

T6K14

COLUMN AND ROW DRIVER LSI FOR A DOT MATRIX GRAPHIC LCD

The T6K14 is a driver for a small-to-medium-sized dot matrix graphic LCD, especially for reflective color STN LCD. It realizes a 4-color or 4-gray-scale display. This driver can be interfaced to the MPU via an 8-bit (68/80-series) or a serial interface, and is operated asynchronously with the MPU. Since the T6K14 contains a CR oscillator, it can generate the timing signals required for the LCD. Since the T6K14 has 128 outputs for the LCD drive (segment) signals that constitute display data, 65 outputs for the LCD drive (common) signals that constitute scanning signals and 65 × 128 × 2 bits display RAM, this single device allows you to drive an LCD panel comprised of up to 128 × 64 dots and 128 icons with a minimize of power requirement. It has 4 gray-scale function. The display RAM of this driver is a 2 port RAM so that the MPU accesses without any wait time. It has various power circuits such as a voltage regulators, voltage divider resistors, a power supply op-amp, a contrast control circuit, a temperature compensation circuit, and DC-DC converter (×2, ×3, ×4, ×5). All these circuits enable the LCD panel to be driven with a single power supply.

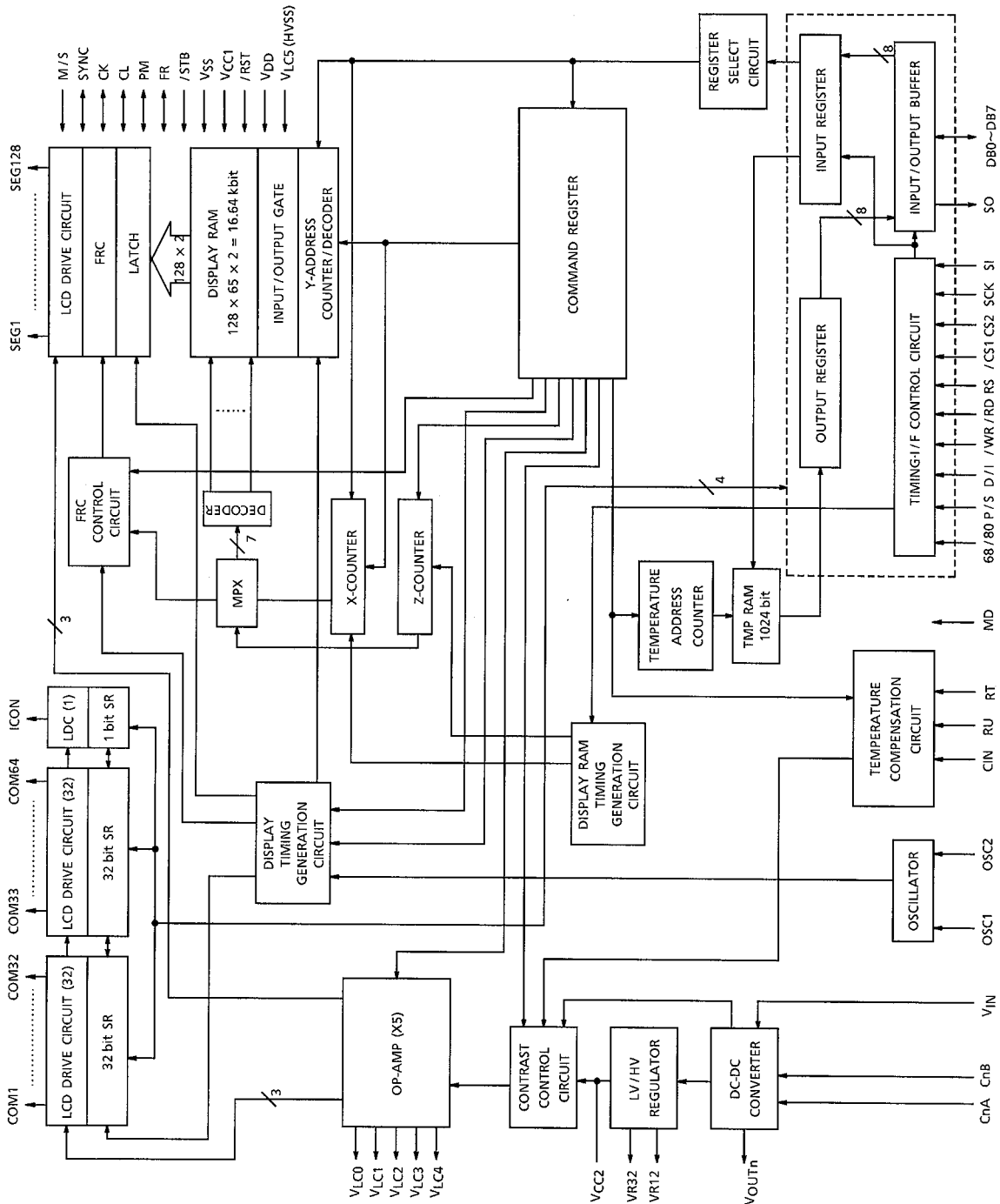
Unit: mm		
T6K14	Lead Pitch	
	IN	OUT
(UBW, 5NS)	0.60	0.23
Please contact with Toshiba agents for each packaging outline dimensions.		
TCP (Tape Carrier Package)		

Features

- LCD driver output : 64 rows + 128 columns + 128 icons
- Built in display RAM : 65 × 128 × 2 = 16640 bits, 2-port RAM
- Gray scale : 4 gray-scale selectable
- Word length : 8-bit/word
- Duty cycle : 1/2 duty (power save mode)
1/35, 1/49, 1/57, 1/65 duty selectable (normal display mode)Display mode
- Display modes : Normal mode (Full display)
Power save mode (Icon display)
Stand by mode (Clock stopped)
- Clock oscillator : CR oscillator with external resistors
Low frequency operation 82 kHz oscillation for FR frequency 70 Hz (1/65 duty)
- Power circuit : Voltage regulator, Voltage divider, Voltage follower op-amp.
DC-DC converter (×2, ×3, ×4, ×5), Temperature compensation circuit, Contrast control circuit.
- CPU interface : Interfacing with 68/80 series MPU and Serial Interface
- Logic operating voltage : VDD = 2.4 to 3.3 V, VIN = 2.7 to 3.3 V
- LCD drive voltage : VCC1, 2 = 6.0 to 16.5 V, if case of used the voltage Regulator, VCC2 output voltage at 12.5 V or 11.0 V (typ.) Ta = 25°C
- CMOS process
- Low power consumption : ISS = 200 μA (typ.)
Condition : VDD = 2.7 V, VIN = 2.7 V, using the DC-DC converter (×5), no data access, op-amp on, fosc = 82 kHz (internal clock), no load, 1/65 duty, temperature compensation circuit off.
- Package :

Product	Package
T6K14 (×××, ×××)	TCP (Tape carrier package)
JBT6K14-AS	Gold bump chip

Block Diagram



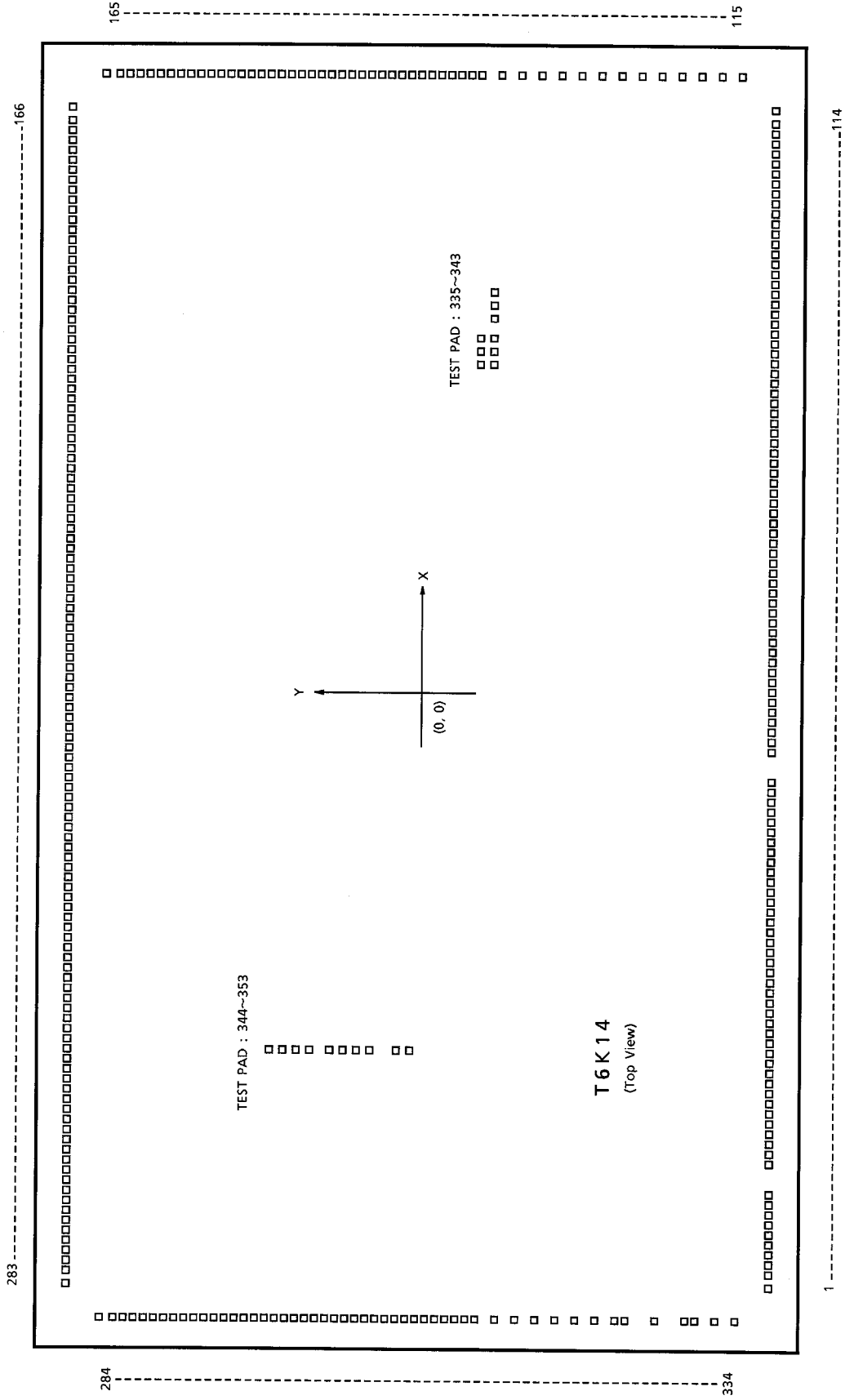
PAD Specification

Item		Size	Unit
Chip Size		8960×5050	μm
Chip Tip Coordinates	(1)	-4480, -2525	μm
	(2)	-4480, 2525	
	(3)	4480, 2525	
	(4)	4480, -2525	
Bump Pitch		70 (Min)	μm
Bump Height		15 (Typ.)	μm

Item	Number of Pins	
Input Pin	114 (Including dummy pins)	
Output Pin	208 (Including dummy pins)	
FUSE Pin	12	(Note 1)
TEST Pin	19	(Note 1)

Note 1: FUSE (No.115 to 126) and TEST (No.335 to 353) are LSI test pins, leave these pins open.

Pad Layout



Pad Coordinates

[Unit: μm]

No.	Name	X-Point	Y-Point	No.	Name	X-Point	Y-Point	No.	Name	X-Point	Y-Point
1	DUMMY1	-4203	-2293	48	V _{IN}	-737	-2293	95	/RD	2719	-2293
2	V _{LC2}	-4121	-2293	49	DUMMY11	-665	-2293	96	V _{SS}	2791	-2293
3	V _{LC2}	-4049	-2293	50	DUMMY12	-521	-2293	97	RS	2863	-2293
4	DUMMY2	-3977	-2293	51	VR32	-449	-2293	98	V _{DD}	2935	-2293
5	V _{LC1}	-3905	-2293	52	VR32	-377	-2293	99	CS2	3007	-2293
6	V _{LC1}	-3833	-2293	53	VR12	-305	-2293	100	/CS1	3079	-2293
7	DUMMY3	-3761	-2293	54	VR12	-233	-2293	101	V _{SS}	3151	-2293
8	V _{LC0}	-3689	-2293	55	V _{SS}	-161	-2293	102	DB0	3223	-2293
9	V _{LC0}	-3617	-2293	56	V _{SS}	-89	-2293	103	DB1	3295	-2293
10	DUMMY4	-3545	-2293	57	V _{SS}	-17	-2293	104	DB2	3367	-2293
11	DUMMY5	-3401	-2293	58	V _{SS}	55	-2293	105	DB3	3439	-2293
12	V _{CC2}	-3329	-2293	59	V _{SS}	127	-2293	106	DB4	3511	-2293
13	V _{CC2}	-3257	-2293	60	DUMMY13	199	-2293	107	DB5	3583	-2293
14	DUMMY6	-3185	-2293	61	OSC2	271	-2293	108	DB6	3655	-2293
15	DUMMY7	-3113	-2293	62	DUMMY14	343	-2293	109	DB7	3727	-2293
16	DUMMY8	-3041	-2293	63	OSC1	415	-2293	110	DUMMY16	3799	-2293
17	DUMMY9	-2969	-2293	64	DUMMY15	487	-2293	111	DUMMY17	3871	-2293
18	V _{CC1}	-2897	-2293	65	V _{DD}	559	-2293	112	DUMMY18	3943	-2293
19	V _{CC1}	-2825	-2293	66	V _{DD}	631	-2293	113	DUMMY19	4015	-2293
20	V _{CC1}	-2753	-2293	67	V _{DD}	703	-2293	114	DUMMY20	4097	-2293
21	V _{CC1}	-2681	-2293	68	V _{DD}	775	-2293	115	FUSE25	4280	-2129
22	DUMMY10	-2609	-2293	69	C _{IN}	847	-2293	116	FUSE24	4280	-1994
23	V _{OUT4}	-2537	-2293	70	RT	919	-2293	117	FUSE2G	4280	-1869
24	V _{OUT4}	-2465	-2293	71	RU	991	-2293	118	FUSE23	4280	-1744
25	C4B	-2393	-2293	72	V _{DD}	1063	-2293	119	FUSE22	4280	-1619
26	C4B	-2321	-2293	73	/STB	1135	-2293	120	FUSE21	4280	-1494
27	C4A	-2249	-2293	74	FR	1207	-2293	121	FUSE35	4280	-1369
28	C4A	-2177	-2293	75	PM	1279	-2293	122	FUSE34	4280	-1244
29	V _{OUT3}	-2105	-2293	76	CL	1351	-2293	123	FUSE3G	4280	-1119
30	V _{OUT3}	-2033	-2293	77	CK	1423	-2293	124	FUSE33	4280	-994
31	C3B	-1961	-2293	78	SYNC	1495	-2293	125	FUSE32	4280	-869
32	C3B	-1889	-2293	79	V _{SS}	1567	-2293	126	FUSE31	4280	-744
33	C3A	-1817	-2293	80	M/S	1639	-2293	127	DUMMY21	4280	-619
34	C3A	-1745	-2293	81	V _{DD}	1711	-2293	128	COM32	4280	-468
35	V _{OUT2}	-1673	-2293	82	MD	1783	-2293	129	COM31	4280	-398
36	V _{OUT2}	-1601	-2293	83	V _{SS}	1855	-2293	130	COM30	4280	-328
37	C2B	-1529	-2293	84	SCK	1927	-2293	131	COM29	4280	-258
38	C2B	-1457	-2293	85	SI	1999	-2293	132	COM28	4280	-188
39	C2A	-1385	-2293	86	SO	2071	-2293	133	COM27	4280	-118
40	C2A	-1313	-2293	87	V _{DD}	2143	-2293	134	COM26	4280	-48
41	V _{OUT1}	-1241	-2293	88	68/80	2215	-2293	135	COM25	4280	22
42	V _{OUT1}	-1169	-2293	89	V _{SS}	2287	-2293	136	COM24	4280	92
43	C1B	-1097	-2293	90	RS	2359	-2293	137	COM23	4280	162
44	C1B	-1025	-2293	91	V _{DD}	2431	-2293	138	COM22	4280	232
45	C1A	-953	-2293	92	/RST	2503	-2293	139	COM21	4280	302
46	C1A	-881	-2293	93	D/I	2575	-2293	140	COM20	4280	372
47	V _{IN}	-809	-2293	94	/WR	2647	-2293	141	COM19	4280	442

