



# 128-common x 128-segment 4-level Gray Scale BITMAP LCD DRIVER

## ■ GENERAL DESCRIPTION

The **NJU6680** is a 128-common x 128-segment 4-level gray scale bit map LCD driver to display graphics or characters.

It contains 32,768-bit display data RAM, microprocessor interface circuits, instruction decoder, and common and segment drivers.

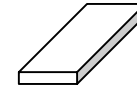
An image data from CPU through the serial or 8-bit parallel interface are stored into the 32,768-bit internal display data RAM and are displayed on the LCD panel through the commons and segments drivers.

The **NJU6680** features 4-level gray scale display function creating 4 types of gray scale (white / light gray / dark gray / black) and black & white display function.

The **NJU6680** contains a built-in OSC circuit for reducing external components. And it features Partial Display Function containing selectable active display block and optimizing the duty cycle ratio. This function dramatically reduces the operating current, setting the optimum boosted voltage combined with a programmable voltage booster circuit and an electrical variable resistor. As result, it reduces the operating current.

The operating voltage from 2.2V to 3.6V and low operating current are suitable for small size battery operation items.

## ■ PACKAGE OUTLINE



NJU6680CL

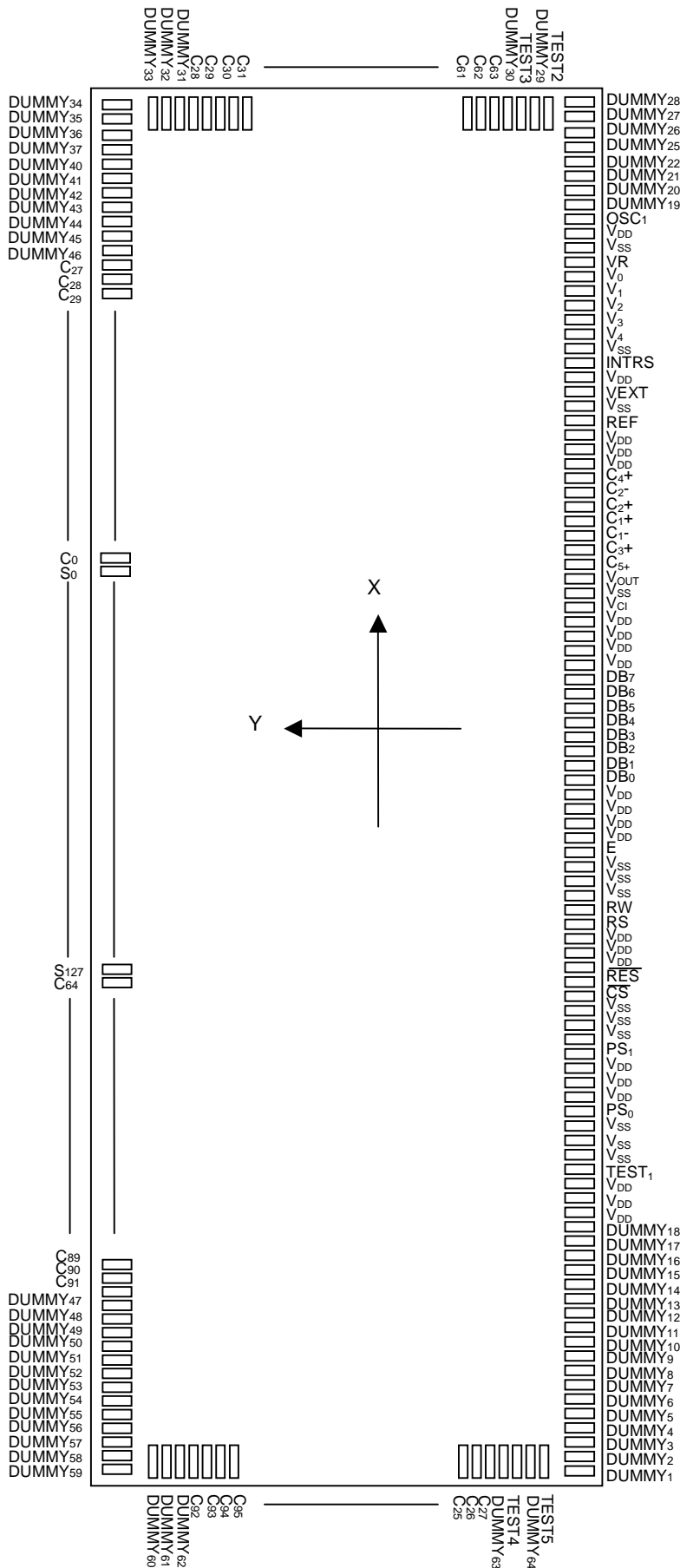
## ■ FEATURES

- Direct Correspondence of Display Data RAM to LCD Pixel
- Display Method – 4-level Gray Scale / Black & White
- Display Data RAM – 32,768 bits ;( 128-Com x 128-Seg) x 2bit
- LCD drivers – 128-common and 128-segment
- Direct connection to 8-bit Microprocessor interface for both of 68 and 80 type MPU
- Serial Interface (SI, SCL, RS, CS)
- Partial Display Function
- Easy Vertical Scroll by setting the start line address of over size display data RAM
- Programmable Bias ratio selection ; 1/5, 1/6, 1/7, 1/8, 1/9, 1/10, 1/11, 1/12 bias
- Useful Instruction Sets
  - Status read, Display data write, Column address set, Page address set, Initial display line set, Initial COM<sub>0</sub> line set, Display ON/OFF, Entire display ON/OFF, Reverse display ON/OFF, N-line inversion set, N-line inversion OFF, ADC select, COM scan direction select, Internal resistor ratio set, Power control set, Partial display duty set, LCD bias set, Boost level set, Contrast level set, Power save mode ON, Power save mode OFF, Internal oscillator ON, Display data length set, Reset, FRC & PWM set, Grey scale mode set Display mode set.
- Power Supply Circuit for LCD; Programmable Booster Circuits (6 times maximum, Voltage boosting polarity : Positive Voltage (V<sub>SS</sub> Common), Voltage Regulator, Voltage Follower (x 4))
- Precision Electrical Variable Resistance (64 Step)
- Low Operating Current  $I_{OUT1}=400\mu A$  (TYP.)
- Operating Voltage 2.2 to 3.6 V
- LCD Driving Voltage 6.0 to 18.0V
- Package Outline Bumped Chip
- C-MOS Technology ( Substrate : P )



# NJU6680

## ■ PAD LOCATION



Chip Center	:X=0μm,Y=0μm
Chip Size	:X=13.11m,Y=3.08mm
Chip Thickness	:675μm +/- 30um
Bump Size	:40μm x 83μm
Pad Pitch	:60μm (min)
Bump Height	:15μm (typ)
Bump Material	:Au
Voltage boosting polarity :	
	Positive Voltage (VSS Common)
Substrate	: P

**■ PAD Coordinates**

Chip Size 13.11×3.08mm(Chip Center X=0μm, Y=0μm)

PAD No.	Terminal	X(μm)	Y(μm)
1	DUMMY <sub>1</sub>	-6302	-1384
2	DUMMY <sub>2</sub>	-6242	-1384
3	DUMMY <sub>3</sub>	-6182	-1384
4	DUMMY <sub>4</sub>	-6122	-1384
5	DUMMY <sub>5</sub>	-6062	-1384
6	DUMMY <sub>6</sub>	-6002	-1384
7	DUMMY <sub>7</sub>	-5942	-1384
8	DUMMY <sub>8</sub>	-5882	-1384
9	DUMMY <sub>9</sub>	-5822	-1384
10	DUMMY <sub>10</sub>	-5762	-1384
11	DUMMY <sub>11</sub>	-5702	-1384
12	DUMMY <sub>12</sub>	-5642	-1384
13	DUMMY <sub>13</sub>	-5582	-1384
14	DUMMY <sub>14</sub>	-5522	-1384
15	DUMMY <sub>15</sub>	-5462	-1384
16	DUMMY <sub>16</sub>	-5402	-1384
17	DUMMY <sub>17</sub>	-5342	-1384
18	DUMMY <sub>18</sub>	-5282	-1384
19	V <sub>DD</sub>	-5222	-1384
20	V <sub>DD</sub>	-5162	-1384
21	V <sub>DD</sub>	-5102	-1384
22	TEST <sub>1</sub>	-4897	-1384
23	V <sub>SS</sub>	-4712	-1384
24	V <sub>SS</sub>	-4652	-1384
25	V <sub>SS</sub>	-4592	-1384
26	PS <sub>0</sub>	-4397	-1384
27	V <sub>DD</sub>	-4209	-1384
28	V <sub>DD</sub>	-4149	-1384
29	V <sub>DD</sub>	-4089	-1384
30	PS <sub>1</sub>	-3892	-1384
31	V <sub>SS</sub>	-3707	-1384
32	V <sub>SS</sub>	-3647	-1384
33	V <sub>SS</sub>	-3587	-1384
34	$\overline{CS}$	-3394	-1384
35	$\overline{RES}$	-3165	-1384
36	V <sub>DD</sub>	-2982	-1384
37	V <sub>DD</sub>	-2922	-1384
38	V <sub>DD</sub>	-2862	-1384
39	RS	-2669	-1384
40	R/W	-2440	-1384
41	V <sub>SS</sub>	-2257	-1384
42	V <sub>SS</sub>	-2197	-1384
43	V <sub>SS</sub>	-2137	-1384
44	E	-1940	-1384
45	V <sub>DD</sub>	-1760	-1384
46	V <sub>DD</sub>	-1700	-1384
47	V <sub>DD</sub>	-1640	-1384
48	V <sub>DD</sub>	-1580	-1384
49	DB <sub>0</sub>	-1370	-1384
50	DB <sub>1</sub>	-1150	-1384

PAD No.	Terminal	X(μm)	Y(μm)
51	DB <sub>2</sub>	-930	-1384
52	DB <sub>3</sub>	-710	-1384
53	DB <sub>4</sub>	-490	-1384
54	DB <sub>5</sub>	-270	-1384
55	DB <sub>6</sub>	-50	-1384
56	DB <sub>7</sub>	170	-1384
57	V <sub>DD</sub>	362	-1384
58	V <sub>DD</sub>	422	-1384
59	V <sub>DD</sub>	482	-1384
60	V <sub>DD</sub>	542	-1384
61	V <sub>CI</sub>	739	-1384
62	V <sub>SS</sub>	957	-1384
63	V <sub>OUT</sub>	1067	-1384
64	C5 <sup>+</sup>	1284	-1384
65	C3 <sup>+</sup>	1547	-1384
66	C1 <sup>-</sup>	1810	-1384
67	C1 <sup>+</sup>	2073	-1384
68	C2 <sup>+</sup>	2336	-1384
69	C2 <sup>-</sup>	2599	-1384
70	C4 <sup>+</sup>	2862	-1384
71	V <sub>DD</sub>	3070	-1384
72	V <sub>DD</sub>	3130	-1384
73	V <sub>DD</sub>	3190	-1384
74	REF	3377	-1384
75	V <sub>SS</sub>	3557	-1384
76	VEXT	3754	-1384
77	V <sub>DD</sub>	3952	-1384
78	INTRS	4132	-1384
79	V <sub>SS</sub>	4315	-1384
80	V <sub>4</sub>	4425	-1384
81	V <sub>3</sub>	4535	-1384
82	V <sub>2</sub>	4645	-1384
83	V <sub>1</sub>	4755	-1384
84	V <sub>0</sub>	4974	-1384
85	VR	5084	-1384
86	V <sub>SS</sub>	5287	-1384
87	V <sub>DD</sub>	5377	-1384
88	OSC <sub>1</sub>	5558	-1384
89	DUMMY <sub>19</sub>	5757	-1384
90	DUMMY <sub>20</sub>	5817	-1384
91	DUMMY <sub>21</sub>	5877	-1384
92	DUMMY <sub>22</sub>	5937	-1384
93	DUMMY <sub>23</sub>	5997	-1384
94	DUMMY <sub>24</sub>	6057	-1384
95	DUMMY <sub>25</sub>	6117	-1384
96	DUMMY <sub>26</sub>	6177	-1384
97	DUMMY <sub>27</sub>	6237	-1384
98	DUMMY <sub>28</sub>	6297	-1384
99	TEST <sub>2</sub>	6400	-1273
100	DUMMY <sub>29</sub>	6400	-1213



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PAD No.	Terminal	X(um)	Y(um)
101	TEST <sub>3</sub>	6400	-1153
102	DUMMY <sub>30</sub>	6400	-1033
103	COM <sub>63</sub>	6400	-973
104	COM <sub>62</sub>	6400	-913
105	COM <sub>61</sub>	6400	-853
106	COM <sub>60</sub>	6400	-793
107	COM <sub>59</sub>	6400	-733
108	COM <sub>58</sub>	6400	-673
109	COM <sub>57</sub>	6400	-613
110	COM <sub>56</sub>	6400	-553
111	COM <sub>55</sub>	6400	-493
112	COM <sub>54</sub>	6400	-433
113	COM <sub>53</sub>	6400	-373
114	COM <sub>52</sub>	6400	-313
115	COM <sub>51</sub>	6400	-253
116	COM <sub>50</sub>	6400	-193
117	COM <sub>49</sub>	6400	-133
118	COM <sub>48</sub>	6400	-73
119	COM <sub>47</sub>	6400	-13
120	COM <sub>46</sub>	6400	47
121	COM <sub>45</sub>	6400	107
122	COM <sub>44</sub>	6400	167
123	COM <sub>43</sub>	6400	227
124	COM <sub>42</sub>	6400	287
125	COM <sub>41</sub>	6400	347
126	COM <sub>40</sub>	6400	407
127	COM <sub>39</sub>	6400	467
128	COM <sub>38</sub>	6400	527
129	COM <sub>37</sub>	6400	587
130	COM <sub>36</sub>	6400	647
131	COM <sub>35</sub>	6400	707
132	COM <sub>34</sub>	6400	767
133	COM <sub>33</sub>	6400	827
134	COM <sub>32</sub>	6400	887
135	COM <sub>31</sub>	6400	947
136	COM <sub>30</sub>	6400	1007
137	COM <sub>29</sub>	6400	1067
138	COM <sub>28</sub>	6400	1127
139	DUMMY <sub>31</sub>	6400	1187
140	DUMMY <sub>32</sub>	6400	1247
141	DUMMY <sub>33</sub>	6400	1307
142	DUMMY <sub>34</sub>	6270	1384
143	DUMMY <sub>35</sub>	6210	1384
144	DUMMY <sub>36</sub>	6150	1384
145	DUMMY <sub>37</sub>	6090	1384
146	DUMMY <sub>38</sub>	6030	1384
147	DUMMY <sub>39</sub>	5970	1384
148	DUMMY <sub>40</sub>	5910	1384
149	DUMMY <sub>41</sub>	5850	1384
150	DUMMY <sub>42</sub>	5790	1384

