HD66730/HD66731

(Dot-Matrix Liquid Crystal Display Controller/Driver Supporting Japanese Kanji, Korean Font Display)

HITACHI

Description

The HD66730/1 is a dot-matrix liquid crystal display controller (LCD) and driver LSI that displays Japanese characters consisting of kanji, hiragana and katakana according to the Japanese Industrial Standard (JIS) Level-1 Kanji Set. The HD66730/1 incorporates the following five functions on a single chip: (i) display control function for the dot matrix LCD, (ii) a display RAM to store character codes, (iii) ROM fonts to support kanji, (iv) liquid crystal driver, and (v) a booster to drive the LCD. A two 6-character (HD66730) or four 10-character (HD66731) kanji display can easily be achieved by receiving character codes (2 bytes/character) from the MPU.

The font ROM includes 2,965 kanji from the JIS Level-1 Kanji Set, 524 JIS non-kanji characters, and 128 half-size alphanumeric characters and symbols. Full-size fonts such as Japanese kanji and half-size of fonts such as alphanumeric characters can be displayed together.

In addition, display control equivalent to full bit mapping can be performed through horizontal and vertical dot-by-dot smooth scroll functions for each display line. To help make systems more compact, a three-line clock synchronous serial transfer method is adopted in addition to an 8-bit bus for interfacing with a microcomputer.

Features

- Dot-matrix liquid crystal display controller/driver supporting the display of kanji according to JIS Level-1 Kanji Set
- Large character generator ROM: 510 kbits
  - Kanji according to JIS Level-1 Kanji Set (11 × 12 dots): 2,965-character font
  - JIS non-kanji (11 × 12 dots): 524-character font
  - Half-size alphanumeric characters and symbols (5 × 12 dots): 128-character font
- Display of 11 × 12 dots for full-size fonts consisting of kanji and kana, 5 × 12 dots for half-size fonts of alphanumeric characters and symbols in the same display
- 2-line 6-character full-size font display with a single chip (HD66730)
- 4-line 10-character full-size font display with a single chip (HD66731)
- Expansion driver interface: maximum 2-line 20-character (or 4-line 10-character) display (HD66730)
- Dot matrix font and 71 marks and icons (96 at HD66731)

- Various display control functions: horizontal smooth scroll (in dot units), vertical smooth scroll, white black inversion/blinking/white black inversion blinking character display, cursor display, display on/off
- Display data RAM: 40 × 2 bytes (stores codes to support 40 characters in a full-size font)
- Character generator RAM: 8 × 26 bytes (displays 8 characters of a 12 × 13 dot user font)
- 16-byte 96-segment RAM
- Three-line clock synchronous serial bus, 8-bit bus interface
- Built-in double/triple liquid-crystal voltage booster circuit and built-in oscillator (operating frequency can be adjusted through external resistors)
- Operating power supply voltage: 2.4V to 5.5V; liquid crystal display voltage: 3.0V to 13.0V
- HD66730: QFP 1420-128 (0.5 mm pitch), bare-chip
- HD66731: TCP-171 (straight), TCP-206 (bent), chip with bump

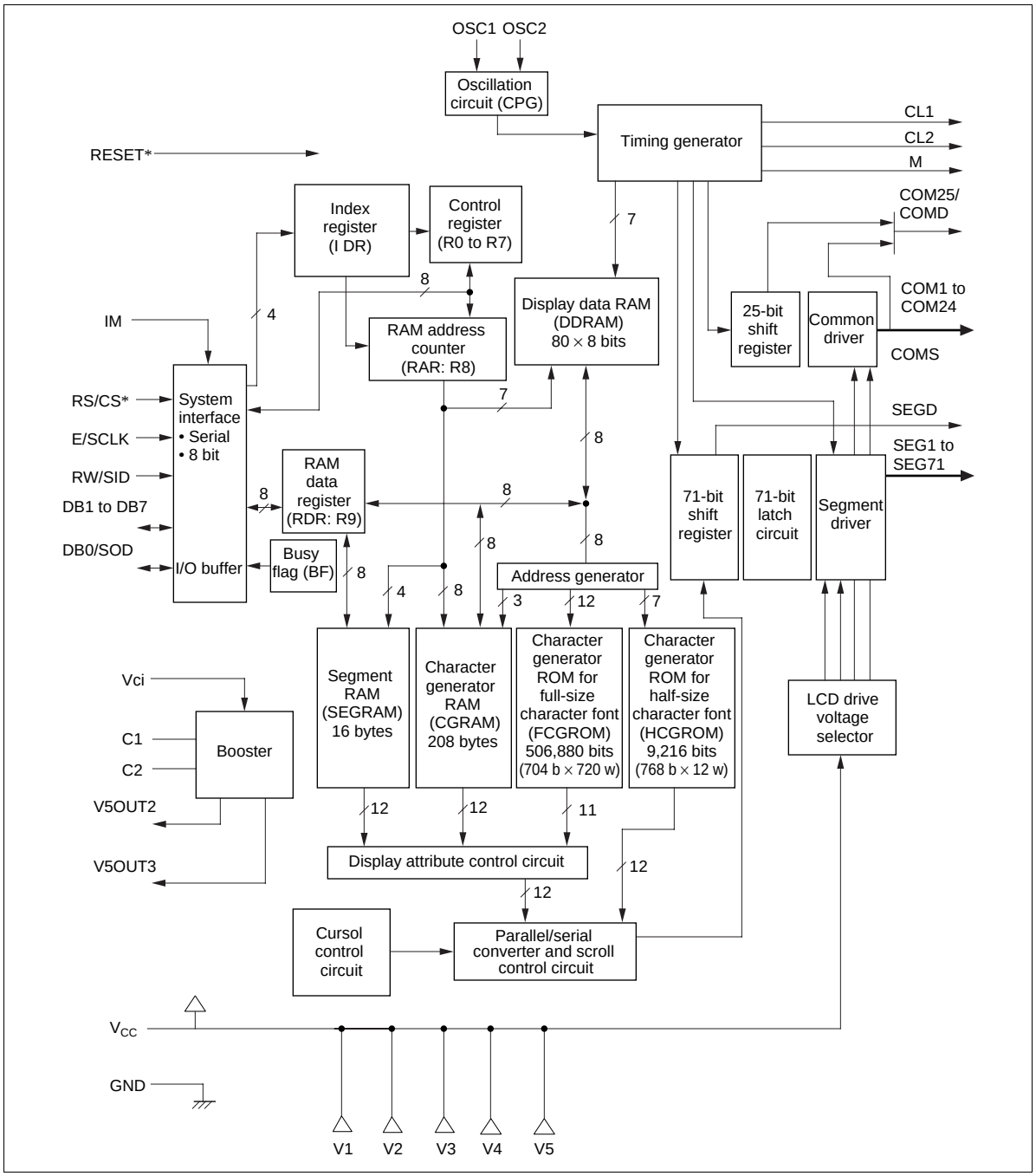
List 1 Programmable Duty Cycles

Duty Drive Setting	Number of Display Characters in Full-Size Font		Number of Segments/Marks	
	HD66730	HD66731	HD66730	HD66731
1/14	One 6-character	One 10-character	71pcs	96pcs
1/27	Two 6-character	Two 10-character	71pcs	96pcs
1/40	—	Three 10-characters	—	96pcs
1/53	—	Four 10-characters	—	96pcs

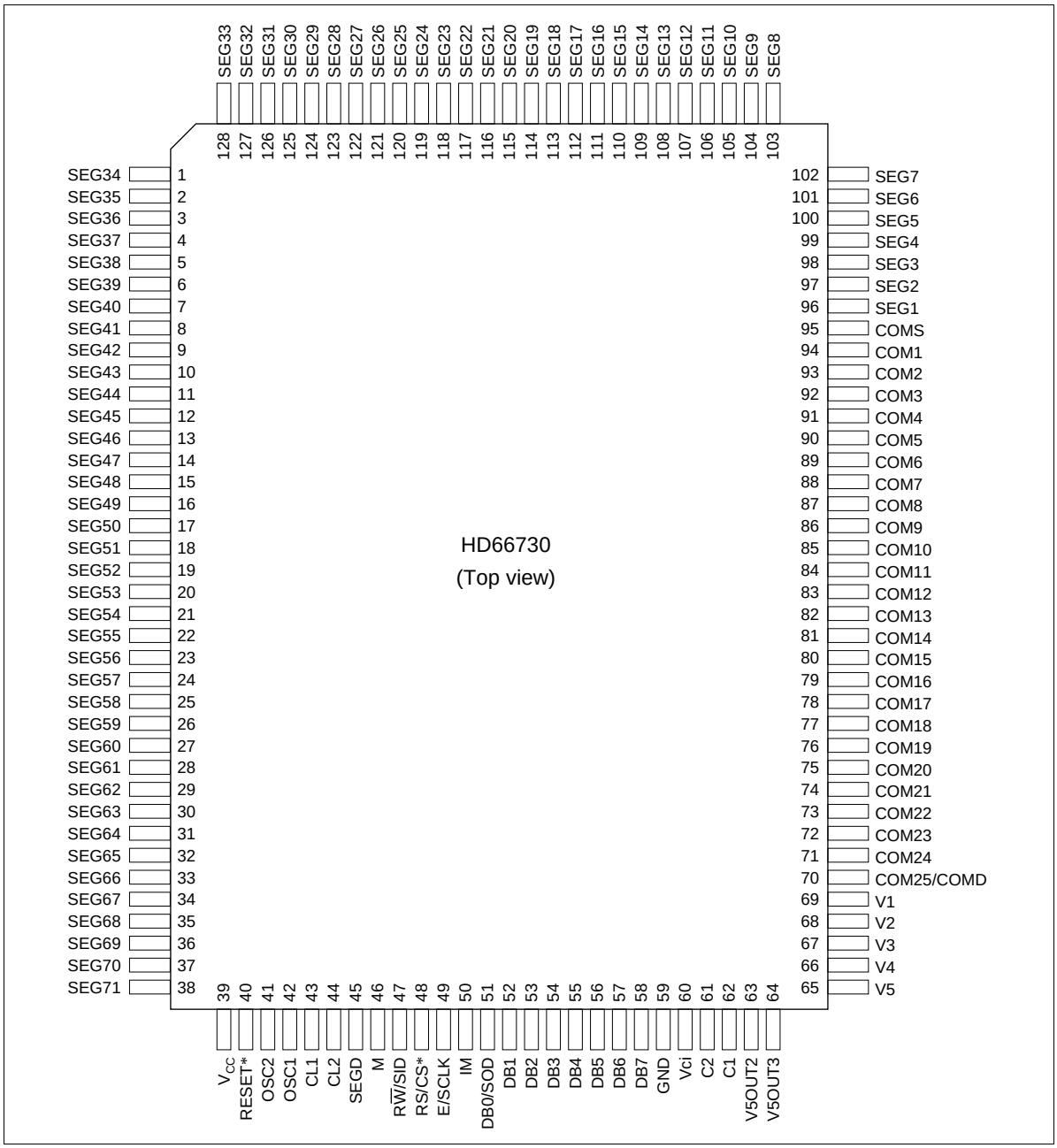
Ordering Information

Type No.	Package	Number of Display character	CGROM
HD66730A00FS	FP-128	Two 6-characters	JIS Level-1 Kanji (A00)
HCD66730A00	Bare chip	Two 6-characters	
HD66731A00TA0L	Straight TCP	Three 8-characters	
HD66731A00TB0L	Bending TCP	Four 10-characters	
HCD66731A00BP	Au-bumped chip	Four 10-characters	
HD66730A01FS	FP-128	Two 6-characters	Korean font (A01)
HCD66730A01	Bare chip	Two 6-characters	
HD66731A01TA0L	Straight TCP	Three 8-characters	
HD66731A01TB0L	Bending TCP	Four 10-characters	
HCD66731A01BP	Au-bumped chip	Four 10-characters	

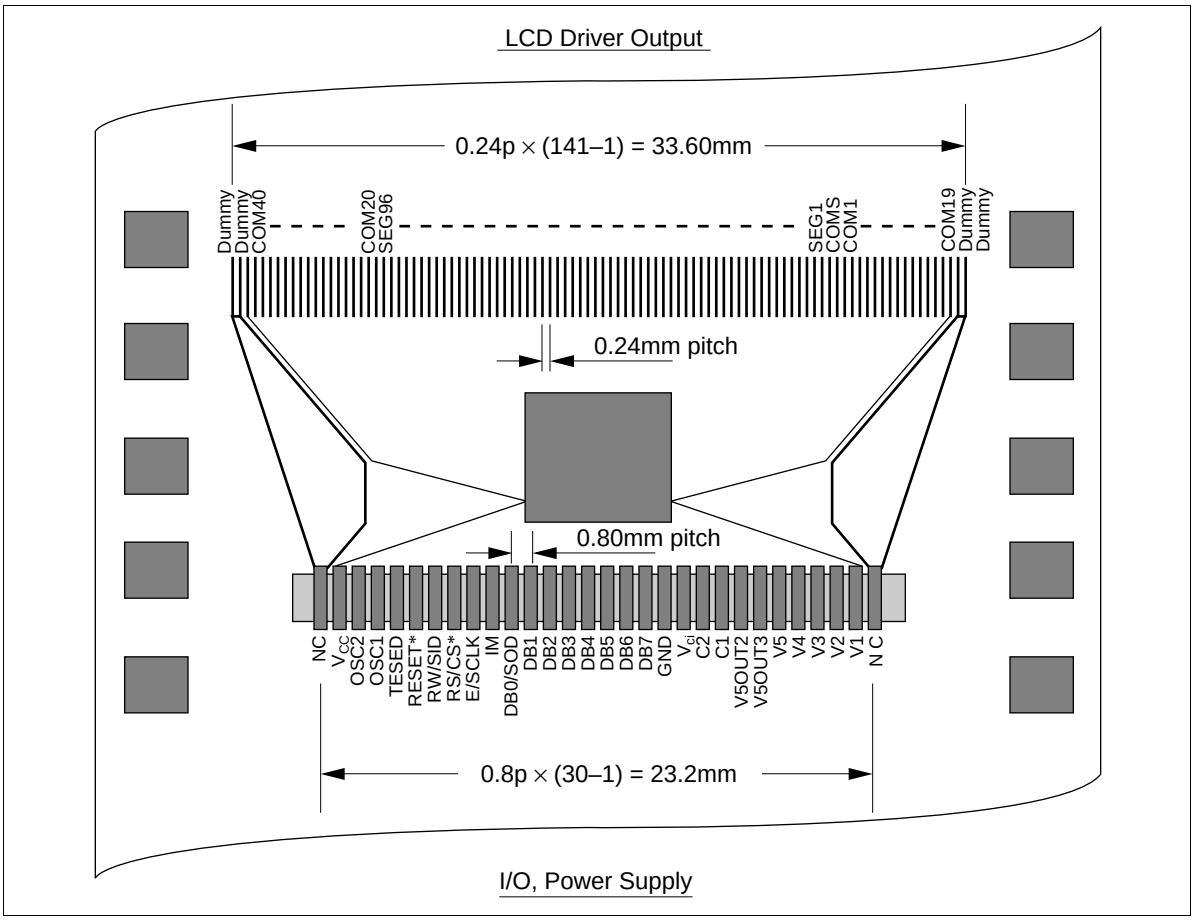
Block Diagram (HD66730)



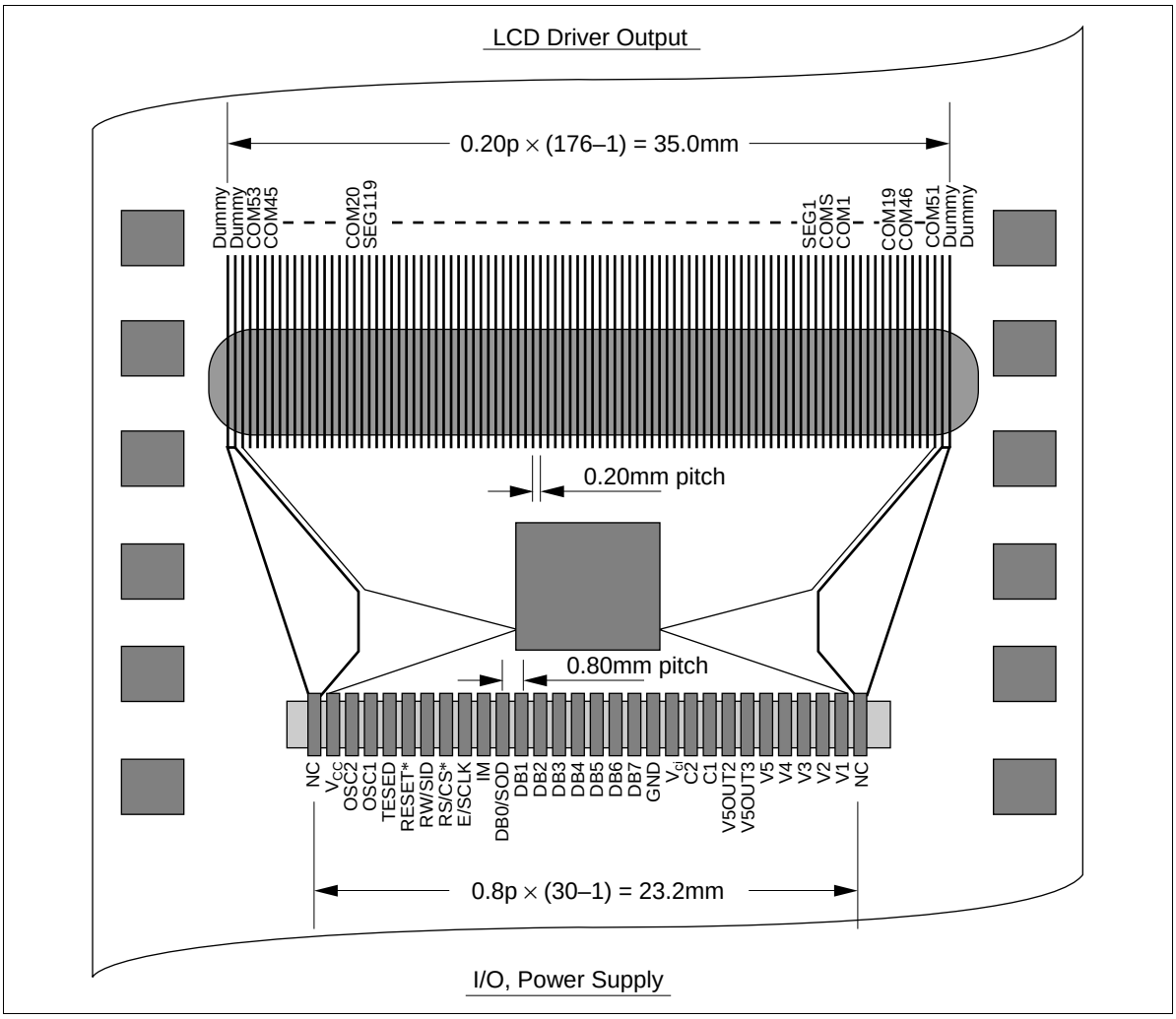
Pin Arrangement (HD66730)



TCP Dimensions (HD66731TA0: Three 8-characters)

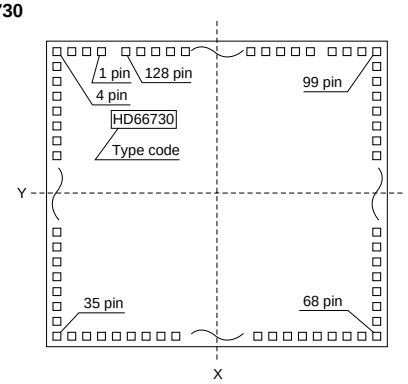


TCP Dimensions (HD66731TB0: Four 10-characters)



The Location of Bonding Pads (HD66730)

HCD66730



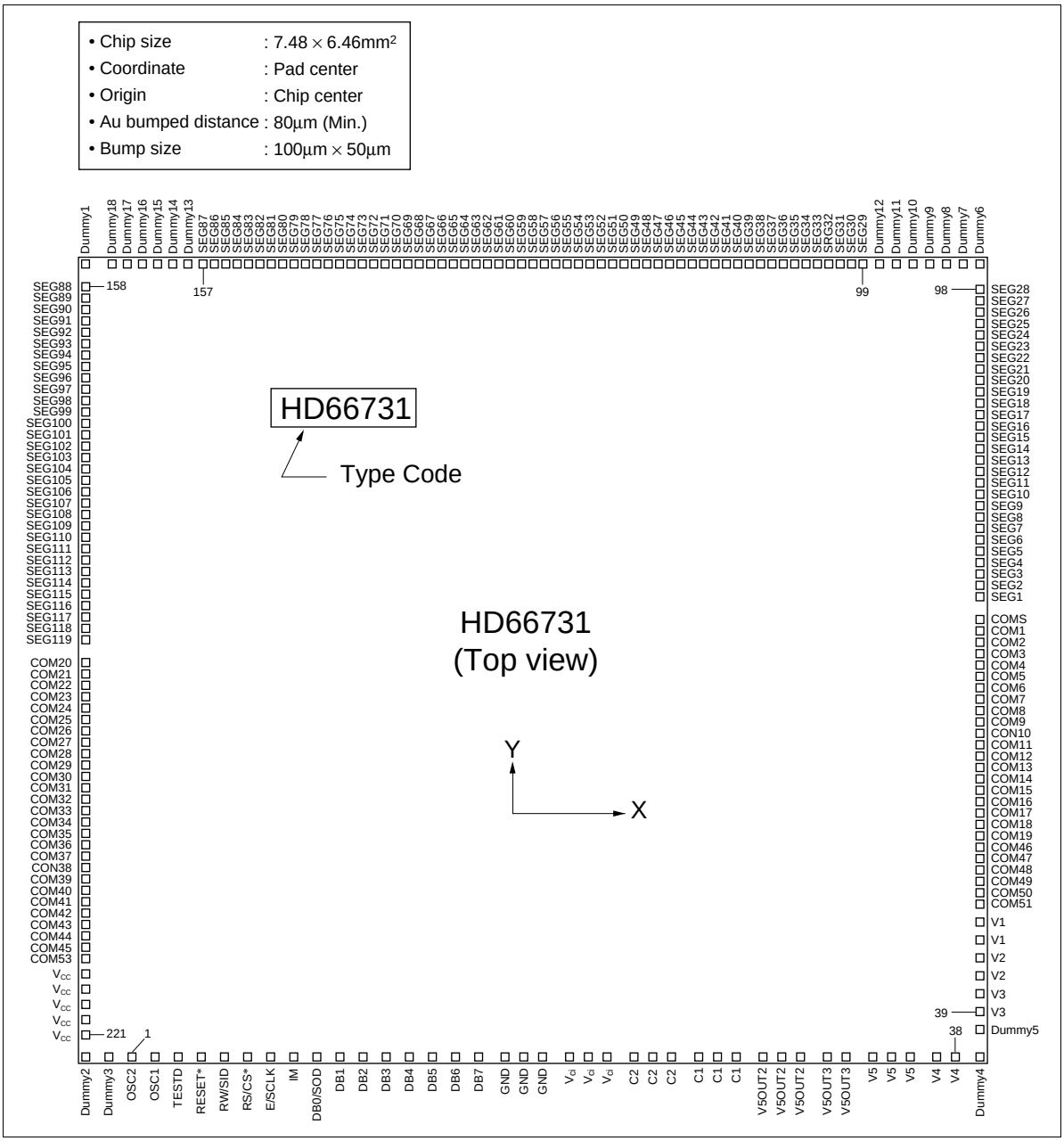
Chip size (X × Y): 7.48 × 6.46 mm²
Coordinate: Pad center
Origin: Chip center
Pad size (X × Y): 100 × 100 μm²

(unit: μm)

Pin No.	Function	Coordinate X	Coordinate Y
1	SEG34	–2602	3012
2	SEG35	–2984	3012
3	SEG36	–3263	3012
4	SEG37	–3522	3012
5	SEG38	–3522	2782
6	SEG39	–3522	2582
7	SEG40	–3522	2341
8	SEG41	–3522	2161
9	SEG42	–3522	1981
10	SEG43	–3522	1801
11	SEG44	–3522	1621
12	SEG45	–3522	1440
13	SEG46	–3522	1260
14	SEG47	–3522	1030
15	SEG48	–3522	800
16	SEG49	–3522	620
17	SEG50	–3522	439
18	SEG51	–3522	259
19	SEG52	–3522	79
20	SEG53	–3522	–101
21	SEG54	–3522	–281
22	SEG55	–3522	–462
23	SEG56	–3522	–642
24	SEG57	–3522	–822
25	SEG58	–3522	–1002
26	SEG59	–3522	–1182
27	SEG60	–3522	–1363
28	SEG61	–3522	–1543
29	SEG62	–3522	–1723
30	SEG63	–3522	–1939
31	SEG64	–3522	–2183
32	SEG65	–3522	–2364
33	SEG66	–3522	–2544
34	SEG67	–3522	–2774
35	SEG68	–3522	–2984
36	SEG69	–3160	–2984
37	SEG70	–2860	–2984
38	SEG71	–2660	–2984
39	V_{CC}	–2435	–2984
40	RESET*	–2233	–2984
41	OSC2	–2063	–2984
42	OSC1	–1859	–2984
43	CL1	–1689	–2984
44	CL2	–1519	–2984
45	SEGD	–1349	–2984
46	M	–1179	–2984
47	RW/SID	–975	–2984
48	RS/CS*	–771	–2984
49	E/SCLK	–567	–2984
50	IM	–363	–2984
51	DB0/SOD	–146	–2984
52	DB1	71	–2984
53	DB2	287	–2984
54	DB3	504	–2984
55	DB4	721	–2984
56	DB5	938	–2984
57	DB6	1154	–2984
58	DB7	1371	–2984
59	GND	1533	–2984
60	Vci	1730	–2959
61	C2	1896	–2959
62	C1	2057	–2959
63	V5OUT2	2219	–2959
64	V5OUT3	2478	–2959
65	V5	2782	–2984
66	V4	3016	–2984
67	V3	3253	–2984
68	V2	3522	–2984
69	V1	3522	–2806
70	COM25/D	3522	–2626
71	COM24	3522	–2445
72	COM23	3522	–2265
73	COM22	3522	–2085
74	COM21	3522	–1855
75	COM20	3522	–1625
76	COM19	3522	–1444
77	COM18	3522	–1264
78	COM17	3522	–1084
79	COM16	3522	–854
80	COM15	3522	–624
81	COM14	3522	–443
82	COM13	3522	–263
83	COM12	3522	–83
84	COM11	3522	97
85	COM10	3522	277
86	COM9	3522	458
87	COM8	3522	638
88	COM7	3522	818
89	COM6	3522	998
90	COM5	3522	1178

Pin No.	Function	Coordinate X	Coordinate Y
91	COM4	3522	1409
92	COM3	3522	1639
93	COM2	3522	1819
94	COM1	3522	1999
95	COMS	3522	2179
96	SEG1	3522	2410
97	SEG2	3522	2590
98	SEG3	3522	2819
99	SEG4	3522	3012
100	SEG5	3222	3012
101	SEG6	2942	3012
102	SEG7	2662	3012
103	SEG8	2332	3012
104	SEG9	2152	3012
105	SEG10	1972	3012
106	SEG11	1791	3012
107	SEG12	1611	3012
108	SEG13	1431	3012
109	SEG14	1251	3012
110	SEG15	1071	3012
111	SEG16	890	3012
112	SEG17	710	3012
113	SEG18	530	3012
114	SEG19	350	3012
115	SEG20	170	3012
116	SEG21	–11	3012
117	SEG22	–191	3012
118	SEG23	–371	3012
119	SEG24	–551	3012
120	SEG25	–731	3012
121	SEG26	–912	3012
122	SEG27	–1092	3012
123	SEG28	–1272	3012
124	SEG29	–1452	3012
125	SEG30	–1632	3012
126	SEG31	–1813	3012
127	SEG32	–1993	3012
128	SEG33	–2173	3012

The Location of Bonding Pads (HD66731)



Pin No.	Function	Coordinate X	Coordinate Y
—	Dummy3	–3202	–2984
1	OSC2	–2926	–2984
2	OSC1	–2722	–2984
3	TESTD	–2543	–2984
4	RESET*	–2339	–2984
5	RW/SID	–2135	–2984
6	RS/CS	–1931	–2984
7	E/SCLK	–1727	–2984
8	IM	–1523	–2984
9	DB0/SOD	–1306	–2984
10	DB1	–1090	–2984
11	DB2	–873	–2984
12	DB3	–656	–2984
13	DB4	–439	–2984
14	DB5	–223	–2984
15	DB6	–6	–2984
16	DB7	211	–2984
17	GND	373	–2971
18	GND	509	–2971
19	GND	645	–2971
20	Vci	781	–2971
21	Vci	917	–2971
22	Vci	1053	–2971
23	C2	1189	–2971
24	C2	1325	–2971
25	C2	1461	–2971
26	C1	1597	–2971
27	C1	1733	–2971
28	C1	1869	–2971
29	V5OUT2	2005	–2971
30	V5OUT2	2141	–2971
31	V5OUT2	2277	–2971
32	V5OUT3	2413	–2971
33	V5OUT3	2549	–2971
34	V5	2685	–2971
35	V5	2821	–2971
36	V5	2957	–2971
37	V4	3093	–2971
38	V4	3229	–2971
—	dummy4	3474	–2971
—	dummy5	3474	–2699
39	V3	3474	–2563
40	V3	3474	–2427
41	V2	3474	–2291
42	V2	3474	–2155
43	V1	3474	–2019
44	V1	3474	–1883
45	COM51	3474	–1621
46	COM50	3474	–1541
47	COM49	3474	–1460
48	COM48	3474	–1379
49	COM47	3474	–1298
50	COM46	3474	–1218
51	COM19	3474	–1137
52	COM18	3474	–1056
53	COM17	3474	–975
54	COM16	3474	–895
55	COM15	3474	–814
56	COM14	3474	–733
57	COM13	3474	–652
58	COM12	3474	–572
59	COM11	3474	–491
60	COM10	3474	–410
61	COM9	3474	–329
62	COM8	3474	–249
63	COM7	3474	–168
64	COM6	3474	–87
65	COM5	3474	–6
66	COM4	3474	74
67	COM3	3474	155
68	COM2	3474	236
69	COM1	3474	317
70	COMS	3474	397
71	SEG1	3474	559
72	SEG2	3474	640
73	SEG3	3474	720
74	SEG4	3474	801
75	SEG5	3474	882
76	SEG6	3474	963
77	SEG7	3474	1043
78	SEG8	3474	1124
79	SEG9	3474	1205
80	SEG10	3474	1286
81	SEG11	3474	1366
82	SEG12	3474	1447
83	SEG13	3474	1528
84	SEG14	3474	1609
85	SEG15	3474	1689
86	SEG16	3474	1770
87	SEG17	3474	1851
88	SEG18	3474	1932
89	SEG19	3474	2012
90	SEG20	3474	2093
91	SEG21	3474	2174
92	SEG22	3474	2255
93	SEG23	3474	2335
94	SEG24	3474	2416
95	SEG25	3474	2497
96	SEG26	3474	2578
97	SEG27	3474	2658
98	SEG28	3474	2739
—	dummy6	3474	3027
—	dummy7	3202	3027
—	dummy8	3066	3027
—	dummy9	2930	3027
—	dummy10	2794	3027
—	dummy11	2658	3027
—	dummy12	2522	3027
99	SEG29	2343	2963
100	SEG30	2262	2963
101	SEG31	2182	2963
102	SEG32	2101	2963
103	SEG33	2020	2963
104	SEG34	1939	2963
105	SEG35	1859	2963
106	SEG36	1778	2963
107	SEG37	1697	2963
108	SEG38	1616	2963
109	SEG39	1536	2963
110	SEG40	1455	2963
111	SEG41	1374	2963
112	SEG42	1293	2963
113	SEG43	1213	2963
114	SEG44	1132	2963
115	SEG45	1051	2963
116	SEG46	970	2963
117	SEG47	890	2963
118	SEG48	809	2963
119	SEG49	728	2963
120	SEG50	647	2963
121	SEG51	567	2963
122	SEG52	468	2963
123	SEG53	405	2963
124	SEG54	324	2963
125	SEG55	244	2963
126	SEG56	163	2963
127	SEG57	82	2963
128	SEG58	1	2963
129	SEG59	–79	2963
130	SEG60	–160	2963
131	SEG61	–241	2963

Pin No.	Function	Coordinate X	Coordinate Y
132	SEG62	–322	2963
133	SEG63	–402	2963
134	SEG64	–483	2963
135	SEG65	–564	2963
136	SEG66	–645	2963
137	SEG67	–725	2963
138	SEG68	–806	2963
139	SEG69	–887	2963
140	SEG70	–968	2963
141	SEG71	–1048	2963
142	SEG72	–1129	2963
143	SEG73	–1210	2963
144	SEG74	–1291	2963
145	SEG75	–1371	2963
146	SEG76	–1452	2963
147	SEG77	–1533	2963
148	SEG78	–1614	2963
149	SEG79	–1694	2963
150	SEG80	–1775	2963
151	SEG81	–1856	2963
152	SEG82	–1937	2963
153	SEG83	–2017	2963
154	SEG84	–2098	2963
155	SEG85	–2179	2963
156	SEG86	–2260	2963
157	SEG87	–2340	2963
—	dummy13	–2522	3027
—	dummy14	–2658	3027
—	dummy15	–2794	3027
—	dummy16	–2930	3027
—	dummy17	–3066	3027
—	dummy18	–3202	3027
—	dummy1	–3474	3027

Pin No.	Function	Coordinate X	Coordinate Y
158	SEG88	–3474	2728
159	SEG89	–3474	2647
160	SEG90	–3474	2567
161	SEG91	–3474	2486
162	SEG92	–3474	2405
163	SEG93	–3474	2324
164	SEG94	–3474	2244
165	SEG95	–3474	2163
166	SEG96	–3474	2082
167	SEG97	–3474	2001
168	SEG98	–3474	1921
169	SEG99	–3474	1840
170	SEG100	–3474	1759
171	SEG101	–3474	1678
172	SEG102	–3474	1598
173	SEG103	–3474	1517
174	SEG104	–3474	1436
175	SEG105	–3474	1355
176	SEG106	–3474	1275
177	SEG107	–3474	1194
178	SEG108	–3474	1113
179	SEG109	–3474	1032
180	SEG110	–3474	952
181	SEG111	–3474	871
182	SEG112	–3474	79
183	SEG113	–3474	709
184	SEG114	–3474	629
185	SEG115	–3474	548
186	SEG116	–3474	467
187	SEG117	–3474	386
188	SEG118	–3474	306
189	SEG119	–3474	225
190	COM20	–3474	63

Pin No.	Function	Coordinate X	Coordinate Y
191	COM21	–3474	–17
192	COM22	–3474	–98
193	COM23	–3474	–179
194	COM24	–3474	–260
195	COM25	–3474	–340
196	COM26	–3474	–421
197	COM27	–3474	–502
198	COM28	–3474	–583
199	COM29	–3474	–663
200	COM30	–3474	–744
201	COM31	–3474	–825
202	COM32	–3474	–906
203	COM33	–3474	–986
204	COM34	–3474	–1067
205	COM35	–3474	–1148
206	COM36	–3474	–1229
207	COM37	–3474	–1309
208	COM38	–3474	–1390
209	COM39	–3474	–1471
210	COM40	–3474	–1552
211	COM41	–3474	–1632
212	COM42	–3474	–1713
213	COM43	–3474	–1794
214	COM44	–3474	–1875
215	COM45	–3474	–1955
216	COM53	–3474	–2036
217	V_{CC}	–3474	–2169
218	V_{CC}	–3474	–2305
219	V_{CC}	–3474	–2441
220	V_{CC}	–3474	–2577
221	V_{CC}	–3474	–2713
—	dymmy2	–3474	–2984

Pin Function (HD66730)

Table 1 Pin Functional Description

Signal	Number of Pins	I/O	Device Interfaced with	Function
RESET*	1	I	—	Acts as a reset input pin. The LSI is initialized during low level. Refer to Reset Function. Must be reset after power-on.
IM	1	I	—	Selects interface mode with the MPU; Low: Serial mode High: 8-bit bus mode
RS/CS*	1	I	MPU	Selects registers during bus mode: Low: Index register (write); Status register (read) High: Control register (write); RAM data (read/write) Acts as chip-select during serial mode: Low: Select (access enable) High: Not selected (access disable)
R$\overline{W}$/SID	1	I	MPU	Selects read/write during bus mode; Low: Write High: Read Inputs serial data during serial mode.
E/SCLK	1	I	MPU	Starts data read/write during bus mode; Inputs (Receives) serial clock during serial mode.
DB1 to DB7	7	I/O	MPU	Seven high-order bidirectional tristate data bus pins. Used for data transfer between the MPU and the HD66730. DB7 can be used as a busy flag. Open these pins during serial mode since these signals are not used.
DB0/ SOD	1	I/O /O	MPU	The lowest bidirectional data bit (DB0) during bus mode. Outputs (transmits) serial data during serial mode. Open this pin if reading (transmission) is not performed.
SEG1 to SEG71	71	O	LCD	Display data output signals for the segment extension driver.
COMS	1	O	LCD	Acts as a common output signal for segment display. Used to display icon and marks beside the character display.
COM1 to COM24	24	O	LCD	Acts as common output signals for character display. COM15 toCOM24 become non-selective waveforms when the duty ratio is 1/14.
COM25/ COMD	1	O	LCD/ extension driver	Acts as common output sign al (COM25) for character display when EXT2 bit is 0. Acts as a common extension pulse signal (COMD) when EXT2 bit is 1. The pin is grounded after RESET input is cleared. When this signal is used as COMD, GND ≥ V5 must be maintained.

Table 1 Pin Functional Description (cont. HD66730)

Signal	Number of Pins	I/O	Device Interfaced with	Function
CL1	1	O	Extension driver	Outputs the latch pulse of segment extension driver.Cam also be used as a shift clock of common extention driver. Exters tristate when both EXT1 and EXT2 are 0.
CL2	1	O	Extension driver	Outputs shift clock of segment extension driver. Can also be used as a common extension driver latch clock. Enters tristate when both EXT1 and EXT2 are 0.
SEGD	1	O	Extension driver	Outputs data of extension driver. Data after the 72nd dot is output. Enters tristate when EXT1 bit is 0.
M	1	O	Extension driver	Acts as an alternating current signal of extension driver. Enters tristate when both EXT1 and EXT2 bits are 0.
V1 to V5	5	—	Power supply	Power supply for LCD drive V_{CC} – V5 = 15V (max)
V_{CC}/GND	2	—	Power supply	V_{CC}: +2.4V to +5.5V, GND: 0V
OSC1/ OSC2	2	—	Oscillation resistor/ clock	When crystal oscillation is performed, an external resistor must be connected. When the pin input is an external clock, it must be input to OSC1.
Vci	1	I	—	Inputs voltage to the booster to generate the liquid crystal display drive voltage. Vci is reference voltage and power supply for the booster. Vci: 1.0V to 5.0V ≤ V_{CC}.
V5OUT2	1	O	V5 pin/ booster capacitor	Voltage input to the Vci pin is boosted twice and output. When the voltage is boosted three times, a capacitor with the same capacitance as that of C1–C2 should be connected here.
V5OUT3	1	O	V5 pin	Voltage input to the Vci pin is boosted three times and output.
C1/C2	2	—	Booster capacitor	External capacitor should be connected here when using the booster.

Pin Function (HD66731)

Table 2 Pin Functional Description

Signal	Number of Pins	I/O	Device Interfaced with	Function
RESET*	1	I	—	Acts as a reset input pin. The LSI is initialized during low level. Refer to Reset Function. Must be reset after power-on.
IM	1	I	—	Selects interface mode with the MPU; Low: Serial mode High: 8-bit bus mode
RS/CS*	1	I	MPU	Selects registers during bus mode: Low: Index register (write); Status register (read) High: Control register (write); RAM data (read/write) Acts as chip-select during serial mode: Low: Select (access enable) High: Not selected (access disable)
R$\overline{W}$/SID	1	I	MPU	Selects read/write during bus mode; Low: Write High: Read Inputs serial data during serial mode.
E/SCLK	1	I	MPU	Starts data read/write during bus mode; Inputs (Receives) serial clock during serial mode.
DB1 to DB7	7	I/O	MPU	Seven high-order bidirectional tristate data bus pins. Used for data transfer between the MPU and the HD66731. DB7 can be used as a busy flag. Open these pins during serial mode since these signals are not used.
DB0/ SOD	1	I/O /O	MPU	The lowest bidirectional data bit (DB0) during bus mode. Outputs (transmits) serial data during serial mode. Open this pin if reading (transmission) is not performed.
SEG1 to SEG119	119	O	LCD	Display data output signals for the segment extension driver.
COMS	1	O	LCD	Acts as a common output signal for segment display. Used to display icon and marks beside the character display.
COM1 to COM51	51	O	LCD	Acts as common output signals for character display. COM14 acts as same as COMS when 1/14 duty. COM27 acts as same as COMS when 1/27 duty. COM40 acts as same as COMS when 1/40 duty. Unused common pins output non-selective waveforms.
COM53	1	O	LCD	Acts as common output signal for segment display when 1/53 duty. The waveform is same as coms. This COM53 outputs non-selective waveform when another duty.

Table 2 Pin Functional Description (cont. HD66731)

Signal	Number of Pins	I/O	Device Interfaced with	Function
V1 to V5	5	—	Power supply	Power supply for LCD drive V_{CC} – V5 = 15V (max)
V_{CC}/GND	2	—	Power supply	V_{CC}: +2.4V to +5.5V, GND: 0V
OSC1/ OSC2	2	—	Oscillation resistor/ clock	When crystal oscillation is performed, an external resistor must be connected. When the pin input is an external clock, it must be input to OSC1.
Vci	1	I	—	Inputs voltage to the booster to generate the liquid crystal display drive voltage. Vci is reference voltage and power supply for the booster. Vci: 1.0V to 5.0V ≤ V_{CC}.
V5OUT2	1	O	V5 pin/ booster capacitor	Voltage input to the Vci pin is boosted twice and output. When the voltage is boosted three times, a capacitor with the same capacitance as that of C1–C2 should be connected here.
V5OUT3	1	O	V5 pin	Voltage input to the Vci pin is boosted three times and output.
C1/C2	2	—	Booster capacitor	External capacitor should be connected here when using the booster.
TESTD	1	O	—	Test pin. Must be left disconnected.
Dummy1 to Dummy18	18	—	—	Dummy pads. These pads are electrically floating level.

Function Description

System Interface

The HD66730/1 has two system interfaces: a synchronized serial one and an 8-bit bus. Both are selected by the IM pin.

The HD66730/1 has five types of 8-bit registers: an index register (IDR), status register (STR), various control registers, RAM address register (RAR), and RAM data register (RDR).

The index register (IDR) selects control registers, the RAM address register (RAR) or the RAM data register (RDR) for performing data transfer.

The status register (STR) indicates the internal state of the system. Various control registers store display control data here.

The RAM address register (RAR) stores the address data of display data RAM (DDRAM), character generator RAM (CGRAM), and segment RAM (SEGRAM).

The RAM data register (RDR) temporarily stores data to be written into DDRAM, CGRAM, or SEGRAM. Data written into the RDR from the MPU is automatically written into DDRAM, CGRAM, or SEGRAM by internal operations. The RDR is also used for data storage when reading data from DDRAM, CGRAM, or SEGRAM. Here, when address information is written into the RAR, data is read and then stored into the RDR from DDRAM, CGRAM, or SEGRAM by internal operations.

Data transfer between the MPU is then completed when the MPU reads the RDR. After this read, data in DDRAM, CGRAM, or SEGRAM stored at the next address is sent to the RDR at the next data read from the MPU.

These registers can be selected by the register select signal (RS) and the read/write signal (R/W) in the 8-bit bus interface, and by the RS bit and R/W bit of start-byte data in the synchronized serial interface.

Busy Flag

When the busy flag is 1, the HD66730/1 is in internal operation mode, and only the status register (STR) can be accessed. The busy flag (BF) is output from bit 7 (DB7). Access of other registers can be performed only after confirming that the busy flag is 0.

RAM Address Counter (RAR)

The RAM address counter (RAR) provides addresses for accessing DDRAM, CGRAM, or SEGRAM. When an initial address value is written into the RAM counter (RAR), the RAR is automatically incremented or decremented by 1. Note that a control register specifies which RAM (DDRAM, CGRAM, SEGRAM) to select.

Table 3 Register Selection

RS	R/$\overline{W}$	Operation
0	0	IDR write
0	1	STR read
1	0	Control register write, RAM address register (RAR) write, and RAM data register (RDR) write
1	1	RAM data register (RDR) read

Display Data RAM (DDRAM)

Display data RAM (DDRAM) stores character codes and display attribute codes for displaying data.

A full-size font is displayed using two bytes, and a half-size font is displayed using one byte. Since the RAM capacity is 80 bytes, 40 full-size characters or 80 half-size characters can be stored.

DDRAM displays only that data stored within the range corresponding to the number of display columns. Data stored outside the range is ignored. Refer to Combined Display of Full-Size and Half-Size characters for details on character codes stored in DDRAM. The relationship between DDRAM addresses and LCD display position depends on the number of display lines (1 line/2 lines/4 lines).

Execution of the display-clear instruction writes H'A0 corresponding to the half-size character for “space” throughout DDRAM.

Note: The HD66730/1 performs display by reading character codes from the DDRAM according to the number of display columns set by the control register. In particular, reading from the DDRAM begins at the position corresponding to the rightmost character as set by the maximum number of display columns. This means that one byte of a two-byte full-size character code should not be set in a position exceeding the maximum number of display columns. For example, do not write a full-size code (2 bytes) in the 12th and 13th byte when the display is set for six characters.

- 1-line display (NL1/0 = 00)

  80 bytes of consecutive addresses from H'00 to H'4F are allocated for DDRAM addresses. When there are fewer than 40 display characters (at full size), only the number of display characters specified by NC1/0 are displayed starting from H'00 in the DDRAM. For example, 12 bytes of addresses from H'00 to H'0B are used when a 6-character display (NC1/0 = 00) is performed using one HD66730; addresses from H'0C on are ignored. In this case, do not write a full-size code into bytes H'0B and H'0C because a half-size character may be displayed. See Figure 1 for a 1-line display.
- 2-line display (NL1/0 = 01)

  The first line in the DDRAM address is displayed for the 40 bytes of addresses from H'00 to H'27, and the second line is displayed for the 40 bytes of addresses from H'40 to H'67. When there are fewer than 20 display characters (at full size), only the number of display characters specified by NC1/0 will be displayed starting from the leftmost address of the DDRAM. For example, 24 bytes of addresses from H'00 to H'0B and H'40 to H'4B are used when a 6-character display (NC1/0 = 00) is performed using one HD66730. Addresses from H'0C and H'4C on are ignored. See Figure 2 for a 2-line display.
- 4-line display (NL1/0 = 11)

  The first line in the DDRAM address is displayed from H'00 to H'13, the second line from H'20 to H'33, the third line from H'40 to H'53, and the fourth line from H'60 to H'73. For a 6-character display (NC1/0 = 00) (at full-size), only 12 bytes from the leftmost address of DDRAM are displayed. See Figure 3 for a 4-line display.

