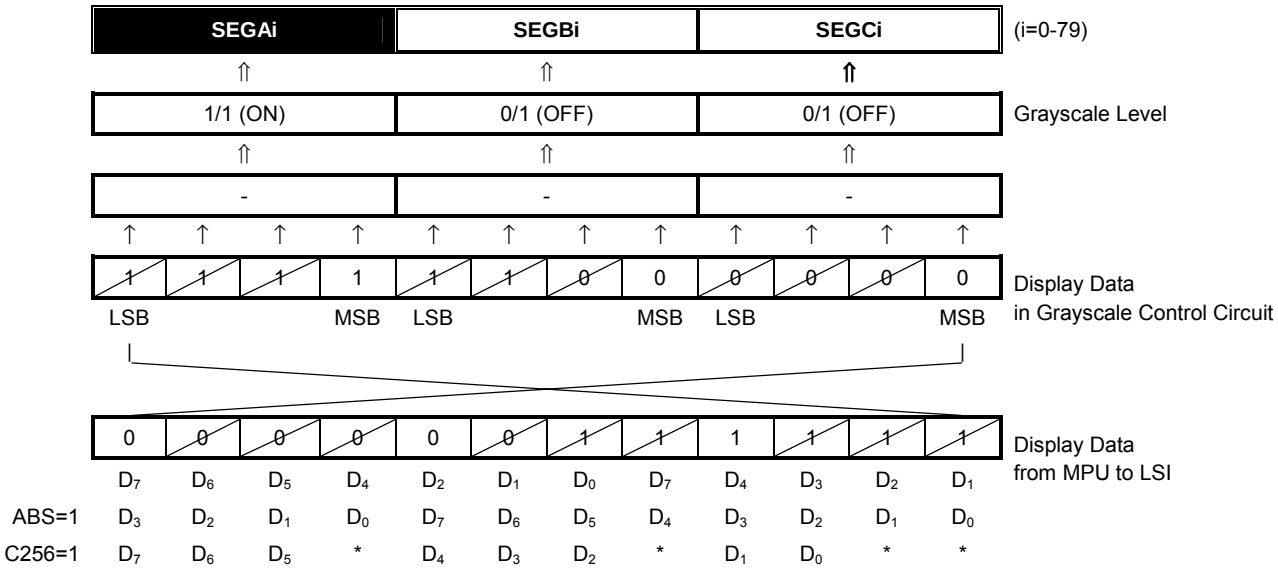
NOTE1) Without a special note on the left, the ABS and C256 bits are regarded as “0”.
NOTE2) The data indicated with a slash mark (/) is invalid.

8-bit Bus Length

SWAP=0



SWAP=1



NOTE1) Without a special note on the left, the ABS and C256 bits are regarded as “0”.
NOTE2) The data indicated with a slash mark (/) is invalid.

(17) RELATION BETWEEN ROW ADDRESS AND COMMON DRIVER

The relation between row address and common driver is changed by the D_3 (SHIFT) bit of the “Display Control (1)” and the “Duty Cycle Ratio”, “Initial Display Line” and “Initial COM” instructions.

When the “Initial Display Line” is set to (LA6:LA0=00H: Address “0”), the row address corresponding to an initial COM is “0”. However, if the “Initial Display Line” is other than “0”, the row address is shifted from “0” by just that address. For instance, when the initial display line address is (LA6:LA0=05H: Address “5”) and the initial COM is (SC3:SC0=1H), the row address on the initial COM is “5” and the initial COM is “COM_4”.

(17-1) through (17-5) illustrate the examples of the relation between row address and common driver.

(17-1) SHIFT=0, Initial Display Line “0”, Duty Cycle Ratio “1/129”

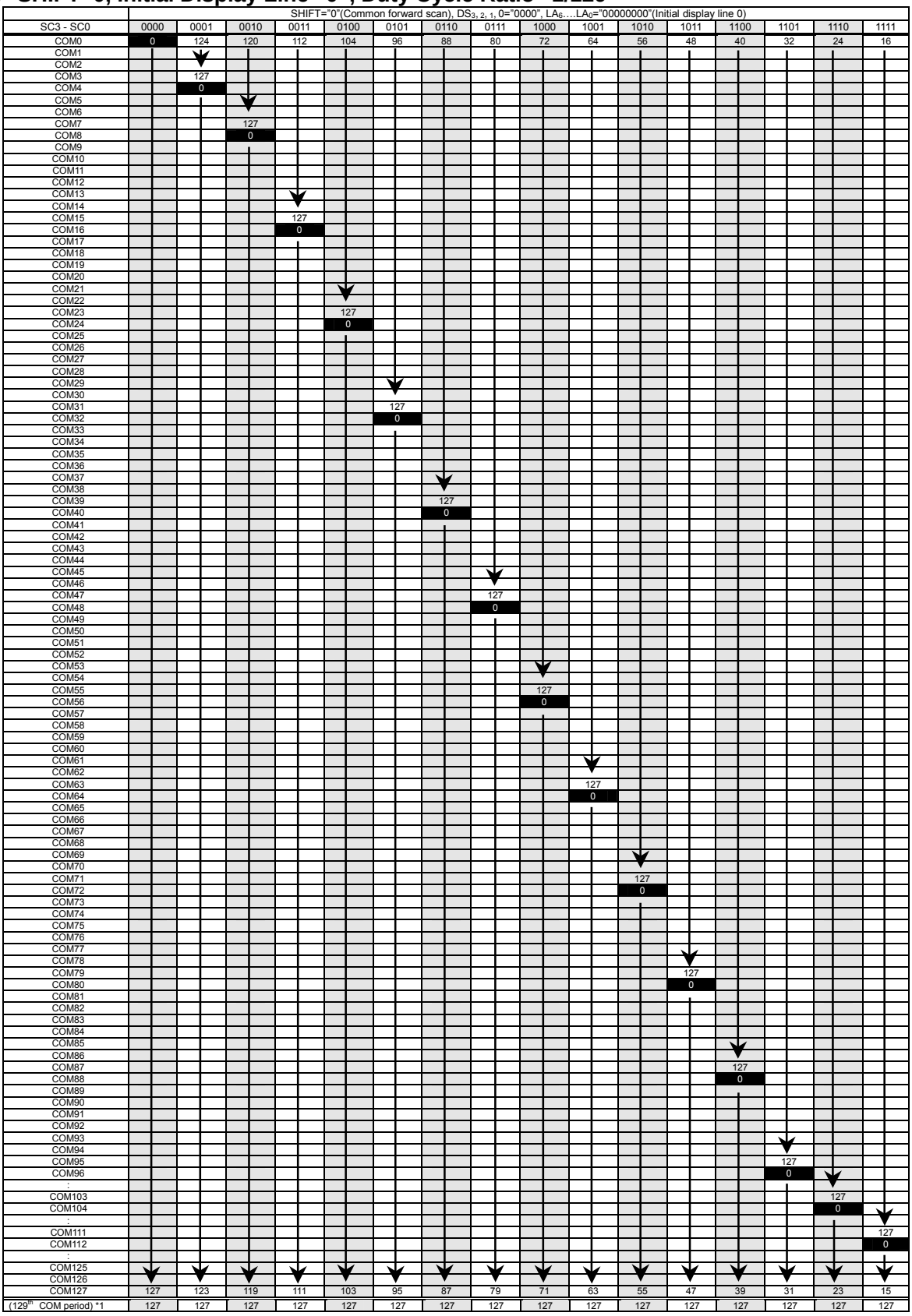


Fig 24 Relation between Row address and Common Driver (1)

NOTE1) DS: Duty Cycle Ratio / SC: Initial COM / LA: Initial Display Line Address
NOTE2) Segment waveforms for 129th COM timing are the same as for 128th COM timing (Row address “127”).

(17-2) SHIFT=0, Initial Display Line “0”, Duty Cycle Ratio “1/17”

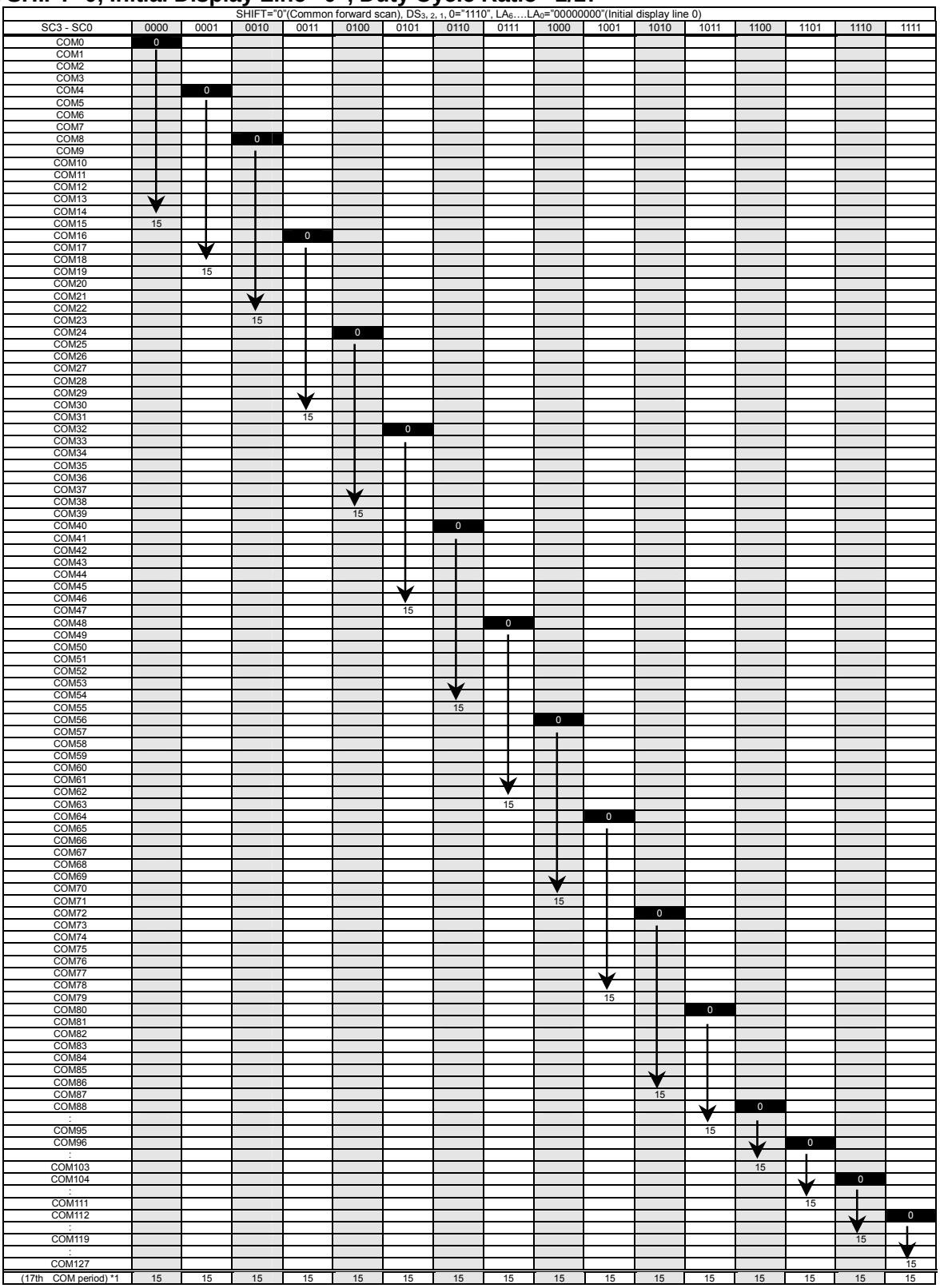


Fig 25 Relation between Row address and Common Driver (2)

NOTE1) DS: Duty Cycle Ratio / SC: Initial COM / LA: Initial Display Line Address
NOTE2) Segment waveforms for 17th COM timing are the same as for 16th COM timing (Row address “15”).