[Unit: μm]

No.	Name	X-Point	Y-Point	No.	Name	X-Point	Y-Point	No.	Name	X-Point	Y-Point
142	COM18	4280	512	189	SEG29	2486	2325	236	SEG76	-804	2325
143	COM17	4280	582	190	SEG30	2416	2325	237	SEG77	-874	2325
144	COM16	4280	652	191	SEG31	2346	2325	238	SEG78	-944	2325
145	COM15	4280	722	192	SEG32	2276	2325	239	SEG79	-1014	2325
146	COM14	4280	792	193	SEG33	2206	2325	240	SEG80	-1084	2325
147	COM13	4280	862	194	SEG34	2136	2325	241	SEG81	-1154	2325
148	COM12	4280	932	195	SEG35	2066	2325	242	SEG82	-1224	2325
149	COM11	4280	1002	196	SEG36	1996	2325	243	SEG83	-1294	2325
150	COM10	4280	1072	197	SEG37	1926	2325	244	SEG84	-1364	2325
151	COM9	4280	1142	198	SEG38	1856	2325	245	SEG85	-1434	2325
152	COM8	4280	1212	199	SEG39	1786	2325	246	SEG86	-1504	2325
153	COM7	4280	1282	200	SEG40	1716	2325	247	SEG87	-1574	2325
154	COM6	4280	1352	201	SEG41	1646	2325	248	SEG88	-1644	2325
155	COM5	4280	1422	202	SEG42	1576	2325	249	SEG89	-1714	2325
156	COM4	4280	1492	203	SEG43	1506	2325	250	SEG90	-1784	2325
157	COM3	4280	1562	204	SEG44	1436	2325	251	SEG91	-1854	2325
158	COM2	4280	1632	205	SEG45	1366	2325	252	SEG92	-1924	2325
159	COM1	4280	1702	206	SEG46	1296	2325	253	SEG93	-1994	2325
160	ICOM1A	4280	1772	207	SEG47	1226	2325	254	SEG94	-2064	2325
161	SEG1	4280	1842	208	SEG48	1156	2325	255	SEG95	-2134	2325
162	SEG2	4280	1912	209	SEG49	1086	2325	256	SEG96	-2204	2325
163	SEG3	4280	1982	210	SEG50	1016	2325	257	SEG97	-2274	2325
164	SEG4	4280	2052	211	SEG51	946	2325	258	SEG98	-2344	2325
165	SEG5	4280	2133	212	SEG52	876	2325	259	SEG99	-2414	2325
166	SEG6	4107	2325	213	SEG53	806	2325	260	SEG100	-2484	2325
167	SEG7	4026	2325	214	SEG54	736	2325	261	SEG101	-2554	2325
168	SEG8	3956	2325	215	SEG55	666	2325	262	SEG102	-2624	2325
169	SEG9	3886	2325	216	SEG56	596	2325	263	SEG103	-2694	2325
170	SEG10	3816	2325	217	SEG57	526	2325	264	SEG104	-2764	2325
171	SEG11	3746	2325	218	SEG58	456	2325	265	SEG105	-2834	2325
172	SEG12	3676	2325	219	SEG59	386	2325	266	SEG106	-2904	2325
173	SEG13	3606	2325	220	SEG60	316	2325	267	SEG107	-2974	2325
174	SEG14	3536	2325	221	SEG61	246	2325	268	SEG108	-3044	2325
175	SEG15	3466	2325	222	SEG62	176	2325	269	SEG109	-3114	2325
176	SEG16	3396	2325	223	SEG63	106	2325	270	SEG110	-3184	2325
177	SEG17	3326	2325	224	SEG64	36	2325	271	SEG111	-3254	2325
178	SEG18	3256	2325	225	SEG65	-34	2325	272	SEG112	-3324	2325
179	SEG19	3186	2325	226	SEG66	-104	2325	273	SEG113	-3394	2325
180	SEG20	3116	2325	227	SEG67	-174	2325	274	SEG114	-3464	2325
181	SEG21	3046	2325	228	SEG68	-244	2325	275	SEG115	-3534	2325
182	SEG22	2976	2325	229	SEG69	-314	2325	276	SEG116	-3604	2325
183	SEG23	2906	2325	230	SEG70	-384	2325	277	SEG117	-3674	2325
184	SEG24	2836	2325	231	SEG71	-454	2325	278	SEG118	-3744	2325
185	SEG25	2766	2325	232	SEG72	-524	2325	279	SEG119	-3814	2325
186	SEG26	2696	2325	233	SEG73	-594	2325	280	SEG120	-3884	2325
187	SEG27	2626	2325	234	SEG74	-664	2325	281	SEG121	-3954	2325
188	SEG28	2556	2325	235	SEG75	-734	2325	282	SEG122	-4024	2325

[Unit: μm]

No.	Name	X-Point	Y-Point
283	SEG123	-4105	2325
284	SEG124	-4280	2133
285	SEG125	-4280	2052
286	SEG126	-4280	1982
287	SEG127	-4280	1912
288	SEG128	-4280	1842
289	COM33	-4280	1772
290	COM34	-4280	1702
291	COM35	-4280	1632
292	COM36	-4280	1562
293	COM37	-4280	1492
294	COM38	-4280	1422
295	COM39	-4280	1352
296	COM40	-4280	1282
297	COM41	-4280	1212
298	COM42	-4280	1142
299	COM43	-4280	1072
300	COM44	-4280	1002
301	COM45	-4280	932
302	COM46	-4280	862
303	COM47	-4280	792
304	COM48	-4280	722
305	COM49	-4280	652
306	COM50	-4280	582

No.	Name	X-Point	Y-Point
307	COM51	-4280	512
308	COM52	-4280	442
309	COM53	-4280	372
310	COM54	-4280	302
311	COM55	-4280	232
312	COM56	-4280	162
313	COM57	-4280	92
314	COM58	-4280	22
315	COM59	-4280	-48
316	COM60	-4280	-118
317	COM61	-4280	-188
318	COM62	-4280	-258
319	COM63	-4280	-328
320	COM64	-4280	-398
321	ICOM1B	-4280	-468
322	DUMMY22	-4280	-619
323	V _{LC5}	-4280	-744
324	V _{LC5}	-4280	-869
325	V _{LC5}	-4280	-994
326	V _{LC5}	-4280	-1119
327	DUMMY23	-4280	-1244
328	V _{LC4}	-4280	-1369
329	V _{LC4}	-4280	-1441
330	DUMMY24	-4280	-1619

No.	Name	X-Point	Y-Point
331	V _{LC3}	-4280	-1797
332	V _{LC3}	-4280	-1869
333	DUMMY25	-4280	-1994
334	DUMMY26	-4280	-2119
335	TEG1	2249	-450
336	TEG2	2349	-450
337	TEG3	2449	-450
338	TEG4	2588	-450
339	TEG5	2688	-450
340	TEG6	2788	-450
341	TEG7	2249	-301
342	TEG8	2349	-301
343	TEG9	2449	-301
344	TEG10	-2448	1172
345	TEG11	-2448	1072
346	TEG12	-2448	972
347	TEG13	-2448	872
348	TEG14	-2448	699
349	TEG15	-2448	599
350	TEG16	-2448	499
351	TEG17	-2448	399
352	TEG18	-2448	201
353	TEG19	-2448	101

Pin Function (1)

Pin Name	I/O	Function
SEG1 to SEG128	Output	LCD drive column (segment) signals
COM1 to COM64	Output	LCD drive row (common) signals
ICON	Output	LCD drive row (common) signals for icon
DB0 to DB7	I/O	Data bus
/CS1	Input	Input for chip select signal Data write: Data write enable at the rising edge of /CS1. Data read: Data read out while /CS1 is in Low level.
CS2	Input	Input for chip select signal Data write: Data write enable at the falling edge of CS2. Data read: Data read out while CS2 is in High level.
D/I	Input	Input for Data/Instruction select signal <ul style="list-style-type: none"> • D/I = H → Indicates that the data on DB0 to DB7 or SI is the display data. • D/I = L → Indicates that the data on DB0 to DB7 or SI is the instruction data.
/WR	Input	Input for write enable signal <ul style="list-style-type: none"> • /WR = L → State of select
/RD	Input	Input for read enable signal <ul style="list-style-type: none"> • /RD = L → State of select
RS	Input	Input for register/mode select signal
P/S	Input	Input for parallel interface/serial interface select signal <ul style="list-style-type: none"> • P/S = H → Parallel interface is selected. SI and SCK must be connected to V_{DD} or V_{SS}. • P/S = L → Serial interface is selected. DB0 to DB7, /WR and /RD must connected to V_{DD} or V_{SS}.
68/80	Input	Input for 68 series MPU/80 series MPU select signal <ul style="list-style-type: none"> • 68/80 = H → 68 series MPU selected • 68/80 = L → 80 series MPU selected
SO	Output	Output for serial data
SI	Input	Input for serial data
SCK	Input	Input for serial clock
/RST	Input	Input for reset signal <ul style="list-style-type: none"> • /RST = L → State of select

Pin Function (2)

Pin Name	I/O	Function
/STB	Input	Input for standby signal <ul style="list-style-type: none"> • Usually connected to V_{DD} • /STB = L → T6K14 is the state of standby. Column and row drive signal is V_{SS} level, and on-chip oscillator is stop.
OSC1, OSC2	I/O	When using a internal clock oscillator, connect a resistor between OSC1 and OSC2. When using a external clock, input the clock to OSC1 and leave OSC2 open.
V_{IN}	—	Power supply for DC-DC converter
CIN	I/O	Input for clock of temperature compensation
RU	—	Connect with standard resistor
RT	—	Connect with thermistor
C1A, C1B	—	Connect with capacitance for ×2 mode
V_{OUT1}	—	DC-DC converter output terminal (×2 level)
C2A, C2B	—	Connect with capacitance for ×3 mode
V_{OUT2}	—	DC-DC converter output terminal (×3 level)
C3A, C3B	—	Connect with capacitance for ×4 mode
V_{OUT3}	—	DC-DC converter output terminal (×4 level)
C4A, C4B	—	Connect with capacitance for ×5 mode
V_{OUT4}	—	DC-DC converter output terminal (×5 level)
VR12	—	LV regulator monitor terminal (Note)
VR32	—	LV regulator monitor terminal (Note)
V_{CC1}	—	Power supply for LCD driver circuit
V_{CC2}	—	Power supply for HV regulator monitor terminal (Note)
V_{LC0} to V_{LC5}	—	Power supply for LCD driver circuit V_{LC5} terminal is connect to V_{SS} . (Note)
V_{SS} , V_{DD}	—	Power supply for logic circuit. Ground: Reference

Note: Connect the capacitance between this terminal and V_{SS} .

Pin Function (3)

Pin Name	I/O	Function
MD	Input	Mode detect pin for Status Read
M/S	Input	Input for master/slave selects <ul style="list-style-type: none"> • M/S = H → T6K14 is master chip • M/S = L → T6K14 is slave chip
CL	I/O	Input/Output for shift clock pulse <ul style="list-style-type: none"> • Master mode (M/S = H) → output • Slave mode (M/S = L) → input
PM	I/O	Input/Output for frame signal <ul style="list-style-type: none"> • Master mode (M/S = H) → output • Slave mode (M/S = L) → input
FR	I/O	Input/Output for display synchronous signal <ul style="list-style-type: none"> • Master mode (M/S = H) → output • Slave mode (M/S = L) → input
SYNC	I/O	Input/Output for grayscale signal data <ul style="list-style-type: none"> • Master mode (M/S = H) → output • Slave mode (M/S = L) → input
CK	I/O	Input/Output for grayscale signal data <ul style="list-style-type: none"> • Master mode (M/S = H) → output • Slave mode (M/S = L) → input

Pin Function (4)

PS	68/80	Interface Type	/CS1	CS2	D/I	RS	/WR	/RD	SO	SI	SCK	DB0 to DB7
H	L	80 series MPU (/CS1)	/CS1	H	A0	A1	/WR	/RD	Open	L/H	L/H	DB0 to DB7
		80 series MPU (CS2)	L	CS2	A0	A1	/WR	/RD	Open	L/H	L/H	DB0 to DB7
	H	68 series MPU	L	H	A0	A1	R/W	E	Open	L/H	L/H	DB0 to DB7
L	L/H	Serial interface	L	H	L/H	L/H	L/H	L/H	SO	SI	SCK	Open

Note: H denotes the V_{DD} level; L denotes the V_{SS} level.

