

## 241 OUTPUT GATE DRIVER WITH POWER SUPPLY FOR TFT-LCD GATE DRIVER

### DESCRIPTION

The  $\mu$ PD161644 is a TFT-LCD gate driver with power supply for TFT-LCD driver. Because this gate driver has a level shift circuit for logic input, it can output a high gate scanning voltage in response to a CMOS-level input. This ICs can generate the levels which TFT-LCD driver need, from 2.7 V.

### FEATURES

- High breakdown voltage output ( $V_{DD1}-V_{SS3} = 40$  V MAX.)
- 2.7 V CMOS level input
- Number of output: 241 output selectable
- To generate 4 levels from single voltage input
- To integrate regulator circuit for source driver
- Mode setting from source driver: Serial I/F or pin control
- On-chip VCOM driver
- On-chip gate output low-level selector

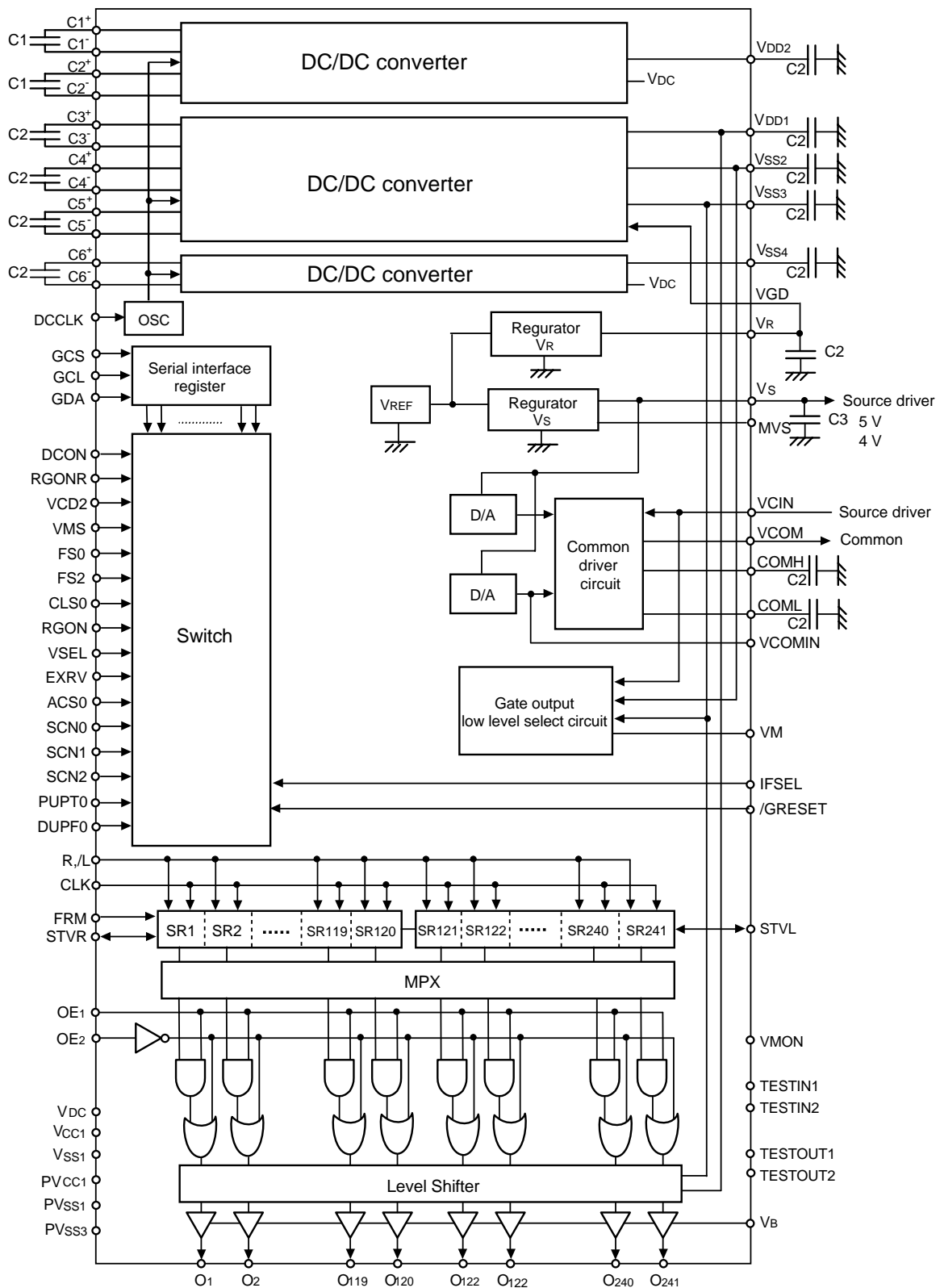
### ORDERING INFORMATION

Part number	Package
$\mu$ PD161644P	Chip

**Remark** Purchasing the above chip entails the exchange of documents such as a separate memorandum or product quality, so please contact one of our sales representatives.

The information contained in this document is being issued in advance of the production cycle for the device. The parameters for the device may change before final production or NEC Corporation, at its own discretion, may withdraw the device prior to its production.  
 Not all devices/types available in every country. Please check with local NEC representative for availability and additional information.

1. BLOCK DIAGRAM/SYSTEM DIAGRAM

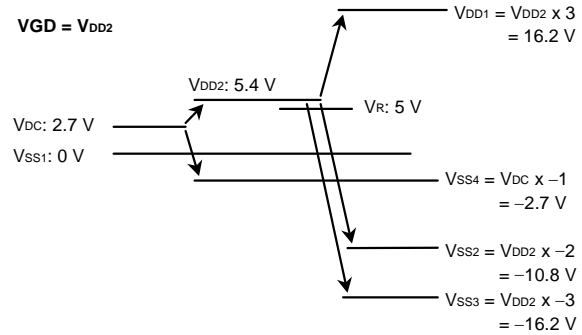
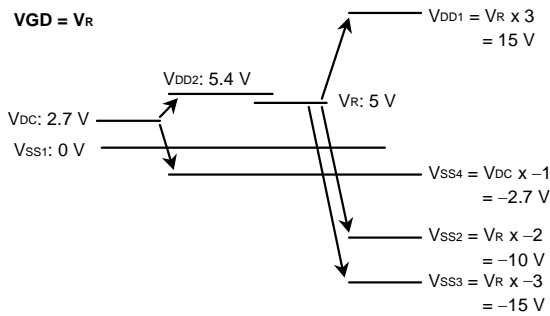


Remarks 1./xxx indicates active low signal.

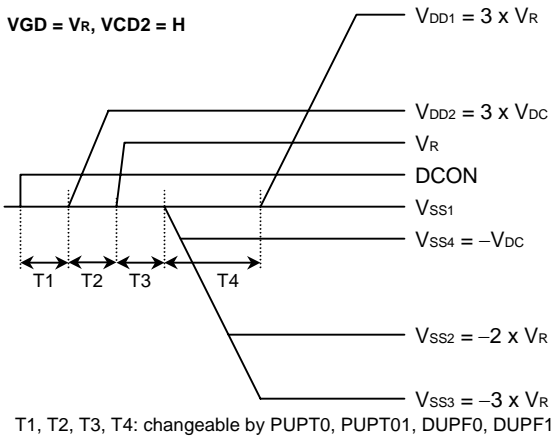
2.Level Shifter (LS): Interfaces between 2.7 V CMOS level and V<sub>DD1</sub> to V<sub>B</sub> level.

### 1.1 Boost Voltage Construction

The boost voltage generated in μPD161644 is shown below.

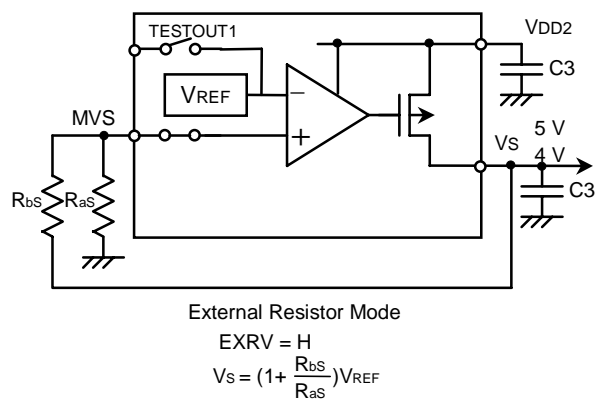
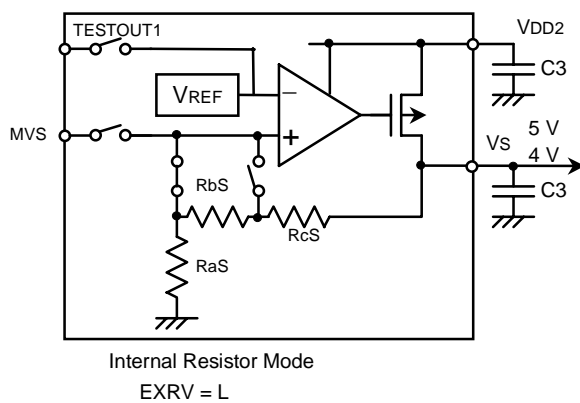


### 1.2 Boost Voltage Auto Start and Rising Order



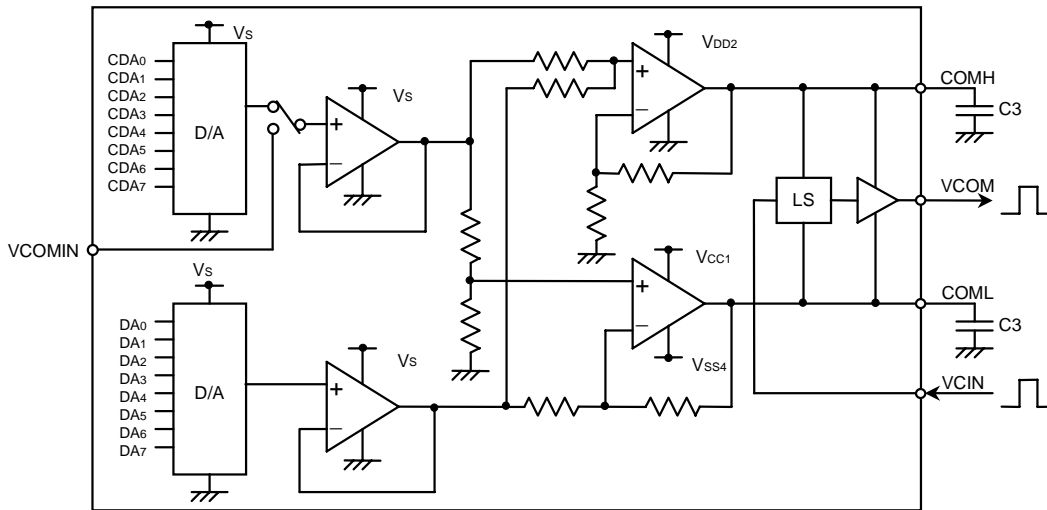
### 1.3 V<sub>S</sub>\_AMP Circuit

V<sub>S</sub>\_AMP circuits are shown below.



1.4 Common Drive Circuit

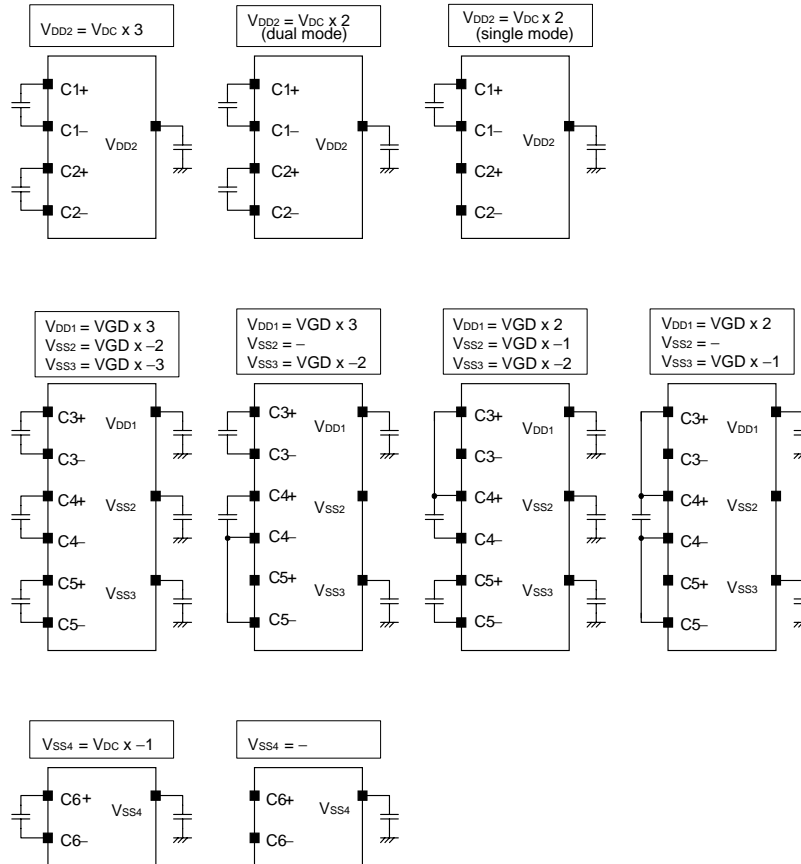
The common drive circuit is shown below.



### 1.5 Variable Boost Steps

The boost steps of  $V_{DD1}$ ,  $V_{SS2}$ ,  $V_{SS3}$  are selected according to how the external capacitor is connected.

The examples of connection are shown below.  $V_s$  is selected as a boost reference voltage in these examples (short between the  $V_s$  and  $V_{GD}$  pins).



2. PIN CONFIGURATION (Pad Layout)

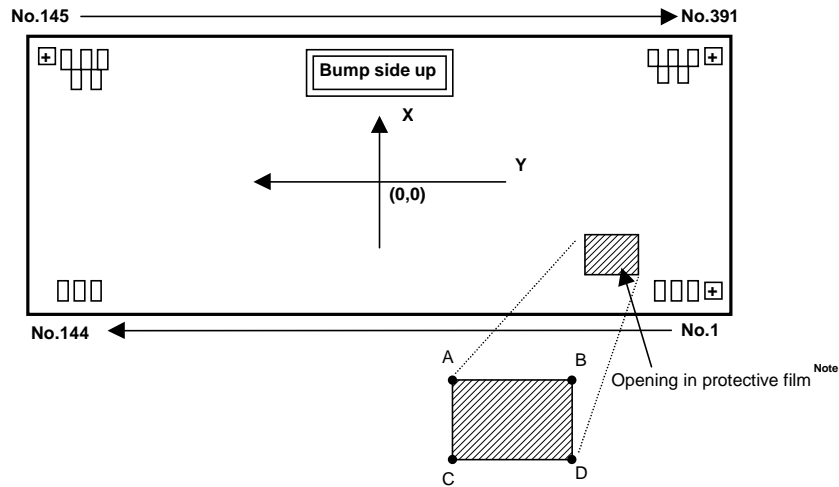
Chip size: 2.8 x 9.4 mm<sup>2</sup>

Bump size

Input/Left/Right (includes DUMMY of input side) : 100 x 40 μm<sup>2</sup>

Output (includes DUMMY output side) : 86 x 35 μm<sup>2</sup>

Figure 2-1. Chip Schematic



**Note** A part of the protective film on the chip surface is absent to enable a transistor check at shipment.

The position of this opening is indicated by the shaded section in the above chip schematic. The specific coordinates of this opening are as follows.

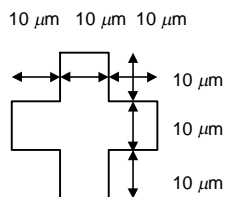
	X (μm)	Y (μm)
A	-847.74	-3143.37
B	-687.75	-3143.37
C	-687.75	-3438.78
D	-847.74	-3438.78

Alignment Mark Coordinate (mark center, unit: mm)

X	Y	Shape of Alignment Mark
-1.125	-4.5705	Type A
0.9705	4.5495	Type B
0.9705	-4.5495	Type B

Alignment Mark

Type A



Type B

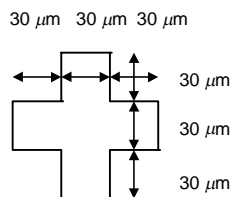


Table 2-1. Pad Layout (1/3)

