

RM68050 Data Sheet

Single Chip Driver with 262K color

for 240RGBx320 a-Si TFT LCD

Revision : 0.1

Date : Sept 1, 2009

Revision History :

Revision	Description Of Change	Date
0.1	New creation	2009/09/01

Table of Content

1.	General Description.....	1
2.	Features.....	1
3.	Block Diagram.....	5
4.	Pin Diagram	6
5.	Pin Function	14
6.	Bump Arrangement	20
7.	Function Description.....	21
7.1	System Interface.....	21
7.2	External Display Interface (RGB, VSYNC interfaces)	23
7.3	Address Counter (AC).....	23
7.4	Graphics RAM (GRAM)	23
7.5	Grayscale Voltage Generating Circuit	23
7.6	Timing Generator	24
7.7	Oscillator (OSC).....	24
7.8	Liquid Crystal Driver Circuit.....	24
7.9	Internal Logic Power Supply Regulator	24
8.	GRAM Address Map	25
9.	Instruction.....	27
9.1	Outline.....	27
9.2	Instruction Data Format.....	27
9.3	Index (IR)	28
9.4	ID code (R00h).....	28
9.5	Display control.....	28

9.5.1	Driver Output Control (R01h)	28
9.5.2	LCD Driving Wave Control (R02h).....	29
9.5.3	Entry Mode (R03h).....	29
9.5.4	16bits Data Format Selection (R05h).....	31
9.5.5	Display Control 1 (R07h).....	33
9.5.6	Display Control 2 (R08h).....	34
9.5.7	Display Control 3 (R09h).....	35
9.5.8	Display Control 4 (R0Ah).....	36
9.5.9	External Display Interface Control 1 (R0Ch)	36
9.5.10	Frame Marker Position (R0Dh).....	37
9.5.11	External Display Interface Control 2 (R0Fh).....	37
9.6	Power Control	38
9.6.1	Power Control 1 (R10h).....	38
9.6.2	Power Control 2 (R11h).....	39
9.6.3	Power Control 3 (R12h).....	40
9.6.4	Power Control 4 (R13h).....	41
9.7	RAM Access Instruction.....	41
9.7.1	RAM Address Set (Horizontal Address) (R20h).....	41
9.7.2	RAM Address Set (Vertical Address) (R21h).....	41
9.7.3	Write Data to GRAM (R22h)	42
9.7.4	Read Data from GRAM (R22h).....	42
9.8	Power Control 7 (R29h)	43
9.9	Frame Rate and Color Control (R2Bh).....	44
9.10	γ Control	44
9.11	Window Address Write Control Instruction.....	45

9.12	Base Image Display Control Instruction	45
9.13	SPI Read/Write Control (R66h, Write Only).....	48
9.14	Partial Display Control Instruction	48
9.14.1	Partial Image 1: Display Position (R80h).....	48
9.14.2	Partial Image 1: RAM Address (Start Line Address) (R81h), (End Line Address) (R82h)	48
9.14.3	Partial Image 2: Display Position (R83h).....	48
9.14.4	Partial Image 2: RAM Address (Start Line Address) (R84h), (End Line Address) (R85h)	49
9.15	Panel Interface Control Instruction.....	49
9.15.1	Panel Interface Control 1 (R90h)	49
9.15.2	Panel Interface Control 2 (R92h)	50
9.15.3	Panel Interface Control 4 (R95h)	50
9.15.4	Panel Interface Control 5 (R97h)	51
9.16	OTP VCM Control	51
9.16.1	OTP VCM Programming Control 1 (RA1h).....	51
9.16.2	OTP VCM Status and Enable (RA2h).....	51
9.16.3	OTP VCM Programming ID Key (RA5h).....	52
9.17	CABC control.....	52
9.17.1	Write Display Brightness Value (RB1h).....	52
9.17.2	Read Display Brightness Value (RB2h).....	52
9.17.3	Write CTRL Display Value (RB3h)	52
9.17.4	Read CTRL Display Value (RB4h)	53
9.17.5	Write Content Adaptive Brightness Control Value (RB5h).....	53
9.17.6	Read Content Adaptive Brightness Control Value (RB6h).....	53

9.17.7	Write CABC Minimum Brightness (RBEh)	54
9.17.8	Read CABC Minimum Brightness (RBFh).....	54
9.18	Deep standby control	54
10.	<i>Instruction List</i>	55
11.	<i>Interface and Data Format</i>	58
12.	<i>System Interface</i>	59
12.1	80-system 18-bit Bus Interface	59
12.2	80-system 16-bit Bus Interface	61
12.3	80-system 9-bit Bus Interface	63
12.4	80-system 8-bit Bus Interface	65
12.5	Serial Interface	67
12.6	9-bit 3-wire Serial Interface	70
12.7	8-bit 4-wire Serial Interface	72
13.	<i>VSYNC Interface</i>	75
14.	<i>RGB Interface</i>	79
14.1	RGB Interface Timing	80
14.2	Moving Pictures Mode.....	81
14.3	RAM access via system interface in RGB interface operation.....	82
14.4	6-bit RGB interface.....	83
14.5	Data Transfer Synchronization in 6-bit Bus Interface Operation.....	83
14.6	16-bit RGB interface.....	84
14.7	18-bit RGB interface.....	84
14.8	Notes to external display interface operation.....	84
15.	<i>Partial Display Function</i>	87
16.	<i>Window Address Function</i>	88

17. CABC (Content Adaptive Brightness Control)	89
18. γ Correction Function	90
18.1 Ladder resistors and 8-to-1 selector Block configuration	93
18.2 Variable resistors	93
18.3 8-to-1 selectors	93
19. Power-Supply Generating Circuit	94
19.1 Voltage Setting Pattern Diagram	94
19.2 Liquid crystal application voltage waveform and electrical potential	95
20. OTP control sequence	96
21. Power Supply Instruction Setting	97
21.1 Power Supply Instruction Setting	97
21.2 Display On / Off Instruction Setting	98
21.3 Sleep mode/Standby mode SET/EXIT sequence	99
22. Application Circuit	100
23. Absolute Maximum Ratings	101
24. Electrical Characteristics	102
24.1 DC Electrical Characteristics	102
24.2 AC Timing Characteristics	103
24.2.1 80-System Bus Interface	103
24.2.2 Clock Synchronous Serial Interface	104
24.2.3 RGB Interface	105
24.3 Reset Timing Characteristics	106

1. General Description

The RM68050 is a single-chip liquid crystal controller driver LSI for a-Si TFT panel, comprising 172,800 bytes RAM for a maximum 240 RGB x 320 dots graphics display, source driver, gate driver and power supply circuit. For efficient data transfer, the RM68050 supports high-speed interface via 8-/9-/16-/18-bit ports as system interface to the microcomputer and high-speed RAM write function. As moving picture interface, the RM68050 supports RGB interface (VSYNC, HSYNC, DOTCLK, ENABLE, and DB17-0).

Also, the RM68050 incorporates step-up circuit and voltage follower circuit to generate TFT liquid crystal panel drive voltages.

The RM68050's power management functions such as 8-color display and power operation mode such as deep standby mode, standby mode and sleep mode make this LSI a perfect driver for the medium or small sized portable products with color display systems such as digital cellular phones or hand-held devices with outstanding battery consistency.

2. Features

- A single-chip controller driver incorporating a gate circuit and a power supply circuit for a maximum 240 RGB x 320 dots graphics display on amorphous TFT panel in 262k colors
- System interface
 1. High-speed interface via 8-, 9-, 16-, 18-bit parallel ports
 2. Clock synchronous serial interface
- Moving picture display interface
 1. 6-, 16-, 18-bit RGB interface (VSYNC, HSYNC, DOTCLK, ENABLE, DB17-0)
 2. VSYNC interface (System interface + VSYNC)
- High-speed RAM write function
- Window address function to specify a rectangular area writing data in the internal RAM
- Write data within a rectangular area in the internal RAM via moving picture interface
- Reduce data transfer repeat by specifying the area in the RAM to rewrite data
- Support displaying still picture data in RAM area while displaying moving pictures simultaneously

- Abundant color display and drawing functions
 1. Programmable γ -correction function for 262k-color display
 2. Partial display function
- Low power consumption architecture (allowing direct input of interface I/O power supply)
 1. Deep standby mode
 2. Standby mode
 3. Sleep mode
 4. 8-color display function
 5. Input power supply voltages: $IOVCC = 1.65V \sim 3.3V$ (interface I/O power supply)
 $VCI = 2.5V \sim 3.3V$ (liquid crystal analog circuit power supply)
- Incorporates a liquid crystal drive power supply circuit
 1. Source driver liquid crystal drive/VCOM power supply: $DDVDH-GND = 4.5V \sim 6.0V$
 $VCL-GND = -2.0V \sim -3.0V$
 $VCI-VCL \leq 6.0V$
 2. Gate drive power supply: $VGH-GND = 10.0V \sim 19.8V$
 $VGL-GND = -4.5V \sim -13.5V$
 $VGH-VGL \leq 30.0V$
 3. VCOM drive (VCOM power supply): $VCOMH = (VCI+0.2)V \sim (DDVDH-0.2)V$
 $VCOML = (VCL+0.2)V \sim 0V$
 $VCOMH-VCOML$ amplitude = 6.0V (max.)
- Liquid crystal power supply startup sequencer
- TFT storage capacitance: Cst only (common VCOM formula)
- 172,800-byte internal RAM
- Internal 720-channel source driver and 320-channel gate driver
- Single-chip solution for COG module with the arrangement of gate circuits on both sides of the

glass substrate

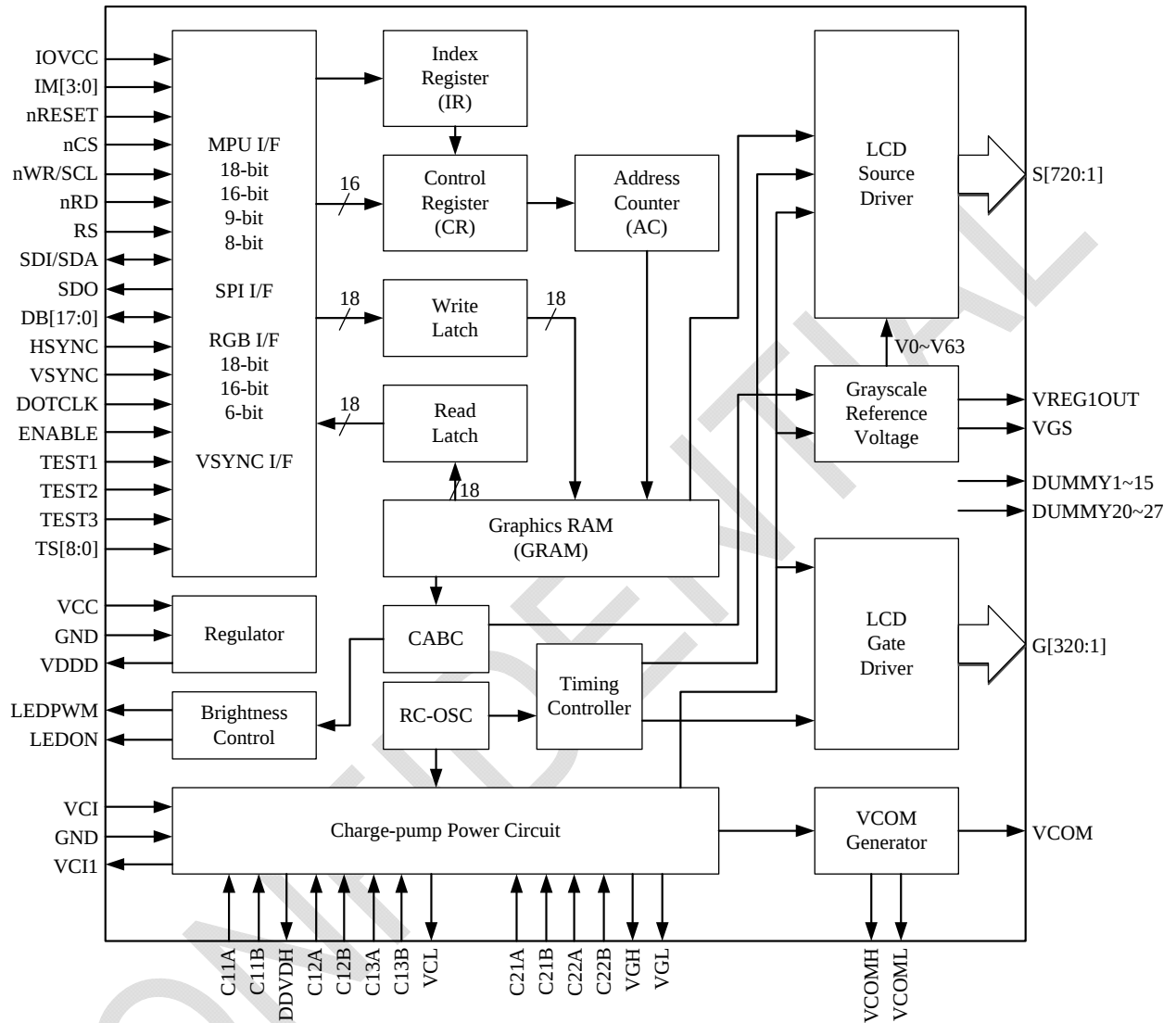
- Internal reference voltage: to generate VREG1OUT
- CABC (Content Adaptive Brightness Control)

CONFIDENTIAL

Table 1 Power Supply Specifications

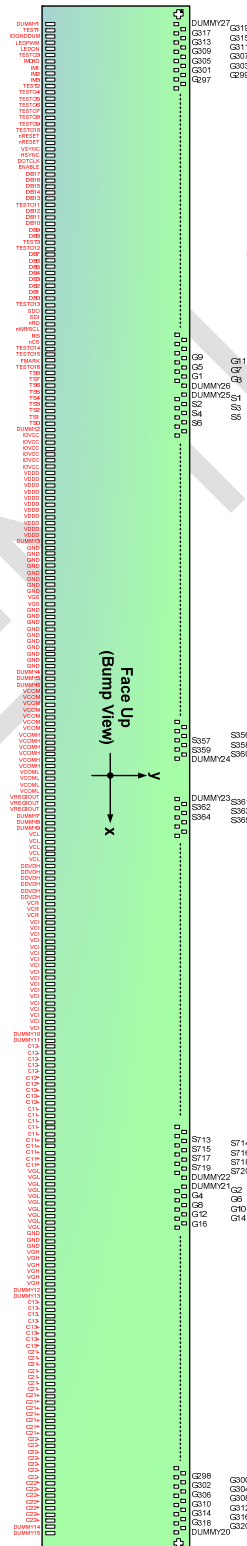
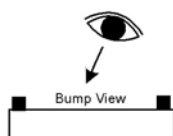
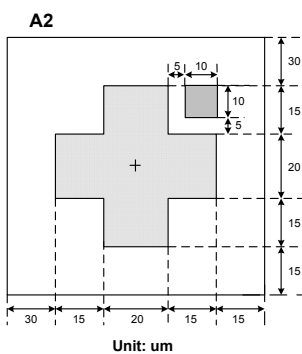
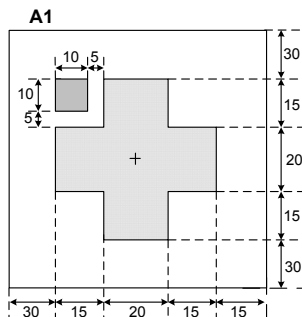
No.	Item		RM68050
1	TFT data lines		720 output
2	TFT gate lines		320 output
3	TFT display storage capacitance		Cst only (Common VCOM)
4	Liquid crystal drive output	S1~S720	V0~V63 grayscales
		G1~G320	VGH-VGL
		VCOM	Change VCOMH-VCOML amplitude with electronic volume Change VCOMH with either electronic volume or from VCOMR
5	Input voltage	IOVCC (interface voltage)	1.65V~3.30V Power supply to IM0/ID, IM1-3, nRESET, DB17-0, nRD, SDI, SDO, WR/SCL, RS, nCS, VSYNC, HSYNC, DOTCLK, ENABLE, FMARK. Connect to VCC and VCI on the FPC when the electrical potentials are the same.
		VCI (liquid crystal drive power supply voltage)	2.40V~3.30V Connect to IOVCC and VCC on the FPC when the electrical potentials are the same.
6	Liquid crystal drive voltages	DDVDH	4.5V ~ 6.0V
		VGH	10.0V ~ 19.8V
		VGL	-4.5V ~ -13.5V
		VGH-VGL	Max. 30.0V
		VCL	-1.9V ~ -3.3V
		VCI-VCL	Max. 6.0V
7	Internal step-up circuits	VLOUT1 (DDVDH)	VCI1x2
		VLOUT2 (VGH)	VCI1x4, x5, x6
		VLOUT3 (VGL)	VCI1x-3, -4, -5
		VCL	VCI1x-1

3. Block Diagram



4. Pin Diagram

Alignment Marks



- Chip size: 17.82 mm x 0.73 mm (Include sealing and scribe line)
- Chip thickness: 280 um (typ.)
- PAD coordinates: PAD center
- PAD coordinates origin: Chip center
- Au bump size

4.1.1 16um x 98um: Gate:G1~G320, Source:S1~S720

4.1.2 50um x 80um: Input Pads, Pad 1 ~ 243

- Au bump pitch: See PAD coordinates table
- Au bump height: 12um (typ.)
- Alignment mark

Alignment mark shape	X	Y
Type A	-8751.0	214.5
	8751.0	214.5

Pad Coordinate (Unit: um)

No	Name	X	Y	No	Name	X	Y	No	Name	X	Y	No	Name	X	Y
1	DUMMY1	-8610	-252	61	TS4	-4130	-252	121	VCOML	70	-252	181	C11+	4270	-252
2	TEST1	-8540	-252	62	TS3	-4060	-252	122	VCOML	140	-252	182	C11+	4340	-252
3	IOGNDDUM	-8470	-252	63	TS2	-3990	-252	123	VCOML	210	-252	183	C11+	4410	-252
4	LEDPWM	-8400	-252	64	TS1	-3920	-252	124	VCOML	280	-252	184	C11+	4480	-252
5	LEDON	-8330	-252	65	TS0	-3850	-252	125	VREGIOUT	350	-252	185	VGL	4550	-252
6	TESTO3	-8260	-252	66	DUMMY2	-3780	-252	126	VREGIOUT	420	-252	186	VGL	4620	-252
7	IM0/ID	-8190	-252	67	IOVCC	-3710	-252	127	VREGIOUT	490	-252	187	VGL	4690	-252
8	IM1	-8120	-252	68	IOVCC	-3640	-252	128	DUMMY7	560	-252	188	VGL	4760	-252
9	IM2	-8050	-252	69	IOVCC	-3570	-252	129	DUMMY8	630	-252	189	VGL	4830	-252
10	IM3	-7980	-252	70	IOVCC	-3500	-252	130	DUMMY9	700	-252	190	VGL	4900	-252
11	TEST2	-7910	-252	71	IOVCC	-3430	-252	131	VCL	770	-252	191	VGL	4970	-252
12	TESTO4	-7840	-252	72	IOVCC	-3360	-252	132	VCL	840	-252	192	VGL	5040	-252
13	TESTO5	-7770	-252	73	VDDD	-3290	-252	133	VCL	910	-252	193	VGL	5110	-252
14	TESTO6	-7700	-252	74	VDDD	-3220	-252	134	VCL	980	-252	194	VGL	5180	-252
15	TESTO7	-7630	-252	75	VDDD	-3150	-252	135	VCL	1050	-252	195	GND	5250	-252
16	TESTO8	-7560	-252	76	VDDD	-3080	-252	136	DDVDH	1120	-252	196	GND	5320	-252
17	TESTO9	-7490	-252	77	VDDD	-3010	-252	137	DDVDH	1190	-252	197	GND	5390	-252
18	TESTO10	-7420	-252	78	VDDD	-2940	-252	138	DDVDH	1260	-252	198	VGH	5460	-252
19	nRESET	-7350	-252	79	VDDD	-2870	-252	139	DDVDH	1330	-252	199	VGH	5530	-252
20	nRESET	-7280	-252	80	VDDD	-2800	-252	140	DDVDH	1400	-252	200	VGH	5600	-252
21	VSYN	-7210	-252	81	VDDD	-2730	-252	141	DDVDH	1470	-252	201	VGH	5670	-252
22	HSYN	-7140	-252	82	VDDD	-2660	-252	142	VCI	1540	-252	202	VGH	5740	-252
23	DOTCLK	-7070	-252	83	VDDD	-2590	-252	143	VCI	1610	-252	203	VGH	5810	-252
24	ENABLE	-7000	-252	84	DUMMY3	-2520	-252	144	VCI	1680	-252	204	DUMMY12	5880	-252
25	DB17	-6905	-252	85	GND	-2450	-252	145	VCI	1750	-252	205	DUMMY13	5950	-252
26	DB16	-6825	-252	86	GND	-2380	-252	146	VCI	1820	-252	206	C13-	6020	-252
27	DB15	-6745	-252	87	GND	-2310	-252	147	VCI	1890	-252	207	C13-	6090	-252
28	DB14	-6665	-252	88	GND	-2240	-252	148	VCI	1960	-252	208	C13-	6160	-252
29	DB13	-6585	-252	89	GND	-2170	-252	149	VCI	2030	-252	209	C13-	6230	-252
30	TESTO11	-6495	-252	90	GND	-2100	-252	150	VCI	2100	-252	210	C13+	6300	-252
31	DB12	-6405	-252	91	GND	-2030	-252	151	VCI	2170	-252	211	C13+	6370	-252
32	DB11	-6325	-252	92	GND	-1960	-252	152	VCI	2240	-252	212	C13+	6440	-252
33	DB10	-6245	-252	93	VGS	-1890	-252	153	VCI	2310	-252	213	C13+	6510	-252
34	DB9	-6165	-252	94	VGS	-1820	-252	154	VCI	2380	-252	214	C21-	6580	-252
35	DB8	-6085	-252	95	GND	-1750	-252	155	VCI	2450	-252	215	C21-	6650	-252
36	TEST3	-5990	-252	96	GND	-1680	-252	156	VCI	2520	-252	216	C21-	6720	-252
37	TESTO12	-5920	-252	97	GND	-1610	-252	157	VCI	2590	-252	217	C21-	6790	-252
38	DB7	-5825	-252	98	GND	-1540	-252	158	VCI	2660	-252	218	C21-	6860	-252
39	DB6	-5745	-252	99	GND	-1470	-252	159	VCI	2730	-252	219	C21-	6930	-252
40	DB5	-5665	-252	100	GND	-1400	-252	160	VCI	2800	-252	220	C21-	7000	-252
41	DB4	-5585	-252	101	GND	-1330	-252	161	VCI	2870	-252	221	C21+	7070	-252
42	DB3	-5505	-252	102	GND	-1260	-252	162	VCI	2940	-252	222	C21+	7140	-252
43	DB2	-5425	-252	103	GND	-1190	-252	163	DUMMY10	3010	-252	223	C21+	7210	-252
44	DB1	-5345	-252	104	GND	-1120	-252	164	DUMMY11	3080	-252	224	C21+	7280	-252
45	DB0	-5265	-252	105	DUMMY4	-1050	-252	165	C12-	3150	-252	225	C21+	7350	-252
46	TESTO13	-5180	-252	106	DUMMY5	-980	-252	166	C12-	3220	-252	226	C21+	7420	-252
47	SDO	-5110	-252	107	DUMMY6	-910	-252	167	C12-	3290	-252	227	C21+	7490	-252
48	SDI	-5040	-252	108	VCOM	-840	-252	168	C12-	3360	-252	228	C22-	7560	-252
49	nRD	-4970	-252	109	VCOM	-770	-252	169	C12-	3430	-252	229	C22-	7630	-252
50	nWR/SCL	-4900	-252	110	VCOM	-700	-252	170	C12+	3500	-252	230	C22-	7700	-252
51	RS	-4830	-252	111	VCOM	-630	-252	171	C12+	3570	-252	231	C22-	7770	-252
52	nCS	-4760	-252	112	VCOM	-560	-252	172	C12+	3640	-252	232	C22-	7840	-252
53	TESTO14	-4690	-252	113	VCOM	-490	-252	173	C12+	3710	-252	233	C22-	7910	-252
54	TESTO15	-4620	-252	114	VCOM	-420	-252	174	C12+	3780	-252	234	C22-	7980	-252
55	FMARK	-4550	-252	115	VCOMH	-350	-252	175	C11-	3850	-252	235	C22+	8050	-252
56	TESTO16	-4480	-252	116	VCOMH	-280	-252	176	C11-	3920	-252	236	C22+	8120	-252
57	TS8	-4410	-252	117	VCOMH	-210	-252	177	C11-	3990	-252	237	C22+	8190	-252
58	TS7	-4340	-252	118	VCOMH	-140	-252	178	C11-	4060	-252	238	C22+	8260	-252
59	TS6	-4270	-252	119	VCOMH	-70	-252	179	C11-	4130	-252	239	C22+	8330	-252
60	TS5	-4200	-252	120	VCOMH	0	-252	180	C11+	4200	-252	240	C22+	8400	-252

No	Name	X	Y	No	Name	X	Y	No	Name	X	Y	No	Name	X	Y
241	C22+	8470	-252	301	G208	7747	265	361	G88	6787	265	421	S706	5807	148
242	DUMMY14	8540	-252	302	G206	7731	148	362	G86	6771	148	422	S705	5791	265
243	DUMMY15	8610	-252	303	G204	7715	265	363	G84	6755	265	423	S704	5775	148
244	DUMMY20	8659	148	304	G202	7699	148	364	G82	6739	148	424	S703	5759	265
245	G320	8643	265	305	G200	7683	265	365	G80	6723	265	425	S702	5743	148
246	G318	8627	148	306	G198	7667	148	366	G78	6707	148	426	S701	5727	265
247	G316	8611	265	307	G196	7651	265	367	G76	6691	265	427	S700	5711	148
248	G314	8595	148	308	G194	7635	148	368	G74	6675	148	428	S699	5695	265
249	G312	8579	265	309	G192	7619	265	369	G72	6659	265	429	S698	5679	148
250	G310	8563	148	310	G190	7603	148	370	G70	6643	148	430	S697	5663	265
251	G308	8547	265	311	G188	7587	265	371	G68	6627	265	431	S696	5647	148
252	G306	8531	148	312	G186	7571	148	372	G66	6611	148	432	S695	5631	265
253	G304	8515	265	313	G184	7555	265	373	G64	6595	265	433	S694	5615	148
254	G302	8499	148	314	G182	7539	148	374	G62	6579	148	434	S693	5599	265
255	G300	8483	265	315	G180	7523	265	375	G60	6563	265	435	S692	5583	148
256	G298	8467	148	316	G178	7507	148	376	G58	6547	148	436	S691	5567	265
257	G296	8451	265	317	G176	7491	265	377	G56	6531	265	437	S690	5551	148
258	G294	8435	148	318	G174	7475	148	378	G54	6515	148	438	S689	5535	265
259	G292	8419	265	319	G172	7459	265	379	G52	6499	265	439	S688	5519	148
260	G290	8403	148	320	G170	7443	148	380	G50	6483	148	440	S687	5503	265
261	G288	8387	265	321	G168	7427	265	381	G48	6467	265	441	S686	5487	148
262	G286	8371	148	322	G166	7411	148	382	G46	6451	148	442	S685	5471	265
263	G284	8355	265	323	G164	7395	265	383	G44	6435	265	443	S684	5455	148
264	G282	8339	148	324	G162	7379	148	384	G42	6419	148	444	S683	5439	265
265	G280	8323	265	325	G160	7363	265	385	G40	6403	265	445	S682	5423	148
266	G278	8307	148	326	G158	7347	148	386	G38	6387	148	446	S681	5407	265
267	G276	8291	265	327	G156	7331	265	387	G36	6371	265	447	S680	5391	148
268	G274	8275	148	328	G154	7315	148	388	G34	6355	148	448	S679	5375	265
269	G272	8259	265	329	G152	7299	265	389	G32	6339	265	449	S678	5359	148
270	G270	8243	148	330	G150	7283	148	390	G30	6323	148	450	S677	5343	265
271	G268	8227	265	331	G148	7267	265	391	G28	6307	265	451	S676	5327	148
272	G266	8211	148	332	G146	7251	148	392	G26	6291	148	452	S675	5311	265
273	G264	8195	265	333	G144	7235	265	393	G24	6275	265	453	S674	5295	148
274	G262	8179	148	334	G142	7219	148	394	G22	6259	148	454	S673	5279	265
275	G260	8163	265	335	G140	7203	265	395	G20	6243	265	455	S672	5263	148
276	G258	8147	148	336	G138	7187	148	396	G18	6227	148	456	S671	5247	265
277	G256	8131	265	337	G136	7171	265	397	G16	6211	265	457	S670	5231	148
278	G254	8115	148	338	G134	7155	148	398	G14	6195	148	458	S669	5215	265
279	G252	8099	265	339	G132	7139	265	399	G12	6179	265	459	S668	5199	148
280	G250	8083	148	340	G130	7123	148	400	G10	6163	148	460	S667	5183	265
281	G248	8067	265	341	G128	7107	265	401	G8	6147	265	461	S666	5167	148
282	G246	8051	148	342	G126	7091	148	402	G6	6131	148	462	S665	5151	265
283	G244	8035	265	343	G124	7075	265	403	G4	6115	265	463	S664	5135	148
284	G242	8019	148	344	G122	7059	148	404	G2	6099	148	464	S663	5119	265
285	G240	8003	265	345	G120	7043	265	405	DUMMY21	6083	265	465	S662	5103	148
286	G238	7987	148	346	G118	7027	148	406	DUMMY22	6047	265	466	S661	5087	265
287	G236	7971	265	347	G116	7011	265	407	S720	6031	148	467	S660	5071	148
288	G234	7955	148	348	G114	6995	148	408	S719	6015	265	468	S659	5055	265
289	G232	7939	265	349	G112	6979	265	409	S718	5999	148	469	S658	5039	148
290	G230	7923	148	350	G110	6963	148	410	S717	5983	265	470	S657	5023	265
291	G228	7907	265	351	G108	6947	265	411	S716	5967	148	471	S656	5007	148
292	G226	7891	148	352	G106	6931	148	412	S715	5951	265	472	S655	4991	265
293	G224	7875	265	353	G104	6915	265	413	S714	5935	148	473	S654	4975	148
294	G222	7859	148	354	G102	6899	148	414	S713	5919	265	474	S653	4959	265
295	G220	7843	265	355	G100	6883	265	415	S712	5903	148	475	S652	4943	148
296	G218	7827	148	356	G98	6867	148	416	S711	5887	265	476	S651	4927	265
297	G216	7811	265	357	G96	6851	265	417	S710	5871	148	477	S650	4911	148
298	G214	7795	148	358	G94	6835	148	418	S709	5855	265	478	S649	4895	265
299	G212	7779	265	359	G92	6819	265	419	S708	5839	148	479	S648	4879	148
300	G210	7763	148	360	G90	6803	148	420	S707	5823	265	480	S647	4863	265

No	Name	X	Y	No	Name	X	Y	No	Name	X	Y	No	Name	X	Y
481	S646	4847	148	541	S586	3887	148	601	S526	2927	148	661	S466	1967	148
482	S645	4831	265	542	S585	3871	265	602	S525	2911	265	662	S465	1951	265
483	S644	4815	148	543	S584	3855	148	603	S524	2895	148	663	S464	1935	148
484	S643	4799	265	544	S583	3839	265	604	S523	2879	265	664	S463	1919	265
485	S642	4783	148	545	S582	3823	148	605	S522	2863	148	665	S462	1903	148
486	S641	4767	265	546	S581	3807	265	606	S521	2847	265	666	S461	1887	265
487	S640	4751	148	547	S580	3791	148	607	S520	2831	148	667	S460	1871	148
488	S639	4735	265	548	S579	3775	265	608	S519	2815	265	668	S459	1855	265
489	S638	4719	148	549	S578	3759	148	609	S518	2799	148	669	S458	1839	148
490	S637	4703	265	550	S577	3743	265	610	S517	2783	265	670	S457	1823	265
491	S636	4687	148	551	S576	3727	148	611	S516	2767	148	671	S456	1807	148
492	S635	4671	265	552	S575	3711	265	612	S515	2751	265	672	S455	1791	265
493	S634	4655	148	553	S574	3695	148	613	S514	2735	148	673	S454	1775	148
494	S633	4639	265	554	S573	3679	265	614	S513	2719	265	674	S453	1759	265
495	S632	4623	148	555	S572	3663	148	615	S512	2703	148	675	S452	1743	148
496	S631	4607	265	556	S571	3647	265	616	S511	2687	265	676	S451	1727	265
497	S630	4591	148	557	S570	3631	148	617	S510	2671	148	677	S450	1711	148
498	S629	4575	265	558	S569	3615	265	618	S509	2655	265	678	S449	1695	265
499	S628	4559	148	559	S568	3599	148	619	S508	2639	148	679	S448	1679	148
500	S627	4543	265	560	S567	3583	265	620	S507	2623	265	680	S447	1663	265
501	S626	4527	148	561	S566	3567	148	621	S506	2607	148	681	S446	1647	148
502	S625	4511	265	562	S565	3551	265	622	S505	2591	265	682	S445	1631	265
503	S624	4495	148	563	S564	3535	148	623	S504	2575	148	683	S444	1615	148
504	S623	4479	265	564	S563	3519	265	624	S503	2559	265	684	S443	1599	265
505	S622	4463	148	565	S562	3503	148	625	S502	2543	148	685	S442	1583	148
506	S621	4447	265	566	S561	3487	265	626	S501	2527	265	686	S441	1567	265
507	S620	4431	148	567	S560	3471	148	627	S500	2511	148	687	S440	1551	148
508	S619	4415	265	568	S559	3455	265	628	S499	2495	265	688	S439	1535	265
509	S618	4399	148	569	S558	3439	148	629	S498	2479	148	689	S438	1519	148
510	S617	4383	265	570	S557	3423	265	630	S497	2463	265	690	S437	1503	265
511	S616	4367	148	571	S556	3407	148	631	S496	2447	148	691	S436	1487	148
512	S615	4351	265	572	S555	3391	265	632	S495	2431	265	692	S435	1471	265
513	S614	4335	148	573	S554	3375	148	633	S494	2415	148	693	S434	1455	148
514	S613	4319	265	574	S553	3359	265	634	S493	2399	265	694	S433	1439	265
515	S612	4303	148	575	S552	3343	148	635	S492	2383	148	695	S432	1423	148
516	S611	4287	265	576	S551	3327	265	636	S491	2367	265	696	S431	1407	265
517	S610	4271	148	577	S550	3311	148	637	S490	2351	148	697	S430	1391	148
518	S609	4255	265	578	S549	3295	265	638	S489	2335	265	698	S429	1375	265
519	S608	4239	148	579	S548	3279	148	639	S488	2319	148	699	S428	1359	148
520	S607	4223	265	580	S547	3263	265	640	S487	2303	265	700	S427	1343	265
521	S606	4207	148	581	S546	3247	148	641	S486	2287	148	701	S426	1327	148
522	S605	4191	265	582	S545	3231	265	642	S485	2271	265	702	S425	1311	265
523	S604	4175	148	583	S544	3215	148	643	S484	2255	148	703	S424	1295	148
524	S603	4159	265	584	S543	3199	265	644	S483	2239	265	704	S423	1279	265
525	S602	4143	148	585	S542	3183	148	645	S482	2223	148	705	S422	1263	148
526	S601	4127	265	586	S541	3167	265	646	S481	2207	265	706	S421	1247	265
527	S600	4111	148	587	S540	3151	148	647	S480	2191	148	707	S420	1231	148
528	S599	4095	265	588	S539	3135	265	648	S479	2175	265	708	S419	1215	265
529	S598	4079	148	589	S538	3119	148	649	S478	2159	148	709	S418	1199	148
530	S597	4063	265	590	S537	3103	265	650	S477	2143	265	710	S417	1183	265
531	S596	4047	148	591	S536	3087	148	651	S476	2127	148	711	S416	1167	148
532	S595	4031	265	592	S535	3071	265	652	S475	2111	265	712	S415	1151	265
533	S594	4015	148	593	S534	3055	148	653	S474	2095	148	713	S414	1135	148
534	S593	3999	265	594	S533	3039	265	654	S473	2079	265	714	S413	1119	265
535	S592	3983	148	595	S532	3023	148	655	S472	2063	148	715	S412	1103	148
536	S591	3967	265	596	S531	3007	265	656	S471	2047	265	716	S411	1087	265
537	S590	3951	148	597	S530	2991	148	657	S470	2031	148	717	S410	1071	148
538	S589	3935	265	598	S529	2975	265	658	S469	2015	265	718	S409	1055	265
539	S588	3919	148	599	S528	2959	148	659	S468	1999	148	719	S408	1039	148
540	S587	3903	265	600	S527	2943	265	660	S467	1983	265	720	S407	1023	265

