



ST7781R

**240RGB x 320 dot 262K Color with Frame Memory
Single-Chip TFT Controller/Driver**

Datasheet

**Preliminary Version 0.1
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Sitronix Technology Corporation

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1 GENERAL DESCRIPTION

The ST7781R is a single-chip controller/driver for 262K-color, graphic type TFT-LCD. It consists of 720 source line and 320 gate line driving circuits. This chip is capable of connecting directly to an external microprocessor, and accepts, 8-bits/9-bits/16-bits/18-bits parallel interface. Display data can be stored in the on-chip display data RAM of 240x320x18 bits. It can perform display data RAM read/write operation with no external operation clock to minimize power consumption. In addition, because of the integrated power supply circuit necessary to drive liquid crystal; it is possible to make a display system with the fewest components.

2 FEATURES

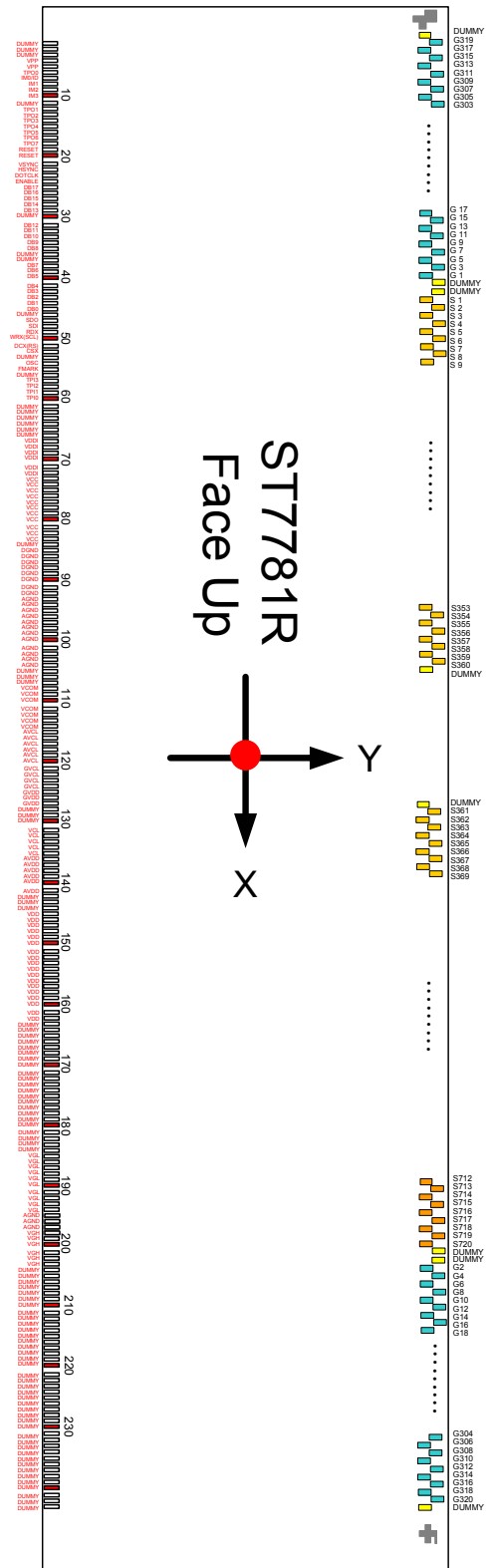
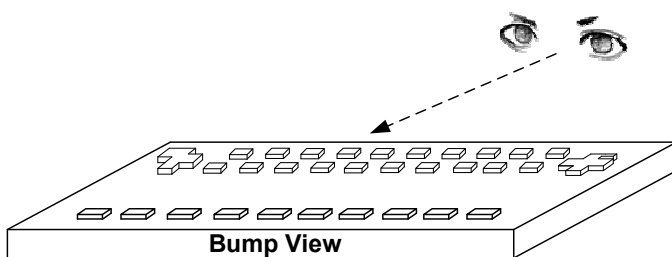
- Single chip TFT-LCD Controller/Driver with On-chip Frame Memory (FM)
- Display Resolution: 240*RGB (H) *320(V)
- Frame Memory Size: 240 x 320 x 18-bit = 1,382,400 bits
- LCD Driver Output Circuits
 - Source Outputs: 240 RGB Channels
 - Gate Outputs: 320 Channels
 - Common Electrode Output
- Display Colors (Color Mode)
 - Full Color: 262K, RGB=(666) max., Idle Mode Off
 - Color Reduce: 8-color, RGB=(111), Idle Mode On
- Programmable Pixel Color Format (Color Depth) for Various Display Data input Format
 - 12-bit/pixel: RGB=(444) using the 1.38M -bit frame memory
 - 16-bit/pixel: RGB=(565) using the 1.38M -bit frame memory
 - 18-bit/pixel: RGB=(666) using the 1.38M-bit frame memory
- MCU Interface
 - Parallel 8080-series MCU Interface (8-bit, 9-bit, 16-bit & 18-bit)
 - 6/16/18 RGB Interface(VSYNC, HSYNC, DOTCLK, ENABLE, DB[17:0])
 - Serial Peripheral Interface(SPI Interface)
 - VSYNC Interface
- Display Features
 - Programmable Partial Display Duty
 - Resizing Function (x1/2, x1/4)
- Support LC Type Option
 - MVA LC Type
 - Transflective LC Type
 - Transmissive LC Type
- On Chip Build-In Circuits
 - DC/DC Converter
 - Adjustable VCOM Generation
 - Non-Volatile (NV) Memory to Store Initial Register Setting and Factory Default Value (Module ID, Module Version, etc)
 - Oscillator for Display Clock Generation
 - Timing Controller
- Build-In NV Memory for LCD Initial Register Setting
 - 7-bits for ID2
 - 5-bits for flicker adjustment

- Driving Algorithm
 - Dot Inversion
 - Column Inversion
- Wide Supply Voltage Range
 - I/O Voltage (VDDI to DGND): 1.65V ~ 3.3V
 - Analog Voltage (VDD to AGND): 2.5V ~ 3.3V
- On-Chip Power System
 - Source Voltage (GVDD to GVCL): +4.7~-4.7V
 - VCOM level: -0.425V ~ -2V
 - Gate driver HIGH level (VGH to AGND): +10.0V ~ +15V
 - Gate driver LOW level (VGL to AGND): -13V ~ -7.5V
- Optimized layout for COG Assembly
- Operate temperature range: -30°C to +85°C
- Lower Power Consumption

3 PAD ARRANGEMENT

3.1.. Output Bump Dimension

Au bump height	12μm
Au bump size	16μm×90μm
	Gate : G1~G320
	Source : S1~S720
	50μm×80μm
	Input Pads : Pad1 to Pad243

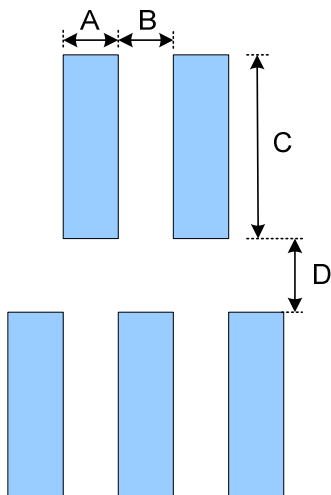


3.2.. Input Bump Dimension

- Input Pads**

S1~S720、G1~G320、DUMMY

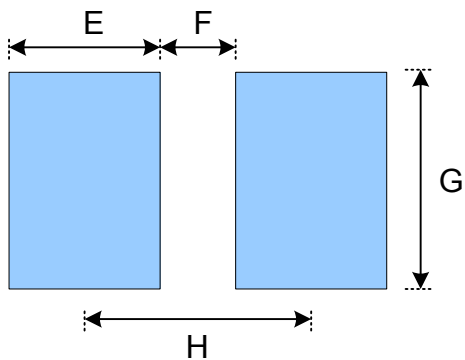
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Symbol	Item	Size
A	Bump Width	16 um
B	Bump Gap 1 (Horizontal)	16 um
C	Bump Height	90 um
D	Bump Gap 2 (Vertical)	27 um

- Output Pads**

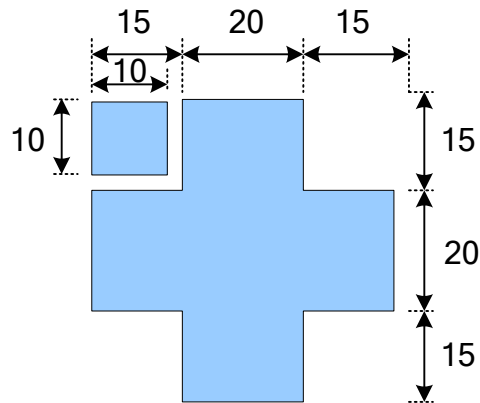
No.1~243



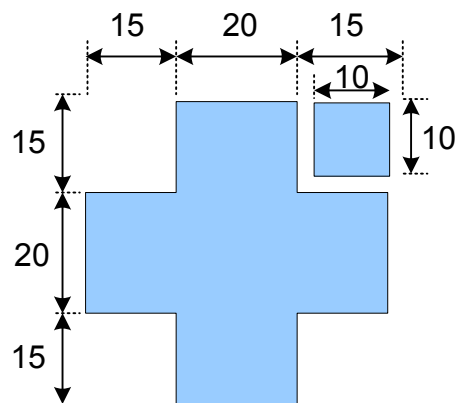
Symbol	Item	Size
E	Bump Width	50 um
F	Bump Gap	20、30、35 um
G	Bump Height	80 um
H	Bump Pitch	70、80、85 um

3.3.. Alignment Mark Dimension

- Alignment Mark: A1(X,Y)=(8751,227.5)



- Alignment Mark: A2(X,Y)=(-8751,227.5)



3.4.. Chip Information

Chip size	17688μm x750μm
Chip thickness	300μm
Pad Location	Pad center
Coordinate Origin	Chip center

4 PAD CENTER COORDINATES

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
1	DUMMY	-8610	-279	34	DB9	-6165	-279
2	DUMMY	-8540	-279	35	DB8	-6085	-279
3	DUMMY	-8470	-279	36	DUMMY	-5990	-279
4	VPP	-8400	-279	37	DUMMY	-5920	-279
5	VPP	-8330	-279	38	DB7	-5825	-279
6	TPO0	-8260	-279	39	DB6	-5745	-279
7	IM0/ID	-8190	-279	40	DB5	-5665	-279
8	IM1	-8120	-279	41	DB4	-5585	-279
9	IM2	-8050	-279	42	DB3	-5505	-279
10	IM3	-7980	-279	43	DB2	-5425	-279
11	DUMMY	-7910	-279	44	DB1	-5345	-279
12	TPO1	-7840	-279	45	DB0	-5265	-279
13	TPO2	-7770	-279	46	DUMMY	-5180	-279
14	TPO3	-7700	-279	47	SDO	-5110	-279
15	TPO4	-7630	-279	48	SDI	-5040	-279
16	TPO5	-7560	-279	49	RDX	-4970	-279
17	TPO6	-7490	-279	50	WRX(SCL)	-4900	-279
18	TPO7	-7420	-279	51	DCX(RS)	-4830	-279
19	RESET	-7350	-279	52	CSX	-4760	-279
20	RESET	-7280	-279	53	DUMMY	-4690	-279
21	VSYNC	-7210	-279	54	OSC	-4620	-279
22	HSYNC	-7140	-279	55	FMARK	-4550	-279
23	DOTCLK	-7070	-279	56	DUMMY	-4480	-279
24	ENABLE	-7000	-279	57	TPI3	-4410	-279
25	DB17	-6905	-279	58	TPI2	-4340	-279
26	DB16	-6825	-279	59	TPI1	-4270	-279
27	DB15	-6745	-279	60	TPI0	-4200	-279
28	DB14	-6665	-279	61	DUMMY	-4130	-279
29	DB13	-6585	-279	62	DUMMY	-4060	-279
30	DUMMY	-6495	-279	63	DUMMY	-3990	-279
31	DB12	-6405	-279	64	DUMMY	-3920	-279
32	DB11	-6325	-279	65	DUMMY	-3850	-279
33	DB10	-6245	-279	66	DUMMY	-3780	-279

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
67	VDDI	-3710	-279	101	AGND	-1330	-279
68	VDDI	-3640	-279	102	AGND	-1260	-279
69	VDDI	-3570	-279	103	AGND	-1190	-279
70	VDDI	-3500	-279	104	AGND	-1120	-279
71	VDDI	-3430	-279	105	DUMMY	-1050	-279
72	VDDI	-3360	-279	106	DUMMY	-980	-279
73	VCC	-3290	-279	107	DUMMY	-910	-279
74	VCC	-3220	-279	108	VCOM	-840	-279
75	VCC	-3150	-279	109	VCOM	-770	-279
76	VCC	-3080	-279	110	VCOM	-700	-279
77	VCC	-3010	-279	111	VCOM	-630	-279
78	VCC	-2940	-279	112	VCOM	-560	-279
79	VCC	-2870	-279	113	VCOM	-490	-279
80	VCC	-2800	-279	114	VCOM	-420	-279
81	VCC	-2730	-279	115	AVCL	-350	-279
82	VCC	-2660	-279	116	AVCL	-280	-279
83	VCC	-2590	-279	117	AVCL	-210	-279
84	DUMMY	-2520	-279	118	AVCL	-140	-279
85	DGND	-2450	-279	119	AVCL	-70	-279
86	DGND	-2380	-279	120	AVCL	0	-279
87	DGND	-2310	-279	121	GVCL	70	-279
88	DGND	-2240	-279	122	GVCL	140	-279
89	DGND	-2170	-279	123	GVCL	210	-279
90	DGND	-2100	-279	124	GVCL	280	-279
91	DGND	-2030	-279	125	GVDD	350	-279
92	DGND	-1960	-279	126	GVDD	420	-279
93	AGND	-1890	-279	127	GVDD	490	-279
94	AGND	-1820	-279	128	DUMMY	560	-279
95	AGND	-1750	-279	129	DUMMY	630	-279
96	AGND	-1680	-279	130	DUMMY	700	-279
97	AGND	-1610	-279	131	VCL	770	-279
98	AGND	-1540	-279	132	VCL	840	-279
99	AGND	-1470	-279	133	VCL	910	-279
100	AGND	-1400	-279	134	VCL	980	-279

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
135	VCL	1050	-279	169	DUMMY	3430	-279
136	AVDD	1120	-279	170	DUMMY	3500	-279
137	AVDD	1190	-279	171	DUMMY	3570	-279
138	AVDD	1260	-279	172	DUMMY	3640	-279
139	AVDD	1330	-279	173	DUMMY	3710	-279
140	AVDD	1400	-279	174	DUMMY	3780	-279
141	AVDD	1470	-279	175	DUMMY	3850	-279
142	DUMMY	1540	-279	176	DUMMY	3920	-279
143	DUMMY	1610	-279	177	DUMMY	3990	-279
144	DUMMY	1680	-279	178	DUMMY	4060	-279
145	VDD	1750	-279	179	DUMMY	4130	-279
146	VDD	1820	-279	180	DUMMY	4200	-279
147	VDD	1890	-279	181	DUMMY	4270	-279
148	VDD	1960	-279	182	DUMMY	4340	-279
149	VDD	2030	-279	183	DUMMY	4410	-279
150	VDD	2100	-279	184	DUMMY	4480	-279
151	VDD	2170	-279	185	VGL	4550	-279
152	VDD	2240	-279	186	VGL	4620	-279
153	VDD	2310	-279	187	VGL	4690	-279
154	VDD	2380	-279	188	VGL	4760	-279
155	VDD	2450	-279	189	VGL	4830	-279
156	VDD	2520	-279	190	VGL	4900	-279
157	VDD	2590	-279	191	VGL	4970	-279
158	VDD	2660	-279	192	VGL	5040	-279
159	VDD	2730	-279	193	VGL	5110	-279
160	VDD	2800	-279	194	VGL	5180	-279
161	VDD	2870	-279	195	AGND	5250	-279
162	VDD	2940	-279	196	AGND	5320	-279
163	DUMMY	3010	-279	197	AGND	5390	-279
164	DUMMY	3080	-279	198	VGH	5460	-279
165	DUMMY	3150	-279	199	VGH	5530	-279
166	DUMMY	3220	-279	200	VGH	5600	-279
167	DUMMY	3290	-279	201	VGH	5670	-279
168	DUMMY	3360	-279	202	VGH	5740	-279

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
203	VGH	5810	-279	237	DUMMY	8190	-279
204	DUMMY	5880	-279	238	DUMMY	8260	-279
205	DUMMY	5950	-279	239	DUMMY	8330	-279
206	DUMMY	6020	-279	240	DUMMY	8400	-279
207	DUMMY	6090	-279	241	DUMMY	8470	-279
208	DUMMY	6160	-279	242	DUMMY	8540	-279
209	DUMMY	6230	-279	243	DUMMY	8610	-279
210	DUMMY	6300	-279	244	DUMMY	8659	157
211	DUMMY	6370	-279	245	G320	8643	274
212	DUMMY	6440	-279	246	G318	8627	157
213	DUMMY	6510	-279	247	G316	8611	274
214	DUMMY	6580	-279	248	G314	8595	157
215	DUMMY	6650	-279	249	G312	8579	274
216	DUMMY	6720	-279	250	G310	8563	157
217	DUMMY	6790	-279	251	G308	8547	274
218	DUMMY	6860	-279	252	G306	8531	157
219	DUMMY	6930	-279	253	G304	8515	274
220	DUMMY	7000	-279	254	G302	8499	157
221	DUMMY	7070	-279	255	G300	8483	274
222	DUMMY	7140	-279	256	G298	8467	157
223	DUMMY	7210	-279	257	G296	8451	274
224	DUMMY	7280	-279	258	G294	8435	157
225	DUMMY	7350	-279	259	G292	8419	274
226	DUMMY	7420	-279	260	G290	8403	157
227	DUMMY	7490	-279	261	G288	8387	274
228	DUMMY	7560	-279	262	G286	8371	157
229	DUMMY	7630	-279	263	G284	8355	274
230	DUMMY	7700	-279	264	G282	8339	157
231	DUMMY	7770	-279	265	G280	8323	274
232	DUMMY	7840	-279	266	G278	8307	157
233	DUMMY	7910	-279	267	G276	8291	274
234	DUMMY	7980	-279	268	G274	8275	157
235	DUMMY	8050	-279	269	G272	8259	274
236	DUMMY	8120	-279	270	G270	8243	157

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
271	G268	8227	274	305	G200	7683	274
272	G266	8211	157	306	G198	7667	157
273	G264	8195	274	307	G196	7651	274
274	G262	8179	157	308	G194	7635	157
275	G260	8163	274	309	G192	7619	274
276	G258	8147	157	310	G190	7603	157
277	G256	8131	274	311	G188	7587	274
278	G254	8115	157	312	G186	7571	157
279	G252	8099	274	313	G184	7555	274
280	G250	8083	157	314	G182	7539	157
281	G248	8067	274	315	G180	7523	274
282	G246	8051	157	316	G178	7507	157
283	G244	8035	274	317	G176	7491	274
284	G242	8019	157	318	G174	7475	157
285	G240	8003	274	319	G172	7459	274
286	G238	7987	157	320	G170	7443	157
287	G236	7971	274	321	G168	7427	274
288	G234	7955	157	322	G166	7411	157
289	G232	7939	274	323	G164	7395	274
290	G230	7923	157	324	G162	7379	157
291	G228	7907	274	325	G160	7363	274
292	G226	7891	157	326	G158	7347	157
293	G224	7875	274	327	G156	7331	274
294	G222	7859	157	328	G154	7315	157
295	G220	7843	274	329	G152	7299	274
296	G218	7827	157	330	G150	7283	157
297	G216	7811	274	331	G148	7267	274
298	G214	7795	157	332	G146	7251	157
299	G212	7779	274	333	G144	7235	274
300	G210	7763	157	334	G142	7219	157
301	G208	7747	274	335	G140	7203	274
302	G206	7731	157	336	G138	7187	157
303	G204	7715	274	337	G136	7171	274
304	G202	7699	157	338	G134	7155	157

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
339	G132	7139	274	373	G64	6595	274
340	G130	7123	157	374	G62	6579	157
341	G128	7107	274	375	G60	6563	274
342	G126	7091	157	376	G58	6547	157
343	G124	7075	274	377	G56	6531	274
344	G122	7059	157	378	G54	6515	157
345	G120	7043	274	379	G52	6499	274
346	G118	7027	157	380	G50	6483	157
347	G116	7011	274	381	G48	6467	274
348	G114	6995	157	382	G46	6451	157
349	G112	6979	274	383	G44	6435	274
350	G110	6963	157	384	G42	6419	157
351	G108	6947	274	385	G40	6403	274
352	G106	6931	157	386	G38	6387	157
353	G104	6915	274	387	G36	6371	274
354	G102	6899	157	388	G34	6355	157
355	G100	6883	274	389	G32	6339	274
356	G98	6867	157	390	G30	6323	157
357	G96	6851	274	391	G28	6307	274
358	G94	6835	157	392	G26	6291	157
359	G92	6819	274	393	G24	6275	274
360	G90	6803	157	394	G22	6259	157
361	G88	6787	274	395	G20	6243	274
362	G86	6771	157	396	G18	6227	157
363	G84	6755	274	397	G16	6211	274
364	G82	6739	157	398	G14	6195	157
365	G80	6723	274	399	G12	6179	274
366	G78	6707	157	400	G10	6163	157
367	G76	6691	274	401	G8	6147	274
368	G74	6675	157	402	G6	6131	157
369	G72	6659	274	403	G4	6115	274
370	G70	6643	157	404	G2	6099	157
371	G68	6627	274	405	DUMMY	6083	274
372	G66	6611	157	406	DUMMY	6047	274

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
407	S720	6031	157	441	S686	5487	157
408	S719	6015	274	442	S685	5471	274
409	S718	5999	157	443	S684	5455	157
410	S717	5983	274	444	S683	5439	274
411	S716	5967	157	445	S682	5423	157
412	S715	5951	274	446	S681	5407	274
413	S714	5935	157	447	S680	5391	157
414	S713	5919	274	448	S679	5375	274
415	S712	5903	157	449	S678	5359	157
416	S711	5887	274	450	S677	5343	274
417	S710	5871	157	451	S676	5327	157
418	S709	5855	274	452	S675	5311	274
419	S708	5839	157	453	S674	5295	157
420	S707	5823	274	454	S673	5279	274
421	S706	5807	157	455	S672	5263	157
422	S705	5791	274	456	S671	5247	274
423	S704	5775	157	457	S670	5231	157
424	S703	5759	274	458	S669	5215	274
425	S702	5743	157	459	S668	5199	157
426	S701	5727	274	460	S667	5183	274
427	S700	5711	157	461	S666	5167	157
428	S699	5695	274	462	S665	5151	274
429	S698	5679	157	463	S664	5135	157
430	S697	5663	274	464	S663	5119	274
431	S696	5647	157	465	S662	5103	157
432	S695	5631	274	466	S661	5087	274
433	S694	5615	157	467	S660	5071	157
434	S693	5599	274	468	S659	5055	274
435	S692	5583	157	469	S658	5039	157
436	S691	5567	274	470	S657	5023	274
437	S690	5551	157	471	S656	5007	157
438	S689	5535	274	472	S655	4991	274
439	S688	5519	157	473	S654	4975	157
440	S687	5503	274	474	S653	4959	274

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
475	S652	4943	157	509	S618	4399	157
476	S651	4927	274	510	S617	4383	274
477	S650	4911	157	511	S616	4367	157
478	S649	4895	274	512	S615	4351	274
479	S648	4879	157	513	S614	4335	157
480	S647	4863	274	514	S613	4319	274
481	S646	4847	157	515	S612	4303	157
482	S645	4831	274	516	S611	4287	274
483	S644	4815	157	517	S610	4271	157
484	S643	4799	274	518	S609	4255	274
485	S642	4783	157	519	S608	4239	157
486	S641	4767	274	520	S607	4223	274
487	S640	4751	157	521	S606	4207	157
488	S639	4735	274	522	S605	4191	274
489	S638	4719	157	523	S604	4175	157
490	S637	4703	274	524	S603	4159	274
491	S636	4687	157	525	S602	4143	157
492	S635	4671	274	526	S601	4127	274
493	S634	4655	157	527	S600	4111	157
494	S633	4639	274	528	S599	4095	274
495	S632	4623	157	529	S598	4079	157
496	S631	4607	274	530	S597	4063	274
497	S630	4591	157	531	S596	4047	157
498	S629	4575	274	532	S595	4031	274
499	S628	4559	157	533	S594	4015	157
500	S627	4543	274	534	S593	3999	274
501	S626	4527	157	535	S592	3983	157
502	S625	4511	274	536	S591	3967	274
503	S624	4495	157	537	S590	3951	157
504	S623	4479	274	538	S589	3935	274
505	S622	4463	157	539	S588	3919	157
506	S621	4447	274	540	S587	3903	274
507	S620	4431	157	541	S586	3887	157
508	S619	4415	274	542	S585	3871	274

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
543	S584	3855	157	577	S550	3311	157
544	S583	3839	274	578	S549	3295	274
545	S582	3823	157	579	S548	3279	157
546	S581	3807	274	580	S547	3263	274
547	S580	3791	157	581	S546	3247	157
548	S579	3775	274	582	S545	3231	274
549	S578	3759	157	583	S544	3215	157
550	S577	3743	274	584	S543	3199	274
551	S576	3727	157	585	S542	3183	157
552	S575	3711	274	586	S541	3167	274
553	S574	3695	157	587	S540	3151	157
554	S573	3679	274	588	S539	3135	274
555	S572	3663	157	589	S538	3119	157
556	S571	3647	274	590	S537	3103	274
557	S570	3631	157	591	S536	3087	157
558	S569	3615	274	592	S535	3071	274
559	S568	3599	157	593	S534	3055	157
560	S567	3583	274	594	S533	3039	274
561	S566	3567	157	595	S532	3023	157
562	S565	3551	274	596	S531	3007	274
563	S564	3535	157	597	S530	2991	157
564	S563	3519	274	598	S529	2975	274
565	S562	3503	157	599	S528	2959	157
566	S561	3487	274	600	S527	2943	274
567	S560	3471	157	601	S526	2927	157
568	S559	3455	274	602	S525	2911	274
569	S558	3439	157	603	S524	2895	157
570	S557	3423	274	604	S523	2879	274
571	S556	3407	157	605	S522	2863	157
572	S555	3391	274	606	S521	2847	274
573	S554	3375	157	607	S520	2831	157
574	S553	3359	274	608	S519	2815	274
575	S552	3343	157	609	S518	2799	157
576	S551	3327	274	610	S517	2783	274

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
611	S516	2767	157	645	S482	2223	157
612	S515	2751	274	646	S481	2207	274
613	S514	2735	157	647	S480	2191	157
614	S513	2719	274	648	S479	2175	274
615	S512	2703	157	649	S478	2159	157
616	S511	2687	274	650	S477	2143	274
617	S510	2671	157	651	S476	2127	157
618	S509	2655	274	652	S475	2111	274
619	S508	2639	157	653	S474	2095	157
620	S507	2623	274	654	S473	2079	274
621	S506	2607	157	655	S472	2063	157
622	S505	2591	274	656	S471	2047	274
623	S504	2575	157	657	S470	2031	157
624	S503	2559	274	658	S469	2015	274
625	S502	2543	157	659	S468	1999	157
626	S501	2527	274	660	S467	1983	274
627	S500	2511	157	661	S466	1967	157
628	S499	2495	274	662	S465	1951	274
629	S498	2479	157	663	S464	1935	157
630	S497	2463	274	664	S463	1919	274
631	S496	2447	157	665	S462	1903	157
632	S495	2431	274	666	S461	1887	274
633	S494	2415	157	667	S460	1871	157
634	S493	2399	274	668	S459	1855	274
635	S492	2383	157	669	S458	1839	157
636	S491	2367	274	670	S457	1823	274
637	S490	2351	157	671	S456	1807	157
638	S489	2335	274	672	S455	1791	274
639	S488	2319	157	673	S454	1775	157
640	S487	2303	274	674	S453	1759	274
641	S486	2287	157	675	S452	1743	157
642	S485	2271	274	676	S451	1727	274
643	S484	2255	157	677	S450	1711	157
644	S483	2239	274	678	S449	1695	274

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
679	S448	1679	157	713	S414	1135	157
680	S447	1663	274	714	S413	1119	274
681	S446	1647	157	715	S412	1103	157
682	S445	1631	274	716	S411	1087	274
683	S444	1615	157	717	S410	1071	157
684	S443	1599	274	718	S409	1055	274
685	S442	1583	157	719	S408	1039	157
686	S441	1567	274	720	S407	1023	274
687	S440	1551	157	721	S406	1007	157
688	S439	1535	274	722	S405	991	274
689	S438	1519	157	723	S404	975	157
690	S437	1503	274	724	S403	959	274
691	S436	1487	157	725	S402	943	157
692	S435	1471	274	726	S401	927	274
693	S434	1455	157	727	S400	911	157
694	S433	1439	274	728	S399	895	274
695	S432	1423	157	729	S398	879	157
696	S431	1407	274	730	S397	863	274
697	S430	1391	157	731	S396	847	157
698	S429	1375	274	732	S395	831	274
699	S428	1359	157	733	S394	815	157
700	S427	1343	274	734	S393	799	274
701	S426	1327	157	735	S392	783	157
702	S425	1311	274	736	S391	767	274
703	S424	1295	157	737	S390	751	157
704	S423	1279	274	738	S389	735	274
705	S422	1263	157	739	S388	719	157
706	S421	1247	274	740	S387	703	274
707	S420	1231	157	741	S386	687	157
708	S419	1215	274	742	S385	671	274
709	S418	1199	157	743	S384	655	157
710	S417	1183	274	744	S383	639	274
711	S416	1167	157	745	S382	623	157
712	S415	1151	274	746	S381	607	274

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
747	S380	591	157	781	S348	-479	274
748	S379	575	274	782	S347	-495	157
749	S378	559	157	783	S346	-511	274
750	S377	543	274	784	S345	-527	157
751	S376	527	157	785	S344	-543	274
752	S375	511	274	786	S343	-559	157
753	S374	495	157	787	S342	-575	274
754	S373	479	274	788	S341	-591	157
755	S372	463	157	789	S340	-607	274
756	S371	447	274	790	S339	-623	157
757	S370	431	157	791	S338	-639	274
758	S369	415	274	792	S337	-655	157
759	S368	399	157	793	S336	-671	274
760	S367	383	274	794	S335	-687	157
761	S366	367	157	795	S334	-703	274
762	S365	351	274	796	S333	-719	157
763	S364	335	157	797	S332	-735	274
764	S363	319	274	798	S331	-751	157
765	S362	303	157	799	S330	-767	274
766	S361	287	274	800	S329	-783	157
767	DUMMY	271	157	801	S328	-799	274
768	DUMMY	-271	157	802	S327	-815	157
769	S360	-287	274	803	S326	-831	274
770	S359	-303	157	804	S325	-847	157
771	S358	-319	274	805	S324	-863	274
772	S357	-335	157	806	S323	-879	157
773	S356	-351	274	807	S322	-895	274
774	S355	-367	157	808	S321	-911	157
775	S354	-383	274	809	S320	-927	274
776	S353	-399	157	810	S319	-943	157
777	S352	-415	274	811	S318	-959	274
778	S351	-431	157	812	S317	-975	157
779	S350	-447	274	813	S316	-991	274
780	S349	-463	157	814	S315	-1007	157

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
815	S314	-1023	274	849	S280	-1567	274
816	S313	-1039	157	850	S279	-1583	157
817	S312	-1055	274	851	S278	-1599	274
818	S311	-1071	157	852	S277	-1615	157
819	S310	-1087	274	853	S276	-1631	274
820	S309	-1103	157	854	S275	-1647	157
821	S308	-1119	274	855	S274	-1663	274
822	S307	-1135	157	856	S273	-1679	157
823	S306	-1151	274	857	S272	-1695	274
824	S305	-1167	157	858	S271	-1711	157
825	S304	-1183	274	859	S270	-1727	274
826	S303	-1199	157	860	S269	-1743	157
827	S302	-1215	274	861	S268	-1759	274
828	S301	-1231	157	862	S267	-1775	157
829	S300	-1247	274	863	S266	-1791	274
830	S299	-1263	157	864	S265	-1807	157
831	S298	-1279	274	865	S264	-1823	274
832	S297	-1295	157	866	S263	-1839	157
833	S296	-1311	274	867	S262	-1855	274
834	S295	-1327	157	868	S261	-1871	157
835	S294	-1343	274	869	S260	-1887	274
836	S293	-1359	157	870	S259	-1903	157
837	S292	-1375	274	871	S258	-1919	274
838	S291	-1391	157	872	S257	-1935	157
839	S290	-1407	274	873	S256	-1951	274
840	S289	-1423	157	874	S255	-1967	157
841	S288	-1439	274	875	S254	-1983	274
842	S287	-1455	157	876	S253	-1999	157
843	S286	-1471	274	877	S252	-2015	274
844	S285	-1487	157	878	S251	-2031	157
845	S284	-1503	274	879	S250	-2047	274
846	S283	-1519	157	880	S249	-2063	157
847	S282	-1535	274	881	S248	-2079	274
848	S281	-1551	157	882	S247	-2095	157

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
883	S246	-2111	274	917	S212	-2655	274
884	S245	-2127	157	918	S211	-2671	157
885	S244	-2143	274	919	S210	-2687	274
886	S243	-2159	157	920	S209	-2703	157
887	S242	-2175	274	921	S208	-2719	274
888	S241	-2191	157	922	S207	-2735	157
889	S240	-2207	274	923	S206	-2751	274
890	S239	-2223	157	924	S205	-2767	157
891	S238	-2239	274	925	S204	-2783	274
892	S237	-2255	157	926	S203	-2799	157
893	S236	-2271	274	927	S202	-2815	274
894	S235	-2287	157	928	S201	-2831	157
895	S234	-2303	274	929	S200	-2847	274
896	S233	-2319	157	930	S199	-2863	157
897	S232	-2335	274	931	S198	-2879	274
898	S231	-2351	157	932	S197	-2895	157
899	S230	-2367	274	933	S196	-2911	274
900	S229	-2383	157	934	S195	-2927	157
901	S228	-2399	274	935	S194	-2943	274
902	S227	-2415	157	936	S193	-2959	157
903	S226	-2431	274	937	S192	-2975	274
904	S225	-2447	157	938	S191	-2991	157
905	S224	-2463	274	939	S190	-3007	274
906	S223	-2479	157	940	S189	-3023	157
907	S222	-2495	274	941	S188	-3039	274
908	S221	-2511	157	942	S187	-3055	157
909	S220	-2527	274	943	S186	-3071	274
910	S219	-2543	157	944	S185	-3087	157
911	S218	-2559	274	945	S184	-3103	274
912	S217	-2575	157	946	S183	-3119	157
913	S216	-2591	274	947	S182	-3135	274
914	S215	-2607	157	948	S181	-3151	157
915	S214	-2623	274	949	S180	-3167	274
916	S213	-2639	157	950	S179	-3183	157

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
951	S178	-3199	274	985	S144	-3743	274
952	S177	-3215	157	986	S143	-3759	157
953	S176	-3231	274	987	S142	-3775	274
954	S175	-3247	157	988	S141	-3791	157
955	S174	-3263	274	989	S140	-3807	274
956	S173	-3279	157	990	S139	-3823	157
957	S172	-3295	274	991	S138	-3839	274
958	S171	-3311	157	992	S137	-3855	157
959	S170	-3327	274	993	S136	-3871	274
960	S169	-3343	157	994	S135	-3887	157
961	S168	-3359	274	995	S134	-3903	274
962	S167	-3375	157	996	S133	-3919	157
963	S166	-3391	274	997	S132	-3935	274
964	S165	-3407	157	998	S131	-3951	157
965	S164	-3423	274	999	S130	-3967	274
966	S163	-3439	157	1000	S129	-3983	157
967	S162	-3455	274	1001	S128	-3999	274
968	S161	-3471	157	1002	S127	-4015	157
969	S160	-3487	274	1003	S126	-4031	274
970	S159	-3503	157	1004	S125	-4047	157
971	S158	-3519	274	1005	S124	-4063	274
972	S157	-3535	157	1006	S123	-4079	157
973	S156	-3551	274	1007	S122	-4095	274
974	S155	-3567	157	1008	S121	-4111	157
975	S154	-3583	274	1009	S120	-4127	274
976	S153	-3599	157	1010	S119	-4143	157
977	S152	-3615	274	1011	S118	-4159	274
978	S151	-3631	157	1012	S117	-4175	157
979	S150	-3647	274	1013	S116	-4191	274
980	S149	-3663	157	1014	S115	-4207	157
981	S148	-3679	274	1015	S114	-4223	274
982	S147	-3695	157	1016	S113	-4239	157
983	S146	-3711	274	1017	S112	-4255	274
984	S145	-3727	157	1018	S111	-4271	157

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
1019	S110	-4287	274	1053	S76	-4831	274
1020	S109	-4303	157	1054	S75	-4847	157
1021	S108	-4319	274	1055	S74	-4863	274
1022	S107	-4335	157	1056	S73	-4879	157
1023	S106	-4351	274	1057	S72	-4895	274
1024	S105	-4367	157	1058	S71	-4911	157
1025	S104	-4383	274	1059	S70	-4927	274
1026	S103	-4399	157	1060	S69	-4943	157
1027	S102	-4415	274	1061	S68	-4959	274
1028	S101	-4431	157	1062	S67	-4975	157
1029	S100	-4447	274	1063	S66	-4991	274
1030	S99	-4463	157	1064	S65	-5007	157
1031	S98	-4479	274	1065	S64	-5023	274
1032	S97	-4495	157	1066	S63	-5039	157
1033	S96	-4511	274	1067	S62	-5055	274
1034	S95	-4527	157	1068	S61	-5071	157
1035	S94	-4543	274	1069	S60	-5087	274
1036	S93	-4559	157	1070	S59	-5103	157
1037	S92	-4575	274	1071	S58	-5119	274
1038	S91	-4591	157	1072	S57	-5135	157
1039	S90	-4607	274	1073	S56	-5151	274
1040	S89	-4623	157	1074	S55	-5167	157
1041	S88	-4639	274	1075	S54	-5183	274
1042	S87	-4655	157	1076	S53	-5199	157
1043	S86	-4671	274	1077	S52	-5215	274
1044	S85	-4687	157	1078	S51	-5231	157
1045	S84	-4703	274	1079	S50	-5247	274
1046	S83	-4719	157	1080	S49	-5263	157
1047	S82	-4735	274	1081	S48	-5279	274
1048	S81	-4751	157	1082	S47	-5295	157
1049	S80	-4767	274	1083	S46	-5311	274
1050	S79	-4783	157	1084	S45	-5327	157
1051	S78	-4799	274	1085	S44	-5343	274
1052	S77	-4815	157	1086	S43	-5359	157

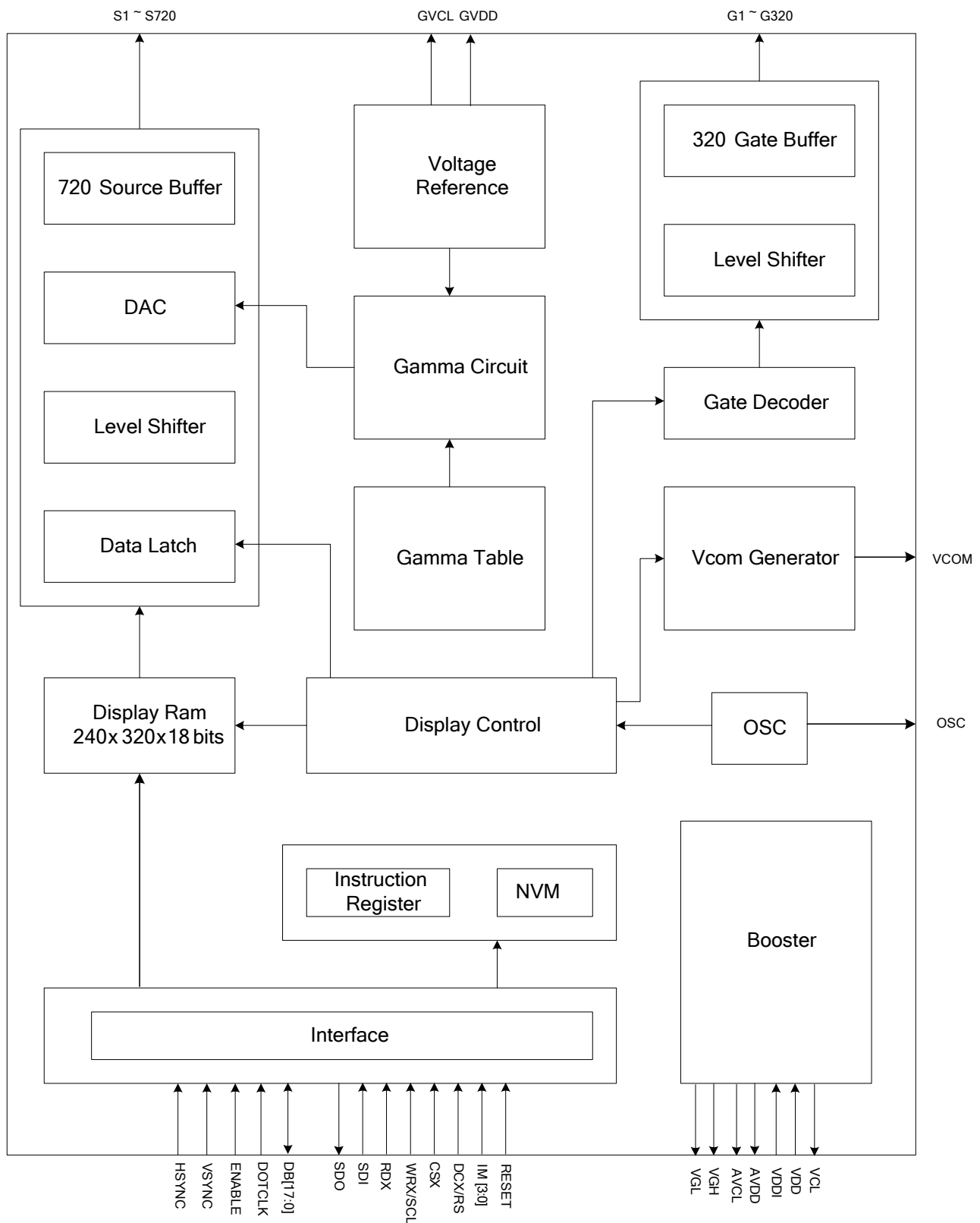
PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
1087	S42	-5375	274	1121	S8	-5919	274
1088	S41	-5391	157	1122	S7	-5935	157
1089	S40	-5407	274	1123	S6	-5951	274
1090	S39	-5423	157	1124	S5	-5967	157
1091	S38	-5439	274	1125	S4	-5983	274
1092	S37	-5455	157	1126	S3	-5999	157
1093	S36	-5471	274	1127	S2	-6015	274
1094	S35	-5487	157	1128	S1	-6031	157
1095	S34	-5503	274	1129	DUMMY	-6047	274
1096	S33	-5519	157	1130	DUMMY	-6083	274
1097	S32	-5535	274	1131	G1	-6099	157
1098	S31	-5551	157	1132	G3	-6115	274
1099	S30	-5567	274	1133	G5	-6131	157
1100	S29	-5583	157	1134	G7	-6147	274
1101	S28	-5599	274	1135	G9	-6163	157
1102	S27	-5615	157	1136	G11	-6179	274
1103	S26	-5631	274	1137	G13	-6195	157
1104	S25	-5647	157	1138	G15	-6211	274
1105	S24	-5663	274	1139	G17	-6227	157
1106	S23	-5679	157	1140	G19	-6243	274
1107	S22	-5695	274	1141	G21	-6259	157
1108	S21	-5711	157	1142	G23	-6275	274
1109	S20	-5727	274	1143	G25	-6291	157
1110	S19	-5743	157	1144	G27	-6307	274
1111	S18	-5759	274	1145	G29	-6323	157
1112	S17	-5775	157	1146	G31	-6339	274
1113	S16	-5791	274	1147	G33	-6355	157
1114	S15	-5807	157	1148	G35	-6371	274
1115	S14	-5823	274	1149	G37	-6387	157
1116	S13	-5839	157	1150	G39	-6403	274
1117	S12	-5855	274	1151	G41	-6419	157
1118	S11	-5871	157	1152	G43	-6435	274
1119	S10	-5887	274	1153	G45	-6451	157
1120	S9	-5903	157	1154	G47	-6467	274