(17-3) SHIFT=1, Initial Display Line “0”, Duty Cycle Ratio “1/129”

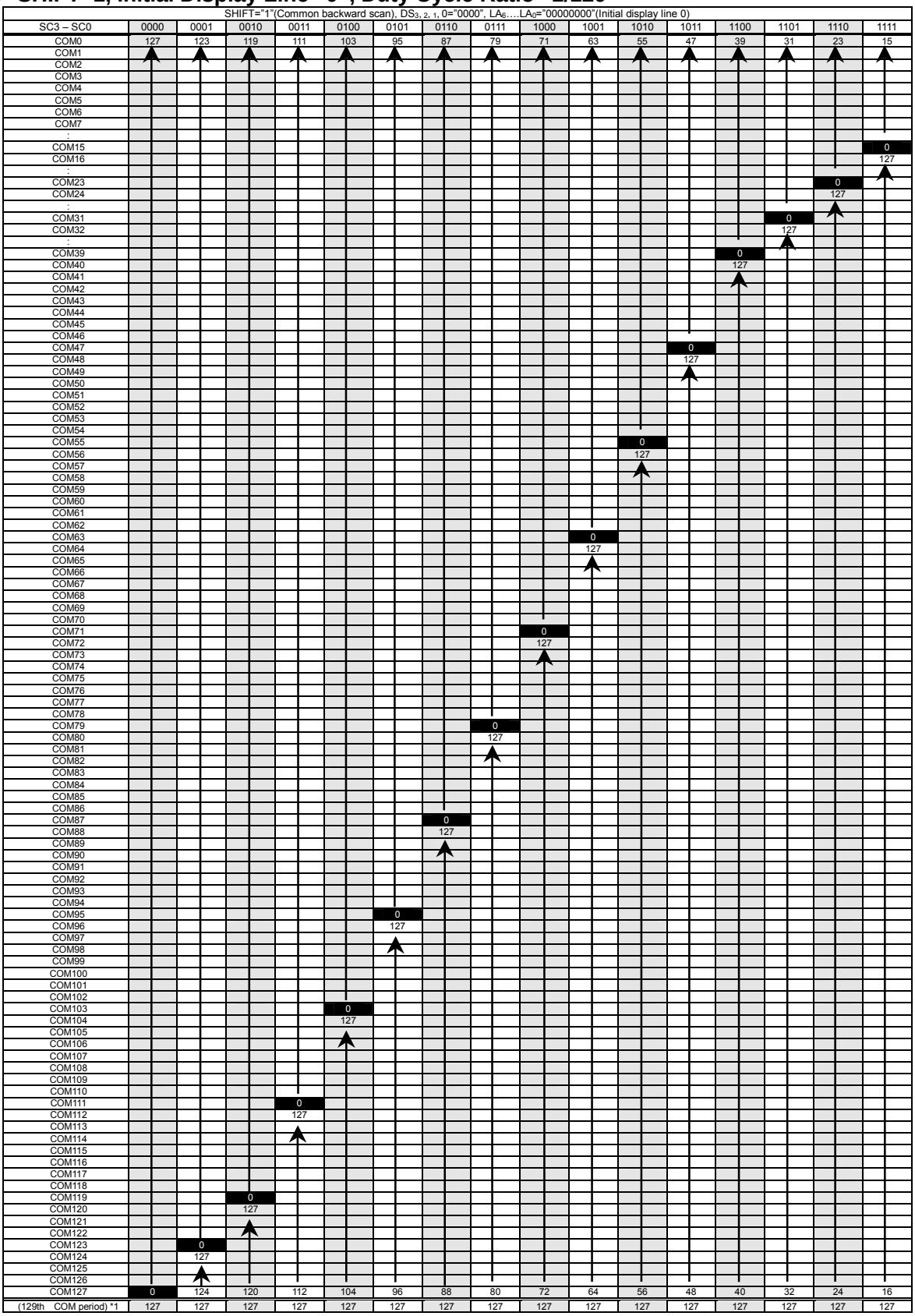


Fig 26 Relation between Row address and Common Driver (3)

NOTE1) DS: Duty Cycle Ratio / SC: Initial COM / LA: Initial Display Line Address
NOTE2) Segment waveforms for 129th COM timing are the same as for 128th COM timing (Row address “127”).

(17-4) SHIFT=0, Initial Display Line “5”, Duty Cycle Ratio “1/129”

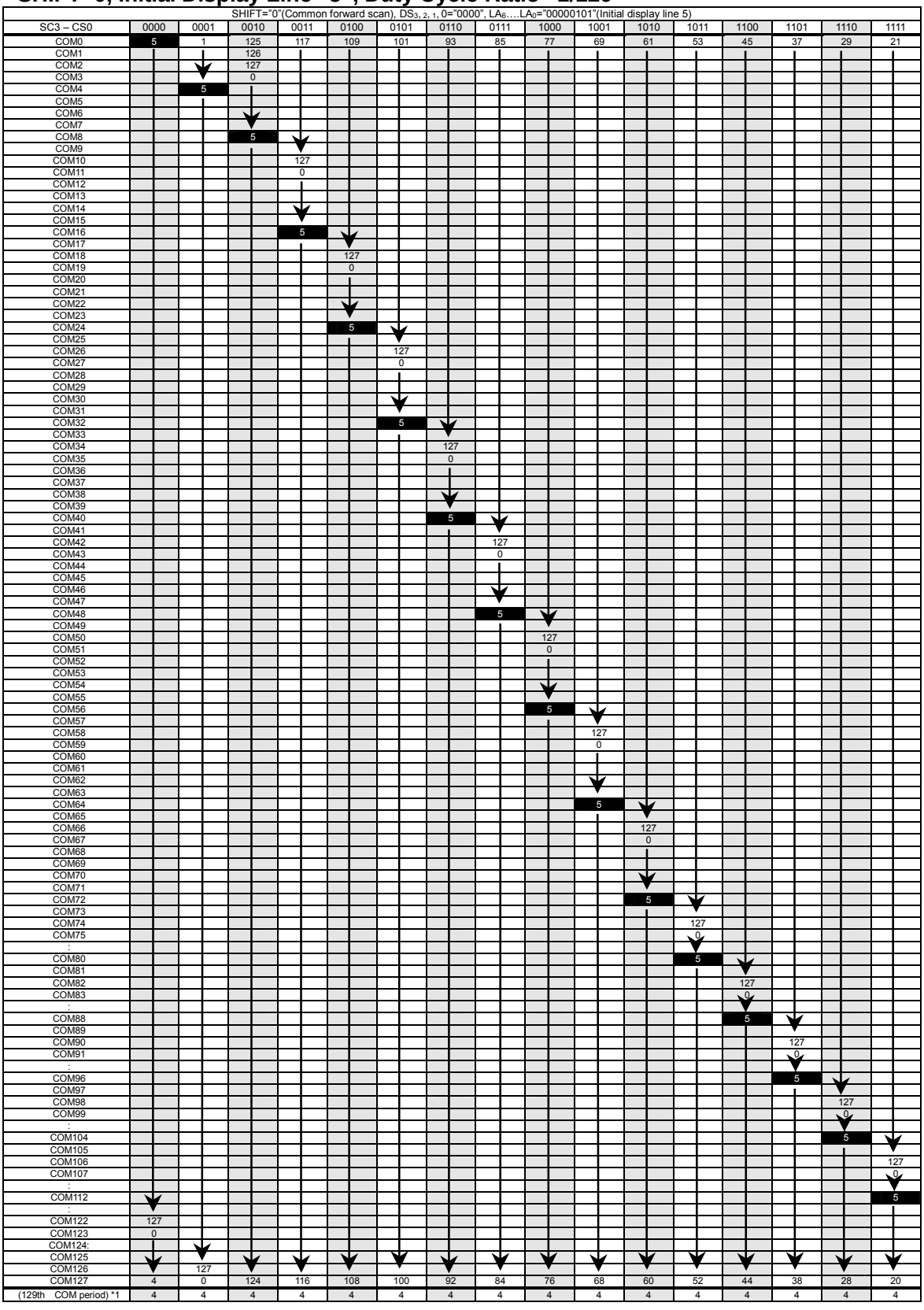


Fig 27 Relation between Row address and Common Driver (4)

NOTE1) DS: Duty Cycle Ratio / SC: Initial COM / LA: Initial Display Line Address
NOTE2) Segment waveforms for 129th COM timing are the same as for 128th COM timing (Row address “127”).