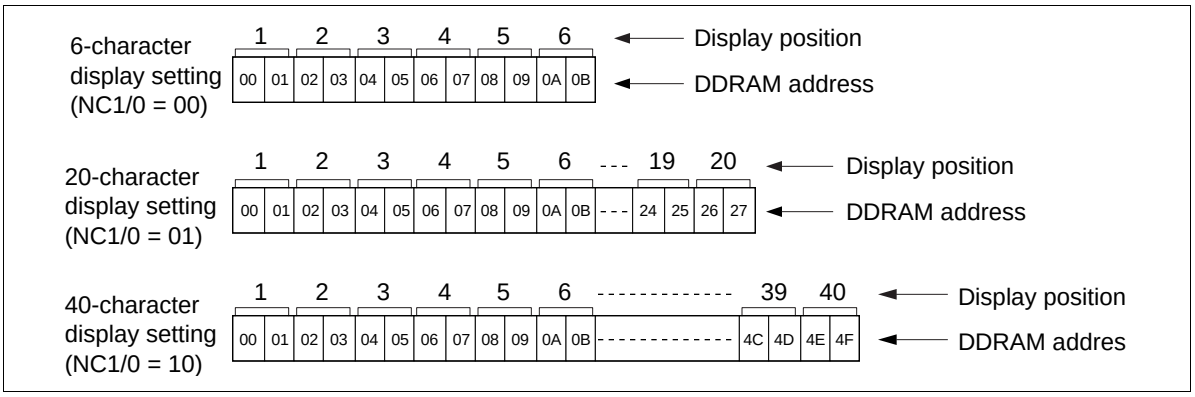


Figure 1 1-Line Display (NL1/0 = 00)

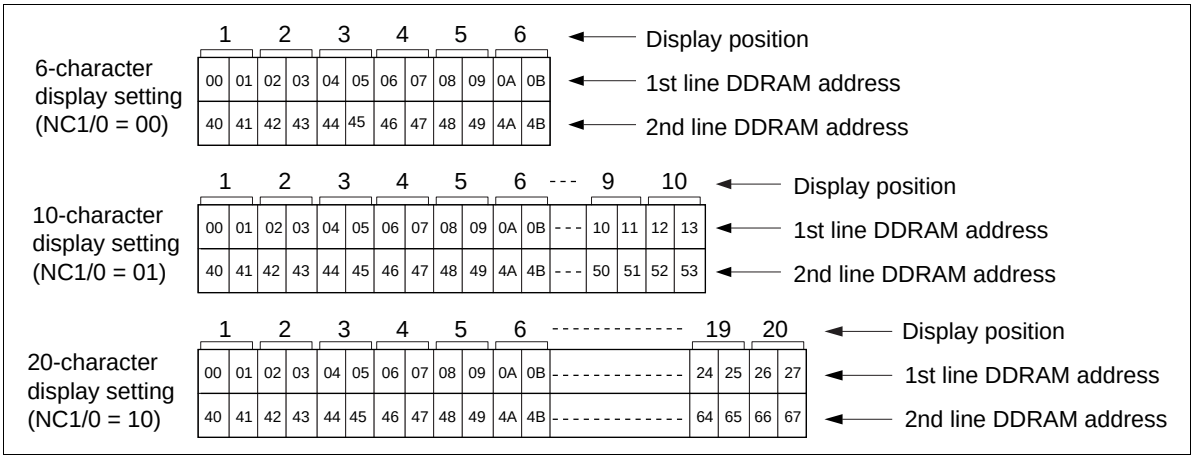


Figure 2 2-Line Display (NL1/0 = 01)

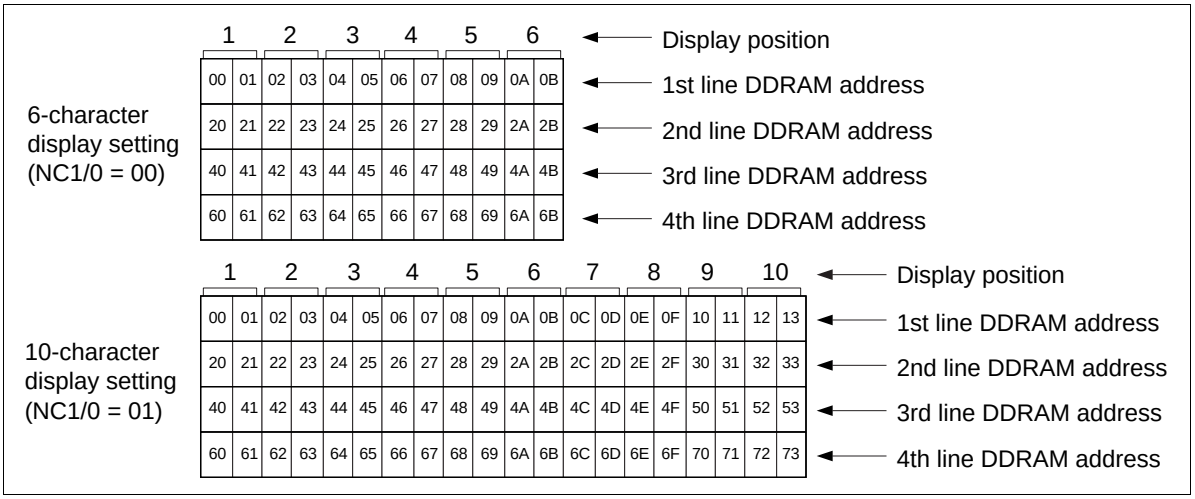


Figure 3 4-Line Display (NL1/0 = 11)

Character Generator ROM for a Full-Size Font (FCGROM)

The character generator ROM for a full-size font (FCGROM) generates 3,840 11 × 12 dot full-size character patterns from a 12-bit character code. This includes 2,965 kanji according to the JIS Level-1 Kanji Set and 524 JIS non-kanji. Table 4 shows the relationship between character codes set in DDRAM and full-size font patterns. Refer to Combined Display of Full-Size and Half-Size Characters for the relationship between JIS codes and the character codes to be set in the DDRAM.

Character Generator ROM for a Half-Size Font (HCGROM)

The character generator ROM for a half-size font (HCGROM) generates 128 6 × 12 dot character patterns from 7-bit character codes. A half-size font (alphanumeric characters and symbols) can be displayed together with a full-size font. Refer to Combined Display of Full-Size and Half-Size Characters for details.

Character Generator RAM (CGRAM)

The character generator RAM (CGRAM) allows the user to display arbitrary full-size font patterns. It can display 8 12 × 13 dot fonts.

This RAM can also display double-size characters and figures by combining multiple CGRAM fonts. Specify character codes from H'000 to H'007 in a full size of character code when displaying font patterns stored in the CGRAM.

Segment RAM (SEGRAM)

The segment RAM (SEGRAM) is used to control icons and marks in segment units by the user program. Bits in SEGRAM corresponding to segments to be displayed are directly set by the MPU, regardless of the contents of DDRAM and CGRAM. The SEGRAM is read and displayed when the COMS output pin is selected.

Up to 71 icons can be displayed using a single HD66730. Up to 96 icons can be displayed by expanding the drivers on the segment side. SEGRAM data is stored in eight bits. The lower six bits control the display of each segment, and the upper two bits control segment blinking.

HD66731 can display 96 icons without the expanding driver.

Timing Generator

The timing generator generates timing signals for the operation of internal circuits such as DDRAM, FCGROM, HCGROM, CGRAM, and SEGRAM. RAM read timing for display and internal operation timing for MPU access are generated separately to avoid interference. This prevents undesirable interferences, such as flickering, in areas other than the display area when writing data to DDRAM, for example.

The timing generator of HD66730 generates interface control signals CL1, CL2, M, and COMD-output of extension drivers for a extension configuration.

Display Attribute Controller

The display attribute controller displays white/black inverse, blinking, and white/black inverse blinking for a full size font in FCGROM according to the attribute code set in the DDRAM. Refer to Display Attribute Designation for details.

Fonts in CGRAM and bit patterns in SEGRAM control display attributes using the upper two bits (bits 7 and 6) in each display-pattern data.

Cursor Control Circuit

The cursor control circuit is used to produce a cursor on a displayed character corresponding to the DDRAM address set in the RAM address counter (RAR). Cursors can be chosen from three types: 12th raster-row cursor that is displayed only on the 12th raster-row of each font; blink cursor that periodically displays the whole font in black and white and black inverted cursor that periodically displays the font in white and black (see Figure 9). Note that when the RAM address counter (RAR) is selecting CGRAM or SEGRAM, a cursor would be generated at that address, however, it does not have any meaning.

Note: One display line consists of 13 raster-rows.

Smooth Scroll Control Circuit

The smooth scroll control circuit is used to perform a smooth-scroll in units of dots.

When the number of characters to be displayed is greater than that possible at one time in the liquid crystal module, this horizontal smooth scroll can be used to display characters in an easy-to-read manner for each line. Refer to Horizontal Smooth Scroll for details for each line.

Liquid Crystal Display Driver Circuit

The liquid crystal display driver circuit of HD66730 consists of 26 common signal drivers and 71 segment signal drivers. HD66731 has 54 common signal drivers and 119 segment signal drivers. When the liquid crystal driver duty ratio is set by a program, the necessary common signal drivers output drive waveforms and the remaining common drivers output non-selected waveforms. In addition, drivers can be expanded on the common and segment sides through register settings.

Display pattern data is sent serially through a shift register and latched when all needed data has arrived. The latched data then enables the LCD driver to generate drive waveform outputs. This serial data is sent from the display pattern that corresponds to the last address of the DDRAM and is latched when the character pattern of the display data corresponding to the first address enters the internal shift register.

Booster

The booster outputs a voltage that is two or three times higher than the reference voltage input from pin Vci. Since the LCD voltage can be generated from the LSI operation power supply, this circuit can operate with a single power supply. Refer to Power Supply for Liquid Crystal Display Drive for details.

Oscillator

The HD66730/1 performs R-C oscillation by adding a single external oscillation resistor. The oscillation frequency corresponding to display size and frame frequency can be adjusted by changing the oscillation resistor. Refer to Oscillator for details.

Table 4 Relationship between Full-Size Character Code and Kanji

Upper / Lower	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
0 2	丼	亜	唖	娃	阿	哀	愛	挨	姶	逢	葵	茜	穐	悪	握	渥
0 3	旭	葦	芦	鯵	梓	圧	斡	扱	宛	姐	虻	飴	絢	綾	鮎	或
0 4	粟	袷	安	庵	按	暗	案	闇	鞍	杏	以	伊	位	依	偉	囲
0 5	夷	委	威	尉	惟	意	慰	易	椅	為	畏	異	移	維	緯	胃
0 6	萎	衣	謂	違	遺	医	井	亥	域	育	郁	磯	一	壱	溢	逸
0 7	稲	茨	芋	鰯	允	印	咽	員	因	姻	引	飲	淫	胤	蔭	▯
0 A	院	陰	隠	韻	吋	右	宇	烏	羽	迂	雨	卯	鵜	窺	丑
0 B	碓	臼	渦	嘘	唄	鬱	蔚	鰻	姥	厩	浦	瓜	閏	噂	云	運
0 C	雲	荏	餌	叡	営	嬰	影	映	曳	栄	永	泳	洩	瑛	盈	穎
0 D	頴	英	衛	詠	鋭	液	疫	益	駅	悦	謁	越	閲	榎	厭	円
0 E	園	堰	奄	宴	延	怨	掩	援	沿	演	炎	焔	煙	燕	猿	縁
0 F	艶	苑	薗	遠	鉛	鴛	塩	於	汚	甥	凹	央	奥	往	応	▯
1 2	苺	押	旺	横	欧	殴	王	翁	襖	鴬	鴎	黄	岡	沖	荻	億
1 3	屋	憶	臆	桶	牡	乙	俺	卸	恩	温	穏	音	下	化	仮	何
1 4	伽	価	佳	加	可	嘉	夏	嫁	家	寡	科	暇	果	架	歌	河
1 5	火	珂	禍	禾	稼	箇	花	苛	茄	荷	華	菓	蝦	課	嘩	貨
1 6	迦	過	霞	蚊	俄	峨	我	牙	画	臥	芽	蛾	賀	雅	餓	駕
1 7	介	会	解	回	塊	壊	廻	快	怪	悔	恢	懐	戒	拐	改	▯
1 A	渕	魁	晦	械	海	灰	界	皆	絵	芥	蟹	開	階	貝	凱	劾
1 B	外	咳	害	崖	慨	概	涯	碍	蓋	街	該	鎧	骸	浬	馨	蛙
1 C	垣	柿	蛎	鈎	劃	嚇	各	廊	拡	撹	格	核	殻	獲	確	穫
1 D	覚	角	赫	較	郭	閣	隔	革	学	岳	楽	額	顎	掛	笠	樫
1 E	橿	梶	鰍	潟	割	喝	恰	括	活	渇	滑	葛	褐	轄	且	鰹
1 F	叶	椛	樺	鞄	株	兜	竈	蒲	釜	鎌	噛	鴨	栢	茅	萱	▯
2 2	澤	粥	刈	苅	瓦	乾	侃	冠	寒	刊	勘	勧	巻	喚	堪	姦
2 3	完	官	寛	干	幹	患	感	慣	憾	換	敢	柑	桓	棺	款	歓
2 4	汗	漢	潤	潅	環	甘	監	看	竿	管	簡	緩	缶	翰	肝	艦
2 5	莞	観	諌	貫	還	鑑	間	閑	関	陥	韓	館	舘	丸	含	岸
2 6	厳	玩	癌	眼	岩	翫	贋	雁	頑	顔	願	企	伎	危	喜	器
2 7	基	奇	嬉	寄	岐	希	幾	忌	揮	机	旗	既	期	棋	棄	▯
2 A	萌	機	帰	毅	気	汽	畿	祈	季	稀	紀	徽	規	記	貴	起
2 B	軌	輝	飢	騎	鬼	亀	偽	儀	妓	宜	戯	技	擬	欺	犠	疑
2 C	祇	義	蟻	誼	議	掬	菊	鞠	吉	吃	喫	桔	橘	詰	砧	杵
2 D	黍	却	客	脚	虐	逆	丘	久	仇	休	及	吸	宮	弓	急	救
2 E	朽	求	汲	泣	灸	球	究	窮	笈	級	糾	給	旧	牛	去	居
2 F	巨	拒	拠	拳	渠	虚	許	距	鋸	漁	禦	魚	亨	享	京	▯
3 2	峯	供	侠	僑	兇	競	共	凶	協	匡	卿	叫	喬	境	峡	強
3 3	彊	怯	恐	恭	挟	教	橋	況	狂	狭	矯	胸	脅	興	蕎	郷
3 4	鏡	響	饗	驚	仰	凝	尭	暁	業	局	曲	極	玉	桐	粁	僅
3 5	勤	均	巾	錦	斤	欣	欽	琴	禁	禽	筋	緊	芹	菌	衿	襟
3 6	謹	近	金	吟	銀	九	倶	句	区	狗	玖	矩	苦	躯	駆	駈
3 7	駒	具	愚	虞	喰	空	偶	寓	遇	隅	串	櫛	釧	屑	屈	▯
3 A	茘	掘	窟	沓	靴	轡	窪	熊	隈	粂	栗	繰	桑	鍬	勲	君
3 B	薫	訓	群	軍	郡	卦	袈	祁	係	傾	刑	兄	啓	圭	珪	型
3 C	契	形	径	恵	慶	慧	憩	掲	携	敬	景	桂	渓	畦	稽	系
3 D	経	継	繋	罫	茎	荊	蛍	計	詣	警	軽	頚	鶏	芸	迎	鯨
3 E	劇	戟	撃	激	隙	桁	傑	欠	決	潔	穴	結	血	訣	月	件
3 F	倹	倦	健	兼	券	剣	喧	圏	堅	嫌	建	憲	懸	拳	捲	▯

Table 4 Relationship between Full-Size Character Code and Kanji (cont)

Upper / Lower	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
4 2	訃	検	権	牽	犬	献	研	硯	絹	県	肩	見	謙	賢	軒	遣
4 3	鍵	険	顕	験	鹸	元	原	厳	幻	弦	減	源	玄	現	絃	舷
4 4	言	諺	限	乎	個	古	呼	固	姑	孤	己	庫	弧	戸	故	枯
4 5	湖	狐	糊	袴	股	胡	菰	虎	誇	跨	鈷	雇	顧	鼓	五	互
4 6	伍	午	呉	吾	娯	後	御	悟	梧	檎	瑚	碁	語	誤	護	醐
4 7	乞	鯉	交	佼	侯	候	倖	光	公	功	効	勾	厚	口	向	𠮟
4 A	膠	后	喉	坑	垢	好	孔	孝	宏	工	巧	巷	幸	広	庚	康
4 B	弘	恒	慌	抗	拘	控	攻	昂	晃	更	杭	校	梗	構	江	洪
4 C	浩	港	溝	甲	皇	硬	稿	糠	紅	紘	絞	綱	耕	考	肯	肱
4 D	腔	膏	航	荒	行	衡	講	貢	購	郊	酵	鉱	砿	鋼	閤	降
4 E	項	香	高	鴻	剛	劫	号	合	壕	拷	濠	豪	轟	麹	克	刻
4 F	告	国	穀	酷	鵠	黒	獄	漉	腰	甑	忽	惚	骨	狛	込	𢌞
5 2	餃	此	頃	今	困	坤	墾	婚	恨	懇	昏	昆	根	梱	混	痕
5 3	紺	艮	魂	些	佐	叉	唆	嵯	左	差	査	沙	瑳	砂	詐	鎖
5 4	裟	坐	座	挫	債	催	再	最	哉	塞	妻	宰	彩	才	採	栽
5 5	歳	済	災	采	犀	砕	砦	祭	斎	細	菜	裁	載	際	剤	在
5 6	材	罪	財	冴	坂	阪	堺	榊	肴	咲	崎	埼	碕	鷺	作	削
5 7	詐	搾	昨	朔	柵	窄	策	索	錯	桜	鮭	笹	匙	冊	刷	𠮷
5 A	𠮟	察	拶	撮	擦	札	殺	薩	雑	皐	鯖	捌	錆	鮫	皿	晒
5 B	三	傘	参	山	惨	撒	散	桟	燦	珊	産	算	纂	蚕	讃	賛
5 C	酸	餐	斬	暫	残	仕	仔	伺	使	刺	司	史	嗣	四	士	始
5 D	姉	姿	子	屍	市	師	志	思	指	支	孜	斯	施	旨	枝	止
5 E	死	氏	獅	祉	私	糸	紙	紫	肢	脂	至	視	詞	詩	試	誌
5 F	諮	資	賜	雌	飼	歯	事	似	侍	児	字	寺	慈	持	時	𤔔
6 2	𤇾	次	滋	治	爾	璽	痔	磁	示	而	耳	自	蒔	辞	汐	鹿
6 3	式	識	鳴	竺	軸	宍	雫	七	叱	執	失	嫉	室	悉	湿	漆
6 4	疾	質	実	蔀	篠	偲	柴	芝	屡	蕊	縞	舎	写	射	捨	赦
6 5	斜	煮	社	紗	者	謝	車	遮	蛇	邪	借	勺	尺	杓	灼	爵
6 6	酌	釈	錫	若	寂	弱	惹	主	取	守	手	朱	殊	狩	珠	種
6 7	腫	趣	酒	首	儒	受	呪	寿	授	樹	綬	需	囚	収	周	𤔔
6 A	𤇾	宗	就	州	修	愁	拾	洲	秀	秋	終	繍	習	臭	舟	蒐
6 B	衆	襲	讐	蹴	輯	週	酋	酬	集	醜	什	住	充	十	従	戎
6 C	柔	汁	渋	獣	縦	重	銃	叔	夙	宿	淑	祝	縮	粛	塾	熟
6 D	出	術	述	俊	峻	春	瞬	竣	舜	駿	准	循	旬	楯	殉	淳
6 E	準	潤	盾	純	巡	遵	醇	順	処	初	所	暑	曙	渚	庶	緒
6 F	署	書	薯	藷	諸	助	叙	女	序	徐	恕	鋤	除	傷	償	𤔔
7 2	𤇾	勝	匠	升	召	哨	商	唱	嘗	奨	妾	娼	宵	将	小	少
7 3	尚	庄	床	廠	彰	承	抄	招	掌	捷	昇	昌	昭	晶	松	梢
7 4	樟	樵	沼	消	渉	湘	焼	焦	照	症	省	硝	礁	祥	称	章
7 5	笑	粧	紹	肖	菖	蒋	蕉	衝	裳	訟	証	詔	詳	象	賞	醤
7 6	鉦	鍾	鐘	障	鞘	上	丈	丞	乗	冗	剰	城	場	壌	嬢	常
7 7	情	擾	条	杖	浄	状	畳	穣	蒸	譲	醸	錠	嘱	埴	飾	𠮷
7 A	𤇾	拭	植	殖	燭	織	職	色	触	食	蝕	辱	尻	伸	信	侵
7 B	唇	娠	寝	審	心	慎	振	新	晋	森	榛	浸	深	申	疹	真
7 C	神	秦	紳	臣	芯	薪	親	診	身	辛	進	針	震	人	仁	刃
7 D	塵	壬	尋	甚	尽	腎	訊	迅	陣	靱	笥	諏	須	酢	図	厨
7 E	逗	吹	垂	帥	推	水	炊	睡	粋	翠	衰	遂	酔	錐	錘	随
7 F	瑞	髄	崇	嵩	数	枢	趨	雛	据	杉	椙	菅	頗	雀	裾	𤔔

Table 4 Relationship between Full-Size Character Code and Kanji (cont)

Upper / Lower	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
8 2		澄	摺	寸	世	瀬	畝	是	凄	制	勢	姓	征	性	成	政
8 3	整	星	晴	棲	栖	正	清	牲	生	盛	精	聖	声	製	西	誠
8 4	誓	請	逝	醒	青	静	斉	税	脆	隻	席	惜	戚	斥	昔	析
8 5	石	積	籍	績	脊	責	赤	跡	蹟	碩	切	拙	接	摂	折	設
8 6	窃	節	説	雪	絶	舌	蝉	仙	先	千	占	宣	専	尖	川	戦
8 7	扇	撰	栓	梅	泉	浅	洗	染	潜	煎	煽	旋	穿	箭	線	
8 A		繊	羨	腺	舛	船	薦	詮	賤	践	選	遷	銭	銑	閃	鮮
8 B	前	善	漸	然	全	禅	繕	膳	糎	噌	塑	岨	措	曾	曽	楚
8 C	狙	疏	疎	礎	祖	租	粗	素	組	蘇	訴	阻	遡	鼠	僧	創
8 D	双	叢	倉	喪	壮	奏	爽	宋	層	匝	惣	想	捜	掃	挿	掻
8 E	操	早	曹	巣	槍	槽	漕	燥	争	痩	相	窓	糟	総	綜	聡
8 F	草	荘	葬	蒼	藻	装	走	送	遭	鎗	霜	騒	像	増	憎	
9 2		臓	蔵	贈	造	促	側	則	即	息	捉	束	測	足	速	俗
9 3	属	賊	族	続	卒	袖	其	揃	存	孫	尊	損	村	遜	他	多
9 4	太	汰	詑	唾	堕	妥	惰	打	柁	舵	楕	陀	駄	騨	体	堆
9 5	対	耐	岱	帯	待	怠	態	戴	替	泰	滞	胎	腿	苔	袋	貸
9 6	退	逮	隊	黛	鯛	代	台	大	第	醍	題	鷹	滝	瀧	卓	啄
9 7	宅	托	択	拓	沢	濯	琢	託	鐸	濁	諾	茸	凧	蛸	只	
9 A		叩	但	達	辰	奪	脱	巽	竪	辿	棚	谷	狸	鱈	樽	誰
9 B	丹	単	嘆	坦	担	探	旦	歎	淡	湛	炭	短	端	箪	綻	耽
9 C	胆	蛋	誕	鍛	団	壇	弾	断	暖	檀	段	男	談	値	知	地
9 D	弛	恥	智	池	痴	稚	置	致	蜘	遅	馳	築	畜	竹	筑	蓄
9 E	逐	秩	窒	茶	嫡	着	中	仲	宙	忠	抽	昼	柱	注	虫	衷
9 F	註	酎	鋳	駐	樗	瀦	猪	苧	著	貯	丁	兆	凋	喋	寵	
A 2		帖	帳	庁	弔	張	彫	徴	懲	挑	暢	朝	潮	牒	町	眺
A 3	聴	脹	腸	蝶	調	諜	超	跳	銚	長	頂	鳥	勅	捗	直	朕
A 4	沈	珍	賃	鎮	陳	津	墜	椎	槌	追	鎚	痛	通	塚	栂	掴
A 5	槻	佃	漬	柘	辻	蔦	綴	鍔	椿	潰	坪	壺	嬬	紬	爪	吊
A 6	釣	鶴	亭	低	停	偵	剃	貞	呈	堤	定	帝	底	庭	廷	弟
A 7	悌	抵	挺	提	梯	汀	碇	禎	程	締	艇	訂	諦	蹄	逓	
A A		邸	鄭	釘	鼎	泥	摘	擢	敵	滴	的	笛	適	鏑	溺	哲
A B	徹	撤	轍	迭	鉄	典	填	天	展	店	添	纏	甜	貼	転	顛
A C	点	伝	殿	澱	田	電	兎	吐	堵	塗	妬	屠	徒	斗	杜	渡
A D	登	菟	賭	途	都	鍍	砥	砺	努	度	土	奴	怒	倒	党	冬
A E	凍	刀	唐	塔	塘	套	宕	島	嶋	悼	投	搭	東	桃	梼	棟
A F	盗	淘	湯	涛	灯	燈	当	痘	祷	等	答	筒	糖	統	到	
B 2		董	蕩	藤	討	謄	豆	踏	逃	透	鐙	陶	頭	騰	闘	働
B 3	動	同	堂	導	憧	撞	洞	瞳	童	胴	萄	道	銅	峠	鴇	匿
B 4	得	徳	涜	特	督	禿	篤	毒	独	読	栃	橡	凸	突	椴	届
B 5	鳶	苫	寅	酉	瀞	噸	屯	惇	敦	沌	豚	遁	頓	呑	曇	鈍
B 6	奈	那	内	乍	凪	薙	謎	灘	捺	鍋	楢	馴	縄	畷	南	楠
B 7	軟	難	汝	二	尼	弐	迩	匂	賑	肉	虹	廿	日	乳	入	
B A		如	尿	韮	任	妊	忍	認	濡	禰	祢	寧	葱	猫	熱	年
B B	念	捻	撚	燃	粘	乃	廼	之	埜	嚢	悩	濃	納	能	脳	膿
B C	農	覗	蚤	巴	把	播	覇	杷	波	派	琶	破	婆	罵	芭	馬
B D	俳	廃	拝	排	敗	杯	盃	牌	背	肺	輩	配	倍	培	媒	梅
B E	楳	煤	狽	買	売	賠	陪	這	蝿	秤	矧	萩	伯	剥	博	拍
B F	柏	泊	白	箔	粕	舶	薄	迫	曝	漠	爆	縛	莫	駁	麦	

Table 4 Relationship between Full-Size Character Code and Kanji (cont)

Upper / Lower	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
C 2	▒	函	箱	硲	箸	肇	筈	櫨	幡	肌	畑	畠	八	鉢	溌	発
C 3	醗	髪	伐	罰	抜	筏	閥	鳩	噺	塙	蛤	隼	伴	判	半	反
C 4	叛	帆	搬	斑	板	氾	汎	版	犯	班	畔	繁	般	藩	販	範
C 5	釆	煩	頒	飯	挽	晩	番	盤	磐	蕃	蛮	匪	卑	否	妃	庇
C 6	彼	悲	扉	批	披	斐	比	泌	疲	皮	碑	秘	緋	罷	肥	被
C 7	誹	費	避	非	飛	樋	簸	備	尾	微	枇	毘	琵	眉	美	▒
C A	▒	鼻	柊	稗	匹	疋	髭	彦	膝	菱	肘	弼	必	畢	筆	逼
C B	桧	姫	媛	紐	百	謬	俵	彪	標	氷	漂	瓢	票	表	評	豹
C C	廟	描	病	秒	苗	錨	鋲	蒜	蛭	鰭	品	彬	斌	浜	瀕	貧
C D	賓	頻	敏	瓶	不	付	埠	夫	婦	富	冨	布	府	怖	扶	敷
C E	斧	普	浮	父	符	腐	膚	芙	譜	負	賦	赴	阜	附	侮	撫
C F	武	舞	葡	蕪	部	封	楓	風	葺	蕗	伏	副	復	幅	服	▒
D 2	▒	福	腹	複	覆	淵	弗	払	沸	仏	物	鮒	分	吻	噴	墳
D 3	憤	扮	焚	奮	粉	糞	紛	雰	文	聞	丙	併	兵	塀	幣	平
D 4	弊	柄	並	蔽	閉	陛	米	頁	僻	壁	癖	碧	別	瞥	蔑	箆
D 5	偏	変	片	篇	編	辺	返	遍	便	勉	娩	弁	鞭	保	舗	鋪
D 6	圃	捕	歩	甫	補	輔	穂	募	墓	慕	戊	暮	母	簿	菩	倣
D 7	俸	包	呆	報	奉	宝	峰	峯	崩	庖	抱	捧	放	方	朋	▒
D A	▒	法	泡	烹	砲	縫	胞	芳	萌	蓬	蜂	褒	訪	豊	邦	鋒
D B	飽	鳳	鵬	乏	亡	傍	剖	坊	妨	帽	忘	忙	房	暴	望	某
D C	棒	冒	紡	肪	膨	謀	貌	貿	鉾	防	吠	頬	北	僕	卜	墨
D D	撲	朴	牧	睦	穆	釦	勃	没	殆	堀	幌	奔	本	翻	凡	盆
D E	摩	磨	魔	麻	埋	妹	昧	枚	毎	哩	槙	幕	膜	枕	鮪	柾
D F	鱒	桝	亦	俣	又	抹	末	沫	迄	侭	繭	麿	万	慢	満	▒
E 2	▒	漫	蔓	味	未	魅	巳	箕	岬	密	蜜	湊	蓑	稔	脈	妙
E 3	粍	民	眠	務	夢	無	牟	矛	霧	鵡	椋	婿	娘	冥	名	命
E 4	明	盟	迷	銘	鳴	姪	牝	滅	免	棉	綿	緬	面	麺	摸	模
E 5	茂	妄	孟	毛	猛	盲	網	耗	蒙	儲	木	黙	目	杢	勿	餅
E 6	尤	戻	籾	貰	問	悶	紋	門	匁	也	冶	夜	爺	耶	野	弥
E 7	矢	厄	役	約	薬	訳	躍	靖	柳	薮	鑓	愉	愈	油	癒	▒
E A	▒	諭	輸	唯	佑	優	勇	友	宥	幽	悠	憂	揖	有	柚	湧
E B	涌	猶	猷	由	祐	裕	誘	遊	邑	郵	雄	融	夕	予	余	与
E C	誉	輿	預	傭	幼	妖	容	庸	揚	揺	擁	曜	楊	様	洋	溶
E D	熔	用	窯	羊	耀	葉	蓉	要	謡	踊	遥	陽	養	慾	抑	欲
E E	沃	浴	翌	翼	淀	羅	螺	裸	来	莱	頼	雷	洛	絡	落	酪
E F	乱	卵	嵐	欄	濫	藍	蘭	覧	利	吏	履	李	梨	理	璃	▒
F 2	▒	痢	裏	裡	里	離	陸	律	率	立	葎	掠	略	劉	流	溜
F 3	琉	留	硫	粒	隆	竜	龍	侶	慮	旅	虜	了	亮	僚	両	凌
F 4	寮	料	梁	涼	猟	療	瞭	稜	糧	良	諒	遼	量	陵	領	力
F 5	緑	倫	厘	林	淋	燐	琳	臨	輪	隣	鱗	麟	瑠	塁	涙	累
F 6	類	令	伶	例	冷	励	嶺	怜	玲	礼	苓	鈴	隷	零	霊	麗
F 7	齢	暦	歴	列	劣	烈	裂	廉	恋	憐	漣	煉	簾	練	聯	▒
F A	▒	蓮	連	錬	呂	魯	櫓	炉	賂	路	露	労	婁	廊	弄	朗
F B	楼	榔	浪	漏	牢	狼	篭	老	聾	蝋	郎	六	麓	禄	肋	録
F C	論	倭	和	話	歪	賄	脇	惑	枠	鷲	亙	亘	鰐	詫	藁	蕨
F D	椀	湾	碗	腕	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒	▒
F E	Ⅰ	Ⅱ	Ⅲ	Ⅳ	Ⅴ	Ⅵ	Ⅶ	Ⅷ	Ⅸ	Ⅹ	Ⅺ	Ⅻ	㍾	㍽	㍼	㍻
F F	ⅰ	ⅱ	ⅲ	ⅳ	ⅴ	ⅵ	ⅶ	ⅷ	ⅸ	ⅹ	ⅺ	ⅻ	㏍	㏑	㏒	㏕

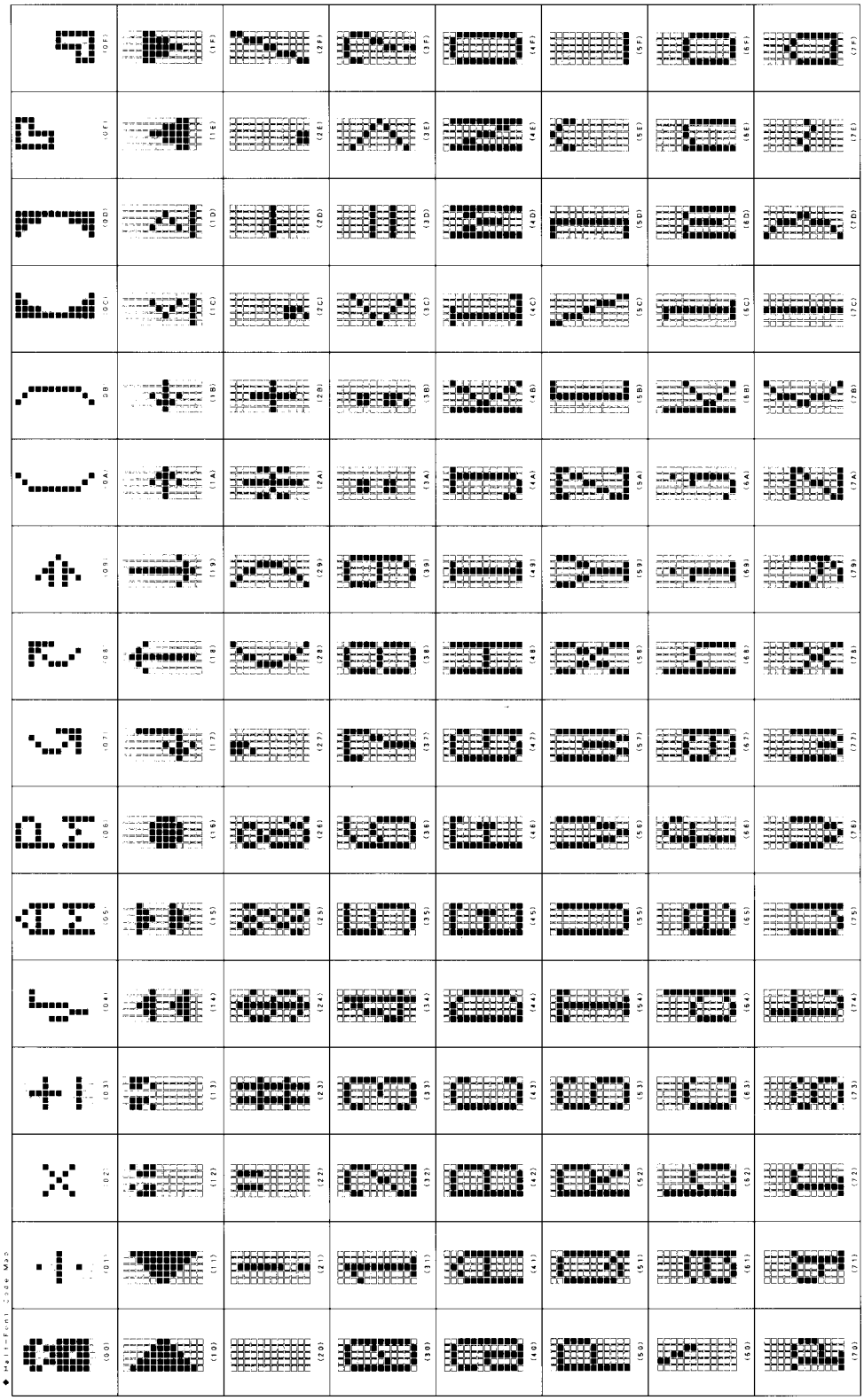
Table 5 Relationship between Full-Size Character Code and Non-Kanji

Upper / Lower	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
4 8			、	。	，	．	・	：	；	？	！	゛	゜	´	｀	¨
4 9	＾	￣	＿	ヽ	ヾ	ゝ	ゞ	〃	仝	々	〆	〇	ー	―	‐	／
8 8	＼	～	‖	｜	…	‥	‘	’	“	”	（	）	〔	〕	［	］
8 9	｛	｝	〈	〉	《	》	「	」	『	』	【	】	＋	－	±	×
C 8	÷	＝	≠	＜	＞	≦	≧	∞	∴	♂	♀	°	′	″	℃	￥
C 9	＄	¢	£	％	＃	＆	＊	＠	§	☆	★	○	●	◎	◇	
5 0		◆	□	■	△	▲	▽	▼	※	〒	→	←	↑	↓	〓	
5 1											∈	∋	⊆	⊇	⊂	⊃
9 0	∪	∩									∧	∨	¬	⇒	⇔	∀
9 1	∃												∠	⊥	⌒	∂
D 0	∇	≡	≒	≪	≫	√	∽	∝	∵	∫	∬					
D 1			Å	‰	♯	♭	♪	†	‡	¶					◯	
5 8	⓪	①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭	⑮
5 9	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
9 8		A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
9 9	P	Q	R	S	T	U	V	W	X	Y	Z					
D 8		a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
D 9	p	q	r	s	t	u	v	w	x	y	z					
6 0		ぁ	あ	ぃ	い	ぅ	う	ぇ	え	ぉ	お	か	が	き	ぎ	く
6 1	ぐ	け	げ	こ	ご	さ	ざ	し	じ	す	ず	せ	ぜ	そ	ぞ	た
A 0	だ	ち	ぢ	っ	つ	づ	て	で	と	ど	な	に	ぬ	ね	の	は
A 1	ば	ぱ	ひ	び	ぴ	ふ	ぶ	ぷ	へ	べ	ぺ	ほ	ぼ	ぽ	ま	み
E 0	む	め	も	ゃ	や	ゅ	ゆ	ょ	よ	ら	り	る	れ	ろ	ゎ	わ
E 1	ゐ	ゑ	を	ん												
6 8		ァ	ア	ィ	イ	ゥ	ウ	ェ	エ	ォ	オ	カ	ガ	キ	ギ	ク
6 9	グ	ケ	ゲ	コ	ゴ	サ	ザ	シ	ジ	ス	ズ	セ	ゼ	ソ	ゾ	タ
A 8	ダ	チ	ヂ	ッ	ツ	ヅ	テ	デ	ト	ド	ナ	ニ	ヌ	ネ	ノ	ハ
A 9	バ	パ	ヒ	ビ	ピ	フ	ブ	プ	ヘ	ベ	ペ	ホ	ボ	ポ	マ	ミ
E 8	ム	メ	モ	ャ	ヤ	ュ	ユ	ョ	ヨ	ラ	リ	ル	レ	ロ	ヮ	ワ
E 9	ヰ	ヱ	ヲ	ン	ヴ	ヵ	ヶ	16	17	18	19	20				
7 0		Α	Β	Γ	Δ	Ε	Ζ	Η	Θ	Ι	Κ	Λ	Μ	Ν	Ξ	Ο
7 1	Π	Ρ	Σ	Τ	Υ	Φ	Χ	Ψ	Ω							
B 0		α	β	γ	δ	ε	ζ	η	θ	ι	κ	λ	μ	ν	ξ	ο
B 1	π	ρ	σ	τ	υ	φ	χ	ψ	ω							
F 0																
F 1																
7 8		А	Б	В	Г	Д	Е	Ё	Ж	З	И	Й	К	Л	М	Н
7 9	О	П	Р	С	Т	У	Ф	Х	Ц	Ч	Ш	Щ	Ъ	Ы	Ь	Э
B 8	Ю	Я														
B 9		а	б	в	г	д	е	ё	ж	з	и	й	к	л	м	н
F 8	о	п	р	с	т	у	ф	х	ц	ч	ш	щ	ъ	ы	ь	э
F 9	ю	я														
4 0		─	│	┌	┐	┘	└	├	┬	┤	┴	┼	━	┃	┏	┓
4 1	┛	┗	┣	┳	┫	┻	╋	┠	┯	┨	┷	┿	┝	┰	┥	┸
8 0	╂															
8 1																
C 0																
C 1																

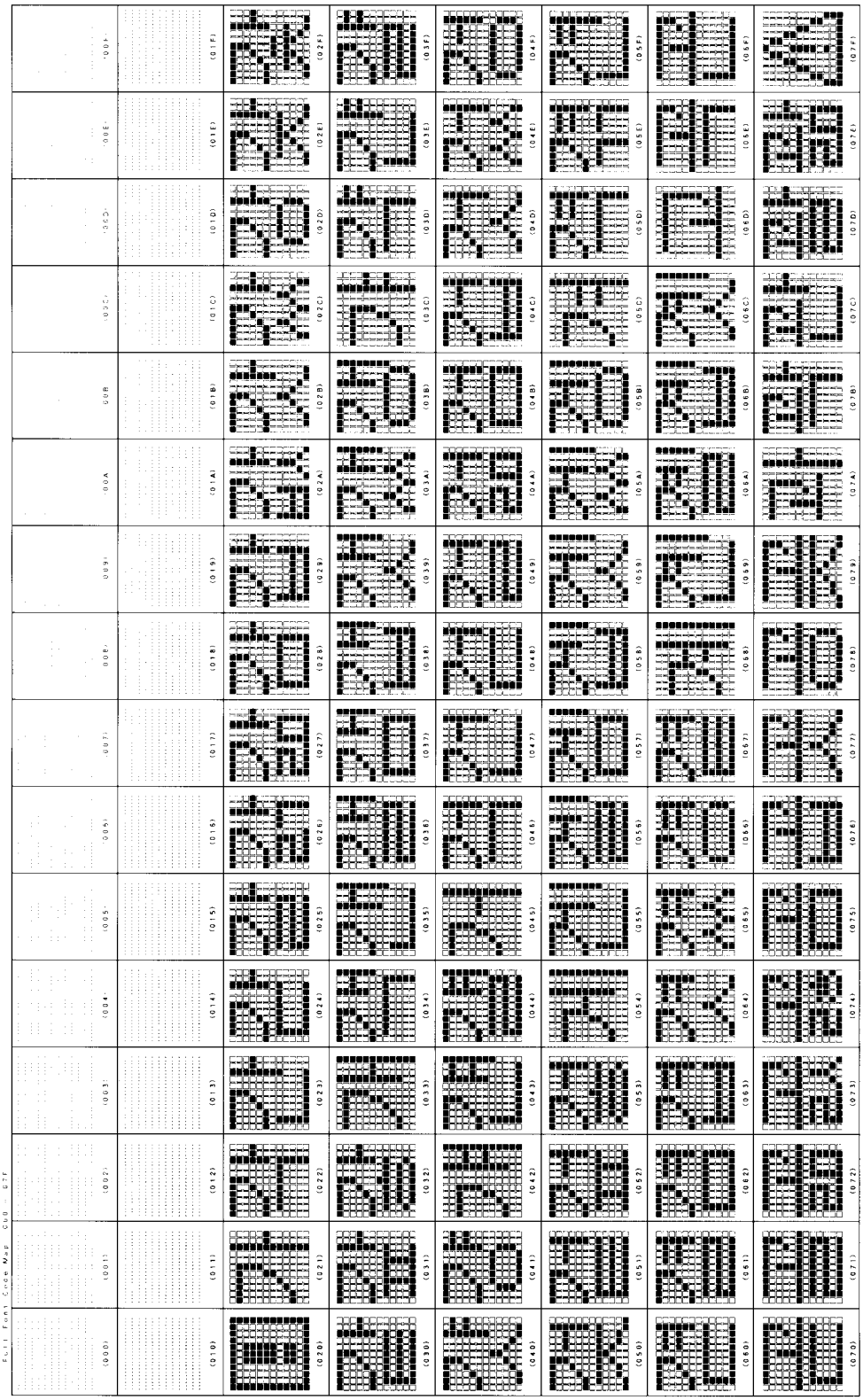
Table 6 Relationship between Half-Size Character Code and Character Pattern (ROM Code: A00)

Upper (4 bits) / Lower (3 bits)	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111
xxxx 000					(Space)											
xxxx 001																
xxxx 010																
xxxx 011																
xxxx 100																
xxxx 101																
xxxx 110																
xxxx 111																

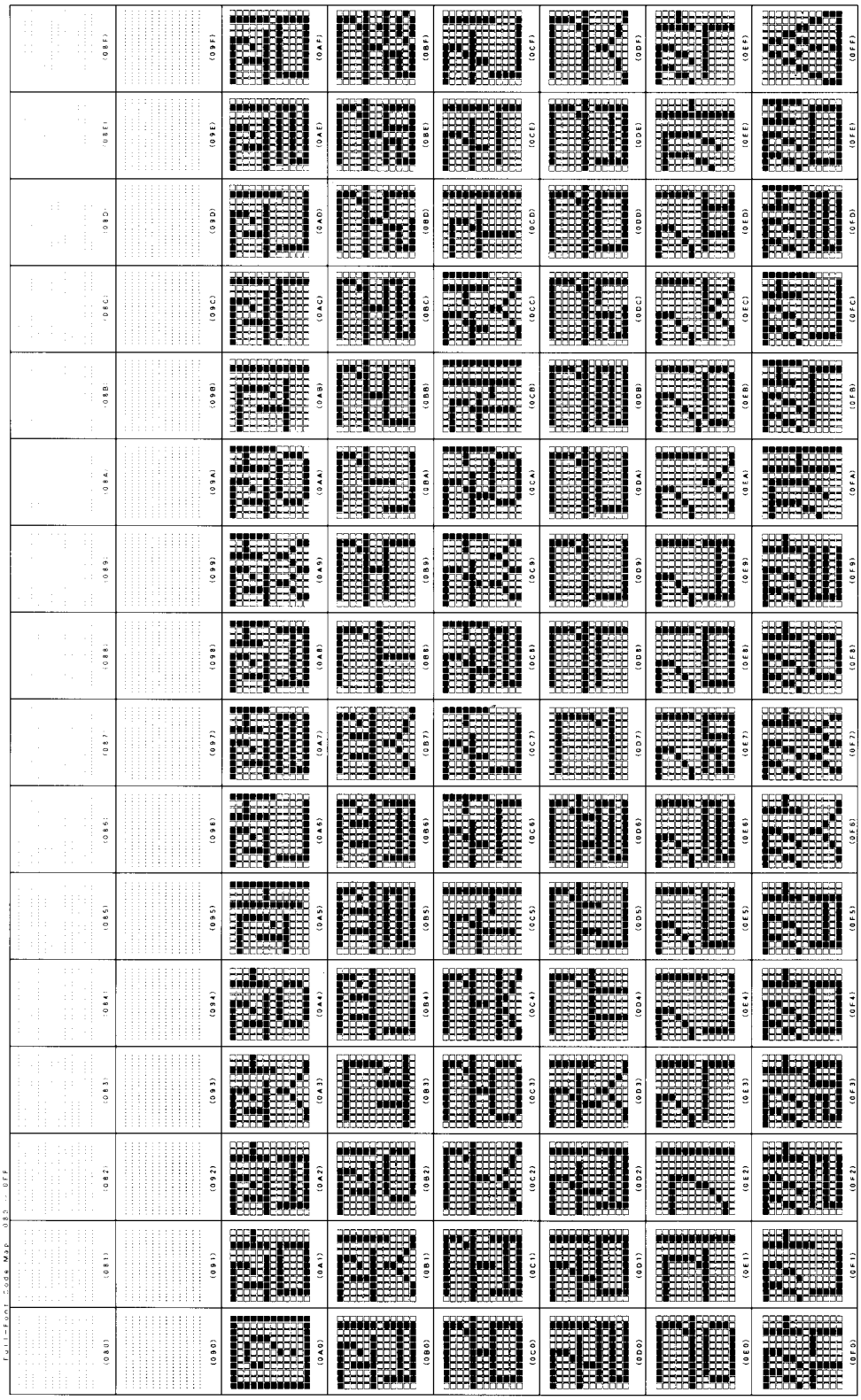
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