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
1155	G49	-6483	157	1189	G117	-7027	157
1156	G51	-6499	274	1190	G119	-7043	274
1157	G53	-6515	157	1191	G121	-7059	157
1158	G55	-6531	274	1192	G123	-7075	274
1159	G57	-6547	157	1193	G125	-7091	157
1160	G59	-6563	274	1194	G127	-7107	274
1161	G61	-6579	157	1195	G129	-7123	157
1162	G63	-6595	274	1196	G131	-7139	274
1163	G65	-6611	157	1197	G133	-7155	157
1164	G67	-6627	274	1198	G135	-7171	274
1165	G69	-6643	157	1199	G137	-7187	157
1166	G71	-6659	274	1200	G139	-7203	274
1167	G73	-6675	157	1201	G141	-7219	157
1168	G75	-6691	274	1202	G143	-7235	274
1169	G77	-6707	157	1203	G145	-7251	157
1170	G79	-6723	274	1204	G147	-7267	274
1171	G81	-6739	157	1205	G149	-7283	157
1172	G83	-6755	274	1206	G151	-7299	274
1173	G85	-6771	157	1207	G153	-7315	157
1174	G87	-6787	274	1208	G155	-7331	274
1175	G89	-6803	157	1209	G157	-7347	157
1176	G91	-6819	274	1210	G159	-7363	274
1177	G93	-6835	157	1211	G161	-7379	157
1178	G95	-6851	274	1212	G163	-7395	274
1179	G97	-6867	157	1213	G165	-7411	157
1180	G99	-6883	274	1214	G167	-7427	274
1181	G101	-6899	157	1215	G169	-7443	157
1182	G103	-6915	274	1216	G171	-7459	274
1183	G105	-6931	157	1217	G173	-7475	157
1184	G107	-6947	274	1218	G175	-7491	274
1185	G109	-6963	157	1219	G177	-7507	157
1186	G111	-6979	274	1220	G179	-7523	274
1187	G113	-6995	157	1221	G181	-7539	157
1188	G115	-7011	274	1222	G183	-7555	274

PAD No.	PIN Name	X	Y	PAD No.	PIN Name	X	Y
1223	G185	-7571	157	1257	G253	-8115	157
1224	G187	-7587	274	1258	G255	-8131	274
1225	G189	-7603	157	1259	G257	-8147	157
1226	G191	-7619	274	1260	G259	-8163	274
1227	G193	-7635	157	1261	G261	-8179	157
1228	G195	-7651	274	1262	G263	-8195	274
1229	G197	-7667	157	1263	G265	-8211	157
1230	G199	-7683	274	1264	G267	-8227	274
1231	G201	-7699	157	1265	G269	-8243	157
1232	G203	-7715	274	1266	G271	-8259	274
1233	G205	-7731	157	1267	G273	-8275	157
1234	G207	-7747	274	1268	G275	-8291	274
1235	G209	-7763	157	1269	G277	-8307	157
1236	G211	-7779	274	1270	G279	-8323	274
1237	G213	-7795	157	1271	G281	-8339	157
1238	G215	-7811	274	1272	G283	-8355	274
1239	G217	-7827	157	1273	G285	-8371	157
1240	G219	-7843	274	1274	G287	-8387	274
1241	G221	-7859	157	1275	G289	-8403	157
1242	G223	-7875	274	1276	G291	-8419	274
1243	G225	-7891	157	1277	G293	-8435	157
1244	G227	-7907	274	1278	G295	-8451	274
1245	G229	-7923	157	1279	G297	-8467	157
1246	G231	-7939	274	1280	G299	-8483	274
1247	G233	-7955	157	1281	G301	-8499	157
1248	G235	-7971	274	1282	G303	-8515	274
1249	G237	-7987	157	1283	G305	-8531	157
1250	G239	-8003	274	1284	G307	-8547	274
1251	G241	-8019	157	1285	G309	-8563	157
1252	G243	-8035	274	1286	G311	-8579	274
1253	G245	-8051	157	1287	G313	-8595	157
1254	G247	-8067	274	1288	G315	-8611	274
1255	G249	-8083	157	1289	G317	-8627	157
1256	G251	-8099	274	1290	G319	-8643	274

PAD No.	PIN Name	X	Y
1291	DUMMY	-8659	157

5 BLOCK DIAGRAM



6 PIN DESCRIPTION

6.1.. Power Supply Pins

Name	I/O	Description	Connect Pin
VDD	I	Power Supply for Analog, Digital System and Booster Circuit.	VDD
VDDI	I	Power Supply for I/O System.	VDDI
AGND	I	System Ground for Analog System and Booster Circuit.	GND
DGND	I	System Ground for I/O System and Digital System.	GND

6.2.. Interface Logic Pins

Name	I/O	Description	Connect Pin																																																																								
IM3, IM2, IM1, IM0/ID	I	-The MCU interface mode select.<table><tr><th>IM3</th><th>IM2</th><th>IM1</th><th>IM0</th><th>MPU Interface Mode</th><th>Data pin</th></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>Setting invalid</td><td></td></tr><tr><td>0</td><td>0</td><td>0</td><td>1</td><td>Setting invalid</td><td></td></tr><tr><td>0</td><td>0</td><td>1</td><td>0</td><td>80-16bit</td><td>DB[17:10], DB[8:1]</td></tr><tr><td>0</td><td>0</td><td>1</td><td>1</td><td>80-8 bit</td><td>DB[17:10],</td></tr><tr><td>0</td><td>1</td><td>0</td><td>ID</td><td>SPI</td><td>SDI, SDO</td></tr><tr><td>0</td><td>1</td><td>1</td><td>--</td><td>Setting invalid</td><td></td></tr><tr><td>1</td><td>0</td><td>0</td><td>0</td><td>Setting invalid</td><td></td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>Setting invalid</td><td></td></tr><tr><td>1</td><td>0</td><td>1</td><td>0</td><td>80-18bit</td><td>DB[17:0],</td></tr><tr><td>1</td><td>0</td><td>1</td><td>1</td><td>80-9bit</td><td>DB[17:9],</td></tr><tr><td>1</td><td>1</td><td>--</td><td>--</td><td>Setting invalid</td><td></td></tr></table> -When the SPI interface is selected, IM0 pin will be used for the ID setting.	IM3	IM2	IM1	IM0	MPU Interface Mode	Data pin	0	0	0	0	Setting invalid		0	0	0	1	Setting invalid		0	0	1	0	80-16bit	DB[17:10], DB[8:1]	0	0	1	1	80-8 bit	DB[17:10],	0	1	0	ID	SPI	SDI, SDO	0	1	1	--	Setting invalid		1	0	0	0	Setting invalid		1	0	0	1	Setting invalid		1	0	1	0	80-18bit	DB[17:0],	1	0	1	1	80-9bit	DB[17:9],	1	1	--	--	Setting invalid		DGND/VDDI
IM3	IM2	IM1	IM0	MPU Interface Mode	Data pin																																																																						
0	0	0	0	Setting invalid																																																																							
0	0	0	1	Setting invalid																																																																							
0	0	1	0	80-16bit	DB[17:10], DB[8:1]																																																																						
0	0	1	1	80-8 bit	DB[17:10],																																																																						
0	1	0	ID	SPI	SDI, SDO																																																																						
0	1	1	--	Setting invalid																																																																							
1	0	0	0	Setting invalid																																																																							
1	0	0	1	Setting invalid																																																																							
1	0	1	0	80-18bit	DB[17:0],																																																																						
1	0	1	1	80-9bit	DB[17:9],																																																																						
1	1	--	--	Setting invalid																																																																							
RESET	I	-This signal will reset the device and it must be applied to properly initialize the chip. -Signal is active low.	MCU																																																																								
CSX	I	-Chip selection pin Low enable. High disable.	MCU																																																																								
DCX (RS)	I	-Display data/command selection pin in MCU interface. DCX='1': display data or parameter. DCX='0': command data. -If not used, please fix this pin at VDDI or DGND level.	MCU																																																																								
RDX	I	-Read enable in 8080 MCU parallel interface. -If not used, please fix this pin at VDDI or DGND level.	MCU																																																																								
WRX (SCL)	I	-Write enable in MCU parallel interface. In SPI mode, this is used as SCL. -If not used, please fix this pin at VDDI or DGND level.	MCU																																																																								
VSYNC	I	-Vertical (Frame) synchronizing input signal for RGB interface operation. VSPL = "0": Active low. VSPL = "1": Active high.	MCU																																																																								

Name	I/O	Description	Connect Pin
		-Fix to the GND level when not in use.	
HSYNC	I	-Horizontal (Line) synchronizing input signal for RGB interface operation. HSPL = "0": Active low. HSPL = "1": Active high. -Fix to the GND level when not in use	MCU
ENABLE	I	-Data enable signal for RGB interface operation. Low: Select (access enabled) High: Not select (access disabled) The EPL bit inverts the polarity of the ENABLE signal. -If not used, please fix this pin at VDDI or DGND level.	MCU
DOTCLK	I	-Dot clock signal for RGB interface operation. DPL = "0": Input data on the rising edge of DOTCLK DPL = "1": Input data on the falling edge of DOTCLK -If not used, please fix this pin at DGND level.	MCU
SDI	I	-SPI interface input pin. -The data is latched on the rising edge of the SCL signal. -If not used, please fix this pin at VDDI or DGND level.	MCU
SDO	O	-SPI interface output pin. -The data is outputted on the falling edge of the SCL signal. If not used, please fix this pin at floating.	MCU
DB[17:0]	I/O	-DB[17:0] are used as MCU parallel interface data bus. 8-bit I/F: DB[17:10] is used. 9-bit I/F: DB[17:9] is used. 16-bit I/F: DB[17:10] and DB[8:1] is used. 18-bit I/F: DB[17:0] is used. -DB[17:0] are used as RGB interface data bus. 6-bit RGB I/F: DB[17:12] are used. 16-bit RGB I/F: DB[17:13] and DB[11:1] are used. 18-bit RGB I/F: DB[17:0] are used. -If not used, please fix this pin at VDDI or DGND level.	MCU
FMARK	O	-Output a frame head pulse signal is used as synchronies MCU to frame rate -If not used, Let this pin open	MCU

Note1. "1" = VDDI level, "0" = DGND level.

Note2. When in parallel mode, unused data pins must be connected to "1" or "0".

Note3. When CSX="1", there is no influence to the parallel and serial interface.

6.3.. Driver Output Pins

Name	I/O	Description	Connect pin
S1 to S720	O	-Source driver output pins -To change the shift direction of signal outputs, use the SS bit. SS = "0", the data in the RAM address "h00000" is output from S1. SS = "1", the data in the RAM address "h00000" is output from S720. -When SS="0" S1, S4, S7, ... display red (R), S2, S5, S8, ... display green (G), and S3, S6, S9 ... display blue (B)	LCD
G1 to G320	O	-Gate driver output pins. VGH: Selecting Gate Lines Level. VGL: Non-selecting Gate Lines Level.	LCD
AVDD	O	-Power pad for analogy circuit. -Connect a capacitor for stabilization.	Capacitor
GVDD	O	- A power output of grayscale voltage generator. - When internal GVDD generator is not used, connect an external power supply (AVDD-0.5V) to this pin.	-
AVCL	O	- A power supply pin for generating GVCL. - Connect a capacitor for stabilization.	Capacitor
GVCL	O	- A power output (Negative) of grayscale voltage generator. - When internal GVCL generator is not used, connect an external power supply (AVCL+0.5V) to this pin.	-
VCL	O	- A power output of VCOM voltage (Negative) generator.	-
VGH	O	- Power output pin for gate driver	-
VGL	O	- Power output (Negative) pin for gate driver	-
VCC	O	- Monitoring pin of internal digital reference voltage.	-
VCOM	O	- A power supply for the TFT-LCD common electrode.	Common Electrode
VPP	I	- When writing NVM, it needs external power supply voltage (7.5V). - If not used, Let this pin open.	

6.4.. Test Pins

Name	I/O	Description	Connect pin
TPI3 TPI2 TPI1 TPI0	I	-These test pins for Driver vender test used. -Please connect these pins to DGND.	DGND
TPO7 TPO6 TPO5 TPO4 TPO3 TPO2 TPO1 TPO0	O	-These test pins for Driver vender test used. -Please open these pins.	Open
OSC	O	-This pin is for testing. -Please let these pin open.	-
Dummy	-	-These pins are dummy (have no function inside). -Can allow signal traces pass through these pads on TFT glass. -Please open these pins.	Open

7 DRIVER ELECTRICAL CHARACTERISTICS

7.1.. Absolute Operation Range

Item	Symbol	Rating	Unit
Supply Voltage	VDD	- 0.3 ~ +4.6	V
Supply Voltage (Logic)	VDDI	- 0.3 ~ +4.6	V
Supply Voltage (Digital)	VCC	-0.3 ~ +4.6	V
Driver Supply Voltage	VGH-VGL	-0.3 ~ +30.0	V
Logic Input Voltage Range	VIN	0.5 ~ VDDI + 0.5	V
Logic Output Voltage Range	VO	0.5 ~ VDDI + 0.5	V
Operating Temperature Range	TOPR	-30 ~ +85	°C
Storage Temperature Range	TSTG	-40 ~ +125	°C

Table 1 Absolute Operation Range

Note: If one of the above items is exceeded its maximum limitation momentarily, the quality of the product may be degraded. Absolute maximum limitation, therefore, specify the values exceeding which the product may be physically damaged. Be sure to use the product within the recommend range.

7.2.. DC Characteristics

Parameter	Symbol	Condition	Specification			Unit	Related Pins
			MIN.	TYP.	MAX.		
Power & Operation Voltage							
System Voltage	VDD	Operating voltage	2.5	2.75	3.3	V	
Interface Operation Voltage	VDDI	I/O Supply Voltage	1.65	1.8	3.3	V	
Gate Driver High Voltage	VGH		10		15	V	
Gate Driver Low Voltage	VGL		-12.4		-7.5	V	
Gate Driver Supply Voltage		VGH-VGL	17.5		27.4	V	
Input / Output							
Logic-High Input Voltage	VIH		0.8VDDI		VDDI	V	Note 1
Logic-Low Input Voltage	VIL		VSS		0.2VDDI	V	Note 1
Logic-High Output Voltage	VOH	IOH = -1.0mA	0.8VDDI		VDDI	V	Note 1
Logic-Low Output Voltage	VOL	IOL = +1.0mA	VSS		0.2VDDI	V	Note 1
Logic-High Input Current	IIH	VIN = VDDI			1	uA	Note 1
Logic-Low Input Current	IIL	VIN = VSS	-1			uA	Note 1
Input Leakage Current	IIL	IOH = -1.0mA	-0.1		+0.1	uA	Note 1
VCOM Voltage							
VCOM amplitude	VCOM		-2		-0.425	V	
Source Driver							
Source Output Range	VSout		GVCL		GVDD	V	
Gamma Reference Voltage(Positive)	GVDD		3.15		4.7	V	
Gamma Reference Voltage(Negative)	GVCL		-4.7		-3.15	V	
Source Output Settling Time	Tr	Below with 99% precision			20	us	Note 2
Output Offset Voltage	VOFFSET				35	mV	Note 3

Table 2 Basic DC Characteristics

Notes:

1. TA= -30 to 85 °C.
2. Source channel loading= 2KΩ+12pF/channel, Gate channel loading=5KΩ+40pF/channel.
3. The Max. value is between measured point of source output and gamma setting value.

7.3.. Power Consumption

Ta=25°C, Frame rate = 60Hz, Registers setting are IC default setting.

Operation Mode	Image	Current Consumption			
		Typical		Maximum	
		IDD (mA)	IDD (mA)	IDD (mA)	IDD (mA)
Normal Mode	Note 1	TBD	TBD	TBD	TBD
Stand-by Mode	Note 1	TBD	TBD	TBD	TBD

Table 3 Power Consumption

Notes:

1. All pixels black.
2. All pixels white.
3. The Current Consumption is DC characteristics of ST7781R.
4. Typical: VDDI=1.8V, VDD=2.75V; Maximum: VDDI=1.65 to 3.3V, VDD=2.5 to 3.3V

7.4.. AC Characteristics

7.4.1 8080 Series MCU Parallel Interface Characteristics: 18/16/9/8-bit Bus

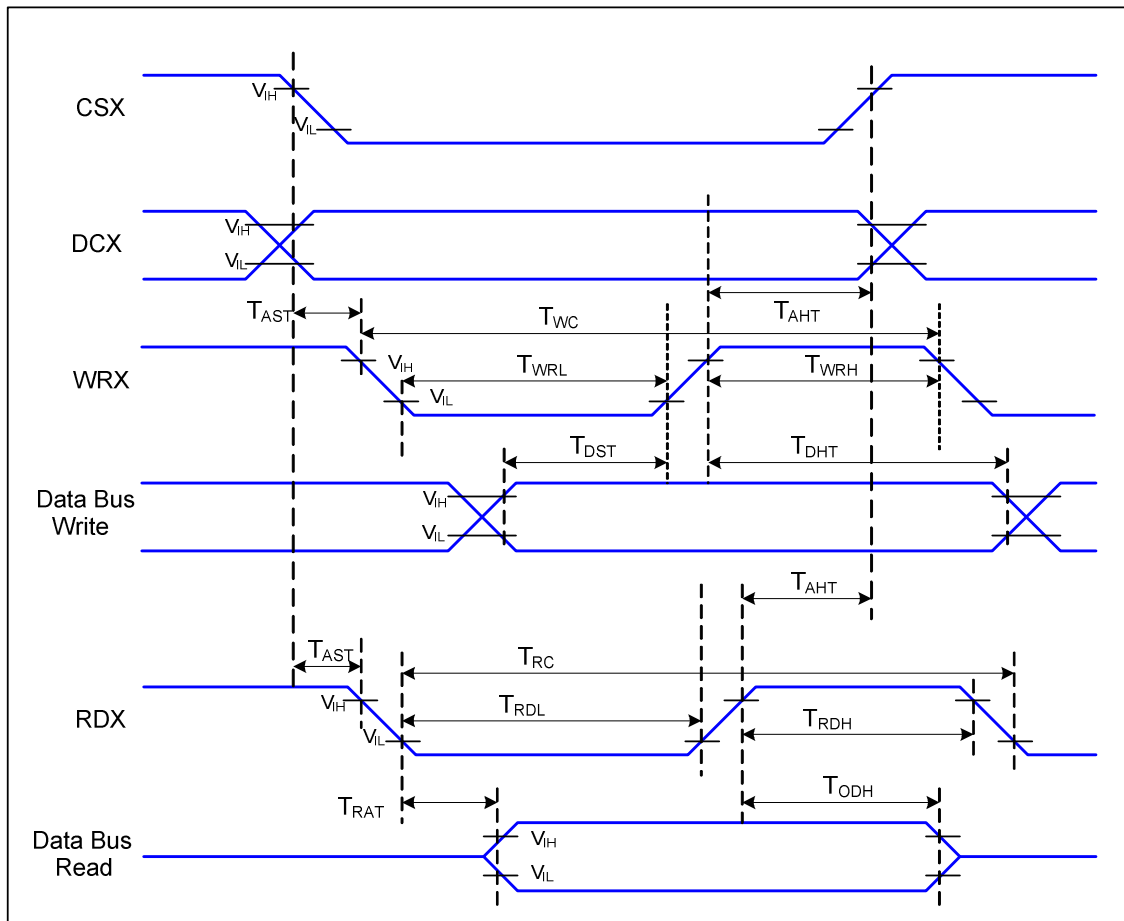


Figure 1 Parallel Interface Timing Characteristics (8080-Series MCU Interface)

$V_{DDI}=1.65$ to $3.3V$, $V_{DD}=2.5$ to $3.3V$, $AGND=DGND=0V$, $T_a=25^{\circ}C$

Signal	Symbol	Parameter	Min	Max	Unit	Description
DCX	TAST	Address Setup Time	TBD		ns	
	TAHT	Address Hold Time (Write/Read)	TBD		ns	
WRX	TWC	Write Cycle	TBD		ns	
	TWRH	Control Pulse "H" Duration	TBD		ns	
	TWRL	Control Pulse "L" Duration	TBD		ns	
RDX	TRC	Read Cycle (ID)	TBD		ns	When Read ID Data
	TRDH	Control Pulse "H" Duration (ID)	TBD		ns	
	TRDL	Control Pulse "L" Duration (ID)	TBD		ns	
DB[17:0]	TDST	Data Setup Time	TBD		ns	TRAT, TRATFM: 3K

Signal	Symbol	Parameter	Min	Max	Unit	Description
	TDHT	Data Hold Time	TBD		ns	ohm Pull up or Down and 30pF Parallel Cap. To GND. TODH: 3K ohm Pull up or Down.
	TRAT	Read Access Time (ID)		TBD	ns	
	TODH	Output Disable Time	TBD	TBD	ns	

Table 4 8080 Parallel Interface Characteristics

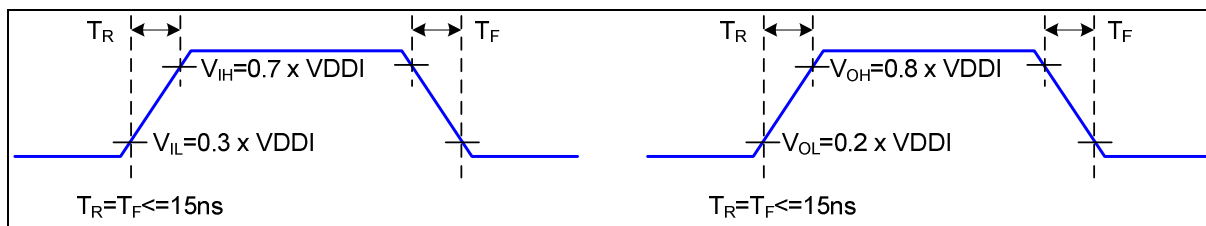


Figure 2 Rising and Falling Timing for I/O Signal

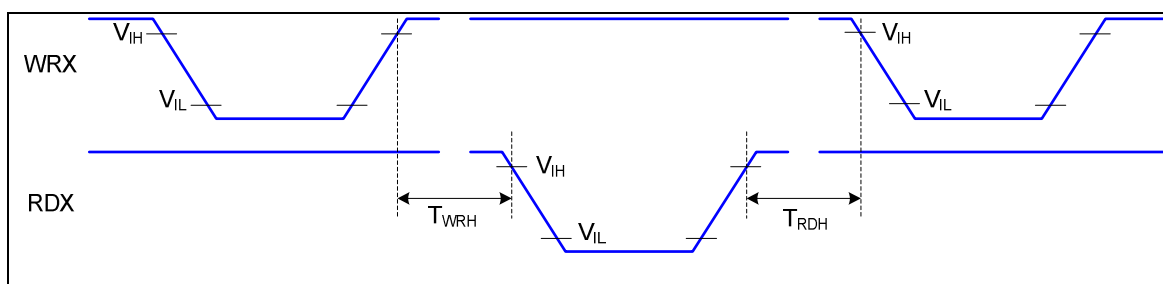


Figure 3 Write-to-Read and Read-to-Write Timing

Note: The rising time and falling time (T_r , T_f) of input signal and fall time are specified at 15 ns or less. Logic high and low levels are specified as 30% and 70% of VDDI for Input signals.

7.4.2 Serial Data Transfer Interface Characteristics:

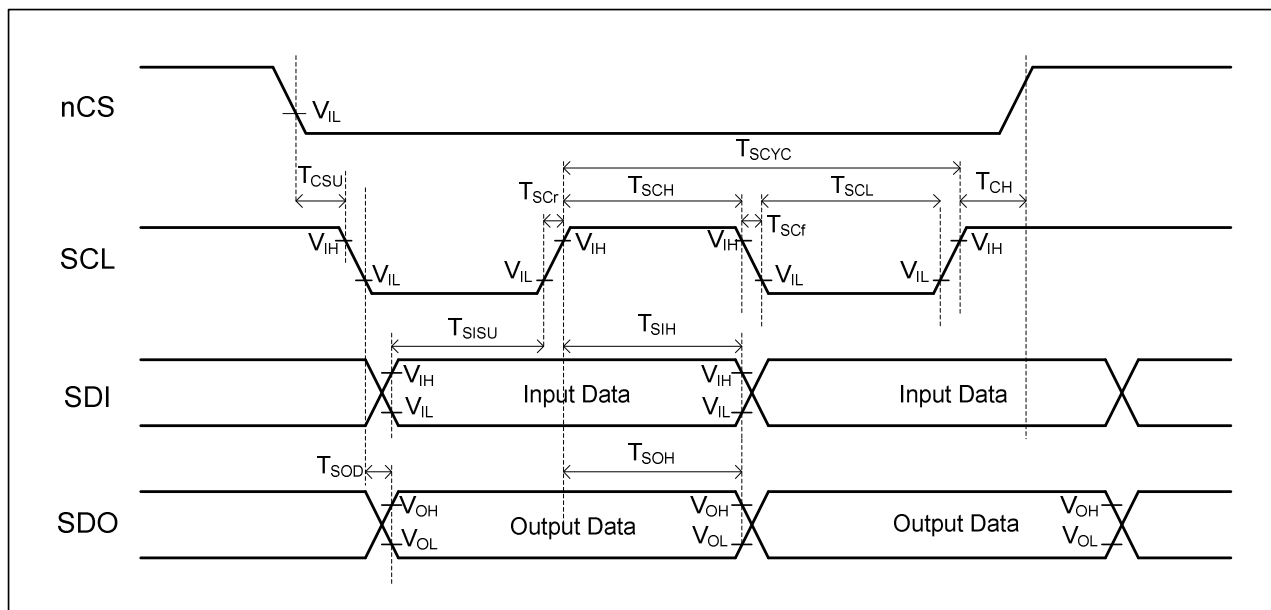


Figure 4 SPI Interface Timing Characteristics

VDDI=1.65 to 3.3V, VDD=2.5 to 3.3V, AGND=DGND=0V, Ta=25 °C

Signal	Symbol	Parameter	Min	Max	Unit	Description
CSX	TCSU	Chip Select Setup Time			ns	-
	TCH	Chip Select Hold Time			ns	
SCL	TSCr, TSCf	Serial clock rise/fall time			ns	
	TSCH	SCL "H" pulse width (Write)			ns	
	TSCH	SCL "H" pulse width (Read)			ns	
	TSCYC	Serial clock cycle (Write)			μs	
	TSCYC	Serial clock cycle (Read)			μs	
	TSCL	SCL "L" pulse width (Write)			ns	
	TSCL	SCL "L" pulse width (Read)			ns	
SDI	TSISU	Serial Input Data Setup Time			ns	
	TSIH	Serial Input Data Hold Time			ns	
SDO	TSOD	Serial Output Data Setup Time			ns	
	TSOH	Serial Output Data Hold Time			ns	

Table 5 SPI Interface Characteristics

7.4.3 RGB Interface Characteristics:

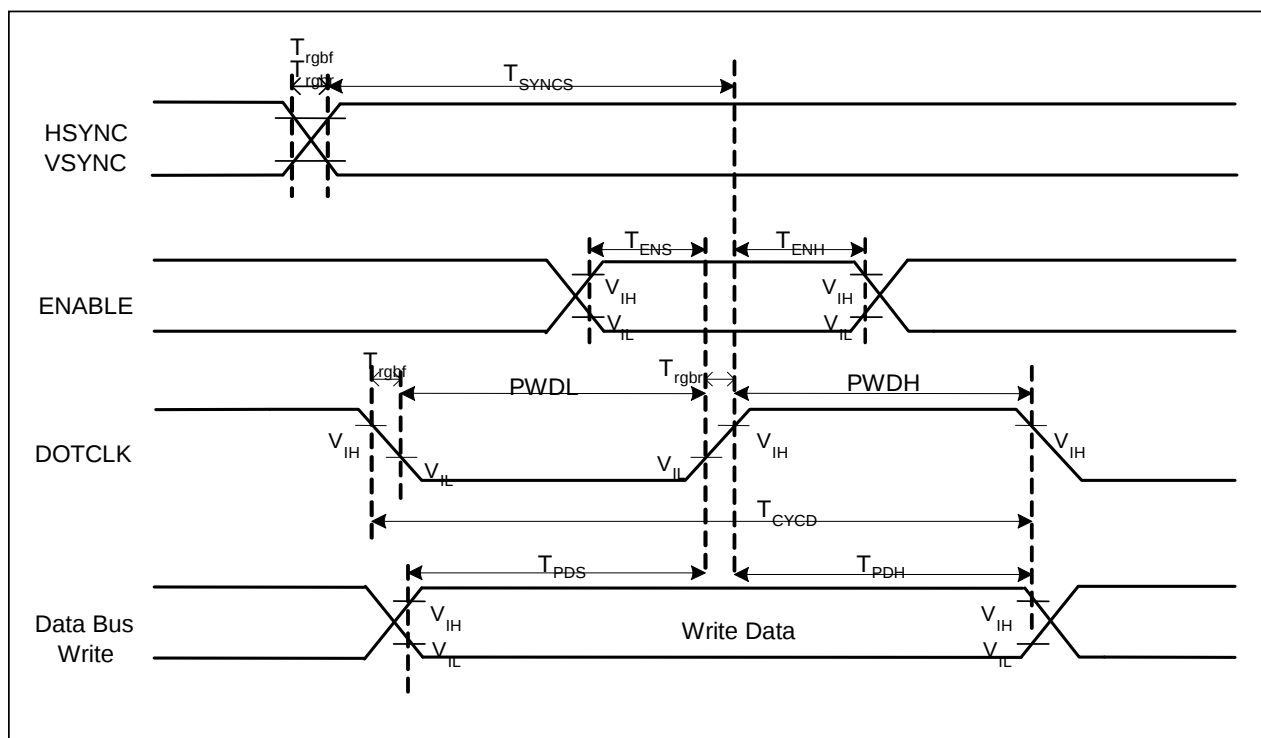


Figure 5 RGB Interface Timing Characteristics

VDDI=1.65 to 3.3V, VDD=2.5 to 3.3V, AGND=DGND=0V, Ta=25 °C

Signal	Symbol	Parameter	MIN	MAX	Unit	Description
HSYNC, VSYNC	TSYNCS	VSYNC, HSYNC Setup Time			ns	
	Trghr, Trghf	VSYNC, HSYNC Rise/Fall time			ns	
ENABLE	TENS	Enable Setup Time			ns	
	TENH	Enable Hold Time			ns	
DOTCLK	PWDH	DOTCLK High-level Pulse Width			ns	
	PWDL	DOTCLK Low-level Pulse Width			ns	
	TCYCD	DOTCLK Cycle Time			ns	
	Trghr, Trghf	DOTCLK Rise/Fall time			ns	
DB	TPDS	PD Data Setup Time			ns	
	TPDH	PD Data Hold Time			ns	

Table 6 18/16 Bits RGB Interface Timing Characteristics

Signal	Symbol	Parameter	MIN	MAX	Unit	Description
HSYNC, VSYNC	TSYNCS	VSYNC, HSYNC Setup Time			ns	
	Trghr, Trghf	VSYNC, HSYNC Rise/Fall time			ns	
ENABLE	TENS	Enable Setup Time			ns	
	TENH	Enable Hold Time			ns	
DOTCLK	PWDH	DOTCLK High-level Pulse Width			ns	
	PWDL	DOTCLK Low-level Pulse Width			ns	
	TCYCD	DOTCLK Cycle Time			ns	
	Trghr, Trghf	DOTCLK Rise/Fall time			ns	
DB	TPDS	PD Data Setup Time			ns	
	TPDH	PD Data Hold Time			ns	

Table 7 6 Bits RGB Interface Timing Characteristics

8 INTERFACE

8.1.. MPU Interface Type Selection

ST7781R supports 8/16/9/18 bit parallel data bus for 8080 series CPU, RGB serial interfaces. Selection of these interfaces are set by IM[3:0] pins as shown below.

IM3	IM2	IM1	IM0	Interface	Read Back Data Bus Selection
0	0	0	0	Setting invalid	
0	0	0	1	Setting invalid	
0	0	1	0	8080 MCU 16-bit Parallel	16-bit Read Data and 8-bit Read Parameter
0	0	1	1	8080 MCU 8-bit Parallel	8-bit Read Data and 8-bit Read Parameter
0	1	0	ID	Serial Peripheral Interface(SPI)	16-bit Command and 16 / 24bit Parameter
0	1	1	--	Setting invalid	
1	0	0	0	Setting invalid	
1	0	0	1	Setting invalid	
1	0	1	0	8080 MCU 18-bit Parallel	18-bit Read Data and 8-bit Read Parameter
1	0	1	1	8080 MCU 9-bit Parallel	9-bit Read Data and 8-bit Read Parameter
1	1	--	--	Setting invalid	

Table 8 Interface Type Selection

8.2.. 8080-Series MCU Write Cycle Sequence

The write cycle means that the host writes information (command / data) to the display via the interface. Each write cycle (WRX high-low-high sequence) consists of 3 control signals (DCX, RDX, WRX) and data signals (DB[17:0]). DCX bit is a control signal, which tells if the data is a command or a data. The data signals are the command if the control signal is low (= '0') and vice versa it is data (= '1').

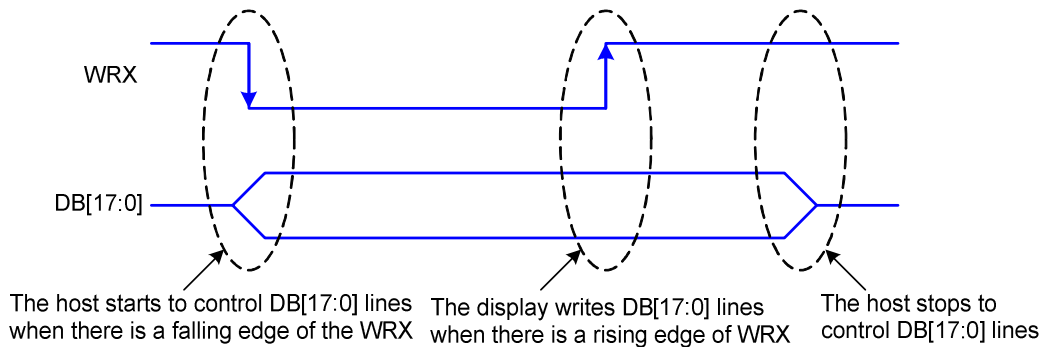


Figure 6 8080-Series WRX Protocol

Note: WRX is an unsynchronized signal (It can be stopped).

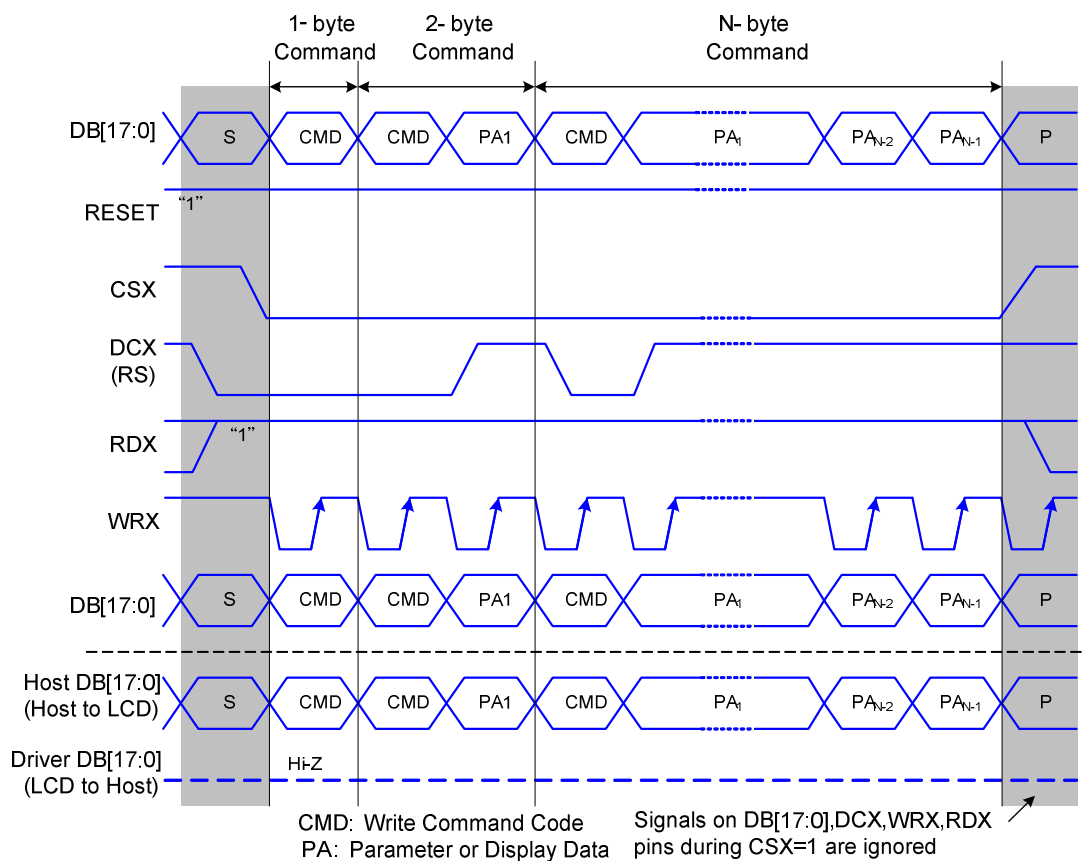


Figure 7 8080-Series Parallel Bus Protocol, Write to Register or Display RAM

8.2.1 8080-18 bits Interface Write Data Format

The 8080-18bits interface is selected by setting the IM [3:0] = "1010". This mode only 262k colors format in display. In this interface write instructions and DRAM method following figure.

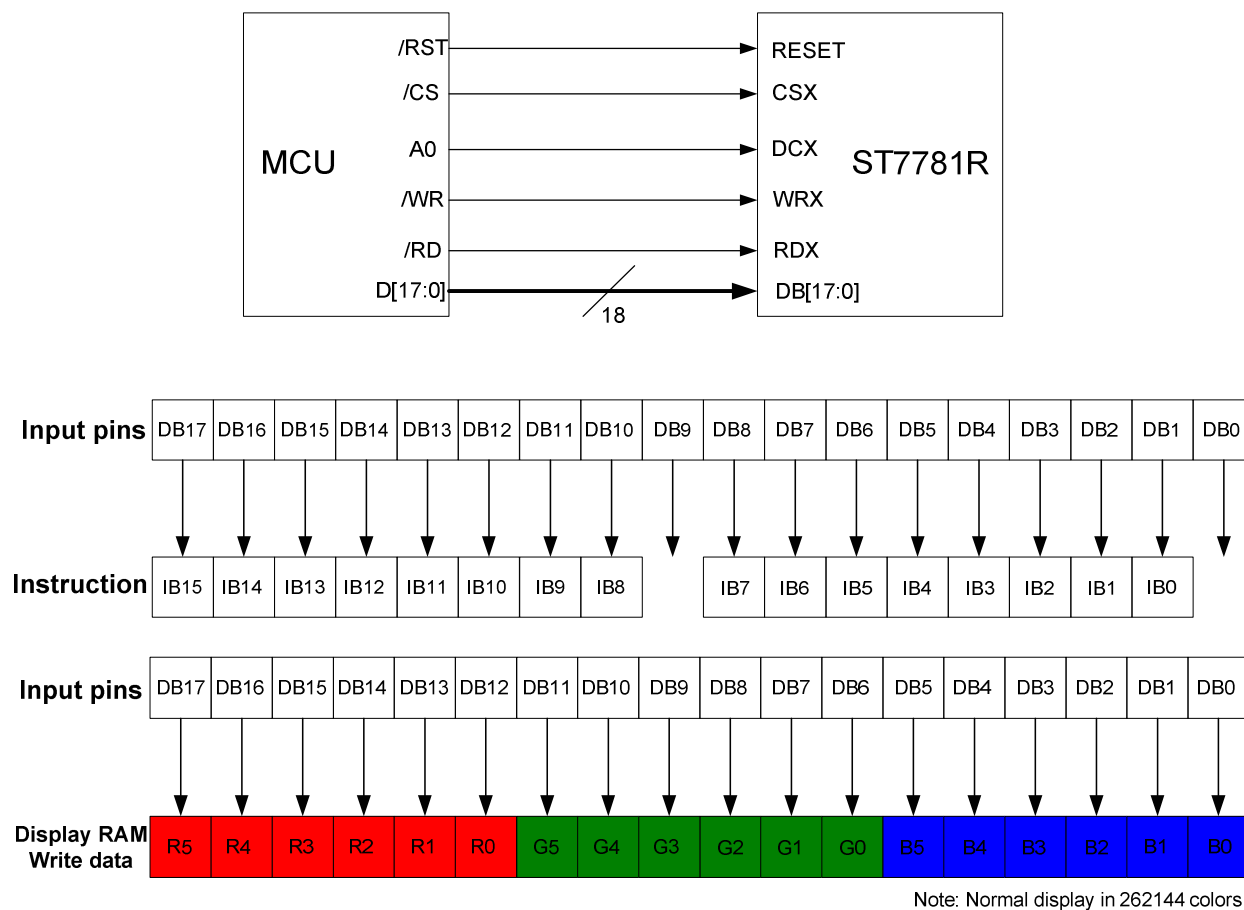


Figure 8 8080-18 bits Interface Data Format (Command Write/DRAM Write)

8.2.2 8080-16 bits Interface Write Data Format

The 8080-16bits interface is selected by setting IM [3:0] = "0010". The mode can display 262k or 65k colors format. When the 262k color format is display, two transfers mode is used (first transfer: 2 bits, second transfer: 16 bits or first transfer: 16 bits, second transfer: 2 bits).

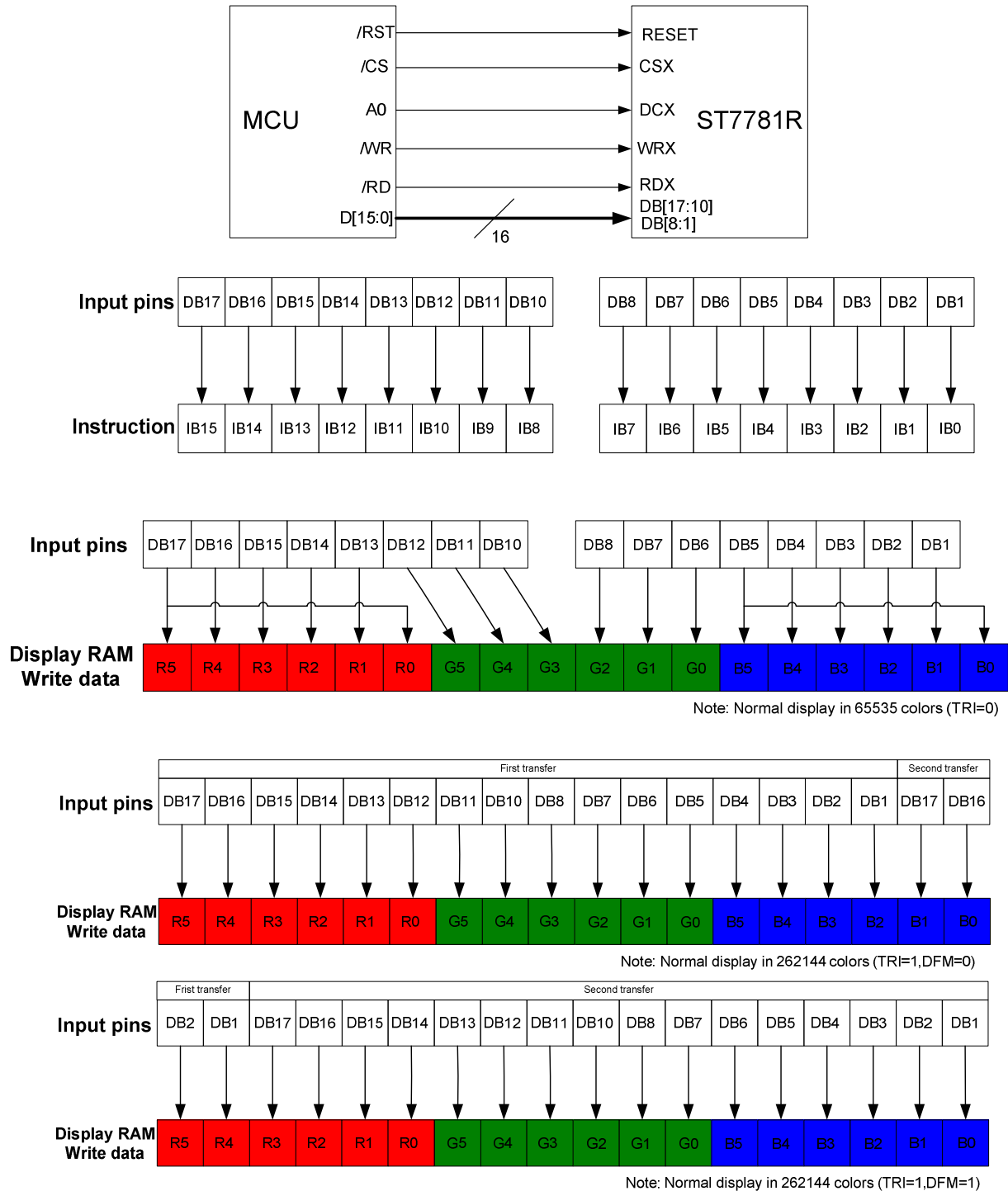


Figure 9 8080-16 bits Interface Data Format (Command Write/Display RAM Write)

8.2.3 8080-9 bits Interface Write Data Format

The 8080-9bits interface is selected by setting the IM [3:0] = "1011" and the DB [17:9] pins are used to transfer the data. When writing the 16-bit register, the data is divided into upper byte and lower byte and the upper byte is transferred first. The display data is also divided in upper byte (9 bits) and lower byte, and the upper byte is transferred first. The unused DB [8:0] pins must be tied to either VDDI or DGND.