(17-5) SHIFT=0, Initial Display Line “0”, Duty Cycle Ratio “1/128” (Dity-1 ON)

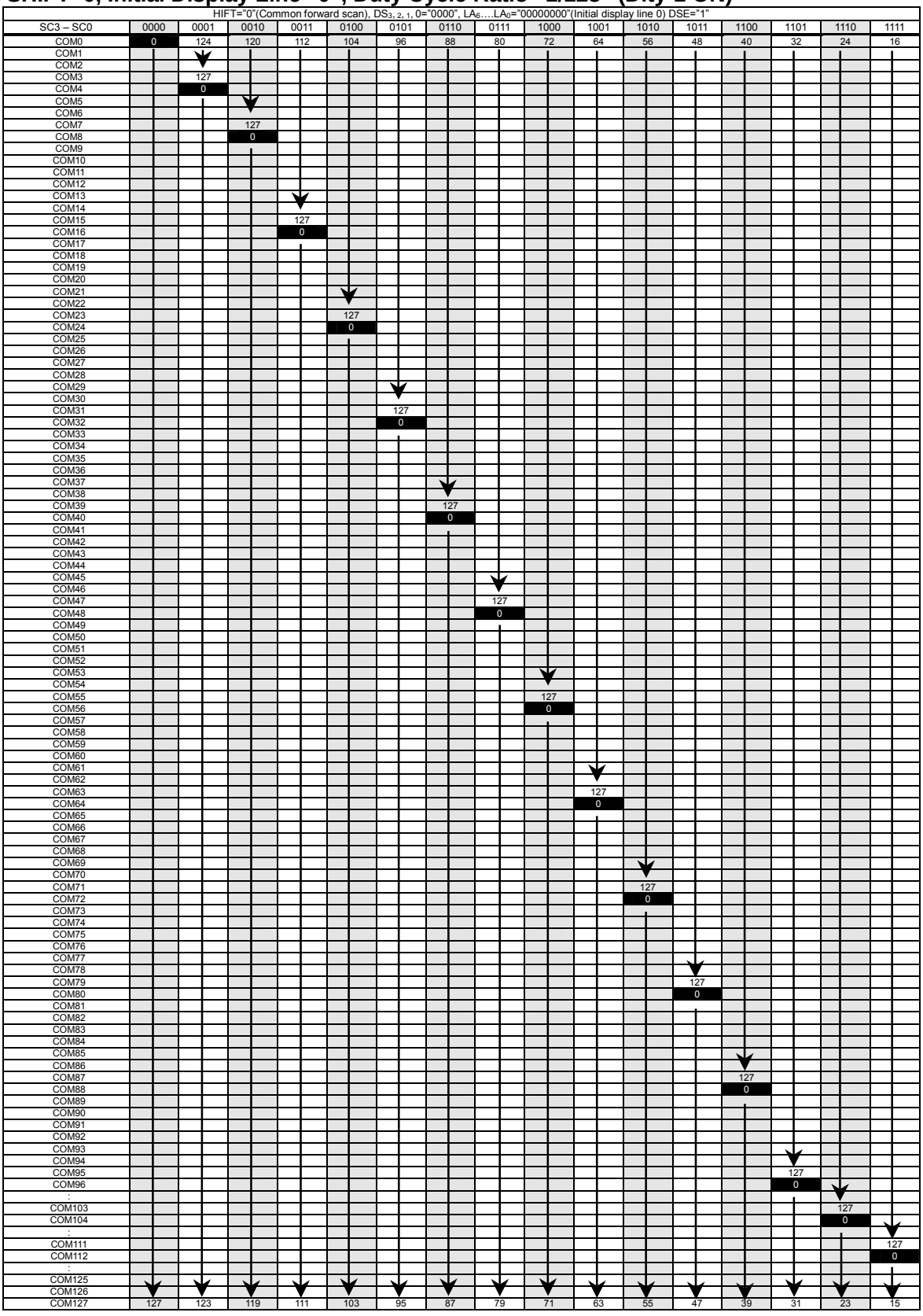
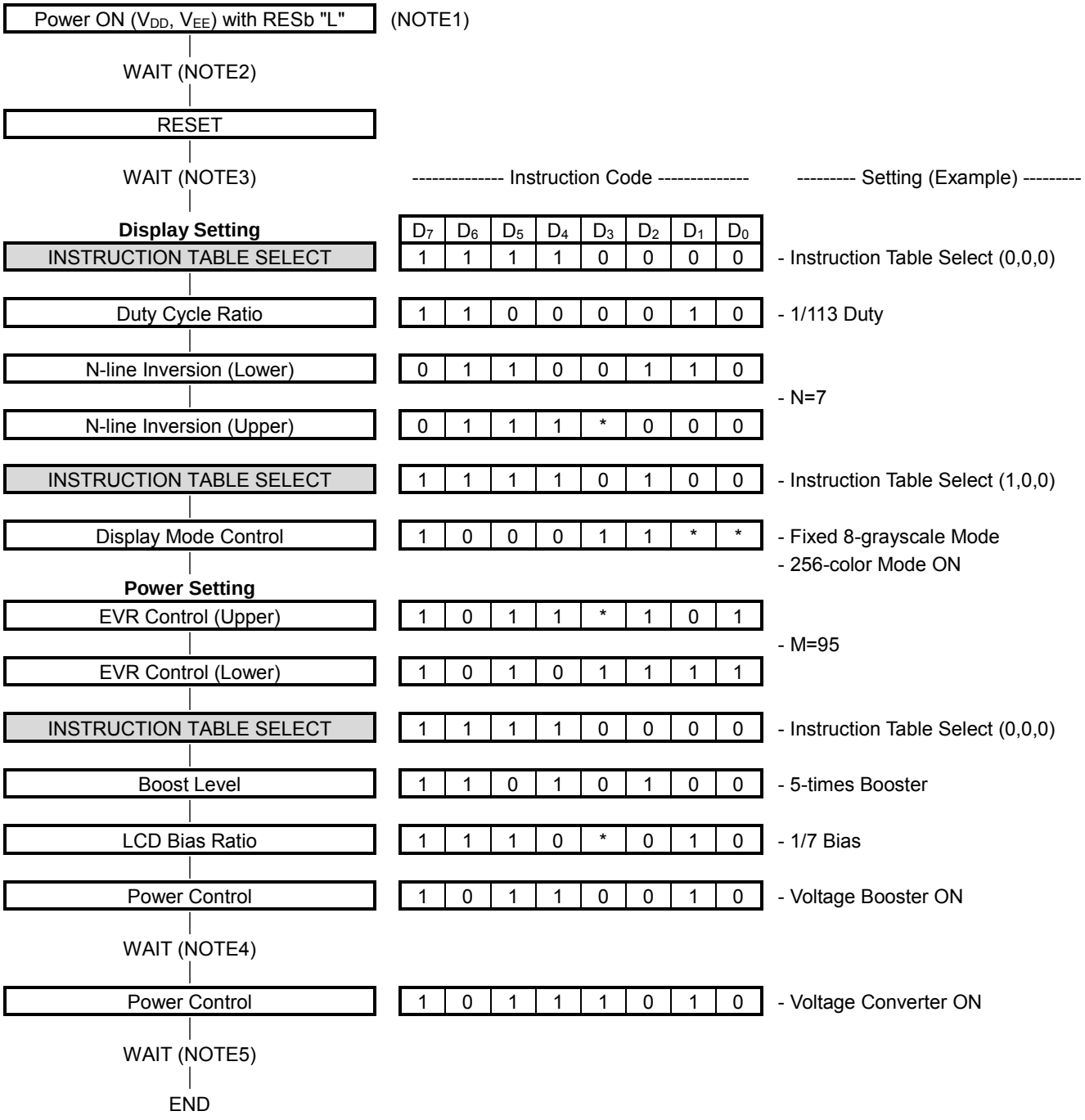


Fig 28 Relation between Row address and Common Driver (5)

NOTE1) DS: Duty Cycle Ratio / SC: Initial COM / LA: Initial Display Line Address

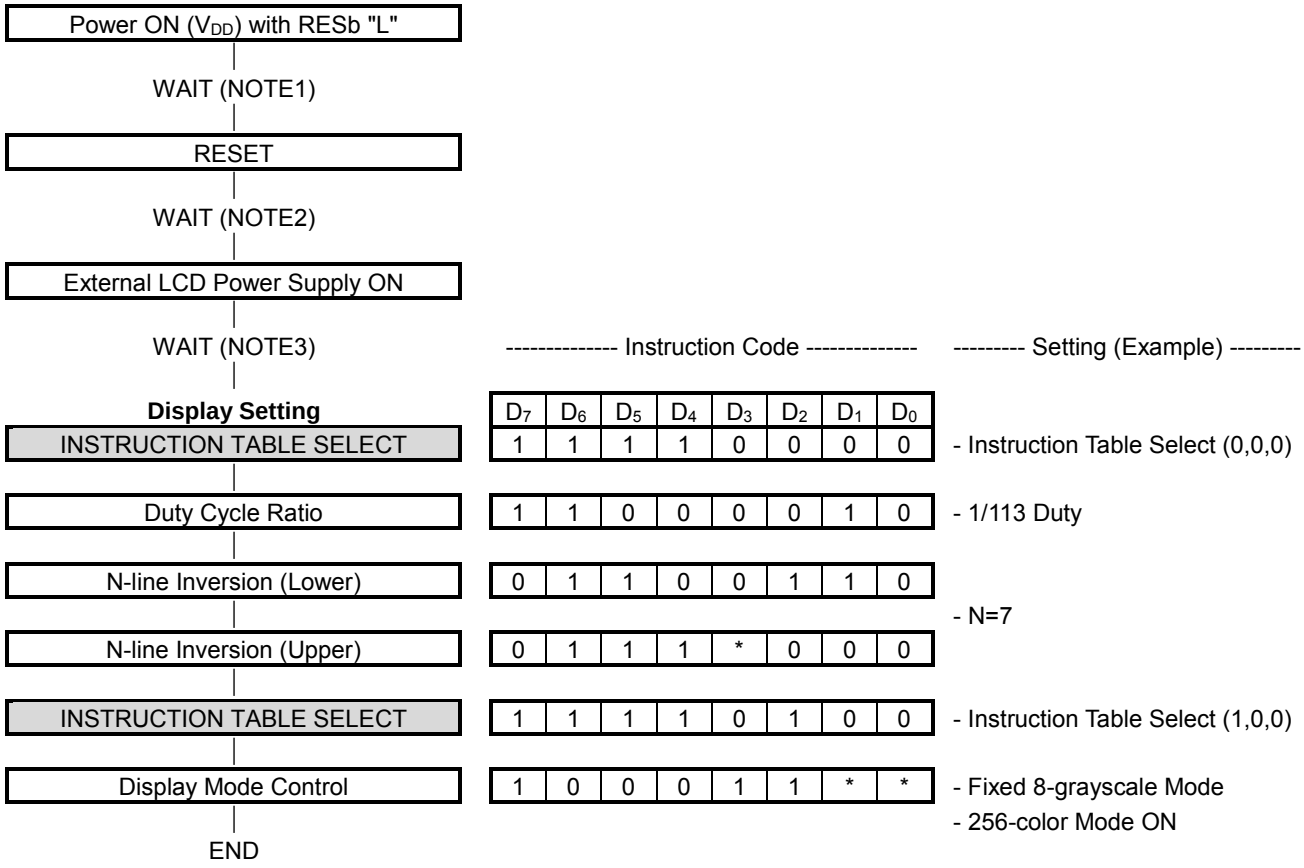
(18) TYPICAL INSTRUCTION SEQUENCES

(18-1) Initialization Sequence in Using Internal LCD Power Supply



NOTE1) If different power sources are applied to the V_{DD} and the V_{EE}, turn on the V_{DD} first.
NOTE2) Wait until the V_{DD} and V_{EE} are stabilized.
NOTE3) Wait 10 [us] or more.
NOTE4) Wait until the V_{OUT} is stabilized.
NOTE5) Wait until the V_{LCD} and V_1-V_4 are stabilized.