Function of Each Block

• Interface logic

The T6K14 can be operated with 80 series MPUs or 68 series MPUs or Serial Interface.

Fig. 1 shows an example of interface. For details, please refer to the example interface part of application circuit.

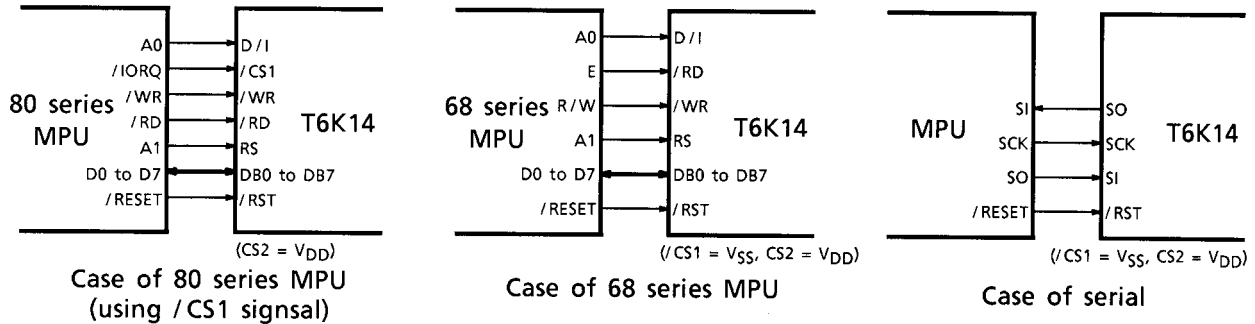


Fig. 1

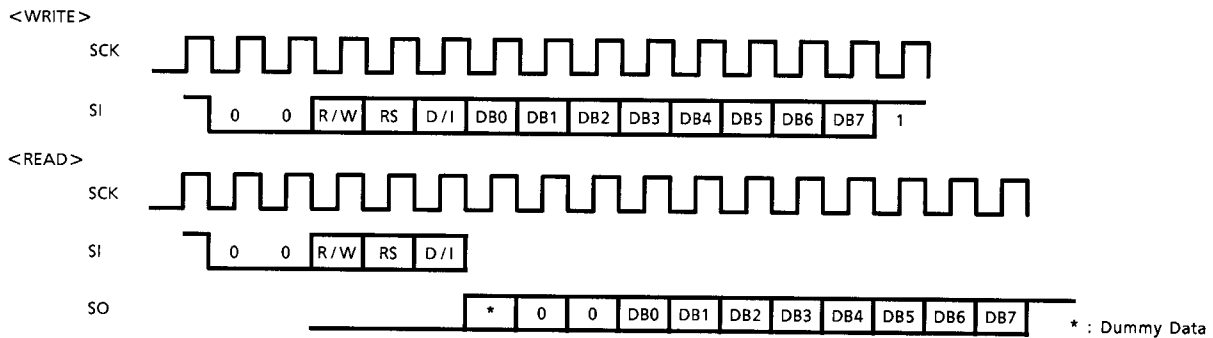


Fig. 2

• Input register

The register stores 8 bit data from MPU. D/I signal discriminate between command data and display data.

• X-address counter

X-address counter is 64-Up/Down counter. It holds the row address for the display RAM. Then it is selected by the command, writing to or reading the data of display RAM causes the X-address to automatically increment or decrement.

• Y (Page) -address counter

The Y (Page) -address counter is 32-Up/Down counter. It holds the column address for the display RAM. This counter is selected by the command. Writing to or reading the display RAM causes the Y-address to automatically increment or decrement.

• Z-address counter

The Z-address counter is 64-Up counter that provide the display RAM data for the LCD drive circuit. The data stored in Z-Address Register is send to Z-Address counter as Z start address.

For instance, when Z start address is 16, the counter increment like this: 16, 17, 18..., 62, 63, 0, 1, 2...14, 15, 16. Therefore, the display start line is 16-line of the display RAM.

- **Up/Down register**

The 1 bit data stored in this register selects Up or Down mode of X and Y (Page) -address counter.

- **Counter select register**

The 1 bit data stored in this register selects X-address counter or Y (Page) -address counter.

- **Display ON/OFF register**

This 1 bit register holds the display ON or OFF state. In the OFF state, the output data from the display RAM is not selected. In the On state, the display data appears according to the display RAM data. The display ON or OFF state does not affect the data of display RAM.

- **Z-address register**

This 6 bits register holds the data that indicates the display start line.

- **Oscillator**

The T6K14 has an on-chip oscillator. When using this oscillator, connect an external resistor between OSC1 and OSC2. When using external clock, input the clock to OSC1 and open OSC2, as shown in Fig. 3.

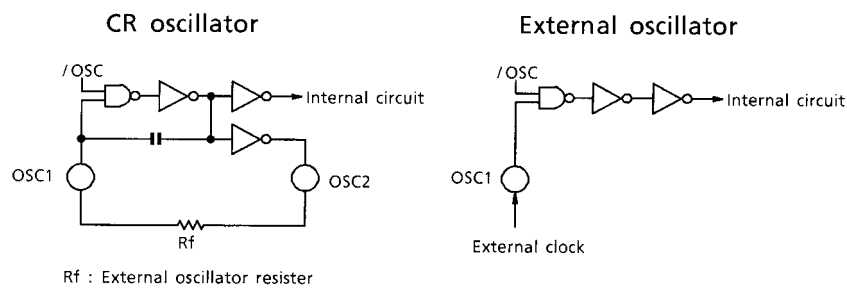


Fig. 3

- **Timing generation circuit**

The circuit divides the signals from the oscillator and generates display timing signals and operating clock.

- **Shift-register**

The T6K14 has two 32 bits shift-register and shift register of ICON. These shift-register construct 65 bits shift-register.

- **Latch circuit**

This latch circuit latches the data from the display RAM.

• **Column driver circuit**

Column driver circuit consists of 128 driver circuits. One of the four LCD driving level is selected by the combination of M (internal signal) and the display data transferred from the latch circuit. Details of column driver circuit are shown in Fig. 4.

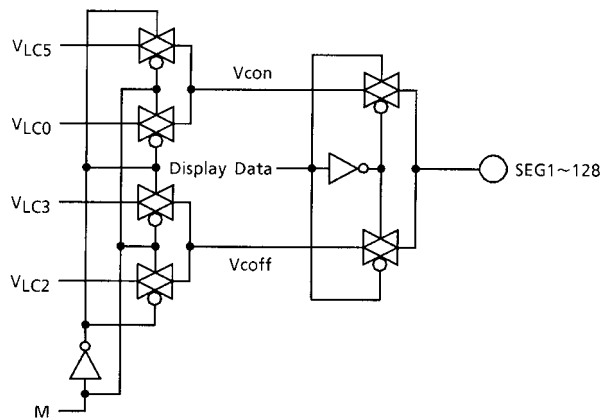


Fig. 4

• **Row driver circuit**

Row driver circuit consists of 65 drive circuits. One of the four LCD driving level is selected by the combination of M (internal signal) and the data from the sift register. Details of row driver circuit are shown in Fig. 5.

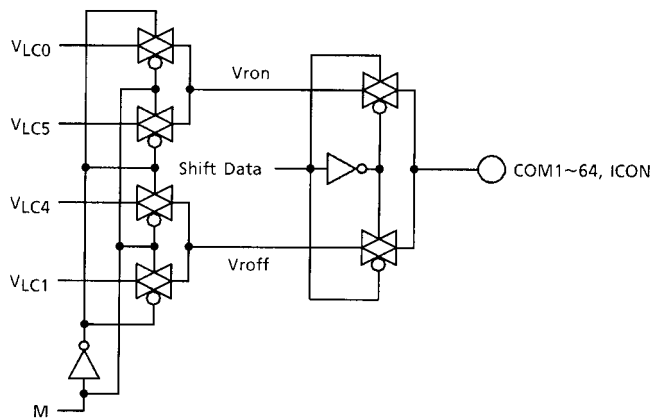


Fig. 5

● **DC-DC converter**

The T6K14 built in DC-DC converter circuit 2/3/4/5 times.

$V_{outn} = 0$ (VSS level) is at the time of /RST = L or /STB = L.

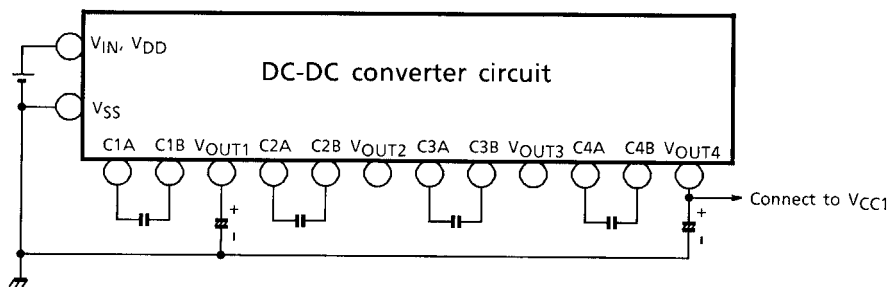
The capacitor for DC-DC converter and the capacitor for DC-DC level maintenance usually use about 1.0 μ F. Since the power supply V_{IN} terminal for DC-DC converter circuit can input voltage usually higher than a digital system power supply V_{DD} terminal, it can generate required LCD voltage in a DC-DC converter.

However, since the maximum of LCD operation voltage is 16.5 V (max) be careful about the relation of the voltage conditions (V_{IN} voltage) and the number of the DC-DC steps which are used in a DC-DC converter so that the DC-DC converted voltage (voltage value outputted from V_{out}) does not exceed 16.5 V.

Note 1: Power supply voltage $3.3\text{ V} \geq V_{IN} \geq 2.7\text{ V}$, $V_{IN} \geq V_{DD}$

Note 2: LCD voltage $16.5\text{ V} \geq V_{IN} \times n$
(n: number of DC-DC steps)

ex) Using the $\times 5$ mode



About Terminal Processing

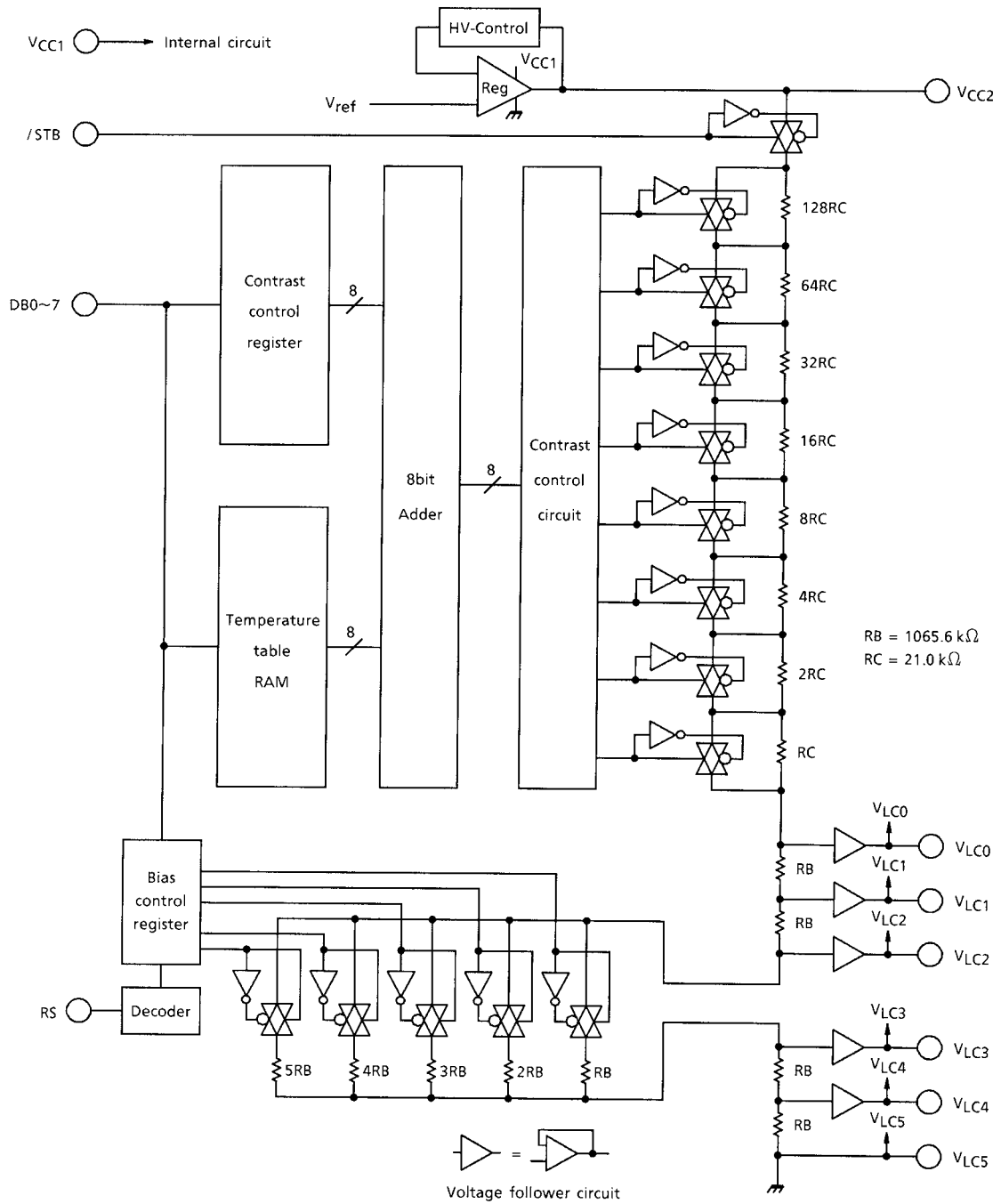
Conditions	C1A, C1B	V _{OUT1}	C2A, C2B	V _{OUT2}	C3A, C3B	V _{OUT3}	C4A, C4B	V _{OUT4}
$\times 2$ mode	O	O	Open	Open	Open	Open	Open	Open
$\times 3$ mode	O	O	O	O	Open	Open	Open	Open
$\times 4$ mode	O	O	O	Open	O	O	Open	Open
$\times 5$ mode	O	O	O	Open	O	Open	O	O
None	Open	Open	Open	Open	Open	Open	Open	Open

Note: O = Connect the capacitance.