PADTYPE : BUMP SIZE 100 μm x 40 μm				PADTYPE : BUMP SIZE 100 μm x 40 μm			
GATE INPUTS				GATE INPUTS			
PAD No.	PAD NAME	X [mm]	Y [mm]	PAD No.	PAD NAME	X [mm]	Y [mm]
1	DUMMY	-1.242	-4.5500	73	C2+	-1.242	-0.0300
2	TESTOUT2	-1.242	-4.4900	74	C2+	-1.242	0.0300
3	TESTIN2	-1.242	-4.4300	75	C2+	-1.242	0.0900
4	TESTIN1	-1.242	-4.3700	76	C1-	-1.242	0.1600
5	TESTOUT1	-1.242	-4.3100	77	C1-	-1.242	0.2200
6	PVCC1	-1.242	-4.2500	78	C1-	-1.242	0.2800
7	DUPF0	-1.242	-4.1900	79	C1-	-1.242	0.3400
8	PUPT0	-1.242	-4.1300	80	C1+	-1.242	0.4100
9	SCN2	-1.242	-4.0700	81	C1+	-1.242	0.4700
10	SCN1	-1.242	-4.0100	82	C1+	-1.242	0.5300
11	SCN0	-1.242	-3.9500	83	C1+	-1.242	0.5900
12	ACS0	-1.242	-3.8900	84	VDD2	-1.242	0.6600
13	EXRV	-1.242	-3.8300	85	VDD2	-1.242	0.7200
14	VSEL	-1.242	-3.7700	86	VDD2	-1.242	0.7800
15	CLS0	-1.242	-3.7100	87	VDD2	-1.242	0.8400
16	FS2	-1.242	-3.6500	88	VSS1	-1.242	0.9100
17	FS0	-1.242	-3.5900	89	VSS1	-1.242	0.9700
18	VMS	-1.242	-3.5300	90	VSS1	-1.242	1.0300
19	RGONR	-1.242	-3.4700	91	VSS1	-1.242	1.0900
20	PVSS1	-1.242	-3.4100	92	DUMMY	-1.242	1.1600
21	PVSS3	-1.242	-3.3500	93	VDC	-1.242	1.2300
22	VMON	-1.242	-3.2900	94	VDC	-1.242	1.2900
23	DUMMY	-1.242	-3.2300	95	VDC	-1.242	1.3500
24	PVCC1	-1.242	-3.1700	96	VDC	-1.242	1.4100
25	R/L	-1.242	-3.1100	97	VDC	-1.242	1.4700
26	IFSEL	-1.242	-3.0500	98	VDC	-1.242	1.5300
27	PVSS1	-1.242	-2.9900	99	VDC	-1.242	1.5900
28	VCOMIN	-1.242	-2.9200	100	VDC	-1.242	1.6500
29	VCOM	-1.242	-2.8500	101	VCC1	-1.242	1.7200
30	VCOM	-1.242	-2.7900	102	VCC1	-1.242	1.7800
31	VCOM	-1.242	-2.7300	103	VCC1	-1.242	1.8400
32	COML	-1.242	-2.6600	104	VCC1	-1.242	1.9000
33	COML	-1.242	-2.6000	105	VSS1	-1.242	1.9700
34	COMH	-1.242	-2.5300	106	VSS1	-1.242	2.0300
35	COMH	-1.242	-2.4700	107	VSS1	-1.242	2.0900
36	VM	-1.242	-2.4000	108	VSS1	-1.242	2.1500
37	VM	-1.242	-2.3400	109	VSS1	-1.242	2.2100
38	VB	-1.242	-2.2700	110	VSS1	-1.242	2.2700
39	VB	-1.242	-2.2100	111	VR	-1.242	2.3400
40	VSS3	-1.242	-2.1400	112	VR	-1.242	2.4000
41	VSS3	-1.242	-2.0800	113	VR	-1.242	2.4600
42	VSS3	-1.242	-2.0200	114	VGD	-1.242	2.5300
43	VSS4	-1.242	-1.9500	115	VGD	-1.242	2.5900
44	VSS4	-1.242	-1.8900	116	VGD	-1.242	2.6500
45	VSS4	-1.242	-1.8300	117	MVS	-1.242	2.7200
46	VSS2	-1.242	-1.7600	118	VS	-1.242	2.7900
47	VSS2	-1.242	-1.7000	119	VS	-1.242	2.8500
48	VSS2	-1.242	-1.6400	120	VS	-1.242	2.9100
49	C6-	-1.242	-1.5700	121	VS	-1.242	2.9700
50	C6-	-1.242	-1.5100	122	VS	-1.242	3.0300
51	C6+	-1.242	-1.4400	123	VS	-1.242	3.0900
52	C6+	-1.242	-1.3800	124	DUMMY	-1.242	3.1600
53	C5-	-1.242	-1.3100	125	PVCC1	-1.242	3.2300
54	C5-	-1.242	-1.2500	126	VCD2	-1.242	3.3000
55	C5+	-1.242	-1.1800	127	RGON	-1.242	3.3700
56	C5+	-1.242	-1.1200	128	DCON	-1.242	3.4400
57	C4-	-1.242	-1.0500	129	FRM	-1.242	3.5100
58	C4-	-1.242	-0.9900	130	VCIN	-1.242	3.5800
59	C4+	-1.242	-0.9200	131	PVSS1	-1.242	3.6500
60	C4+	-1.242	-0.8600	132	/GRESET	-1.242	3.7200
61	C3-	-1.242	-0.7900	133	GCS	-1.242	3.7900
62	C3-	-1.242	-0.7300	134	GCL	-1.242	3.8600
63	C3+	-1.242	-0.6600	135	GDA	-1.242	3.9300
64	C3+	-1.242	-0.6000	136	STVR	-1.242	4.0000
65	VDD1	-1.242	-0.5300	137	STVL	-1.242	4.0700
66	VDD1	-1.242	-0.4700	138	DCCLK	-1.242	4.1400
67	VDD1	-1.242	-0.4100	139	CLK	-1.242	4.2100
68	C2-	-1.242	-0.3400	140	OE1	-1.242	4.2800
69	C2-	-1.242	-0.2800	141	OE2	-1.242	4.3500
70	C2-	-1.242	-0.2200	142	DUMMY	-1.242	4.4200
71	C2-	-1.242	-0.1600	143	VSS3	-1.242	4.4900
72	C2+	-1.242	-0.0900	144	DUMMY	-1.242	4.5600

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

PADTYPE : BUMP SIZE 86 μm x 35 μm			
GATE OUTPUTS 35 μm pitch			
PAD No.	PAD NAME	X [mm]	Y [mm]
145	DUMMY	1.249	4.3050
146	DUMMY	1.127	4.2700
147	DUMMY	1.249	4.2350
148	O241	1.127	4.2000
149	O240	1.249	4.1650
150	O239	1.127	4.1300
151	O238	1.249	4.0950
152	O237	1.127	4.0600
153	O236	1.249	4.0250
154	O235	1.127	3.9900
155	O234	1.249	3.9550
156	O233	1.127	3.9200
157	O232	1.249	3.8850
158	O231	1.127	3.8500
159	O230	1.249	3.8150
160	O229	1.127	3.7800
161	O228	1.249	3.7450
162	O227	1.127	3.7100
163	O226	1.249	3.6750
164	O225	1.127	3.6400
165	O224	1.249	3.6050
166	O223	1.127	3.5700
167	O222	1.249	3.5350
168	O221	1.127	3.5000
169	O220	1.249	3.4650
170	O219	1.127	3.4300
171	O218	1.249	3.3950
172	O217	1.127	3.3600
173	O216	1.249	3.3250
174	O215	1.127	3.2900
175	O214	1.249	3.2550
176	O213	1.127	3.2200
177	O212	1.249	3.1850
178	O211	1.127	3.1500
179	O210	1.249	3.1150
180	O209	1.127	3.0800
181	O208	1.249	3.0450
182	O207	1.127	3.0100
183	O206	1.249	2.9750
184	O205	1.127	2.9400
185	O204	1.249	2.9050
186	O203	1.127	2.8700
187	O202	1.249	2.8350
188	O201	1.127	2.8000
189	O200	1.249	2.7650
190	O199	1.127	2.7300
191	O198	1.249	2.6950
192	O197	1.127	2.6600
193	O196	1.249	2.6250
194	O195	1.127	2.5900
195	O194	1.249	2.5550
196	O193	1.127	2.5200
197	O192	1.249	2.4850
198	O191	1.127	2.4500
199	O190	1.249	2.4150
200	O189	1.127	2.3800
201	O188	1.249	2.3450
202	O187	1.127	2.3100
203	O186	1.249	2.2750
204	O185	1.127	2.2400
205	O184	1.249	2.2050
206	O183	1.127	2.1700
207	O182	1.249	2.1350
208	O181	1.127	2.1000
209	O180	1.249	2.0650
210	O179	1.127	2.0300
211	O178	1.249	1.9950
212	O177	1.127	1.9600
213	O176	1.249	1.9250
214	O175	1.127	1.8900
215	O174	1.249	1.8550
216	O173	1.127	1.8200

PADTYPE : BUMP SIZE 86 μm x 35 μm			
GATE OUTPUTS 35 μm pitch			
PAD No.	PAD NAME	X [mm]	Y [mm]
217	O172	1.249	1.7850
218	O171	1.127	1.7500
219	O170	1.249	1.7150
220	O169	1.127	1.6800
221	O168	1.249	1.6450
222	O167	1.127	1.6100
223	O166	1.249	1.5750
224	O165	1.127	1.5400
225	O164	1.249	1.5050
226	O163	1.127	1.4700
227	O162	1.249	1.4350
228	O161	1.127	1.4000
229	O160	1.249	1.3650
230	O159	1.127	1.3300
231	O158	1.249	1.2950
232	O157	1.127	1.2600
233	O156	1.249	1.2250
234	O155	1.127	1.1900
235	O154	1.249	1.1550
236	O153	1.127	1.1200
237	O152	1.249	1.0850
238	O151	1.127	1.0500
239	O150	1.249	1.0150
240	O149	1.127	0.9800
241	O148	1.249	0.9450
242	O147	1.127	0.9100
243	O146	1.249	0.8750
244	O145	1.127	0.8400
245	O144	1.249	0.8050
246	O143	1.127	0.7700
247	O142	1.249	0.7350
248	O141	1.127	0.7000
249	O140	1.249	0.6650
250	O139	1.127	0.6300
251	O138	1.249	0.5950
252	O137	1.127	0.5600
253	O136	1.249	0.5250
254	O135	1.127	0.4900
255	O134	1.249	0.4550
256	O133	1.127	0.4200
257	O132	1.249	0.3850
258	O131	1.127	0.3500
259	O130	1.249	0.3150
260	O129	1.127	0.2800
261	O128	1.249	0.2450
262	O127	1.127	0.2100
263	O126	1.249	0.1750
264	O125	1.127	0.1400
265	O124	1.249	0.1050
266	O123	1.127	0.0700
267	O122	1.249	0.0350
268	O121	1.127	0.0000
269	O120	1.249	-0.0350
270	O119	1.127	-0.0700
271	O118	1.249	-0.1050
272	O117	1.127	-0.1400
273	O116	1.249	-0.1750
274	O115	1.127	-0.2100
275	O114	1.249	-0.2450
276	O113	1.127	-0.2800
277	O112	1.249	-0.3150
278	O111	1.127	-0.3500
279	O110	1.249	-0.3850
280	O109	1.127	-0.4200
281	O108	1.249	-0.4550
282	O107	1.127	-0.4900
283	O106	1.249	-0.5250
284	O105	1.127	-0.5600
285	O104	1.249	-0.5950
286	O103	1.127	-0.6300
287	O102	1.249	-0.6650
288	O101	1.127	-0.7000



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

PADTYPE : BUMP SIZE 86 μm x 35 μm			
GATE OUTPUTS 35 μm pitch			
PAD No.	PAD NAME	X [mm]	Y [mm]
289	O100	1.249	-0.7350
290	O99	1.127	-0.7700
291	O98	1.249	-0.8050
292	O97	1.127	-0.8400
293	O96	1.249	-0.8750
294	O95	1.127	-0.9100
295	O94	1.249	-0.9450
296	O93	1.127	-0.9800
297	O92	1.249	-1.0150
298	O91	1.127	-1.0500
299	O90	1.249	-1.0850
300	O89	1.127	-1.1200
301	O88	1.249	-1.1550
302	O87	1.127	-1.1900
303	O86	1.249	-1.2250
304	O85	1.127	-1.2600
305	O84	1.249	-1.2950
306	O83	1.127	-1.3300
307	O82	1.249	-1.3650
308	O81	1.127	-1.4000
309	O80	1.249	-1.4350
310	O79	1.127	-1.4700
311	O78	1.249	-1.5050
312	O77	1.127	-1.5400
313	O76	1.249	-1.5750
314	O75	1.127	-1.6100
315	O74	1.249	-1.6450
316	O73	1.127	-1.6800
317	O72	1.249	-1.7150
318	O71	1.127	-1.7500
319	O70	1.249	-1.7850
320	O69	1.127	-1.8200
321	O68	1.249	-1.8550
322	O67	1.127	-1.8900
323	O66	1.249	-1.9250
324	O65	1.127	-1.9600
325	O64	1.249	-1.9950
326	O63	1.127	-2.0300
327	O62	1.249	-2.0650
328	O61	1.127	-2.1000
329	O60	1.249	-2.1350
330	O59	1.127	-2.1700
331	O58	1.249	-2.2050
332	O57	1.127	-2.2400
333	O56	1.249	-2.2750
334	O55	1.127	-2.3100
335	O54	1.249	-2.3450
336	O53	1.127	-2.3800
337	O52	1.249	-2.4150
338	O51	1.127	-2.4500
339	O50	1.249	-2.4850
340	O49	1.127	-2.5200
341	O48	1.249	-2.5550
342	O47	1.127	-2.5900
343	O46	1.249	-2.6250
344	O45	1.127	-2.6600
345	O44	1.249	-2.6950
346	O43	1.127	-2.7300
347	O42	1.249	-2.7650
348	O41	1.127	-2.8000
349	O40	1.249	-2.8350
350	O39	1.127	-2.8700
351	O38	1.249	-2.9050
352	O37	1.127	-2.9400
353	O36	1.249	-2.9750
354	O35	1.127	-3.0100
355	O34	1.249	-3.0450
356	O33	1.127	-3.0800
357	O32	1.249	-3.1150
358	O31	1.127	-3.1500
359	O30	1.249	-3.1850
360	O29	1.127	-3.2200

PADTYPE : BUMP SIZE 86 μm x 35 μm			
GATE OUTPUTS 35 μm pitch			
PAD No.	PAD NAME	X [mm]	Y [mm]
361	O28	1.249	-3.2550
362	O27	1.127	-3.2900
363	O26	1.249	-3.3250
364	O25	1.127	-3.3600
365	O24	1.249	-3.3950
366	O23	1.127	-3.4300
367	O22	1.249	-3.4650
368	O21	1.127	-3.5000
369	O20	1.249	-3.5350
370	O19	1.127	-3.5700
371	O18	1.249	-3.6050
372	O17	1.127	-3.6400
373	O16	1.249	-3.6750
374	O15	1.127	-3.7100
375	O14	1.249	-3.7450
376	O13	1.127	-3.7800
377	O12	1.249	-3.8150
378	O11	1.127	-3.8500
379	O10	1.249	-3.8850
380	O9	1.127	-3.9200
381	O8	1.249	-3.9550
382	O7	1.127	-3.9900
383	O6	1.249	-4.0250
384	O5	1.127	-4.0600
385	O4	1.249	-4.0950
386	O3	1.127	-4.1300
387	O2	1.249	-4.1650
388	O1	1.127	-4.2000
389	DUMMY	1.249	-4.2350
390	DUMMY	1.127	-4.2700
391	DUMMY	1.249	-4.3050

3. PIN FUNCTIONS

(1/5)

Symbol	Pin Name	Pad No.	I/O	Function
V <sub>DC</sub>	DC/DC converter reference voltage	93 to 100	–	Reference voltage input pin for DC/DC converter.
V <sub>CC1</sub>	Logic reference voltage	101 to 104	–	2.5 to 3.3 V LS (level shifter) reference voltage input pin.
V <sub>SS1</sub>	Ground	88 to 91, 105 to 110	–	Connect to the system ground.
V <sub>GD</sub>	Power supply input for DC/DC converter	114 to 116	Input	Reference voltage input pin for V <sub>DD1</sub> , V <sub>SS1</sub> to V <sub>SS4</sub> boost. Connect to any of V <sub>DD2</sub> , V <sub>R</sub> or V <sub>S</sub> .
V <sub>DD1</sub>	DC/DC converter output	65 to 67	Output	Boost output voltage of DC/DC converter (V <sub>GD</sub> x 2 or x 3). The boost step number of V <sub>DD1</sub> is selected according to how the external capacitor is connected. The boost reference voltage can be set using V <sub>GD</sub> . Refer to the function of V <sub>GD</sub> pin.
V <sub>DD2</sub>	DC/DC converter output	84 to 87	Output	Boost output voltage of DC/DC converter (V <sub>DC</sub> x 2 or x 3). The boost step number of V <sub>DD2</sub> can be set using V <sub>CD2</sub> .
V <sub>SS2</sub>	DC/DC converter output	46 to 48	Output	Boost output voltage of DC/DC converter (V <sub>GD</sub> x –1 or x –2). The boost step number of V <sub>SS2</sub> is selected according to how the external capacitor is connected. The boost reference voltage can be set using V <sub>GD</sub> . Refer to the function of V <sub>GD</sub> pin.
V <sub>SS3</sub>	DC/DC converter output	40 to 42, 143	Output	Boost output voltage of DC/DC converter (V <sub>GD</sub> x –2 or x –3). The boost step number of V <sub>SS3</sub> is selected according to how the external capacitor is connected. The boost reference voltage can be set using V <sub>GD</sub> . Refer to V <sub>GD</sub> pin function.
V <sub>SS4</sub>	DC/DC converter output	43 to 45	Output	Boost output voltage of DC/DC converter (V <sub>DC</sub> x –1).
V <sub>M</sub>	Gate output low level select voltage	36, 37	Output	The voltage level of V <sub>SS2</sub> or V <sub>SS3</sub> is output synchronized with the V <sub>CIN</sub> input. V <sub>CIN</sub> = 0: Output the voltage level of V <sub>SS3</sub> V <sub>CIN</sub> = 1: Output the voltage level of V <sub>SS2</sub> The timing chart is shown in <b>Figure 3-1</b> .
V <sub>B</sub>	Driver negative voltage	38, 39	Input	Negative voltage of output buffer. This is the input pin of the liquid crystal driver negative voltage. Input the negative power supply of the gate output. V <sub>B</sub> pin connection examples are shown in <b>Figure 3-2</b> .
C <sub>1</sub> <sup>+</sup> , C <sub>1</sub> <sup>–</sup> C <sub>2</sub> <sup>+</sup> , C <sub>2</sub> <sup>–</sup> C <sub>3</sub> <sup>+</sup> , C <sub>3</sub> <sup>–</sup> C <sub>4</sub> <sup>+</sup> , C <sub>4</sub> <sup>–</sup> C <sub>5</sub> <sup>+</sup> , C <sub>5</sub> <sup>–</sup> C <sub>6</sub> <sup>+</sup> , C <sub>6</sub> <sup>–</sup>	Capacitor connect pin for boost	80 to 83, 76 to 79, 72 to 75, 68 to 71, 63, 64, 61, 62, 59, 60, 57, 58, 55, 56, 53, 54, 51, 52, 49, 50	Output	To connect booster for DC/DC converter. For the recommended values of the capacitance and withstanding voltage of each capacitor, refer to <b>9. RECOMMENDED CAPACITANCE VALUES OF EXTERNAL CAPACITOR</b> .
V <sub>R</sub>	Power supply output for DC/DC converter	111 to 113	Output	Positive power supply voltage output for the DC/DC converter. The V <sub>R</sub> output voltage can be changed by setting VRSEL0 to VRSEL2.

(2/5)

Symbol	Pin Name	Pad No.	I/O	Function
Vs	Positive power output supply for driver	118 to 123	Output	Positive power supply voltage output for source driver. The Vs output voltage can be changed by setting VSEL0 to VSEL2.
MVS	External resistor input	117	Input	Any output voltage can be set by connecting an external resistor. <EXRV = 0> Leave open. <EXRV = 1> Connect to external resistor.
PVcc1	Pull-up voltage	6, 24, 125	–	Pull-up voltage for mode setting pin.
PVss1	Pull-down voltage	20, 27, 131	–	Pull-down voltage for mode setting pin.
PVss3	Pull-down voltage	21	–	Pull-down voltage for mode setting pin.
CLK	Shift clock input	139	Input	Shift clock input pin of the internal shift resistor. The contents of internal shift resistor are shifted at the rising edge of CLK. Connect to GCLK pin of source driver.
STVR, STVL	Start pulse input/output pin	136, 137	I/O	Input/output pin of the internal shift resistor. Start pulse signal is read at the rising edge of shift clock CLK and a scan signal is output from the driver output pin. The valid level of the STVR/STVL pin is determined by the setting of STVSEL. When STVSEL = L, the pulse becomes low level at the falling edge of the 240th shift clock CLK and high level at falling edge of the 241st clock.
OE1	Enable input	140	Input	If the level selected by OE1SEL is input, the driver output is fixed to low level (When OE1SEL = L the driver output is fixed to low level if a low level is input). However, the shift resistor is not cleared. And, output enable actuation is asynchronous in the clock. Connect to GOE1 pin of source driver.
OE2	Enable input	141	Input	If the level selected by OE2SEL is input, the driver output is fixed to high level (When OE2SEL = L the driver output is fixed to low level if a high level is input). However, the shift resistor is not cleared. And, output enable actuation is asynchronous in the clock. Connect to GOE2 pin of source driver.
R,/L	Shift direction control	25	Input	The shift direction control pin of shift register. The shift directions of the shift registers are as follows. R,/L = H (right shift): STVR input, O1 → O241, STVL output R,/L = L (left shift) : STVL input, O241 → O1, STVR output
FRM	Frame signal input	129	Input	Input frame reverse signals. Connect to GFRAME pin of source driver.
DCCLK	Clock input for DC/DC converter	138	Input	To input the external clock for the DC/DC converter. This pin is valid only when CLS0 = 1 and CLS1 = 1. In other settings, leave open.