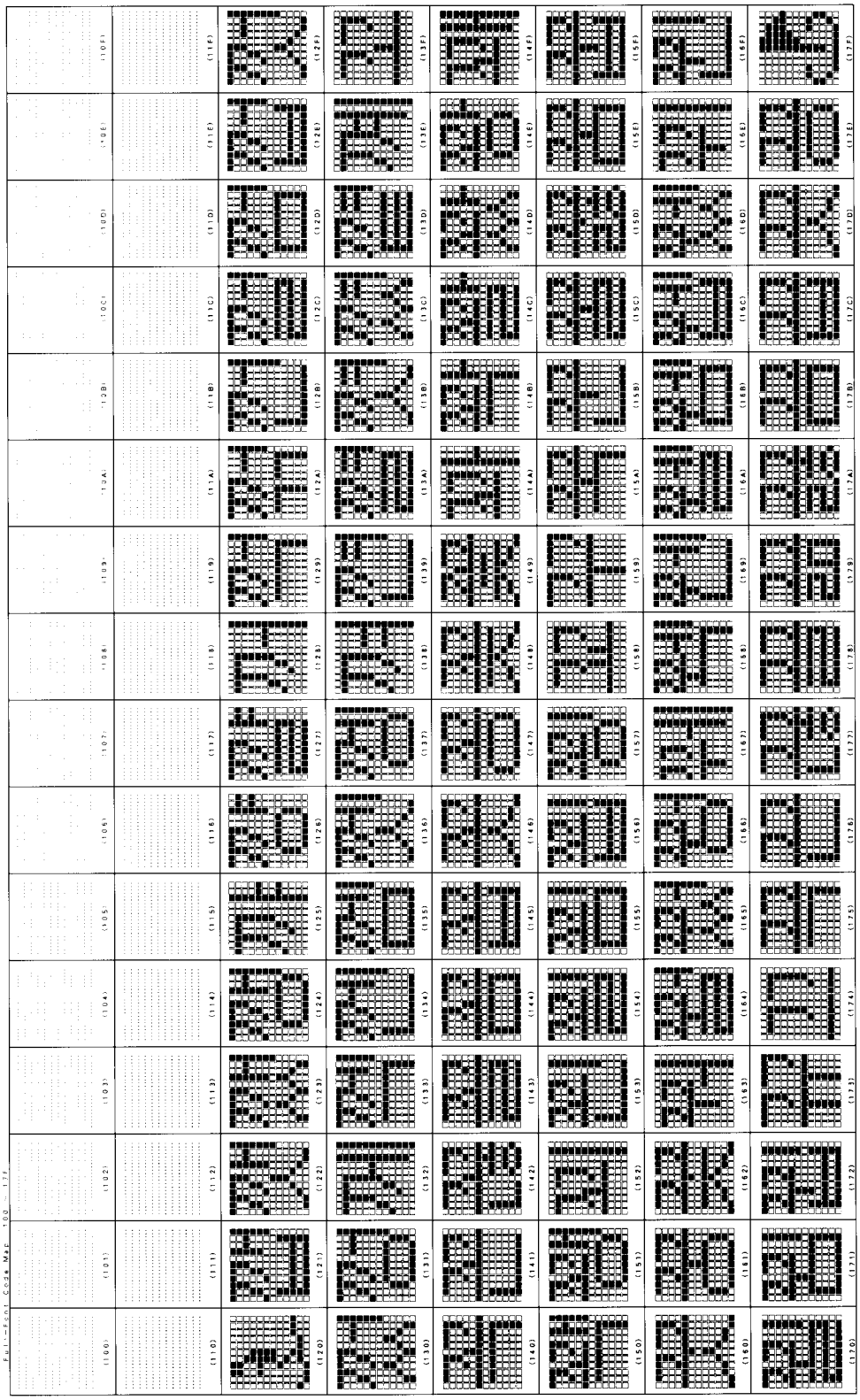
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



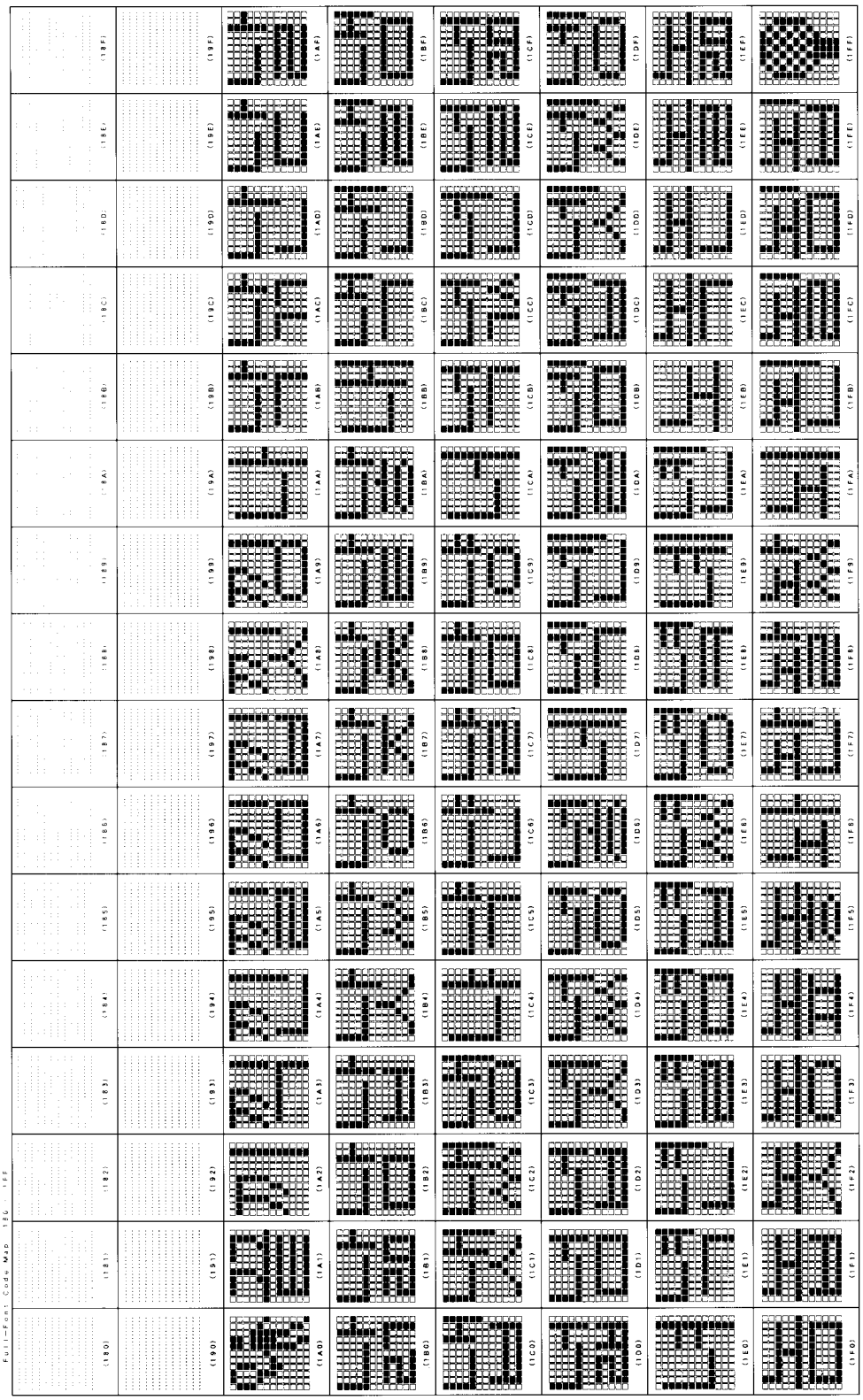
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



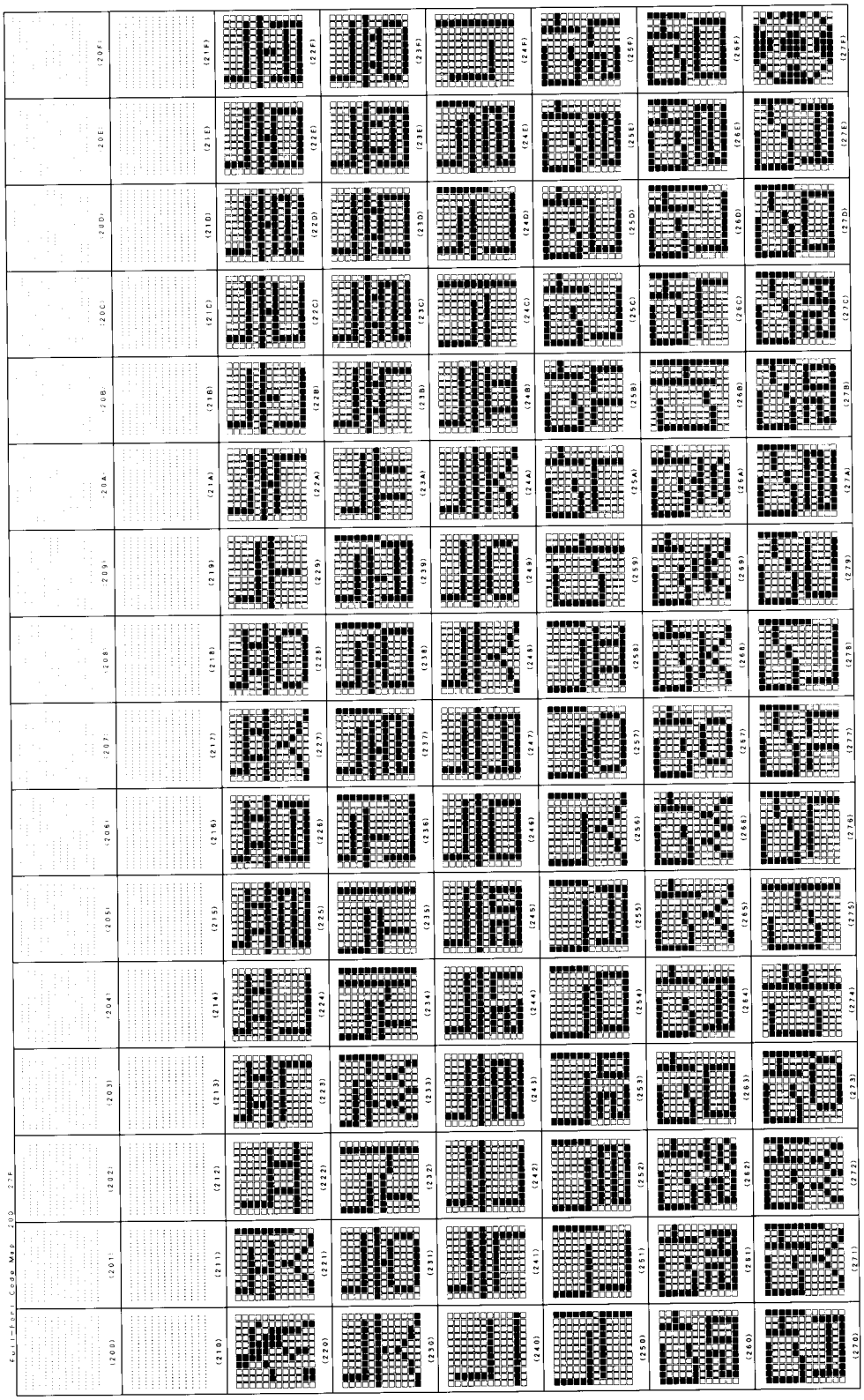
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



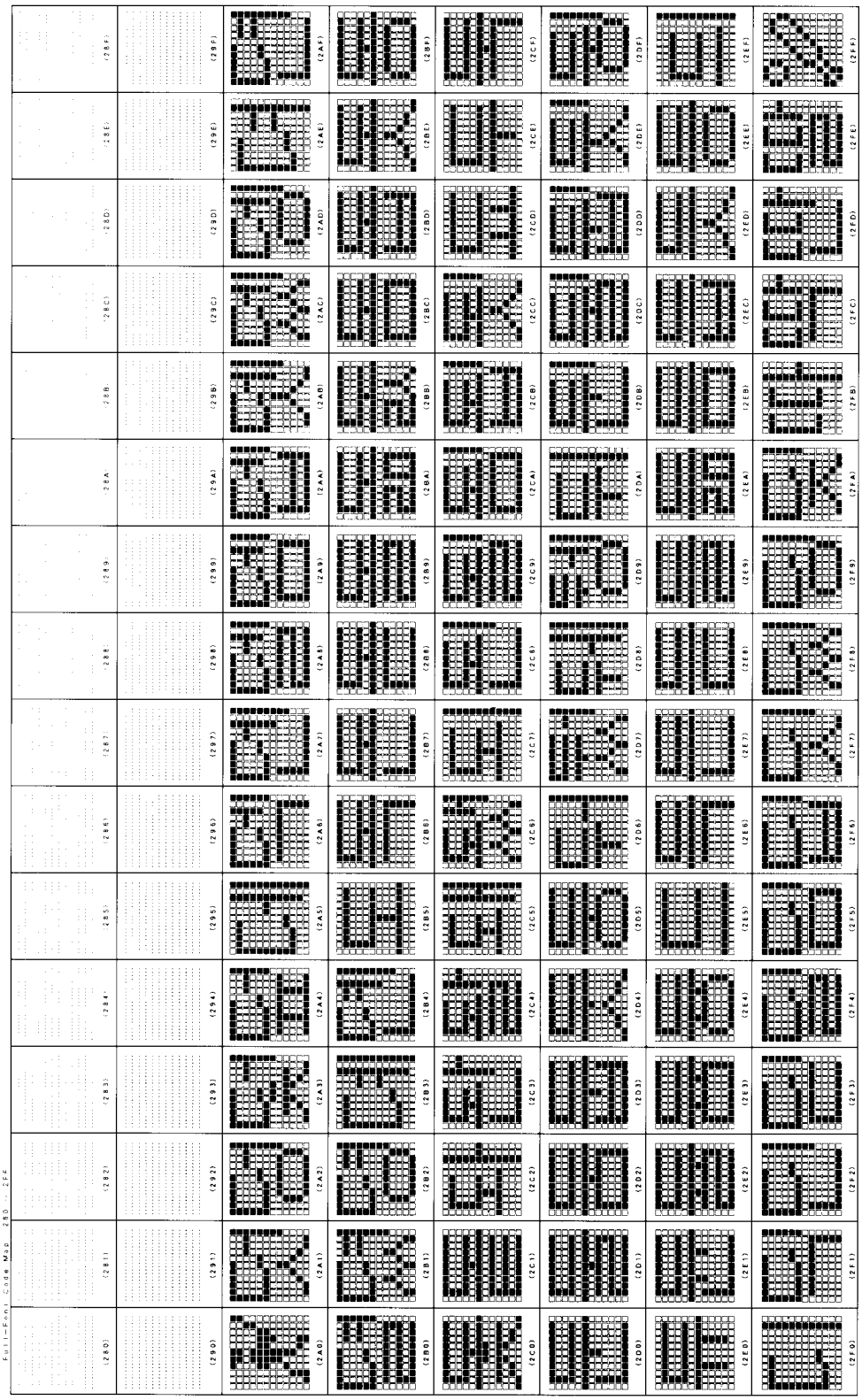
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



HD66730/731 A01 Korean font set (KS C 5601–1992 subset)

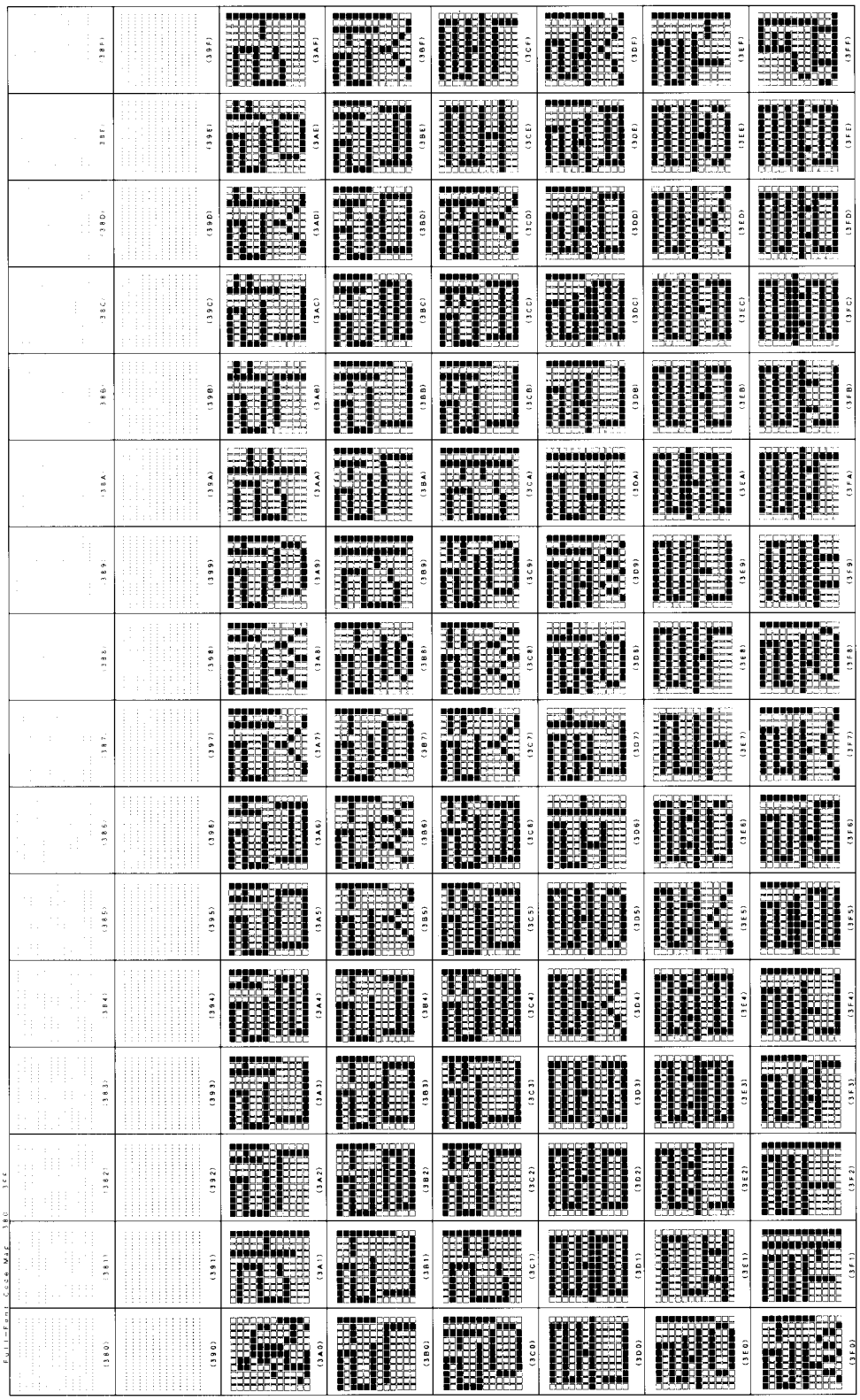


HD66730/731 A01 Korean font set (KS C 5601–1992 subset)

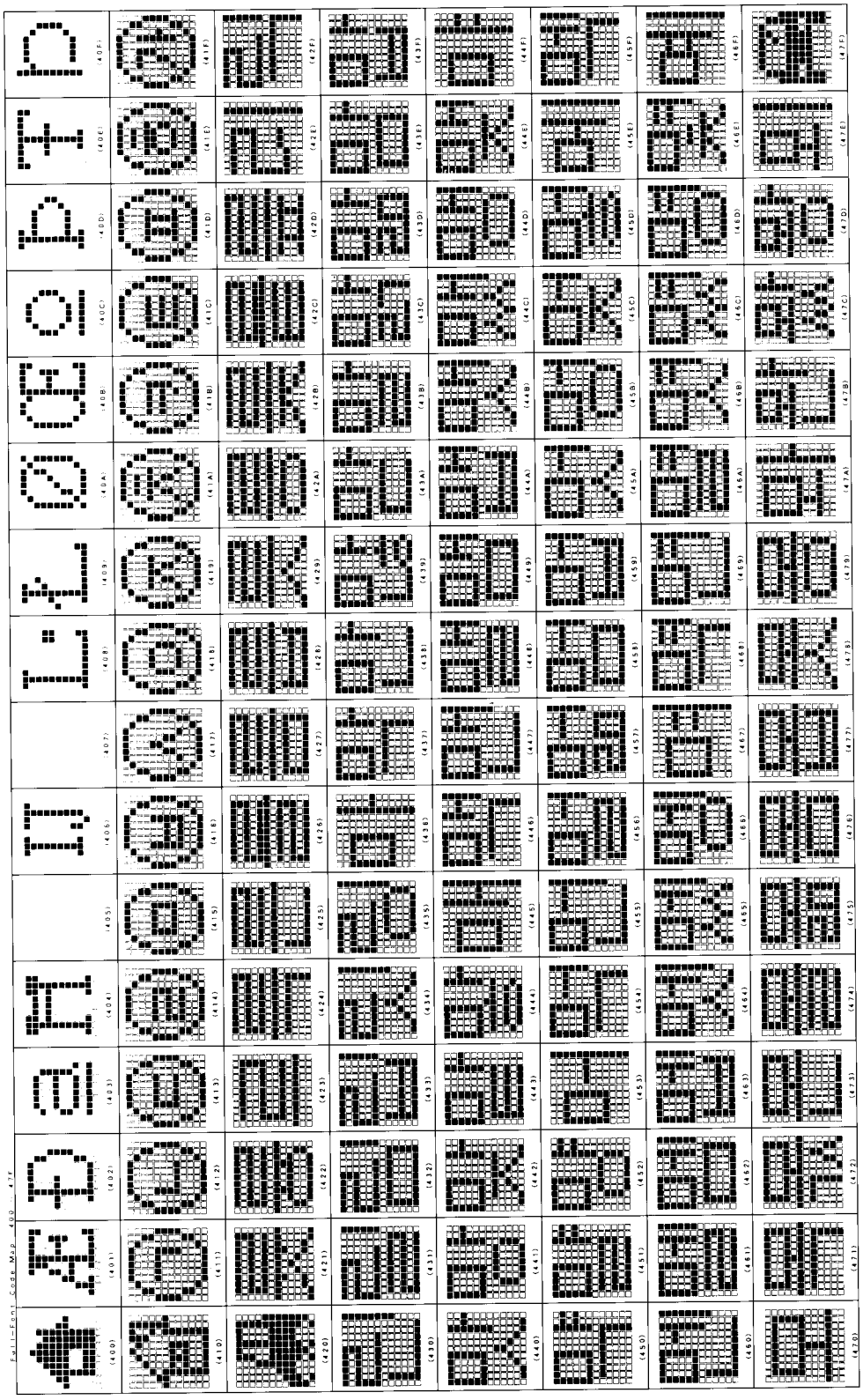


HD66730/731 A01 Korean font set (KS C 5601–1992 subset)

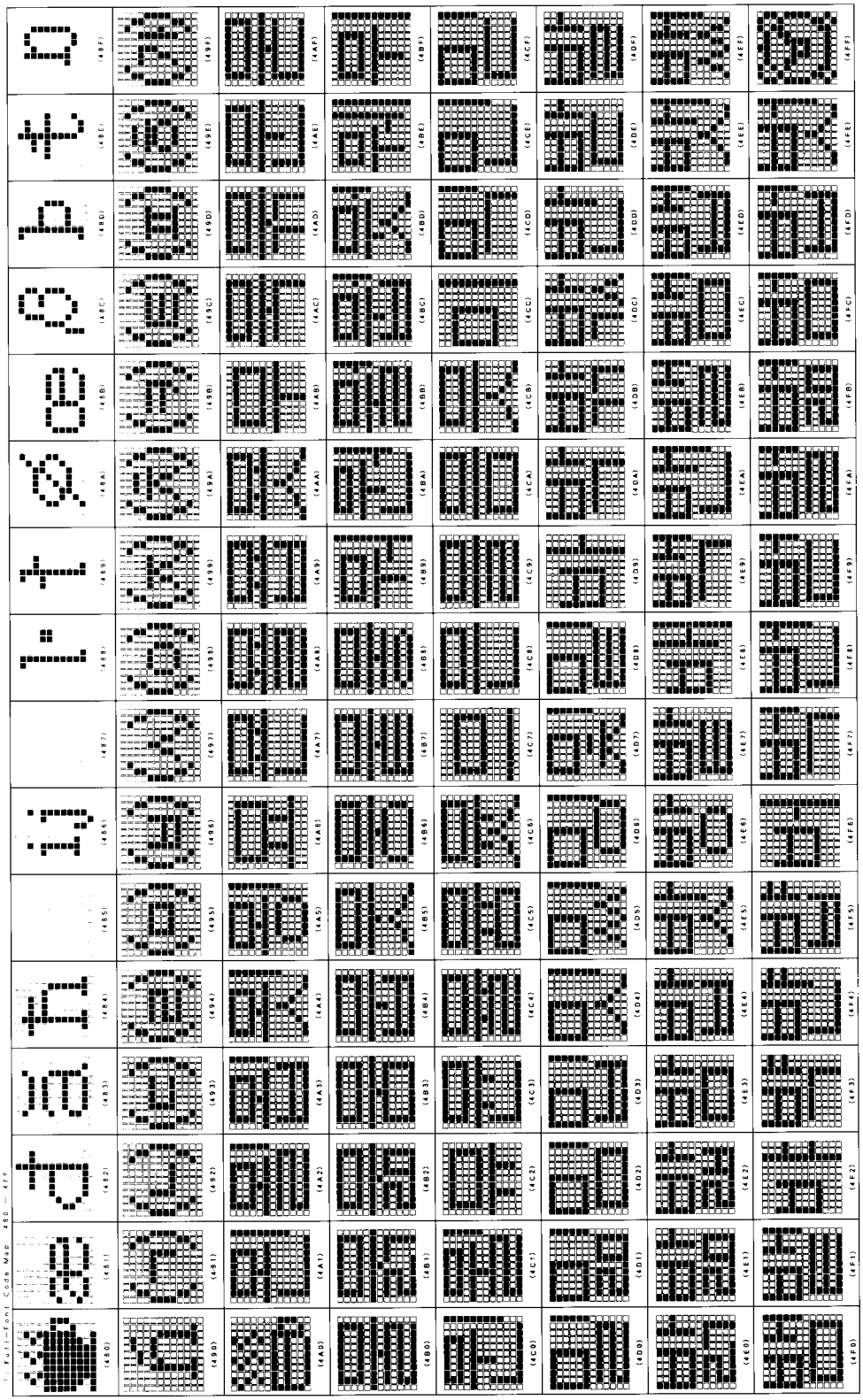
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



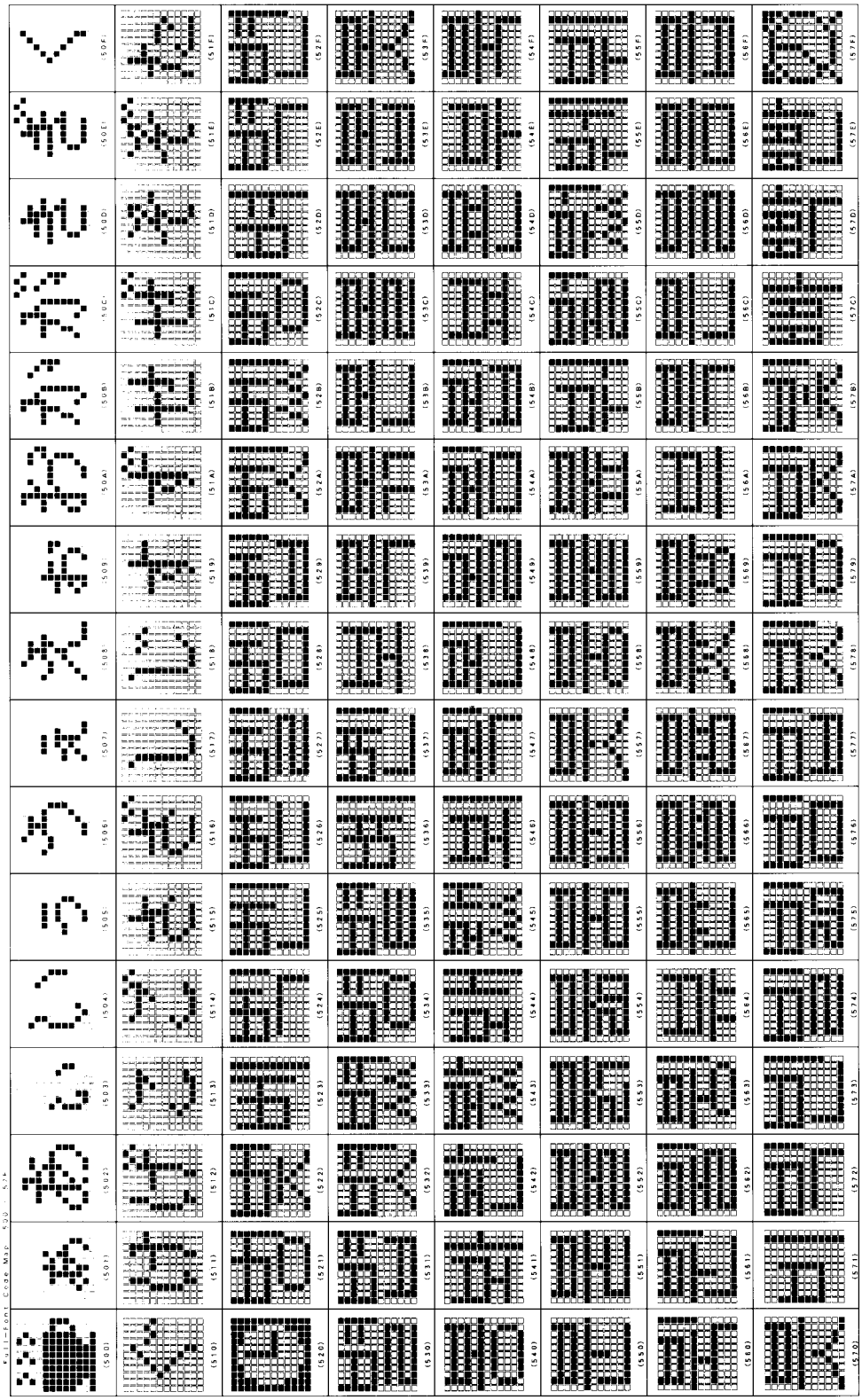
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



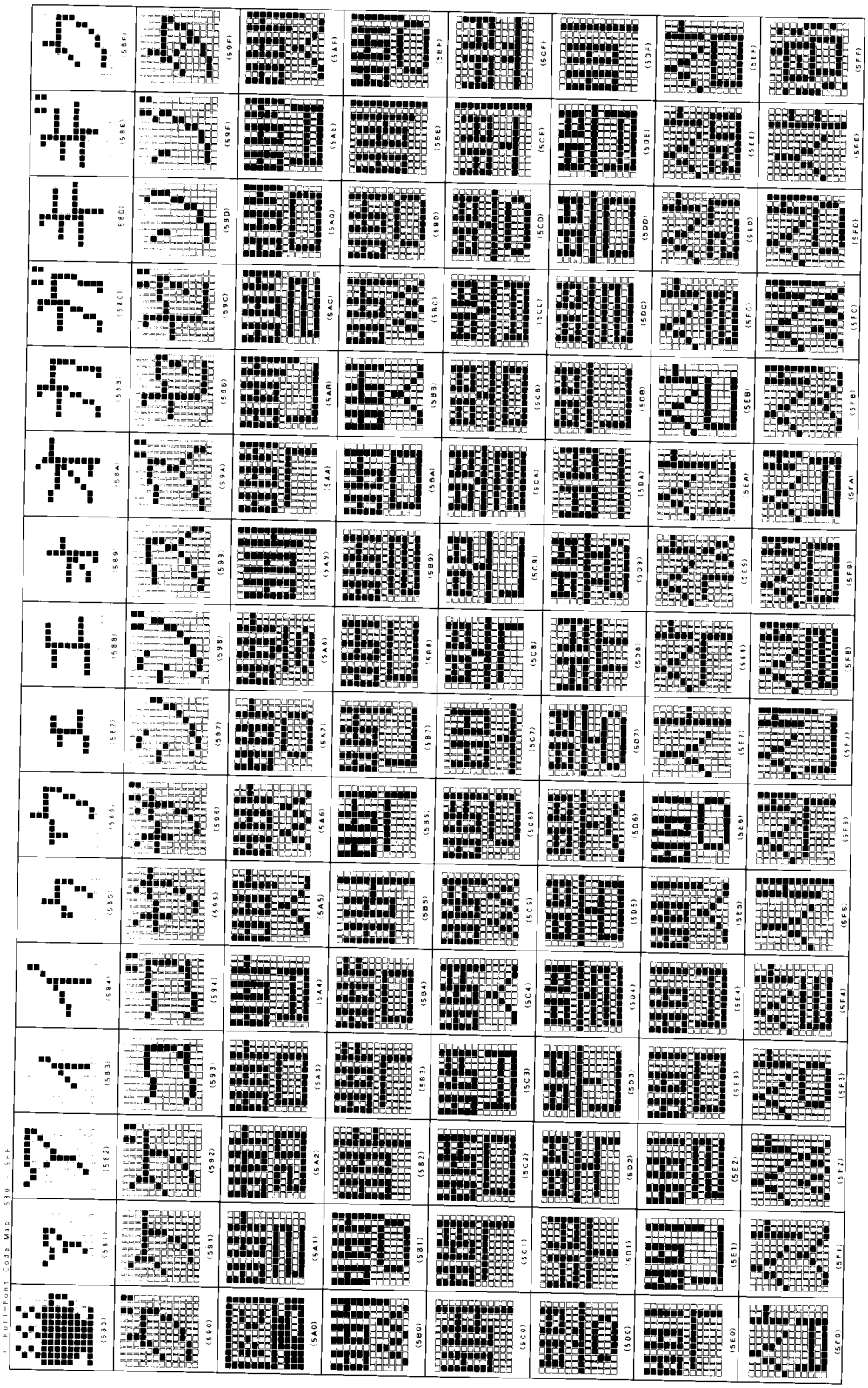
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



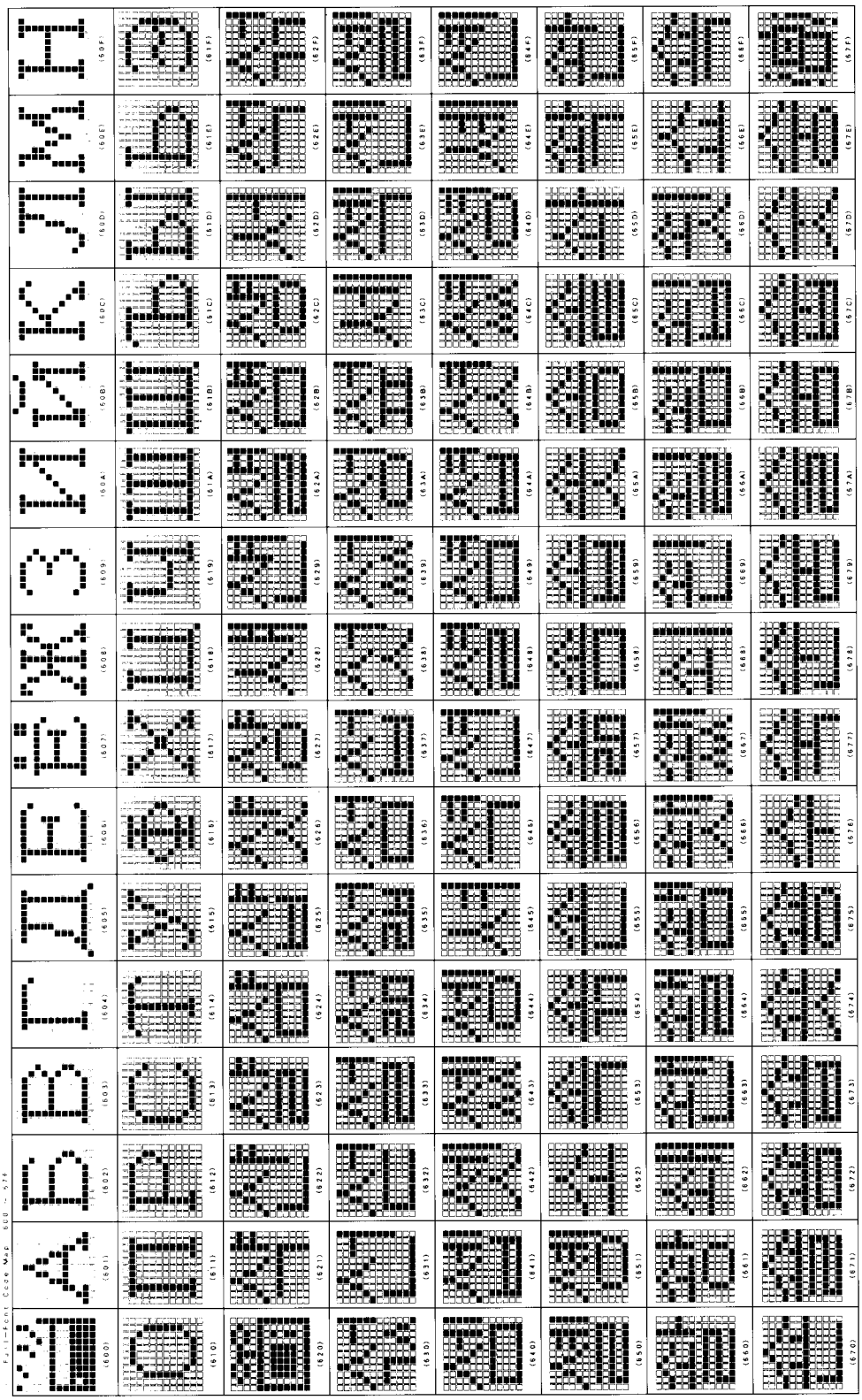
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



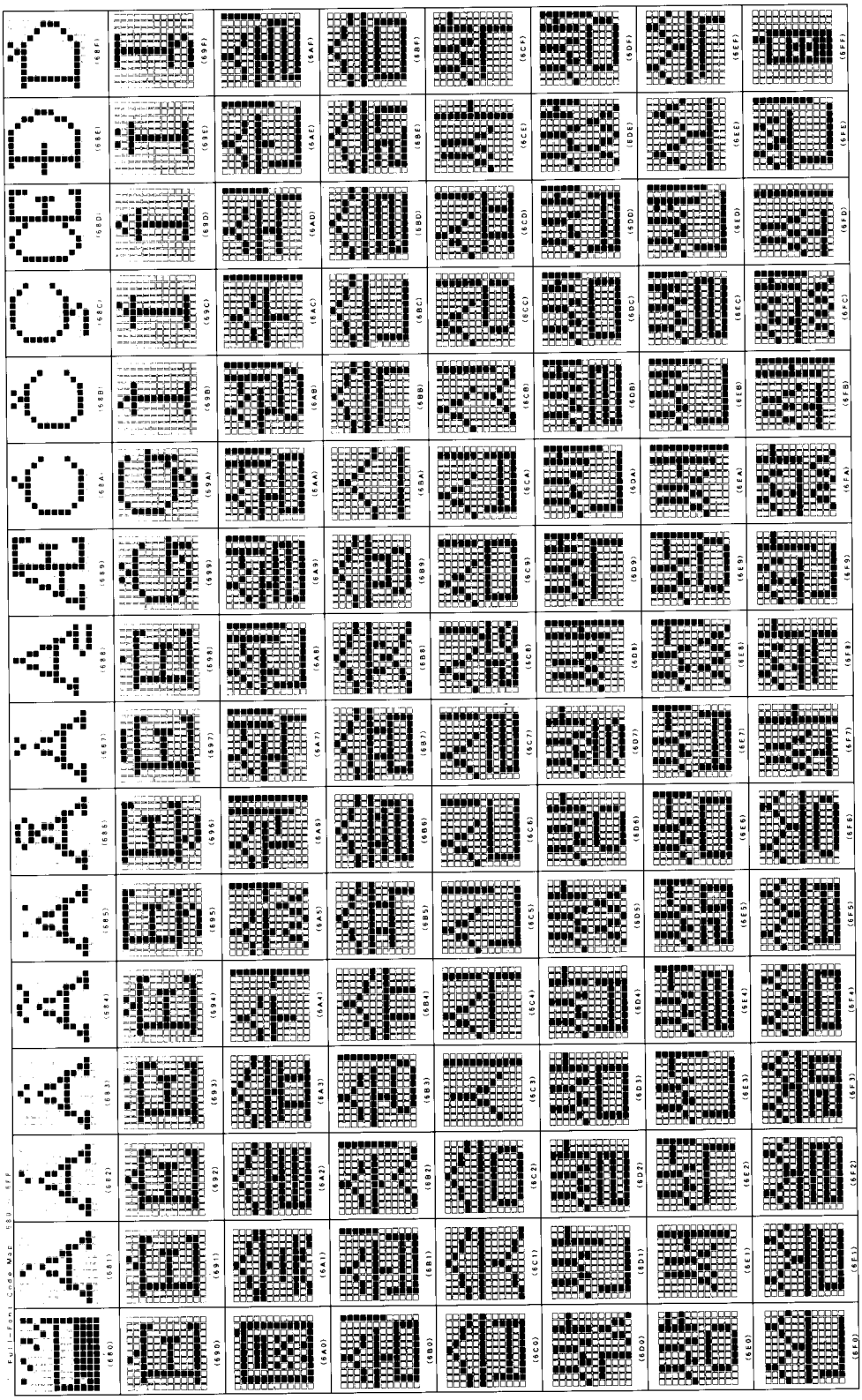
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



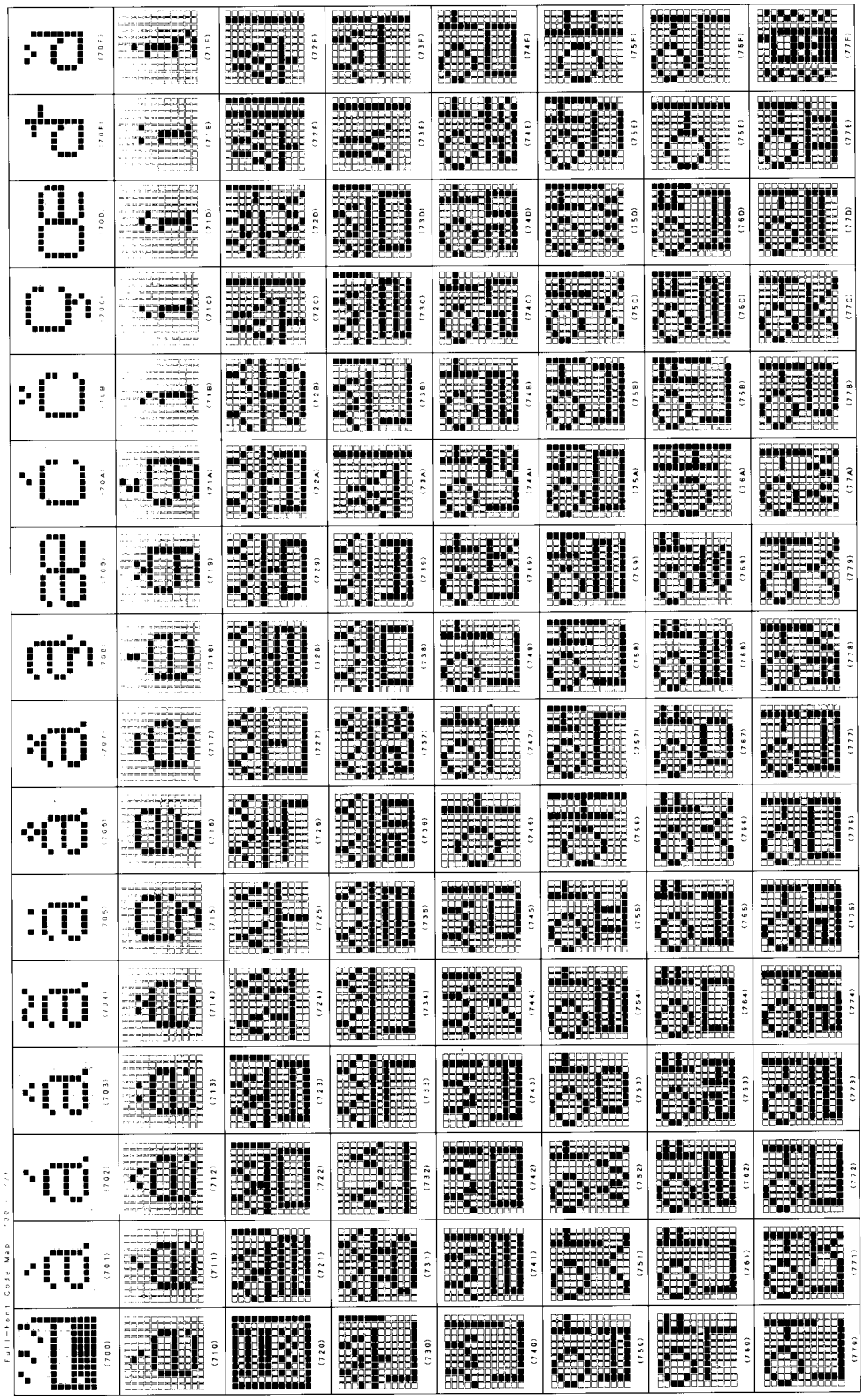
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



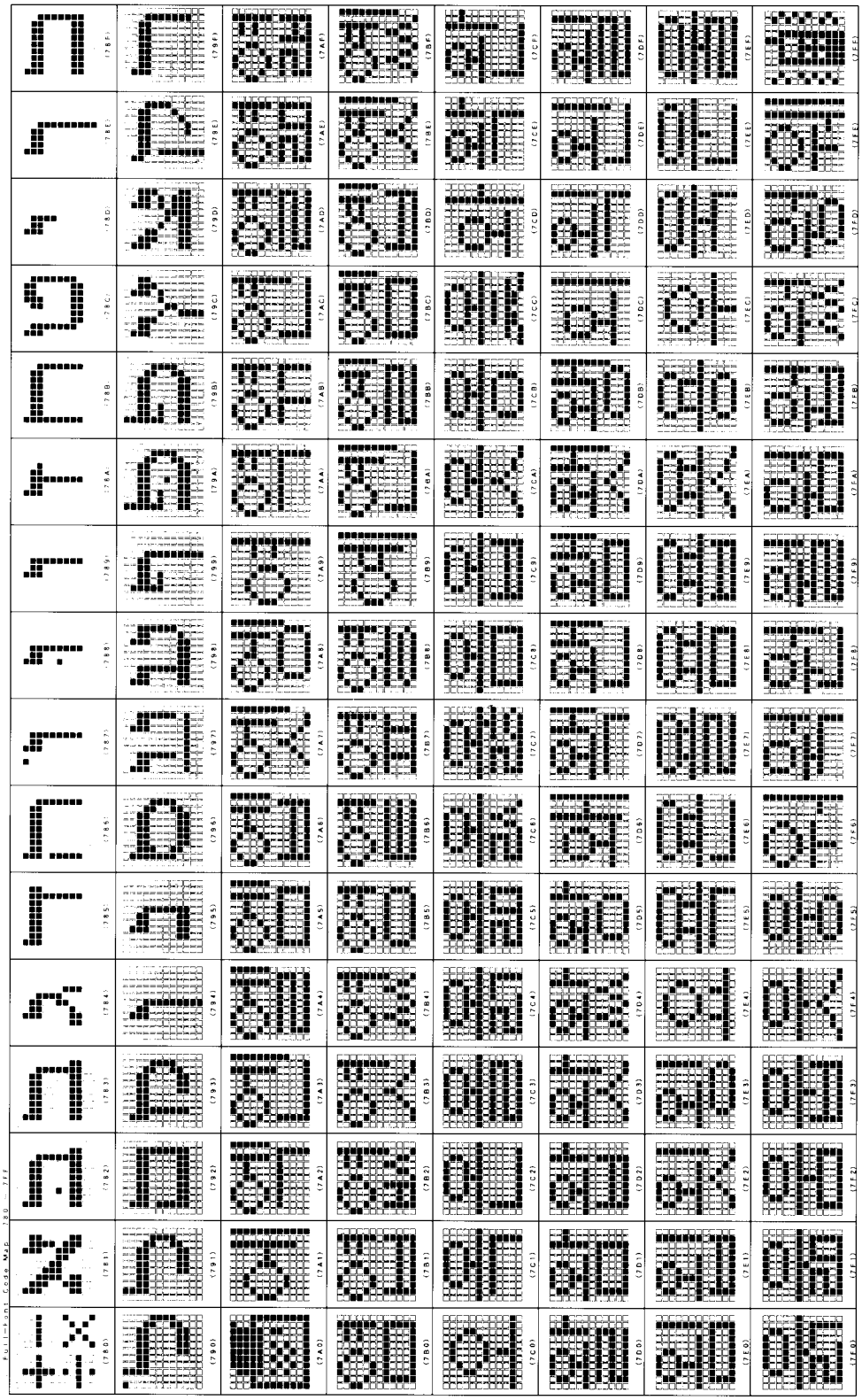
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