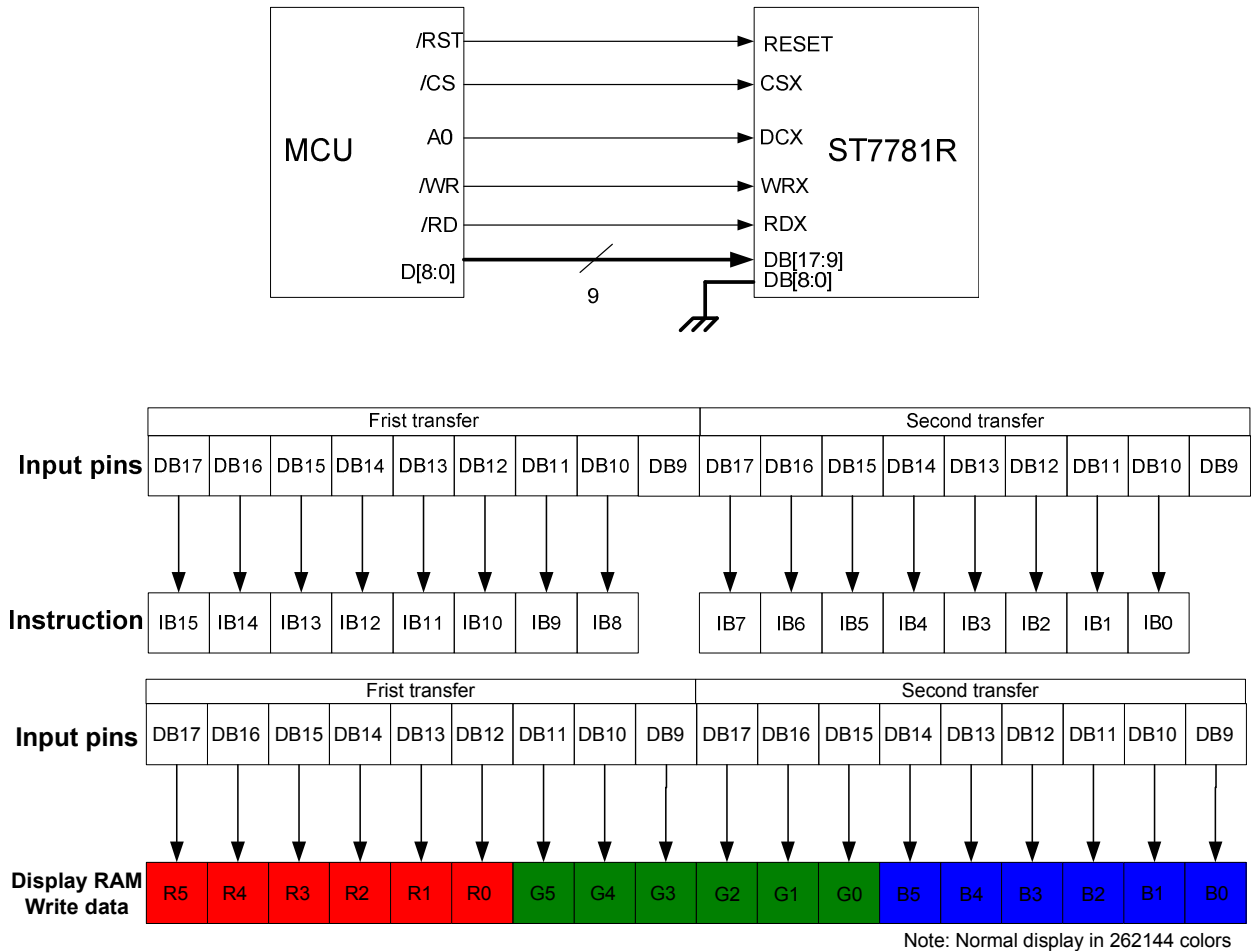
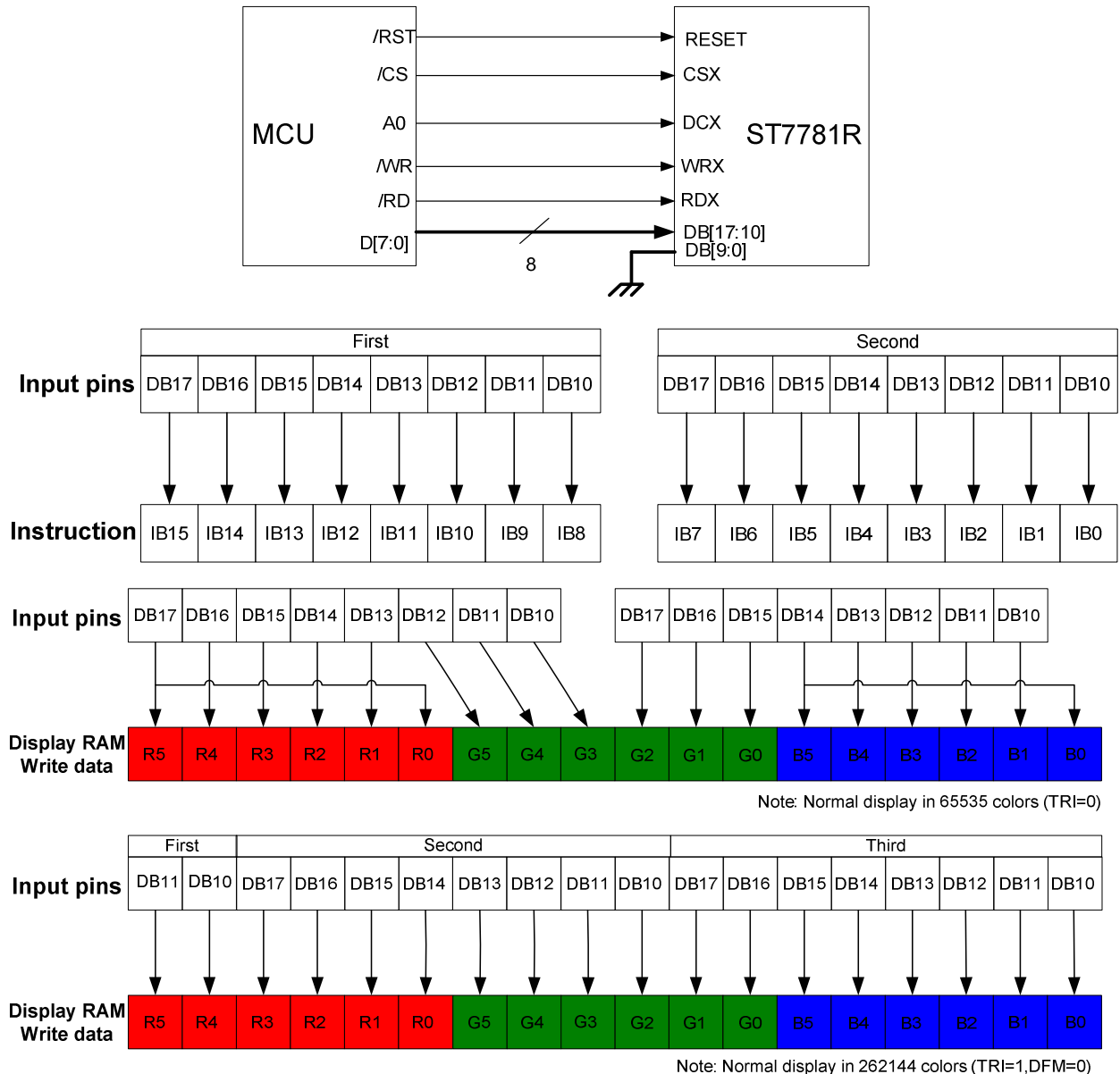
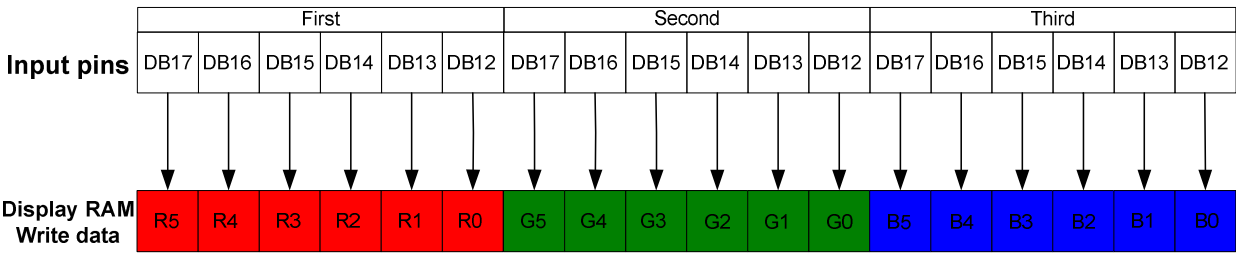


Figure 10 8080-9 bits Interface Data Format (Command Write/Display RAM Write)

8.2.4 8080-8 bits Interface Write Data Format

The 8080 8-bit interface is selected by setting the IM [3:0] as “0011” and the DB [17:10] pins are used to transfer the data. The mode can display 262k or 65k colors format. When writing the 16-bit register, the data is divided into upper byte lower byte and the upper byte is transferred first. The display data is also divided in upper byte (8 bits) and lower byte, and the upper byte is transferred first. The written data is expanded into 18 bits internally (see the figure below) and then written into DRAM. The unused DB [9:0] pins must be tied to either VDDI or DGND.





Note: Normal display in 262144 colors (TRI=1,DFM=1)

Figure 11 8080-8 bits interface data format (command write/Display RAM write)

8.2.5 8080-series MCU Read Cycle Sequence

The read cycle (RDX “1”- “0”- “1” sequence) means that the host reads information from display via interface. The driver sends data (DB [17:0]) to the host when there is a falling edge of RDX and the host reads data when there is a rising edge of RDX.

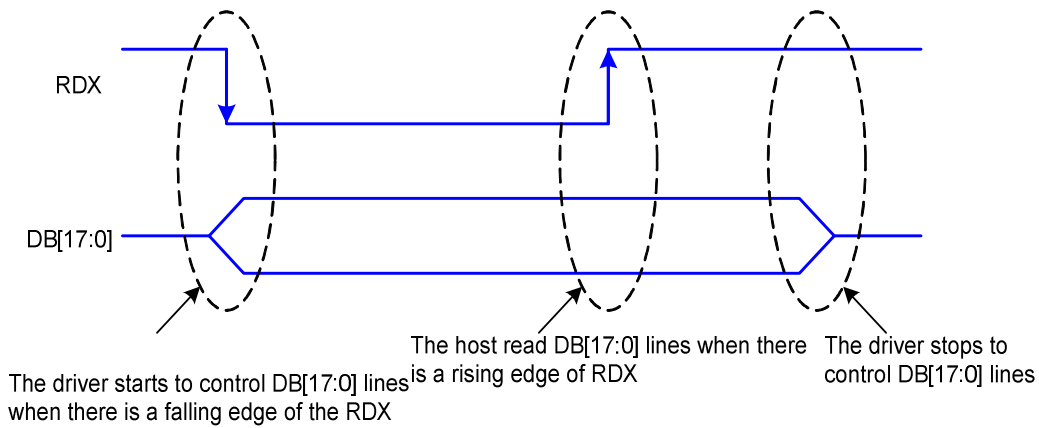


Figure 12 8080-Series RDX Protocol

Note1: RDX is an unsynchronized signal (It can be stopped)

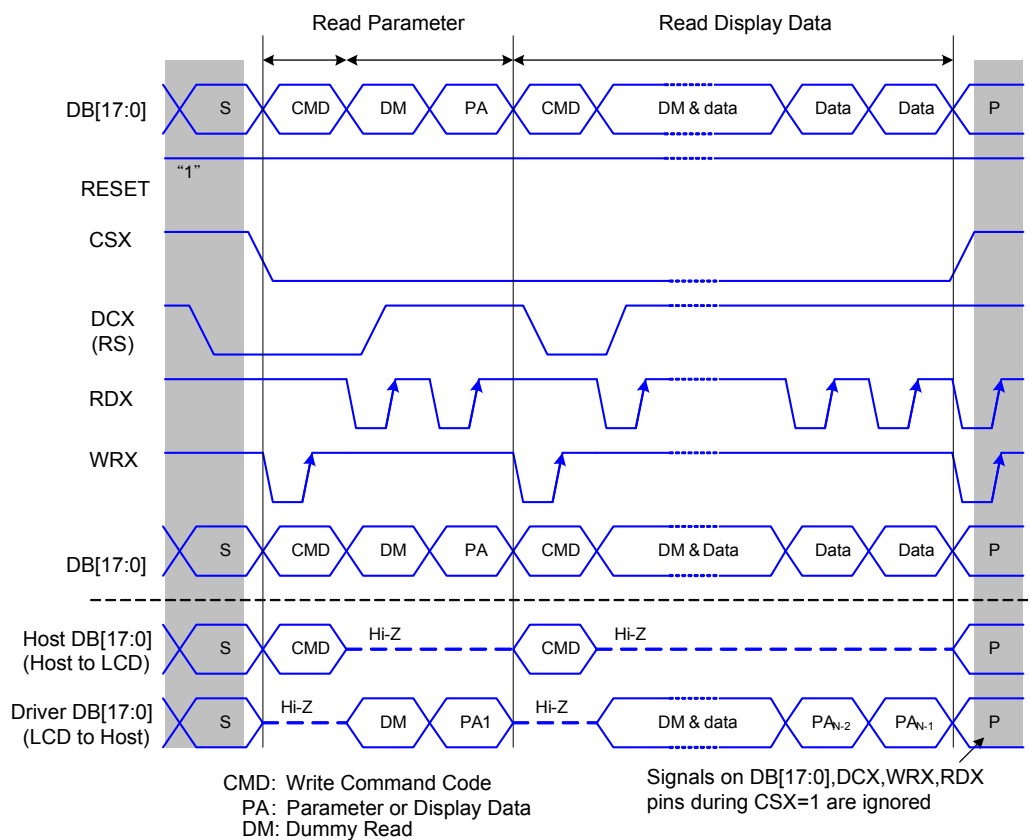


Figure 13 8080-series parallel bus protocol, read data from register or display RAM

8.2.6 8080-18bits interface read data format

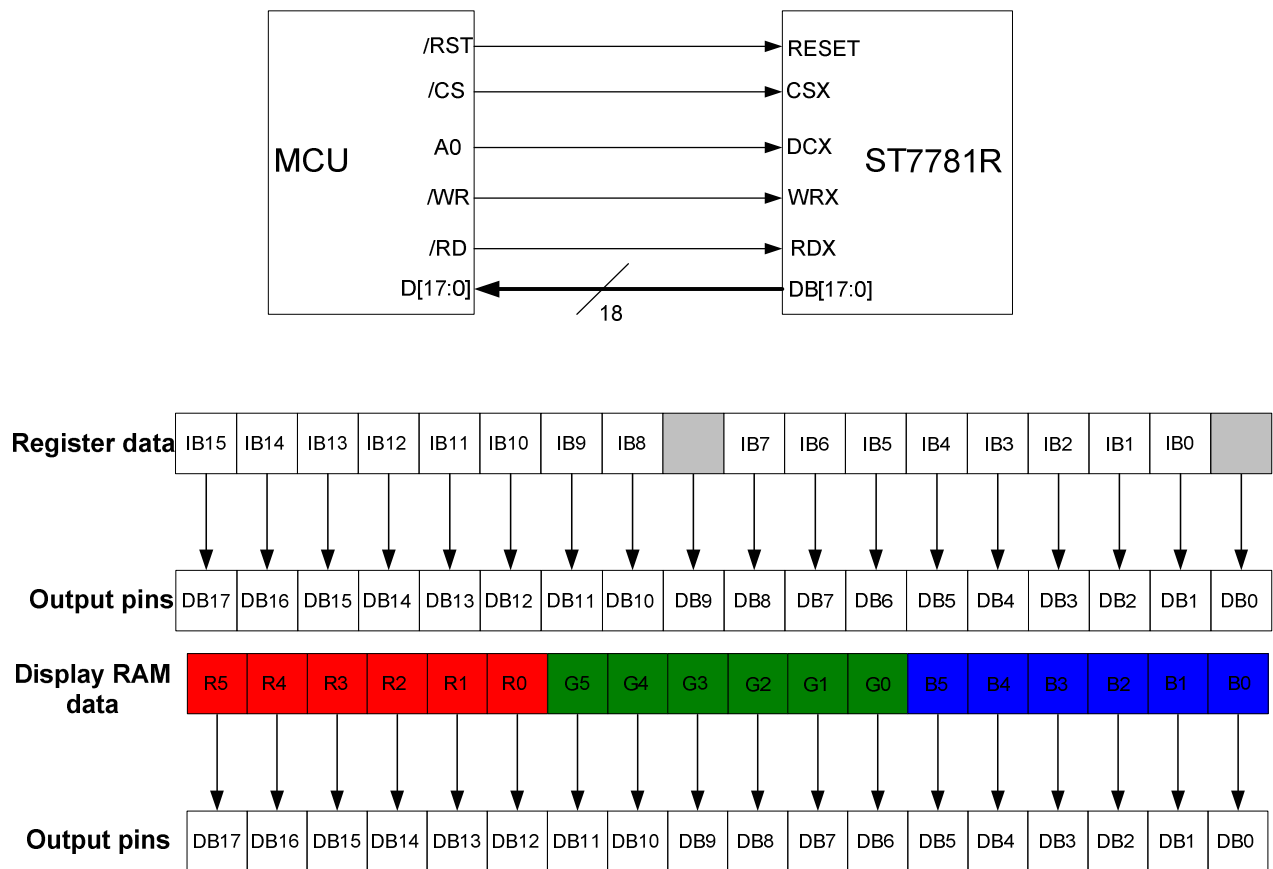


Figure 14 8080-18 bits Interface Data Format (Command Read/Display RAM Read)

8.2.7 8080-16bits Interface Read Data Format

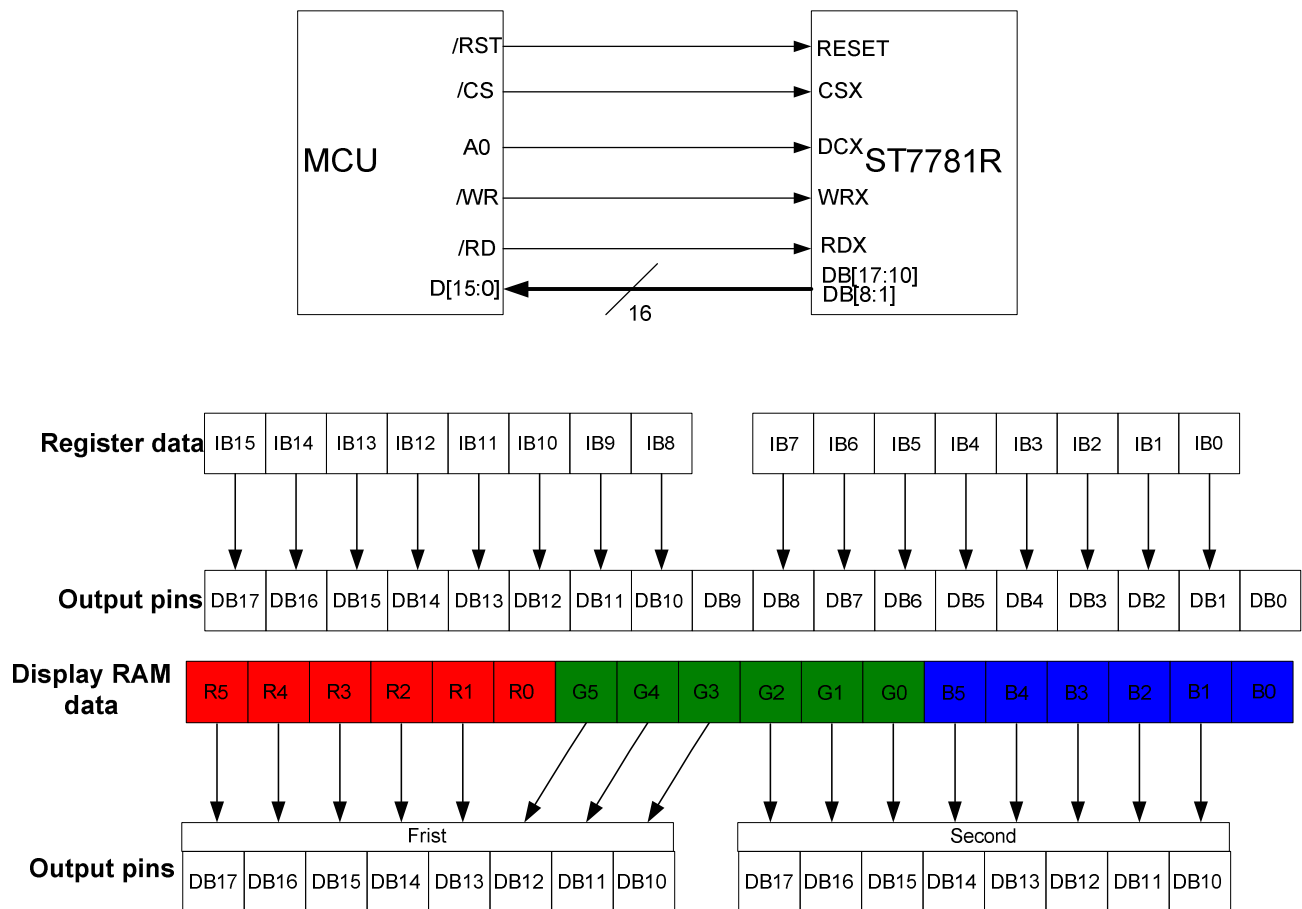


Figure 15 8080-16 bits Interface Data Format (Command Read/Display RAM Read)

8.2.8 8080-9bits Interface Read Data Format

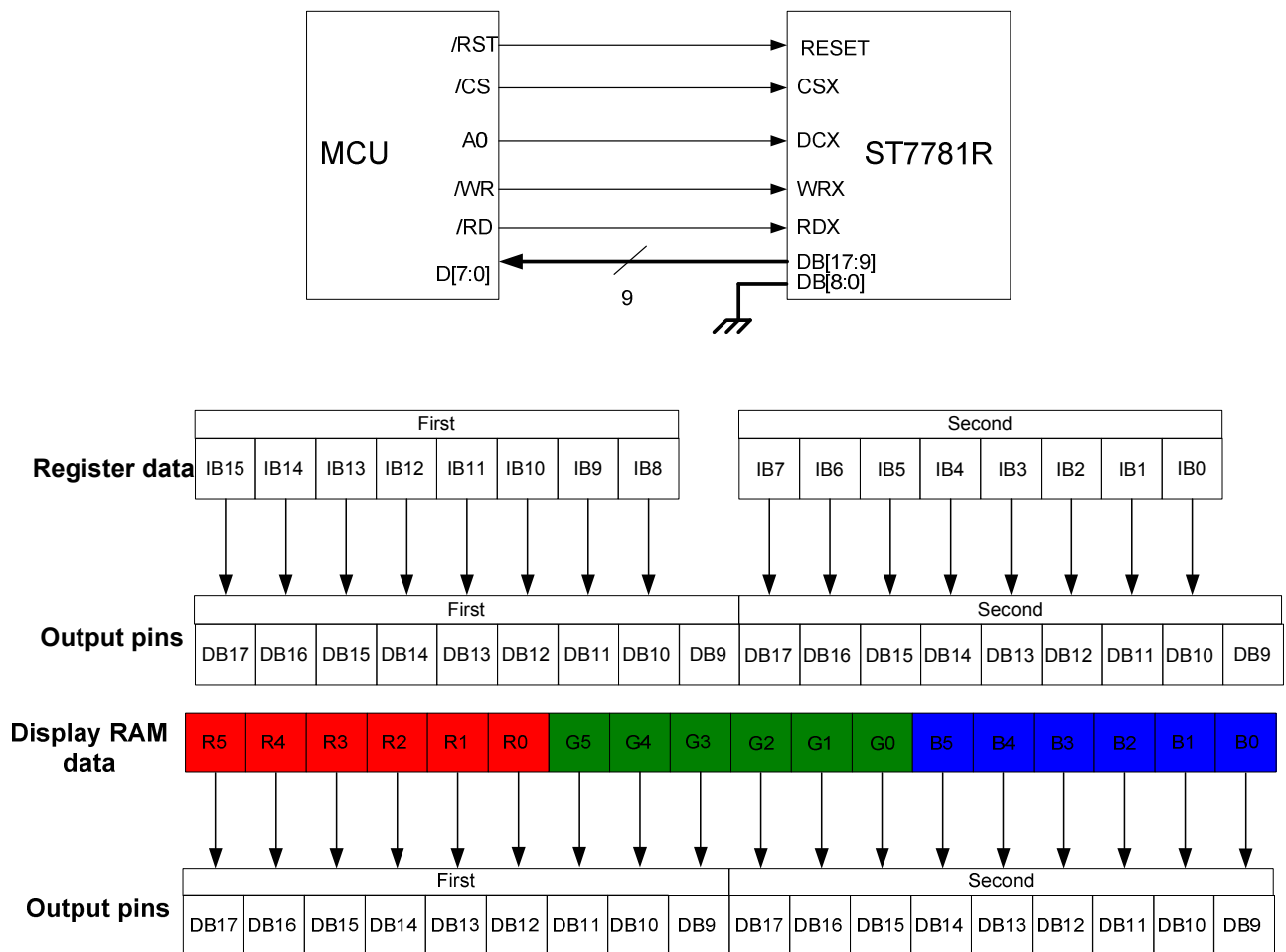


Figure 16 8080-9 bits Interface Data Format (Command Read/Display RAM Read)

8.2.9 8080-8bits Interface Read Data Format

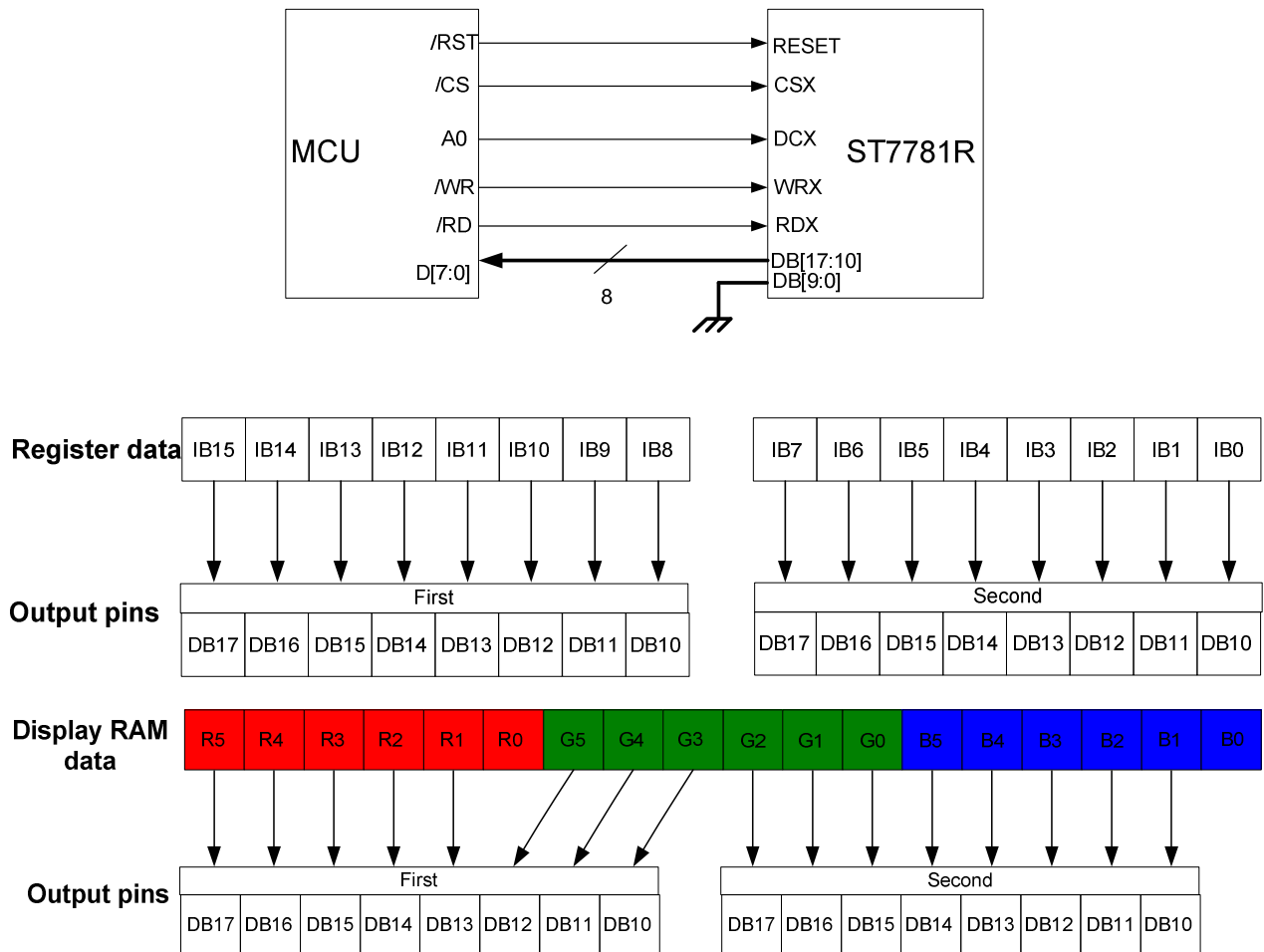


Figure 17 8080-8 bits Interface Data Format (Command Read/Display RAM Read)

GS = '1'	GS = '0'	SS = '0'	S1	S2	S3	S4	S5	S6	-----	S715	S716	S717	S718	S719	S720
		SS = '1'	S718	S719	S720	S715	S716	S717	-----	S4	S5	S6	S1	S2	S3
		BGR='0'	R	G	B	R	G	B	-----	R	G	B	R	G	B
		BGR='1'	B	G	R	B	G	R		B	G	R	B	G	R
G320	G1	X Address	"0000"h			"0001"h			-----	"00EE"h			"00EF"h		
		Y Address	"0000"h			"0000"h				"0000"h			"0000"h		
G319	G2	X Address	"0000"h			"0001"h			-----	"00EE"h			"00EF"h		
		Y Address	"0001"h			"0001"h				"0001"h			"0001"h		
—	—								-----						
—	—														
—	—														
—	—														
G2	G319	X Address	"0000"h			"0001"h			-----	"00EE"h			"00EF"h		
		Y Address	"013E"h			"013E"h				"013E"h			"013E"h		
G1	G320	X Address	"0000"h			"0001"h			-----	"00EE"h			"00EF"h		
		Y Address	"013F"h			"013F"h				"013F"h			"013F"h		

Figure 18 DRAM Address Map Table

Note:

X Address Start Instruction : R50h

X Address End Instruction : R51h

Y Address Start Instruction : R52h

Y Address End Instruction : R53h

SS/GS Setting Instruction : R01h

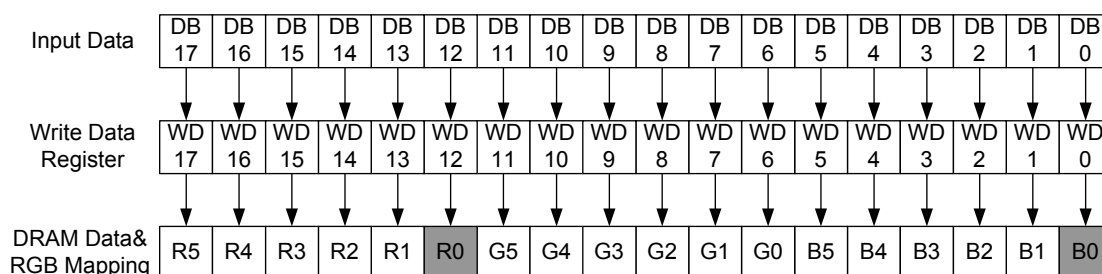
BGR Setting Instruction : R03h

8.3.. RGB Input Interface

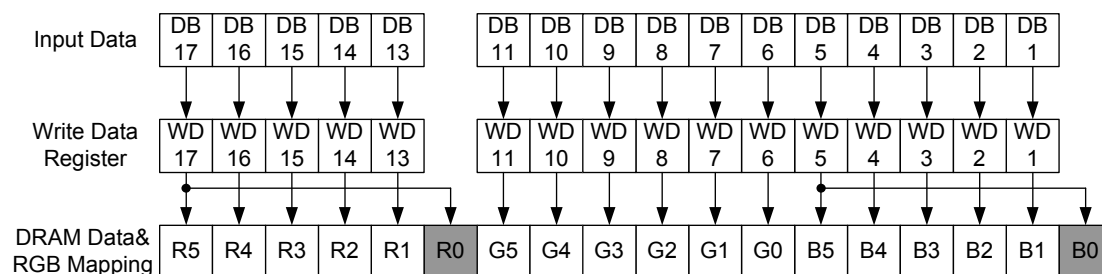
The RGB Interface mode for ST7781R is selected by setting the RIM[1:0] bits as following table.

RIM1	RIM0	RGB Interface Mode	Data pins
0	0	18-bit RGB Interface	DB[17:0]
0	1	16-bit RGB Interface	DB[17:13], DB[11:1]
1	0	6-bit RGB Interface	DB[17:12]
1	1	Setting prohibited	

18-bit RGB Interface (262K colors)



16-bit RGB Interface (65K colors)



6-bit RGB Interface (262K colors)

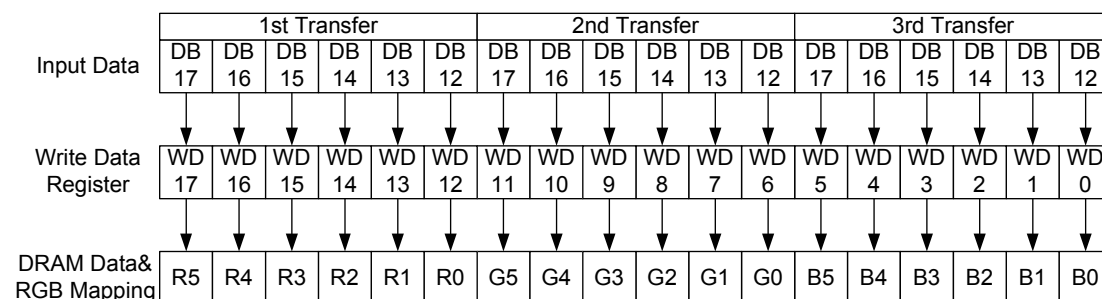


Figure 19 RGB Interface Data Format

8.3.1 RGB Interface

The display operation via the RGB interface is synchronized with the VSYNC, HSYNC, and DOTCLK signals. The data can be written only within the specified area with low power consumption by using window address function and high-speed write mode (HWM = 1). The back porch and front porch are used to set the RGB interface timing.

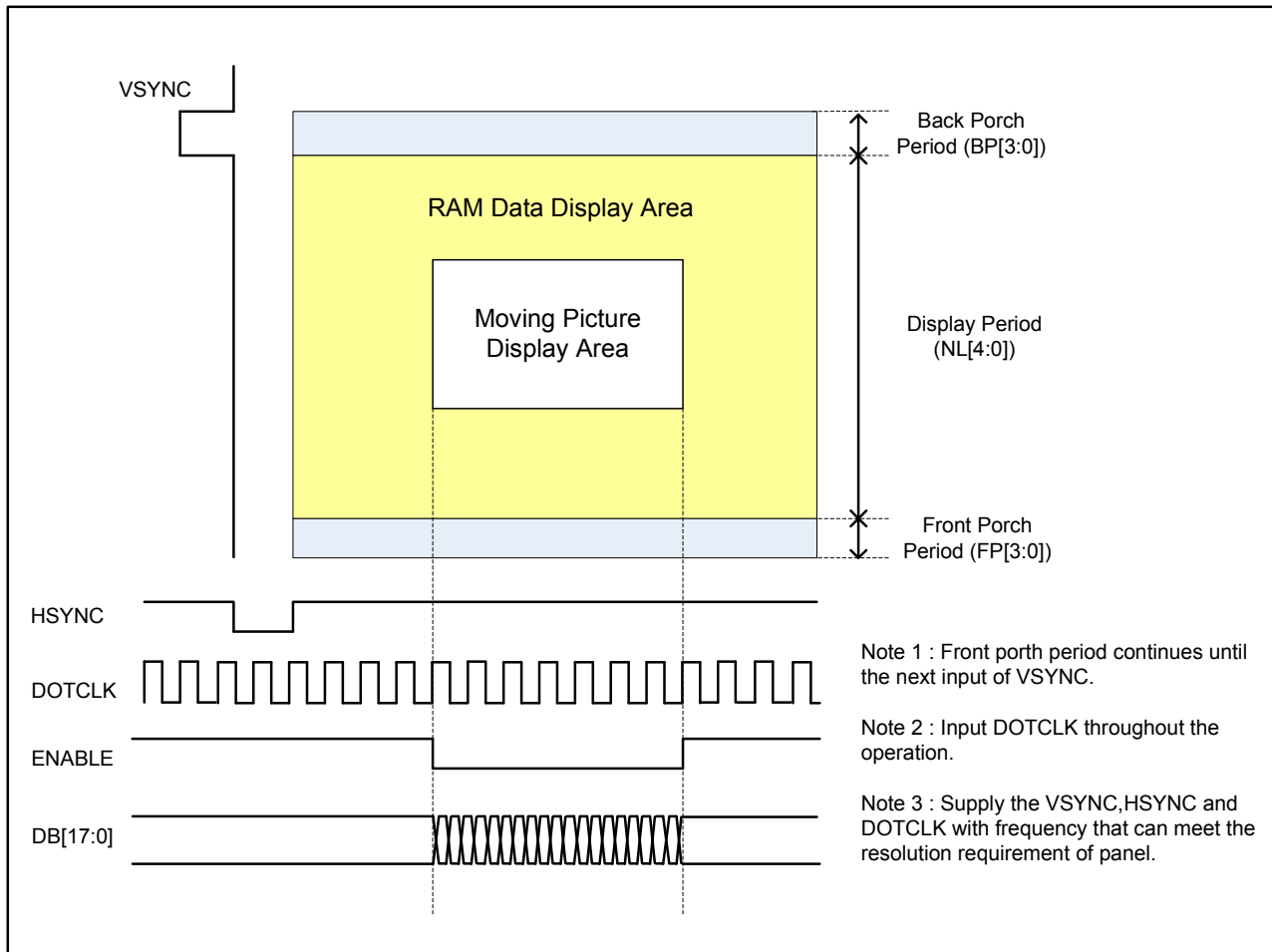


Figure 20 DRAM Access Area by RGB Interface

8.3.2 RGB Interface Timing

The timing chart of 18-/16-bit RGB interface mode is shown as follows.

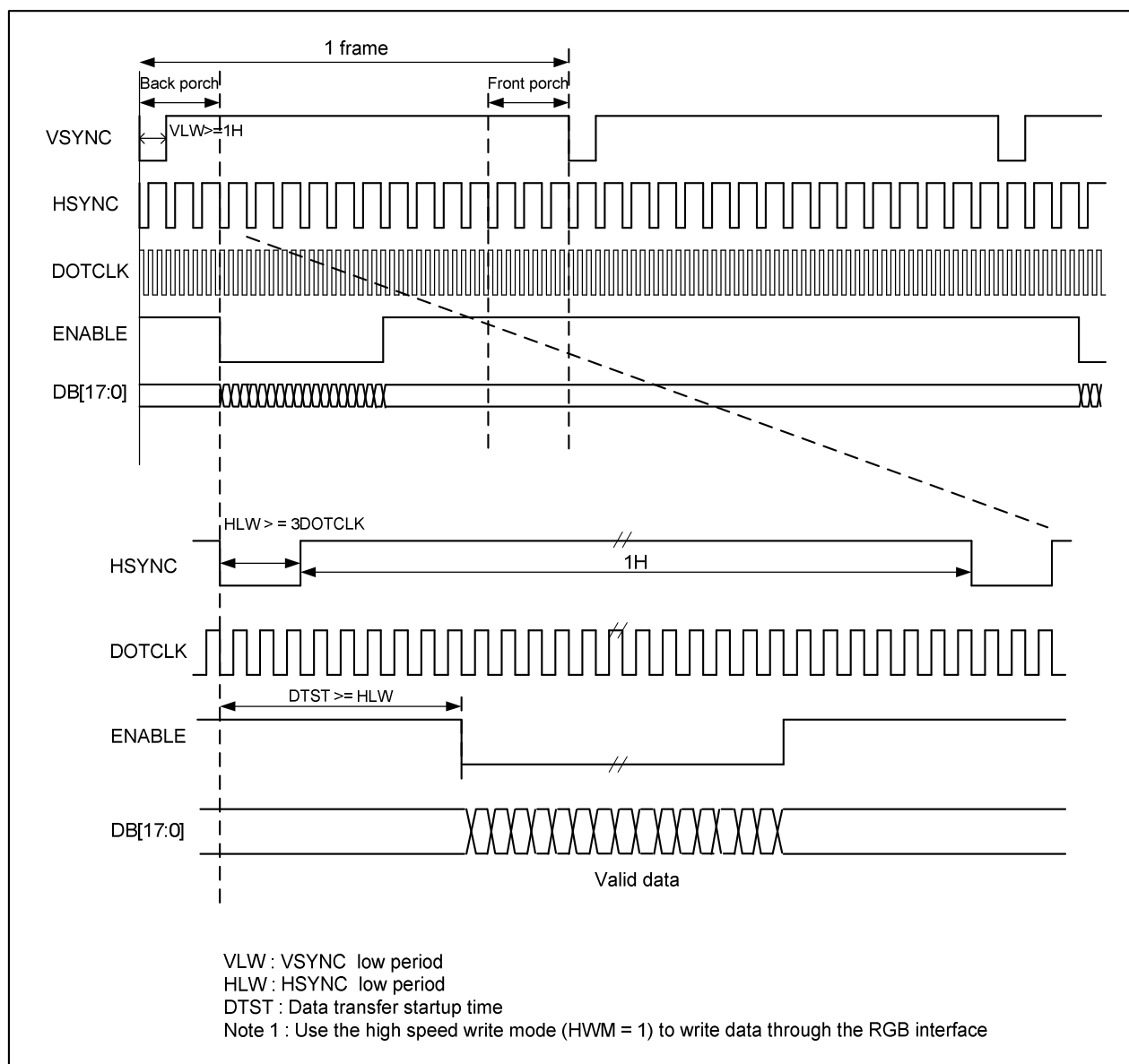


Figure 21 Timing Chart of Signals in 18-/16-bit RGB Interface Mode

The timing chart of 6-bit RGB interface mode is shown as follows.