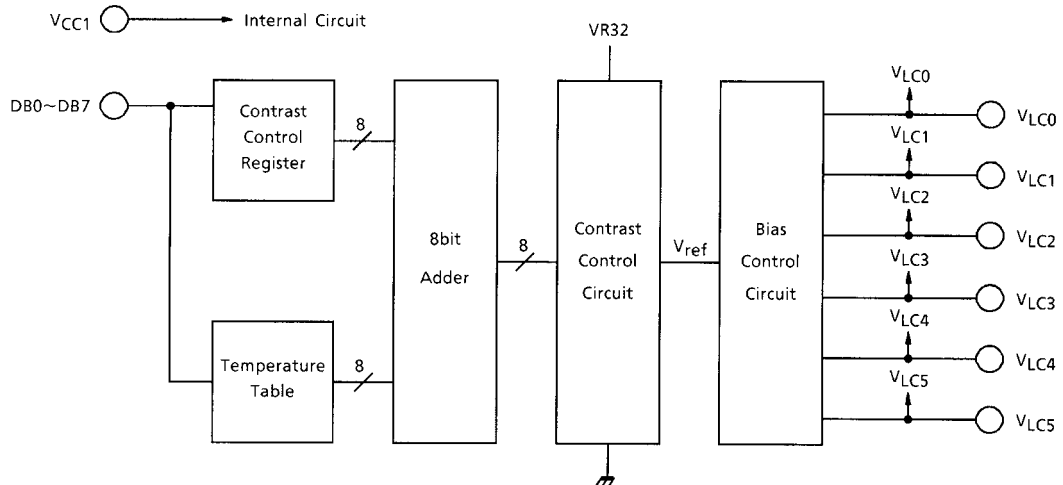
Note: The voltage outputted from DC-DC converter changes with voltage condition, temperature environment, substrate environment, etc.

• Voltage driver resistor, contrast control circuit (Normal mode)

The T6K14 has on-chip resistors to divide bias voltage with op-amp., and a contrast control circuit. The voltage bias is changed by instruction command. And one of four bias is selected.



• Contrast control circuit (Power Save Mode)

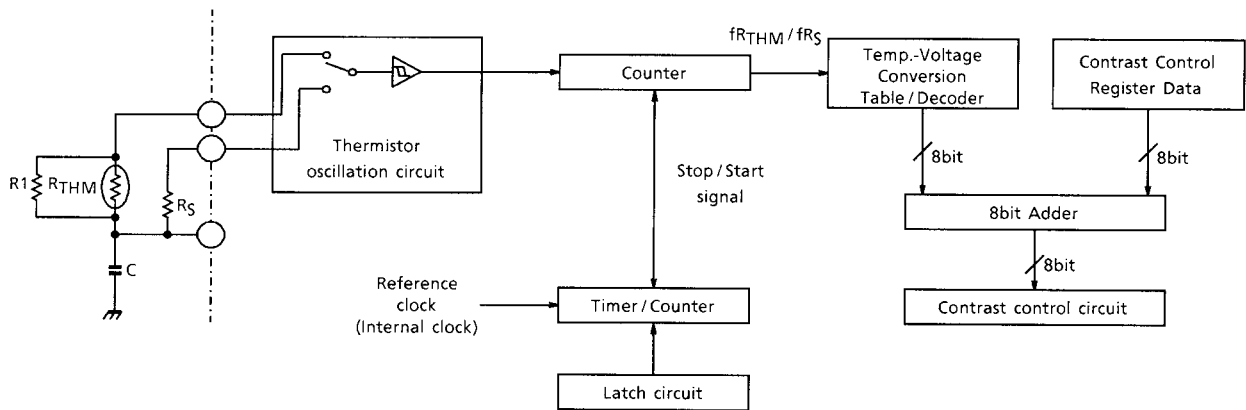


Contrast control output voltage (VLC0) (Typical Value)

Condition	VR32 [V]	V _{LCO} (min) [V]	V _{LCO} (max) [V]	Contrast Step [mV]	Bias
Power Save	3.2	2.2	5.0	11.0	1/12

• **Temperature compensation circuit**

The T6K14 has the temperature compensation circuit.



- R1 : 91 kΩ
- RS : 47 kΩ
- RTHM: 100 kΩ Thermistor
Semitec Type 104HT-1P
- C : 1000 pF

While this temperature compensation circuit detects temperature, it controls automatically built-in contrast control. And, original contrast control suitable for all LCD material can be created by writing data in RAM for temperature compensation circuit (TMP-RAM). Please refer to description of a function about the usage.

Command Definition

Command	Reg. No.	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Register set (REG)	—	0	0	0	1	0	0	0	Register (0 to 31)				
Status read (STRD)	—	0	0	1	0	MD	*	TMP	HVR	N/F	DP	Y/X	U/D
Data mode (DMD)	R0	0	1	0	1	0	0	0	0	0	D/TM	Y/X	U/D
Display mode (DPE)	R1	0	1	0	1	0	CDR	SDR	0	0	0	N/F	DP
Power mode (PWE)	R2	0	1	0	1	×4/×5	0	0	0	0	VR	OP	DC
Duty/Bias Select (DTE)	R3	0	1	0	1	Bias (5 to 9)			0	0	Duty (0 to 3)		
Oscillation (OSE)	R4	0	1	0	1	0	0	0	0	0	0	0	OSC
X, Y-address (SXYE)	R5	0	1	0	1	1	F/N	X-Address (0 to 63)					
						0	0	0	Y-Address (0 to 31)				
Z-address (SZE)	R6	0	1	0	1	0	0	Z-Address (0 to 63)					
Contrast control (SCE)	R7	0	1	0	1	Contrast Control (0 to 255)							
TMP mode (TMPM)	R8	0	1	0	1	0	0	0	0	TMO F	0	time (0 to 3)	
TMP-RAM address (TMPA)	R9	0	1	0	1	0	TMP-RAM address (0 to 127)						
FRS control mode (FRSC)	R10	0	1	0	1	0	0	FR control (0 to 63)					
Grayscale (1) (GR1) Normal display pattern	R11	0	1	0	1	Grayscale pattern data (1) Normal display data = "00" ... 16 bits							
	R12	0	1	0	1								
Grayscale (2) (GR2) Normal display pattern	R13	0	1	0	1	Grayscale pattern data (2) Normal display data = "01" ... 16 bits							
	R14	0	1	0	1								
Grayscale (3) (GR3) Normal display pattern	R15	0	1	0	1	Grayscale pattern data (3) Normal display data = "10" ... 16 bits							
	R16	0	1	0	1								
Grayscale (4) (GR4) Normal display pattern	R17	0	1	0	1	Grayscale pattern data (4) Normal display data = "11" ... 16 bits							
	R18	0	1	0	1								
Grayscale (5) (GR5) Power save display pattern	R19	0	1	0	1	Grayscale pattern data (5) Power save display data = "00" ... 16 bits							
	R20	0	1	0	1								
Grayscale (6) (GR6) Power save display pattern	R21	0	1	0	1	Grayscale pattern data (6) Power save display data = "01" ... 16 bits							
	R22	0	1	0	1								
Grayscale (7) (GR7) Power save display pattern	R23	0	1	0	1	Grayscale pattern data (7) Power save display data = "10" ... 16 bits							
	R24	0	1	0	1								
Grayscale (8) (GR8) Power save display pattern	R25	0	1	0	1	Grayscale pattern data (8) Power save display data = "11" ... 16 bits							
	R26	0	1	0	1								
TMP-RAM address read	R27	0	1	1	0	*	TMP-RAM address data (7 bits)						
Test mode	R28 to 31	0	1	0	1	Please do not using this register							
Data write (DAWR)	—	1	1	0	1	Write data							
Data read (DARD)	—	1	1	1	0	Read data							

- **Register set**

Identify register number
R0 (00H) to R31 (1FH)

Note: R28 to R31 registers are provided for test. Please do not choose these registers.

- **R0: Data mode**

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	0	1	0	0	0	0	0	D/TM	Y/X	U/D

- D/TM : Selects between display RAM address and TMP-RAM address counters.
D/TM = 1: Display RAM counter is selected. D/TM = 0: TMP-RAM counter is selected.
- Y/X : Selects between X-counter and Y-counter.
Y/X = 1: Y-counter is selected. Y/X = 0: X-counter is selected.
- U/D : Sets a counter mode.
U/D = 1: Up mode is selected. U/D = 0: Down mode is selected.

- **R1: Display mode**

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	0	1	0	CDR	SDR	0	0	0	N/F	DP

- CDR : Sets the common data scanning direction.
CDR = 1: COM1 → COM64 → ICON CDR = 0: COM64 → COM1 → ICON
- SDR : Sets the segment data direction
See "RAM map and CDR, SDR relation"
- N/F : Selects between normal display mode and Power save mode.
N/F = 1: Normal display mode is selected. N/F = 0: Power save mode (Flag display only) is selected.
- DP : Turns display ON or OFF.
DP = 1: Display is turned ON. DP = 0: Display is turned OFF.

● **R2: Power management**

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	0	1	X4/X5	0	0	0	0	VR	OP	DC

X4/X5 :

X4/X5 = 0: LCD voltage regulator output voltage is 12.5 V typ. (at Ta = 25°C)

X4/X5 = 1: LCD voltage regulator output voltage is 11.0 V typ. (at Ta = 25°C)

VR : LCD voltage regulator (HVR)

VR = 1: Voltage regulator is turned ON.

VR = 0: Voltage regulator is turned OFF.

Input the voltage to V_{CC2} pin.

OP : Op-amp

OP = 1: Op-amp is turned ON.

OP = 0: Op-amp is turned OFF.

Input various voltage to V_{LC0} to V_{LC4} pins.

DC : DC-DC converter

DC = 1: DC-DC converter is turned ON.

DC = 0: DC-DC converter is turned OFF.

Input the voltage to V_{CC1} pin.

Note: Refer to the description of a function for the combination of a power supply setup.

● **R3: Bias/Duty select**

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	0	1	Bias				0	0	Duty	

Bias select :

	DB7	DB6	DB5	DB4	
	1	0	0	1	1/9 bias
	1	0	0	0	1/8 bias
	0	1	1	1	1/7 bias
	0	1	1	0	1/6 bias
	0	1	0	1	1/5 bias

Duty select :

	DB1	DB0	
	1	1	1/65 duty
	1	0	1/57 duty
	0	1	1/49 duty
	0	0	1/35 duty

(Note): The T6K14's COM output which corresponds to the line of LCD is changed by the Duty.
When CDR = 1, COM outputs in each Duty are shown below.

1/n duty	LCD	1 st line, 2 nd line, , n th line, ICON
1/65 duty		COM1, COM2, ,COM32, COM33, COM34, ,COM64, ICON
1/57 duty		COM1, COM2, ,COM28, COM33, COM34, ,COM60, ICON
1/49 duty		COM1, COM2, ,COM24, COM33, COM34, ,COM56, ICON
1/35 duty		COM1, COM2, ,COM17, COM33, COM34, ,COM49, ICON

● **R4: Oscillator control**

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	0	1	0	0	0	0	0	0	0	OSC

OSC : Oscillator

OSC = 1: Oscillator is turned ON.

OSC = 0: Oscillator is turned OFF.

Input an external clock to OSC1 pin.

● **R5: X-address, Y-address set**

(1) **X-address set**

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	0	1	1	F/N	X-Address (0~63)					

F/N = 0: Sets display RAM address (in the range 0 to 63 (Note)).

F/N = 1: Sets flag RAM (The data from DB0 to DB5 is ignored)

Note: Since the effective range of X-address changes by duty setup, please be careful.

(2) **Y-address set**

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	0	1	0	0	0	Y-Address (0~31)				

● **R6: Z-address set**

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	0	1	0	0	Z-Address (0~63)					

This command sets a Z-address. The display RAM and flag RAM are separated and only the display RAM is selected. By selecting any address in the column direction of the display RAM, it is possible to set the first line on the LCD screen. The display data can be scrolled in the vertical direction by setting the first line in this way.

Since the effective range of Z-address changes by duty setup, please be careful.

Please refer to description of a function for details.

● **R7: Contrast control**

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	0	1	Contrast Control (0~255)							

This command sets contrast.

It becomes the maximum contrast when data is 255, and it becomes the minimum contrast when data is 0.

When a temperature compensation circuit is used, data for a contrast control circuit are changed to the sum of R7 register 8-bit data and TMP-RAM 8-bit data. Therefore, the contrast is controlled.

● **R8: TMP mode**

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	0	1	0	0	0	0	TMOF	0	TIME	

TMOF: Temperature compensation ON/OFF

TMOF = 1: ON

TMOF = 0: OFF (Note 1)

DB1	DB0	
1	1	4 sec cycle
1	0	2 sec cycle
0	1	1 sec cycle
0	0	No measurement

Note 1: Data on the output bus of the temperature table RAM are fixed on Low data. Therefore, data on the contrast control register are inputted to contrast control circuit.

● **R9: TMP-RAM address**

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	0	1	0	TMP-RAM address (0~127)						

This command sets TMP-RAM address.
In case of using this command, counter up mode only.

● **R10: FRS control**

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	0	1	0	0	FR control (0~63)					

This command sets the number of the row lines for polarity change.
The setting of FRS corresponds to the row line number, see following table.

FRS	Frame
0	In case 1/x duty is selected by R3, FR signal inverts on every x line. (Note)
n	FR signal inverts on every (n + 1) line.

Note: In case FRS = 0;
FR signal inverts synchronously with the earlier edge of COM1.
In case FRS ≠ 0 (1 to 63);
FR signal inverts synchronously with the edge of COMm. (m = 1 to 64, or ICON)
“m” shows a COM line right after the instruction practice.

● **R11 to R26: Grayscale data**

This register have the PWM (Pulse Width Modulation) and FRC (Frame Rate Control) control data. PWM chooses one of 10 kinds and assigns data of PWM to four frames.

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	0	1	1st FR data				0th FR data			
					3rd FR data				2nd FR data			

This register is constituted from “0th FR data” by 4 bits of “3rd FR data”, and inputs PWM data into four FR data. That is, it becomes data of one color (one grayscale level) by 4 frames.