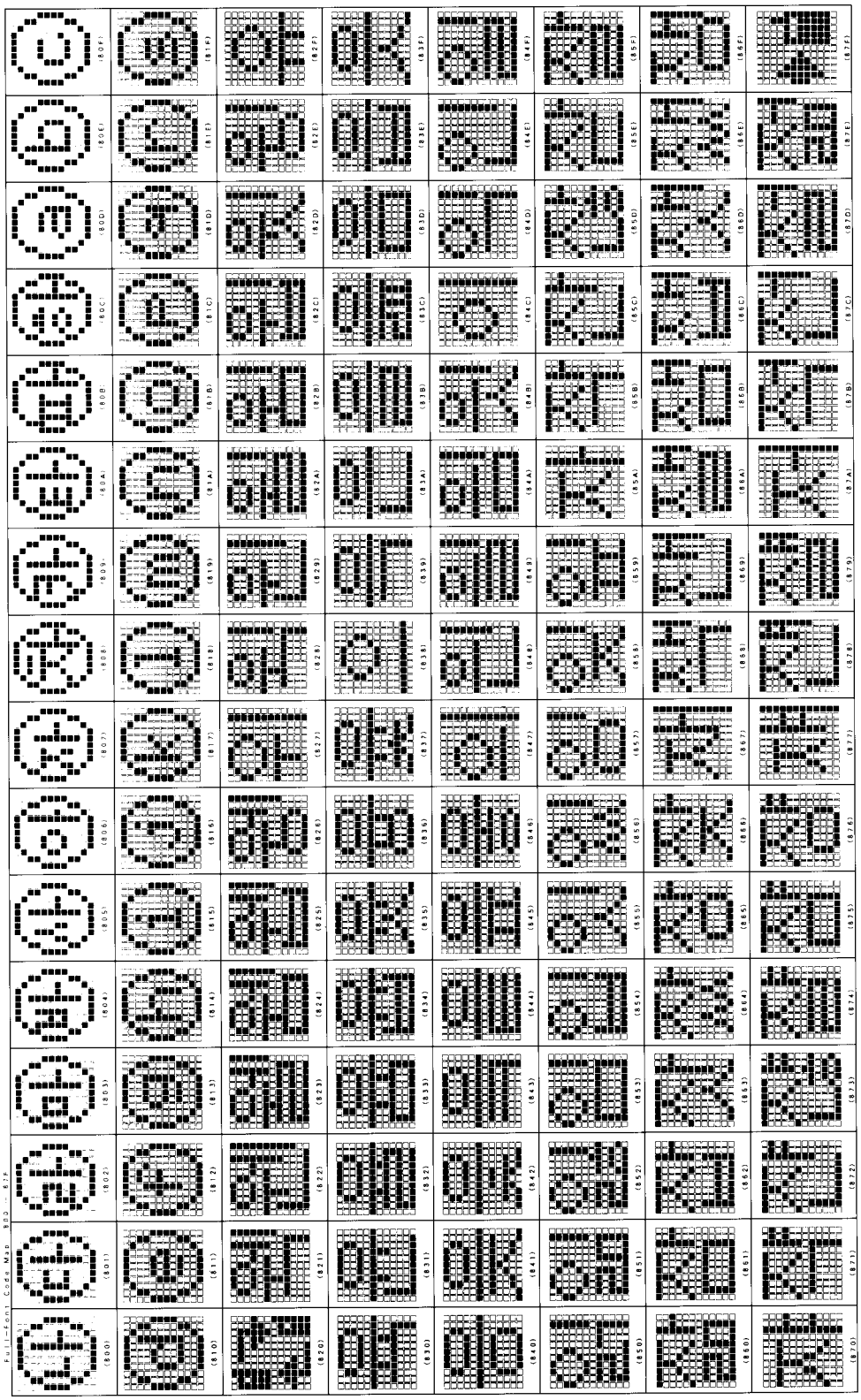
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



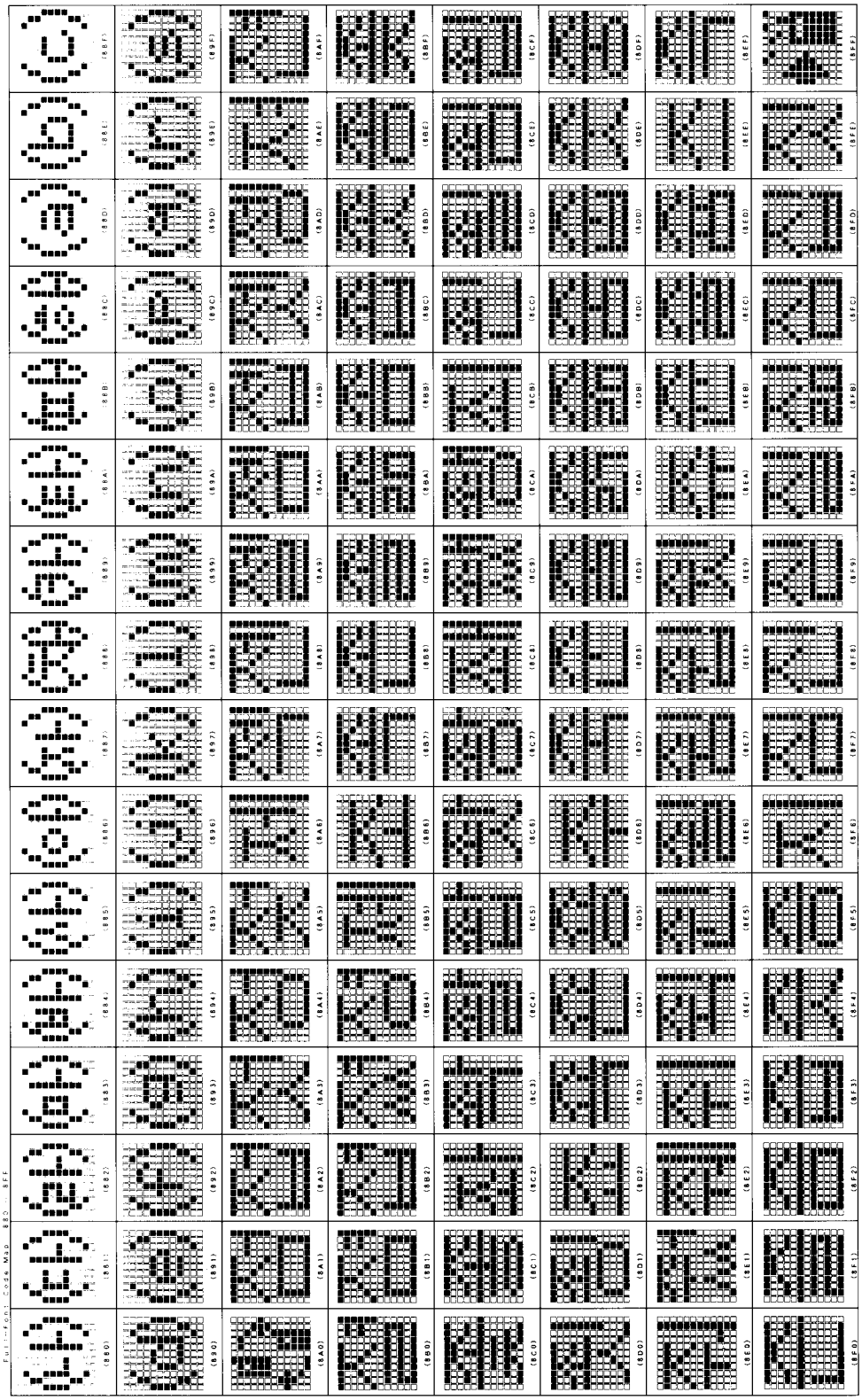
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



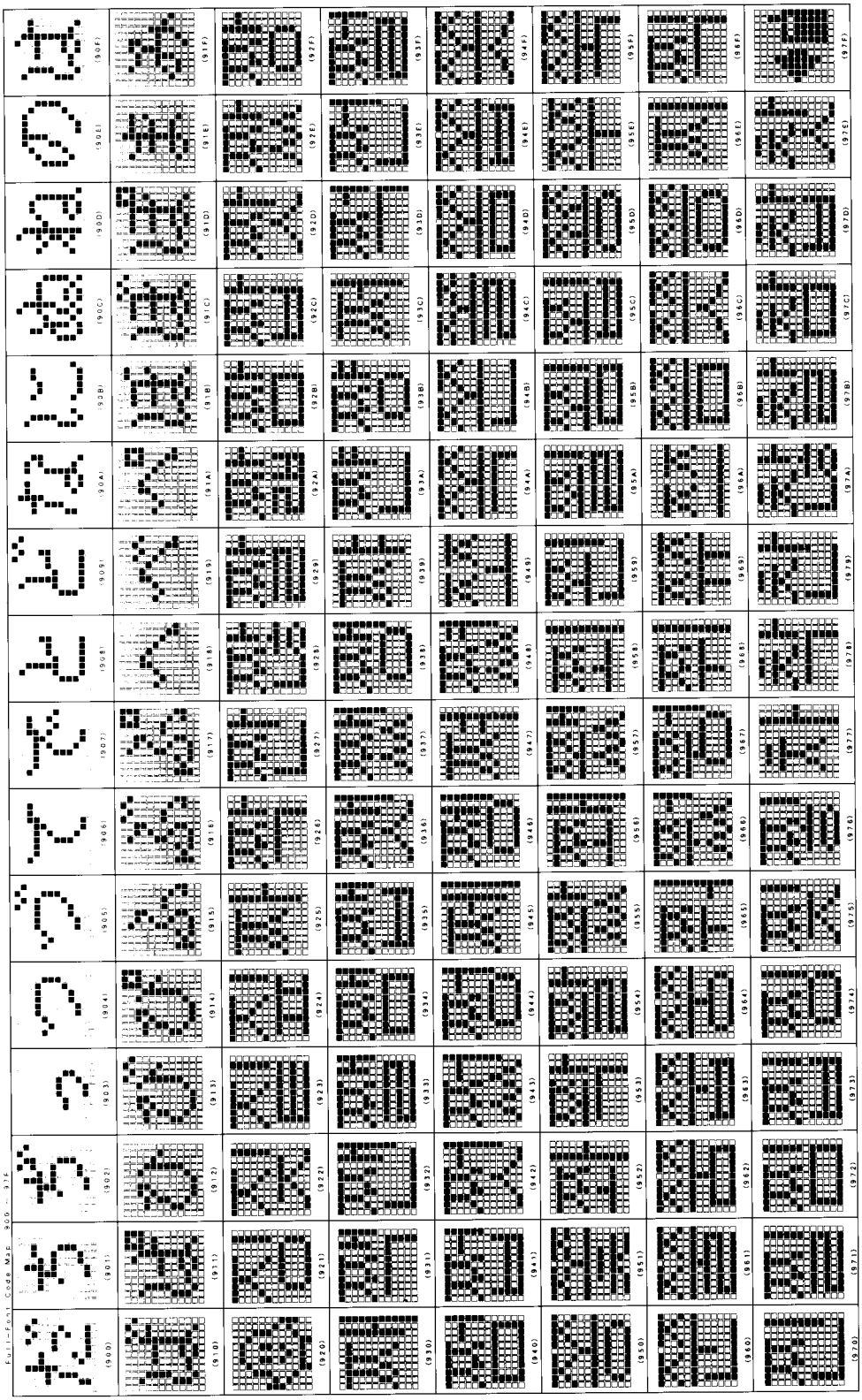
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



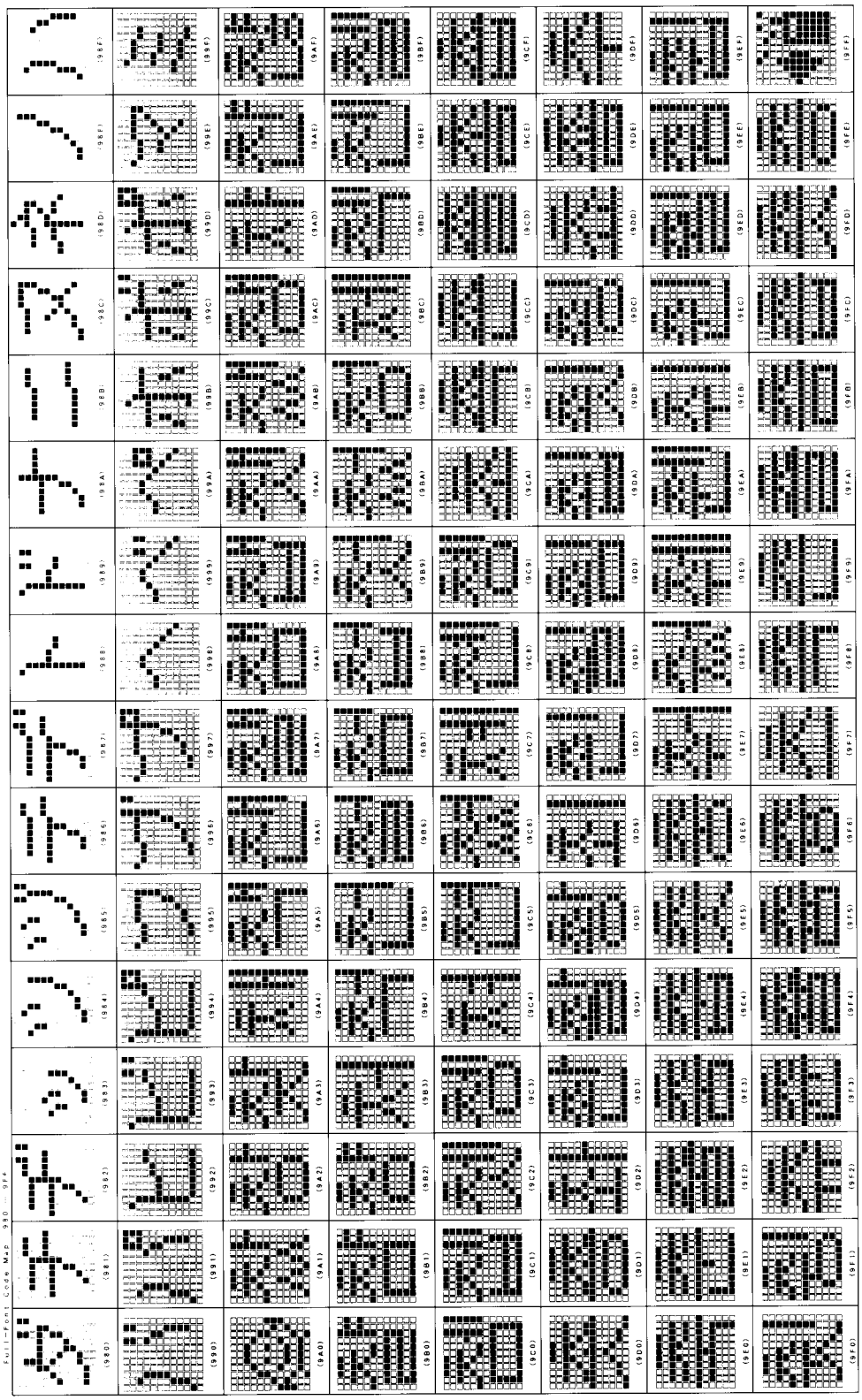
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



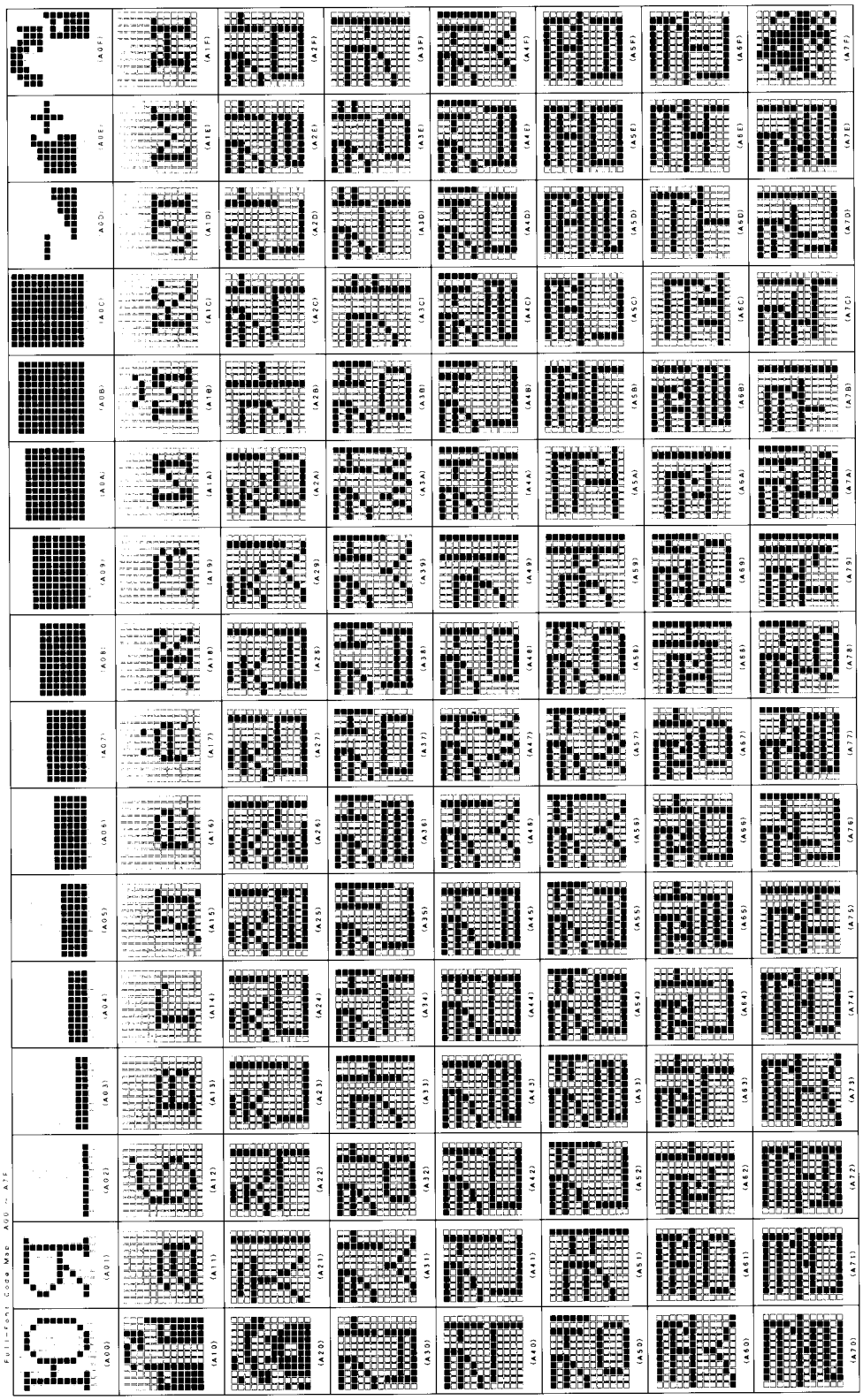
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



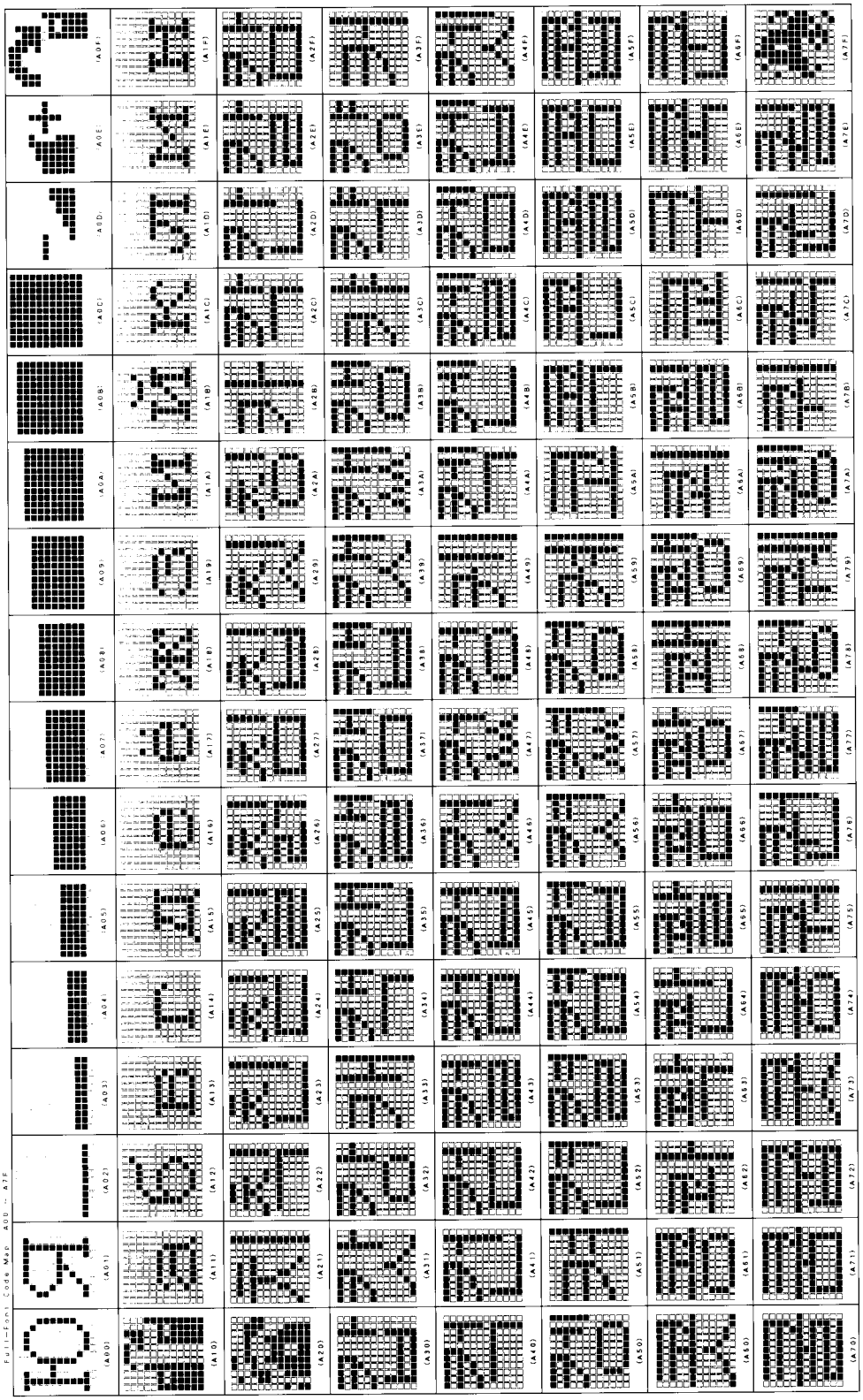
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



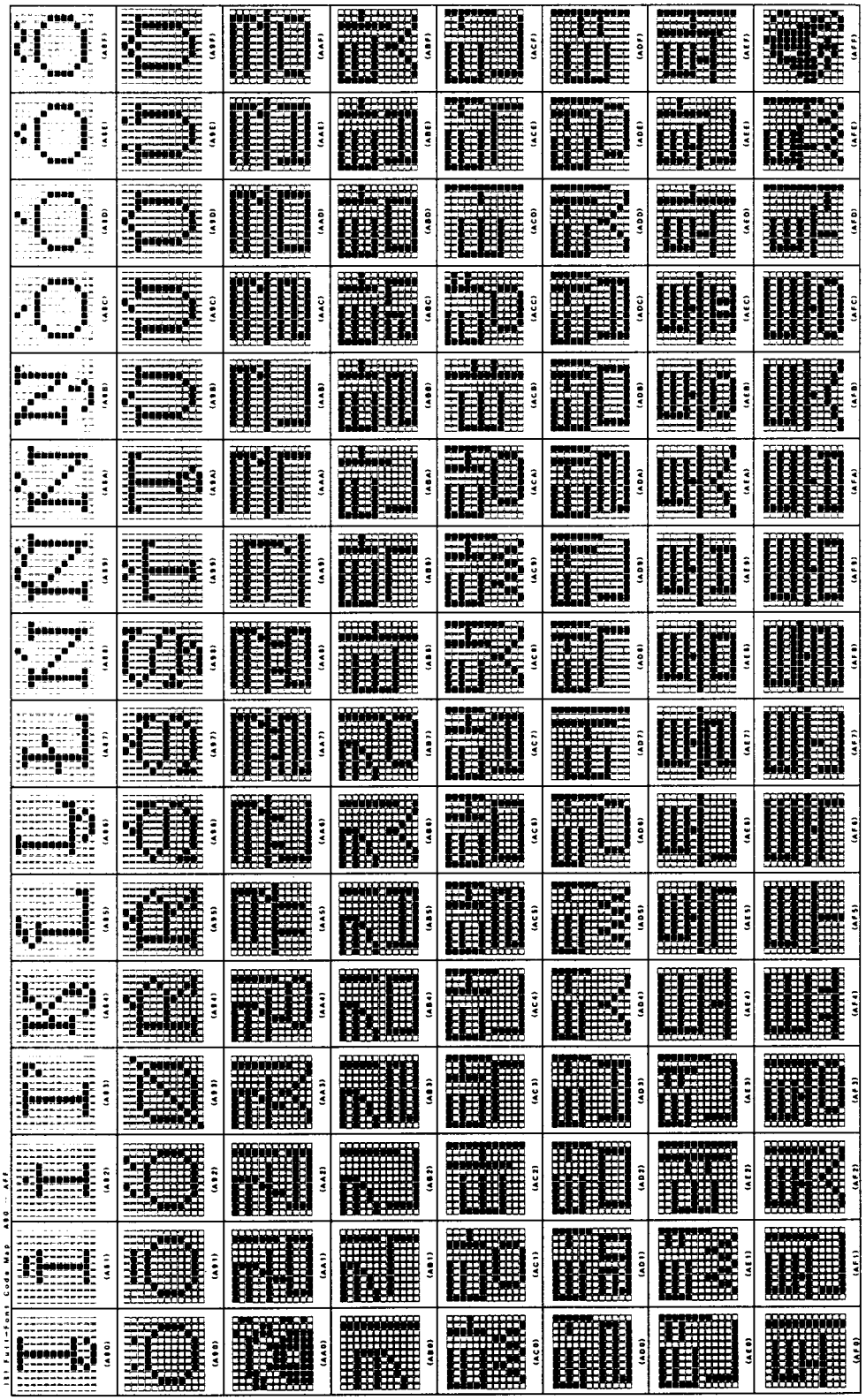
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



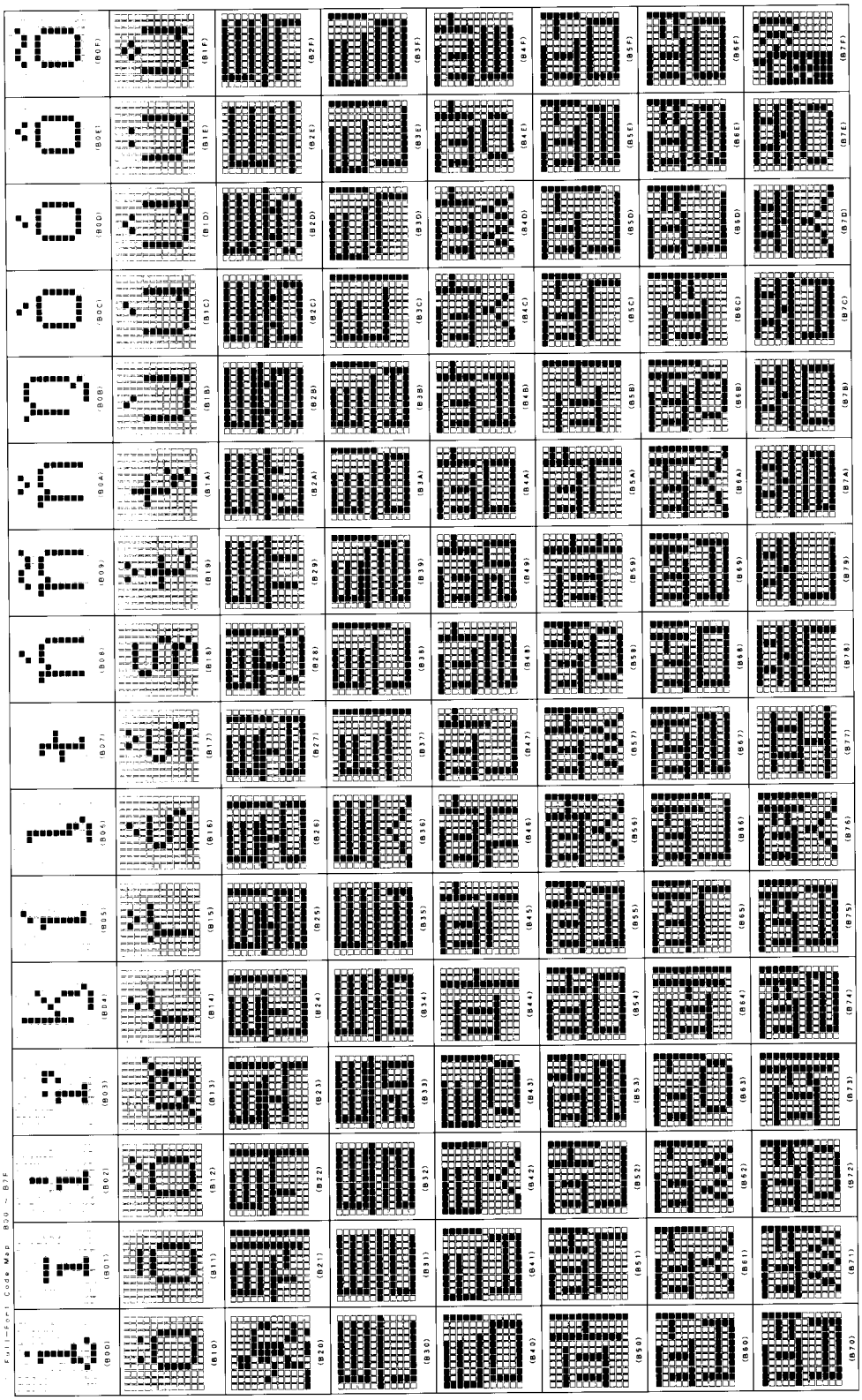
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



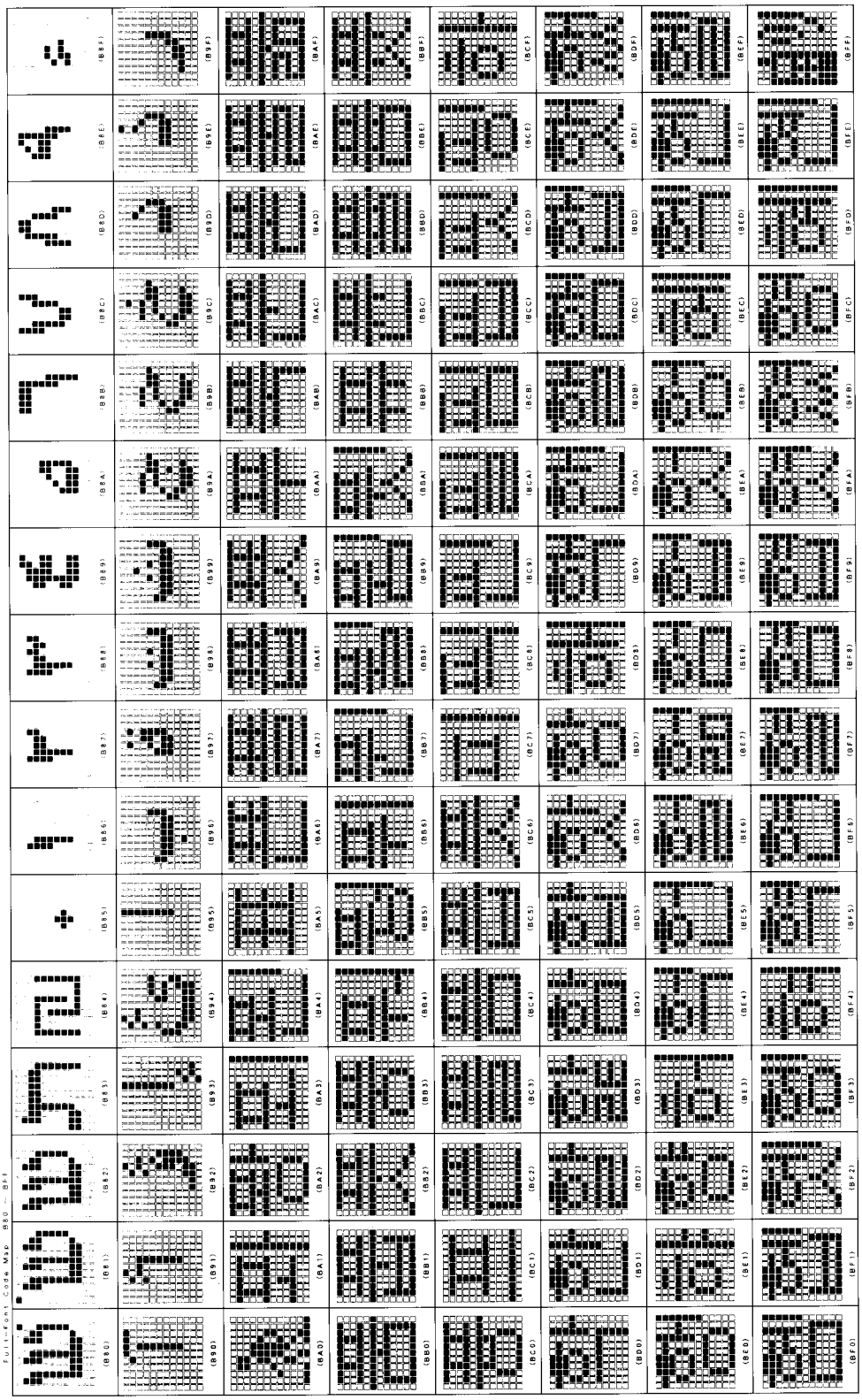
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



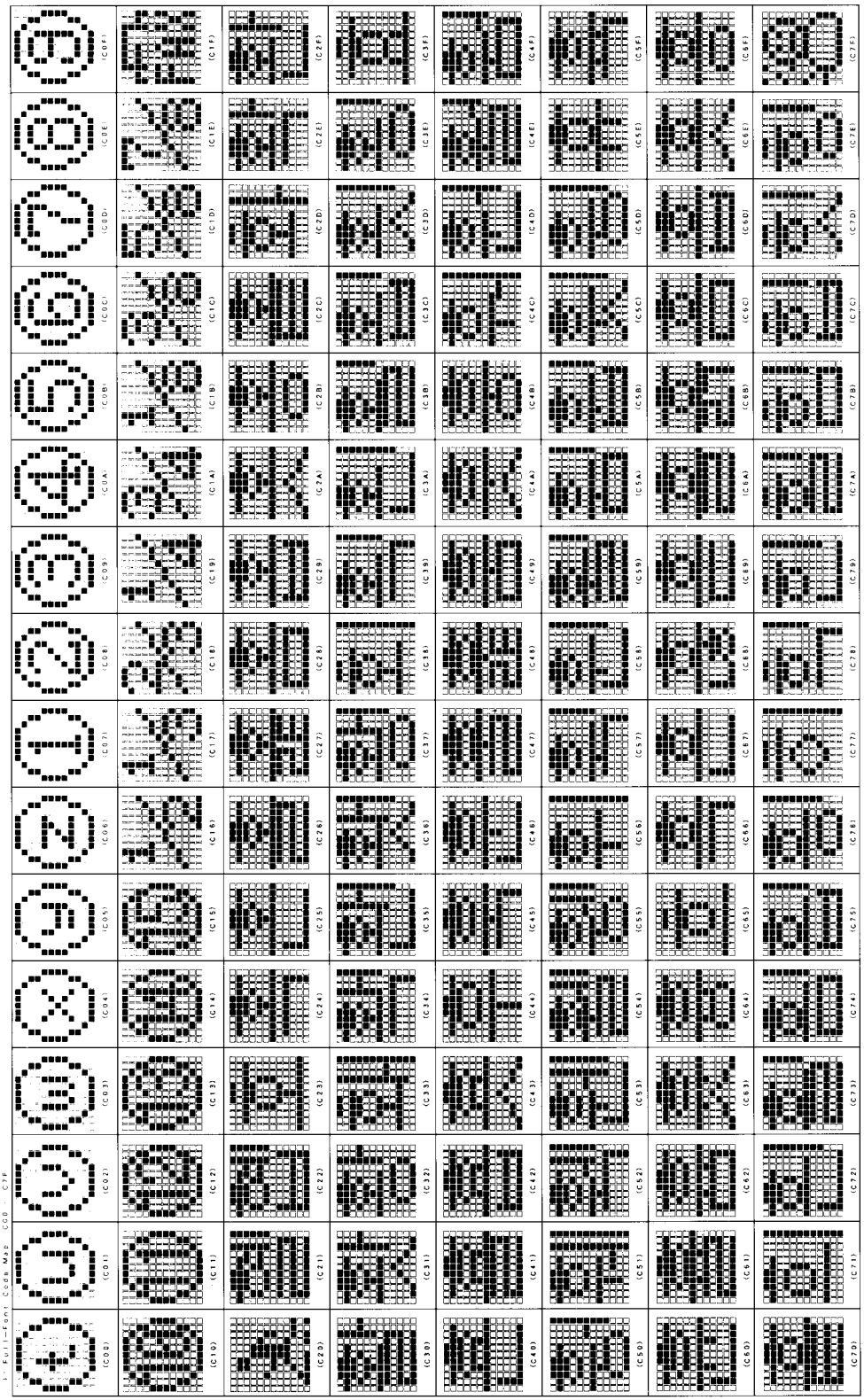
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



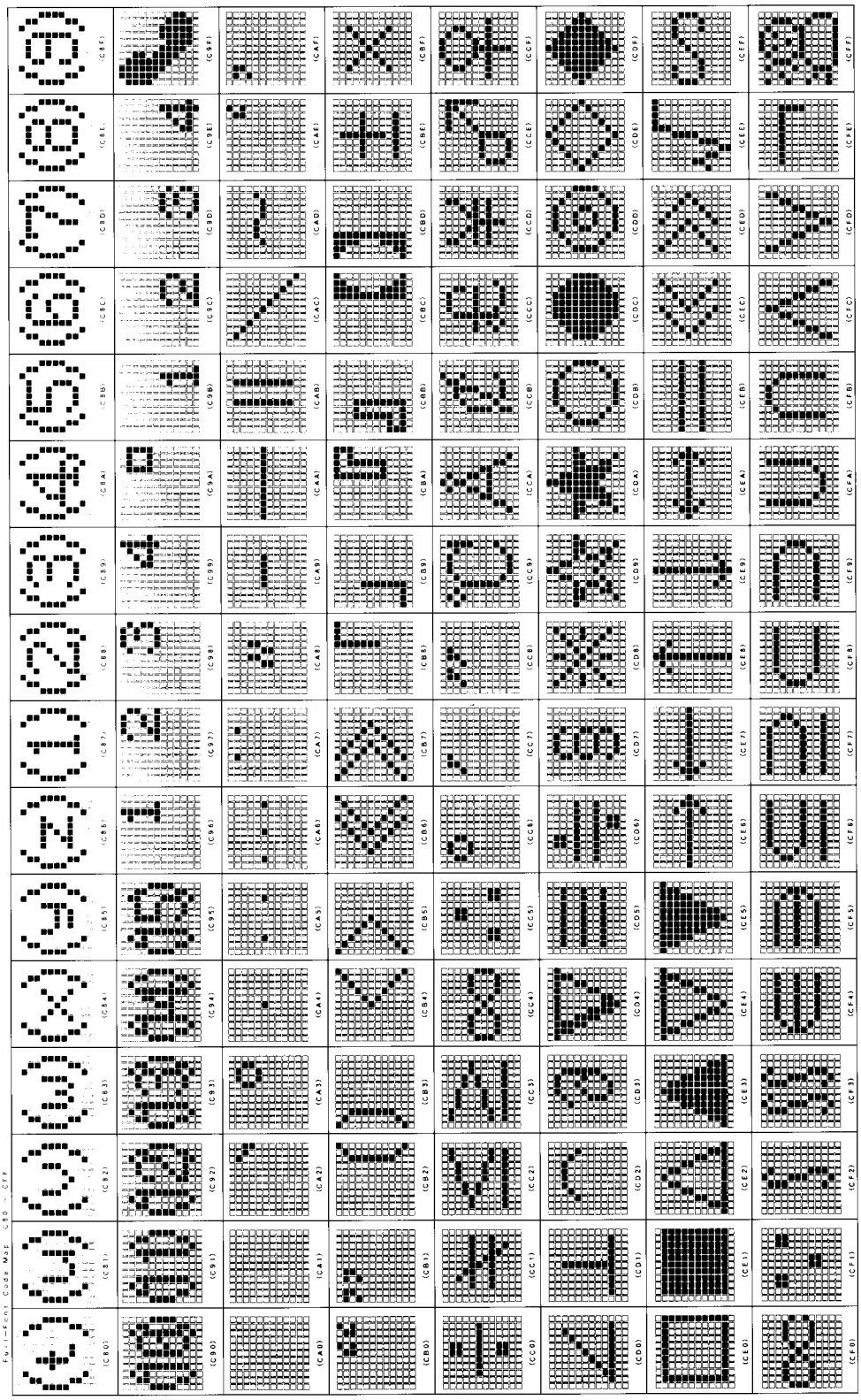
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



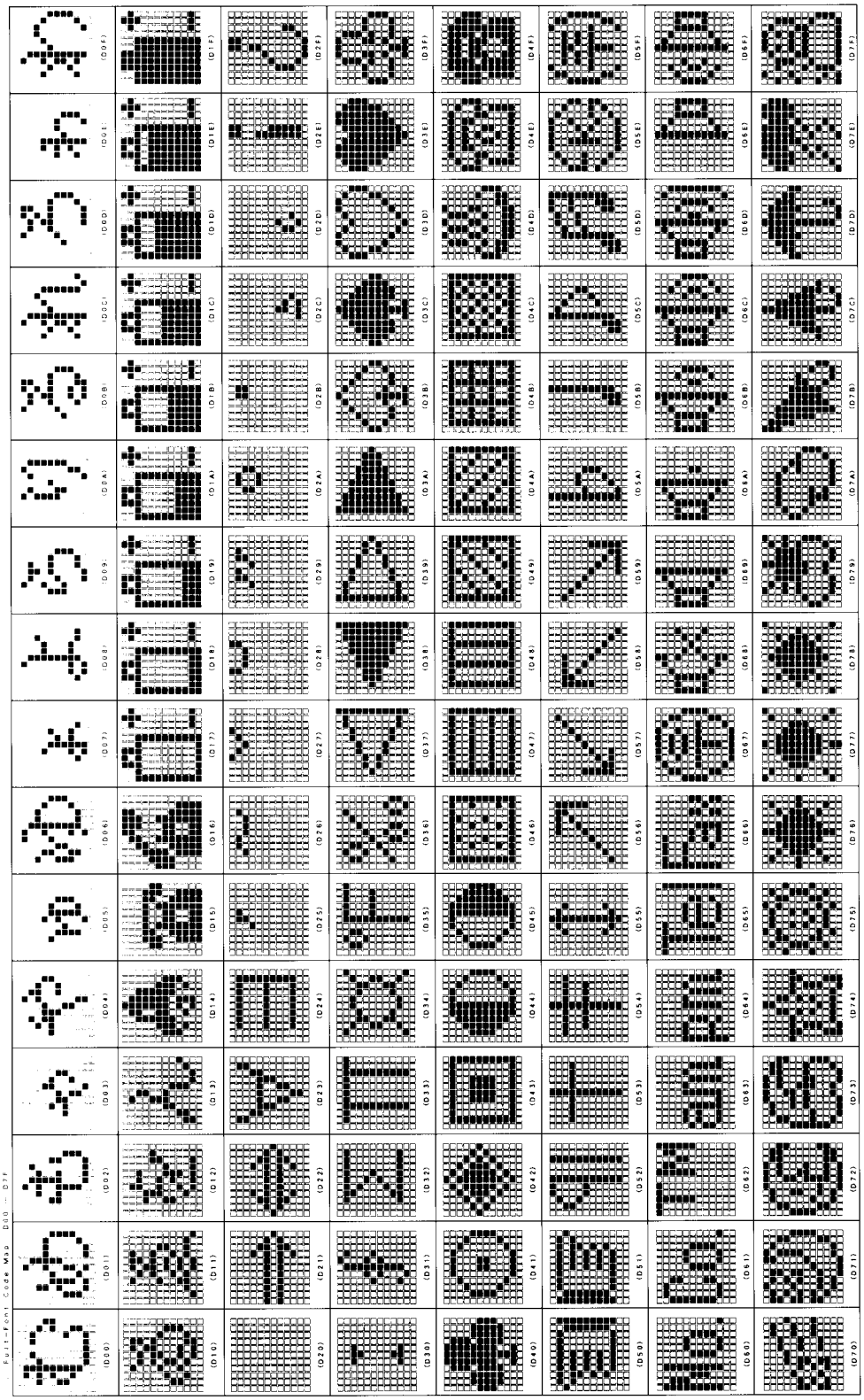
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



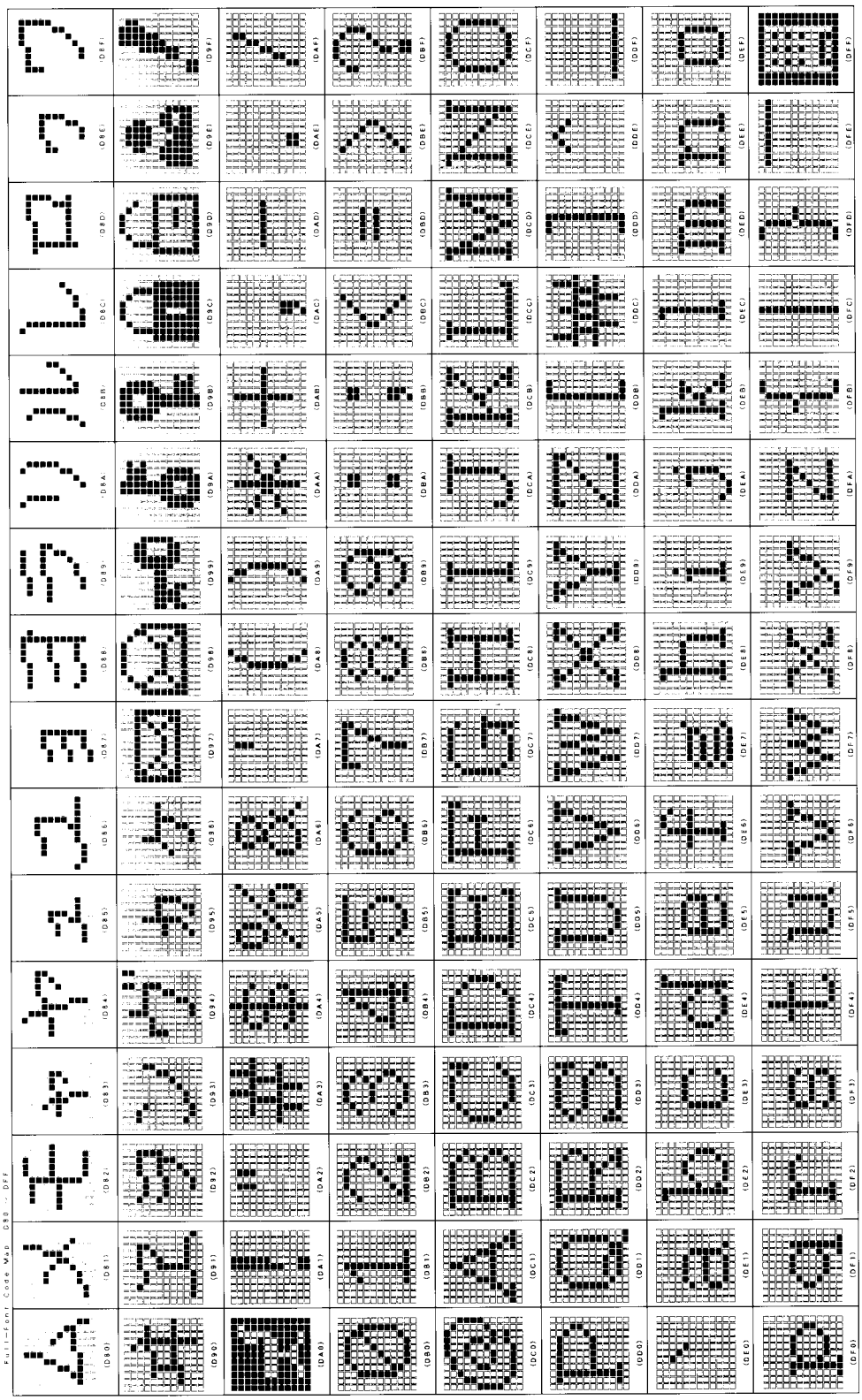
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



