

1/65 DUTY LCD CONTROLLER/DRIVER WITH ON-CHIP RAM

DESCRIPTION

The μ PD16682A is a LCD controller/driver that includes enough RAM capacity to drive full-dot LCD displays. Each chip can drive a full-dot LCD display consisting of up to 132 x 65 dots.

This chip is suitable for cellular phones, Japanese or Chinese-language pagers, and other devices that display Japanese or Chinese characters using either 16 x 16 or 12 x 12 dots per character.

FEATURES

- LCD controller/driver with on-chip display RAM
- Able to operate using +3-V single power supply
- On-chip booster circuit: switchable between 3x and 4x modes
- RAM for dot displays: 132 x 65 bits
- Outputs : 132 segments, 65 commons
- Serial or 8-bit parallel data inputs (switchable between 80 and 68 series CPUs)
- On-chip divider resistor
- Selectable bias settings (can be set as 1/9 or 1/7 bias)
- On-chip oscillation circuit

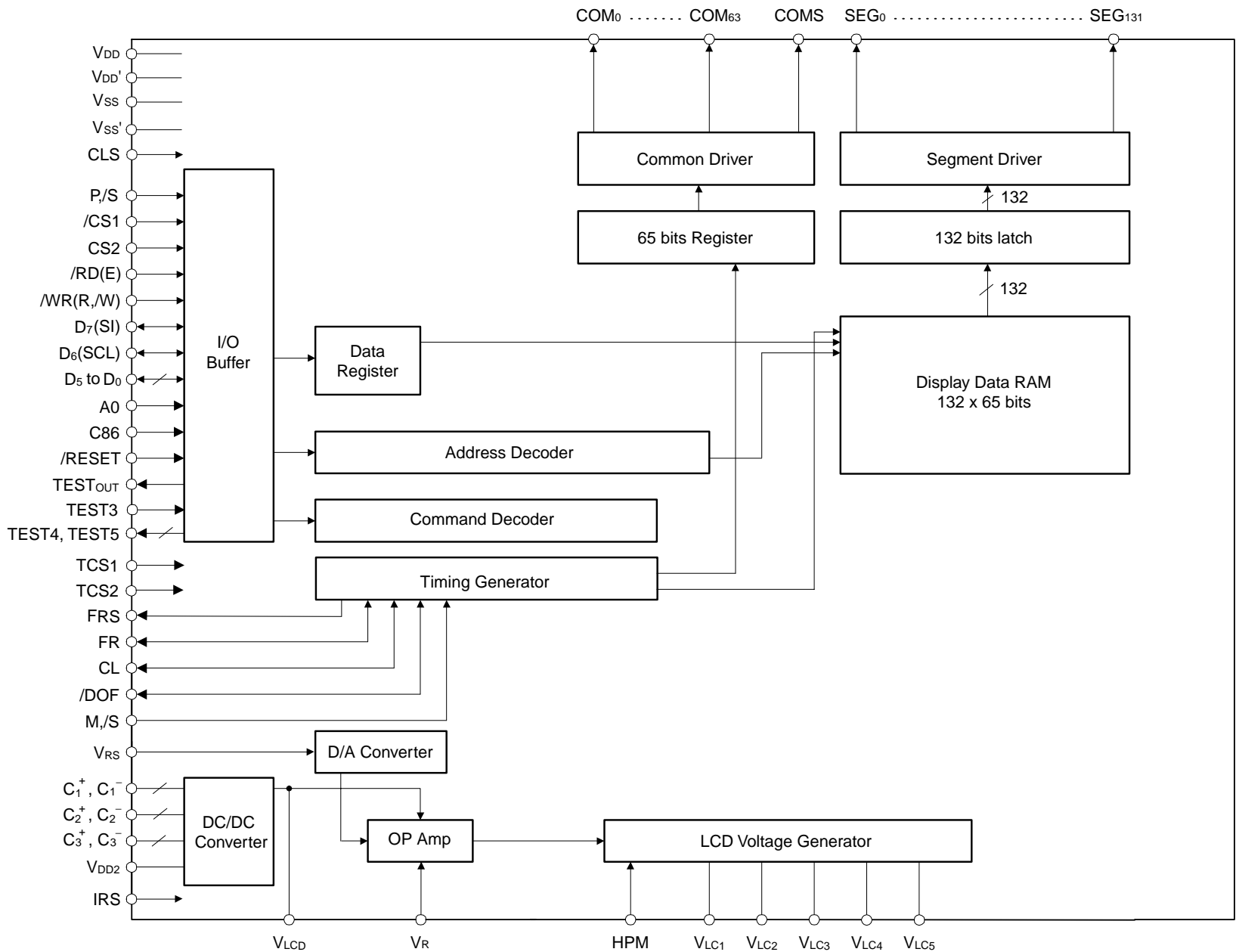
★ ORDERING INFORMATION

Part number	Package
μ PD16682AW	Wafer
μ PD16682AP	Chip

Remark Purchasing the above products in term of chips per requires an exchange of other documents as well, including a memorandum on the product quality. Therefore those who are interested in this regard are advised to contact one of our sales representatives.

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Not all devices/types available in every country. Please check with local NEC representative for availability and additional information.

1. BLOCK DIAGRAM



Remark /xxx indicates active low signals.

2. PIN CONFIGURATION (Pad Layout)

Chip Size : 2.66 x 9.84 mm²

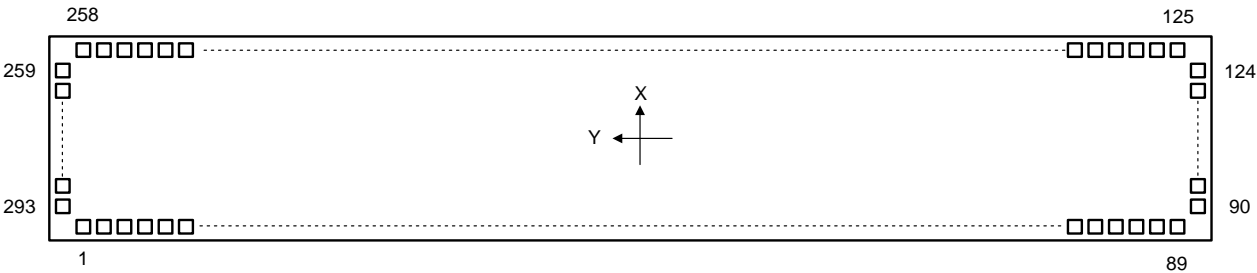


Table 2-1. Pad Layout (1/3)

Pad No.	Pad Name	X [μm]	Y [μm]	Pad Type	Pad No.	Pad Name	X [μm]	Y [μm]	Pad Type
1	DUMMY1	-1197.68	3984.44	C	59	V _{LC5}	-1197.68	-1268	B
2	FRS	-1197.68	3862	B	60	V _{LC5}	-1197.68	-1358	B
3	FR	-1197.68	3772	B	61	V _{LC4}	-1197.68	-1448	B
4	CL	-1197.68	3682	B	62	V _{LC4}	-1197.68	-1538	B
5	/DOF	-1197.68	3592	B	63	V _{LC3}	-1197.68	-1628	B
6	TEST _{OUT}	-1197.68	3502	B	64	V _{LC3}	-1197.68	-1718	B
7	V _{SS'}	-1197.68	3412	B	65	V _{LC2}	-1197.68	-1808	B
8	/CS1	-1197.68	3322	B	66	V _{LC2}	-1197.68	-1898	B
9	CS2	-1197.68	3232	B	67	V _{LC1}	-1197.68	-1988	B
10	V _{DD'}	-1197.68	3142	B	68	V _{LC1}	-1197.68	-2078	B
11	/RESET	-1197.68	3052	B	69	V _R	-1197.68	-2168	B
12	A0	-1197.68	2962	B	70	V _R	-1197.68	-2258	B
13	V _{SS'}	-1197.68	2872	B	71	V _{SS'}	-1197.68	-2348	B
14	/WR(R,W)	-1197.68	2782	B	72	V _{SS'}	-1197.68	-2438	B
15	/RD(E)	-1197.68	2692	B	73	TCS1	-1197.68	-2528	B
16	V _{DD'}	-1197.68	2602	B	74	TCS2	-1197.68	-2618	B
17	D ₀	-1197.68	2512	B	75	TEST3	-1197.68	-2708	B
18	D ₁	-1197.68	2422	B	76	TEST4	-1197.68	-2798	B
19	D ₂	-1197.68	2332	B	77	TEST5	-1197.68	-2888	B
20	D ₃	-1197.68	2242	B	78	V _{DD'}	-1197.68	-2978	B
21	D ₄	-1197.68	2152	B	79	M/S	-1197.68	-3068	B
22	D ₅	-1197.68	2062	B	80	CLS	-1197.68	-3158	B
23	D ₆ (SCL)	-1197.68	1972	B	81	V _{SS'}	-1197.68	-3248	B
24	D ₇ (SI)	-1197.68	1882	B	82	C86	-1197.68	-3338	B
25	V _{DD}	-1197.68	1792	B	83	P/S	-1197.68	-3428	B
26	V _{DD}	-1197.68	1702	B	84	V _{DD'}	-1197.68	-3518	B
27	V _{DD}	-1197.68	1612	B	85	HPM	-1197.68	-3608	B
28	V _{DD2}	-1197.68	1522	B	86	V _{SS'}	-1197.68	-3698	B
29	V _{DD2}	-1197.68	1432	B	87	IRS	-1197.68	-3788	B
30	V _{DD2}	-1197.68	1342	B	88	V _{DD'}	-1197.68	-3878	B
31	V _{DD2}	-1197.68	1252	B	89	DUMMY2	-1197.68	-4000.44	C
32	V _{SS}	-1197.68	1162	B	90	DUMMY3	-1032.44	-4787.68	C
33	V _{SS}	-1197.68	1072	B	91	COM ₃₁	-940	-4787.68	A
34	V _{SS}	-1197.68	982	B	92	COM ₃₀	-880	-4787.68	A
35	V _{SS}	-1197.68	892	B	93	COM ₂₉	-820	-4787.68	A
36	V _{SS}	-1197.68	802	B	94	COM ₂₈	-760	-4787.68	A
37	V _{SS}	-1197.68	712	B	95	COM ₂₇	-700	-4787.68	A
38	V _{LCD}	-1197.68	622	B	96	COM ₂₆	-640	-4787.68	A
39	V _{LCD}	-1197.68	532	B	97	COM ₂₅	-580	-4787.68	A
40	V _{LCD}	-1197.68	442	B	98	COM ₂₄	-520	-4787.68	A
41	C ₁ ⁺	-1197.68	352	B	99	COM ₂₃	-460	-4787.68	A
42	C ₁ ⁺	-1197.68	262	B	100	COM ₂₂	-400	-4787.68	A
43	C ₁ ⁻	-1197.68	172	B	101	COM ₂₁	-340	-4787.68	A
44	C ₁ ⁻	-1197.68	82	B	102	COM ₂₀	-280	-4787.68	A
45	C ₂ ⁺	-1197.68	-8	B	103	COM ₁₉	-220	-4787.68	A
46	C ₂ ⁺	-1197.68	-98	B	104	COM ₁₈	-160	-4787.68	A
47	C ₂ ⁻	-1197.68	-188	B	105	COM ₁₇	-100	-4787.68	A
48	C ₂ ⁻	-1197.68	-278	B	106	COM ₁₆	-40	-4787.68	A
49	C ₃ ⁺	-1197.68	-368	B	107	COM ₁₅	20	-4787.68	A
50	C ₃ ⁺	-1197.68	-458	B	108	COM ₁₄	80	-4787.68	A
51	C ₃ ⁻	-1197.68	-548	B	109	COM ₁₃	140	-4787.68	A
52	C ₃ ⁻	-1197.68	-638	B	110	COM ₁₂	200	-4787.68	A
53	V _{DD'}	-1197.68	-728	B	111	COM ₁₁	260	-4787.68	A
54	V _{DD'}	-1197.68	-818	B	112	COM ₁₀	320	-4787.68	A
55	V _{RS}	-1197.68	-908	B	113	COM ₉	380	-4787.68	A
56	V _{RS}	-1197.68	-998	B	114	COM ₈	440	-4787.68	A
57	V _{SS'}	-1197.68	-1088	B	115	COM ₇	500	-4787.68	A
58	V _{SS'}	-1197.68	-1178	B	116	COM ₆	560	-4787.68	A

Table 2-1. Pad Layout (2/3)

Pad No.	Pad Name	X [μm]	Y [μm]	Pad Type	Pad No.	Pad Name	X [μm]	Y [μm]	Pad Type
117	COM ₅	620	-4787.68	A	175	SEG ₄₉	1197.68	-990.4	A
118	COM ₄	680	-4787.68	A	176	SEG ₅₀	1197.68	-930.4	A
119	COM ₃	740	-4787.68	A	177	SEG ₅₁	1197.68	-870.4	A
120	COM ₂	800	-4787.68	A	178	SEG ₅₂	1197.68	-810.4	A
121	COM ₁	860	-4787.68	A	179	SEG ₅₃	1197.68	-750.4	A
122	COM ₀	920	-4787.68	A	180	SEG ₅₄	1197.68	-690.4	A
123	COMS	980	-4787.68	A	181	SEG ₅₅	1197.68	-630.4	A
124	DUMMY4	1072.6	-4787.68	C	182	SEG ₅₆	1197.68	-570.4	A
125	DUMMY5	1197.68	-4022.84	C	183	SEG ₅₇	1197.68	-510.4	A
126	SEG ₀	1197.68	-3930.4	A	184	SEG ₅₈	1197.68	-450.4	A
127	SEG ₁	1197.68	-3870.4	A	185	SEG ₅₉	1197.68	-390.4	A
128	SEG ₂	1197.68	-3810.4	A	186	SEG ₆₀	1197.68	-330.4	A
129	SEG ₃	1197.68	-3750.4	A	187	SEG ₆₁	1197.68	-270.4	A
130	SEG ₄	1197.68	-3690.4	A	188	SEG ₆₂	1197.68	-210.4	A
131	SEG ₅	1197.68	-3630.4	A	189	SEG ₆₃	1197.68	-150.4	A
132	SEG ₆	1197.68	-3570.4	A	190	SEG ₆₄	1197.68	-90.4	A
133	SEG ₇	1197.68	-3510.4	A	191	SEG ₆₅	1197.68	-30.4	A
134	SEG ₈	1197.68	-3450.4	A	192	SEG ₆₆	1197.68	29.6	A
135	SEG ₉	1197.68	-3390.4	A	193	SEG ₆₇	1197.68	89.6	A
136	SEG ₁₀	1197.68	-3330.4	A	194	SEG ₆₈	1197.68	149.6	A
137	SEG ₁₁	1197.68	-3270.4	A	195	SEG ₆₉	1197.68	209.6	A
138	SEG ₁₂	1197.68	-3210.4	A	196	SEG ₇₀	1197.68	269.6	A
139	SEG ₁₃	1197.68	-3150.4	A	197	SEG ₇₁	1197.68	329.6	A
140	SEG ₁₄	1197.68	-3090.4	A	198	SEG ₇₂	1197.68	389.6	A
141	SEG ₁₅	1197.68	-3030.4	A	199	SEG ₇₃	1197.68	449.6	A
142	SEG ₁₆	1197.68	-2970.4	A	200	SEG ₇₄	1197.68	509.6	A
143	SEG ₁₇	1197.68	-2910.4	A	201	SEG ₇₅	1197.68	569.6	A
144	SEG ₁₈	1197.68	-2850.4	A	202	SEG ₇₆	1197.68	629.6	A
145	SEG ₁₉	1197.68	-2790.4	A	203	SEG ₇₇	1197.68	689.6	A
146	SEG ₂₀	1197.68	-2730.4	A	204	SEG ₇₈	1197.68	749.6	A
147	SEG ₂₁	1197.68	-2670.4	A	205	SEG ₇₉	1197.68	809.6	A
148	SEG ₂₂	1197.68	-2610.4	A	206	SEG ₈₀	1197.68	869.6	A
149	SEG ₂₃	1197.68	-2550.4	A	207	SEG ₈₁	1197.68	929.6	A
150	SEG ₂₄	1197.68	-2490.4	A	208	SEG ₈₂	1197.68	989.6	A
151	SEG ₂₅	1197.68	-2430.4	A	209	SEG ₈₃	1197.68	1049.6	A
152	SEG ₂₆	1197.68	-2370.4	A	210	SEG ₈₄	1197.68	1109.6	A
153	SEG ₂₇	1197.68	-2310.4	A	211	SEG ₈₅	1197.68	1169.6	A
154	SEG ₂₈	1197.68	-2250.4	A	212	SEG ₈₆	1197.68	1229.6	A
155	SEG ₂₉	1197.68	-2190.4	A	213	SEG ₈₇	1197.68	1289.6	A
156	SEG ₃₀	1197.68	-2130.4	A	214	SEG ₈₈	1197.68	1349.6	A
157	SEG ₃₁	1197.68	-2070.4	A	215	SEG ₈₉	1197.68	1409.6	A
158	SEG ₃₂	1197.68	-2010.4	A	216	SEG ₉₀	1197.68	1469.6	A
159	SEG ₃₃	1197.68	-1950.4	A	217	SEG ₉₁	1197.68	1529.6	A
160	SEG ₃₄	1197.68	-1890.4	A	218	SEG ₉₂	1197.68	1589.6	A
161	SEG ₃₅	1197.68	-1830.4	A	219	SEG ₉₃	1197.68	1649.6	A
162	SEG ₃₆	1197.68	-1770.4	A	220	SEG ₉₄	1197.68	1709.6	A
163	SEG ₃₇	1197.68	-1710.4	A	221	SEG ₉₅	1197.68	1769.6	A
164	SEG ₃₈	1197.68	-1650.4	A	222	SEG ₉₆	1197.68	1829.6	A
165	SEG ₃₉	1197.68	-1590.4	A	223	SEG ₉₇	1197.68	1889.6	A
166	SEG ₄₀	1197.68	-1530.4	A	224	SEG ₉₈	1197.68	1949.6	A
167	SEG ₄₁	1197.68	-1470.4	A	225	SEG ₉₉	1197.68	2009.6	A
168	SEG ₄₂	1197.68	-1410.4	A	226	SEG ₁₀₀	1197.68	2069.6	A
169	SEG ₄₃	1197.68	-1350.4	A	227	SEG ₁₀₁	1197.68	2129.6	A
170	SEG ₄₄	1197.68	-1290.4	A	228	SEG ₁₀₂	1197.68	2189.6	A
171	SEG ₄₅	1197.68	-1230.4	A	229	SEG ₁₀₃	1197.68	2249.6	A
172	SEG ₄₆	1197.68	-1170.4	A	230	SEG ₁₀₄	1197.68	2309.6	A
173	SEG ₄₇	1197.68	-1110.4	A	231	SEG ₁₀₅	1197.68	2369.6	A
174	SEG ₄₈	1197.68	-1050.4	A	232	SEG ₁₀₆	1197.68	2429.6	A