Display Mode	Display RAM Data		Register No.	Grayscale Data
Normal Display Mode	0	0	R11, 12	4 bits × 4
	0	1	R13, 14	4 bits × 4
	1	0	R15, 16	4 bits × 4
	1	1	R17, 18	4 bits × 4
Power Save Mode	0	0	R19, 20	4 bits × 4
	0	1	R21, 22	4 bits × 4
	1	0	R23, 24	4 bits × 4
	1	1	R25, 26	4 bits × 4

- Data of PWM (Pulse Width Modulation)

FR DATA	HEX	PWM (ON WIDTH)	NOTE
0000	0	0 (0/9)	
0001	1	1/9	
0010	2	2/9	
0011	3	3/9	
0100	4	4/9	
0101	5	5/9	
0110	6	6/9	
0111	7	7/9	
1000	8	8/9	
1001	9	1 (9/9)	
1010 ⋮ 1111	A ⋮ F	0 (0/9)	(Note)

*: The phase of PWM turn over by the even/odd of the output pin.

Note: This area is selected to off level (0/9 level)

- R27: TMP-RAM address read

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	1	0	*	d	d	d	d	d	d	d

This register stores the address equivalent to the temperature detected by the temperature compensation circuit. (Read out only). When the temperature compensation circuit is used, the contrast is controlled by the sum of TMP-RAM data specified by this address, and the data in the R7 register.

- R28 to 31: Test mode

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	1	0	1	Test mode							

Please don't access this register.

- **Status read**

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Code	0	0	1	0	MD	*	TMP	HVR	N/F	DP	Y/X	V/D

- MD : When MD terminal is connected to V_{DD} level, MD (DB7) = 1.
When MD terminal is connected to V_{SS} level, MD (DB7) = 0.
- TMP : When TMP = 1, the temperature compensation circuit is turned ON.
When TMP = 0, the temperature compensation circuit is turned OFF.
- HVR : When HVR = 1, HV - Regulator X 4 mode is selected.
When HVR = 0, HV - Regulator X 5 mode is selected.
- N/F : When N/F = 1, Normal display mode is selected.
When N/F = 0, Power save mode (FLAG display only) is selected.
- DP : When DP = 1, Display is turned ON.
When DP = 0, Display is turned OFF.
- Y/X : When Y/X = 1, Y - counter is selected.
When Y/X = 0, X - counter is selected.
- U/D : When U/D = 1, X and Y counters are in up mode.
When U/D = 0, X and Y counters are in down mode.

- **Write/read data (DAWR/DARD)**

	D/I	RS	/WR	/RD	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
Code	1	1	0	1	d	d	d	d	d	d	d	d	DAWR
	1	1	1	0	d	d	d	d	d	d	d	d	DARD

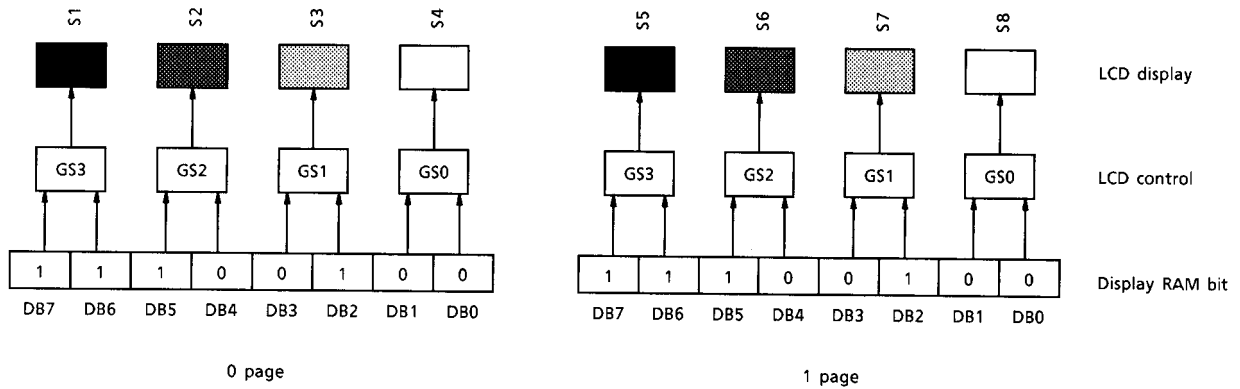
DAWR : Data write
DARD : Data read

The command DAWR writes 8-bit data to Display RAM or TMP-RAM.
The command DARD reads 8-bit data from Display RAM or TMP-RAM.

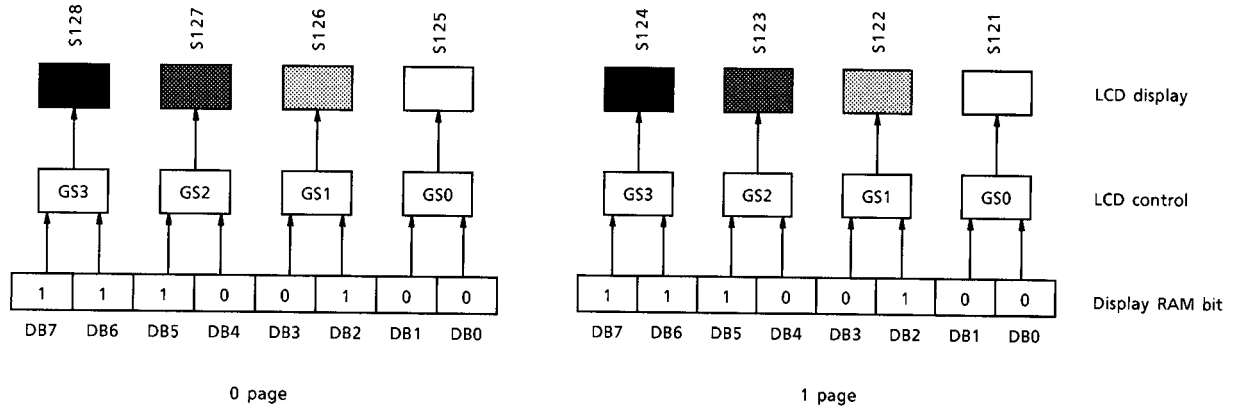
Function Description

- Display data bit

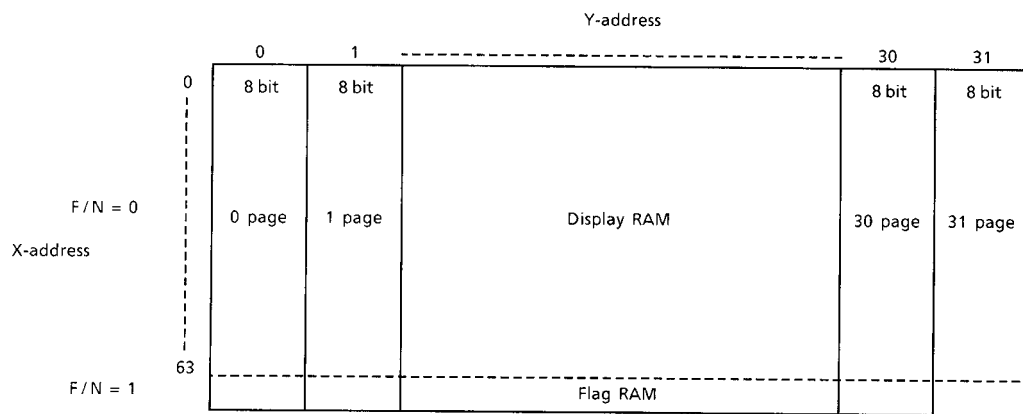
SDR = 1



SDR = 0



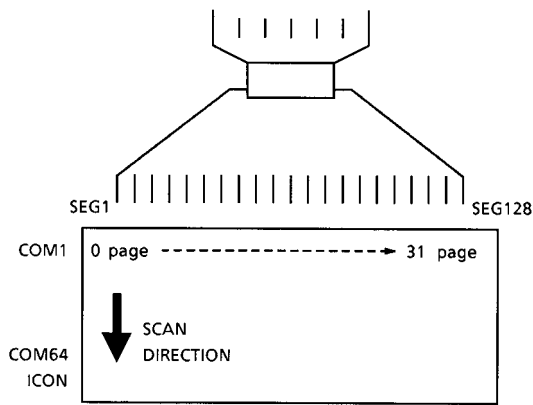
- Display mode



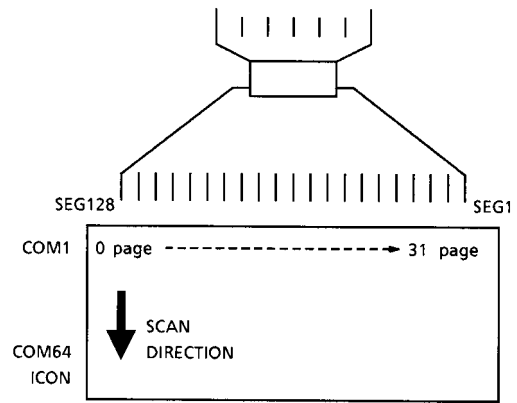
256 (128 × 2) bit

RAM map and CDR, SDR relation

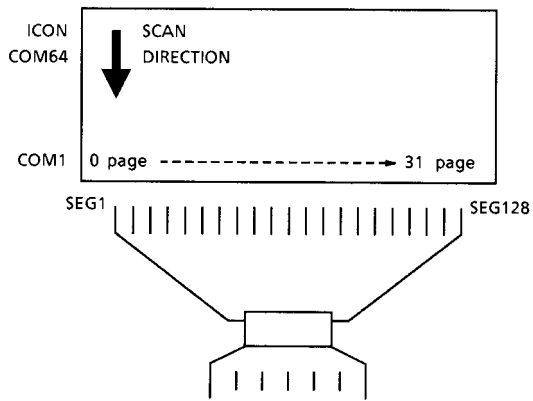
(1) CDR = 1, SDR = 1



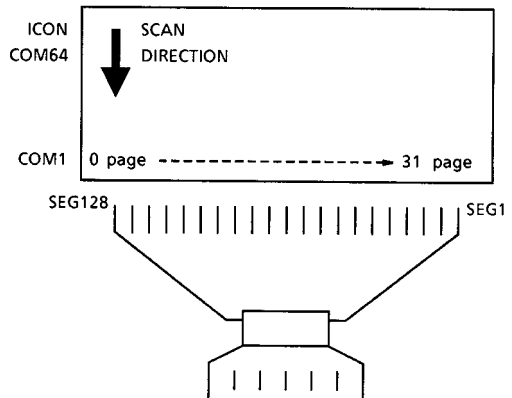
(2) CDR = 1, SDR = 0



(3) CDR = 0, SDR = 1



(4) CDR = 0, SDR = 0



- **Reset function**

When/RST = L, reset function is executed and following instruction (resister) are executed.

Command	Reg No.	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0
Data mode	R0	*	*	*	*	*	1	1	1
Display mode	R1	*	1	1	*	*	*	1	0
Power mode	R2	1	*	*	*	*	0	0	0
Duty/Bias	R3	1	0	0	1	*	*	1	1
Oscillator	R4	*	*	*	*	*	*	*	1
X, Y-address	R5	0	0	0	0	0	0	0	0
Z-address	R6	*	*	0	0	0	0	0	0
Contrast control	R7	0	0	0	0	0	0	0	0
TMP mode	R8	*	*	*	*	0	*	0	0
TMP-RAM address	R9	*	0	0	0	0	0	0	0
FRS control mode	R10	*	*	0	0	0	0	0	0
Gray scale	R11 to R27	0	0	0	0	0	0	0	0

- **Standby function**

When/STB = L, the T6K14 is in standby state. The internal oscillation is stopped, power consumption is reduced, and power supply for LCD (VLC0 to VLC5) become VSS.

• **Expansion function**

The T6K14 has expansion function. When using this function, the T6K14 (2 chip) can drive $256 \times 64 + \text{icon}$ dots LCD panel (maximum) or $128 \times 128 + \text{icon}$ dots LCD panel (Maximum).
 Next table shows the selectable function by using M/S pins.

M/S	
H	L
<ul style="list-style-type: none"> • One chip mode Disable expansion model • Two chips mode (Master chip) Timing signal and power voltage supply to Slave chip. 	<ul style="list-style-type: none"> • Two chips mode (Slave chip) Timing signal and power voltage are supplied from Master chip.

Fig. 6 and Fig.7 illustrate the application example of disable expansion mode and enable expansion mode.
 In enable expansion mode (Two chip mode)
 As shown in Fig.7-1, Fig.7-2 Master chip supplies LCD drive signals and power voltage to slave chip. (The oscillator, the timing circuits, Op-amp, and Contrast control circuit are disable.)