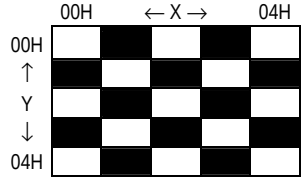
(18-2) Initialization Sequence in Using External LCD Power Supply



NOTE1) Wait until the V_{DD} is stabilized.
NOTE2) Wait 10 [us] or more.
NOTE3) Wait until the external LCD power supply (V_{OUT}, V_{LCD}, V_1-V_4) are stabilized.

(18-3) Display Data Write Sequence

Optional Status	Instruction Code								Setting (Example)
	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	
INSTRUCTION TABLE SELECT	1	1	1	1	0	0	0	0	- Instruction Table Select (0,0,0)
Initial Display Line (Lower)	0	1	0	0	0	0	0	0	
Initial Display Line (Upper)	0	1	0	1	*	0	0	0	-Initial Display Line (00)H
Increment/Decrement Control	1	0	1	0	1	0	1	1	- Read-modify-write ON - Horizontal Direction - X&Y Increment
Window Start Column Address (Lower)	0	0	0	0	0	0	0	0	
Window Start Column Address (Upper)	0	0	0	1	0	0	0	0	- Window Start Column Address (00)H
Window Start Row Address (Lower)	0	0	1	0	0	0	0	0	
Window Start Row Address (Upper)	0	0	1	1	0	0	0	0	- Window Start Row Address (00)H
INSTRUCTION TABLE SELECT	1	1	1	1	0	1	0	1	- Instruction Table Select (1,0,1)
Window End Column Address (Lower)	0	0	0	0	0	1	0	0	
Window End Column Address (Upper)	0	0	0	1	0	0	0	0	-Window End Column Address (04)H
Window End Row Address (Lower)	0	0	1	0	0	1	0	0	
Window End Row Address (Upper)	0	0	1	1	0	0	0	0	- Window End Row Address (04)H
Display Data Write	0	0	0	0	0	0	0	0	- Writing Display Data on the DDRAM for Checker Flag in B&W Mode (Example)
:	1	1	1	1	1	1	1	1	
:	:	:	:	:	:	:	:	:	
:	:	:	:	:	:	:	:	:	
:	Repeating All “0” and All “1” Alternately								
:	:	:	:	:	:	:	:	:	
:	:	:	:	:	:	:	:	:	
:	1	1	1	1	1	1	1	1	
Display Data Write	0	0	0	0	0	0	0	0	
INSTRUCTION TABLE SELECT	1	1	1	1	0	0	0	0	- Instruction Table Select (0,0,0)
Display Control (1)	1	0	0	0	0	0	0	1	- Display ON
END									

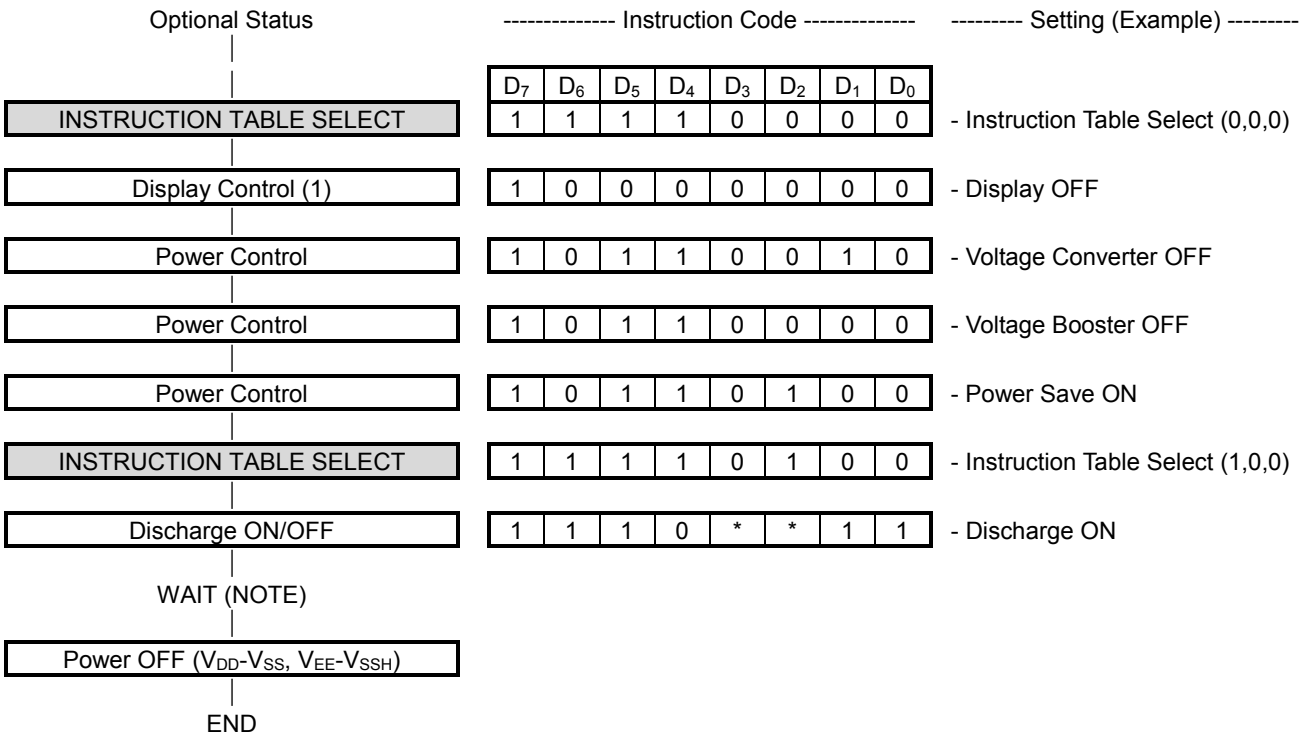


(18-4) Partial Display Sequence

Optional Status	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	Setting (Example)
INSTRUCTION TABLE SELECT	1	1	1	1	0	0	0	0	- Instruction Table Select (0,0,0)
Display Control (1)	1	0	0	0	0	0	0	0	- Display OFF
Power Control	1	0	1	1	0	0	1	0	- Voltage Converter OFF
Power Control	1	0	1	1	0	0	0	0	- Voltage Booster OFF
WAIT (NOTE1)									
Display Setting									
Duty Cycle Ratio	1	1	0	0	1	0	0	0	- 1/65 Duty
Initial Display Line (Lower)	0	1	0	0	0	0	0	0	- Initial Display Line (00)H
Initial Display Line (Upper)	0	1	0	1	*	0	0	0	
INSTRUCTION TABLE SELECT	1	1	1	1	0	1	0	0	- Instruction Table Select (1,0,0)
Initial COM	0	1	1	0	0	0	0	0	- Initial COM: COM0
Power Setting									
EVR Control (Upper)	1	0	1	1	*	0	1	1	- M=60
EVR Control (Lower)	1	0	1	0	1	1	0	0	
INSTRUCTION TABLE SELECT	1	1	1	1	0	0	0	0	- Instruction Table Select (0,0,0)
Boost Level	1	1	0	1	*	0	1	0	- 3-times Booster
LCD Bias Ratio	1	1	1	0	*	1	0	0	- 1/5 Bias
Power Control	1	0	1	1	0	0	1	0	- Voltage Booster ON
WAIT (NOTE2)									
Power Control	1	0	1	1	1	0	1	0	- Voltage Converter ON
WAIT (NOTE3)									
Display Control (1)	1	0	0	0	0	0	0	1	- Display ON
END									

NOTE1) Wait until the voltage booster is completely turned off. Make sure what is the wait time in the particular application.
NOTE2) Wait until the V_{OUT} is stabilized.
NOTE3) Wait until the V_{LCD} and V_1-V_4 are stabilized.

(18-5) Power OFF Sequence



NOTE) Wait until the Discharge is completed.

■ ABSOLUTE MAXIMUM RATINGS

PARAMETER	SYMBOL	CONDITION	TERMINAL	RATING	UNIT
Supply Voltage (1)	V_{DD}	V_{SS}=0V V_{SSH}=0V Ta = +25°C	V_{DD}	-0.3 to +4.0	V
Supply Voltage (2)	V_{EE}		V_{EE}	-0.3 to +4.0	V
Supply Voltage (3)	V_{OUT}		V_{OUT}	-0.3 to +20.0	V
Supply Voltage (4)	V_{REG}		V_{REG}	-0.3 to +20.0	V
Supply Voltage (5)	V_{LCD}		V_{LCD}	-0.3 to +20.0	V
Supply Voltage (6)	V_1, V_2, V_3, V_4		V_1, V_2, V_3, V_4	-0.3 to V_{LCD} + 0.3	V
Input Voltage	V_I		*1	-0.3 to V_{DD} + 0.3	V
Storage Temperature	Tstg			-45 to +125	°C

NOTE1) D_0 to D_{15}, CSb, RS, RDb, WRb, OSC1, RESb, TEST1, and TEST2
NOTE2) To stabilize the LSI operation, place decoupling capacitors between V_{DD} and V_{SS} and between V_{EE} and V_{SSH}.

■ RECOMMENDED OPERATING CONDITIONS

PARAMETER	SYMBOL	TERMINAL	MIN	TYP	MAX	UNIT	NOTE
Supply Voltage	V_{DD1}	V_{DD}	1.7		3.3	V	1
	V_{DD2}		2.4		3.3	V	2
	V_{EE}	V_{EE}	2.4		3.3	V	3
Operating Voltage	V_{LCD}	V_{LCD}	5		18.0	V	4
	V_{OUT}	V_{OUT}			18.0	V	
	V_{REG}	V_{REG}			$V_{OUT} \times 0.9$	V	
	V_{REF}	V_{REF}	2.1		3.3	V	5
Operating Temperature	Topr		-30		85	°C	

NOTE1) Applied to the condition when the reference voltage generator is not used.
NOTE2) Applied to the condition when the reference voltage generator is used.
NOTE3) Applied to the condition when the voltage booster is used.
NOTE4) The following relation among the LCD bias voltages must be maintained.
$V_{SSH} < V_4 < V_3 < V_2 < V_1 < V_{LCD} < V_{OUT}$
NOTE5) Relation: $V_{REF} < V_{EE}$ must be maintained.