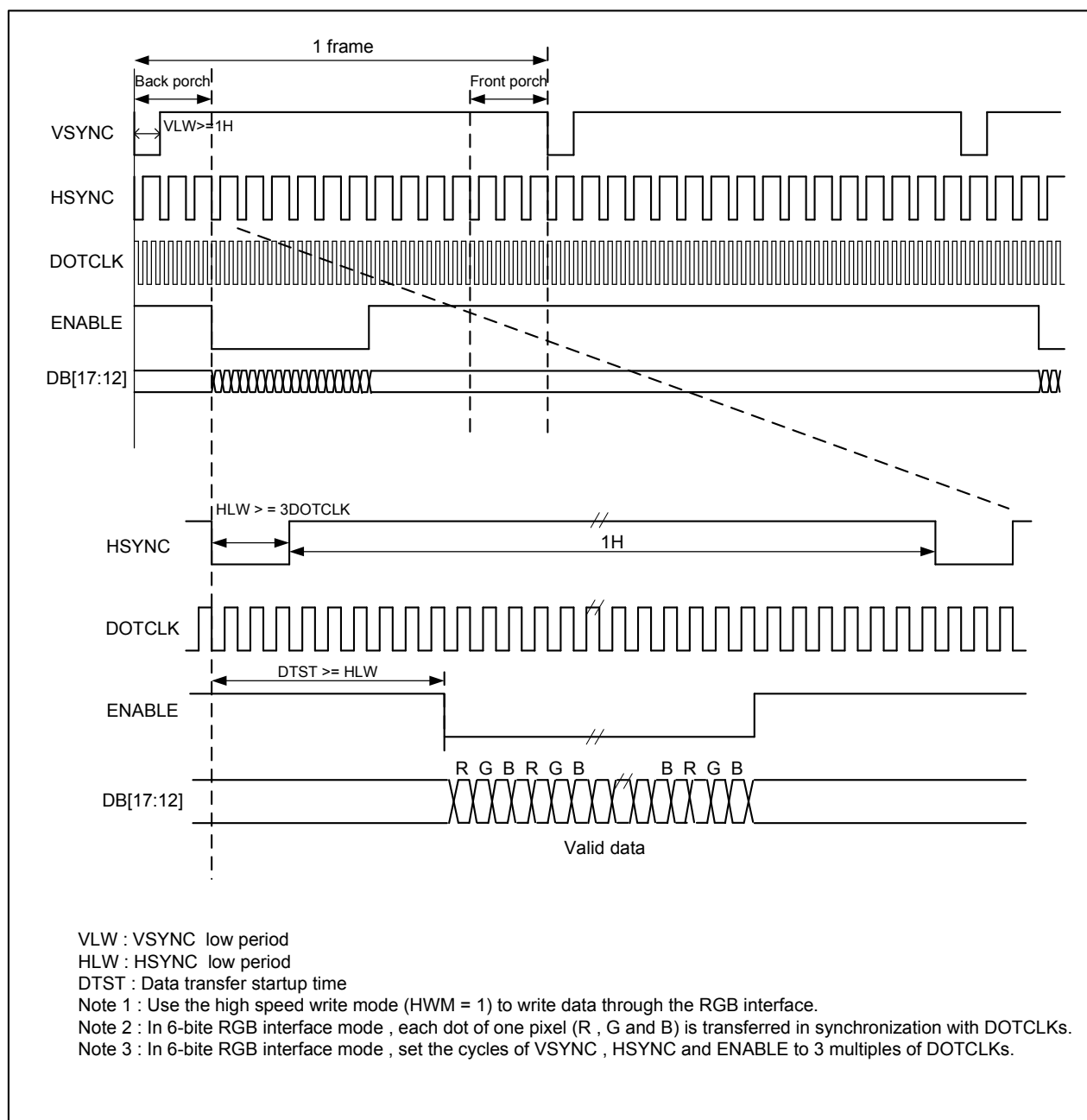


Figure 22 Timing chart of signals in 6-bit RGB interface mode

8.3.3 Moving Picture Mode

ST7781R has the RGB interface to display moving picture and incorporates DRAM to store display data, which has following merits in displaying a moving picture.

- The window address function defined the update area of DRAM.
- The DRAM is updated only the moving picture area.
- It can contribute to lower the power consumption of the system by reducing data transfer.
- When display the moving picture in RGB interface mode, the DB[17:0] can be switched as system interface to update still picture area and registers, such as icons.

RAM access via a system interface in RGB-I/F mode

ST7781R allows DRAM access via the system interface in RGB interface mode. In RGB interface mode, data are written to the internal DRAM in synchronization with DOTCLK while ENABLE signal is "Low". When write data to the internal DRAM by the system interface, set ENABLE("High") to stop write data via RGB interface. Then set RM = "0" to enable RAM access via system interface. When restart RAM access in RGB interface mode, wait one read/write cycle, set RM = "1" and then the index register (R22h) to start accessing RAM via the RGB interface. If RAM accesses via two interfaces conflicts, there is no guarantee that data are written to the internal DRAM.

The following figure illustrates the operation of the ST7781R when displaying a moving picture via the RGB interface and rewriting the still picture RAM area via the system interface.

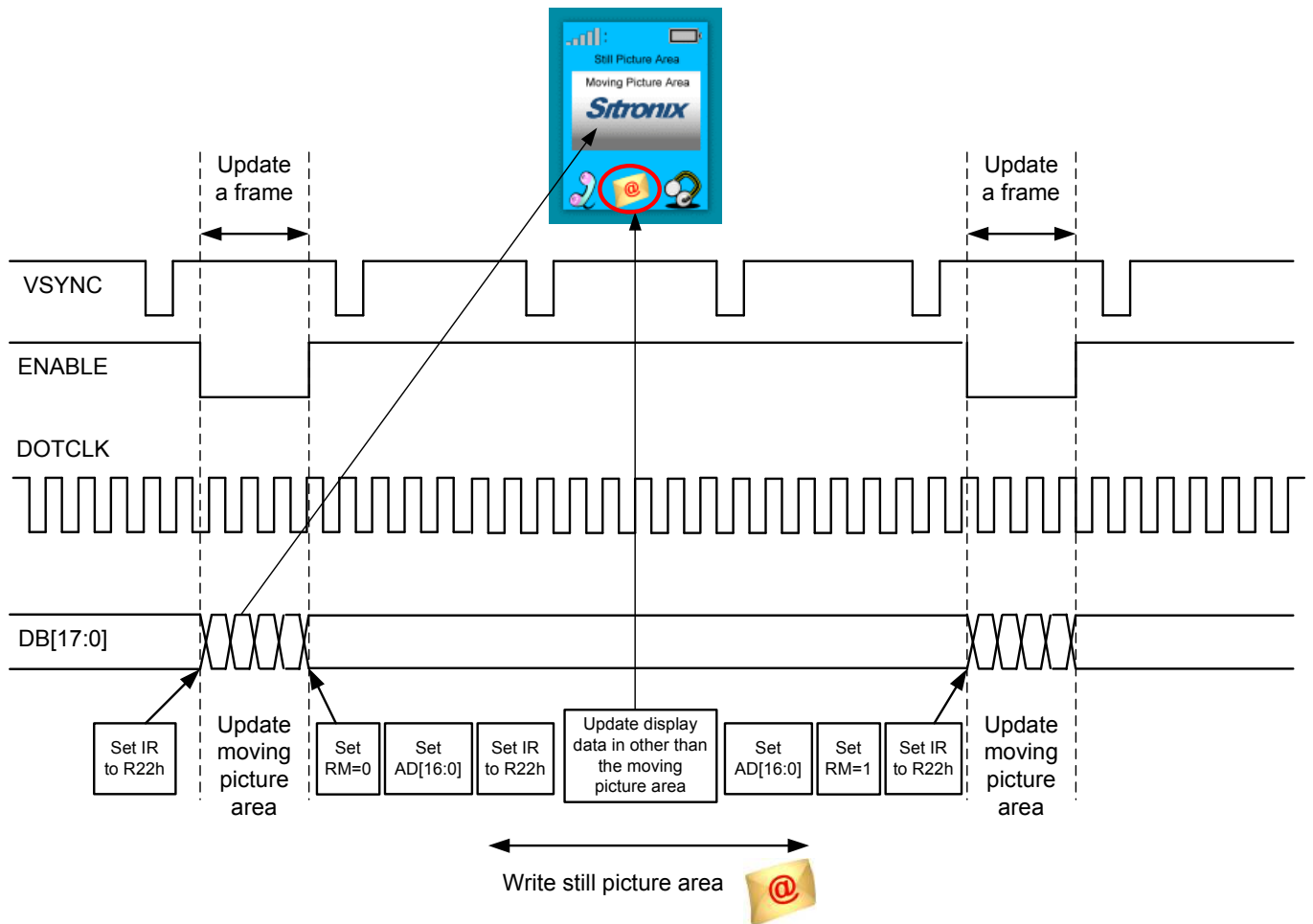
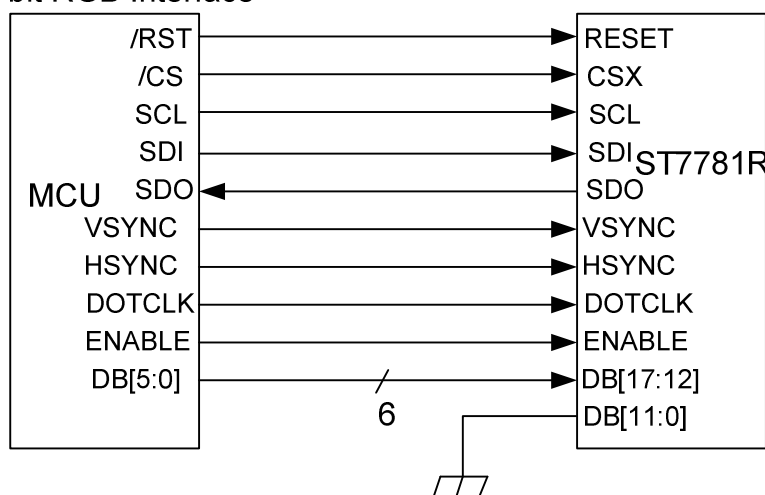


Figure 23 Example of update the still and moving picture

8.3.4 6-bit RGB Interface

The 6-bit RGB interface is selected by setting the RIM[1:0] bits to "10". The display operation is synchronized with VSYNC, HSYNC, and DOTCLK signals. Display data are transferred to the internal DRAM in synchronization with the display operation via 6-bit RGB data bus (DB[17:12]) according to the data enable signal (ENABLE). Unused pins (DB[11:0]) must be fixed at GND level. Registers can be set by the system interface (i80/SPI).

6-bit RGB Interface



RGB Interface With 6-bit Data Bus (RIM=10)

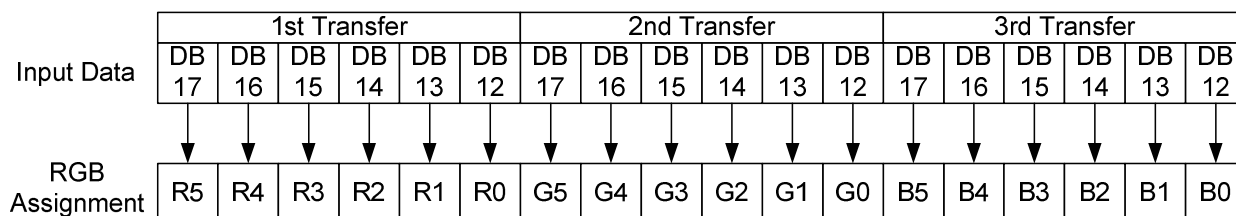


Figure 24 Example of 6-bit RGB interface data format

Data transfer synchronization in 6-bit RGB interface mode

St7781R has counters to count the first, second, third 6 bit transfers via 6-bit RGB interface. The transfer counters are always reset to first data on the falling edge of VSYNC from the next frame period. If a mismatch data transfer occurs, the correct data transfer will be restart via 6 bit interface in next frame period. When data transfer is consecutively in moving picture operation, this function can help the display system restoring normal display operation and minimizes effects in occurring mismatch data transfer.

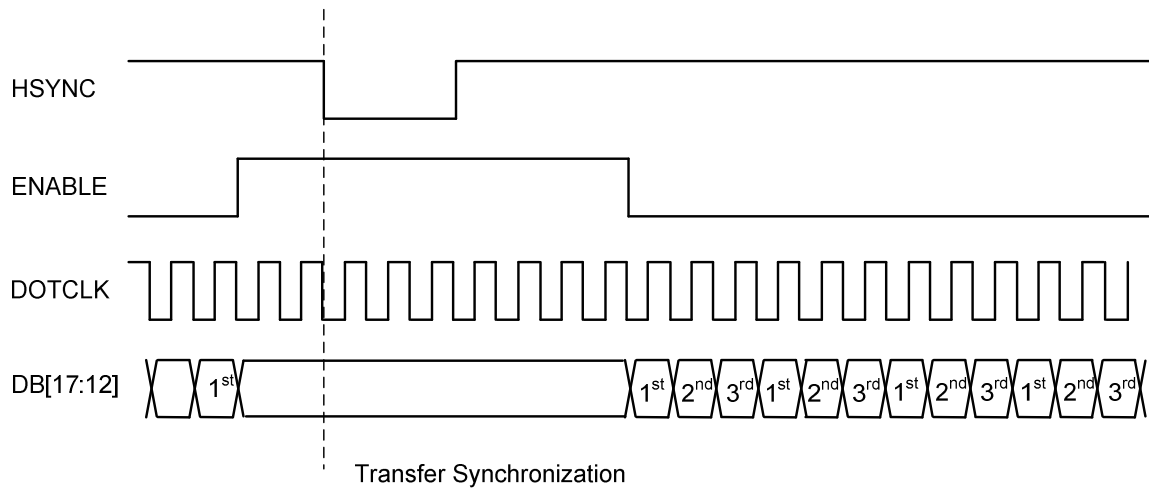
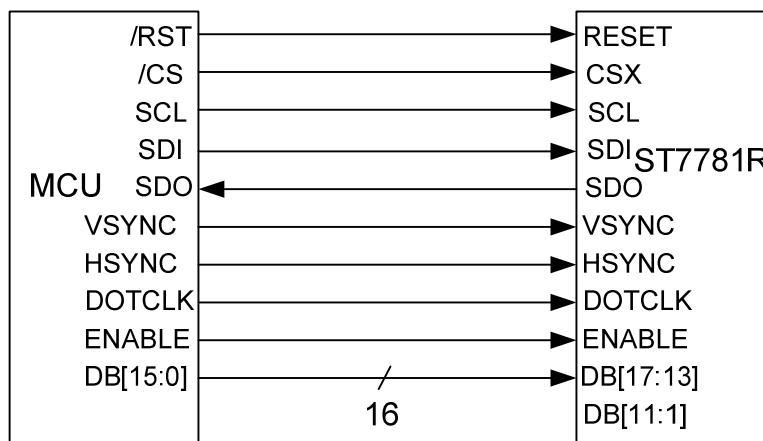


Figure 25 6-bit Transfer Synchronization

8.3.5 16-bit RGB Interface

The 16-bit RGB interface is selected by setting the RIM[1:0] bits to "01". The display operation is synchronized with VSYNC, HSYNC, and DOTCLK signals. Display data are transferred to the internal RAM in synchronization with the display operation via 16-bit RGB data bus (DB[17:13], DB[11:1]) according to the data enable signal (ENABLE). Registers are set only via the system interface.

16-bit RGB Interface



16-bit RGB Interface (65K colors)

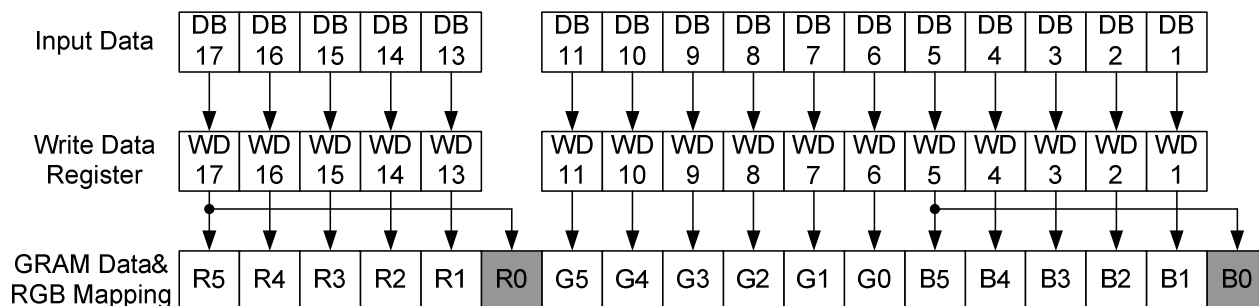
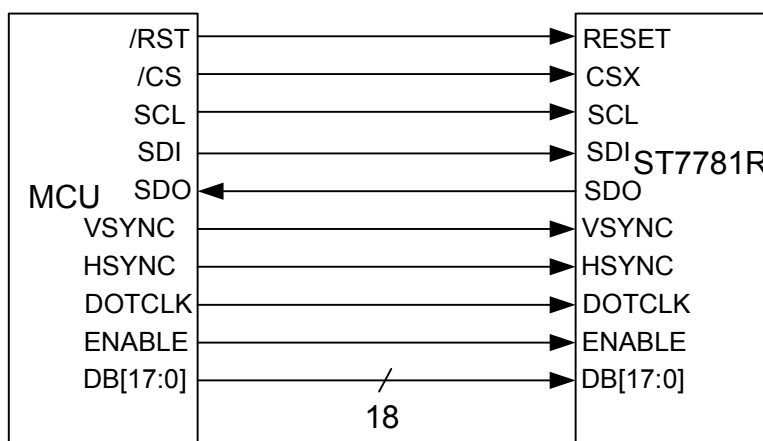


Figure 26 Example of 16-Bit RGB Interface and Data Format

8.3.6 18-bit RGB Interface

The 18-bit RGB interface is selected by setting the RIM[1:0] bits to "00". The display operation is synchronized with VSYNC, HSYNC, and DOTCLK signals. Display data are transferred to the internal RAM in synchronization with the display operation via 18-bit RGB data bus (DB[17:0]) according to the data enable signal (ENABLE). Registers are set only via the system interface.

18-bit RGB Interface



RGB Interface With 18-bit Data Bus

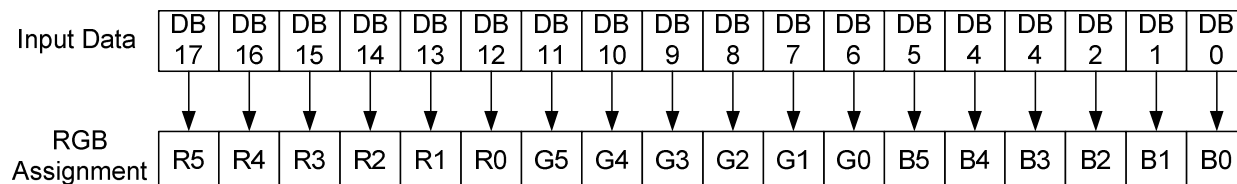


Figure 27 Example of 18-bit RGB Interface and Data Format

Notes to external display in using the RGB Input Interface

- The following are the functions not available in RGB Input Interface mode.

Function	RGB Interface	I80 System Interface
Partial display	Not available	Available
Scroll function	Not available	Available
Interlaced scan	Not available	Available
Graphics operation function	Not available	Available

- VSYNC, HSYNC, and DOTCLK signals must be supplied during a display operation period.
- In RGB interface mode, the panel controlling signals are generated from DOTCLK, not the internal clock generated from the internal oscillator.

4. In 6-bit RGB interface mode, each of RGB dots are transferred in synchronization with DOTCLK signals. In other words, one pixel data needs to take three DOTCLKs to transfer.
5. In 6-bit RGB interface mode, the cycles of VSYNC, HSYNC, ENABLE, DOTCLK signals must be set correctly so that the data transfer is completed in units of pixels.
6. When switching between the internal operation mode and the external display interface operation mode, follow the sequences below in setting instruction.
7. In RGB interface mode, the front porch period continues until the next VSYNC input is detected after drawing one frame.
8. In RGB interface mode, a RAM address (AD[16:0]) is set in the address counter every frame on the falling edge of VSYNC.

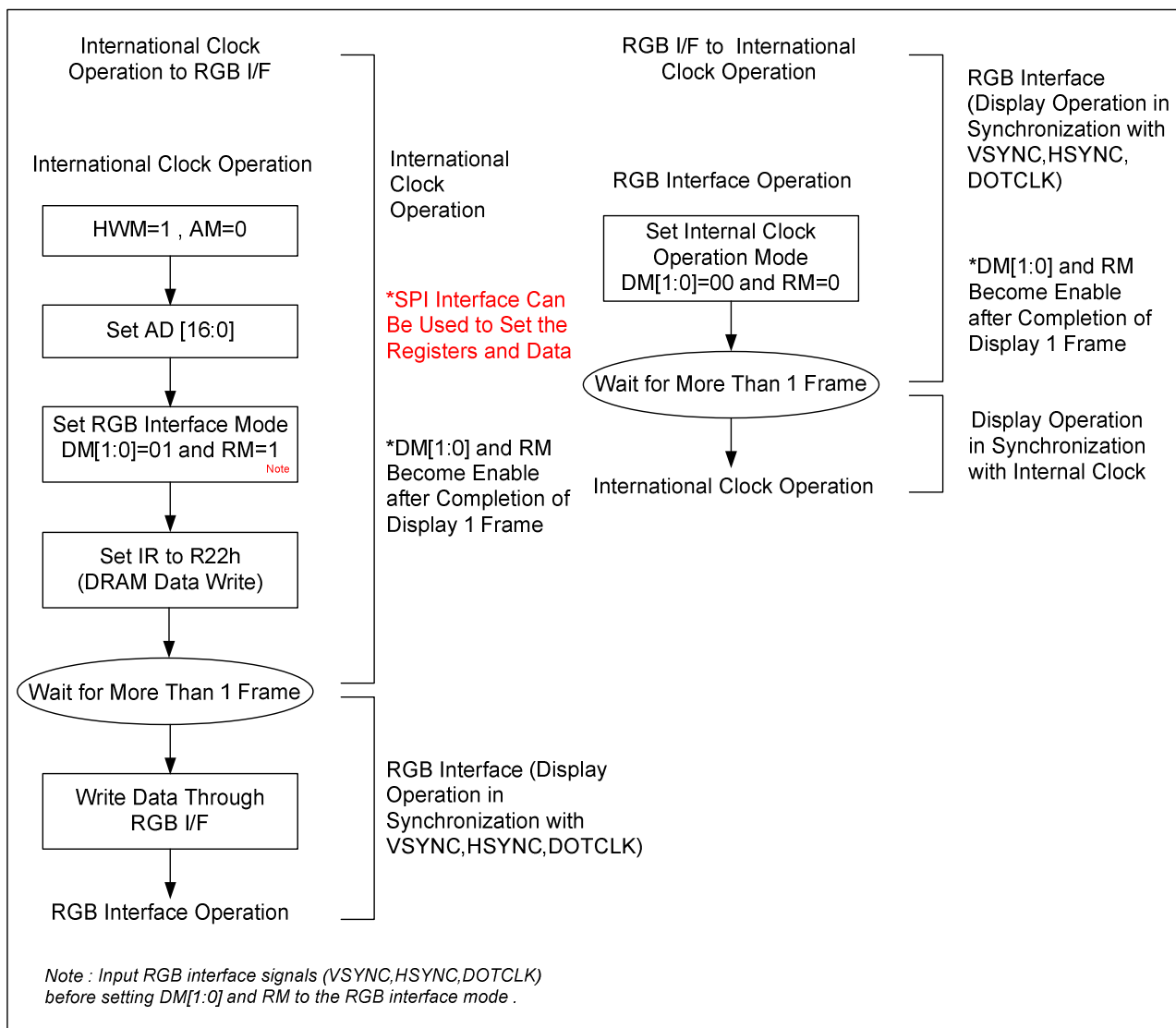


Figure 28 Internal clock operation/RGB interface mode switching

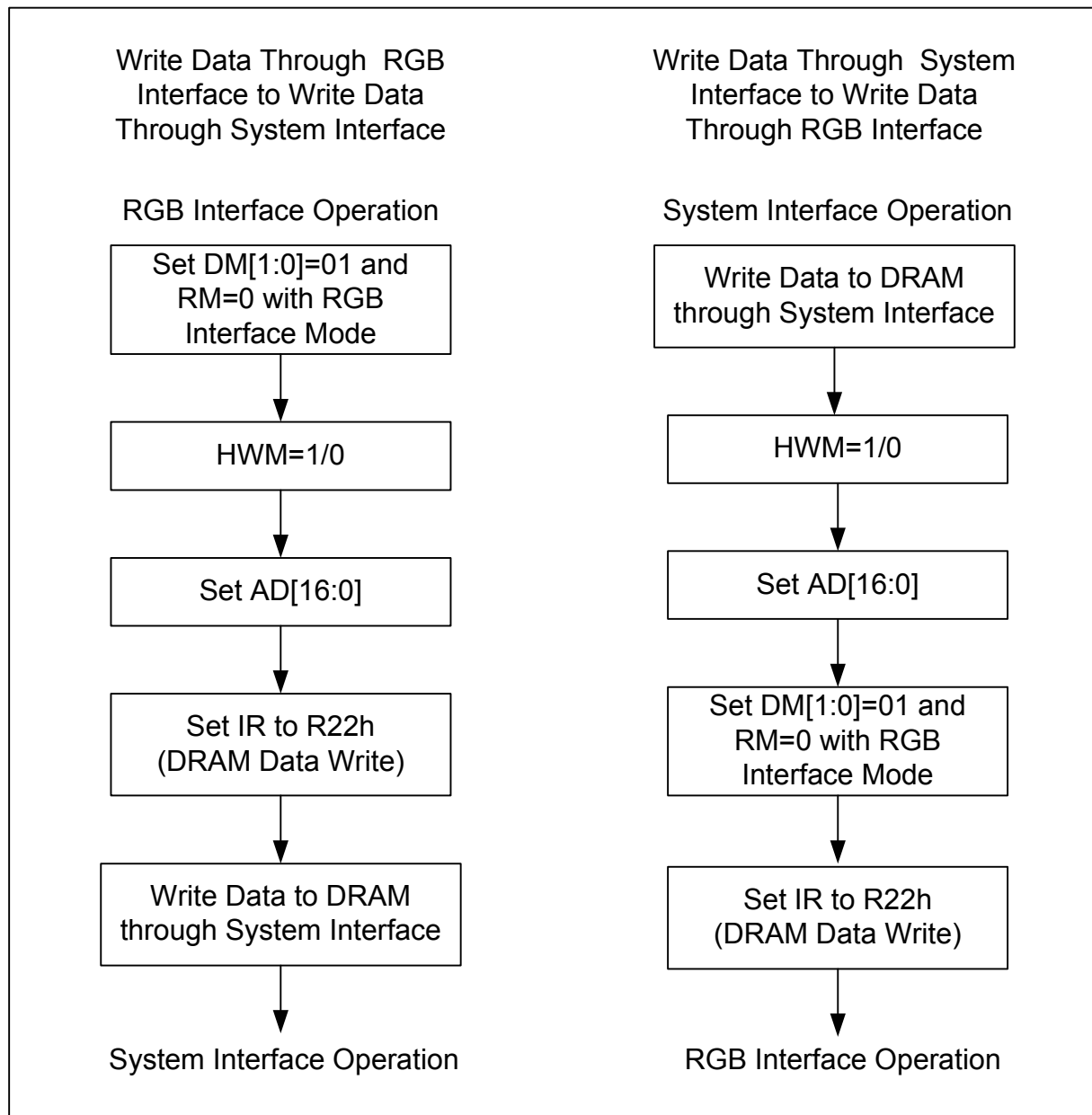


Figure 29 DRAM access between system interface and RGB interface

8.4.. Serial Peripheral Interface (SPI)

The Serial Peripheral Interface (SPI) is selected by setting the IM[3:0] pins as “010x” level. The chip select pin (CSX), the serial transfer clock pin (SCL), the serial data input pin (SDI) and the serial data output pin (SDO) are used in SPI mode. The ID pin sets the least significant bit of the identification code. The DB[17:0] pins, which are not used, must be tied to GND.

The SPI interface operation enables from the falling edge of CSX and ends of data transfer on the rising edge of CSX. The start byte is transferred to start the SPI interface and the read/write operation and RS information are also included in the start byte. When the start byte is matched, the subsequent data is received by ST7781R.

The seventh bit of start byte is RS bit. When RS = “0”, either index write operation or status read operation is executed. When RS = “1”, either register write operation or RAM read/write operation is executed. The eighth bit of the start byte is used to select either read or write operation (R/W bit). Data is written when the R/W bit is “0” and read back when the R/W bit is “1”.

After receiving the start byte, ST7781R starts to transfer or receive the data in unit of byte and the data transfer starts from the MSB bit. All the registers of the ST7781R are 16-bit format and receive the first and the second byte data as the upper and the lower eight bits of the 16-bit register respectively. In SPI mode, 5 bytes dummy read is necessary and the valid data starts from 6th byte of read back data.

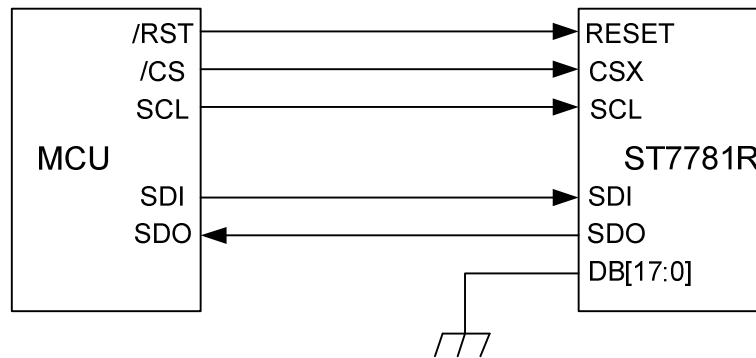
Start Byte Format

Transferred bits	S	8	7	6	5	4	3	2	1
Start byte format	Transfer start	R/W	RS	Device IC Code					
		1/0	1/0	ID	0	1	1	1	0

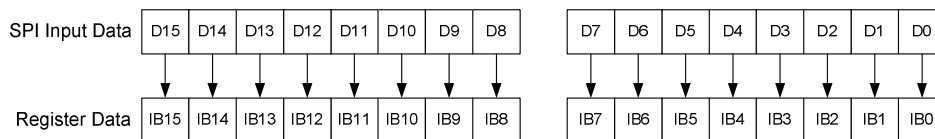
Notes: .ID bit is selected by setting the IM0/ID pin

RS and R/W Bit Function

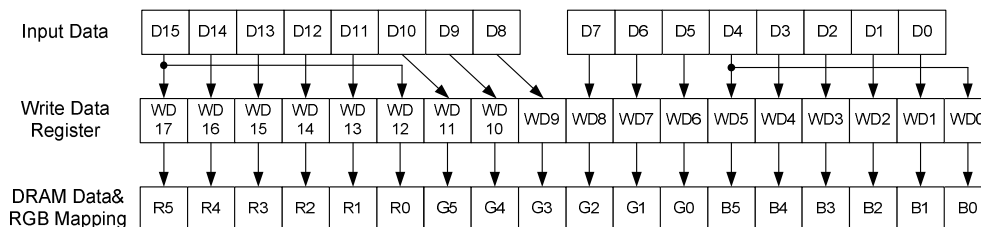
RS	R/W	Function
0	0	Set an index register
0	1	Read a status
1	0	Write a register or DRAM data
1	1	Read a register or DRAM data



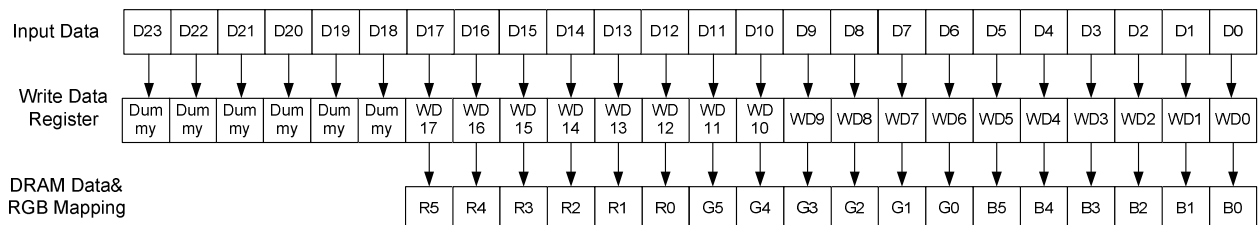
Serial Peripheral Interface for register access



Serial Peripheral Interface 65K colors



Serial Peripheral Interface 262K colors (TRI=1,DFM=0)



Serial Peripheral Interface 262K colors (TRI=1,DFM=1)

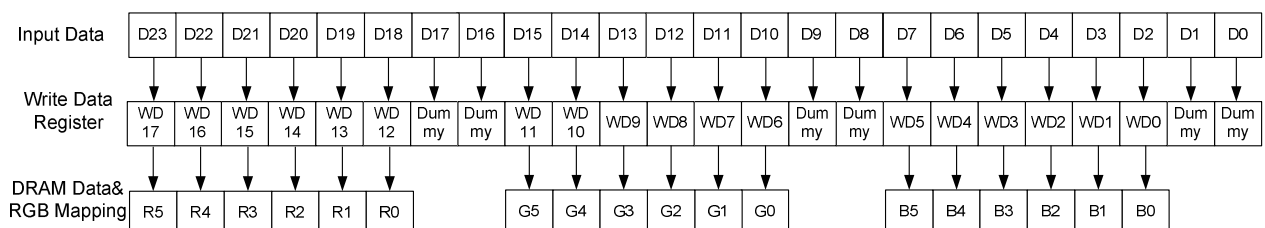


Figure 30 Data Format of SPI Interface

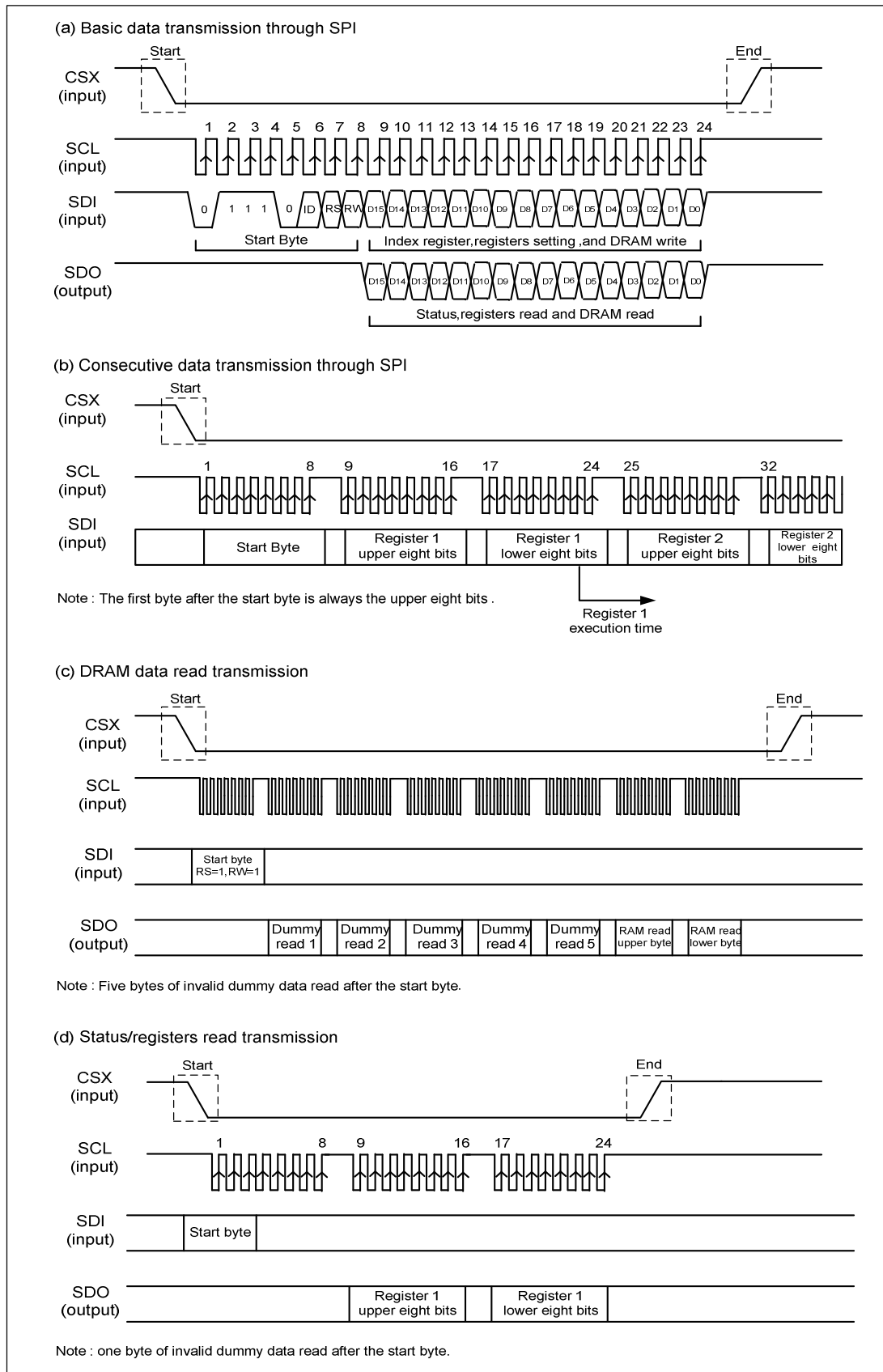
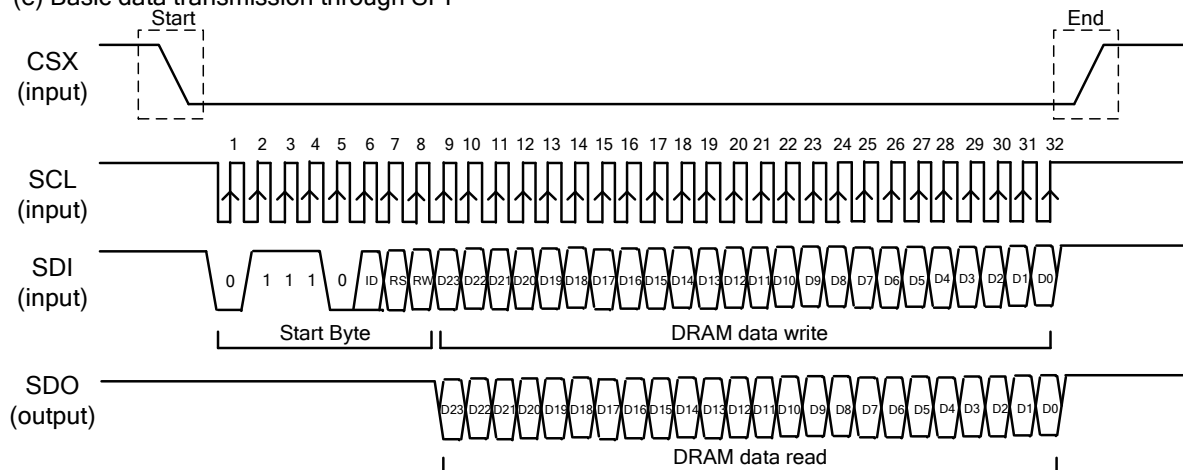
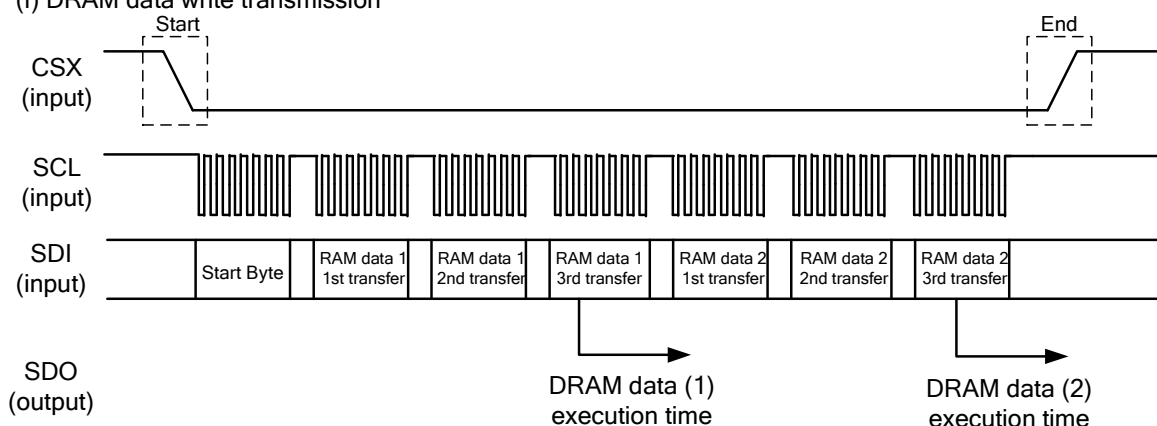


Figure 31 Data transmission through serial peripheral interface (SPI)

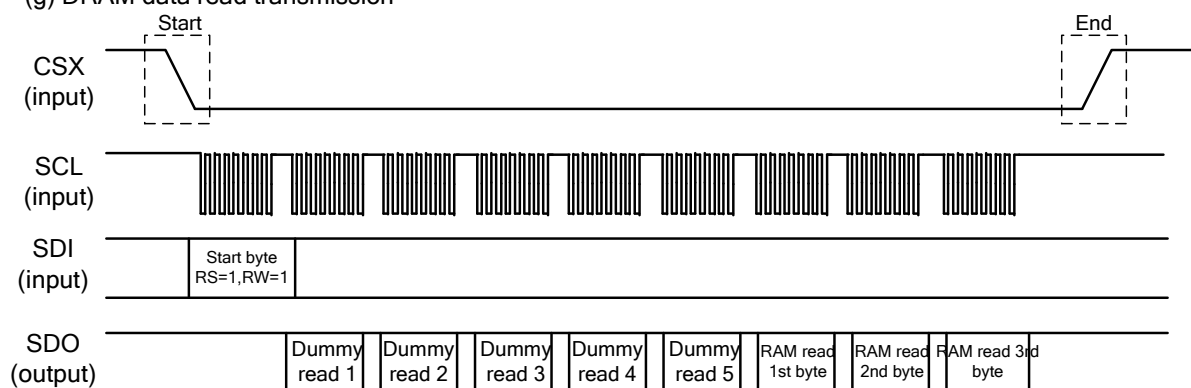
(e) Basic data transmission through SPI



(f) DRAM data write transmission



(g) DRAM data read transmission



Note : Five bytes of invalid dummy data read after the start byte.

RAM data transfer in SPI mode when TRI = 1 and DFM = 1 or 0

Figure 32 Data transmission through serial peripheral interface (SPI, TRI="1" and DFM="1 or 0")

8.5.. VSYNC Interface

8.5.1 18-bit RGB Interface

The ST7781R incorporates VSYNC interface, which enables motion pictures to be displayed with only the conventional system interface and the frame synchronization signal (VSYNC). This interface requires minimal changes from the conventional system to display motion pictures.

When DM[1:0]="10" and RM="0", VSYNC interface is available. In this interface the internal display operation is synchronized with VSYNC. Data for display is written to RAM via the system interface with higher speed than for internal display operation. This method enables tearing-free display of motion pictures with the conventional interface.

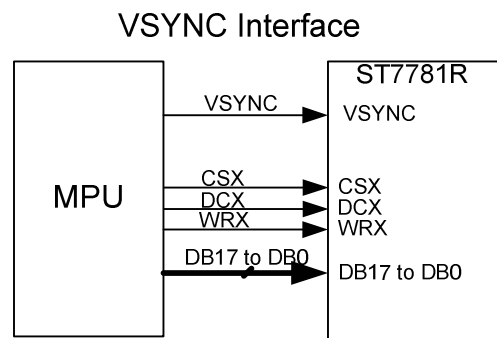


Figure 33 Data transmission through VSYNC interface

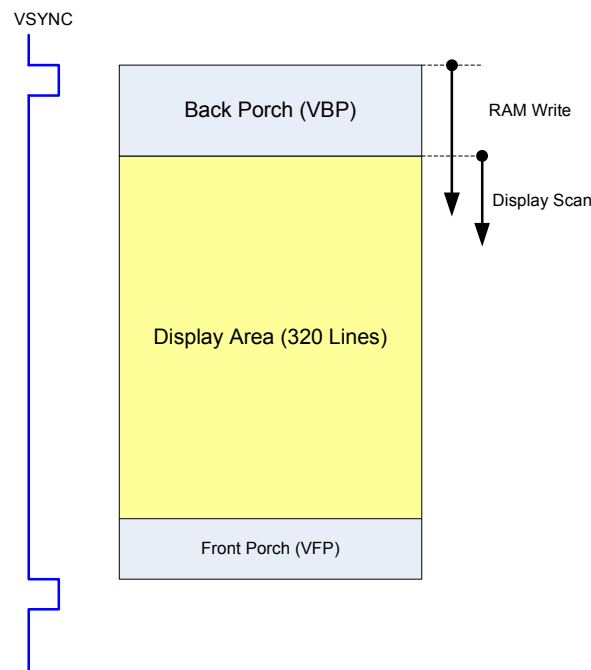


Figure 34 Operation through VSYNC Interface

Display operation can be achieved by using the internal clock generated by the internal oscillator and the VSYNC input. Because all the data for display is written to RAM, only the data to be rewritten is transferred. This method reduces the amount of data transferred during motion picture display operation.