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Table 2-1. Pad Layout (3/3)

Pad No.	Pad Name	X [μm]	Y [μm]	Pad Type
233	SEG107	1197.68	2489.6	A
234	SEG108	1197.68	2549.6	A
235	SEG109	1197.68	2609.6	A
236	SEG110	1197.68	2669.6	A
237	SEG111	1197.68	2729.6	A
238	SEG112	1197.68	2789.6	A
239	SEG113	1197.68	2849.6	A
240	SEG114	1197.68	2909.6	A
241	SEG115	1197.68	2969.6	A
242	SEG116	1197.68	3029.6	A
243	SEG117	1197.68	3089.6	A
244	SEG118	1197.68	3149.6	A
245	SEG119	1197.68	3209.6	A
246	SEG120	1197.68	3269.6	A
247	SEG121	1197.68	3329.6	A
248	SEG122	1197.68	3389.6	A
249	SEG123	1197.68	3449.6	A
250	SEG124	1197.68	3509.6	A
251	SEG125	1197.68	3569.6	A
252	SEG126	1197.68	3629.6	A
253	SEG127	1197.68	3689.6	A
254	SEG128	1197.68	3749.6	A
255	SEG129	1197.68	3809.6	A
256	SEG130	1197.68	3869.6	A
257	SEG131	1197.68	3929.6	A
258	DUMMY6	1197.68	4022.2	C
259	DUMMY7	1032.44	4787.68	C
260	COM32	940	4787.68	A
261	COM33	880	4787.68	A
262	COM34	820	4787.68	A
263	COM35	760	4787.68	A
264	COM36	700	4787.68	A
265	COM37	640	4787.68	A
266	COM38	580	4787.68	A
267	COM39	520	4787.68	A
268	COM40	460	4787.68	A
269	COM41	400	4787.68	A
270	COM42	340	4787.68	A
271	COM43	280	4787.68	A
272	COM44	220	4787.68	A
273	COM45	160	4787.68	A
274	COM46	100	4787.68	A
275	COM47	40	4787.68	A
276	COM48	-20	4787.68	A
277	COM49	-80	4787.68	A
278	COM50	-140	4787.68	A
279	COM51	-200	4787.68	A
280	COM52	-260	4787.68	A
281	COM53	-320	4787.68	A
282	COM54	-380	4787.68	A
283	COM55	-440	4787.68	A
284	COM56	-500	4787.68	A
285	COM57	-560	4787.68	A
286	COM58	-620	4787.68	A
287	COM59	-680	4787.68	A
288	COM60	-740	4787.68	A
289	COM61	-800	4787.68	A
290	COM62	-860	4787.68	A
291	COM63	-920	4787.68	A
292	COMS	-980	4787.68	A
293	DUMMY8	-1072.6	4787.68	C

Remark Pad Type A:

Pad size (Al): 47 x 105 μm² (TYP.)

Bump size: 35 x 92.5 μm² (TYP.)

Bump height: 17 μm (TYP.)

Pad Type B:

Pad size (Al): 75 x 105 μm² (TYP.)

Bump size: 67 x 92.5 μm² (TYP.)

Bump height: 17 μm (TYP.)

Pad Type C:

Pad size (Al): 118 x 105 μm² (TYP.)

Bump size: 110 x 92.5 μm² (TYP.)

Bump height: 17 μm (TYP.)

3. PIN FUNCTIONS

3.1 Power Supply System Pins

Pin Symbol	Pin Name	Pad No.	I/O	Description
V _{DD}	Logic power supply pins	25 to 27	—	Power supply pins for logic. Apply the logic power supply voltage from an external source.
V _{DD2}	Booster circuit power supply pins	28 to 31	—	Power supply pins for booster circuit. Apply the booster circuit power supply voltage from an external source.
V _{SS}	Logic/driver ground pins	32 to 37	—	Ground pins for logic and driver circuit. Connect these pins to an external ground.
V _{LCD}	Driver power supply pins	38 to 40	—	Power supply pins for driver. Output pins for internal booster circuit. Connect a 1-μF capacitor for boosting between these pins and the GND pins. If not using the internal booster circuit, a direct driver power supply can be input.
V _{DD} '	Power supply pins for fixed mode pins	10,16,53,54, 78,84,88	—	These power supply pins are used to set the mode pins as fixed.
V _{SS} '	Ground pins for fixed mode pins	7,13,57,58, 71,72,81,86	—	These ground pins are used to set the mode pins as fixed.
V _{LC1} to V _{LC5}	Reference power supply pins for driver	59 to 68	—	These are reference power supply pins for the LCD driver. Connect a smoothing capacitor if an internal bias has been selected.
C ₁ ⁺ , C ₁ ⁻ C ₂ ⁺ , C ₂ ⁻ C ₃ ⁺ , C ₃ ⁻	Capacitor connection pins	41 to 52	—	These are capacitor connection pins for the booster circuit. Connect a 1-μF capacitor.

3.2 Logic System Pins (1/3)

Pin Symbol	Pin Name	Pad No.	I/O	Description
P _/ S	Select data input	83	Input	This pin is used to select between parallel data input and serial data input. P _/ S = H : Parallel data input P _/ S = L : Serial data input This setting cannot be switched after power-on. For details, see 5. DESCRIPTION OF FUNCTIONS.
/CS1, CS2	Chip select	8,9	Input	These pins are used for the chip select signal. When /CS1 = L and CS2 = H, this signal is active and can be used for I/O of data and commands.
/RD(E)	Read (enable)	15	Input	<ul style="list-style-type: none"> When connected to 80 series CPU : active low This pin connects the 80 series CPU's RD signal. Data bus output status is set when this signal is low. When connected to 68 series CPU : active high It is used as the enable clock input pin for the 68 series CPU.
/WR(R, _/ W)	Write (read/write)	14	Input	<ul style="list-style-type: none"> When connected to 80 series CPU: active low This pin connects the 80 series CPU's /WR signal. Signals on the data bus are latched at the rising edge of the /WR signal. When connected to 68 series CPU This pin is an input pin for read/write control signals. R,_/W = H : Read R,_/W = L : Write
C86	Interface select	82	Input	This pin is used to select the CPU interface. C86 = H : 68 series CPU interface C86 = L : 80 series CPU interface
D ₀ to D ₅	Data bus	17 to 22	Input /Output	When used with a parallel interface, these pins correspond to data bus bits D ₀ to D ₅ . When used with a serial interface, they are pulled down internally.
D ₆ (SCL)	Data bus/serial clock	23	Input /Output	When used with a parallel interface, this pin corresponds to data bus bit D ₆ . When used with a serial interface, it is a serial clock input pin.
D ₇ (SI)	Data bus/serial data input	24	Input /Output	When used with a parallel interface, this pin corresponds to data bus bit D ₇ . When used with a serial interface, it is a serial data input pin.
A0	Data command	12	Input	This pin is connected to the LSB in the ordinary CPU address bus to distinguish between data and commands. A0 = H : Indicates that display data exists in bits D ₀ to D ₇ . A0 = L : Indicates that display control commands exist in bits D ₀ to D ₇ .
TEST _{OUT}	Test output	6	Output	This pin is used as a test output. Leave this pin open when used for this purpose.
/RESET	Reset	11	Input	This pin is used to perform an internal reset when at low level.
CLS	Clock select	80	Input	This pin is used to select the valid/invalid setting for the display clock's on-chip oscillation circuit. CLS = H : On-chip oscillation circuit is valid CLS = L : On-chip oscillation circuit is invalid (external input) When CLS = L, a display clock is input via the CL pin.

3.2 Logic System Pins (2/3)

Pin Symbol	Pin Name	Pad No.	I/O	Description																																						
FR	Frame signal	3	Input /Output	This pin is used as an I/O pin for the LCD's AC conversion signal. This pin is used (along with the FRS pin) for the static drive.																																						
FRS	Static signal	2	Output	This pin is used as an output pin for the static drive. This pin is used (along with the FR pin) for the static drive.																																						
M,/S	Master/Slave	79	Input	<div>This pin is used to select master or slave operation mode. Timing signals required for the LCD are output during master mode and are input during slave mode to ensure synchronization of the LCD block.</div> <div>M,/S = H: Master operation mode</div> <div>M,/S = L: Slave operation mode</div> <div>Note the settings below, based on the status of the M,/S and CLS pins.</div> <table><tr><th>M,/S</th><th>CLS</th><th>Oscillation Circuit</th><th>Power supply circuit</th><th>CL</th><th>FR</th><th>FRS</th><th>/DOF</th></tr><tr><td rowspan="2">H</td><td>H</td><td>Valid</td><td>Valid</td><td>Output</td><td>Output</td><td>Output</td><td>Output</td></tr><tr><td>L</td><td>Invalid</td><td>Valid</td><td>Input</td><td>Output</td><td>Output</td><td>Output</td></tr><tr><td rowspan="2">L</td><td>H</td><td>Invalid</td><td>Invalid</td><td>Input</td><td>Input</td><td>Hi-Z</td><td>Input</td></tr><tr><td>L</td><td>Invalid</td><td>Invalid</td><td>Input</td><td>Input</td><td>Hi-Z</td><td>Input</td></tr></table>	M,/S	CLS	Oscillation Circuit	Power supply circuit	CL	FR	FRS	/DOF	H	H	Valid	Valid	Output	Output	Output	Output	L	Invalid	Valid	Input	Output	Output	Output	L	H	Invalid	Invalid	Input	Input	Hi-Z	Input	L	Invalid	Invalid	Input	Input	Hi-Z	Input
M,/S	CLS	Oscillation Circuit	Power supply circuit	CL	FR	FRS	/DOF																																			
H	H	Valid	Valid	Output	Output	Output	Output																																			
	L	Invalid	Valid	Input	Output	Output	Output																																			
L	H	Invalid	Invalid	Input	Input	Hi-Z	Input																																			
	L	Invalid	Invalid	Input	Input	Hi-Z	Input																																			
CL	Display clock input	4	Input /Output	<div>This pin is used as the display clock I/O pin. Note the settings below, based on the status of the M,/S and CLS pins.</div> <table><tr><th>M,/S</th><th>CLS</th><th>CL</th></tr><tr><td>H</td><td>H</td><td>Output</td></tr><tr><td></td><td>L</td><td>Input</td></tr><tr><td>L</td><td>H</td><td>Input</td></tr><tr><td></td><td>L</td><td>Input</td></tr></table> <div>When using this pin in master or slave mode, connect it to the corresponding CL pin.</div>	M,/S	CLS	CL	H	H	Output		L	Input	L	H	Input		L	Input																							
M,/S	CLS	CL																																								
H	H	Output																																								
	L	Input																																								
L	H	Input																																								
	L	Input																																								
/DOF	Blink control	5	Input /Output	<div>This pin is used to control blinking in the LCD.</div> <div>M,/S = H : Output</div> <div>M,/S = L : Input</div> <div>When using this pin in master or slave mode, connect it to the corresponding /DOF pin.</div>																																						
HPM	Power supply circuit select pin for LCD driver	85	Input	<div>This pin is used as a power control pin of the power supply circuit for the LCD driver.</div> <div>HPM = H : Normal mode</div> <div>HPM = L : High-power mode</div>																																						
IRS	Select pin for V _{LC1} regulating resistor	87	Input	<div>This pin is used to select the resistor that is used to regulate the V_{LC1} voltage.</div> <div>IRS = H : Select on-chip resistor</div> <div>IRS = L : Do not select on-chip resistor. The V_{LC1} voltage is regulated via the V_R pin and an external divided resistor.</div> <div>Use of the on-chip resistor cannot be selected or deselected via a hard reset or via a reset command. Instead, use this pin to select the setting.</div>																																						

3.2 Logic System Pins (3/3)

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Pin Symbol	Pin Name	Pad No.	I/O	Description															
TCS1,TCS2	Temperature gradient select	73,74	Input	<div>These pins are used to select temperature gradient. Note the temperature gradient below, based on the status of the TCS1, TCS2.</div> <table><tr><th>TCS2</th><th>TCS1</th><th>Temperature gradient (% / °C)</th></tr><tr><td>L</td><td>L</td><td>−0.09</td></tr><tr><td>L</td><td>H</td><td>0</td></tr><tr><td>H</td><td>L</td><td>−0.05</td></tr><tr><td>H</td><td>H</td><td>−0.14</td></tr></table>	TCS2	TCS1	Temperature gradient (% / °C)	L	L	−0.09	L	H	0	H	L	−0.05	H	H	−0.14
TCS2	TCS1	Temperature gradient (% / °C)																	
L	L	−0.09																	
L	H	0																	
H	L	−0.05																	
H	H	−0.14																	
TEST3	Test pins	75	Input	These are test pins for IC tests. Normally, these pins should be left open.															
TEST4,TEST5	Test pins	76,77	Output	These are test pins for IC tests. Normally, these pins should be left open.															

3.3 Driver System Pins

Pin Symbol	Pin Name	Pad No.	I/O	Description
SEG ₀ to SEG ₁₃₁	Segment	126 to 257	Output	Segment output pins
COM ₀ to COM ₆₃	Common	91 to 122, 260 to 291	Output	Common output pins
COMS	Indicator common	123,292	Output	Common output pins for indicator The same signal is output from pin 2.
V _{RS}	Op amp inputs	55,56	Input	These are input pins for the op amp that regulates the LCD driver voltage. Leave the V _{RS} pin open when using the on-chip power supply. When not using the on-chip power supply, a reference voltage V _{REG} must be input. When using an external power supply, connect the V _R pin to a resistor used to regulate the LCD voltage.
V _R		69,70		
DUMMY1 to DUMMY8	Dummy pins	1,89,90,124,125, 258,259,293	—	Since these pins are not connected to any internal circuits, they should be left open when they are not being used.