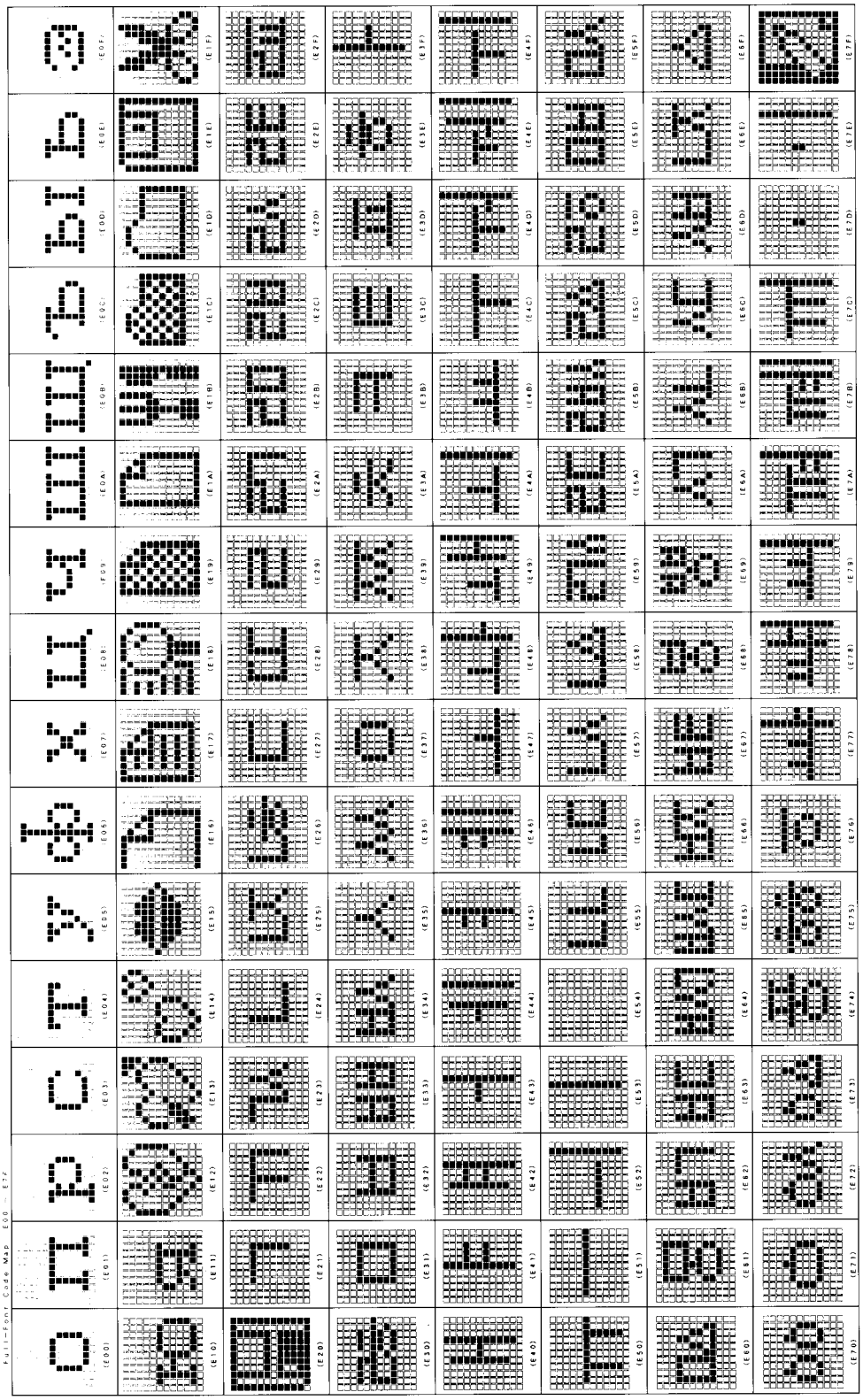
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



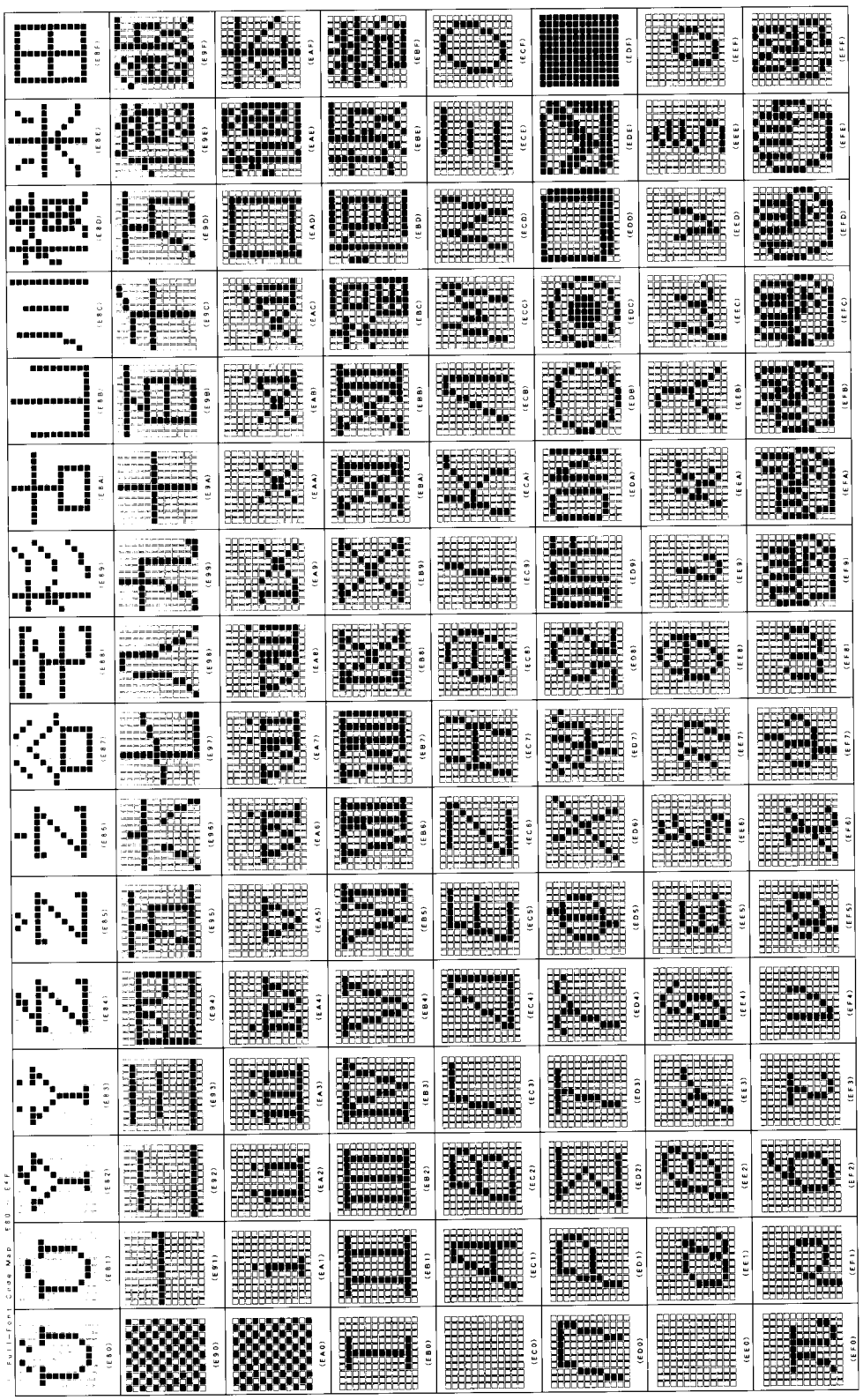
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



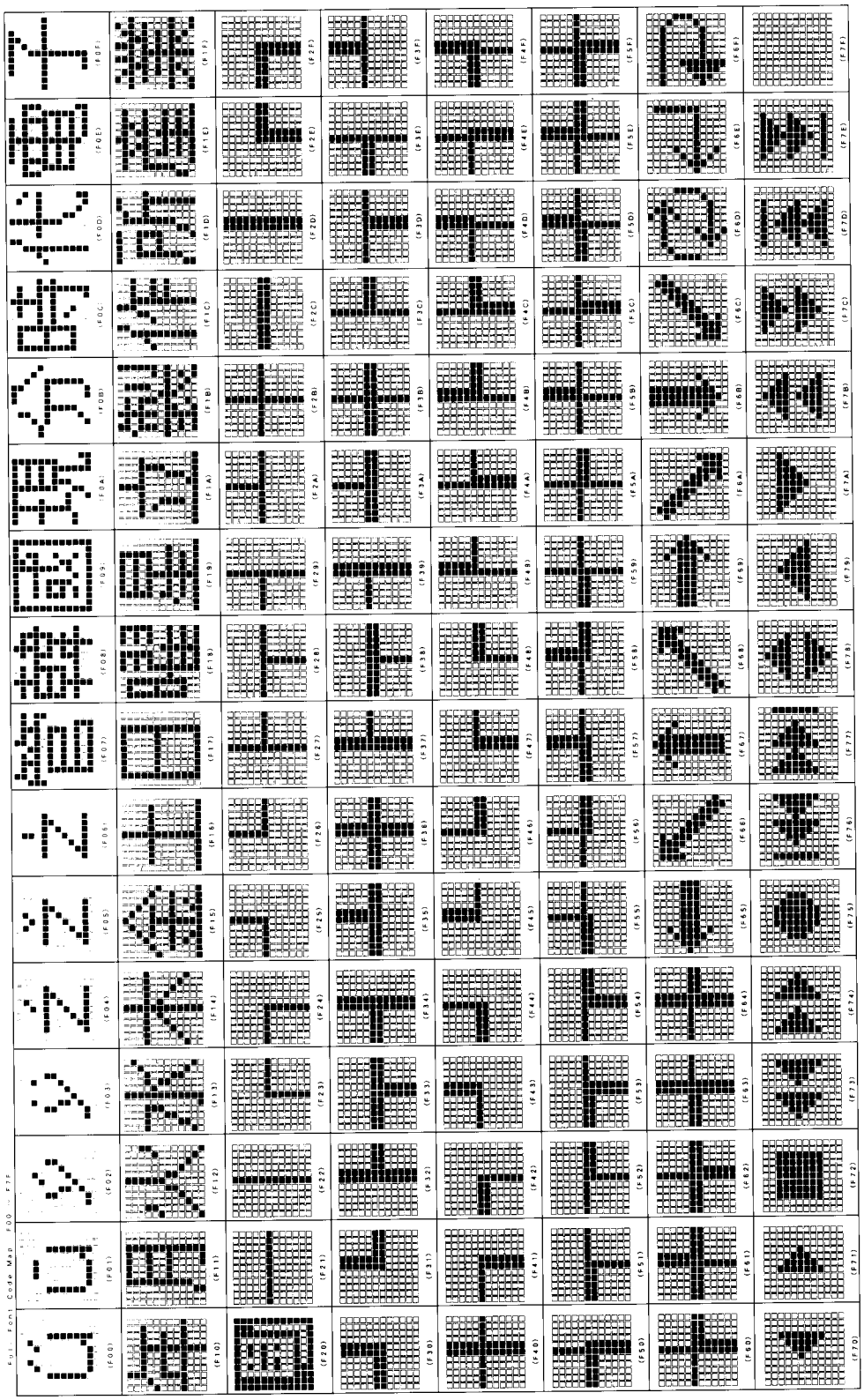
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



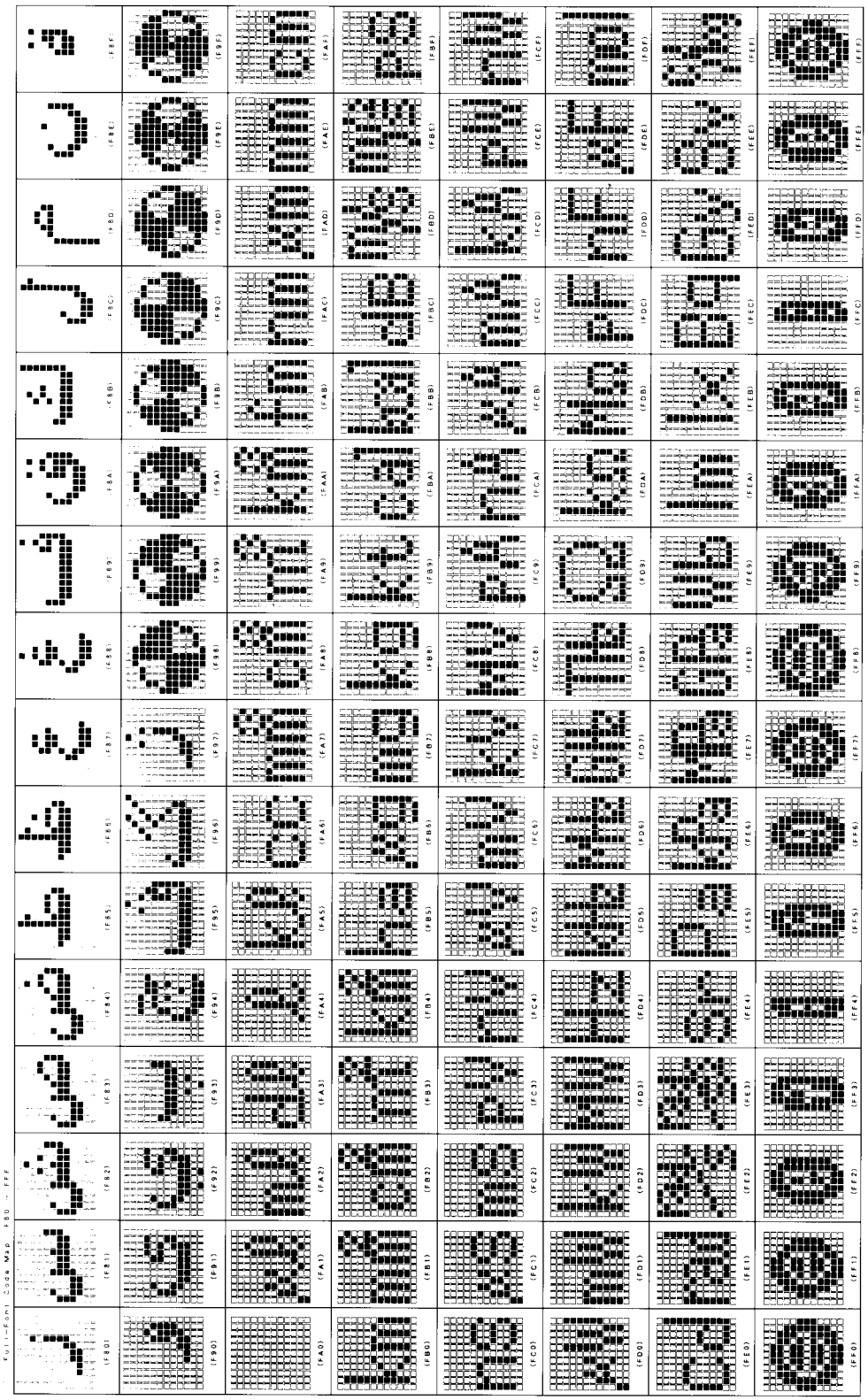
HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



HD66730/731 A01 Korean font set (KS C 5601–1992 subset)



Relationship between Character Codes (DDRAM), CGRAM Addresses, and Display Characters

Full size character codes H'000 to H'007 can be used to access 8 character patterns in the CGRAM. Since each character pattern can be displayed up to 12 × 13 dots, CGRAM patterns can be displayed immediately next to each other (to the right, left, top, or bottom) without any character spaces between them. Table 6 shows the correspondence between CGRAM addresses and full-size character codes for access of the CGRAM by the MPU.

Table 7 Relationship between Character Codes (DDRAM), CGRAM Addresses, and Display Characters

Character Code				CGRAM Address							CGRAM Data														
											A0 = 0								A0 = 1							
C11 ---------- C3	C7	C6	C5	A7	A6	A5	A4	A3	A2	A1	D7	D6	D5	D4	D3	D2	D1	D0	D7	D6	D5	D4	D3	D2	D1	D0
0 0 0 0 0 0 0 0 0 0	0	0	0	0	0	0	0	0	0	0	A	A	0	0	0	0	0	0	A	A	0	0	0	0	0	0
							0	0	0	1	A	A	0	1	1	1	1	1	A	A	1	1	1	1	0	0
							0	0	1	0	A	A	0	1	0	0	0	0	A	A	0	0	0	1	0	0
							0	0	1	1	A	A	0	1	0	0	0	0	A	A	0	0	0	1	0	0
							0	1	0	0	A	A	0	1	0	0	0	0	A	A	0	0	0	1	0	0
							0	1	0	1	A	A	0	1	0	0	0	0	A	A	0	0	0	1	0	0
							0	1	1	0	A	A	0	1	1	1	1	1	A	A	1	1	1	1	0	0
							0	1	1	1	A	A	0	1	0	0	0	0	A	A	0	0	0	1	0	0
							1	0	0	0	A	A	0	1	0	0	0	0	A	A	0	0	0	1	0	0
							1	0	0	1	A	A	0	1	0	0	0	0	A	A	0	0	0	1	0	0
							1	0	1	0	A	A	0	1	0	0	0	0	A	A	0	0	0	1	0	0
							1	0	1	1	A	A	0	1	1	1	1	1	A	A	1	1	1	1	0	0
							1	1	0	0	A	A	0	0	0	0	0	0	A	A	0	0	0	0	0	0
0 0 0 0 0 0 0 0 0 1	0	0	1	0	0	1	0	0	0	0	A	A	0	0	0	0	0	1	A	A	0	0	0	0	0	0
							0	0	0	1	A	A	0	0	0	0	0	0	A	A	1	0	0	0	0	0
							0	0	1	0	A	A	0	1	1	1	1	1	A	A	1	1	1	1	0	0
							0	0	1	1	A	A	0	0	0	0	0	0	A	A	0	0	0	0	0	0
							0	1	0	0	A	A	0	0	1	0	0	0	A	A	0	0	1	0	0	0
							0	1	0	1	A	A	0	0	1	0	0	0	A	A	0	0	1	0	0	0
							0	1	1	0	A	A	0	0	1	0	0	0	A	A	0	0	1	0	0	0
							0	1	1	1	A	A	0	0	0	1	0	0	A	A	0	1	0	0	0	0
							1	0	0	0	A	A	0	0	0	1	0	0	A	A	0	1	0	0	0	0
							1	0	0	1	A	A	0	0	0	1	0	0	A	A	0	1	0	0	0	0
							1	0	1	0	A	A	0	0	0	0	0	0	A	A	0	0	0	0	0	0
							1	0	1	1	A	A	1	1	1	1	1	1	A	A	1	1	1	1	1	0
							1	1	0	0	A	A	0	0	0	0	0	0	A	A	0	0	0	0	0	0
0 0 0 0 0 0 0 0 0 0	1	1	1	1	1	1	0	0	0	0	A	A	0	0	1	0	0	0	A	A	0	0	1	0	0	0
							0	0	0	1	A	A	0	1	0	0	0	1	A	A	0	0	0	1	0	0
							0	0	1	0	A	A	0	1	0	0	1	1	A	A	0	0	0	1	0	0
							0	0	1	1	A	A	1	0	0	0	0	1	A	A	0	0	0	0	1	0
							0	1	0	0	A	A	1	0	0	0	0	1	A	A	0	0	0	0	1	0
							0	1	0	1	A	A	1	0	0	0	0	1	A	A	0	0	0	0	1	0
							0	1	1	0	A	A	1	0	0	0	0	1	A	A	0	0	0	0	1	0
							0	1	1	1	A	A	1	0	0	0	0	1	A	A	0	0	0	0	1	0
							1	0	0	0	A	A	1	0	0	0	0	1	A	A	0	0	0	0	1	0
							1	0	0	1	A	A	0	1	0	0	0	1	A	A	0	0	0	1	0	0
							1	0	1	0	A	A	0	1	0	0	0	1	A	A	0	0	0	1	0	0
							1	0	1	1	A	A	0	0	1	0	1	1	A	A	1	0	1	0	0	0
							1	1	0	0	A	A	0	0	0	0	0	0	A	A	0	0	0	0	0	0

Character pattern (1)

Character pattern (2)

Character pattern (8)

Notes:
1. CGRAM is selected when the upper 9 bits (C3 to C11) of the full size character codes are 0. In this case, the lower 3 bits (C0 to C2) of the character code correspond to bits 5 to 7 (A5 to A7) (3 bits: 8 types) in the CGRAM address.
2. CGRAM address bits 1 to 4 (A1 to A4) designate the character pattern line position. The 12th line is the cursor position and its display is formed by a logical OR with the cursor.
3. CGRAM address 0 (A0) corresponds to the left-half and right-half of a full-size character pattern.
4. The character data is stored with the rightmost character element in bit 0 (LSB), as shown in the table above. Pattern produced by bits 0 to 5 is displayed and 13 raster-rows are displayed together. Thus, an arbitrary character pattern consisting of 12 $\times$ 13 dots can be displayed.
5. A set bit in the CGRAM data corresponds to display selection, and 0 to non-selection.
6. The upper two bits (AA) of CGRAM data indicate the display attribute for the lower 6-bit pattern. In this case, display attributes specified for the DDRAM during full-size character display is disabled. When these upper two bits are 00, the CGRAM pattern is simply displayed as set; when 01, the pattern reverses (black/white), when 10, the pattern blinks; and when 11, the pattern reverses and blinks.

Relationship between SEGRAM Addresses and Display Patterns

SEGRAM data is displayed when the select level of the COMS pin is output. Since SEGRAM data does not depend on character code data in DDRAM, and does not undergo horizontal smooth scroll, it can be used to display icon and marks. The following shows the relationship between SEGRAM addresses and segment output pins.

Table 8 Relationship between SEGRAM Addresses and Display Patterns

SEGRAM Address				SEGRAM Data							
A3	A2	A1	A0	D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	0	B1	B0	SEG1	SEG2	SEG3	SEG4	SEG5	SEG6
0	0	0	1	B1	B0	SEG7	SEG8	SEG9	SEG10	SEG11	SEG12
0	0	1	0	B1	B0	SEG13	SEG14	SEG15	SEG16	SEG17	SEG18
0	0	1	1	B1	B0	SEG19	SEG20	SEG21	SEG22	SEG23	SEG24
0	1	0	0	B1	B0	SEG25	SEG26	SEG27	SEG28	SEG29	SEG30
0	1	0	1	B1	B0	SEG31	SEG32	SEG33	SEG34	SEG35	SEG36
0	1	1	0	B1	B0	SEG37	SEG38	SEG39	SEG40	SEG41	SEG42
0	1	1	1	B1	B0	SEG43	SEG44	SEG45	SEG46	SEG47	SEG48
1	0	0	0	B1	B0	SEG49	SEG50	SEG51	SEG52	SEG53	SEG54
1	0	0	1	B1	B0	SEG55	SEG56	SEG57	SEG58	SEG59	SEG60
1	0	1	0	B1	B0	SEG61	SEG62	SEG63	SEG64	SEG65	SEG66
1	0	1	1	B1	B0	SEG67	SEG68	SEG69	SEG70	SEG71	SEG72
1	1	0	0	B1	B0	SEG73	SEG74	SEG75	SEG76	SEG77	SEG78
1	1	0	1	B1	B0	SEG79	SEG80	SEG81	SEG82	SEG83	SEG84
1	1	1	0	B1	B0	SEG85	SEG86	SEG87	SEG88	SEG89	SEG90
1	1	1	1	B1	B0	SEG91	SEG92	SEG93	SEG94	SEG95	SEG96

Blinking control — Pattern on/off

Notes: 1. SEG1 to SEG71 are pin numbers of the segment output driver of the HD66730. Pin SEG1 is positioned on the left edge of the display. Segments from SEG72 on are displayed by extension drivers. After SEG 96, display is performed from SEG1 again.

2. The lower six bits (D0 to D5) indicate display on/off for of each segment. A bit setting of 1 selects display while 0 selects no display.

3. Pattern blinking of the lower six bits is controlled by the upper two bits (D6 and D7) of SEGRAM data. When the upper two bits (B0 and B1) are 10, segments whose corresponding bits in the lower 6 bits are set to 1 will blink on the display. When the upper two bits (B0 and B1) are 01, only the bit-5 pattern can blink. Do not attempt to set the upper two bits (B0 and B1) to 11 (setting is prohibited).

Register Functions

Outline

Data can be written from the MPU to the internal control registers and internal RAM of the HD66730/1 via an 8-bit bus interface or a serial interface. There are five types of internal control registers, as follows (details are described later):

- Index register: Selects and designates which control register the MPU is to access
- Status register: Indicates the internal state
- Control registers: Designates display control
- RAM address register: Sets an address for accessing the various RAMs
- RAM data register: Receives and transmits data to and from the various RAMs

Table 17 shows the instruction list and the number of execution cycles of each instruction after performing register setting. Instructions that perform data transfer with the RAM data register tend to be used the most. However, auto-incrementation by 1 (or auto decrementation by 1) of internal HD66730/1 RAM addresses after each data write can lighten the program load on the MPU. Note that when an instruction is being executed (internal operations are being performed), only the busy flag in the status register can be read.

Since the busy flag is 1 during execution, the MPU should check this value before accessing a register. When accessing a register without checking the busy flag, an interval longer than the instruction execution time is needed before the next access. Refer to Table 17 Instruction Registers, for instruction execution times.

When rewriting DDRAM, character display will momentarily breakdown if the data (character codes) that is being rewritten is also being read by the system for display. For this reason, check the display read line position (NF) and the display read raster-row position (LF) in the status register (SR), and rewrite a DDRAM line that is not being read and displayed.

Functional Description

Index Register (IR)

The index register (Figure 4) designates control registers (R0 to R7), RAM address register (RAR: R8), and RAM data register (RDR: R9). The register number must be set between addresses 0000 to 1001 in binary digits. Note that if address 1111 is set, the test register will be selected. Addresses 1010 to 1110 are ignored.

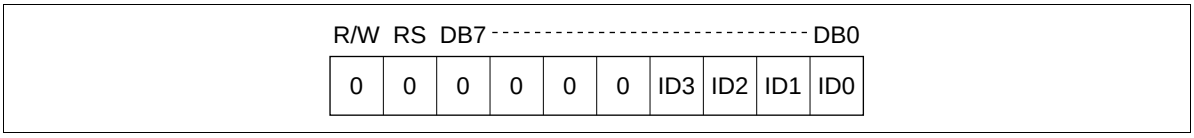


Figure 4 Index Register

Status Register (ST)

The status register (Figure 5) includes the busy flag (BF), display line bits (NF1/0), and display raster-row bits (LF0 to LF3). If BF is 1, an instruction is being executed, and another instruction will not be accepted during this time. Any attempt to write data to a register at this time is ignored.

Rasters-rows are driven one at a time according to specific timing to perform liquid crystal display. Bits NF1 and NF0 indicate display lines, and bits LF3 to LF0 indicate the raster-row in a line. If character display degenerates when rewriting DDRAM, rewrite only those display lines that are not currently being read out by the system for display. During segment display, the next state of the last raster-row in the character display is read out.

Table 9 Display State According to NF1 and NF0

NF1	NF0	Display State
0	0	Displaying the first line
0	1	Displaying the second line
1	0	Displaying the third line
1	1	Displaying the fourth line

Table 10 Display State According to LF3 to LF0

LF3	LF2	LF1	LF0	Display State
0	0	0	0	Displaying the first raster-row
0	0	0	1	Displaying the second raster-row
0	0	1	0	Displaying the third raster-row
0	0	1	1	Displaying the fourth raster-row
•				•
•				•
•				•
1	1	0	0	Displaying the 13th raster-row

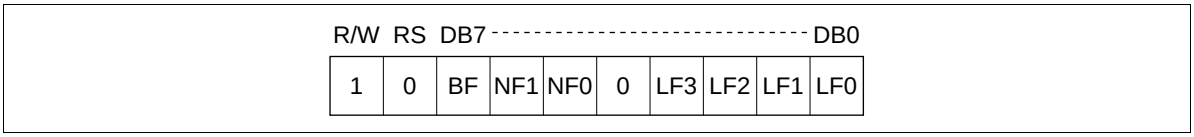


Figure 5 Status Register

Entry Mode Register (R0)

The entry mode register (Figure 6) includes bits I/D, RM1, and RM0.

I/D: Increments (I/D = 1) or decrements (I/D = 0) the DDRAM address by 1 when a character code is written into or read out from the DDRAM. When the DDRAM address is incremented by 1, the cursor or blinking will also shift to the right. This applies to both CGRAM and SEGRAM.

RM1/0: Selects DDRAM, CGRAM, or SEGRAM for access (Table 10).

Table 11 RAM Selection by RM1 and RM0

RM1	RM0	Selected RAM
0	0/1	Display data RAM (DDRAM)
1	0	Character generator RAM (CGRAM)
1	1	Segment RAM (SEGRAM)

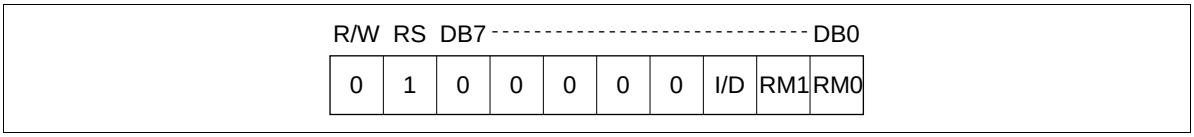


Figure 6 Entry Mode Register

Function Set Register (R1)

The function set register (Figure 7) includes bits BST, EXT2, EXT1, DT1, DT0, and DCL.

BST: When BST is 1, the booster starts to operate. When the LCD voltage is external, set BST to 0 to stop operation of the internal booster. In addition, the consumption current can be suppressed by stopping the booster when entering standby mode without display.

EXT2/1: Extends the common driver and segment driver of HD66730. Set EXT2 to 1 to extend the driver to the common side if the duty ratio is 1/40 or 1/53. Extend the driver to the segment side by setting EXT1 to 1 when displaying 7 or more digits (of full size) in the horizontal direction. DDRAM capacity is 80 bytes. When the HD66731, these EXT2/1 bits must be set to 1.

DT1/0: Selects the duty ratio of the LCD (Table 11). Although this bit can be set separately from the display line designation (NL1/0), the duty ratio must be selected so that it will be smaller than the number of display lines.

DCL: When DCL is 1, the display is cleared by writing the code for half-size space (H'A0) into all DDRAM addresses. Then H'00 is written into the RAM address counter (RAR) and the DDRAM is selected. The character code for character code H'A0 must be a blank pattern when rewriting HCGROM used for half-size characters.

Cursor Control Register (R2)

The cursor control register includes bits CHM, C, CM1, and CM0.

CHM: When CHM is set to 1, DDRAM is selected, the RAM address counter (RAR) is set to 0, and the cursor home instruction is executed. The contents of DDRAM do not change. The cursor or blinking moves to the left edge of the display (the left edge of the first line if two lines are displayed).

C: When C = 1, cursor display is turned on. The cursor is displayed at the position corresponding to the count value of the RAM address counter (RAR). To set data in the RAR, set the index register (IDR) to 1000 to select it, and modify the data in the RAR. Note that the RAM address counter (RAR) automatically increments (decrements) when the RAM is accessed, and the cursor will move accordingly.

CM1/0: Selects cursor display mode (Table 12 and Figure 9). The blinking frequency (cycle) of the blink cursor and the white/black inverted cursor has 64 frames.

Table 12 Duty Drive Ratio

DT1	DT0	Duty Drive Ratio
0	0	1/14 duty drive
0	1	1/27 duty drive
1	0	1/40 duty drive
1	1	1/53 duty drive

Table 13 Cursor Mode Selection

CM1	CM0	Selected Cursor Mode
0	0	12th raster-row cursor
0	1	Blink cursor
1	0/1	White/black inverted cursor

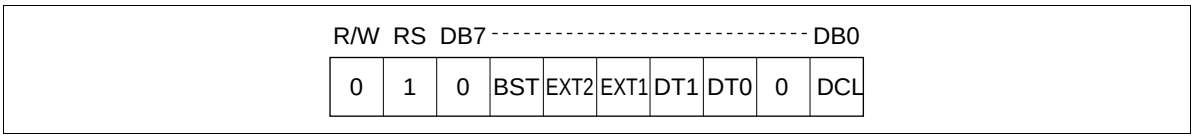


Figure 7 Function Set Register

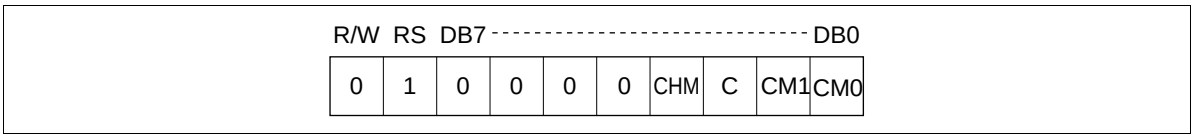


Figure 8 Cursor Control Register

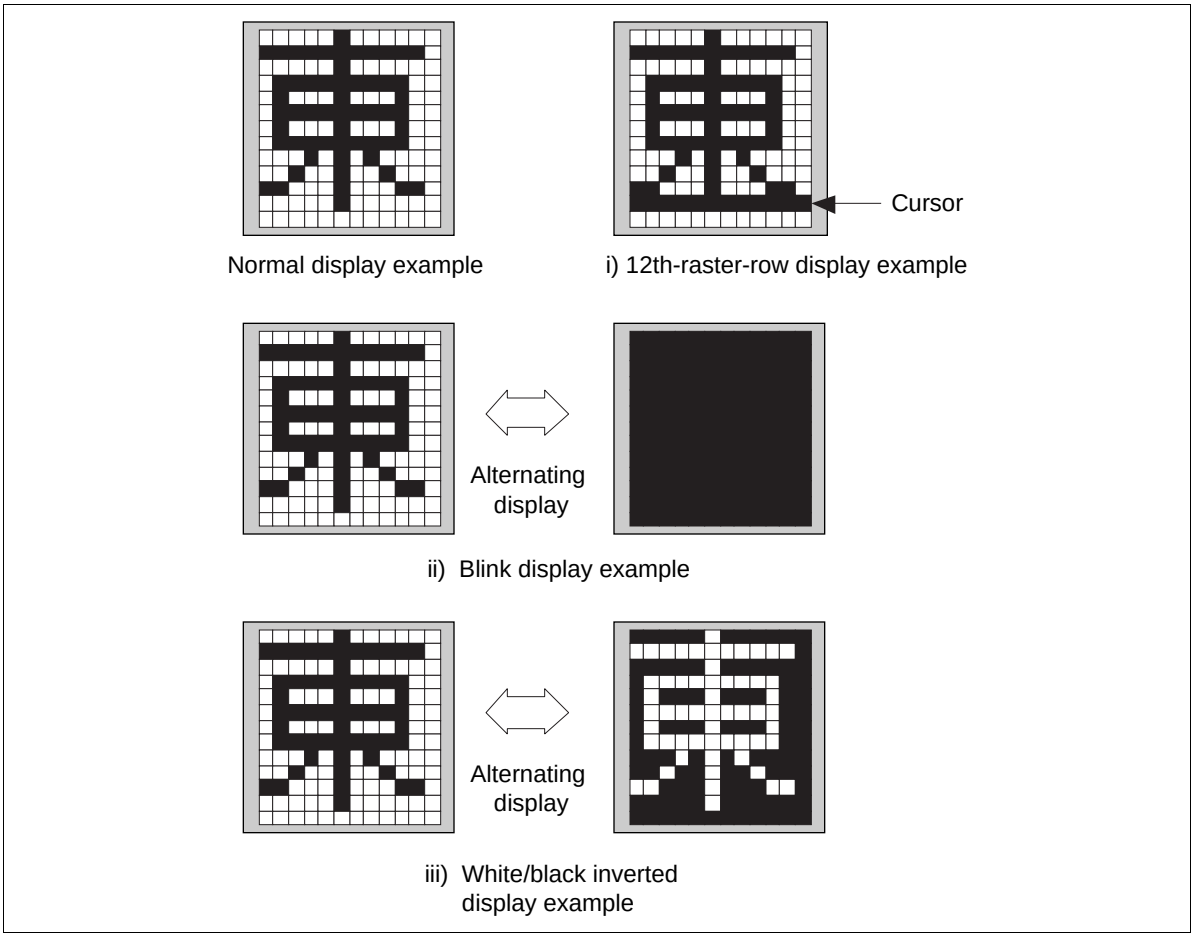


Figure 9 Cursor Display Examples

Display Control Register 1 (R3)

The display control register 1 (Figure 10) includes bits ST, DC, and DS.

ST: When ST is 1, the display control register 1 enters the standby mode. The internal operation clock is divided into 32. Data cannot be displayed on the LCD panel, however, the consumption current can be suppressed during the standby mode. Note that the register setting value and the data inside the RAM are maintained.

DC: When DC is 1, the character display is turned on.

DS: When DS is 1, the segment display is turned on. Bit DS can selectively display marks.

Display Control Register 2 (R4)

NC1/0: Selects the display character in the horizontal direction. When performing a horizontal smooth scroll, set the number of display characters larger than the actual number of liquid crystal drive characters. When the frame frequency (cycle) is stable, the operation frequency is proportional to the display characters. Operation frequency must be suppressed by setting the number of display character as small as possible because the consumption current is proportional to the operation frequency. Refer to Oscillator for details.

NL1/0: Sets the number of display lines. Set the number of display lines larger than the duty drive ratio (DT1/0). Do not set 10 to these bits. Table 13 indicates the settings of the display lines.

Table 14 Display Control Register 2 Setting

Display Lines	Display Characters: NC1/0		
NL1/0	**00**	**01**	**10**
00	1-line 6 characters	1-line 20 characters	1-line 40 characters
01	2-line 6 characters	2-line 10 characters	2-line 20 characters
10		Setting is inhibited.	
11	4-line 6 characters	4-line 10 characters	4-line 10 characters

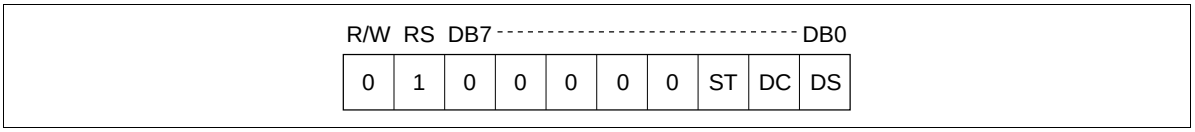


Figure 10 Display Control Register 1

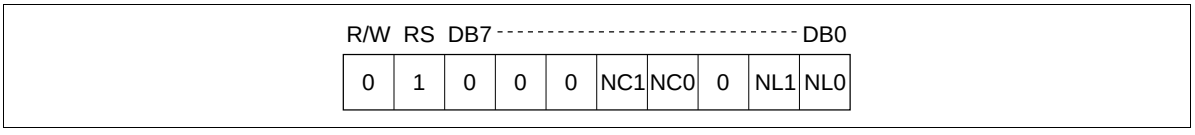


Figure 11 Display Control Register 2

Scroll Control Register 1 (R5)

The scroll control register 1 (Figure 12) includes bits SN1, SN0, SL3, SL2, SL1, and SL0.

SN1/0: Selects the starting line to be displayed. When SN1/0 shows 00, display begins from the first line. When SN1/0 shows 01, 10, 11, display begins from the second, third, or fourth line, respectively. Use these bits within the display line setting (NL1/0). SN can be used to display a smooth scroll and DDRAM memory bank switching.

SL0 to SL3: Selects the scroll starting raster-row of the line set by the start display line (SL1/0). When these bits show 0000, a display line starting from the head raster-row (first raster-row) is displayed and can be set to 1100 (13th raster-row) showing the last raster-row. A vertical smooth scroll can be performed by sequentially incrementing the first raster-row. Refer to Vertical Smooth Scroll for details. Note that bits SL0 to SL3 that are set to a value above 1100 will not operate correctly.

Scroll Control Register 2 (R6)

The scroll control register 2 (Figure 13) includes bits PS1, PS0, SE4, SE3, SE2, and SE1.

PS1/0: Selects the partial smooth scroll mode. When PS1/0 bits are 00, all characters scroll horizontally across the display. When bits PS1/0 are 01, only the leftmost character is fixed and the remaining characters perform horizontal smooth scroll display. When bits PS1/0 are 10, the two leftmost bits, and when 11, the three leftmost characters are fixed and the remaining characters perform horizontal smooth scroll Refer to Partial Smooth Scroll for details.

SE1 to SE4: These bits enable a dot scroll in display lines designated by scroll control register 3 (R7). When bit SE is 1, the first line is scrolled according to scroll control register 3 (R7). When SE2 is 1, the second line scrolls independently, when SE3 is 1, the third line scrolls independently, when SE4 is 1, the fourth line scrolls independently. Scrolling multiple lines at the same time is also possible.

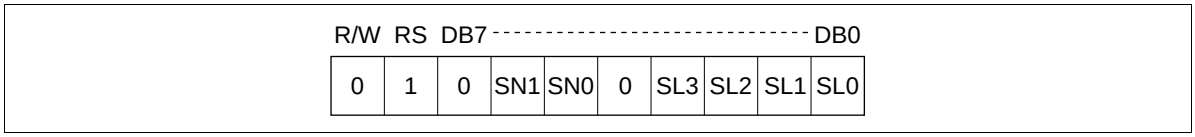


Figure 12 Scroll Control Register 1

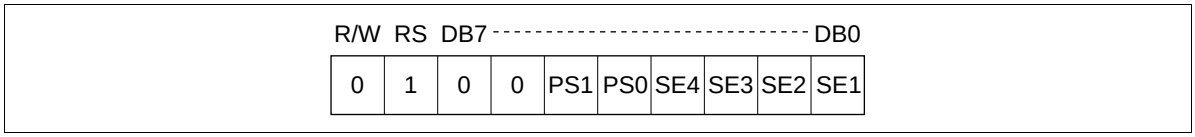


Figure 13 Scroll Control Register 2

Scroll Control Register 3 (R7)

The scroll control register 3 (Figure 14) includes bits SQ5, SQ4, SQ3, SQ2, SQ1, and SQ0.

SQ0 to SQ5: These bits designate the number of dots to be horizontally scrolled to the left on the panel. Horizontal smooth scroll can be performed for any number of dots between 1 and 48 inclusive by using the non-display DDRAM area. When these bits are 000000, scrolling is not performed. When these bits are 110000, 48 dots are scrolled to the left. If these bits are set to a value above 110000, 48 dots are still scrolled. Refer to Horizontal Smooth Scroll for details.

RAM Address Register (R8)

The RAM address register (Figure15) initially contains the RAM address at which incrementation (decrementation) starts. RAM selection bits (RM1/0) in the entry mode register (R0) select which RAM to access (DDRAM/CGRAM/SEGRAM). When DDRAM (RM1/0 = 00) is selected, address allocation differs according to the number of display lines, but in all cases the most significant bit (RA7) is ignored. During a 1-line display (NL1/0 = 00), addresses H'00 to H'4F are allocated to that line. During a 2-line display, addresses H'00 to H'27 are allocated to the first line, and addresses H'40 to H'67 are allocated to the second line. During a 4-line display, addresses H'00 to H'13 are allocated to the first line, H'20 to H'33 to the second , H'40 to H'53 to the third, and H'60 to H'73 to the fourth. See Table 14.

When CGRAM (RM1/0 = 10) is selected, addresses H'00 to H'19 are allocated to the first character and addresses H'20 to H'39 are allocated to the second character, and so on (Table 15). The setting of addresses between characters (example: H'1A to H'1F) is ignored here. When SEGRAM is selected (RM1/0 = 11), addresses H'0 to H'F are allocated to the RAM and the upper four bits (R4 to R7) are ignored (Table 16).

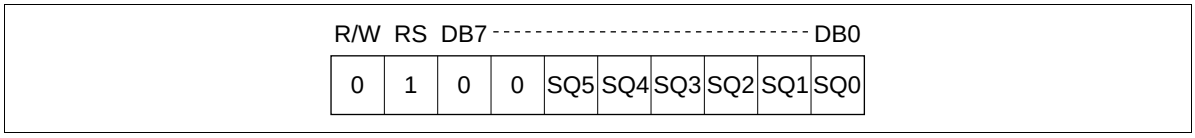


Figure 14 Scroll Control Register 3

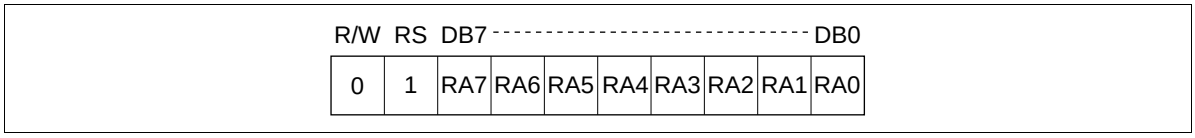


Figure 15 RAM Address Register

Table 15 DDRAM Address Allocation

Displayed Lines	1-Line Display (NL1/0 = 00)	2-Line Display (NL1/0 = 01)	4-Line Display (NL1/0 = 00)
First line	H'00 to H'4F	H'00 to H'27	H'00 to H'13
Second line	—	H'40 to H'67	H'20 to H'33
Third line	—	—	H'40 to H'53
Fourth line	—	—	H'60 to H'73

Table 16 CGRAM Address Allocation

Displayed Character	CGRAM Address
First character	H'00 to H'19
Second character	H'20 to H'39
Third character	H'40 to H'59
Fourth character	H'60 to H'79
Fifth character	H'80 to H'99
Sixth character	H'A0 to H'B9
Seventh character	H'C0 to H'D9
Eighth character	H'E0 to H'F9

Table 17 SEGRAM Address Allocation

Displayed Segment	SEGRAM Address
SEG1 to SEG6	H'0
SEG7 to SEG12	H'1
SEG13 to SEG18	H'2
SEG19 to SEG24	H'3
SEG25 to SEG30	H'4
SEG31 to SEG36	H'5
SEG37 to SEG42	H'6
SEG43 to SEG48	H'7
SEG49 to SEG54	H'8
SEG55 to SEG60	H'9
SEG61 to SEG66	H'A
SEG67 to SEG72	H'B
SEG73 to SEG78	H'C
SEG79 to SEG84	H'D
SEG85 to SEG90	H'E
SEG91 to SEG96	H'F

Note: SEG72 to SEG96 are driven by extension drivers.

RAM Data Register (R9)

This register (Figure 16) stores 8-bit data that is written to or read from the DDRAM, CGRAM, or SEGRAM at the address indicated by the RAM address counter (RAC). The RAM selection bit (RM1/0) selects the RAM (DDRAM, CGRAM, SEGRAM). After the said RAM is accessed, RAM address is automatically incremented (decremented) by 1 according to the I/D bit.

Note that RAM selection bits (RM1/0) and RAM address register (R8) must be set before reading. If not, the first data read is invalid. If read instructions continue to be executed, however, data will be read correctly from the second read.

Test Register (RF)

This is a test register (Figure 17) and must be set to H'00 at all times. This register is automatically cleared (H'00) by reset input; however, it must be cleared by software after power-on if the reset pin is not used.

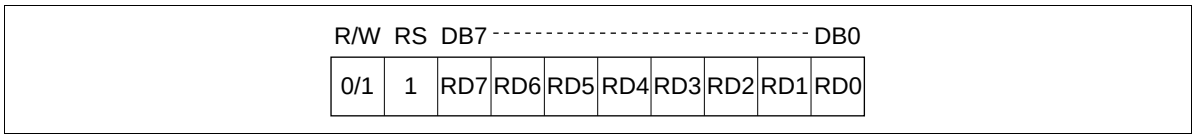


Figure 16 RAM Data Register

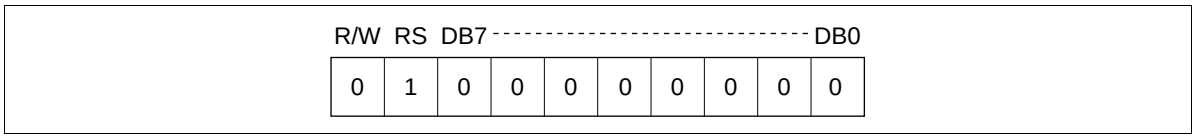


Figure 17 Test Register

Table 18 Instruction Registers

Reg. No.	Index (Hex)	Register	Code R/W	RS	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Description	Execution Clock Cycle
IR	—	Index (IDR)	0	0	—	—	—	—	ID3	ID2	ID1	ID0	Designates the register number of the instruction register to access. ID = 0000: R0 to 1001: R9	12
SR	—	Status (STR)	1	0	BF	NF1	NF0	—	LF3	LF2	LF1	LF0	Indicates the busy flag (BF), display read line position (NF1/0), display read raster-row position(NL0 to NL3).	0
R0	0	Entry mode (EMR)	0	1	0	0	0	0	0	I/D	RM1	RM0	Designates RAM address in crementation or decrementation (I/D) and RAM selection (RM1/0).	12
R1	1	Function set (FSR)	0	1	0	BST	EXT2	EXT1	DT1	DT0	0	DCL	Clears display (DCL) and initializes the DDRAM address. Selects duty drive ratio(DT1/0), enables extension driver (EXT2/1) and sets the booster operation on.	DCL = 1: 492 Other: 12
R2	2	Cursor control (CCR)	0	1	0	0	0	0	CHM	C	CM1	CM0	Designates cursor-on (C) and cursor display mode(CM1/0). Executes cursor home (CHM) instruction.	12
R3	3	Display control 1 (DCR1)	0	1	0	0	0	0	0	ST	DC	DS	Designates standby mode (ST), character display on (DC), and segment display on (DS).	12
R4	4	Display control 2 (DCR2)	0	1	0	0	NC1	NC0	0	0	NL1	NL0	Sets the number of display characters(NC1/0) and display lines(NL1/0).	12
R5	5	Scroll control 1 (SCR1)	0	1	0	SN1	SN0	0	SL3	SL2	SL1	SL0	Sets the display start line (SN1/0) and start raster-row (ST0 to ST3).	12
R6	6	Scroll control 2 (SCR2)	0	1	0	0	PS1	PS0	SE4	SE3	SE2	SE1	Designates partial scroll columns (PS1/0) and scroll display line enable(SE1 to SE4).	12
R7	7	Scroll control 3 (SCR3)	0	1	0	0	SQ5	SQ4	SQ3	SQ2	SQ1	SQ0	Sets the number of dots to be scrolled (SQR0 to SQR5).	12

Table 18 Instruction Registers (cont)

Reg. No.	Index (Hex)	Register	Code R/W	RS	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	Description	Execution Clock Cycle
R8	8	RAM address (RAR)	0	1	RA7	RA6	RA5	RA4	RA3	RA2	RA1	RA0	Resets the address address counter for DDRAM/CGRAM/ SEGRAM. RAM is selected by RM1/0.	12
R9	9	RAM data (RDR)	0/1	1	RD7	RD6	RD5	RD4	RD3	RD2	RD1	RD0	Writes or reads data to and from DDRAM/CGRAM/ SEGRAM. RAM is selected by RM1/0.	12
RF	F	Test (TSR)	0	1	0	0	0	0	0	0	0	0	This is a test register. Set 00 in this register.	12

Note: The execution time depends on the input or oscillation frequency.