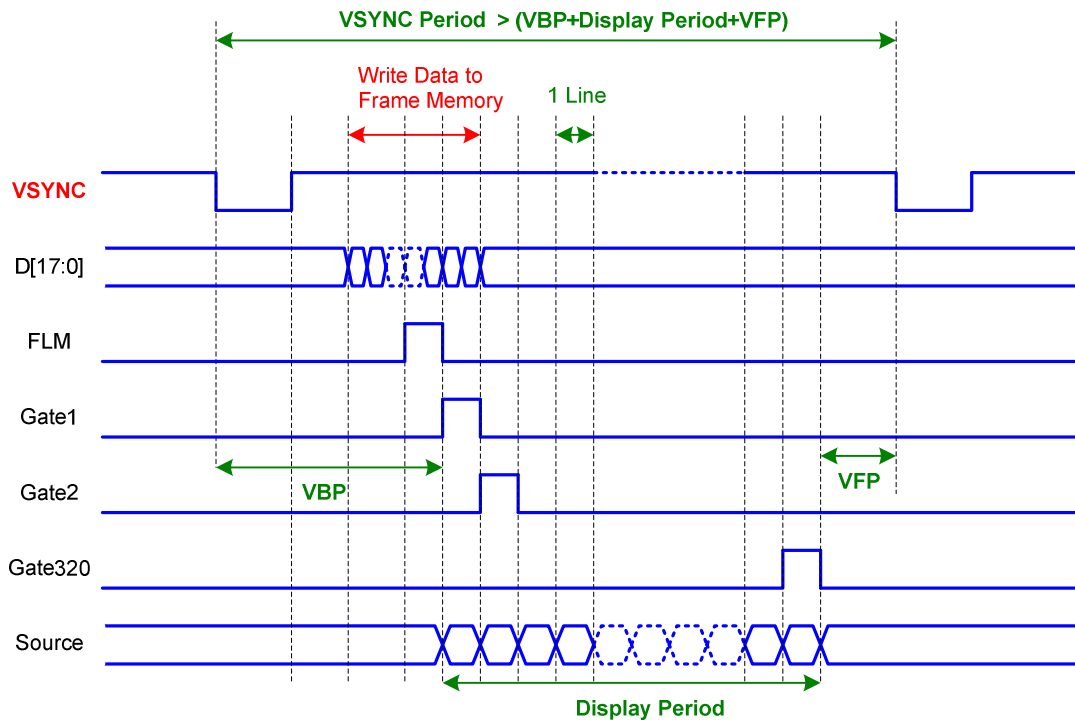


Figure 35 Timing Diagram of VSYNC Interface

VSYNC interface requires taking the minimum speed for RAM writing via the system interface and the frequency of the internal clock into consideration. RAM writing should be performed with higher speed than the result obtained from the calculation shown below. The internal memory writing address counter is reset by VSYNC. So, insure interval time between VSYNC falling and DRAM data writing.

Note:

1. VSYNC period should always be constant. If not, some degradation of display such as flicker may occur in LCD system.
2. Display data don't need to be written for every VSYNC period. For example, any system is working under 60Hz frame rate and 30-fps motion picture condition. So being written display data for every other frame would be enough.

8.5.2 VSYNC Interface Mode

8.5.2.1 Leading Mode

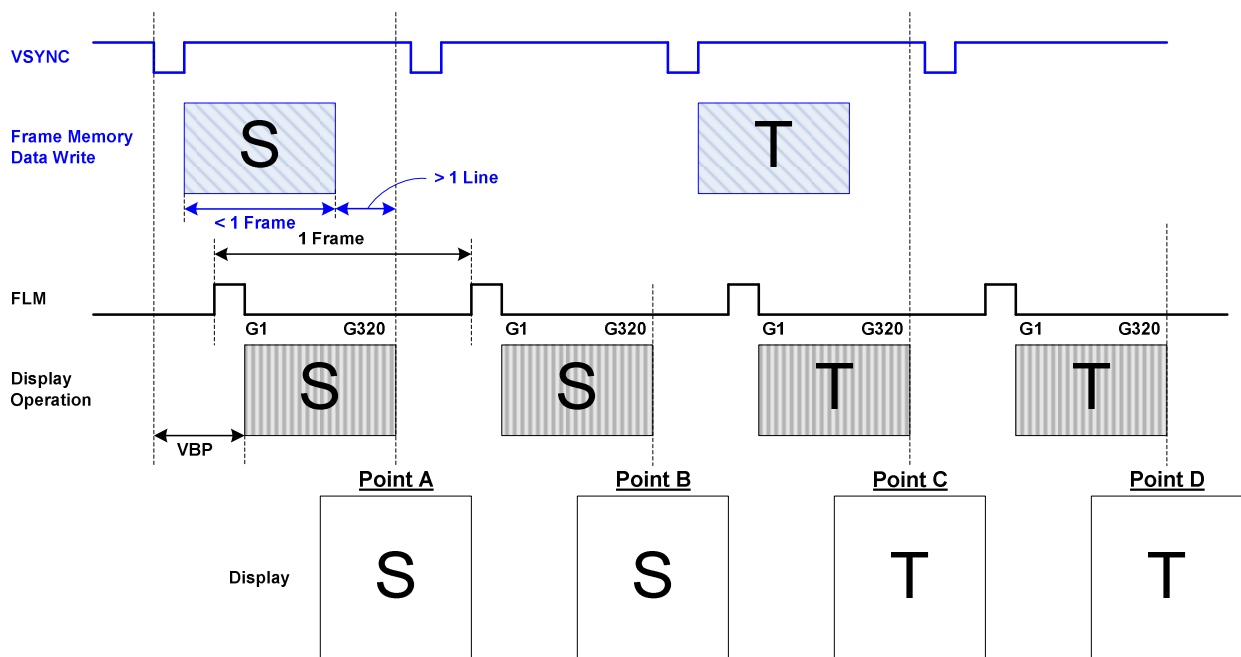


Figure 36 Operation for Leading Mode of VSYNC Interface

8.5.2.2 Lagging Mode

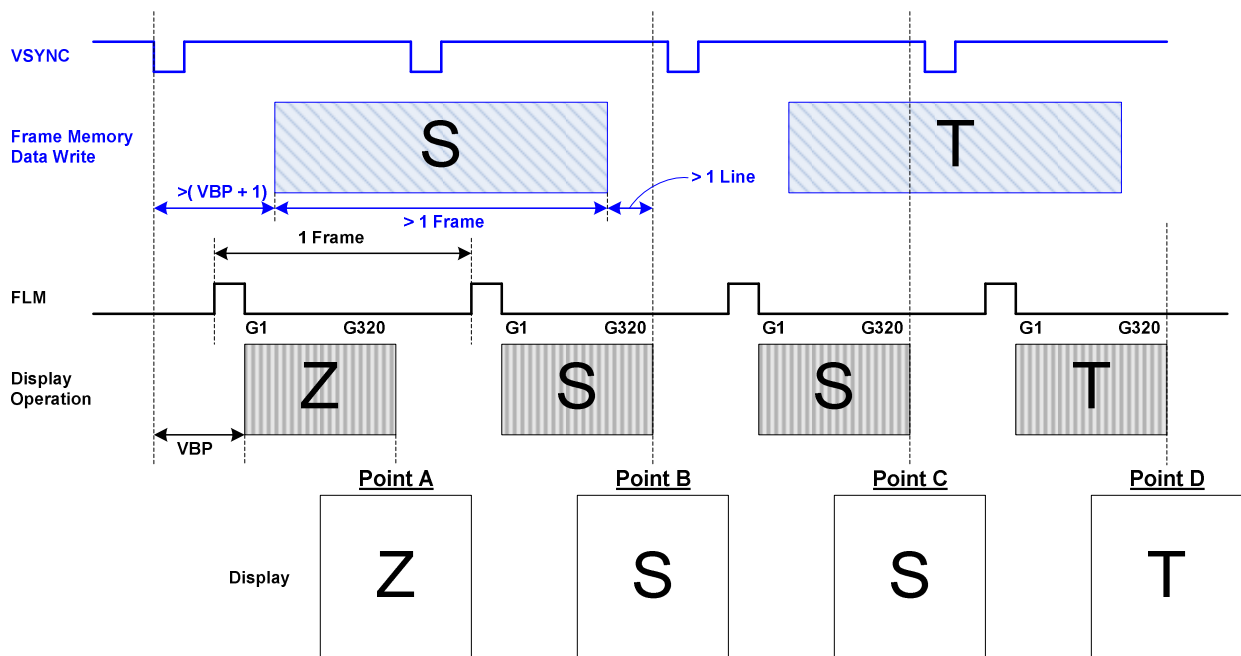


Figure 37 Operation for Lagging Mode of VSYNC Interface

Notes:

1. When RAM writing does not start immediately after the falling edge of VSYNC, the time between the falling edge of VSYNC and the RAM writing start timing must also be considered.
1. The minimum DRAM write speed must be satisfied and the frequency variation must be taken into consideration.
2. The display frame rate is determined by the VSYNC signal and the period of VSYNC must be longer than the scan period of an entire display.
3. When switching from the internal clock operation mode (DM[1:0] = "00") to the VSYNC interface mode or inversely, the switching starts from the next VSYNC cycle, i.e. after completing the display of the frame.
4. The partial display, vertical scroll, and interlaced scan functions are not available in VSYNC interface mode and set the AM bit to "0" to transfer display data.

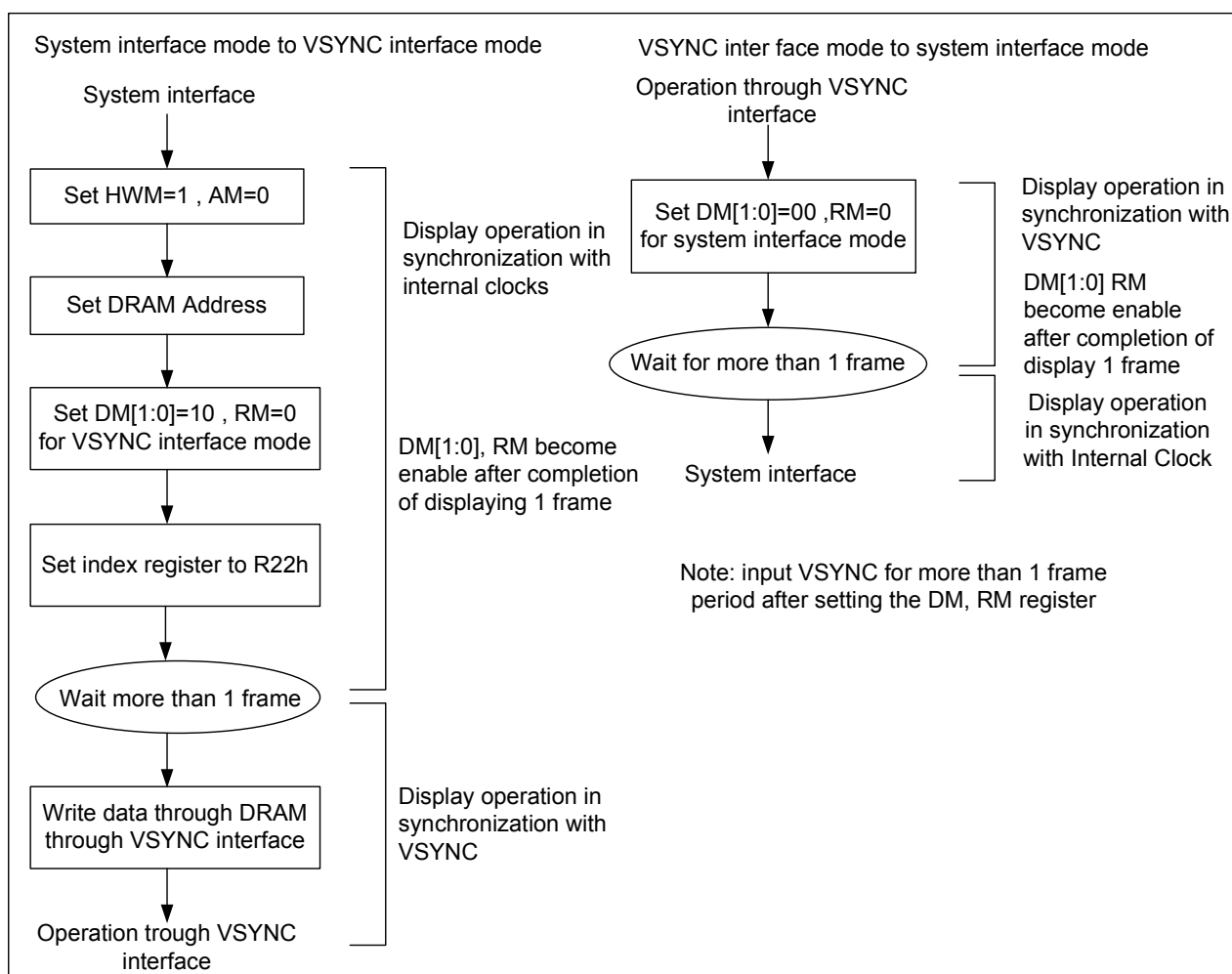


Figure 38 Transition flow between VSYNC and internal clock operation modes

8.6.. Interface Timing

The following are diagrams of interfacing timing with LCD panel control signals in internal operation and RGB interface.

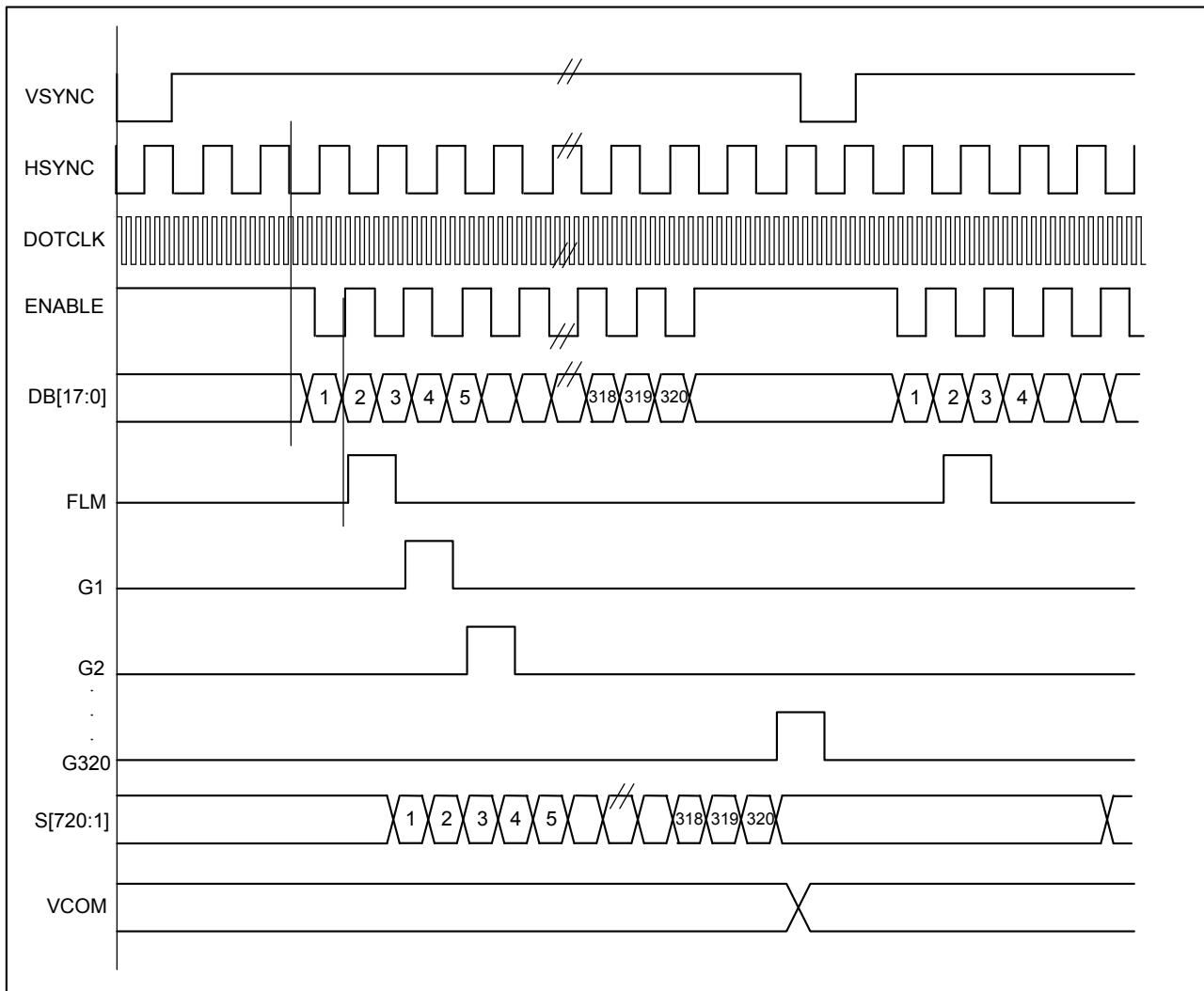


Figure 39 Relationship between RGB I/F signals and LCD Driving Signals for Panel

8.7.. Register Descriptions

ST7781R adopts 18-bit bus interface architecture for high-performance microprocessor. All the functional Blocks of ST7781R starts to work after receiving the correct instruction from the external microprocessor by the 18-, 16-, 9-, 8-bit interface. The index register (IR) stores the register address to which the instructions and Display data will be written. The register selection signal (RS), the read/write signals (RDX/WRX) and data bus D[17:0] are used to read/write the instructions and data of ST7781R. The registers of the ST7781R are categorized into the following groups.

1. Specify the index of register (IR)
2. Read a status
3. Display control
4. Power management Control
5. Graphics data processing
6. Set internal DRAM address (AC)
7. Transfer data to/from the internal DRAM (R22)
8. Internal grayscale γ -correction (R30 ~ R39)

Normally, the display data (DRAM) is most often updated, and in order since the ST7781R can update internal DRAM address automatically as it writes data to the internal DRAM and minimize data transfer by using the window address function, there are fewer loads on the program in the microprocessor. The way of assigning data to the 16 register bits (D[15:0]) varies for each interface. Send registers in accordance with the following data transfer format.

Serial Peripheral Interface for register access

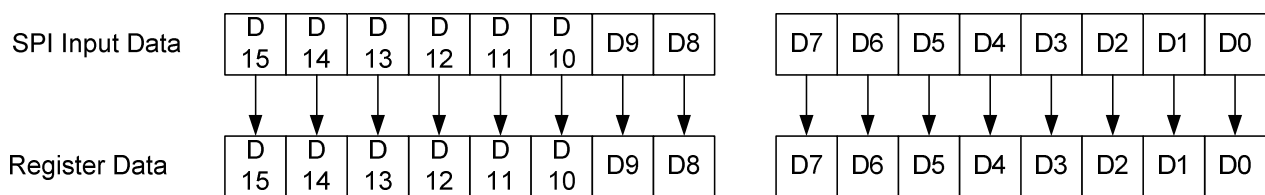
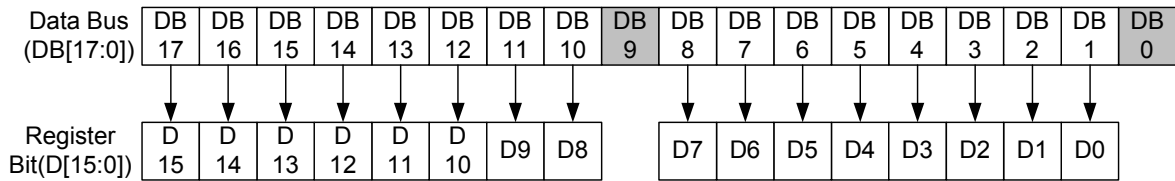
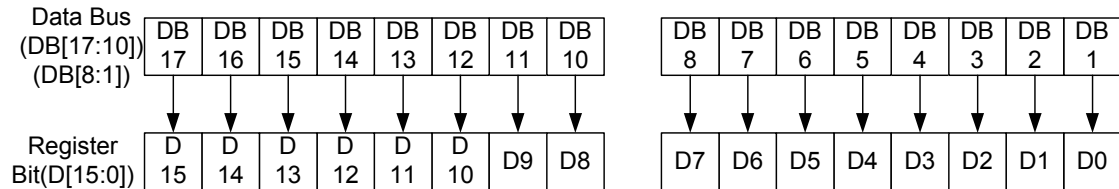


Figure 40 Register Setting with Serial Peripheral Interface (SPI)

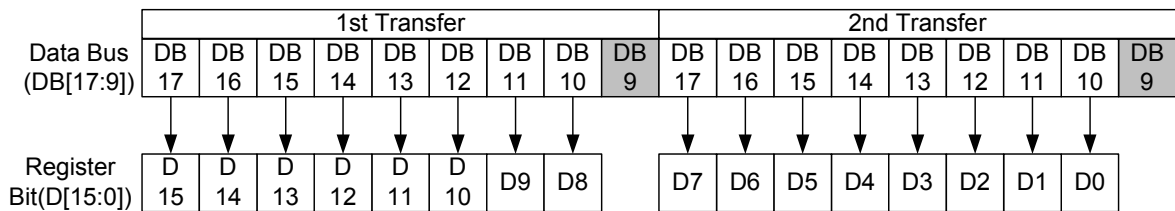
i80-18bits Data bus Interface



i80-16bits Data bus Interface



i80-9bits Data bus Interface



i80-8bits Data bus Interface / Serial Peripheral Interface (2/3 transmission)

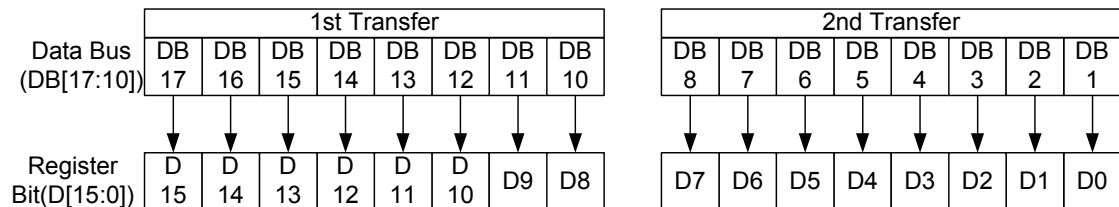
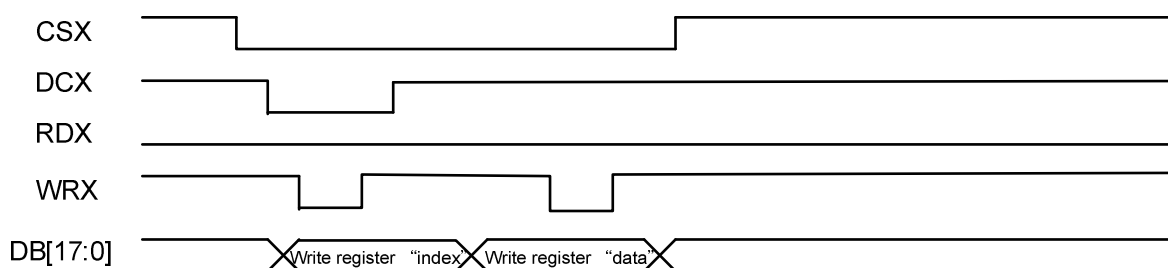


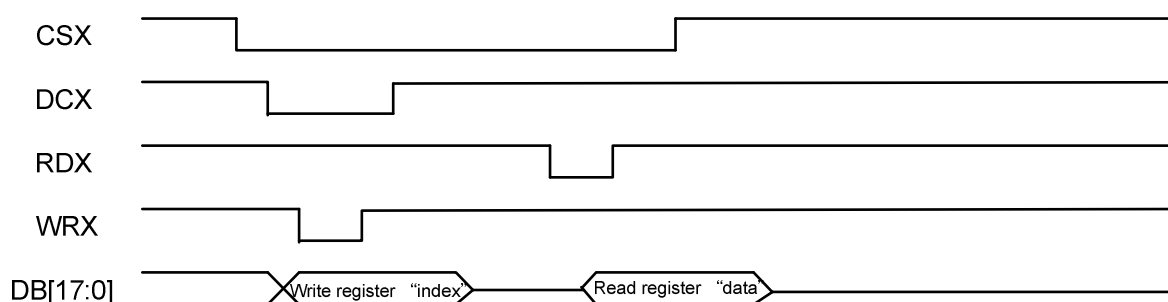
Figure 41 Register setting with i80 System Interface

i80 18-/16-bit System Bus Interface Timing

(a) Write to register

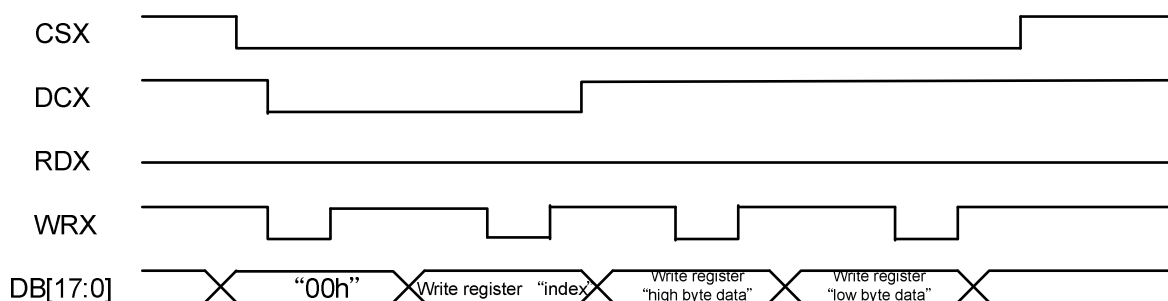


(b) Read from register



i80 9-/8-bit System Bus Interface Timing

(a) Write to register



(b) Read from register

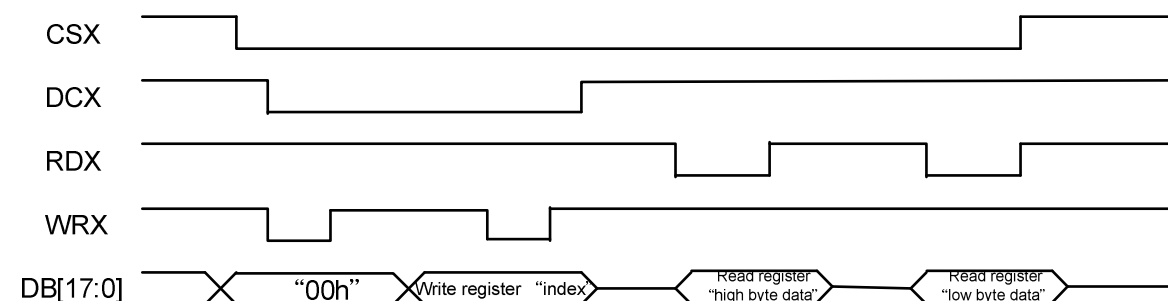


Figure 42 Register Read/Write Timing of i80 System Interface

9 COMMAND
9.1.. System Function Command List

No	Registers	W/R	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	
1R	Index Register	W	0	-	-	-	-	-	-	-	-	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0	
00h	Driver Code Read	R	1	0	1	1	1	0	1	1	1	1	0	0	0	0	0	1	1	
01h	Driver Output Control	W/R	1	0	0	0	0	0	SM	0	SS	0	0	0	0	0	0	0	0	
02h	LCD Driving Control	W/R	1	0	0	0	0	0	1	BC0	EOR	0	0	0	0	0	0	0	0	
03h	Entry Mode	W/R	1	TRI	DFM	0	BGR	0	0	HWM	0	ORG	0	I/D1	I/D0	AM	0	0	0	
04h	Resize Control	W/R	1	0	0	0	0	0	0	RCV1	RCV0	0	0	RCH1	RCH0	0	0	RSZ1	RSZ0	
07h	Display Control 1	W/R	1	0	0	PTDE1	PTDE0	0	0	0	BASEE	0	0	GON	DTE	CL	0	D1	D0	
08h	Display control 2	W/R	1	0	FP6	FP5	FP4	FP3	FP2	FP1	FP0	0	BP6	BP5	BP4	BP3	BP2	BP1	BP0	
09h	Display Control 3	W/R	1	0	0	0	0	0	0	PTS1	PTS0	0	0	PTG1	PTG0	ISC3	ISC2	ISC1	ISC0	
0Ah	Display Control 4	W/R	1	0	0	0	0	0	0	0	0	0	0	0	0	FMARKOE	FMI2	FMI1	FMI0	
0Ch	RGB Display Interface Control 1	W/R	1	0	ENC2	ENC1	ENC0	0	0	0	RM	0	0	DM1	DM0	0	0	RIM1	RIM0	
0Dh	Frame Marker Position	W/R	1	0	0	0	0	0	0	0	FMP8	FMP7	FMP6	FMP5	FMP4	FMP3	FMP2	FMP1	FMP0	
0Fh	RGB Display Interface Control 2	W/R	1	0	0	0	0	0	0	0	0	0	0	0	0	VSPL	HSPL	0	DPL	EPL
10h	Power Control 1	W/R	1	0	0	0	SAP	0	0	0	0	APE	AP2	AP1	AP0	0	DSTB	SLP	STB	
20h	Horizontal DRAM Address Set	W/R	1	0	0	0	0	0	0	0	0	AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0	
21h	Vertical DRAM Address Set	W/R	1	0	0	0	0	0	0	0	AD16	AD15	AD14	AD13	AD12	AD11	AD10	AD9	AD8	
22h	Write Data to GRAM	W	1	DRAM Write Data (WD17-0) / Read Data (RD17-0)																
22h	Read Data from GRAM	R	1																	
30h	Gamma Control 1	W/R	1	0	0	0	0	0	KP1[2]	KP1[1]	KP1[0]	0	0	0	0	0	KP0[2]	KP0[1]	KP0[0]	
31h	Gamma Control 2	W/R	1	0	0	0	0	0	KP3[2]	KP3[1]	KP3[0]	0	0	0	0	0	KP2[2]	KP2[1]	KP2[0]	
32h	Gamma Control 3	W/R	1	0	0	0	0	0	KP5[2]	KP5[1]	KP5[0]	0	0	0	0	0	KP4[2]	KP4[1]	KP4[0]	
35h	Gamma Control 4	W/R	1	0	0	0	0	0	RP1[2]	RP1[1]	RP1[0]	0	0	0	0	0	RP1[2]	RP1[1]	RP1[0]	
36h	Gamma Control 5	W/R	1	0	0	0	VRP1[4]	VRP1[3]	VRP1[2]	VRP1[1]	VRP1[0]	0	0	0	0	VRP0[3]	VRP0[2]	VRP0[1]	VRP0[0]	
37h	Gamma Control 6	W/R	1	0	0	0	0	0	KN1[2]	KN1[1]	KN1[0]	0	0	0	0	0	KN0[2]	KN0[1]	KN0[0]	
38h	Gamma Control 7	W/R	1	0	0	0	0	0	KN3[2]	KN3[1]	KN3[0]	0	0	0	0	0	KN2[2]	KN2[1]	KN2[0]	
39h	Gamma Control 8	W/R	1	0	0	0	0	0	KN5[2]	KN5[1]	KN5[0]	0	0	0	0	0	KN4[2]	KN4[1]	KN4[0]	
3Ch	Gamma Control 9	W/R	1	0	0	0	0	0	RN1[2]	RN1[1]	RN1[0]	0	0	0	0	0	RN1[2]	RN1[1]	RN1[0]	
3Dh	Gamma Control 10	W/R	1	0	0	0	VRN1[4]	VRN1[3]	VRN1[2]	VRN1[1]	VRN1[0]	0	0	0	0	VRN0[3]	VRN0[2]	VRN0[1]	VRN0[0]	
50h	Horizontal Address Start Position	W/R	1	0	0	0	0	0	0	0	0	HSA7	HSA6	HSA5	HSA4	HSA3	HSA2	HSA1	HSA0	
51h	Horizontal Address End Position	W/R	1	0	0	0	0	0	0	0	0	HEA7	HEA6	HEA5	HEA4	HEA3	HEA2	HEA1	HEA0	
52h	Vertical Address Start Position	W/R	1	0	0	0	0	0	0	0	0	VSA8	VSA7	VSA6	VSA5	VSA4	VSA3	VSA2	VSA1	
53h	Vertical Address End Position	W/R	1	0	0	0	0	0	0	0	0	VEA8	VEA7	VEA6	VEA5	VEA4	VEA3	VEA2	VEA1	

60h	Driver Output Control 2	W/R	1	GS	0	NL5	NL4	NL3	NL2	NL1	NL0	0	0	SCN5	SCN4	SCN3	SCN2	SCN1	SCN0
61h	Base Image Display Control	W/R	1	h	0	0	0	0	0	0	0	0	0	0	0	0	NDL	VLE	REV
6Ah	Vertical Scroll Control	W/R	1	0	0	0	0	0	0	0	VL8	VL7	VL6	VL5	VL4	VL3	VL2	VL1	VL0
80h	Partial Image 1 Display Position	W/R	1	0	0	0	0	0	0	0	PTDP08	PTDP07	PTDP06	PTDP05	PTDP04	PTDP03	PTDP02	PTDP01	PTDP00
81h	Partial Image 1 Area (Start Line)	W/R	1	0	0	0	0	0	0	0	PTSA08	PTSA07	PTSA06	PTSA05	PTSA04	PTSA03	PTSA02	PTSA01	PTSA00
82h	Partial Image 1 Area (End Line)	W/R	1	0	0	0	0	0	0	0	PTEA08	PTEA07	PTEA06	PTEA05	PTEA04	PTEA03	PTEA02	PTEA01	PTEA00
83h	Partial Image 2 Display Position	W/R	1	0	0	0	0	0	0	0	PTDP18	PTDP17	PTDP16	PTDP15	PTDP14	PTDP13	PTDP12	PTDP11	PTDP10
84h	Partial Image 2 Area (Start Line)	W/R	1	0	0	0	0	0	0	0	PTSA18	PTSA17	PTSA16	PTSA15	PTSA14	PTSA13	PTSA12	PTSA11	PTSA10
85h	Partial Image 2 Area (End Line)	W/R	1	0	0	0	0	0	0	0	PTEA18	PTEA17	PTEA16	PTEA15	PTEA14	PTEA13	PTEA12	PTEA11	PTEA10
90h	Panel Interface Control 1	W/R	1	0	0	0	0	0	0	DIV1	DIV0	0	RTNI6	RTNI5	RTNI4	RTNI3	RTNI2	RTNI1	RTNI0
95h	Panel Interface Control 2	W/R	1	0	0	0	0	0	0	DIVE1	DIVE0	0	0	0	0	0	0	0	0
B0h	Power Control 2	W/R	1	0	0	VCM5	VCM4	VCM3	VCM2	VCM1	VCM0	0	0	VGLSEL1	VGLSEL0	1	1	VGHBT1	VGHBT0
B1h	Power Control 3	W/R	1	0	0	0	VRHN4	VRHN3	VRHN2	VRHN1	VRHN0	0	0	0	VRHP4	VRHP3	VRHP2	VRHP1	VRHP0
B2h	Power Control 4	W/R	1	0	0	0	0	0	AVCLS2	AVCLS1	AVCLS0	0	0	BCLK_DI_V1	BCLK_DI_V0	0	AVDDS2	AVDDS1	AVDDS0
B3h	Power Control 5	W/R	1	0	0	0	0	DC11	DC10	DC9	DC8	DC7	DC6	DC5	DC4	DC3	DC2	DC1	DC0
B5h	Power Control 6	W/R	1	0	0	0	0	0	MODE1	MODE0	OSAP2	OSAP1	OSAP0	0	0	0	0	0	0
B6h	Power Control 7	W/R	1	0	0	0	0	0	0	0	0	NO1	NO0	0	0	SDT1	SDT0	0	0
D2h	NVM ID Code	W/R	1	0	0	0	0	0	0	0	0	0	ID6	ID5	ID4	ID3	ID2	ID1	ID0
D9h	NVM Control Status	W/R	1	0	0	0	0	0	0	0	0	0	VMF_EN	0	0	0	0	0	0
DFh	NVM Write Command	W	1	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1
FAh	NVM Enable	W/R	1	0	0	0	0	0	0	0	0	PROG_MODE	0	0	0	0	1	MTP_PROG	0
FEh	NVM VCOM Offset	W/R	1	0	0	0	0	0	0	0	0	1	0	0	VMF4	VMF3	VMF2	VMF1	VMF0
FFh	NVM Command Enable	W	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	CMD2_EN

Table 9 System Function Command List

9.2.. System Function Command

9.2.1 Index (IR)

Note: “-”Don't care

Index(IR)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
0	↑	1	-	-	-	-	-	-	-	-	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0
Description			The index register specifies the index R00h to RFFh of the control register or RAM control to be accessed. The access to the register and instruction bits in it is prohibited unless the index is specified in the index register.															

9.2.2 Device ID Code Read (R00h)

Device ID Code Read Out (R00h)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	1	↑	0	1	1	1	0	1	1	1	1	0	0	0	0	0	1	1
Description			When read this register, the device output device ID code															

9.2.3 Device Output Control (R01h)

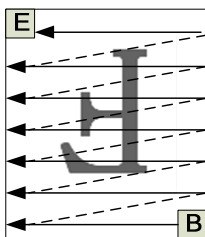
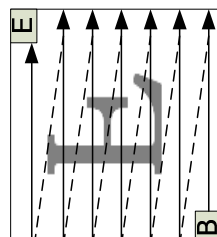
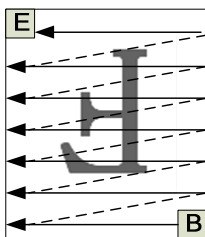
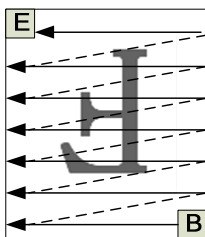
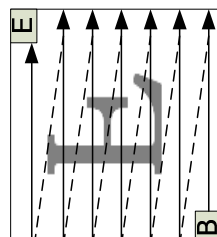
Device Output Control (R01H)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	0	0	SM	0	SS	0	0	0	0	0	0	0	0
Default value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Description			SS: Select the shift direction of outputs from the source driver. When SS = 0, the shift direction of outputs is from S1 to S720 When SS = 1, the shift direction of outputs is from S720 to S1. In addition to the shift direction, the settings for both SS and BGR bits are required to change the Assignment of R, G, B dots to the source driver pins. To assign R, G, B dots to the source driver pins from S1 to S720, set SS = 0. To assign R, G, B dots to the source driver pins from S720 to S1, set SS = 1. <i>Note: When changing SS or BGR bits, DRAM data must be rewritten.</i> SM: Sets the gate driver pin arrangement in combination with the GS bit (R60h) to select the optimal scan mode for the module.															

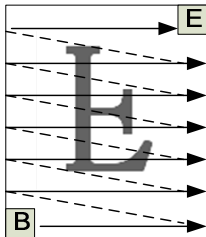
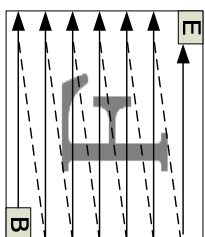
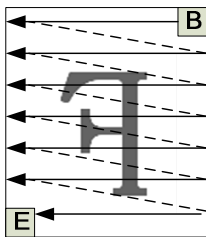
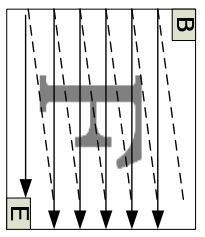
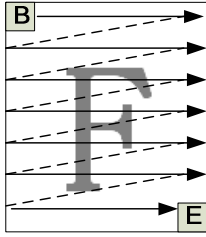
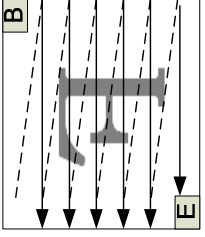
SM	GS	Scan Direction	Gate Output Sequence
0	0		G1,G2,G3,G4.....,G316 G317,G318,G319, G320
0	1		G320,G319,.....G316 G7,G6,G5,G4,G3,G2,G1
1	0		G1,G3,G5.....G311 G313,G315,G317,G319 G2,G4,G6.....G312 G314,G316,G318,G320
1	1		G320,G318,.....G14 G12,G10,G8,G6,G4,G2 G319,G317.....G13 G11,G9,G7,G5,G3,G1

9.2.4 LCD Driving Wave Control (R02h)

LCD Driving Wave Control (R02h)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	0	0	1	B/C	EOR	0	0	0	0	0	0	0	0
Default value			0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
Description			B/C: VCOM Driving Wave Control. When B/C = 0, the column inversion is selected When B/C = 1 and EOR=1, the dot inversion is selected.															

9.2.5 Entry Mode (R03h)

Entry Mode (R03h)																											
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0									
1	↑	1	TRI	DFM	0	BGR	0	0	HWM	0	ORG	0	I/D1	I/D0	AM	0	0	0									
Default value			0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0									
Description			AM: Sets the DRAM Update Direction When AM = “0”, set the horizontal writing direction. When AM = “1”, set the vertical writing direction. When a window area is set by registers R50h ~R53h, only the addressed DRAM area is updated based on I/D [1:0] and AM bits setting.																								
			I/D [1:0]: Control the address counter (AC) to automatically increase or decrease by 1 when update one pixel display data.																								
			<table><tr><th>AM</th><th>ID[1:0]</th><th>Write DRAM Direction</th><th>AM</th><th>ID[1:0]</th><th>Write DRAM Direction</th></tr><tr><td>0</td><td>00</td><td></td><td>1</td><td>00</td><td></td></tr></table>																AM	ID[1:0]	Write DRAM Direction	AM	ID[1:0]	Write DRAM Direction	0	00	
AM	ID[1:0]	Write DRAM Direction	AM	ID[1:0]	Write DRAM Direction																						
0	00		1	00																							

		0	01		1	01	
		0	10		1	10	
		0	11		1	11	

ORG: Moves the origin address according to the ID setting when a window address area is made. This function is enabled when writing data with the window address area using high-speed RAM write.

ORG = "0": The origin address is not moved. In this case, specify the address to start write operation according to the DRAM address map within the window address area.

ORG = "1": The original address "00000h" moves according to the I/D[1:0] setting.

Notes 1: When ORG=1, only the origin address address"00000h" can be set in the RAM address set registers R20h, and R21h.

Notes2: In RAM read operation, make sure to set ORG=0.

HWM: The ST7781R writes data in high speed with low power consumption by setting HWM = 1. The data to be written within the window address area is buffered in order to write the data in units of horizontal lines. This can minimize the Number of RAM access and the power consumption required in data write operation.

When HWM = 1, make sure to set AM = 0 (horizontal direction) and write the data in each horizontal line of the window address area at a time. If the data is not enough to rewrite the horizontal line of the window address area, the DRAM data in that line is not overwritten.

Notes1: The ST7781R requires no dummy write operation in high-speed write operation.

Notes2: When terminating DRAM data write operation in the middle of the line and executing another instruction, the data in the buffer is cleared.

BGR: Reverses the order from RGB to BGR in writing 18-bit pixel data in the DRAM.

BGR = 0: Write data in the order of RGB to the DRAM.

BGR=0																	
D17	D16	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
R5	R4	R3	R2	R1	R0	G5	G4	G3	G2	G1	G0	B5	B4	B3	B2	B1	B0

BGR = 1: Reverse the order from RGB to BGR in writing data to the DRAM.

BGR=1																	
D17	D16	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
B5	B4	B3	B2	B1	B0	G5	G4	G3	G2	G1	G0	R5	R4	R3	R2	R1	R0

TRI: When TRI = "1", data are transferred to the internal DRAM in 8-bit x 3 transfers mode via the 8-bit interface. It is also possible to send data via the 16-bit interface in the transfer mode that realizes display in 262k colors in combination with DFM bits. When not using these interface modes, be sure to set TRI = "0".