PAD No.	Terminal	X(um)	Y(um)
151	DUMMY <sub>43</sub>	5730	1384
152	DUMMY <sub>44</sub>	5670	1384
153	DUMMY <sub>45</sub>	5610	1384
154	DUMMY <sub>46</sub>	5550	1384
155	COM <sub>27</sub>	5490	1384
156	COM <sub>26</sub>	5430	1384
157	COM <sub>25</sub>	5370	1384
158	COM <sub>24</sub>	5310	1384
159	COM <sub>23</sub>	5250	1384
160	COM <sub>22</sub>	5190	1384
161	COM <sub>21</sub>	5130	1384
162	COM <sub>20</sub>	5070	1384
163	COM <sub>19</sub>	5010	1384
164	COM <sub>18</sub>	4950	1384
165	COM <sub>17</sub>	4890	1384
166	COM <sub>16</sub>	4830	1384
167	COM <sub>15</sub>	4770	1384
168	COM <sub>14</sub>	4710	1384
169	COM <sub>13</sub>	4650	1384
170	COM <sub>12</sub>	4590	1384
171	COM <sub>11</sub>	4530	1384
172	COM <sub>10</sub>	4470	1384
173	COM <sub>9</sub>	4410	1384
174	COM <sub>8</sub>	4350	1384
175	COM <sub>7</sub>	4290	1384
176	COM <sub>6</sub>	4230	1384
177	COM <sub>5</sub>	4170	1384
178	COM <sub>4</sub>	4110	1384
179	COM <sub>3</sub>	4050	1384
180	COM <sub>2</sub>	3990	1384
181	COM <sub>1</sub>	3930	1384
182	COM <sub>0</sub>	3870	1384
183	SEG <sub>0</sub>	3810	1384
184	SEG <sub>1</sub>	3750	1384
185	SEG <sub>2</sub>	3690	1384
186	SEG <sub>3</sub>	3630	1384
187	SEG <sub>4</sub>	3570	1384
188	SEG <sub>5</sub>	3510	1384
189	SEG <sub>6</sub>	3450	1384
190	SEG <sub>7</sub>	3390	1384
191	SEG <sub>8</sub>	3330	1384
192	SEG <sub>9</sub>	3270	1384
193	SEG <sub>10</sub>	3210	1384
194	SEG <sub>11</sub>	3150	1384
195	SEG <sub>12</sub>	3090	1384
196	SEG <sub>13</sub>	3030	1384
197	SEG <sub>14</sub>	2970	1384
198	SEG <sub>15</sub>	2910	1384
199	SEG <sub>16</sub>	2850	1384
200	SEG <sub>17</sub>	2790	1384



PAD No.	Terminal	X(um)	Y(um)
201	SEG <sub>18</sub>	2730	1384
202	SEG <sub>19</sub>	2670	1384
203	SEG <sub>20</sub>	2610	1384
204	SEG <sub>21</sub>	2550	1384
205	SEG <sub>22</sub>	2490	1384
206	SEG <sub>23</sub>	2430	1384
207	SEG <sub>24</sub>	2370	1384
208	SEG <sub>25</sub>	2310	1384
209	SEG <sub>26</sub>	2250	1384
210	SEG <sub>27</sub>	2190	1384
211	SEG <sub>28</sub>	2130	1384
212	SEG <sub>29</sub>	2070	1384
213	SEG <sub>30</sub>	2010	1384
214	SEG <sub>31</sub>	1950	1384
215	SEG <sub>32</sub>	1890	1384
216	SEG <sub>33</sub>	1830	1384
217	SEG <sub>34</sub>	1770	1384
218	SEG <sub>35</sub>	1710	1384
219	SEG <sub>36</sub>	1650	1384
220	SEG <sub>37</sub>	1590	1384
221	SEG <sub>38</sub>	1530	1384
222	SEG <sub>39</sub>	1470	1384
223	SEG <sub>40</sub>	1410	1384
224	SEG <sub>41</sub>	1350	1384
225	SEG <sub>42</sub>	1290	1384
226	SEG <sub>43</sub>	1230	1384
227	SEG <sub>44</sub>	1170	1384
228	SEG <sub>45</sub>	1110	1384
229	SEG <sub>46</sub>	1050	1384
230	SEG <sub>47</sub>	990	1384
231	SEG <sub>48</sub>	930	1384
232	SEG <sub>49</sub>	870	1384
233	SEG <sub>50</sub>	810	1384
234	SEG <sub>51</sub>	750	1384
235	SEG <sub>52</sub>	690	1384
236	SEG <sub>53</sub>	630	1384
237	SEG <sub>54</sub>	570	1384
238	SEG <sub>55</sub>	510	1384
239	SEG <sub>56</sub>	450	1384
240	SEG <sub>57</sub>	390	1384
241	SEG <sub>58</sub>	330	1384
242	SEG <sub>59</sub>	270	1384
243	SEG <sub>60</sub>	210	1384
244	SEG <sub>61</sub>	150	1384
245	SEG <sub>62</sub>	90	1384
246	SEG <sub>63</sub>	30	1384
247	SEG <sub>64</sub>	-30	1384
248	SEG <sub>65</sub>	-90	1384
249	SEG <sub>66</sub>	-150	1384
250	SEG <sub>67</sub>	-210	1384

PAD No.	Terminal	X(um)	Y(um)
251	SEG <sub>68</sub>	-270	1384
252	SEG <sub>69</sub>	-330	1384
253	SEG <sub>70</sub>	-390	1384
254	SEG <sub>71</sub>	-450	1384
255	SEG <sub>72</sub>	-510	1384
256	SEG <sub>73</sub>	-570	1384
257	SEG <sub>74</sub>	-630	1384
258	SEG <sub>75</sub>	-690	1384
259	SEG <sub>76</sub>	-750	1384
260	SEG <sub>77</sub>	-810	1384
261	SEG <sub>78</sub>	-870	1384
262	SEG <sub>79</sub>	-930	1384
263	SEG <sub>80</sub>	-990	1384
264	SEG <sub>81</sub>	-1050	1384
265	SEG <sub>82</sub>	-1110	1384
266	SEG <sub>83</sub>	-1170	1384
267	SEG <sub>84</sub>	-1230	1384
268	SEG <sub>85</sub>	-1290	1384
269	SEG <sub>86</sub>	-1350	1384
270	SEG <sub>87</sub>	-1410	1384
271	SEG <sub>88</sub>	-1470	1384
272	SEG <sub>89</sub>	-1530	1384
273	SEG <sub>90</sub>	-1590	1384
274	SEG <sub>91</sub>	-1650	1384
275	SEG <sub>92</sub>	-1710	1384
276	SEG <sub>93</sub>	-1770	1384
277	SEG <sub>94</sub>	-1830	1384
278	SEG <sub>95</sub>	-1890	1384
279	SEG <sub>96</sub>	-1950	1384
280	SEG <sub>97</sub>	-2010	1384
281	SEG <sub>98</sub>	-2070	1384
282	SEG <sub>99</sub>	-2130	1384
283	SEG <sub>100</sub>	-2190	1384
284	SEG <sub>101</sub>	-2250	1384
285	SEG <sub>102</sub>	-2310	1384
286	SEG <sub>103</sub>	-2370	1384
287	SEG <sub>104</sub>	-2430	1384
288	SEG <sub>105</sub>	-2490	1384
289	SEG <sub>106</sub>	-2550	1384
290	SEG <sub>107</sub>	-2610	1384
291	SEG <sub>108</sub>	-2670	1384
292	SEG <sub>109</sub>	-2730	1384
293	SEG <sub>110</sub>	-2790	1384
294	SEG <sub>111</sub>	-2850	1384
295	SEG <sub>112</sub>	-2910	1384
296	SEG <sub>113</sub>	-2970	1384
297	SEG <sub>114</sub>	-3030	1384
298	SEG <sub>115</sub>	-3090	1384
299	SEG <sub>116</sub>	-3150	1384
300	SEG <sub>117</sub>	-3210	1384



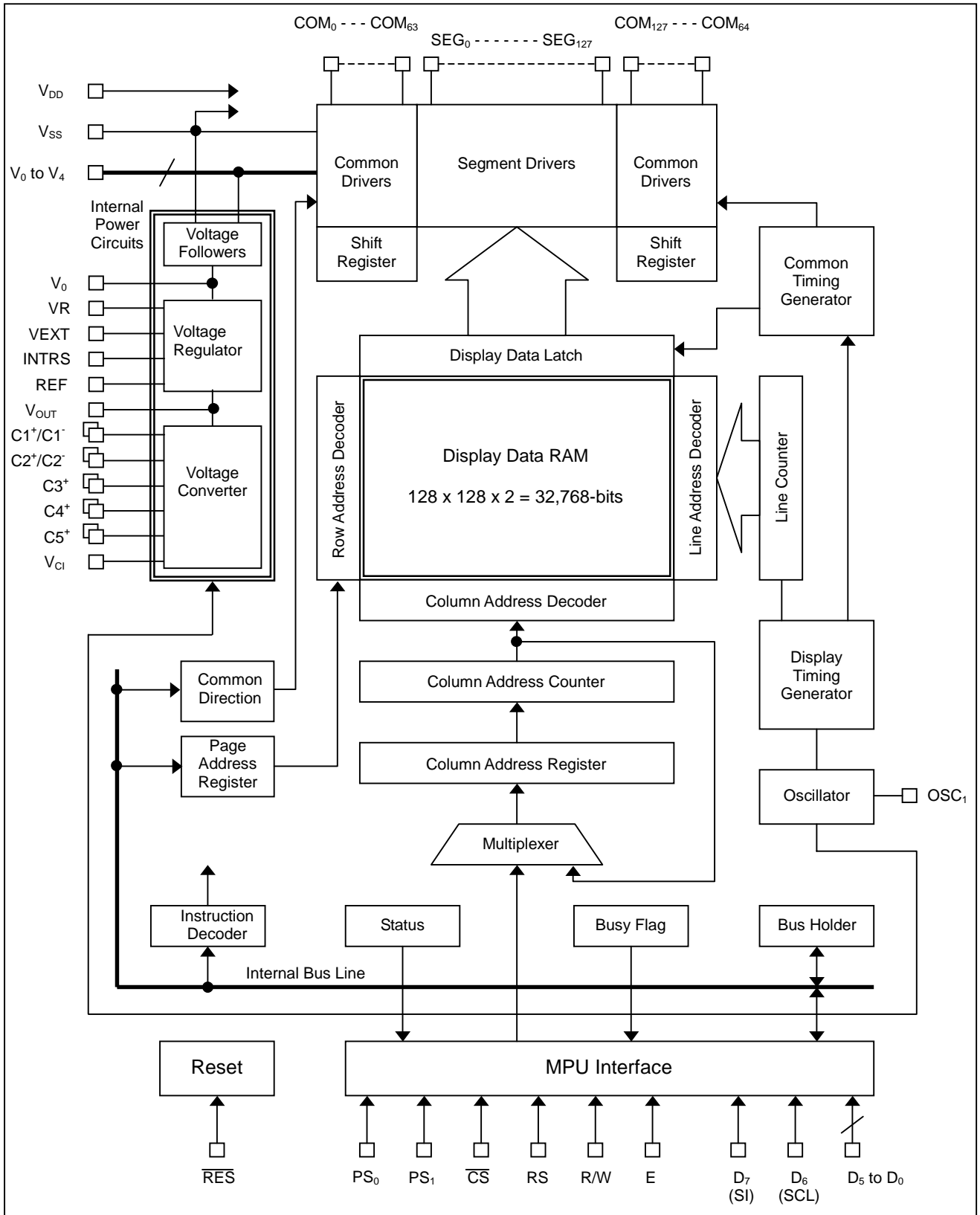
# NJU6680

PAD No.	Terminal	X(um)	Y(um)
301	SEG <sub>118</sub>	-3270	1384
302	SEG <sub>119</sub>	-3330	1384
303	SEG <sub>120</sub>	-3390	1384
304	SEG <sub>121</sub>	-3450	1384
305	SEG <sub>122</sub>	-3510	1384
306	SEG <sub>123</sub>	-3570	1384
307	SEG <sub>124</sub>	-3630	1384
308	SEG <sub>125</sub>	-3690	1384
309	SEG <sub>126</sub>	-3750	1384
310	SEG <sub>127</sub>	-3810	1384
311	COM <sub>64</sub>	-3870	1384
312	COM <sub>65</sub>	-3930	1384
313	COM <sub>66</sub>	-3990	1384
314	COM <sub>67</sub>	-4050	1384
315	COM <sub>68</sub>	-4110	1384
316	COM <sub>69</sub>	-4170	1384
317	COM <sub>70</sub>	-4230	1384
318	COM <sub>71</sub>	-4290	1384
319	COM <sub>72</sub>	-4350	1384
320	COM <sub>73</sub>	-4410	1384
321	COM <sub>74</sub>	-4470	1384
322	COM <sub>75</sub>	-4530	1384
323	COM <sub>76</sub>	-4590	1384
324	COM <sub>77</sub>	-4650	1384
325	COM <sub>78</sub>	-4710	1384
326	COM <sub>79</sub>	-4770	1384
327	COM <sub>80</sub>	-4830	1384
328	COM <sub>81</sub>	-4890	1384
329	COM <sub>82</sub>	-4950	1384
330	COM <sub>83</sub>	-5010	1384
331	COM <sub>84</sub>	-5070	1384
332	COM <sub>85</sub>	-5130	1384
333	COM <sub>86</sub>	-5190	1384
334	COM <sub>87</sub>	-5250	1384
335	COM <sub>88</sub>	-5310	1384
336	COM <sub>89</sub>	-5370	1384
337	COM <sub>90</sub>	-5430	1384
338	COM <sub>91</sub>	-5490	1384
339	DUMMY <sub>47</sub>	-5550	1384
340	DUMMY <sub>48</sub>	-5610	1384
341	DUMMY <sub>49</sub>	-5670	1384
342	DUMMY <sub>50</sub>	-5730	1384
343	DUMMY <sub>51</sub>	-5790	1384
344	DUMMY <sub>52</sub>	-5850	1384
345	DUMMY <sub>53</sub>	-5910	1384
346	DUMMY <sub>54</sub>	-5970	1384
347	DUMMY <sub>55</sub>	-6030	1384
348	DUMMY <sub>56</sub>	-6090	1384
349	DUMMY <sub>57</sub>	-6150	1384
350	DUMMY <sub>58</sub>	-6210	1384

PAD No.	Terminal	X(um)	Y(um)
351	DUMMY <sub>59</sub>	-6270	1384
352	DUMMY <sub>60</sub>	-6400	1307
353	DUMMY <sub>61</sub>	-6400	1247
354	DUMMY <sub>62</sub>	-6400	1187
355	COM <sub>92</sub>	-6400	1127
356	COM <sub>93</sub>	-6400	1067
357	COM <sub>94</sub>	-6400	1007
358	COM <sub>95</sub>	-6400	947
359	COM <sub>96</sub>	-6400	887
360	COM <sub>97</sub>	-6400	827
361	COM <sub>98</sub>	-6400	767
362	COM <sub>99</sub>	-6400	707
363	COM <sub>100</sub>	-6400	647
364	COM <sub>101</sub>	-6400	587
365	COM <sub>102</sub>	-6400	527
366	COM <sub>103</sub>	-6400	467
367	COM <sub>104</sub>	-6400	407
368	COM <sub>105</sub>	-6400	347
369	COM <sub>106</sub>	-6400	287
370	COM <sub>107</sub>	-6400	227
371	COM <sub>108</sub>	-6400	167
372	COM <sub>109</sub>	-6400	107
373	COM <sub>110</sub>	-6400	47
374	COM <sub>111</sub>	-6400	-13
375	COM <sub>112</sub>	-6400	-73
376	COM <sub>113</sub>	-6400	-133
377	COM <sub>114</sub>	-6400	-193
378	COM <sub>115</sub>	-6400	-253
379	COM <sub>116</sub>	-6400	-313
380	COM <sub>117</sub>	-6400	-373
381	COM <sub>118</sub>	-6400	-433
382	COM <sub>119</sub>	-6400	-493
383	COM <sub>120</sub>	-6400	-553
384	COM <sub>121</sub>	-6400	-613
385	COM <sub>122</sub>	-6400	-673
386	COM <sub>123</sub>	-6400	-733
387	COM <sub>124</sub>	-6400	-793
388	COM <sub>125</sub>	-6400	-853
389	COM <sub>126</sub>	-6400	-913
390	COM <sub>127</sub>	-6400	-973
391	DUMMY <sub>63</sub>	-6400	-1033
392	TEST <sub>4</sub>	-6400	-1153
393	DUMMY <sub>64</sub>	-6400	-1213
394	TEST <sub>5</sub>	-6400	-1273