BF = 1: Internal processing being performed
NF1/0: Position of display read line
LF0 to LF3: Position of display read raster-row
ID= 1: Address increment
= 0: Address decrement
RM1/0: RAM selection (00/01: DDRAM. (10: GGRAM, 11: SEGRAM)
BST = 1: Booster on
EXT2 = 1: Common driver extension enable
EXT1 = 1: Segment driver extension enable
DT1/0: Duty ratio (00: 1/14, 01: 1/27, 10: 1/40, 11: 1/53)
DCL = 1: Executes display-clear instruction
CHM = 1: Executes cursor-home instruction
C = 1: Cursor on
CM1/0: Designates cursor mode (00: 12th raster-row, 01: blinking, 10: white/black inverse)
ST = 1: Standby mode
DC = 1: Character display on
DS = 1: Segment display on
NC1/0: Sets the number of display characters (6 to 40 characters)
NL1/0: Sets the number of display lines (00: 1 line, 01: 2 lines, 11: 4 lines)
SN1/0: Designates the line to start displaying (00: first line, 01: second line, 10: third line, 11: fourth line)
SL0 to SL3: Designates scroll starting raster-row(0000: first raster-row, 1100: 13th raster-row)
PS1/0: Designates partial scroll (00: all columns scroll. 01: the leftmost column fixed, 10: the two leftmost columns fixed, 11: the three leftmost columns fixed)
SE1 to SE4: Designates which line to scroll (SE = 1: enables the first line to be scrolled, etc.)
SQ0 to SQ5: Number of dots to scroll (0 to 48 dots)
RA0 to RA7: RAM address
RD0 to RD7: RAM data

Reset Function

The HD66730/1 is reset by setting the RESET pin to low level. During reset, the system performs next-control-register setting and executes instructions. The busy flag (BF) therefore indicates a busy state (BF = 1) at this time, which means that only the index register and status register can be accessed.

Display clear (DDRAM reset) is performed automatically by reset input. Since more than 1,000 clocks of execution cycles are needed to initialize the DDRAM, the reset period must be set to more than this number. Note that if the reset input conditions specified in Electrical Characteristics are not satisfied, the HD66730/1 will not operate correctly, and reset should be performed by software.

Initialization of Instruction Register Function

1. Index Register: IR
   The index register cannot be initialized by reset. After reset release, the index register must be set to access a control register.
2. Status register: SR
   BF = 1: Busy state
3. Entry mode register: R0
   I/D = 1: +1 (incrementation)
   RM1/0 = 00: DDRAM selection
4. Function set register: R1
   BST = 0: Booster off
   EXT2/1 = 11: Driver extension enable
   DT1/0 = 11: 1/53 duty drive
   DCL = 1: Display-clear execution

Note: At least 1,000 clock cycles of execution time is needed to clear the DDRAM.

5. Cursor control register: R2
   CHM = 1: Cursor home execution
   C = 0: Cursor display off
   CM1/0 = 00: 12th raster-row cursor display mode
6. Display control register 1: R3
   ST = 0: Standby mode clear
   DC = 0: Character display off
   DS = 0: Segment display off
7. Display control register 2: R4
   NC1/0 = 00: 6-column display mode
   NL1/0 = 00: 1-line display mode
8. Scroll control register 1: R5
   SN1/0 = 00: Starts displaying from the first line.
   SL3 to SL0 = 0000: Starts displaying from the first raster-row.
9. Scroll control register 2: R6
   PS1/0 = 00: Partial scroll release
   SE4 to SE1 = 0000: Disables dot scrolling for all lines.
10. Scroll control register 3: R7
    SQ5 to SQ0 = 000000: Number of dots to be scrolled = 0
11. RAM address register: R8
    RAM address register is automatically incremented during reset when display-clear is executed. Note that after reset is released, this register must be reset by software before accessing RAM.

Initial Setting of Pin Functions

1. Bus/serial interface

   The input level of pin IM selects the 8-bit bus or serial interface. For an 8-bit bus interface, data is written into the index register or read from the status register according to the level of pin R/W. Note that pin RS must be held low during this time. For serial interface, data is written into the index register according to bit R/W. Note that bit RS must be 0 during this time. During reset, only the index register and status register can be set and RAM cannot be accessed.

2. LCD driver output

   Since segment drivers (pins SEG1 to SEG71/119) are in a display-off state during reset, they output non-selective levels (V2/V3 level) during reset. At this time, a 4-line 6-character display alternates its current. Common drivers (pins COM1 to COM24/53 and COMS) output non-selective levels (V1/V4 level) during reset, and alternate its current for a 4-line 6-character display.

Note: Pins COM25/COMD of HD66730 are grounded (0V) during reset. When pin COM25 is used without expanding drivers to the common side, display may be performed using the liquid crystal drive voltage. In this case, adjust the liquid crystal voltage during reset.

3. Extension driver interface output (HD66730)

   Since bits EXT2/1 are 11 during reset, extension is performed to both segment side and common side. Pin CL2 outputs the oscillation (operation) frequency clock. Pins CL1 and M output signals in a cycle corresponding to a 4-line 6-character display size. In addition, pins SEGD and COM25/COMD output low (ground level) since the display is turned off.

4. Booster output

   The operation of the internal booster stops because bit BST becomes 0 during reset.

Note: The potential of pins V5OUT2 and V5OUT3 increases by about +0.7 V with respect to GND level when the booster stops. When using external polarized capacitors, make sure that no reverse bias occurs.

Interfacing to the MPU

The HD66730/1 enters 8-bit bus interface mode when the IM pin is set high. The HD66730/1 can interface with the MPU via an I/O port. Use the serial interface when there are restraints in the bus wiring width.

Instruction is executed when data is written into the control register. In this case, only the status register can be read (busy check, etc.). In this case, check the busy flag when accessing (polling), or insert an interval considering the execution time and perform the next access when the internal process has completely finished. The instruction execution time depends on the HD66730/1 operation frequency. When using the internal oscillation circuit of the HD66730/1, the instruction time will change as the oscillation frequency does. Figure 18 shows an example of an 8-bit data transfer timing sequence. Figure 19 shows an example of interface between HD66730/1 and 8-bit microcomputers.

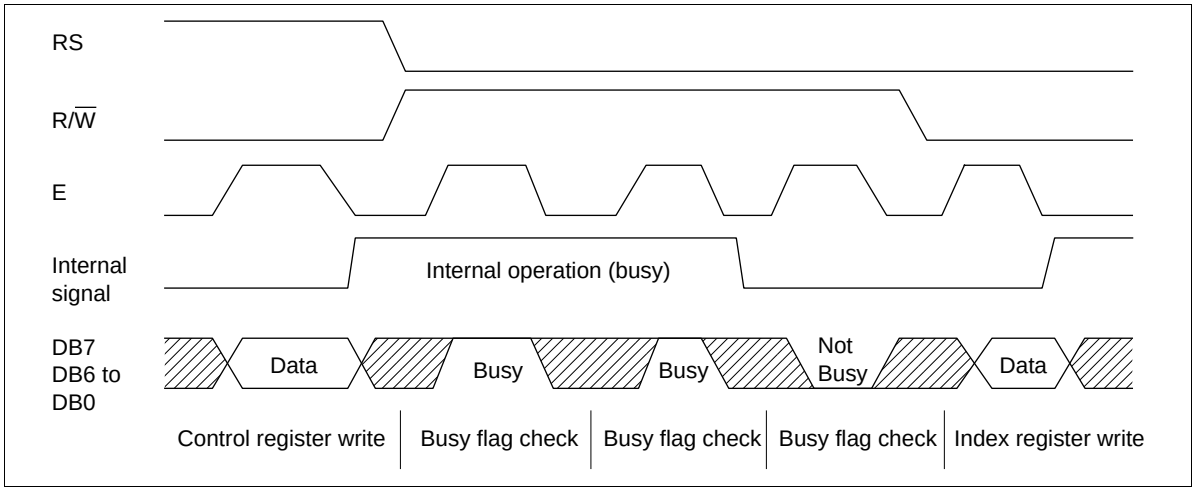


Figure 18 Example of an 8-bit Data Transfer Timing Sequence

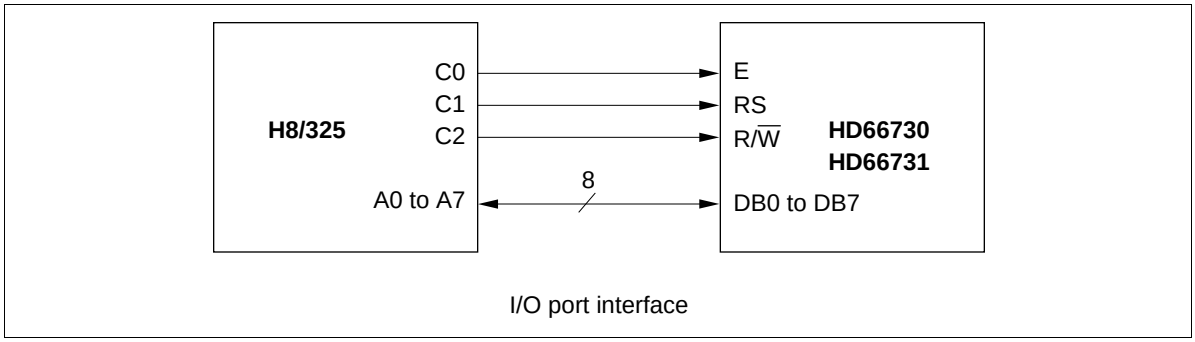


Figure 19 Example of Interfacing with 8-Bit Microcomputers

Transferring Serial Data

The HD66730/1 enters serial interface mode when the IM pin is set low. A three-line clock-synchronous transfer method is used. The HD66730/1 receives serial input data (SID) and transmits serial output data (SOD) by synchronizing with a transfer clock (SCLK) sent from the master side.

When the HD66730/1 interfaces with several chips, chip select pin (CS*) must be used. The transfer clock (SCLK) input is activated by making chip select (CS*) low. In addition, the transfer counter of the HD66730/1 can be reset and serial transfer synchronized by making chip select (CS*) high. Here, since the data which was being sent at reset is cleared, restart the transfer from the first bit of this data. In a minimum system where a single HD66730/1 interfaces to a single MPU, an interface can be constructed from the transfer clock (SCLK) and serial input data (SID). In this case, chip select (CS*) should be fixed to low.

The transfer clock (SCLK) is independent of operational clock (CLK) of the HD66730/1. However, when several instructions are continuously transferred, the instruction execution time determined by the operational clock (CLK) (see Continuous Transfer) must be considered since the HD66730/1 does not have an internal transmit/receive buffer.

Figure 20 shows the basic procedure for transferring serial data. To begin with, transfer the start byte. By receiving five consecutive bits of 1 (synchronizing bit string) at the beginning of the start byte, the transfer counter of the HD66730/1 is reset and serial transfer is synchronized. The 2 bits following the synchronizing bit string (5 bits) specify transfer direction (R/$\overline{W}$ bit) and register select (RS bit). Be sure to transfer 0 in the 8th bit.

After receiving the start byte, instructions are received and the data/busy flag is transmitted. When the transfer direction and register select remain the same, data can be continuously transmitted or received.

The transfer protocol is described in detail in the following.

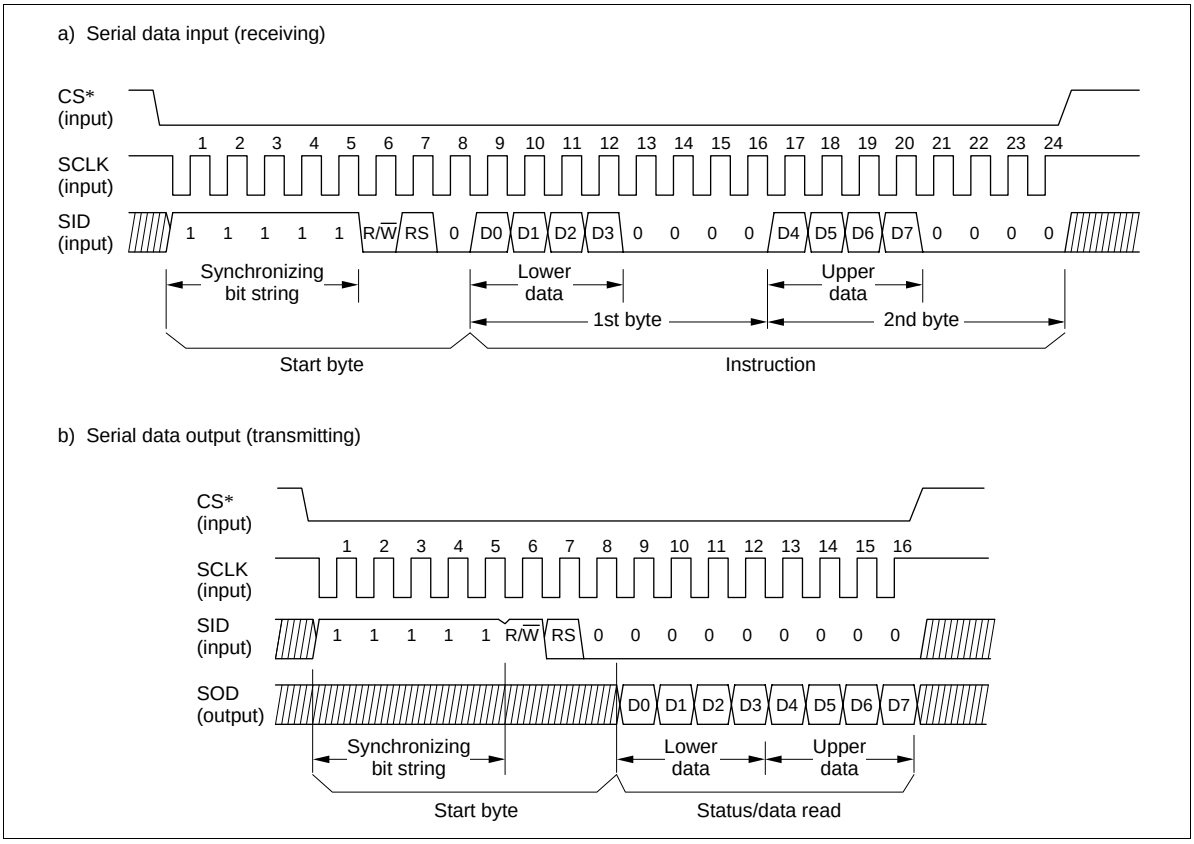


Figure 20 Basic Procedure for Transferring Serial Data

- Receiving (write)

  After receiving the start synchronizing bit string, the R/W bit (= 0), and the RS bit in the start byte, an 8-bit instruction is received in 2 bytes: the lower 4 bits of the instruction are placed in the LSB of the first byte, and the higher 4 bits of the instruction are placed in the LSB of the second byte. Be sure to transfer 0 in the following 4 bits of each byte. When instructions are received with R/W bit and RS bit unchanged, continuous transfer is possible (see Continuous Transfer in the following).

- Transmitting (read)

  After receiving the synchronizing bit string, the R/W bit (= 0), and the RS bit in the start byte, 8-bit read data is transmitted from pin SOD in the same way as receiving. When read data is transmitted with R/W bit and RS bit unchanged, continuous transfer is possible (see Continuous Transfer in the following).

  The status register (SR) is read when the RS bit is 0. RAM data is read out when the RS bit is set to 1 after designating RAM data register (R9) with the index register (IR). Bits RM1/0 of entry mode register (R0) select the RAM. When reading RAM data, an interval longer than the RAM reading time must be taken after the start byte has been accepted and before the first data has been read out. During transmission (data output), the SID input is continuously monitored for a start synchronizing bit string (11111). Once this has been detected, the R/$\overline{W}$ and RS bits are received. Accordingly, 0 must always be input to SID when transmitting data continuously.

- Continuous Transfer

  When instructions are received with the R/W bit and RS bit unchanged, continuous receive is possible without inserting a start byte between instructions.

  After receiving the last bit (the 8th bit in the 2nd byte) of an instruction, the system begins to execute it. To execute the next instruction, the instruction execution time of the HD66730/1 must be considered. If the last bit (the 8th bit in the 2nd byte) of the next instruction is received during execution of the previous instruction, the instruction will be ignored.

  In addition, if the next unit of data is read before read execution of previous data is completed for RAM data, normal data is not sent. To transfer data normally, the busy flag must be checked. However, if the amount of wiring used for transmission needs to be reduced, or if the burden of polling on the CPU needs to be lightened, transfer can be performed without reading the busy flag. In this case, insert a transfer wait between instructions so that the current instruction has time to complete execution. Figure 21 shows the procedure for continuous data transfer.

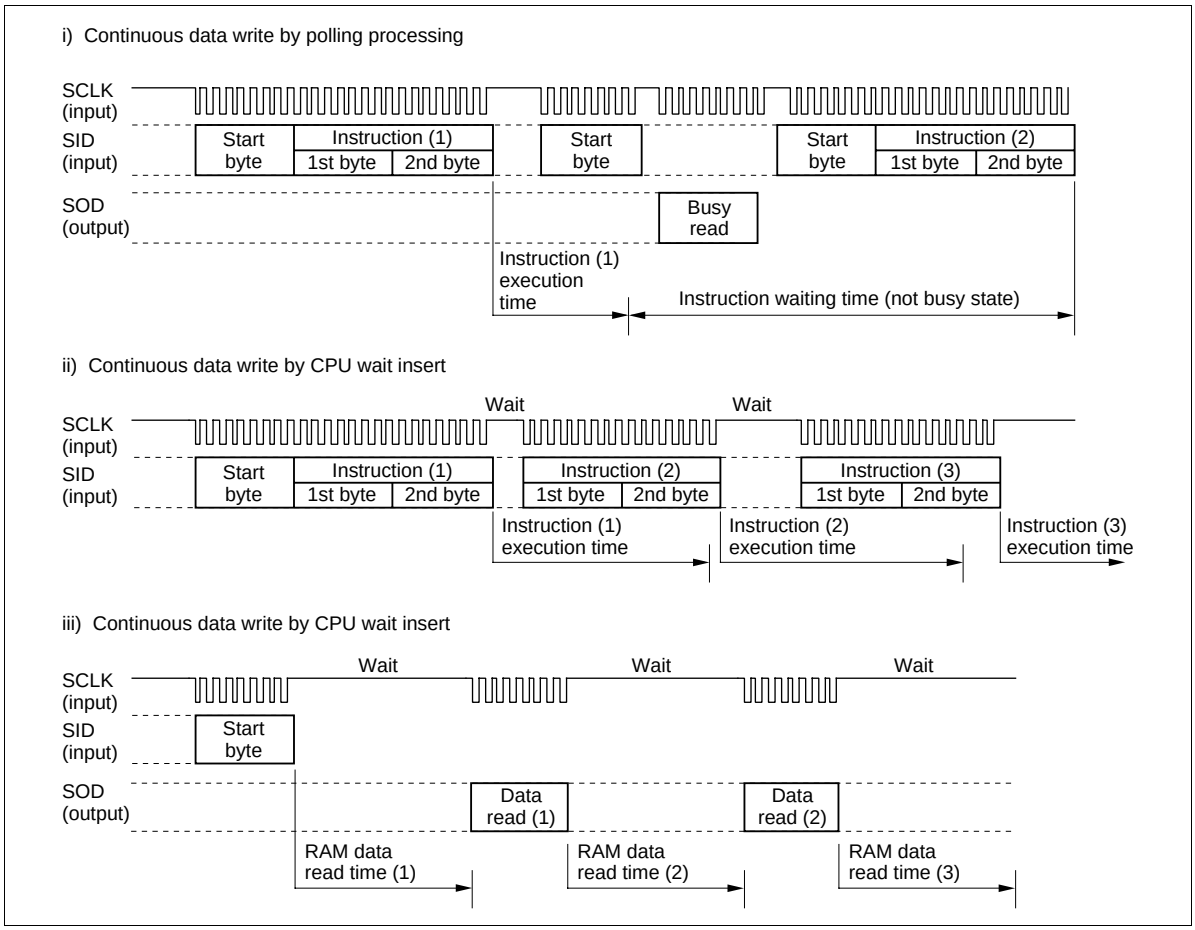


Figure 21 Procedure for Continuous Data Transfer

Combined Display of Full-Size and Half-Size Characters

The HD66730/1 performs display from the left edge of the display combining 12-dot full-size (character size: 11 × 12 dots) and 6-dot half-size characters (character size: 6× 12 dots). There will be a one-dot space between these fonts.

The most significant bit in the data (8 bits) in DDRAM is allocated to the designation bit indicating a full-size or half-size character. When this MSB is 0, the full-size character is selected, and when 1, the half-size character is selected.

When the full-size character is selected, 2 bytes of DDRAM are linked and used as a 16-bit code (Figure 22). In this case, the lower byte is written into the smaller DDRAM address. 12 bits of this 16-bit code are used as character codes. Up to 4096 character codes can be specified. In addition, two of the remaining four bits can be allocated to a display-attribute code and can designate white/black inverted display for individual characters (refer to Display Attribute Designation). Table 18 shows the relationship between the 16-bit designated JIS code and the HD66730/1 12-bit character code. 8-bit data designating half-size characters are used as an 8-bit code (Figure 23). Specifically, 7 bits of the 8-bit half-size characters become the character codes, so that a total of 128 characters can be displayed (alphanumeric characters and symbols can be displayed as half-size characters).

User fonts can be displayed using the CGRAM. Special symbols not included in the internal CGROM or the JIS Level-2 Kanji Set can be displayed as needed. Since the display font size of the CGRAM is 12 × 13 dots, CGRAM fonts can be displayed to the right, left, top or bottom, in order to be used to display double-size characters or graphics. Note that the display-attribute code (A1/A0) designation that is to be written into the DDRAM is ignored when the CGRAM is used. In this case, bits 6 and 7 in the CGRAM are used for display-attribute-code designation. Refer to CGRAM for details.

Table 19 Relationship between JIS Codes and HD66730 Character Codes

- JIS first byte code: b1 to b7 (7 bits)
- JIS second byte code: a1 to a7 (7 bits)
- CGRAM address for user fonts: u0 to u2 (3 bits)

	Character Code Arrangement of HD66730														
JIS	**b7**	**b6**	**b5**	**C11**	**C10**	**C9**	**C8**	**C7**	**C6**	**C5**	**C4**	**C3**	**C2**	**C1**	**C0**
Non-kanji	0	1	0	a7	a6	b3	b2	b1	0	0	a5	a4	a3	a2	a1
Level 1 kanji	0	1	1	b7	b4	b3	b2	b1	a7	a6	a5	a4	a3	a2	a1
Level 1 kanji	1	0	0	b7	b4	b3	b2	b1	a7	a6	a5	a4	a3	a2	a1
User font	—	—	—	0	0	0	0	0	0	0	0	0	u2	u1	u0
				Upper byte				Lower byte							

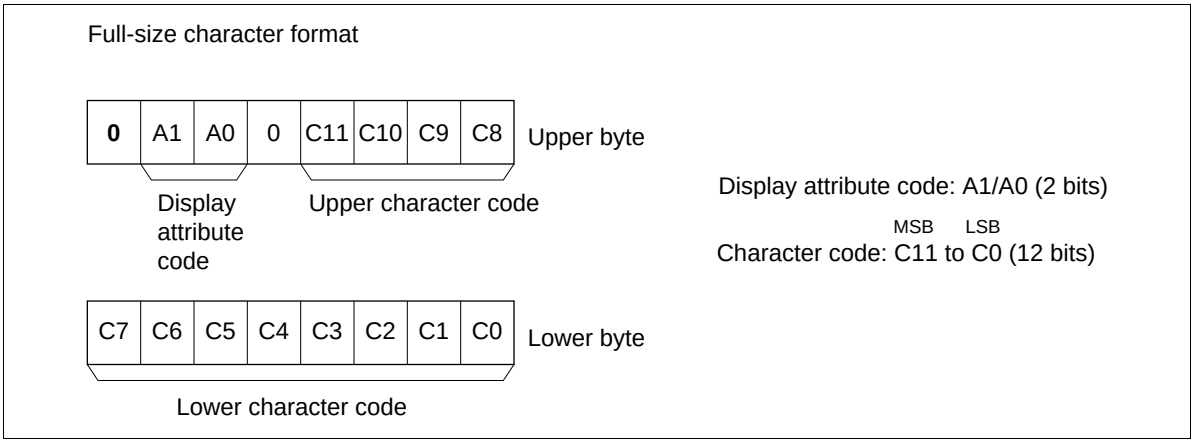


Figure 22 Full-Size Character Codes

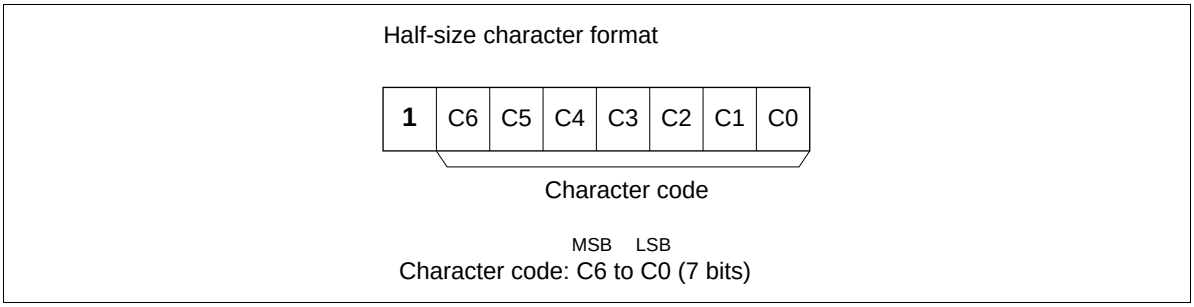


Figure 23 Half-Size Character Codes

An example of displaying full-size and half-size characters together is described here.

Full-size character display conforms to JIS (16 bits). Perform code conversion (16 bits → 12 bits) according to the relationship between the 16-bit JIS code and the HD66730/1 12-bit character code and write two-byte character data to the DDRAM (write the lower byte to the smaller DDRAM address). The example is shown in Table 19. When displaying a half-size character, refer to Table 5 the HD66730/1 Half-size Font List and write one-byte character data into the DDRAM. The example is shown in Table 20.

Figure 24 shows how to set data to the DDRAM when performing a 2-line display and Figure 25 shows the resulting liquid crystal display.

Table 20 Example of Full-Size Font Conversion

Displayed Character	JIS Code (First/Second Byte)	Character Code (C11 to C0)
東	45/6C (Hex)	AEC (Hex)
京	35/7E (Hex)	2FE (Hex)
都	45/54 (Hex)	AD4 (Hex)
小	3E/2E (Hex)	72E (Hex)
平	4A/3F (Hex)	D3F (Hex)
市	3B/54 (Hex)	5D4 (Hex)
本	4B/5C (Hex)	DDC (Hex)
町	44/2E (Hex)	A2C (Hex)
の	24/4E (Hex)	A0E (Hex)

Table 21 Example of Half-Size Font Code

Display Character	Character Code (C0 to C11)
1	31 (Hex)
2	32 (Hex)
0	30 (Hex)
,	2C (Hex)
M	4D (Hex)
C	43 (Hex)

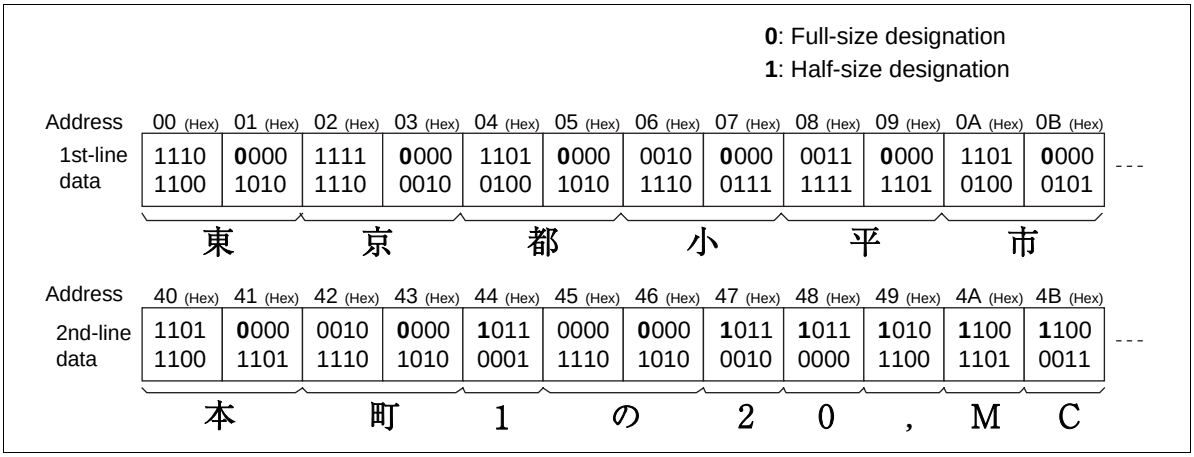


Figure 24 Example of DDRAM Character Code (2-Line Display Mode)

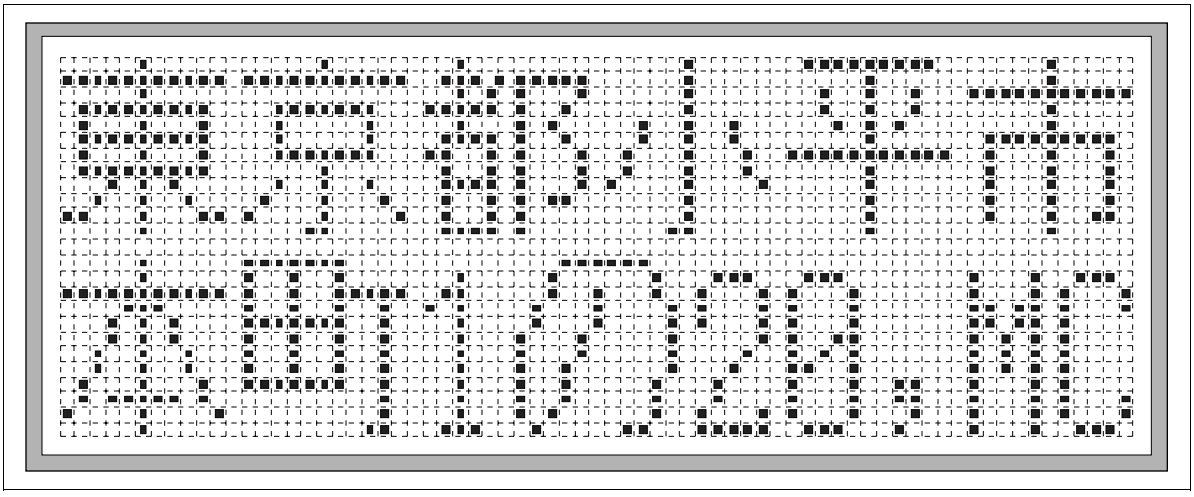


Figure 25 Example of Liquid Crystal Display

Display Attribute Designation

The HD66730/1 allocates 12 bits of the full-size 16-bit code character to an abbreviated character code and 2 bits to a display-attribute code (Figure 26). White/black inverted display, blinking display, and white/black inverted blinking display can be designated for each full-size character (Table 21). Display attribute control is performed for a 12 × 13 dot matrix unit that includes a 11 × 12 dot full-size character and a column of dots to the right and a row of dots to the bottom (Figure 27). The blinking cycle for blinking display and white/black inverted blinking display is 64 frames. Blinking display is performed by changing the display pattern every 32 frames. Since the 8-bit code designated for half-size characters cannot accommodate a display attribute, they will always be displayed normally.

Table 22 Display Attribute Designation

A1	A0	Display State
0	0	Normal display
0	1	White/black inverted display
1	0	Blinking display
1	1	White/black inverted blinking display

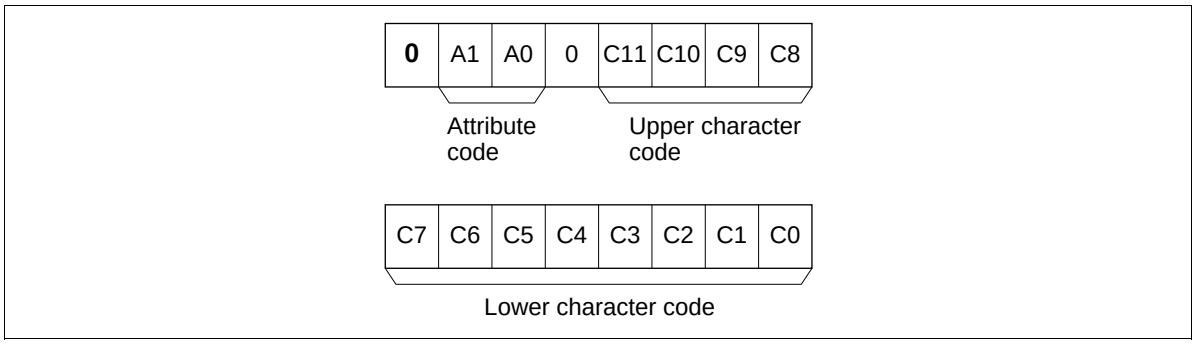


Figure 26 Full-Size Code Format

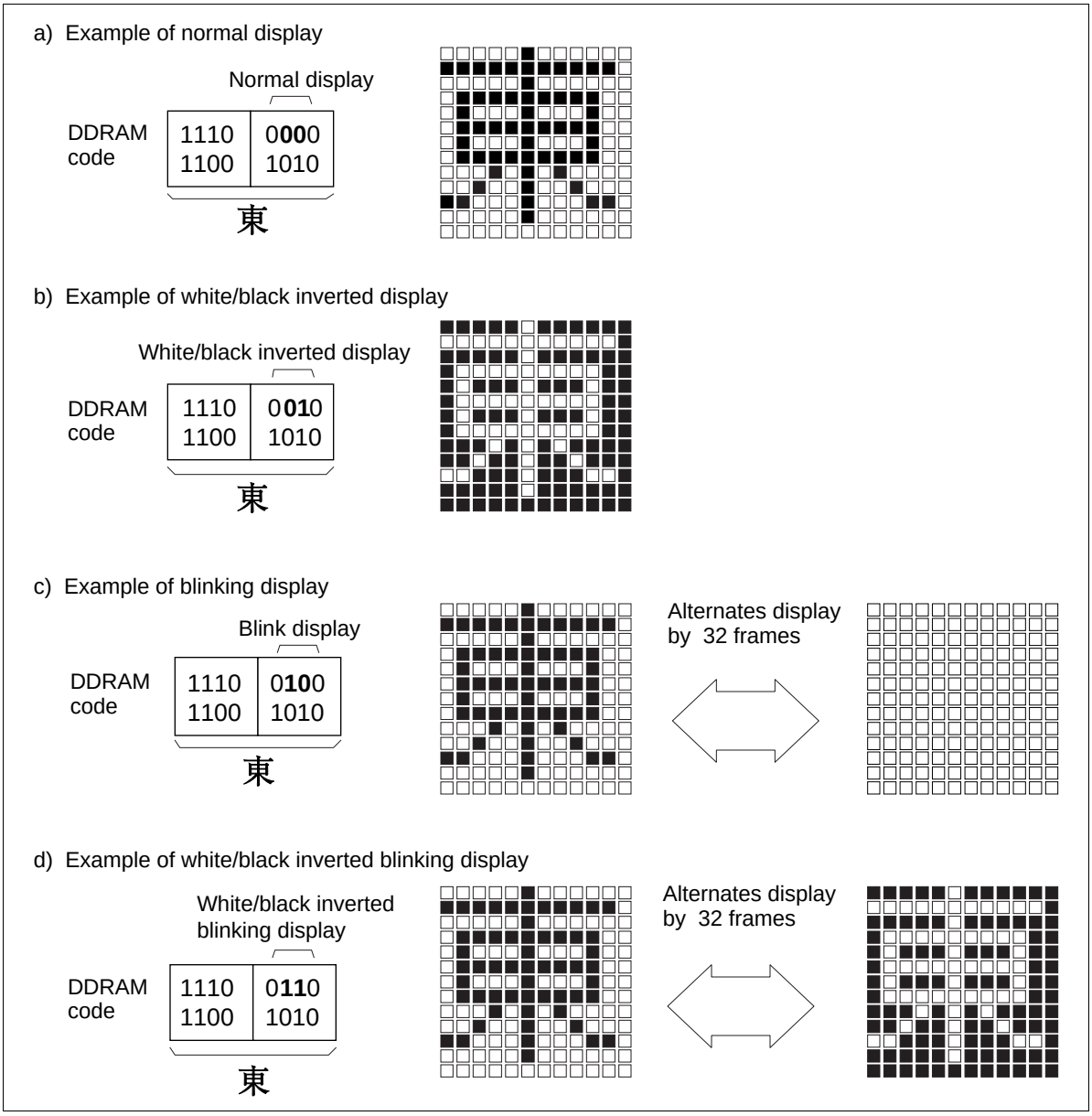


Figure 27 Setting Codes in the DDRAM and Display Examples

Horizontal Smooth Scroll

Data shown on the display can be scrolled horizontally to the left for a specified number of dots (Figure 28). The number of dots are set in scroll control register 3 (SCR3: R7), and the display lines to be scrolled are designated by the display line enable bits (SE1/SE2/SE3/SE4) in scroll control register 2 (SCR2: R6). Because the number of dots that can be set for scrolling here is 48, scrolling for more than this number can be achieved by shifting to the left by four characters of character code data in DDRAM for the scroll display line in question, rewriting the characters, and then scrolling again. When rewriting DDRAM while displaying characters, however, character output will momentarily breakdown, and the display may flicker. In this case, first check which display lines are currently being displayed by referring to NF1/0 (line 1 to the line 4) and display raster-rows LF0 to LF3 (raster-row 1 to raster-row 13) in the status register, and then rewrite a DDRAM line that is not being displayed. Keep in mind that scroll display line enable bits (SE1 to SE4) can be used to designate those display lines for which horizontal smooth scroll is desired.

In partial scroll, one to three leftmost characters on the display as specified by the partial scroll bits (PS1/0) of the scroll control register 2 (SCR: R6) are fixed and the remaining characters undergo a smooth scroll to perform partial smooth scroll.

When performing horizontal smooth scroll, the number of characters to be displayed (NC1/0: R4) must be at least 4 characters more than the number of characters actually displayed on the liquid crystal display. For example, set 10 or more display characters (NC1/0) for a single-chip 6-character display.

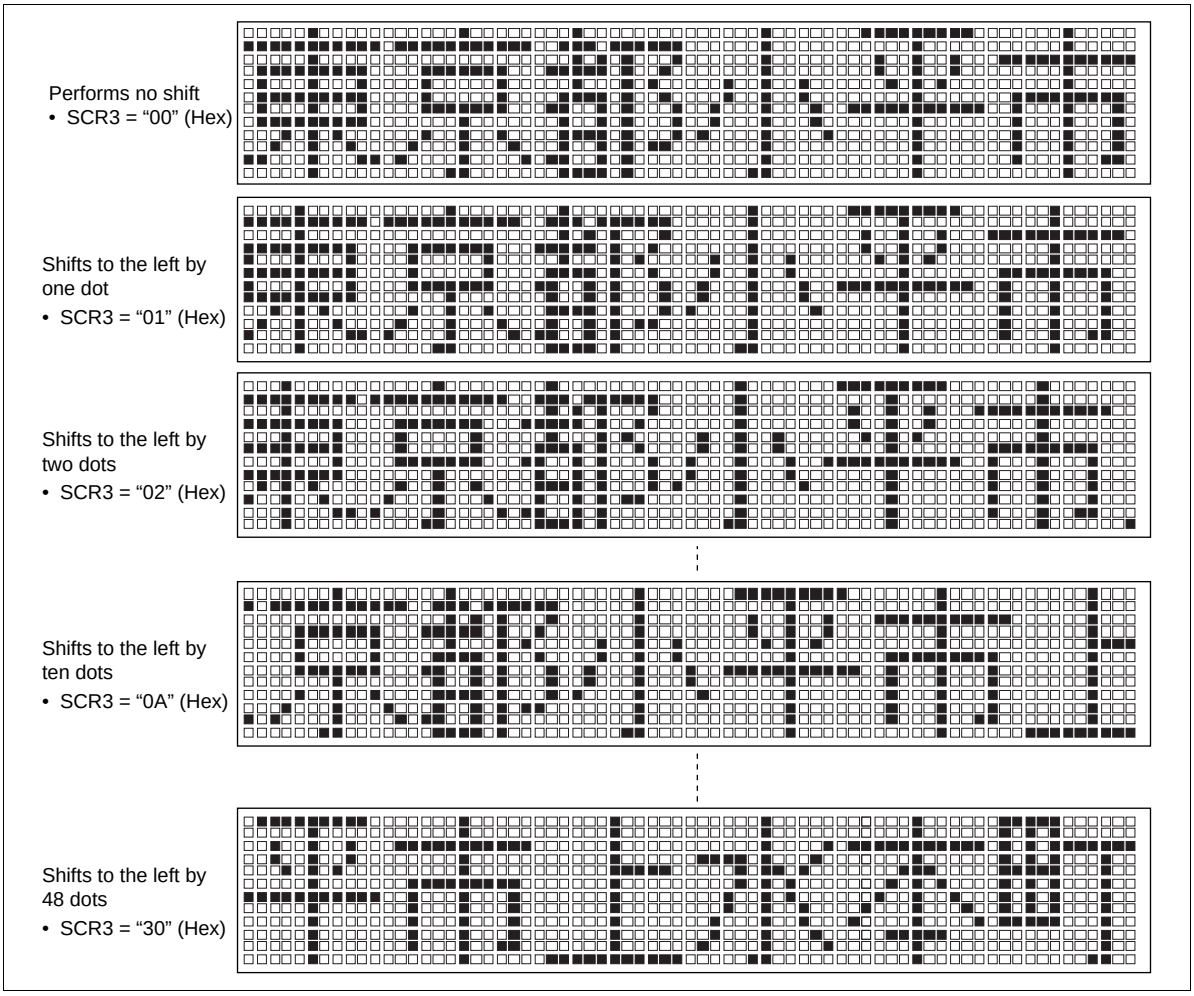
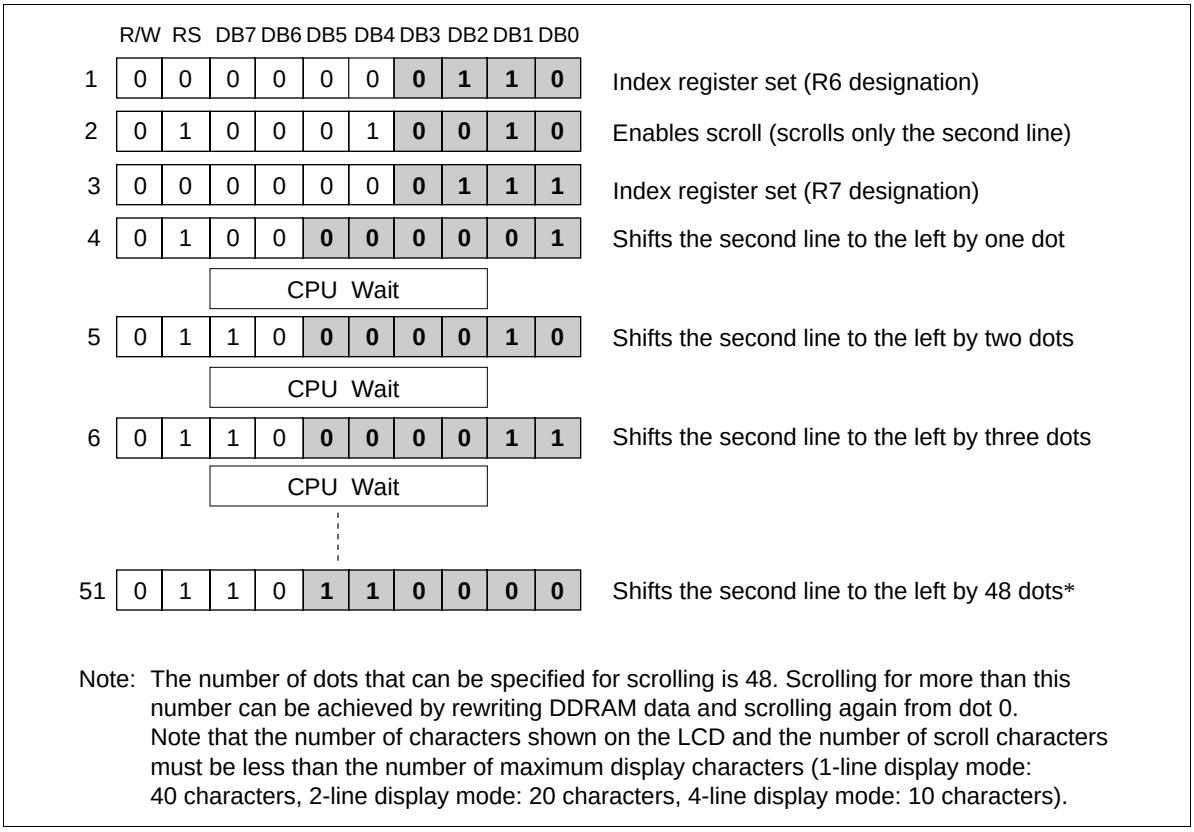


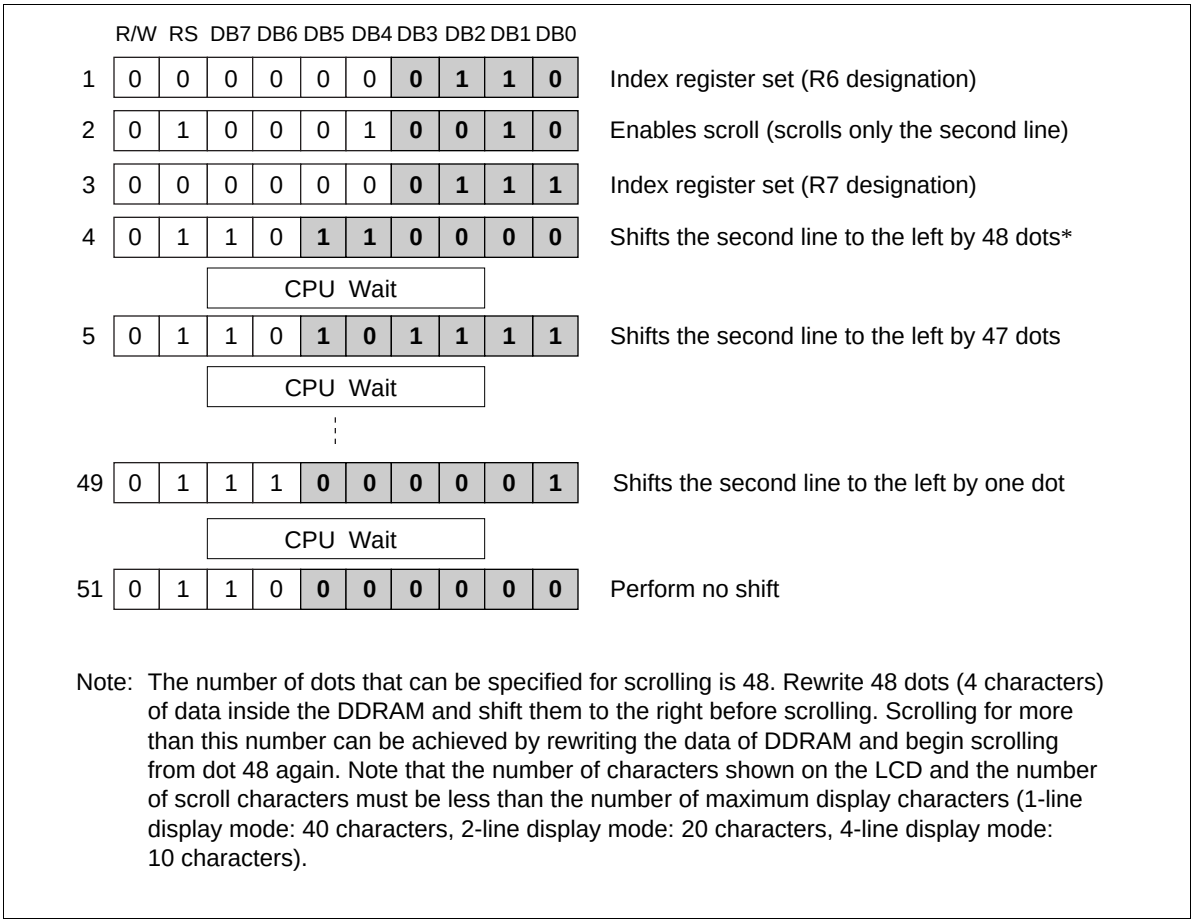
Figure 28 Example of Horizontal Smooth Scroll Display

Examples of Register Setting



Note: The number of dots that can be specified for scrolling is 48. Scrolling for more than this number can be achieved by rewriting DDRAM data and scrolling again from dot 0. Note that the number of characters shown on the LCD and the number of scroll characters must be less than the number of maximum display characters (1-line display mode: 40 characters, 2-line display mode: 20 characters, 4-line display mode: 10 characters).