DFM: Set the mode of transferring data to the internal RAM when TRI = "1".

TRI	DFM	8080-16bits Interface Color Format																																																																																						
0	*	<table><tr><td colspan="16">First</td></tr><tr><td>DB17</td><td>DB16</td><td>DB15</td><td>DB14</td><td>DB13</td><td>DB12</td><td>DB11</td><td>DB10</td><td></td><td>DB8</td><td>DB7</td><td>DB6</td><td>DB5</td><td>DB4</td><td>DB3</td><td>DB2</td><td>DB1</td></tr><tr><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td></tr><tr><td>R5</td><td>R4</td><td>R3</td><td>R2</td><td>R1</td><td>R0</td><td>G5</td><td>G4</td><td>G3</td><td>G2</td><td>G1</td><td>G0</td><td>B5</td><td>B4</td><td>B3</td><td>B2</td><td>B1</td><td>B0</td></tr></table>																First																DB17	DB16	DB15	DB14	DB13	DB12	DB11	DB10		DB8	DB7	DB6	DB5	DB4	DB3	DB2	DB1	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	R5	R4	R3	R2	R1	R0	G5	G4	G3	G2	G1	G0	B5	B4	B3	B2	B1	B0			
First																																																																																								
DB17	DB16	DB15	DB14	DB13	DB12	DB11	DB10		DB8	DB7	DB6	DB5	DB4	DB3	DB2	DB1																																																																								
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓																																																																								
R5	R4	R3	R2	R1	R0	G5	G4	G3	G2	G1	G0	B5	B4	B3	B2	B1	B0																																																																							
1	0	<table><tr><td colspan="15">First</td><td colspan="2">Second</td></tr><tr><td>DB17</td><td>DB16</td><td>DB15</td><td>DB14</td><td>DB13</td><td>DB12</td><td>DB11</td><td>DB10</td><td>DB8</td><td>DB7</td><td>DB6</td><td>DB5</td><td>DB4</td><td>DB3</td><td>DB2</td><td>DB1</td><td>DB17</td><td>DB16</td></tr><tr><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td></tr><tr><td>R5</td><td>R4</td><td>R3</td><td>R2</td><td>R1</td><td>R0</td><td>G5</td><td>G4</td><td>G3</td><td>G2</td><td>G1</td><td>G0</td><td>B5</td><td>B4</td><td>B3</td><td>B2</td><td>B1</td><td>B0</td></tr></table>																First															Second		DB17	DB16	DB15	DB14	DB13	DB12	DB11	DB10	DB8	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB17	DB16	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	R5	R4	R3	R2	R1	R0	G5	G4	G3	G2	G1	G0	B5	B4	B3	B2	B1	B0
First															Second																																																																									
DB17	DB16	DB15	DB14	DB13	DB12	DB11	DB10	DB8	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB17	DB16																																																																							
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓																																																																							
R5	R4	R3	R2	R1	R0	G5	G4	G3	G2	G1	G0	B5	B4	B3	B2	B1	B0																																																																							
1	1	<table><tr><td colspan="2">First</td><td colspan="14">Second</td></tr><tr><td>DB1</td><td>DB0</td><td>DB17</td><td>DB16</td><td>DB15</td><td>DB14</td><td>DB13</td><td>DB12</td><td>DB11</td><td>DB10</td><td>DB8</td><td>DB7</td><td>DB6</td><td>DB5</td><td>DB4</td><td>DB3</td><td>DB2</td><td>DB1</td></tr><tr><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td><td>↓</td></tr><tr><td>R5</td><td>R4</td><td>R3</td><td>R2</td><td>R1</td><td>R0</td><td>G5</td><td>G4</td><td>G3</td><td>G2</td><td>G1</td><td>G0</td><td>B5</td><td>B4</td><td>B3</td><td>B2</td><td>B1</td><td>B0</td></tr></table>																First		Second														DB1	DB0	DB17	DB16	DB15	DB14	DB13	DB12	DB11	DB10	DB8	DB7	DB6	DB5	DB4	DB3	DB2	DB1	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	R5	R4	R3	R2	R1	R0	G5	G4	G3	G2	G1	G0	B5	B4	B3	B2	B1	B0	
First		Second																																																																																						
DB1	DB0	DB17	DB16	DB15	DB14	DB13	DB12	DB11	DB10	DB8	DB7	DB6	DB5	DB4	DB3	DB2	DB1																																																																							
↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓																																																																							
R5	R4	R3	R2	R1	R0	G5	G4	G3	G2	G1	G0	B5	B4	B3	B2	B1	B0																																																																							

TRI	DFM	8080-8bits Interface Color Format
0	*	First DB17 DB16 DB15 DB14 DB13 DB12 DB11 DB10 DB17 DB16 DB15 DB14 DB13 DB12 DB11 DB10 Second R5 R4 R3 R2 R1 R0 G5 G4 G3 G2 G1 G0 B5 B4 B3 B2 B1 B0
1	0	First DB11 DB10 DB17 DB16 DB15 DB14 DB13 DB12 DB11 DB10 DB17 DB16 DB15 DB14 DB13 DB12 DB11 DB10 Second DB17 DB16 DB15 DB14 DB13 DB12 DB11 DB10 Third R5 R4 R3 R2 R1 R0 G5 G4 G3 G2 G1 G0 B5 B4 B3 B2 B1 B0
1	1	First DB17 DB16 DB15 DB14 DB13 DB12 DB17 DB16 DB15 DB14 DB13 DB12 Second DB17 DB16 DB15 DB14 DB13 DB12 Third R5 R4 R3 R2 R1 R0 G5 G4 G3 G2 G1 G0 B5 B4 B3 B2 B1 B0

9.2.6 Resizing Control (R04h)

Resizing Control (R04h)																																	
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0															
1	↑	1	0	0	0	0	0	0	RCV1	RCV0	0	0	RCH1	RCH0	0	0	RSZ1	RSZ0															
Default value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0															
Description			RSZ [1:0]: Sets the resizing factor. When the RSZ [1:0] are set for resizing, the ST7781R writes the data according to the resizing factor so that the original image is displayed in horizontal and vertical dimensions contracted according to the factor.																														
			<table><tr><th>RSZ1</th><th>RSZ0</th><th>Resizing Scale</th></tr><tr><td>0</td><td>0</td><td>No Resizing (X1)</td></tr><tr><td>0</td><td>1</td><td>X 1/2</td></tr><tr><td>1</td><td>0</td><td>Setting Inhibited</td></tr><tr><td>1</td><td>1</td><td>X1/4</td></tr></table>																RSZ1	RSZ0	Resizing Scale	0	0	No Resizing (X1)	0	1	X 1/2	1	0	Setting Inhibited	1	1	X1/4
			RSZ1	RSZ0	Resizing Scale																												
			0	0	No Resizing (X1)																												
			0	1	X 1/2																												
			1	0	Setting Inhibited																												
1	1	X1/4																															
RCH [1:0]: Sets the number of pixels made as the remainder in horizontal direction when resizing a picture. By specifying the number of remainder pixels with RCH [1:0] the data can be transferred without taking the reminder pixels into consideration. Make sure that RCH [1:0] = “00” when not using the resizing function (RCH [1:0]=”00”) or there are no remainder pixels.																																	
<table><tr><th>RCH1</th><th>RCH0</th><th>Number of Remainder Pixels in Horizontal Direction</th></tr><tr><td>0</td><td>0</td><td>0 Pixel</td></tr><tr><td>0</td><td>1</td><td>1 Pixel</td></tr><tr><td>1</td><td>0</td><td>2 Pixel</td></tr><tr><td>1</td><td>1</td><td>3 Pixel</td></tr></table>																RCH1	RCH0	Number of Remainder Pixels in Horizontal Direction	0	0	0 Pixel	0	1	1 Pixel	1	0	2 Pixel	1	1	3 Pixel			
RCH1	RCH0	Number of Remainder Pixels in Horizontal Direction																															
0	0	0 Pixel																															
0	1	1 Pixel																															
1	0	2 Pixel																															
1	1	3 Pixel																															
RCV [1:0]: Sets the number of pixels made as the remainder in vertical direction when resizing a picture. By specifying the number of remainder pixels with the RCV bits, the data can be transferred without taking the reminder pixels into consideration. Make sure that RCV [1:0] =”00 “when not using the resizing function RCV [1:0] =”00 “or there are no remainder pixels.																																	
<table><tr><th>RCV1</th><th>RCV0</th><th>Number of Remainder Pixels in Vertical Direction</th></tr><tr><td>0</td><td>0</td><td>0 Pixel</td></tr><tr><td>0</td><td>1</td><td>1 Pixel</td></tr><tr><td>1</td><td>0</td><td>2 Pixel</td></tr><tr><td>1</td><td>1</td><td>3 Pixel</td></tr></table>																RCV1	RCV0	Number of Remainder Pixels in Vertical Direction	0	0	0 Pixel	0	1	1 Pixel	1	0	2 Pixel	1	1	3 Pixel			
RCV1	RCV0	Number of Remainder Pixels in Vertical Direction																															
0	0	0 Pixel																															
0	1	1 Pixel																															
1	0	2 Pixel																															
1	1	3 Pixel																															

9.2.7 Display Control 1 (R07h)

Display Control 1 (R07h)																																																					
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0																																			
1	↑	1	0	0	PTDE1	PTDE0	0	0	0	BASEE	0	0	GON	DTE	CL	0	D1	D0																																			
Default value			0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0																																			
Description			D [1:0]: A graphics display is turned on the screen when writing D1 = “1”, and is turned off when writing D1 = “0”. When writing D1 = “0”, the graphics display data is retained in the internal DRAM and the ST7781R displays the data when writing D1 = “1”. When D1 = “0”, i.e. while no display is shown on the panel, all source outputs becomes the GND level to reduce charging/discharging current, which is generated within the LCD while driving liquid crystal with AC voltage. When the display is turned off by setting D [1:0] =00, the ST7781R's internal display operation is halted completely. In combination with the GON setting, the D [1:0] setting controls display ON/OFF. <table><thead><tr><th>D1</th><th>D0</th><th>BASEE</th><th>Source, VCOM Output</th><th>Internal Operation</th></tr></thead><tbody><tr><td>0</td><td>0</td><td>0</td><td>GND</td><td>Halt</td></tr><tr><td>0</td><td>1</td><td>1</td><td>GND</td><td>Operate</td></tr><tr><td>1</td><td>0</td><td>0</td><td>Non-lit display</td><td>Operate</td></tr><tr><td>1</td><td>1</td><td>0</td><td>Non-lit display</td><td>Operate</td></tr><tr><td>1</td><td>1</td><td>1</td><td>Base Image display</td><td>Operate</td></tr></tbody></table> <i>Note1: Data write operation from the microcontroller is performed irrespective of the setting of D [1:0] bits.</i> <i>Note2: The D [1:0] setting is valid on both 1st and 2nd displays.</i> <i>Note3: The non-lit display level from the source output pins is determined by instruction (PTS).</i> CL: When CL = “1”, the ST7781R halt grayscale amplifiers to display 8-color with low power consumption. When setting 8-color display mode, follow the sequence of 8-color display mode setting. <table><thead><tr><th>CL</th><th>Display color</th></tr></thead><tbody><tr><td>0</td><td>262,144</td></tr><tr><td>1</td><td>8</td></tr></tbody></table> <i>Note: When CL = 1, do not write the data corresponding to the grayscales, for which the operation of amplifier is halted.</i> GON, DTE: The combination of GON and DTE settings set the output level form gate lines (G1 ~ G320).															D1	D0	BASEE	Source, VCOM Output	Internal Operation	0	0	0	GND	Halt	0	1	1	GND	Operate	1	0	0	Non-lit display	Operate	1	1	0	Non-lit display	Operate	1	1	1	Base Image display	Operate	CL	Display color	0	262,144	1	8
			D1	D0	BASEE	Source, VCOM Output	Internal Operation																																														
			0	0	0	GND	Halt																																														
			0	1	1	GND	Operate																																														
			1	0	0	Non-lit display	Operate																																														
			1	1	0	Non-lit display	Operate																																														
			1	1	1	Base Image display	Operate																																														
			CL	Display color																																																	
			0	262,144																																																	
			1	8																																																	

GON	DTE	Gate Output
0	0	VGH
0	1	VGH
1	0	VGL
1	1	Normal display

BASEE: Base image display enable bit.

BASEE = 0: No base image is displayed. The ST7781R drives liquid crystal with non-lit display level or drives only partial image display areas.

BASEE = 1: A base image is displayed on the screen.

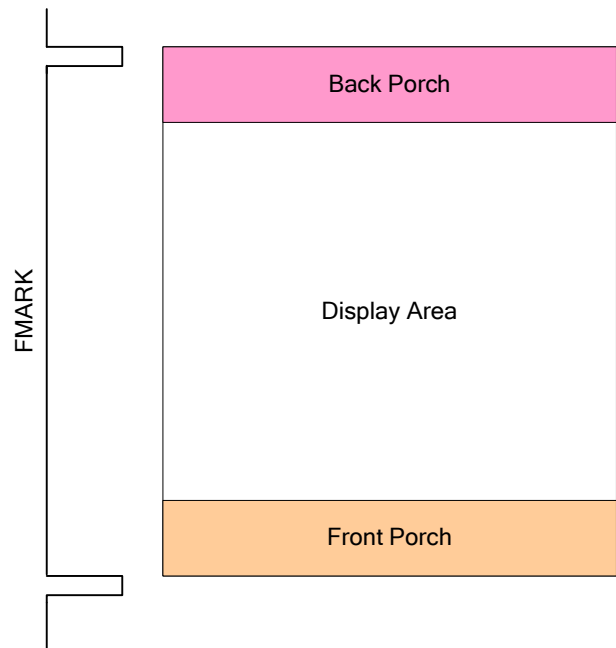
PTDE [1:0]: Partial image 2 and Partial image 1 enable bits

PTDE1/0 = 0: turns off partial image. Only base image is displayed.

PTDE1/0 = 1: turns on partial image.

9.2.8 Display Control 2 (R08h)

Display Control 2 (R08h)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	FP6	FP5	FP4	FP3	FP2	FP1	FP0	0	BP6	BP5	BP4	BP3	BP2	BP1	BP0
Default value			0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0
Description			FP [6:0]: Sets the number of lines for a front porch period (a blank period following the end of display). BP [6:0]: Sets the number of lines for a back porch period (a blank period made before the beginning of display). Note: In 8080 interface operation mode, BP>=2 lines, FP>=2 lines In external display interface operation, a back porch (BP) period starts on the falling edge of the FMARK signal and the display operation starts after the back porch period. A blank period will start after a front porch (FP) period and it will continue until next FMARK input is detected.															
			FP[6:0] BP[6:0]		Porch Lines													
			7'h00		Setting Prohibited													
			7'h01		Setting Prohibited													
			7'h02		2 lines													
			7'h03		3 lines													
			7'h04		4 lines													
			7'h05		5 lines													
			7'h06		6 lines													
			7'h07		7 lines													
			7'h08		8 lines													
			7'h09		9 lines													
			7'h0A		10 lines													
			7'h0B		11 lines													
			:		:													
			7'h7D		125 lines													
			7'h7E		126 lines													
			7'h7F		127 lines													



Note: The output timing to the LCD is delayed by 2 lines period from the input FMARK signal.

9.2.9 Display Control 3 (R09h)

Display Control 3 (R09h)																																				
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0																		
1	↑	1	0	0	0	0	0	0	PTS1	PTS0	0	0	PTG1	PTG0	ICS3	ICS2	ICS1	ICS0																		
Default value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																		
Description			PTS [1:0]: Sets the source output level in non-display area drive period. <table><tr><th rowspan="2">PTS[1:0]</th><th colspan="2">Source Output Level</th></tr><tr><th>Positive Polarity</th><th>Negative Polarity</th></tr><tr><td>00</td><td>V63P</td><td>V63N</td></tr><tr><td>01</td><td>V0P</td><td>V0N</td></tr><tr><td>10</td><td>AGND</td><td>AGND</td></tr><tr><td>11</td><td>Hi-Z</td><td>Hi-Z</td></tr></table>																PTS[1:0]	Source Output Level		Positive Polarity	Negative Polarity	00	V63P	V63N	01	V0P	V0N	10	AGND	AGND	11	Hi-Z	Hi-Z	
			PTS[1:0]	Source Output Level																																
				Positive Polarity	Negative Polarity																															
			00	V63P	V63N																															
			01	V0P	V0N																															
			10	AGND	AGND																															
			11	Hi-Z	Hi-Z																															
			PTG [1:0]: Sets the scan mode in non-display area. The scan mode selected by PTG [1:0] bits is applied in the non-display area when the base image is turned off and the non-display area other than the first and second partial display areas. <table><tr><th>PTG[1:0]</th><th>Gate Output in Non-Display Area</th></tr><tr><td>00</td><td>Normal Scan</td></tr><tr><td>01</td><td>Setting Prohibited</td></tr><tr><td>10</td><td>Interval Scan</td></tr><tr><td>11</td><td>Setting Prohibited</td></tr></table>																PTG[1:0]	Gate Output in Non-Display Area	00	Normal Scan	01	Setting Prohibited	10	Interval Scan	11	Setting Prohibited								
			PTG[1:0]	Gate Output in Non-Display Area																																
			00	Normal Scan																																
01	Setting Prohibited																																			
10	Interval Scan																																			
11	Setting Prohibited																																			
ICS [3:0]: Set the scan cycle when PTG [1:0] selects interval scan in non-display area drive period. The scan cycle is defined by n frame periods, where n is an odd number from 0 to 29. The polarity of liquid crystal drive voltage from the gate driver is inverted in the same timing as the interval scan cycle. <table><tr><th>ICS[3:0]</th><th>Scan</th><th>$f_{FLM} = 60\text{Hz}$</th></tr><tr><td>0000</td><td>0 frame</td><td>-</td></tr><tr><td>0001</td><td>1 frame</td><td>17ms</td></tr><tr><td>0010</td><td>3 frame</td><td>50ms</td></tr><tr><td>0011</td><td>5 frame</td><td>84ms</td></tr><tr><td>0100</td><td>7 frame</td><td>117ms</td></tr><tr><td>0101</td><td>9 frame</td><td>150ms</td></tr></table>																ICS[3:0]	Scan	$f_{FLM} = 60\text{Hz}$	0000	0 frame	-	0001	1 frame	17ms	0010	3 frame	50ms	0011	5 frame	84ms	0100	7 frame	117ms	0101	9 frame	150ms
ICS[3:0]	Scan	$f_{FLM} = 60\text{Hz}$																																		
0000	0 frame	-																																		
0001	1 frame	17ms																																		
0010	3 frame	50ms																																		
0011	5 frame	84ms																																		
0100	7 frame	117ms																																		
0101	9 frame	150ms																																		

		0110	11 frame	184ms	
		0111	13 frame	217ms	
		1000	15 frame	251ms	
		1001	17 frame	284ms	
		1010	19 frame	317ms	
		1011	21 frame	351ms	
		1100	23 frame	384ms	
		1101	25 frame	418ms	
		1110	27 frame	451ms	
		1111	29 frame	484ms	
<i>Note1: The power efficiency improved by halting grayscale amplifiers and slowing down the step-up clock frequency can be obtained in non-display drive period.</i> <i>Note2: The gate output level in non-display drive period is controlled by the PTG setting (off-scan mode).</i>					

9.2.10 Display Control 4 (R0Ah)

Display Control 4 (R0Ah)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	0	0	0	0	0	0	0	0	0	FMARKOE	FMI2	FMI1	FMI0
Default value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Description			FMARKOE: When FMARKOE = 1, the ST7781R starts outputting FMARK signal from the FMARK pin in the output interval set by FMI[2:0] bits															
			FMI [2:0]: Sets the output interval of FMARK signal according to the display data rewrite cycle and data transfer rate.															
			FMI[2:0]		Output Interval													
			000		1 Frame													
			001		2 Frames													
			011		4 Frames													
			101		6 Frames													
			Others		Setting Prohibited													

9.2.11 RGB Display Interface Control 1 (R0Ch)

RGB Display Interface Control 1 (R0Ch)																																				
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0																		
1	↑	1	0	ENC2	ENC1	ENC0	0	0	0	RM	0	0	DM1	DM0	0	0	RIM1	RIM0																		
Default value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																		
Description			ENC [2:0]: Set the RAM write cycle through the RGB interface																																	
			<table><tr><th>ENC[2:0]</th><th>RAM Write Cycle(Frame periods)</th></tr><tr><td>000</td><td>1 Frame</td></tr><tr><td>001</td><td>2 Frames</td></tr><tr><td>010</td><td>3 Frames</td></tr><tr><td>011</td><td>4 Frames</td></tr><tr><td>100</td><td>5 Frames</td></tr><tr><td>101</td><td>6 Frames</td></tr><tr><td>110</td><td>7 Frames</td></tr><tr><td>111</td><td>8 Frames</td></tr></table>																ENC[2:0]	RAM Write Cycle(Frame periods)	000	1 Frame	001	2 Frames	010	3 Frames	011	4 Frames	100	5 Frames	101	6 Frames	110	7 Frames	111	8 Frames
			ENC[2:0]	RAM Write Cycle(Frame periods)																																
			000	1 Frame																																
			001	2 Frames																																
			010	3 Frames																																
			011	4 Frames																																
			100	5 Frames																																
			101	6 Frames																																
			110	7 Frames																																
111	8 Frames																																			
RM: Select the interface to access the RAM.																																				
<table><tr><th>Display Status</th><th>Operation Mode</th><th>RAM Access(RM)</th><th>Display Operation Mode(DM[1:0])</th></tr><tr><td>Still picture</td><td>Internal clock operation</td><td>System interface(RM = 0)</td><td>Internal clock operation (DM[1:0] = 00)</td></tr><tr><td>Moving picture</td><td>RGB interface (1)</td><td>RGB interface(RM = 1)</td><td>RGB interface (DM[1:0] = 01)</td></tr><tr><td>Rewrite still picture area while displaying moving pictures.</td><td>RGB interface (2)</td><td>System interface(RM = 0)</td><td>RGB interface (DM[1:0] = 01)</td></tr><tr><td>Moving pictures</td><td>VSYNC interface</td><td>System interface(RM = 0)</td><td>VSYNC interface (DM[1:0] = 10)</td></tr></table>																Display Status	Operation Mode	RAM Access(RM)	Display Operation Mode(DM[1:0])	Still picture	Internal clock operation	System interface(RM = 0)	Internal clock operation (DM[1:0] = 00)	Moving picture	RGB interface (1)	RGB interface(RM = 1)	RGB interface (DM[1:0] = 01)	Rewrite still picture area while displaying moving pictures.	RGB interface (2)	System interface(RM = 0)	RGB interface (DM[1:0] = 01)	Moving pictures	VSYNC interface	System interface(RM = 0)	VSYNC interface (DM[1:0] = 10)	
Display Status	Operation Mode	RAM Access(RM)	Display Operation Mode(DM[1:0])																																	
Still picture	Internal clock operation	System interface(RM = 0)	Internal clock operation (DM[1:0] = 00)																																	
Moving picture	RGB interface (1)	RGB interface(RM = 1)	RGB interface (DM[1:0] = 01)																																	
Rewrite still picture area while displaying moving pictures.	RGB interface (2)	System interface(RM = 0)	RGB interface (DM[1:0] = 01)																																	
Moving pictures	VSYNC interface	System interface(RM = 0)	VSYNC interface (DM[1:0] = 10)																																	
Note1: Registers are set only via the system interface or SPI interface.																																				
Note2: Refer to the flowcharts of “RGB Input Interface” section for the mode switch.																																				

DM [1:0]: Select the display operation mode.

DM[1:0]	Display Interface
00	Internal system clock
01	RGB interface
10	VSYNC interface
11	Setting disabled

Note1: The DM[1:0] setting allows switching between internal clock operation mode and external display interface operation mode. However, switching between the RGB interface operation mode and the VSYNC interface operation mode is prohibited.

RIM [1:0]: Select the RGB interface data format.

RIM[1:0]	RGB Interface Mode
00	18-bit RGB interface (1 transfer/pixel), DB[17:0]
01	16-bit RGB interface (1 transfer/pixel), DB[17:13] and DB[11:1]
10	6-bit RGB interface (3 transfers/pixel), DB[17:12]
11	Setting disabled

Note1: Registers are set only by the system interface.

Note2: Be sure that one pixel (3 dots) data transfer finished when interface switch.

9.2.12 Frame Marker Position (R0Dh)

Frame Marker Position (R0Dh)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	0	0	0	0	FMP8	FMP7	FMP6	FMP5	FMP4	FMP3	FMP2	FMP1	FMP0
Default value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Description			FMP [8:0]: Sets the output position of frame cycle signal (frame marker). When FMP[8:0] = 9'h000, a high-active pulse FMARK is output at the start of back porch period for 1H period. FMARK can be used as the trigger signal for frame synchronous write operation.															
			FMP[8:0]		FMARK Output Position													
			9'h000		0th line													
			9'h001		1st line													
			9'h002		2nd line													
			9'h003		3rd line													
			.		.													
			.		.													
			.		.													
			9'h174		372nd line													
			9'h175		373rd line													
			9'h176		374th line													
			9'h177		375th line													

9.2.13 RGB Display Interface Control 2 (R0Fh)

RGB Display Interface Control (R0Fh)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	0	0	0	0	0	0	0	0	VSPL	HSPL	0	EPL	DPL
Default value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Description			VSPL : Sets the signal polarity of the VSYNC pin. VSPL="0", Low active VSPL="1", High active															
			HSPL : Sets the signal polarity of the HSYNC pin. HSPL="0", Low active HSPL="1", High active															
			EPL : Sets the signal polarity of the ENABLE pin. EPL = "0" The data DB17-0 is written when ENABLE = "0". Disable data write operation when ENABLE = "1". EPL = "1" The data DB17-0 is written when ENABLE = "1". Disable data write operation when ENABLE = "0".															
			DPL : Sets the signal polarity of the DOTCLK pin. DPL = "0" The data is input on the positive edge of DOTCLK DPL = "1" The data is input on the negative edge of DOTCLK															

9.2.14 Power Control 1 (R10h)

Power Control 1 (R10h)																																													
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0																											
1	↑	1	0	0	0	SAP	0	0	0	0	APE	AP2	AP1	AP0	0	0	SLP	STB																											
Default value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																											
Description			SAP: Source Driver output control SAP="0", Source driver is disabled. SAP="1", Source driver is enabled. When starting the charge-pump of LCD in the Power ON stage, make sure that SAP="0", and set the SAP="1", after starting up the LCD power supply circuit. APE: Power supply enable bit. Set APE = "1" to start generation of power supply according to the power supply startup sequence. AP [2:0]: Adjusts the constant current in the operational amplifier circuit in the LCD power supply circuit. The larger constant current enhances the drivability of the LCD, but it also increases the current consumption. Adjust the constant current taking the trade-off into account between the display quality and the current consumption. In no-display period, set AP[2:0]= "000" to halt the operational amplifier circuits and the step-up circuits to reduce current consumption. <table><tr><th>AP[2:0]</th><th>Gamma Driver Amplifier</th><th>Source Driver Amplifier</th></tr><tr><td>000</td><td>Halt</td><td>Halt</td></tr><tr><td>001</td><td>1.5</td><td>1.5</td></tr><tr><td>010</td><td>1.25</td><td>1.25</td></tr><tr><td>011</td><td>1.00</td><td>1.00</td></tr><tr><td>100</td><td>0.75</td><td>0.75</td></tr><tr><td>101</td><td>0.5</td><td>0.5</td></tr><tr><td>110</td><td>0.25</td><td>0.25</td></tr><tr><td>111</td><td>Setting Prohibited</td><td>Setting Prohibited</td></tr></table> SLP: When SLP = "1", ST7781R enters the sleep mode and the display operation stops except the RC oscillator to reduce the power consumption. No change to the DRAM data and instruction setting is accepted and the DRAM data and the instruction setting are maintained in SLP mode. STB: When STB = "1", ST7781R enters the standby mode and the display operation stops except the DRAM power supply to reduce the power consumption. No change to the DRAM data and instruction setting is accepted and the DRAM data and the instruction setting are maintained in STB mode.																AP[2:0]	Gamma Driver Amplifier	Source Driver Amplifier	000	Halt	Halt	001	1.5	1.5	010	1.25	1.25	011	1.00	1.00	100	0.75	0.75	101	0.5	0.5	110	0.25	0.25	111	Setting Prohibited	Setting Prohibited
			AP[2:0]	Gamma Driver Amplifier	Source Driver Amplifier																																								
			000	Halt	Halt																																								
			001	1.5	1.5																																								
			010	1.25	1.25																																								
			011	1.00	1.00																																								
			100	0.75	0.75																																								
			101	0.5	0.5																																								
			110	0.25	0.25																																								
			111	Setting Prohibited	Setting Prohibited																																								

9.2.15 DRAM Horizontal/Vertical Address Set (R20h, R21h)

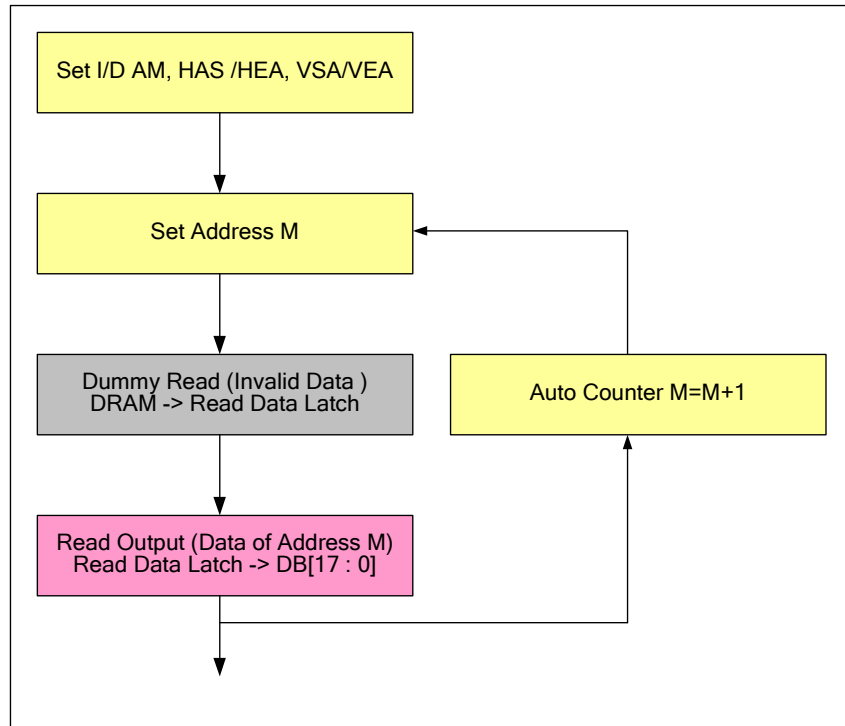
DRAM Horizontal/Vertical Address Set (R20h,R21h)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	0	0	0	0	0	AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0
Default value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	↑	1	0	0	0	0	0	0	0	AD16	AD15	AD14	AD13	AD12	AD11	AD10	AD9	AD8
Default value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Description			AD [16:0]: A DRAM address set initially in the AC (Address Counter). The address in the AC is automatically updated according to the combination of AM, I/D[1:0] settings as the ST7781R writes data to the internal DRAM so that data can be written consecutively without resetting the address in the AC.															
			AD[16:0]										DRAM Data Map					
			17'h00000~17'h000EF										1st line DRAM Data					
			17'h00100~17'h001EF										2nd line DRAM Data					
			17'h00200~17'h002EF										3rd line DRAM Data					
			17'h00300~17'h003EF										4th line DRAM Data					
			.										.					
			.										.					
			.										.					
			17'h13D00~17'h13DEF										318th line DRAM Data					
			17'h13E00~17'h13EEF										319th line DRAM Data					
			17'h13F00~17'h13FFE										320h line DRAM Data					

9.2.16 Write Data to DRAM (R22h)

Write Data to DRAM (R22h)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	WD [17:0] - DRAM Write Data															
Description			WD [17:0]: The ST7781R develops data into 18 bits internally in write operation. The format to develop data into 18 bits is different in different interface operation. The DRAM data represents the grayscale level. The DRAM data represents the grayscale level. ST7781R automatically updates the address to the begin point according to AM and I/D[1:0] settings as it's wrote this register. The DFM bit sets the format to develop 16-bit data into the 18-bit data in 16-bit or 8-bit interface operation.															

9.2.17 Read Data from DRAM (R22h)

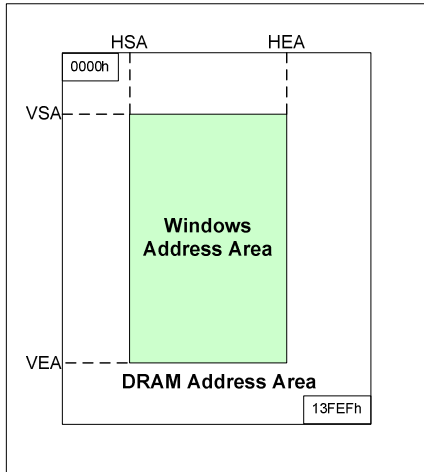
Read Data from DRAM (R22h)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	1	↑	RD [17:0] - DRAM Read Data															
Description			RD [17:0]: 18-bit data read from the DRAM. RAM read data RD [17:0] is transferred via different data bus in different interface operation. When the ST7781R reads data from the DRAM to the microcomputer, the first word read immediately after RAM address set is executed is taken in the internal read-data latch and invalid data is sent to the data bus. Valid data is sent to the data bus when the ST7781R reads out the second and subsequent words. When either 8-bit or 16-bit interface is selected, the LSBs of R and B dot data are not read out.															
			Set I/D AM, HAS /HEA, VSA/VEA Set Address M Dummy Read (Invalid Data) DRAM -> Read Data Latch Read Output (Data of Address M) Read Data Latch -> DB[17 : 0] Read Output (Data of Address M+1) Read Data Latch -> DB[17 : 0] Set Address N Dummy Read (Invalid Data) DRAM -> Read Data Latch Read Output (Data of Address N) Read Data Latch -> DB[17 : 0] The ST7781R also support function that automatically updates the address according to AM and I/D[1:0] settings as it read data continuously address in the DRAM															



9.2.18 Gamma Control (R30h~R3Dh)

Gamma Control (R30h~R3Dh)																			
R30h	RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
	1	↑	1	0	0	0	0	0	KP1[2]	KP1[1]	KP1[0]	0	0	0	0	0	KP0[2]	KP0[1]	KP0[0]
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R31h	1	↑	1	0	0	0	0	0	KP3[2]	KP3[1]	KP3[0]	0	0	0	0	0	KP2[2]	KP2[1]	KP2[0]
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R32h	1	↑	1	0	0	0	0	0	KP5[2]	KP5[1]	KP5[0]	0	0	0	0	0	KP4[2]	KP4[1]	KP4[0]
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R35h	1	↑	1	0	0	0	0	0	RP1[2]	RP1[1]	RP1[0]	0	0	0	0	0	RP0[2]	RP0[1]	RP0[0]
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R36h	1	↑	1	0	0	0	VRP1[4]	VRP1[3]	VRP1[2]	VRP1[1]	VRP1[0]	0	0	0	0	VRP0[3]	VRP0[2]	VRP0[1]	VRP0[0]
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R37h	1	↑	1	0	0	0	0	0	KN1[2]	KN1[1]	KN1[0]	0	0	0	0	0	KN0[2]	KN0[1]	KN0[0]
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R38h	1	↑	1	0	0	0	0	0	KN3[2]	KN3[1]	KN3[0]	0	0	0	0	0	KN2[2]	KN2[1]	KN2[0]
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R39h	1	↑	1	0	0	0	0	0	KN5[2]	KN5[1]	KN5[0]	0	0	0	0	0	KN4[2]	KN4[1]	KN4[0]
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R3Ch	1	↑	1	0	0	0	0	0	RN1[2]	RN1[1]	RN1[0]	0	0	0	0	0	RN0[2]	RN0[1]	RN0[0]
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R3Dh	1	↑	1	0	0	0	VRN1[4]	VRN1[3]	VRN1[2]	VRN1[1]	VRN1[0]	0	0	0	0	VRN0[3]	VRN0[2]	VRN0[1]	VRN0[0]
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Description				KP5-0[2:0]: γfine Adjustment Register for Positive Polarity. RP1-0[2:0]: γgradient Adjustment Register for Positive Polarity. VRP1 [4:0]: γamplitude Adjustment Register for Positive Polarity. VRP0 [3:0]: γamplitude Adjustment Register for Positive Polarity. KN5-0[2:0]: γfine Adjustment Register for Negative Polarity. RN1-0[2:0]: γgradient Adjustment Register for Negative Polarity. VRN1 [4:0]: γamplitude Adjustment Register for Negative Polarity. VRN0 [3:0]: γamplitude Adjustment Register for Negative Polarity.															

9.2.19 Horizontal and Vertical RAM Address Position (R50h, R51h, R52h, R53h)

Horizontal and Vertical RAM Address Position(R50h,R51h,R52h,R53h)																				
R50h	RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0	
	1	↑	1	0	0	0	0	0	0	0	0	HSA7	HSA6	HSA5	HSA4	HSA3	HSA2	HSA1	HSA0	
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
R51h	1	↑	1	0	0	0	0	0	0	0	0	HEA7	HEA6	HEA5	HEA4	HEA3	HEA2	HEA1	HEA0	
Default value				0	0	0	0	0	0	0	0	1	1	1	0	1	1	1	1	
R52h	1	↑	1	0	0	0	0	0	0	0	VSA8	VSA7	VSA6	VSA5	VSA4	VSA3	VSA2	VSA1	VSA0	
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R53h	1	↑	1	0	0	0	0	0	0	0	VEA8	VEA7	VEA6	VEA5	VEA4	VEA3	VEA2	VEA1	VEA0	
Default value				0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1	1
Description				HSA [7:0], HEA [7:0] HSA[7:0] and HEA[7:0] are the start and end addresses of the window address area in horizontal direction, respectively. HSA [7:0] and HEA [7:0] specify the horizontal range to write data. Set HSA [7:0] and HEA [7:0] before starting RAM write operation. In setting, make sure that 8’h00 ≤ HAS < HEA ≤ 8’hEF VSA [8:0], VEA [8:0] VSA [8:0] and VEA [8:0] are the start and end addresses of the window address area in vertical direction, respectively. VSA [8:0] and VEA [8:0] specify the vertical range to write data. Set VSA [8:0] and VEA [8:0] before starting RAM write operation. In setting, make sure that 9’h000 ≤ VSA < VEA ≤ 9’h13F.																
								“00”h ≤HSA[7:0] ≤HEA[7:0] ≤”EF”h “00”h ≤VSA[8:0] ≤VEA[8:0] ≤”13F”h												
				Note1. The window address range must be within the DRAM address space. Note2. Data are written to DRAM in four-words when operating in high speed mode, the dummy write operations should be inserted depending on the window address area.																

9.2.20 Gate Scan Control (R60h, R61h, R6Ah)

Gate Scan Control (R60h,R61h)																																																																																										
R60h	RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0																																																																							
	1	↑	1	GS	0	NL5	NL4	NL3	NL2	NL1	NL0	0	0	SCN5	SCN4	SCN3	SCN2	SCN1	SCN0																																																																							
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																																																																							
R61h	1	↑	1	0	0	0	0	0	0	0	0	0	0	0	0	0	NDL	VLE	REV																																																																							
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																																																																						
R6Ah	1	↑	1	0	0	0	0	0	0	0	VL8	VL7	VL6	VL5	VL4	VL3	VL2	VL1	VL0																																																																							
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0																																																																						
Description	GS: Sets the direction of scan by the gate driver. Set GS bit in combination with SM and SS bits for the convenience of the display module configuration and the display direction. When GS=0, the scan direction is from G1 to G320 When GS=1, the scan direction is from G320 to G1 NL [5:0]: Sets the number of lines to drive the LCD at an interval of 8 lines. The DRAM address mapping is not affected by the number of lines set by NL[5:0]. The number of lines must be the same or more than the number of lines necessary for the size of the liquid crystal panel. <table><tr><th>NL[5:0]</th><th>LCD Drive Line</th><th>NL[5:0]</th><th>LCD Drive Line</th></tr><tr><td>6'h1D</td><td>240 lines</td><td>6'h23</td><td>288 lines</td></tr><tr><td>6'h1E</td><td>248 lines</td><td>6'h24</td><td>296 lines</td></tr><tr><td>6'h1F</td><td>256 lines</td><td>6'h25</td><td>304 lines</td></tr><tr><td>6'h20</td><td>264 lines</td><td>6'h26</td><td>312 lines</td></tr><tr><td>6'h21</td><td>272 lines</td><td>6'h27</td><td>320 lines</td></tr><tr><td>6'h22</td><td>280 lines</td><td>Others</td><td>Setting inhibited</td></tr></table> SCN [5:0]: Specifies the gate line where the gate driver starts scan. <table><tr><th rowspan="3">SCN[5:0]</th><th colspan="4">Scanning Start Position</th></tr><tr><th colspan="2">SM=0</th><th colspan="2">SM=1</th></tr><tr><th>GS=0</th><th>GS=1</th><th>GS=0</th><th>GS=1</th></tr><tr><td>00h</td><td>G1</td><td>G320</td><td>G1</td><td>G320</td></tr><tr><td>01h</td><td>G9</td><td>G312</td><td>G17</td><td>G304</td></tr><tr><td>02h</td><td>G17</td><td>G304</td><td>G33</td><td>G288</td></tr><tr><td>03h</td><td>G25</td><td>G296</td><td>G49</td><td>G272</td></tr><tr><td>04h</td><td>G33</td><td>G288</td><td>G65</td><td>G265</td></tr><tr><td>05h</td><td>G41</td><td>G280</td><td>G81</td><td>G240</td></tr></table>																			NL[5:0]	LCD Drive Line	NL[5:0]	LCD Drive Line	6'h1D	240 lines	6'h23	288 lines	6'h1E	248 lines	6'h24	296 lines	6'h1F	256 lines	6'h25	304 lines	6'h20	264 lines	6'h26	312 lines	6'h21	272 lines	6'h27	320 lines	6'h22	280 lines	Others	Setting inhibited	SCN[5:0]	Scanning Start Position				SM=0		SM=1		GS=0	GS=1	GS=0	GS=1	00h	G1	G320	G1	G320	01h	G9	G312	G17	G304	02h	G17	G304	G33	G288	03h	G25	G296	G49	G272	04h	G33	G288	G65	G265	05h	G41	G280	G81	G240
	NL[5:0]	LCD Drive Line	NL[5:0]	LCD Drive Line																																																																																						
	6'h1D	240 lines	6'h23	288 lines																																																																																						
	6'h1E	248 lines	6'h24	296 lines																																																																																						
	6'h1F	256 lines	6'h25	304 lines																																																																																						
	6'h20	264 lines	6'h26	312 lines																																																																																						
	6'h21	272 lines	6'h27	320 lines																																																																																						
	6'h22	280 lines	Others	Setting inhibited																																																																																						
	SCN[5:0]	Scanning Start Position																																																																																								
		SM=0		SM=1																																																																																						
GS=0		GS=1	GS=0	GS=1																																																																																						
00h	G1	G320	G1	G320																																																																																						
01h	G9	G312	G17	G304																																																																																						
02h	G17	G304	G33	G288																																																																																						
03h	G25	G296	G49	G272																																																																																						
04h	G33	G288	G65	G265																																																																																						
05h	G41	G280	G81	G240																																																																																						

	06h	G49	G272	G97	G224
	07h	G57	G264	G113	G208
	08h	G65	G256	G129	G192
	09h	G73	G248	G145	G176
	0Ah	G81	G240	G161	G160
	0Bh	G89	G232	G177	G144
	0Ch	G97	G224	G193	G128
	0Dh	G105	G216	G209	G112
	0Eh	G113	G208	G2	G96
	0Fh	G121	G200	G18	G80
	10h	G129	G192	G34	G64
	11h	G137	G184	G50	G48
	12h	G145	G176	G66	G32
	13h	G153	G168	G82	G16
	14h	G161	G152	G114	G303
	15h	G169	G152	G114	G303
	16h	G177	G144	G130	G287
	17h	G185	G136	G146	G271
	18h	G193	G128	G162	G255
	19h	G201	G120	G178	G239
	1Ah	G209	G112	G194	G223
	1Bh	G217	G104	G114	G207
	1Ch	G225	G96	G130	G191
	1Dh	G233	G88	G146	G175
	1Eh	G241	G80	G162	G159
	1Fh	G249	G72	G178	G143
	20h	G257	G64	G194	G127
	21h	G265	G56	G210	G111
	22h	G273	G48	G226	G95
	23h	G281	G40	G242	G79
	24h	G289	G32	G258	G63
	25h	G297	G24	G274	G47
	26h	G305	G16	G290	G31
	27h	G313	G8	G30	G15
	28h ~ 3Fh	Setting disabled	Setting disabled	Setting disabled	Setting disabled

NDL: Sets the source output level in non display area. NDL bit can keep the non-display area lit on.