## ■ BLOCK DIAGRAM





# NJU6680

## ■ TERMINAL DESCRIPTION

### • Power Supply

No.	Terminal	Description
19-21, 27-29, 36-38, 45-48, 57-60, 71-73, 77,87	V <sub>DD</sub>	Power Supply
23-25, 31-33, 41-43, 62,75, 79,86	V <sub>SS</sub>	Ground, 0V

### • Internal Power Circuits

No.	Terminal	Description
61	V <sub>CI</sub>	Voltage converter input terminal
63	V <sub>OUT</sub>	Voltage converter output terminal
84 83 82 81 80	V <sub>0</sub> V <sub>1</sub> V <sub>2</sub> V <sub>3</sub> V <sub>4</sub>	LCD driving voltage terminals <ul style="list-style-type: none"> <li>• When the internal power circuits are used, the LCD driving voltages (V<sub>0</sub> to V<sub>4</sub>) are enabled by the "Power control set" instruction and an LCD bias ratio is selected by the "LCD bias set" instruction.</li> <li>• When the internal power circuits are not used, the external voltages (V<sub>0</sub> to V<sub>4</sub>) are required on these terminals. The external voltages should be maintained in the relationship: V<sub>SS</sub> ≤ V<sub>4</sub> ≤ V<sub>3</sub> ≤ V<sub>2</sub> ≤ V<sub>1</sub> ≤ V<sub>0</sub>.</li> </ul>
67 66	C1 <sup>+</sup> C1 <sup>-</sup>	Capacitor terminals for voltage converter
68 69	C2 <sup>+</sup> C2 <sup>-</sup>	Capacitor terminals for voltage converter
65	C3 <sup>+</sup>	Capacitor terminal for voltage converter
70	C4 <sup>+</sup>	Capacitor terminal for voltage converter
64	C5 <sup>+</sup>	Capacitor terminal for voltage converter
85	VR	V <sub>0</sub> voltage adjustment terminal
74	REF	Internal or external reference voltage select terminal "H": Internal "L": External
76	VEXT	External reference voltage input terminal <ul style="list-style-type: none"> <li>• This terminal is valid when the REF terminal is connected to "L".</li> </ul>
78	INTRS	Internal resistor select terminal "H": Internal "L": External





## • MPU Interface Circuits

No.	Terminal	Description
26	PS <sub>0</sub>	Parallel or serial interface select terminal PS <sub>0</sub> ="L", PS <sub>1</sub> ="L": 3-line serial PS <sub>0</sub> ="L", PS <sub>1</sub> ="H": 4-line serial PS <sub>0</sub> ="H", PS <sub>1</sub> ="L": 80 type MPU parallel interface PS <sub>0</sub> ="H", PS <sub>1</sub> ="H": 68 type MPU parallel interface
30	PS <sub>1</sub>	
34	$\overline{CS}$	Chip select terminal Active "L"
56-49	D <sub>7</sub> -D <sub>0</sub>	Data bus terminals Parallel interface: D <sub>7</sub> to D <sub>0</sub> Serial interface: SI (D <sub>7</sub> terminal), SCL (D <sub>6</sub> terminal)
39	RS	Register select terminal • This signal distinguishes instruction data or display data when the LSI is used in the 4-line serial or parallel interface mode. RS="H": D <sub>7</sub> to D <sub>0</sub> are Display data RS="L": D <sub>7</sub> to D <sub>0</sub> are Instruction data
44	E (RD)	68 type MPU: Active "H" 80 type MPU: Active "L"
40	R/W (WR)	68 type MPU: R/W="H": Read operation R/W="L": Write operation 80 type MPU: Active "L"
35	$\overline{RES}$	Reset terminal Active "L"
88	OSC <sub>1</sub>	OSC terminal • When the internal oscillator is used, the external resistor, R <sub>f</sub> , is required between this terminal and the V <sub>DD</sub> . R <sub>f</sub> =270kΩ: Frame frequency=165Hz (typ.)

## • LCD drivers

No.	Terminal	Description
182-155, 138-103, 311-338, 355-390	COM <sub>0</sub> -- COM <sub>127</sub>	Common (row) drivers COM <sub>0</sub> -COM <sub>127</sub>
182-310	SEG <sub>0</sub> -- SEG <sub>127</sub>	Segment (column) drivers SEG <sub>0</sub> -SEG <sub>127</sub>

## • Dummy

No.	Terminal	Description
1-18, 89-98, 100,102 139-154, 339-354, 391,393	DUMMY <sub>1</sub> -- DUMMY <sub>64</sub>	No connections. Dummy pads

## • Test terminals

No.	Terminal	Description
22,99, 101,392, 394	TEST <sub>1</sub> -- TEST <sub>5</sub>	No connections. Used for maker test



# NJU6680

## ■ Functional Description

### (1) Description of each blocks

#### (1-1) Busy Flag (BF)

The BF is used to indicate whether the LSI is busy or not. During the busy status, the LSI cannot accept any instruction except the "Status read" instruction, which reads out the BF through the D<sub>7</sub> terminal. When the cycle time (tcyc) mentioned in "AC characteristics" is satisfied, the BF is not required after each instruction so that it is possible to improve the process performance of an MPU.

#### (1-2) Initial display line register

The initial display line register is used to specify the DDRAM line address corresponding to the COM<sub>0</sub> by the "Initial display line set" instruction. It is used not only for normal display but also vertical scrolling and page switching displays without changing the display data in the DDRAM.

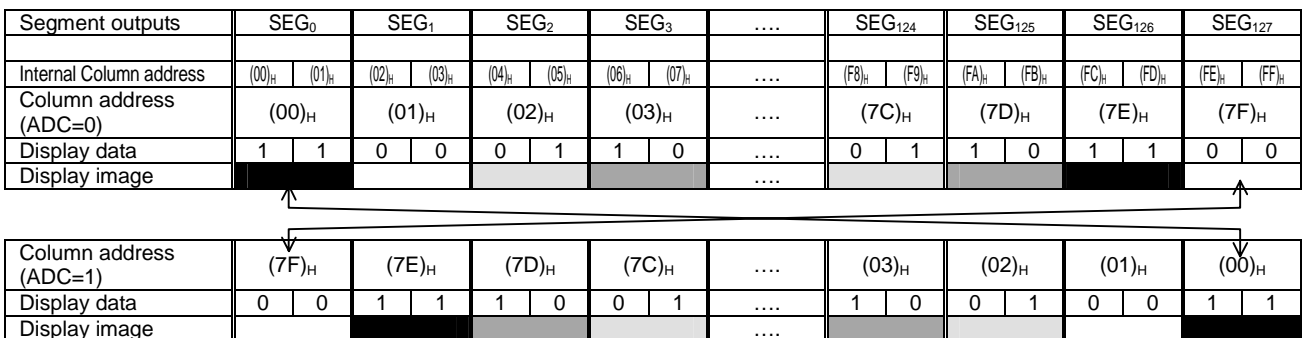
#### (1-3) Line Counter

The line counter is used to provide the DDRAM line address. The line address is initialized whenever the polarity of an internal frame signal (FR) is switched, and then it is counted up in synchronization of a common timing signal.

#### (1-4) Column Address Counter

An MPU can access only 7-bit [C6:C0] "column address" by the "Column address LSB set" and "Column address MSB set" instructions. When both 4-bit LSB and 3-bit MSB data is set into the column address register, 8-bit "internal column address" is established in the LSI as illustrated in the following figure, and accordingly, 2-bit display data must be written for each pixel with two successive bytes.

The column address automatically increases by 1 (+1) after each 2-byte display data and wraps around to the column address (00)<sub>H</sub> in the same page after the last column is addressed. The assignment of the column address for the segment drivers can be reversed by the "ADC set" instruction.



#### (1-5) Page Address Register

The page address register is used to provide the DD RAM page address.

#### (1-6) Display data RAM (DD RAM)

The Display data RAM (DD RAM) is the bit map RAM consisting of 32,768-bit to store the display data corresponding to 128x128 pixels on LCD panel. Each LCD pixel corresponds to two bits in the display data RAM in gray scale mode and to one bit in black & white mode, display data respectively.

The DD RAM data : "00" = Gray Scale Level 0 ( Set by the "Gray Scale Level Select" instruction)

The DD RAM data : "01" = Gray Scale Level 1 ( " )

The DD RAM data : "10" = Gray Scale Level 2 ( " )

The DD RAM data : "11" = Gray Scale Level 3 ( " )

The DD RAM data and the state of the LCD in Black & White Mode:

In Normal Display : "1"=Turn-On Display, "0" =Turn-Off Display

In Reverse Display : "1"=Turn-Off Display, "0" =Turn-On Display

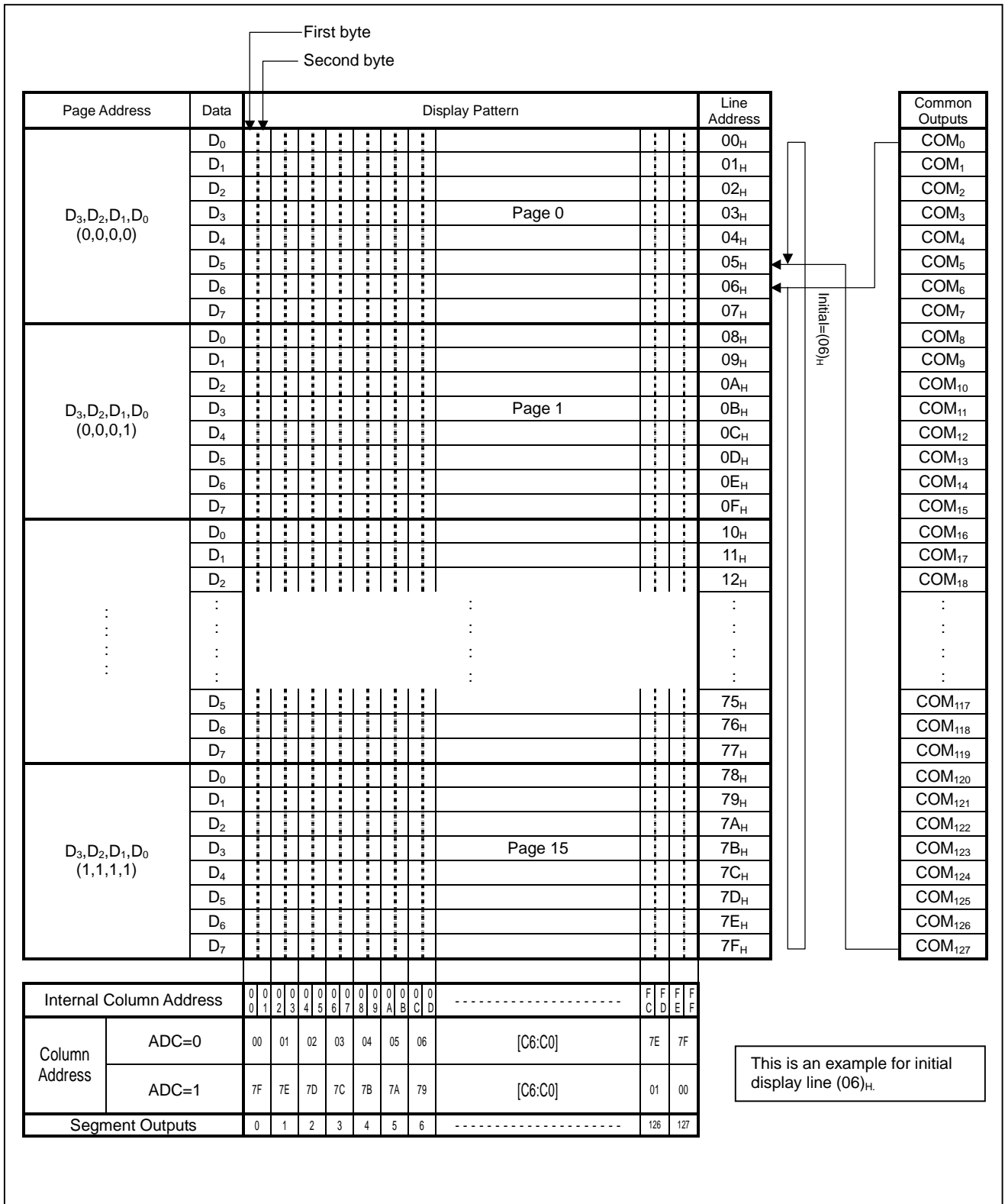


Fig.1 Display data RAM (DDRAM) Map



# NJU6680

## (1-7) Common Direction Register

The common direction register is used to select a common scan direction by setting the  $S_0$  in the "COM scan direction select" instruction.

$S_0$	COM scan direction
0	COM <sub>0</sub> to COM <sub>127</sub>
1	COM <sub>127</sub> to COM <sub>0</sub>

## (1-8) Reset Circuit

The reset circuit is used to initialize the LSI to the following default status by setting the  $\overline{RES}$  terminal to "0" level.

Default status by using of the  $\overline{RES}$  terminal

1. Page address : (0) page
2. Column address : (00)<sub>H</sub>
3. COM scan direction :  $S_0=0$
4. ADC select :  $S_0=0$
5. Initial display line : (00)<sub>H</sub>
6. Initial COM0 line : (00)<sub>H</sub>
7. Display ON/OFF : OFF
8. Reverse display ON/OFF : OFF
9. Entire display ON/OFF : OFF
10. N-line inversion ON/OFF : OFF
11. Partial display duty ratio : 1/128 duty
12. Power control register : (VC,VR,VF)=(0,0,0)
13. Boost level : 3x boost
14. Contrast level : 32 level
15. LCD bias : 1/12 bias
16. Internal resistor ratio :  $1+R_b/R_a=2.3$
17. Internal oscillator ON/OFF : OFF
18. Power save mode ON/OFF : OFF
19. Display data length : (0,0,0,0)
20. White mode set : OFF
21. White palette register : (0,0,0,0)
22. Light gray mode set : OFF
23. Light gray palette register : (0,0,0,0)
24. Dark gray mode set : OFF
25. Dark gray palette register : (1,1,1,1)
26. Black mode set : OFF
27. Black palette register : (1,1,1,1)
28. FRC & PWM mode : 4-frame, 9-level
29. Display mode set : Gray scale mode

The  $\overline{RES}$  terminal is usually connected to the MPU's reset terminal in order that the LSI is initialized at the same timing of the MPU reset. The reset time must be at least 10us or longer, as mentioned in "DC characteristics". The LSI will return to normal operation after about 1us from the rising edge of the rest signal. In case that an external power supply is used for the LCD driving voltage, the  $\overline{RES}$  terminal is required to be maintained in the "0" level when the external power supply is turned on.