4. PIN I/O CIRCUITS AND RECOMMENDED CONNECTION OF UNUSED PINS

The input/output circuit type of each pin and recommended connection of unused pins are shown in the following table.

Pin Name	I/O	Recommended Connection of Unused Pins	Notes
P _/ S	Input	Mode setting pin	1
/CS1	Input	Connect to V _{SS}	
CS2	Input	Connect to V _{DD}	
/RD(E)	Input	Connect to V _{DD} (80 series interface), connect to V _{DD} or V _{SS} (serial interface)	
/WR (R _/ W)	Input	Connect to V _{DD} or V _{SS} (serial interface)	
C86	Input	Mode setting pin	1
D ₀ to D ₅	Input/Output	Leave open (when using serial interface)	2
D ₆ (SCL)	Input/Output		
D ₇ (SI)	Input/Output		
A0	Input	Data/command setting pin	3
TEST _{OUT}	Output	Leave open	
/RESET	Input	Connect to V _{DD}	
CLS	Input	Mode setting pin	1
FR	Input/Output	Leave open (when using master mode, M _/ S = H)	
FRS	Output	Leave open	
/DOF	Input/Output	Leave open (when using master mode, M _/ S = H)	
M _/ S	Input	Mode setting pin	1
CL	Input/Output	Display clock	4
HPM	Input	Mode setting pin	1
IRS	Input	Mode setting pin	1
TCS1	Input	Mode setting pin	1
TCS2	Input	Mode setting pin	1
TEST3	Input	Leave open	2
TEST4	Output	Leave open	
TEST5	Output	Leave open	

- Notes**
1. Connect to V_{DD} or V_{SS} according to the selected mode.
 2. These pins are pulled down to V_{SS} in the IC.
 3. Input CPU output from V_{DD} or V_{SS} according to the selected register.
 4. This pin is an output when M_/S = H and CLS = H but should otherwise be used to input the display clock.

5. DESCRIPTION OF FUNCTIONS

5.1 CPU Interface

5.1.1 Select interface type

The μPD16682A transfers data either via an 8-bit bidirectional data bus (D₇ to D₀) or via a serial data input (SI). The P,_/S pin can be set to either high or low levels to select 8-bit parallel data input or serial data input, as shown in the table below.

P, _/ S	/CS1	CS2	A0	/RD	/WR	C86	D ₇	D ₆	D ₅ - D ₀
H: Parallel input	/CS1	CS2	A0	/RD	/WR	C86	D ₇	D ₆	D ₅ - D ₀
L: Serial input	/CS1	CS2	A0	Note 1	Note 1	Note1	SI	SCL	Note2

Notes 1. Fix this pin as either H or L.

2. High impedance

5.1.2 Parallel interface

If the parallel interface has been selected (P,_/S = H), setting the C86 pin either high or low determines whether to connect directly to the 80 series CPU or the 68 series CPU, as shown in the table below.

P, _/ S	/CS1	CS2	A0	/RD	D ₇ - D ₀
H: 68 series CPU bus	/CS1	CS2	A0	E	D ₇ - D ₀
L: 80 series CPU bus	/CS1	CS2	A0	/RD	D ₇ - D ₀

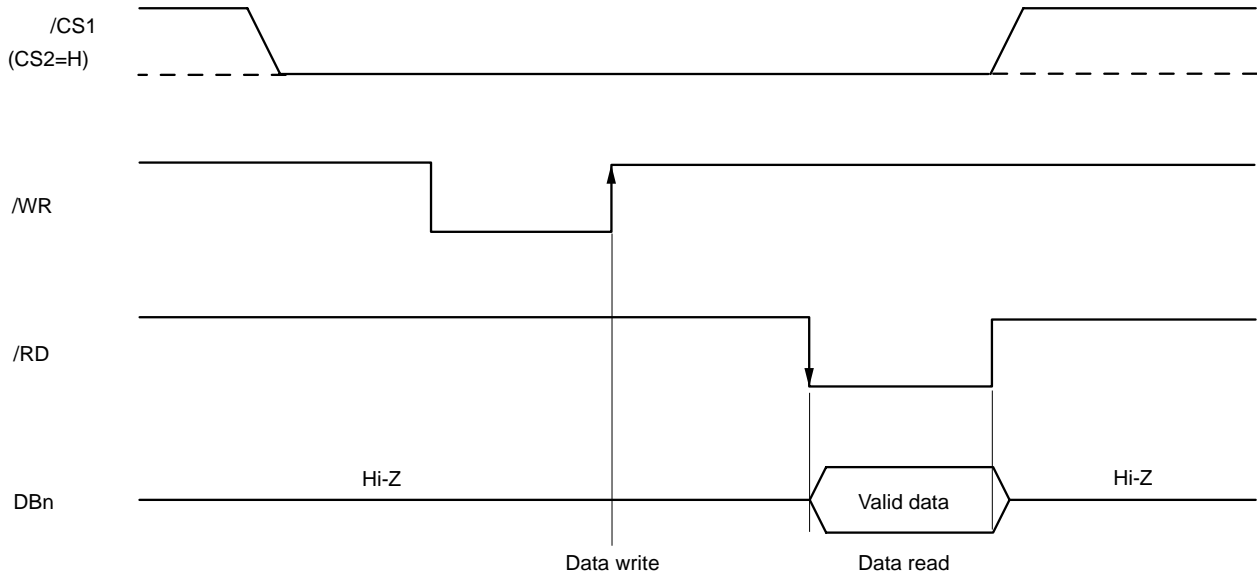
The data bus signal can be identified according to the combination of A0, /RD(E), and /WR (R,_/W) signals, as shown in the table below.

Common	68 Series	80 Series		Function
A0	R, _/ W	/RD	/WR	
H	H	L	H	Read display data
H	L	H	L	Write display data
L	H	L	H	Read status
L	L	H	L	Write control data (command)

(1) 80 Series Parallel Interface

When 80 series parallel data transfer has been selected, data is written to the μPD16682A at the rising edge of the /WR signal. The data is output to the data bus when the /RD signal is L.

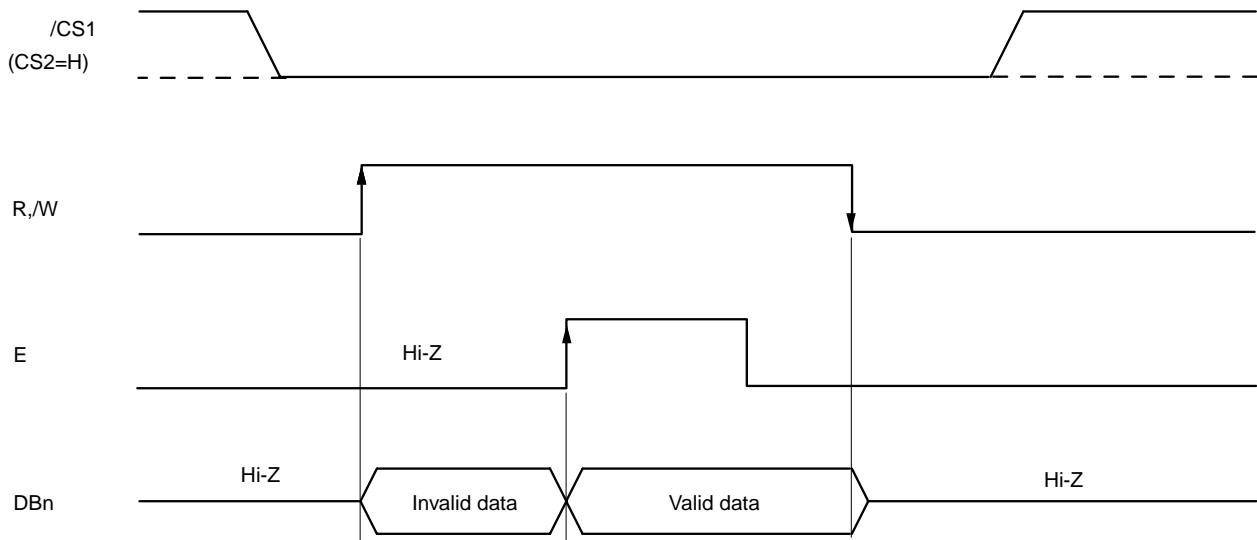
Figure 5-1 80 Series Interface Data Bus Status



(2) 68 Series Parallel Interface

When 68 series parallel data transfer has been selected, data is written at the falling edge of the E signal when the R,/W signal is L. During the data read operation, the data bus enters the output status when the R,/W signal is H, outputs valid data at the rising edge of the E signal, and enters the high-impedance state at the falling edge of the R,/W signal (R,/W = L).

Figure 5-2 68 Series Interface Data Bus Status



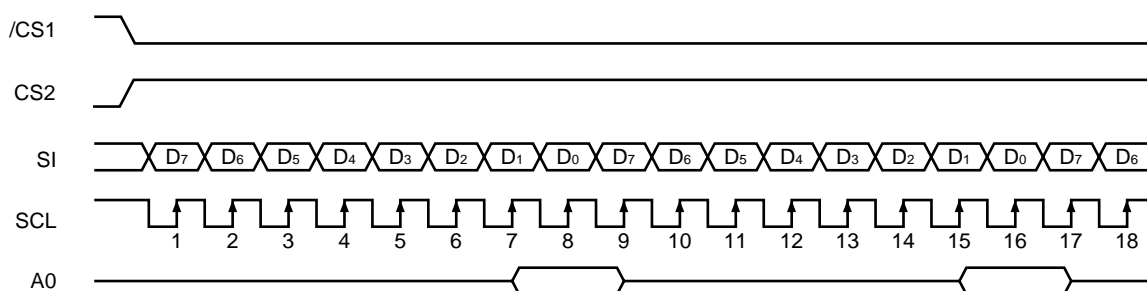
5.1.3 Serial interface

If the serial interface has been selected ($P/S = L$) and if the chip is in the active state ($/CS1 = L$ and $CS2 = H$), both serial data input (SI) and serial clock input (SCL) can be received. The serial interface includes an 8-bit shift register and a 3-bit counter. Serial data is captured at the rising edge of the serial clock and is clocked in via the serial data input pins in sequence from D_7 to D_0 . At the rising edge of the eighth serial clock, data is converted to 8-bit parallel data.

Input via the $A0$ pin can be used to determine whether the input serial data is display data or a command (display data when $A0 = H$, command when $A0 = L$). The timing for reading and identifying input via $A0$ occurs at the rising edge of the "eighth x n" serial clock once the chip's status is active.

A serial interface signal chart is shown below.

Figure 5-3. Serial Interface chart



- Remarks**
1. When the chip's status is inactive, the shift register and counter are both reset to their initial values.
 2. Data cannot be read when using the serial interface.
 3. For the SCL signal, caution is advised concerning the wire's terminating reflection and noise from external sources. We recommend to check the operation on the actual equipment.

5.1.4 Chip select

The μ PD16682A has two chip select pins ($/CS1$ and $CS2$). The CPU interface or serial interface can be used only when $/CS1 = L$ and $CS2 = H$.

When the chip select pin is inactive, D_7 to D_0 are set to high impedance (invalid) and input of $A0$, $/RD$, or $/WR$ is invalid. If the serial interface has been selected, the shift register and counter are both reset.

5.1.5 Display data RAM and internal register access

Access to the μ PD16682A from the CPU supports high-speed data transfers since the cycle time (t_{CYC}) is met and there is no need for wait time.

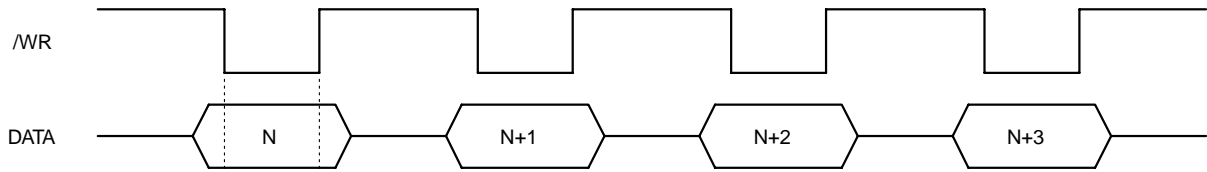
When data transfer occurs between the μ PD16682A and the CPU, the data is held in a bus holder belonging to the internal data bus and is written to the display data RAM before the next data write cycle. When the CPU reads the contents of the display data RAM, the data read during the first data read cycle (dummy cycle) is first held in the bus holder and is read from the bus holder to the system bus during the next data read cycle.

Note with caution that, due to constraints on the read sequence for the display data RAM, when the address is set, the data is not output from the address specified by the next read command but rather is output to the address specified during the second data read operation. Consequently, one dummy read operation is strictly required after setting an address or after a write cycle. Figure 5-4 illustrates this situation.

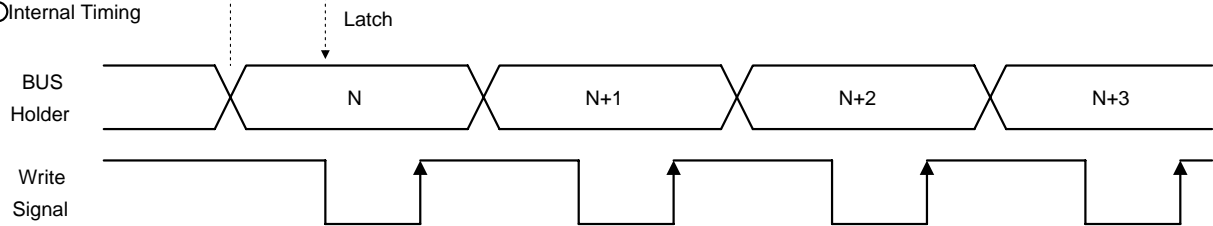
Figure 5-4. Write and Read Operations

Writing

○CPU

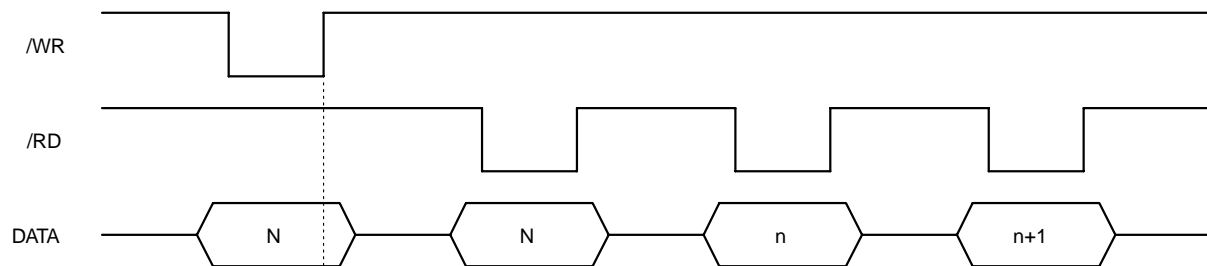


○Internal Timing

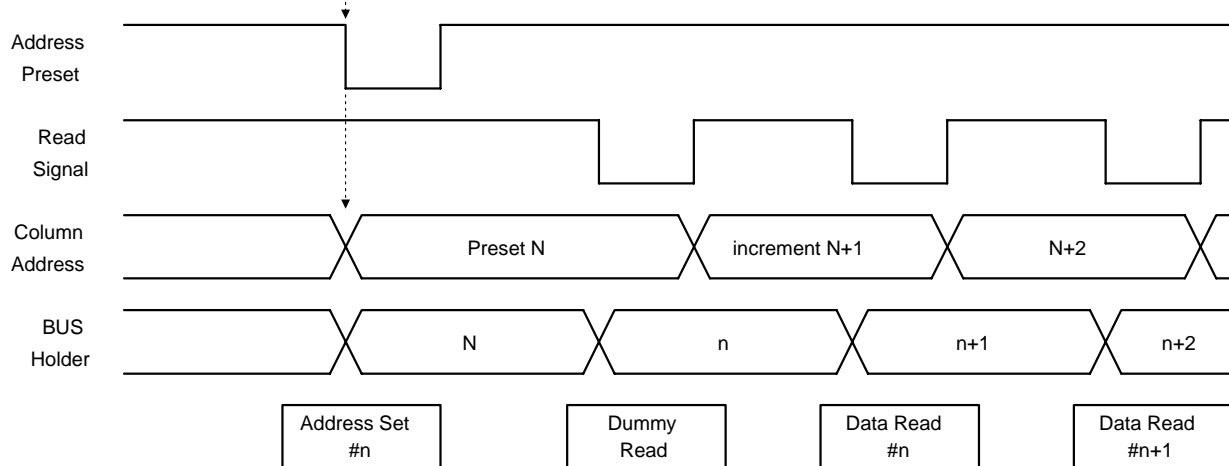


Reading

○CPU



○Internal Timing



6. DISPLAY DATA RAM

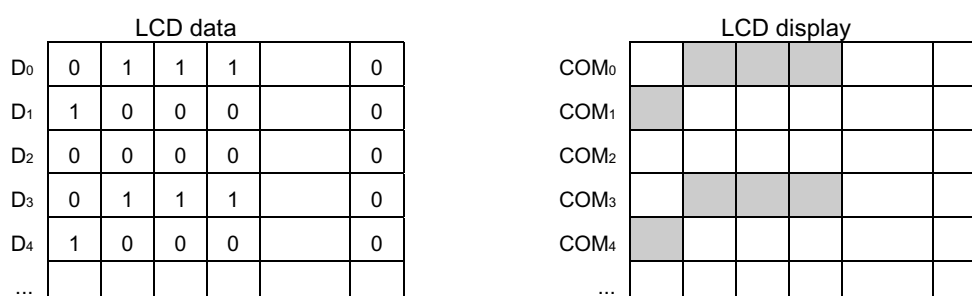
6.1 Display Data RAM

This is the RAM that is used to store the display's dot data. The RAM configuration is 65 (8 pages x 8 bits + 1) x 132 bits. Any specified bit can be accessed by selecting the corresponding page address and column address.