No	Name	X	Y	No	Name	X	Y	No	Name	X	Y	No	Name	X	Y
721	S406	1007	148	781	S348	-479	265	841	S288	-1439	265	901	S228	-2399	265
722	S405	991	265	782	S347	-495	148	842	S287	-1455	148	902	S227	-2415	148
723	S404	975	148	783	S346	-511	265	843	S286	-1471	265	903	S226	-2431	265
724	S403	959	265	784	S345	-527	148	844	S285	-1487	148	904	S225	-2447	148
725	S402	943	148	785	S344	-543	265	845	S284	-1503	265	905	S224	-2463	265
726	S401	927	265	786	S343	-559	148	846	S283	-1519	148	906	S223	-2479	148
727	S400	911	148	787	S342	-575	265	847	S282	-1535	265	907	S222	-2495	265
728	S399	895	265	788	S341	-591	148	848	S281	-1551	148	908	S221	-2511	148
729	S398	879	148	789	S340	-607	265	849	S280	-1567	265	909	S220	-2527	265
730	S397	863	265	790	S339	-623	148	850	S279	-1583	148	910	S219	-2543	148
731	S396	847	148	791	S338	-639	265	851	S278	-1599	265	911	S218	-2559	265
732	S395	831	265	792	S337	-655	148	852	S277	-1615	148	912	S217	-2575	148
733	S394	815	148	793	S336	-671	265	853	S276	-1631	265	913	S216	-2591	265
734	S393	799	265	794	S335	-687	148	854	S275	-1647	148	914	S215	-2607	148
735	S392	783	148	795	S334	-703	265	855	S274	-1663	265	915	S214	-2623	265
736	S391	767	265	796	S333	-719	148	856	S273	-1679	148	916	S213	-2639	148
737	S390	751	148	797	S332	-735	265	857	S272	-1695	265	917	S212	-2655	265
738	S389	735	265	798	S331	-751	148	858	S271	-1711	148	918	S211	-2671	148
739	S388	719	148	799	S330	-767	265	859	S270	-1727	265	919	S210	-2687	265
740	S387	703	265	800	S329	-783	148	860	S269	-1743	148	920	S209	-2703	148
741	S386	687	148	801	S328	-799	265	861	S268	-1759	265	921	S208	-2719	265
742	S385	671	265	802	S327	-815	148	862	S267	-1775	148	922	S207	-2735	148
743	S384	655	148	803	S326	-831	265	863	S266	-1791	265	923	S206	-2751	265
744	S383	639	265	804	S325	-847	148	864	S265	-1807	148	924	S205	-2767	148
745	S382	623	148	805	S324	-863	265	865	S264	-1823	265	925	S204	-2783	265
746	S381	607	265	806	S323	-879	148	866	S263	-1839	148	926	S203	-2799	148
747	S380	591	148	807	S322	-895	265	867	S262	-1855	265	927	S202	-2815	265
748	S379	575	265	808	S321	-911	148	868	S261	-1871	148	928	S201	-2831	148
749	S378	559	148	809	S320	-927	265	869	S260	-1887	265	929	S200	-2847	265
750	S377	543	265	810	S319	-943	148	870	S259	-1903	148	930	S199	-2863	148
751	S376	527	148	811	S318	-959	265	871	S258	-1919	265	931	S198	-2879	265
752	S375	511	265	812	S317	-975	148	872	S257	-1935	148	932	S197	-2895	148
753	S374	495	148	813	S316	-991	265	873	S256	-1951	265	933	S196	-2911	265
754	S373	479	265	814	S315	-1007	148	874	S255	-1967	148	934	S195	-2927	148
755	S372	463	148	815	S314	-1023	265	875	S254	-1983	265	935	S194	-2943	265
756	S371	447	265	816	S313	-1039	148	876	S253	-1999	148	936	S193	-2959	148
757	S370	431	148	817	S312	-1055	265	877	S252	-2015	265	937	S192	-2975	265
758	S369	415	265	818	S311	-1071	148	878	S251	-2031	148	938	S191	-2991	148
759	S368	399	148	819	S310	-1087	265	879	S250	-2047	265	939	S190	-3007	265
760	S367	383	265	820	S309	-1103	148	880	S249	-2063	148	940	S189	-3023	148
761	S366	367	148	821	S308	-1119	265	881	S248	-2079	265	941	S188	-3039	265
762	S365	351	265	822	S307	-1135	148	882	S247	-2095	148	942	S187	-3055	148
763	S364	335	148	823	S306	-1151	265	883	S246	-2111	265	943	S186	-3071	265
764	S363	319	265	824	S305	-1167	148	884	S245	-2127	148	944	S185	-3087	148
765	S362	303	148	825	S304	-1183	265	885	S244	-2143	265	945	S184	-3103	265
766	S361	287	265	826	S303	-1199	148	886	S243	-2159	148	946	S183	-3119	148
767	DUMMY23	271	148	827	S302	-1215	265	887	S242	-2175	265	947	S182	-3135	265
768	DUMMY24	-271	148	828	S301	-1231	148	888	S241	-2191	148	948	S181	-3151	148
769	S360	-287	265	829	S300	-1247	265	889	S240	-2207	265	949	S180	-3167	265
770	S359	-303	148	830	S299	-1263	148	890	S239	-2223	148	950	S179	-3183	148
771	S358	-319	265	831	S298	-1279	265	891	S238	-2239	265	951	S178	-3199	265
772	S357	-335	148	832	S297	-1295	148	892	S237	-2255	148	952	S177	-3215	148
773	S356	-351	265	833	S296	-1311	265	893	S236	-2271	265	953	S176	-3231	265
774	S355	-367	148	834	S295	-1327	148	894	S235	-2287	148	954	S175	-3247	148
775	S354	-383	265	835	S294	-1343	265	895	S234	-2303	265	955	S174	-3263	265
776	S353	-399	148	836	S293	-1359	148	896	S233	-2319	148	956	S173	-3279	148
777	S352	-415	265	837	S292	-1375	265	897	S232	-2335	265	957	S172	-3295	265
778	S351	-431	148	838	S291	-1391	148	898	S231	-2351	148	958	S171	-3311	148
779	S350	-447	265	839	S290	-1407	265	899	S230	-2367	265	959	S170	-3327	265
780	S349	-463	148	840	S289	-1423	148	900	S229	-2383	148	960	S169	-3343	148

No	Name	X	Y	No	Name	X	Y	No	Name	X	Y	No	Name	X	Y
961	S168	-3359	265	1021	S108	-4319	265	1081	S48	-5279	265	1141	G21	-6259	148
962	S167	-3375	148	1022	S107	-4335	148	1082	S47	-5295	148	1142	G23	-6275	265
963	S166	-3391	265	1023	S106	-4351	265	1083	S46	-5311	265	1143	G25	-6291	148
964	S165	-3407	148	1024	S105	-4367	148	1084	S45	-5327	148	1144	G27	-6307	265
965	S164	-3423	265	1025	S104	-4383	265	1085	S44	-5343	265	1145	G29	-6323	148
966	S163	-3439	148	1026	S103	-4399	148	1086	S43	-5359	148	1146	G31	-6339	265
967	S162	-3455	265	1027	S102	-4415	265	1087	S42	-5375	265	1147	G33	-6355	148
968	S161	-3471	148	1028	S101	-4431	148	1088	S41	-5391	148	1148	G35	-6371	265
969	S160	-3487	265	1029	S100	-4447	265	1089	S40	-5407	265	1149	G37	-6387	148
970	S159	-3503	148	1030	S99	-4463	148	1090	S39	-5423	148	1150	G39	-6403	265
971	S158	-3519	265	1031	S98	-4479	265	1091	S38	-5439	265	1151	G41	-6419	148
972	S157	-3535	148	1032	S97	-4495	148	1092	S37	-5455	148	1152	G43	-6435	265
973	S156	-3551	265	1033	S96	-4511	265	1093	S36	-5471	265	1153	G45	-6451	148
974	S155	-3567	148	1034	S95	-4527	148	1094	S35	-5487	148	1154	G47	-6467	265
975	S154	-3583	265	1035	S94	-4543	265	1095	S34	-5503	265	1155	G49	-6483	148
976	S153	-3599	148	1036	S93	-4559	148	1096	S33	-5519	148	1156	G51	-6499	265
977	S152	-3615	265	1037	S92	-4575	265	1097	S32	-5535	265	1157	G53	-6515	148
978	S151	-3631	148	1038	S91	-4591	148	1098	S31	-5551	148	1158	G55	-6531	265
979	S150	-3647	265	1039	S90	-4607	265	1099	S30	-5567	265	1159	G57	-6547	148
980	S149	-3663	148	1040	S89	-4623	148	1100	S29	-5583	148	1160	G59	-6563	265
981	S148	-3679	265	1041	S88	-4639	265	1101	S28	-5599	265	1161	G61	-6579	148
982	S147	-3695	148	1042	S87	-4655	148	1102	S27	-5615	148	1162	G63	-6595	265
983	S146	-3711	265	1043	S86	-4671	265	1103	S26	-5631	265	1163	G65	-6611	148
984	S145	-3727	148	1044	S85	-4687	148	1104	S25	-5647	148	1164	G67	-6627	265
985	S144	-3743	265	1045	S84	-4703	265	1105	S24	-5663	265	1165	G69	-6643	148
986	S143	-3759	148	1046	S83	-4719	148	1106	S23	-5679	148	1166	G71	-6659	265
987	S142	-3775	265	1047	S82	-4735	265	1107	S22	-5695	265	1167	G73	-6675	148
988	S141	-3791	148	1048	S81	-4751	148	1108	S21	-5711	148	1168	G75	-6691	265
989	S140	-3807	265	1049	S80	-4767	265	1109	S20	-5727	265	1169	G77	-6707	148
990	S139	-3823	148	1050	S79	-4783	148	1110	S19	-5743	148	1170	G79	-6723	265
991	S138	-3839	265	1051	S78	-4799	265	1111	S18	-5759	265	1171	G81	-6739	148
992	S137	-3855	148	1052	S77	-4815	148	1112	S17	-5775	148	1172	G83	-6755	265
993	S136	-3871	265	1053	S76	-4831	265	1113	S16	-5791	265	1173	G85	-6771	148
994	S135	-3887	148	1054	S75	-4847	148	1114	S15	-5807	148	1174	G87	-6787	265
995	S134	-3903	265	1055	S74	-4863	265	1115	S14	-5823	265	1175	G89	-6803	148
996	S133	-3919	148	1056	S73	-4879	148	1116	S13	-5839	148	1176	G91	-6819	265
997	S132	-3935	265	1057	S72	-4895	265	1117	S12	-5855	265	1177	G93	-6835	148
998	S131	-3951	148	1058	S71	-4911	148	1118	S11	-5871	148	1178	G95	-6851	265
999	S130	-3967	265	1059	S70	-4927	265	1119	S10	-5887	265	1179	G97	-6867	148
1000	S129	-3983	148	1060	S69	-4943	148	1120	S9	-5903	148	1180	G99	-6883	265
1001	S128	-3999	265	1061	S68	-4959	265	1121	S8	-5919	265	1181	G101	-6899	148
1002	S127	-4015	148	1062	S67	-4975	148	1122	S7	-5935	148	1182	G103	-6915	265
1003	S126	-4031	265	1063	S66	-4991	265	1123	S6	-5951	265	1183	G105	-6931	148
1004	S125	-4047	148	1064	S65	-5007	148	1124	S5	-5967	148	1184	G107	-6947	265
1005	S124	-4063	265	1065	S64	-5023	265	1125	S4	-5983	265	1185	G109	-6963	148
1006	S123	-4079	148	1066	S63	-5039	148	1126	S3	-5999	148	1186	G111	-6979	265
1007	S122	-4095	265	1067	S62	-5055	265	1127	S2	-6015	265	1187	G113	-6995	148
1008	S121	-4111	148	1068	S61	-5071	148	1128	S1	-6031	148	1188	G115	-7011	265
1009	S120	-4127	265	1069	S60	-5087	265	1129	DUMMY25	-6047	265	1189	G117	-7027	148
1010	S119	-4143	148	1070	S59	-5103	148	1130	DUMMY26	-6063	265	1190	G119	-7043	265
1011	S118	-4159	265	1071	S58	-5119	265	1131	G1	-6079	148	1191	G121	-7059	148
1012	S117	-4175	148	1072	S57	-5135	148	1132	G3	-6115	265	1192	G123	-7075	265
1013	S116	-4191	265	1073	S56	-5151	265	1133	G5	-6131	148	1193	G125	-7091	148
1014	S115	-4207	148	1074	S55	-5167	148	1134	G7	-6147	265	1194	G127	-7107	265
1015	S114	-4223	265	1075	S54	-5183	265	1135	G9	-6163	148	1195	G129	-7123	148
1016	S113	-4239	148	1076	S53	-5199	148	1136	G11	-6179	265	1196	G131	-7139	265
1017	S112	-4255	265	1077	S52	-5215	265	1137	G13	-6195	148	1197	G133	-7155	148
1018	S111	-4271	148	1078	S51	-5231	148	1138	G15	-6211	265	1198	G135	-7171	265
1019	S110	-4287	265	1079	S50	-5247	265	1139	G17	-6227	148	1199	G137	-7187	148
1020	S109	-4303	148	1080	S49	-5263	148	1140	G19	-6243	265	1200	G139	-7203	265

No	Name	X	Y	No	Name	X	Y
1201	G141	-7219	148	1261	G261	-8179	148
1202	G143	-7235	265	1262	G263	-8195	265
1203	G145	-7251	148	1263	G265	-8211	148
1204	G147	-7267	265	1264	G267	-8227	265
1205	G149	-7283	148	1265	G269	-8243	148
1206	G151	-7299	265	1266	G271	-8259	265
1207	G153	-7315	148	1267	G273	-8275	148
1208	G155	-7331	265	1268	G275	-8291	265
1209	G157	-7347	148	1269	G277	-8307	148
1210	G159	-7363	265	1270	G279	-8323	265
1211	G161	-7379	148	1271	G281	-8339	148
1212	G163	-7395	265	1272	G283	-8355	265
1213	G165	-7411	148	1273	G285	-8371	148
1214	G167	-7427	265	1274	G287	-8387	265
1215	G169	-7443	148	1275	G289	-8403	148
1216	G171	-7459	265	1276	G291	-8419	265
1217	G173	-7475	148	1277	G293	-8435	148
1218	G175	-7491	265	1278	G295	-8451	265
1219	G177	-7507	148	1279	G297	-8467	148
1220	G179	-7523	265	1280	G299	-8483	265
1221	G181	-7539	148	1281	G301	-8499	148
1222	G183	-7555	265	1282	G303	-8515	265
1223	G185	-7571	148	1283	G305	-8531	148
1224	G187	-7587	265	1284	G307	-8547	265
1225	G189	-7603	148	1285	G309	-8563	148
1226	G191	-7619	265	1286	G311	-8579	265
1227	G193	-7635	148	1287	G313	-8595	148
1228	G195	-7651	265	1288	G315	-8611	265
1229	G197	-7667	148	1289	G317	-8627	148
1230	G199	-7683	265	1290	G319	-8643	265
1231	G201	-7699	148	1291	DUMMY27	-8659	148
1232	G203	-7715	265				
1233	G205	-7731	148				
1234	G207	-7747	265				
1235	G209	-7763	148				
1236	G211	-7779	265				
1237	G213	-7795	148				
1238	G215	-7811	265				
1239	G217	-7827	148				
1240	G219	-7843	265				
1241	G221	-7859	148				
1242	G223	-7875	265				
1243	G225	-7891	148				
1244	G227	-7907	265				
1245	G229	-7923	148				
1246	G231	-7939	265				
1247	G233	-7955	148				
1248	G235	-7971	265				
1249	G237	-7987	148				
1250	G239	-8003	265				
1251	G241	-8019	148				
1252	G243	-8035	265				
1253	G245	-8051	148				
1254	G247	-8067	265				
1255	G249	-8083	148				
1256	G251	-8099	265				
1257	G253	-8115	148				
1258	G255	-8131	265				
1259	G257	-8147	148				
1260	G259	-8163	265				

5. Pin Function

Table 2 Interface

Signal	I/O	Connect to	Function	When not in use																																																																																																
IM3-1, IM0/ID	I	IOGND or IOVCC	Select a mode to interface to an MPU. In serial interface operation, the IM0 pin is used to set the ID bit of device code.	-																																																																																																
			<table><tr><td>IM3</td><td>IM2</td><td>IM1</td><td>IM0 /ID</td><td>Interface Mode</td><td>DB Pin</td></tr><tr><td>0</td><td>0</td><td>0</td><td>0</td><td>Setting disabled</td><td>-</td></tr><tr><td>0</td><td>0</td><td>0</td><td>1</td><td>Setting disabled</td><td>-</td></tr><tr><td>0</td><td>0</td><td>1</td><td>0</td><td>80-system 16-bit interface</td><td>DB17-10, DB8-1</td></tr><tr><td>0</td><td>0</td><td>1</td><td>1</td><td>80-system 8-bit interface</td><td>DB17-10</td></tr><tr><td>0</td><td>1</td><td>0</td><td>(ID)</td><td>Clock synchronous serial interface</td><td>-</td></tr><tr><td>0</td><td>1</td><td>1</td><td>0</td><td>9-bit 3 wires Serial Peripheral Interface</td><td>SDA, SCL, nCS</td></tr><tr><td>0</td><td>1</td><td>1</td><td>1</td><td>8-bit 4 wires Serial Peripheral Interface</td><td>SDA, SCL, nCS, RS(D/CX)</td></tr><tr><td>1</td><td>0</td><td>0</td><td>0</td><td>Setting disabled</td><td>-</td></tr><tr><td>1</td><td>0</td><td>0</td><td>1</td><td>Setting disabled</td><td>-</td></tr><tr><td>1</td><td>0</td><td>1</td><td>0</td><td>80-system 18-bit interface</td><td>DB17-0</td></tr><tr><td>1</td><td>0</td><td>1</td><td>1</td><td>80-system 9-bit interface</td><td>DB17-9</td></tr><tr><td>1</td><td>1</td><td>0</td><td>0</td><td>Setting disabled</td><td>-</td></tr><tr><td>1</td><td>1</td><td>0</td><td>1</td><td>Setting disabled</td><td>-</td></tr><tr><td>1</td><td>1</td><td>1</td><td>0</td><td>Setting disabled</td><td>-</td></tr><tr><td>1</td><td>1</td><td>1</td><td>1</td><td>Setting disabled</td><td>-</td></tr></table>	IM3	IM2	IM1	IM0 /ID	Interface Mode	DB Pin	0	0	0	0	Setting disabled	-	0	0	0	1	Setting disabled	-	0	0	1	0	80-system 16-bit interface	DB17-10, DB8-1	0	0	1	1	80-system 8-bit interface	DB17-10	0	1	0	(ID)	Clock synchronous serial interface	-	0	1	1	0	9-bit 3 wires Serial Peripheral Interface	SDA, SCL, nCS	0	1	1	1	8-bit 4 wires Serial Peripheral Interface	SDA, SCL, nCS, RS(D/CX)	1	0	0	0	Setting disabled	-	1	0	0	1	Setting disabled	-	1	0	1	0	80-system 18-bit interface	DB17-0	1	0	1	1	80-system 9-bit interface	DB17-9	1	1	0	0	Setting disabled	-	1	1	0	1	Setting disabled	-	1	1	1	0	Setting disabled	-	1	1	1	1	Setting disabled	-	
			IM3	IM2	IM1	IM0 /ID	Interface Mode	DB Pin																																																																																												
			0	0	0	0	Setting disabled	-																																																																																												
			0	0	0	1	Setting disabled	-																																																																																												
			0	0	1	0	80-system 16-bit interface	DB17-10, DB8-1																																																																																												
			0	0	1	1	80-system 8-bit interface	DB17-10																																																																																												
			0	1	0	(ID)	Clock synchronous serial interface	-																																																																																												
			0	1	1	0	9-bit 3 wires Serial Peripheral Interface	SDA, SCL, nCS																																																																																												
			0	1	1	1	8-bit 4 wires Serial Peripheral Interface	SDA, SCL, nCS, RS(D/CX)																																																																																												
			1	0	0	0	Setting disabled	-																																																																																												
			1	0	0	1	Setting disabled	-																																																																																												
			1	0	1	0	80-system 18-bit interface	DB17-0																																																																																												
			1	0	1	1	80-system 9-bit interface	DB17-9																																																																																												
			1	1	0	0	Setting disabled	-																																																																																												
			1	1	0	1	Setting disabled	-																																																																																												
			1	1	1	0	Setting disabled	-																																																																																												
			1	1	1	1	Setting disabled	-																																																																																												
nCS	I	MPU	Chip select signal. Amplitude: IOVCC-IOGND Low: the RM68050 is selected and accessible High: the RM68050 is not selected and not accessible.	IOGND																																																																																																
RS	I	MPU	Register select signal. Amplitude: IOVCC-IOGND Low: select Index or status register High: select control register Fix to either IOVCC or DGND when not in use	IOVCC																																																																																																
nWR/SCL	I	MPU	Write strobe signal in 80-system bus interface operation and enables write operation when nWR is low. Synchronous clock signal (SCL) in serial interface operation. Amplitude: IOVCC-IOGND	IOVCC																																																																																																
nRD	I	MPU	Read strobe signal in 80-system bus interface operation and enables read operation when nRD is low.	IOVCC																																																																																																

			Amplitude: IOVCC-IOGND	
SDI/SDA	I/O	MPU	Serial data input (SDI) pin in serial interface operation. The data is inputted and latched on the rising edge of the SCL signal. In the 8/9-bit SPI, this pin is a bi-directional data pin. Amplitude: IOVCC-IOGND	IOGND or IOVCC
SDO	I	MPU	Serial data output (SDO) pin in serial interface operation. The data is outputted on the falling edge of the SCL signal. Amplitude: IOVCC-IOGND	Open
DB0-DB17	I/O	MPU	18-bit parallel bi-directional data bus for 80-system interface operation. Amplitude: IOVCC-IOGND. 8-bit I/F: DB17-DB10 are used. 9-bit I/F: DB17-DB9 are used. 16-bit I/F: DB17-DB10 and DB8-DB1 are used. 18-bit I/F: DB17-DB0 are used. 18-bit parallel bi-directional data bus for RGB interface operation. Amplitude: IOVCC-IOGND. 6-bit I/F: DB17-DB12 are used. 16-bit I/F: DB17-DB13 and DB11-DB1 are used. 18-bit I/F: DB17-DB0 are used. Unused pins must be fixed to IOGND level.	IOGND or IOVCC
ENABLE	I	MPU	Data enable signal for RGB interface operation. Amplitude: IOVCC-IOGND. Low: accessible (select) High: Not accessible (Not select) The polarity of ENABLE signal can be inverted by setting the EPL bit.	IOGND or IOVCC
VSYNC	I	MPU	Frame synchronous signal for RGB interface operation.. Amplitude: IOVCC-IOGND. VSPL = "0": Active low. VSPL = "1": Active high.	IOGND or IOVCC
HSYNC	I	MPU	Line synchronous signal for RGB interface operation. Amplitude: IOVCC-IOGND. HSPL = "0": Active low. HSPL = "1": Active high.	IOGND or IOVCC
DOTCLK	I	MPU	Dot clock signal for RGB interface operation. The data input timing is on the rising edge of DOTCLK. Amplitude: IOVCC-IOGND. DPL = "0": Input data on the rising edge of DOTCLK	IOGND or IOVCC

			DPL = "1": Input data on the falling edge of DOTCLK	
FMARK	I	MPU	Frame head pulse signal, which is used when writing data to the internal RAM. (Amplitude: IOVCC-IOGND).	Open

Table 3 Reset, RC oscillation

Signal	I/O	Connect to	Function	When not in use
nRESET	I	MPU	Reset signal. Initializes the RM68050 when it is low. Make sure to execute a power-on reset when turning on power supply. Amplitude: IOVCC-IOGND.	IOGND or IOVCC

Table 4 Power supply

Signal	I/O	Connect to	Function	When not in use
GND	I	Power supply	GND for the analog side: GND = 0V.	-
VDDD	O	Stabilizing Capacitor	Internal logic regulator output, which is used as the power supply to internal logic. Connect a stabilizing capacitor.	-
IOVCC	I	Power supply	Power supply to the interface pins: IM[3:0], nRESET, nCS, WR, nRD, RS, DB17-0, VSYNC, HSYNC, DOTCLK, ENABLE, SCL, SDI, and SDO. IOVCC = 1.65V ~ 3.3V. VCC ≥ IOVCC. In case of COG, connect to VCC on the FPC if IOVCC=VCC, to prevent noise.	-

Table 5 Step-up circuit

Signal	I/O	Connect to	Function	When not in use
VCI	I	Power supply	Power supply to the liquid crystal power supply analog circuit. Connect to an external power supply of 2.5V ~ 3.3V.	-
VCI1	O	Stabilizing Capacitor	An internal reference voltage for the step-up circuit1. The amplitude between VCI and DGND is determined by the VC[2:0] bits. Make sure to set the VCI1 voltage so that the DDVDH, VGH and VGL voltages are set within the respective specification.	-
DDVDH	O	Stabilizing Capacitor	Power supply for the source driver liquid crystal drive unit and VCOM drive. DDVDH = 4.5V ~ 6.0V	-
VGH	O	Stabilizing Capacitor	Liquid crystal gate driver power supply.	-
VGL	O	Stabilizing Capacitor	Liquid crystal gate driver power supply.	-
VCL	O	Stabilizing Capacitor	VCOML drive power supply. Make sure to connect to stabilizing capacitor. VCL = 0.5V ~ -VCI	-
C11+, C11- C12+, C12-	I O	Step-up capacitor	Capacitor connection pins for the step-up circuit 1.	-
C13+, C13- C21+, C21- C22+, C22-	I O	Step-up capacitor	Capacitor connection pins for the step-up circuit 2.	-
VREG1 OUT	O	Stabilizing Capacitor	Output voltage generated from the reference voltage. The voltage level is set with the VRH bits. VREG1OUT is (1) a source driver grayscale reference voltage, (2)VcomH level reference voltage, and (3) Vcom amplitude reference voltage. Connect to a stabilizing capacitor. VREG1OUT = 3.0 ~ (DDVDH – 0.5)V.	Open

Table 6 LCD drive

Signal	I/O	Connect to	Function	When not in use
VCOM	O	TFT panel common electrode	Power supply to TFT panel's common electrode. VCOM alternates between VCOMH and VCOML. The alternating cycle is set by internal register.	Open
VCOMH	O	Stabilizing Capacitor	The High level of VCOM amplitude. Connect to a stabilizing capacitor.	Open
VCOML	O	Stabilizing Capacitor	The Low level of VCOM amplitude. Adjust the VCOML level with the VDV bits. Make sure to connect to stabilizing capacitor.	Open
VGS	I	GND or external resistor	Reference level for the grayscale voltage generating circuit. The VGS level can be changed by connecting to an external resistor.	-
S1~S720	O	LCD	Liquid crystal application voltages. To change the shift direction of segment signal output, set the SS bit as follows. When SS = 0, the data in the RAM address h00000 is outputted from S1. When SS = 1, the data in the RAM address h00000 is outputted from S720.	Open
G1~G320	O	LCD	Gate line output signals. VGH: gate line select level VGL: gate line non-select level	Open

Table 7 Brightness control

Signal	I/O	Connect to	Function	When not in use
LEDPWM	O	VCI	PWM signal output to control LED driver for LED brightness dimming	Open
LEDON	O	VCI	LED driver control pin to turn on/off the LED backlight	Open

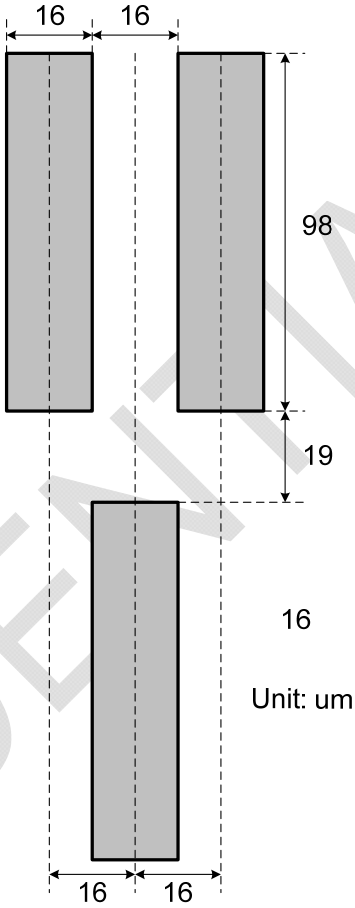
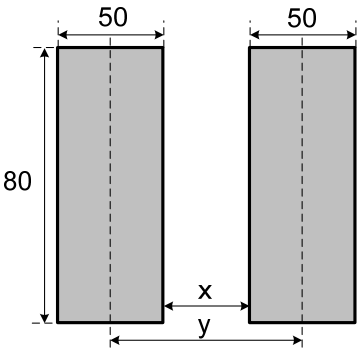
Table 8 Others (test, dummy pins)

Signal	I/O	Connect to	Function	When not in use
DUMMY1-15 DUMMY20-27	-	-	Dummy pad. Leave these pins as open.	-
I0GND DDUM	O	GND	GND pin.	-

TEST03-16	O	Open	Test pins. Leave them open.	Open
TEST1, 2, 3	I	Open	Test pins (internal pull low). Connect to GND or leave these pins as open.	I0GND
TS8-0	I	Open	Test pins (internal pull low). Leave them open.	Open

CONFIDENTIAL

6. Bump Arrangement

Pad	Arrangement
S1 ~ S720 G1 ~ G320 DUMMY20 ~ 27 (No. 244 ~ 1291)	 Unit: um
I/O Pads (No. 1 ~ 243)	x=20,30,35 y=70,80,85  Unit: um

7. Function Description

7.1 System Interface

The RM68050 supports 80-system high-speed interface via 8-, 9-, 16-, 18-bit parallel ports and a clock synchronous serial interface. The interface is selected by setting the IM3-0 pins.

The RM68050 has a 16-bit index register (IR), an 18-bit write-data register (WDR), and an 18-bit read-data register (RDR). The IR is the register to store index information about control register and internal GRAM. The WDR is the register to temporarily store data to be written to control register and internal GRAM. The RDR is the register to temporarily store the data read from the GRAM. The data from the MPU to be written to the internal GRAM is first written to the WDR and then automatically written to the internal GRAM in internal operation. The data is read via RDR from the internal GRAM. Therefore, invalid data is sent to the data bus when the RM68030 performs the first read operation from the internal GRAM. Valid data is read out when the RM68030 performs the second and subsequent read operation.

The instruction execution time except that of starting oscillation takes 0 clock cycle to allow writing instructions consecutively.

Table 9 Register Selection (80-system 8/9/16/18-bit Parallel Interface)

nWR	nRD	RS	Function
0	1	0	Write index to IR
1	0	0	Setting disabled
0	1	1	Write to control register or internal GRAM via WDR
1	0	1	Read from internal GRAM and register via RDR

Table 10 Register Selection (Clock synchronous serial interface)

Start byte		
R/W	RS	Function
0	0	Write index to IR
1	0	Setting disabled
0	1	Write to control register or internal GRAM via WDR
1	1	Read from internal GRAM and register via RDR

Table 11 IM Bit Settings and System Interface

IM3	IM2	IM1	IM0	System interface	DB pins	RAM write data	Instruction write transfer
0	0	0	0	Setting disabled	-	-	-
0	0	0	1	Setting disabled	-	-	-
0	0	1	0	80-system 16-bit interface	DB17-10, DB8-1	Single transfer (16 bits) 2 transfers (1st: 2 bits, 2nd: 16 bits) 2 transfers (1st: 16 bits, 2nd: 2 bits)	Single transfer (16 bits)
0	0	1	1	80-system 8-bit interface	DB17-10	2 transfers (1st: 8 bits, 2nd: 8 bits) 3 transfers (1st: 6 bits, 2nd: 6 bits, 3rd: 6 bits)	2 transfers (1st: 8 bits, 2nd: 8 bits)
0	1	0	*	Clock synchronous serial interface	(SDI, SDO)	2 transfers (1st: 8 bits, 2nd: 8 bits)	2 transfers (1st: 8 bits, 2nd: 8 bits)
0	1	1	0	9-bit 3-wire SPI	SDA, SCL, nCS	2 transfers (1st: 8 bits, 2nd: 8 bits) 3 transfers (1st: 6 bits, 2nd: 6 bits, 3rd: 6 bits)	Single transfer (8 bits)
0	1	1	1	8-bit 4-wire SPI	SDA, SCL, nCS, RS(D/CX)	2 transfers (1st: 8 bits, 2nd: 8 bits) 3 transfers (1st: 6 bits, 2nd: 6 bits, 3rd: 6 bits)	Single transfer (8 bits)
1	0	0	0	Setting disabled	-	-	-
1	0	0	1	Setting disabled	-	-	-
1	0	1	0	80-system 18-bit interface	DB17-0	Single transfer (18 bits)	Single transfer (16 bits)
1	0	1	1	80-system 9-bit interface	DB17-9	2 transfers (1st: 9 bits, 2nd: 9 bits)	2 transfers (1st: 8 bits, 2nd: 8 bits)
1	1	*	*	Setting disabled	-	-	-

7.2 External Display Interface (RGB, VSYNC interfaces)

The RM68050 supports RGB interface and VSYNC interface as the external interface to display moving picture. When the RGB interface is selected, the display operation is synchronized with externally supplied signals, VSYNC, HSYNC, and DOTCLK. In RGB interface operation, data (DB17-0) is written in synchronization with these signals when the polarity of enable signal (ENABLE) allows write operation in order to prevent flicker while updating display data.

In VSYNC interface operation, the display operation is synchronized with the internal clock except frame synchronization, which synchronizes the display operation with the VSYNC signal. The display data is written to the internal GRAM via system interface. When writing data via VSYNC interface, there are constraints in speed and method in writing data to the internal RAM. For details, see the "External Display interface" section.

The RM68050 allows switching interface by instruction according to the still and/or moving pictures display required. Via the RGB interface, the RM68050 writes all display data to the internal GRAM in order to transfer data only when updating the data and thereby reduce the data transfer and power consumption for moving picture display.

7.3 Address Counter (AC)

The address counter (AC) gives an address to the internal GRAM. When the index of the register to set a RAM address in the AC is written to the IR, the address information is sent from the IR to the AC. As the RM68050 writes data to the internal GRAM, the address in the AC is automatically increased or decreased one step. The window address function enables writing data only within the rectangular area specified in the GRAM.

7.4 Graphics RAM (GRAM)

GRAM is graphics RAM, which can store bit-pattern data of 172,800 (240RGB x 320 x18/8) bytes with 18 bits per pixel.

7.5 Grayscale Voltage Generating Circuit

The grayscale voltage generating circuit generates liquid crystal driving voltages according to the grayscale data in the γ -correction registers to enable 262k-color display. For details, see the γ -Correction Register section.

7.6 Timing Generator

The timing generator produces timing signals for the operations of internal circuits such as the internal GRAM, source driver, etc. The timing signals for display operations such as RAM read operation and the timing signals for internal operations such as RAM access from the MPU are generated separately in order to avoid mutual interference.

7.7 Oscillator (OSC)

The RM68050 generates the RC oscillation clock by internal RC oscillator circuit. The frame rate is adjusted by the register setting.

7.8 Liquid Crystal Driver Circuit

The liquid crystal driver circuit of the RM68050 consists of a 720-output source driver (S1 ~ S720) and a 320-output gate driver (G1~G320). The display pattern data is latched when 720 bits of data are inputted. The latched data control the source driver and output drive waveforms. The gate driver for scanning gate lines outputs either VGH or VGL level. The shift direction of 720-bit source output from the source driver can be changed by setting the SS bit and the shift direction of gate output from the gate driver can be changed by setting the GS bit. The scan mode by the gate driver can be changed by setting the SM bit. Sets the gate driver pin arrangement in combination with the GS bit to select the optimal scan mode for each LCD module.

7.9 Internal Logic Power Supply Regulator

The internal logic power supply regulator generates internal logic power supply VDD.

8. GRAM Address Map

Table 12 GRAM address and display position on the panel (SS = 0, BGR = 0)

GS=0		S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	.....	S709	S710	S711	S712	S713	S714	S715	S716	S717	S718	S719	S720
GS=0	GS=1	WD[17:0]			WD[17:0]			WD[17:0]			WD[17:0]			.....	WD[17:0]			WD[17:0]			WD[17:0]			WD[17:0]		
G1	G320	h00000			h00001			h00002			h00003			.....	h000EC			h000ED			h000EE			h000EF		
G2	G319	h00100			h00101			h00102			h00103			.....	h001EC			h001ED			h001EE			h001EF		
G3	G318	h00200			h00201			h00202			h00203			.....	h002EC			h002ED			h002EE			h002EF		
G4	G317	H00300			h00301			h00302			h00303			.....	h003EC			h003ED			h003EE			h003EF		
G5	G316	h00400			h00401			h00402			h00403			.....	h004EC			h004ED			h004EE			h004EF		
G6	G315	h00500			h00501			h00502			h00503			.....	h005EC			h005ED			h005EE			h005EF		
G7	G314	h00600			h00601			h00602			h00603			.....	h006EC			h006ED			h006EE			h006EF		
G8	G313	h00700			h00701			h00702			h00703			.....	h007EC			h007ED			h007EE			h007EF		
G9	G312	h00800			h00801			h00802			h00803			.....	h008EC			h008ED			h008EE			h008EF		
G10	G311	h00900			h00901			h00902			h00903			.....	h009EC			h009ED			h009EE			h009EF		
G11	G310	h00A00			h00A01			h00A02			h00A03			.....	h00AEC			h00AED			h00AEE			h00AEF		
G12	G309	h00B00			h00B01			h00B02			h00B03			.....	h00BEC			h00BED			h00BEE			h00BEF		
G13	G308	h00C00			h00C01			h00C02			h00C03			.....	h00CEC			h00CED			h00CEE			h00CEF		
G14	G307	h00D00			h00D01			h00D02			h00D03			.....	h00DEC			h00DED			h00DEE			h00DEF		
G15	G306	h00E00			h00E01			h00E02			h00E03			.....	h00EEC			h00EED			h00EEE			h00EEF		
G16	G305	h00F00			h00F01			h00F02			h00F03			.....	h00FEC			h00FED			h00FEE			h00FEF		
G17	G304	h01000			h01001			h01002			h01003			.....	h010EC			h010ED			h010EE			h010EF		
G18	G303	h01100			h01101			h01102			h01103			.....	h011EC			h011ED			h011EE			h011EF		
G19	G302	h01200			h01201			h01202			h01203			.....	h012EC			h012ED			h012EE			h012EF		
G20	G301	h01300			h01301			h01302			h01303			.....	h013EC			h013ED			h013EE			h013EF		
⋮	⋮	⋮			⋮			⋮			⋮			⋮	⋮			⋮			⋮			⋮		
G305	G16	h13000			h13001			h13002			h13003			.....	h130EC			h130ED			h130EE			h130EF		
G306	G15	h13100			h13101			h13102			h13103			.....	h131EC			h131ED			h131EE			h131EF		
G307	G14	h13200			h13201			h13202			h13203			.....	h132EC			h132ED			h132EE			h132EF		
G308	G13	h13300			h13301			h13302			h13303			.....	h133EC			h133ED			h133EE			h133EF		
G309	G12	h13400			h13401			h13402			h13403			.....	h134EC			h134ED			h134EE			h134EF		
G310	G11	h13500			h13501			h13502			h13503			.....	h135EC			h135ED			h135EE			h135EF		
G311	G10	h13600			h13601			h13602			h13603			.....	h136EC			h136ED			h136EE			h136EF		
G312	G9	h13700			h13701			h13702			h13703			.....	h137EC			h137ED			h137EE			h137EF		
G313	G8	h13800			h13801			h13802			h13803			.....	h138EC			h138ED			h138EE			h138EF		
G314	G7	h13900			h13901			h13902			h13903			.....	h139EC			h139ED			h139EE			h139EF		
G315	G6	h13A00			h13A01			h13A02			h13A03			.....	h13AEC			h13AED			h13AEE			h13AEF		
G316	G5	h13B00			h13B01			h13B02			h13B03			.....	h13BEC			h13BED			h13BEE			h13BEF		
G317	G4	h13C00			h13C01			h13C02			h13C03			.....	h13CEC			h13CED			h13CEE			h13CEF		
G318	G3	h13D00			h13D01			h13D02			h13D03			.....	h13DEC			h13DED			h13DEE			h13DEF		
G319	G2	h13E00			h13E01			h13E02			h13E03			.....	h13EEC			h13EED			h13EEE			h13EEF		
G320	G1	h13F00			h13F01			h13F02			h13F03			.....	h13FEC			h13FED			h13FEE			h13FEF		

Table 13 GRAM address and display position on the panel (SS = 1, BGR = 1)

GS=0		S720	S719	S718	S717	S716	S715	S714	S713	S712	S711	S710	S709	.....	S12	S11	S10	S9	S8	S7	S6	S5	S4	S3	S2	S1
GS=0	GS=1	WD[17:0]			WD[17:0]			WD[17:0]			WD[17:0]			.....	WD[17:0]			WD[17:0]			WD[17:0]			WD[17:0]		
G1	G320	h00000			h00001			h00002			h00003			.....	h000EC			h000ED			h000EE			h000EF		
G2	G319	h00100			h00101			h00102			h00103			.....	h001EC			h001ED			h001EE			h001EF		
G3	G318	h00200			h00201			h00202			h00203			.....	h002EC			h002ED			h002EE			h002EF		
G4	G317	h00300			h00301			h00302			h00303			.....	h003EC			h003ED			h003EE			h003EF		
G5	G316	h00400			h00401			h00402			h00403			.....	h004EC			h004ED			h004EE			h004EF		
G6	G315	h00500			h00501			h00502			h00503			.....	h005EC			h005ED			h005EE			h005EF		
G7	G314	h00600			h00601			h00602			h00603			.....	h006EC			h006ED			h006EE			h006EF		
G8	G313	h00700			h00701			h00702			h00703			.....	h007EC			h007ED			h007EE			h007EF		
G9	G312	h00800			h00801			h00802			h00803			.....	h008EC			h008ED			h008EE			h008EF		
G10	G311	h00900			h00901			h00902			h00903			.....	h009EC			h009ED			h009EE			h009EF		
G11	G310	h00A00			h00A01			h00A02			h00A03			.....	h00AEC			h00AED			h00AEE			h00AEF		
G12	G309	h00B00			h00B01			h00B02			h00B03			.....	h00BEC			h00BED			h00BEE			h00BEF		
G13	G308	h00C00			h00C01			h00C02			h00C03			.....	h00CEC			h00CED			h00CEE			h00CEF		
G14	G307	h00D00			h00D01			h00D02			h00D03			.....	h00DEC			h00DED			h00DEE			h00DEF		
G15	G306	h00E00			h00E01			h00E02			h00E03			.....	h00EEC			h00EED			h00EEE			h00EEF		
G16	G305	h00F00			h00F01			h00F02			h00F03			.....	h00FEC			h00FED			h00FEE			h00FEF		
G17	G304	h01000			h01001			h01002			h01003			.....	h010EC			h010ED			h010EE			h010EF		
G18	G303	h01100			h01101			h01102			h01103			.....	h011EC			h011ED			h011EE			h011EF		
G19	G302	h01200			h01201			h01202			h01203			.....	h012EC			h012ED			h012EE			h012EF		
G20	G301	h01300			h01301			h01302			h01303			.....	h013EC			h013ED			h013EE			h013EF		
⋮	⋮	⋮			⋮			⋮			⋮			⋮	⋮			⋮			⋮			⋮		
G305	G16	h13000			h13001			h13002			h13003			.....	h130EC			h130ED			h130EE			h130EF		
G306	G15	h13100			h13101			h13102			h13103			.....	h131EC			h131ED			h131EE			h131EF		
G307	G14	h13200			h13201			h13202			h13203			.....	h132EC			h132ED			h132EE			h132EF		
G308	G13	h13300			h13301			h13302			h13303			.....	h133EC			h133ED			h133EE			h133EF		
G309	G12	h13400			h13401			h13402			h13403			.....	h134EC			h134ED			h134EE			h134EF		
G310	G11	h13500			h13501			h13502			h13503			.....	h135EC			h135ED			h135EE			h135EF		
G311	G10	h13600			h13601			h13602			h13603			.....	h136EC			h136ED			h136EE			h136EF		
G312	G9	h13700			h13701			h13702			h13703			.....	h137EC			h137ED			h137EE			h137EF		
G313	G8	h13800			h13801			h13802			h13803			.....	h138EC			h138ED			h138EE			h138EF		
G314	G7	h13900			h13901			h13902			h13903			.....	h139EC			h139ED			h139EE			h139EF		
G315	G6	h13A00			h13A01			h13A02			h13A03			.....	h13AEC			h13AED			h13AEE			h13AEF		
G316	G5	h13B00			h13B01			h13B02			h13B03			.....	h13BEC			h13BED			h13BEE			h13BEF		
G317	G4	h13C00			h13C01			h13C02			h13C03			.....	h13CEC			h13CED			h13CEE			h13CEF		
G318	G3	h13D00			h13D01			h13D02			h13D03			.....	h13DEC			h13DED			h13DEE			h13DEF		
G319	G2	h13E00			h13E01			h13E02			h13E03			.....	h13EEC			h13EED			h13EEE			h13EEF		
G320	G1	h13F00			h13F01			h13F02			h13F03			.....	h13FEC			h13FED			h13FEE			h13FEF		

9. Instruction

9.1 Outline

The RM68050 adopts 18-bit bus architecture in order to interface to high-performance microcomputer in high speed. All the functional blocks of RM68050 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 (nRD/nWR) and data bus D17-0 are used to read/write the instructions and data of RM68050. When accessing the RM68050's internal RAM, data is processed in units of 18 bits. The following are the categories of instruction in RM68050.