Symbol	Pin Name	Pad No.	I/O	Function
O <sub>1</sub> to O <sub>241</sub>	Driver output pins	388 to 148	Output	Scan signal output pins that drive the gate electrode of a TFT-LCD. The status of each output pin changes in synchronization with the rising edge of shift clock CLK. The output voltage of the driver is V <sub>DD1</sub> to V <sub>B</sub> .
COMH	Common high level output	34, 35	Output	<COMON = 1> High level of common voltage is output. The voltage level changes accordance with DA <sub>0</sub> to DA <sub>7</sub> and CDA <sub>0</sub> to CDA <sub>7</sub> . <COMON = 0> Leave open when not using it.
COML	Common low level output	32, 33	Output	<COMON = 1> Low level of common voltage is output. The voltage level changes accordance with DA <sub>0</sub> to DA <sub>7</sub> and CDA <sub>0</sub> to CDA <sub>7</sub> . <COMON = 0> Leave open when not using it.
VCOM	Common output	29 to 31	Output	<COMON = 1> The common voltage synchronized with the VCIN input is output. Connect to common pin of panel. <COMON = 0> Leave open when not using it.
VCOMIN	VCOM center voltage input	28	Input	VCOM center voltage input pin. Leave open when COMSEL = 0. <COMSEL = 0> Internal D/A is valid. <COMSEL = 1> VCOMIN input voltage is valid.
VCIN	Common pulse input	130	Input	To input common pulse. Connect to VCOUT3 pin of source driver. Fix this pin to low when not using it.
/GRESET	Reset input	132	Input	Reset input pin. Connect to /GRESET pin of source driver. If /GRESET is made low, the serial interface is initialized (the register values are not initialized). A reset operation is executed according to the level of the /GRESET signal. Be sure to execute a reset using this pin at power application.
IFSEL	Interface selection	26	Input	The serial interface input switching pin. <IFSEL = 0> Serial interface input. The DCON, RGONR, VCD2, VMS, FS0, FS2, CLS0, RGON, VSEL, EXRV, ACS0, SCN0 to SCN2, PUPT0, DUPF0 pins should be left open. <IFSEL = 1> Control pin input. The GCS, GCL, GDA pins should be left open.
GCS	Chip select input	133	Input	<IFSEL = 0> To input chip select signals. Connect to GCS pin of source driver. <IFSEL = 1> Leave open.
GCL	Serial clock input	134	Input	<IFSEL = 0> To input serial clock signals. Connect to GCL pin of source driver. <IFSEL = 1> Leave open.
GDA	Serial data input	135	Input	<IFSEL = 0> To input serial data signals. Connect to GDA pin of source driver. <IFSEL = 1> Leave open.

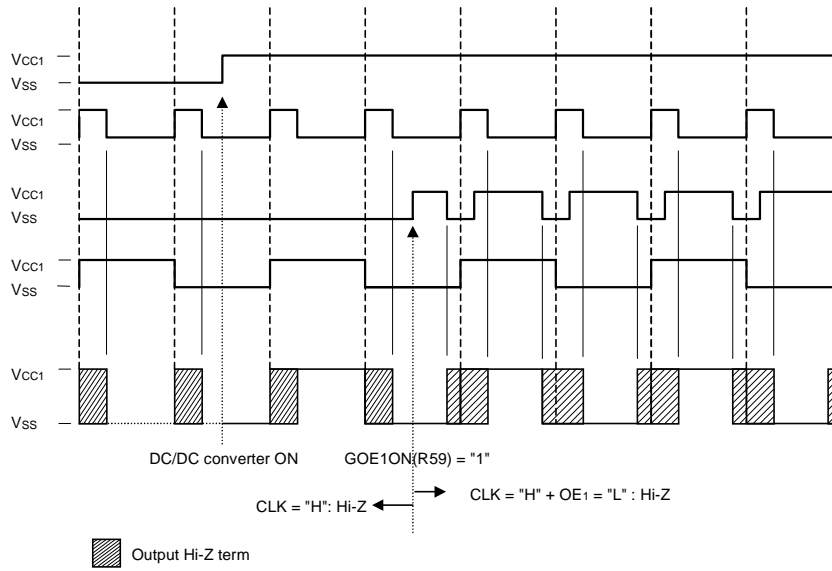
(4/5)

Symbol	Pin Name	Pad No.	I/O	Function
DCON	DC/DC converter control	128	Input	<p>&lt;IFSEL = 0&gt; Leave open (Internal resistors are valid).</p> <p>&lt;IFSEL = 1&gt; The DC/DC converter ON/OFF control signal is input. Connect to the DCON pin of the source driver.</p> <p>&lt;DCON = 0&gt; DC/DC converter OFF</p> <p>&lt;DCON = 1&gt; DC/DC converter ON</p>
RGONR	V <sub>R</sub> regulator control	19	Input	<p>&lt;IFSEL = 0&gt; Leave open (Internal resistors are valid).</p> <p>&lt;IFSEL = 1&gt; The V<sub>R</sub> regulator ON/OFF control signal is input.</p> <p>&lt;RGONR = 0&gt; V<sub>R</sub> regulator OFF</p> <p>&lt;RGONR = 1&gt; V<sub>R</sub> regulator ON</p>
VCD2	V <sub>DD2</sub> boost selection	126	Input	<p>&lt;IFSEL = 0&gt; Leave open (Internal resistors are valid).</p> <p>&lt;IFSEL = 1&gt; The V<sub>DD2</sub> boost step number select pin.</p> <p>&lt;VCD2 = 0&gt; V<sub>DD2</sub> = V<sub>DC</sub> x 2</p> <p>&lt;VCD2 = 1&gt; V<sub>DD2</sub> = V<sub>DC</sub> x 3</p>
VMS	V <sub>DD2</sub> boost selection	18	Input	<p>&lt;IFSEL = 0&gt; Leave open (Internal resistors are valid).</p> <p>&lt;IFSEL = 1&gt; V<sub>DD2</sub> boost mode select pin.</p> <p>&lt;VMS = 0&gt; V<sub>DD2</sub>: single boost mode</p> <p>&lt;VMS = 1&gt; V<sub>DD2</sub>: dual boost mode</p>
FS0	V <sub>DD2</sub> , V <sub>SS4</sub> boost frequency selection in scan mode	17	Input	<p>&lt;IFSEL = 0&gt; Leave open (Internal resistors are valid).</p> <p>&lt;IFSEL = 1&gt; V<sub>DD2</sub>, V<sub>SS4</sub> boost frequency select pin in scan mode.</p> <p>&lt;FS0 = 0 &gt; fosc/2 &lt;FS0 = 1 &gt; fosc/4</p>
FS2	V <sub>DD1</sub> , V <sub>SS2</sub> , V <sub>SS3</sub> boost frequency selection in scan mode	16	Input	<p>&lt;IFSEL = 0&gt; Leave open (Internal resistors are valid).</p> <p>&lt;IFSEL = 1&gt; V<sub>DD1</sub>, V<sub>SS2</sub>, V<sub>SS3</sub> boost frequency select pin in scan mode.</p> <p>&lt;FS2 = 0 &gt; fosc/2 &lt;FS2 = 1, &gt; fosc/4</p>
CLS0	DC/DC OSC frequency selection	15	Input	<p>&lt;IFSEL = 0&gt; Leave open (Internal resistors are valid).</p> <p>&lt;IFSEL = 1&gt; Select pin of the OSC oscillation frequency for DC/DC converter.</p> <p>&lt;CLS0 = 0&gt; fosc = 25 kHz, DCCLK: Open</p> <p>&lt;CLS0 = 1&gt; External CK input mode</p>
RGON	V <sub>s</sub> regulator control	127	Input	<p>&lt;IFSEL = 0&gt; Leave open (Internal resistors are valid).</p> <p>&lt;IFSEL = 1&gt; The V<sub>s</sub> regulator ON/OFF control signal is input. Connect this pin to the RGON pin of the source driver.</p> <p>&lt;RGON = 0&gt; V<sub>s</sub> regulator OFF</p> <p>&lt;RGON = 1&gt; V<sub>s</sub> regulator ON</p>
VSEL	V <sub>s</sub> regulator voltage selection	14	Input	<p>&lt;IFSEL = 0&gt; Leave open (Internal resistors are valid).</p> <p>&lt;IFSEL = 1&gt; Select pin of output voltage for V<sub>s</sub> regulator.</p> <p>&lt;VSEL = 1&gt; V<sub>s</sub> = 4 V</p> <p>&lt;VSEL = 0&gt; V<sub>s</sub> = 5 V</p>
EXRV	V <sub>s</sub> regulating resistor selection	13	Input	<p>&lt;IFSEL = 0&gt; Leave open (Internal resistors are valid).</p> <p>&lt;IFSEL = 1&gt; Select pin of external resistor for V<sub>s</sub> regulator.</p> <p>&lt;EXRV = 0&gt; Internal resistor setting mode.</p> <p>&lt;EXRV = 1&gt; Any output voltage can be set by connecting MVS to an external resistor.</p>

(5/5)

Symbol	Pin Name	Pad No.	I/O	Function
ACS0	Amp. current selection in scan mode	12	Input	<p>&lt;IFSEL = 0&gt; Leave open (Internal resistors are valid).</p> <p>&lt;IFSEL = 1&gt; Amp. current select pin in scan mode.</p> <p>&lt;ACS0 = 0&gt; Amp. current = 5 μA</p> <p>&lt;ACS0 = 1&gt; Amp. current = 15 μA</p>
SCN0, SCN1, SCN2	Gate scan selection	11, 10, 9	Input	<p>&lt;IFSEL = 0&gt; Leave open (Internal resistors are valid).</p> <p>&lt;IFSEL = 1&gt; Select pin of gate scan order.</p> <p>&lt;SCN0 = 1, SCN1 = 1, SCN2 = 1&gt; MODE1</p> <p>&lt;SCN0 = 1, SCN1 = 1, SCN2 = 0&gt; MODE2</p> <p>&lt;SCN0 = 1, SCN1 = 0, SCN2 = 1&gt; MODE3</p> <p>&lt;SCN0 = 1, SCN1 = 0, SCN2 = 0&gt; MODE4</p> <p>&lt;SCN0 = 0, SCN1, SCN2 = x&gt; MODE5</p>
PUPT0	Setting pin of DC/DC converter power on time	8	Input	<p>&lt;IFSEL = 0&gt; Leave open (Internal resistors are valid).</p> <p>&lt;IFSEL = 1&gt; This pin sets the rising time of VDD1, VDD2, VSS2 to VSS4 at DC/DC converter power on time.</p>
DUPF0	Operating frequency setting pin at DC/DC converter power on	7	Input	<p>&lt;IFSEL = 0&gt; Leave open (Internal resistors are valid).</p> <p>&lt;IFSEL = 1&gt; This pin sets the operating frequency at DC/DC converter power on time.</p> <p>&lt;DUPT0 = 0&gt; fosc/8</p> <p>&lt;DUPT0 = 1&gt; fosc/16</p>
VMON	Stand-by current reduction control pin	22	Input	<p>The standby current reduction control pin.</p> <p>&lt;VMON = PVSS3&gt; Normal mode.</p> <p>A quiescent current of about 0.5 μA is consumed in standby mode.</p> <p>When the Vcc1 voltage drops, the driver output pins are fixed to ALL-High.</p> <p>&lt;VMON = PVCC1&gt; Standby current reduction mode.</p> <p>Makes the quiescent current consumed in standby mode 0.</p> <p>When the Vcc1 voltage drops, the driver output pins are undefined.</p>
TESTOUT1	VREF reference voltage output	5	Output	The VREF voltage measurement pin. Leave open.
TESTIN1, TESTIN2	TEST input pin	4, 3	Input	Test input pins. Leave open.
TESTOUT2	TEST output pin	2	Output	Test output pin. Leave open.
DUMMY	Dummy	1, 23, 92, 124, 142, 144 to 147, 389 to 391	–	Dummy data

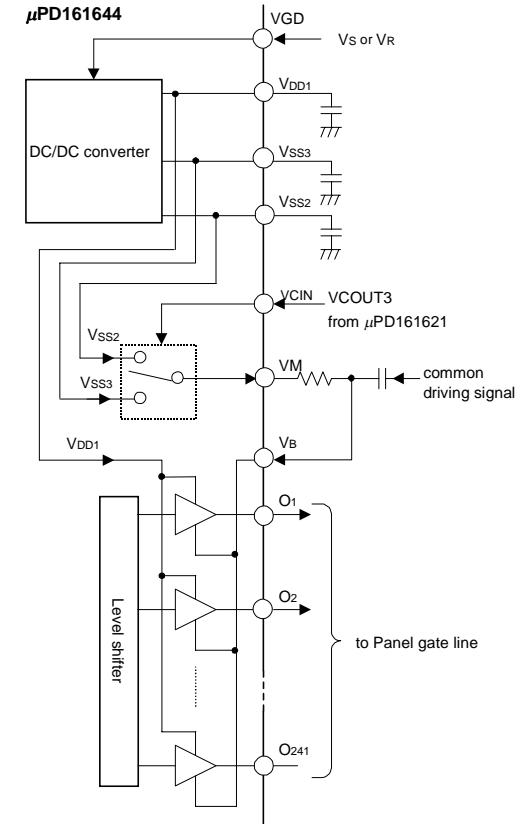
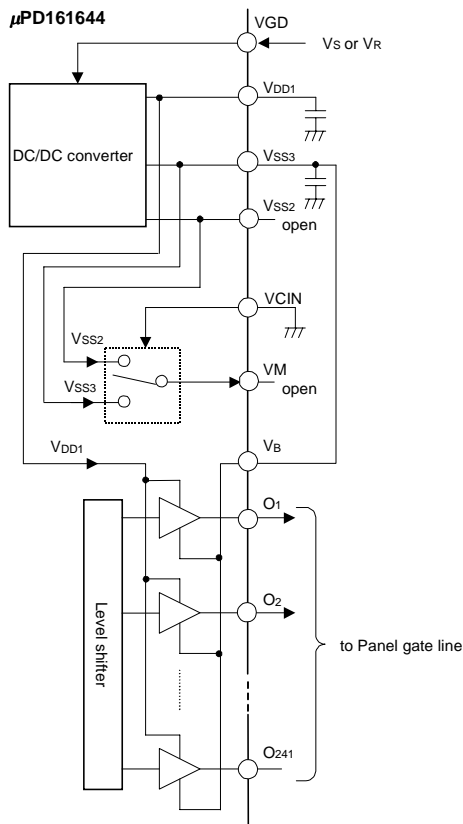
Figure 3-1. VM signal Timing Chart



Remark Hi-Z (High impedance)

Figure 3-2. Examples of V<sub>B</sub> pin connection

- (a) When the negative voltage level of the gate output is set to V<sub>SS3</sub>
- (b) When the negative voltage level of the gate output is switched between V<sub>SS2</sub> and V<sub>SS3</sub>



## 4. COMMAND

### 4.1 Command List

								Data bit									
7	6	5	4	3	2	1	0	Rn	Register	D7	D6	D5	D4	D3	D2	D1	D0
0	0	0	1	1	0	0	0	R24	DC/DC operation setting		RGONR	VS4ON	VS3ON	VS2ON	VD2ON	VD1ON	DCON
0	0	0	1	1	0	0	1	R25	DC/DC step setting				VRSEL2	VRSEL1	VRSEL0	VMS	VCD2
0	0	0	1	1	0	1	0	R26	DC/DC oscillation setting		FUP	CLS1	CLS0	FS3	FS2	FS1	FS0
0	0	0	1	1	0	1	1	R27	Regulator output setting		ACS1	ACS0	EXRV	VSEL2	VSEL1	VSEL0	RGON
0	0	0	1	1	1	0	0	R28	LPM setting		LACS1	LACS0	LFS3	LFS2	LFS1	LFS0	LPM
0	0	0	1	1	1	0	1	R29	Gate scan setting			OE2SEL	OE1SEL	STVSEL	SCN2	SCN1	SCN0
0	0	0	1	1	1	1	0	R30	Gate mode setting				COMHI	COMSEL	COMON	NLINE2	NLINE1
0	0	0	1	1	1	1	1	R31	Common amplitude setting	DA7	DA6	DA5	DA4	DA3	DA2	DA1	DA0
0	0	1	0	0	0	0	0	R32	Common center setting	CDA7	CDA6	CDA5	CDA4	CDA3	CDA2	CDA1	CDA0
0	0	1	0	0	0	0	1	R33	DC/DC power on setting			PONM	PON	DUPF1	DUPF0	PUPT1	PUPT0
0	0	1	0	0	0	1	0	R34	Reset								RES

### 4.2 Command Description

Reset the internal data at power application by inputting a low level to the /GRESET pin.