As is shown in Figure 6–1 below, the display data (D₇ to D₀) from the CPU corresponds to the common direction in the LCD, so that if a multiple set of μPD16682A chips is used, there are fewer constraints on transfers of display data and relatively more freedom for display configurations.

The CPU accesses the display data RAM for read/write operations via the I/O buffer, and these operations are independent of the LCD driver signal read operations. Therefore, there are absolutely no adverse effects (such as flicker) in the display when display data RAM is accessed asynchronously in relation to the LCD contents.

Figure 6–1. LCD Data and LCD Display



6.2 Page Address Circuit

The page address set command specifies the page address in the display data RAM, as is shown in Figure 6–2. To access a different page, simply specify a different page address using this command.

Page address 8 (D₃,D₂,D₁,D₀ = 1,0,0,0) is a RAM area that is used exclusively for indicator, so only display data D₀ is valid.

6.3 Column Address Circuit

The column address set command specifies the column address in the display data RAM, as is shown in Figure 6–2. The specified column address is incremented each time a display data read or write command is input, so the CPU is able to successively access display data.

Incrementation of the column address stops at 83H. The column address and page address are mutually independent, which means that to switch from column 83H on page 0 to column 00H on page 1, both the page address and column address must be separately specified again.

Also, as is shown in Table 6–1, the ADC command (segment driver direction select command) can be used to invert the correspondence between the display data RAM's column address and segment output. This reduces the number of IC layout constraints that are imposed when setting up the LCD module.

Table 6–1. Relation between Display Data RAM Column Address and Segment Output

SEG Output		SEG ₀		SEG ₁₃₁
ADC (D ₀)	"0"	00H	→ Column Address →	83H
	"1"	83H	← Column Address ←	00H

6.5 Display Data Latch Circuit

The display data latch circuit is used for temporary storage of display data that has been output to the LCD driver circuit from the display data RAM.

The commands that are used to set normal/inverted display modes, display ON/OFF status, and display all ON/OFF status are commands that control data in this latch so that there is no modification of the data in the display data RAM.

7. OSCILLATION CIRCUIT

This is a CR-type oscillation circuit that generates the display clock. The oscillation circuit is valid only when CLS = H. When CLS = L, oscillation is stopped and the display clock is input via the CL pin.

8. DISPLAY TIMING GENERATOR

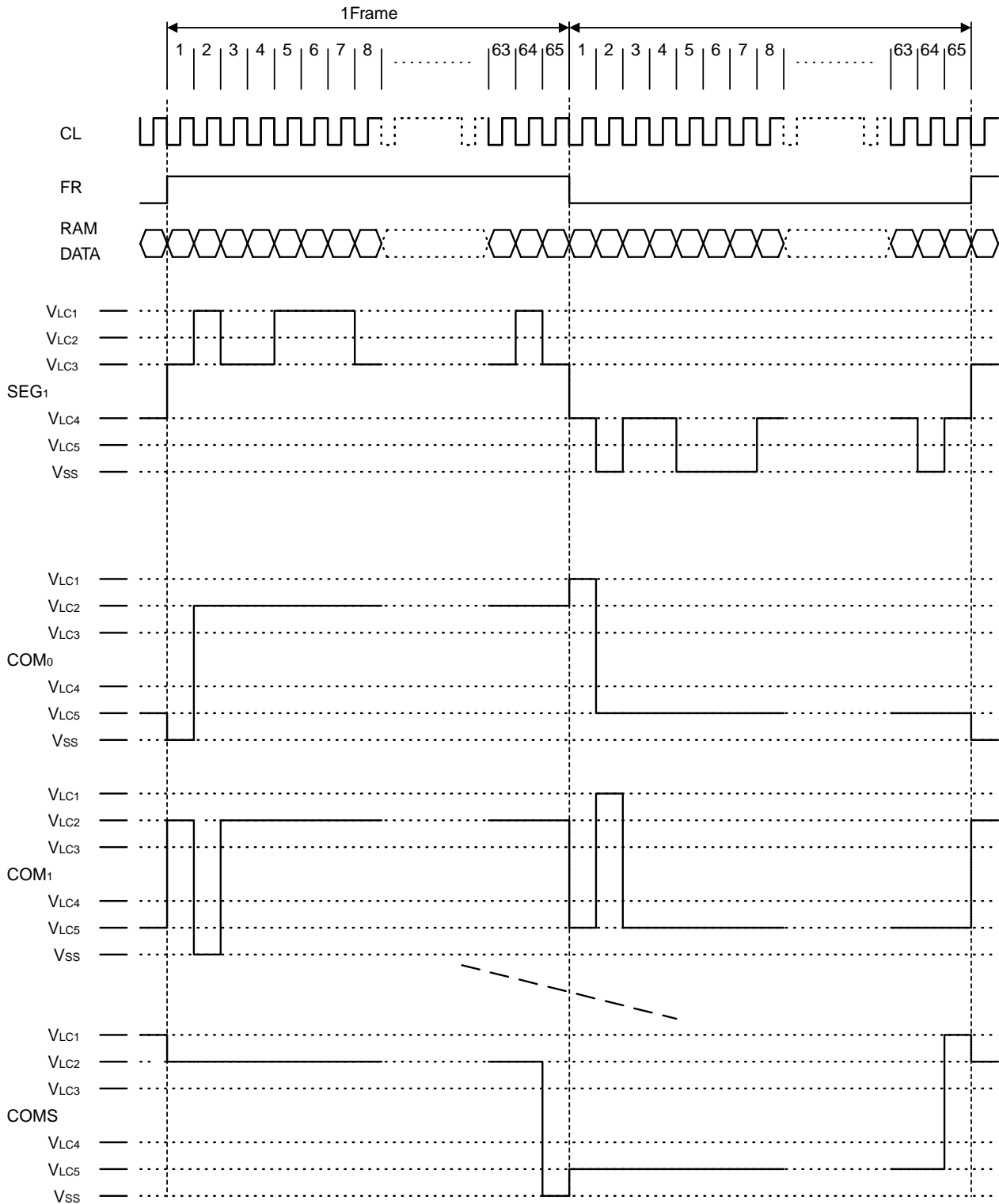
The display timing generator generates timing signals from the display clock to the line address circuit and the display data latch circuit. Display data is latched into the display data latch circuit in synch with the display clock and is output via segment driver output pins. Reading of the display data is completely independent of the CPU's accessing of the display data RAM. Consequently, there are no adverse effects (such as flicker) on the LCD panel even when the display data RAM is accessed asynchronously in relation to the LCD contents.

The internal common timing and LCD's AC conversion signal (FR) are both generated from the display clock. As is shown in Figure 8-1, a drive waveform based on the two-frame AC drive method is generated for the LCD driver circuit.

If a multiple set of μPD16682A chips is used, the display timing signals (FR, CL, and /DOF) for the slave side must be supplied from the master side.

Operation Mode		FR	CL	/DOF
Master (M,/S = H)	On-chip oscillation circuit is valid (CLS = H)	Output	Output	Output
	On-chip oscillation circuit is invalid (CLS = L)	Output	Input	Output
Slave (M,/S = L)	On-chip oscillation circuit is invalid (CLS = H)	Input	Input	Input
	On-chip oscillation circuit is invalid (CLS = L)	Input	Input	Input

Figure 8-1. Drive Waveform when Using Two-Frame AC Drive Method



9. COMMON OUTPUT STATUS SELECT CIRCUIT

With the μPD16682A, the common output status select command can be used to set the scan direction for COM outputs (see **Table 9–1**). As a result, there are fewer IC layout constraints when setting up the LCD module.

Table 9–1. Setting of Scan Direction for COM Outputs

Status	COM Scan Direction	
Normal (forward)	COM ₀	→ COM ₆₃
Inverted (reverse)	COM ₆₃	→ COM ₀

10. POWER SUPPLY CIRCUIT

10.1 Power Supply Circuit

The power supply circuit, which supplies the voltage needed to drive the LCD, includes a booster circuit, voltage regulator circuit, and voltage follower circuit.

The power control set command is used to control the ON/OFF status of the power supply circuit's booster circuit, voltage regulator circuit (V regulator circuit), and voltage follower circuit (V/F circuit). This makes it possible to jointly use an external power supply along with certain functions of the on-chip power supply. Table 10–1 shows the function that controls the 3-bit data in the power control set command and Table 10–2 shows a reference chart of combinations.

Table 10–1. Control Values Set to Bits in Power Control Set Command

Item		Status	
		H	L
D ₂	Booster circuit control bit	ON	OFF
D ₁	Voltage regulator circuit control bit	ON	OFF
D ₀	Voltage follower circuit control bit	ON	OFF

Table 10–2. Reference Chart of Combinations

Use Status	D ₂	D ₁	D ₀	Booster Circuit	V Regulator Circuit	V/F Circuit	External Power Supply Input	Booster-related Pin
<1> Use on-chip power supply	H	H	H	i	i	i	V _{DD2}	Used
<2> Use V regulator circuit and V/F circuit only	L	H	H	×	i	i	V _{LCD}	Open
<3> Use V/F circuit only	L	L	H	×	×	i	V _{LC1}	Open
<4> Use External power supply only	L	L	L	×	×	×	V _{LC1} to V _{LC5}	Open

- Remarks**
1. The booster-related pins are indicated as pins C₁⁺, C₁[−], C₂⁺, C₂[−], C₃⁺, and C₃[−].
 2. Although combinations other than those shown above are possible, they have no practical uses and therefore cannot be recommended.

10.2 Booster circuit

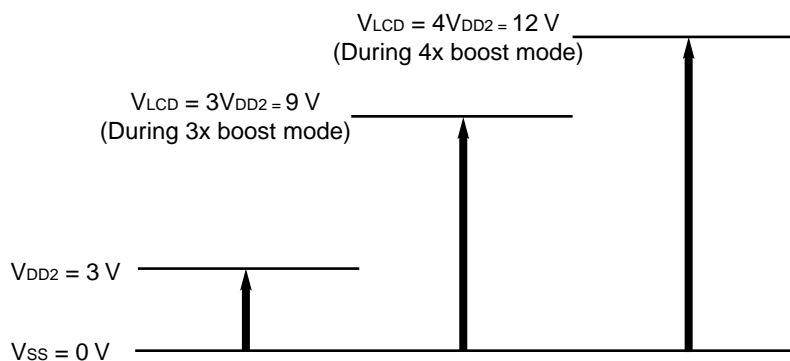
3x and 4x booster circuits have been incorporated in chip to generate the current driving the LCD.

When using the internal power supply, connect the booster-related capacitor between C_1^+ and C_1^- , C_2^+ and C_2^- , and C_3^+ and C_3^- . Also, connect the level stabilization-related capacitor between V_{LCD} and V_{SS} and set D2 high to boost the potential between V_{DD2} and V_{SS} from 3 to 4 times.

Since the booster circuit uses signals from the internal oscillation circuit, the oscillation circuit must be operating. The relation between the boosted voltage and the potential is described below.

The C_1^+ , C_1^- , C_2^+ , C_2^- , C_3^+ , C_3^- , and V_{DD2} pins all relate to the booster circuit, so the wire impedance should be minimized.

Figure 10–1. 3x and 4x Booster Circuits



Caution When set to 3x boost mode, connect booster-related capacitors between C_2^- and C_3^+ and between C_1^+ and C_1^- .

10.3 Voltage Regulator Circuit

The boost voltage that was generated at V_{LCD} is output via the voltage regulator circuit as the LCD drive voltage V_{LC1} . Since the μ PD16682A has a 64-level electronic volume function and an on-chip resistor for V_{LC1} voltage regulation, various components can be used to configure a highly accurate voltage regulator circuit.

10.3.1 Use of on-chip resistor for V_{LC1} voltage regulation

The on-chip resistor for V_{LC1} voltage regulation and the electronic volume function can be used to regulate the darkness of the LCD contents, not only by adding an external resistor but also by controlling the LCD drive voltage V_{LC1} by using commands only. The V_{LC1} voltage can be determined using equation 10–1 as within the range of $V_{LC1} < V_{LCD}$.

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Equation 10-1

$$V_{LC1} = (1 + \frac{R_b}{R_a}) V_{EV}$$

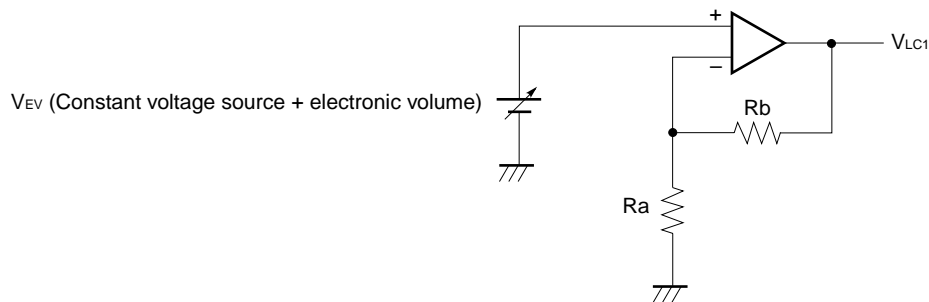
The equation for determining V_{EV} varies according to the temperature gradient.

$$V_{EV} = \frac{162}{202} (1 - \frac{\alpha}{162}) V_{REG} \quad (-0.05\% / ^\circ\text{C})$$

$$V_{EV} = \frac{162}{179} (1 - \frac{\alpha}{162}) V_{REG} \quad (-0.09\% / ^\circ\text{C})$$

$$V_{EV} = (1 - \frac{\alpha}{162}) V_{REG} \quad (-0.14\% / ^\circ\text{C})$$

$$V_{EV} = \frac{162}{232} (1 - \frac{\alpha}{162}) V_{REG} \quad (0\% / ^\circ\text{C})$$



V_{REG} is the IC's internal constant voltage source, whose voltage values (at $T_A = 25^\circ\text{C}$) are listed in Table 10-3 below.

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Table 10-3. V_{REG}

TCS2	TCS1	Temperature Gradient (%/ $^\circ\text{C}$)	V_{REG} (V)
L	L	-0.09	1.87
L	H	0	2.41
H	L	-0.05	2.10
H	H	-0.14	1.69

Given α as the electronic volume command value, when data is set to the 6-bit electronic volume register, one of 64 statuses is set. Values for α corresponding to various electronic volume register settings are listed in Table 10-4 below.

Table 10-4. α Values Determined by Electronic Volume Register Settings

D ₅	D ₄	D ₃	D ₂	D ₁	D ₀	α
0	0	0	0	0	0	63
0	0	0	0	0	1	62
0	0	0	0	1	1	61
0	0	0	0	1	1	60
:	:	:	:	:	:	:
1	1	1	1	0	1	2
1	1	1	1	1	0	1
1	1	1	1	1	1	0

Rb/Ra is an on-chip resistance factor used for the V_{LC1} voltage regulator. This factor can be controlled among eight levels using the V_{LC1} voltage regulator resistance factor set command. Table 10–5 lists reference values for (1+Rb/Ra) which are set when 3-bit data is set to the V_{LC1} voltage regulator resistance factor register.