1. Specify the index of register
2. Display control
3. Power management control
4. Set internal GRAM address
5. Transfer data to and from the internal GRAM
6. γ -correction
7. Window address control
8. Panel display control
9. CABC control

The internal GRAM address is updated automatically as data is written to the internal GRAM, which, in combination with the window address function, contributes to minimizing data transfer and thereby lessens the loading on the microcomputer. The RM68050 writes instructions consecutively by executing the instruction within the cycle when it is written, meanwhile, there is no instruction execution time required.

9.2 Instruction Data Format

The data bus used to transfer 16 instruction bits (IB[15:0]) is different according to the interface format. Make sure to transfer the instruction bits according to the format of the selected interface. For more details, please refer to section of "System Interface".

The following are detail descriptions of instruction bits (IB15-0). Note that the instruction bits IB[15:0] in the following figures are transferred according to the format of the selected interface.

9.3 Index (IR)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	0	*	*	*	*	*	*	*	*	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0

The index register specifies the index R00h to RFFh of the control register or RAM control to be accessed using a binary number from “0000_0000” to “1111_1111”. The access to the register and instruction bits in it is prohibited unless the index is specified in the index register.

9.4 ID code (R00h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
RO	1	1	0	0	1	0	0	1	1	0	0	1	0	0	1	0	1

9.5 Display control

9.5.1 Driver Output Control (R01h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	SM	0	SS	0	0	0	0	0	0	0	0
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SS: Sets the shift direction of output from the source driver.

When SS = “0”, the source driver output shift from S1 to S720.

When SS = “1”, the source driver output shift from S720 to S1.

The combination of SS and BGR settings determines the RGB assignment to the source driver pins S1 ~ S720.

When SS = “0” and BGR = “0”, RGB dots are assigned one to one from S1 to S720.

When SS = “1” and BGR = “1”, RGB dots are assigned one to one from S720 to S1.

When changing the SS bit, RAM data must be rewritten.

SM: Controls the scan mode in combination with GS setting. See “Scan mode setting”.

9.5.2 LCD Driving Wave Control (R02h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	B/C	0	0	0	0	0	0	0	0	0
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

BC0: Selects the liquid crystal drive waveform VCOM..

BC0 = 0: frame inversion waveform is selected.

BC0 = 1: line inversion waveform is selected.

9.5.3 Entry Mode (R03h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	TRI	DFM	0	BGR	0	0	0	0	ORG	0	I/D1	I/D0	AM	0	0	0
Default		0	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0

AM: Sets either horizontal or vertical direction in updating the address counter automatically as the RM68050 writes data to the internal GRAM.

AM = "0", sets the horizontal direction.

AM = "1", sets the vertical direction.

When making a window address area, the data is written only within the area in the direction determined by I/D[1:0] and AM.

I/D[1:0]: Either increments or decrements the address counter automatically as the data is written to the GRAM. The I/D[0] bit sets either increment or decrement in horizontal direction (updates the address AD[7:0]). The I/D[1] bit sets either increment or decrement in vertical direction (updates the address AD[8:16]).

ORG: Moves the origin address according to the ID setting when a window address area is made. This function is enabled when writing data within the window address area using high-speed RAM write function. Also see Figure 3 and Figure 4.

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

ORG = 1: The origin address "h00000" is moved according to the I/D[1:0] setting.

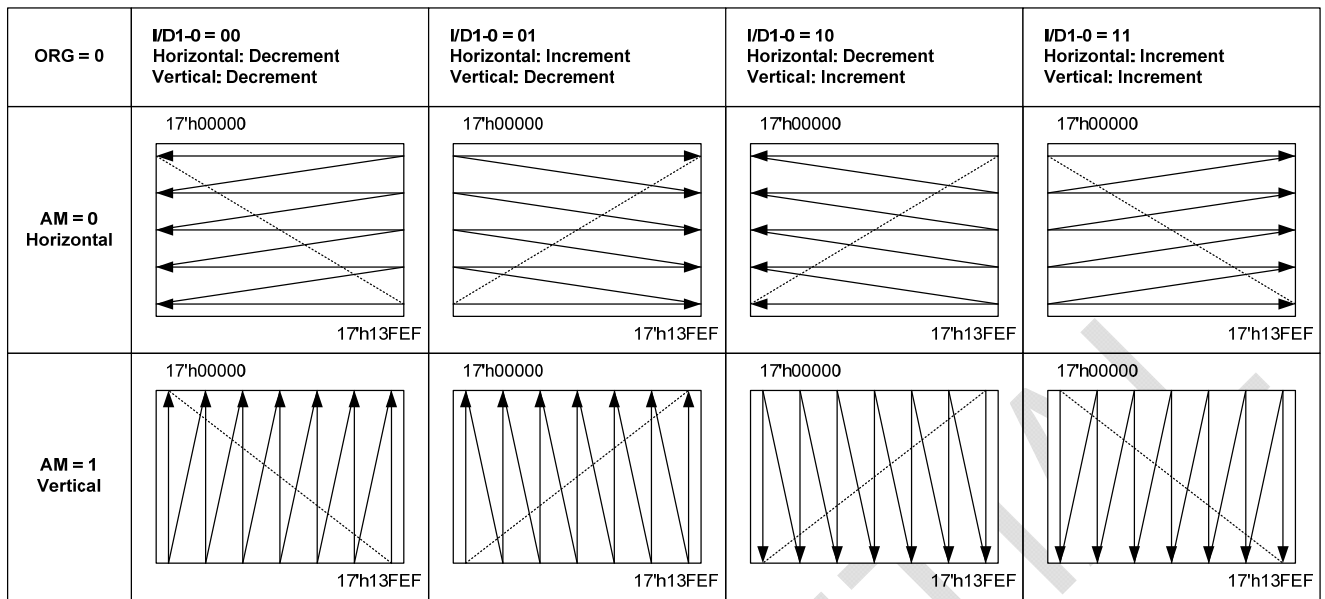


Figure 1 Automatic address update (ORG = 0, AM, ID)

Note: When writing data within the window address area with ORG = 0, any address within the window address area can be designated as the starting point of RAM write operation.

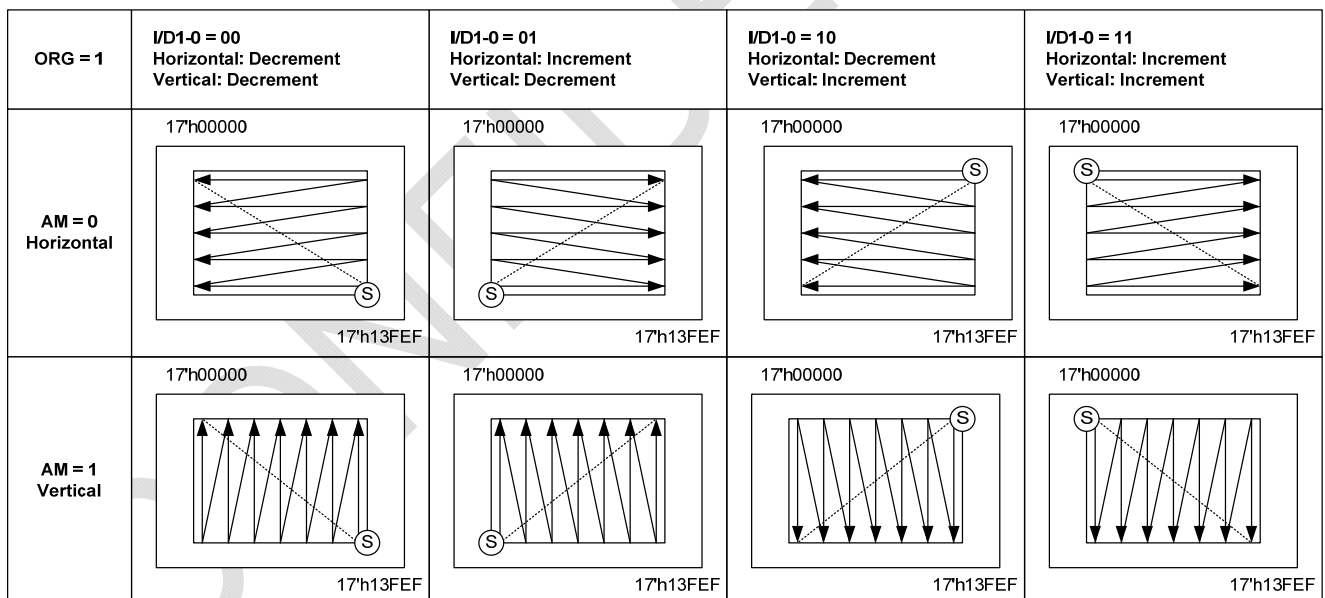


Figure 2 Automatic address update (ORG = 1, AM, ID)

Note: 1. When ORG = 1, make sure to set the address "h00000" in the RAM address set registers (R210h, R21h). Setting other addresses is inhibited. 2. When ORG = 1, the starting point of writing data within the window address area can be set at either corner of the window address area ("S" in circle in the above figure).

BGR: Reverse the order from RGB to BGR in writing 18-bit pixel data in the GRAM.

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

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

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

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

DFM: In combination with the TRI setting, sets the format to develop 16-/8-bit data to 18-bit data when using either 16-bit or 8-bit bus interface.

TRI: Selects the format to transfer data bits via 16-bit or 8-bit interface.

In 16-bit bus interface operation,

TRI = 0: 16-bit RAM data is transferred in one transfer.

TRI = 1: 18-bit RAM data is transferred in two transfers.

In 8-bit interface operation,

TRI = 0: 16-bit RAM data is transferred in two transfers.

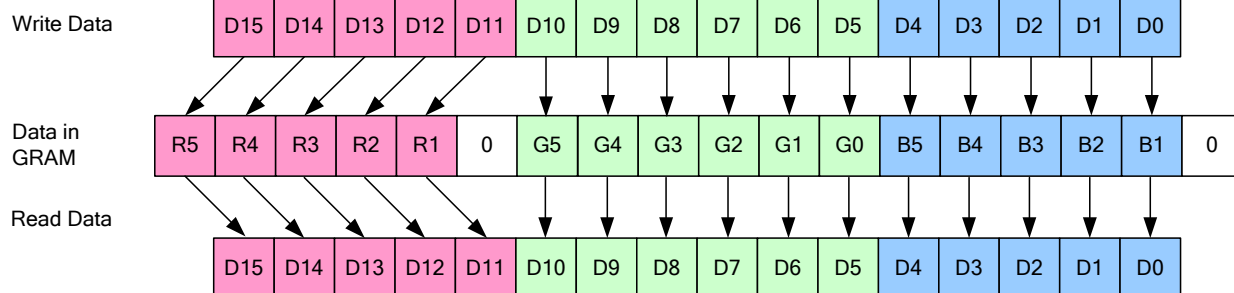
TRI = 1: 18-bit RAM data is transferred in three transfers.

9.5.4 16bits Data Format Selection (R05h)

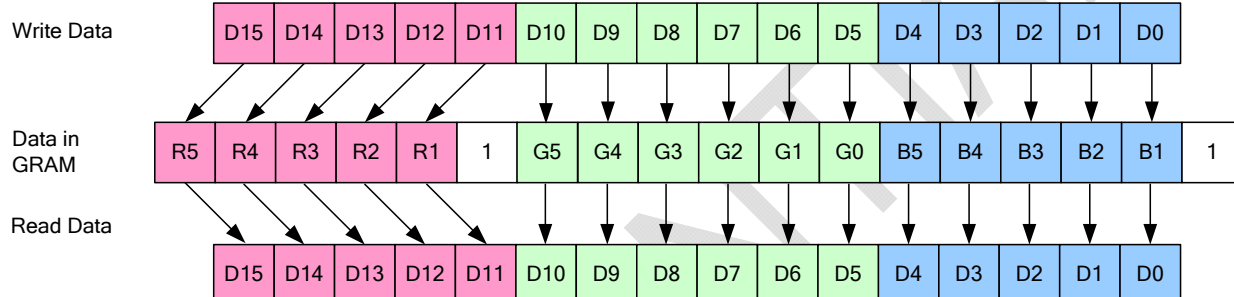
R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FPF1	FPF0
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0

FPF[1:0]: The extension method for transforming 16bits data format to 18bits data format.

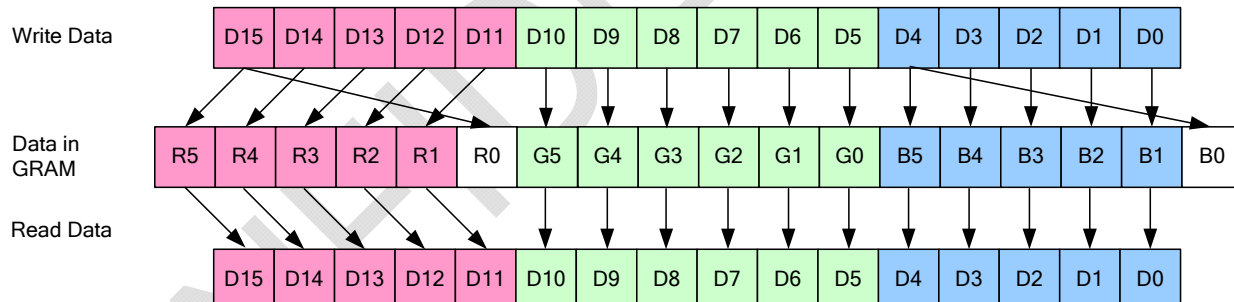
FPF[1:0]=00



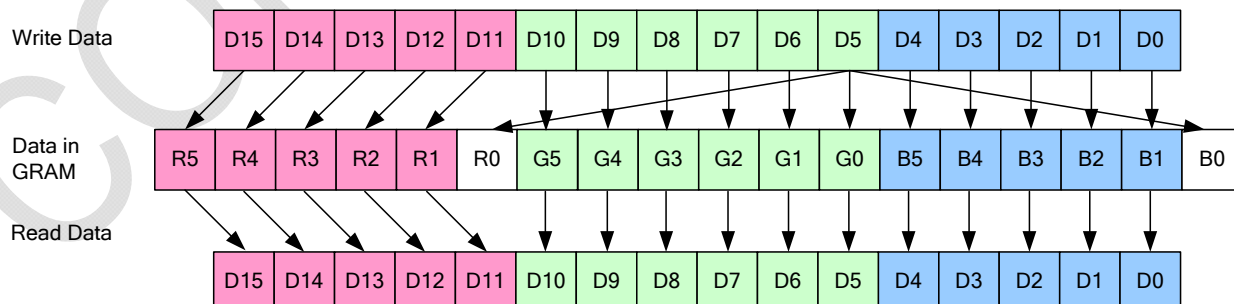
FPF[1:0]=01



FPF[1:0]=10



FPF[1:0]=11



9.5.5 Display Control 1 (R07h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	PTDE1	PTDE0	0	0	0	BASEE	0	0	GON	DTE	CL	0	D1	D0
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

D[1:0]: A graphics display is turned on 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 GRAM and the RM68050 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 D1-0 = 2'b01, the RM68050 continues internal display operation. When the display is turned off by setting D1-0 = 2'b00, the RM68050's internal display operation is halted completely. In combination with the GON, DTE setting, the D[1:0] setting controls display ON/OFF.

D[1:0]	BASEE	Source, VCOM Output	Internal Operation
2'h0	*	GND	Halt
2'h1	*	GND	Operation
2'h2	*	Non-lit display	Operation
2'h3	0	Non-lit display	Operation
	1	Base-image display	Operation

Note:

1. The data write operation from the microcomputer is independent on the D[1:0] setting.
2. The D[1:0] setting is valid on both 1st and 2nd displays
3. The non-lit display level from the source output pins is determined by instruction (PTS).

CL: When CL = 1, the RM68050 displays in 8-colors with low power consumption.

CL	Display color
0	262,144
1	8

GON, DTE: The combination of GON and DTE settings set the output level form gate lines (G1 ~ G320).

GON	DTE	G1~G320 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 RM68050 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.

The D[1:0] setting has precedence over the BASEE setting.

PTDE[1:0]: PTDE[0] is the display enable bit of partial image 1. PTDE[1] is the display enable bit of partial image 2. When PTDE1/0 = 0, the partial image is turned off and only base image is displayed on the screen.

When PTDE1/0 = 1, the partial image is displayed on the screen. In this case, turn off the base image by setting BASEE = 0.

9.5.6 Display Control 2 (R08h)

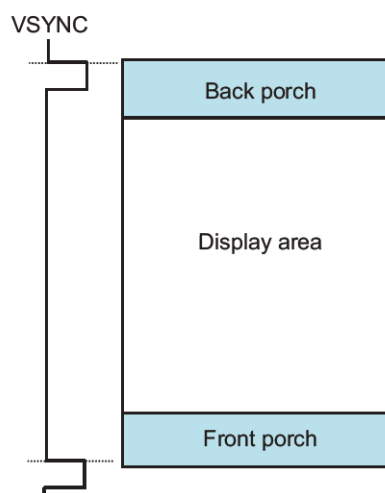
R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	FP3	FP2	FP1	FP0	0	0	0	0	BP3	BP2	BP1	BP0
Default		0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0

FP [3:0] / BP [3:0]: Sets the number of lines for a front porch period / back porch period (a blank period following the end of display / (a blank period made before the beginning of display).

In external display interface operation, a back porch (BP) period starts on the falling edge of the VSYNC 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 VSYNC input is detected.

Internal clock operation mode	BP ≥ 2 lines	FP ≥ 2 lines	FP + BP ≤ 16 lines
RGB interface operation	BP ≥ 2 lines	FP ≥ 2 lines	FP + BP ≤ 16 lines
VSYNC interface operation	BP ≥ 2 lines	FP ≥ 2 lines	FP + BP = 16 lines

FP[3:0] BP[3:0]	Front and Back Porch period (Line periods)
4'h0	Setting disabled
4'h1	Setting disabled
4'h2	2 lines
4'h3	3 lines
4'h4	4 lines
4'h5	5 lines
4'h6	6 lines
4'h7	7 lines
4'h8	8 lines
4'h9	9 lines
4'hA	10 lines
4'hB	11 lines
4'hC	12 lines
4'hD	13 lines
4'hE	14 lines
4'hF	Setting disabled



Note : The output timing to the LCD panel is delayed by two line periods from the synchronous signal (VSYNC) input timing.

9.5.7 Display Control 3 (R09h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	PTS1	PTS0	0	0	PTG1	PTG0	ISC3	ISC 2	ISC 1	ISC 0
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

ISC [3:0]: Set the scan cycle when setting PTG[1:0]="10" to selects interval scan. The scan cycle is defined by from 0 to 31 as table below. The polarity is inverted in the same timing every interval scan cycle.

ISC[3:0]	Scan cycle	Time for interval when (f_{FLM}) = 60Hz
4'h1	0 frames	-
4'h2	0 frames	-
4'h3	3 frames	50 ms
4'h4	5 frames	84 ms
4'h5	7 frames	117 ms
4'h6	9 frames	150 ms
4'h7	11 frames	184 ms
4'h8	13 frames	217 ms
4'h9	15 frames	251 ms
4'hA	19 frames	317 ms
4'hB	21 frames	351 ms
4'hC	23 frames	384 ms
4'hD	25 frames	418 ms
4'hE	27 frames	451 ms
4'hF	29 frames	484 ms

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.

PTG1	PTG0	Gate in non-display area	Source in non-display area	VCOM output
0	0	Normal scan	PTS[2:0] setting	VCOMH/VCOML
0	1	Setting disabled	-	-
1	0	Interval scan	PTS[2:0] setting	VCOMH/VCOML
1	1	Setting disabled	-	-

PTS[2:0]: Sets the source output level in non-display area drive period. When PTS[2] = 1, the operation of amplifiers which generates the grayscales other than V0 and V63 are halted and the step-up clock frequency becomes half the normal frequency in order to reduce power consumption.

PTS[1:0]	Source / VCOM output in non-display area	
	Frame with gate scan	Frame without gate scan
2'h0	White	V63 / VCOML
2'h1	Black	V0 / VCOML
2'h2	White	GND / GND
2'h3	White	Hi-Z / Hi-Z

9.5.8 Display Control 4 (R0Ah)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	0	0	0	0	FMARKOE	FMI2	FMI1	FMI0
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

FMI[2:0]: Sets the output interval of FMARK signal according to the display data rewrite cycle and data transfer rate.

FMARKOE: When FMARKOE = 1, the RM68050 starts outputting FMARK signal from the FMARK pin in the output interval set by FMI[2:0] bits.

FMI[2]	FMI[1]	FMI[0]	FMARK output interval
0	0	0	1 frame
0	0	1	2 frames
0	1	1	4 frames
1	0	1	6 frames
Other settings			Setting disabled

9.5.9 External Display Interface Control 1 (R0Ch)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	ENC2	ENC1	ENC0	0	0	0	RM	0	0	DM1	DM0	0	0	RIM1	RIM 0
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

RIM[1:0]: Sets the interface format in RGB interface.

RIM[1:0]	RGB interface operation	Display color
2'h0	18-bit RGB interface (1 transfer/pixel) via DB17-0	262,144
2'h1	16-bit RGB interface (1 transfer/pixel) via DB17-13 and DB 11-1	65,536
2'h2	6-bit RGB interface (3 transfers/pixel) via DB17-12	262,144
2'h3	Setting disabled	-

Note:

1. Instruction bits are set via system interface.
2. Transfer the RGB dot data one by one in synchronization with DOTCLK in 6-bit RGB interface operation.

DM[1:0]: Selects the interface for the display operation. 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.

DM[1:0]	Display Interface
2'h0	Internal clock operations
2'h1	RGB interface
2'h2	VSYNC interface
2'h3	Setting disabled

RM: Selects the interface for RAM access operation. RAM access is possible only via the interface selected by the RM bit. Set RM = 1 when writing display data via RGB interface. When RM = 0, it is possible to write data via system interface while performing display operation via RGB interface.

RM	RAM Access Interface
0	System interface / VSYNC interface
1	RGB interface

ENC[2:0]: Sets the RAM write cycle via RGB interface.

ENC[2:0]	RAM Write Cycle (frame periods)
3'h0	1 frame
3'h1	2 frames
3'h2	3 frames
3'h3	4 frames
3'h4	5 frames
3'h5	6 frames
3'h6	7 frames
3'h7	8 frames

9.5.10 Frame Marker Position (R0Dh)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	FMP8	FMP7	FMP6	FMP5	FMP4	FMP3	FMP2	FMP1	FMP0
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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 outputted at the start of back porch period for 1H period .

Make sure the setting restriction $9'h000 \leq FMP \leq BP+NL+FP$.

FMP[8:0]	FMARK output position
9'h000	0
9'h001	1 st line
9'h002	2 nd line
...	...
9'h175	373 rd line
9'h176	374 th line
9'h177	375 th line

9.5.11 External Display Interface Control 2 (R0Fh)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	0	0	0	VSPL	HSPL	0	EPL	DPL
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DPL: Sets the signal polarity of DOTCLK pin.

DPL = 0: input data on the rising edge of DOTCLK

DPL = 1: input data on the falling edge of DOTCLK

EPL: Sets the signal polarity of ENABLE pin.

EPL = 0: writes data DB17-0 when ENABLE = "0" and disables data write operation when ENABLE = "1".

EPL = 1: writes data DB17-0 when ENABLE = "1" and disables data write operation when ENABLE = "0".

HSPL: Sets the signal polarity of HSYNC pin.

HSPL = 0: low active

HSPL = 1: high active

VSPL: Sets the signal polarity of VSYNC pin.

VSPL = 0: low active

VSPL = 1: high active

9.6 Power Control

9.6.1 Power Control 1 (R10h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	SAP	0	BT2	BT1	BT0	APE	AP2	AP1	AP0	0	0	SLP	STB
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

SLP: When SLP = 1, the RM68050 enters the sleep mode. In sleep mode, the internal display operation except RC oscillation is halted to reduce power consumption. In the sleep mode, the GRAM data and instructions cannot be updated except the following instruction, Exit sleep mode (SLP = "0").

STB: When STB = 1, the RM68050 enters the standby mode and the display operation stops except the GRAM power supply to reduce the power consumption. In the standby mode, the GRAM data and instructions cannot be updated except the following instruction, Exit standby mode (STB = "0").

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] = 3'h0 to halt the operational amplifier circuits and the step-up circuits to reduce current consumption.

AP[2:0]	Gamma driver amplifiers	Source driver amplifiers
3'h0	Halt operation	Halt operation
3'h1	1.00	1.00
3'h2	1.00	0.75
3'h3	1.00	0.50
3'h4	0.75	1.00
3'h5	0.75	0.75
3'h6	0.75	0.50
3'h7	0.50	0.50

APE: Power supply enable bit.

Set APE = "1" to start the generation of power supply according to the power supply startup sequence.

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.

BT[2:0]: Sets the factor used in the step-up circuits. Select the optimal step-up factor for the operating voltage. To reduce power consumption, set a smaller factor.

BT[2:0]	DDVDH	VCL	VGH	VGL
3'h0				-VCI1 x 5
3'h1			VCI1 x 6	-VCI1 x 4
3'h2				-VCI1 x 3
3'h3	VCI1 x 2	-VCI1		-VCI1 x 5
3'h4			VCI1 x 5	-VCI1 x 4
3'h5				-VCI1 x 3
3'h6			VCI1 x 4	-VCI1 x 4
3'h7				-VCI1 x 3

Notes:

1. Connect capacitors where required when using DDVDH, VGH, VGL and VCL voltages.
2. Set the following voltages within the respective ranges:
DDVDH = 6.0V (max.)

9.6.2 Power Control 2 (R11h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	DC12	DC11	DC10	0	DC02	DC01	DC00	0	VC2	VC1	VC0
Default		0	0	0	0	0	1	1	1	0	1	1	1	0	0	0	0

DC0[2:0] / DC1[2:0]: Selects the operating frequency of the step-up circuit 1 / step-up circuit 2. The higher step-up operating frequency enhances the drivability of the step-up circuit and the quality of display but increases the current consumption. Adjust the frequency taking the trade-off between the display quality and the current consumption into account.

DC0[2:0]	Step-up circuit 1: step-up frequency (f_{DCDC1})	DC1[2:0]	Step-up circuit 2: step-up frequency (f_{DCDC2})
3'h0	fbclk	3'h0	fbclk / 4
3'h1	fbclk / 2	3'h1	fbclk / 8
3'h2	fbclk / 4	3'h2	fbclk / 16
3'h3	fbclk / 8	3'h3	fbclk / 32
3'h4	fbclk / 16	3'h4	fbclk / 64
3'h5	fbclk / 32	3'h5	fbclk / 128
3'h6	fbclk / 64	3'h6	fbclk / 256
3'h7	Halt Step-up circuit 1	3'h7	Halt Step-up circuit 2

Note: Make sure the DC0, DC1 setting restriction: $f_{DCDC1} \geq f_{DCDC2}$. "fbclk" is a clock for boost circuit.

9.6.3 Power Control 3 (R12h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	VCIRE	0	0	0	VRH3	VRH2	VRH1	VRH0
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

VCIRE: Select the external reference voltage VCI or internal reference voltage VCIR.

VCIRE = 0 External reference voltage VCI (default)

VCIRE = 1 Internal reference voltage 2.5V

VRH[3:0]: Sets the factor to generate VREG1OUT from VCI.

	VCIRE=0	VCIRE=1
VRH[3:0]	VREG1OUT Voltage	VREG1OUT Voltage
4'h0	Halt	Halt
4'h1	VCI x 2.00	2.5V x 2.00 = 5.000V
4'h2	VCI x 2.05	2.5V x 2.05 = 5.125V
4'h3	VCI x 2.10	2.5V x 2.10 = 5.250V
4'h4	VCI x 2.20	2.5V x 2.20 = 5.500V
4'h5	VCI x 2.30	2.5V x 2.30 = 5.750V
4'h6	VCI x 2.40	2.5V x 2.40 = 6.000V
4'h7	VCI x 2.40	2.5V x 2.40 = 6.000V
4'h8	VCI x 1.60	2.5V x 1.60 = 4.000V
4'h9	VCI x 1.65	2.5V x 1.65 = 4.125V
4'hA	VCI x 1.70	2.5V x 1.70 = 4.250V
4'hB	VCI x 1.75	2.5V x 1.75 = 4.375V
4'hC	VCI x 1.80	2.5V x 1.80 = 4.500V
4'hD	VCI x 1.85	2.5V x 1.85 = 4.625V
4'hE	VCI x 1.90	2.5V x 1.90 = 4.750V
4'hF	VCI x 1.95	2.5V x 1.95 = 4.875V

Notes:

1. Make sure the VC and VRH setting restrictions: $VREG1OUT \leq (DDVDH-0.5)V$.
2. When $VCI < 2.5V$, internal reference voltage will be same as VCI.

9.6.4 Power Control 4 (R13h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	VDV4	VDV3	VDV2	VDV1	VDV0	0	0	0	0	0	0	0	0
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

VDV[4:0]: Select the factor of VREG1OUT to set the amplitude of VCOM alternating voltage from 0.70 to 1.24 xVREG1OUT

VDV[4:0]	VCOM Amplitude	VDV[4:0]	VCOM Amplitude
5'h0	VREG1OUT x 0.70	5'h10	VREG1OUT x 0.94
5'h1	VREG1OUT x 0.72	5'h11	VREG1OUT x 0.96
5'h2	VREG1OUT x 0.74	5'h12	VREG1OUT x 0.98
5'h3	VREG1OUT x 0.76	5'h13	VREG1OUT x 1.00
5'h4	VREG1OUT x 0.78	5'h14	VREG1OUT x 1.02
5'h5	VREG1OUT x 0.80	5'h15	VREG1OUT x 1.04
5'h6	VREG1OUT x 0.82	5'h16	VREG1OUT x 1.06
5'h7	VREG1OUT x 0.84	5'h17	VREG1OUT x 1.08
5'h8	VREG1OUT x 0.86	5'h18	VREG1OUT x 1.10
5'h9	VREG1OUT x 0.88	5'h19	VREG1OUT x 1.12
5'hA	VREG1OUT x 0.90	5'h1A	VREG1OUT x 1.14
5'hB	VREG1OUT x 0.92	5'h1B	VREG1OUT x 1.16
5'hC	VREG1OUT x 0.94	5'h1C	VREG1OUT x 1.18
5'hD	VREG1OUT x 0.96	5'h1D	VREG1OUT x 1.20
5'hE	VREG1OUT x 0.98	5'h1E	VREG1OUT x 1.22
5'hF	VREG1OUT x 1.00	5'h1F	VREG1OUT x 1.24

9.7 RAM Access Instruction**9.7.1 RAM Address Set (Horizontal Address) (R20h)**

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

9.7.2 RAM Address Set (Vertical Address) (R21h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	AD16	AD15	AD14	AD13	AD12	AD11	AD10	AD9	AD8
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

AD[16:0]: A GRAM 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 RM68050 writes data to the internal GRAM so that data can be written consecutively without resetting the address in the AC. The address is not automatically updated when reading data from the internal GRAM.

Note: In RGB interface operation (RM = "1"), the address AD16-0 is set in the address counter every frame on the falling edge of VSYNC.

AD[16:0]	GRAM Data Setting
17'h00000 ~ 17'h000EF	Bitmap data on the 1 st line
17'h00100 ~ 17'h001EF	Bitmap data on the 2 nd line
17'h00200 ~ 17'h002EF	Bitmap data on the 3 rd line
17'h00300 ~ 17'h003EF	Bitmap data on the 4 th line
17'h00400 ~ 17'h004EF	Bitmap data on the 5 th line
..	..
17'h13C00 ~ 17'h13CEF	Bitmap data on the 317 th line
17'h13D00 ~ 17'h13DEF	Bitmap data on the 318 th line
17'h13E00 ~ 17'h13EEF	Bitmap data on the 319 th line
17'h13F00 ~ 17'h13FEF	Bitmap data on the 320 th line

9.7.3 Write Data to GRAM (R22h)

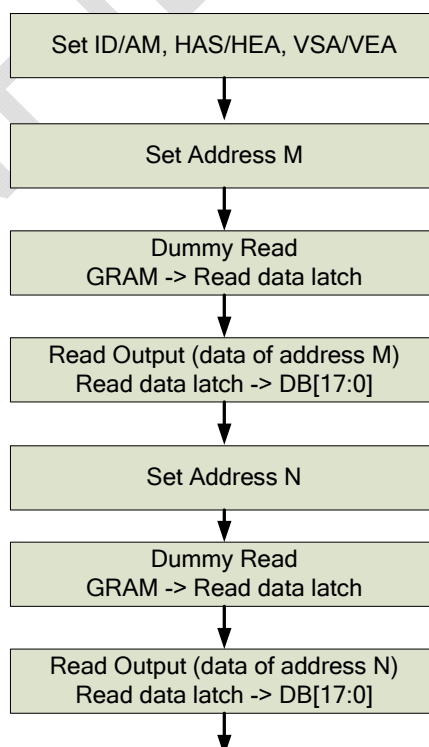
R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	RAM write data WD[17:0] is transferred via different data bus in different interface operation.															

This register is the GRAM access port. When update the display data through this register, the address counter (AC) is increased/decreased automatically.

9.7.4 Read Data from GRAM (R22h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	RAM read data RD[17:0] is transferred via different data bus in different interface operation.															

Read 18-bit data from GRAM through the read data register (RDR).



9.8 Power Control 7 (R29h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	0	0	VCM5	VCM4	VCM3	VCM2	VCM1	VCM0
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

VCM [5:0]: Set internal VCOMH voltages.