Figure 29 Example of Executing Smooth Scroll to the Left



Note: The number of dots that can be specified for scrolling is 48. Rewrite 48 dots (4 characters) of data inside the DDRAM and shift them to the right before scrolling. Scrolling for more than this number can be achieved by rewriting the data of DDRAM and begin scrolling from dot 48 again. Note that the number of characters shown on the LCD and the number of scroll characters must be less than the number of maximum display characters (1-line display mode: 40 characters, 2-line display mode: 20 characters, 4-line display mode: 10 characters).

Figure 30 Example of Executing Smooth Scroll to the Right

Partial Smooth Scroll

Partial smooth scroll displays one to three leftmost characters as fixed while the remaining ones undergo a horizontal smooth scroll in the left and right direction. Specifically, the number of leftmost characters to be fixed is specified by the partial scroll bits (PS1/0) in the scroll control register 2 (SCR2: R6). For example, when bits PS1/0 are 10, the two leftmost characters are fixed; when 11, the three leftmost characters are fixed.

Although half-size characters can be displayed in a fixed display area, they must be displayed in even-numbered groups of two, four or six characters. Figure 31 shows an example of smooth scroll performed in a display when bits PS1/0 are set to 10. The two leftmost characters (住所) are displayed as fixed, and the remaining four characters undergo a smooth scroll.

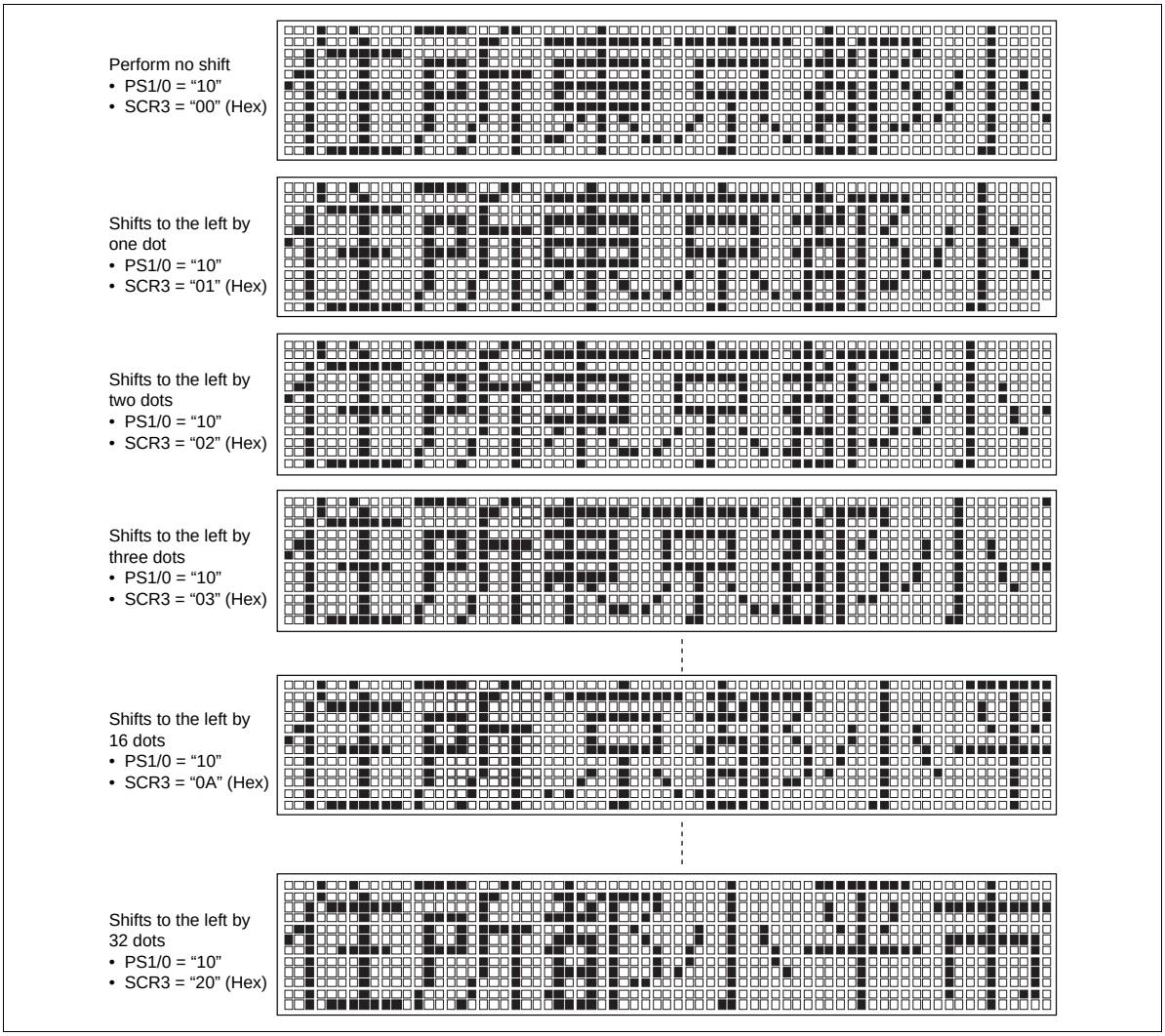


Figure 31 Example of Partial Smooth Scroll Display

Vertical Smooth Scroll

Vertical smooth scroll up and down can be performed by setting the number of display lines (NL1/0: R4) to a value greater than the actual number of liquid crystal display lines, which can be set by the duty drive ratio (DT1/0: R1) to 1/14 (1-line display), 1/27 (2-line display), 1/40 (3-line display), or 1/53 (4-line display). The display line setting (NL1/0: R4), which controls the display, can select 1-line display mode, 2-line display mode, or 4-line display mode.

For example, to perform normal vertical smooth scroll for a 3-line liquid crystal display with a duty ratio of 1/40, set the number of display lines (NL1/0: R4) to 4 lines. Note that if vertical smooth scroll is performed when the number of actual liquid display lines is the same as the number of set display lines, the display line that has scrolled out of the display will appear again from the bottom (or the top) (this function is called lap-around). In a 4-line crystal liquid display, only the lap-around function can be performed. Vertical smooth scroll is controlled by incrementing or decrementing the display line (SN1/0), which indicates which line to start from, and the display raster-row (SL0 to SL3). For example, when performing smooth scroll up, the display raster-row (SL0 to SL3) is incremented from 0000 to 1100 in order to scroll 12 raster-rows. Moreover, by incrementing the display line (SN1/0) and then incrementing the display raster-row from 0000 to 1100 again, a total of 25 raster-rows can be scrolled. Since the DDRAM is only 80 bytes, its data must be rewritten when performing continuous scroll exceeding this capacity.

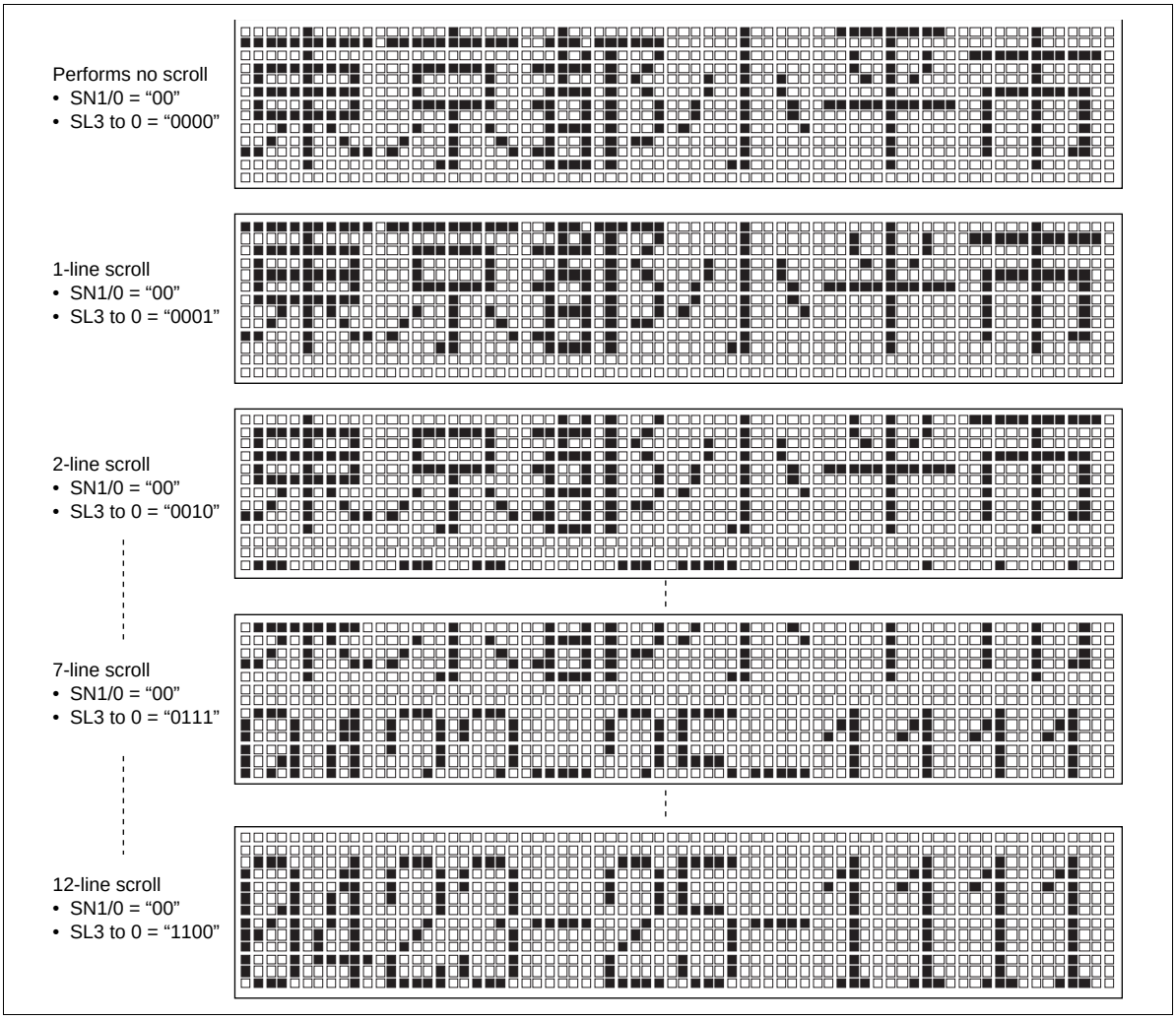
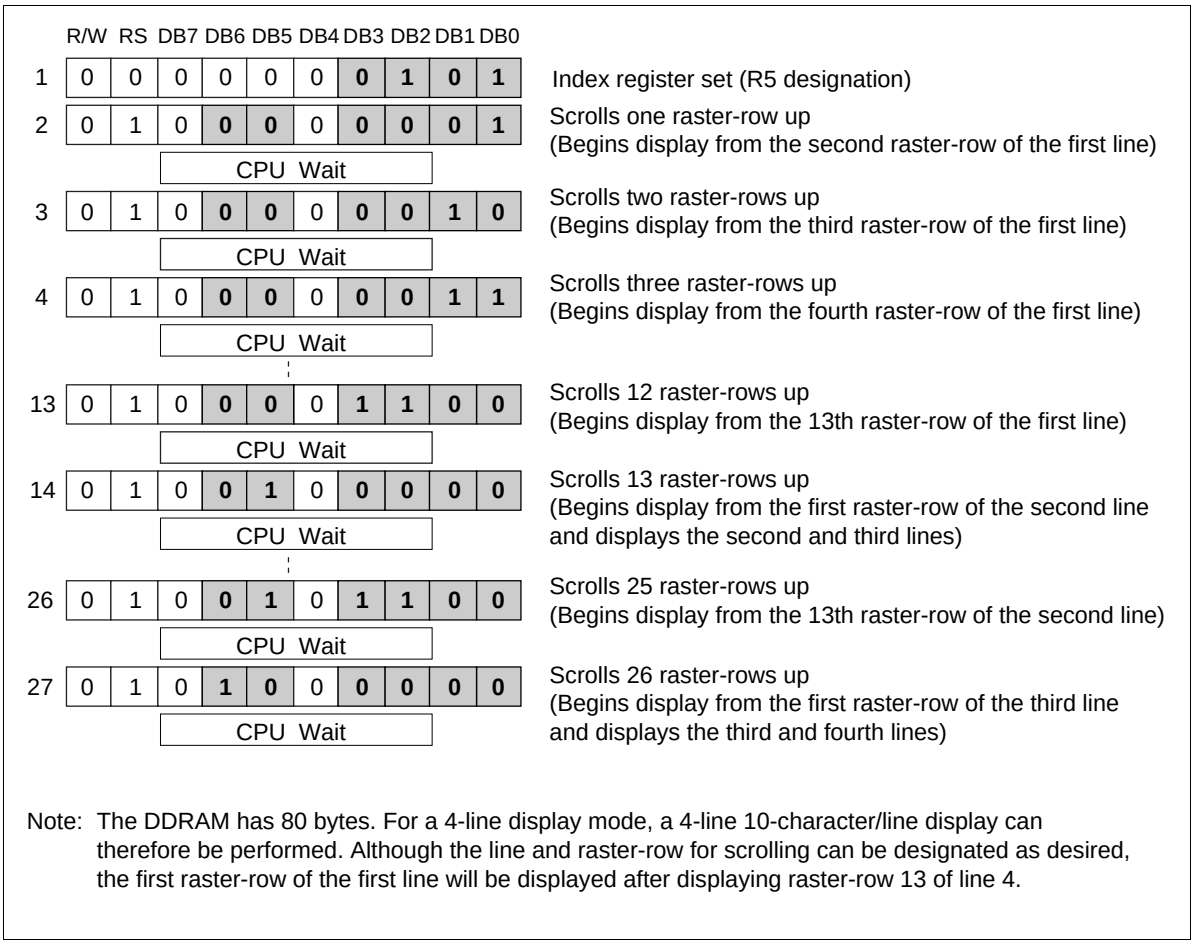


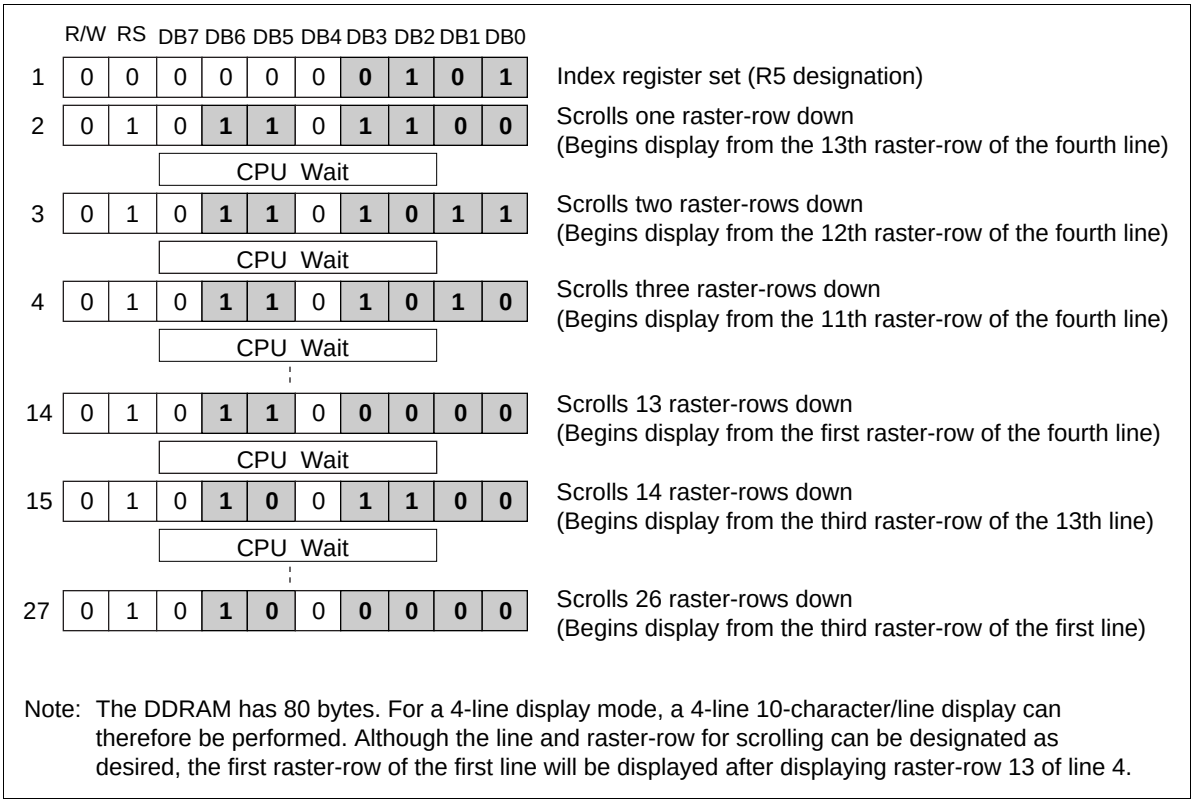
Figure 32 Example of Vertical Smooth Scroll Display

Examples of Register Setting (2-Line Liquid Crystal Drive: DT1/0 = 01, 4-Line Display Mode: NL1/0 = 11)



Note: The DDRAM has 80 bytes. For a 4-line display mode, a 4-line 10-character/line display can therefore be performed. Although the line and raster-row for scrolling can be designated as desired, the first raster-row of the first line will be displayed after displaying raster-row 13 of line 4.

Figure 33 Example of Performing Smooth Scroll Up



Note: The DDRAM has 80 bytes. For a 4-line display mode, a 4-line 10-character/line display can therefore be performed. Although the line and raster-row for scrolling can be designated as desired, the first raster-row of the first line will be displayed after displaying raster-row 13 of line 4.

Figure 34 Example of Performing Smooth Scroll Down

Extension Driver LSI Interface (HD66730)

The HD66730 can interface with extension drivers using extension driver interface signals CL1, CL2, D, and M output from the HD66730, increasing the number of display characters (Figure 35). Although the liquid crystal driver voltage that drives the booster of the HD66730 can also be used as the driver power supply of extension drivers, the output voltage drop of the booster increases as the load of the booster increases.

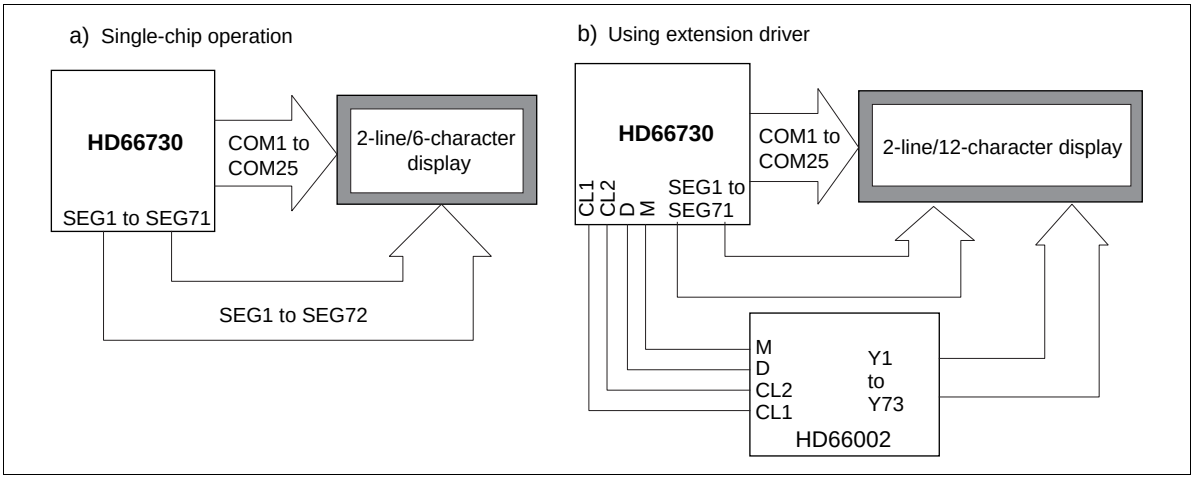


Figure 35 HD66730 and Extension Driver LSI Connection

Interfacing with the Liquid Crystal Panel

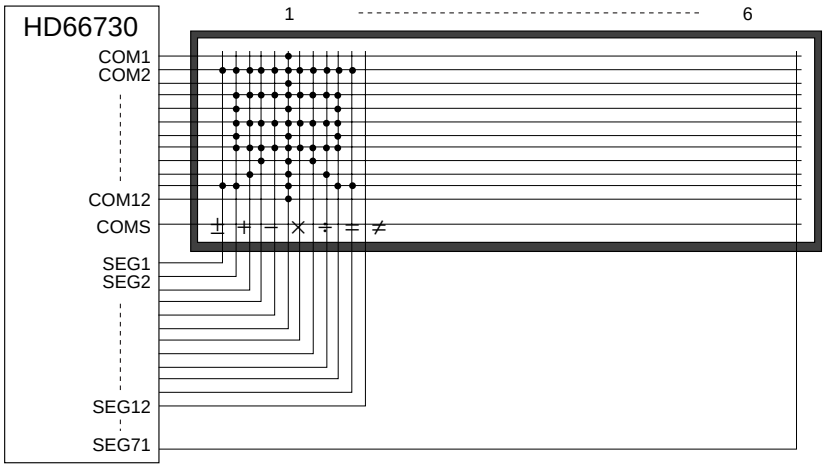
By connecting the HD66730 to extension drivers, the display can be expanded up to a 1-line/40-character, 2-line/20-character, or a 4-line/10-character display configuration. Bits DT1/0 set the duty drive ratio and bits NC1/0 set the number of characters per line. In addition, bits NL1/0 sets the number of display lines during display read control. Table 22 shows the relationship between the number of characters actually displayed on the liquid crystal panel and the corresponding number of extension drivers needed.

Table 23 Relationship between the Number of Liquid Crystal Display Characters and Extension Drivers

	Number of Display Characters per Line						
Display Lines	**6 Characters**	**10 Characters**	**12 Characters**	**16 Characters**	**20 Characters**	**40 Characters**	**Duty Drive**
1 line	(0/0)	(2/0)	(2/0)	(3/0)	(5/0)	(11/0)	1/14
2 lines	(0/0)	(2/0)	(2/0)	(3/0)	(5/0)	Display disabled	1/27
3 lines	(0/1)	(2/1)	Display disabled	Display disabled	Display disabled	Display disabled	1/40
4 lines	(0/1)	(2/1)	Display disabled	Display disabled	Display disabled	Display disabled	1/53

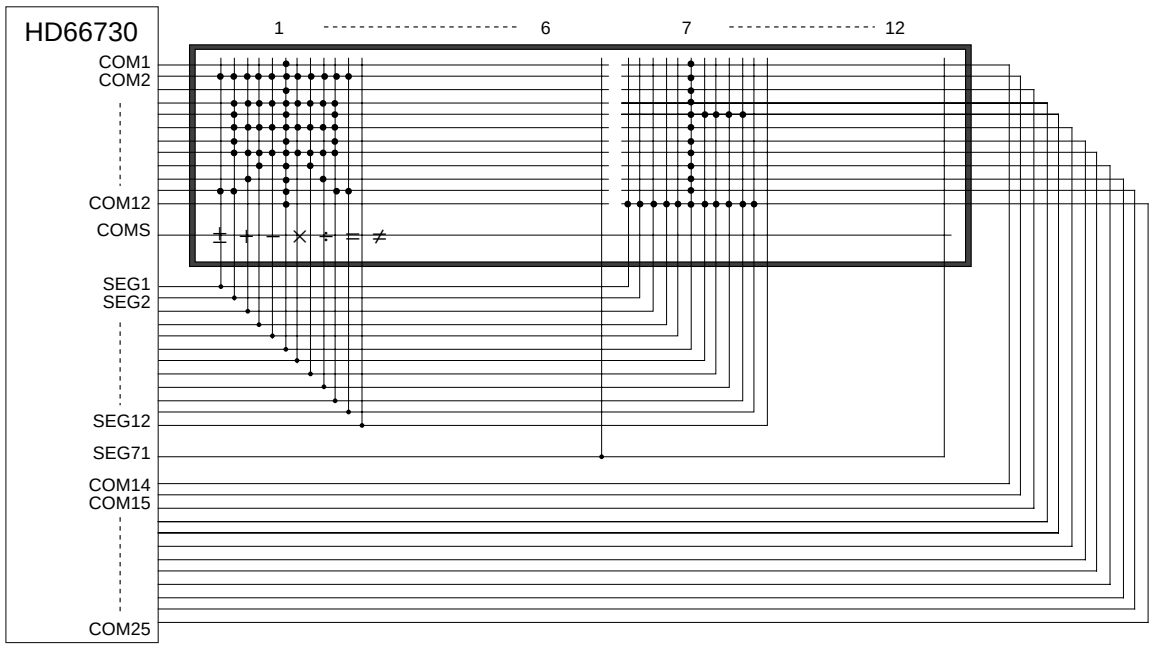
Notes:
1. Numbers in parentheses = (number of extension segment drivers/number of common drivers)
2. This is an example when using the 40 output extension drivers, and when Nh represents display characters and Nd extension driver outputs, the number of extension drivers needed can generally be calculated as follows:
   [Number of extension drivers] = $(12 * Nh - 71 - 1)/Nd] \uparrow$
3. The right-edge segment (space between characters) is not displayed in 6-character or 16-character display.
4. Horizontal smooth scroll cannot be performed during an 1-line/40-character, 2-line/20-character, 3-line/10-character, or 4-line/10-character display.

Example of Interfacing with a 1-Line Display Panel



Note: The rightmost dot-column space of the 6th character cannot be displayd.

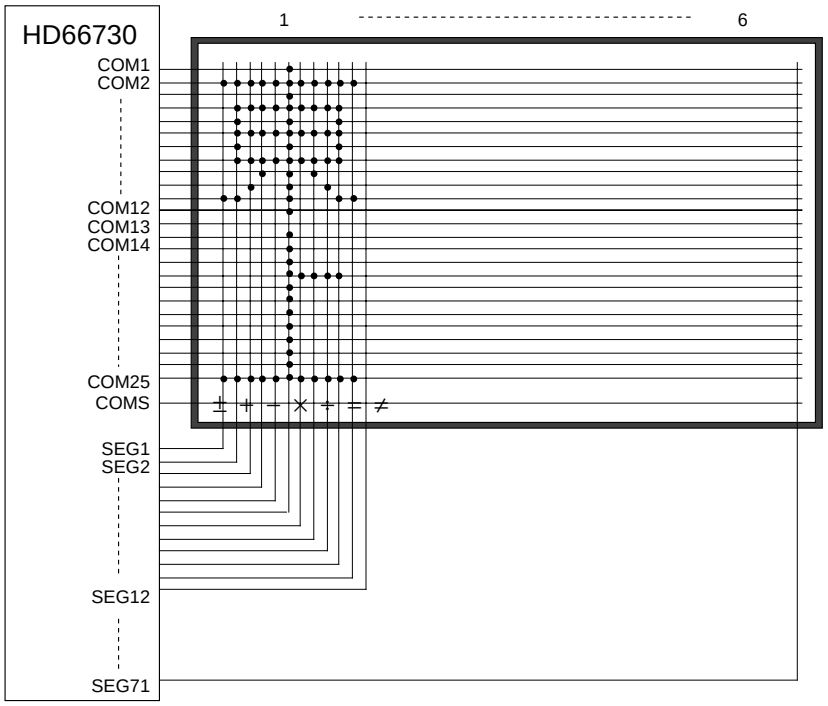
Figure 36 Example of 1-Line/6-Character + 71-Segment Display (Using 1/14 Duty)



Note: 1. The above figure shows how a liquid crystal panel can be arranged into a 1-line/12-character display while operating the HD66730 in 2-line/6-character display mode. Although the duty ratio becomes high, extension drivers will not be needed. COM13 for spaces between display lines will not be needed.

Figure 37 Example of 1-Line/12-Character + 71-Segment Display (Using 1/27 Duty)

Example of Interfacing with a 2-Line Display Panel



Note: 1. When performing vertical smooth scroll, or displaying double-size characters or graphic figures by the CGRAM, COM13 can be used for spaces between lines. Display can be performed continuously vertically.

Figure 38 Example of 2-Line/6-Character + 71-Segment Display (Using 1/27 Duty)

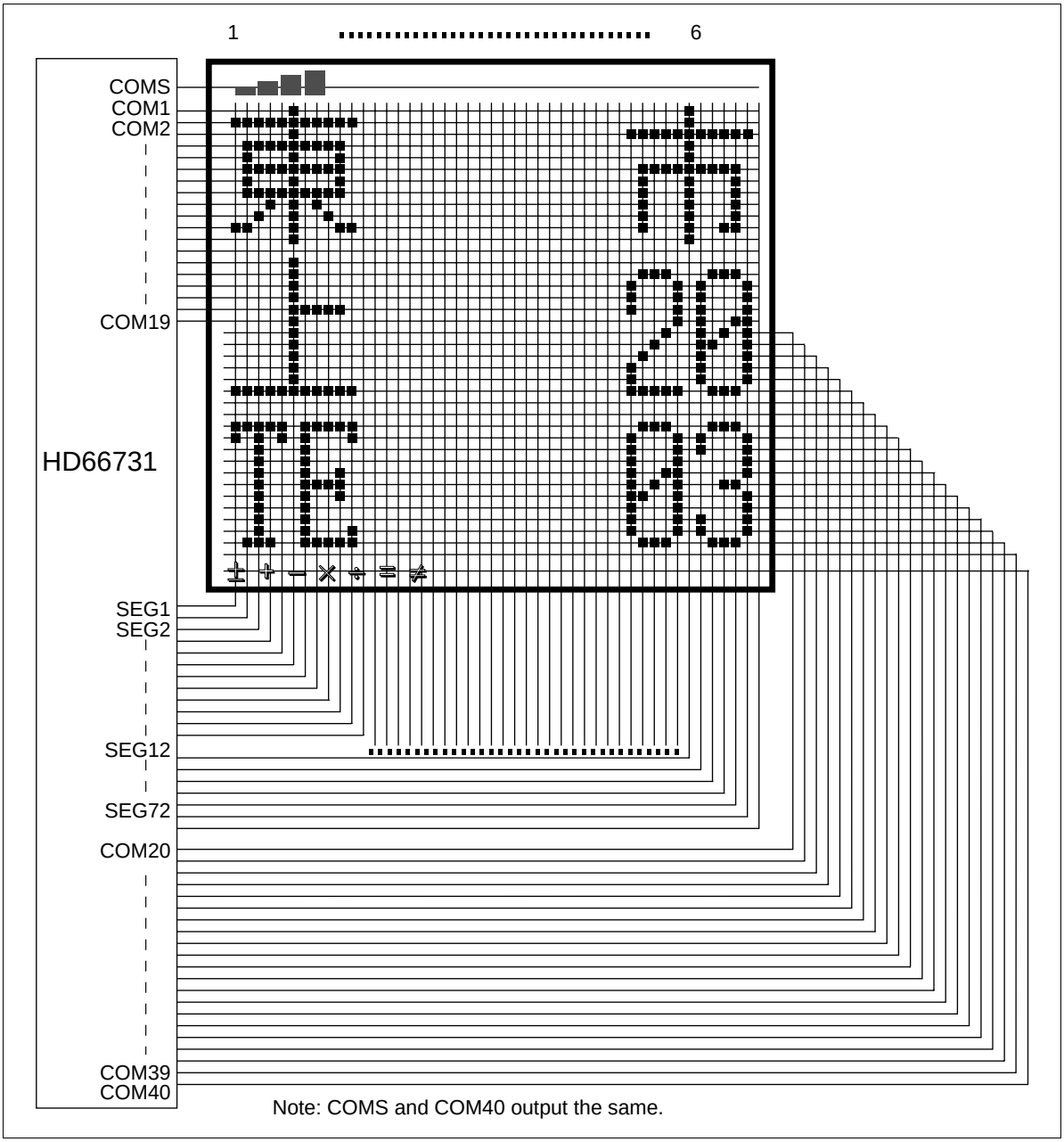


Figure 39 Example of 3-Line/6-Character + 72-Segment Display (Using 1/40 Duty)

Interfacing between HD66730 and HD66002

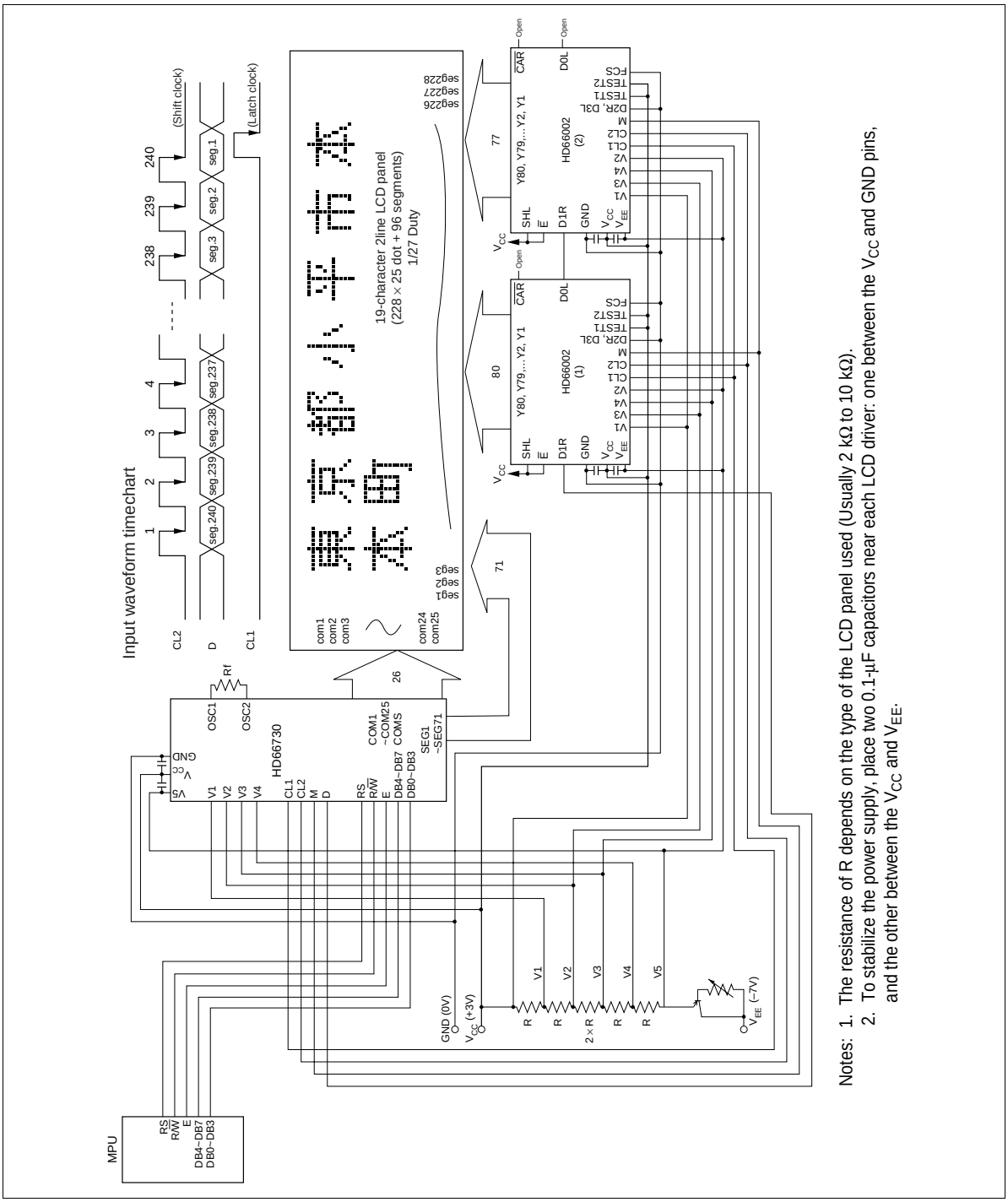
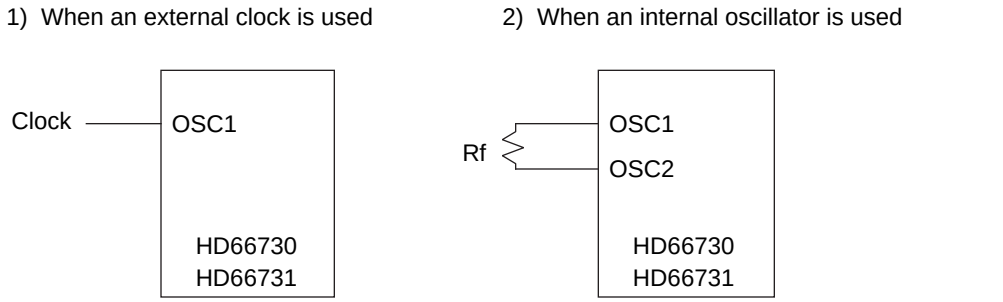


Figure 40 Example of Display Extension Curcuit

Oscillator

Figure 41 shows the optimal value of the oscillation frequency or the external clock frequency depends on the duty drive ratio setting (DT1/0), number of display lines (NL1/0), and the number of display characters (NC1/0) in the HD66730/1. The oscillation frequency or the external clock frequency must be adjusted according to the frame frequency of the liquid crystal drive.



Note: The oscillator frequency can be adjusted by an oscillator resistor (Rf). Refer to Electrical Characteristics for the relationship between the oscillator resistor (Rf) and the oscillator frequency. If Rf is increased or power supply voltage is decreased, the oscillator frequency decreases.

Figure 41 Oscillator Connections

Relationship between the Oscillation Frequency and the Liquid Crystal Display Frame Frequency

Figures 42 to 45 and Tables 24 to 27 show the oscillation frequency and the external clock frequency for various registor settings when the frame frequency is 80 Hz.

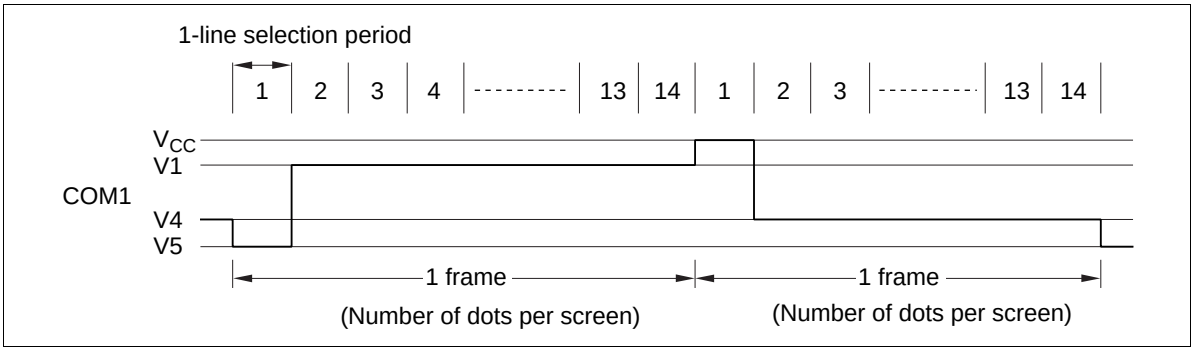


Figure 42 Frame Frequency (1/14 Duty Cycle)

Table 24 1/14 Duty Drive

Number of Display Lines:	**1-Line Display**		
(NL1/0 Set Value):	**(00)**		
Number of display characters	6 characters	20 characters	40 characters
(NC1/0 set value)	(00)	(01)	(11)
1-line selection period (dot)	72 dots	240 dots	480 dots
Number of dots per screen (dot)	1008 dots	3360 dots	6720 dots
Oscillation frequency (kHz)*	70	235	475

Number of Display Lines:	**2-line Display**		
(NL1/0 Set Value):	**(01)**		
Number of display characters	6 characters	20 characters	40 characters
(NC1/0 set value)	(00)	(01)	(11)
1-line selection period (dot)	72 dots	120 dots	240 dots
Number of dots per screen (dot)	1008 dots	1680 dots	3360 dots
Oscillation frequency (kHz)*	70	120	235

Number of Display Lines:	**4-Line Display**	
(NL1/0 Set Value):	**(11)**	
Number of display characters	6 characters	10 characters
(NC1/0 set value)	(00)	(01)
1-line selection period (dot)	72 dots	120 dots
Number of dots per screen (dot)	1008 dots	1680 dots
Oscillation frequency (kHz)*	70	120

Note: * The frequencies in Table 23 are examples when the frame frequency is set to 70 Hz. Adjust the oscillation frequency so that a optimum frame frequency can be obtained.

1/27 Duty Cycle (DT1/0 = 01: 2-Line Drive)

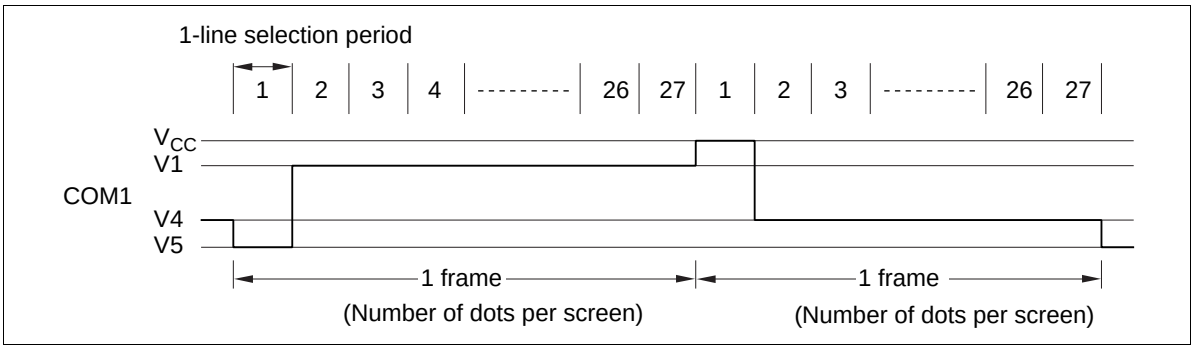


Figure 43 Frame Frequency (1/27 Duty Cycle)

Table 25 1/27 Duty Drive

Number of Display Lines:	**2-Line Display**		
(NL1/0 Set Value):	**(01)**		
Number of display characters	6 characters	10 characters	20 characters
(NC1/0 set value)	(00)	(01)	(11)
1-line selection period (dot)	72 dots	120 dots	240 dots
Number of dots per screen (dot)	1944 dots	3240 dots	6480 dots
Oscillation frequency (kHz)*	135	225	475

Number of Display Lines:	**4-Line Display**	
(NL1/0 Set Value):	**(11)**	
Number of display characters	6 characters	10 characters
(NC1/0 set value)	(00)	(01)
1-line selection period (dot)	72 dots	120 dots
Number of dots per screen (dot)	1944 dots	3240 dots
Oscillation frequency (kHz)*	135	225

Note: * The frequencies in Table 24 are examples when the frame frequency is set to 70 Hz. Adjust the oscillation frequency so that an optimum frame frequency can be obtained.

1/40 Duty Cycle (DT1/0 = 10: 3-Line Drive)

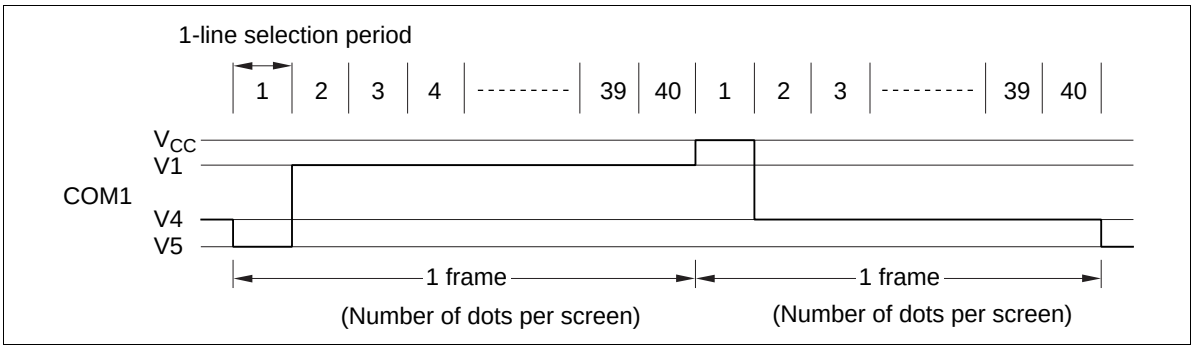


Figure 44 Frame Frequency (1/40 Duty Cycle)

Table 26 1/40 Duty Drive

Number of Display Lines:	**4-Line Display**	
(NL1/0 set value):	**(11)**	
Number of display characters	6 characters	10 characters
(NC1/0 set value)	(00)	(01)
1-line selection period (dot)	72 dots	120 dots
Number of dots per screen (dot)	2880 dots	4800 dots
Oscillation frequency (kHz)*	200	335

Note: * The frequencies in Table 25 are examples when the frame frequency is set to 70 Hz. Adjust the oscillation frequency so that an optimum frame frequency can be obtained.

1/53 Duty Cycle (DT1/0 = 11: 4-Line Drive)

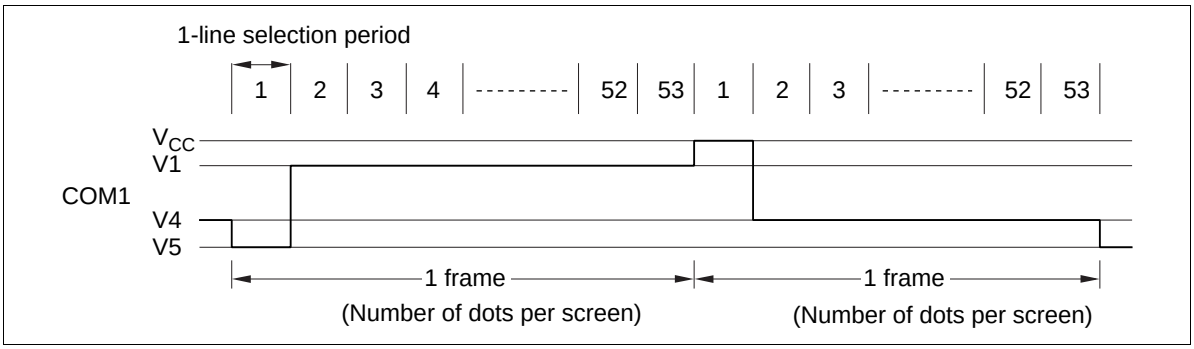


Figure 45 Frame Frequency (1/53 Duty Cycle)

Table 27 1/53 Duty Drive

Number of Display Lines:	**4-line Display (11)**	
(NL1/0 Setting Value):	**(00)**	**(01)**
Number of display characters	6 characters	10 characters
(NC1/0 setting value)	(00)	(01)
1-line selection period (dot)	72 dots	120 dots
Number of dots per screen (dot)	3816 dots	6360 dots
Oscillation frequency (kHz)*	265	445

Note: * The frequencies in Table 26 are examples when the frame frequency is to 80 Hz. Adjust the oscillation frequency so that an optimum frame frequency can be obtained.

Power Supply for Liquid Crystal Display Drive

The HD66730/1 incorporates a booster for raising the LCD voltage two or three times that of the reference voltage input below V_{CC} (Figure 48). A two or three times boosted voltage can be obtained by externally attaching two or three 1-µF capacitors.

If the LCD panel is large and needs a large amount of drive current, the values of bleeder resistors that generate the V1 to V5 potential are made smaller. However, the load current in the booster and the voltage drop increases in this case.