■ DC CHARACTERISTICS

V_{SS}=0V, V_{SSH}=0V, V_{DD}=+1.7 to +3.3V, Ta=-30 to +85°C

PARAMETER	SYMBOL	CONDITION		MIN	TYP	MAX	UNIT	NOTE
"H" Level Input Voltage	V_{IH}			0.8 V_{DD}		V_{DD}	V	1
"L" Level Input Voltage	V_{IL}			0		0.2V_{DD}	V	1
"H" Level Output Voltage	V_{OH1}	I_{OH} = -0.4mA		V_{DD} - 0.4			V	2
"L" Level Output Voltage	V_{OL1}	I_{OL} = 0.4mA				0.4	V	2
"H" Level Output Voltage	V_{OH2}	I_{OH} = -0.1mA		V_{DD} - 0.4			V	3
"L" Level Output Voltage	V_{OL2}	I_{OL} = 0.1mA				0.4	V	3
Input Leakage Current	I_{LI}	V_I = V_{SS} or V_{DD}		-10		10	µA	4
Output Leakage Current	I_{LO}	V_I = V_{SS} or V_{DD}		-10		10	µA	5
Driver ON-resistance	R_{ON1}	$\|\Delta V_{ON}\|$ = 0.5V	V_{LCD} = 10V		1	2	kΩ	6
			V_{LCD} = 6V		2	4		
Stand-by Current	I_{STB}	CSb=V_{DD}, Ta=25°C	V_{DD} = 3V			15	µA	7
Oscillation Frequency Using Internal Resistor	f_{OSC1}	V_{DD} = 3V, Ta = 25°C		490	600	710	kHz	8
	f_{OSC2}			110	135.5	160		9
	f_{OSC3}			15.9	19.4	22.9		10
Oscillation Frequency Using External Resistor	f_{r1}	Rf=15kΩ			575		kHz	11
	f_{r2}	Rf=68kΩ			135			
	f_{r3}	Rf=510kΩ			19.6			
Voltage Booster Output Voltage	V_{OUT}	N-time boost (N=2 to 6) RL = 500kΩ (V_{OUT} - V_{SSH})		(N x V_{EE}) x 0.95			V	12
Operating Current (1)	I_{DD1}	V_{DD} = 3V, 6-time boost All pixels ON			760	1140	µA	13
Operating Current (2)	I_{DD2}	V_{DD} = 3V, 6-time boost Checker flag display			930	1400		
Operating Current (3)	I_{DD3}	V_{DD} = 3V, 5-time boost All pixels ON			520	780		
Operating Current (4)	I_{DD4}	V_{DD} = 3V, 5-time boost Checker flag display			650	980		
Operating Current (5)	I_{DD5}	V_{DD} = 3V, 4-time boost All pixels ON			360	540		
Operating Current (6)	I_{DD6}	V_{DD} = 3V, 4-time boost Checker flag display			450	680		
V_{BA} Output Voltage	V_{BA}	V_{EE} = 2.4 to 3.3V		(0.9 V_{EE}) x 0.98	0.9 V_{EE}	(0.9 V_{EE}) x 1.02	V	14
V_{REG} Output Voltage	V_{REG}	V_{EE} = 2.4 to 3.3V, V_{REF} = 0.9 x V_{EE}, N-time boost (N=2 to 6)		(V_{REF} x N) x 0.97	(V_{REF} x N)	(V_{REF} x N) x 1.03	V	15
LCD Bias Voltages	V_2			-100	0	+100	mV	16
	V_3			-100	0	+100		
	V_{D12}			-30	0	+30		
	V_{D34}			-30	0	+30		
	V_{D24}			-30	0	+30		

■ OSCILLATION FREQUENCY AND FRAME FREQUENCY

OSCILLATOR /EXTERNAL CLOCK	SYM BOL	DISPLAY MODE	FRAME FREQUENCY (FLM) DUTY CYCLE RATIO (1/D) <DSE=0>			
			1/129 to 1/81	1/73 to 1/41	1/33 to 1/25	1/17
Using Internal Oscillator	f_{OSC1}	Variable 8-/16-level Grayscale Mode	f_{OSC} / (62xD)	f_{OSC} / (62xDx2)	f_{OSC} / (62xDx4)	f_{OSC} / (62xDx8)
	f_{OSC2}	Fixed 8-level Grayscale Mode	f_{OSC} / (14xD)	f_{OSC} / (14xDx2)	f_{OSC} / (14xDx4)	f_{OSC} / (14xDx8)
	f_{OSC3}	B&W Mode	f_{OSC} / (2xD)	f_{OSC} / (2xDx2)	f_{OSC} / (2xDx4)	f_{OSC} / (2xDx8)
Using External Clock	f_{CK1}	Variable 8-/16-level Grayscale Mode	f_{CK} / (62xD)	f_{CK} / (62xDx2)	f_{CK} / (62xDx4)	f_{CK} / (62xDx8)
	f_{CK2}	Fixed 8-level Grayscale Mode	f_{CK} / (14xD)	f_{CK} / (14xDx2)	f_{CK} / (14xDx4)	f_{CK} / (14xDx8)
	f_{CK3}	B&W Mode	f_{CK} / (2xD)	f_{CK} / (2xDx2)	f_{CK} / (2xDx4)	f_{CK} / (2xDx8)

NOTE1) D_0-D_{15}, CSb, RS, RDb, WRb, P/S, SEL68 and RESb

NOTE2) D_0-D_{15}

NOTE3) CL, FLM, FR and CLK

NOTE4) CSb, RS, SEL68, RDb, WRb, P/S, RESb and OSC1

NOTE5) D_0-D_{15} in high impedance

NOTE6) $SEGA_0$-$SEGA_{79}$, $SEGB_0$-$SEGB_{79}$, $SEGC_0$-$SEGC_{79}$ and COM_0-COM_{127}
This parameter defines the resistance between each COM/SEG and each LCD bias (V_{LCD}, V_1, V_2, V_3 and V_4).
- 0.5V Difference / 1/9 LCD Bias

NOTE7) V_{DD}
Oscillator is halted.
- CSb=1 (Disabled) / No-load on COM/SEG

NOTE8) CLK
This parameter defines the oscillation frequency by using the internal resistor, in the Variable grayscale mode.
- (Rf2, Rf1, Rf0)=(0,0,0)

NOTE9) CLK
This parameter defines the oscillation frequency by using the internal resistor, in the 8-level fixed grayscale mode.
- (Rf2, Rf1, Rf0)=(0,0,0)

NOTE10) CLK
This parameter defines the oscillation frequency by using the internal resistor, in the B&W mode.
- (Rf2, Rf1, Rf0)=(0,0,0)

NOTE11) OSC2
- V_{DD}=3V / Ta=25°C

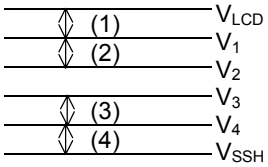
NOTE12) V_{OUT}
This parameter is applied to the condition that the internal LCD power supply and the internal oscillator are used.
- V_{EE}=2.4V to 3.3V / EVR= (1,1,1,1,1,1,1,1) / 1/5 to 1/12 LCD Bias / 1/129 Duty Cycle / No-load on COM/SEG / RL=500kΩ between V_{OUT} and V_{SSH} / CA1=CA2=1.0uF / CA3=0.1uF / DCON="1" / AMPON="1"

NOTE13) V_{SS}, V_{SSH}
This parameter is applied to the condition that the internal LCD power supply and the internal oscillator are used.
- EVR= (1,1,1,1,1,1,1,1) / All Pixels ON or Checker Flag Display / No-load on COM/SEG / No-access from MPU / V_{DD}=V_{EE} / V_{REF}=0.9V_{EE} / CA1=CA2=1.0uF / CA3=0.1uF / DCON="1" / AMPON="1" / NLIN="0" / 1/129 Duty cycle / Ta=25°C

NOTE14) V_{BA}
- V_{BA}=V_{REF} / Boost Level (N)="1",/ DCON="0" / V_{OUT}=13.5V

NOTE15) V_{REG}
- V_{EE}=2.4V to 3.3V / V_{REF}=0.9V_{EE} / V_{OUT}=18V / 1/5 to 1/12 LCD bias ratio / 1/129 duty cycle / EVR=(1,1,1,1,1,1,1,1) / Checker flag display / No-load on COM/SEG / Boost Level (N)="2" to "6" / CA1=CA2=1.0uF / CA3=0.1uF / DCON="0" / AMPON="1" / NLIN="0"

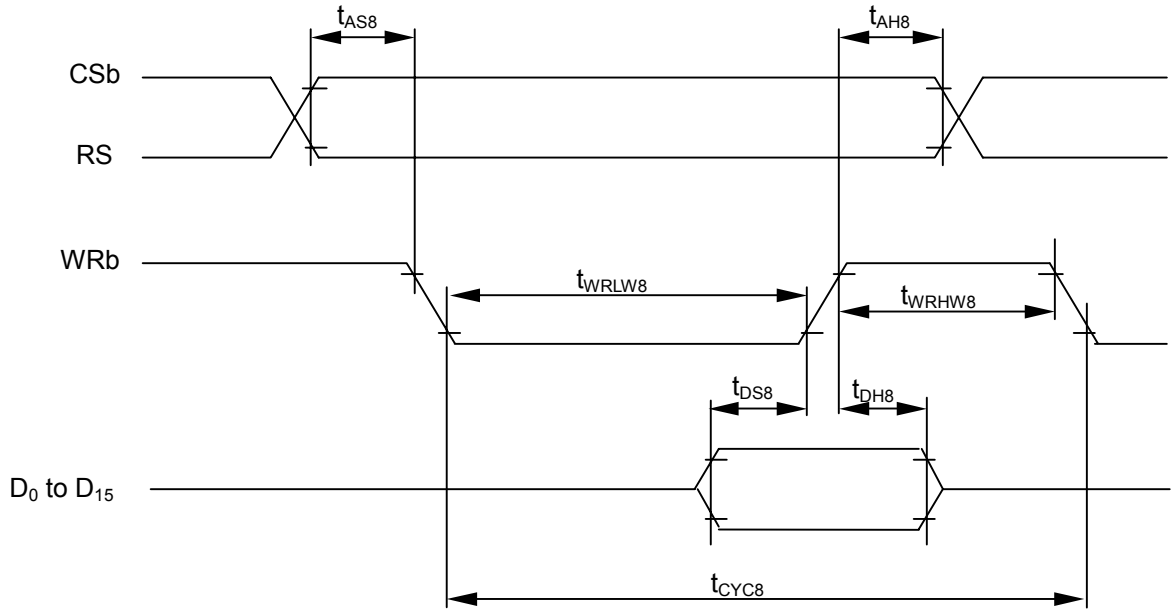
NOTE16) V_{LCD}, V_1, V_2, V_3 and V_4
- V_{EE}=3.0V / V_{REF}=0.9V_{EE} / V_{OUT}=15V / 1/5 to 1/12 LCD Bias / EVR= (1,1,1,1,1,1,1,1) / Display OFF / No-load on COM/SEG / Boost Level (N)="5" / CA1=CA2=1.0uF / CA3=0.1uF / DCON="0" / AMPON="1"



V_{D12}: (1)-(2)
V_{D34}: (3)-(4)
V_{D24}: (2)-(4) (VD24 is applied to the condition that VD12 and VD34 are out of specifications.)