VCM1[5:0]	VCOMH Voltage
6'h00	VREG1OUT x 0.685
6'h01	VREG1OUT x 0.690
6'h02	VREG1OUT x 0.695
6'h03	VREG1OUT x 0.700
6'h04	VREG1OUT x 0.705
6'h05	VREG1OUT x 0.710
6'h06	VREG1OUT x 0.715
6'h07	VREG1OUT x 0.720
6'h08	VREG1OUT x 0.725
6'h09	VREG1OUT x 0.730
6'h0A	VREG1OUT x 0.735
6'h0B	VREG1OUT x 0.740
6'h0C	VREG1OUT x 0.745
6'h0D	VREG1OUT x 0.750
6'h0E	VREG1OUT x 0.755
6'h0F	VREG1OUT x 0.760
6'h10	VREG1OUT x 0.765
6'h11	VREG1OUT x 0.770
6'h12	VREG1OUT x 0.775
6'h13	VREG1OUT x 0.780
6'h14	VREG1OUT x 0.785
6'h15	VREG1OUT x 0.790
6'h16	VREG1OUT x 0.795
6'h17	VREG1OUT x 0.800
6'h18	VREG1OUT x 0.805
6'h19	VREG1OUT x 0.810
6'h1A	VREG1OUT x 0.815
6'h1B	VREG1OUT x 0.820
6'h1C	VREG1OUT x 0.825
6'h1D	VREG1OUT x 0.830
6'h1E	VREG1OUT x 0.835
6'h1F	VREG1OUT x 0.840

VCM1[5:0]	VCOMH Voltage
6'h20	VREG1OUT x 0.845
6'h21	VREG1OUT x 0.850
6'h22	VREG1OUT x 0.855
6'h23	VREG1OUT x 0.860
6'h24	VREG1OUT x 0.865
6'h25	VREG1OUT x 0.870
6'h26	VREG1OUT x 0.875
6'h27	VREG1OUT x 0.880
6'h28	VREG1OUT x 0.885
6'h29	VREG1OUT x 0.890
6'h2A	VREG1OUT x 0.895
6'h2B	VREG1OUT x 0.900
6'h2C	VREG1OUT x 0.905
6'h2D	VREG1OUT x 0.910
6'h2E	VREG1OUT x 0.915
6'h2F	VREG1OUT x 0.920
6'h30	VREG1OUT x 0.925
6'h31	VREG1OUT x 0.930
6'h32	VREG1OUT x 0.935
6'h33	VREG1OUT x 0.940
6'h34	VREG1OUT x 0.945
6'h35	VREG1OUT x 0.950
6'h36	VREG1OUT x 0.955
6'h37	VREG1OUT x 0.960
6'h38	VREG1OUT x 0.965
6'h39	VREG1OUT x 0.970
6'h3A	VREG1OUT x 0.975
6'h3B	VREG1OUT x 0.980
6'h3C	VREG1OUT x 0.985
6'h3D	VREG1OUT x 0.990
6'h3E	VREG1OUT x 0.995
6'h3F	VREG1OUT x 1.000

9.9 Frame Rate and Color Control (R2Bh)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	0	0	0	0	FRS2	FRS2	FRS1	FRS0
Default		0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0

FRS[4:0] Set the frame rate when the internal resistor is used for oscillator circuit.

FRS[3:0]	Frame Rate	FRS[3:0]	Frame Rate
0000	30	1000	51
0001	31	1001	56
0010	33	1010	62
0011	35	1011	70 (default)
0100	38	1100	83
0101	40	1101	93
0110	43	1110	Setting Prohibited
0111	47	1111	Setting Prohibited

9.10 γ Control

	R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
R30h	W	1	0	0	0	0	0	KP1[2]	KP1[1]	KP1[0]	0	0	0	0	0	KP0[2]	KP0[1]	KP0[0]
R31h	W	1	0	0	0	0	0	KP3[2]	KP3[1]	KP3[0]	0	0	0	0	0	KP2[2]	KP2[1]	KP2[0]
R32h	W	1	0	0	0	0	0	KP5[2]	KP5[1]	KP1[0]	0	0	0	0	0	KP4[2]	KP4[1]	KP4[0]
R35h	W	1	0	0	0	0	0	RP1[2]	RP1[1]	RP1[0]	0	0	0	0	0	RP0[2]	RP0[1]	RP0[0]
R36h	W	1	0	0	0	VRP1[4]	VRP1[3]	VRP1[2]	VRP1[1]	VRP1[0]	0	0	0	VRP0[4]	VRP0[3]	VRP0[2]	VRP0[1]	VRP0[0]
R37h	W	1	0	0	0	0	0	KN1[2]	KN1[1]	KN1[0]	0	0	0	0	0	KN0[2]	KN0[1]	KN0[0]
R38h	W	1	0	0	0	0	0	KN3[2]	KN3[1]	KN3[0]	0	0	0	0	0	KN2[2]	KN2[1]	KN2[0]
R39h	W	1	0	0	0	0	0	KN5[2]	KN5[1]	KN1[0]	0	0	0	0	0	KN4[2]	KN4[1]	KN4[0]
R3Ch	W	1	0	0	0	0	0	RN1[2]	RN1[1]	RN1[0]	0	0	0	0	0	RN0[2]	RN0[1]	RN0[0]
R3Dh	W	1	0	0	0	VRN1[4]	VRN1[3]	VRN1[2]	VRN1[1]	VRN1[0]	0	0	0	VRN0[4]	VRN0[3]	VRN0[2]	VRN0[1]	VRN0[0]

KP5-0[2:0] / KN5-0[2:0] : γ Fine Adjustment Register for positive/negative polarity

PRP1-0[2:0] / PRN1-0[2:0] : γ Gradient Adjustment Register for positive/negative polarity

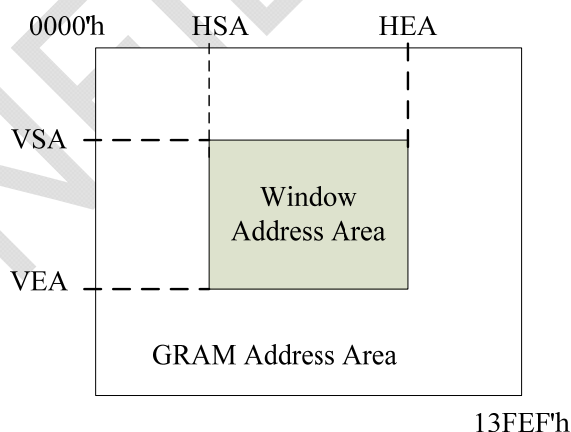
VRP1-0[4:0] / VRN1-0[4:0]: γ Amplitude Adjustment Register for positive/negative polarity

9.11 Window Address Write Control Instruction

	R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
R50h	W	1	0	0	0	0	0	0	0	0	HSA7	HSA6	HSA5	HSA4	HSA3	HSA2	HSA1	HSA0
R51h	W	1	0	0	0	0	0	0	0	0	HEA7	HSA6	HSA5	HEA4	HEA3	HEA2	HEA1	HEA0
R52h	W	1	0	0	0	0	0	0	0	VSA8	VSA7	VSA6	VSA5	VSA4	VSA3	VSA2	VSA1	VSA0
R53h	W	1	0	0	0	0	0	0	0	VEA8	VEA7	VSA6	VSA5	VEA4	VEA3	VEA2	VEA1	VEA0
R50h	Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R51h			0	0	0	0	0	0	0	0	1	1	1	0	1	1	1	1
R52h			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
R53h			0	0	0	0	0	0	0	1	0	0	1	1	1	1	1	1

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 $8'h00 \leq HAS < HEA \leq 8'hEF$ and $8'h01 \leq HEA - HSA$.

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 $9'h000 \leq VSA < VEA \leq 9'h13F$.



Note: The window address range must be within the GRAM address space.

9.12 Base Image Display Control Instruction

	R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
R60h	W	1	GS	0	NL5	NL4	NL3	NL2	NL1	NL0	0	0	SCN5	SCN4	SCN3	SCN2	SCN1	SCN0

R61h	W	1	0	0	0	0	0	0	0	0	0	0	0	0	0	NDL	VLE	REV
R6Ah	W	1	0	0	0	0	0	0	0	VL8	VL7	VL6	VL5	VL4	VL3	VL2	VL1	VL0
R60h	Default		0	0	1	0	0	1	1	1	0	0	0	0	0	0	0	0
R61h			0	0	0	0	0	0	0	1	1	1	0	1	1	1	1	1
R6Ah			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

REV: Enables the grayscale inversion of the image by setting REV = 1. This enables the RM68050 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	GRAM Data	Source Output Level in Display Area	
		Positive Polarity	Negative Polarity
0	18'h00000	V63	V0
	...	...	...
	18'h3FFFF	V0	V63
1	18'h00000	V0	V63
	...	...	...
	18'h3FFFF	V63	V0

VLE: Vertical scroll display enable bit. When VLE = 1, the RM68050 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
0	Fixed
1	Enable scrolling

NL[5:0]: Sets the number of lines to drive the LCD at an interval of 8 lines. The GRAM 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.

NL[5:0]	Number of Lines	NL[5:0]	Number of Lines	NL[5:0]	Number of Lines
6'h00	8 (lines)	6'h0E	112	6'h1C	232
6'h01	16	6'h0F	120	6'h1D	240
6'h02	24	6'h10	128	6'h1E	248
6'h03	32	6'h11	136	6'h1F	256
6'h04	40	6'h12	144	6'h20	264
6'h05	48	6'h13	152	6'h21	272
6'h06	48	6'h14	160	6'h22	280
6'h07	56	6'h15	168	6'h23	288
6'h08	64	6'h16	176	6'h24	296
6'h09	72	6'h17	184	6'h25	304
6'h0A	80	6'h18	192	6'h26	312

6'h0B	88	6'h19	200	6'h27	320
6'h0C	96	6'h1A	216	Others	Setting inhibited
6'h0D	104	6'h1B	224		

SCN[5:0]: Specifies the gate line where the gate driver starts scan.

SCN[5:0]	Gate Line No (Scan start position)			
	SM=0		SM=1	
	GS=0	GS=1	GS=0	GS=1
6'h00	G1	G320	G1	G320
6'h01	G9	G312	G17	G304
6'h02	G17	G304	G33	G288
6'h03	G25	G296	G49	G272
6'h04	G33	G288	G65	G256
6'h05	G41	G280	G81	G240
6'h06	G49	G272	G97	G224
6'h07	G57	G264	G113	G208
6'h08	G65	G256	G129	G192
6'h09	G73	G248	G145	G176
6'h0A	G81	G240	G161	G160
6'h0B	G89	G232	G177	G144
6'h0C	G97	G224	G193	G128
6'h0D	G105	G216	G209	G112
6'h0E	G113	G208	G225	G96
6'h0F	G121	G200	G241	G80
6'h10	G129	G192	G257	G64
6'h11	G137	G184	G273	G48
6'h12	G145	G176	G289	G32
6'h13	G153	G168	G305	G16
6'h14	G161	G160	G2	G319
6'h15	G169	G152	G18	G303
6'h16	G177	G144	G34	G287
6'h17	G185	G136	G50	G271
6'h18	G193	G128	G66	G255
6'h19	G201	G120	G82	G239
6'h1A	G209	G112	G98	G223
6'h1B	G217	G104	G114	G207
6'h1C	G225	G96	G130	G191
6'h1D	G233	G88	G146	G175
6'h1E	G241	G80	G162	G159
6'h1F	G249	G72	G178	G143
6'h20	G257	G64	G194	G127
6'h21	G265	G56	G210	G111
6'h22	G273	G48	G226	G95
6'h23	G281	G40	G242	G79
6'h24	G289	G32	G258	G63
6'h25	G297	G24	G274	G47
6'h26	G305	G16	G290	G31
6'h27	G313	G8	G306	G15
6'h28~6'h3F	Setting disabled	Setting disabled	Setting disabled	Setting disabled

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

NDL	Non-display area	
	Positive	Negative

0	V63	V0
1	V0	V63

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

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.

9.13 SPI Read/Write Control (R66h, Write Only)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	R/WX
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

This register controls the read/write function when 3-wire or 4-wire SPI interface is used. If the read function needs to be active, R/WX has to be set to '1'. Otherwise, it is '0'.

R/WX	Function
0	Register write mode
1	Register read mode

9.14 Partial Display Control Instruction

9.14.1 Partial Image 1: Display Position (R80h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	PTDP0[8]	PTDP0[7]	PTDP0[6]	PTDP0[5]	PTDP0[4]	PTDP0[3]	PTDP0[2]	PTDP0[1]	PTDP0[0]
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

9.14.2 Partial Image 1: RAM Address (Start Line Address) (R81h), (End Line Address) (R82h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	PTSA0[8]	PTSA0[7]	PTSA0[6]	PTSA0[5]	PTSA0[4]	PTSA0[3]	PTSA0[2]	PTSA0[1]	PTSA0[0]
W	1	0	0	0	0	0	0	0	PTEA0[8]	PTEA0[7]	PTEA0[6]	PTEA0[5]	PTEA0[4]	PTEA0[3]	PTEA0[2]	PTEA0[1]	PTEA0[0]
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

9.14.3 Partial Image 2: Display Position (R83h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	PTDP1[8]	PTDP1[7]	PTDP1[6]	PTDP1[5]	PTDP1[4]	PTDP1[3]	PTDP1[2]	PTDP1[1]	PTDP1[0]
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

9.14.4 Partial Image 2: RAM Address (Start Line Address) (R84h), (End Line Address) (R85h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	PTSA1[8]	PTSA1[7]	PTSA1[6]	PTSA1[5]	PTSA1[4]	PTSA1[3]	PTSA1[2]	PTSA1[1]	PTSA1[0]
W	1	0	0	0	0	0	0	0	PTEA1[8]	PTEA1[7]	PTEA1[6]	PTEA1[5]	PTEA1[4]	PTEA1[3]	PTEA1[2]	PTEA1[1]	PTEA1[0]
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PTDP0[8:0]: Sets the display position of partial image 1.

PTDP1[8:0]: Sets the display position of partial image 2.

PTSA0[8:0] and PTEA0[8:0]: Sets the start line and end line addresses of the RAM area, respectively for the partial image 1. In setting, make sure that $PTSA0 \leq PTEA0$.

PTSA1[8:0] and PTEA1[8:0]: Sets the start line and end line addresses of the RAM area, respectively for the partial image 2. In setting, make sure that $PTSA1 \leq PTEA1$.

9.15 Panel Interface Control Instruction**9.15.1 Panel Interface Control 1 (R90h)**

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	DIVI1	DIVI0	0	0	0	RTNI4	RTNI3	RTNI2	RTNI1	RTNI0
Default		0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0

RTNI[4:0]: Sets 1H (line) period. This setting is enabled while the RM68050's display operation is synchronized with internal clock.

DIVI[1:0]: Sets the division ratio of the internal clock frequency.

Frame Frequency Calculation

$$\text{Frame frequency} = \frac{f_{osc}}{\text{Clocks per line} \times \text{division ratio} \times (\text{line} + BP + FP)} [\text{Hz}]$$

f_{osc} : RC oscillation frequency

Line : Number of lines to drive the LCD (NL bits)

Division ratio : DIVI

Clocks per line : RTNI

DIVI[1:0]	Division Ratio	Internal operation clock unit
2'h0	1/1	1 OSC
2'h1	1/2	2 OSC
2'h2	1/4	4 OSC
2'h3	1/8	8 OSC

RTNI[4:0]	Clocks per line	RTNI[4:0]	Clocks per line	RTNI[4:0]	Clocks per line
5'h00~5'h0F	Setting inhibited	5'h15	21 clocks	5'h1B	27 clocks
5'h10	16 clocks	5'h16	22 clocks	5'h1C	28 clocks
5'h11	17 clocks	5'h17	23 clocks	5'h1D	29 clocks
5'h12	18 clocks	5'h18	24 clocks	5'h1E	30 clocks
5'h13	19 clocks	5'h19	25 clocks	5'h1F	31 clocks
5'h14	20 clocks	5'h1A	26 clocks		

9.15.2 Panel Interface Control 2 (R92h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	NOWI[2]	NOWI[1]	NOWI[0]	0	0	0	0	0	0	0	0
Default		0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0

NOWI[2:0]: Sets the non-overlap period of adjacent gate outputs. The setting is enabled in display operation synchronizing with the internal clock.

NOWI[2:0]	Non-overlap period	NOWI[2:0]	Non-overlap period
3'h0	Setting inhibited	3'h4	4
3'h1	1 (internal clock)	3'h5	5
3'h2	2	3'h6	6
3'h3	3	3'h7	Setting inhibited

Note: The internal clock is the frequency divided clock, which is set by DIVI[[1:0] bits.

9.15.3 Panel Interface Control 4 (R95h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	DIVE1	DIVE0	0	0	0	0	0	0	0	0
Default		0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0

DIVE[1:0]: Sets the division ratio of DOTCLK when RM68050 display operation is synchronized with RGB interface signals.

DIVE[1:0]	Division Ratio	Internal operation clock unit (DOTCLK)			
		18-bit, 1 transfer RGB interface	DOTCLK = 5 MHz	8-bit, 3 transfer RGB interface	DOTCLK = 15 MHz
2'h0	Setting inhibited	Setting inhibited	-	Setting inhibited	-
2'h1	1/4	4 DOTCLKs	0.8 us	12 DOTCLKs	0.8 us
2'h2	1/8	8 DOTCLKs	1.6 us	24 DOTCLKs	1.6 us
2'h3	1/16	16 DOTCLKs	3.2 us	48 DOTCLKs	3.2 us

9.15.4 Panel Interface Control 5 (R97h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	NOWE[3]	NOWE[2]	NOWE[1]	NOWE[0]	0	0	0	0	0	0	0	0
Default		0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0

NOWE[3:0]: Sets the non-overlap period of adjacent gate outputs. The setting is enabled in display operation via RGB interface.

NOWE[3:0]	Non-overlap period	NOWE[3:0]	Non-overlap period
4'h0	Setting inhibited	4'h8	8
4'h1	1 (clocks)	4'h9	9
4'h2	2	4'hA	10
4'h3	3	4'hB	11
4'h4	4	4'hC	12
4'h5	5	4'hD	13
4'h6	6	4'hE	14
4'h7	7	4'hF	15

Note: 1 clock = (Number of data transfers/pixel) x DIVE (division ratio) [DOTCLK].

9.16 OTP VCM Control

9.16.1 OTP VCM Programming Control 1 (RA1h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	OTP_PGM_EN	0	0	0	0	0	VCM_OTP5	VCM_OTP4	VCM_OTP3	VCM_OTP2	VCM_OTP1	VCM_OTP0
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

OTP_PGM_EN: OTP programming enable. When program OTP, must set this bit.

OTP data can be programmed 3 times.

VCM_OTP[5:0]: OTP programming data for VCOMH voltage, the voltage refer to VCM[5:0] value.

9.16.2 OTP VCM Status and Enable (RA2h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	PGM_CNT1	PGM_CNT0	VCM_D5	VCM_D4	VCM_D3	VCM_D2	VCM_D1	VCM_D0	0	0	0	0	0	0	0	VCM_EN
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

PGM_CNT[1:0]: OTP programmed record. These bits are read only.

OTP_PGM_CNT[1:0]	Description
2'h0	OTP clean
2'h1	OTP programmed 1 time
2'h2	OTP programmed 2 times
2'h3	OTP programmed 3 times

VCM_D[5:0]: OTP VCM data read value. These bits are read only.

VCM_EN: OTP VCM data enable.

VCM_EN=1: Set this bit to enable OTP VCM data to replace R29h VCM value.

VCM_EN=0: Default value, use R29h VCM value.

9.16.3 OTP VCM Programming ID Key (RA5h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	KEY 15	KEY 14	KEY 13	KEY 12	KEY 11	KEY 10	KEY 9	KEY 8	KEY 7	KEY 6	KEY 5	KEY 4	KEY 3	KEY 2	KEY 1	KEY 0
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

KEY[15:0]: OTP Programming ID key protection. Before writing OTP programming data RA1h, it must write RA5h with 0xAA55 value first to make OTP programming successfully. If RA5h is not written with 0xAA55, OTP programming will be fail. See OTP Programming flow.

9.17 CABC control

9.17.1 Write Display Brightness Value (RB1h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	DBV7	DBV6	DBV5	DBV4	DBV3	DBV2	DBV1	DBV0

This command is used to adjust the brightness value of the display.

DBV[7:0]: control the brightness of manual setting or CABC in RM68050. The PWM output signal, LEDPWM, controls the LED driver IC to decide the display brightness

9.17.2 Read Display Brightness Value (RB2h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
R	1	0	0	0	0	0	0	0	0	DBV7	DBV6	DBV5	DBV4	DBV3	DBV2	DBV1	DBV0

This command is used to return the brightness value of the display.

DBV[7:0] is reset when display is in sleep-in mode.

DBV[7:0] is '0' when bit BCTRL of "Write CTRL Display (B3h)" command is '0'.

DBV[7:0] is manual set brightness specified with "Write CTRL Display (B3h)" command when BCTRL bit is '1'.

When bit BCTRL of "Write CTRL Display (B3h)" command is '1' and C1/C0 bit of "Write Content Adaptive Brightness Control (B5h)" command are '0', DBV[7:0] output is the brightness value specified with "Write Display Brightness (B1h)" command.

9.17.3 Write CTRL Display Value (RB3h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	0	0	BCTRL	0	DD	BL	0	0

This command is used to set the brightness control mechanism.

BCTRL: Brightness control block on/off. This bit is always used to switch brightness for display.

BCTRL	Description
0	Brightness Control Block OFF (DBV[7:0]=00H)
1	Brightness Control Block ON (DBV[7:0] is active)

DD: Display Dimming Control.

DD	Description
0	Display Dimming OFF
1	Display Dimming ON

BL: Backlight Control.

BL	Description
0	Backlight Control OFF
1	Backlight Control ON

Dimming function is adapted to the brightness registers for display when bit BCTRL is changed at DD=1, e.g. BCTRL: 0 → 1 or 1 → 0.

When BL bit change from “On” to “Off”, backlight is turned off without gradual dimming, even if dimming-on (DD=1) are selected

9.17.4 Read CTRL Display Value (RB4h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
R	1	0	0	0	0	0	0	0	0	0	0	BCTRL	0	DD	BL	0	0

This command is used to read the status of the brightness control mechanism.

9.17.5 Write Content Adaptive Brightness Control Value (RB5h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C[1]	C[0]

This command is used to set parameters for image content based adaptive brightness control functionality. There is possible to use 4 different modes for content adaptive image functionality, which are defined on a table below.

C[1:0]	Description
2'h0	CABC OFF
2'h1	User Interface Image
2'h2	Still Picture
2'h3	Moving Image

9.17.6 Read Content Adaptive Brightness Control Value (RB6h)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
R	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C[1]	C[0]

This command is used to read the status for image content based adaptive brightness control functionality.

9.17.7 Write CABC Minimum Brightness (RBEh)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	CMB[7]	CMB[6]	CMB[5]	CMB[4]	CMB[3]	CMB[2]	CMB[1]	CMB[0]

This command is used to set the minimum brightness value of the display for CABC function.

CMB[7:0]: CABC minimum brightness control, this parameter is used to avoid too much brightness reduction.

When CABC is active, CABC can not reduce the display brightness to less than CABC minimum brightness setting. Image processing function is worked as normal, even if the brightness can not be changed. This function does not affect to the other function, manual brightness setting. Manual brightness can be set the display brightness to less than CABC minimum brightness. Smooth transition and dimming function can be worked as normal.

When display brightness is turned off (BCTRL=0 of "Write CTRL Display (B3h)"), CABC minimum brightness setting is ignored.

In principle relationship is that 00h value means the lowest brightness for CABC and FFh value means the highest brightness for CABC.

9.17.8 Read CABC Minimum Brightness (RBFh)

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
R	1	0	0	0	0	0	0	0	0	CMB[7]	CMB[6]	CMB[5]	CMB[4]	CMB[3]	CMB[2]	CMB[1]	CMB[0]

This command is used to read the minimum brightness value of the display for CABC function.

9.18 Deep standby control

R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
W	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DSTB
Default		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

DSTB: When DSTB = 1, the RM68050 enters the deep standby mode. In deep standby mode, the internal logic power supply is turned off to reduce power consumption. The GRAM data and instruction setting are not kept when the RM68050 enters the deep standby mode, and they would be reset automatically after exiting deep standby mode.

To exit deep standby mode, nCS pin needs to be toggled from low to high 6 times.

10. Instruction List

No.	Register Name	R/W	RS	D15	D14	D13	D12	D11	D10	D9	D8	D7	D6	D5	D4	D3	D2	D1	D0
IR	Index Register	W	0	*	*	*	*	*	*	*	*	ID7	ID6	ID5	ID4	ID3	ID2	ID1	ID0
00h	Driver Code Read	RO	1	1	0	0	1	0	0	1	1	0	0	1	0	0	1	0	1
01h	Driver Output Control 1	W	1	0	0	0	0	0	SM	0	SS	0	0	0	0	0	0	0	0
02h	LCD Driving Control	W	1	0	0	0	0	0	0	B/C	0	0	0	0	0	0	0	0	0
03h	Entry Mode	W	1	TRI	DFM	0	BGR	0	0	0	0	ORG	0	I//D1	I/D0	AM	0	0	0
05h	16 bits data format control	W	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	FPF1	FPF0
07h	Display Control 1	W	1	0	0	PTDE1	PTDE0	0	0	0	BASEE	0	0	GON	DTE	CL	0	D1	D0
08h	Display Control 2	W	1	0	0	0	0	FP3	FP2	FP1	FP0	0	0	0	0	BP3	BP2	BP1	BP0
09h	Display Control 3	W	1	0	0	0	0	0	0	PTS1	PTS0	0	0	PTG1	PTG0	ISC3	ISC2	ISC1	ISC0
0Ah	Display Control 4	W	1	0	0	0	0	0	0	0	0	0	0	0	0	FMAR KOE	FMI2	FMI1	FMI0
0Ch	RGB Display Interface Control 1	W	1	0	ENC2	ENC1	ENC0	0	0	0	RM	0	0	DM1	DM0	0	0	RIM1	RIM 0
0Dh	Frame Maker Position	W	1	0	0	0	0	0	0	0	FMP8	FMP7	FMP6	FMP5	FMP4	FMP3	FMP2	FMP1	FMP0
0Fh	RGB Display Interface Control 2	W	1	0	0	0	0	0	0	0	0	0	0	0	VSPL	HSPL	0	EPL	DPL
10h	Power Control 1	W	1	0	0	0	SAP	0	BT2	BT1	BT0	APE	AP2	AP1	AP0	0	0	SLP	STB
11h	Power Control 2	W	1	0	0	0	0	0	DC12	DC11	DC10	0	DC02	DC01	DC00	0	VC2	VC1	VC0
12h	Power Control 3	W	1	0	0	0	0	0	0	0	0	VCIRE	0	0	0	VRH3	VRH2	VRH1	VRH0
13h	Power Control 4	W	1	0	0	0	VDV4	VDV 3	VDV 2	VDV 1	VDV 0	0	0	0	0	0	0	0	0
20h	Horizontal GRAM Address Set	W	1	0	0	0	0	0	0	0	0	AD7	AD6	AD5	AD4	AD3	AD2	AD1	AD0
21h	Vertical GRAM Address Set	W	1	0	0	0	0	0	0	0	AD16	AD15	AD14	AD13	AD12	AD11	AD10	AD9	AD8
22h	Write Data to GRAM	RAM write data WD[17:0] / read data RD[17:0] is transferred via different data bus in different interface operation.																	

29h	Power Control 7	W	1	0	0	0	0	0	0	0	0	0	0	VCM5	VCM4	VCM3	VCM2	VCM1	VCM0	
2Bh	Frame Rate and Color Control	W	1	0	0	0	0	0	0	0	0	0	0	0	0	FRS2	FRS2	FRS1	FRS0	
30h	Gamma Control 1	W	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	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	1	0	0	0	0	0	KP5[2]	KP5[1]	KP1[0]	0	0	0	0	0	KP4[2]	KP4[1]	KP4[0]	
35h	Gamma Control 4	W	1	0	0	0	0	0	RP1[2]	RP1[1]	RP1[0]	0	0	0	0	0	RP0[2]	RP0[1]	RP0[0]	
36h	Gamma Control 5	W	1	0	0	0	VRP1[4]	VRP1[3]	VRP1[2]	VRP1[1]	VRP1[0]	0	0	0	VRP0[4]	VRP0[3]	VRP0[2]	VRP0[1]	VRP0[0]	
37h	Gamma Control 6	W	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	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	1	0	0	0	0	0	KN5[2]	KN5[1]	KN1[0]	0	0	0	0	0	KN4[2]	KN4[1]	KN4[0]	
3Ch	Gamma Control 9	W	1	0	0	0	0	0	RN1[2]	RN1[1]	RN1[0]	0	0	0	0	0	RN0[2]	RN0[1]	RN0[0]	
3Dh	Gamma Control 10	W	1	0	0	0	VRN1[4]	VRN1[3]	VRN1[2]	VRN1[1]	VRN1[0]	0	0	0	VRN0[4]	VRN0[3]	VRN0[2]	VRN0[1]	VRN0[0]	
50h	Horizontal Address Start Position	W	1	0	0	0	0	0	0	0	0	HSA7	HSA6	HSA5	HSA4	HSA3	HSA2	HSA1	HSA0	
51h	Horizontal Address End Position	W	1	0	0	0	0	0	0	0	0	HEA7	HSA6	HSA5	HEA4	HEA3	HEA2	HEA1	HEA0	
52h	Vertical Address Start Position	W	1	0	0	0	0	0	0	0	0	VSA8	VSA7	VSA6	VSA5	VSA4	VSA3	VSA2	VSA1	VSA0
53h	Vertical Address End Position	W	1	0	0	0	0	0	0	0	0	VEA8	VEA7	VSA6	VSA5	VEA4	VEA3	VEA2	VEA1	VEA0
60h	Driver Output Control 2	W	1	GS	0	NL5	NL4	NL3	NL2	NL1	NL0	0	0	SCN5	SCN4	SCN3	SCN2	SCN1	SCN0	
61h	Base Image Display Control	W	1	0	0	0	0	0	0	0	0	0	0	0	0	0	NDL	VLE	REV	
66h	SPI Read/Write Control	W	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	R/WX	
6Ah	Vertical Scroll Control	W	1	0	0	0	0	0	0	0	0	VL8	VL7	VL6	VL5	VL4	VL3	VL2	VL1	VL0
80h	Partial Image 1 Display Position	W	1	0	0	0	0	0	0	0	0	PTDP0[8]	PTDP0[7]	PTDP0[6]	PTDP0[5]	PTDP0[4]	PTDP0[3]	PTDP0[2]	PTDP0[1]	PTDP0[0]
81h	Partial Image 1 Area (Start Line)	W	1	0	0	0	0	0	0	0	0	PTSA0[8]	PTSA0[7]	PTSA0[6]	PTSA0[5]	PTSA0[4]	PTSA0[3]	PTSA0[2]	PTSA0[1]	PTSA0[0]
82h	Partial Image 1 Area (End Line)	W	1	0	0	0	0	0	0	0	0	PTEA0[8]	PTEA0[7]	PTEA0[6]	PTEA0[5]	PTEA0[4]	PTEA0[3]	PTEA0[2]	PTEA0[1]	PTEA0[0]
83h	Partial Image 2 Display Position	W	1	0	0	0	0	0	0	0	0	PTDP1[8]	PTDP1[7]	PTDP1[6]	PTDP1[5]	PTDP1[4]	PTDP1[3]	PTDP1[2]	PTDP1[1]	PTDP1[0]

84h	Partial Image 2 Area (Start Line)	W	1	0	0	0	0	0	0	0	0	PTSA1[8]	PTSA1[7]	PTSA1[6]	PTSA1[5]	PTSA1[4]	PTSA1[3]	PTSA1[2]	PTSA1[1]	PTSA1[0]
85h	Partial Image 2 Area (End Line	W	1	0	0	0	0	0	0	0	0	PTEA1[8]	PTEA1[7]	PTEA1[6]	PTEA1[5]	PTEA1[4]	PTEA1[3]	PTEA1[2]	PTEA1[1]	PTEA1[0]
90h	Panel Interface Control 1	W	1	0	0	0	0	0	0	DIV11	DIV10	0	0	0	RTNI4	RTNI3	RTNI2	RTNI1	RTNI0	
92h	Panel Interface Control 2	W	1	0	0	0	0	0	NOWI[2]	NOWI[1]	NOWI[0]	0	0	0	0	0	0	0	0	0
95h	Panel Interface Control 4	W	1	0	0	0	0	0	0	DIVE1	DIVE0	0	0	0	0	0	0	0	0	0
97h	Panel Interface Control 5	W	1	0	0	0	0	NOWE[3]	NOWE[2]	NOWE[1]	NOWE[0]	0	0	0	0	0	0	0	0	0
A1h	OTP VCM Programming Control	W	1	0	0	0	0	OTP_PG_M_EN	0	0	0	0	0	0	VCM_OTP5	VCM_OTP4	VCM_OTP3	VCM_OTP2	VCM_OTP1	VCM_OTP0
A2h	OTP VCM Status and Enable	W	1	PGM_CNT1	PGM_CNT0	VCM_D5	VCM_D4	VCM_D3	VCM_D2	VCM_D1	VCM_D0	0	0	0	0	0	0	0	0	VCM_EN
A5h	OTP Programming ID Key	W	1	KEY_15	KEY_14	KEY_13	KEY_12	KEY_11	KEY_10	KEY_9	KEY_8	KEY_7	KEY_6	KEY_5	KEY_4	KEY_3	KEY_2	KEY_1	KEY_0	
B1h	Write Display Brightness	W	1	0	0	0	0	0	0	0	0	DBV7	DBV6	DBV5	DBV4	DBV3	DBV2	DBV1	DBV0	
B2h	Read Display Brightness	R	1	0	0	0	0	0	0	0	0	DBV7	DBV6	DBV5	DBV4	DBV3	DBV2	DBV1	DBV0	
B3h	Write CTRL Display value	W	1	0	0	0	0	0	0	0	0	0	0	0	BCTRL	0	DD	BL	0	0
B4h	Read CTRL Display value	R	1	0	0	0	0	0	0	0	0	0	0	0	BCTRL	0	DD	BL	0	0
B5h	Write Content Adaptive	W	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C[1]	C[0]
B6h	Brightness Control value	R	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	C[1]	C[0]
BEh	Read Content Adaptive	W	1	0	0	0	0	0	0	0	0	CMB[7]	CMB[6]	CMB[5]	CMB[4]	CMB[3]	CMB[2]	CMB[1]	CMB[0]	
BFh	Brightness Control value	R	1	0	0	0	0	0	0	0	0	CMB[7]	CMB[6]	CMB[5]	CMB[4]	CMB[3]	CMB[2]	CMB[1]	CMB[0]	
E6h	Deep stand by mode control	W	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	DSTB

11. Interface and Data Format

The RM68050 supports system interface for making instruction and other settings, and external display interface for displaying a moving picture. The RM68050 can select the optimum interface for the display (moving or still picture) in order to transfer data efficiently.

As external display interface, the RM68050 supports RGB interface and VSYNC interface, which enables data rewrite operation without flicker effect of the moving picture on display.

In RGB interface operation, the display operation is executed in synchronization with synchronous signals VSYNC, HSYNC, and DOTCLK. In synchronization with these signals, the RM68050 writes display data according to data enable signal (ENABLE) via RGB data signal bus (DB17-0). The display data is stored in the RM68050's GRAM so that data is transferred only when rewriting the frames of moving picture and the data transfer required for moving picture display can be minimized. The window address function specifies the RAM area to write data for moving picture display, which enables displaying a moving picture and RAM data in other than the moving picture area simultaneously.

In VSYNC interface operation, the internal display operation is synchronized with the frame synchronization signal (VSYNC). The VSYNC interface enables a moving picture display via system interface by writing the data to the GRAM at faster than the minimum calculated speed in synchronization with the falling edge of VSYNC. In this case, there are restrictions in setting the frequency and the method to write data to the internal RAM.

The RM68050 operates in either one of the following four modes according to the state of the display. The operation mode is set in the external display interface control register (R0Ch). When switching from one mode to another, make sure to follow the relevant sequence in setting instruction bits.

Operation Mode	RAM Access Setting (RM)	Display Operation Mode (DM)
Internal clock operation (displaying still pictures)	System interface (RM = 0)	Internal clock operation (DM1-0 = 00)
RGB interface (1) (displaying moving pictures)	RGB interface (RM = 1)	RGB interface (DM1-0 = 01)
RGB interface (2) (rewriting still pictures while displaying moving pictures)	System interface (RM = 0)	RGB interface (DM1-0 = 01)
VSYNC interface (displaying moving pictures)	System interface (RM = 0)	VSYNC interface (DM1-0 = 10)

Notes:

1. Instructions are set only via system interface.
2. The RGB and VSYNC interfaces cannot be used simultaneously.

12. System Interface

The following are the kinds of system interfaces available with the RM68050. The interface operation is selected by setting the IM3/2/1/0 pins. The system interface is used for instruction setting and RAM access.