Table 10–5. Reference Values for (1 + Rb/Ra)

Register			Reference Value
D ₃	D ₂	D ₁	
0	0	0	3.5
0	0	1	4.0
0	1	0	4.5
0	1	1	5.0
1	0	0	5.5
1	0	1	6.0
1	1	0	6.5
1	1	1	7.0

10.3.2 When using external resistor (not using on-chip resistor for V_{LC1} voltage regulator)

Instead of using the on-chip resistor for the V_{LC1} voltage regulator (IRS pin = L), resistors (Ra' and Rb') can be added between V_{SS} and V_R and between V_R and V_{LC1} to set the LCD power supply voltage V_{LC1}. In such cases, the electronic volume function can be used to control the LCD power supply voltage V_{LC1} using commands to regulate the darkness of the LCD contents. The V_{LC1} voltage can be determined using equation 10–2 as within the range of V_{LC1} < V_{LCD}.

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Equation 10–2

$$V_{LC1} = (1 + \frac{Rb'}{Ra'}) V_{EV}$$

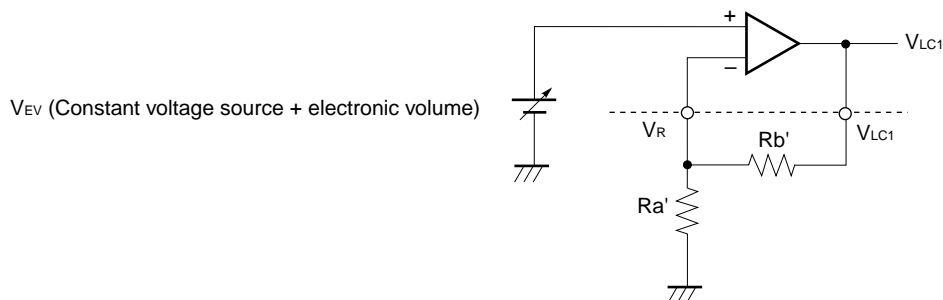
The equation for determining V_{EV} varies according to the temperature gradient.

$$V_{EV} = \frac{162}{202} (1 - \frac{\alpha}{162}) V_{REG} \quad (-0.05\% / ^\circ C)$$

$$V_{EV} = \frac{162}{179} (1 - \frac{\alpha}{162}) V_{REG} \quad (-0.09\% / ^\circ C)$$

$$V_{EV} = (1 - \frac{\alpha}{162}) V_{REG} \quad (-0.14\% / ^\circ C)$$

$$V_{EV} = \frac{162}{232} (1 - \frac{\alpha}{162}) V_{REG} \quad (0\% / ^\circ C)$$



10.4 Op Amp Control for Level Power Supply

The μPD16682A's on-chip power supply circuit is designed for low power consumption (HPM = H). Consequently, display quality may be diminished when a large LCD device or panel is used. In such cases, the display quality can be improved by setting HPM = L (high-power mode). We recommend that you check the actual display quality before deciding whether or not to use high-power mode.

If setting high-power mode still does not sufficiently improve the display quality, the LCD driver's power supply must be provided from an external source.

10.5 Command Sequence for Stepping Down On-chip Power Supply

As shown in the following command sequence, we recommend that you set low power mode and turn off the power before stepping down the on-chip power supply.

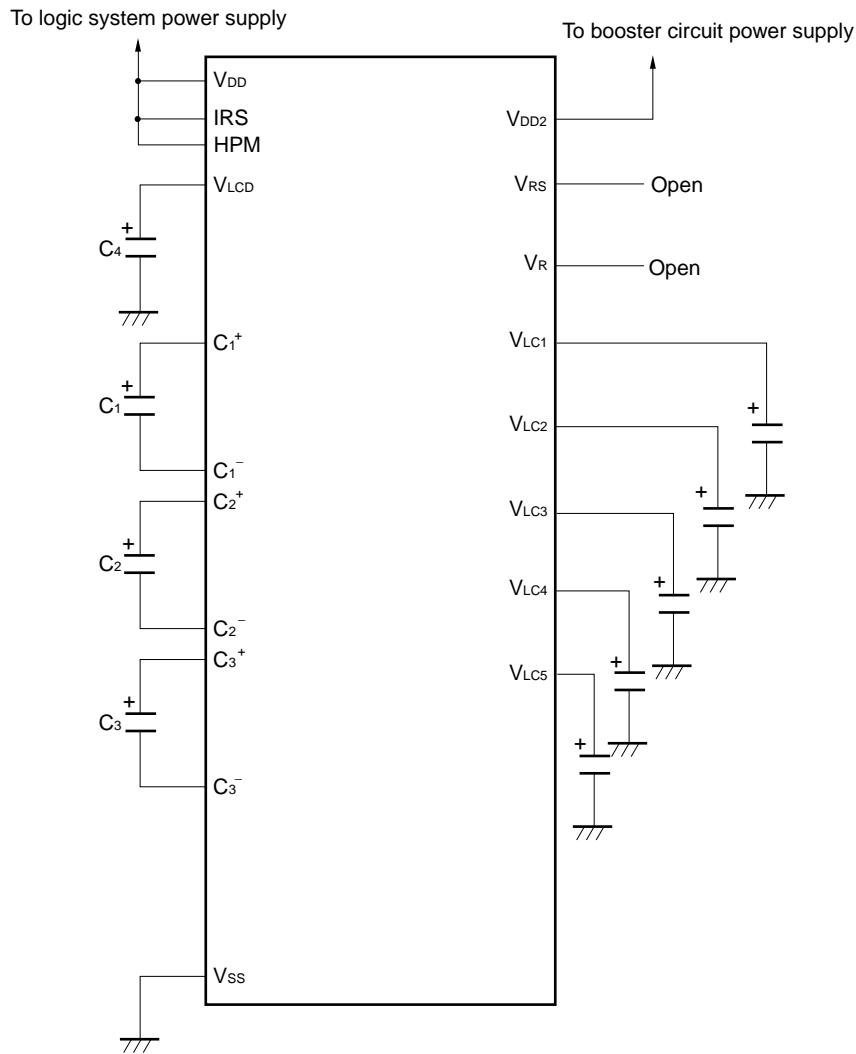
Step	Description (Command, Status)	Command Address							
		D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
Step1	Display OFF	1	0	1	0	1	1	1	0
Step2	Display all ON	1	0	1	0	0	1	0	1
End	On-chip power supply OFF								

Power save command
(compound)

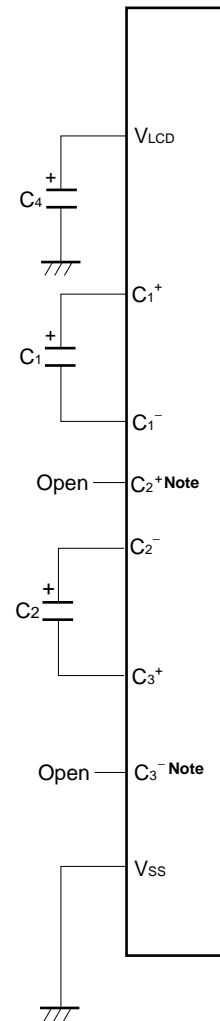
↓

10.6 Use Example of Power Supply Circuit

A) 4x boost (normal mode/using on-chip power supply)



B) 3x boost



Note Leave the C_2^+ and C_3^- pins open.

Remark $C_1 = C_2 = C_3 = C_4 = 1.0 \mu F$

11. RESET CIRCUIT

In the μPD16682A, when the /RESET input is at low level, a reset is executed. The reset (default) settings are described below.

1. Display OFF
2. Normal display direction
3. ADC select: normal direction (ADC command $D_0 = L$)
4. Power control register: $(D_2, D_1, D_0) = (0, 0, 0)$
5. Data cleared from register in serial interface
6. LCD power supply bias: 1/9 bias
7. Read modify write OFF
8. Power save canceled
9. SEG/COM output: V_{SS}
10. Static indicator OFF
Static indicator register: $(D_2, D_1) = (0, 0)$
11. Display start line: set to line 1
12. Column address: set to address 0
13. Page address: set to page 0
14. Common output status: Normal
15. Canceled mode set for on-chip resistance factor for V_{LC1} voltage regulator
 V_{LC1} voltage regulator resistance factor register $(D_2, D_1, D_0) = (0, 0, 0)$
16. Canceled mode set for electronic volume register
Electronic volume register: $(D_5, D_4, D_3, D_2, D_1, D_0) = (1, 0, 0, 0, 0, 0)$
17. Test mode canceled
18. Display all OFF (display all ON/OFF command, $D_0 = L$)

Only items 1, 7, and 9 to 18 above are executed when a reset command is used.

12. COMMANDS

The μ PD16682A uses a combination of A0, /RD(E), and /WR(R,/W) to identify data bus signals. Command interpretation and execution is performed using internal timing that does not depend on any external clock.

The 80 series CPU interface activates commands using low pulse input to the /RD pin during read and activates commands using low pulse input to the /WR pin during write. The 68 series CPU interface sets read mode using high-level input to the R,/W pin and sets write mode using low-level input to the R,/W pin. The command is activated using high pulse input to the E pin.

Thus, the 68 series CPU interface differs from the 80 series CPU interface in that /RD(E) is at high level during status read and display data read operations, as is shown in the command descriptions and command table.

Command descriptions using an 80 series CPU interface are shown below.

If the serial interface has been selected, data is input sequentially starting from D₇.

12.1 Display ON/OFF

This command specifies the display's ON/OFF status.

A0	E,/RD	R,/W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀	Setting
0	1	0	1	0	1	0	1	1	1	1	Display ON
										0	Display OFF

Executing the display all ON command while the display is OFF sets power save (low power) mode. For details, see

12.20 Power Save (Compound Command).

When the display is OFF, output via all driver outputs (segment and common) is at V_{SS} level.

12.2 Display Start Line Set

This command specifies the address of the display start line in the display data RAM, as was shown in Figure 6-2.

The display area extends from the specified line address in the direction of higher line addresses, and includes the number of lines that corresponds to the display duty setting. The display can be smoothly scrolled vertically by using this command to dynamically modify the specified line addresses.

For details, see **6.4 Line Address Circuit**.

A0	E,/RD	R,/W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀	Line Address
0	1	0	0	1	0	0	0	0	0	0	0
					0	0	0	0	0	1	1
					0	0	0	0	1	0	2
							↓				↓
					1	1	1	1	1	0	62
					1	1	1	1	1	1	63

12.3 Page Address Set

This command specifies the page address corresponding to the row address when accessing the display data RAM from the CPU side, as was shown in Figure 6-2. The specified bit in display data RAM can be accessed by selecting the corresponding page address and column address. If the page address is changed, the display mode does not change.

For details, see **6.2 Page Address Circuit**.

A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀	Page Address
0	1	0	1	0	1	1	0	0	0	0	0
							0	0	0	1	1
							0	0	1	0	2
									↓		↓
							0	1	1	1	7
							1	0	0	0	8

12.4 Column Address Set

This command specifies the column address in display data RAM, as was shown in Figure 6-2. The column address is set in a (basically continuous) series of two specifications, one for the high-order four bits and another for the low-order four bits. The column address is automatically incremented (+1) each time the display data RAM is accessed, so the CPU is able to continuously read or write display data. Incrementation of the column address stops at 83H. At that point the page address can no longer be continuously modified. For details, see **6.3 Column Address Circuit**.

A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
0	1	0	0	0	0	1	A ₇	A ₆	A ₅	A ₄
						0	A ₃	A ₂	A ₁	A ₀

A ₇	A ₆	A ₅	A ₄	A ₃	A ₂	A ₁	A ₀	Column Address
0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1	1
0	0	0	0	0	0	1	0	2
				↓				↓
1	0	0	0	0	0	1	0	130
1	0	0	0	0	0	1	1	131

12.5 Status Read

A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
0	0	1	0	ADC	ON/OFF	RESET	0	0	0	0

ADC	This indicates the relation between the column address and the segment driver. 0: Inverted (column address 131-n \longleftrightarrow SEGN) 1: Normal (column address n \longleftrightarrow SEGN)
ON/OFF	ON/OFF: Indicates the display's ON/OFF status. 0: Display ON 1: Display OFF (This is the opposite of the display ON/OFF command's polarity.)
RESET	This indicates whether or not the system is undergoing a reset via the /RESET signal or the reset command. 0: Operating mode 1: Reset in progress

12.6 Display Data Write

This command writes 8 bits of data to the specified address in display data RAM. After this data has been written, the column address is automatically incremented (+1), which enables the CPU to continuously write display data.

A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
1	1	0	Write Data							

12.7 Display Data Read

This command reads 8 bits of data from the specified address in display data RAM. After this data has been read, the column address is automatically incremented (+1), which enables the CPU to continuously read several words of data.

A single dummy read operation is required immediately after the column address has been set. For details, see

5.1.5 Display data RAM and internal register access.

Note that the display data cannot be read when using a serial interface.

A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
1	0	1	Read Data							

12.8 ADC Select (Segment Driver Direction Select)

This command inverts the relation between the display data RAM's column address and segment driver output, as was shown in Figure 6-2. Consequently, the segment driver output pin number can be inverted by this command. For details, see **6.3 Column Address Circuit**. Incrementation (+1) of the column address when display data is either written or read is performed according to the column address shown in Figure 6-2.

This command should be input during initialization.

A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀	Setting
0	1	0	1	0	1	1	0	0	0	0	Normal (forward direction)
										1	Inverted (reverse direction)

12.9 Display Normal/Inverted

This command can be used to invert the display ON/OFF control without replacing any of the display data RAM contents. The display data RAM contents are retained when this command is executed.

A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀	Setting
0	1	0	1	0	1	0	0	1	1	0	RAM data: H LCD ON potential (normal)
										1	RAM data: L LCD ON potential (inverted)

12.10 Display All ON/OFF

This command can be used to set the display all ON status forcibly regardless of the display data RAM contents. The display data RAM contents are retained when this command is executed.

This command takes priority over the display normal/inverted command.

A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀	Setting
0	1	0	1	0	1	0	0	1	0	0	Normal display mode
										1	Display all ON

12.11 LCD Bias Set

This command selects the bias setting of the voltage required to drive the LCD. This command is valid when the power supply circuit's V/F circuit is operating.

A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀	Setting
0	1	0	1	0	1	0	0	0	1	0	1/9 bias
										1	1/7 bias

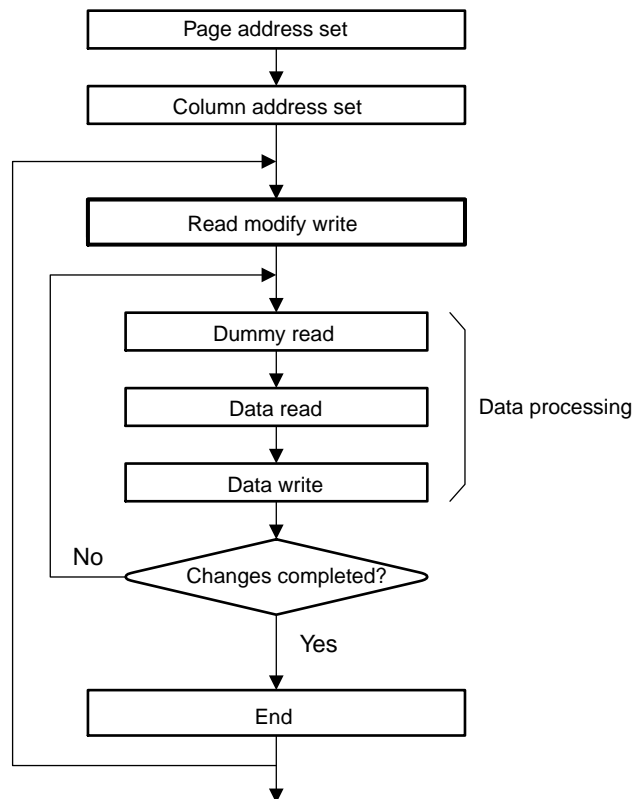
12.12 Read Modify Write

This command is used in a pair with the end command. When this command has been input, the column address is not changed by the display data read command and can be incremented (+1) only by the display data write command. This status is retained until an end command is input. Once an end command has been input, the column address returns to the address that was used when the read modify write command was input. This function can be used to lighten the burden on the CPU when repeatedly modifying data in special display areas such as the blinking cursor.