NDL	Non- Display Area	
	Positive Polarity	Negative Polarity
0	V63	V0
1	V0	V63

REV: Enables the grayscale inversion of the image by setting REV = 1. This enables the ST7781R to display the same image from the same set of data whether the liquid crystal panel is normally black or white. The source output level during front, back porch periods and blank periods is determined by register setting (PTS).

REV	DRAM Data	Non- Display Area	
		Positive Polarity	Negative Polarity
0	18'h00000	V63	V0
	.	.	.
	.	.	.
	.	.	.
1	18'h3FFFF	V0	V63
	18'h00000	V0	V63
	.	.	.
	.	.	.
1	.	.	.
	.	.	.
	.	.	.
	18'h3FFFF	V63	V0

VLE: Vertical scroll display enable bit. When VLE = 1, the ST7781R starts displaying the base image from the line (of the physical display) determined by VL[8:0] bits. VL[8:0] sets the amount of scrolling, which is the number of lines to shift the start line of the display from the first line of the physical display. Note that the partial image display position is not affected by the base image scrolling.

The vertical scrolling is not available in external display interface operation. In this case, make sure to set VLE = "0".

VLE	Base Image Display
0	Fixed
1	Enable Scrolling

VL[8:0]: Sets the scrolling amount of base image. The base image is scrolled in vertical direction and displayed from the line determined by VL[8:0]. Make sure that $VL[8:0] \leq 320$.

9.2.21 Partial Image 1 Display Position (R80h)

Partial Image 1 Display Position (R80h)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	0	0	0	0	PTDP08	PTDP07	PTDP06	PTDP05	PTDP04	PTDP03	PTDP02	PTDP01	PTDP00
Default value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Description			PTDP0 [8:0]: Sets the display start position of partial image 1. The display areas of the partial images 1 and 2 must not overlap each another.															

9.2.22 Partial Image 1 Start/End Address (R81h, R82h)

Partial Image 1 Start/End Address(R81h,R82h)																			
R81h	RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
	1	↑	1	0	0	0	0	0	0	0	PTSA08	PTSA07	PTSA06	PTSA05	PTSA04	PTSA03	PTSA02	PTSA01	PTSA00
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R82h	1	↑	1	0	0	0	0	0	0	0	PTEA08	PTEA07	PTEA06	PTEA05	PTEA04	PTEA03	PTEA02	PTEA01	PTEA00
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Description				PTSA0 [8:0] and PTEA0 [8:0]: Sets the start line and end line addresses of the RAM area, respectively for the partial image															
				Note1: Make sure that PTSA0 ≤ PTEA0.															

9.2.23 Partial Image 2 Display Position (R83h)

Partial Image 2 Display Position (R83h)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	0	0	0	0	PTDP18	PTDP17	PTDP16	PTDP15	PTDP14	PTDP13	PTDP12	PTDP11	PTDP10
Default value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Description			PTDP1 [8:0]: Sets the display start position of partial image Note1. The display areas of the partial images 1 and 2 must not overlap each another.															

9.2.24 Partial Image 2 Start / End Address (R84h, R85h)

Partial Image 2 Start/End Address(R84h,R85h)																			
R84h	RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
	1	↑	1	0	0	0	0	0	0	0	PTSA18	PTSA17	PTSA16	PTSA15	PTSA14	PTSA13	PTSA12	PTSA11	PTSA10
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R85h	1	↑	1	0	0	0	0	0	0	0	PTEA18	PTEA17	PTEA1	PTEA15	PTEA14	PTEA13	PTEA12	PTEA11	PTEA10
Default value				0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Description				PTSA1[8:0] and PTEA1[8:0]: Sets the start line and end line addresses of the DRAM area, respectively for the partial image Note1: Make sure that PTSA1 ≤ PTEA1.															

9.2.25 Panel Interface Control 1 (R90h)

Panel Interface Control 1 (R90h)																																	
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0															
1	↑	1	0	0	0	0	0	0	DIVI1	DIVI0	0	RTNI6	RTNI5	RTNI4	RTNI3	RTNI2	RTNI1	RTNI0															
Default value			0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0															
Description			DIVI [1:0] : Sets the division ratio of the internal clock frequency. The ST7781R's internal operation is synchronized with the frequency divided internal clock. When DIVI[1:0] setting is changed, the width of the reference clock for liquid crystal panel control signals is changed. The frame frequency can be adjusted by register setting (RTNI and DIVI bits). When changing the number of lines to drive the liquid crystal panel, adjust the frame frequency too.																														
			<table><tr><th>DIVI[1:0]</th><th>Division Ratio</th><th>Internal Operation Clock Frequency</th></tr><tr><td>00</td><td>1</td><td>Fosc/1</td></tr><tr><td>01</td><td>2</td><td>Fosc/2</td></tr><tr><td>10</td><td>4</td><td>Fosc/4</td></tr><tr><td>11</td><td>8</td><td>Fosc/8</td></tr></table>																DIVI[1:0]	Division Ratio	Internal Operation Clock Frequency	00	1	Fosc/1	01	2	Fosc/2	10	4	Fosc/4	11	8	Fosc/8
			DIVI[1:0]	Division Ratio	Internal Operation Clock Frequency																												
			00	1	Fosc/1																												
			01	2	Fosc/2																												
			10	4	Fosc/4																												
11	8	Fosc/8																															
RTNI [6:0] : Sets 1H (line) period. This setting is enabled while the ST7781R's display operation is synchronized with internal clock.																																	

RTNI[6:0]	Clocks/Line	RTNI[6:0]	Clocks/Line	RTNI[6:0]	Clocks/Line	RTNI[6:0]	Clocks/Line
00h	0 clock	20h	32 clocks	40h	64 clocks	60h	96 clocks
01h	1 clock	21h	33 clocks	41h	65 clocks	61h	97 clocks
02h	2 clocks	22h	34 clocks	42h	66 clocks	62h	98 clocks
03h	3 clocks	23h	35 clocks	43h	67 clocks	63h	99 clocks
04h	4 clocks	24h	36 clocks	44h	68 clocks	64h	100 clocks
05h	5 clocks	25h	37 clocks	45h	69 clocks	65h	101 clocks
06h	6 clocks	26h	38 clocks	46h	70 clocks	66h	102 clocks
07h	7 clocks	27h	39 clocks	47h	71 clocks	67h	103 clocks
08h	8 clocks	28h	40 clocks	48h	72 clocks	68h	104 clocks
09h	9 clocks	29h	41 clocks	49h	73 clocks	69h	105 clocks
0Ah	10 clocks	2Ah	42 clocks	4Ah	74 clocks	6Ah	106 clocks
0Bh	11 clocks	2Bh	43 clocks	4Bh	75 clocks	6Bh	107 clocks
0Ch	12 clocks	2Ch	44 clocks	4Ch	76 clocks	6Ch	108 clocks
0Dh	13 clocks	2Dh	45 clocks	4Dh	77 clocks	6Dh	109 clocks
0Eh	14 clocks	2Eh	46 clocks	4Eh	78 clocks	6Eh	110 clocks
0Fh	15 clocks	2Fh	47 clocks	4Fh	79 clocks	6Fh	111 clocks
10h	16 clocks	30h	48 clocks	50h	80 clocks	70h	112 clocks
11h	17 clocks	31h	49 clocks	51h	81 clocks	71h	113 clocks
12h	18 clocks	32h	50 clocks	52h	82 clocks	72h	114 clocks
13h	19 clocks	33h	51 clocks	53h	83 clocks	73h	115 clocks
14h	20 clocks	34h	52 clocks	54h	84 clocks	74h	116 clocks
15h	21 clocks	35h	53 clocks	55h	85 clocks	75h	117 clocks
16h	22 clocks	36h	54 clocks	56h	86 clocks	76h	118 clocks
17h	23 clocks	37h	55 clocks	57h	87 clocks	77h	119 clocks
18h	24 clocks	38h	56 clocks	58h	88 clocks	78h	120 clocks
19h	25 clocks	39h	57 clocks	59h	89 clocks	79h	121 clocks
1Ah	26 clocks	3Ah	58 clocks	5Ah	90 clocks	7Ah	122 clocks
1Bh	27 clocks	3Bh	59 clocks	5Bh	91 clocks	7Bh	123 clocks
1Ch	28 clocks	3Ch	60 clocks	5Ch	92 clocks	7Ch	124 clocks
1Dh	29 clocks	3Dh	61 clocks	5Dh	93 clocks	7Dh	125 clocks
1Eh	30 clocks	3Eh	62 clocks	5Eh	94 clocks	7Eh	126 clocks
1Fh	31 clocks	3Fh	63 clocks	5Fh	95 clocks	7Fh	127 clocks

9.2.26 Panel Interface Control 2 (R95h)

Panel Interface Control 2 (R95h)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	0	0	0	DIVE1	DIVE0	0	0	0	0	0	0	0	0
Default value			0	0	0	0	0	0	1	0	0	0	0	1	1	1	1	0
Description			DIVE[1:0]: Sets the division ratio of DOTCLK when ST7781R display operation is synchronized with RGB interface signals.															
			DIVE[1:0]		Division Ratio		18/16-bit RGB Interface				6-bit x 3 Transfers RGB Interface							
			00		1/2		2 DOTCLKS				6 DOTCLKS							
			01		1/4		4 DOTCLKS				12 DOTCLKS							
			10		1/8		8 DOTCLKS				24 DOTCLKS							
			11		1/16		16 DOTCLKS				48 DOTCLKS							

9.2.27 Power Control 2 (RB0h)

Power Control 2 (RB0h)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	VCM5	VCM4	VCM3	VCM2	VCM1	VCM0	0	0	VGLSEL1	VGLSEL0	1	1	VGHBT1	VGHBT0
Default value			0	0	0	0	1	1	1	0	0	0	0	0	1	1	0	0
Description			VCM [5:0]: VCOM voltage setting															
			VCM[5:0]	VCOM		VCM[5:0]	VCOM											
			000000	-0.425		100000	-1.225											
			000001	-0.45		100001	-1.25											
			000010	-0.475		100010	-1.275											
			000011	-0.5		100011	-1.3											
			000100	-0.525		100100	-1.325											
			000101	-0.55		100101	-1.35											
			000110	-0.575		100110	-1.375											
			000111	-0.6		100111	-1.4											
			001000	-0.625		101000	-1.425											
			001001	-0.65		101001	-1.45											
			001010	-0.675		101010	-1.475											
			001011	-0.7		101011	-1.5											
			001100	-0.725		101100	-1.525											
			001101	-0.75		101101	-1.55											
			001110	-0.775		101110	-1.575											
			001111	-0.8		101111	-1.6											
			010000	-0.825		110000	-1.625											
			010001	-0.85		110001	-1.65											
			010010	-0.875		110010	-1.675											
			010011	-0.9		110011	-1.7											
			010100	-0.925		110100	-1.725											
			010101	-0.95		110101	-1.75											
			010110	-0.975		110110	-1.775											
			010111	-1		110111	-1.8											
			011000	-1.025		111000	-1.825											
			011001	-1.05		111001	-1.85											
			011010	-1.075		111010	-1.875											

011011	-1.1	111011	-1.9
011100	-1.125	111100	-1.925
011101	-1.15	111101	-1.95
011110	-1.175	111110	-1.975
011111	-1.2	111111	-2

VGLSEL [1:0]: Set the VGL supply power level.

VGLSEL[1:0]	VGL
00	-7.5
01	-10
10	-12.5
11	-13

VGHBT [1:0]: Set the VGH supply power level.

VGHBT[1:0]	VGH
00	$2 \times \text{AVDD} + \text{VDD}$
01	$3 \times \text{AVDD}$
10	$3 \times \text{AVDD} + \text{VDD}$
11	Don't use this setting, reserve for testing.

9.2.28 Power Control 3 (RB1h)

Power Control 3 (RB1h)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	VRHN4	VRHN3	VRHN2	VRHN1	VRHN0	0	0	0	VRHP4	VRHP3	VRHP2	VRHP1	VRHP0
Default value			0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
Description			VRHN/VRHP [4:0]: GVCL/GVDD voltage setting															
			VRHN[4:0]				GVCL				VRHP[4:0]				GVDD			
			00000				-4.7				00000				4.7			
			00001				-4.65				00001				4.65			
			00010				-4.6				00010				4.6			
			00011				-4.55				00011				4.55			
			00100				-4.5				00100				4.5			
			00101				-4.45				00101				4.45			
			00110				-4.4				00110				4.4			
			00111				-4.35				00111				4.35			
			01000				-4.3				01000				4.3			
			01001				-4.25				01001				4.25			
			01010				-4.2				01010				4.2			
			01011				-4.15				01011				4.15			
			01100				-4.1				01100				4.1			
			01101				-4.05				01101				4.05			
			01110				-4				01110				4			
			01111				-3.95				01111				3.95			
			10000				-3.9				10000				3.9			
			10001				-3.85				10001				3.85			
			10010				-3.8				10010				3.8			
			10011				-3.75				10011				3.75			
			10100				-3.7				10100				3.7			
			10101				-3.65				10101				3.65			
			10110				-3.6				10110				3.6			
			10111				-3.55				10111				3.55			
			11000				-3.5				11000				3.5			
			11001				-3.45				11001				3.45			
			11010				-3.4				11010				3.4			

		11011	-3.35	11011	3.35	
		11100	-3.3	11100	3.3	
		11101	-3.25	11101	3.25	
		11110	-3.2	11110	3.2	
		11111	-3.15	11111	3.15	

9.2.29 Power Control 4 (RB2h)

Power Control 4 (RB2h)																																				
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0																		
1	↑	1	0	0	0	0	0	AVCLS2	AVCLS1	AVCLS0	0	0	BCLK_DIV1	BCLK_DIV0	0	AVDDS2	AVDDS1	AVDDS0																		
Default value			0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1																		
Description			AVCLS [2:0]: AVCL voltage setting																																	
			<table><tr><th>AVCLS[2:0]</th><th>AVCL</th></tr><tr><td>000</td><td>-4.5</td></tr><tr><td>001</td><td>-4.6</td></tr><tr><td>010</td><td>-4.7</td></tr><tr><td>011</td><td>-4.8</td></tr><tr><td>100</td><td>-4.9</td></tr><tr><td>101</td><td>-5</td></tr><tr><td>110</td><td>-5.1</td></tr><tr><td>111</td><td>Don't use this setting, reserve for testing.</td></tr></table>																AVCLS[2:0]	AVCL	000	-4.5	001	-4.6	010	-4.7	011	-4.8	100	-4.9	101	-5	110	-5.1	111	Don't use this setting, reserve for testing.
			AVCLS[2:0]	AVCL																																
			000	-4.5																																
			001	-4.6																																
			010	-4.7																																
			011	-4.8																																
			100	-4.9																																
			101	-5																																
			110	-5.1																																
111	Don't use this setting, reserve for testing.																																			
BCLK_DIV [1:0]: Boost pump frequency.																																				
<table><tr><th>BCLK_DIV [1:0]</th><th>Frequency (KHz)</th></tr><tr><td>00</td><td>4000</td></tr><tr><td>01</td><td>2000</td></tr><tr><td>10</td><td>1333</td></tr><tr><td>11</td><td>1000</td></tr></table>																BCLK_DIV [1:0]	Frequency (KHz)	00	4000	01	2000	10	1333	11	1000											
BCLK_DIV [1:0]	Frequency (KHz)																																			
00	4000																																			
01	2000																																			
10	1333																																			
11	1000																																			
AVDDS [2:0]: AVDD voltage setting																																				
<table><tr><th>AVDDS[2:0]</th><th>AVDD</th></tr><tr><td>000</td><td>4.5</td></tr><tr><td>001</td><td>4.6</td></tr></table>																AVDDS[2:0]	AVDD	000	4.5	001	4.6															
AVDDS[2:0]	AVDD																																			
000	4.5																																			
001	4.6																																			

		010	4.7	
		011	4.8	
		100	4.9	
		101	5	
		110	5.1	
		111	Don't use this setting, reserve for testing.	

9.2.30 Power Control 5 (RB3h)

Power Control 5 (RB3h)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	0	DC11	DC10	DC9	DC8	DC7	DC6	DC5	DC4	DC3	DC2	DC1	DC0
Default value			0	0	0	0	0	1	0	1	0	1	0	1	0	1	0	0
Description			DC [11:0]: Set the Booster circuit Step-up cycle.															
			DC	Step1-DC [11:10]		Step2-DC [9:8]		Step3-DC [7:6]		Step4-DC [5:4]		Step5-DC [3:2]		Step6-DC [1:0]				
			00	BCLK/1		BCLK/1		BCLK/1		BCLK/1		BCLK/1		BCLK/1				
			01	BCLK/2		BCLK/2		BCLK/2		BCLK/2		BCLK/2		BCLK/2				
			10	BCLK/3		BCLK/3		BCLK/3		BCLK/3		BCLK/3		BCLK/3				
			11	BCLK/4		BCLK/4		BCLK/4		BCLK/4		BCLK/4		BCLK/4				

9.2.31 Power Control 6 (RB5h)

Power Control 6 (RB5h)																																				
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0																		
1	↑	1	0	0	0	0	0	0	MODE1	MODE0	OSAP2	OSAP1	OSAP0	0	0	0	0	0																		
Default value			0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0																		
Description			Mode [1:0]																																	
			<table><tr><th>MODE[1:0]</th><th>Function</th></tr><tr><td>00</td><td>2X</td></tr><tr><td>01</td><td>2X</td></tr><tr><td>10</td><td>AUTO</td></tr><tr><td>11</td><td>3X</td></tr></table>																MODE[1:0]	Function	00	2X	01	2X	10	AUTO	11	3X								
			MODE[1:0]	Function																																
			00	2X																																
			01	2X																																
			10	AUTO																																
			11	3X																																
			OSAP [2:0]: Amount of output stage current in Operational Amplifier																																	
			<table><tr><th>OSAP[2:0]</th><th>Amplifier</th></tr><tr><td>000</td><td>0.06</td></tr><tr><td>001</td><td>0.16</td></tr><tr><td>010</td><td>0.55</td></tr><tr><td>011</td><td>0.82</td></tr><tr><td>100</td><td>1</td></tr><tr><td>101</td><td>1.56</td></tr><tr><td>110</td><td>2.02</td></tr><tr><td>111</td><td>2.34</td></tr></table>																OSAP[2:0]	Amplifier	000	0.06	001	0.16	010	0.55	011	0.82	100	1	101	1.56	110	2.02	111	2.34
			OSAP[2:0]	Amplifier																																
000	0.06																																			
001	0.16																																			
010	0.55																																			
011	0.82																																			
100	1																																			
101	1.56																																			
110	2.02																																			
111	2.34																																			

9.2.32 Power Control 7 (RB6h)

Power Control 7 (RB6h)																					
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0			
1	↑	1	0	0	0	0	0	0	0	0	NO1	NO0	0	0	SDT1	SDT0	0	0			
Default value			0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	0			
Description			NO [1:0]: Sets the gate output non-overlap period when the ST7781R display operation is synchronized with RGB interface signals.																		
			NO[1:0]		Gate Non-overlap Period																
			00		2 clocks																
			01		3 clocks																
			10		4 clocks																
			11		5 clocks																
			SDT [1:0]: Source delay time.			SDT[1:0]		Delay time													
						00		2 clocks													
						01		4 clocks													
						10		6 clocks													
11		8 clocks																			

9.2.33 NVM ID Code (RD2h)

NVM ID Code (RD2h)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	0	0	0	0	0	0	ID6	ID5	ID4	ID3	ID2	ID1	ID0
Default value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Description			ID [6:0]: ST7781R supply 7bit ID code for LCD module version ID															

9.2.34 NVM Control Status (RD9h)

NVM Control Status (RD9h)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	0	0	0	0	0	0	VMF_EN	0	0	0	0	0	0
Default value			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Description			VMF_EN: "1" = Command NVM VCOM Offset Control (RFEh) Enable. "0" = Command NVM VCOM Offset Control (RFEh) Disable.															

9.2.35 NVM Write Command (RDFh)

NVM Write Command (RDFh)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	0	0	0	0	0	1	0	1	0	0	1	0	1
Description			NVM Write Command. NVM Program Flow <pre> graph TD A[/Modify CMD register (D2h) CMD D2h, 00xxh/] --> B[/Modify CMD register (FEh) CMD D9h, 0040h CMD FEh, 00xxh CMD D9h, 0000h/] B --> C[/Enable NVM : CMD FFh, 0001h CMD FAh, 0086h External VPP = 7.5V ON/] C --> D[/Erase CMD: CMD DFh, 00C5h CMD DFh, 00A5h/] D --> E[/Program CMD: CMD DFh, 003Ah CMD DFh, 00A5h/] E --> F[/Wait 20ms/] F --> G[/Disable NVM : CMD FAh, 0004h CMD FFh, 0000h External VPP = 7.5V OFF/] </pre> Legend - Command - Parameter - Display - Action - Mode - Sequential transfer															

9.2.36 NVM Enable (RFAh)

NVM Enable (RFAh)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	0	0	0	0	0	PROG_MODE	0	0	0	0	1	NVM_PROG	0
Default value			0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
Description			PROG_MODE: "1" = Enable NVM digital Function.															
			NVM_PROG: "1" =Enable NVM Function.															

9.2.37 NVM VCOM Offset (RFEh)

NVM VCOM Offset (RFEh)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	0	0	0	0	0	1	0	0	VMF4	VMF3	VMF2	VMF1	VMF0
Default value			0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0
Description			VCMF[4:0]: Set VCOM voltage level for reduce the flicker issue. (Max:-0.425V Min: -2V)															
			VCMF[4:0]								VCOM Output Level							
			00000								"VCM"-16d							
			00001								"VCM"-15d							
			01110								"VCM"-2d							
			01111								"VCM"-1d							
			10000								"VCM"							
			10001								"VCM"+1d							
			10010								"VCM"+2d							
			11110								"VCM"+14d							
			11111								"VCM"+15d							

9.2.38 NVM Command Enable (RFFh)

NVM Command Enable (RFFh)																		
RS	WRX	RDX	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
1	↑	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	CMD2_EN
Description			CMD2_EN:"1" for enable DFh function.															

10 RESET FUNCTION

The ST7781R is initialized by the RESET input. During reset period, the ST7781R is in a busy state and instruction from the MCU and DRAM access are not accepted. The ST7781R's internal power supply circuit unit is initialized also by the RESET input. The RESET period must be secured for at least 1ms. In case of power-on reset, wait until the RC oscillation frequency stabilizes (for 1 ms). During this period, DRAM access and initial instruction setting are prohibited.

10.1.. System Function Command List

See the Instruction description. The default value is shown in the parenthesis of each instruction bit cell.

10.2.. RAM Data Initialization

The RAM data is not automatically initialized by the RESET input. It must be initialized by software in display-off period.

10.3.. Note on Reset Function

- When a RESET input is entered into the ST7781R while it is in deep standby mode, the ST7781R starts up the inside logic regulator and makes a transition to the initial state. During this period, the state of the interface pins may become unstable. For this reason, do not enter a RESET input in deep standby mode.
- When transferring instruction in either two or three transfers via 8-/9-/16-bit interface, make sure to execute data transfer synchronization after reset operation.

10.4.. Reset Timing Characteristic

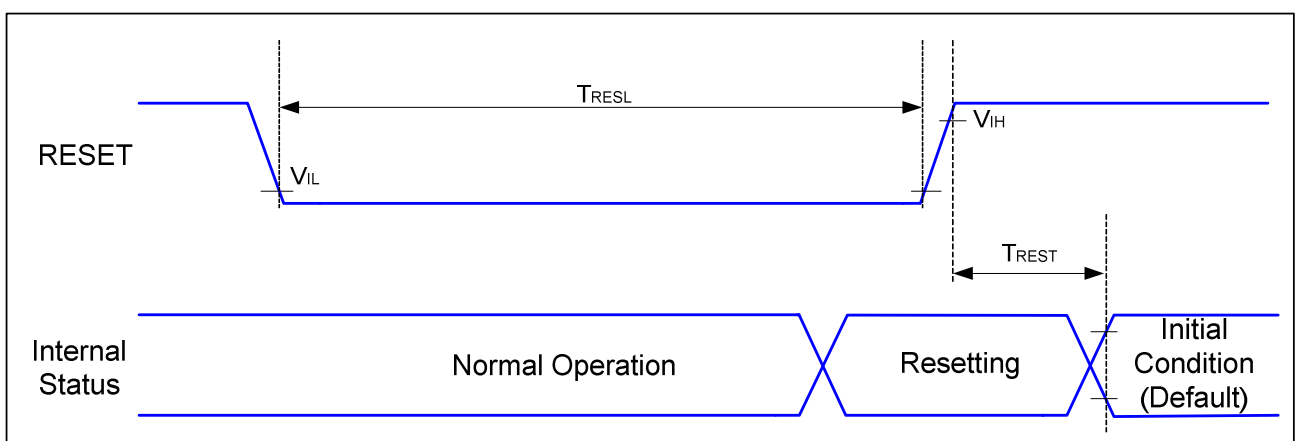


Figure 43 Reset Timing

Signal	Symbol	Parameter	Min	Max	Unit	Description
RESET	TRESL	Reset Low Level Width	1	-	ms	-
	TREST	Reset Complete Time	1		ms	

Table 10 Reset timing Characteristics

11 FMARK FUNCTION

The ST7781R outputs an FMARK pulse when the ST7781R is driving the line specified by FMP[8:0] bits. The FMARK signal can be used as a trigger signal to write display data in synchronization with display operation by detecting the address where data is read out for display operation.

FMI[2:0]	Output Interval
000	1 Frame
001	2 Frame
011	4 Frame
101	6 Frame
Others	Setting Prohibited

Table 11 FMARK Interval

FMP[8:0]	FMARK Output Position
9'h000	0 th line
9'h001	1 st line
9'h002	2 nd line
9'h003	3 rd line
.	.
.	.
.	.
9'h174	372 th line
9'h175	373 th line
9'h176	374 th line
9'h177	375 th line

Table 12 FMARK Output Position

11.1.1.. FMP Setting Example

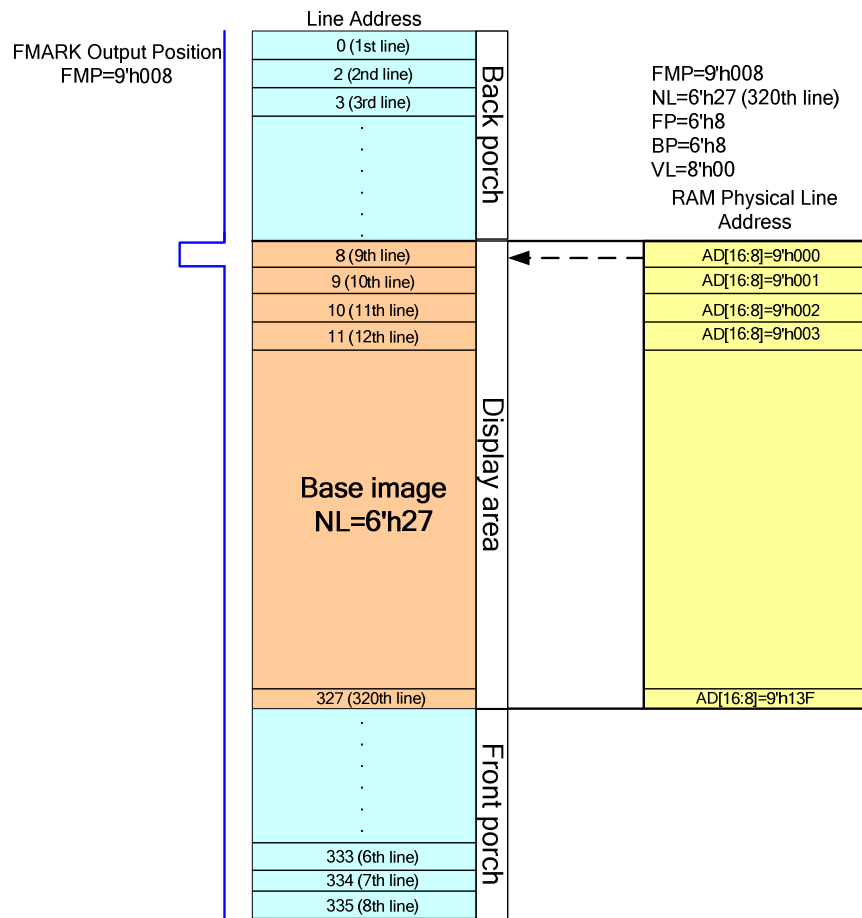


Figure 44 FMARK Setting Example

11.2.. Display Operation Synchronous Data Transfer using FMARK

The ST7781R uses FMARK signal as a trigger signal to start writing data to the internal DRAM in synchronization with display scan operation.

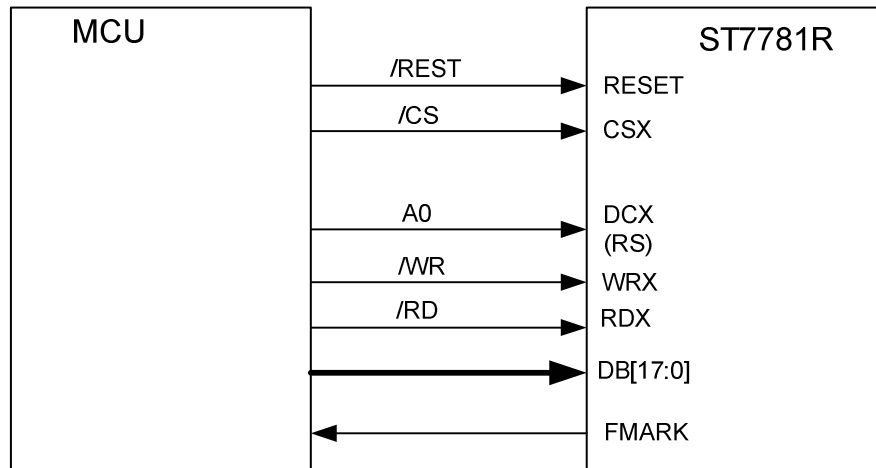


Figure 45 Display Synchronous Data Transfer Interface

In this operation, moving picture display is enabled via system interface by writing data at higher than the internal display operation frequency to a certain degree, which guarantees rewriting the moving picture DRAM area without causing flicker on the display. The data is written in the internal RAM in order to transfer only the data written over the moving picture display area and minimize the data transfer required for moving picture display.

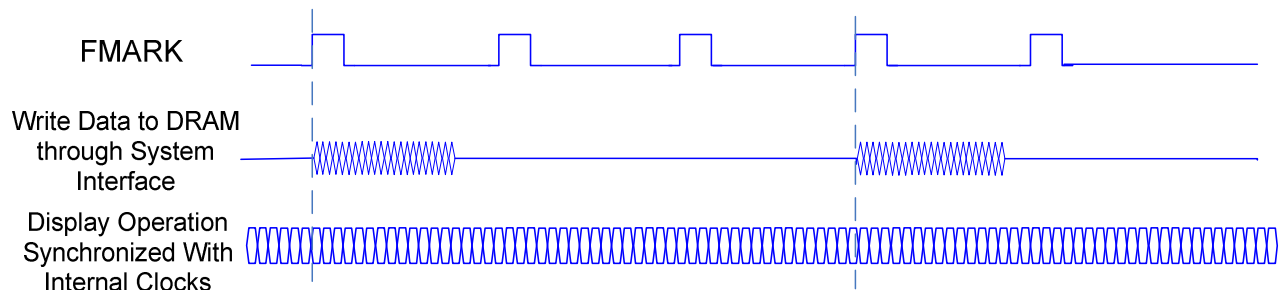


Figure 46 Moving Picture Data Transfers via FMARK Function

When transferring data in synchronization with FMARK signal, minimum DRAM data write speed and internal clock frequency must be taken into consideration. They must be more than the values calculated from the following equations.

$$\begin{aligned}
 & \text{Internal clock frequency } (f_{osc}) [Hz] \\
 & = \text{Frame Frequency (min.)} [Hz] \times (\text{DisplayPorch (NL)} + \text{FrontPorch (FP)} + \text{BackPorch (BP)}) \times 16 (\text{clocks}) \times \text{variance} \\
 & \text{RAMWriteSpeed (min.)} [Hz] > \frac{240 \times \text{DisplayLines (NL)}}{(\text{FrontPorch (FP)} + \text{BackPorch (BP)} + \text{DisplayLines (NL)} - \text{margin}) \times 16 (\text{clocks}) \times \frac{1}{f_{osc}}}
 \end{aligned}$$

Note: When RAM write operation is not started immediately following the rising edge of FMARK, the time from the rising edge of FMARK until the start of RAM write operation must also be taken into account.

Examples of DRAM writes speed and the frequency of the internal clocks are as follows.

Example:

Display size	320 RGB x 240 lines,
Total number of lines (NL)	320 lines
Back/Front porch:	14/2 lines
Frame frequency	60 Hz

Internal Clock Frequency (fosc) [Hz] = 60Hz x (320+2+14) x 16 clocks x 1.1/0.9 = 394 kHz

Note1. When setting the internal clock frequency, possible causes of fluctuation must also be taken into consideration. In this example, the internal clock frequency allows for a margin of $\pm 10\%$ for variances and guarantee that display operation is completed within one FMARK cycle.

Note2. This example includes variances attributed to LSI fabrication process and room temperature. Other possible causes of variances, such as differences in external resistors and voltage change are not considered in this example. It is necessary to include a margin for these factors.

Minimum Speed for DRAM Writing [Hz] > $240 \times 320 / \{((14+320-2)\text{lines} \times 16 \text{ clocks}) / 394\text{kHz}\} = 5.7\text{MHz}$

Note1. In this example, it is assumed that the ST7781R starts writing data in the internal DRAM on the rising edge of FMARK.

Note2. There must be at least a margin of 2 lines between the line to which the ST7781R has just written data and the line where display operation on the LCD is performed.

Note3. The FMARK signal output position is set to the line specified by FMP[8:0] bits.

In this example, DRAM write operation at a speed of 5.67MHz or more, when starting on the rising edge of FMARK, guarantees the completion of data write operation in a certain line address before the ST7781R starts the display operation of the data written in that line and can write moving picture data without causing flicker on the display.

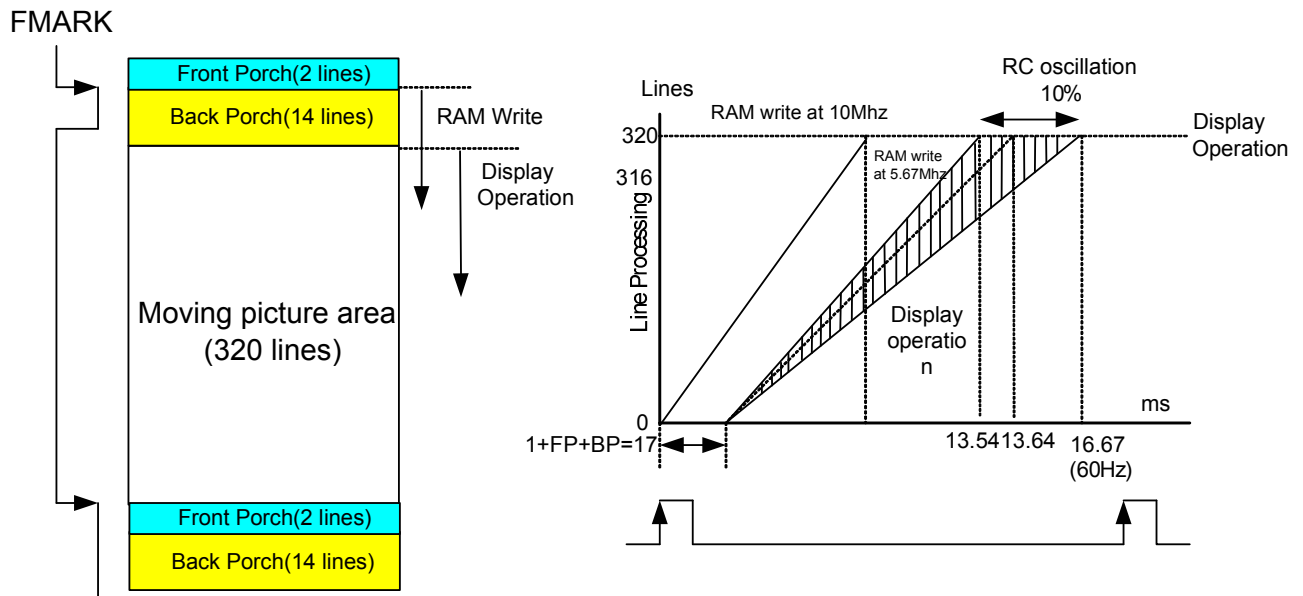


Figure 47 Write/Display Operation Timing

12 8 - COLOR DISPLAY MODE

The ST7781R has a function to display in 8 colors. In this display mode, only V0 and V63 are used and power supplies to other grayscales are turned off to reduce power consumption. In 8-color display mode, the γ -adjustment registers KP5-0[2:0], RP1-0[2:0], VRP0 [3:0], KN5-0[2:0], RN1-0[2:0], VRN1 [4:0], VRN0 [3:0], are disabled and the power supplies to V1 to V62 are halted. The ST7781R does not require DRAM data rewrite for 8-color display by writing the MSB to the rest in each dot data to display in 8 colors.

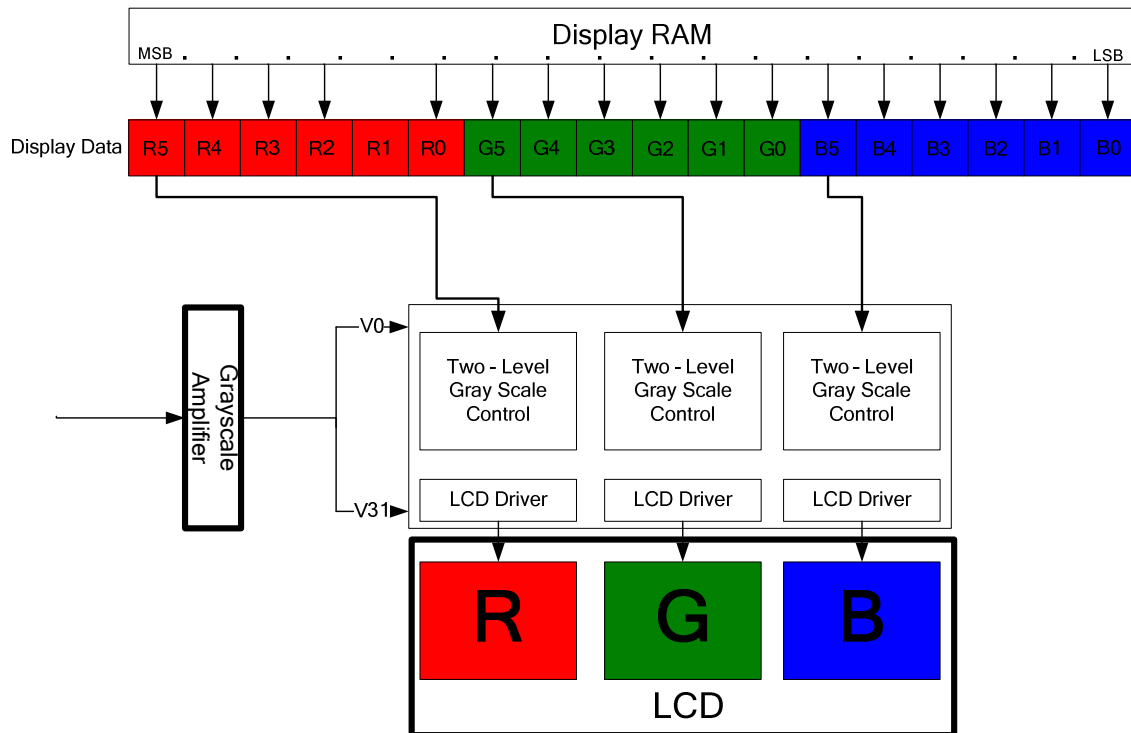


Figure 48 8-Color Display Mode

13 WINDOW ADDRESS FUNCTION

The window address function enables writing display data consecutively in a rectangular area (a window address area) made on the internal DRAM. The window address area is made by setting the horizontal address register (star: HAS[7:0], end HEA[7:0] bits) and the vertical address register(start: VSA[8:0], end: VEA[8:0] bits) The AM bits sets the transition direction of RAM address(either increment or decrement). These bits enable the ST7781R to write data including image data consecutively not taking data wrap positions into account.

The window address area must be made within the GRAN address map area. Also, DRAM address bits (RAM address set register) must be an address within the window address area.

[Window address setting area]

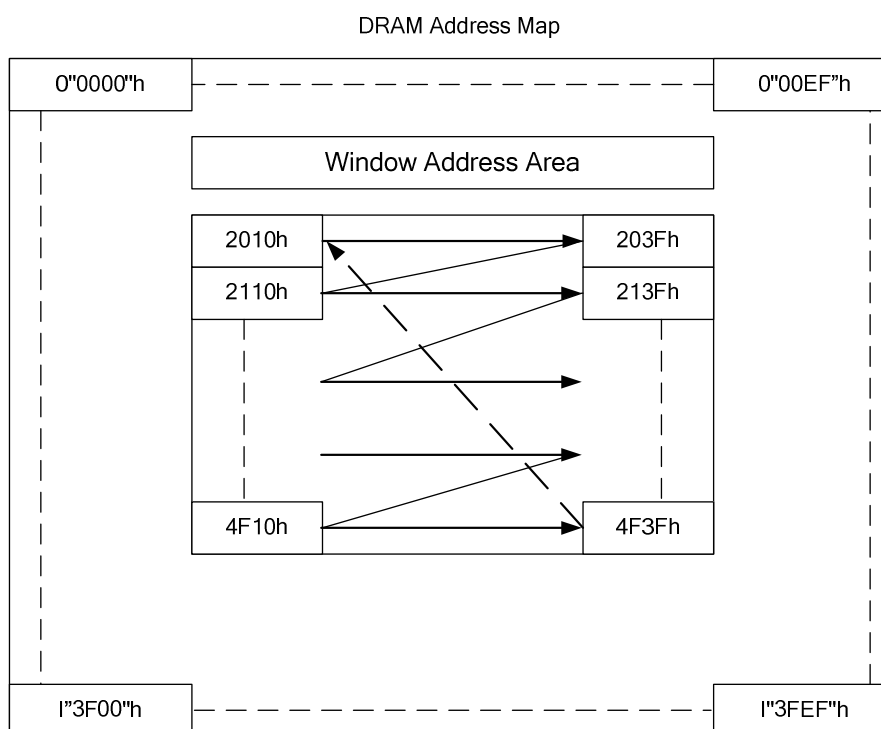
(Horizontal direction) $00H \leq HSA[7:0] \leq HEA[7:0] \leq "EF"H$

(Vertical direction) $00H \leq VSA[8:0] \leq VEA[8:0] \leq "13F"H$

[RAM address, AD (an address within a window address area)]

(RAM address) $HSA[7:0] \leq AD[7:0] \leq HEA[7:0]$

$VSA[8:0] \leq AD[15:8] \leq VEA[8:0]$



Window address setting area

HSA[7:0] = 1 0 h , HSA[7:0] = 3 F h , I/D = 1 (increment)
VSA[8:0] = 2 0 h , VSA[8:0] = 4 F h , AM = 0 (horizontal writing)

Figure 49 DRAM Access Window Map

14 GAMMA CORRECTION

ST7781R incorporate the γ - correction function to display 262,244 colors for the LCD panel. The γ -correction is performed with 3 groups of registers determining eight reference grayscale levels, which are gradient adjustment, amplitude adjustment and fine- adjustment registers for positive and negative polarities, to make ST7781R available with liquid crystal panels of various characteristics.