IM3	IM2	IM1	IM0	Interfacing Mode with MPU	DB pins	Colors
0	0	0	0	Setting inhibited	-	-
0	0	0	1	Setting inhibited	-	-
0	0	1	0	80-system 16-bit interface	DB17-10, DB8-1	262,144
0	0	1	1	80-system 8-bit interface	DB17-10	262,144
0	1	0	ID	Clock synchronous serial interface	(SDI, SDO)	65,536
0	1	1	0	9-bit 3 wires Serial Peripheral Interface	SDA, SCL, nCS	262,144
0	1	1	1	8-bit 4 wires Serial Peripheral Interface	SDA, SCL, nCS, RS(D/CX)	262,144
1	0	0	*	Setting inhibited	-	-
1	0	1	0	80-system 18-bit interface	DB17-0	262,144
1	0	1	1	80-system 9-bit interface	DB17-9	262,144
1	1	*	*	Setting inhibited	-	-

12.1 80-system 18-bit Bus Interface

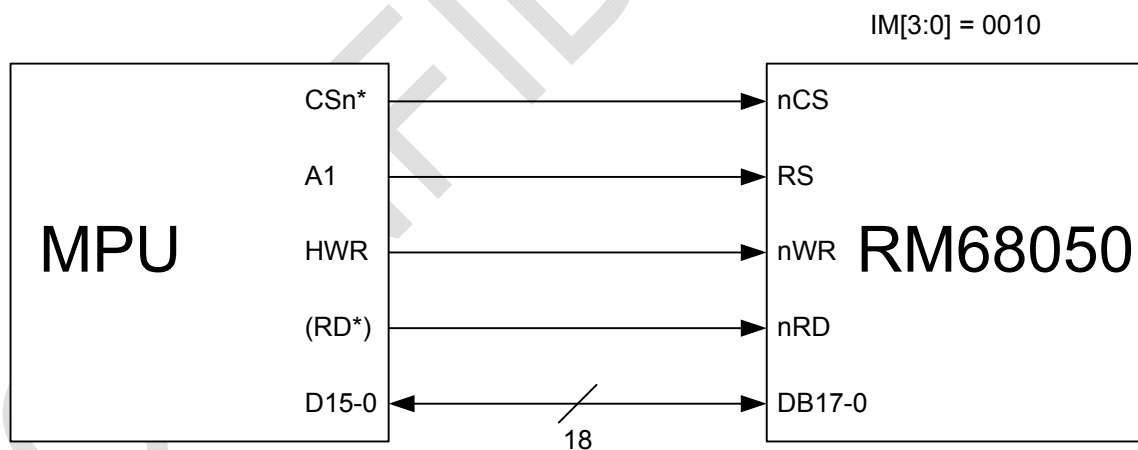
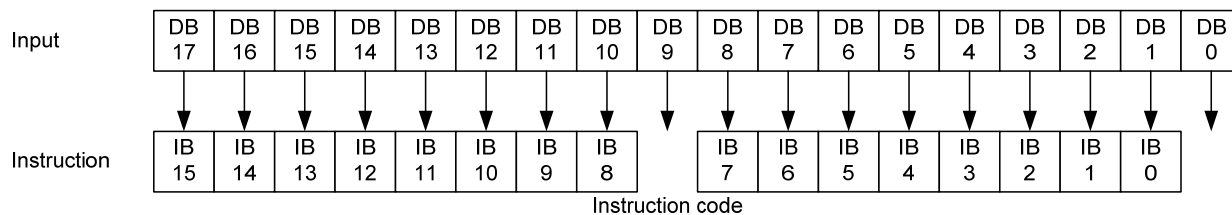


Figure 3 18-bit bus interface for 80-system

Instruction write



Instruction read

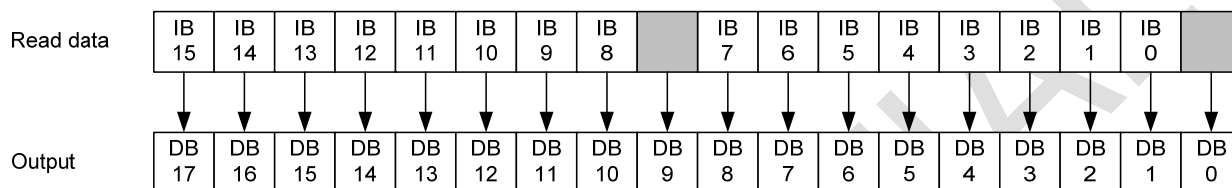
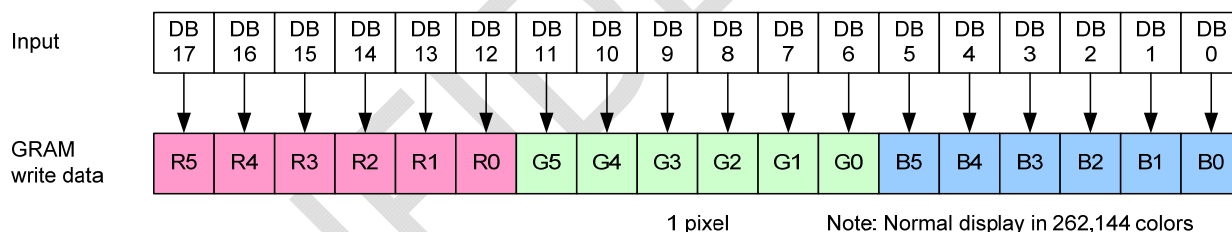


Figure 4 18-bit Interface Data Format (Instruction Write / Instruction Read)

RAM data write



RAM data read

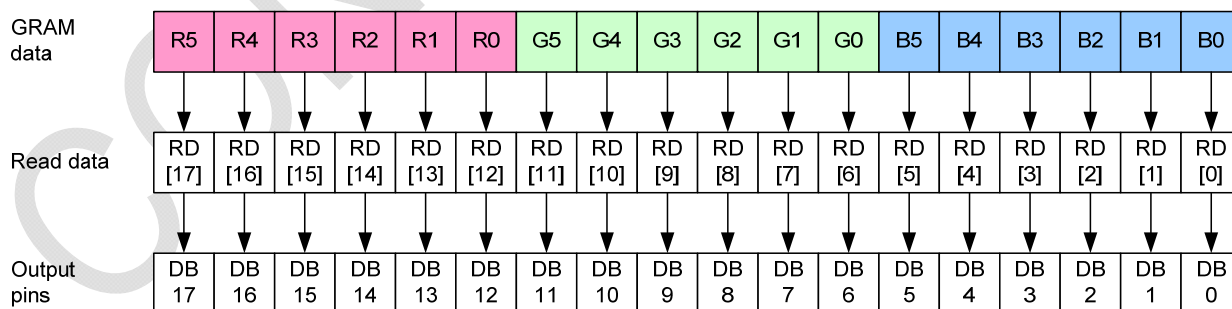


Figure 5 18-bit Interface Data Format (RAM Data Write / RAM Data Read)

12.2 80-system 16-bit Bus Interface

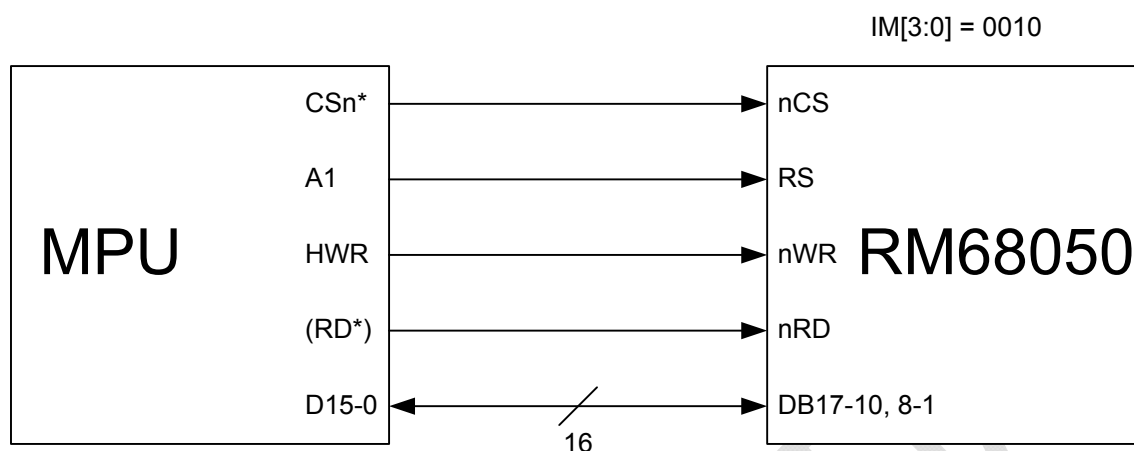
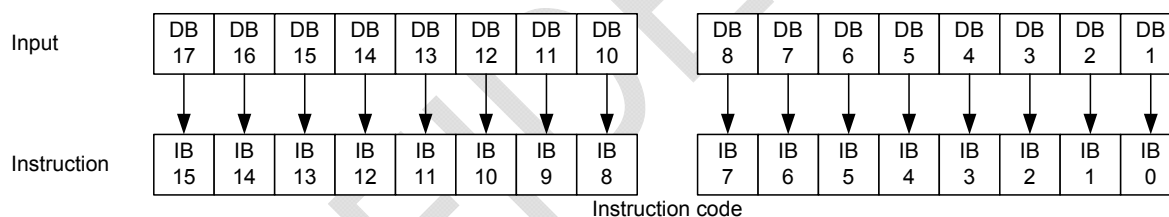
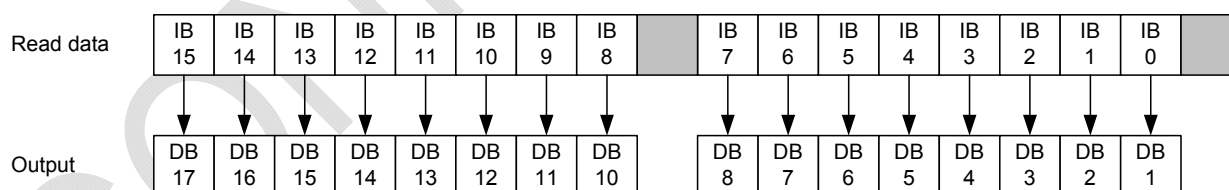


Figure 6 16-bit bus interface for 80-system

Instruction write



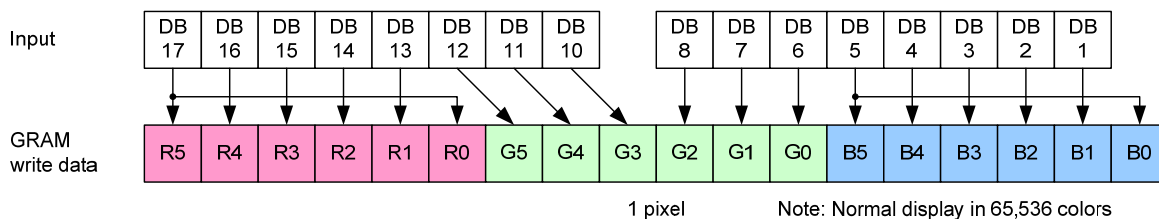
Instruction read



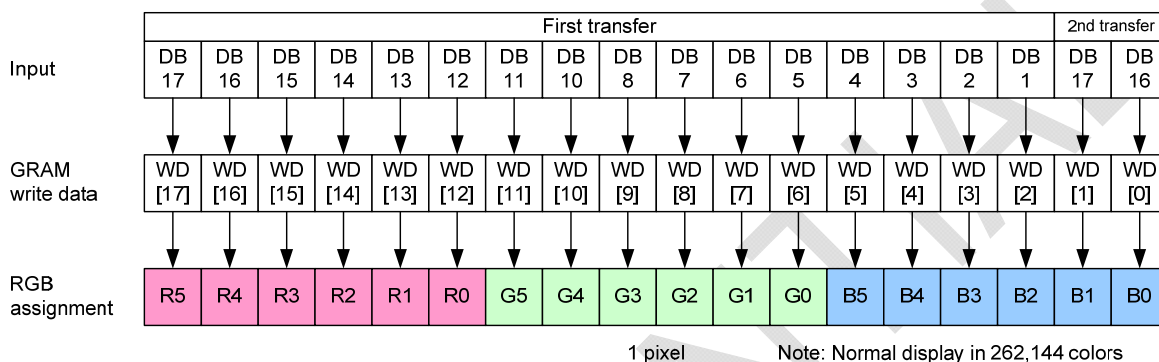
Note: Data cannot be transferred in twice in read operation via 16-bit interface

Figure 7 16-bit Interface Data Format (Instruction Write / Instruction Read)

RAM data write (single transfer mode: TRIREG = 0)



RAM data write (2 transfer mode: TRIREG = 1, DFM = 0)



RAM data write (2 transfer mode: TRIREG = 1, DFM = 1)

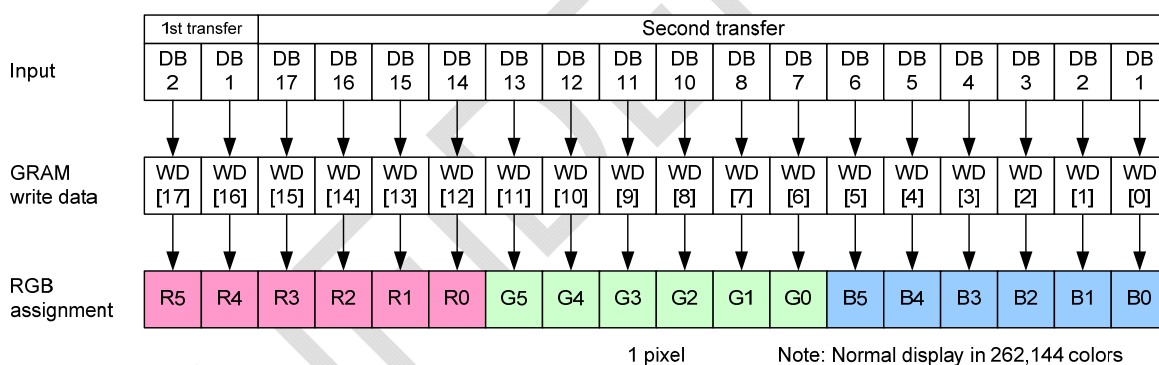


Figure 8 16-bit Interface Data Format (RAM data write)

RAM data read (single transfer: TRIREG = 0)

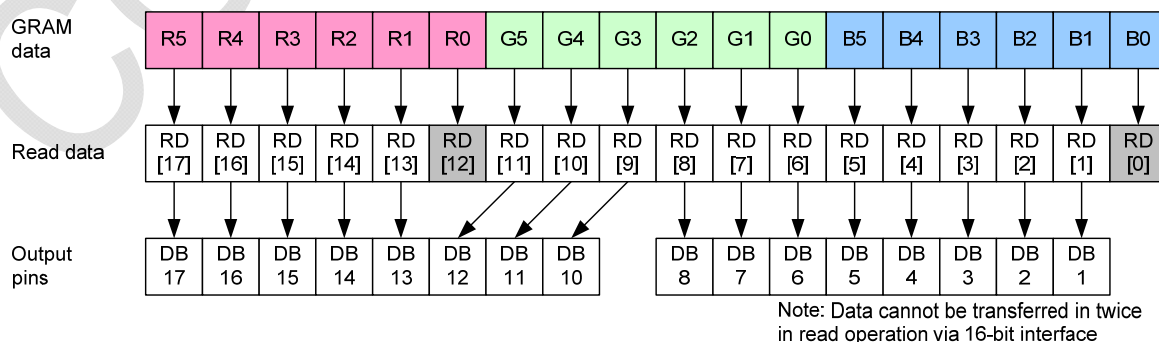


Figure 9 16-bit Interface Data Format (RAM data read)

12.3 80-system 9-bit Bus Interface

When transferring 16-bit instruction, it is divided into upper and lower 8 bits, and the upper 8 bits are transferred first (the LSB is not used). The RAM write data is also divided into upper and lower 9 bits, and the upper 9 bits are transferred first. The unused DB pins must be fixed at either IOVCC or IOGND level. When transferring the index register setting, make sure to write upper byte (8 bits).

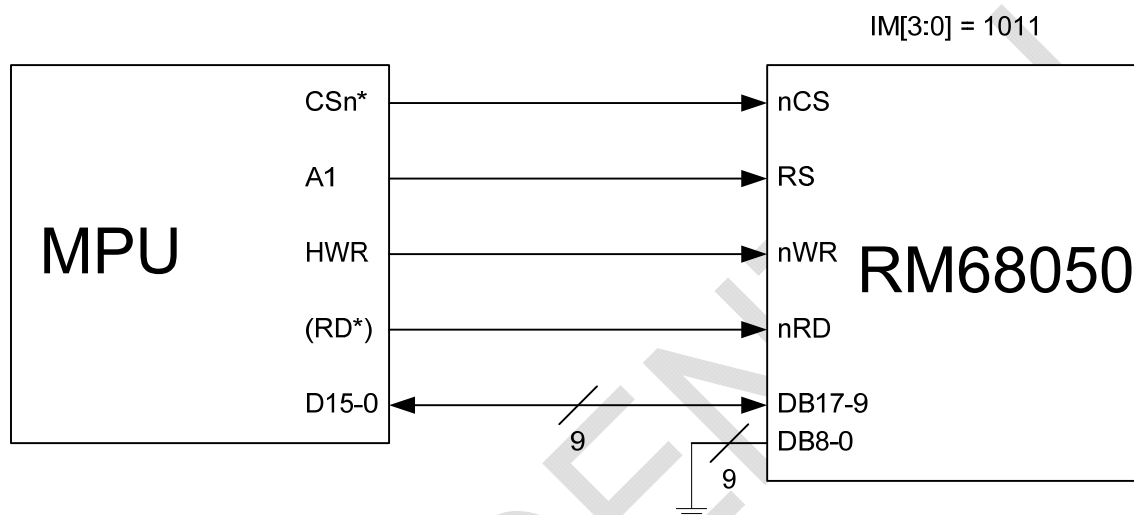
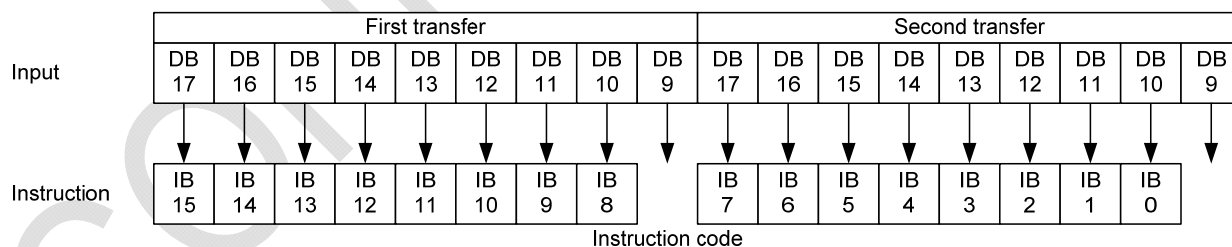


Figure 10 9-bit bus interface for 80-system

Instruction write



Device code read

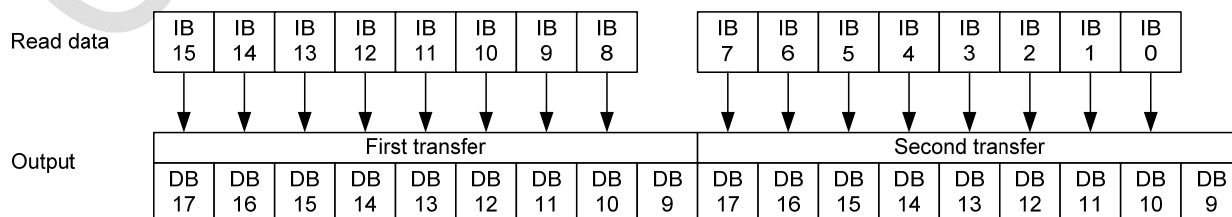
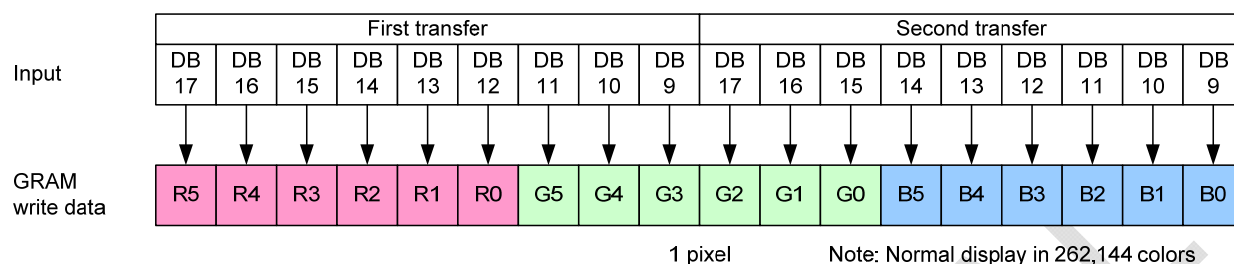


Figure 11 9-bit Interface Data Format (Instruction Write / Device Code Read)

RAM data write



RAM data read

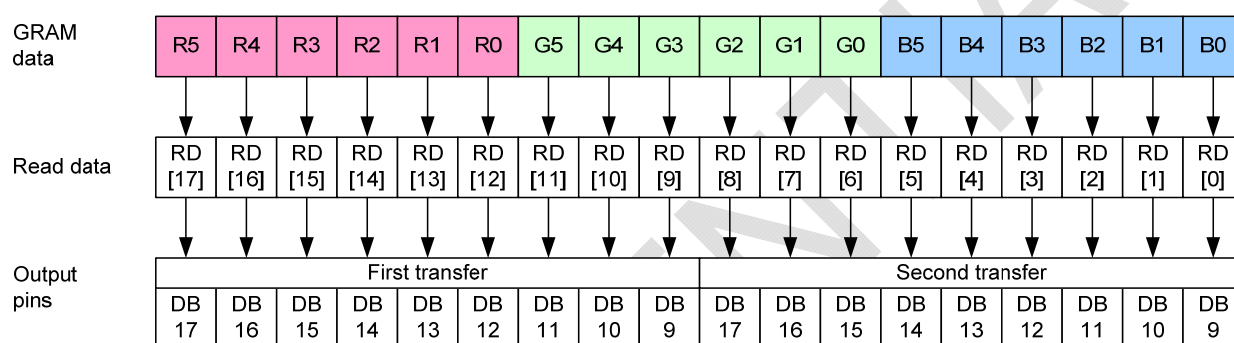


Figure 12 9-bit Interface Data Format (RAM Data Write / RAM Data Read)

12.4 80-system 8-bit Bus Interface

When transferring 16-bit instruction, it is divided into upper and lower 8 bits, and the upper 8 bits are transferred first. The RAM write data is also divided into upper and lower 8 bits, and the upper 8 bits are transferred first. The RAM write data is expanded into 18 bits internally as shown below. The unused DB pins must be fixed at either IOVCC or IOGND level. When transferring the index register setting, make sure to write upper byte (8 bits).

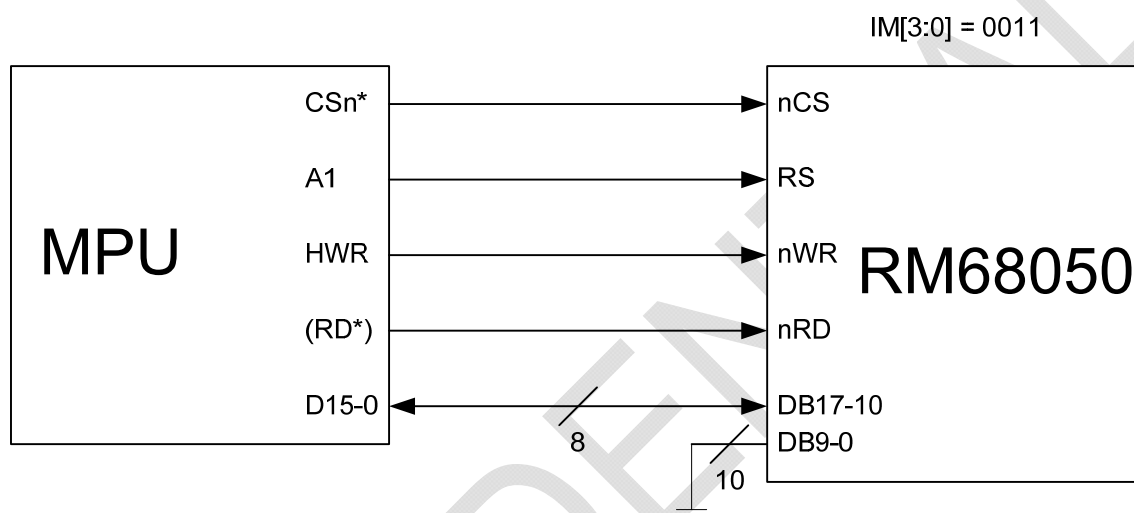
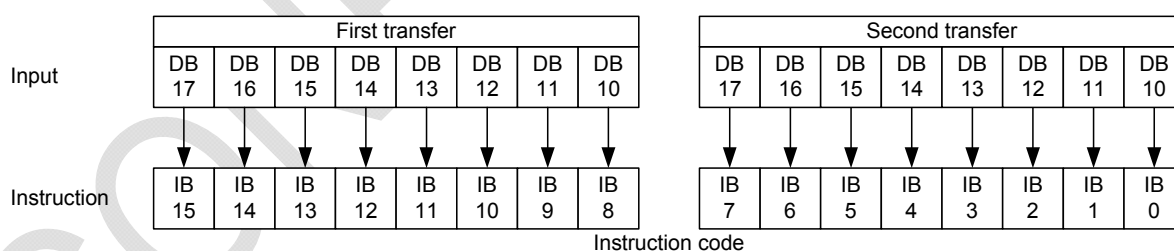


Figure 13 8-bit bus interface for 80-system

Instruction write



Device code read

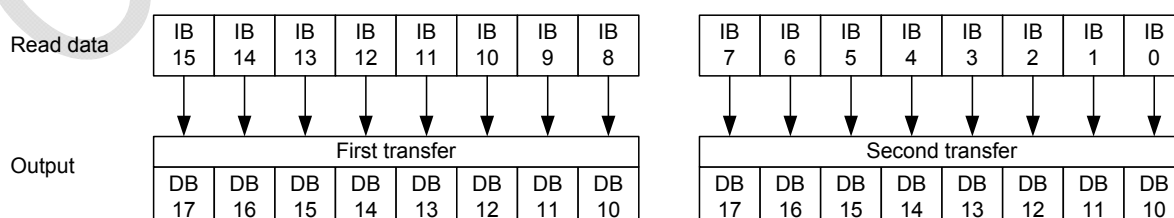
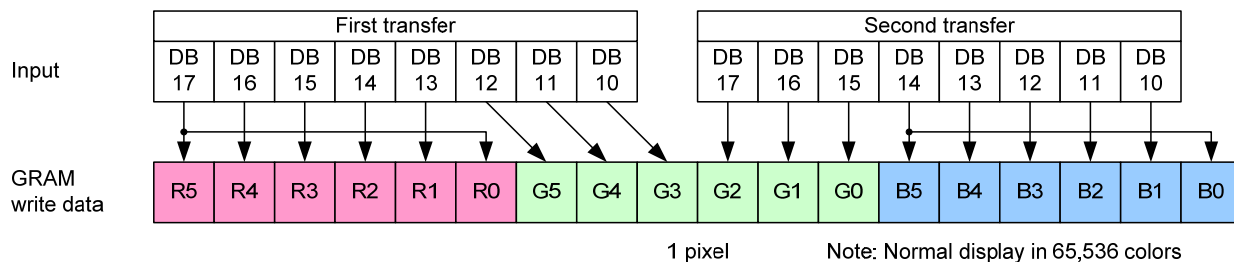
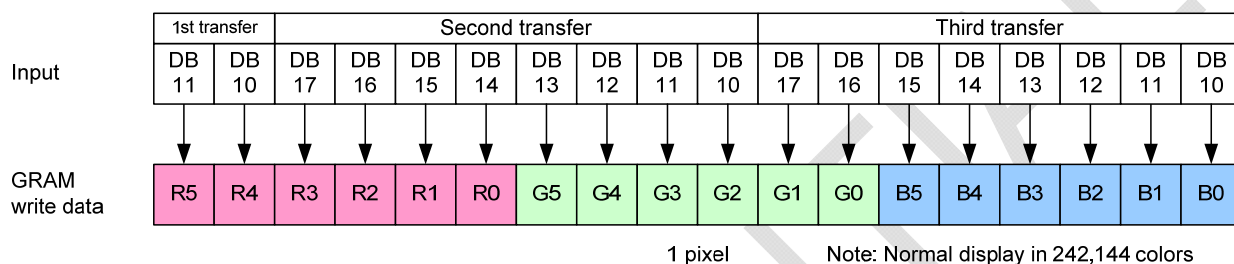


Figure 14 8-bit Interface Data Format (Instruction Write / Device Code Read)

RAM data write (2-transfer mode: TRIREG = 0)



RAM data write (3-transfer mode: TRIREG = 1, DFM = 0)



RAM data write (3-transfer mode: TRIREG = 1, DFM = 1)

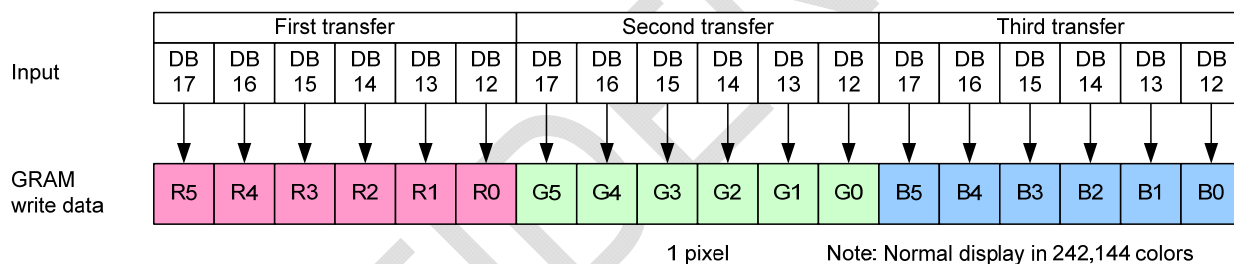
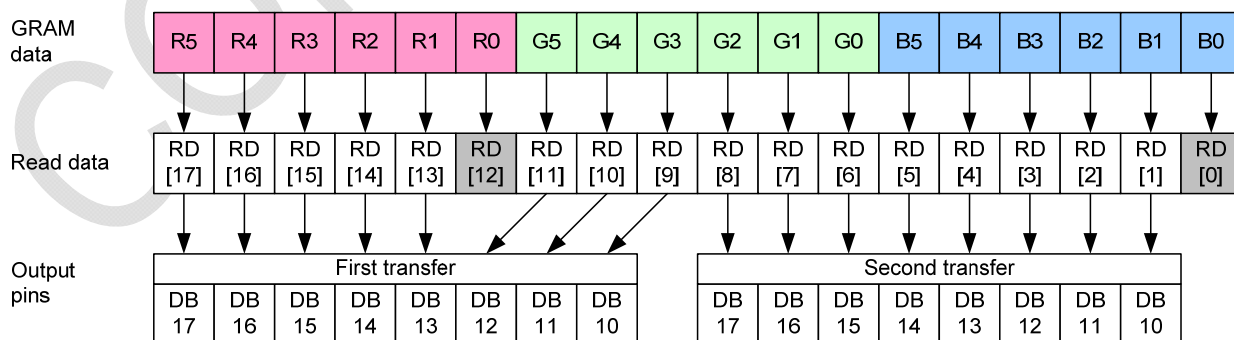


Figure 15 8-bit Interface Data Format (RAM Data Write)

RAM data read



Note: Data cannot be transferred in 3 times in read operation via 8-bit interface

Figure 16 8-bit Interface Data Format (RAM Data Read)

12.5 Serial Interface

The serial interface is selected by setting the IM3/2/1 pins to the IOGND/IOVCC/IOGND levels, respectively. The data is transferred via chip select line (nCS), serial transfer clock line (SCL), serial data input line (SDI), and serial data output line (SDO). In serial interface operation, the IM0/ID pin functions as the ID pin, and the DB17-0 pins, not used in this mode, must be fixed at either IOVCC or GND level.

The SPI interface operation enables from the falling edge of nCS and ends of data transfer on the rising edge of nCS. 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 RM68050.

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, RM68050 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 RM68050 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.

Table 14 Start Byte Format

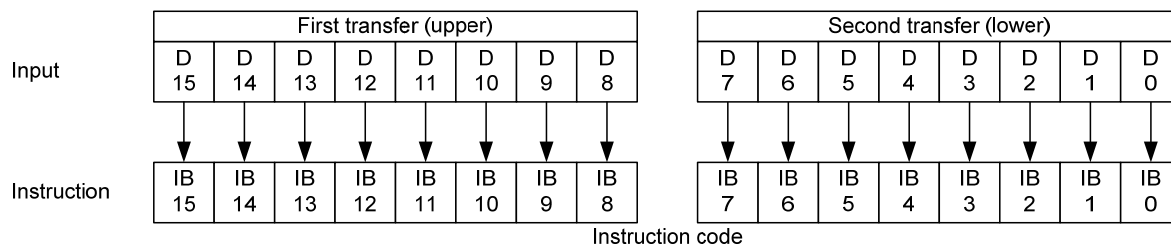
Transferred Bits	S	1	2	3	4	5	6	7	8
Start byte format	Transfer start	Device ID code						RS	R/W
		0	1	1	1	0	ID		

Note: The ID bit is determined by setting the IM0/ID pin.

Table 15 Functions of RS, R/W bits

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

Instruction



RAM data write

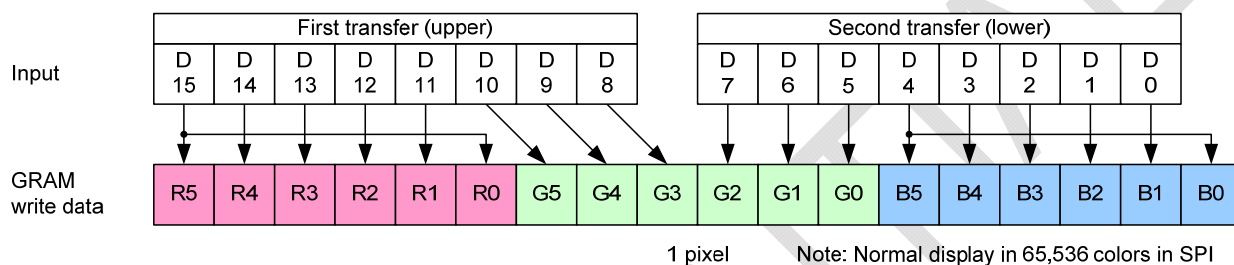
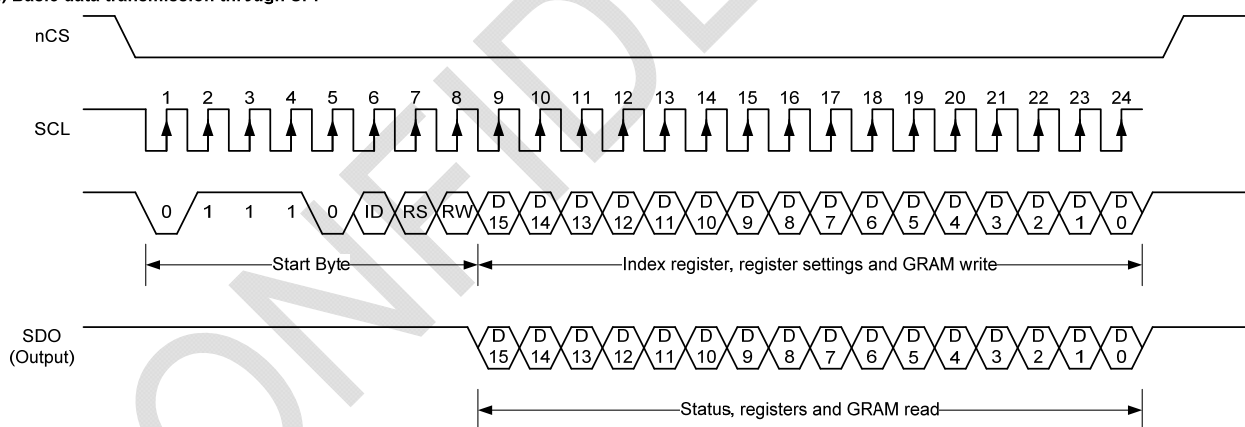
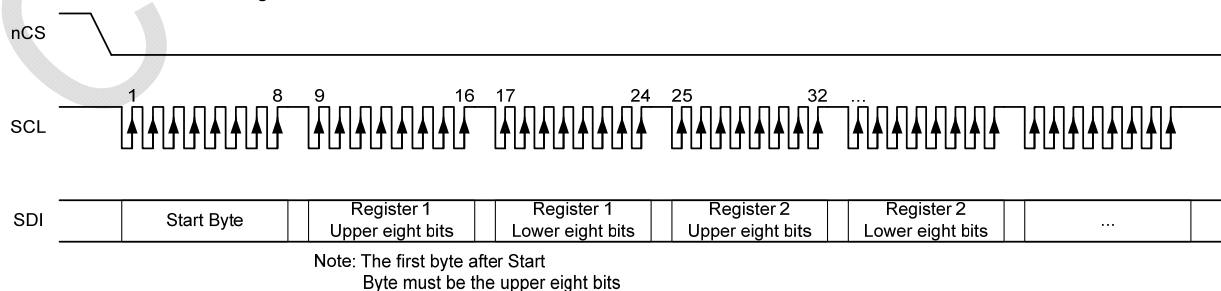


Figure 17 Serial Interface Data Format

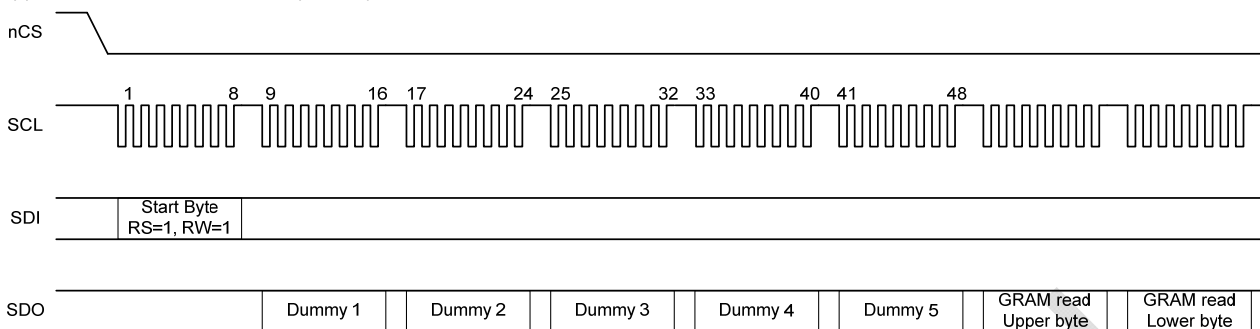
(a) Basic data transmission through SPI



(b) Consecutive transmission through SPI

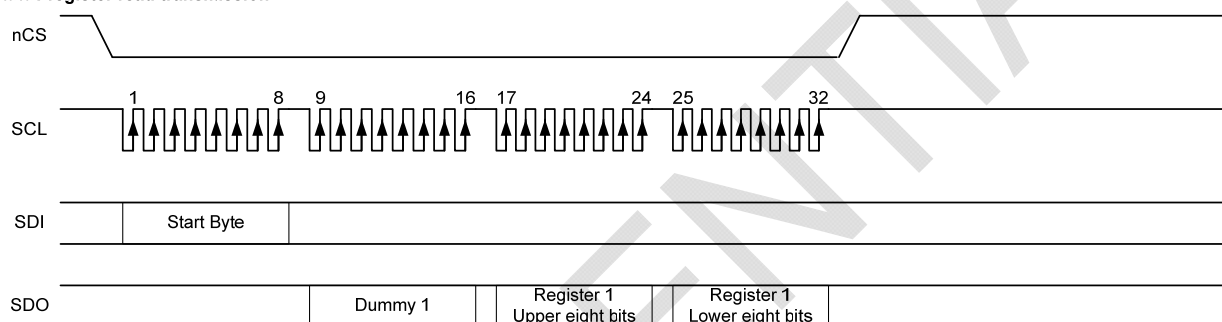


(c) GRAM data read transmission (TRI="0")



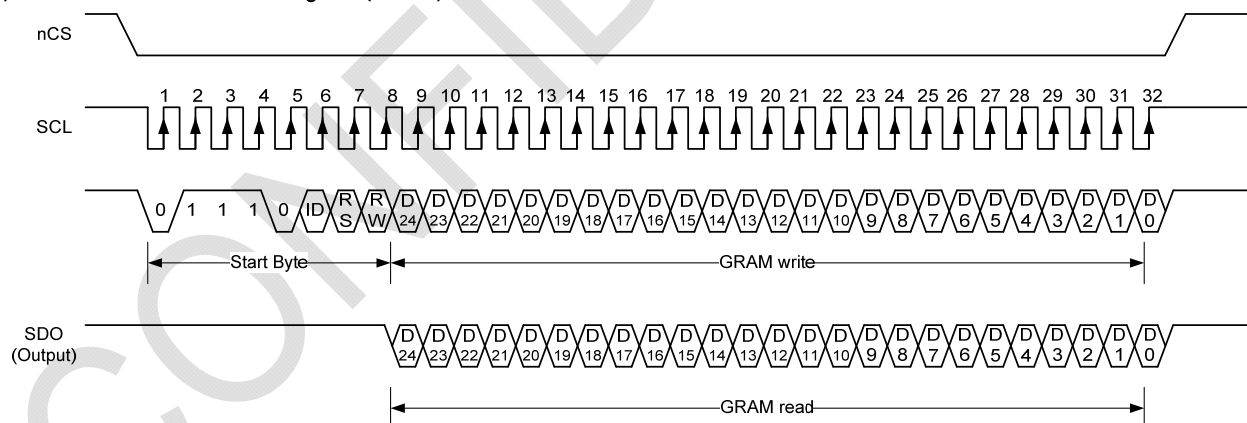
Note: Five bytes of dummy data are right after the Start Byte

(d) Status/register read transmission

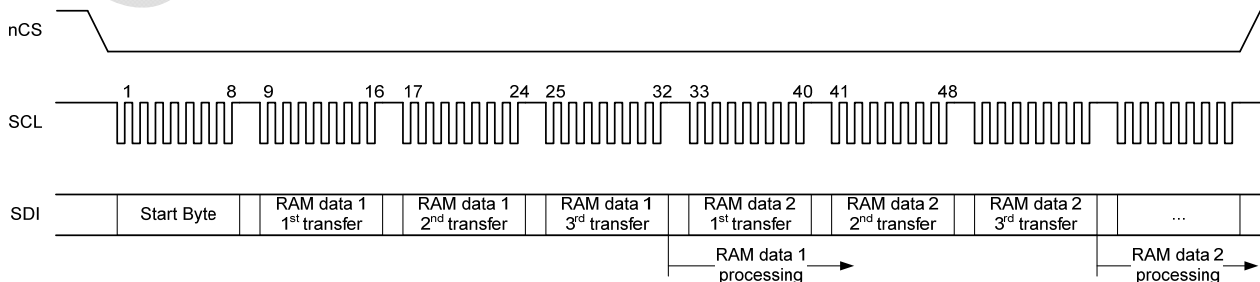


Note: One byte of dummy data is right after the Start Byte

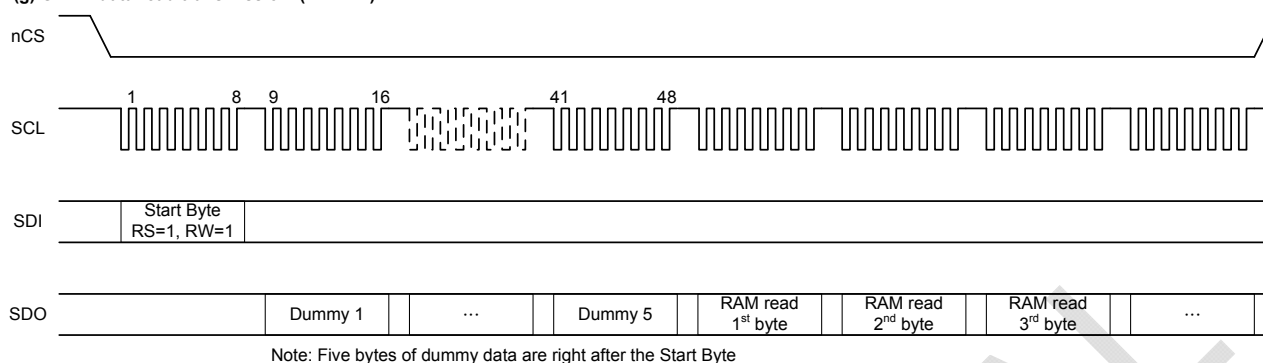
(e) Basic RAM data transmission through SPI (TRI="1")



(f) GRAM data write transmission through SPI (TRI="1")



(g) GRAM data read transmission (TRI="1")

**Figure 18 Data Transfer in Serial Interface**

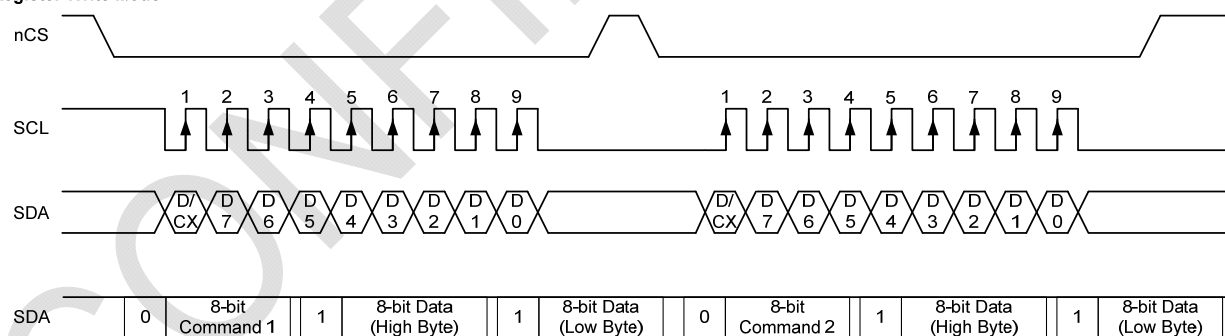
12.6 9-bit 3-wire Serial Interface

This SPI mode uses a 3-wire 9-bit serial interface. The chip-select nCS (active low) enables and disables the serial interface. SCL is the serial data clock and SDA is serial data.