(1/5)

Resistor	Bit	Symbol	Reset	Function	Description
R24	D0	DCON	0	DC/DC converter control	Control ON/OFF of DC/DC converter. <DCON = 0> DC/DC converter OFF <DCON = 1> DC/DC converter ON
	D1	VD1ON	0	VDD1 boost control	Control ON/OFF of VDD1 boost. <VD1ON = 0> VDD1 boost OFF <VD1ON = 1> VDD1 boost ON
	D2	VD2ON	0	VDD2 boost control	Control VDD2 boost ON/OFF. <VD2ON = 0> VDD2 boost OFF <VD2ON = 1> VDD2 boost ON
	D3	VS2ON	0	VSS2 boost control	Control VSS2 boost ON/OFF. <VS2ON = 0> VSS2 boost OFF <VS2ON = 1> VSS2 boost ON
	D4	VS3ON	0	VSS3 boost control	Control VSS3 boost ON/OFF. <VS3ON = 0> VSS3 boost OFF <VS3ON = 1> VSS3 boost ON
	D5	VS4ON	0	VSS4 boost control	Control VSS4 boost ON/OFF. <VS4ON = 0> VSS4 boost OFF <VS4ON = 1> VSS4 boost ON
	D6	RGONR	0	Vr regulator control	Control ON/OFF of Vr regulator. <RGONR = 0> Vr regulator OFF <RGONR = 1> Vr regulator ON



(2/5)

Resistor	Bit	Symbol	Reset	Function	Description
R25	D0	VCD2	0	VDD2 boost selection	Select the number of VDD2 boost step (x2/x3). <VCD2 = 0> VDD2 = VDC x 2 <VCD2 = 1> VDD2 = VDC x 3
	D1	VMS	1	VDD2 boost mode selection	Select VDD2 boost mode. <VMS = 0> VDD2 = Single boost mode <VMS = 1> VDD2 = Dual boost mode
	D2	VRSEL0	1	VR regulator output voltage selection	Select output voltage of VR regulator. When IFSEL = 1, VR is fixed to 5 V. <VRSEL0 = 0, VRSEL1 = 0, VRSEL2 = 0> VR = 3 V <VRSEL0 = 1, VRSEL1 = 0, VRSEL2 = 0> VR = 3.5 V <VRSEL0 = 0, VRSEL1 = 1, VRSEL2 = 0> VR = 4 V <VRSEL0 = 1, VRSEL1 = 1, VRSEL2 = 0> VR = 4.5 V <VRSEL0 = 0, VRSEL1 = 0, VRSEL2 = 1> VR = 4.75 V <VRSEL0 = 1, VRSEL1 = 0, VRSEL2 = 1> VR = 5 V <VRSEL0 = 0, VRSEL1 = 1, VRSEL2 = 1> VR = 5.25 V <VRSEL0 = 1, VRSEL1 = 1, VRSEL2 = 1> VR = 5.5 V
	D3	VRSEL1	0		
	D4	VRSEL2	1		
R26	D0	FS0	1	VDD2, VSS4 boost frequency selection in scan mode	Select VDD2, VSS4 boost frequency in scan mode. When IFSEL = 1, FS1 is fixed to 0. <FS0 = 0, FS1 = 0> fosc/2 <FS0 = 1, FS1 = 0> fosc/4 <FS0 = 0, FS1 = 1> fosc/8 <FS0 = 1, FS1 = 1> fosc/16
	D1	FS1	0		
	D2	FS2	1	VDD1, VSS2, VSS3 boost frequency selection in scan mode	Select VDD1, VSS2, VSS3 boost frequency in scan mode. When IFSEL = 1, FS3 is fixed to 0. <FS2 = 0, FS3 = 0> fosc/2 <FS2 = 1, FS3 = 0> fosc/4 <FS2 = 0, FS3 = 1> fosc/8 <FS2 = 1, FS3 = 1> fosc/16
	D3	FS3	0		
	D4	CLS0	1	DC/DC OSC frequency selection	Select oscillation frequency of OSC for DC/DC converter. When IFSEL = 1, CLS1 is fixed to 1. <CLS0 = 0, CLS1 = 0> fosc = 18 kHz, DCCLK: Open <CLS0 = 1, CLS1 = 0> fosc = 25 kHz, DCCLK: Open <CLS0 = 0, CLS1 = 1> fosc = 37 kHz, DCCLK: Open <CLS0 = 1, CLS1 = 1> External CK input mode
	D5	CLS1	0		
	D6	FUP	0	Switching of DC/DC OSC frequency	Select oscillation frequency of OSC for DC/DC converter. When IFSEL = 1, the frequency is fixed to fosc. <FUP = 0> fosc <FUP = 1> fosc x 2

(3/5)

Resistor	Bit	Symbol	Reset	Function	Description
R27	D0	RGON	0	Vs regulator control	Control ON/OFF of Vs regulator. <RGON = 0> Vs regulator OFF <RGON = 1> Vs regulator ON
	D1	VSEL0	1	Vs regulator output voltage selection	Select the output voltage of Vs regulator. VSEL0 = 0: Vs = 5 V, VSEL = 1: Vs = 4 V when IFSEL = 1. <VSEL0 = 0, VSEL1 = 0, VSEL2 = 0> Vs = 3 V <VSEL0 = 1, VSEL1 = 0, VSEL2 = 0> Vs = 3.5 V <VSEL0 = 0, VSEL1 = 1, VSEL2 = 0> Vs = 4 V <VSEL0 = 1, VSEL1 = 1, VSEL2 = 0> Vs = 4.5 V <VSEL0 = 0, VSEL1 = 0, VSEL2 = 1> Vs = 4.75 V <VSEL0 = 1, VSEL1 = 0, VSEL2 = 1> Vs = 5 V <VSEL0 = 0, VSEL1 = 1, VSEL2 = 1> Vs = 5.25 V <VSEL0 = 1, VSEL1 = 1, VSEL2 = 1> Vs = 5.5 V
	D2	VSEL1	0		
	D3	VSEL2	1		
	D4	EXRV	0	Vs regulator resistor selection	Select external resistor of Vs regulator. <EXRV = 0> Internal resistor mode <EXRV = 1> Connect external resistor to MVS and set any level of voltage
	D5	ACS0	0	Amp. current selection in scan mode	Select Amp. current of VR and Vs regulators in scan mode. When IFSEL = 1, ACS1 is fixed to 0. <ACS0 = 0, ACS1 = 0> Amp. current = 5 μA <ACS0 = 0, ACS1 = 1> Amp. current = 10 μA <ACS0 = 1, ACS1 = 0> Amp. current = 15 μA <ACS0 = 1, ACS1 = 1> Amp. current = 30 μA
	D6	ACS1	0		
R28	D0	LPM	0	Low power mode control	Control in low power mode. When IFSEL = 1, LPM is fixed to 0. <LPM = 0> Scan mode <LPM = 1> Low power mode
	D1	LFS0	0	VDD2, VSS4 boost frequency selection in low power mode	Select boost frequency of VDD2, VSS4 in low power mode. <LFS0 = 0, LFS1 = 0> fosc/8 <LFS0 = 1, LFS1 = 0> fosc/16 <LFS0 = 0, LFS1 = 1> fosc/32 <LFS0 = 1, LFS1 = 1> fosc/64
	D2	LFS1	0		
	D3	LFS2	0	VDD1, VSS2, VSS3 boost frequency selection in low power mode	Select boost frequency of VDD1, VSS2, VSS3 in low power mode. <LFS2 = 0, LFS3 = 0> fosc/8 <LFS2 = 1, LFS3 = 0> fosc/16 <LFS2 = 0, LFS3 = 1> fosc/32 <LFS2 = 1, LFS3 = 1> fosc/64
	D4	LFS3	0		
	D5	LACS0	0	Amp. current selection in low power mode	Select Amp. current in low power mode. <LACS0 = 0, LACS1 = 0> Amp. current = 1.25 μA <LACS0 = 0, LACS1 = 1> Amp. current = 2.5 μA <LACS0 = 1, LACS1 = 0> Amp. current = 5 μA <LACS0 = 1, LACS1 = 1> Amp. current = 7.5 μA
	D6	LACS1	0		

(4/5)

Resistor	Bit	Symbol	Reset	Function	Description
R29	D0	SCN0	1	Gate scan selection	Select scan order of gate scan. <SCN0 = 1, SCN1 = 1, SCN2 = 1> MODE1 <SCN0 = 1, SCN1 = 1, SCN2 = 0> MODE2 <SCN0 = 1, SCN1 = 0, SCN2 = 1> MODE3 <SCN0 = 1, SCN1 = 0, SCN2 = 0> MODE4 <SCN0 = 0, SCN1, SCN2 = X> MODE5
	D1	SCN1	1		
	D2	SCN2	1		
	D3	STVSEL	0	Start pulse input/output valid level selection	Select start pulse input/output valid level to STVR/STVL. But there is no pin to select start pulse input/output valid level. When IFSEL = H (When using control pins), low-fixed is valid. Refer to <b>4.3 Command Setting Values When IFSEL = H (When Using Control Pins)</b> . <STVSEL= 0> Low level is valid. <STVSEL= 1> High level is valid.
	D4	OE1SEL	0	OE1 valid level selection	Select valid level of OE1. But there is no pin to select valid level of OE1. When IFSEL = H (When using control pins), low-fixed is valid. Refer to <b>4.3 Command Setting Values When IFSEL = H (When Using Control Pins)</b> . <OE1SEL = 0> OE1 = Low, gate output OFF <OE1SEL = 1> OE1 = High, gate output OFF
	D5	OE2SEL	0	OE2 valid level selection	Select valid level of OE2. There is no pin to select valid level of OE2. When IFSEL = H (When using control pins), low-fixed is valid. Refer to <b>4.3 Command Setting Values When IFSEL = H (When Using Control Pins)</b> . <OE2SEL = 0> OE2 = Low, gate output ON <OE2SEL = 1> OE2 = High, gate output ON
R30	D0	NLINE1	1	Gate mode selection	Select 1-line skip, 2-line skip or N frame inversion of a gate scan. When IFSEL = 1, this is fixed to normal mode. <NLINE1 = 1, NLINE2 = 1> Normal mode <NLINE1 = 1, NLINE2 = 0> 1-line skip mode <NLINE1 = 0, NLINE2 = 1> 2-line skip mode <NLINE1 = 0, NLINE2 = 0> N frame inversion
	D1	NLINE2	1		
	D2	COMON	0	COM output control	Control ON/OFF of COM output. When IFSEL = 1, COMON is fixed to 0. <COMON = 0> COM_AMP, COM output OFF <COMON = 1> COM_AMP, COM output ON
	D3	COMSEL	0	VCOM center input selection	Select VCOM center voltage input. <COMSEL = 0> Internal D/A is valid. <COMSEL = 1> VCOMIN input voltage is valid.
	D4	COMHI	0	VCOM output selection	Select VCOM output. <COMHI = 0> VCOM = Hi-Z <COMHI = 1> VCOM = Output

(5/5)

Resistor	Bit	Symbol	Reset	Function	Description
R31	D <sub>0</sub> to D <sub>7</sub>	DA <sub>0</sub> to DA <sub>7</sub>	0	COM amplitude control	Control COM output amplitude using 8-bit D/A.
R32	D <sub>0</sub> to D <sub>7</sub>	CDA <sub>0</sub> to CDA <sub>7</sub>	0	COM center level control	Control COM output center level using 8-bit D/A.
R33	D <sub>0</sub>	PUPT0	0	Setting of DC/DC converter power on time	This pin sets the ON time of V <sub>DD1</sub> and V <sub>DD2</sub> , V <sub>SS2</sub> to V <sub>SS4</sub> , and RGON when the DC/DC converter is started up. This setting is valid only when PONM = 1. When IFSEL = 1, PUPT1 is fixed to 0.
	D <sub>1</sub>	PUPT1	1		
	D <sub>2</sub>	DUPF0	1	Setting of DC/DC converter power on operating frequency	This pin sets the DC/DC operating frequency when the DC/DC converter is started up. When IFSEL = 1, DUPF1 is fixed to 0. <DUPF0 = 0, DUPF1 = 0> fosc/8 <DUPF0 = 1, DUPF1 = 0> fosc/16 <DUPF0 = 0, DUPF1 = 1> fosc/2 <DUPF0 = 1, DUPF1 = 1> fosc/4
	D <sub>3</sub>	DUPF1	0		
	D <sub>4</sub>	PON	0	Switching DC/DC converter startup operating frequency	This pin selects the V <sub>DD1</sub> , V <sub>DD2</sub> , V <sub>SS2</sub> to V <sub>SS4</sub> rising operating frequency when the DC/DC converter is started up. This setting is valid only when PONM = 1. <PON = 0> Normal operation <PON = 1> Power on operation startup operation
	D <sub>5</sub>	PONM	1	DC/DC operation startup operating selection	Select internal/external sequence of DC/DC converter power on operation. <PONM = 0> External sequence <PONM = 1> Internal sequence
R34	D <sub>0</sub>	RES	–	Command reset	This is the command reset function. A command reset must always be executed after power application. All contents of registers are initialized.  This bit is automatically cleared after command reset execution (RES = 1). It is therefore not necessary to set this bit to 0 again by software (to select normal operation). Also, because this bit changes from 1 to 0 very quickly following a command reset, it is not necessary to leave any time before setting the next command after setting a command reset.  <RES = 0> Normal operation <RES = 1> Command reset

4.3 Command Setting Values When IFSEL = H (When Using Control Pins)

(1/2)

Register	Bit	Symbol	Setting value	Conditions
R24	D0	DCON	–	DCON control pin is valid.
	D1	VD1ON	1	<VD1ON = 1> V <sub>DD1</sub> boost ON
	D2	VD2ON	1	<VD2ON = 1> V <sub>DD2</sub> boost ON
	D3	VS2ON	1	<VS2ON = 1> V <sub>SS2</sub> boost ON
	D4	VS3ON	1	<VS3ON = 1> V <sub>SS3</sub> boost ON
	D5	VS4ON	0	<VS4ON = 0> V <sub>SS4</sub> boost OFF
	D6	RGONR	–	RGONR control pin is valid.
R25	D0	VCD2	–	VCD2 control pin is valid.
	D1	VMS	–	VMS control pin is valid.
	D2	VRSEL0	1	<VRSEL0 = 1, VRSEL1 = 0, VRSEL2 = 1 > V <sub>R</sub> = 5 V
	D3	VRSEL1	0	
	D4	VRSEL2	1	
R26	D0	FS0	–	FS0 control pin is valid.
	D1	FS1	0	<FS0 = 0> fosc/2, <FS0 = 1> fosc/4
	D2	FS2	–	FS2 control pin is valid.
	D3	FS3	0	<FS2 = 0> fosc/2, <FS2 = 1> fosc/4
	D4	CLS0	–	CLS1 control pin is valid.
	D5	CLS1	1	<CLS0 = 0> fosc = 37 kHz, <CLS0 = 1> External
	D6	FUP	0	<FUP = 0> fosc
R27	D0	RGON	–	RGON control pin is valid.
	D1	VSEL0	–	VSEL control pin is valid.
	D2	VSEL1	–	<VSEL = 0> V <sub>s</sub> = 5 V
	D3	VSEL2	–	<VSEL = 1> V <sub>s</sub> = 4 V
	D4	EXRV	–	EXRV control pin is valid.
	D5	ACS0	–	ACS0 control pin is valid.
	D6	ACS1	0	<ACS0 = 0> Current = 5 μA, <ACS0 = 1> Current = 15 μA
R28	D0	LPM	0	<LPM = 0> Scan mode
	D1, D2	LFS0, LFS1	0,1	<LFS0 = 0, LFS1 = 1> fosc/32
	D3, D4	LFS2, LFS3	0,1	<LFS2 = 0, LFS3 = 1> fosc/32
	D5, D6	LACS0, LACS1	0,1	<LACS0 = 0, LACS1 = 1> Amp. current = 2.5 μA
R29	D0	SCN0	–	SCN0 control pin is valid
	D1	SCN1	–	SCN1 control pin is valid
	D2	SCN2	–	SCN2 control pin is valid
	D3	STVSEL	0	<STVSEL = 0> low-level is valid
	D4	OE1SEL	0	<OE1SEL = 0> OE1 = low-level, gate output OFF
	D5	OE2SEL	0	<OE2SEL = 0> OE2 = low-level, gate output ON

**Remark** When IFSEL = H (when using the control pins), the GCS, GCL, and GDA pins are pulled down to low level, so be sure to leave these pins open.

When IFSEL = L (when using the serial interface), DCON, RGONR, VCD2, VMS, FS0, FS2, CLS0, RGON, VSEL, EXRV, ACS0, SCN0, SCN1, SCN2, PUPT0, DUPF0 pins should be left open.

(2/2)

Register	Bit	Symbol	Setting value	Conditions
R30	D0	NLINE1	1	<NLINE = 1, NLINE2 = 1> normal mode
	D1	NLINE2	1	
	D2	COMON	0	<COMON = 0> COM_AMP, COM output OFF
R31	D0 to D7	DA0 to DA7	0	<DA0 to DA7> 0
R32	D0 to D7	CDA0 to CDA7	0	<CDA0 to CDA7> 0
R33	D0	PUPT0	–	PUPT0 control pin is valid
	D1	PUPT1	0	<PUPT0 = 0> RGONR = 2048/fosc
				<PUPT0 = 1> RGONR = 256/fosc
	D2	DUPF0	–	DUPF0 control pin is valid
	D3	DUPF1	0	<DUPF0 = 0> fosc/8
				<DUPF0 = 1> fosc/16
D4	PON	1	<PON = 1> Internal sequence	
D5	PONM	1	<PONM = 1> Internal sequence	
R34	D0	RES	0	<RES = 0> Normal operation

**Remark** When IFSEL = H (when using the control pins), the GCS, GCL, and GDA pins are pulled down to low level, so be sure to leave these pins open.  
 When IFSEL = L (when using the serial interface), DCON, RGONR, VCD2, VMS, FS0, FS2, CLS0, RGON, VSEL, EXRV, ACS0, SCN0, SCN1, SCN2, PUPT0, DUPF0 pins should be left open.