■ AC CHARACTERISTICS

(1) Write Operation (Parallel Interface / 80-series MPU)



(V_{DD}=2.5 to 3.3V, Ta=-30 to +85°C)

PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
Address hold time Address setup time	t_{AH8} t_{AS8}		0 0		ns ns	CSb RS
System cycle time Enable "L" level pulse width Enable "H" level pulse width	t_{CYC8} t_{WRLW8} t_{WRHW8}		90 35 35		ns ns ns	WRb
Data setup time Data hold time	t_{DS8} t_{DH8}		30 5		ns ns	D_0 to D_{15}

(V_{DD}=2.2 to 2.5V, Ta=-30 to +85°C)

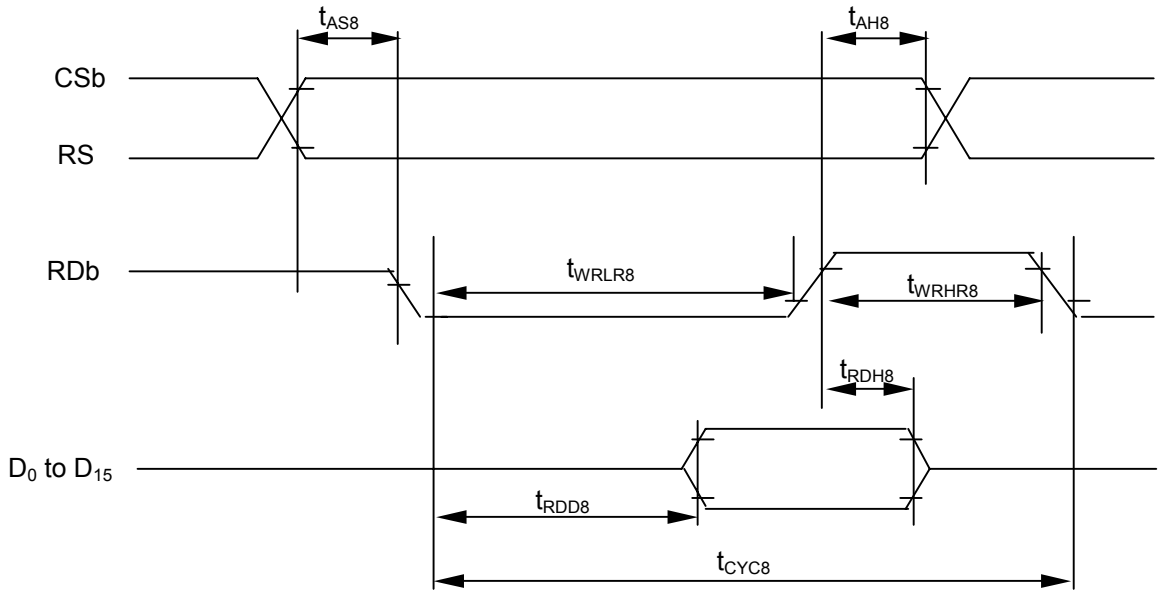
PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
Address hold time Address setup time	t_{AH8} t_{AS8}		0 0		ns ns	CSb RS
System cycle time Enable "L" level pulse width Enable "H" level pulse width	t_{CYC8} t_{WRLW8} t_{WRHW8}		160 70 70		ns ns ns	WRb
Data setup time Data hold time	t_{DS8} t_{DH8}		40 5		ns ns	D_0 to D_{15}

(V_{DD}=1.7 to 2.2V, Ta=-30 to +85°C)

PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
Address hold time Address setup time	t_{AH8} t_{AS8}		0 0		ns ns	CSb RS
System cycle time Enable "L" level pulse width Enable "H" level pulse width	t_{CYC8} t_{WRLW8} t_{WRHW8}		180 80 80		ns ns ns	WRb
Data setup time Data hold time	t_{DS8} t_{DH8}		70 10		ns ns	D_0 to D_{15}

NOTE) Each timing is specified based on 20% and 80% of V_{DD}.

(2) Read Operation (Parallel Interface / 80-series MPU)



(V_{DD}=2.5 to 3.3V, Ta=-30 to +85°C)

PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
Address hold time Address setup time	t_{AH8} t_{AS8}		0 0		ns ns	CSb RS
System cycle time Enable "L" level pulse width Enable "H" level pulse width	t_{CYC8} t_{WRLR8} t_{WRHR8}		180 80 80		ns ns ns	RDb
Read Data delay time Read Data hold time	t_{RDD8} t_{RDH8}	CL=15pF	 0	60	ns ns	D_0 to D_{15}

(V_{DD}=2.2 to 2.5V, Ta=-30 to +85°C)

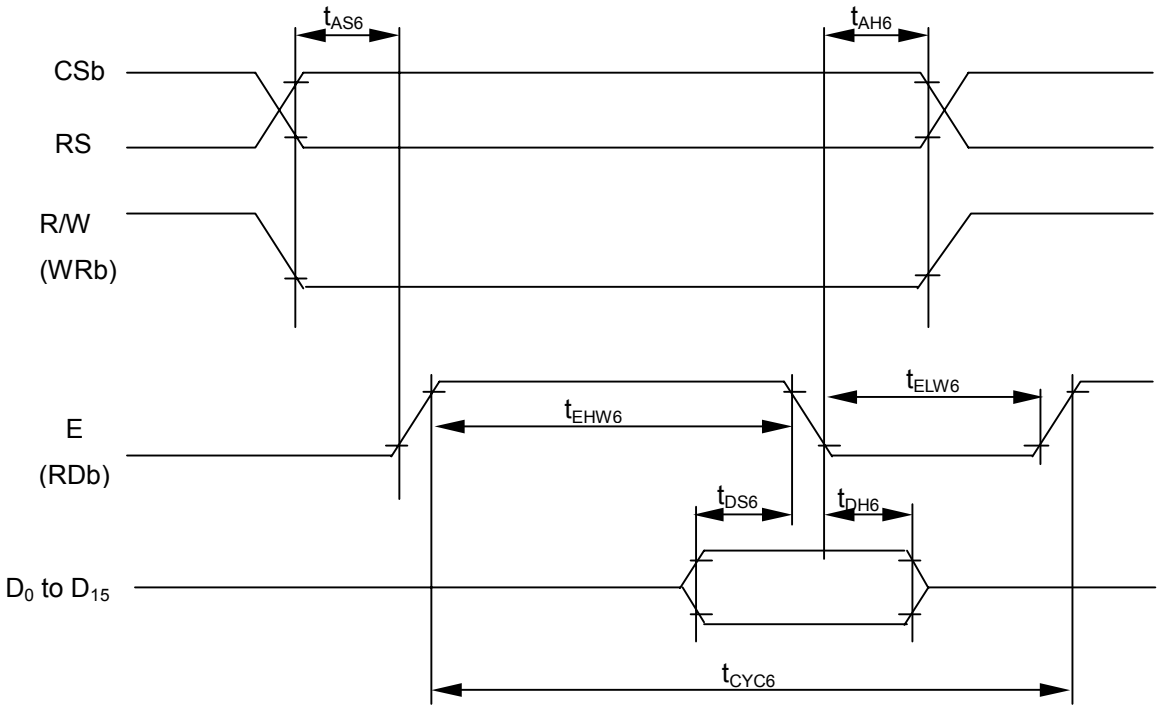
PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
Address hold time Address setup time	t_{AH8} t_{AS8}		0 0		ns ns	CSb RS
System cycle time Enable "L" level pulse width Enable "H" level pulse width	t_{CYC8} t_{WRLR8} t_{WRHR8}		180 80 80		ns ns ns	RDb
Read Data delay time Read Data hold time	t_{RDD8} t_{RDH8}	CL=15pF	 0	60	ns ns	D_0 to D_{15}

(V_{DD}=1.7 to 2.2V, Ta=-30 to +85°C)

PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
Address hold time Address setup time	t_{AH8} t_{AS8}		0 0		ns ns	CSb RS
System cycle time Enable "L" level pulse width Enable "H" level pulse width	t_{CYC8} t_{WRLR8} t_{WRHR8}		300 140 140		ns ns ns	RDb
Read Data delay time Read Data hold time	t_{RDD8} t_{RDH8}	CL=15pF	 0	130	ns ns	D_0 to D_{15}

NOTE) Each timing is specified based on 20% and 80% of V_{DD}.

(3) Write Operation (Parallel Interface / 68-series MPU)



(V_{DD}=2.5 to 3.3V, Ta=-30 to +85°C)

PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
Address hold time Address setup time	t_{AH6} t_{AS6}		0 0		ns ns	CSb RS
System cycle time Enable "L" level pulse width Enable "H" level pulse width	t_{CYC6} t_{ELW6} t_{EHW6}		90 35 35		ns ns ns	E
Data setup time Data hold time	t_{DS6} t_{DH6}		40 5		ns ns	D_0 to D_{15}

(V_{DD}=2.2 to 2.5V, Ta=-30 to +85°C)

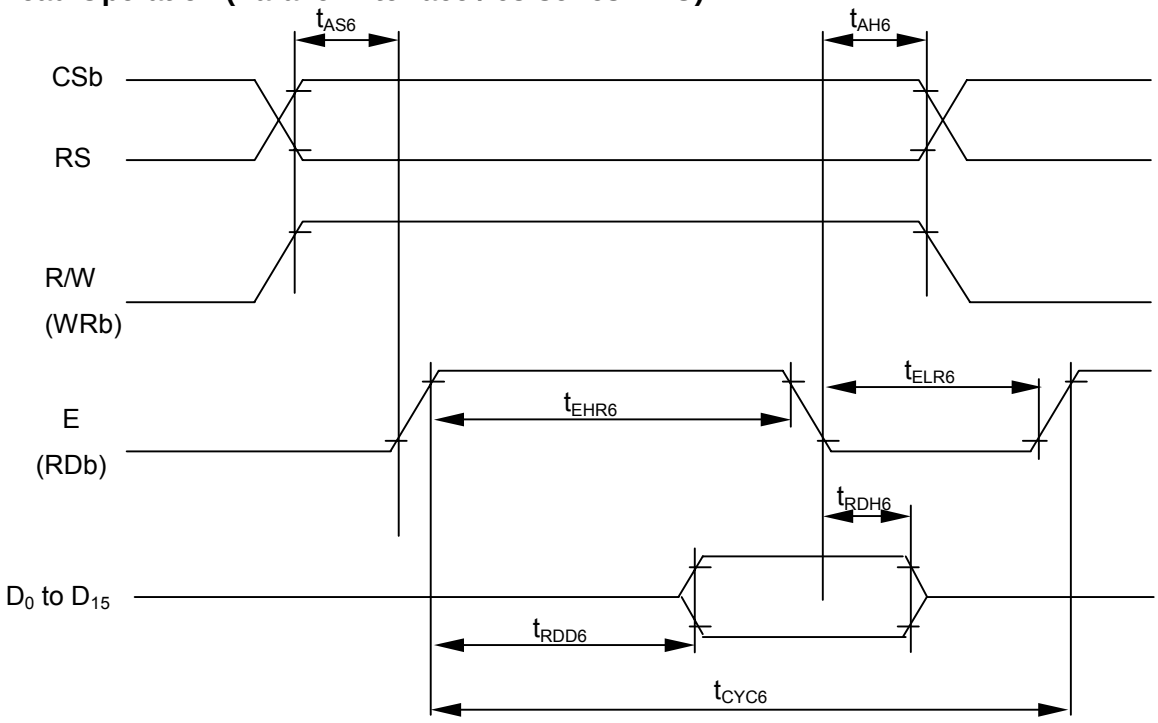
PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
Address hold time Address setup time	t_{AH6} t_{AS6}		0 0		ns ns	CSb RS
System cycle time Enable "L" level pulse width Enable "H" level pulse width	t_{CYC6} t_{ELW6} t_{EHW6}		160 70 70		ns ns ns	E
Data setup time Data hold time	t_{DS6} t_{DH6}		50 5		ns ns	D_0 to D_{15}

(V_{DD}=1.7 to 2.2V, Ta=-30 to +85°C)

PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
Address hold time Address setup time	t_{AH6} t_{AS6}		0 0		ns ns	CSb RS
System cycle time Enable "L" level pulse width Enable "H" level pulse width	t_{CYC6} t_{ELW6} t_{EHW6}		180 80 80		ns ns ns	E
Data setup time Data hold time	t_{DS6} t_{DH6}		70 10		ns ns	D_0 to D_{15}

NOTE) Each timing is specified based on 20% and 80% of V_{DD}.