The "Reset" instruction in Table 3 cannot be substituted for the reset operation by the  $\overline{RES}$  terminal. It can execute only 1,2,5,14,16,19 to 28 items listed above.

**(1-9) LCD display circuits****(a) Common and segment drivers**

The common and segment drivers are used to generate LCD driving waveforms in accordance with the combination of display data, common timing signal (CL) and internal frame signal (FL).

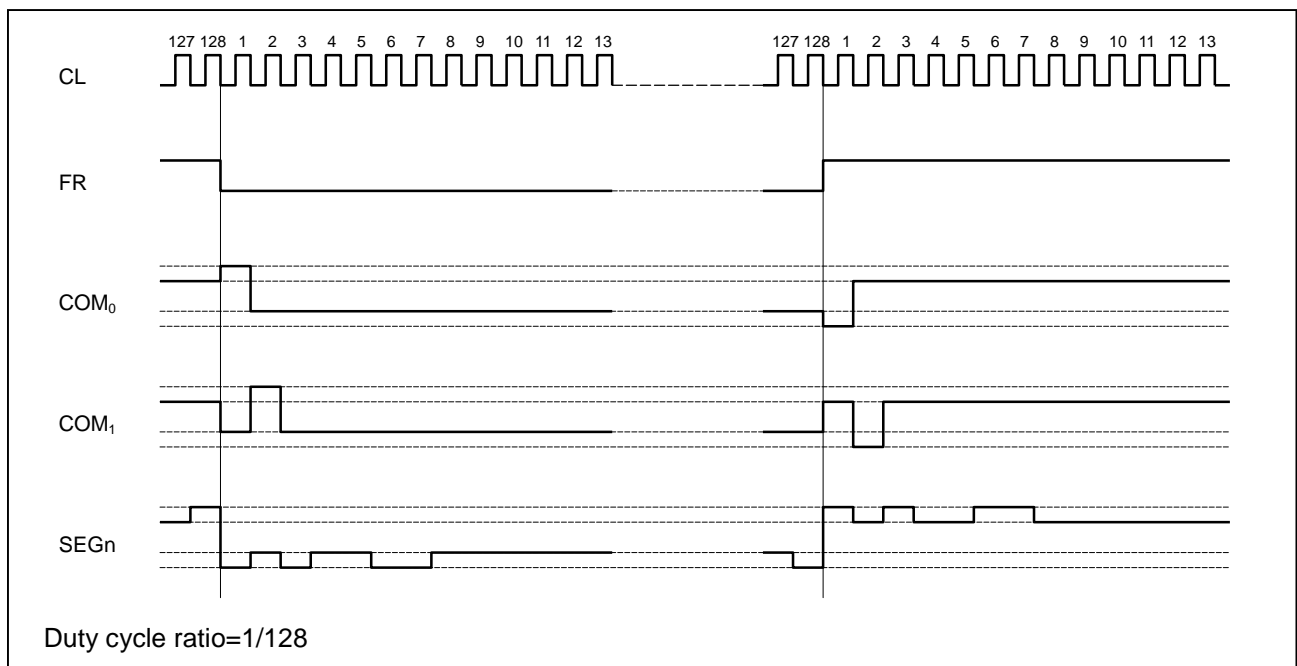
**(b) Display timing generator**

The display timing generator is used to generate the common timing signal (CL) and the internal frame signal (FR). The FR signal adopts the 2-frame AC driving method, in which the FR signal is toggled to alternate the crystal polarization on an LCD panel. It toggles on every frame in the default setting or once every N frames in the N-line inversion mode setting, as illustrated in Fig.2-1 and Fig.2-2.

**(c) Display Data Latch Circuit**

The display data latch circuit is used to temporarily store the 128-bit display data transferred from the DDRAM and output these display data onto the segment drivers in synchronization of the CL signal. The output timing for the display data, from display latch circuits to segment drivers, is independent of the access timing from MPU to DDRAM. As a result, the LCD display is not affected by the DDRAM access.

The “Display ON/OFF”, “Reverse display ON/OFF” and “Entire display ON/OFF” instructions control the display data in the display data latch circuit, however they do not change the display data in the DDRAM.

**Fig.2-1 LCD driving Waveforms**



# NJU6680

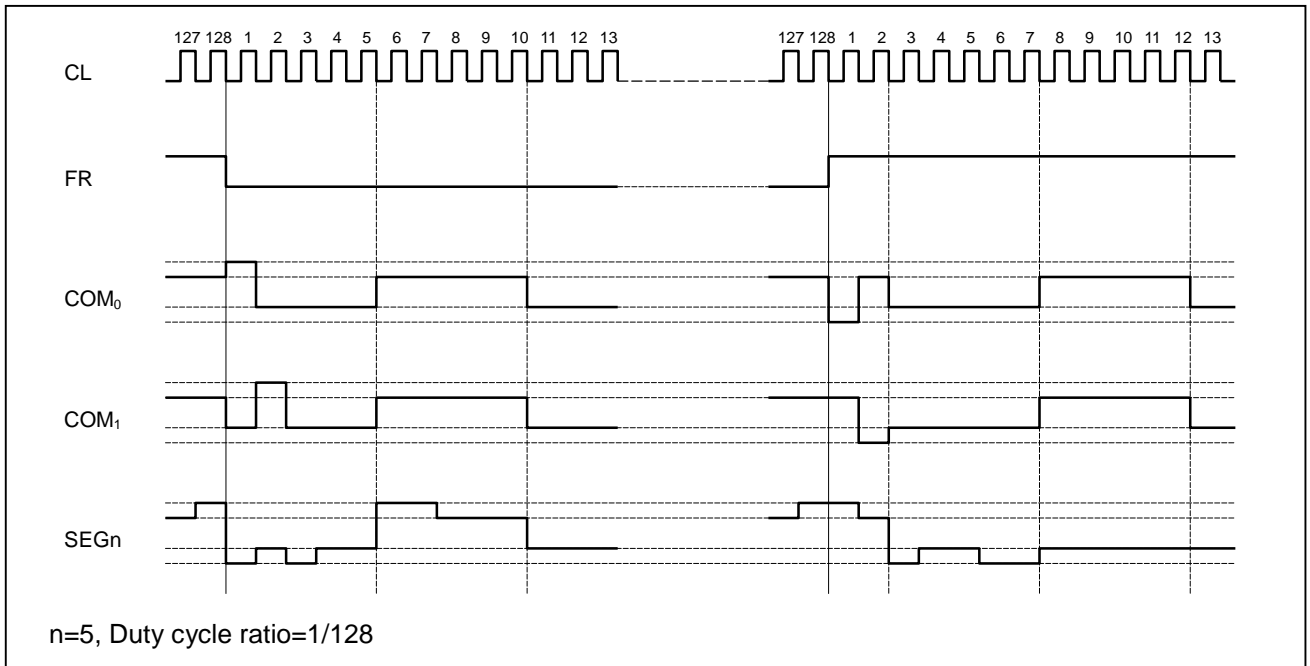


Fig. 2-2. LCD driving waveforms in the n-line inversion mode

(d) Oscillator

The internal oscillator is used to create internal clocks for the display timing signals (CL, FR) and the voltage converter.

**(e) Internal Power Circuits**

The internal power circuits are composed of the voltage converter, voltage regulator with 64-level EVR, and voltage followers. The status of the internal power circuits is arranged by the "Power control set" instruction, as shown in Table 1. For this arrangement, the part of the internal power circuits can be used in combination with an external power supply, as shown in Table 2.

The internal power circuits require the optimum values for the passive components, such as  $V_0$  to  $V_4$  capacitors and external feedback resistors in accordance with an LCD panel; and accordingly should be evaluated by using of actual LCD module samples to decide these values.

Table 1. Power control set

Bits	Portions	Status	
		1: ON	0: OFF
VC	Voltage converter	1: ON	0: OFF
VR	Voltage regulator	1: ON	0: OFF
VF	Voltage followers	1: ON	0: OFF

Table 2. Power supply combinations

Combination	Instruction			Power supply circuits			Output terminals		
	VC	VR	VF	Voltage converter	Voltage regulator	Voltage followers	$V_{OUT}$	$V_0$	$V_1-V_4$
Using all internal power circuits	1	1	1	ON	ON	ON	Open	Open	Open
Using voltage regulator and voltage followers	0	1	1	OFF	ON	ON	External	Open	Open
Using voltage followers	0	0	1	OFF	OFF	ON	Open	External	Open
Using only external power Supply	0	0	0	OFF	OFF	OFF	Open	External	External

Note) De coupling capacitors on the  $V_0$  to  $V_4$  terminals are required when the voltage followers are enabled.



# NJU6680

## ● Power Supply Circuits example

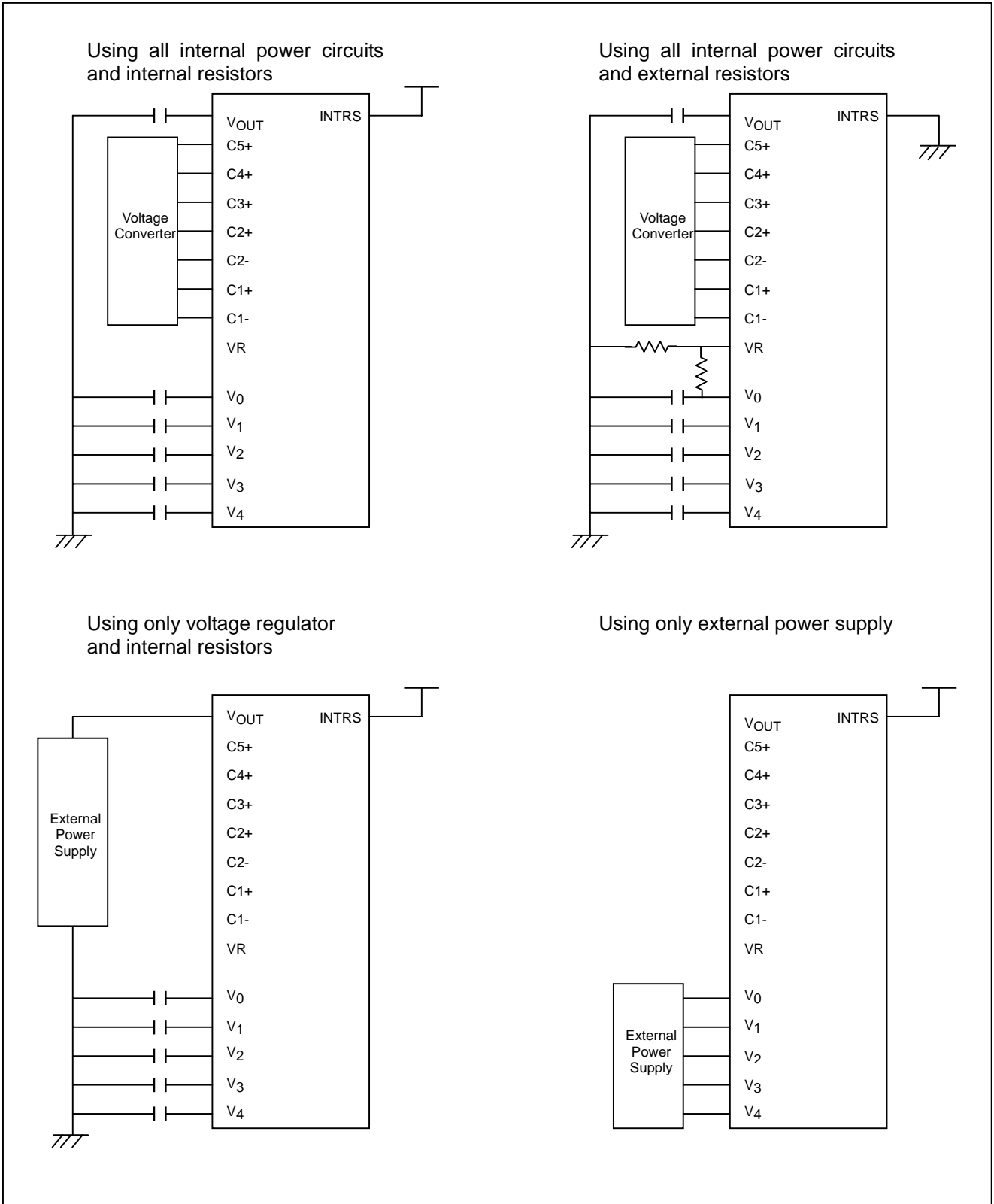


Fig. 3. Power circuits configuration





## (2) Instructions

The **NJU6680** distinguishes the data on the data bus D<sub>0</sub> to D<sub>7</sub> as an instruction by combination of RS and R/W signals. The decoding of the instruction and execution performs with only high speed internal timing without relation to the external clock.

In case of the serial interface, the data input as MSB(D<sub>7</sub>) first serially.