5. MODE DESCRIPTION

5.1 Output Mode and Gate Scan Selection

Normal mode: NLINE1 =1, NLINE2 = 1

Scan MODE	R,/L	Scan direction	Dummy output	Cascade output
MODE1	H	1→240, 241	241	240
	L	241→2,1	1	2
MODE2	H	1→121 • 241→123, 122	122	123
	L	122→241 • 121→2, 1	1	2
MODE3	H	1→161 • 241→163, 162	162	163
	L	162→241 • 161→2, 1	1	2
MODE4	H	1→201, 241→203, 202	202	203
	L	202→241 • 201→2, 1	1	2
MODE5	H	1, 241, 2, 240, 3, 239.....118, 124, 119, 123, 120, 122, 121	121	122
	L	121, 122, 120, 123, 119, 124.....4, 239, 3, 240, 2, 241, 1	1	241

1-line step mode: NLINE1 =1, NLINE2 = 0

Scan MODE	R,/L	Scan direction	Dummy output	Cascade output
MODE1	H	1, 3, 5...235, 237, 239, 241 • 2, 4, 6...236, 238, 240	241	240
	L	241, 239, 237...7, 5, 3, 1 • 240, 238, 236...6, 4, 2	1	2
MODE2	H	1, 3, 5...117, 119, 121 • 240, 238, 236...128, 126, 124, 122, • 2, 4, 6...116, 118, 120 • 241, 239, 237...127, 125, 123	122	123
	L	122, 124, 126...236, 238, 240 • 121, 119, 117...7, 5, 3, 1, • 123, 125, 127...237, 239, 241 • 120, 118, 116...6, 4, 2	1	2
MODE3	H	1, 3, 5...157, 159, 161 • 240, 238, 236...168, 166, 164, 162 • 2, 4, 6...156, 158, 160 • 241, 239, 237...167, 165, 163	162	163
	L	162, 164, 166...236, 238, 240 • 161, 159, 157...7, 5, 3, 1, • 163, 165, 167...237, 239, 241 • 160, 158, 156...6, 4, 2	1	2
MODE4	H	1, 3, 5...197, 199, 201 • 240, 238, 236...208, 206, 204, 202, • 2, 4, 6...196, 198, 200 • 241, 239, 237...207, 205, 203	202	203
	L	202, 204, 206...236, 238, 240 • 201, 199, 197...7, 5, 3, 1, • 203, 205, 207...237, 239, 241 • 200, 198, 196...6, 4, 2	1	2

**2-line step mode: NLINE1 = 0, NLINE2 = 1**

Scan MODE	R,/L	Scan direction	Dummy output	Cascade output
MODE1	H	1, 4, 7...232, 235, 238, 241 • 2, 5, 8...233, 236, 239 • 3, 6, 9...234, 237, 240	241	240
	L	241, 238, 235...10, 7, 4, 1 • 240, 237, 234...9, 6, 3 • 239, 236, 233...8, 5, 2	1	2
MODE2	H	1, 4, 7...115, 118, 121 • 239, 236, 233...131, 128, 125, 122, • 2, 5, 8...113, 116, 119 • 241, 238, 235...130, 127, 124 • 3, 6, 9...114, 117, 120 • 240, 237, 234...129, 126, 123	122	123
	L	122, 125, 128...233, 236, 239 • 121, 118, 115...10, 7, 4, 1, • 123, 126, 129...234, 237, 240 • 120, 117, 114...9, 6, 3 • 124, 127, 130...235, 238, 241 • 119, 116, 113...8, 5, 2	1	2
MODE3	H	1, 4, 7...154, 157, 160 • 240, 237, 234...171, 168, 165, 162, • 2, 5, 8...155, 158, 161 • 239, 236, 233...170, 167, 164 • 3, 6, 9...153, 156, 159 • 241, 238, 235...169, 166, 163	162	163
	L	162, 165, 168...234, 237, 240 • 160, 157, 154...10, 7, 4, 1, • 163, 166, 169...235, 238, 241 • 159, 156, 153...9, 6, 3 • 164, 167, 170...233, 236, 239 • 161, 158, 155...8, 5, 2	1	2
MODE4	H	1, 4, 7...193, 196, 199 • 241, 238, 235...211, 208, 205, 202, • 2, 5, 8...194, 197, 200 • 240, 237, 234...210, 207, 204 • 3, 6, 9...195, 198, 201 • 239, 236, 233...209, 206, 203	202	203
	L	202, 205, 208...235, 238, 241 • 199, 196, 193...10, 7, 4, 1, • 203, 206, 209...2337, 236, 239 • 201, 198, 195...9, 6, 3 • 204, 207, 210...234, 240, 200 • 197, 194...8, 5, 2	1	2

**N-frame reverse: NLINE1 = 0, NLINE2 = 0**

Scan MODE	R,/L	FMR	Scan direction	Dummy output	Cascade output
MODE1	H	1	1→240, 241	241	240
		0	241→2, 1 (reverse operation)	241	2
	L	1	241→2, 1	1	2
		0	1→240, 241 (reverse operation)	1	240

**5.2 DC/DC OSC Frequency Selection**

CLS0	CLS1	OSC oscillation frequency for DC/DC converter	DCCLK
0	0	fosc = 18 kHz	Open
1	0	fosc = 25 kHz	Open
0	1	fosc = 37 kHz	Open
1	1	fosc = External CK	External CK input



**5.3 DC/DC Converter Control**

DCON	VD1ON	VD2ON	VS2ON	VS3ON	VS4ON	State of VDD1, VDD2, VSS2, VSS3, VSS4
0	x	x	x	x	x	VDD1, VDD2, VSS2, VSS3, VSS4: OFF
1	0	–	–	–	–	VDD1: OFF
1	1	–	–	–	–	VDD1: ON
1	–	0	–	–	–	VDD2: OFF
1	–	1	–	–	–	VDD2: ON
1	–	–	0	–	–	VSS2: OFF
1	–	–	1	–	–	VSS2: ON
1	–	–	–	0	–	VSS3: OFF
1	–	–	–	1	–	VSS3: ON
1	–	–	–	–	0	VSS4: OFF
1	–	–	–	–	1	VSS4: ON

**Remark** x: 0 or 1

**5.4 VDD2 Boost Selection**

VCD2	VDD2
0	V <sub>DC</sub> x 2 boost
1	V <sub>DC</sub> x 3 boost

**5.5 Division Ratio Selection of the DC/DC Converter at Power on**

PONM	PON	DUPF0	DUPF1	Division ratio of the DC/DC converter OSC frequency
1	x	0	0	Internal sequence: OSC = fosc/8
1	x	1	0	Internal sequence: OSC = fosc/16
1	x	0	1	Internal sequence: OSC = fosc/2
1	x	1	1	Internal sequence: OSC = fosc/4
0	1	0	0	External sequence: OSC = fosc/8
0	1	1	0	External sequence: OSC = fosc/16
0	1	0	1	External sequence: OSC = fosc/2
0	1	1	1	External sequence: OSC = fosc/4
0	0	x	x	Normal mode

**Remark** x: 0 or 1

**5.6 DC/DC Converter Power on Time Selection**

PONM	PON	PUPT0	PUPT1	VD2ON	RGONR	VS2ON to VS4ON	VD1ON	
1	x	0	0	16/fosc	2048/fosc	1.5 x 2048/fosc	2.5 x 2048/fosc	Internal sequence
1	x	1	0	16/fosc	256/fosc	1.5 x 256/fosc	2.5 x 256/fosc	Internal sequence
1	x	0	1	16/fosc	512/fosc	1.5 x 512/fosc	2.5 x 512/fosc	Internal sequence
1	x	1	1	16/fosc	1024/fosc	1.5 x 1024/fosc	2.5 x 1024/fosc	Internal sequence
0	1	x	x	External input	External input	External input	External input	External sequence
0	0	x	x					Normal mode

**Remark** x: 0 or 1

5.7 Division Ratio Selection of the DC/DC Converter OSC Frequency

LPM	FS0	FS1	FS2	FS3	LFS0	LFS1	LFS2	LFS3	Division ratio of the DC/DC converter OSC frequency
0	0	0	x	x	x	x	x	x	VDD2, VSS4: fosc/2
0	1	0	x	x	x	x	x	x	VDD2, VSS4: fosc/4
0	0	1	x	x	x	x	x	x	VDD2, VSS4: fosc/8
0	1	1	x	x	x	x	x	x	VDD2, VSS4: fosc/16
0	x	x	0	0	x	x	x	x	VDD1, VSS2, VSS3: fosc/2
0	x	x	1	0	x	x	x	x	VDD1, VSS2, VSS3: fosc/4
0	x	x	0	1	x	x	x	x	VDD1, VSS2, VSS3: fosc/8
0	x	x	1	1	x	x	x	x	VDD1, VSS2, VSS3: fosc/16
1	x	x	x	x	0	0	x	x	VDD2, VSS4: fosc/8
1	x	x	x	x	1	0	x	x	VDD2, VSS4: fosc/16
1	x	x	x	x	0	1	x	x	VDD2, VSS4: fosc/32
1	x	x	x	x	1	1	x	x	VDD2, VSS4: fosc/64
1	x	x	x	x	x	x	0	0	VDD1, VSS2, VSS3: fosc/8
1	x	x	x	x	x	x	0	0	VDD1, VSS2, VSS3: fosc/16
1	x	x	x	x	x	x	1	1	VDD1, VSS2, VSS3: fosc/32
1	x	x	x	x	x	x	1	1	VDD1, VSS2, VSS3: fosc/64

Remark x: 0 or 1

5.8 Amp. Current Selection

RGON, RGONR	LPM	ACS0	ACS1	LACS0	LACS1	V <sub>R</sub> condition	V <sub>S</sub> condition	State of Circuit Current
0	x	x	x	x	x	VSS1	VSS1	Amp, CS Power OFF
1	0	0	0	x	x	Output	Output	Amp. current = 5 μA
1	0	0	1	x	x	Output	Output	Amp. current = 10 μA
1	0	1	0	x	x	Output	Output	Amp. current = 15 μA
1	0	1	1	x	x	Output	Output	Amp. current = 30 μA
1	1	x	x	0	0	Output	Output	Amp. current = 1.25 μA
1	1	x	x	0	1	Output	Output	Amp. current = 2.5 μA
1	1	x	x	1	0	Output	Output	Amp. current = 5 μA
1	1	x	x	1	1	Output	Output	Amp. current = 7.5 μA

Remark x: 0 or 1

5.9 V<sub>R</sub> Regulator Selection Output

Register control

RGONR	VRSEL0	VRSEL1	VRSEL2	V <sub>R</sub>
0	x	x	x	V <sub>R</sub> regulator OFF (V <sub>R</sub> = VSS1)
1	0	0	0	3 V : Internal resistor connection
1	1	0	0	3.5 V : Internal resistor connection
1	0	1	0	4 V : Internal resistor connection
1	1	1	0	4.5 V : Internal resistor connection
1	0	0	1	4.75 V : Internal resistor connection
1	1	0	1	5 V : Internal resistor connection
1	0	1	1	5.25 V : Internal resistor connection
1	1	1	1	5.5 V : Internal resistor connection

Remark x: 0 or 1

**Pin control**

RGONR	V <sub>R</sub>
0	V <sub>R</sub> regulator OFF (V <sub>R</sub> = V <sub>SS1</sub> )
1	5 V: Internal resistor connection

**5.10 V<sub>s</sub> Regulator Selection Output**

**Register control**

RGON	EXRV	VSEL0	VSEL1	VSEL2	MVS condition	V <sub>s</sub>
0	x	x	x	x	Hi-Z	V <sub>s</sub> regulator OFF (V <sub>s</sub> = V <sub>SS1</sub> )
1	1	x	x	x	Amp.-input	External resistor connection
1	0	0	0	0	Hi-Z	3 V : Internal resistor connection
1	0	1	0	0	Hi-Z	3.5 V : Internal resistor connection
1	0	0	1	0	Hi-Z	4 V : Internal resistor connection
1	0	1	1	0	Hi-Z	4.5 V : Internal resistor connection
1	0	0	0	1	Hi-Z	4.75 V : Internal resistor connection
1	0	1	0	1	Hi-Z	5 V : Internal resistor connection
1	0	0	1	1	Hi-Z	5.25 V : Internal resistor connection
1	0	1	1	1	Hi-Z	5.5 V : Internal resistor connection

**Remark** x: 0 or 1

**Pin control**

RGON	VSEL	V <sub>R</sub>
0	x	V <sub>s</sub> regulator OFF (V <sub>s</sub> = V <sub>SS1</sub> )
1	0	5 V : Internal resistor connection
1	1	4 V : Internal resistor connection

**Remark** x: 0 or 1

**5.11 Control of VM Output Control, VCOM Output**

COMON	COMHI	DAC, COM_AMP	VCOM
0	x	OFF	Hi-Z
1	0	ON	Hi-Z
1	1	ON	Output

**Remark** x: 0 or 1

★ 5.12 VCOM Output Frequency Adjustment

This is used to adjust the output amplitude of VCOM output. The VCOM output amplitude voltage ( $V_{COMpp}$ ) can be adjusted as shown by the expression below using power supply control register 9 (R31), which is the output voltage of a D/A converter circuit for which  $V_s$  is the reference potential.

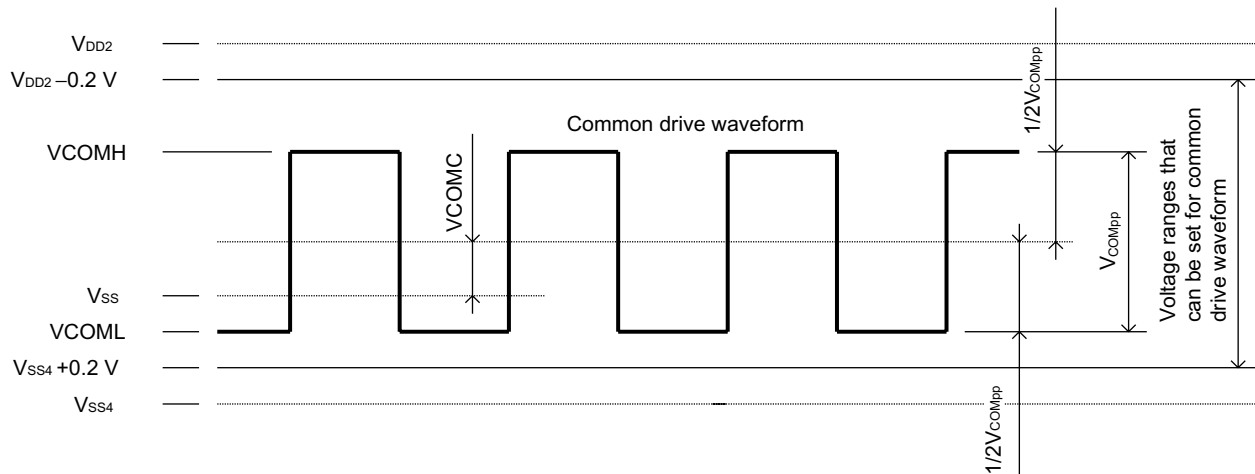
$$V_{COMpp} = V_s \times 2 \times \{4/5 \times (DA_{R31}/255)\}$$

**Remark**  $DA_{R31}$ : R31 setting values

The values of R31 that can be set are determined by the relationship of booster voltages  $V_{DD2}$  and  $V_{SS4}$  to the potential level of the actual common drive waveform after VCOM center adjustment.

Set the VCOM output amplitude voltage according to R31, the VCOM output center potential voltage setting level according to power supply control register 10 (R32), or the VCOM output center potential input from VCOMIN in the relationships shown in the figure below.

**Figure 5-1. Voltage Ranges that can be set for Common Drive Waveform**



<Conditions on common drive waveform voltage settings>

- $V_{COMpp} \geq 2V$
- $V_{COMH} \leq V_{DD2} - 0.2V$
- $V_{COML} \geq V_{SS4} + 0.2V$

**Remark**  $V_{COMH} = \frac{1}{2} V_{COMpp} + V_{COMC}$   
 $V_{COML} = \frac{1}{2} V_{COMpp} - V_{COMC}$   
 $V_{COMC}$ : R32 setting values [ $COMSEL(R30) = 0$ ] or VCOMIN input voltage level [ $COMSEL (R30) = 1$ ]

**VCOM output amplitude voltage (VCOMpp) adjustment and D/A converter setting values**

DA7	DA6	DA5	DA4	DA3	DA2	DA1	DA0	DAR31	VCOMpp (Vs = 5 V)
0	0	0	0	0	0	0	0	0	0.0000 V (Setting prohibited)
0	0	0	0	0	0	0	1	1	0.0314 V (Setting prohibited)
0	0	0	0	0	0	1	0	2	0.0627 V (Setting prohibited)
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
0	0	1	1	1	1	1	0	62	1.9451 V (Setting prohibited)
0	0	1	1	1	1	1	1	63	1.9765 V (Setting prohibited)
0	1	0	0	0	0	0	0	64	2.0078 V
0	1	0	0	0	0	0	1	65	2.0392 V
0	1	0	0	0	0	1	0	66	2.0706 V
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
1	1	1	1	1	1	0	1	253	7.9373 V
1	1	1	1	1	1	1	0	254	7.9686 V
1	1	1	1	1	1	1	1	255	8.0000 V

**Remark** The range in which the VCOM output amplitude can be varied is restricted by the output voltage of VDD2 and VSS4.

★ **5.13 VCOM Output Center Adjustment**

This is used to adjust the center potential level of VCOM output. The VCOM output center potential voltage (VCOMC) can be adjusted as shown by the expression below using power supply control register 9 (R32), which is the output voltage of a D/A converter circuit for which Vs is the reference potential.

$$V_{COMpp} = V_s \times \{4/5 \times (DAR_{32}/255)\}$$

**Remark** DAR32: R32 setting values

**VCOM output center potential voltage (VCOMC) and D/A converter setting values**

DA7	DA6	DA5	DA4	DA3	DA2	DA1	DA0	DAR31	VCOMC (Vs = 5 V)
0	0	0	0	0	0	0	0	0	0.0000 V
0	0	0	0	0	0	0	1	1	0.0157 V
0	0	0	0	0	0	1	0	2	0.0314 V
0	0	0	0	0	0	1	1	3	0.0471 V
0	0	0	0	0	1	0	0	4	0.0627 V
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.
1	1	1	1	1	1	0	1	253	3.9686 V
1	1	1	1	1	1	1	0	254	3.9843 V
1	1	1	1	1	1	1	1	255	4.0000 V

**Remark** The range in which the VCOM output center can be varied is restricted by the output voltage of VDD2 and VSS4.

The values of R32 that can be set are determined by the relationship of booster voltages  $V_{DD2}$  and  $V_{SS4}$  to the potential level of the actual common drive waveform due to VCOM output amplitude voltage ( $V_{COMpp}$ ) adjustment.

Refer to **5.12 VCOM Output Frequency Adjustment** for the relationship between the VCOM output center potential voltage according to R32 and the VCOM output amplitude voltage ( $V_{COMpp}$ ) according to power supply control register 9 (R31).

**5.14 VCOM Center Adjustment Selection**

The method of setting the center voltage of common drive waveform VCOM is selected according to the setting of COMSEL (R30).

When COMSEL is set to 1, directly input the VCOM center voltage to the VOMIN pin from outside the IC.

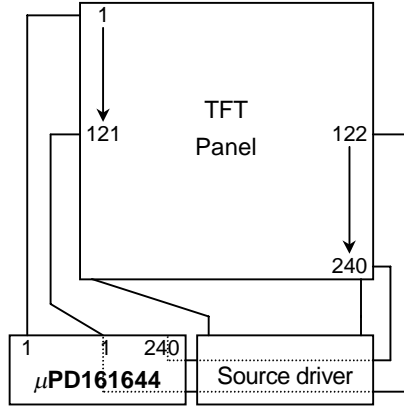
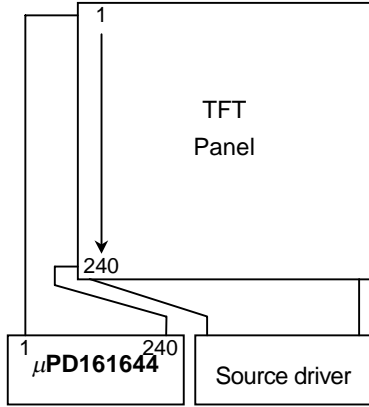
COMSEL	VCOM center adjustment
0	Internal D/A is valid (R31 setting is valid).
1	VCOMIN input voltage is valid.