A0	E, /RD	R,/W, /WR	D7	D6	D5	D4	D3	D2	D1	D0
0	1	0	1	1	1	0	0	0	0	0

Caution The commands other than the display data read/write commands can be used even during read modify write mode. However, the column address set command cannot be used.

Figure 12-1. Sequence for Cursor Display

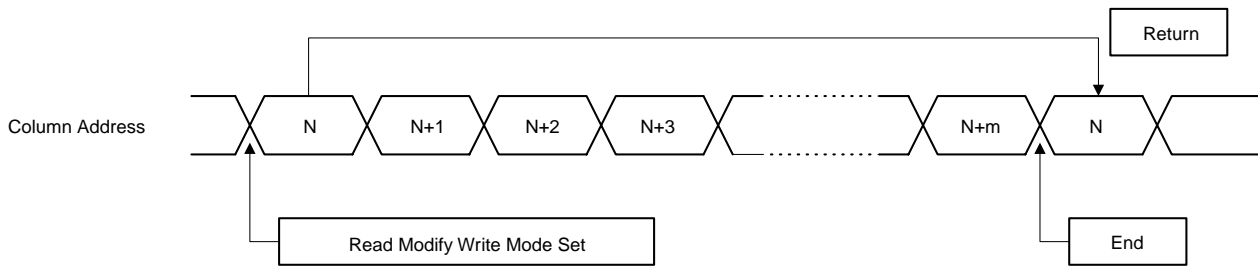


12.13 End

This command is used to cancel read modify write mode and return to the address that was used during column address mode reset.

A0	E, /RD	R,/W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
0	1	0	1	1	1	0	1	1	1	0

Figure 12-2. End



12.14 Reset

This command initializes the contents of the various command registers. The display data RAM is not affected. For details, see 11. **RESET CIRCUIT**.

The reset operation is performed after the reset command has been input.

A0	E, /RD	R,/W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
0	1	0	1	1	1	0	0	0	1	0

The reset that occurs when the power supply is applied is performed by issuing a reset signal to the /RESET pin. It cannot be used as a substitute for the reset command.

12.15 Common Output Status Select

This command can be used to select the scan direction for the COM output pins. For details, see 9. **COMMON OUTPUT STATUS SELECT CIRCUIT**.

A0	E, /RD	R,/W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀	Setting
0	1	0	1	1	0	0	0	X	X	X	Normal (forward)
							1				Inverted (reverse)

Remark X: Don't care

Status	Selected status	
Normal (forward)	COM ₀	→ COM ₆₃
Inverted (reverse)	COM ₆₃	→ COM ₀

12.16 Power Control Set

This command is used to set the function of the power supply circuit. For further description, see **10. POWER SUPPLY CIRCUIT**.

A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀	Selected Status
0	1	0	0	0	1	0	1	0	X	X	Booster circuit: OFF
								1	X	X	Booster circuit: ON
								X	0	X	V regulator circuit: OFF
								X	1	X	V regulator circuit: ON
								X	X	0	V/F circuit: OFF
								X	X	1	V/F circuit: ON

Remark X: Don't care

12.17 Set On-chip Resistance Factor for V_{LC1} Voltage Regulator

This command is used to set the on-chip resistance factor for the V_{LC1} voltage regulator. For details, see **10.3 Voltage Regulator Circuit**.

A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀	(1+Rb/Ra)
0	1	0	0	0	1	0	0	0	0	0	3.5
								0	0	1	4.0
								0	1	0	4.5
								0	1	1	5.0
								1	0	0	5.5
								1	0	1	6.0
								1	1	0	6.5
								1	1	1	7.0

12.18 Electronic Volume (Two-Byte Command)

This command can be used to control the LCD drive voltage V_{LC1} (which is output from the on-chip LCD power supply's voltage regulator circuit) to regulate the darkness of the LCD contents.

This command is a two-byte command that is used in a pair with the electronic volume mode set command and the electronic volume register set command, so be sure to use both commands consecutively.

12.18.1 Electronic volume mode set command (first byte)

Once this command is input, the electronic volume register set command becomes valid. And once the electronic volume mode has been set, any command other than the electronic volume register set command cannot be used.

This restriction is cleared once data has been set to the register by the electronic volume register set command.

A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
0	1	0	1	0	0	0	0	0	0	1

12.18.2 Electronic volume register set command (second byte)

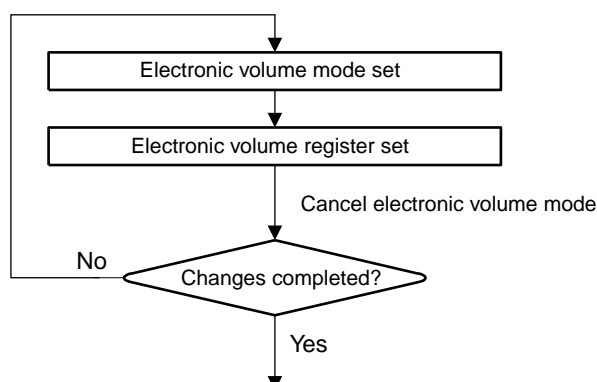
When six bits of data are set to the electronic volume register by this command, the LCD drive voltage V_{LC1} is set to one of 64 possible voltage values.

Once this command has been input and the electronic volume register has been set, electronic volume mode is canceled.

A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀	V_{LC1}
0	1	0	X	X	0	0	0	0	0	0	Smaller value
			X	X	0	0	0	0	0	1	
			X	X	0	0	0	0	1	0	
											↓
			X	X	1	1	1	1	1	0	
			X	X	1	1	1	1	1	1	Larger value

Remark X: Don't Care

Figure 12-3. Sequence of Electronic Volume Register Set Operations



12.19 Static Indicator (Two-Byte Command)

This command is used to control the indicator display for the static drive system. Only this command can control the static indicator display, and it operates independently of other display control commands.

One of the electrodes for the static indicator's LCD driver is connected to the FR pin and the other is connected to the FRS pin. We recommend that these status indicator electrodes be implemented in a pattern that is separate from the electrodes used for the dynamic drive. The LCD and the electrodes themselves may deteriorate if the patterns are laid out too close to each other.

The static indicator ON command is a two-byte command that is used in a pair with the static indicator register set command, so be sure to use both commands consecutively. (The static indicator OFF command is a one-byte command.)

12.19.1 Static indicator ON/OFF

When the static indicator ON command is input, the static indicator register set command becomes valid. Once the static indicator ON command has been input, any command other than the static indicator register set command cannot be used. This restriction is cleared once data has been set to the register by the static indicator register set command.

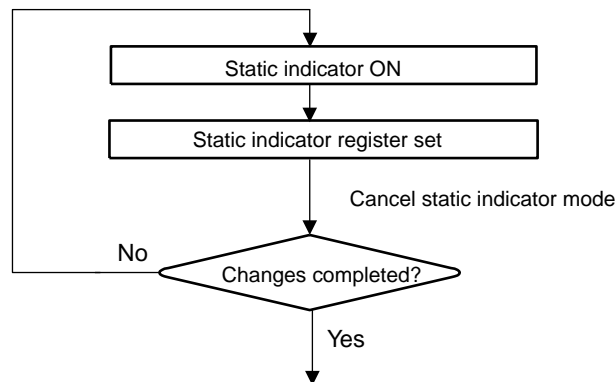
A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀	Static Indicator
0	1	0	1	0	1	0	1	1	0	0	OFF
										1	ON

12.19.2 Static indicator register set

This command sets data to the two-bit static indicator register and then sets the static indicator to blink mode.

A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀	Static Indicator
0	1	0	X	X	X	X	X	X	0	0	OFF
									0	1	ON (blinks at one-second interval)
									1	0	ON (blinks at half-second interval)
									1	1	ON (always ON)

Figure 12-4. Sequence of Static Indicator Register Set Operations



12.20 Power Save (Compound Command)

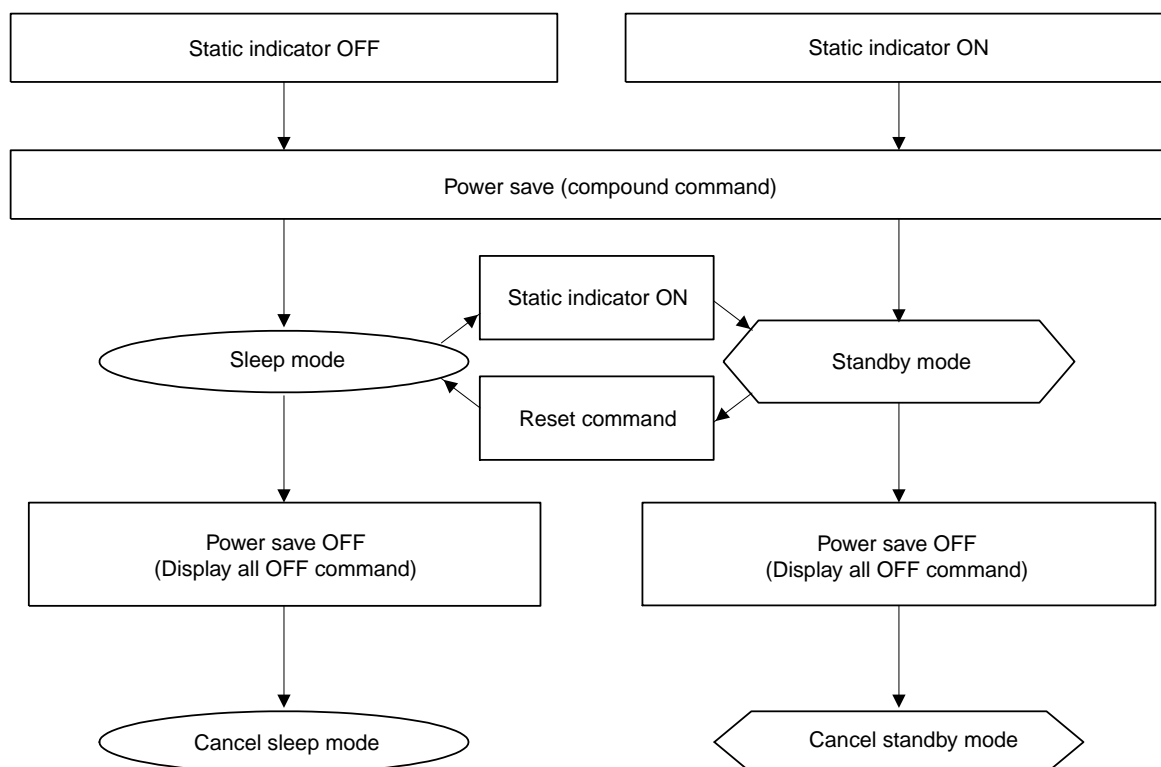
The current consumption can be greatly reduced by entering the power save status by inputting the display all ON command while the display is in OFF mode.

The power save (low power) mode includes two modes; sleep mode and standby mode. Turning the static indicator OFF sets sleep mode and turning it ON sets standby mode.

During either sleep mode or standby mode, the display data is retained as it was before the power save function was activated. Also, access to the display data RAM from the CPU is possible during either mode.

Use the display all OFF command to cancel power save mode.

Figure 12-5. Power Save



12.20.1 Sleep mode

During this mode, all LCD operations are stopped and there is no access from the CPU, so current consumption can be reduced almost as low as the static current level. The internal status during sleep mode is as follows.

- (1) The oscillation circuit and LCD power supply circuit are stopped.
- (2) All LCD drive circuits are stopped and both segment and common driver outputs output at the V_{SS} level.

12.20.2 Standby mode

During this mode, all duty LCD display system operations are stopped and only the static drive system for the indicators operate, which reduces the current consumption to the minimum amount needed for static drive. The internal status during standby mode is as follows.

- (1) The LCD's power supply circuit is stopped. The oscillation circuit operates.
- (2) The duty drive system's LCD drive circuit is stopped and both segment and common driver outputs output at the V_{SS} level. The static drive system operates.

When a reset command is executed while in standby mode, it sets sleep mode.

- Remarks1.** If you are using an external power supply, we recommend that you stop the external power supply circuit's functions when activating the power save function. For example, if you are using an external divided resistor circuit to provide LCD drive voltage at different levels, we recommend that you add a circuit to cut the current flowing on the divided resistor circuit while the power save function is being activated.
2. The μPD16682A includes the /DOF pin which is used to control blinking LCD displays is set to low level when activating the power save function. The output from /DOF can be used to stop the external power supply circuit's function.
 3. When the display has been set to OFF mode, executing the display all ON command sets power save mode no matter which command is entered afterward.

12.21 NOP

This command is used to set NOP (Non-Operation) mode.

A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
0	1	0	1	1	1	0	0	0	1	1

12.22 Test

This command is used for IC testing. Do not use this command. If you use it by mistake, either set the /RESET input low or use the reset command or NOP command to cancel the test command setting.

A0	E, /RD	R, /W, /WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀
0	1	0	1	1	1	1	X	X	X	X

Remark X: Don't care

Table 12-1. List of μPD16682A Commands (1/2)

Command	Command code											Function
	A0	/RD	/WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀	
Display ON/OFF	0	1	0	1	0	1	0	1	1	1	0 1	Sets LCD's ON/OFF status 0: OFF, 1: ON
Display start line set	0	1	0	0	1	Display start address					Sets display RAM's display start line address	
Page address set	0	1	0	1	0	1	1	Page address				Sets display RAM's page address
Column address set (high-order bits)	0	1	0	0	0	0	1	High-order column address				Sets high-order four bits of display RAM's column address
Column address set (low-order bits)	0	1	0	0	0	0	0	Low-order column address				Sets low-order four bits display RAM's column address
Status read	0	0	1	0	Status			0	0	0	0	Read status information
Display data write	1	1	0	Write data							Writes to display RAM	
Display data read	1	0	1	Read data							Reads from display RAM	
ADC select	0	1	0	1	0	1	0	0	0	0	0 1	Sets correspondence of SEG output to display RAM address 0: Normal, 1: Inverted
Display normal/inverted	0	1	0	1	0	1	0	0	1	1	0 1	Sets normal/inverted direction of display
Display all ON/OFF	0	1	0	1	0	1	0	0	1	0	0 1	Sets display all ON 0: Normal display, 1: All ON
LCD bias set	0	1	0	1	0	1	0	0	0	1	0 1	Sets the bias setting of the LCD drive voltage 0: 1/9 bias, 1: 1/7 bias
Read modify write	0	1	0	1	1	1	0	0	0	0	0	Specifies incrementation of the column address During write: +1, During read: 0
End	0	1	0	1	1	1	0	1	1	1	0	Cancels read modify write
Reset	0	1	0	1	1	1	0	0	0	1	0	Sets an internal reset
Selects scan direction for COM outputs	0	1	0	1	1	0	0	0 1	X X	X X	X X	Selects scan direction for COM outputs 0: Normal (forward), 1: Inverted (reverse)

Remark X: Don't care

Table 12-1. List of μPD16682A Commands (2/2)

Command	Command code											Function
	A0	/RD	/WR	D ₇	D ₆	D ₅	D ₄	D ₃	D ₂	D ₁	D ₀	
Power control set	0	1	0	0	0	1	0	1	Operation mode			Selects operation mode of internal power supply
Sets V _{LC1} output voltage to electronic volume register	0	1	0	0	0	1	0	0	Resistance factor setting			Selects on-chip resistance factor for (Ra/Rb)
Electronic volume mode set	0	1	0	1	0	0	0	0	0	0	1	Sets V _{LC1} output voltage to electronic volume register
Electronic volume register set	0	1	0	X	X	Electronic volume value						
Static indicator ON/OFF	0	1	0	1	0	1	0	1	1	0	0	0: OFF, 1: ON
Static indicator register set	0	1	0	X	X	X	X	X	X	Mode		Sets ON mode
Power save												Compound command for setting display OFF and all display ON
NOP	0	1	0	1	1	1	0	0	0	1	1	Command for Non-Operation mode
Test	0	1	0	1	1	1	1	X	X	X	X	Command used for IC testing Caution Do not use this command.