(1) Disable expansion mode

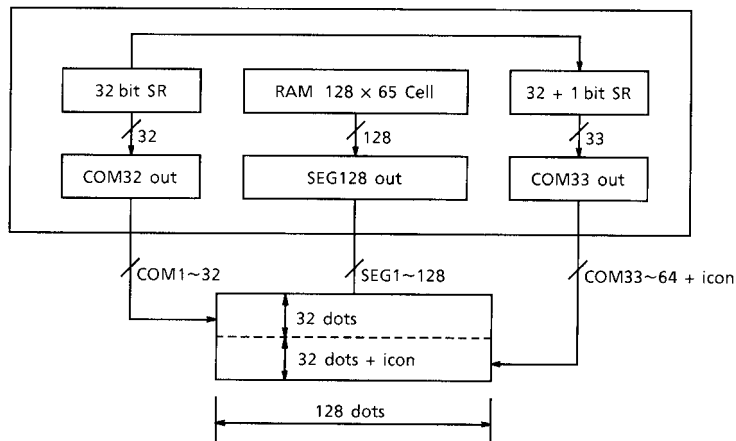


Fig. 6

(2) Enable expansion mode

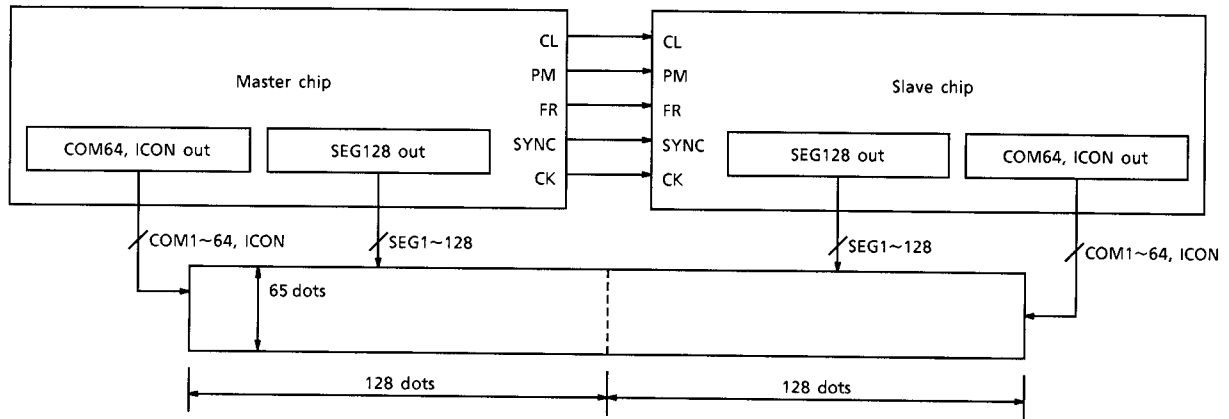


Fig. 7-1

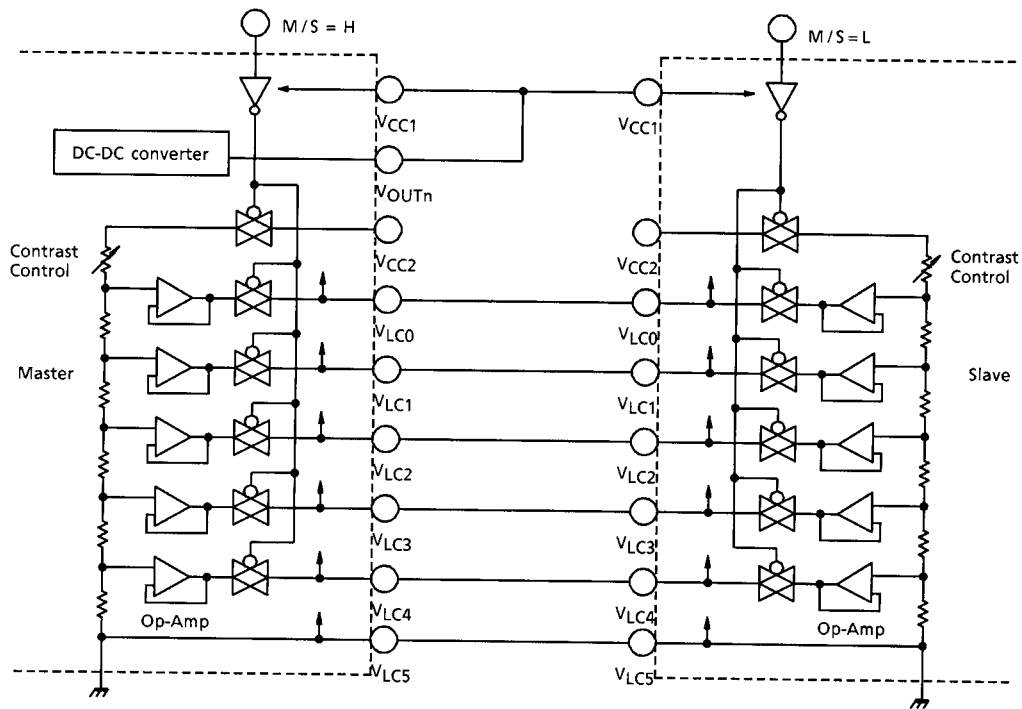


Fig. 7-2

• X-address counter and Y (Page) -address counter

Fig. 8-1 shows a sample of operating procedure for the X-address counter. After reset is executed, X-address becomes X-address = 0, then select X-counter/Up mode. Next set the X-address to 62 by commanding SXYE (R5). After data has been written to or read, the X-address is automatically incremented by one. After X-counter/Down mode has been selected and data has been written to or read, the X-address is automatically decremented by one. When the X-counter is selected, Y-counter does not count up or down. And flag-counter does not count up or down too.

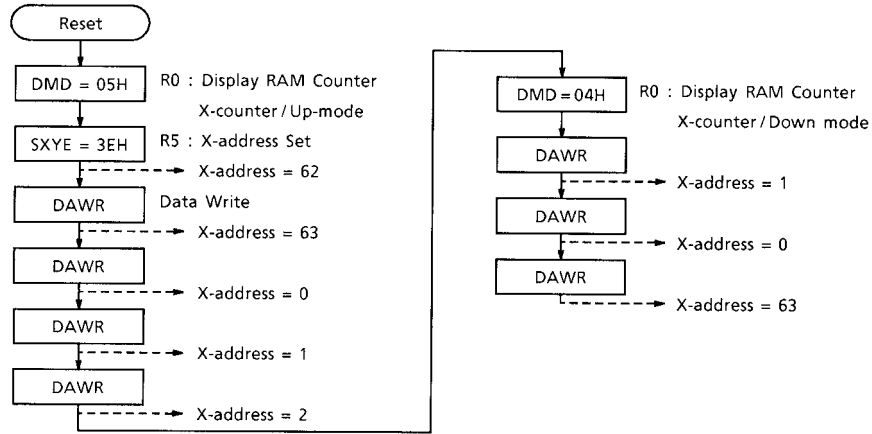


Fig. 8-1

Fig. 8-2 shows a sample operating procedure for the Y-address counter. After reset is executed, Y (Page) -address becomes Y-address = 0, then select Y (Page) -counter/Up mode. After data has been written to or read, the Y (Page) -address counter is automatically incremented by one. After Y (Page) -counter/Down mode has been selected and data has been written to or read, the Y (Page) -address is automatically decremented by one. When the Y (Page) -counter is selected, X -counter doesn't count up or down.

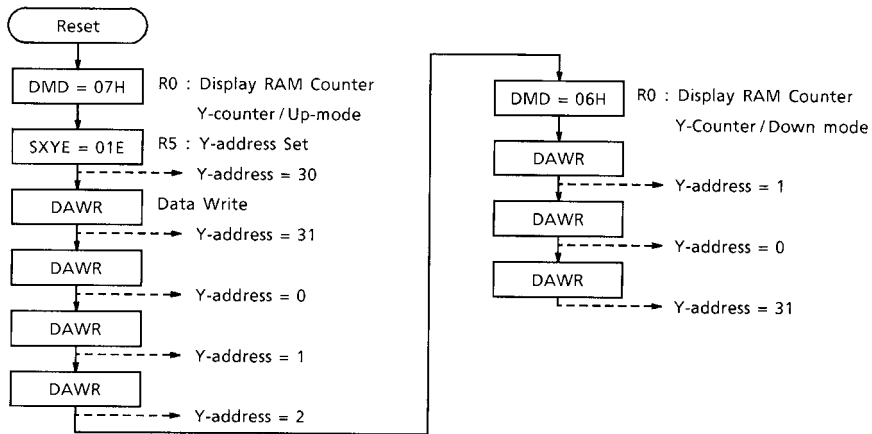
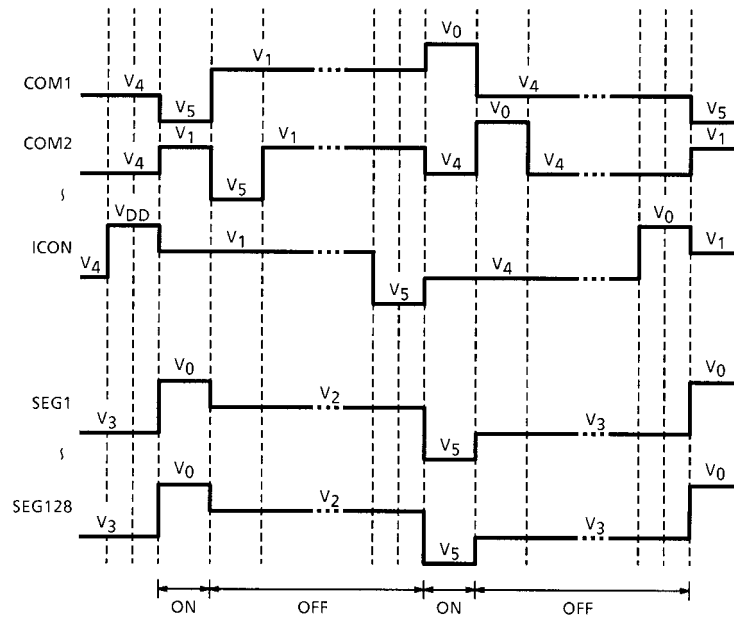


Fig. 8-2

• LCD Driver Waveform (Case of normal mode)



LCD driver timing chart (1/65 duty)

Maximum Ratings (Ta = 25°C)

Item	Symbol	Rating	Unit
Supply Voltage (1)	V_{DD} (Note 1)	-0.3 to 7.0	V
Supply Voltage (2)	$V_{LC1, 2, 3, 4, 5}$ V_{CC1}, V_{CC2}	$V_{SS} + 18.0$ to $V_{SS} - 0.3$	V
Input Voltage	V_{inp} (Note 1, 2)	-0.3 to $V_{DD} + 0.3$	V
Operating Temperature	T_{opr}	-30 to 85	°C
Storage Temperature	T_{stg}	-55 to 125	°C

Note 1: Referred to $V_{SS} = 0$ V

Note 2: Applied data bus terminals and Input terminals expect $V_{CC1}, V_{CC2}, V_{LC0}, V_{LC1}, V_{LC2}, V_{LC3}, V_{LC4}, V_{LC5}$.

Electrical Characteristics

DC Characteristics (1) (Test conditions: Unless Otherwise Noted, $V_{SS} = 0\text{ V}$, $V_{DD} = 2.4\text{ to }3.3\text{ V}$, $V_{IN} = 2.7\text{ to }3.3\text{ V}$, $V_{CC} = 6.0\text{ to }16.5\text{ V}$, $T_a = 25^\circ\text{C}$)

Item	Symbol	Test Circuit	Condition	Min	Typ.	Max	Unit	Applicable Terminal
Operating Supply (1)	V_{DD}	—	—	2.4	—	3.3	V	V_{DD}
Operating Supply (2)	V_{IN}	—	—	2.7	—	3.3	V	V_{IN}
Operating Supply (3)	V_{LC0} $V_{CC1, 2}$	—	—	6.0 - V_{SS}	—	16.5 - V_{SS}	V	V_{LC0} , V_{CC1} , V_{CC2}
Input Level	H Level	V_{IH}	—	$V_{DD} = 2.8\text{ to }3.3\text{ V}$ 0.7 V_{DD}	—	V_{DD}	V	DB0 to DB7, D/I,WR, /RD,/CS1, CS2,/RST, /STB, RS, SI, SCK, P/S, 68/80, CL, PM, FR, SYNC, CK
	L Level	V_{IL}	—	$V_{DD} = 2.4\text{ to }2.8\text{ V}$ 0.8 V_{DD}	—	V_{DD}		
Output Level	H Level	V_{OH}	—	$I_{OH} = -400\ \mu\text{A}$ V_{DD} - 0.2	—	V_{DD}	V	DB0 to DB7, SO, CL, PM, FR, SYNC, CK
	L Level	V_{OL}	—	$I_{OL} = 400\ \mu\text{A}$ 0	—	0.2	V	
Column Driver On Resistance	Normal Mode	R_{col1}	—	(Note 1)	—	7.5	k Ω	SEG1 to SEG128
	Power Save Mode	R_{col2}	—	(Note 2)	—	15.0	k Ω	SEG1 to SEG128
Row Driver On Resistance	Normal Mode	R_{row1}	—	(Note 1)	—	1.5	k Ω	COM1 to COM64,ICON
	Power Save Mode	R_{row2}	—	(Note 2)	—	5.0	k Ω	COM1 to COM64, ICON
Input Leakage	I_{IL}	—	$V_{inp} = V_{DD}\text{ to GND}$	-1	—	1	μA	DB0 to DB7, D/I,WR, /RD,/CS1, CS2,/RST, /STB, RS, SI, SCK, P/S, 68/80, CL, PM, FR, SYNC, CK
Operating Freq	f_{OSC}	—	(Note 7)	69	82	95	kHz	OSC1
External Clock Freq	f_{ex}	—	(Note 6)	—	82	—	kHz	OSC1
External Clock Duty	f_{duty}	—	—	45	50	55	%	OSC1
External Clock Rise/Fall Time	tr/tf	—	—	—	—	50	ns	OSC1
Current Consumption (1)	I_{SS1}	—	(Note 3)	—	200	350	μA	V_{SS}
Current Consumption (2)	I_{SS2}	—	(Note 4)	—	500	700	μA	V_{SS}
Current Consumption (3)	I_{SSSTB}	—	(Note 5)	-1	—	1	μA	V_{SS}

Note 1: $V_{SS} + V_{LC0} = 11.0\text{ V}$, Load voltage = $\pm 0.5\text{ V}$, 1/9 bias

Note 2: $V_{SS} + V_{LC0} = 3.0\text{ V}$, Load voltage = $\pm 0.5\text{ V}$, 1/12 bias

Note 3: $V_{DD} = 2.7\text{ V}$, $V_{CC1, 2} = V_{OUT4}$ (X5 mode), No data access, Internal clock ($f_{OSC} = 82\text{ kHz}$), LCD out pin No Load, 1/9 bias, 1/65 duty, op-amp. on, regulator on

Note 4: $V_{DD} = 3.0\text{ V}$, $V_{CC1, 2} = V_{OUT4}$ (X5 mode), Data access cycle $f_{\overline{CE}} = 1\text{ MHz}$, Internal clock ($OSC = 82\text{ kHz}$), LCD out pin No Load, 1/9 bias, 1/65 duty, op-amp. on, regulator on

Note 5: $V_{DD} = 3.3\text{ V}$, $V_{CC1, 2} - V_{SS} = 16.5\text{ V}$, /STB = L

Note 6: In case of 1/65 duty and $f_{FR} = 70\text{ Hz}$

Note 7: $V_{DD} = 3.0\text{ V}$, 1/65 duty, $f_{FR} = 70\text{ Hz}$, $R_{osc} = 430\text{ k}\Omega$, $T_a = 25^\circ\text{C}$

DC Characteristics (2)

(Test conditions: Unless Otherwise Noted, $V_{SS} = 0\text{ V}$, $V_{DD} = 2.4\text{ to }3.3\text{ V}$, $T_a = 25^\circ\text{C}$)