Table.3-1, 3-2 shows the instruction codes of the **NJU6680**

Table 3-1. Instruction Codes

Instruction	Code										Descriptions
	RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	
(a) Status read	0	1	Busy	ON	RES	0	0	0	0	0	-
(b) Display data write	1	0	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	-
(c) Column address LSB set	0	0	0	0	0	0	C <sub>3</sub>	C <sub>2</sub>	C <sub>1</sub>	C <sub>0</sub>	Lower 4-bit
	0	0	0	0	0	1	0	C <sub>6</sub>	C <sub>5</sub>	C <sub>4</sub>	Upper 3-bit
(d) Internal resistor ratio set	0	0	0	0	1	0	0	R <sub>2</sub>	R <sub>1</sub>	R <sub>0</sub>	-
(e) Power control set	0	0	0	0	1	0	1	VC	VR	VF	-
(f) Initial display line set (Dual instructions)	0	0	0	1	0	0	0	0	*	*	Set initial display line mode
	0	0	*	L <sub>6</sub>	L <sub>5</sub>	L <sub>4</sub>	L <sub>3</sub>	L <sub>2</sub>	L <sub>1</sub>	L <sub>0</sub>	Specify line address
(g) Initial COM <sub>0</sub> line set (Dual instructions)	0	0	0	1	0	0	0	1	*	*	Set initial COM <sub>0</sub> line mode
	0	0	*	C <sub>6</sub>	C <sub>5</sub>	C <sub>4</sub>	C <sub>3</sub>	C <sub>2</sub>	C <sub>1</sub>	C <sub>0</sub>	Specify line address
(h) Partial display duty set (Dual instructions)	0	0	0	1	0	0	1	0	*	*	Set partial display mode
	0	0	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	Specify duty cycle ratio
(i) N-line inversion set (Dual instructions)	0	0	0	1	0	0	1	1	*	*	Set N-line inversion mode
	0	0	*	*	*	N <sub>4</sub>	N <sub>3</sub>	N <sub>2</sub>	N <sub>1</sub>	N <sub>0</sub>	Specify the number of N-line
(j) LCD bias set	0	0	0	1	0	1	0	B <sub>2</sub>	B <sub>1</sub>	B <sub>0</sub>	-
(k) Boost level set	0	0	0	1	1	0	0	1	B <sub>1</sub>	B <sub>0</sub>	-
(l) Contrast level set (Dual instructions)	0	0	1	0	0	0	0	0	0	1	Set contrast level mode
	0	0	*	*	C <sub>5</sub>	C <sub>4</sub>	C <sub>3</sub>	C <sub>2</sub>	C <sub>1</sub>	C <sub>0</sub>	Specify contrast level
(m) ADC select	0	0	1	0	1	0	0	0	0	S <sub>0</sub>	Select segment direction
(n) Entire display ON/OFF	0	0	1	0	1	0	0	1	0	E <sub>0</sub>	E <sub>0</sub> =0: OFF, E <sub>0</sub> =1: ON
(o) Reverse display ON/OFF	0	0	1	0	1	0	0	1	1	R <sub>0</sub>	R <sub>0</sub> =0: OFF, R <sub>0</sub> =1: ON
(p) Power save mode ON	0	0	1	0	1	0	1	0	0	1	Power save mode
(q) Internal oscillator ON	0	0	1	0	1	0	1	0	1	1	-
(r) Display ON/OFF	0	0	1	0	1	0	1	1	1	D <sub>0</sub>	D <sub>0</sub> =0: OFF, D <sub>0</sub> =1: ON
(s) Page address set	0	0	1	0	1	1	P <sub>3</sub>	P <sub>2</sub>	P <sub>1</sub>	P <sub>0</sub>	-
(t) COM scan direction select	0	0	1	1	0	0	S <sub>0</sub>	*	*	*	Select common direction
(u) Power save mode OFF	0	0	1	1	1	0	0	0	0	1	-
(v) Reset	0	0	1	1	1	0	0	0	1	0	-
(w) N-line inversion OFF	0	0	1	1	1	0	0	1	0	0	-
(x) Display data length set (Dual instructions)	0	0	1	1	1	0	1	0	0	0	Set display data length
	0	0	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	Specify the data length
(y) FRC & PWM set	0	0	1	0	0	1	0	FRC	PWM <sub>1</sub>	PWM <sub>0</sub>	-

(\*:Don't Care)



# NJU6680

Table 3-2. Instruction Codes

Instruction		Code										Descriptions
		RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	
(z)	White mode set, 1st/2nd frame	0	0	1	0	0	0	1	0	0	0	Specify mode & frame Sets 4-bit pallet registers
	White mode set, 3rd/4th frame	0	0	WB <sub>3</sub>	WB <sub>2</sub>	WB <sub>1</sub>	WB <sub>0</sub>	WA <sub>3</sub>	WA <sub>2</sub>	WA <sub>1</sub>	WA <sub>0</sub>	Specify mode & frame Sets 4-bit pallet registers
	Light gray mode set, 1st/2nd frame	0	0	1	0	0	0	1	0	1	0	Specify mode & frame Sets 4-bit pallet registers
	Light gray mode set, 3rd/4th frame	0	0	LD <sub>3</sub>	LD <sub>2</sub>	LD <sub>1</sub>	LD <sub>0</sub>	LC <sub>3</sub>	LC <sub>2</sub>	LC <sub>1</sub>	LC <sub>0</sub>	Specify mode & frame Sets 4-bit pallet registers
	Dark gray mode set, 1st/2nd frame	0	0	1	0	0	0	1	1	0	0	Specify mode & frame Sets 4-bit pallet registers
	Dark gray mode set, 3rd/4th frame	0	0	DB <sub>3</sub>	DB <sub>2</sub>	DB <sub>1</sub>	DB <sub>0</sub>	DA <sub>3</sub>	DA <sub>2</sub>	DA <sub>1</sub>	DA <sub>0</sub>	Specify mode & frame Sets 4-bit pallet registers
	Black mode set, 1st/2nd frame	0	0	1	0	0	0	1	1	1	0	Specify mode & frame Sets 4-bit pallet registers
	Black mode set, 3rd/4th frame	0	0	BB <sub>3</sub>	BB <sub>2</sub>	BB <sub>1</sub>	BB <sub>0</sub>	BA <sub>3</sub>	BA <sub>2</sub>	BA <sub>1</sub>	BA <sub>0</sub>	Specify mode & frame Sets 4-bit pallet registers
(aa)	Display mode set	0	0	1	1	1	0	1	1	1	DM <sub>0</sub>	DM <sub>0</sub> =0: Gray scale mode DM <sub>0</sub> =1: Black & White mode
(bb)	Test mode	0	0	1	1	1	1	*	*	*	*	Don't use.

(\*:Don't Care)

**(2-1) Descriptions of the Instruction Codes****(a) Status read**

The "Status read" instruction is used to read out an LSI internal status. It is available only in the parallel interface mode.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	1	BUSY	ON	RES	0	0	0	0	0

**BUSY**      0: The LSI is idle.  
               1: The LSI is busy and cannot accept any instruction except the "Status read".

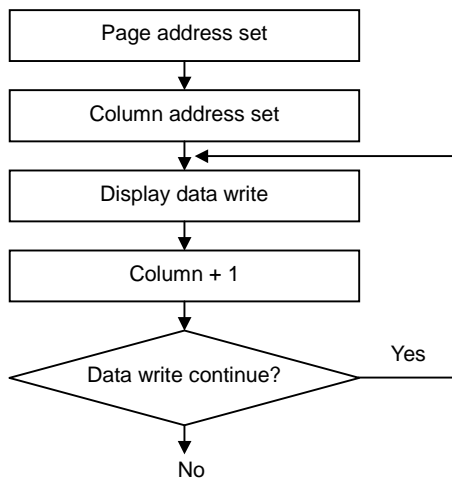
**ON**         0: Display OFF  
               1: Display ON

**RES**         0: The LSI is idle.  
               1: The LSI is executing the reset operation.

**(b) Display data write**

The "Display data write" instruction is used to write display data into the DDRAM, which address is designated by the "Column address set" and "Page address set" instructions. The column address automatically increases by 1 (+1) after each 2-byte display data and wraps around to the column address 00<sub>H</sub> in the same page after the last column is addressed. In case that the LSI is used in the 3-line serial interface mode, the "Display data length set" instruction is required before the "Display data write" instruction.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
1	0	Display data							

**Sequence for the display data writing**



# NJU6680

## (c) Column address set

The “Column address set” instruction is used to specify the column address for display data. It is required before the “Display data write” instruction. An MPU can access only 7-bit [C6:C0] “column address” by the “Column address LSB set” and “Column address MSB set” instructions. When both 4-bit LSB and 3-bit MSB data is set into the column address register, 8-bit “internal column address” is established in the LSI. For this reason, 2-bit display data must be written for each pixel with two successive bytes.

The column address automatically increases by 1 (+1) after each 2-byte display data and wraps around to the column address 00<sub>H</sub> in the same page after the last column is addressed, and therefore, the DDRAM can be continuously accessed without another “Column address set” instruction.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	
0	0	0	0	0	0	C <sub>3</sub>	C <sub>2</sub>	C <sub>1</sub>	C <sub>0</sub>	LSB column address
0	0	0	0	0	1	0	C <sub>6</sub>	C <sub>5</sub>	C <sub>4</sub>	MSB column address

C <sub>6</sub>	C <sub>5</sub>	C <sub>4</sub>	C <sub>3</sub>	C <sub>2</sub>	C <sub>1</sub>	C <sub>0</sub>	Column address	Internal Column address
0	0	0	0	0	0	0	00 <sub>H</sub>	00 <sub>H</sub>
								01 <sub>H</sub>
0	0	0	0	0	0	1	01 <sub>H</sub>	02 <sub>H</sub>
								03 <sub>H</sub>
:	:	:	:	:	:	:	:	:
:	:	:	:	:	:	:	:	:
1	1	1	1	1	1	0	7E <sub>H</sub>	FC <sub>H</sub>
								FD <sub>H</sub>
1	1	1	1	1	1	1	7F <sub>H</sub>	FE <sub>H</sub>
								FF <sub>H</sub>

## (d) Internal resistor ratio set

The “Internal resistor ratio set” instruction is used to determine the internal resistor ratio (1+R<sub>b</sub>/R<sub>a</sub>) for the voltage regulator. For more information, refer to (3-3) “Setting for internal resistor ratio”.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	0	0	1	0	0	R <sub>2</sub>	R <sub>1</sub>	R <sub>0</sub>

R <sub>2</sub>	R <sub>1</sub>	R <sub>0</sub>	1+(R <sub>b</sub> /R <sub>a</sub> )
0	0	0	2.3
0	0	1	3.0
0	1	0	3.7
0	1	1	4.4
1	0	0	5.1
1	0	1	5.8
1	1	0	6.5
1	1	1	7.2

## (e) Power control set

The “Power control set” instruction is used to configure the internal power circuits. For more information, refer to (3) “Internal power circuits”.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	0	0	1	0	1	VC	VR	VF

VC	VR	VF	
0	-	-	Voltage converter OFF
1	-	-	Voltage converter ON
-	0	-	Voltage regulator OFF
-	1	-	Voltage regulator ON
-	-	0	Voltage followers OFF
-	-	1	Voltage followers ON

**(f) Initial display line set**

The “Initial display line set” instruction is used to specify the line address, which corresponds to the initial COM<sub>0</sub> line (COM<sub>0</sub>).

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	0	1	0	0	0	0	*	*
0	0	*	L <sub>6</sub>	L <sub>5</sub>	L <sub>4</sub>	L <sub>3</sub>	L <sub>2</sub>	L <sub>1</sub>	L <sub>0</sub>

Set initial display line  
Specify line address

L <sub>6</sub>	L <sub>5</sub>	L <sub>4</sub>	L <sub>3</sub>	L <sub>2</sub>	L <sub>1</sub>	L <sub>0</sub>	Line address
0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	1
0	0	0	0	0	1	0	2
:	:	:	:	:	:	:	:
1	1	1	1	1	0	1	125
1	1	1	1	1	1	0	126
1	1	1	1	1	1	1	127

**(g) Initial COM<sub>0</sub> line set**

The “Initial COM<sub>0</sub> line set” instruction is specify the common driver, which starts scanning the display data in the DDRAM.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	0	1	0	0	0	1	*	*
0	0	*	C <sub>6</sub>	C <sub>5</sub>	C <sub>4</sub>	C <sub>3</sub>	C <sub>2</sub>	C <sub>1</sub>	C <sub>0</sub>

Set initial COM<sub>0</sub> line  
Specify initial COM<sub>0</sub>

C <sub>6</sub>	C <sub>5</sub>	C <sub>4</sub>	C <sub>3</sub>	C <sub>2</sub>	C <sub>1</sub>	C <sub>0</sub>	Initial COM <sub>0</sub>
0	0	0	0	0	0	0	COM <sub>0</sub>
0	0	0	0	0	0	1	COM <sub>1</sub>
0	0	0	0	0	1	0	COM <sub>2</sub>
:	:	:	:	:	:	:	:
1	1	1	1	1	0	1	COM <sub>125</sub>
1	1	1	1	1	1	0	COM <sub>126</sub>
1	1	1	1	1	1	1	COM <sub>127</sub>

**(h) Partial display duty set**

The “Partial display duty set” instruction is used to specify the duty cycle ratio for the partial display. The LSI can be programmed to select not only the duty cycle ratio, but also the LCD bias ratio, boost level and contrast level by the instructions so that it is possible to optimize the LSI’s condition in accordance with the partial display status. For more information, refer to (7) “Partial display function”.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	0	1	0	0	1	0	*	*
0	0	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>

Set partial display duty  
Specify duty cycle ratio

D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	Duty
0	0	0	0	0	0	0	0	Invalid
:	:	:	:	:	:	:	:	
0	0	0	0	1	1	1	1	
0	0	0	1	0	0	0	0	1/16
:	:	:	:	:	:	:	:	:
1	0	0	0	0	0	0	0	1/128
1	0	0	0	0	0	0	1	Invalid
:	:	:	:	:	:	:	:	
1	1	1	1	1	1	1	1	



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## (i) N-line inversion register set

The “N-line inversion register set” instruction is used to control the alternate rates of the crystal polarization on an LCD panel. In the N-line inversion mode, the FR signal toggles once every N frames, which number is selected in between 3 and 33 lines, and therefore, prevents a cross talk. If the N-line inversion is disabled by the “N-line inversion mode OFF” instruction, the FR signal toggles by the frame.

The number of the N-line should not be set to 1/2 of the display duty cycle ratio in order to avoid generating a DC bias when the partial display is used.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	0	1	0	0	1	1	*	*
0	0	*	*	*	N <sub>4</sub>	N <sub>3</sub>	N <sub>2</sub>	N <sub>1</sub>	N <sub>0</sub>

Set N-line inversion  
Specify N-line number

N <sub>4</sub>	N <sub>3</sub>	N <sub>2</sub>	N <sub>1</sub>	N <sub>0</sub>	Number of N-line
0	0	0	0	0	0
0	0	0	0	1	3 lines
:	:	:	:	:	:
1	1	1	1	0	32 lines
1	1	1	1	1	33 lines

## (j) LCD bias set

The “LCD bias set” instruction is used to select the LCD bias ratio. For more information, refer to (3-8) “Voltage followers”.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	0	1	0	1	0	B <sub>2</sub>	B <sub>1</sub>	B <sub>0</sub>

B <sub>2</sub>	B <sub>1</sub>	B <sub>0</sub>	Bias
0	0	0	1/5
0	0	1	1/6
0	1	0	1/7
0	1	1	1/8
1	0	0	1/9
1	0	1	1/10
1	1	0	1/11
1	1	1	1/12

## (k) Boost level set

The “Boost level set” instruction is used to select the multiple for the voltage converter. For detailed information, refer to (3-1) “Voltage converter”.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	0	1	1	0	0	1	B <sub>1</sub>	B <sub>0</sub>

B <sub>1</sub>	B <sub>0</sub>	Boost
0	0	3x
0	1	4x
1	0	5x
1	1	6x

## (l) Contrast level set

The “Contrast level set” instruction is used to fine-tune the LCD driving voltage ( $V_{LCD}$ ) in accordance with an LCD panel. For detailed information, refer to (3-2) “Voltage regulator”.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	0	0	0	0	0	0	1
0	0	*	*	C <sub>5</sub>	C <sub>4</sub>	C <sub>3</sub>	C <sub>2</sub>	C <sub>1</sub>	C <sub>0</sub>

Set contrast level  
Specify contrast level

**(m) ADC select**

The “ADC select” instruction is used to reverse the column address assignment for the segment drivers, so that it is possible to reduce the restriction for the placement of the LSI in an LCD module. For more information, refer to “- Connection between the LSI and LCD panel”.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	0	1	0	0	0	0	S <sub>0</sub>

S <sub>0</sub>	Segment direction
0	SEG <sub>0</sub> to SEG <sub>127</sub>
1	SEG <sub>127</sub> to SEG <sub>0</sub>

**(n) Entire display ON/OFF**

The “Entire display ON/OFF” instruction is used to enable or disable the entire display, which turns on all pixels without changing the display data in the DDRAM.