Remark X: Don't care

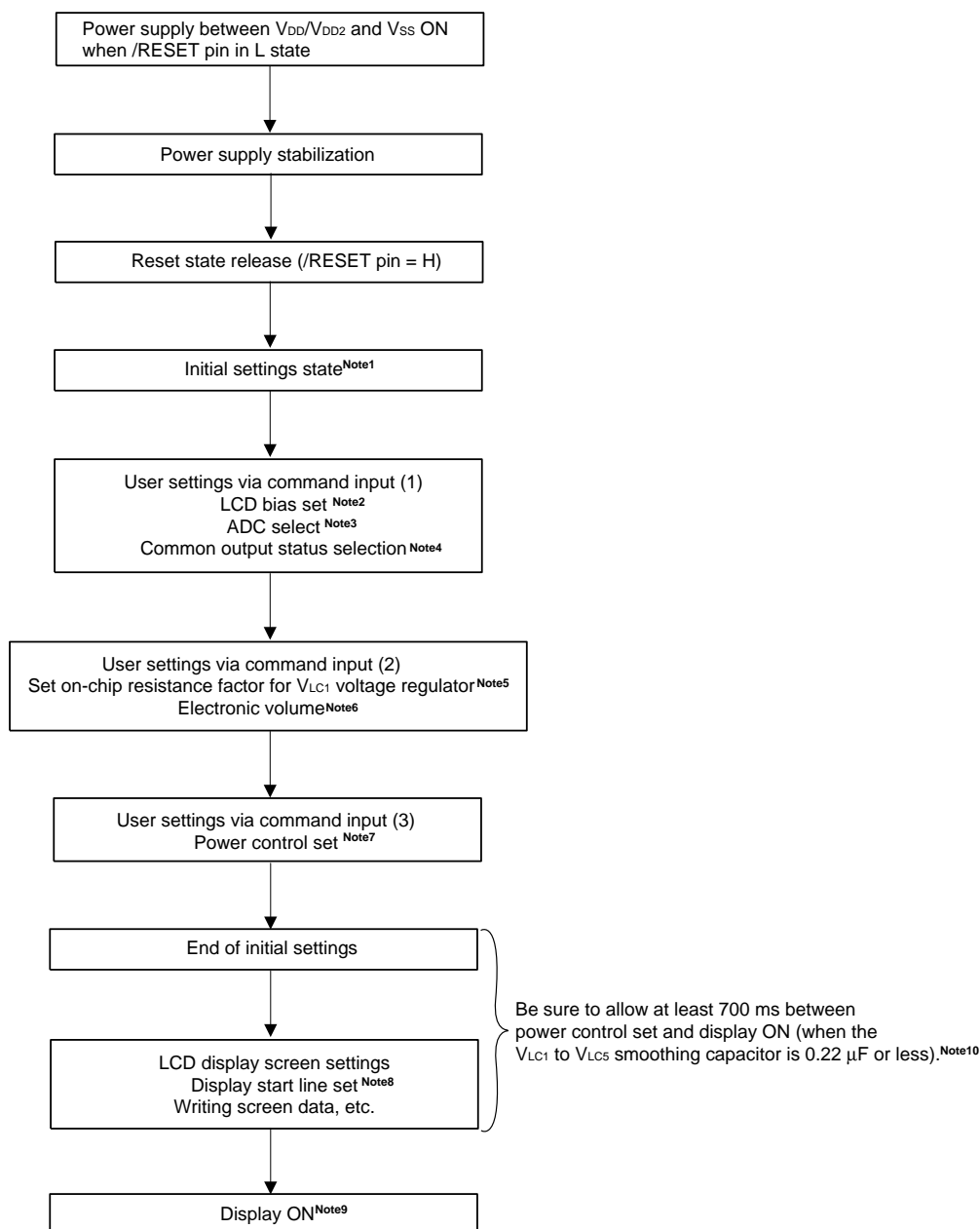
13. ACCESS PROCEDURE

13.1 Instruction setting example

13.1.1 Initialization setting example (from power application to display ON)

Although a V_{SS} level is output from the SEG and COM LCD drive output pins when power is applied to the IC, if there is electric charge remaining in the smoothing capacitor connected between the driver reference power supply pins (V_{LC1} to V_{LC5}) and V_{SS} , or if the DC/DC converter's booster voltage does not reach the prescribed booster potential or the levels of the reference power supplies (V_{LCn}) do not reach the prescribed voltages when power is applied, abnormalities such as a temporary screen blackout may occur when the display turns on.

The following power application flow is recommend to avoid the occurrence of abnormal operation when the power is turned on.



Notes 1. See 11. RESET CIRCUIT.

2. See 12.11 LCD Bias Set.

3. See 12.8 ADC Select (Segment Driver Direction Select).

4. See 12.15 Common Output Status Select.

5. See 12.17 Set On-chip Resistance Factor for V_{LC1} Voltage Regulator.

6. See 12.18 Electronic Volume (Two-Byte Command).

7. See 12.16 Power Control Set.

8. See 12.2 Display Start Line Set.

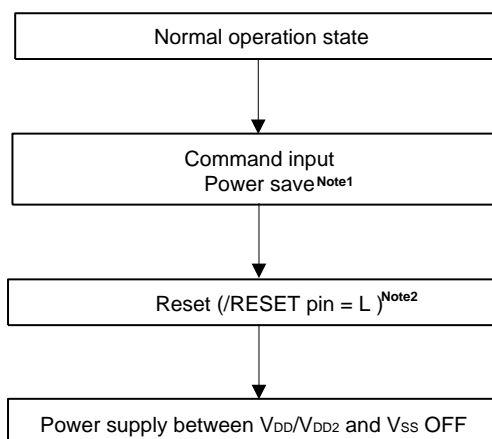
9. See 12.1 Display ON/OFF.

10. This period changes depending on the panel characteristics and the capacitance of the booster/smoothing capacitor. It is recommended to determine this value after sufficient evaluation using the actual device.

13.1.2 Example of power OFF

When turning the power of the IC off in the normal operation state (liquid crystal display ON, on-chip power supply circuits operating), because there is electric charge remaining in the power supply level smoothing capacitor connected between the driver reference power supply pins (V_{LC1} to V_{LC5}) and V_{SS} , power continues to be supplied to the LCD drive circuit and voltage may be applied to the LCD panel from the SEG and COM pins. At this time, the LCD panel may momentarily display data.

Moreover, because the visual quality of the LCD panel may be affected, be sure to turn off the power to the IC in the following sequence.



Notes 1. See 12.20 Power Save (Compound Command).

2. Application of a reset is optional.

14. ELECTRICAL SPECIFICATIONS

Absolute Maximum Ratings (T_A = 25°C, V_{SS} = 0 V)

Parameter	Symbol	Rating	Unit
★ Supply voltage	V _{DD}	−0.3 to +6.0	V
Supply voltage 2 (4x boost)	V _{DD2}	−0.3 to +3.75	V
Supply voltage 2 (3x boost)	V _{DD2}	−0.3 to +5.0	V
Driver supply voltage	V _{LCD}	−0.3 to +15.0, V _{DD} ≤ V _{LCD}	V
Driver reference supply input voltage	V _{LC1} to V _{LC5}	−0.3 to V _{LCD} +0.3	V
Logic system input voltage	V _{IN1}	−0.3 to V _{DD} +0.3	V
Logic system output voltage	V _{OUT1}	−0.3 to V _{DD} +0.3	V
Logic system input/output voltage	V _{I/O1}	−0.3 to V _{DD} +0.3	V
Driver system input voltage	V _{IN2}	−0.3 to V _{LCD} +0.3	V
Driver system output voltage	V _{OUT2}	−0.3 to V _{LCD} +0.3	V
Operating ambient temperature	T _A	−40 to +85	°C
Storage temperature	T _{stg}	−55 to +150	°C

Caution Product quality may suffer if the absolute maximum rating is exceeded even momentarily for any parameter. That is, the absolute maximum ratings are rated values at which the product is on the verge of suffering physical damage, and therefore the product must be used under conditions that ensure that the absolute maximum ratings are not exceeded.

Recommended Operating Range

Parameter	Symbol	MIN.	TYP.	MAX.	Unit
Supply voltage	V _{DD}	1.8		4.5	V
Supply voltage 2 (4x boost)	V _{DD2}	2.4		3.0	V
Supply voltage 2 (3x boost)	V _{DD2}	2.4		4.0	V
Driver supply voltage	V _{LCD}	6	10	12	V
Logic system input voltage	V _{IN}	0		V _{DD}	V
Driver system input voltage	V _{LC1} to V _{LC5}	0		V _{LCD}	V

Remarks 1. When using an external power supply, be sure to maintain these relations:

$$V_{SS} < V_{LC5} < V_{LC4} < V_{LC3} < V_{LC2} < V_{LC1} \leq V_{LCD}$$

2. Maintain V_{DD} ≤ V_{LCD} when turning the power on or off.

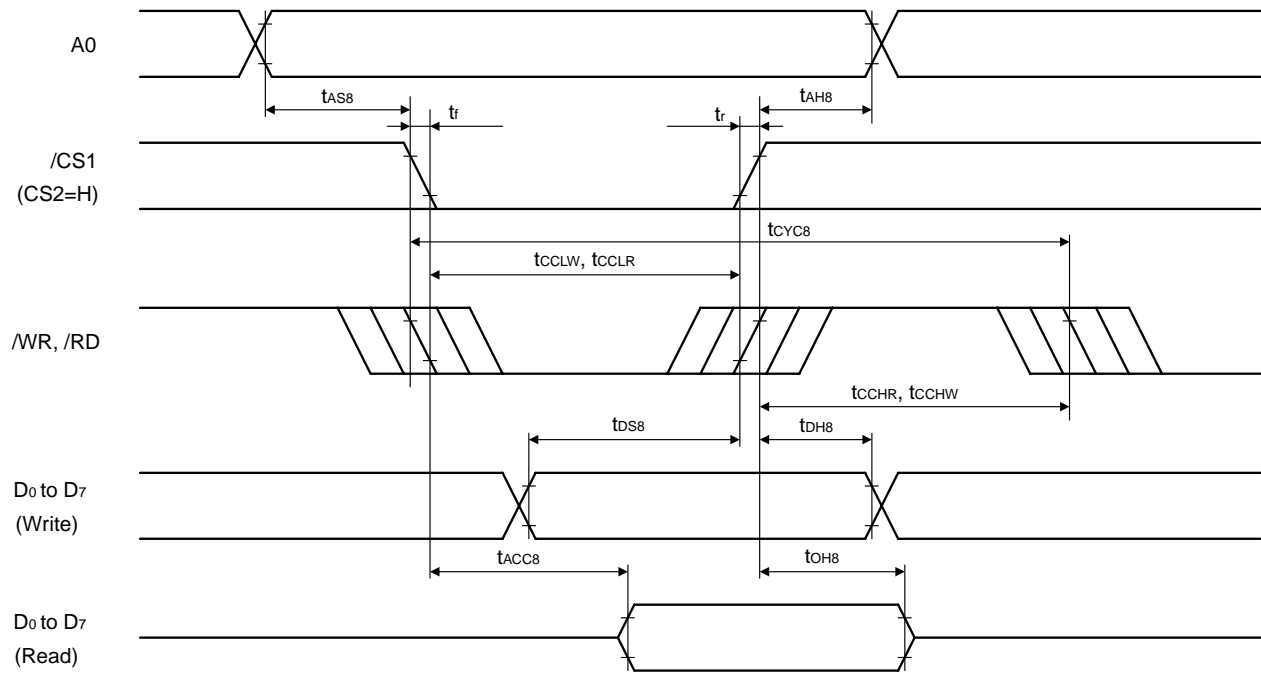
Electrical Characteristics (unless otherwise specified, T_A = –40 to +85°C, V_{DD} = 2.7 to 3.3 V, during 4x boost mode: V_{DD2} = 2.7 to 3.0 V, or V_{DD2} = 2.7 to 4.0 V)

Parameter	Symbol	Condition	MIN.	TYP. ^{Note}	MAX.	Unit
High-level input voltage	V _{IH}		0.8 V _{DD}			V
Low-level input voltage	V _{IL}				0.2 V _{DD}	V
High-level input current	I _{IH1}	Except for D ₇ (SI), D ₆ (SCL), and D ₅ to D ₀			1	μA
Low-level input current	I _{IL1}	Except for D ₇ (SI), D ₆ (SCL), and D ₅ to D ₀			–1	μA
High-level output voltage	V _{OH}	I _{OUT} = –1.5 mA, except OSC _{OUT}	V _{DD} – 0.5			V
Low-level output voltage	V _{OL}	I _{OUT} = 4 mA, except OSC _{OUT}			0.5	V
High-level leakage current	I _{LOH}	D ₇ (SI), D ₆ (SCL), and D ₅ to D ₀ V _{IN/OUT} = V _{DD}			10	μA
Low-level leakage current	I _{LOL}	D ₇ (SI), D ₆ (SCL), and D ₅ to D ₀ V _{IN/OUT} = V _{SS}			–10	μA
Common output ON resistance	R _{COM}	V _{LCn} → COM _n , V _{LCD} ≥ 3V _{DD2} , I _{LOL} = 50 μA			2	kΩ
Segment output ON resistance	R _{SEG}	V _{LCn} → SEG _n , V _{LCD} ≥ 3V _{DD2} , I _{LOL} = 50 μA			4	kΩ
Driver voltage (boost voltage)	V _{LCD}	During 3x boost	2.7 V _{DD}		3.0 V _{DD}	V
		During 4x boost	3.6 V _{DD}		4.0 V _{DD}	V
Current consumption (normal mode)	I _{DD11}	f _{OSC} = 22 kHz, all display OFF data output, V _{DD} = V _{DD2} = 3.0 V during 3x boost mode, T _A = 25°C		60	110	μA
		f _{OSC} = 22 kHz, all display OFF data output, V _{DD} = V _{DD2} = 3.0 V during 4x boost mode, T _A = 25°C		90	135	μA
Current consumption (high-power mode)	I _{DD12}	f _{OSC} = 22 kHz, all display OFF data output, V _{DD} = V _{DD2} = 3.0 V during 3x boost mode, T _A = 25°C		105	190	μA
		f _{OSC} = 22 kHz, all display OFF data output, V _{DD} = V _{DD2} = 3.0 V during 4x boost mode, T _A = 25°C		155	230	μA
Current consumption (standby mode)	I _{DD21}	f _{OSC} = 22 kHz, V _{DD} = V _{DD2} = 3.0 V, T _A = 25°C		7	15	μA
Current consumption (sleep mode)	I _{DD22}	V _{DD} = V _{DD2} = 3.0 V, T _A = 25°C		0.2	5	μA
Oscillation frequency	f _{OSC}	T _A = 25°C, V _{DD} = V _{DD2} = 3.0 V ± 10%	17	22	25	kHz

Note The TYP. value is a reference value when T_A = 25°C.

Required timing conditions (unless otherwise specified, $T_A = -40$ to $+85^\circ\text{C}$)

80 Series CPU



(V_{DD} = 2.7 to 4.5 V)

Parameter	Symbol	Conditions	MIN.	TYP. ^{Note}	MAX.	Unit
Address hold time	t _{AH8}	A0	0			ns
Address setup time	t _{AS8}	A0	0			ns
System cycle time	t _{CYC8}		300			ns
Control L pulse /width (/WR)	t _{CCLW}	/WR	60			ns
Control L pulse width (/RD)	t _{CCLR}	/RD	120			ns
Control H pulse width (/WR)	t _{CCHW}	/WR	60			ns
Control H pulse width (/RD)	t _{CCHR}	/RD	60			ns
Data setup time	t _{DS8}	D ₀ to D ₇	40			ns
Data hold time	t _{DH8}	D ₀ to D ₇	15			ns
/RD access time	t _{ACC8}	D ₀ to D ₇ , C _L = 100 pF			140	ns
Output disable time	t _{OH8}	D ₀ to D ₇ , C _L = 100 pF	10		100	ns

Note The TYP. value is a reference value when T_A = 25°C.