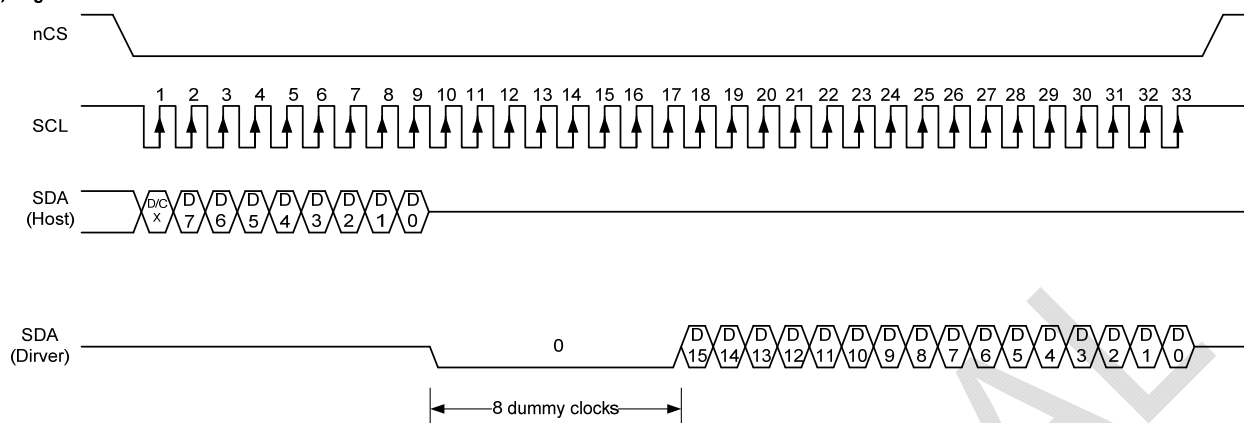
Serial data must be input to SDA in the sequence D/CX, D7 to D0. The RM68050 catches the data at the rising edge of SCL signal. The first bit of serial data D/CX is data/command flag. D/CX = "1" indicates that D7 to D0 bits are display RAM data or command parameters. D/CX = "0" indicates that D7 to D0 bits are commands.

When users need to read back the register or GRAM data, the register R66h must be set to "1" first, and then write the register index to read back the register or GRAM data.

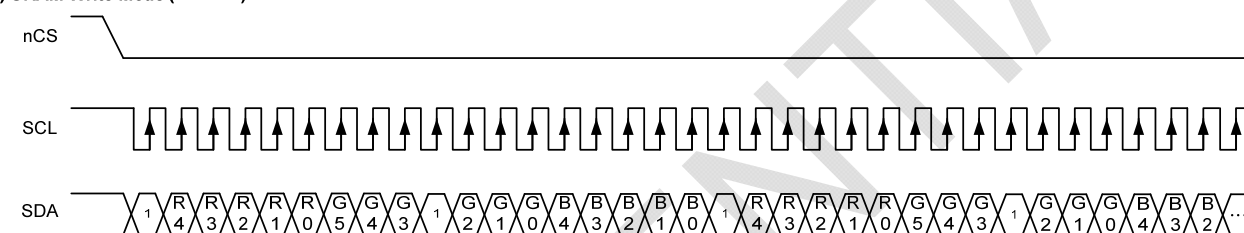
(a) Register Write Mode



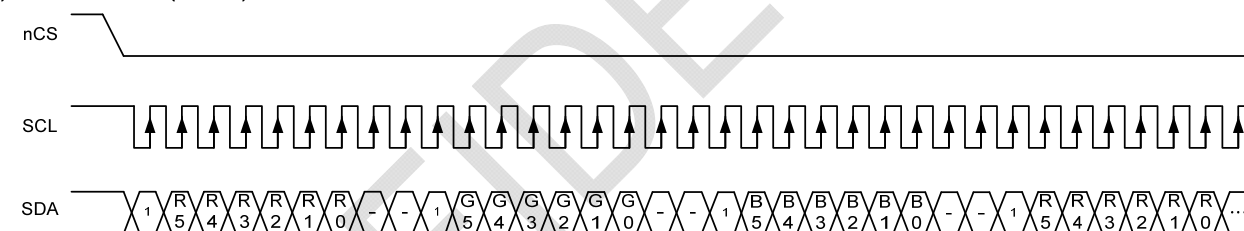
(b) Register Read Mode



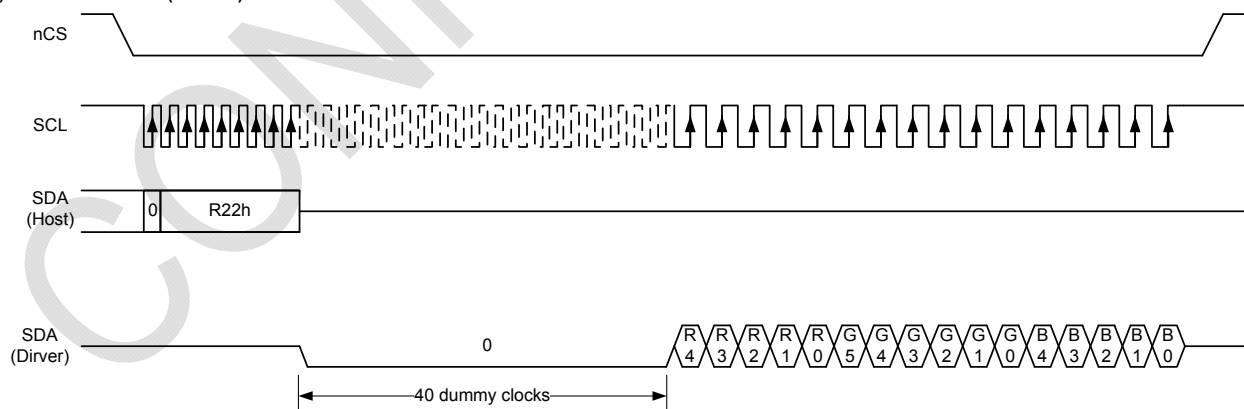
(c) GRAM Write Mode (TRI="0")



(d) GRAM Write Mode (TRI="1")



(e) GRAM Read Mode (TRI="0")



(f) GRAM Read Mode (TRI="1")

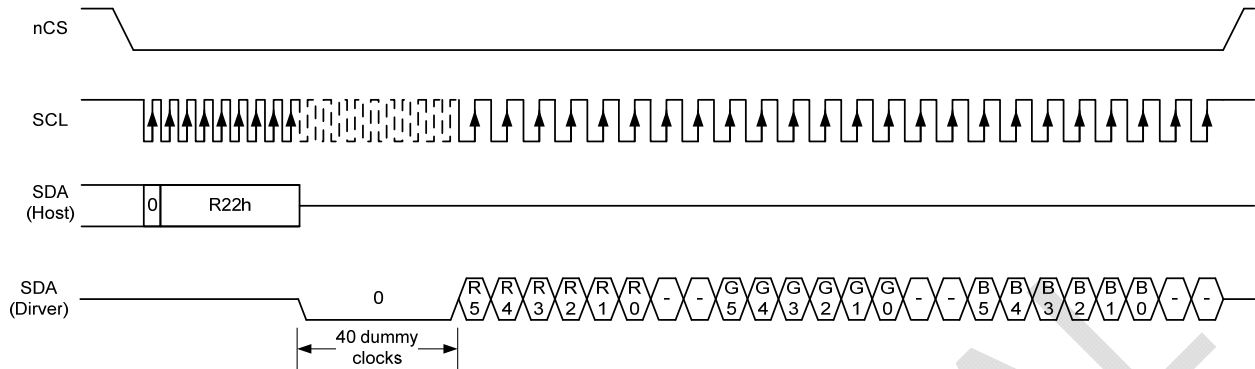


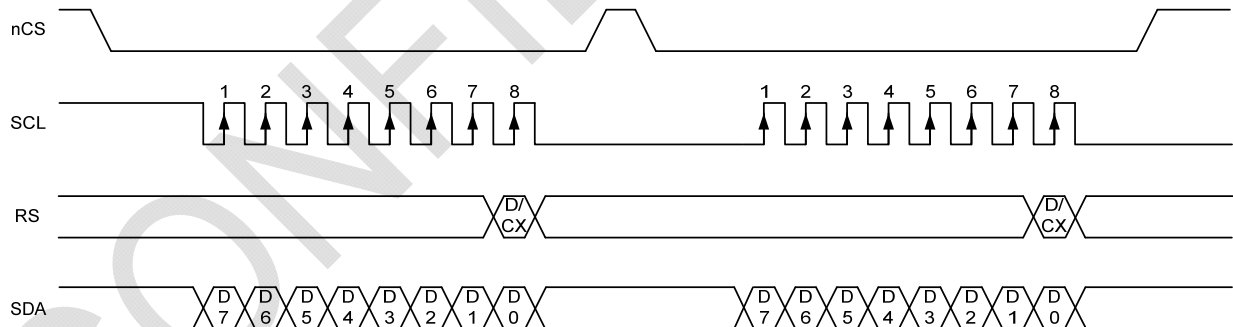
Figure 19 Data Transfer in 3-wire Serial Interface

12.7 8-bit 4-wire Serial Interface

This SPI mode uses a 4-wire 9-bit serial interface. The chip-select nCS (active low) enables and disables the serial interface. D/CX (input through RS pin) is the command or data select signal, SCL is the serial data clock and SDA is serial data.

Serial data must be input to SDA in the sequence D7 to D0. The RM68050 catches the data at the rising edge of SCL signal. The D/CX signal indicates data/command. D/CX = "1" indicates that D7 to D0 bits are display RAM data or command parameters. D/CX = "0" indicates that D7 to D0 bits are commands.

(a) Register Write Mode



Timing diagram for the I2C interface. The signals shown are:

- nCS**: Active low chip select signal.
- SCL**: Serial Clock signal.
- RS**: Active low reset signal.
- SDA**: Serial Data signal, showing a sequence of data bytes: R4, R3, R2, R1, R0, G5, G4, G3, G2, G1, G0, B4, B3, B2, B1, B0, R4, R3, R2, R1, R0, G5, G4, G3, G2, G1, G0, B4, B3, B2, B1, B0, ...

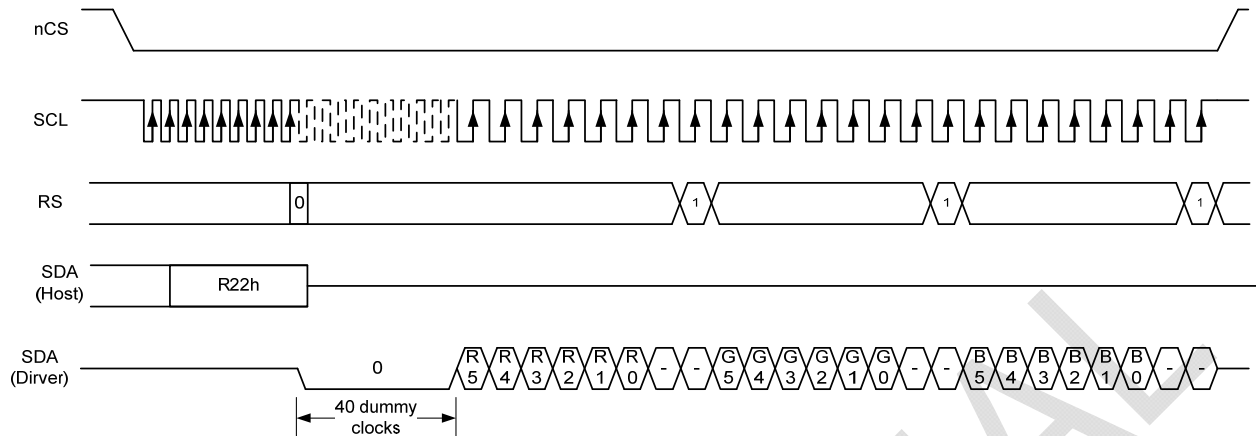
The diagram illustrates the timing of the I2C protocol. It shows four signals: nCS, SCL, RS, and SDA. nCS is high initially and then goes low. SCL is a continuous clock signal. RS shows four data transfer cycles, each with a '1' in the middle. SDA shows the data being transferred: 543210, 543210, B543210, B543210, 543210, and then an ellipsis.

The timing diagram shows the following signals and their states:

- nCS**: Active-low chip select, shown as a high signal.
- SCL**: Serial clock, shown as a series of pulses.
- RS**: Register select, shown as a signal that transitions from 0 to 1.
- SDA (Host)**: Serial data bus, shown as a signal that transitions from high to low and then back to high.
- SDA (Driver)**: Serial data bus, shown as a signal that transitions from high to low and then back to high.

The diagram also includes a label for the 40 dummy clock period, indicating the duration of the dummy clock signal.

(f) GRAM Read Mode (TR="1")



13. VSYNC Interface

RM68050 supports the VSYNC interface in synchronization with the frame-synchronizing signal VSYNC to display the moving picture with the system interface. When the VSYNC interface is selected to display a moving picture, the minimum GRAM update speed is limited and the VSYNC interface is enabled by setting DM[1:0] = "10" and RM = "0".

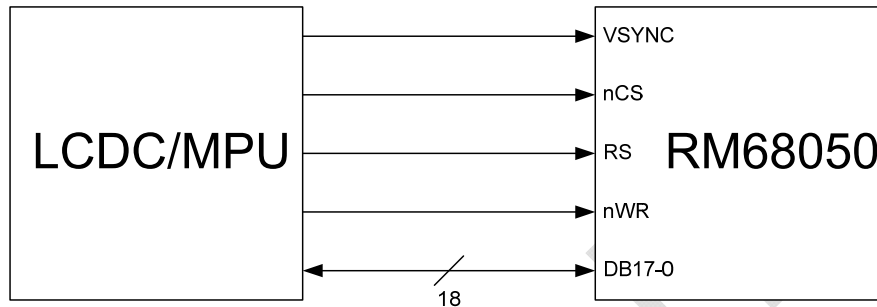


Figure 20 VSYNC Interface connection

In the VSYNC mode, the display operation is synchronized with the internal clock and VSYNC input and the frame rate is determined by the pulse rate of VSYNC signal. All display data are stored in GRAM to minimize total data transfer required for moving picture display.

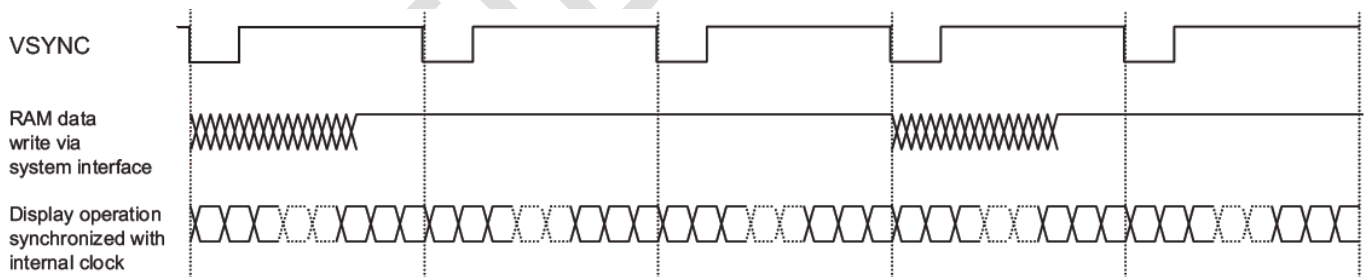


Figure 21 Moving Picture Data Transfers via VSYNC Interface

The VSYNC interface has the minimum for RAM data write speed and internal clock frequency, which must be more than the values calculated from the following formulas, respectively.

Internal clock frequency (fosc)[Hz]

$$= \text{FrameRate} \times (\text{DisplayLines(NL)} + \text{FrontPorch(FP)} + \text{BackPorch(BP)}) \times \text{ClocksPerLine(RTN)} \times \text{variance}$$

$$\text{RAM Write Speed(min.)[Hz]} > \frac{240 \times \text{DisplayLines(NL)}}{(\text{FrintPorch(FP)} + \text{BackPorch(BP)} + \text{DisplayLines(NL)} - \text{margins}) \times 16(\text{clocks}) \times \frac{1}{f_{\text{osc}}}}$$

Note: When RAM write operation is not started right after the falling edge of VSYNC, the time from the falling edge of VSYNC until the start of RAM write operation must also be taken into account.

An example of calculating minimum RAM writing speed and internal clock frequency in VSYNC interface operation is as follows.

[Example]

Panel Size	240 RGB x 320 lines (NL = 6'h27: 320 lines)
Total number of lines (NL)	320 lines
Black/front porch	14/2 lines (BP = 4'hE, FP = 4'h2)
Frame frequency	60 Hz

Internal clock frequency (fosc) [Hz]

$$= 60 \text{ Hz} \times (320 + 2 + 14) \text{ lines} \times 16 \text{ clocks} \times 1.1 / 0.9 = 394 \text{ kHz}$$

When calculate the internal clock frequency, the oscillator variation is needed to be taken into consideration. In the above example, the calculated internal clock frequency with $\pm 10\%$ margin variation is considered and ensures to complete the display operation within one VSYNC cycle. The causes of frequency variation come from fabrication process of LSI, room temperature, external resistors and VCI voltage variation.

Minimum speed for RAM writing [Hz]

$$> 240 \times 320 / \{((14 + 320 - 2) \text{ lines} \times 16 \text{ clocks}) \times 1/394 \text{ kHz}\} = 5.7 \text{ MHz}$$

The above theoretical value is calculated based on the premise that the RM68050 starts to write data into the internal GRAM on the falling edge of VSYNC. There must at least be a margin of 2 lines between the physical display line and the GRAM line address where data writing operation is performed. The GRAM write speed of 5.7MHz or more will guarantee the completion of GRAM write operation before the RM68050 starts to display the GRAM data on the screen and enable to rewrite the entire screen without flicker.

Notes:

1. The minimum GRAM 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 and vertical scroll functions are not available in VSYNC interface mode and set the AM bit to "0" to transfer display data.

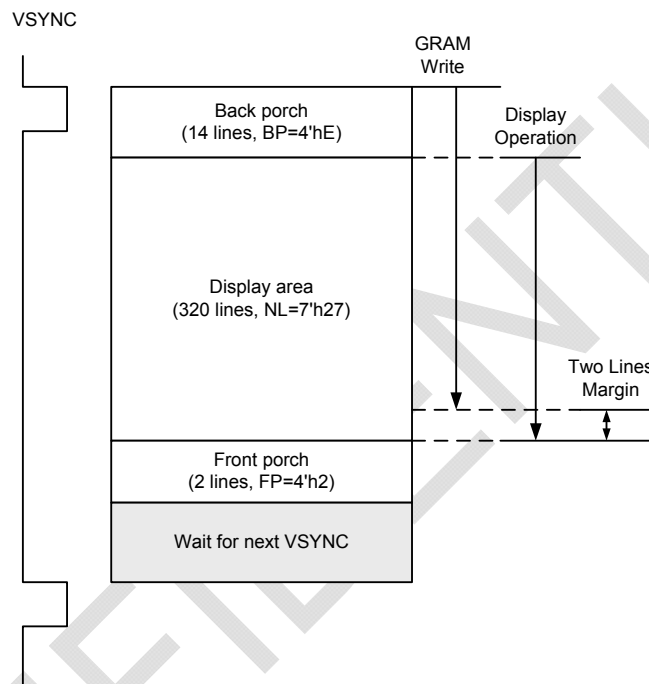
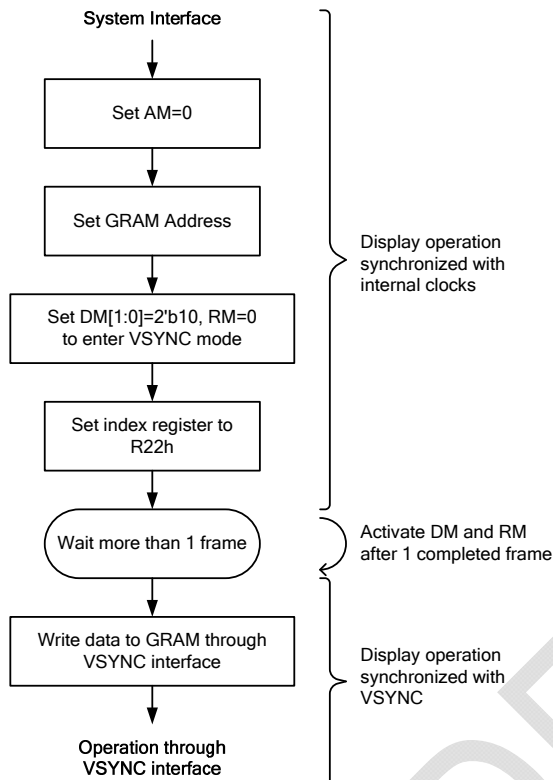


Figure 22 RAM Write Speed Margins

System Interface Mode à VSYNC Interface Mode



VSYNC Interface Mode à System Interface Mode

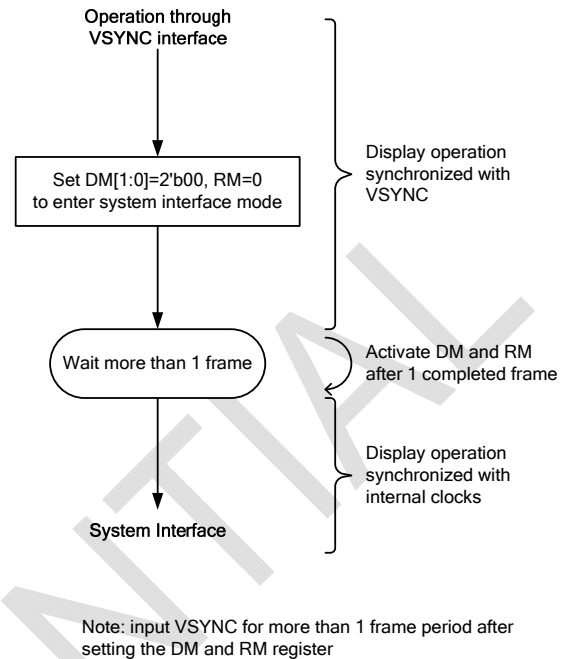


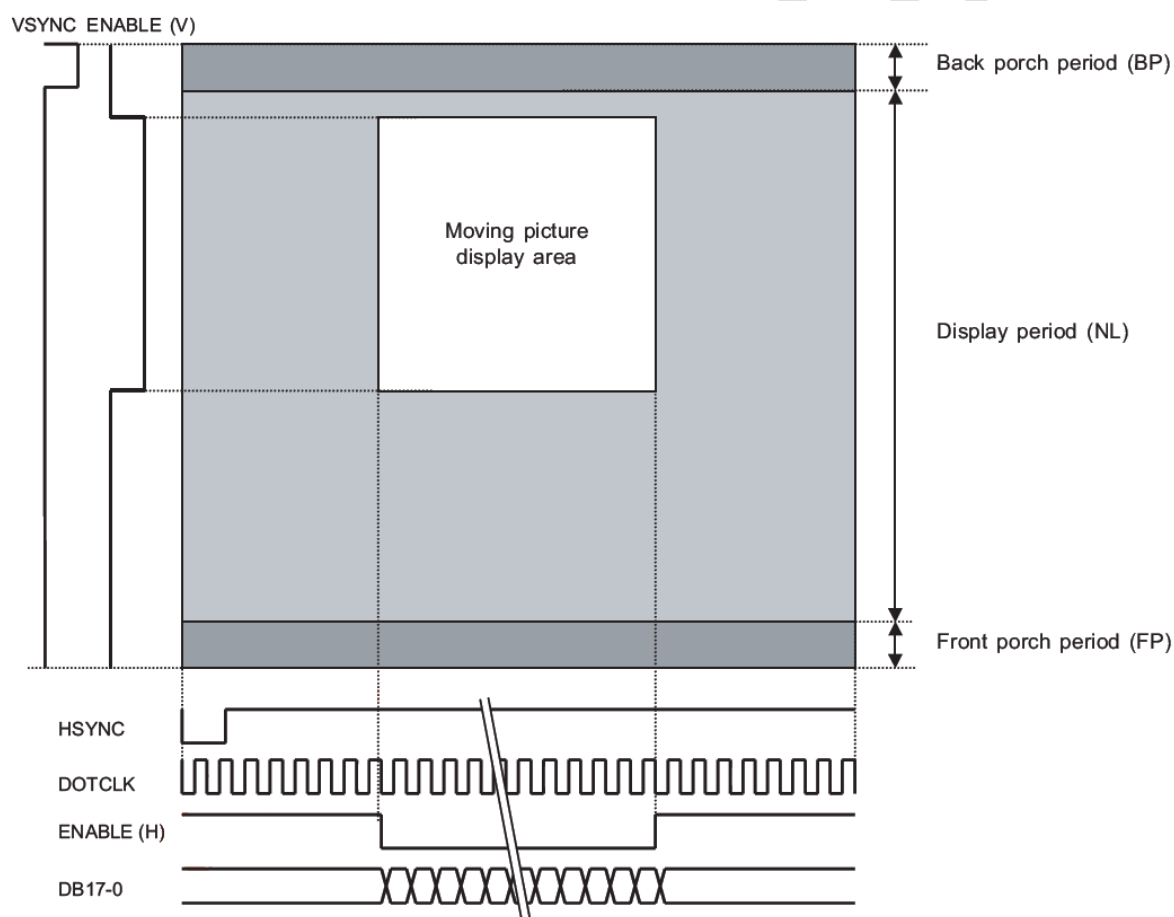
Figure 23 Sequences to Switch between VSYNC and Internal Clock Operation Modes

14. RGB Interface

The RM68050 supports the RGB interface. The interface format is set by RIM[1:0] bits. The internal RAM is accessible via RGB interface.

Table 16 RGB interface

RIM1	RIM0	RGB Interface	DB Pin
0	0	18-bit RGB interface	DB17-0
0	1	16-bit RGB interface	DB17-13, DB11-1
1	0	6-bit RGB interface	DB17-12
1	1	Setting inhibited	-



- Notes: 1. The front porch period continues until next VSYNC input is detected.
2. Make sure to match the VSYNC, HSYNC, and DOTCLK frequencies to the resolution of liquid crystal panel.

Figure 24 Display Operation via RGB Interface

14.1 RGB Interface Timing

The timing relationship of signals in RGB interface operation is as follows.

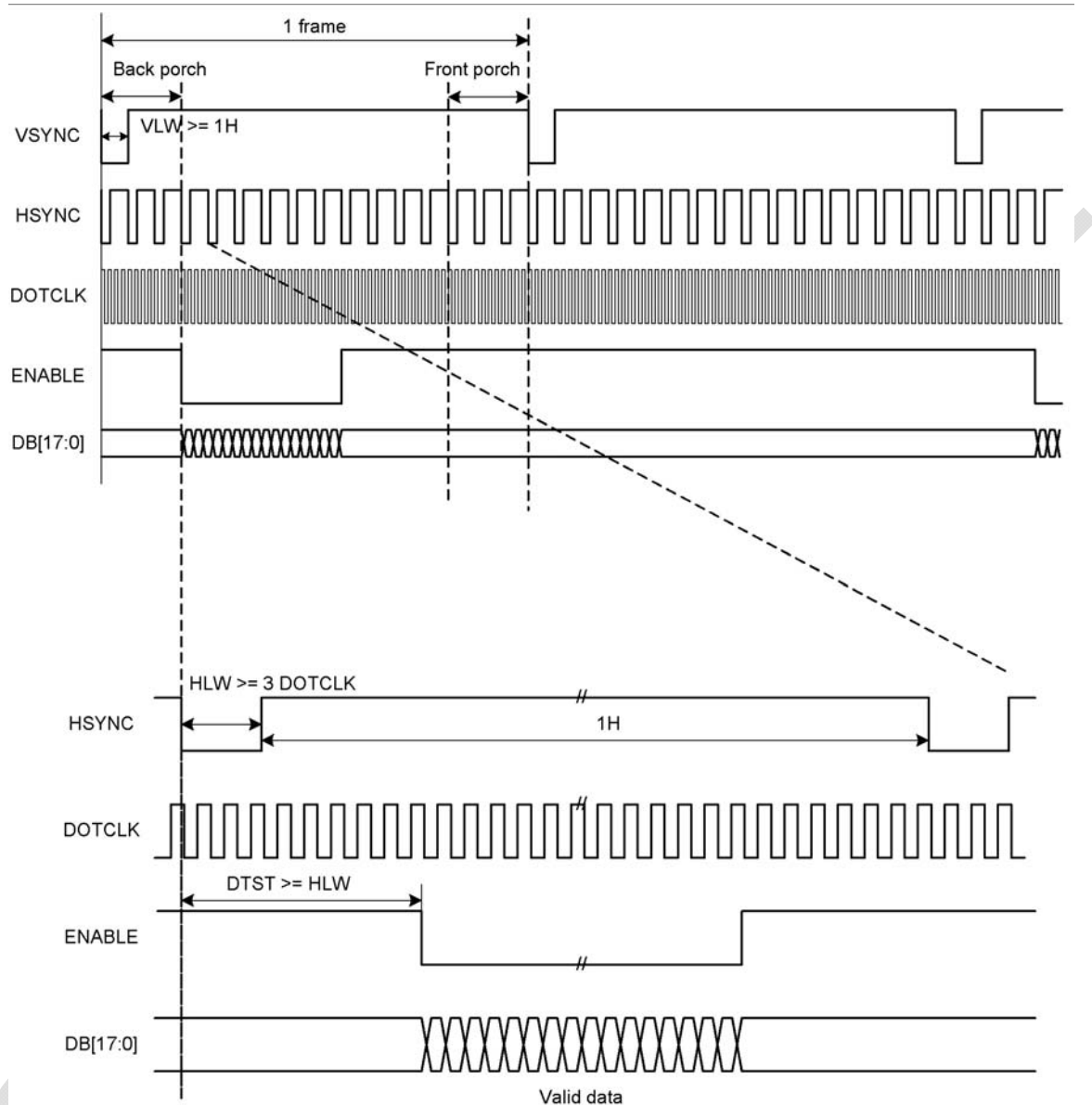


Figure 25 16-/18-bit RGB Interface Timing

Notes:

1. VLW: VSYNC Low period,
2. HLW: HSYNC Low period,
3. DTST: data transfer setup time

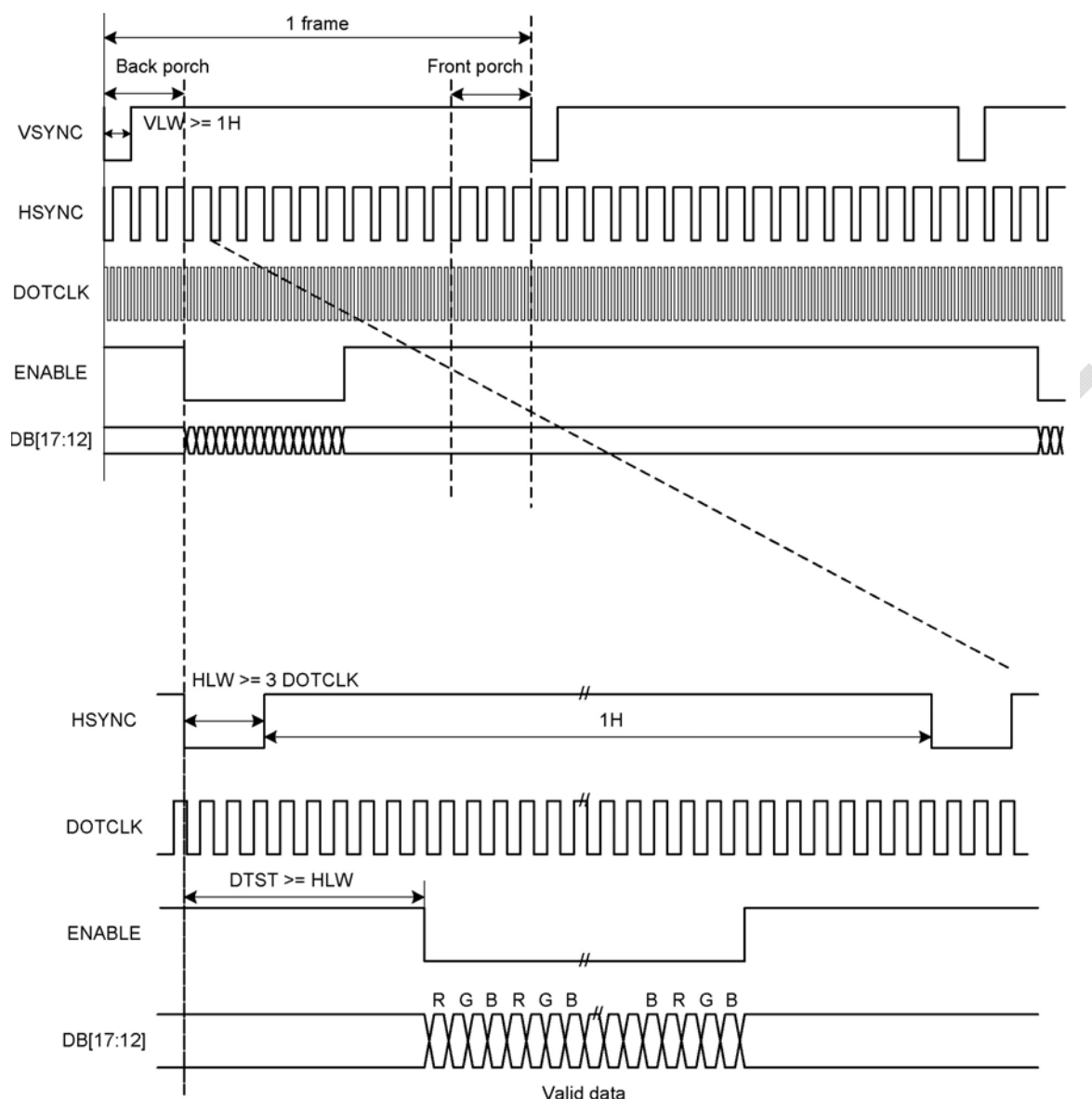


Figure 26 6-bit RGB Interface Timing

Notes:

1. VLW: VSYNC Low period,
2. HLW: HSYNC Low period,
3. DTST: data transfer setup time
4. In 6-bit RGB interface operation, set the VSYNC, HSYNC, ENABLE, DOTCLK cycles so that one pixel is transferred in units of three DOTCLKs via DB17-12.