The “Entire display ON/OFF” instruction has a priority over the “Reverse display ON/OFF” instruction and the “Display ON/OFF” instruction has the priority over the “Entire display ON/OFF” instruction. As a result, even though the “Entire display ON” can be accepted during the “Display OFF”, the visual state of the LCD panel does not change.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	0	1	0	0	1	0	E <sub>0</sub>

E <sub>0</sub>	Mode
0	Entire display OFF (Normal)
1	Entire display ON

**(o) Reverse display ON/OFF**

The “Reverse display ON/OFF” instruction is used to enable or disable the reverse display, which reverses the illumination of each pixel without changing the display data in the DDRAM.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	0	1	0	0	1	1	R <sub>0</sub>

R <sub>0</sub>	Mode
0	Reverse display OFF (Normal)
1	Reverse display ON

**Reverse display OFF (Normal)**

Display data	1	1	1	0	0	1	0	0
Illumination								

**Reverse display ON**

Display data	1	1	1	0	0	1	0	0
Illumination								



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## (p) Power save mode ON

The “Power save mode ON” instruction is used to enable the power save mode, where it is possible to reduce the power consumption down to stand-by current level. Both of the LSI’s internal status and the display data in the DDRAM before the “Power save mode ON” instruction are maintained during the power save mode, in which it is possible to access to the DDRAM. The internal status of the LSI in the power save mode is listed below.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	0	1	0	1	0	0	1

Mode	Description
Power save mode	Oscillator OFF LCD power supply OFF COM/SEG outputs V <sub>SS</sub>

## (q) Internal oscillator ON

The “Internal oscillator ON” instruction is used to enable the internal oscillator. Since the oscillator always turns off after the reset operation, this instruction must be executed for the initialization.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	0	1	0	1	0	1	1

## (r) Display ON/OFF

The “Display ON/OFF” instruction is used to control the display ON or OFF without changing the display data in the DDRAM.

The “Display ON/OFF” instruction has a priority over the “Entire display ON/OFF” and “Reverse display ON/OFF” instructions. Accordingly, even though the “Entire display ON” and “Reverse display ON” instructions can be accepted during the “Display OFF”, the visual state of the LCD panel does not change.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	0	1	0	1	1	1	D <sub>0</sub>

D <sub>0</sub>	Mode
0	Display OFF
1	Display ON

## (s) Page address set

The “Page address set” instruction is used to specify the page address for display data. It is required before the “Display data write” instruction.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	0	1	1	P <sub>3</sub>	P <sub>2</sub>	P <sub>1</sub>	P <sub>0</sub>

## (t) COM scan direction select

The “COM scan direction select” is used to select the COM scan direction, so that it is possible to reduce the restriction for the placement of the LSI in an LCD module. For more information, refer to “-Connection between the LSI and LCD panel”.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	1	0	0	S <sub>0</sub>	*	*	*

S <sub>0</sub>	COM scan direction
0	COM <sub>0</sub> to COM <sub>127</sub>
1	COM <sub>127</sub> to COM <sub>0</sub>



**(u) Power save mode OFF**

The "Power save mode OFF" instruction is used to release the LSI from the power save mode.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	1	1	0	0	0	0	1

**(v) Reset**

The "Reset" instruction is used to reset the LSI to the following status. It doesn't change the display data in the DDRAM. It cannot be substituted for the reset operation by the RES terminal. For more information regarding to the reset operation by the RES terminal, refer to (1-8) "Reset circuits".

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	1	1	0	0	0	1	0

Reset status by "Reset" instruction

1. Page address : (0) page
2. Column address : (00)<sub>H</sub>
3. Initial display line : (00)<sub>H</sub>
4. Contrast level set : 32 level
5. Internal resistor ratio :  $1+R_b/R_a=2.3$
6. Display data length : (0,0,0,0)
7. White mode set : OFF
8. White palette register : (0,0,0,0)
9. Light gray mode set : OFF
10. Light gray palette register : (0,0,0,0)
11. Dark gray mode set : OFF
12. Dark gray palette register : (1,1,1,1)
13. Black mode set : OFF
14. Black palette register : (1,1,1,1)
15. FRC, PWM mode : 4-frame, 9-level

**(w) N-line inversion mode OFF**

The "N-line inversion mode OFF" instruction is used to disable the n-line inversion.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	1	1	0	0	1	0	0

**(x) Display data length set**

The "Display data length set" instruction is used in the 3-line serial interface mode in order to specify the data length in between 1 and 256 bytes for the display data transferred to the DDRAM. The next transferred data after the display data is distinguished as instruction data.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	1	1	0	1	0	0	0
0	0	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>

Set display data length  
Specify the data length



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## (y) FRC & PWM set

The “FRC & PWM set” instruction is used to specify the configuration of PWM and FRC for the 4 gray scale display.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	0	0	1	0	FRC	PWM <sub>1</sub>	PWM <sub>0</sub>

FRC	Frame rate
0	4-frame
1	3-frame

PWM <sub>1</sub>	PWM <sub>0</sub>	PWM level
0	0	9-level
0	1	9-level
1	0	12-level
1	1	15-level

## (z) Gray scale mode and register set

The “Gray scale mode and register set” instruction is composed of two bytes and is used to specify the contrast level for each of the gray scale modes. The first byte specifies the gray scale mode and the frame number, and then the second byte sets pallet values into the specified 4-bit pallet register. For detailed information regarding the gray scale function, refer to (5) “Gray scale function”.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	
0	0	1	0	0	0	1	0	0	0	White mode set, 1st/2nd frame
0	0	WB <sub>3</sub>	WB <sub>2</sub>	WB <sub>1</sub>	WB <sub>0</sub>	WA <sub>3</sub>	WA <sub>2</sub>	WA <sub>1</sub>	WA <sub>0</sub>	4-bit pallet registers
0	0	1	0	0	0	1	0	0	1	White mode set, 3rd/4th frame
0	0	WD <sub>3</sub>	WD <sub>2</sub>	WD <sub>1</sub>	WD <sub>0</sub>	WC <sub>3</sub>	WC <sub>2</sub>	WC <sub>1</sub>	WC <sub>0</sub>	4-bit pallet registers
0	0	1	0	0	0	1	0	1	0	Light gray mode set, 1st/2nd frame
0	0	LB <sub>3</sub>	LB <sub>2</sub>	LB <sub>1</sub>	LB <sub>0</sub>	LA <sub>3</sub>	LA <sub>2</sub>	LA <sub>1</sub>	LA <sub>0</sub>	4-bit pallet registers
0	0	1	0	0	0	1	0	1	1	Light gray mode set, 3rd/4th frame
0	0	LD <sub>3</sub>	LD <sub>2</sub>	LD <sub>1</sub>	LD <sub>0</sub>	LC <sub>3</sub>	LC <sub>2</sub>	LC <sub>1</sub>	LC <sub>0</sub>	4-bit pallet registers
0	0	1	0	0	0	1	1	0	0	Dark gray mode set, 1st/2nd frame
0	0	DB <sub>3</sub>	DB <sub>2</sub>	DB <sub>1</sub>	DB <sub>0</sub>	DA <sub>3</sub>	DA <sub>2</sub>	DA <sub>1</sub>	DA <sub>0</sub>	4-bit pallet registers
0	0	1	0	0	0	1	1	0	1	Dark gray mode set, 3rd/4th frame
0	0	DD <sub>3</sub>	DD <sub>2</sub>	DD <sub>1</sub>	DD <sub>0</sub>	DC <sub>3</sub>	DC <sub>2</sub>	DC <sub>1</sub>	DC <sub>0</sub>	4-bit pallet registers
0	0	1	0	0	0	1	1	1	0	Black mode set, 1st/2nd frame
0	0	BB <sub>3</sub>	BB <sub>2</sub>	BB <sub>1</sub>	BB <sub>0</sub>	BA <sub>3</sub>	BA <sub>2</sub>	BA <sub>1</sub>	BA <sub>0</sub>	4-bit pallet registers
0	0	1	0	0	0	1	1	1	1	Black mode set, 3rd/4th frame
0	0	BD <sub>3</sub>	BD <sub>2</sub>	BD <sub>1</sub>	BD <sub>0</sub>	BC <sub>3</sub>	BC <sub>2</sub>	BC <sub>1</sub>	BC <sub>0</sub>	4-bit pallet registers

## (aa) Display mode set

The “Display mode set” instruction is used to select either “Gray scale mode” or “Black & White mode”. For more information, refer to (6) “Black & White mode”.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	1	1	0	1	1	1	DM <sub>0</sub>

DM <sub>0</sub>	Display mode
0	Gray scale mode
1	Black & White mode

## (bb) Test mode

This instruction is used only for manufacturer’s tests.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	1	1	1	*	*	*	*

**(3) Internal power circuits**

The internal power circuits are composed of the voltage converter, voltage regulator with 64-level EVR, and voltage followers. The status of the internal power circuits is arranged by the "Power control set" instruction, as shown in Table 4. For this arrangement, the part of the internal power circuits can be used in combination with an external power supply, as shown in Table 5.

The internal power circuits require the optimum values for the passive components, such as V0 to V4 capacitors and external feedback resistors in accordance with an LCD panel; and accordingly should be evaluated by using of actual LCD module samples to decide these values.

Table 4. Power control set

Bits	Portions	Status	
V <sub>C</sub>	Voltage converter	1: ON	0: OFF
V <sub>R</sub>	Voltage regulator	1: ON	0: OFF
V <sub>F</sub>	Voltage followers	1: ON	0: OFF

Table 5. Power supply combinations

Combination	Instruction			Power supply circuits			Output terminals		
	V <sub>C</sub>	V <sub>R</sub>	V <sub>F</sub>	Voltage converter	Voltage regulator	Voltage followers	V <sub>OUT</sub>	V <sub>0</sub>	V <sub>1</sub> -V <sub>4</sub>
Using all internal power circuits	1	1	1	ON	ON	ON	Open	Open	Open
Using voltage regulator and voltage followers	0	1	1	OFF	ON	ON	External	Open	Open
Using voltage followers	0	0	1	OFF	OFF	ON	Open	External	Open
Using only external power Supply	0	0	0	OFF	OFF	OFF	Open	External	External

Note) Decoupling capacitors on the V<sub>0</sub> to V<sub>4</sub> terminals are required when the voltage followers are enabled.



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## (3-1) Voltage converter

The voltage converter is designed to generate a maximum 6x voltage from the voltage difference between the  $V_{CI}$  and  $V_{SS}$  terminals. It is programmed so that the boost level can be selected out of 3x, 4x, 5x or 6x by the "Boost level set" instruction. Since the voltage converter operates by using of the internal clocks supplied from the oscillator, the oscillator is required to be working during the voltage converter operation. The boosted voltage  $V_{OUT}$  must not exceed beyond the 18.0V described in "Absolute maximum ratings". Otherwise, the voltage stress may cause a permanent damage to the LSI. Fig.4 illustrates the capacitor connections for the voltage converter.

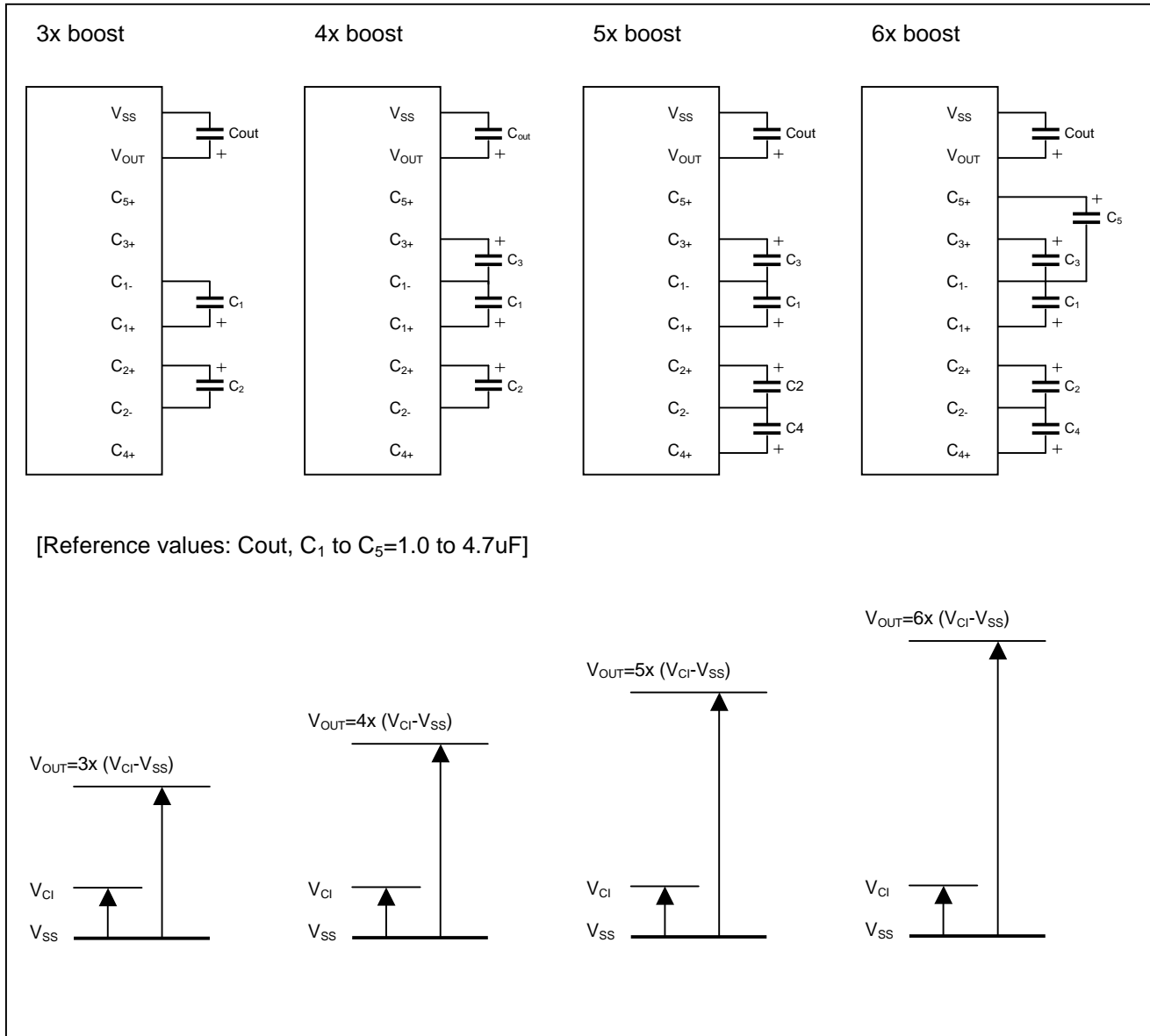
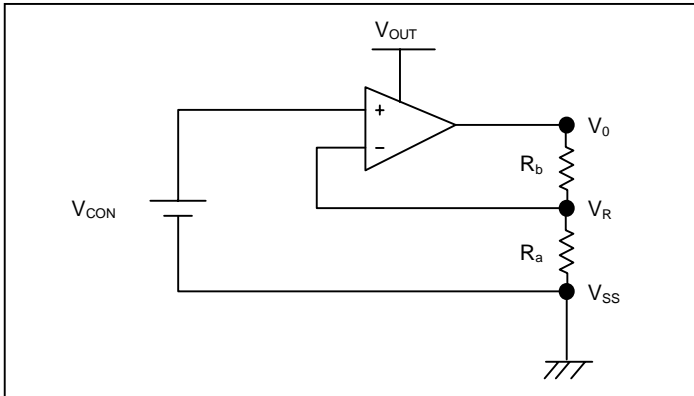


Fig.4 Capacitors connections for the voltage converter

### (3-2) Voltage regulator

The voltage regulator is composed of the reference voltage generator, 64-level EVR, operational amplifier, and internal (or external) feedback resistors, as illustrated in Fig.5 and used to generate the LCD driving voltage  $V_0$ . In the voltage regulator, the reference voltage  $V_{REF}$  is gained with the EVR to produce regulated voltage  $V_{CON}$ , which is used for the input voltage of the internal operational amplifier. Namely, the  $V_0$  is determined in accordance with the setting for the EVR and internal (or external) resistor ratio, as calculated by the following equations [1] and [2].



$$V_0 = (1 + R_b/R_a) \times V_{CON} \quad [1]$$

$$V_{CON} = (1 - (63 - n)/210) \times V_{REF} \quad [2]$$

$V_0$  : LCD driving voltage  
 $R_a, R_b$  : Feed back resistors  
 $V_{CON}$  : Contrast control voltage  
 $n$  : Parameter decided instruction  
 $V_{REF}$  : Reference voltage

Fig.5 Voltage regulator

### (3-3) Setting for internal resistor ratio

Either external or internal feedback resistors can be selected by setting the INTRS terminal to "0" or "1", as shown in Table 6. In case that the internal resistors are used, the resistor ratio  $(1 + R_b/R_a)$  can be selected by the "Internal resistor ratio" instruction, as listed in Table 7.