Item	Symbol	Test Circuit	Condition	Min	Typ.	Max	Unit	Applicable Terminal
Output Voltage (X2 Mode)	VO1	(1)	(Note 8)	4.60	5.10	—	V	V _{OUT1}
Output Voltage (X3 Mode)	VO2	(2)	(Note 9)	6.80	7.60	—	V	V _{OUT2}
Output Voltage (X4 Mode)	VO3	(3)	(Note 10)	9.10	10.20	—	V	V _{OUT3}
Output Voltage (X5 Mode)	VO4	(4)	(Note 11)	11.40	12.70	—	V	V _{OUT4}

Note 8: $V_{IN} = 2.7\text{ V}$, $I_{Load} = 200\ \mu\text{A}$, $V_{CC1, 2} = 5.40\text{ V}$ (external power supply) $C_{nA} - C_{nB} = 1.0\ \mu\text{F}$, $V_{OUT1} - V_{SS} = 1.0\ \mu\text{F}$, $OSC = 82\text{ kHz}$, $T_a = 25^\circ\text{C}$

Note 9: $V_{IN} = 2.7\text{ V}$, $I_{Load} = 200\ \mu\text{A}$, $V_{CC1, 2} = 8.10\text{ V}$ (external power supply) $C_{nA} - C_{nB} = 1.0\ \mu\text{F}$, $V_{OUT1} - V_{SS} = 1.0\ \mu\text{F}$, $OSC = 82\text{ kHz}$, $T_a = 25^\circ\text{C}$

Note 10: $V_{IN} = 2.7\text{ V}$, $I_{Load} = 200\ \mu\text{A}$, $V_{CC1, 2} = 10.80\text{ V}$ (external power supply) $C_{nA} - C_{nB} = 1.0\ \mu\text{F}$, $V_{OUT1} - V_{SS} = 1.0\ \mu\text{F}$, $OSC = 82\text{ kHz}$, $T_a = 25^\circ\text{C}$

Note 11: $V_{IN} = 2.7\text{ V}$, $I_{Load} = 200\ \mu\text{A}$, $V_{CC1, 2} = 13.50\text{ V}$ (external power supply) $C_{nA} - C_{nB} = 1.0\ \mu\text{F}$, $V_{OUT1} - V_{SS} = 1.0\ \mu\text{F}$, $OSC = 82\text{ kHz}$, $T_a = 25^\circ\text{C}$

DC Characteristics (3)

(Test conditions: Unless Otherwise Noted, $V_{SS} = 0\text{ V}$, $V_{DD} = 2.4\text{ to }3.3\text{ V}$)

Item	Symbol	Test Circuit	Condition	Min	Typ.	Max	Unit	Applicable Terminal
Regulator Reference High Voltage (1)	VHR	—	$X4/X5 = 0$, $T_a = 25^\circ\text{C}$ (Note 12)	12.3	12.5	12.7	V	V _{CC2}
		—	$X4/X5 = 1$, $T_a = 25^\circ\text{C}$ (Note 12)	10.8	11.0	11.2	V	V _{CC2}
Regulator Reference High Voltage (2)	VHRC	—	$T_a = -20^\circ\text{C}$ (Note 12)	0.999 × VHR	1.012 × VHR	1.025 × VHR	V	V _{CC2}
Regulator Reference High Voltage (3)	VHRH	—	$T_a = 60^\circ\text{C}$ (Note 12)	0.982 × VHR	0.994 × VHR	1.006 × VHR	V	V _{CC2}

Note 12: $V_{CC1} \geq 12.8\text{ V}$ at $T_a = -20\text{ to }60^\circ\text{C}$

DC Characteristics (4)

(Test conditions: Unless Otherwise Noted, $V_{SS} = 0\text{ V}$, $V_{DD} = 2.4\text{ to }3.3\text{ V}$, $T_a = 25^\circ\text{C}$)

Item	Symbol	Test Circuit	Condition	Min	Typ.	Max	Unit	Applicable Terminal
Op-amp Output Voltage Offset (1)	V_{opoff}	—	(Note 13)	-100	—	100	mV	V_{LC0} , V_{LC1} , V_{LC2} , V_{LC3} , V_{LC4}
Op-amp Output Voltage Offset (2)	V_{opoffs}	—	(Note 14)	-90	—	90	mV	V_{LC0} , V_{LC1} , V_{LC2} , V_{LC3} , V_{LC4}

Note 13: $V_{DD} = 2.7\text{ to }3.3\text{ V}$, $V_{SS} = 0\text{ V}$, 1/9 bias, 1/65 duty
 $V_{CC1} = 13.0\text{ V}$, $V_{CC2} = 12.5\text{ V}$, Contrast control = max
 Op-amp ON, DC-DC OFF, regulator OFF, LCD outpin No Load

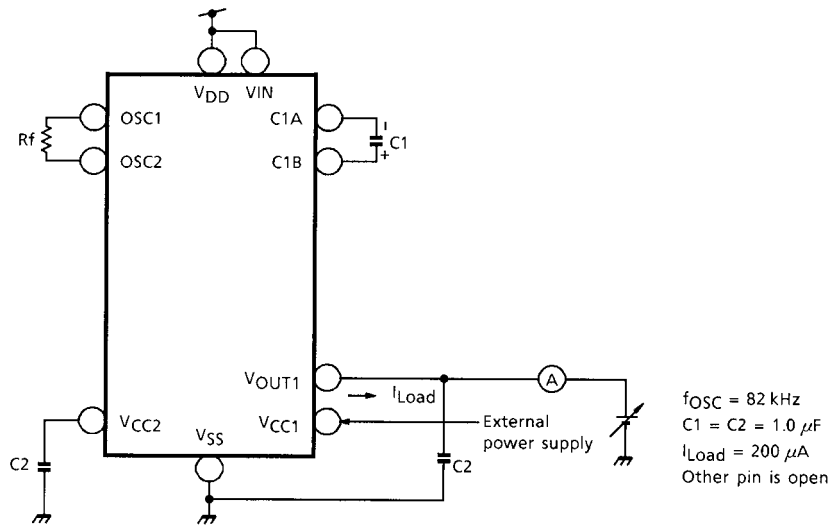
Case of V_{LC0} : $12.5 - V_{LC0} = V_{opoff}$
 V_{LC1} : $(V_{LC0} \times 8/9) - V_{LC1} = V_{opoff}$
 V_{LC2} : $(V_{LC0} \times 7/9) - V_{LC2} = V_{opoff}$
 V_{LC3} : $(V_{LC0} \times 2/9) - V_{LC3} = V_{opoff}$
 V_{LC4} : $(V_{LC0} \times 1/9) - V_{LC4} = V_{opoff}$

Note 14: $V_{DD} = 2.7\text{ to }3.3\text{ V}$, $V_{SS} = 0\text{ V}$, 1/9 bias, 1/65 duty
 $V_{CC1} = 13.0\text{ V}$, $V_{CC2} = 12.5\text{ V}$, Contrast control = max
 Op-amp ON, DC-DC OFF, regulator OFF, LCD outpin No Load

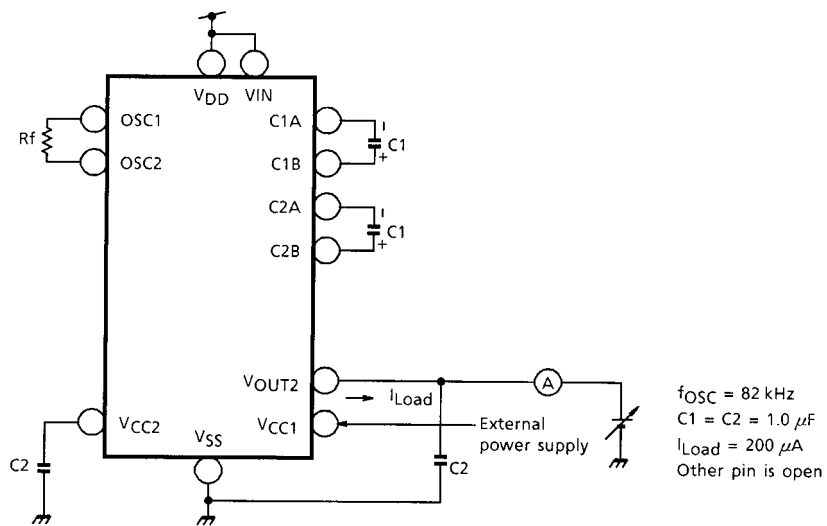
$V_{opoffs} = ((V_{LC1} - V_{LC2}) - (V_{LC0} - V_{LC1})) + ((V_{LC3} - V_{LC4}) - (V_{LC4} - V_{LC5}))$

Test Circuit

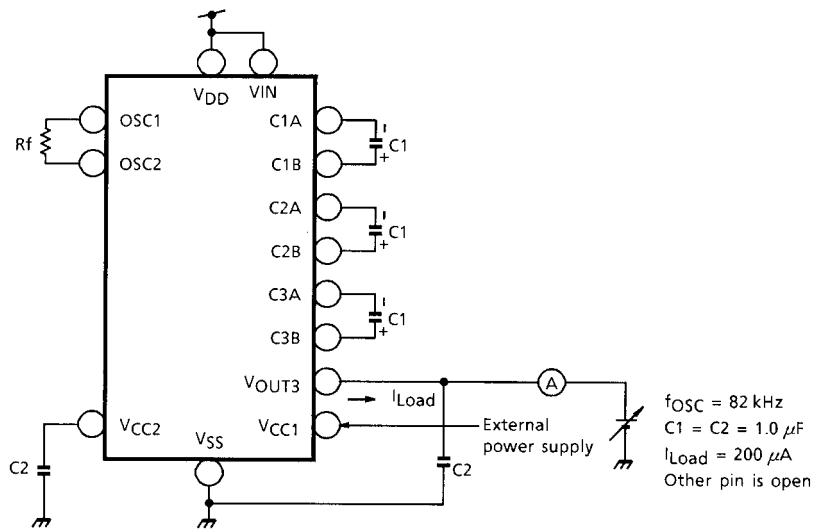
(1) DC-DC converter X2 mode



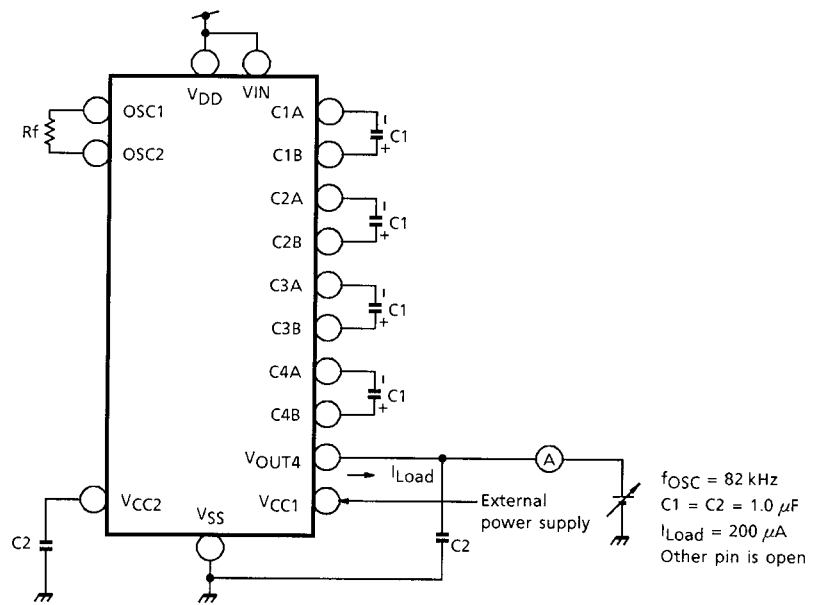
(2) DC-DC converter X3 mode



(3) DC-DC converter X4 mode

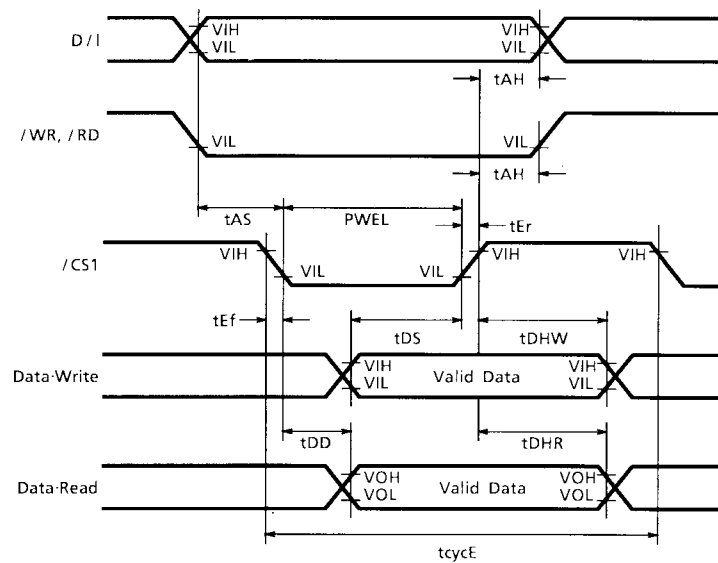


(4) DC-DC converter X5 mode



AC Characteristics (1)

- **Switching characteristics (80 series MPU 8-bit interface)**

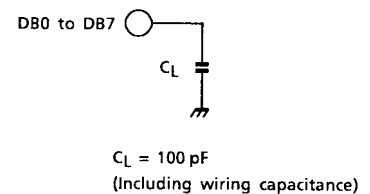


Test Conditions

(Unless Otherwise Noted,, $V_{SS} = 0\text{ V}$, $V_{DD} = 2.4\text{ to }3.3\text{ V}$, $T_a = 25^\circ\text{C}$)

Item	Symbol	Min	Max	Unit
Enable Cycle Time	tcycE	500	—	ns
Enable Pulse Width	PWEL	410	—	ns
Enable Rise/Fall Time	tEr, tEf	—	25	ns
Address Set-up Time	tAS	20	—	ns
Address Hold Time	tAH	0	—	ns
Data Set-up Time	tDS	140	—	ns
Data Hold Time	tDHW	20	—	ns
Data Delay Time	tDD (Note)	—	330	ns
Data Hold Time	tDHR (Note)	20	—	ns

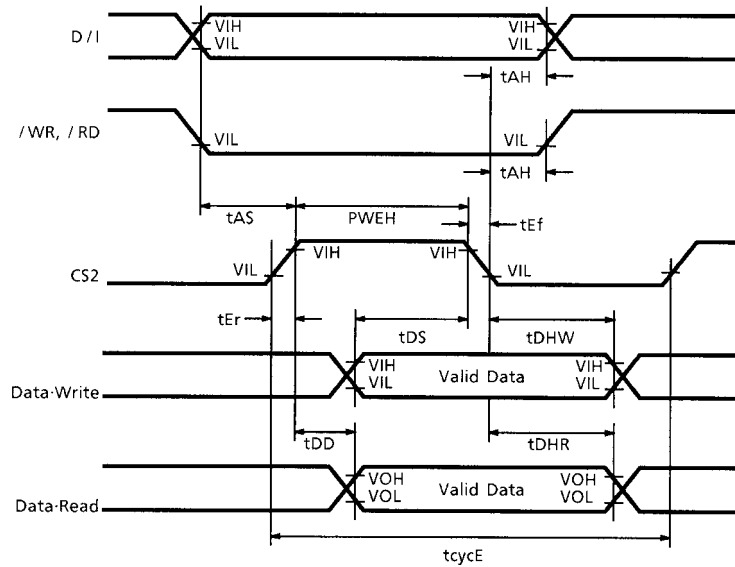
Load Circuit



Note: Connect to Load circuit.