14.2 Moving Pictures Mode

RM68050 has the RGB interface to display moving picture and incorporates GRAM to store display data, which has following advantages in displaying a moving picture.

- The window address function defined the update area of GRAM.
- Only the moving picture area of GRAM is updated.
- 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.

14.3 RAM access via system interface in RGB interface operation

RM68050 allows GRAM access via the system interface in RGB interface mode. In RGB interface mode, data are written to the internal GRAM in synchronization with DOTCLK and ENABLE signals. When write data to the internal GRAM by the system interface, set ENABLE to terminate the RGB interface and switch to the system interface to update the registers (RM = "0") and the still picture of GRAM. When restart RAM access in RGB interface mode, wait one read/write cycle and then set RM = "1" and the index register to 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 GRAM.

The following figure illustrates the operation of the RM68050 when displaying a moving picture via the RGB interface and rewriting the still picture RAM area via the system interface.

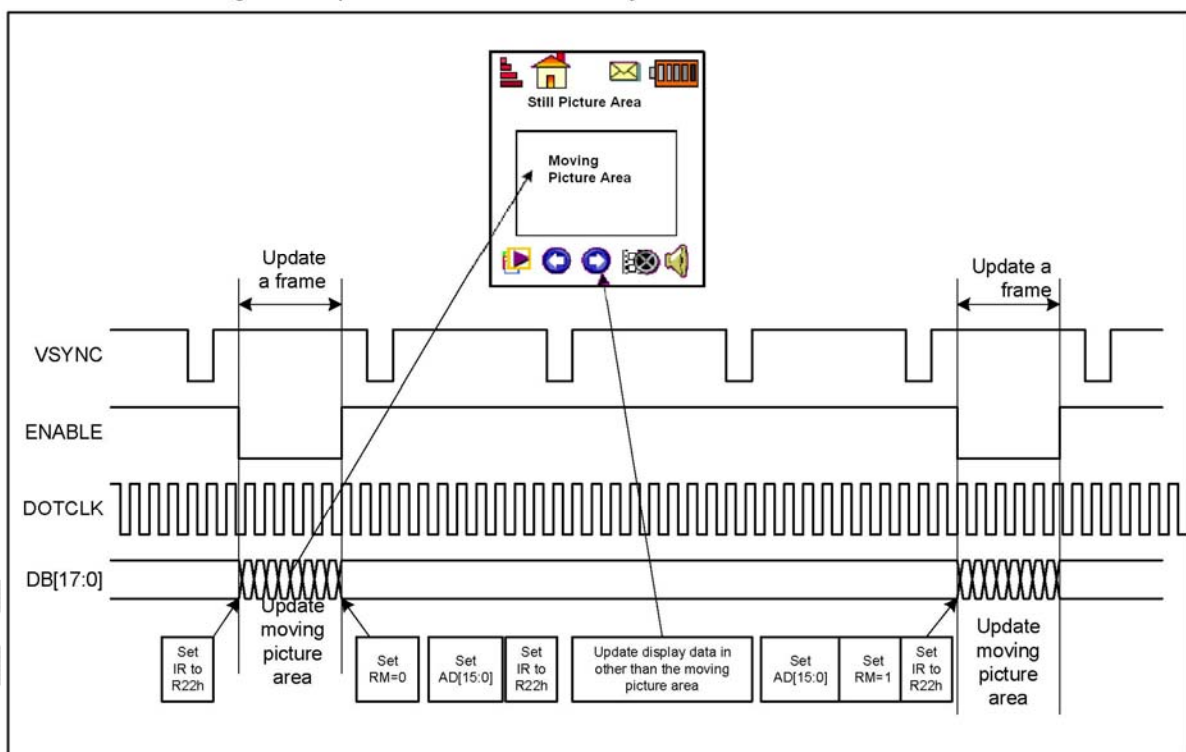


Figure 27 Updating the Still Picture Area while Displaying Moving Picture

14.4 6-bit RGB interface

The 6-bit RGB interface is selected by setting RIM[1:0] = 2'b10. The display operation is synchronized with VSYNC, HSYNC, and DOTCLK signals. The display data is transferred to the internal RAM in synchronization with the display operation via 6-bit port while data enable signal (ENABLE) allows RAM access via RGB interface. Unused pins DB11-0 (DB17-6) must be fixed at either IOVCC or IOGND level.

Instruction bits can be transferred only via system interface.

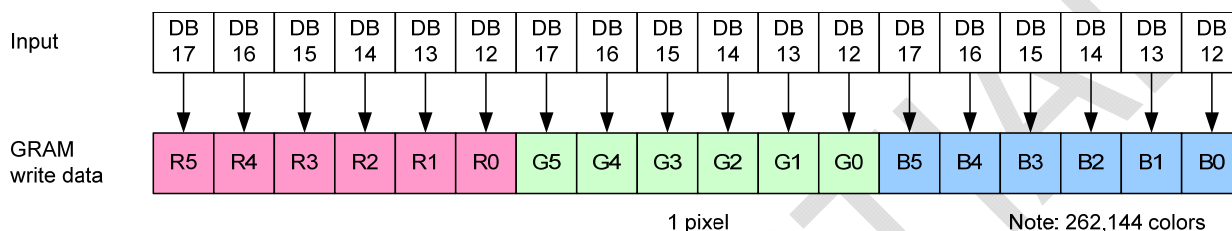


Figure 28 Example of 6-bit RGB Interface and Data Format

14.5 Data Transfer Synchronization in 6-bit Bus Interface Operation

The RM68050 has counters, which indicate the first, second, and third 6-bit transfer via 6-bit RGB interface. The counters are reset on the falling edge of VSYNC so that the data transfer will start from the first 6 bits of 18-bit RGB data from the next frame period. Accordingly, the data transfer via 6-bit interface can restart in correct order from the next frame period even if a mismatch occurs in transferring 6-bit data. This function can minimize the effect from data transfer mismatch and help the display system return to normal display operation when data is transferred consecutively in moving picture operation.

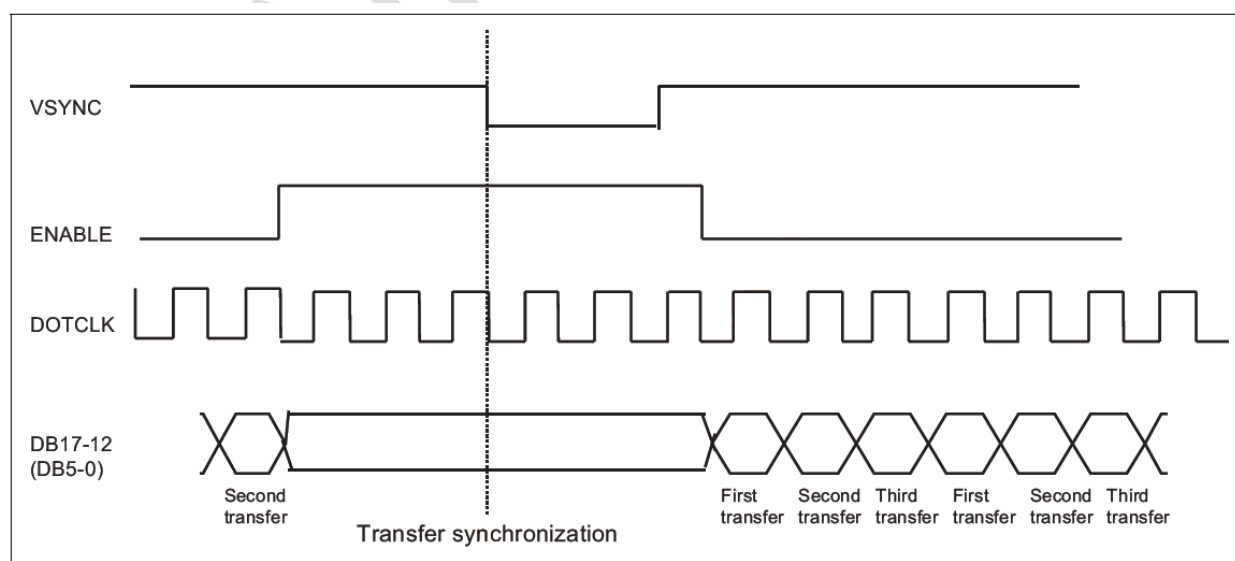


Figure 29 6-bit Transfer Synchronization

14.6 16-bit RGB interface

The 16-bit RGB interface is selected by setting RIM[1:0] = 2'b01. The display operation is synchronized with VSYNC, HSYNC, and DOTCLK signals. The display data is transferred to the internal RAM in synchronization with the display operation via 16-bit ports while data enable signal (ENABLE) allows RAM access via RGB interface.

Instruction bits can be transferred only via system interface.

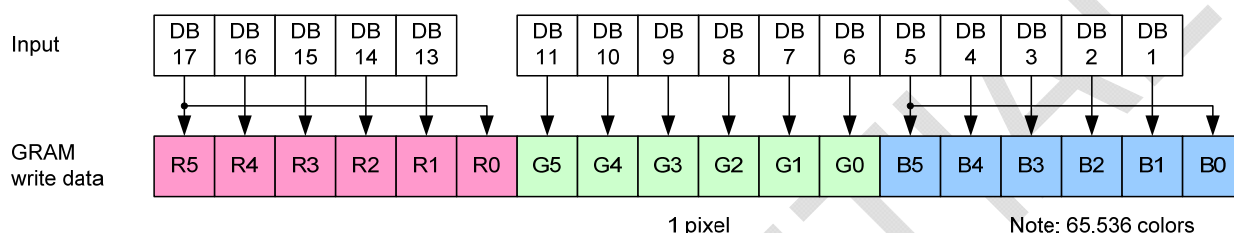


Figure 30 Example of 16-bit RGB Interface and Data Format

14.7 18-bit RGB interface

The 18-bit RGB interface is selected by setting RIM[1:0] = 2'b00. The display operation is synchronized with VSYNC, HSYNC, and DOTCLK signals. The display data is transferred to the internal RAM in synchronization with the display operation via 18-bit ports (DB17-0) while data enable signal (ENABLE) allows RAM access via RGB interface.

Instruction bits can be transferred only via system interface.

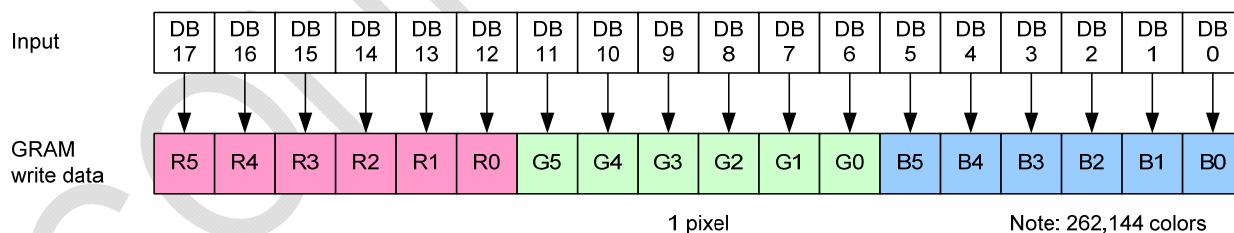


Figure 31 Example of 18-bit RGB Interface and Data Format

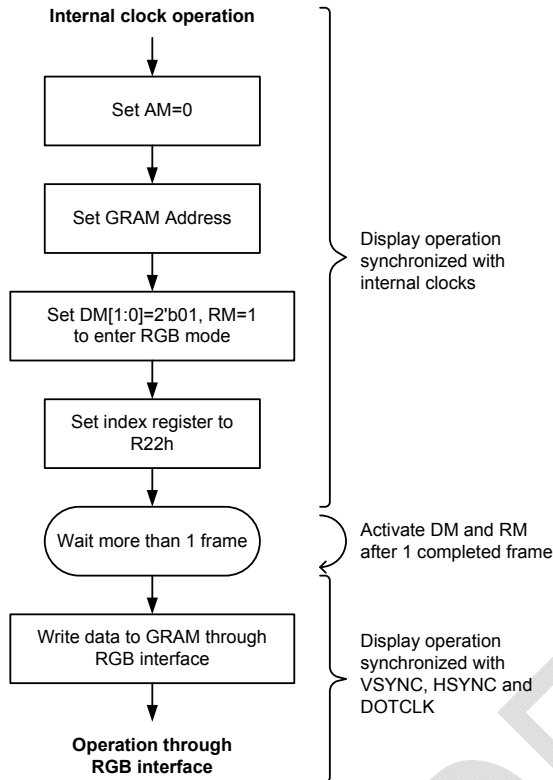
14.8 Notes to external display interface operation

- The following functions are not available in external display interface operation.

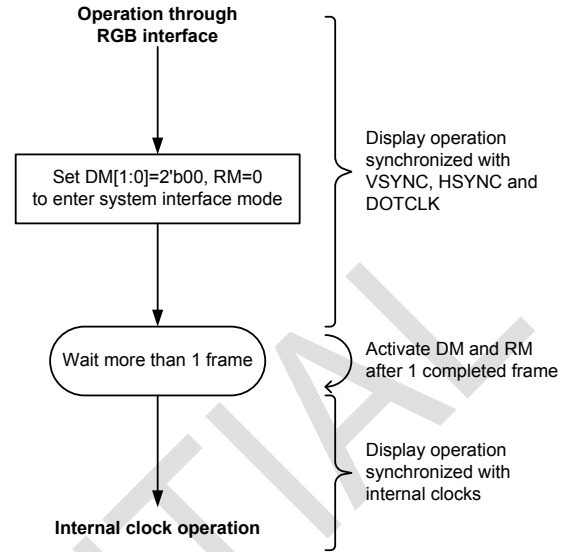
Function	External Display Interface	Internal Display Operation
Partial display	Not available	Available
Scroll function	Not available	Available

2. The VSYNC, HSYNC, and DOTCLK signals must be supplied during display period.
3. The period set with the NOWE[1:0] bits (gate output non-overlap period) is not based on the internal clock but based on DOTCLK in RGB interface mode.
4. In 6-bit RGB interface mode, each of RGB dots is transferred in synchronization with a DOTCLK input. In other words, it takes 3 DOTCLK inputs to transfer one pixel. Be sure to complete data transfer in units of 3 DOTCLK inputs in 6-bit RGB interface mode.
5. In 6-bit RGB interface mode, data of one pixel, which consists of RGB dots, are transferred in units of 3 DOTCLK. Accordingly, set the cycle of each signal in 6-bit interface mode (VSYNC, HSYNC, ENABLE, DB[17:0]) to contain DOTCLK inputs of a multiple of 3 to complete data transfer in units of pixels.
6. When switching from the internal operation mode to the RGB Input Interface mode, or the other way around, follow the sequence below.
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[15:0]) is set in the address counter every frame on the falling edge of VSYNC.

Internal Clock Operation → RGB Interface



RGB Interface → Internal Clock Operation



Note: input VSYNC, HSYNC and DOTCLK before setting the DM and RM register

Figure 32 RGB and Internal Clock Operation Mode Switching Sequences

15. Partial Display Function

The RM68050 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:

Partial image 1 display instruction		Partial image 2 display instruction		Other instruction	
PTDE0	1	PTDE1	1	BASEE	0
PTSA0[8:0]	9'h000	PTSA1[8:0]	9'h020	NL[5:0]	6'h27
PTEA0[8:0]	9'h00F	PTEA1[8:0]	9'h02F		
PTDP0[8:0]	9'h080	PTDP1[8:0]	9'h0C0		

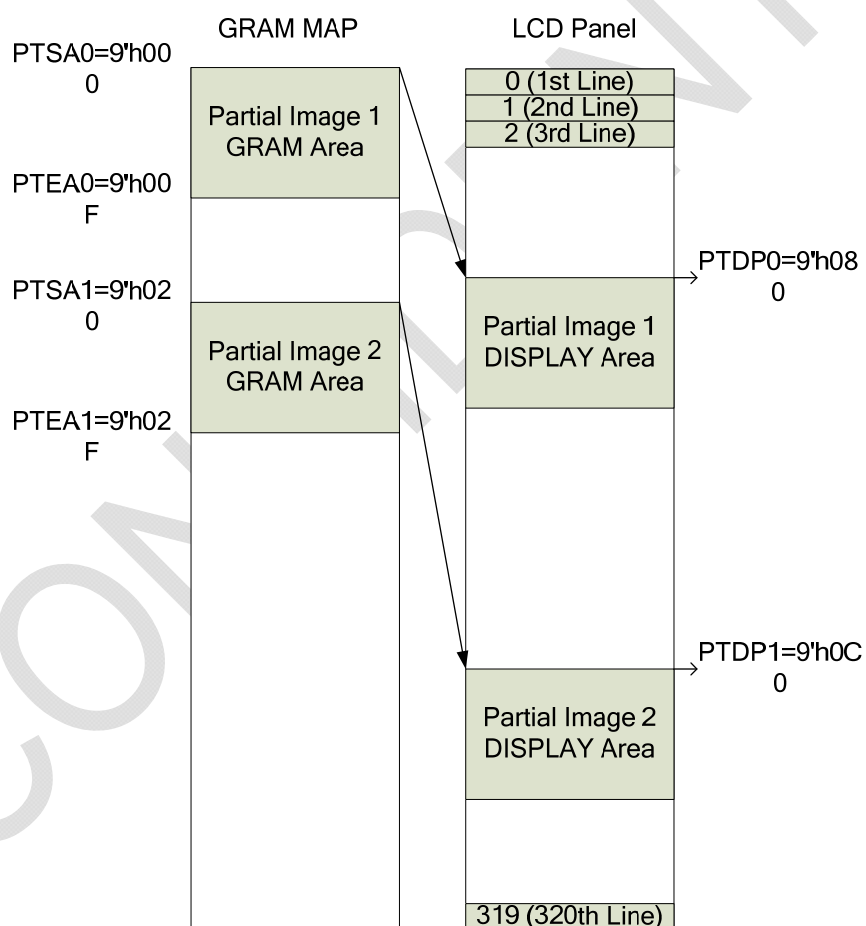


Figure 33 Partial Display example

16.Window Address Function

The window address function enables writing display data consecutively in a rectangular area (a window address area) made in the internal RAM. The window address area is made by setting the horizontal address register (start: HSA7-0, end: HEA 7-0 bits) and the vertical address register (start: VSA8-0, end: VEA8-0 bits). The AM and I/D bits set the transition direction of RAM address (increment or decrement, horizontal or vertical, respectively). Setting these bits enables the RM68050 to write data including image data consecutively without taking the data wrap position into account.

The window address area must be made within the GRAM address map area. Also, the AD16-0 bits (RAM address set register) must be set to an address within the window address area.

	Window address area setting range	RAM address area setting range
Horizontal direction	$8'h00 \leq HSA \leq HEA \leq 8'hEF$	$HSA \leq AD[7:0] \leq HEA$
Vertical direction	$9'h000 \leq VSA \leq VEA \leq 9'h13F$	$VSA \leq AD[16:8] \leq VEA$

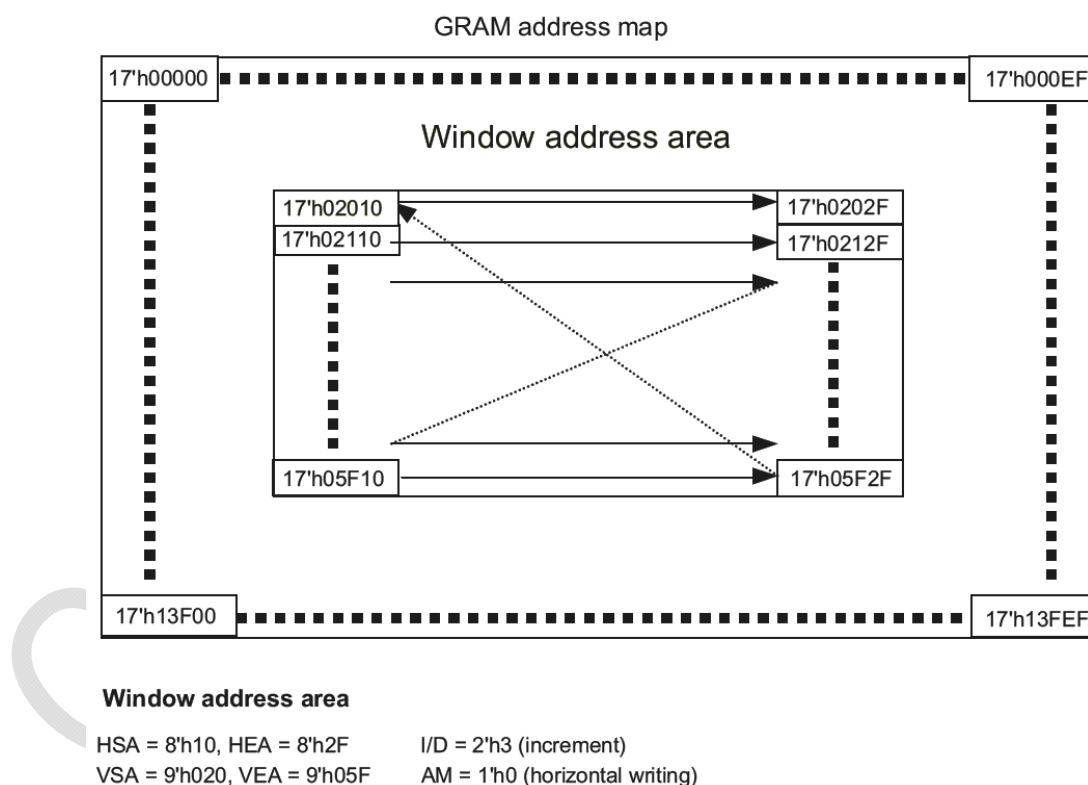
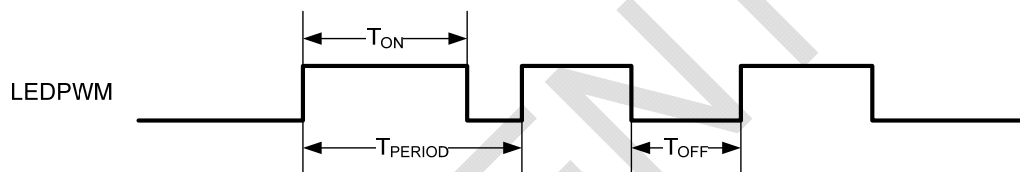


Figure 34 Automatic address update within a Window Address Area

17. CABC (Content Adaptive Brightness Control)

RM68050 provide a dynamic backlight control function as CABC (Content adaptive brightness control) to reduce the power consumption of the luminance source. RM68050 will refer the gray scale content of display image to output a PWM waveform to LED driver for backlight brightness control. Content adaptation means that the content of gray sale can be increased while simultaneously lowering brightness of the backlight to achieve the same perceived brightness. The adjusted gray level scale and thus the power consumption reduction depend on the content of the image.

RM68050 can calculate the backlight brightness level and send a PWM pulse to LED driver via LEDPWM pin for backlight brightness control purpose. The figure in the following is the basic timing diagram which is applied RM68050 to control LED driver.



18. γ Correction Function

The RM68050 supports γ -correction function to display in 262,144 colors simultaneously using gradient adjustment, amplitude-adjustment, and fine-adjustment registers. Each register consists of positive-polarity register and negative-polarity register to allow optimal gamma correction setting for the characteristics of the panel by enabling different settings for positive and negative polarities.

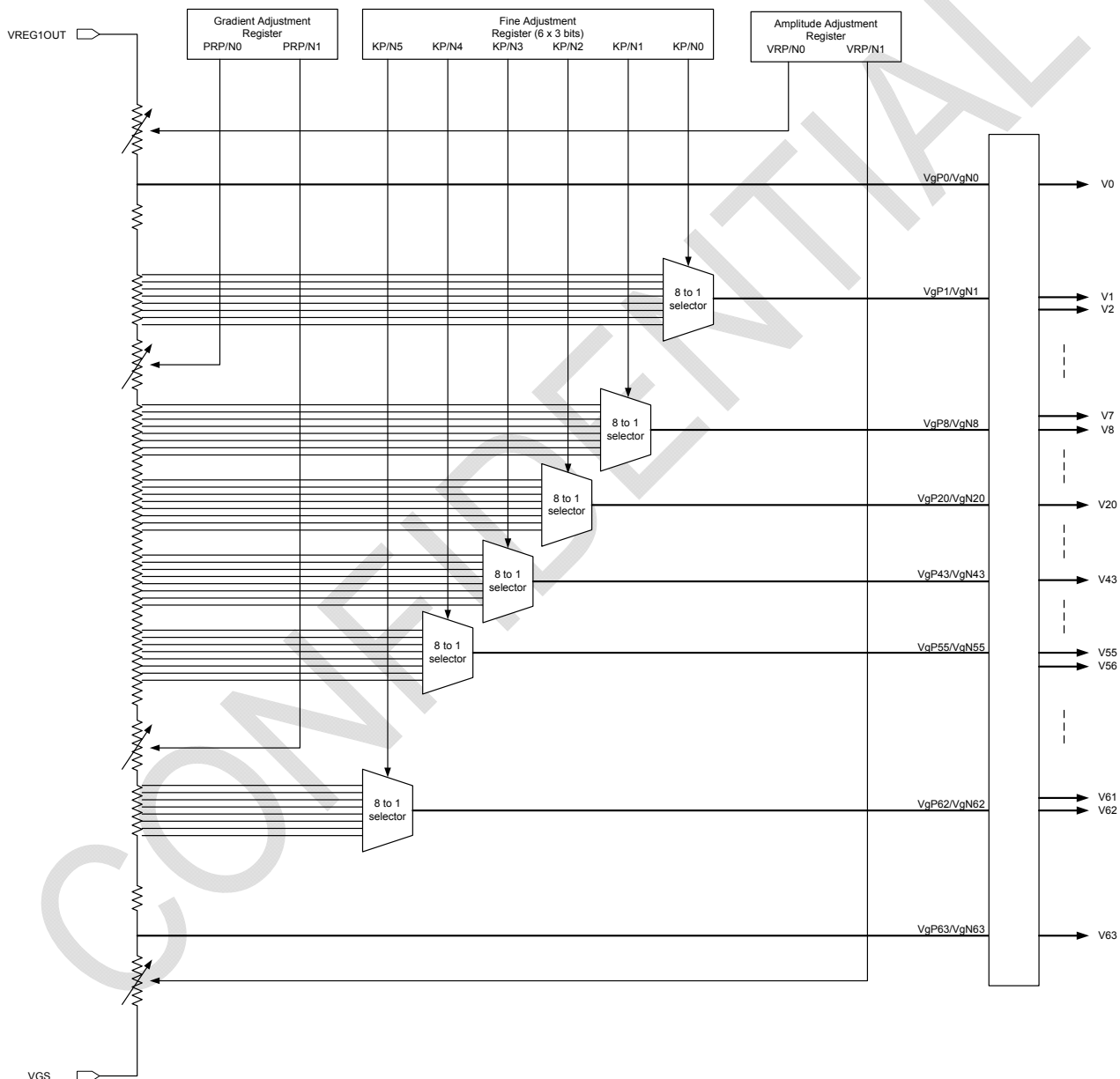


Figure 35 Structure of gamma correction function

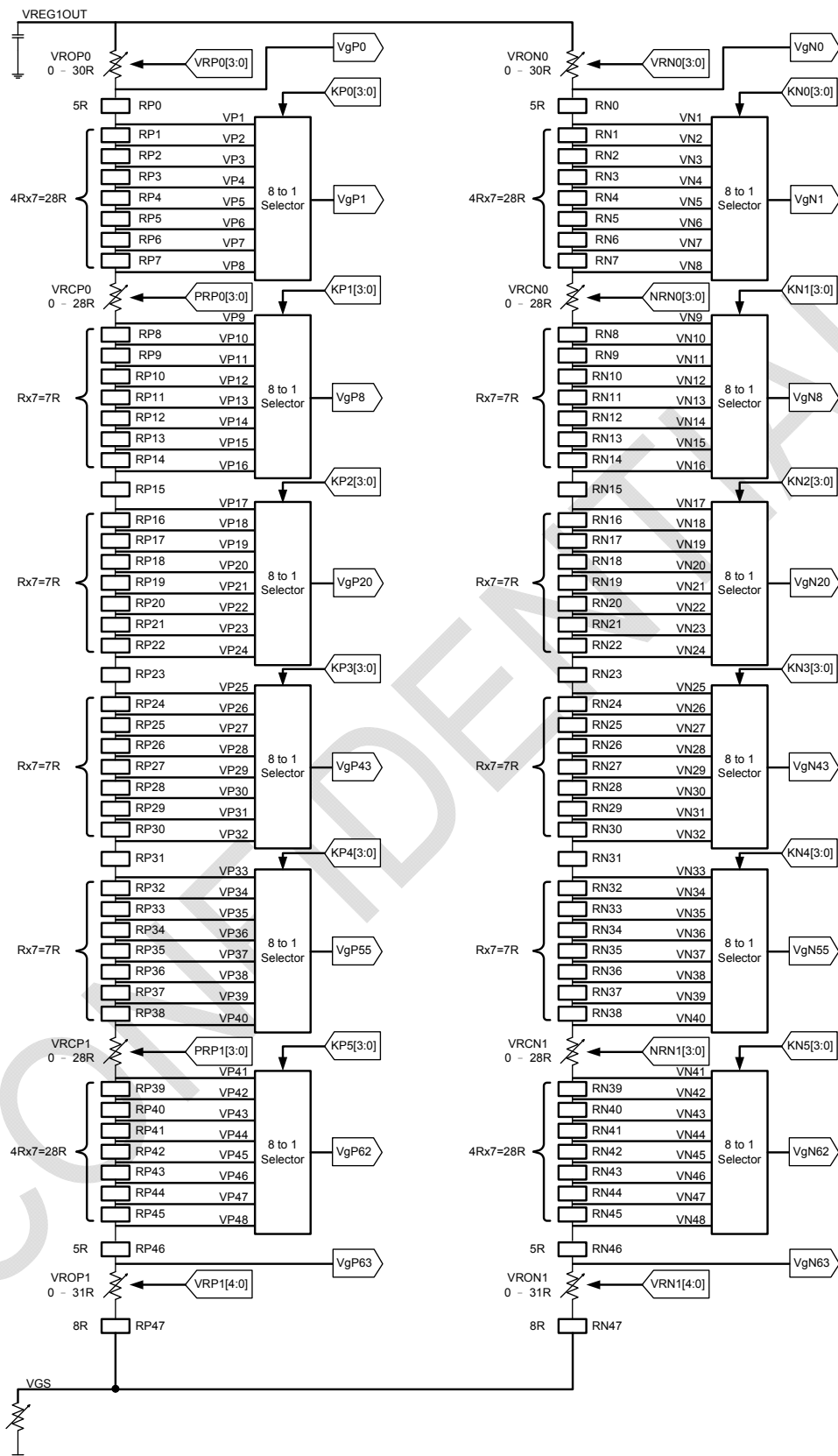


Figure 36 Grayscale Voltage Adjustment

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 bottom of the ladder resistor are adjusted. Same as the gradient registers, the amplitude adjustment registers consist of positive and negative polarity registers.

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 levels, 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.

Register	Positive	Negative	Function
Gradient	PRP0 [2:0]	PRN1 [2:0]	Variable resistor VRCP0, VRCN0
	PRP1 [2:0]	PRN0 [2:0]	Variable resistor VRCP1, VRCN1
Amplitude	VRP0 [4:0]	VRN1 [4:0]	Variable resistor VROP0, VRON0
	VRP1 [4:0]	VRN0 [4:0]	Variable resistor VROP1, VRON1
Fine adjustment	KP0 [2:0]	KN5 [2:0]	8-to-1 selector (voltage level of V1)
	KP1 [2:0]	KN4 [2:0]	8-to-1 selector (voltage level of V8)
	KP2 [2:0]	KN3 [2:0]	8-to-1 selector (voltage level of V20)
	KP3 [2:0]	KN2 [2:0]	8-to-1 selector (voltage level of V43)
	KP4 [2:0]	KN1 [2:0]	8-to-1 selector (voltage level of V55)
	KP5 [2:0]	KN0 [2:0]	8-to-1 selector (voltage level of V62)

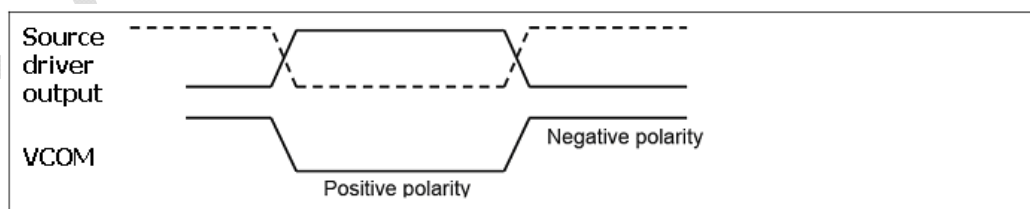


Figure 37 Source output waveform and VCOM polarity relationship

18.1 Ladder resistors and 8-to-1 selector Block configuration

The reference voltage generating 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 characteristics of panels.

18.2 Variable resistors

RM68050 uses variable resistors for 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]	VRCP(N)0/1	VRP(N)0[3:0]	VROP(N)0	VRP(N)0[4:0]	VROP(N)0
3'h0	0R	4'h0	0R	5'h00	0R
3'h1	4R	4'h1	2R	5'h01	1R
3'h2	8R	4'h2	4R	5'h02	2R
3'h3	12R	...	...	...	...
3'h4	16R	4'hD	26R	5'h1D	29R
3'h5	20R	4'hE	28R	5'h1E	30R
3'h6	24R	4'hF	30R	5'h1F	31R
3'h7	28R				

18.3 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													
KP(N)[2:0]	VgP(N)1		VgP(N)8		VgP(N)20		VgP(N)43		VgP(N)55		VgP(N)62		
	voltage	resistor	voltage	resistor	voltage	resistor	voltage	resistor	voltage	resistor	voltage	resistor	
3'h0	VP(N)1	0R	VP(N)9	0R	VP(N)17	0R	VP(N)25	0R	VP(N)33	0R	VP(N)41	0R	
3'h1	VP(N)2	4R	VP(N)10	1R	VP(N)18	1R	VP(N)26	1R	VP(N)34	1R	VP(N)42	4R	
3'h2	VP(N)3	8R	VP(N)11	2R	VP(N)19	2R	VP(N)27	2R	VP(N)35	2R	VP(N)43	8R	
3'h3	VP(N)4	12R	VP(N)12	3R	VP(N)20	3R	VP(N)28	3R	VP(N)36	3R	VP(N)44	12R	
3'h4	VP(N)5	16R	VP(N)13	4R	VP(N)21	4R	VP(N)29	4R	VP(N)37	4R	VP(N)45	16R	
3'h5	VP(N)6	20R	VP(N)14	5R	VP(N)22	5R	VP(N)30	5R	VP(N)38	5R	VP(N)46	20R	
3'h6	VP(N)7	24R	VP(N)15	6R	VP(N)23	6R	VP(N)31	6R	VP(N)39	6R	VP(N)47	24R	
3'h7	VP(N)8	28R	VP(N)16	7R	VP(N)24	7R	VP(N)32	7R	VP(N)40	7R	VP(N)48	28R	

19. Power-Supply Generating Circuit

19.1 Voltage Setting Pattern Diagram

The following are the diagrams of voltage generation in the RM68050 and the TFT display application voltage waveforms and electrical potential relationship.

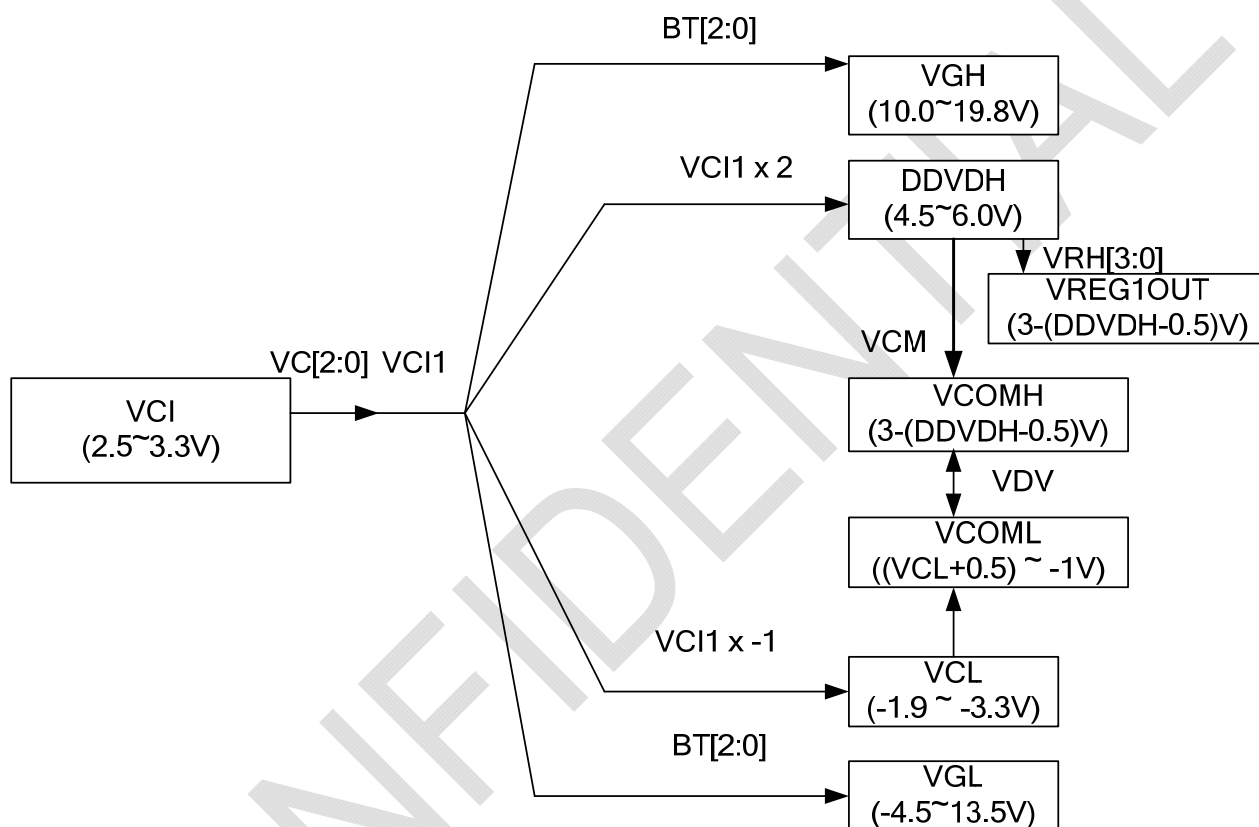


Figure 38 Diagram of voltage generation

Notes:

1. The DDVDH, VGH, VGL, and VCL output voltages will become lower than their theoretical levels (ideal voltages) due to current consumption at each output level. Make sure that output voltage level in operation maintains the following relationship: $(DDVDH - VREG1OUT) \geq 0.5V$, $(VCOML - VCL) > 0.5V$. Also make sure $VGH - VGL \leq 28V$, $VCI - VCL \leq 6V$. When the alternating cycle of VCOM is high (e.g. polarity inverts every line cycle), current consumption will increase. In this case, check the voltage before use.
2. In operation, setting voltages within the respective voltage ranges are recommended.