Table 6. Setting for the INTRS terminal

INTRS	Ra, Rb
0	External resistors
1	Internal resistors

Table 7. Setting for the internal resistor ratio

R <sub>2</sub>	R <sub>1</sub>	R <sub>0</sub>	1+(R <sub>b</sub> /R <sub>a</sub> )
0	0	0	2.3
0	0	1	3.0
0	1	0	3.7
0	1	1	4.4
1	0	0	5.1
1	0	1	5.8
1	1	0	6.5
1	1	1	7.2

### (3-4) Contrast control voltage VCON

In the equation [2], the VCON depends on the parameter "n", which is determined in between 0 and 63 by the "Contrast level set" instruction.

Table 8. Setting for the contrast level

C5	C4	C3	C2	C1	C0	n	V <sub>CON</sub>
0	0	0	0	0	0	0	MIN.
:	:	:	:	:	:	:	:
1	1	1	1	1	1	63	MAX.



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### (3-5) Reference voltage $V_{REF}$

Either external or internal reference voltage  $V_{REF}$  is selected by setting the REF terminal to "0" or "1", as shown in Table 9. When the internal reference voltage  $V_{REF}$  is selected, the  $V_{REF}$  is designed to be 2.1V Typ. and its temperature coefficient becomes  $-0.125\%/^{\circ}\text{C}$  Typ.

Table 9. Setting for the REF terminal

REF	$V_{REF}$ (V)	Temperature coefficient
0	External voltage on the VEXT terminal	-
1	Internal voltage ( $V_{REF}=2.1\text{V Typ.}$ )	$-0.125\%/^{\circ}\text{C Typ.}$

### (3-6) Range for the contrast control

The LCD driving voltage  $V_0$  is determined in accordance with the setting for the EVR and the internal (or external) resistor ratio. Fig.6 graphs the range for the contrast control using the "Contrast level set" and "Internal resistor set" instructions.

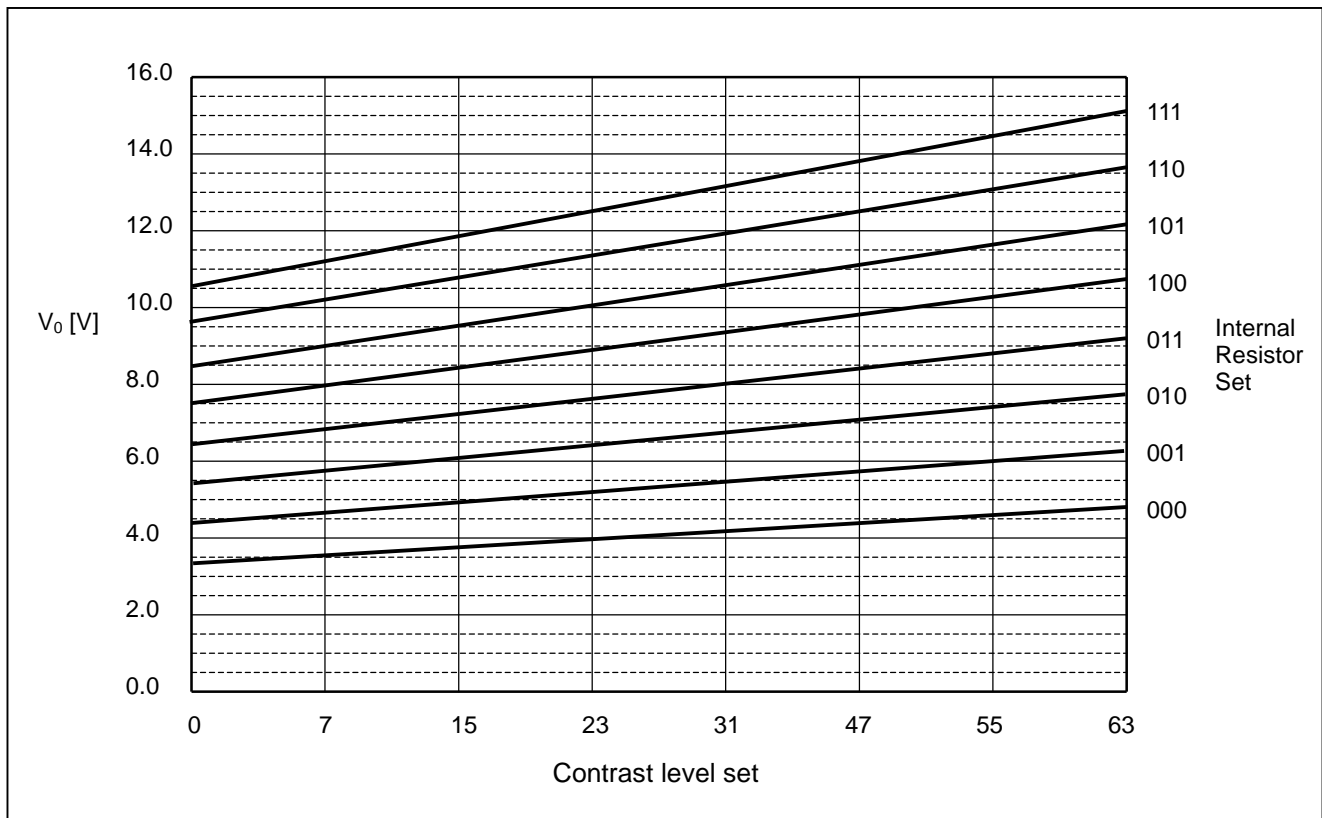


Fig.6 Range for the contrast control

**(3-7) Using external Ra and Rb resistors**

In case that the external feedback resistors (Ra, Rb) are used by setting the INTRS terminal to "0", these external resistors are required to be placed between the V<sub>SS</sub> and V<sub>R</sub> and between the V<sub>R</sub> and V<sub>0</sub> terminals. The LCD driving voltage V<sub>0</sub> is determined in accordance with the setting for the EVR and the external resistor ratio (1+Rb/Ra) in the following equations [1] and [2], as well as the setting in using the internal resistors Ra and Rb.

$$V_0 = (1+Rb/Ra) \times V_{CON} \quad [1]$$

$$V_{CON} = (1-(63-n)/210) \times V_{REF} \quad [2]$$

V<sub>0</sub> : LCD driving voltage  
 Ra, Rb : Feed back resistors  
 V<sub>CON</sub> : Contrast control voltage  
 n : Parameter decided instruction  
 V<sub>REF</sub> : Reference voltage

The following calculations describe the setting example to decide the external resistors Ra and Rb values.

**Requirements:**

1. LCD driving voltage V<sub>0</sub>=14.0V (when the contrast level parameter "n"=32)
2. The maximum current flowing through the external Ra and Rb = 5uA

**Calculations:**

Following the equation [2],

$$V_{CON} = (1-(63-32)/210) \times 2.1V = 1.79V$$

Following the equation [1],

$$Rb/Ra = V_0/V_{CON} - 1 = 14.0V/1.79V - 1 = 6.821 \text{ -----[A]}$$

Following the requirement 2,

$$Ra+Rb = 14.0V/5uA = 2.8M \text{ ohm -----[B]}$$

Finally, the values for the Ra and Rb are determined by the results [A] and [B],

Ra = 0.358M ohm

Rb = 2.442M ohm

Contrast level [n]	V <sub>0</sub> [V]
0	11.5V
:	:
32	14.0V
:	:
63	16.4V

**(3-8) Voltage followers**

The voltage followers are used to stabilize and output the LCD driving voltages (V<sub>0</sub>, V<sub>1</sub>, V<sub>2</sub>, V<sub>3</sub> and V<sub>4</sub>), which are produced by the internal bleeder resistors. It can be programmed to select the LCD bias in the range of 1/5 and 1/12 by the "LCD bias set" instruction. Generally, the optimum bias ratio is determined by the following equation: LCD bias ratio=1/(1+(√duty ratio)). For instance, in case of 1/80 duty cycle ratio, it should be 1/10 in accordance with the calculation: 1/(1+(√80)).

When the voltage followers are used, the capacitors for the V<sub>0</sub> to V<sub>4</sub> terminals are required in order to stabilize the LCD driving voltages and should be in between 0.47uF and 2.0uF.



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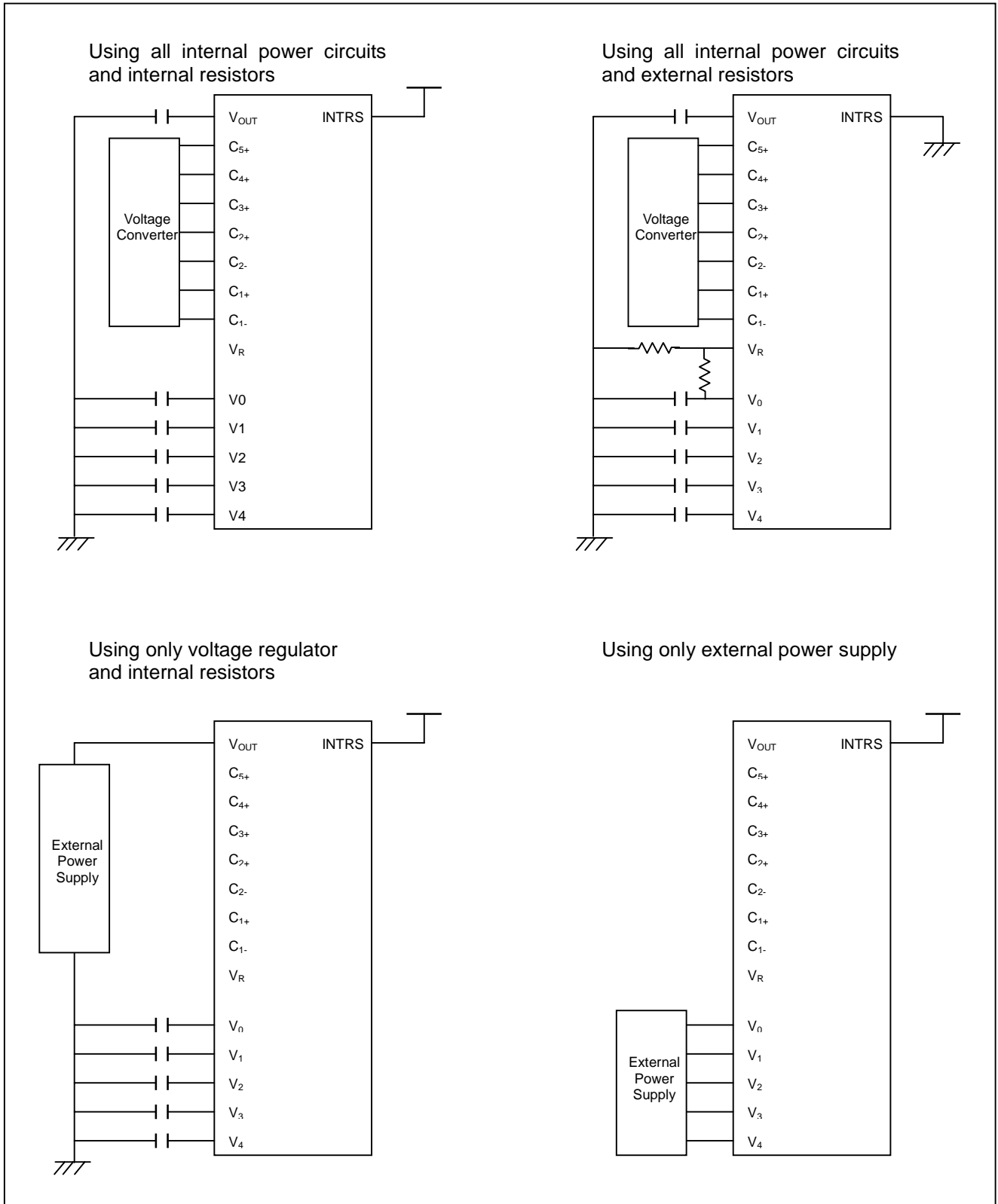


Fig.7 Power circuits configuration



## (4) MPU Interface

### (4-1) Interface type selection

The interface type (the parallel or serial interface) is determined by the condition of the PS<sub>0</sub> and PS<sub>1</sub> terminals connecting to "H" or "L" level as shown in Table 10. In the 3- or 4- line serial interface mode, the "Status read" instruction cannot be used.

Table 10

PS <sub>0</sub>	PS <sub>1</sub>	Type	CS	RS	E	W/R	Data bus terminals
L	L	3-line serial	$\overline{CS}$	*	*	*	SI, SCL
L	H	4-line serial	$\overline{CS}$	RS	*	*	SI, SCL
H	L	80-type MPU parallel	$\overline{CS}$	RS	$\overline{RD}$	$\overline{WR}$	D <sub>7</sub> to D <sub>0</sub>
H	H	68-type MPU parallel	$\overline{CS}$	RS	E	R/W	D <sub>7</sub> to D <sub>0</sub>

\*:Don't care

### (4-2) Parallel interface

In the 68- or 80- type PU parallel interface mode, the transferred data on the D<sub>7</sub> to D<sub>0</sub> terminals is processed in accordance with the polarities of the RS, E( $\overline{RD}$ ), and R/W(WR) signals as shown in table 11.

Table 11 Data Distinction

$\overline{CS}$	RS	68 type		80 type		Operation
		E	R/W	$\overline{RD}$	WR	
L	H	H	H	L	H	None
L	H	H	L	H	L	Write display data
L	L	H	H	L	H	Read out status read
L	L	H	L	H	L	Write instruction data

### (4-3) Serial Interface

In the serial interface mode, when the chip select is active ( $\overline{CS}$ ="0") the SI and SCL are enabled. While the chip select is not active ( $\overline{CS}$ ="1"), the SI & SCL are disabled and the internal 8-bit shift register and the 3-bit counter are being initialized. The 8-bit serial data on the SI terminal is fetched at the at the rising edge of the SCL signals in order of D<sub>7</sub>, D<sub>6</sub>...D<sub>0</sub> data, and the fetched data is converted into 8-bit parallel data on the 8<sup>th</sup> SCL signals.