6. PANNEL CONNECTION EXAMPLES

[MODE1]

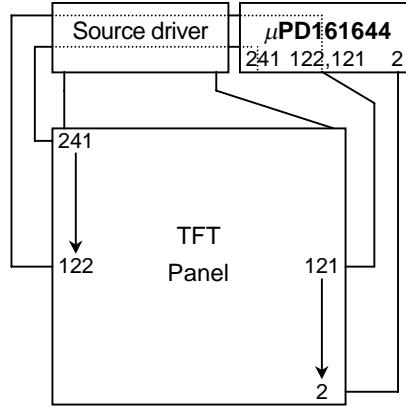
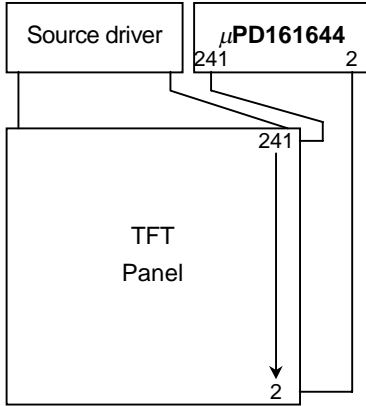
MODE1R (SCN0 = 1, SCN1 = 1, SCN2 = 1, R,/L = 1)

MODE1R (SCN0 = 1, SCN1 = 1, SCN2 = 1, R,/L = 1)



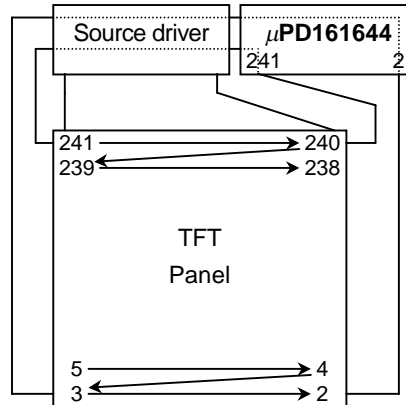
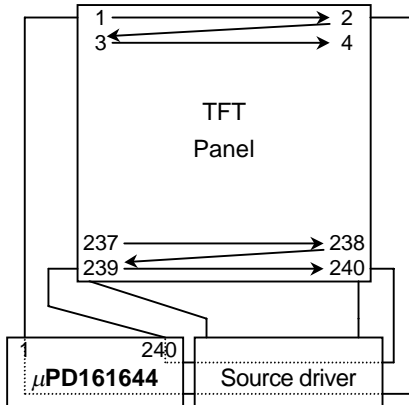
MODE1L (SCN0 = 1, SCN1 = 1, SCN2 = 1, R,/L = 0)

MODE1L (SCN0 = 1, SCN1 = 1, SCN2 = 1, R,/L = 0)



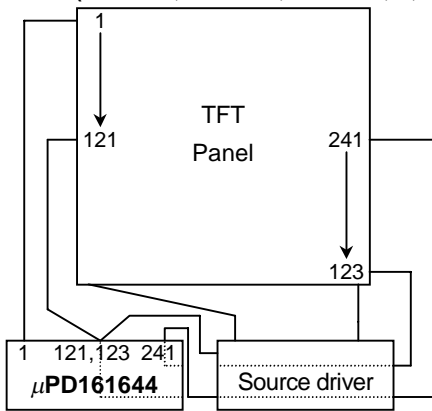
MODE1R (SCN0 = 1, SCN1 = 1, SCN2 = 1, R,/L = 1)

MODE1L (SCN0 = 1, SCN1 = 1, SCN2 = 1, R,/L = 0)

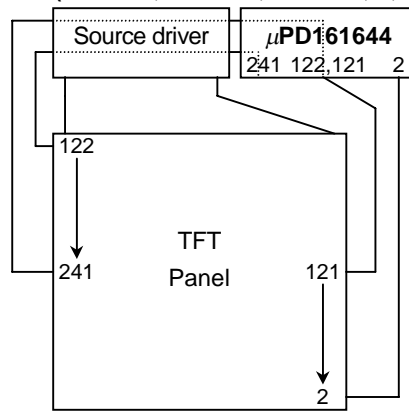


[MODE2]

MODE2R (SCN0 = 1, SCN1 = 1, SCN2 = 0, R,/L = 1)

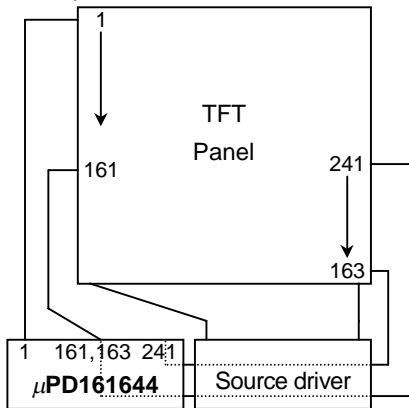


MODE2L (SCN0 = 1, SCN1 = 1, SCN2 = 0, R,/L = 0)

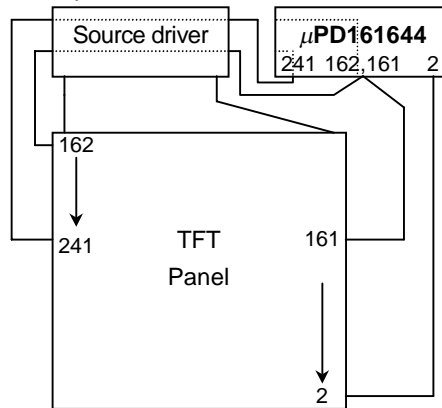


[MODE3]

MODE3R (SCN0 = 1, SCN1 = 0, SCN2 = 1, R,/L = 1)

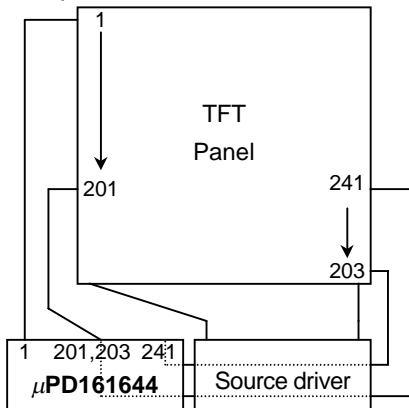


MODE3L (SCN0 = 1, SCN1 = 0, SCN2 = 1, R,/L = 0)

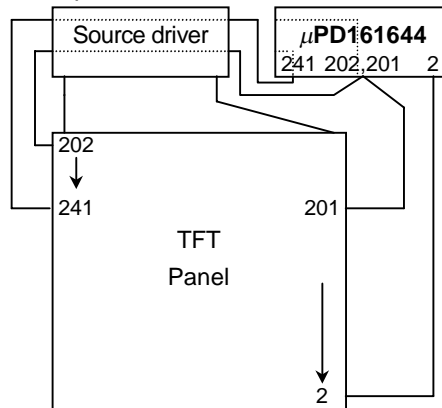


[MODE4]

MODE4R (SCN0 = 1, SCN1 = 0, SCN2 = 0, R,/L = 1)

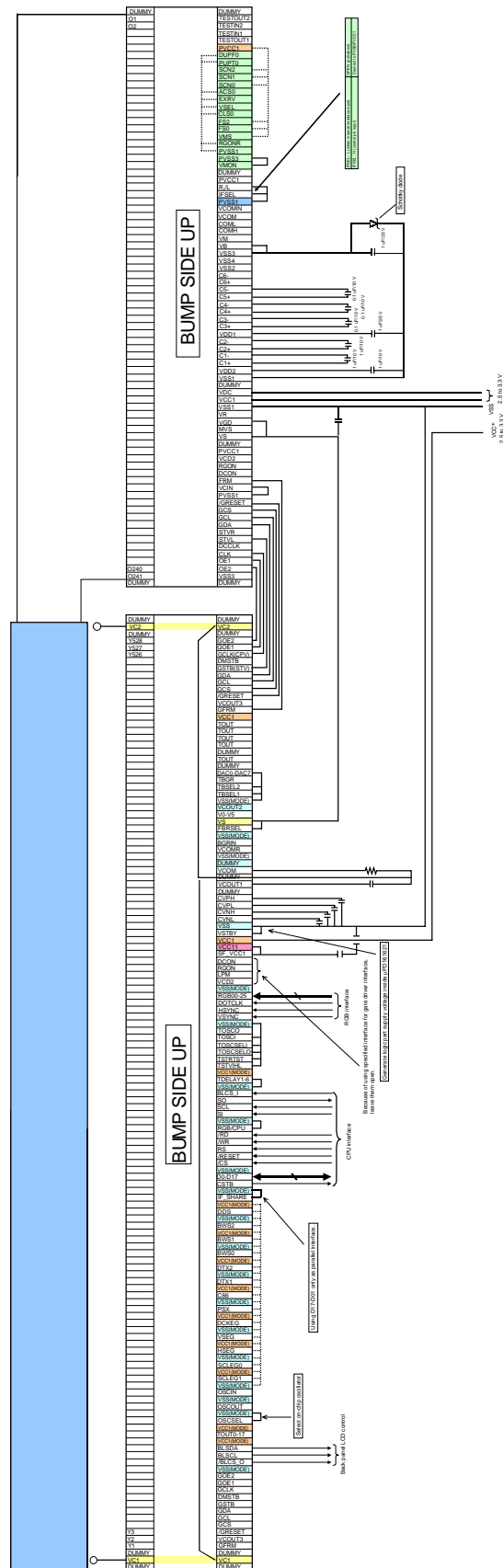


MODE4L (SCN0 = 1, SCN1 = 0, SCN2 = 0, R,/L = 0)





7. CONNECTION EXAMPLE WITH SOURCE DRIVER



**8. VALUE OF WIRING RESISTANCE TO EACH PIN**

The recommended wiring resistance values are shown below. The wiring resistance values affect the current capacity of the power supply, so be sure to design using values that do not exceed those recommended.

**Table 8-1. Recommended Wiring Resistor Values**

Pin name	Wiring Resistor Values (Ω)
VSS1	< 10
VCC1	< 10
VDC	< 10
Vs	< 10
VDD2	< 10
C1 <sup>+</sup>	< 10
C1 <sup>-</sup>	< 10
C2 <sup>+</sup>	< 10
C2 <sup>-</sup>	< 10
VDD1	< 50
VSS2	< 50
VSS3	< 50
VSS4	< 50
C3 <sup>+</sup>	< 50
C3 <sup>-</sup>	< 50
C4 <sup>+</sup>	< 50
C4 <sup>-</sup>	< 50
C5 <sup>+</sup>	< 50
C5 <sup>-</sup>	< 50
C6 <sup>+</sup>	< 50
C6 <sup>-</sup>	< 50

**9. RECOMMENDED CAPACITANCE VALUES OF EXTERNAL CAPACITOR**

The recommended capacitance values of the external capacitor are shown below. These values should be finally determined only after performing sufficient evaluation on the module.

**Table 9-1. Recommended Values of External Capacitor**

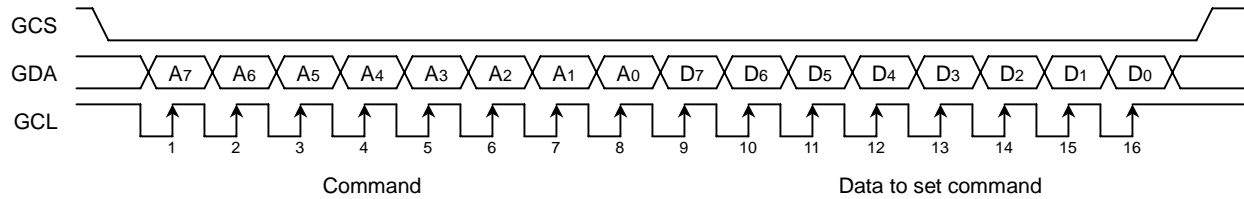
Pin name	Recommended value of capacitors (μF)	Withstanding voltage (V)
Vs	1 to 4.7	6.3 or more
VR	1 to 4.7	6.3 or more
VDD1	0.47 to 1	25 or more
VDD2	1 to 4.7	15 or more
VSS2	0.47 to 1	25 or more
VSS3	0.47 to 1	25 or more
VSS4	1 to 4.7	10 or more
COMH	1 to 4.7	6.3 or more
COML	1 to 4.7	6.3 or more
C1 <sup>+</sup> , C1 <sup>-</sup>	1 to 4.7	10 or more
C2 <sup>+</sup> , C1 <sup>-</sup>	1 to 4.7	10 or more
C3 <sup>+</sup> , C1 <sup>-</sup>	0.47 to 1	10 or more
C4 <sup>+</sup> , C1 <sup>-</sup>	0.47 to 1	10 or more
C5 <sup>+</sup> , C1 <sup>-</sup>	0.47 to 1	10 or more
C6 <sup>+</sup> , C1 <sup>-</sup>	1 to 4.7	10 or more

10. SERIAL INTERFACE

When the serial interface has been selected, if the chip is active (GCS = L), serial data input (GDA) and serial clock input (GCL) can be received. Serial data is read from D7 and then from D6 to D0 on the rising edge of the serial clock, via the serial input pin. This data is synchronized on the eighth serial clock's rising edge and is then converted to parallel data for processing.

The serial interface signal chart is shown below.

Figure 10-1. Serial Interface Signal Chart

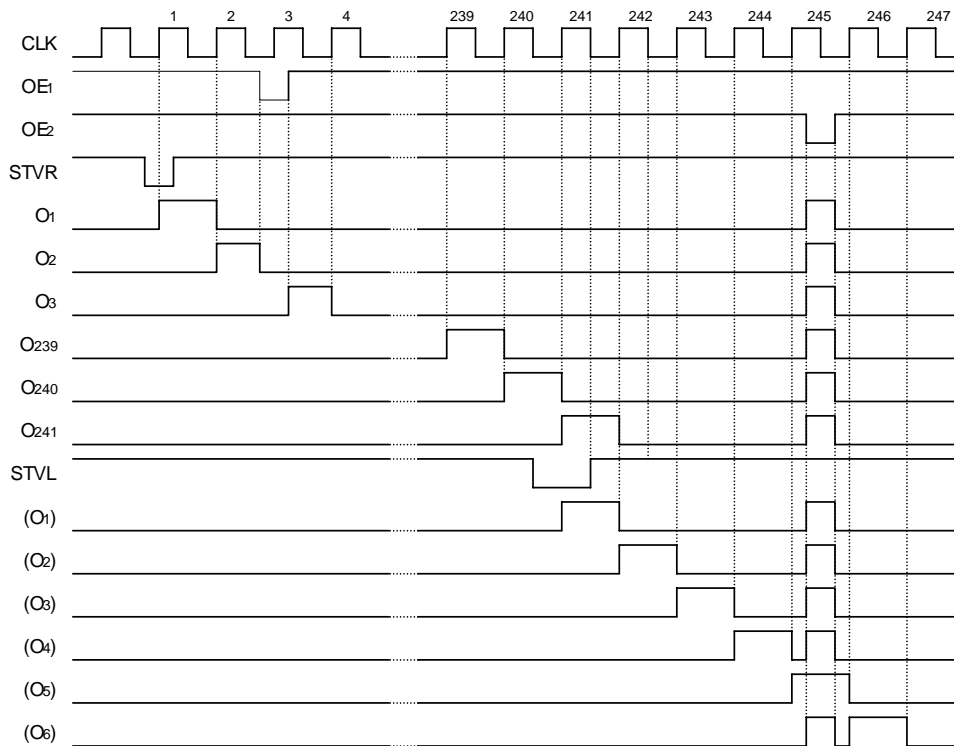


Note that odd bytes of data received after the reset command is input are recognized as commands, and even bytes of data are recognized as data values to be set to commands.

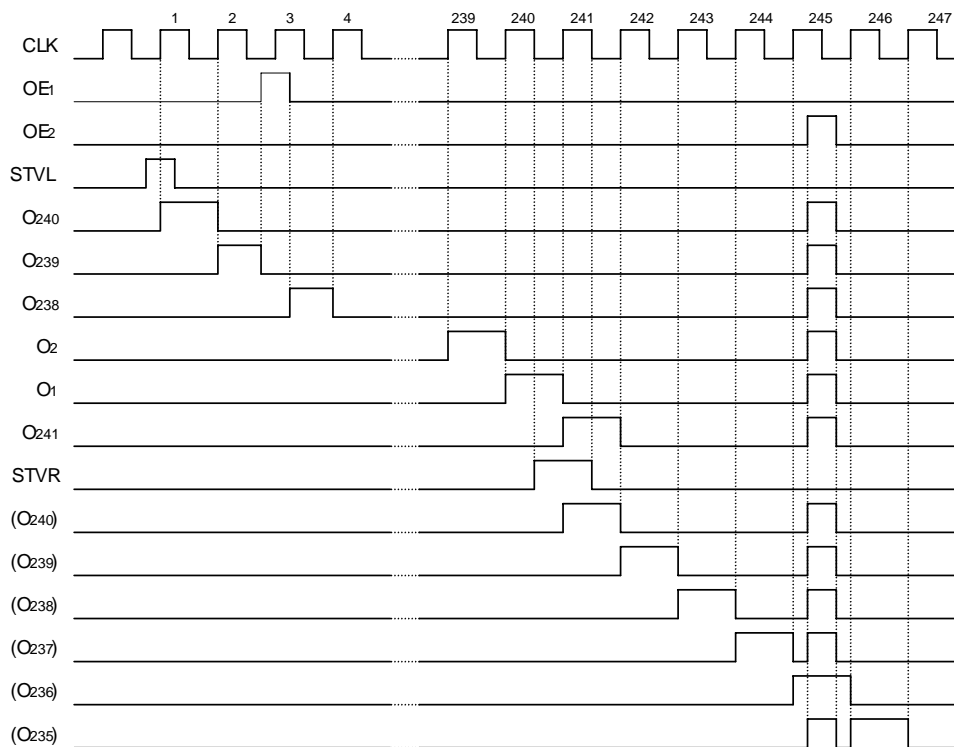
- Remarks 1.** The shift register and counter are reset to their initial values when the chip select signal is inactive. Do not set the chip select signal to inactive between transmission of an 8-bit command and transmission of the 8-bit data set for the command.
- 2.** When using GCL wiring, take care concerning the possible effects of terminating reflection and noise from external sources. We recommend checking operation with the actual device.