(4) Read Operation (Parallel Interface / 68-series MPU)



(V_{DD}=2.5 to 3.3V, Ta=-30 to +85°C)

PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
Address hold time Address setup time	t_{AH6} t_{AS6}		0 0		ns ns	CSb RS
System cycle time Enable "L" level pulse width Enable "H" level pulse width	t_{CYC6} t_{ELR6} t_{EHR6}		180 80 80		ns ns ns	E
Read Data delay time Read Data hold time	t_{RDD6} t_{RDH6}	CL=15pF	0	70	ns ns	D_0 to D_{15}

(V_{DD}=2.2 to 2.5V, Ta=-30 to +85°C)

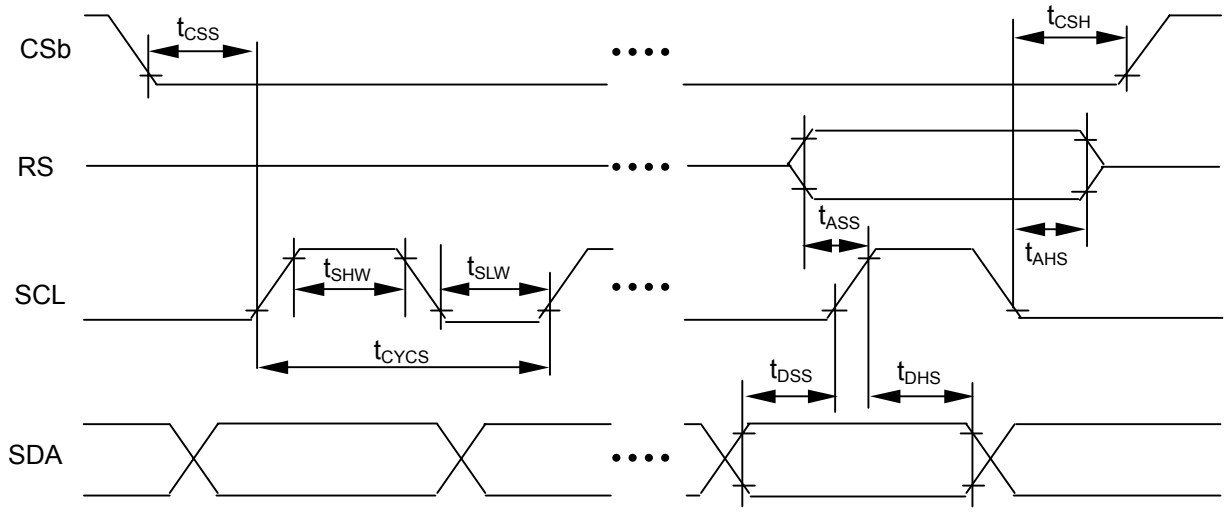
PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
Address hold time Address setup time	t_{AH6} t_{AS6}		0 0		ns ns	CSb RS
System cycle time Enable "L" level pulse width Enable "H" level pulse width	t_{CYC6} t_{ELR6} t_{EHR6}		180 80 80		ns ns ns	E
Read Data delay time Read Data hold time	t_{RDD6} t_{RDH6}	CL=15pF	0	70	ns ns	D_0 to D_{15}

(V_{DD}=1.7 to 2.2V, Ta=-30 to +85°C)

PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
Address hold time Address setup time	t_{AH6} t_{AS6}		0 0		ns ns	CSb RS
System cycle time Enable "L" level pulse width Enable "H" level pulse width	t_{CYC6} t_{ELR6} t_{EHR6}		300 140 140		ns ns ns	E
Read Data delay time Read Data hold time	t_{RDD6} t_{RDH6}	CL=15pF	0	130	ns ns	D_0 to D_{15}

NOTE) Each timing is specified based on 20% and 80% of V_{DD}.

(5) Serial Interface



(V_{DD}=2.5 to 3.3V, Ta=-30 to +85°C)

PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
Serial clock cycle SCL "H" level pulse width SCL "L" level pulse width	t_{CYCS} t_{SHW} t_{SLW}		50 20 20		ns ns ns	SCL
Address setup time Address hold time	t_{ASS} t_{AHS}		20 20		ns ns	RS
Data setup time Data hold time	t_{DSS} t_{DHS}		20 20		ns ns	SDA
CSb – SCL time CSb hold time	t_{CSS} t_{CSH}		20 20		ns ns	CSb

(V_{DD}=2.2 to 2.5V, Ta=-30 to +85°C)

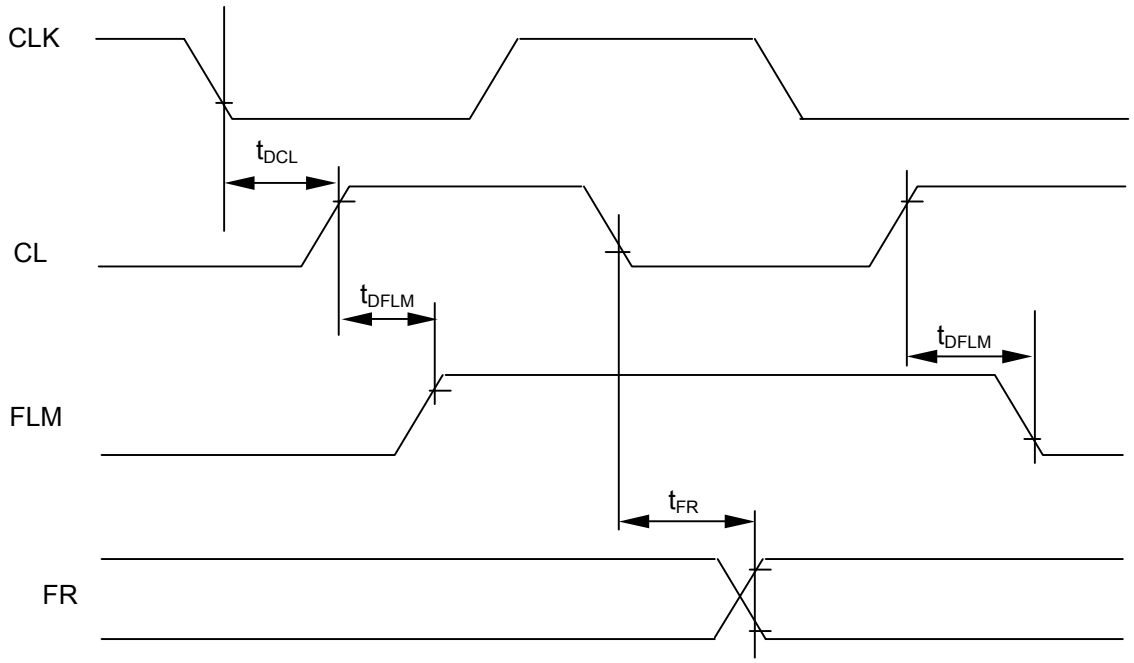
PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
Serial clock cycle SCL "H" level pulse width SCL "L" level pulse width	t_{CYCS} t_{SHW} t_{SLW}		50 20 20		ns ns ns	SCL
Address setup time Address hold time	t_{ASS} t_{AHS}		20 20		ns ns	RS
Data setup time Data hold time	t_{DSS} t_{DHS}		20 20		ns ns	SDA
CSb – SCL time CSb hold time	t_{CSS} t_{CSH}		20 20		ns ns	CSb

(V_{DD}=1.7 to 2.2V, Ta=-30 to +85°C)

PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
Serial clock cycle SCL "H" level pulse width SCL "L" level pulse width	t_{CYCS} t_{SHW} t_{SLW}		80 35 35		ns ns ns	SCL
Address setup time Address hold time	t_{ASS} t_{AHS}		35 35		ns ns	RS
Data setup time Data hold time	t_{DSS} t_{DHS}		35 35		ns ns	SDA
CSb – SCL time CSb hold time	t_{CSS} t_{CSH}		35 35		ns ns	CSb

NOTE) Each timing is specified based on 20% and 80% of V_{DD}.

(6) Display Control Timing



Output timing (V_{DD}=2.4 to 3.3V, Ta=-30 to +85°C)

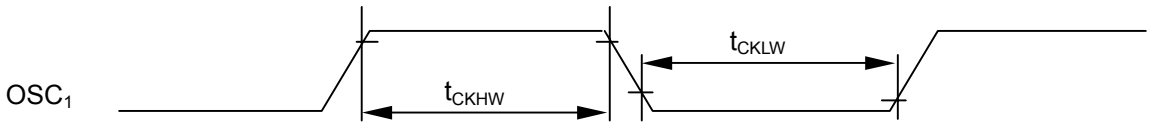
PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
FLM delay time	t_{DFLM}	CL=15pF	0	500	ns	FLM
FR delay time	t_{FR}		0	500	ns	FR
CL delay time	t_{DCL}		0	200	ns	CL

Output timing (V_{DD}=1.7 to 2.4V, Ta=-30 to +85°C)

PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
FLM delay time	t_{DFLM}	CL=15pF	0	1000	ns	FLM
FR delay time	t_{FR}		0	1000	ns	FR
CL delay time	t_{DCL}		0	200	ns	CL

NOTE) Each timing is specified based on 20% and 80% of V_{DD}.