#### (a) 4-line serial interface

In the 4-line serial interface mode, the transferred data on the SI terminal is distinguished as display data or instruction data in accordance with the polarity of the RS signal at the 8th SCL signal, as illustrated in Fig. 8-1.

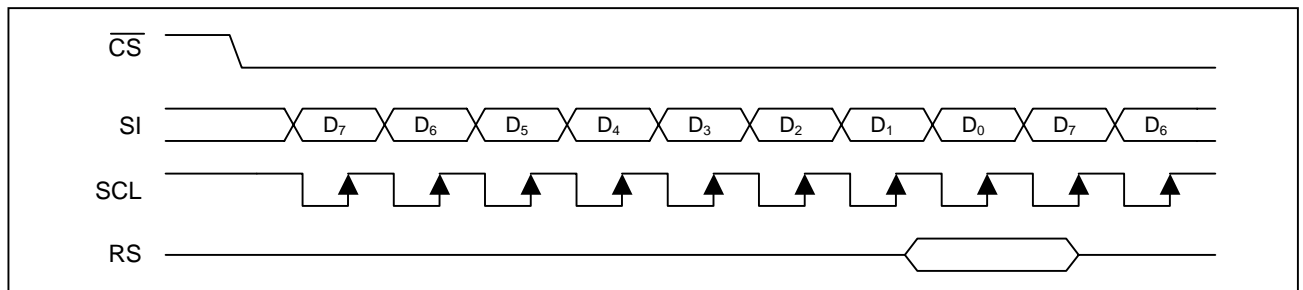


Fig. 8-1 4-line serial interface timing



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## (b) 3-line serial interface

In the 3-line serial interface mode, the “Display data length set” instruction is used to specify the data length in between 1 and 256 bytes for the display data transferred to the DDRAM. The “Display data length set” instruction is executed by 2 bytes data, after which the display data can be continuously transferred. The next transferred data after the display data is distinguished as instruction data. Fig 8-2 illustrates the timing and setting example for the data transmission in the 3-line serial interface mode.

When the chip select becomes non-active ( $\overline{CS}$ ="1") during a serial display data stream, the interrupted byte data is invalid, however all previous transferred display data is valid and next transferred data will be distinguished as instruction data.

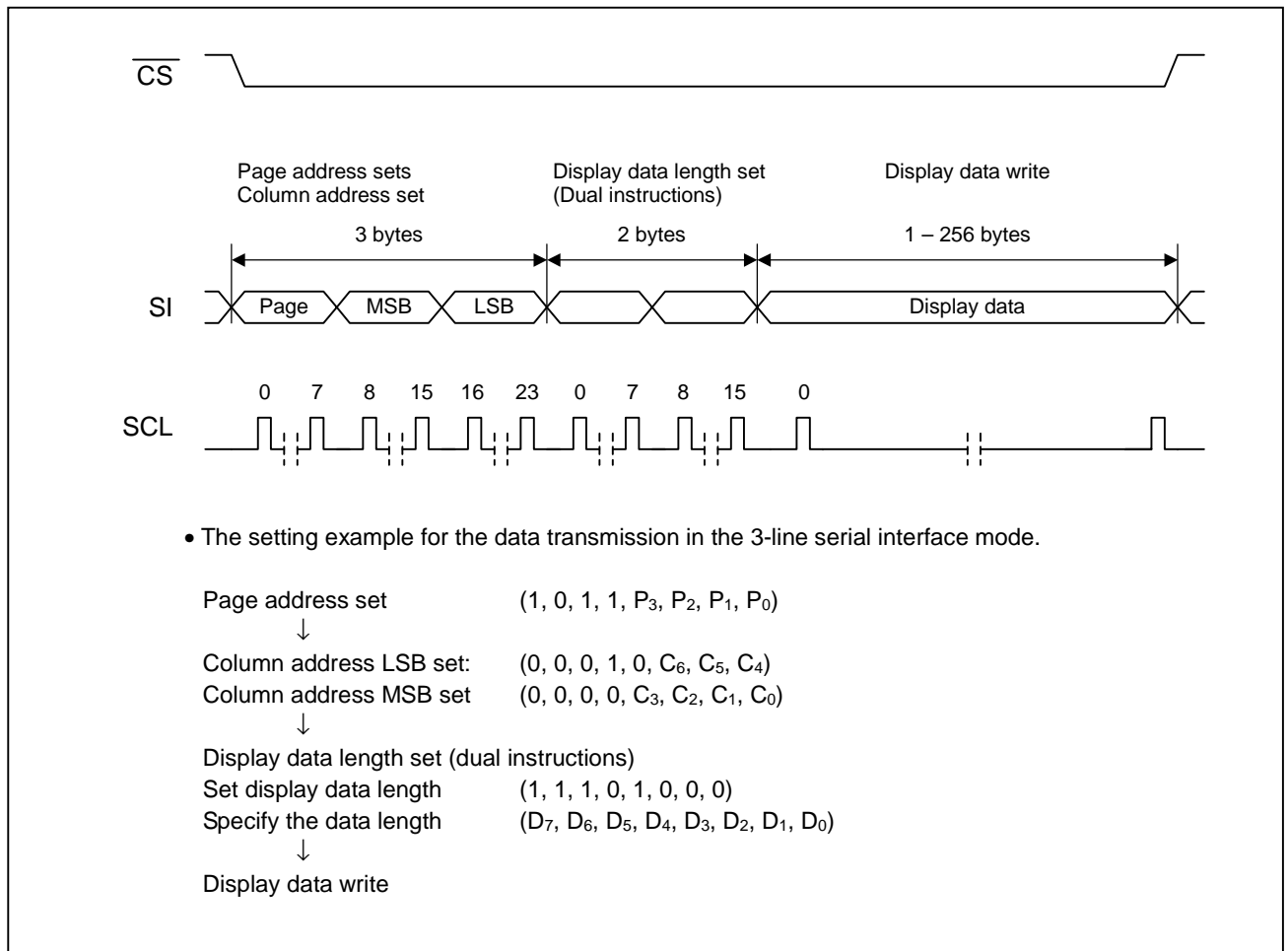


Fig 8-2 3-line serial interface timing

**(5) Gray scale function****(5-1) FRC (Frame Rate Control) and PWM (Pulse Width Modulation)**

The 4-gray scale function is controlled by the setting for the FRC and PWM configurations and the palette values into the 4-bit palette registers, and provides required gray scale levels. This setting is executed by the "FRC & PWM set" and "Gray scale mode and register set" instructions, as described in the following.

**(5-2) FRC & PWM set**

The "FRC & PWM set" instruction is used to specify the PWM and FRC configurations.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	0	0	1	0	FRC	PWM <sub>1</sub>	PWM <sub>0</sub>

FRC	Frame rate
0	4-frame
1	3-frame

PWM <sub>1</sub>	PWM <sub>0</sub>	PWM level
0	0	9-level
0	1	9-level
1	0	12-level
1	1	15-level

**(5-3) Gray scale mode & Register set**

The "Gray scale mode and register set" instruction is composed of two bytes and used to specify the contrast level for each of the gray scale modes. The first byte specifies the gray scale mode and frame number and then the second byte sets the pallet value into the specified 4-bit pallet register.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>	
0	0	1	0	0	0	1	GM <sub>2</sub>	GM <sub>1</sub>	GM <sub>0</sub>	Gray scale mode & frame 4-bit pallet register set
0	0	4-bit pallet register				4-bit pallet register				

GM <sub>2</sub>	GM <sub>1</sub>	GM <sub>0</sub>	Gray scale mode & Frame	
0	0	0	White mode	1st/2nd frame
0	0	1		3rd/4th frame
0	1	0	Light gray mode	1st/2nd frame
0	1	1		3rd/4th frame
1	0	0	Dark gray mode	1st/2nd frame
1	0	1		3rd/4th frame
1	1	0	Black mode	1st/2nd frame
1	1	1		3rd/4th frame



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## (5-4) Setting tables for the FRC and PWM

Table 12-1. Gray scale table for the 4-FRC

Gray scale level	Display data	MSB (D <sub>7</sub> to D <sub>4</sub> )	LSB (D <sub>3</sub> to D <sub>0</sub> )
White	00	2nd frame	1st frame
		4th frame	3rd frame
Light gray	01	2nd frame	1st frame
		4th frame	3rd frame
Dark gray	10	2nd frame	1st frame
		4th frame	3rd frame
Black	11	2nd frame	1st frame
		4th frame	3rd frame

Table 12-2. Gray scale table for the 3-FRC

Gray scale level	Display data	MSB (D <sub>7</sub> to D <sub>4</sub> )	LSB (D <sub>3</sub> to D <sub>0</sub> )
White	00	2nd frame	1st frame
		*	3rd frame
Light gray	01	2nd frame	1st frame
		*	3rd frame
Dark gray	10	2nd frame	1st frame
		*	3rd frame
Black	11	2nd frame	1st frame
		*	3rd frame

Note) \*: Don't care.

Table 13. Gray scale table for the PWM

4-bit palett register	9-PWM	12-PWM	15-PWM
0,0,0,0	0	0	0
0,0,0,1	1/9	1/12	1/15
0,0,1,0	2/9	2/12	2/15
0,0,1,1	3/9	3/12	3/15
0,1,0,0	4/9	4/12	4/15
0,1,0,1	5/9	5/12	5/15
0,1,1,0	6/9	6/12	6/15
0,1,1,1	7/9	7/12	7/15
1,0,0,0	8/9	8/12	8/15
1,0,0,1	1	9/12	9/15
1,0,1,0	0	10/12	10/15
1,0,1,1	0	11/12	11/15
1,1,0,0	0	1	12/15
1,1,0,1	0	0	13/15
1,1,1,0	0	0	14/15
1,1,1,1	0	0	1

**(6) Black & White mode**

As an extended function, the LSI is designed to support the black & white mode, which can be switched from the gray scale mode by the "Display mode set" instruction. The gray scale mode is set in the default status.

**(6-1) Display mode set instruction**

The "Display mode set" instruction is used to select either gray scale or black & white mode. It is required that the "Display OFF" instruction and DDRAM initialization are executed before the "Display mode set" instruction.

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	1	1	1	1	0	1	1	1	DM <sub>0</sub>

DM <sub>0</sub>	Display mode
0	Gray scale mode
1	Black & White mode

**(6-2) Display data RAM (DDRAM)**

Although the DDRAM's capability in the gray scale mode is 32,768-bit (128-line by 256-column) for the LCD panel with up to 128x128 pixels, the capability in the black & white mode is 16,384-bit out of the total memory area, as illustrated in the Fig 9. In the black and white mode, 1-bit display data is used for 1-pixel.

**(6-3) Column address set**

In the black & white mode, an MPU can access 7-bit [C6:C0] column address by the "Column address LSB set" and "Column address MSB set" instructions. The column address automatically increases by 1 (+1) after each 1-byte display data.

**(6-4) Display data length set**

The "Display data length set" instruction is used in the 3-line serial interface mode in order to specify the data length in between 1 and 128 bytes in the black & white mode. The D<sub>7</sub> bit in the "Display data length set" instruction must be "0".

RS	R/W	D <sub>7</sub>	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>
0	0	1	1	1	0	1	0	0	0
0	0	(D <sub>7</sub> )	D <sub>6</sub>	D <sub>5</sub>	D <sub>4</sub>	D <sub>3</sub>	D <sub>2</sub>	D <sub>1</sub>	D <sub>0</sub>

Set display data length  
Specify the data length

(D<sub>7</sub>) : Must be "0" in the black & white mode



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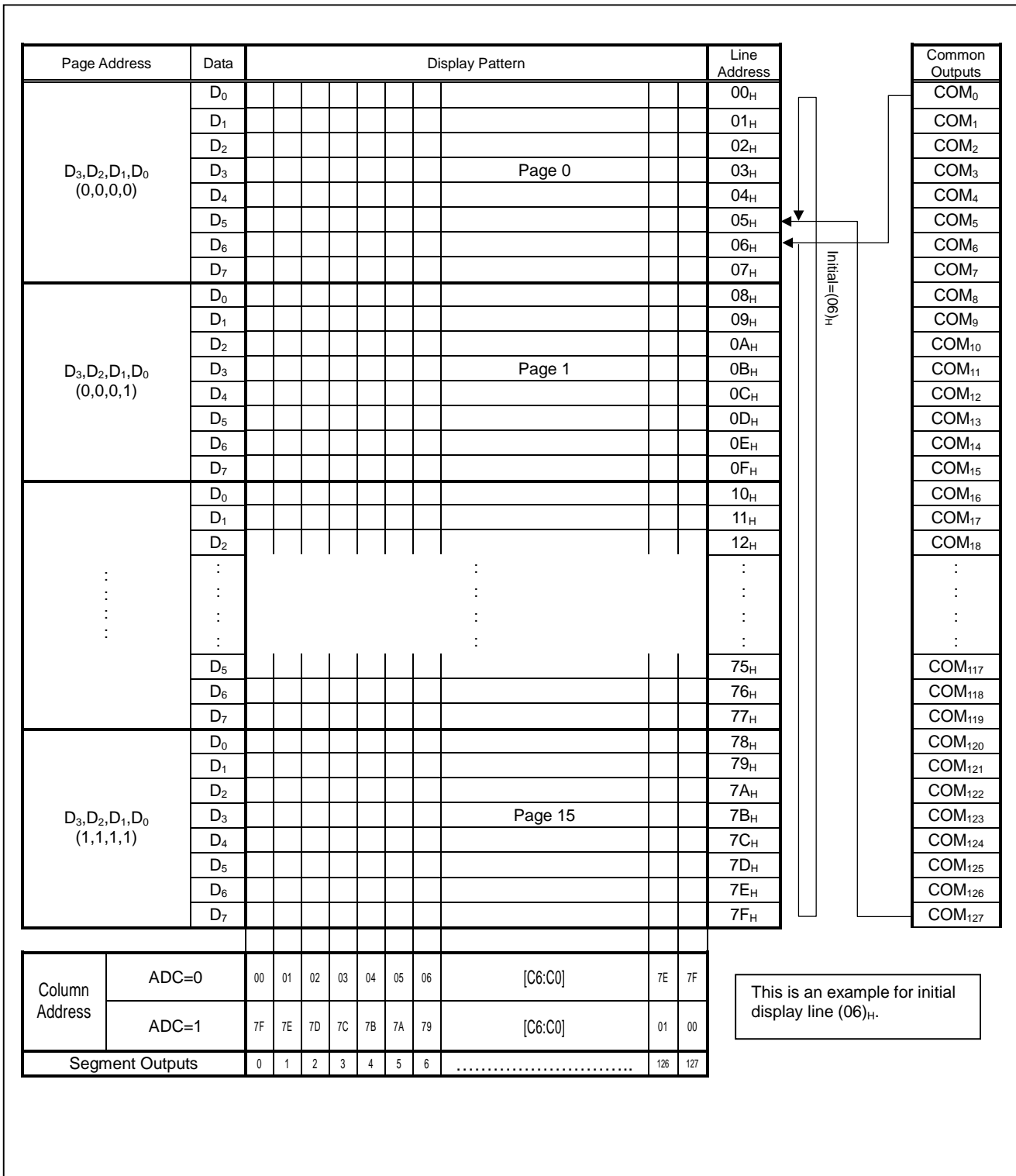


Fig.9 Display data RAM (DDRAM) Map in the Black & White mode







