19.2 Liquid crystal application voltage waveform and electrical potential

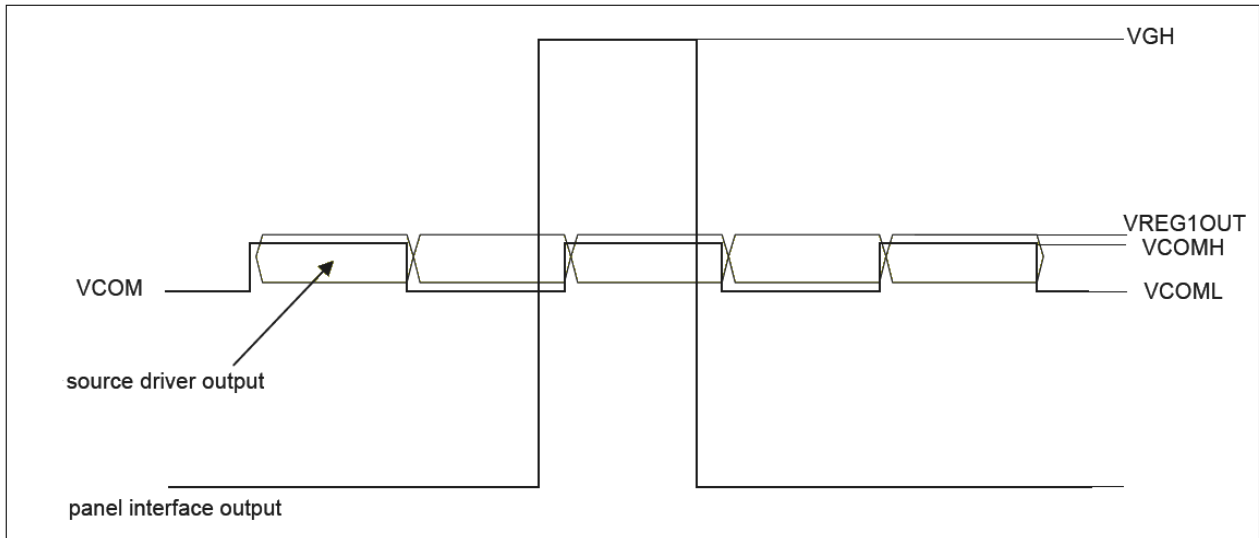


Figure 39 Voltage output to TFT LCD Panel

CONFIDENTIAL

20.OTP control sequence

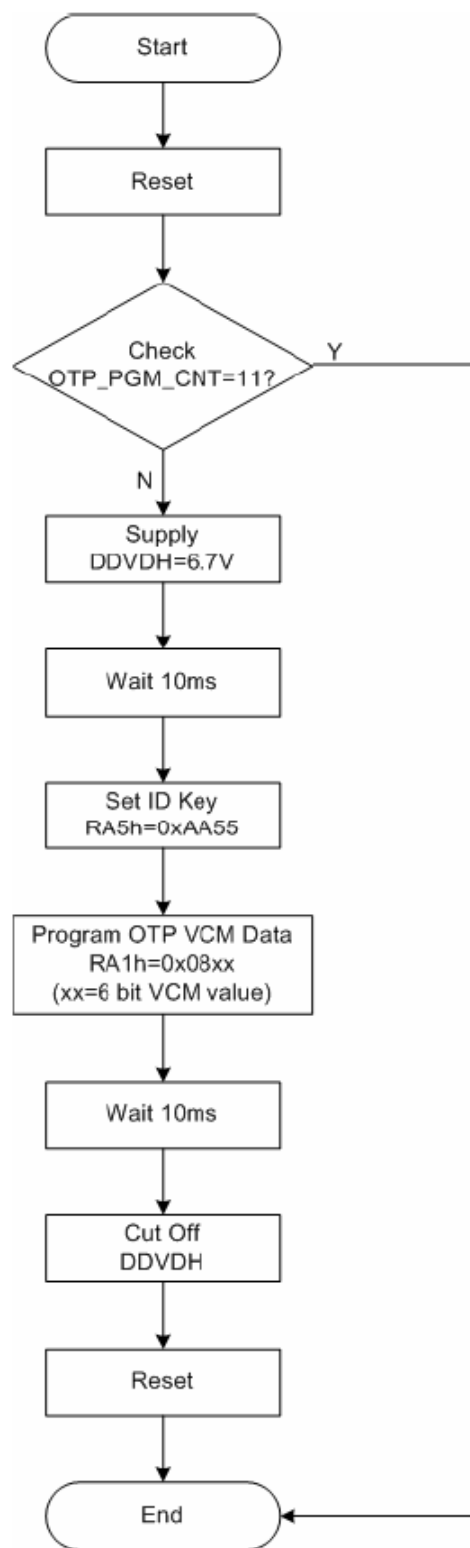
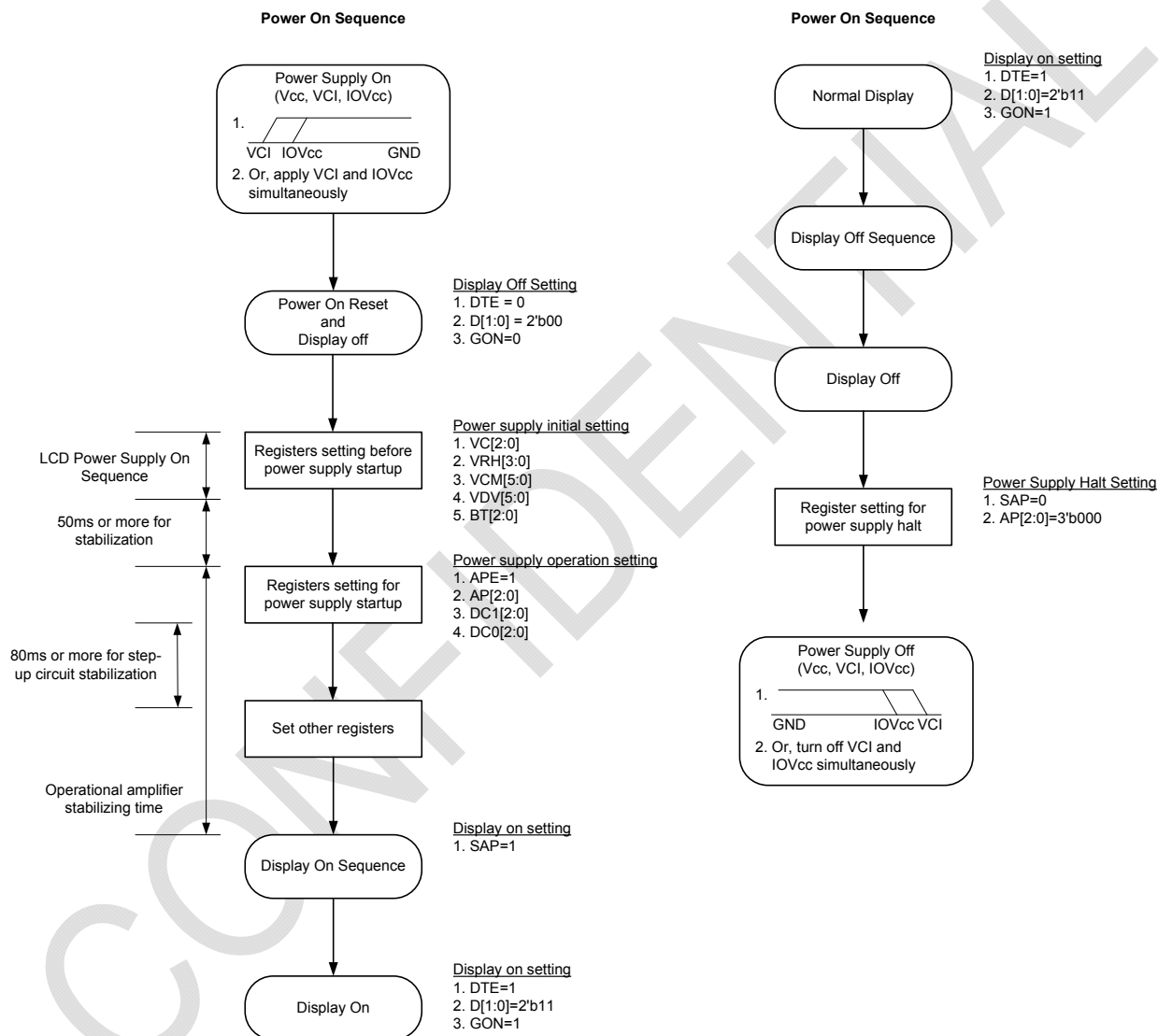


Figure 40 OTP control sequence diagram

21. Power Supply Instruction Setting

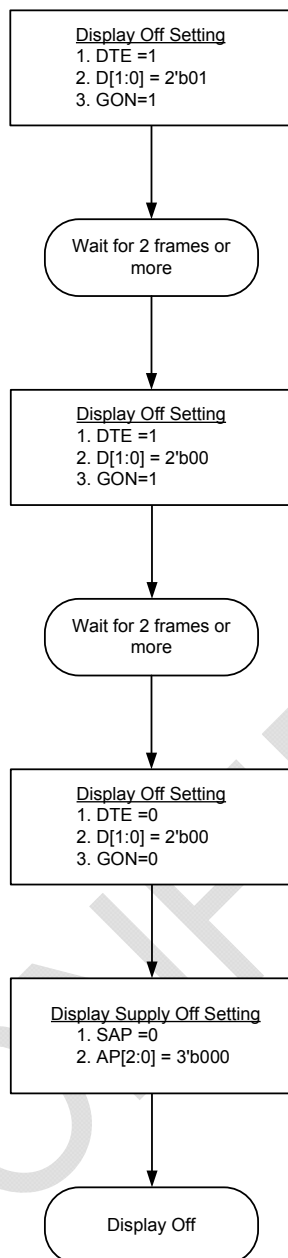
The following are the sequences for setting power supply ON/OFF instructions. Set power supply ON/OFF instructions according to the following sequences in Display ON/OFF, Sleep set/exit sequences.

21.1 Power Supply Instruction Setting

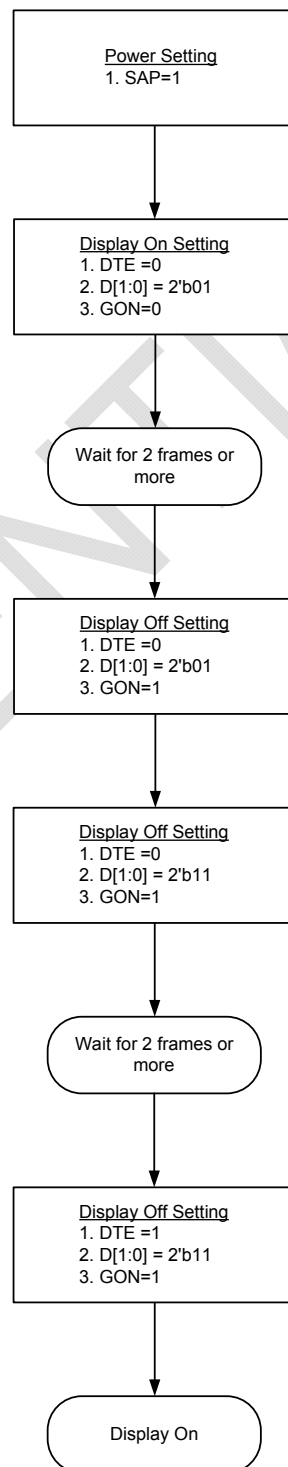


21.2 Display On / Off Instruction Setting

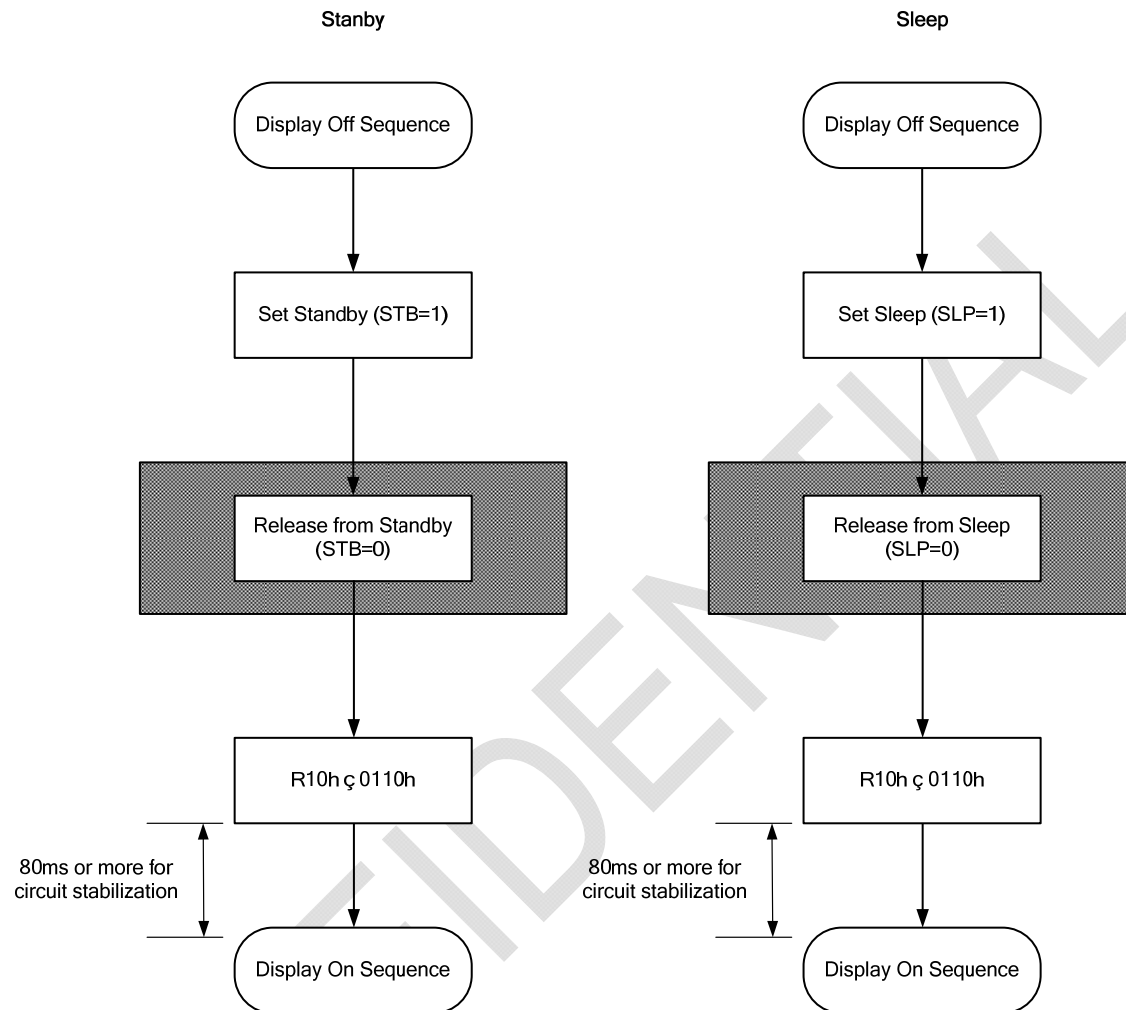
Display Off Sequence



Display On Sequence



21.3 Sleep mode/Standby mode SET/EXIT sequence



The diagram illustrates the pinout of a 100-pin connector, organized into four main sections: Power and Ground (pins 1-10), Signal and Test Points (pins 11-40), Power and Ground (pins 41-50), and Signal and Test Points (pins 51-100). The pins are labeled with their functions, test points, and associated components.

Pin 1-10: Power and Ground

- Pin 1: +5VDC
- Pin 2: GND
- Pin 3: +5VDC
- Pin 4: GND
- Pin 5: +5VDC
- Pin 6: GND
- Pin 7: +5VDC
- Pin 8: GND
- Pin 9: +5VDC
- Pin 10: GND

Pin 11-40: Signal and Test Points

- Pin 11: TEST1
- Pin 12: TEST2
- Pin 13: TEST3
- Pin 14: TEST4
- Pin 15: TEST5
- Pin 16: TEST6
- Pin 17: TEST7
- Pin 18: TEST8
- Pin 19: TEST9
- Pin 20: TEST10
- Pin 21: TEST11
- Pin 22: TEST12
- Pin 23: TEST13
- Pin 24: TEST14
- Pin 25: TEST15
- Pin 26: TEST16
- Pin 27: TEST17
- Pin 28: TEST18
- Pin 29: TEST19
- Pin 30: TEST20
- Pin 31: TEST21
- Pin 32: TEST22
- Pin 33: TEST23
- Pin 34: TEST24
- Pin 35: TEST25
- Pin 36: TEST26
- Pin 37: TEST27
- Pin 38: TEST28
- Pin 39: TEST29
- Pin 40: TEST30

Pin 41-50: Power and Ground

- Pin 41: +5VDC
- Pin 42: GND
- Pin 43: +5VDC
- Pin 44: GND
- Pin 45: +5VDC
- Pin 46: GND
- Pin 47: +5VDC
- Pin 48: GND
- Pin 49: +5VDC
- Pin 50: GND

Pin 51-100: Signal and Test Points

- Pin 51: TEST31
- Pin 52: TEST32
- Pin 53: TEST33
- Pin 54: TEST34
- Pin 55: TEST35
- Pin 56: TEST36
- Pin 57: TEST37
- Pin 58: TEST38
- Pin 59: TEST39
- Pin 60: TEST40
- Pin 61: TEST41
- Pin 62: TEST42
- Pin 63: TEST43
- Pin 64: TEST44
- Pin 65: TEST45
- Pin 66: TEST46
- Pin 67: TEST47
- Pin 68: TEST48
- Pin 69: TEST49
- Pin 70: TEST50
- Pin 71: TEST51
- Pin 72: TEST52
- Pin 73: TEST53
- Pin 74: TEST54
- Pin 75: TEST55
- Pin 76: TEST56
- Pin 77: TEST57
- Pin 78: TEST58
- Pin 79: TEST59
- Pin 80: TEST60
- Pin 81: TEST61
- Pin 82: TEST62
- Pin 83: TEST63
- Pin 84: TEST64
- Pin 85: TEST65
- Pin 86: TEST66
- Pin 87: TEST67
- Pin 88: TEST68
- Pin 89: TEST69
- Pin 90: TEST70
- Pin 91: TEST71
- Pin 92: TEST72
- Pin 93: TEST73
- Pin 94: TEST74
- Pin 95: TEST75
- Pin 96: TEST76
- Pin 97: TEST77
- Pin 98: TEST78
- Pin 99: TEST79
- Pin 100: TEST80

Face Up (Bump View)

The diagram shows the connector from the "Face Up (Bump View)" perspective. The X and Y axes are indicated, with the Y-axis pointing upwards and the X-axis pointing to the right.

Optional

The diagram includes a red dashed box labeled "Optional" around pins 51-54, indicating that these pins are optional for the connector.

23. Absolute Maximum Ratings

Table 17

Item	Symbol	Unit	Value	Note
Power Supply Voltage 1	VCI, IOVCC	V	-0.3 ~ +4.6	1, 2
Power Supply Voltage 2	VCI – GND	V	-0.3 ~ +4.6	1, 3
Power Supply Voltage 3	DDVDH –GND	V	-0.3 ~ +6.0	1, 4
Power Supply Voltage 4	AGND – VCL	V	-0.3 ~ +4.6	1
Power Supply Voltage 5	DDVDH – VCL	V	-0.3 ~ +9.0	1, 5
Power Supply Voltage 6	VGH – GND	V	-0.3 ~ +18.5	1, 6
Power Supply Voltage 7	GND – VGL	V	-0.3 ~ +18.5	1
Input Voltage	Vt	V	-0.3 ~ IOVCC + 0.3	1
Operating Temperature	Topr	°C	-40 ~ +85	1, 7
Storage Temperature	Tstg	°C	-55 ~ +110	1, 7

Notes:

1. The absolute maximum rating is listed on table above. When RM68050 is used out of the absolute maximum ratings, the RM68050 may be permanently damaged. To use the RM68050 within the following electrical characteristics limit is strongly recommended for normal operation. If exposed to the condition not within the electrical characteristics, it may affect the reliability of the device.
2. Make sure $V_{CI}(\text{high}) \geq DGND(\text{low})$, $IOVCC(\text{high}) \geq DGND(\text{low})$.
3. Make sure $V_{CI}(\text{high}) \geq DGND(\text{low})$.
4. Make sure $DDVDH(\text{high}) \geq AGND(\text{low})$
5. Make sure $DDVDH(\text{high}) \geq VCL(\text{low})$.
6. Make sure $AGND(\text{high}) \geq VGL(\text{low})$..

24. Electrical Characteristics

24.1 DC Electrical Characteristics

(VCC = 2.50V ~ 3.30V, IOVCC = 1.65V ~ 3.30V, Ta = -40°C ~ +85°C)

Item	Symbol	Unit	Test Condition	Min.	Typ	Max.
Input "High" level voltage	V _{IH}	V	IOVCC = 1.65V~3.30V	0.80 x IOVCC	-	IOVCC
Input "Low" level voltage	V _{IL}	V	IOVCC = 1.65V~3.30V	-0.3	-	0.2 x IOVCC
Output "High" level voltage 1 (DB0-17, FMARK)	V _{OH}	V	IOVCC = 1.65V~3.30V IOH = -0.1mA	0.80 x IOVCC	-	-
Output "Low" level voltage 1 (DB0-17, FMARK)	V _{OL}	V	IOVCC = 1.65V~3.30V IOL = 0.1mA	-	-	0.2 x IOVCC
Input/Output leak current	I _{LI}	uA	Vin = 0~IOVCC	-0.1	-	0.1
Current Consumption (IOVCC-IOGND)+(VCC-GND) Normal operation mode (262k-colors, display operation)	I _{OP1}	uA	fosc=512kHz (320line drive), IOVCC=VCC=2.80V, Ta=25°C, RAM data: 18'h000000	--	TBD	--
Current Consumption (IOVCC-IOGND)+(VCC-GND) Deep standby mode	I _{DST}	uA	IOVCC=VCC=2.80V, Ta=25°C	-	1	--
LCD Power Supply Current (VCI-GND) 262k-color display operation	I _{ci1}	mA	IOVCC=VCC=2.80V, ddv _{dh} =5.20V, VREG1OUT=4.8V, Frame Rate=70Hz, Ta=25, RAM data: 18'h000000, line-inversion	-	TBD	--
Output Voltage dispersion	ΔV _O	mV	-	-	TBD	-
Average output voltage variance	ΔV _Δ	mV	-	-	TBD	-

24.2 AC Timing Characteristics

24.2.180-System Bus Interface

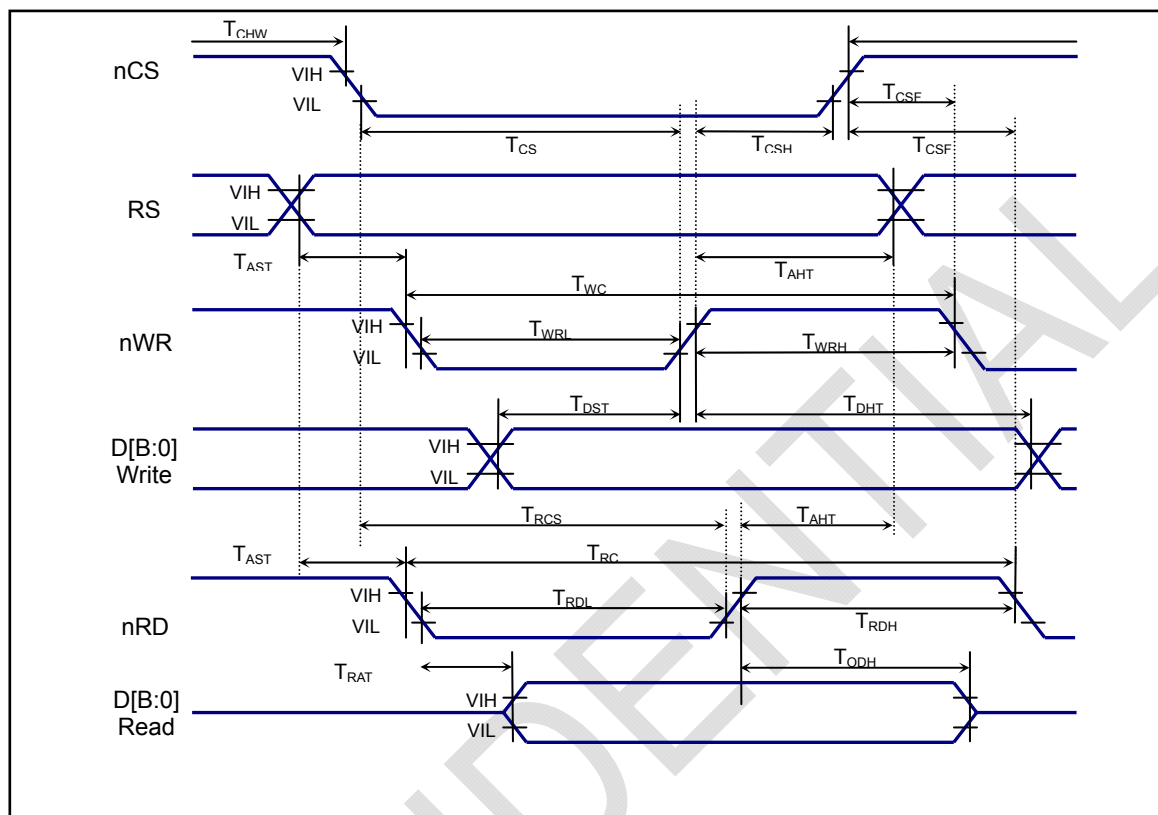


Figure 41 80-system Bus Interface

Normal Write Mode (IOVCC = 1.65~3.3V, VCC=2.4~3.3V)

Signal	Symbol	Parameter	MIN	MAX	Unit	Description
RS	T_{AST}	Address setup time	10		ns	
	T_{AHT}	Address hold time (Write/Read)	5		ns	
nCS	T_{CHW}	Chip select "H" pulse width	0		ns	
	T_{CS}	Chip select setup time (Write)	10		ns	
	T_{RCS}	Chip select setup time (Read)	5		ns	
nWR	T_{WC}	Write cycle	100		ns	
	T_{WRH}	Control pulse "H" duration	50		ns	
	T_{WRL}	Control pulse "L" duration	50		ns	
nRD (ID)	T_{RC}	Read cycle	300		ns	
	T_{RDH}	Control pulse "H" duration	150		ns	
	T_{RDL}	Control pulse "L" duration	150		ns	
D[17:0]	T_{DST}	Data setup time	10		ns	
	T_{DHT}	Data hold time	15		ns	
	T_{RAT}	Read access time		100	ns	
	T_{ODH}	Output disable time	5		ns	

24.2.2 Clock Synchronous Serial Interface

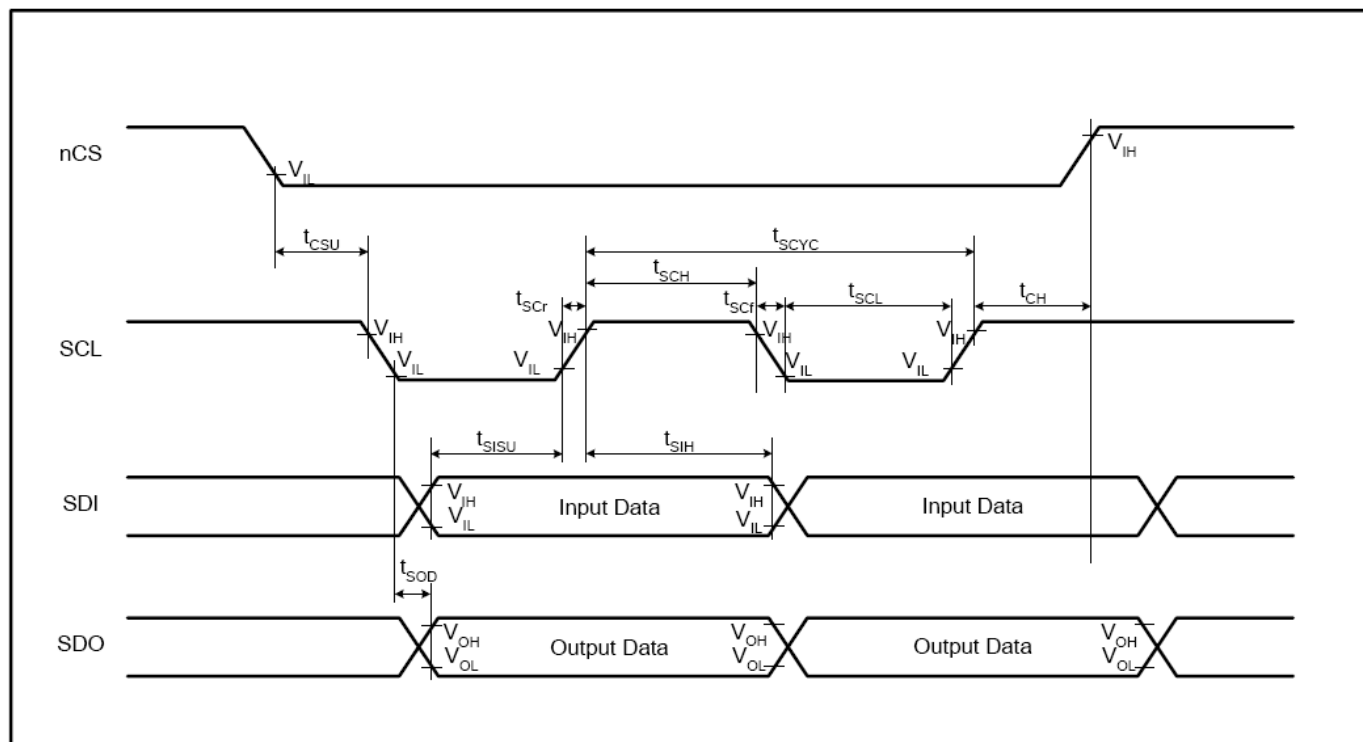


Figure 42 Clock Synchronous Serial Interface

IOVCC = 1.65~3.3V, VCC=2.4~3.3V

Signal	Symbol	Parameter	MIN	MAX	Unit	Description
SCL	T _{SCYC}	Clock cycle (Write)	100		us	-
	T _{SCYC}	Clock cycle (Read)	200		us	
	T _{SCH}	Clock “H” pulse width (Write)	40		ns	
	T _{SCH}	Clock “H” pulse width (Read)	100		ns	
	T _{SCL}	Clock “L ” pulse width (Write)	40		ns	
	T _{SCL}	Clock “L ” pulse width (Read)	100		ns	
	T _{SCr}	Clock rise time		5	ns	
nCS	T _{SCf}	Clock fall time		5	ns	-
	T _{CSU}	Chip select setup time	10		ns	
	T _{CH}	Chip select hold time	50		ns	
SDI	T _{WRL}	Control pulse “L” duration	15		ns	-
	T _{SISU}	Data input setup time	20		ns	
SDO	T _{SIH}	Data input hold time	20		ns	-
	T _{SOD}	Data output setup time		100	ns	
	T _{SOH}	Data output hold time	5		ns	

24.2.3 RGB Interface

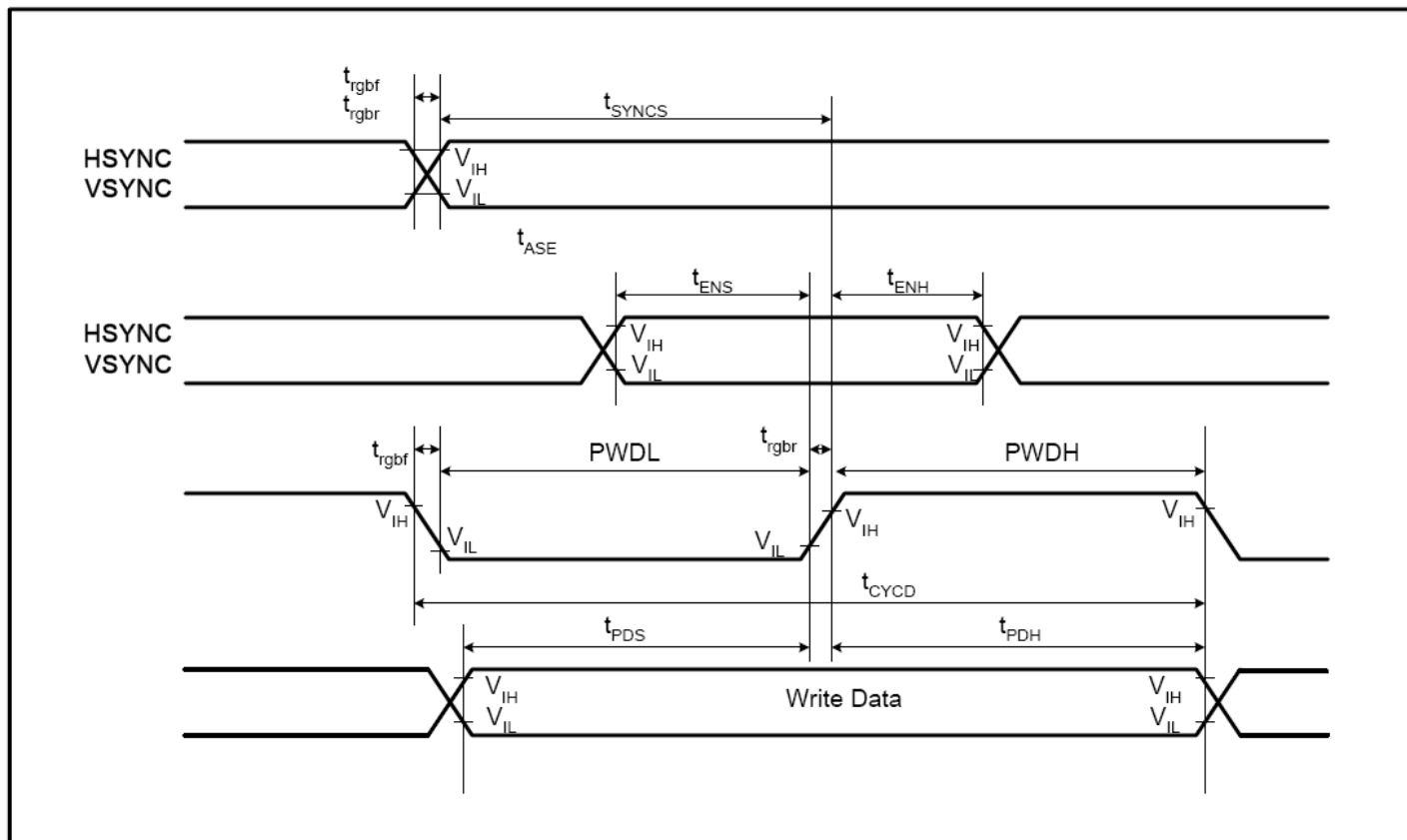


Figure 43 Timing chart for RGB Interface

18/16-bit Bus RGB Interface Mode (IOVCC = 1.65~3.3V, VCC=2.4~3.3V)

Signal	Symbol	Parameter	MIN	MAX	Unit	Description
VSYNC	T _{SYNCS}	VSYNC setup time	0		ns	-
	T _{rghr}	VSYNC rise time		25	ns	
	T _{rghf}	VSYNC fall time		25	ns	
HSYNC	T _{SYNCS}	HSYNC setup time	0		ns	-
	T _{rghr}	HSYNC rise time		25	ns	
	T _{rghf}	HSYNC fall time		25	ns	
ENABLE	T _{ENS}	ENABLE setup time	10		ns	-
	T _{ENH}	ENABLE hold time	10		ns	
DB[17:0]	T _{PDS}	Data input setup time	10		ns	-
	T _{PDH}	Data input hold time	40		ns	
DOTCLK	PWDH	DOTCLK "H" pulse width	40		ns	-
	PWDL	DOTCLK "L" pulse width	40		ns	
	T _{CYCD}	DOTCLK clock cycle	100		ns	
	T _{rghr}	DOTCLK rise time		25	ns	
	T _{rghf}	DOTCLK fall time		25	ns	

6-bit Bus RGB Interface Mode (IOVCC = 1.65 ~ 3.3V, VCC=2.4~3.3V)

Signal	Symbol	Parameter	MIN	MAX	Unit	Description
VSYNC	T _{SYNCS}	VSYNC setup time	0		ns	-
	T _{rghr}	VSYNC rise time		25	ns	
	T _{rghf}	VSYNC fall time		25	ns	

HSYNC	T_{SYNCS}	HSYNC setup time	0		ns	-
	T_{rghr}	HSYNC rise time		25	ns	
	T_{rghf}	HSYNC fall time		25	ns	
ENABLE	T_{ENS}	ENABLE setup time	10		ns	-
	T_{ENH}	ENABLE hold time	10		ns	
DB[17:0]	T_{PDS}	Data input setup time	10		ns	-
	T_{PDH}	Data input hold time	30		ns	
DOTCLK	PWDH	DOTCLK "H" pulse width	30		ns	-
	PWDL	DOTCLK "L" pulse width	30		ns	
	T_{CYCD}	DOTCLK clock cycle	80			
	T_{rghr}	DOTCLK rise time		25	ns	
	T_{rghf}	DOTCLK fall time		25	ns	

24.3 Reset Timing Characteristics

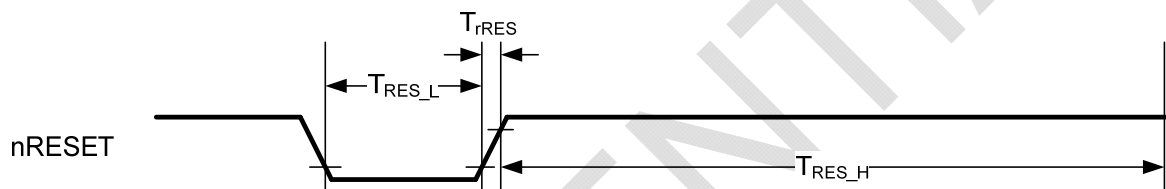


Figure 44 Reset Operation

Reset Timing Characteristics (VCC = 1.8 ~ 3.3 V, IOVCC = 1.65 ~ 3.3 V)

Item	Symbol	MIN	MAX	Unit	Description
Reset low-level width	$T_{\text{RES_L}}$	1		ns	-
Reset rise time	T_{RES}		10	us	-
Reset high-level width	$T_{\text{RES_H}}$	50		ns	-

With collaboration of <https://www.displayfuture.com>