11. TIMING CHARTS (MODE1: SCN0 = 1, SCN1 = 1, SCN2 = 1)

R,/L = H, STVSEL = 0, OE1SEL = 0, OE2SEL = 0



R,/L = L, STVSEL = 1, OE1SEL = 1, OE2SEL = 1



12. POWER ON/OFF SEQUENCE

There are three ways to turn on the power of the μPD161644:

<When power supply is controlled by serial interface>

- Simple sequence
- Command control sequence

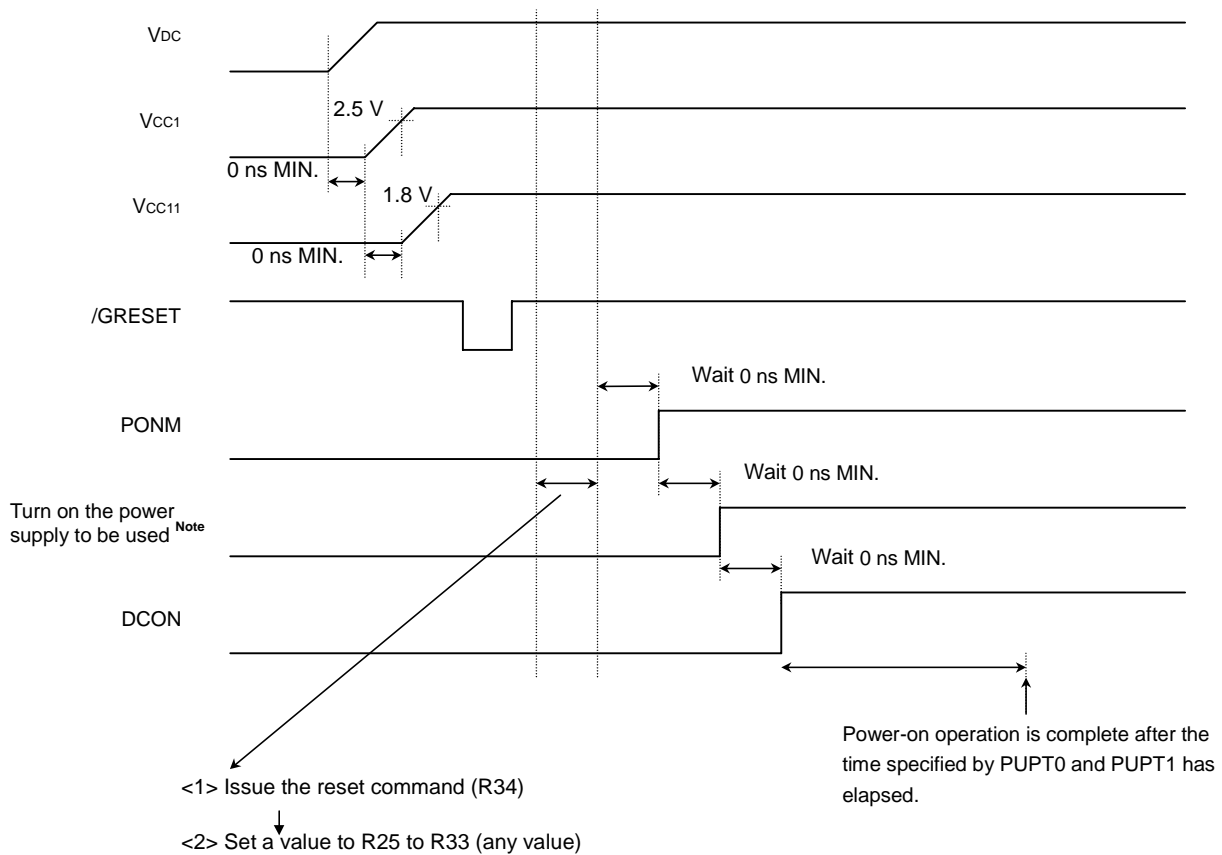
<When power supply is controlled by pin>

- Simple sequence

12.1 Power ON sequence

(1) Power supply control via serial interface (simple sequence)

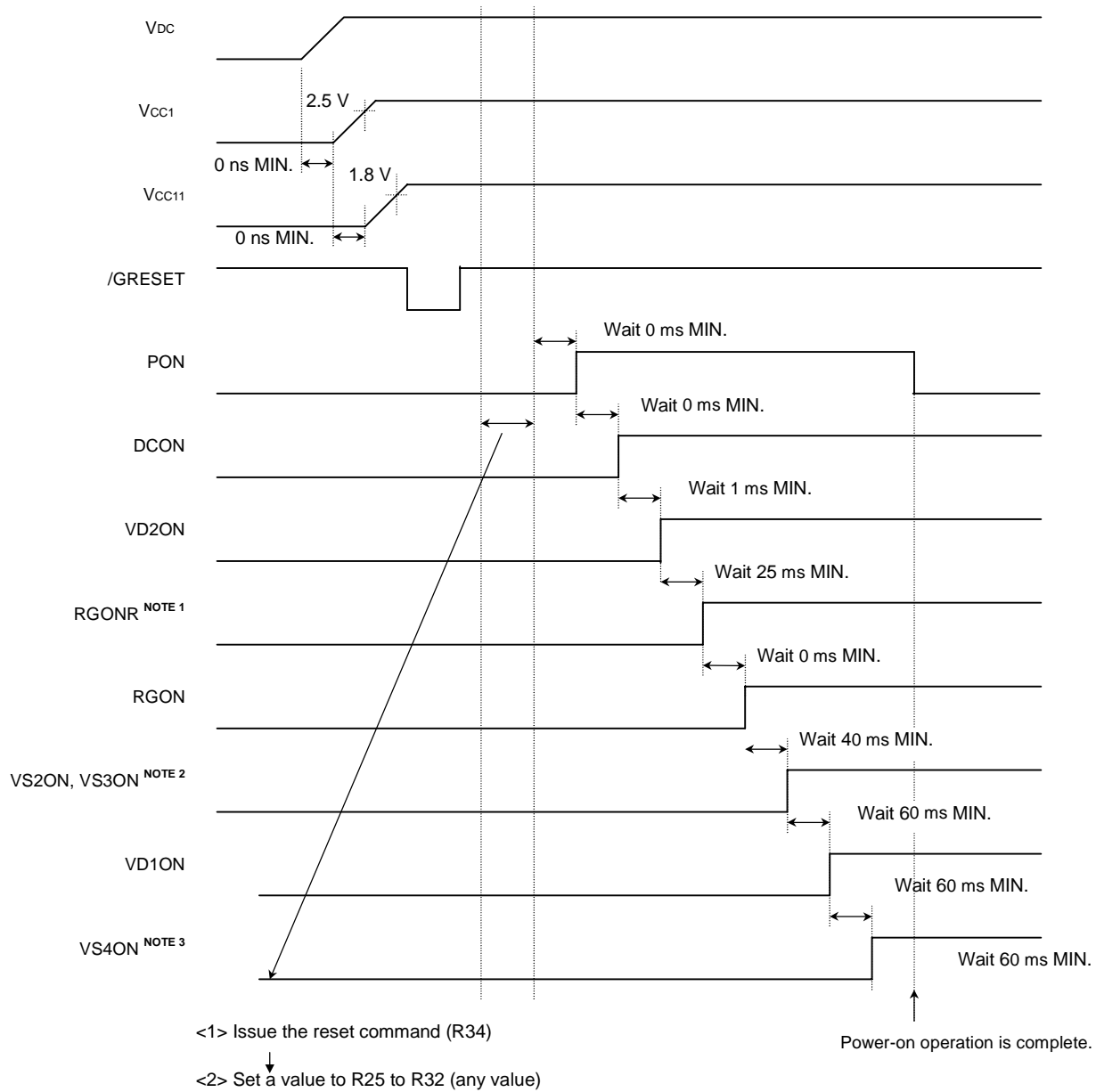
Control /GRESET pin and each command of PONM, VD2ON, RGONR, RGON, VS2ON, VS3ON, VD1ON, and DCON using the following sequence, after applying power to V<sub>DC</sub>, V<sub>CC1</sub>, and V<sub>CC11</sub>.



**Note** Turn on the power supply to be used among VD2ON, RGONR, RGON, VS2ON, VS3ON, and VD1ON.

**(2) Power control by serial interface (command control sequence)**

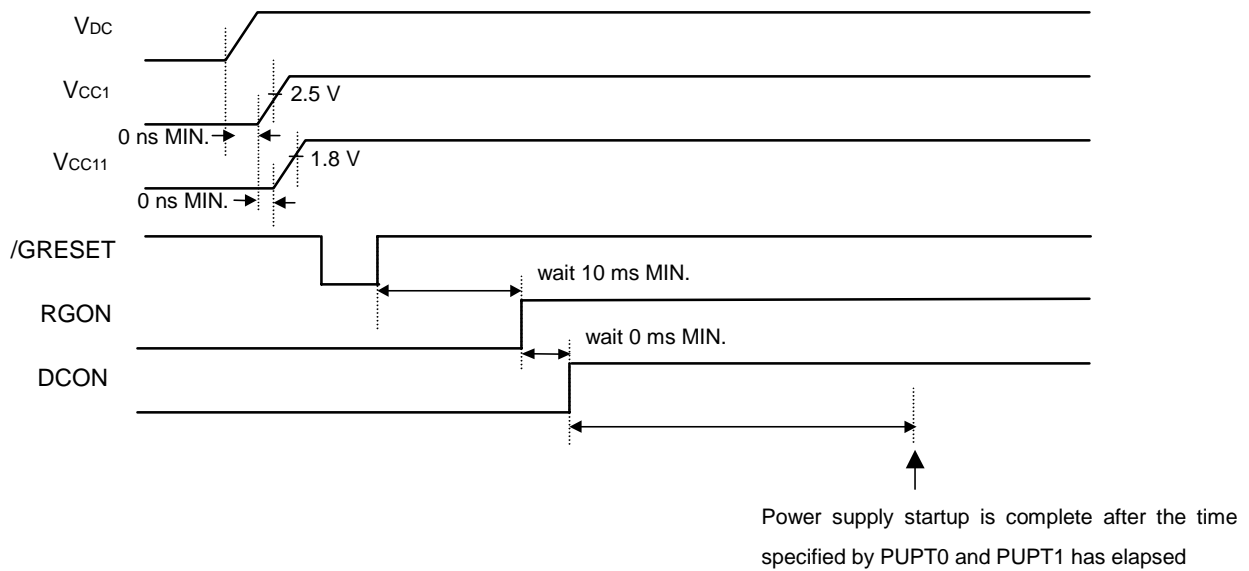
Control /GRESET pin and each command of PON, DCON, VD2ON, RGONR, RGON, VS2ON, VS3ON, VD1ON, and VS4ON after power on of V<sub>DC</sub>, V<sub>CC1</sub>, V<sub>CC11</sub> as shown below.



- Notes 1.** This pin only needs to be controlled when the V<sub>R</sub> amplifier is used.
- 2.** VS2ON only needs to be controlled when V<sub>SS2</sub> is used.
- 3.** This pin only needs to be controlled when V<sub>COM</sub> is used.

**(3) Power control by pins (simple sequence)**

Control each pin of /GRESET, RGON, and DCON after power on of  $V_{DC}$ ,  $V_{CC1}$ ,  $V_{CC11}$  as shown below.



- Remarks 1.** When using  $\text{RGON}$ , pull it up to the high level by wiring the  $\text{RGONR}$  pin.  
**2.** When using  $V_{SS4}$ , pull it up to the high level by wiring the  $\text{COMON}$  pin.

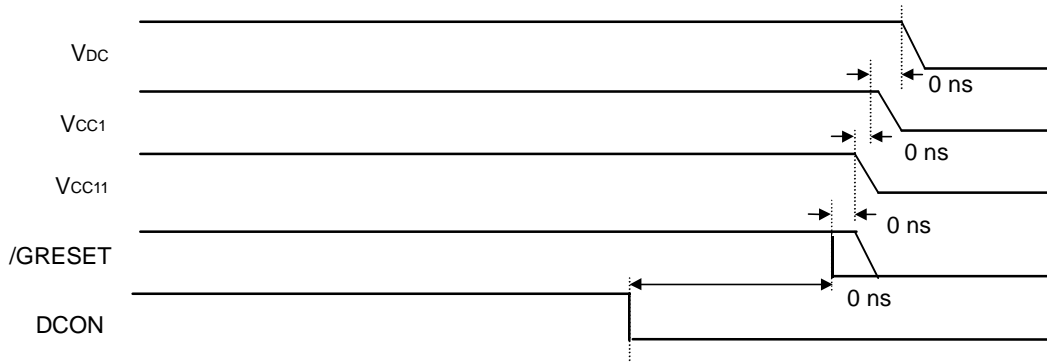


**12.2 Power OFF sequence**

When turning the power off, turn off the pins and commands used for control simultaneously, both when performing control via the serial interface and via the pins.

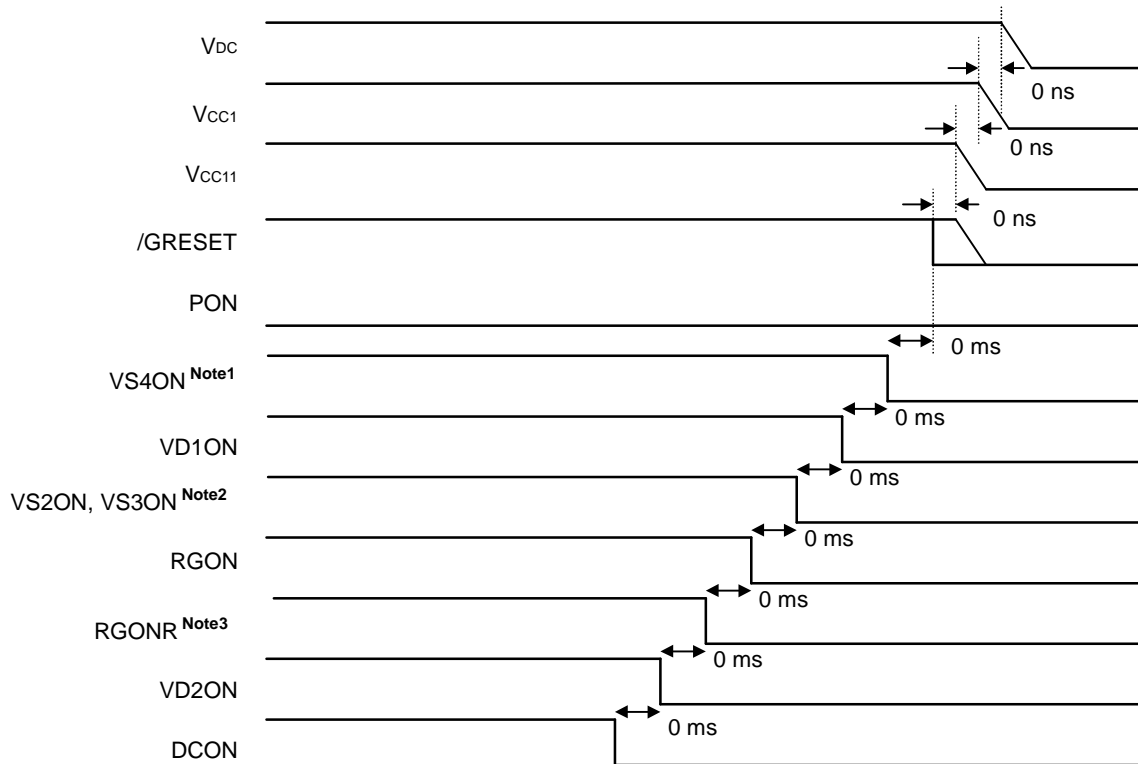
**(1) Power control by serial interface (Simplified sequence)**

Control DCON pin as shown below.



**(2) Power control by serial interface (Command control sequence)**

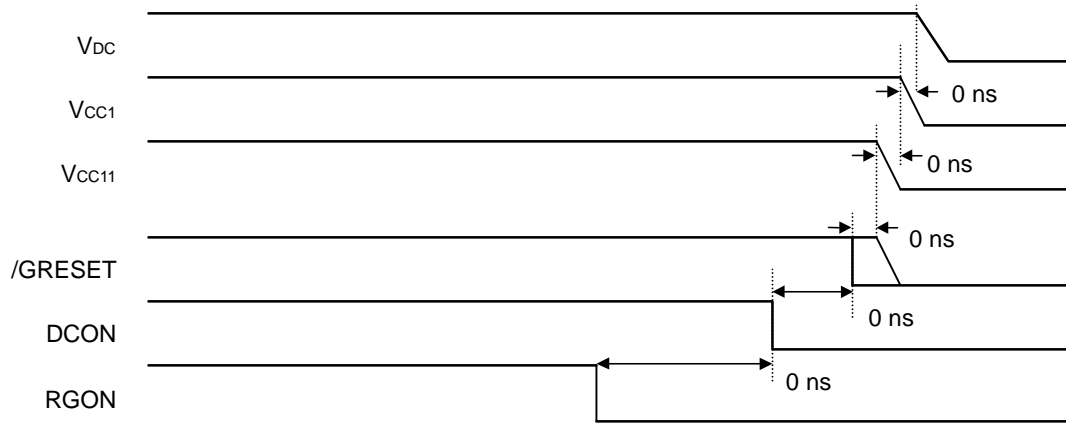
Control each pin of /GRESET, RGON, and DCON as shown below.



- Notes 1.** This pin only needs to be controlled when the VCOM is used.
- 2.** VS2ON only needs to be controlled when Vss2 is used.
- 3.** This pin only needs to be controlled when VR amplifier is used.

**(3) Power control by pins (Simplified sequence)**

Control each pin of /GRESET, RGON, and DCON as shown below.



- Remarks 1.** When using RGON, pull it up to the high level by wiring the RGONR pin.
- 2.** When using V<sub>SS4</sub>, pull it up to the high level by wiring the COMON pin.