We recommend setting the resistance value of each bleeder larger than 4.7 kΩ and to hold down the DC load current to 0.4 mA if using a booster circuit. An external power supply should supply LCD voltage if the DC load current exceeds 0.7 mA (Figure 49). Refer to Electrical Characteristics showing the relationship between the load current and booster voltage output. Table 27 shows the duty factor and bleeder resistor value for power supply for liquid crystal display drive.

Table 28 Duty Factor and Bleeder Resistor Value for Power Supply for Liquid Crystal Display Drive

Item		Data			
Drive lines (DT1/0 setting value)		1	2	3	4
Duty factor		1/14	1/27	1/40	1/53
Bias		1/4.7	1/6.2	1/7.3	1/8.3
Bleeder resistance value	R1	R	R	R	R
	R0	R*0.7	R*2.2	R*3.3	R*4.3

Note: * R changes depending on the size of a liquid crystal panel. Normally, R must be 4.7 kΩ to 20 kΩ. Adjust R to the optimum value with the consumption current and display picture quality.

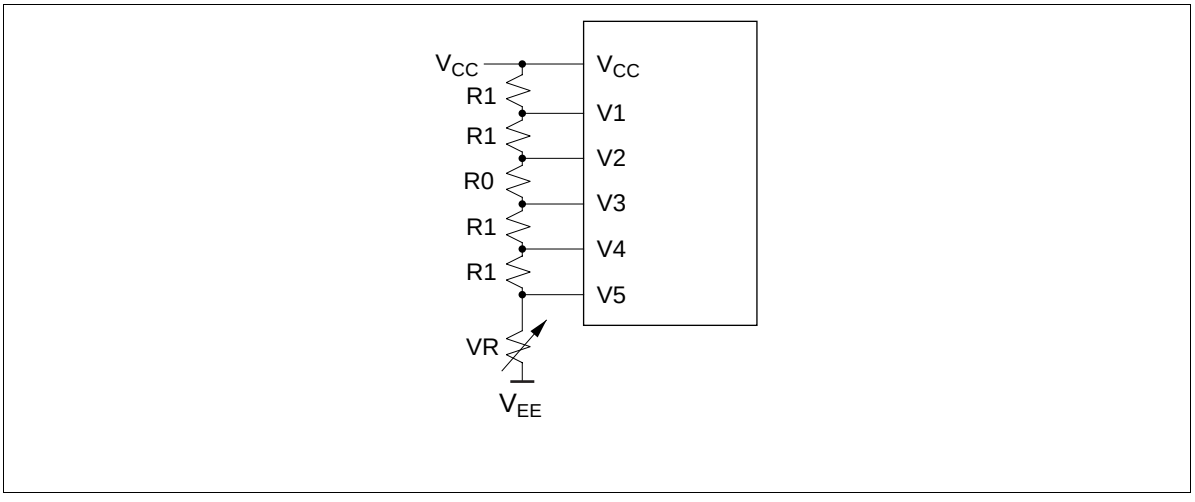
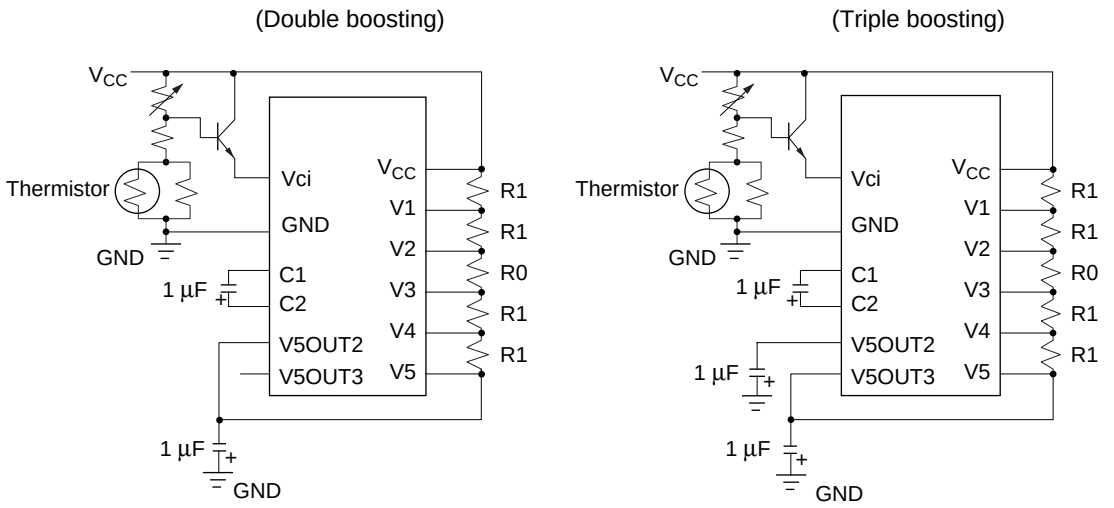


Figure 46 Example of Power Supply for Liquid Crystal Display Drive (with External Power Supply)



Notes:
1. The reference voltage input (Vci) must be set below the power supply (V_{CC}).
2. Current that flows into reference voltage input (Vci) is 2-3 times larger than the load current flowing through bleeder resistors. Note that a reference voltage drop occurs due to the current flowing into the Vci input when a reference voltage (Vci) is generated by resistor division.
3. The amount of output voltage (V5OUT2/V5OUT3) drop of a booster circuit also increases as the load current flowing through bleeder resistors increases. Thus, set the bleeder resistance as large as possible (4.7 kΩ or greater) without affecting display picture quality.
4. Adjust the reference voltage input (Vci) according to the fluctuation of booster characteristics because the output voltage (V5OUT2/V5OUT3) drop depends on the load current, operation temperature, operation frequency, capacitance of external capacitors, and manufacturing tolerance. Refer to Electrical Characteristics for details.
5. Adjust the reference voltage input (Vci) so that the output voltage (V5OUT2/V5OUT3) after boosting will not exceed the absolute maximum rating of liquid crystal power supply voltage (15V).
6. Make sure that you connect polarized capacitors correctly.

Figure 47 Example of Power Supply for Liquid Crystal Display Drive (with Internal Booster)

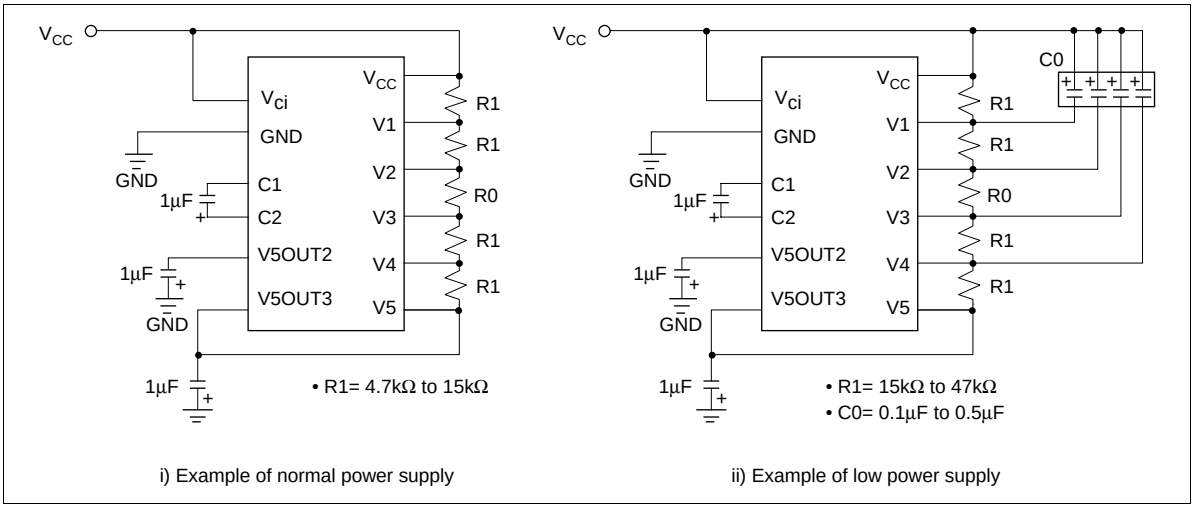


Figure 48 Example of Power Supply for Low Power Consumption

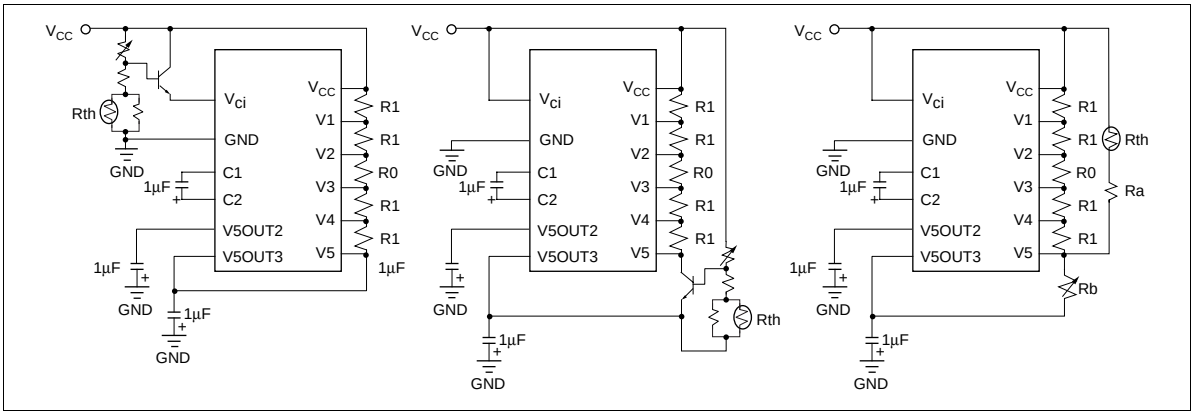


Figure 49 Example of Temperature Compensation Circuit

Absolute Maximum Ratings (HD66730)*

Item	Symbol	Value	Unit	Notes
Power supply voltage (1)	V_{CC}	–0.3 to +7.0	V	1
Power supply voltage (2)	V_{CC}–V5	–0.3 to +17.0	V	1, 2
Input voltage	Vt	–0.3 to V_{CC} + 0.3	V	1
Operating temperature	T_{opr}	–30 to +75	°C	
Storage temperature	T_{stg}	–55 to +125	°C	4

Note: * If the LSI is used above these absolute maximum ratings, it may become permanently damaged. Using the LSI within the following electrical characteristic limits is strongly recommended for normal operation. If these electrical characteristic conditions are also exceeded, the LSI will malfunction and cause poor reliability.

Absolute Maximum Ratings (HD66731)*

Item	Symbol	Value	Unit	Notes
Power supply voltage (1)	V_{CC}	–0.3 to +7.0	V	1
Power supply voltage (2)	V_{CC}–V5	–0.3 to +17.0	V	1, 2
Input voltage	Vt	–0.3 to V_{CC} + 0.3	V	1
Operating temperature	T_{opr}	–40 to +85	°C	
Storage temperature	T_{stg}	–55 to +110	°C	4

Note: * If the LSI is used above these absolute maximum ratings, it may become permanently damaged. Using the LSI within the following electrical characteristic limits is strongly recommended for normal operation. If these electrical characteristic conditions are also exceeded, the LSI will malfunction and cause poor reliability.

DC Characteristics (V_{CC} = 2.4 V to 5.5 V, T_a = –30 to +75°C*[3])

Item	Symbol	Min	Typ	Max	Unit	Test Condition	Notes
Input high voltage (1) (except OSC1)	VIH1	$0.7V_{CC}$	—	V_{CC}	V		5, 6
Input low voltage (1) (except OSC1)	VIL1	–0.3	—	$0.2V_{CC}$	V	V_{CC} = 2.4 to 3.0V	5, 6
		–0.3	—	0.6	V	V_{CC} = 3.0 to 4.5V	
Input high voltage (2) (OSC1)	VIH2	$0.7V_{CC}$	—	V_{CC}	V		15
Input low voltage (2) (OSC1)	VIL2	—	—	$0.2V_{CC}$	V		15
Output high voltage (1) (D0–D7)	VOH1	$0.75V_{CC}$	—	—	V	$–I_{OH}$ = 0.1 mA	7
Output low voltage (1) (D0–D7)	VOL1	—	—	$0.2V_{CC}$	V	I_{OL} = 0.1 mA	7
Output high voltage (2) (except D0–D7)	VOH2	$0.8V_{CC}$	—	—	V	$–I_{OH}$ = 0.04 mA	8
Output low voltage (2) (except D0–D7)	VOL2	—	—	$0.2V_{CC}$	V	I_{OL} = 0.04 mA	8
Driver ON resistance (COM)	R_{COM}	—	2	20	kΩ	±Id = 0.05 mA, VLCD = 4V	13
Driver ON resistance (SEG)	R_{SEG}	—	2	30	kΩ	±Id = 0.05 mA, VLCD = 4V	13
I/O leakage current	I_{LI}	–1	—	1	µA	VIN = 0 to V_{CC}	9
Pull-up MOS current (RESET* pin)	$–I_p$	5	50	120	µA	V_{CC} = 3V VIN = 0V	
Power supply current	I_{CC1}	—	150	300	µA	R_f oscillation, external clock V_{CC} = 3V, f_{OSC} = 215 kHz	10, 14
	I_{CC2}	—	25	—	µA	Sleep mode V_{CC} = 3V f_{OSC} = 215 kHz	
LCD voltage	VLCD	3.0	—	15.0	V	V_{CC}–V5	16

Booster Characteristics

Item	Symbol	Min	Typ	Max	Unit	Test Condition	Notes*
Output voltage (V5OUT2 pin)	VUP2	8.2	8.9	—	V	V_{CC} = Vci = 4.5V, I_o = 0.25 mA, C = 1 µF, f_{OSC} = 215 kHz, T_a = 25°C	18
Output voltage (V5OUT3 pin)	VUP3	7.2	7.8	—	V	V_{CC} = Vci = 2.7V, I_o = 0.25 mA, C = 1 µF, f_{OSC} = 215 kHz, T_a = 25°C	18
Input voltage	VCi	1.0	—	5.0	V	Vci ≤ V_{CC}	18, 19

AC Characteristics (V_{CC} = 2.4V to 5.5V, T_a = –30 to +75°C*[3])

Clock Characteristics (V_{CC} = 2.7 V to 5.5 V, T_a = –30 to +75°C*[3])

Item		Symbol	Min	Typ	Max	Unit	Test Condition	Notes*
External clock operation	External clock frequency	f_{cp}	80	215	350	kHz	V_{CC} = 2.4 to 2.7V	11
			80	215	550	kHz	V_{CC} = 2.7 to 5.5V	
	External clock duty	Duty	45	50	55	%		
	External clock rise time	t_{rcp}	—	—	0.2	µs		
	External clock fall time	t_{rcp}	—	—	0.2	µs		
R_f oscillation	Clock oscillation frequency (HD66730)	f_{OSC}	110	150	200	kHz	R_f = 150 kΩ, V_{CC} = 3V	12
	Clock oscillation frequency (HD66731)	f_{OSC}	150	215	275	kHz	R_f = 91 kΩ, V_{CC} = 3V	12

System Interface Timing Characteristics (1) (V_{CC} = 2.4V to 4.5V, T_a = –30 to +75°C*[3])

Bus Write Operation

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Enable cycle time	t_{CYCE}	500	—	—	ns	Figure 50
Enable pulse width (high level)	PW_{EH}	250	—	—		V_{CC} = 2.4 to 3.0V
		150	—	—		V_{CC} = 3.0 to 4.5V
Enable rise/fall time	t_{Er}, t_{Ef}	—	—	20		Figure 50
Address set-up time (RS, R/$\overline{W}$ to E)	t_{AS}	80	—	—		
Address hold time	t_{AH}	20	—	—		
Data set-up time	t_{DSW}	140	—	—		
Data hold time	t_H	30	—	—		

Bus Read Operation

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Enable cycle time	t_{CYCE}	1000	—	—	ns	Figure 51
Enable pulse width (high level)	PW_{EH}	450	—	—		
Enable rise/fall time	t_{Er}, t_{Ef}	—	—	25		
Address set-up time (RS, R/$\overline{W}$ to E)	t_{AS}	60	—	—		
Address hold time	t_{AH}	20	—	—		
Data delay time	t_{DDR}	—	—	360		
Data hold time	t_{DHR}	5	—	—		

Serial Interface Operation

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Serial clock cycle time	t_{SCYC}	1	—	20	µs	Figure 52
Serial clock (high level width)	t_{SCH}	400	—	—	ns	
Serial clock (low level width)	t_{SCL}	400	—	—		
Serial clock rise/fall time	t_{scr}, t_{scf}	—	—	50		
Chip select set-up time	t_{CSU}	60	—	—		
Chip select hold time	t_{CH}	200	—	—		
Serial input data set-up time	t_{SISU}	200	—	—		
Serial input data hold time	t_{SIH}	200	—	—		
Serial output data delay time	t_{SOD}	—	—	360		
Serial output data hold time	t_{SOH}	5	—	—		

System Interface Timing Characteristics (2) (V_{CC} = 4.5V to 5.5V, T_a = –30 to +75°C*[3])

Bus Write Operation

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Enable cycle time	t_{CYCE}	500	—	—	ns	Figure 50
Enable pulse width (high level)	PW_{EH}	150	—	—		
Enable rise/fall time	t_{Er}, t_{Ef}	—	—	20		
Address set-up time (RS, R/$\overline{W}$ to E)	t_{AS}	40	—	—		
Address hold time	t_{AH}	30	—	—		
Data set-up time	t_{DSW}	80	—	—		
Data hold time	t_H	30	—	—		

Bus Read Operation

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Enable cycle time	t_{CYCE}	500	—	—	ns	Figure 51
Enable pulse width (high level)	PW_{EH}	230	—	—		
Enable rise/fall time	t_{Er}, t_{Ef}	—	—	20		
Address set-up time (RS, R/$\overline{W}$ to E)	t_{AS}	40	—	—		
Address hold time	t_{AH}	30	—	—		
Data delay time	t_{DDR}	—	—	160		
Data hold time	t_{DHR}	5	—	—		

Serial Interface Sequence

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Serial clock cycle time	t_{SCYC}	0.5	—	20	µs	Figure 52
Serial clock (high level width)	t_{SCH}	200	—	—	ns	
Serial clock (low level width)	t_{SCL}	200	—	—		
Serial clock rise/fall time	t_{scr}, t_{scf}	—	—	50		
Chip select set-up time	t_{CSU}	60	—	—		
Chip select hold time	t_{CH}	100	—	—		
Serial input data set-up time	t_{SISU}	100	—	—		
Serial input data hold time	t_{SIH}	100	—	—		
Serial output data delay time	t_{SOD}	—	—	160		
Serial output data hold time	t_{SOH}	5	—	—		

HD66730 Segment Extension Signal Timing Characteristics (V_{CC} = 2.4V to 5.5V, T_a = –30 to +75°C*[3])

Item		Symbol	Min	Typ	Max	Unit	Test Condition
Clock pulse width	High level	t_{CWH}	800	—	—	ns	Figure 53
	Low level	t_{CWL}	800	—	—		
Clock set-up time		t_{CSU}	500	—	—		
Data set-up time		t_{SU}	300	—	—		
Data hold time		t_{DH}	300	—	—		
M delay time		t_{DM}	–1000	—	1000		
COMD set-up time		t_{DSU}	300				
Clock rise/fall time	COMD	t_{ct1}	—	—	700		
	Pins except COMD	t_{ct2}	—	—	200		

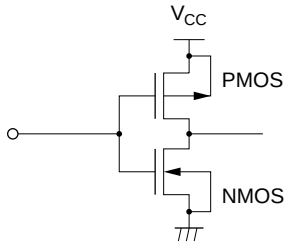
Reset Timing Characteristics (V_{CC} = 2.4V to 5.5V, T_a = –30 to +75°C*[3])

Item	Symbol	Min	Typ	Max	Unit	Test Condition
Reset low-level width	t_{RES}	10	—	—	ms	Figure 54

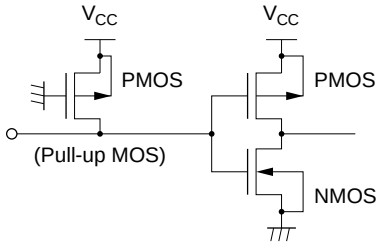
Electrical Characteristics Notes

1. All voltage values are referred to GND = 0V. If the LSI is used above the absolute maximum ratings, it may become permanently damaged. Using the LSI within the electrical characteristic is strongly recommended to ensure normal operation. If these electrical characteristic are exceeded, the LSI may malfunction or exhibit poor reliability.
2. $V_{CC} \geq V5$ must be maintained. When the COM25/COMD pin is used as a extention driver interface signal (COMD), GND ≥ V5 must be maintained.
3. For die products, specified at 75°C.
4. For die products, specified by the die shipment specification.
5. The following four circuits are I/O pin configurations except for liquid crystal display output.

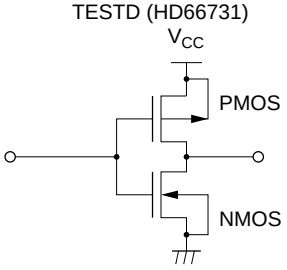
Input pin
Pin: E/SCLK, RS/CS*, RW/SID, IM,



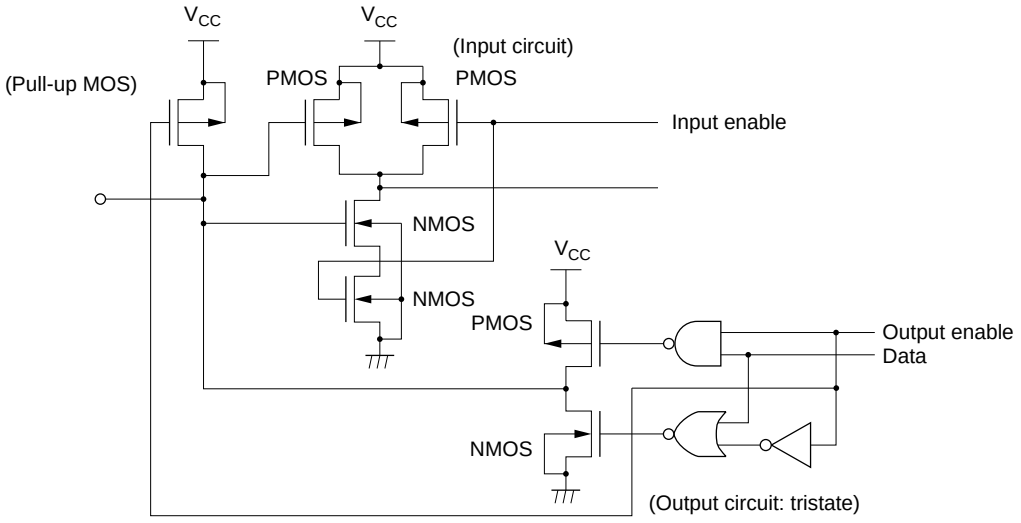
Input pin
Pins: RESET*



Output pin
Pins: CL1, CL2, M, SEGD (HD66730)
TESTD (HD66731)

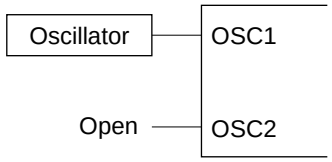


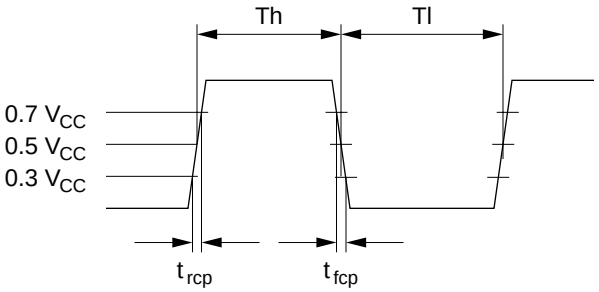
I/O Pin
Pins: DB0/SOD to DB7



6. Applies to input pins and I/O pins, excluding the OSC1 pin.
7. Applies to I/O pins.
8. Applies to output pins of HD66730.
9. Current flowing through pull-up MOSs, excluding output drive MOSs.

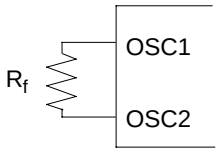
10. Input/output current is excluded. When input is at an intermediate level with CMOS, the excessive current flows through the input circuit to the power supply. To avoid this from happening, the input level must be fixed high or low.
11. Applies only to external clock operation.





$$\text{Duty} = \frac{Th}{Th + Tl} \times 100\%$$

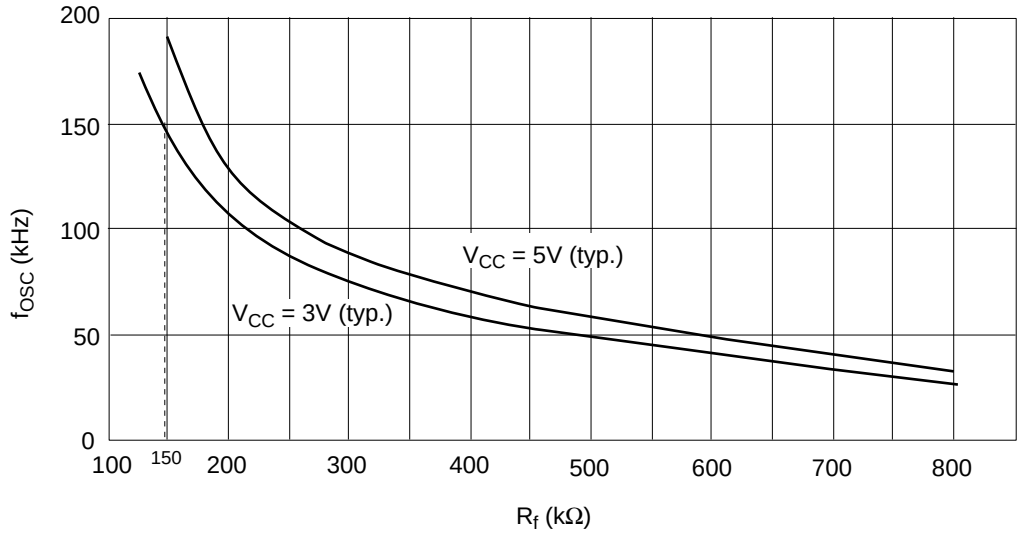
12. Applies only to the internal oscillator operation using oscillation resistor R_f.



Recommended registor value

R_f: 150kΩ±2% (When V_{CC} = 3V to 4V)
R_f: 180kΩ±2% (When V_{CC} = 4V to 5V)

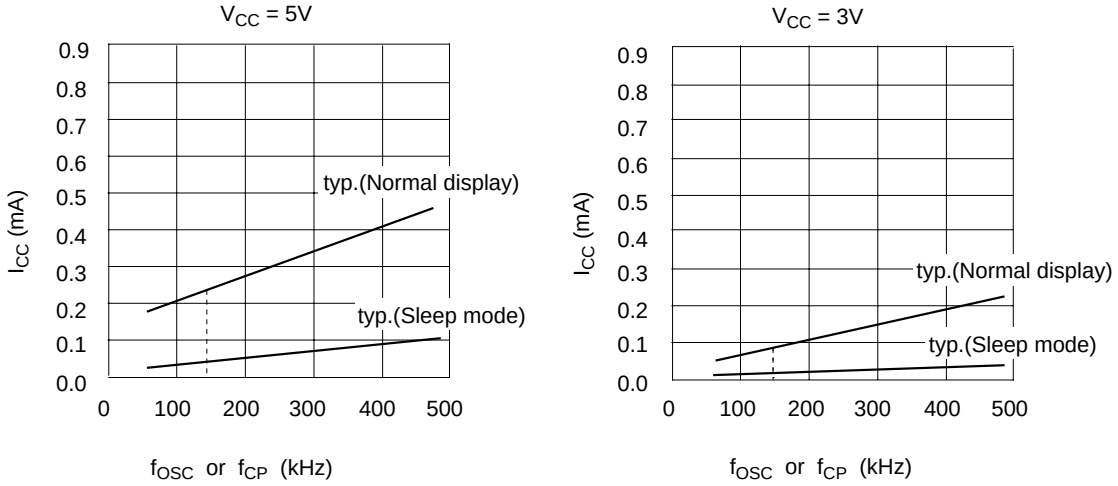
Since oscillation frequency varies depending on OSC1 and OSC2 terminal capacitance,wiring length to these pins should be minimized.



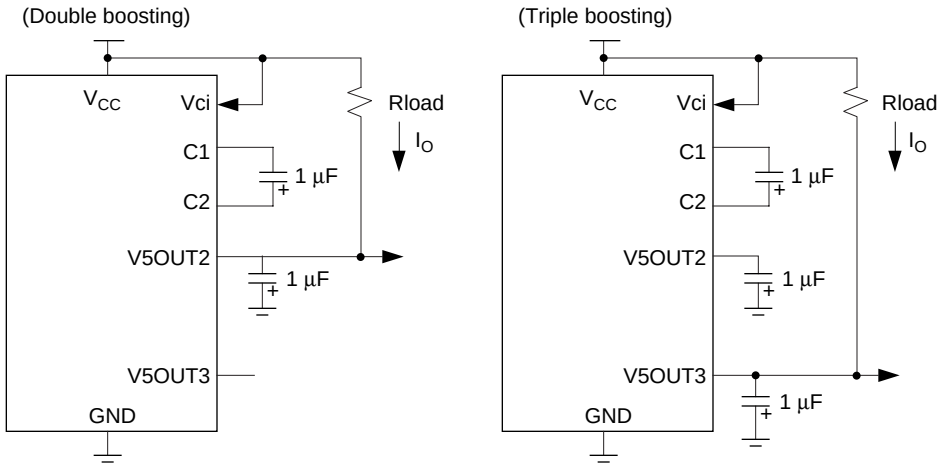
13. RCOM is the resistance between the power supply pins (V_{CC}, V1, V4, V5) and each common signal pin (COM0 to COM25/COM53).

    RSEG is the resistance between the power supply pins (V_{CC}, V2, V3, V5) and each segment signal pin (SEG1 to SEG71/SEG119).

14. The following graphs show the relationship between operation frequency and current consumption (referential data).

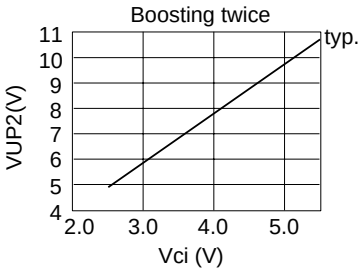


15. Applies to the OSC1 pin.
16. Each COM and SEG output voltage is within ±0.15V of the LCD voltage (V_{CC}, V1, V2, V3, V4, V5) when there is no load.
17. The TEST pin must be fixed to ground, and the IM pin must also be connected to V_{CC} or ground.
18. Booster characteristics test circuits are shown below.

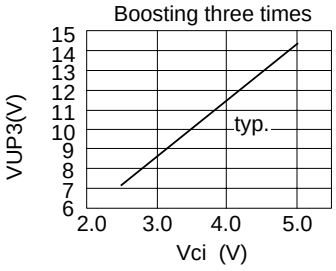


VUP2=V_{CC} –V5OUT2 VUP3=V_{CC} –V5OUT3

(i) VUP2,VUP3 vs Vci

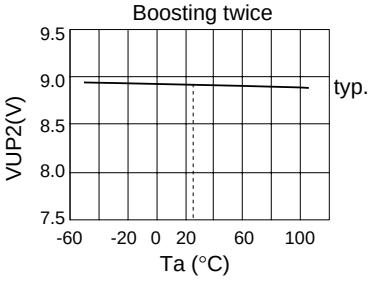


Test condition : Vci=V_{CC}, f_{cp}=140kHz, Ta=25°C

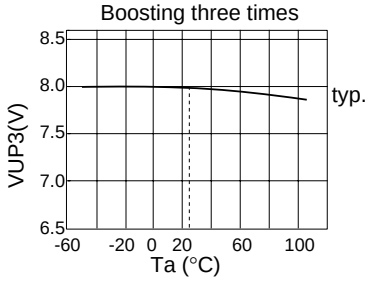


Test condition : Vci=V_{CC}, f_{cp}=140kHz, Ta=25° C

(ii) VUP2, VUP3 vs Ta

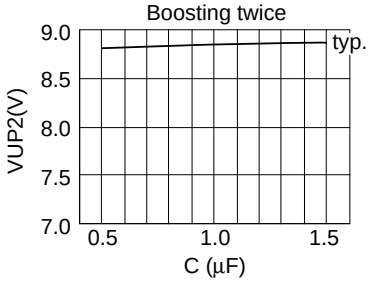


Test condition : Vci=V_{CC}=4.5V, R_f=180kΩ
I_O=0.1mA

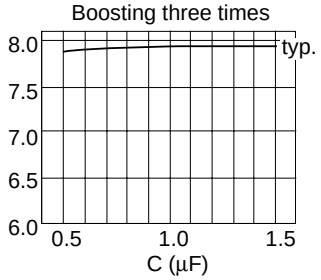


Test condition : Vci=V_{CC}=2.7V, R_f=150kΩ
I_O=0.1mA

(iii) VUP2, VUP3 vs Capacitance

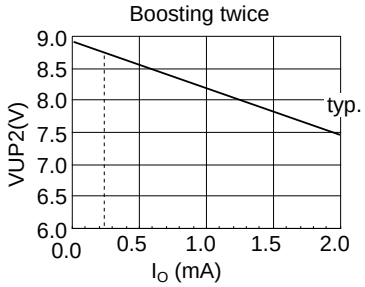


Test condition : Vci=V_{CC}=4.5V,R_f=180kΩ
I_O=0.1mA

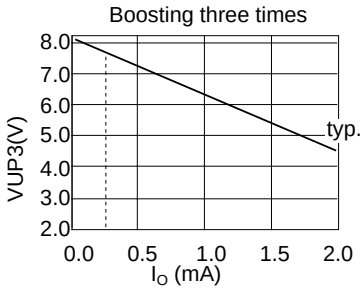


Test condition : Vci=V_{CC}=2.7V, R_f=150kΩ
I_O=0.1mA

(iv) VUP2, VUP3 vs I_O



Test condition : Vci=V_{CC}=4.5V,R_f=180kΩ
Ta=25°C

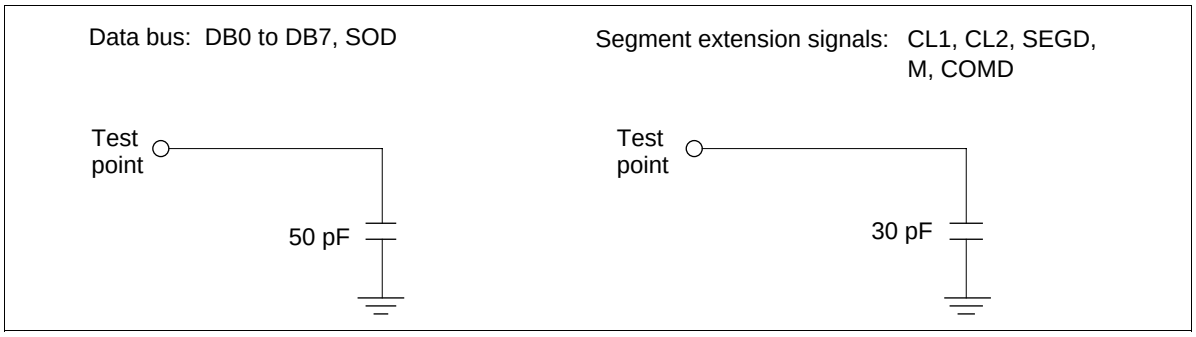


Test condition : Vci=V_{CC}=2.7V, R_f=150kΩ
Ta=25°C

19. Vci ≤ V_{CC} must be maintained.

Load Circuits

AC Characteristics Test Load Circuits



Timing Characteristics

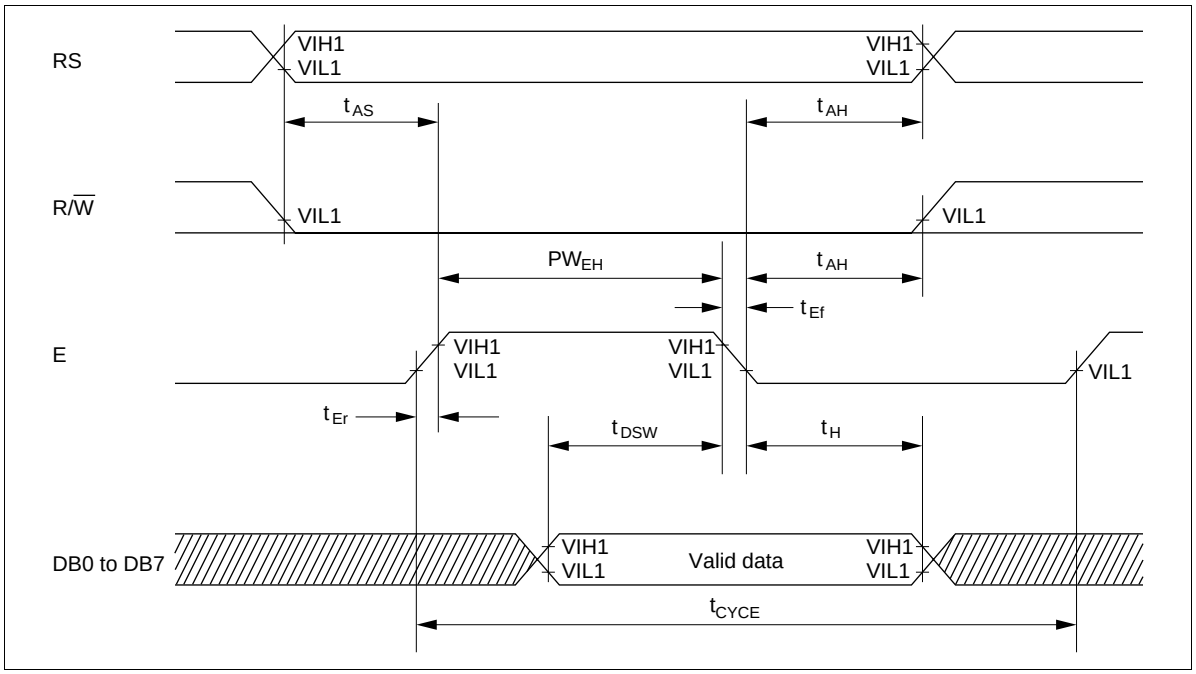


Figure 50 Bus Write Operation

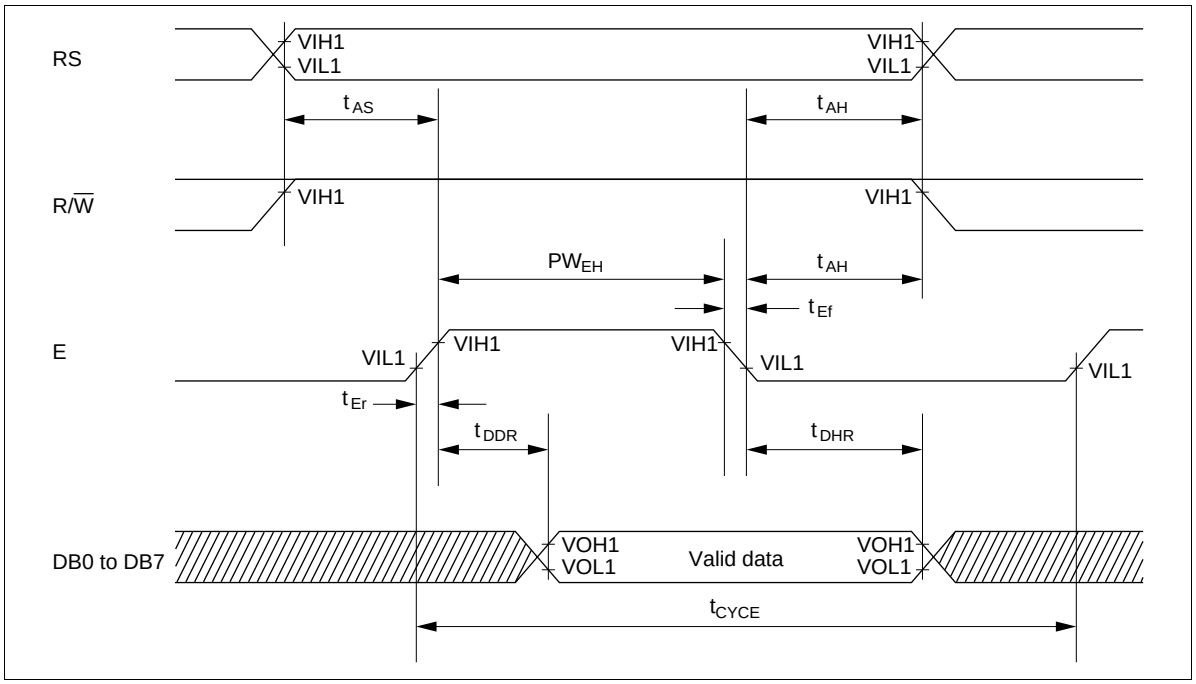


Figure 51 Bus Read Operation

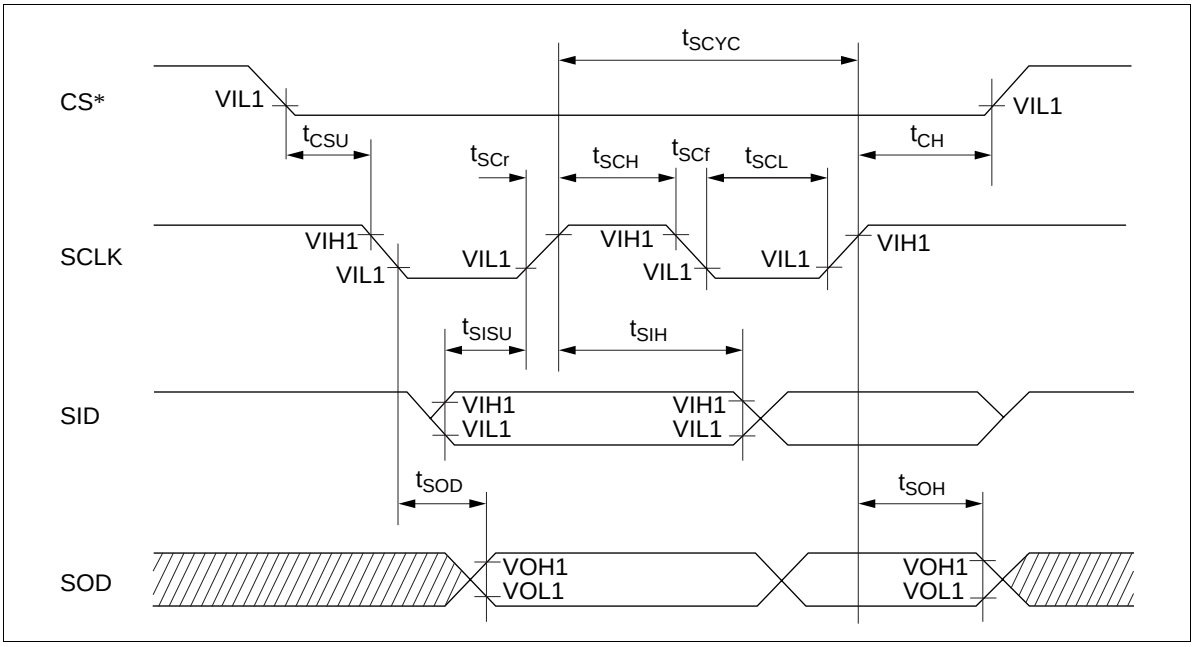


Figure 52 Serial Interface Timing

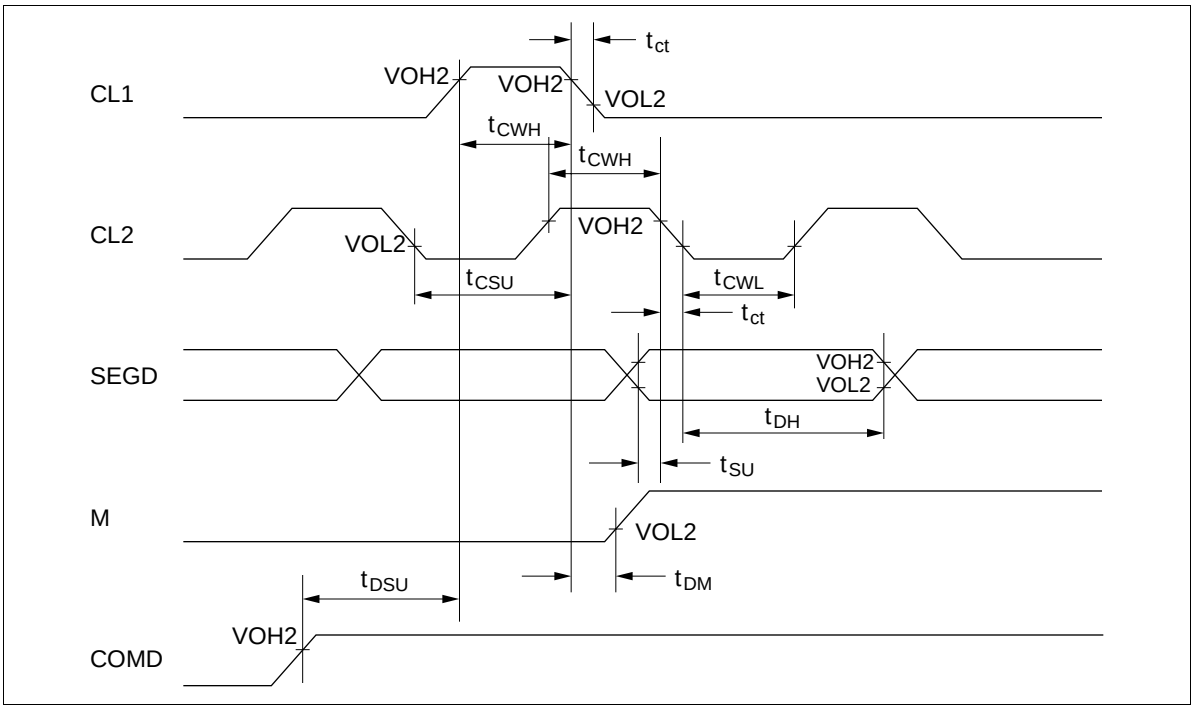


Figure 53 Interface Timing with Extension Driver

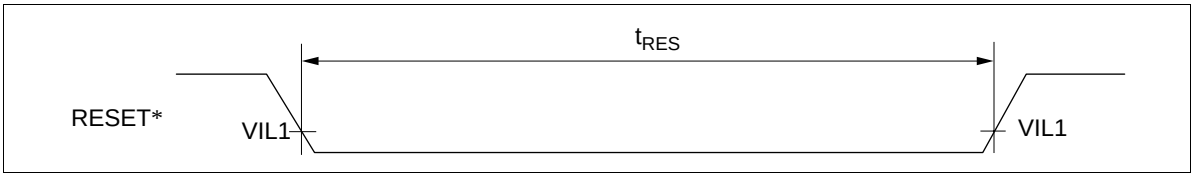
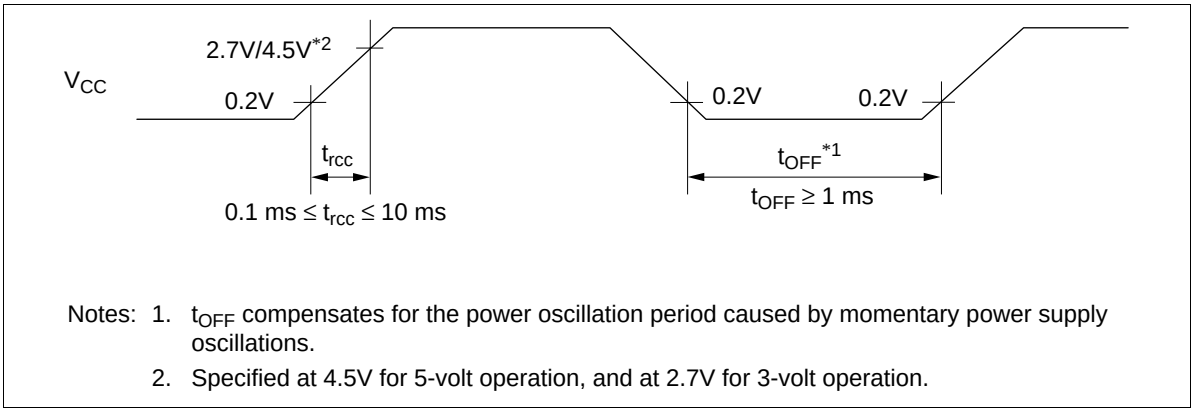


Figure 54 Reset Timing



Notes: 1. t_{OFF} compensates for the power oscillation period caused by momentary power supply oscillations.
2. Specified at 4.5V for 5-volt operation, and at 2.7V for 3-volt operation.

Figure 55 Power Supply Sequence