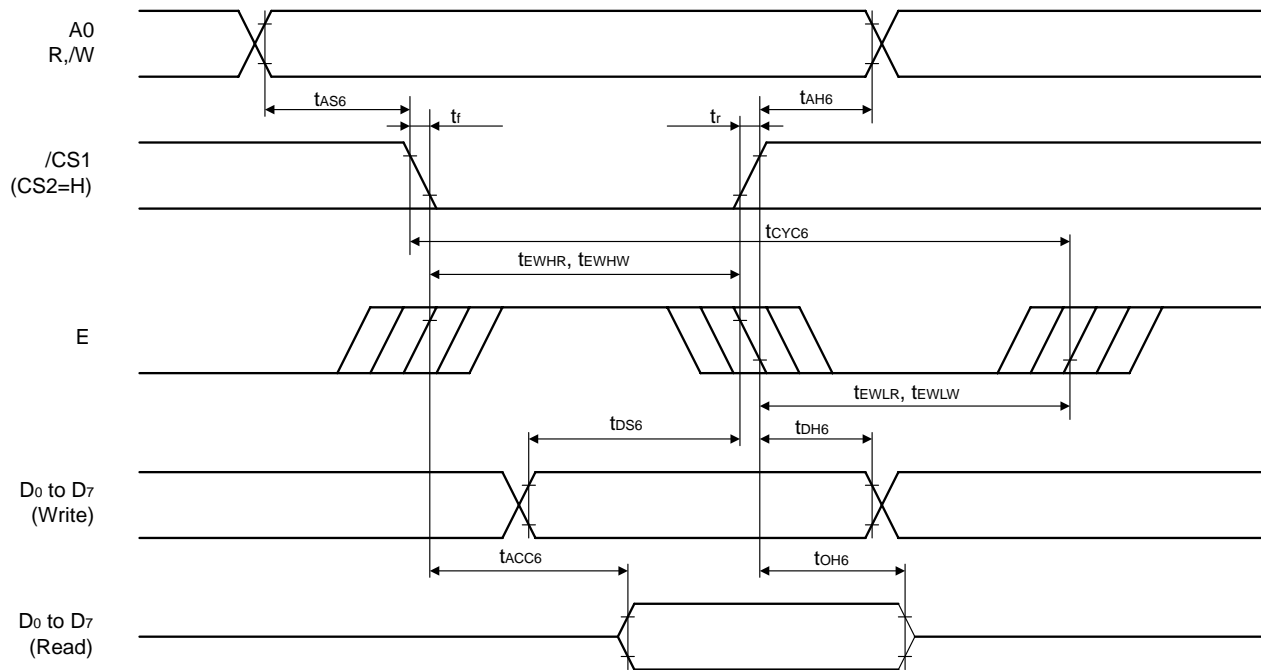
(V_{DD} = 2.4 to 2.7 V)

Parameter	Symbol	Conditions	MIN.	TYP. ^{Note}	MAX.	Unit
Address hold time	t _{AH8}	A0	0			ns
Address setup time	t _{AS8}	A0	0			ns
System cycle time	t _{CYC8}		1000			ns
Control L pulse width (/WR)	t _{CCLW}	/WR	120			ns
Control L pulse width (/RD)	t _{CCLR}	/RD	240			ns
Control H pulse width (/WR)	t _{CCHW}	/WR	120			ns
Control H pulse width (/RD)	t _{CCHR}	/RD	120			ns
Data setup time	t _{DS8}	D ₀ to D ₇	80			ns
Data hold time	t _{DH8}	D ₀ to D ₇	30			ns
/RD access time	t _{ACC8}	D ₀ to D ₇ , C _L = 100 pF			280	ns
Output disable time	t _{OH8}	D ₀ to D ₇ , C _L = 100 pF	10		200	ns

Note The TYP. value is a reference value when T_A = 25°C.

- Remarks**
1. The rise and fall times (t_r and t_f) of input signals are rated at 15 ns or less. When using a fast system cycle time, the rated value range is either (t_r + t_f) < (t_{CYC8} - t_{CCLW} - t_{CCHW}) or (t_r + t_f) < (t_{CYC8} - t_{CCLR} - t_{CCHR}).
 2. All timing is rated based on 20% or 80% of V_{DD}.
 3. t_{CCLW} and t_{CCLR} are rated as the overlap time when /CS1 is at low level (CS2 = H) and /WR and /RD are also at low level.
 4. D₀ to D₇ change to output regardless of the state of the E signal when R,/W becomes H in the state of /CS1 = L, CS2 = H (See 5.1.2 (2) 68 Series Parallel Interface.).

68 Series CPU



(V_{DD} = 2.7 to 4.5 V)

Parameter		Symbol	Conditions	MIN.	TYP. ^{Note}	MAX.	Unit
Address hold time		t _{AH6}	A0	0			ns
Address setup time		t _{AS6}	A0	0			ns
System cycle time		t _{CYC6}		300			ns
Data setup time		t _{DS6}	D ₀ to D ₇	40			ns
Data hold time		t _{DH6}	D ₀ to D ₇	15			ns
Access time		t _{ACC6}	D ₀ to D ₇ , C _L = 100 pF			140	ns
Output disable time		t _{OH6}	D ₀ to D ₇ , C _L = 100 pF	10			ns
Enable H pulse width	Read	t _{EWHR}	E	120			ns
	Write	t _{EWHW}	E	60			ns
Enable L pulse width	Read	t _{EWLR}	E	60			ns
	Write	t _{EWLW}	E	60			ns

Note The TYP. value is a reference value when T_A = 25°C.

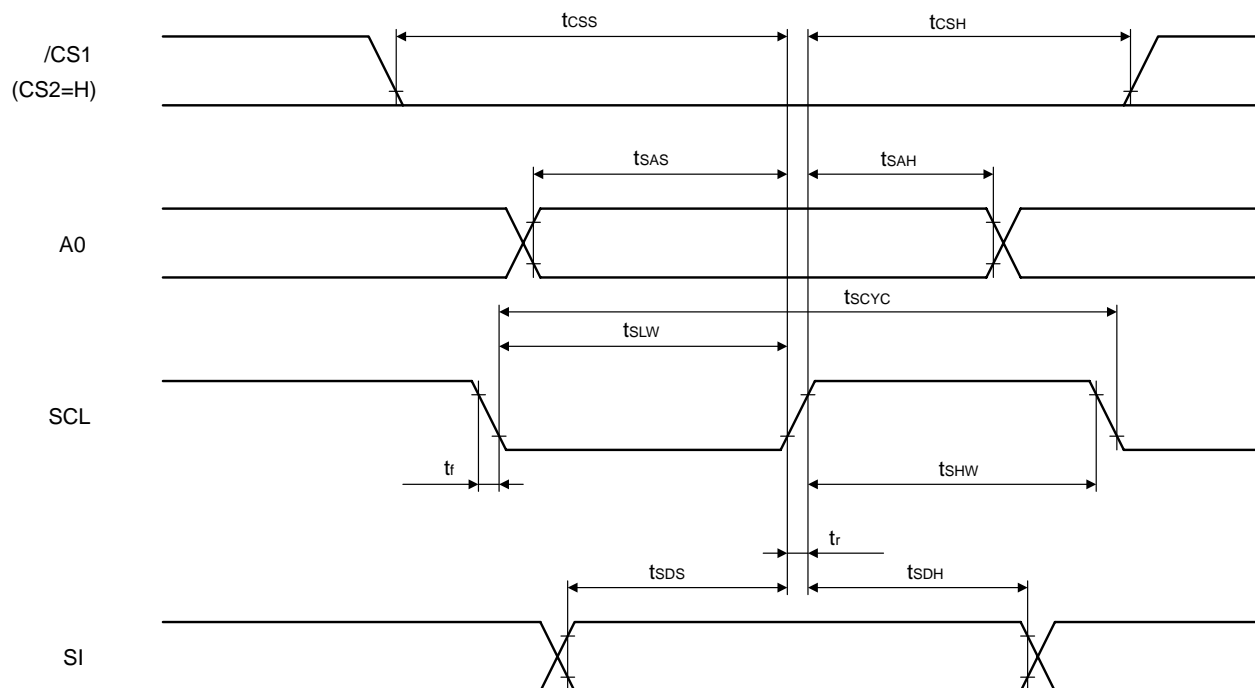
(V_{DD} = 2.4 to 2.7 V)

Parameter		Symbol	Conditions	MIN.	TYP. ^{Note}	MAX.	Unit
Address hold time		t _{AH6}	A0, R,/W	0			ns
Address setup time		t _{AS6}	A0, R,/W	0			ns
System cycle time		t _{CYC6}		1000			ns
Data setup time		t _{DS6}	D ₀ to D ₇	80			ns
Data hold time		t _{DH6}	D ₀ to D ₇	30			ns
Access time		t _{ACC6}	D ₀ to D ₇ , C _L = 100 pF			280	ns
Output disable time		t _{OH6}	D ₀ to D ₇ , C _L = 100 pF	10			ns
Enable H pulse width	Read	t _{EWHR}	E	240			ns
	Write	t _{EWHW}	E	120			ns
Enable L pulse width	Read	t _{EWLR}	E	120			ns
	Write	t _{EWLW}	E	120			ns

Note The TYP. value is a reference value when T_A = 25°C.

- Remarks**
1. The rise and fall times (t_r and t_f) of input signals are rated at 15 ns or less. When using a fast system cycle time, the rated value range is either (t_r + t_f) ≤ (t_{CYC6} - t_{EWLW} - t_{EWHW}) or (t_r + t_f) ≤ (t_{CYC6} - t_{EWLR} - t_{EWHR}).
 2. All timing is rated based on 20% or 80% of V_{DD}.
 3. t_{EWHW} and t_{EWLW} are rated as the overlap time when /CS1 is at low level (CS2 = H) and E is at high level.

Serial Interface



(V_{DD} = 2.7 to 4.5 V)

Parameter	Symbol	Conditions	MIN.	TYP. ^{Note}	MAX.	Unit
Shift clock cycle	t _{SCYC}	SCL	250			ns
SCL H pulse width	t _{SHW}	SCL	100			ns
SCL L pulse width	t _{SLW}	SCL	100			ns
Address setup time	t _{SAS}	A0	150			ns
Address hold time	t _{SAH}	A0	150			ns
Data setup time	t _{SDS}	SI	100			ns
Data hold time	t _{SDH}	SI	100			ns
CS-SCL time	t _{CSS}	/CS1,CS2	150			ns
	t _{CSH}	/CS1,CS2	150			ns

Note The TYP. value is a reference value when T_A = 25°C.

(V_{DD} = 2.4 to 2.7 V)

Parameter	Symbol	Conditions	MIN.	TYP. ^{Note}	MAX.	Unit
Shift clock cycle	t _{SCYC}	SCL	400			ns
SCL H pulse width	t _{SHW}	SCL	150			ns
SCL L pulse width	t _{SLW}	SCL	150			ns
Address setup time	t _{SAS}	A0	250			ns
Address hold time	t _{SAH}	A0	250			ns
Data setup time	t _{SDS}	SI	150			ns
Data hold time	t _{SDH}	SI	150			ns
CS-SCL time	t _{CSS}	/CS1,CS2	250			ns
	t _{CSH}	/CS1,CS2	250			ns

Note The TYP. value is a reference value when T_A = 25°C.

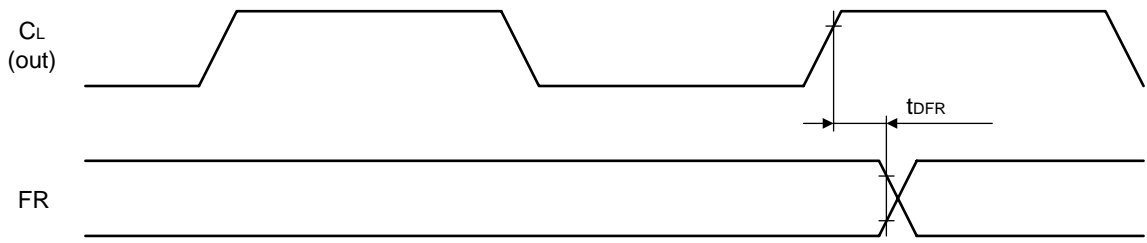
- Remarks**
1. The rise and fall times (t_r and t_f) of input signals are rated at 15 ns or less.
 2. All timing is rated based on 20% or 80% of V_{DD}.

Common

Parameter	Symbol	Conditions	MIN.	TYP. ^{Note}	MAX.	Unit
Oscillation frequency	f _{CL}	C _L , When using external input, T _A = 25°C, V _{DD} = V _{DD2} = 3.0 V ± 10%	17	22	25	kHz

- Remarks**
1. The rise and fall times (t_r and t_f) of input signals are rated at 15 ns or less.
 2. The frame time can be determined using the following equation.
 1 frame = 1/f_{OSC} or 1/f_{CL} x 4 x duty value
 Therefore, when f_{OSC} and f_{CL} = 22 kHz and the duty value is 1/65:
 1 frame = 45.5 μs x 4 x 65 = 11.8 ms (approximately 84.6 kHz)

Output timing for display output control



($V_{DD} = 2.7$ to 4.5 V)

Parameter	Symbol	Conditions	MIN.	TYP. ^{Note}	MAX.	Unit
FR delay time	t_{DFR}	FR, $C_L = 50$ pF		20	80	ns

Note The TYP. value is a reference value when $T_A = 25^{\circ}\text{C}$.

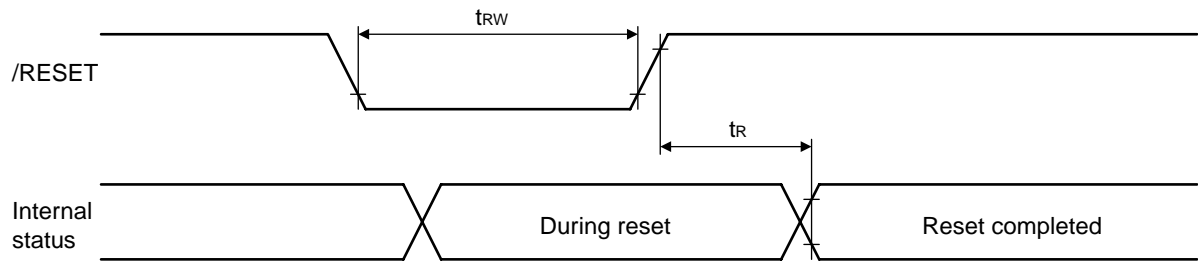
($V_{DD} = 2.4$ to 2.7 V)

Parameter	Symbol	Conditions	MIN.	TYP. ^{Note}	MAX.	Unit
FR delay time	t_{DFR}	FR, $C_L = 50$ pF		50	200	ns

Note The TYP. value is a reference value when $T_A = 25^{\circ}\text{C}$.

Remark All timing is rated based on 20% or 80% of V_{DD} .

Reset input timing



($V_{DD} = 2.7$ to 4.5 V)

Parameter	Symbol	Conditions	MIN.	TYP. ^{Note}	MAX.	Unit
Reset time	t_R				1.0	μs
Reset L pulse width	t_{RW}	/RESET	1.0			μs

Note The TYP. value is a reference value when $T_A = 25^\circ C$.

($V_{DD} = 2.4$ to 2.7 V)

Parameter	Symbol	Conditions	MIN.	TYP. ^{Note}	MAX.	Unit
Reset time	t_R				1.5	μs
Reset L pulse width	t_{RW}	/RESET	1.5			μs

Note The TYP. value is a reference value when $T_A = 25^\circ C$.

Remark All timing is rated based on 20% or 80% of V_{DD} .

[MEMO]

[MEMO]

NOTES FOR CMOS DEVICES

① PRECAUTION AGAINST ESD FOR SEMICONDUCTORS

Note:

Strong electric field, when exposed to a MOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop generation of static electricity as much as possible, and quickly dissipate it once, when it has occurred. Environmental control must be adequate. When it is dry, humidifier should be used. It is recommended to avoid using insulators that easily build static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work bench and floor should be grounded. The operator should be grounded using wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions need to be taken for PW boards with semiconductor devices on it.

② HANDLING OF UNUSED INPUT PINS FOR CMOS

Note:

No connection for CMOS device inputs can be cause of malfunction. If no connection is provided to the input pins, it is possible that an internal input level may be generated due to noise, etc., hence causing malfunction. CMOS devices behave differently than Bipolar or NMOS devices. Input levels of CMOS devices must be fixed high or low by using a pull-up or pull-down circuitry. Each unused pin should be connected to V_{DD} or GND with a resistor, if it is considered to have a possibility of being an output pin. All handling related to the unused pins must be judged device by device and related specifications governing the devices.

③ STATUS BEFORE INITIALIZATION OF MOS DEVICES

Note:

Power-on does not necessarily define initial status of MOS device. Production process of MOS does not define the initial operation status of the device. Immediately after the power source is turned ON, the devices with reset function have not yet been initialized. Hence, power-on does not guarantee out-pin levels, I/O settings or contents of registers. Device is not initialized until the reset signal is received. Reset operation must be executed immediately after power-on for devices having reset function.