13. ELECTRICAL SPECIFICATIONS

**Absolute Maximum Ratings (T<sub>A</sub> = 25°C, V<sub>SS</sub> = 0 V)**

Parameter	Symbol	Rating	Unit
Supply Voltage	V <sub>CC1</sub>	-0.5 to +4.0	V
Supply Voltage	V <sub>DC</sub>	-0.5 to +4.0	V
Supply Voltage	V <sub>SS3</sub>	V <sub>DD1</sub> -42 V to +0.5	V
Supply Voltage	V <sub>DD1</sub> -V <sub>SS3</sub>	-0.5 to +42	V
Input Voltage <sup>Note 1</sup>	V <sub>I</sub>	-0.5 to V <sub>CC1</sub> +0.5	V
Input Current <sup>Note 1</sup>	I <sub>I</sub>	±1	mA
Output Current <sup>Note 2</sup>	I <sub>O1</sub>	±10	mA
Output Current <sup>Note 3</sup>	I <sub>O2</sub>	+10	mA
Operating Ambient Temperature	T <sub>A</sub>	-40 to +85	°C
Storage Temperature	T <sub>stg</sub>	-55 to +150	°C

- Notes 1.** CLK, STVR, STVL, R,/L, OE<sub>1</sub>, OE<sub>2</sub>, GCS, GCL, GDA, DCCLK, VCIN, DCON, RGON, VCD2, /GRESET, IFSEL, EXRV, SCN0, SCN1
- 2.** STVR, STVL, VM, VCOM
- 3.** V<sub>S</sub>

**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 Conditions (T<sub>A</sub> = -40 to +85°C, V<sub>SS</sub> = 0 V)**

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Supply Voltage	V <sub>CC1</sub>		2.5	2.7	3.3	V
Supply Voltage	V <sub>DC</sub>		2.5	2.7	3.3	V
Supply Voltage	V <sub>DD1</sub>		10	15	20	V
Supply Voltage	V <sub>SS3</sub>		-20	-15	-10	V
Supply Voltage	V <sub>DD1</sub> -V <sub>SS3</sub>		20	30	40	V
Supply Voltage	V <sub>GD</sub>				6.0	V
Input Voltage <sup>Note</sup>	V <sub>I</sub>		0		V <sub>CC1</sub>	V

**Note** CLK, STVR, STVL, R,/L, OE<sub>1</sub>, OE<sub>2</sub>, GCS, GCL, GDA, DCCLK, VCIN, DCON, RGON, VCD2, /GRESET, IFSEL, EXRV, SCN0, SCN1

**Electrical Characteristics** (T<sub>A</sub> = -40 to +85°C, V<sub>CC1</sub> = 2.5 to 3.3 V, V<sub>DC</sub> = 2.5 to 3.3 V, V<sub>DD1</sub> = 15 V, V<sub>SS3</sub> = -15 V, V<sub>S</sub> = 5 V, V<sub>SS1</sub> = 0 V)

(1/2)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
High-level input voltage	V <sub>IH1</sub>	<b>Note 1</b>	0.8 V <sub>CC1</sub>			V
Low-level input voltage	V <sub>IL1</sub>				0.2 V <sub>CC1</sub>	V
High-level output voltage	V <sub>OH</sub>	STVR, STVL, I <sub>OH</sub> = -40 μA	V <sub>CC1</sub> -0.4		V <sub>CC1</sub>	V
Low-level output voltage	V <sub>OL</sub>	STVR, STVL, I <sub>OH</sub> = +40 μA	0		0.4	V
V <sub>DD1</sub> boost voltage	V <sub>DD1</sub>	I <sub>DD1</sub> = 300 μA, 3 x boost, <b>Note 2</b>	2.7 V <sub>GD</sub>	-	3 V <sub>GD</sub>	V
V <sub>DD2</sub> boost voltage1	V <sub>DD21</sub>	I <sub>DD2</sub> = 1 mA, V <sub>CD2</sub> = L, V <sub>MS</sub> = H (2 x boost, dual), <b>Note 2</b>	1.9 V <sub>DC</sub>	-	2 V <sub>DC</sub>	V
V <sub>DD2</sub> boost voltage2	V <sub>DD22</sub>	I <sub>DD2</sub> = 1 mA, V <sub>CD2</sub> = L, V <sub>MS</sub> = L (2 x boost, single), <b>Note 2</b>	1.8 V <sub>DC</sub>	-	2 V <sub>DC</sub>	V
V <sub>DD2</sub> boost voltage3	V <sub>DD23</sub>	I <sub>DD2</sub> = 1 mA, V <sub>CD2</sub> = H (3 x boost), <b>Note 2</b>	2.7 V <sub>DC</sub>	-	3 V <sub>DC</sub>	V
V <sub>SS2</sub> boost voltage	V <sub>SS2</sub>	I <sub>SS2</sub> = -300 μA, -2 x boost, <b>Note 2</b>	-2 V <sub>S</sub>	-	-1.8 V <sub>S</sub>	V
V <sub>SS3</sub> boost voltage	V <sub>SS3</sub>	I <sub>SS3</sub> = -300 μA, -3 x boost, <b>Note 2</b>	-3 V <sub>S</sub>	-	-2.7 V <sub>S</sub>	V
V <sub>SS4</sub> boost voltage	V <sub>SS4</sub>	I <sub>SS4</sub> = -300 μA, -1 x boost, <b>Note 2</b>	-V <sub>DC</sub>	-	-0.9 V <sub>DC</sub>	V
V <sub>DD1</sub> output resistor	R <sub>VDD1</sub>	I <sub>DD1</sub> = 300 μA, 3 x boost, <b>Note 2</b>	-	3	5	kΩ
V <sub>DD2</sub> output resistor1	R <sub>VDD21</sub>	I <sub>DD2</sub> = 1 mA, V <sub>CD2</sub> = L, V <sub>MS</sub> = H (2x boost, dual), <b>Note 2</b>	-	100	200	Ω
V <sub>DD2</sub> output resistor2	R <sub>VDD22</sub>	I <sub>DD2</sub> = 1 mA, V <sub>CD2</sub> = L, V <sub>MS</sub> = L (2x boost, single), <b>Note 2</b>	-	250	400	Ω
V <sub>DD2</sub> output resistor3	R <sub>VDD23</sub>	I <sub>DD2</sub> = 1 mA, V <sub>CD2</sub> = H (3 x boost), <b>Note 2</b>	-	450	700	Ω
V <sub>SS2</sub> output resistor	R <sub>VSS2</sub>	I <sub>SS2</sub> = -300 μA, -2 x boost, <b>Note 2</b>	-	3	5	kΩ
V <sub>SS3</sub> output resistor	R <sub>VSS3</sub>	I <sub>SS2</sub> = -300 μA, -3 x boost, <b>Note 2</b>	-	3	5	kΩ
V <sub>SS4</sub> output resistor	R <sub>VSS4</sub>	I <sub>SS2</sub> = -300 μA, -1 x boost, <b>Note 2</b>	-	300	500	Ω
V <sub>S</sub> output voltage	V <sub>S</sub>	No load	4.5	5	5.5	V
V <sub>R</sub> output voltage	V <sub>R</sub>	No load	4.5	5	5.5	V
V <sub>S</sub> output resistor	R <sub>Vs</sub>	V <sub>DD2</sub> = 6 V, I <sub>S</sub> = 1 mA, V <sub>S</sub> = 5 V	-	15	30	Ω
V <sub>R</sub> output resistor	R <sub>Vr</sub>	V <sub>DD2</sub> = 6 V, I <sub>R</sub> = 1 mA, V <sub>R</sub> = 5 V	-	15	30	Ω
COMH output voltage	V <sub>comH</sub>	No load, DA (7:0) = CDA (7:0) = A0H	4.5	5	5.5	V
COML output voltage	V <sub>comL</sub>	No load, DA (7:0) = CDA (7:0) = A0H	-0.5	0	0.5	V
V <sub>COM</sub> output high-level voltage	V <sub>VcomH</sub>	I <sub>VCOM</sub> = 1 mA, DA (7:0) = CDA (7:0) = A0H, V <sub>CIN</sub> = H	4.5	5	5.5	V
V <sub>COM</sub> output low-level voltage	V <sub>VcomL</sub>	I <sub>VCOM</sub> = -1 mA, DA (7:0) = CDA (7:0) = A0H, V <sub>CIN</sub> = L	-0.5	0	0.5	V
COM output resistor1	R <sub>COM1</sub>	COM output = High, I <sub>COM</sub> = 1 mA	-	100	200	Ω
COM output resistor2	R <sub>COM2</sub>	COM output = Low, I <sub>COM</sub> = -1 mA	-	100	200	Ω
VM output high-level voltage	V <sub>M1H</sub>	No load	0.9 V <sub>SS2</sub>	V <sub>SS2</sub>	1.1 V <sub>SS2</sub>	V
VM output low-level voltage	V <sub>M1L</sub>	No load	0.9 V <sub>SS3</sub>	V <sub>SS3</sub>	1.1 V <sub>SS3</sub>	V
VM output resistance	R <sub>M1</sub>	When I <sub>VM</sub> = 100 μA, V <sub>SS2</sub> is selected.	-	300	400	Ω
Output ON resistance	R <sub>ON1</sub>	O <sub>1</sub> to O <sub>241</sub>	1	2	4	kΩ

**Notes 1.** CLK, STVR, STVL, R<sub>/L</sub>, OE<sub>1</sub>, OE<sub>2</sub>, GCS, GCL, GDA, V<sub>COM</sub>, DCON, RGON, LPM, V<sub>CD2</sub>, /GRESET, IFSEL, EXRV, SCN0, SCN1, V<sub>CIN</sub>

**2.** External capacitor: 1 μF, CLS0 = H, CLS1 = L, FS0 = H, FS1 = L, FS2 = H, FS3 = L, FUP = L

**3.** ACS0 = H, ACS1 = H, V<sub>DD2</sub> = V<sub>DC</sub> x 2, dual mode, V<sub>DD1</sub> = V<sub>GD</sub> x 3, V<sub>SS2</sub> = V<sub>GD</sub> x (-2), V<sub>SS3</sub> = V<sub>GD</sub> x (-3), V<sub>SS4</sub> = V<sub>DC</sub> x (-1), V<sub>GD</sub> = V<sub>S</sub>, CLS0 = H, CLS1 = L, FS0 = H, FS1 = L, FS2 = H, FS3 = L, FUP = L

(2/2)

Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Input current	I <sub>I1</sub>	<b>Note 1</b>	-1	0	1	μA
Input leak current	I <sub>IL</sub>	STVR, STVL	-1	0	1	μA
Dynamic current	I <sub>CC1</sub>	V <sub>CC1</sub> , f <sub>CLK</sub> = 12.5 kHz, no load, <b>Note 3</b>	-	-	200	μA
Dynamic current	I <sub>DC</sub>	V <sub>DC</sub> , f <sub>CLK</sub> = 12.5 kHz, no load, <b>Note 3</b>	-	-	1.8	mA
Static current	I <sub>CC1</sub>	V <sub>CC1</sub> , stand-by	-	-	5	μA
Static current	I <sub>DC</sub>	V <sub>DC</sub> , stand-by	-	-	5	μA
V <sub>REF</sub> voltage	V <sub>REF</sub>		1.08	1.20	1.32	V

**Notes 1.** CLK, STVR, STVL, R<sub>/L</sub>, OE<sub>1</sub>, OE<sub>2</sub>, GCS, GCL, GDA, VCOM, DCON, RGON, LPM, VCD2, /GRESET, IFSEL, EXRV, SCN0, SCN1, VCIN

**2.** External capacitor: 1 μF, CLS0 = H, CLS1 = L, FS0 = H, FS1 = L, FS2 = H, FS3 = L, FUP = L

**3.** ACS0 = H, ACS1 = H, V<sub>DD2</sub> = V<sub>DC</sub> x 2, dual mode, V<sub>DD1</sub> = V<sub>GD</sub> x 3, V<sub>SS2</sub> = V<sub>GD</sub> x (-2), V<sub>SS3</sub> = V<sub>GD</sub> x (-3), V<sub>SS4</sub> = V<sub>DC</sub> x (-1), V<sub>GD</sub> = V<sub>S</sub>, CLS0 = H, CLS1 = L, FS0 = H, FS1 = L, FS2 = H, FS3 = L, FUP = L

**Switching Characteristics (T<sub>A</sub> = -40 to +85°C, V<sub>CC1</sub> = 2.5 to 3.3 V, V<sub>DC</sub> = 2.5 to 3.3 V, V<sub>DD1</sub> = 15 V, V<sub>SS3</sub> = -15 V, V<sub>S</sub> = 5 V, V<sub>SS1</sub> = 0 V)**

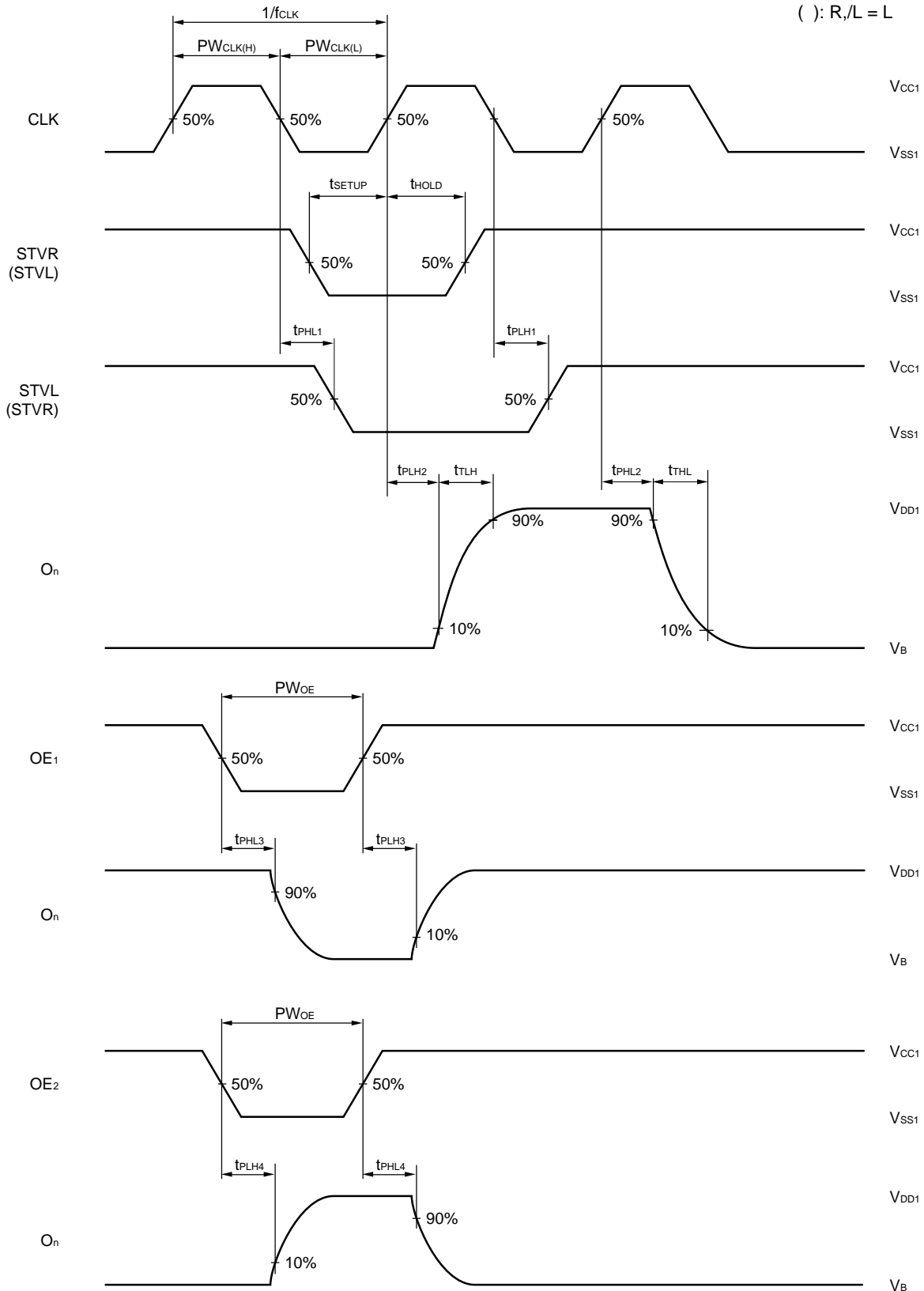
Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Cascade Output Delay Time	t <sub>PHL1</sub>	CL = 20 pF			800	ns
	t <sub>PLH1</sub>	CLK → STVL (STVR)			800	ns
Driver Output Delay Time 1	t <sub>PHL2</sub>	CL = 50 pF			1	μs
	t <sub>PLH2</sub>	CLK → O <sub>n</sub>			1	μs
Driver Output Delay Time2	t <sub>PHL3</sub>	CL = 50 pF			1	μs
	t <sub>PLH3</sub>	OE <sub>1</sub> → O <sub>n</sub>			1	μs
Driver Output Delay Time 3	t <sub>PHL4</sub>	CL = 50 pF			1	μs
	t <sub>PLH4</sub>	OE <sub>2</sub> → O <sub>n</sub>			1	μs
Output Rise Time	t <sub>TLH</sub>	CL = 50 pF			1	μs
Output Fall Time	t <sub>THL</sub>				1	μs
Input Capacitance	C <sub>i</sub>	T <sub>A</sub> = 25°C			15	pF
DC/DC Oscillation Frequency	f <sub>DCDC</sub>	CLS1 = L, CLS0 = H, FUP = L	12.5	25	37.5	kHz
DCCLK Input Frequency	f <sub>DCCLK</sub>				50	kHz
VCIN Input Frequency	f <sub>VCIN</sub>				50	kHz
Clock Input Frequency	f <sub>CLK</sub>	When connected in cascade			400	kHz

**Timing Requirement (T<sub>A</sub> = -40 to +85°C, V<sub>CC1</sub> = 2.5 to 3.3 V, V<sub>DC</sub> = 2.5 to 3.3 V, V<sub>DD1</sub> = 15 V, V<sub>SS3</sub> = -15 V, V<sub>S</sub> = 5 V, V<sub>SS1</sub> = 0 V)**

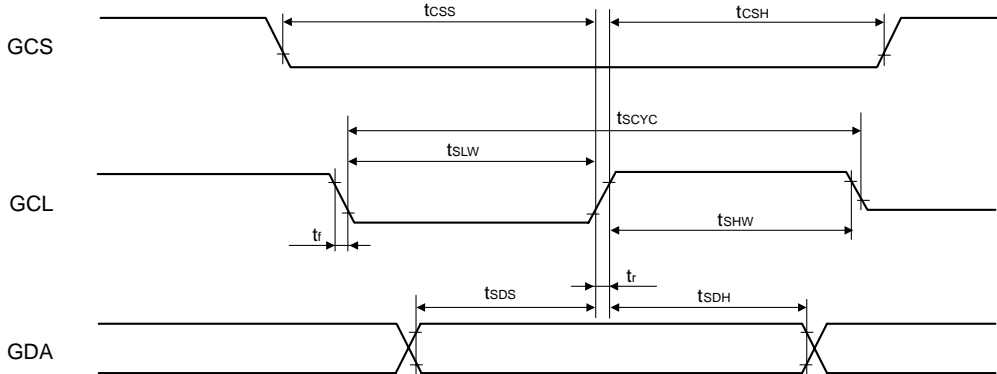
Parameter	Symbol	Condition	MIN.	TYP.	MAX.	Unit
Clock Pulse High Period	PW <sub>CLK(H)</sub>	CLK	500			ns
Clock Pulse Low Period	PW <sub>CLK(L)</sub>	CLK	500			ns
Enable Pulse High Period	PW <sub>OE</sub>	OE <sub>1</sub> , OE <sub>2</sub>	1.0			μs
Data Setup Time	t <sub>SETUP</sub>	STVR (STVL) ↓ → CLK↑	200			ns
Data Hold Time	t <sub>HOLD</sub>	CLK↑ → STVR (STVL) ↑	200			ns
Serial Clock Cycle	t <sub>SCYC</sub>	GCL	250			ns
GCL High-level Pulse Width	t <sub>SHW</sub>	GCL	100			ns
GCL Low-level Pulse Width	t <sub>SLW</sub>	GCL	100			ns
GDA Data Setup Time	t <sub>SDS</sub>	GDA	100			ns
GDA Data Hold Time	t <sub>SDH</sub>	GDA	100			ns
GCS-GCL Time	t <sub>CSS</sub>	GCS	150			ns
GCL-GCS Time	t <sub>CSH</sub>	GCS	150			ns

Switching Characteristics Waveform (R,/L = H, STVSEL = 0, OE1SEL = 0, OE2SEL = 0)

(a) Gate interface



(b) Serial interface





[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.

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