(7) Input Clock Timing

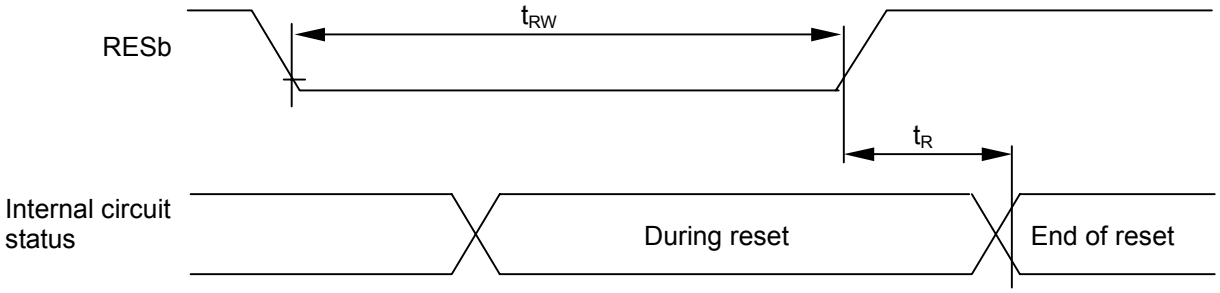


(V_{DD}=1.7 to 3.3V, Ta=-30 to +85°C)

PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	TERMINAL
OSC1 “H” level pulse width (1)	t_{CKHW1}		0.70	1.02	µs	OSC1 (NOTE2)
OSC1 “L” level pulse width (1)	t_{CKLW1}		0.70	1.02	µs	
OSC1 “H” level pulse width (2)	t_{CKHW2}		3.13	4.55	µs	OSC1 (NOTE3)
OSC1 “L” level pulse width (2)	t_{CKLW2}		3.13	4.55	µs	
OSC1 “H” level pulse width (3)	t_{CKHW3}		21.8	31.4	µs	OSC1 (NOTE4)
OSC1 “L” level pulse width (3)	t_{CKLW3}		21.8	31.4	µs	

NOTE1) Each timing is specified based on 20% and 80% of V_{DD}.
NOTE2) Applied to Variable 8-/16-level grayscale mode (MON=”0”,PWM=”0”)
NOTE3) Applied to fixed 8-level grayscale mode (MON=”0”,PWM=”1”)
NOTE4) Applied to B&W mode (MON=”1”)

(8) Reset Input Timing



(V_{DD}=2.4 to 3.3V, Ta=-30 to +85°C)

PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	Terminal
Reset time	t_R			1.0	µs	
RESb “L” level pulse width	t_{RW}		10.0		µs	RESb

(V_{DD}=1.7 to 2.4V, Ta=-30 to +85°C)

PARAMETER	SYMBOL	CONDITION	MIN.	MAX.	UNIT	Terminal
Reset time	t_R			1.5	µs	
RESb “L” level pulse width	t_{RW}		10.0		µs	RESb

NOTE) Each timing is specified based on 20% and 80% of V_{DD}.

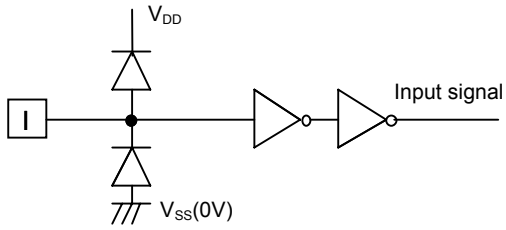
(9) Delay Time of Gate

PARAMETER	SYMBOL	MIN	TYP	MAX	UNIT
Delay time of gate	Ta=+25°C, V_{SS}=0V, V_{DD}=3.0V		10		ns

■ INPUT/OUTPUT BLOCK DIAGRAMS

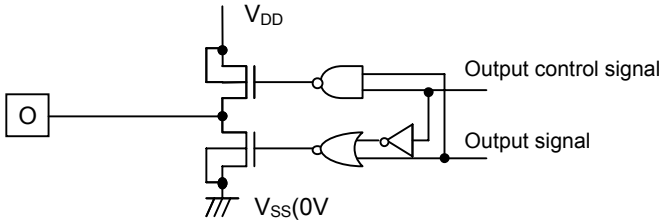
Input Block Diagram

Terminals CSb, RS, RDb, WRb, SEL68, P/S,RESb



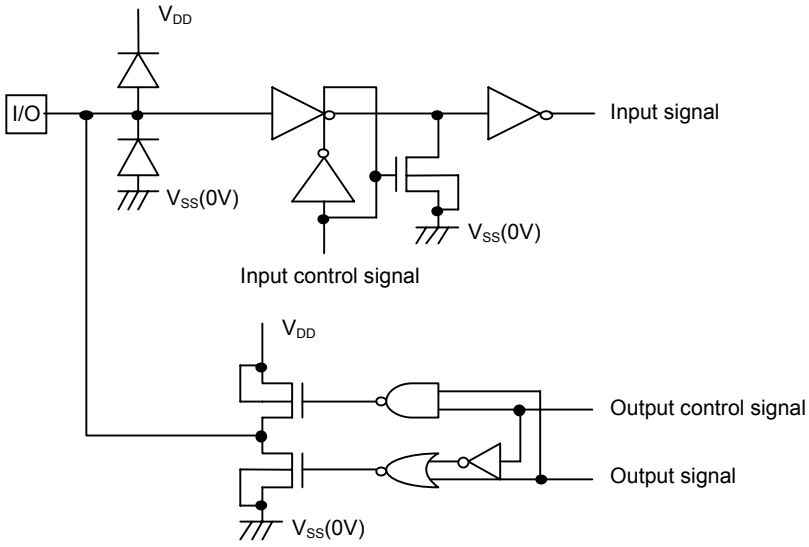
Output Block Diagram

Terminals : FLM, CL, FR, CLK



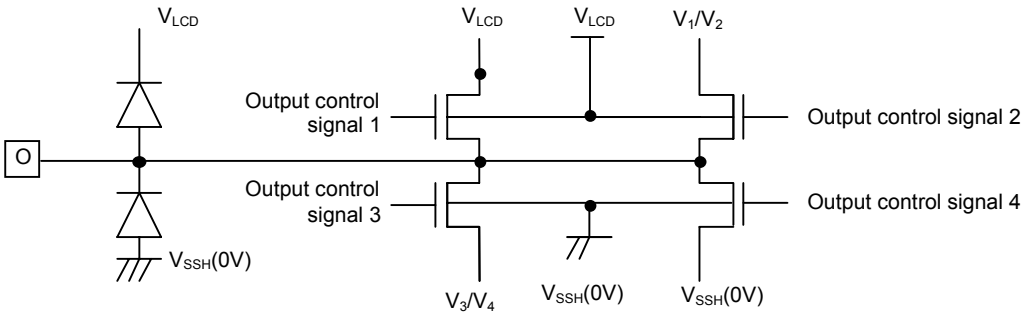
Input/Output Block Diagram

Terminals : D_0 - D_{15}



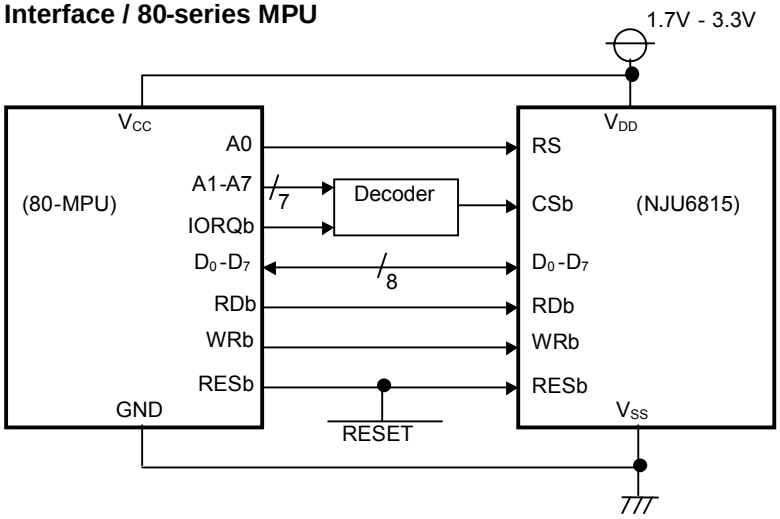
COM/SEG Driver Block Diagram

Terminals : $SEGA_0/B_0/C_0$ - $SEGA_{79}/B_{79}/C_{79}$, COM_0 - COM_{127}

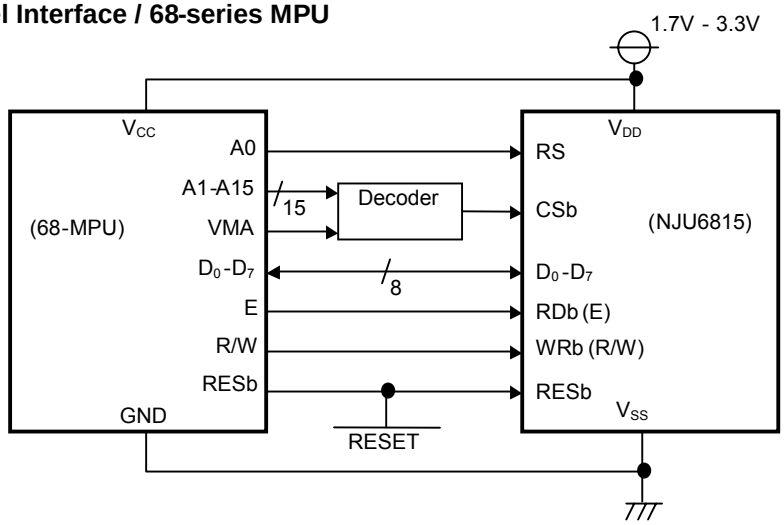


■ MPU CONNECTIONS

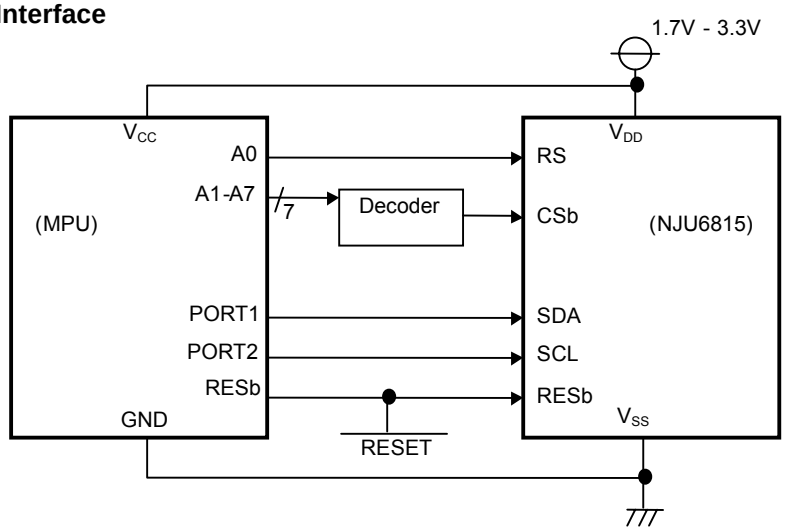
Parallel Interface / 80-series MPU



Parallel Interface / 68-series MPU



Serial Interface



[CAUTION]
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