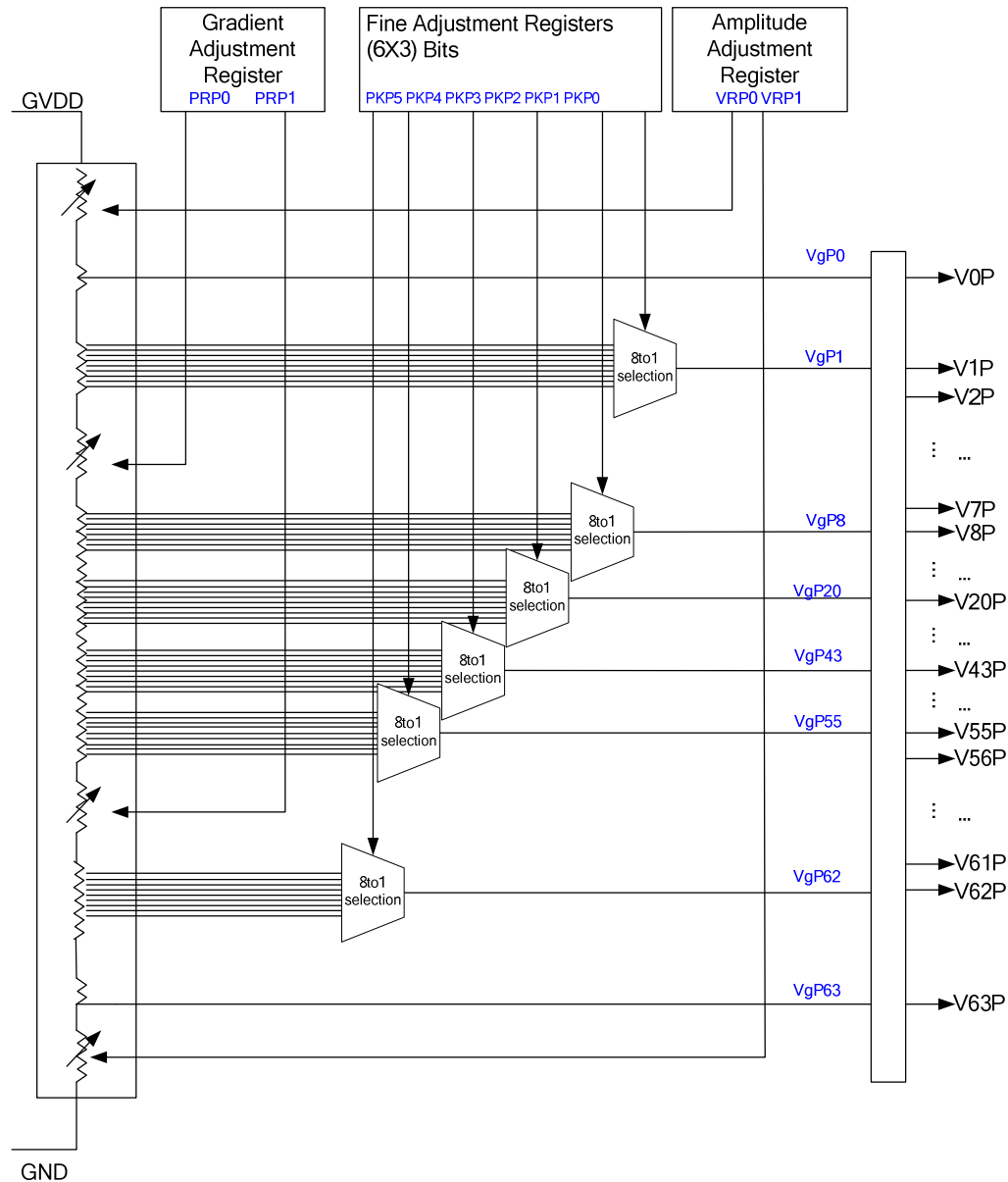


Figure 50 Grayscale Voltage Generation (Positive)

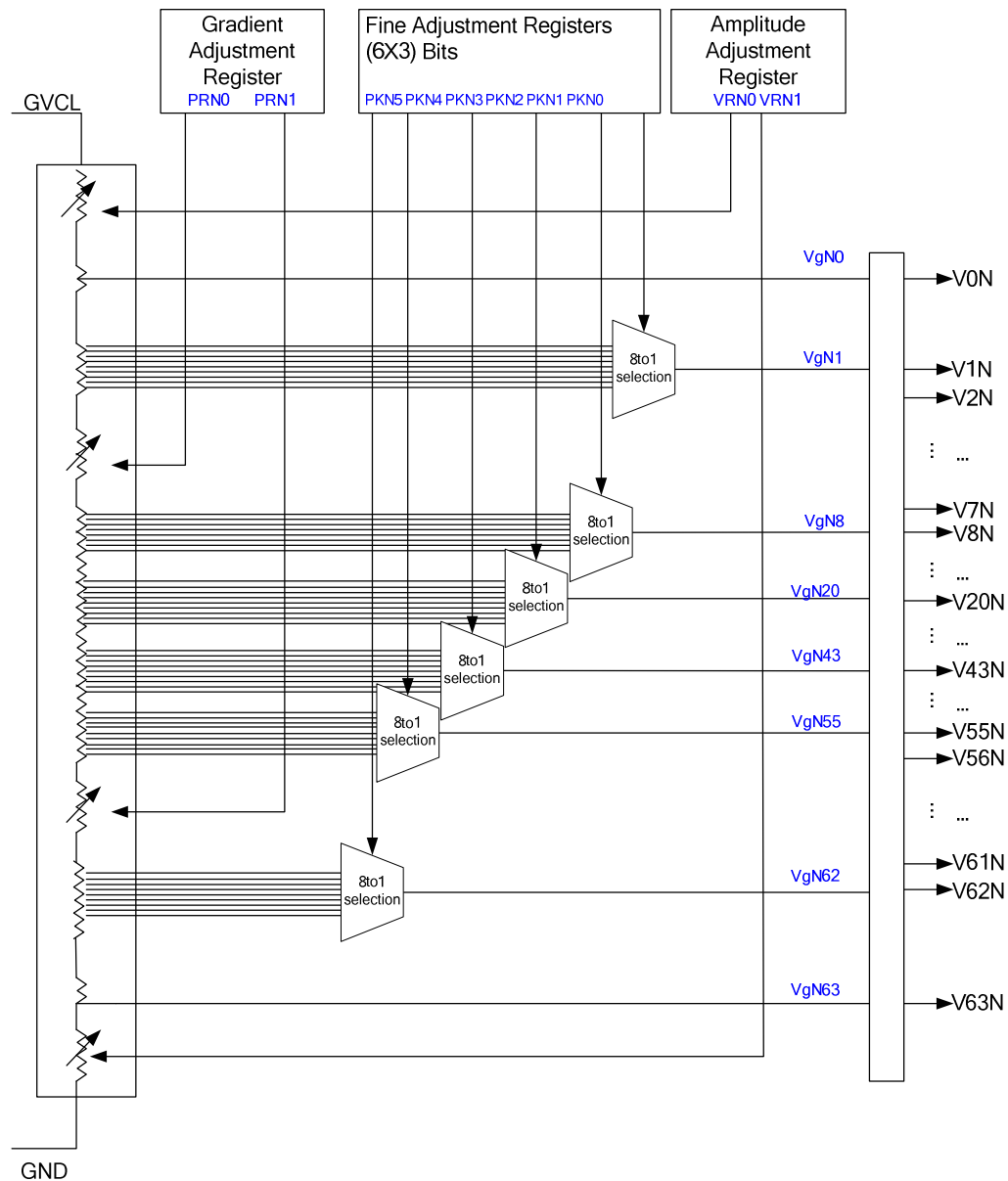


Figure 51 Grayscale Voltage Generation (Negative)

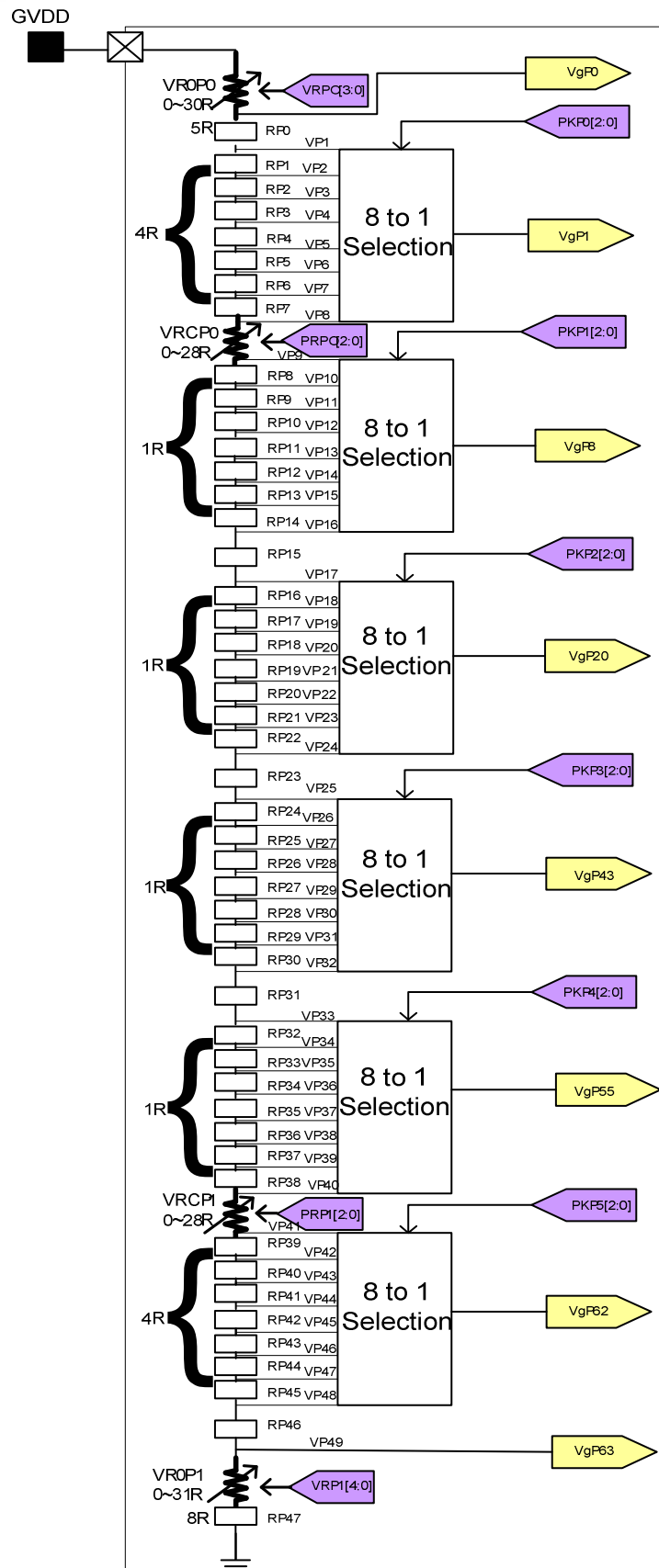


Figure 52 Grayscale Voltage Block (Positive)

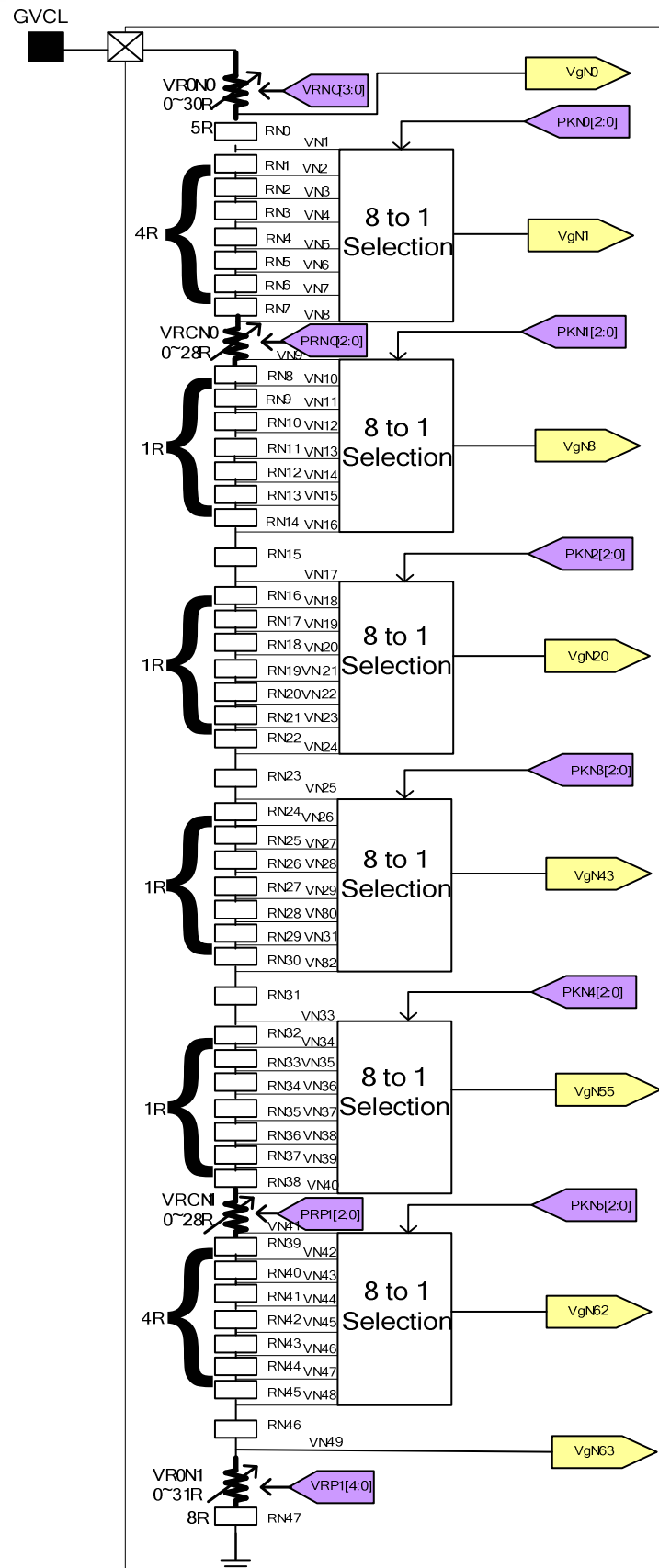


Figure 53 Grayscale Voltage Block (Negative)

1. Gradient Adjustment Registers

The gradient adjustment registers are used to adjust the gradient of the curve representing the relationship between the grayscale and the grayscale reference voltage level. To adjust the gradient, the resistance values of variable resistors in the middle of the ladder resistor are adjusted by registers PRP0[2:0]/PRN0[2:0], PRP1[2:0]/PRN1[2:0]. The registers consist of positive and negative polarity registers, allowing asymmetric drive.

2. Amplitude Adjustment Registers

The amplitude adjustment registers, VRP0[3:0]/VRN0[3:0], VRP1[4:0]/VRN1[4:0], are used to adjust the amplitude of grayscale voltages. To adjust the amplitude, the resistance values of variable resistors at the top and the bottom of the ladder resistor are adjusted.

3. Fine Adjustment Registers

The fine adjustment registers are used to fine-adjust grayscale voltage levels. To fine-adjust grayscale voltage levels, fine adjustment registers adjust the reference voltage level, 8 levels for each register generated from the ladder resistor, in respective 8-to-1 selectors. Same with other registers, the fine adjustment registers consist of positive and negative polarity registers.

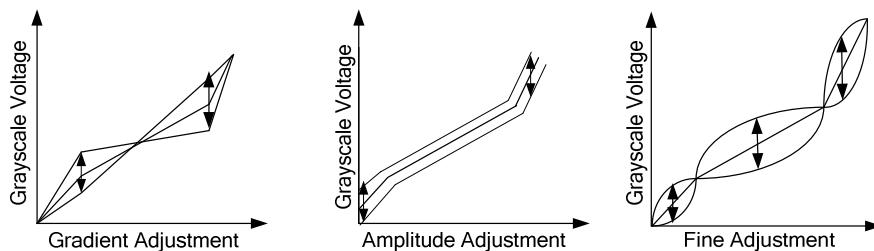


Figure 54 Gamma curve adjustment

Register Groups	Positive Polarity	Negative Polarity	Description
Gradient Adjustment	PRP0[2:0]	PRN0[2:0]	Variable Resistor VRCP0,VRCN0
	PRP1[2:0]	PRN1[2:0]	Variable Resistor VRCP1,VRCN1
Amplitude Adjustment	VRP0[3:0]	VRN0[3:0]	Variable Resistor VROP0,VRON0
	VRP1[4:0]	VRN1[4:0]	Variable Resistor VROP1,VRON1
Fine Adjustment	KP0[2:0]	KN0[2:0]	8-to-1 Selector (Voltage Level of Grayscale1)
	KP1[2:0]	KN1[2:0]	8-to-1 Selector (Voltage Level of Grayscale8)
	KP2[2:0]	KN2[2:0]	8-to-1 Selector (Voltage Level of Grayscale20)
	KP3[2:0]	KN3[2:0]	8-to-1 Selector (Voltage Level of Grayscale43)
	KP4[2:0]	KN4[2:0]	8-to-1 Selector (Voltage Level of Grayscale55)
	KP5[2:0]	KN5[2:0]	8-to-1 Selector (Voltage Level of Grayscale62)

Table 13 Register Description

14.1.. Ladder Resistors and 8-to-1 Selector Block Configuration

The reference voltage generation block consists of two ladder resistor units including variable resistors and 8-to-1 selectors. Each 8-to-1 selector selects one of the 8 voltage levels generated from the ladder resistor unit to output as a grayscale reference voltage. Both variable resistors and 8-to-1 selectors are controlled according to the γ -correction registers. This unit has pins to connect a volume resistor externally to compensate differences in various characteristic of panels.

14.2.. Variable Resistors

ST7781R uses variable resistors of the following three purposes: gradient adjustment (VRCP(N)0/VRCP(N)1); amplitude adjustment (1) (VROP(N)0); and the amplitude adjustment (2) (VROP(N)1). The resistance values of these variable resistors are set by gradient adjustment registers and amplitude adjustment registers as follows.

Gradient Adjustment		Amplitude Adjustment (1)		Amplitude Adjustment (2)	
PRP(N)0/1[2:0] Register	VRCP(N)0 Resistance	VRP(N)0[3:0] Register	VROP(N)0 Resistance	VRP(N)1[4:0] Register	VROP(N)1 Resistance
000	0R	0000	0R	00000	0R
001	4R	0001	2R	00001	1R
010	8R	0010	4R	00010	2R
011	12R	:	:	:	:
100	16R	:	:	:	:
101	20R	1101	26R	11101	29R
110	24R	1111	28R	11110	30R
111	28R	1111	30R	11111	31R

Table 14 Resistance Adjustment

14.3.. 8-to-1 selectors

The 8-to-1 selector selects one of eight voltage levels generated from the ladder resistor unit according to the fine adjustment register and output the selected voltage level as a reference grayscale voltage (VgP(N)1~6). The table below shows the setting in the fine adjustment register and the selected voltage levels for respective reference grayscale voltages.

Fine Adjustment Registers and Selected Voltage						
Register	Selected Voltage					
KP(N)[2:0]	VgP(N)1	VgP(N)8	VgP(N)20	VgP(N)43	VgP(N)55	VgP(N)62
000	VP(N)1	VP(N)9	VP(N)17	VP(N)25	VP(N)33	VP(N)41
001	VP(N)2	VP(N)10	VP(N)18	VP(N)26	VP(N)34	VP(N)42
010	VP(N)3	VP(N)11	VP(N)19	VP(N)27	VP(N)35	VP(N)43
011	VP(N)4	VP(N)12	VP(N)20	VP(N)28	VP(N)36	VP(N)44
100	VP(N)5	VP(N)13	VP(N)21	VP(N)29	VP(N)37	VP(N)45
101	VP(N)6	VP(N)14	VP(N)22	VP(N)30	VP(N)38	VP(N)46
110	VP(N)7	VP(N)15	VP(N)23	VP(N)31	VP(N)39	VP(N)47
111	VP(N)8	VP(N)16	VP(N)24	VP(N)32	VP(N)40	VP(N)48

Table 15 Fine Adjustment Registers and Selected Voltage

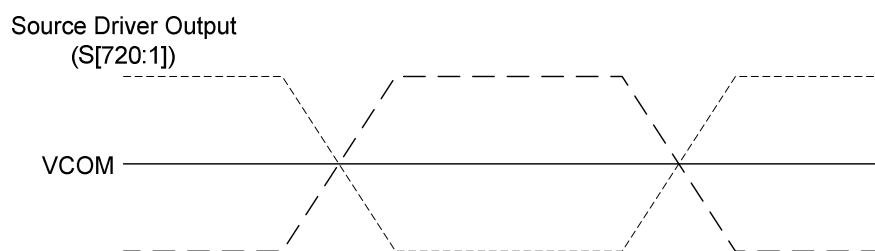


Figure 55 Relationship between Source Output and VCOM

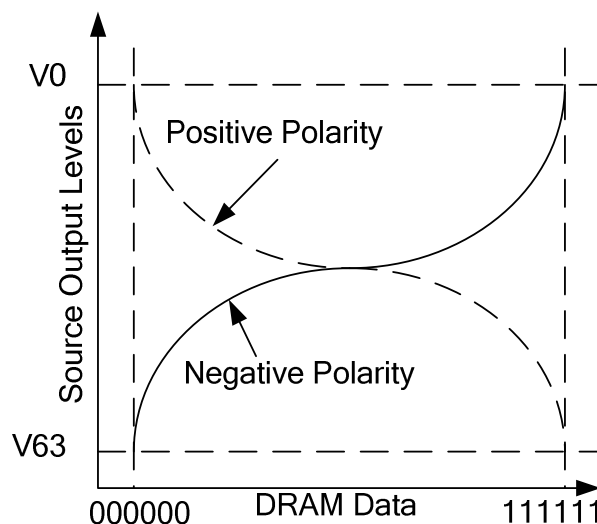
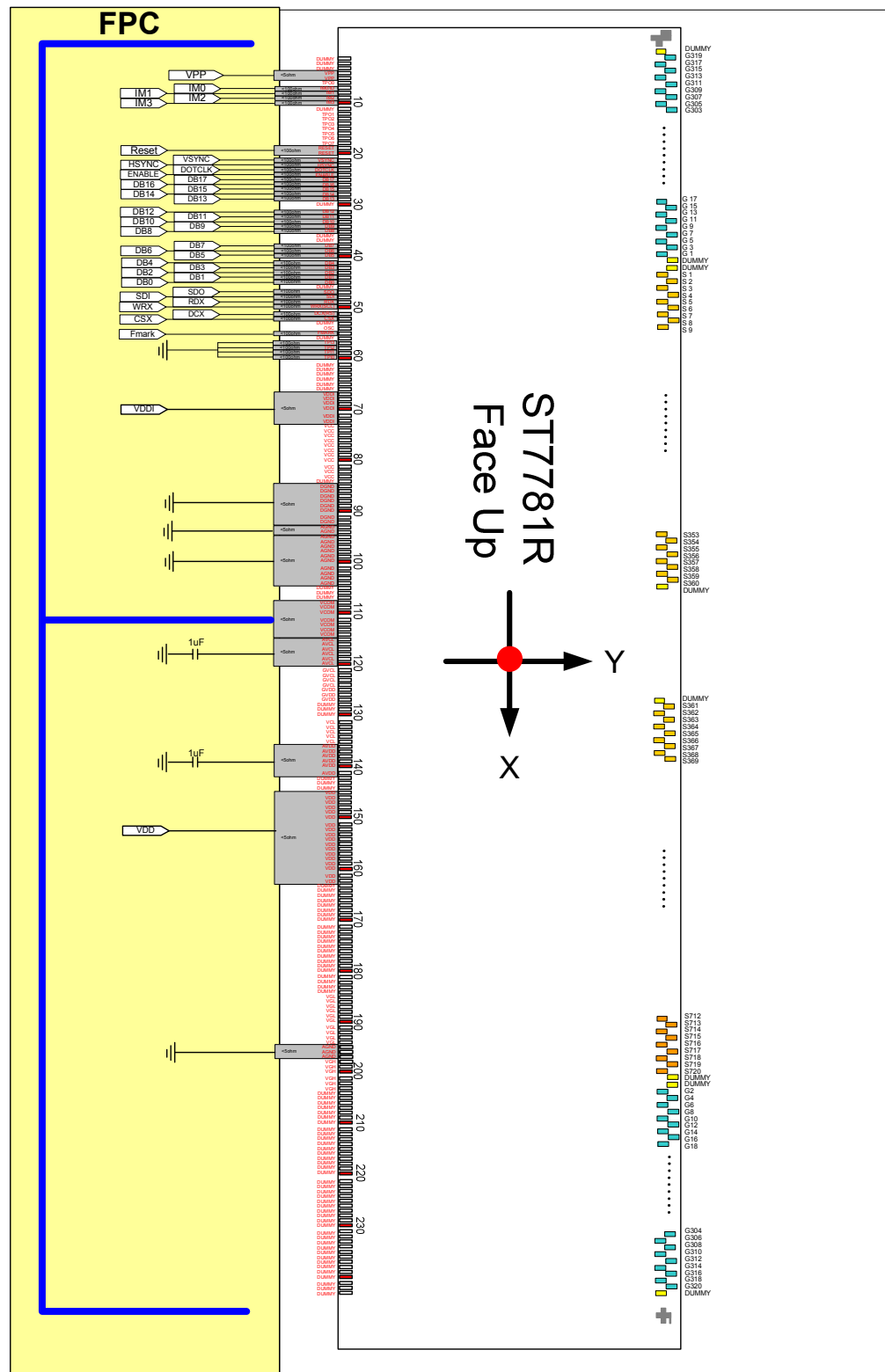


Figure 56 Relationship between DRAM Data and Output Level

15.1.. Configuration of Power Supply Circuit



The following table shows specifications of external elements connected to the ST7781R power supply circuit.

Items	Recommended Specification	Pin Connection
1 μ F Capacity	6.3 V	AVCL, AVDD

Table 16 Outside Components

15.2.. Standby Mode

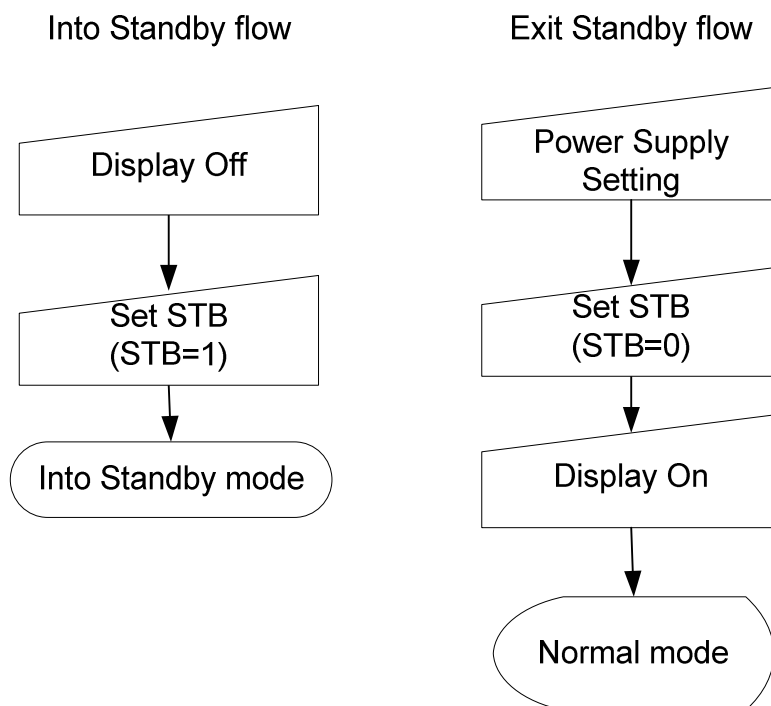


Figure 58 Standby Mode Register Setting Sequence

15.3.. Power Supply Configuration

When supplying and cutting off power, follow the sequence below. The setting time for oscillators, circuits and operational amplifiers depends on external resistance and capacitance.

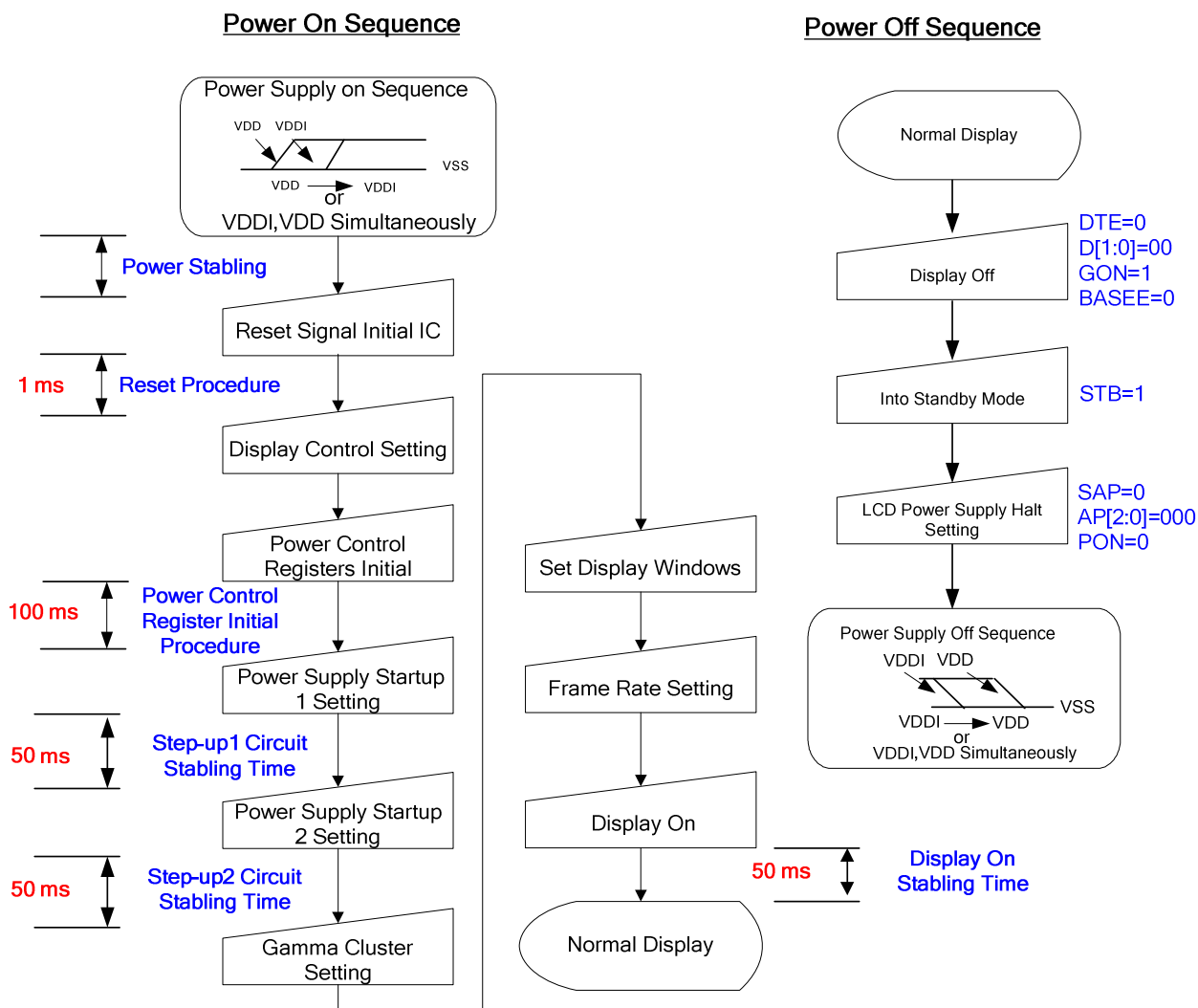


Figure 59 Power Supply ON/OFF Sequence

15.4.. Voltage Generation

The pattern diagram for setting the voltages and the waveforms of the voltages of the ST7781R are as follows.

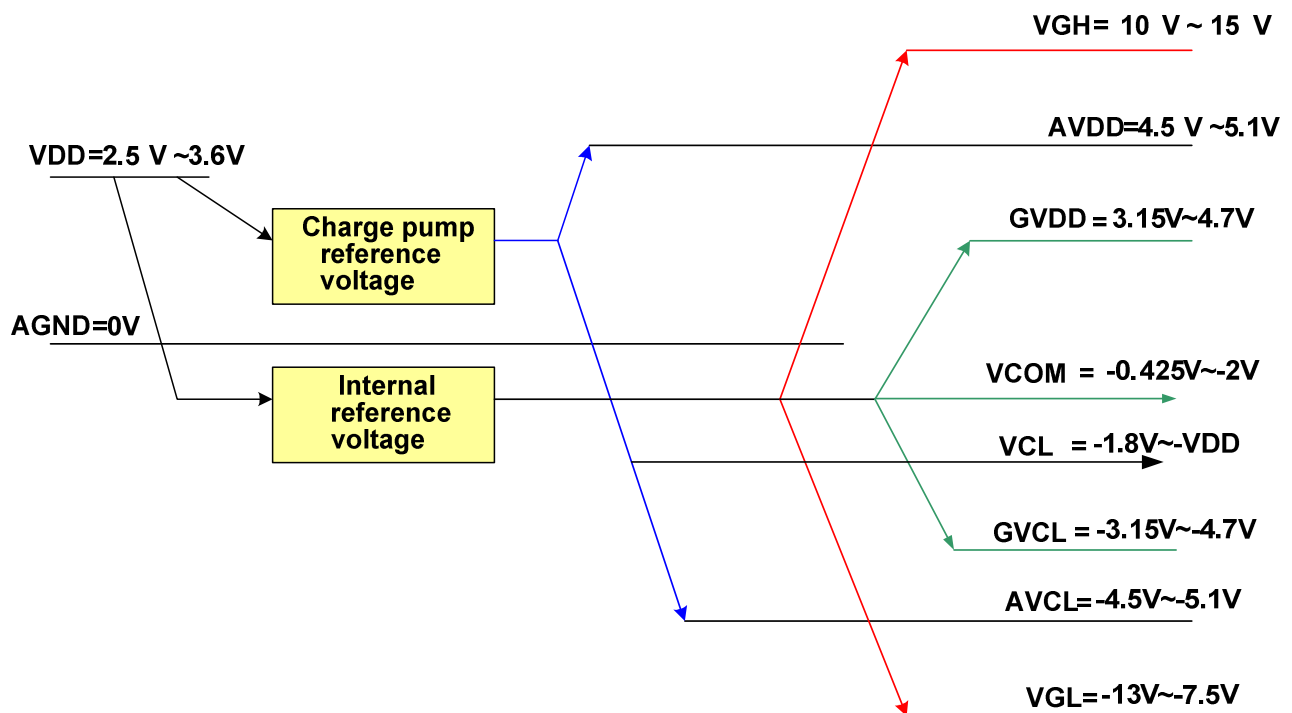


Figure 60 Power Booster Level

15.5.. Applied Voltage to the TFT panel

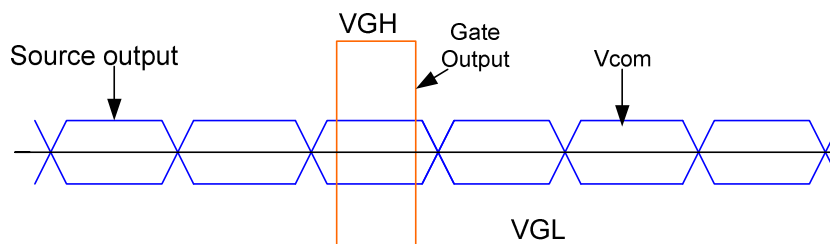


Figure 61 Voltage Output to TFT LCD Panel

15.6.. Partial Display Function

The ST7781R allows selectively driving two partial images on the screen at arbitrary positions set in the screen drive position registers. The following example shows the setting for partial display function:

Base Image Display Setting	
BASEE	0
NL[5:0]	6'h27
Partial Image 1 Display Setting	
PTDE0	1
PTSA0[8:0]	9'h000
PTEA0[8:0]	9'h00F
PTDP0[8:0]	9'h080
Partial Image 2 Display Setting	
PTDE1	1
PTSA1[8:0]	9'h020
PTEA1[8:0]	9'h02F
PTDP1[8:0]	9'h0C0

Table 17 Partial Setting Example

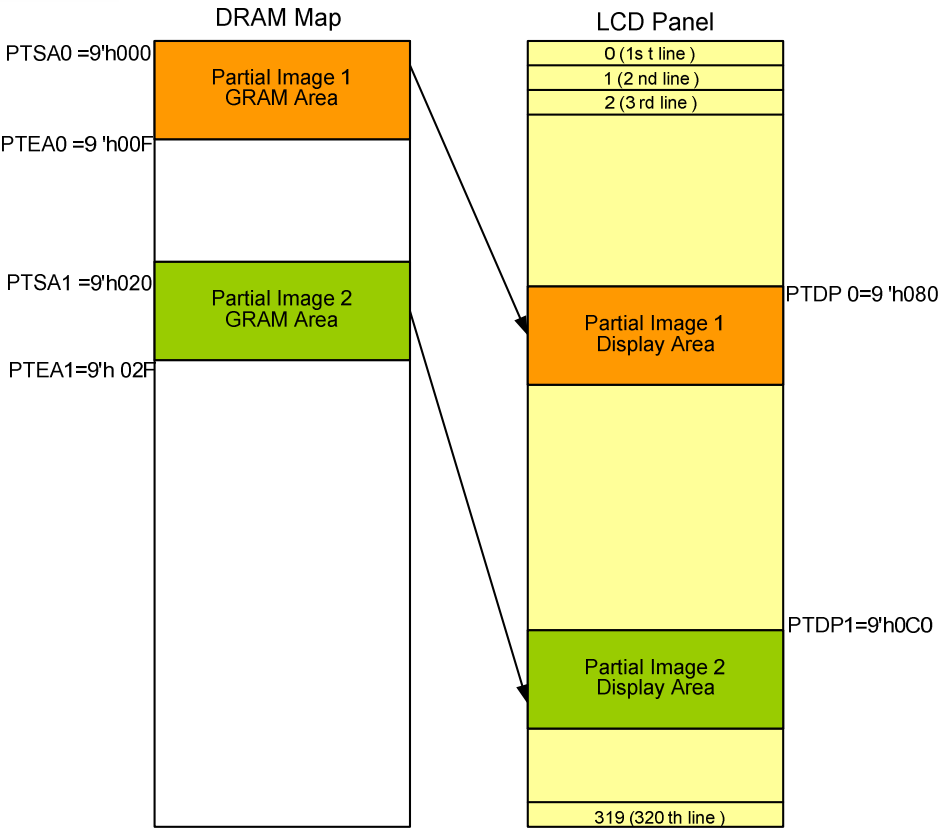


Figure 62 Partial Display Example

15.7.. Resizing Function

ST7781R supports resizing function (x1/2, x1/4), which is performed when writing image data to DRAM. The resizing function is enabled by setting a window address area and the RSZ bit which represents the resizing factor (x1/2, x1/4) of image. The resizing function allows the system to transfer the original-size image data into the DRAM with resized image data.

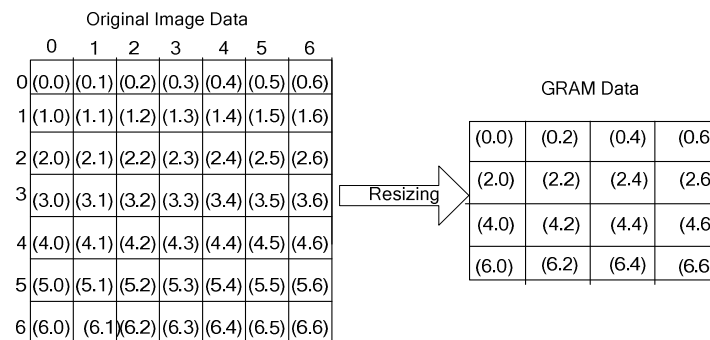


Figure 63 Data Transfer in Resizing Mode

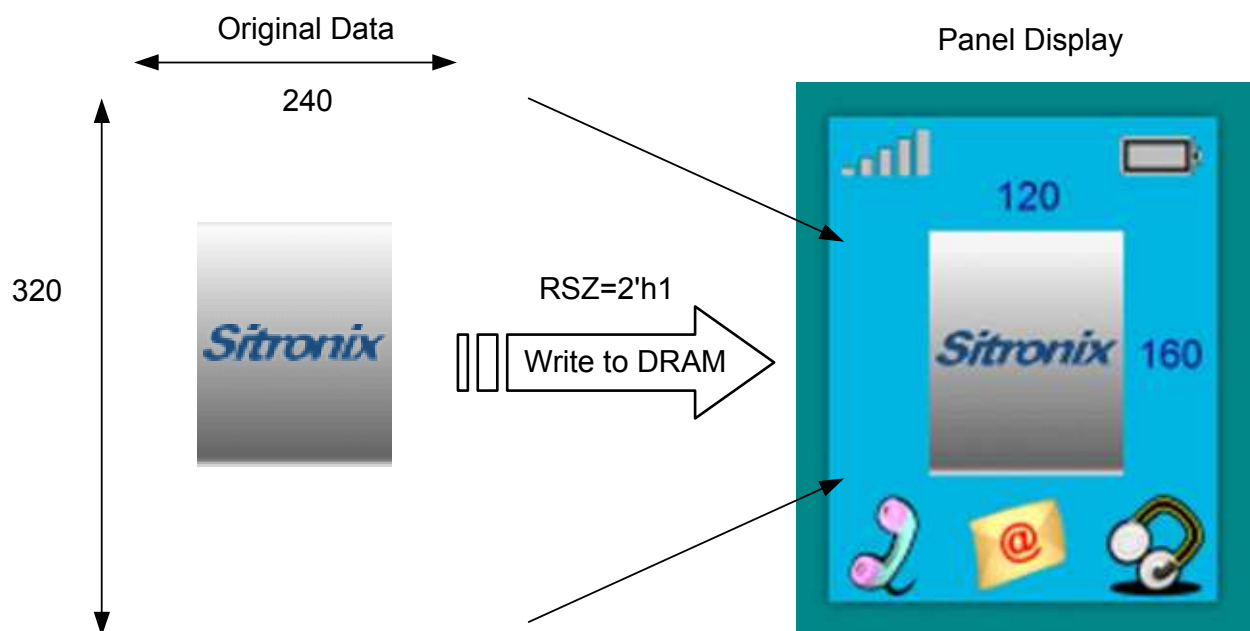


Figure 64 Resizing Example

Original Image Size (X × Y)	Resized Image Resolution	
	1/2 (RSZ=2'h1)	1/4 (RSZ=2'h3)
640 × 480	320 × 240	160 × 120
352 × 288	176 × 144	88 × 72
320 × 240	60 × 120	80 × 60
176 × 144	88 × 72	44 × 36
120 × 160	60 × 80	30 × 40
132 × 132	66 × 66	33 × 33

Table 18 Resized Image Resolution

The RSZ bit sets the resizing factor of an image. When setting a window address area in the internal DRAM, the DRAM window address area must fit the size of resized image. The following examples show the resizing setting.

Original image data number in horizontal direction		X
Original image data number in Vertical direction		Y
Resizing Ration		1/N
Resizing Setting	RSZ	N-1
Remainder pixels in horizontal direction	RCH	H
Remainder pixels in vertical direction	RCV	V
DRAM writing start address	AD	(X0, Y0)
DRAM window setting	HAS	X0
	HEA	X0+dX-1
	VSA	Y0
	VEA	Y0+dY-1

Table 19 Resized Coefficient

16 REVISION HISTORY

Version	Date	Description
Draft	2009/09/01	Draft
0.1	2009/12/23	Page 11: Au bump height 15→12μm
0.1	2009/12/23	Page 37: SDI description
0.1	2009/12/23	Page 38: VPP description
0.1	2009/12/23	Page120: AVCL description
0.1	2009/12/23	Page117: VGH, VGL description
0.1	2009/12/23	Page 150: NVM Flow
0.1	2009/12/23	Page 119: RB3h description
0.1	2009/12/23	Page 118: RB0h VGH and V25 description
0.1	2009/12/23	Page 125: RB0h Vcom offset description
0.1	2009/12/23	Page 146: Volotage description
0.1	2009/12/23	Page 10: VCOM voltage description
0.1	2009/12/23	Page86: Register default setting