AC Characteristics (2)

- **Switching characteristics (80 series MPU 8-bit interface)**



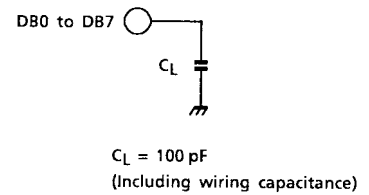
Test Conditions

(Unless Otherwise Noted, $V_{SS} = 0\text{ V}$, $V_{DD} = 2.4\text{ to }3.3\text{ V}$, $T_a = 25^\circ\text{C}$)

Item	Symbol	Min	Max	Unit
Enable Cycle Time	tcycE	500	—	ns
Enable Pulse Width	PWEH	410	—	ns
Enable Rise/Fall Time	tEr, tEf	—	25	ns
Address Set-up Time	tAS	20	—	ns
Address Hold Time	tAH	0	—	ns
Data Set-up Time	tDS	140	—	ns
Data Hold Time	tDHW	20	—	ns
Data Delay Time	tDD (Note)	—	330	ns
Data Hold Time	tDHR (Note)	20	—	ns

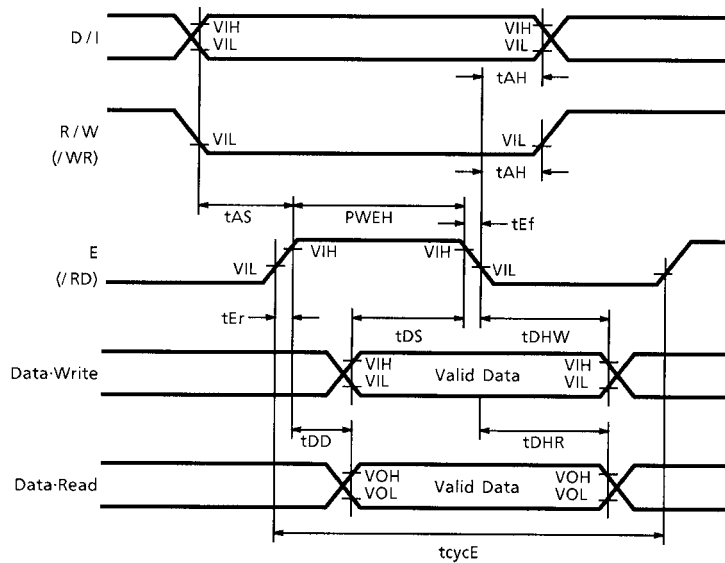
Note: Connect to Load circuit.

Load Circuit



AC Characteristics (3)

- **Switching characteristics (68 series MPU 8-bit interface)**

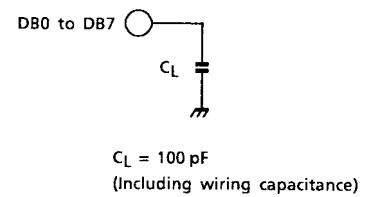


Test Conditions

(Unless Otherwise Noted, $V_{SS} = 0\text{ V}$, $V_{DD} = 2.4\text{ to }3.3\text{ V}$, $T_a = 25^\circ\text{C}$)

Item	Symbol	Min	Max	Unit
Enable Cycle Time	tcycE	500	—	ns
Enable Pulse Width	PWEH	410	—	ns
Enable Rise/Fall Time	tEr, tEf	—	25	ns
Address Set-up Time	tAS	20	—	ns
Address Hold Time	tAH	0	—	ns
Data Set-up Time	tDS	140	—	ns
Data Hold Time	tDHW	20	—	ns
Data Delay Time	tDD (Note)	—	330	ns
Data Hold Time	tDHR (Note)	20	—	ns

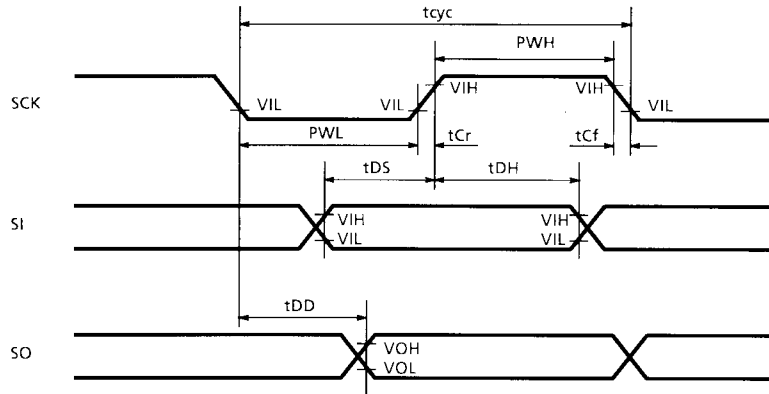
Load Circuit



Note: Connect to Load circuit.

AC Characteristics (4)

- **Switching characteristics (serial interface)**



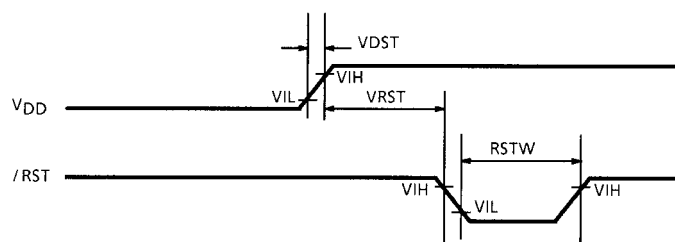
Test Conditions

(Unless Otherwise Noted, $V_{SS} = 0\text{ V}$, $V_{DD} = 2.4\text{ to }3.3\text{ V}$, $T_a = 25^\circ\text{C}$)

Item	Symbol	Min	Max	Unit
Clock Cycle Time	t_{cycC}	2000	—	ns
Clock Pulse Width	PWCL, PWCH	900	—	ns
Clock Rise/Fall Time	t_{Cr} , t_{Cf}	—	25	ns
Data Set-up Time	t_{DS}	300	—	ns
Data Hold Time	t_{DH}	100	—	ns
Data Delay Time	t_{DD}	—	200	ns

AC Characteristics (5)

- Switching characteristics



Test Condition

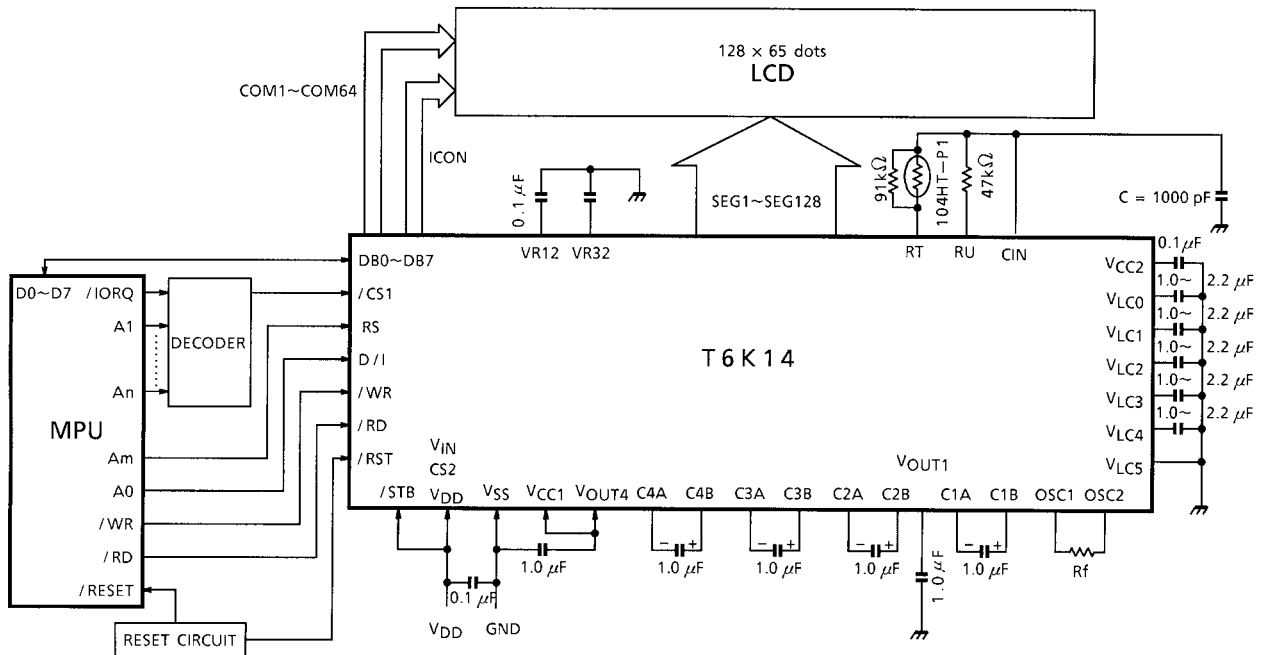
(Unless Otherwise Noted, V_{SS} = 0 V, V_{DD} = 2.4 to 3.3 V, Ta = 25°C)

Item	Symbol	Min	Max	Unit
VDD Rise Time	VDST	—	1	ms
Reset Hold Time	VRST	1	—	μs
Reset Pulse Width	RSTW	1	—	μs

Application Circuit (1)

T6K14 One chip mode

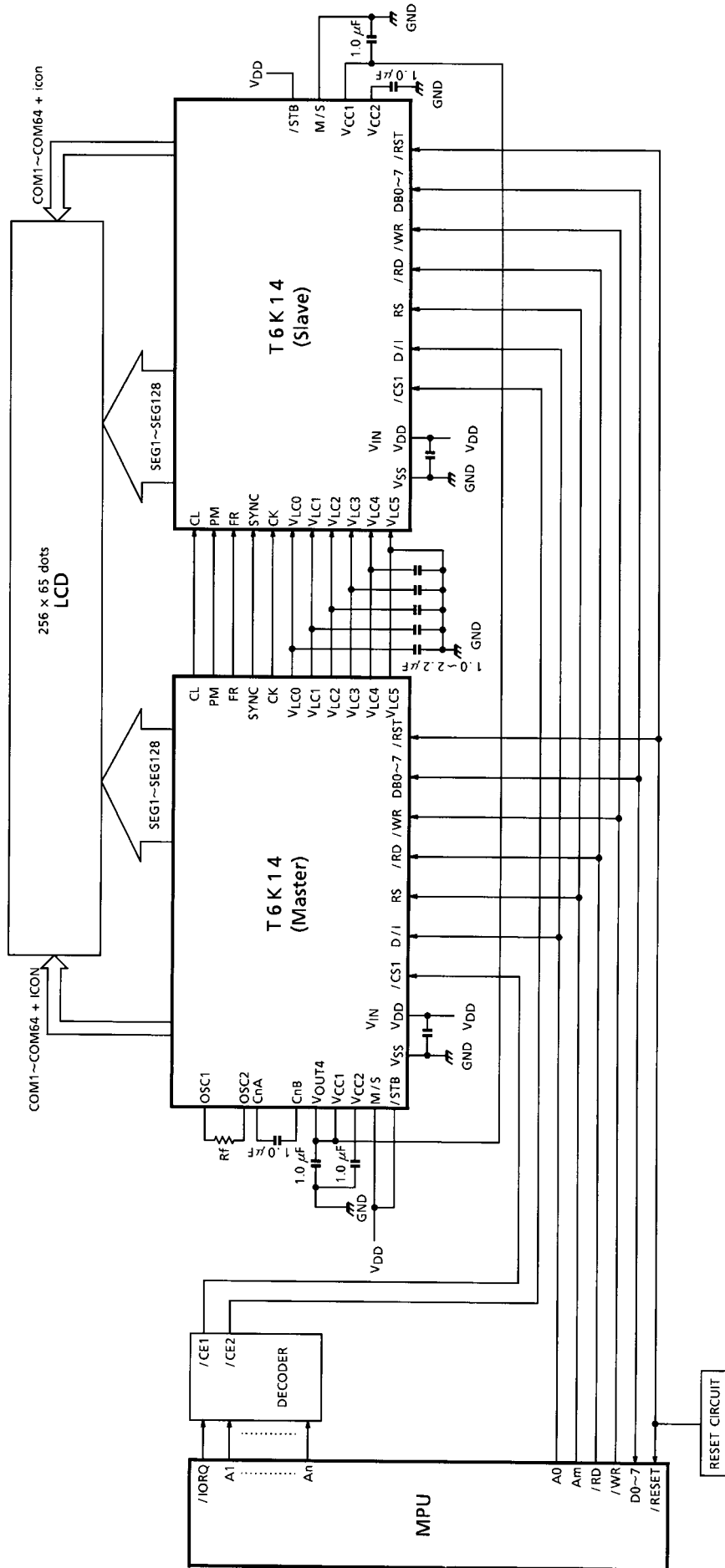
- Using CR oscillator
- LCD drive bias 1/9
- Using DC-DC converter (X5 mode)
- Using 80 series MPU
- Using temperature compensation



Application Circuit (2)

T6K14 Two chip mode

- Using CR oscillator
- LCD drive bias 1/9
- Using DC-DC converter (X5 mode)
- Using 80 series MPU
- Using temperature compensation



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